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May 10, 2002

Division of Water Rights
State Water Resources Control Board
P.O. Box 2000
Sacramento, CA 95812-2000
Attention: Jean McCue

Re: American River FAS Petition

Dear Ms. McCue:

Somach, Simmons & Dunn serves as special legal counsel to Sacramento County and the Sacramento County Water Agency. Please find attached hereto the written testimony of Keith DeVore, Director of the Department of Water Resources and Paul Bratovich and George Link of Surface Water Resources Inc. submitted on behalf of Sacramento County and the Sacramento County Water Agency.

If you have any questions, please do not hesitate to contact me.

Very truly yours,

William E. Hvidsten

cc: Attached Proof of Service List

WEH:sb

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COUNTY OF SACRAMENTO and
SACRAMENTO COUNTY WATER AGENCY

EXEMPT FROM FILING FEES PURSUANT TO GOVERNMENT CODE SECTION 6103

BEFORE THE STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In Re: Petition to Revise Declaration of Fully Appropriated Stream Systems Designation of American River, Sacramento County	COUNTY OF SACRAMENTO'S AND SACRAMENTO COUNTY WATER AGENCY'S OPENING STATEMENT

1. INTRODUCTION

In order to address the "Key Issues" listed in the State Water Resources Control Board's ("SWRCB") Notice Regarding Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County ("Notice") and to determine if the Southern California Water Company's ("SCWC") Petition should be granted, it is necessary to look at all of the facts and circumstances that exist and give rise to the instant situation. In this light, and based upon this broad perspective, the County of Sacramento and the Sacramento County Water Agency (hereinafter collectively referred to as "Sacramento County") believe that the SWRCB should not revise the Declaration of Fully Appropriated Stream Systems Regarding the American River ("FAS Declaration") to allow the Division of Water Rights to accept and process water

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rights applications to appropriate "treated groundwater discharged into the American River." (See Key Issue No. 1 at Notice, p. 4.)

In dealing with SCWC's Petition regarding the FAS Declaration, it is critical that the SWRCB consider the matter in context. To do otherwise would result in inappropriate and impermissible piecemeal consideration of matters that are integrally related and inter-dependent.

2. GROUNDWATER USE

There appears to be no dispute that the so-called "new water" which is the subject of SCWC's Petition is, in fact, water within the Central Sacramento County sub-basin. In this regard, there also appears to be no dispute that this groundwater is percolating groundwater as opposed to "surface water" as that latter term is defined within the Water Code. (The question of whether this groundwater is tributary, in some manner, to the lower American River is a different question which may or may not be implicated in the instant case.) Finally, in this regard, there also appears to be no dispute that many individuals and entities currently rely upon this water. This includes Sacramento County, California-American Water Company ("Cal-Am"), SCWC, undoubtedly overlying landowners, and perhaps even Aerojet. These individuals and entities have current rights to this water as well as the right to continue to increase production from this groundwater resource, with the exercise of due diligence.

3. ENVIRONMENTAL PROTECTION AGENCY ("EPA")/REGIONAL WATER QUALITY CONTROL BOARD ("RWQCB")ORDERS

The "new water" which is the subject of SCWC's Petition, in addition to being water upon which others rely and to which others have a current and future legal right, is groundwater contaminated by Aerojet's operations. This contaminated groundwater is pumped, treated and discharged to Buffalo Creek, tributary to the American River. This RWQCB/EPA authorized and ordered pumping is about 3,500 gallons per minute ("gpm") with a potential increase of an additional 6,000 gpm. This equates to about 15,243 acre-feet annually ("afa") that is being taken from existing users and from those with existing rights. (See Testimony of Keith DeVore, Sacramento County Exhibit No. 1; see also SCWC's Exhibit No. 25.)

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The significance of this process to Sacramento County, one of the entities with existing rights to this "new water," is detailed in the testimony of Keith DeVore, Director, Department of Water Resources, County of Sacramento. (Sacramento County Exhibit No. 1.) The County has lost 5,800 gpm of its original production capacity of 11,500 gpm in the Mather area and Sunrise Corridor area. While some mitigation has occurred, Sacramento County's capacity to meet peak water demands during hot and dry summer conditions, increased demands of existing customers, or demand attributable to new development remains at risk. There is no available capacity to replace water supply wells that may be shut down in the future due to contamination. Sacramento County has no water supply replacement option for its Mather and Sunrise Corridor service areas.

In addition to the current impact that this pumping is having on Sacramento County's own existing rights and use of water, the pumping is being undertaken without any comprehensive review of the sustained yield of the affected groundwater basin. A great deal of regional planning, including the Water Forum Agreement, is being ignored. Treating the water being pumped and discharged by Aerojet as "new water," rather than as groundwater, exacerbates this problem. Unless this water is identified as groundwater, water purveyors like Sacramento County, having once been victimized by Aerojet's contamination, will be further victimized by a "solution" that threatens to cure the contamination through dewatering and mining the groundwater basin.

In this context, one cannot ignore the relevant EPA Record of Decision ("ROD") associated with these discharges. That ROD did not call for the re-injection of pumped and treated contaminated groundwater, nor did it contemplate that this pumped and discharged water would be treated as unappropriated surface water. Instead, EPA intended "for discharge of the treated groundwater to surface water in order to allow for the greatest potential for *reuse of the treated groundwater to provide replacement water supplies for those lost due to contamination in the Rancho Cordova and surrounding areas.*" (SCWC Exhibit No. 25, p. 2 of appended "Information Sheet," emphasis added.) Thus, the EPA/RWQCB view and interest was and is identical with that of Sacramento County. The groundwater in question is not "new water" free

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for appropriation, but rather is groundwater to be recovered by those who have lost water supplies due to the Aerojet contamination.

This concept is consistent with fundamental concepts of water law.[1] The law draws a clear distinction between how it treats groundwater and how it treats surface water. In this context, there are legions of cases which describe, for example, the difference between percolating groundwater, to which the law of groundwater applies, and water flowing underground in known and definite channels or as the underflow of a surface water body, to which the law of surface water applies. These cases, among other things, underscore the legal distinction between these two sources of water.

In this context, numerous cases as well as the Water Code also deal with the fact that surface water retains its essential legal quality as surface water, even when it is stored underground. In a similar manner, groundwater should not lose its character as groundwater just because it is placed within a surface water system, particularly under the facts of this case.

Indeed, the body of law dealing with foreign waters would, with limited exception, seem to be dispositive of this point. The use of Buffalo Creek and the American River to convey this foreign groundwater is appropriate and does not change this situation. (Indeed, the RWQCB/EPA Orders and the EPA ROD clearly anticipate that those who have lost water supplies were to recover and reuse the water that Aerojet discharged.)

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[1] It has been asserted that the water in question is "treated wastewater" and that "treated wastewater" belongs to the entity that discharges it. While this result does avoid inappropriate manipulation by third parties such as Reclamation, it does not address the mischief that will be caused by Aerojet. It is apparent that if this line of reasoning prevails, Aerojet, as the technical "discharger" of this water, will seek to take this water for sale to third parties. This will not further the RWQCB/EPA goal of providing a replacement for those whose water supply has been taken by Aerojet's actions.

On a much more fundamental basis, this position is not supported by the law. The treated water at issue here is not the type of wastewater that is dealt with in relevant statutory provisions. The wastewater dealt with in Water Code section 1210 *et seq.* is wastewater from a sanitary sewer system. That is simply not the situation that exists here. (See Sacramento County Exhibit No. 1.)

While this would be the result under different facts, it is compelled by the actual facts in this case. Here SCWC, Cal-Am, and Sacramento County have legitimate appropriative groundwater rights which they have exercised in producing a water supply, including drinking water, for a significant portion of Sacramento County. They intend to continue and, in the exercise of due diligence, expand on this municipal use of water

Aerojet and others have contaminated potions of the groundwater basin and because of this contamination, SCWC, Cal-Am and Sacramento County wells have been shut down and other wells are currently threatened. In order to address this problem and to clean up the groundwater basin, EPA and the RWQCB have ordered Aerojet to pump and treat this contaminated groundwater and to discharge this water into Buffalo Creek and then to the American River. Also, as part of this regulatory scheme, EPA and the RWQCB have ordered that this discharged water be made available for reuse by those with groundwater rights lost by Aerojet's contamination.

In this context, SCWC's Petition is nothing more than the attempt of an entity whose water supply has been taken from it by contamination to make itself whole.[2] The problem with the means that it has attempted to use is that it has the potential for mischief by third parties who will attempt to exploit the situation for their own material gain. The position of the United States Bureau of Reclamation ("USBR" or "Reclamation") is an excellent example. They have taken the position that if the treated groundwater is "surface water," then it has been abandoned and is subject to appropriation by senior appropriators, such as itself and the Department of Water Resources ("DWR"). Moreover, Reclamation (and DWR) contend that certain conditions associated with surface water, including Term 91, must apply to the diversion of this "new water."

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[2] SCWC's citation to SWRCB Order WR 2000-12, dealing with the revision of the FAS Declaration regarding the Santa Ana River, is not at all compelling. There the "new water" associated with a portion of the Order was, in fact, surface flood flows that previously could not be captured. The revision recognized the current (at the time of Order WR 2000-12) ability to capture and divert this surface water. The remaining increment of "new water," at issue in Order WR 2000-12, derived from discharges from a wastewater treatment plant. This wastewater treatment plant was of the kind dealt with in Water Code section 1210 *et seq.* (See fn.1, *supra.*)

In this context, Aerojet's insistence that the scope of these hearings not include a discussion of the ownership of surface water is quite telling. (See Aerojet's Motion to Exclude Evidence.) As their legal counsel's cross-examination of Reclamation witnesses telegraphed, they will claim that this "new" surface water is theirs, free for them to sell to others. This view, of course, ignores EPA's ROD and the fact that this "new water" has, from the beginning, been earmarked for use by those with lost groundwater supplies.

The point, however, is that the water at issue is, in fact and law, not new surface water, but groundwater for which parties have a current right. The fact that it may be now conveyed through surface water sources does not change that reality. If it did, then the entire EPA/RWQCB process would be flawed in a fundamental manner.

EPA and the RWQCB seek to clean up the groundwater basin and make water purveyors and others who rely upon effluent and groundwater whole. This can only be done if the water pumped and discharged is earmarked as groundwater available for use by those with groundwater rights to it. To do otherwise would transmute a legitimate pump, treat and discharge groundwater remediation program into a "pump and dump" scheme that provides little or no actual benefit. Indeed, as noted in the DeVore testimony, a pump and dump scenario would be an unreasonable use of groundwater in violation of Article X, section 2, of the California State Constitution.

The SWRCB, as the ultimate authority with respect to water quality as well as post-1914 surface water rights, must interpret the RWQCB's Order in a manner that is reasonable and rational. At a very fundamental basis, this means insuring that those sought to be protected by EPA and the RWQCB's Order are not inadvertently victimized by it. This can only be done by recognizing that the water in question is groundwater and not "new" surface water.

4. SWRCB'S JURISDICTION WITHIN THE SCOPE OF THE FAS DETERMINATION

As noted in Sacramento County's Opposition to Aerojet's Objection and Motion to Exclude Testimony, a decision by the SWRCB to revise the FAS Declaration would lead to an ultimate evaluation by the SWRCB of what to do with the "new" unappropriated surface water. That question is outside of the scope of this hearing. A decision not to adjust the FAS

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Declaration, however, would necessitate some further finding that would preclude third parties from treating this groundwater as "abandoned" or otherwise available surface water.

The SWRCB, of course, has no direct jurisdiction over groundwater. It does, however, have responsibilities associated with the RWQCB's actions which have given rise to the instant situation and it also has the clear power and authority to preclude the diversion of "treated groundwater discharged into the American River" by stating that this water cannot be diverted as surface water (since it is not surface water). This would allow treated groundwater to be recovered by those with overlying and appropriative rights to it.

In this context, the type of finding/order that would be most appropriate, consistent with prior FAS Declarations, would contain within it something like the following:

> IT IS HEREBY ORDERED that SCWC's Petition to revise the FAS Declaration Regarding American River, Sacramento County, is DENIED, subject to the following determinations:
>
> 1. The "new water" sought by SCWC to be declared as unappropriated surface water is, in fact, groundwater subject to the rights of rediversion and use by entities and individuals with overlying or appropriative rights within the groundwater basin from which it was pumped. These entities include, but are not necessarily limited to, SCWC, Sacramento County, and Cal-Am.
>
> 2. The instant determination is consistent with relevant EPA decisions, court decrees and orders associated with the clean-up of contamination within the relevant groundwater basin and the intent that water pumped, treated and discharged be replacement water supplies for those lost due to contamination in the Rancho Cordova and surrounding areas.
>
> 3. This groundwater shall not be diverted as surface water, nor shall it be diverted as "abandoned water."
>
> 4. The diversion of this surface water shall not be the subject of Term 91 requirements or any other terms or conditions limiting surface water diversions.
>
> 5. Nothing herein is intended to provide that the actual diversion of groundwater is being authorized by the SWRCB. The SWRCB is here only determining that the water at issue is groundwater.

5. ENVIRONMENTAL COMPLIANCE

Sacramento County's Exhibit No. 2 addresses issues associated with the environmental impacts to the American River of the diversion of the subject groundwater from the American River. In summary, this testimony and the accompanying sub-exhibits conclude that there will be

no significant adverse impact if this water is diverted by those with rights to this groundwater. This type of analysis will be utilized as part of any needed environmental review of a project to re-divert this groundwater by those whose supplies have been adversely affected by Aerojet's contamination.

6. KEY ISSUES

The SWRCB posed five Key Issues in its Notice. These issues in many respects ignore the first question that should be posed: Should the "new water" in question be treated as "surface water" or as "groundwater"? Sacramento County's response to this question is that it should be treated as groundwater.

In this context, Sacramento County answers the first Key Issue in the negative: The SWRCB should *not* revise the Declaration to allow the Division of Water Rights to accept and process water right applications to appropriate "treated groundwater discharged into the American River." Treated groundwater is still groundwater and the fact that it is discharged into the American River does not change this fact.

The rest of the Key Issues, in a very material way, beg the very question that should be at issue. One can answer each of these questions in the affirmative or provide the requested information with respect to the extent of "new water" that may be within the lower American River without ever addressing how that water should properly be characterized and dealt with. Again, Sacramento County believes this water should be dealt with as groundwater subject to diversion solely by those who have been or will be adversely affected by the contamination that precipitated the pump-treat-discharge process.

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7. CONCLUSION

Based upon the foregoing, Sacramento County respectfully requests that the SWRCB treat the "new water" at issue as groundwater and, in that context, Sacramento County further requests that the SWRCB preclude those with surface water rights from diverting this water, reserving or preserving its diversion and use to those with groundwater rights that have been adversely affected by contamination.

Dated: June 12, 2002

ROBERT A. RYAN, JR., COUNTY COUNSEL
COUNTY OF SACRAMENTO

SOMACH, SIMMONS & DUNN
A Professional Corporation

By: _____
Stuart L. Somach

Attorneys for
COUNTY OF SACRAMENTO and
SACRAMENTO COUNTY WATER AGENCY

PROOF OF SERVICE

I am employed in the County of Sacramento; my business address is 400 Capitol Mall, Suite 1900, Sacramento, California; I am over the age of 18 years and not a party to the foregoing action.

On June 12, 2002, I served the following document(s):

COUNTY OF SACRAMENTO'S AND SACRAMENTO COUNTY WATER AGENCY'S OPENING STATEMENT

X (**by electronic submission**) on the following parties, at their e-mail addresses as provided, in said action listed below:

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AND

X (**by facsimile transmission**) to the person at the address and phone number set forth below:

X (**by mail**) on all parties in said action listed below, in accordance with Code of Civil Procedure §1013a(3), by placing a true copy thereof enclosed in a sealed envelope in a designated area for outgoing mail, addressed as set forth below. At Somach, Simmons & Dunn, mail placed in that designated area is given the correct amount of postage and is deposited that same day, in the ordinary course of business, in a United States mailbox in the City of Sacramento, California.

SEE ATTACHED SERVICE LIST

I declare under penalty of perjury that the foregoing is true and correct under the laws of the State of California. Executed on June 12, 2002, at Sacramento, California.

Susan Bentley

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Samantha Olson
State Water Resources Control Board
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Exhibit Identification Index

Participant: County of Sacramento AND Sacramento County Water Agency

Exhibit No.	Description (If exhibit is in electronic format, please include file name.)	Status as Evidence		
		Introduced	Accepted	By Official Notice
Sacramento Co. Exh. 1	Written Testimony submitted on behalf of the County of Sacramento and Sacramento County Water Agency [5 10 02TestimonyFASHrg.pdf]			
Sacramento Co. Exh. 2	Expert Testimony on Lower American River Fisheries and Hydrologic Issues [5 10 02CvrShtExpertTest'yFAS.pdf] [5 10 02ExpertTestimonyFASHr.pdf] Attachment A to Expert Testimony [5 10 02AtchA ExpertTestim'y.pdf]			
SCWC Exh. 25	NPDES No. 00083861 [Sacramento County/Sacramento County Water Agency intend to rely on SCWC Exhibit 25 and will not submit additional copies.]			

PROOF OF SERVICE

I am employed in the County of Sacramento; my business address is 400 Capitol Mall, Suite 1900, Sacramento, California; I am over the age of 18 years and not a party to the foregoing action.

On May 10, 2002, I served a true and correct copy of

EXHIBIT IDENTIFICATION INDEX; WRITTEN TESTIMONY OF KEITH DEVORE, DIRECTOR, DEPARTMENT OF WATER RESOURCES, COUNTY OF SACRAMENTO, AND SACRAMENTO COUNTY WATER AGENCY; and EXPERT TESTIMONY ON LOWER AMERICAN RIVER FISHERIES AND HYDROLOGIC ISSUES

X (**by electronic submission**) on the following parties, at their e-mail addresses as provided, in said action listed below:

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[Representing California-American Water Company]

AND

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SEE ATTACHED SERVICE LIST

I declare under penalty of perjury that the foregoing is true and correct under the laws of the State of California. Executed on May 10, 2002, at Sacramento, California.

Susan Bentley

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Petition to Revise Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County

Written Testimony of
Keith DeVore, Director, Department of Water Resources,
County of Sacramento and Sacramento County Water Agency

Hearing Date: May 31, 2002

This written testimony is submitted on behalf of the County of Sacramento and Sacramento County Water Agency. The County of Sacramento is governed by elected Board members who represent all those constituents impacted by groundwater contamination emanating from the Aerojet Superfund site and the Inactive Rancho Cordova Test Site ("IRCTS"). The Sacramento County Water Agency is responsible for the water supply needs of approximately 25,000 homes and businesses within the central Sacramento County groundwater sub-basin (south of the American River). The Department of Water Resources serves as staff to both entities.

I. INTRODUCTION

The Southern California Water Company ("SCWC") by its Petition to Revise the Declaration of Fully Appropriated Streams for the Lower American River ("Petition") seeks a revision of the State Water Resources Control Board ("SWRCB") Declaration that the American River system in Sacramento County is fully appropriated from the confluence of the Sacramento River upstream ("FAS Declaration"). The focus of SCWC's Petition is groundwater contaminated by Aerojet's operations, which is pumped, treated and discharged to Buffalo Creek, a tributary of the American River. Aerojet has an approved NPDES permit authorizing the discharge of 3,500 gpm to Buffalo Creek. (SCWC Exhibit 25; NPDES No. 00083861 (Tentative), Finding No. 6.) Aerojet has submitted a request to the Central Valley Regional Water Quality Control Board ("RWQCB") to increase the allowable discharge by an additional 6,000 gpm. (*Ibid.*, Finding No. 15.) SCWC contends that the contaminated groundwater extracted, treated and discharged is non-native water not considered by the SWRCB when it declared the American River to be fully appropriated. Sacramento County agrees that the discharge constitutes new water that was not considered in its FAS Declaration. However, the County does not believe that the process of extracting and treating groundwater and subsequently discharging it into the American River converts that water into surface water subject to appropriation by any subsequent applicants. To do so would infringe on the rights of all parties holding property rights to the groundwater and who rely on that groundwater for their drinking water supply.

The SWRCB must make findings that: (1) the "new" water at issue is groundwater subject to the exclusive diversion by those with rights to groundwater within the affected groundwater basin; (2) recognize the exclusive rights of Sacramento County and the other affected water purveyors to divert water for use within the areas affected by

Aerojet's contamination and NPDES Permits; and (3) interpret RWQCB orders to limit the "pump and dump" method of groundwater extraction and remediation impacts on the safe yield.

II. FACTUAL BACKGROUND

A. Impact on Sacramento County Water Purveyors

In dealing with the situation presented by SCWC's Petition, the SWRCB must consider the broad factual predicate that gave rise to the current situation. Aerojet contaminated significant portions of the groundwater sub-basin from which Sacramento County and other water purveyors appropriate water for public drinking water purposes. Groundwater contamination resulting from perchlorate and NDMA plumes migrating from the Aerojet Superfund site and the adjacent IRCTS, for which Aerojet is also partly responsible, has resulted in the loss of at least fourteen public water supply wells in Sacramento County. Thirteen additional wells are at risk of removal from service in the near future. Of the ten water supply wells originally operated by the County in the Sunrise/Mather area, only the four Mather Housing water supply wells remain as viable sources of water supply for this entire area. The Aerojet and IRCTS plumes have not only caused the closure of many existing water supply wells, but also they have precluded the construction of new water supply wells in groundwater outside the plumes.

The County's water system overlays portions of the Aerojet/IRCTS sites. The County service areas impacted to date by the Aerojet/IRCTS contamination are known as the Mather area and the Sunrise Corridor area. The County has lost 5,800 gpm of its original production capacity of 11,500 gpm in this area. A new water line and storage tank constructed and partially funded by Aerojet have somewhat mitigated the problem by redistributing the County's remaining water supply capacity. As a result, capacity to meet peak water demands during hot and dry summer conditions, increased demands of existing customers, or demands attributable to new development is at risk. There is also no available capacity to replace water supply wells that may be shut down in the future due to contamination. The County has no water supply replacement options for its Mather and Sunrise Corridor areas.

B. Discharges of Treated Groundwater

The United States Environmental Protection Agency ("EPA"), the RWQCB, and the Department of Toxic Substances Control directed Aerojet to construct groundwater extraction and treatment facilities ("GET") for the remediation of a portion of the groundwater contamination. The contaminated groundwater extracted by Aerojet from the American River Study Area ("ARSA") is treated at and discharged from the facility known as the AR-GET facility. Aerojet is authorized to discharge up to 3,450 gpm from the AR-GET facility pursuant to Order 98-113 (NPDES No. CA0083861) issued by the RWQCB. Aerojet has submitted a

request to the RWQCB to revise its existing NPDES permit to include a discharge of up to 6,000 gpm of treated groundwater from its GET E/F facility. (SCWC Exhibit 25.)

Sacramento County objects to Aerojet discharging large amounts of groundwater to the American River absent the completion of a cumulative impacts study of the groundwater remediation project on the available yield of the groundwater basin. Sacramento County believes that these extractions will have significant adverse impacts on the groundwater basin. Groundwater is the source of over one-half of the water used in the Sacramento Region. Sound groundwater management practices are necessary to protect the viability of this resource for both current and future users. It is critical that the sustained yield of the groundwater basin be examined in the RWQCB's consideration of Aerojet's proposed NPDES permit revision.

Sustainable yield is defined as the amount of groundwater that can be safely pumped from the groundwater basin over a long period of time while maintaining acceptable groundwater elevations and avoiding undesirable effects. Examples of undesirable effects might include increased pumping costs and the accelerated movement of underground pollutants. Sustainable yield requires a balance between pumping and basin recharge and is expressed as the number of acre feet of water per year that can be pumped from the basin on a long-term average annual basis. The inability to maintain a sustainable yield creates the conditions that have historically given rise to overdraft, litigation and groundwater basin adjudication.

The Water Forum Agreement, entered into by stakeholder representatives from numerous local governing boards, business entities and the public in Sacramento County, seeks to avoid that situation by recommending management of the basin so as to prevent basin-wide pumping in excess of sustainable yield. The Water Forum recommended an average annual sustainable yield for the south area of Sacramento County (defined as the area between the American and Cosumnes Rivers) of 273,000 acre-feet. These calculations of sustainable yield did not account for the more than 23,000 acre-feet of groundwater per year Aerojet seeks to extract.

At present, there is insufficient demand to utilize the treated water to be discharged by Aerojet into the American River. Moreover, there is no comprehensive plan for use of the water. As a result, this water will no longer be available to the basin and the beneficial use of the groundwater is negatively impacted. Aerojet's disposal of the treated water in this manner will have a profound effect on available water supplies in the future as it substantially reduces the water available within the sustained yield of the groundwater sub-basin. Pumping that amount of water to the American River is tantamount to adding 30,000 new homes of water supply demand to the groundwater basin. Furthermore, the decision to pump, treat, and discharge to waste does nothing to address the water supplies lost due to direct contamination of the groundwater or indirect contamination as the result of new well prohibitions within a several-mile radius of the contaminated areas. It compounds the problem. Thus, having first been victimized by Aerojet's contamination, water purveyors are now threatened with a "solution"

that threatens to cure the contamination problem through the dewatering and mining of the groundwater basin.

At current levels, and considering proposals for increased levels of discharge, a significant concern associated with the mining of the groundwater sub-basin is raised. In its comments to Aerojet's proposed NPDES Permit revision, the County requested the RWQCB to make a finding of fact that the discharge of treated groundwater to the American River without a viable reuse option violates Article X, Section 2, of the California Constitution. Article X, Section 2, of the California Constitution requires that water resources be put to beneficial use to the fullest extent possible. Moreover, it requires that waste, unreasonable use or unreasonable method of use of water be prevented and that the conservation of water is to be exercised with a view to reasonable and beneficial use. The discharge of treated groundwater into the American River without storage requirements or a viable reuse option violates the California Constitution. To address that finding, the County recommends that the ownership of the extracted water be determined prior to the commencement of any full-scale treatment and discharge operations. Further, the RWQCB should incorporate immediate water storage requirements into the proposed permit conditions in order to preclude or limit the waste of water discharged to the American River. The RWQCB has postponed its consideration of Aerojet's NPDES Permit revision until at least July, 2002.

III. TREATED GROUNDWATER DISCHARGED BY AEROJET CANNOT BE DEEMED "NEW WATER" SUBJECT TO APPROPRIATION

A. The Treated Water Discharged by Aerojet Is Groundwater

The fundamental point that the SWRCB must address is whether contaminated groundwater that Aerojet extracts, treats and discharges should be treated as surface water. Sacramento County believes that under the circumstances presented here, any treated groundwater discharged by Aerojet and reaching the American River is still, by nature, groundwater and should be dedicated for use by those with rights to that groundwater. That water is part of the sustained yield of the groundwater sub-basin and should be used within the sub-basin. The treated and discharged groundwater is, in fact, non-native water that was not considered by the SWRCB when it declared the American River to be fully appropriated. Aerojet's discharges of treated groundwater nonetheless cannot be dealt with as unappropriated water in the American River system justifying revision of the FAS Declaration for the purpose of accepting and processing water rights applications by any subsequent applicant related to those discharges. The normal procedural steps for appropriation of surface water are not directly applicable to the groundwater at issue here.

B. Existing Interests in the Treated Groundwater

As discussed above, Aerojet is authorized to discharge up to 3,450 gpm from the AR-GET facility pursuant to Order 98-113 (NPDES No. CA0083861) issued by the RWQCB. Aerojet does not own the ARSA property and has no overlying rights to that groundwater. Aerojet has submitted a request to the RWQCB to revise its existing NPDES permit to include a discharge of up to 6,000 gpm of treated groundwater from its GET E/F facility. Groundwater from beneath the Aerojet property is treated at and is to be discharged from the GET E/F facility. SCWC characterizes the groundwater treated at and discharged from the AR-GET and GET E/F facilities as "new water" subject to appropriation. (SCWC Exhibit 25.)

Under California water law, an overlying landowner has the common right to beneficially use groundwater on its overlying lands along with all other owners overlying the same groundwater supply. In this context, Aerojet, as an overlying landowner, may have an entitlement to groundwater treated at and extracted from the GET E/F facility. However, its entitlement to that water is limited to use on overlying lands for reasonable beneficial purposes. The "pump and dump" scheme authorized by the RWQCB is not an overlying use. At best, Aerojet might be considered an appropriator of groundwater, because the groundwater it extracts for treatment at the AR-GET and GET E/F facilities is not used on overlying lands. As an appropriator, Aerojet may only appropriate surplus water in the basin. If Aerojet is pumping anything other than surplus groundwater, that groundwater is not available for appropriation and would belong to the prior appropriators, including Sacramento County.

Sacramento County also owns the property on which some of Aerojet's extraction wells are located. It has rights to that groundwater both as an overlying landowner and as an appropriator. A determination by the SWRCB that the "pumped and dumped" groundwater, to which Sacramento County has overlying and/or appropriative rights, is "new" water available for appropriation would constitute a taking of those rights.

SCWC has not provided adequate information on the status of the groundwater basin to determine whether there is surplus water available to appropriate. SCWC must also analyze what impacts, if any, Aerojet's pumping of significant amounts of groundwater has on the water supply available to other appropriators of groundwater in the vicinity of Aerojet's operations.

Additional water supply replacement measures are currently being pursued to provide temporary and/or final replacement for lost water supplies, and to provide temporary supplies in the event additional wells are shutdown in the future. (February 27, 2002 Letter from RWQCB to Mr. Ed Anton ("2/27/02 Pinkos Letter"), p. 5.) The Record of Decision ("ROD")[1]

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[1] United States Environmental Protection Agency, Region 9, Record of Decision for the Western Groundwater Operable Unit OU-3, Aerojet Sacramento Site, Rancho Cordova, California, dated July 20, 2001.

requires Aerojet to develop, implement and augment a short-term water replacement contingency plan ("SWRCP"). As part of the plan, Aerojet is required to replace water supply wells upon an initial finding of contamination. In the SWRCP, Aerojet must provide for at least two-year replacement capacity for water supplies lost due to Aerojet contamination. Aerojet is also required to develop and implement a long-term water replacement contingency plan ("LWRCP") for the permanent replacement of contaminated water supply wells with an equivalent water supply. As pointed out by the RWQCB, the ROD contemplates that the treated groundwater will be discharged to surface water and would be available for use in the affected area to compensate for impacts to the groundwater basin caused by the contamination. (2/27/02 Pinkos Letter, p. 5.) The contaminated groundwater extracted and treated by Aerojet should therefore be available exclusively to the parties that have experienced the loss of groundwater supplies due to Aerojet's contamination. Designation of that treated and discharged groundwater as "new" water available for appropriation would frustrate the intent of the ROD to provide interim and long-term replacement water supplies to those parties adversely affected by Aerojet's contamination.

C. Use of American River as a Conduit

The discharge of the treated groundwater into the American River making it available to those who have lost groundwater supplies is nothing more than a direct transfer of groundwater within the basin over which the SWRCB has no jurisdiction. The analysis does not change simply because the American River is being used as a conduit for the transfer. Even though those entities with rights to the groundwater will not be taking the same molecules of water discharged into the river, the legal assumption is that there is a diversion of groundwater, not surface water. Water Code section 1211, which requires SWRCB approval of any change of point of discharge or place of use, is inapplicable. Section 1211 pertains only to the discharge of treated wastewater from a sanitary sewer system. By its own terms, therefore, it does not apply to the type of groundwater extraction and treatment system being constructed and operated by Aerojet

D. The Treated Groundwater Discharged by Aerojet Is Not Wastewater

In Aerojet's Waste Discharge Requirements ("WDR"), the RWQCB states "[p]rior to making any change in the discharge point, place of use, or purpose of use of the *wastewater*, the Discharger shall obtain the approval of or clearance from the [SWRCB]." (WDR, Provision 9 (emphasis added).) WDR Provision 9 mirrors the requirements in Water Code section 1211, subsection (a), which deals with treated wastewater. Water Code section 1210 provides that "[t]he owner of a waste water treatment plant operated for the purposes of treating wastes from a sanitary sewer system" holds the exclusive right to the treated waste water against anyone who supplied water to the treatment plant. As discussed above, Aerojet is not operating a facility that treats waste from a sanitary sewer system and therefore does not hold the exclusive right to the discharged water.

IV. PROHIBITION AGAINST MINING OF GROUNDWATER – CALIFORNIA CONSTITUTION ARTICLE X, SECTION 2

Article X, section 2, of the California Constitution limits the right to water to reasonable and beneficial uses. In this context, in order to determine whether there is surplus water available for appropriation, there must be a consideration of all factors involved, including reasonable methods of use and reasonable methods of diversion

The RWQCB Orders that lead to the "pump and dump" solution, in order to be valid, must be read to contemplate the prohibition of waste and unreasonable use contained within Article X, section 2, of the California Constitution. Interpreting those Orders to allow Aerojet to mine the groundwater basin to the detriment of water purveyors already adversely affected by contamination would clearly violate Article X, section 2. This violation of the California Constitution would be compounded if the SWRCB allowed the pumped and dumped water to be appropriated as unappropriated surface water and exported form the basin.

In this context, the RWQCB Orders must be read to limit Aerojet to a pump and dump scheme that falls within the safe yield of the groundwater basin and which earmarks the treated water for the exclusive use of water purveyors that otherwise would have had the right to extract groundwater from the affected groundwater basin. The County is recommending that the RWQCB modify the revised tentative NPDES Permit to include the following conditions: (1) Groundwater pumped, treated and sought to be discharged by Aerojet must be dedicated to entities with rights to the groundwater through their status as overlying landowners and/or prior appropriators; (2) the pumping, treating and discharging of groundwater shall be conducted in a manner that does not constitute mining of the groundwater basin; and (3) Aerojet shall make arrangements for the immediate storage of the treated groundwater discharged into the American River pursuant to its permit in order to preclude or limit the waste of water discharged to the American River.

V. CONCLUSION

The SWRCB should make clear that the "new" water at issue is groundwater that is subject to the exclusive diversion by those with rights to groundwater within the affected groundwater basin. Moreover, the SWRCB should take this opportunity to interpret the relevant RWQCB's Orders as limiting the "pump and dump" scheme to quantities of water that are within the safe yield of the groundwater basin.

EXPERT TESTIMONY ON LOWER AMERICAN RIVER FISHERIES AND HYDROLOGICAL ISSUES BY SURFACE WATER RESOURCES, INC., FOR SACRAMENTO COUNTY

PREPARED FOR:

State of California
State Water Resources Control Board
Public Hearing and Petition to Revise
Declaration of Fully Appropriated Stream Systems
Regarding the American River, Sacramento County

PREPARED BY:

Paul Bratovich, M.S., Vice President and Principal Scientist, SWRI
George Link, P.E., President and Principal Engineer, SWRI

Sacramento County Exh. 2

EXPERT TESTIMONY ON LOWER AMERICAN RIVER FISHERIES AND HYDROLOGIC ISSUES

1.0 INTRODUCTION

This document presents joint written testimony by Paul Bratovich and George Link regarding fisheries and hydrological issues on the lower American River, as these issues pertain to the *Public Hearing and Petition to Revise the Declaration of Fully Appropriated Stream Systems* (FAS Declaration) regarding the American River, Sacramento County. Paul Bratovich and George Link are expert witness representing the County of Sacramento. Their qualifications as expert witnesses are presented below.

1.1 PAUL M. BRATOVICH, M.S. - SURFACE WATER RESOURCES, INC.

Mr. Paul Bratovich serves as the head of Surface Water Resources, Inc.'s (SWRI) fisheries and aquatic sciences team, and oversees all fisheries-related aspects of project work in addition to conducting project-level fisheries impact assessments. With a Master of Science degree in Fishery Resources and over 19 years of experience in California, he is a recognized fisheries expert, actively participating in a broad range of forums in a variety of consultative, advisory, and technical expert capacities. He has extensive experience in the area of regulatory and technical consultations with federal and state agencies such as the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Fish and Game (CDFG), and California Department of Water Resources (DWR) in the areas of flow-habitat relationships, habitat restoration, population dynamics, endangered species, impact assessment, and strategic water resources planning.

Mr. Bratovich is recognized as a leading fisheries expert in the American River Basin. A few relevant examples of his American River Basin experience include:

- Served as SWRI's Principal-in-Charge for the Water Forum's successfully completed environmental impact report (EIR), overseeing the development of the impact analysis framework for the EIR, and preparing the fisheries and aquatic resources impact analysis.

- Principal Scientist in the preparation of the Fisheries and Aquatic Habitat Management Plan, an integral component of the River Corridor Management Plan (RCMP) for the lower American River.

- Principal Scientist in the development and implementation of a new lower American River flow standard, including overseeing the preparation of the Lower American River Flow Management Plan.

- Developed water temperature objectives schedules for the modeling of lower American River water temperatures and salmon mortality to determine the monthly Folsom Reservoir target water temperature release objectives that would provide maximum benefit to both chinook salmon and steelhead in the lower American River.

- SWRI's Principal-in-Charge for the preparation of the environmental impact statement (EIS)/ environmental impact report (EIR) for the American River Pump Station and River Restoration Project on behalf of the U.S. Bureau of Reclamation (Reclamation) and Placer County Water Agency (PCWA).

- SWRI's Principal-in-Charge for the American River Basin Cumulative Report prepared for Reclamation - a comprehensive cumulative impact analysis for Reclamation's use in several environmental documents and biological assessments for reasonably foreseeable federal actions within the American River Basin.

- Principal Scientist in the preparation of environmental documents for Sacramento Area Flood Control Agency (SAFCA) to determine the effects of interim reoperation of Folsom Dam and Reservoir given demands on the Central Valley Project (CVP) and instream requirements of the lower American River. Prepared the fisheries and aquatic resources impact analysis for the environmental assessment and biological assessment for the long-term reoperation of Folsom Dam and Reservoir.

- Responsible for the experimental design, implementation and report preparation of a multi-faceted aquatic ecology investigation of the lower American River. Investigative elements included habitat classification and mapping; application of the Instream Flow Incremental Methodology (IFIM) to evaluate instream flow needs; estimation of juvenile chinook salmon abundance and distribution by habitat type; microhabitat suitability data acquisition, juvenile salmon emigration data acquisition, and water temperature monitoring. The results of these investigations were used by Paul Bratovich in his service as a technical expert on the Alameda County Superior Court Lower American River Technical Advisory Committee associated with the retained jurisdiction in the case of the *Environmental Defense Fund et al. vs. East Bay Municipal Utility District.*

- Serves as a technical expert to the Lower American River Operations Working Group (AROWG) that meets regularly to consider and recommend streamflow releases from Folsom Dam to the lower American River based on predicted inflow, storage, coldwater pool availability, and demand releases.

1.2 GEORGE W. LINK, P.E. - SURFACE WATER RESOURCES, INC.

Mr. Link has over 27 years of experience in real-time multi-purpose water project operations, analysis and management of water systems, development of operations and planning mathematic computer models, and real-time management of power scheduling and demand-side load management. He utilizes operations and planning models to solve problems related to water supply, water quality, fish and wildlife considerations, power supply, flood control, and recreation. Mr. Link is a Professional Engineer, with a Bachelors of Science degree in Civil Engineering. His work history includes 10 years with Reclamation, where he spent five years as a Supervisory Hydraulic Engineer in the Central Valley Operations Coordinating Office. While there, he directed the daily water operations for the federal CVP.

Mr. Link has considerable expertise on the American River including:

- Served as SWRI's Principal Engineer for the Water Forum's successfully completed EIR, overseeing all hydrologic, water temperature, and salmon mortality modeling used as a basis of the impact assessment for water supply, fisheries resources, riparian vegetation, recreation, and cultural resources. He was directly responsible for water supply and power impact analyses and development of the modeling assumptions for the EIR.

- Principal Engineer in the development and implementation of a new lower American River flow standard, including developing the rules to implement the modeled minimum flow standard on a real-time basis.

- Prepared the iterative modeling of lower American River water temperatures and salmon mortality to determine the monthly Folsom Reservoir target water temperature release objectives that would provide maximum benefit to both chinook salmon and steelhead in the lower American River.

- SWRI's Principal Engineer for the hydrologic modeling associated with the preparation of the EIS/EIR for the American River Pump Station and River Restoration Project on behalf of Reclamation and PCWA.

- SWRI's Principal Engineer for the American River Basin Cumulative Report prepared for Reclamation, a comprehensive cumulative impact analysis for Reclamation's use in several environmental documents and biological assessments for reasonably foreseeable federal actions within the American River Basin.

- Principal Engineer in the preparation of feasibility studies for SAFCA to determine the effects of reoperation of Folsom Dam and Reservoir given demands on the CVP and instream requirements of the lower American River. He was responsible for directing all aspects of hydrologic, water temperature, salmon mortality, and hydropower modeling supporting the long-term reoperation environmental assessment analysis.

2.0 BACKGROUND

On November 16, 1989, the State Water Resource Control Board (SWRCB) determined that the entire flow of the American River and its tributaries from July 1 through October 31 is required to satisfy prior rights on the American River and in the Sacramento-San Joaquin Delta (SWRCB Order WR 89-25 Decisions (D) 1108 and 1211). The SWRCB adopted an updated and revised order by the same name on August 22, 1991 (SWRCB Order WR 91-07). SWRCB Order WR 98-08, dated November 19, 1998, included additions and revisions to the provisions of the previous FAS Declarations (SWRCB Orders WR 89-25 and WR 91-07). No specific revisions were made to the decisions concerning the American River as a fully appropriated stream under the conditions stipulated above. Thus, the decisions contained in Orders WR 89-25 and WR 91-07 concerning the American River were confirmed (SWRCB Order WR 98-08, 1998).

Placing a stream on the FAS Declaration precludes the SWRCB from accepting any application to appropriate water from a specified stream system where the proposed appropriation is

inconsistent with the conditions contained in the FAS Declaration. The SWRCB may revise a condition of the FAS Declaration to allow for the acceptance for filing and processing of an application to appropriate water from a stream system previously declared to be fully appropriated. The environmental effects of any proposed diversion, public trust concerns, and fishery needs will be addressed if, and when any application is processed by the SWRCB (SWRCB 2002).

In addition, the lower American River, from Nimbus Dam to its junction with the Sacramento River, is protected throughout the year under the California Wild and Scenic Rivers Act (Pub. Resources Code & 5093 et seq). State and federal wild and scenic river stream systems are included in the FAS Declaration in recognition of the restrictions on appropriation of water under applicable provisions of state and federal law. In accordance with California Code of Regulations, title 23, section 734(c), the SWRCB may accept for filing an application to appropriate water in connection with construction of a water diversion facility on any river designated in Public Resources Code Section 5093.54, other than a dam, reservoir, or other water impoundment facility *"...[p]rovided, no permit is issued on any such application unless the Secretary of the Resources Agency first determines (1) that such facility is needed to supply domestic water to the residents of the county or counties through which the river flows and (2) that such facility will not adversely affect its free-flowing condition or natural character."* Thus, the most recent update of the SWRCB list of fully appropriated streams (SWRCB Order WR 98-08, Appendix A), also lists the lower American River as unavailable for new appropriations year-round due to its inclusion on the California List of Wild and Scenic Rivers (See California Public Resources Code && 5093 et seq). The effects of any proposed diversion on the wild and scenic status of the lower American River will be addressed if, and when any application is processed by the SWRCB (SWRCB 2002).

2.1 Petition to Revise the Declaration of Fully Appropriated Stream Systems

Aerojet-General Corporation (Aerojet) pumps contaminated groundwater, treats it, and then discharges the treated groundwater into Buffalo Creek, which is tributary to the American River. Aerojet is authorized to discharge up to 3,450 gallons per minute (gpm) (7.7 cubic feet per second (cfs)) under the Central Valley Regional Water Quality Control Board's (CVRWQCB) Order No. 98-113, National Pollutant Discharge Elimination System (NPDES) No. CA0083861, adopted on April 17, 1998. On November 8, 2001, the Southern California Water Company (SCWC) submitted a petition and supporting information requesting that the FAS Declaration be revised to allow for acceptance and processing of an application appropriate water discharged by Aerojet into the American River. SCWC states in its petition that the water that is the subject of the petition is non-native water that was not considered by the SWRCB when it declared the American River to be fully appropriated. On January 18, 2002, SCWC submitted an application to appropriate the same amount of water from the American River that is discharged by Aerojet, less conveyance cost. The proposed application has not been accepted, but has been retained by the SWRCB (SWRCB 2002).

The Chief of Division of Water Rights has reviewed the petition and supporting information provided by SCWC, and concluded that there is reasonable cause to conduct a hearing on the questions of whether the FAS Declaration should be revised to allow for acceptance and processing of water right applications to appropriate treated groundwater that is discharged to the

American River. The hearing is limited to the purpose of determining if the FAS Declaration should be revised to allow the SWRCB to process water right applications filed to appropriate water added to the American River in connection with discharges of treated groundwater (SWRCB 2002).

According to the Notice of Pre-Hearing Conference, Public Hearing and Petitions to Revise Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County (Page 4): *"Should the SWRCB revise the Declaration to allow the Division of Water Rights to accept and process water right applications to appropriate "treated groundwater discharged into the American River"?*

- *Has adequate information been provided to demonstrate that there is a change in circumstances since the American River system was included in the FAS Declaration?*
- *How much, if any, of the water discharged by groundwater treatment operations is water that was not considered at the time the American River system was included in the FAS Declaration?*
- *To what extent, if any, have flows in the American River been affected by groundwater treatment operations, including both pumping and discharging, since the American River system was included in the FAS Declaration?*
- *Has the petitioner provided sufficient hydrologic data, water usage data, or other relevant information to support a determination that there is unappropriated water in the American River system during the season applied for to justify revising the FAS Declaration for the purpose of accepting and processing water right applications related to the discharges of treated groundwater into the American River?"*

3.0 PURPOSE AND INTENT OF THIS DOCUMENT

The purpose of this document is to address certain key issues raised by the SWRCB on their document titled *Notice of Pre-Hearing Conference, Public Hearing and Petition of Fully Appropriated Stream Systems regarding the American River, Sacramento County,* dated March 7, 2002, and to address potential environmental effects associated with the petition requesting the revision of the FAS Declaration. These key issues and potential environmental impacts are discussed in detail below.

4.0 RESPONSES TO ISSUES RAISED BY THE STATE WATER RESOURCE CONTROL BOARD

4.1 WATER PLANNING AND REGULATORY COMPLIANCE

Issue No. 1 - *"Has adequate information been provided to demonstrate that there is a change in circumstances since the American River system was included in the FAS Declaration?"*

D-1108 in SWRCB Order WR 89-25, in which the American River was declared a fully appropriated stream from July 1 to October 31, is based on Application 20478 and all information on file therewith, including D-893, D-990, D-1082, and D-1098 of the State Water Rights Board (SWRB). D-1211, in SWRCB Order WR 89-25, also is based on D-893, D-1045, D-1082 and D-1092.

D-1098, used as part of the basis for D-1108, was adopted on September 26, 1962. This decision states that (page 2): *"The Board in previous decisions has found that there is no unappropriated water available in the American River watershed, ...during the months of August, September, and October, and that there is no unappropriated water during the months of July and August in the reach of the Sacramento River to which the American River is tributary."* D-1098 is based on Application 19632, and all relevant information on file therewith, including D-893 and D-990 of the SWRB.

D-893 was adopted on March 18, 1958. In D-893, the SWRCB found that unappropriated water normally exists in the American River system except during the months of August, September, and October. D-893 states that (Page 41): *"...Unappropriated water may be deemed to exist in the American River at such times as flows passing Fair Oaks exceed requirements below that point for consumptive purposes along the American River, for fish conservation in the American River, and for that portion of the requirements for consumptive purposes and salinity repulsion in the Delta that devolves upon the American River to provide."*

Several decisions implementing instream flows necessary to protect fisheries and recreation on the lower American River have been issued since the issuance of D-893, and other decisions that were the basis for including the American River among the stream systems declared to be fully appropriated (SWRCB 2002). As stated on the *Notice of Pre-Hearing Conference, Public Hearing and Petition to Revise Declaration of Fully Appropriated Stream Systems regarding the American River, Sacramento County* (2002), in 1958 the SWRCB issued D-893 and other decisions that were the basis for including the American River among the stream systems declared to be fully appropriated. In 1972, the SWRCB issued D-1400, setting fisheries flows for the American River higher than those in D-893, as a condition of the permits for the proposed Auburn Dam. Although Auburn Dam was never constructed, and D-1400 flows were never imposed, Reclamation recently implemented modified D-1400 flows that incorporated the flow objectives of the Anadromous Fisheries Restoration Program (AFRP), pursuant to the Central Valley Project Improvement Act (CVPIA). The subject of water rights and instream flows also was addressed in a January 2, 1990, judgment of the Superior Court for the County of Alameda (*Environmental Defense Fund, Inc. v. East Bay Municipal Utility District, (Super. CT. County of Alameda, 1990, No. 425955) Hodge Decision).* While only binding on the parties involved in the litigation, the 1990 judgment provided a basis for crafting a physical solution that includes minimum instream flows for various seasons in the American River (SWRCB 2002). In addition, numerous regulatory requirements and processes, water user demands and allocations also have changed, which have an effect on water supply. These regulatory requirements and processes, water demands and allocations include, but are not necessarily limited to:

- Central Valley Project (CVP) and State Water Project (SWP) Coordinated Operations Agreement (COA)

- Sacramento Area Water Forum Agreement (Water Forum) and Habitat Management Element (HME)
- East Bay Municipal Utility District (EBMUD) Amendatory Contract
- American River Operations Working Group (AROWG)
- CALFED Bay Delta Program Record of Decision (ROD) and RCMP
- Trinity River Mainstem Fishery Restoration ROD
- Change in water user demands
- Lower American River Flow Management Plan (FMP)
- Folsom Dam and Reservoir Flood Control Diagram and Reoperations

4.1.1 Coordinated Operations Agreement

The COA obligates both the CVP and SWP to meet water quality and outflow standards taken from SWRCB D-1485 for protecting beneficial uses of the Sacramento-San Joaquin Delta water supply. This agreement is designed to increase the efficient use of existing water supplies by defining a sharing process for the SWP and the CVP to meet in-basin use and exports. The intent of the COA is to comply with, rather than to update, established standards for environmental protection. *Exhibit A* of the COA presents the set of flow standards, water quality standards, and export restrictions that define the Delta portion of in-basin use requirements.

4.1.2 Sacramento Area Water Forum Agreement and Habitat Management Element

The Habitat Management Element (HME) for the lower American River, combined with other elements of the Water Forum Agreement, fulfills one of the Water Forum's two coequal objectives: "*...to preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River.*" The HME contains five programmatic components that together address river flow, water temperature, physical habitat, and recreation issues for the lower American River. These programmatic components include the Habitat Management Plan (HMP), habitat improvement projects that benefit the lower American River ecosystem, monitoring and evaluation efforts, project-specific mitigation and/or conservation measures, and lower American River recreational activities.

As delineated in the Water Forum Agreement, the HMP is to include descriptions of reasonable and feasible projects that could be implemented to avoid and/or offset potential impacts to the lower American River fish and riparian resources due to the increased surface water diversions defined under the Water Forum Agreement. The HMP also is to identify and define the following:

- Performance standards to be used as indicators of the health of the lower American River;
- Conceptual (e.g., mitigation banking or other) and technical framework for the HMP;
- Schedule and technical assistance required for development, implementation, and monitoring of the HMP;

- The manner with which the HMP will be coordinated with other programs, plans, initiatives, and/or mandates that affect the lower American River ecosystem;
- Logistics and responsibilities associated with administering the HMP;
- Implementation priorities, strategies, and schedules for the proposed projects;
- Lead organizations for implementation of each project;
- The manner with which the HMP could serve as the framework for addressing federal Endangered Species Act (ESA) and California Endangered Species Act (CESA) requirements; and
- Cost-sharing obligations and specific funding commitments.

4.1.3 East Bay Municipal Utility District Amendatory Contract

In 1970, EBMUD signed a water service contract with Reclamation for delivery of up to 150,000 acre-feet (AF) of American River water annually from the Folsom South Canal (FSC). EBMUD has been paying for water under the contract since shortly following the signing of the water service contract.

Since signing the contract, EBMUD has pursued obtaining water supplies from the American River to supplement its current customer needs. Reclamation has amended the original contract to provide for the delivery of CVP water to EBMUD's point(s) of delivery subject to the following conditions:

- *"In recognition of dry year conditions, EBMUD is willing to forego deliveries in certain years when the CVP system faces operational limits and EBMUD has sufficient carryover storage under its exclusive control."*
- *"Historic Use" of Project Water is not an appropriate basis for calculating the supply of Project Water to be made available to EBMUD during years in which Project Water shortages are being imposed on Project Contractors north of the Sacramento/San Joaquin River Delta, and therefore this Amendatory Contract must incorporate a different methodology for calculating the amount of Project Water to be made available to EBMUD during water-short years.*

The Amendatory Contract shall remain effective through December 31, 2012. Under the Amendatory Contract, Reclamation shall make available for delivery to EBMUD Project Water pursuant to either subdivision (1), (2), or (3) below:

(1) *"At Freeport on the Sacramento River, EBMUD will be entitled to take delivery of up to 133,000 AF of project water for municipal and industrial (M&I) purposes in any year in which EBMUD's March 1 forecast of its October 1 Total System Storage is less than 500,000 AF base on a 50 percent exceedance. The entitlement shall not exceed a total of 165,000 AF of water delivered in any*

three consecutive-year period that EBMUD's Total System Storage forecast remains below 500,000 AF."

(2) *At Site five on the lower American River, EBMUD shall be entitled to take deliver of up to a total of 150,000 AF of project water for M&I purposes in any year, provided that conditions in Article 5(a)(2) of the Amendatory Contract are satisfied.*

(3) *At Station 666+50 on the FSC, EBMUD shall be entitled to take delivery of up to a total of 150,000 AF of project water for M&I purposes in any year, only under the terms and conditions of Article 5(a)(3) of the Amendatory Contract.*

Because the capacity of the CVP to deliver water has been constrained in recent years, and may be constrained in the future due to many factors including hydrologic conditions and implementation of federal and state laws, the likelihood of EBMUD actually receiving the amount of water set out in subdivision (1), (2), and (3), in any given year is uncertain. Reclamation's most recent modeling projected that the contract total will not be made available in many years.

4.1.4 Lower American River Operations Working Group

An operational working group has been established for the lower American River, known as the AROWG. This group includes representatives from Reclamation, U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Fish and Game (CDFG), SAFCA, Water Forum, City of Sacramento, County of Sacramento, Western Area Power Administration (WAPA), and the Save the American River Association (SARA). The AROWG generally convenes monthly, or more frequently, with the purpose of providing input to Reclamation on the management of Folsom Reservoir for fish resources in the lower American River, within the confines of water availability and other operational considerations.

Reclamation provides this group with information such as flows for the prior several months, reservoir storage, projected reservoir inflow, water temperature data, and projected outflows. The AROWG uses this information to plan and develop the annual flow release schedule for Folsom Dam. This planning activity takes place on a monthly basis, or more frequently, with the group adapting and refining the projected flow release schedule for the next month, and making necessary adjustments for the remainder of the year.

4.1.5 CALFED Bay-Delta Program Record of Decision and RCMP

CALFED is a cooperative effort among state and federal agencies and California's environmental, urban, and agricultural communities. It was initiated in 1995 to develop a long-term strategy to restore environmental health and resolve water management problems in the Bay-Delta, and its numerous watersheds. In January 2000, CALFED approved funding for 31 restoration projects in the Bay-Delta estuary and its watershed under the federal Bay-Delta Act and California Proposition 204. Projects were selected from a pool of 226 proposals submitted to CALFED in April 1999. The lower American RCMP development project was among those approved and partially funded by CALFED, with additional funding by the Water Forum and SAFCA.

The lower American River and its watershed have been recognized as important components in the pursuit of CALFED'S vision and objectives for ecosystem restoration throughout California. Based on the core involvement of local, state, and federal agencies, as well as business and community groups, the comprehensive RCMP will serve as the planning framework that will allow local entities to coordinate their management activities related to the lower American River, and to assist CALFED in evaluating appropriate lower American River restoration actions.

The CALFED Programmatic Record of Decision (ROD), dated August 28, 2000, adopted a general target of continuously improving Delta water quality for all uses. This ROD for the CALFED Bay-Delta Final Programmatic EIS/EIR represents the culmination of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) processes. The ROD reflects a final selection of a long-term plan (i.e., Preferred Program Alternative), which includes specific actions to fix the Bay-Delta, describes a strategy for implementing the plan, and identifies complementary actions the CALFED agencies also will pursue.

4.1.6 Trinity River Mainstem Fishery Restoration Record of Decision

The Draft Trinity River Mainstem Fishery Restoration EIS/EIR was prepared by USFWS, Hoopa Valley Tribe, Trinity County, and Reclamation, and was released for public review in October 1999. The draft EIS/EIR addresses the environmental issues associated with restoration of the natural production of anadromous fish on the Trinity River mainstem downstream of Lewiston Dam. The Final EIS/EIR was released in October 2000. The ROD was released in December 2000, but has been challenged by Westlands Water District, Sacramento Municipal Utility District (SMUD), and Northern California Power Association (NCPA). The court has ordered the lead agencies to prepare a supplemental EIS, which is scheduled to be completed in 2003.

4.1.7 Change in water user demands

CVP water demands have changed since the FAS Declaration. Significantly, these changes include water demands of purveyors in the American River Basin, and EBMUD. For additional detail, please refer to section 4.1.2 and 4.1.3.

4.1.8 Lower American River Flow Management Plan

The goal of the lower American River Flow Management Plan (FMP) is to increase the minimum release requirement for the river in conjunction with establishing an adaptive management process for Folsom Reservoir and lower American River operations, geared towards the protection and enhancement of fish species of priority management concern. The FMP flow regime is intended to accomplish the management objective of allocating annual water supply to maximize initial year-class strength of chinook salmon and steelhead.

4.1.9 Folsom Dam and Reservoir Flood Control Diagram and Reoperations

In the 1999 Water Resources Development Act (WRDA) (P.L. 106-53) (Appendix A), Congress directed the U.S. Army Corps of Engineers (Corps) to implement a 400/600 variable storage space flood control diagram upon completion of modifications to the outlet works at Folsom Dam and Reservoir. Congress directed the Secretary of the Army to coordinate with the Secretary of the Interior with respect to the design and construction of these modifications. Modifications to the outlet works will allow the release of more water from Folsom Dam earlier in a flood event. This more flexible flood control operation will enable the Corps to promulgate a new 400/600 flood control diagram for Folsom Dam and Reservoir. This new diagram will continue to link flood control operations at Folsom Dam to reservoir levels in the non-federal reservoirs upstream in the watershed. The minimum flood control storage requirement (400,000 AF) will not change. However, because of the increased release capacity of the modified outlet works, the new diagram will reduce the maximum storage requirement to 600,000 AF (from 670,000 AF). Congress has directed the Secretary of the Army as follows:

> *"Upon completion of the improvements to Folsom Dam authorized by subparagraph (A) [new outlets], the variable space allocated to flood control within the Reservoir shall be reduced from the current operating range of 400,000-670,000 acre-feet to 400,000-600,000 acre-feet."*

At full pool (i.e., elevation 466 feet mean sea level [msl]), Folsom Reservoir has a maximum storage capacity of about 977,000 AF. Water supplies are delivered and power is generated by releases through three penstocks located on the right side of the main dam, with an intake centerline of 307 feet msl. Under the currently effective diagram (1986 Diagram), dated November 7, 1986, Reclamation must reduce the reservoir pool to 577,000 AF (elevation 425 feet msl) during the winter in order to create 400,000 AF of empty space for flood storage.

During a flood event, releases from Folsom Reservoir are made through the power penstocks (i.e., 8,000 cfs total capacity), and through eight gated river outlets (26,000 cfs maximum total capacity) until inflowing waters cause the reservoir to fill to elevation 429 feet msl (605,000 AF of storage). At that point, releases are then raised incrementally to 115,000 cfs (design release), which represents the safe carrying capacity of the leveed channel downstream of the dam. Because of the current configuration of the spillway, the designed release cannot be achieved until the reservoir pool reaches 446 feet msl, at which point the pool contains 762,000 AF of water and only 215,000 AF of empty space remains to store inflows in excess of the design release.

The 400/670 variable-space flood control diagram is an adaptive management plan that varies reservoir storage in Folsom Reservoir based on storage conditions in French Meadows, Hell Hole, and Union Valley reservoirs (the three largest upstream reservoirs). The plan calls for maintaining the minimum flood control storage of 400,000 AF of empty space mandated by the 1986 Diagram as long as the three upstream reservoirs have space available to store at least 200,000 AF of flood water. Any reduction in this upstream flood storage capacity below 200,000 AF must be offset by an increase in the empty space available for flood control at Folsom Reservoir. Complete exhaustion of upstream flood storage capacity requires that space available for flood storage at Folsom Reservoir be increased to 670,000 AF.

4.2 SOURCE OF SUBJECT WATER

Issue No. 2 *– "How much, if any, of the water discharged by groundwater treatment operations is water that was not considered at the time the American River system was included in the FAS Declaration?"*

Issue No. 4 – *"Has the petitioner provided sufficient hydrologic data, water usage data, or other relevant information to support a determination that there is unappropriated water in the American River system during the season applied for to justify revising the FAS Declaration for the purpose of accepting and processing water right applications related to the discharges of treated groundwater into the American River?"*

The treated groundwater (i.e., 3,450 gpm (7.7 cfs)) discharged by Aerojet into Buffalo Creek, and subsequently discharged into the American River, is water not considered in any of the FAS Declarations previously certified. Moreover, to the knowledge of the authors of this testimony, this water has not been included in any hydrologic modeling conducted by the resource agencies for CEQA, NEPA and ESA compliance documents. These environmental compliance documents include, but are not limited to:

- CVPIA Programmatic EIR/EIS
- Trinity River Mainstem Fishery Restoration EIR/EIS
- CALFED Ecosystem Restoration Program Plan Programmatic EIR/EIS
- EBMUD Supplemental Water Supply Project EIR/EIS

In addition, the subject water has not been incorporated in any hydrological modeling conducted in recent environmental documents prepared by SWRI on behalf of various resource agencies. These environmental documents include, but are not limited to:

- Water Forum EIR
- PCWA and Northridge Water District Groundwater Stabilization Project EIR
- PCWA and Reclamation American River Pump Station EIS/EIR
- Reclamation's American River Basin Cumulative Impact Report (Cumulative Report)
- SMUD/Sacramento Water County Agency (SCWA) Water Assignment EIR
- SAFCA's Long-Term Reoperation of Folsom Dam and Reservoir Environmental Assessment

The following is a description of the resource agencies NEPA, CEQA and ESA compliance documents and the documents prepared by SWRI that do not include the 7.7 cfs discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.1 CENTRAL VALLEY PROJECT IMPROVEMENT ACT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

The Draft PEIS for the CVPIA was prepared pursuant to NEPA by Reclamation for the Department of the Interior. The Draft PEIS was released for public review on November 7,

1997. The CVPIA amends the previous authorizations of CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement having an equal priority with power generation. The Draft PEIS addresses the potential impacts of implementation of the CVPIA. The Draft PEIS for the CVPIA does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.2 Trinity River Mainstem Fishery Restoration Environmental Impact Report/ Environmental Impact Statement

The Draft Trinity River Mainstem Fishery Restoration EIS/EIR was prepared by USFWS, Hoopa Valley Tribe, Trinity County, and Reclamation, and was released for public review in October 1999. The draft EIS/EIR addresses the environmental issues associated with restoration of the natural production of anadromous fish on the Trinity River mainstem downstream of Lewiston Dam, including the effects of reduced water availability for CVP operations, of which Folsom Dam and Reservoir (and lower American River) is part. The Final EIS/EIR was released in October 2000. The ROD was released in December 2000, but has been challenged by Westlands Water District, Sacramento Municipal Utility District (SMUD), and Northern California Power Association (NCPA). The court has ordered the lead agencies to prepare a supplemental EIS, which is scheduled to be completed in 2003. The Trinity River Mainstem Fishery Restoration EIS/EIR does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.3 CALFED Environmental Impact Report/ Environmental Impact Statement

The CALFED Final PEIS/EIR was prepared by the CALFED Bay-Delta Program Reclamation, USFWS, NMFS, U.S. Environmental Protection Agency, Natural Resources Conservation Service, Corps, and the California Resources Agency, and was released in July 2000. The Final PEIS/EIR was prepared in review of Phase II of the CALFED Program, which includes development of the Preferred Program Alternative and development of an Implementation Plan focusing on the first seven years following the ROD and state Certification (CERT) of the Final PEIS/EIR. CALFED PEIS/EIR does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.4 East Bay Municipal Utility District Supplemental Water Supply Project Environmental Impact Report/Environmental Impact Statement

In November 1997, the Draft EIS/EIR on the proposed EBMUD Supplemental Water Supply Project and possible water service contract amendment for water from the American River Division of the CVP was released for public review and comment. EBMUD was the state lead agency, and Reclamation was the federal lead agency for the DEIR/EIS. During the public review period of the 1997 DEIR/EIS, Reclamation and EBMUD received a number of comments regarding the range of alternatives considered in detail in the DEIR/EIS and on certain impact assessment methodologies related to water temperatures and fishery resources. In response to comments, EBMUD and Reclamation prepared the recirculated EIR/supplemental EIS (REIR/SEIS) to address specific comments.

The REIR/SEIS describes the environmental effects of taking delivery of water under EBMUD's contract from the lower American River near its confluence with the Sacramento River, two locations on the Sacramento River between its confluence with the American River and Freeport, and the Bixler location in the Sacramento-San Joaquin River Delta. Emphasis is directed toward potential effects related to American River fisheries, endangered species, CVP users, pipeline construction, and biological resources in the EBMUD's service area. The REIR/SEIS was released in October 2000. EBMUD's EIR/EIS does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.5 Water Forum Environmental Impact Report

The Draft EIR for the Water Forum Proposal was prepared for the Sacramento City-County Office of Metropolitan Water Planning by SWRI and EDAW. The Draft EIR was released for public review in January 1999. The Water Forum Proposal is a comprehensive regional water plan that is intended to achieve two coequal objectives: "*Provide a reliable and safe water supply for the region's economic health and planned development to the year 2030:*" and "*Preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River.*" The purpose the Final EIR is to provide the Co-Lead Agencies and responsible Agencies with the environmental information necessary to make an informed decision when they decide whether to approve and adopt the Water Forum Proposal. The Water Forum EIR does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.6 PCWA and Northridge Water District Groundwater Stabilization Project

PCWA prepared the EIR, regarding the delivery of up to 29,000 AF annually of surface water to Northridge Water District (Northridge) from the PCWA Middle Fork Project (MFP) on the American River. PCWA is the lead agency for the EIR, pursuant to CEQA. For the purposes of the proposed project, SWRCB and Northridge are the responsible agencies and the CDFG is a Trustee Agency (CEQA Guidelines Sections 15381 and 15386). The Draft EIR was released for public review in October 1998. The PCWA EIR does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.7 PCWA and Reclamation American River Pump Station Environmental Impact Statement/ Environmental Impact Report

PCWA and Reclamation American River Pump Station Project Draft EIS/EIR was prepared by SWRI, and issued for public review in August 2001. The Draft EIS/EIR describes the potential adverse and beneficial impacts of the proposed American River Pump Station Project. The EIS/EIR analyzes the direct, indirect, and cumulative impacts to the physical and natural environment that may result from construction, operation, and maintenance of the permanent pump station project. Responses to comments on the Draft EIS/EIR are currently being prepared. The Final EIS/EIR is expected to be issued and certified in June 2002. The ROD is expected to be filed in July 2002. The PCWA and Reclamation EIS/EIR does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.8 American River Basin Cumulative Impact Report

The Cumulative Report was prepared by SWRI for Reclamation, and was released for public review in August 2001. The Cumulative Report was prepared to serve as an integral component of NEPA, CEQA, and ESA compliance documentation for the CVP American River Diversion actions identified as reasonably foreseeable. The evaluation includes an assessment of the diversion-related and service area impacts of past and future water diversions and CVP facility operations affecting the water and land-based resources of the American River watershed. Reclamation's Cumulative Report does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.9 Sacramento Water County Agency Water Assignment Environmental Impact Report

SWRI is in the process of preparing a Draft EIR for the *SMUD-SCWA Water Assignment* (proposed project). SMUD is the lead agency for the proposed project and SCWA is the responsible agency for the propose project. The DEIR contains a project-level environmental analysis of the assignment of up to 30,000 AF per annum of SMUD's existing entitlement for municipal and industrial (M&I) water from the CVP under water service contract with Reclamation. It is anticipated that the Draft EIR will be released for public review during the summer of 2002. The SMUD-SCWA EIR does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.2.10 Sacramento Area Flood Control Agency's Long-Term Reoperation of Folsom Dam and Reservoir Environmental Assessment

In 1995, SAFCA and Reclamation entered into a contract concerning the operation of Folsom Dam and Reservoir (Interim Agreement). The Interim Agreement improved flood control operations in the American River watershed by increasing the storage space available for winter flood flows in Folsom Dam and Reservoir, whenever such space is unavailable in the three largest non-federal reservoirs in the watershed. Under this variable storage space operation, Reclamation must provide a minimum of 400,000 AF and a maximum of 670,000 AF of flood control storage (400/670) in Folsom during the December to March flood season. The Interim Agreement has twice been extended for one-year periods. The purpose of the Environmental Assessment (EA) is to evaluate the environmental effects of continuing the 400/670 variable storage space operations on a long-term basis. The EA was prepared by SWRI for Reclamation and released for public review in September 2001. SAFCA and Reclamation EA does not include water discharged by Aerojet into Buffalo Creek and subsequently into the American River.

4.3 Conclusion Regarding Issues Raised by the State Water Resources Control Board

As previously stated, decisions implementing instream flows necessary to protect fisheries and recreation on the lower American River have been issued since the promulgation of D-893. Also, numerous regulatory requirements and processes, water user demands and allocations have

changed, which have an effect on water supply. Hence, a change in circumstances since the American River system was included in the FAS Declaration has occurred.

5.0 Potential Environmental Effects Associated with the Petition For Revision of the Declaration of Fully Appropriated Streams

5.1 Operational Considerations

The subject non-native water consists of the main flow from the Aerojet American River Study Areas Groundwater Extraction and Treatment System to Buffalo Creek. Buffalo Creek discharges to the American River just upstream of Sunrise Bridge crossing in Section 13, R6E, T9N, MDB&M. If determined by the SWRCB that the subject water is available for appropriation, it is assumed that this water will be diverted using existing diversion facilities, and the diversions will be limited to the same amount of water as is discharged by Aerojet. It is assumed that "existing facilities" refers to the FSC.

5.2 Water Supply Considerations

If the SWRCB deems the subject water to be available for appropriation, a small decrease in flow from Nimbus Dam to Buffalo Creek would occur. Because of the existing physical facilities, the appropriation could affect CVP American River water. If the diversion at the FSC is greater than 7.7 cfs at any time that Folsom Reservoir would otherwise be storing water, or when Folsom Reservoir is releasing stored water, there would be an effect on CVP operations. Folsom Reservoir storage is water that already has been adjudicated, and it already has been included in the FAS Declarations concerning the lower American River.

In order to avoid supporting the appropriation of the subject water with Folsom Reservoir storage, Nimbus Dam releases would necessarily be reduced by the amount of the appropriation. It is assumed that the water would be diverted at the FSC, upstream of the Buffalo Creek inflows, with an instantaneous rate equivalent to the Buffalo Creek discharge (i.e., one for one). Therefore, for the reach between Nimbus Dam and Buffalo Creek, a 7.7-cfs diminishment in American River flow would occur.

5.3 Hydrological and Biological Considerations

Documents prepared by SWRI have identified as fish of priority management concern in the lower American River the following species: fall-run chinook salmon (*Oncorhynchus tsawytscha*), steelhead (*O. mykiss*), Sacramento splittail (*Pogonichthys macrelopidotus*), American shad (*Alosa sapidissima*) and striped bass (*Morone saxatilis*). These designations are supported by the CALFED Bay-Delta Program Ecosystem Restoration Program Plan (2001). These species are of priority management concern due either to the importance of their commercial and/or recreational fisheries (i.e., chinook salmon, steelhead, American shad, and striped bass) and/or because they are a species currently listed under the federal ESA and/or CESA (i.e., steelhead and splittail). Because the species selected for species-specific assessments include those sensitive to changes in both river flow and water temperature throughout the year, an evaluation of impacts to these species is believed to reasonably

encompass the range of potential impacts to lower American River fish resources that could occur under the appropriation of the subject non-native water relative to the existing conditions.

5.3.1 Incremental Contribution to the Existing Condition

SWRI has conducted recent hydrological modeling for CEQA, NEPA and ESA compliance documents to assess potential impacts associated with various projects on the lower American River. No new modeling was conducted for this petition to revise the FAS Declaration, and none of SWRI's projects have attempted to estimate such small changes in flow. The most recent environmental document prepared by SWRI is the PCWA and Reclamation's American River Pump Station EIS/EIR, which proposes an annual diversion of 35,500 AF, relative to an existing annual diversion of 8,500 AF, thus resulting in a difference of 27,000 AF annually. Therefore, our most recent efforts to analyze potential hydrological changes and biological effects of a diversion from the American River are nearly five times more than the diversion specific to the petition for revision of the FAS Declaration. These modeling results associated with diversion of larger amounts of flows from the American River provide the framework of potential impacts associated with the appropriation of the non-native treated groundwater currently being discharged in Buffalo Creek, and subsequently in the American River. These modeling results are based in the following assumptions: (1) diversion of up to 100 cfs for an annual water supply diversion of up to 35,000 AF; and (2) the diversion represents an increase of up to 27,000 AF over the existing conditions (i.e., diversion rate of up to 50 cfs for an annual water supply diversion of up to 8,500 AF). Modeling results are presented below. Tables and figures illustrating these results are included in **Attachment A**.

Water temperature changes resulting from the hydrological modeling also are presented below. These results stem from models that estimate monthly mean water temperatures based on flow and storage quantities simulated by the Project Simulation Model (PROSIM). Tables and figures illustrating the results also are included in Attachment A.

5.3.1.1 Modeling Tools and Considerations

5.3.1.1.1 PROSIM Model

PROSIM simulates CVP and SWP operations and the hydrologic effects of those operations on the major Central Valley river and reservoir systems. The model simulates system operations within the geographical area affected by CVP and SWP facilities, including the Delta.

PROSIM uses a mass balance approach to simulate the occurrence, regulation, and movement of water from one node (i.e., computation point) to another. Various physical processes (e.g., surface water inflow or accretion, flow from another node, groundwater accretion or depletion, and diversion) are simulated or assumed. Operational constraints, such as reservoir size and seasonal storage limits or minimum instream flow requirements, also are defined for each node.

The model uses a monthly time step. Flows are specified as a mean flow for the month and reservoir storage volumes are specified as end-of-month content.

5.3.1.1.2 Water Temperature Models

Reclamation has developed water temperature models for the Sacramento and American river systems. These models estimate monthly mean water temperatures based on flow and storage quantities simulated by PROSIM. They are used to identify changes in water temperature caused by changes in CVP operations.

5.3.1.1.3 Historical Periods of Records

The 70-year and 69-year periods of record for PROSIM and water temperature modeling, respectively, provide an index of the kinds of changes that would be expected to occur with implementation of a specified set of operational conditions. The output of these models can then be compared to determine: (1) whether these conditions would be expected to change with implementation of the project methodologies; (2) the months in which river flows and water temperature changes could occur; and (3) a relative index of the magnitude of change that could occur during specific months of particular water year types, and whether the relative magnitude anticipated would be expected to result in impacts to fish resources within the regional area.

5.3.1.1.4 Models Capabilities and Limitations

The models used, although mathematically precise, should be viewed as having "reasonable detection limits." Establishing reasonable detection limits is useful to those using the modeling output for impact assessment purposes, and prevents making inferences: (1) beyond the capabilities of the models; and (2) beyond an ability to actually measure changes. Although data from the models are output to the nearest 100 AF, tenth of a foot in elevation, tenth of a cfs, tenth of a degree Fahrenheit (F), and tenth of a percent in salmon mortality, these values should be rounded when interpreting differences for a given parameter between two modeling simulations. For example, two simulations having river flows at a given location within one percent of each other should be considered to be essentially equivalent. Rounding of modeled output should be performed in order to assure the reasonableness of the impact assessments.

Commonly used field-temperature monitoring equipment (in situ temperature loggers, thermometers, electronic meters) have a total error of measurement of 0.2°F or more. Therefore, modeled differences in water temperature of 0.2°F or less cannot be consistently detected in the river by actual monitoring of water temperatures. In addition, as mentioned above, output from Reclamation's water temperature models provides a "relative index" of water temperatures under the various operational conditions modeled. Output values indicate whether the temperatures would be expected to increase, remain unchanged, or decrease, and provide insight regarding the relative magnitude of potential changes under one operational condition compared to another. Therefore, for the purposes of impact assessment, modeled water temperature changes that are within 0.3°F between modeled simulations are considered to represent no measurable change, whereas temperature differences of more than 0.3°F should be assessed for their biological significance. This approach is very conservative (rigorous). For example, USFWS and Reclamation, in the *Trinity River Mainstem Fishery Restoration Draft EIS/EIR* (USFWS et al. 1999), used a change in long-term average water temperature of 0.5°F as a threshold of significance, and the CVRWQCB generally uses a change of 1.0°F or more as a threshold of significance.

5.3.1.2 FLOW AND HABITAT CONSIDERATIONS

Habitat considerations have been evaluated using hydrological modeling, assessing changes in flow resulting from an annual diversion of 35,500 AF relative to an existing annual diversion of up to 8,500 AF. To assess flow-related impacts expected to occur from an annual diversion of 35,500 cfs, relative to a diversion of 8,500 AF, monthly mean flows at Watt Avenue and Nimbus Dam were compared and evaluated. Watt Avenue represents the river location above which approximately 98 percent of fall-run chinook salmon spawning occurs. However, because Nimbus Dam is closer to Buffalo Creek, where the subject non-native water is currently being discharged by Aerojet, modeling results at both locations are presented.

The proposed appropriation of the subject water involves 7.7 cfs for an annual water supply diversion of up to 5,575 AF. Therefore, any modeling results presented for an annual diversion of 27,000 AF (i.e., 35,500 AF- 8,500 AF) are considered to encompass the range of potential effects of the smaller 5,575 AF annual diversion. In addition to total annual amounts of diversion, monthly reductions in flow in the lower American River relative to the 7.7 cfs are presented for comparative purposes.

5.3.1.2.1 Habitat Availability and Stage Discharge

The impact assessment associated with changes in flow under the 35,500 AF annual diversion is presented below. Aquatic resources for which the impact assessment is presented include anadromous salmonids (i.e., fall-run chinook salmon and steelhead) and other species of priority management concern (i.e., Sacramento splittail, American shad and striped bass) in the lower American River.

5.3.1.2.1.1 Anadromous Salmonid Species

Minimal potential differences in the lower American River flows resulting from the modeling of an annual diversion of 35,500 AF relative to the existing condition (i.e., up to 8,500 AF) would not be expected to adversely affect fall-run chinook salmon and steelhead immigration, spawning and incubation, or juvenile rearing or emigration. The maximum relative (i.e., percent) reduction in long-term average flow below Nimbus Dam associated with the increased diversion occurs during September, and does not exceed 1.9 percent (**Table 1**). At Watt Avenue, the maximum relative reduction in the long-term average flow also occurs during September, and does not exceed two percent (**Table 2**). For all the months of the year, during the 70-year period of record, the absolute maximum reduction in flow below Nimbus Dam and at Watt Avenue, relative to the existing condition would be 1,009 cfs during the month of January for one of the 70 years modeled (i.e., 1935). The largest reduction in long-term monthly mean flow at both below Nimbus Dam and at Watt Avenue resulting from the increased diversion relative to the existing conditions would be 73 cfs during the month of May for the entire 70-year period of record. These reductions in flows below Nimbus Dam and at Watt Avenue do not represent substantial changes, relative to the existing condition, and are not expected to represent a significant impact to anadromous salmonid: (1) upstream passage or olfactory response; (2) annual early lifestage survival and long-term initial year-class strength (i.e., "reproductive success"); and (3) juvenile rearing and emigration. Because the subject non-native water

proposed for appropriation only consists of 5,575 AF annually, negligible changes in flows (i.e., about 7.7 cfs) would occur. Moreover, as previously stated, the greatest long-term modeled monthly mean flow reductions at either Watt Avenue or below Nimbus Dam associated with the 35,500 annual AF diversion relative to the existing 8,500 annual AF diversion would be 73 cfs during the month of May. This represented a less-than-significant impact to aquatic resources in the lower American River. Clearly, the long-term 73 cfs flow reduction represents a much greater reduction than the 7.7 cfs proposed for appropriation of Buffalo Creek water. For the remaining months of the year, long-term monthly mean flow reductions below Nimbus Dam and at Watt Avenue ranges from six to 73 cfs and six to 72 cfs, respectively. Most of these flow reductions (except for the month of October at both locations) exceed the 7.7 cfs flow reduction proposed for appropriation at Buffalo Creek. Moreover, potential flow reductions of up to 7.7 cfs associated with the proposed appropriation of Buffalo Creek water would only occur in the short reach of the river extending from Nimbus Dam to Buffalo Creek. Because of these considerations, therefore, no adverse impacts to anadromous salmonids are expected to occur.

Presented below are exceedance curves to further support the conclusions that an annual diversion of 35,500 AF (i.e., 100 cfs) represents less-than significant impacts to anadromous salmonids in the lower American River (**Figures 1** through **3**). These exceedance curves show that during typically low-flow months (i.e., July, August and September), diversion of up to 100 cfs (35,500 AF annually) would result in flows slightly different to the existing condition (i.e., up to 8,500 AF annually), thus representing minor changes in flow. Of these minor changes, 7.7 cfs, which is the amount of non-native water discharged by Aerojet, would be imperceptible, and would be depicted as less than the thickness of the line of the exceedance curves representing the annual diversion of 35,000 AF. Moreover, a change in river flow of 7.7 cfs during the driest of conditions (i.e., Nimbus Dam release of about 600 cfs) would equal a change in river stage of no more than 0.01 foot, or approximately an eighth of an inch. During normal conditions (i.e., Nimbus Dam release greater than 2,500 cfs), 7.7 cfs would result in an imperceptible change (i.e., less than 0.01 foot) in river stage. These changes in river stage are, therefore, negligible and would represent a less-than-significant impact to anadromous salmonids present in the river.

5.3.1.2.1.2 Non-Anadromous Salmonids Species of Priority Management Concern

Flow reductions associated with an annual diversion of 35,500 AF relative to the existing condition (up to 8,500 annual AF) would result in a long- term average monthly mean flow reduction no greater than 73 cfs during the month of May. This flow reduction would represent a less-than-significant impact to Sacramento splittail, American shad and striped bass in the lower American River. Therefore, a change in river flow of 5,575 annual AF (7.7 cfs), which is clearly a lesser reduction in flows than 73 cfs also represents a less-than-significant impact.

Sacramento Splittail

During February through May (i.e., the Sacramento splittail spawning period), modeling performed under conditions resulting from a simulated diversion of 35,500 AF annually shows that the long-term average usable inundated riparian habitat between River Mile (RM) 8 and 9 would not decrease relative to the existing conditions (i.e., 8,500 AF). For the 70-year period of record, the amount of riparian habitat inundated in this portion of the river under the modeled 35,500 AF diversion would remain unchanged 100 percent of the time during February, 97

percent of the time during March, 90 percent of the time during April, and 89 percent of the time during May relative to existing conditions. Because the subject non-native water proposed for appropriation only consists of 5,575 AF annually (i.e., 7.7 cfs), which is significantly less than 35,500 AF (which would result in a long-term monthly mean flow reductions of 23, 44, 17 and 73 cfs during the months of February, March, April and May, respectively), negligible changes in average useable habitat and inundated riparian habitat are expected to occur.

American Shad

The majority of American shad spawning migrations into the lower American River are believed to occur during May and June. Flow levels of 3,000 to 4,000 cfs have been recommended as sufficient flows to sustain the American shad fishery in the lower American River (Snider and Gerstung 1986). Because flow in the lower American River downstream of Buffalo Creek would be equal under the appropriation and the modeling characterization of the existing conditions, no impact would be expected to occur. Nonetheless, simulations of an annual diversion of 35,500 AF, relative to an annual diversion of 8,500 AF (under existing conditions), showed no differences in the number of years that the flow at the mouth of the lower American River would be below 3,000 cfs in May and June. Relative to the existing condition, an annual diversion of 35,500 AF would result in a long-term average flow at the mouth of one percent less for May and June. Because the subject non-native water only consists of 5,575 AF annually (7.7 cfs), which is significantly less than 35,500 AF (which would result in a long-term monthly mean flow reductions at the American River mouth of 44 and 37 cfs during May and June) , negligible changes are expected to occur as a result of the appropriation of this water.

Striped Bass

The number of adult striped bass entering the lower American River during the summer is believed to vary with flow levels and food production. Flows of 1,500 cfs during May and June have been recommended as sufficient flows to maintain the striped bass sport fishery in the lower American River (Snider and Gerstung 1986). Because flow in the lower American River downstream of Buffalo Creek would be equal under the appropriation and the modeling characterization of the existing conditions, no impact would be expected to occur. Nonetheless, simulations of an annual diversion of 35,500 cfs, relative to an annual diversion of 8,500 (i.e., existing conditions) show that monthly mean flows would be below the 1,500 cfs during only one additional year (one percent more often) during May and June. Because the subject non-native water only consists of 5,575 AF annually (i.e., 7.7 cfs), which is significantly less than 35,500 AF(which would result in a long-term monthly mean flow reductions at the American River mouth of 44 and 37 cfs during May and June) , negligible changes are expected to occur as a result of the appropriation of this water. Thus; potential impacts to the striped bass sport fishery would be less than significant.

5.3.1.2.2 Conclusions Regarding the Flow Assessment for the Incremental Contribution to the Existing Condition

As previously stated, significant impacts to the species of priority management concern in the lower American River were not identified as stemming from flow changes associated with an annual diversion of 35,500 AF (i.e., 100 cfs). Because the subject non-native water proposed for

appropriation would consist of 5,575 AF (i.e., 7.7 cfs), which is much less than 35,500 AF, and because this water has not been accounted as existing water in the lower American River by previous environmental documents, changes in flow and river stage would be negligible and potential adverse impacts to species of priority management concern associated with the appropriation of the subject water are not expected to occur.

5.3.1.3 WATER TEMPERATURE CONSIDERATIONS

Because available water temperature information for Buffalo Creek (California Regional Water Quality Control Board 1998) describe water temperatures in terms of averages (i.e., average water temperature is 70°F in the summer, 59°F in the winter), the following water temperature assessment also is based on long-term average water temperatures.

Water temperatures generally warm with increasing distance downstream in the lower American River during summer months. October is a transition month. Conversely, water temperatures generally cool with increasing distance downstream during the period November through January. In addition, water temperatures generally change little between Nimbus Dam and Watt Avenue during February, and Nimbus Dam is closer to Buffalo Creek than Watt Avenue. Thus, water temperature assessment includes water temperature estimates at Watt Avenue and below Nimbus Dam.

5.3.1.3.1 Anadromous Salmonid Species

Below Nimbus Dam and at Watt Avenue, the modeled maximum increase in the long-term water temperatures associated with an annual diversion of 35,500 AF occurs during March and June, and June and July, respectively. These increases do not exceed 0.1°F. These changes in water temperatures below Nimbus Dam and at Watt Avenue are not expected to represent a significant impact to anadromous salmonid: (1) adult immigration; (2) annual early lifestage survival and long-term initial year-class strength (i.e., "reproductive success"); and (3) juvenile rearing and emigration.

Results from the salmon mortality model further support the conclusions that an annual diversion of 35,500 AF (i.e., 100 cfs) represents less-than-significant water temperature-related impacts to anadromous salmonids in the lower American River. The long-term average annual early lifestage survival for fall-run chinook salmon in the American River would be 84.9 percent under the existing conditions (up to 8,500 AF annually) and 85 percent under the 35,500 AF annual diversion (up to 100 cfs). Substantial increases or decreases in survival would not occur in any individual year of the 69-year simulation. Because the subject non-native water appropriation is less than the simulated reduction in flow, potential water temperature-related impacts to anadromous salmonids would be less than significant.

5.3.1.3.2 Non-Anadromous Salmonids Species of Priority Management Concern

In addition to representing a less-than-significant impact to anadromous salmonids in the lower American River, water temperature changes associated with an annual diversion of 35,500 AF would represent less-than-significant impacts to Sacramento splittail, American shad, and striped bass in the lower American River relative to the existing condition (i.e., up to 8,500 AF

annually). Therefore, because the subject non-native water appropriation is less than the simulated reduction in flow, potential water temperature-related impacts to anadromous salmonids would be less than significant.

Sacramento Splittail

Monthly mean water temperatures at Watt Avenue modeled for an annual diversion of 35,500 AF are essentially equivalent to or less than the existing condition (i.e., up to 8,500 AF annually) for 270 months of the 276 months included in the analysis. Over the 69-year period of simulation, February through May water temperatures at Watt Avenue under the annual diversion of 35,500 AF would be above 68°F, the upper limit of the reported preferred range for Sacramento splittail spawning, in only one month of one year, relative to the existing condition. Therefore, water temperature-related impacts to Sacramento splittail spawning would be considered less than significant because no substantial change in the frequency of water temperature exceeding the reported preferred range for splittail spawning would occur. Because the subject non-native water only consists of 5,575 AF (i.e., 7.7 cfs) annually, which is much less than the 35,500 annual AF modeled (resulting in long-term monthly mean flow reductions of 23, 44, 17 and 73 cfs during the months of February, March, April and May, respectively), imperceptible changes in water temperature in the lower American River are expected to occur.

American Shad

Monthly mean water temperatures in May and June below Nimbus Dam and at the mouth would be within the reported preferred range for American shad spawning of 60°F to 70°F only one year less under an annual diversion of 35,500 AF, as compared to the existing condition (i.e., up to 8,500 annual AF). The frequency with which suitable water temperatures for American shad spawning would not substantially differ; thus water temperature-related impacts to American shad are considered to be less than significant. Because the subject non-native water only consists of 5,575 AF annually, which is much less than the 35,500 annual AF modeled, (resulting in long-term monthly mean flow reductions of 44 and 37 cfs during the months of May and June, respectively), imperceptible changes are expected to occur as a result of the appropriation of the subject non-native water.

Striped Bass

Under an annual diversion of 35,500 AF, the number of years that monthly mean water temperatures would be within the reported preferred range for striped bass juvenile rearing of 61°F to 73°F would increase by one year during both May and June below Nimbus Dam, and decrease by one year in both months at the mouth of the American River. Because the frequency of suitable water temperatures for juvenile striped bass rearing in the lower American River would remain essentially unchanged, water temperature-related impacts to juvenile striped bass rearing also are considered to be less than significant. Because the subject non-native water only consists of 5,575 AF annually, which is much less than the 35,500 annual AF modeled (resulting in long-term monthly mean flow reductions of 44 and 37 cfs during the months of May and June, respectively), negligible changes in water temperature are expected to occur as a result of the appropriation of the subject non-native water. Potential impacts to the striped bass sport fishery would be less than significant.

5.3.1.3.3 Conclusions Regarding the Water Temperature Assessment for Incremental Contribution Relative to the Existing Condition

As previously stated, significant impacts to the species of priority management concern in the lower American River were not identified as stemming from water temperature changes associated with an annual diversion of 35,500 AF (i.e., 100 cfs). Because (1): the subject non-native water proposed for appropriation would consist of 5,575 AF, which is much less than 35,500 AF, and potential flow reductions in the lower American River are much less than those previously modeled; (2) any changes in water temperatures associated with the appropriation of the subject non-native water are not within the detection capability of water temperature models; and (3) the subject water has not been accounted as existing water in the lower American River by previous environmental documents, adverse potential water-temperature-related impacts to species of priority management concern associated with the appropriation of this water are not expected to occur.

5.3.2 Incremental Contribution of the Appropriation of the Subject Non-Native Water to the Cumulative Condition

The cumulative condition compared to the existing condition is presented to identify the cumulative impacts of all reasonable foreseeable actions related to the American River Basin. The evaluation of the 35,500 annual AF incremental contribution to the cumulative condition is based on a comparison between predicted CVP operations in the cumulative condition (i.e., 2025), and a future base condition (essentially future without the 35,500 AF where an annual diversion is maintained at the existing level of 8,500 AFA). Tables and figures illustrating the presented results are included in Attachment A.

5.3.2.1 Modeling Tools and Consideration

Please refer to Section 5.3.1.1 for references on modeling tools and considerations relevant to the evaluation of the incremental contribution of the appropriation of the subject non-native water to the cumulative condition.

5.3.2.2 Cumulative Condition

The Cumulative Report was prepared by SWRI for Reclamation to serve as an integral component of NEPA, CEQA and ESA compliance documentation for CVP American River Diversion actions identified as reasonably foreseeable. The evaluation includes an assessment of the diversion-related and service area impacts of past and future water diversions and CVP facility operations affecting the water and land-based resources of the American River watershed.

The Cumulative Report has been prepared to supplement the analysis provided in EISs, EAs and biological assessments for Reclamation's identified reasonably foreseeable actions within the American River Basin. Reasonably foreseeable actions are defined as federal or other projects or agreements that are likely to take place within the same timeframe as the project under consideration. These actions are evaluated for the potential cumulative impacts that may occur on environmental resources potentially affected by a proposed action.

The actions included in the Cumulative Report evaluation include CVP water service contracts (new, amended and renewal contracts) Warren Act contracts, Folsom Dam reoperation for flood control, and Water Forum dry-year actions that could affect aquatic and terrestrial resources of the American River Basin and places of water use. Modeling results including all of these actions relative to the existing condition (i.e., 8,500 AF annually) are presented below.

5.3.2.2.1 Flow and Habitat Considerations

Habitat considerations have been evaluated using hydrological modeling assessing changes in flow resulting from the cumulative condition (annual diversion of 596,700 AF) relative to an existing annual diversion of 297,000 AF. These increases in water use include water rights water, and are not limited to CVP American River Division water contract amounts. Dry year water allocations would range between 450,000 AF to 545,600 AF, depending on the water availability at Folsom Reservoir. In these years, increased conservation efforts or use of groundwater or reclaimed water would be arranged to supplement the reduced surface water supply.

To assess flow-related impacts expected to occur from the cumulative condition relative to existing conditions, monthly mean flows at Watt Avenue and below Nimbus Dam were compared. Watt Avenue represents the river location above which approximately 98 percent of fall-run chinook salmon spawning occurs. However, because below Nimbus Dam is closer to Buffalo Creek (where the subject non-native water is currently being discharged by Aerojet), modeling results both below Nimbus Dam and at Watt Avenue are presented.

5.3.2.2.1.1 Habitat Availability

The impact assessment associated with changes in flow under the cumulative condition is presented below. Aquatic resources for which the impact assessment is presented include anadromous salmonids (i.e., fall-run chinook salmon and steelhead) and other species of priority management concern (i.e., Sacramento splittail, American shad and striped bass). For the purpose of this document, under the *Anadromous Salmonid* section, only impacts identified as significant are presented.

5.3.2.2.1.1.1 Anadromous Salmonid Species

The cumulative condition would result in periods of reduced flows in the lower American River during the October through December fall-run chinook salmon spawning period, relative to the existing condition (i.e., up to 8,500 AF annually). Further flow reductions occurring at already low-flow levels could result in increased redd superimposition and eventual lower year-class strength. Flow reductions also would occur for the driest 20 percent of the years during May. These flow reductions may adversely affect long-term juvenile fall-run chinook salmon rearing habitat availability.

For steelhead, the cumulative condition would result in periods of reduced flows in the lower American River during the March through June juvenile steelhead rearing period, relative to the existing condition. Further flow reductions during July through September may adversely affect long-term summer rearing success of juvenile steelhead. Consequently, the overall effect of the

cumulative condition relative to the existing condition represents a potentially significant impact to steelhead in the lower American River.

Fall-Run Chinook Salmon Spawning And Incubation

The long-term average flow below Nimbus Dam under the cumulative condition would be up to 13.6 percent (October) less than the flow under the existing condition (i.e., up to 8,500 AF annually) during all months of the October through February fall-run chinook salmon spawning and incubation period (**Table 3**). Similarly, changes in long-term average flows at Watt Avenue would be up to 14.3 percent less (i.e., October) during the October through February period, as shown in **Table 4.** These flow reductions at Watt Avenue and below Nimbus Dam would result in long-term monthly mean flow reductions of up to 326 cfs during the month of November.

Figures 4 through **8** show exceedance curves for the American River release from Nimbus Dam for the October through February period. These curves demonstrate that flows under the cumulative condition would be significantly different than those under the existing condition. Differences in flows in the lower flow ranges would be of particular concern. In October, November and December, when the existing condition flow would be 2,500 cfs or less, the cumulative condition would result in flow reductions of up to 750 cfs nearly 50 percent of the time. Effects on flow in January and February would be small. These reductions in flows would reduce the amount of available chinook salmon spawning habitat, which could result in increased redd superimposition during years when adult returns are high enough for spawning habitat to be limiting. These reductions in flow are of sufficient magnitude, and occur with enough frequency to have a significant adverse effect on long-term initial year-class strength of lower American River fall-run chinook salmon, resulting in a potentially significant impact.

Fall-Run Chinook Salmon and Steelhead Rearing

Relatively small differences in flow would occur between the cumulative condition and the existing condition during the March through June juvenile fall-run chinook salmon and steelhead rearing period. Under the cumulative condition, the largest reduction in the long-term average flow at Watt Avenue would occur during May (i.e., 6.3 percent, up to 247 cfs) for any given month of the March through June period (Table 4). However, most reductions in flow during the month of May occurred during the driest 20 percent of the years, when flows are already at relatively low levels (i.e., less than 2,000 cfs). These differences in flow may adversely affect long-term juvenile fall-run chinook salmon or steelhead rearing habitat availability, and therefore represent a potentially significant impact.

Steelhead Over-Summer Rearing

Under the cumulative condition, the long-term average flow below Nimbus Dam would decrease, compared to the existing condition, by about seven percent in July, 10 percent in August, and 15 percent in September (Table 3). The long-term average flow at Watt Avenue would decrease compared to the existing condition by 7.9 percent in July, 10.9 percent in August, and 16.4 percent in September (Table 4). These flow reductions would result in long-term monthly mean flow reductions of up to 370 cfs and 383 during the month of September below Nimbus Dam and at Watt Avenue, respectively.

Figures 9 through **11** provide flow exceedance curves for American River flows at Watt Avenue during July, August and September. These curves demonstrate that flow reductions at Watt Avenue under the cumulative condition relative to the existing condition would occur about 70 percent of the time during July, about 85 percent of the time during August, and about 90 percent of the time during September. Furthermore, relatively large reductions in flow (i.e., 500 cfs) would occur when flows are already at low levels (i.e., 1,500 cfs or less). Flow reductions under the cumulative condition may reduce juvenile steelhead summer rearing habitat. Moreover, reductions in flow associated with the cumulative condition may adversely affect long-term rearing success of juvenile steelhead, and therefore represent a potentially significant impact.

5.3.2.2.1.1.2 Non-Anadromous Salmonid Species of Priority Management Concern

Flow reductions associated with the cumulative condition would represent a less-than-significant impact to American shad and striped bass in the lower American River, but represent a potentially significant impact for Sacramento splittail.

Sacramento Splittail

Under the cumulative condition, the long-term average flow at Watt Avenue during the period February through May would be 1.6 percent to 6.3 percent less (i.e., long-term monthly mean flow reductions of up to 247 cfs during the month of May). than under the existing condition, as shown in Table 4. Using flows at Watt Avenue, the acreage of usable riparian vegetation inundated between RM 8 and RM 9 was calculated and employed as an index of the relative amount of inundated riparian vegetation that would occur in the lower portion of the river for a given flow rate. The amount of long-term riparian habitat inundated in this portion of the river under the cumulative condition would remain unchanged in 70 years (100 percent of the time) during February, 66 years (94 percent of the time) during March, 59 years (84 percent of the time) during April, and 51 years (73 percent of the time) during May. Therefore, habitat reductions may be expected to occur during most months of this period. In many years, riparian vegetation would not be inundated under either the cumulative or the existing condition.

The amount of riparian habitat between RM 8 and RM 9 under the cumulative relative to the existing condition would be reduced for each month of the February through May Sacramento splittail spawning period, particularly during April (i.e., 11.1 percent) and May (i.e., 8.3 percent). Under the cumulative condition, reductions in inundated riparian habitat would occur virtually every month during the February through May period, during those years when habitat would be inundated under the existing condition. Relatively little Sacramento splittail habitat is available under either the cumulative or existing condition. Given the uncertainty as to the magnitude and extent of splittail spawning habitat in the lower American River, and the actual amount of potential spawning habitat at specific flow rates throughout the river, the effects of flow reductions from the February through May period also are uncertain and, therefore, represent a potentially significant impact.

American Shad

The relative long-term monthly mean flow at the American River mouth under the cumulative condition relative to the existing condition would be seven (i.e., 268 cfs) and 3.4 percent (i.e., 133 cfs) less in May and June, respectively (**Table 5**). In addition to this analysis, further analysis was performed to determine the probability that lower American River flows at the mouth in May and June would be greater than 3,000 cfs. The simulations showed there would be one less year under the cumulative condition relative to the existing condition when the flow at the mouth would be greater than 3,000 cfs in both May and June. In addition, American shad spawn opportunistically where suitable conditions are found. Therefore, production of American shad within the Sacramento River system would not be affected. Potential flow-related impacts to American shad are considered to be less than significant.

Striped Bass

Under the cumulative condition, monthly mean flows at the mouth of the lower American River would be below the 1,500 cfs attraction flow index during one additional year (one percent more often) for the May through June period, relative to the existing condition. Because flows at the mouth that are believed to be sufficient to maintain the striped bass fishery would be met or exceeded in most years during both May and June, and because substantial changes in the strength of the striped bass fishery would not be expected to occur when May and/or June monthly mean flows fall below 1,500 cfs, flow-related impacts to the striped bass fishery that could potentially occur under the cumulative condition would be less than significant.

5.3.2.2.1.2 Conclusions Regarding the Flow Assessment for Cumulative Conditions

Several potentially significant impacts to anadromous salmonids (i.e., fall-run chinook salmon and steelhead) and Sacramento splittail were identified as stemming from the cumulative condition. The finding of potentially significant flow-related cumulative impacts is important, because as it will be seen in later sections, although the proposed appropriation of the subject non-native water does not result in a significant contribution to the cumulative condition, every diversion from the river decreases the amount of water that is directed to aquatic resources. Because every diversion diminishes water in the river for biological purposes, approving additional new diversions in the lower American River, despite the size of the diversion rate, must be carefully considered.

5.3.2.2.2 Water Temperature Considerations

Water temperature assessment includes water temperature below Nimbus Dam and Watt Avenue. As previously stated, because the water temperature information available for Buffalo Creek describe water temperatures in terms of averages (i.e., average water temperature is 70°F in the summer, 59°F in the winter), the following water temperature assessment also is based on long-term average water temperatures.

5.3.2.2.2.1 Anadromous Salmonid Species

Water temperature increases would occur during March through June, potentially representing a significant impact to juvenile fall-run chinook salmon rearing. Consequently, the overall effect of

the cumulative condition relative to the existing condition is considered to represent a potentially significant impact to fall-run chinook salmon in the lower American River.

For steelhead, water temperature increases represent a potentially significant impact to juvenile steelhead rearing. Consequently, the overall effect of the cumulative condition relative to the existing condition represents a potentially significant impact to steelhead in the lower American River.

Fall-Run Chinook Salmon and Steelhead Juvenile Rearing

Under the cumulative condition, there would be three more occurrences during April, and the same number of occurrences during March, June and July, in which water temperatures at Watt Avenue would be above 65°F, relative to the existing condition. Under the cumulative condition, long-term average water temperature at Watt Avenue would not change by more than 0.3°F during any month of the March through June period, compared to the existing condition, as shown in **Table 6**. Temperature data at Watt Avenue shows a water temperature increase greater than 0.3°F occurring in six years during the month of March, in eight years during the month of April, in 15 years during the month of May and in 18 years during the month of June. However, water temperature decreases greater than 0.3°F occur in five years during the month of March, nine years during the month of April, three years during the month of May, and in 10 years during the month of June. The largest water temperature increase associated with the cumulative condition, relative to the existing condition, would be expected to occur during the month of May. Although the long-term average water temperature during May increased by only 0.3°F, the cumulative condition would increase the frequency and magnitude of relatively warm temperatures (i.e., greater than or equal to 65°F). Therefore, these increases in water temperatures may represent a potentially significant impact to fall-run chinook salmon and steelhead juvenile rearing.

Steelhead Over-Summer Rearing

Temperature modeling indicates that the long-term average water temperature at Watt Avenue would increase slightly each month during July, August and September under the cumulative condition, relative to the existing condition (Table 6). The cumulative condition would result in no additional occurrences during July, one less occurrence during August, and two less occurrences during September, in which water temperatures at Watt Avenue would be above 65°F, relative to the existing condition.

Figures 12, 13, and **14** present the exceedance curves for water temperature at Watt Avenue under the existing condition and the cumulative condition during the months of July, August, and September, respectively. During July and August, water temperatures under the cumulative condition are higher than those under the existing condition when water temperatures would already be relatively warm (i.e., 68°F). In fact, water temperatures could increase by as much as 3.0°F when temperatures under the existing condition are at 70°F or more. During September, water temperatures at Watt Avenue under the cumulative condition are generally equal to or lower than those under the existing condition. However, water temperature increases that would be expected to occur during July and August represent a potentially significant cumulative impact to juvenile steelhead summer rearing.

5.3.2.2.2.2 Non-Anadromous Salmonid Species of Priority Management Concern

Water temperature changes associated with the cumulative condition would represent a less-than-significant impact to Sacramento splittail, American shad and striped bass in the lower American River.

Sacramento Splittail

During the February through May period, water temperatures at Watt Avenue would increase above 68°F (the reported preferred range for splittail spawning) under the cumulative condition relative to the existing condition in only three years of the 69-year period of record (i.e., during the month of May). During February, March and April, water temperatures would not increase above 68°F under the cumulative condition for any year of the 69-year period of record. Therefore, significant temperature-related impacts would not be expected to occur to splittail under the cumulative condition.

American Shad

Under cumulative conditions, monthly mean water temperatures in May and June below Nimbus Dam and at the mouth would be within the reported preferred range for American shad spawning of 60°F to 70°F one less year for both months, relative to the existing condition. Because the frequency with which suitable water temperatures for American shad spawning would not differ substantially, water temperature-related impacts to American shad also would be considered to be less than significant. Overall, potential impacts to American shad under the cumulative condition would be less than significant.

Striped Bass

Monthly mean water temperatures below Nimbus Dam would be within the reported preferred range for striped bass juvenile rearing of 61°F to 73°F by only one less year in May, but one additional year in June. At the mouth, the number of years within this preferred range would increase by two years in May and remain unchanged in June. Because the frequency of suitable water temperatures for juvenile striped bass rearing in the lower American River would remain essentially unchanged, water temperature-related impacts to juvenile striped bass rearing also are considered to be less than significant. Overall, potential impacts to striped bass would be less than significant.

5.3.2.2.2.3 Conclusions Regarding Water Temperature Assessment for Cumulative Conditions

As with the flow assessment, several potentially significant water temperature-related impacts to anadromous salmonids (i.e., fall-run chinook salmon and steelhead) were identified as stemming from the cumulative condition. As it will be seen in later sections, although the proposed appropriation of the subject non-native water does not result in a significant contribution to the cumulative condition, every diversion from the river decreases the amount of water that is directed to aquatic resources. As a result of these diversions, water temperature may experience increases that may have adverse effects on the aquatic resources in the American River. The

approval of additional new diversions in the lower American River, despite the size of the diversion rate, must be carefully considered.

5.3.2.3 Incremental Contribution To Potentially Significant Cumulative Impacts

The simulation used as a comparison to evaluate the incremental contribution of the 35,500 annual AF to the cumulative condition is the future base condition, which is essentially future without the 35,500 AF annual diversion, but with an existing level of 8,500 annual AF. Because the incremental contribution of the subject non-native water only is 7.7 cfs (i.e., 5,575 annual AF), as opposed to the 35,500 annual AF used in this simulation, the following analysis is considered very rigorous and protective of aquatic resources in the American River.

5.3.2.3.1 Flow and Habitat Considerations

Because the incremental contribution to the cumulative condition is relevant only when significant impacts associated with the cumulative condition have been identified, the following evaluation only includes incremental contribution assessment for cumulative impacts previously identified as significant. As previously discussed, this assessment is considered very conservative, because the simulation includes an incremental contribution to the cumulative of 27,000 AF (i.e., 35,500 AF- 8,500 AF), which is much larger than the actual amount of the subject non-native water proposed for appropriation (i.e., 5,575 AF).

Fall-Run Chinook Salmon Spawning and Incubation

As shown in **Table 7**, the long-term average flow below Nimbus Dam under the cumulative condition (i.e., with the annual diversion of up to 35,000 AF) would be within two percent of the flow under the future base condition (i.e., future with existing diversion of 8,500 AF) during all months of the October through February spawning and incubation period. In addition, as presented in **Table 8,** changes in long-term average flows at Watt Avenue under the cumulative condition also would be within two percent for each month in the October through February period. These changes would result in long-term monthly mean flow reductions of up to 36 cfs (i.e., November) at Watt Avenue and below Nimbus Dam. The incremental contribution analysis indicates that monthly mean flows would be essentially equivalent or higher at both below Nimbus Dam and at Watt Avenue in 296 of the 350 months simulated. Flow reductions associated with the annual diversion of 35,500 AF would not occur with sufficient magnitude or frequency to significantly adversely affect fall-run chinook salmon spawning and incubation, and therefore represent a less-than-significant contribution to the cumulative condition. Because the increment of the subject non-native water (i.e., 7.7 cfs) is much less than the change simulated (27,000 AF annually, which would result in long-term monthly mean flow reductions of up to 36 cfs during November for the fall-run chinook salmon spawning and incubation period), the appropriation also represents a less-than-significant contribution to the cumulative condition.

Fall-Run Chinook Salmon and Steelhead Juvenile Rearing

The incremental contribution analysis indicates that under the cumulative condition, the long-term average flow at Watt Avenue would be within two percent (i.e., up to 56 cfs during May) of the flow under the future base condition during the March through June period (Table 8).

Monthly mean flows would be essentially equivalent for 262 months of the 276 months included in the analysis.

Figures 15 through **18** show the exceedance curves for the lower American River flow at Watt Avenue for the months of March through June. For flows below 2,000 cfs during May, the cumulative condition would result in slight decreases compared to the future base condition. In April (Figure 16), the cumulative condition provided an increase in flow when flows ranging between 1,500 cfs and 2,000 cfs, and for flows between 400 cfs and 800 cfs. However, slight flow decreases occur when flows range from 800 to 1,500 cfs. The long-term average flows during May would decrease by less than 1.5 percent under the cumulative condition relative to the future base condition. For the relatively small reductions in flow that do occur during May, most occurred at relatively high (greater than 2,000 cfs) flow levels. These small differences in flow would not be expected to adversely affect long-term juvenile fall-run chinook salmon or steelhead rearing success. Therefore, implementation of the 35,500 AF annual diversion would not significantly contribute to future potentially significant cumulative flow-related impacts to fall-run chinook salmon and steelhead juvenile rearing. Because the increment of the subject non-native water (i.e., 7.7 cfs) is much less than the change simulated (i.e., 27,000 AF annually, which would result in long-term monthly mean flow reductions of up to 56 cfs during the month of May for the fall-run chinook salmon and steelhead juvenile rearing period), the appropriation also represents a less-than-significant contribution to the cumulative condition.

Steelhead Over-Summer Rearing

The incremental contribution analysis indicates that, under the cumulative condition, the long-term average flow on the American River below Nimbus Dam would decrease by approximately two percent during July, 1.5 percent during August, and one percent during September (Table 5). Long-term average flows at Watt Avenue would exhibit similar decreases to those below Nimbus Dam (Table 6).

Figures 19 through **21** present the comparison of flow exceedance curves for the cumulative and future base condition flows at Watt Avenue during July (i.e., 60 cfs), August (i.e., 38 cfs), and September (i.e., 30 cfs). Although small reductions in flows potentially would occur during July, these reductions would not be expected to be of such magnitude to adversely affect long-term summer rearing success of juvenile steelhead. Flows under the cumulative and future base condition are essentially equivalent during August and September.

Based on these findings, flow reductions under the cumulative condition, relative to the future base condition, would not be expected to significantly reduce juvenile steelhead rearing habitat. The potential small and infrequent reductions in flow would not be expected to adversely affect long-term rearing success of juvenile steelhead. Therefore, the implementation of the 35,500 annual AF diversion would not significantly contribute to future potentially significant cumulative flow-related impacts to steelhead rearing. Because the increment of the subject non-native water (i.e., 7.7 cfs) is much less than the change simulated (i.e., 27,000 AF annually, which would result in long-term monthly mean flow reductions of up to 60 cfs during the month of July for the steelhead over-summer rearing period), the appropriation also represents a less-than-significant contribution to the cumulative condition.

Sacramento Splittail

Under the cumulative condition, relative to the future base condition, average long-term usable inundated riparian habitat would not change for any month of the February through May splittail spawning period. Although small and infrequent decreases in the amount of usable inundated riparian habitat associated with the cumulative condition relative to the future base condition occur during this period, these differences would not be of sufficient magnitude or occur with enough frequency to represent a significant contribution to the identified potentially significant cumulative impact. Because the increment of the subject non-native water (i.e., 7.7 cfs) is much less than the change simulated (i.e., 27,000 AF annually, which would result in long-term monthly mean flow reductions of up to 56 cfs during the month of May for the Sacramento splittail spawning period), the appropriation also represents a less-than-significant contribution to the cumulative condition.

5.3.2.2.1.1 Conclusions Regarding the Flow Assessment for the Incremental Contribution Relative to the Cumulative Condition

No significant contribution to the cumulative condition, as it relates to flow changes, was identified for a diversion of 35,500 annual AF relative to the cumulative condition. Because the subject non-native water proposed for appropriation only would consists of 5,575 AF (i.e., 7.7 cfs), which is much less than 35,500 annual AF (i.e., resulting in long-term monthly mean flow reductions of up to 60 cfs during the month of July at Watt Avenue or below Nimbus Dam), adverse impacts to species of priority management concern associated with the appropriation of the subject water are not expected to occur.

5.3.2.3.2 Water Temperature Considerations

Water temperature assessment includes water temperature below Nimbus Dam and at Watt Avenue. As previously stated, because the water temperature information available for Buffalo Creek describe water temperatures in terms of averages (i.e., average water temperature is 70°F in the summer, 59°F in the winter), the following water temperature assessment also is based on long-term average water temperatures.

Fall-Run Chinook Salmon and Steelhead Rearing

Under the cumulative condition, the long-term average water temperature at Watt Avenue would not change by more than an estimated 0.1°F during any month of the March through June period, compared to the future base condition (**Table 9**). Monthly mean water temperatures are expected to exceed 65°F approximately 10 percent of the time during May and approximately 30 percent of the time during June under both the future base and the cumulative condition. Further, examination of the exceedance curves for water temperatures during May and June comparing the future base and the cumulative condition indicates no substantial differences in water temperatures between the two conditions. Therefore, implementation of the 35,500 AF diversion would not significantly contribute to potentially significant cumulative temperature-related impacts to fall-run chinook salmon and steelhead juvenile rearing. Because the increment of the subject non-native water (i.e., 7.7 cfs) is much less than the change simulated (i.e., 27,000 AF annually, which results in a long-term monthly mean flow reduction of up to 56 cfs during the month of May for the fall-run chinook salmon and steelhead juvenile rearing period), the appropriation also represents a less-than-significant contribution to the cumulative condition.

Steelhead Over-Summer Rearing

The long-term average monthly mean water temperatures at Watt Avenue under the cumulative condition would be essentially equivalent to those under the future base condition during July, August and September (Table 9).

Figures 22, 23, and 24 show water temperature exceedance curves at Watt Avenue during July, August and September under the cumulative condition and future base condition. As shown, water temperatures are essentially identical for both conditions. Small and infrequent differences in water temperatures at Watt Avenue occurred between both conditions. The cumulative condition would result in only one additional occurrence in July, no additional occurrences in August and one less occurrence in September of water temperatures at Watt Avenue exceeding 65° F, relative to the future base condition. Therefore, implementation of the 35,500 AF annually would not significantly contribute to future potentially significant cumulative temperature-related impacts to steelhead rearing. Because the increment of the subject non-native water (i.e., 7.7 cfs) is much less than the change simulated (i.e., 27,000 AF annually, which would result in long-term monthly mean flow reductions of up to 60 cfs during the month of July for the steelhead over-summer rearing period), the appropriation also represents a less-than-significant contribution to the cumulative condition.

5.3.2.3.2.1 Conclusions Regarding the Water Temperature Assessment for the Incremental Contribution Relative to the Cumulative Condition

No significant contribution to the cumulative condition, as it relates to water temperature changes, is identified for an additional diversion of 35,500 annual AF. Because the subject non-native water proposed for appropriation would consist of 5,575 AF (i.e., 7.7 cfs), which is much less than 35,500 annual AF (i.e., resulting in long-term monthly mean flow reductions of up to 60 cfs during the month of July at Watt Avenue or below Nimbus Dam), adverse impacts to species of priority management concern associated with the appropriation of the subject water are not expected to occur.

5.4 RESTORATION CONSIDERATIONS

SWRI, with Paul Bratovich as the Principal Scientist, has participated in numerous activities and projects associated with the compilation of known information pertinent to lower American River and the restoration and enhancement of anadromous salmonids and their habitat along the lower American River. These restoration projects and activities include: The Lower American River Baseline Report, The Initial Fisheries and Instream Habitat Management and Restoration Plan for the Lower American River, the RCMP, the Lower American River Temperature Improvement Study Draft Function Analysis Workshop Report (Function Analysis Report), and the FMP (currently under preparation). In the Function Analysis Report, the restoration of Buffalo Creek has been considered as an action to increase steelhead abundance in the lower American River. Although in the Function Analysis Report, the restoration of Buffalo Creek has not been recommended because of considerations of funding, potential impacts on the creek, and availability of suitable sites, nevertheless, restoring Buffalo Creek as a living stream may present the unique opportunity for potential steelhead restoration in the lower American River. Steelhead has evolved to swim upstream and spawn and rear in small tributary streams, and the lower American River is a big mainstem river. Thus, restoring Buffalo Creek is a unique opportunity to provide more of a native stream than this species would have found historically if they would had been able to migrate for over 100 miles past Nimbus and Folsom dams. A diversion of water from Buffalo Creek, therefore, would potentially have adverse consequences to anadromous salmonid restoration in the lower American River. In fact, every effort should be made to examine the capability and potential efficacy of undertaking significant restoration actions to re-establish and provide appropriate habitat for the federally threatened steelhead in Buffalo Creek, as a tributary to the lower American River.

6.0 GENERAL CONCLUSIONS

A change in circumstances since the American River system was included in the FAS Declaration has occurred. These changes in circumstances exist because implementation of instream flows, numerous regulatory requirements and processes, water user demands and allocations have changed since the promulgation of D-893, the decision used as part of the basis for the FAS Declaration. In addition, the subject non-native water discharged by Aerojet has not been considered in the present FAS Declaration or in relatively recent NEPA, CEQA and ESA compliance documents completed by resource agencies or SWRI.

Care must be exercised in the characterization of the appropriation. In some circumstances, if the subject diversion is allowed to exceed a 1:1 ratio to Buffalo Creek discharge, Folsom Reservoir storage would be necessary to support the appropriation. This condition would be contrary to the FAS Declaration.

Additionally, potential environmental effects on species of priority management concern associated with the appropriation of the subject water are not expected to occur. Significant impacts to the species of priority management concern in the lower American River were not identified as stemming from flow or water temperature changes associated with an annual diversion of 35,500 annual AF (i.e., 100 cfs), which is much greater than 5,575 annual AF (i.e., 7.7 cfs), the subject non-native water proposed for appropriation.

Conversely, several potentially significant flow and water temperature-related impacts to anadromous salmonids (i.e., fall-run chinook salmon and steelhead) and Sacramento splittail were identified as stemming from the cumulative condition. Although the proposed appropriation of the subject non-native water does not result in a significant contribution to the cumulative condition, every diversion in the river increases the amount of water that is directed to resources other than aquatic. Because every diversion contributes to less water in the river for biological purposes, approving additional new diversions in the lower American River, despite the size of the diversion rate, must be carefully considered.

Also, the restoration of Buffalo Creek is a unique opportunity to provide more of a native stream for steelhead in the American River. A diversion of water from Buffalo Creek, therefore, may preclude the achievement of the full potential of Buffalo Creek as a restoration site for the federally threatened steelhead.

In consideration of: (1) the change in circumstances as it relates to the FAS Declaration; (2) the non-consideration of the subject non-native water by resource agencies and SWRI in NEPA, CEQA and ESA compliance documents; and (3) the lack of significant impacts on aquatic resources associated with the appropriation of the subject non-native water, there is no physical or biological basis to preclude the SWRCB from revising the FAS Declaration to allow the Division of Water Rights to accept and process water right applications to appropriate the subject non-native water (i.e., 7.7 cfs) currently being discharged by Aerojet into Buffalo Creek, and subsequently into the American River. However, considerations of potentially significant cumulative impacts to aquatic resources in the lower American River, and the potential for steelhead restoration in Buffalo Creek, should be carefully examined before the approval of the appropriation of this water.

Finally, we make no conclusions or offer any opinions with respect to legal characterization of the water discharged by Aerojet as groundwater or surface water, or any water rights thereto.

7.0 LITERATURE CITED

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Figure 9

Lower American River Flow at Watt Avenue During July Under Existing and Cumulative Conditions

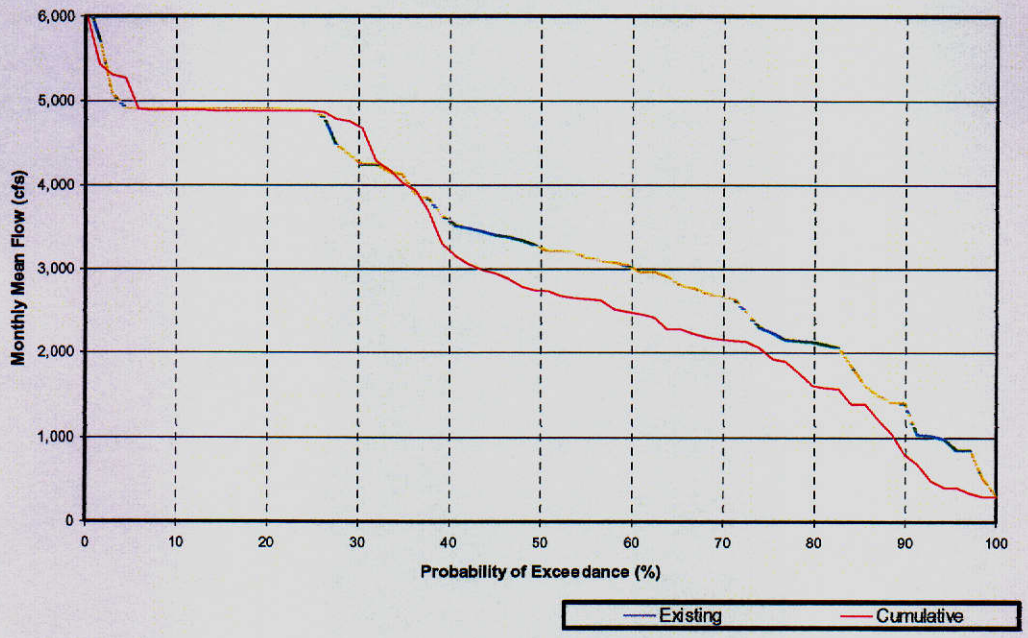


Figure 10

Lower American River Flow at Watt Avenue During August Under Existing and Cumulative Conditions

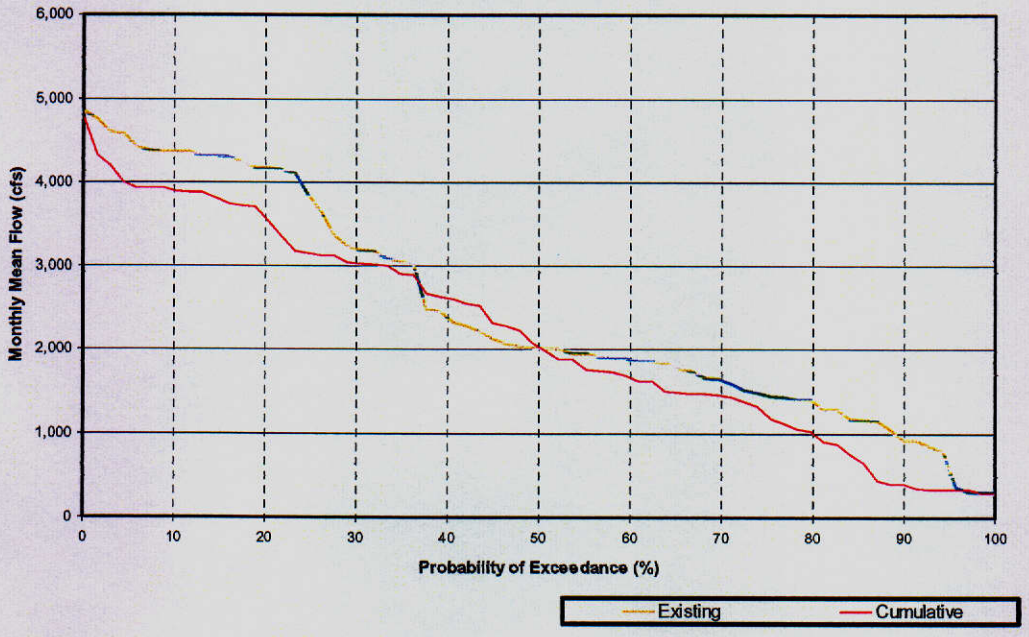


Figure 6

Lower American River Release From Nimbus Dam During December Under Existing and Cumulative Conditions

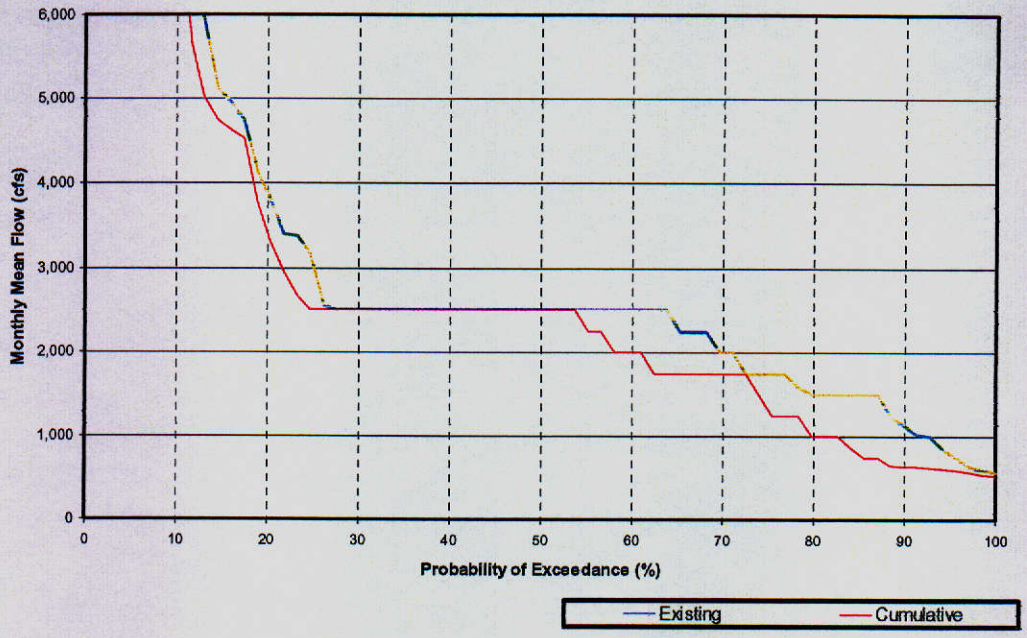


Figure 7

Lower American River Release From Nimbus Dam During January Under Existing and Cumulative Conditions

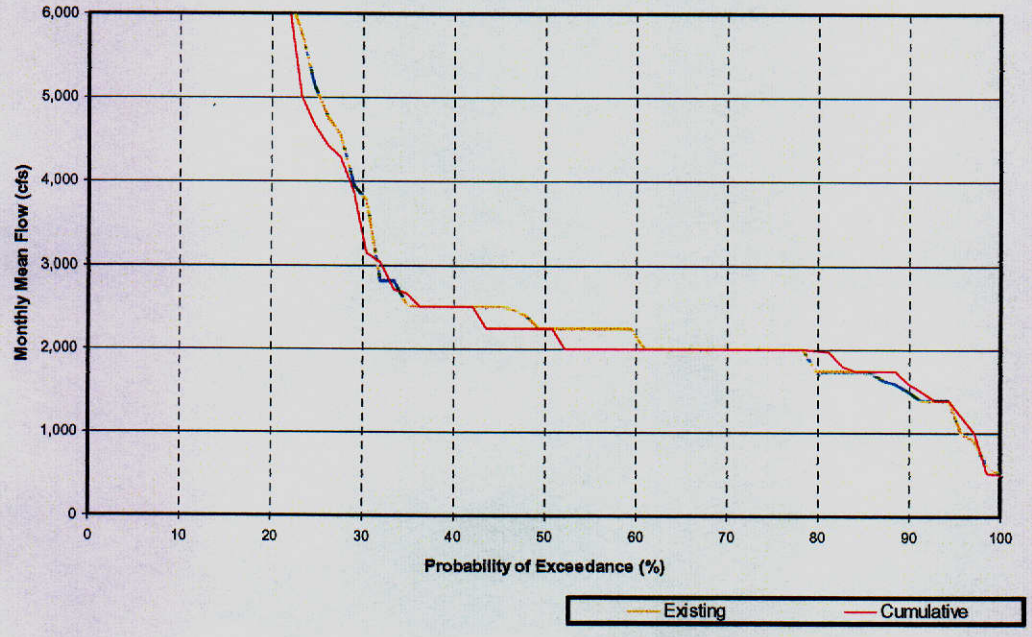


Figure 4

Lower American River Release From Nimbus Dam During October Under Existing and Cumulative Conditions

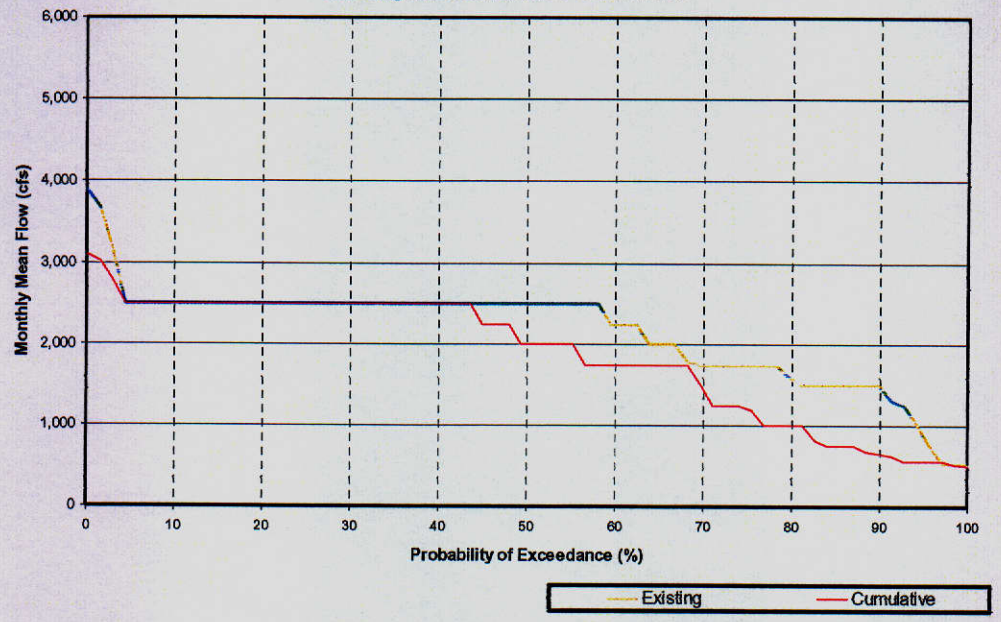


Figure 5

Lower American River Release From Nimbus Dam During November Under Existing and Cumulative Conditions

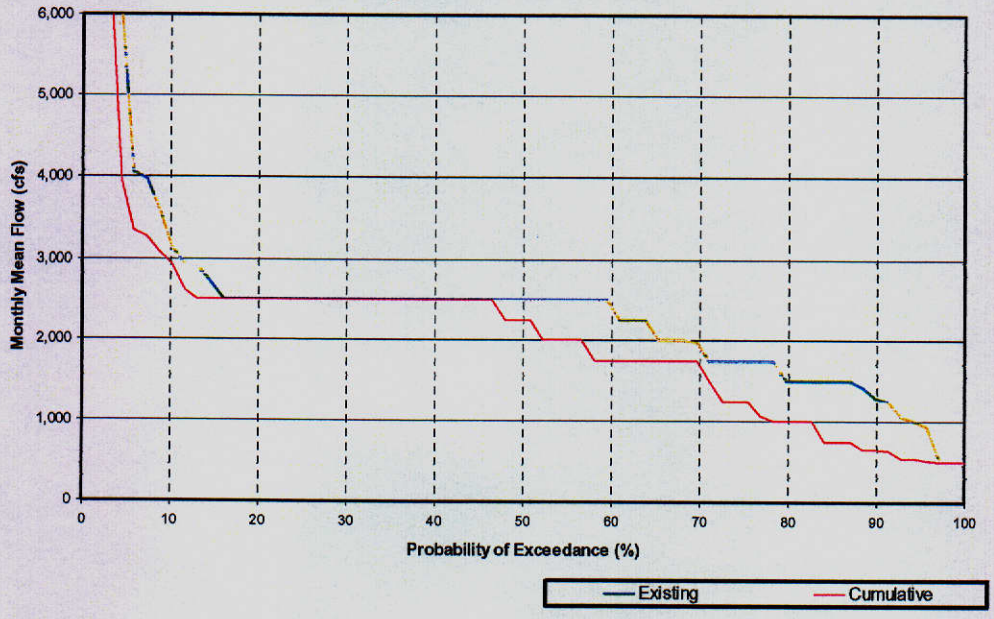


Table 9

Long-term Average Water Temperature in the American River at Watt Ave Under Future Base and Cumulative Conditions			
Month	Water Temperature[1] (°F)		
	Future Base	Cumulative	Difference (°F)
Oct	60.2	60.2	0.0
Nov	55.9	55.9	0.0
Dec	48.8	48.8	0.0
Jan	46.0	45.9	-0.1
Feb	47.8	47.8	0.0
Mar	51.6	51.5	-0.1
Apr	56.6	56.7	0.1
May	60.7	60.8	0.1
Jun	64.7	64.7	0.0
Jul	68.1	68.2	0.1
Aug	68.5	68.5	0.0
Sep	68.0	68.0	0.0

[1] Based on 69 years modeled.

Table 8

Long-term Average Flow at Watt Avenue Under Future Base and Cumulative Conditions				
Month	Monthly Mean Flow[1] (cfs)		Difference	
	Future Base	Cumulative	(cfs)	(%)[2]
Oct	1830	1795	-35	-1.9
Nov	2362	2326	-36	-1.5
Dec	3333	3299	-34	-1.0
Jan	4165	4154	-11	-0.3
Feb	4795	4772	-23	-0.5
Mar	3833	3790	-43	-1.1
Apr	3381	3358	-23	-0.7
May	3743	3687	-56	-1.5
Jun	4001	3948	-53	-1.3
Jul	3103	3044	-59	-1.9
Aug	2229	2191	-38	-1.7
Sep	1982	1951	-31	-1.6

[1] Based on 70 years modeled.
[2] Relative difference of the monthly long-term average.

Table 7

Long-term Average Release From Nimbus Dam Under Future Base and Cumulative Conditions				
Month	Monthly Mean Flow[1] (cfs)		Difference	
	Future Base	Cumulative	(cfs)	(%)[2]
Oct	1894	1858	-36	-1.9
Nov	2395	2359	-36	-1.5
Dec	3346	3312	-34	-1.0
Jan	4172	4162	-10	-0.2
Feb	4806	4784	-22	-0.5
Mar	3857	3814	-43	-1.1
Apr	3437	3414	-23	-0.7
May	3835	3779	-56	-1.5
Jun	4106	4053	-53	-1.3
Jul	3211	3151	-60	-1.9
Aug	2334	2296	-38	-1.6
Sep	2074	2044	-30	-1.4

[1] Based on 70 years modeled.
[2] Relative difference of the monthly long-term average.

Table 6

Long-term Average Water Temperature at Nimbus Dam or Watt Avenue Under Existing and Cumulative Conditions				
Month	Location[2]	Water Temperature[1] (°F)		
		Existing	Cumulative	Difference
Oct	Watt	60.0	60.2	0.2
Nov	Nimbus	56.9	56.6	-0.3
Dec	Nimbus	50.0	49.6	-0.4
Jan	Nimbus	46.3	46.2	-0.1
Feb	Nimbus	47.3	47.3	0.0
Mar	Watt	51.5	51.5	0.0
Apr	Watt	56.7	56.7	0.0
May	Watt	60.5	60.8	0.3
Jun	Watt	64.6	64.7	0.1
Jul	Watt	68.0	68.2	0.2
Aug	Watt	68.4	68.5	0.1
Sep	Watt	68.2	68.0	-0.2

[1] Based on 69 years modeled.

[2] Nimbus temperature is shown for November through February because it is expected to be higher than Watt during these months. Watt temperature is shown for March through October because it is expected to be higher than Nimbus during these months.

Table 5

Long-term Average Flow at the Mouth Under Existing and Cumulative Conditions				
Month	Monthly Mean Flow[1] (cfs)		Difference	
	Existing	Cumulative	(cfs)	(%)[2]
Oct	2021	1698	-323	-16.0
Nov	2589	2259	-330	-12.7
Dec	3550	3258	-292	-8.2
Jan	4205	4122	-83	-2.0
Feb	4890	4740	-150	-3.1
Mar	3897	3742	-155	-4.0
Apr	3340	3272	-68	-2.0
May	3838	3570	-268	-7.0
Jun	3933	3800	-133	-3.4
Jul	3178	2872	-306	-9.6
Aug	2340	2034	-306	-13.1
Sep	2234	1831	-403	-18.0

[1] Based on 70 years modeled.
[2] Relative difference of the monthly long-term average.

Table 4

Long-term Average Flow at Watt Avenue Under Existing and Cumulative Conditions				
Month	Monthly Mean Flow[1] (cfs)		Difference	
	Existing	Cumulative	(cfs)	(%)[2]
Oct	2095	1795	-300	-14.3
Nov	2652	2326	-326	-12.3
Dec	3605	3299	-306	-8.5
Jan	4255	4154	-101	-2.4
Feb	4924	4772	-152	-3.1
Mar	3955	3790	-165	-4.2
Apr	3414	3358	-56	-1.6
May	3934	3687	-247	-6.3
Jun	4052	3948	-104	-2.6
Jul	3305	3044	-261	-7.9
Aug	2460	2191	-269	-10.9
Sep	2334	1951	-383	-16.4

[1] Based on 70 years modeled.
[2] Relative difference of the monthly long-term average.

Table 3

Long-term Average Release From Nimbus Dam Under Existing and Cumulative Conditions				
Month	Monthly Mean Flow[1] (cfs)		Difference	
	Existing	Cumulative	(cfs)	(%)[2]
Oct	2150	1858	-292	-13.6
Nov	2681	2359	-322	-12.0
Dec	3616	3312	-304	-8.4
Jan	4261	4162	-99	-2.3
Feb	4936	4784	-152	-3.1
Mar	3978	3814	-164	-4.1
Apr	3464	3414	-50	-1.4
May	4017	3779	-238	-5.9
Jun	4144	4053	-91	-2.2
Jul	3395	3151	-244	-7.2
Aug	2548	2296	-252	-9.9
Sep	2414	2044	-370	-15.3

[1] Based on 70 years modeled.
[2] Relative difference of the monthly long-term average.

Table 2

Long-term Average Flow at Watt Avenue Under Existing and Project Conditions				
Month	Monthly Mean Flow[1] (cfs)		Difference	
	Existing	Project	(cfs)	(%)[2]
Oct	2095	2089	-6	-0.3
Nov	2652	2638	-14	-0.5
Dec	3605	3581	-24	-0.7
Jan	4123	4215	92	2.2
Feb	4924	4901	-23	-0.5
Mar	3955	3911	-44	-1.1
Apr	3414	3397	-17	-0.5
May	3934	3861	-73	-1.9
Jun	4052	3980	-72	-1.8
Jul	3305	3257	-48	-1.5
Aug	2460	2425	-35	-1.4
Sep	2334	2288	-46	-2.0

[1] Based on 70 years modeled.
[2] Relative difference of the monthly long-term average.

Table 1

Long-term Average Release From Nimbus Dam Under Existing and Project Conditions				
Month	Monthly Mean Flow[1] (cfs)		Difference	
	Existing	Project	(cfs)	(%)[2]
Oct	2150	2144	-6	-0.3
Nov	2681	2667	-14	-0.5
Dec	3616	3593	-23	-0.6
Jan	4129	4220	91	2.2
Feb	4936	4913	-23	-0.5
Mar	3978	3933	-45	-1.1
Apr	3464	3447	-17	-0.5
May	4017	3944	-73	-1.8
Jun	4144	4071	-73	-1.8
Jul	3395	3347	-48	-1.4
Aug	2548	2513	-35	-1.4
Sep	2414	2367	-47	-1.9

[1] Based on 70 years modeled.
[2] Relative difference of the monthly long-term average.

Figure 2

Lower American River Release From Nimbus Dam During August Under 8,500 AFA and 35,500 AFA

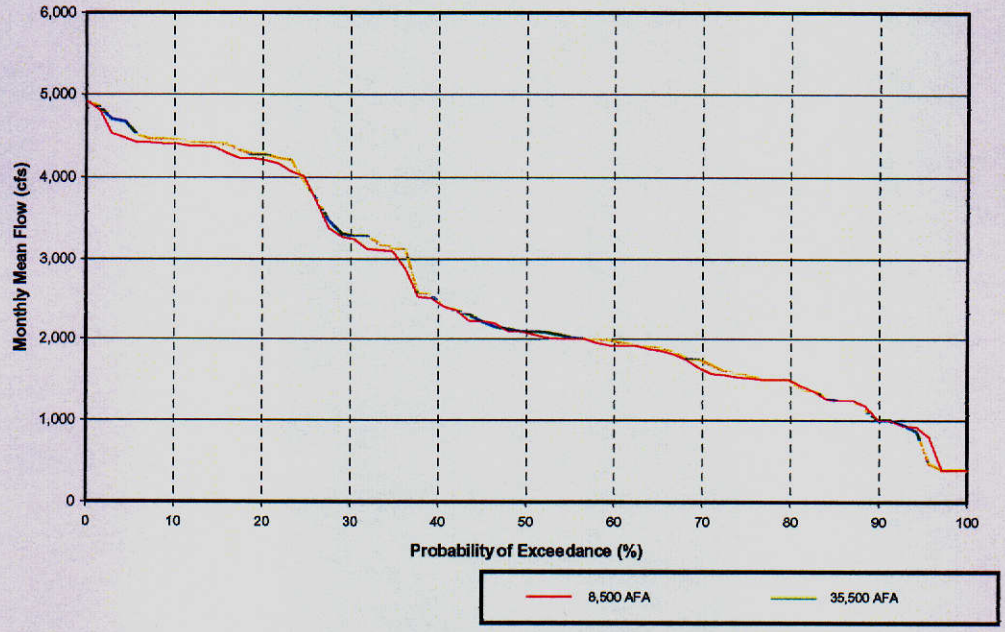


Figure 3

Lower American River Release From Nimbus Dam During September Under 8,500 AFA and 35,500 AFA

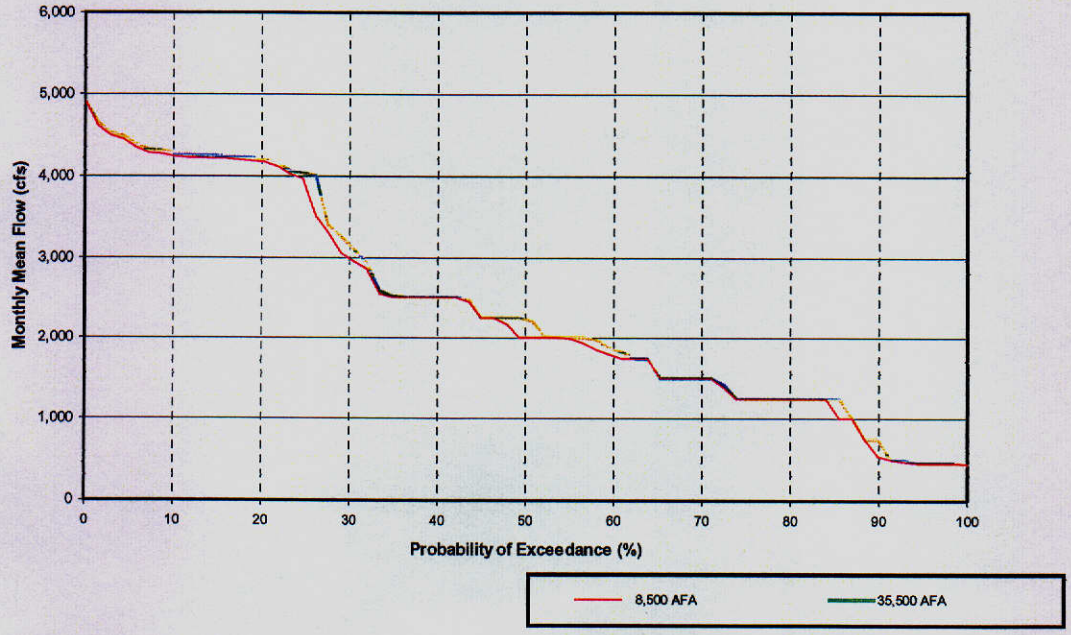


Figure 23

Temperature in the American River at Watt Ave During August Under Future Base and Cumulative Conditions

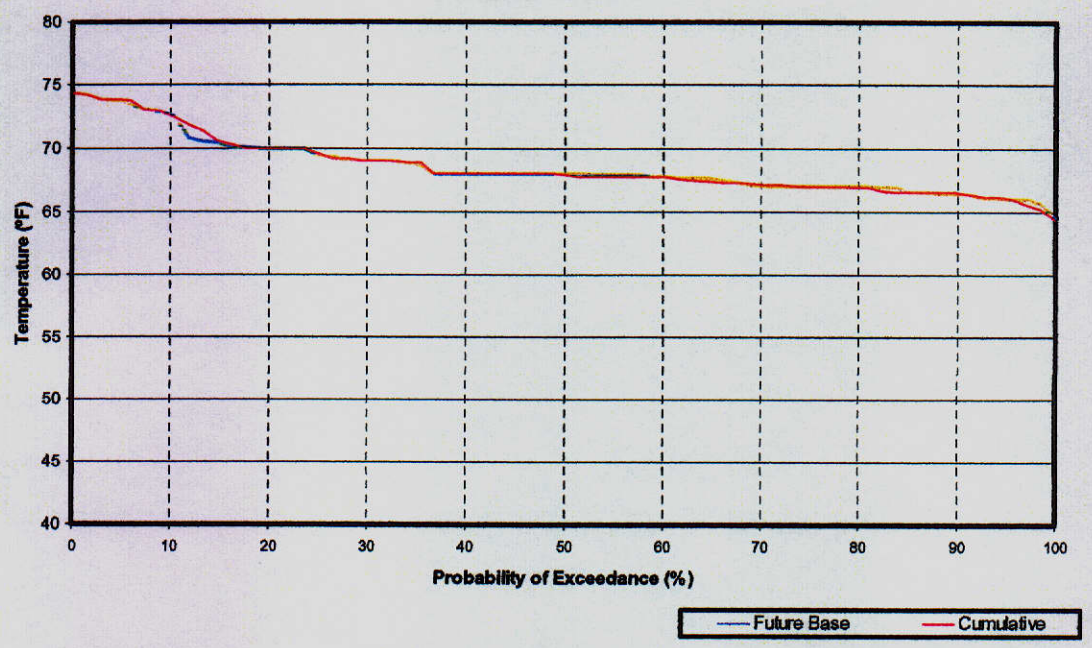


Figure 24

Temperature in the American River at Watt Ave During September Under Future Base and Cumulative Conditions

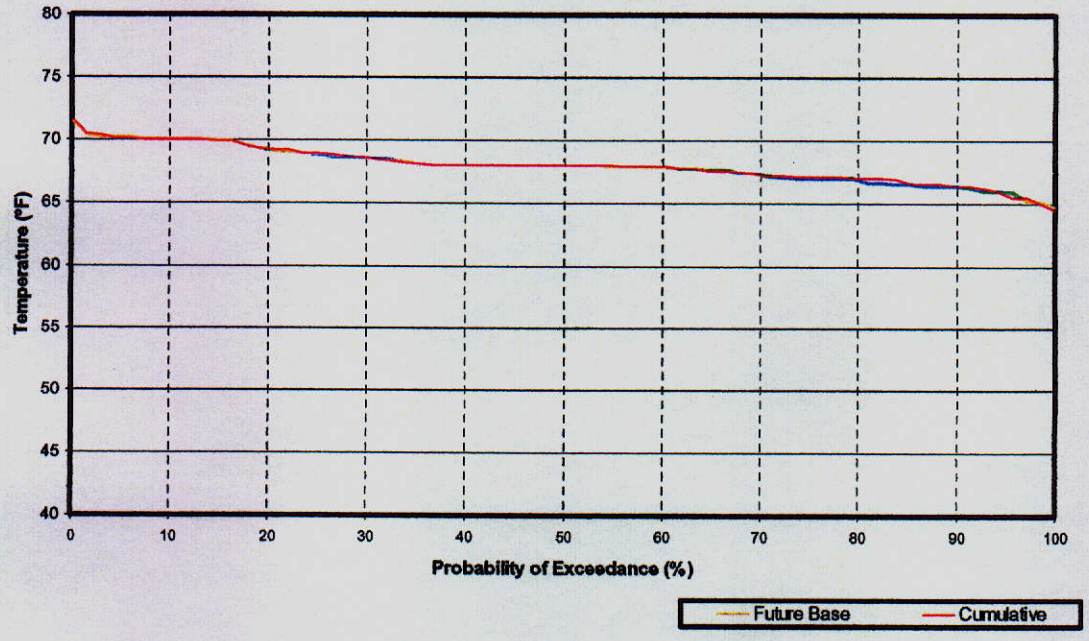


Figure 22

Temperature in the American River at Watt Ave During July Under Future Base and Cumulative Conditions

Figure 20

Lower American River Flow at Watt Avenue During August Under Future Base and Cumulative Conditions

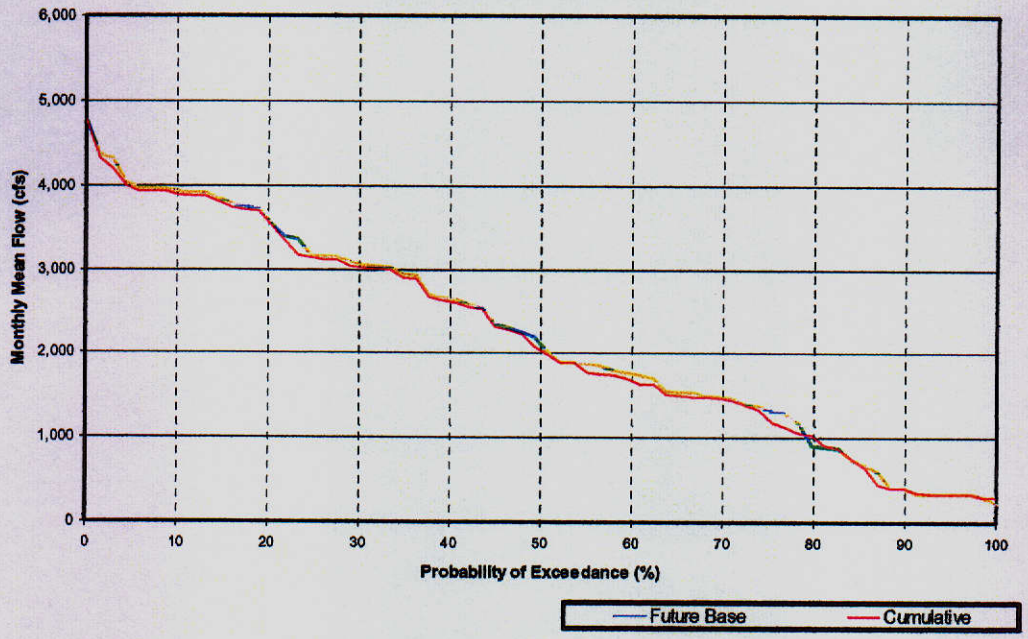


Figure 21

Lower American River Flow at Watt Avenue During September Under Future Base and Cumulative Conditions

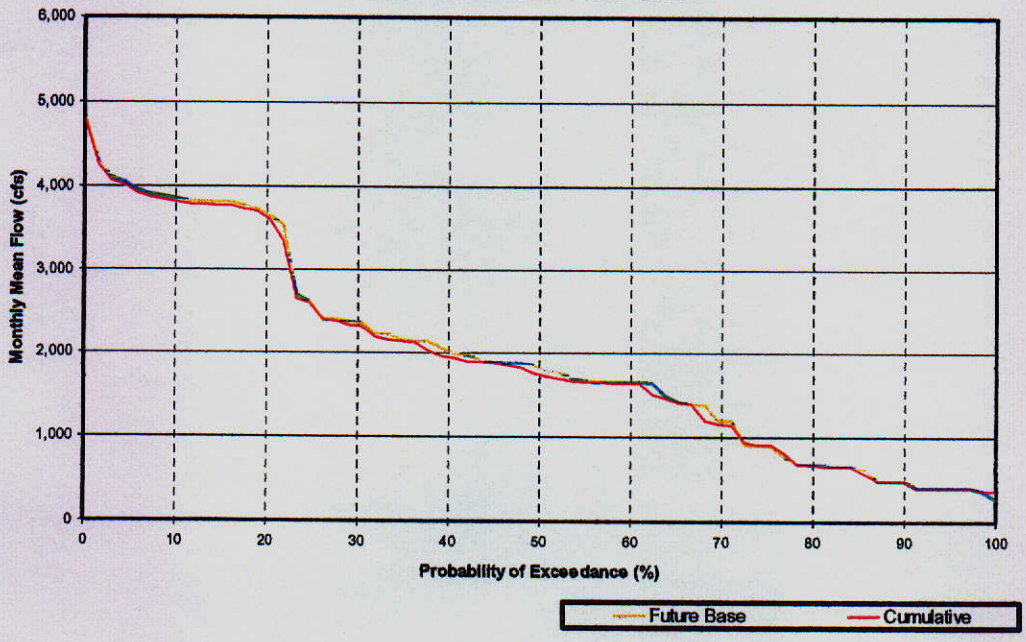


Figure 19

Lower American River Flow at Watt Avenue During July Under Future Base and Cumulative Conditions

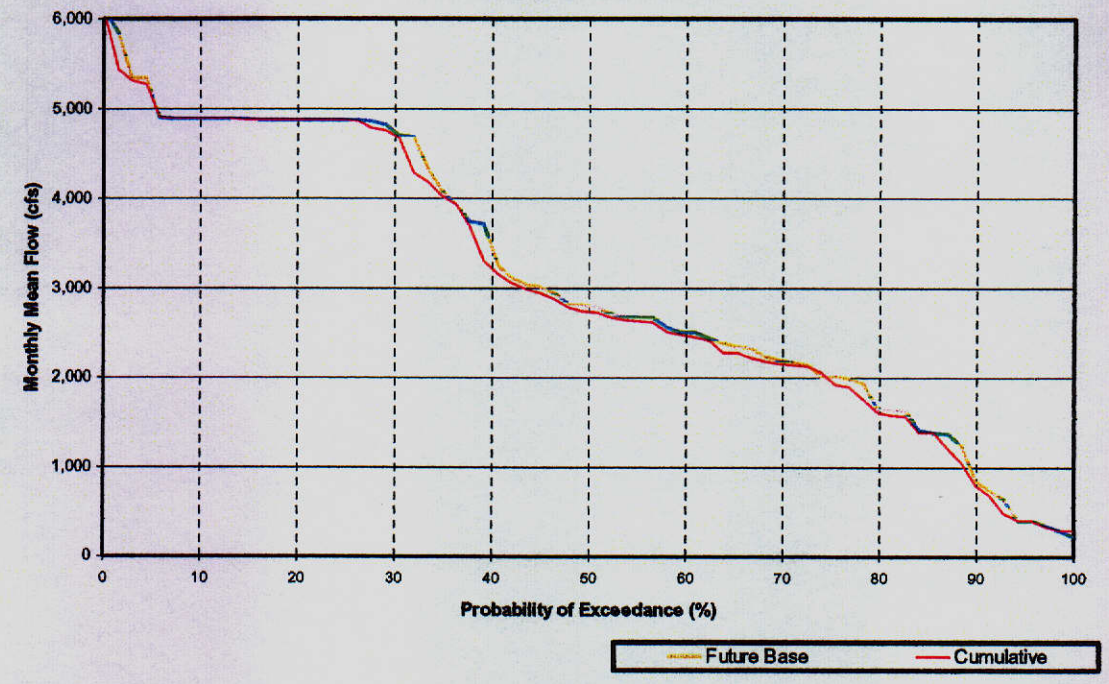


Figure 18

Lower American River Flow at Watt Avenue During June Under Future Base and Cumulative Conditions

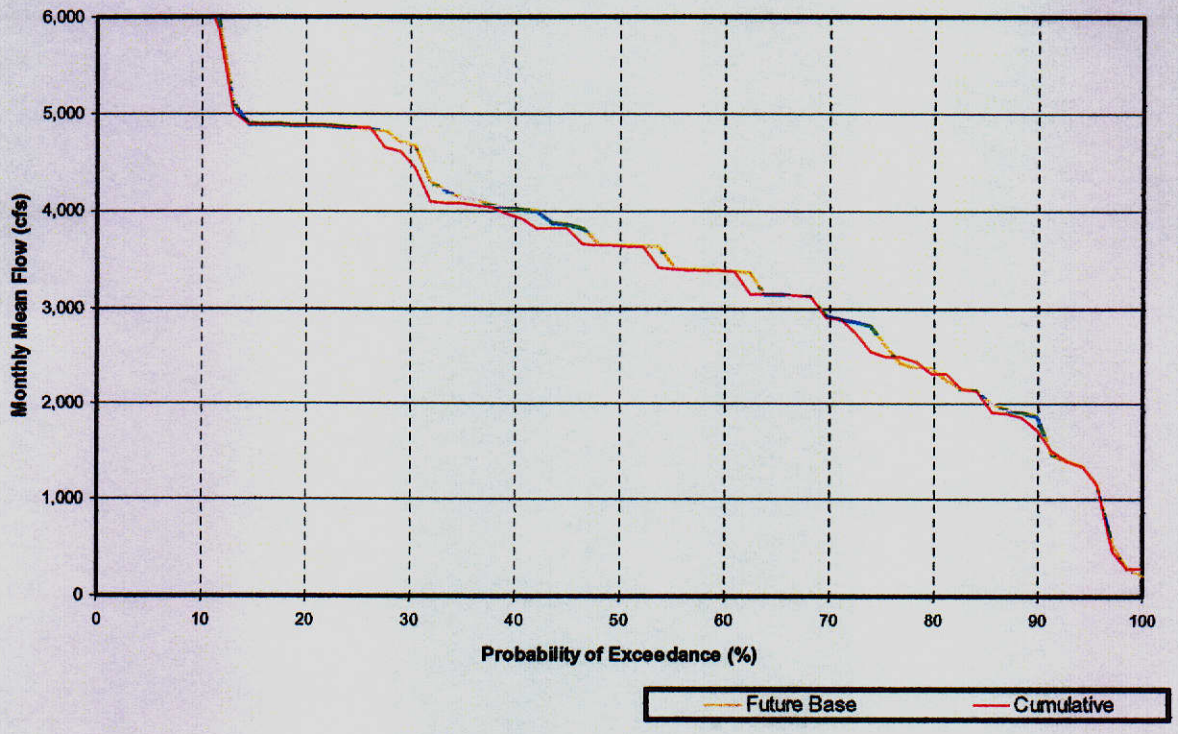


Figure 16

Lower American River Flow at Watt Avenue During April Under Future Base and Cumulative Conditions

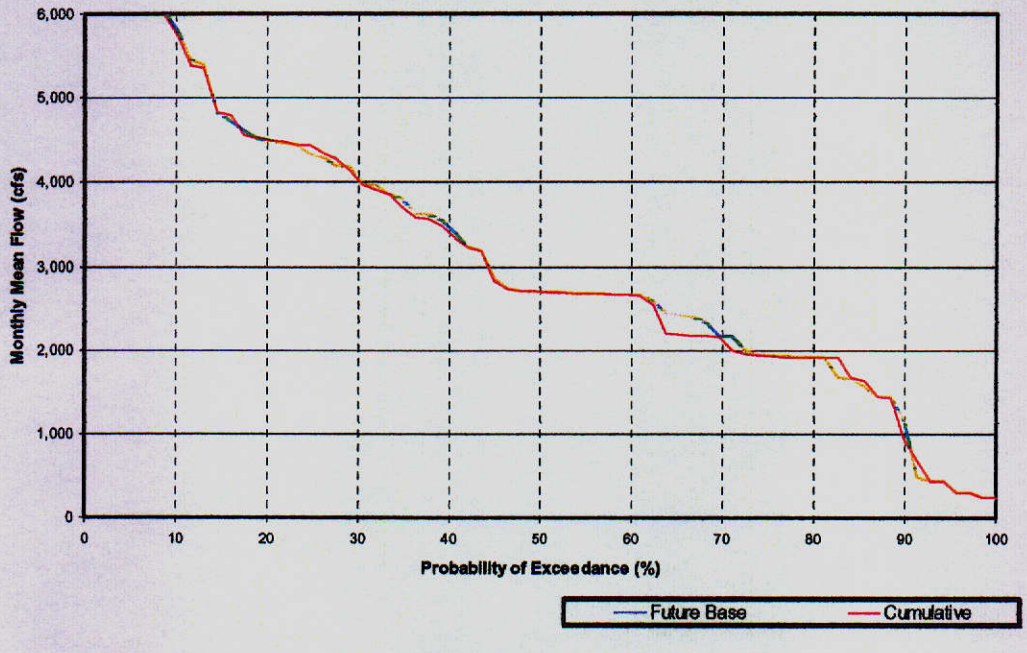


Figure 17

Lower American River Flow at Watt Avenue During May Under Future Base and Cumulative Conditions

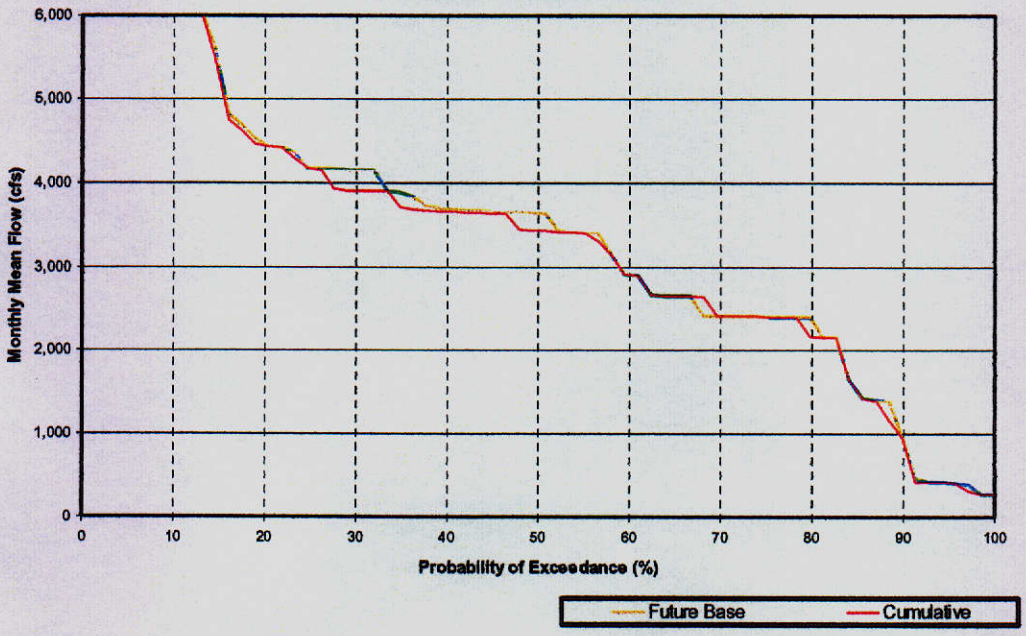


Figure 15

Lower American River Flow at Watt Avenue During March Under Future Base and Cumulative Conditions

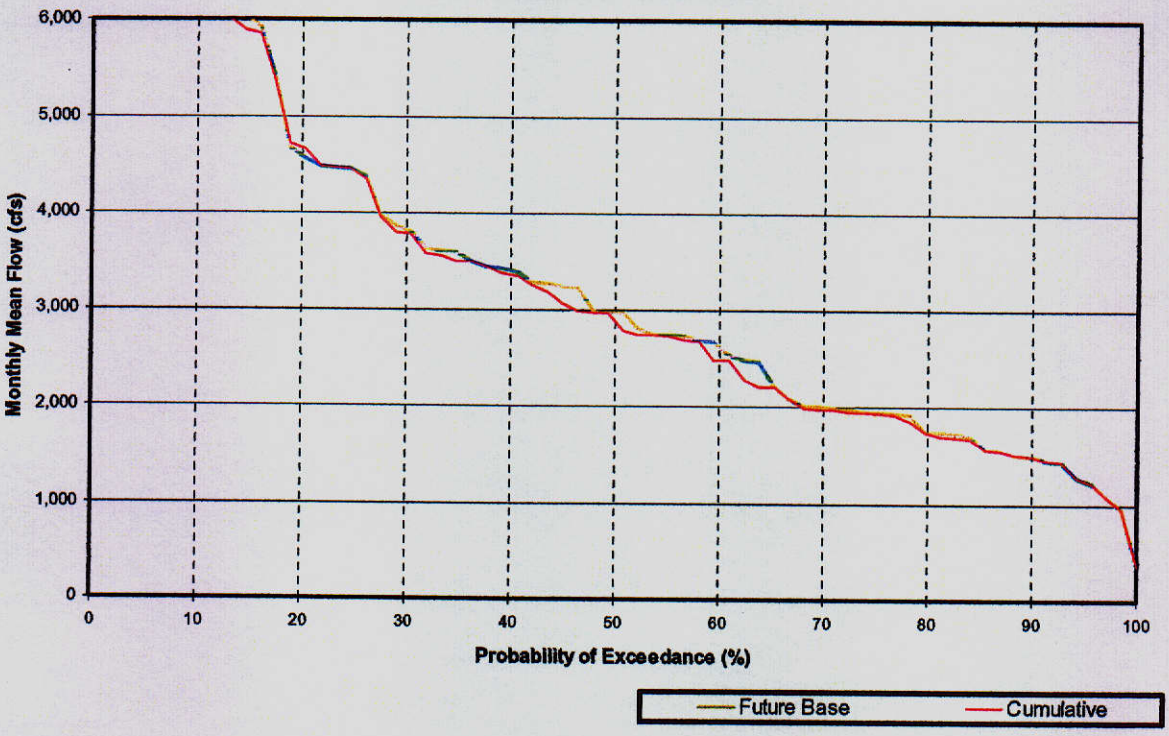


Figure 14

Lower American River Flow at Watt Avenue During September Under Existing and Cumulative Conditions

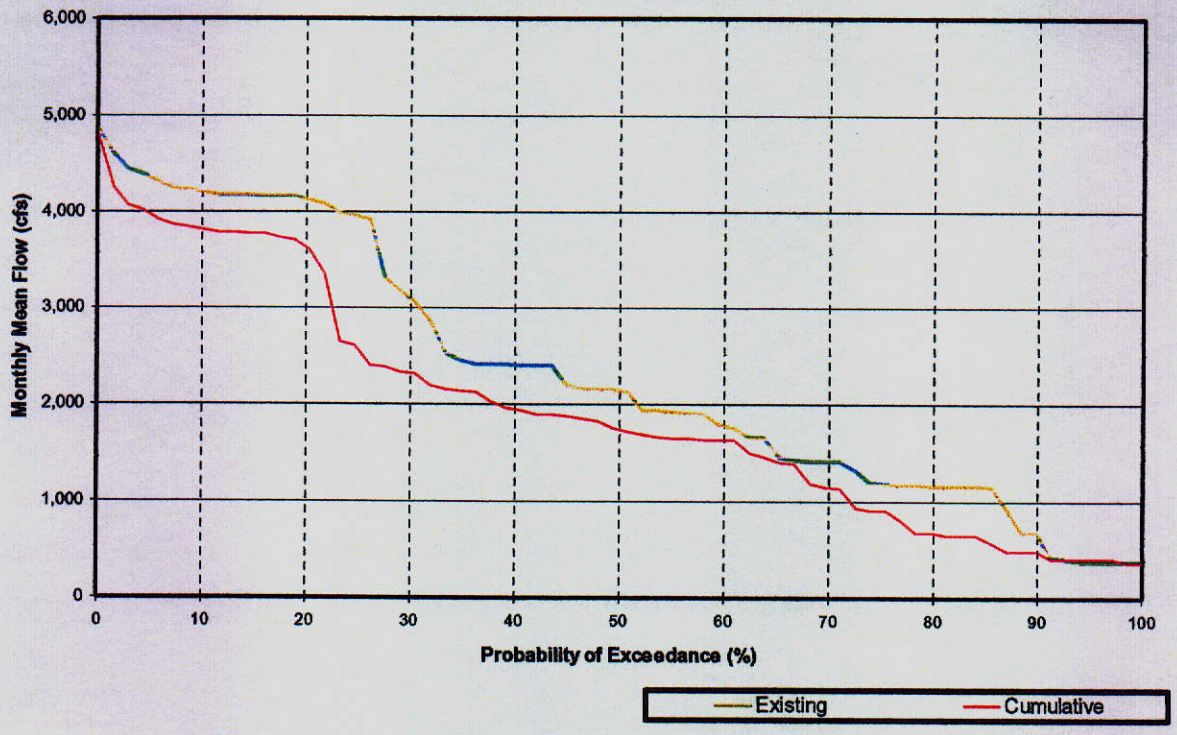


Figure 12

Lower American River Flow at Watt Avenue During July Under Existing and Cumulative Conditions

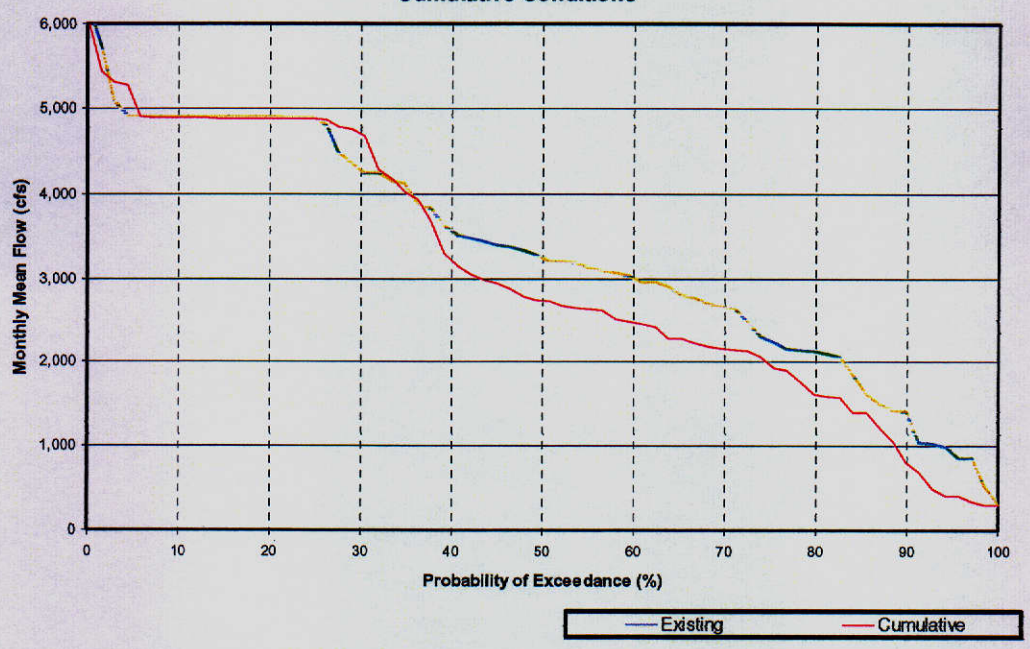


Figure 13

Lower American River Flow at Watt Avenue During August Under Existing and Cumulative Conditions

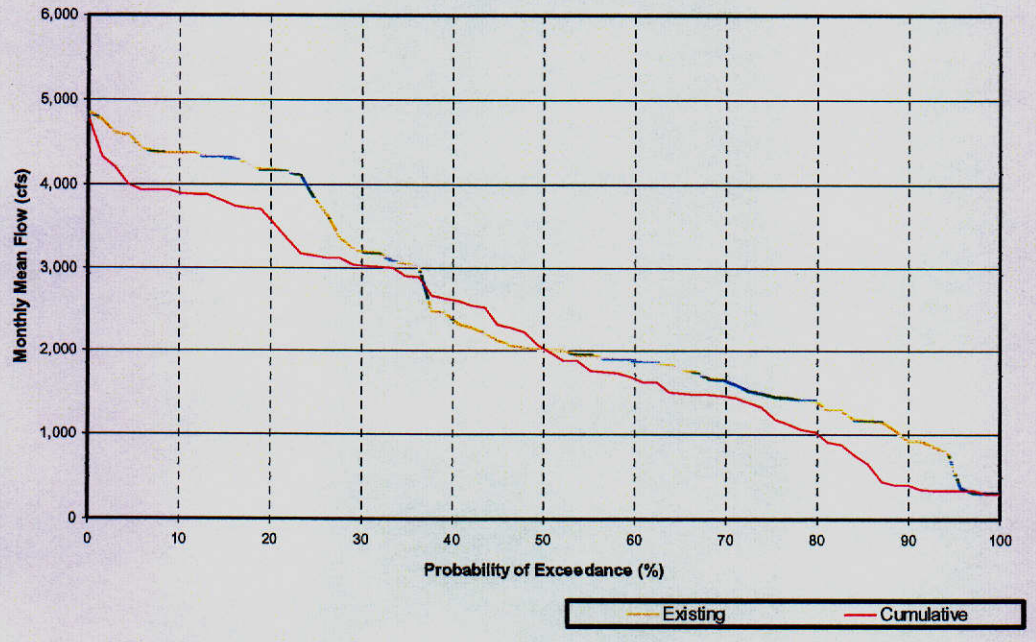


Figure 11

Lower American River Flow at Watt Avenue During September Under Existing and Cumulative Conditions

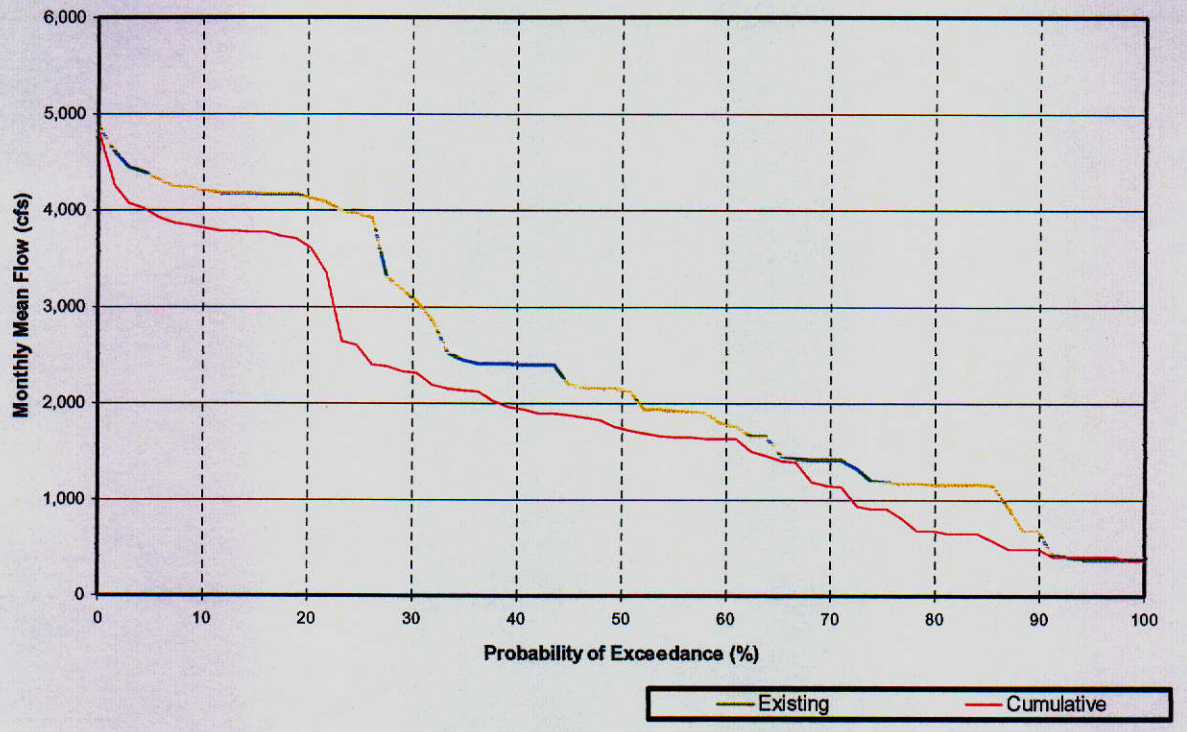


Figure 1
Lower American River Release From Nimbus Dam During July
Under 8,500 AFA and 35,500 AFA

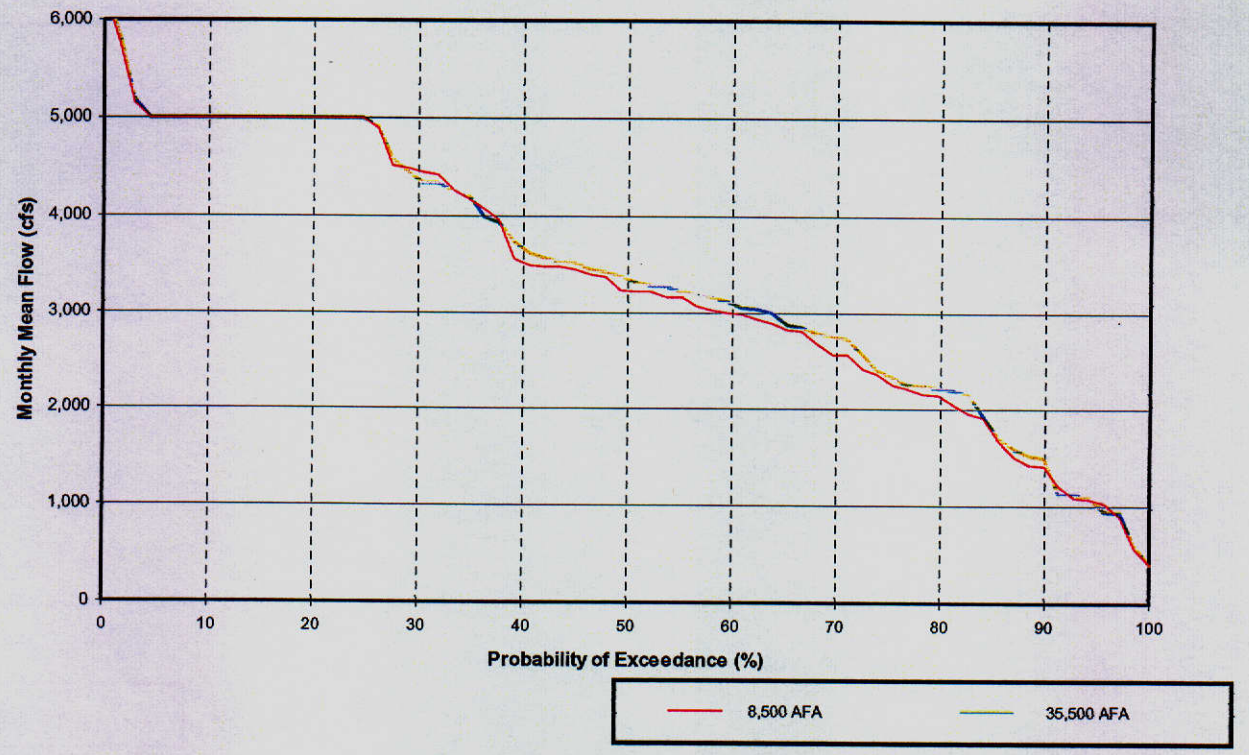
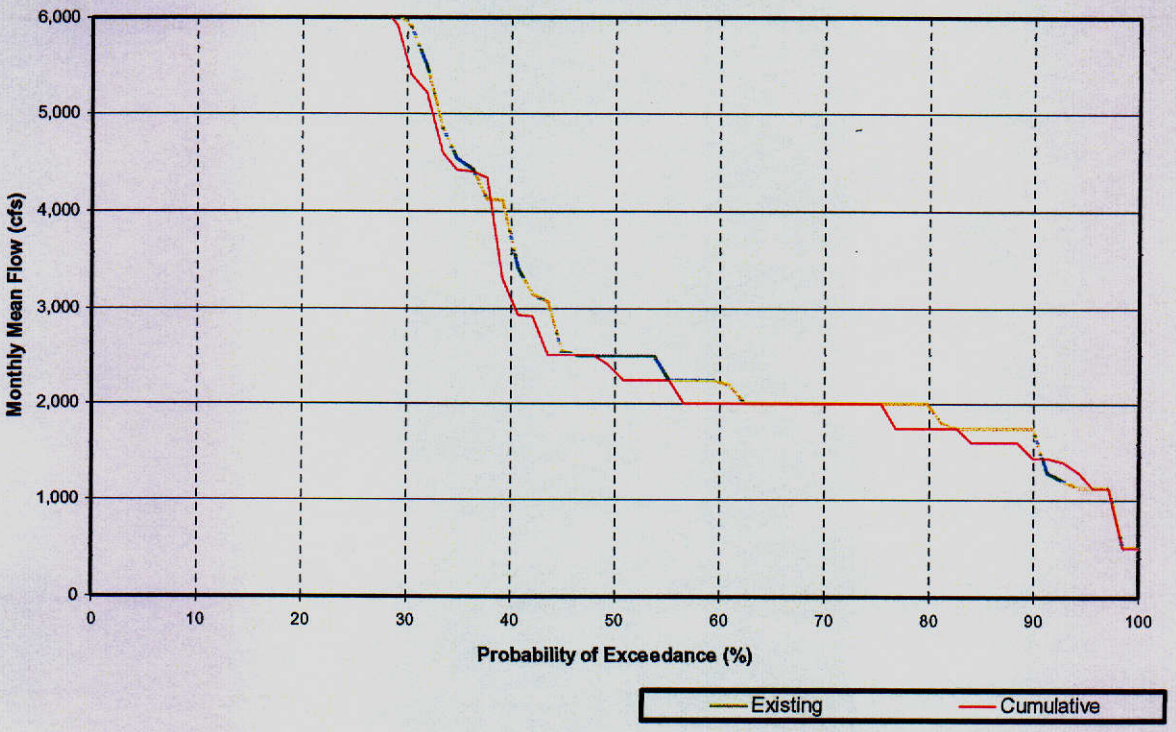


Figure 8

Lower American River Release From Nimbus Dam During February Under Existing and Cumulative Conditions



STATE OF CALIFORNIA-THE RESOURCES AGENCY GRAY DAVIS, Governor
DEPARTMENT OF FISH AND GAME
1416 Ninth Street
Sacramento, California 94244-2090
Telephone: (916) 654-3821

May 9, 2002

VIA HAND DELIVERY

Division of Water Rights
State Water Resources Control Board
P. O. Box 2000
Sacramento, California 95812-2000
Attn: Jean McCue

Re: American River FAS Petition

Dear Ms. McCue:

Enclosed please find five copies of the EXHIBIT IDENTIFICATION INDEX, EXHIBITS 1-32 and Proof of Service in the above-referenced matter.

If you have any questions, please contact me at (916) 654-3830.

Very truly yours,

JENNIFER A. DECKER
Staff Counsel

Enclosures

cc: Mailing List

Banky Curtis, Regional Manager
Department of Fish and Game

JD/jmw

Participant: Department of Fish and Game

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
1	Resume of Stephen D. Reynolds			
2	Dr. R. J. Shlemon, "Quaternary Geology of Northern Sacramento County, California: Annual Field Trip Guidebook of the Geological Society of Sacramento," Plates, 1967.			
3	Shlemon, et al, "Diagram of Geologic Cross Sections Specific Locations (AA' and BB') on the American River," referenced above.			
4	Shlemon, et al, referenced above, pp. 27-28, Plate 3 and Attachment 3.			
5	Ralph C. Heath, "Basic Ground-water Hydrology," U. S. Geological Survey Water-Supply Paper 2220, pp. 12-13, 1993.			
6	Heath, referenced above, p. 23.			
7	C. W. Fetter, Applied Hydrolgeology, Third Edition, Macmillian College Pub. Co., pp. 58-60, 1994.			
8	Gencorp Aerojet, American River Study, Figures 2-8 and 2-9, Groundwater Elevation Contour Maps, April 1995, from the Engineering Evaluation/Cost Analysis, for the American River Study Area."			
9	Figures A-7 (Aquifer A), A-8 (Aquifer B) and A-9 (Aquifer C) from Western Groundwater Operable Unit, Remedial Investigation/Feasibility Study, Vol. II, Appendix A.			
10	Well Number 8N6E8F001M, from Department of Water Resources well production records.			
11	Well Number 9N6E27D001M from Department of Water Resources well production records.			
12	Well Number 7N6E8H001M from Department of Water Resources well production records.			
13	Well Number 9N6E34R001M from Department of Water Resources well production records.			

Participant: Department of Fish and Game

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
14	Well Number 8N6E9Q004M from Department of Water Resources well production records.			
15	Graph showing the results of cumulative departure analysis of long-term groundwater level trends.			
15A	Hydrographs from monitoring wells located near the American River in the vicinity of the Aerojet Site.			
15B	Hydrographs from monitoring wells located near the American River in the vicinity of the Aerojet Site.			
15C	Hydrographs from monitoring wells located near the American River in the vicinity of the Aerojet Site.			
16	Location of well on American River Study Area "Well Location Map" by Gencorp Aerojet Environmental Operations.			
17	Aquifer Test Results for Well 4325, from Engineering Evaluation/Cost Analysis, for the American River Study Area, Vol. II, Appendix A and GET Effectiveness Evaluation for the American River Study Area dated 2/2000.			
18	Aquifer Test Results for Well 4330 , from Engineering Evaluation/Cost Analysis, for the American River Study Area, Vol. II, Appendix A and GET Effectiveness Evaluation for the American River Study Area dated 2/2000.			
19	Aquifer Test Results for Well 4335, from Engineering Evaluation/Cost Analysis, for the American River Study Area, Vol. II, Appendix A and GET Effectiveness Evaluation for the American River Study Area dated 2/2000.			
19A	Aquifer Test Summary, from Engineering Evaluation/Cost Analysis, for the American River Study Area, Vol. I, 1996.			
19B	Aerojet analysis of aquifer test results, pp. 3-22 and attachments, from GET Effectiveness Evaluation for the American River Study Area dated 2/2000.			
20	R. Allan Freeze, John A. Cherry, Groundwater, Prentice-Hall, New Jersey, excerpts attached, pp. 330-346, 1979.			

Participant: Department of Fish and Game

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
21	G. P. Kruseman, N. A. de Ridder, Analysis and Evaluation of Pumping Test Data, Second Edition, International Institute for Land Reclamation and Improvement, Publication 47, Netherlands, excerpts, pp. 109-123, 1991.			
22-A	Graph of cumulative departure analysis and raw data from 1905 to 1999, from U.S. Geologic Survey gage number 11446500, with mean derived from 1934 through 1954.			
22-B	Graph of cumulative departure analysis and raw data from 1905 to 1999, from U.S. Geologic Survey gage number 11446500 with mean derived from 1905 to 1999 data.			
23	Brief of County of Sacramento, in the Matter of Applications 12140, etc., City of Sacramento, et al., Applicants S. Clemens Horst Company, et al., Protestants, Submitted September 16, 1957.			
24	"Water Rights Investigation dated November 1956 for Major Pending Applications to Appropriate Water From the American River," p. 49, found in SWRCB Hearing File for Application 12140, Item 49, Folder 5-M, Exhibit 1.			
25	Union Properties, Inc. Protest, p. 4.			
26	The Protest of Reclamation District 756 Situated in San Joaquin County, California, pp. 3-4.			
27	Excerpt from Index for Application 12140 Hearing File Index.			
28	State Water Resources Board, Bulletin No. 21, "American River Basin Investigation: Report on Development Proposed for the California Water Plan," Volume 1, selected excerpts, June 1955.			
29	State Water Resources Board, Bulletin No. 21, "American River Basin Investigation: Report on Development Proposed for the California Water Plan," Volume II-A, "Ground Water Studies," June 1955.			
30	United States Geological Survey, "Water-Supply Paper 1345: Surface Water Supply of the United States, Part II, Pacific Slope Basins in California, 1956," Selected Excerpts.			

Participant: Department of Fish and Game

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
31	U.S. Bureau of Reclamation, "Folsom North Unit, Central Valley Project, Reconnaissance Studies of Bureau of Water Problems," Chapter III Water Resources, p. 1, Map of Study Area, and p. 39 for "Water Problems," dated 1956.			
32	Testimony of Stephen D. Reynolds			

PROOF OF SERVICE

I hereby declare as follows:

I am employed in the County of Sacramento, State of California. I am eighteen years of age or older and am not a party to the within entitled action. My business address is 1416 Ninth Street, P. O. Box 944209, Sacramento, California 94244-2090. I am familiar with the business practice of the California Department of Fish and Game with regard to the collection and processing of documents for mailing with the United States Postal Service.

On May 9, 2002, I caused to be served the attached LETTER TO JEAN McCUE, DEPARTMENT OF FISH AND GAME'S EXHIBIT IDENTIFICATION INDEX and EXHIBITS 1-32 **by placing a true copy thereof in the manner set forth below and addressed as follows:**

Via Hand Delivery (5 copies):

Division of Water Rights
State Water Resources Control Board
P. O. Box 2000
Sacramento, California 95812-2000
Attn: Jean McCue

Via U.S. Mail by Depositing a Copy in a Sealed Envelope Via First Class Mail with the United States Postal Service with Postage Fully Paid Thereon To:

See Attached List

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed in Sacramento, California on May 9, 2002.

Jan Wilcox

JAN WILCOX

MICHAEL FIFE
HATCH & PARENT
21 EAST CARRILLO STREET
SANTA BARBARA, CA 93101

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LENNIHAN LAW APC
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SACRAMENTO, CA 95816

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PSW REGION
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SACRAMENTO, CA 95825

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400 CAPITOL MALL, 27TH FLOOR
SACRAMENTO, CA 95814-4417

JENNIFER DECKER
DEPARTMENT OF FISH AND GAME
1416 NINTH STREET, 12TH FLOOR
SACRAMENTO, CA 95814

STEPHEN D. REYNOLDS

EDUCATION

Under Graduate: Bachelor of Science Degree; Physical Geology. California State University Hayward, 1979.
Post Graduate: Mr. Reynolds has taken numerous university and short courses in the areas of soil science, hydrogeology, hydrology, fluvial geomorphology, computer modeling, community relations, and project management.

PROFESSIONAL LICENSES

California Registered Geologist, # 4022, Certified Engineering Geologist, # 1286, Certified Hydrogeologist # 200.

PROFESSIONAL EXPERIENCE

Senior Engineering Geologist (Specialist). Department of Conservation, California Geological Survey, April 2001 to present.

Mr. Reynolds works closely with interdisciplinary watershed teams providing recommendations on the geologic and hydrologic issues associated with stream restoration projects. Mr. Reynolds also works independently on the analysis of watershed issues regarding sediment sources, slope stability, fluvial geomorphology, and the design of restoration measures for impacted streams

Associate Engineering Geologist. Department of Conservation, January 1998 to April 2001.

As the geologic lead in the Abandoned Mine Lands Program, Mr. Reynolds developed the protocol to evaluate and rank abandoned mine lands (AML) with respect to potential risks to human health and the environment. In addition, Mr. Reynolds responsibilities include preparing the geotechnical elements of AML reclamation plans for third parties. This includes the evaluation of slope stability, seismicity, foundation conditions for proposed fills, embankments, etc., hydrogeology, soil and ground-water contamination, and evaluation of the fate and transport of toxicants in soil and ground water.

Associate Engineering Geologist. Department of Toxic Substances Control, November 1997 to January 1998.

Mr. Reynolds provided hydrogeologic and geotechnical support to the Department's regional offices in the area of permitting, compliance, and enforcement for the State's Resource Conservation and Recovery Act (RCRA) program. Mr. Reynolds principle responsibility was the evaluation of potential impacts to human health and the environment via the ground-water and soil pathways. This involved both the assessment of current and future exposure and the integration of these findings into the risk appraisal process, and to design mitigation measures for the anticipated exposure.

Technical Team Leader (Hydrogeologist), United States Army, Corps of Engineers, Sacramento District, November 1992 to November 1997.

As a Technical Team Leader Mr. Reynolds' responsibilities included developing and overseeing exposure assessments for contaminated ground water and soil. Duties included preparation of scopes of work, specifications, oversight and supervision of field staff, budgets and finance, and preparation of reports presenting interpretation of findings and recommendations for future actions to address technical, regulatory compliance, and administrative concerns.

In addition, Mr. Reynolds' responsibilities also included independent work on specific challenging or sensitive projects involving ground-water investigations and ground-water modeling. Projects include: the numerical ground-water flow modeling of the Chena River Flood control Project, Fairbanks Alaska; development of hydrogeologic database and insitu data-gathering network for Sierra Army Depot, Herlong California; exposure assessment and risk appraisal of contaminated soils and ground water at Fort Irwin, California, Camp Navajo, Arizona, Hawthorne AAP, Nevada, and Fort Huachuca, New Mexico; development of comprehensive environmental assessment plans for Hawthorne Army Depots, Nevada and Camp Navajo, Arizona; dewatering and environmental compliance plans for channel improvements at San Pablo and Wildcat Creeks , San Pablo, California.

Associate Engineering Geologist. Department of Toxic Substances Control, June 1990 to November 1992

Mr. Reynolds was the hydrogeologic lead on the interdisciplinary team responsible for developing the protocol and methodology for fate and transport modeling to be used as the basis for health-based waste treatment standards. For this project Mr. Reynolds was responsible for developing the hydrogeologic models forming the basis of the fate and transport analysis. In addition, Mr. Reynolds was the division's in-house geologic consultant, conducting assessments of the impacts to ground-water and soils of low-level radio active waste repositories, the development of siting criteria for treatment residuals repositories, hazardous waste injection wells. Mr. Reynolds routinely provided technical support to the Department's regional offices on site assessment and remediation.

Senior Hazardous Materials Specialist. Department Health Services, December 1988 to June 1990

As manager of the McColl Project, Mr. Reynolds was responsible for the oversight and direction of the seven person staff and contractors conducting the assessment and mitigation of this federal superfund site. Tasks performed by the McColl Team included the ground water remedial investigation, evaluation of current and future exposures to residents via ground water, soil, and air pathways, and preparation of the Environmental Impact Report and Remedial Action Plan. Other responsibilities included coordinating with legal staff on compliance with environmental laws, regulatory compliance and litigation efforts, negotiating with responsible parties, preparing budgets and fiscal documents, negotiating grants with the USEPA, and preparation of annual and long-range project plans for purposes of staffing and budgeting. In addition, Mr. Reynolds acted as the States liaison with the local citizen groups, local government, and the US Congress.

Associate Engineering Geologist. Department of Health Services, August 1983 to December 1988.

Mr. Reynolds was responsible for either conducting or performing review and oversight of site assessments performed at over 125 State Bond Sites. Mr. Reynolds principle responsibility was the evaluation of potential impacts to human health and the environment via the ground-water and soil pathways. This involved both the assessment of current and future exposure and integrates these findings into the risk appraisal process, and to design mitigation measures for the anticipated exposure. Mr. Reynolds was also responsible for preparing the Department's guidance manual(s) and standards for the evaluation of hydrogeology at waste sites.

Engineering Geologist. Department of Water Resources, Project Geology Branch. August 1979 to August 1983.

Mr. Reynolds was responsible for evaluating the geologic feasibility of proposed civil engineering works, including slope stability and seismicity, design and installation of wells for construction water supply, and the design and installation of well fields for dewatering deep excavations. In final design Mr. Reynolds was responsible for evaluating the effects of site geology upon construction. During construction Mr. Reynolds was responsible for providing the resident engineer recommendations on methods to ameliorate unforeseen geologic conditions and providing contractor oversight.

WRS

QUATERNARY GEOLOGY OF THE SACRAMENTO AREA

Association of Engineering Geologists, Sacramento Section

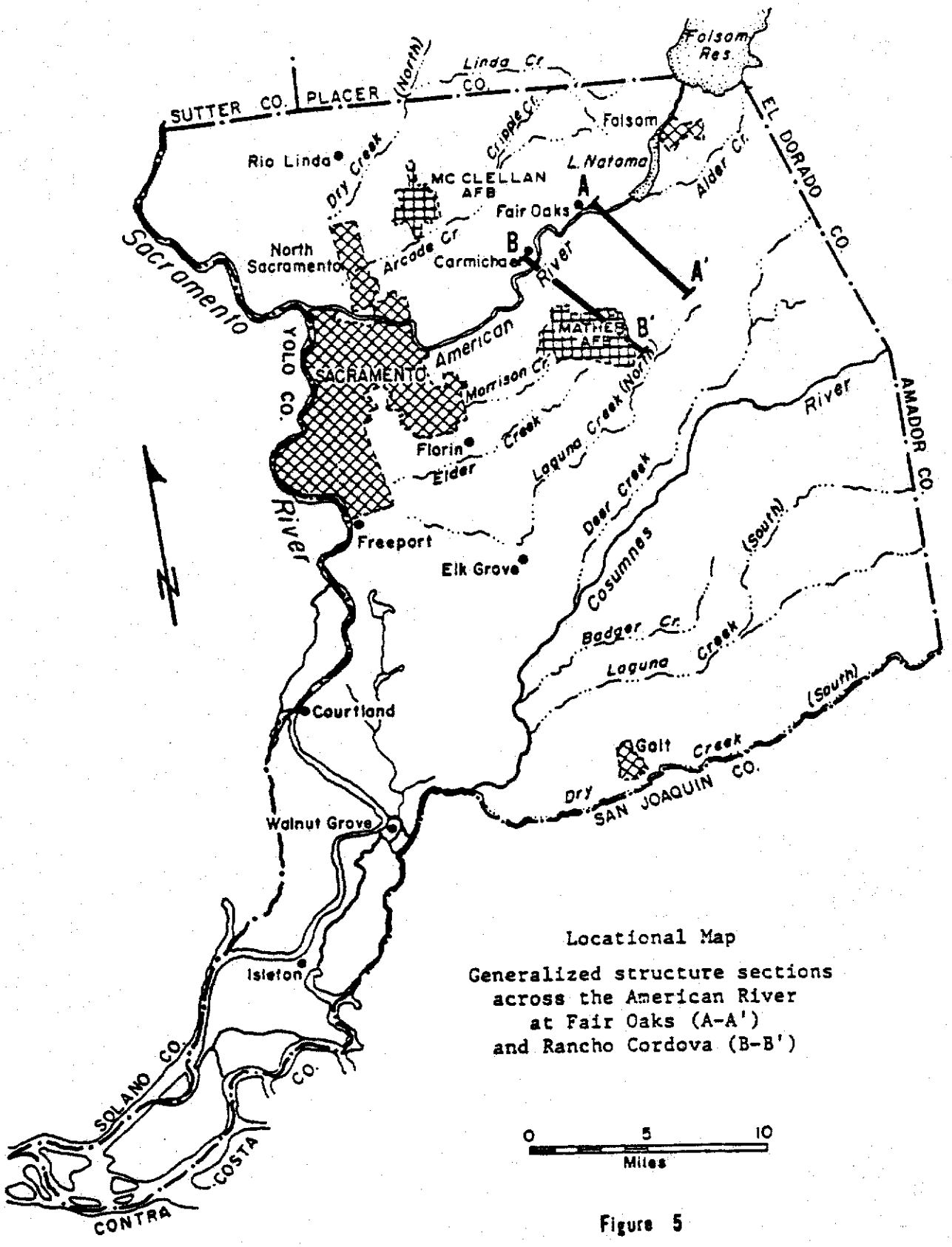
Guidebook for Field Trip, 25 March 2000

Leaders

Dr. Roy J. Shlemon, Consultant

Dr. Tim Horner, California State University, Sacramento

Dr. Joan Florsheim, University of California, Davis



Locational Map

Generalized structure sections across the American River at Fair Oaks (A-A') and Rancho Cordova (B-B')

Figure 5

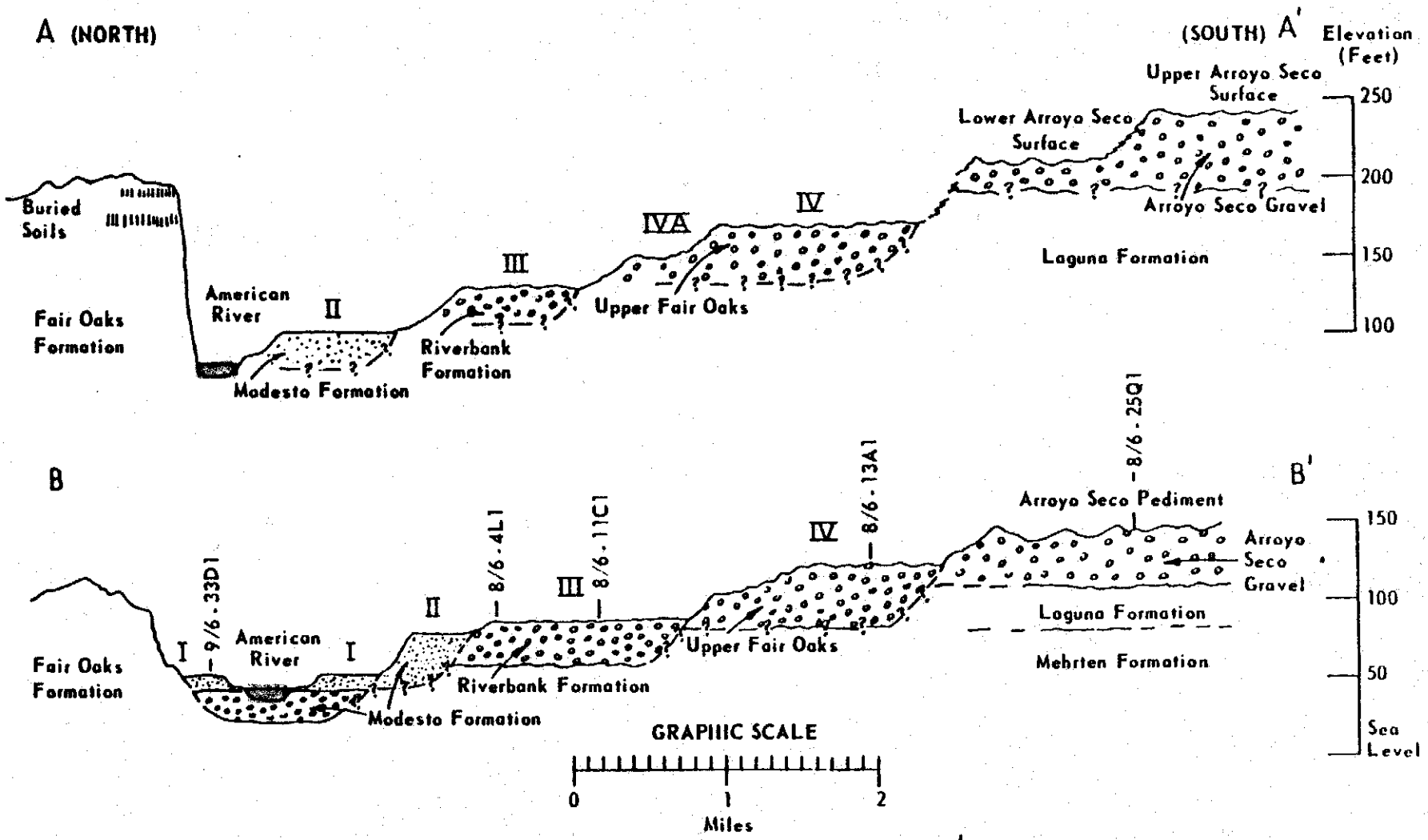
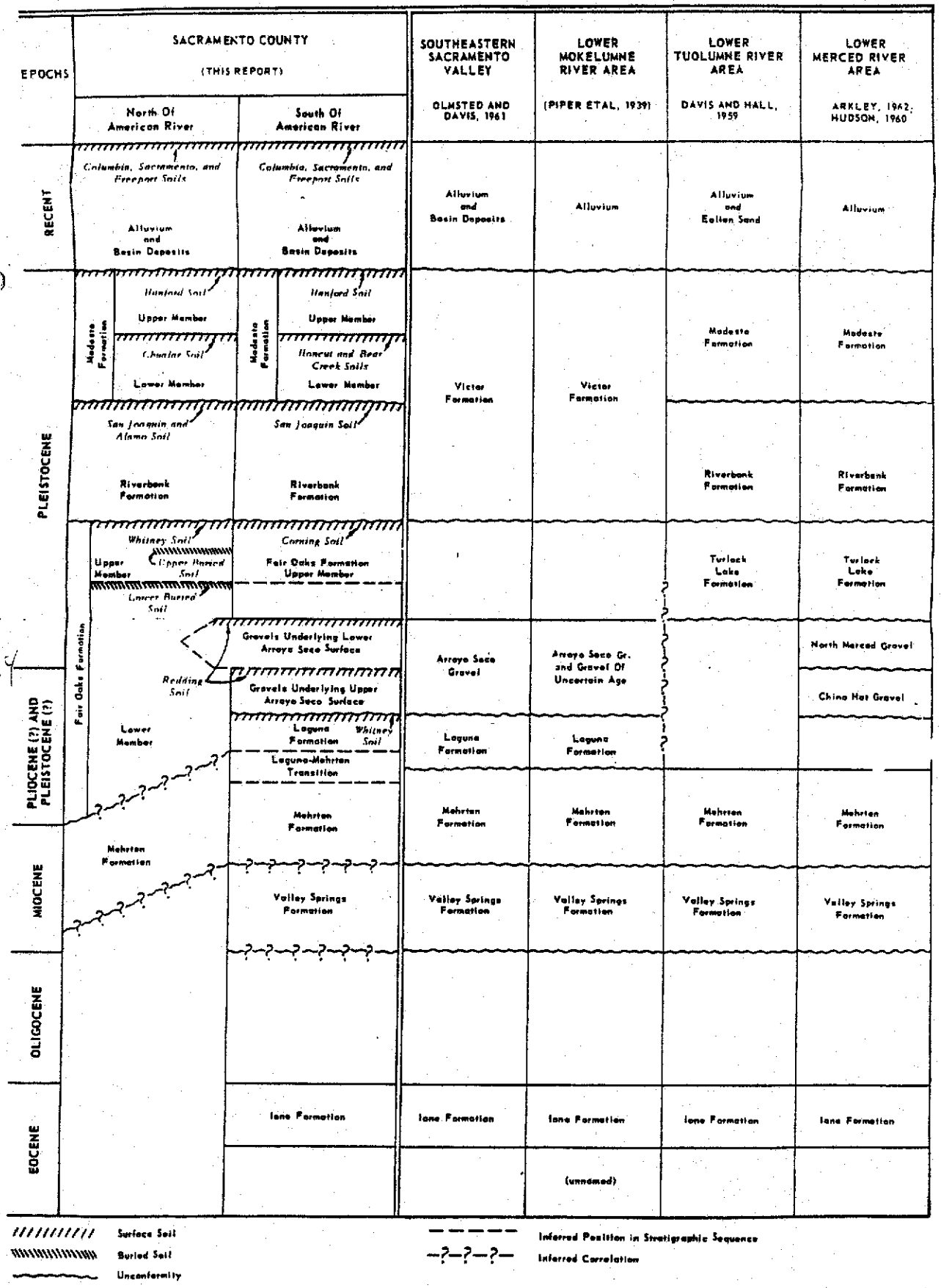


Figure 6 – Generalized structure sections across the American River at Fair Oaks (A-A') and downstream near the Rancho Cordova District (B-B'). American River terraces designated by Roman numerals; subsurface contacts along section B-B' based on well log control as indicated e.g., 9/6 - 33D1, 8/6 - 4L1 etc.

TABLE 2

CORRELATION OF CENOZOIC FORMATIONS ALONG THE EAST SIDE OF THE GREAT VALLEY

(ASSOCIATED SOILS INDICATED FOR SACRAMENTO COUNTY SECTION)



QUATERNARY GEOLOGY OF THE SACRAMENTO AREA

Association of Engineering Geologists, Sacramento Section

Guidebook for Field Trip, 25 March 2000

Leaders

Dr. Roy J. Shlemon, Consultant

Dr. Tim Horner, California State University, Sacramento

Dr. Joan Florsheim, University of California, Davis

Close examination with a hand lens will reveal 80-90% gray to purple andesite clasts with traces of basalt, feldspar, ferromagnesian minerals and magnetite. This purplish-gray color and presence of magnetite are distinctive features of the Mehrten Formation. It is also important to note the *absence* of detrital quartz (Giorgis, 1997). The Mehrten Formation is essentially devoid of sand-sized quartz.

At least one ash-rich horizon is present in this section, and impermeable, silty, ash-rich intervals make up at least 10% of the total unit thickness in this outcrop. A thin, relatively pure ash is exposed about 0.5 meter above the bike trail at the southeastern end of the ravine. Follow this interval as we walk around the bend in the bike trail to the west, past the dam and across the level bike trail on the south side (front) of the hill. The finer-grained silty sediment at the level of the bike trail is very ash-rich, and probably represents fluvial reworking of an air fall volcanic event.

Debris flow and mudflow deposits are a common feature in other exposures of the Mehrten Formation (Curtis, 1955), but these features are not found at the Nimbus Dam and Old Fair Oaks Bridge localities. An ash-rich mudflow deposit in the upper Mehrten Formation is exposed west of the Sunrise Bridge at Sailor bar (5.6 km west of this field trip stop), but the lateral extent of this feature is unknown. Debris flow deposits are also common north of interstate 80 along Sierra College Blvd. and south of Rt. 50 along Grant line Rd. near the intersection with Kiefer Rd. These mudflow and debris flow intervals are a reminder of the volcanic source for the Mehrten Formation, although material that we will examine on this trip is reworked by fluvial processes and deposition on an alluvial fan.

Fair Oaks unit:

Continue walking westward along the bike path, but take the uphill fork toward the top of the Hazel bridge rather than following the bike trail under the bridge. The Mehrten/Fair Oaks contact occurs near the north end of the Hazel Ave. bridge, approximately 1 meter below road level. This contact is covered by vegetation on the south side of the hill. The Fair Oaks unit has thinned since we saw it near the Old Fair Oaks Bridge. Total thickness of the Fair Oaks unit at Nimbus Dam is approximately 8 m (25 ft), but this is variable due to the erosional nature of the overlying Arroyo Seco Gravels.

Grain composition is a distinguishing feature of the Fair Oaks unit. Fair Oaks sand layers are composed of 20-30% subangular to angular clear quartz grains, 30-40% white or subrounded feldspar, 20-30% mottled plutonic rock fragments and up to 20% brassy euhedral biotite mica (Plate 3). Low angle trough cross beds and ripples are common in sandy intervals, and finer intervals may have carbonized rootlets. At this outcrop finer silty and clay– rich material is dominant, and represents approximately 60-70% of the total unit thickness. Fining upward cycles and paleosols aren't as evident here as they were at the Sunrise Blvd. outcrop or Winding Way construction site, but the grain composition and lithologies are distinctive of the Fair Oaks unit.

Environmental interpretations for this exposure are similar to environmental interpretations discussed for Fair Oaks outcrops to the west; braided streams and associated floodplain deposits formed this sandy, silty and clay-rich interval. Ancient soils are weakly to moderately developed in finer-grained intervals, and soil formation was probably inhibited by moderately high rates of deposition and frequent switching of the braided stream channel.

Arroyo Seco Gravels:

The term Arroyo Seco Gravels is used in this report to be consistent with the terminology of Shlemon (1967a). Arroyo Seco gravel was originally defined to describe a thin veneer of material on the Arroyo Seco pediment (Piper et al., 1939), but this was a weathered surface eleven feet thick rather than a depositional unit, and the original term had very broad geographic use. Arroyo Seco Gravels in this report are Pliocene/Pleistocene deposits that form fluvial terraces south of the American River, with the exception of a few isolated pockets that border the American River near Nimbus Dam and Sailor Bar. The thickness of these gravels above Nimbus Dam is greater than 20 meters. This is more than three times the thickness of the original pediment cap defined by Piper et al. (1939), and the origin of these sediments as a depositional unit rather than a lag deposit is very clear.

Arroyo Seco Gravels have an erosional lower contact with the underlying Fair Oaks unit. Relief on this contact exceeds two meters at Nimbus Dam, and a similar contact with more than three meters of relief can be seen along Illinois Ave. 0.5 km north of Sailor Bar (approximately 6.4 km west of Nimbus Dam). Scoured surfaces at the contact are interpreted as channel deposits, and have cut and fill structure with poorly sorted sandy fill. Typical Arroyo Seco sediments consist of 60-70% pebble to cobble conglomerate with 30-40% poorly to moderately sorted silty clay matrix. This unit has a characteristic brick-red color (5YR 3/3 dark reddish brown to 5YR 5/6 yellowish red) that includes a spectrum of weathering and iron cementation. Clasts range from 0.5 to 15 cm in diameter, and are dominated by well-rounded quartzite, greenstone and igneous grains. Volcanic and plutonic (granitic) grains are so highly weathered that they are frequently absent or barely recognizable in outcrop. Matrix consists of clay, silt and sand in subequal proportions. Sand grains in the matrix have a plutonic source, with quartz, feldspar and biotite mica common as matrix components (Plate 4).

Most Arroyo Seco Gravels are poorly bedded to massive, and may show one or two episodes of weathering and paleosol development (Shlemon, 1967a, 1967b). Paleosols have not been described at Nimbus Dam, but the distinctive color, composition, sorting and bedding of the sediment allows identification of the Arroyo Seco Gravels. Gravels are weakly bedded to massive, with rare sandy lenses. Sheets of material interfinger laterally with slightly finer or slightly coarser sandy and pebbly beds. The section at Nimbus Dam also has an atypical clay bed that is almost two meters thick. This is interpreted as a lacustrine (pond) deposit, and is not representative of the unit at other localities.

Features described for the Arroyo Seco Gravels at Nimbus Dam are consistent with sedimentation on a midfan or distal fan surface, where runoff events caused sheet flow as high flow events over-topped the incised distributary channels. The source for the granitic matrix was erosion of the Rocklin/Penryn pluton and/or reworking of the underlying granitic debris from the Fair Oaks unit. Resistant metamorphic clasts were derived from the metamorphic belt in the foothills of the Sierra. The Arroyo Seco Gravels mark the first significant input from this metamorphic source area, and the abundance of metamorphic clasts is used to distinguish this unit from other conglomeratic intervals. South of Nimbus Dam, interfingering and sheet flow are not as evident. Periods of weathering, low rates of sediment accumulation and moderate to well-developed soils are characteristic of Arroyo Seco Gravels as river terrace deposits stepped progressively northward and deeper into the underlying sediment (Shlemon; 1967a, 1967b, 1974).

Stratigraphy:

The stratigraphic sequence that we have observed is used to interpret the depositional history north of the river. Work by Roy Shlemon (1967a, 1967b) has provided complimentary evidence south of the river. In the following discussion these histories are merged to give a summary of deposition on the Sacramento fan.

Lithostratigraphy of the older (widespread) fan surface:

From a geologic perspective, we are now standing on the upper surface of the large composite alluvial fan that was discussed at the Fair Oaks Bridge stop. Sediment eroded from the Sierra Nevada was delivered to the edge of the Central Valley by ancestral channels of the American River (Lindgren, 1911, Jenkins, 1932), then dumped in huge, poorly sorted fan-shaped sheets that extend outward into the valley. A large-scale geologic map of the area (CDMG 1:250,000 Sacramento sheet) shows a series of fan-shaped wedges that originate in the Auburn area and step outward into the Central Valley. Older units are dissected by younger channels and partially covered by younger units, but the general fan shape is preserved with remarkable symmetry, especially on the north side of the American River.

We propose to name this composite feature the Sacramento Fan. Source areas and sediment composition of the fan material changed as material was contributed by events that included Sierran volcanism, unroofing of the Rocklin/Penryn pluton, breaches in the metamorphic belt, shifting of the major river system, and reworking of older fan sediments (Table 1). Climatic variability and uplift of the Sierra were also significant events in the history of the Sacramento Fan. DWR (1974) and Shlemon (1998) point out that successively younger units were deposited on an increasingly steep gradient caused by uplift of the Sierra Nevada. This results in an "offlap" pattern, where younger units cover the outer edges of older units that are now buried beneath the valley floor. This pattern of deposition may have started as early as Miocene time with deposition of the

Valley Springs Formation, and continued through deposition of the Riverbank Formation in Pleistocene time (Table 1).

This model of deposition on an alluvial fan is complicated by several factors. Uplift of the Sierra Nevada resulted in downcutting of the ancestral river, and in Late Pliocene to Pleistocene time the river eroded into the underlying Rocklin/Penryn pluton. This resulted in a significant change in source area and clast composition for sediment that was delivered to the alluvial fan. Older units (Valley Springs and Mehrten Formations) have a volcanic source, but later units (lower Fair Oaks and Arroyo Seco Formation) contain abundant quartz, feldspar and mica clasts that were derived from the pluton. Downcutting eventually breached the top of the Jurassic/Cretaceous metamorphic belt, and Arroyo Seco Gravels contain abundant rounded metamorphic clasts in a matrix of eroded granitic material (quartz, feldspar and mica) (see Table 1).

Erosion to the level of the pluton eventually had an effect on the course of the ancestral American River. Continued uplift of the Sierra Nevada resulted in topographic instability over the Rocklin/Penryn Pluton, where resistant crystalline rocks prevented further downcutting. Passage to the south was blocked by the Pine Hill intrusive complex, so the path of lesser resistance was a route through Folsom.

At this point the discussion becomes speculative; did the river move south in incremental stages, led by the South Fork of the ancestral American River as it entered the Folsom area from the east? Or was stream capture responsible for wholesale, catastrophic southerly avulsion (shifting) of the American River, resulting in a more sudden cutoff of sediment supply for the larger fan surface to the north? It is likely that the river moved to the south when the required base level of the ancestral American River dropped below the elevation of the Rocklin/Penryn pluton. This created instability on the older fan surface to the north, and deposition north of the modern American River ceased until Pleistocene (Riverbank) time.

Deposits from the upper Fair Oaks unit and most of the Arroyo Seco Gravels are missing on the northern fan surface, implying that the northern fan surface was less active or inactive for parts of Pliocene to Pleistocene time. Weak drainage systems may have existed if the American River moved incrementally southward, or the northern fan surface may have been completely abandoned if southward shifting of the American River was more sudden. Isolated Arroyo Seco Gravels are preserved on a few ridges near the present American River (Nimbus Dam and Sailor Bar localities), but these are probably part of a new more southerly fan deposit that formed at mid-to-lower elevations by the redirected, south-flowing river system. Stream migration and terrace deposition continued to the south during this inactive period on the northern fan surface,.

Deposition on the edge of the northern fan surface resumed with emplacement of the Pleistocene Riverbank Formation. Riverbank deposits are found as an apron of sediment that offlap the fan surface and completely surround the fan on the northern, western and southern edges. Once again the mode of emplacement is problematic. Did a fork or forks of the American River escape the southerly capture and resume deposition across the northern fan surface? Was a northern fork of the American River still present but less active until Riverbank time? These questions will be the focus of further research.

In either case, sediment bypassed the elevated northern fan surface, and Riverbank deposits are found as a fringe of material that extends into the subsurface of the Central Valley (DWR, 1974). Pleistocene Riverbank sediments are the youngest sedimentary unit that can be described as fan deposits on the Sacramento fan surface. Erosion, incision and weathering are currently modifying the fan surface, but significant deposition in the form of fan-shaped sheet deposits is lacking.

Lithostratigraphy of the younger (southern) fan surface:

Construction, destruction and preservation are key issues in this discussion of fan morphology. The older (northern) fan surface was constructional, and extended southward at least to the modern Cosumnes River. Remnants of the Mehrten Formation are preserved in the south-facing bluffs that overlook the Cosumnes River Divide, and these surface exposures demonstrate a minimum southward extent of the old constructional fan surface. Subsurface correlation of fan sediments (DWR, 1974) confirms the lateral extent of constructional fan deposits at depth in the Central Valley.

After shifting southward, the ancestral American River system began a destructional phase. The Folsom area acted like a pivot point, and the river has rotated northward (clockwise) around this point since Pleistocene time. Pleistocene interglacial events may have been a factor in altering sediment supply to the system, and there was also a complex interplay between channel length and uplift in the Sierra that affected stream competence (ability to transport clastic material). Whatever the cause, the river began migrating northward (back toward the pivot point), removing the edge of the old fan as the channel shifted and cut deeper. Accumulation during this younger (and overall destructional phase) is limited to shallow, highly weathered stepped terraces of Shelemon's (1967a) Upper Fair Oaks unit, Arroyo Seco and Riverbank. These surfaces were cut and filled during northward migration of the river channel. The net effect was to remove large volumes of fan material from the southern flank of the older fan system.

Shlemon (1967a, 1967b, 1974, 1998) provides a very accurate description of the terraces and channels that formed during this northward migration. A potential source of confusion with these younger deposits is the variety of names that have been used by geologists who mapped the Sacramento area. Equivalent names include "Gravels underlying Arroyo Seco surface" and "upper Fair Oaks" (Shlemon, 1967), "Gravel of uncertain age" (Piper et al., 1939), "fanglomerate" and "Red Bluff Formation" (Olmsted and Davis, 1961), "Arroyo Seco Gravels", "Gravels of uncertain age" and "South Fork Gravels" (Ford, 1972; DWR, 1974) and "Laguna Formation" (CDMG, 1984). All of these names have been used to refer to essentially the same material, although the usage is not always consistent between authors or even within studies.

In general, Late Pliocene to Pleistocene gravels south of the modern American river are composed of pebble to cobble-sized metamorphic and highly weathered igneous clasts in a poorly sorted, clay-rich matrix that contains quartz and feldspar grains and abundant iron cement. Several soils with well-developed B_T horizons formed during periods of low sediment accumulation and intense weathering, and the units are

distinguished mainly on the basis of superposition and relative terrace levels. Each erosional event cut slightly lower into the older and underling fan apron. This resulted in mixing of older fan material with clastic sediment delivered by the younger river system, and produced the stepped terraces and inverted topography described by Shlemon (1967a, 1967b, 1974, 1998).

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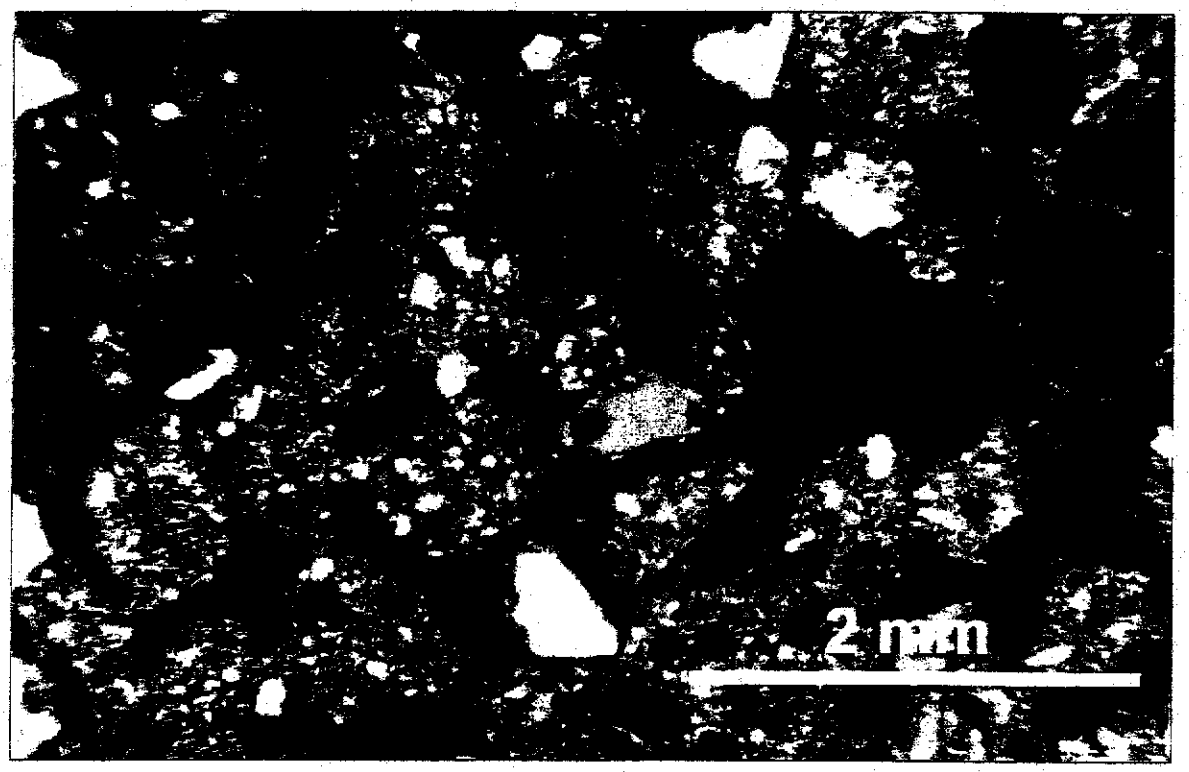

Plate 1: Thin section shows volcanic sand of intermediate composition (andesitic) collected 5 meters below the Old Fair Oaks Bridge. Gray and white grains are orthoclase feldspar. Cross-polarized light.

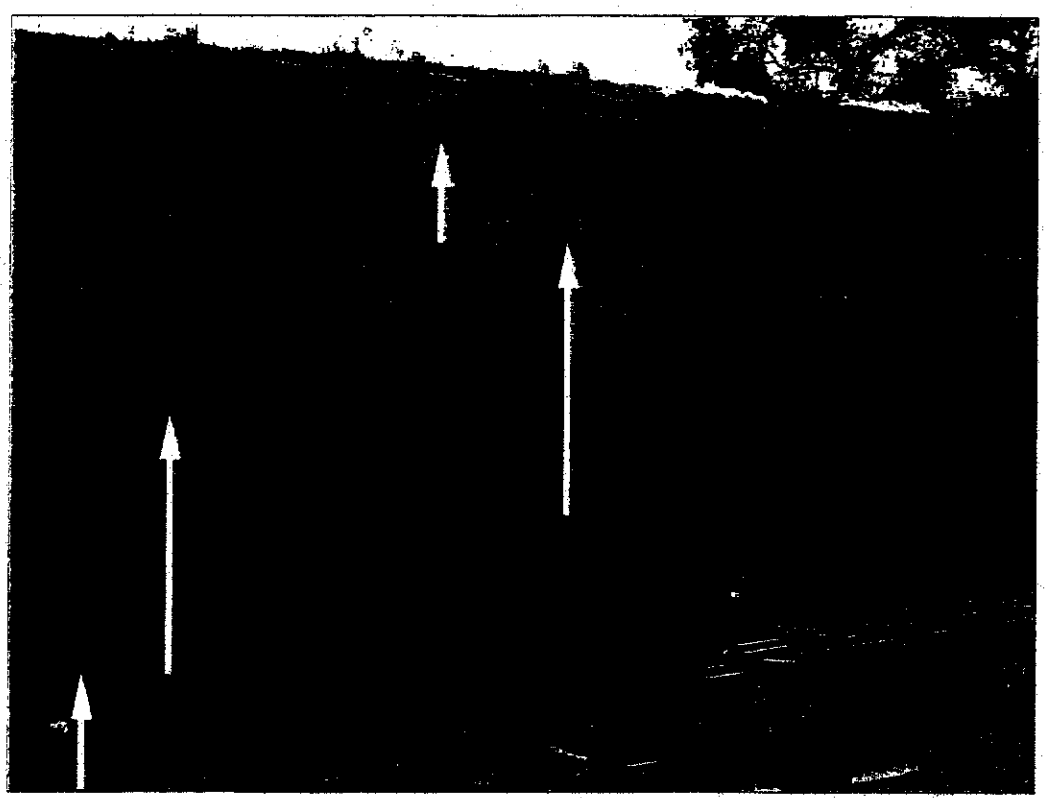

Plate 2: Construction site at Sunrise and Winding Way shows Fair Oaks unit with composite fining upward cycles. Thicker sandy beds have scoured lower bounding surfaces and are trough-crossbedded. Cycles fine upward to rooted, red or blue-gray mottled clay. Soil development probably occurred in a humid environment.

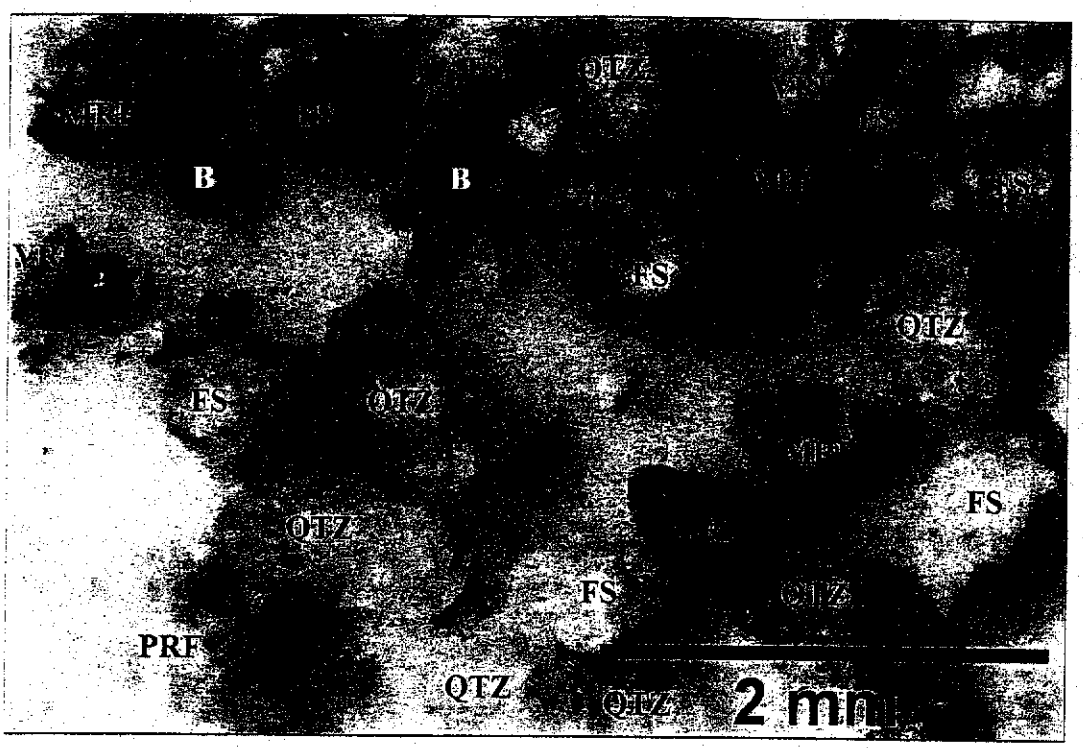

Plate 3: Unconsolidated sand from Fair Oaks unit at Nimbus Dam. QTZ = quartz, FS = feldspar (predominantly orthoclase), B = biotite, VRF = volcanic rock fragment, MRF = metamorphic rock fragment, PRF = plutonic rock fragment. The high proportion of quartz, feldspar and mica suggest a granitic source. with minor mixing from metamorphic and volcanic source areas

Plate 4: Unconsolidated sandy matrix from Arroyo Seco Gravels at Nimbus Dam has a marked similarity to Fair Oaks sand. See Plate 3 for key. The source for matrix from both units was the Rocklin/Penryn pluton. Coarser metamorphic clasts and reddish iron stain are used to distinguish Arroyo Seco Gravels..

PLEISTOCENE CHANNELS OF THE LOWER AMERICAN RIVER, SACRAMENTO COUNTY, CALIFORNIA

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INTRODUCTION

At casual glance, the Sacramento area appears to be geomorphically rather benign. Indeed, prior to urbanization, the only obvious landforms were the approximately 10 foot high natural levees that border the lower Sacramento River, and the almost 50 foot high bluffs that mark the north side of the American River at the town of Fair Oaks. Only a few other minor landforms broke this apparent flat topography; namely, 5 to 10 foot "escarpments" south of the American River where crossed by Jackson Road (Highway 16) between Perkins and the Cosumnes River (Figure 1). These escarpments are significant, however, for they prove to be fluvial terraces, geomorphic expressions of several Pleistocene–age gravel–filled channels of the lower American River that, when traced into the subsurface by water well logs, extend to depths of 60 feet below sea level. Underneath Sacramento, therefore, from the modern American River on the north to almost the town of Franklin some 20 miles to the south (Fig. 1), is a buried topography with up to 75 feet of local relief that marks several epochs of channel cutting and filling and records major Pleistocene changes of climate, hydrology and sedimentation in the adjacent Sierra Nevada mountains.

The ancient American River deposits are mainly basal boulders and cobbles progressively overlain by fining–upward sands and silts which, in turn, are capped by buried paleosols. These deposits have long had economic and engineering geologic significance: (1) the gravels were first exploited for gold, particularly during the late 19th and early 20th centuries when Yuba–type bucket–line dredges plied the modern channel and adjacent terraces from Folsom downstream to Mather Air Force Base; (2) the gravels and overlying sands are still quarried for high–quality aggregate and road metal ; and (3) the gravels are highly permeable and, though once a primarily source for domestic water, are now, unfortunately, excellent pathways for downstream contaminant movement.

QUATERNARY FRAMEWORK

Four major Quaternary formations are recognized in the Sacramento area: the Modesto (youngest), the Riverbank, the Fair Oaks/Turlock Lake/Laguna complex, and the Arroyo Seco and older gravels (Shlemon, 1967, 1972; Helley and Harwood, 1985). Also present near the foothills, and particularly south of the American River, is the Plio– Pleistocene Mehrten formation (Gale and others, 1939), a term now generally applied to any sediments dominantly andesitic in lithology. The Modesto, Riverbank and Turlock Lake formations have been "extrapolated" from type localities in Stanislaus County (Davis and Hall, 1959); the Arroyo Seco, Laguna and Mehrten formations were described in adjacent San Joaquin and Amador counties (Gale and others, 1939); and the Fair Oaks formation was informally designated from bluff exposures on the north side of the American River between Fair Oaks and Folsom (Fig. 1; Shlemon, 1967).

As elsewhere in the Central Valley of California, the Sacramento Quaternary formations are distinguished and dated by geomorphic expression, by relative development of capping soil profiles, by radiocarbon and uranium–series dates, by magneto–stratigraphy and by association with

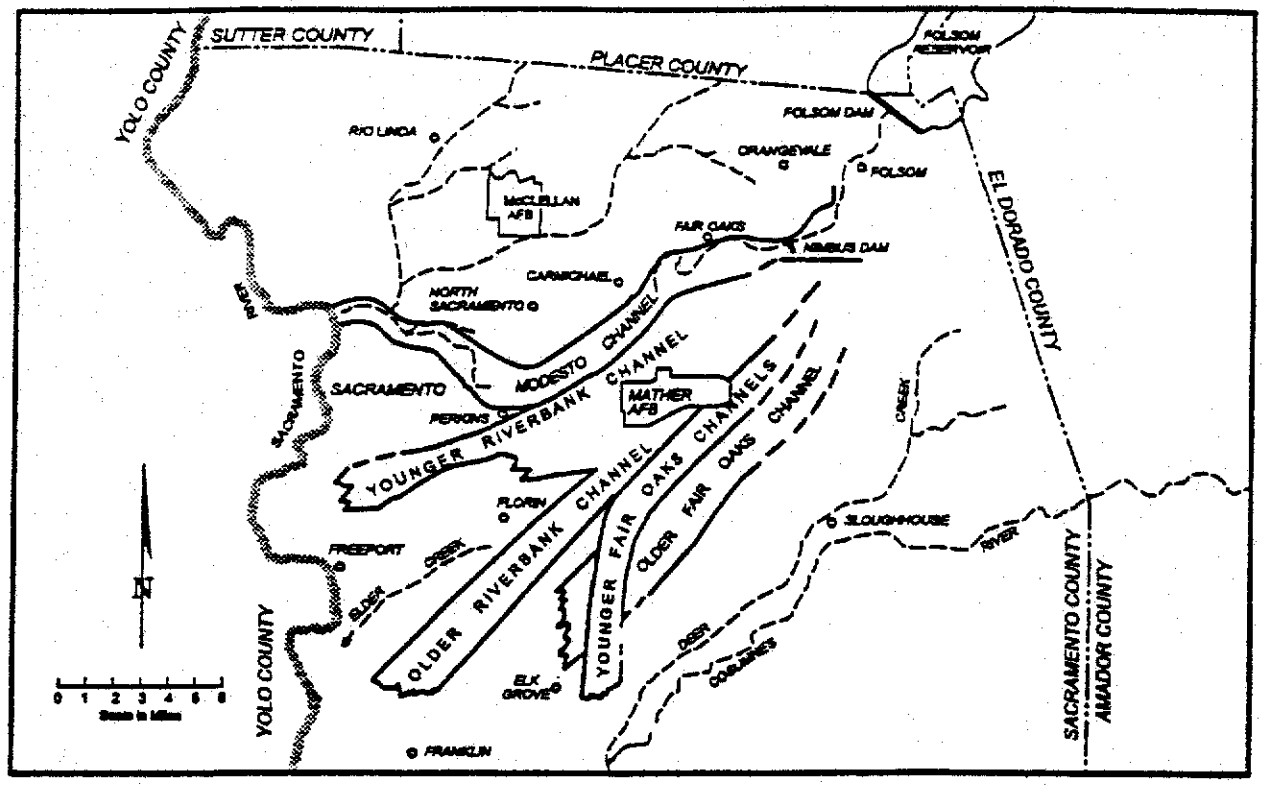

Fig. 1: Pleistocene channels of the lower American River (after Shlemon, 1972).

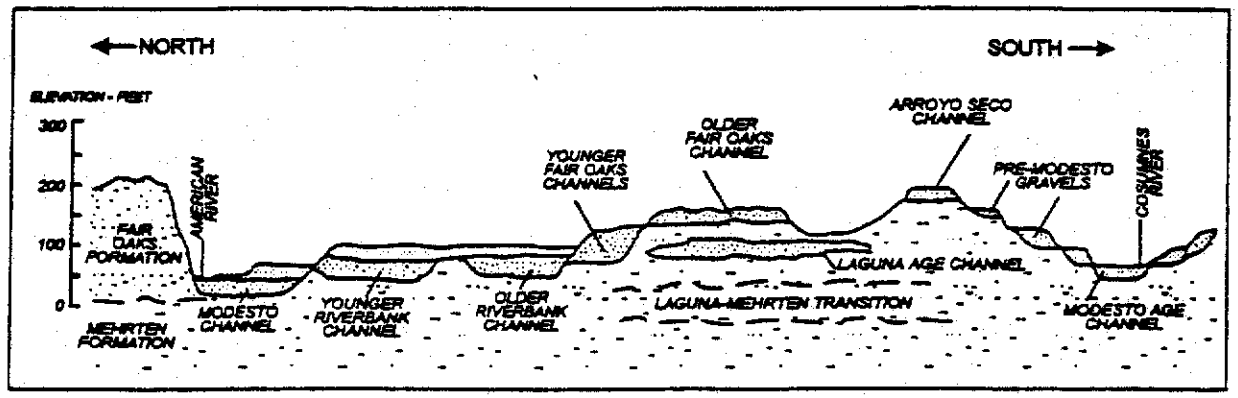

Fig. 2: Generalized composite cross section from the American River near Fair Oaks to the Cosumnes River showing Quaternary formations and the surface and buried channels. Vertical scale exaggerated (after Shlemon, 1972).

Sierra Nevada glacial events and the marine oxygen– isotope stage chronology (Janda and Croft, 1967; Shlemon, 1967, 1972; Hansen and Begg, 1970; Harden and Marchand, 1977; Marchand and Allwardt, 1981; Cherven, 1984; Helley and Harwood, 1985; Busacca and others, 1989). Each Sacramento–area formation is characterized by two or more basal gravel–filled channels. As shown on a schematic cross–section (Fig. 2), the channels have "migrated" northward throughout Pleistocene time from their "apex" near Folsom. The modern American River and underlying gravel of "late Modesto age," are now about 15 miles northwest of "early Fair Oaks" deposits (Figs. 1 and 2). The reason for this progressive northward movement is unknown; but may relate to differential subsidence in this portion of the Sacramento Valley (Shlemon, 1967).

PLEISTOCENE CHANNELS

Modesto–Age Channels

A younger Modesto–age channel underlies the modern American River from Folsom downstream to the Sacramento River confluence (Fig. 1). The basal gravel–filled channel, approximately 3,000 feet wide and up to 30 feet thick, was laid down during the last major Sierra Nevada glaciation (Tioga; isotope stage 2) about 12,000 to 20,000 yrs ago. Terrace remnants of an earlier Modesto channel (Tahoe ?; stage 4) were once apparent south of the American River at Rancho Cordova, but most have since been obliterated by dredging and urbanization.

Riverbank–Age Channels

Two distinct Riverbank–age channels are recognized in the Sacramento area: a younger terrace gravel, now dredged between Folsom and Mather Air Force Base, that is traced to 50 feet from Perkins to below the Sacramento Municipal Airport in South Sacramento; and an older gravel of similar thickness and depth identified in the subsurface almost to the town of Franklin in southwestern Sacramento County (Fig. 1).

The Riverbank–age channels are an estimated 150,000 and 250,000–yrs old respectively (isotope stages 6 and 8), and inferentially correlated to the Donner Lake and older glaciations in the Sierra Nevada. Soils capping Riverbank–age sediments are relict paleosols, and range in relative development from "strong" where preserved on permeable terrace gravels, to "very strong" with distinct argillic and silcrete horizons (Abruptic Durixeralf) where formed on overbank silts. A minimum age for the younger Riverbank deposits is about 100,000 years, as deduced by uranium–series dates (Hansen and Begg, 1970) on vertebrate fossils (camelops, mammuthus, equus) exposed in gravel quarries near Perkins (Fig. 1). Nearby quarry– exposed fossil redwood, sycamore and willow logs yielded expected radiocarbon dates greater than about 35,000 years (Shlemon, 1972).

The Riverbank–age channels have long extensively exploited for gold (Weatherbe, 1907; Winston and Janin, 1910). The last bucket–line dredge ceased operation adjacent to Mather AFB in 1964. The channels today are still economically important sources of high–quality aggregate as obtained from 50 feet deep gravel quarries in the Perkins area (Fig. 1).

Fair Oaks Channels

The informal type locality for the Fair Oaks formation is bluff exposures on the north bank of the American River adjacent to the Sunrise Avenue Bridge (Shlemon, 1967). Exposed here, near the top of the bluffs, are two, reddish–brown, strongly–developed buried paleosols, each capping overbank sands and silts. The paleosols are judged to have formed during interglacial epochs of regional landscape stability (Shlemon, 1967, 1972). Two less–distinct buried paleosols are exposed lower in the section, but can be observed only during times of low water. A magnetic reversal between the two paleosols is interpreted to mark the approximately 790,000–yr old Brunhes–Matuyama boundary. Accordingly, based on stratigraphic position between the younger Riverbank and the older Mehrten deposits, the Fair Oaks formation is probably equivalent in part to the Laguna formation mapped in southern Sacramento County (Gale and others,

1939), and to the Turlock Lake formation in Stanislaus County (Davis and Hall, 1959; Arkley, 1962).

The "glacial" channels of the Fair Oaks formation all lie south of the present American River (Figs. 1 and 2). Two and possibly three channels are present, each expressed geomorphically by low escarpments south of Mather AFB, and by gravels traced in the subsurface to more than 50 feet below land surface southward near Florin (Fig. 1). Most Fair Oaks deposits are sufficiently dissected such that the capping soil profiles are, at best, only moderately developed, forming on the modern micro–relief.

Numeric ages for the Fair Oaks channels and related overbank deposits are presently lacking; however, based primarily on stratigraphic position, on associated paleosols, and on magneto– stratigraphy, the formation probably reflects climatically controlled, periodic deposition and soil formation between about 450,000 and 800,000–yrs ago.

The Arroyo Seco and Older Gravels

The Arroyo Seco gravels were originally defined as broad pediment deposits that covered the Laguna and older formations (Gale and others, 1939). However, more recent investigations show that many Arroyo Seco gravels are remnant fluvial channels preserved on the highest– level drainage divides separating major west–flowing streams debouching from the Sierra Nevada (Arkley, 1962; Shlemon, 1967; Harden and Marchand, 1977; Marchand and Allwardt, 1981; Busacca and others, 1989). In the Sacramento area, the Arroyo Seco gravels are best preserved on the divide between the American and the Cosumnes River (Fig. 2). Soil profiles are typically very strongly developed (Palexeralfs), and locally a duripan (silcrete) is present. The age of the Arroyo Seco is unknown, but from stratigraphic position, it is likely to be at least a million years old.

Remnants of still older gravel channels, presumably deposited by ancestral American or Cosumnes Rivers, underlie the Arroyo Seco gravels. Most have no surface expression and are identified mainly in well logs and in road or canal–cut exposures, particularly apparent during the late 1960's construction of the Folsom South Canal (near the intersection of Jackson Road and Sunrise Avenue; Fig. 2).

SUMMARY

Each of the several Pleistocene channels of the lower American River area was cut during a major glaciation in the Sierra Nevada. Many now–buried channels are traceable eastward almost to the Sacramento River and to depths well below present sea level. The channel depth was also controlled by glacio– eustatic sea level lowering that affected the Sacramento, the Mokelumne, and other rivers that combine to form the Sacramento–San Joaquin Delta (Shlemon, 1971; Shlemon and Begg, 1975). For reasons yet unknown, the lower American River channels "migrated" northward throughout much of Pleistocene time; the present confluence with the Sacramento River was probably established in late Modesto time, about 12,000 to 20,000 years ago.

With periodic, climatically controlled fluctuation in discharge and rising sea level, the gravel– filled channels were eventually filled with overbank deposits and ultimately completely buried by distributary fan sediments. Most covering deposits were then subject to epochs of general landscape stability which permitted formation of strongly developed soil profiles.

Downstream channel reaches and covering soils were eventually incised and buried during the next epoch of regional climatic change as recorded by the distinctive subsurface gravels and buried paleosols. Upstream channel segments are geomorphically preserved as fluvial terrace gravels. The capping soils, particularly on Riverbank–age and older deposits, are generally strongly developed relict paleosols.

The lower American River channels and capping soils thus record at least a million years of changes in Pleistocene climatic, hydrology and sedimentation. In contrast to

the high Sierra Nevada where successive glaciations tend to destroy evidence of earlier advances, the Sacramento area records major depositional epochs (channel gravels) as well as interglacial periods of relative landscape stability (soil formation). And most of this million–yr old stratigraphy is preserved less than 100 feet below the city and suburban streets of Sacramento.

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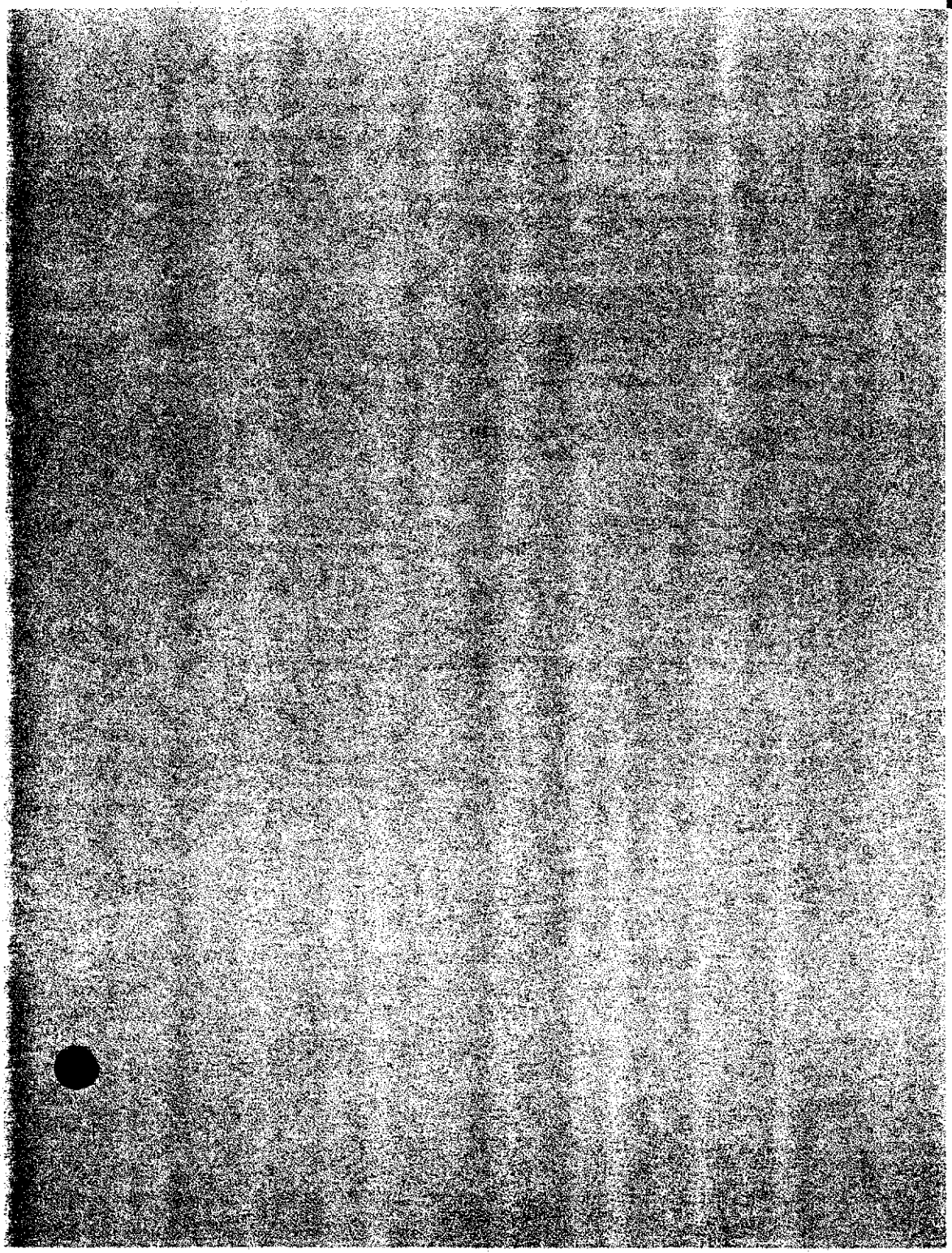
Basic Ground-Water Hydrology



United States Geological Survey Water-Supply Paper 2220

Prepared in cooperation with the North Carolina Department of Natural Resources and Community Development

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BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Robert M. Hirsch, Acting Director

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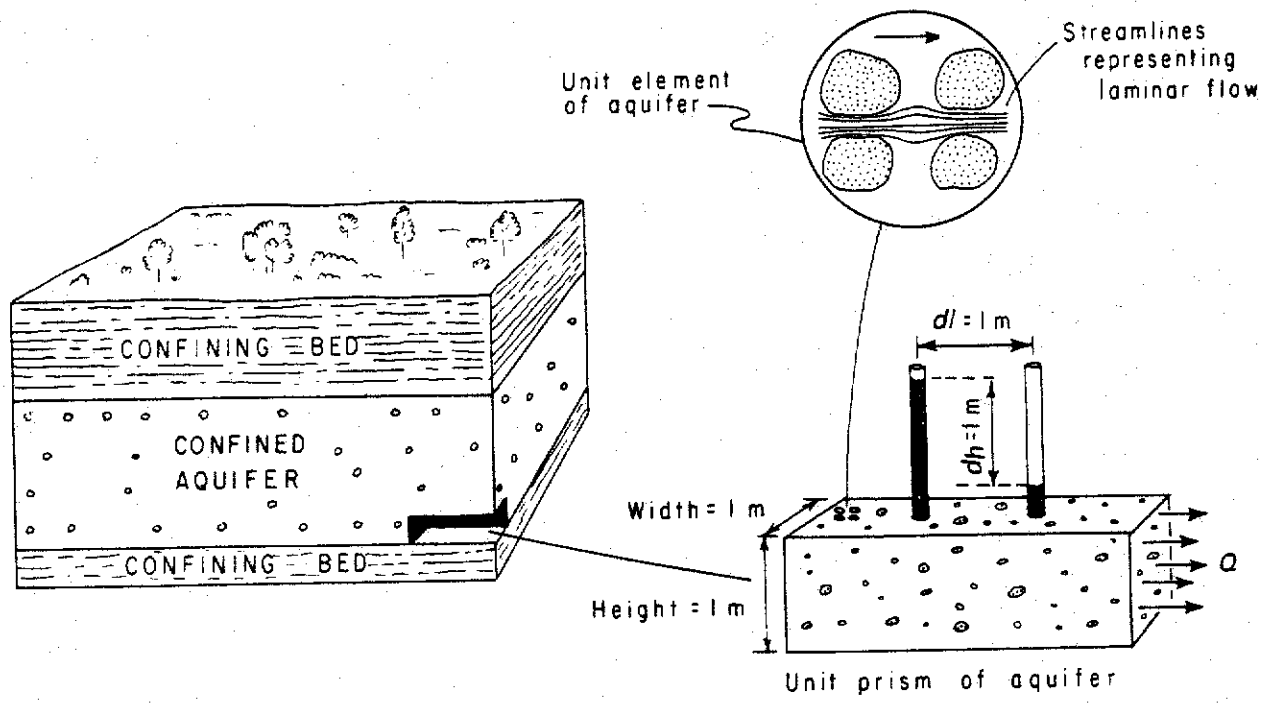
HYDRAULIC CONDUCTIVITY



(1)

Aquifers transmit water from recharge areas to discharge areas and thus function as porous conduits (or pipelines filled with sand or other water-bearing material). The factors controlling ground-water movement were first expressed in the form of an equation by Henry Darcy, a French engineer, in 1856. Darcy's law is

$$Q = KA\left|\frac{dh}{dl}\right| \qquad (1)$$

where Q is the quantity of water per unit of time; K is the hydraulic conductivity and depends on the size and arrangement of the water-transmitting openings (pores and fractures) and on the dynamic characteristics of the fluid (water) such as kinematic viscosity, density, and the strength of the gravitational field; A is the cross-sectional area, at a right angle to the flow direction, through which the flow occurs; and dh/dl is the hydraulic gradient.[1]

Because the quantity of water (Q) is directly proportional to the hydraulic gradient (dh/dl), we say that ground-water flow is *laminar*—that is, water particles tend to follow discrete streamlines and not to mix with particles in adjacent streamlines (1). (See "Ground-Water Flow Nets.")

If we rearrange equation 1 to solve for K, we obtain

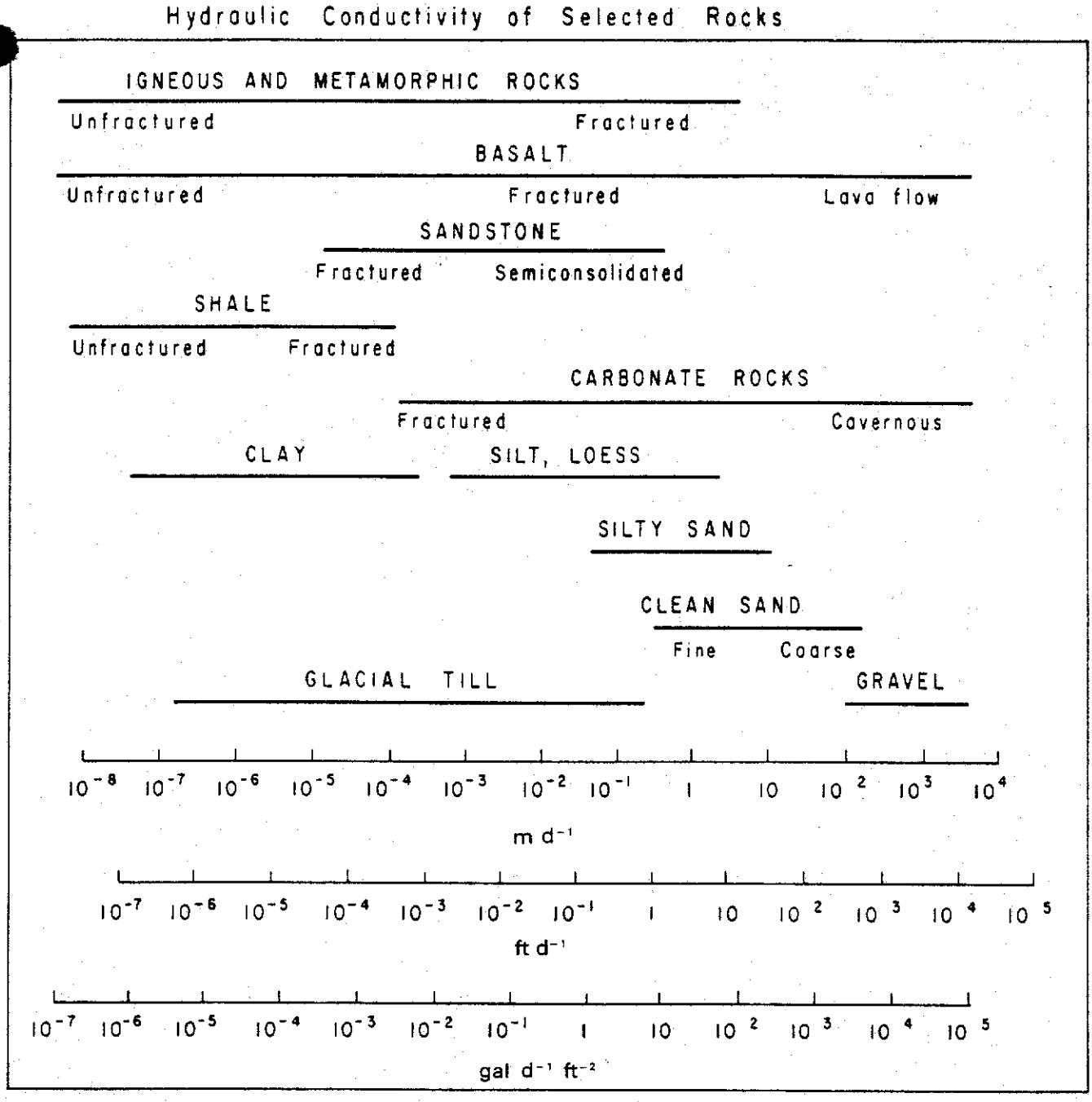
$$K = \frac{Qdl}{Adh} = \frac{(m^3\ d^{-1})(m)}{(m^2)(m)} = \frac{m}{d} \qquad (2)$$

Thus, the units of hydraulic conductivity are those of velocity (or distance divided by time). It is important to note from equation 2, however, that the factors involved in the definition of hydraulic conductivity include the volume of water (Q) that will move in a unit of time (commonly, a day) under a unit hydraulic gradient (such as a meter per meter) through a unit area (such as a square meter). These factors are illustrated in sketch 1. Expressing hydraulic conductivity in terms of a unit gradient, rather than of an actual gradient at some place in an aquifer, permits ready comparison of values of hydraulic conductivity for different rocks.

Hydraulic conductivity replaces the term "field coefficient of permeability" and should be used in referring to the water-transmitting characteristic of material in quantitative terms. It is still common practice to refer in qualitative terms to "permeable" and "impermeable" material.

The hydraulic conductivity of rocks ranges through 12 orders of magnitude (2). There are few physical parameters whose values range so widely. Hydraulic conductivity is not only different in different types of rocks but may also be different from place to place in the same rock. If the hydraulic conductivity is essentially the same in any area, the aquifer in

[1]Where hydraulic gradient is discussed as an independent entity, as it is in "Heads and Gradients," it is shown symbolically as h_L/L and is referred to as head loss per unit of distance. Where hydraulic gradient appears as one of the factors in an equation, as it does in equation 1, it is shown symbolically as dh/dl to be consistent with other ground-water literature. The gradient dh/dl indicates that the unit distance is reduced to as small a value as one can imagine, in accordance with the concepts of differential calculus.



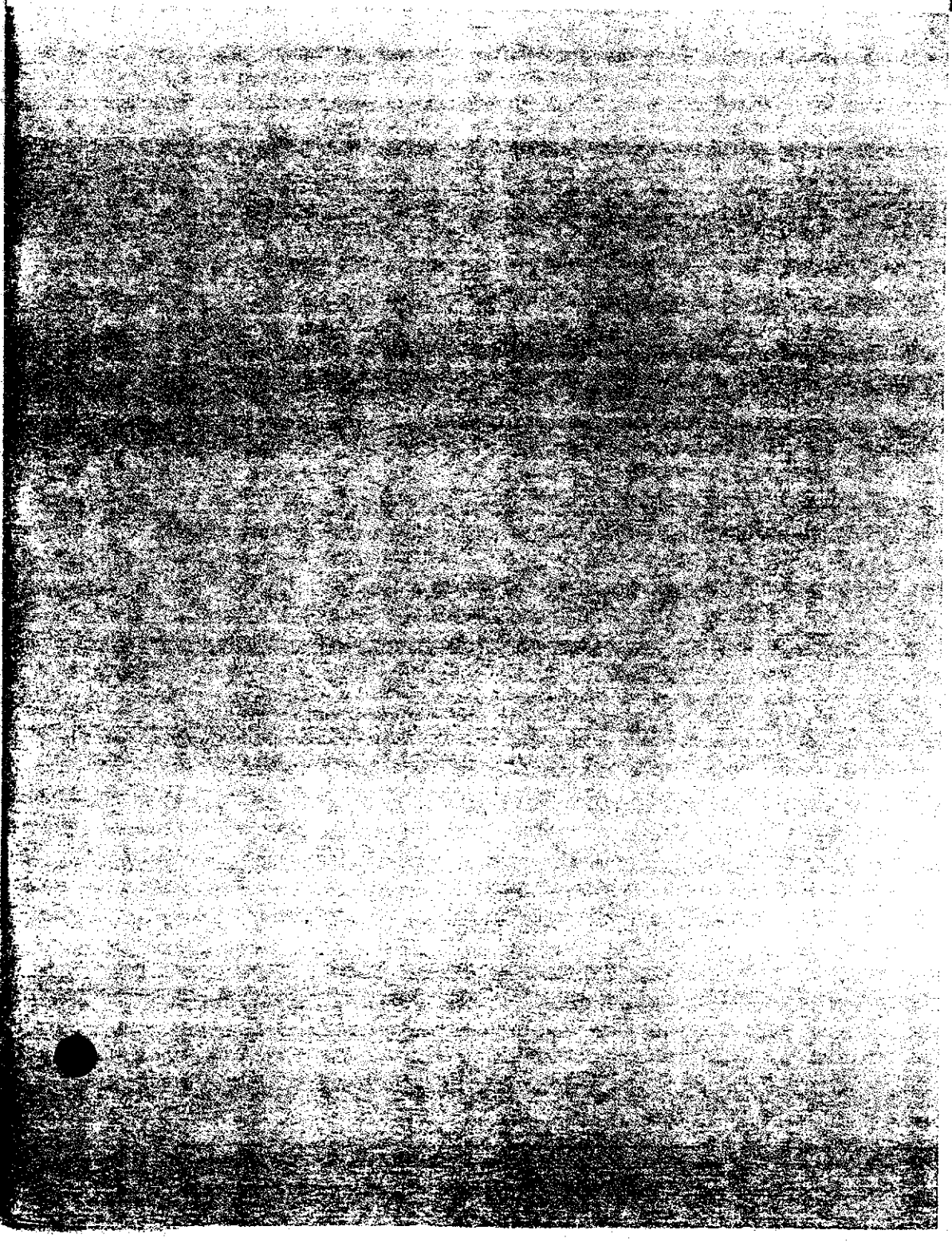
(2)

that area is said to be *homogeneous*. If, on the other hand, the hydraulic conductivity differs from one part of the area to another, the aquifer is said to be *heterogeneous*.

Hydraulic conductivity may also be different in different directions at any place in an aquifer. If the hydraulic conductivity is essentially the same in all directions, the aquifer is said to be *isotropic*. If it is different in different directions, the aquifer is said to be *anisotropic*.

Although it is convenient in many mathematical analyses of ground-water flow to assume that aquifers are both homogeneous and isotropic, such aquifers are rare, if they exist at all. The condition most commonly encountered is for hydraulic conductivity in most rocks and especially in unconsolidated deposits and in flat-lying consolidated sedimentary rocks to be larger in the horizontal direction than it is in the vertical direction.

Basic Ground-Water Hydrology



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Prepared in cooperation with the North Carolina Department of Natural Resources and Community Development

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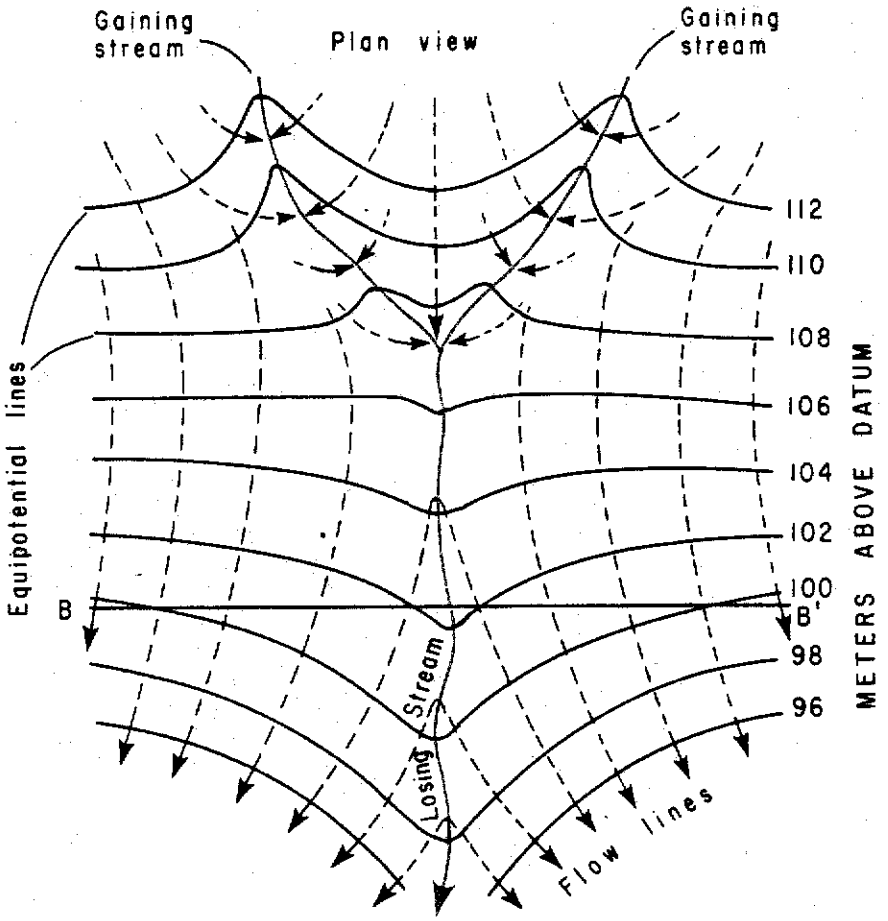
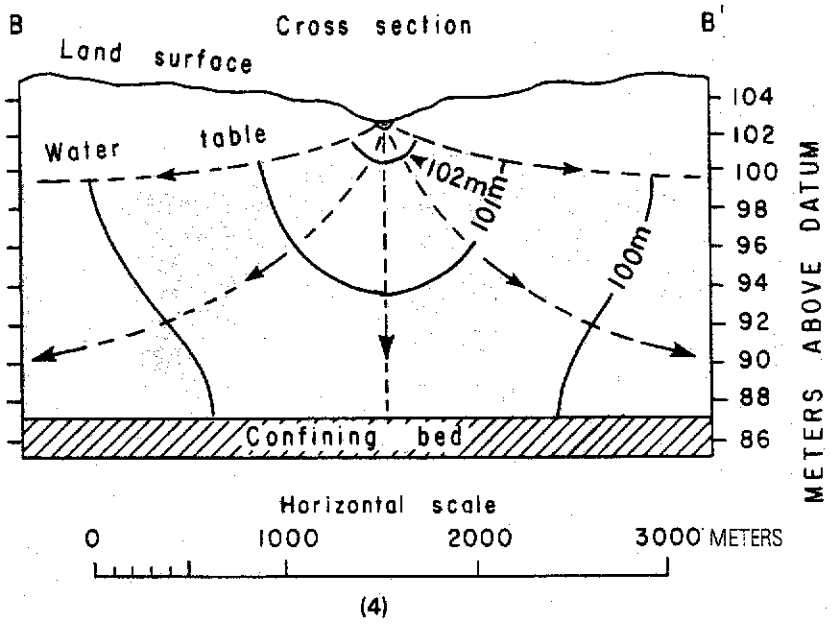

Gaining stream
Plan view
Gaining stream
Equipotential lines
112
110
108
106
104
102
100
98
96
METERS ABOVE DATUM
B
B'
Losing Stream
Flow lines

(3)


B
Cross section
B'
Land surface
Water table
102m
101m
100m
Confining bed
104
102
100
98
96
94
92
90
88
86
METERS ABOVE DATUM
Horizontal scale
0
1000
2000
3000 METERS

(4)

AQUIFER BOUNDARIES

One of the assumptions inherent in the Theis equation (and in most other fundamental ground-water flow equations) is that the aquifer to which it is being applied is infinite in extent. Obviously, no such aquifer exists on Earth. However, many aquifers are areally extensive, and, because pumping will not affect recharge or discharge significantly for many years, most water pumped is from ground-water storage; as a consequence, water levels must decline for many years. An excellent example of such an aquifer is that underlying the High Plains from Texas to South Dakota.

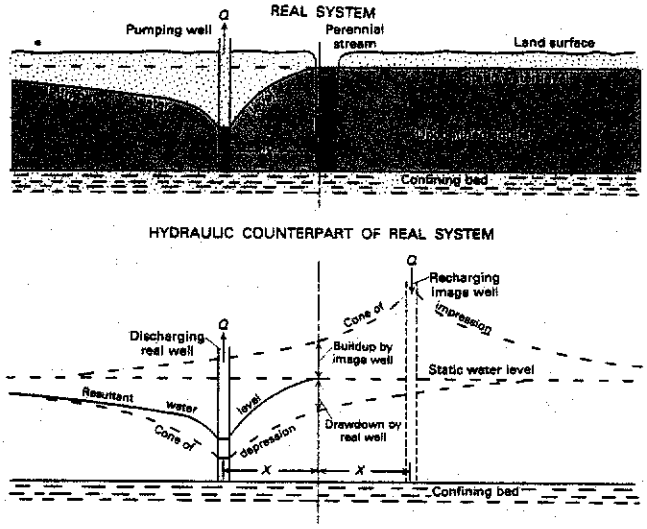
All aquifers are bounded in both the vertical direction and the horizontal direction. For example, vertical boundaries may include the water table, the plane of contact between each aquifer and each confining bed, and the plane marking the lower limit of the zone of interconnected openings—in other words, the base of the ground-water system.

Hydraulically, aquifer boundaries are of two types: recharge boundaries and impermeable boundaries. A *recharge boundary* is a boundary along which flow lines originate. In other words, such a boundary will, under certain hydraulic conditions, serve as a source of recharge to the aquifer. Examples of recharge boundaries include the zones of contact between an aquifer and a perennial stream that completely penetrates the aquifer or the ocean.

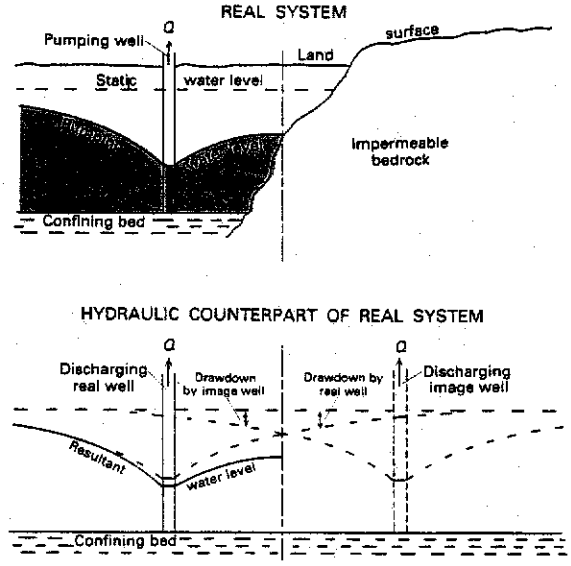
An *impermeable boundary* is a boundary that flow lines do not cross. Such boundaries exist where aquifers terminate against "impermeable" material. Examples include the contact between an aquifer composed of sand and a laterally adjacent bed composed of clay.

The position and nature of aquifer boundaries are of critical importance in many ground-water problems, including the movement and fate of pollutants and the response of aquifers to withdrawals. Depending on the direction of the hydraulic gradient, a stream, for example, may be either the source or the destination of a pollutant.

Lateral boundaries within the cone of depression have a profound effect on the response of an aquifer to withdrawals. To analyze, or to predict, the effect of a lateral boundary, it is necessary to "make" the aquifer appear to be of infinite extent. This feat is accomplished through the use of imaginary



(1)



(2)

wells and the *theory of images*. Sketches 1 and 2 show, in both plan view and profile, how image wells are used to compensate, hydraulically, for the effects of both recharging and impermeable boundaries. (See "Well Interference.")

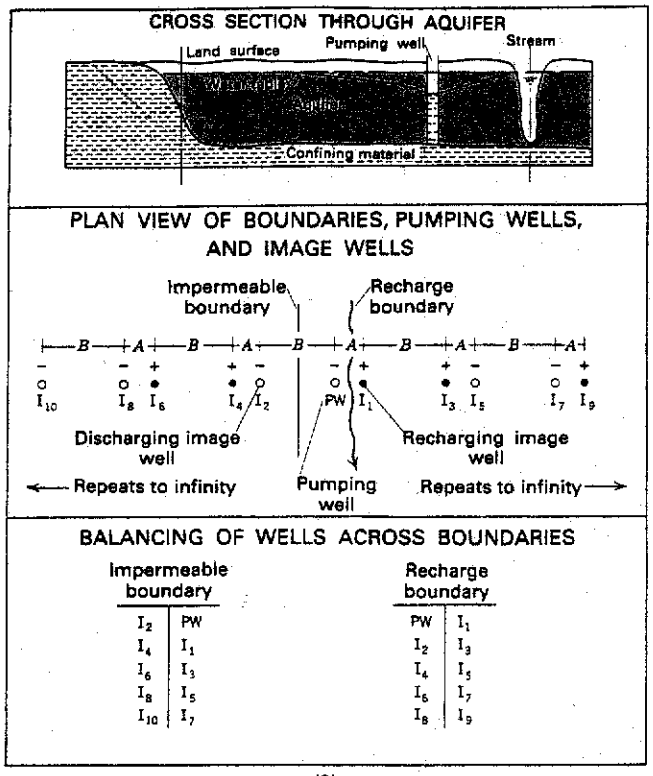
The key feature of a recharge boundary is that withdrawals from the aquifer do not produce drawdowns across the boundary. A perennial stream in intimate contact with an aquifer represents a recharge boundary because pumping from the aquifer will induce recharge from the stream. The hydraulic effect of a recharge boundary can be duplicated by assuming that a recharging image well is present on the side of the boundary opposite the real discharging well. Water is injected into the image well at the same rate and on the same schedule that water is withdrawn from the real well. In the plan view in sketch 1, flow lines originate at the boundary, and equipotential lines parallel the boundary at the closest point to the pumping (real) well.

The key feature of an impermeable boundary is that no water can cross it. Such a boundary, sometimes termed a "no-flow boundary," resembles a divide in the water table or the potentiometric surface of a confined aquifer. The effect of an impermeable boundary can be duplicated by assuming that a discharging image well is present on the side of the boundary opposite the real discharging well. The image well withdraws water at the same rate and on the same schedule as the real well. Flow lines tend to be parallel to an impermeable boundary, and equipotential lines intersect it at a right angle.

The image-well theory is an essential tool in the design of well fields near aquifer boundaries. Thus, on the basis of minimizing the lowering of water levels, the following conditions apply:

1. Pumping wells should be located parallel to and as close as possible to recharging boundaries.
2. Pumping wells should be located perpendicular to and as far as possible from impermeable boundaries.

Sketches 1 and 2 illustrate the effect of single boundaries and show how their hydraulic effect is compensated for through the use of single image wells. It is assumed in these sketches that other boundaries are so remote that they have a negligible effect on the areas depicted. At many places, however, pumping wells are affected by two or more boundaries. One example is an alluvial aquifer composed of sand and gravel bordered on one side by a perennial stream (a recharge boundary) and on the other by impermeable bedrock (an impermeable boundary).



(3)

Contrary to first impression, these boundary conditions cannot be satisfied with only a recharging image well and a discharging image well. Additional image wells are required, as sketch 3 shows, to compensate for the effect of the image wells on the opposite boundaries. Because each new image well added to the array affects the opposite boundary, it is necessary to continue adding image wells until their distances from the boundaries are so great that their effect becomes negligible.

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storm hydrograph for a drainage basin of 2100 mi^2 has been separated. For the given basin, D is equal to 4.6 d.

3.2.3 Gaining and Losing Streams

The typical stream of a humid region receives ground-water discharge; therefore, as one goes downstream the baseflow increases, even if no tributaries enter. This is a **gaining,** or **effluent,** stream. The water table slopes toward the stream, so that the hydraulic gradient of the aquifer is toward the stream. Figure 3.10A shows a cross section through a gaining reach of a stream.

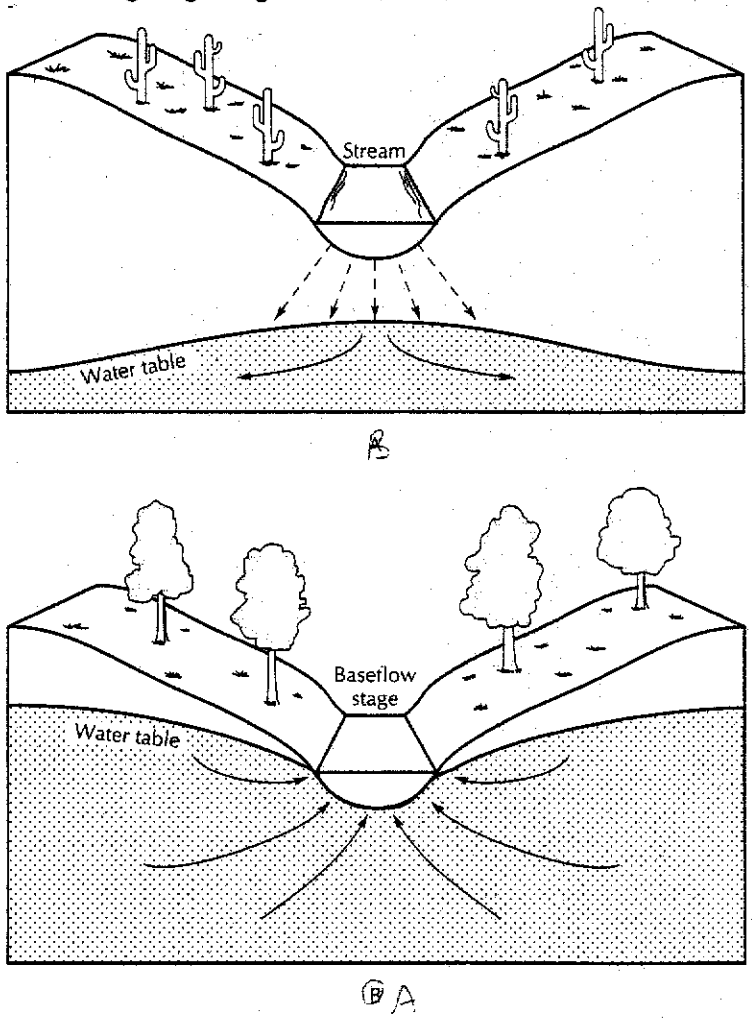


FIGURE 3.10 (A) Cross section of a gaining stream, which is typical of humid regions, where ground water recharges streams. (B) Cross section of a losing stream, which is typical of arid regions, where streams can recharge ground water.

In arid regions, many rivers are fed by overland flow, interflow, and baseflow at high altitudes. As they wind their way to a lower elevation, the local precipitation amounts decrease; consequently, there is less infiltration and a lower water table. There may also be a dramatic change in the depth to ground water when a stream draining a high-altitude basin of lower-permeability material flows out onto coarse alluvial materials. For whatever reason, if the bottom of the stream channel is higher than the local water table, water may drain from the stream into the ground (Figure 3.10B). As one goes downstream, less and less water will be found in the channel. The stream is **losing,** or *influent*. The rate of water loss is a function of the depth of water and the hydraulic conductivity of the underlying alluvium. Fine-grained deposits on the channel bottom will retard the rate of loss to the ground water.

A stream that is normally a gaining stream during baseflow recessions may temporarily become a losing stream during floods. If the flood-crest depth in the channel is greater than the local water-table elevation, the hydraulic gradient in the aquifer next to the stream is reversed. Water flows from the stream into the ground (Figure 3.11). The result is a temporary storage of flood water in the aquifer next to the stream. When the flood crest passes, the hydraulic gradient again reverses, and the stream is once again gaining (Figure 3.12).

Tabidian, Pederson, and Tabidian (1992) studied the impact on ground-water levels of a 75- to 100-y flood event of the Big Blue River in Nebraska. The river is connected to an aquifer consisting of alluvium and glacial deposits, which vary from gravel to clay in nature. The river is normally gaining, but during the flood the gradient became reversed and water drained from the river into the aquifer. In some areas ground-water levels rose more than 10 ft in less than a week, and rises in ground-water level were recorded as much as 2 mi from the river. Due to the heterogeneous nature of the aquifer, water-level rises were not uniform along the river, nor were they symmetrical across the river.

Heavy ground-water pumping near a stream can lower the water table to an elevation below the level of the stream bottom. The reach of the stream affected by the lowered water table will become a losing stream, while upstream

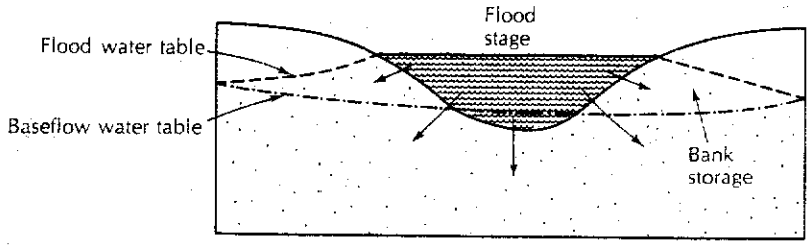


FIGURE 3.11 A stream that is gaining during low-flow periods can temporarily become a losing stream during flood stage.

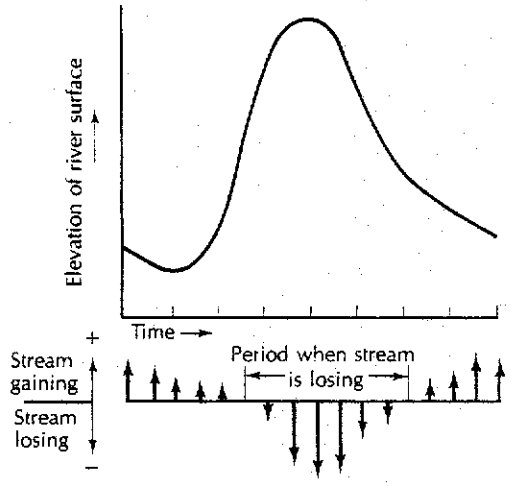


FIGURE 3.12 Effect of flood state on the ground-water regime adjacent to the river. As t flood peak passes, the normal direction of ground-water flow into the stream is reversed.

and downstream reaches can still be gaining. Figure 3.13 is an idealization of th phenomenon, based on the behavior of the well field along the Fenton River of th University of Connecticut at Storrs.

Conjunctive use of ground and surface water is discussed in Secti 12.10. Legal issues have arisen when ground-water pumping has depleted strear

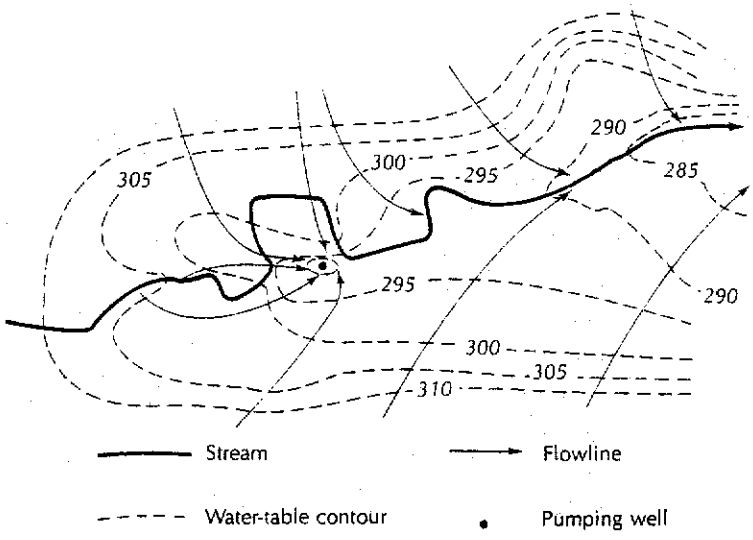
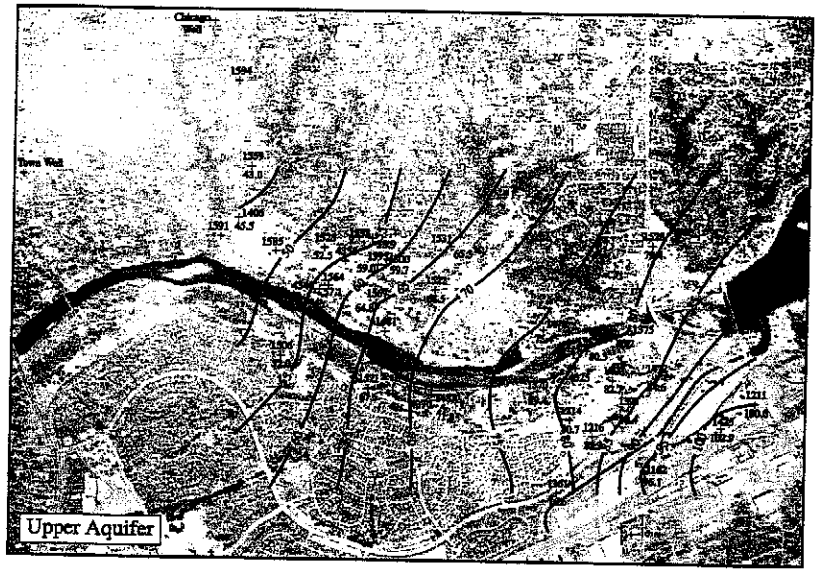
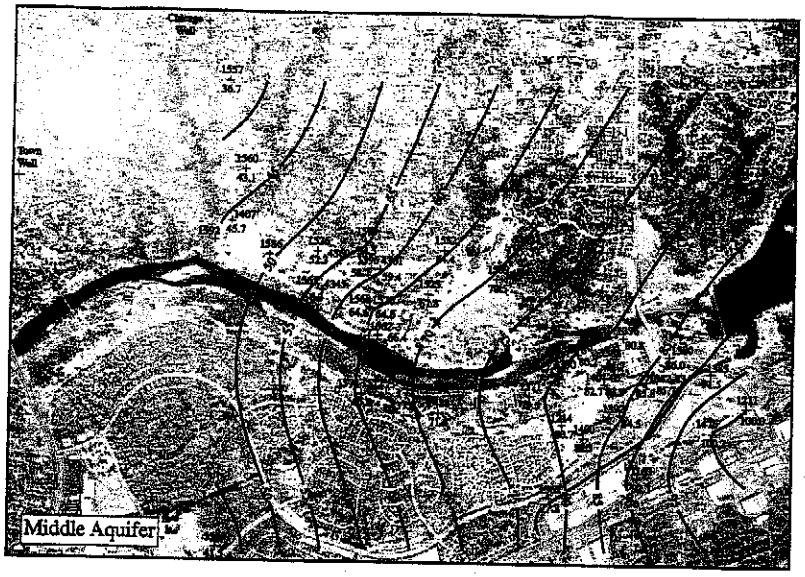
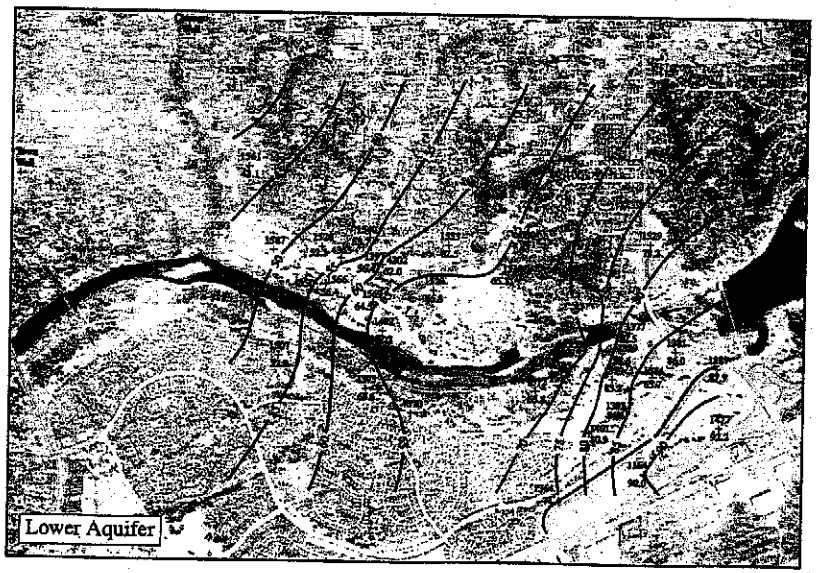
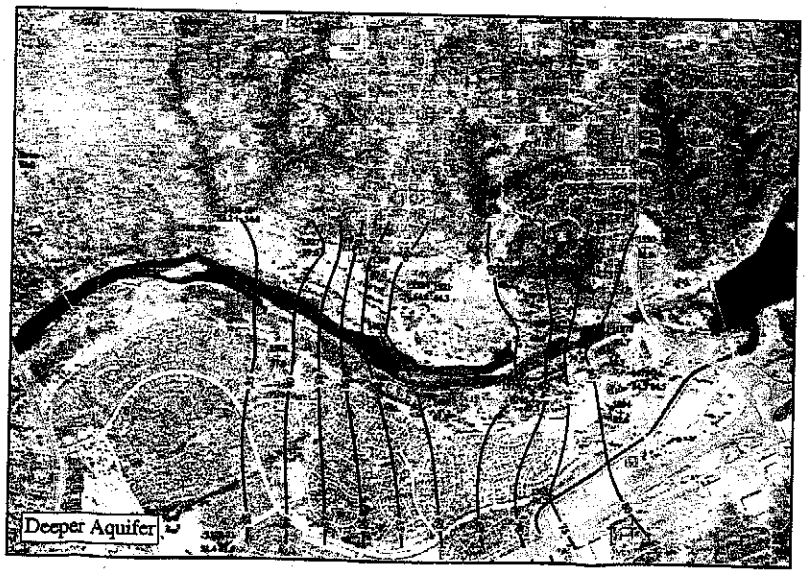


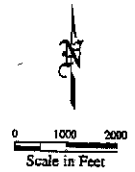
FIGURE 3.13 Induced stream-bed infiltration caused by a pumping well. Source: P. Rahn, *Ground Water* 6, no. 3 (1968):21–32.











GENCORP
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American River Study Area

Figure 2-8
Groundwater Elevation
Contour Maps (feet, MSL)
April 1995

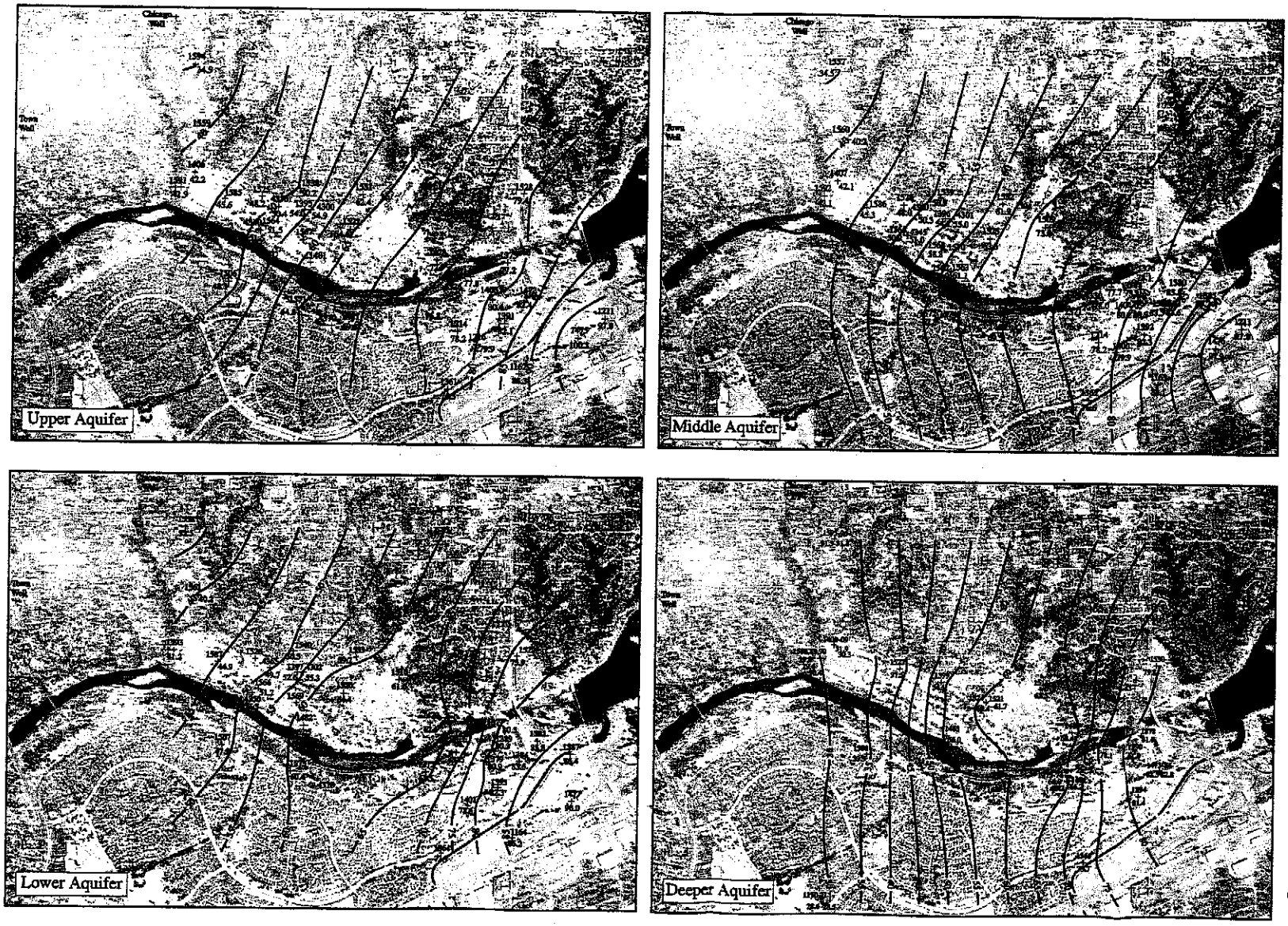

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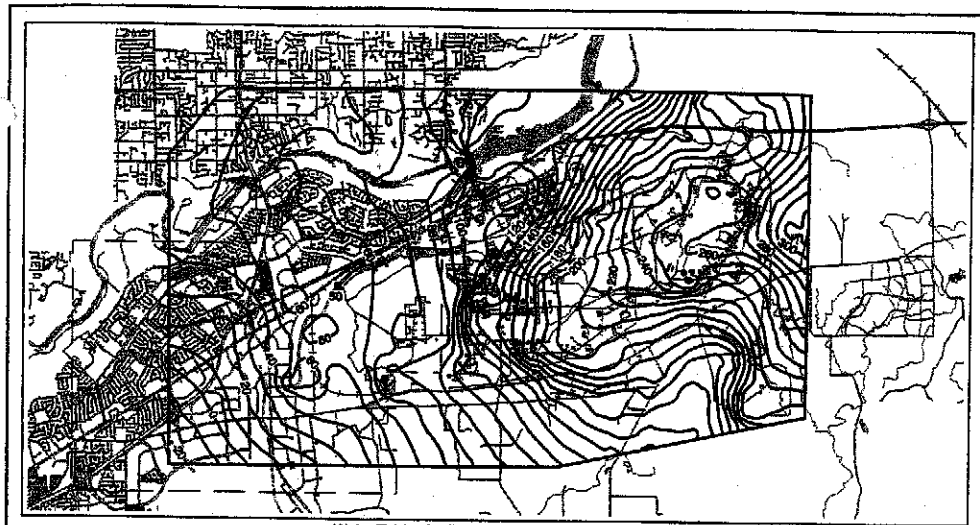
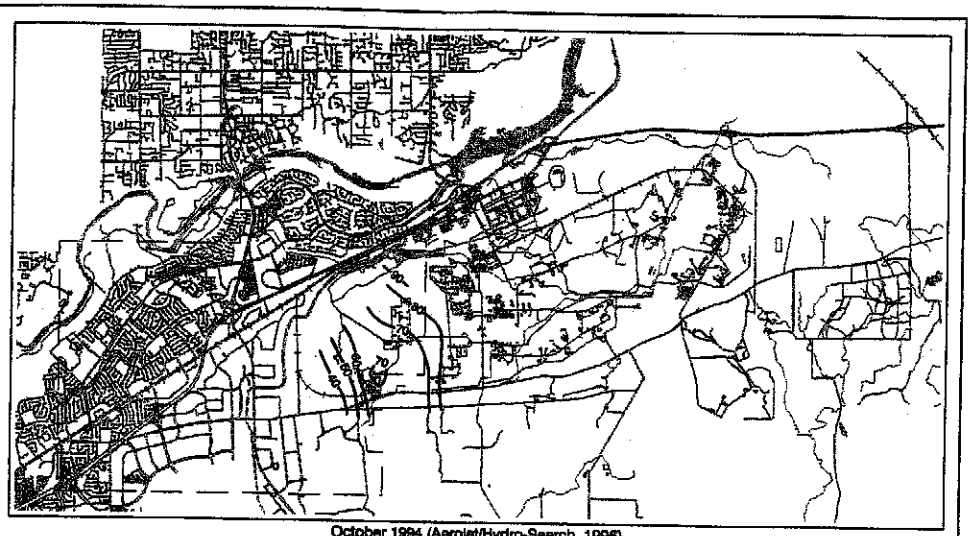
Figure 2-9
Groundwater Elevation
Contour Maps (feet, MSL)
October 1995



Water Table, April 1991 (ICF Technology, 1992)



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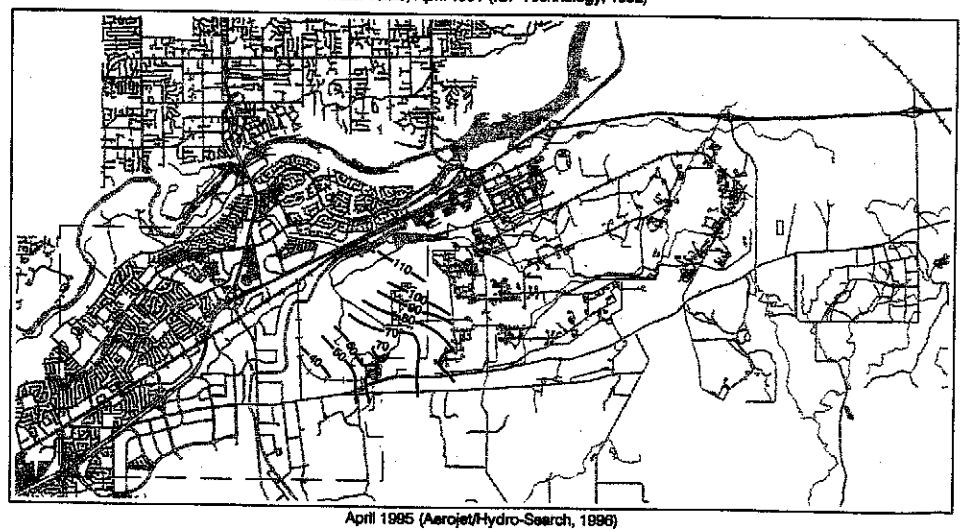

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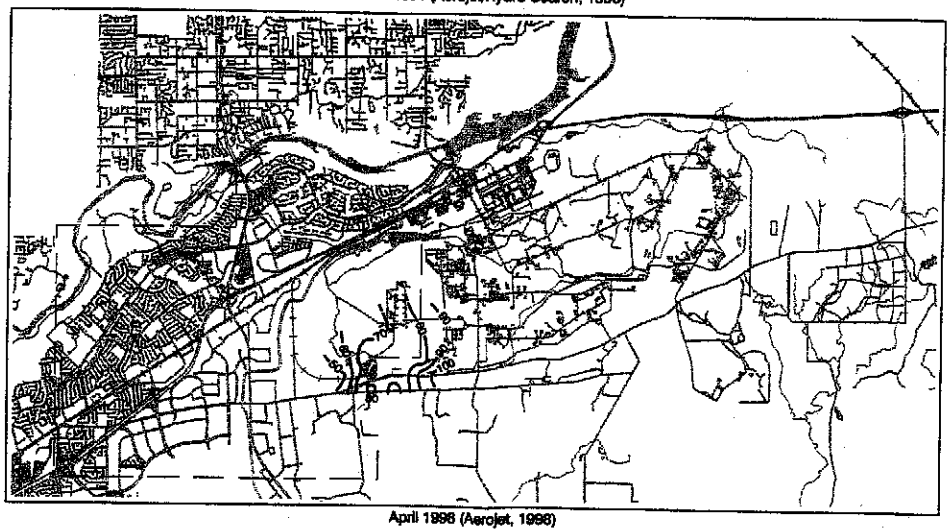

April 1998 (Aerojet, 1998)

EXPLANATION

Study Area Boundary

60 Ground Water Surface Elevation (feet MSL)

N

Scale: 1" = 8000'

0 4000 8000

AEROJET
Environmental Remediation

FIGURE A-7

Western Groundwater Study Area
Layer A
Contour Maps of Potentiometric Surface

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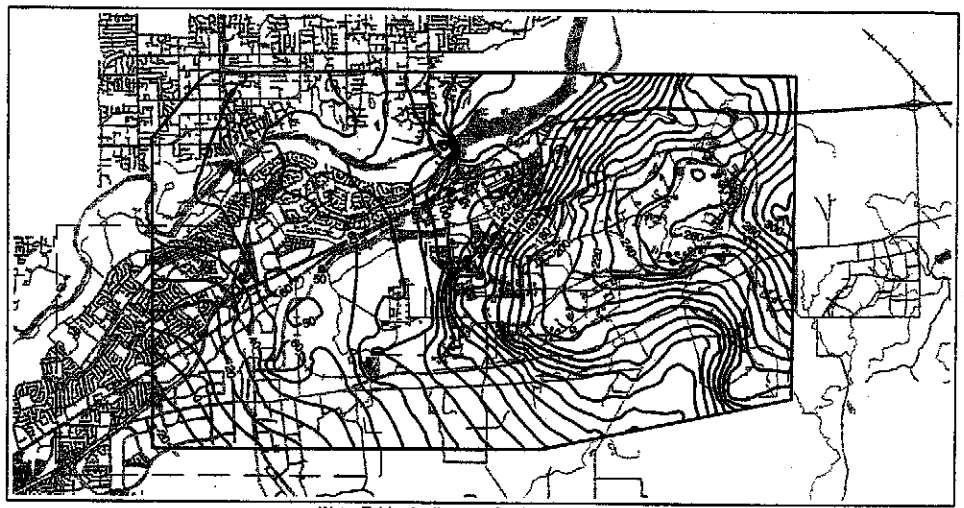

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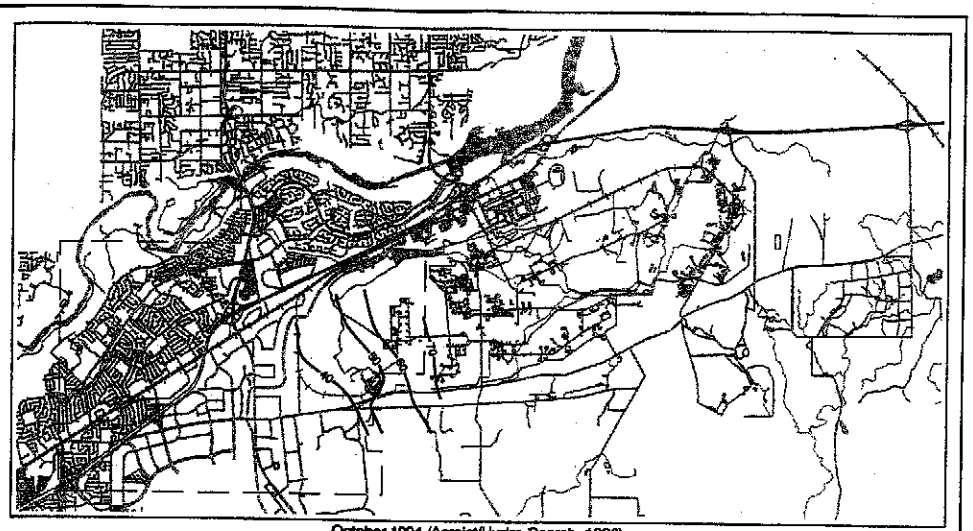

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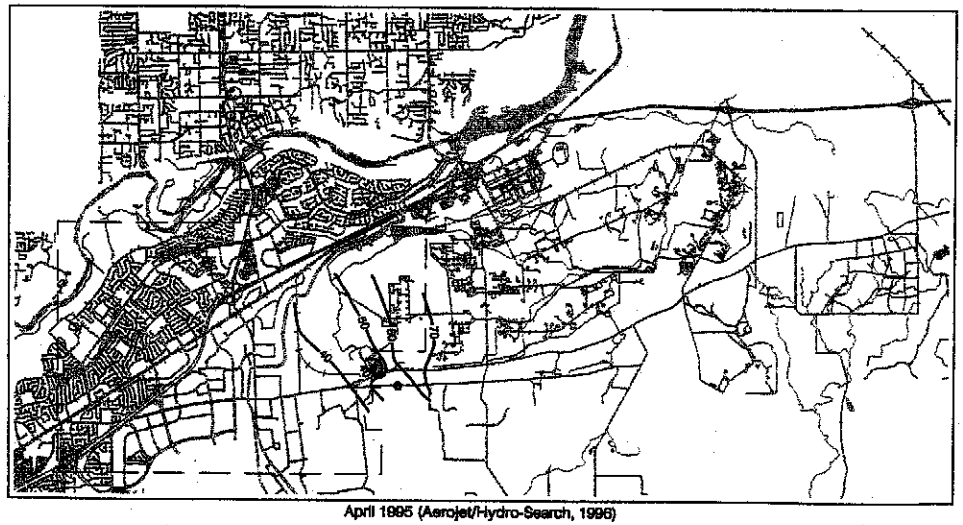

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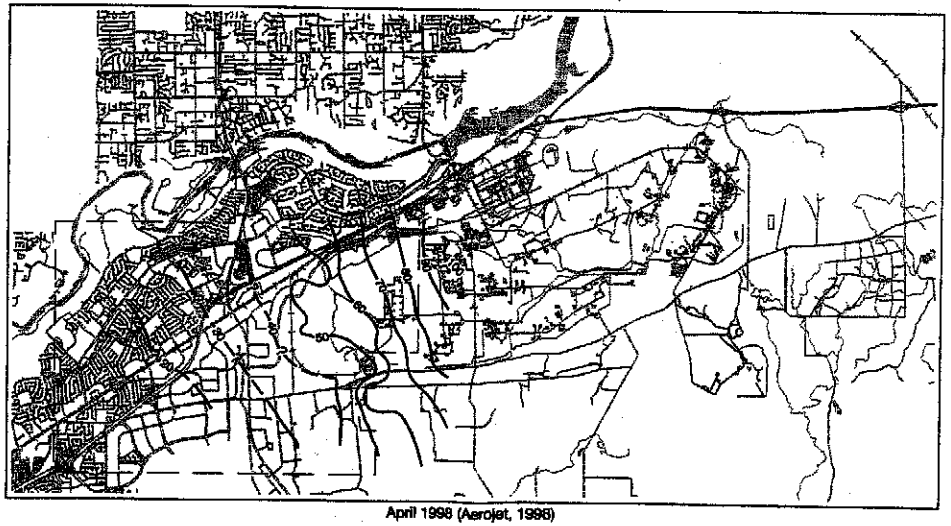

April 1998 (Aerojet, 1998)

EXPLANATION

Study Area Boundary

80 Ground Water Surface Elevation (feet MSL)

N

Scale: 1" = 8000'

0 4000 8000

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Environmental Remediation

FIGURE A-8

Western Groundwater Study Area
Layer B
Contour Maps of Potentiometric Surface

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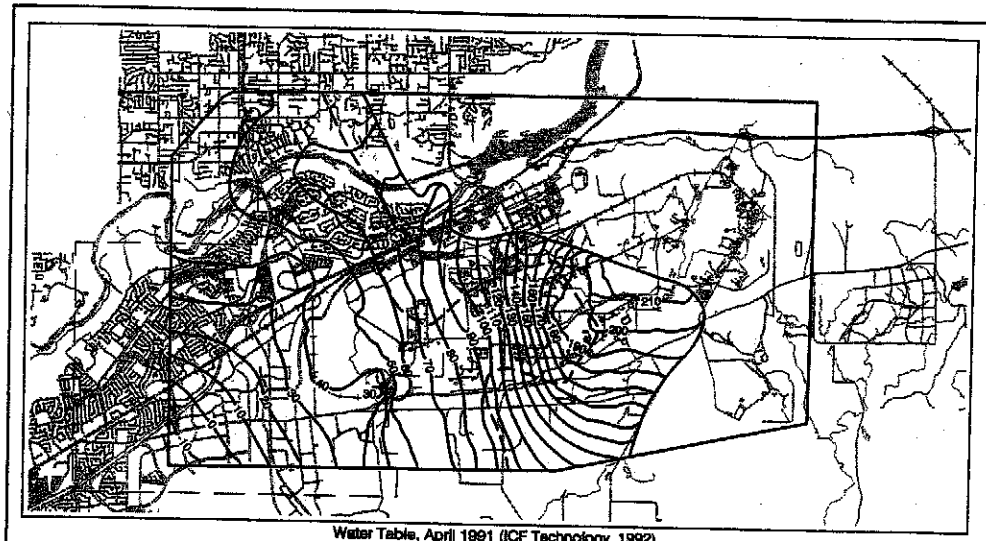
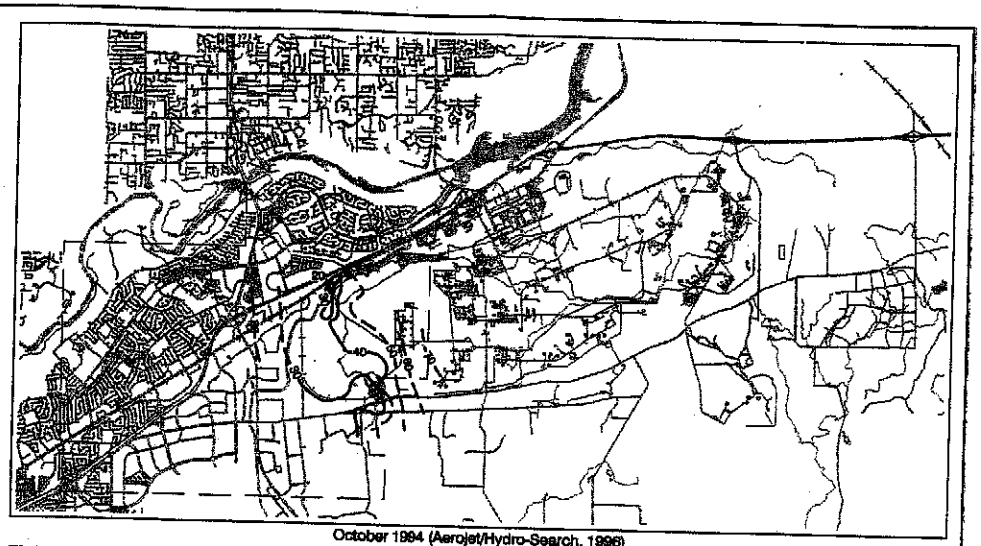


Water Table, April 1991 (ICF Technology, 1992)



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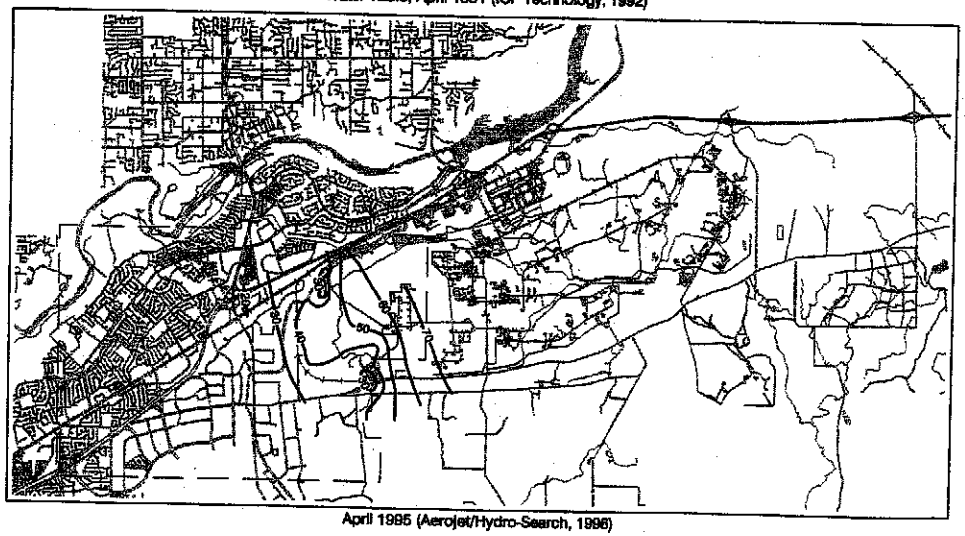

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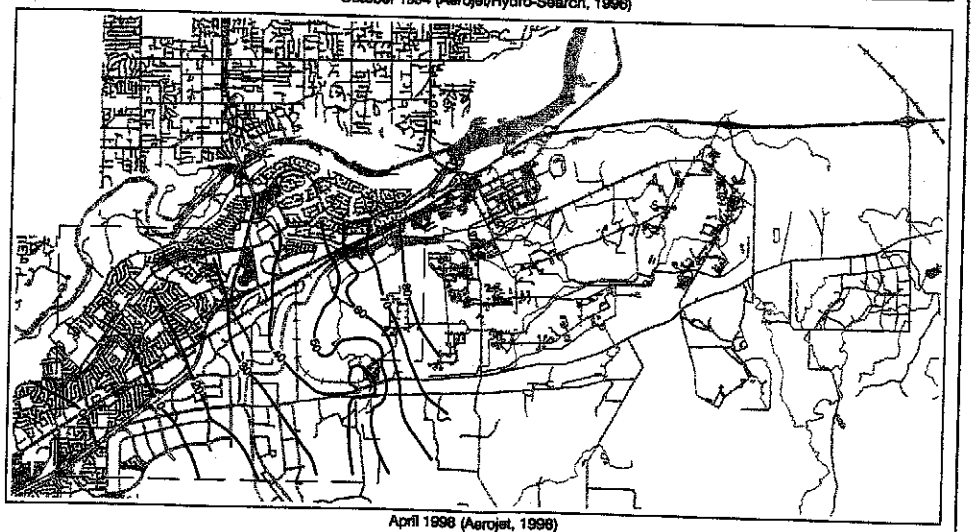


April 1998 (Aerojet, 1998)

EXPLANATION

Study Area Boundary

Ground Water Surface Elevation (feet MSL)

N

Scale: 1" = 8000'

0 4000 8000

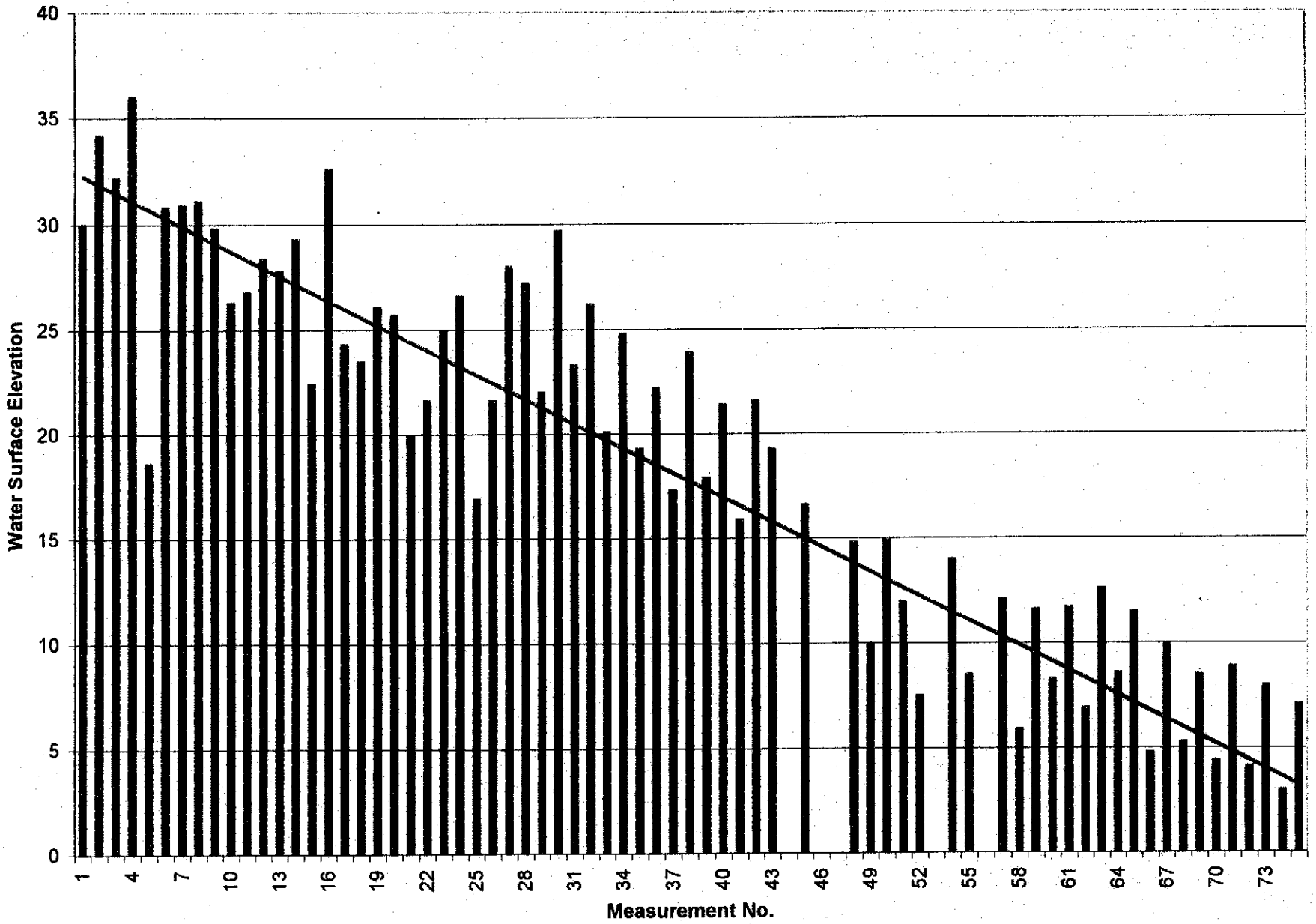
AEROJET
Environmental Remediation

FIGURE A-9

Western Groundwater Study Area
Layer C
Contour Maps of Potentiometric Surface

4/14/00 ch SR10109429

Ground-Water Elevation Data 1942 to 1977; 08N06E08F001M



State Well	Meas.Date	R.P.Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency	Measurement No.	WSE		Departure	Cumulative Departure
08N06E08I	8/5/42	57.8	57.8	27.8	30	27.8			5001	0	0			
08N06E08I	9/9/42	57.8	57.8	23.6	34.2	23.6			5001	1	30		4.46	4.46
08N06E08I	12/17/42	57.8	57.8	25.6	32.2	25.6			5001	2	34.2		8.66	13.12
08N06E08I	4/14/43	57.8	57.8	21.8	36	21.8			5001	3	32.2		6.66	19.78
08N06E08I	7/29/43	57.8	57.8	39.2	18.6	39.2			5001	4	36		10.46	30.24
08N06E08I	2/12/46	57.8	57.8	27	30.8	27			5001	5	18.6		-6.94	23.30
08N06E08I	3/8/46	57.8	57.8	26.9	30.9	26.9			5001	6	30.8		5.26	28.56
08N06E08I	4/11/46	57.8	57.8	26.7	31.1	26.7			5001	7	30.9		5.36	33.92
08N06E08I	7/18/46	57.8	57.8	28	29.8	28			5001	8	31.1		5.56	39.48
08N06E08I	10/3/46	57.8	57.8	31.5	26.3	31.5			5001	9	29.8		4.26	43.74
08N06E08I	1/6/47	57.8	57.8	31	26.8	31			5001	10	26.3		0.76	44.50
08N06E08I	1/8/47	57.8	57.8	29.4	28.4	29.4			5001	11	26.8		1.26	45.76
08N06E08I	4/1/47	57.8	57.8	30	27.8	30			5001	12	28.4		2.86	48.62
08N06E08I	4/4/47	57.8	57.8	28.5	29.3	28.5			5001	13	27.8		2.26	50.88
08N06E08I	7/6/47	57.8	57.8	35.4	22.4	35.4			5001	14	29.3		3.76	54.64
08N06E08I	7/11/47	57.8	57.8	25.2	32.6	25.2			5001	15	22.4		-3.14	51.50
08N06E08I	10/2/47	57.8	57.8	33.5	24.3	33.5			5001	16	32.6		7.06	58.56
08N06E08I	10/5/47	57.8	57.8	34.3	23.5	34.3			5001	17	24.3		-1.24	57.32
08N06E08I	1/3/49	57.8	57.8	31.7	26.1	31.7			5001	18	23.5		-2.04	55.28
08N06E08I	4/12/49	57.8	57.8	32.1	25.7	32.1			5001	19	26.1		0.56	55.84
08N06E08I	7/7/49	57.8	57.8	37.9	19.9	37.9			5001	20	25.7		0.16	56.00
08N06E08I	10/6/49	57.8	57.8	36.2	21.6	36.2			5001	21	19.9		-5.64	50.36
08N06E08I	1/11/50	57.8	57.8	32.9	24.9	32.9			5001	22	21.6		-3.94	46.42
08N06E08I	4/14/50	57.8	57.8	31.2	26.6	31.2			5001	23	24.9		-0.64	45.78
08N06E08I	8/18/50	57.8	57.8	40.9	16.9	40.9			5001	24	26.6		1.06	46.84
08N06E08I	10/17/50	57.8	57.8	36.2	21.6	36.2			5001	25	16.9		-8.64	38.20
08N06E08I	1/30/51	57.8	57.8	29.8	28	29.8			5001	26	21.6		-3.94	34.26
08N06E08I	4/11/51	57.8	57.8	30.6	27.2	30.6			5001	27	28		2.46	36.72
08N06E08I	10/25/51	57.8	57.8	35.8	22	35.8			5001	28	27.2		1.66	38.38
08N06E08I	4/15/52	57.8	57.8	28.1	29.7	28.1			5001	29	22		-3.54	34.84
08N06E08I	10/27/52	57.8	57.8	34.5	23.3	34.5			5001	30	29.7		4.16	39.00
08N06E08I	3/18/53	57.8	57.8	31.6	26.2	31.6			5001	31	23.3		-2.24	36.76
08N06E08I	11/3/53	57.8	57.8	37.7	20.1	37.7			5001	32	26.2		0.66	37.42
08N06E08I	4/8/54	57.8	57.8	33	24.8	33			5001	33	20.1		-5.44	31.98
08N06E08I	10/27/54	57.8	57.8	38.5	19.3	38.5			5001	34	24.8		-0.74	31.24
08N06E08I	3/29/55	57.8	57.8	35.6	22.2	35.6			5001	35	19.3		-6.24	25.00
08N06E08I	10/31/55	57.8	57.8	40.5	17.3	40.5			5001	36	22.2		-3.34	21.66
08N06E08I	3/29/56	57.8	57.8	33.9	23.9	33.9			5001	37	17.3		-8.24	13.42
08N06E08I	10/22/56	57.8	57.8	39.9	17.9	39.9			5001	38	23.9		-1.64	11.78
08N06E08I	4/2/57	57.8	57.8	36.4	21.4	36.4			5001	39	17.9		-7.64	4.14
08N06E08I	10/23/57	57.8	57.8	41.9	15.9	41.9			5001	40	21.4	25.54	-4.14	0.00
08N06E08I	4/30/58	57.8	57.8	36.2	21.6	36.2			5001	41	15.9		-9.64	-9.64
08N06E08I	4/6/59	57.8	57.8	38.5	19.3	38.5			5001	42	21.6		-3.94	-13.58
08N06E08I	11/10/59	57.8	57.8	69.8	-12	69.8			5001	43	19.3		-6.24	-19.82
08N06E08I	2/16/60	57.8	57.8	41.2	16.6	41.2		3	5050	44	0		-25.54	-45.36

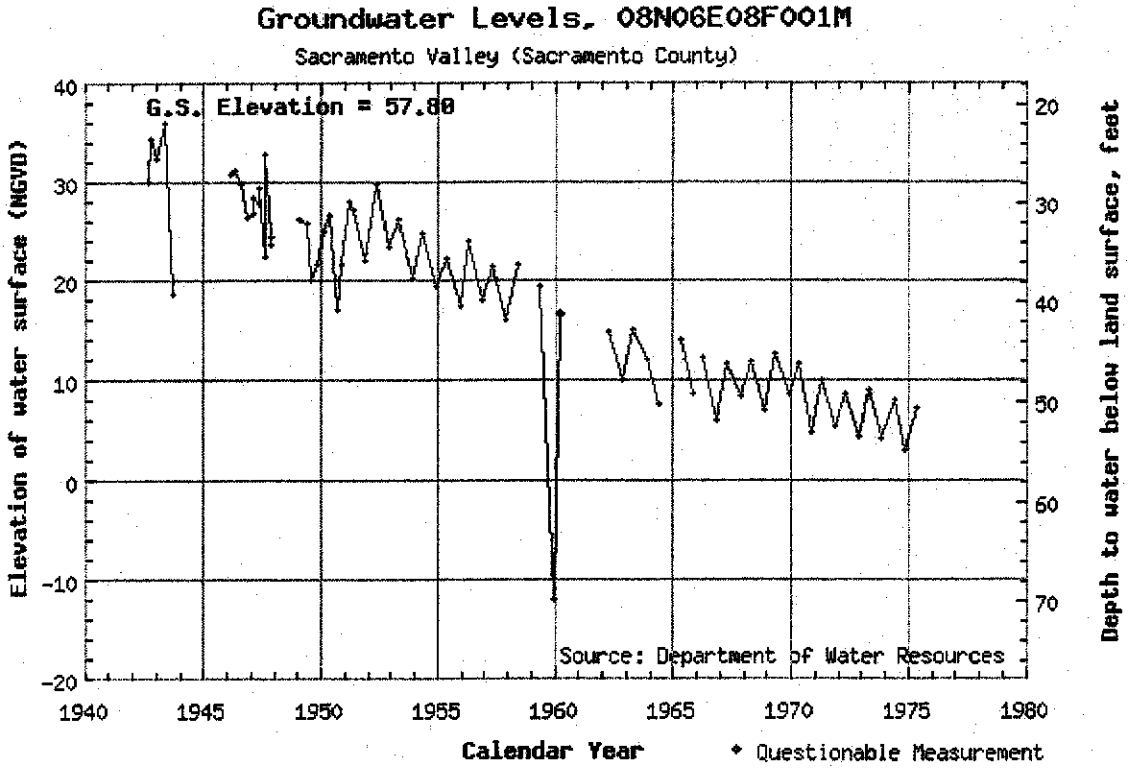
08N06E08I	4/13/61	57.8	57.8				3	5050	45	16.6	-8.94	-54.30
08N06E08I	10/5/61	57.8	57.8				3	5050	46	0	-25.54	-79.84
08N06E08I	3/9/62	57.8	57.8	43	14.8	43		5050	47	0	-25.54	-105.38
08N06E08I	10/11/62	57.8	57.8	47.8	10	47.8		5050	48	14.8	-10.74	-116.12
08N06E08I	3/21/63	57.8	57.8	42.9	14.9	42.9		5050	49	10	-15.54	-131.66
08N06E08I	10/17/63	57.8	57.8	45.8	12	45.8		5108	50	14.9	-10.64	-142.30
08N06E08I	4/6/64	57.8	57.8	50.3	7.5	50.3		5108	51	12	-13.54	-155.84
08N06E08I	10/9/64	57.8	57.8				3	5108	52	7.5	-18.04	-173.88
08N06E08I	3/12/65	57.8	57.8	43.8	14	43.8		5108	53	0	-25.54	-199.42
08N06E08I	10/7/65	57.8	57.8	49.3	8.5	49.3		5108	54	14	-11.54	-210.96
08N06E08I	3/11/66	57.8	57.8				3	5108	55	8.5	-17.04	-228.00
08N06E08I	3/18/66	57.8	57.8	45.7	12.1	45.7		5050	56	0	-25.54	-253.54
08N06E08I	10/6/66	57.8	57.8	51.9	5.9	51.9		5050	57	12.1	-13.44	-266.98
08N06E08I	3/9/67	57.8	57.8	46.2	11.6	46.2		5050	58	5.9	-19.64	-286.62
08N06E08I	10/9/67	57.8	57.8	49.5	8.3	49.5		5050	59	11.6	-13.94	-300.56
08N06E08I	3/13/68	57.8	57.8	46.1	11.7	46.1		5050	60	8.3	-17.24	-317.80
08N06E08I	10/14/68	57.8	57.8	50.9	6.9	50.9		5050	61	11.7	-13.84	-331.64
08N06E08I	4/3/69	57.8	57.8	45.2	12.6	45.2		5050	62	6.9	-18.64	-350.28
08N06E08I	10/22/69	57.8	57.8	49.2	8.6	49.2		5050	63	12.6	-12.94	-363.22
08N06E08I	3/23/70	57.8	57.8	46.3	11.5	46.3		5050	64	8.6	-16.94	-380.16
08N06E08I	10/15/70	57.8	57.8	53	4.8	53		5050	65	11.5	-14.04	-394.20
08N06E08I	3/17/71	57.8	57.8	47.9	9.9	47.9		5050	66	4.8	-20.74	-414.94
08N06E08I	10/18/71	57.8	57.8	52.5	5.3	52.5		5050	67	9.9	-15.64	-430.58
08N06E08I	3/10/72	57.8	57.8	49.3	8.5	49.3		5050	68	5.3	-20.24	-450.82
08N06E08I	10/11/72	57.8	57.8	53.4	4.4	53.4		5050	69	8.5	-17.04	-467.86
08N06E08I	3/21/73	57.8	57.8	48.9	8.9	48.9		5050	70	4.4	-21.14	-489.00
08N06E08I	10/8/73	57.8	57.8	53.7	4.1	53.7		5050	71	8.9	-16.64	-505.64
08N06E08I	5/7/74	57.8	57.8	49.8	8	49.8		5050	72	4.1	-21.44	-527.08
08N06E08I	10/16/74	57.8	57.8	54.8	3	54.8		5050	73	8	-17.54	-544.62
08N06E08I	4/10/75	57.8	57.8	50.7	7.1	50.7		5050	74	3	-22.54	-567.16
08N06E08I	10/27/75	57.8	57.8				6	5050	75	7.1	-18.44	-585.60

DWR
California Department of Water Resources

Query Results for 08N06E08F001M

DPLA Home
WDL Home
- Water Quality
- Groundwater

Your selection returned a total of **76** records. Wells in the Department of Water Resources monitoring network are identified by a State Well Number, which is based on the Public Land Grid System. The table headings and records contain several codes and abbreviations. Press the ***New Search*** or ***Nearby Search*** buttons or at the bottom of the page to begin a new data retrieval. Data for this well can also be downloaded in MS Excel or text delimited format.



Meas. Date	R.P. Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency
08-05-1942	57.8	57.8	27.8	30.0	27.8			5001
09-09-1942	57.8	57.8	23.6	34.2	23.6			5001
12-17-1942	57.8	57.8	25.6	32.2	25.6			5001
04-14-1943	57.8	57.8	21.8	36.0	21.8			5001
07-29-1943	57.8	57.8	39.2	18.6	39.2			5001
02-12-1946	57.8	57.8	27.0	30.8	27.0			5001
03-08-1946	57.8	57.8	26.9	30.9	26.9			5001
04-11-1946	57.8	57.8	26.7	31.1	26.7			5001
07-18-1946	57.8	57.8	28.0	29.8	28.0			5001
10-03-1946	57.8	57.8	31.5	26.3	31.5			5001
01-06-1947	57.8	57.8	31.0	26.8	31.0			5001
01-08-1947	57.8	57.8	29.4	28.4	29.4			5001
04-01-1947	57.8	57.8	30.0	27.8	30.0			5001
04-04-1947	57.8	57.8	28.5	29.3	28.5			5001
07-06-1947	57.8	57.8	35.4	22.4	35.4			5001
07-11-1947	57.8	57.8	25.2	32.6	25.2			5001
10-02-1947	57.8	57.8	33.5	24.3	33.5			5001

10-05-1947	57.8	57.8	34.3	23.5	34.3			5001
01-03-1949	57.8	57.8	31.7	26.1	31.7			5001
04-12-1949	57.8	57.8	32.1	25.7	32.1			5001
07-07-1949	57.8	57.8	37.9	19.9	37.9			5001
10-06-1949	57.8	57.8	36.2	21.6	36.2			5001
01-11-1950	57.8	57.8	32.9	24.9	32.9			5001
04-14-1950	57.8	57.8	31.2	26.6	31.2			5001
08-18-1950	57.8	57.8	40.9	16.9	40.9			5001
10-17-1950	57.8	57.8	36.2	21.6	36.2			5001
01-30-1951	57.8	57.8	29.8	28.0	29.8			5001
04-11-1951	57.8	57.8	30.6	27.2	30.6			5001
10-25-1951	57.8	57.8	35.8	22.0	35.8			5001
04-15-1952	57.8	57.8	28.1	29.7	28.1			5001
10-27-1952	57.8	57.8	34.5	23.3	34.5			5001
03-18-1953	57.8	57.8	31.6	26.2	31.6			5001
11-03-1953	57.8	57.8	37.7	20.1	37.7			5001
04-08-1954	57.8	57.8	33.0	24.8	33.0			5001
10-27-1954	57.8	57.8	38.5	19.3	38.5			5001
03-29-1955	57.8	57.8	35.6	22.2	35.6			5001
10-31-1955	57.8	57.8	40.5	17.3	40.5			5001
03-29-1956	57.8	57.8	33.9	23.9	33.9			5001
10-22-1956	57.8	57.8	39.9	17.9	39.9			5001
04-02-1957	57.8	57.8	36.4	21.4	36.4			5001
10-23-1957	57.8	57.8	41.9	15.9	41.9			5001
04-30-1958	57.8	57.8	36.2	21.6	36.2			5001
04-06-1959	57.8	57.8	38.5	19.3	38.5			5001
11-10-1959	57.8	57.8	69.8	-12.0	69.8			5001
02-16-1960	57.8	57.8	41.2	16.6	41.2	3		5050
04-13-1961	57.8	57.8					3	5050
10-05-1961	57.8	57.8					3	5050
03-09-1962	57.8	57.8	43.0	14.8	43.0			5050
10-11-1962	57.8	57.8	47.8	10.0	47.8			5050
03-21-1963	57.8	57.8	42.9	14.9	42.9			5050
10-17-1963	57.8	57.8	45.8	12.0	45.8			5108
04-06-1964	57.8	57.8	50.3	7.5	50.3			5108
10-09-1964	57.8	57.8					3	5108
03-12-1965	57.8	57.8	43.8	14.0	43.8			5108
10-07-1965	57.8	57.8	49.3	8.5	49.3			5108
03-11-1966	57.8	57.8					3	5108
03-18-1966	57.8	57.8	45.7	12.1	45.7			5050
10-06-1966	57.8	57.8	51.9	5.9	51.9			5050
03-09-1967	57.8	57.8	46.2	11.6	46.2			5050
10-09-1967	57.8	57.8	49.5	8.3	49.5			5050
03-13-1968	57.8	57.8	46.1	11.7	46.1			5050
10-14-1968	57.8	57.8	50.9	6.9	50.9			5050
04-03-1969	57.8	57.8	45.2	12.6	45.2			5050
10-22-1969	57.8	57.8	49.2	8.6	49.2			5050
03-23-1970	57.8	57.8	46.3	11.5	46.3			5050
10-15-1970	57.8	57.8	53.0	4.8	53.0			5050
03-17-1971	57.8	57.8	47.9	9.9	47.9			5050
10-18-1971	57.8	57.8	52.5	5.3	52.5			5050
03-10-1972	57.8	57.8	49.3	8.5	49.3			5050
10-11-1972	57.8	57.8	53.4	4.4	53.4			5050

03-21-1973	57.8	57.8	48.9	8.9	48.9		5050
10-08-1973	57.8	57.8	53.7	4.1	53.7		5050
05-07-1974	57.8	57.8	49.8	8.0	49.8		5050
10-16-1974	57.8	57.8	54.8	3.0	54.8		5050
04-10-1975	57.8	57.8	50.7	7.1	50.7		5050
10-27-1975	57.8	57.8				6	5050

For more information contact:
Department of Water Resources, Central District
Geology and Groundwater Section
3251 'S' Street
Sacramento, CA 95816

Phone: 916-227-7590
Fax: 916-227-7600

New Search

Search for wells within 0.5 mile radius. Nearby Search

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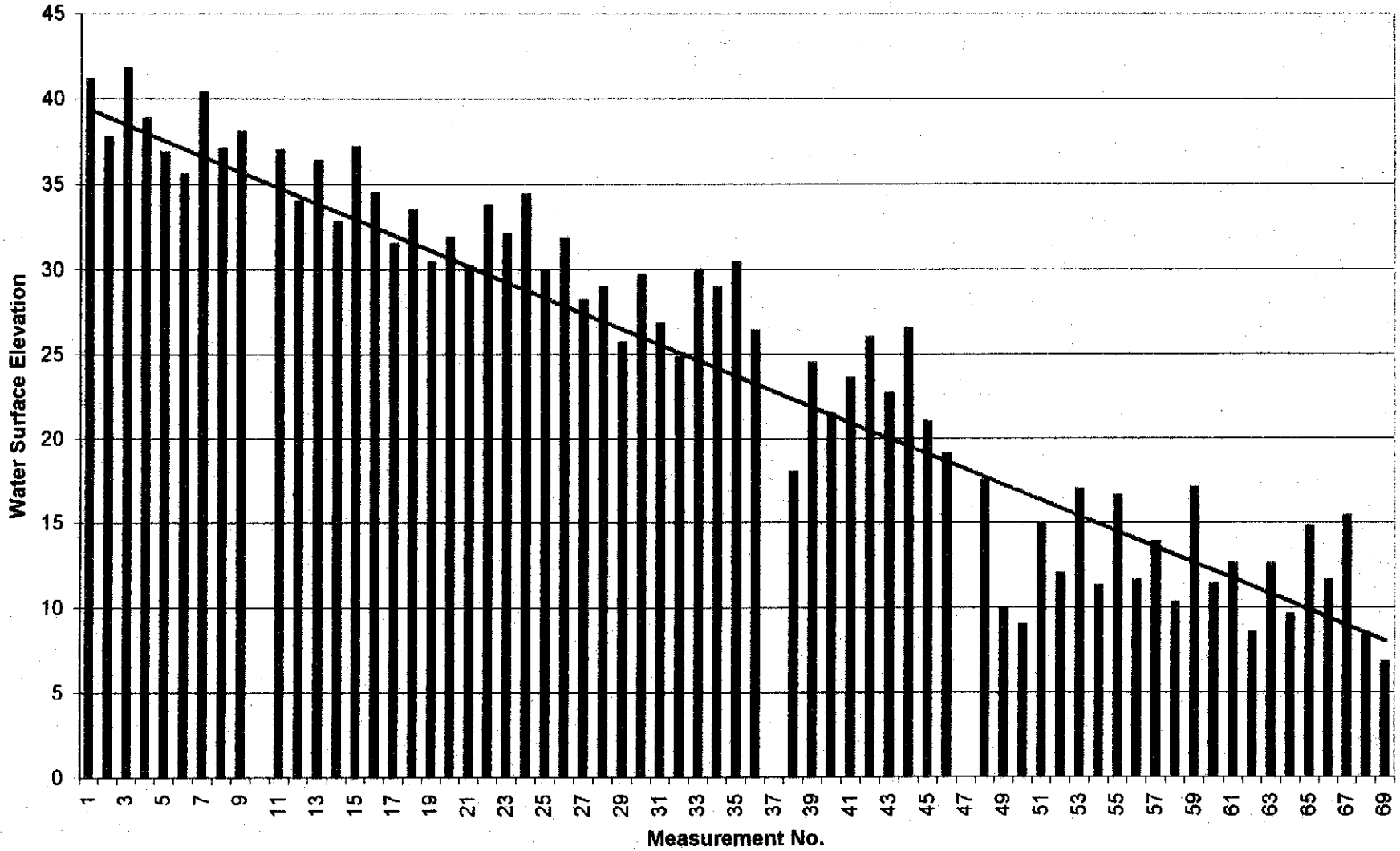
Ground-Water Elevation Data 1962 to 2000; 09N06E27D001M



State Well	Meas.Date	R.P.Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency	Measurement No.	WSE
09N06E27I	4/30/62	72.5	71	31.3	41.2	29.8			5108	1	41.2
09N06E27I	10/15/62	72.5	71	34.7	37.8	33.2			5108	2	37.8
09N06E27I	3/21/63	72.5	71	30.7	41.8	29.2			5108	3	41.8
09N06E27I	10/18/63	72.5	71	33.6	38.9	32.1			5108	4	38.9
09N06E27I	4/7/64	72.5	71	35.6	36.9	34.1			5108	5	36.9
09N06E27I	10/13/64	72.5	71	36.9	35.6	35.4			5108	6	35.6
09N06E27I	3/19/65	72.5	71	32.1	40.4	30.6			5108	7	40.4
09N06E27I	10/8/65	72.5	71	35.4	37.1	33.9			5108	8	37.1
09N06E27I	3/11/66	72.5	71	34.4	38.1	32.9			5108	9	38.1
09N06E27I	10/7/66	72.5	71					9	5108	10	0
09N06E27I	3/9/67	71	71	34	37	34			5108	11	37
09N06E27I	10/18/67	71	71	37	34	37			5108	12	34
09N06E27I	3/12/68	71	71	34.6	36.4	34.6			5108	13	36.4
09N06E27I	10/29/68	71	71	38.2	32.8	38.2			5108	14	32.8
09N06E27I	4/2/69	71	71	33.8	37.2	33.8			5108	15	37.2
09N06E27I	4/16/70	71	71	36.5	34.5	36.5			5108	16	34.5
09N06E27I	10/22/70	71	71	39.5	31.5	39.5			5108	17	31.5
09N06E27I	4/30/71	71	71	37.5	33.5	37.5			5108	18	33.5
09N06E27I	10/12/71	71	71	40.6	30.4	40.6			5108	19	30.4
09N06E27I	3/13/72	71	71	39.1	31.9	39.1			5108	20	31.9
09N06E27I	10/17/72	71	71	40.8	30.2	40.8			5108	21	30.2
09N06E27I	3/14/73	71	71	37.2	33.8	37.2			5108	22	33.8
09N06E27I	10/10/73	71	71	38.9	32.1	38.9			5108	23	32.1
09N06E27I	3/13/74	71	71	36.6	34.4	36.6			5108	24	34.4
09N06E27I	10/9/74	71	71	41	30	41			5108	25	30
09N06E27I	3/11/75	71	71	39.2	31.8	39.2			5108	26	31.8
09N06E27I	10/14/75	71	71	42.8	28.2	42.8			5108	27	28.2
09N06E27I	3/9/76	71	71	42	29	42			5108	28	29
09N06E27I	10/13/76	71	71	45.3	25.7	45.3			5108	29	25.7
09N06E27I	3/15/77	71	71	41.3	29.7	41.3			5108	30	29.7
09N06E27I	5/18/77	71	71	44.2	26.8	44.2			5108	31	26.8
09N06E27I	10/12/77	71	71	46.2	24.8	46.2			5108	32	24.8

09N06E27I	3/17/78	71	71	41	30	41			5108	33	30
09N06E27I	10/24/78	71	71	42	29	42			5108	34	29
09N06E27I	3/20/79	71	71	40.6	30.4	40.6			5108	35	30.4
09N06E27I	10/4/79	71	71	44.6	26.4	44.6			5108	36	26.4
09N06E27I	3/13/80	71	71					4	5108	37	0
09N06E27I	10/8/80	71	71	53	18	53			5108	38	18
09N06E27I	3/12/81	71	71	46.5	24.5	46.5			5108	39	24.5
09N06E27I	10/21/81	71	71	49.5	21.5	49.5			5108	40	21.5
09N06E27I	11/4/82	71	71	47.4	23.6	47.4			5108	41	23.6
09N06E27I	3/23/83	71	71	45	26	45			5108	42	26
09N06E27I	10/18/83	71	71	48.3	22.7	48.3			5108	43	22.7
09N06E27I	3/13/84	71	71	44.5	26.5	44.5			5108	44	26.5
09N06E27I	10/22/84	71	71	50	21	50			5108	45	21
09N06E27I	10/9/86	71	71	51.9	19.1	51.9			5108	46	19.1
09N06E27I	3/1/87	71	71					7	5108	47	0
09N06E27I	3/28/88	71	71	53.5	17.5	53.5			5108	48	17.5
09N06E27I	5/8/90	71	71	61	10	61			5108	49	10
09N06E27I	10/5/90	71	71	62	9	62	8		5108	50	9
09N06E27I	2/25/91	71	71	56	15	56	8		5108	51	15
09N06E27I	10/17/91	71	71	59	12	59	8		5108	52	12
09N06E27I	4/8/92	71	71	54	17	54	8		5108	53	17
09N06E27I	10/14/92	71	71	59.7	11.3	59.7	8		5108	54	11.3
09N06E27I	3/18/93	71	71	54.4	16.6	54.4			5108	55	16.6
09N06E27I	10/5/93	71	71	59.4	11.6	59.4			5108	56	11.6
09N06E27I	4/5/94	71	71	57.1	13.9	57.1	8		5108	57	13.9
09N06E27I	11/2/94	71	71	60.7	10.3	60.7	8		5108	58	10.3
09N06E27I	4/13/95	71	71	53.9	17.1	53.9	8		5108	59	17.1
09N06E27I	10/6/95	71	71	59.6	11.4	59.6	8		5108	60	11.4
09N06E27I	4/3/96	71	71	58.4	12.6	58.4	8		5108	61	12.6
09N06E27I	10/7/96	71	71	62.5	8.5	62.5	8		5108	62	8.5
09N06E27I	4/3/97	71	71	58.4	12.6	58.4	8		5108	63	12.6
09N06E27I	10/23/97	71	71	61.4	9.6	61.4	8		5108	64	9.6
09N06E27I	4/9/98	71	71	56.2	14.8	56.2	8		5108	65	14.8
09N06E27I	10/8/98	71	71	59.4	11.6	59.4	8		5108	66	11.6
09N06E27I	4/27/99	71	71	55.6	15.4	55.6	8		5108	67	15.4
09N06E27I	10/21/99	71	71	62.7	8.3	62.7	8		5108	68	8.3
09N06E27I	4/27/00	71	71	64.2	6.8	64.2	8		5108	69	6.8

DWR
California Department of Water Resources

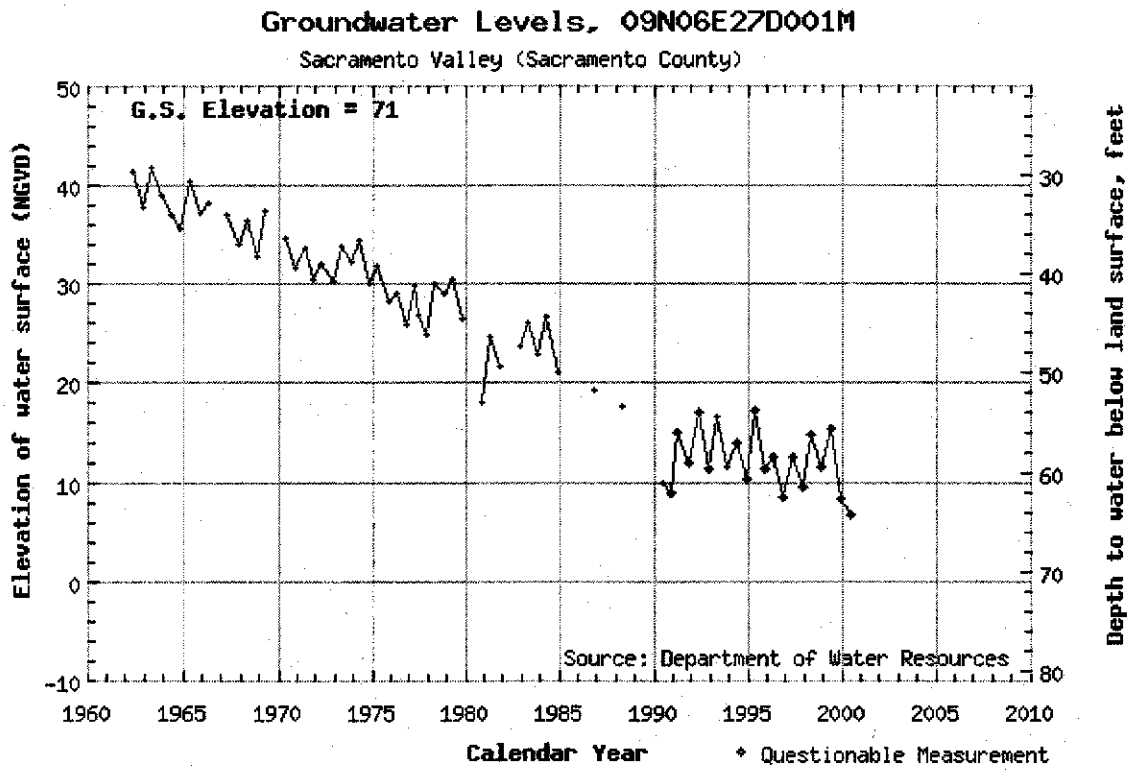
Query Results for 09N06E27D001M

DPLA Home

WDL Home

- *Water Quality*
- *Groundwater*

Your selection returned a total of **69** records. Wells in the Department of Water Resources monitoring network are identified by a State Well Number, which is based on the Public Land Grid System. The table headings and records contain several codes and abbreviations. Press the ***New Search*** or ***Nearby Search*** buttons or at the bottom of the page to begin a new data retrieval. Data for this well can also be downloaded in MS Excel or text delimited format.

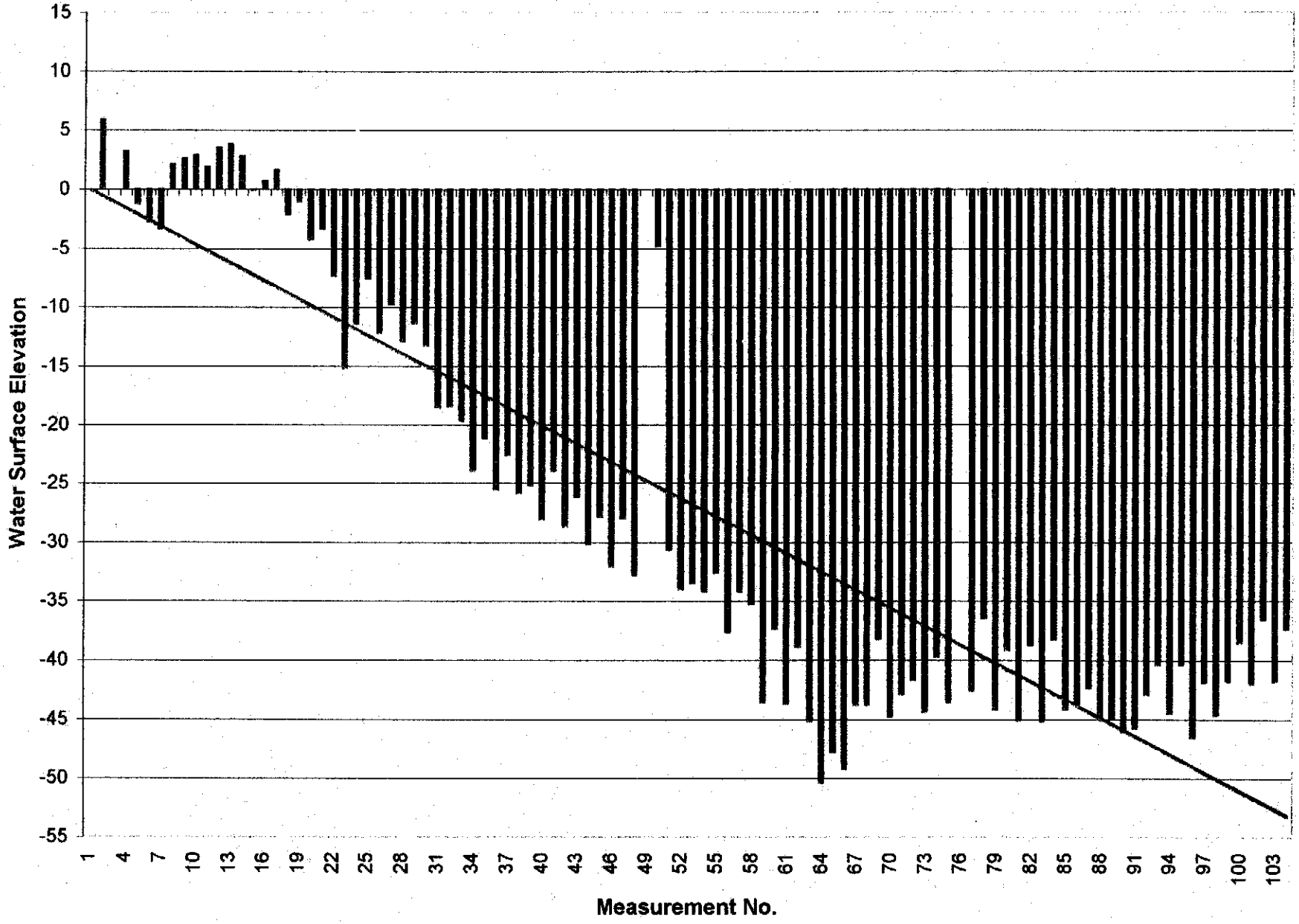


Meas. Date	R.P. Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency
04-30-1962	72.5	71.0	31.3	41.2	29.8			5108
10-15-1962	72.5	71.0	34.7	37.8	33.2			5108
03-21-1963	72.5	71.0	30.7	41.8	29.2			5108
10-18-1963	72.5	71.0	33.6	38.9	32.1			5108
04-07-1964	72.5	71.0	35.6	36.9	34.1			5108
10-13-1964	72.5	71.0	36.9	35.6	35.4			5108
03-19-1965	72.5	71.0	32.1	40.4	30.6			5108
10-08-1965	72.5	71.0	35.4	37.1	33.9			5108
03-11-1966	72.5	71.0	34.4	38.1	32.9			5108
10-07-1966	72.5	71.0					9	5108
03-09-1967	71.0	71.0	34.0	37.0	34.0			5108
10-18-1967	71.0	71.0	37.0	34.0	37.0			5108
03-12-1968	71.0	71.0	34.6	36.4	34.6			5108
10-29-1968	71.0	71.0	38.2	32.8	38.2			5108
04-02-1969	71.0	71.0	33.8	37.2	33.8			5108
04-16-1970	71.0	71.0	36.5	34.5	36.5			5108
10-22-1970	71.0	71.0	39.5	31.5	39.5			5108

04-30-1971	71.0	71.0	37.5	33.5	37.5			5108
10-12-1971	71.0	71.0	40.6	30.4	40.6			5108
03-13-1972	71.0	71.0	39.1	31.9	39.1			5108
10-17-1972	71.0	71.0	40.8	30.2	40.8			5108
03-14-1973	71.0	71.0	37.2	33.8	37.2			5108
10-10-1973	71.0	71.0	38.9	32.1	38.9			5108
03-13-1974	71.0	71.0	36.6	34.4	36.6			5108
10-09-1974	71.0	71.0	41.0	30.0	41.0			5108
03-11-1975	71.0	71.0	39.2	31.8	39.2			5108
10-14-1975	71.0	71.0	42.8	28.2	42.8			5108
03-09-1976	71.0	71.0	42.0	29.0	42.0			5108
10-13-1976	71.0	71.0	45.3	25.7	45.3			5108
03-15-1977	71.0	71.0	41.3	29.7	41.3			5108
05-18-1977	71.0	71.0	44.2	26.8	44.2			5108
10-12-1977	71.0	71.0	46.2	24.8	46.2			5108
03-17-1978	71.0	71.0	41.0	30.0	41.0			5108
10-24-1978	71.0	71.0	42.0	29.0	42.0			5108
03-20-1979	71.0	71.0	40.6	30.4	40.6			5108
10-04-1979	71.0	71.0	44.6	26.4	44.6			5108
03-13-1980	71.0	71.0					4	5108
10-08-1980	71.0	71.0	53.0	18.0	53.0			5108
03-12-1981	71.0	71.0	46.5	24.5	46.5			5108
10-21-1981	71.0	71.0	49.5	21.5	49.5			5108
11-04-1982	71.0	71.0	47.4	23.6	47.4			5108
03-23-1983	71.0	71.0	45.0	26.0	45.0			5108
10-18-1983	71.0	71.0	48.3	22.7	48.3			5108
03-13-1984	71.0	71.0	44.5	26.5	44.5			5108
10-22-1984	71.0	71.0	50.0	21.0	50.0			5108
10-09-1986	71.0	71.0	51.9	19.1	51.9			5108
03-01-1987	71.0	71.0					7	5108
03-28-1988	71.0	71.0	53.5	17.5	53.5			5108
05-08-1990	71.0	71.0	61.0	10.0	61.0			5108
10-05-1990	71.0	71.0	62.0	9.0	62.0	8		5108
02-25-1991	71.0	71.0	56.0	15.0	56.0	8		5108
10-17-1991	71.0	71.0	59.0	12.0	59.0	8		5108
04-08-1992	71.0	71.0	54.0	17.0	54.0	8		5108
10-14-1992	71.0	71.0	59.7	11.3	59.7	8		5108
03-18-1993	71.0	71.0	54.4	16.6	54.4			5108
10-05-1993	71.0	71.0	59.4	11.6	59.4			5108
04-05-1994	71.0	71.0	57.1	13.9	57.1	8		5108
11-02-1994	71.0	71.0	60.7	10.3	60.7	8		5108
04-13-1995	71.0	71.0	53.9	17.1	53.9	8		5108
10-06-1995	71.0	71.0	59.6	11.4	59.6	8		5108
04-03-1996	71.0	71.0	58.4	12.6	58.4	8		5108
10-07-1996	71.0	71.0	62.5	8.5	62.5	8		5108
04-03-1997	71.0	71.0	58.4	12.6	58.4	8		5108
10-23-1997	71.0	71.0	61.4	9.6	61.4	8		5108
04-09-1998	71.0	71.0	56.2	14.8	56.2	8		5108
10-08-1998	71.0	71.0	59.4	11.6	59.4	8		5108
04-27-1999	71.0	71.0	55.6	15.4	55.6	8		5108
10-21-1999	71.0	71.0	62.7	8.3	62.7	8		5108
04-27-2000	71.0	71.0	64.2	6.8	64.2	8		5108

For more information contact:

Ground-Water Elevation Data 1950 to 2000; 07N06E08H001M



State Well	Meas.Date	R.P.Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency	Measurement No.	WSE
07N06E08I	4/4/50	58.8	58.5	52.9	5.9	52.6			5050	1	5.9
07N06E08I	5/9/50	58.8	58.5	58.8	0	58.5		1	5050	2	0
07N06E08I	6/14/50	58.8	58.5	55.6	3.2	55.3		1	5050	3	3.2
07N06E08I	7/13/50	58.8	58.5	60.1	-1.3	59.8		1	5050	4	-1.3
07N06E08I	8/9/50	58.8	58.5	61.6	-2.8	61.3		1	5050	5	-2.8
07N06E08I	9/13/50	58.8	58.5	62.2	-3.4	61.9		1	5050	6	-3.4
07N06E08I	10/6/50	58.8	58.5	56.7	2.1	56.4			5050	7	2.1
07N06E08I	11/10/50	58.8	58.5	56.2	2.6	55.9			5050	8	2.6
07N06E08I	12/6/50	58.8	58.5	55.9	2.9	55.6			5050	9	2.9
07N06E08I	1/5/51	58.8	58.5	56.9	1.9	56.6			5050	10	1.9
07N06E08I	2/8/51	58.8	58.5	55.3	3.5	55			5050	11	3.5
07N06E08I	3/5/51	58.8	58.5	55	3.8	54.7			5050	12	3.8
07N06E08I	4/10/51	58.8	58.5	56	2.8	55.7			5050	13	2.8
07N06E08I	10/5/51	58.8	58.5	58.9	-0.1	58.6			5050	14	-0.1
07N06E08I	11/6/51	58.8	58.5	58.1	0.7	57.8			5050	15	0.7
07N06E08I	4/2/52	58.8	58.5	57.2	1.6	56.9			5050	16	1.6
07N06E08I	10/30/52	58.8	58.5	61	-2.2	60.7			5050	17	-2.2
07N06E08I	3/4/53	58.8	58.5	59.9	-1.1	59.6			5050	18	-1.1
07N06E08I	11/5/53	58.8	58.5	63.1	-4.3	62.8			5001	19	-4.3
07N06E08I	4/2/54	58.8	58.5	62.2	-3.4	61.9			5001	20	-3.4
07N06E08I	11/4/54	58.8	58.5	66.2	-7.4	65.9			5001	21	-7.4
07N06E08I	3/24/55	58.8	58.5	74	-15.2	73.7			5001	22	-15.2
07N06E08I	10/27/55	58.8	58.5	70.2	-11.4	69.9			5050	23	-11.4
07N06E08I	3/23/56	58.8	58.5	66.4	-7.6	66.1			5050	24	-7.6
07N06E08I	10/18/56	58.8	58.5	71	-12.2	70.7			5001	25	-12.2
07N06E08I	3/29/57	58.8	58.5	68.6	-9.8	68.3			5001	26	-9.8
07N06E08I	10/22/57	58.8	58.5	71.7	-12.9	71.4			5001	27	-12.9
07N06E08I	4/29/58	58.8	58.5	70.2	-11.4	69.9			5001	28	-11.4
07N06E08I	4/2/59	58.8	58.5	72.1	-13.3	71.8			5001	29	-13.3
07N06E08I	11/10/59	58.8	58.5	77.4	-18.6	77.1			5001	30	-18.6
07N06E08I	2/16/60	58.8	58.5	77.3	-18.5	77		6	5050	31	-18.5
07N06E08I	4/11/61	58.8	58.5	78.5	-19.7	78.2			5050	32	-19.7
07N06E08I	10/4/61	58.8	58.5	82.8	-24	82.5			5050	33	-24

07N06E08I	3/7/62	58.8	58.5	80	-21.2	79.7		5050	34	-21.2
07N06E08I	10/9/62	58.8	58.5	84.4	-25.6	84.1		5050	35	-25.6
07N06E08I	3/19/63	58.8	58.5	81.4	-22.6	81.1		5050	36	-22.6
07N06E08I	10/15/63	58.8	58.5	84.7	-25.9	84.4		5108	37	-25.9
07N06E08I	4/3/64	58.8	58.5	84	-25.2	83.7		5108	38	-25.2
07N06E08I	10/7/64	58.8	58.5	86.9	-28.1	86.6		5108	39	-28.1
07N06E08I	3/17/65	58.8	58.5	82.8	-24	82.5		5108	40	-24
07N06E08I	10/5/65	58.8	58.5	87.5	-28.7	87.2		5108	41	-28.7
07N06E08I	3/10/66	58.8	58.5	85	-26.2	84.7		5108	42	-26.2
07N06E08I	10/5/66	58.8	58.5	89	-30.2	88.7		5108	43	-30.2
07N06E08I	3/20/67	58.8	58.5	86.7	-27.9	86.4		5108	44	-27.9
07N06E08I	10/11/67	58.8	58.5	90.9	-32.1	90.6		5108	45	-32.1
07N06E08I	3/5/68	58.8	58.5	86.8	-28	86.5		5108	46	-28
07N06E08I	10/10/68	58.8	58.5	91.6	-32.8	91.3		5108	47	-32.8
07N06E08I	3/26/69	58.8	58.5	52	6.8	51.7	6	5108	48	
07N06E08I	4/8/70	58.8	58.5	63.6	-4.8	63.3	6	5108	49	-4.8
07N06E08I	3/18/71	58.8	58.5	89.5	-30.7	89.2		5108	50	-30.7
07N06E08I	10/5/71	58.8	58.5	92.8	-34	92.5		5108	51	-34
07N06E08I	3/7/72	58.8	58.5	92.3	-33.5	92		5108	52	-33.5
07N06E08I	10/13/72	58.8	58.5	93	-34.2	92.7		5108	53	-34.2
07N06E08I	3/8/73	58.8	58.5	91.4	-32.6	91.1		5108	54	-32.6
07N06E08I	10/3/73	58.8	58.5	96.5	-37.7	96.2		5108	55	-37.7
07N06E08I	3/5/74	58.8	58.5	93	-34.2	92.7		5108	56	-34.2
07N06E08I	10/4/74	58.8	58.5	94.1	-35.3	93.8		5108	57	-35.3
07N06E08I	3/6/75	58.8	58.5	102.4	-43.6	102.1		5108	58	-43.6
07N06E08I	10/8/75	58.8	58.5	96.2	-37.4	95.9		5108	59	-37.4
07N06E08I	3/4/76	58.8	58.5	102.5	-43.7	102.2		5108	60	-43.7
07N06E08I	10/8/76	58.8	58.5	97.7	-38.9	97.4		5108	61	-38.9
07N06E08I	3/9/77	58.8	58.5	104	-45.2	103.7		5108	62	-45.2
07N06E08I	10/5/77	58.8	58.5	109.2	-50.4	108.9		5108	63	-50.4
07N06E08I	3/14/78	58.8	58.5	106.6	-47.8	106.3		5108	64	-47.8
07N06E08I	10/18/78	58.8	58.5	108	-49.2	107.7		5108	65	-49.2
07N06E08I	3/13/79	58.8	58.5	102.6	-43.8	102.3		5108	66	-43.8
07N06E08I	10/2/79	58.8	58.5	102.6	-43.8	102.3		5108	67	-43.8
07N06E08I	3/11/80	58.8	58.5	97	-38.2	96.7		5108	68	-38.2
07N06E08I	10/2/80	58.8	58.5	103.6	-44.8	103.3		5108	69	-44.8
07N06E08I	3/10/81	58.8	58.5	101.7	-42.9	101.4		5108	70	-42.9

07N06E08I	10/15/81	58.8	58.5	100.5	-41.7	100.2		5108	71	-41.7
07N06E08I	10/28/82	58.8	58.5	103.2	-44.4	102.9		5108	72	-44.4
07N06E08I	3/17/83	58.8	58.5	98.5	-39.7	98.2		5108	73	-39.7
07N06E08I	10/5/83	58.8	58.5	102.4	-43.6	102.1		5108	74	-43.6
07N06E08I	3/8/84	58.8	58.5				7	5108	75	0
07N06E08I	10/15/84	58.8	58.5	101.4	-42.6	101.1		5108	76	-42.6
07N06E08I	3/21/85	58.8	58.5	95.3	-36.5	95		5108	77	-36.5
07N06E08I	10/16/85	58.8	58.5	103	-44.2	102.7		5108	78	-44.2
07N06E08I	3/18/86	58.8	58.5	98	-39.2	97.7		5108	79	-39.2
07N06E08I	10/7/86	58.8	58.5	103.9	-45.1	103.6		5108	80	-45.1
07N06E08I	3/16/87	58.8	58.5	97.6	-38.8	97.3		5108	81	-38.8
07N06E08I	10/17/87	58.8	58.5	104	-45.2	103.7		5108	82	-45.2
07N06E08I	3/17/88	58.8	58.5	97.1	-38.3	96.8		5108	83	-38.3
07N06E08I	5/3/90	58.8	58.5	103	-44.2	102.7		5108	84	-44.2
07N06E08I	10/3/90	58.8	58.5	102.6	-43.8	102.3		5108	85	-43.8
07N06E08I	2/21/91	58.8	58.5	101.2	-42.4	100.9		5108	86	-42.4
07N06E08I	10/9/91	58.8	58.5	103.9	-45.1	103.6		5108	87	-45.1
07N06E08I	4/2/92	58.8	58.5	103.7	-44.9	103.4		5108	88	-44.9
07N06E08I	10/6/92	58.8	58.5	104.9	-46.1	104.6		5108	89	-46.1
07N06E08I	3/11/93	58.8	58.5	104.6	-45.8	104.3		5108	90	-45.8
07N06E08I	9/30/93	58.8	58.5	101.7	-42.9	101.4		5108	91	-42.9
07N06E08I	3/31/94	58.8	58.5	99.2	-40.4	98.9		5108	92	-40.4
07N06E08I	10/27/94	58.8	58.5	103.3	-44.5	103		5108	93	-44.5
07N06E08I	4/10/95	58.8	58.5	99.2	-40.4	98.9		5108	94	-40.4
07N06E08I	10/4/95	58.8	58.5	105.4	-46.6	105.1		5108	95	-46.6
07N06E08I	4/5/96	58.8	58.5	100.7	-41.9	100.4		5108	96	-41.9
07N06E08I	10/9/96	58.8	58.5	103.5	-44.7	103.2		5108	97	-44.7
07N06E08I	4/2/97	58.8	58.5	100.6	-41.8	100.3		5108	98	-41.8
07N06E08I	4/7/98	59.5	58.5	98.1	-38.6	97.1		5108	99	-38.6
07N06E08I	10/7/98	59.5	58.5	101.5	-42	100.5		5108	100	-42
07N06E08I	4/13/99	59.5	58.5	96.1	-36.6	95.1		5108	101	-36.6
07N06E08I	10/13/99	59.5	58.5	101.3	-41.8	100.3		5108	102	-41.8
07N06E08I	4/26/00	59.5	58.5	96.9	-37.4	95.9		5108	103	-37.4

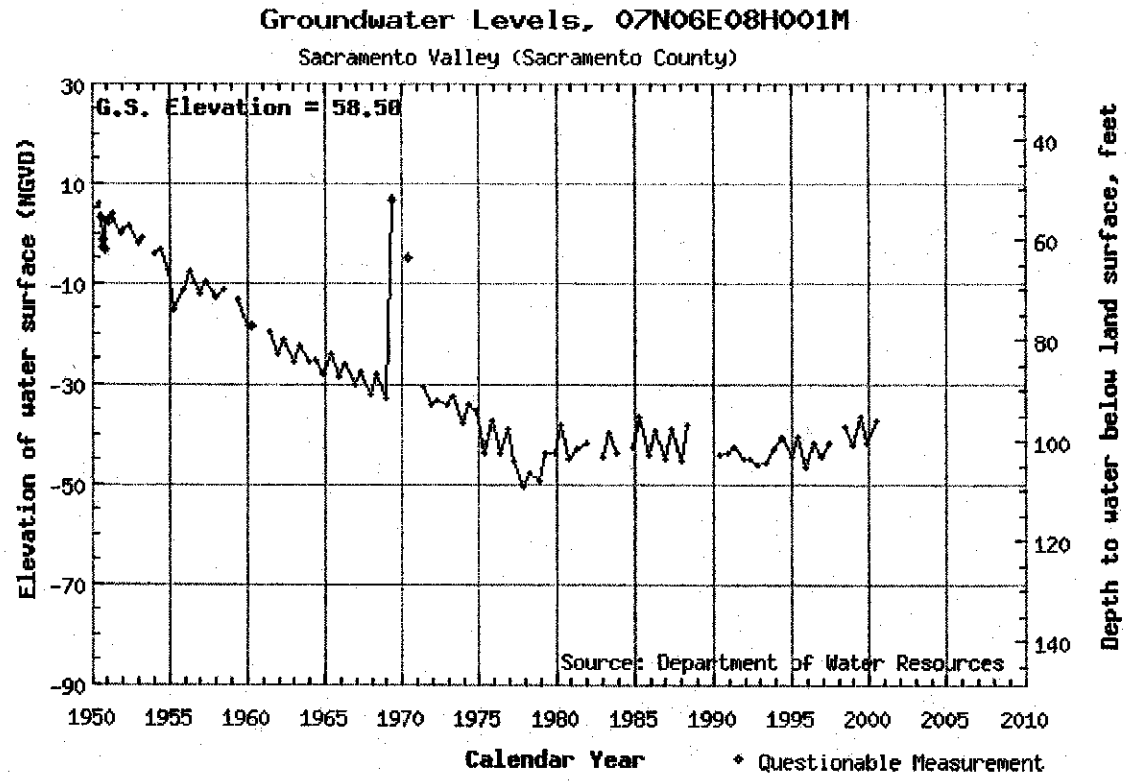
Query Results for 07N06E08H001M

DPLA Home

WDL Home

- *Water Quality*
- *Groundwater*

Your selection returned a total of **103** records. Wells in the Department of Water Resources monitoring network are identified by a State Well Number, which is based on the Public Land Grid System. The table headings and records contain several codes and abbreviations. Press the ***New Search*** or ***Nearby Search*** buttons or at the bottom of the page to begin a new data retrieval. Data for this well can also be downloaded in MS Excel or text delimited format.



Meas. Date	R.P. Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency
04-04-1950	58.8	58.5	52.9	5.9	52.6			5050
05-09-1950	58.8	58.5	58.8	0.0	58.5	1		5050
06-14-1950	58.8	58.5	55.6	3.2	55.3	1		5050
07-13-1950	58.8	58.5	60.1	-1.3	59.8	1		5050
08-09-1950	58.8	58.5	61.6	-2.8	61.3	1		5050
09-13-1950	58.8	58.5	62.2	-3.4	61.9	1		5050

10-09-1962	58.8	58.5	84.4	-25.6	84.1		5050
03-19-1963	58.8	58.5	81.4	-22.6	81.1		5050
10-15-1963	58.8	58.5	84.7	-25.9	84.4		5108
04-03-1964	58.8	58.5	84.0	-25.2	83.7		5108
10-07-1964	58.8	58.5	86.9	-28.1	86.6		5108
03-17-1965	58.8	58.5	82.8	-24.0	82.5		5108
10-05-1965	58.8	58.5	87.5	-28.7	87.2		5108
03-10-1966	58.8	58.5	85.0	-26.2	84.7		5108
10-05-1966	58.8	58.5	89.0	-30.2	88.7		5108
03-20-1967	58.8	58.5	86.7	-27.9	86.4		5108
10-11-1967	58.8	58.5	90.9	-32.1	90.6		5108
03-05-1968	58.8	58.5	86.8	-28.0	86.5		5108
10-10-1968	58.8	58.5	91.6	-32.8	91.3		5108
03-26-1969	58.8	58.5	52.0	6.8	51.7	6	5108
04-08-1970	58.8	58.5	63.6	-4.8	63.3	6	5108
03-18-1971	58.8	58.5	89.5	-30.7	89.2		5108
10-05-1971	58.8	58.5	92.8	-34.0	92.5		5108
03-07-1972	58.8	58.5	92.3	-33.5	92.0		5108
10-13-1972	58.8	58.5	93.0	-34.2	92.7		5108
03-08-1973	58.8	58.5	91.4	-32.6	91.1		5108
10-03-1973	58.8	58.5	96.5	-37.7	96.2		5108
03-05-1974	58.8	58.5	93.0	-34.2	92.7		5108
10-04-1974	58.8	58.5	94.1	-35.3	93.8		5108
03-06-1975	58.8	58.5	102.4	-43.6	102.1		5108
10-08-1975	58.8	58.5	96.2	-37.4	95.9		5108
03-04-1976	58.8	58.5	102.5	-43.7	102.2		5108
10-08-1976	58.8	58.5	97.7	-38.9	97.4		5108
03-09-1977	58.8	58.5	104.0	-45.2	103.7		5108
10-05-1977	58.8	58.5	109.2	-50.4	108.9		5108
03-14-1978	58.8	58.5	106.6	-47.8	106.3		5108
10-18-1978	58.8	58.5	108.0	-49.2	107.7		5108
03-13-1979	58.8	58.5	102.6	-43.8	102.3		5108
10-02-1979	58.8	58.5	102.6	-43.8	102.3		5108
03-11-1980	58.8	58.5	97.0	-38.2	96.7		5108
10-02-1980	58.8	58.5	103.6	-44.8	103.3		5108
03-10-1981	58.8	58.5	101.7	-42.9	101.4		5108
10-15-1981	58.8	58.5	100.5	-41.7	100.2		5108
10-28-1982	58.8	58.5	103.2	-44.4	102.9		5108
03-17-1983	58.8	58.5	98.5	-39.7	98.2		5108
10-05-1983	58.8	58.5	102.4	-43.6	102.1		5108
03-08-1984	58.8	58.5				7	5108
10-15-1984	58.8	58.5	101.4	-42.6	101.1		5108
03-21-1985	58.8	58.5	95.3	-36.5	95.0		5108

Geology and Groundwater Section
3251 'S' Street
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New Search

Search for wells within 0.5 mile radius. Nearby Search

Back

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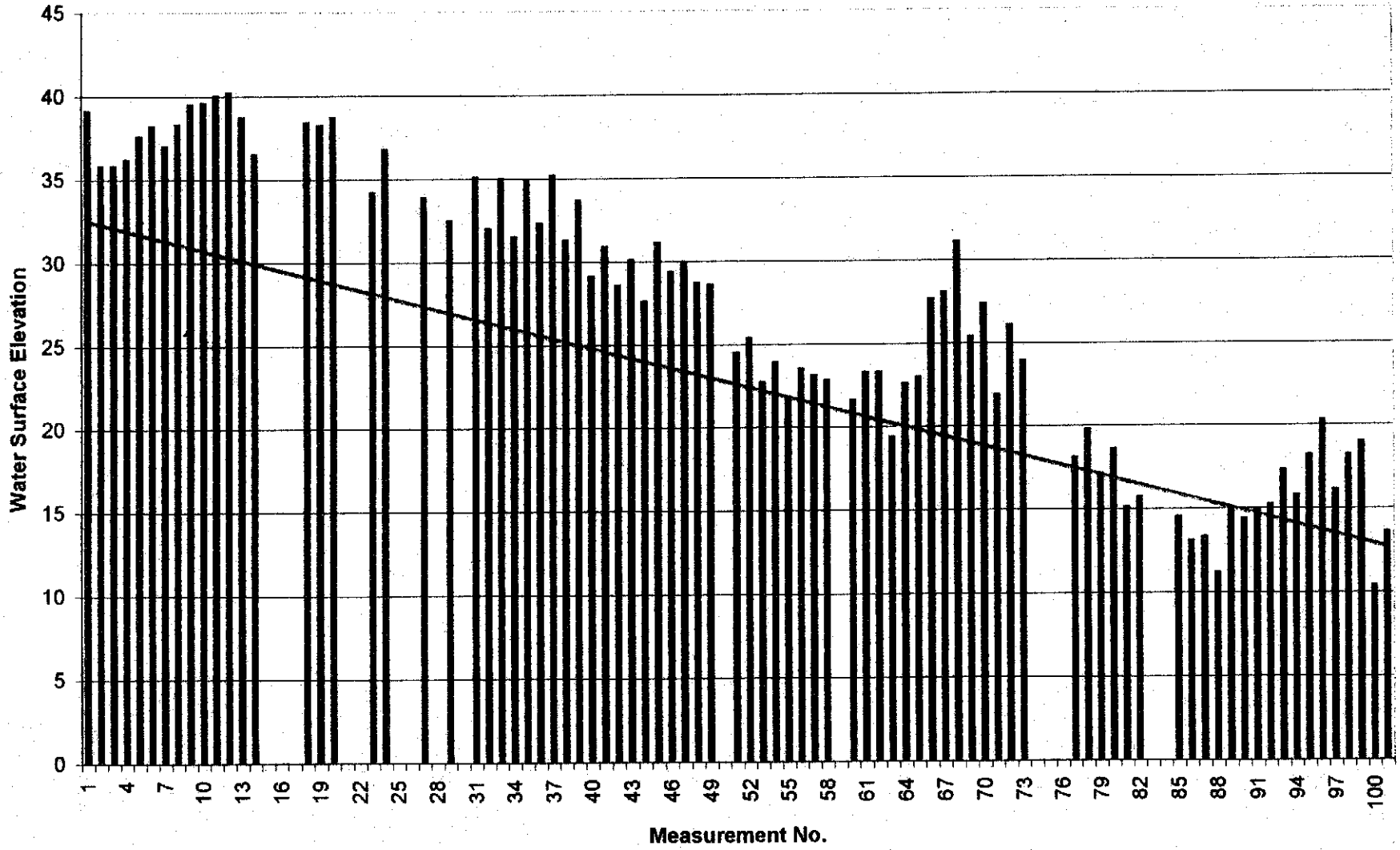
Ground-Water Elevation Data 1962 to 2001; 09N06E34R001M



State Well	Meas.Date	R.P.Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency	Measurement No.	WSE
09N06E34I	4/17/62	97.3	96.3	58.2	39.1	57.2			5050	1	39.1
09N06E34I	7/25/62	97.3	96.3	61.5	35.8	60.5			5050	2	35.8
09N06E34I	8/27/62	97.3	96.3	61.5	35.8	60.5			5050	3	35.8
09N06E34I	9/24/62	97.3	96.3	61.1	36.2	60.1			5050	4	36.2
09N06E34I	10/25/62	97.3	96.3	59.7	37.6	58.7			5050	5	37.6
09N06E34I	11/27/62	97.3	96.3	59.1	38.2	58.1			5050	6	38.2
09N06E34I	12/24/62	97.3	96.3	60.3	37	59.3		4	5050	7	37
09N06E34I	1/28/63	97.3	96.3	59	38.3	58			5050	8	38.3
09N06E34I	2/20/63	102.3	96.3	62.8	39.5	56.8			5050	9	39.5
09N06E34I	3/20/63	102.3	96.3	62.7	39.6	56.7			5050	10	39.6
09N06E34I	4/23/63	102.3	96.3	62.3	40	56.3			5050	11	40
09N06E34I	5/27/63	102.3	96.3	62.1	40.2	56.1			5050	12	40.2
09N06E34I	6/25/63	102.3	96.3	63.6	38.7	57.6			5050	13	38.7
09N06E34I	7/25/63	102.3	96.3	65.8	36.5	59.8			5050	14	36.5
09N06E34I	8/27/63	102.3	96.3					1	5050	15	0
09N06E34I	9/25/63	102.3	96.3					1	5050	16	0
09N06E34I	10/29/63	102.3	96.3					9	5050	17	0
09N06E34I	11/22/63	102.3	96.3	63.9	38.4	57.9			5050	18	38.4
09N06E34I	12/23/63	102.3	96.3	64.1	38.2	58.1			5050	19	38.2
09N06E34I	1/28/64	102.3	96.3	63.6	38.7	57.6			5050	20	38.7
09N06E34I	2/24/64	102.3	96.3					1	5050	21	0
09N06E34I	3/23/64	102.3	96.3					1	5050	22	0
09N06E34I	10/9/64	102.3	96.3	68.1	34.2	62.1			5108	23	34.2
09N06E34I	3/19/65	102.3	96.3	65.5	36.8	59.5			5108	24	36.8
09N06E34I	10/7/65	102.3	96.3					1	5108	25	0
09N06E34I	3/11/66	102.3	96.3					1	5108	26	0
09N06E34I	3/18/66	102.3	96.3	68.4	33.9	62.4			5050	27	33.9
09N06E34I	10/3/66	102.3	96.3					5	5050	28	0
09N06E34I	11/4/66	102.3	96.3	69.8	32.5	63.8			5050	29	32.5
09N06E34I	3/7/67	102.3	96.3					1	5050	30	0
09N06E34I	3/16/67	102.3	96.3	67.2	35.1	61.2			5050	31	35.1
09N06E34I	10/13/67	102.3	96.3	70.3	32	64.3			5050	32	32
09N06E34I	3/8/68	102.3	96.3	67.3	35	61.3		0	5050	33	35

09N06E34I	11/1/68	102.3	96.3	70.8	31.5	64.8			5050	34	31.5
09N06E34I	3/26/69	102.3	96.3	67.4	34.9	61.4			5050	35	34.9
09N06E34I	10/6/69	102.3	96.3	70	32.3	64			5050	36	32.3
09N06E34I	3/25/70	102.3	96.3	67.1	35.2	61.1			5050	37	35.2
09N06E34I	10/16/70	102.3	96.3	71	31.3	65			5050	38	31.3
09N06E34I	3/29/71	102.3	96.3	68.6	33.7	62.6			5050	39	33.7
09N06E34I	11/2/71	102.3	96.3	73.2	29.1	67.2	4		5050	40	29.1
09N06E34I	3/9/72	102.3	96.3	71.4	30.9	65.4			5050	41	30.9
09N06E34I	12/27/72	102.3	96.3	73.7	28.6	67.7			5050	42	28.6
09N06E34I	3/8/73	102.3	96.3	72.2	30.1	66.2			5050	43	30.1
09N06E34I	10/9/73	102.3	96.3	74.7	27.6	68.7			5050	44	27.6
09N06E34I	3/8/74	102.3	96.3	71.2	31.1	65.2			5050	45	31.1
09N06E34I	11/26/74	102.3	96.3	72.9	29.4	66.9			5050	46	29.4
09N06E34I	3/14/75	102.3	96.3	72.4	29.9	66.4			5050	47	29.9
09N06E34I	10/17/75	102.3	96.3	73.6	28.7	67.6			5050	48	28.7
09N06E34I	3/9/76	102.3	96.3	73.7	28.6	67.7			5050	49	28.6
09N06E34I	10/8/76	102.3	96.3					1	5050	50	0
09N06E34I	11/15/76	102.3	96.3	77.8	24.5	71.8			5050	51	24.5
09N06E34I	3/9/77	102.3	96.3	76.9	25.4	70.9			5050	52	25.4
09N06E34I	11/29/77	102.3	96.3	79.6	22.7	73.6			5050	53	22.7
09N06E34I	3/21/78	102.3	96.3	78.4	23.9	72.4			5050	54	23.9
09N06E34I	11/28/78	102.3	96.3	80.5	21.8	74.5			5050	55	21.8
09N06E34I	3/26/79	102.3	96.3	78.8	23.5	72.8			5050	56	23.5
09N06E34I	11/26/79	102.3	96.3	79.2	23.1	73.2			5050	57	23.1
09N06E34I	3/21/80	102.3	96.3	79.5	22.8	73.5			5050	58	22.8
09N06E34I	10/7/80	102.3	96.3					1	5050	59	0
09N06E34I	11/26/80	102.3	96.3	80.7	21.6	74.7			5050	60	21.6
09N06E34I	1/23/81	102.3	96.3	79	23.3	73			5050	61	23.3
09N06E34I	3/23/81	102.3	96.3	79	23.3	73			5050	62	23.3
09N06E34I	10/7/81	102.3	96.3	82.9	19.4	76.9			5050	63	19.4
09N06E34I	3/9/82	102.3	96.3	79.7	22.6	73.7			5050	64	22.6
09N06E34I	10/26/82	102.3	96.3	79.3	23	73.3			5050	65	23
09N06E34I	3/16/83	102.3	96.3	74.6	27.7	68.6			5050	66	27.7
09N06E34I	11/4/83	102.3	96.3	74.2	28.1	68.2			5050	67	28.1
09N06E34I	3/14/84	102.3	96.3	71.2	31.1	65.2			5050	68	31.1
09N06E34I	10/12/84	102.3	96.3	76.9	25.4	70.9			5050	69	25.4
09N06E34I	3/7/85	102.3	96.3	74.9	27.4	68.9			5050	70	27.4

09N06E34I	10/21/85	102.3	96.3	80.4	21.9	74.4			5050	71	21.9
09N06E34I	3/12/86	102.3	96.3	76.2	26.1	70.2			5050	72	26.1
09N06E34I	11/26/86	102.3	96.3	78.4	23.9	72.4			5050	73	23.9
09N06E34I	3/19/87	102.3	96.3					1	5050	74	0
09N06E34I	10/20/87	102.3	96.3					1	5050	75	0
09N06E34I	3/15/88	102.3	96.3					1	5050	76	0
09N06E34I	10/18/88	102.3	96.3	84.2	18.1	78.2			5050	77	18.1
09N06E34I	3/23/89	102.3	96.3	82.5	19.8	76.5			5050	78	19.8
09N06E34I	10/9/89	102.3	96.3	85.2	17.1	79.2			5050	79	17.1
09N06E34I	3/23/90	102.3	96.3	83.7	18.6	77.7			5050	80	18.6
09N06E34I	10/17/90	102.3	96.3	87.2	15.1	81.2			5050	81	15.1
09N06E34I	3/21/91	102.3	96.3	86.6	15.7	80.6			5050	82	15.7
09N06E34I	4/15/92	102.3	96.3					7	5050	83	0
09N06E34I	12/15/92	102.3	96.3					4	5050	84	0
09N06E34I	3/22/93	102.3	96.3	87.8	14.5	81.8			5050	85	14.5
09N06E34I	10/26/93	102.3	96.3	89.2	13.1	83.2			5050	86	13.1
09N06E34I	3/15/94	102.3	96.3	89	13.3	83			5050	87	13.3
09N06E34I	11/9/94	102.3	96.3	91.1	11.2	85.1			5050	88	11.2
09N06E34I	4/12/95	102.3	96.3	87.4	14.9	81.4			5050	89	14.9
09N06E34I	11/9/95	102.3	96.3	87.9	14.4	81.9			5050	90	14.4
09N06E34I	3/28/96	102.3	96.3	87.4	14.9	81.4			5050	91	14.9
09N06E34I	12/2/96	102.3	96.3	87.1	15.2	81.1			5050	92	15.2
09N06E34I	4/21/97	102.3	96.3	85	17.3	79			5050	93	17.3
09N06E34I	11/6/97	102.3	96.3	86.5	15.8	80.5			5050	94	15.8
09N06E34I	11/9/98	102.3	96.3	84.1	18.2	78.1			5050	95	18.2
09N06E34I	3/26/99	102.3	96.3	82	20.3	76			5050	96	20.3
09N06E34I	11/1/99	102.3	96.3	86.2	16.1	80.2			5050	97	16.1
09N06E34I	4/20/00	102.3	96.3	84.1	18.2	78.1			5050	98	18.2
09N06E34I	11/6/00	102.3	96.3	83.3	19	77.3			5050	99	19
09N06E34I	5/22/01	102.3	96.3	91.9	10.4	85.9			5050	100	10.4
09N06E34I	11/26/01	102.3	96.3	88.7	13.6	82.7			5050	101	13.6

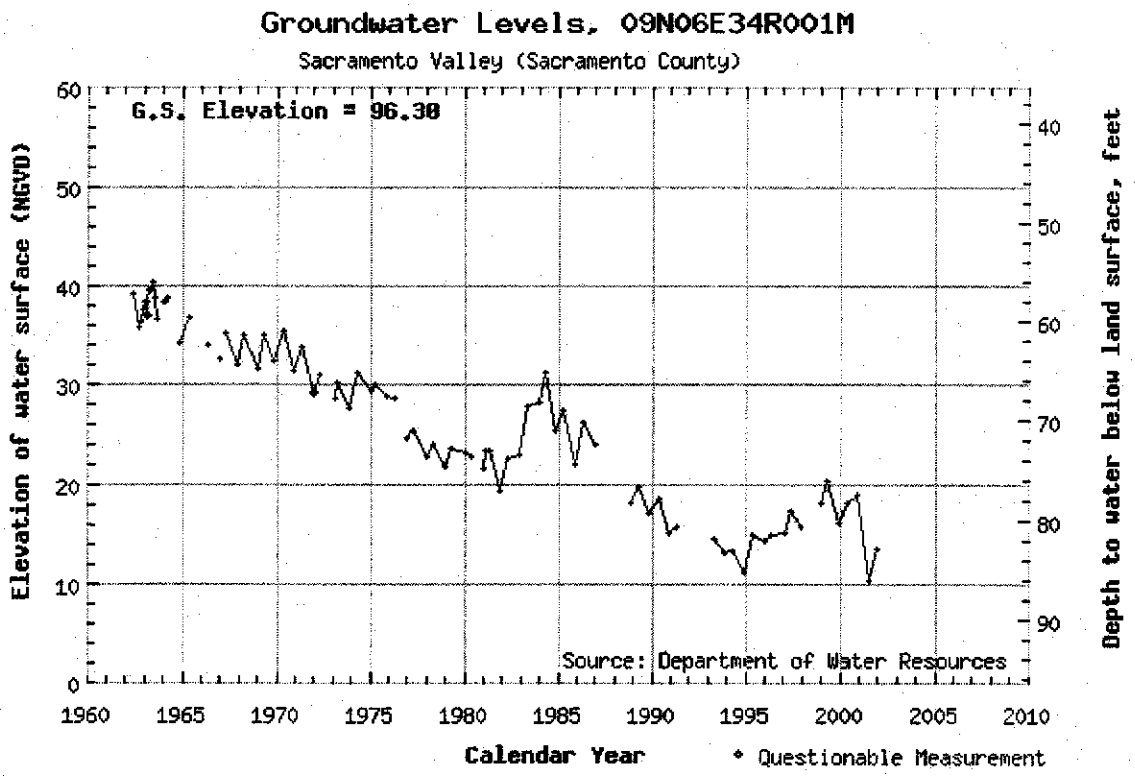
Query Results for 09N06E34R001M

DPLA Home

WDL Home

- *Water Quality*
- *Groundwater*

Your selection returned a total of **101** records. Wells in the Department of Water Resources monitoring network are identified by a State Well Number, which is based on the Public Land Grid System. The table headings and records contain several codes and abbreviations. Press the ***New Search*** or ***Nearby Search*** buttons or at the bottom of the page to begin a new data retrieval. Data for this well can also be downloaded in MS Excel or text delimited format.



Meas. Date	R.P. Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency
04-17-1962	97.3	96.3	58.2	39.1	57.2			5050
07-25-1962	97.3	96.3	61.5	35.8	60.5			5050
08-27-1962	97.3	96.3	61.5	35.8	60.5			5050
09-24-1962	97.3	96.3	61.1	36.2	60.1			5050
10-25-1962	97.3	96.3	59.7	37.6	58.7			5050
11-27-1962	97.3	96.3	59.1	38.2	58.1			5050
12-24-1962	97.3	96.3	60.3	37.0	59.3	4		5050
01-28-1963	97.3	96.3	59.0	38.3	58.0			5050
02-20-1963	102.3	96.3	62.8	39.5	56.8			5050
03-20-1963	102.3	96.3	62.7	39.6	56.7			5050
04-23-1963	102.3	96.3	62.3	40.0	56.3			5050
05-27-1963	102.3	96.3	62.1	40.2	56.1			5050
06-25-1963	102.3	96.3	63.6	38.7	57.6			5050
07-25-1963	102.3	96.3	65.8	36.5	59.8			5050
08-27-1963	102.3	96.3					1	5050
09-25-1963	102.3	96.3					1	5050

10-29-1963	102.3	96.3					9	5050
11-22-1963	102.3	96.3	63.9	38.4	57.9			5050
12-23-1963	102.3	96.3	64.1	38.2	58.1			5050
01-28-1964	102.3	96.3	63.6	38.7	57.6			5050
02-24-1964	102.3	96.3					1	5050
03-23-1964	102.3	96.3					1	5050
10-09-1964	102.3	96.3	68.1	34.2	62.1			5108
03-19-1965	102.3	96.3	65.5	36.8	59.5			5108
10-07-1965	102.3	96.3					1	5108
03-11-1966	102.3	96.3					1	5108
03-18-1966	102.3	96.3	68.4	33.9	62.4			5050
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03-07-1967	102.3	96.3					1	5050
03-16-1967	102.3	96.3	67.2	35.1	61.2			5050
10-13-1967	102.3	96.3	70.3	32.0	64.3			5050
03-08-1968	102.3	96.3	67.3	35.0	61.3	0		5050
11-01-1968	102.3	96.3	70.8	31.5	64.8			5050
03-26-1969	102.3	96.3	67.4	34.9	61.4			5050
10-06-1969	102.3	96.3	70.0	32.3	64.0			5050
03-25-1970	102.3	96.3	67.1	35.2	61.1			5050
10-16-1970	102.3	96.3	71.0	31.3	65.0			5050
03-29-1971	102.3	96.3	68.6	33.7	62.6			5050
11-02-1971	102.3	96.3	73.2	29.1	67.2	4		5050
03-09-1972	102.3	96.3	71.4	30.9	65.4			5050
12-27-1972	102.3	96.3	73.7	28.6	67.7			5050
03-08-1973	102.3	96.3	72.2	30.1	66.2			5050
10-09-1973	102.3	96.3	74.7	27.6	68.7			5050
03-08-1974	102.3	96.3	71.2	31.1	65.2			5050
11-26-1974	102.3	96.3	72.9	29.4	66.9			5050
03-14-1975	102.3	96.3	72.4	29.9	66.4			5050
10-17-1975	102.3	96.3	73.6	28.7	67.6			5050
03-09-1976	102.3	96.3	73.7	28.6	67.7			5050
10-08-1976	102.3	96.3					1	5050
11-15-1976	102.3	96.3	77.8	24.5	71.8			5050
03-09-1977	102.3	96.3	76.9	25.4	70.9			5050
11-29-1977	102.3	96.3	79.6	22.7	73.6			5050
03-21-1978	102.3	96.3	78.4	23.9	72.4			5050
11-28-1978	102.3	96.3	80.5	21.8	74.5			5050
03-26-1979	102.3	96.3	78.8	23.5	72.8			5050
11-26-1979	102.3	96.3	79.2	23.1	73.2			5050
03-21-1980	102.3	96.3	79.5	22.8	73.5			5050
10-07-1980	102.3	96.3					1	5050
11-26-1980	102.3	96.3	80.7	21.6	74.7			5050
01-23-1981	102.3	96.3	79.0	23.3	73.0			5050
03-23-1981	102.3	96.3	79.0	23.3	73.0			5050
10-07-1981	102.3	96.3	82.9	19.4	76.9			5050
03-09-1982	102.3	96.3	79.7	22.6	73.7			5050
10-26-1982	102.3	96.3	79.3	23.0	73.3			5050
03-16-1983	102.3	96.3	74.6	27.7	68.6			5050
11-04-1983	102.3	96.3	74.2	28.1	68.2			5050

03-14-1984	102.3	96.3	71.2	31.1	65.2		5050
10-12-1984	102.3	96.3	76.9	25.4	70.9		5050
03-07-1985	102.3	96.3	74.9	27.4	68.9		5050
10-21-1985	102.3	96.3	80.4	21.9	74.4		5050
03-12-1986	102.3	96.3	76.2	26.1	70.2		5050
11-26-1986	102.3	96.3	78.4	23.9	72.4		5050
03-19-1987	102.3	96.3				1	5050
10-20-1987	102.3	96.3				1	5050
03-15-1988	102.3	96.3				1	5050
10-18-1988	102.3	96.3	84.2	18.1	78.2		5050
03-23-1989	102.3	96.3	82.5	19.8	76.5		5050
10-09-1989	102.3	96.3	85.2	17.1	79.2		5050
03-23-1990	102.3	96.3	83.7	18.6	77.7		5050
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04-15-1992	102.3	96.3				7	5050
12-15-1992	102.3	96.3				4	5050
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10-26-1993	102.3	96.3	89.2	13.1	83.2		5050
03-15-1994	102.3	96.3	89.0	13.3	83.0		5050
11-09-1994	102.3	96.3	91.1	11.2	85.1		5050
04-12-1995	102.3	96.3	87.4	14.9	81.4		5050
11-09-1995	102.3	96.3	87.9	14.4	81.9		5050
03-28-1996	102.3	96.3	87.4	14.9	81.4		5050
12-02-1996	102.3	96.3	87.1	15.2	81.1		5050
04-21-1997	102.3	96.3	85.0	17.3	79.0		5050
11-06-1997	102.3	96.3	86.5	15.8	80.5		5050
11-09-1998	102.3	96.3	84.1	18.2	78.1		5050
03-26-1999	102.3	96.3	82.0	20.3	76.0		5050
11-01-1999	102.3	96.3	86.2	16.1	80.2		5050
04-20-2000	102.3	96.3	84.1	18.2	78.1		5050
11-06-2000	102.3	96.3	83.3	19.0	77.3		5050
05-22-2001	102.3	96.3	91.9	10.4	85.9		5050
11-26-2001	102.3	96.3	88.7	13.6	82.7		5050

For more information contact:
Department of Water Resources, Central District
Geology and Groundwater Section
3251 'S' Street
Sacramento, CA 95816

Phone: 916-227-7590
Fax: 916-227-7600

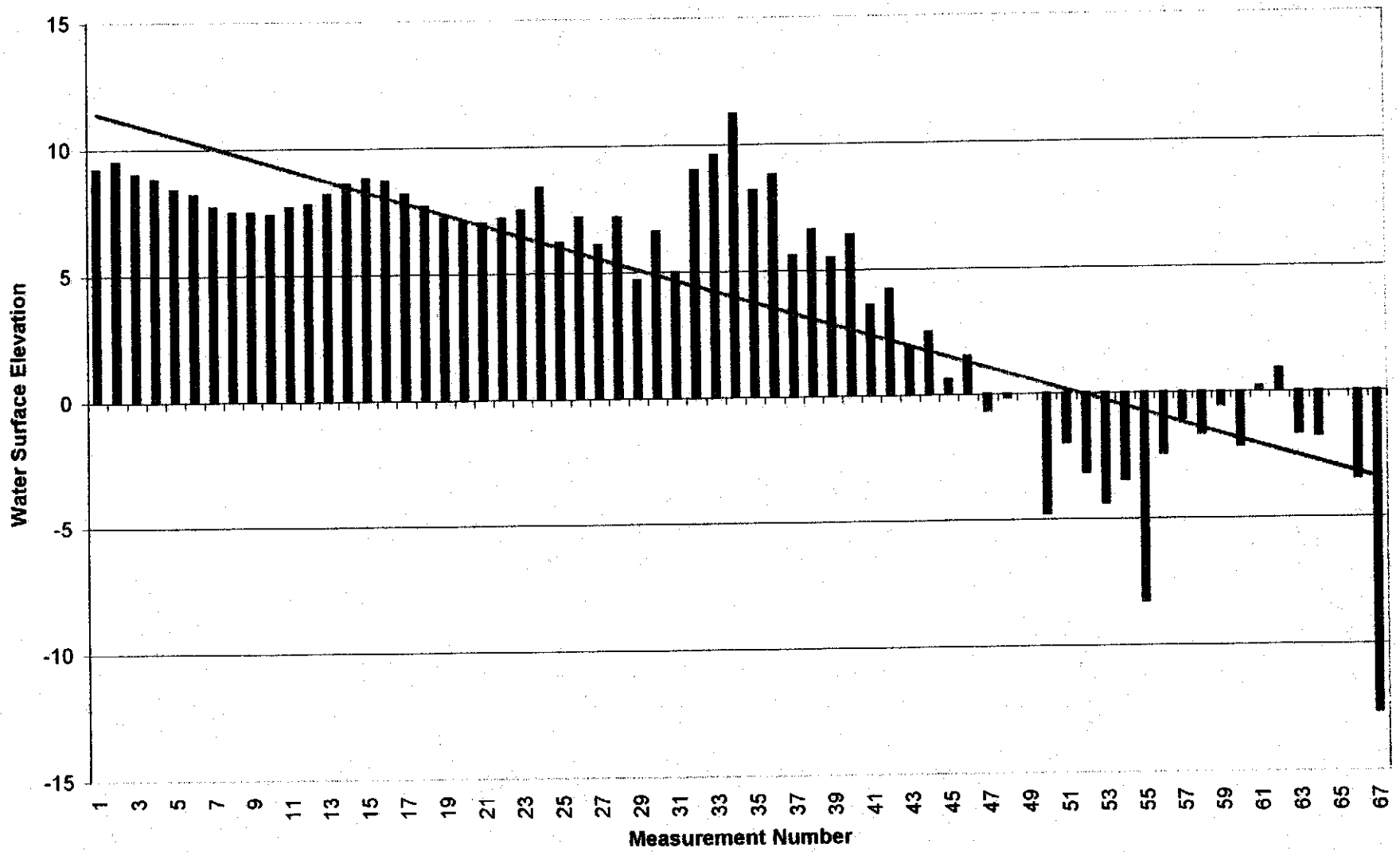
New Search

Search for wells within 0.5 mile radius. Nearby Search

Back

Send mail to webmaster with questions or comments about this web site.

Ground-Water Elevation Data 1977 to 2001; 08N06E09Q004M



State Well Number	Meas.Date	R.P.Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency
08N06E09Q004M	2/25/77	75.2	74	66	9.2	64.8			5050
08N06E09Q004M	3/24/77	75.2	74	65.7	9.5	64.5			5050
08N06E09Q004M	4/26/77	75.2	74	66.2	9	65			5050
08N06E09Q004M	5/25/77	75.2	74	66.4	8.8	65.2			5050
08N06E09Q004M	6/30/77	75.2	74	66.8	8.4	65.6			5050
08N06E09Q004M	7/28/77	75.2	74	67	8.2	65.8			5050
08N06E09Q004M	8/30/77	75.2	74	67.5	7.7	66.3			5050
08N06E09Q004M	9/28/77	75.2	74	67.7	7.5	66.5			5050
08N06E09Q004M	10/25/77	75.2	74	67.7	7.5	66.5			5050
08N06E09Q004M	11/29/77	75.2	74	67.8	7.4	66.6			5050
08N06E09Q004M	12/20/77	75.2	74	67.5	7.7	66.3			5050
08N06E09Q004M	1/25/78	75.2	74	67.4	7.8	66.2			5050
08N06E09Q004M	2/23/78	75.2	74	67	8.2	65.8			5050
08N06E09Q004M	3/30/78	75.2	74	66.6	8.6	65.4			5050
08N06E09Q004M	4/26/78	75.2	74	66.4	8.8	65.2			5050
08N06E09Q004M	5/31/78	75.2	74	66.5	8.7	65.3			5050
08N06E09Q004M	6/27/78	75.2	74	67	8.2	65.8			5050
08N06E09Q004M	7/25/78	75.2	74	67.5	7.7	66.3			5050
08N06E09Q004M	8/29/78	75.2	74	68	7.2	66.8			5050
08N06E09Q004M	9/26/78	75.2	74	68.2	7	67			5050
08N06E09Q004M	10/26/78	75.2	74	68.2	7	67			5050
08N06E09Q004M	11/28/78	75.2	74	68	7.2	66.8			5050
08N06E09Q004M	12/18/78	75.2	74	67.7	7.5	66.5			5050
08N06E09Q004M	3/26/79	75.2	74	66.8	8.4	65.6			5050
08N06E09Q004M	10/5/79	75.2	74	69	6.2	67.8			5050
08N06E09Q004M	3/21/80	75.2	74	68	7.2	66.8			5050
08N06E09Q004M	10/7/80	75.2	74	69.1	6.1	67.9			5050
08N06E09Q004M	3/23/81	75.2	74	68	7.2	66.8			5050
08N06E09Q004M	10/1/81	75.2	74	70.5	4.7	69.3			5050
08N06E09Q004M	3/22/82	75.2	74	68.6	6.6	67.4			5050
08N06E09Q004M	10/20/82	75.2	74	70.2	5	69			5050
08N06E09Q004M	3/16/83	75.2	74	66.2	9	65			5050
08N06E09Q004M	10/7/83	75.2	74	65.6	9.6	64.4			5050
08N06E09Q004M	3/15/84	75.2	74	64	11.2	62.8			5050
08N06E09Q004M	10/19/84	75.2	74	67	8.2	65.8			5050
08N06E09Q004M	3/7/85	75.2	74	66.4	8.8	65.2			5050

08N06E09Q004M	10/16/85	75.2	74	69.6	5.6	68.4		5050
08N06E09Q004M	3/17/86	75.2	74	68.6	6.6	67.4		5050
08N06E09Q004M	10/20/86	75.2	74	69.7	5.5	68.5		5050
08N06E09Q004M	3/19/87	75.2	74	68.8	6.4	67.6		5050
08N06E09Q004M	10/19/87	75.2	74	71.6	3.6	70.4		5050
08N06E09Q004M	3/16/88	75.2	74	71	4.2	69.8		5050
08N06E09Q004M	10/17/88	75.2	74	73.3	1.9	72.1		5050
08N06E09Q004M	3/10/89	75.2	74	72.7	2.5	71.5		5050
08N06E09Q004M	10/9/89	75.2	74	74.6	0.6	73.4		5050
08N06E09Q004M	3/23/90	75.2	74	73.7	1.5	72.5		5050
08N06E09Q004M	10/18/90	75.2	74	75.9	-0.7	74.7		5050
08N06E09Q004M	3/13/91	75.2	74	75.4	-0.2	74.2		5050
08N06E09Q004M	4/15/92	75.2	74				7	5050
08N06E09Q004M	12/15/92	75.2	74	80	-4.8	78.8		5050
08N06E09Q004M	4/15/93	75.2	74	77.2	-2	76		5050
08N06E09Q004M	11/17/93	75.2	74	78.4	-3.2	77.2		5050
08N06E09Q004M	3/16/94	75.2	74	79.6	-4.4	78.4		5050
08N06E09Q004M	12/5/94	75.2	74	78.7	-3.5	77.5		5050
08N06E09Q004M	4/17/95	75.2	74	83.5	-8.3	82.3		5050
08N06E09Q004M	12/8/95	75.2	74	77.7	-2.5	76.5		5050
08N06E09Q004M	4/26/96	75.2	74	76.3	-1.1	75.1		5050
08N06E09Q004M	12/11/96	75.2	74	76.9	-1.7	75.7		5050
08N06E09Q004M	4/21/97	75.2	74	75.8	-0.6	74.6		5050
08N06E09Q004M	11/6/97	75.2	74	77.4	-2.2	76.2		5050
08N06E09Q004M	11/9/98	75.2	74	75	0.2	73.8		5050
08N06E09Q004M	4/26/99	75.2	74	74.3	0.9	73.1		5050
08N06E09Q004M	11/3/99	75.2	74	76.9	-1.7	75.7		5050
08N06E09Q004M	5/3/00	75.2	74	77	-1.8	75.8		5050
08N06E09Q004M	11/6/00	75.2	74				1	5050
08N06E09Q004M	5/23/01	75.2	74	78.7	-3.5	77.5		5050
08N06E09Q004M	11/26/01	75.2	74	87.9	-12.7	86.7		5050

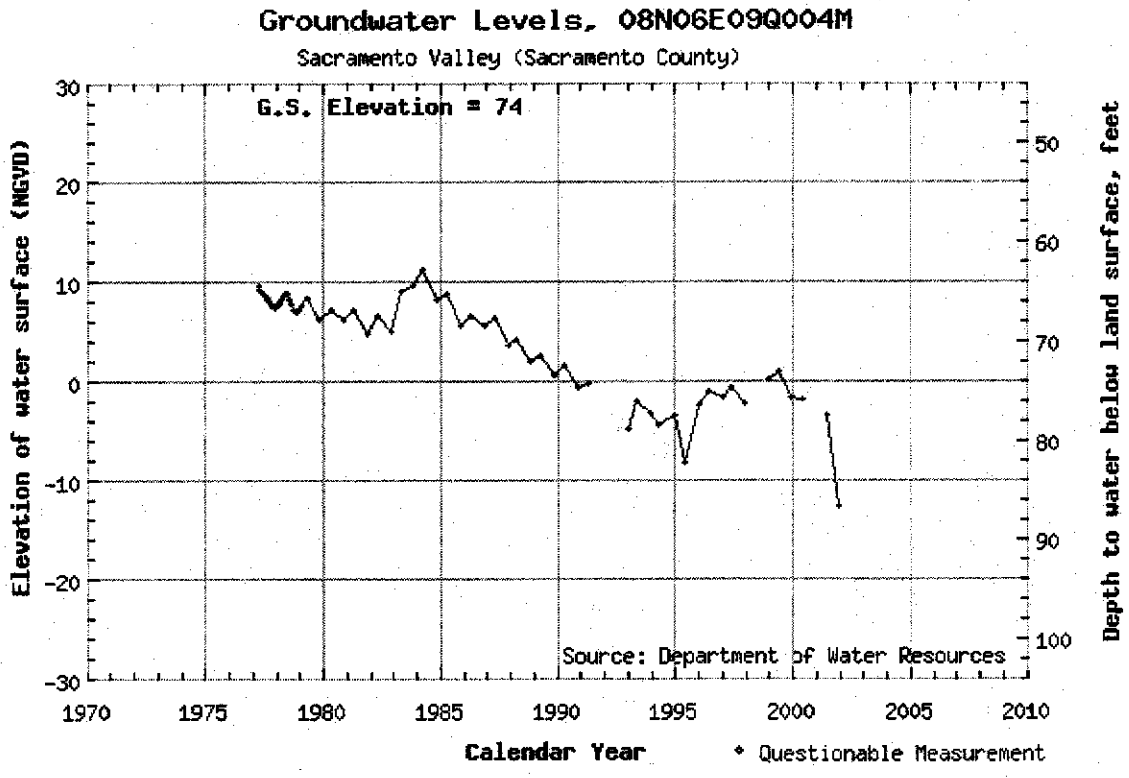
Query Results for 08N06E09Q004M

DPLA Home

WDL Home

- Water Quality
- Groundwater

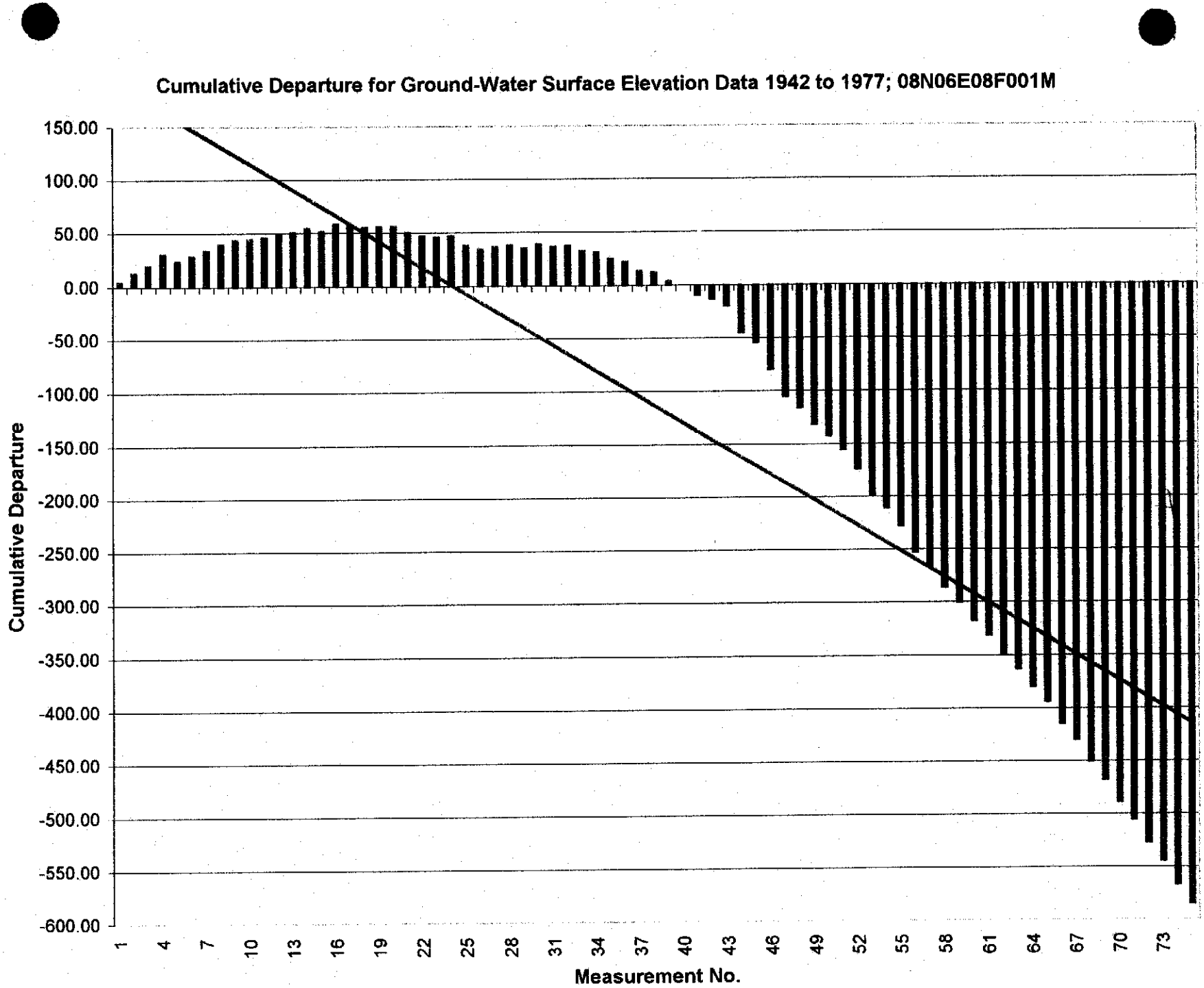
Your selection returned a total of **67** records. Wells in the Department of Water Resources monitoring network are identified by a State Well Number, which is based on the Public Land Grid System. The table headings and records contain several codes and abbreviations. Press the ***New Search*** or ***Nearby Search*** buttons or at the bottom of the page to begin a new data retrieval. Data for this well can also be downloaded in MS Excel or text delimited format.



Meas. Date	R.P. Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency
02-25-1977	75.2	74.0	66.0	9.2	64.8			5050
03-24-1977	75.2	74.0	65.7	9.5	64.5			5050
04-26-1977	75.2	74.0	66.2	9.0	65.0			5050
05-25-1977	75.2	74.0	66.4	8.8	65.2			5050
06-30-1977	75.2	74.0	66.8	8.4	65.6			5050
07-28-1977	75.2	74.0	67.0	8.2	65.8			5050
08-30-1977	75.2	74.0	67.5	7.7	66.3			5050
09-28-1977	75.2	74.0	67.7	7.5	66.5			5050
10-25-1977	75.2	74.0	67.7	7.5	66.5			5050
11-29-1977	75.2	74.0	67.8	7.4	66.6			5050
12-20-1977	75.2	74.0	67.5	7.7	66.3			5050
01-25-1978	75.2	74.0	67.4	7.8	66.2			5050
02-23-1978	75.2	74.0	67.0	8.2	65.8			5050
03-30-1978	75.2	74.0	66.6	8.6	65.4			5050
04-26-1978	75.2	74.0	66.4	8.8	65.2			5050
05-31-1978	75.2	74.0	66.5	8.7	65.3			5050
06-27-1978	75.2	74.0	67.0	8.2	65.8			5050

07-25-1978	75.2	74.0	67.5	7.7	66.3		5050
08-29-1978	75.2	74.0	68.0	7.2	66.8		5050
09-26-1978	75.2	74.0	68.2	7.0	67.0		5050
10-26-1978	75.2	74.0	68.2	7.0	67.0		5050
11-28-1978	75.2	74.0	68.0	7.2	66.8		5050
12-18-1978	75.2	74.0	67.7	7.5	66.5		5050
03-26-1979	75.2	74.0	66.8	8.4	65.6		5050
10-05-1979	75.2	74.0	69.0	6.2	67.8		5050
03-21-1980	75.2	74.0	68.0	7.2	66.8		5050
10-07-1980	75.2	74.0	69.1	6.1	67.9		5050
03-23-1981	75.2	74.0	68.0	7.2	66.8		5050
10-01-1981	75.2	74.0	70.5	4.7	69.3		5050
03-22-1982	75.2	74.0	68.6	6.6	67.4		5050
10-20-1982	75.2	74.0	70.2	5.0	69.0		5050
03-16-1983	75.2	74.0	66.2	9.0	65.0		5050
10-07-1983	75.2	74.0	65.6	9.6	64.4		5050
03-15-1984	75.2	74.0	64.0	11.2	62.8		5050
10-19-1984	75.2	74.0	67.0	8.2	65.8		5050
03-07-1985	75.2	74.0	66.4	8.8	65.2		5050
10-16-1985	75.2	74.0	69.6	5.6	68.4		5050
03-17-1986	75.2	74.0	68.6	6.6	67.4		5050
10-20-1986	75.2	74.0	69.7	5.5	68.5		5050
03-19-1987	75.2	74.0	68.8	6.4	67.6		5050
10-19-1987	75.2	74.0	71.6	3.6	70.4		5050
03-16-1988	75.2	74.0	71.0	4.2	69.8		5050
10-17-1988	75.2	74.0	73.3	1.9	72.1		5050
03-10-1989	75.2	74.0	72.7	2.5	71.5		5050
10-09-1989	75.2	74.0	74.6	0.6	73.4		5050
03-23-1990	75.2	74.0	73.7	1.5	72.5		5050
10-18-1990	75.2	74.0	75.9	-0.7	74.7		5050
03-13-1991	75.2	74.0	75.4	-0.2	74.2		5050
04-15-1992	75.2	74.0				7	5050
12-15-1992	75.2	74.0	80.0	-4.8	78.8		5050
04-15-1993	75.2	74.0	77.2	-2.0	76.0		5050
11-17-1993	75.2	74.0	78.4	-3.2	77.2		5050
03-16-1994	75.2	74.0	79.6	-4.4	78.4		5050
12-05-1994	75.2	74.0	78.7	-3.5	77.5		5050
04-17-1995	75.2	74.0	83.5	-8.3	82.3		5050
12-08-1995	75.2	74.0	77.7	-2.5	76.5		5050
04-26-1996	75.2	74.0	76.3	-1.1	75.1		5050
12-11-1996	75.2	74.0	76.9	-1.7	75.7		5050
04-21-1997	75.2	74.0	75.8	-0.6	74.6		5050
11-06-1997	75.2	74.0	77.4	-2.2	76.2		5050
11-09-1998	75.2	74.0	75.0	0.2	73.8		5050
04-26-1999	75.2	74.0	74.3	0.9	73.1		5050
11-03-1999	75.2	74.0	76.9	-1.7	75.7		5050
05-03-2000	75.2	74.0	77.0	-1.8	75.8		5050
11-06-2000	75.2	74.0				1	5050
05-23-2001	75.2	74.0	78.7	-3.5	77.5		5050
11-26-2001	75.2	74.0	87.9	-12.7	86.7		5050

For more information contact:
Department of Water Resources, Central District
Geology and Groundwater Section
3251 'S' Street


Cumulative Departure for Ground-Water Surface Elevation Data 1942 to 1977; 08N06E08F001M
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Measurement No.

State Well	Meas.Date	R.P.Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency	Measurement No.	WSE		Departure	Cumulative Departure
08N06E08I	8/5/42	57.8	57.8	27.8	30	27.8			5001	0	0			
08N06E08I	9/9/42	57.8	57.8	23.6	34.2	23.6			5001	1	30		4.46	4.46
08N06E08I	12/17/42	57.8	57.8	25.6	32.2	25.6			5001	2	34.2		8.66	13.12
08N06E08I	4/14/43	57.8	57.8	21.8	36	21.8			5001	3	32.2		6.66	19.78
08N06E08I	7/29/43	57.8	57.8	39.2	18.6	39.2			5001	4	36		10.46	30.24
08N06E08I	2/12/46	57.8	57.8	27	30.8	27			5001	5	18.6		-6.94	23.30
08N06E08I	3/8/46	57.8	57.8	26.9	30.9	26.9			5001	6	30.8		5.26	28.56
08N06E08I	4/11/46	57.8	57.8	26.7	31.1	26.7			5001	7	30.9		5.36	33.92
08N06E08I	7/18/46	57.8	57.8	28	29.8	28			5001	8	31.1		5.56	39.48
08N06E08I	10/3/46	57.8	57.8	31.5	26.3	31.5			5001	9	29.8		4.26	43.74
08N06E08I	1/6/47	57.8	57.8	31	26.8	31			5001	10	26.3		0.76	44.50
08N06E08I	1/8/47	57.8	57.8	29.4	28.4	29.4			5001	11	26.8		1.26	45.76
08N06E08I	4/1/47	57.8	57.8	30	27.8	30			5001	12	28.4		2.86	48.62
08N06E08I	4/4/47	57.8	57.8	28.5	29.3	28.5			5001	13	27.8		2.26	50.88
08N06E08I	7/6/47	57.8	57.8	35.4	22.4	35.4			5001	14	29.3		3.76	54.64
08N06E08I	7/11/47	57.8	57.8	25.2	32.6	25.2			5001	15	22.4		-3.14	51.50
08N06E08I	10/2/47	57.8	57.8	33.5	24.3	33.5			5001	16	32.6		7.06	58.56
08N06E08I	10/5/47	57.8	57.8	34.3	23.5	34.3			5001	17	24.3		-1.24	57.32
08N06E08I	1/3/49	57.8	57.8	31.7	26.1	31.7			5001	18	23.5		-2.04	55.28
08N06E08I	4/12/49	57.8	57.8	32.1	25.7	32.1			5001	19	26.1		0.56	55.84
08N06E08I	7/7/49	57.8	57.8	37.9	19.9	37.9			5001	20	25.7		0.16	56.00
08N06E08I	10/6/49	57.8	57.8	36.2	21.6	36.2			5001	21	19.9		-5.64	50.36
08N06E08I	1/11/50	57.8	57.8	32.9	24.9	32.9			5001	22	21.6		-3.94	46.42
08N06E08I	4/14/50	57.8	57.8	31.2	26.6	31.2			5001	23	24.9		-0.64	45.78
08N06E08I	8/18/50	57.8	57.8	40.9	16.9	40.9			5001	24	26.6		1.06	46.84
08N06E08I	10/17/50	57.8	57.8	36.2	21.6	36.2			5001	25	16.9		-8.64	38.20
08N06E08I	1/30/51	57.8	57.8	29.8	28	29.8			5001	26	21.6		-3.94	34.26
08N06E08I	4/11/51	57.8	57.8	30.6	27.2	30.6			5001	27	28		2.46	36.72
08N06E08I	10/25/51	57.8	57.8	35.8	22	35.8			5001	28	27.2		1.66	38.38
08N06E08I	4/15/52	57.8	57.8	28.1	29.7	28.1			5001	29	22		-3.54	34.84
08N06E08I	10/27/52	57.8	57.8	34.5	23.3	34.5			5001	30	29.7		4.16	39.00
08N06E08I	3/18/53	57.8	57.8	31.6	26.2	31.6			5001	31	23.3		-2.24	36.76
08N06E08I	11/3/53	57.8	57.8	37.7	20.1	37.7			5001	32	26.2		0.66	37.42
08N06E08I	4/8/54	57.8	57.8	33	24.8	33			5001	33	20.1		-5.44	31.98
08N06E08I	10/27/54	57.8	57.8	38.5	19.3	38.5			5001	34	24.8		-0.74	31.24
08N06E08I	3/29/55	57.8	57.8	35.6	22.2	35.6			5001	35	19.3		-6.24	25.00
08N06E08I	10/31/55	57.8	57.8	40.5	17.3	40.5			5001	36	22.2		-3.34	21.66
08N06E08I	3/29/56	57.8	57.8	33.9	23.9	33.9			5001	37	17.3		-8.24	13.42
08N06E08I	10/22/56	57.8	57.8	39.9	17.9	39.9			5001	38	23.9		-1.64	11.78
08N06E08I	4/2/57	57.8	57.8	36.4	21.4	36.4			5001	39	17.9		-7.64	4.14
08N06E08I	10/23/57	57.8	57.8	41.9	15.9	41.9			5001	40	21.4	25.54	-4.14	0.00
08N06E08I	4/30/58	57.8	57.8	36.2	21.6	36.2			5001	41	15.9		-9.64	-9.64
08N06E08I	4/6/59	57.8	57.8	38.5	19.3	38.5			5001	42	21.6		-3.94	-13.58
08N06E08I	11/10/59	57.8	57.8	69.8	-12	69.8			5001	43	19.3		-6.24	-19.82
08N06E08I	2/16/60	57.8	57.8	41.2	16.6	41.2		3	5050	44	0		-25.54	-45.36

08N06E08I	4/13/61	57.8	57.8				3	5050	45	16.6	-8.94	-54.30
08N06E08I	10/5/61	57.8	57.8				3	5050	46	0	-25.54	-79.84
08N06E08I	3/9/62	57.8	57.8	43	14.8	43		5050	47	0	-25.54	-105.38
08N06E08I	10/11/62	57.8	57.8	47.8	10	47.8		5050	48	14.8	-10.74	-116.12
08N06E08I	3/21/63	57.8	57.8	42.9	14.9	42.9		5050	49	10	-15.54	-131.66
08N06E08I	10/17/63	57.8	57.8	45.8	12	45.8		5108	50	14.9	-10.64	-142.30
08N06E08I	4/6/64	57.8	57.8	50.3	7.5	50.3		5108	51	12	-13.54	-155.84
08N06E08I	10/9/64	57.8	57.8				3	5108	52	7.5	-18.04	-173.88
08N06E08I	3/12/65	57.8	57.8	43.8	14	43.8		5108	53	0	-25.54	-199.42
08N06E08I	10/7/65	57.8	57.8	49.3	8.5	49.3		5108	54	14	-11.54	-210.96
08N06E08I	3/11/66	57.8	57.8				3	5108	55	8.5	-17.04	-228.00
08N06E08I	3/18/66	57.8	57.8	45.7	12.1	45.7		5050	56	0	-25.54	-253.54
08N06E08I	10/6/66	57.8	57.8	51.9	5.9	51.9		5050	57	12.1	-13.44	-266.98
08N06E08I	3/9/67	57.8	57.8	46.2	11.6	46.2		5050	58	5.9	-19.64	-286.62
08N06E08I	10/9/67	57.8	57.8	49.5	8.3	49.5		5050	59	11.6	-13.94	-300.56
08N06E08I	3/13/68	57.8	57.8	46.1	11.7	46.1		5050	60	8.3	-17.24	-317.80
08N06E08I	10/14/68	57.8	57.8	50.9	6.9	50.9		5050	61	11.7	-13.84	-331.64
08N06E08I	4/3/69	57.8	57.8	45.2	12.6	45.2		5050	62	6.9	-18.64	-350.28
08N06E08I	10/22/69	57.8	57.8	49.2	8.6	49.2		5050	63	12.6	-12.94	-363.22
08N06E08I	3/23/70	57.8	57.8	46.3	11.5	46.3		5050	64	8.6	-16.94	-380.16
08N06E08I	10/15/70	57.8	57.8	53	4.8	53		5050	65	11.5	-14.04	-394.20
08N06E08I	3/17/71	57.8	57.8	47.9	9.9	47.9		5050	66	4.8	-20.74	-414.94
08N06E08I	10/18/71	57.8	57.8	52.5	5.3	52.5		5050	67	9.9	-15.64	-430.58
08N06E08I	3/10/72	57.8	57.8	49.3	8.5	49.3		5050	68	5.3	-20.24	-450.82
08N06E08I	10/11/72	57.8	57.8	53.4	4.4	53.4		5050	69	8.5	-17.04	-467.86
08N06E08I	3/21/73	57.8	57.8	48.9	8.9	48.9		5050	70	4.4	-21.14	-489.00
08N06E08I	10/8/73	57.8	57.8	53.7	4.1	53.7		5050	71	8.9	-16.64	-505.64
08N06E08I	5/7/74	57.8	57.8	49.8	8	49.8		5050	72	4.1	-21.44	-527.08
08N06E08I	10/16/74	57.8	57.8	54.8	3	54.8		5050	73	8	-17.54	-544.62
08N06E08I	4/10/75	57.8	57.8	50.7	7.1	50.7		5050	74	3	-22.54	-567.16
08N06E08I	10/27/75	57.8	57.8				6	5050	75	7.1	-18.44	-585.60

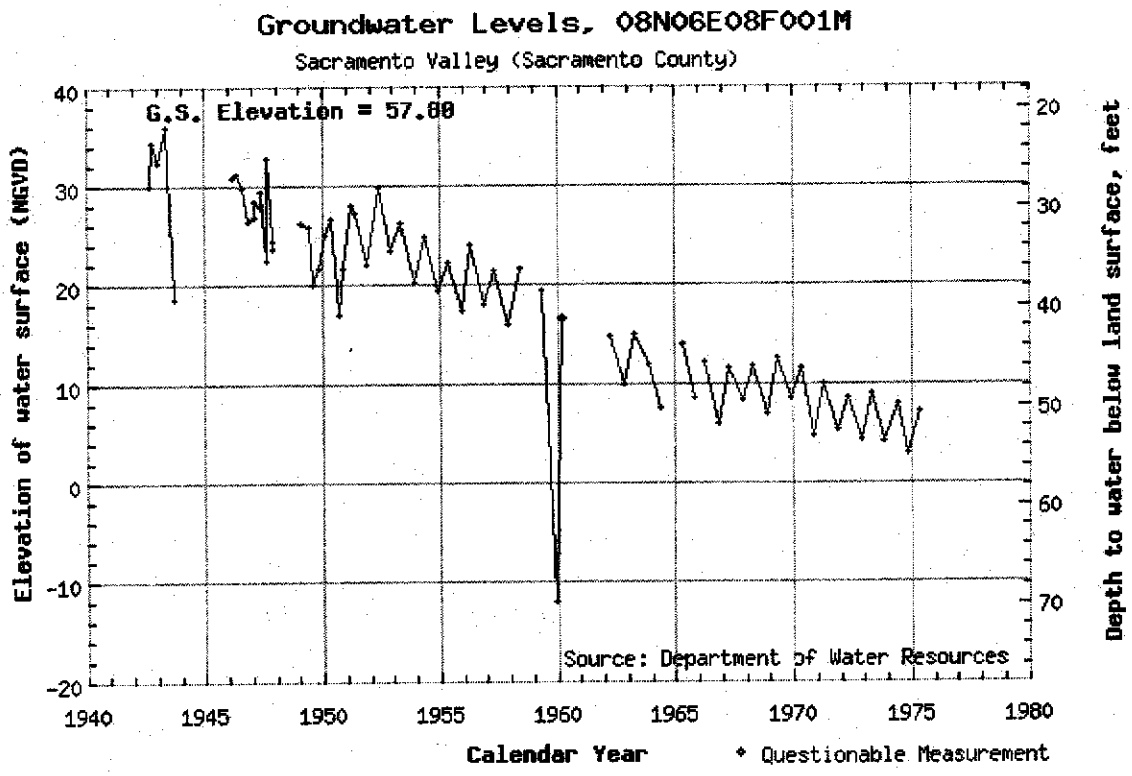
Query Results for 08N06E08F001M

DPLA Home

WDL Home

- *Water Quality*
- *Groundwater*

Your selection returned a total of **76** records. Wells in the Department of Water Resources monitoring network are identified by a State Well Number, which is based on the Public Land Grid System. The table headings and records contain several codes and abbreviations. Press the ***New Search*** or ***Nearby Search*** buttons or at the bottom of the page to begin a new data retrieval. Data for this well can also be downloaded in MS Excel or text delimited format.



Meas. Date	R.P. Elev.	G.S. Elev.	RPWS	WSE	GSWS	QMC	NMC	Agency
08-05-1942	57.8	57.8	27.8	30.0	27.8			5001
09-09-1942	57.8	57.8	23.6	34.2	23.6			5001
12-17-1942	57.8	57.8	25.6	32.2	25.6			5001
04-14-1943	57.8	57.8	21.8	36.0	21.8			5001
07-29-1943	57.8	57.8	39.2	18.6	39.2			5001
02-12-1946	57.8	57.8	27.0	30.8	27.0			5001
03-08-1946	57.8	57.8	26.9	30.9	26.9			5001
04-11-1946	57.8	57.8	26.7	31.1	26.7			5001
07-18-1946	57.8	57.8	28.0	29.8	28.0			5001
10-03-1946	57.8	57.8	31.5	26.3	31.5			5001
01-06-1947	57.8	57.8	31.0	26.8	31.0			5001
01-08-1947	57.8	57.8	29.4	28.4	29.4			5001
04-01-1947	57.8	57.8	30.0	27.8	30.0			5001
04-04-1947	57.8	57.8	28.5	29.3	28.5			5001
07-06-1947	57.8	57.8	35.4	22.4	35.4			5001
07-11-1947	57.8	57.8	25.2	32.6	25.2			5001
10-02-1947	57.8	57.8	33.5	24.3	33.5			5001

10-05-1947	57.8	57.8	34.3	23.5	34.3			5001
01-03-1949	57.8	57.8	31.7	26.1	31.7			5001
04-12-1949	57.8	57.8	32.1	25.7	32.1			5001
07-07-1949	57.8	57.8	37.9	19.9	37.9			5001
10-06-1949	57.8	57.8	36.2	21.6	36.2			5001
01-11-1950	57.8	57.8	32.9	24.9	32.9			5001
04-14-1950	57.8	57.8	31.2	26.6	31.2			5001
08-18-1950	57.8	57.8	40.9	16.9	40.9			5001
10-17-1950	57.8	57.8	36.2	21.6	36.2			5001
01-30-1951	57.8	57.8	29.8	28.0	29.8			5001
04-11-1951	57.8	57.8	30.6	27.2	30.6			5001
10-25-1951	57.8	57.8	35.8	22.0	35.8			5001
04-15-1952	57.8	57.8	28.1	29.7	28.1			5001
10-27-1952	57.8	57.8	34.5	23.3	34.5			5001
03-18-1953	57.8	57.8	31.6	26.2	31.6			5001
11-03-1953	57.8	57.8	37.7	20.1	37.7			5001
04-08-1954	57.8	57.8	33.0	24.8	33.0			5001
10-27-1954	57.8	57.8	38.5	19.3	38.5			5001
03-29-1955	57.8	57.8	35.6	22.2	35.6			5001
10-31-1955	57.8	57.8	40.5	17.3	40.5			5001
03-29-1956	57.8	57.8	33.9	23.9	33.9			5001
10-22-1956	57.8	57.8	39.9	17.9	39.9			5001
04-02-1957	57.8	57.8	36.4	21.4	36.4			5001
10-23-1957	57.8	57.8	41.9	15.9	41.9			5001
04-30-1958	57.8	57.8	36.2	21.6	36.2			5001
04-06-1959	57.8	57.8	38.5	19.3	38.5			5001
11-10-1959	57.8	57.8	69.8	-12.0	69.8			5001
02-16-1960	57.8	57.8	41.2	16.6	41.2	3		5050
04-13-1961	57.8	57.8					3	5050
10-05-1961	57.8	57.8					3	5050
03-09-1962	57.8	57.8	43.0	14.8	43.0			5050
10-11-1962	57.8	57.8	47.8	10.0	47.8			5050
03-21-1963	57.8	57.8	42.9	14.9	42.9			5050
10-17-1963	57.8	57.8	45.8	12.0	45.8			5108
04-06-1964	57.8	57.8	50.3	7.5	50.3			5108
10-09-1964	57.8	57.8					3	5108
03-12-1965	57.8	57.8	43.8	14.0	43.8			5108
10-07-1965	57.8	57.8	49.3	8.5	49.3			5108
03-11-1966	57.8	57.8					3	5108
03-18-1966	57.8	57.8	45.7	12.1	45.7			5050
10-06-1966	57.8	57.8	51.9	5.9	51.9			5050
03-09-1967	57.8	57.8	46.2	11.6	46.2			5050
10-09-1967	57.8	57.8	49.5	8.3	49.5			5050
03-13-1968	57.8	57.8	46.1	11.7	46.1			5050
10-14-1968	57.8	57.8	50.9	6.9	50.9			5050
04-03-1969	57.8	57.8	45.2	12.6	45.2			5050
10-22-1969	57.8	57.8	49.2	8.6	49.2			5050
03-23-1970	57.8	57.8	46.3	11.5	46.3			5050
10-15-1970	57.8	57.8	53.0	4.8	53.0			5050
03-17-1971	57.8	57.8	47.9	9.9	47.9			5050
10-18-1971	57.8	57.8	52.5	5.3	52.5			5050
03-10-1972	57.8	57.8	49.3	8.5	49.3			5050
10-11-1972	57.8	57.8	53.4	4.4	53.4			5050

03-21-1973	57.8	57.8	48.9	8.9	48.9		5050
10-08-1973	57.8	57.8	53.7	4.1	53.7		5050
05-07-1974	57.8	57.8	49.8	8.0	49.8		5050
10-16-1974	57.8	57.8	54.8	3.0	54.8		5050
04-10-1975	57.8	57.8	50.7	7.1	50.7		5050
10-27-1975	57.8	57.8				6	5050

For more information contact:
Department of Water Resources, Central District
Geology and Groundwater Section
3251 'S' Street
Sacramento, CA 95816

Phone: 916-227-7590
Fax: 916-227-7600

New Search

Search for wells within 0.5 mile radius. Nearby Search

Back

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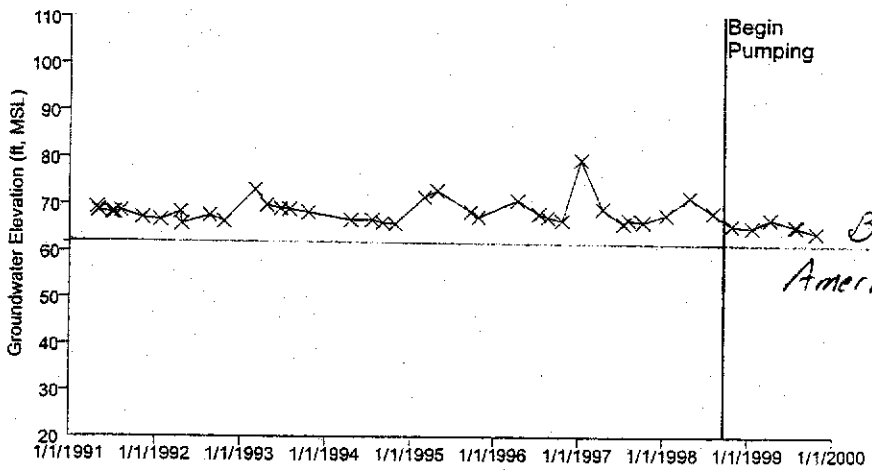
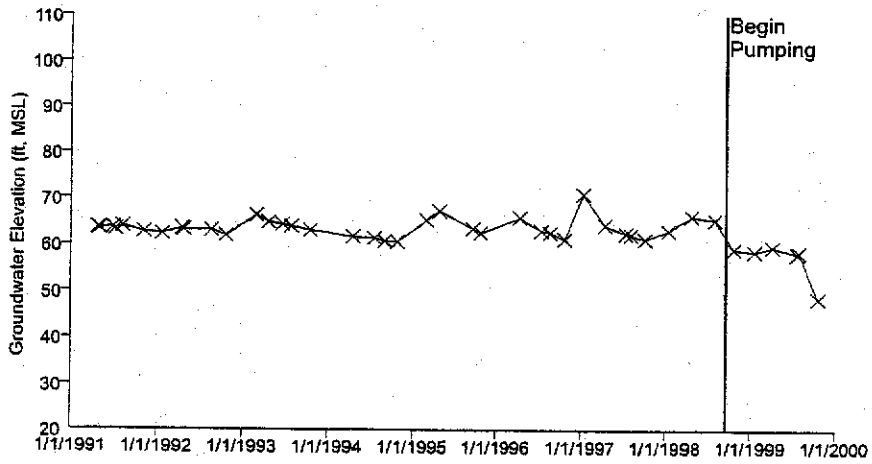
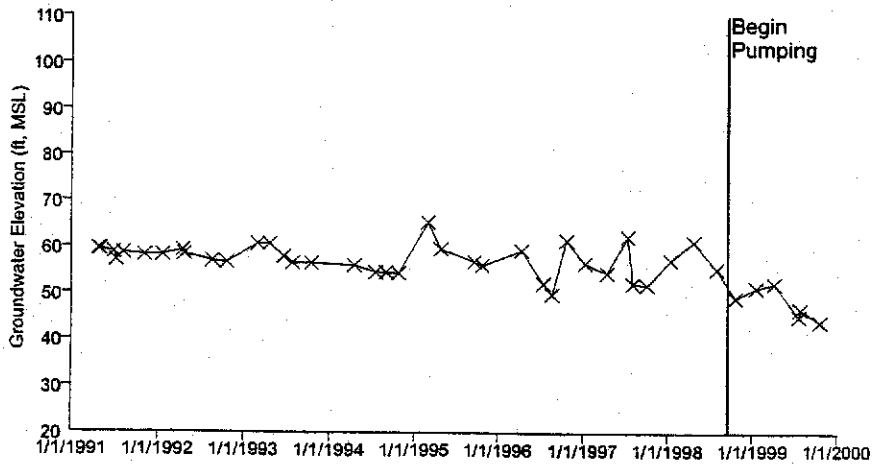
Well 1481

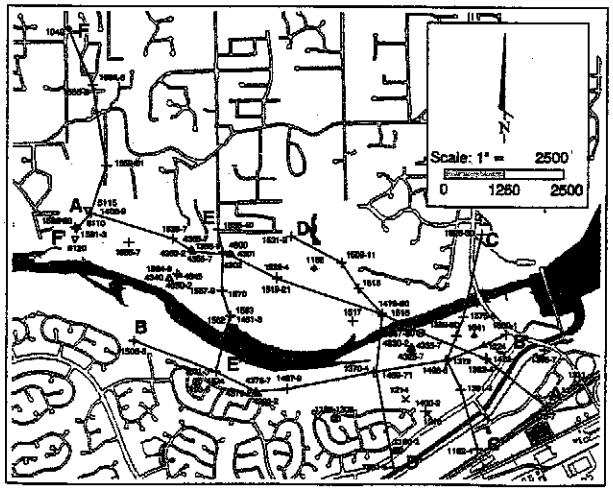


Well 1482

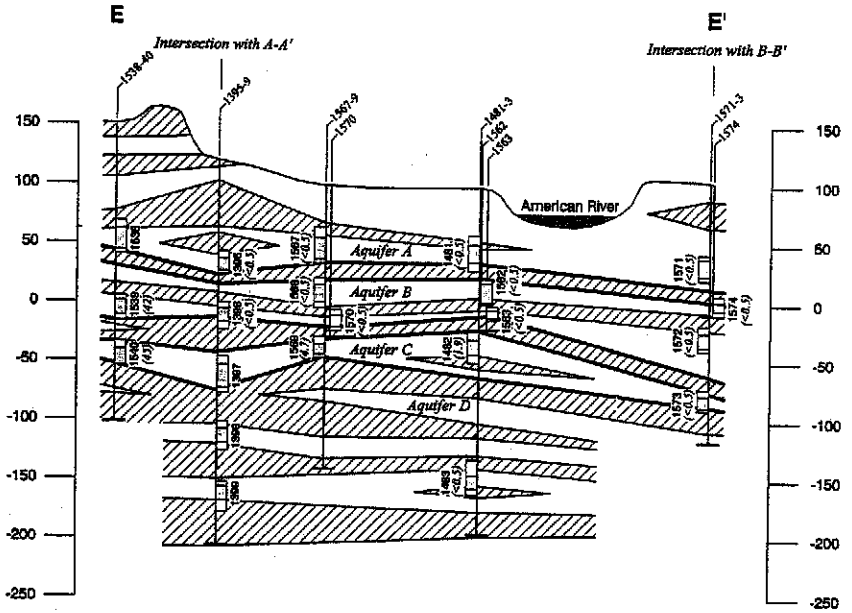


Well 1483





Cross Section Location Map



EXPLANATION

- Geologic Contact
- Aquifer Materials - cobbles, gravels, sands, silty or clayey sands, sandy silts, sandy clays. Main aquifer units outlined in bold line.
- Aquitard Materials - silts, clays, silty clays, clayey silts.
- Gravel Pack Interval
- Screened Interval
- TCE in µg/L
- Well Designation
- Total Borehole Depth

Vertical Scale 1" = 100'

Horizontal Scale 1" = 600'

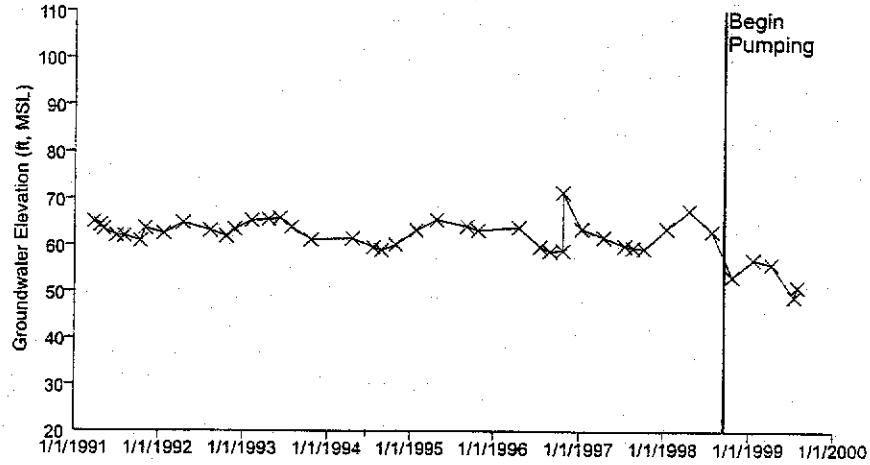
GenCorp Aerojet — Environmental Operations

FIGURE 3-6

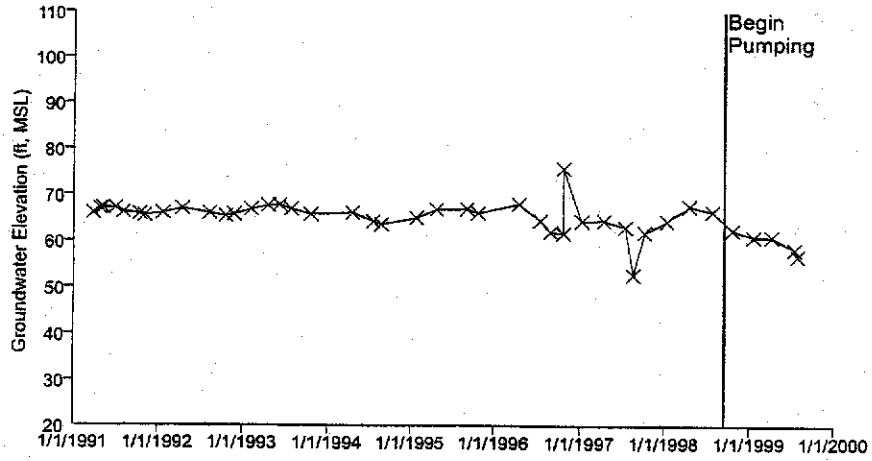
Hydrogeologic Cross Section E - E'

2/10/00 ah SR10109093

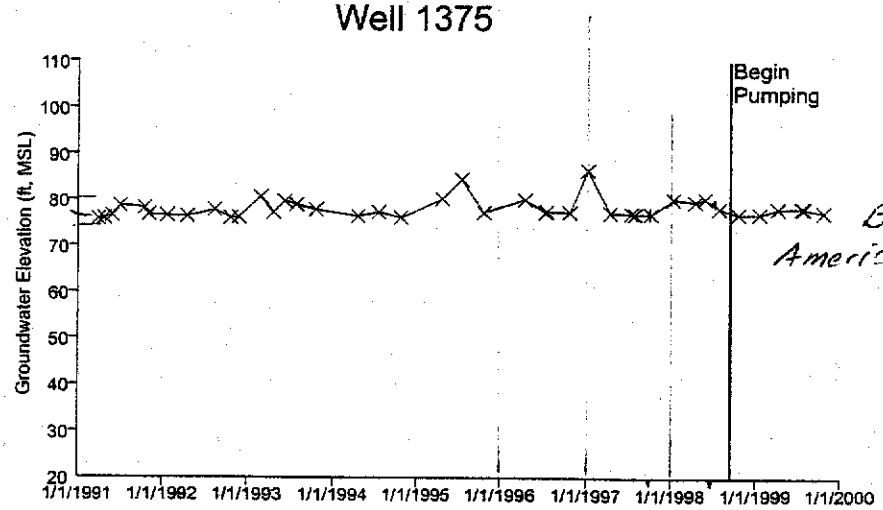
Well 1373

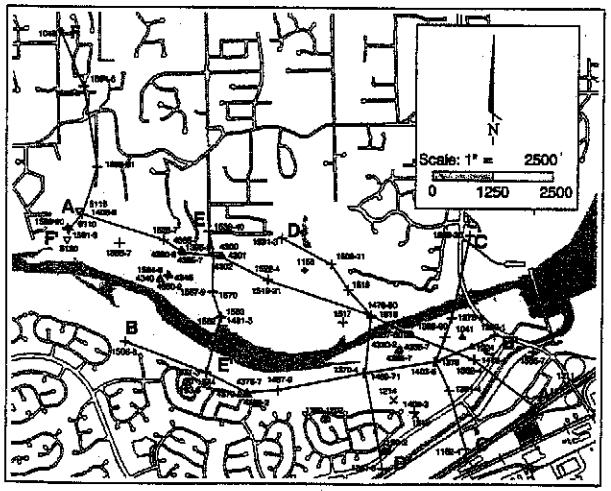


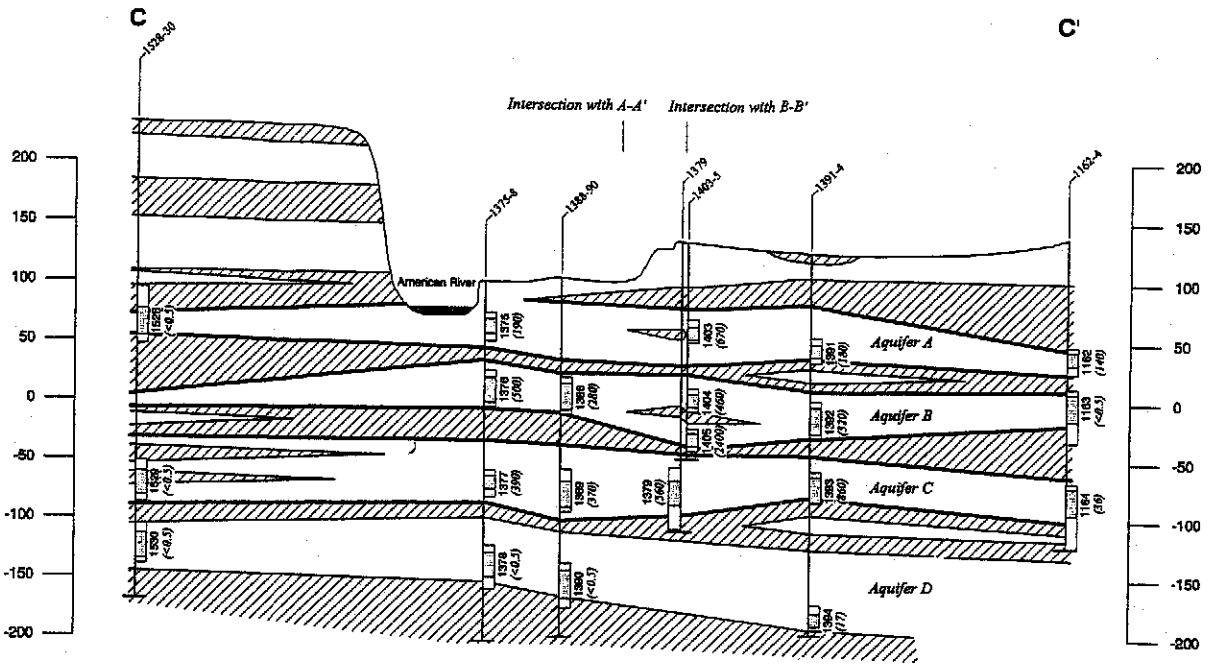
Well 1374



Well 1375







EXPLANATION

- Geologic Contact
- Aquifer Materials - cobbles, gravels, sands, silty or clayey sands, sandy silts, sandy clays. Main aquifer units outlined in bold line.
- Aquitard Materials - silts, clays, silty clays, clayey silts.
- Gravel Pack Interval
- Screened Interval
- TCE in µg/L
- Well Designation
- Total Borehole Depth

Vertical Scale 1" = 100'

Horizontal Scale 1" = 600'

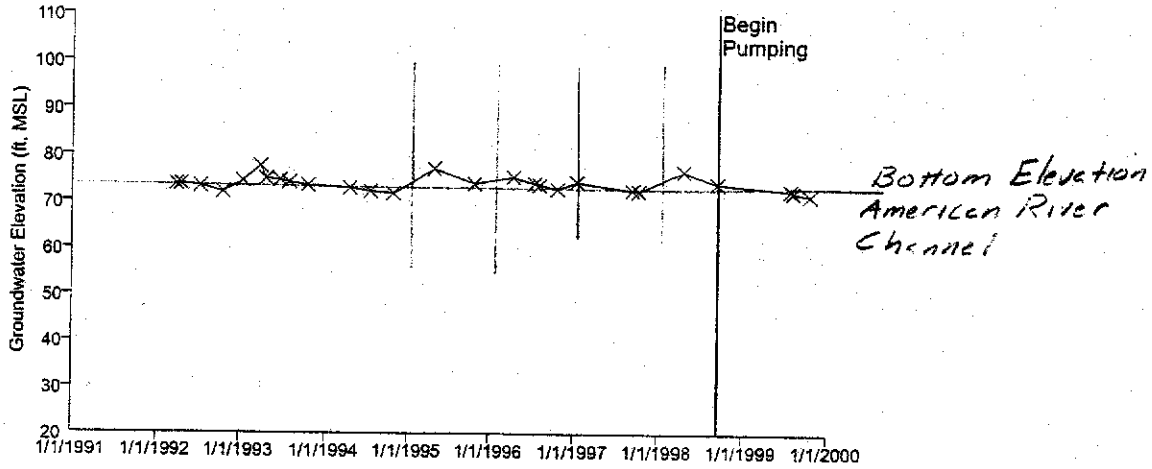
GenCorp Aerojet — Environmental Operations

FIGURE 3-4

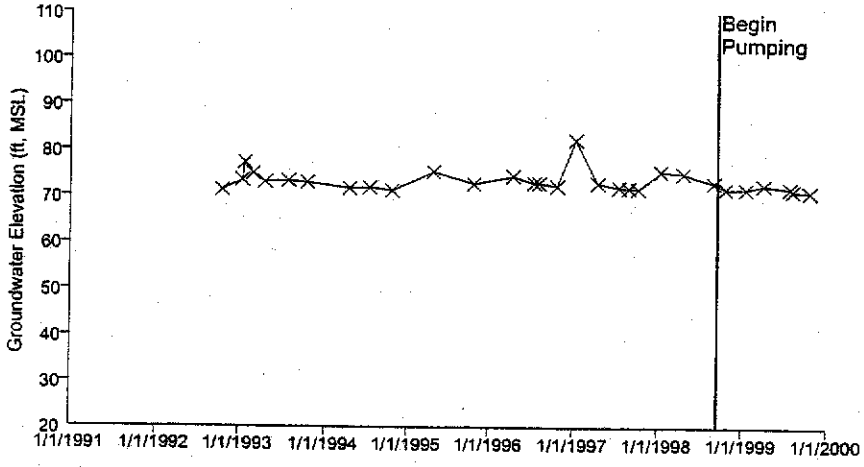
Hydrogeologic Cross Section C - C'

2/10/00 ah SR10109089

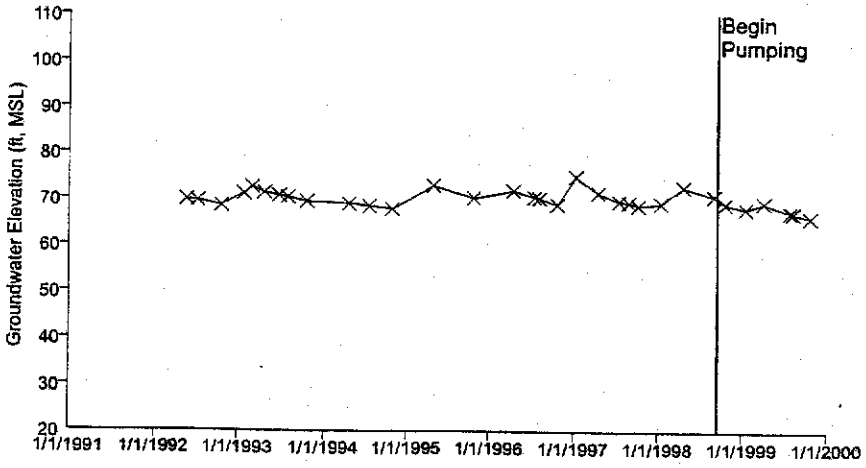
Well 1516

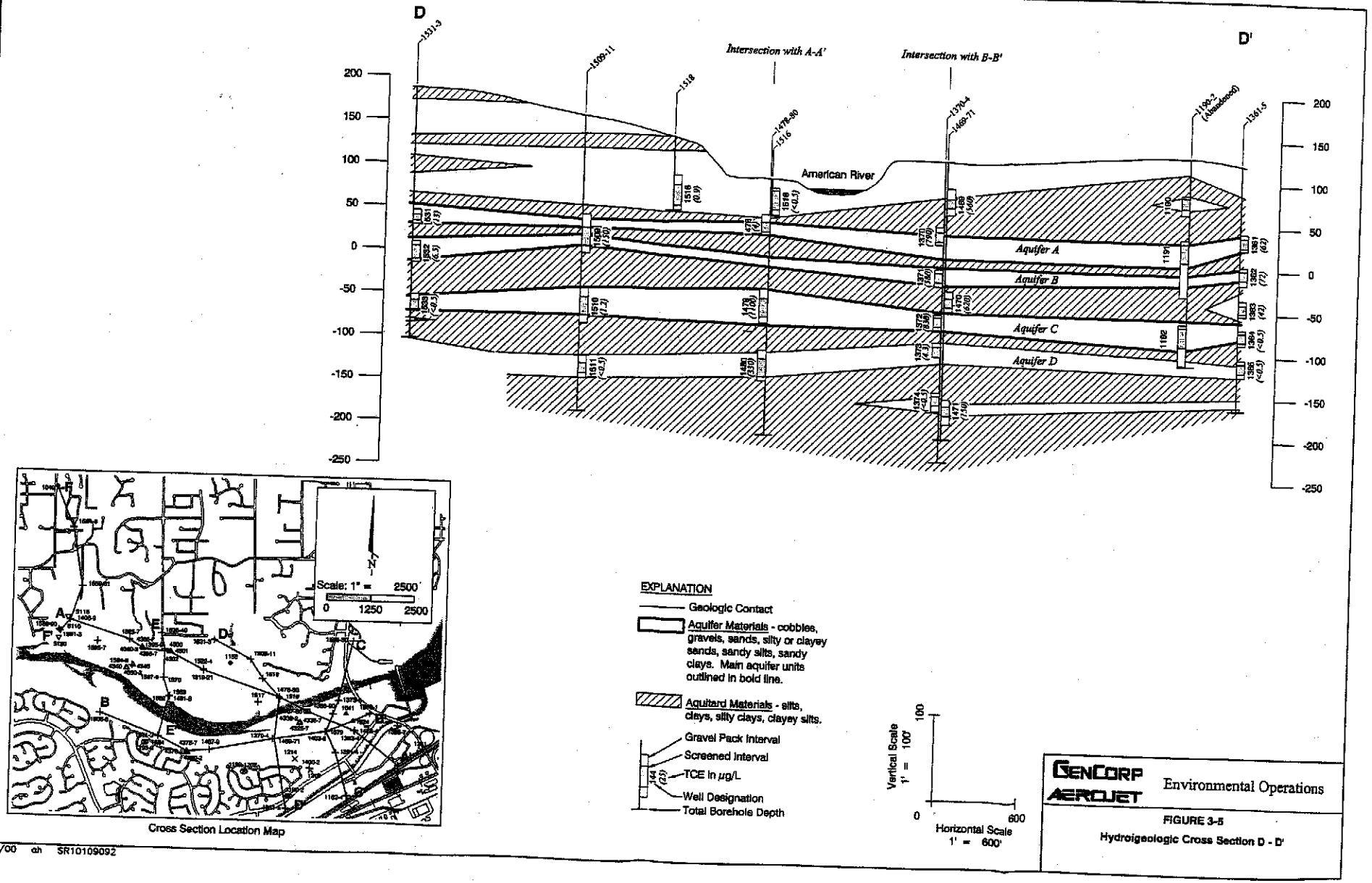


Well 1517



Well 1518





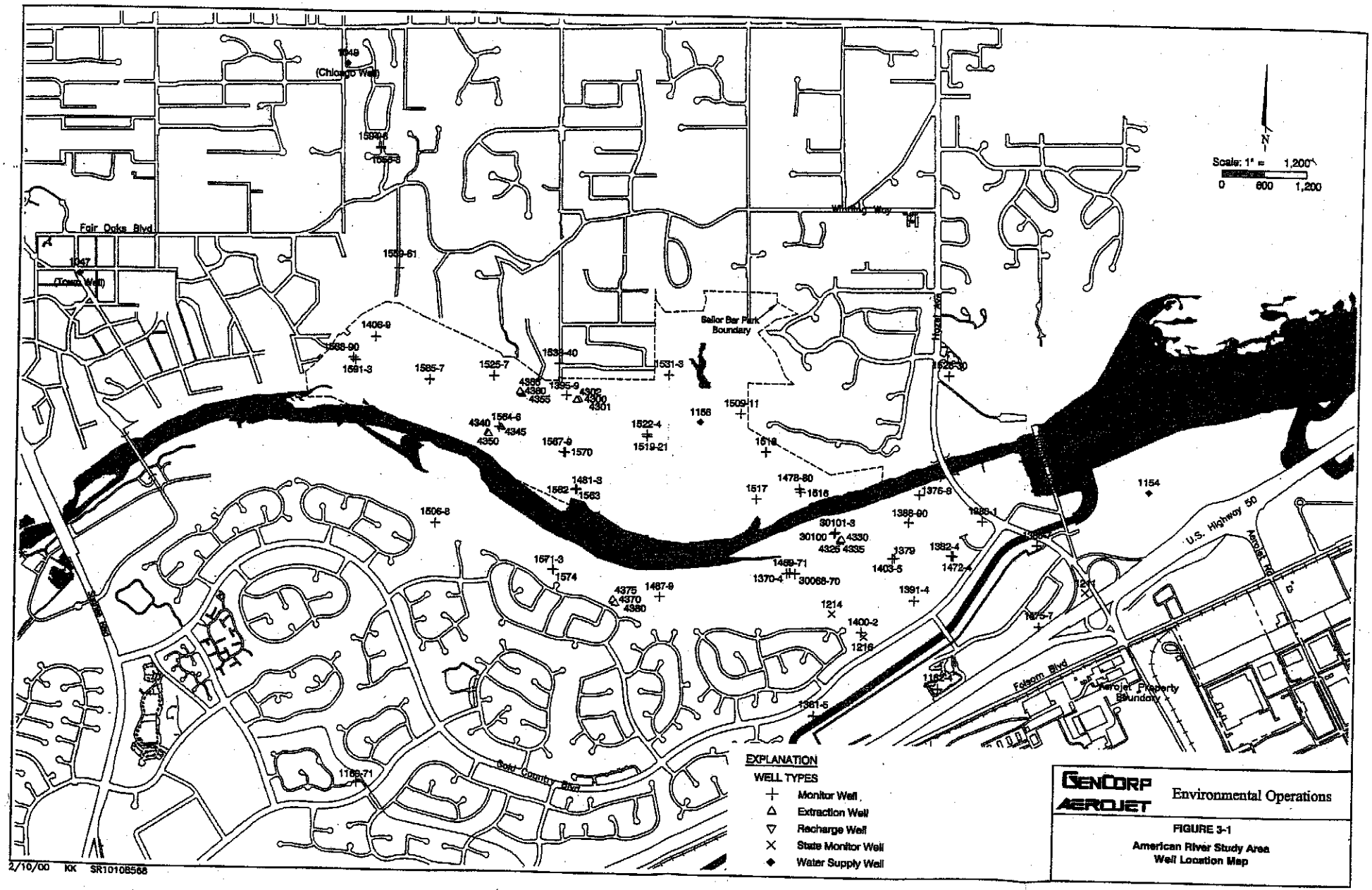
Cross Section Location Map

GenCorp Aerojet — Environmental Operations

FIGURE 3-5

Hydroigeologic Cross Section D - D'

2/20/00 ah SR10109092

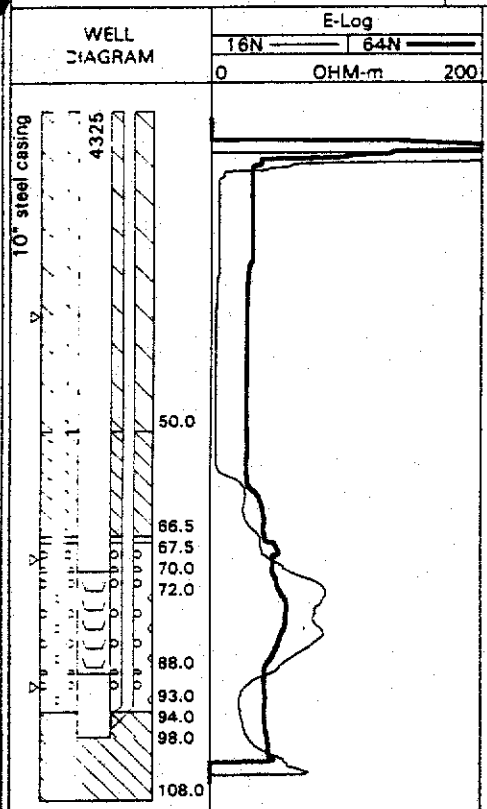


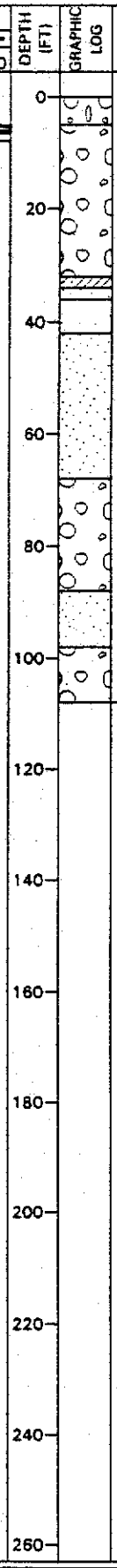
2/10/00 KK SR10108568

Appendix A EECA Vol II

AEROJET

TOTAL DEPTH BORING ft: 108.0	WELL ID: 4325 Page 1 of 1
TOTAL DEPTH WELL ft: 98.0	SITE: Nimbus Fish Hatchery
SURFACE ELEVATION ft MSL: 108.0	EAST = 2220257.3 NORTH = 352888.5
TOC ELEVATION ft MSL: 108.03	
BOREHOLE DIAMETER: 42"/22"	DATE COMPLETED: 8/15/94 LOGGED BY: D. Dettloff





DESCRIPTION

0 to 5' [GP]: BOULDERS (Dredge Tailings), loose, well sorted, well rounded, dry.

5' to 32' [SP]: GRAVELLY SAND; very dark gray brown (10YR, 3/4), loose, well sorted, coarse, angular to subrounded, dry.

32' to 34' [CH]: CLAY; yellowish-brown (10YR, 5/4), soft, sticky, plastic.

34' to 36' [SP]: SAND; dark grayish-brown (10YR, 4/2), loose, well sorted, subangular to rounded, dry.

36' to 42' [SM]: SANDY SILT; dark yellowish-brown (10YR, 4/4), loose, 60% to 80% silt, 20% to 40% fine to very fine sand, moist.

42' to 68' [SP]: SAND; very dark gray (10YR, 3/1), moderately sorted, angular to subrounded, predominantly metamorphics and volcanics, micaceous, wet.

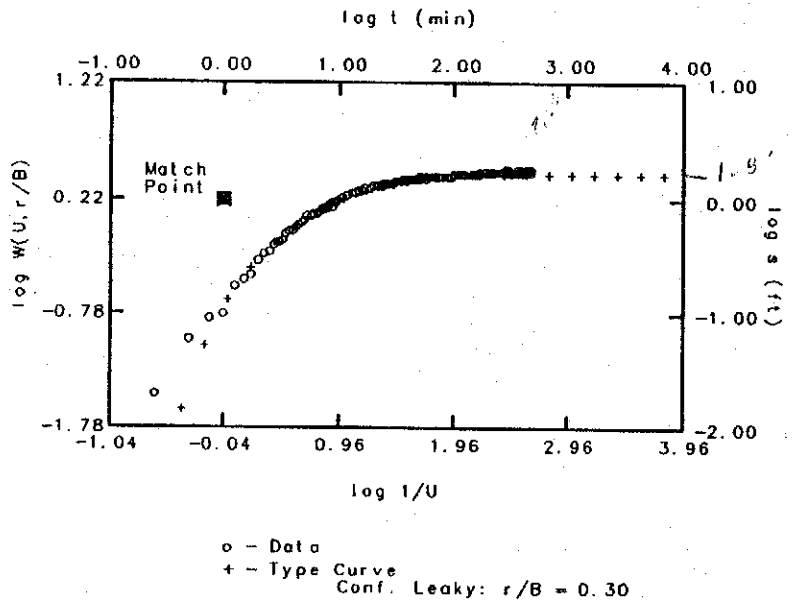
68' to 88' [GP]: SANDY GRAVEL; black (10YR, 2/1), poorly sorted, angular to subangular, predominantly metamorphics and volcanics with some granite, quartz, and feldspar, 60% gravel, 40% coarse sand, micaceous, wet.

88' to 98' [SP/SW]: SAND; very dark gray (10YR, 3/1), moderately sorted, angular to rounded, predominantly metamorphics and volcanics, micaceous, wet.

98' to 108' [GW]: SANDY GRAVEL; very dark gray (10YR, 3/1), poorly sorted, angular to subangular, predominantly metamorphics and volcanics, micaceous, wet.

Total Depth of Borehole: 108 feet
24" surface casing installed to a depth of 56 feet.
Dec-94 land-surface elevations (ft-msl) for:
10" well casing at 108.03,
3" gravel fill tube at 108.02,
2" sounding tube at 108.03.
Well screen: 0.125" core-10 shutter
Well casing: 4325
Sounding tube: 4326
Gravel fill tube: 4327
Gravel: RMC Special Blend

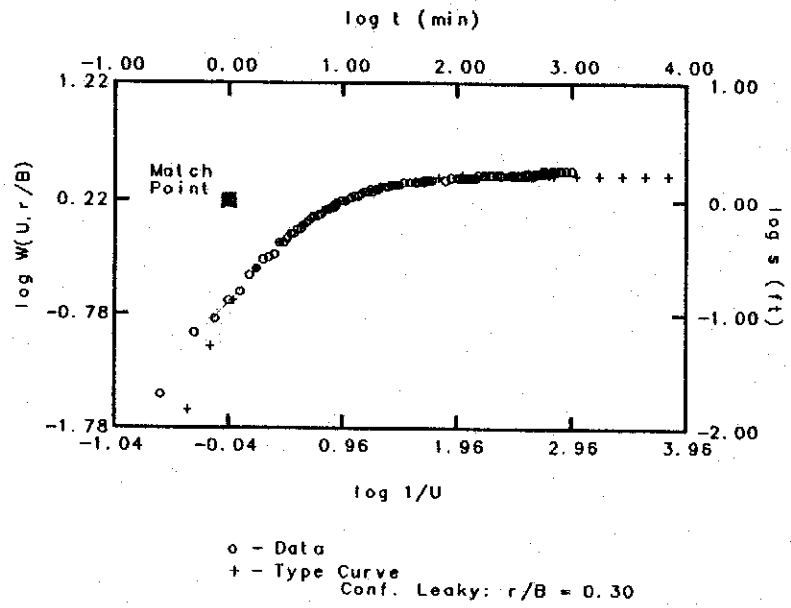
4325 Test – Drawdown Well 1357



MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 8.077E+0004 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 8.077E+0004 gpd/sq ft
1/U	= 9.120E-0001	Storativity	= 1.964E-0004
W(U,r/B)	= 1.660E-0001	Leakage Factor	= 1.364E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325DD
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.092E+0002 ft

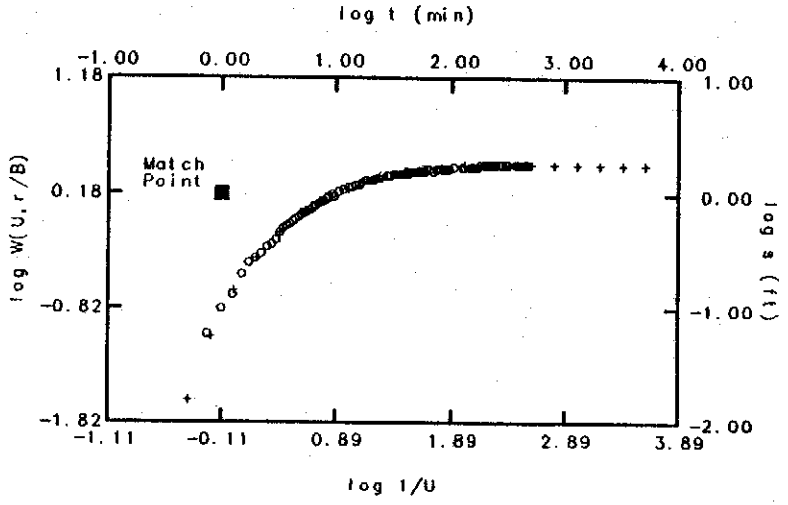
4325 Test – Recovery Well 1357



MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 8.077E+0004 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 8.077E+0004 gpd/sq ft
1/U	= 9.120E-0001	Storativity	= 1.964E-0004
W(U,r/B)	= 1.660E-0001	Leakage Factor	= 1.364E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.092E+0002 ft

4325 Test – Drawdown Well 1358

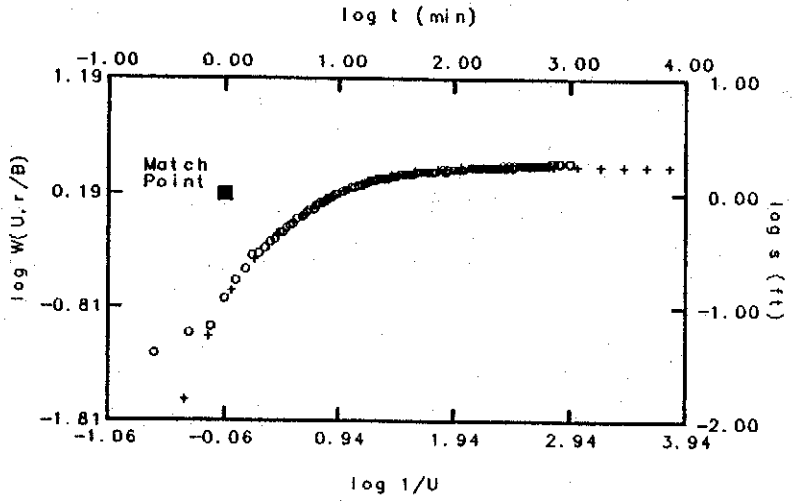


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	7.366E+0004 gpd/ft
s =	1.000E+0000	Hydraulic. Cond. =	7.366E+0004 gpd/sq ft
1/U =	7.762E-0001	Storativity =	2.105E-0004
W(U,r/B) =	1.514E-0001	Leakage Factor =	1.364E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325DD
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.092E+0002 ft

4325 Test – Recovery Well 1358

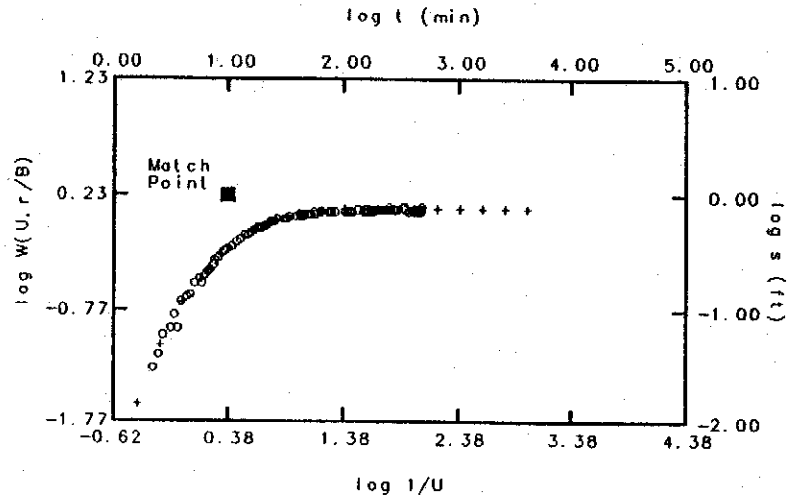


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	7.538E+0004 gpd/ft
s =	1.000E+0000	Hydraulic. Cond. =	7.538E+0004 gpd/sq ft
1/U =	8.710E-0001	Storativity =	1.920E-0004
W(U,r/B) =	1.549E-0001	Leakage Factor =	1.364E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.092E+0002 ft

4325 Test – Drawdown Well 1370

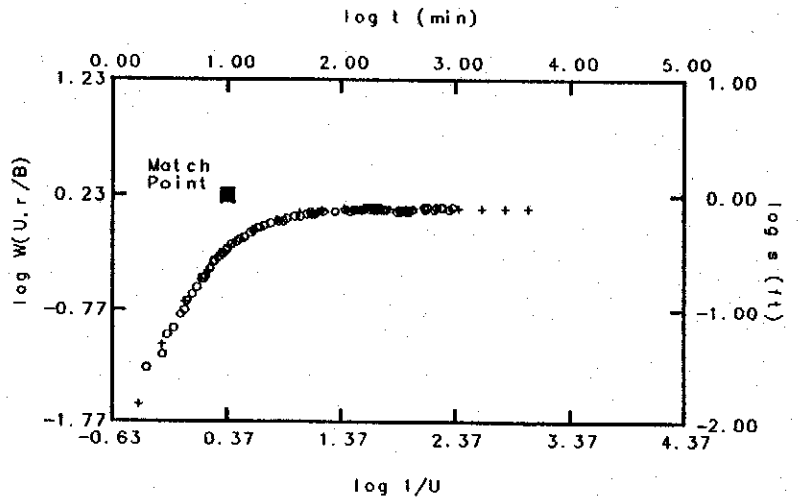


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 8.265E+0004 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 8.265E+0004 gpd/sq ft
1/U	= 2.399E+0000	Storativity	= 1.658E-0004
W(U,r/B)	= 1.698E-0001	Leakage Factor	= 1.255E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.785E+0002 ft

4325 Test – Recovery Well 1370

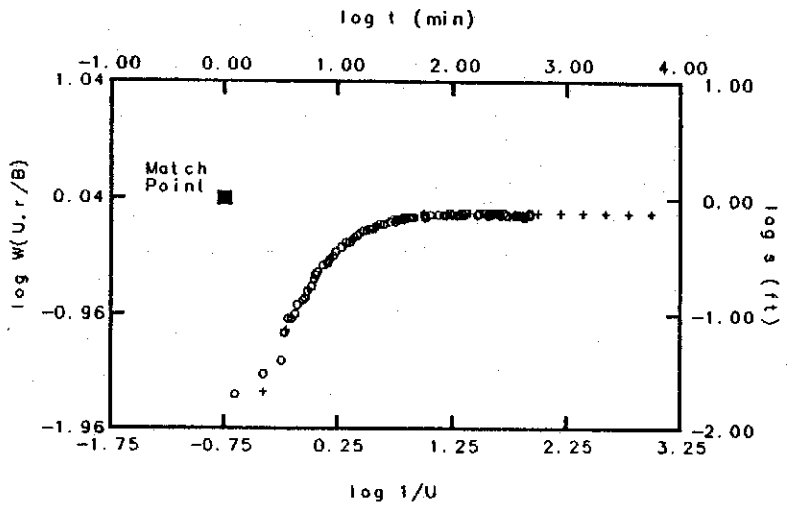


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 8.265E+0004 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 8.265E+0004 gpd/sq ft
1/U	= 2.344E+0000	Storativity	= 1.697E-0004
W(U,r/B)	= 1.698E-0001	Leakage Factor	= 1.255E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.785E+0002 ft

4325 Test – Drawdown Well 1371

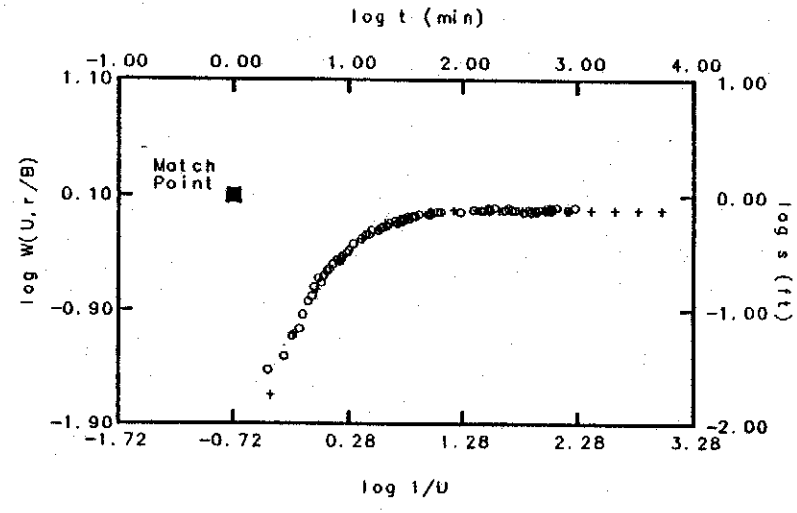


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 1.00

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.337E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	5.337E+0004 gpd/sq ft
1/U	=	1.778E-0001	Storativity	=	1.444E-0004
W(U,r/B)	=	1.096E-0001	Leakage Factor	=	8.785E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.785E+0002 ft

4325 Test – Recovery Well 1371

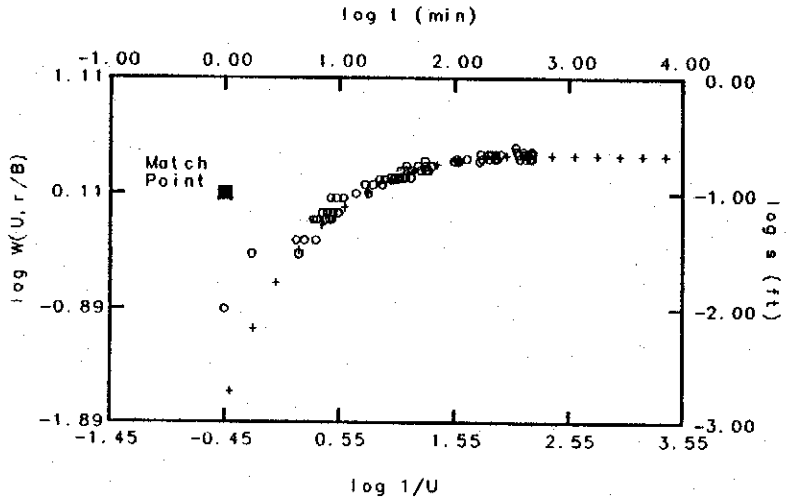


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.127E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	6.127E+0004 gpd/sq ft
1/U	=	1.905E-0001	Storativity	=	1.547E-0004
W(U,r/B)	=	1.259E-0001	Leakage Factor	=	9.761E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.785E+0002 ft

4325 Test – Drawdown Well 1388



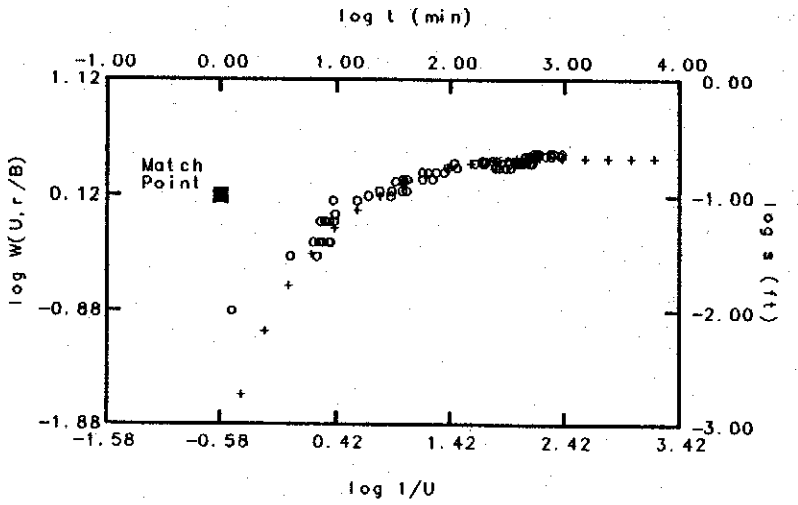
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.270E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	6.270E+0005 gpd/sq ft
1/U	=	3.548E-0001	Storativity	=	6.520E-0004
W(U,r/B)	=	1.288E-0001	Leakage Factor	=	3.344E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.003E+0003 ft

4325 Test – Recovery Well 1388



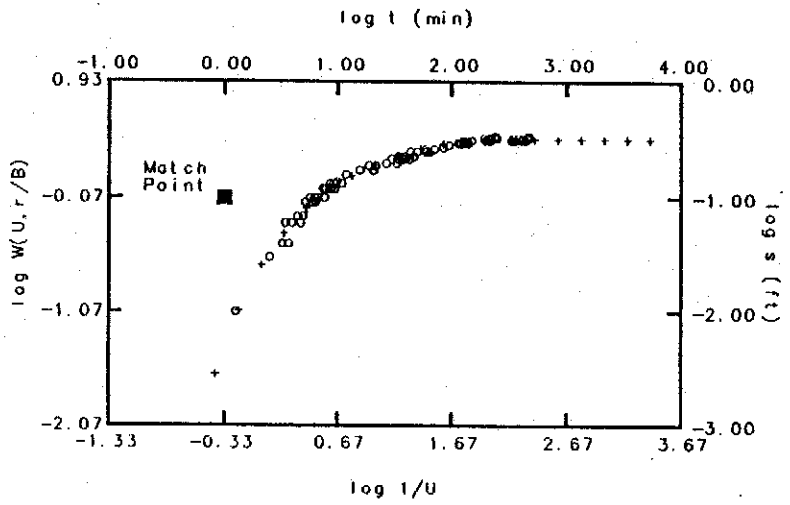
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.416E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	6.416E+0005 gpd/sq ft
1/U	=	2.630E-0001	Storativity	=	9.005E-0004
W(U,r/B)	=	1.318E-0001	Leakage Factor	=	3.343E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.003E+0003 ft

4325 Test – Drawdown Well 1404

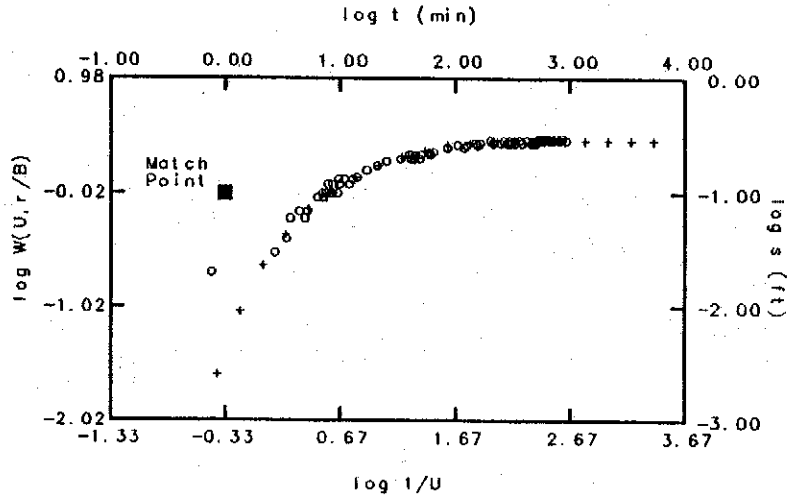


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.142E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.142E+0005 gpd/sq ft
1/U	=	4.677E-0001	Storativity	=	5.488E-0004
W(U,r/B)	=	8.511E-0002	Leakage Factor	=	2.581E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.742E+0002 ft

4325 Test – Recovery Well 1404

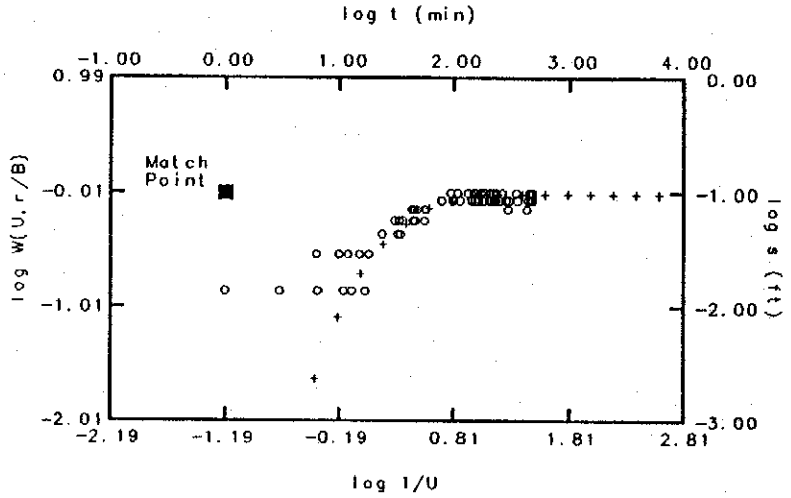


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.648E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.648E+0005 gpd/sq ft
1/U	=	4.677E-0001	Storativity	=	6.157E-0004
W(U,r/B)	=	9.550E-0002	Leakage Factor	=	2.581E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.742E+0002 ft

4325 Test – Drawdown Well 1469

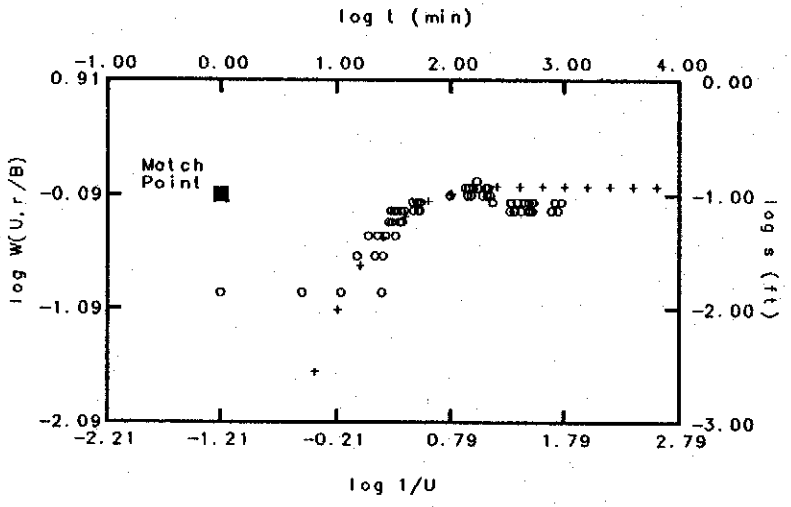


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.756E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.756E+0005 gpd/sq ft
1/U	=	6.457E-0002	Storativity	=	3.931E-0003
W(U,r/B)	=	9.772E-0002	Leakage Factor	=	9.270E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.343E+0002 ft

4325 Test – Recovery Well 1469

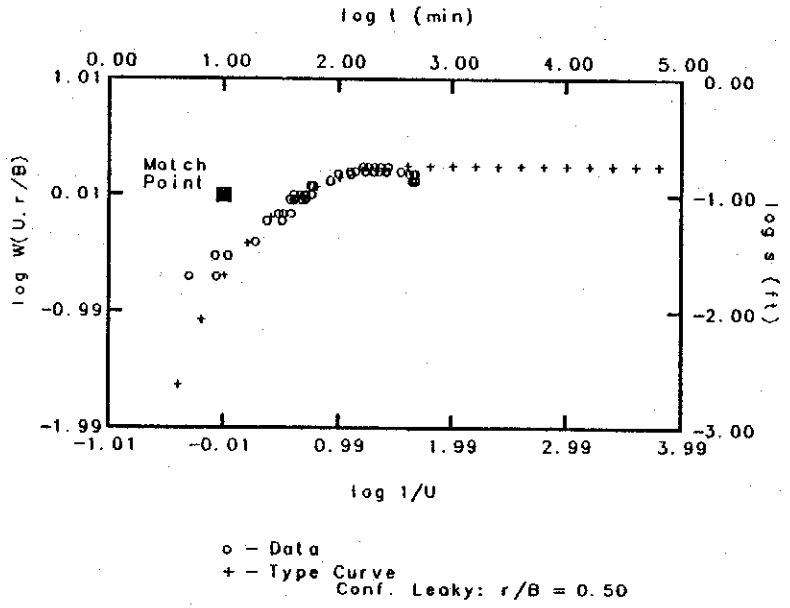


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	3.956E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.956E+0005 gpd/sq ft
1/U	=	6.166E-0002	Storativity	=	3.423E-0003
W(U,r/B)	=	8.128E-0002	Leakage Factor	=	9.270E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.343E+0002 ft

4325 Test – Drawdown Well 1478

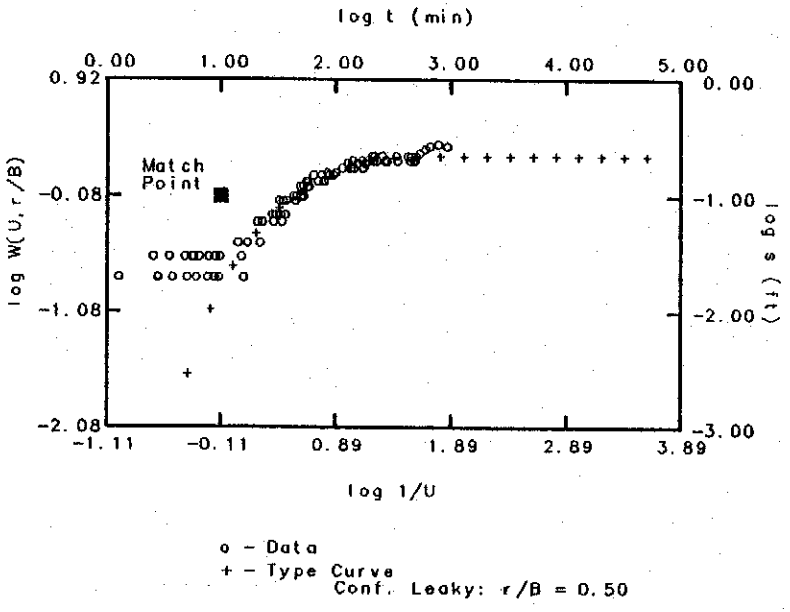


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.50

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	4.980E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.980E+0005 gpd/sq ft
1/U	=	9.772E-0001	Storativity	=	1.917E-0003
W(U,r/B)	=	1.023E-0001	Leakage Factor	=	1.987E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.936E+0002 ft

4325 Test – Recovery Well 1478



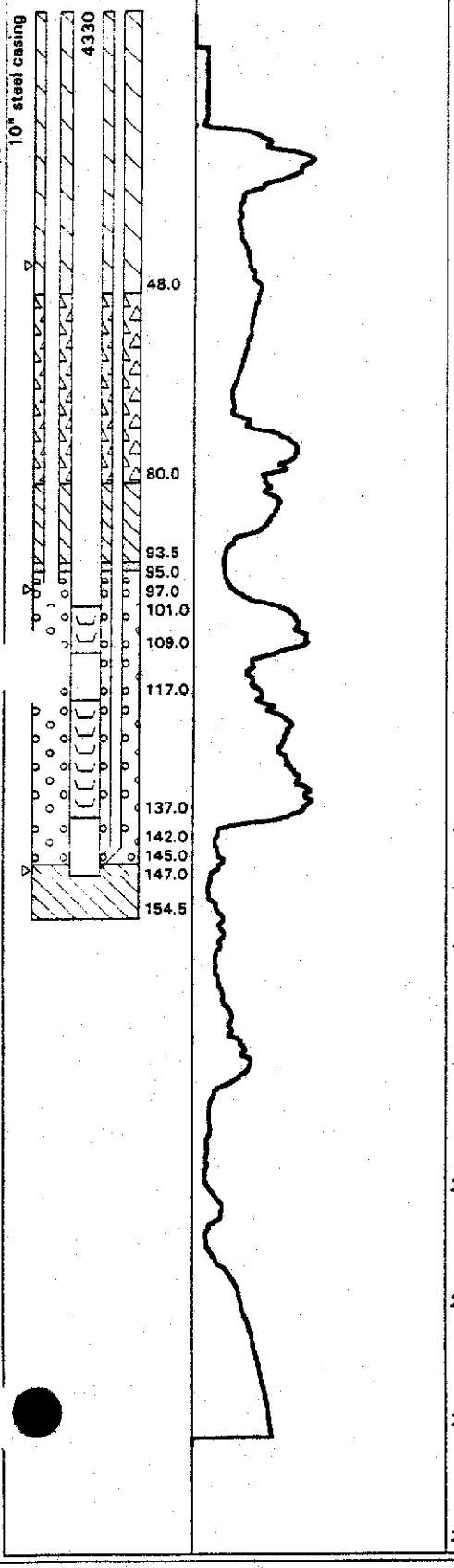
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.50

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	4.048E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.048E+0005 gpd/sq ft
1/U	=	7.762E-0001	Storativity	=	1.962E-0003
W(U,r/B)	=	8.318E-0002	Leakage Factor	=	1.987E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.936E+0002 ft

AEROJET

TOTAL DEPTH BORING ft: 154.5	**WELL ID: 4330** Page 1 of 1
TOTAL DEPTH WELL ft: 147	
SURFACE ELEVATION ft MSL: 107.7	SITE: Nimbus Fish Hatchery
TOC ELEVATION ft MSL: 107.67	EAST = 2220258.3 NORTH = 352911.0
BOREHOLE DIAMETER: 42"/22"	DATE COMPLETED: 8/9/94 LOGGED BY: D. Dettloff



DESCRIPTION

0 to 5' [GP]: BOULDERS (Dredge tailings); loose, well sorted, wel rounded, dry.

5' to 32' [SP]: GRAVELLY SAND; very dark gray brown (10YR, 3/4), loose, well sorted, angular to subrounded, coarse, dry.

32' to 34' [CH]: CLAY; yellowish-brown (10YR, 5/4), soft, sticky, plastic.

34' to 36' [SP]: SAND; dark grayish-brown (10YR, 4/2), loose, well sorted, subangular to rounded, dry.

36' to 42' [SM]: SANDY SILT; dark yellowish-brown (10YR, 4/4', loose, 60% to 80% silt and 20% to 40% fine to very fine sand, moist.

42' to 70' [SP]: SAND; dark brown (10YR, 4/3), slightly indurated, moderately sorted, subangular to rounded, moist.

70' to 88' [SW]: GRAVELLY SAND; dark brown (10YR, 4/3), poorly sorted, subangular to rounded, 75% sand and 25% gravel, moist.

88' to 99' [GW]: SANDY GRAVEL; black (10YR, 2/1), poorly sorted, subangular to subrounded, 70% gravel and 30% sand, moist.

99' to 125' [SP]: SAND; very dark gray (10YR, 3/1), well sorted, coarse, angular to very angular, micaceous, wet.
Bit chattering from 101' to 139'.

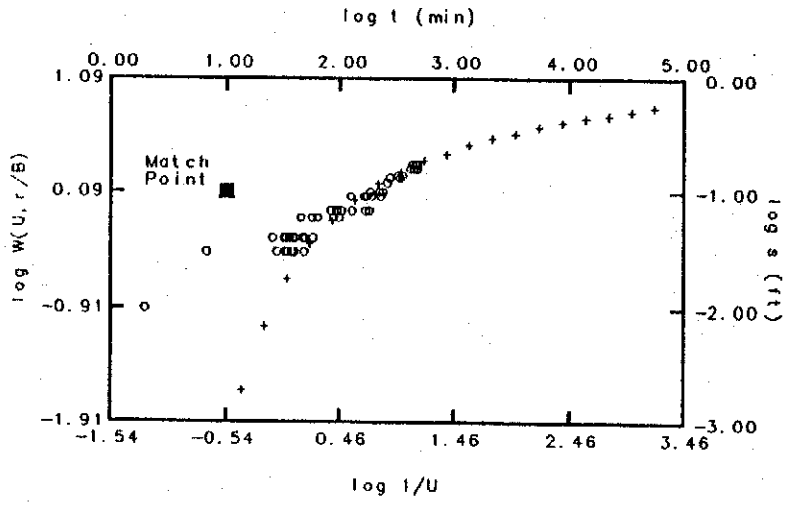
125' to 139' [GP]: GRAVEL; very dark gray (10YR, 3/1), well sorted, angular to subangular, micaceous, wet.

139' to 160' [CL]: SANDY CLAY; pale olive (5Y, 6/4), soft, 5% to 10% fine to coarse sand, moist.

Total Depth of Borehole: 154.5 feet
E-log from Corehole, ARCH-94-2
24" surface casing installed to depth of 50 feet.
Dec-94 land-surface elevations (ft-msl) for:
10" well casing at 107.7,
3" gravel fill tube at 107.73,
2" sounding tube at 107.67.
Well screen: 0.125" core-10 shutter
Well casing: 4330
Sounding tube: 4331
Gravel fill tube: 4332
Gravel: RMC Special Blend

HSI AERO NOT A ... 6/16/06

4330 Test – Drawdown Well 1379

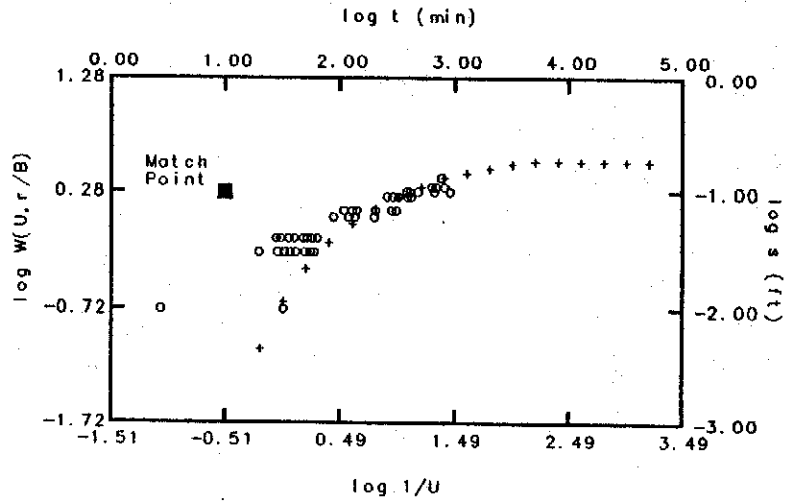


o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	6.381E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	6.381E+0005 gpd/sq ft
1/U	=	2.884E-0001	Storativity	=	1.272E-0002
W(U,r/B)	=	1.230E-0001			

WELL INFORMATION		
WELL IDENTIFICATION	:	4330D
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	8.038E+0002 ft

4330 Test – Recovery Well 1379

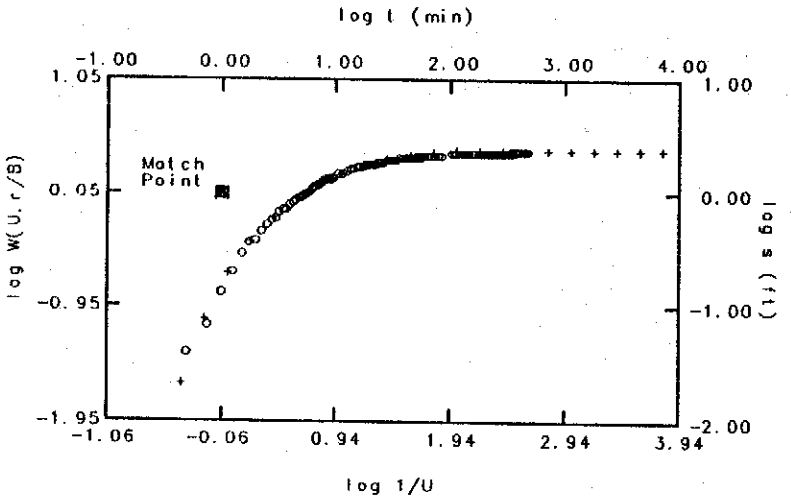


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	9.883E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	9.883E+0005 gpd/sq ft
1/U	=	3.090E-0001	Storativity	=	1.838E-0002
W(U,r/B)	=	1.905E-0001	Leakage Factor	=	4.019E+0003 ft

WELL INFORMATION		
WELL IDENTIFICATION	:	4330R
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	8.038E+0002 ft

4330 Test – Drawdown Well 1357

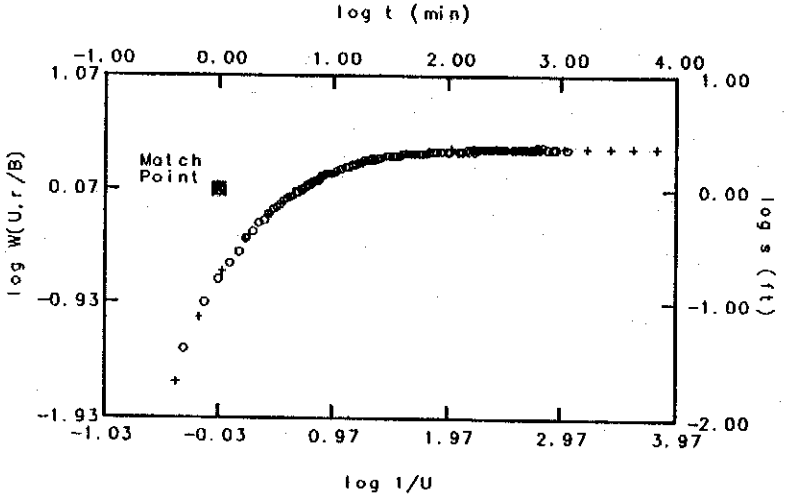


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.819E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	5.819E+0004 gpd/sq ft
1/U	=	8.710E-0001	Storativity	=	1.637E-0004
W(U,r/B)	=	1.122E-0001	Leakage Factor	=	1.298E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330DD
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 3.894E+0002 ft

4330 Test – Recovery Well 1357

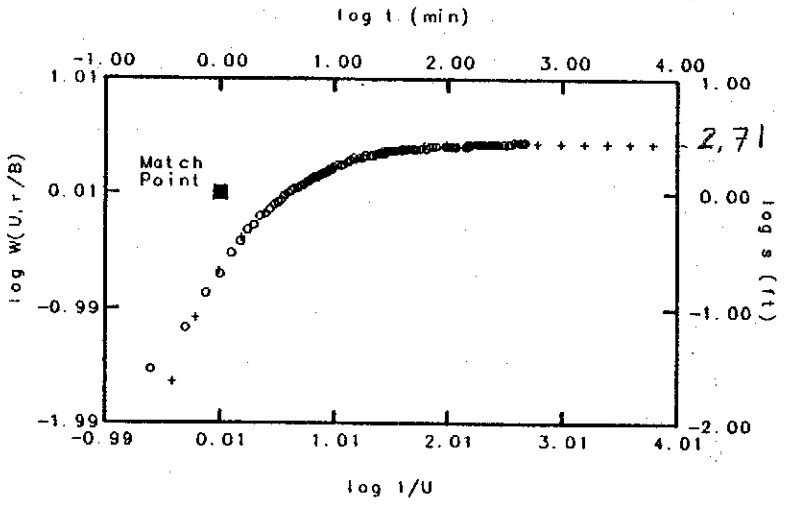


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.094E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	6.094E+0004 gpd/sq ft
1/U	=	9.333E-0001	Storativity	=	1.599E-0004
W(U,r/B)	=	1.175E-0001	Leakage Factor	=	1.298E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 3.894E+0002 ft

4330 Test – Drawdown Well 1358



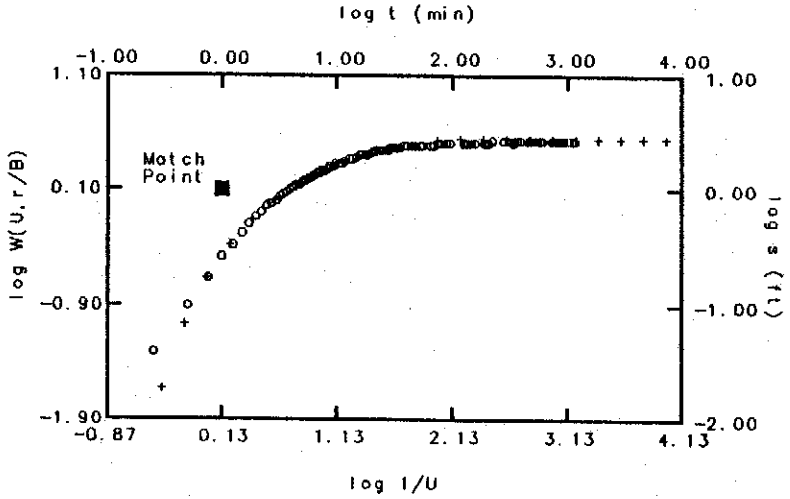
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.307E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	5.307E+0004 gpd/sq ft
1/U	=	1.023E+0000	Storativity	=	1.270E-0004
W(U,r/B)	=	1.023E-0001	Leakage Factor	=	1.298E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4330DD
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	3.894E+0002 ft

4330 Test – Recovery Well 1358



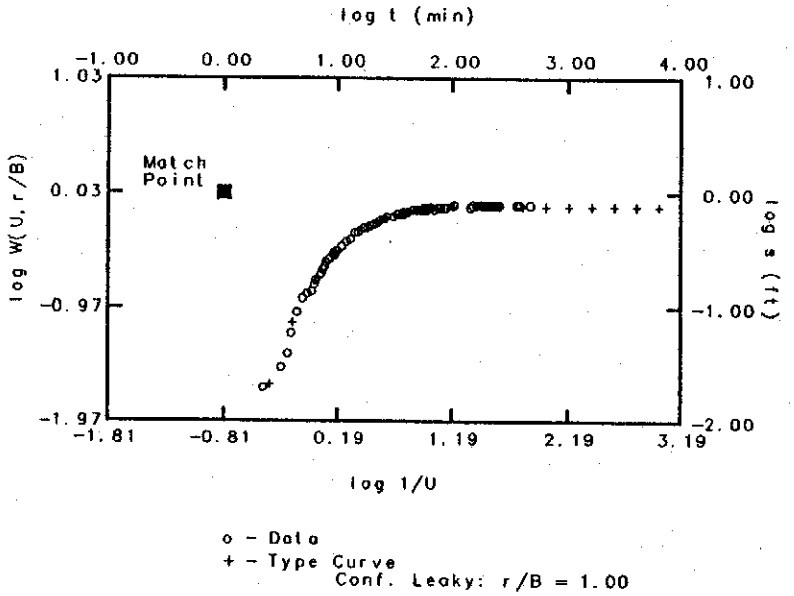
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.530E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	6.530E+0004 gpd/sq ft
1/U	=	1.349E+0000	Storativity	=	1.186E-0004
W(U,r/B)	=	1.259E-0001	Leakage Factor	=	1.947E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4330R
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	3.894E+0002 ft

4330 Test – Drawdown Well 1370

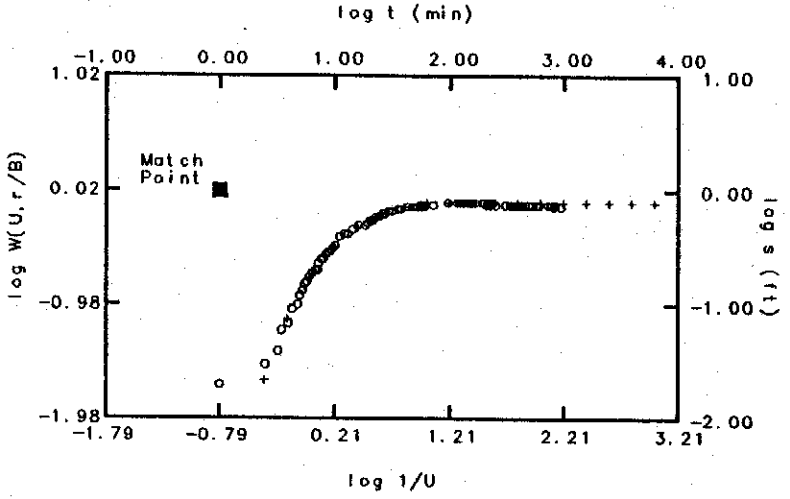


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 1.00

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.558E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	5.558E+0004 gpd/sq ft
1/U	=	1.549E-0001	Storativity	=	1.677E-0004
W(U,r/B)	=	1.072E-0001	Leakage Factor	=	8.914E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.914E+0002 ft

4330 Test – Recovery Well 1370

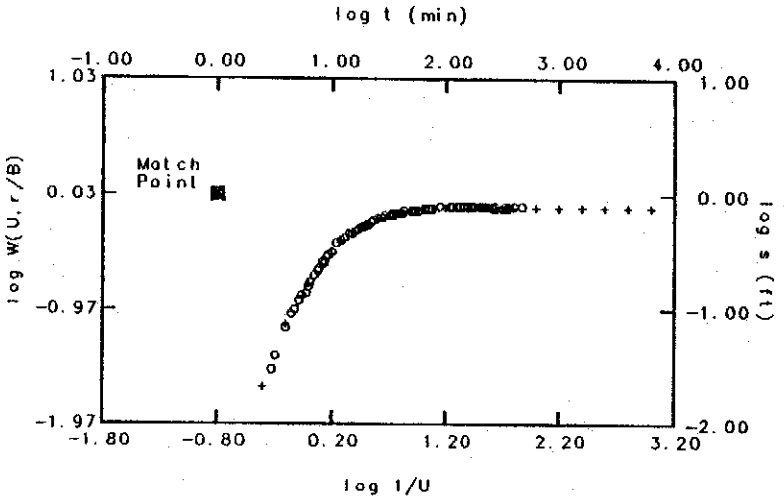


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 1.00

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.431E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	5.431E+0004 gpd/sq ft
1/U	=	1.622E-0001	Storativity	=	1.565E-0004
W(U,r/B)	=	1.047E-0001	Leakage Factor	=	8.914E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.914E+0002 ft

4330 Test – Drawdown Well 1371



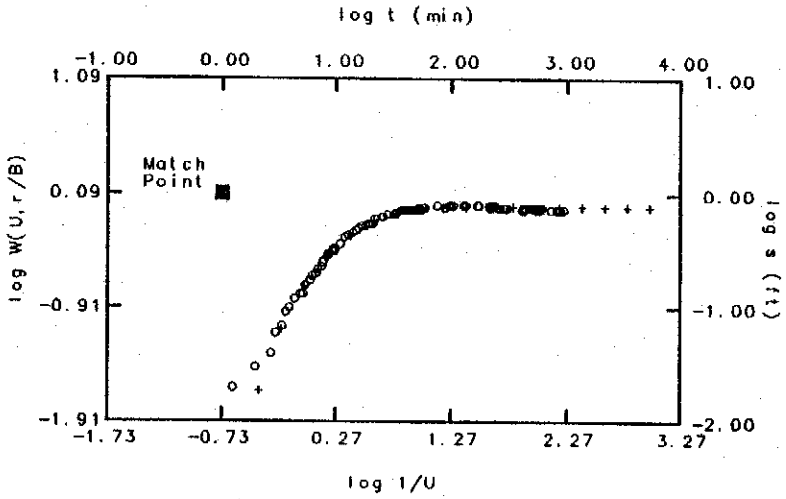
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 1.00

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.558E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	5.558E+0004 gpd/sq ft
1/U	=	1.585E-0001	Storativity	=	1.639E-0004
W(U,r/B)	=	1.072E-0001	Leakage Factor	=	8.914E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.914E+0002 ft

4330 Test – Recovery Well 1371



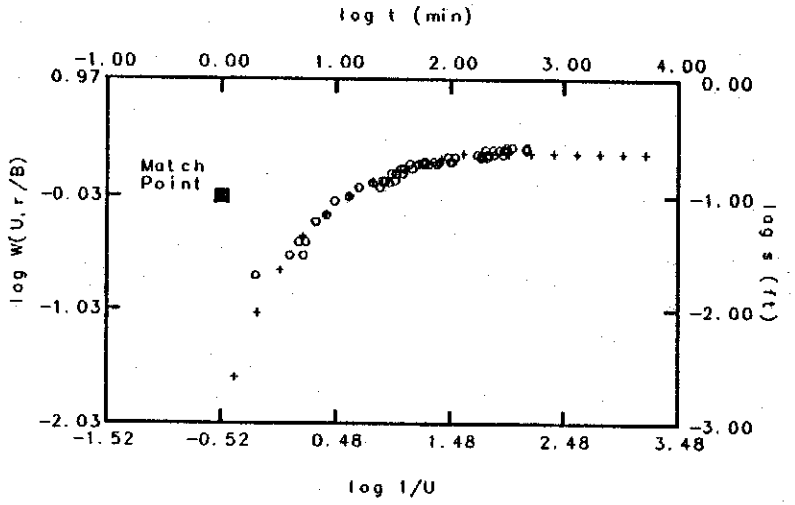
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.381E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	6.381E+0004 gpd/sq ft
1/U	=	1.862E-0001	Storativity	=	1.602E-0004
W(U,r/B)	=	1.230E-0001	Leakage Factor	=	9.904E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.914E+0002 ft

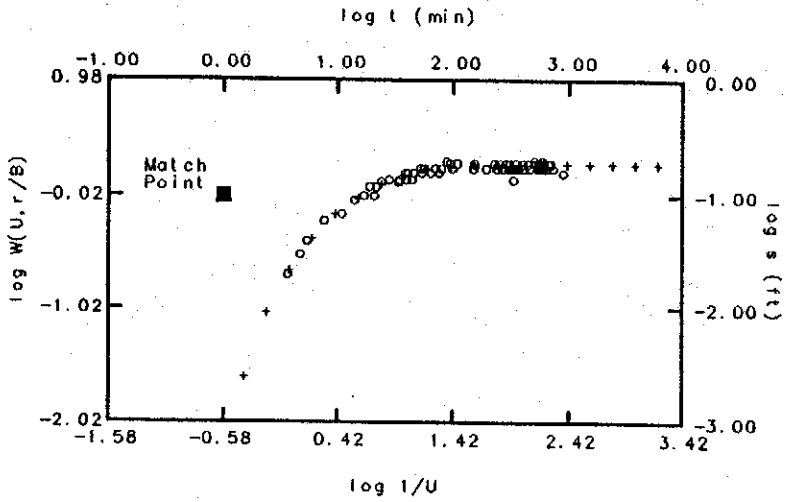
4330 Test – Drawdown Well 1388



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.840E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.840E+0005 gpd/sq ft
1/U	=	3.020E-0001	Storativity	=	6.007E-0004
W(U,r/B)	=	9.333E-0002	Leakage Factor	=	2.489E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.955E+0002 ft

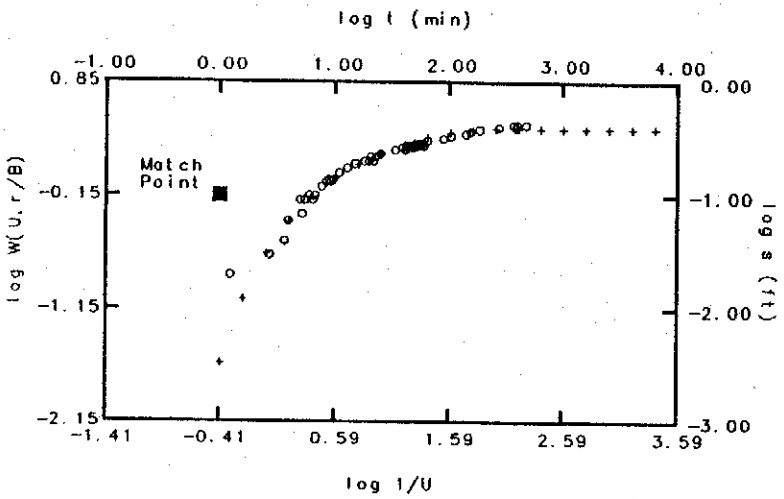
4330 Test – Recovery Well 1388



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.953E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.953E+0005 gpd/sq ft
1/U	=	2.630E-0001	Storativity	=	7.057E-0004
W(U,r/B)	=	9.550E-0002	Leakage Factor	=	1.991E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.955E+0002 ft

4330 Test – Drawdown Well 1404



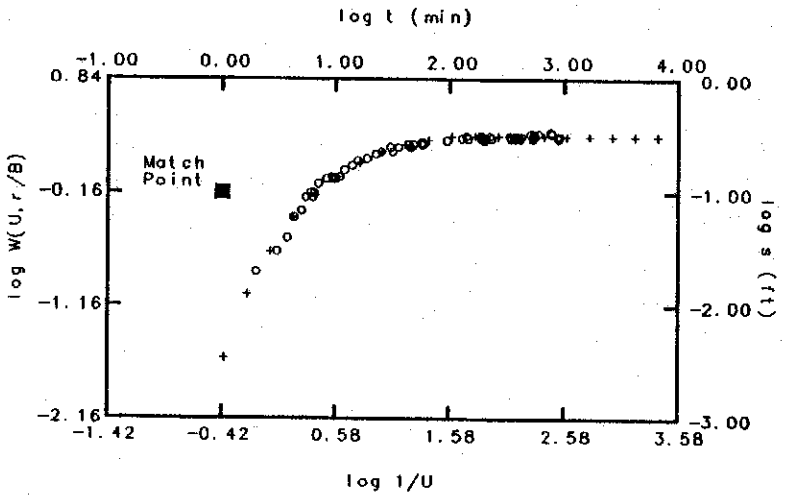
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	3.672E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.672E+0005 gpd/sq ft
1/U	=	3.890E-0001	Storativity	=	5.762E-0004
W(U,r/B)	=	7.079E-0002	Leakage Factor	=	2.600E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.800E+0002 ft

4330 Test – Recovery Well 1404



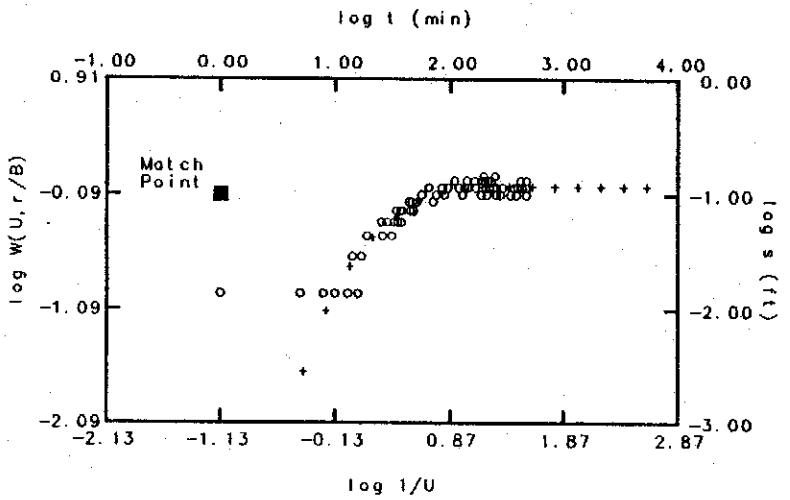
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	3.588E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.588E+0005 gpd/sq ft
1/U	=	3.802E-0001	Storativity	=	5.762E-0004
W(U,r/B)	=	6.918E-0002	Leakage Factor	=	1.950E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.800E+0002 ft

4330 Test – Drawdown Well 1469

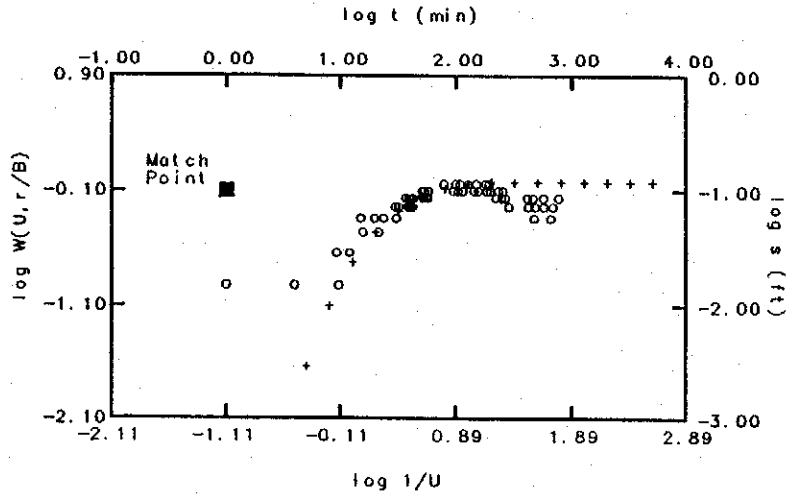


MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 4.216E+0005 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 4.216E+0005 gpd/sq ft
1/U	= 7.413E-0002	Storativity	= 2.940E-0003
W(U,r/B)	= 8.128E-0002	Leakage Factor	= 9.418E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.476E+0002 ft

4330 Test – Recovery Well 1469

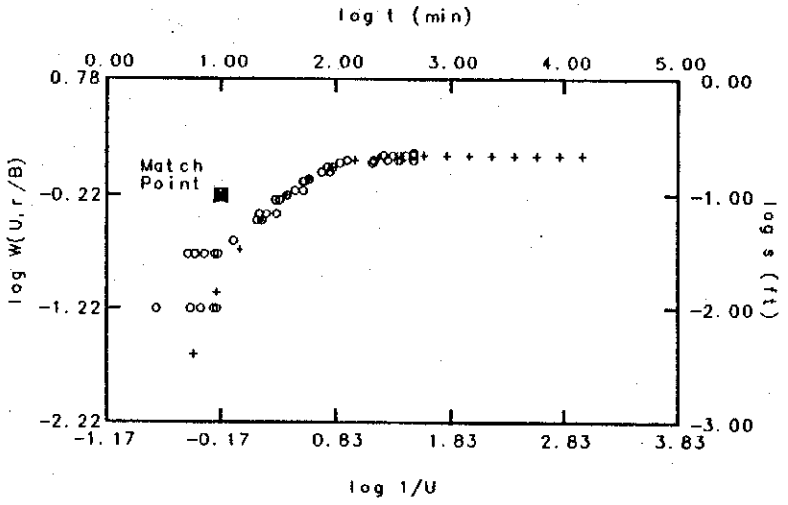


MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 4.120E+0005 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 4.120E+0005 gpd/sq ft
1/U	= 7.762E-0002	Storativity	= 2.744E-0003
W(U,r/B)	= 7.943E-0002	Leakage Factor	= 9.418E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.476E+0002 ft

4330 Test – Drawdown Well 1478

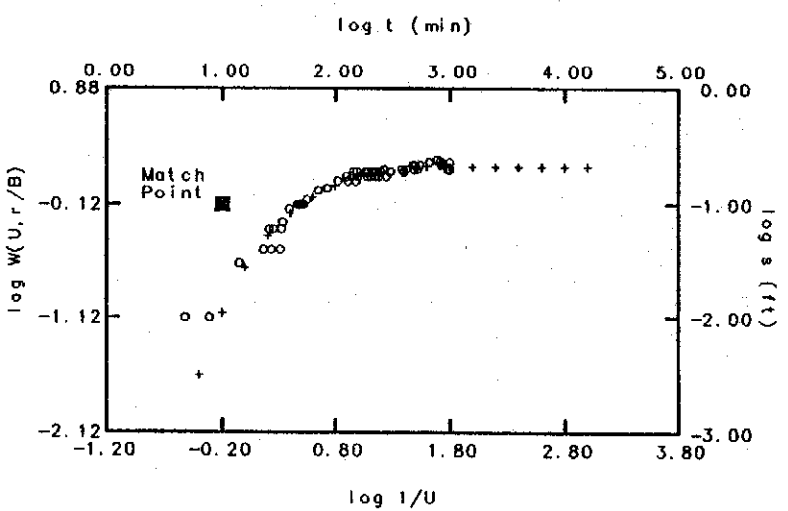


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	3.125E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.125E+0005 gpd/sq ft
1/U	=	6.761E-0001	Storativity	=	1.797E-0003
W(U,r/B)	=	6.026E-0002	Leakage Factor	=	1.396E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

4330 Test – Recovery Well 1478

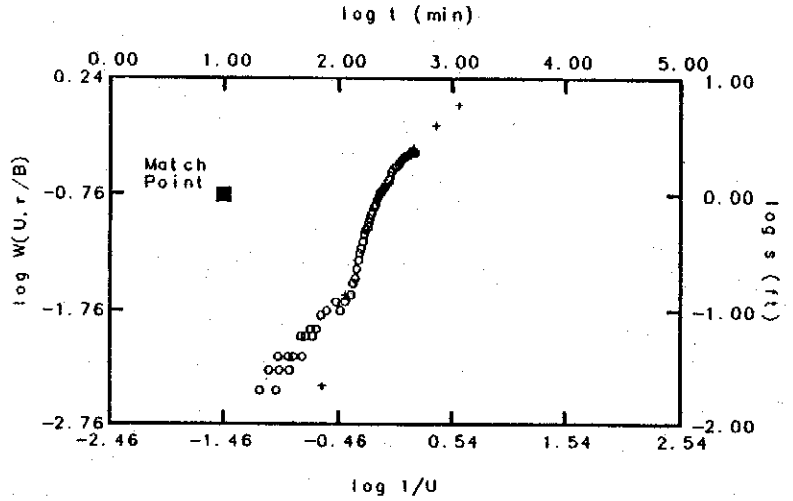


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.60

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	3.934E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.934E+0005 gpd/sq ft
1/U	=	6.310E-0001	Storativity	=	2.424E-0003
W(U,r/B)	=	7.586E-0002	Leakage Factor	=	1.629E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

4330 Test – Drawdown Well 1479

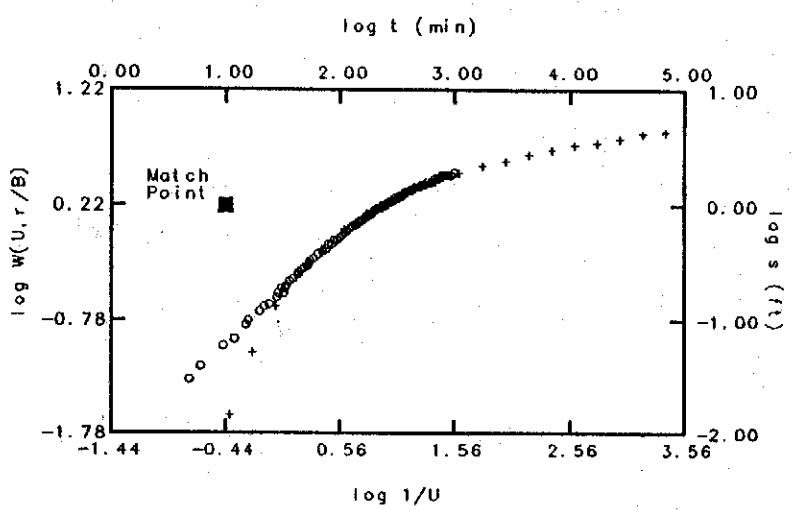


o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	9.013E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	9.013E+0003 gpd/sq ft
1/U	=	3.467E-0002	Storativity	=	1.010E-0003
W(U,r/B)	=	1.738E-0002			

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

4330 Test – Recovery Well 1479

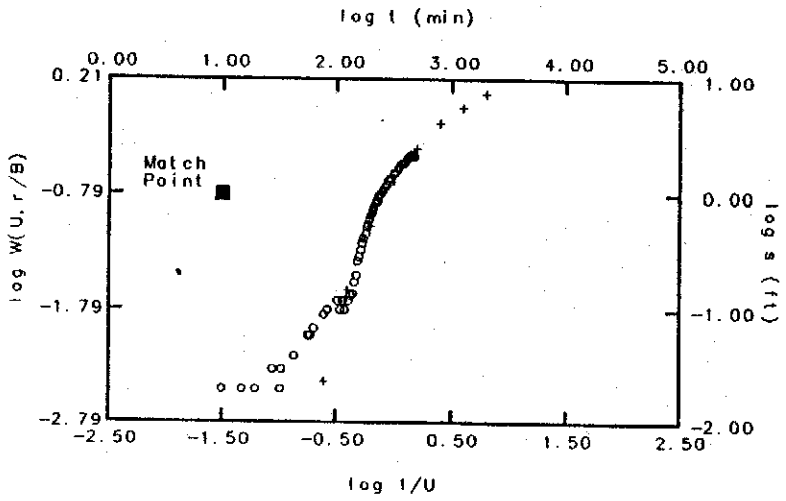


o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	8.608E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	8.608E+0004 gpd/sq ft
1/U	=	3.631E-0001	Storativity	=	9.215E-0004
W(U,r/B)	=	1.660E-0001			

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

4330 Test – Drawdown Well 1480

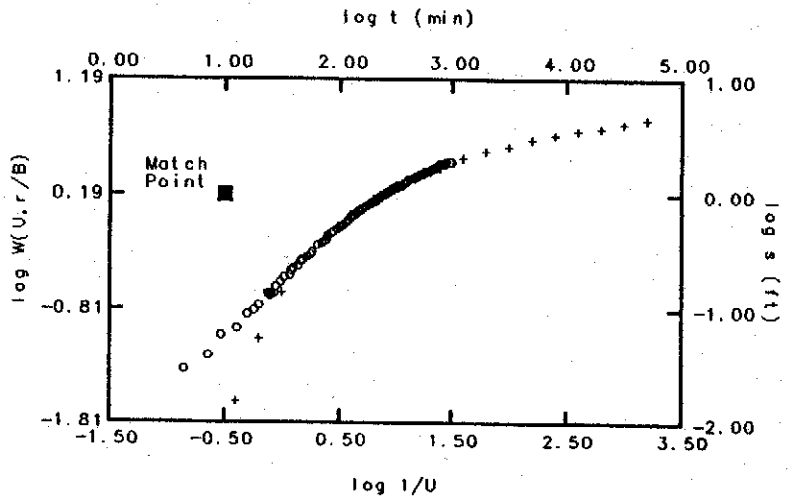


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.50

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	8.412E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	8.412E+0003 gpd/sq ft
1/U	=	3.162E-0002	Storativity	=	1.034E-0003
W(U,r/B)	=	1.622E-0002	Leakage Factor	=	1.955E+0003 ft

WELL INFORMATION		
WELL IDENTIFICATION	:	4330D
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	9.775E+0002 ft

4330 Test – Recovery Well 1480



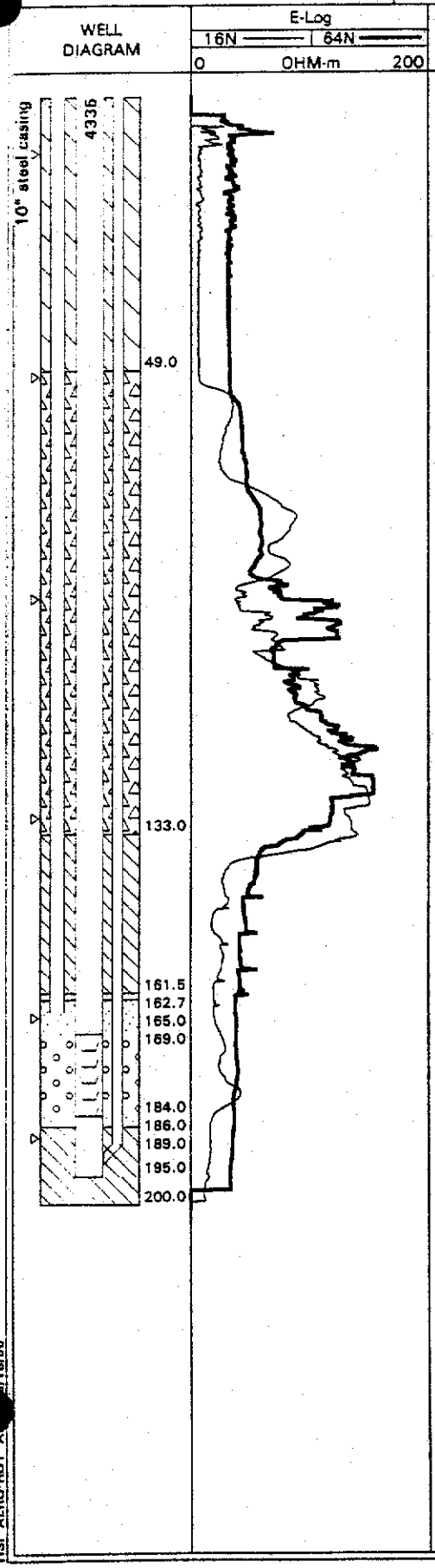
o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	8.033E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	8.033E+0004 gpd/sq ft
1/U	=	3.162E-0001	Storativity	=	9.874E-0004
W(U,r/B)	=	1.549E-0001			

WELL INFORMATION		
WELL IDENTIFICATION	:	4330R
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	9.775E+0002 ft

AEROJET

TOTAL DEPTH BORING ft: 200.0	WELL ID: 4335 Page 1 of 1
TOTAL DEPTH WELL ft: 195.0	SITE: Nimbus Fish Hatchery
SURFACE ELEVATION ft MSL: 107.3	EAST = 2220278.2 NORTH = 352917.4
TOC ELEVATION ft MSL: 107.23	
BOREHOLE DIAMETER: 42"/22"	DATE COMPLETED: 8/24/94 LOGGED BY: D. Dettloff



DESCRIPTION

0 to 5' [GP]: BOULDERS (Dredge tailings); loose, well sorted, well rounded, dry.

5' to 32' [SP]: GRAVELLY SAND; very dark gray-brown (10YR, 3/4), loose, well sorted, coarse, angular to subrounded, dry.

32' to 34' [CH]: CLAY; yellowish-brown (10YR, 5/4), soft, sticky, plastic.

34' to 36' [SP]: SAND; dark grayish-brown (10YR, 4/2), loose, well sorted, subangular to rounded, dry.

36' to 42' [SM]: SANDY SILT; dark yellowish-brown (10YR, 4/4), loose, 60% to 80% silt and 20% to 40% fine to very fine sand, moist.

42' to 67' [SP]: SAND; very dark gray (10YR, 3/1), loose, well sorted, angular to rounded, predominantly volcanics and metamorphics, micaceous, wet.

67' to 87' [GW]: SANDY GRAVEL; black (10YR, 2/1), loose, poorly sorted, extremely angular to subrounded, 60% to 65% gravel and 35% to 40% coarse sand, predominantly volcanics with some quartz, feldspar, and metamorphics, wet.

87' to 98' [SP]: SAND; black (10YR, 2/1), loose, well sorted, angular to rounded, predominantly volcanics, micaceous, wet.

98' to 139' [GW]: SANDY GRAVEL; very dark gray (10YR, 3/1), loose, poorly sorted, extremely angular to rounded, 60% to 75% gravel (increasing with depth) and 25% to 40% coarse sand, predominantly volcanics and metamorphics, micaceous, wet.

139' to 177' [CL]: CLAY; brown (10YR, 5/3), moderately indurated, stiff, wet.

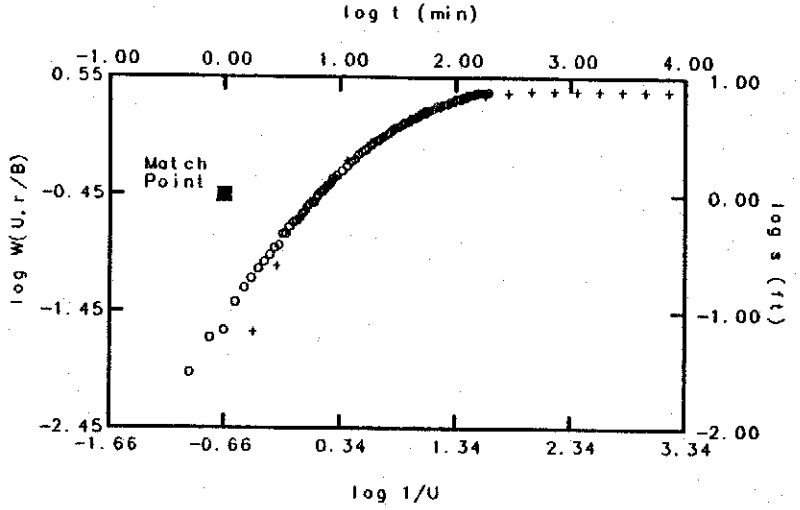
177' to 181' [GW]: SANDY GRAVEL; very dark gray (10YR, 3/1), loose, poorly sorted, angular to subrounded, 60% gravel and 40% coarse sand, predominantly volcanics and metamorphics, micaceous, wet.

181' to 200' [CL]: CLAY; brown (10YR, 5/3), poorly indurated, very soft, wet.

Total Depth of Borehole: 200 feet
24" surface casing installed to a depth of 50 feet.
Dec-94 land surface elevations (ft-msl) for:
10" well casing at 107.23,
3" gravel fill tube at 107.28,
2" sounding tube at 107.27.
Well screen: 0.045" core-10 shutter
Well casing: 4335
Sounding tube: 4336
Gravel fill tube: 4337
Gravel: 8 x 16

ISI AEHQ-NO1 A 1/18/96

4335 Test – Drawdown Well 1359

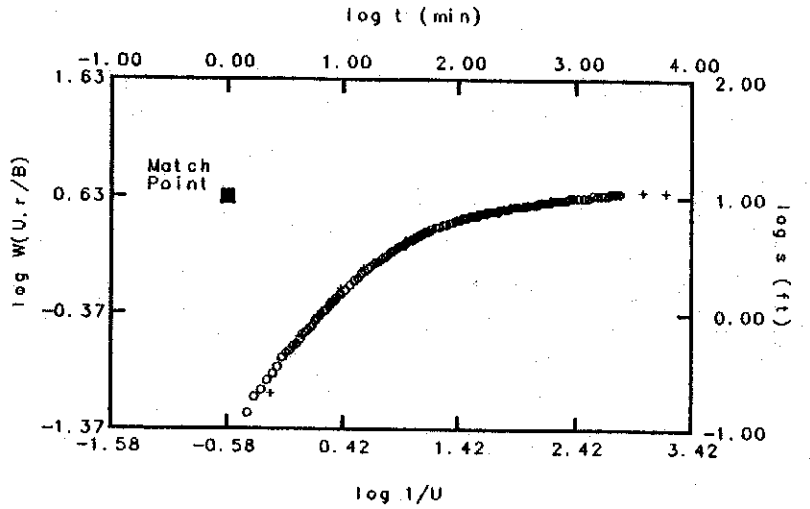


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	9.687E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	9.687E+0003 gpd/sq ft
1/U	=	2.188E-0001	Storativity	=	1.177E-0004
W(U,r/B)	=	3.548E-0002	Leakage Factor	=	1.246E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335DD
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.167E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 3.738E+0002 ft

4335 Test – Recovery Well 1359

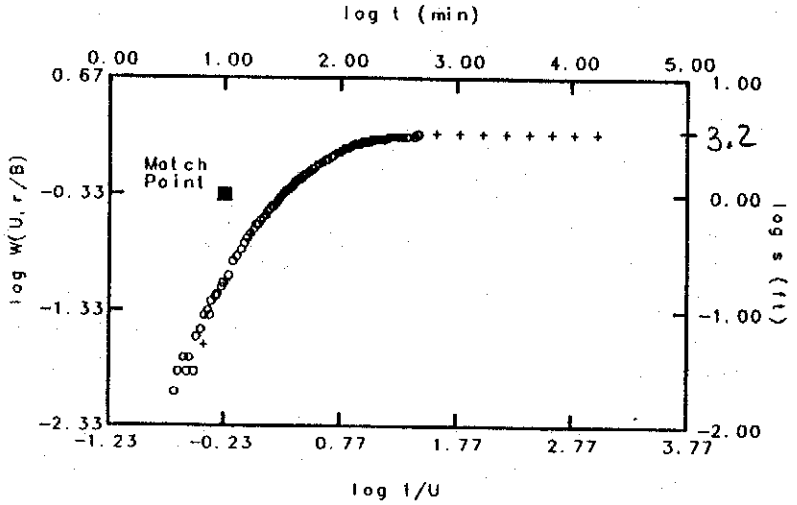


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.165E+0004 gpd/ft
s	=	1.000E+0001	Hydraulic. Cond.	=	1.165E+0004 gpd/sq ft
1/U	=	2.630E-0001	Storativity	=	1.177E-0004
W(U,r/B)	=	4.266E-0001	Leakage Factor	=	3.738E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.167E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 3.738E+0002 ft

4335 Test – Drawdown Well 1372

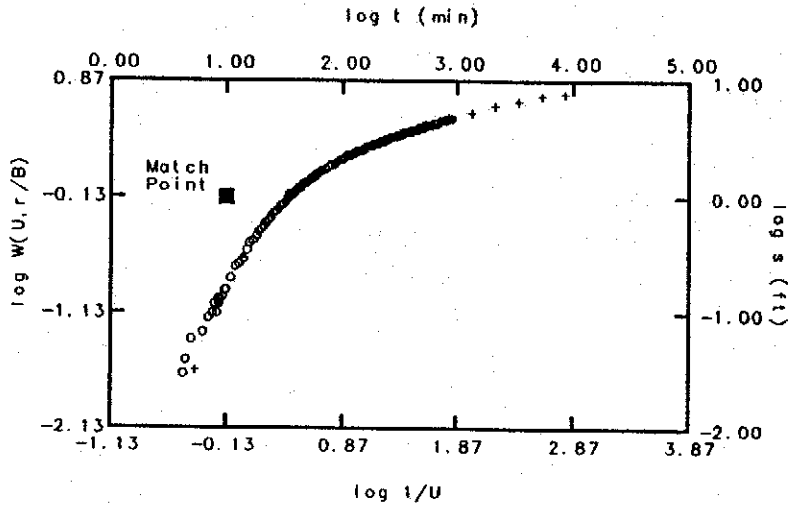


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.60

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.277E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.277E+0004 gpd/sq ft
1/U	=	5.888E-0001	Storativity	=	9.695E-0005
W(U,r/B)	=	4.677E-0002	Leakage Factor	=	1.519E+0003 ft

WELL INFORMATION		
WELL IDENTIFICATION	:	4335D
DATE OF AQUIFER TEST	:	8/22/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	2.383E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	9.115E+0002 ft

4335 Test – Recovery Well 1372

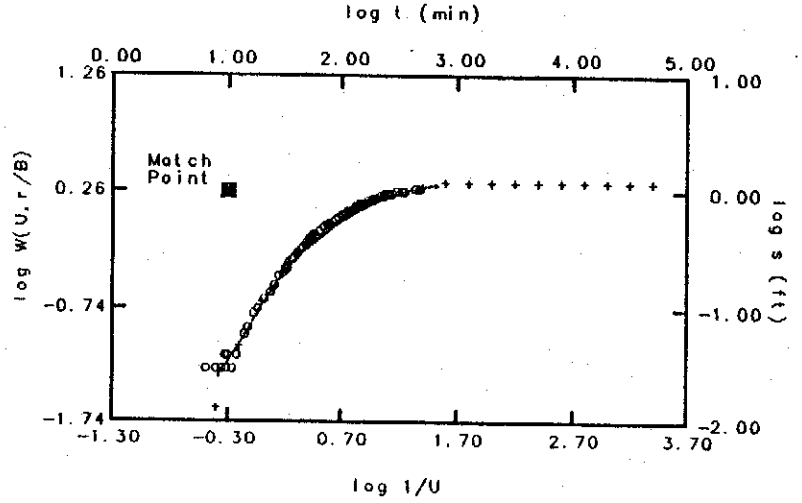


o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	2.024E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	2.024E+0004 gpd/sq ft
1/U	=	7.413E-0001	Storativity	=	1.220E-0004
W(U,r/B)	=	7.413E-0002			

WELL INFORMATION		
WELL IDENTIFICATION	:	4335R
DATE OF AQUIFER TEST	:	8/22/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	2.383E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	9.115E+0002 ft

4335 Test – Drawdown Well 1389

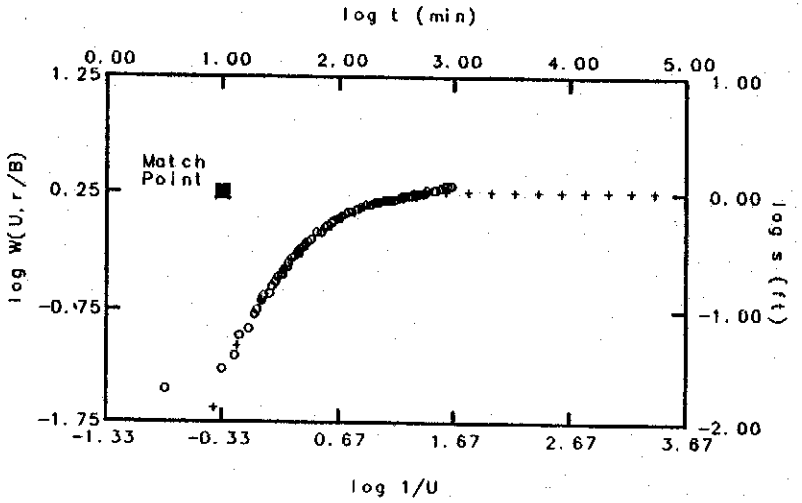


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	4.968E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	4.968E+0004 gpd/sq ft
1/U	=	5.012E-0001	Storativity	=	3.875E-0004
W(U,r/B)	=	1.820E-0001	Leakage Factor	=	2.437E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335D
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.747E+0002 ft

4335 Test – Recovery Well 1389

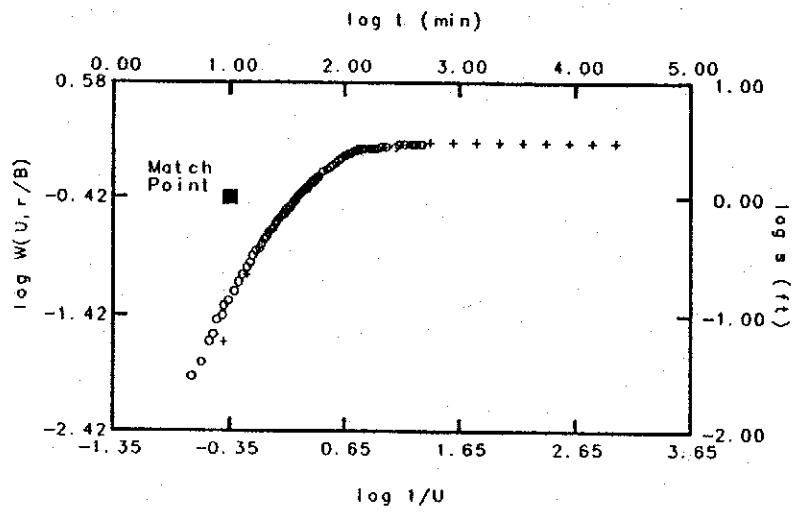


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.50

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	4.855E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	4.855E+0004 gpd/sq ft
1/U	=	4.677E-0001	Storativity	=	4.058E-0004
W(U,r/B)	=	1.778E-0001	Leakage Factor	=	1.949E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.747E+0002 ft

4335 Test – Drawdown Well 1479

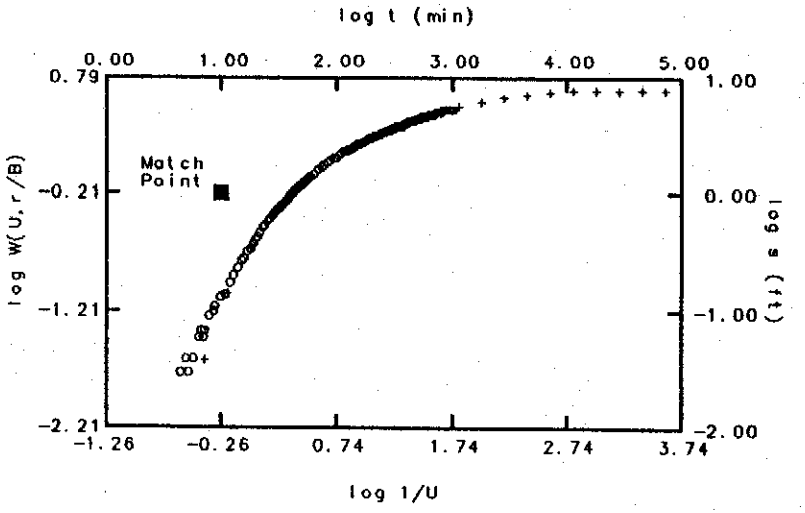


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.80

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.038E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.038E+0004 gpd/sq ft
1/U	=	4.467E-0001	Storativity	=	8.874E-0005
W(U,r/B)	=	3.802E-0002	Leakage Factor	=	1.233E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335D
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.862E+0002 ft

4335 Test – Recovery Well 1479

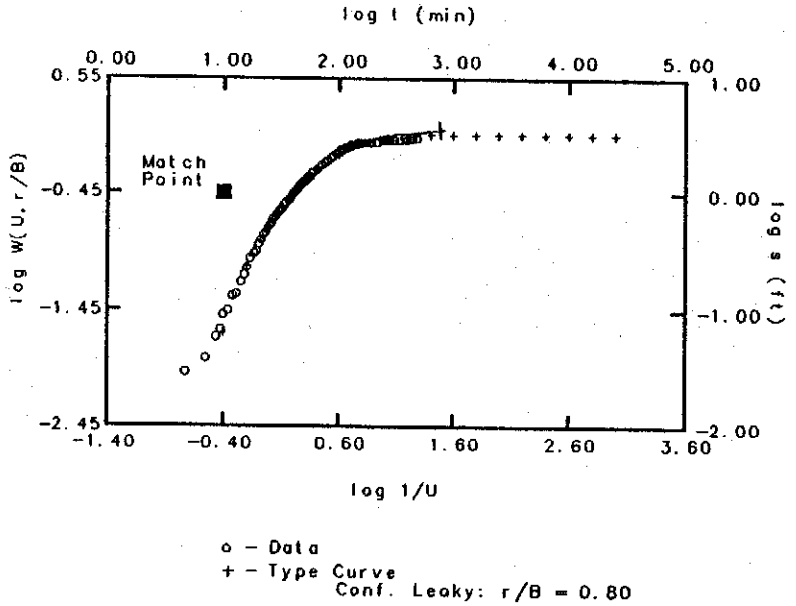


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.683E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.683E+0004 gpd/sq ft
1/U	=	5.495E-0001	Storativity	=	1.170E-0004
W(U,r/B)	=	6.166E-0002	Leakage Factor	=	9.862E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.862E+0002 ft

4335 Test – Drawdown Well 1480

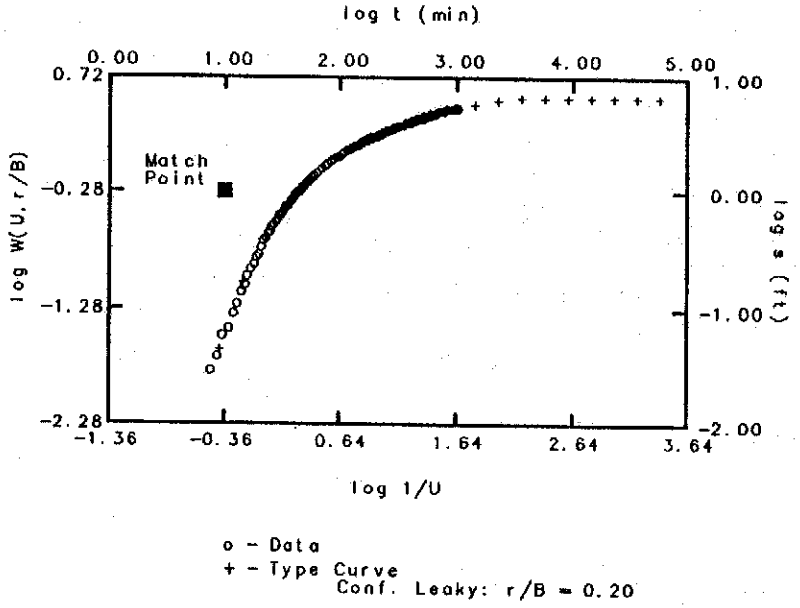


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.80

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	9.687E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	9.687E+0003 gpd/sq ft
1/U	=	3.981E-0001	Storativity	=	9.292E-0005
W(U,r/B)	=	3.548E-0002	Leakage Factor	=	1.233E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335D
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.862E+0002 ft

4335 Test – Recovery Well 1480

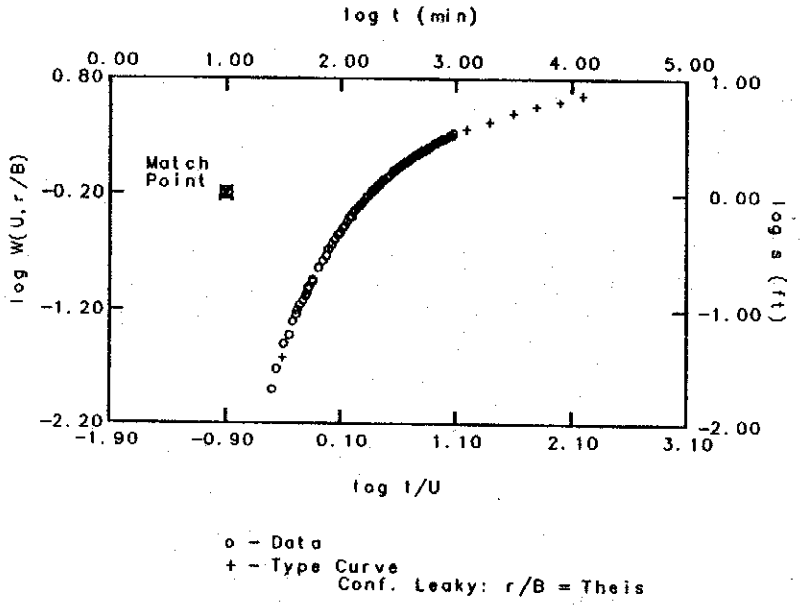


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.433E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.433E+0004 gpd/sq ft
1/U	=	4.365E-0001	Storativity	=	1.253E-0004
W(U,r/B)	=	5.248E-0002	Leakage Factor	=	4.931E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.862E+0002 ft

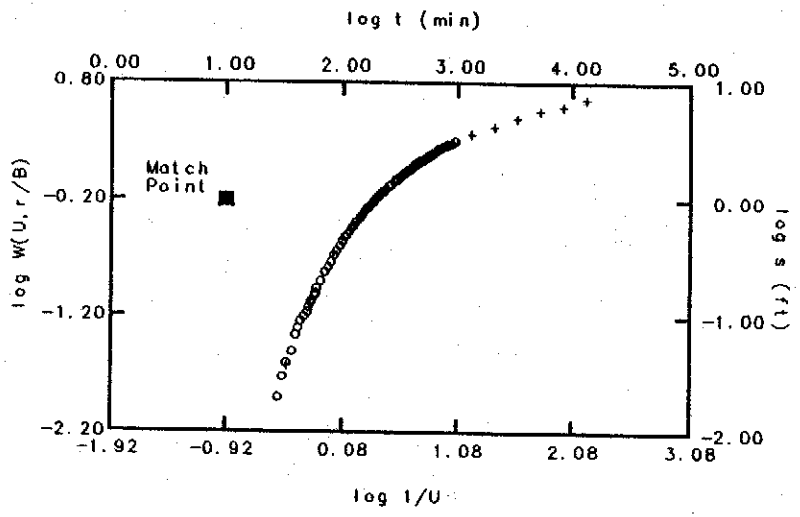
4335 Test – Recovery Well 1510



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.723E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.723E+0004 gpd/sq ft
1/U	=	1.259E-0001	Storativity	=	9.584E-0005
W(U,r/B)	=	6.310E-0002			

WELL INFORMATION		
WELL IDENTIFICATION	:	4335R
DATE OF AQUIFER TEST	:	822/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	2.383E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	2.303E+0003 ft

4335 Test – Recovery Well 1511



o – Data
\+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 1.723E+0004 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 1.723E+0004 gpd/sq ft
1/U	= 1.202E-0001	Storativity	= 1.004E-0004
W(U,r/B)	= 6.310E-0002		

WELL INFORMATION	
WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 822/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 2.303E+0003 ft

Table 2-3
American River Study Area
Aquifer Pumping Test Summary

Pumped Well (Aquifer)	Test Date (Duration)	Q (gpm)	Obs. Wells for Analysis	Obs. Well Aquifer	r (feet)	s (feet)	T (gpd/ft)	T (ft^2/day)	S	L (feet)	Type Curve (r/B)
4300 (Upper)	11/8-12/93 (96 hrs.)	308.8	1395 D	Upper	158	2.70	81,050	10,835	9.8E-05	394	0.4
			1395 R	Upper	158	–	154,440	20,646	9.0E-05	788	0.2
4301 (Middle)	11/15-19/93 (96 hrs.)	218.3	1396 D	Middle	178	3.30	26,190	3,501	1.3E-04	592	0.3
			1396 R	Middle	178	–	24,440	3,267	1.2E-04	592	0.3
			1539 D	Lower	593	0.71	88,740	11,863	2.7E-04	742	0.8
			1539 R	Lower	593	–	62,820	8,398	2.5E-04	593	1.0
4302 (Lower)	11/1-3/93 (96 hrs.)	35.0	1397 D	Lower	139	6.70	697	93	1.9E-04	174	0.8
			1397 R	Lower	139	–	621	83	1.8E-04	154	0.9
			1540 D	Lower	581	0.58	4,103	548	3.1E-04	387	1.5
			1540 R	Lower	581	–	4,103	548	2.5E-04	387	1.5
4302 (Lower)	11/22-24/93 (48 hrs.)	35.3	1397 D	Lower	139	6.90	789	105	2.0E-04	199	0.7
			1397 R	Lower	139	–	598	80	1.7E-04	154	0.9
			1533 D	Lower	1,343	0.39	9,054	1,210	3.8E-04	1,492	0.9
			1533 R	Lower	1,343	–	10,890	1,456	3.0E-04	1,343	1.0
			1540 D	Lower	581	0.64	4,334	579	2.9E-04	387	1.5
			1540 R	Lower	581	–	3,522	471	2.7E-04	387	1.5
4325 (Upper)	8/29/95 (8 hrs.)	424.8	1357D	Upper	409	1.80	80,770	10,797	2.0E-04	1,364	0.3
			1357R	Upper	409	–	80,770	10,797	2.0E-04	1,364	0.3
			1358D	Middle	409	1.86	73,660	9,847	2.1E-04	1,364	0.3
			1358R	Middle	409	–	75,350	10,073	1.9E-04	1,364	0.3
			1370D	Upper	879	0.77	82,650	11,049	1.7E-04	1,255	0.7
			1370R	Upper	879	–	82,650	11,049	1.7E-03	1,255	0.7
			1371D	Middle	879	0.77	53,370	7,135	1.4E-04	879	1.0
			1371R	Middle	879	–	61,270	8,191	1.5E-04	976	0.9
			1388D	Middle	1,003	0.23	627,000	83,818	6.5E-04	3,344	0.3
			1388R	Middle	1,003	–	641,600	85,769	9.0E-04	3,343	0.3
			1404D	Middle	774	0.35	414,200	55,371	5.4E-04	2,581	0.3
			1404R	Middle	774	–	464,800	62,135	6.2E-04	2,581	0.3
			1469D	Upper	834	0.10	475,600	63,578	3.9E-03	927	0.9
			1469R	Upper	834	–	395,600	52,884	3.4E-03	927	0.9
			1478D	Upper	994	0.17	498,000	66,573	1.9E-03	1,987	0.5
			1478R	Upper	994	–	404,800	54,114	2.0E-03	1,987	0.5
4330 (Middle)	8/24/95 (8 hrs.)	452.7	1357D	Upper	389	2.40	58,190	7,779	1.6E-04	1,298	0.3
			1357R	Upper	389	–	60,940	8,146	1.6E-04	1,298	0.3
			1358D	Middle	389	2.71	53,070	7,094	1.3E-04	1,298	0.3
			1358R	Middle	389	–	65,300	8,729	1.2E-04	1,947	0.2
			1370D	Upper	891	0.81	55,580	7,430	1.7E-04	891	1.0
			1370R	Upper	891	–	54,310	7,260	1.6E-04	891	1.0
			1371D	Middle	891	0.81	55,580	7,430	1.6E-04	891	1.0
			1371R	Middle	891	–	63,810	8,530	1.6E-04	990	0.9
			1379D	Lower	804	0.17	638,100	85,302	1.3E-02	N/A	Theis
			1379R	Lower	804	–	988,300	132,117	4.0E-03	4,019	0.2
			1388D	Middle	996	0.25	484,000	64,701	6.0E-04	2,489	0.4
			1388R	Middle	996	–	495,300	66,212	7.1E-04	1,991	0.5
			1404D	Middle	780	0.41	367,200	49,088	5.8E-04	2,600	0.3
			1404R	Middle	780	–	358,800	47,965	5.8E-04	1,950	0.4
			1469D	Upper	848	0.13	421,600	56,360	2.9E-03	942	0.9
			1469R	Upper	848	–	412,000	55,076	2.7E-03	942	0.9
			1478D	Upper	978	0.22	312,500	41,775	1.8E-03	1,396	0.7
			1478R	Upper	978	–	393,400	52,590	2.4E-03	1,629	0.6
			1479D	Lower	978	2.25	9,013	1,205	1.0E-03	N/A	Theis
			1479R	Lower	978	–	86,080	11,507	9.3E-04	N/A	Theis
			1480D	Deeper	978	2.08	8,412	1,125	2.0E-03	1,955	0.5
			1480R	Deeper	978	–	80,330	10,739	9.9E-04	N/A	Theis
4335 (Lower)	8/22/95 (8 hrs.)	238.3	1359D	Lower	374	8.10	9,687	1,295	1.8E-04	1,246	0.3
			1359R	Lower	374	–	11,650	1,557	1.8E-04	3,738	0.1
			1372D	Lower	912	3.28	12,770	1,707	9.7E-05	1,519	0.6
			1372R	Lower	912	–	20,240	2,706	1.2E-04	N/A	Theis
			1389D	Lower	975	1.04	49,680	6,641	3.9E-04	2,437	0.4
			1389R	Lower	975	–	48,550	6,490	4.1E-04	1,949	0.5
			1479D	Lower	986	2.90	10,380	1,388	8.9E-05	1,233	0.8
			1479R	Lower	986	–	16,830	2,250	1.2E-04	9,862	0.1
			1480D	Deeper	986	2.99	9,687	1,295	9.3E-05	1,233	0.8
			1480R	Deeper	986	–	14,330	1,916	1.3E-04	4,931	0.2

Pumped Well (Aquifer)	Test Date (Duration)	Q (gpm)	Obs. Wells for Analysis	Obs. Well Aquifer	r (feet)	s (feet)	T (gpd/ft)	T (ft^2/day)	S	L (feet)	Type Curve (r/B)
4340 (Upper)	3/7/95 (8 hrs.)	25.3	1564D	Upper	186	0.65	43,870	5,865	8.9E-04	1,864	0.1
			1564R	Upper	186	–	60,560	8,096	9.4E-04	1,864	0.1
4345 (Middle)	12/12/94 (8 hrs.)	387.9	1396D	Middle	1,020	0.24	424,400	56,734	3.9E-04	2,039	0.5
			1396R	Middle	1,020	–	280,400	37,484	4.6E-04	1,133	0.9
			1397D	Lower	1,020	0.23	337,100	45,064	3.0E-03	1,699	0.6
			1397R	Lower	1,020	–	454,800	60,798	3.2E-03	1,699	0.6
			1525D	Upper	748	0.29	672,700	89,927	2.0E-03	1,869	0.4
			1525R	Upper	748	–	754,700	100,889	3.1E-03	3,738	0.2
			1526D	Middle	748	0.33	546,800	73,097	9.8E-04	2,492	0.3
			1526R	Middle	748	–	405,300	54,181	1.5E-03	1,869	0.4
			1564D	Upper	288	1.18	116,900	15,627	6.0E-02	96	0.3
			1564R	Upper	288	–	189,600	25,346	4.3E-02	288	0.1
			1565D	Middle	288	9.80	6,135	820	1.1E-03	41	0.7
			1565R	Middle	288	–	6,135	820	1.5E-03	41	0.7
			1566D	Lower	288	5.37	8,275	1,106	5.7E-03	32	0.9
			1566R	Lower	288	–	8,087	1,081	7.2E-03	32	0.9
4350 (Lower)	12/19/94 (8 hrs.)	61.5	1565D	Middle	179	0.45	21,770	2,910	5.7E-04	256	0.7
			1565R	Middle	179	–	3,614	483	5.7E-04	90	2.0
			1566D	Lower	179	1.00	8,090	1,081	2.5E-04	224	0.8
			1566R	Lower	179	–	3,221	431	3.3E-04	119	1.5
4355 (Upper)	11/23/94 (8 hrs.)	387.7	1395D	Upper	640	0.17	2,126,000	284,205	6.1E-04	12,800	0.05
			1395R	Upper	640	–	2,331,000	311,609	1.1E-03	12,800	0.05
			1396D	Middle	640	0.18	866,100	115,781	1.6E-03	6,401	0.1
			1396R	Middle	640	–	487,000	65,102	2.2E-03	914	0.7
			1397D	Lower	640	0.16	119,600	15,988	7.3E-03	427	1.5
			1525D	Upper	487	0.17	627,400	83,871	3.3E-03	1,219	0.4
			1525R	Upper	487	–	971,800	129,911	6.2E-03	1,625	0.3
			1526D	Middle	487	0.19	227,800	30,452	3.1E-03	542	0.9
			1526R	Middle	487	–	286,800	38,340	2.5E-03	542	0.9
			1564D	Upper	573	0.14	510,000	68,177	8.2E-03	955	0.6
			1565D	Middle	573	0.23	928,000	124,056	2.1E-03	N/A	Theis
			1565R	Middle	573	–	1,252,000	167,368	2.8E-03	N/A	Theis
4360 (Middle)	12/1/94 (8 hrs.)	434.2	1395D	Upper	662	0.20	1,435,000	191,832	1.0E-03	13,250	0.05
			1395R	Upper	662	–	2,122,000	283,670	1.4E-03	13,250	0.05
			1396D	Middle	662	0.37	464,300	62,068	4.3E-04	3,312	0.2
			1396R	Middle	662	–	249,300	33,327	4.8E-04	946	0.7
			1397D	Lower	662	0.30	38,620	5,163	2.1E-03	331	2.0
			1397R	Lower	662	–	80,680	10,785	3.5E-03	442	1.5
			1525D	Upper	460	0.40	433,300	57,924	2.6E-03	2,298	0.2
			1525R	Upper	460	–	788,400	105,394	1.6E-03	4,595	0.1
			1526D	Middle	460	0.51	377,400	50,451	9.2E-04	2,298	0.2
			1526R	Middle	460	–	612,000	81,813	6.8E-04	7,658	0.06
			1565D	Middle	579	0.33	368,800	49,301	2.8E-03	1,448	0.4
			1565R	Middle	579	–	453,700	60,651	4.0E-03	1,448	0.4
4365 (Lower)	12/7/94 (8 hrs.)	568.0	1397D	Lower	680	0.10	11,570	1,547	6.3E-04	340	2.0
			1397R	Lower	680	–	11,310	1,512	6.7E-04	340	2.0
			1566D	Lower	587	0.12	115,700	15,467	9.3E-04	1,173	0.5
			1566R	Lower	587	–	136,000	18,181	3.3E-03	1,173	0.5
4370 (Upper)	8/4/95 (8 hrs.)	391.8	1488D	Middle	648	0.16	391,000	52,269	9.3E-03	926	0.7
4375 (Middle)	8/2/95 (8 hrs.)	210.9	1488D	Middle	657	0.16	191,900	25,653	3.3E-03	938	0.7
			1488R	Middle	657	–	179,100	23,942	2.6E-03	821	0.8
			1572D	Middle	952	0.13	96,190	12,859	1.3E-03	635	1.5
			1572R	Middle	952	–	149,000	19,918	9.2E-04	952	1.0
			1573D	Lower	952	0.17	36,570	4,889	9.0E-04	476	2.0
			1573R	Lower	952	–	34,930	4,669	8.8E-04	476	2.0
4380 (Lower)	8/8/95 (8 hrs.)	98.9	1489D	Deeper	628	1.23	13,620	1,821	7.7E-04	1,569	0.4
			1489R	Deeper	628	–	15,290	2,044	1.1E-03	1,569	0.4
			1573D	Lower	1,006	0.13	16,760	2,240	1.3E-03	503	2.0
			1573R	Lower	1,006	–	12,420	1,660	1.2E-03	402	2.5

Notes: D = drawdown analysis
R = recovery analysis
r = distance from pumped well
s = maximum drawdown measured during test
b = aquifer thickness
T = aquifer transmissivity
S = aquifer storage coefficient
L = Leakage Factor [r/(r/B)]

Table 2-3

2.0 ARSA GET FACILITY DESCRIPTION

2.1 System Components

2.1.1 Extraction Wells

Five sets of three extraction wells are located within the ARSA, three north of the river and two south of the river (Figure 2-1). The extraction well sets consist of three wells, each screened in one of the three aquifer units, Aquifer A, Aquifer B and Aquifer C. The aquifer units were screened individually to assure that groundwater would be extracted from each unit at each location and to allow variation of the pumping rates in each unit. One set of wells (4325, 4330 and 4335) is located in the area of highest chemical concentrations, south of the American River on the Nimbus Fish Hatchery property. These wells are intended to expedite removal of chemical mass from the subsurface. The other four sets of extraction wells are located along the downgradient side of the chemical plumes and placed to attempt to maximize the zone of capture created by the groundwater extraction system. The locations of the downgradient extraction wells were somewhat controlled by the geography and land use in the study area. The extraction wells north of the river were all placed on County land within Sailor Bar Park. It was not feasible to locate extraction wells in either residential areas or the heavily wooded ravines north of the river. Average flow rates and total amount of water pumped for each well is summarized in Table 2-1.

2.1.2 Influent Pipelines

The ARSA system utilizes two separate pipelines for collection and conveyance of groundwater from the five sets of extraction wells to the treatment system. One pipeline is dedicated to the conveyance of water produced by the higher concentration wells - 4325, 4330 and 4335 - located on the Nimbus Fish Hatchery property. This pipeline is constructed of 10" x 14" double-walled polyethylene as required by the Agencies to carry the elevated concentration of VOCs present in these wells. Water from the remaining extraction wells contains much lower VOC concentrations and is conveyed using standard single-wall PVC pipe. Various pipe sizes are utilized in this collection system with the largest, a 20" transmission line, beginning at the intersection of the southern end of the river crossing and continuing to the treatment system. Figure 2-1 shows the general

alignment of the two collection pipelines as well as the other components of the ARGET system.

2.1.3 River Crossing

Groundwater produced by the extraction well north of the American River crosses under the American River and is then conveyed to Aerojet property located to the south for treatment. The under-river crossing was accomplished with a 2,200-foot horizontal boring. After completion of the boring, a 30" steel casing was pulled into the bore to provide an installation conduit for the pipeline. Within this steel casing, a centralized 18" x 24" double-walled polyethylene pipe was installed.

2.1.4 Treatment Components

Treatment of groundwater produced by the extraction system is accomplished with advanced oxidation and air stripping processes. As shown in Figure 2-2, water produced by higher concentration wells 4325, 4330 and 4335, is conveyed in a separate pipeline and treated first by advanced oxidation. Three 90 kilowatt ultraviolet (UV) reactors skids, installed in parallel, are used to remove the majority of the target compounds present in the water. Hydrogen peroxide is metered into the influent of the UV skids to provide photo-initiated oxidation of target compounds not amenable to direct photolysis. Effluent from the UV system is then combined with the influent line from all other extraction wells in the ARGET system for the removal of the remainder of the target compounds using a single air-stripping tower.

2.1.5 Effluent Disposal

The ARGET treatment system effluent is discharged to the American River by way of Buffalo Creek as shown on Figure 2-1. On 17 April 1998, the California Regional Water Quality Control Board, Central Valley Region adopted waste discharge requirements for this effluent under the National Pollutant Discharge Elimination System (NPDES) and issued permit # CA 0083861.

The ARGET chemical or compound effluent limits specified in the NPDES permit are as follows:

Constituent	Units	Daily Maximum	Monthly Average
Total Copper	µg/l	17	11
Total Lead	µg/l	15	2.5
Total Zinc	µg/l	110	100
Volatile Organics	µg/l	0.5	
Perchlorate	µg/l	18	18
1,4-dioxane	µg/l	15	10

2.2 Evaluation of Treatment Effectiveness

The ARGET system has removed approximately 2,600 pounds of target compounds from the 1,661 million gallons processed by the treatment facility between August 1998 and November 1999. The treatment system has functioned as designed, producing effluent that routinely meets effluent discharge standards with only minor exceptions that are further discussed in Section 2.3.2.

2.2.1 Air Emissions

Estimates of influent groundwater concentrations, UV treatment equipment effluent concentration, and the treatment system flow rate were developed to evaluate air emission rates from the stripping tower as part of the 1996 EE/CA. These estimated emission rates were used to quantify health effects and determine if installation of air emission control equipment was necessary. According to the 1996 EE/CA, total and reactive organic compounds (ROCs) emissions at system start-up were estimated to be 1.9 and 1.7 pounds per day respectively. According to SMAQMD Rule 202, Section 301.1, the application of best available control technology (BACT) was not required since the emissions did not exceed the 10 pounds per day limit for ROCs (SMAQMD, Procedure for Permit Processing). In addition, an assessment was completed to determine if the emission rate would result in a cancer risk value in excess of the 0.1 x 10^{-6} deminimus level since the off-gas from the air stripper also contained compounds regulated as toxic organics. This assessment concluded that the deminimus level was not exceeded and the application of toxic best available control technology (T-BACT) would not be required. The 1996 EE/CA also concluded that if groundwater chemical concentrations increase where the cancer risk deminimus value or limit for ROCs might

be exceeded, the treatment system would be modified, including installation of additional UV/Oxidation equipment, to maintain ROC emissions levels and risk values below the regulatory limits. The 1996 EE/CA presented estimated worst-case influent groundwater concentrations that could be encountered in the future. These estimates result in total and ROCs emission rates of 15.2 and 14.3 pound per day respectively, and a residential 70-year maximum exposed individual (MEI) cancer risk value of 0.30×10^{-6} without the installation of air emission control equipment.

Table 2-2 compares the air emission rates estimated in the 1996 EE/CA to the calculated average air emission rates from operation of ARGET between 8/26/98 and 10/10/99. The actual emission rate of ROCs was 0.33 lb/day, well below the SMAQMD daily limit. Air emission rates presented in the 1996 EE/CA were calculated at an estimated treatment system flow rate of 3,445 gpm, whereas actual air emission rates presented in Table 2-2 are calculated using the actual ARGET treatment system average flow rate of 2,740 gpm.

2.2.2 Effluent Chemicals and Concentrations

Review of water quality results obtained from the effluent of the ARGET system from system start up through November 1999, generally shows routine compliance with the waste discharge requirements established under the current NPDES permit (CA 0083861). Except for a single TCE value of 1.7 µg/l that occurred on 8 July 1998, the system has complied with the discharge permit for VOCs. In addition, several occurrences of a tentatively identified compound, possibly PCE, were identified in analytical results obtained using Method 8270. These results did not agree with the analytical results obtained on the same date using the more sensitive Method 601. Also, 17 unknown compounds were reported during the period 18 August 1998 through 10 November 1999 in analytical results provided by Method 8270 analysis.

Perchlorate was not evaluated as part of the 1996 EE/CA, but subsequent events resulted in establishment of an effluent discharge standard of 18 µg/l. Perchlorate is currently detected in the influent pipeline associated with the Fish Hatchery Wells (4325, 4330, and 4335) at a concentration of approximately 21 µg/l. Perchlorate in not currently detected in the influent pipeline associated with the remaining wells. When the two influent pipelines are combined the resultant average perchlorate concentration measured in the treatment system effluent is approximately 6 µg/l.

3.0 SUBSURFACE CONDITIONS

3.1 Geology

Figure 3-1 shows the monitor, extraction, recharge and water supply wells from which data were collected for the evaluation of subsurface conditions for this project. Evaluation of lithologic and geophysical logs shows that the sediments consist of Tertiary- and Quaternary-age alluvial deposits from previous courses of the American River. Historic gold-dredging operations have disturbed the shallow sediments in the area.

Lithologic and geophysical logs of monitor, extraction, recharge and public water supply wells were used to construct six hydrogeologic cross-sections through the area (Figures 3-2 through 3-7). Finer-grained materials (silts, clays, siltstones, and claystones) were grouped together as aquitards while the coarser-grained materials (sands, gravels, and sandstones) were grouped together as aquifers. The interpretation of the continuity of lenses and layers shown on the cross-sections is based on geophysical logs, lithologic descriptions, and the response of water levels to pumping. In general, lateral variations in stratigraphy are greater in the north-south direction than in the east-west direction. This configuration is consistent with the depositional patterns expected from the ancestral American River, which flowed westward.

In previous ARSA reports, the hydrostratigraphy has been divided into four main aquifer units, labeled the Upper, Middle, Lower and Deeper Aquifers. To adapt the aquifer labeling for other related projects including on-site studies and the Western Operable Unit Feasibility Study, these aquifers are relabeled herein as Aquifer A, Aquifer B, Aquifer C and Aquifer D, respectively.

Aquifer pumping tests were performed on the 15 extraction wells installed in the ARSA in 1993 through 1995. The purpose of these tests was to determine the approximate quantity of water each well would produce under full-scale operating conditions and to evaluate the hydrologic characteristics of the aquifers being pumped. The results of these tests were presented in the 1996 EE/CA. Table 3-1 presents a summary of the aquifer testing and analyses including test dates, duration, pumping rates, drawdown, distance to pumping wells, transmissivity and storage coefficient as originally published in the 1996 EE/CA.

Aquifers A, B and C contain the majority of the chemical mass in the study area addressed by this report. Below Aquifer C is a relatively continuous aquitard as well as additional water-bearing units, identified as a group as Aquifer D. Aquifers A through C tend to be thicker in the eastern portion of the study area near the fish hatcheries and become thinner to the west. Conversely, Aquifer D becomes thicker and more prevalent than aquitard materials to the west, while aquitard materials are more prevalent at depth in the eastern portion of the study area.

Aquifer A

Aquifer A consists of higher permeability sands and gravels with lenses of interbedded sediments of lower permeability and extends to a depth of approximately 25 to 100 feet below ground surface. Groundwater in Aquifer A exists under both unconfined and semi-confined conditions as determined by local stratigraphy. The average transmissivity for Aquifer A calculated from the ARSA aquifer tests is 70,000 feet squared per day (ft^2/d) and the average storage coefficient is $4.8x10^{-3}$.

Aquifer B

Aquifer B is separated from Aquifer A by a relatively continuous aquitard ranging from approximately 10 to 55 feet in thickness. In general, Aquifer B consists of sands, gravels, and silty sands ranging in thickness between 10 and 70 feet. In the central and western portions of the study area Aquifer B is bifurcated into two water bearing units as shown on cross-sections B-B' and E-E' on Figures 3-3 and 3-6, respectively. The average transmissivity for Aquifer B calculated from the ARSA aquifer tests is 42,500 ft^2/d and the average storage coefficient is $1.3x10^{-3}$.

Aquifer C

Aquifer C is separated from the Aquifer B by an aquitard ranging in thickness from approximately 15 to 50 feet. In general, Aquifer C consists of sands, gravels, and silty sands ranging in thickness between 15 and 55 feet. The average transmissivity for Aquifer C calculated from the ARSA aquifer tests is 11,500 ft^2/d and the average storage coefficient is $9.6x10^{-3}$.

Aquifer D

For this study, the water-bearing zones below Aquifer C are grouped together as Aquifer D; therefore the thickness of this unit is not well defined. Aquifer D is separated from Aquifer C by a relatively continuous aquitard ranging in thickness from approximately 15 to 100 feet. Aquifer D contains more finer-grained sands and silts than overlying aquifers. This is reflected in the somewhat lower average transmissivity for Aquifer D of 3,200 ft^2/d, calculated from the ARSA aquifer tests. The average storage coefficient is $8.4x10^{-4}$.

3.2 Groundwater Flow

3.2.1 Water Level Changes

As described in section 2.1.1 above, the 15 ARGET extraction wells consist of five wells each screened in Aquifer A, Aquifer B and Aquifer C. The average total pumping rate from these wells is approximately 2,750 gpm: approximately 1,100 gpm from the Aquifer A wells, 1,300 gpm from the Aquifer B wells and 350 gpm from the Aquifer C wells (see Table 2-1).

Water levels have declined throughout the ARSA since commencement of pumping in August of 1998. Table 3-2 presents a summary of the water level changes in monitor wells from April 1998 through October of 1999. The water level declines range from 1.6 to 26.5 feet, with an average decline of 8.3 feet in Aquifer A, 9.0 feet in Aquifer B and 12.0 feet in Aquifer C. Despite the fact that there are no extraction wells screened in Aquifer D, pumping from the overlying aquifers has also apparently caused water levels to decline an average of 12.0 feet in this unit.

Figure 3-8 is a hydrograph of wells 30100 and 30101-30103 located approximately 130 feet northwest and just downgradient of extraction wells 4325, 4330 and 4335 on the south side of the river. These wells replaced monitor well 1357-1360 which was lost due to riverbank erosion in 1997. Water levels in these wells have declined 8.8 to 25.5 feet since the start of pumping. The largest decline was noted in Well 30102 completed in Aquifer C.

Figure 3-9 is a hydrograph of well 1395-1399 located approximately 160 feet west and downgradient of extraction wells 4300, 4301 and 4302 on the north side of the river. Water levels in these wells have declined 12.3 to 20.7 feet since the start of pumping. The largest decline was noted in well 1395 completed in Aquifer A. Water levels in these wells are now at their all-time lowest point for data collected since 1991.

Figure 3-10 is a hydrograph of well 1538-1540 located approximately 590 feet northwest and downgradient of extraction wells 4300, 4301 and 4302. Well 1538 completed in Aquifer A went dry after pumping commenced. Water levels in wells 1539 and 1540 have declined 16.1 and 15.0 feet, respectively since the start of pumping. Water levels in these wells are now at their all-time lowest point for data collected since 1993.

Figure 3-11 is a hydrograph of well 1525-1527 located approximately 475 feet west and downgradient of extraction wells 4355, 4360 and 4365. Water levels in these wells have declined 11.6 to 17.0 feet since the start of pumping. Water levels in these wells are now at their all-time lowest point for data collected since 1992.

Figure 3-12 is a hydrograph of well 1585-1587 located approximately 1,175 feet northwest and downgradient of extraction wells 4340, 4345 and 4350. Water levels in these wells have declined 11.8 to 12.1 feet since the start of pumping. Water levels in these wells are now at their all-time lowest point for data collected since 1995.

Figure 3-13 is a hydrograph of wells 1519-1521 and 1522-1524 located approximately 1,100 feet southeast and upgradient of extraction wells 4300, 4301 and 4302. Water levels in these wells have declined 9.7 to 18.9 feet since the start of pumping. The largest decline was noted in well 1521 completed in Aquifer D. Water levels in these wells are now at their all-time lowest point for data collected since 1992.

Figure 3-14 is a hydrograph of wells 1571-1573 and 1574 located approximately 965 feet northwest and downgradient of extraction wells 4370, 4375 and 4380. Water levels in these wells have declined 6.2 to 8.2 feet since the start of pumping. The largest decline was noted in well 1573 completed in Aquifer C. Water levels in these wells are now at their all-time lowest point for data collected since 1994.

Hydrographs for the remaining monitor wells are presented in Appendix A.

3.2.2 Groundwater Gradients

Figures 3-15 through 3-18 present groundwater elevation contour maps of each aquifer based upon data collected during plant-wide soundings conducted in April 1998, October 1998, April 1999 and October 1999. These four dates represent non-pumping conditions prior to startup of the ARGET, two months of pumping, eight months of pumping and 14 months of pumping, respectively. Water levels taken from extraction wells during pumping were adjusted upward to compensate for assumed well losses which would otherwise exaggerate their effect on the contoured surfaces. Table 3-3 presents the measured and corrected water levels and the estimated well efficiencies used to calculate the corrections. The estimated well efficiencies were based on performance during aquifer tests and water levels in nearby monitor wells.

Aquifer A

The April 1998 potentiometric surface map for Aquifer A on Figure 3-15 indicates that, under non-pumping conditions, groundwater flows generally to the west-northwest. The gradient ranges from approximately 0.015 feet per foot (79 feet per mile) in the eastern portion of the study area to approximately 0.004 to 0.006 feet per foot (20 to 33 feet per mile) in the central and western portion of the study area. The average non-pumping gradient across the study area is approximately 0.006 feet per foot (31 feet per mile). The remaining three contour maps on Figure 3-15 show the effect of pumping of the ARSA extraction wells on the potentiometric surface.

Although the unconfined to semi-confined nature of Aquifer A suggests that some hydraulic connection exists between the American River and Aquifer A, the presence of chemicals in Aquifer A on the north side of the river and the configuration of the potentiometric surface of Aquifer A indicate that the river is not a significant barrier to chemical migration or groundwater flow.

Aquifer B

Groundwater in Aquifer B exists under confined to semi-confined conditions. The April 1998 potentiometric surface map for Aquifer B on Figure 3-16 indicates that, under non-pumping conditions, groundwater flows generally to the west-northwest under a gradient of approximately 0.008 feet per foot (40 feet per mile) in the eastern portion of the study

area and gradient of approximately 0.005 feet per foot (26 feet per mile) in the western portion of the study area. The average gradient across the study area is approximately 0.006 feet per foot (31 feet per mile). The remaining three contour maps on Figure 3-16 show the effects of pumping of the ARSA extraction wells on the potentiometric surface.

Aquifer C

Groundwater in Aquifer C exists under confined to semi-confined conditions. The April 1998 potentiometric surface map for Aquifer C on Figure 3-17 indicates that, under non-pumping conditions, groundwater flows generally to the west-northwest under a gradient of approximately 0.01 feet per foot (51 feet per mile) in the eastern portion of the study area and under a gradient of approximately 0.006 feet per foot (31 feet per mile) in the western portion of the study area. In the central portion of the study area, there is an area with a relatively flat gradient, 0.002 feet per foot (9 feet per mile). The average gradient across the study area is approximately 0.005 feet per foot (28 feet per mile). The remaining three contour maps on Figure 3-17 show the effect of pumping of the ARSA extraction wells on the potentiometric surface.

Aquifer D

Groundwater in Aquifer D exists under confined to semi-confined conditions. The April 1998 potentiometric surface map for Aquifer D on Figure 3-18 indicates that, under non-pumping conditions, groundwater flows generally to the west under a gradient of approximately 0.008 feet per foot (43 feet per mile) in the eastern portion of the study area, approximately 0.002 feet per foot (11 feet per mile) in the central portion of the study area and 0.009 feet per foot (47 feet per mile) in the western portion of the study area. The average gradient across the study area is approximately 0.006 feet per foot (34 feet per mile). The remaining three contour maps on Figure 3-18 show the effect of pumping of the ARSA extraction wells on the potentiometric surface. Pumping of the overlying aquifers does not significantly alter the general configuration of the potentiometric surface of Aquifer D.

3.2.3 Capture Zones

Figures 3-19 through 3-21 present estimated capture zones for Aquifers A, B and C, respectively. The capture zones are based on potentiometric surface maps for the

October 1999 water level data. The Surfer vector map function was used to create working maps of groundwater flow vectors. From these maps, the capture zones were estimated. In areas where data is sparse and the contours are somewhat suspect, the capture zones were adjusted to more realistically depict their effect on the groundwater flow system.

3.2.4 Vertical Gradients

Figures 3-22 through 3-27 present contour maps of the vertical gradients between Aquifers A and B, Aquifers B and C, and Aquifers C and D. For each pair of aquifers there is one map for data collected prior to pumping in April 1998 and one map for data collected after eight months of pumping in April 1999. Shaded areas indicate areas of upward gradients. April 1998 was the last full round of water level measurements prior to startup of the ARGET system. April 1999 was chosen for comparison so that seasonal variability in water levels would not be introduced in the evaluation.

The vertical gradients were calculated by selecting locations where monitor wells exist in adjacent aquifers. The water level difference between the adjacent wells divided by the vertical distance between the middle of the well screens resulted in the calculated vertical gradient. Positive values indicate downward gradients and negative values indicate upward gradients. Table 3-4 presents the data used to calculate these values. Values close to zero indicate little or no potential for vertical groundwater movement.

The vertical gradients between Aquifers A and B range from –0.021 to 0.184 with an average value of 0.012 under non-pumping conditions. Under pumping conditions the values range from –0.021 to 0.288 with an average of 0.024, indicating that pumping increases the downward vertical gradient between Aquifers A and B.

The vertical gradients between Aquifers B and C range from –0.040 to 0.235 with an average value of 0.035 under non-pumping conditions. Under pumping conditions the values range from –0.168 to 0.375 with an average of 0.042, indicating that pumping increases the downward vertical gradient between Aquifers B and C. It is also evident that the downward vertical gradient between Aquifers B and C is greater than between Aquifers A and B.

The vertical gradients between Aquifers C and D range from –0.095 to 0.175 with an average value of 0.020 under non-pumping conditions. Under pumping conditions the values range from –0.254 to 0.175 with an average of 0.009, indicating that pumping decreases the downward (or increases the upward) vertical gradient between Aquifers C and D. It is also evident that under pumping conditions the downward vertical gradient between Aquifers C and D is considerably less than between Aquifers A and B or between Aquifers B and C.

3.3 Distribution of Chemicals in Groundwater

Chemicals, primarily volatile organic compounds (VOCs), have been identified in groundwater within the ARSA at depths of approximately 50 to 250 feet below ground surface. Results for samples collected between January 1990 and April 1993 were presented in Appendix D of the 1993 EE/CA. Results for samples collected between January 1993 and January 1996 were presented in Appendix D of the 1996 EE/CA. Results of samples collected between January 1996 and September 1999 have been presented in quarterly monitoring reports and monthly database submittals to the regulatory agencies.

The five most common VOCs found in the groundwater at highest-concentrations in the ARSA are as follows; trichloroethylene (TCE), Freon-113, cis- and/or trans-1,2-dichloroethylene (1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and perchloroethylene (PCE). The graph presented in Figure 3-28 shows the composition and trend of these five compounds since March 1991 for well 1405 which is located in the more highly concentrated portion of the plume on the south side of the American River. Because TCE is the most prevalent chemical and its distribution encompasses that of the other chemicals, TCE has been chosen as the indicator to define the maximum extent of VOCs in the groundwater.

In addition to VOCs, perchlorate and 1,4-dioxane have also been identified in the groundwater in the ARSA. These two chemicals have been identified primarily in wells located in the vicinity of the fish hatcheries, south of the American River. The distribution of perchlorate and 1,4-dioxane are encompassed within the TCE plume. In 1998 31 monitor wells were also sampled and analyzed for n-nitrosodimethylamine (NDMA). None of the samples were found to contain NDMA above the laboratory detection limits of 0.02 and 0.0075 µg/l. The laboratory detection limit was being

lowered during this time, which is why some of the results are at 0.02 µg/l and some are at 0.0075 µg/l. Table 3-5 presents the analytical results for the five main VOCs, perchlorate, 1,4-dioxane, and NDMA for samples collected from January 1998 through September 1999.

The chemical distribution maps discussed below are based upon data collected from monitor, extraction and water supply wells during the summer quarter 1998, the last complete round of sampling prior to startup of the ARGET system, and the summer quarter 1999, representing 10 to 12 months of pumping of the ARGET system. The summer quarterly sampling events include all the ARSA monitor wells, while the other three quarterly sampling events include only a select group of wells. Distribution maps for TCE are presented here, while maps for the other four VOCs, perchlorate and 1,4-dioxane are presented in Appendix B.

The highest TCE concentrations in each aquifer are located in a relatively small area in the central part of the study area under the western portion of the fish hatchery property south of the American River. The highest concentrations and widest distribution of chemicals are within Aquifer B.

Aquifer A

Figures 3-29 and 3-30 present the distribution of TCE in Aquifer A for summer 1998 and summer 1999, respectively. The overall extent of TCE in Aquifer A has remained about the same, although the highest concentrations have decreased significantly. The 1,000-µg/l contour is no longer present. TCE concentrations in wells 1162 and 1361 along the southern border of the plume have increased somewhat from 67 and 57 µg/l to 140 and 62 µg/l, respectively. The estimated capture zone for Aquifer A created by pumping is also shown of Figure 3-30. The Aquifer A capture zone encompasses the majority of the Aquifer A TCE plume. A relatively small area of the plume (<100 µg/l) falls outside the capture zone in the southern portion of the map. Both the TCE distribution and capture zone are not well defined in this area due to a limited number of monitor wells. This is the Gold River residential area where previous attempts to install monitor wells were unsuccessful and placing additional monitor wells is problematic.

Aquifer B

Figures 3-31 and 3-32 present the distribution of TCE in Aquifer B for summer 1998 and summer 1999, respectively. The overall extent of TCE in Aquifer B has remained approximately the same, although the highest concentrations have decreased significantly. The 1,000-µg/l contour has significantly decreased in size. TCE concentrations along the southern border of the plume have decreased slightly, while the TCE concentration in well 1509 in the northern portion of the plume has increased from 47 to 150 µg/l. The estimated capture zone created by pumping is also shown on Figure 3-32. The Aquifer B capture zone encompasses the majority of the Aquifer B TCE plume. Two relatively small areas of the plume (<100 µg/l) fall outside the capture zone the northeastern portion and in the southern portion of the map. Both the TCE distribution and capture zone are not well defined in these areas due to a limited number of monitor wells. These are both residential areas where placing additional monitor wells is problematic. In addition, the terrain is quite steep in the northeastern area, limiting access for wells

Aquifer C

Figures 3-33 and 3-34 present the distribution of TCE in Aquifer C for summer 1998 and summer 1999, respectively. The overall extent of TCE in Aquifer C has remained about the same, although the highest concentrations have decreased significantly. The 1,000-µg/l contour is now much smaller. TCE concentrations along the southern border of the plume have decreased somewhat. TCE concentration in well 1540 located north of extraction well 4302 has decreased from 140 to 45 µg/l. The estimated capture zone created by pumping is also shown of Figure 3-34. The Aquifer C capture zone encompasses almost the entire Aquifer C TCE plume. A relatively small area of the plume (< 50 µg/l) falls outside the capture zone in the southern portion of the map. Both the TCE distribution and capture zone are not well defined in this area due to a limited number of monitor wells. This is the Gold River residential area where placing additional monitor wells is problematic.

Aquifer D

Figures 3-35 and 3-36 present the distribution of TCE in Aquifer D for summer 1998 and summer 1999, respectively. The overall extent and the highest concentrations of TCE in

Aquifer D have remained about the same over the one year period of ARGET operation. As shown on the Figures 3-35 and 3-36, one monitor well, 1480, has shown an increase of TCE from 230 µg/l to 330 µg/l, while all other wells have similar or lower concentrations during this period. There are no extraction wells screened in Aquifer D. Some hydraulic capture of TCE in this aquifer is likely occurring by leakage from Aquifer D into Aquifer C where the vertical gradient between the two aquifers is upward from D to C (Figure 3-27).

3.4 Chemical Concentration Trends

The general decrease in VOC concentrations indicates that the ARGET system is proving to be very effective at removing chemical mass. Approximately 2,600 pounds of VOCs were removed during the first 15 months of operation. To assess the ARGET's effectiveness at minimizing downgradient migration of chemicals, graphs showing the trend of VOC concentrations in wells located near the perimeter of the plume and/or downgradient of extraction wells were prepared. VOC trend graphs for selected wells are shown here, while VOC trend graphs for the remaining wells are presented in Appendix C.

Figure 3-37 is a graph of VOC concentration trends for wells 1531-1533 located in the northern portion of the VOC plume and within the estimated capture zone of the ARGET system. Wells 1531 and 1532, completed in Aquifers A and B, respectively, had been showing an increasing trend of relatively low TCE concentrations since 1994. Since startup of the ARGET, TCE concentrations in these wells have shown a decreasing trend. Well 1533, completed in Aquifer C, shows no evidence of VOCs prior to or since startup of the ARGET.

Figure 3-38 is a graph of VOC concentration trends for wells 1538-1540 located just north and downgradient of extraction wells 4300, 4301 and 4302 and within the estimated capture zone of the ARGET system. Well 1538, completed in Aquifer A, had been showing an increasing trend of relatively low TCE concentrations since 1995. Since startup of the ARGET, well 1538 has been dry so no additional samples have been collected. Well 1539, completed in Aquifer B, had a general decreasing trend of TCE, 1,2-DCE and PCE since 1996. After startup of the ARGET, there was an increase in the first sample collected from this well followed by a decreasing trend in subsequent samples. Well 1540, completed in Aquifer C, had an increasing trend in TCE, 1,2-DCE

and PCE since 1995. After startup of the ARGET, there was an increase in the first sample collected from this well followed by a decreasing trend in subsequent samples.

Figure 3-39 is a graph of VOC concentration trends for wells 1525-1527 located northwest and downgradient of extraction wells 4355, 4360 and 4365 and within the estimated capture zone of the ARGET system. Well 1525, completed in Aquifer A, and well 1526, completed in both Aquifers B and C, continue to show no evidence of VOCs. Well 1527, completed in Aquifer D, had a general increasing trend of relatively low TCE concentrations since 1996. After startup of the ARGET, the TCE concentration has appeared to stabilize at approximately 5 to 10 µg/l.

Figure 3-40 is a graph of VOC concentration trends for wells 1585-1587 located west of extraction wells 4355, 4360 and 4365 and beyond the estimated capture zone of the ARGET system. Well 1585, completed in Aquifer A, shows no evidence of VOCs prior to or since startup of the ARGET. Well 1586, completed in Aquifer B, had a decreasing trend of relatively low TCE concentrations since 1995. After startup of the ARGET, the TCE concentration increased somewhat followed by a decreasing trend for subsequent samples. Well 1587, completed in Aquifer C, had a slightly increasing trend in relatively low VOC concentrations since 1995. After startup of the ARGET, samples have shown a slight decreasing trend in VOC concentrations.

Figure 3-41 is a graph of VOC concentration trends for wells 1509-1511 located within the VOC plume, upgradient of extraction wells 4300, 4301, and 4302 and within the ARGET capture zone. Well 1509, completed in Aquifer B, had in increasing trend in TCE and 1,2-DCE prior to startup of the ARGET. Since startup of the ARGET system, TCE, 1,2-DCE and PCE have shown increasing concentrations. This may be a result of the higher concentration portion of the plume approaching this well. The well is located well within the capture zone of the ARGET system. Well 1510, completed in Aquifer C, had a decreasing trend of relatively low TCE concentrations since 1996. After startup of the ARGET, TCE concentrations increased somewhat, followed by a decreasing trend for subsequent samples. TCE concentrations for well 1510 remain below 2 µg/l. Well 1511, completed in Aquifer D, shows no evidence of VOCs in the four years prior to or since startup of the ARGET.

Figure 3-42 is a graph of VOC concentration trends for wells 1480, 1489 and 1524, all completed in Aquifer D. These wells all exhibited an increasing trend in VOC

concentrations since 1992/1993. After startup of the ARGET, VOCs in well 1480 increased significantly then decreased somewhat. VOCs in well 1489 have increased somewhat since startup of the ARGET. The VOC concentrations in well 1524 have stayed relatively consistent since 1996.

Figure 3-43 is a graph of VOC concentration trends for wells 1394, 1402 and 1471, all completed in Aquifer D. These wells have exhibited somewhat irregular trends in VOC concentrations since 1992. After startup of the ARGET, VOC concentrations in all three wells have decreased.

4.0 Conclusions and Recommendations

4.1 Conclusions

- The ARGET treatment system is very effective at removing VOCs from groundwater (Table 2-2). Approximately 2,600 pounds of VOCs were removed from approximately 1.7 billion gallons of water during the first 15 months of operation of the system.

- Analysis of chemical distribution maps and capture zones for Aquifers A, B and C indicate that the ARGET system is effectively capturing the vast majority of the VOC plume and reducing the mass of VOCs in the groundwater. The plume appears to be within the capture zones except for small areas of relatively low concentrations, which are either in residential neighborhoods or steep terrain. The installation of additional wells is problematic in these areas.

- Analyses of chemical trend graphs indicate that the ARGET system is effectively controlling the downgradient migration of chemicals in groundwater in Aquifers A, B and C.

- Analysis of chemical distribution and VOC trends for Aquifer D since ARGET began operation indicates that VOCs in this aquifer are, except for monitor well 1480, relatively stable or declining. The cause of the increase at well 1480 is not clear, however significant downward movement of VOCs from Aquifer C is unlikely at this location based on the near neutral head gradient between Aquifers C and D at this location.

4.2 Recommendations

- Aerojet recommends collecting an additional four quarters of monitoring data to further evaluate the distribution and concentration trends of VOCs in Aquifer D. This data will be collected during the four quarters of calendar year 2000. The Aquifer D plume appears to be moving relatively slowly and is well defined horizontally by a series of clean monitor wells. These wells will provide for early warning of changes in the leading edge of the plume and thus protect downgradient resources. To better define concentration trends, five Aquifer D

monitor wells will be changed from annual sampling to quarterly sampling, including wells 1373, 1471, 1483, 1508 and 1524 (Figure 3-36). Other proposed changes to the monitoring program are to reduce sampling frequency of Aquifer D monitor wells 1409, 1589 and 1590 (Figure 3-36) from quarterly sampling to annual sampling. These wells are located approximately 3,500 feet downgradient (northwest) of the leading edge of the Aquifer D plume and show a relatively consistent history of non-detects or very low VOC concentrations. Note that two shallower Aquifer D wells (wells 1408 and 1588) will continue to be sampled quarterly at these two locations.

- A letter report addressing Aquifer D will be submitted March 1, 2001 which will present an evaluation of the quarterly monitoring and provide appropriate recommendations for either further field work or the preparation of a Remedial Action Plan Workplan or other remedial action selection documentation in accordance with CERCLA and the NCP. A revised schedule for the ARSA program is presented in Table 4-1.

5.0 References

Gencorp Aerojet, Engineering Evaluation and Cost Analysis for the American River Study Area, Aerojet Sacramento Site, May 1993

Gencorp Aerojet, Final Revised Engineering Evaluation and Cost Analysis for the American River Study Area, Aerojet Sacramento Site, September 1996

Gencorp Aerojet, Scoping Report, December 1989

Table 2-1
American River Study Area
Flow Rates for Extraction Wells and Treatment Plant
August 1998 - August 1999

Well	Millions of Gallons Pumped	Average Flow Rate (gpm)	Aquifer
4300	137.8	262	A
4301	77.0	147	B
4302	12.2	23	C
4325	77.0	147	A
4330	110.0	209	B
4335	97.9	186	C
4340	4.7	9	A
4345	198.6	378	B
4350	18.8	36	C
4355	215.0	409	A
4360	182.4	347	B
4365	26.0	49	C
4370	158.8	302	A
4375	93.8	178	B
4380	29.4	56	C
Totals:	1,439.3	2,739	
Aquifer A	593.3	1,129	
Aquifer B	661.8	1,259	
Aquifer C	184.2	351	
Treatment Plant Sample Points			
7065 (influent)	271.8	517	Wells 4325, 4330, 4335
7067 (influent)	1,007.7	1,917	Remaining 12 Wells
7069 (effluent)	1,311.3	2,495	Combined effluent

Table 3-2
American River Study Area
Summary of Water Level Changes

Well No.	Aquifer	Water Level Change (feet) Apr-98 - Apr-99	Oct-98 - Oct-99	Apr-98 - Oct-99
1162	A	-2.6	-4.7	-7.8
1211	A	-6.4	-4.4	-9.7
1214	A	-3.4	-2.6	-6.2
1216	A	-2.9	-3.3	-6.7
1361	A	-1.4	-4.6	-5.7
1370	A	-3.7	-1.8	-5.7
1375	A	-1.4	0.4	-2.3
1391	A	-3.1	-3.2	-6.5
1395	A	-17.7	-4.3	-20.7
1403	A	-3.9	-2.2	-6.1
1406	A	-6.7	-4.5	-10.4
1469	A	-2.9	-1.4	-4.8
1472	A	-2.7	-2.7	-5.2
1475	A	NM	-4.8	-7.5
1478	A	-2.8	-1.8	-5.0
1481	A	-4.5	-1.5	-7.5
1487	A	-3.3	-1.7	-4.9
1506	A	-6.5	-3.9	-9.9
1519	A	-6.4	-3.6	-9.8
1522	A	-6.3	-3.7	-9.7
1525	A	-13.9	-5.0	-17.0
1528	A	0.0	-1.9	-1.6
1531	A	-7.0	-4.7	-10.2
1538	A	Dry	Dry	Dry
1559	A	-5.8	-4.1	-8.9
1564	A	-14.3	-3.7	-16.9
1567	A	-9.7	-3.2	-13.1
1571	A	-4.2	-1.8	-6.2
1585	A	-8.6	-4.5	-12.1
1591	A	NM	-4.4	NM
1594	A	-3.5	-3.9	-6.2
30068	A	-3.8	-1.6	-5.8
30100	A	-6.6	-1.2	-8.0
	Maximum	0.0	0.4	-1.6
	Minimum	-17.7	-5.0	-20.7
	Average	-5.5	-3.1	-8.3
1163	B	-2.6	-4.7	-7.9
1169	B	-2.5	NM	NM
1211	B	-6.4	-4.4	-9.7
1214	B	-3.4	-2.6	-6.2
1362	B	-1.5	-4.7	-6.0
1363	B	-1.4	-4.9	-6.8
1371	B	-3.7	-1.9	-5.8
1376	B	-2.0	-0.2	-3.2
1380	B	-2.9	-2.1	-5.0
1382	B	-2.7	-2.7	-5.5
1383	B	-3.0	-2.7	-5.9
1385	B	-3.0	-5.3	-7.8
1386	B	-3.0	-1.1	-3.8
1388	B	-2.8	-4.2	-4.4

Table 3-2
American River Study Area
Summary of Water Level Changes

Well No.	Aquifer	Water Level Change (feet) Apr-98 - Apr-99	Oct-98 - Oct-99	Apr-98 - Oct-99
1392	B	-3.2	-3.3	-6.5
1396	B	-16.7	-4.0	-19.6
1400	B	-3.3	-3.1	-6.7
1404	B	-3.9	-2.1	-6.3
1405	B	-3.8	-2.3	-6.3
1407	B	-6.6	-4.6	-10.3
1470	B	-7.3	-2.8	-11.9
1476	B	NM	-4.7	-7.3
1488	B	-3.5	-1.5	-5.3
1509	B	-3.9	-3.6	-7.1
1519	B	-6.4	-3.6	-9.8
1523	B	-7.0	-3.3	-10.1
1526	B	-13.7	-4.6	-16.7
1532	B	-6.9	-4.8	-10.1
1539	B	-13.5	-4.5	-16.1
1557	B	-3.2	-3.4	-6.1
1560	B	-5.8	-4.2	-9.0
1562	B	-8.1	-2.7	-11.2
1563	B	-8.1	-3.5	-11.2
1565	B	-23.6	-4.1	-26.5
1568	B	-9.6	-3.0	-12.7
1570	B	-9.4	-1.9	-12.5
1572	B	-4.7	-2.1	-7.1
1574	B	-4.3	-1.9	-6.4
1586	B	-8.3	-4.4	-11.8
1592	B	NM	-4.5	NM
30101	B	-7.4	-1.6	-8.8
	Maximum	-1.4	-0.2	-3.2
	Minimum	-23.6	-5.3	-26.5
	Average	-6.0	-3.3	-9.0
1164	C	-1.7	-3.6	-6.3
1364	C	-2.5	-4.1	-9.3
1372	C	-11.0	-3.9	-18.0
1377	C	-4.6	-2.4	-7.7
1379	C	-4.2	-2.6	-7.5
1381	C	-3.3	-2.5	-5.9
1384	C	-3.1	-2.8	-6.2
1387	C	-2.4	-3.0	-5.1
1389	C	-4.7	-2.5	-7.9
1393	C	-3.3	-3.3	-6.9
1397	C	-16.1	-3.3	-19.0
1401	C	-3.8	-3.2	-7.6
1470	C	-7.3	-2.8	-11.9
1477	C	NM	-4.1	-6.5
1479	C	-11.6	-6.0	-19.9
1482	C	-6.6	-10.6	-17.7
1507	C	-6.7	-3.8	-9.9
1510	C	-10.0	-7.3	-18.8
1520	C	-7.8	-4.4	-12.8
1526	C	-13.7	-4.6	-16.7

Table 3-2
American River Study Area
Summary of Water Level Changes

Well No.	Aquifer	Water Level Change (feet)		
		Apr-98 - Apr-99	Oct-98 - Oct-99	Apr-98 - Oct-99
1529	C	-5.3	-3.9	-9.6
1533	C	-8.9	-6.5	-16.4
1540	C	-12.1	-4.7	-15.0
1558	C	-3.8	-5.0	-8.0
1561	C	-5.8	-4.3	-9.0
1566	C	-18.4	-3.5	-21.2
1569	C	-9.5	-3.0	-12.6
1573	C	-5.2	-2.5	-8.2
1587	C	-8.2	-4.5	-11.9
1593	C	NM	-4.5	NM
30102	C	-18.8	-2.9	-25.5
	Maximum	-1.7	-2.4	-5.1
	Minimum	-18.8	-10.6	-25.5
	Average	-7.6	-4.1	-12.0
1170	D	-4.1	NM	NM
1171	D	-4.1	NM	NM
1365	D	-1.4	-4.6	-8.6
1373	D	-11.5	-4.6	-18.9
1374	D	-6.7	-6.9	-12.1
1378	D	-3.6	-3.1	-6.8
1390	D	-3.1	-3.2	-6.4
1394	D	-2.1	-3.4	-5.4
1398	D	-7.8	-5.6	-12.3
1399	D	-8.7	-6.3	-16.1
1402	D	-1.9	-3.6	-5.4
1408	D	-6.7	-7.4	-11.3
1409	D	-4.5	-8.2	-11.8
1471	D	-6.9	-6.3	-12.3
1473	D	-2.7	-3.0	-5.6
1474	D	-2.6	-2.9	-5.6
1480	D	-11.8	-7.0	-21.1
1483	D	-9.0	-5.2	-17.3
1489	D	-8.7	-2.7	-15.9
1508	D	-5.3	-5.4	-10.4
1511	D	-9.9	-7.1	-18.9
1521	D	-10.0	-6.8	-18.9
1524	D	-9.8	-6.5	-18.4
1527	D	-6.5	-6.2	-11.6
1530	D	-4.3	-4.2	-8.3
1588	D	NM	-8.7	NM
1589	D	NM	-8.7	NM
1590	D	NM	-8.5	NM
1595	D	-7.2	-5.8	-8.9
1596	D	-7.2	-5.5	-8.6
30069	D	-11.8	-4.9	-19.3
30070	D	-6.6	-4.6	-10.5
30103	D	-6.0	-5.4	-9.5
	Maximum	-1.4	-2.7	-5.4
	Minimum	-11.8	-8.7	-21.1
	Average	-6.4	-5.6	-12.0

Table 3-3
American River Study Area
Extraction Well Water Level Corrections

Extraction Well	Aquifer	Estimated Efficiency*	October 1998			April 1999			October 1999		
			Measured Elevation (ft, MSL)	Corrected Elevation (ft, MSL)	Correction (feet)	Measured Elevation (ft, MSL)	Corrected Elevation (ft, MSL)	Correction (feet)	Measured Elevation (ft, MSL)	Corrected Elevation (ft, MSL)	Correction (feet)
4300	A	95%	34.0	35.5	1.5	36.1	37.5	1.4	33.7	35.3	1.7
4325	A	75%	60.4	66.6	6.2	62.8	68.5	5.7	58.6	66.0	7.4
4340	A	85%	30.0	34.4	4.4	37.9	41.1	3.3	30.0	34.8	4.9
4355	A	75%	25.5	33.7	8.2	22.5	31.5	9.0	17.4	28.4	11.0
4370	A	45%	38.6	58.7	20.2	37.6	58.4	20.9	30.4	56.8	26.4
4301	B	50%	7.9	35.8	27.9	3.0	33.5	30.5	-6.9	30.0	37.0
4330	B	50%	55.9	71.3	15.4	41.6	64.3	22.7	14.9	52.5	37.6
4345	B	50%	-4.9	27.4	32.3	-2.5	28.7	31.2	-12.2	25.4	37.6
4360	B	50%	3.9	31.3	27.4	2.3	30.6	28.3	2.2	32.1	29.9
4375	B	50%	19.1	46.9	27.8	17.6	46.3	28.7	16.7	47.3	30.7
4302	C	45%	-27.4	24.0	51.4	-18.5	27.8	46.3	-17.5	30.6	48.2
4335	C	35%	-32.5	39.3	71.8	-29.4	40.1	69.6	-39.1	39.6	78.7
4350	C	40%	-38.2	21.9	60.1	-27.3	26.0	53.4	-27.5	28.6	56.1
4365	C	35%	-33.0	28.1	61.0	-31.8	28.3	60.1	-34.4	30.2	64.6
4380	C	30%	-36.4	40.8	77.2	-14.6	47.1	61.7	-2.5	53.8	56.3

*Estimated efficiency based on the extraction well response compared to nearby wells during aquifer tests

Table 3-4
American River Study Area
Summary of Vertical Gradients

Well Pair	Vertical Distance (feet)	Water Level Difference (feet)		Vertical Gradient (negative denotes upward)	
		Apr-98	Apr-99	Apr-98	Apr-99
Aquifer A - Aquifer B					
1162-3	40.5	-0.36	-0.41	-0.009	-0.010
1361-2	38.0	-0.56	-0.53	-0.015	-0.014
1370-1	48.0	-0.14	-0.09	-0.003	-0.002
1375-6	53.5	-0.95	-0.35	-0.018	-0.007
1472-1382	59.9	-1.25	-1.25	-0.021	-0.021
1391-2	59.5	-0.14	-0.10	-0.002	-0.002
1395-6	43.0	0.22	-0.76	0.005	-0.018
1403-4	57.0	0.13	0.21	0.002	0.004
1406-7	55.0	0.13	0.06	0.002	0.001
1475-6	44.5	2.56	NM	0.058	NM
1481-1562	34.5	6.35	9.92	0.184	0.288
1487-8	64.5	0.23	0.45	0.004	0.007
1522-3	36.5	0.94	1.57	0.026	0.043
1525-6	36.5	0.19	0.00	0.005	0.000
1531-2	40.5	0.80	0.70	0.020	0.017
1538-9	58.5	-0.63	NM	-0.011	NM
1559-60	47.0	-0.01	-0.02	0.000	0.000
1564-5	53.0	0.75	9.98	0.014	0.188
1567-8	38.0	0.20	0.13	0.005	0.003
1571-2	63.0	1.70	2.18	0.027	0.035
1585-6	56.0	0.36	0.07	0.006	0.001
1591-2	55.0	NM	0.22	NM	0.004
1594-1557	52.2	0.34	0.05	0.007	0.001
30100-1	34.0	-0.07	0.68	-0.002	0.020
			Maximum	0.184	0.288
			Minimum	-0.021	-0.021
			Average	0.012	0.024
Aquifer B - Aquifer C					
1163-4	80.0	3.56	2.69	0.044	0.034
1363-4	33.0	5.69	6.87	0.172	0.208
1371-2	52.0	12.20	19.52	0.235	0.375
1376-7	78.5	-3.11	-0.54	-0.040	-0.007
1405-1379	45.8	1.17	0.74	0.026	0.016
1380-1	58.0	-0.18	0.25	-0.003	0.004
1383-4	46.5	0.09	0.20	0.002	0.004
1386-7	68.5	1.92	1.33	0.028	0.019
1388-9	83.0	-1.93	-0.01	-0.023	0.000
1392-3	59.0	-0.15	0.02	-0.003	0.000
1396-7	52.0	2.22	1.65	0.043	0.032
1400-1	46.5	1.59	2.05	0.034	0.044
1476-7	95.5	8.57	NM	0.090	NM
1563-1482	27.3	-0.81	-2.30	-0.030	-0.084
1509-10	80.5	3.49	9.59	0.043	0.119
1519-20	67.5	1.53	2.89	0.023	0.043
1532-3	61.0	0.60	2.56	0.010	0.042
1539-40	41.5	0.79	-0.58	0.019	-0.014
1557-8	48.0	0.64	1.26	0.013	0.026
1560-1	36.0	-0.02	-0.03	-0.001	-0.001
1565-6	32.0	-0.23	-5.36	-0.007	-0.168

Table 3-4
American River Study Area
Summary of Vertical Gradients

Well Pair	Vertical Distance (feet)	Water Level Difference (feet)		Vertical Gradient (negative denotes upward)	
		Apr-98	Apr-99	Apr-98	Apr-99
1568-9	48.0	-0.13	-0.27	-0.003	-0.006
1572-3	52.0	2.35	2.82	0.045	0.054
1586-7	25.5	0.14	0.09	0.005	0.004
1592-3	32.5	NM	0.87	NM	0.027
30101-2	80.5	11.24	22.64	0.140	0.281
			Maximum	0.235	0.375
			Minimum	-0.040	-0.168
			Average	0.035	0.042
Aquifer C - Aquifer D					
1364-5	36.0	-1.50	-2.66	-0.042	-0.074
1372-3	34.8	0.02	0.46	0.001	0.013
1377-8	71.0	-0.39	-1.37	-0.005	-0.019
1384-1473	67.6	1.50	1.03	0.022	0.015
1389-90	76.0	-0.04	-1.60	-0.001	-0.021
1393-4	110.5	2.44	1.22	0.022	0.011
1397-8	50.0	8.73	0.47	0.175	0.009
1401-2	144.0	2.24	0.39	0.016	0.003
1470-1	127.0	4.75	4.40	0.037	0.035
1479-80	70.0	0.07	0.23	0.001	0.003
1482-3	115.0	4.94	7.26	0.043	0.063
1507-8	89.0	12.92	11.57	0.145	0.130
1510-11	73.0	0.11	0.04	0.002	0.001
1520-21	76.0	0.09	2.37	0.001	0.031
1526-7	127.5	10.96	3.76	0.086	0.029
1529-30	53.0	-3.32	-4.28	-0.063	-0.081
1558-1595	20.8	0.19	3.64	0.009	0.175
1593-88	110.5	NM	10.67	NM	0.097
30102-3	80.5	-7.68	-20.47	-0.095	-0.254
			Maximum	0.175	0.175
			Minimum	-0.095	-0.254
			Average	0.020	0.009

Figure 3-8
Hydrograph Wells 30100, 30101-03

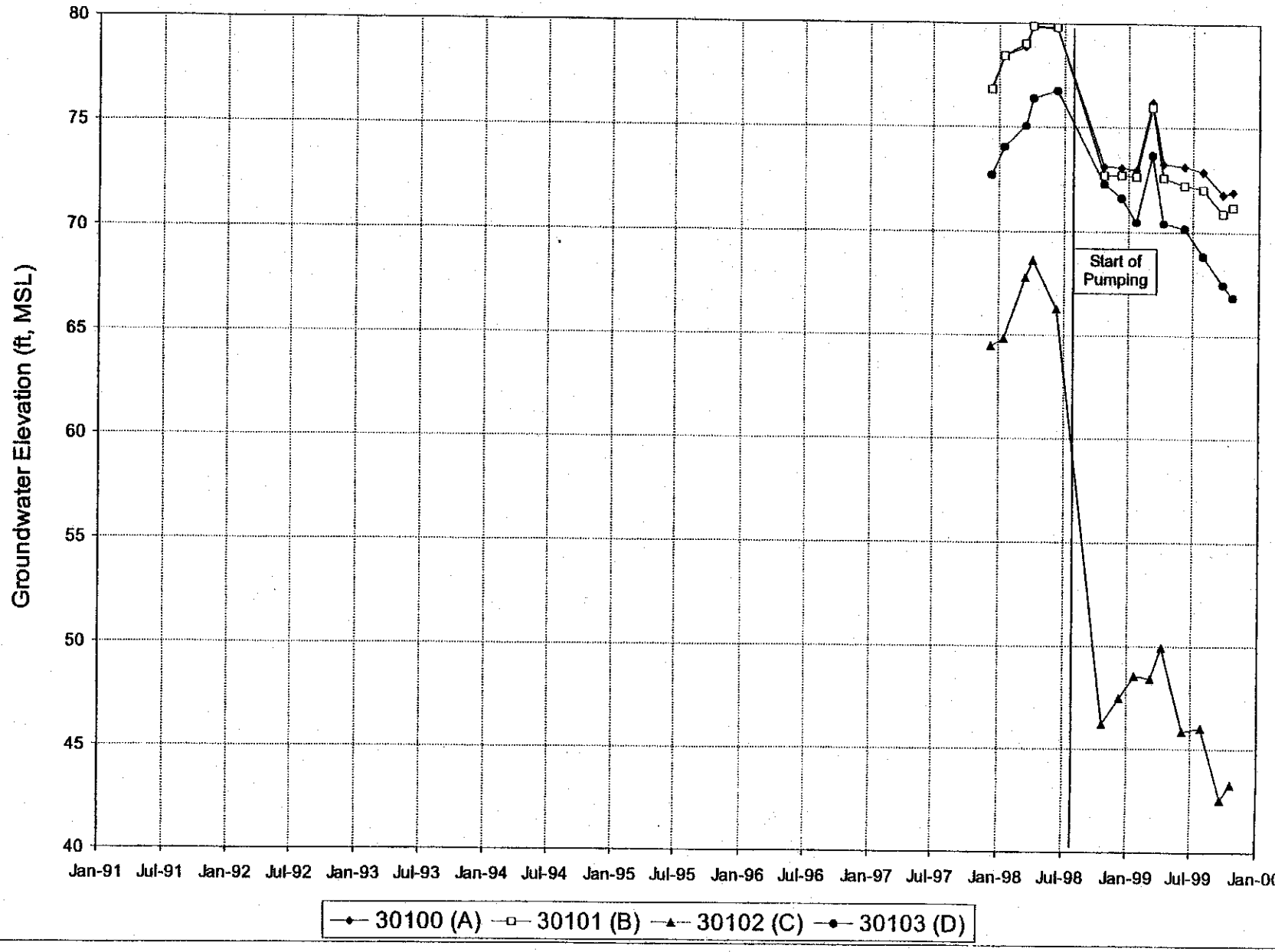


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Figure 3-9
Hydrograph Wells 1395-99

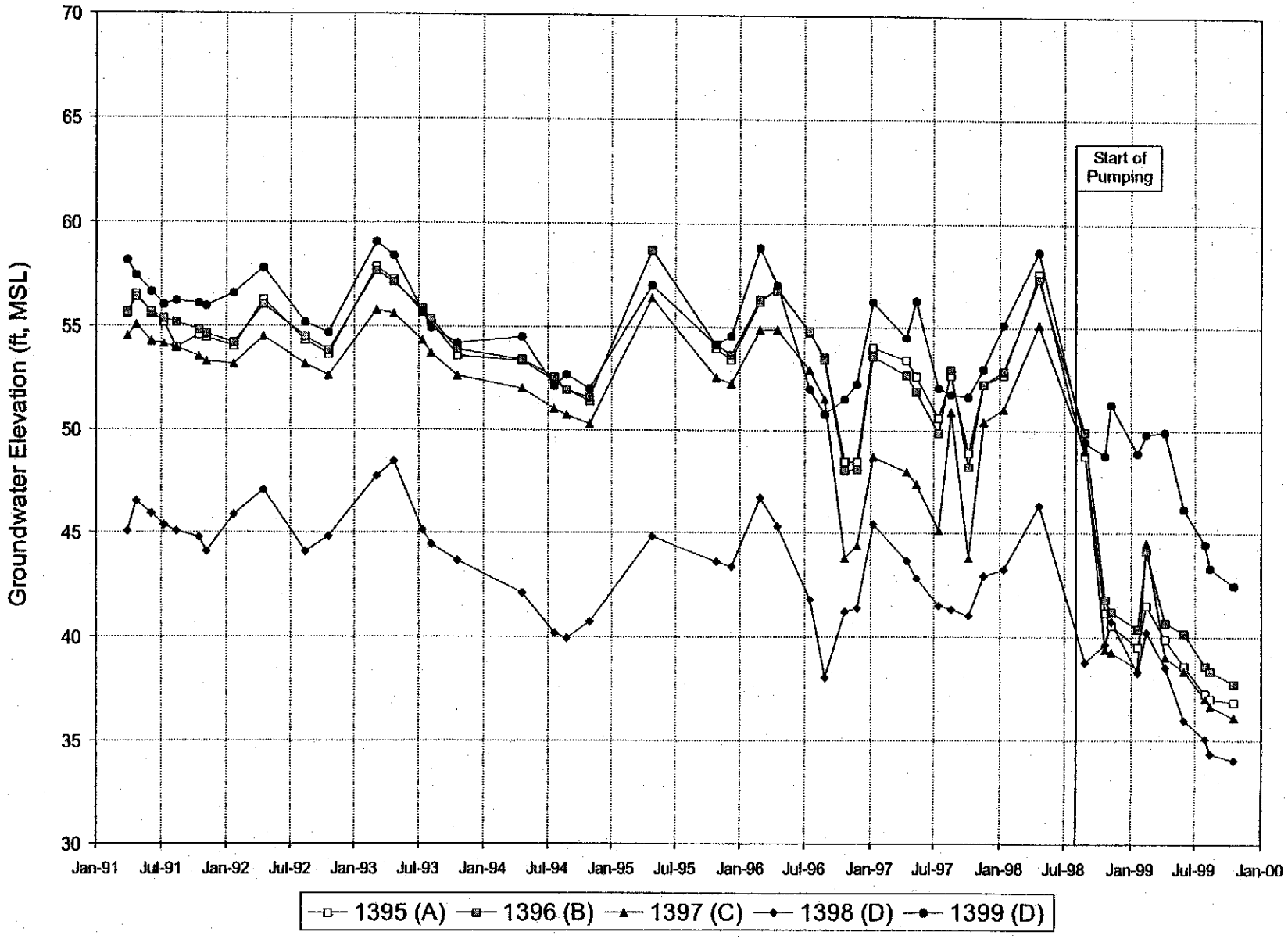

Figure 3-10
Hydrograph Wells 1538-40

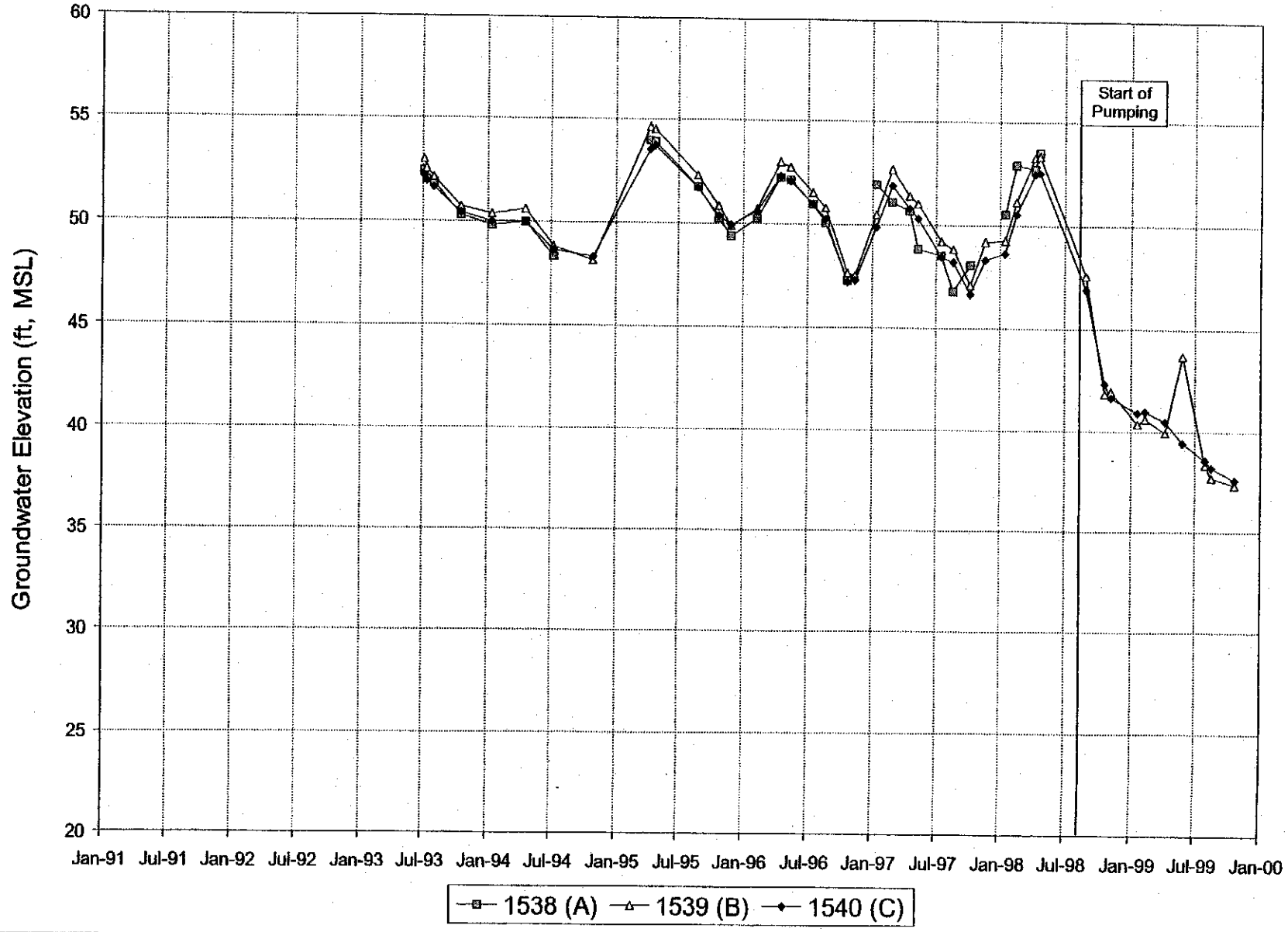

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Figure 3-11
Hydrograph Wells 1525-27

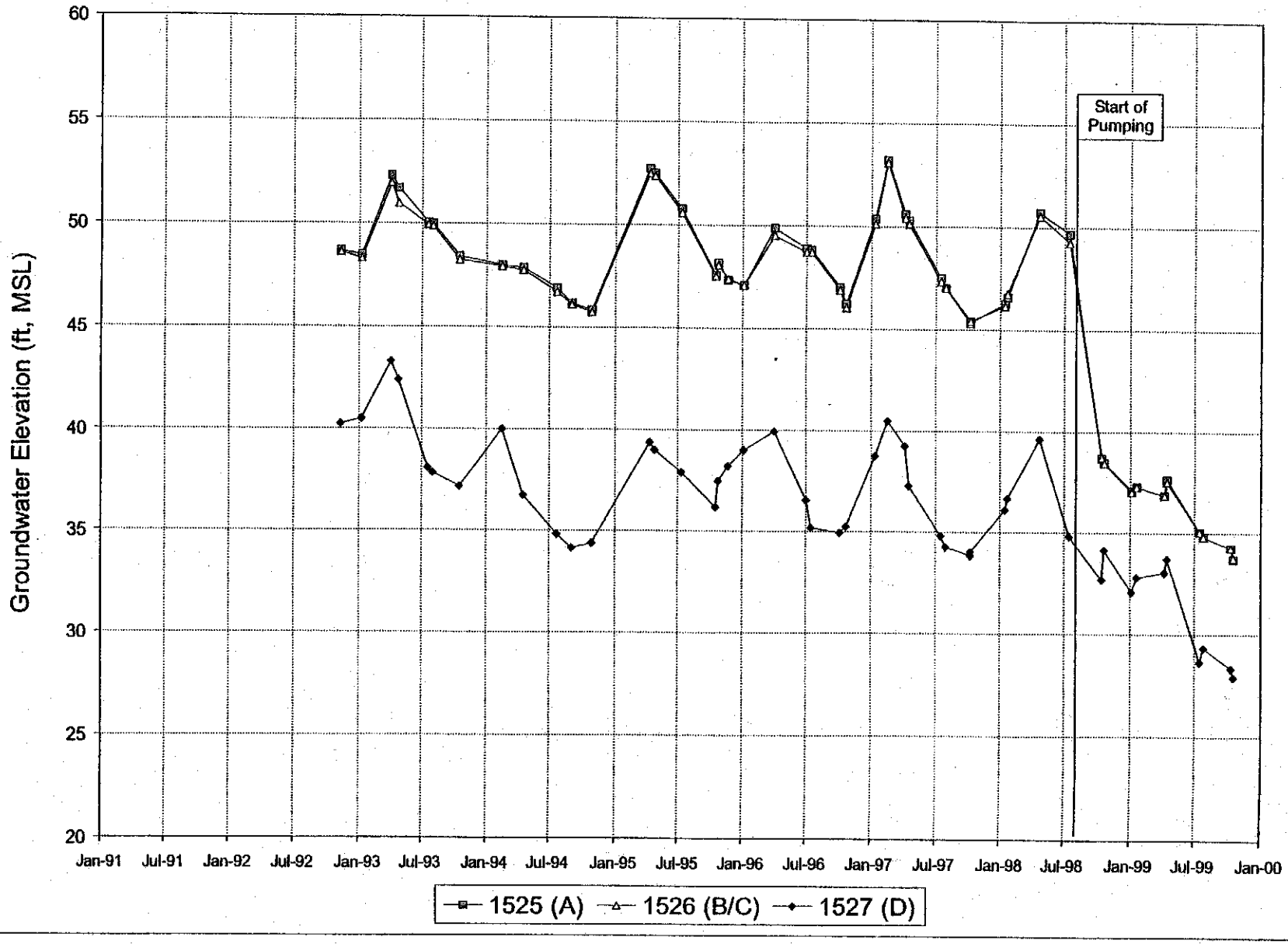

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Figure 3-12
Hydrograph Wells 1585-87

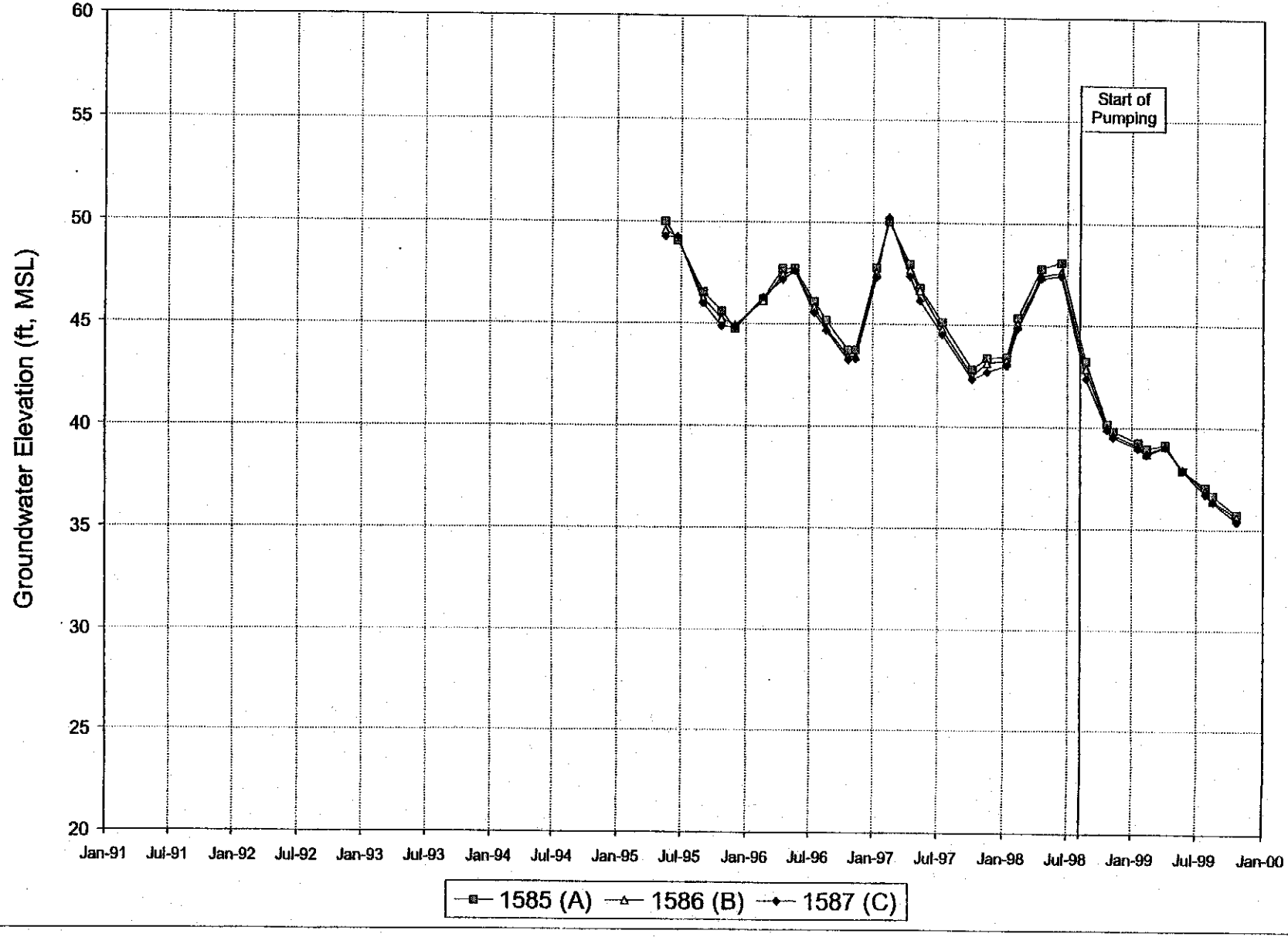

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Figure 3-13
Hydrograph Wells 1519-21, 1522-24

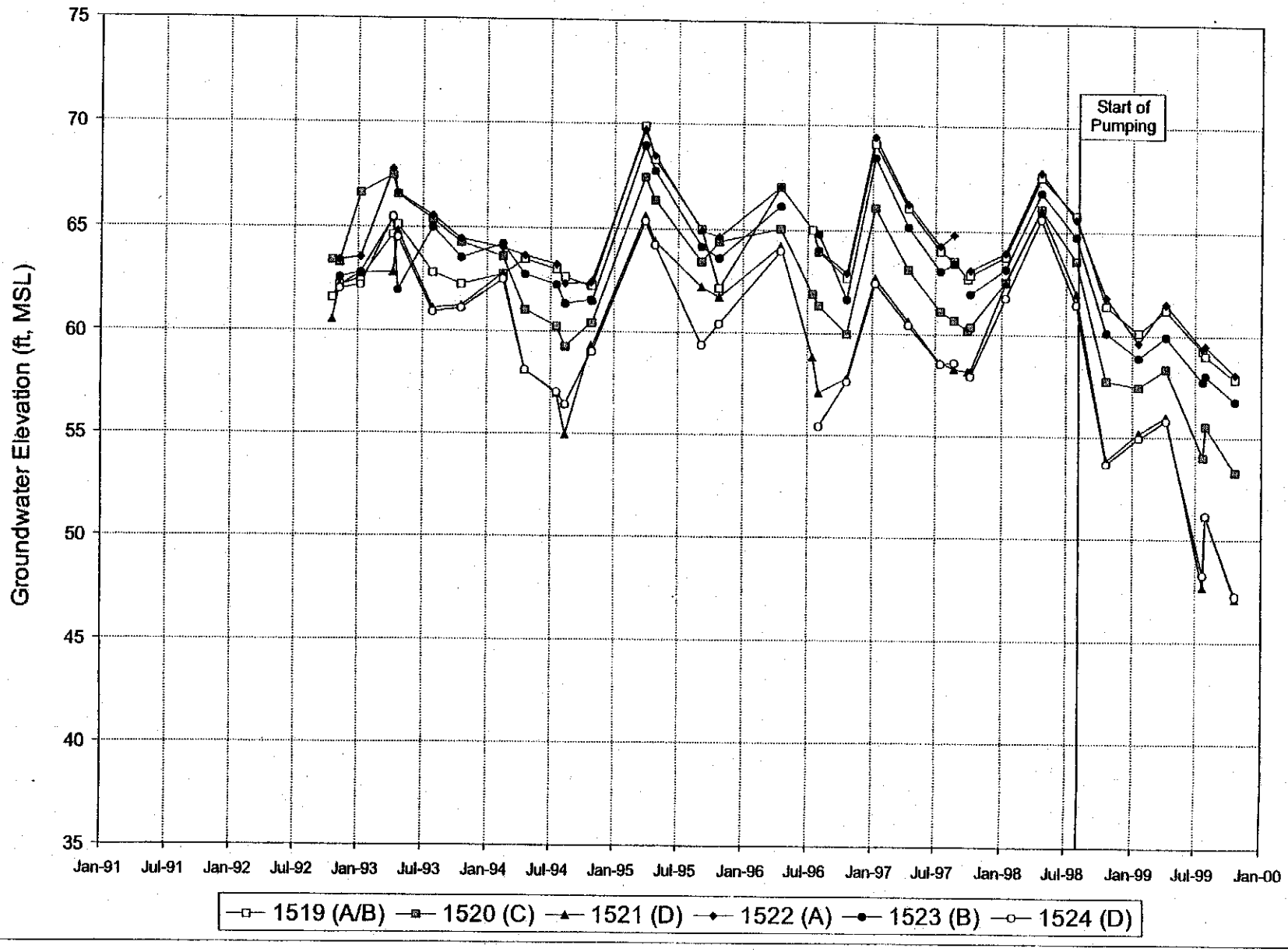

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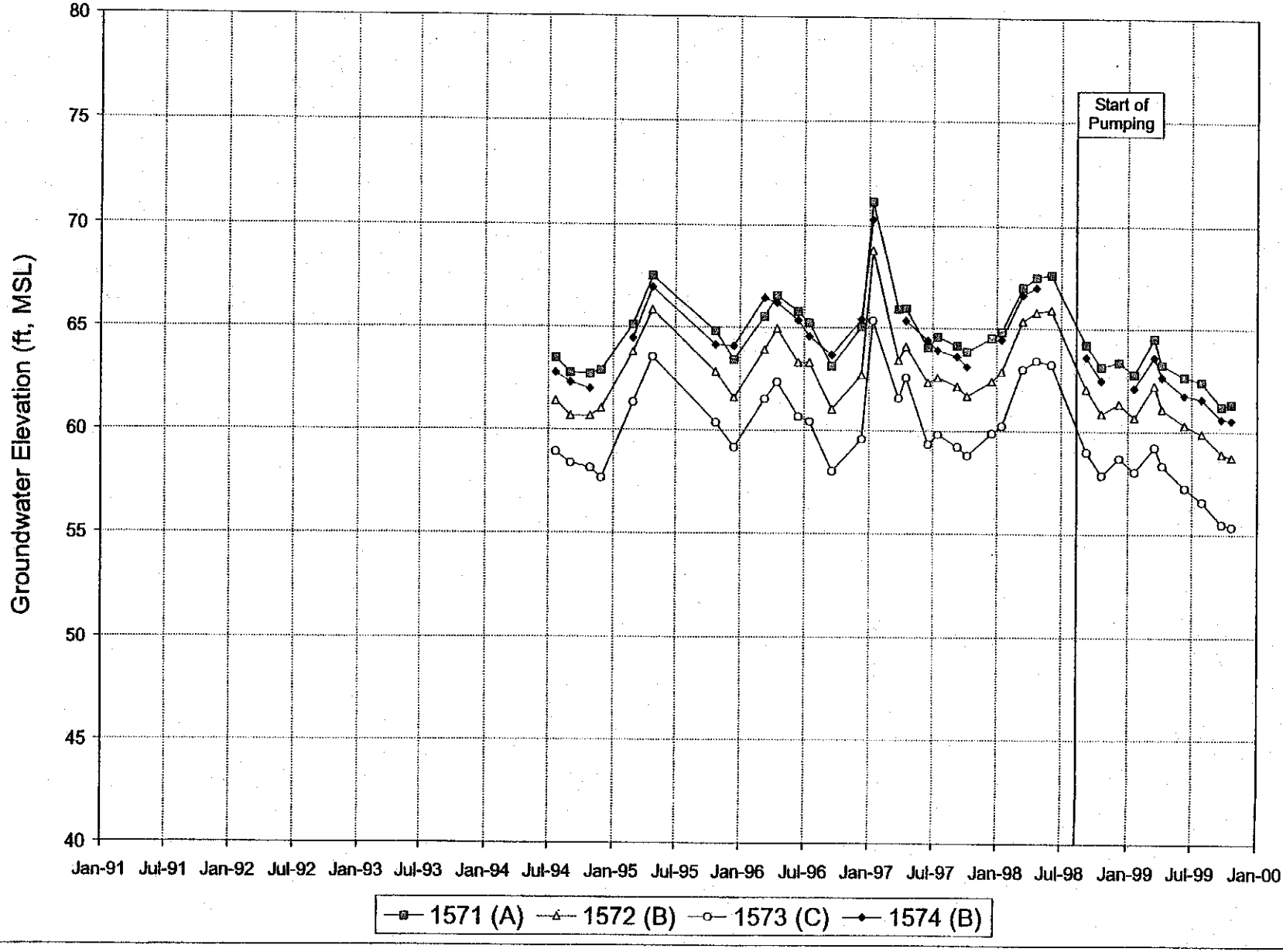
Figure 3-14
Hydrograph Wells 1571-73, 1574



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Bounded Aquifers

When a confined aquifer is bounded on one side by a straight-line impermeable boundary, drawdowns due to pumping will be greater near the boundary [Figure 8.15(a)] than those that would be predicted on the basis of the Theis equation for an aquifer of infinite areal extent. In order to predict head drawdowns in such systems, the method of images, which is widely used in heat-flow theory, has been adapted for application in the groundwater milieu (Ferris et al., 1962). With this approach, the real bounded system is replaced for the purposes of analysis by an

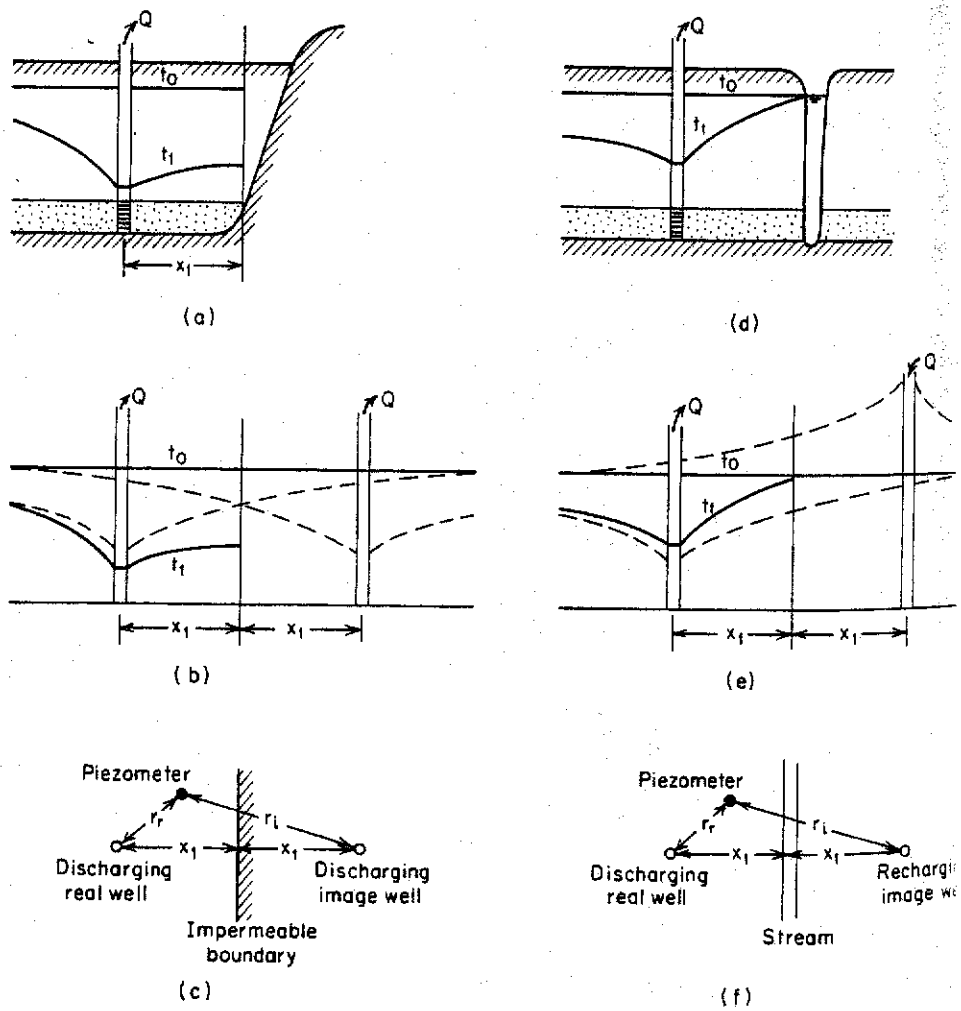

Figure 8.15 (a) Drawdown in the potentiometric surface of a confined aquifer bounded by an impermeable boundary; (b) equivalent system of infinite extent; (c) plan view.

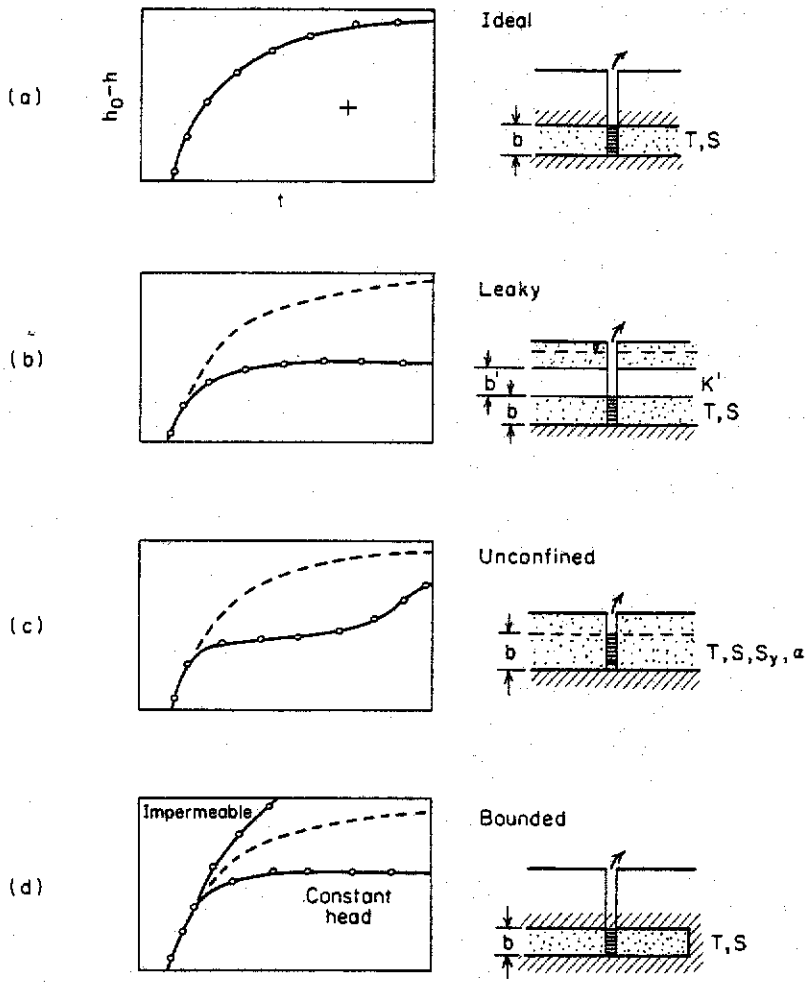

Figure 8.23 Comparison of log-log $h_0 - h$ versus t data for ideal, leaky, unconfined, and bounded systems.

those of Figure 8.9. The method only requires matching against the Theis curve, and calculations are relatively easy to carry out.

As an alternative approach (Wolff, 1970), one can simply read off a T_f value from Figure 8.17 given a hydraulic head value h measured in an aquitard piezometer at elevation z at time t. Knowing the aquitard thickness, b', one can solve Eq. (8.23) for c_v. If an α value can be estimated, Eq. (8.22) can be solved for K'.

For unconfined aquifers the time-drawdown data should be matched against the unconfined type curves of Figure 8.12. The η value of the matched curve, together with the match-point values of $W(u_A, u_B, \eta)$, u_A, u_B, $h_0 - h$, and t can be substituted into Eqs. (8.13) through (8.15) to yield the aquifer coefficients T, S, and S_y. Moench and Prickett (1972) discuss the interpretation of data at sites

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Second Edition (Completely Revised)

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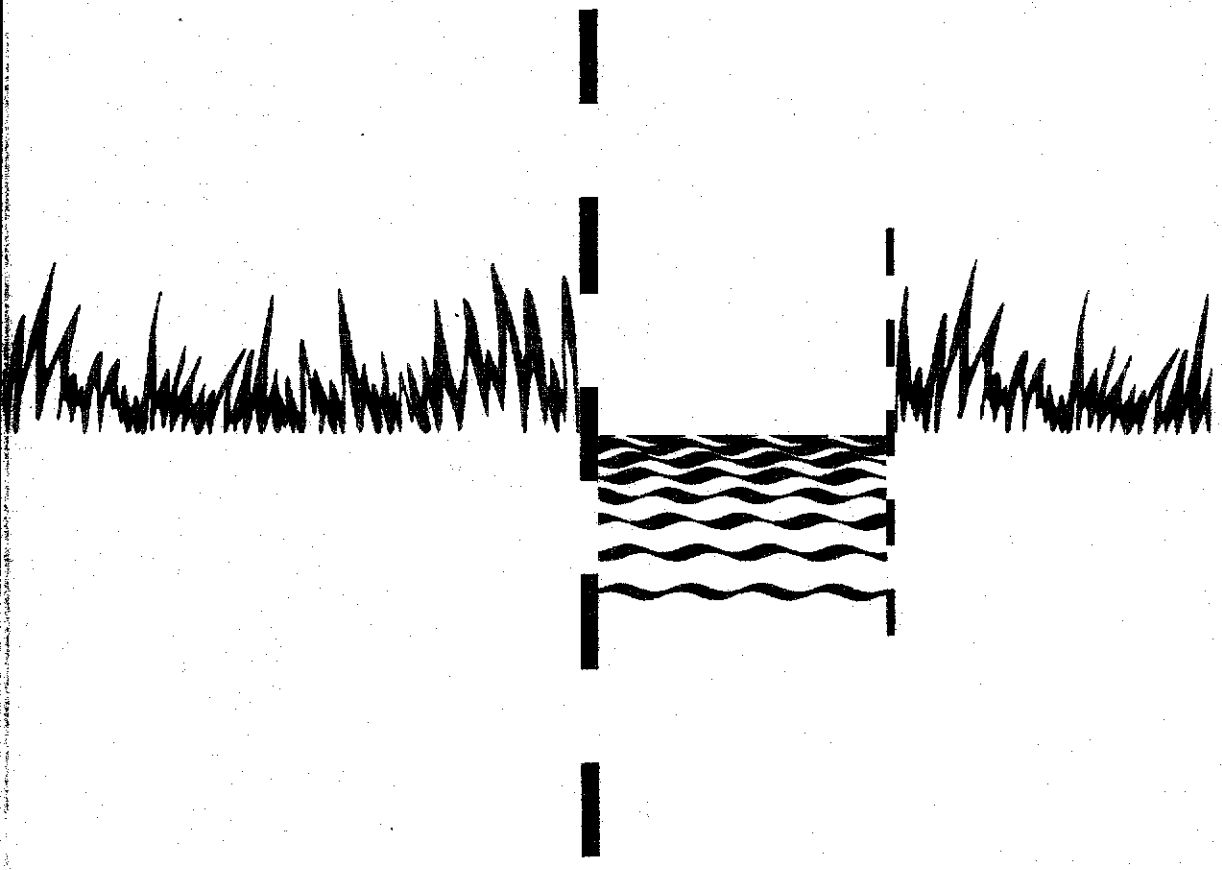


6 Bounded aquifers

Pumping tests sometimes have to be performed near the boundary of an aquifer. A boundary may be either a recharging boundary (e.g. a river or a canal) or a barrier boundary (e.g. an impermeable valley wall). When an aquifer boundary is located within the area influenced by a pumping test, the general assumption that the aquifer is of infinite areal extent is no longer valid.

Presented in Sections 6.1 and 6.2 are methods of analysis developed for confined or unconfined aquifers with various boundaries and boundary configurations. Section 6.3 presents a method for leaky or confined aquifers bounded laterally by two parallel barrier boundaries.

To analyze the flow in bounded aquifers, we apply the principle of superposition. According to this principle, the drawdown caused by two or more wells is the sum of the drawdown caused by each separate well. So, by introducing imaginary wells, or image wells, we can transform an aquifer of finite extent into one of seemingly infinite extent, which allows us to use the methods presented in earlier chapters.

Figure 6.1A shows a fully penetrating straight canal which forms a recharging boundary with an assumed constant head. In Figure 6.1B, we replace this bounded system with an equivalent system, i.e. an imaginary system of infinite areal extent. In this system, there are two wells: the real discharging well on the left and an image recharging well on the right. The image well recharges the aquifer at a constant rate Q equal to the constant discharge of the real well. Both the real well and the image well are located on a line normal to the boundary and are equidistant from the boundary (Figure 6.1C). If we now sum the cone of depression from the real well and the cone of impression from the image well, we obtain an imaginary zero drawdown in the infinite system at the real constant-head boundary of the real bounded system.

Figure 6.1D shows a system with a straight impermeable valley wall which forms a barrier boundary. Figure 6.1E shows the real bounded system replaced by an equivalent system of infinite areal extent. The imaginary system has two wells discharging at the same constant rate: the real well on the left and an image well on the right. The image well induces a hydraulic gradient from the boundary towards the image well, which is equal to the hydraulic gradient from the boundary towards the real well. A groundwater divide thus exists at the boundary and there is no flow across the boundary. The resultant real cone of depression is the algebraic sum of the depression cones of both the real and the image well. Note that between the real well and the boundary, the real depression cone is flatter than it would be if no boundary were present, and is steeper on the opposite side away from the boundary.

If there is more than one boundary, more image wells are needed. For instance, if two boundaries are at right angles to each other, the imaginary system includes two primary image wells, both reflections of the real well, and one secondary image well, which is a reflection of the primary image wells. If the boundaries are parallel to one another, the number of image wells is theoretically infinite, but in practice it is only necessary to add pairs of image wells until the next pair would have a negligible

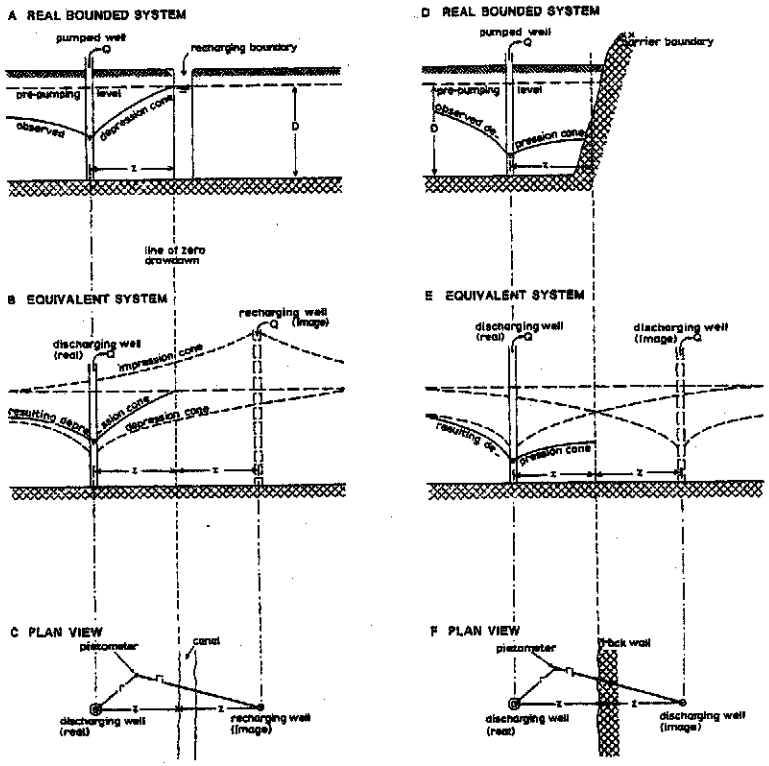


Figure 6.1 Drawdowns in the watertable of an aquifer bounded by:
A) A recharging boundary;
D) A barrier boundary.
B) and E) Equivalent systems of infinite areal extent.
C) and F) Plan views

influence on the sum of all image-well effects. Some of these boundary configurations will be discussed below.

6.1 Bounded confined or unconfined aquifers, steady-state flow

6.1.1 Dietz's method, one or more recharge boundaries

Dietz (1943) published a method of analyzing tests conducted in the vicinity of straight recharge boundaries under conditions of steady-state flow. Dietz's method, which is based on the work of Muskat (1937), uses Green's functions to describe the influence of the boundaries: in a piezometer with coordinates x_i and y_i, the steady-state drawdown caused by a well with coordinates x_w and y_w is given by

$$s_m = \frac{Q}{2\pi KD} G(x,y) \tag{6.1}$$

where $G(x,y)$ = Green's function for a certain boundary configuration.

For one straight recharge boundary (Figure 6.2A), the function reads

$$G(x,y) = \frac{1}{2} \ln \frac{(x_i + x_w)^2 + (y_i - y_w)^2}{(x_i - x_w)^2 + (y_i - y_w)^2} \tag{6.2}$$

For two straight recharge boundaries at right angles to each other (Figure 6.2B), the function reads

$$G(x,y) = \frac{1}{2} \ln \frac{[(x_i - x_w)^2 + (y_i + y_w)^2]\,[(x_i + x_w)^2 + (y_i - y_w)^2]}{[(x_i - x_w)^2 + (y_i - y_w)^2]\,[(x_i + x_w)^2 + (y_i + y_w)^2]} \tag{6.3.}$$

For two straight parallel recharge boundaries (Figure 6.2C), the function reads

$$G(x,y) = \frac{1}{2} \ln \frac{\cosh \frac{\pi(y_i - y_w)}{2a} + \cos \frac{\pi(x_i + x_w)}{2a}}{\cosh \frac{\pi(y_i - y_w)}{2a} - \cos \frac{\pi(x_i - x_w)}{2a}} \tag{6.4}$$

For a U-shaped recharge boundary (Figure 6.2D), the function reads

$$G(x,y) = \frac{1}{2} \ln \frac{\left[\cosh \frac{\pi(y_i - y_w)}{2a} + \cos \frac{\pi(x_i + x_w)}{2a}\right]}{\left[\cosh \frac{\pi(y_i - y_w)}{2a} - \cos \frac{\pi(x_i - x_w)}{2a}\right]} \times \frac{\left[\cosh \frac{\pi(y_i + y_w)}{2a} - \cos \frac{\pi(x_i - x_w)}{2a}\right]}{\left[\cosh \frac{\pi(y_i + y_w)}{2a} + \cos \frac{\pi(x_i + x_w)}{2a}\right]} \tag{6.5}$$

The assumptions and conditions underlying the Dietz method are:
- The assumptions listed at the beginning of Chapter 3, except for the first and second assumptions, which are replaced by:
  - The aquifer is confined or unconfined;
  - Within the zone influenced by the pumping test, the aquifer is crossed by one or more straight, fully penetrating recharge boundaries with a constant water level;
  - The hydraulic contact between the recharge boundaries and the aquifer is as permeable as the aquifer.

The following condition is added:
- The flow to the well is in a steady state.

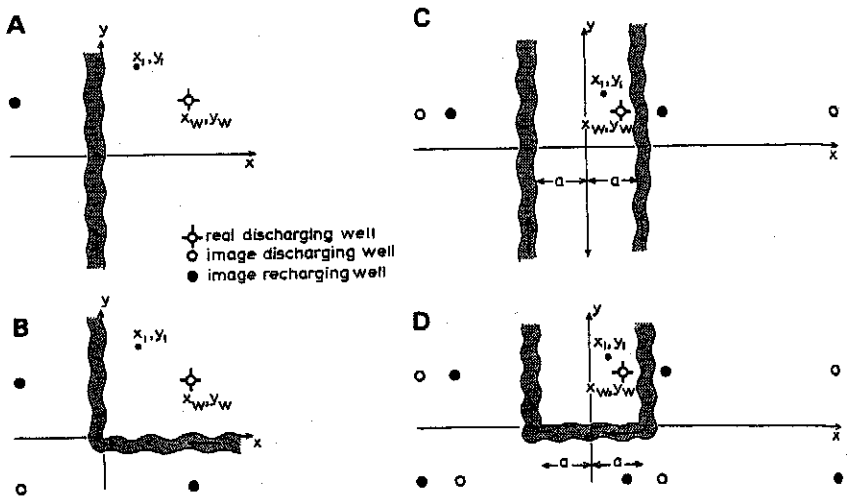


Figure 6.2 Image well systems for bounded aquifers (Dietz method)
A) One straight recharge boundary
B) Two straight recharge boundaries at right angles
C) Two straight parallel recharge boundaries
D) U-shaped recharge boundary

Procedure 6.1
- Determine the boundary configuration and substitute the appropriate Green function into Equation 6.1;
- Measure the values of x_w, y_w, x_i, and y_i on the map of the pumping site;
- Substitute the values of Q, x_w, y_w, x_i, y_i, and s_m into Equation 6.1 and calculate KD;
- Repeat this procedure for all available piezometers. The results should show a close agreement.

Remarks
- The angles in Equations 6.4 and 6.5 are expressed in radians;
- For unconfined aquifers, the maximum drawdown s_m should be replaced by $s'_m = s_m - (s^2_m/2D)$.

6.2 Bounded confined or unconfined aquifer, unsteady-state flow

6.2.1 Stallman's method, one or more boundaries

Stallman (as quoted by Ferris et al. 1962) developed a curve-fitting method for aquifers that have one or more straight recharge or barrier boundaries.

The distance between the real well and a piezometer is r; the distance between an image well and the piezometer is r_i, and their ratio is $r_i/r = r_r$.
If

$$u = \frac{r^2 S}{4KDt} \tag{6.6}$$

and

$$u_i = \frac{r_i^2 S}{4KDt} = \frac{r^2_r r^2 S}{4KDt} = r_r^2 u \tag{6.7}$$

the drawdown in the piezometer is described by

$$s = \frac{Q}{4\pi KD}[W(u) \pm W(r_{r1}^2 u) \pm W(r_{r2}^2 u) \pm \ldots \pm W(r_{rn}^2 u)] \tag{6.8}$$

or

$$s = \frac{Q}{4\pi KD} W(u, r_{r1 \to n}) \tag{6.9}$$

Numerical values of $W(r_r^2 u)$ are given in Annex 6.1. In Equation 6.8, the number of terms between brackets depends on the number of image wells. If there is only one image well, there are two terms between brackets: the term $(Q/4\pi KD)\,W(u)$ describing the influence of the real well and the term $(Q/4\pi KD)\,W(r_r^2 u)$ describing the influence of the image well. If there are two straight boundaries intersecting at right angles, three image wells are required, and there are consequently four terms between brackets. With parallel boundaries, the number of image wells becomes infinite, but those where $r_r > 100$ can be neglected.

A discharge well – real or image – gives terms with a positive sign; a recharge well gives terms with a negative sign. Consequently, the drawdown in a piezometer caused by a well near a boundary can be described by the following equations.

One straight boundary
One recharge boundary (Figure 6.1A-C)

$$s = \frac{Q}{4\pi KD}[W(u) - W(r_r^2 u)] \tag{6.10}$$

or

$$s = \frac{Q}{4\pi KD} W_R(u, r_r) \tag{6.11}$$

One barrier boundary (Figure 6.1D-F)

$$s = \frac{Q}{4\pi KD}[W(u) + W(r_r^2 u)] \tag{6.12}$$

or

$$s = \frac{Q}{4\pi KD} W_B(u, r_r) \tag{6.13}$$

Two straight boundaries at right angles to each other
One barrier boundary and one recharge boundary (Figure 6.3A)

$$s = \frac{Q}{4\pi KD}[W(u) + W(r_{i1}^2u) - W(r_{i2}^2u) - W(r_{i3}^2u)] \quad (6.14)$$

Two barrier boundaries (Figure 6.3B)

$$s = \frac{Q}{4\pi KD}[W(u) + W(r_{i1}^2u) + W(r_{i2}^2u) + W(r_{i3}^2u)] \quad (6.15)$$

Two recharge boundaries (Figure 6.3C)

$$s = \frac{Q}{4\pi KD}[W(u) - W(r_{i1}^2u) - W(r_{i2}^2u) + W(r_{i3}^2u)] \quad (6.16)$$

Two parallel boundaries
One barrier and one recharge boundary (Figure 6.4A)

$$s = \frac{Q}{4\pi KD}[W(u) + W(r_{i1}^2u) - W(r_{i2}^2u) - W(r_{i3}^2u) - \ldots \pm W(r_{in}^2u)] \quad (6.17)$$

Two barrier boundaries (Figure 6.4B)

$$s = \frac{Q}{4\pi KD}[W(u) + W(r_{i1}^2u) + W(r_{i2}^2u) + W(r_{i3}^2u) + \ldots + W(r_{in}^2u)] \quad (6.18)$$

Two recharge boundaries (Figure 6.4C)

$$s = \frac{Q}{4\pi KD}[W(u) - W(r_{i1}^2u) - W(r_{i2}^2u) + W(r_{i3}^2u) + \ldots \pm W(r_{in}^2u)] \quad (6.19)$$

For three and four straight boundaries (Figures 6.5 and 6.6), the drawdown equations can be composed in the same way.

Stallman's method can be applied if the following assumptions and conditions are satisfied:
- The assumptions listed at the beginning of Chapter 3, with the exception of the first and second assumptions, which are replaced by:
  - The aquifer is confined or unconfined;
  - Within the zone influenced by the pumping test, the aquifer is crossed by one or more straight, fully penetrating recharge or barrier boundaries;
  - Recharge boundaries have a constant water level and the hydraulic contacts between the recharge boundaries and the aquifer are as permeable as the aquifer.

The following condition is added:
- The flow to the well is in unsteady state.

Procedure 6.2
- Determine the boundary configuration and prepare a plan of the equivalent system of image wells;
- Determine for one of the piezometers the value of r and the value or values of r_i;
- Calculate $r_r = r_i/r$ for each of the image wells and determine the sign for each of the terms between brackets in Equation 6.8;

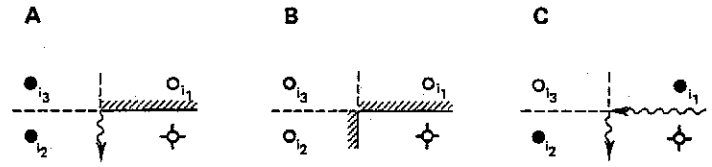


Figure 6.3 Two straight boundaries intersecting at right angles

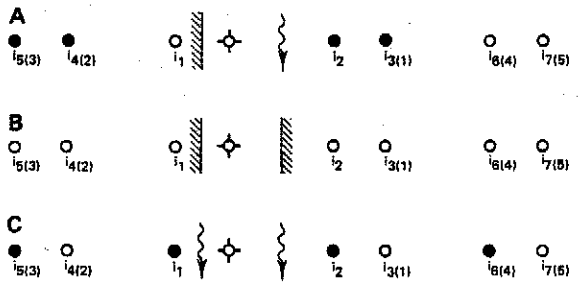


Figure 6.4 Two straight parallel boundaries

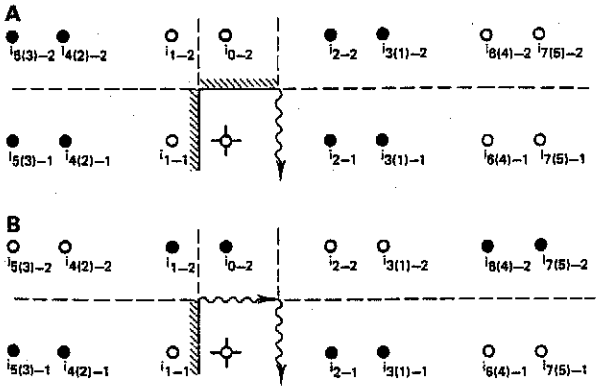


Figure 6.5 Two straight parallel boundaries intersected at right angles by a third boundary

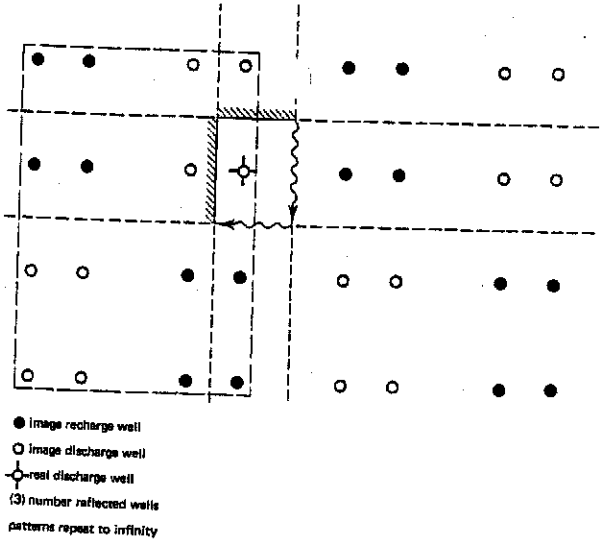


Figure 6.6 Four straight boundaries, i.e. two pairs of straight parallel boundaries intersecting at right angles

- Using Annex 6.1, calculate the numerical values of $W(u,r_{rl-n})$ with respect to u according to the appropriate form of Equation 6.8, and plot the type curve $W(u,r_{rl-n})$ versus u on log-log paper;
  (For one-boundary systems, the values of $W_R(u,r_r)$ and $W_B(u,r_r)$ can be read directly from Annexes 6.2 and 6.3);
- On another sheet of log-log paper, plot s as observed in the piezometer versus 1/t; this is the observed data curve;
- Match the observed data curve with the type curve;
- Select a matchpoint A and note its coordinate values u, $W(u,r_{rl-n})$, s, and 1/t;
- Substitute these values of s and $W(u,r_{rl-n})$ and the known value of Q into Equation 6.9 and calculate KD;
- Substitute the values of Q, r, u, KD, and 1/t into Equation 6.6 and calculate S;
- Repeat this procedure for all available piezometers. It will be noted that each piezometer has its own type curve because the value of $W(u,r_{rl-n})$ depends on the value of the ratio $r_i/r = r_r$, which is different for each piezometer.

Remarks

- This method can also be used to analyze the drawdown data from an aquifer pumped

- Equation 6.8 is based on the Theis well function for confined aquifers. Stallman's method, however, is also applicable to data from unconfined aquifers as long as Assumption 7 (Chapter 3) is met, i.e. no delayed watertable response is appr t.

6.2.2 Hantush's method, one recharge boundary

The Hantush image method is useful when the effective line of recharge does not correspond with the bank or the streamline of the river or canal. This may be due to the slope of the bank, to partial penetration effects of the river or canal, or to an entrance resistance at the boundary contact. When the effects of these conditions are small but not negligible, they can be compensated for by making the distance between the pumped well and the hydraulic boundary in the equivalent system (line of zero drawdown in Figure 6.1B) greater than the distance between the pumped well and the actual boundary (Figure 6.7).

As was shown by the Stallman method, the drawdown in an aquifer limited at one side by a recharge boundary can be expressed by Equation 6.10

$$s = \frac{Q}{4\pi KD}[W(u) - W(r_r^2 u)]$$

where, according to Equation 6.6,

$$u = \frac{r^2 S}{4KDt}$$

and

$$r_r = \frac{r_i}{r}$$

$r = \sqrt{(x^2 + y^2)}$ is the distance between the piezometer and the real discharging well

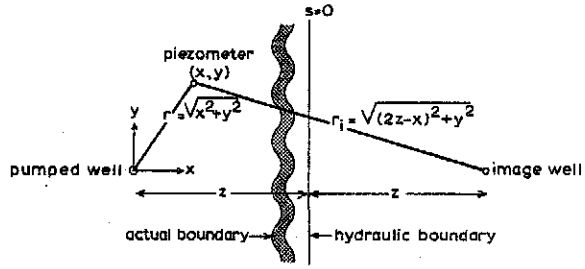


Figure 6.7 The parameters in the Hantush image method

$r_i = \sqrt{\{(2z-x)^2 + y^2\}}$ is the distance between the piezometer and the recharging well; x, y are the coordinates of the piezometer with respect to the real discharging well (see Figure 6.7)

The distance between the real discharging well and the recharging image well is 2z. The hydraulic boundary, i.e. the effective line of recharge, intersects the connecting line midway between the real well and the image well. The lines are at right angles to each other. It should be kept in mind that, especially with recharge boundaries, the hydraulic boundary does not always coincide with the bank of the river or its streamline. It is not necessary to know z beforehand, nor the location of the image well, nor the distance r_i dependent on it; neither need the relation $r_i/r = r_r$ be known beforehand.
The relation between r_r, x, r, and z is given by

$$4z^2 - 4xz - r^2(r_r^2 - 1) = 0 \tag{6.20}$$

Hantush (1959b) observed that if the drawdown s is plotted on semi-log paper versus t (with t on logarithmic scale), there is an inflection point P on the curve (Figure 6.8). At this point, the value of u is given by

$$u_p = \frac{r^2 S}{4KDt_p} = \frac{2 \ln r_r}{r_r^2 - 1} \tag{6.21}$$

The slope of the curve at this point is

$$\Delta s_p = \frac{2.30Q}{4\pi KD}\left(e^{-u_p} - r^{-r_r^2 u_p}\right) \tag{6.22}$$

and the drawdown at this point is

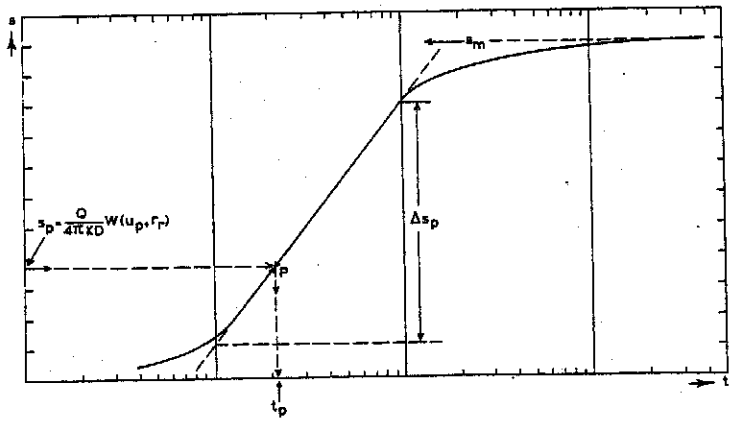


Figure 6.8 The application of the Hantush image method

$$s_p = \frac{Q}{4\pi KD} W(u_p, r_r) \tag{6.23}$$

For values of $t > 4t_p$, the drawdown s approaches the maximum drawdown

$$s_m = \frac{Q}{2\pi KD} \ln r_r \tag{6.24}$$

It will be noted that the ratio of s_m, as given by Equation 6.24, and Δs_p, as given by Equation 6.22, depends solely on the value of r_r. So

$$\frac{s_m}{\Delta s_p} = \frac{2 \log r_r}{e^{-u_p} - e^{-r_r^2 u_p}} = f(r_r) \tag{6.25}$$

where u_p is given by Equation 6.21.

The Hantush image method is based on the following assumptions and conditions:
- The assumptions listed at the beginning of Chapter 3, with the exception of the first and second assumptions, which are replaced by:
  - The aquifer is confined or unconfined;
  - The aquifer is crossed by a straight recharge boundary within the zone influenced by the pumping test;
  - The recharge boundary has a constant water level, but the effective line of recharge need not necessarily be known beforehand. Entrance resistances, however, should be small, although not negligible.

The following conditions are added:
- The flow to the well is in unsteady state;
- It should be possible to extrapolate the steady-state drawdown for each of the piezometers.

Procedure 6.3
- On semi-log paper, plot s versus t for one of the piezometers (t on logarithmic scale), and draw the time-drawdown curve through the plotted points (Figure 6.8);
- Extrapolate the curve to determine the value of the maximum drawdown s_m;
- Calculate the slope Δs_p of the straight portion of the curve; this is an approximation of the slope at the inflection point P;
- Calculate the ratio $s_m/\Delta s_p$ according to Equation 6.25; this is equal to $f(r_r)$. Use Annex 6.4 to find the value of r_r from $f(r_r)$;
- Substitute the values of s_m, Q, and r_r into Equation 6.24 and calculate KD;
- Obtain the values of u_p and $W(u_p, r_r)$ from Annex 6.4;
- Substitute the values of Q, KD, and $W(u_p, r_r)$ into Equation 6.23 and calculate s_p;
- Knowing s_p, locate the inflection point on the curve and read t_p;
- Substitute the values of KD, t_p, u_p, and r into Equation 6.21 and calculate S;
- Using Equation 6.20, calculate z;
- Apply this procedure to the data from all available piezometers. The calculated values of KD and S should show a close agreement.

Remarks
- To check whether any errors have been made in the approximation of s_m and Δs_p,

the theoretical time-drawdown curve should be calculated with Equations 6.6 and 6.10, Annex 6.2, and the calculated values of r_n, KD, and S. This theoretical curve should show a close agreement with the observed time-drawdown curve. If not, the procedure should be repeated with corrected approximations of s_m and Δs_p.

- Procedure 6.3 can be applied to analyze data from unconfined aquifers when Assumption 7 (Chapter 3) is met.

6.3 Bounded leaky or confined aquifers, unsteady-state flow

6.3.1 Vandenberg's method (strip aquifer)

Leaky aquifers bounded laterally by two parallel barrier boundaries form an 'infinite strip aquifer', or a 'parallel channel aquifer'. In the analysis of such aquifers, we have to consider not only boundary effects, but also leakage effects. Vandenberg (1976; 1977) proposed a method by which the values of KD, S, and L of such aquifers can be determined.

If the distance, x, measured along the axis of the channel between the pumped well and the piezometer (Figure 6.9), is greater than the width of the channel, w, (i.e. x/w > 1), Vandenberg showed that for parallel unsteady-state flow the following drawdown function is applicable

$$s = \frac{Qx}{(2KDw)} F(u,x/L) \qquad (6.26)$$

where

$$F(u,x/L) = \frac{1}{2\sqrt{\pi}} \int_u^\infty y^{-3/2} \exp(-y - x^2/4L^2 y)dy \qquad (6.27)$$

$$u = \frac{x^2 S}{4KDt} \qquad (6.28)$$

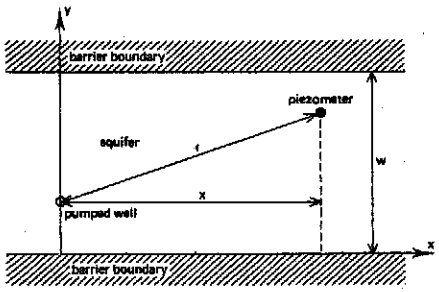


Figure 6.9 Plan view of a parallel channel aquifer

$L = \sqrt{KDc}$ = leakage factor in m (6.29)
x = projection of distance r in m between pumped well and piezometer, along the direction of the channel
w = width of the channel in m

Presented in Annex 6.5 are values of the function F(u,x/L) for different values of u and x/L, as given by Vandenberg (1976). These values can be plotted as a family of type curves (Figure 6.10).

The Vandenberg curve-fitting method can be used if the following assumptions and conditions are satisfied:

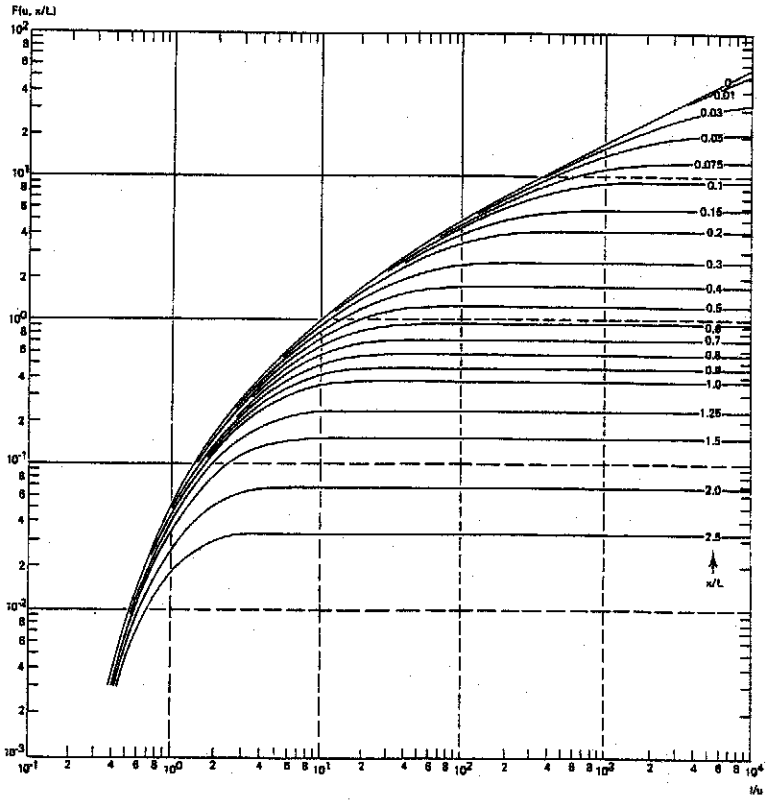


Figure 6.10 Family of Vandenberg's type curves F(u,x/L) versus 1/u for different values of x/L

- The assumptions listed at the beginning of Chapter 3, with the exception of the first and second assumptions, which are replaced by:
  - The aquifer is leaky;
  - Within the zone influenced by the pumping test, the aquifer is bounded by two straight parallel fully penetrating barrier boundaries.

The following conditions are added:
- The flow to the well is in unsteady state;
- The width and direction of the aquifer are both known with sufficient accuracy;
- $x/w > 1$.

Procedure 6.4
- Using Annex 6.5, construct on log-log paper a family of Vandenberg type curves by plotting F(u,x/L) versus 1/u for a range of values of x/L;
- On another sheet of log-log paper of the same scale, plot s versus t for a single piezometer at a projected distance x from the pumped well;
- Match the observed data curve with one of the type curves;
- Select a match point on the superimposed sheets, and note for this point the values of F(u,x/L), 1/u, s, and t. Note also the value of x/L of the selected type curve;
- Substitute the values of F(u,x/L) and s, together with the known values of Q, x, and w into Equation 6.26 and calculate KD;
- Substitute the values of u and t, together with the known values of KD and x, into Equation 6.28 and calculate S;
- Knowing x/L and x, calculate L;
- Calculate c from Equation 6.29;
- Repeat the procedure for all available piezometers ($x/w > 1$). The calculated values of KD, S, and c should show reasonable agreement.

Remarks
- If the direction of the channel is known, but not its width w, the same procedure as above can be followed, except that instead of calculating KD and S, the products KDw and Sw are calculated;
- If the direction of the channel is not known and the data from only one piezometer are available, the distance r may be used instead of x. For those cases where $r \gg w$, only a small error will be introduced;
- When $x/L = 0$, i.e. when $L \to \infty$, the drawdown function (Equation 6.26) becomes the drawdown function for parallel flow in a confined channel aquifer

$$s = \frac{Qx}{2KDw} F(u) \tag{6.30}$$

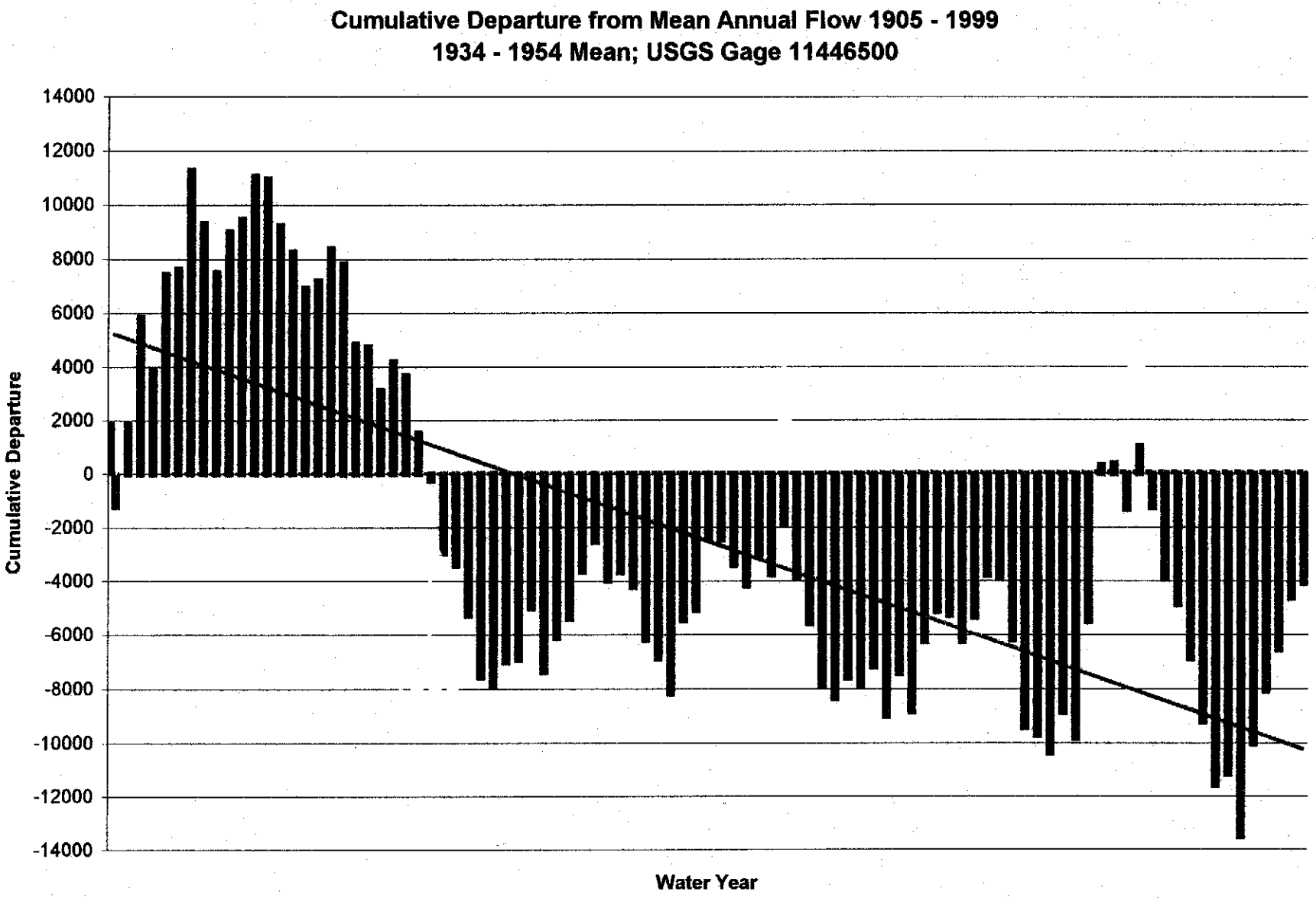
where

$$F(u) = \exp(-u/\sqrt{\pi u}) - \operatorname{erfc}(\sqrt{u}) \tag{6.31}$$

With the type curve F(u.x/L) versus 1/u for $x/L = 0$ (Annex 6.5), the values of KD and S of confined parallel channel aquifers can be determined;
- If $x/w < 1$, Equation 6.26 is not sufficiently accurate and the following drawdown equation for a system of real and image wells should be used (Vandenberg 1976; see also Bukhari et al. 1969)

$$s = \frac{Q}{4\pi KD} \left[W(u,r/L) + \sum_{i=1}^{\infty} W(u_i,r_i/L) \right] \tag{6.32}$$

where W(u,r/L) is the function for radial flow towards a well in a leaky aquifer of infinite extent.
Type curves can be constructed from the exact solution of Equation 6.32. For each particular configuration of pumped well and piezometer, however, a different set of curves is required. Vandenberg (1976) provides 16 sets of type curves and gives a listing and user's guide for a Fortran program that will plot a set of type curves for any well/piezometer configuration.


Cumulative Departure from Mean Annual Flow 1905 - 1999
1934 - 1954 Mean; USGS Gage 11446500
14000
12000
10000
8000
6000
4000
2000
0
-2000
-4000
-6000
-8000
-10000
-12000
-14000
Cumulative Departure
Water Year

An[redacted] Mean Stream Flow in Cubic Feet per Second (cfs); Data From USGS Gage No. 11446500

Water Year	Flow	Water Year	Flow	Water Year	Flow	Water Year	Flow
1905	2,600	1929	1,690	1953	3,741	1977	573
1906	6,936	1930	2,048	1954	2,885	1978	3,532
1907	7,765	1931	1,109	1955	3,050	1979	3,175
1908	1,845	1932	3,378	1956	5,007	1980	5,334
1909	7,386	1933	1,946	1957	3,056	1981	2,848
1910	4,030	1934	1,521	1958	5,681	1982	8,141
1911	7,457	1935	3,502	1959	1,810	1983	9,644
1912	1,834	1936	4,688	1960	2,144	1984	3,897
1913	2,023	1937	3,923	1961	1,471	1985	2,092
1914	5,338	1938	5,753	1962	3,397	1986	6,186
1915	4,274	1939	1,419	1963	4,572	1987	1,524
1916	5,414	1940	5,079	1964	3,492	1988	1,239
1917	3,709	1941	4,552	1965	4,547	1989	2,799
1918	2,100	1942	5,578	1966	2,015	1990	1,801
1919	2,848	1943	4,923	1967	5,369	1991	1,472
1920	2,465	1944	2,378	1968	2,421	1992	1,465
1921	4,105	1945	4,142	1969	6,395	1993	4,238
1922	5,016	1946	3,259	1970	4,960	1994	1,475
1923	3,255	1947	1,832	1971	3,661	1995	7,296
1924	833	1948	3,127	1972	2,859	1996	5,793
1925	3,731	1949	2,547	1973	4,714	1997	5,332
1926	2,200	1950	6,518	1974	5,384	1998	5,753
1927	4,893	1951	4,219	1975	3,758	1999	4,362
1928	3,278	1952	6,505	1976	1,477		

2,600	5,681
6,936	1,810
7,765	2,144
1,845	1,471
7,386	3,397
4,030	4,572
7,457	3,492
1,834	4,547
2,023	2,015
5,338	5,369
4,274	2,421
5,414	6,395
3,709	4,960
2,100	3,661
2,848	2,859
2,465	4,714
4,105	5,384
5,016	3,758
3,255	1,477
833	573
3,731	3,532
2,200	3,175
4,893	5,334
3,278	2,848
1,690	8,141
2,048	9,644
1,109	3,897

Water Year	Mean Flow	Departure 3820	Chart 3 Cumulative Departure 3,820	Departure 3777	[redacted] Cumulative Departure 3777
1905	2,600	-1,220	-1,220	-1,177	-1,177
6	6,936	3,116	1,896	3,159	1,982
7	7,765	3,945	5,841	3,988	5,970
8	1,845	-1,975	3,866	-1,932	4,038
9	7,386	3,566	7,432	3,609	7,647
10	4,030	210	7,642	253	7,900
11	7,457	3,637	11,279	3,680	11,580
12	1,834	-1,986	9,293	-1,943	9,637
13	2,023	-1,797	7,496	-1,754	7,883
14	5,338	1,518	9,014	1,561	9,444
15	4,274	454	9,468	497	9,941
16	5,414	1,594	11,062	1,637	11,578
17	3,709	-111	10,951	-68	11,510
18	2,100	-1,720	9,231	-1,677	9,833
19	2,848	-972	8,259	-929	8,904
20	2,465	-1,355	6,904	-1,312	7,592
21	4,105	285	7,189	328	7,920
22	5,016	1,196	8,385	1,239	9,159
23	3,255	-565	7,820	-522	8,637
24	833	-2,987	4,833	-2,944	5,693
25	3,731	-89	4,744	-46	5,647
26	2,200	-1,620	3,124	-1,577	4,070
27	4,893	1,073	4,197	1,116	5,186
28	3,278	-542	3,655	-499	4,687
29	1,690	-2,130	1,525	-2,087	2,600
30	2,048	-1,772	-247	-1,729	871
31	1,109	-2,711	-2,958	-2,668	-1,797

Calendar Year Streamflow Statistics for California

USGS 11446500 AMERICAN R A FAIR OAKS CA

Available data for this site: Surface-water: Annual streamflow statistics | GO

Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°38'08", Longitude 121°13'36" NAD27
Drainage area 1,888.00 square miles
Gage datum 71.53 feet above sea level NGVD29

Output formats

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- Tab-separated data
- Reselect output format

Year	Annual mean streamflow, in ft^3/s	Year	Annual mean streamflow, in ft^3/s	Year	Annual mean streamflow, in ft^3/s	Year	Annual mean streamflow, in ft^3/s
1905	2,600	1929	1,690	1953	3,741	1977	573
1906	6,936	1930	2,048	1954	2,885	1978	3,532
1907	7,765	1931	1,109	1955	3,050	1979	3,175
1908	1,845	1932	3,378	1956	5,007	1980	5,334
1909	7,386	1933	1,946	1957	3,056	1981	2,848
1910	4,030	1934	1,521	1958	5,681	1982	8,141
1911	7,457	1935	3,502	1959	1,810	1983	9,644
1912	1,834	1936	4,688	1960	2,144	1984	3,897
1913	2,023	1937	3,923	1961	1,471	1985	2,092
1914	5,338	1938	5,753	1962	3,397	1986	6,186
1915	4,274	1939	1,419	1963	4,572	1987	1,524
1916	5,414	1940	5,079	1964	3,492	1988	1,239
1917	3,709	1941	4,552	1965	4,547	1989	2,799

1919	2,848	**1943**	4,923	**1967**	5,369	**1991**	1,472
1920	2,465	**1944**	2,378	**1968**	2,421	**1992**	1,465
1921	4,105	**1945**	4,142	**1969**	6,395	**1993**	4,238
1922	5,016	**1946**	3,259	**1970**	4,960	**1994**	1,475
1923	3,255	**1947**	1,832	**1971**	3,661	**1995**	7,296
1924	833	**1948**	3,127	**1972**	2,859	**1996**	5,793
1925	3,731	**1949**	2,547	**1973**	4,714	**1997**	5,332
1926	2,200	**1950**	6,518	**1974**	5,384	**1998**	5,753
1927	4,893	**1951**	4,219	**1975**	3,758	**1999**	4,362
1928	3,278	**1952**	6,505	**1976**	1,477		

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Surface Water data for California: Calendar Year Streamflow Statistics
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Site Map for California

USGS 11446500 AMERICAN R A FAIR OAKS CA

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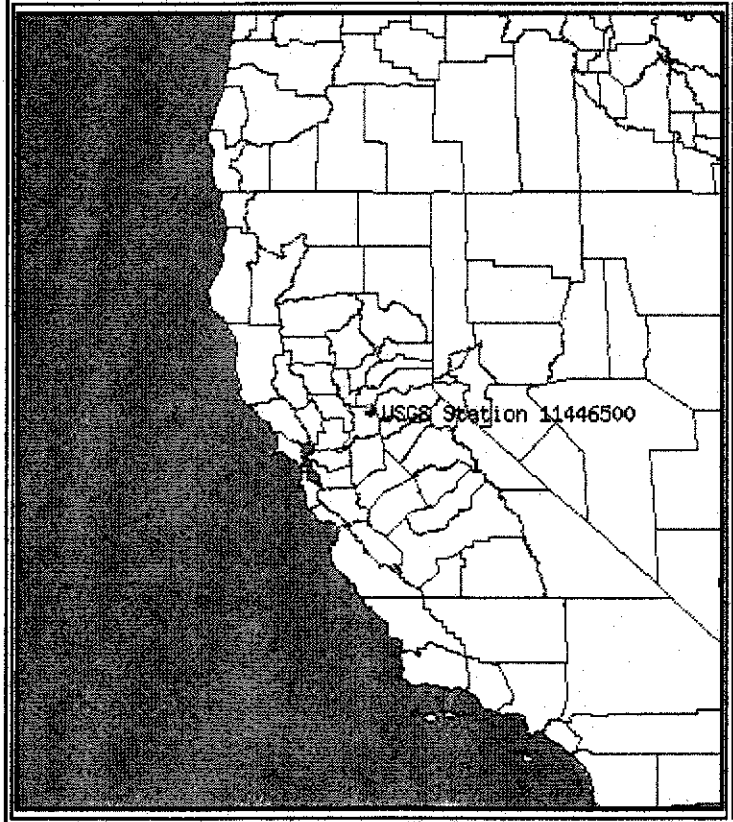
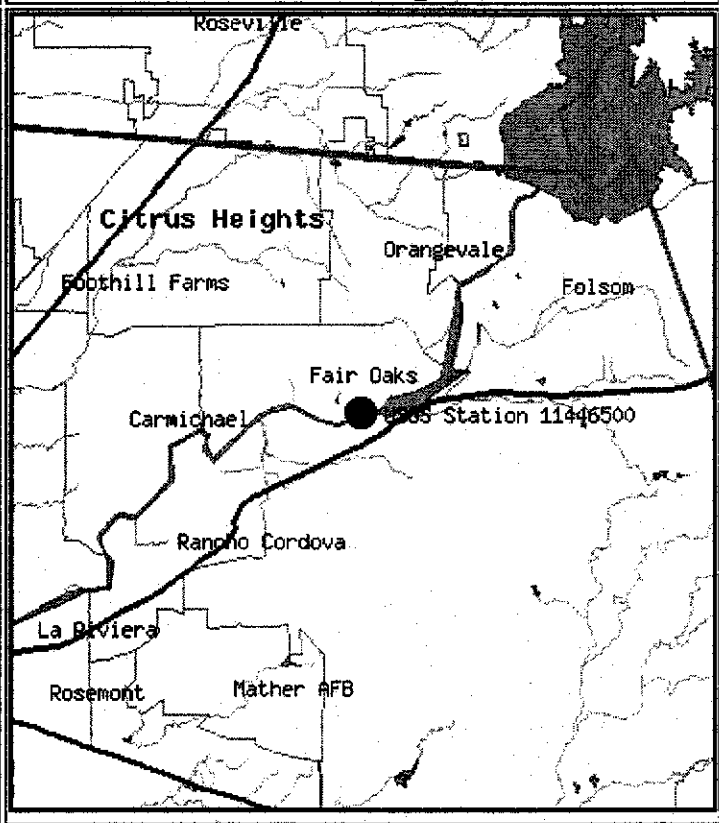
Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°38'08", Longitude 121°13'36" NAD27
Drainage area 1,888.00 square miles
Gage datum 71.53 feet above sea level NGVD29

Location of the site in California.



Site map.



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Daily Streamflow Statistics for California

USGS 11446500 AMERICAN R A FAIR OAKS CA (@ Main Ave)

Available data for this site Surface-water: Daily streamflow statistics GO

Sacramento County, California Hydrologic Unit Code 18020111 Latitude 38°38'08", Longitude 121°13'36" NAD27 Drainage area 1,888.00 square miles Gage datum 71.53 feet above sea level NGVD29	**Output formats** HTML table of all data Tab-separated data Reselect output format

Day of month	Mean of daily mean values for this day for 96 years of record[1], in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	4391	5168	4948	6117	6360	5740	3217	1840	1275	1152	1253	2033
2	4645	6630	5049	6084	6516	5741	3130	1811	1257	1155	1232	2518
3	4554	5518	5233	6157	6542	5612	3011	1724	1244	1158	1277	2778
4	3913	5687	5281	6264	6783	5585	2915	1648	1247	1115	1293	2994
5	3937	5998	5461	6558	6929	5540	2849	1645	1249	1132	1312	2381
6	3800	5930	5321	6721	6973	5485	2776	1633	1256	1134	1316	2372
7	3479	5479	5427	6277	6971	5507	2658	1608	1261	1101	1333	2846
8	3659	5247	5380	6521	6870	5348	2599	1607	1265	1110	1306	2910
9	3671	5335	5787	6125	6771	5160	2560	1584	1246	1101	1288	2849
10	3384	5276	6401	6117	6875	5001	2493	1535	1219	1101	1482	2732
11	3358	5726	5777	6182	6922	4916	2482	1567	1234	1140	1401	3515
12	3982	5329	5629	6461	6999	4828	2457	1577	1203	1150	1361	2893
13	4350	5149	5866	6324	6897	4613	2409	1588	1171	1160	1441	2805
14	5734	5585	5931	6028	7060	4436	2396	1579	1158	1158	1502	2778
15	5786	5293	5617	5961	7018	4372	2330	1558	1149	1127	1593	2479

16	5446	5840	5446	6276	6991	4528	2274	1482	1124	1167	1687	2418
17	5151	6590	5756	6185	7143	4535	2422	1485	1128	1238	1820	2194
18	6304	6939	5987	6074	6917	4407	2505	1449	1151	1183	2442	2024
19	5453	6803	6634	6075	6624	4197	2422	1431	1157	1152	3232	2010
20	5004	6586	6757	6230	6506	4056	2335	1428	1173	1133	3081	2196
21	5655	7063	6395	6233	6312	3975	2263	1395	1179	1113	3869	2419
22	6573	6489	6141	6399	6290	3888	2182	1361	1184	1123	2327	3420
23	6339	5894	5941	6526	6223	3750	2122	1330	1208	1127	2030	4573
24	6146	5639	6576	6574	6248	3659	2062	1319	1228	1152	2082	5121
25	6222	5574	7366	6478	6318	3507	2029	1286	1224	1164	2109	4692
26	6042	5237	7050	6405	6395	3439	1986	1320	1252	1131	1922	4276
27	5921	5419	6747	6485	6251	3346	1984	1326	1278	1165	2151	4414
28	5637	5361	5780	6786	6263	3312	1988	1324	1260	1170	2009	4596
29	5036	6309	5796	6656	5976	3268	1971	1331	1224	1154	2006	4433
30	5325		6226	6535	5667	3269	1918	1314	1222	1188	1988	4128
31	4972		6105		5618		1882	1318		1320		4500

1 -- Available period of record may be less than value shown for certain days of the year.

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Daily Streamflow for California

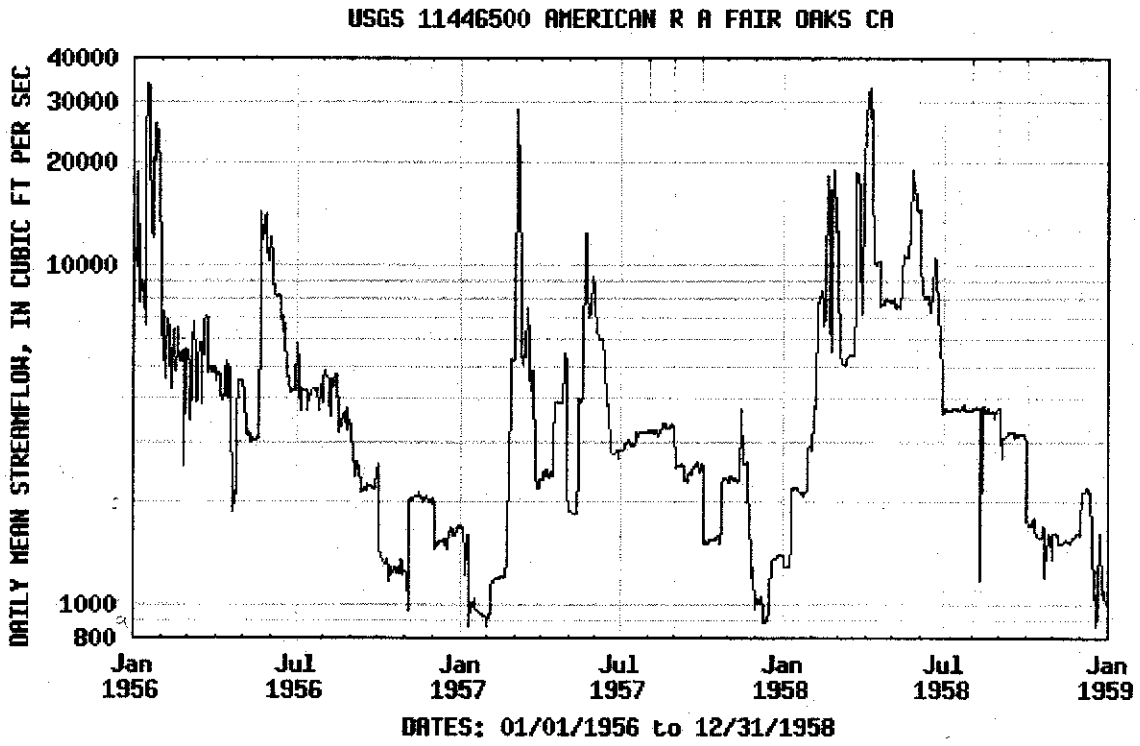
USGS 11446500 AMERICAN R A FAIR OAKS CA

Available data for this site Surface-water: Daily streamflow GO

Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°38'08", Longitude 121°13'36" NAD27
Drainage area 1,888.00 square miles
Gage datum 71.53 feet above sea level NGVD29

Output formats

Tab-separated data file
Graph
Reselect output format



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Daily Streamflow for California

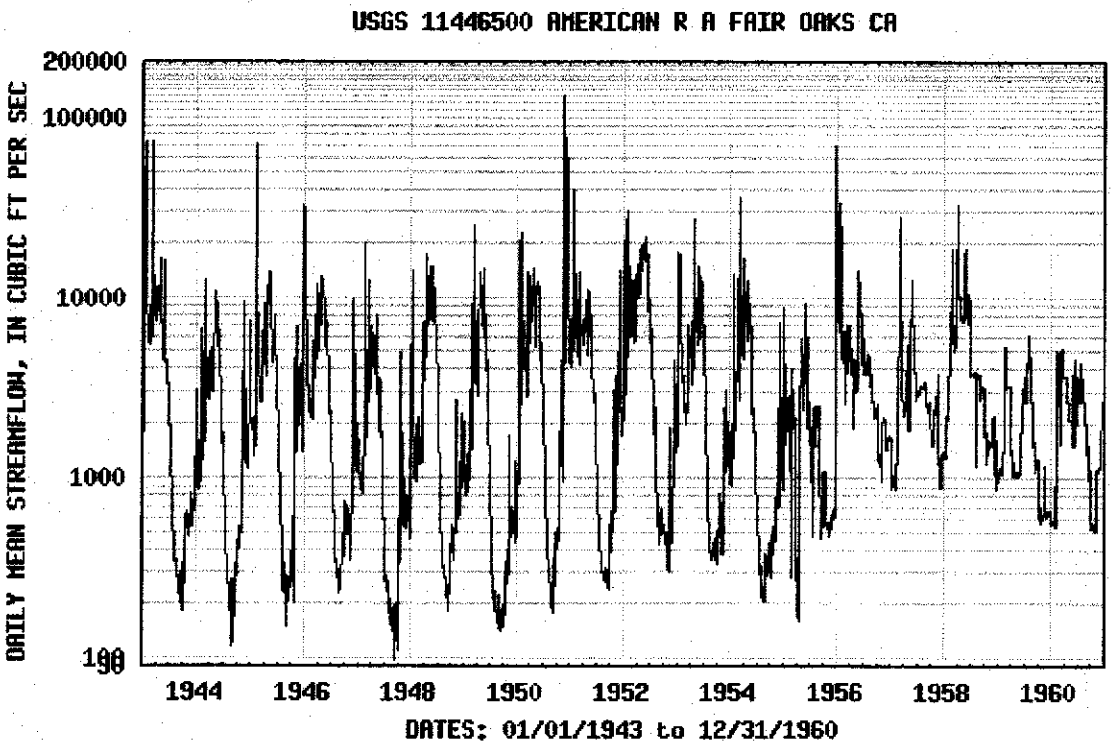
USGS 11446500 AMERICAN R A FAIR OAKS CA

Available data for this site Surface-water: Daily streamflow | GO

Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°38'08", Longitude 121°13'36" NAD27
Drainage area 1,888.00 square miles
Gage datum 71.53 feet above sea level NGVD29

Output formats

- Tab-separated data file
- Graph
- Reselect output format



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Daily Streamflow for California

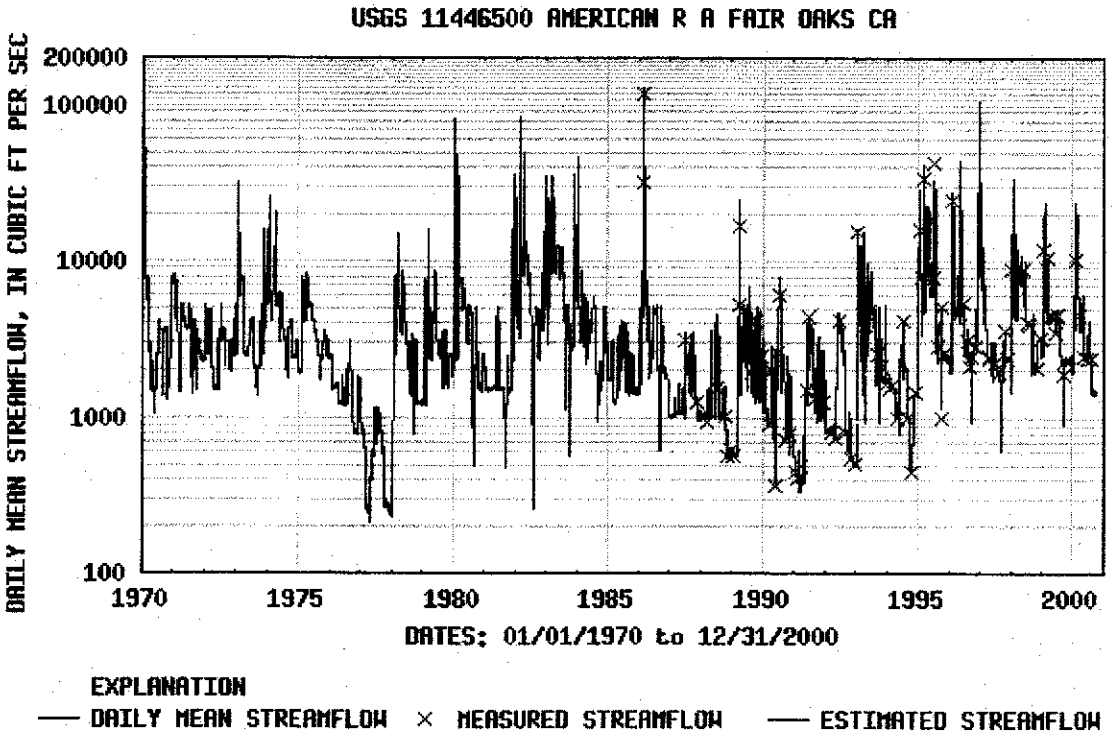
USGS 11446500 AMERICAN R A FAIR OAKS CA

Available data for this site Surface-water: Daily streamflow | GO

Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°38'08", Longitude 121°13'36" NAD27
Drainage area 1,888.00 square miles
Gage datum 71.53 feet above sea level NGVD29

Output formats

Tab-separated data file
Graph
Reselect output format



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Streamflow Measurements for California

11446500 AMERICAN R A FAIR OAKS CA

Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°38'08",
Longitude 121°13'36" NAD27
Drainage area 1,888.00
square miles
Gage datum
71.53 feet above sea level
NGVD29

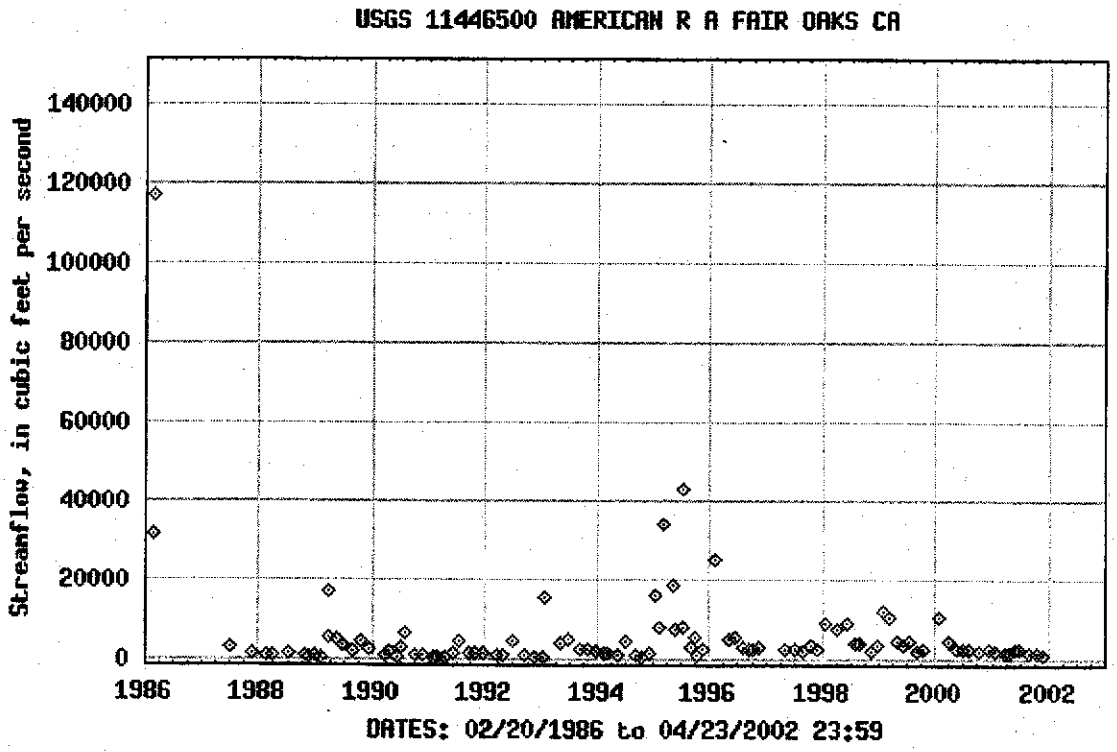
Output formats

HTML table of all measurement data

Tab-separated data

Graph of measurement data (GIF format)

Reselect output format



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Site Map for California

USGS 11447000 AMERICAN R A SACRAMENTO CA

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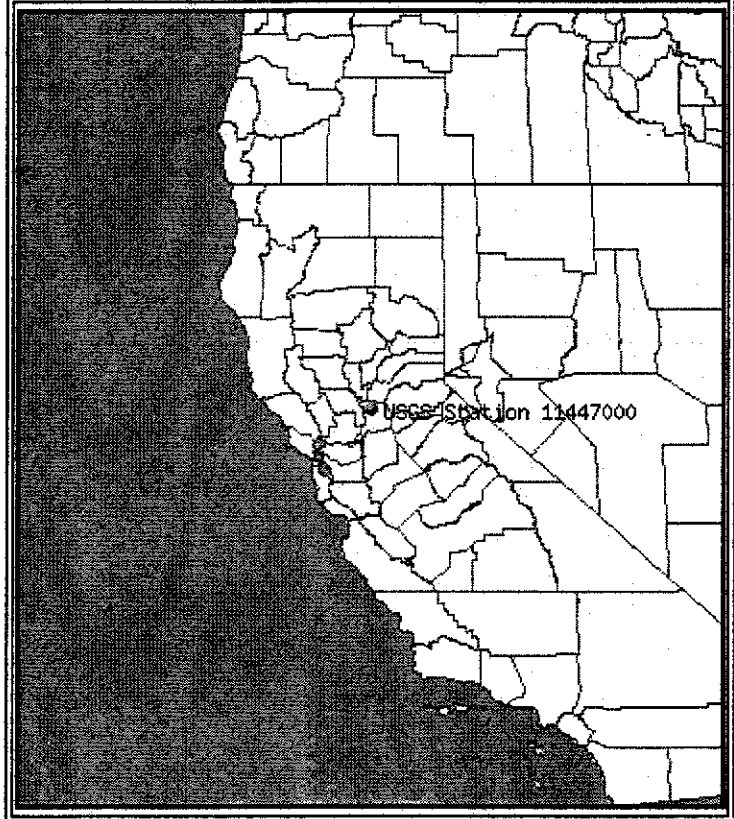
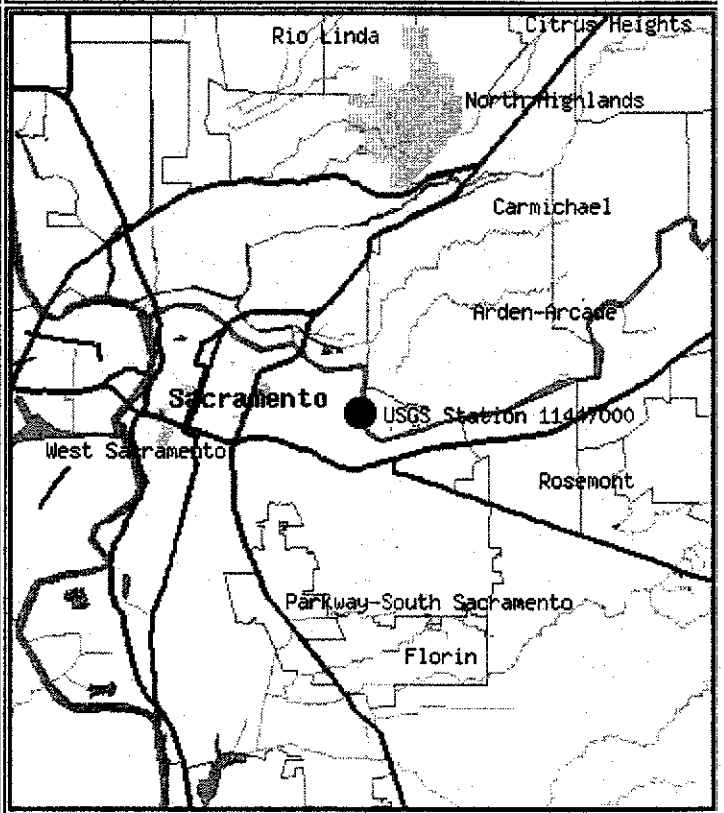
Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°34'05", Longitude 121°25'20" NAD27
Drainage area 1,936.00 square miles

Location of the site in California.



Site map.



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Data Category: Surface Water | Geographic Area: California | GO

Daily Streamflow Statistics for California

USGS 11447000 AMERICAN R A SACRAMENTO CA

Available data for this site Surface-water: Daily streamflow statistics | GO

Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°34'05", Longitude 121°25'20" NAD27
Drainage area 1,936.00 square miles

Output formats

HTML table of all data
Tab-separated data
Reselect output format

10/43 -> 11/59

Day of month	Mean of daily mean values for this day for 16 years of record[1], in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3478	3371	4668	5691	7561	7566	2707	1590	999	753	1278	1738
2	3444	7084	4386	5658	7749	7362	2579	1555	957	642	1124	2390
3	3267	6758	5161	6127	7783	7035	2479	1469	919	691	1086	2652
4	3047	5266	5251	6435	8138	6656	2398	1389	904	637	1242	5953
5	3429	5590	5574	6978	8063	6520	2245	1379	890	661	1305	3539
6	3672	5423	5967	7818	8149	6468	2163	1331	896	646	1111	2899
7	3046	4619	5636	7937	8532	6465	2052	1307	882	638	1023	4227
8	3446	4221	4879	7067	8126	6044	1986	1316	896	645	1019	4845
9	3808	4327	5223	6939	7591	5959	1918	1343	905	654	976	4416
10	3718	3988	6863	6787	7179	5635	1863	1194	819	661	1407	3241
11	3259	4049	6178	6369	7357	5324	1853	1241	801	677	1547	2550
12	4064	4257	5169	5853	7431	5046	1848	1278	783	679	1261	2345
13	3637	5119	5084	5772	7553	4746	1800	1275	779	697	1341	2030
14	3790	4792	4787	5840	8028	4623	1799	1282	777	667	1311	2437
15	4893	4351	4712	5806	8146	4470	1789	1242	775	679	1472	2623

16	5303	3879	5229	6302	7758	4445	1744	1154	772	675	1390	2077
17	5476	4258	4941	7238	7927	4388	1727	1141	774	895	1445	1870
18	6337	4748	4871	7756	7747	4572	1679	1098	790	855	2486	1717
19	6025	4669	5118	7300	7519	4413	1681	1104	796	756	5944	1699
20	4228	4709	5694	7320	8171	4291	1651	1101	794	730	5084	1821
21	4162	4436	5224	7491	8021	4131	1597	1107	805	702	7449	1883
22	5830	3874	4869	7743	8339	3963	1464	1085	812	739	3790	3587
23	5983	3761	5053	7923	7996	3610	1522	1098	809	760	2519	6191
24	6458	3772	5736	8078	8118	3552	1514	1098	812	789	2238	6804
25	5685	4048	6099	7976	8319	3316	1450	1067	819	891	1908	7104
26	5604	4019	5908	8091	8594	3101	1443	1121	837	894	1702	7306
27	4677	4408	5627	7989	8493	2972	1460	1113	846	971	1504	6199
28	4272	4344	5163	9456	8139	2799	1540	1120	844	986	1517	6160
29	4066	6160	5023	8548	7744	2726	1549	1085	841	849	1573	6843
30	3805		5444	8048	7429	2792	1549	1065	864	910	1498	5345
31	3256		5481		7446		1602	1064		1593		3985

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Daily Streamflow for California

USGS 11447000 AMERICAN R A SACRAMENTO CA

Available data for this site Surface-water: Daily streamflow | GO

Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°34'05", Longitude 121°25'20" NAD27
Drainage area 1,936.00 square miles

Output formats

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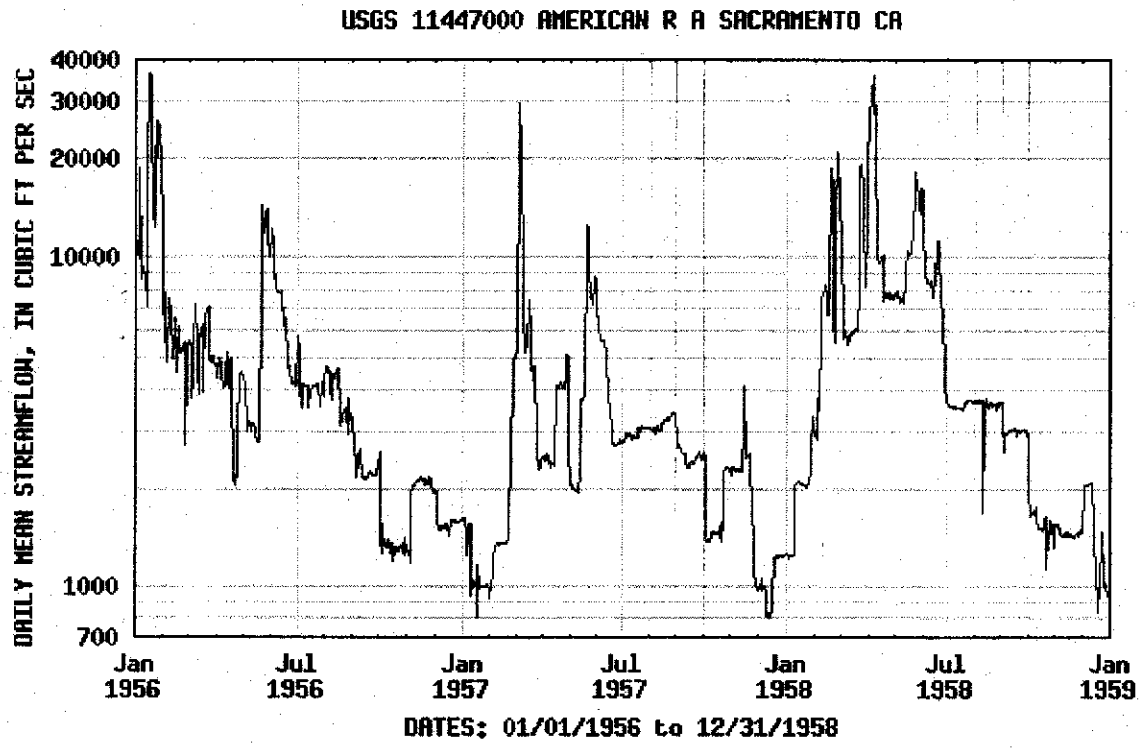

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Daily Streamflow for California

USGS 11447000 AMERICAN R A SACRAMENTO CA

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Sacramento County, California
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Latitude 38°34'05", Longitude 121°25'20" NAD27
Drainage area 1,936.00 square miles

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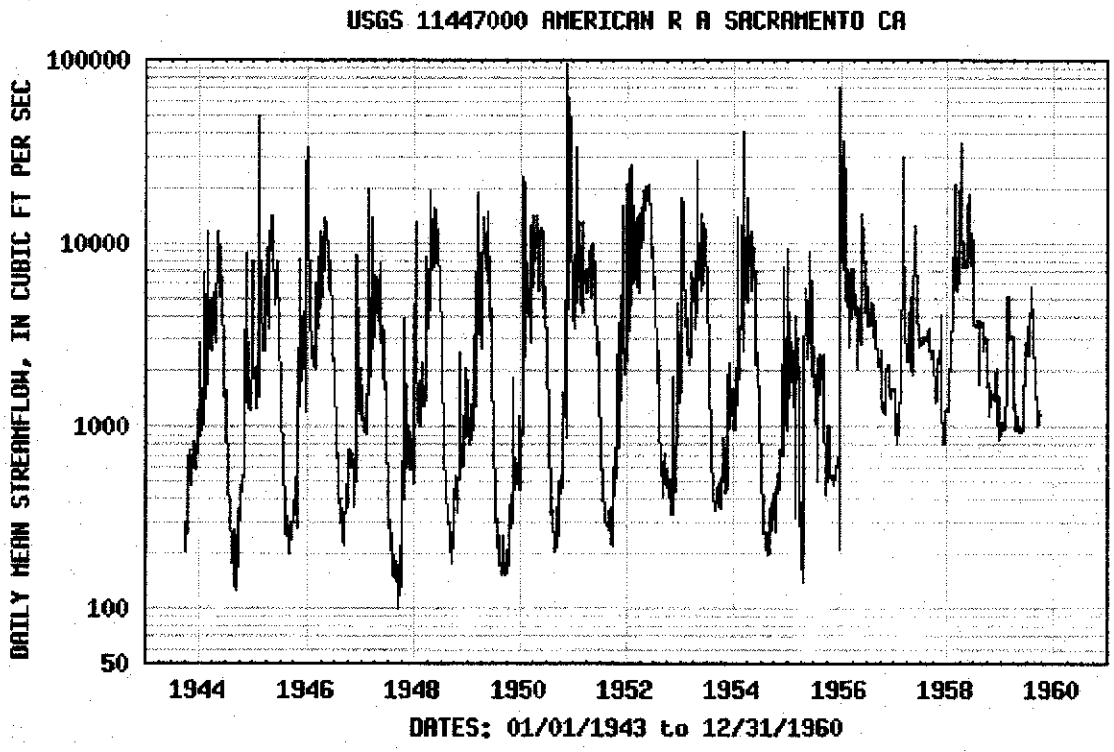

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Monthly Streamflow Statistics for California

USGS 11446500 AMERICAN R A FAIR OAKS CA

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Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°38'08", Longitude 121°13'36" NAD27
Drainage area 1,888.00 square miles
Gage datum 71.53 feet above sea level NGVD29

Output formats

HTML table of all data
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YEAR	Monthly mean streamflow, in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1904										1,429	918	1,339
1905	3,266	4,228	6,149	6,875	6,118	3,010	695	270	138	147	194	254
1906	7,258	5,934	14,149	12,100	15,079	16,050	6,336	1,021	419	298	563	3,972
1907	4,152	14,850	24,710	15,640	12,200	11,110	5,505	1,497	813	693	824	1,787
1908	2,600	1,958	3,294	4,487	4,595	2,604	870	200	123	384	441	605
1909	24,290	15,540	6,462	7,994	9,509	7,652	2,314	607	287	511	4,591	9,379
1910	8,524	5,245	10,500	10,490	7,951	2,263	516	213	201	342	539	1,597

1911	13,869	10,600	12,980	15,090	14,499	17,720	3,199	459	304	350	430	400
1912	1,132	800	1,923	2,868	6,843	4,768	830	209	331	243	1,469	599
1913	1,574	1,287	1,746	6,036	7,215	2,545	614	283	154	155	487	2,149
1914	17,110	7,015	8,114	9,420	11,660	6,594	2,114	451	191	332	375	681
1915	1,545	9,214	4,649	8,512	15,520	8,032	1,767	391	225	217	378	1,312
1916	7,743	10,160	13,130	11,770	9,874	6,707	1,971	340	220	626	651	2,009
1917	1,586	7,334	4,469	9,231	10,300	8,917	1,680	372	198	185	181	520
1918	284	2,233	5,089	7,403	5,000	1,939	322	69.9	415	940	805	778
1919	677	6,498	5,114	9,442	9,658	1,606	269	138	134	159	151	688
1920	633	650	3,870	6,068	7,139	2,722	547	178	157	564	2,562	4,425
1921	7,700	5,685	8,692	7,256	8,568	6,244	1,241	326	246	399	785	2,205
1922	1,915	6,687	5,498	8,193	16,550	11,270	1,595	358	264	499	1,065	6,488
1923	4,363	3,158	3,545	9,512	9,962	4,678	1,581	351	377	646	468	470
1924	619	2,004	879	1,998	1,487	207	26.8	15.8	24.4	234	965	1,608
1925	1,528	10,880	5,183	10,190	9,810	4,337	1,081	324	283	438	542	893
1926	793	4,656	3,150	7,979	3,207	812	247	168	206	353	2,923	2,248
1927	3,619	13,869	7,175	12,220	9,784	6,927	1,239	381	329	458	1,974	1,666
1928	1,699	2,345	16,139	9,011	6,193	1,337	414	224	218	362	568	705
1929	719	1,832	2,439	3,595	5,548	2,658	482	171	129	100	85.0	2,520
1930	2,226	2,602	5,200	5,769	4,459	2,424	414	181	230	258	568	330
1931	860	1,265	2,143	2,612	1,923	654	136	64.4	93.8	250	518	2,779
1932	2,863	5,766	4,792	6,518	10,390	6,754	1,502	302	220	381	516	693
1933	776	989	2,333	4,006	5,721	5,533	633	250	143	409	654	1,902
1934	2,679	3,157	4,107	3,090	1,593	661	192	196	147	219	1,174	1,166

1935	2,836	2,620	3,393	13,510	10,530	5,802	1,009	273	221	477	713	756
1936	6,721	13,500	6,965	10,490	9,315	5,780	1,364	463	420	490	575	689
1937	901	6,277	6,644	8,524	10,840	3,649	873	316	294	555	1,173	7,189
1938	2,345	9,931	13,160	12,070	16,310	9,846	2,101	575	486	683	950	989
1939	1,082	1,545	3,840	5,203	2,582	784	165	106	108	458	516	691
1940	7,798	10,650	13,780	10,450	8,040	3,232	734	387	410	421	941	4,299
1941	5,845	8,731	7,501	7,591	11,430	4,639	1,319	459	354	475	1,076	5,463
1942	9,685	10,320	4,955	10,510	11,610	9,163	2,402	541	378	360	2,736	4,757
1943	11,480	7,052	15,380	10,060	7,141	4,337	1,273	350	248	427	614	780
1944	1,247	2,796	4,062	3,819	7,497	3,116	632	215	224	448	2,178	2,317
1945	1,813	10,200	4,214	6,865	8,940	4,573	1,052	270	268	663	2,574	8,792
1946	4,981	2,723	5,574	8,554	8,692	3,242	753	290	376	557	1,671	1,670
1947	1,055	3,130	4,794	4,780	3,936	1,452	272	179	149	806	887	665
1948	2,891	1,468	2,572	8,774	10,160	7,381	1,298	308	240	456	841	1,189
1949	1,084	1,823	5,917	8,521	8,416	2,599	371	184	165	247	591	629
1950	5,149	6,278	5,635	9,852	9,569	5,356	1,194	280	339	922	16,450	17,360
1951	9,667	7,819	7,039	7,141	7,431	2,509	623	294	272	686	1,901	5,437
1952	9,041	9,726	8,162	13,750	18,200	11,100	3,878	919	526	458	555	1,952
1953	7,638	2,828	3,772	7,856	7,956	8,402	2,576	447	404	559	1,061	1,408
1954	2,285	3,965	7,342	9,186	5,828	1,741	445	243	348	432	779	2,149
1955	2,669	1,831	1,654	1,110	4,236	3,767	1,779	2,158	1,057	802	550	14,690
1956	16,360	5,563	5,402	3,982	6,380	6,761	4,268	3,968	2,343	1,342	1,967	1,625
1957	1,149	1,681	6,820	3,296	5,220	4,374	3,035	3,273	2,485	1,845	2,211	1,156
1958	1,997	8,746	8,332	15,020	11,050	8,246	3,734	3,644	3,152	1,613	1,565	1,530

1959	1,082	2,665	3,001	1,185	1,055	2,138	4,079	3,343	1,253	632	687	617
1960	587	2,695	3,784	3,151	1,901	2,889	3,367	2,368	1,235	533	1,092	2,153
1961	2,232	923	687	983	1,031	2,076	3,763	3,195	1,068	598	509	495
1962	350	4,383	6,903	5,754	3,090	2,087	3,414	3,530	2,654	3,014	3,055	2,621
1963	2,010	11,570	3,384	8,337	7,141	4,150	3,512	3,499	3,074	2,157	3,373	3,347
1964	1,974	2,122	1,777	1,239	1,198	1,835	3,467	3,383	2,798	1,414	1,023	19,360
1965	13,790	6,278	4,154	4,212	7,057	2,139	3,127	3,502	3,212	2,165	2,090	2,800
1966	2,111	1,753	2,663	1,608	953	1,621	1,921	2,176	954	776	2,212	5,356
1967	6,280	6,036	7,400	7,672	7,742	8,284	4,803	3,367	3,071	2,372	3,288	4,209
1968	2,166	3,910	4,979	2,649	1,196	2,925	3,261	1,348	943	933	1,893	2,909
1969	16,850	9,941	9,873	8,169	7,796	4,326	2,044	2,426	3,018	4,102	3,735	4,615
1970	19,190	6,794	5,541	1,821	1,485	1,928	3,658	3,315	3,595	1,880	2,536	7,640
1971	6,201	3,555	1,778	4,698	4,064	4,175	4,544	3,539	3,464	2,758	2,432	2,720
1972	3,313	3,729	3,205	1,577	1,544	2,760	3,219	3,459	3,009	2,437	2,646	3,420
1973	10,520	7,880	6,045	2,543	2,705	3,834	3,240	2,016	2,025	2,692	7,050	6,203
1974	12,310	5,006	9,155	9,538	5,504	4,961	3,002	3,096	3,635	3,153	2,642	2,542
1975	1,968	5,111	5,363	6,012	5,238	4,433	3,449	2,745	2,304	3,054	2,782	2,789
1976	2,130	1,550	1,580	1,242	1,275	1,277	1,731	1,991	1,696	810	817	1,612
1977	850	722	273	258	520	1,135	869	855	602	284	272	252
1978	2,737	4,790	7,769	5,084	6,643	3,338	2,551	2,345	2,944	1,786	1,232	1,231
1979	3,045	4,258	3,232	2,696	6,687	3,429	2,574	2,555	3,015	2,110	2,426	2,142
1980	16,630	11,520	7,499	5,800	4,444	3,554	4,561	1,991	2,356	1,908	1,519	2,367
1981	1,685	1,524	1,535	1,547	2,832	3,235	1,762	1,334	1,176	1,554	5,223	10,640
1982	10,210	14,740	8,984	17,760	9,503	7,046	3,504	3,787	3,434	2,895	6,243	10,290

1983	7,859	12,640	19,340	9,546	12,310	9,828	7,055	4,500	3,924	3,011	11,700	14,190
1984	8,057	5,269	4,922	3,255	3,769	4,082	5,203	2,065	1,890	2,048	2,989	3,194
1985	1,756	2,273	1,479	1,833	2,660	2,960	3,057	2,402	2,030	1,713	1,472	1,479
1986	2,674	31,140	14,910	5,816	2,288	2,854	4,820	3,298	2,392	2,470	1,912	1,696
1987	1,105	1,039	1,071	1,219	1,080	1,365	2,625	2,206	2,076	2,266	1,163	1,022
1988	1,022	1,028	1,055	1,110	1,337	1,579	2,833	1,457	1,126	1,002	681	611
1989	588	588	4,868	2,807	3,664	3,628	4,549	2,999	1,903	3,007	3,045	1,728
1990	1,166	1,180	931	1,880	872	2,343	5,995	2,650	1,465	1,242	918	886
1991	548	408	373	407	717	2,367	3,135	2,773	1,459	2,321	1,166	1,881
1992	864	816	844	786	1,666	3,913	3,477	2,554	857	668	584	517
1993	4,284	6,213	7,342	3,380	5,406	5,773	5,446	3,872	2,271	2,706	1,855	2,378
1994	1,780	1,598	1,598	1,145	1,034	2,025	2,317	1,792	1,006	606	1,346	1,445
1995	8,789	5,449	18,140	7,942	14,270	7,413	10,710	2,854	3,878	2,849	2,429	2,398
1996	2,151	14,270	4,980	5,517	9,510	4,903	2,849	2,722	2,168	2,688	3,483	14,590
1997	31,780	7,219	4,147	2,607	2,415	2,621	2,233	1,961	1,553	2,416	2,436	2,385
1998	5,770	12,440	6,601	7,624	9,141	7,652	4,353	4,008	4,014	2,271	2,733	3,052
1999	6,084	12,340	5,926	4,345	4,413	3,957	4,293	2,489	2,064	2,401	2,357	2,289
2000	3,699	10,080	5,613	4,387	3,622	2,630	3,261	1,797	1,463			
Mean of monthly streamflows	4,964	5,824	5,930	6,327	6,588	4,501	2,407	1,497	1,214	1,151	1,838	3,171

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Monthly Streamflow Statistics for California

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Sacramento County, California
Hydrologic Unit Code 18020111
Latitude 38°34'05", Longitude 121°25'20" NAD27
Drainage area 1,936.00 square miles

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YEAR	Monthly mean streamflow, in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1943										454	647	808
1944	1,291	2,870	4,123	3,854	7,567	3,022	647	223	231	476	2,188	2,378
1945	1,781	10,280	4,288	6,711	9,203	4,686	949	280	295	661	2,468	8,581
1946	5,185	2,651	5,503	8,687	9,015	3,383	803	307	374	637	1,658	1,762
1947	1,145	3,254	4,725	4,838	3,940	1,435	279	167	143	809	952	736
1948	2,910	1,498	2,623	9,040	10,570	7,691	1,308	339	239	475	825	1,094
1949	1,034	1,693	5,988	8,464	8,635	2,446	379	186	171	266	576	624

1950	5,087	6,211	5,757	10,040	9,699	5,471	1,205	280	357	920	12,650	15,709
1951	9,234	7,684	6,872	6,916	7,409	2,502	586	298	279	726	1,928	5,498
1952	8,935	9,653	8,143	13,930	18,970	11,080	3,802	923	552	468	546	1,930
1953	7,225	2,975	3,897	7,812	8,024	8,423	2,528	448	415	599	931	1,262
1954	2,267	4,032	7,354	9,197	5,919	1,641	413	230	343	445	784	2,130
1955	2,645	1,828	1,638	1,073	4,293	3,763	1,792	2,088	1,059	764	536	14,540
1956	16,930	5,768	5,506	4,004	6,296	6,719	4,129	3,861	2,307	1,361	1,994	1,593
1957	1,164	1,771	7,012	3,331	5,242	4,212	2,958	3,173	2,505	1,773	2,145	1,060
1958	1,930	8,714	8,858	15,290	10,770	8,867	3,604	3,567	3,012	1,565	1,464	1,439
1959	997	2,510	2,880	1,124	970	1,985	3,855	3,144	1,159			
Mean of monthly streamflows	4,360	4,587	5,323	7,144	7,907	4,833	1,827	1,220	840	775	2,018	3,822

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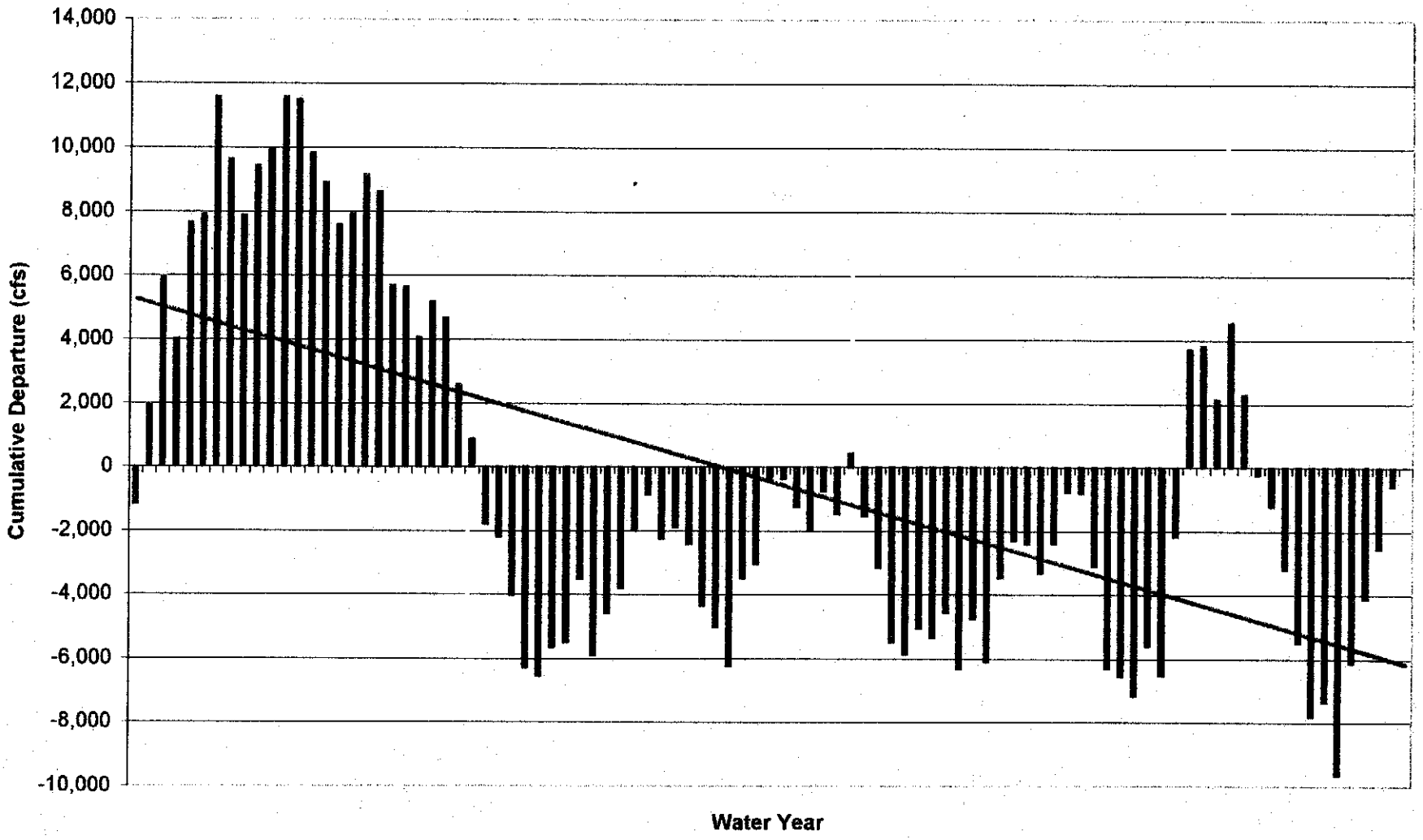
Cumulative Departure from Mean Annual Flow 1905 - 1999
1905 - 1999 Mean; USGS Gage 11446500



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In the matter of	
Applications 12140, etc.,	
CITY OF SACRAMENTO, et al.,	BRIEF OF COUNTY
Applicants	OF SACRAMENTO
E. CLEMENS HORST COMPANY, et al.,	
Protestants	

The County of Sacramento has two applications pending at this hearing, 12314 and 12315. It produced two witnesses in support of them, Mr. M. D. Tarshes, County Executive (Tr. Jan. 31, 1957, sec. 1, p. 11) and Mr. Weber D. Rothwell, Head of the Water Development Division in the County's Department of Public Works (id. p. 45). Mr. Rothwell prepared and presented thirteen exhibits.

The County's applications contemplate the diversion and storage of water for municipal and irrigation purposes at Folsom Dam (Sacto. Co. Exh. 6). The total ultimate quantity of new water required in the County from the American River for the various service areas, excluding

the City of Sacramento, was estimated at about 864,000 acre-feet (Sacto. Co. Exh. 10). It had already been shown by exhibits of the United States (USBR Exh. 55) that greater quantities than this would be produced from the unappropriated waters of the river. Numerous agencies empowered to supply water now exist. (Exhs. 4 and 5.)

I. County's Relation to Other Applicants

Since the County does not own or control Folsom Reservoir, a statement of the purpose of its applications was made by the County's Executive Officer (Tr. Jan. 31, 1957, sec. 1, pp. 11-13). What follows under this heading is summarized from that statement:

Historically the County has supported the construction of a reservoir at Folsom, at first by state or local agencies, then by the U.S. Corps of Engineers, and finally by the U.S. Bureau of Reclamation, which is now actually operating it. The reservoir provides badly needed flood control and hydroelectric power and will provide water for the future irrigation and domestic needs of the County.

Because of the great complexity of the water rights picture in California it was deemed desirable for the County to have its own applications at Folsom Reservoir. Some have argued that permits should be granted to the local

agencies who use the water, rather than to the United States which owns and operates the reservoir as a trustee. If this Board determines to adopt that policy, permits should be issued to Sacramento County for the water which it needs from Folsom Reservoir. There is a county-wide Sacramento County Water Agency (Stats. 1st ex. sess. 1952, ch. 10, p. 315) to which the permits will be assigned, and that agency will provide for serving the County, by contract with the United States and otherwise.

The districts in the southern part of Sacramento County, in particular, are seeking the issuance of permits to themselves, since they have a beneficial interest in county filings, the County has indicated its willingness to make water available by assignments or some other means to those areas if any permits are issued to the County.

The County's position is in no way in conflict with the application of the City of Sacramento, which has its own diversion and distribution system which it has operated for more than 100 years, or with any other applicant within the County. Sacramento County believes that the great projects on the American River now constructed and proposed should receive adequate water rights under conditions which will provide water for the areas in the County logically dependent on that source.

II. Conditions in Permits

The applications of the United States provide for a very large service area, including Sacramento County, but extending south to Mendota pool and Hollister and west to Vallejo (USBR Exh. 6), for much of which area the project provides supplemental water to local supplies and other units of the Central Valley Project.

Service in Sacramento County by the United States, except to the City of Sacramento and its service area, is largely dependent on the construction of canals which have been proposed, but not yet authorized. Reports on the "Folsom South" canal were required of the Secretary of Interior by the "American River Act," approved October 14, 1949 (P.L. 356, 81st Cong.; 63 Stat. 852); this report (SWRB Exh. 24) has been submitted by the Regional Director to the Commissioner, but no action has been taken on it. A reconnaissance type report on the Folsom North Canal has also been made (SWRB Exh. 23). A canal to serve the Folsom East area has been suggested, but not yet studied in detail.

Under all these circumstances, it seems appropriate to make some reservation of water for the areas to be served by these canals in Sacramento County, if permits are to be issued to the United States. This would carry out the principle of the "watershed protection law" (Wat. C. 11460)

recently made applicable to the American River by the addition of section 11265 to the Water Code by ch. 1121, Stats. 1957.

The quantities of water required from the American River for ultimate development of Sacramento County are, as previously indicated, set out in Sacto. Co. Exh. 10. At the request of the Board, the county is filing simultaneously with this brief three proposed new exhibits, Nos. 14, 15 and 16, showing the extent, in acreage and estimated water requirements, of overlap between the applications of the various agencies for service within the county, so that if permits are granted to them, the amounts required by the County can be adjusted by the extent of the overlap.

The situation with respect to the Folsom North and Folsom East service areas requires some special attention:

A. Folsom North Service Area

An analysis of the evidence on the needs of Sacramento County's Folsom North service area demonstrates that whether or not ground water is principally relied on for large portions of the area, the demand on the American River may be, under assumed certain circumstances, about the same, through use of that source for ground water replenishment. The analysis follows:

From the Bureau of Reclamations Folsom North Reconnaissance Report (SWRB Exh. 23), it is estimated that in 1954 the water use in the Sacramento County area of the Folsom North Service Area was 87,500 acre-feet, with an estimated 61,000 acre-feet being furnished by ground water and the remaining 26,500 being surface water.

In the San Juan Suburban study area of the Folsom North Reconnaissance Report, anomalous ground water levels indicated the existence of an apparent ground water "barrier" that impeded the westward migration of ground water. East of this "barrier", ground water conditions are sporadic and generally poor and were not considered to be favorable for significant additional development. The area east of the "barrier" (22,000 acres) was excluded from the ground water study area.

It was estimated in this report that in 1954 the ground water pumpage for this ground water study area was 74,600 acre-feet and from this it is estimated that approximately 58,846 acre-feet were pumped in 1954 in the ground water study area within Sacramento County.

Of the total estimated net recharge of 63,000 acre-feet for the entire ground water study area 22,200 acre-feet was attributed to the American River.

Under the existing conditions it would be safe to attribute the whole 22,200 acre-feet as contributing to the ground water recharge of the Sacramento County area within the ground water study.

Sacramento County Exh. 10 shows an estimated ultimate water need in its Folsom North Service Area as outlined in Sacramento County Exh. 3 of 245,534 acre-feet.

With an estimated water use of 87,500 acre-feet in 1954 there is a total of 158,034 acre-feet to be supplied from one source or another to meet this ultimate need.

U.S.B.R. Exh. 19 estimates the ultimate water

use along the American River below Folsom Reservoir and which could be assigned to the County of Sacramento's Folsom North Service Area as follows:

North Fork Ditch Co.	33,000 A.F.	
Carmichael Irrig. Dist.	8,370 A.F.	
Riparian Lands	10,048 A.F.	(54.67% of 8181 acres)
Ground Water Recharge	9,500 A.F.	
Total	60,918 A.F.	

Of this amount approximately 48,500 acre-feet could be charged to surface water, 2,930 acre-feet to ground water and 9,500 acre-feet to ground water recharge.

This results in an increase of 22,000 acre-feet over the estimated surface water use in 1954 and of 4,111 acre-feet in estimated ground water used in 1954 in the riparian land area.

This 4,111 acre-feet was obtained by adding 3,280 acre-feet (54.67% of the 6,000 acre-feet of the estimated 25,000 acre-feet maximum recharge from the American River which was already reflected in the water requirements for riparian lands) to the 2,930 acre-feet of riparian land use not assigned to surface water and subtracting from it the estimate ground water use of the riparian lands in 1954.

It can be concluded that as of 1954 there has been established in the Sacramento County Folsom North Service Area, as outlined in Sacramento County Exh. 3, a recognized water use and water rights totaling 113,611 acre-feet, and there is no doubt that to date, due to the increased use of ground water since 1954, this total has been increased and is being increased every day.

On the basis of this total water use and rights of 1954 there will be a further need of 131,923 acre-feet to meet the estimated ultimate water demand of 245,534 acre-feet.

The source of supply used to meet this need will no doubt be dictated by the economics of the problem.

The Folsom North Reconnaissance Report has indicated that based on certain priced surface water, it would be as economical to pump ground water from 150 to 200 foot levels as to import a surface water supply from the Folsom Dam. This report estimates that the safe ground-water yield, of the Folsom North Unit ground waters study area with the 150-foot average annual water-level stage would be about 200,000 acre-feet. For the Sacramento County area of the ground water study area an estimate of 180,000 acre-feet can be used.

Since the estimated ground water use in the Sacramento County area of the ground water study area is 62,957 acre-feet (58,846 / 4111) it could be possible to meet part of this further need by pumping another 117,000 acre-feet from the ground water study area.

In the ground water recharge study, the recharge was attributed to percolation of precipitation, American River flows, other stream flows entering the study area and from irrigation and other water applied to the soil.

In view of the fact that the largest portion of the future development will be residential or industrial the contributions to the ground water recharge of all factors with the exception of the American River will be greatly reduced. It is possible that the American River will furnish approximately 75% of the ground water recharge necessary to meet the demands of the heavy ground water pumping.

The Bureau of Reclamation in its operational studies assigned approximately 12,780 acre-feet of water to ground water recharge.

To offset this heavy demand on the American River for ground water recharge is the estimate that approximately 50% of the water use will be returned to the American River.

B. Folsom East Service Area

In response to the Board's particular request, the following statement is made with respect to this service area:

> The State of California, State Water Resources Board's Bulletin No. 2 (SWRB. Exh. 4), Volume II Appendices and Plates of June, 1955 included the Folsom East Service Area as shown on Sacto. Co. Exh. 3 in Hydrographic Unit No. 62 - Ione. The description of this unit states that it consists of those portions of the lower foothills of Western Amador and El Dorado Counties, and Eastern San Joaquin and Sacramento Counties, which are capable of being irrigated from canals delivering water developed at the Nashville dam site on the Cosumnes River. The easterly limit of the unit follows the possible lines of these canals. The south canal would divert at an elevation of approximately 800 feet with a secondary diversion from Dry Creek (Ione) at an elevation of about 400 feet. The southerly limit of the unit is the Mokelumne River. The westerly limit follows the line of the proposed Folsom South Canal at an approximate elevation of 100 feet. The northerly limit is the southerly edge of the Folsom Reservoir. Of the total area in this unit approximately 40 per cent is in Sacramento County.
>
> Statistics given in Volume I of Bulletin 2 give the approximate gross area of presently irrigated lands of Hydrographic Unit No. 62 as 8600 acres and the probable ultimate area of irrigated lands as 150,000 acres of gross irrigatable area with an approximate net irrigated area of 115,000 acres.
>
> Under the California Water Plan as outlined in Bulletin No. 3 (SWRB Exh. 5-A) the Folsom East Area would be largely served from the development of the Cosumnes River Basin. However, this development contemplates the diverting of approximately 76,000 acre-feet per season from the South Fork of the American River and a far larger quantity if off-stream storage for water from the south fork of the American River is obtained in Nashville Reservoir instead of in the Salmon Falls Reservoir (Coloma).

Under Sacramento Municipal Utility District's Modified plan for Development of the American River Basin (see DWR Exh. 9), a small portion of the Folsom East Service Area could be served from a proposed Malby Reservoir to be located just east of the Sacramento County line near White Rock. This reservoir would be supplied from Folsom Reservoir and with a capacity of 26,000 acre-feet would meet the ultimate requirements of about 8,500 acres of land in Sacramento and El Dorado Counties below the 450 foot elevation.

The east boundary line of the proposed Folsom South Canal Service area extends east of the westerly limits of Hydrographic Unit No. 62, so some of that area will be served from the Folsom South Canal.

Practically all the north half of the Folsom East Service Area is below the 450 foot elevation and therefore could be supplied from the Malby Reservoir. The other half could be served from the Cosumnes River Basin Development. It seems however that no matter what plan is used to furnish water to the Folsom East Service Area as outlined on Sacto. Co. Exh. 3, a large portion of the water must be furnished from the American River.

Respectfully submitted this 16th day of September, 1957.

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Martin McDonough

Attorneys for Applicant

the Water Code. The rights on the American River stream system have not been so adjudicated. Limited information is available in the files of the State Water Rights Board as to the alleged rights of the several protestants to the applications being considered in this report.

Appropriative Rights Initiated Since 1914

Since December 19, 1914, the appropriation of water in California has been governed by the Water Commission Act, now included in the Water Code. Initiation of an appropriative right is now effected by an application to the State Water Rights Board in accordance with Part 2 of Division 2 of that Code. A summary of the active applications, excluding the applications discussed in Chapter II and excluding all applications for diversion of 0.5 cubic foot per second and/or 50 acre-feet per annum or less, for the waters of the American River watershed, as of October 1, 1956, is contained in Appendix B of this report. It is estimated that the total number of minor applications excluded from the tabulation is about 385.

CHAPTER V. WATER SUPPLY

Presented herein is a summary of basic hydrographic data relating to water supply in the American River Basin. These data were derived largely by rearrangement of pertinent information abstracted from State Water Resources Board Bulletins Nos. 1, 2, 10 and 21, all of which will be offered into evidence at the hearing to be conducted by the State Water Rights Board.

Precipitation

The pattern of occurrence of precipitation in the American River Basin is such as to cause the isohyets, shown on Plate 2 of State Water Resources Board Bulletin No. 21, to take a general shape of the contours of a mountain with a peak precipitation of 70 inches occurring in the upper reaches of the Middle Fork watershed. From this peak the amount of precipitation decreases to the east and west and decreases to about 24 inches in the vicinity of Folsom.

Most of the precipitation in the American River Basin occurs during the late fall, winter and early spring months, usually as snow above an elevation of 5,000 feet. Summer thunderstorms are a common occurrence at the higher altitudes in the watershed but they contribute little to water supply. At an elevation of about 3,500 feet, which corresponds roughly to the maximum suitable for cultivation, the annual depth of precipitation averages about 55 inches.

According to Table 56 of State Water Resources Board Bulletin No. 1, twenty precipitation stations are located within or adjacent to the American River Basin that have unbroken records of 10 years or longer. These stations are listed under the following names:

Towle, Lake Spaulding, Summit, Soda Springs, Auburn, Blue Canyon, Cisco, Colfax, Drum Forebay, Emigrant Gap, Gold Run, Iowa Hill, Newcastle, Rocklin, Pilot Creek, Georgetown, Placerville, Twin Lakes, Shingle Springs and Folsom. Over the period of record these stations have recorded annual precipitation varying from minimum of 10.19 inches at Folsom during the season of 1876-77, to a maximum of 102.56 inches at Lake Spaulding during the season of 1903-04.

Runoff

Numerous independent or cooperative stream gaging stations have been maintained over the past years on various streams within the American River Basin by Federal, State and private agencies. Stream flow records of these streams are available in the Water Supply Papers, Part 11. Pacific Slope Basins in California, published by the United States Geological Survey and/or the Reports of Sacramento-San Joaquin Water Supervision published by the former Division of Water Resources. These records have been summarized in Table 60 of State Water Resources Board Bulletin No. 1 by setting forth the average, maximum and minimum seasonal runoff passing these various gaging stations. Runoff quantities for the principal streams of the American River Basin are given in the following tabulation:

No.*	Stream and location of gaging station	Average, period of record, acre-feet	Maximum Season	Maximum Acre-feet	Minimum Season	Minimum Acre-feet
	North Fork American River					
5-264	near Colfax	468,000	1937-38	933,200	1923-24	110,000
5-284	at Rattlesnake Bridge	1,688,000	1941-42	2,572,000	1930-31	414,000
	Middle Fork American River					
5-282	near Auburn	987,000	1913-14	1,900,000	1923-24	229,000
	South Fork American River					
5-294	near Kyburz	269,000	1937-38	412,800	1930-31	33,400
5-303	near Camino	637,000	1937-38	1,089,000	1923-24	117,000
5-306	at Coloma	698,000	1937-38	1,330,000	1930-31	219,000
	Major Tributaries to South Fork American River					
5-292	Silver Fork near Kyburz	148,000	1937-38	284,000	1930-31	60,400
5-296	Alder Creek near Whitehall	24,300	1937-38	49,300	1923-24	2,900
5-300	Silver Creek near Placerville	279,000	1937-38	509,800	1923-24	82,800
	American River					
5-309	at Fair Oaks	2,677,000	1910-11	6,480,000	1923-24	530,000

*Table 60 State Water Resources Bulletin No. 1

Stream flow of the three forks of the American River passing the foregoing gaging stations is regulated or impaired by the following described upstream developments:

North Fork

The flow upstream from the gage "North Fork at Colfax" is impaired and regulated by diversions from Lake Valley Reservoir located on the headwater of the North Fork of North Fork of American River about two miles west of Cisco. The flow above this gage is also regulated and impaired by diversions from Big Reservoir located on the headwaters of Shirttail Canyon.

In the reach of the North Fork below the gaging station at Colfax and the high water line of Folsom Reservoir the flow is regulated in the North Fork Debris Reservoir and is released into the North Fork American River.

The former diverting facilities of the North Fork Ditch Company, now owned by the San Juan Suburban Water District, located on the North Fork have been inundated by Folsom Reservoir and the District is presently being served direct from Folsom Reservoir.

Middle Fork

The flow of the Middle Fork watershed is impaired by diversions made by the Georgetown Divide Public Utility District on Gerle Creek, South Fork Rubicon River and Pilot Creek through the Georgetown Ditch. The District also regulates the flow above its point of diversion on Gerle Creek in Loon Lake Reservoir. Minor impairments occur from small dams constructed in the interest of fish, wildlife, and recreation.

South Fork

Water for power, irrigation and other purposes is regulated in Silver Lake and Twin Lake Reservoirs within the Silver Fork watershed

and in Medley Lakes Reservoir on Avalanche Creek. The flow of the South Fork is impaired by diversion into the El Dorado Ditch at a point on the South Fork just below the mouth of the Silver Fork for power and irrigation purposes.

The flow of Weber Creek is regulated and impaired by diversion made at Weber Creek Reservoir for irrigation purposes.

A more detailed description of the aforementioned facilities is set forth in Chapter VI.

Imported and Exported Water

Waters originating in the Bear and Yuba Rivers are imported to the North Fork of the American River through the Drum System of Pacific Gas and Electric Company by means of the South Canal from the Wise Power Plant. On the average, about 200,000 acre-feet seasonally are presently released from the Wise Power Plant, of which about 70,000 acre-feet are diverted for irrigation and municipal use in the vicinity of Loomis, Rocklin and Roseville. The remaining 130,000 acre-feet are presently conveyed by the Company's South Canal and discharged into the North Fork of the American River.

About 2,000 acre-feet of water are imported each year from Echo Lake in the Truckee River drainage system by means of a short tunnel to the South Fork of the American River.

A minor quantity, about 1700 acre-feet diverted from the Cosumnes River Basin, through Diamond Ditch, reaches and is used in the drainage basin of South Fork American River west of Placerville. Additional supplies of Cosumnes River Basin water aggregating about 20,000 acre-feet seasonally have been developed at Sly Park Reservoir for use in

the vicinity of Placerville. Ultimately, it is anticipated that, because of changing operation of Sly Park Reservoir, only about 16,300 acre-feet of Cosumnes River Basin water will be imported to the American River Basin.

ESTIMATED ULTIMATE MEAN SEASONAL IMPAIRED FLOW OF THE AMERICAN RIVER AT FOLSOM DAM*

(In acre-feet)

Item		: Quantity
Natural runoff		2,774,000
Imports		
From Echo Lake	2,000	
From South Fork Yuba River	112,000	
From Wise Power Plant	84,000	
From Cosumnes River	16,300	214,300
Return flow		35,000
Increase in runoff due to change in land use		43,700
Subtotal		3,067,000
Exports		
From enlarged Lake Valley Reservoir	107,200	
From Auburn Reservoir	84,000	
Irrigation diversions from basin streams	216,500	
Irrigation diversions of Cosumnes River water	16,300	
Evaporation (except Folsom Reservoir)	46,000	470,000
Net inflow to Folsom Reservoir		2,597,000
Folsom Reservoir evaporation		27,000
ULTIMATE IMPAIRED FLOW		2,570,000

*Table 7 State Water Resources Board Bulletin No. 21

Ground Water

The mountainous areas of the American River Basin are composed chiefly of igneous and metamorphic rocks overlain by some volcanic rocks.

Locally, these rocks furnish limited quantities of water from joints and fractures, but generally they do not contain an important supply of usable ground water and do not afford a media for significant amounts of underground transfer of water.

An estimate of the deep percolation from the American River into the alluvium filled valley floor below Folsom is given in State Water Resources Board Bulletin 21, Vol. II, p. A-43. Under present conditions, about 25,000 acre-feet of water per season is seeping into the ground water basin. Under ultimate development it is estimated that about 64,000 acre-feet of water per season would percolate to the ground water from stream channel seepage.

Water Quality

Analyses of surface water samples, collected in May, 1952, by the Water Quality section of the former Division of Water Resources, from the American River and three of its branches, showed that at that time the waters of these streams were of excellent mineral quality and well suited for irrigation and other beneficial uses. The waters were characterized by a very low content of total mineral solubles and chloride, no boron, and very low sodium percentage. Complete mineral analyses of the four water samples collected in May, 1952, are presented in Table 7 of State Water Resources Board Bulletin 21.

CHAPTER VI. WATER UTILIZATION

Present Water Developments and Use

The present development of the water resources of the American River Basin is of relatively small magnitude as compared with the available runoff. With the completion of Folsom and Nimbus Dams, it has been estimated in State Water Resources Board Bulletin 21 that only 37 per cent of the conservation and 25 per cent of the power potential of the American River Basin has been realized.

North Fork

There are at present three major developments within the North Fork American River watershed, namely, (1) Lake Valley Reservoir (2) Morning Star Dam and (3) North Fork Debris Dam.

Lake Valley Reservoir, owned by the Pacific Gas and Electric Company and containing about 8,000 acre-feet of water at maximum storage, is created by an earthfill dam 940 feet in length and 74 feet in height. Regulated releases of water from this reservoir are diverted by natural water course and conduit into the Drum Canal, and thence through the Drum System of the Pacific Gas and Electric Company for hydroelectric power generation, and for irrigation, industrial, and domestic use in Placer County.

It may be noted that in connection with the above described development, winter releases of water from the Wise Power Plant, originating in the Bear, Yuba and North Fork of North Fork of American River, enter the North Fork American River through the South Canal.

The Morning Star Dam, located on the headwaters of Shirttail Canyon, owned by the McGeachin Placer Gold Mining Company, creates Big Reservoir of 2,200 acre-foot storage capacity. The dam is a hydraulic fill, 835 feet in length and 44 feet in height, and was originally used to store water for mining purposes, but presently serves only a limited domestic and agricultural use on nearby Iowa Hill.

The North Fork Debris Dam on the North Fork of the American River was constructed by the Corps of Engineers in 1939, and is operated by the California Debris Commission. It is a variable radius arch dam, 620 feet in length and 147 feet in height. The reservoir, 14,600 acre-feet in storage capacity, is intended mainly for the storage of hydraulic mining debris. However, the top 45 feet of storage depth is operated for water conservation until needed for debris storage.

With the completion of Folsom Dam, the former diverting facility of the San Juan Suburban Water District, commonly known as the North Fork Ditch was inundated by Folsom Reservoir. Diversions are now being made direct from Folsom Reservoir and thence, through existing and improved conduits for use in eastern Sacramento County north of the American River and south of Roseville.

Middle Fork

Lands located within the area bounded by the Middle and South Forks of the American River, known as the Georgetown divide, are presently served by the Georgetown ditch and its laterals. This ditch, originally constructed for mining purposes but now owned and operated by the Georgetown Divide Public Utility District, diverts from Gerle Creek. Gerle Creek heads in Loon Lake where a low dam affords about 10,000

acre-feet of storage capacity. The upper reach of the Georgetown Ditch is about 12 miles in length, and is also known as the Upper Georgetown or Gerle Creek ditch. It is mostly unlined canal and wooden flume, with a discharge capacity varying from 35 second-feet at its headworks to 26 second-feet where it spills into Pilot Creek. Enroute to Pilot Creek the ditch intercepts the flow of the South Fork Rubicon River. Downstream on Pilot Creek the flows of Pilot Creek, the South Fork Rubicon River, Gerle Creek, and the releases from Loon Lake are rediverted by a small masonry structure into the lower section of the Georgetown ditch. This section has a maximum capacity of 30 second-feet, and is about 14 miles in length from the intake on Pilot Creek to Georgetown. From Georgetown the Kelsey lateral runs south to Kelsey, while the main canal continues on to the vicinity of Cool and Pilot Hill. Scattered parcels of lands totaling 1,579 acres were irrigated from this ditch in 1950.

South Fork

The principal water developments on the South Fork consist of the El Dorado and American River hydroelectric power facilities of the Pacific Gas and Electric Company, the irrigation facilities of the El Dorado Irrigation District, and the Natomas Company ditch.

Water for power, irrigation, and other purposes is stored and regulated in Silver Lake Reservoir and on the Silver Fork, Twin Lakes Reservoir on Cables Creek, in Medley Lakes Reservoir on Avalanche Creek, and in Echo Lake, which is in the Truckee River watershed. Releases from these reservoirs together with the natural flow of the South Fork are diverted at a point on the South Fork just below the mouth of the Silver Fork into the El Dorado ditch. This ditch, with a discharge

capacity of 165 second-feet, extends along the rugged south canyon wall of the South Fork for a distance of 25 miles to the El Dorado Forebay, a 400 acre-foot regulating basin. Portions of the conduit are in flume, siphon, and tunnel. From the El Dorado Forebay, diversions are made to the El Dorado Irrigation District but the bulk of the water flows through a long penstock to the El Dorado Power Plant, located on the south bank of the South Fork. This plant has a static head of 1,910 feet, and an installed power capacity of 21,000 kilowatts. About five miles below the El Dorado Power Plant the flow is again diverted from the South Fork, by a rock-filled timber crib dam, into the American River Flume on the right bank. This flume has a discharge capacity of 165 second-feet, and extends westwardly for a distance of 7.3 miles to serve the American River Power Plant on the South Fork. This plant operates under a static head of approximately 572 feet, and has an installed power capacity of 5,600 kilowatts. All of the above described facilities are owned or controlled by the Pacific Gas and Electric Company.

The El Dorado Irrigation District encompasses the area on the divide between the South Fork of the American River and Weber Creek. Its limits extend approximately 12 miles and 6 miles, respectively, east and west of Placerville. It has a gross area of 32,582 acres, of which about 20,000 acres are irrigable, and of which some 5,600 acres were irrigated in 1955. It presently receives its water supply by diversions from El Dorado Forebay, from Weber Reservoir on Weber Creek, from the North Fork Cosumnes River and from Sly Park Creek.

According to the "Annual Report for the Calendar Year ending December 31, 1955, submitted to the California District Securities Commission by the El Dorado Irrigation District, a total of 20,628

acre-feet of water was diverted or purchased by the District of which 6,800 acre-feet were diverted through facilities owned by the District, 11,858 acre-feet were purchased from the Pacific Gas and Electric Company and 1,970 acre-feet were purchased from the Bureau of Reclamation. The report indicated that the segregation of acreage within the District as to crops is as follows:

Deciduous fruits	5,300 acres
Miscellaneous	300 acres
Dry farmed	1,500 acres
Total cultivated	7,100 acres

A supplemental water supply of about 20,000 acre-feet seasonally is now provided by Sly Park Reservoir, recently completed by the Federal Bureau of Reclamation. This 40,000 acre-foot reservoir, located on Sly Park Creek in the Cosumnes River Basin, receives part of its inflow by tunnel diversion from Camp Creek in the same basin. Water released from Sly Park Reservoir is conveyed to the district, in the vicinity of Camino, by 9.3 miles of 100 second-foot capacity conduit.

The Natomas ditch, owned by the Natomas Company, formerly diverted from the South Fork about two miles upstream from Salmon Falls. The ditch followed the left bank of the South Fork into Sacramento County with a discharge capacity of about 60 second-feet before branching to the several areas of use. Since the filling of Folsom Reservoir, diversion into the Natomas Ditch or its branches has been made direct from the reservoir.

Main Stem between the Forks and Fair Oaks

Water resource developments on the main stem of the American River include Folsom Reservoir, the Nimbus Afterbay, and the Folsom and

Nimbus Power Plants. These facilities are all federally owned and operated. Downstream from Nimbus Dam several diversions for irrigation and municipal use are made by pumping direct from the American River. In addition, a salmon and steelhead fish hatchery has been constructed downstream from Nimbus Dam, to replace natural spawning areas inundated by Folsom Reservoir and Lake Natoma.

A brief summary of the principal characteristics of these developments is as follows:

Folsom Reservoir, gross storage capacity	1,000,000 acre-feet
Lake Natoma, gross storage capacity	8,900 acre-feet
Folsom Power Plant, installed power capacity	162,000 kilowatts
Nimbus Power Plant, installed power capacity	13,500 kilowatts
Nimbus Fish Hatchery, incubation capacity	50,000,000 eggs per year

Main Stem Below Fair Oaks

In the reach of the River between Fair Oaks and the mouth there are approximately twenty pumps which divert water from the river for irrigation and industrial purposes. These pumps range in size from 1½ inches to 12 inches. The Carmichael Irrigation District is the principal diverter.

Sacramento-San Joaquin Water Supervision, a function of the Department of Water Resources, has records of these diversions from the American River below Fair Oaks for the period 1924 to date. Summaries of these diversions accompanied by available water rights information for each diverter are tabulated for the period 1924 to 1950 in "Reports on Sacramento Valley Water Utilization, Report U, Lands Served by Diversion on American River Below Fair Oaks", published by the former Division of Water Resources dated May, 1954.

The 1953 Sacramento-San Joaquin Water Supervision Report lists sixteen diverters. The total diversions March to October aggregated 4862 acre-feet or an average of 10 second-feet during the irrigation season. The reported irrigated acreage was 4,572 acres. It was noted, however, that on some acreages additional water was received from other sources.

Summary of Present Development

The total storage capacity of existing water developments in the American River Basin consists of about 67,000 acre-feet in natural lakes and reservoirs used for irrigation and power operation, about 15,000 acre-feet in debris control reservoirs, and about 1,000,000 acre-feet in multipurpose reservoirs. In addition, there are 14 smaller dams and reservoirs having an aggregate storage capacity of about 3,000 acre-feet. These are used principally for stream flow maintenance in the interests of fish, wildlife, and recreation. The present installed hydroelectric power capacity in the American River Basin is 202,000 kilowatts.

CHAPTER VII. MISCELLANEOUS CONSIDERATIONS

Other Plans for Water Development

Other than the plans outlined in applications which are the subject of this report, the only known major plans for water development are elements of The California Water Plan. It is anticipated that the applicants involved and the Department of Water Resources will supply adequate information, exhibits and testimony relative to their various plans.

Legislative Resolutions Citing Necessity for Special Terms and Conditions in Permits and Licenses for Federal Reclamation Projects

On August 7, 1951, the State Legislative Joint Committee on Water Problems adopted a resolution which requested the State Engineer to defer issuance of permits to the Bureau of Reclamation until such time as the Committee could study and make recommendations with respect to appropriate terms and conditions for insertion in such permits.

On March 13, 1952, the Joint Committee made a report to the Legislature in which it was stated in substance that the public interest requires that the State Engineer incorporate in all permits and licenses granted to the United States to appropriate water for irrigation purposes through Federal reclamation projects specific conditions to the effect that the agencies and landowners receiving water are the beneficiaries of each permit and each license; and that the right to receive water appropriated under the permits and licenses is permanent and appurtenant to the lands upon which the water is used.

Pursuant to the report of the Joint Committee, the Legislature in Assembly Concurrent Resolution No. 2 of the 1952 first extraordinary

session and Senate Concurrent Resolution No. 8 of the 1952 regular session, identical in language, recited that the recommendations of the Joint Committee were found by the Legislature to be necessary in the public interest and memorialized the Director of Public Works and the State Engineer specifically as follows:

> "1. That, in issuing permits and licenses to appropriate water for federal reclamation projects, due consideration be given to the possibility and desirability of issuing such permits and licenses to appropriate water for irrigation purposes to the contracting public agencies of the State rather than the United States.
>
> "2. That licenses issued to the United States for irrigation purposes in connection with federal reclamation projects be limited to water subject to contracts between public agencies of the State and the United States which the State Engineer finds to be in the public interest and to conform to state law and that any permits and licenses issued for such purposes contain, in the public interest, the following conditions among, but not to the exclusion of, other conditions:
>
> > "(a) That the beneficiaries of each permit and each license are and shall be the public agency or agencies of the State together with the owners of land within such agency or agencies to be served with the water appropriated under the permit and license.
> >
> > "(b) That the rights of the agencies and owners of land within the agencies to be served with the water appropriated under the permits and licenses are, subject to continued beneficial uses, permanent and appurtenant to the lands upon which the water is used.
> >
> > "(c) That the uses of water appropriated under the permits and licenses are subject to the reasonable requirements of the watershed or area wherein the water originates or area immediately adjacent thereto and that no transfer of water of one watershed or area of origin to another watershed or area shall be consummated unless and until provision is made to meet such reasonable water requirements of the former . . .".

Permits have been issued on two federal reclamation projects, the Vaquero Project on the Cuyama River, which is a tributary of the Santa Maria River, and the Sly Park Project on Sly Park Creek, a tributary of the Cosumnes River. The special terms and conditions inserted in the permits in response to the legislative memorialization are listed below.

Vaquero Project

4. Subject to the prior right of the United States to utilize the project works for flood control purposes, the satisfaction of existing water rights, and compliance by the public agencies concerned with any and all present and future contract obligations with the United States regarding the Santa Maria project, the Santa Barbara County Water Agency, on behalf of the Santa Maria Valley Water Conservation District and its landowners, shall, consistent with other terms of this permit, have the perpetual right to use all water that becomes available through the construction and operation of Vaquero Dam and Reservoir, which right shall be appurtenant to land upon which the water is applied to beneficial use.

Sly Park Project

2. The right to divert and store water, and apply said water to beneficial use as provided in this permit is granted to the United States as trustee for the benefit of the public agencies of the State, together with the owners of land and water users within such agencies, to be supplied with the water which is the subject of this permit.

3. Any and all rights acquired or to be acquired pursuant to this permit are and shall be permanent and, except where water is

distributed to the general public by an agency in charge of a public use, shall be appurtenant to the land to which said water shall be applied, subject to continued beneficial use and the right to change the point of diversion, place of use and purpose of use as provided in Chapter 10 of Part 2 of Division 2 of the Water Code of the State of California, and further subject to the right to dispose of a temporary surplus.

4. Upon completion of the project contemplated under this permit and the application of the water to beneficial use, any license or licenses which may be issued pursuant to Chapter 9 of Part 2 of Division 2 of the California Water Code shall be issued to the public agencies of the State within which the water has been found by inspection by the State Engineer to have been applied to beneficial use.

5. Permittee shall at all times bypass at Sly Park Dam a minimum of one cubic foot per second or the natural flow of Sly Park Creek, whichever is less, and shall at all times bypass at Camp Creek Diversion Dam a minimum of two cubic feet per second or the natural flow of Camp Creek, whichever is less, to maintain fish life.

Area of Origin Considerations

In view of the nine State Filings proposing appropriation at various points within the American River Basin any permits that will be issued pursuant to the applications being heard will be subject to these State Filings. The counties of origin would receive protection through appropriate reservations at the time assignments or releases of the State Filings are executed by the Department of Water Resources. Due to the fact that the Folsom Project has not been included as a unit of the Central Valley Project under State Law, Section 11460 of the Water Code is believed not to be applicable.

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SACRAMENTO

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STATE OF CALIFORNIA - DEPARTMENT OF PUBLIC WORKS

DIVISION OF WATER RESOURCES

In the Matter of Applications
Nos. 12140 and 16060

CITY OF SACRAMENTO
c/o Martin McDonough, Esq.
926 J Street Building,
SACRAMENTO 14, CALIFORNIA

ORIGINAL

PROTEST OF UNION PROPERTIES, INC.

The undersigned, UNION PROPERTIES, INC., a corporation, (hereinafter referred to as "Protestant"), hereby protests the aforementioned applications to appropriate water and, in support of this protest, respectfully alleges and shows as follows:

I

That protestant owns a large tract of agricultural land situated on Union Island, San Joaquin County, California. Said tract is commonly known as, and will, for sake of brevity, be sometimes hereinafter referred to as "The Burns Tract". Said tract comprises approximately four thousand acres of good farm land, and is now, and for over twenty years last past, had been used to grow various agricultural crops, including alfalfa and asparagus. Said tract, and the crops thereon, are now, and for over twenty years, have been irrigated with surface water from the Middle River branch of the San Joaquin River system (and from

other natural sloughs and water courses) and, in addition to said surface water supplies, said lands and crops have derived (and now derive) a large amount of their necessary water supply by means of subirrigation. Said tract is riparian to said rivers, and river channels, and it also overlies a vast body of underground percolating water fed and maintained by the flow of the Sacramento and San Joaquin River systems. Said tract is situated in Township One (1) South, Range Five (5) East, MDM and it has several diversion structures and conduits taking out of the Middle River Channel (of the San Joaquin River System) in that section of said Middle River channel which forms the north boundary of The Burns Tract on Union Island. That the aforementioned water supplies which are needed and used for the surface irrigation and subirrigation of said property of protestant are derived from the surface and subsurface flows of both the Sacramento and San Joaquin River systems.

II

That The Burns Tract is located in what is commonly known as, and referred to as, "The Delta Area"; that in said Delta Area the Sacramento River and the San Joaquin River have their confluence and thereafter flow in a general westerly and southwesterly direction and as a common body of water, to the San Francisco Bay Area. That in said Delta Area a myriad of, and a highly complicated and complex pattern of, natural channels and sloughs, including the aforementioned Middle River Channel, comprise the lower San Joaquin and the lower Sacramento River systems and their aforementioned confluence.

That the proposed diversion covered by the above numbered applications is from the American River or one of its tributary streams. That said river is an important tributary of the Sacramento River and all of the unused waters of the American River flow into the Sacramento River and a large portion thereof flow

into and become a part of the water resources of said Delta Area.

III

That the proposed diversions of water which the above named applicant seeks to make and perfect are and will be a direct and serious infringement upon the water and property rights of protestant (as well as all other water right owners in said Delta Area) for the following reasons, among others, to wit:

(1) All of the natural flows of said rivers are now needed to supply vested water rights, including riparian water rights, both now being exercised, and those which will in the future be exercised, by owners of land riparian to said rivers. No surplus water exists which can be legally and rightfully appropriated. This phase is more fully covered in Paragraph IV hereinbelow.

(2) A serious salt water incursion or intrusion problem exists in said Delta Area, and said unfavorable condition will be materially aggravated by the proposed diversions under said applications. This phase is more fully covered hereinafter in Paragraph V.

(3) That the diversion plans of the applicant under these filings will seriously and wrongfully and unlawfully interfere with, and impede, the drainage of said land of protestant. This phase is more fully covered hereinafter in Paragraph VI.

IV - NO SURPLUS WATER EXISTS

That situated along the Sacramento and San Joaquin River systems are vast areas of riparian lands which now require substantial portions of the flow of said rivers for their irrigation. That large portions of said lands are not now fully developed for agricultural uses but, in the normal course of events, will be

thus developed. That this further development will entail and require the use of large additional amounts of water from said rivers. That the present water right owners along said rivers, including protestant, own and require, and will require, for the proper irrigation and development of their lands, all the water naturally flowing in said river systems.

That the aforementioned Delta Area is underlaid by a vast body of percolating ground water which is fed and maintained by the natural flows of said rivers and their various branches. That said vast body of underground percolating water is of vital importance to said lands, both as a source of substantial irrigation or subirrigation, and also as a source of pump water.

V - SALT WATER PROBLEM

That there is now, and has been for many years, a serious problem caused by the intrusion into the aforementioned Delta Area of salt water from the San Francisco Bay, and its upper Bay connection (San Pablo Bay and Suisun Bay). That the entire natural flow of the lower San Joaquin River and the lower Sacramento River, except that portion which is now lawfully diverted by present water right owners, is necessary to act as a barrier of fresh water against said salt water incursion and to prevent it from becoming more serious and aggravated. Said intrusion of salt water into the Delta Area has had the direct effect of rendering large acreages of rich agricultural land unfit for such use, and of polluting, and rendering unfit for use, the groundwater in said areas of intrusion.

VI - DRAINAGE INTERFERENCE

That in the normal course of the agricultural activities which have for many years past been carried on on said lands of this protestant, it has become necessary, from time to time during each year, to drain said lands by means of drainage channels which empty into Middle River, a branch of the lower San Joaquin River.

That the proposed plans of applicant, if carried into execution, will materially interfere with the proper and necessary drainage of said lands of protestant.

VII

That for all of the reasons hereinabove briefly summarized, and for other reasons which will be duly established by proper proof at the hearing or hearings in connection with these applications, said plans and water project of applicant are illegal, improper and unjustifiable.

WHEREFORE, protestant respectfully prays that said applications above numbered be denied.

DATED: JUNE 4, 1956.

Respectfully submitted,

(SEAL)

UNION PROPERTIES, INC.,
a corporation

By Norman J. Ronald
Secretary

Walter M. Gleason

WALTER M. GLEASON
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333 Montgomery Street
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Attorneys for Reclamation District 756 Situated in San Joaquin County, California.

STATE OF CALIFORNIA - DEPARTMENT OF PUBLIC WORKS

DIVISION OF WATER RESOURCES

In the Matter of Applications Nos. 13370, 13371, 13372 and 14662 By the United States of America, Department of the Interior, Bureau of Reclamation, Region II, to appropriate unappropriated water.

PROTEST OF RECLAMATION DISTRICT 756 SITUATED IN SAN JOAQUIN COUNTY, CALIFORNIA

RECLAMATION DISTRICT 756 SITUATED IN SAN JOAQUIN COUNTY, CALIFORNIA, does hereby protest the above mentioned applications to appropriate water and in support of this protest respectfully alleges and shows as follows:

INTRODUCTION

Reclamation District 756 Situated in San Joaquin County, California, is a Reclamation District duly organized and existing under and by virtue of the laws of the State of California.

Said Reclamation District 756 Situated in San Joaquin County, California, is located in the County of San Joaquin, State of California, and on Bouldin Island in said County. The said Reclamation District 756 Situated in San Joaquin County, California, is located in the San Joaquin River Delta and is bounded on the North by the South Fork of the Mokelumne River, on the West by the North Fork of

the Mokelumne River and the Mokelumne River and San Joaquin River, on the South by Potato Slough, and on the East by Little Potato Slough.

The lands within said Reclamation District are devoted almost entirely to agriculture and particularly to the intensive production of irrigated crops. The agricultural activities within the Reclamation District are made possible primarily by virtue of the irrigation from the rivers and channels bounding the District. Likewise drainage from The District is pumped into these channels.

The said Reclamation District is surrounded by levees constructed and maintained at the cost of the owners of land lying within the District.

The proposed diversions for which the above mentioned applications are made are an integral part of the Central Valley Project and should be considered in connection with the entire Central Valley Project. This protestant is informed and believes that the operation of the Central Valley Project will interfere with and change the water supply in the San Joaquin River Delta in regard to the amount of such supply, the quality of the water supply and the nature of the water. Foreign and stored waters will be brought into and comingled with the natural flow of the San Joaquin River system. The operation of the Central Valley Project will, if permitted, result in the removing and diverting from the San Joaquin River system of a portion of the natural flow thereof.

Representatives of the United States Bureau of Reclamation have made statements from time to time to the effect that the Bureau in its program in connection with the Central Valley Project would not act adversely or in hostility to valid and subsisting water rights.

HISTORY OF OPERATIONS IN RECLAMATION DISTRICT 756 SITUATED IN SAN JOAQUIN COUNTY, CALIFORNIA

From time immemorial the flow in the San Joaquin River system has varied greatly from year to year and from season to season within each year. In the late summer and fall the flow is low, and it rises in the winter, spring and early summer as a result of the rains and the run off from the melting snow. Changes in and interference with the flow of water may have an adverse effect on these levees by virtue of the cutting and washing of the levees by the currents. Any increase in the flow in times of high water may increase the flood hazard and increase the cost of reclamation work.

The individual owners of land in said District claim the right to the water flowing in the channels by virtue of riparian rights, prescriptive rights and appropriators' rights based on applications made and permits granted. The owners of land also claim vested rights in the underground water supply which is fed by the rivers and channels in the Delta area.

Any change in the level of the flow of the channels bounding the District has of course a material effect upon these farming operations. If the flow is low the owners of land may be without adequate quantity of water for irrigation, and at times the water becomes unfit because of the incursion of salt water from San Francisco Bay. Likewise if the flow is low the cost of operating the irrigation pumps is increased. If the flow is high a flood hazard arises.

With regard to drainage, a change in the flow in the rivers and channels surrounding the Reclamation District has a material effect. It may increase the amount of drainage necessary and thereby increase the cost of operation to the owners of land.

This Reclamation District holds License No. 1405 issued by the Division of Water Resources of California for

the appropriation of water out of San Joaquin and Mokelumne Rivers, the South Fork of the Mokelumne River and Potato Slough.

BASIS OF PROTEST

The Sacramento River and the San Joaquin River Delta are connected by a myriad of channels, canals and sloughs. By means of these interconnecting channels, canals and sloughs the waters of the San Joaquin and Sacramento Rivers flowing into the two Delta areas are comingled, and the combined flow of the two river systems, the Sacramento River and the San Joaquin River, furnishes the water supply in these Delta areas including the underground water supply. The American River is a tributary to the Sacramento River.

This protestant does allege that to the extent that water is diverted and taken from the Sacramento River or any of its tributaries, including the American River, the water supply flowing in the channels bounding the Reclamation District and the underground water supply in the Delta area will be adversely affected both as to quantity and as to quality thereby depriving protestant and the owners of land lying within the boundaries of this Reclamation District of valuable property and water rights.

The applications relate to an integral part of the Central Valley Project. The Central Valley Project when in operation will have a material effect on the flow of water and the quality of water and the nature of the water in the Sacramento and San Joaquin River Deltas and the underground water supply in the Delta area. The applications should not be considered alone but rather in the light of the entire Central Valley Project and its operations. This Reclamation District claims water and property rights in and to the natural flow in the channels surrounding this Reclamation District by virtue of its said License No. 1405 issued by the Division of Water Resources of California and by virtue of riparian rights held and owned by this Reclamation

District.

PROTEST AGAINST GRANTING OF PERMITS

The Board of Trustees of Reclamation District 756 Situated in San Joaquin County, California, being convinced that injury to said Reclamation District and the owners of land lying therein if Applications Nos. 13370, 13371, 13372 and 14662 are granted, does protest the granting of the same upon the following grounds, to-wit:

1. That the proposed diversions, if permitted, will reduce and change the natural flow in the rivers and channels in the San Joaquin Delta.

2. That the proposed diversions, if permitted, may change the quality of the water in the rivers and channels bounding said Reclamation District by permitting the incursion of salt water from San Francisco Bay.

3. That the character of the water supply in the channels and rivers bounding said Reclamation District may be changed by reason of the proposed diversions and storage of the water of the American River in that foreign or stored waters may be comingled with the natural flow.

4. That as a result of the operations of the Central Valley Project this Reclamation District and the owners of land lying within it may become dependent for late summer and fall water supply upon the flows of the Sacramento River and its tributaries including the American River.

5. That the proposed diversions and the related program of the Central Valley Project may cause material damage and injury to the levees and other reclamation works of this Reclamation District thereby increasing the cost of maintenance of the same.

6. That the proposed diversions if permitted and the operation of the Central Valley Project will constitute an infringe-

ment upon the water and property rights of protestant and owners of land lying within the boundaries of this protestant.

7. That this protestant is advised of no program or plans by the United States or the Bureau of Reclamation for the protection or recognition by the United States or the Bureau of Reclamation of the property and water rights of this Reclamation District and the owners of land lying therein or of a means for ascertaining whether or not such rights are or will be impaired or jeopardized by the proposed diversions or the operation of the Central Valley Project.

Dated: June 13th, 1952.

Respectfully Submitted,

RECLAMATION DISTRICT 756 SITUATED IN SAN JOAQUIN COUNTY, CALIFORNIA

By _____

ATTEST:

_____
Secretary of Reclamation District 756 Situated in San Joaquin County, California

LOUTTIT, LOUTTIT & WILSON

By _____
Attorneys for Reclamation District 756 Situated in San Joaquin County, California.

Campbell Water Co.

Exhibit 8. Water Requirement Summary, Campbell Water Company

9. Graph, Services by Years, Campbell Water Company.

10. Graph, Annual Water Production Campbell Water Company.

11. Graph. Rainfall and Ground Water Levels, Campbell Water Co. February 1957.

Hollister Irrigation District.

Exhibit 1. Qualifications of Harlan H. Heath

2. Map Showing Location and Boundaries of Hollister Irrigation District.

3. Present and Estimated Future Land Use.

4. Estimated Present and Future Water Requirements.

5. Present Ground Water Pumpage, Net Recharge, and Overdraft.

6. Summary of Present Supply, Total Water Requirements, and Supplemental Water Requirements.

Item 48 (Folder SM) SIERRA CLUB

Exhibit 1. Statement of Harold C. Bradley.

Item 49 STATE WATER RIGHTS BOARD (by ALL reference)

Exhibit 1. Report on Major Pending Applications to Appropriate Water from the American River Stream System, November, 1956. (Folder SM)

2. Records of Water right application proposing major appropriations from the American River Stream System.

3. California State Water Resources Board, "Water Resources in California", Bulletin No. 1, 1951.

4. California State Water Resources Board "Water Utilization and Requirements of California", Bulletin No. 2, Volume I (Text) and Volume II (Plates), June, 1955.

5. California State Water Resources Board, "The California Water Plan", Bulletin No. 3, Volumes I, II and III, Map, 1956.

6. California State Water Resources Board, "Placer County Investigation", Bulletin No. 10, June, 1955.

7. California State Water Resources Board, "San Joaquin County Investigation", Bulletin No. 11, June 22 1955.

8. California State Water Resources Board, "American River Basin Investigation", Bulletin No. 21, Volume I (Text and Related Plates) and Volume II (Appendixes and Related Plates, June, 1955.

9. California State Department of Public Works, Division of Engineering and Irrigation, "Flow in California Streams", Bulletin No. 5, 1923.

10. California State Department of Public Works, Division of Water Resources, "Report of Sacrament-San Joaquin Water Supervision for the Period 1924-1928", Bulletin No. 23, 1930.

11. California State Department of Public Works, Division of Water Resources "Report to Legislature on State Water Plan", Bulletin No. 29, 1930.

12. California State Department of Public Works, Division of Water Resources, "Irrigation Requirements of California Crops", Bulletin No, 51, 1945.

13. United States Department of the Interior, Geological Water Supply Papers, Park 11. Pacific Slope Basins in California.

14. California State Department of Public Works, Division of Water Resources, "Report of Sacramento-San Joaquin Water Supervision", Annual Reports for the Years 1929 to Date.

15. California State Department of Public Works, Division of Water Resources, "Report on Applications Made and Filed by the State Department of Finance to Appropriate Water of the State as Authorized by Chapter 286, Statutes of 1927, as Amended with Particular Reference to Application 5637, 5638 and 9369 Which the U. S. Bureau of Reclamation Has Requested as Assignment Thereof", August, 1939.

16. California State Department of Public Works, Division of Water Resources, "Supplemental Report on Applications Made and Filed by the Department of Finance to Appropriate Waters of the State as Authorized by Chapter 286, Statutes of 1927, as Amended, with Particular Reference to Request by U. S. Bureau of Reclamation for Assignment of Applications Nos. 9363, 9366, 9367 and 9368", August, 1941.

17. California State Department of Public Works, Division of Water Resources, "Review of Proposed Report of Regional Director Region 2, U. S. Bureau of Reclamation on Union Valley Unit, American River Division, Central Valley Project (Ultimate Plan)", August 11, 1953.

18. California State Department of Public Works, Division of Water Resources, "Water Right Applications by State Department of Finance, Assignments Thereof, Reservations for Counties of Origin, and Other Related Matters", February, 1955.

19. United States Geological Water Supply Paper 493, "Hydro-Electrical Power Systems of California and Their Extensions into Oregon and Nevada", 1923.

20. United States Geological Survey topographic maps covering any or all areas under consideration.

21 United States Department of Commerce, Bureau of the Census, "1950 United States Census of Agriculture", Volume III, Part 3, 1952.

22. United States Department of the Interior, Bureau of Reclamation, Region 2, "Factual Report El Dorado Irrigation District Central Valley Project", September, 1952.

23. United States Department of the Interior, Bureau of Reclamation, Region 2, "Folsom North Unit Central Valley Project, California", April, 1956.

24. United States Department of the Interior, Bureau of Reclamation, "Folsom South Unit Central Valley Project, California", April, 1956.

25. Edson, Mark S., "Ultimate Requirements of American and Cosumnes Basins and Lake Tahoe Region, El Dorado County, California", Sept. 1955.

26. Bonner, Frank E., "Report to the Federal Power Commission on the Water Powers of California", 1928.

27. United States War Department, Corps of Engineers, "Preliminary Definite Project Report Folsom Dam, Reservoir and Power Plant American River, California", March 28, 1947.

28. California State Department of Public Works, "Supplemental Report with Reference to Size of Folsom Reservoir of American River Development", August 8, 1947.

29. Deleted at request of U. S. Bureau of Reclamation.

30. California State Department of Public Works, "Views and Recommendations of State of California on Substitute Report of Secretary of the Interior Entitled Comprehensive Plan for Water Resources Development Central Valley Basin, California", April 28, 1948.

31. State Water Resources Board, Bulletin No. 7, Santa Clara County Investigation, June, 1955.

32. Division of Water Resources, Bulletin No. 56, Survey of Mountainous Areas, December, 1955.

33. State Water Resources Board, Preliminary Report No. 7, "Quality of Ground Water in the Stockton Area", November, 1954.

34. California State Department of Public Works, Division of Water Resources, "Sacramento River and Sacramento-San Joaquin Delta Trial Water Distribution 1955", January, 1956.

~~35. California State Department of Public Works, Division of Water~~

35. California State Department of Public Works, Division of Water Resources, "A Proposed Major Development on American River ", Bulletin No. 24, 1929.

36. California State Department of Public Works, Division of Water Resources, "Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay", Bulletin No. 27, 1931.

37. California State Department of Public Works, Division of Engineering and Irrigation, "Water Resources of California", Bulletin No. 4, 1923.

38. California Department of Public Works, Division of Engineering and Irrigation, "Summary Report on the Water Resources of California and a Coordinated Plan for their Development", Bulletin No. 12, 1927.

Sacramento River and Delta Water Association

39. Hearings at Sacramento, California., before a special sub-committee on irrigation and reclamation of the Committee on Interior and Insular Affairs, House of Representatives, 82d Congress, 1st session, and a joint interim committee on water problems of the California State Legislature on "Central Valley Project, California, Water Rights, Supplies, and Uses" October 29, 30, and 31, 1951, Serial no. 13.

40. Report of a Special Subcommittee on Irrigation and Reclamation (Committee of Interior and Insular Affairs, House of Representatives) ...on Central Valley Project, California as a result of Hearings Held October 29, 30, and 31, Sacramento, Calif. 1952.

41. State of California, Department of Public Works, Division of Water Resources, Sacramento River, Trial Water Distribution 1954, summary report of data, December 1954.

42. Water Project Authority of the State of California, "Sacramento River and Sacramento-San Joaquin Delta, Trial Water Distribution 1954, Report of Analyses", April, 1955.

43. State of California, Department of Public Works, Division of Water Resources, "Water Resources and Water Conservation Appendix E of Report to the Water Project Authority of the State of California on Feasibility of Construction by the State of Barriers in the San Francisco Bay System", September 1955.

44. Water Project Authority of the State of California "Investigation of the Sacramento-San Joaquin Delta, Report No. 2, Water Supply and Water Utilization on Medford Island", May 1956.

45. Department of Water Resources, "Investigation of the Sacramento-San Joaquin Delta, Report No. 4, Quantity and Quality of Waters Applied to and Drained from the Delta Lowlands".

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STATE OF CALIFORNIA

GOODWIN J. KNIGHT
GOVERNOR

PUBLICATION OF
California STATE WATER RESOURCES BOARD

BULLETIN NO. 21

AMERICAN RIVER BASIN INVESTIGATION

REPORT ON DEVELOPMENT PROPOSED FOR THE CALIFORNIA WATER PLAN

PRELIMINARY DATA
SUBJECT TO REVISION

VOLUME I (Text and Related Plates)

(Seal of State of California)

LEGISLATIVE COUNSEL

JUNE, 1955

and by photogrammetry. A total of 68 reservoir possibilities was examined during the course of the investigation.

Valley Floor Investigations

These investigations centered principally on the downstream areas appropriate for American River water use, and particularly on the planned operation of ground water storage underlying these areas. The investigations dealt essentially with the present and ultimate patterns of land use of the areas, and their water supplies and water requirements, as developed in State Water Resources Board Bulletin No. 2.

The planned operation of ground water storage capacity in conjunction with surface storage capacity in the American River Basin required determination of the location, magnitude, and usability of the ground water storage underlying the areas of use. These factors were estimated for ground water storage units that were defined by natural land divisions and by consideration of subsurface geology. The magnitude of the ground water storage capacity was determined for the 20- to 200-foot depth range, where possible. The capacity was found by correlating rock samples of known specific yield with material indicated by well drillers' logs. The usability of this ground water storage was ascertained by considering the present and future quality of water within the basin, ground water withdrawal potentialities, and ground water recharge possibilities. Future possible degradation in quality of the water due to greater consumptive use and to connate water intrusion was considered. Potential ground water withdrawal rates were estimated from studies of existing well development and of the geology

involved. Recharge possibilities, natural and artificial, were developed from a study of soil samples, geology, ground water level fluctuations, and data obtained from field investigations.

Results of the investigation of the American River Basin are presented in the four ensuing chapters of this bulletin. Chapter II deals with the water supply of the basin. Many of the data presented therein are derived by rearrangement of pertinent information from State Water Resources Board Bulletin No. 1. Supplemental data on floods and flood flows were obtained from the records of the United States Geological Survey. Sources of other hydrologic data are acknowledged in appropriate sections of Chapter II. The subject of underground hydrology, including ground water storage possibilities and methods, efficiencies and costs of recharge and extraction, is treated in Appendix A, "Ground Water Studies".

Chapter III describes existing water developments, establishes the ultimate water requirements of the upstream areas, and evaluates factors of water demand pertinent to planning. The upstream water requirements are predicated essentially on estimates developed for State Water Resources Board Bulletin No. 2.

Chapter IV contains descriptions of the project works, both existing and proposed, and their operation, costs, and accomplishments. More detailed estimates of cost are given in Appendix B, and the subject of recreation, including fish and wildlife, is treated in Appendix C. Appendix D contains a comparison of Salmon Falls Reservoir with possible alternatives.

Chapter V presents a summary of the results of the investigation and the conclusions to be drawn therefrom.

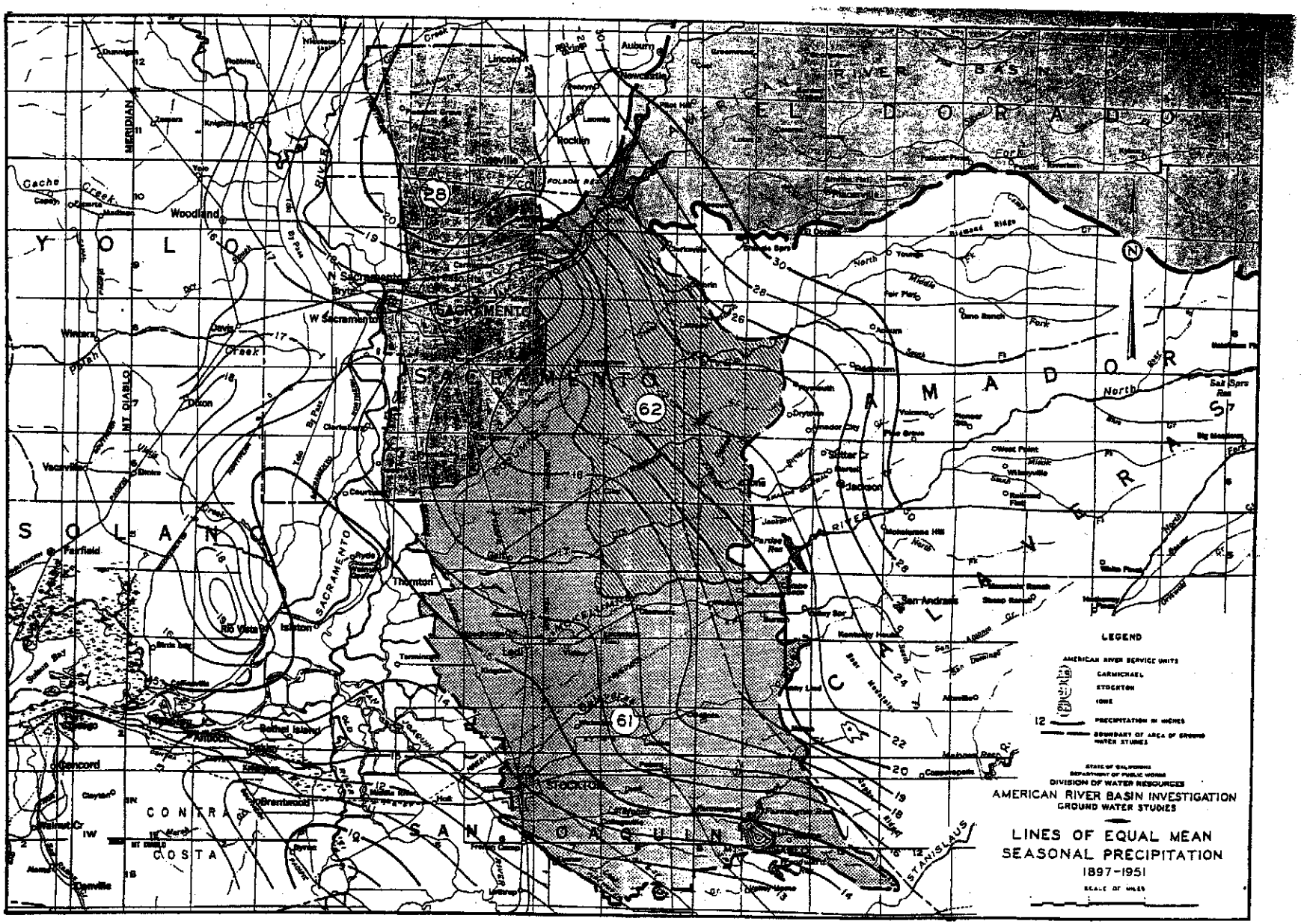
were estimated to be about 168,000 acre-feet per season, and the maintenance of a desirable salt balance in the ground water basin would require the pumping and disposal of about 96,000 acre-feet of water per season. Thus, the ultimate seasonal requirements for consumptive use of water and losses to the service area would aggregate about 1,887,000 acre-feet per season. It is notable that the water lost to the service area would not necessarily be lost to beneficial use elsewhere.

In addition to the foregoing requirements, Folsom Reservoir would have the duty of maintaining a substantial flow in the American River below Lake Natoma in the interests of fish, wildlife, and recreation and for export. Water released from the reservoir for such purposes would also afford incidental benefits relating to certain phases of navigation. In a joint paper by the United States Fish and Wildlife Service and the California Department of Fish and Game, entitled "A Plan for the Protection and Maintenance of Salmon and Steelhead in the American River, Together With Recommendations for Action", dated June 20, 1953, it was recommended that a minimum release of water at the rate of 500 second-feet be sustained during the king salmon spawning period, from September 15 through December 31, and that a minimum release at the rate of 250 second-feet be sustained during the remainder of the year. For the purposes of the present study, a constant release at the rate of 600 second-feet was assumed, after considering probable losses of stream flow to seepage, and the requirements for export which logically would be the eventual use of this high quality regulated water. Of the 432,000 acre-foot seasonal release of water

from Folsom Reservoir that would be made for these purposes, it was estimated that about 64,000 acre-feet would penetrate to the ground water, leaving a net seasonal supply of about 368,000 acre-feet available for export from or before reaching the Delta.

In considering the manner in which releases of water from Folsom Reservoir should be made, the logic of eventually meeting the gross water requirements of the Sacramento metropolitan area directly from the reservoir appeared uncontestable. The water would be of high quality, low mineral content, cool, and palatable. Of the 252,000 acre-feet per season of such water that would ultimately be required in the Sacramento metropolitan area, it was estimated that 126,000 acre-feet would be consumptively used, 88,000 acre-feet would be sewage outflow which could be reclaimed by proper treatment or otherwise disposed of by conduit beyond the confines of the service area, and 38,000 acre-feet would penetrate to and replenish the ground water. The water would be released from Folsom Reservoir on an urban demand schedule, in accordance with the data in Table 17.

With the ultimate firm demands on Folsom Reservoir for stream flow maintenance and urban use established in accordance with the preceding discussion, the remaining firm demand on the reservoir was that for irrigation. Supplemental releases of water for direct ground water recharge and for irrigation would be made from the reservoir in seasons when surplus water would be available. In the method of conjunctive operation proposed herein, it was assumed that the gross requirements for irrigation water in the American River Service Area would be met by a constant seasonal supply. This supply would be obtained from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AMERICAN RIVER SERVICE UNITS
CARMICHAEL
STOCKTON
IONE
PRECIPITATION IN INCHES
BOUNDARY OF AREA OF GROUND WATER STUDIES
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
AMERICAN RIVER BASIN INVESTIGATION
GROUND WATER STUDIES
LINES OF EQUAL MEAN SEASONAL PRECIPITATION
1897-1951
SCALE OF MILES
SACRAMENTO
YOLO
SOLANO
CONTRA COSTA
SAN JOAQUIN
EL DORADO
AMERICAN RIVER BASIN
Woodland
Vacaville
Fairfield
Dixon
Davis
Winters
Rio Vista
Concord
Martinez
Antioch
Stockton
Lodi
Folsom
Roseville
Auburn
Placerville
Jackson
Sutter Creek
Pleasant Grove
Thornton
Isleton
Terminous
Bethel Island
Brentwood
Clayton
Danville
Alamo
Walnut Cr
Cache Creek
Putah Creek
Sacramento River
Mokelumne River
Stanislaus River
Mt. Diablo Meridian
W Sacramento
N Sacramento
Elk Grove
Galt
Ione
San Andreas
Valley Springs
Camanche
Salt Springs Res
Pardee Res
Camanche Res
Folsom Res
Clarksville
Freeport
Courtland
Walnut Grove
Rio Vista
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Byron
Tracy
Livermore
Pittsburg
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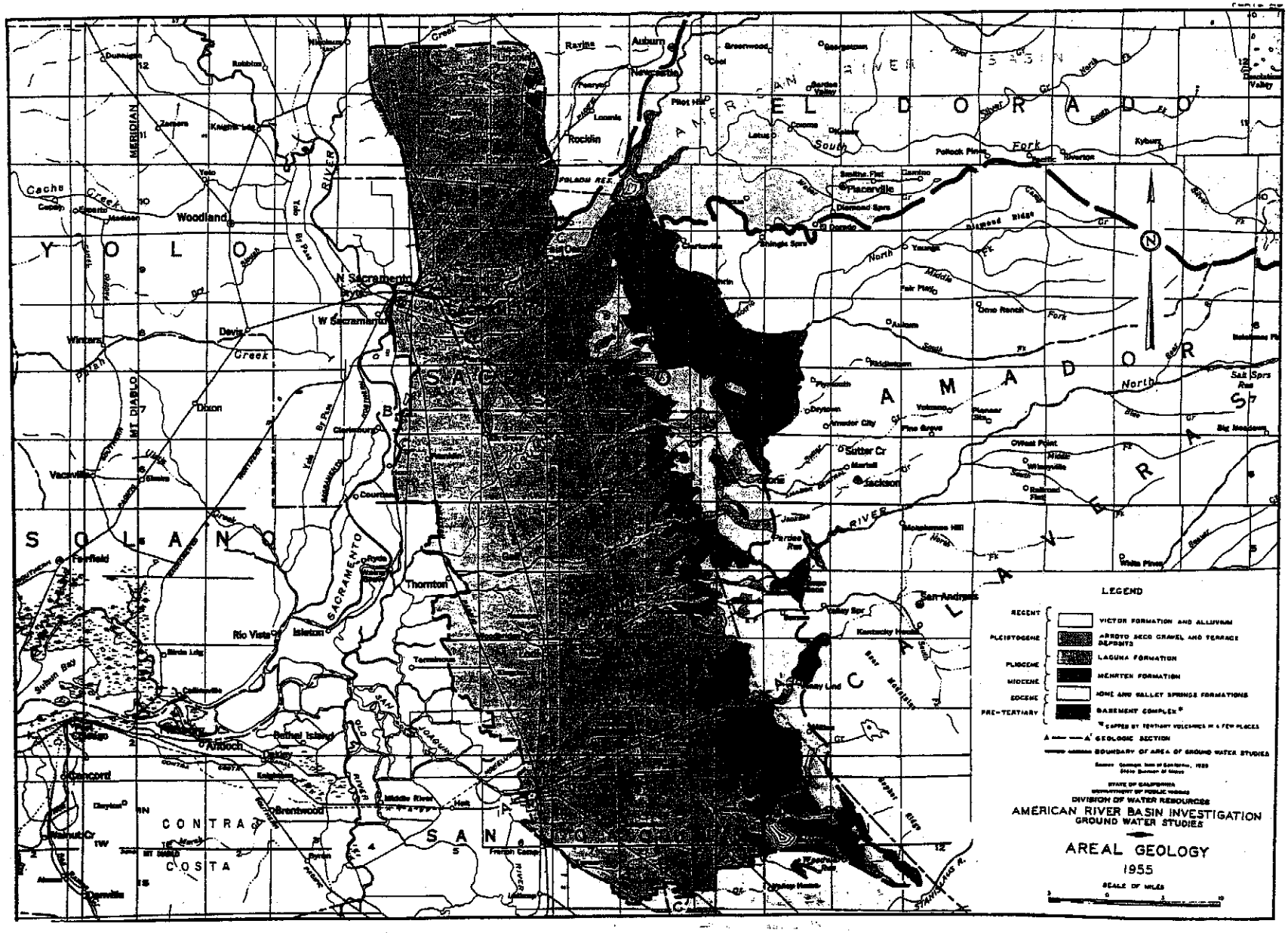
Isleton
Thornton
Pleasant Grove


LEGEND
RECENT
PLEISTOCENE
PLIOCENE
MIOCENE
EOCENE
PRE-TERTIARY
VICTOR FORMATION AND ALLUVIUM
ARROYO SECO GRAVEL AND TERRACE DEPOSITS
LAGUNA FORMATION
MEHRTEN FORMATION
IONE AND VALLEY SPRINGS FORMATIONS
BASEMENT COMPLEX
CAPPED BY TERTIARY VOLCANICS IN A FEW PLACES
A GEOLOGIC SECTION
BOUNDARY OF AREA OF GROUND WATER STUDIES
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
AMERICAN RIVER BASIN INVESTIGATION
GROUND WATER STUDIES
AREAL GEOLOGY
1955
SCALE OF MILES
Y O L O
S O L A N O
C O N T R A
C O S T A
E L D O R A D O
A M A D O R
P L A C E R
S A C R A M E N T O
S A N J O A Q U I N
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Davis
Dixon
Vacaville
Fairfield
Rio Vista
Antioch
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Brentwood
Placerville
Jackson
Sutter Cr
San Andreas
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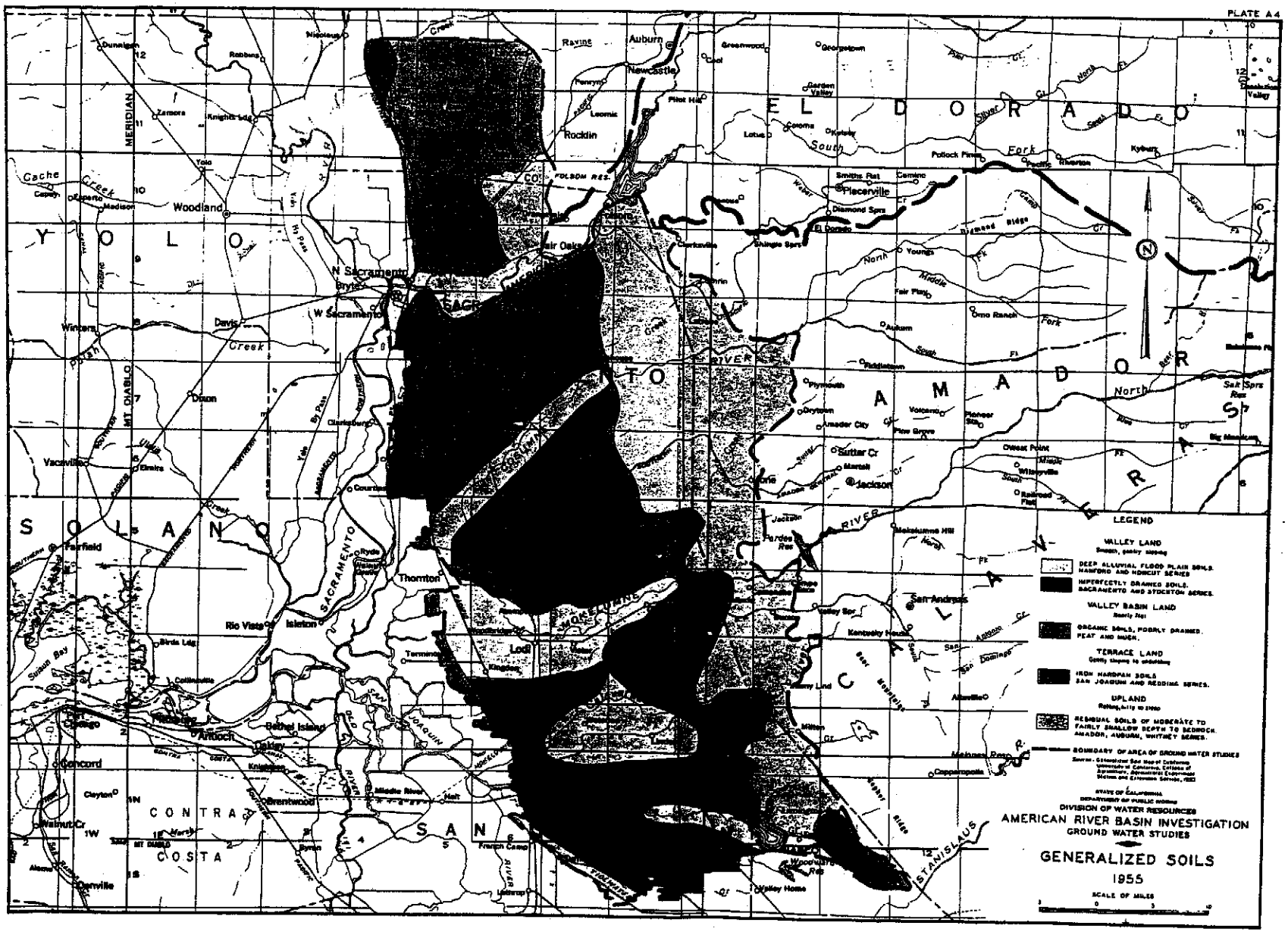
Isleton
Pittsburg
Walnut Cr
Martinez
Clarksburg
Courtland
Auburn
Rocklin
Roseville
Folsom
Folsom Res.
Pilot Hill
Georgetown
Diamond Springs
Shingle Springs
Plymouth
Drytown
Volcano
Pine Grove
Valley Spr
Kentucky House
Mokelumne Hill
Pardee Res.
Camanche Res.
Tracy
Livermore
Byron
Bethel Island
Oakley
Knightsen
Clayton
Mt. Diablo
Cache Creek
Putah Creek
Sacramento River
American River
Mokelumne River
Stanislaus R.
Middle River
Old River
Delta-Mendota Canal
Contra Costa Canal
Suisun Bay
Carquinez Strait
Clifton Court Forebay
Tracy Blvd.
Altamont Pass
Corral Hollow Creek
Arroyo Del Valle
Arroyo Las Positas
Arroyo Mocho
Alameda Creek
Coyote Creek
Los Gatos Creek
Guadalupe River
Calaveras River
Stockton Diverting Canal
Mormon Slough
Bear Creek
Dry Creek
Cosumnes River
Mokelumne River
Middle Fork
North Fork
South Fork
Silver Fork
Rubicon River
Rubicon Springs
Loomis
Lincoln
Auburn
Newcastle
Penryn
Greenwood
Georgetown
Coloma
Lotus
Placerville
Diamond Springs
Shingle Springs
Folsom
Folsom Res.
Pilot Hill
Rocklin
Roseville
Sheridan
Wheatland
Yuba City
Marysville
Oroville
Live Oak
Gridley
Colusa
Williams
Arbuckle
Zamora
Knights Landing
Winters
Esparto
Madison
Capay
Yolo
Dunnigan
Robbins
Hamilton City
Orland
Willows
Maxwell
Princeton
Glenn
Stonyford
Elk Creek
Newville
Paskenta
Corning
Red Bluff
Tehama
Vina
Chico
Oroville
Bangor
Biggs
Gridley
Live Oak
Sutter
Yuba City
Marysville
Wheatland
Olivehurst
Linda
Arboga
Loma Rica
Dobbins
Oregon House
Camptonville
Challenge
Brownsville
Smartsville
Timbuctoo
Rough and Ready
Grass Valley
Nevada City
Penn Valley
North San Juan
Colfax
Applegate
Weimar
Meadow Vista
Foresthill
Michigan Bluff
Yankee Jim
Iowa Hill
Forest Hill
Dutch Flat
Alta
Gold Run
Emigrant Gap
Blue Canyon
Cisco
Soda Springs
Donner Summit
Truckee
Tahoe City
Kings Beach
Carnelian Bay
Homewood
Meeks Bay
Emerald Bay
Fallen Leaf Lake
Echo Summit
Strawberry
Kyburz
Pollock Pines
Camino
Diamond Springs
Placerville
Shingle Springs
Cameron Park
Latrobe
Fair Play
Somerset
Omo Ranch
Kelsey
Coloma
Lotus
Georgetown
Greenwood
Auburn
Newcastle
Penryn
Loomis
Rocklin
Roseville
Folsom
Folsom Res.
Pilot Hill

PLATE A4


Auburn
Newcastle
Rocklin
Roseville
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Woodland
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Suisun Bay
Rio Vista
Isleton
Thornton
Lodi
Stockton
Antioch
Pittsburg
Concord
Martinez
Walnut Cr
Brentwood
Oakley
Byron
Tracy
San Andreas
Jackson
Sutter Cr
Amador City
Ione
Volcano
Plymouth
Shingle Springs
Diamond Springs
Pollock Pines
Georgetown
Greenwood
Garden Valley
Lotus
Coloma
Kyburz
Cameron
Smiths Flat
Meloland
Mokelumne Hill
Copperopolis
Valley Home
Woodward Res
Farmington
Knights Ldg
Winters
Elmira
Courtland
Isleton
Byron
Clayton
Oakley
Knightsen
Bethel Island
Collinsville
Birds Landing
Terminous
Liberty Island
Middle River
Holt
French Camp
Mokelumne Res
Pardee Res
Camanche Res
Valley Springs
Kennedy Tailings
Milton
Altaville
Angels Camp
Murphys
Sheep Ranch
Big Meadows
Forest Ranch
Chico
Paradise
Oroville
Marysville
Yuba City
Colusa
Willows
Orland
Red Bluff
Tehama
Corning
Gerber
Los Molinos
Vina
Chester
Susanville
Quincy
Portola
Truckee
Tahoe City
Meadow Valley
Oroville
Feather River
Sacramento River
Cache Creek
Putah Creek
Solano Canal
Delta Cross Channel
Old River
Middle River
Mokelumne River
Calaveras River
San Joaquin River
Stanislaus River
Tuolumne River
Merced River
Yuba River
Bear River
Middle Fork
North Fork
South Fork
Dry Creek
Clear Creek
Cottonwood Creek
Thomes Creek
Stony Creek
Elder Creek
Deer Creek
Mill Creek
Big Chico Creek
Butte Creek
Honcut Creek
Wadsworth Canal
Tule Canal
Sutter Bypass
Colusa Basin Drain
Knights Landing Ridge Cut
Yolo Bypass
Cache Slough
Lindsey Slough
Barker Slough
Suisun Slough
Montezuma Slough
Grizzly Slough
Old River
Fremont Weir
Sacramento Weir
Moore Cut
Georgiana Slough
Steamboat Slough
Sutter Slough
Miner Slough
Elk Slough
Snodgrass Slough
Mokelumne River
Calaveras River
Stanislaus River
Tuolumne River
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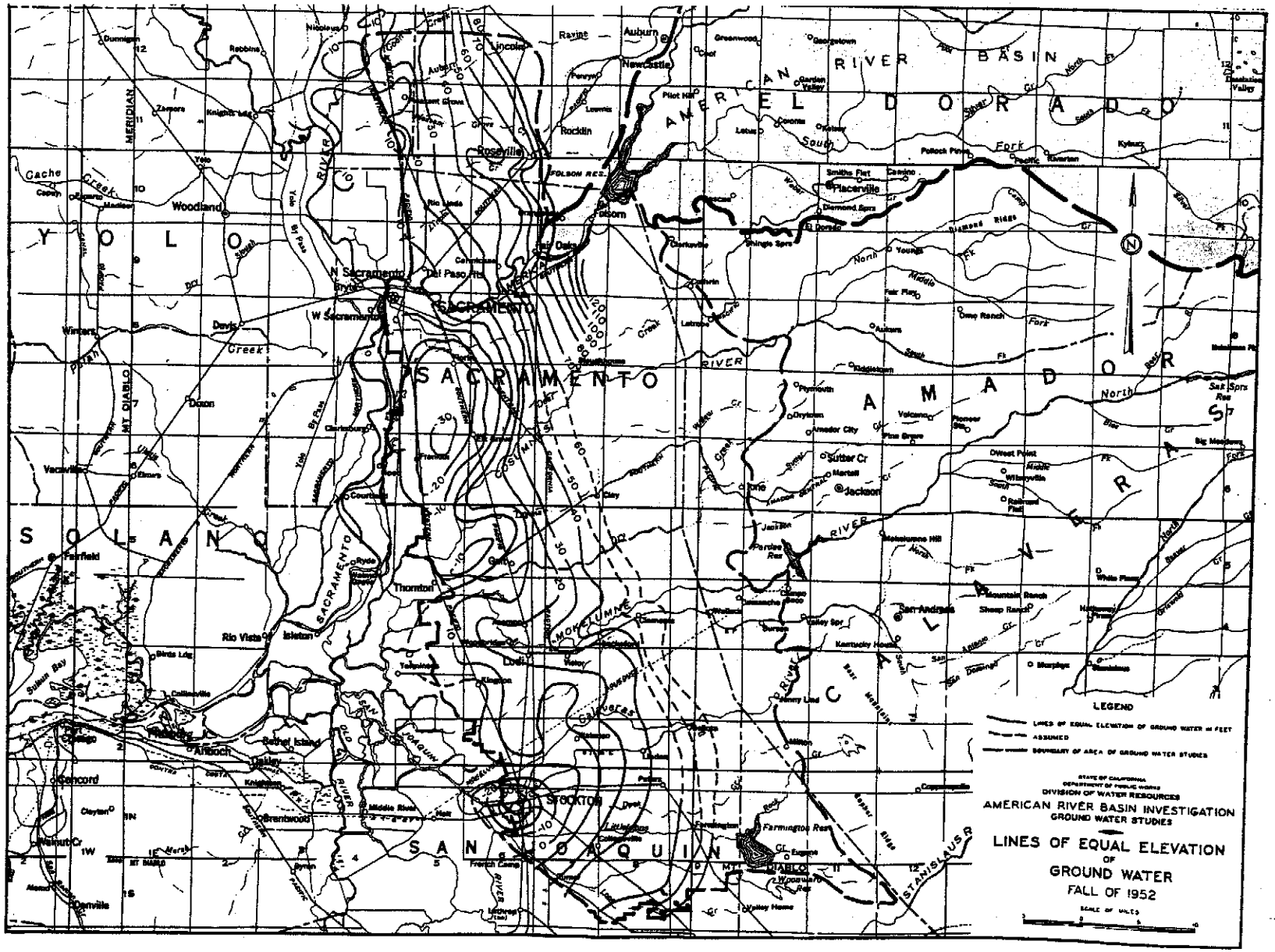
South Fork
Dry Creek
Clear Creek
Cottonwood Creek
Thomes Creek
Stony Creek
Elder Creek
Deer Creek
Mill Creek
Big Chico Creek
Butte Creek
Honcut Creek
Wadsworth Canal
Tule Canal
Sutter Bypass
Colusa Basin Drain
Knights Landing Ridge Cut
Yolo Bypass
Cache Slough
Lindsey Slough
Barker Slough
Suisun Slough
Montezuma Slough
Grizzly Slough
Old River
Fremont Weir
Sacramento Weir
Moore Cut
Georgiana Slough
Steamboat Slough
Sutter Slough
Miner Slough
Elk Slough
Snodgrass Slough
YOLO
SOLANO
CONTRA COSTA
SAN JOAQUIN
SACRAMENTO
AMADOR
CALAVERAS
EL DORADO
LEGEND
VALLEY LAND
DEEP ALLUVIAL FLOOD PLAIN SOILS. HANFORD AND HONCUT SERIES
IMPERFECTLY DRAINED SOILS. SACRAMENTO AND STOCKTON SERIES.
VALLEY BASIN LAND
ORGANIC SOILS, POORLY DRAINED. PEAT AND MUCK.
TERRACE LAND
IRON HARDPAN SOILS. SAN JOAQUIN AND REDDING SERIES.
UPLAND
RESIDUAL SOILS OF MODERATE TO FAIRLY SHALLOW DEPTH TO BEDROCK. AMADOR, AUBURN, WHITNEY SERIES.
BOUNDARY OF AREA OF GROUND WATER STUDIES
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
AMERICAN RIVER BASIN INVESTIGATION
GROUND WATER STUDIES
GENERALIZED SOILS
1955
SCALE OF MILES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SOLANO
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SAN JOAQUIN
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Placerville
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Isleton
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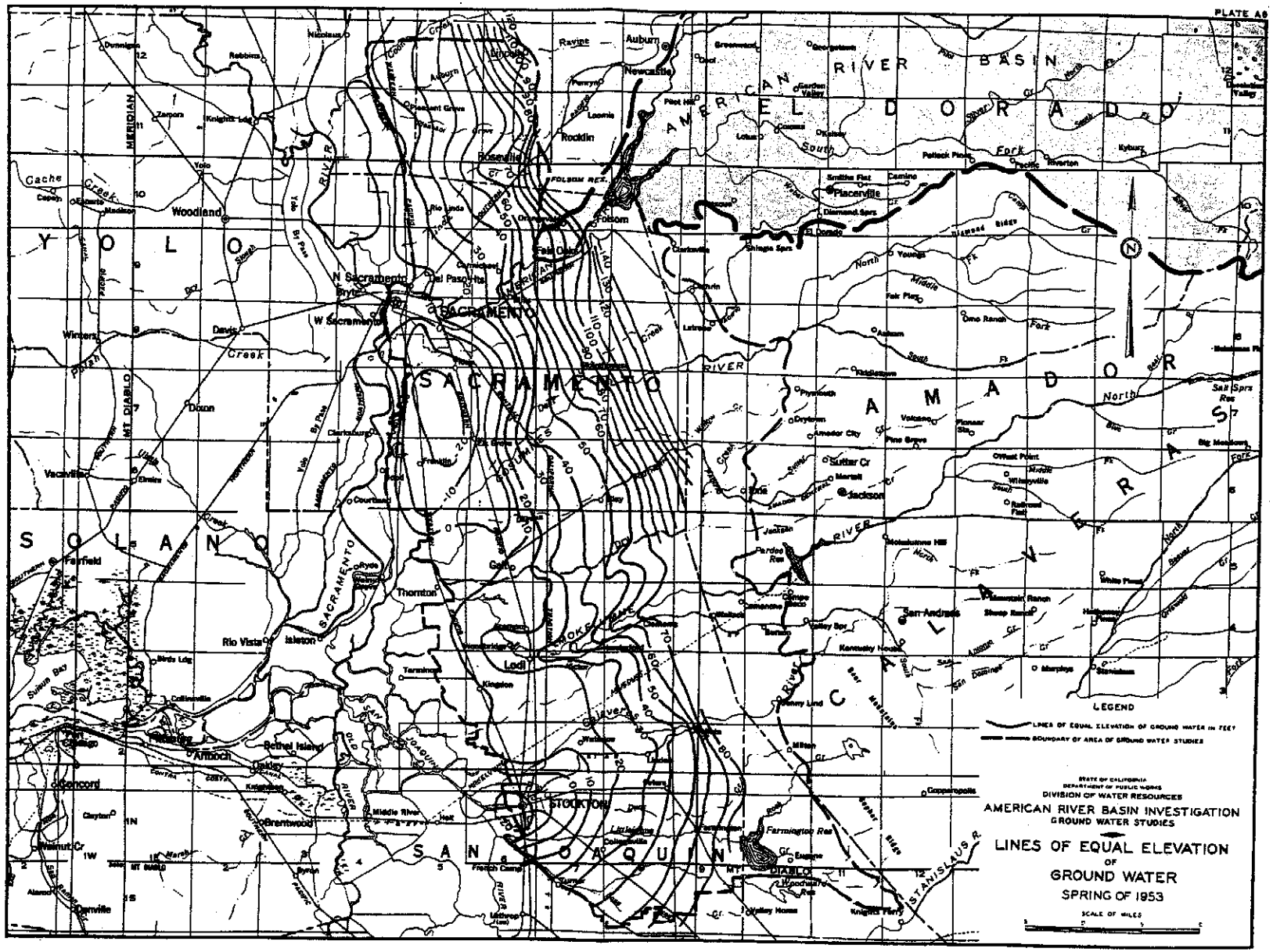
Lodi
Stockton
Antioch
Pittsburg
Concord
Martinez
Danville
Jackson
Sutter Cr
Ione
San Andreas
Farmington Res.
Mt. Diablo
Mokelumne River
Cosumnes River
Sacramento River
American River
Stanislaus R.
LEGEND
LINES OF EQUAL ELEVATION OF GROUND WATER IN FEET
ASSUMED
BOUNDARY OF AREA OF GROUND WATER STUDIES
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
AMERICAN RIVER BASIN INVESTIGATION
GROUND WATER STUDIES
LINES OF EQUAL ELEVATION
OF
GROUND WATER
FALL OF 1952
SCALE OF MILES

PLATE A8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SAN JOAQUIN
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CALAVERAS
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Roseville
Rocklin
Folsom
Placerville
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Winters
Dixon
Vacaville
Fairfield
Suisun Bay
Rio Vista
Isleton
Thornton
Lodi
Stockton
Antioch
Concord
Brentwood
Oakley
Bethel Island
Walnut Cr
Danville
San Andreas
Jackson
Sutter Cr
Ione
Farmington Res
Copperopolis
Milton
Valley Springs
Knights Ferry
Oakdale
Riverbank
Modesto
Turlock
Merced
Los Banos
Tracy
Livermore
Pleasanton
Dublin
Hayward
Oakland
San Francisco
Martinez
Benicia
Vallejo
N Sacramento
W Sacramento
Elk Grove
Florin
Folsom Res
Camino
Smith Flat
Diamond Springs
El Dorado
Salmon Falls
Latrobe
Shingle Springs
Cameron Park
Pollock Pines
Riverton
Kyburz
Volcano
Pioneer
Amador City
Pine Grove
Drytown
Plymouth
Fiddletown
Sutter Creek
Jackson
Jamestown
Sonora
Tuolumne
Columbia
Angels Camp
Murphys
Valley Springs
Mokelumne Hill
Paradise Res
Camanche Res
Pardee Res
Farmington Res
Hogan Res
Tulloch Res
Woodbridge
Terminous
Kingston
Walnut Grove
Courtland
Clarksburg
Freeport
Elmira
Birds Landing
Collinsville
Montezuma Hills
Suisun Marsh
Grizzly Bay
Honker Bay
Middle River
Old River
Victoria Canal
Clifton Court
French Camp
Byron
Tracy
Livermore
Dublin
Pleasanton
Sunol
Niles
Hayward
Oakland
San Leandro
Alameda
San Francisco
Martinez
Benicia
Vallejo
Napa
Sacramento River
San Joaquin River
Mokelumne River
Calaveras River
Stanislaus River
Cosumnes River
American River
Yuba River
Feather River
Bear River
Putah Creek
Cache Creek
Willow Creek
Dry Creek
Putah South Canal
Delta-Mendota Canal
Contra Costa Canal
Folsom South Canal
Main Canal
Mt. Diablo Meridian
Base Line
10
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100
110
120
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140
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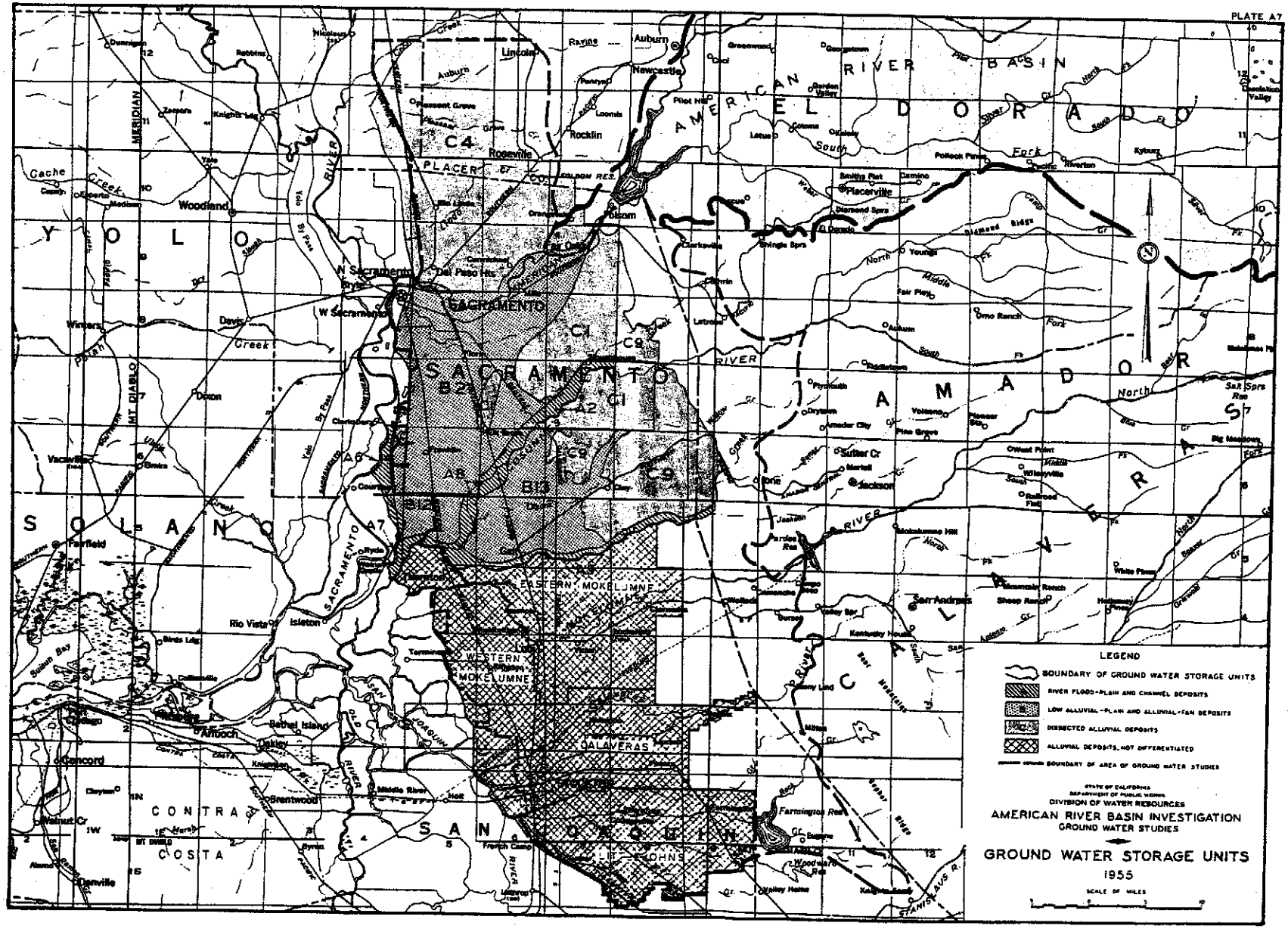
190
200
LEGEND
LINES OF EQUAL ELEVATION OF GROUND WATER IN FEET
BOUNDARY OF AREA OF GROUND WATER STUDIES
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
AMERICAN RIVER BASIN INVESTIGATION
GROUND WATER STUDIES
LINES OF EQUAL ELEVATION
OF
GROUND WATER
SPRING OF 1953
SCALE OF MILES
0
5
10

PLATE A7


AMERICAN RIVER BASIN
EL DORADO
YOLO
SACRAMENTO
SOLANO
CONTRA COSTA
SAN JOAQUIN
PLACER CO.
C1
C2
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C9
A2
A6
A8
A7
B12
B13
B22
EASTERN MOKELUMNE
WESTERN MOKELUMNE
CALAVERAS
Woodland
Davis
Dixon
Winters
Vacaville
Fairfield
Rio Vista
Isleton
Suisun Bay
Benicia
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Pittsburg
Antioch
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Walnut Cr
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Brentwood
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Bethel Island
Roseville
Rocklin
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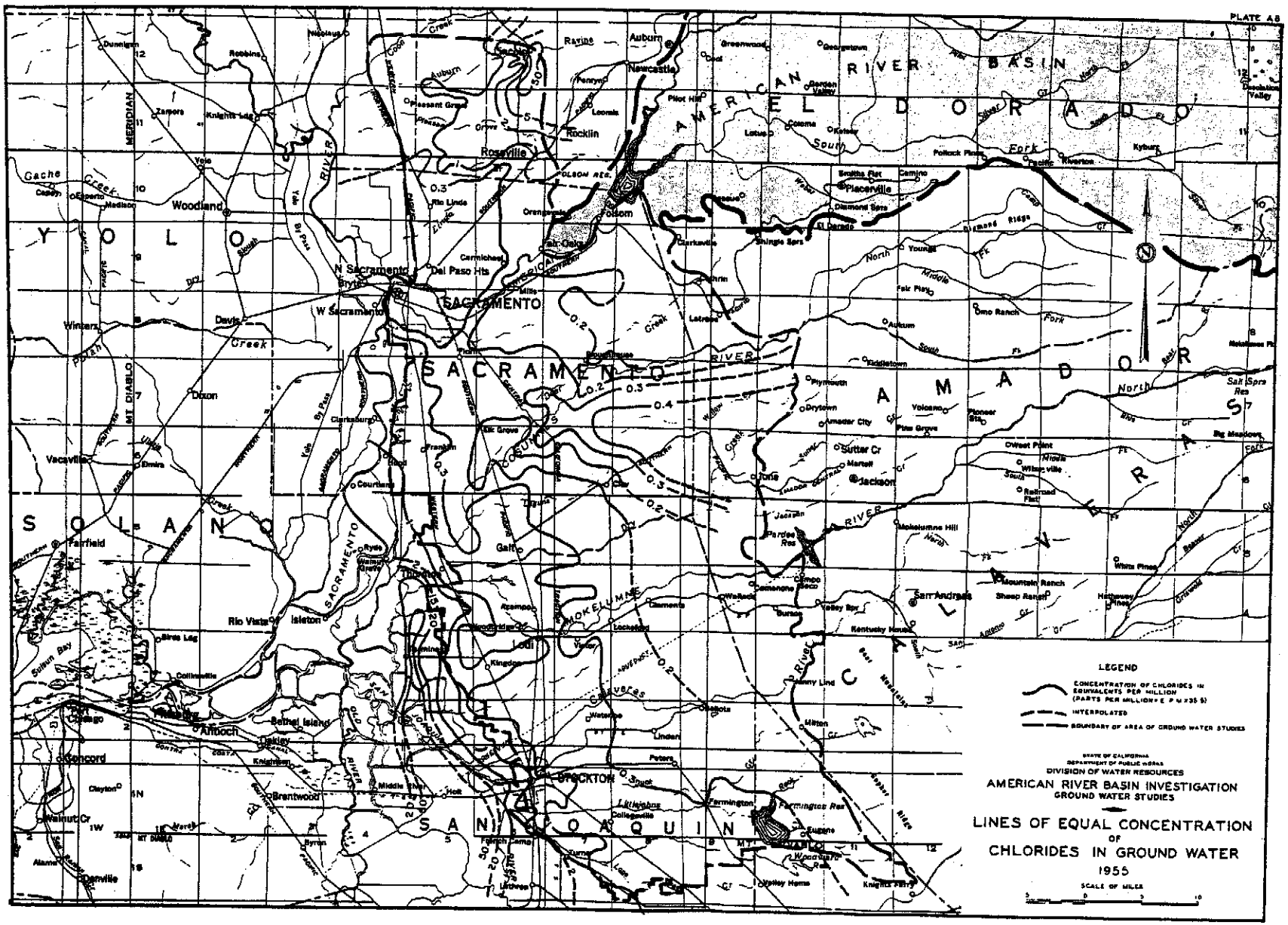
Auburn
Newcastle
Loomis
Penryn
Folsom
Folsom Res.
Placerville
Diamond Springs
Clarksville
Latrobe
Shingle Springs
Cameron Park
Coloma
Lotus
Pollock Pines
Rubicon
Riverton
Georgetown
Greenwood
Cool
Garden Valley
Yuba City
Marysville
Olivehurst
Plumas Lake
Wheatland
Sutter Cr
Jackson
Pardee Res.
Amador City
Drytown
Volcano
Pioneer
Willow Springs
Ione
Buena Vista
Sheep Ranch
Kentucky House
Valley Springs
Farmington Res.
Woodward Res.
Valley Home
Knightsen
Byron
Tracy
Mt. Diablo
Sacramento R.
San Joaquin R.
Cosumnes R.
Mokelumne R.
Calaveras R.
Stanislaus R.
Bear R.
Yuba R.
Feather R.
American R.
Middle R.
Old R.
Fabian Canal
Delta Cross Channel
Clifton Court
Contra Canal
Tracy Blvd.
Mt. Diablo Meridian
LEGEND
BOUNDARY OF GROUND WATER STORAGE UNITS
RIVER FLOOD-PLAIN AND CHANNEL DEPOSITS
LOW ALLUVIAL-PLAIN AND ALLUVIAL-FAN DEPOSITS
DISSECTED ALLUVIAL DEPOSITS
ALLUVIAL DEPOSITS, NOT DIFFERENTIATED
BOUNDARY OF AREA OF GROUND WATER STUDIES
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
AMERICAN RIVER BASIN INVESTIGATION
GROUND WATER STUDIES
GROUND WATER STORAGE UNITS
1955
SCALE OF MILES

PLATE A8


AMERICAN RIVER BASIN
EL DORADO
YOLO
SACRAMENTO
SOLANO
SAN JOAQUIN
AMADOR
CALAVERAS
Woodland
Davis
Winters
Vacaville
Dixon
Fairfield
Rio Vista
Isleton
Antioch
Pittsburg
Concord
Walnut Cr
Danville
Brentwood
Oakley
Bethel Island
Collinsville
Suisun Bay
Roseville
Rocklin
Auburn
Newcastle
Folsom
Placerville
Galt
Lodi
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Ripon
Manteca
Tracy
Livermore
Pleasanton
Sacramento
Elk Grove
Clarksburg
Courtland
Walnut Grove
Thornton
Terminous
Jackson
Sutter Cr
Plymouth
Drytown
Amador City
Volcano
Ione
Sheep Ranch
Mountain Ranch
Angels Camp
Valley Springs
Farmington
Escalon
Linden
Lockeford
Woodbridge
Clements
Camanche Res
Pardee Res
New Hogan Res
Salt Spring Res
Folsom Res
Natoma
Orangevale
Carmichael
Del Paso Hts
N Sacramento
W Sacramento
Bryte
Pocket
Meridian
Cache Creek
Putah Creek
Sacramento River
Mokelumne River
Calaveras River
San Joaquin River
Delta-Mendota Canal
Folsom South Canal
Main Canal
Contra Costa Canal
Tracy Pumping Plant
Banta-Carbona Canal
Old River
Middle River
Victoria Canal
Clifton Court Forebay
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Alameda
Livermore
Dublin
Pleasanton
Sunol
Niles
Hayward
San Leandro
Oakland
Alameda
Berkeley
Richmond
San Pablo
Martinez
Pittsburg
Antioch
Brentwood
Oakley
Knightsen
Bethel Island
Collinsville
Suisun Bay
Rio Vista
Isleton
Walnut Grove
Thornton
Terminous
Lodi
Galt
Elk Grove
Clarksburg
Courtland
Woodbridge
Clements
Camanche Res
Pardee Res
New Hogan Res
Salt Spring Res
Folsom Res
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Del Paso Hts
N Sacramento
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Cache Creek
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Sacramento River
Mokelumne River
Calaveras River
San Joaquin River
Delta-Mendota Canal
Folsom South Canal
Main Canal
Contra Costa Canal
Tracy Pumping Plant
Banta-Carbona Canal
Old River
Middle River
Victoria Canal
Clifton Court Forebay
Byron
Alameda
Livermore
Dublin
Pleasanton
Sunol
Niles
Hayward
San Leandro
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Alameda
Berkeley
Richmond
San Pablo
Martinez
0.2
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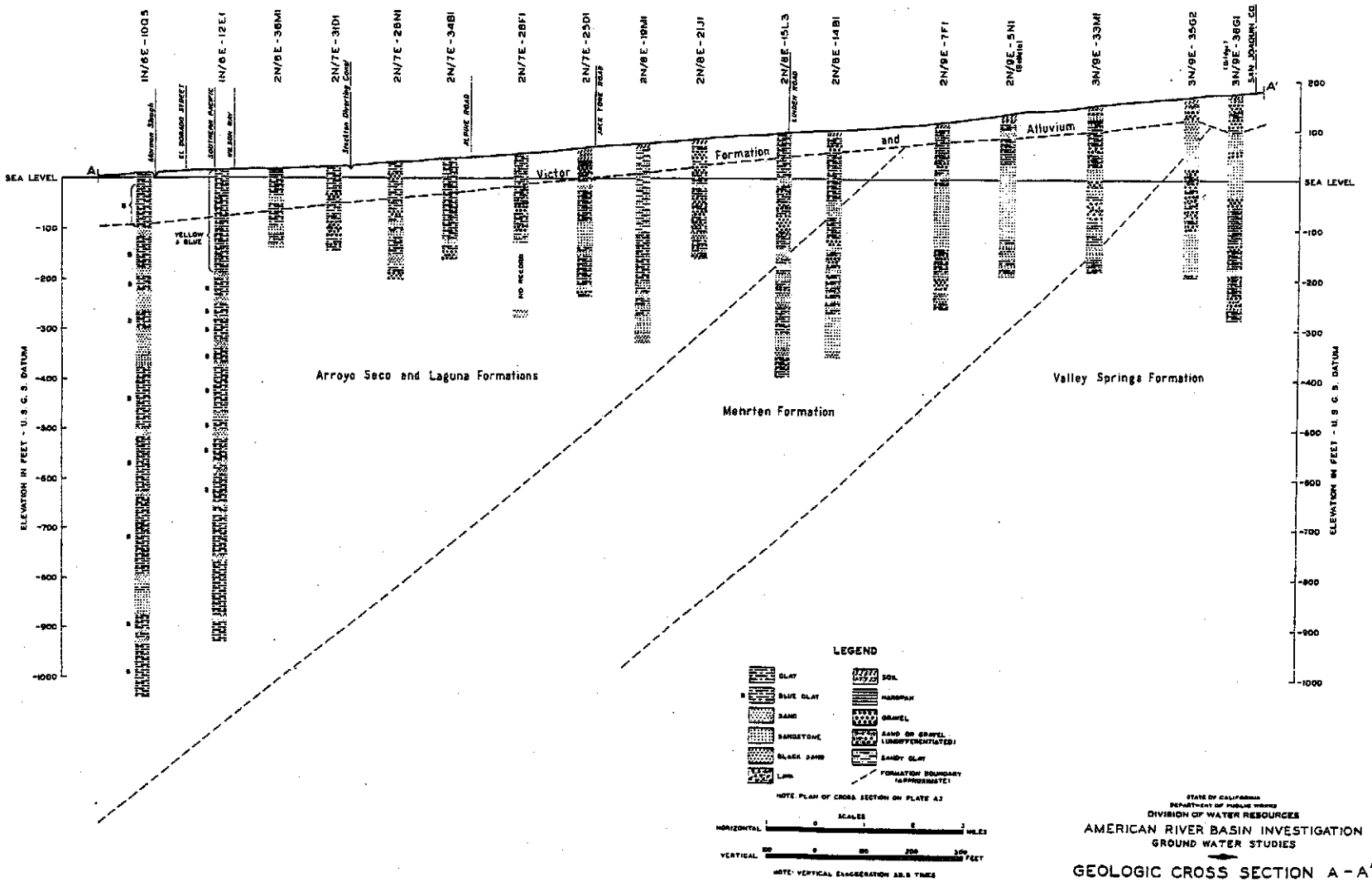
0.5
LEGEND
CONCENTRATION OF CHLORIDES IN EQUIVALENTS PER MILLION (PARTS PER MILLION x E P M x 35.5)
INTERPOLATED
BOUNDARY OF AREA OF GROUND WATER STUDIES
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
AMERICAN RIVER BASIN INVESTIGATION
GROUND WATER STUDIES
LINES OF EQUAL CONCENTRATION OF CHLORIDES IN GROUND WATER
1955
SCALE OF MILES
0
5
10

PLATE A3-A



STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

AMERICAN RIVER BASIN INVESTIGATION
GROUND WATER STUDIES

GEOLOGIC CROSS SECTION A - A'

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STATE OF CALIFORNIA

GOODWIN J. KNIGHT
GOVERNOR

PUBLICATION OF
California, STATE WATER RESOURCES BOARD

BULLETIN NO. 21

AMERICAN RIVER BASIN INVESTIGATION

REPORT ON DEVELOPMENT PROPOSED FOR THE CALIFORNIA WATER PLAN

PRELIMINARY DATA
SUBJECT TO REVISION

VOLUME II (Appendixes and Related Plates)

(Seal of State of California)

LEGISLATIVE COUNSEL

JUNE, 1955

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APPENDIX A

GROUND WATER STUDIES

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GROUND WATER STUDIES

Introduction

The purpose of this appendix is to present background material relating to the possible conjunctive operation of surface and ground water reservoirs to conserve the waters of the American River. It is the basic postulate of the appendix that the water-bearing aquifers of the Central Valley could be used and operated as a conservation reservoir. For study purposes, the basic assumption was made that the area of ground water study on the floor of the Central Valley would receive water from the American River and from direct precipitation only.

Justification for Basic Assumption

For purposes of the studies reported herein, it was assumed that waters of the American River would serve the valley floor, urban, and agricultural areas within hydrographic units 28, 61, and 62 of the Central Valley, as delineated in State Water Resources Board Bulletin No. 2. These hydrographic units, shown on Plate A-1, "Location of Area of Ground Water Study", and Plate A-2, "Lines of Equal Mean Seasonal Precipitation", are presently served by surface and ground water supplies originating in the Bear, Yuba, American, Cosumnes, Mokelumne, Calaveras, Stanislaus, and Sacramento Rivers, and numerous small intervening streams. Obviously, until definite plans for the ultimate development and use of the waters of these streams are prepared and adopted, it would not be possible to clearly define a specific downstream service area for the American River.

Even with such ultimate development and use, certain of the other streams would no doubt continue to supply portions of these hydrographic units. The problem is further complicated by the continuity of the underlying ground water basin, which is replenished not only by these streams, but perhaps by many others, and by precipitation as well.

Notwithstanding these complications, it is considered that dependable quantitative results may be obtained from studies based on the assumption that an area of study with the characteristics of these hydrographic units could be supplied by and be entirely dependent on waters from the American River and from direct precipitation as the only sources of water supply and ground water replenishment. In actual conjunctive operation it is probable that under conditions of ultimate development the principal variance from this assumption would be that some of the American River water would be transferred to and used in adjoining or distant service areas, if replenishment from the other streams should continue as at present.

Area of Ground Water Study

Selection of an area of ground water study was prefaced by an estimate of the American River's proportionate share of the land use, water requirements, and ground water storage capacity of the Central Valley. The proportionate share of these items were based on the ratio of the natural flow of the American River to the total natural flow of all streams entering the Central Valley. For purposes of hydrologic analyses the area finally selected was assumed to have the physical characteristics

of hydrographic units 28, 61, and 62, as defined in State Water Resources Board Bulletin No. 2.

Hydrographic unit 28, the Carmichael unit, is situated on the east side of the southernmost portion of the Sacramento Valley. It encompasses about 479 square miles of valley lands on both sides of the American River. Hydrographic units 61 and 62, the Stockton and Ione units, are located on the east side of the northernmost portion of the San Joaquin Valley. The north-south boundary between these two units is approximately the eastern limit of water service from the Folsom South Canal, proposed by the United States Bureau of Reclamation. Hydrographic unit 61 contains about 897 square miles, including most of the better agricultural lands of San Joaquin County outside the Delta. Hydrographic unit 62 has about 424 square miles of area, and lies mostly above the valley floor in the foothill area.

Portions of seven counties, San Joaquin, Sacramento, Sutter, Placer, El Dorado, Amador, and Calaveras, lie within these hydrographic units, but the largest part of the area of study is covered by the first two listed counties. The over-all length of the area is about 75 miles. Its northern boundary intersects Auburn Ravine and Coon Creek about 22 miles north of the City of Sacramento, while its southern boundary extends to Lone Tree Creek about 10 miles south of the City of Stockton. The greatest east-west dimension of the area is about 33 miles, approximately on a line through the towns of Florin and Sloughhouse. The mean width of the area is about 24 miles, and the total area under consideration is about 1,800 square miles.

Climate

The climate of the Area of Ground Water Study is characterized by dry summers with high daytime temperatures and warm nights, and wet winters with moderate temperatures. More than 80 per cent of the seasonal precipitation falls during the five months of November through March. The growing season is long, there being about 300 days between killing frosts along the west side of the area. Temperature extremes at Sacramento and Stockton have ranged from 17° F. to over 110° F., and the monthly average for the period from 1872 to 1950 ranges from about 45° F. in January to 74° F. in July.

Precipitation. The Area of Ground Water Study lies within the southern fringe of storms which periodically sweep inland from the North Pacific during winter months. Although the rainfall resulting from these storms is moderate on the average, direct precipitation provides a substantial portion of the water supply of the area.

Areal distribution of precipitation is presented on Plate A-2. The isohyets delineated on this plate differ from those of most previously published reports. Recent acquisitions of additional records in and near the area, plus revisions of reliability estimates and normals for other records, account for the change of pattern of the isohyets. The same general pattern of precipitation still exists, with the mean seasonal depth of precipitation increasing generally from southwest to northeast. The most significant changes occur in the vicinity of the American River. The change in mean seasonal depth of

precipitation for the entire area was found to be negligible.

Precipitation on the area of study consists almost entirely of rainfall, with rare falls of snow. Mean seasonal depth of precipitation varies from about 13 inches along the southern boundary of the area to about 26 inches near the northeastern boundary. Precipitation varies over wide limits from season to season, ranging from less than 50 per cent to over 200 per cent of the seasonal mean.

The values of total mean seasonal quantity of precipitation and mean seasonal depth of precipitation were estimated by weighting the areas between isohyets on Plate A-2. The results are presented in Table A-1.

Geology

The geologic formations underlying the Area of Ground Water Study range in age from pre-Cretaceous to Recent. The geology of much of the area has been described in two United States Geological Survey Water-Supply Papers, No. 619, "Geology and Water Resources of the Mokelumne Area, California", and No. 780, "Geology and Ground Water Hydrology of the Mokelumne Area, California". California State Water Resources Board Bulletin No. 10, "Placer County Investigation", and Bulletin No. 11, "San Joaquin County Investigation", describe geologic features of Placer and San Joaquin Counties. The surface geology of the area is delineated on Plate A-3, "Areal Geology", which was obtained from the "Geologic Map of California", published by the State Division of Mines in 1938. Geologic cross-sections are shown on Plates A-3A, A-3B, and A-3C, entitled "Geologic Cross-

TABLE A-1

ESTIMATED WEIGHTED MEAN SEASONAL DEPTH AND TOTAL QUANTITY OF PRECIPITATION ON AREA OF GROUND WATER STUDY

Hydrographic unit	Depth, in inches	Quantity, in acre-feet
28	19.4	497,000
61	16.3	779,000
62	20.8	470,000
TOTALS	18.2	1,746,000

Section A-A'", "B-B'", and "C-C'", respectively. A brief discussion of the composition and water-bearing qualities of the geologic formations is presented in the following paragraphs.

The surface of the pre-Cretaceous basement complex dips gently westward from the Sierra Nevada toward the center of the Central Valley. This basement complex is composed chief of igneous and metamorphic rocks overlain by some volcanic rocks. Locally, these rocks furnish limited quantities of water from joints and fractures, but generally they do not contain an important supply of usable ground water.

Overlying the basement complex is a wedge of post-Cretaceous sediments of Eocene to Recent age. Thickest toward the center of the valley, these sediments feather out against the basement complex of the Sierra Nevada. All of the post-Cretaceous sediments appear to yield water to wells. However, the Ione formation and the Valley Springs formation are so deeply buried in most of the area, and have such relatively low permeabilities, that only rarely are wells drilled deeply enough to tap them west of their outcrop areas. For this reason, these two formations are not differentiated on Plate A-3.

The Mehrten formation is mainly made up of siltstone, sandstone, and conglomerate, along with discontinuous beds of clay, unconsolidated sands, and layers of volcanic agglomerate. "Black sands", which are a common marker of the Mehrten formation, are so called because of their high content of grains derived from andesite. The Mehrten sands are highly permeable, and furnish water to many deep wells in the southeastern part of the area. These aquifers receive percolate from the major

streams in their outcrop area south of the American River. West of the outcrop area some of the aquifers are partially confined by relatively impervious strata, both in the Mehrten and the overlying Laguna formation.

The Laguna formation and the younger Arroyo Seco Gravel generally cropout between the Mehrten and the more recent sediments to the west. Both formations seem to thicken westward. The Laguna formation is composed of a mixture of stream-laid clays, silts, sands, and gravels. Consequently, hydrologic characteristics of the formation are extremely variable; that is, perched water bodies are common in the area of outcrop, but farther west it is not unusual to find wells having large specific capacities pumping from the Laguna formation. The Arroyo Seco formation consists of a thin unit made up of cobbles, sand, and gravel in the outcrop area, but it is grouped with the Laguna formation on the geologic cross-sections because of the inability to differentiate between the two formations in well logs.

The Victor formation includes the deposits of the alluvial plains on the east side of the Central Valley where alluvium is not now, or under natural stream regimen would not be, actively accumulating. This formation is made up of clays, silts, sands, and gravels which were deposited on the growing alluvial fans of the various streams as they debouched from the Sierra Nevada.

Many small or domestic wells, and several large irrigation wells in the area derive their water from Victor sediments. However, most of the irrigation wells in the Area of

Ground Water Study receive their water almost entirely from strata underlying the Victor formation.

Comprising the Recent alluvium are sands, gravels, and silts in active stream channels, and silts in areas subject to overflow. These deposits generally have the ability to transmit water to underlying material, but in most places are so shallow that the water table lies beneath them.

Soils

Soils of the Area of Ground Water Study vary in their physical characteristics and adaptabilities in accordance with differences in parent material, manner of deposition, drainage, and age or degree of development. The soils, delineated on Plate A-4, "Generalized Soils", may be divided into four broad groups: (1) UPLAND, comprising residual soils formed in place by weathering of the underlying bedrock; (2) TERRACE, comprising soils derived from old valley fill or terrace deposits; (3) VALLEY, comprising soils derived from more recent alluvial deposits; and (4) VALLEY BASIN, comprising soils derived from organic materials.

The upland or residual soils occur in the eastern part of the Area of Ground Water Study. These soils are suited for irrigated agriculture wherever topographic conditions are favorable. Crop adaptabilities vary from orchard crops to irrigated pasture, depending upon the depth of soil. The residual soils have a high infiltration potential, but are generally located outside the ground water storage units of the area. They may provide opportunity for ground water recharge by subsurface

inflow to the ground water storage units where the soils are of sufficient depth.

The terrace soils can be further divided into high terrace and low terrace soils. The high terrace soils are usually gravelly, with moderately compacted to strongly developed hardpan layers. Some of the smoother, less gravelly soils are suitable for irrigated pasture. The low terrace soils are fairly extensive throughout the area of study, occupying a position somewhat lower in elevation than the high terraces and adjacent to the recent alluvial depositions. The low terrace soils vary in profile development from moderately compacted to iron-cemented hardpan layers. Their infiltration potential, while not as good as upland soils, is adequate to permit some recharge. Where terrace soils are sufficnetly deep and overlie areas of discontinuous and fractured hardpan, significant deep percolation may be expected from rainfall and applied water.

The valley soils, derived from the more recent alluvial deposits, can be divided into two broad groups: alluvial fans and flood plain soils, and basin soils. The alluvial fan and flood plain soils consist of the more recent depositions of the various stream systems. These soils vary somewhat, depending upon the nature of the geological materials within the drainage basins of the different streams. As an example, soils along the Calaveras River have developed mainly from basic igneous alluvium, whereas the Mokelumne River alluvial fan and flood plain soils are composed largely of granitic rock outwash material. The alluvial fan and flood plain soils are highly valued for agriculture, and have wide crop adaptabilities. They

generally possess the highest infiltration potential of any soils in the area of study.

The valley basin soils, developed under poorly drained conditions, occupy the broad interfan areas between the major streams. They are extensive in the southern part of the Area of Ground Water Study. Their crop adaptabilities are largely limited to rice and shallow-rooted crops, due to the poor drainage and fine texture of the soils. The infiltration potential of the basin soils is rather low, though some recharge may be expected when basin soils are farmed to rice, because of the extended period during which the land is inundated.

The valley basin soils, comprising organic or peat soils, have developed in place from the decomposition of tules, reeds, and other plants. They occur along the western margin of the Area of Ground Water Study from Stockton to the Cosumnes River. These soils are highly productive when drained, and are suitable for a wide variety of crops. However, due to their limited extent and location, the amount of ground water recharge that would be contributed to the area of study by areas of organic soils should not be expected to be large.

Present and Probable Ultimate Development

For purposes of the studies reported herein, present conditions of development in the Area of Ground Water Study were important only as a guide for predicting probable ultimate conditions of development. The estimates of ultimate development were utilized to derive forecasts of probable ultimate water requirements, from which the minimum required degree of water development could then be estimated.

Population. The 1950 federal census indicated that approximately 350,000 persons then resided within the boundaries of the Area of Ground Water Study. About 70 per cent of the population lived within cities and towns of more than 1,000 occupants, and almost 95 per cent were listed within the urban-suburban-nonfarm rural classifications. The rural population was generally distributed throughout the area, with lesser population densities in the eastern portion of the area. Estimates of the ultimate state population indicate that the present population should increase some fourfold. In the Area of Ground Water Study, this would indicate an ultimate population of about 1,400,000 persons.

Land Use. Surveys to determine the nature and extent of present land use in the Area of Ground Water Study were conducted by federal and state agencies between 1948 and 1950. The findings of these surveys are tabulated in State Water Resources Board Bulletin No. 2. During the past decade, several federal and state agencies have conducted land classification surveys to determine the inherent capabilities of lands of the area to support further development and use. The results of these surveys were combined and compiled to obtain an estimate of the ultimate area requiring water service. The present land use pattern was then expanded, with modifications, to fit the ultimate area. Estimates of present and probable ultimate land use in the Area of Ground Water Study are presented in Table A-2.

Water Service Agencies. Several public, municipal, corporate, mutual, and private water service agencies have been

TABLE A-2

ESTIMATED PRESENT AND PROBABLE ULTIMATE LAND USE IN AREA OF GROUND WATER STUDY

(In acres)

Land use	Hydrographic unit 28 (Carmichael)		Hydrographic unit 61 (Stockton)		Hydrographic unit 62 (Ione)		Totals	
	Present	Ultimate	Present	Ultimate	Present	Ultimate	Present	Ultimate
Net irrigated areas								
Pasture	19,500	36,000	56,900	36,900	1,400	54,300	77,800	127,200
Rice	6,300	26,000	6,100	75,000	———	———	12,400	101,000
Miscellaneous field crops	4,300	34,100	16,500	56,200	300	8,100	21,100	98,400
Hay and grain	———	38,300	———	25,100	———	30,400	———	93,800
Vineyard	6,800	15,600	43,600	63,000	———	5,000	50,400	83,600
Alfalfa	3,600	15,100	11,200	56,000	300	6,000	15,100	77,100
Orchard	4,800	9,000	25,800	50,000	600	4,000	31,200	63,000
Truck	2,000	7,000	16,200	29,600	500	7,000	18,700	43,600
Sugar beets	———	14,400	———	10,000	———	———	———	24,400
Citrus	———	———	———	———	1,500	———	1,500	———
Subtotals	47,300	195,500	176,300	401,800	4,600	114,800	228,200	712,100
Farm lots	1,500	2,800	5,400	6,900	1,300	1,900	8,200	11,600
Nonwater-using areas	4,700	37,700	15,600	80,200	2,700	33,000	23,000	150,900
GROSS IRRIGATED AREA	53,500	236,000	197,300	488,900	8,600	149,700	259,400	874,600
GROSS URBAN AREA	55,000	60,000	12,900	24,100	300	900	68,200	85,000
REMAINDER	198,300	10,800	363,800	61,000	262,700	121,000	824,800	192,800
TOTALS	306,800	306,800	574,000	574,000	271,600	271,600	1,152,400	1,152,400

organized within the Area of Ground Water Study. The most common and largest source of water supply for these agencies is the ground water, although some small surface diversions are made from most of the tributary streams. Imports of Bear and Yuba River waters supply some of the domestic and irrigation requirements of hydrographic unit 28. The only large concentrated use of surface water is in the City of Sacramento, and this water supply may be considered to originate in the Sacramento River proper. It has been estimated that in San Joaquin County approximately 80 per cent of the area under water service is supplied from ground water. No corresponding figures are available for Sacramento County.

Several reclamation districts have been organized to deal with the problems of land reclamation and drainage. Most of these districts have been formed near the western boundary of the area of study. The provisions of California reclamation district laws have been used extensively to effect the unwatering of lowlands and to protect them from overflow.

Water Supply and Requirements

The present sources of water supply of the Area of Ground Water Study are direct precipitation on overlying lands and tributary surface and subsurface inflow. As was explained earlier, the ultimate sources of water supply to the area were assumed to be restricted to direct precipitation on the overlying lands and the tributary flow of the American River. So far as can be determined, the few present imports of water to or exports of water from the area of study have a negligible significance when related to the total water supply.

Runoff

The runoff from the highly productive watersheds of the Sierra Nevada constitutes the most important source of water supply available to the Area of Ground Water Study. As was indicated previously, surface flows of the tributary stream systems meet only about 20 per cent of the present water requirements. The primary reason for this condition is that the flows of these streams are at a minimum during the periods of maximum demand. However, flows of the tributary streams are a primary source of replenishment of the ground water basin which meets about 80 per cent of the present water requirement.

The extreme variation of seasonal flows of the tributary streams is characterized by that of the American River. Seasonal estimates of the natural runoff of the American River at Fair Oaks, as it would be if unaltered by upstream diversion, storage, import, export, or change in upstream consumptive use of water caused by development, are included in State Water Resources Board Bulletin No. 1, "Water Resources of California". These estimates for the maximum, minimum, and median seasons are depicted graphically on Plate 3 of the main report. As shown on this plate, the estimated maximum natural seasonal flow of the American River, in 1906-07, was more than 10 times as large as the minimum, in 1923-24. Variations of flow within seasons are also very large. The maximum recorded instantaneous discharge was 180,000 second-feet on November 21, 1950, and the minimum recorded flow was 3.6 second-feet on August 16, 1924. Estimated mean monthly distribution of the natural flow of the American River at Fair Oaks is presented in Table A-3.

TABLE A-3

ESTIMATED MEAN MONTHLY DISTRIBUTION OF NATURAL FLOW OF AMERICAN RIVER AT FAIR OAKS

Month	Runoff, in acre-feet	Per cent of seasonal total
October	25,000	0.9
November	61,000	2.2
December	136,000	4.9
January	275,000	9.9
February	347,000	12.5
March	433,000	15.6
April	502,000	18.1
May	555,000	20.0
June	324,000	11.7
July	83,000	3.0
August	19,000	0.7
September	14,000	0.5
TOTALS	2,774,000	100.0

Inflow

As was explained earlier in this section, it was necessary to assume that the Area of Ground Water Study in its ultimate stage of development would receive its entire water supply from the American River and from direct precipitation, with no water from any other source. The water that would be supplied to the area of study by the American River under such conditions is referred to henceforth as inflow, or American River releases. An estimate of the mean seasonal inflow, taken from the Folsom Reservoir operation study in Table 94 of the main report is summarized in Table A-4.

The stream flow maintenance releases were based primarily on export considerations and also would satisfy the requirements set up by the California Department of Fish and Game. It was assumed that part of the stream flow maintenance releases would percolate to ground water, and that the remainder would be available for export from the Sacramento-San Joaquin Delta. The urban releases equal the estimated ultimate urban water requirement of hydrographic unit 28. It was assumed that the ultimate urban requirements of the other two hydrographic units would be met by pumping from the ground water basin, as at present. The firm irrigation releases would be furnished every year. The secondary irrigation releases would be made when available, from water conserved in the flood control zone of Folsom Reservoir after April 1st. The quantities of this class of water would be extremely variable, ranging from an estimated 1,137,000 acre-feet in the maximum year to zero in the minimum year. The releases

TABLE A-4

ESTIMATED ULTIMATE MEAN SEASONAL INFLOW TO AREA OF GROUND WATER STUDY FROM AMERICAN RIVER

Nature of release from Folsom Reservoir	Acre-feet	
Safe yield		
Stream flow maintenance	432,000	
Urban	252,000	
Irrigation	721,000	1,405,000
Secondary yield		
Irrigation	579,900	
Direct ground water replenishment	170,200	750,100
Spill		414,900
TOTAL INFLOW TO AREA		2,570,000

for direct ground water replenishment would be surplus waters that would otherwise spill and be wasted. These waters would be diverted and used as a source of direct ground water recharge up to an estimated rate of 90,000 acre-feet per month and 450,000 acre-feet per season. A graphical presentation of the foregoing releases from Folsom Reservoir is presented on Plates 14 and 15 of the main report.

Underground Hydrology

The Area of Ground Water Study overlies a portion of the ground water reservoir of the Sacramento and San Joaquin Valleys. Ground water replenishment to this reservoir presently occurs through infiltration of rainfall, subsurface inflow, percolation from surface streams, and infiltration from the unconsumed portion of applied irrigation waters. For the most part, free ground water exists throughout present zones of pumping, but locally there appear to be instances of confinement in certain depth zones.

Structure. Throughout most of the Area of Ground Water Study, surface and subsurface deposits from the Valley Springs formation to the Arroyo Seco formation dip gently in a direction slightly south of west. This dip is believed to be due to the tilting of the Sierra Nevada block during the Pleistocene epoch. The sediments of the Victor formation are relatively flat-lying. Incomplete information from petroleum geologists reveals the presence of two arches, and at least one probable fault, that disturb the regional dip. Information is

lacking on the size and nature of these structures, but it is believed that they occur at a depth great enough to have little or no effect on the movement of ground water within the zones considered in this study.

Movement of Ground Water. As was stated, ground water enters the water-bearing formations of the Area of Ground Water Study by percolation of water from surface streams, by deep penetration of precipitation and unconsumed applied water, and to a lesser degree by subsurface inflow along some reaches of the eastern edge of the area.

Movement of ground water is in a general westerly direction throughout most of the area of study, as shown on Plate A-5, "Lines of Equal Elevation of Ground Water, Fall of 1952", and Plate A-6, "Lines of Equal Elevation of Ground Water, Spring of 1953". A marked cone of depression exists under the area of the City of Stockton, and another north-south-trending depression extends southward from Florin to Bruceville. The water level contours suggest that considerable ground water recharge is contributed by the Mokelumne River. It appears that the Cosumnes River also contributes to the ground water body in the area between Elk Grove and Galt. Other sources of recharge by stream seepage are the American River from a point near Fair Oaks to a point near the confluence with the Sacramento River, and the Sacramento River in the area between Freeport and Courtland.

Specific Yield and Ground Water Storage Capacity. The term "specific yield", when used in connection with ground

water, refers to the ratio of the volume of water a saturated soil will yield by gravity to its own volume, and is commonly expressed as a percentage. Estimates of specific yield and gross storage capacity of the sediments of ground water units of the Area of Ground Water Study to a depth of 200 feet have been made by the United States Geological Survey and the Division of Water Resources. This was done by the Division in connection with the San Joaquin County Investigation for the State Water Resources Board. Division estimates were also made for the area bounded by the Cosumnes River and Dry Creek. The Geological Survey made its estimates for the entire Sacramento Valley in cooperation with the Division. The ground water storage units, as defined in these various studies, are delineated on Plate A-7, "Ground Water Storage Units". Table A-5 lists the units and the estimates of specific yield and storage capacity for each.

Usability of Ground Water Storage Capacity. The portion of the total storage capacity in a ground water basin that can be shown to be capable of being dewatered during periods of deficient surface supply, and capable of being resaturated during periods of excess surface supply may be considered as the usable storage capacity. Obviously, the amount of the usable capacity is limited by the inability either to withdraw water or to replenish the basin at rates sufficient for cyclic operation. Water quality factors may further reduce the amount of the gross storage capacity that can be classed as usable. If the ground water in storage is so related to bodies of low

TABLE A-5

ESTIMATED CHARACTERISTICS OF GROUND WATER STORAGE UNITS IN THE AREA OF GROUND WATER STUDY

Unit (Number on Plate A-7)	Area, in acres	Weighted average specific yield, in per cent — Depth zone from ground surface, in feet				Average specific capacity, in gallons per minute per foot of drawdown	Weighted average gross storage capacity, in thousands of acre-feet — Depth zone from ground surface, in feet				Extraction potential, in per cent	Recharge potential, in per cent	Quality potential, in per cent	Usability factor, in per cent	Usable storage capacity, in thousands of acre-feet
		20-50	50-100	100-200	20-200		20-50	50-100	100-200	20-200					
A-2	9,630	11.8	11.2	7.6	9.3	55	34	54	73	161	95	95	100	95	153
A-6	4,040	9.7	10.0	8.6	9.2	50	12	20	35	67	95	95	100	95	64
A-7	6,690	13.3	8.6	6.5	8.2	45	27	29	43	99	95	95	100	95	94
A-8	10,010	5.1	7.8	4.8	5.7	48	15	39	48	102	95	95	100	95	97
A-9	4,020	9.8	8.3	6.2	7.4	34	12	16	25	53	90	95	100	90	48
B-2	127,010	9.9	7.3	6.0	7.0	51	379	463	759	1,601	95	80	90	80	1,281
B-12	16,640	6.2	5.6	4.9	5.3	46	31	47	81	159	95	80	90	80	127
B-13	56,740	5.4	7.9	6.3	6.6	45	92	224	358	674	95	80	100	80	539
C-1	73,490	7.1	6.2	7.1	6.8	37	156	226	524	906	90	75	100	75	680
C-4	141,600	5.5	5.8	6.3	6.0	35	233	407	888	1,528	90	75	90	75	1,146
C-9	77,750	5.8	6.3	6.2	6.2	32	135	245	482	862	90	75	100	75	647
Western Mokelumne[1]	74,910	6.8	6.1	5.9	6.2	77	125	224	217	566	95	95	90	90	509
Eastern Mokelumne[2]	110,770	7.1	7.3	7.9	7.6	73	196	406	867	1,469	95	80	100	80	1,175
Calaveras[2,3]	86,900	5.8	6.9	7.1	6.6	81	125	299	536	960	95	80	90	80	768
Littlejohns[2]	94,460	7.0	7.0	7.0	7.0	84	166	331	664	1,161	95	80	100	80	929
TOTALS	894,660									10,368					8,257

1 - For depth zones 25'-50', 50'-100', 100'-150', and 25'-150'.
2 - For depth zones 25'-50', 50'-100', 100'-200', and 25'-200'.
3 - Storage capacity for 10,000 acres in western part of area estimated for 25'-100' depth range.

quality water, use of the under ground storage capacity should be correspondingly limited. If the lowering of ground water levels, and the resultant reduction in outflow from the basin would cause mineralization of the water in storage to the point that it becomes unusable, then this degree of extraction should not be permitted.

Table A-5 shows the estimated ground water storage capacity by units within the Area of Ground Water Study, and the limitations placed upon its usability for the reasons indicated. It may be noted that in most cases the limiting factor is the inability to recharge the aquifers.

Yield of Wells. An estimate of the ability of the ground water reservoirs in the area of study to yield water to wells under conditions of ultimate development was made possible by use of available pump test data. In Sacramento County, the data were obtained from the Sacramento Municipal Utility District. Similar data for San Joaquin County were furnished by the Pacific Gas and Electric Company.

From these data a map was prepared showing the specific capacity of wells in the Area of Ground Water Study. The term "specific capacity" refers to the number of gallons of water per minute produced by a pumping well per foot of drawdown. Lines of equal specific capacity were drawn, and a weighted average value was determined for each ground water unit. These estimates of weighted average specific capacities are presented in Table A-5. In order to estimate yields that could be expected from wells under ultimate conditions, the well having the

highest specific capacity in each 640-acre section was used to represent the average well characteristics for ultimate conditions in the section. It was considered reasonable to expect these more favorable average well characteristics in the future, in the light of the present interim stage in the development of well hydrology and construction methods. A study of these better yielding present wells indicated that extraction of water from similar wells to meet estimated maximum rates of future demand could be made without undue difficulty.

Safe Ground Water Yield. The term "safe ground water yield" refers to the maximum rate of extraction of water from a ground water basin which, if continued over an indefinitely long period of years, would result in the maintenance of certain desirable fixed conditions. Commonly, safe ground water yield is determined by one or more of the following criteria.

1. Mean seasonal extraction of water from the ground water basin does not exceed mean seasonal replenishment to the basin.

2. Water levels are not so lowered as to cause harmful impairment of the quality of the ground water by intrusion of other water of undesirable quality, or by accumulation and concentration of degradants or pollutants.

3. Water levels are not so lowered as to imperil the economy of ground water users by excessive costs of pumping from the ground water basin, or by exclusion of users from a supply therefrom.

In this ground water study, the first listed criterion defined the safe ground water yield. The second criterion placed limitations on the usable ground water storage capacity, and the third was taken into account by assuming certain limits of pumping depth. It is possible that legal considerations might modify the safe ground water yield, but the actual physical quantity would be determined by utilizing the three criteria listed above.

Estimated mean seasonal replenishment, which equals the estimated mean seasonal safe yield, of ground water storage in the Area of Ground Water Study is presented in Table A-6. The actual ultimate replenishment to the area of study would probably be higher than the values derived in the current estimates by the amount of seepage from channels of tributary streams other than the American River. The quantity of deep penetration of precipitation as estimated for the study is, as is subsequently developed, believed to be a minimum value, and any excess over this amount would add directly to the safe ground water yield.

Quality of Water

In the planned conjunctive operation of surface and subsurface reservoirs, provision must be made for the export of a portion of the water involved in order to prevent a gradual build-up of mineral salts in the ground water basin and to maintain a desirable water quality. In the Area of Ground Water Study the only limiting factor foreseen, as regards water quality, is a concentration of mineral salts. The amount of outflow

TABLE A-6

ESTIMATED MEAN SEASONAL SAFE GROUND WATER YIELD OR REPLENISHMENT OF GROUND WATER STORAGE IN AREA OF GROUND WATER STUDY

(In acre-feet)

Source	:Replenishment
Applied irrigation water	576,700
Applied urban water	54,300
Stream flow maintenance releases, American River	63,600
Direct ground water recharge	170,200
Precipitation	100,000
SAFE GROUND WATER YIELD	964,800

from the area required to maintain salt balance would be dependent upon the quality of the surface water supply, as well as the amount of soluble salts in the formations comprising the ground water storage space.

Surface Water Quality. The mineral quality of surface water that emanates from the watersheds to the east of the Area of Ground Water Study is excellent. The waters of the American River are among the highest in mineral quality in the Central Valley. An increase in upstream irrigation might cause a slight increase in total salt concentrations in the waters. However, there is no reason to believe that this water from the Sierra Nevada will significantly change in quality under conditions of ultimate development.

Some surface waters that lie to the west of the Area of Ground Water Study in the Delta channels will probably be unsatisfactory in quality for irrigation purposes under ultimate conditions. The Delta channels will probably carry return flows from the vast irrigated areas of the San Joaquin Valley. Though these inferior return waters would probably not be used in the area of study, the contemplated cyclic dewatering of the ground water basin beneath the area of study would tend to induce inflow of these poor quality waters into the ground water basin.

Ground Water Quality. Ground water of excellent mineral quality occurs generally throughout the Area of Ground Water Study. This is indicated on Plate A-8, "Lines of Equal Concentration of Chlorides in Ground Water".

Lines of equal elevation of water in wells in the Area of Ground Water Study, shown on Plates A-5 and A-6, indicate some localities where significant lowering of ground water levels has occurred in recent years. These localities were studied to determine whether or not salinity problems have developed as a result of the lowering.

In two relatively small areas some wells were found to contain waters with excessive concentrations of mineral solubles. One such area is in the vicinity of Lincoln, where the source of degradation is believed to be marine sediments that underlie the area at varying depths. In this case, however, an area that yielded only ground water of poor mineral quality could not be delimited. Nevertheless, it was considered necessary to limit the estimated usable ground water storage capacity in this area to that available in the alluvial deposits which overlie the marine sediments.

The other local area where ground water usability is limited by mineral quality is that just east of the City of Stockton. Prior investigations have suggested limiting ground water withdrawal to a depth of 100 feet in this locality because of the underlying highly saline waters.

The indications are that a depositional barrier exists at the fringe of the Delta area that effectively resists subsurface movement of water from the Delta into the ground water basin underlying the Area of Ground Water Study. The extent of this lithologic barrier to the north and south of the Stockton area has not been determined. In addition to the resistance furnished by this barrier, degradation of ground water quality

in the area of study would be further inhibited by pumping from that portion of the ground water basin bordering the source of saline waters, and wasting the pumpage to the Delta. Such pumping would remove both the mineralized ground water and some of the induced surface water infiltrate from the Delta.

The foregoing limiting factors served as a basis for estimating the usable ground water storage capacity of the Area of Ground Water Study with respect to water quality. The estimated percentage of usable storage capacity for each ground water unit in the area of study is shown in Table A-5 under the heading "Quality potential".

The water quality studies conducted for this investigation disclosed no serious threat to the planned ultimate water resource development of the American River. The ground water of the Area of Ground Water Study is generally of excellent mineral quality, with the exception of two localities where simple precautions should prevent degradation of the usable ground water supplies. If the quality of water in these or other localities should deteriorate under the plan of conjunctive operation, it is probable that ground water pumping could be decreased in the affected localities, and that pumping to greater depths in the remainder of the area of study could be effected in order to provide the required amount of ground water storage capacity.

Water Requirements

The present water requirements of the Area of Ground Water Study were estimated in State Water Resources Board

Bulletin No. 2 by the application of appropriate unit factors of consumptive use of applied water and water service area efficiencies to the pattern of present land use. The probable ultimate water requirements were similarly estimated, by the use of an ultimate pattern of land use projected from the present pattern on the basis of land classification data. It was assumed that under ultimate conditions of development, all irrigable lands would be developed as water-using areas. The estimates of present and probable ultimate water requirements, as set forth in State Water Resources Board Bulletin No. 2, are presented in Table A-7.

Ground Water Replenishment

Under the plan for conjunctive operation of surface and ground water reservoirs, ground water replenishment in the Area of Ground Water Study would be made up of deep percolation of water applied for irrigation, direct ground water recharge using surplus surface flows of the American River, deep percolation of precipitation on the overlying lands, seepage from the American River, and deep percolation of water delivered for urban use. It was estimated that the ultimate mean seasonal ground water replenishment from these sources would total about 965,000 acre-feet, as is shown in Table A-6, and illustrated on Plate 15 of the main report. Brief discussions of each of the sources of ground water replenishment, and of the estimated quantity from each source, are presented in the ensuing paragraphs.

TABLE A-7

ESTIMATED PRESENT AND PROBABLE ULTIMATE MEAN SEASONAL CONSUMPTIVE USE OF APPLIED WATER AND WATER REQUIREMENTS IN AREA OF GROUND WATER STUDY

(In acre-feet)

Land use	Hydrographic unit 28 (Carmichael)		Hydrographic unit 61 (Stockton)		Hydrographic unit 62 (Ione)		Totals	
	Present	Ultimate	Present	Ultimate	Present	Ultimate	Present	Ultimate
Consumptive use of applied water								
Irrigated lands	103,600	342,800	321,200	789,400	9,000	201,300	433,800	1,333,500
Farmsteads	800	1,400	2,700	3,500	700	1,000	4,200	5,900
Urban and suburban	28,800	126,000	12,200	54,200	100	900	41,100	181,100
Unclassified	2,000	2,000	0	0	0	0	2,000	2,000
TOTALS	135,200	472,200	336,100	847,100	9,800	203,200	481,100	1,522,500
Water requirements								
Irrigated lands	159,400	571,300	803,000	928,700	22,500	335,500	984,900	1,835,500
Farmsteads	1,600	2,800	5,400	6,900	1,300	2,000	8,300	11,700
Urban and suburban	57,600	252,000	24,400	108,400	200	1,800	82,200	362,200
Unclassified	2,000	2,000	0	0	0	0	2,000	2,000
TOTALS	220,600	828,100	832,800	1,044,000	24,000	339,300	1,077,400	2,211,400

Deep Percolation of Irrigation Applications

In the Central Valley, ground water recharge resulting from deep penetration accompanying the application of irrigation waters is highly significant for two reasons: first, under favorable conditions, relatively large quantities of water are recharged; and second, there is little or no effort or expense attributed to the recharge operation. However, expense might be incurred in connection with this means of recharge in an area of surface water service that varies in extent each year according to the amount of surface water available. In such a case, part of the service area must at times be served by surface water, and at other times by ground water, entailing the construction and operation of a distribution system that is capable of delivering water from either source.

For purposes of this study, deep percolation of applied irrigation water was considered to be that portion of the applied water that percolates below the plant root zone, and then passes into storage in the ground water body. Under the usual irrigation conditions, deep percolation may vary in amount from 20 to 60 per cent of the applied irrigation water. Common irrigation practices are extravagant of developed water in the sense that much more water is applied to the surface of the land than can be consumed by the plant. Irrigation efficiency is the ratio of consumptive use of applied irrigation water to the total amount of water applied, expressed as a percentage. In the Central Valley, irrigation efficiencies commonly range from 40 to 70 per cent, with extremes of 25 to 90 per cent, and an over-all average of perhaps 50 per cent.

In the Area of Ground Water Study an ultimate irrigation efficiency of 60 per cent was assumed. By studying the surface and subsurface drainage characteristics of soils within the area, it was estimated that about 64 per cent of the unconsumed applied water would percolate to the ground water body. Then, assuming that the surface runoff from an irrigation application could be recaptured and be used once again, it was estimated that for every 100 acre-feet of irrigation water initially applied to the land, the following would be its disposition.

Initial irrigation application - 100 acre-feet	
Consumptive use	60 acre-feet
Deep percolation	24 acre-feet
Surface runoff (captured)	16 acre-feet
Reapplication - 16 acre-feet	
Consumptive use	10 acre-feet
Deep percolation	4 acre-feet
Surface runoff (lost)	2 acre-feet

Thus, in terms of the initially applied irrigation water the ultimate service area efficiency would be about 70 per cent, with some 28 per cent of the applied water percolating to ground water, and 2 per cent flowing from the Area of Ground Water Study as an irrecoverable loss to the area. Therefore, of the estimated 2,060,000 acre-feet of water per season that would ultimately be applied to irrigable lands within the area of study, it was estimated that some 577,000 acre-feet would percolate to the ground water body seasonally.

The foregoing estimate represents an average for the entire Area of Ground Water Study. Because a large part of the irrigable lands of the area are underlain with hardpans of the Redding and San Joaquin series, additional data were collected to justify and verify the estimates of deep percolation of

applied irrigation water through these hardpan soils. As a result of the experience of representatives of several irrigation districts on the east side of the San Joaquin Valley, it was concluded that little or no water percolates through continuous nonfractured hardpans. It was also concluded that where the hardpan is fractured or discontinuous, a considerable amount of percolation takes place.

The hardpans of the area are strongly developed, and are derived from old alluvial deposits of the Sierra Nevada. However, a field inspection of railroad and highway cuts throughout the area indicated that the hardpans are lenticular and discontinuous. An indication of the amount of percolation that takes place through the iron-cemented hardpans, which are typical of the San Joaquin series, was found from the results of seepage loss tests along Coon Creek and Auburn Ravine. These two streams are largely underlain by hardpans in the investigated reaches. The average seepage losses of water were found to be about 0.16 cubic foot per square foot of wetted surface per day. This rate appears to be very low. However, if it is applied to the estimated ultimate net irrigated acreage of the Area of Ground Water Study, the indicated total quantity of potential deep percolation exceeds 100,000 acre-feet per day.

Under the plan of conjunctive operation, an estimated 577,000 acre-feet of unconsumed applied irrigation water would have to be percolated in an area of 712,000 acres during an irrigation season of more than 200 days. From these figures it can be calculated that an average percolation rate of less than 0.004 foot per day would be needed. Even during July, the month

of heaviest application of irrigation water, the required weighted average percolation rate for the entire Area of Ground Water Study would be less than 0.006 foot per day. It is indicated that these rates could be achieved over large areas of even the tighter soils. Considering the more favorable soils over much of the area, it is considered probable that ground water replenishment by deep percolation of irrigation applications, in the amounts contemplated in the plan for conjunctive operation, could be achieved.

Direct Ground Water Recharge

For purposes of this study, direct ground water recharge was considered to be that replenishment of the ground water storage which is accomplished by diverting water from surface reservoirs that would otherwise be spilled, and by delivering the water to the land for the express purpose of recharging the ground water basin.

A number of methods of direct replenishment of ground water storage might be used in the Area of Ground Water Study. However, after investigation of various methods, it was determined that the most economic method for use in the area would be by means of stream channel seepage, and by spreading on the extensive areas of dredger tailings near the American River.

Stream Channel Seepage. This method of ground water replenishment is a natural one, and is relatively inexpensive. On the valley fill, which makes up the bulk of the Area of Ground Water Study, most stream channels percolate some of their

flow to the ground water. Conservative estimates indicate that under average present conditions the seepage to ground water from streams of the area, other than the American River, totals more than 135,000 acre-feet per season.

Under the ultimate plan of conjunctive operation, it is considered probable that the present rate of stream seepage would be at least trebled. This large increase in seepage would be accomplished by maintaining more nearly constant flows in the stream channels, and by lowering the average ground water levels. The primary cause of the increased seepage from stream channels would be the lowered water tables.

To more accurately estimate the probable ultimate seepage from stream channels, a greater knowledge of the relatively impervious strata underlying each stream would have to be obtained. However, from a study of sediments in the channel deposits of the American River, it was indicated that the most probable limiting factor to stream channel percolation, other than high ground water levels, is the less permeable strata that are found in characteristic channel deposits. On the basis of present knowledge, and notwithstanding the cited limiting factors, it was estimated that water at rates up to 600 second-feet, or 36,000 acre-feet per month, could be added to the ground water storage of the Area of Ground Water Study by seepage from stream channels.

Spreading on Dredger Tailings. Because of a general lack of inexpensive lands at lower elevation, with good infiltration and percolation characteristics, in the Area of Ground

Water Study, a survey was made of the rather extensive areas of dredger tailings to determine their usefullness for storage and eventual percolation of surplus flows of American River water. After field inspection and study of the topography, it was estimated that about one-half of the 16,600 acres of tailings would not be usable because of location, topography, or depth of the tailings. In the remaining 8,300 acres, it was determined that the average depth of dredging was about 70 feet. It was estimated that an average of approximately 50 feet of this depth would be usable for storage and deep percolation of water. With an estimated 20 per cent average porosity in the 50 effective feet, a storage capacity of over 80,000 acre-feet would be available. If 0.15 of a foot of depth per day were the maximum sustained rate at which water would flow from the gravels into the ground water reservoir, then 38,000 acre-feet of water per month could be placed in ground water storage. The foregoing rate is probably conservative.

After a study of the availability of surplus surface waters, it was concluded that a limit of five months should be placed on the direct recharge operations in order to simplify the conjunctive operation criteria. Based on the foregoing conclusions and estimates, the following total quantities of water could probably be used to replenish the ground water storage of the area of study during the five-month direct recharge period.

From stream seepage at 36,000 acre-feet per month	180,000 acre-feet
From storage in dredger tailings	80,000 acre-feet
From percolation of water in dredger tailings at 38,000 acre-feet per month	190,000 acre-feet
TOTAL	450,000 acre-feet

Thus, the estimated potential rate of direct ground water recharge would be about 90,000 acre-feet per month or 1,500 second-feet.

Deep Percolation of Precipitation

Early in the study of ground water replenishment in the Area of Ground Water Study, several independent estimates were made of the amount of deep percolation to the ground water of direct precipitation on the overlying lands. The results of these estimates varied from slightly more than 100,000 acre-feet per season to more than 300,000 acre-feet per season. Since any increase in the amount of deep percolation of precipitation would cause a corresponding increase in the safe ground water yield, it was decided that the 100,000-acre-foot figure would be used throughout the study, as it was the minimum and probably a conservative estimate. This minimum figure was determined by deducting the estimated consumptive use of precipitation and the estimated runoff of precipitation originating within the area of study from the total precipitation on the area, and by assuming that the difference would all percolate to ground water.

Seepage From the American River

Estimates of deep percolation from the American River in the Area of Ground Water Study, under present conditions, indicate that about 25,000 acre-feet of water per season is seeping into the ground water basin on both sides of the river. In order to obtain an estimate of possible increased seepage under ultimate conditions of development, a study was made of

the stream flow below Fair Oaks during the 57-year mean period as it would have been under present conditions, and another study as it would have been with full upstream development and conjunctive operation. Results of this study indicate that about 64,000 acre-feet of water per season would percolate to the ground water. Though this estimate is subject to revision as more data become available, it is felt that it represents a reasonable mean seasonal value of ground water replenishment by stream channel seepage from the American River.

Deep Percolation of Water Delivered for Urban Use

In urban areas of the Central Valley the applied or delivered water supply is disposed of by consumptive use, by sewage and surface outflow, and by deep percolation to the underlying ground water. Basic data collected from nine cities in the Central Valley, to determine urban consumptive use of water, was re-evaluated to determine sewage outflow including accretions of drainage water. The results were then checked against basic data of the Raymond Basin Reference, and a reasonable correlation was found. The results indicate that approximately 50 per cent of the water delivered to urban areas in the Central Valley is consumed, and that approximately 70 per cent of the unconsumed water flows out in the sewers. It was assumed that the remaining 30 per cent of the unconsumed water would percolate to the ground water basin. While this 30 per cent factor is not conservative, the quantities of water involved are small when compared with the whole water supply of the Central Valley. In the Area of Ground Water Study, deep percolation of water

delivered to urban areas would amount to only about 54,000 acre-feet per season under ultimate conditions of development.

Ground Water Draft

At the ultimate stage of development in the Area of Ground Water Study, with complete conjunctive operation, the ground water basin would be used to meet a part of the urban and irrigation requirements of the area. In addition, a quantity of water would be pumped from the ground water basin each year to prevent adverse conditions relating to salt balance in the ground water supplies. Mean seasonal quantities of ground water draft for these purposes are shown in Table A-8.

Pumping for Irrigation

Draft on the ground water basin for irrigation would vary widely from season to season, ranging from an estimated 202,000 acre-feet in the wettest season to 1,339,000 acre-feet in the dry seasons. As is illustrated on Plate 14 of the main report, the ground water basin would be used to augment the surface irrigation diversions, so that a constant seasonal supply would be provided. During the maximum month of the dry seasons approximately 4,750 second-feet would be the required rate of draft from the ground water supplies. Since this peak rate would occur during only one month of any dry season, and during only 10 seasons out of the 57-year mean period, it was assumed that no standby wells would have to be installed. Then, assuming a pumping rate of about 2 second-feet per well, approximately 2,375 wells would be required for the ultimate ground water draft

TABLE A-8

ESTIMATED ULTIMATE MEAN SEASONAL
DRAFT ON GROUND WATER IN
AREA OF GROUND WATER STUDY

Use	: Acre-feet
Irrigation	758,700
Urban	110,000
Salt balance	96,100
TOTAL	964,800

for irrigation in the Area of Ground Water Study. Existing wells would be used where practicable. However, because of lack of complete knowledge of existing installations, and in the interest of conservatism, it was assumed that all wells required for conjunctive operation would be new units.

It would be possible to reduce the peak pumping demands during the four peak months of a dry irrigation season by revising the schedule of surface water releases for irrigation so that all surface releases would be made during the four peak months. It was estimated that with such a revised schedule a reduction of up to 400 pumping units might be achieved.

Pumping for Urban Purposes

As was stated earlier, it was assumed that the urban water requirements of hydrographic unit 28 would be met from surface sources, while those of hydrographic units 61 and 62 would be met by water pumped from the ground water supplies. At the ultimate stage of development the water pumped to meet urban requirements would total an estimated 110,000 acre-feet per season, with a maximum constant pumping rate during the month of July of 228 second-feet. With wells of the same type and size as those assumed for irrigation pumping about 125 wells would be required to furnish the urban water during this maximum month. This includes a 10 per cent increase in the number of wells for standby purposes. Many of the existing urban wells in the Area of Ground Water Study could probably be integrated into the over-all pumping plan. However, the cost estimates for conjunctive operation include the full cost of the 125 urban wells.

Pumping for Salt Balance

It is generally conceded that depreciation of the quality of ground water can be caused by unfavorable conditions relating to salt balance. This condition is most pronounced where the water supply of a basin is largely utilized, or where there is little or no movement of ground water from the basin. Both of these conditions may exist at the ultimate stage of development in the Central Valley. Under such conditions, the salinity caused by even a relatively innocuous waste may build up over a period of years until the ground water becomes less suitable for beneficial use.

Practically no data are available on the quantities of pumpage necessary to prevent an adverse salt balance. Theoretical methods have been derived for estimating future changes in the quality of ground water by making assumptions as to the total dissolved solids to be found in the influent waters and the salts that might be leached out as the percolate descends through the soils. To obtain the basic data for a reliable estimate by these theoretical methods was beyond the scope of the present study. For this reason, in the preliminary studies of conjunctive operation, it was arbitrarily assumed that 10 per cent of the amount of the mean seasonal replenishment of ground water would be pumped to prevent an adverse salt balance.

Later, estimates of irrecoverable losses from the Area of Ground Water Study were obtained from basic data for State Water Resources Board Bulletin No. 2. These losses include sewage and surface outflows of water applied in urban and

agricultural areas as well as subsurface outflow and pumping for salt balance. The quantities of sewage and surface outflows of water applied in urban and agricultural areas were estimated and deducted from the total estimated irrecoverable losses of the area. The remainder, some 96,000 acre-feet of water per season, was considered to be the subsurface outflow and pumping for salt balance. After a study of the land configuration, slope of the water table, and the suspected presence of an impediment to subsurface flow at the edge of the Delta, it was assumed that the subsurface outflow would be negligible. Therefore, pumping to prevent an adverse salt balance would total some 96,000 acre-feet per season, or about 10 per cent of the mean seasonal ground water replenishment.

For the purposes of the ground water study, it was assumed that pumping for salt balance would be a constant seasonal amount. It was further assumed that this pumping would be done near the Delta, so that a flow pattern would be maintained from the upper reaches of the ground water basin toward the Delta. The water pumped for this purpose would be exported from the area of study, and would probably be used for salinity repulsion in the Delta. However, if the water should prove to be of sufficiently high quality, it might be put to many other beneficial uses. In this study it was assumed that water pumped to prevent an adverse salt balance in the ground water basin would be coordinated with sewage and surface outflows from applied urban and agricultural water to effect a nearly constant flow for salinity repulsion in the Delta. Such scheduling, demonstrated in Table A-9, would permit use of the well installations involved during the off peak pumping season.

TABLE A-9

ESTIMATED AVERAGE MONTHLY
IRRECOVERABLE LOSSES OF WATER FROM
THE AREA OF GROUND WATER STUDY

(In thousands of acre-feet)

Month	Pumping for salt balance	Surface outflow	Totals
October	10.6	11.4	22.0
November	13.5	7.8	21.3
December	13.5	7.2	20.7
January	13.5	7.0	20.5
February	13.6	6.4	20.0
March	13.3	8.2	21.5
April	8.8	13.2	22.0
May	4.1	17.9	22.0
June	---	23.6	23.6
July	---	25.2	25.2
August	---	23.2	23.2
September	5.2	16.8	22.0
TOTALS	96.1	167.9	264.0

Possibilities for Increased Safe Yield From Conjunctive Operation

The primary factor limiting safe yield from conjunctive operation of surface and ground water reservoirs appears to be the ability to replenish the ground water. Therefore, any method for increasing the quantity of replenishment will increase the conjunctive safe yield. Several methods of ground water replenishment are being used, have been experimented with, or have been proposed throughout the arid and semiarid regions of the world. Some of these were considered for use in the Area of Ground Water Study. A brief discussion of possible methods for increasing deep percolation from some of the previously discussed sources of ground water replenishment is presented in this section. It must be realized that the relative economics of the various methods would dictate the selection of those to be used for increasing ground water replenishment. Also, when the cost of such increased replenishment approaches or equals the cost of increased safe yield from surface storage, an evaluation of the relative economics would have to be made before selection of a course of action.

In addition to methods for increasing conjunctive safe yield by increasing the quantities of ground water replenishment, a study was made of the possibilities for increased conjunctive safe yield by revision of the operation of surface storage reservoirs.

Increased Ground Water Replenishment From Irrigation Applications

The amount of replenishment of ground water from applied irrigation water could be increased over that heretofore estimated by increasing the acreage irrigated from surface water supplies, and by increasing the quantity of irrigation applications. In the current study, the full irrigation requirements were not met directly by surface water supplies in even the maximum year of runoff because of economic limitations on the size of conveyance facilities. By increasing the size of the main conveyance unit so that the full irrigation requirements could be met from available surface water supplies, the conjunctive safe yield might be increased by as much as 110,000 acre-feet per season with an increase of 1,700 second-feet in the main canal capacity. Increasing the main canal capacity to meet the full irrigation requirements would, in effect, increase the area irrigated from surface water supplies.

In addition to increasing the conveyance capacity, the quantity of water applied could be increased during years of surplus surface flows. This could be accomplished during the early months of the irrigation season when the surplus waters would be available, and when the main canals would have excess capacity. With 712,000 net irrigated acres in the area of study, an increase of less than 0.25 foot of applied water per season should result in an increased replenishment to the ground water of about 100,000 acre-feet in those seasons that surplus surface water would be available. Such a program of over-irrigation would require the cooperation of irrigators, and would cause the

design capacities of the drainage and recapture system to be increased slightly.

Increased Direct Ground Water Recharge

Direct ground water recharge, as was defined earlier, is that water applied to the land for the express purpose of replenishing the ground water supplies. Several methods of artificial recharge of ground water basins are being used at the present time. The most common is by means of the spreading basin or percolation pond. Most of the presently used spreading basins are located on coarse-grained stream deposits. Experimental work on the infiltration rates of soils common to the San Joaquin Valley are being conducted in Kern County. Infiltration rate is the rate at which water will pass through the surface of the soil, commonly expressed in feet per day. Results of the experimental work indicate that average infiltration rates of over two feet per day might be obtained for periods up to 120 days under the most favorable conditions of excellent soils and subsurface structure. Rates of one foot per day could probably be sustained under good conditions. It is indicated that an over-all average of 0.5 foot per day would be a reasonable assumption for large areas with variable soil and subsurface conditions.

The term "spreading basin" is generally applied to ponds wherein the depth of water above the ground surface is less than two feet. Some experimentation has been done on the possibility of increasing the recharge rate per unit of area by increasing the depth of water. Insufficient data are available

to properly evaluate the effect of head on the recharge rate under natural conditions. Other experiments with soil conditioners, plants, and organic additives have been tried for the same purpose. Data available on these experiments show an increase in the infiltration rate for some of the materials tested. Almost all the tests for which data are available have been conducted on very small plots, and the results provide a good indication of possible infiltration rates. The validity of such tests, when applied to large-scale spreading operations, is doubtful, as subsurface conditions in the Central Valley frequently reduce percolation rates to less than the infiltration rates. More experimentation is needed before the possibilities of ground water recharge can be evaluated for spreading basins on common Central Valley soils.

Trenches, holes, shafts, and injection wells have all been tried in efforts to induce ground water replenishment. Under certain conditions these methods have proved to be successful. However, the cost of establishing the conditions required for successful operation might preclude the use of some of these methods. This is true of injection wells particularly. The primary objective of all these methods is to get the water below the impermeable surface and subsurface strata and into the aquifers. The most successful recharge operations using these methods have been effected when the recharge water had the same characteristics as the ground water. Most of the unsuccessful operations could trace their failure to one of these causes: physical contaminants in the water, microorganisms in the soil and/or water, or mechanical failure of the recharge facility. The mechanical difficulties can be overcome if sound engineering

principles are applied to the design of the facility. The physical contaminants can be filtered or precipitated from the water, and the microorganisms can be rendered ineffective by the addition of chlorine. It is probable that dependable, adequate recharge rates could be obtained for the subsurface recharge methods if sufficient experimentation were conducted to permit improvement and refinement of the methods. Almost all available test results from present installations are not applicable to conditions of subsurface structure existing in the Central Valley.

A special variation on the use of trenches has been proposed that would largely eliminate the need for special spreading basins and areas. The primary deterrent to rapid deep percolation in the Area of Ground Water Study is the presence of hardpans and clays in the top 60 feet of soil below the land surface. By penetrating below these impervious strata, this proposed method would establish direct contact between the aquifers and the artificial water supply. This method would involve gravel-filled trenches under the main conveyance canals of the area. The canals would be fully lined, and some means of conveying water from the center of flow to the gravels below would be provided every few hundred feet. Recently designed trenchers, with widths of cut up to 15 feet and depths of cut up to 40 feet, have made this method appear to be feasible. With average depths of canals cut of about 30 feet, the bottom of the gravel-filled trench would extend some 70 feet below the original ground surface on the average. It was estimated that water at rates up to 50 second-feet per mile of canal could be

diverted for direct ground water replenishment by this method in the Area of Ground Water Study.

Increased Deep Percolation of Precipitation

The quantity of precipitation that percolates to ground water will probably increase as the ultimate stage of development is approached. If presently undeveloped lands were cleared, with no other changes in the land being effected, it is probable that the runoff would increase, with an attendant decrease in deep percolation of precipitation. However, modern land development methods stress land leveling, contour plowing, terracing, and other changes in the land surface that effect a decrease in unit runoff. With such an indicated future decrease in runoff from the irrigable valley floor lands, it is probable that an increase in ground water replenishment from precipitation would result. This increase was not evaluated because of a lack of basic data. It is indicated, however, that this increase would be of relatively small magnitude when compared with the total amount of ultimate deep percolation.

Increased Seepage From the American River

The replenishment of the ground water by seepage from the American River could be increased by deepening the flow of the river in ponds. This method could also be used in other streams tributary to the Area of Ground Water Study. Such a plan would enhance the summer recreation potential of the streams involved. However, the cost of the necessary structures might preclude their use for the exclusive purpose of increasing

ground water replenishment. In addition, the flood control problems on the American River would probably be increased.

Increased Ground Water Replenishment From Water Delivered for Urban Use

If a program for the reclamation of sewage were established in the Area of Ground Water Study, and the water thus reclaimed were of sufficiently good quality, the effluent from the treatment plants could be put to beneficial use, or could be used to replenish the ground water supplies.

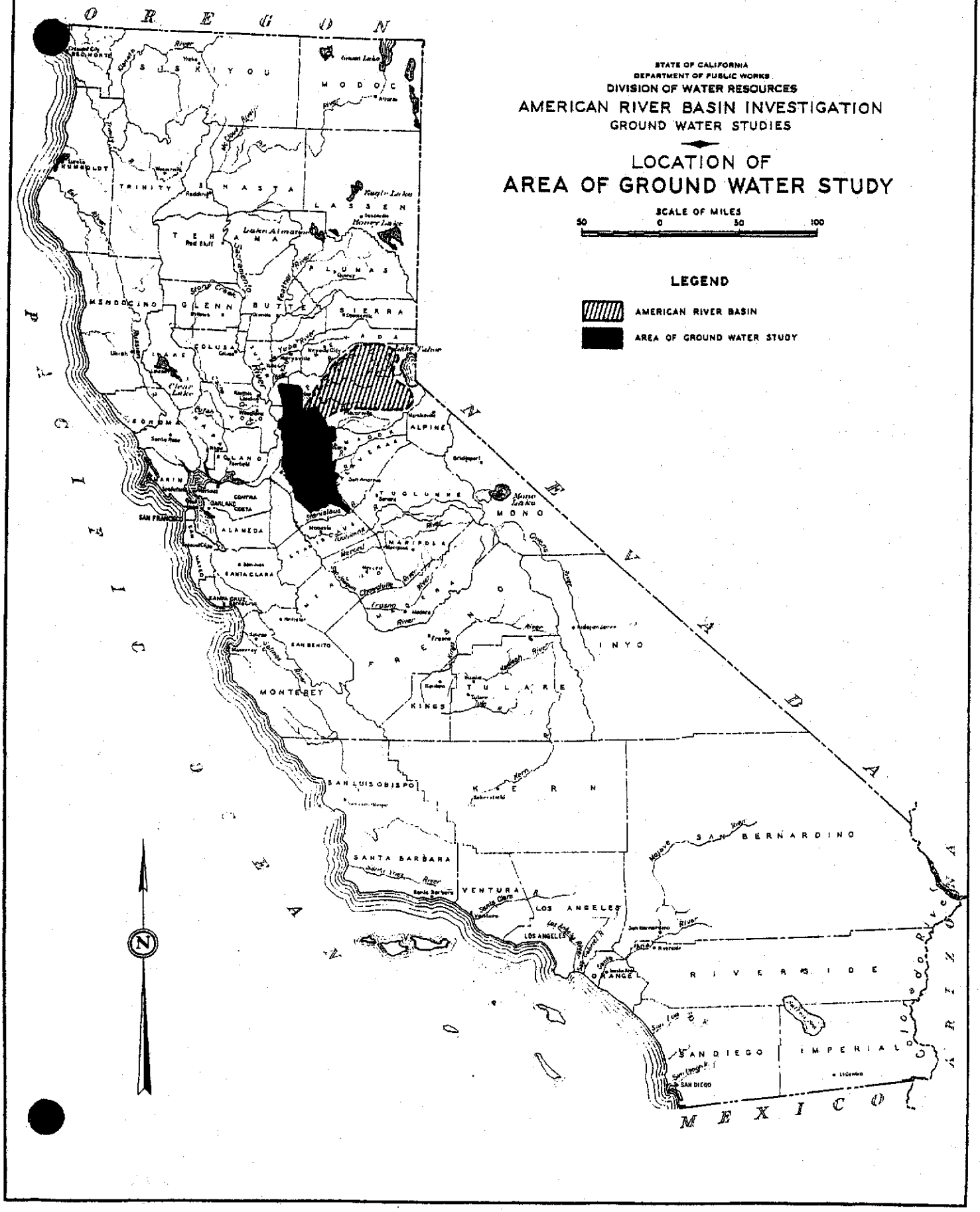
Increased Safe Yield From Revised Schedule of Operating Surface Reservoirs

By operating the downstream conservation reservoirs of the American River Basin on a fill-and-draw schedule, the conjunctive safe yield could be increased. Such a schedule would involve demands on the reservoirs that would empty them at the end of the irrigation season.

Under the plan of operation of Folsom Reservoir proposed in the main report, a partial fill-and-draw schedule would be maintained. Only 350,000 acre-feet of conservation space would be reserved for hold-over storage during drought periods, while 563,000 acre-feet of flood conservation and flood control space would be used seasonally to provide additional water to downstream service areas. Actually, there could be an infinite number of combinations of conservation and fill-and-draw space reservations, ranging from full conservation reservation to full fill-and-draw operation.

In order to increase the conjunctive safe yield, it was proposed that Auburn Reservoir would continue to furnish a firm urban and export supply of water, while Folsom and Salmon Falls Reservoirs would be operated on a fill-and-draw schedule. An analysis of this proposal was not made. However, in a preliminary study, with all proposed reservoirs above Folsom in existence and operating on the proposed ultimate demand schedule, Folsom Reservoir was operated on a fill-and-draw schedule. This study indicated 93 per cent conservation of the estimated inflow to Folsom Reservoir for the 57-year mean period.

The fill-and-draw schedule would have several disadvantages; including reduced firm power generation and recreational benefits, increased conveyance and distribution capacities, and increased pumping from ground water, all of which would tend to increase the cost of delivered water. The principal advantages of the method would be increased conjunctive safe yield, utilizing only the proposed storage capacity, and greater flood control. Economically the disadvantages would outweigh the advantages. However, if greater conservation of the flow of the American River should be needed, it could be obtained by utilizing fill-and-draw operation in any or all of the three lowest reservoirs in the basin. Based on the findings of the previously discussed study, it was estimated that over 95 per cent of the mean seasonal inflow to the lowermost reservoirs of the American River Basin could be developed if the available storage space were used for fill-and-draw operation.



STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

AMERICAN RIVER BASIN INVESTIGATION
GROUND WATER STUDIES

LOCATION OF
AREA OF GROUND WATER STUDY

SCALE OF MILES
50 0 50 100

LEGEND

AMERICAN RIVER BASIN

AREA OF GROUND WATER STUDY

Surface Water Supply of the United States 1954

Part 11. Pacific Slope Basins in California

Prepared under the direction of J. V. B. WELLS, *Chief, Surface Water Branch*

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1345

Prepared in cooperation with the States of California and Oregon and with other agencies

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1956

Georgetown ditch above Pilot Creek near Georgetown, Calif.

Location (revised).--Lat 38°56'18", long. 120°28'42", in SE¼ sec. 26, T. 13 N., R. 13 E., on left bank 0.7 mile northeast of Uncle Toms Cabin and 20 miles east of Georgetown.

Records available.--May 1947 to September 1954.

Gage.--Water-stage recorder and wooden control. Altitude of gage is 5,080 ft, revised (from topographic map). Prior to June 10, 1949, staff gage at same site at different datum.

Average discharge.--5 years (1949-54), 6.16 cfs (4,460 acre-ft per year).

Extremes.--1947-54: Maximum daily discharge, 27 cfs Aug. 15-19, 1949, Sept. 30, 1950; no flow for several months each year.

Remarks.--Records good except those for period of fragmentary gage-height record, which are poor. Ditch receives water from Loon Lake (capacity, 8,000 acre-ft) via Gerle Creek, Rubicon River basin, and at times from Little South Fork Rubicon River, and discharges into Pilot Creek. Flow is then diverted from Pilot Creek about 8 miles downstream, for domestic and irrigation purposes in vicinity of Georgetown (see Georgetown ditch near Georgetown on following page).

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	20							0	13	21	21	18
2	20							0	13	20	21	18
3	20							0	15	20	21	18
4	20							0	15	20	21	19
5	20							0	18	19	21	18
6	20							0	18	19	22	18
7	19							0	17	20	22	18
8	18							0	17	20	21	18
9	17							0	19	17	21	18
10	17					(*)		*0	19	20	22	18
11	17							0	18	20	22	18
12	17							0	18	19	22	18
13	17							1.0	18	20	22	17
14	17							2.6	17	20	22	20
15	16							2.5	18	20	22	22
16	16							2.3	15	21	22	21
17	16							1.6	14	22	22	19
18	15	(*)						1.1	15	23	22	19
19	15							.6	18	21	22	21
20	15							5.7	18	21	22	21
21	*13							8.8	14	21	22	21
22	f6							9.4	14	21	22	*21
23	0							8.0	2.6	21	22	21
24	0							9.5	3.0	20	21	18
25	0							*13	13	20	21	17
26	0							13	22	20	19	17
27	.1							13	22	*21	19	16
28	0							13	22	19	19	16
29	0		(*)					13	21	22	18	14
30	0							14	21	22	18	13
31	0							13		22	18	
Total	371.1	0	0	0	0	0	0	147.1	482.6	632	652	551
Mean	12.0	0	0	0	0	0	0	4.75	16.1	20.4	21.0	18.4
Ac-ft	736	0	0	0	0	0	0	292	957	1,250	1,290	1,090

Calendar year 1953: Max 20 Min 0 Mean 5.40 Ac-ft 3,910
Water year 1953-54: Max 23 Min 0 Mean 7.77 Ac-ft 5,620

* Discharge measurement or observation of no flow made on this day.
f Fragmentary gage-height record; discharge estimated on basis of recorder graph and records for Georgetown ditch near Georgetown and Pilot Creek near Georgetown.

Georgetown ditch near Georgetown, Calif.

Location (revised).--Lat 38°54'12", long. 120°36'12", near center of sec. 11, T. 12 N., R. 12 E., on left bank 1.0 mile downstream from intake and 12 miles east of Georgetown.

Records available.--February 1910 to January 1914, March 1947 to September 1954. Published as Pilot Creek ditch near Quintette, 1910-14.

Gage.--Water-stage recorder. Altitude of gage is 4,170 ft (from topographic map). February 1910 to January 1914, staff gage about 6 miles downstream at different datum.

Average discharge.--7 years (1947-54), 13.4 cfs (9,700 acre-ft per year).

Extremes.--1947-54: Maximum daily discharge, 32 cfs July 11, 1950; minimum daily, 0.1 cfs Nov. 14, 1951, Nov. 16-18, 1952.

Remarks.--Records good. Ditch diverts from Pilot Creek, about one mile above station on Pilot Creek, for domestic and irrigation use in vicinity of Georgetown. (See also Georgetown ditch above Pilot Creek, near Georgetown, preceding page.)

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	24	6.3	4.8	b4.8	4.1	3.8	2.6	11	26	28	25	25
2	25	6.5	4.8	b4.8	4.0	3.7	2.7	13	26	28	25	25
3	24	6.4	5.0	4.5	4.0	3.5	2.8	17	27	26	25	25
4	24	6.2	5.8	4.4	3.9	3.2	3.3	19	28	28	25	26
5	24	6.4	5.3	4.3	3.8	3.0	6.2	20	29	28	25	26
6	23	7.1	5.2	4.2	3.5	2.8	9.4	21	28	27	26	26
7	22	6.9	5.5	4.6	3.5	2.9	9.7	22	28	26	26	26
8	22	6.8	5.3	b4.3	3.8	*3.1	8.5	21	29	28	26	26
9	22	6.7	5.2	b4.3	3.6	7.8	7.6	23	29	27	26	25
10	23	6.9	5.1	4.1	3.4	9.5	6.6	*23	27	27	26	25
11	23	7.3	5.1	4.1	3.4	8.2	5.7	23	28	28	25	25
12	21	7.1	5.0	4.0	4.4	7.4	8.0	22	29	27	26	25
13	18	7.4	5.0	b4.0	8.9	6.2	4.4	21	29	27	26	25
14	18	8.2	5.0	4.1	7.8	5.4	3.9	22	28	26	26	26
15	18	7.7	5.0	4.0	6.1	4.7	3.5	22	28	27	26	26
16	18	6.6	5.0	4.1	5.6	4.4	3.1	21	28	27	26	26
17	16	5.4	5.0	4.5	8.9	4.0	2.8	19	28	27	26	27
18	17	5.3	5.0	4.4	6.8	3.5	2.8	18	27	27	26	26
19	17	*5.2	5.0	4.5	6.3	3.2	2.6	17	28	27	26	26
20	16	5.2	5.1	4.2	6.0	2.9	2.6	18	28	27	26	26
21	*16	5.2	5.1	4.1	5.6	2.8	2.5	25	26	28	26	26
22	13	5.2	5.1	4.2	5.2	2.7	2.3	26	27	28	25	25
23	15	5.1	b5.0	6.9	4.9	2.6	5.9	25	20	28	25	*24
24	8.2	5.1	4.9	7.9	4.7	2.5	9.8	24	10	27	25	25
25	7.4	5.0	4.9	5.8	4.5	2.4	9.5	*27	14	27	26	24
26	6.9	4.9	4.8	5.2	4.3	2.2	8.9	*28	27	28	27	24
27	6.7	4.8	4.9	4.8	4.1	2.2	15	27	29	27	27	23
28	6.5	4.8	4.9	4.6	4.0	2.2	16	27	28	23	26	23
29	6.5	4.8	b4.9	4.5	-	2.5	12	27	28	26	26	22
30	6.4	4.8	*b4.9	4.3	-	2.7	11	27	28	*26	25	20
31	6.3		b4.9	4.2	-	2.7	-	27	-	26	25	-
Total	513.9	181.6	156.6	144.2	136.3	120.4	188.5	683	795	843	788	751
Mean	16.6	6.05	5.05	4.65	4.87	3.88	6.28	22.0	26.5	27.2	25.7	25.0
Ac-ft	1,020	360	311	286	270	239	374	1,350	1,580	1,670	1,560	1,490

Calendar year 1953: Max 27 Min 0.7 Mean 12.4 Ac-ft 8,980
Water year 1953-54: Max 29 Min 2.2 Mean 14.6 Ac-ft 10,530

* Discharge measurement made on this day.
b Stage-discharge relation affected by ice.

Pilot Creek near Georgetown, Calif.

Location.--Lat 38°54'15", long. 120°36'10", in NW¼ sec. 11, T. 12 N., R. 12 E., on left bank 2.6 miles upstream from Mutton Canyon and 12 miles east of Georgetown.

Drainage area.--15.1 sq mi.

Records available.--February 1910 to July 1914, January 1946 to September 1954. Published as "near Quintette" 1910-14.

Gage.--Water-stage recorder. Altitude of gage is 4,100 ft (from topographic map). February 1910 to July 1914, staff gage at site 1.9 miles downstream at different datum. Jan. 1, 1946, to June 25, 1952, at site 300 ft downstream at datum 5.67 ft lower.

Average discharge.--8 years (1945-54), 27.7 cfs (20,050 acre-ft per year).

Extremes.--Maximum discharge during year, 252 cfs Mar. 10 (gage height, 4.27 ft); minimum, 0.5 cfs Sept. 27.
1946-54: Maximum discharge, 3,040 cfs Nov. 18, 1950 (gage height, 10.84 ft in gage well, 13.3 ft outside, from floodmarks, site and datum then in use), from rating curve extended above 150 cfs on basis of slope-area determination of peak flow; minimum, 0.3 cfs Oct. 28 to Nov. 7, 1949.

Remarks.--Records good. Some inflow and diversion above station (see records for Georgetown ditch above Pilot Creek near Georgetown, p. 450, and Georgetown ditch near Georgetown, preceding page, which diverts about 1 mile above station).

Revisions.--WSP 1215: Drainage area.

Rating table, water year 1953-54 (gage height, in feet, and discharge, in cubic feet per second)

1.5	0.6	2.3	15
1.6	1.2	2.6	28
1.7	2.1	3.0	57
1.8	3.2	3.5	109
2.0	6.5	4.1	212

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1.1	0.7	4.7	3.6	15	39	44	24	3.2	1.7	1.0	0.8
2	1.1	.7	4.2	4.1	15	37	47	21	2.6	1.6	1.0	.8
3	.9	.7	7.4	5.6	14	35	49	14	2.4	1.6	.9	.8
4	.9	.7	22	5.4	14	34	54	11	3.5	1.5	.9	.8
5	.9	.8	10	4.7	14	32	95	9.4	6.1	1.5	1.0	.8
6	1.1	4.1	9.0	4.9	13	31	118	7.3	8.0	1.4	1.0	.7
7	1.4	2.7	13	9.2	13	30	100	6.3	6.7	1.4	1.0	.7
8	1.4	1.8	9.2	6.3	13	*40	114	5.6	6.7	1.4	1.0	.7
9	1.3	1.4	8.2	5.7	13	207	83	6.5	11	1.4	1.0	.7
10	1.9	2.5	7.3	5.9	13	208	76	*5.2	10	1.3	.9	.7
11	2.8	5.2	6.7	5.6	12	118	70	3.5	8.7	1.3	.9	.7
12	3.3	4.2	6.1	5.2	30	92	66	3.1	7.8	1.3	.9	.7
13	5.2	4.7	5.9	4.7	94	79	62	2.6	8.7	1.3	.9	.7
14	5.2	17	5.7	4.7	74	70	60	2.6	6.9	1.3	1.0	.7
15	5.0	9.7	5.7	4.7	57	63	57	2.5	5.7	1.3	1.1	.7
16	4.7	6.9	5.7	5.2	49	60	54	2.3	5.0	1.2	1.0	.8
17	5.6	8.7	5.6	9.7	71	55	52	2.3	3.5	1.1	1.0	.8
18	15	6.7	5.6	10	70	49	48	2.2	3.0	1.1	.9	.8
19	12	*6.3	5.6	8.7	61	47	45	2.0	3.1	1.0	.8	.8
20	8.7	6.5	6.3	7.5	57	44	43	1.9	3.5	1.1	.8	.8
21	*7.5	5.7	5.6	7.1	51	42	41	2.2	3.2	1.1	.8	.7
22	4.1	7.5	4.9	7.3	48	40	39	2.3	2.3	1.0	.9	.7
23	6.1	8.7	4.4	100	45	39	51	1.8	2.0	1.0	.8	*.7
24	1.4	8.7	4.4	70	44	39	26	1.6	1.4	1.0	.8	.7
25	1.1	7.5	4.2	39	44	36	25	*2.1	1.2	1.1	.9	.6
26	.9	6.7	3.9	28	43	35	24	*2.6	1.3	1.1	.9	.6
27	.9	6.3	3.9	22	41	36	38	3.4	1.8	1.1	1.0	.7
28	.8	5.6	3.8	20	40	37	39	3.2	1.9	1.1	1.0	.7
29	.8	5.0	3.6	18	-	42	51	3.1	1.8	1.0	.9	.8
30	.7	4.9	*3.4	16	-	45	28	3.2	1.7	*1.0	.9	.8
31	.7		3.5	16		44		3.5		1.0	.8	
Total	104.5	158.4	199.5	463.8	1,068	1,803	1,659	164.3	134.5	38.5	28.8	21.9
Mean	3.37	5.28	6.44	15.0	38.1	58.2	55.3	5.30	4.48	1.24	0.93	0.73
Ac-ft	207	314	396	920	2,120	3,580	3,290	326	267	76	57	43

Calendar year 1953: Max 162 Min 0.7 Mean 24.6 Ac-ft 17,810
Water year 1953-54: Max 207 Min 0.6 Mean 16.0 Ac-ft 11,600

Peak discharge (base, 150 cfs).--Jan. 23 (4:30 p.m.) 152 cfs (3.80 ft); Mar. 10 (4:30 a.m.) 252 cfs (4.27 ft).
* Discharge measurement made on this day.

Middle Fork American River near Auburn, Calif.

Location.--Lat 38°55'05", long. 121°00'20", in SE¼ sec. 6, T. 12 N., R. 9 E., on left bank at abandoned plant of Mountain Quarry Co., 1.9 miles upstream from mouth and 3.5 miles northeast of Auburn.

Drainage area.--619 sq mi.

Records available.--October 1911 to September 1954.

Gage.--Water-stage recorder. Datum of gage is 568.5 ft above mean sea level (river-profile survey). Prior to December 1930, staff gage at site half a mile downstream at different datum.

Average discharge.--43 years, 1,399 cfs (1,013,000 acre-ft per year).

Extremes.--Maximum discharge during year, 22,600 cfs Mar. 9 (gage height, 18.65 ft); minimum, 57 cfs Sept. 30.
1911-54: Maximum discharge, 68,500 cfs Nov. 20, 1950 (gage height, 34.7 ft, from floodmarks), from rating curve extended above 32,000 cfs on basis of slope-area determination of peak flow; minimum, 20 cfs Sept. 6, 1931, Sept. 19, 1934.

Remarks.--Records good. Small storage and diversions above station. See Remarks for Rubicon River near Georgetown.

Revisions (water years).--WSP 861: 1928.

Rating table, water year 1953-54 (gage height, in feet, and discharge, in cubic feet per second)

0.9	50	6.0	1,580
1.3	95	8.0	2,770
1.7	150	10.0	4,720
2.1	218	12.0	7,660
3.0	424	15.0	13,600
4.0	740	18.0	20,900

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	96	107	226	186	570	*1,330	1,840	2,490	890	377	112	77
2	95	109	218	184	835	1,260	1,800	2,210	882	367	108	75
3	95	112	218	195	670	1,180	1,870	2,490	870	343	105	71
4	94	112	611	228	666	1,150	1,970	2,640	922	324	102	69
5	91	114	408	209	642	1,140	6,410	3,070	902	309	99	68
6	89	137	298	204	621	1,170	6,770	3,190	842	300	98	67
7	88	171	377	271	618	1,170	4,800	3,420	761	284	98	67
8	87	146	411	350	628	1,530	3,840	3,610	716	269	96	67
9	85	130	320	278	652	18,200	3,330	3,690	800	254	94	67
10	88	133	293	254	624	14,200	3,140	2,680	768	246	93	68
11	105	164	282	*250	597	6,280	2,930	2,680	702	240	90	64
12	114	258	265	238	810	4,040	3,020	2,730	670	228	89	64
13	105	267	256	228	3,330	3,150	3,220	2,590	1,040	214	87	66
14	102	537	258	214	3,180	2,680	3,450	2,520	858	205	87	66
15	103	552	273	213	1,890	2,380	3,580	2,510	764	204	88	69
16	103	*390	300	282	1,360	2,260	3,870	2,480	754	200	88	72
17	102	348	300	1,270	1,990	2,100	4,410	2,790	778	189	88	73
18	121	313	293	868	3,280	1,860	3,490	2,870	691	180	87	71
19	200	262	289	455	2,070	1,850	4,240	2,840	642	172	85	69
20	179	273	304	385	1,700	1,790	3,970	2,680	628	166	82	68
21	152	236	480	336	1,490	1,800	3,870	2,320	652	160	82	65
22	135	224	408	313	1,370	1,720	4,220	1,760	684	160	82	63
23	128	313	315	3,340	1,350	1,730	4,400	1,480	665	153	81	63
24	126	583	271	3,940	1,440	1,760	3,870	1,430	638	146	77	62
25	126	585	262	1,710	1,490	1,640	3,680	1,330	591	140	75	61
26	122	441	242	1,100	1,540	1,530	3,490	1,200	537	139	83	60
27	112	343	226	846	1,480	1,520	4,530	*1,110	483	137	93	59
28	108	291	218	719	1,370	1,620	4,730	1,070	458	132	93	58
29	105	256	207	635	-	1,780	3,400	1,070	424	126	87	58
30	105	254	198	586	-------	2,380	3,010	1,010	393	122	82	58
31	107		193	567	-------	2,010		914		116	*79	
Total	3,468	8,039	9,220	20,652	38,043	90,190	112,150	70,874	21,403	6,602	2,791	1,983
Mean	112	268	297	666	1,359	2,909	3,738	2,286	713	213	90.0	66.1
Ac-ft	6,880	15,950	18,290	40,980	75,460	178,900	222,400	140,600	42,450	13,090	5,540	3,930

Calendar year 1953: Max 12,300 Min 85 Mean 1,434 Ac-ft 1,038,000
Water year 1953-54: Max 18,200 Min 58 Mean 1,056 Ac-ft 764,400

Peak discharge (base, 6,500 cfs).--Jan. 23 (7 p.m.) 7,220 cfs (11.60 ft); Mar. 9 (1 p.m.) 22,600 cfs (18.65 ft); Apr. 5 (2 p.m.) 7,830 cfs (12.15 ft); Apr. 27 (11 p.m.) 6,530 cfs (11.37 ft).
* Discharge measurement made on this day.

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North Fork American River at Rattlesnake Bridge, Calif.

Location (revised).--Lat 38°48'50", long. 121°05'35", in SW¼ sec. 9, T. 11 N., R. 8 E., on left bank 800 ft downstream from Rattlesnake Bridge, 3.6 miles downstream from Pilot Creek, and 6 miles south of Auburn.

Drainage area.--999 sq mi.

Records available.--November 1930 to September 1937, December 1938 to September 1954.

Gage.--Water-stage recorder. Datum of gage is 343.65 ft above mean sea level (river-profile survey).

Average discharge.--21 years (1931-37, 1939-54), 2,448 cfs (1,772,000 acre-ft per year).

Extremes.--Maximum discharge during year, 34,800 cfs Mar. 9 (gage height, 14.54 ft); minimum daily, 100 cfs Aug. 14-17, 23-25.
1930-54: Maximum discharge, 115,000 cfs Nov. 21, 1950 (gage height, 29.5 ft), from rating curve extended above 15,000 cfs on basis of previous rating curves defined below 70,000 cfs and summation of North and Middle Fork peak discharges; minimum, 6.5 cfs Aug. 15, 1931.

Remarks.--Records excellent except those for periods of fragmentary or no gage-height record, which are fair. Flow slightly regulated by small reservoirs above station; low flow greatly affected by diversions into North Fork ditch and inflow from Bear and Yuba River basins through South Canal of Pacific Gas & Electric Co.

Rating tables, water year 1953-54 (gage height, in feet, and discharge, in cubic feet per second)

Oct. 1 to Mar. 9				Mar. 10 to Sept. 30			
0.4	147	4.0	3,430	0.0	90	3.0	2,340
.7	251	6.0	7,240	.2	140	5.0	5,520
1.0	385	8.0	12,000	.5	240	7.0	9,740
1.5	695	10.0	17,500	1.0	500	10.0	17,500
2.0	1,070	13.0	28,400	1.5	870	13.0	28,400
3.0	2,110			2.0	1,300		

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	254	440	*745	878	1,320	2,070	4,170	4,340	1,450	482	118	158
2	178	*284	700	700	1,400	*2,010	4,020	3,900	1,490	514	118	153
3	196	245	760	730	1,450	1,910	4,020	4,250	1,410	422	118	184
4	284	296	1,470	708	1,450	1,850	4,150	4,280	1,440	380	118	250
5	262	221	1,120	643	1,400	1,800	10,700	4,980	1,460	360	118	194
6	288	207	880	678	1,350	1,790	11,800	5,160	1,460	335	118	162
7	291	263	974	768	1,310	1,800	8,530	5,500	1,270	325	115	171
8	280	218	1,090	974	1,360	2,110	6,960	5,780	1,260	300	115	204
9	272	179	926	872	1,380	*26,100	6,060	6,020	1,260	280	115	194
10	339	182	895	820	1,370	*25,900	5,650	4,510	1,250	272	115	190
11	299	221	880	*782	1,330	*11,900	5,270	4,410	1,120	280	110	202
12	391	342	828	760	1,640	7,740	5,290	4,440	1,010	*280	110	208
13	345	385	790	730	5,710	6,160	5,570	4,260	1,380	248	110	100
14	391	1,080	798	750	6,880	5,480	5,880	4,140	1,300	256	100	197
15	403	1,010	858	722	3,940	4,940	6,080	4,090	1,090	222	100	210
16	366	730	888	901	2,900	4,870	6,400	4,090	1,060	208	100	236
17	457	657	895	3,460	3,740	4,680	7,060	4,410	1,090	194	100	260
18	484	598	858	1,840	6,480	4,200	7,200	4,580	990	184	143	239
19	615	532	820	1,280	4,070	4,220	6,920	4,570	934	177	115	234
20	582	738	842	1,120	3,320	4,250	6,580	4,280	870	164	110	240
21	556	790	1,140	1,010	2,940	4,310	6,300	3,750	902	155	110	256
22	514	615	1,030	942	2,720	4,180	6,720	2,880	934	155	110	196
23	496	895	880	5,440	2,400	4,100	7,040	2,440	902	146	100	270
24	514	1,120	820	7,960	2,360	4,120	6,400	2,290	854	140	100	281
25	520	1,330	812	3,420	2,430	3,930	6,080	*2,260	798	135	100	278
26	520	1,080	790	2,330	2,450	3,610	5,720	1,960	710	138	160	275
27	508	880	738	1,890	2,390	3,540	6,980	1,870	633	138	206	268
28	498	820	715	1,640	2,180	3,680	7,540	1,790	591	132	208	276
29	490	768	692	1,470	-	3,880	5,880	1,760	542	122	179	247
30	490	760	678	1,380	-	5,140	5,070	1,650	488	184	206	253
31	484		671	1,320	-	4,570	-	1,520	-	122	174	-
Total	12,545	17,884	26,903	48,698	73,670	170,830	191,620	116,180	31,928	7,430	5,919	6,670
Mean	405	596	870	1,571	2,631	5,511	6,387	3,747	1,064	240	126	222
Ac-ft	24,880	35,470	53,520	96,590	146,100	338,800	380,100	230,400	63,330	14,740	7,770	13,230

Calendar year 1953: Max 17,800 Min 178 Mean 2,484 Ac-ft 1,799,000
Water year 1953-54: Max 26,100 Min 100 Mean 1,941 Ac-ft 1,405,000

Peak discharge (base, 12,000 cfs).--Jan. 23 (9 p.m.) 13,500 cfs (8.57 ft); Mar. 9 (12 m.) 34,800 cfs (14.54 ft); Apr. 5 (4 p.m.) 14,100 cfs (8.78 ft).
* Discharge measurement made on this day.
Note.--No gage-height record Aug. 11-17, 20-25; discharge estimated on basis of gradual recession. Fragmentary gage-height record Sept. 1-14, 18-23, 29-30; discharge computed from reconstructed gage-height graph.

Echo Lake conduit near Phillips, Calif.

Location.--Lat 38°50', long. 120°02', in NW¼ sec. 6, T. 11 N., R. 18 E., on right bank 0.5 mile downstream from intake and 2 miles northeast of Phillips.

Records available.--August 1923 to November 1954. August 1923 to November 1943 published as Echo Lake flume near Vade. September 1944 to November 1952 published as Echo Lake conduit near Vade.

Gage.--Water-stage recorder. Altitude of gage is 7,500 ft (from topographic map). Prior to July 16, 1929, staff gage at site 0.4 mile upstream at different datum.

Extremes.--1923-54: Maximum daily discharge, 28 cfs Sept. 9, 10, 1952; no flow during most of each year.

Remarks.--Records good. No flow except during periods for which discharge is published. Conduit diverts from Echo Lake in Truckee River basin into basin of South Fork American River for power and irrigation.

Cooperation.--Water-stage-recorder graph and four discharge measurements furnished by Pacific Gas & Electric Co., in connection with a Federal Power Commission project.

Discharge, in cubic feet per second, September to November 1954

Day	Sept.	Oct.	Nov.
1	0	0.5	1.4
2	0	6.8	1.2
3	0	6.0	1.2
4	0	6.4	1.1
5	0	*8.0	1.1
6			
7	0	5.2	1.0
8	12	5.8	.9
9	26	6.9	.8
10	28	6.3	.8
11	25	5.6	.5
12	25	5.1	.6
13	24	3.9	.1
14	24	2.8	0
15	23	4.8	0
16	24	5.1	0
17	*23	3.2	0
18	24	.4	0
19	23	.4	0
20	22	3.5	0
21	21	3.6	0
22	21	3.4	0
23	20	3.7	0
24	18	3.8	0
25	16	3.0	0
26	14	2.3	0
27	14	2.2	0
28	14	2.1	0
29	12	2.1	0
30	10	1.9	0
31	8.8	1.5	0
Total	469.8	123.2	10.7
Mean	15.7	3.97	0.36
Ac-ft	932	244	21

Calendar year : Max - Min - Mean - Ac-ft
Water season : Max - Min - Mean - Ac-ft 1,200

* Discharge measurement made on this day.

Medley Lakes Outlet near Phillips, Calif.

Location.--Lat 38°51', long. 120°08', in NW¼ sec. 32, T. 12 N., R. 17 E., on left bank 1 mile downstream from main dam at Medley Lakes and 5 miles northwest of Phillips.

Drainage area.--4.2 sq mi, approximately.

Records available.--September 1922 to September 1954. Prior to October 1952, published as "near Vade."

Gage.--Water-stage recorder. Altitude of gage is 8,100 ft (from topographic map).

Average discharge.--32 years, 17.6 cfs (12,740 acre-ft per year).

Extremes.--Maximum discharge during year, 58 cfs June 23 (gage height, 1.90 ft), minimum daily not determined.
1922-54: Maximum discharge, 388 cfs Dec. 8, 1950 (gage height, 4.80 ft); from rating curve extended above 130 cfs by logarithmic plotting; no flow at times in some years.

Remarks.--Records good except those for period of no gage-height record, which are poor. Contents in Medley Lakes, above station, 593 acre-ft on Sept. 30, 1953, and 216 acre-ft on Sept. 30, 1954.

Cooperation.--Water-stage-recorder graph and one discharge measurement furnished by Pacific Gas & Electric Co. in connection with a Federal Power Commission project.

Revisions.--WSP 1151: Drainage area.

Rating tables, water year 1953-54 (gage height, in feet, and discharge, in cubic feet per second)

Oct. 1 to Apr. 28		Apr. 29 to Sept. 30	
0.7	3.8	0.8	4.6
.9	8.5	1.0	10
1.2	19	1.2	18
1.7	46	1.4	27
		1.6	39
		1.9	58

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	41	4.5	5.1					8.3	25	28	37	31
2	40	5.3	4.9					9.2	14	26	37	30
3	39	4.9	5.1					12	15	25	36	29
4	38	4.2	7.2					14	12	25	36	28
5	38	4.2	7.8					15	11	23	36	28
6	27	5.1	8.0					16	11	21	36	28
7	7.2	4.7	7.5					16	12	19	36	28
8	5.1	4.5	6.2				7	20	14	18	36	28
9	4.7	4.5	6.5					16	18	17	36	28
10	4.7	5.1	6.8					14	*16	16	35	27
11	4.9	7.2		5				16	17	15	35	27
12	4.9	6.5						14	20	15	35	27
13	4.7	6.0						14	24	25	35	27
14	4.7	6.5						14	27	30	34	26
15	4.9	5.8						14	32	32	34	*26
16	4.9	5.3			6	7		15	39	32	34	26
17	4.9	5.6						16	37	40	34	26
18	6.0	4.9						17	35	40	34	26
19	5.6	4.9						18	35	40	33	25
20	4.9	5.6						19	39	40	33	25
21	4.9	5.3	6					18	45	40	33	21
22	4.9	5.3						35	52	40	33	7.0
23	4.9	5.8					8	38	54	40	33	5.5
24	4.9	8.0						39	53	40	32	5.0
25	4.9	6.8						37	40	39	32	5.0
26	4.9	7.5		5.5				33	31	39	32	5.0
27	4.9	8.2						28	33	39	32	4.8
28	4.9	7.0						28	30	39	31	4.8
29	4.9	6.5						28	27	39	31	4.8
30	4.9	5.1					8.6	27	28	38	31	4.8
31	4.9						8.6	28		37	31	
Total	349.0	170.8	191.1	160.5	168	217	226.2	636.5	846	955	1,053	613.7
Mean	11.3	5.69	6.16	5.18	6	7	7.54	20.5	28.2	30.8	34.0	20.5
Ac-ft	692	339	379	318	333	430	449	1,260	1,680	1,890	2,090	1,220

Calendar year 1953: Max 144 Min - Mean 19.2 Ac-ft 13,880
Water year 1953-54: Max 54 Min - Mean 15.3 Ac-ft 11,080

* Discharge measurement made on this day.
Note.--No gage-height record Dec. 11 to Apr. 28; discharge estimated on basis of recorded range in stage, weather records, and records for nearby stations.

Silver Lake Outlet near Kirkwood, Calif.

Location.--Lat 38°40', long. 120°08', in SW¼ sec. 32, T. 10 N., R. 17 E., on right bank 1,000 ft downstream from Silver Lake Dam and 3 miles southwest of Kirkwood.

Drainage area.--14.9 sq mi.

Records available.--September 1922 to September 1954.

Gage.--Water-stage recorder. Altitude of gage is 7,200 ft (from topographic map).

Average discharge.--32 years, 33.3 cfs (24,110 acre-ft per year).

Extremes.--Maximum discharge during year, 228 cfs May 9 (gage height, 3.26 ft); no flow Jan. 13, 14.
1922-54: Maximum discharge, 676 cfs Nov. 21, 1950 (gage height, 6.03 ft), from rating curve extended above 200 cfs by logarithmic plotting; no flow for many days in February and March 1948 and Jan. 13, 14, 1954.

Remarks.--Records good. Contents in Silver Lake were about 4,450 acre-ft on Sept. 30, 1953, and about 2,950 acre-ft on Sept. 30, 1954. Some water, in addition to that released through dam and over spillway, escapes from Silver Lake through porous rock formation.

Cooperation.--Water-stage-recorder graph and five discharge measurements furnished by Pacific Gas & Electric Co. in connection with a Federal Power Commission project.

Rating table, water year 1953-54 (gage height, in feet, and discharge, in cubic feet per second)

0.43	0	1.1	20
.5	.20	1.5	49
.6	1.0	2.0	93
.7	2.5	3.0	196
.8	5.0	4.0	332
.9	9.0		

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	*54	27	10	2.0	0.5	0.3	33	81	6.4	3.6	2.7	2.0
2	53	27	9.9	1.8	.5	.2	15	78	8.4	3.5	2.7	2.0
3	51	26	9.4	1.8	.6	.2	16	91	25	3.3	2.5	2.0
4	51	25	10	1.8	2.3	.2	18	116	67	3.3	2.5	2.0
5	51	24	9.9	1.6	6.8	.2	24	146	40	3.6	*2.5	2.0
6	49	24	9.9	1.6	9.2	.2	27	172	24	3.6	2.5	35
7	49	23	a9.5	2.0	.4	.2	25	191	12	3.3	2.5	73
8	48	22	a9	2.0	.4	.8	25	212	5.0	3.3	2.5	71
9	48	22	a9	1.8	.4	1.8	25	226	*12	3.1	2.5	70
10	47	22	a8.5	1.8	.4	.7	26	207	23	3.1	2.5	68
11	45	22	a8	1.6	.4	.6	29	197	25	3.1	2.5	66
12	44	21	a7.5	1.2	.4	.8	39	192	28	3.1	2.5	65
13	43	21	a7	0	.4	1.1	55	184	37	3.1	2.3	63
14	43	19	a6.5	0	.4	1.4	76	184	29	3.1	2.3	62
15	41	18	6.4	.2	.4	3.1	95	186	26	3.1	2.3	*61
16	40	18	6.0	1.5	.4	96	124	191	26	3.1	2.1	60
17	39	17	6.0	.8	.4	184	171	202	*30	3.1	2.1	58
18	39	16	5.7	.1	.4	200	197	152	26	3.1	2.1	57
19	38	15	5.7	.1	.4	197	200	151	21	3.1	2.1	56
20	36	15	5.7	.1	.4	183	190	152	22	3.1	2.1	55
21	35	15	5.7	.1	.4	112	110	156	*31	3.1	2.1	55
22	33	14	1.8	.1	.3	47	3.1	114	25	3.1	2.0	53
23	32	14	3.1	.1	.3	32	3.8	58	15	2.9	2.0	51
24	32	14	2.9	.1	.3	31	5.0	7.2	9.9	2.9	2.0	51
25	31	13	2.7	.1	.3	25	21	6.4	6.4	2.9	2.0	50
26	31	12	2.5	.2	.3	22	57	6.0	3.8	2.9	2.0	49
27	30	12	1.4	.2	.3	19	91	6.4	5.6	2.9	2.0	48
28	29	11	1.6	.2	.3	18	99	6.4	5.6	2.9	2.0	47
29	28	11	2.1	.2	-	18	96	6.4	3.6	2.7	2.0	43
30	27	11	2.0	.3		19	89	6.4	3.6	2.7	2.0	43
31	27		2.0	.4		23		6.4		2.7	2.0	
Total	1,244	551	187.4	25.8	28.0	1,237.8	1,984.9	5,670.6	599.3	96.2	69.9	1,420.0
Mean	40.1	18.4	6.05	0.83	1.00	39.9	66.2	118	20.0	3.10	2.25	47.3
Ac-ft	2,470	1,090	372	50	56	2,460	3,940	7,280	1,190	191	139	2,820

Calendar year 1953: Max 204 Min - Mean 32.0 Ac-ft 23,170
Water year 1953-54: Max 228 Min 0 Mean 30.5 Ac-ft 22,060

* Discharge measurement made on this day.
a No gage-height record; discharge interpolated.

Twin Lakes Outlet near Kirkwood, Calif.

Location.--Lat 38°42', long. 120°03', in SW¼ sec. 18, T. 10 N., R. 18 E., on right bank 500 ft downstream from main dam and outlet gate of Twin Lakes and 1 mile east of Kirkwood.

Drainage area.--12.4 sq mi.

Records available.--September 1922 to September 1954 (October 1934 to September 1954, except May and June 1945, include flow over Twin Lakes spillway).

Gage.--Water-stage recorder and concrete control for outlet, staff gage with once-daily readings for spillway. Altitude of gage is 7,900 ft (from topographic map).

Average discharge.--31 years (1922-44, 1945-54), 35.0 cfs (25,340 acre-ft per year; including flow over Twin Lakes spillway).

Extremes.--Maximum combined daily discharge during year for outlet and spillway, 105 cfs Dec. 2-9; minimum daily, 2.0 cfs Feb. 24.
1922-54: Maximum combined daily discharge for outlet and spillway, 405 cfs Dec. 8, 1950; minimum daily, 0.1 cfs Mar. 25-31, 1944.

Remarks.--Records good. No diversion. Flow regulated by Twin Lakes, contents of which were 17,100 acre-ft on Sept. 30, 1953, and 11,000 acre-ft on Sept. 30, 1954. Flow over Twin Lakes spillway occurred June 24 to July 30, and is included in table below.

Cooperation.--Water-stage-recorder graph and seven discharge measurements furnished by Pacific Gas & Electric Co. in connection with a Federal Power Commission project.

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	*17	96	101	62	16	2.6	2.6	4.2	2.9	3.4	76	96
2	22	99	106	62	16	2.6	2.6	4.6	2.6	6.7	76	98
3	22	101	105	62	16	2.6	2.8	5.2	2.3	18	76	95
4	*22	101	105	62	16	2.9	2.8	4.6	2.3	23	76	96
5	25	101	105	62	11	2.9	2.6	4.2	2.3	24	*75	96
6	28	101	105	28	6.4	2.9	2.6	4.2	2.3	23	76	96
7	28	101	105	29	6.4	2.6	2.6	4.2	2.6	23	76	96
8	29	101	105	36	6.4	3.2	2.6	4.6	2.6	23	76	42
9	29	101	105	50	6.4	4.8	2.6	4.6	2.6	23	76	2.9
10	29	101	101	41	6.4	3.2	2.6	4.6	*2.6	28	79	7.1
11	29	101	99	35	6.4	2.6	2.6	4.6	2.6	*38	85	16
12	29	101	104	35	9.6	2.6	2.6	4.2	2.6	38	83	22
13	29	101	102	44	12	2.6	2.9	4.6	2.6	45	83	22
14	29	101	97	32	12	2.6	2.9	4.9	2.6	48	84	24
15	29	101	93	26	12	2.6	3.2	2.6	2.8	48	87	27
16	29	101	73	27	12	2.3	3.5	2.9	2.6	48	87	27
17	29	101	47	20	12	3.2	5.8	2.9	2.6	48	87	28
18	29	101	51	16	12	4.5	4.2	2.9	2.6	47	87	29
19	31	101	59	16	12	2.3	4.2	2.9	2.9	48	87	29
20	35	101	59	16	12	2.3	4.2	2.9	2.9	55	87	29
21	36	101	59	21	12	2.3	4.6	2.9	2.9	60	88	32
22	58	101	68	19	12	2.6	4.9	2.9	2.9	60	91	46
23	91	101	83	16	4.9	2.6	4.9	2.9	2.9	*60	91	56
24	90	101	73	16	2.0	2.6	4.9	2.9	2.9	60	91	56
25	90	82	48	18	2.6	2.6	4.9	2.9	3.1	60	91	58
26	92	71	48	16	2.6	2.6	4.2	2.9	3.5	60	91	65
27	95	88	48	18	2.6	2.6	3.8	2.9	3.1	60	91	65
28	96	97	48	16	2.6	2.3	3.5	2.9	3.1	68	91	66
29	96	97	51	16	-	2.6	3.8	2.9	3.0	73	91	75
30	96	100	62	18	-	2.6	3.8	2.9	3.3	73	91	83
31	96	-	62	16	-	2.6	-	2.9	-	73	93	83
										76	*96	-
Total	1,485	2,952	2,474	935	260.3	85.7	105.0	110.9	83.2	1,419.1	2,637	1,565.4
Mean	47.8	98.4	79.8	30.2	9.30	2.76	3.50	3.58	2.77	45.8	85.1	52.2
Ac-ft	2,940	5,860	4,910	1,850	516	170	208	220	165	2,810	5,230	3,100

Calendar year 1953: Max 218 Min 2.6 Mean 43.0 Ac-ft 31,160
Water year 1953-54: Max 105 Min 2.0 Mean 38.7 Ac-ft 27,980

* Discharge measurement made on this day.

El Dorado Canal near Kyburz, Calif.

Location.--Lat 38°46', long. 120°19', in SE¼ sec. 29, T. 11 N., R. 15 E., on left bank 400 ft downstream from intake and 2 miles west of Kyburz.

Records available.--October 1922 to September 1954.

Gage.--Water-stage recorder. Altitude of gage is 4,100 ft (from topographic map). Prior to July 18, 1924, staff gage at site half a mile downstream at different datum.

Average discharge.--32 years, 107 cfs (77,460 acre-ft per year).

Extremes.--1922-54: Maximum daily discharge, 207 cfs Feb. 5, 8, 1951; no flow at times.

Remarks.--Records good. Canal diverts from left bank of South Fork American River just below Silver Fork of South Fork; water used for power and irrigation.

Cooperation.--Water-stage-recorder graph and nine discharge measurements furnished by Pacific Gas & Electric Co. in connection with a Federal Power Commission project.

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	145	150	148	102	94	141	139	158	152	161	152	146
2	143	152	149	102	*97	139	140	139	152	151	152	147
3	137	156	153	107	104	*139	138	142	155	152	148	144
4	136	*158	152	107	103	139	138	143	155	153	147	143
5	84	155	155	*106	104	143	139	130	154	151	147	145
6	42	156	155	88	103	146	135	146	153	*143	148	141
7	0	155	155	88	100	146	132	141	153	139	148	141
8	0	152	154	66	100	149	132	142	*154	138	144	142
9	30	152	*154	89	102	138	133	141	158	138	145	141
10	110	155	154	102	100	130	133	137	158	141	148	138
11	108	158	146	84	98	127	134	141	157	133	148	148
12	30	158	155	80	108	126	135	143	157	128	148	152
13	0	158	155	72	119	124	137	143	162	138	145	150
14	0	145	155	82	118	128	138	143	162	145	150	*150
15	0	148	155	70	110	132	139	143	163	148	152	151
16	0	150	153	67	112	134	141	143	166	143	151	150
17	51	146	115	76	121	134	143	144	170	143	149	148
18	121	150	105	71	125	*134	143	144	171	145	148	147
19	119	152	115	64	122	134	141	147	171	142	147	144
20	114	155	131	58	128	133	141	148	172	152	146	141
21	110	152	128	54	130	133	141	147	172	152	150	143
22	104	155	109	74	136	133	143	146	173	148	150	153
23	141	155	124	116	135	133	150	144	173	146	148	145
24	155	156	152	133	131	135	149	148	172	145	148	157
25	154	155	108	112	135	137	148	151	172	144	148	143
26	155	142	100	92	142	138	*148	152	171	144	146	141
27	158	134	100	96	141	138	148	153	172	141	146	138
28	162	153	94	87	141	139	143	153	172	151	145	141
29	158	151	92	88	-	140	141	153	171	148	142	147
30	156	151	98	85	-	139	141	153	168	146	141	148
31	153	-	101	86	-	138	-	152	-	152	147	-
Total	2,973	4,566	4,100	2,700	3,257	4,217	4,201	4,490	4,909	4,499	4,568	4,341
Mean	95.9	152	132	87.1	116	136	140	145	164	145	147	145
Ac-ft	5,900	9,060	8,130	5,360	6,460	8,360	8,330	8,910	9,740	8,920	9,060	8,610

Calendar year 1953: Max 166 Min 0 Mean 144 Ac-ft 103,900
Water year 1953-54: Max 173 Min 0 Mean 134 Ac-ft 98,840

* Discharge measurement made on this date.

South Fork American River near Kyburz, Calif.

Location.--Lat 38°46', long. 120°19', in S½ sec. 29, T. 11 N., R. 15 E., on right bank beside U. S. Highway 50, 0.7 mile downstream from Silver Fork of South Fork and 2 miles west of Kyburz.

Drainage area.--196 sq mi.

Records available.--August to December 1907, October 1922 to September 1954.

Gage.--Water-stage recorder. Altitude of gage is 4,030 ft (from topographic map).

Average discharge.--32 years (1922-54), 393 cfs (284,500 acre-ft per year), combined flow of South Fork American River near Kyburz and El Dorado Canal.

Extremes.--Maximum discharge during year, 3,190 cfs Mar. 9 (gage height, 6.17 ft); minimum daily, 4.0 cfs Jan. 25, 30.
1922-54: Maximum discharge, 14,500 cfs Nov. 21, 1950 (gage height, 9.40 ft), from rating curve extended above 6,500 cfs on basis of contracted-opening computation; minimum daily, 0.3 cfs Nov. 9-11, 1928.

Remarks.--Records good. Flow at low and medium stages greatly regulated by four reservoirs since beginning of record (total usable capacity, 35,500 acre-ft). El Dorado Canal (see preceding page) diverts 0.5 mile above station.

Cooperation.--Water-stage-recorder graph and 11 discharge measurements furnished by Pacific Gas & Electric Co. in connection with a Federal Power Commission project.

Rating tables, water year 1953-54 (gage height, in feet, and discharge in cubic feet per second)

Oct. 1 to Oct. 9		Oct. 10 to Sept. 30			
0.8	6.8	0.7	3.9	2.0	84
1.0	15	.8	6.0	2.5	174
1.2	21	.9	8.8	3.0	315
1.8	45	1.0	12	4.0	800
2.0	84	1.2	21	5.0	1,600
2.5	132	1.8	45	6.0	2,900

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	7.5	8.5	6.0	8.5	4.8	55	111	824	261	7.0	5.0	8.5
2	7.2	6.8	8.2	6.8	*6.0	44	127	674	238	8.2	5.0	8.5
3	8.0	*7.6	12	8.8	4.8	*45	163	896	256	6.0	4.8	8.8
4	7.2	6.8	15	7.6	6.0	46	196	1,100	292	6.8	*4.6	8.5
5	55	6.8	12	*6.2	4.6	50	426	1,210	264	6.5	4.8	8.8
6	89	6.8	15	5.5	5.5	55	434	1,310	219	*6.5	4.6	8.8
7	121	6.8	21	6.8	4.6	58	350	1,400	186	5.2	4.4	8.5
8	112	6.8	13	6.0	4.8	324	343	1,580	*161	4.6	4.8	8.2
9	83	6.8	*14	11	4.8	2,310	315	1,380	208	4.6	4.6	8.2
10	7.9	8.2	14	6.0	4.6	1,070	350	1,090	196	4.8	4.8	8.8
11	7.6	27	6.0	5.0	4.2	540	394	1,170	201	4.8	4.8	8.4
12	67	21	7.9	4.6	6.5	358	462	1,140	219	5.0	4.8	8.8
13	103	19	13	4.8	36	273	592	1,100	312	5.2	4.8	8.8
14	103	62	10	5.0	13	235	734	1,120	216	5.5	5.0	8.5
15	103	37	14	5.0	10	219	824	1,110	193	5.2	5.0	8.5
16	101	28	6.8	4.4	5.5	198	1,010	1,170	186	5.0	5.0	*8.5
17	55	32	4.8	5.8	23	186	1,250	1,270	174	5.2	5.0	8.5
18	9.8	16	4.4	4.6	14	*163	1,320	1,250	146	6.2	4.8	8.2
19	5.2	12	8.2	4.2	7.9	181	1,250	1,170	109	6.0	4.8	8.2
20	8.0	10	23	5.8	7.0	152	1,190	1,110	130	6.5	4.8	8.2
21	6.0	7.9	6.5	6.0	6.8	136	1,220	896	152	5.0	5.0	8.5
22	5.8	15	4.8	3.5	8.2	113	1,220	718	148	4.8	5.0	8.8
23	6.7	20	7.3	37	22	113	1,210	624	121	4.8	5.0	7.9
24	6.8	47	8.5	34	42	108	1,110	535	101	4.8	5.0	8.5
25	6.5	39	5.2	4.0	48	95	1,040	462	78	4.8	5.0	8.5
26	6.5	6.0	5.8	4.2	55	90	1,050	398	47	4.8	7.0	8.2
27	7.0	5.0	5.5	4.6	48	106	*1,260	350	39	4.8	8.5	8.5
28	7.0	7.0	4.8	4.2	44	127	980	340	29	5.0	8.5	8.5
29	6.5	6.2	4.8	4.2	-	132	880	332	14	4.8	6.8	7.9
30	6.8	6.2	5.5	4.0	------	*119	758	285	9.4	4.6	8.8	8.2
31	6.5	------	8.8	4.6	------	104	------	261	------	4.8	9.4	------
Total	1,128.5	493.2	293.8	234.7	453.4	7,797	22,539	28,075	4,907.4	165.8	171.8	254.7
Mean	36.4	16.4	9.48	7.57	16.2	252	751	906	164	5.35	5.54	8.49
Ac-ft	2,240	978	583	466	899	15,470	44,710	55,690	9,730	329	341	505

Calendar year 1953: Max 2,610 Min 4.1 Mean 292 Ac-ft 211,600
Water year 1953-54: Max 2,510 Min 4.0 Mean 182 Ac-ft 131,900

Peak discharge (base, 2,000 cfs).--Mar. 9 (7:30 a.m.) 3,190 cfs (6.17 ft); May 8 (9 p.m.) 2,220 cfs (5.52 ft).
* Discharge measurement made on this day.

Alder Creek near Whitehall, Calif.

Location (revised).--Lat 38°45'19", long. 120°22'17", in NE¼SE¼ sec. 35, T. 11 N., R. 14 E., on right bank 0.9 mile upstream from mouth and 2.2 miles southeast of Whitehall.

Drainage area.--22.8 sq mi.

Records available.--October 1922 to September 1954 (include diversions by pipeline).

Gage.--Water-stage recorder. Altitude of gage is 3,840 ft (revised) (from topographic map). Prior to July 23, 1924, staff gage at same site and datum.

Average discharge.--32 years, 36.7 cfs (26,570 acre-ft per year).

Extremes.--Maximum discharge during year, 455 cfs Mar. 9 (gage height, 3.30 ft); no flow Dec. 16 to Jan. 22.
1922-54: Maximum discharge, about 3,700 cfs Mar. 25, 1928 (gage height, 7.1 ft, from floodmarks), from rating curve extended above 500 cfs by logarithmic plotting; no flow at times during several years.

Remarks.--Records good. Records (except extremes) include computed flow in feeder pipeline that diverted just above station into El Dorado Canal Oct. 2-12, Oct. 17 to June 14.

Cooperation.--Water-stage-recorder graph and 9 discharge measurements furnished by Pacific Gas & Electric Co. in connection with a Federal Power Commission project.

Revisions (water years).--WSP 1215: 1928(M).

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1.1	1.1	2.4	2.3	15	48	53	118	11	4.5	1.1	0.5
2	1.3	1.1	2.4	2.3	*17	46	58	103	9.5	4.1	1.0	.5
3	1.3	*1.1	2.4	2.3	18	*45	65	102	9.5	4.1	.9	.5
4	1.2	1.1	2.4	2.3	17	43	72	102	9.5	3.8	*.9	.5
5	1.2	1.1	2.4	*2.3	18	43	155	98	9.5	3.5	.9	.5
6	1.2	1.1	2.4	2.3	18	43	196	96	9.5	3.5	.9	.5
7	1.1	1.1	2.4	2.3	17	43	172	93	9.5	3.5	.8	.5
8	1.1	1.1	*2.4	2.3	18	79	154	92	*9.5	3.2	.8	.5
9	1.1	1.1	2.4	2.3	18	411	145	92	11	3.0	.8	.5
10	1.1	1.1	2.4	2.3	18	568	138	82	10	2.8	.8	.5
11	1.1	1.1	2.4	2.3	17	225	130	76	10	2.6	.8	.5
12	.4	1.1	2.4	2.3	28	160	140	68	11	2.4	.7	.5
13	.5	2.2	2.4	2.3	68	128	151	65	12	2.2	.7	.5
14	.6	4.9	2.4	2.3	50	107	160	62	11	2.2	.7	*.5
15	.6	3.2	2.4	2.3	36	96	169	56	10	2.2	.7	.5
16	.6	2.6	2.3	2.3	33	88	183	52	11	2.0	.7	.5
17	1.1	2.5	2.3	2.3	49	77	196	49	10	1.9	.7	.5
18	1.3	2.5	2.3	2.3	57	64	205	47	9.6	1.9	.7	.5
19	1.4	2.5	2.7	2.3	43	60	191	43	8.4	1.7	.7	.5
20	1.2	2.4	2.9	2.3	43	56	179	39	7.8	1.6	.7	.5
21	1.2	2.4	2.9	2.3	41	53	172	34	7.3	1.6	.7	.5
22	1.1	2.4	2.9	2.3	41	51	174	31	6.8	1.6	.6	.5
23	1.1	2.4	2.8	44	42	50	167	27	6.5	1.4	.6	.5
24	1.1	2.4	2.9	66	46	47	154	24	5.8	1.4	.6	.5
25	1.1	2.4	2.9	53	48	45	143	23	5.8	1.3	.6	.4
26	1.1	2.4	2.5	19	50	42	132	20	5.3	1.3	.6	.4
27	1.1	2.4	2.3	18	50	43	*181	18	5.3	1.3	.5	.4
28	1.1	2.4	2.3	17	50	48	181	16	5.3	1.3	.5	.4
29	1.1	2.4	2.3	17	-	51	154	15	4.9	1.2	.5	.4
30	1.1	2.4	2.3	15		*51	134	14	4.9	1.2	.5	.4
31	1.1		2.3	15		51	------	14	------	1.1	.5	
Total	32.7	60.0	77.0	295.6	988	2,762	4,510	1,769	257.0	71.4	22.2	14.4
Mean	1.05	2.00	2.48	9.54	34.5	89.1	150	57.1	8.57	2.30	0.72	0.48
Ac-ft	65	119	153	586	1,920	5,480	8,950	3,510	510	142	44	29

Calendar year 1953: Max 528 Min 0.4 Mean 40.4 Ac-ft 29,220
Water year 1953-54: Max 411 Min 0.4 Mean 29.7 Ac-ft 21,510

Peak discharge (base, 120 cfs).--Mar. 9 (7 a.m.) 455 cfs (3.30 ft); Apr. 6 (1 a.m.) 192 cfs (2.51 ft); Apr. 27 (5 a.m.) 219 cfs (2.61 ft).
* Discharge measurement made on this day.

Silver Creek at Union Valley, Calif.

Location (revised).--Lat 38°51'55", long. 120°25'36", in SE¼ sec. 20, T. 12 N., R. 14 E., on right bank 0.6 mile downstream from confluence of Big Silver Creek and Jones Fork Silver Creek, near lower end of Union Valley, and 6.6 miles north of Riverton.

Drainage area.--82.7 sq mi.

Records available.--October 1924 to September 1954.

Gage.--Water-stage recorder. Altitude of gage is 4,530 ft (from topographic map).

Average discharge.--29 years (1924-27, 1928-54), 212 cfs (153,500 acre-ft per year).

Extremes.--Maximum discharge during year, 3,540 cfs Mar. 9 (gage height, 9.06 ft), from rating curve extended above 2,200 cfs on basis of previous high-water rating; minimum, 4.1 cfs Sept. 28.
1924-54: Maximum discharge, 12,100 cfs Nov. 20, 1950 (gage height, 16.55 ft), from rating curve extended above 2,200 cfs on basis of slope-area determination of peak flow; minimum, 1.9 cfs Aug. 27, 28, 1931.

Remarks.--Records good. No storage or diversion above station.

Revisions (water years).--WSP 1215: 1928(M), 1938(M), 1943(M).

Rating tables, water year 1953-54 (gage height, in feet, and discharge, in cubic feet per second)

Oct. 1 to Mar. 9				Mar. 10 to Sept. 30	
0.8	6.4	4.0	704	0.4	2.7
.7	10	5.0	1,120	.5	4.7
1.0	30	6.0	1,580	.6	7.3
1.4	69	7.0	2,160	.8	18
1.8	128	8.0	2,800	1.0	30
2.4	244	9.0	3,500		
3.0	387				

Note.--Same as preceding table above 1.0 ft.

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	7.6	10	41	30	77	203	205	374	174	47	8.2	5.5
2	7.8	12	33	28	86	188	223	431	165	43	7.9	5.3
3	7.6	12	36	35	93	197	244	598	167	39	7.3	5.1
4	7.6	11	42	35	*93	192	263	731	176	36	6.7	5.1
5	7.2	11	34	34	93	203	682	742	160	33	6.4	5.1
6	7.2	19	44	36	96	213	612	753	165	31	6.4	5.1
7	7.2	18	47	48	101	215	436	796	181	28	6.4	5.1
8	7.2	17	42	36	109	474	403	860	147	26	6.1	5.1
9	6.8	18	42	39	112	2,840	379	697	207	24	6.1	5.3
10	7.2	21	42	38	107	1,490	403	542	182	23	5.8	5.1
11	9.7	36	41	36	102	664	422	625	194	21	5.8	5.3
12	8.9	36	41	35	140	456	491	598	295	20	5.8	5.3
13	8.4	45	43	32	219	363	584	584	321	19	5.8	5.3
14	8.0	82	51	33	156	320	625	864	208	18	6.1	5.3
15	8.0	60	59	33	129	305	693	574	174	18	6.4	5.5
16	8.0	51	53	33	114	283	860	636	171	16	6.7	5.5
17	8.0	*52	52	36	186	252	940	664	149	15	6.4	5.5
18	23	37	49	39	186	234	916	625	126	14	6.4	5.5
19	27	32	52	41	151	225	840	584	114	14	6.4	5.3
20	*20	32	95	37	147	213	808	528	112	13	6.4	5.3
21	17	31	73	35	143	205	852	387	117	13	6.1	5.1
22	15	42	50	36	142	194	940	296	109	12	6.1	*4.9
23	13	61	41	300	156	192	888	276	95	12	6.1	4.9
24	13	107	46	256	180	184	789	*265	88	11	5.8	4.7
25	12	96	40	149	192	*178	712	254	78	11	5.8	4.7
26	12	70	37	109	201	176	675	225	69	11	6.1	4.7
27	12	57	36	90	197	194	956	213	65	11	6.4	4.7
28	12	50	33	79	192	215	719	213	59	10	6.1	4.5
29	12	44	30	74	-	223	564	205	53	*9.4	5.8	4.7
30	11	45	28	72		211	467	180	49	9.4	5.8	4.7
31	10		31	72		195		167		8.6	5.5	
Total	341.2	1,217	1,384	1,986	3,900	11,693	18,531	15,205	4,371	616.4	195.1	153.0
Mean	11.0	40.6	44.6	64.1	139	377	618	490	146	19.9	6.29	5.10
Ac-ft	677	2,410	2,750	3,940	7,740	23,190	36,760	30,160	8,670	1,220	387	303

Calendar year 1953: Max 2,220 Min 6.8 Mean 238 Ac-ft 172,200
Water year 1953-54: Max 2,840 Min 4.5 Mean 163 Ac-ft 118,200

Peak discharge (base, 960 cfs).--Mar. 9 (8 a.m.) 3,540 cfs (9.06 ft); Apr. 22 (9:30 p.m.) 1,470 cfs (5.78 ft); May 8 (9:30 p.m.) 1,300 cfs (5.40 ft).
* Discharge measurement made on this day.

South Fork Silver Creek near Ice House, Calif.

Location (revised).--Lat 38°49'18", long. 120°21'37", in SE¼SW¼ sec. 1, T. 11 N., R. 14 E., on left bank 0.3 mile upstream from Peavine Creek, 0.9 mile northeast of Ice House, and 5.9 miles northeast of Riverton.

Drainage area.--28.4 sq mi.

Records available.--October 1924 to September 1954.

Gage.--Water-stage recorder. Altitude of gage is 5,300 ft (from topographic map).

Average discharge.--30 years, 74.3 cfs (53,790 acre-ft per year).

Extremes.--Maximum discharge during year, 746 cfs Mar. 9 (gage height, 3.57 ft); minimum, 0.8 cfs Sept. 9-13.
1924-54: Maximum discharge, 3,900 cfs Nov. 18, 1950 (gage height, 6.69 ft), from rating curve extended above 540 cfs on basis of slope-area determination of peak flow; minimum, 0.1 cfs Aug. 21 to Sept. 6, 1931.

Remarks.--Records good except those for periods of ice effect, or no gage-height record, which are fair. No storage or diversion above station.

Rating table, water year 1953-54, except periods of ice effect (gage height, in feet, and discharge, in cubic feet per second)

0.3	0.5	1.6	119
.4	2.6	2.0	216
.5	7.1	2.5	360
.6	13	3.0	520
.9	34	3.5	715
1.2	80		

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	2.9	3.7	15	b9	b18	39	46	140	76	29	3.7	1.6
2	3.3	4.2	13	b9	b19	38	54	177	75	26	3.3	1.5
3	3.3	4.6	13	b9	*b21	40	60	260	80	25	2.6	1.1
4	2.9	4.6	11	8.9	b22	39	65	339	85	24	2.2	.9
5	2.6	4.6	14	b10	b22	42	103	363	82	24	2.2	.9
6	2.6	5.6	17	11	b23	43	101	372	78	22	2.2	.9
7	2.6	5.6	16	11	23	45	85	393	71	20	2.2	.9
8	2.6	5.6	19	b15	b24	65	80	429	65	19	1.9	.9
9	2.6	6.1	18	10	b25	550	80	360	82	18	1.9	.9
10	2.9	7.1	16	10	b24	343	65	280	80	17	1.6	.8
11	4.2	12	15	10	23	162	94	312	79	16	1.6	.8
12	3.7	15	14	10	24	121	108	315	128	15	1.8	.8
13	3.5	16	14	10	24	96	127	312	167	14	1.6	.9
14	3.3	23	14	10	23	82	159	303	110	13	1.6	1.1
15	3.3	20	16	10	b23	72	187	300	89	12	1.6	1.3
16	3.3	19	16	10	23	66	246	327	90	11	1.6	1.3
17	3.3	*18	16	10	26	58	316	369	83	11	1.6	1.3
18	8.3	b14	15	10	28	59	321	360	72	10	1.6	1.3
19	9.6	b12	16	10	31	57	300	339	66	8.9	1.6	1.3
20	*7.1	b11	26	10	29	53	297	300	68	8.3	1.6	1.3
21	6.1	11	26	10	28	51	318	227	75	7.7	1.6	1.3
22	5.1	14	22	15	28	48	366	157	73	7.1	1.5	*1.3
23	4.2	16	18	75	29	46	372	138	72	6.6	1.3	1.3
24	3.7	26	18	70	31	*44	330	*138	66	6.6	1.3	1.3
25	3.7	34	15	50	31	43	303	123	57	6.6	1.6	1.3
26	3.7	27	14	30	32	42	303	108	47	6.1	1.9	1.1
27	3.7	23	12	25	35	44	330	98	42	6.1	1.9	1.1
28	4.2	21	11	20	39	47	246	96	36	5.6	1.9	1.1
29	4.2	18	10	19	-	52	206	94	31	*5.6	1.9	1.1
30	4.2	17	b10	18	------	52	172	82	31	5.1	1.6	1.3
31	3.7	------	b10	b18	------	48	------	76	------	4.2	1.6	------
Total	124.2	418.7	478	552.9	728	2,587	5,864	7,687	2,258	410.5	58.0	33.8
Mean	4.01	14.0	15.4	17.8	26.0	83.5	195	248	75.2	13.2	1.87	1.13
Ac-ft	246	830	948	1,100	1,440	5,130	11,630	15,250	4,470	814	115	67

Calendar year 1953: Max 579 Min 2.6 Mean 83.7 Ac-ft 60,600
Water year 1953-54: Max 550 Min 0.8 Mean 58.1 Ac-ft 42,040

Peak discharge (base, 340 cfs).--Mar. 9 (4 p.m.) 746 cfs (3.57 ft); Apr. 22 (9 p.m.) 485 cfs (2.90 ft); May 8 (7 p.m.) 571 cfs (3.14 ft).
* Discharge measurement made on this day.
b Stage-discharge relation affected by ice.
Note.--No gage-height record Jan. 9-30; discharge estimated on basis of recorded range in stage and records for Silver Creek at Union Valley.

Silver Creek near Placerville, Calif.

Location (revised).--Lat 38°47'30", long. 120°35'15", in NE¼ sec. 24, T. 11 N., R. 12 E., on right bank 0.2 mile upstream from mouth and 12 miles northeast of Placerville.

Drainage area.--176 sq mi.

Records available.--December 1921 to September 1954.

Gage.--Water-stage recorder. Altitude of gage is 2,070 ft, revised (from topographic map). Prior to Oct. 19, 1930, at site 400 ft downstream at different datum.

Average discharge.--32 years (1922-54), 408 cfs (295,400 acre-ft per year).

Extremes.--Maximum discharge during year, 4,410 cfs Mar. 9 (gage height, 8.31 ft); minimum, 24 cfs Sept. 10, 26-30.
1921-54: Maximum discharge, 25,800 cfs Nov. 18, 1950 (gage height, 14.25 ft), from rating curve extended above 3,900 cfs on basis of slope-area determination of peak flow; minimum, 5.5 cfs Sept. 18, 1934.

Remarks.--Records good. No storage or diversion above station.

Revisions (water years).--WSP 1215: 1928(M), 1938, 1940(P), 1943(P), 1945(M).

Rating tables, water year 1953-54 (gage height, in feet, and discharge, in cubic feet per second)

Oct. 1 to Mar. 9				Mar. 10 to Sept. 30			
1.8	36	4.0	616	1.4	23	4.0	616
1.8	51	5.0	1,120	1.7	41	5.0	1,120
2.0	71	6.0	1,780	2.0	68	6.0	1,780
2.5	150	8.0	3,950	2.5	142	8.0	3,950
3.0	268			3.0	258		

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	40	43	90	68	166	407	482	696	322	106	36	28
2	40	45	*82	64	177	387	468	696	316	100	35	28
3	40	44	79	77	183	390	528	906	319	96	34	27
4	39	43	170	81	183	374	545	1,090	322	92	33	26
5	38	44	89	71	190	390	1,110	1,170	348	85	32	28
6	37	57	94	73	180	393	1,340	1,170	319	81	32	25
7	37	56	146	115	197	400	1,030	1,220	332	76	32	25
8	37	51	105	81	199	554	906	1,290	280	73	32	25
9	37	50	100	81	211	3,740	830	1,250	382	69	32	25
10	39	55	94	89	209	2,780	815	875	342	67	30	24
11	43	77	90	81	199	1,370	820	988	375	64	30	25
12	43	81	90	78	276	982	880	988	358	61	30	28
13	42	91	90	63	750	795	960	944	692	60	30	26
14	42	193	96	77	523	698	1,020	933	440	58	31	26
15	42	148	108	72	390	651	1,080	922	351	55	32	26
16	42	107	108	71	348	616	1,230	960	332	52	32	28
17	42	113	102	131	504	566	1,410	1,070	313	50	31	27
18	59	94	100	105	534	504	1,380	1,050	264	48	31	27
19	97	79	96	94	434	492	1,290	999	245	46	30	28
20	82	81	144	87	410	473	1,240	911	237	45	30	26
21	54	73	142	83	380	458	1,260	785	248	44	30	26
22	50	96	107	87	357	432	*1,380	566	*242	43	30	26
23	49	122	81	741	*357	436	1,410	500	227	43	29	26
24	46	170	93	876	380	443	1,260	512	208	42	*29	25
25	45	192	91	367	400	411	1,150	481	186	41	29	25
26	45	150	79	268	421	400	1,110	425	162	43	28	25
27	45	122	81	226	410	429	1,420	404	146	41	30	24
28	44	105	75	192	404	454	1,210	389	135	39	29	24
29	44	96	68	171	-----	500	1,000	369	121	38	29	24
30	43	91	62	168	-----	512	850	351	113	37	28	24
31	43	-----	66	158	-----	458	-----	322	-----	36	28	-----
Total	1,406	2,767	3,016	4,800	9,382	21,893	31,414	25,232	8,677	1,831	965	
Mean	45.4	92.2	97.3	155	335	706	1,047	814	289	59.1	31.1	
Ac-ft	2,790	5,490	5,980	9,520	18,610	43,420	62,310	50,050	17,210	3,630	1,890	

Calendar year 1953: Max 3,090 Min 37 Mean 444 Ac-ft 321,300
Water year 1953-54: Max 3,740 Min 24 Mean 307 Ac-ft 222,400

Peak discharge (base, 1,600 cfs).--Mar. 9 (10:30 a.m.) 4,410 cfs (8.31 ft); Apr. [illegible] cfs (8.18 ft); May 9 (12:30 a.m.) 1,790 cfs (6.01 ft).
* Discharge measurement made on this day.

American River flume near Camino, Calif.

Location.--Lat 38°46', long. 120°42', in SW¼ sec. 25, T. 11 N., R. 11 E., on right bank 300 ft upstream from Iowa Canyon Creek, 1 mile downstream from diversion dam, and 3 miles northwest of Camino.

Records available.--November 1922 to September 1954. Published as "Western States Gas & Electric Co.'s Flume" 1922-29, and as "South Fork of American River Flume" 1930-35.

Gage.--Water-stage recorder. Altitude of gage is 1,710 ft (from topographic map). Prior to Oct. 27, 1929, staff gage at same site and datum.

Average discharge.--32 years, 112 cfs (81,080 acre-ft per year).

Extremes.--1922-54: Maximum daily discharge, 189 cfs Aug. 15, 16, 1942, June 28, 1944; no flow at times in each year.

Remarks.--Records good. Flume diverts from South Fork American River in SW¼ sec. 24, T. 11 N., R. 11 E., for power development in SW¼ sec. 20, T. 11 N., R. 11 E., just above Rock Creek, at which point water is returned to South Fork.

Cooperation.--Water-stage-recorder graph and seven discharge measurements furnished by Pacific Gas & Electric Co. in connection with a Federal Power Commission project.

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	162	169	168	146	187	164	0	170	170	167	146	130
2	162	168	166	148	166	162	0	170	170	168	146	134
3	162	*167	164	149	166	162	0	170	170	167	148	134
4	162	167	169	*159	167	165	0	171	170	165	*141	133
5	158	167	168	157	167	165	0	171	170	164	142	132
6	158	167	169	154	167	165	0	170	170	162	144	130
7	162	167	169	163	167	165	0	171	*172	*161	142	128
8	162	167	*168	164	164	163	0	172	172	162	145	132
9	162	168	168	145	165	158	0	172	170	165	139	128
10	162	167	168	164	165	162	0	172	172	162	140	128
11	161	167	164	162	165	159	0	172	172	163	137	128
12	142	167	167	159	167	159	0	172	172	160	139	146
13	151	166	166	153	164	162	0	172	170	154	138	130
14	161	165	165	147	166	162	0	172	172	154	138	*137
15	161	164	166	158	163	65	5.2	172	172	155	140	139
16	161	164	167	150	165	0	42	172	172	157	139	138
17	161	164	168	167	165	0	86	172	172	152	140	138
18	160	164	164	168	160	0	114	172	172	149	140	130
19	160	163	163	166	163	0	130	172	173	152	140	132
20	160	163	165	164	165	0	147	172	175	150	138	136
21	158	163	168	160	166	0	157	171	173	153	138	134
22	160	163	167	160	167	0	161	171	171	152	138	141
23	156	163	160	165	164	0	163	171	170	147	139	149
24	160	167	160	164	164	0	163	171	170	148	137	146
25	160	170	166	165	165	0	162	171	170	142	130	144
26	166	170	156	168	166	0	166	170	170	143	133	141
27	160	168	156	168	166	0	170	170	170	144	138	145
28	168	167	153	168	166	0	*170	170	169	144	140	148
29	168	157	147	168	-	0	169	170	169	150	128	152
30	167	167	144	169	-----	0	170	170	167	152	136	156
31	168	-----	145	169	-----	0	-----	170	-----	150	137	-----
Total	4,991	4,988	5,054	4,966	4,629	2,338	2,175.2	5,304	5,125	4,808	4,312	4,117
Mean	161	166	163	160	165	75.4	72.5	171	171	155	139	137
Ac-ft	9,900	9,890	10,020	9,850	9,180	4,640	4,310	10,520	10,170	9,540	8,550	8,170

Calendar year 1953: Max 170 Min 142 Mean 161 Ac-ft 116,600
Water year 1953-54: Max 173 Min 0 Mean 145 Ac-ft 104,700

* Discharge measurement made on this day.

South Fork American River near Camino, Calif.

Location.--Lat 38°46', long. 120°42', in SW¼ sec. 26, T. 11 N., R. 11 E., on right bank 300 ft upstream from Iowa Canyon Creek, 1 mile downstream from intake of American River flume, and 3 miles northwest of Camino.

Drainage area.--497 sq mi.

Records available.--October 1922 to September 1954.

Gage.--Water-stage recorder. Altitude of gage is 1,640 ft (from topographic map). Nov. 1, 1950, to Dec. 5, 1951, staff gage at same site and datum.

Average discharge.--32 years, 946 cfs (684,900 acre-ft per year), combined flow of South Fork American River near Camino and American River flume.

Extremes.--Maximum discharge during year, 9,340 cfs Mar. 9 (gage height, 13.15 ft); minimum daily, 5.4 cfs Oct. 13.
1922-54: Maximum discharge, 46,000 cfs Nov. 21, 1950 (gage height, 29.4 ft, from floodmarks), from rating curve extended above 24,000 cfs on basis of flow at upstream and downstream stations; minimum daily, 1.3 cfs Aug. 24, 1931.

Remarks.--Records good. Flow partly regulated by four reservoirs since beginning of record (total usable capacity, 35,500 acre-ft). Two diversions above station; American River flume (see preceding page) and El Dorado Canal (see p. 459). Water from El Dorado Canal is returned to river above gage.

Cooperation.--Water-stage-recorder graph and 11 discharge measurements furnished by Pacific Gas & Electric Co. in connection with a Federal Power Commission project.

Revisions (water years).--WSP 931: 1928, 1938, 1940(M).

Rating table, water year 1953-54 (gage height, in feet, and discharge, in cubic feet per second)

0.9	5.0	3.0	242
1.0	7.5	4.0	578
1.3	20	5.0	1,000
1.6	42	7.0	2,200
2.0	83	10.0	5,150
2.5	152	12.0	7,700

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	50	67	126	59	*173	603	1,090	1,620	710	126	17	9.2
2	29	78	108	60	189	*595	1,110	1,570	591	75	19	9.1
3	28	*64	117	79	221	576	1,200	2,000	576	93	14	8.4
4	28	58	373	*78	202	562	1,250	2,460	622	93	*11	9.7
5	8.7	71	169	71	210	554	2,200	2,690	667	87	10	8.4
6	16	89	148	72	208	591	3,070	2,840	591	66	15	8.1
7	31	93	255	125	195	572	2,360	2,900	*554	*62	11	7.5
8	28	67	*194	87	206	796	2,130	3,210	475	54	9.1	8.4
9	27	79	170	23	218	7,360	1,870	3,210	648	54	12	8.1
10	51	90	151	98	216	5,950	1,850	2,220	595	54	11	7.8
11	51	125	149	71	200	2,900	1,820	2,430	629	36	9.4	7.8
12	5.6	158	138	55	326	1,950	1,930	2,440	599	51	12	9.1
13	5.4	121	128	41	1,380	1,560	2,160	2,300	1,090	45	14	8.4
14	20	383	149	44	1,100	1,340	2,360	2,320	742	42	10	*11
15	28	210	174	49	679	1,340	2,480	2,280	584	54	14	15
16	24	155	132	42	554	1,340	2,800	2,290	565	34	12	13
17	24	191	163	231	850	*1,250	3,300	2,820	547	45	11	11
18	55	168	102	134	1,030	1,120	3,400	2,570	468	27	12	9.5
19	145	122	95	111	734	1,100	3,130	2,420	390	35	12	10
20	62	144	138	72	652	1,060	2,980	2,280	393	24	9.1	9.4
21	45	128	178	27	595	1,040	2,960	1,850	414	39	16	8.7
22	40	139	132	53	569	975	3,080	1,460	427	44	13	15
23	39	223	85	1,060	554	990	3,230	1,250	380	26	12	30
24	89	218	102	1,280	603	1,000	2,860	1,170	329	37	10	26
25	73	274	120	569	633	946	2,560	1,070	283	30	8.7	33
26	69	210	66	366	652	918	2,500	905	234	22	11	29
27	66	158	77	286	648	941	3,270	810	195	24	12	27
28	68	125	57	233	625	1,020	*2,830	766	176	24	13	21
29	70	130	53	196	-----	*1,120	2,360	766	155	19	9.2	17
30	46	123	51	174	-----	1,290	1,960	702	122	18	9.7	21
31	57	-----	65	162	-----	1,080	-----	633	-----	23	9.4	-----
Total	1,378.7	4,279	4,153	6,008	14,422	44,439	72,160	60,052	14,751	1,462	368.6	416.6
Mean	44.5	143	134	194	515	1,434	2,405	1,937	492	47.2	11.9	13.9
Ac-ft	2,730	8,490	8,240	11,920	28,610	88,140	143,100	119,100	29,260	2,900	731	826

Calendar year 1953: Max 6,860 Min 5.4 Mean 918 Ac-ft 663,400
Water year 1953-54: Max 7,360 Min 5.4 Mean 613 Ac-ft 444,000

Peak discharge (base, 4,100 cfs).--Mar. 9 (11 a.m.) 9,340 cfs (13.15 ft); Apr. 23 (2 a.m.) 4,380 cfs (9.35 ft); May 9 (1 a.m.) 4,650 cfs (9.58 ft).
* Discharge measurement made on this day.

South Fork American River near Lotus, Calif.

Location.--Lat 38°49'05", long. 120°56'45", in SW¼ sec. 11, T. 11 N., R. 9 E., on left bank 0.4 miles downstream from Greenwood Creek, 2.4 miles northwest of Lotus, and 3.3 miles northwest of Coloma.

Drainage area.--678 sq mi.

Records available.--May 1951 to September 1954.

Gage.--Water-stage recorder. Altitude of gage is 635 ft (from topographic map).

Extremes.--Maximum discharge during year, 10,000 cfs Mar. 9 (gage height, 10.51 ft); minimum, 131 cfs Sept. 7, 11, 13.
1951-54: Maximum discharge, that of Mar. 9, 1954; minimum, 104 cfs Sept. 26, 1951. Maximum stage known since 1862, 20.4 ft Nov. 21, 1950, from floodmarks (discharge, 52,200 cfs on basis of slope-area determination of peak flow).

Remarks.--Records excellent. Flow partly regulated by 2 powerhouses and 4 reservoirs since beginning of record (total usable capacity now 35,500 acre-ft). Diversions for irrigation and domestic supply above station (see records for El Dorado Canal, p. 459.

Rating table, water year 1953-54 (gage height, in feet, and discharge, in cubic feet per second)

4.1	139	7.0	2,090
4.5	229	8.0	3,580
5.0	387	9.0	5,840
5.5	620	10.0	8,440
6.0	1,030		

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	224	251	318	240	387	786	1,550	1,930	786	302	184	160
2	226	*254	309	237	398	786	1,460	1,810	786	293	179	162
3	206	257	312	243	402	738	1,480	2,120	762	257	181	160
4	206	249	910	278	410	730	1,480	2,670	786	272	173	158
5	196	251	462	269	391	706	3,190	2,870	859	278	175	164
6	179	266	367	263	402	746	3,890	2,930	818	263	173	160
7	193	284	441	312	410	730	3,040	3,060	738	246	179	154
8	208	283	437	341	380	810	2,530	3,220	669	246	177	158
9	201	266	385	278	396	7,240	2,260	3,460	834	237	164	156
10	206	269	362	237	402	7,730	2,130	2,500	834	237	171	156
11	246	306	351	278	395	3,870	2,050	2,570	810	245	166	154
12	208	321	348	266	517	2,520	2,100	2,600	754	215	166	166
13	171	296	325	249	2,300	2,030	2,260	2,460	1,210	224	168	156
14	166	316	331	229	2,660	1,760	2,430	2,480	994	216	168	160
15	203	495	362	237	1,450	1,600	2,560	2,460	*786	*213	168	164
16	206	369	328	254	1,050	1,600	2,810	2,380	730	224	175	168
17	206	395	341	1,120	1,300	1,610	3,360	2,700	714	201	171	*166
18	218	376	299	558	2,050	1,460	3,900	2,690	648	208	171	154
19	310	321	287	391	1,330	1,500	*3,350	2,550	586	193	*175	156
20	281	362	309	358	1,090	1,450	3,150	2,430	525	198	166	158
21	251	334	378	*302	958	1,560	3,090	2,180	535	191	168	160
22	224	328	338	263	877	1,480	3,170	1,660	572	203	171	164
23	216	390	287	1,500	810	1,390	3,380	1,450	535	203	168	181
24	229	363	281	2,240	854	1,450	3,040	1,370	498	189	166	189
25	257	425	312	1,080	868	1,480	2,780	1,290	453	193	164	181
26	249	417	278	698	868	1,310	2,700	1,140	414	191	175	191
27	246	362	251	550	868	1,240	3,220	1,050	373	184	181	186
28	246	325	257	498	834	1,260	3,500	*976	348	179	181	184
29	246	318	237	445	-	1,380	2,630	976	354	184	179	186
30	246	315	232	414	-----	2,560	2,260	913	318	181	166	184
31	221	-----	229	395	-----	1,800	-----	854	-----	184	173	-----
Total	6,913	10,064	10,680	15,001	25,039	57,292	80,330	65,649	19,979	6,846	5,342	4,994
Mean	223	335	345	484	894	1,848	2,678	2,118	666	221	172	166
Ac-ft	13,710	19,960	21,180	29,750	49,660	113,600	159,300	130,200	39,630	13,580	10,600	9,910

Calendar year 1953: Max 6,450 Min 171 Mean 1,130 Ac-ft 817,900
Water year 1953-54: Max 7,730 Min 154 Mean 844 Ac-ft 611,100

Peak discharge (base, 5,600 cfs).--Mar. 9 (1:50 p.m.) 10,000 cfs (10.51 ft).
* Discharge measurement made on this day.

American River at Sacramento, Calif.

Location.--Lat 38°34'05", long. 121°25'20", on left bank at H Street Bridge, just east of Sacramento, Sacramento County, 6.5 miles upstream from mouth.

Records available.--July to October 1921, October 1929 to October 1932, May 1934 to December 1942 (low-water periods only), May 1943 to September 1954.

Gage.--Water-stage recorder. Gage is set to datum of Corps of Engineers. Auxiliary water-stage recorder 2.8 miles downstream from base gage.

Average discharge.--11 years (1943-54), 3,707 cfs (2,684,000 acre-ft per year).

Extremes.--Maximum discharge during year, 41,800 cfs Mar. 10 (gage height, 31.95 ft); minimum, 180 cfs Aug. 13, 14.
1921, 1929-32, 1934-54: Maximum discharge, 106,000 cfs plus estimated overflow of 70,000 cfs Nov. 21, 1950 (gage height, 45.73 ft); minimum recorded, 21 cfs Aug. 14, 1931.

Remarks.--Records good. Flow regulated by reservoirs and powerplants above station. Some regulation of high flows by temporary pondage at Folsom Dam, under construction during year. Diversions for irrigation of about 4,400 acres between stations at Fair Oaks and at Sacramento. Some inflow from Bear and Yuba River basins.

Cooperation.--Records collected and prepared in cooperation with California Division of Water Resources.

Discharge, in cubic feet per second, water year October 1953 to September 1954

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	*458	718	1,050	960	1,960	2,860	5,920	8,870	*2,170	740	248	317
2	415	655	1,010	990	*2,010	3,100	5,420	5,520	2,180	740	231	293
3	368	530	1,020	990	2,060	2,850	5,330	*5,520	2,050	712	*231	270
4	356	514	1,730	1,010	2,130	2,740	5,500	6,430	2,020	609	228	293
5	429	546	2,240	1,030	2,170	2,660	9,300	7,490	2,160	609	215	287
6	422	*436	1,400	950	1,900	2,610	*17,800	8,080	2,220	609	210	323
7	415	506	1,270	1,030	1,880	2,840	*15,000	*8,560	1,940	555	215	270
8	429	554	1,610	1,280	1,840	2,630	11,300	9,020	1,910	499	215	293
9	436	482	*1,430	1,330	1,990	13,200	9,410	9,450	1,780	475	215	293
10	429	458	1,310	1,130	1,980	*41,000	8,320	9,080	2,080	430	210	323
11	508	466	1,280	1,100	1,950	*23,100	7,850	7,100	1,810	460	200	311
12	514	570	1,250	1,100	2,020	*12,600	*7,630	7,140	1,740	*460	200	305
13	562	709	1,200	1,050	8,170	9,240	7,810	6,960	1,800	452	195	305
14	508	1,040	1,170	1,020	12,400	7,120	*8,140	5,770	2,330	400	200	305
15	548	1,940	*1,240	1,000	*8,980	6,340	8,490	6,680	1,900	394	205	311
16	578	1,300	1,310	1,060	4,750	6,300	8,800	5,570	1,880	388	210	354
17	570	1,080	1,290	4,030	4,600	6,590	10,200	7,080	1,880	374	210	368
18	864	1,050	1,280	*4,260	10,000	8,080	10,900	7,330	1,530	342	215	380
19	727	950	1,280	2,140	*6,500	5,710	10,700	7,230	1,460	*329	258	368
20	772	*900	1,160	*1,740	5,660	5,840	9,980	6,870	1,370	305	200	374
21	860	1,170	1,380	1,500	4,460	5,910	*9,330	*6,250	1,310	311	200	368
22	800	1,040	1,580	1,340	4,100	5,830	9,470	5,000	1,370	287	210	361
23	754	990	1,320	2,350	3,870	5,400	9,930	4,020	1,340	287	210	342
24	763	1,340	1,160	13,800	3,850	5,470	9,500	3,570	1,280	287	200	400
25	772	1,700	1,140	6,390	3,450	5,580	8,660	3,480	1,200	264	200	415
26	781	1,640	1,140	*3,780	3,820	4,970	8,060	3,230	1,100	270	210	408
27	763	1,360	1,080	*2,970	3,620	4,820	8,020	2,920	990	258	264	408
28	745	1,180	1,000	2,660	3,200	4,660	11,800	2,710	920	253	354	394
29	736	1,080	980	2,430	-	*4,780	9,810	2,640	840	242	342	415
30	745	1,060	960	2,180		8,150	7,920	2,580	*780	220	*305	422
31	745	- - -	950	1,870	- - - -	7,190	- - - - -	2,380	- - - -	254	329	- - - -
Total	18,566	27,944	39,110	70,270	112,900	227,970	275,900	183,480	49,240	12,805	7,133	10,278
Mean	599	931	1,262	2,267	4,032	7,354	9,197	5,919	1,641	413	230	343
Ac-ft	36,830	55,430	77,570	139,400	223,900	452,200	547,200	363,900	97,670	25,400	14,150	20,380

Calendar year 1953: Max 28,100 Min 344 Mean 3,710 Ac-ft 2,688,000
Water year 1953-54: Max 41,000 Min 195 Mean 2,857 Ac-ft 2,054,000

* Discharge measurement made on this day.

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CENTRAL VALLEY PROJECT
CALIFORNIA

Reconnaissance Studies of Water Problems.

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RECONNAISSANCE REPORT

BUREAU OF RECLAMATION
REGION 2, SACRAMENTO, CALIFORNIA

RECONNAISSANCE REPORT

FOLSOM NORTH UNIT

CENTRAL VALLEY PROJECT

CALIFORNIA

RECONNAISSANCE STUDIES OF WATER PROBLEMS

U.S. BUREAU OF RECLAMATION

REGION 2, SACRAMENTO, CALIFORNIA

MARCH, 1956

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Regional Office, Region 2
P. O. Box 2511
Sacramento, California

March 15, 1956

To: Commissioner, Bureau of Reclamation

From: Regional Director

Subject: Reconnaissance report on Folsom North Unit

This report on the Folsom North Unit has been prepared to assemble engineering data upon one of the foremost problems confronting the people of the area north of the American River between Folsom Dam and the city of Sacramento -- the provision of a future water supply. In the last fourteen years the population of the area has more than tripled, with a consequent change in character from semirural with a few urban centers, toward urban and suburban development. In effect a new and still rapidly growing fringe area of the city of Sacramento has been created.

With this change in character has come the problem of providing such necessities and amenities of urban living as streets, schools, and public utilities. The area has been fortunate in possessing in the western portion a ground-water supply at no great depth, and having in the eastern portion established districts distributing American River water. The districts in the eastern portion of the area are already negotiating for more water from Folsom Dam on the American River, while those now supplied from ground water have been considering the desirability of obtaining water from the Folsom source, in part at least because of concern over declining ground-water levels.

Photocopied

The Bureau of Reclamation, in accordance with the directive contained in the American River Development Act which reauthorized the Central Valley Project to include Folsom Dam in October 1949, has been engaged in developing plans to dispose of the water developed at Folsom Reservoir. Recently, attention has been focused on a study of the immediate Folsom North area shown on plate 1.

Reconnaissance ground-water analyses made in the course of this study indicate that, although ground-water levels will continue to decline as the supply is increasingly drawn upon until a balance is reached between draft and replenishment, water levels will stabilize in the western portion of the area at depths economically feasible for municipal use. Surface water supplies can be obtained from the American River from water stored behind Folsom Dam or from future American River storage. The eastern portion of the area will require additional supplies from this source.

The quality of both the ground-water and surface supplies is potentially excellent, but there are a few advantages and disadvantages for each that should be noted. Surface supplies will require moderate filtration and chlorination to provide safe clear water at all times, and will have some odor and taste problems for the first few years, but will be somewhat softer than ground water. Ground-water wells will require proper design and installation to prevent contamination, but the water will not require filtration and from information available may not require chlorination.

Two other points deserve consideration. A system utilizing ground water is more flexible in meeting demands when and where they

General Description

This chapter outlines the physical and economic setting of the area. The following chapters present information upon the present use and source of water, projected future water requirements, the results of ground-water studies and reconnaissance cost estimates of obtaining American River water supplies from Folsom Reservoir.

Characteristics of the Area

The Folsom North area, in earlier Bureau of Reclamation investigations, extended 26 miles northward from the American River to the Bear River and contained about 250,000 acres. Because of the different types of service which appear to be required and the different degrees of interest in water supply, the south half of the area has been made the subject of the most recent and intensive investigation.

The Folsom North Unit described in this report contains about 116,000 acres of land bounded on the south and east by the American River, on the north by an east-west line one-half mile north of the Roseville city limits, and on the west by the Western Pacific Railroad. The area is shown on plate 1. The topography varies from rolling hills in the eastern portion to gently sloping lands in the southwest. Except for a few minor areas adjacent to the American River, the drainage is in a westerly direction.

The city of North Sacramento is located in the southwestern part of the area and the city of Roseville in the north central part. In addition to the unincorporated communities of Rio Linda and Fair Oaks there are numerous localized urban developments, many with extensive

CHAPTER II

PRESENT WATER USES AND FUTURE REQUIREMENTS

To establish a basis for engineering consideration of methods of providing future water supplies for the Folsom North area, it is necessary to start with estimates of the amount of present water use and the organizations which supply it, and then to prepare estimates of the amount of water which will be needed in the future. Thus, this chapter begins with a discussion of the amount of water used at present and the types of organizations supplying it and then presents estimates of quantities to meet future needs. The methods of preparing the quantity estimates are described in some detail so that future investigators may form a clearer opinion of their validity and usefulness. As mentioned previously, the area is undergoing a period of explosive population growth, and this introduces more than the usual uncertainty into predictions of conditions as they may be thirty or forty years from now. Even with this uncertainty however, the estimates are believed to be adequate to serve the intended purpose.

Present (1954) water use is estimated to be about 111,000 acre-feet, an increase of about 30,000 acre-feet since 1951. It is estimated that future water requirements may reach about 225,000 acre-feet in 1980 and about 300,000 acre-feet in the year 2000. An acre-foot of water is the quantity represented by one acre of land covered one foot deep. Considering the entire area of 116,000 acres in the Folsom North Unit, which includes many thousands of acres of undeveloped land, it is evident that the present <u>average</u> water use is about one acre-foot per acre per year. For the year 1980 the estimated <u>average</u> use would be almost

two acre-feet per acre per year, while in the year 2000 the average use would raise to about two and one-half acre-feet per acre per year.

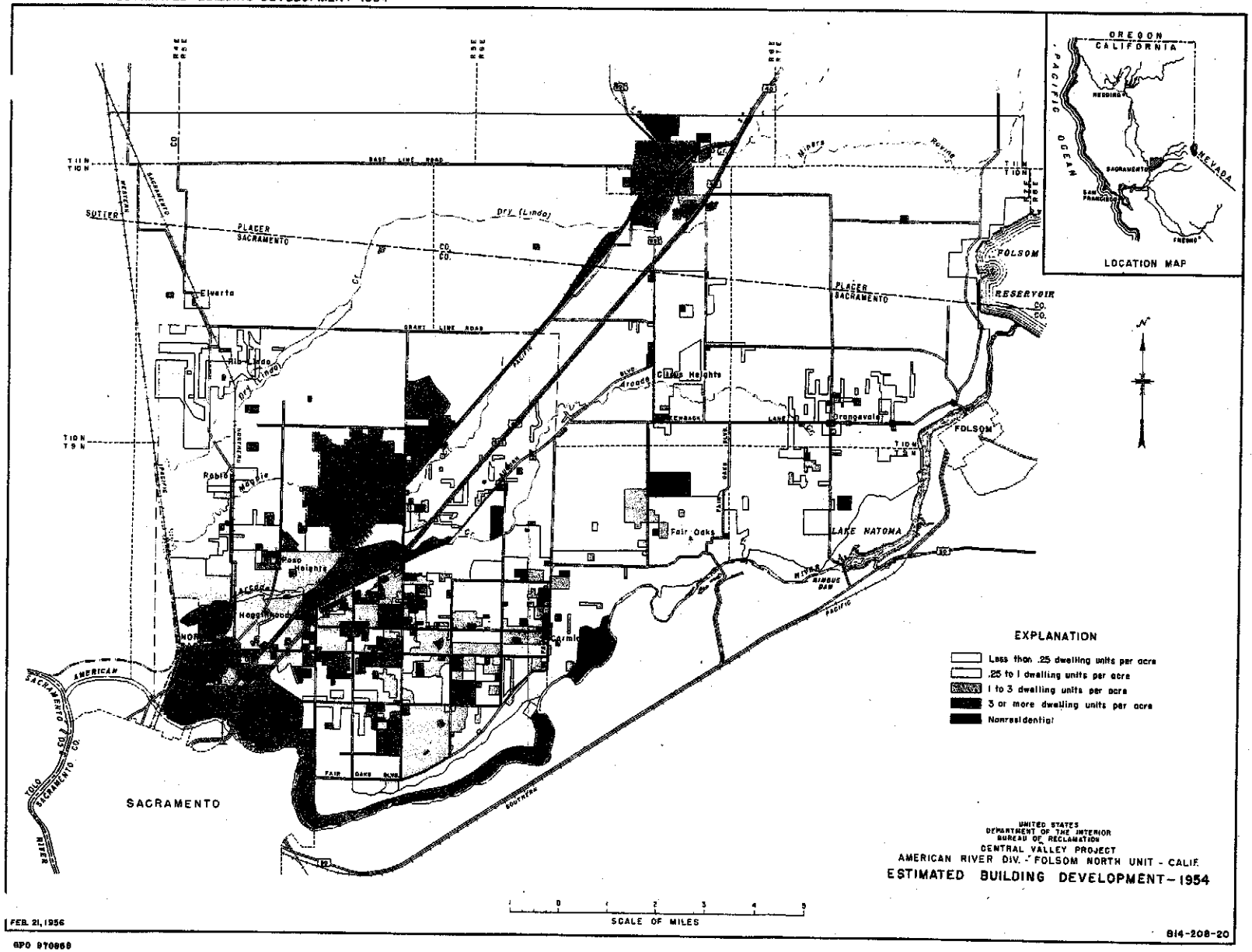
Present Water Uses

Of the 111,000 acre-feet of water used in the Folsom North area in 1954, it is estimated that about 70 percent was pumped from ground water and 25 percent was diverted from the American River. The remaining 5 percent was supplied from the Yuba-Bear River (Drum) system of the Pacific Gas and Electric Company and from Dry Creek. About half of the water was pumped or diverted by individual farmers or home owners and the remainder by water service organizations. These organizations ranged in size from small associations serving as few as six homes to large enterprises providing service to as many as six thousand.

Types of water service organizations.--Of the thirty organizations found in the area in 1954, twenty-four (nine privately owned utility companies, and fifteen public organizations) distributed water for general public use. The remaining six were themselves large public or private water consuming installations, including Del Paso Park picnic grounds (Sacramento County), Haggin Oaks Golf Course (Sacramento City), Del Paso Country Club, McClellan Air Force Base, and the Southern Pacific and Pacific Fruit Express companies at Roseville.

The 15 public organizations consisted of 5 county maintenance districts, 3 irrigation districts, 1 county water district, 4 mutual water companies, 1 water users association, and the city of Roseville. The maintenance districts are special tax assessment districts operated by

PLATE I ESTIMATED BUILDING DEVELOPMENT-1954



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ESTIMATED BUILDING DEVELOPMENT - 1954

FEB. 21, 1956

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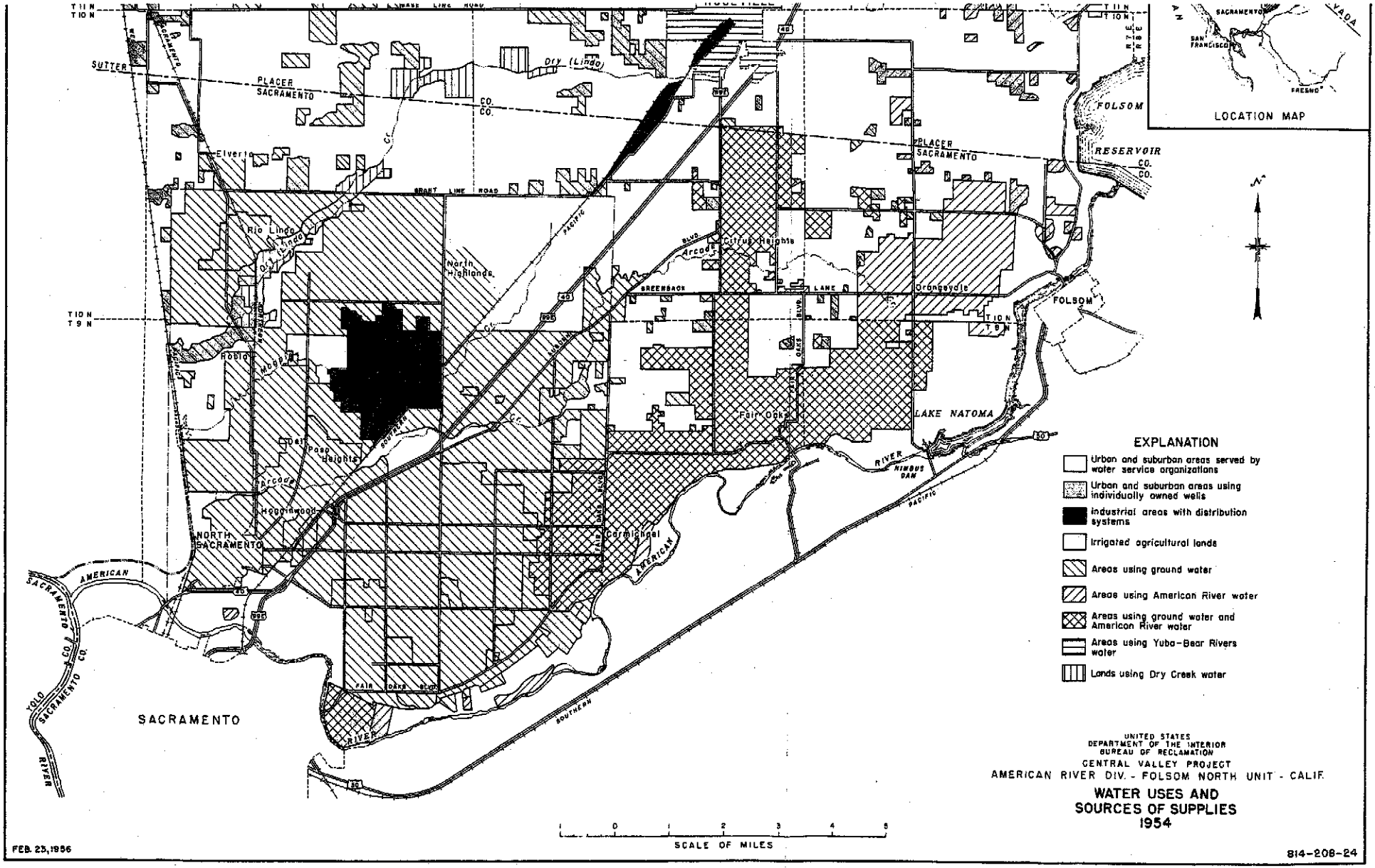
T11N
T10N
SUTTER
PLACER
SACRAMENTO
CO.
CO.
DRY (LINDA)
Elverta
SHORT LINE ROAD
Rio Linda
North Highlands
Arcade Blvd
Citrus Heights
GREENBACK LANE
Orangevale
FOLSOM
RESERVOIR
T10N
T9N
ROBLA
Del Paso Heights
Arcade
Hagginwood
NORTH SACRAMENTO
Fair Oaks
LAKE NATOMA
NIMBUS DAM
RIVER
Carmichael
AMERICAN
SACRAMENTO CO.
YOLO
SACRAMENTO
SACRAMENTO
SOUTHERN PACIFIC
FAIR OAKS BLVD.
SCALE OF MILES
0 1 2 3 4 5
LOCATION MAP
SACRAMENTO
SAN FRANCISCO
FRESNO
YUBA
EXPLANATION
Urban and suburban areas served by water service organizations
Urban and suburban areas using individually owned wells
Industrial areas with distribution systems
Irrigated agricultural lands
Areas using ground water
Areas using American River water
Areas using ground water and American River water
Areas using Yuba-Bear Rivers water
Lands using Dry Creek water
UNITED STATES
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AMERICAN RIVER DIV. - FOLSOM NORTH UNIT - CALIF.
WATER USES AND SOURCES OF SUPPLIES
1954
FEB. 23, 1956
814-208-24

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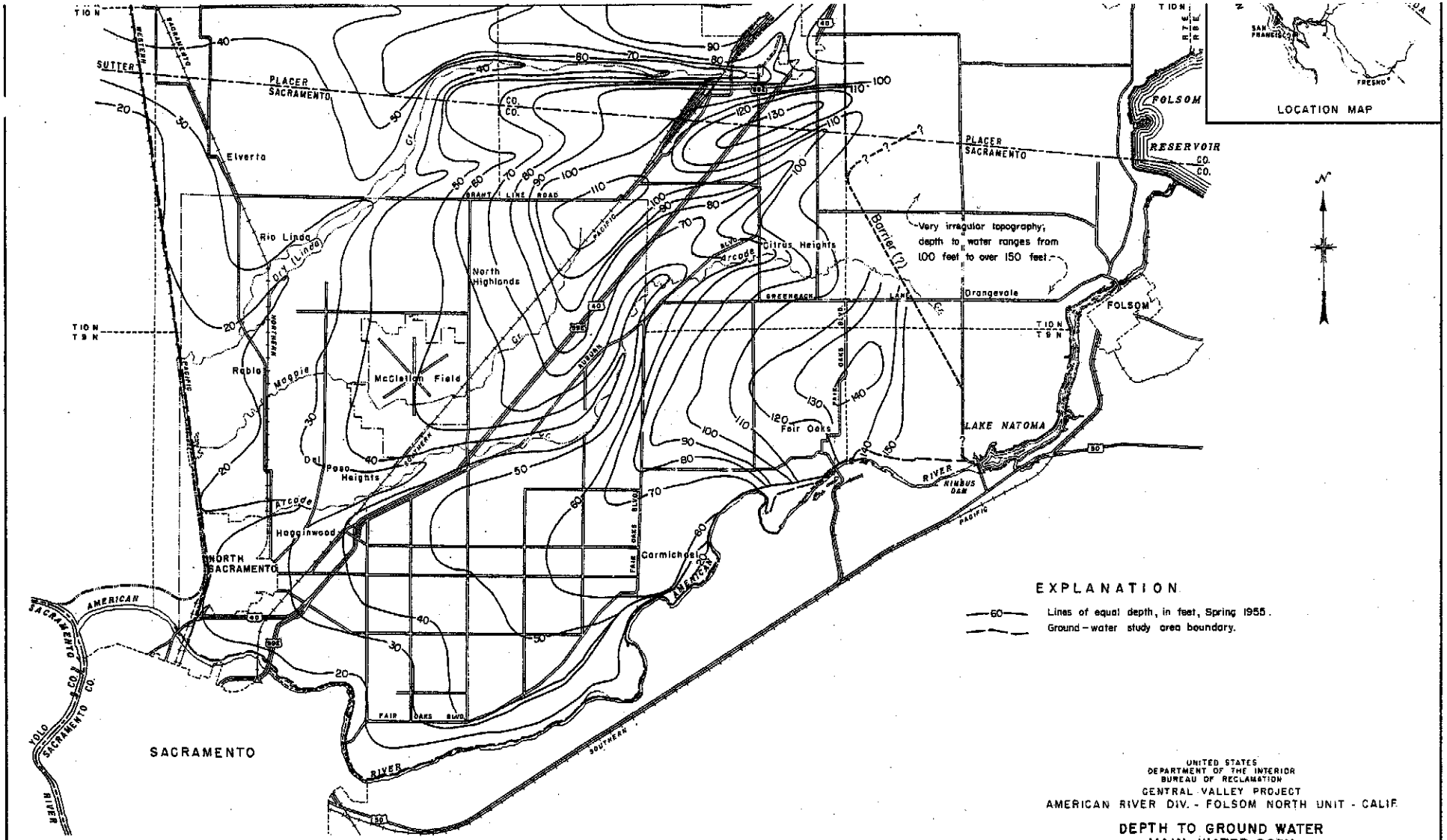

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AMERICAN RIVER DIV. - FOLSOM NORTH UNIT - CALIF.

DEPTH TO GROUND WATER MAIN WATER BODY SPRING 1955

FEB. 21, 1956

814-208-28

OPO 970868

favorable for significant additional development. Therefore the area to the east (22,000 acres) has been excluded from the ground-water study area.

Specific yield of the reservoir rocks, the volume of water which will drain by gravity expressed as a percentage of the total volume of the material, is estimated by the U. S. Geological Survey to be 5.8 percent in this general area.[1/] Specific yield was used to determine changes in ground-water storage.

Ground-water conditions.--Ground-water conditions in the Folsom North Unit have been analyzed largely on the basis of ground-water observation well measurements made by the Bureau of Reclamation and the State of California, Division of Water Resources. At the present time depth-to-water measurements are being made in approximately 135 wells in the spring of the year at the annual high water level stage, and in the fall at the annual low stage.

Ground water in this area is considered to be generally unconfined, although artesian conditions may exist in certain localities. Two distinct water table conditions have been defined, the main ground-water body, and a perched water table.

The main ground-water body is fairly uniform throughout all but the easternmost part of the area. Ground-water elevations on either

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1/ Poland, J. F.; Davis, G. H.; Olmstead, F. H.; and Kunkel, Fred; "Water Resources of California", Cal. State Water Resources Board, Bull. 1, Appen. B., 1951.

side of the previously noted "barrier" vary as much as 30 feet in a distance of less than one-half mile. This, coupled with water level contours and fluctuations, indicates that hydrologic continuity across the "barrier" is poor. As shown on plate 9, in the spring of 1955, the water table was at an estimated average depth of about 60 feet, ranging from over 150 feet just west of the "barrier" to less than 20 feet along the American River.

Although only one perched water body of significant extent has been defined in this study (plate 12), several shallower perched bodies reportedly exist in several places, probably as localized and isolated zones. The perched water table defined in this study covers about 60 square miles in the eastern and northern parts of the area. In the spring of 1955, the estimated average depth to this perched body was approximately 45 feet, ranging from less than 10 feet in the easternmost part of the area to about 90 feet west of the community of Fair Oaks. Only domestic and stock wells are known to produce exclusively from the perched zone and most of these are indicated to be relatively weak. Therefore, production from the perched zone is considered to be relatively insignificant in both present and ultimate development.

The main water body is recharged by percolation of precipitation, American River and other stream flows, water applied for irrigation, septic tank and seepage pit effluent, and subsurface inflow from the foothills. Ground water moves from the foothills and the American River (plate 10), into the study area at rates varying with water level

gradients. Ground-water elevation contours indicate that a ground-water depression has been developed in the northwest corner of the area by irrigation pumping; also that a pumping depression may currently be developing in the southwest part of the area. Migrating ground water, not intercepted by pumping wells, moves out of the area as subsurface flow along the western boundary and the extreme northwest corner of the area.

Perched ground-water in this area is also derived from deep percolation of precipitation, streamflow, water applied for irrigation, and septic tank and seepage pit effluent. Perched water migrates westward, intersecting the main water table in the western part of the area; some downward movement also occurs through wells and percolation through the sediments. Thus much of the perched ground water is assumed to be available eventually to wells producing from the main water body and no separate quantitative analysis was made of the perched body.

Water-level fluctuations.--Both spring and fall static levels of the main water table in most of the area have gradually declined through the period of record, the rate being accelerated in recent years due to increased ground-water withdrawals. The area-wide average decline of static levels from spring 1951 to spring 1955 was about 7.5 feet, or about 1.9 feet per year (plate 11), ranging from less than 1 foot per year in the general vicinity of Fair Oaks to more than 3 feet in the northwest corner of the area. The average annual decline for the period 1953-55 was slightly over 2 feet.

Water levels in wells adjacent to the American River below the vicinity of Carmichael were unusually high during the springs of 1951 and 1952. Thus, the spring 1951 to spring 1955 water level change map (plate 11) shows relatively large declines for this period along the American River. The higher 1951 levels probably resulted from above-normal recharge locally from the American River by the overbank flooding during the winter of 1950-51.

Perched water levels measured in wells in this area do not always fluctuate with the high stage in the spring and low stage in the fall; nor do they consistently show the gradual decline through the period of record reflected in the deeper wells. This is probably due to seepage of water applied for irrigation and other uses and also reflects the very small pumpage from this zone.

Wells and pumpage.--Wells in this area consist of larger wells for irrigation, public supply, and limited industrial purposes, and smaller wells for domestic and stock use. The largest irrigation wells are located in the Dry Creek subarea where ground-water irrigation practices are the most extensive in Folsom North Unit. Many of the larger irrigation wells are over 500 feet deep and yield up to 1,500 gallons per minute or more. Water service organization wells for municipal supply, located chiefly in the Arden-Arcade and North Sacramento subareas, range from less than 200 feet to over 900 feet in depth, and yield from 200 to 2,000 gallons per minute. Domestic wells, scattered throughout

Recharge.--Ground-water recharge to the study area has been computed by two different methods, the results of which are virtually the same. The ground-water reservoir has been considered as a whole, with recharge to the main and perched water bodies considered as one in these computations. With consideration of available ground-water data, increasing ground-water development, and normal recharge opportunities, the year 1954 was selected for recharge determination.

Net recharge from all sources was computed as the algebraic sum of gross pumpage and change in ground-water storage on a spring to spring basis. Using a pumpage of 74,600 acre-feet and a storage change of 11,700 acre-feet (the product of water level change and specific yield) 1954 net recharge was determined to be about 62,900 acre-feet.

Recharge was also derived by evaluating each source of supply to the area. Recharge sources and corresponding estimated recharge quantities for 1954 are given as follows:

Percolation of precipitation	34,600 a.f.
Percolation of American River flows	22,200 a.f.
Percolation of other stream flows entering study area	6,300 a.f.
Percolation from irrigation and other water applied to soil	11,000 a.f.
Subsurface inflow	2,300 a.f.

Thus, total 1954 recharge as the sum of these items equals 76,400 acre-feet. The difference between subsurface outflow, computed to be about 13,100 acre-feet, and total recharge is net recharge, or 63,300 acre-feet.

These two methods of determining recharge serve as a close check on each other and 1954 net recharge is therefore considered to be about 63,000 acre-feet.

Although 1954 was considered the best year for recharge determination, rainfall for this year was somewhat above the long-term normal and American River and Dry Creek flows were below normal. Other sources of recharge, as well as ground-water use, were about normal. Recharge for 1954 was therefore adjusted to average by departures from normal for rainfall and streamflow with consideration of their proportionate contributions to total recharge. Net recharge for 1954 would thus have been about 64,000 acre-feet if rainfall and runoff had been normal.

Overdraft.--When pumpage continuously exceeds net recharge in an area over a period of years, water levels progressively decline, and ground-water storage is depleted. Under such conditions a state of overdraft is usually considered to exist. Although these conditions are generally present in the ground-water study area, overdraft here cannot be regarded as alarming from an overall supply standpoint.

In 1954, pumpage exceeded net recharge by some 11,600 acre-feet and this amount of storage was depleted. This quantity adjusted to average conditions is about 10,600 acre-feet. Water-level declines averaged slightly over two feet and represented a hydrologic adjustment by which inflow gradients were steepened and recharge increased. Therefore, if pumping demand would remain at the 1954 level for several years,

the water table could be expected to stabilize, possibly within five to ten feet below the 1954 stage.

The current water level declines are important, however, to private well owners who pump mainly for domestic use. Pumps in many such wells have had to be lowered and some shallower wells have even gone dry.

Safe yield.--The term "safe yield", as used in this report, refers to the maximum pumpage of ground water which would not exceed net recharge, impair water quality, or cause pumping to become uneconomical. Ground-water quality is good. Recharge can be increased substantially by lowering water levels in the area, thereby steepening subsurface inflow gradients from the foothills and the American River. Similarly, subsurface outflow can be decreased and probably eliminated, also increasing net recharge. Safe yield is therefore based on the quantity of recharge which can be induced with maximum water depths within assumed economic limits. Recharge possibilities have thus been estimated for average annual depths to water of 150 and 200 feet, considering spring static levels and fall pumping levels. Since the 200-foot level is within economic reach of the urban and suburban type of development expected in this area, the corresponding recharge is considered to indicate safe yield. Future pumping development in the areas to the west and north of the Folsom North Unit cannot be realistically predicted at present, therefore, it is assumed that neither of these average water level stages will induce subsurface inflow to, or outflow from, the study area.

The estimated net ground-water recharge with the 150-foot average annual water-level stage would be about 200,000 acre-feet. The safe ground-water yield, or pumpage, of the Folsom North Unit ground-water study area, considered to equal probable net recharge with the 200-foot average annual water-level stage, is estimated to be on the order of 230,000 acre-feet a year.

Surface Water Supplies

Present supplies and use.--Of the approximately 111,000 acre-feet of water used in the Folsom North Unit during 1954 about 35,500 acre-feet were obtained by surface diversions. Local streamflows are being used for irrigation of agricultural lands, primarily along Dry Creek. Minor quantities are used from other streams for both lawn and agricultural irrigation. The summer flows in Dry Creek primarily consist of waste water from the operations of the Pacific Fruit and Express Company, the Pacific Gas and Electric Company, and the city of Roseville's sewerage disposal plant. Table 7 presents users, quantities, and sources of the 1954 diversions.

Future supplies.--Folsom Dam on the American River, which began operation during 1955, has made additional dependable water supplies available from the American River at either the reservoir or the river downstream from the dam. The Folsom North Unit is an area that could be served physically from Folsom Reservoir by either gravity or pumping, depending upon the stage of the reservoir.

Table 7--Estimated Surface Water Diversions by Sources - 1954

Folsom North Unit

	American River (acre-feet)	Yuba-Bear Rivers[a]	Dry Creek
North Fork Ditch Co.			
Citrus Heights I. D.	5039	0	0
Fair Oaks I. D.	7129	0	0
Orangevale Water Co.	5074	0	0
North Fork Ditch Co.retail	4650	0	0
Total N.F.D. Co. diversions	21,892	0	0
Carmichael I. D.	5015	0	0
Pacific Gas & Electric Co.			
Roseville City	0	3094	0
Southern Pacific Co.	0	751	0
P. G. & E. retail area[b]	0	397	0
Total P. G. & E. deliveries	0	4242	0
Individuals	1070	0	3265
Totals	27,977	4,242	3,265
Rounded	28,000	4,200	3,300

a/ Water from Lake Valley Reservoir in the Upper American River basin is also diverted to the Yuba-Bear River hydroelectric system of the Pacific Gas and Electric Company.

b/ Includes deliveries to Hidden Valley Community Association

Water Resources

Water service from the Yuba and Bear Rivers being furnished by the Pacific Gas and Electric Company to the city of Roseville and other users presumedly will continue to be available in the area. These supplies could be used by the city of Roseville, or for agricultural irrigation, or for the suburban and resort development now beginning in the Stallman area or for other purposes within the Unit, dependent upon the desires of the local people and the arrangements made with the Pacific Gas and Electric Company.

Presently developed surface supplies, such as in Folsom Reservoir, will probably be committed within a comparatively few years. If additional surface supplies are desired or needed in this area, there are several potential projects on the American River that can be developed to provide water at a moderate cost for municipal, industrial and domestic use. Some potential projects on the upper reaches of the South and Middle Fork systems, such as the Sacramento Municipal Utility District's proposed Silver Creek Development, can develop enough power to pay for all or a considerable portion of the cost of storage, so that considerable quantities of water for consumptive use can be produced as a by-product or at a comparatively low cost.

Additional and larger quantities of water can be developed by storing North and South Fork waters in large foothill reservoirs, such as one that could be constructed on the North Fork near Auburn. Comparatively less power could be developed by these reservoirs, however, so

the net cost of water for consumptive uses would be higher, but still within reason for municipal, industrial, and domestic use.

Actual costs of water from future American River developments will depend upon the nature of the project, the developing agency, the method of financing, and many other factors.

Exhibit 32

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STATE OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

In the Matter of: HEARING ON THE SOUTHERN CALIFORNIA WATER COMPANY PETITION TO REVISE DECLARATION OF FULLY APPROPRIATED STREAM SYSTEMS REGARDING THE AMERICAN RIVER	TESTIMONY OF STEPHEN D. REYNOLDS CERTIFIED ENGINEERING GEOLOGIST (CEF)

TESTIMONY OF STEPHEN D. REYNOLDS

I, Stephen D. Reynolds, provide the following written testimony under penalty of perjury in relation to the State Water Resources Control Board's Hearing on the Petition filed by Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County.

QUALIFICATIONS:

I hold a Bachelor of Science in Geology from California State University, Hayward, and I have approximately 20 units of graduate credit at U.C. Davis and other universities in the areas of soils and hydrogeology. I am a California Registered Geologist, RG4022; a Certified Engineering Geologist, EG1286, and a Certified Hydrogeologist, CH200. I have twenty-three

years of professional experience in engineering geology and hydrogeology. I am presently employed as a Senior Engineering Geologist with the Department of Conservation's California Geological Survey (formerly the Division of Mines and Geology) in the Watershed Restoration Program providing hydrologic and fluvial geomorphic analysis for watershed and stream restoration projects. Through an interagency contract, I also regularly provide technical analysis for the Department of Fish and Game (DFG) on stream flows and groundwater.

My career as an engineering geologist has included working as an independent consultant and for public agencies in the area of hydrogeology and environmental restoration. My work as a private consultant included the following: 1) hydrogeologic evaluations of groundwater resources, groundwater contamination, and well design; and 2) geotechnical, seismic, and landslide hazard investigations and monitoring.

My experience working for public agencies has included the following: 1) Technical Team Leader responsibilities at the U.S. Army Corps of Engineers included developing and overseeing programs for the evaluation of contaminated ground water and soil from which the data form the basis of exposure assessments; responsibilities also included independent work on specific challenging or sensitive projects involving groundwater investigations and groundwater modeling. Projects included: the numerical ground- and surface water interaction modeling of the Chena River Flood Control Project, Fairbanks Alaska; development of hydrogeologic database and insitu data-gathering network for Sierra Army Depot, Herlong California; exposure assessment and risk appraisal of contaminated soils and ground water at Fort Irwin, California, Camp Navajo, Arizona, Hawthorne AAP, Nevada, and Fort Huachuca, New Mexico; development of comprehensive environmental assessment plans for Hawthorne Army Depot, Nevada and Camp Navajo, Arizona; environmental compliance plans for channel improvements

at San Pablo and Wildcat Creeks , San Pablo, California. I authored the chapters on subsurface characterization and aquifer testing for the U.S. Army Corp of Engineer's updated Ground Water Engineering Manual. 2) At the California Department of Toxic Substances Control (DTSC), I was the hydrogeologic lead on the interdisciplinary team responsible for developing the protocol and methodology for fate and transport for health-based waste treatment standards. At DTSC, I also evaluated potential impacts to human health and the environment via the groundwater and soil pathways at over 125 State Bond Sites (State Superfund Sites). This involved both the assessment of current and future exposure, integration of those findings into the risk appraisal process, and design of mitigation measures for the anticipated exposure. In addition, I prepared the DTSC's guidance manual(s) and standards for the evaluation of hydrogeology. 3) At the California Department of Water Resources (DWR), I evaluated the geologic feasibility of proposed civil engineering works, including slope stability and seismicity, design and installation of wells for construction water supply, the design and installation of well fields for dewatering deep excavations, and geotechnical support to resident engineer during construction.

My resume has been provided separately as **DFG Exhibit 1.**

KEY ISSUES:

Should the SWRCB revise the Declaration to allow the Division of Water Rights to accept and process water right applications to appropriate "treated groundwater discharged into the American River"?

The SWRCB should not revise the Declaration of Fully Appropriated Streams (FAS) to accept any applications to appropriate treated groundwater discharged into the American River. This water is not "new" water but is rather "old" water that was accounted for by the Board in the original water budget analysis for the FAS. When the FAS was declared, the Board relied on

then-available American River flow data that showed sufficient flows to meet downstream appropriations, fish flows, salinity control needs, and to replenish groundwater. Data taken since 1958 confirms that American River flows before the FAS Declaration were significantly higher than today, and the river water budget, including groundwater recharge from the river, was assumed to be in balance. However, various sources of data from 1958 to the present confirm that the river hydrology has changed. Since the FAS Declaration, American River flows have steadily decreased and groundwater levels have continued to drop. Today, it is clear that the river is a losing stream. The data confirms that the Aerojet Site is hydraulically connected to the American River. If treated groundwater -- "old" water accounted for by the Board in 1958 -- is made available for possible appropriation, the total flows in the American River will decrease resulting in degradation of beneficial uses downstream.[1]

SPECIFIC QUESTIONS ASKED BY THE BOARD:

1. **Has adequate information been provided to demonstrate that there is a change in circumstances since the American River system was included in the FAS Declaration?**

Hydrogeologic Setting:

There is much new hydrologic data to show negative changes in circumstances since the American River system was included in the FAS Declaration. To fully appreciate these changed

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[1] The Board's "Revised Schedule and Clarification of Scope of Proceeding" limits the May 31, 2002 hearing to testimony on whether the extracted water from the Aerojet treatment is "new" water or whether the water was considered by the Board when it reached the FAS Declaration. The Board asked that public trust issues including biological affects of reduced flows be addressed in the latter phases of this hearing, that is, if and when applications are actually filed. DFG respectfully reserves the right to submit testimony on public trust resource needs and the best evidence currently available on minimum flows for fish, riparian habitat, and other resources affected by the American River at that time.

circumstances and the impact of the proposed petition, however, it is first necessary to understand the hydrogeologic setting of the American River.[2]

DFG Exhibit 2 is a schematic map representing the location of geologic cross sections at right angles or normal to the channel of the American River. (**DFG Exhibit 2**, Dr. R.J. Shlemon, "Quaternary Geology of Northern Sacramento County, California: Annual Field Trip Guidebook of the Geological Society of Sacramento, 1967, Plates).[3] Geologic section AA' on DFG Exhibit 2 is located approximately 1 mile downstream of Nimbus Dam, roughly located near Hazel Avenue, with geologic section B,B' on the map located approximately 5 miles downstream of Nimbus Dam, roughly located at the Sunrise Bridge. DFG Exhibit 3 is a detailed diagram of the geologic cross sections at these specific locations (AA' and BB') on the American River. (**DFG Exhibit 3**, from Shlemon, Plates). On the right side of DFG Exhibit 3 representing the south

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[2] This hydrogeologic setting analysis for the American River comes in part from being an Associate Engineering Geologist, assigned to the Aerojet Superfund Site for DTSC during the 1980's and my personal review of approximately 200 well logs located in the vicinity of the Aerojet site. (DFG Exhibit 1, Resume). My review included evaluating the construction of the wells and the record of the thickness and type of sediments penetrated by the wells. Where pumping data existed, I also evaluated that information. This analysis also incorporates the hydrogeologic information from numerous technical reports relied on by the Board in reaching its FAS Declaration including, but not limited to: State Water Resources Board, Bulletin No. 21, "American River Basin Investigation: Report on Development Proposed for the California Water Plan," June 1955, Volumes 1 and 2 (selected excerpts from Volume 1 attached as **DFG Exhibit 28**; Appendix II-A, "Ground Water Studies," attached in its entirety as DFG Exhibit 29, "SWRB Bulletin 21"); United States Geological Survey, "Water-Supply Paper 1345: Surface Water Supply of the United States, Part II, Pacific Slope Basins in California, 1956," (selected excerpts attached as **DFG Exhibit 30**); State Water Resources Board, Bulletin No. 2, "Water Utilization and Requirements of California," Vol. 1, June 1955; State of California Department of Public Works, Division of Engineering and Irrigation, Bulletin No. 5, "Flow in California Streams, Appendix A to the Report to the Legislature of 1923."

[3] Schlemon, Dr. R.J., Dr. T. Horner, Dr. J. Florsheim, "Quaternary Geology of the Sacramento Area," Association of Engineering Geologists, Guidebook for Field Trip, Mary 25, 2000.

side of the river, there is a series of river terraces that were cut by the American River flows from approximately 10,000 years ago for the Modesto Formation to many millions of years ago for the Mehrten and Laguna Formations. The location of the American River as it flows today occupies the topographic low on the cross section, colored blue in Exhibit 3. This map shows that the American River has cut down and back filled -- with water-bearing alluvium -- a discrete or confined basin. The cross sections on Exhibit 3 illustrate that the American River today and its associated sediments are contained within a discrete, isolated and finite feature, something like a trough at the bottom of the river terraces. This geologic trough varies from approximately 1 to 1 ½ miles in width.

An important feature of the geology of this area is what is known as the Fair Oaks Formation, located on the north side of the American River's present location and noted on the left side of DFG Exhibit 3. The Fair Oaks Formation is bluff-forming and restricts the flow of the American River on the north side because the formation is made of 60-70% silt and clay materials. These materials are ancient, low permeability sediments that permit only limited transmission of water. (**Exhibit 4**, Schlemon, et al, pp. 27-28, Plate 3 and Attachment 3; see also Plate A3-C-1 of DFG Exhibit 29, from SWRB Bulletin 21, Vol. II, "Ground Water Studies," June 1955). Put simply, very little water is exchanged between the river flows and the Fair Oaks Formation.

In contrast to the Fair Oaks Formation, the sediments underlying the River and the terraces on the south side of the River are composed mostly of sands and gravels. Sediments composed of sands and gravels have a high degree of permeability and therefore permit the easy and rapid exchange of water between the water-bearing sediments and river flow. (See, e.g., **Exhibit 5**, Ralph C. Heath, "Basic Ground-Water Hydrology," U.S. Geological Survey Water-

Supply Paper 2220, 1993, pp. 12-13; see also Plate A3-C-1 and pages A-10 to A-16 of DFG Exhibit 29, from State Board Bulletin 21, Vol. II, "Ground Water Studies," June 1955).

Changed Circumstances: Lower Ground-Water Levels

There are many indicators of the interconnection between surface water sources and aquifers and the changes in those interconnections over time. One of the most fundamental indicators is groundwater contour mapping. These maps display lines of equal elevation of water in the aquifers, similar to how topographical maps show lines of equal elevation on the earth's surface. The shape and orientation of these contour lines are influenced by the interaction of the aquifer with surface water bodies such as rivers and lakes. When a river provides water to the aquifer, that is, the river is a "losing stream," the contour lines point or deflect downstream. (**DFG Exhibit 6**, Heath, p. 23; see also **DFG Exhibit 7**, C.W. Fetter, Applied Hydrogeology, Third Edition, MacMillan College Pub. Co., 1994, pp. 58-60).

The groundwater contour data for the American River displays this characteristic losing stream pattern. Before Aerojet began extracting groundwater near the river, the contour lines were already deflected downstream, indicating that the American River was losing water to the adjacent aquifers. (**DFG Exhibit 8**, Gencorp Aerojet, American River Study, Figures 2-8 and 2-9, Groundwater Elevation Contour Maps, April 1995, from the Engineering Evaluation/Cost Analysis, for the American River Study Area, hereinafter referred to as "EE/CA.") The groundwater contour data in the Remedial Investigation and Feasibility Study (hereinafter "RI/FS") -- also taken prior to Aerojet extracting groundwater near the river -- similarly displays the same characteristics as shown in Figures 2-8 and 2-9 from the EECA. (**DFG Exhibit 9**,

Figures A-7 (Aquifer A), A-8 (Aquifer B) and A-9 (Aquifer C) from Western Groundwater Operable Unit, RI/FS, Vol. II, Appendix A.)[4]

This interpretation is further supported by the long-term groundwater level monitoring data, collected by the California Department of Water Resources (hereinafter "DWR"). The DWR data shows that groundwater levels have been declining since 1942. I personally looked at the records of approximately 20 production wells, located north and south of the American River in the vicinity of Aerojet. Attached to this testimony are graphs showing water level measurements from five representative wells and the associated raw data taken over a period of between 24 and 50 years by DWR (**DFG Exhibits 10-14**, well numbers 8N6E8F001M, 9N6E27D001M, 7N6E8H001M, 9N6E34R001M, and 8N6E9Q004M, respectively). While I evaluated the data from all the wells, I only graphed these five wells because they had the most complete data records available for wells in the area of interest. These graphs are basic bar graphs showing ground water level elevation on the Y axis versus time. (Time is noted on the X axis as "measurement No."). The red line on each graph is the trend line obtained by doing a linear regression analysis of the data. The trend line indicates that groundwater levels have been dropping over the last sixty years. These data support and are consistent with the interpretation of the contour lines discussed previously for the American River. That is, the declining water table has increased the head differential between the river and groundwater. This has increased the driving force moving water out of the river and into the aquifer and thereby resulted in increasing losses from the river as it recharges groundwater.

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[4] Note that for the purposes of this analysis, I have assumed that the contour maps are valid representations of the underlying raw data. I have not independently analyzed the data on which the contour maps are based.

To further illustrate the significance of the groundwater level data and its impact on the American River, I performed a cumulative departure analysis of long-term groundwater level trends.[5] I selected well 8N6E8F001M for the cumulative departure analysis because this well had the most complete DWR record and the most extensive pre-1958 data available for wells in the vicinity of Aerojet. Attached as **DFG Exhibit 15** is a graph showing the results of this cumulative departure analysis. This analysis indicates that prior to 1958, the groundwater levels for this portion of the American River hovered around the mean groundwater level. This shows that groundwater usage was in balance with the natural infiltration rate from the American River. Importantly, the departure analysis is strong evidence that since 1958, there has been a cumulative decline in groundwater levels near the American River, thereby inducing greater recharge from the American River as explained above. By relying on the contour maps and the historic data, it is clear that the American River is a losing stream, i.e., that groundwater is recharged by the American River. Put another way, the American River is losing water to the adjacent aquifers. As more groundwater is pumped, more water is removed from the River, and the River flows decrease. (See, e.g., DFG Exhibit 7, Fetter at 58-60). The importance of this conclusion is that there are greater losses of American River flows to groundwater recharge today than at the time the FAS Declaration was made in 1958.

Finally, attached are hydrographs from monitoring wells located near the American River in the vicinity of the Aerojet Site. (**DFG Exhibits 15-A, 15-B** and **15-C**). The hydrographs indicate that while groundwater levels have been dropping, they are still above the bottom of the

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[5] Cumulative departure analysis for hydrologic data has been accepted by the Board in previous hearings and is a commonly used method of analysis.

river. This shows that the river is in direct connection with the water table and that there is no vadose zone.

Drill Logs Indicate Interconnection of Aquifers and the River:

As noted in footnote 2, I have personally reviewed over 200 well logs located within the subject area. These well logs were from primarily water supply wells with some monitoring and extraction wells. The wells ranged in depth from 50 feet to 580 feet, with a mean of 225 feet.[6]

The vast majority of these wells were constructed in a manner that interconnects the shallow, intermediate, and lower aquifers. That is, these wells were constructed with a large-diameter surface casing, typically to a depth of 50 feet, then a smaller-diameter single well casing having multiple perforated segments and a gravel pack (formation stabilizer) that extends from the total depth of the well up to ground surface. The result of this interconnection via the well and the gravel pack is the free movement of water throughout and between the various aquifers. While there are several clay layers that could form a natural barrier to the free movement of water between the aquifers, these barriers have been perforated by the numerous extraction and production wells in the area. (See, e.g., SCWC Exhibit 25, "Draft Aerojet Vicinity Wells;" see also **DFG Exhibit 16**, American River Study Area Well Location Map by Gencorp Aerojet Environmental Operations, hereinafter "Well Map"). The degree of interconnection is more than sufficient for the American River to lose water not only to the upper aquifer but also to the lower aquifers as well. Today, any groundwater extraction in the vicinity

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[6] The well log data is not attached to this testimony because pursuant to Water Code section 13752, that information is confidential except under limited circumstances. Government agencies such as DFG and the Water Board can access the well logs for studies. The logs are available to private individuals, such as the Petitioner, with prior written authorization from the well owner.

of the Aerojet Site, regardless of the depth of origin of that water, will include water drawn from the American River.

Aquifer Tests Confirm the River is a Losing Stream:

Aquifer tests conducted by the Gencorp Aerojet Environmental Operations adjacent to the American River also demonstrate that these sediments have high to very high hydraulic conductivities. Aquifer test results are derived by analyzing graphs of observation well water level decline versus pumping time. These tests provide valuable information about the hydraulic conductivity of the sediments between the observation well and the pumping well. For example, the more conductive the sediments in the aquifer, the easier water moves through them. This is reflected in a slower rate of water-level decline in observation wells with respect to pumping time. The more conductive the aquifer sediments, the slower the rate of decline. Less conductive sediments such as silty sand have a much higher rate of water level decline with respect to pumping time.

I have personally reviewed the aquifer tests included in the EECA.[7] For example, attached to my testimony is a true and complete copy of the aquifer test results for extraction well 4325, located approximately 3,000 feet downstream of Nimbus Dam, 400 feet south of the American River, and drilled to a depth of 98 feet, into the Upper Aquifer (also referred to as Aquifer A). (See DFG Exhibit 16, for location of well highlighted on Well Map; and **DFG Exhibit 17**, Aquifer Test Results for Well 4325, from EECA, Vol. II, Appendix A and GET Effectiveness Evaluation for the American River Study Area dated 2/2000). As a second example, I have attached a true and complete copy of the aquifer test results for a deeper

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[7] These aquifer tests were conducted by Gencorp Aerojet to refine the final design of the Aerojet groundwater treatment system for the Aerojet Superfund Site. All aquifer test results can be found in the EECA, Vol. II, Appendix A.

extraction well, number 4330, drilled to a depth of 147 feet deep into the Lower Aquifer (also referred to as Aquifer B) and located adjacent to extraction well 4325. (See DFG Exhibit 16, Well Map; and **DFG Exhibit 18**, Aquifer Test Results for Well 4330). Finally, I have attached a true and complete copy of the aquifer test results for extraction well number 4335, drilled to a depth of 195 feet into the Deeper Aquifer (also referred to as Aquifer C), again located adjacent to extraction wells 4325 and 4330. (See DFG Exhibit 16, Well Map; and **DFG Exhibit 19**, Aquifer Test Results for Well 4335). The rate and magnitude of decline of the water level in the aquifers, as evidenced by the shape of the curve of the aquifer test result graphs for these wells, show the hydraulic conductivities are very high adjacent to the American River and therefore that water moves easily through these sediments. (**DFG Exhibit 19-A**, Aquifer Test Summary; see, e.g., Exhibit 5, Heath, p. 13). Aerojet's analysis of this data also supports that materials of high conductivity are ubiquitous on and in the vicinity of the Aerojet Site. (**DFG Exhibit 19-B**). The fact that the water moves easily and readily through these sediments, at a depth of 98 feet, 147 feet and at 195 feet, respectively, confirms the interconnection between the American River and the adjacent sediments of the river terraces. (DFG Exhibit 3; see also DFG Exhibit 5, Heath, p. 13). From a hydrogeologic perspective, the results of these aquifer tests confirm that the American River is a recharge boundary, supplying water to the adjacent aquifers. (DFG Exhibit 5, Heath, p. 12-13 and p. 46-47; see also **DFG Exhibit 20**, Excerpts from R. Allan Freeze, John A. Cherry, Groundwater, Prentice-Hall, New Jersey, 1979, pp. 330-346; and **DFG Exhibit 21**, Excerpts from G.P. Kruseman, N.A. de Ridder, Analysis and Evaluation of Pumping Test Data, Second Edition, International Institute for Land Reclamation and Improvement, Publication 47, Netherlands, 1991, pp. 109 to 123).

Aquifer tests also provide information about the source of water pumped. If water is removed solely from an aquifer, the aquifer test result would show a curve that would continue to slope upwards or rise over time. If the aquifer is connected to a secondary source of water such as a river, the aquifer test result curve would flatten and remain flat throughout the test. The aquifer test result curve for extraction well 4325 (drilled to a depth of 98 feet) begins to flatten at approximately 100 minutes, indicating the time that recharge begins. The only recharge source within the influence of this pumped well is the American River. The recharge source can only be the American River because the curves for the deeper observation wells display a similar geometry or pattern, flattening out in response to recharge. (DFG Exhibit 17). The aquifer test result curves for extraction well 4330 (drilled to a depth of 147 feet), (DFG Exhibit 18) and 4335 (drilled to a depth of 195 feet) (DFG Exhibit 19), show similar results. These tests support that the primary source of water to those sediments is the water in the American River.[8]

Changed Circumstances: Flows in the American River

To date, flows in the American River have not been greatly affected by groundwater treatment operations because current treatment operations return the extracted water to the River, and the system is operating at limited flow rates. The only current loss caused by the groundwater treatment operations comes from transmission losses.

However; the critical question for the Board is what would be the impact if the extracted water were not returned to the American River if the FAS Declaration is modified as requested

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[8] In my evaluation of the aquifer test data, I have considered the influence of delayed yield on the aquifer test data graphs. Given the texture of the sediments comprising the aquifers, one would anticipate seeing the effects of delayed yield on the graphs within the duration of the test. I did not see that effect on the data plots on which I relied.

by Petitioner and the water is appropriated. Of equal importance is the effects if the flow rates are dramatically increased as planned. While the total volume of water to be extracted as allegedly "new" water by the Petitioner is not completely clear,[9] historic flows and groundwater data show that very little if any water extracted by Aerojet can be considered "new" water.

The increased losses of American River flows due to groundwater extraction and increased diversions are reflected in the nearly one hundred years of data taken from the U.S. Geologic Survey gage number 11446500, located near the Aerojet site. To illustrate the long-term reduction in flows in the River, I have completed a cumulative departure analysis for the data from 1905 to 1999. (**DFG Exhibit 22-A**, graph plus raw data). The mean flow used in this cumulative departure analysis was derived from data for 1934 through 1954 to correlate with the data set relied upon by the Board to generate its mean flow value used in reaching its FAS Declaration. The departure analysis shows that between 1905 and 1930, cumulative flows exceeded the mean established by the Board. After 1930, the flows were below the mean over time except for a short period during the mid-1980 floods. (Exhibit 22-A graph). As discussed previously, the red line on the chart is the trend line for this data set. The orientation of the trend line indicates that the cumulative flows in the river have been steadily decreasing over the last 95

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[9] The Petition, as written, implies that Petitioner is asking for appropriations of all future treatment waters, that is, an unlimited volume. The information provided by Petitioner on April 29, 2002 does not make clarify the total volume of groundwater Petitioner plans to extract, the timing of those extractions, or the exact location of the extraction. The Supplemental Information re Aerojet ARGET and GET E/F Facilities, dated May 1, 2002, provides somewhat more detailed information. Yet it is still difficult to assess exactly what flows the Petitioner seeks and when. For example, the water treatment plant extraction system will have different treatment rates over time. Therefore, for the purposes of this testimony, I have assumed that Petitioner seeks to appropriate treated groundwater year-round at the maximum rate extracted by Aerojet operations, that is, at least 27,000 acre feet per year. This assumption is consistent with the water availability analysis procedures presented at the Public Workshop on Streamflow and Water Availability Estimates in Ungaged Streams, dated May 1, 2002, given by the Board's Water Rights staff. If my understanding is not correct, I seek clarification on this issue.

years. In addition, the mean flow is now lower than the mean flow assumed in the 1958 FAS Declaration.[10]

To take advantage of the comprehensive data set at gage 11446500, I also performed a second cumulative departure analysis using a mean value derived from the entire data set, e.g., 1905 to 1999. (**DFG Exhibit 22-B**, Cumulative Departure Analysis using 1905 to 1999 flow data). The general character of the graph is similar to that in Exhibit 22-A on which the Board relied in reaching the FAS Declaration. The trend lines on both graphs are also quite similar. The overall data trend is the same regardless of the mean value used in the analysis, that is, cumulative flows in the American River continue to decline.

In conjunction with all the data discussed previously that show the hydraulic connection between the river and the aquifers, and the ever increasing demand on the limited groundwater resources,[11] it is highly unlikely that the mean American River flows assumed in 1958 will ever be reestablished. In addition, it is my opinion that the available data -- nearly one hundred years of flow data, hundreds of well logs, and other findings – is more than sufficient to establish that water extracted by Aerojet is "old" water in that it had been accounted for in the water balance by the Board in Decision D 893 and in the FAS.

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[10] Decision D 893 includes flow records. (See, e.g., D 893 at 44, citing "Water Supply Papers," excerpts attached as DFG Exhibit 30).

[11] The flow analysis above does not take into consideration water rights projects that have already been approved by the Board but are not yet complete. Yet, the Board's hearing file for Application 12140 includes petitions for extensions of time to complete construction work under applications approved decades ago. At the Board's Public Workshop on Streamflow and Water Availability Estimates in Ungaged Streams, dated May 1, 2002, Board staff explained that their standard protocols for water balance and flow analyses which assume maximum diversions from permitted water rights. If that was also standard procedure in 1958, incomplete projects permitted long ago but not yet on-line should have no affect on the Decision D 893 flow analyses. If that is not the case, once all such projects are on-line, the flows in the River would decrease further.

2. How much, if any, of the water discharged by groundwater treatment operations is water that was not considered at the time the American River system was included in the FAS Declaration?

As explained above and incorporated by reference, the best data available today confirms that most if not all of the groundwater at Aerojet is "old" water accounted for in the Board's water budget analysis in 1958 and that it comes from the American River. Importantly, the conclusion that the groundwater and American River are linked is not a new one. In 1958 when the Board reached its FAS Declaration, with less groundwater and flow data available to it, the Board knew that the River recharged the underlying aquifers and accounted for this in its underlying analysis. The evidentiary record from the Decision D 893 includes numerous technical discussions about the importance of the American River for recharging groundwater. Without citing from each document referred to in the hearing file, I offer only a few as examples to show that the parties clearly raised this issue to the Board, that the Board fully considered this water in its1958 water balance, and that the extracted Aerojet water is not "new" water.

The Brief of County of Sacramento, filed on September 16, 1957, in the matter of Applications 12140, provides an analysis of the water balance known in 1958 from the Folsom North service area, near the American River. **(DFG Exhibit 23)**.[12] The Brief states, in part:

> "From the Bureau of Reclamations [sic] Folsom North Reconnaissance Report (SWRB Exh. 23), it is estimated that in 1954 the water use in the Sacramento County area of the Folsom North Service Area was 87,500 acre-feet, with an estimated 61,000 acre-feet being furnished by ground water and the remaining 26,500 being surface water.
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[12] This document is titled "Brief of County of Sacramento, In the matter of Applications 12140, etc., City of Sacramento, et al., Applicants S. Clemens Horst Company, et al., Protestants, Submitted September 16, 1957" and is referred to hereinafter as "Brief of County of Sacramento."

"Of the total estimated net recharge of 63,000 acre-feet for the entire ground water study area 22,200 acre-feet was attributed to the American River.

"Under the existing conditions it would be safe to attribute the whole 22,200 acre-feet as contributing to the ground water recharge of the Sacramento County area within the ground water study. (Exhibit 23, p. 6; see also DFG Exhibit 31, excerpts from original source document, Chapter III).

Later in the document, the County cites U.S.B.R. Exhibit 19, which "estimates the ultimate water use along the American River below Folsom Reservoir and which could be assigned to the County of Sacramento's Folsom North Service Area . . . ." The water balance table includes 9,500 acre-feet for ground water recharge. The Brief of County of Sacramento continues:

"In the ground water recharge study, the recharge was attributed to percolation of precipitation, American River flows, other stream flows entering the study area and from irrigation and other water applied to the soil.

"In view of the fact that the largest portion of the future development will be residential or industrial[,] the contributions to the ground water recharge of all factors with the exception of the American River will be greatly reduced. It is possible that the American River will furnish approximately 75% of the ground water recharge necessary to meet the demands of the heavy ground water pumping.

"The Bureau of Reclamation in its operational studies assigned approximately 12,780 acre-feet of water to ground water recharge.

"To offset this heavy demand on the American River for ground water recharge is the estimate that approximately 50% of the water use will be returned to the American River." (Exhibit 23, p. 8).

Thus the Board was explicitly told that the American River was a losing stream and was the primary source for groundwater recharge.[13]

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[13] Given the limited data sets available in 1958, it is likely that the accuracy of the estimates of future demands and yields of the system are not truly representative of conditions as they exist today.

The Decision D 893 Hearing file contains many other references discussing the connection between groundwater and flows including the "Water Rights Investigation dated November 1956 for Major Pending Applications to Appropriate Water From the American River."[14] On page 49 of the Water Rights Investigation, it states:

> "An estimate of the deep percolation from the American River into the alluvium filled valley floor below Folsom is given in State Water Resources Board Bulletin 21, Vol. II, p. A-43. Under present conditions, about 25,000 acre-feet of water per season is seeping into the ground water basin. Under ultimate development it is estimated that about 64,000 acre-feet of water per season would percolate to the ground water from stream channel seepage." (**DFG Exhibit 24** at 49; see also DFG Exhibit 29, p. A-43, original source of information).

The issues raised to the Board in the protests filed for Decision D 893 show that the Board was also briefed on the connection between flows in the American River and groundwater recharge throughout the system and into the Delta.[15] (See also **DFG Exhibit 26**, pp. 3-4, Protest of Reclamation District 756, San Joaquin County).

Decision D 893 itself shows that the Board carefully considered the limits of the American River system, including flows and groundwater recharge requirements, when conducting its water balance analysis and in reaching the FAS Declaration. The key pages of the Board's decision are from the "Watershed" discussion on page 25 through page 46. In these pages, the Board primarily refers to the U.S. Geological Survey Water Supply Paper No. 1345 ("Water Supply Paper 1345") and State Water Resources Board Bulletin 21 ("SWRB Bulletin 21") as the technical basis for its water balance discussion and conclusions. **DFG Exhibit 28**

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[14] **DFG's Exhibit 24**, the "Water Rights Investigation" document, can be found in the Board's hearing file for Application 12140, Item 49, Folder 5-M, Exhibit 1.

[15] The protest of Union Properties, Inc. states that Union Properties owned the "Burns Tract," a large tract of agricultural land situated on Union Island, San Joaquin County, in the Delta. (**Exhibit 25**, p. 1).

contains excerpts from Volume 1 of SWRB Bulletin 21. **DFG Exhibit 29** is a complete copy of the "Ground Water Studies," found at Attachment A, Volume II of SWRB Bulletin 21. **DFG Exhibit 30** is a complete copy of the pages from the Water Supply Paper 1345 pertaining to the American River for October 1953 to September 1954.[16] The scope of Decision D 893 and whether the Aerojet water is "new" water can only be fully understood by reading Decision 893 in light of these references directly cited by the Board. For example, the Board's discussion of "Streamflow" on page 28 of Decision 893 comes from the "Summary of Conclusions, and Recommendations" found at Chapter 5 of SWRB Bulletin 21. This section of SWRB Bulletin 21 summarizes some 92 pages of detailed technical discussions about the American River which make explicit references to two additional SWRB Bulletins. While the following quotation from the Introduction to SWRB Bulletin 21 is quite lengthy, it is intended to convey the depth of the SWRB's field investigations, analysis and research that resulted in production of SWRB Bulletin 21. SWRB looked at dozens of factors when conducting the final water balance for the American River on which the FAS Declaration is based. It is explicit in this water balance that American River flows recharge groundwater and that flows in the FAS would be sufficient to meet both groundwater recharge demands and downstream surface water rights. The "Introduction" to SWRB Bulletin 21 explains, in part,

> "These [Valley Floor I]nvestigations centered principally on the downstream areas appropriate for American River water use, and particularly on the planned operation of ground water storage underlying these areas. The investigations dealt essentially with the present and ultimate patterns of land use of the areas, and their water supplies and water requirements, as developed in State Water Resources Board Bulletin No. 2.
>
> "The planned operation of ground water storage capacity in conjunction with surface water storage capacity in the American River Basin required determination of the location, magnitude, and usability of the ground water storage underlying the areas of use. These factors were estimated for

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[16] The flow data at the Fair Oaks station is found on page 469 of the Water Supply Paper 1345, attached to this testimony at DFG Exhibit 30.

ground water storage units that were defined by natural land divisions and by consideration of subsurface geology. The magnitude of the ground water storage capacity was determined for the 20- to 200-foot depth range, where possible. The capacity was found by correlating rock samples of known specific yield with material indicated by well drillers' logs. The usability of this ground water storage was ascertained by considering the present and future quality of water within the basin, ground water withdrawal potentialities, and ground water recharge possibilities. Future possible degradation in quality of the water due to greater consumptive use and to connate water intrusion was considered. Potential ground water withdrawal rates were estimated from studies of existing well development and of the geology involved. Recharge possibilities, natural and artificial, were developed from a study of soil samples, geology, ground water level fluctuations, and data obtained from field observations.

"Results of the investigation of the American River Basin are presented in the four ensuring chapters of this bulletin. Chapter II deals with the water supply of the basin. Many of the data presented therein are derived by rearrangement of pertinent information from State Water Resources Board Bulletin No. 1. Supplemental data on floods and flood flows were obtained from the records of the United States Geological Survey. Sources of other hydrologic data are acknowledged in appropriate sections of Chapter II. The subject of underground hydrology, including ground water storage possibilities and methods, efficiencies and costs of recharge and extraction, is treated in Appendix A, "Ground Water Studies".

"Chapter III describes existing water developments, establishes the ultimate water requirements of the upstream areas, and evaluates factors of water demand pertinent to planning. . . . " (DFG Exhibit 28, SWRB Bulletin 21, pp. 1-11 to 1-12).

Factors from geology, native cover, temperatures in the American River Basin, farming seasons, monthly average snowfall, topography, irrigable lands, population and basin economy, among others, are analyzed. Chapter II, "Water Supply," looks at precipitation, flow data, and water quality. Chapter III, "Ultimate Water Requirements," discusses water demands, including those for fish and wildlife, under "probable ultimate conditions of development" based on the assumptions and data available at the time.

With respect to groundwater recharge from the American River flows, SWRB Bulletin 21 states that of the releases of water from Folsom Reservoir for maintenance of

fish, 64,000 acre-feet would "penetrate to ground water . . . ." (DFG Exhibit 28, pp. 313-314). The "Ground Water Studies" of Appendix A to SWRB Bulletin 21, when explaining the movement of groundwater in the area, concludes that "[o]ther sources of recharge by stream seepage are the American River from a point near Fair Oaks to a point near the confluence with the Sacramento River . . . ." (DFG Exhibit 29 at A-25). Finally, on page A-30, Bulletin 21 explains that "[e]stimated mean seasonal replenishment, which equals the estimated mean seasonal safe yield, of ground water storage in the Area of Ground Water Study is presented in Table A-6." Table A-6, found at DFG Exhibit 29 on page A-31, lists groundwater replenishment from stream flow maintenance releases from the American River as 63,600 acre-feet.[17] Put simply, SWRB was quite comprehensive in its Bulletin 21 analysis of the factors that influence American River hydrology and concluded that stream flows from the American River replenish groundwater.

The importance of Bulletin 21 and the other documents referenced in Decision D 893 is that the Board implicitly and often explicitly adopted the analyses contained therein. The Board cites the Water Supply Papers monthly mean flows over a twenty-year period (Decision D 893 at 27), and there is a lengthy discussion of "Time of Occurrence of Unappropriated Water." (Decision D 893 at 41). The Board's conclusions about finding sufficient water, "after full basin development . . . to supply upstream requirements, to maintain at all times a substantial flow in its bed, to serve an urban population of 500,000 and to irrigate up to 500,000 acres" come directly from SWRB Bulletin 21 conclusions. (Decision D 893 at 28). Importantly, the Board fully understood that the SWRB Bulletin 21 and other investigations found American River

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[17] Note that several proposed or future possible ground water storage components are discussed in SWRB Bulletin 21, Appendix A, but these are not the subject of this testimony.

water sources were finite. Several times in Decision D 893, the Board stated that there is only a limited water supply in the American River. For example, the Board noted that Department of Finance applications "together with the State filings previously discussed, far exceed the total flow of the American River in a normal year." (Decision D 893 at 30-31). On the following page, the Board commented that the aggregate of water sought by the applicants was "of the order of 29,000 cubic feet per second plus 9,150,000 acre-feet per annum. The amounts the applicants seek to appropriate plainly exceed the normal, annual flow of American River at the Fair Oaks gaging station." (Decision D 893 at 31).

The Board further estimated that the total flow of 1,400,000 acre-feet was necessary for salinity repulsion in the Delta from April through October; approximately "64,000 acre-feet during the same 7 month period . . . is the share that logically should be provided from the American River." (Decision D 893 at 39). Again, the figure of 64,000 comes from the comprehensive SWRB Bulletin 21. The Board's discussion in Decision D 893 includes a review of additional downstream demands on American River flows, flood control needs, and fish conservation flows. Implicit in the Board's understanding in Decision D 893 is that the system would be in balance and self-sustaining, based on the analyses adopted by the Board by reference. As thoroughly explained in these references, their analyses included the understanding that American River flows replenish groundwater.

Some of the other documents on which the Water Board staff relied for the groundwater analyses in the FAS Declaration are telling. (See **Exhibit 27**, Exerpt from Index for Application 12140 Hearing File Index).[18] The Bureau of Reclamation's "Folsom North Unit, Central Valley

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[18] At the Pre-hearing Status Conference held April 25, 2002, DFG sought a continuance of two months in order to look through voluminous Aerojet Superfund files and the State Board files associated with the 1958 hearing. The Board agreed to extend the deadline for submittal of written testimony by a few days in order for the Petitioner to inform the Parties of basic facts missing in the petition such as flow rates and well locations. To preserve its objection for

Project, Reconnaissance Studies of Water Problems," Chapter III, is dedicated to "Water Resources." The Bureau calculated groundwater recharge for the Folsom Study Area by two methods and found "the results of which are virtually the same." (**DFG Exhibit 31**, U.S. Bureau of Reclamation, "Folsom North Unit, Central Valley Project, Reconnaissance Studies of Water Problems," Chapter III Water Resources, 1956, p. 1, Map of Study Area, and p. 39 for analysis). The Bureau found recharge sources and corresponding estimated recharge quantities for 1954 to be:

Percolation of precipitation	34,600 a.f.
Percolation of American River flows	22,200 a.f.
Percolation of other stream flows entering study area	6,300 a.f.
Percolation from irrigation and other	11,000 a.f.
Subsurface inflow	2,300 a.f.

The Bureau's final calculation is that net recharge is 63,300 acre-feet. (DFG Exhibit 31 at 39). The Bureau goes on to explain that "[r]echarge can be increased substantially by lowing water levels in the area, thereby steepening subsurface inflow gradients from the foothills and the American River." (DFG Exhibit 31 at 39). This analysis by the Bureau is consistent with the analysis of current data presented in this testimony.

The evidentiary record that is available confirms that the Board was informed in 1958 by various sources that the American River was a losing stream, that groundwater was being pumped to meet population demands, that the American River recharged the groundwater, and that the American River was a limited water supply. Given the data that has been collected since 1958 on river flows, groundwater levels, the increased number of groundwater wells and

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possible appeal, DFG reiterates that the short deadlines set for this proceeding are fundamentally unfair in light of the size of record as a whole.

the increased population in the area, among other factors, I believe that most of the groundwater being extracted and treated from Aerojet ultimately comes from the American River.

3. To what extent, if any, have flows in the American River been affected by groundwater treatment operations, including both pumping and discharging, since the American River system was included in the FAS Declaration?

As explained previously, ongoing groundwater treatment operations in the vicinity of Aerojet have only had a minimal adverse impact on flows in a short reach of the American River. To date, the impacts have been minimized because the current operation returns the extracted water to the River. The only current loss caused by the groundwater treatment operation comes from transmission losses. Any increase in groundwater extraction will further degrade the flows in the river. Most importantly, any groundwater treatment extractions that fail to return the treated water back to the river will result in the long-term decrease of surface water flows.

4. Has the petitioner provided sufficient hydrologic data, water usage data, or other relevant information to support a determination that there is unappropriated water in the American River system during the season applied for to justify revising the Declaration for the purpose of accepting and processing water right applications related to the discharges of treated groundwater into the American River?

No. The data provided to date in the EECA, the RI/FS, and in this testimony support the Board's original findings in the FAS Declaration that the American River has no unappropriated water during the summer months. Importantly, these data also indicate that increasing demands on the water resources of the American River and its associated groundwater approach, if not equal, the total flows of the river. The American River is a losing stream. Flow data confirms that the American River has been a losing stream year-round since the FAS Declaration. Groundwater levels have continued to drop since the FAS Declaration was issued. From a hydrogeologic perspective, numerous indicators support the conclusion that the American River is hydraulically connected to the adjacent aquifers, that the River is the source of groundwater

recharge, and that the extracted groundwater from Aerojet is "old" water accounted for in the FAS Declaration. Having looked through much of the Hearing file and the documents referenced in Decision D 893, it is my opinion that the Board staff expended a great deal of effort in 1958 to fully investigate and understand the complicated hydrology of the American River and the factors that impact flows and groundwater recharge. Based on that understanding, they declared the American River flows fully appropriated. Petitioner has not provided any data or an updated water balance to change the Board's conclusions in the FAS Declaration or otherwise prove that the Aeroject treated groundwater is "new" water.

I, Stephen D. Reynolds, declare under penalty of perjury under the laws of the State of California that I have read the foregoing "Testimony of Stephen D. Reynolds" and know its contents. The matters stated in it are true of my own knowledge except as to those matters which are stated based on information and belief, and as to those matters, as I believe them to be true.

Executed on May 9, 2002 at Sacramento, California.

Stephen D. Reynolds

By: STEPHEN D. REYNOLDS
Certified Engineering Geologist

United States Department of the Interior

OFFICE OF THE SOLICITOR
Pacific Southwest Region
2800 Cottage Way
Room E-1712
Sacramento, California 95825-1890

IN REPLY
REFER TO:

May 6, 2002

State Water Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95812-2000
Attn: Jean McCue

Subject: American River FAS Petition

Dear Ms. McCue:

Enclosed for filing are the original and five (5) copies of an Exhibit Identification Index listing and designating as separate exhibits the written opening statement, testimony and exhibits that are to be presented on behalf of the Bureau of Reclamation either during the hearing on the subject petition which is scheduled to begin on May 31, 2002, and continue on June 13, 2002. A copy of this letter, with a single copy of the enclosures, is being sent to each of the parties identified on the attached list of parties, with the exception of the undersigned.

Sincerely,

Daniel G. Shillito.
Regional Solicitor

James E. Turner

By: James E. Turner
Assistant Regional Solicitor

Enclosure

cc: See attached list of parties
MP-440

AMERICAN RIVER FAS PETITION HEARING

Exhibit Identification Index

Participant United States Bureau of Reclamation

Exhibit No.	Description (If exhibit is in electronic format, please include file name.)	Status as Evidence		
		Introduced	Accepted	By Official Notice
1	Plate 1 from D-1400			
2	1990 Delta Conditions and Nimbus Releases			
3	1991 Delta Conditions and Nimbus Releases			
4	1992 Delta Conditions and Nimbus Releases			
5	1993 Delta Conditions and Nimbus Releases			
6	1994 Delta Conditions and Nimbus Releases			
7	1995 Delta Conditions and Nimbus Releases			
8	1996 Delta Conditions and Nimbus Releases			
9	1997 Delta Conditions and Nimbus Releases			
10	1998 Delta Conditions and Nimbus Releases			
11	1999 Delta Conditions and Nimbus Releases			
12	2000 Delta Conditions and Nimbus Releases			
13	2001 Delta Conditions and Nimbus Releases			
14	Opening Statement by James E. Turner			
15	Testimony by John A. Renning			

United States Department of the Interior

OFFICE OF THE SOLICITOR
Pacific Southwest Region
2800 Cottage Way
Room E-1712
Sacramento, California 95825-1890

IN REPLY
REFER TO:

May 9, 2002

State Water Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95812-2000
Attn: Jean McCue

Subject: American River FAS Petition

Dear Ms. McCue:

Enclosed is a copy of the Certificate of Service you requested.

Sincerely,

David G. Shillito
Regional Solicitor

James E. Turner

By: James E. Turner
Assistant Regional Solicitor

Enclosure

cc: See attached list of parties
MP-440

CERTIFICATE OF SERVICE

The undersigned hereby certifies that she is an employee in the Office of the Regional Solicitor, Pacific Southwest Region, 2800 Cottage Way, Room E-1712, Sacramento, CA. 95825, and is a person of such age and discretion to be competent to serve papers

That on May 8, 2002, she served copies of the following documents:

May 6, 2002 Letter from Assistant Regional Solicitor James E. Turner to SWRCB, Division of Water Rights, attn: Jane McCue on the subject "American River FAS Petition" with enclosed copy of United States Bureau of Reclamation Exhibit Identification Index, written opening statement, testimony and exhibits to be presented on behalf of the Bureau of Reclamation during the hearing on the subject petition

by causing said copies to be placed in a prepaid envelope addressed to **State Water Resources Control Board, Division of Water Rights, P.O. Box 2000, Sacramento, CA 95812-2000, attn: Jean McCue** and the persons identified on the attached **List of Parties to Exchange Information,** with the exception of James E. Turner, Office of the Regional Solicitor, at the places and addresses stated therein by depositing said envelope and contents in the United States mail at Sacramento, CA.

Dorothy Hernandez

Dorothy Hernandez

LIST OF PARTIES TO EXCHANGE INFORMATION

Hearing on Petition to Revise Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County

(Note: the parties whose E-mail addresses are listed below agreed to accept electronic service, pursuant to the rules specified in the Hearing Notice.)

Michael Fife
Hatch & Parent
21 East Carrillo Street
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Rep: Southern California Water Company
Mfife@hatchparent.com

Ronald M. Stork
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Sacramento, CA 95814
Rep: Friends of the River
rstork@friendsoftheriver.org

Jan S. Driscoll
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San Diego, CA 92101
Rep: California-American Water Company
JDRISCOLL@ALLENMATKINS.COM

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Sacramento, CA 95814
Rep: Sacramento County/ Sacramento County Water Agency
Ssomach@lawssd.com
bhvidsten@lawssd.com

Janet K. Goldsmith
400 Capitol Mall, 27th Floor
Sacramento, CA 95814-4417
Rep: Aerojet-General Corporation

Martha H. Lennihan
Lennihan Law APC
2311 Capitol Avenue
Sacramento, CA 95816
Rep: City of Sacramento

Jennifer Decker
Department of Fish and Game
1416 Ninth Street, 12th Floor
Sacramento, CA 95814

M. Catherine George, Staff Counsel
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95812
Rep: Central Valley Regional Water Quality Control Board (CVRWQCB)
(NOI states that the CVRWQCB plans to present an opening statement and reserves the right to cross examine witnesses, present rebuttal evidence and submit closing briefs, if permitted.)

James E. Turner
Office of the Regional Solicitor
PSW Region
2800 Cottage Way, E-1712
Sacramento, CA 95825
Rep: U.S. Bureau of Reclamation

Opening Statement of Assistant Regional Solicitor James E. Turner
on behalf of the United States Bureau Of Reclamation
before
State Water Resources Control Board
at
Hearing on Declaration of Fully Appropriated Stream Systems
Regarding the American River, Sacramento County
May 3`, 2002

Southern California Water Company's Petition for a Limited Revision of the Declaration of Fully Appropriated Stream Status of the Lower American River and its related Application to Appropriate the water Aerojet-General Corporation is introducing into Buffalo Creek in accordance with RWQCB Order No. 98-113 should both be denied for the simple reason that the introduced water has already been appropriated by individuals and entities who currently hold rights to divert water from the American River. The facts presented in the Petition are strikingly similar to the facts addressed by the 1853 California Supreme Court in a lawsuit entitled Eddy v. Simpson, 3 Cal. 249. In that case, the defendants had a right to divert water from Grizzly Cannon and Bloody Run. After they diverted and used that water at Cherokee Corral, its found its way into the waters of Shady Creek on which the plaintiffs had previously constructed a dam and diverted water for their use. The defendants, subsequently constructed a dam upstream of the plaintiffs' dam and commenced diverting the water that flowed into Shady Creek from Grizzly Cannon and Bloody Run. The Court ruled against the defendants by specifically holding, in pertinent part:

"When the water of Grizzly Cannon and Bloody Run left the possession of the defendants at Cherokee Corral, all right to and interest in that water was lost by the defendants. . . . As defendants had lost all right in the water, they could have no right to withdraw it from the possession of the plaintiffs"

The Southern California Water Company is seeking the same relief as that which was denied to the defendants in that lawsuit.

In 1855, the California Supreme Court issued a similar ruling in the lawsuit entitled Kelly v. The Natomas Water Co., 6 Cal 105. In that case, the defendants constructed a dam about one hundred yards above a dam previously constructed by the plaintiffs to prevent the plaintiffs from capturing water escaping from an upstream dam, Walker's dam, that the defendants had previously acquired. The Court ruled that:

"The purchase, by the defendants, of Walker's dam was an actual appropriation of the waters of the creek so far, but no further; and until they built a dam below, in order to make a further appropriation, any one else had the right to do so. If they had commenced first to build the dam in good faith. then, although their power of enjoyment would not commence until its completion, yet the right, as against others, would bear relation to the time of commencement . . . "

We recognize that a natural water channel can be used to convey water appropriated from

another source. However, as stated in the 1858 California Supreme Court decision in the lawsuit entitled The Butte Canal and Ditch Company v. Vaughn, 11 Cal. 143:

"The prior right to the use of the natural water of a stream does not entitle the owner of such a right to the exclusive use of the channel.. So long as his right is not interfered with, there is no reason why the bed if the stream may not be used by others as a channel for conducting water.. If the plaintiffs in the present case receive their full supply, as previous to the introduction of water by the defendants, they have no cause of complaint. . . . The first appropriator of the water of a stream . . . has the right to insist that the water shall be subject to his use and enjoyment to the extent of his original appropriation, and that its quality not be impaired so as to defeat the purpose of his appropriation. In subordination to those rights, subsequent appropriators may make such use of the steam as they think proper . . ."

In the case at hand, like the defendant in Eddy v. Simpson, Aerojet-General Corporation loses all its right to and interest in the groundwater it pumps and treats when it discharges that water into Buffalo Creek and granting Southern California Water Company's application to divert that water from the Lower American River will interfere with the ability of the existing holders of rights to divert water from that fully appropriated River from fully exercising their exiting rights to make such diversions.

I now call Bureau of Reclamation water right specialist, John Renning to explain why how granting Southern California Water Company's petition for the limited revision of the declaration of the fully appropriated status of the lower American River and granting that Company's related application to appropriate water from that River will interfere with the Bureau of Reclamation's ability to fully implement its existing water rights on the American River, thereby affecting its operation of the Central Valley Project, as a whole.

Testimony of United States Bureau of Reclamation
before
State Water Resources Control Board
at
Hearing on Declaration of Fully Appropriated Stream Systems
Regarding the American River, Sacramento County
May 31, 2002

My name is John A. Renning. I am the Regional Water Rights Officer for the Mid-Pacific Region of the Bureau of Reclamation. My testimony will address the primary issue that the State Board identified in its notice for this hearing:

> Should the SWRCB revise the Declaration [of Fully Appropriated Streams System regarding the American River] to allow the Division of Water Rights to accept and process water right applications to appropriate "treated groundwater discharged into the American River"?

The answer to that question is no. There is no evidence that Reclamation is aware of that would support a revision of that declaration. In fact, the evidence supports the declaration as it currently exists.

The State Board's determination that the American River was fully appropriated for the period July 1 through October 31 was based on evidence presented in a number of water right hearings resulting in decisions regarding the American River and Delta. The evidence presented in those hearings showed that unappropriated water ceases to exist on the American River system for the summer and early fall of most years. This is shown in USBR Exhibit 1. This is a plate from D-1400 and compares the full natural flow of the American River to the minimum required flows in the Lower American River for several different circumstances. When the flow of the American River (that is the inflow to Folsom Reservoir) is less than the required flows on the Lower American River, then that inflow has now been fully utilized and is unavailable for further appropriation. The required flows on the Lower American River, in fact, necessitate storage releases from Folsom Reservoir. This exhibit was based on evidence that was presented at the D-1400 hearings in the early 1970s.

D-1594 which addresses conditions on the Delta watershed also concluded that unappropriated water does not exist in the summer months of most years.

Actual operations bear out the conclusion of these decisions. USBR Exhibits 2 through 13 show the operations of Folsom Reservoir and the American River for the period 1990 through 2001. These exhibits show the following information:

1. Inflow to Folsom Reservoir.
2. Releases from Nimbus Reservoir.
3. The periods the Delta is in or out of balance.
4. The periods that conditions for Term 91 implementation are in place.

From this information, it is apparent that the period the State Board has declared the American River fully appropriated, July 1 through October 31, is also the period that generally:

1. Releases from Folsom Reservoir are greater than inflow to Folsom.
2. The Delta is in balance.
3. Term 91 conditions are in place.

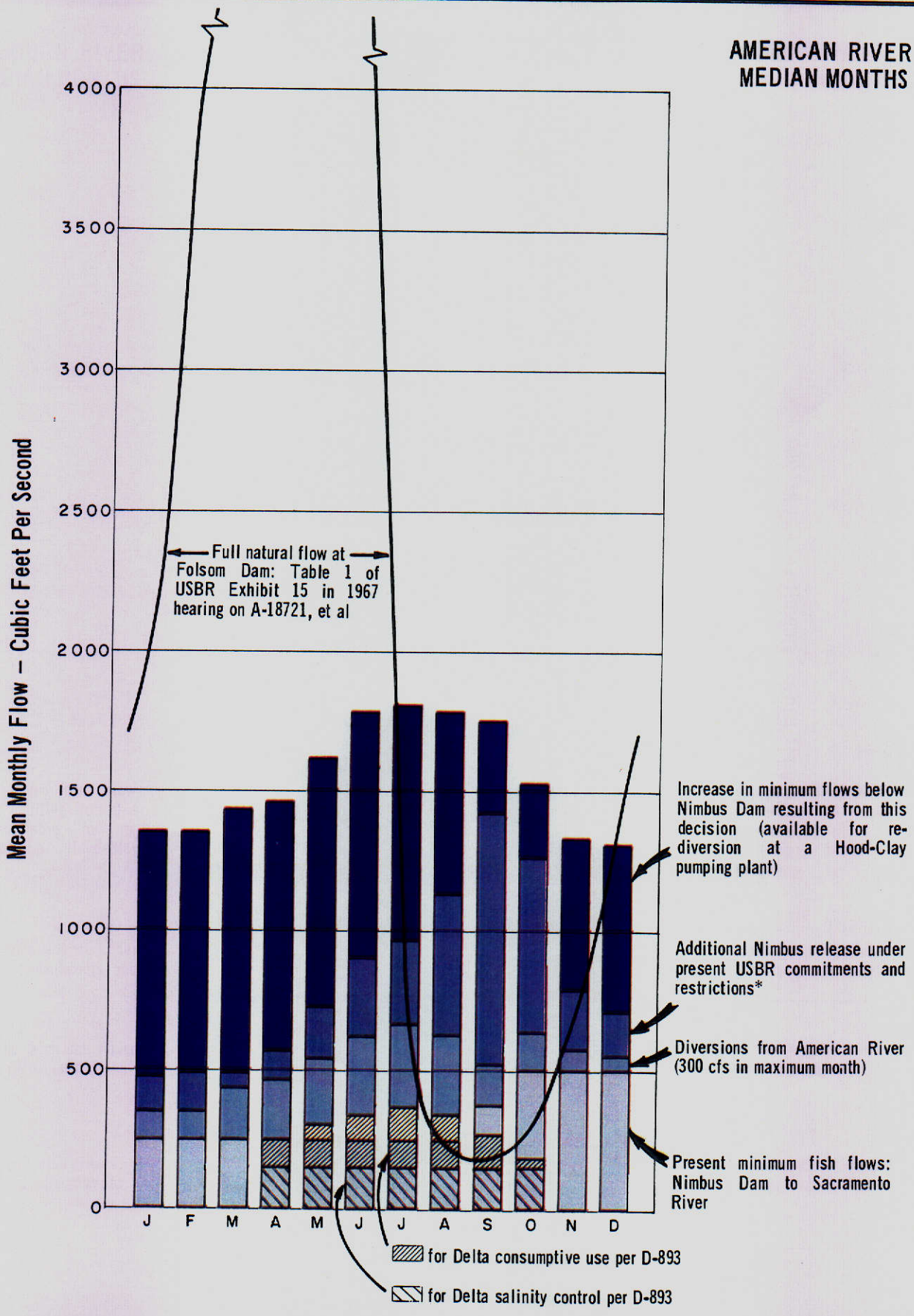
These three factors are evidence that shows unappropriated water does not exist on the American River watershed and on the Delta watershed, and confirms that conclusion in State Board decisions regarding the American River and Delta, and in their declaration for the American River.

The addition of flows in the range contemplated here (5 to 40 cfs) from abandoned groundwater to the American River system will not change these conclusions. The groundwater that Aerojet is apparently abandoning will be used by existing right holders, including the United States, to meet demands under their water rights. Such water becomes available to right holders in the system according to the priority of their rights, and those senior rights will use the water abandoned by Aerojet. As noted, under current conditions no unappropriated water exists on the American River system in the summer months of most years and the demands and requirements of existing water rights must be met with storage releases at those times.

Though this is not a topic for this hearing, Reclamation would note that unappropriated water does not necessarily universally exist in the remaining periods of the year (outside the July 1 through October 31 period). The availability of unappropriated water is a function of hydrology, prior rights and flow requirements for the American River and Delta. These flow requirements may change in the future. Any permit issued for those periods may require terms and conditions specific to the applicant's situation regarding the availability of unappropriated water and other matters to protect existing water right holders.

Attached: USBR Exhibits 1 through 13

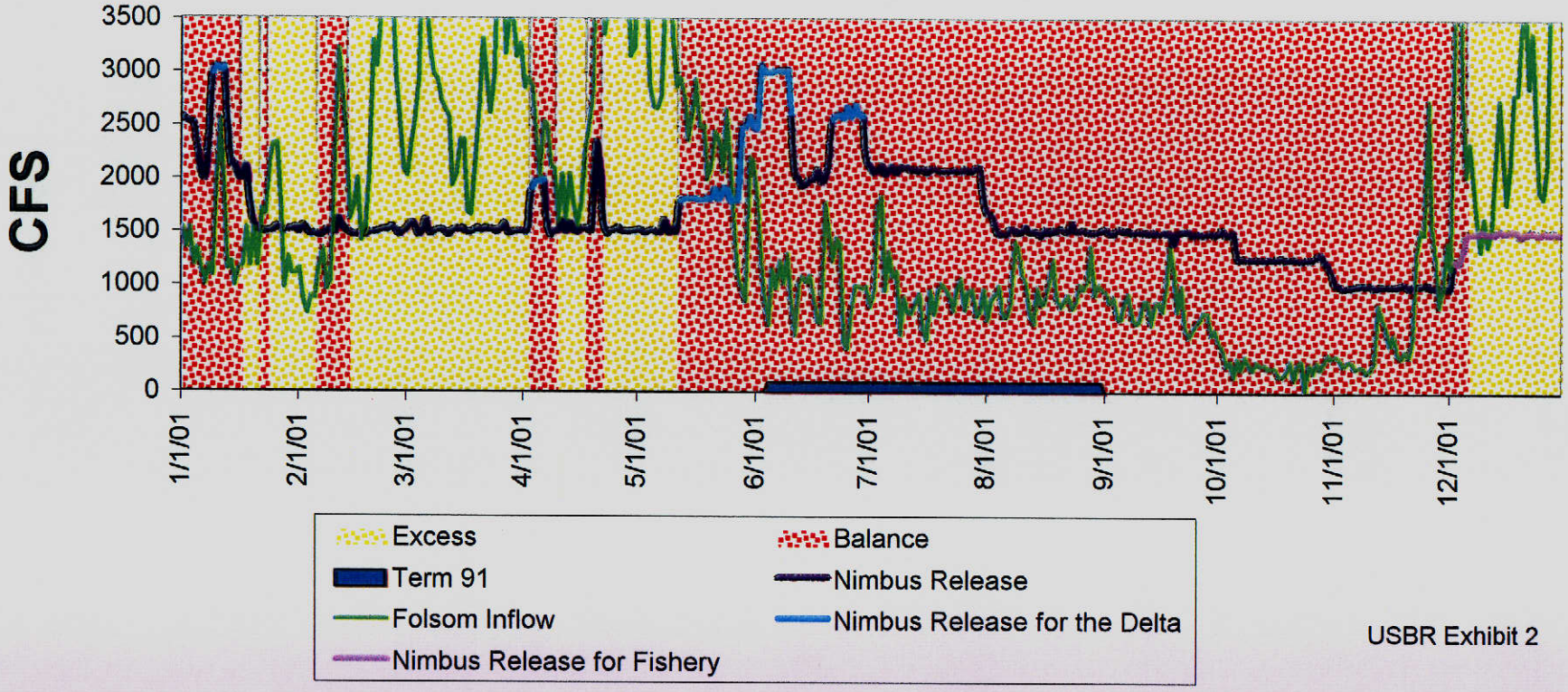
PLATE 1



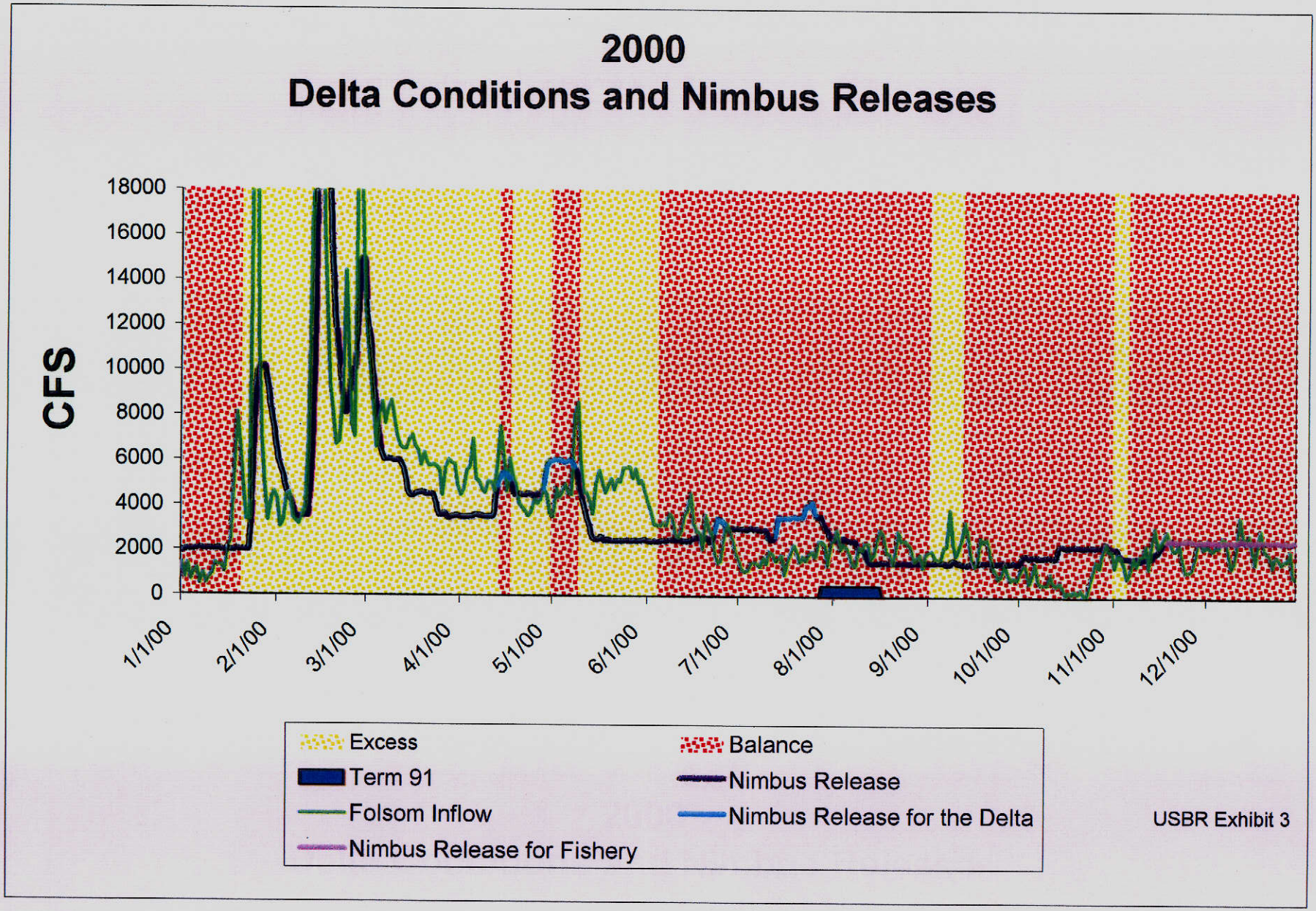
*Staff estimate: from USBR 29A except Aug.-Sept.-Oct. from Table 10 (modified) of USBR Exhibit 15 in 1967 hearing on A-18721, et al

USBR Exhibit 1

2001
Delta Conditions and Nimbus Releases



USBR Exhibit 2


2000
Delta Conditions and Nimbus Releases
CFS
18000
16000
14000
12000
10000
8000
6000
4000
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1/1/00
2/1/00
3/1/00
4/1/00
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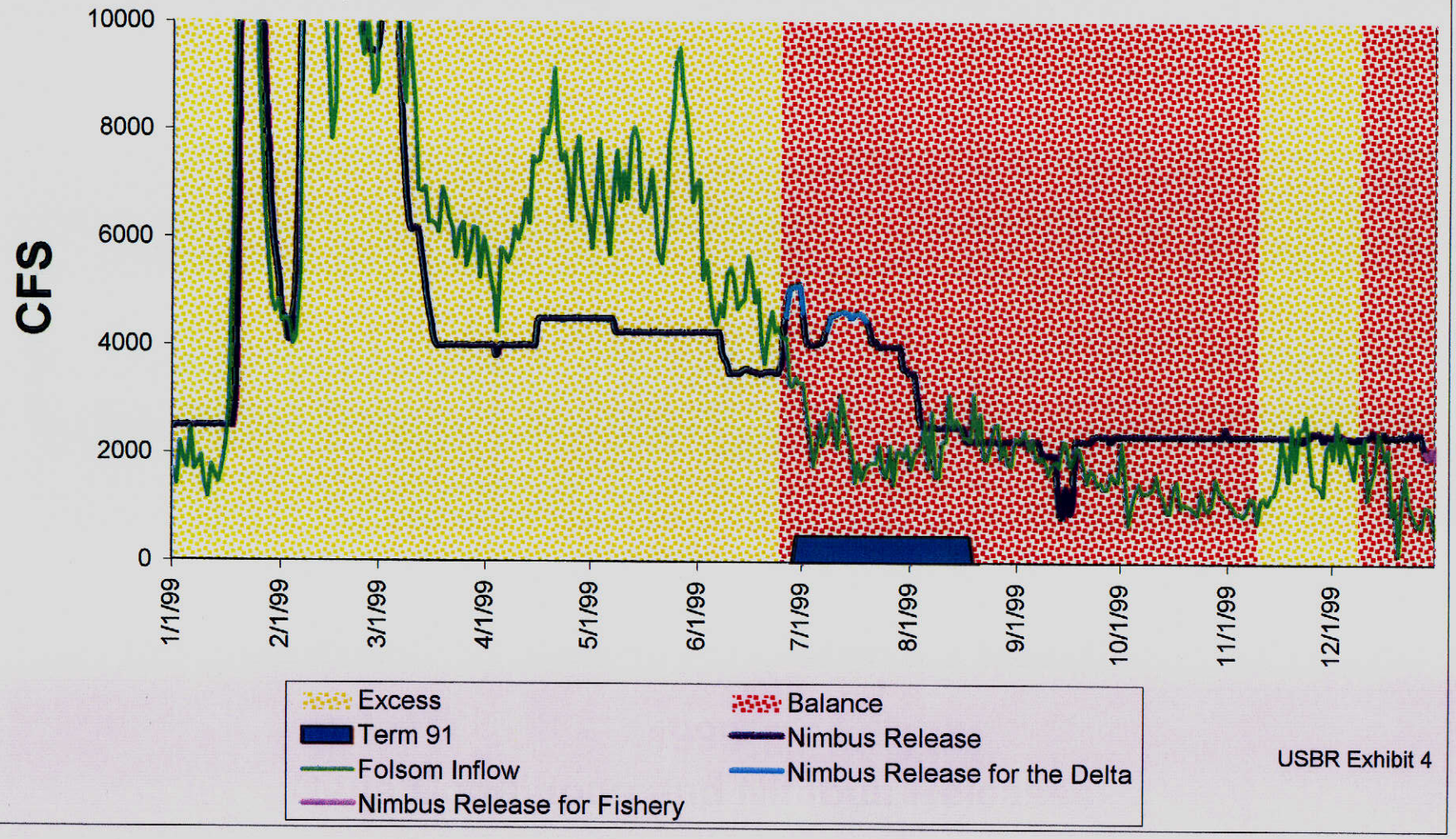
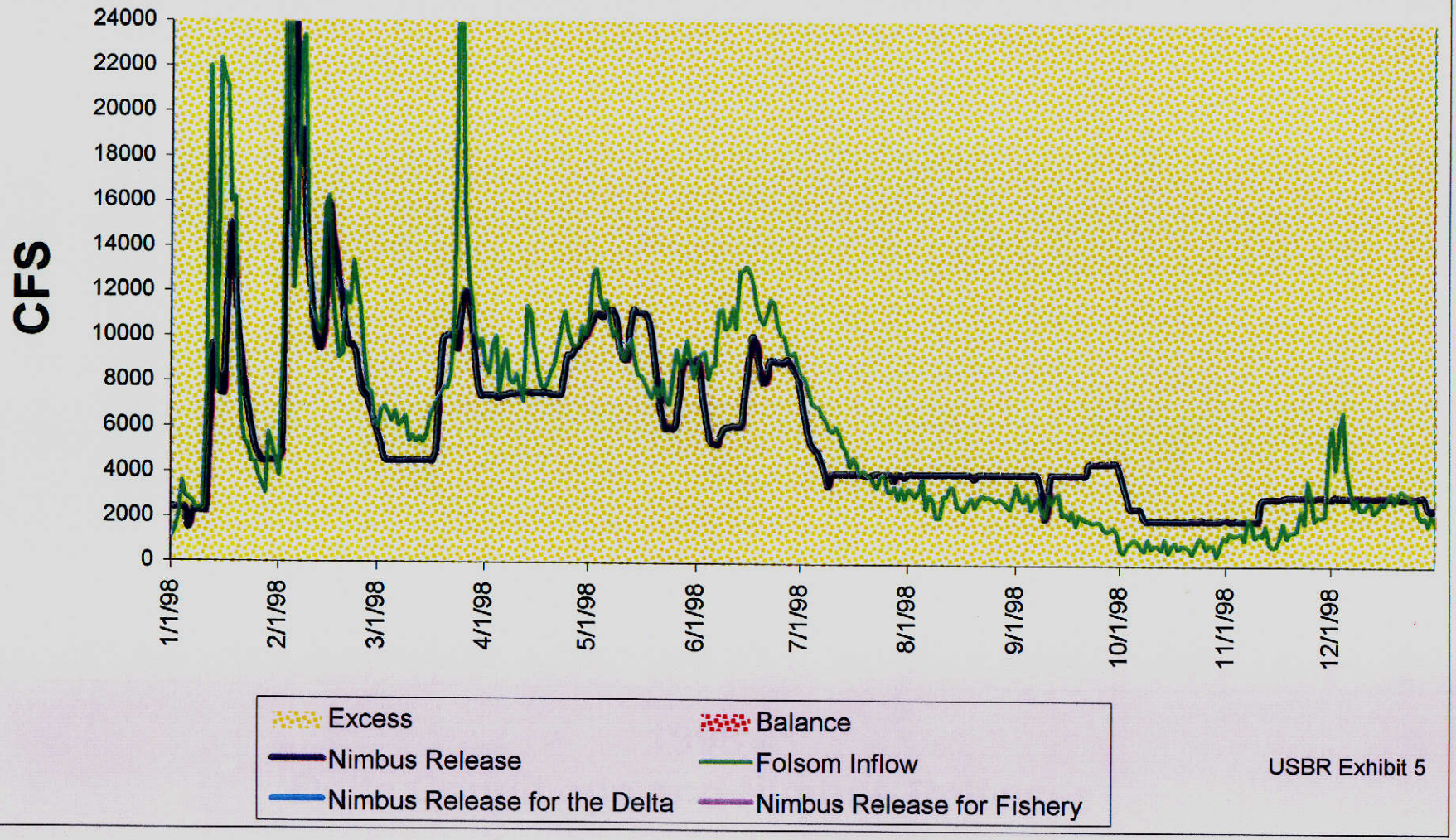
9/1/00
10/1/00
11/1/00
12/1/00
Excess
Balance
Term 91
Nimbus Release
Folsom Inflow
Nimbus Release for the Delta
Nimbus Release for Fishery
USBR Exhibit 3

1999
Delta Conditions and Nimbus Releases



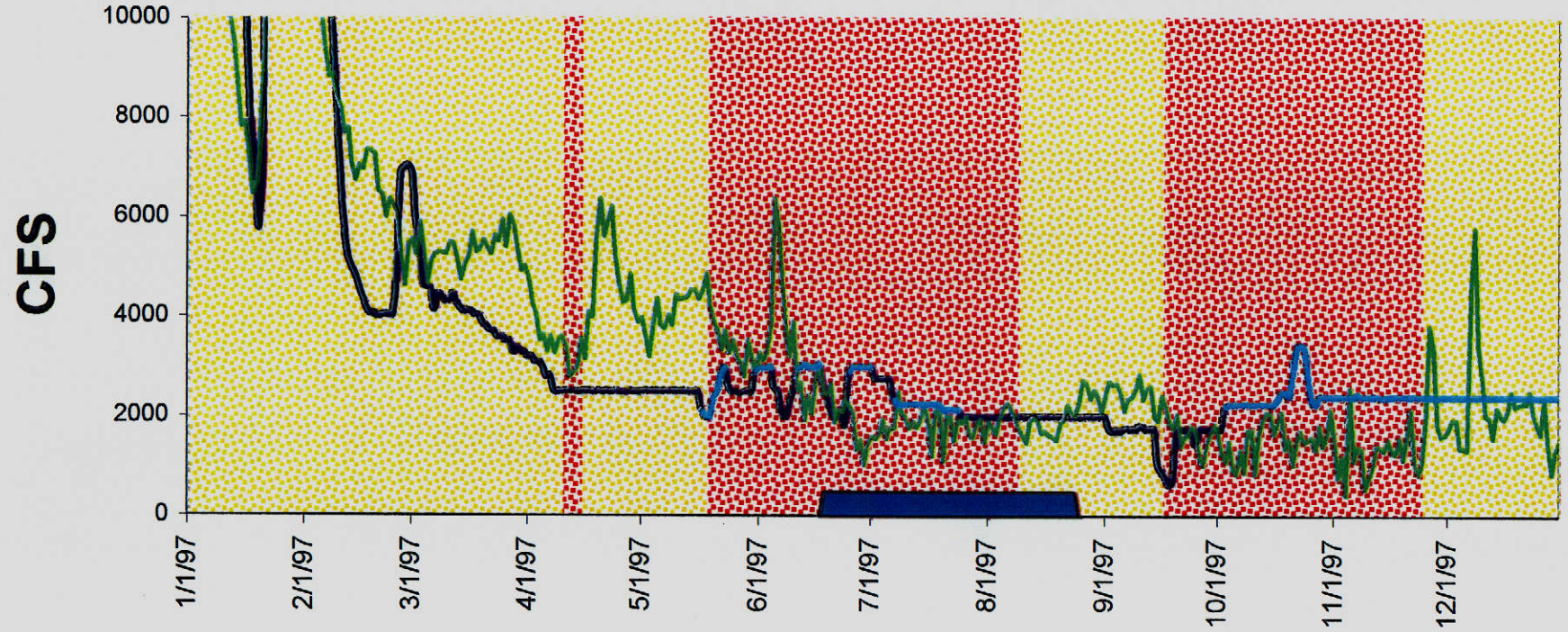
USBR Exhibit 4

1998
Delta Conditions and Nimbus Releases



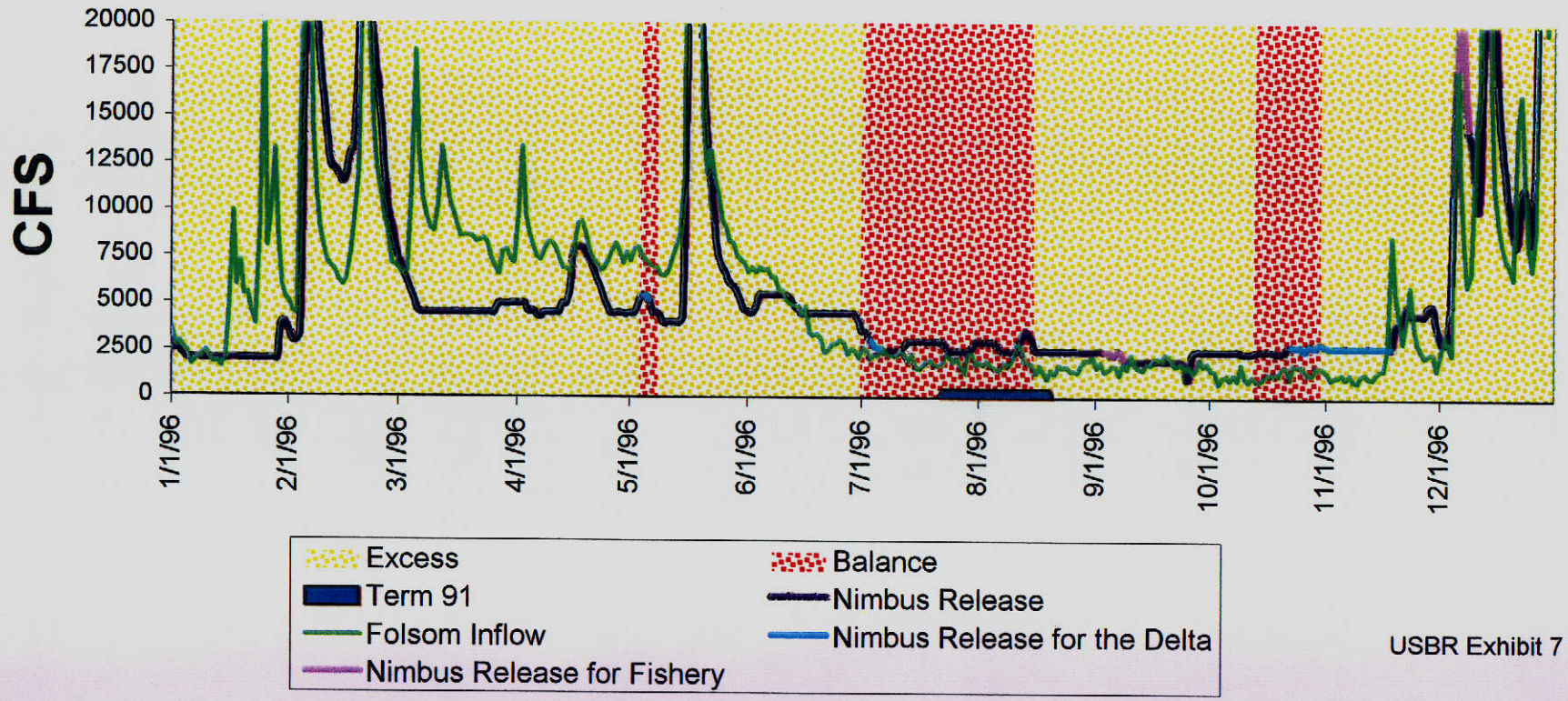
USBR Exhibit 5

1997
Delta Conditions and Nimbus Releases



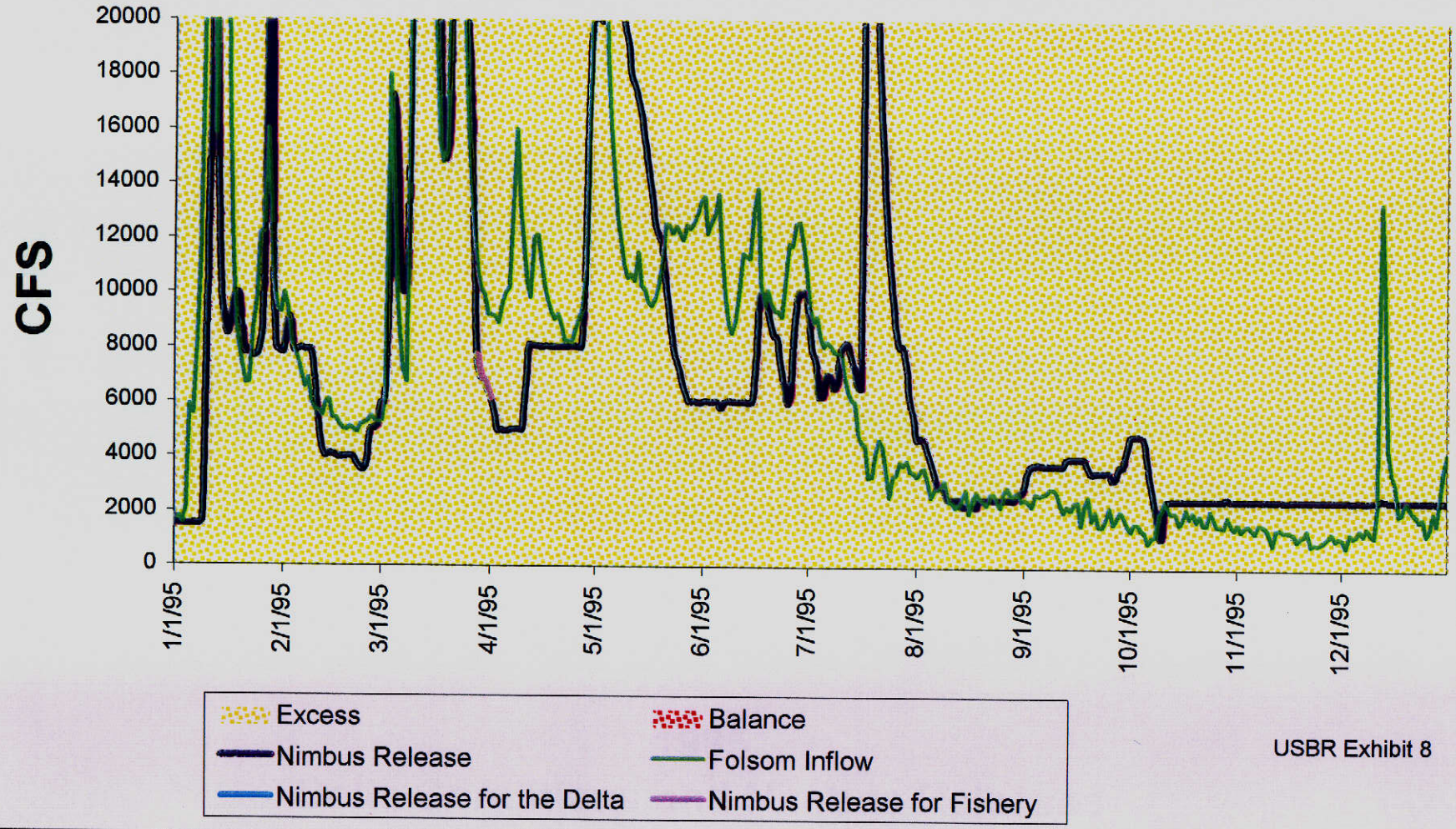
USBR Exhibit 6

1996
Delta Conditions and Nimbus Releases



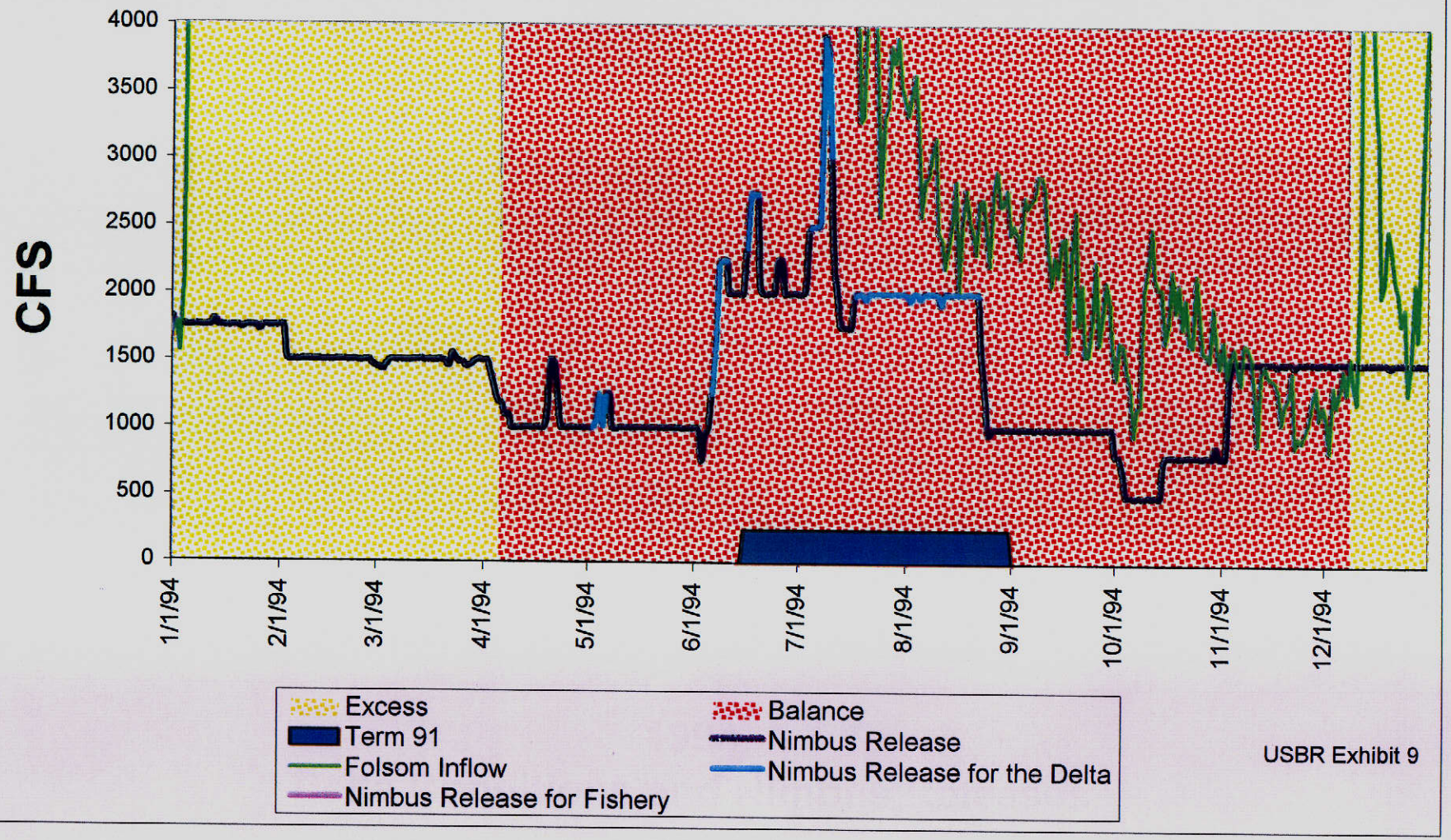
USBR Exhibit 7

1995
Delta Conditions and Nimbus Releases



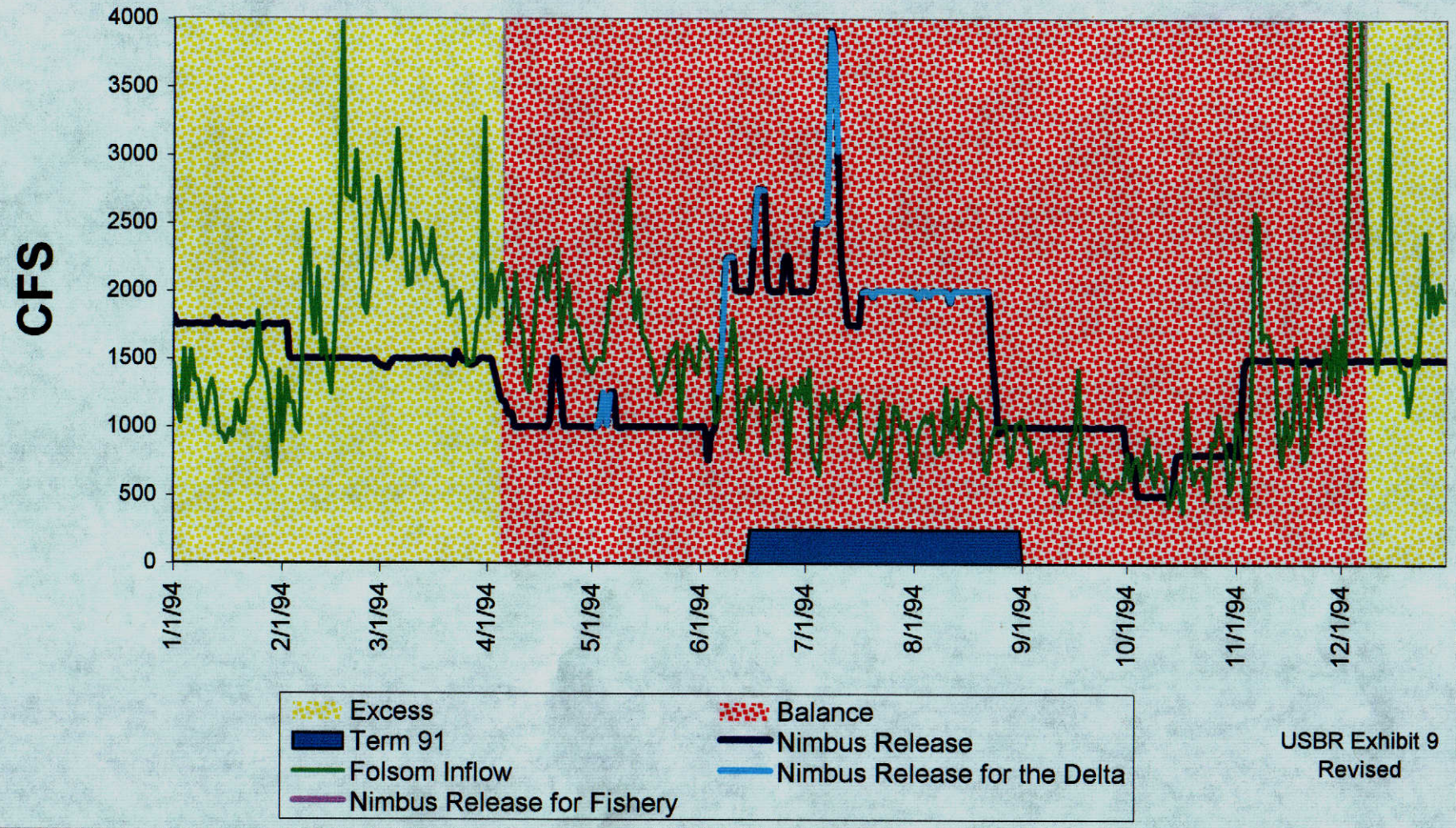
USBR Exhibit 8

1994
Delta Conditions and Nimbus Releases



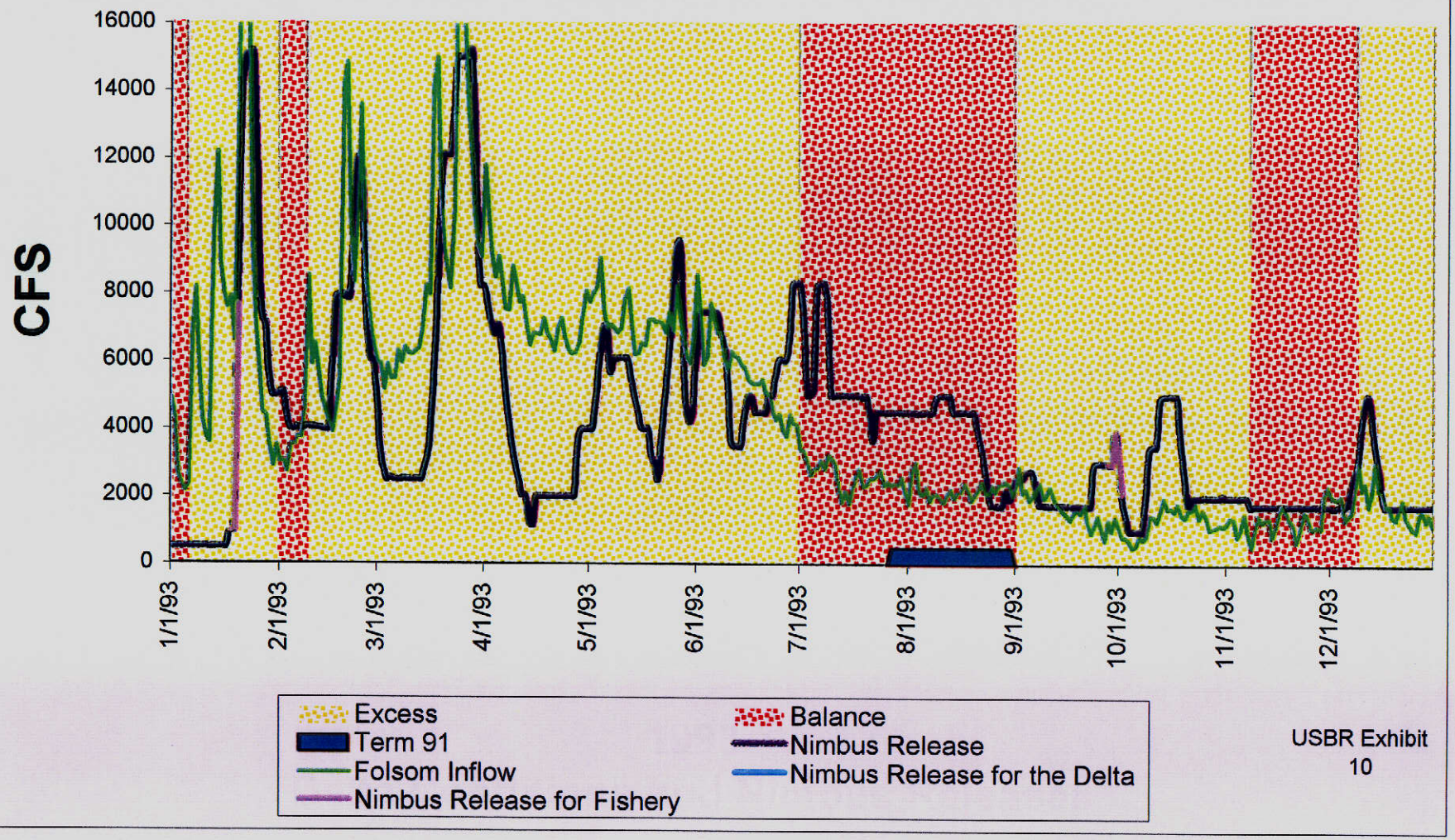
USBR Exhibit 9

1994
Delta Conditions and Nimbus Releases



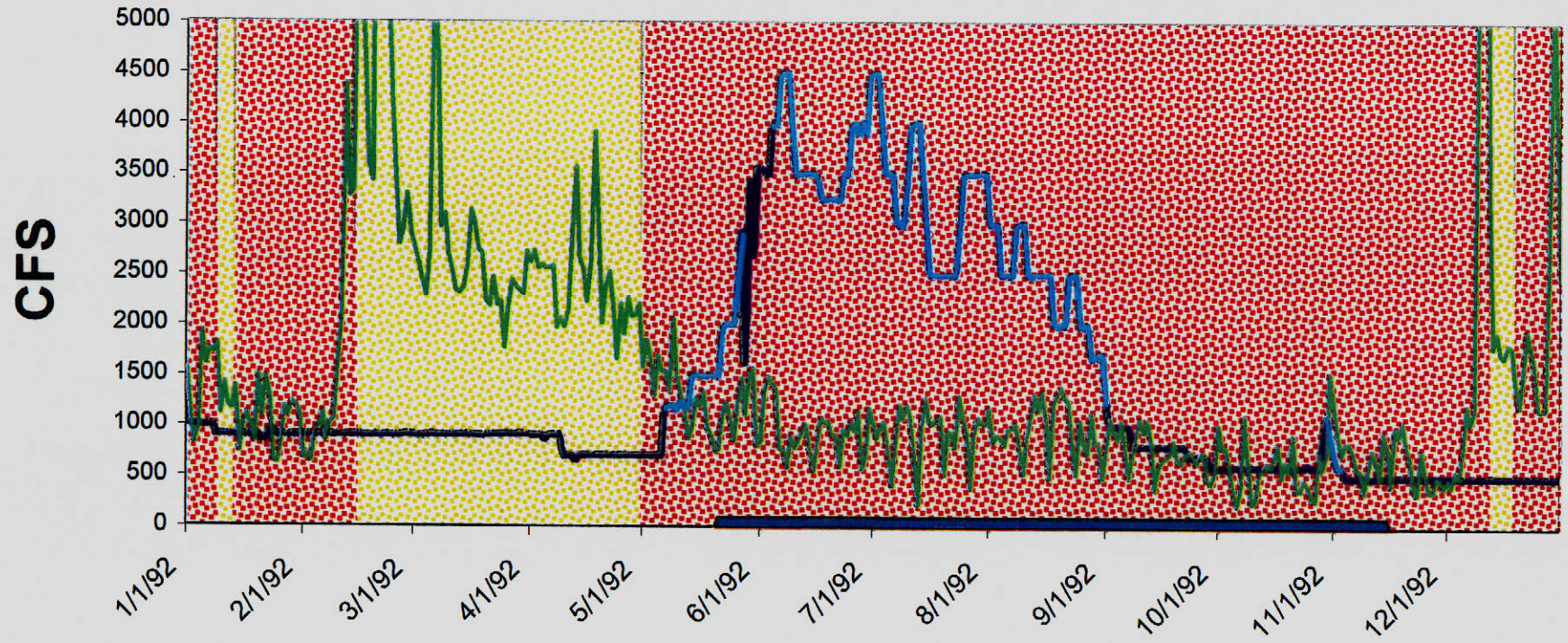
USBR Exhibit 9
Revised

1993
Delta Conditions and Nimbus Releases



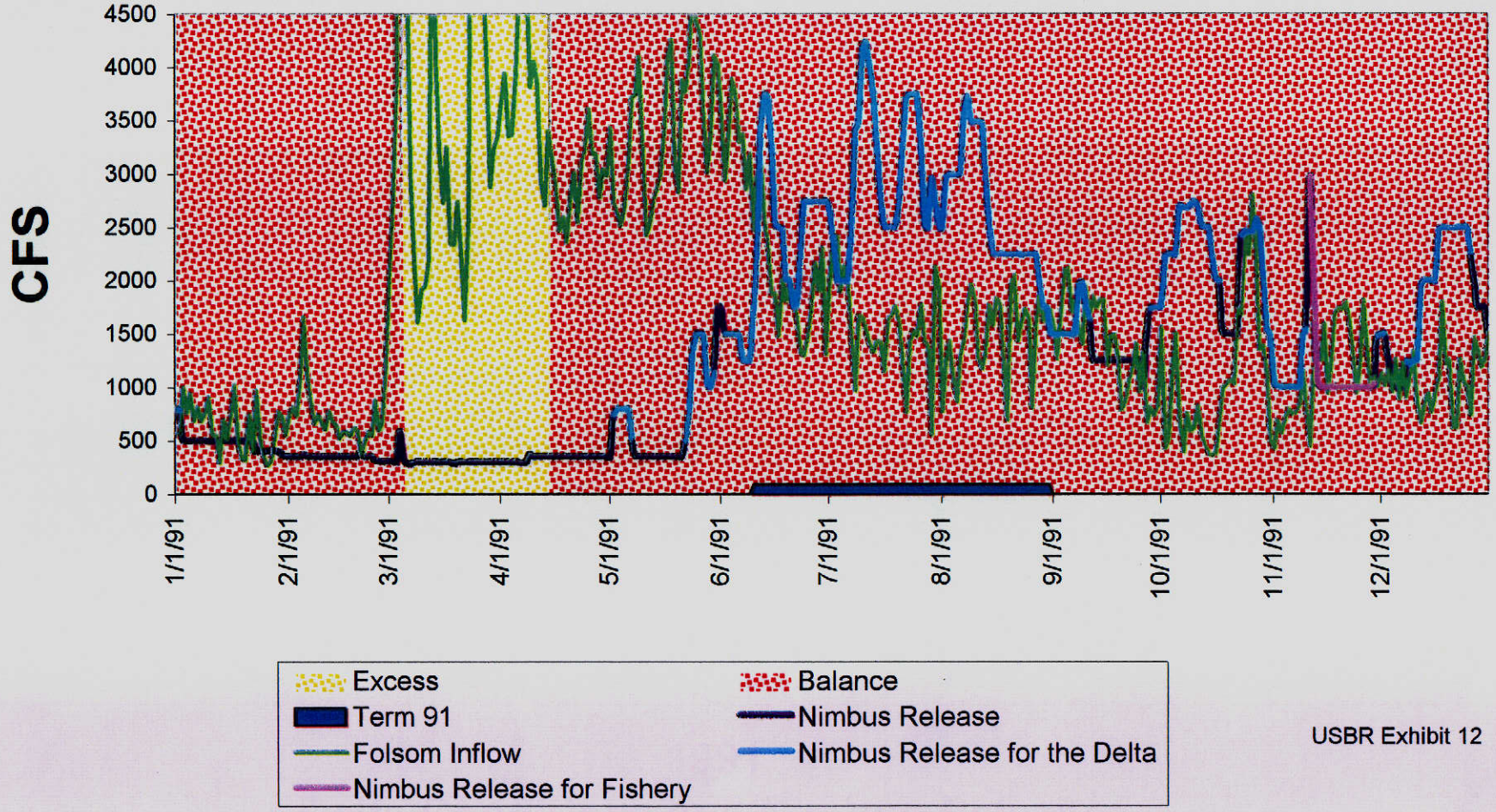
USBR Exhibit 10

1992
Delta Conditions and Nimbus Releases



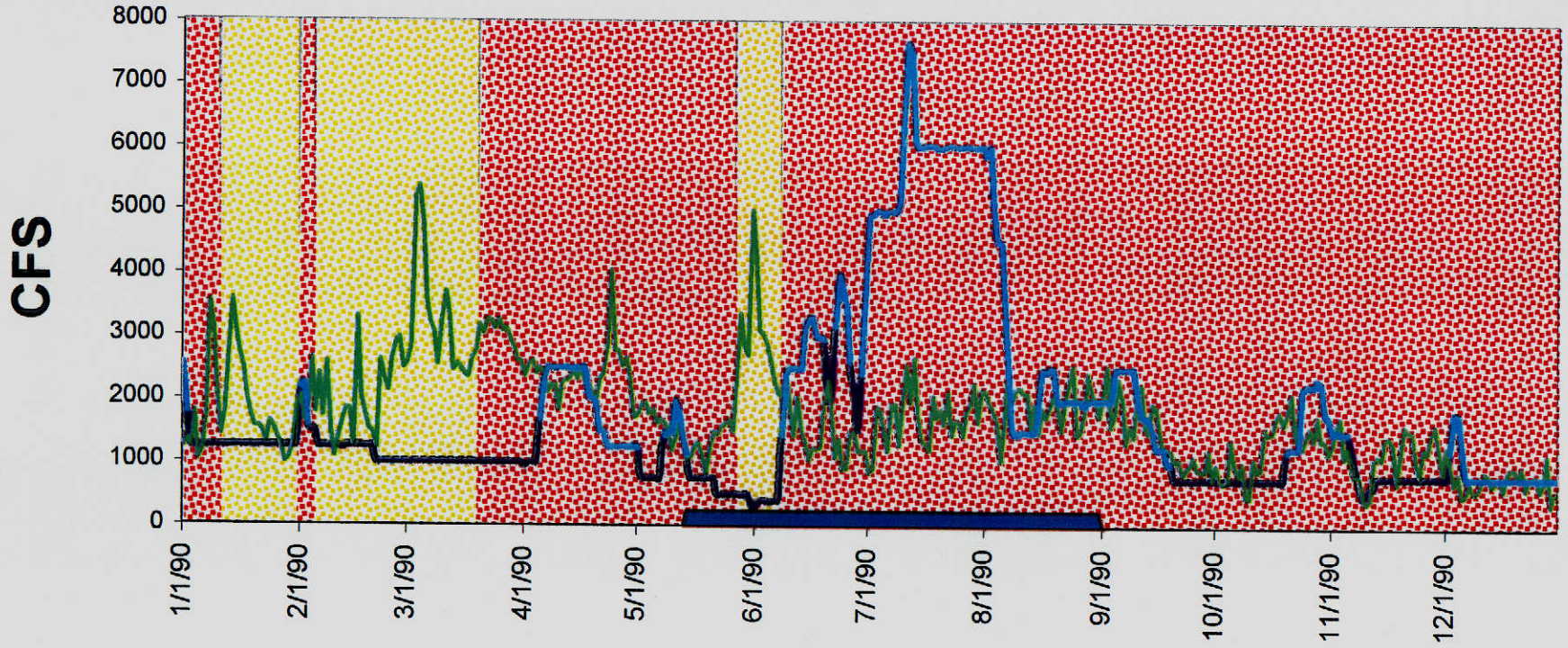
USBR Exhibit 11

1991
Delta Conditions and Nimbus Releases



USBR Exhibit 12

1990
Delta Conditions and Nimbus Releases



USBR Exhibit 13

LIST OF PARTIES TO EXCHANGE INFORMATION

Hearing on Petition to Revise Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County

(Note: the parties whose E-mail addresses are listed below agreed to accept electronic service, pursuant to the rules specified in the Hearing Notice.)

Michael Fife
Hatch & Parent
21 East Carrillo Street
Santa Barbara, CA 93101
Rep: Southern California Water Company
Mfife@hatchparent.com

Ronald M. Stork
915 20th Street
Sacramento, CA 95814
Rep: Friends of the River
rstork@friendsoftheriver.org

Jan S. Driscoll
501 W. Broadway, Ninth Floor
San Diego, CA 92101
Rep: California-American Water Company
JDRISCOLL@ALLENMATKINS.COM

Stuart L. Somach/ William E. Hvidsten
400 Capitol Mall, Suite 1900
Sacramento, CA 95814
Rep: Sacramento County/ Sacramento County Water Agency
Ssomach@lawssd.com
bhvidsten@lawssd.com

Janet K. Goldsmith
400 Capitol Mall, 27th Floor
Sacramento, CA 95814-4417
Rep: Aerojet-General Corporation

Martha H. Lennihan
Lennihan Law APC
2311 Capitol Avenue
Sacramento, CA 95816
Rep: City of Sacramento

Jennifer Decker
Department of Fish and Game
1416 Ninth Street, 12th Floor
Sacramento, CA 95814

M. Catherine George, Staff Counsel
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95812
Rep: Central Valley Regional Water Quality Control Board (CVRWQCB)
(NOI states that the CVRWQCB plans to present an opening statement and reserves the right to cross examine witnesses, present rebuttal evidence and submit closing briefs, if permitted.)

James E. Turner
Office of the Regional Solicitor
PSW Region
2800 Cottage Way, E-1712
Sacramento, CA 95825
Rep: U.S. Bureau of Reclamation

LENNIHAN LAW
A PROFESSIONAL CORPORATION
2311 Capitol Avenue
Sacramento, CA 95816

Telephone: 916.321.4460
Facsimile 916.321.4422

MARTHA H. LENNIHAN
mlennihan@lennihan.net

LORI LEI "RICO" K. OZAKI
lozaki@lennihan.net

May 10, 2002

Via E-mail

State Water Resources Control Board
Division of Water Rights
PO Box 2000
Sacramento, CA 95812-2000
Att: Jean McCue

RE: Petition to Revise Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County

Dear Ms. McCue:

Enclosed for filing are e-mail attachments of the City of Sacramento's Exhibit Identification Index and Exhibits as listed thereon.

A copy of this package has been sent via first class mail to each of the parties identified on the attached service list.

If you have any questions, please contact me.

Sincerely
LENNIHAN LAW
A Professional Corporation

By: _____
Martha H. Lennihan

Enclosure(s) as Indicated
cc: Service List
Gary Reents, Department of Utilities, City of Sacramento
Joe Robinson, Office of the Attorney, City of Sacramento
f:MHL 051002 McCue ltremail.wpd

AMERICAN RIVER FAS PETITION HEARING

Exhibit Identification Index

Participant CITY OF SACRAMENTO

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
CITY A	Written Testimony of Gary Reents			
CITY B	City American River Water Right Permits (4)			
CITY C	Written Testimony of Robert Wagner			
CITY D	Resume of Robert Wagner			
CITY E	American River Study Area : Monitoring Well Locations and Potentiometric Surface Elevations			
CITY F	Aerojet GET Effectiveness Evaluation for the American River Study Area, February 2000			
CITY G	Hydrologic Cross Section A-A' – Figure 3-2 from Aerojet GET Effectiveness Evaluation for the American River Study Area, February 2000			
CITY H	USGS: American River Bed Elevation			
CITY I	Potentiometric Surface Elevations (Figures 1, 2 and 3)			
CITY J	Department of Water Resources Bulletin 133			

City of Sacramento
Exhibit CITY A

Testimony of Gary Reents

State Water Resources Control Board Hearing Re: Southern California Water Company Petition for Relief from Fully Appropriated Determination, American River

City of Sacramento Exhibit CITY A

WRITTEN TESTIMONY OF GARY REENTS

1. My name is Gary Reents. I am a registered civil engineer (CA license C40290). I am the Engineering Services Manager of the Department of Utilities, City of Sacramento, 1395 35th Avenue, Sacramento, CA 95822-2911. I have held this position since July 8, 1995. The Department of Utilities manages the City's water diversions, treatment and distribution, including its diversions from the Lower American River at the Fairbairn Water Treatment Plant. As Engineering Services Manager, I work directly for the Director of the Department, focusing on engineering matters and special projects and supervising a staff of 63 people. I am familiar with the City's water supply facilities and operations.

2. The City holds four water right permits on the lower American River issued by the State Water Resources Control Board. The Permit and Application Numbers are:
   A. Permit No. 11358 (Application 12140);

   B. Permit 11359 (Application 12321);

   C. Permit 11360 (Application 12622); and

   D. Permit 11361 (Application 16060)

   These Permits are in the above referenced Application files at the SWRCB, are public records prepared by a public agency, and are incorporated herein by reference as City of Sacramento Exhibit CITY B.

   The City's primary points of diversion for these permits are near the confluence of the American and the Sacramento Rivers, downstream of the location of the Aerojet groundwater remediation project, and the Southern California Water Company proposed diversion of groundwater discharged to the Lower American River.

3. The City uses and relies upon the water supply derived from these water rights to provide municipal and industrial water for beneficial uses by residents and businesses within the permitted places of use. The City also has a water right settlement contract with the United States Bureau of Reclamation.

4. The City is a participant in the Sacramento regional Water Forum. As part of the Water Forum process the City and other water purveyors in the region entered into agreements in furtherance of maintenance of adequate instream flows in the Lower American River. When flows become low in the American River, the City is required to cease use of the additional capacity the City is now constructing at its Fairbairn Water Diversion and Treatment Facility on the Lower American River, and if possible utilize instead capacity in its Sacramento River Diversion and Treatment Plant.

5. The City is appearing in this proceeding for the purpose of protecting its water rights and because a reduction in flows in the American River, particularly under low flow conditions, can cause a significant burden on and injury to the City. The SWRCB should not grant relief from the Declaration of Full Appropriation for the American River absent a clear demonstration that there is "new" water not taken into account in the decisions upon which the existing determination of full appropriation is premised, and that this water is not needed to meet existing demands.

City of Sacramento
Exhibit CITY B

City of Sacramento Water Right Permits

City of Sacramento Water Right Permits

The following City of Sacramento water right permits are contained in the Application files at the SWRCB, are public records prepared by a public agency, and are incorporated herein by reference pursuant to 23 CCR section 648.3 as City of Sacramento Exhibit CITY B. The specific Permit and Application numbers are:

A. Permit No. 11358 (Application 12140)

B. Permit No. 11359 (Application 12321)

C. Permit No. 11360 (Application 12622)

D. Permit No. 11361 (Application 16060)

City of Sacramento
Exhibit CITY C

Testimony of Robert C. Wagner

City of Sacramento
State Water Resources Control Board Hearing Re: Southern California Water Company Petition for Relief from Fully Appropriated Determination, American River

EXHIBIT CITY C

WRITTEN TESTIMONY
OF ROBERT C. WAGNER

1. I am a licensed Civil Engineer in the State of California and President of the firm of Wagner&Bonsignore Consulting Civil Engineers in Sacramento, California. I presently serve in the capacity of Engineer for the Court Appointed Watermaster in the matter of Barstow v. Adelanto, a major groundwater adjudication involving 475 parties and 1500 wells in San Bernardino County, California. In addition, I am the Engineer for a number of municipalities, water districts, community service districts and private clients involved in groundwater resource matters and matters related surface water rights. I have been qualified and testified as an expert witness in hydrology in the Superior Courts in San Bernardino and Riverside Counties and before the State Water Resources Control Board (State Board) in the water rights proceeding which culminated in Decision 1635 on the South Fork of the American River. A true and correct copy of my professional resume is attached (City of Sacramento Exhibit CITY D).

2. Petitioner Southern California Water Company (SCWC) submitted a Petition (Petition) to the State Board on November 7, 2001 requesting a revision to the Fully Appropriated Streams Declaration for the Lower American River (FAS Determination). SCWC is asking the State Board to revise the FAS Determination so as to accept a water right application, Application No. X003385 (Application), and to grant it a permit to appropriate "non tributary water" discharged to the American River via Buffalo Creek by Aerojet Corporation. SCWC indicates in its Petition that Aerojet is now authorized to discharge up to 3500 gpm into Buffalo Creek, which is tributary to the Lower American

River. The Petition indicates that Aerojet may be authorized to increase the amount it discharges in the future and that the additional discharges would also be subject to appropriation by SCWC.

3. SCWC's May 1, 2002 letter served on the parties to this proceeding indicates that the amount of water SCWC seeks to appropriate could be an additional 6,000 gpm from facilities known as "GET E/F", pending a "tentative revision of Areojet's NPDES permit No. CA0083861." SCWC also identifies up to 8,000 gpm that is anticipated to be produced from Western Groundwater Operable Unit Treatment System (WGOU). If these amounts are additive and if all of this water was pumped and discharged, the amount of water sought by SCWC would be 17,500 gpm or as much as 28,000 acre-feet per year. Neither the Petition nor the Application state how much water is sought to be appropriated, or where the points of diversion are.

4. The State Board in its April 26, 2002 letter regarding this matter set forth the scope of the proceeding as follows: "For purposes of this proceeding, a finding that water is available simply refers to whether there is new water, different from the water understood to be available when the orders that are the basis for listing the stream on the Declaration were issued." Based upon this direction, relief from the State Board's existing FAS Determination for the American River can be granted only if Petitioner SCWC demonstrates that there is "new water" developed from Aerojet's groundwater pumping and discharge, that was not taken into consideration as part of the American River Stream System at the time of State Board Decisions 1108 and 1211 (1963 and 1965 respectively). Any such demonstration must include an analysis of the conditions that existed in the groundwater aquifers and surface water systems, prior to and during those years. The analysis must evaluate whether or not the groundwater system was tributary to the surface flow of the river and to what degree, at the time when the river system physically became fully appropriated. The data and analysis submitted to date by Petitioner SCWC including and in support of its Petition is insufficient to make such a determination. The testimony and evidence to be submitted by SCWC may adequately address this. However, it is not yet available to the parties.

5. The City did not undertake the work mentioned above. However, on behalf of the City, I did gather information that is relevant and useful to this Board's inquiry into whether the groundwater pumped by Aerojet's American River Groundwater Extraction and Treatment (ARGET) project is hydraulically connected to the American River, and whether it would contribute flow during the season that the State Board determined the lower American River to be fully appropriated (July 1 through October 31). Based upon this preliminary review, my observations and findings thus far are as follows.

6. The area of my investigation is shown on City of Sacramento Exhibit CITY E. This area is located on the north and south sides of the reach of the American River downstream from Nimbus Dam and between Hazel Avenue and Sunrise Blvd. in Sacramento County. While this area is limited in scope relative to the entirety of Aerojet's groundwater remediation effort, it shows the interaction of the groundwater and river system in an area subject to pumping and monitoring, and identified by SCWC as a source of water sought to be appropriated. Shown on Exhibit CITY E are the locations of various monitoring wells and extraction wells that are part of the ARGET project. I prepared City of Sacramento Exhibit CITY E using data obtained from a document titled "GET Effectiveness Evaluation for the American River Study Area, Gencorp Aerojet, February 2000" (GET, Feb 2000) (City of Sacramento Exhibit CITY F).

7. The ARGET project pumps contaminated groundwater into a treatment system and discharges the water into the American River via Buffalo Creek. Various aquifers have been mapped and designated by Aerojet as layers A through E. Layer A is the upper most aquifer unit and layer E is the lowest (in elevation) aquifer unit. Layers A through D are most prevalent within this area. A hydrologic cross section showing these units is attached as City of Sacramento Exhibit CITY G. This cross section is a copy of Figure 3-2 from GET, Feb 2000 (City of Sacramento Exhibit CITY F).

8. According to the United States Geological Survey (USGS), the approximate elevation of the river channel bottom, at a location about 340 downstream of the USGS gaging station American River at Fair Oaks, is 68.62 feet above mean sea level (msl) (City of Sacramento Exhibit CITY H). I have estimated that the elevation of the channel bottom decreases in the westward direction at the rate of about 1 foot per 1,000 feet of distance along thread of the river.

9. Water levels measured in some of the monitoring wells during April 1998 show that the potentiometric surface in aquifer units A through D are at the same elevation or higher in elevation than the bottom of the river channel. This means that under certain hydrologic conditions groundwater has the potential to discharge to the river. The measurements were made prior to the commencement of pumping for this project, and are reported on Figures 3-15, 3-16, 3-17 and 3-18 of GET, Feb 2000 (Exhibit CITY F.) This data is shown graphically on Exhibit CITY E.

10. Figures 1 through 3 (City of Sacramento Exhibit CITY I) show the potentiometric water surfaces measured in the monitoring wells two months after pumping commenced (October 1998), eight months after pumping commenced (April 1999), and fourteen months after pumping commenced (October 1999). I prepared these three figures using data from GET, 2000, Figures 3-15, 3-16, 3-17 and 3-18. After 14 months of pumping the potentiometric surface in some wells was still higher than the bottom of the river channel.

11. The data presented on Exhibit CITY E and Figures 1 through 3 demonstrate that under certain circumstances the groundwater in aquifer units A through D, which is the source of the "new water" identified in the Petition and documents served on the parties by SCWC April 29, 2002 and May 1, 2002, could have been tributary to the river and would not therefore be "new" water. In order to show whether or not the water extracted and discharged by Aerojet that is proposed to be appropriated by SCWC was not previously considered in the FAS Determination, additional information and analysis is needed.

Specifically, it is not adequate to determine whether the pumped and discharged groundwater was recently or is now tributary to the surface flow; the Petitioner must demonstrate whether the groundwater at issue was interconnected with the river system during the period upon which the 1963 and 1965 SWRCB decisions are premised. This requires among other things evaluation of historic water levels in the ground water aquifers at issue. It is very possible that the groundwater was interconnected to a greater degree than it is currently. For example, if there has been a general lowering of the groundwater table since the time that the FAS designation was made the water discharged by ARGET and WGOU may be water that was already a part of the fully appropriated river system.

12. Plate 5 from Department of Water Resources Bulletin 133 (Bulletin 133) shows groundwater contours in the spring of 1946 and spring of 1953. Plate 6 from Bulletin 133 shows groundwater contours in the spring of 1962 and spring of 1963. I note that the water levels as indicated by these contour lines were not correlated to the specific units of the aquifer system as Aerojet and Petitioner SCWC define them. However, this data is indicative of the fact that in the past groundwater levels were generally at a higher elevation than they are currently. Bulletin 133 indicates, "that there has been a general decline throughout the entire area of investigation with the least amount of change occurring where the American River is influencing the recharge. The greatest change, approximately 20 feet, occurs in the Rancho Cordova area where intense urban development has taken place…" Page 18, Bulletin 133. Bulletin 133 is incorporated by reference as City of Sacramento Exhibit CITY J. Cited portions of Bulletin 133 are physically attached in City of Sacramento Exhibit CITY J.

13. A review of Plates 5 and 6 from Bulletin 133 (Exhibit CITY J) indicates that there was also a change in the direction of groundwater flow between 1946 and 1963. Generally, groundwater flows in a direction perpendicular to the contour lines. In 1946 the general direction of flow from the intersection of White Rock Road and Folsom Blvd. to the east, was toward the river. By 1963 the general direction of flow was parallel to the river in the area of west of Sunrise Blvd. East of Sunrise Blvd however the direction of

groundwater flow was still toward the river. Plate 6 indicates that in the spring of 1963 groundwater levels were still higher than the elevation of the bottom of the river channel.

14. Decision 1108 was entered in 1963, and in part is the basis of the FAS Declaration for the American River. The groundwater contours shown on Plates 5 and 6 of Bulletin 133 suggest that at the time of Decision 1108, groundwater may have contributed to the surface flow of the river to a greater degree than is presently the case.

15. Based on the foregoing, the groundwater system has been tributary to the American River through one or more of the aquifer units that are proposed to be the source of water for SCWC's project, and at the locations where wells identified by SCWC for purposes of this Petition and the Application are located. There has been insufficient data and analysis presented to determine whether and how much of the water could be considered "new". There has been insufficient data presented to determine the extent that the American River has been affected by the groundwater treatment operations, both pumping and discharging, since the American River system was included in the FAS Declaration. Consequently, there is insufficient data presented to determine whether or not the water sought by the Petition meets the standard of "new" water not previously considered by the State Board when it declared the American River to be fully appropriated.

16. If any "new" water is demonstrated to be present, an entirely separate analysis is necessary to determine whether any of it is unappropriated, or available for appropriation. Since the SWRCB has determined that that is an issue for a subsequent proceeding on the Application, if any, I do not address it here.

17. City of Sacramento Exhibits CITY D through J are true and correct copies of the documents described in the foregoing testimony.

_____

Robert C. Wagner, P.E.

City of Sacramento
Exhibit CITY D

Resume of Robert C. Wagner

Wagner&Bonsignore
Consulting Civil Engineers, A Corporation

Nicholas F. Bonsignore, P.E.
Robert C. Wagner, P.E.
Paula J. Whealen

ROBERT C. WAGNER
PROFESSIONAL RESUME

REGISTRATION:

Civil Engineer, California (License No. 52903)

EDUCATION:

B.S. Civil Engineering - California State University, Sacramento, CA - 1988

EXPERIENCE:

Wagner & Bonsignore, Consulting Civil Engineers, A Corporation - Sacramento, California
Principal - April 1998 to Present

- Water Resources Management, including Watermaster services, administration of court judgments and litigation support.
- Perform hydrology studies and water availability analysis for water storage and diversion projects.
- Acquisition, defense and administration of water rights.

James C. Hanson, Consulting Civil Engineer, A Corporation - Sacramento, California
Senior Engineer - May 1990 to April 1998

Water rights analysis, water production determinations, hydrologic analysis and land use classifications.

State Water Resources Control Board, Division of Water Rights - Sacramento, California
Assistant Civil Engineer - September 1988 to May 1990

Process water right applications pursuant to State Board policy and Title 23 of the California Code of Regulations.

RECENT EXPERIENCE INCLUDES THE FOLLOWING:

Engineering expert on behalf of City of Ukiah in connection with water rights and hydrology of the Russian River, Mendocino County.

Engineering expert on behalf of Sonoma County Water Agency in connection with development of agricultural reuse project for use of treated wastewater for vineyard irrigation.

Engineering expert and consultant in connection with analysis of water production and hydrologic data for development of water use agreements for over 100 growers in the Dry Creek Valley in Sonoma County.

Engineering expert for City of Santa Maria in connection with the hydrologic resources of the Santa Maria Groundwater Basin.

Engineering expert in the matter of Bonadiman v. Evans in San Bernardino Superior Court on behalf of prevailing party Evans. Research and documentation of water development and water right acquisition dating to 1843.

Engineering expert for The Wildlands Conservancy in connection with water resource matters for extensive land holdings in San Bernardino and Kern Counties.

Engineering expert for Wells Fargo Bank in connection with the analysis of water rights and water availability on the Kern River.

Watermaster Engineer for the Mojave Basin Area Watermaster in the matter of the Mojave River Adjudication, City of Barstow, et al, vs. City of Adelanto, et al. Collection and analysis of data for preparation of Annual Watermaster Report, including groundwater production and hydrology studies of the Mojave River System and groundwater basin in connection with storm flow base flow separation determination and the analysis of water transfers and land use changes. Preparation of Annual Watermaster report.

Engineering expert on behalf of the Mojave Water Agency in connection with Mojave Basin Area Adjudication. Coordinate activities for professional and subprofessional staff for collection, analysis and verification of water production records for approximately 7,000 wells in the Mojave River Basin. Participate in meetings of the Joint Engineer-Attorney Drafting Committee formed to negotiate and draft the Stipulated Judgment. Participation in the drafting and ongoing revisions of the Watermaster Rules and Regulations.

Engineering expert in connection with engineering services for the Warren Valley Basin Watermaster, San Bernardino County. Analysis of groundwater production records and basin hydrology for preparation of Annual Watermaster Report.

Engineering expert in connection with work for East Valley Water District, San Bernardino County, regarding the analysis of surface and subsurface hydrology of the Santa Ana River and the availability of water for the Seven Oaks Dam Project and fully appropriated listing of the Santa Ana River.

Engineering expert on behalf of Kirkwood Associates before the State Water Resources Control Board in the matter of South Fork American River Hearings, October 1995. Analysis of the South Fork American River and Caples Creek hydrology in connection with same.

Engineering expert in connection with work for High Desert Water District, San Bernardino County, regarding the analysis of water quality and ground water elevation data for monitoring the potential impacts of ground water extractions from the Ames Valley Basin.

Engineering expert in connection with work for Hidden Valley Lake Community Services District, Lake County, regarding the hydrologic analysis of Upper Putah Creek Watershed and the Coyote Valley groundwater basin in support of amendments to fully appropriated stream status and applications to appropriate surface and subsurface water from Putah Creek; continued monitoring of the Coyote Valley groundwater basin in connection with administration of water rights.

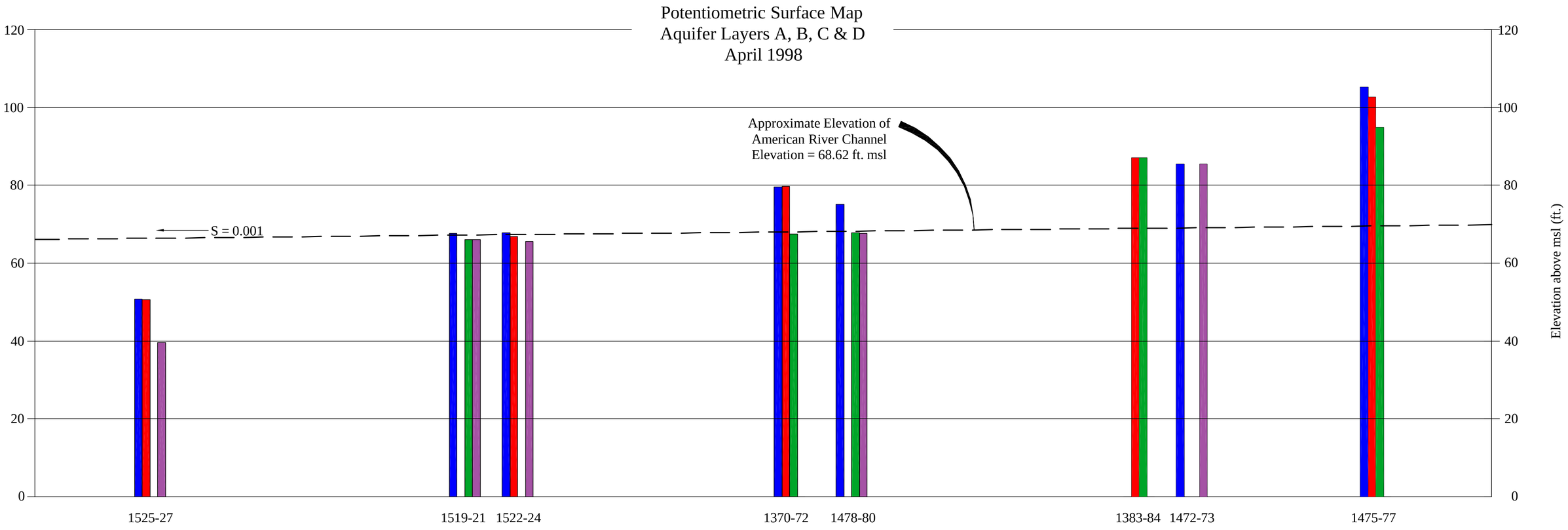
CONTINUING EDUCATION

"California Environmental Quality Act Update", University of California, Davis - February 1992
"California Water Law", University of California, Davis - November 1989 to January 1990
"Understanding Wetlands and 404 Permitting", ASCE July 1997
"Fundamentals of Water Rights and Colorado River Issues", University of Nevada, Las Vegas January 1998

City of Sacramento
Exhibit CITY E

Aerojet American River Study Area
Various Monitoring Well Locations
And Potentiometric Surface, April 1998

Potentiometric Surface Map
Aquifer Layers A, B, C & D
April 1998



Data obtained from GenCorp Aerojet, GET Effectiveness Evaluation for the American River Study Area, Figures 3-15, 3-16, 3-17, 3-18, Feb 2000.

Legend

- Aquifer Layer A
- Aquifer Layer B
- Aquifer Layer C
- Aquifer Layer D
- Monitoring Well Designation (1525-27)
- Approximate Location Extraction Well(s)
- A—A' Hydrogiologic Cross Section A-A', GET Effectiveness Evaluation, Figure 3-2. February 2000

Wagner & Bonsignore
Consulting Civil Engineers, A Corporation

Robert C. Wagner, P.E.
April 2002

CITY OF SACRAMENTO

Aerojet American River Study Area
Various Monitoring Well Locations
and Potentiometric Surface, April 1998

Exhibit CITY E

Q:\Drawings\Lemihan\City of Sacramento \dwg\Monitoring Well Elevations.dwg

City of Sacramento
Exhibit CITY F

Aerojet Sacramento Site
GET Effectiveness Evaluation for the American River Study Area Prepared by Gencorp Aerojet

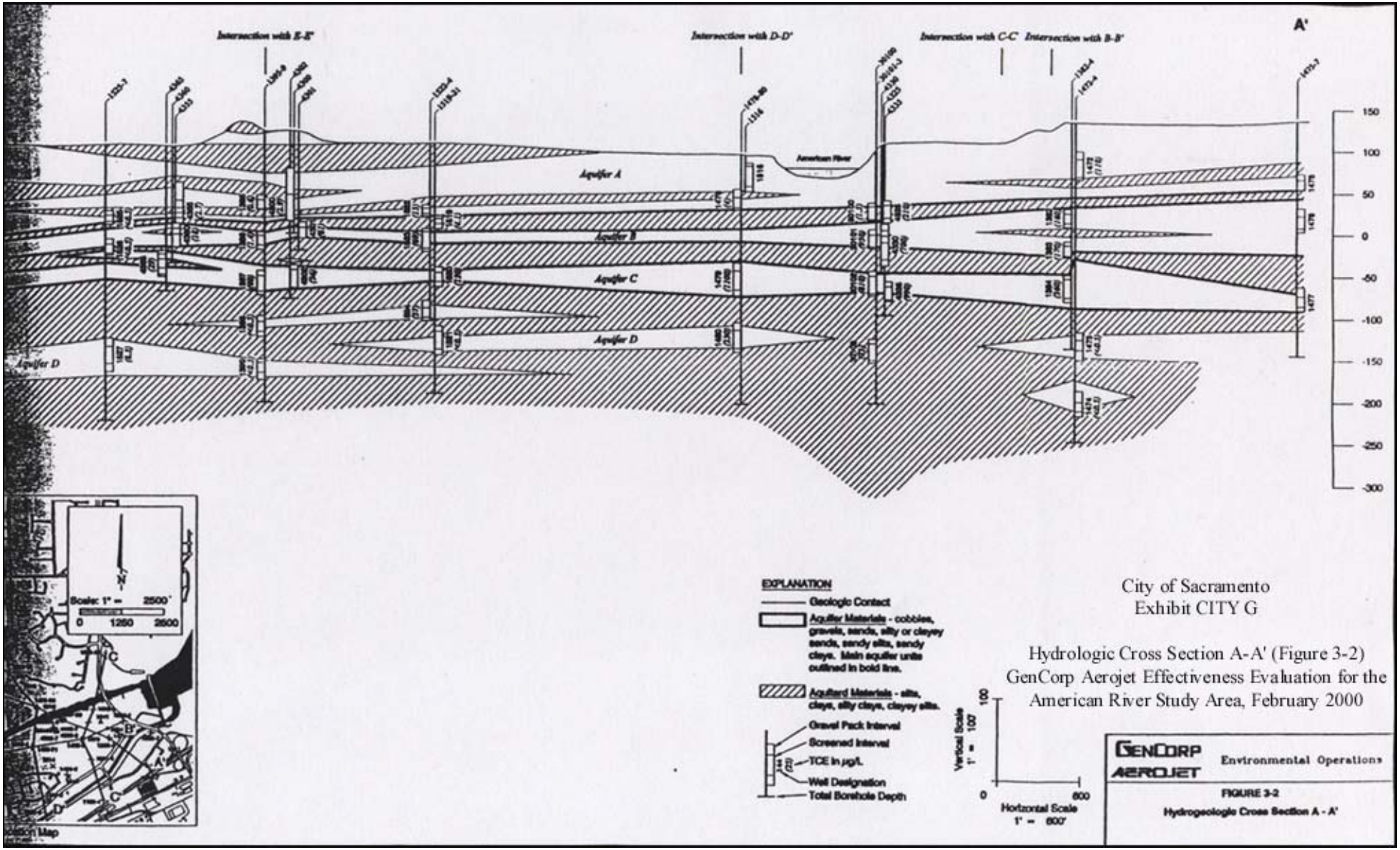
February 2000

Aerojet Sacramento Site
GET Effectiveness Evaluation for the American River Study Area
Prepared by Gencorp Aerojet
February 2000

This document was recently filed with the State Water Resources Control Board in this proceeding and served on all parties as Southern California Water Company Exhibit 18. (SCWC Counsel Letter dated April 29, 2002.) It is already readily available to all parties and to the SWRCB. Pursuant to discussion with SWRCB counsel and in the interest of avoiding unnecessary and wasteful duplication, the City of Sacramento refers to and incorporates this exhibit by reference.

City of Sacramento
Exhibit CITY G

Hydrologic Cross Section A-A' (Figure 3-2)
GenCorp Aerojet Effectiveness Evaluation for the
American River Study Area, February 2000



City of Sacramento
Exhibit CITY G

Hydrologic Cross Section A-A' (Figure 3-2)
GenCorp Aerojet Effectiveness Evaluation for the American River Study Area, February 2000

GENCORP AEROJET Environmental Operations

FIGURE 3-2
Hydrogeologic Cross Section A - A'

City of Sacramento
Exhibit CITY H

United States Geologic Survey
Elevation of Bottom Channel at Cableway Section
American River at Fair Oaks

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
SACRAMENTO FIELD OFFICE
8550 23rd Avenue
Sacramento, Ca 95826

FAX: (916) 381-0556
PHONE: (916) 381-0207

DATE: 4/26/02

TO: Bob Wagner

OFFICE:

FAX NUMBER: 448-3866

FROM THE DESK OF: Jerry Smithson

Phone: 381-0207 X310

2 Pages, including cover page

City of Sacramento
Exhibit CITY H

United States Geologic Survey
Elevation of Bottom Channel
at Cableway Section
American River at Fair Oaks

April, 26, 2002

Bob,

Per our conversation yesterday, April 25, 2002, concerning your question on a approximate above sea level elevation for the cross-section at the cableway located 340 feet downstream of the gaging station for station 11446500, American River at Fair Oaks, I determine that the mean channel bottom was approximately 68.62 ft above sea level on Jan. 15, 2002, base on a measurement made at the cableway on that date. This was determine by doing the following:

71.53 ft (Datum of gage above sea level)
+4.59 ft (mean gage height during measurement, gage datum)

76.12 ft
-7.5 ft (average depth of cross section during measurement)

68.62 ft (average sea level elevation of bottom of channel at cableway section based on Measurement No. 549)

This can only be considered an approximation for this date and for the cross section at the cableway. As the geometry of a natural river channel varies throughout it's reach and is in a continuously state of change.

I'm also faxing you a copy of measurement No. 549. Any further questions please let me know.

Sincerely
Jerry Smithson
Supervisory Hydrologic Technician

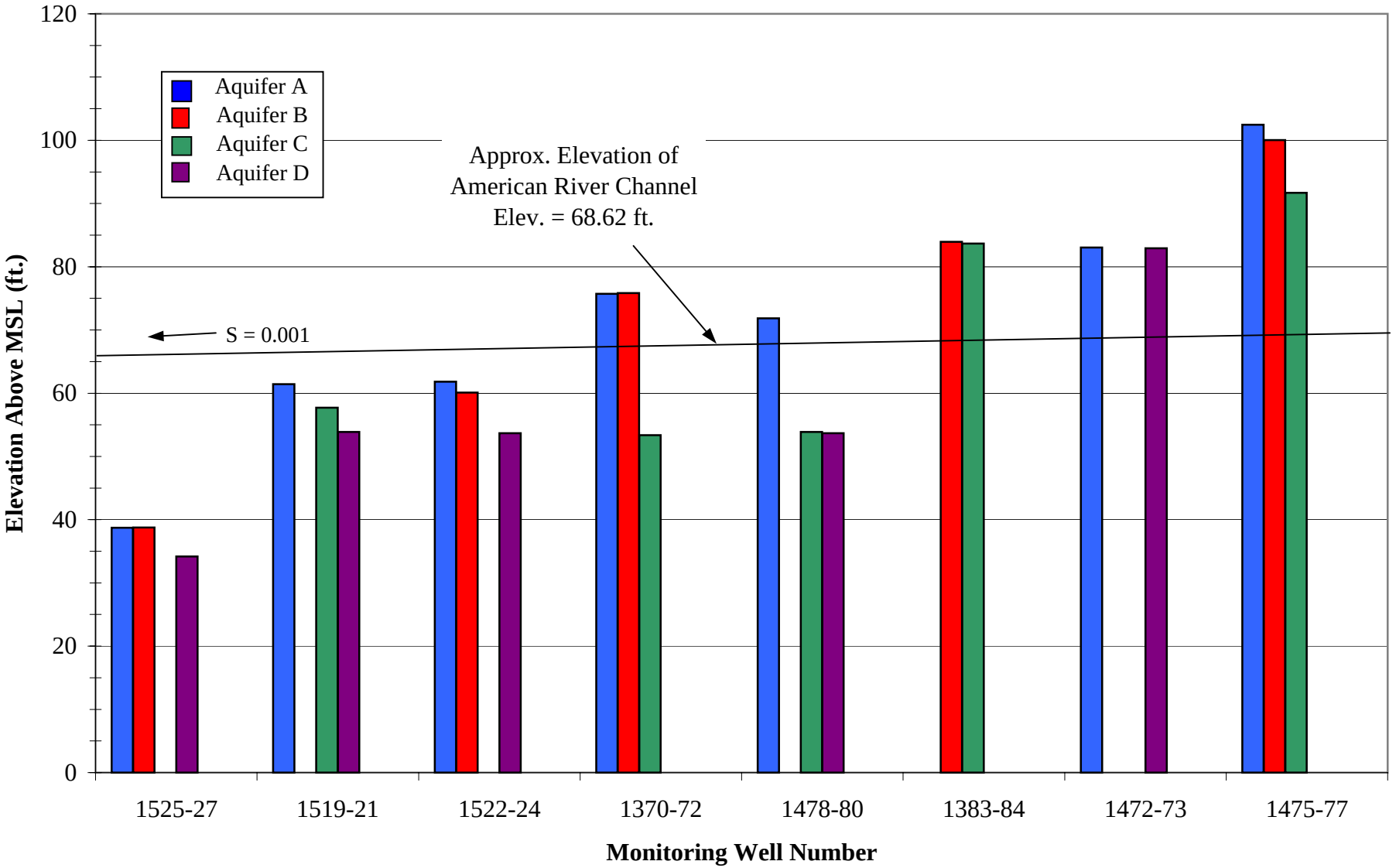
City of Sacramento
Exhibit CITY H

United States Geologic Survey
Elevation of Bottom Channel
at Cableway Section
American River at Fair Oaks

City of Sacramento
Exhibit CITY I

Potentiometric Surface
Aquifer Level A, B, C & D
October 1998, April 1999, October 1999

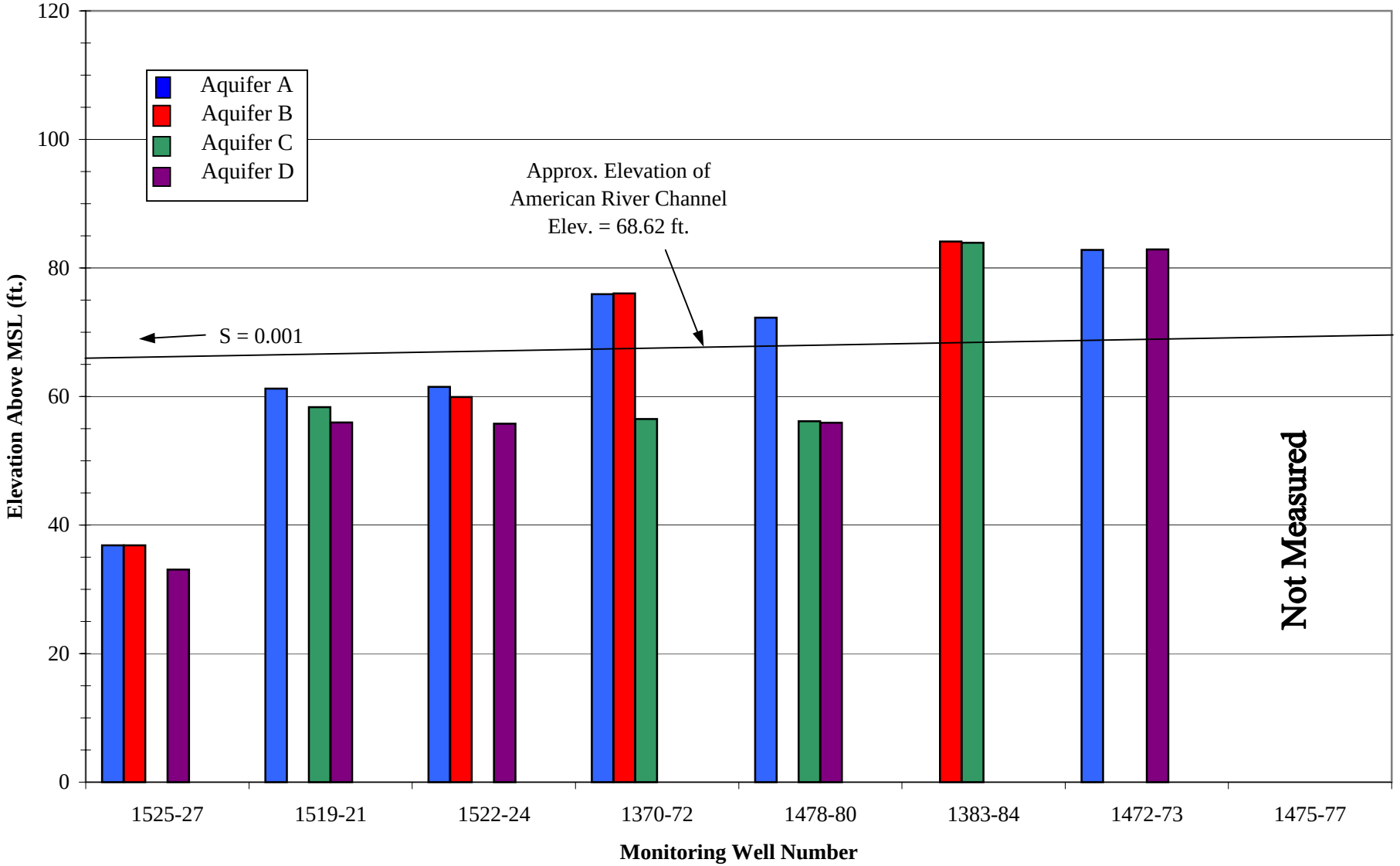
American River Study Area
Potentiometric Surface
Aquifer Level A, B ,C & D
October 1998



Data obtained from, GenCorp Aerojet GET Effectivness Evaluation for the American River Study Area, Figures 3-15, 3-16, 3-17, 3-18, February 2000.

Data for April 1998 is shown on Plate 1

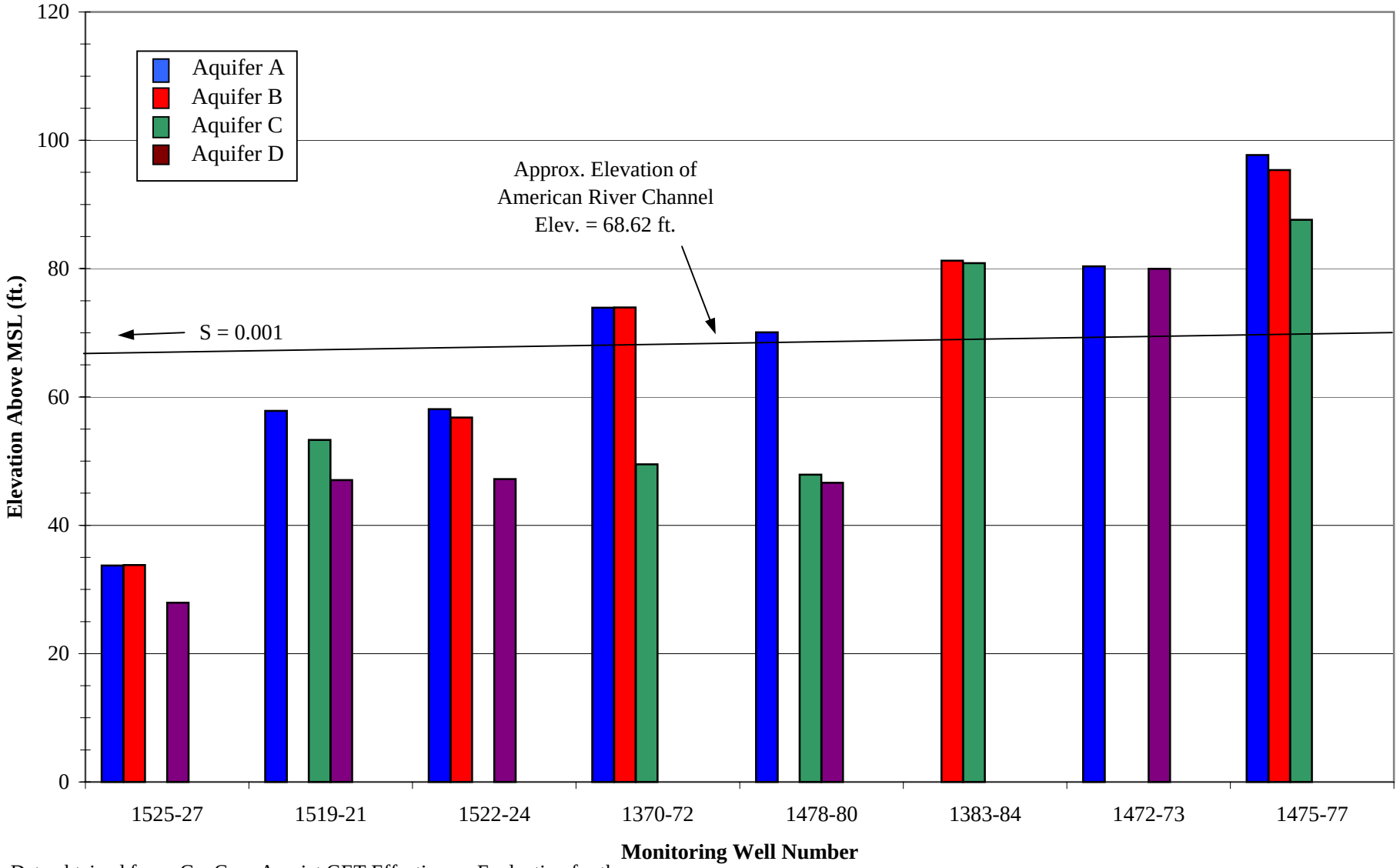
American River Study Area
Potentiometric Surface
Aquifer Level A, B ,C & D
April 1999



Data obtained from, GenCorp Aerojet GET Effectivness Evaluation for the American River Study Area, Figures 3-15, 3-16, 3-17, 3-18, February 2000.

Data for April 1998 is shown on Plate 1

American River Study Area
Potentiometric Surface
Aquifer Level A, B ,C & D
October 1999



Data obtained from, GenCorp Aerojet GET Effectivness Evaluation for the American River Study Area, Figures 3-15, 3-16, 3-17, 3-18, February 2000.

Data for April 1998 is shown on Plate 1

City of Sacramento
Exhibit CITY J

Department of Water Resources
Bulletin No. 133
Folsom – East Sacramento
Ground Water Quality Investigation

March 1964

A copy of this document is located at the California State Library, 900 N Street, Sacramento, CA. Under Call Number W750.B9 #133 and is located on the 3rd floor. A copy of this document was delivered to the Files room of the Division of Water Rights, State Water Resources Control Board at 1001 I Street, Sacramento, CA on May 10, 2002 at 9:00 am with instructions that it be placed in the Division Library on the 14th floor with DWR Publications. Pages 30,79,90,92 and 96 are missing from this copy.

Department of Water Resources Bulletin No. 133
Folsom-East Sacramento Ground Water Quality Investigation
March 1964

This document is a public record prepared and published by a public agency, and is in the files of the State Water Resources Control Board in that agency's library. The City of Sacramento incorporates it herein by reference pursuant to 23 CCR section 648.3. Furthermore, incorporation by reference is justified because this same Bulletin has been filed with the State Water Resources Control Board and served on the parties to this proceeding as Southern California Water Company Exhibit 12. It is already readily available to all parties and to the SWRCB; to duplicate it again would be an unnecessary and wasteful undertaking.

A comparison of the 1953 ground water elevations to the 1963 ground water elevations shows a general decline throughout the entire area of investigation, with the least amount of change occurring where the American River is influencing the recharge. The greatest change, approximately 20 feet, occurs in the Rancho Cordova area where intense urban development has taken place and in the southeastern portion of the area where recharge is very minor. These changes are illustrated on Plate No. 8, "Lines of Equal Change of Elevation of Water in Wells, Spring 1953 to Spring 1963."

During the decade 1953-63, the ground water storage was reduced approximately 67,000 acre-feet, or an average of 6,700 per year. The rate of reduction has apparently been intensified during later years. Between the time that ground water measurements were made in the spring of 1962 and the spring of 1963, ground water storage was reduced by approximately 11,500 acre-feet. This reduction, at an accelerated rate, reflects the increased urban and industrial use of water within the area coupled with a decreasing amount of recharge. The reduced recharge is probably due mainly to the cessation of dredger operations, but also reflects the decrease in land available to receive precipitation as a result of urban and industrial development.

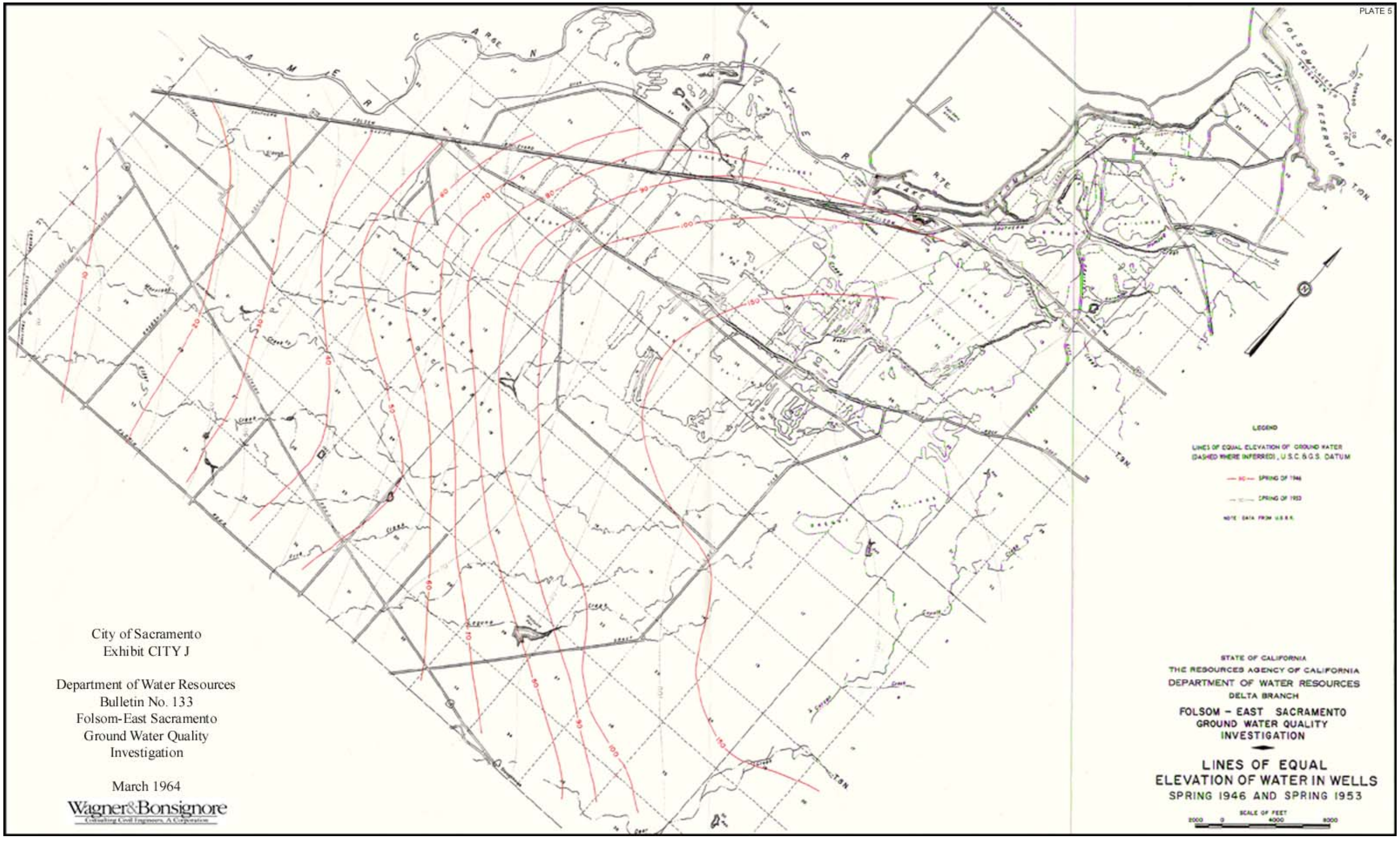
Ground Water Withdrawals

The recent urban and industrial expansion within the area of investigation shown on Plate No. 9, "Urban and Industrial Developments, 1963," requires that a firm and plentiful supply of water be available now and in the future. Though surface water is available, the

City of Sacramento
Exhibit CITY J

Department of Water Resources
Bulletin No. 133
Folsom - East Sacramento
Ground Water Quality Investigation
March 1964

PLATE 5



City of Sacramento
Exhibit CITY J

Department of Water Resources
Bulletin No. 133
Folsom-East Sacramento
Ground Water Quality
Investigation

March 1964

Wagner&Bonsignore
Consulting Civil Engineers, A Corporation

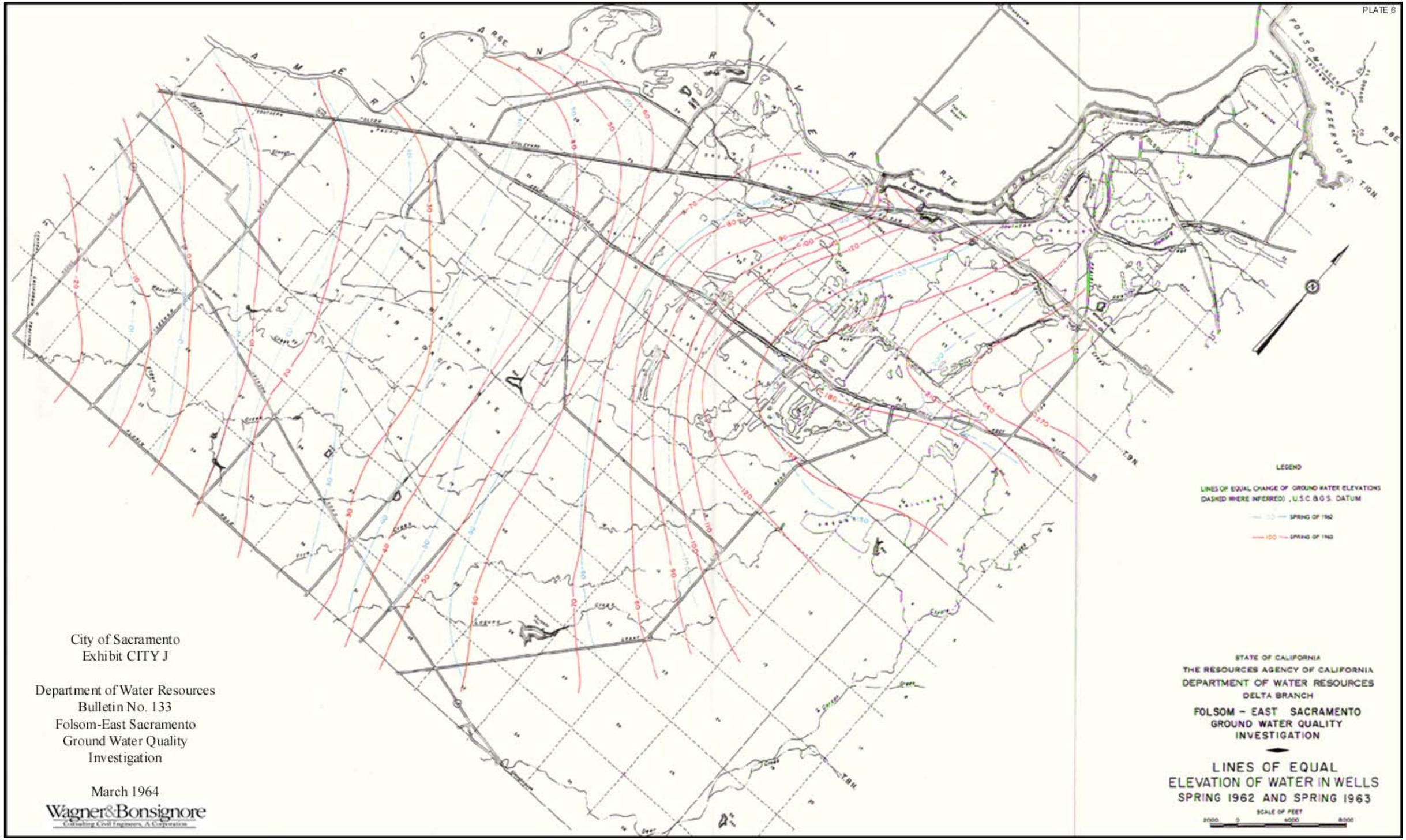
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH

FOLSOM – EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

LINES OF EQUAL ELEVATION OF WATER IN WELLS SPRING 1946 AND SPRING 1953

SCALE OF FEET
2000 0 4000 8000

PLATE 6



City of Sacramento
Exhibit CITY J

Department of Water Resources
Bulletin No. 133
Folsom-East Sacramento
Ground Water Quality
Investigation

March 1964

Wagner&Bonsignore
Consulting Civil Engineers, A Corporation

PROOF OF SERVICE

I am employed in the County of Sacramento, State of California. I am over the age of 18 years and not a party to the foregoing action; I am employed by Lennihan Law, A Professional Corporation, 2311 Capitol Avenue, Sacramento, CA 95816

I am familiar with the regular mail collection and processing practice of said business, and in the ordinary course of business the mail is deposited with the United States Postal Service that same day.

On May 10, 2002 I served a true and correct copy of

EXHIBITS REGARDING AMERICAN RIVER FAS HEARING

on all parties in said action by causing a true copy thereof to be

[ ] (by facsimile transmission) from (916) 321-4422 to the person(s) at the Fax number(s) set forth below.

[**X**] (by mail) on all parties in said action listed below, in accordance with Code of Civil Procedure § 1013a(3), by placing a true copy thereof enclosed in a sealed envelope with postage thereon fully prepaid in the designated area for outgoing mail, addressed as set forth below.

[ ] (by personal delivery) by personally delivering a true copy thereof to the person and at the address set forth below.

as addressed below:

SEE ATTACHED SERVICE LIST

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Executed on May 10, 2002, at Sacramento, California

_____

Sara Leggett

Service List

Michael Fife
Hatch & Parent
21 East Carrillo Street
Santa Barbara, CA 93101
Facsimile No: (805) 965-4333
Rep: Southern California Water Company

Ronald M. Stork
915 20th Street
Sacramento, CA 95814
Facsimile No: (916) 442-3396
Rep: Friends of the River

Jan S. Driscoll
501 W, Broadway, Ninth Floor
San Diego, CA 92101
Facsimile No: (619) 233-1158
Rep: California-American Water Company

Stuart L. Somach/William E. Hvidsten
400 Capitol Mall, Suite 1900
Sacramento, CA 95814
Facsimile No: (916) 446-8199
Rep: Sacramento County/Sacramento County Water Agency

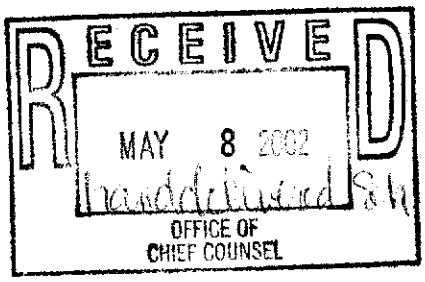
Janet K. Goldsmith
400 Capitol Mall, 27th Floor
Sacramento, CA 95814-4417
Facsimile No: (916) 321-4555
Rep: Aerojet-General Corporation

Jennifer Decker
Department of Fish and Game
1416 Ninth Street, 12th Floor
Facsimile No: (916) 654-3805
Sacramento, CA 95814

M. Catherine George, Staff Counsel
Regional Water Quality Control Board
Central Valley Region
P.O. Box 100
Sacramento, CA 95812
Facsimile No: (916) 341-5199
Rep: CVRWQCB

James E. Turner
Office of the Regional Solicitor
2800 Cottage Way E-1712
Sacramento, CA 95825
Facsimile No: (916)978-5694
Rep: U.S. Bureau of Reclamation

KRONICK
MOSKOVITZ
TIEDEMANN
&GIRARD
A PROFESSIONAL CORPORATION



May 8, 2002

VIA FACSIMILE AND U.S. MAIL

To: American River FAS Hearing Service List

Re: Notice of availability of voluminous exhibit documents; Petition to Revise Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County

Dear Party:

Aerojet-General Corporation plans to file exhibits in the above-titled proceeding including large, multi-volume reports that are voluminous in nature. These reports comprise thousands of pages. Serving copies of these reports on all parties would be unnecessarily costly and duplicative, because most, if not all, parties to the proceeding already have copies of these reports. Moreover, several of these reports have been, and remain, available for public review in at least two convenient, public locations identified below.

Accordingly, you are hereby notified that, pursuant to Title 23 of the California Code of Regulations, Chapter 1.5, Article 2, § 648.4(c) and the Notice of Public Hearing and Petition to Revise Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County and Part 4(c) of Enclosure 1 to the March 6, 2002 Notice of Pre-Hearing Conference, Aerojet General Corp. will provide you with a copy of any of the following documents only upon your request:

- Exhibit AGC 3: Western Groundwater Operable Unit Remedial Investigation/Feasibility Study, Gencorp Aerojet (April 2000) (WGOU RI/FS))*
- Exhibit AGC 4: Final Revised Engineering Evaluation and Cost Analysis for the American River Study Area, Gencorp Aerojet (September 1996) (Final ARSA EE/CA))*
- Exhibit AGC 5: Aerojet Site – GET E and F Effectiveness Evaluation Report, Gencorp Aerojet (April 1996) (1996 GET E/F Evaluation)
- Exhibit AGC 6: Perimeter Groundwater Operable Unit Draft Remedial Investigation/Feasibility Study (RI/FS) Work Plan, Gencorp Aerojet (April 2002) (Perimeter OU RI/FS)**

ATTORNEYS AT LAW
400 CAPITOL MALL, 27TH FLOOR SACRAMENTO, CALIFORNIA 95814-4417 TELEPHONE (916) 321-4500 FAX (916) 321-4555

- Exhibit AGC 7: Groundwater Capture Zone Analysis and Modeling Simulations, American River Study Area, Rancho Cordova, California, CH2M Hill (June 1994)

A single, bold-faced asterisk ("*") denotes a document available for public review at the California State University-Sacramento Library and at the Regional Water Quality Control Board-Central Valley Region office. Double, bold-faced asterisks ("**") denote a document available for public review at the Regional Water Quality Control Board-Central Valley Region office. The street address for the California State University, Sacramento, Library is: 2000 State University Drive, Sacramento, CA 95819. The street address for the Regional Water Quality Control Board, Central Valley Region, is: 3443 Routier Road, Rancho Cordova, CA 95670.

Very truly yours,

KRONICK, MOSKOVITZ, TIEDEMANN & GIRARD
A Professional Corporation

Eric N. Robinson

ENR/dg

698103.1

KRONICK
MOSKOVITZ
TIEDEMANN
&GIRARD
400 CAPITOL MALL
27TH FLOOR
SACRAMENTO, CA
95814-4417
TEL: (916) 321-4500
FAX: (916) 321-4555

PROOF OF SERVICE

I, Do Gentry, declare:

I am a resident of the State of California and over the age of eighteen years, and not a party to the within action; my business address is 400 Capitol Mall, 27th Floor, Sacramento, CA 95814-4416. On May 8, 2002, I served the within documents:

Notice of availability of voluminous exhibit documents.

☒ by transmitting via facsimile from (916) 321-4555 the above listed document(s) without error to the fax number(s) set forth below on this date before 5:00 p.m. A copy of the transmittal/confirmation sheet is attached.

☒ by placing the document(s) listed above in a sealed envelope with postage thereon fully prepaid, in the United States mail at Sacramento, California addressed as set forth below.

☐ by causing personal delivery by messenger of the document(s) listed above to the person(s) at the address(es) set forth below.

☐ by placing the document(s) listed above in a sealed Federal Express envelope and affixing a pre-paid air bill, and causing the envelope to be delivered to a Federal Express agent for delivery

☐ by personally delivering the document(s) listed above to the person(s) at the address(es) set forth below.

Please see attached Service List

I am readily familiar with the firm's practice of collection and processing correspondence for mailing. Under that practice it would be deposited with the U.S. Postal Service on that same day with postage thereon fully prepaid in the ordinary course of business. I am aware that on motion of the party served, service is presumed invalid if postal cancellation date or postage meter date is more than one day after date of deposit for mailing in affidavit.

I declare under penalty of perjury under the laws of the State of California that the above is true and correct.

Executed on May 8, 2002, at Sacramento, California.

Do Gentry

Do Gentry

American River FAS Hearing Service List

Michael Fife
Hatch & Parent
21 East Carrillo Street
Santa Barbara, CA 93101
Facsimile No.: (805) 965-4333
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Facsimile No.: (916) 446-8199
Rep: Sacramento County/Sacramento County Water Agency

Martha H. Lennihan
Lennihan Law APC
2311 Capitol Avenue
Sacramento, CA 95816
Facsimile No.: (916) 321-4422
Rep: City of Sacramento

Jennifer Decker
Department of Fish and Game
1416 Ninth Street, 12th Floor
Sacramento, CA 95814
Facsimile No.: (916) 654-3805

M. Catherine George, Staff Counsel
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95812
Facsimile No.: (916) 341-5199
Rep: Central Valley Regional Water Quality Control Board (CVRWQCB)

James E. Turner
Office of the Regional Solicitor
Pacific Southwest Region
2800 Cottage Way, E-1712
Sacramento, CA 95825
Facsimile No.: (916) 978-5694
Rep: U.S. Bureau of Reclamation

ERIC N. ROBINSON

KRONICK MOSKOVITZ TIEDEMANN & GIRARD
A PROFESSIONAL CORPORATION

May 10, 2002

BY HAND DELIVERY

State Water Resources Control Board
Division of Water Rights
Joe Serna Jr./Cal EPA Building
1001 I Street, 14th Floor
Sacramento, CA 95814

Re: Petition to Revise Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County

Dear Hearing Officer and Division Staff:

Aerojet-General Corporation hereby files its Exhibits and other required documents in support of its case-in-chief in the above-titled proceeding before the State Water Resources Control Board ("SWRCB").

The enclosed Exhibit Identification Index describes Aerojet's exhibits, including the written expert testimony of Thomas M. Johnson. Mr. Johnson's written testimony includes attachments, each of which is deemed a part of the testimony that Aerojet submits as AGC Exhibit 1.

Aerojet has employed two means of avoiding the duplicative filing of documents in this proceeding. First, Aerojet is incorporating as its own exhibit, a document already filed and served in this proceeding by Petitioner Southern California Water Company. Specifically, Aerojet incorporates by reference SCWC Exhibit 18 as Aerojet's AGC Exhibit 2. Second, Aerojet on May 8, 2002, served notice by facsimile and U.S. mail to all parties that it was filing specified voluminous exhibits with the SWRCB and would provide copies to parties only upon request. This notice procedure is authorized by Title 23 of the California Code of Regulations, Chapter 1.5, Article 2, § 648.4(c) and the Notice of Public Hearing and Petition to Revise Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County and Part 4(c) of Enclosure 1 to the March 6, 2002 Notice of Pre-Hearing Conference. A copy of this notice and proof of service were filed with the SWRCB on May 8, 2002.

Finally, electronic copies of Mr. Johnson's written expert testimony and the Exhibit Identification Index either have been submitted to the SWRCB, or are being submitted today, by electronic mail pursuant to the instructions in Enclosure 1 to the Notice of Pre-Hearing Conference.

Please direct any questions concerning this filing to Janet K. Goldsmith or Eric N. Robinson at (916) 321-4500.

Very truly yours,

KRONICK, MOSKOVITZ, TIEDEMANN & GIRARD
A Professional Corporation

Eric N. Robinson

ENR/dg

cc: Michael Fife
Ronald M. Stork
Jan S. Driscoll
Stuart L. Somach/William E. Hvidsten
Martha H. Lennihan
Jennifer Decker
M. Catherine George
James E. Turner
José Uranga
Janet K. Goldsmith
(by U.S. mail)

698317.1

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AEROJET-GENERAL CORPORATION

EXHIBIT IDENTIFICATION INDEX

AGC Exhibit 1 – Testimony of Thomas M. Johnson, R.G., C.Hg.

AGC Exhibit 2 - GET Effectiveness Evaluation for the American River Study Area, Gencorp Aerojet (February 2000; ARSA GET Evaluation)

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AGC Exhibit 7 – Groundwater Capture Zone Analysis and Modeling Simulations, American River Study Area, Rancho Cordova, California, CH2M Hill (June 1994)

AGC EXHIBIT 1

Expert Testimony of Thomas M. Johnson, R.G., C.Hg.
Sr. Vice President, Chief Technical Officer, and Principal Hydrogeologist
LFR Levine·Fricke
May 10, 2002

INTRODUCTION

Following is the expert testimony of Thomas M. Johnson, R.G., C.Hg., Sr. Vice President, Chief Technical Officer, and Principal Hydrogeologist of LFR Levine·Fricke. This testimony is provided on behalf of Aerojet General Corporation ("Aerojet"; "Gencorp Aerojet") in regard to the Petition to Revise Declaration of Fully Appropriated Stream (FAS) System regarding the American River, Sacramento County, submitted by Southern California Water Company.

A list of the documents cited in this testimony, and upon which this testimony is based in part, is provided in the attached List of References and Supporting Documents.

Expert Qualifications

I am currently Sr. Vice President, Principal Hydrogeologist, and Chief Technical Officer of LFR Levine·Fricke, an environmental consulting firm headquartered in Emeryville, California, and with offices nationwide. I have more than 27 years of experience as a hydrogeologist in consulting and research. From 1986 to the present, I have been Principal Hydrogeologist for LFR Levine·Fricke, and from 1975 to 1986, I conducted research on groundwater resources and environmental contamination at the Illinois State Geological Survey, where I was Head of the Groundwater Section. A copy of my resume is attached as Attachment AGC-1(a).

I have a B.A. degree in Geology from Augustana College, and M.S. degrees in Geology and in Water Resources Management from the University of Wisconsin-Madison. I also have completed most requirements for a Ph.D. in Geology from the University of Illinois-Urbana/Champaign. I am a Registered Geologist and Certified Hydrogeologist in the State of California, and am a licensed geologist in Arizona, Illinois, Pennsylvania, and Indiana. Additionally, I am a Registered Professional Hydrogeologist with the American Institute of Hydrology; and a Certified Professional Geologist with the American Institute of Professional Geologists. Prior to joining LFR Levine·Fricke, I conducted research at the Illinois State Geological Survey on groundwater resources and on soil and groundwater contamination from hazardous, radioactive and solid wastes; I have published numerous papers and reports on environmental contamination and remediation.

I have served on the Board of Directors, and most recently was Chairman of the Board of Directors, of the National Ground Water Association (NGWA), Association of Ground Water Scientists and Engineers. I am currently on the Board

of Directors of the California Groundwater Resources Association. For 10 years, I served on the editorial review board of the journal *Ground Water Monitoring and Remediation*. I have also been appointed to National Academy of Sciences/National Research Council Panels to evaluate state and local groundwater protection programs for the U.S. Environmental Protection Agency (U.S. EPA) and, to assess innovative technology decision-making programs for the U.S. Department of Energy. I have lectured extensively throughout the U.S. and internationally on hydrogeology, groundwater resources, and environmental contamination for various universities, state and federal agencies, and organizations such as NGWA.

I have been qualified as an expert in state and federal court on numerous occasions and provided expert testimony in the areas of hydrogeology and groundwater flow, vadose-zone processes, contaminant fate and transport, risk assessment, computer modeling, environmental remediation, and cost allocation. I have also been designated by the Superior Court of the State of California as a court-appointed, neutral expert.

Experience in American River Area

I have worked extensively on multiple projects in the American River Area during the past 10 years. This work has included projects involving the evaluation of hydrogeologic conditions, groundwater resources, and environmental contamination in the vicinity of the American River. These projects have included extensive studies of the Aerojet facility; the nearby Inactive Rancho Cordova Test Site (IRCTS) formerly operated by Aerojet and by McDonnell Douglas Corporation (now Boeing Corporation); Mather Air Force Base; the former White Rock Road Dump; and the surrounding region. Each of these projects involved the evaluation of the impacts of pumping from municipal water supply wells and large-capacity groundwater extraction wells on water resources and environmental contamination.

BACKGROUND

American River Area

The American River is a perennial west-flowing river that traverses the site and that overlies the groundwater contaminant plume in the American River Study Area (ARSA). The location of the American Study Area is shown in Attachment AGC-1(b), Regional Location Map, Figure 1-1 from AGC Exhibit 2 (GET Effectiveness Evaluation for the American River Study Area, Gencorp Aerojet (February 2000; "ARSA GET Evaluation"). The total length of the American River, from its headwaters in the Sierra Nevada to its discharge into the Sacramento River, is approximately 265 miles, with a total watershed area of approximately 2,000 square miles. Near the Aerojet facility, the channel of the American River meanders within the deposits of its historical flood plain, which consists of

unconsolidated sand and gravel deposits (stream channel deposits) as well as unconsolidated deposits of clay, sand, and silt (floodplain deposits).

The flood plain deposits and stream channel deposits in the area of the American River were extensively dredged from the late 1800s to 1962. The Aerojet facility is located within the largest single expanse of dredging activity in the Sacramento area. This dredged area extends from near the town of Folsom southwest nearly to Mather Air Force Base (a distance of 12 miles) with a width that ranges from approximately 1 to 4 miles. Near the Aerojet facility, the majority of this dredging activity took place in flood plain deposits located south of the current American River. However, Sailor Bar Park, located adjacent and north of the American River, was also dredged.

The dredging operation consisted of excavating floodplain deposits at depth, washing the dredged material, and depositing the resulting tailings in windrows of gravel, cobbles, boulders, sand, and silt. The resulting tailings are considered to be very pervious (DWR 1974). Also, the topography resulting from deposition of the tailings is generally "closed" with respect to drainage of surface water. The permeable nature of the dredge tailings, combined with the closed topography of these deposits, contributes to a very high expected recharge rate (DWR 1974).

Surface-water flow in the American River near the Aerojet site has historically ranged from 573 to 7,457 cubic feet per second (cfs), with an average of 3,775 cfs (1,691,200 gallons per minute [gpm]; mean annual flow data from the Fair Oaks station, U.S. Geological Survey (USGS 2002). Since 1956, flow in the American River has been controlled by releases from Nimbus Dam, a concrete gravity dam approximately 87 feet high and 1,093 feet wide. Nimbus Dam forms Lake Natoma, a 540-acre surface-water body, with a capacity of approximately 8,760 acre-feet. Nimbus Dam and Lake Natoma were constructed as an afterbay for Folsom Dam, which is located approximately 7 miles northeast.

The elevation of the water level surface in the American River does not vary significantly with time. Nimbus Dam maintains a constant water elevation in Lake Natoma corresponding to 126 ft msl (elevation in feet relative to mean sea level). Downstream from Lake Natoma, surface-water levels have been reported to decrease from 82 feet immediately adjacent to the dam to 30 ft msl approximately 8 miles west (AGC Exhibit 3; Western Groundwater Operable Unit [WGOU], Remedial Investigation/Feasibility Study [RI/FS], Gencorp Aerojet [April 2000; "WGOU RI/FS"]). The American River is very shallow compared to the depths and thicknesses of permeable zones (A, B, C, and D Aquifers) beneath the river through which groundwater is percolating. The elevation of the river water measured at Sailor Bar in August 1995 was 74.2 ft msl, and the measured depth of the river in that area was generally less than 6 or 7 feet (AGC Exhibit 4; Final Revised Engineering Evaluation and Cost Analysis [EE/CA] for the American River Study Area, Gencorp Aerojet [September 1996; Final ARSA EE/CA]).

Aerojet Sacramento Facility

The Aerojet Sacramento facility comprises some 8,500 acres located approximately 0.5 mile south of the American River and south of Highway 50, near Rancho Cordova (see Attachment AGC-1[b]).

North of the Aerojet site, Folsom South Canal flows west and southwest from Lake Natomas and Nimbus Dam approximately 1 mile, where it crosses beneath Highway 50 and forms the northern and western boundary of the Aerojet site (see Attachment AGC-1[c]; Figure 2-1 from AGC Exhibit 2, ARSA GET Evaluation). Buffalo Creek is an intermittent stream that flows west across the northern portion of the Aerojet site, crossing north beneath Highway 50 approximately 1.3 miles east of Sunrise Boulevard, and flowing another approximately 1.8 miles where it intersects the American River, immediately east of the Sunrise Boulevard river overpass (see Attachment AGC-1[c]).

Regional Hydrogeology

The American River area is located in the southeastern Sacramento River Valley near the foothills of the Sierra Nevada mountain range. The surface of older granitic and metamorphic bedrock material slopes toward the center of the Sacramento Valley. Overlying the steeply dipping metamorphic bedrock is a thick sequence of shallow-dipping (generally less than 1 degree), younger (Cretaceous, Tertiary, and Quaternary) fluvial and marine sediments, more than 2,000 feet thick along the western Aerojet property boundary. These sediments were derived from erosion of the Sierra Nevada to the east by numerous ancestral streams that predate the current American River.

The uppermost sediments over much of the area surrounding the American River and Aerojet site consist of a wide mixture of Quaternary-age sediments that have been disturbed by placer gold mining and dredging activities that occurred between the mid-1800s and the 1960s. Underlying these Quaternary sediments is the Laguna Formation, of late Pliocene to early Pleistocene age. The Laguna Formation consists of fluvial deposits from metamorphic and granitic terrains, and primarily comprises silts and clays, with interbedded layers of sand and gravel. Laguna Formation deposits form a wedge that thickens from east to west, from 125 to 400 feet.

The underlying Mehrten Formation, derived from volcanic lava, primarily comprises relatively permeable sands and gravels that generally yield abundant quantities of water to wells. The formation also includes interbedded silt and clay zones, and local deposits of volcanic ash. The Mehrten Formation also thickens from east to west, from less than 50 feet on the eastern boundary of the Aerojet site to over 1,300 feet in the Sacramento-San Joaquin Delta (DWR 1974).

Groundwater in the Sacramento Valley basin percolates through these sediments, particularly through the widespread, more permeable layers of sand and gravel that underlie the basin. This groundwater primarily originates as infiltrating rainfall, and recharge of rainfall and snowmelt runoff from the Sierra Nevada foothills. Groundwater percolating through these permeable sediments generally flows from areas of higher elevation, such as the Sierra foothills, toward lower elevation areas of the Sacramento Valley to the west.

Large volumes of groundwater in the basin are percolating through these sediments because of the widespread lateral extent and thickness, and the high permeability of the sediments. It is because of the occurrence of these widespread permeable sediments that plumes of chemicals in groundwater have migrated into the area of the American River.

HYDROGEOLOGIC DATA COLLECTION

Since the early 1980s, Aerojet has conducted extensive investigations of hydrogeologic and groundwater conditions in the vicinity of the Aerojet site and nearby American River. Additionally, Aerojet has been conducting widespread groundwater remedial activities in a large area surrounding its site and the American River area. These investigations and remedial activities have resulted in the collection of large volumes of information and data characterizing the hydrogeologic setting and groundwater conditions in the region. These data include lithologic and geophysical logs and other information obtained during drilling of borings and installation of monitor wells, pumping and hydraulic test data, groundwater level data, and chemical concentration data. Additionally, Aerojet has also compiled a large amount of related data and information for public water supply wells in the region.

Information and data regarding the American River Study Area (ARSA), as well as the Western Groundwater Operable Unit (WGOU), E and F Groundwater Extraction and Treatment System (GET E/F), and the Perimeter Groundwater Operable Unit are contained in the following Aerojet reports. These reports, which I have relied on, were prepared by Aerojet and submitted to state and federal regulatory agencies. For convenience, I have attached excerpts from these reports as Attachments to this Expert Testimony.

- GET Effectiveness Evaluation for the American River Study Area. February 2000 (AGC Exhibit 2)
- Western Groundwater Operable Unit Remedial Investigation/Feasibility Study, Gencorp Aerojet (April 2000; AGC Exhibit 3)
- Final Revised Engineering Evaluation and Cost Analysis for the American River Study Area, Aerojet Sacramento Site. September 1996 (AGC Exhibit 4)

- Aerojet Site – GET E and F Effectiveness Evaluation Report. April 1996 (AGC Exhibit 5)
- Perimeter Groundwater Operable Unit Draft Remedial Investigation/Feasibility Study (RI/FS) Workplan. April 22, 2002 (AGC Exhibit 6)
- Groundwater Capture Zone and Modeling Simulations, American River Study Area, Rancho Cordova, California. June 1994 CH2M Hill (AGC Exhibit 7)

Well and Boring Information

Aerojet has installed more than 1,000 on-site and off-site borings and monitor wells in the area of its Sacramento facility. This number includes approximately 110 monitor wells and 17 extraction wells in the American River area north of Highway 50. Locations of monitor wells in the ARSA are shown in Attachment AGC-1(d) (Figure 3-1, Well Location Map, from AGC Exhibit 2, ARSA GET Evaluation). Lithologic and geophysical logs from these borings and wells provide an immense amount of information regarding hydrogeologic conditions. Copies of lithologic and geophysical logs for borings and wells in the vicinity of the American River are provided in the Aerojet reports cited above.

Lithologic and geophysical logs of monitor, extraction, recharge, and public water supply wells were used by Aerojet to construct six hydrogeologic cross sections through the area of the American River and nearby Aerojet site (see Attachments AGC-1[e] through AGC-1[j]; Figures 3-2 through 3-7 from AGC Exhibit 2, ARSA GET Evaluation).

Hydraulic Test and Pumping Data

Between 1993 and 1995, Aerojet performed hydraulic pumping tests of the 15 extraction wells installed in conjunction with the American River Groundwater Extraction and Treatment (ARGET) system. These tests included measurements of pumping rates, and monitoring of groundwater levels in all surrounding monitor wells under full-scale operating conditions to evaluate the hydrologic characteristics of each aquifer unit. The results of these aquifer tests are presented in Attachment AGC-1(k) (Table 3-1 from AGC Exhibit 2, ARSA GET Evaluation).

In August 1998, Aerojet began operation of the ARGET system. That system currently includes 15 groundwater extraction wells, consisting of three wells at different depths at each of five locations, and will soon be expanded to include two additional deep wells. Aerojet has been monitoring the performance of the system continually since its startup. For the one-year period from April 2001 to April 2002, the ARGET system extracted an average 2,047 gpm of water. With the addition of two deeper wells, the extraction rate is expected to increase to approximately 2,500 gpm.

Additionally, Aerojet has compiled an extensive amount of information regarding the locations, operation, and hydraulic characteristics of public water supply wells in the vicinity.

Groundwater Level Measurements

Aerojet has been routinely measuring and compiling groundwater level data from as many as 145 monitor wells in the area of the American River. Most of these wells have been monitored at least quarterly for periods exceeding 10 years. This represents an immense volume of data on groundwater levels and groundwater flow direction for each of the various aquifer zones underlying the American River area. Groundwater level data and maps of groundwater flow direction for each of the aquifer zones are presented in Quarterly Monitoring Reports submitted by Aerojet to the California Regional Water Quality Control Board-Central Valley Region (RWQCB) and in Gencorp Aerojet reports included as AGC Exhibits 2 through 6.

Groundwater Modeling

Western Groundwater Operable Unit RI/FS Modeling

Aerojet and Hydrosearch, Inc. conducted extensive groundwater flow modeling in conjunction with the development and analysis of remedial alternatives presented in the April 6, 2000, Gencorp Aerojet Western Groundwater Operable Unit Remedial Investigation/Feasibility Study (WGOU RI/FS; AGC Exhibit 3). The objectives of the groundwater flow model were to 1) simulate groundwater flow conditions within and around the Rancho Cordova area, and 2) simulate the effects of remedial alternatives on hydrological conditions.

The groundwater flow model was based on the U.S. Geological Survey (USGS) finite-difference MODFLOW code. The model domain covered an area of approximately 100 square miles, of which the Aerojet site only comprises only a small part. The easternmost boundary of the model coincided with the contact of sedimentary and igneous/metamorphic rocks. The model area included the Aerojet site, as well as Lake Natoma and the downstream portion of the American River extending approximately 9 miles west of the Aerojet site.

The groundwater flow model simulated groundwater flow in six layers (Layers A through F), based on the hydrostratigraphic units in AGC Exhibit 5, Aerojet Site – GET E and F Effectiveness Evaluation Report, Gencorp Aerojet (April 1996; "1996 GET E/F Evaluation"). The model assumed that all layers dip westward with a slope of one degree. Hydraulic parameters for each layer (e.g., hydraulic conductivity, vertical leakance, and storativity) were initially established based on data from aquifer tests and lithologic well logs. Groundwater level data were used in an extensive calibration process to determine the distribution of hydraulic parameters for each layer used in the flow modeling.

Groundwater enters the model through infiltration of precipitation, mountain-front recharge, recharge wells, and to a lesser extent the American River. The American River and Lake Natoma in the model act as regions of groundwater recharge or discharge in the model, with the rate of flow between surface water and groundwater depending on differences in their respective water levels and the vertical hydraulic conductivity of the river and lake beds. These processes vary significantly at different locations along the river.

The model also included the effects of pumping wells, including public water supply wells and Aerojet's extraction wells, for the period from 1956 to 1998. Pumping data were obtained from Southern California Water Company, Citizen's Utilities Company, Mather AFB, Sacramento County Water Maintenance District, Fair Oaks Water District, and Aerojet.

A complete description of the model, including assumptions, parameters, calibration and simulation results is provided in Appendix D of AGC Exhibit 3, the WGOU RI/FS.

Groundwater Flow Modeling Conducted by CH2M Hill

Groundwater modeling studies were also performed by CH2M Hill for the U.S. EPA in 1994 to evaluate the conclusions presented in the May 1993 Aerojet Engineering Evaluation/Cost Analysis (EE/CA) for the American River Study Area (CH2M Hill 1994 AGC Exhibit 7). CH2M Hill's modeling studies evaluated the extent of groundwater capture zones resulting from proposed extraction wells to control the contaminant plume that had migrated northwest beneath the American River from the Aerojet site.

The model used by CH2M Hill was MicroFem, a finite-element model capable of simulating transient groundwater flow in multiple aquifer systems and able to include aquifer leakage in the simulations. This model relied on hydraulic testing that Aerojet had recently conducted in the ARSA to compare simulated and actual extraction well capture zones. The modeling assumed steady-state conditions, and did not consider transient influences such as seasonal fluctuations in groundwater levels and recharge rates. The model also assumed that the upper and lower boundaries of the model were no-flow boundaries, and therefore did not consider that the American River had any influence on the simulations. Calibration of the model resulted in close agreement between simulated and observed groundwater levels. CH2M Hill concluded that use of this steady-state model was appropriate to evaluate long-term performance of the extraction system (CH2M Hill 1994).

CHARACTERISTICS OF THE GROUNDWATER BASIN

Hydrostratigraphic Zones

Results of extensive hydrogeologic investigations in the vicinity of the Aerojet site and the American River area have revealed the presence of distinct hydrostratigraphic units based on lithologic descriptions, water levels, geophysical data, pumping test data, and relative depths and thicknesses. This information was used to construct six hydrogeologic cross sections through the area of the American River and nearby Aerojet site (Figures 3-2 through 3-7 in AGC Exhibit 2, ARSA GET Evaluation). These cross sections are provided as Attachments AGC-1(e) through AGC-1(j).

Intervals of fine-grained sediments (silts, clays, siltstones, and claystones) are considered as aquitards, while laterally extensive intervals of coarser-grained, more permeable materials (sands, gravels, and sandstones) have been assigned as individual aquifer units. The February 2000, Aerojet GET Effectiveness Evaluation for the American River Study Area (AGC Exhibit 2) divides the sequence of sediments into four main aquifer units, designated Aquifer A, Aquifer B, Aquifer C, and Aquifer D, consistent with the terminology used in the April 2000 Gencorp Aerojet Western Groundwater Operable Unit RI/FS (WGOU RI/FS; AGC Exhibit 3). These aquifer units were formerly called the Shallow, Middle, Deep, and Deeper Aquifers, respectively, in the September 1996 Gencorp Aerojet Final EE/CA for the American River Study Area (AGC Exhibit 4).

Throughout the area, aquifer zones are generally separated by relatively continuous, lower-permeability aquitard layers. The hydrostratigraphic units include Quaternary-age deposits and the sediments of the Laguna and Mehrten Formations; however, aquifer zone boundaries do not necessarily correlate with those of the regional geologic formations.

Aquifer A

Aquifer A, the uppermost water-bearing unit, occurs at depths of approximately 25 to 100 feet below ground surface (bgs). This hydrostratigraphic unit comprises an interbedded sequence of relatively continuous, permeable, sand and gravel layers separated by much less permeable sediment layers. The lateral continuity of permeable layers and less permeable aquitard layers in Aquifer A, extending beneath the American River, is illustrated in hydrogeologic cross sections presented in Attachments AGC-1(e) through AGC-1(j) (Figures 3-2 through 3-7 from AGC Exhibit 2, ARSA GET Evaluation).

Aquifer A has been extensively disturbed by historical placer gold mining and dredging, resulting in widespread irregular deposits of mine spoil covered with cobbles and gravel. The occurrence of permeable surface materials and closed drainage in dredged areas results in relatively high rates of rainfall infiltration.

Hydraulic test data presented in Attachment AGC-1(k) (Table 3-1, Summary of Aquifer Test Results, from AGC Exhibit 2 [ARSA GET Evaluation]) indicates that the hydraulic characteristics of the A Aquifer are highly variable, reflecting the vastly different natures of sediment layers within this zone. The transmissivity values for Aquifer A calculated from hydraulic testing range from 5,685 to 311,609 feet squared per day (ft^2/d), with an average value of 70,000 ft^2/d.

Aquifer B

Aquifer B is separated from the overlying A Aquifer by a lower-permeability aquitard ranging from approximately 10 to 55 feet in thickness. Aquifer B consists primarily of sands, gravels, and silty sands ranging from 10 to 70 feet in thickness, and extends to depths of approximately 100 to 200 feet bgs. This unit generally represents basal sands and gravels of the Quaternary sediments.

As with Aquifer A, the permeable Aquifer B (and the overlying aquitard layer) are continuous from the vicinity of the Aerojet site, beneath the American River, and extending into the area north of the river. This widespread occurrence of the permeable layers and interbedded aquitards reflects the regional depositional nature of these sediments. In the central and western portions of the American River Study Area (ARSA), Aquifer B occurs as two water-bearing units separated by lower permeability aquitard layers (see Attachments AGC-1[f] and AGC-1[i]; Hydrogeologic Cross Sections B-B' and E-E' [Figures 3-3 and 3-6] from AGC Exhibit 2, ARSA GET Evaluation).

Results of hydraulic testing for Aquifer B revealed varying hydraulic characteristics, also reflecting the highly variable nature of sediment layers within this zone. The transmissivity values for Aquifer B calculated from hydraulic testing range from 820 to 81,813 ft^2/d, with an average of 42,500 ft^2/d.

Aquifer C

Aquifer C consists of sands, gravels, and silty sands ranging from 15 to 55 feet in thickness, and extends to depths of approximately 160 to 230 feet bgs. Aquifer C is separated from the overlying Aquifer B by an aquitard 15 to 50 feet thick. Aquifer C is thickest in the eastern and southern portions of the American River Study Area. Regionally, Aquifer C slopes southwest at an angle of approximately 1 degree, and strikes N12'W.

Results of hydraulic testing for Aquifer C revealed varying hydraulic characteristics, also reflecting the highly variable natures of sediment layers within this zone. The transmissivity values for Aquifer C calculated from hydraulic testing range from 80 to 6,641 ft^2/d, with an average of 1,610 ft^2/d (see Attachment AGC-1[k]; Table 3-1 from AGC Exhibit 2, ARSA GET Evaluation).

Aquifer D

The water-bearing zones occurring below Aquifer C (below depths of 200 to 230 feet) were grouped together as Aquifer D in the February 2000 GET Effectiveness Evaluation for the American River Study Area (AGC Exhibit 2). As a result, the thickness of this unit is not well defined, although lithologic data and hydraulic testing results indicate that the unit becomes thicker and more permeable in the western portion of the ARSA. Aquifer D is separated from the overlying Aquifer C by a relatively consistent aquitard ranging in thickness from 15 to 100 feet.

Transmissivity values for Aquifer D in the ARSA have not been calculated. Hydraulic testing for Aquifers C and D in the GET E area indicate that transmissivity values for the combined C/D Aquifer in that area range from 6,550 to 20,885 ft^2/d (AGC Exhibit 3, WGOU RI/FS).

Aquifer Continuity

Groundwater percolating through permeable aquifers described above in the vicinity of the American River is not flowing through a known and definite channel. There is no channel or underground stream that is bounded or confined by impermeable or low permeability bed, bank, or channel features along the course of the American River.

Results of extensive subsurface investigations and hydraulic testing indicate that the permeable sediments that comprise Aquifers A, B, and C, the zones wherein most chemical migration has occurred, are laterally continuous over a large area in the American River vicinity. These permeable aquifer zones, through which groundwater is percolating, extend beneath the current American River, and are not confined to defined channels. Groundwater in the vicinity of the American River is flowing, or percolating, through these laterally extensive, permeable sediment layers in a direction that is nearly perpendicular to the river. This groundwater is not flowing through a laterally bounded or confined channel formed by any impermeable deposits limiting groundwater flow to areas only within a river valley. The continuity of aquifer units is clearly illustrated in the hydrogeologic cross sections through the American River Study Area, included as Attachments AGC-1(e) through AGC-1(j) (Figures 3-2 through 3-7 from AGC Exhibit 2, ARSA GET Evaluation).

The American River is very shallow downstream from Nimbus Dam, generally less than 10 feet deep and commonly less than 5 feet deep. As a result, the generally much thicker layers of permeable sand and gravel that comprise the A, B, and C Aquifers are not intersected by the current river channel. Additionally, the lower permeability aquitard layers within the A Aquifer interval restrict the interaction of the river with groundwater in the lower portions of the A Aquifer.

Groundwater Levels

Groundwater levels in the A Aquifer near extraction wells 4340 and in the area further downstream from Lake Natoma are lower than the elevation of the adjacent American River, indicating that the A Aquifer is vertically separated from the river. This is based on long-term monitoring of groundwater levels in monitor wells in the ARSA, on USGS measurements of river stage near the Hazel Avenue Bridge (USGS 2002), and on surveys of river elevation in Sailor Bar Park in August 1996 (AGC Exhibit 3; WGOU RI/FS).

The vertical distance between the elevation of the American River and the underlying groundwater in the A aquifer increases as the distance downstream from Lake Natoma increases. Based on groundwater level measurements in April 2001, this vertical distance separating the river water from the underlying groundwater increased from approximately 6 feet near A Aquifer extraction well 4370 to more than 25 feet in the area of A Aquifer well 4340 (see Figure A-5 in AGC Exhibit 6, Perimeter Groundwater Operable Unit Draft RI/FS Workplan, Gencorp Aerojet [April 2002; "Perimeter OU Draft RI/FS Workplan"]). It should be noted that these distances were calculated using groundwater level data from April 2001, when groundwater levels would be highest following winter precipitation, and using river water elevations measured in August 1996, when river water levels would be at their lowest. At other times, especially in the dry season, the separation distance between the river elevation and the underlying groundwater would be expected to be even greater.

In addition to the vertical separation between the elevation of the American River and the underlying groundwater in areas downstream from Lake Natoma, there is generally a significant difference in groundwater levels between the A Aquifer and underlying B, C, and D Aquifers in the vicinity of the river (see Attachments AGC-1[l]; Figure 2-8, Groundwater Elevation Contour Maps, April 1995; and AGC-1[m]; Figure 2-9, Groundwater Elevation Contour Maps, October 1995, from AGC Exhibit 4, Final ARSA EE/CA). These relatively significant vertical hydraulic gradients reflect the presence of lower-permeability aquitard layers separating the aquifers, and separating the lower portions of the A Aquifer from the overlying American River. Such vertical hydraulic gradients generally occur when relatively continuous, low-permeability layers restrict vertical groundwater flow, and when the intervening aquifers are highly permeable.

These observations and conclusions are consistent with monitoring data indicating that groundwater flow and contaminant migration has occurred beneath the American River through the continuous, permeable layers in each aquifer, separated from the overlying river by low-permeability aquitard layers and by vertical separation of the aquifer from the river.

Groundwater Flow

Prior to the August 1998 onset of groundwater extraction, the general direction of groundwater flow in the A, B, C, and D Aquifers in the ARSA was toward the west-northwest. In the area where the contaminant plumes cross the American River, groundwater was flowing in a direction generally transverse to the west-southwest orientation of the river in this area. This is illustrated in Attachments AGC-1(l) and AGC-1(m), maps of groundwater elevations from April and October 1995, respectively (Figures 2-8 and 2-9 from AGC Exhibit 4, Final ARSA EE/CA).

Although the direction of groundwater flow in the various aquifers changed following the start of pumping, the overall west-northwest direction of flow in this area has generally remained constant. The flow of groundwater beneath the river at a direction that is not parallel to the river indicates that this is percolating groundwater, and that this groundwater is not moving as underflow along or beneath the river.

The pattern of groundwater flow beneath the Aerojet site and the surrounding area, including the American River, is primarily controlled by the relatively higher volume of recharge from rainfall onto dredged land and mountain-front runoff in areas east of the Aerojet site. This results in a large recharge area of higher groundwater levels east of the Aerojet site and south of Lake Natoma and the American River. Groundwater flows outward from this area across the Aerojet site through the widespread permeable alluvial deposits, toward the southwest and west, and toward the northwest in the direction of the American River. The direction of groundwater flow in the American River Study Area is transverse to, and underneath the bed, banks, and channel of, the American River. This is illustrated in maps of groundwater elevations in 1996 for each aquifer (Attachment AGC-1[n]; Figure D2-2 from AGC Exhibit 3, WGOU RI/FS). This pattern of groundwater flow is illustrated in maps of groundwater elevations dating from as early as the 1940s (DWR 1964), and the general flow pattern has continued to exist to this day, modified only locally by well pumping and recharge activities.

American River Study Area (ARSA) Groundwater Contaminant Plume

The most compelling evidence that groundwater is not in direct connection with the American River is the migration of the plume of groundwater contamination beneath the river. The plume of contamination, originating south of the river, consists primarily of volatile organic compounds (VOCs), with trichloroethene (TCE) as the primary constituent. High concentrations of TCE, exceeding 100 micrograms per liter (ug/l) were found in the A, B, and C Aquifers migrating beneath the river toward the west-northwest. The contaminant plume continued to migrate toward the west-northwest in the area north of the river through laterally continuous permeable aquifer units separated by overlying and intervening aquitard zones. The American River Groundwater Extraction and Treatment (ARGET)

system extraction wells were installed and began operation in August 1998 to address this plume of contamination.

The migration of the contaminant plume beneath the American River and the lateral extent of the plume is illustrated in Attachments AGC-1(o) and AGC-1(p) (maps of TCE concentrations in groundwater in July-September 1995 and in October-December 1995; Figures 2-14 and 2-15 from AGC Exhibit 4, Final ARSA EE/CA).

The plume of contaminated groundwater readily migrated beneath the American River, through the shallowest aquifer, A Aquifer, as well as through the underlying B and C Aquifers, clearly indicating that the river was not a barrier to groundwater flow or contaminant migration. Elevated concentrations of TCE were found even in the shallowest A Aquifer monitor wells on the north side of the river, including wells 1516, 1517, and 1518 (see Attachment AGC-1[d]; Figure 3-1, American River Study Area Well Location Map, from AGC Exhibit 2, ARSA GET Evaluation). These wells are screened in the uppermost portions of the A Aquifer directly across the river along the axis of the migrating plume. TCE concentrations exceeding 40 ug/l were found in monitor well 1516 in 1992, and more than 50 ug/l TCE has been found in well 1517 (Aerojet February 2000 GET Effectiveness Evaluation for the American River Study Area, Appendix C; AGC Exhibit 2).

Other shallow, A Aquifer monitor wells north of the river found to contain elevated TCE concentrations include wells 1478, 1519, 1522, 1528 and 1538 (Attachment AGC-1[d]). By 1995, the TCE plume in the A aquifer had extended beneath the American River more than 4,800 feet west-northwest to well 1525. Even well 1528, a shallow A Aquifer well located more than 1,500 feet north of the river and east of Hazel Avenue, contained TCE above 10 ug/l. These sampling data confirm that the contaminant plume migrated beneath the American River in the shallow A aquifer in a direction transverse to the orientation of the river, and that the river did not significantly affect the movement of that plume.

In the area south of the river, TCE and other contaminants in the A Aquifer are also migrating downward into the underlying B Aquifer in response to regional hydraulic gradients (see Attachment AGC-1[e], Figure 3-2, Hydrogeologic Cross Section A-A', from AGC Exhibit 2, ARSA GET Evaluation). The zone of highest TCE concentrations (greater than 1,000 ug/l) is encountered in the A, B, and C Aquifers in the area south of the river. Somewhat lower TCE concentrations (less than 700 ug/l) have also been found in the underlying D Aquifer. Groundwater containing elevated TCE concentrations has also migrated downward from the B Aquifer to the C Aquifer, and into the underlying D Aquifer.

The plume of contamination moving through the B, C, and D Aquifers has also continued beneath the American River (see Attachments AGC-1[o] and AGC-1[p]). Elevated concentrations of TCE exceeding 100 ug/l have been found in monitor wells in each of these aquifers north of the American River, extending west-northwest at least 6,000 feet from the river. As with the A Aquifer, the American River is not a barrier to groundwater flow and plume migration through the B, C,

and D Aquifers. The direction of groundwater flow and the observed pattern of plume migration indicates that the river is not directly connected to these Aquifers.

The plume of groundwater from the Aerojet site migrating toward the west-northwest beneath the American River is migrating in response to regional flow gradients, and is not directly controlled by surface-water flow in the American River. The fact that the plume of contaminants in the A Aquifer extends beneath and into the area north of the river shows that the American River is not directly connected to and does not control groundwater flow in these groundwater zones.

Groundwater Recharge

Groundwater beneath the Aerojet site and surrounding area is recharged directly by percolation of rainfall and by recharge from percolation of surface-water runoff from the foothills and the Sierra Nevada to the east.

The average annual precipitation at Folsom Dam is approximately 23 inches per year for the period since 1955 (AGC Exhibit 3, WGOU RI/FS, Appendix D). Most of this precipitation occurs as rainfall during the winter season. The groundwater modeling study conducted by Aerojet and Hydrosearch indicated that as much as 90 percent of the average annual precipitation readily percolates through the subsurface and recharges the underlying groundwater (AGC Exhibit 3, WGOU RI/FS, Appendix D). This relatively high volume of rainfall recharge occurs because of the large area that was dredged in conjunction with gold mining activities. These dredged mine spoils are typically highly permeable and have little or no external drainage. Therefore, the majority of rainwater falling on dredged land percolates into the subsurface, and recharges the underlying groundwater.

Other sources of recharge considered in the Aerojet/Hydrosearch modeling (AGC Exhibit 3, WGOU RI/FS) include infiltration of runoff from the mountains and foothills to the east, and recharge of groundwater by injection wells. The calculated volume of mountain-front recharge entering the entire groundwater model on the eastern side of the Aerojet site is 3,600 acre-feet per year (ac-ft/yr). The volume of water recharged by injection wells since injection began in the 1980s has been as high as 6,000 ac-ft/yr (AGC Exhibit 3, WGOU RI/FS, Appendix D).

Based on data from the WGOU groundwater modeling study (AGC Exhibit 3, WGOU RI/FS), I have calculated the estimated volume of recharge from rainfall in the American River Study Area (ARSA) north of Highway 50. The area used in this calculation was 1,190 acres, and included an area north of Highway 50 extending 7,200 feet west from Hazel Boulevard, and extending 7,200 feet northwest. Based on average annual rainfall of 23 inches per year, and assuming that 90 percent of this rainfall recharged the underlying groundwater, the calculated volume of rainfall recharge in this portion of the ARSA is 2,285 ac-ft/yr.

Evaluation of groundwater modeling results and hydrogeologic data indicates that the amount of water recharged by the American River in the ARSA area is small compared to the amount of recharge from percolating rainfall and surface-water runoff from the foothills and Sierra Nevada, and the volume of groundwater flowing into the ARSA from recharge areas to the south and east.

Groundwater Modeling by CH2M Hill

The groundwater modeling studies performed by CH2M Hill for the U.S. EPA in 1994 (AGC Exhibit 7, Groundwater Capture Zone Analysis and Modeling Simulations, American River Study Area, Rancho Cordova, California, CH2M Hill (1994; "CH2M Hill Modeling Report") evaluated the extent of groundwater capture zones resulting from proposed extraction wells to control the contaminant plume that had migrated northwest beneath the American River from the Aerojet site. CH2M Hill concluded that "implementation of the removal action recommended in Aerojet's May 1993 EE/CA is an environmentally sound first step in an iterative approach to control the migration of the contaminant plume in the American River Study Area" (AGC Exhibit 7, CH2M Hill Modeling Report, p.2).

Comparison of modeling results with hydraulic test data confirmed that the aquifer zones were highly permeable, allowing the plume to migrate from the Aerojet site beneath the river. The CH2M Hill modeling study did not consider that the American River had any influence on the underlying groundwater or contaminant plume.

Pumping of ACWS Water Supply Wells 17 and 22

Arden Cordova Water Service (ACWS) water supply wells 17 and 22 are both located within only a few hundred feet of the river. Both of these wells reportedly pump large volumes of water. We are not aware that operation of these high-capacity wells so close to the river has ever been questioned by the State Water Resources Control Board (SWRCB) or RWQCB as having any impact on the American River. The volume of water pumped by these wells (as well as the ARGET wells) reflects the widespread occurrence and highly permeable nature of sediments in the region, where rainfall is a primary source of groundwater recharge and percolating groundwater flow.

AMERICAN RIVER STUDY AREA (ARSA) GROUNDWATER EXTRACTION AND TREATMENT (ARGET) SYSTEM

Description of ARGET System

In May 1993, Aerojet submitted an Engineering Evaluation/Cost Analysis (EE/CA) for the installation of a groundwater extraction system to minimize the migration of

chemicals in groundwater in the American River Study Area (ARSA). The ARSA comprises the area along the American River north of Highway 50, and west of Hazel Avenue. North of the river, the ARSA includes Sacramento County's Sailor Bar Park, and the surrounding residential properties of Fair Oaks. South of the river, the ARSA includes federal lands of the American River and Nimbus Fish Hatchery, state properties, and various commercial properties, and is bounded to the southwest by the community of Gold River.

In 1995, U.S. EPA issued Unilateral Order No. 95-16 ("U.S. EPA Order") to Aerojet requiring remediation of the plume of groundwater contamination on both sides of the American River. Following extensive public comment and agency negotiations, the EPA rescinded the Order and the California Regional Water Quality Control Board-Central Valley Region (RWQCB) issued a Cleanup and Abatement Order (CAO) requesting that Aerojet implement interim remedial actions for the ARSA. Aerojet submitted a Final EE/CA for the ARSA in September 1996, which called for installation of multiple groundwater extraction wells in the ARSA, construction of a groundwater treatment system on the Aerojet site, and discharge of the treated water to Buffalo Creek.

The American River Groundwater Extraction and Treatment (ARGET) system currently includes 15 extraction wells, with three wells at different depths at each of five locations. Three locations are north of the river and two locations are south of the river. The locations of these wells are shown in Attachment AGC-1(c) (Figure 2-1 from AGC Exhibit 2, ARSA GET Evaluation). The three extraction wells at each location are screened in the three underlying aquifer units, Aquifer A, Aquifer B, and Aquifer C. One set of three wells (4325, 4330, and 4335) is located in the area of highest chemical concentrations south of the American River near the Nimbus Fish Hatchery. The remaining four sets of extraction wells are located further downgradient to capture the groundwater chemical plumes.

The ARGET system began operation in August 1998, with five A Aquifer wells, five B Aquifer wells, and five C Aquifer wells. Two additional D Aquifer extraction wells are planned to begin operation in 2002. The combined extraction rate from the current 15-well extraction system is approximately 2,047 gpm. This rate is expected to increase to approximately 2,500 gpm with the addition of the two new D Aquifer wells. The rates of groundwater extraction from each of the wells and the cumulative rates from each groundwater zone are presented in Attachment AGC-1(q) (ARGET Table 1).

Water from the ARGET system is transferred through two separate pipelines to the treatment system located on the Aerojet site. One double-walled pipeline conveys water from those wells (4325, 4330, and 4335) producing water with higher concentrations of chemicals, while the other single-walled pipeline conveys water from the remaining extraction wells, which produce water containing much lower chemical concentrations. The water is treated using a combination of advanced oxidation and air stripping. The effluent from the ARGET system is discharged to nearby Buffalo Creek, which flows west and northwest approximately 2.8 miles to

the location where it discharges into the American River, near the Sunrise Boulevard overpass. The locations of the treatment plant and the Buffalo Creek discharge are shown in Attachment AGC-1(c) (Figure 2-1 from AGC Exhibit 2, ARSA GET Evaluation).

Hydraulic Testing Results

Extensive aquifer testing conducted by Aerojet in support of the design of the ARGET system provides hydrogeologic data that are consistent with and support the observations presented above regarding high permeability of the sediments in the ARGET area, the groundwater flow direction and orientation of the VOC plume transverse to the American River, and the lack of lower permeable sediments (i.e., bed, bank, or channel features) confining groundwater within any known and definite subterranean channel in the A, B, C, and D Aquifers that underlie the American River. A summary of hydraulic test data is presented in Attachment AGC-1(k), Summary of Aquifer Test Results from AGC Exhibit 2 (ARSA GET Evaluation).

Aquifer test data also indicate that groundwater pumped from the ARGET system is not replenished by or otherwise affected by water from the American River. Rather, aquifer test data indicate that pumping from each groundwater zone interval, including the shallowest (A Aquifer) groundwater in the ARGET area, results in hydraulic responses from the corresponding A Aquifer located on the opposite side of the American River (AGC Exhibit 4, Final ARSA EE/CA, Appendix G). These aquifer test data are consistent with the VOC plume maps, which indicate that the American River is not a hydraulic barrier to groundwater flow in the ARGET area.

Hydraulic Testing of A Aquifer

Aquifer test data indicate that groundwater pumped from the shallowest (A Aquifer) groundwater is not significantly affected by recharge from the American River. For example, pumping groundwater from A Aquifer extraction well 4370 (located south of the American River) resulted in a measured drawdown response of the A Aquifer on the north side of the American River. The magnitude of the drawdown response in the A Aquifer across the American River (0.16 foot, well 1481, approximately 1,700 feet north of and across the American River) was similar to the drawdown response observed in the A Aquifer on the south side (i.e., the same side) of the American River (0.15 foot, well 1469, approximately 2,500 feet east of the pumping well). Similarly, pumping from the A Aquifer at extraction well 4325, also located south of the American River, resulted in a drawdown in the A Aquifer north of (across) the American River (0.17 foot drawdown in well 1478, located approximately 900 feet northwest and across the river from pumping well 4325).

Also, pumping from A Aquifer extraction well 4300, located on the north side of the American River, resulted in a drawdown response in the A Aquifer on the south side of the American River (measured in wells 1357, 1370, 1391, and 1487). The

drawdown response from pumping from well 4300 in A Aquifer sediments adjacent to the American River was very similar in magnitude to the corresponding drawdown response in A Aquifer sediments located away from the river. Pumping from extraction well 4300 resulted in a drawdown of 0.16 foot in well 1538, located approximately 500 feet to the northeast (i.e., away from the American River). The corresponding drawdown measured in well 1481, located 1,300 feet to the south of the pumping well and immediately adjacent to the American River, was 0.17 foot. These data indicate that the drawdown response of A Aquifer sediments located adjacent to the American River was not influenced by leakage from the American River.

Finally, drawdown observations collected from A Aquifer monitor well 1564 during pumping of A Aquifer extraction well 4340 (located approximately 300 feet southwest of well 1564, and adjacent to the American River) over a period of over nine hours indicated that pumping from the A Aquifer did not encounter a recharge boundary (such as would be expected if the river were a significant source of water to the well). Rather, the drawdown curve for well 1564 was still rising after nine hours, indicating that pumping from well 4340 was not being replenished by recharge from the river. These data support the observations of drawdowns caused by pumping of extraction well 4340, which also indicated a lack of groundwater recharge from the river.

These hydraulic test results indicate that pumping from the A Aquifer is not significantly affected by induced leakage from the American River. The fact that the aquifer response to pumping was similar in the areas north and east of the pumping well also indicates the lack of low permeable sediments forming a known and definite subterranean channel along the American River (i.e., bed, banks, or other similar hydraulic boundaries). The higher magnitude of aquifer response in lower zones also confirms the lack of river influence in the aquifers in ARSA.

Hydraulic Testing of Aquifers B and C

Pumping of groundwater from Aquifers B and C also resulted in significant hydraulic responses in the corresponding Aquifers B and C located on the opposite side of the American River. This large hydraulic response reflect the lack of hydraulic connection between the American River and the groundwater zones.

For example, pumping from the C Aquifer from well 4335, located on the south side of the American River, resulted in a hydraulic response (i.e., drawdown) of 3.24 feet and 2.90 feet in C Aquifer wells located on the north side (across) the American River (wells 1510 and 1479, respectively). Conversely, pumping from C Aquifer well 4302, located on the north side of the American River, resulted in a drawdown response in C Aquifer groundwater on the other side of the river (0.14 foot; well 1359).

Similar results were obtained from pumping from the B Aquifer. For example, pumping from B Aquifer extraction well 4330, located on the south side of the American River, resulted in a drawdown response of 2.25 feet in B Aquifer well 1479, located on the north side of the American River. Also, pumping from B Aquifer well 4301, located on the north side of the river, resulted in measurable drawdown in B Aquifer wells 1470, 1362, and 1386, located on the south side of the river.

WESTERN AEROJET SITE – GROUNDWATER EXTRACTION AND TREATMENT E/F (GET E/F) SYSTEM

Background

Groundwater extraction wells in the Groundwater Extraction and Treatment E/F system (GET E/F) collect groundwater containing chemicals migrating toward the western perimeter of the Aerojet property. Currently, this groundwater is intercepted by 11 extraction wells and conveyed by pipeline to the GET E/F treatment facility (see Attachment AGC-1[r]; Figure 4-6 from AGC Exhibit 3, WGOU RI/FS). The Western Groundwater Operable Unit (WGOU) is located west of GET E/F and addresses chemicals that have migrated off site west of Aerojet.

Aerojet began operation of GET E/F individually as GET E and GET F in 1985 and 1984, respectively. The 11 current extraction wells at GET E/F are clustered near the northwestern and southwestern property boundaries, and are shown in Attachment AGC-1(r) (Figure 4-6 in AGC Exhibit 3, WGOU RI/FS) as solid, upward-pointing triangles. Eleven extraction wells were added to GET E/F in the past year; nine of these new wells (Wells 4600, 4594, 4590, 4550, 4545, 4540, 4615, 4605, and 4610) were constructed in a north/south orientation along the western property boundary, and two wells were installed east of GET E along the northwestern Aerojet property boundary (Wells 4530 and 4535). A twelfth new well has been installed but has yet to be connected to GET E/F; that well (Well 4555) is just south of White Rock Road on the IRCTS. The locations of the new extraction well clusters, each containing one to three wells, are shown on Attachment AGC-1(r) (Figure 4-6 in AGC Exhibit 3, WGOU RI/FS) as NEW-1, -2, -3, GET E-1, and GET F-1; these wells will begin operation in the near future.

GET E/F is currently operated at approximately 3,360 gpm, and the treated groundwater is currently discharged to the ground surface on the Aerojet site. The flow rate at GET E/F is anticipated to increase to approximately 6,076 gpm when the treatment plant is expanded (AGC Exhibit 3, WGOU RI/FS). Attachment AGC-1(s) (GET E/F Table 1) shows current pumping at GET E/F, and Attachment AGC-1(t) (GET E/F Table 2) shows the anticipated pumping rates and aquifer zones in GET E/F after expansion. Prior to 1998, the treated groundwater from GET E/F was recharged through recharge wells located near the western Aerojet boundary. In the future, it is anticipated that the treated groundwater will be

discharged to Buffalo Creek or Alder Creek pending adoption of a National Pollutant Discharge Elimination System (NPDES) permit currently under review by the RWQCB.

Description of Data

The saturated sediments beneath GET E/F are categorized based on soil descriptions and groundwater samples collected from over 385 monitor wells. These sediments belong to the same geologic sequence as the sediments described for the American River Study Area (ARSA) and American River Groundwater Extraction and Treatment system (ARGET), and are divided into Layers A through F, which are correlative to the same Aquifer names in the ARSA and ARGET area. Although Layers A and B in the Western Groundwater Operable Unit (WGOU) are geologically continuous between ARGET and GET E/F, groundwater in them does not appear to be continuous; there are numerous dry wells between the two areas. Layers C, D, and E are thicker and are encountered deeper at GET E/F than at ARGET. Cross-section F-F' (see Attachment AGC-1[u]; Figure A-4 from AGC Exhibit 3, WGOU RI/FS) is oriented southwest-northeast, parallel to the direction of groundwater flow. The cross section shows the layers as they thicken and plunge deeper below the land surface moving westward across the Aerojet site. North-south cross-section H-H' (Attachment AGC-1[v]; Figure A-6 from AGC Exhibit 3, WGOU RI/FS) shows the layers from the southern Aerojet site boundary toward the American River.

Data regarding the aquifer beneath GET E/F have been collected and analyzed for almost 20 years. Water level measurements have been collected from all monitor wells twice per year, and extensive analytical sampling of groundwater has been conducted. The aquifer characteristics have been studied by testing many of the extraction and recharge wells at GET E/F. Interpretation of these data are provided in the WGOU RI/FS (AGC Exhibit 3, WGOU RI/FS).

Hydrostratigraphy

The following sections summarize the physical characteristics, groundwater flow conditions, and groundwater pumping in the saturated sediments beneath GET E/F. These sediments are grouped into Layers A through F, although Layer F is not described because it is below the depths of contamination. The depths and distances of the pumped layers relative to the bed of the American River are described, and the source of groundwater beneath GET E/F is discussed to support the conclusions regarding the absence of effects on the American River from pumping at GET E/F.

Water level measurements were used to determine groundwater flow directions and gradients. Four contoured water level maps prepared for Layers A through E from 1991 to 1998 are shown on Attachments AGC-1(w) through AGC-1(aa) (Figures A-7 through A-11, respectively, from AGC Exhibit 3, WGOU RI/FS). These maps portray the potentiometric surfaces under pumping conditions, and show that

groundwater flows west to southwest across the GET E/F area in these layers. The maps also show the response to groundwater pumping at GET E/F, indicating that groundwater is percolating beneath GET E/F area from the east, and not from the direction of the American River. The groundwater flow directions in response to future groundwater pumping was simulated using the groundwater flow model prepared for the WGOU RI/FS (see AGC Exhibit 3, WGOU RI/FS). Attachment AGC-1(bb) (Figure 5-11 from AGC Exhibit 3, WGOU RI/FS) shows the predicted groundwater capture zones after expansion of GET E/F pumping, and indicates that groundwater will continue to percolate beneath GET E/F from the eastern and northeastern portions of Aerojet. There are no observed or predicted impacts on groundwater flow near the American River caused by either current or predicted future groundwater pumping at GET E/F.

Layer A

Layer A is the shallowest layer at GET E/F and is generally encountered at 40 to 100 feet bgs. Layer A contains abundant sand and gravel eroded from the Sierra Nevada and much of Layer A was historically dredged for gold. Layer A is currently dry from the northern property boundary extending south across much of the area. The vadose zone near in the northern half of the GET E/F extraction area contains over 100 feet of unsaturated sediments.

The saturated thickness of Layer A typically ranges from 0 to approximately 20 feet in the southern half of GET E/F. Attachment AGC-1(w) (Figure A-7 from the WGOU RI/FS, AGC Exhibit 3) shows that groundwater is flowing west-southwest with an approximate average hydraulic gradient of 0.005 foot per foot or 25 feet per mile. Attachment AGC-1(s) (GET E/F Table 1) shows that approximately 1 gpm is extracted from Layer A at GET E/F, approximately 15,000 feet south of the American River. The past water level measurements and future, model-predicted capture zones suggest that groundwater in Layer A has flowed and will continue to flow into GET E/F from the east (see Attachments AGC-1[w] and AGC-1[bb]; Figures A-7 and 5-11 from AGC Exhibit 3, WGOU RI/FS).

Layer B

Layer B is beneath Layer A and is typically present at depths of 100 to 180 feet bgs. The permeable portions of Layer B comprise sand, silty sand, and gravel. Layer B is discontinuous on the Aerojet site and is absent on the south half of the site and west of GET E/F. Layer B contains 10 to 60 feet of permeable sediments in the north half of the site and off site west of GET E/F.

Groundwater in Layer B typically flows to the west and southwest with an average hydraulic gradient of 0.004 foot per foot, or 25 feet per mile (Attachment AGC-1[x]; Figure A-8 from AGC Exhibit 3, WGOU RIFS). Attachment AGC-1(s) (GET E/F Table 1) shows that approximately 142 gpm of groundwater is pumped from two extraction wells screened in Layer B in southern GET E/F. Measured

groundwater levels shown in Attachment AGC-1(x) (Figure A-8 from AGC Exhibit 3) indicate that groundwater pumped in Layer B flows beneath GET E/F from the east.

Layer C

Layer C comprises relatively permeable sand, sandstone, and minor gravel with common thin (1- to 10-foot) beds of siltstone and clay. Layer C is present at depths of 150 to approximately 200 feet bgs, and ranges from 50 to 125 feet thick. Layer C contains broad lateral expanses of sand and gravel that are not laterally confined by impermeable sediments. Vertically, Layer C is separated from underlying Layer D by a 10- to 40-foot-thick layer of silt and clay. There are several public water supply wells located between the American River and GET E/F that extract groundwater from this and deeper layers.

As shown on Attachment AGC-1(y) (Figure A-9 from AGC Exhibit 3, WGOU RI/FS), groundwater in Layer C typically flows west-southwest beneath GET E/F from the eastern and northeastern areas on the Aerojet site. The Layer C extraction wells in GET E/F are at least 7,000 to 8,000 feet south of the American River and pump at a combined rate of 2,250 gpm. Pumping rates from Layer C are planned to increase in the near future to approximately 2,984 gpm (see Attachment AGC-1[t]; GET E/F Table 2). Measured groundwater levels shown in Attachment AGC-1(y) and model-predicted capture zones shown in Attachment AGC-1(bb) (Figures A-9 and 5-11, respectively, from AGC Exhibit 3) show that groundwater in Layer C flows from the east and northeast in response to pumping and not from the direction of the American River.

Layer D

Layer D is present at depths ranging from 220 to 350 feet bgs and ranges from 30 to 150 feet thick as shown on cross-section H-H' (Attachment AGC-1[v]; Figure A-6 from AGC Exhibit 3, WGOU RI/FS). The base of Layer D is present at depths of approximately 360 to 400 feet bgs. Layer D comprises widely distributed sand and gravel and is similar to overlying Layer C. Layer D is separated from underlying Layer E by a 10- to 45-foot-thick clay and siltstone layer.

Layer D is saturated and continuous across GET E/F. Attachment AGC-1(z) (Figure A-10 from AGC Exhibit 3) shows that groundwater flows west-southwest beneath GET E/F from the east and northeast portions of the Aerojet site. GET E/F currently pumps approximately 967 gpm of groundwater from Layer D, and planned GET E/F expansion will increase the total pumping in Layer D to 2,075 gpm, as shown on Attachment AGC-1(t) (GET E/F Table 2). Table 2 also shows the nearest Layer D extraction well (4200) is approximately 7,000 feet south of the American River and pumps at a rate of 241 gpm. Measured groundwater levels shown on Attachment AGC-1(z) and model-predicted capture zones shown in Attachment AGC-1(bb) (Figures A-10 and 5-11 from AGC Exhibit 3, WGOU

RI/FS), indicate that groundwater, under pumping conditions, flows from the east and northeast in Layer D and not from the direction of the American River.

Layer E

Layer E is typically present at depths of 350 to 400 feet bgs as shown on cross-section H-H' (Attachment AGC-1[v]; Figure A-6 from AGC Exhibit 3). Layer E comprises sand, sandstone, and gravel with silt and clay lenses. The silt and clay are more abundant in Layer E than in Layers C and D. The available data show that Layer E is at least 100 feet thick.

There are no extraction wells screened in Layer E at GET E/F; however, Attachment AGC-1(aa) (Figure A-11 from AGC Exhibit 3) suggests that some groundwater in Layer E is extracted in response to pumping of the overlying extraction wells at northern GET E/F. Attachment AGC-1(z) (Figure A-11 from AGC Exhibit 3) also shows that groundwater in Layer E originates east of, and flows west across, GET E/F. The new Layer E extraction wells will pump an estimated 900 gpm of groundwater from Layer E, but are not predicted by the WGOU groundwater flow model to draw groundwater from the direction of the American River, as shown on Attachment AGC-1(bb) (Figure 5-11 from AGC Exhibit 3).

Summary – GET E/F

The sediments comprising the shallowest Layers A and B in the GET E/F area are laterally extensive, but are not saturated throughout the area. Layer A is dry throughout most of the GET E/F area, and Layer B is only pumped by two extraction wells near the southernmost Aerojet boundary, at a combined rate of 142 gpm. Layer C is the shallowest layer that is extensively pumped at GET E/F. Layer C is laterally extensive and is present at depths of 150 to 200 feet bgs at GET E/F. The American River is located approximately 7,000 to 8,000 feet north of the closest GET E/F extraction well pumping water from Layer C. This layer is overlain by more than 100 feet of unsaturated sediments and 50 to 100 feet of saturated sediments.

Even after more than 10 years of pumping, maps of groundwater levels show that groundwater extracted at GET E/F does not come from the direction of the American River. Furthermore, predicted groundwater levels after expansion of GET E/F also show that extracted groundwater will not be derived from the vicinity of the American River.

PROPOSED GROUNDWATER EXTRACTION AND TREATMENT SYSTEM – WESTERN GROUNDWATER OPERABLE UNIT

Background

The Western Groundwater Operable Unit (WGOU) addresses contaminants in groundwater west of GET E/F and extending approximately 11,000 feet west of the western Aerojet property boundary. The U.S. EPA recently issued an order for the construction of a groundwater extraction system in the WGOU to intercept chemicals present in groundwater west of the Aerojet facility. The selected remedy was developed using the groundwater flow model prepared for the WGOU RI/FS, and was used to estimate the number of extraction wells and pumping rates for containing affected groundwater west of Aerojet (AGC Exhibit 3, WGOU RI/FS). The following sections briefly summarize the pertinent geologic and hydrologic features in the WGOU, and assess potential effects on the American River due to the proposed groundwater pumping.

Attachment AGC-1(cc) (WGOU Table 1) presents the distances to the American River, flow rates, and pumped layers for the proposed WGOU extraction wells. The proposed locations of the WGOU extraction wells are shown on Attachment AGC-1(r) (Figure 4-6 from AGC Exhibit 3, WGOU RI/FS). The distances to the American River from the proposed WGOU extraction wells range from 4,000 (Wells C9 and C10) to approximately 16,000 feet (Well C10). The nearest extraction wells to the American River will be screened in Layer C. These wells and the remaining Layer C extraction wells are planned to pump an estimated 2,400 gpm from depths of 260 to 340 feet bgs. The extraction wells proposed for Layer D will withdraw an estimated 1,150 gpm from approximate depths of 325 to 400 feet bgs. The extraction wells proposed for Layer E will withdraw an estimated 600 gpm from depths of 400 to 500 feet bgs.

Description of Data

The saturated sediments beneath the WGOU were categorized based on soil descriptions and groundwater samples collected from over 100 monitor wells. These sediments belong to the same geologic sequence and are a continuation of the sediments at GET E/F. The sediments were divided into Layers A through F, which correlate to the same Aquifer names used for GET E/F. Layers A and B may be geologically continuous from GET E/F to the WGOU; however, these layers are unsaturated in areas west of the Aerojet site, and there are numerous dry wells between the GET E/F and WGOU areas. There is no groundwater pumping planned for Layers A and B in the WGOU, and these layers are not specifically addressed further. However, approximately 200 feet of sediments (including Layers A and B) overlie Layers C, D, and E to be pumped by WGOU.

Attachment AGC-1(r) (Figure A-4 from AGC Exhibit 3, WGOU RI/FS) is a southwest-northeast-trending cross section that shows the continuation of Layers C, D, and E from GET E/F through the WGOU. The layers thicken and are encountered deeper moving westward across the WGOU. Layer C is the shallowest pumped layer in the WGOU and will be pumped from depths approximately 260 feet below the base of the American River. Figure A-6 from AGC Exhibit 3 (Attachment AGC-1[v]) shows the trend northwest from the Aerojet site toward the American River. The figure shows that the layers are continuous and laterally unconfined across the WGOU.

Data regarding the aquifer beneath the WGOU have been collected and analyzed for approximately five years. Water-level measurements have been collected from all monitor wells twice per year, and extensive analytical sampling of groundwater has been conducted. The aquifer characteristics were assessed by reviewing pump test data from several public water supply wells. Interpretation of these data are provided in the WGOU RI/FS (AGC Exhibit 3). The WGOU groundwater flow model was used to estimate the number of extraction wells, pumping depths, and pumping rates for the WGOU GET.

Hydrostratigraphy

The following sections summarize the physical characteristics, groundwater flow conditions, and groundwater pumping in the saturated sediments beneath the WGOU. The layers in the WGOU are the same as the layers discussed at GET E/F, except they are thicker and deeper in the WGOU. Layer F is not described because it is below the depths of contamination, and Layers A and B are not described because they will not be pumped in the WGOU. The depths and distances of the pumped layers to the base of the American River are described, and the sources of groundwater to the WGOU are discussed to support the conclusions presented regarding potential pumping effects on the American River.

Water level measurements were used to assess groundwater flow directions and gradients. Four potentiometric surface contour maps prepared for Layers A through E from 1991 to 1998 are shown on Attachments AGC-1(w) through AGC-1(aa) (Figures A-7 through A-11 from AGC Exhibit 3), respectively. These maps show that groundwater generally flows southwest across the WGOU, and that regional groundwater flow directions and gradients have not varied much over time. The response to pumping from future groundwater extraction was simulated in the groundwater flow model prepared for the WGOU RI/FS (AGC Exhibit 3). Attachment AGC-1(bb) (Figure 5-11 from AGC Exhibit 3) shows the model-predicted groundwater capture zones based on future pumping.

Layer C

Cross-section H-H' shown on Attachment AGC-1(v) (Figure A-6 from AGC Exhibit 3, WGOU RI/FS) is oriented southwest, parallel to the direction of

groundwater flow, and shows that Layer C (and Layers D and E) is laterally continuous across GET E/F and the WGOU. The depth to Layer C increases from 170 to 260 feet bgs from east to west across the WGOU. Layer C generally ranges from 80 to 100 feet thick and contains broad lateral expanses of sand and gravel that are not laterally confined by impermeable sediments. Layer C is vertically separated from underlying Layer D by a 10- to 40-foot-thick layer of silt and clay.

Attachment AGC-1(y) (Figure A-9 from AGC Exhibit 3, WGOU RI/FS) shows that groundwater in Layer C flows predominantly southwest from GET E/F through the WGOU. The proposed extraction wells, proposed pumping rates, and distances from the American River are summarized in Attachment AGC-1(cc) (WGOU Table 1) and shown on Attachment AGC-1(r) (Figure 4-6 from AGC Exhibit 3, WGOU RI/FS). There are approximately 10 Layer C extraction wells planned in the WGOU that will operate at a combined pumping rate of 2,400 gpm. The closest extraction wells to the American River in Layer C are proposed 4,000 feet south of the American River, and will pump from depths of 240 to approximately 350 feet below the base of the river. The model-predicted capture zone for Layer C is shown on Attachment AGC-1(bb) (Figure 5-11 from AGC Exhibit 3) and indicates that groundwater will primarily flow into the WGOU from the Aerojet site and from very limited areas north and south of Aerojet.

Layer D

Attachment AGC-1(u) (Figure A-4 from AGC Exhibit 3) is a southwest-trending cross section through the WGOU that shows Layer D beneath Layer C at depths ranging from 250 to 400 feet bgs. Layer D ranges from 80 to 120 feet thick, and the bottom of Layer D is present at depths of approximately 360 to 500 feet bgs. Layer D in the WGOU is laterally continuous with Layer D at GET E/F and comprises broad expanses of sand and gravel that are not laterally confined by impermeable sediments. Layer D is separated from underlying Layer E by a 10- to 45-foot-thick clay and siltstone layer.

Attachment AGC-1(z) (Figure A-10 from AGC Exhibit 3) shows that groundwater in Layer D originates on the Aerojet property east of the WGOU and flows southwest beneath the WGOU. The locations of the planned Layer D extraction wells, pumping rates, and distances from the American River are shown on Attachment AGC-1(bb) (Figure 5-11 from AGC Exhibit 3) and summarized in Attachment AGC-1(cc) (WGOU Table 1). Approximately 1,150 gpm will be extracted from six wells west and southwest of Aerojet. The closest well to the American River is approximately 8,000 feet south of the river and will pump at a rate of 200 gpm from depths of 325 to approximately 400 feet bgs. Measured groundwater levels and model-predicted capture zones shown on Attachments AGC-1(z) and AGC-1(bb), respectively (Figures A-10 and 5-11 from AGC Exhibit 3), indicate that groundwater flows to these wells through Layer D from the Aerojet site to the east, and not from the American River. Several public water supply wells located between the planned Layer D extraction wells and the

American River have pumped groundwater in this area for many years and they are not interpreted to have drawn water from the river. The planned Layer D extraction wells are further away from the American River than those water supply wells.

Layer E

Layer E is the deepest layer in the WGOU and is typically present at depths of 350 to 600 feet bgs as shown on cross-section H-H' (Attachment AGC-1[v]; Figure A-6 from AGC Exhibit 3). Layer E comprises sand, sandstone, and gravel with silt and clay lenses. The silt and clay are more abundant in Layer E than in Layers C and D. The available data indicate that Layer E is at least 100 feet thick. Layer F underlies Layer E and does not contain contaminants.

There are no extraction wells currently screened in Layer E; however, two extraction wells planned for the WGOU are shown on Attachment AGC-1(r) (Figure 4-6 from AGC Exhibit 3). Attachment AGC-1(aa) (Figure A-11 from AGC Exhibit 3) shows groundwater in Layer E is not flowing into the WGOU from the American River, but flows southwest from the Aerojet site into the WGOU. The distances to the American River and estimated pumping rates for extraction wells proposed for Layer E are summarized in Attachment AGC-1(cc) (WGOU Table 1). Two extraction wells are proposed with a combined pumping rate of 600 gpm and pumping depths of approximately 400 to 500 feet bgs. Model-predicted capture zones suggest that groundwater flows to these extraction wells through Layer E primarily from the Aerojet site and will not be derived from the American River (Attachment AGC-1[bb], Figure 5-11, from AGC Exhibit 3, WGOU RI/FS). There are several public water supply wells located between the Layer E extraction wells and the American River as noted above for Layer D.

Summary – Western Groundwater Operable Unit

An anticipated total of 18 extraction wells are planned in the WGOU, to be installed in Layers C, D, and E with a combined pumping rate of approximately 4,150 gpm. The extraction wells will be installed at least 6,000 feet south of the American River and will pump from minimum depths of approximately 240 feet bgs. The shallowest layer (Layer C) that will be pumped by these wells is overlain by at least 30 to 40 feet of unsaturated sediments, and over 200 feet of saturated sediments. In addition, several public water supply wells are located between the proposed extraction wells and the American River.

Based on the large distance from the American River, the depths of the planned WGOU extraction wells, and the presence of multiple, similarly deep public water supply wells between the American River and the WGOU, the American River will not be affected by groundwater extraction in the WGOU.

SUMMARY OF CONCLUSIONS

American River Groundwater Extraction and Treatment (ARGET) System

The following items provide the basis for concluding that the ARGET plume and various groundwater zones are not in direct connection with or controlled by the American River:

- There are no impermeable or low permeability bed, bank, or channel features that confine groundwater flow in the aquifers that underlie the American River area. Groundwater in the vicinity of the American River is not flowing through a known and defined subterranean channel. There is no channel or underground stream that is bounded or confined by impermeable or low-permeability beds, banks, or channel features along the course of the American River.
- Hydrogeologic layers (A, B, C, and D) are widespread, permeable, alluvial sediment intervals that underlie the eastern portion of Sacramento County, and extend laterally far beyond the immediate area of the river.
- The plume of groundwater contamination extending northwest from the Aerojet site toward the American River has migrated beneath the river through the extensive alluvial deposits of permeable sand and gravel that occur throughout the region and comprise the A, B, C, and D Aquifers. The ARGET wells were installed to address this plume of contamination on both the north and south sides of the river.
- The movement of the ARGET groundwater plume is controlled by regional hydraulic gradients causing groundwater to flow northwest from the Aerojet site beneath the American River.
- The plume of contaminated groundwater readily migrated beneath the American River in the shallowest A Aquifer, as well as deeper groundwater zones, clearly indicating that the river is not a barrier to groundwater flow or contaminant migration. The flow of groundwater beneath the river at a direction that is not parallel to the river indicates that this is percolating groundwater, and that this groundwater is not moving as underflow along or beneath the river.

The American River does not significantly affect or control groundwater flow in this area for the following reasons:

- The American River is very shallow compared to the depths and thicknesses of permeable zones (A, B, C, and D Aquifers) beneath the river through which groundwater is percolating.
- Groundwater modeling results and hydrogeologic data indicate that the amount of water recharged by the American River in the ARSA area is small compared to the amount of recharge from percolating rainfall and the volume of groundwater flowing into the ARSA within the A, B, C, and D Aquifers from recharge areas to the south and east.

- Groundwater levels in the underlying permeable A, B, C, and D Aquifers in areas downstream from Nimbus Dam are lower than river elevations, and separated from the river by a vertical distance as great as 30 feet or more. The vertical distance separating groundwater levels from the overlying river elevation increases toward the west, with increasing distance from Nimbus Dam.
- Similar VOC concentrations are found in groundwater on both sides of the river, including the shallowmost A Aquifer. Volatile organic compound-(VOC-) affected groundwater and flow in the deeper A Aquifer, and the B, C, and D Aquifers, are not connected to the American River.
- Results of extensive hydraulic testing in 1993-1995 associated with installation of the ARGET extraction wells support Aerojet's conclusions regarding the high permeability of the sediments in the ARGET area, the groundwater flow direction and orientation of the VOC plume across the American River, and the lack of lower permeable sediments (i.e., subterranean bed, bank, or channel features) along the American River and in the aquifers beneath the river.
- Hydraulic testing also indicated that groundwater pumped from the ARGET system is not significantly replenished by or otherwise significantly affected by water from the American River. Data indicate that pumping from even the shallowest (A Aquifer) groundwater in the ARGET area results in hydraulic responses from the corresponding A Aquifer located on the opposite side of the American River. Similar or greater hydraulic response was measured across the river from pumping from ARGET B and C Aquifer wells. These results indicate that the river does not significantly affect groundwater within any of these zones.
- Pumping of large quantities of water from municipal ACWS water supply well 17 and well 22, located within only a few hundred feet of the river, has never been reported by the SWRCB or RWQCB as having any adverse impact on the American River.

Western Aerojet Site – E/F Groundwater Extraction and Treatment (GET E/F) System

The following provides the basis for concluding that the groundwater extracted by GET E/F is not in direct connection with, or replenished by, the American River.

- The sediments comprising the shallowest Layers A and B in the GET E/F area are laterally extensive, but are not saturated throughout the area. Layer A is dry throughout most of the GET E/F area, and Layer B is only pumped by two extraction wells near the southernmost Aerojet boundary, at a combined rate of 142 gpm.
- Layer C is the shallowest layer that is extensively pumped at GET E/F. Layer C is laterally extensive and is present at depths of 150 to 200 feet bgs at GET E/F.

- The American River is located approximately 7,000 to 8,000 feet north of the closest GET E/F extraction well pumping water from Layer C. This layer is overlain by more than 100 feet of unsaturated sediments and 50 to 100 feet of saturated sediments.
- Even after more than 10 years of pumping, maps of groundwater levels show that groundwater extracted at GET E/F does not come from the direction of the American River. Furthermore, predicted groundwater water levels after expansion of GET E/F also show that extracted groundwater will not be derived from the vicinity of the American River.

Summary – Western Groundwater Operable Unit

- An anticipated total of 18 extraction wells are planned in the WGOU, to be installed in Layers C, D, and E with a combined pumping rate of approximately 4,150 gpm.
- The extraction wells will be installed at least 6,000 feet south of the American River and will pump from minimum depths of approximately 240 feet bgs. The shallowest layer (Layer C) that will be pumped by these wells is overlain by at least 30 to 40 feet of unsaturated sediments, and over 200 feet of saturated sediments. In addition, several public water supply wells located between the proposed extraction wells and the American River.
- Based on the anticipated distance from the American River, the depths of the planned WGOU extraction wells, and the presence of multiple, similarly deep public water supply wells between the American River and the WGOU, the American River will not be affected by groundwater extraction in the WGOU.

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LIST OF EXHIBITS AND ATTACHMENTS
Testimony of Thomas M. Johnson, R.G., C.Hg.
5/10/02

EXHIBITS

AGC Exhibit 1 – Testimony of Thomas M. Johnson, R.G., C.Hg.

AGC Exhibit 2 - GET Effectiveness Evaluation for the American River Study Area, Gencorp Aerojet (February 2000; ARSA GET Evaluation)

AGC Exhibit 3 - Western Groundwater Operable Unit Remedial Investigation/Feasibility Study, Gencorp Aerojet (April 2000; WGOU RI/FS)

AGC Exhibit 4 - Final Revised Engineering Evaluation and Cost Analysis for the American River Study Area, Gencorp Aerojet (September 1996; Final ARSA EE/CA)

AGC Exhibit 5 – Aerojet Site – GET E and F Effectiveness Evaluation Report, Gencorp Aerojet (April 1996; 1996 GET E/F Evaluation)

AGC Exhibit 6 – Perimeter Groundwater Operable Unit Draft Remedial Investigation/Feasibility Study (RI/FS) Work Plan, Gencorp Aerojet (April 2000; Perimeter OU RI/FS)

AGC Exhibit 7 – Groundwater Capture Zone Analysis and Modeling Simulations, American River Study Area, Rancho Cordova, California, CH2M Hill (June 1994)

ATTACHMENTS

AGC-1(a) Resume of Thomas M. Johnson, R.G., C.Hg.

AGC-1(b) Figure 1-1, Regional Location Map (AGC Exhibit 2: GET Effectiveness Evaluation for the American River Study Area, Gencorp Aerojet (February 2000; ARSA GET Evaluation)

AGC-1(c) Figure 2-1, American River GET Facility Location (AGC Exhibit 2, ARSA GET Evaluation)

AGC-1(d) Figure 3-1, Well Location Map (AGC Exhibit 2, ARSA GET Evaluation)

AGC-1(e) Figure 3-2, Hydrogeologic Cross Section A-A' (AGC Exhibit 2, ARSA GET Evaluation)

AGC-1(f) Figure 3-3, Hydrogeologic Cross Section B-B' (AGC Exhibit 2, ARSA GET Evaluation)

AGC-1(g) Figure 3-4, Hydrogeologic Cross Section C-C' (AGC Exhibit 2, ARSA GET Evaluation)

AGC-1(h) Figure 3-5, Hydrogeologic Cross Section D-D' (AGC Exhibit 2, ARSA GET Evaluation)

AGC-1(i) Figure 3-6, Hydrogeologic Cross Section E-E' (AGC Exhibit 2, ARSA GET Evaluation)

AGC-1(j) Figure 3-7, Hydrogeologic Cross Section F-F' (AGC Exhibit 2, ARSA GET Evaluation)

AGC-1(k) Table 3-1, Summary of Aquifer Test Results (AGC Exhibit 2, ARSA GET Evaluation)

AGC-1(l) Figure 2-8, Groundwater Elevation Contour Maps (feet, MSL) April 1995 (AGC Exhibit 4: Final Revised Engineering Evaluation and Cost Analysis for the American River Study Area, Gencorp Aerojet (September 1996; Final ARSA EE/CA)

AGC-1(m) Figure 2-9, Groundwater Elevation Contour Maps (feet, MSL) October 1995 (AGC Exhibit 4, Final ARSA EE/CA)

AGC-1(n) Figure D2-2, Observed Water Levels (AGC Exhibit 3: Western Groundwater Operable Unit Remedial Investigation/Feasibility Study, Gencorp Aerojet (April 2000; WGOU RI/FS)

AGC-1(o) Figure 2-14, TCE in Groundwater (ug/l) July – September 1995 (AGC Exhibit 4, Final ARSA EE/CA)

AGC-1(p) Figure 2-15, TCE in Groundwater (ug/l) October – December 1995 (AGC Exhibit 4, Final ARSA EE/CA)

AGC-1(q) ARGET Table 1, Average Flow Rates from ARGET Extraction Wells, April 2001 – April 2002, and Distance to American River

AGC-1(r) Figure 4-6, Conceptual Containment Well Locations – Alternative 4C, GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors (AGC Exhibit 3, WGOU RI/FS)

AGC-1(s) GET E/F Table 1, Current Flow Rates from GET E/F Extraction Wells and Distance to American River

AGC-1(t) GET E/F Table 2, Projected Future Pumping Rates from GET E/F Extraction Wells and Distance to American River

AGC-1(u) Figure A-4, Hydrostratigraphic Cross Section F-F' (AGC Exhibit 3, WGOU RI/FS)

AGC-1(v) Figure A-6, Hydrostratigraphic Cross Section H-H' (AGC Exhibit 3, WGOU RI/FS)

AGC-1(w) Figure A-7, Layer A – Potentiometric Surface Maps (AGC Exhibit 3, WGOU RI/FS)

AGC-1(x) Figure A-8, Layer B – Potentiometric Surface Maps (AGC Exhibit 3, WGOU RI/FS)

AGC-1(y) Figure A-9, Layer C – Potentiometric Surface Maps (AGC Exhibit 3, WGOU RI/FS)

AGC-1(z) Figure A-10, Layer D – Potentiometric Surface Maps (AGC Exhibit 3, WGOU RI/FS)

AGC-1(aa) Figure A-11, Layer E – Potentiometric Surface Maps (AGC Exhibit 3, WGOU RI/FS)

AGC-1(bb) Figure 5-11, Onsite and Offsite Capture Zones Alternative 4C (AGC Exhibit 3, WGOU RI/FS)

AGC-1(cc) WGOU Table 1, Proposed Extraction Wells, Pumping Rates and Distances from the American River

I, Thomas M. Johnson, have read the foregoing Expert Testimony of Thomas M. Johnson and know the contents thereof. The same is true of my own knowledge. My qualifications are summarized in the preceding written testimony and in the curriculum vitae attached hereto as Attachment AGC-1(a). The basis for my testimony is my academic training, general professional experience, professional experience and observations working at and around the Aerojet site, and my review of documents relating to the groundwater hydrology at and in the region of the Aerojet site, specifically including the list of references and supporting documents attached to this written testimony.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct and that this verification was executed this 9th day of May, 2002, at Elgin, IL.

Thomas M. Johnson, R.G., C.Hg.

AGC-1(a)

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Mr. Johnson is Sr. Vice President, Chief Technical Officer and Principal Hydrogeologist for LFR Levine·Fricke. He is responsible for oversight of LFR technical services, and program management of LFR's environmental contamination investigation and remediation services. He also directs the litigation consulting and expert witness services practice at LFR. Mr. Johnson has extensive expertise in hydrogeology and groundwater flow, contaminant fate and transport, and risk assessment. He is also an expert in modeling groundwater flow and contaminant transport and evaluating remedial technologies for soil and groundwater contamination.

Mr. Johnson has more than 27 years of consulting and research experience involving investigation and remediation of environmental contamination. At LFR, he has directed and managed more than 200 projects involving environmental contamination. At the Illinois State Geological Survey, prior to joining LFR, Mr. Johnson conducted research for 11 years on groundwater contamination resulting from the landfill disposal of solid wastes, hazardous chemical wastes, and low-level radioactive waste. Major areas of expertise include hydrogeology and groundwater flow-system evaluation, vadose-zone processes, environmental site investigation and remediation, computer modeling of water movement and contaminant transport, aerial photography interpretation, risk assessment, regulatory interaction, and cost allocation for environmental remediation. Mr. Johnson has published numerous papers and reports on these topics.

Mr. Johnson is on the Board of Directors of the California Groundwater Resources Association. He also served on the Board of Directors and was Board Chairman for the National Ground Water Association, Association of Ground Water Scientists and Engineers. He served for ten years on the editorial review board for the journal Groundwater Monitoring and Remediation. He has been appointed to National Academy of Sciences/National Research Council Panels to evaluate state and local groundwater protection programs for the U.S. Environmental Protection Agency, and to assess innovative technology decision-making programs for the U.S. Department of Energy. He also lectures extensively throughout the U.S. and internationally on groundwater contamination and remedial actions for various universities,

state and federal agencies, and organizations such as the National Ground Water Association. He has also been an invited instructor and lecturer at numerous seminars and workshops on environmental contamination.

His professional interests and areas of expertise include:

- groundwater flow system and water supply evaluation
- evaluation of contaminant migration resulting from disposal of hazardous chemical wastes, petroleum hydrocarbons, solid wastes, and low-level radioactive wastes
- environmental monitoring and sampling techniques
- unsaturated/vadose-zone water and vapor movement, and contaminant migration
- computer modeling of water flow, vapor movement, and contaminant migration
- remote sensing and aerial photograph interpretation
- environmental and human health risk assessment
- evaluation and implementation of remedial actions for soil and groundwater contamination
- cost evaluation and allocation for environmental remediation

EDUCATION

Ph.D. program (Non-Degree ABD), Geology, University of Illinois, Urbana-Champaign, 1976-1986

M.S., Geology, University of Wisconsin, Madison, 1976

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"Environmental Sampling Techniques: Implications for Cost Allocation Litigation," Los Angeles County Bar Association, Environmental Law Section Seminar, Los Angeles, California.

"Litigation and Expert Witness Services," Groundwater Resources Association of California, Oakland, California.

"Environmental Remediation: New Technologies and Old Limitations," Purdue University School of Civil Engineering and the Environmental Science and Engineering Institute (ESEI) at Purdue, West Lafayette, Indiana.

"Innovative In Situ Environmental Remediation Technologies: Recent Developments." Keynote Address at Groundwater Studies, Tools, and Technology Symposium, Groundwater Division of The Water Management Association of Ohio, Columbus, Ohio.

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"The Role of the Expert Witness in Environmental Litigation," Florida Air and Waste Management Association Annual Meeting, Sandestin, Florida.

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"Site Assessment and Remediation," University of California at Berkeley - Extension, Continuing Course Series.

"Unsaturated Zone Monitoring and Remedial Actions," University of California at Davis - Extension, Continuing Course Series.

"Corrective Actions for Containing and Controlling Groundwater Contamination," National Ground Water Association, Continuing Course Series.

"Theory and Practice of Groundwater Monitoring and Sampling," National Groundwater Association, Continuing Short Course Series.

"Groundwater Pollution Remedial Actions," University of California at Davis Extension, Continuing Seminar Series.

"Groundwater Monitoring," U.S. EPA seminar: Transport of Viruses and Organics in the Subsurface, Ada, Oklahoma.

"Geologic Considerations in Hazardous Waste Disposal," Univ. of Wisconsin-Extension, Dept. of Engineering: Hazardous Waste Management Practices Institute, Madison, Wisconsin.

"Monitoring the Unsaturated Zone," Conference on Environmental Monitoring, sponsored by Geraghty and Miller, Inc., Arlington, Virginia.

"Groundwater Monitoring for Landfills," Univ. of Wisconsin-Extension, Dept. of Engineering: Sanitary Landfill Site Selection and Design Institute, Madison, Wisconsin.

"Interpretation of Groundwater Monitoring Data Collected in the Vicinity of Landfills" and "Monitoring in the Unsaturated Zone," National Council of the Paper Industry for Air and Stream Improvement, Technical Workshop: Groundwater Quality Monitoring at Land Disposal Sites, Chicago, Illinois.

"Groundwater Contamination -- Remedial Actions," University of Wisconsin-Extension, Dept. of Engineering: Groundwater Quality Protection Institute, Madison, Wisconsin.

"Field Investigative Procedures and Remedial Measures Related to Groundwater Contamination," Univ. of Wisconsin-Extension, Dept. of Engineering: Seminar for Wisconsin Department of Natural Resources, Madison, Wisconsin.

"Modeling of Moisture Movement Through Covers Designed to Limit Infiltration at Waste Disposal Sites," U.S. Nuclear Regulatory Commission, Symposium on Low-Level Radioactive Waste Disposal, Washington, DC.

"Waste Disposal and Groundwater Contamination," Minnesota Groundwater Association, Minneapolis, Minnesota.

"Hydrogeologic Investigations of Failure Mechanisms and Migration of Organic Chemicals at Wilsonville, Illinois," National Ground Water Association, National Symposium on Aquifer Restoration and Ground Water Monitoring, Columbus, Ohio.

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FIGURES

AGC-1(b) to AGC-1(bb)

(SEE HARD COPIES)

AGC Exhibit 2, "GET Effectiveness Evaluation For the American River Study Area", February 2000, not scanned.

See SCWC Exhibit 18

Western GW
SACTO.22
OU RI/FS

California Regional Water Quality Control Board
Central Valley Region

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ENVIRONMENTAL OPERATIONS

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TRANSMITTAL OF THE REVISED WESTERN GROUNDWATER OPERABLE UNIT, REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS), EXECUTIVE SUMMARY, SECTION 1 AND APPENDIX B, AEROJET-GENERAL CORPORATION

This letter represents a joint agency response on behalf of the United States Environmental Protection Agency, California Regional Water Quality Control Board (RWQCB) and California Department of Toxic Substances Control (DTSC) accepting the Transmittal of the Revised Western Groundwater Operable Unit Remedial Investigation/Feasibility Study (RI/FS) – Executive Summary, Section 1 and Appendix B submitted by Aerojet's letter of 3 October 2000. This joint agency acceptance completes Aerojet's obligations for Step 3, Phase II RI/FS for the Western Groundwater Operable Unit. We look forward to receiving the Alternate Water Supply Contingency Plan as described in the RWQCB's letter to Aerojet of 13 June 2000.

The final Western Groundwater Operable Unit (OU-3) RI/FS consists of the 17 April 2000 submission with Aerojet's 10 October 2000 replacement Executive Summary, Section 1 and Appendix B, and the Agencies' 29 September 2000 Addendum. The Agencies' addendum pages provide the public with points of clarification and modification in the areas of disagreement between the Agencies and Aerojet. A copy of the Agencies' addendum is attached for your files and also being provided by the RWQCB to those whom they have provided copies of the RI/FS, as well as, the Sacramento State University Library.

If you have any questions regarding this matter, please call me at (916) 255-3025 or Mr. Charles Berrey of USEPA at (415) 744-2223 or Mr. Ed Cargile of DTSC at 255-3703.

ALEXANDER MACDONALD
Senior Engineer

cc: Mr. Charles Berrey, USEPA Region IX, San Francisco
Mr. Ed Cargile, DTSC, Sacramento

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Addendum Cover Page 9/26/00

The regulatory agencies, United States Environmental Protection Agency (USEPA), Central Valley Regional Water Quality Control Board (RWQCB), and Department of Toxic Substances Control (DTSC), have made additions to this Remedial Investigation/Feasibility Study (RI/FS) developed by Aerojet. Those additions are found in pages inserted in the beginning of each appropriate section of the report. The added pages are considered an addendum to the report. The original RI/FS, the addendum, and the attached comments from the regulatory agencies constitute the final approved report and will be used as the basis by USEPA for preparing the draft Proposed Plan.

In addition, the Partial Consent Decree requires the completion of a Phase II RI/FS report for the entire Aerojet site. For the portion of the site within the Western Groundwater Operable Unit, this Final RI/FS completes Aerojet's obligation for a Phase II RI/FS. Additional RI type activities may be necessary during the design and implementation phases of the remedial action for the Western Groundwater Operable Unit, as well as, investigation of adjacent operable units.

Western Groundwater Operable Unit
Remedial Investigation/Feasibility Study

April 17, 2000

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List of Acronyms

ac ft	acre foot of water
ACWS	Arden Cordova Water Company
AFB	Air Force Base
ARAR	applicable or relevant and appropriate requirement
ARGET	American River groundwater extraction and treatment system
ATSDR	Agency for Toxic Substances Disease Registry
Basin Plan	Water Quality Control Plan for the Sacramento and San Joaquin River Basins
bgs	below the ground surface
BRA	Baseline Risk Assessment
Cal-EPA	California Environmental Protection Agency
CAO	Cleanup and Abatement Order
CatOx	catalytic oxidation
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (as amended)
CFR	Code of Federal Regulations
CoPC	contaminant of potential concern
DAA	detailed analysis of alternatives
DCA	dichloroethane
DCE	dichloroethene
DHS	California Department of Health Services
DNAPL	dense non-aqueous phase liquid
DTSC	California Department of Toxic Substances Control
ea	each
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ESD	explanation of significant difference
Freon-11	trichlorofluoromethane
Freon-113	1,1,2-trichloro-1,2,2-trifluoroethane
Freon-12	dichlorodifluoromethane
FS	Feasibility Study
ft	feet
FTE	Full-time equivalent
ft/year	feet per year
GAC	granular activated carbon
gpm	gallons per minute
GWTP	groundwater treatment plant
hp	horsepower
kW	kilowatt
I&C	instrumentation and controls
lin ft	lineal feet
LPGAC	liquid-phase granular activated carbon

List of Acronyms (continued)

LS	lump sum
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	method detection limit
MGD	million gallons per day
ug/L	micrograms per liter
MNA	monitored natural attenuation
msl	mean sea level
NCP	National Contingency Plan
NDMA	n-nitrosodimethylamine
NPL	National Priorities List
O&M	operation and maintenance
OBPA	10, 10'-oxybisphenoxarsine
OU	Operable Unit
PCD	Partial Consent Decree
PCE	tetrachloroethene
PQL	Practical quantitation limit
PRAG	Preliminary Remedial Action Goal
PVC	polyvinyl chloride
RAO	remedial action objectives
RCRA	Resource Conservation and Recovery Act of 1976 (as amended)
RfD	reference dose
RI	Remedial Investigation
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
scfm	Standard cubic feet per minute
SCWC	Southern California Water Company
SDWA	Safe Drinking Water Act
SMAQMD	Sacramento Metropolitan Air Quality Management District
TBC	To-be-considered criteria
TCA	Trichloroethane
TCE	Trichloroethene
TDH	total dynamic head
USGS	U. S. Geological Survey
UTL	upper tolerance limit
VPGAC	vapor-phase granular activated carbon
VOC	volatile organic compound
w	watt
WQO	Water Quality Objectives

Executive Summary Addendum 9/26/00

Pages ES-4 and ES-5, Summary of Baseline Risk Assessment. The RI/FS presents information on risks and discusses a " EPA's acceptable risk range of 10^{-6} to 10^{-4}." It should not be construed that a calculated risk within that risk range will not require remedial action. Risks less than 10^{-6} are acceptable and would likely not require remedial action. Estimated risks that are greater than 10^{-6} but less than 10^{-4} are further evaluated to determine if appropriate remedial action is necessary. Applicable, Relevant and Appropriate Requirements (ARARs) and other criteria are used to establish whether remedial action is necessary regardless of the estimated risk calculated in the Baseline Risk Assessment.

Page ES-9, Compliance with ARARs. It is the opinion of the Regional Board staff that Alternatives 1, 2A and 2B do not comply with all ARARs. Specifically, those alternatives do not comply with the requirements of State Water Resources Control Board Resolution No. 92-49 and the Water Quality Control Plan for the Sacramento and San Joaquin River Basins (Basin Plan).

Page ES-14, Cost. The EPA used the groundwater model developed for the RI/FS to project a completion date for Alternatives 3A through 5B which meet the remedy threshold criteria. All the remedies with current technology are estimated to take hundreds of years to achieve Remedial Action Objectives (RAOs). Based on the time to RAOs EPA's guidance requires a 30 year total present worth cost analysis and suggests a total non-discount cost analysis which estimates the cost of the remedy funded yearly until RAOs are achieved. These estimates are provided in the insert for Appendix E.

EXECUTIVE SUMMARY

This executive summary presents the purpose and scope of this Operable Unit Remedial Investigation/Feasibility Study (OU RI/FS) for the Western Groundwater Operable Unit Study Area and provides summaries of the remedial investigation, baseline risk assessment, and feasibility study.

ES-1 Purpose and Scope

The Remedial Investigation/Feasibility Study (RI/FS) process is the methodology that the Superfund program has established for characterizing the nature and extent of risks posed by contaminated sites (i.e., the remedial investigation) and for evaluating potential remedial options for addressing those risks (i.e., the feasibility study). The purpose of this OU RI/FS is to perform the RI for the Western Groundwater OU Study Area (Figure ES-1) and to prepare an FS that evaluates remedial alternatives for addressing contaminants of potential concern (CoPCs) in groundwater in the Study Area.

In June 1989, Aerojet entered into a Partial Consent Decree (PCD) which requires the completion of an RI/FS for the Aerojet Sacramento site. Pursuant to the PCD, Aerojet has completed a substantial portion of the Phase I RI/FS. This Western Offsite OU RI/FS is submitted as part of the RI/FS pursuant to the PCD and focuses on an operable unit; namely, the Western Groundwater Area. This Western Groundwater OU RI/FS also meets the requirements of the California Regional Water Quality Control Board (RWQCB) Cleanup and Abatement Order (CAO) No. 96-259 to the extent applicable.

The scope of this OU RI/FS can be described as follows:

- Perform the RI for the Study Area to characterize subsurface conditions and the nature and extent of CoPCs in groundwater;
- Prepare a Baseline Risk Assessment (BRA) to identify any potential risks that may be posed to human health and the environment by CoPCs in groundwater in the Study Area; and
- Prepare an FS by developing and evaluating a range of remedial alternatives that provides for protection of human health and the environment, and that considers technical, institutional, and cost considerations in accordance with CERCLA and the NCP so that relevant information regarding the remedial alternatives can be presented to a decision-maker and an appropriate remedy can be selected for groundwater.

ES-2 Summary of Remedial Investigation

The Western Groundwater Study Area encompasses the western portion of the Aerojet Operating Plant, the northwestern corner of the Inactive Rancho Cordova Test Site (IRCTS), the Aerojet-owned land west of the IRCTS, and approximately 10 square miles of commercially and residentially developed areas to the west of the Aerojet Operating Plant in the community of Rancho Cordova (Figure 1-1). The entire Study Area measures approximately 15 square miles.

Historical operations on the Aerojet Site have resulted in the release of CoPCs to soil and groundwater. VOCs (primarily TCE) and perchlorate have been detected in soil and groundwater beneath a number of these source areas. NDMA, which was known to exist on the east side of Aerojet, was more recently detected in groundwater on the west side of the Aerojet Site. Sources of VOCs, perchlorate and NDMA may exist offsite due to activities not associated with the Aerojet facility. Chlorinated solvents, including TCE, were commonly used by different industries. Perchlorate appears to have been and nitrate is a common constituent of fertilizers. NDMA appears to be associated with various industrial and food processing industries and has been a contaminant in foods.

On the western half of the Aerojet Site, groundwater flows generally to the west-southwest through a complex, heterogeneous aquifer. The aquifer has been subdivided into hydrostratigraphic Layers A through E based on similar lithologic and hydrogeologic properties. These hydrostratigraphic layers are generally tabular bodies that increase in depth and thickness from east to west across the Study Area.

Since the mid- to late-1980s, CoPCs in groundwater flowing west from the source areas on the Aerojet Site were intercepted by two interim perimeter groundwater extraction and treatment (GET) facilities, "GETs E and F". GETs E and F captured and treated groundwater for VOCs at northwestern and southwestern locations along the perimeter of the Aerojet Site, respectively. A series of recharge wells installed in the center of the western perimeter of the Aerojet Site provided a hydraulic barrier to direct CoPCs towards the extraction wells. The recharge water contained perchlorate, and, in early 1998 using an improved analytical method, NDMA was detected in the water extracted and recharged at GET E. Treated groundwater from two of the GET F extraction wells was initially discharged after VOCs were removed via a sprayfield located on the northwestern corner of the IRCTS for a period of approximately 6 years. The treated groundwater discharged to the former sprayfield has percolated into Layers B and C beneath the northwestern corner of the IRCTS and formed a plume of perchlorate - impacted groundwater flowing to the west-southwest.

A biological reduction treatment system was added to GET F to remove perchlorate from groundwater in December 1998. The biological perchlorate removal system consists of four fluidized bed reactors each designed to treat 900 gallons per minute (gpm). During the first six months of operation, Aerojet experienced problems controlling the bed height

in one of the two operating reactors. A series of tests were run in the Summer and early Fall of 1999 to control the growth rate of filamentous bacteria that were causing the bed height growth. Bed height growth rates were controlled during these tests and each of the fluidized bed reactors achieved non-detect perchlorate effluent concentrations at full-scale operation between October and November 1999 (Harding Lawson Associates, 2000 pending). Aerojet is continuing to monitor and optimize the operation of the fluidized bed reactors.

In August 1999, Aerojet combined the GET E and F treatment facilities so that groundwater extracted from both GET E and F undergo the same treatment processes. At the same time, ultraviolet (UV)/oxidation was added to the GET E/F treatment train to remove NDMA. The NDMA removal system is designed to treat NDMA to 0.002 µg/L. On September 26, 1999, the NDMA concentration in the combined GET E/F effluent was below the NDMA method detection limit of 0.0075 µg/L.

The majority of perchlorate and NDMA offsite is present in Layers C and D, although some upward and downward migration into Layers B and E, respectively, has occurred near the western perimeter of the Aerojet Site. The perchlorate in Layer C has been detected up to 9,000 feet west of the western Aerojet property boundary. An area of groundwater containing TCE and NDMA is present in Layers C and D northwest of the Aerojet Site. The TCE and NDMA in this area may have been present before GET E began operating, may represent uncaptured groundwater flowing north of GET E, or may be from offsite non-Aerojet sources identified northeast of the intersection of Sunrise and Folsom Boulevards.

ES-3 Summary of Baseline Risk Assessment

A Baseline Risk Assessment (BRA) was prepared for the Western Groundwater Study Area. The purpose of the BRA was to evaluate potential site-specific human health risks associated with hypothetical exposure to chemicals detected in groundwater in the Study Area. Specifically, chemical propellants and solvents have been detected in groundwater samples collected from on- and offsite wells. At the direction of EPA Region IX, a CoPC screening was not conducted for this BRA, and all organic chemicals, as well as perchlorate, NDMA, nitrate, and nitrite were retained as CoPCs.

The risk assessment was conducted assuming that through use of private domestic water supply wells, future residents could potentially contact groundwater containing these chemicals. For purposes of the risk assessment, it was assumed that the groundwater that could be contacted by potential future residents would contain the same concentrations as those detected in the current offsite groundwater plume.

The risk assessment evaluated onsite risk of exposure, although no exposure to groundwater onsite currently exists. Future onsite exposures were evaluated assuming that individual residents or public or private water purveyors could install private wells for domestic potable water supply.

The risk assessment also evaluated risk of offsite exposure. Offsite groundwater is currently used by water purveyors for residential supply. No water containing CoPCs above drinking water standards is currently served. Potential exposure to CoPCs through contact with offsite groundwater supplied by the various water purveyors is assessed by water quality monitoring pursuant to the Exhibit IV monitoring plan of the PCD. The water purveyors, in conjunction with the California DHS, determine when a water supply well should be taken out of service. Private wells also exist in the offsite areas, although most are used for industrial or agricultural purposes, not for domestic (potable) water supply. Future use of offsite groundwater was evaluated assuming individual public or private water supply wells may be installed in the plume area.

Calculated risks associated with potential future use of groundwater that might be obtained from each of the hydrostratigraphic layers beneath the onsite area were developed as part of the risk characterization effort.

Calculated risks for the onsite and offsite areas were compared to EPA's acceptable risk ranges of 10^{-6} to 10^{-4} for potential additional lifetime cancer risk and/or a hazard index greater than one for non-carcinogenic effects.

Onsite CoPCs. In summary, the acceptable risk range for carcinogenic effects on-site were exceeded by 1,2-DCA in Layers A and C; chloroform in Layers A, B, C, and D; 1,1-DCE in Layers B, C, and D; TCE in Layers B, C, D, and E; and NDMA in Layers A, B, C, D and E. Comparison of the calculated risk to the hazard indices indicates that a hazard index of one was exceeded by 1,2-DCA, chloroform, TCE, perchlorate, nitrate, and nitrite in Layer A; 1,1-DCE, 1,2-DCE, chloroform, TCE, and perchlorate in Layer B; 1,1-DCE, 1,2-DCA, chloroform, TCE, and perchlorate in Layer C; chloroform, TCE and perchlorate in Layer D; and TCE and perchlorate in Layer E. Additional chemicals retained as CoPCs for the on-site areas included 1,1,2-TCA, 1,1-DCA, PCE, carbon tetrachloride, Freon-113, and nitrite.

Offsite CoPCs. Layers A and B on-site are not hydraulically connected with Layers A and B off-site and there are no known off-site chemical impacts related to the Aerojet Site in these layers. In summary, the acceptable risk range for carcinogenic effects off-site were exceeded by NDMA in Layers C and D, and TCE in Layer E. Comparison of the calculated risk to the hazard indices indicates that a hazard index of one was exceeded by chloroform, TCE, and perchlorate in Layer C, and perchlorate in Layers D and E. Additional chemicals retained as CoPCs for the off-site areas included: 1,1-DCE, 1,2-DCE, 1,2-DCA, vinyl chloride, nitrate, and nitrite.

ES-4 Summary of Feasibility Study

The FS serves as the mechanism for the development, screening, and detailed evaluation of alternative remedial actions. The development of alternatives requires identifying remedial action objectives (RAOs); identifying technologies that will satisfy these

objectives; screening the technologies based on their effectiveness, implementability, and cost; and assembling technologies into OU-wide alternatives to address the contaminated medium (in the case of this FS, groundwater). Following development of the OU-wide alternatives, the alternatives may be screened to reduce the number of alternatives analyzed in detail. After screening, alternatives are evaluated in detail with respect to nine evaluation criteria that EPA has developed to address the statutory requirements and preferences of CERCLA. The alternatives are analyzed individually against each of the criterion and then compared against one another to determine their respective strengths and weaknesses and to identify the key tradeoffs that must be balanced for the Site. The results of the detailed analysis are summarized and presented to the decision-maker so that an appropriate remedy consistent with CERCLA can be selected.

The initial step in identifying and screening remedial alternatives is to formulate RAOs. RAOs are media-specific goals designed to protect human health and the environment. RAOs specify the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of alternatives to be developed on the basis of chemical-specific applicable or relevant and appropriate requirements (ARARs) and site-specific risk-related factors. The overall goal of any remedial alternative is to protect human health and the environment. In order to achieve this goal for the Western Groundwater Study Area, the following RAOs were developed:

- Protect human health and the environment from exposure to contaminated groundwater;
- Minimize offsite migration of CoPCs where practicable to protect long term beneficial uses;
- Reduce contaminant concentrations in already contaminated groundwater in an efficient cost-effective manner; and
- Protect public drinking water wells and provide treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels.

A range of technologies to address these RAOs for the Western Groundwater Study Area were identified and screened. These technologies consisted of various institutional controls, replacement or substitute water supplies, and groundwater extraction, treatment, and treated water management/reuse options. The technologies that survived the screening process were developed into ten remedial alternatives for the OU. These alternatives were evaluated in detail with respect to the CERCLA evaluation criteria and are described below.

- Alternative 1 - No Action with Limited Groundwater Monitoring

This alternative serves as the baseline for comparison of the other alternatives. The existing GETs E and F system would be terminated and there would be no active remediation of groundwater offsite.

- Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

  This alternative assumes continued migration of the offsite CoPC plume, shutdown of downgradient public water supply wells, and replacement of affected water supply capacity through an alternative water supply.

- Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

  Alternative 2B is the same as 2A except the onsite GETs E/F recharge field would be replaced with extraction wells.

- Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

  This alternative assumes continued migration of the offsite CoPC plume, and providing wellhead treatment on those existing water supply wells that may become affected by the CoPC plume over time.

- Alternative 3B –GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

  Alternative 3B is the same as 3A except the onsite GETs E/F recharge field would be replaced with extraction wells.

- Alternative 4A – GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

  Alternative 4A would establish an offsite hydraulic barrier of extraction wells, intended to contain the offsite plume and prevent further migration of CoPCs downgradient of the barrier in concentrations that would impair beneficial uses of the groundwater.

- Alternative 4B – GETs E and F Extraction Wells with Offsite Extraction Wells

  Alternative 4B is the same as 4A except the onsite GETs E/F recharge field would be replaced with extraction wells.

- Alternative 4C – GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors

  Alternative 4C is the same as 4B except Alternative 4C would also incorporate "multiple containment corridors" by including installation of new extraction wells closer to the estimated leading edge location of the CoPC plume in the D and E layers sooner than planned for the other alternatives.

- Alternative 5A – GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

  Alternative 5A would also provide containment of the offsite CoPC plume using a combination of new extraction and recharge wells to provide hydraulic containment.

- Alternative 5B – GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

  Alternative 5B is the same as 5A except the onsite GETs E/F recharge field would be replaced with extraction wells.

All alternatives include groundwater monitoring. All Alternatives, except Alternative 1 (No Action), involve operation of the existing GETs E and F onsite boundary containment/source control systems and assume that institutional controls would eliminate the pathway by which persons could be exposed to contaminated drinking water. These institutional controls include (1) DHS's enforcement of drinking water regulations requiring water purveyors to take action to monitor and shut down water supply wells that they or DHS consider to be inappropriate for service to customers, and (2) the proposed Consultation Zone provision to the Sacramento County comprehensive well ordinance which will provide Agency oversight of monitor and supply well drilling and use in the Study Area.

Each of Alternatives 2 though 5 include an "A" and "B" alternative (e.g., Alternative 2A and Alternative 2B) for purposes of evaluating continued use of the GETs E and F recharge wells. Alternative 4 also includes a "C" alternative. Each of the "A" alternatives involves continued operation of the GETs E and F recharge wells. Each of the "B" and "C" alternatives involves shut down of the recharge wells and installation of additional extraction wells to maintain onsite capture.

In addition, each of the "A", "B" and "C" alternatives assume that additional extraction wells will be added to the existing GETs E/F extraction system to enhance capture. A potential mechanism that could be used for early implementation of these modifications would be the material modification provision within Exhibit VI of the PCD. The modifications would involve additional extraction wells and optimization of extraction rates from existing GETs E/F extraction wells.

The conceptual design of each of the remedial alternatives was based on the results of a numerical groundwater flow model. This model was also used to assist in evaluating the alternatives with respect to the various evaluation criteria. The model was based on the final site conceptual model as presented in Section 1. Simulated groundwater flow and advective migration of dissolved CoPCs were used to compare and contrast the relative merits of each of the remedial alternatives.

The alternatives were individually analyzed against each of the CERCLA evaluation criteria and then compared against one another to determine their respective strengths and

weaknesses and to identify key tradeoffs. The evaluation criteria are categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria. Threshold criteria are requirements that each alternative must meet to be eligible for selection as the preferred alternative, and include overall protection of human health and the environment and compliance with ARARs (unless a waiver is obtained). Primary balancing criteria are used to weigh effectiveness and cost tradeoffs among alternatives. The primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. Modifying criteria, which include State acceptance and community acceptance, may be used to modify aspects of the preferred alternative when the Proposed Plan is prepared, and are generally evaluated after public comment on the OU RI/FS and the Proposed Plan. Accordingly, only the seven threshold and primary balancing criteria were used in the detailed analysis phase. The results of the detailed analysis are as follows:

Overall Protection of Human Health and the Environment

Alternative 1, which assumes no onsite or offsite containment of the CoPC plumes and no institutional controls, does not provide adequate protection to human health, as exposure to contaminated groundwater would not be prevented. Each of the remaining alternatives include actions that break the pathway through which contaminated groundwater would be supplied for potable use. First, each of the Alternatives 2A through 5B involve operation of GETs E and F at the Aerojet facility boundary, thereby establishing a hydraulic boundary to minimize the risk of the offsite migration of CoPCs. Second, Alternatives 2A through 5B eliminate exposure to unacceptable concentrations of CoPCs through various management options. Alternatives 2A and 2B involve replacement water supplies, Alternatives 3A and 3B include point of use treatment, and Alternatives 4 and 5 involve a hydraulic barrier.

Alternatives 2A and 2B do not prevent the continued migration of CoPCs already offsite and are not protective of the environment in the near-term. Each of Alternatives 3A through 5B involves offsite extraction intended to minimize CoPC migration and protect the environment.

The treated water management/reuse option selected will also be protective of human health and the environment for all alternatives. If wellhead treatment is utilized in all or a portion of the selected remedy, the treated water must meet DHS requirements for a drinking water source. Similarly, if direct reuse of treated groundwater is selected under Alternatives 4A through 5B, the treated water must comply with DHS requirements. Alternatives 4A through 5B must also be protective of the environment if recharge or surface water discharge are selected as treated water management options. This protection will be afforded through the NPDES permitting process for surface water discharge or treatment plant effluent requirements for recharge.

Alternatives 3A through 5B are sufficiently protective of public health and the environment with respect to this threshold criteria.

Compliance with ARARs

Compliance with ARARs also serves as a threshold criterion that must be met by any alternative for it to be selected as a remedy, unless an ARARs waiver is obtained. Each alternative, except Alternative 1 (No Action), has the potential to comply with ARARs.

Chemical-specific ARARs (e.g., MCLs) will be met by Alternatives 3A through 5B, since under each such alternative, impacted groundwater located both on the Aerojet facility and offsite will be treated to concentrations that meet chemical-specific ARARs prior to management/reuse. Alternatives 2A and 2B, which do not include offsite engineered groundwater controls, are less likely to achieve chemical-specific ARARs for offsite groundwater within the short term. However, they have the potential to eventually comply with ARARs through institutional controls, the operation of the GETs E/F extraction and treatment system, and natural attenuation.

Location- and action-specific ARARs do not apply to Alternative 1, the No-Action alternative. The groundwater extraction, conveyance, treatment, and treated groundwater management/reuse systems variously described under Alternatives 3A through 5B can be designed and operated to comply with all location- and action-specific ARARs.

Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence is a measure of the magnitude of residual risk and the adequacy and reliability of controls.

The Alternative 4 and 5 series would appear to provide greater long-term effectiveness and permanence than the remaining alternatives, with the Alternative 4 series, and particularly 4B, providing the greatest potential for long-term effectiveness and permanence.

Alternative 4C may be less effective at maintaining hydraulic capture than Alternatives 4A and B, and 5A and B. Under Alternative 4C, extraction wells are located in Layers D and E between the Aerojet Site and the offsite hydraulic barrier in Layer C. These extraction wells will decrease the head potential in Layers D and E and may cause the downward migration of CoPCs from Layer C into Layers D and E. If this occurs, some CoPCs located beyond the influence of the extraction wells in Layers D and E will not be captured. The CoPC concentrations are generally an order of magnitude greater in Layer C than in Layers D and E.

The Alternative 4 and 5 series are intended to minimize the migration of CoPCs by establishing onsite and offsite barriers. These barriers will permanently remove and treat

CoPCs from affected groundwater, thereby reducing the long-term potential for exposure to CoPCs in offsite groundwater. The potential long-term effectiveness and permanence of the Alternative 4 and 5 series is greater than that for the Alternatives 2 and 3 series because Alternatives 2 and 3 are not specifically designed to remove CoPCs in the offsite areas. It is difficult to accurately predict how far the CoPCs will migrate under Alternatives 2 and 3. However, Alternative 3 does provide a greater degree of long-term effectiveness than Alternative 2 because groundwater modeling indicates that a substantial portion of the offsite CoPCs would be permanently removed and treated through the use of wellhead treatment.

Among the "A", "B" and "C" alternatives, the "B" and "C" alternatives appear to provide the greatest potential to effectively control the migration of CoPCs. Replacing the recharge wells with extraction wells at the western Aerojet boundary enables the "B" and "C" alternatives to remove a greater portion of the CoPCs present in Layers C, D, and E before they migrate offsite. In addition, by eliminating recharge, the "B" and "C" alternatives reduce the total amount of water that must be contained by an offsite hydraulic barrier, thereby increasing the potential effectiveness of the offsite barrier system. Similarly, the Alternative 4 series has a greater potential for long-term effectiveness than the Alternative 5 series because hydraulic control using only extraction is more attainable than achieving hydraulic control using both extraction and recharge.

The Alternative 4 and 5 series involve more remediation and removal of the offsite portions of the CoPCs than the remaining alternatives, although Alternatives 3A and 3B will remove a substantial portion of the offsite CoPCs. Therefore, the Alternative 4 and 5 series probably have the greatest potential to eventually restore the aquifer to beneficial uses and reduce the magnitude of residual risk. However, given the complexity and heterogeneity of the aquifer system and the unknown fate and transport characteristics of some of the CoPCs (i.e., perchlorate and NDMA), there is no realistic basis for evaluating the extent to which aquifer restoration will occur and over what period of time.

Reduction in Toxicity, Mobility, or Volume through Treatment

This criterion is a measure of the statutory preference for treatment as a principal element; irreversibility of treatment; type and quantity of treatment residual; amount of hazardous material destroyed or treated; and reduction in toxicity, mobility, or volume.

With respect to offsite CoPCs, except for Alternative 2, each of the alternatives involves management of contaminated groundwater that will achieve reduction in toxicity, mobility or volume through treatment. The remaining alternatives are equal in their preference for treatment and the irreversibility of treatment processes.

Alternatives 4 and 5 include both onsite and offsite hydraulic boundaries and therefore would be expected to provide greater reduction in toxicity, mobility and volume of the offsite CoPCs than Alternatives 2 and 3, which are not designed to do so (although Alternative 3 does provide containment). Among the "A", "B" and "C" alternatives, the

"B" and "C" alternatives would be expected to provide a greater reduction in mobility of CoPCs in the offsite plume than the "A" alternatives because they would not include recharge of the GETs E/F treated groundwater.

Groundwater would be treated using various processes that are irreversible. No residuals are associated with UV/oxidation treatment because contaminants are destroyed. Air strippers produce VOCs in offgas that may require treatment prior to being emitted to the atmosphere. LPGAC does not destroy contaminants but rather collects VOCs within a carbon vessel. The carbon will periodically require regeneration and offsite treatment or disposal. The groundwater treatment component of Alternatives 3A through 5B meets the statutory preference for treatment to reduce the principal threat because contaminants are destroyed or collected and the total volume of contaminated media is reduced.

The groundwater flow model was used as a basis for comparing the relative amount of the plume area that would be removed by each alternative involving groundwater extraction (i.e., Alternatives 3A through 5B) over the 25-year FS evaluation period. The percent of plume area removed in Layer C ranges from 52 to 87 percent with Alternative 3B removing the least and Alternative 4A providing the most amount of removal. The alternatives involving an offsite hydraulic barrier and continued recharge of GETs E/F treated groundwater (i.e., Alternatives 4A and 5A) remove the greatest amount of plume area over the 25-year evaluation period because of the increased hydraulic gradients caused by recharge. The plume areas estimated to be removed in Layer D are similar for all alternatives, ranging from approximately 68 to 77 percent. The amount of plume area removed in Layer E has the greatest variability of all layers, ranging from 21 to 91 percent. The modeling indicates that Alternative 3B would remove more plume area from Layer E (91%) than any of the other alternatives because several water supply wells located closest to the Aerojet Site are screened in Layer E. Alternatives 5A and 4A would remove the least amount of plume in Layer E because recharge is continued and portions of the plume in Layer E on the west side of the Aerojet Site are not captured until they reach the offsite hydraulic barrier. Layer E comprises only 9 percent of the total plume area, so hydraulic capture of Layer E may not be a significant benefit.

The modeling indicates that Alternatives 3A and 3B would remove the least amount of the total plume area because they rely on existing water supply wells that are not optimally located for CoPC plume removal. Alternatives 4A through 5B are projected to remove between 68 and 77 percent of the total plume area over 25 years. The approximate 13 percent difference among the alternatives modeled to remove the greatest amount (4A) and least amount (5B) of plume areas is within the range of variability of the model, and suggests that plume area removal is similar for each alternative.

Short-Term Effectiveness

Short-term effectiveness is a measure of the protection afforded by each alternative during the construction and implementation process. As such, the time until remedial

response objectives are achieved is an important component of this criterion. The availability of equipment and specialists to implement the alternative is also a consideration. This criterion is typically of greater significance for source control measures. Here, all of the alternatives (except No Action) involve onsite and most involve an offsite response action. Under all alternatives, the community and the environment would be protected from potential exposure to CoPCs through existing institutional controls (i.e., DHS drinking water standards).

All remaining alternatives protect offsite human health and the beneficial uses of the aquifer by minimizing the offsite CoPC migration. Alternatives 3A through 5B involve both onsite and offsite groundwater extraction, and are more protective than Alternatives 2A and 2B that rely on natural processes to reduce CoPC concentrations already offsite. Each of the "B" alternatives and Alternative 4C may be more protective than the "A" alternatives because treated groundwater is not recharged. The complex hydrostratigraphy and uneven lateral and vertical contaminant distribution in the Study Area necessitates that some CoPCs will migrate through unaffected portions of the aquifer prior to reaching the extraction or water supply wells. Alternative 4C involves the most aggressive offsite groundwater extraction and will intercept CoPCs in portions of Layers D and E earlier than the other alternatives. The earlier extraction from Layers D and E is unlikely to effect the beneficial use of the aquifer because, until the CoPCs in Layer C are removed, public water supply wells cannot be installed in Layers D and E due to the potential for the downward migration of CoPCs from Layer C into the supply well. Layer C contains the greatest areal extent and highest CoPC concentrations and will likely have the most impact on beneficial use.

The time required to implement Alternatives 2 and 3 would be shorter than Alternatives 4 and 5, because Alternative 2 would not require substantial offsite construction. Alternative 3 would be implemented on a phased basis as public water supply wells become affected. Alternatives 4 and 5 would require significantly more planning, design, and construction activities for the offsite hydraulic containment components. Alternative 4C would probably require the greatest amount of time to implement because it would involve securing the easements and right-of-way access for two offsite pipeline corridors instead of one.

Several of the alternatives involve extraction of groundwater to achieve containment or collection and therefore have the potential to impact the operation of existing or possible future groundwater supply wells. The maximum water level drawdowns estimated to be observed in water supply wells located in the vicinity of the intersection of Zinfandel Drive and U.S. Highway 50 as a result of implementation of Alternatives 4A through 5B are approximately 35 feet or less. This is not expected to have any significant impact on the aquifer.

It is anticipated that the necessary equipment and specialists are available to implement all alternatives.

It is not technically feasible to estimate the time required to meet the RAO of reducing CoPC concentrations in already contaminated portions of the groundwater due to the aquifer and contaminant distribution complexities discussed throughout this FS. However, it may be useful to compare the amount of plume area modeled to be removed during the 25-year evaluation period among the alternatives for a relative comparison of time. The alternatives modeled to remove the greatest plume area can reasonably be expected to achieve this RAO more quickly than the other alternatives. As discussed in Sections 5 and 6.2.2, Alternatives 4A through 5B are projected to remove between 68 and 77 percent of the total plume area over 25 years. The 13 percent difference in estimated plume area removed among the alternatives is probably insignificant for a remedial action that may be implemented for the Western Groundwater OU. Alternative 2 will not attain a reduction in the offsite CoPC concentrations over any meaningful period of time.

Implementability

Implementability evaluates the technical and administrative difficulties associated with implementing each alternative. Each of the alternatives is implementable to varying degrees, as discussed in this Section. There are several technical and administrative difficulties associated with each of the alternatives. Technical implementability issues include demonstrating hydraulic capture and control of CoPC plumes and demonstrating the ability to treat extracted CoPCs. Administrative difficulties associated with implementing alternatives include obtaining easements and property for wells and pipelines, conducting a large construction project in public roads and neighborhoods, challenges associated with permitting and compliance for wellhead treatment, and exchanging water for potable and nonpotable reuse.

Alternatives 2A and 2B are implementable to the extent that DHS approves treated groundwater for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. If direct reuse is not accepted, and for the projected shortfall of treated water available under Alternative 2A, a surface water treatment plant can be constructed if a suitable location can be found, and if a private or public water purveyor is willing to operate it. It is believed that permission can be obtained from the USBR to use Folsom South Canal as a raw water conveyance system to a surface water treatment plant, if necessary. Between Alternatives 2A and 2B, Alternative 2A assumes that long-term surface water entitlements would be available on the American River, which may not be the case.

Alternatives 3A and 3B are implementable to the extent that the DHS approves wellhead treatment for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. DHS has accepted wellhead treatment at numerous locations throughout the State. If accepted, the well treatment equipment must be capable of fitting in the existing space available at impacted water supply wells, and

the treatment processes must be capable of meeting treatment standards in a demonstrable and reliable manner.

It will be difficult to implement Alternatives 4A through 5B due to the significant amount of offsite infrastructure estimated for these alternatives. Alternatives 4A through 5B are estimated to require from approximately 67,000 to 81,000 feet (approximately 13 to 16 miles) of relatively large diameter piping and from 11 to 30 offsite extraction wells. It will require a substantial effort to identify potential pipeline corridors and secure the necessary permits and easements. This amount of offsite construction may require significant input and participation from Sacramento County and the local community. It is not currently known where extraction wells that require periodic maintenance and monitoring can be located.

In comparing among the "A", "B", and "C" alternatives, the "B" and "C" alternatives should be more implementable, given the preference of using extraction rather than recharge both on and offsite to maintain the hydraulic control, and because the "B" and "C" alternatives involve more containment onsite than the "A" alternatives. With respect to the alternatives that include an offsite hydraulic barrier (Alternatives 4A through 5B), maintaining a hydraulic barrier where recharge wells are used as part of the barrier (Alternatives 5A and 5B) would probably be more difficult to implement as maintaining gradients requires more sophisticated groundwater management to optimize system operation and control

Cost

This criterion evaluates the cost of implementing each alternative. The cost of an alternative encompasses all capital (e.g., construction, equipment and materials, land purchase, insurance and permitting, engineering, construction management, and regulatory agency oversight costs) and any long-term annual operation and maintenance (O&M) costs (e.g., operating labor, maintenance materials, electrical power, chemicals, and sampling/analytical costs). The assessment against this criterion is based on the estimated present worth of these costs for each alternative. Present worth is used to estimate expenditures such as construction and O&M that occur over different lengths of time and discounting all costs to a common year. By discounting all costs to a common base year, the costs for different remedial alternatives can be compared on the basis of a single figure for each alternative. The present worth of a project represents the amount of money that, if invested in the initial year of the remedy and disbursed as needed, would be sufficient to cover all costs associated with the remedial action. Cost estimates for each alternative were prepared in accordance with current EPA guidance with respect to level of accuracy and discount rate (i.e., seven percent). The estimated total capital cost, estimated annual O&M costs, and estimated 25-year present worth cost estimates for

each of the alternatives are as follows:

Alternative	Estimated Capital Costs ($M)	Estimated Annual O&M Costs [Range] ($M/year)	Estimated 25-year Present Worth Costs ($M)
1	0	0.16	2
2A	25	2.1-3.9	48
2B	22	2.5-2.8	54
3A	64	3.5-5.3	93
3B	77	4.0-6.0	115
4A	43	3.0-3.3	78
4B	38	3.3-3.4	77
4C	42	3.5-3.6	85
5A	41	3.3-3.9	78
5B	45	3.8-4.0	87

The following potential additional costs are not included in FS-level cost estimates for Alternatives 4A through 5B, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed Preliminary Remedial Action Goals (PRAGs) and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for these alternatives in Section 4 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Replacement Water Contingency Alternative	Estimated Capital Costs ($M)	Estimated Annual O&M Costs [Range] ($M/year)	Estimated 25-year Present Worth Costs ($M)
Direct Reuse	3.9	0.13	5.5
Indirect Reuse	6.9	0.04	7.4

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Section 1.4 Baseline Risk Assessment (BRA). The revised BRA contained in Appendix B was redone to conform with EPA comments. The EPA considers two types of risks: cancer risk and non-cancer risk. Cancer risk is the excess life time chance of getting cancer due to a chemical exposure. For example a one in a million risk is the equivalent one additional cancer in a hypothetical population of a million people above the background rate of cancer. The EPA manages risk at a site so that the risk falls within a Risk Management Range of one in ten thousand to one in a million. Risk greater than one in ten thousand generally require that action be taken at a site. Off-property in groundwater layers C, D and E, layer C is the most contaminated with a total cancer risk of four in ten thousand. For On-property groundwater layers A, B, C, D and E, layer C is also the most contaminated with a total cancer risk of 100 in ten thousand. Both the on and off-property cancer risk values are above the threshold of one in ten thousand as contained in the Total Risk column for the onsite and offsite table "Summary of Potential Risks due to Hypothetical Groundwater Use" on pages 19 and 20 of Section 1.4. The other columns provided in these two tables do not appropriately show the derivation of the total risk.

1 INTRODUCTION

1.1 Purpose, Scope and Organization of the Western Groundwater OU RI/FS Report

1.1.1 Purpose

The purpose of this Operable Unit (OU) remedial investigation/feasibility study (RI/FS) is to present the RI for the Western Groundwater OU Study Area (Figure 1-1) and to prepare an FS that evaluates remedial alternatives for addressing contaminants of potential concern (CoPCs) in groundwater in the Study Area. In June 1989, Aerojet entered into a Partial Consent Decree (PCD) which requires the completion of an RI/FS for the Aerojet Sacramento site. Pursuant to the PCD, Aerojet has completed a substantial portion of the Phase I RI/FS. This Western Groundwater OU RI/FS is submitted as part of the RI/FS pursuant to the PCD and focuses on an operable unit; namely, the Western Groundwater Area. This Western Groundwater OU RI/FS also meets the requirements of the California Regional Water Quality Control Board (RWQCB) Cleanup and Abatement Order (CAO) No. 96-259 to the extent applicable.

On October 6, 1998, Aerojet submitted a proposal to the PCD oversight Agencies providing for the completion of the Aerojet site RI/FS required by the PCD through the preparation and submittal of a number of sequential OUFSs. On October 27, 1998, the US Environmental Protection Agency (USEPA), California Department of Health Services (DHS), and the California RWQCB accepted this approach for completion of the Aerojet site RI/FS. Currently, Aerojet and the oversight Agencies are negotiating modifications to the PCD to allow for this revised RI/FS approach. This OU RI/FS for the Western Groundwater Study Area is the initial submittal pursuant to this revised approach. It is currently contemplated that the RI/FS for the remaining OUs will be completed through similar OU RI/FSs.

1.1.2 Scope

The scope of this OU RI/FS can be described as follows:

- Conduct the RI for the Study Area to characterize subsurface conditions and the nature and extent of CoPCs in groundwater;
- Prepare a Baseline Risk Assessment (BRA) to identify any potential risks that may be posed to human health and the environment by CoPCs in groundwater in the Study Area;
- Prepare an OU RI/FS by developing and evaluating a range of remedial alternatives that provides for protection of human health and the environment, and that considers technical, institutional, and cost considerations in accordance with CERCLA, as

amended by SARA, and the National Contingency Plan (NCP) so that relevant information regarding the remedial alternatives can be presented to a decision-maker and an appropriate remedy can be selected; and

- Integrate the OU RI/FS with all applicable RI, BRA, and treatability study activities to ensure that all remedial alternatives are developed, screened, and evaluated in a systematic and objective manner.

This OU RI/FS report has been developed to comply with guidelines prepared under the provisions of CERCLA, SARA, the latest revision to the NCP (40 Code of Federal Regulations (CFR) Part 300.430 (1990)), and the following EPA and DTSC guidance documents:

- USEPA, 1988a, Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (Interim Final), EPA/540/6-08/004, OSWER Directive 9355.3-01, October.

- USEPA, 1988b, CERCLA Compliance with Other Laws Manual, OSWER Directive 9234.1-01, August.

- USEPA, 1988c, Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites, OSWER Directive 9238.1-02, December.

- USEPA, 1989c, CERCLA Compliance with Other Laws Manual Clean Air Act, and Other Environmental Statutes and State Requirements, OSWER Directive 9234.1-02, August.

- USEPA, 1996c, Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites, OSWER Directive 9283.1-12, October.

- DTSC, 1992, Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities.

- USEPA, 1989a, Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A), Interim Final, EPA/540/I-89/002, Office of Emergency and Remedial Response, Washington, DC, December.

- USEPA, 1991, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, OSWER Directive 9355.030, Office of Solid Waste and Emergency Response. Washington, DC, April.

- USEPA, 1999b, Region 9 Preliminary Remediation Goals (PRGs) 1999, October 1.

- USEPA, 1997, Exposure Factors Handbook, Volumes I through III. EPA/600/P-95/002Fa through Fc, Office of Research and Development, National Center for Environmental Assessment, August.

- USEPA, 1998a, Risk Assessment Guidance for Superfund, Part D.

1.1.3 Organization of Report

This OU RI/FS report documents the characterization of subsurface conditions and the nature and extent of CoPCs in groundwater for the Western Groundwater Study Area, summarizes the potential risks that may be posed to human health and the environment by CoPCs in groundwater in the Study Area, documents the formulation and evaluation of remedial alternatives, and provides all data and documentation for the decision-making process in the Record of Decision (ROD). The report is organized as follows:

- Section 1 provides a summary of the site conceptual model as finalized in the RI (Aerojet, 2000a) [Appendix A] and a summary of the Baseline Risk Assessment (HSI Geotrans, 2000a) [Appendix B];

- Remedial action objectives (RAOs), potential applicable or relevant and appropriate requirements (ARARs), and preliminary remedial action goals (PRAGs) are discussed in Section 2;

- Identification and screening of general response actions (GRAs) and remedial technologies is presented in Section 3;

- Development of OU-wide remedial alternatives is discussed in Section 4;

- The detailed analysis of alternatives is presented in Section 5 and the comparative analysis of alternatives is conducted in Section 6;

- Section 7 provides the references used in this OU RI/FS report; and

- Appendices A through E provide supplemental or backup information that are the bases for the summaries and analyses presented in Sections 1 through 6. The specific Appendices include:

  - A: Western Groundwater Operable Unit Remedial Investigation Report

  - B: Western Groundwater Operable Unit Baseline Risk Assessment

  - C: ARARs for Western Groundwater OU RI/FS

- D: Western Groundwater OU RI/FS Groundwater Flow Model

- E: Detailed Cost Estimates

1.2 Study Area Description and History

1.2.1 Study Area Description and Background

The Western Groundwater Study Area encompasses a western portion of the Aerojet Operating Plant site, the northwestern corner of the Inactive Rancho Cordova Test Site (IRCTS), and approximately 10 square miles of commercially and residentially developed areas in the community of Rancho Cordova (Figure 1-1). The entire Study Area measures approximately 15 square miles. The Study Area is approximately bounded on the west by Mather Field Road.

The community of Rancho Cordova is located west and north of Aerojet. Commercial and industrial development dominates the areas south of Folsom Boulevard, east of Zinfandel Drive, and west of Aerojet. Residential developments are primarily located in the areas north of Folsom Boulevard, although, pockets of smaller residential development are present throughout the Study Area.

Arden-Cordova Water Service (ACWS), a subsidiary of the Southern California Water Company (SCWC), provides potable water to the majority of residential and industrial users in the Study Area. Sacramento County provides potable water to users in a relatively small corridor of the study area bounded by the Folsom South Canal to the west and north, and Aerojet and the IRCTS to the east. Citizens Utilities Company provides potable water to a small commercial development on the IRCTS (Security Park) and to the communities located west of the Study Area.

The Study Area is characterized by a relatively flat topographic surface gently sloping (less than 1 degree) to the west. Ground surface elevations decrease from approximately 200 feet above MSL in the east to approximately 60 feet above MSL in the west, an average slope of approximately 24 feet per mile. Several ancestral river terraces are present on the north and south sides of the American River. The majority of Rancho Cordova, the Aerojet site, and the IRCTS were dredged for gold from the early 1900's through the 1960's. Dredging involved removal and sorting of sediments from the ground surface to depths up to 80 feet. Redeposition of the dredged sediments has formed the irregular linear patterns visible in the undeveloped portions of the Study Area.

The American River meanders in a generally southwesterly direction through the northwestern portions of the Study Area. Flows in the American River are controlled by the United States Bureau of Reclamation (USBR) through Folsom Dam, located approximately 6 miles upstream (northeast) of Lake Natoma. Lake Natoma serves as the dividing line between the Upper and Lower American River Watersheds, and provides recreational facilities and hydroelectric power. The USBR also controls access and water

diversions through the Folsom South Canal that trends roughly north-south through the Study Area.

1.2.2 Site History

Since the early 1950's, the Aerojet Sacramento site has been devoted to the development of rocket propulsion systems to support national defense, space exploration, and satellite deployment. Industrial activities at the Aerojet site have included solid rocket motor manufacturing and testing, liquid rocket engine manufacturing and testing, and chemical manufacturing. Chemicals used in the manufacturing and testing areas on the Aerojet site have included chlorinated solvents, propellants, metals, oxidizers, and a variety of chemicals produced in the chemical operations areas as described in the Scoping Report (ICF Technology, 1989).

Historical operations at the Aerojet site have resulted in the discharge of chemicals of potential concern (CoPC) to the vadose zone and underlying groundwater. Although numerous types of chemicals have been used historically on the Aerojet Site, trichloroethylene (TCE), perchlorate and N-nitrosodimethlyamine (NDMA) comprise the chemicals of principal concern in the Study Area. TCE was utilized on the Aerojet Site for cleaning and degreasing purposes. Perchlorate was combined with a cation (generally ammonium or potassium) and utilized as an oxidizer in solid rocket propellants. NDMA is a semi-volatile organic compound (SVOC) that was either an impurity in hydrazine-based liquid rocket fuels or was formed as a combustion product of these fuels.

The northwestern portion of the IRCTS was included in the Study Area due to the presence of CoPCS in groundwater in the area and the potential for migration offsite within the Western Groundwater Study Area from upgradient source areas. Aerojet operated an evaporation sprayfield near the northwestern corner of the IRCTS to disperse groundwater treated at its former GET F South treatment facility. Aerojet and the former Douglas Aircraft Company (which was subsequently purchased by the McDonnell Douglas Corporation and then The Boeing Company) operated a propellant burn area on the eastern edge of the former sprayfield. This Western Groundwater OU RI/FS focuses on offsite groundwater within the Study Area that has or might become impacted by upgradient source areas, but does not resolve the relative contribution, if any, among potential source areas on the IRCTS. The IRCTS, excluding the spray field, is the subject of a Consent ISEO issued by DTSC to Boeing and Aerojet. Evaluations undertaken herein and any remedial action selected may be applicable to obligations under the ISEO.

Rocket engine/motor testing, and motor rehabilitation (propellant hogout) were conducted in other portions of the IRCTS that are being jointly investigated by Aerojet and The Boeing Company under a separate Cleanup and Abatement Order (CAO 97-093) issued by the Regional Water Quality Control Board (RWQCB). It is recognized in this FS that there are additional groundwater plumes containing perchlorate and solvents south of the Study Area boundaries that are not being evaluated by the OU RI/FS. The Regional Board Order provides that the remediation efforts under the IRCTS CAO will

be coordinated and may be combined with remediation associated with this OU RI/FS for the Western Groundwater Study Area.

There are potential sources of CoPCs within the Study Area other than the IRCTS and the Aerojet Facility. Chlorinated solvents, including TCE, were commonly used by different industries. Perchlorate appears to have been and nitrate is a common constituent of fertilizers (ES&T, 1999). NDMA appears to have been associated with various industrial and food processing industries and has been a contaminant in foods (ATSDR 1989).

1.2.3 Current Remedial Actions

Since the mid-1980's, Aerojet has installed and operated five interim perimeter groundwater extraction and treatment (GET) facilities (GETs A, B, D, E, and F) designed to remove volatile organic compounds (VOCs) and NDMA (GETs A and B only) from groundwater beneath the site. The treated water is recharged to the groundwater system via surface discharge and infiltration, or by recharge wells. A sixth GET system, the American River Groundwater Extraction and Treatment System (ARGET) began operations in July 1998 in the American River Study Area (ARSA). GET E/F is located within the Study Area on the western boundary of the Aerojet site and is included for evaluation as a final remedy in this FS.

The current configuration for the extraction wells, conveyance pipelines, groundwater treatment facilities, and recharge wells for GET E/F is shown on Figure 1-2. The extraction, treatment, and recharge facilities have been modified several times since their initial construction to increase the effectiveness of the operation and treatment of the systems. The effect of the historical operation of the GET E/F facility on the distribution of CoPCs in the Study Area is discussed in Section 1.3.4.

Approximately 2,000 gallons per minute (gpm) of groundwater is extracted via the five extraction wells previously defined as GET E (wells 4070, 4075, 4200, 4425, and 4435). The six previously defined as GET F extraction wells (4007, 4060, 4140, 4145, 4310, and 4315) extract approximately 1,400 gpm. The treated groundwater is recharged to the aquifer, either through a series of eight passive recharge wells located between the two extraction well fields (Figure 1-2) or by discharge to ground and percolation in the vicinity of the recharge wells. Groundwater recharge in this area forms a hydraulic mound that deflects CoPCs towards the GETs E/F extraction wells. The groundwater modeling simulation performed for this FS indicates that the extraction rates at GET E/F can be reduced by approximately 25 percent and still maintain the current level of capture.

In August 1999, the former GET E treatment facility was removed from service and the GETs E/F treatment systems were combined into a single new treatment facility located at the site of the GET F treatment facility. Treatment processes at the GET F location were also upgraded from only VOC removal via air stripping to include a biological reduction process for perchlorate treatment and an ultraviolet (UV)/oxidation process for

treatment of VOCs and NDMA. New air strippers were also added as a VOC-removal polishing step after the UV/oxidation process. The effluent from the combined GETs E/F treatment facility is routed through a single manifolded pipeline to its discharge point.

As part of the remedy for Western Groundwater, Aerojet is recommending upgrades to the GET E and F onsite source containment extraction well fields. Specifically, an extraction well or wells screened in hydrostratigraphic layers C, D, and E (see discussion of hydrostratigraphic layers in Section 1.3.2) is recommended for the previous GET E extraction well field. It is estimated that the flowrate from this proposed new well(s) would be approximately 1,000 gpm. Groundwater from these new extraction wells will be treated at the expanded GET E/F treatment facility. Aerojet believes it is advantageous to implement these modifications to GET E/F expeditiously and prior to the likely prolonged period of formal remedy selection and preparation of the ROD. A potential mechanism that could be used for early implementation of these modifications would be the material modification provision within Exhibit VI of the PCD.

1.3 Conceptual Model

The conceptual model for the Western Groundwater Study Area is presented in the Remedial Investigation (RI) Report (Appendix A) and is summarized in the following sections. The summary includes discussions of the conceptual regional geologic model, the conceptual regional hydrogeologic model, and the conceptual migration of CoPCs in groundwater, including the nature and extent of contamination in hydrostratigraphic layers A through E.

1.3.1 Conceptual Regional Geologic Model

The conceptual regional geologic model presents the structural and stratigraphic characteristics of the subsurface geology beneath the Study Area. Interpretations of these characteristics are based on features observed during site-wide geologic mapping, subsurface lithologic descriptions, and literature references. The Study Area is located near the eastern edge of the Sacramento Valley at the contact between the Sierra Nevada metamorphic basement rocks and the Great Valley Sequence of sediments (Figure 1-3). The erosional surface of the basement rocks outcrops on the East Side of the Aerojet Site and dips to the west at approximately 4 degrees. The Great Valley Sequence, a relatively thick series of consolidated and semi-consolidated sedimentary rock, onlaps onto the basement rocks.

The Great Valley Sequence is characterized by shallow-dipping (generally less than 1 degree) Cretaceous, Tertiary, and Quaternary-age marine and non-marine sediments (DWR, 1974). Regional geologic formations identified within this sequence include undifferentiated Quaternary sediments and the Laguna, Mehrten, Valley Springs, Ione and Chico Formations. These sediments generally strike north-south and form a wedge

that thickens from tens of feet at the eastern Aerojet Site border to greater than 2,000 feet near the western Aerojet property boundary.

The older (and deepest) geologic formations (Chico and Ione Formations) were deposited in marine and near marine environments and consequently contain saline to brackish water that is typically non-potable (DWR, 1974). The younger geologic formations were deposited in terrestrial environments and include the undifferentiated Quaternary, Laguna, Mehrten, and Valley Springs Formations. These sediments generally comprise the regional potable water aquifer, although portions of the Valley Springs Formation produce low-quality water due to the presence of sulfides, high total dissolved solids or elevated iron and manganese concentrations. The layers addressed by this study exist within the undifferentiated Quaternary, Laguna, and Mehrten Formations.

The type and distribution of sediments within the regional potable water aquifer strongly influence the aquifer characteristics. Most of the sediment in the aquifer was deposited by fluvial (river) and alluvial (deposited by running water) processes. Sediments deposited in these environments range from coarse-grained sands, gravels, and boulders typically deposited in river channels to silt, silty-sand, and clay deposited on overbanks and floodplains. These depositional environments formed heterogeneous packages of sediment that are generally horizontally and vertically discontinuous. It is often difficult to trace individual stratigraphic layers across the Study Area, although, some sedimentary sequences can be grouped based on similar lithologic and hydrogeologic characteristics. The grouping of sediments with similar hydrostratigraphic characteristics forms the basis for the conceptual regional hydrogeologic model presented below.

1.3.2 Conceptual Regional Hydrogeologic Model

The sediments comprising the regional geologic formations have been subdivided into five hydrostratigraphic layers (Layers A to E) that have been correlated across most of the Study Area (Figure 1-3). These layers were defined on the Aerojet Site based on similar lithology, relative depths and thicknesses, electrical conductivity, water levels, aquifer testing, and chemical concentrations (Aerojet, 1992a,b). The depths and thicknesses of the hydrostratigraphic layers vary across the Study Area due to the regional dip, the slope of the ground surface, and the wedge-shaped layers. The overall structure and lithology of the hydrostratigraphic units has formed an aquifer system that is generally leaky and confined to semi-confined.

Layers A and B, the uppermost layers, are present in the eastern and central portions of the Study Area extending approximately to the western Aerojet boundary. These layers are either dry or change their hydrostratigraphic characteristics in the western offsite area (Aerojet, 1996). Layers C, D, and E are more regional features and are present beneath the entire Study Area. A body of fresh-water that underlies Layer E and underlies the deepest known contamination is present above the saline to brackish water-bearing zones.

The depth to water generally increases from 40 feet to approximately 100 feet below ground surface (bgs) from east to west across the Study Area. Locally, perched groundwater may be present above these depths. The regional water table has declined from 30 to 40 feet over the past 40 years. Groundwater elevations range from approximately 85 feet above mean sea level (msl) in the east to approximately sea level in the west. Groundwater does not discharge to the American River or any other surface water body within the Study Area boundaries.

Groundwater flow directions and hydraulic gradients are similar in each of the hydrostratigraphic layers. The regional groundwater flow direction in Layers A through E is generally to the west-southwest. The average slope, or hydraulic gradient, in Layers A and B ranges from 0.004 to 0.005 ft/ft (Aerojet, 1998). The hydraulic gradient in Layers C, D and E is slightly lower, typically averaging 0.004 ft/ft. Groundwater flow directions and gradients vary in the vicinity of the GET E and F extraction and recharge wells and around public water supply wells due to pumping and recharge at these locations.

Vertical movement is a significant component of groundwater flow in portions of the Study Area, primarily in Layers A and B. Potentiometric surface elevations measured in Layer A typically range from 15 to 40 feet above those measured in underlying Layer B. This relatively high vertical head potential suggests there is a strong potential for downward vertical groundwater migration from Layer A to Layer B. A similar but less strong (5 to 15 feet) vertical head potential exists between Layers B and C. Vertical head potentials in Layers C, D and E are relatively minor (i.e., less than 5 feet) throughout the Study Area except near the GET facilities where groundwater pumping occurs. Vertical head potentials induced by groundwater extraction and recharge vary locally depending on which layer the groundwater is extracted from or recharged to.

1.3.3 Conceptual Migration of CoPCs in Groundwater

Groundwater advection is the dominant process governing the fate and transport of the dissolved-phase contaminants in the Study Area groundwater. Relatively high groundwater velocities in the Study Area minimize the effects of dispersion and retardation, although the magnitude of these effects is not clearly understood. Mechanical dispersion appears to dilute the leading edges of the contaminant plumes; however concentrations in the body of the plumes are generally not reduced to below levels of concern. The primary contaminants in the Study Area appear to be chemically and biologically stable and will likely persist in the Study Area groundwater.

The rate at which CoPCs migrate in the aquifer can be estimated from groundwater velocities. Groundwater velocities are estimated by conducting aquifer tests and applying the results of those tests to standard hydraulic equations. Aquifer testing was conducted on the majority of the GET E and F extraction wells. The extraction wells at GET E are screened in both Layers C and D, and the extraction wells at GET F are individually screened in Layers A, B, and C. The range of results obtained from these tests are

representative of conditions onsite at GETs E and F, but may not necessarily reflect conditions in the western offsite areas. The following chart presents a summary of the hydraulic parameters calculated from the onsite aquifer testing:

Summary of Hydraulic Parameters from Onsite Aquifer Testing

	GET E Area		GET F Area	
Hydraulic Parameter	Range	Median	Range	Median
Hydraulic Conductivity (ft/day)	63.5 to 145.6	123.4	7.6 to 38	18.5
Transmissivity (gpd/ft)	49,000 to 156,000	133,000	10,000 to 37,000	21,100

These data show that the median hydraulic conductivities and transmissivities are higher in the GET E area than in the GET F area. This corresponds with field observations that sediments in the vicinity of GET F are generally finer-grained than the sediments observed at GET E. Arden-Cordova Water Service has conducted several aquifer tests in the western offsite area using water supply wells AC19, AC22, and AC23. Data provided to Aerojet for the test performed at well AC22 yielded transmissivities in the range of 210,000 to 252,000 gpd/ft (CH2MHill, 1998). Data collected by Aerojet during the aquifer testing of wells AC19 and AC23 yielded transmissivities of 150,000 and 100,000 gpd/ft, respectively. The transmissivity of public water supply wells are not directly comparable to the GET E and F transmissivities because public water supply wells pump from different depths within the various layers.

Estimates of groundwater velocities can be prepared using the following equation:

$$q = k * i / n_e$$

where: q = average groundwater velocity
k = hydraulic conductivity
i = hydraulic gradient, and
n_e = effective porosity

Using a conservative effective porosity value of 0.25 (typical for clean sands), groundwater velocity estimates at GET E range from 372 to 851 feet per year. Groundwater velocity estimates at GET F range from 45 to 222 feet per year.

Dispersion and retardation of CoPCs during the advective process may increase or decrease the rates of CoPC migration. Some of the processes include molecular diffusion, mechanical dispersion, retardation, dilution, volatilization, and biological degradation. The effect of each of these processes can vary significantly from chemical to chemical, and it is difficult to quantify these effects because there are numerous location and chemical specific variables that cannot be practically measured. Although the individual and combined effects of these processes are not well understood, these effects are probably minimal compared to the effects due to the relatively high

groundwater velocities in the Study Area. The following chart summarizes the relative effects of dispersion, retardation, and destruction for solvents, NDMA, and perchlorate, the primary CoPCs in the Study Area.

Summary of Relative Retardation, Dispersion, and Destruction Effects

CoPC	Dispersion Effects: Molecular Diffusion	Dispersion Effects: Mechanical Dispersion	Retardation Effects: Sorption	Destruction Effects: Volatilization	Destruction Effects: Biological Degradation
Solvents	√√	√	√√√	√√√	√√
NDMA	√√	√√	√√	√	√
Perchlorate	√√√	√√√	√	√	√

Key: √ = No or uncertain effect
√√ = Moderate effect
√√√ = Greatest effect

1.3.4 Nature and Extent of Contamination

Background

Historical activity at the Aerojet site that potentially contributed to CoPCs is discussed in the Phase I RI/FS Zone 2 Stage 1 Report (ICF Kaiser, 1993). Potential source areas in the Study Area on the IRCTS are discussed in the Perchlorate Work Plan for the IRCTS (Aerojet and McDonnell Douglas, 1997). Further information on potential offsite sources is discussed in Appendix A to this report.

In 1984 and 1985, Aerojet initiated operation of groundwater extraction and treatment (GET) facilities E and F on the northwestern and southwestern perimeters of the Aerojet Site, respectively. These GET facilities were designed to mitigate the offsite migration of VOCs by extracting and treating VOC-impacted groundwater. The extraction, treated water discharge, and treatment processes for both GET facilities were modified several times to improve overall effectiveness.

Historical and recent operating procedures at GETs E/F have influenced the distribution of CoPCs in the Study Area. Figure 1-4 depicts the conceptual west to southwest migration of CoPCs from source areas on the Aerojet Site to the GET E/F extraction well fields. Prior to 1998-99, the treated groundwater contained varying amounts of perchlorate and NDMA. The treated groundwater is shown migrating offsite to the west and southwest from the Former GET F Sprayfield and from the GET E/F recharge well fields. In 1998-99, the treatment processes at GET E/F were upgraded to include perchlorate and NDMA removal.

Portions of the offsite CoPC plumes cannot be attributed to GET effluent. VOCs, primarily TCE, are present offsite to the north and west of the GET E extraction wells. The VOC concentrations in this area are higher than the VOC concentrations observed in monitor wells located directly downgradient of the GET E extraction wells. The available data suggest the offsite VOCs are not migrating through the GET E extraction

wells. These VOCs may have been present prior to operating the GET E extraction wells or they may have originated at one or more of the offsite sources that have been documented in this area (HSI GeoTrans, 1999b). Improved analytical detection limits have recently shown that relatively low levels of perchlorate and NDMA are likely migrating offsite northwest of the capture zone for GET E. In addition, there is the potential that there are offsite sources of perchlorate and NDMA other than from the Aerojet site or the IRCTS. For example, perchlorate appears to have been a common constituent of nitrate fertilizers (ES&T, 1999). NDMA appears to have been associated with various industrial and food processing industries and has been a contaminant in foods (ATSDR, 1989).

Trichloroethlyene (TCE), tetrachloroethylene (PCE), chloroform, perchlorate, nitrate, and NDMA have been detected in public water supply wells owned and operated by Arden-Cordova Water Service, Sacramento County, and Mather Air Force Base (currently operated by Sacramento County) west and northwest of the Aerojet Site and the IRCTS. Eight public water supply wells in the Study Area have been removed from service since March 1997 because of reported concentrations of perchlorate or NDMA in the wells. Aerojet currently monitors public water supply wells pursuant to the requirements of the PCD (Exhibit IV Groundwater Monitoring Plan (Aerojet, 1999)).

The following sections describe the distribution of CoPCs in the Study Area by hydrostratigraphic layer. Composite CoPC plume maps were created showing the maximum extent of CoPCs in each layer where the CoPC concentrations exceeded the risk-based values identified in the Baseline Risk Assessment (Appendix B). VOCs were included in the composite plume maps if their concentration exceeded EPA or State of California Primary Maximum Contaminant Levels (MCLs). Perchlorate was included in the composite plumes where its concentration exceeded 18 µg/L. NDMA was included in the composite plume map anywhere it was detected as the current method detection limit for NDMA (0.0075 µg/L) exceeds the health-based risk concentrations (0.002 µg/L).

Layer A

The combined extent of CoPCs in Layer A is presented on Figure 1-5. The CoPCs depicted in Layer A are present at depths generally ranging from 60 to 140 feet bgs, and encompass an area measuring approximately 1.5 square miles. CoPCs from the Aerojet facility originate from manufacturing areas located in Lines 01, 03, 04, 05, and Chemical Plants 1 and 2. The extent of CoPC in Layer A would be substantially greater if these source areas were included; however, most of the source areas are located east of the Study Area boundaries and will be addressed in the RI/FS at a later time.

The combined CoPC plume map for Layer A is comprised primarily of TCE, perchlorate, and NDMA (Figure 1-6). Additional CoPCs present above MCLs in the combined CoPC plume, but not contoured individually, included 1,2-DCA and chloroform.

The results from onsite source area investigations (principally the Stage I RI) suggests vadose zone and groundwater contamination in the source areas provides a continuing source of CoPCs to groundwater. Residual non-aqueous phase liquid (NAPL) TCE, 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethane (1,2-DCA), and 1,1,2-trichloroethane (1,1,2-TCA) are suspected to be present at various source sites located in Lines 01, 03, 04, 05, and Chemical Plants 1 and 2 (ICF Kaiser, 1993). Perchlorate is present in vadose zone soils in Lines 01, 03, 04, and 05. The highest CoPC concentrations in groundwater were detected in the vicinity of source areas with vadose zone contamination.

The highest concentrations of TCE (240,000 µg/L) and perchlorate (100,000 µg/L) were detected in monitor wells located in Line 03, approximately 4000 feet east (upgradient) of GET F. Downgradient concentrations of TCE (50 µg/L) and perchlorate (400 µg/L) at GET F are several orders of magnitude lower than those observed in Line 03. The decrease in CoPC concentrations onsite over a relatively short distance is primarily due to the downward migration of CoPCs into underlying Layer B.

The CoPCs that remain in Layer A have not migrated to the western offsite area. The offsite CoPC migration is inhibited by extraction wells screened in Layer A at GET F, and by relatively strong downward vertical head potentials from Layer A to underlying Layer B. TCE and related breakdown products (1,2-DCE, 1,1-DCE, and vinyl chloride) were detected offsite in Well 30065. Groundwater flow data and the suite of chemicals detected in this well indicate there is a separate source area unrelated to Aerojet activities near this monitor well (Appendix A, Section 3.1.7).

Layer B

The combined extent of CoPCs in Layer B is presented on Figure 1-7. The CoPCs depicted are generally present at depths ranging from 78 to 170 feet bgs and generally increase in depth from east to west across the Study Area. The area of the combined CoPC plume in Layer B measures approximately two square miles on the Aerojet Site, and slightly over one square mile on the IRCTS. This area does not include source areas located east of the Study Area boundaries. The stratigraphic characteristics of Layer B change west of the Aerojet Site and the IRCTS, and CoPCs present in Layer B at these locations appear to migrate vertically into underlying Layer C.

The combined CoPC plume map for Layer B is comprised primarily of TCE, perchlorate, and NDMA (Figure 1-8). Additional CoPCs present above MCLs in the combined CoPC plume, but not contoured individually, include 1,1-DCE, 1,2-DCE, carbon tetrachloride, chloroform and nitrate. The four VOCs were detected in a single monitoring well on the Aerojet Site located adjacent to an extraction well at GET F.

The combined CoPC plume east of the GET E and F extraction wells is comprised predominantly of TCE and perchlorate, although NDMA was detected in several monitor wells (Figure 1-8). Chemical and hydraulic gradient data indicate these constituents

migrated from sources located near the manufacturing line areas and chemical plants, through Layer A, and into Layer B.

The combined CoPC plume in the vicinity of and west of the recharge well field is comprised entirely of perchlorate. The absence of VOCs in this area and the presence of a recharge well partially screened in Layer B (Well 5100) indicate this portion of the plume originated from the recharge well field. The perchlorate treatment added to GETs E and F in December 1998 and August 1999, respectively, eliminate recharge as a source of perchlorate.

On that portion of the groundwater within the IRCTS evaluated as part of this Study area, the combined CoPC plume is comprised of CoPCs that originated at the Former GET F Sprayfield, the Aerojet Operating Plant and the joint propellant burn area. Layer A is dry on the IRCTS and Layer B is the shallowest saturated layer.

Layer C

The combined extent of CoPCs in Layer C is presented on Figure 1-9. The CoPCs depicted are present at depths ranging from approximately 100 to 350 feet bgs, and increase in depth from east to west across the Study Area. The combined extent of CoPCs in Layer C is the most aerially extensive of any of the combined CoPC plumes and encompasses an area measuring approximately 9 square miles.

The combined CoPC plume for Layer C is primarily comprised of TCE, perchlorate, and NDMA (Figure 1-10). Additional CoPCs present above MCLs in the combined CoPC plume, but not contoured individually, include 1,2-DCA, chloroform and nitrate. These three compounds were detected in monitor wells located on the Aerojet Site upgradient of the GET E and F extraction wells.

Perchlorate and TCE comprise the majority of the CoPCs detected on the Aerojet Site, although NDMA was detected in a few monitor wells near Chemical Plant 1 and the Westlake area. Perchlorate and NDMA appear to have migrated offsite northeast of the existing GET E extraction wells. Aerojet is proposing additional extraction wells in this area.

Perchlorate is the predominant CoPC present in the western offsite area. The TCE and NDMA concentrations that exceed health-based criteria are encompassed by the 18-µg/L contour for perchlorate. NDMA is currently characterized using an MDL of 0.0075 µg/L.

The current distributions of perchlorate and NDMA in the western offsite area are primarily due to recharge from the GET E and F recharge well field. The addition of perchlorate and NDMA treatment at GETs E and F is eliminating this source.

The majority of chemical impacts to public water supply wells appear to be from CoPCs migrating through Layer C, although, CoPCs present in Layer D may also be contributing to the public water supply wells closest to Aerojet (e.g., AC15 and AC16). The majority of public water supply wells in the Study Area are open boreholes with sanitary surface seals. It may be beneficial to evaluate the individual borehole flow characteristics for some public water supply wells to determine if sealing portions of the boreholes may prevent CoPCs from entering some of these wells.

Layer D

The combined extent of CoPCs in Layer D is presented on Figure 1-11. The CoPCs depicted are present at depths ranging from approximately 160 to 410 feet bgs, and increase in depth from east to west across the Study Area. The area of the combined CoPC plume emanating from the Aerojet Site is approximately 4.6 square miles. An additional area measuring approximately ½ square mile is present on the IRCTS.

The combined CoPC plume in Layer D on the Aerojet Site is defined primarily by the extents of perchlorate and TCE (Figure 1-12). Additional CoPCs present above MCLs on the Aerojet Site, but not contoured individually, include 1,1-DCE, 1,2-DCA, 1,2-DCE, and chloroform. NDMA, perchlorate, and TCE were detected west of Westlake in the vicinity of the GET E extraction wells. TCE and perchlorate were detected in the vicinity of GET F. There are no extraction wells screened in Layer D at GET F, although vertical head potentials suggest there is the potential for CoPCs present in Layer D to be drawn upwards into Layer C.

In the western offsite area, perchlorate and NDMA comprise the majority of the CoPC plume. TCE was detected up to 8.5 µg/L in a few monitor wells located offsite, several hundred feet west of the GET E extraction wells. The perchlorate and NDMA present northwest of the GET E extraction wells and west and southwest of the GET E and F recharge well field appears to have originated at the recharge well field. The CoPCs emanating from the recharge wells in Layer D have not migrated as far west as the CoPCs emanating from the recharge wells in overlying Layer C.

Perchlorate and TCE are also present in a relatively small area in Layer D on the IRCTS. This portion of the CoPC plume probably represents CoPCs that have migrated vertically downward from overlying Layer C. The southern and eastern extent of perchlorate in Layer D that is south and east of the Study Area appears to be from other sources and is being evaluated under a separate CAO.

Layer E

The combined extent of CoPCs in Layer E is presented on Figure 1-13. The CoPCs depicted are present at depths ranging from approximately 300 to 500 feet bgs, and

increase in depth from east to west across the Study Area. The CoPCs in Layer E encompass an area measuring approximately 1 square mile.

The combined CoPC plume in Layer E can be divided into northern and southern areas based on the sources of chemical to each area. The northern elongated portion of the combined CoPC plume is located along the northwestern Aerojet boundary and extends approximately 4,500 feet offsite. This portion of the plume is comprised of TCE, perchlorate, and NDMA that are emanating from source areas located east of GET E (i.e., Line 05, Chemical Plant 1)[Figure 1-14]. There are no extraction wells in Layer E at this location, however, upward vertical head potential from Layer E to Layer D, suggest the extraction wells screened in Layer D are maintaining some control over offsite migration, which is supported by the relatively low CoPC concentrations detected downgradient.

The southern portion of the combined CoPC plume in Layer E is centered around the GET E and F recharge well field and is comprised of perchlorate and NDMA. The absence of TCE in this area indicates the perchlorate and NDMA originated at the recharge well field. The CoPCs from the recharge well field have not migrated as far to the west as the CoPCs in overlying Layer D. Neither of these constituents were detected offsite west of the recharge well field in Layer E.

1.4 Baseline Risk Assessment

A Baseline Risk Assessment (BRA) was prepared for the Western Groundwater Study Area. The purpose of the BRA is to evaluate potential site-specific human health risks associated with hypothetical exposure to chemicals detected in groundwater in the Study Area. Specifically, chemical propellants and solvents have been detected in groundwater samples collected from on- and offsite wells. The risk assessment was conducted assuming that through use of private domestic water supply wells, future residents could potentially contact groundwater containing these chemicals. For purposes of the risk assessment, it was assumed that the groundwater that could be contacted by potential future residents would contain the same concentrations as those detected in the current offsite groundwater plume; that is a no action scenario that assumes no future site remediation measures are implemented. In addition, hypothetical current exposures were evaluated assuming potential contact with chemicals in a representative production well.

This assessment was completed according to the DTSC Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities Guidance Manual (DTSC 1992) and U.S. Environmental Protection Agency's (EPA) Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Part A (EPA 1989). Exposure assumptions for estimates of chemical intake were based on information presented in those documents as well as: DTSC Preliminary Endangerment Assessment (DTSC 1994); Exposure Factors Handbook (EPA 1997a); EPA Region IX Preliminary Remediation Goals (PRGs) (EPA 1999); and Risk Assessment Guidance for Superfund, Volume I, Part B (EPA 1991). Information on

chemical toxicity was obtained from Integrated Risk Information System (IRIS) (EPA 2000) and the Toxicity Criteria Database from the Office of Environmental Health and Hazard Assessment (OEHHA), California EPA (OEHHA, 2000).

The baseline human health risk assessment follows the EPA risk assessment paradigm (EPA 1989) and consists of the following components:

- Data evaluation and identification of chemicals;
- Exposure assessment;
- Toxicity assessment; and
- Risk characterization.

The maximum concentration of each detected chemical was used in the risk assessment as the potential future exposure point concentration. With the exception of perchlorate, nitrate and nitrite, all inorganic chemicals were considered to be present at naturally occurring concentrations and were not included in the risk assessment. All organic chemicals were retained as CoPCs.

Risks were also calculated based on the concentrations of each chemical as depicted by the plume isopleths. Chemicals for which a plume map was created were those most frequently detected, and those that were not laboratory contaminants. Therefore, plume maps were created for TCE, NDMA, and perchlorate. The plume maps were used as the exposure point concentrations for TCE, NDMA, and perchlorate in addition to the maximum detected concentration of each chemical detected in each hydrostratigraphic layer.

The exposure assessment for the Western Groundwater plume included the following steps:

- Characterization of the exposure setting(s) and identification of potential future receptors;
- Identification of exposure pathways and exposure routes;
- Estimation of exposure point concentrations; and
- Quantification of chemical intake for pathway specific exposures for each potential receptor.

Following EPA guidance (1989a), all complete exposure pathways were selected for evaluation unless:

- Exposure from the pathway is likely to be much less than that from another pathway involving the same medium of the same exposure point;
- The potential magnitude of exposure from a pathway is likely to be very low; or
- The probability of the exposure occurring is very low and the risks associated with the pathway are low.

No exposure to groundwater onsite currently exists as the City of Folsom supplies water used on site from surface water sources. Future onsite exposures were evaluated assuming that the land could be developed for residential uses and assuming that individual residents install private wells for domestic potable water supply. Offsite groundwater is currently used by water purveyors for residential supply. Potential exposure to CoPCs through contact with offsite groundwater supplied by the various water purveyors is assessed by water quality monitoring pursuant to the Exhibit IV monitoring plan under the PCD. The water purveyors, in conjunction with the California DHS, determine when a water supply well should be taken out of service. Private wells also exist in the offsite areas, typically used for non potable purposes (e.g. agricultural). Future use of offsite groundwater was evaluated assuming individual private water supply wells may be installed in the plume area.

Exposure pathways evaluated in the risk assessment included ingestion and dermal contact with groundwater containing CoPCs. The BRA also evaluated the inhalation risk for volatile chemicals. Exposure point concentrations were estimated from plume maps prepared for each hydrostratigraphic layer (Appendix B, Figures B-5 through B-19) in addition to the use of maximum detected concentrations of each CoPC in each hydrostratigraphic layer. The range of concentrations of CoPCs in the groundwater plumes onsite and offsite ranged from 4 to 4,000 ug/L for perchlorate, 0.01 to 1. 0 ug/L for NDMA and 5 to 5,000 ug/L for TCE. Potential intake of these and other CoPCs were estimated for the ingestion, dermal contact and inhalation (volatile chemicals only) pathways using EPA and DTSC default values for exposure frequency, exposure duration, contact rate, body weight and averaging time.

Toxicity information and EPA and DTSC-derived toxicity values were obtained for each of the CoPCs and included information regarding potential carcinogenic as well as potential non-carcinogenic effects. For chemicals which are deemed to be potential carcinogens, such as NDMA and TCE, the calculated intake was evaluated using carcinogenic slope factors that corresponded to the specific routes of exposure to estimate the additional lifetime cancer risk corresponding to the estimated chemical intake. Non-carcinogenic effects were evaluated for all of the chemicals through comparison of potential intake to each chemical's published reference dose; that is the daily intake at which no adverse health effects are expected to occur even in sensitive receptors. The ratio of the estimated intake to each individual chemical's reference dose were calculated

to develop a hazard quotient and the hazard quotients for each pathway were summed to develop a hazard index for each chemical. The chemical specific hazard indices were summed when plumes overlapped to provide a total hazard index. For perchlorate, there is uncertainty regarding the appropriate reference dose. Perchlorate toxicity is currently undergoing extensive evaluation by the United States Environmental Protection Agency and the Agency is anticipating receipt of further animal and human studies before selection of a final reference dose (Rfd) for perchlorate. A provisional "action" level of 18 ppb was developed by DHS, based upon an earlier provisional Rfd developed by EPA. Since then, EPA has considered modification of the provisional Rfd and had proposed a 32 ppb level, which was commented upon by an external panel.

Calculated risks associated with potential future use of groundwater that might be obtained from each of the hydrostratigraphic layers beneath the onsite area were developed as part of the risk characterization effort. The maximum risk values reported below were derived by calculating the risk from the maximum concentration of each CoPC detected over the two-year sampling period and are not indicative of the actual CoPC concentrations that would be expected if the groundwater were extracted. Risks and hazard indices associated with the plumes are also reported. The calculated potential carcinogenic and non-carcinogenic risks associated with each of individual chemicals present in each of the hydrostratigraphic layers beneath the onsite area were as follows:

Summary of Potential Risks due to Hypothetical Groundwater Use from the Onsite Area

Layer	Total Risk	Total Hazard Index	Chemical	Potential Additional Lifetime Carcinogenic Risk from Plume	Hazard Indices from Plume
A	9.4E-3	610	TCE	3.1×10^{-6} to 3.1×10^{-5}	0.18 to 1.8
			Perchlorate	NA	0.22 to 22
			NDMA	7.7×10^{-6} to 7.7×10^{-5}	NA
B	9.4E-3	1800	TCE	3.1×10^{-6} to 3.1×10^{-3}	0.18 to 180
			Perchlorate	NA	0.022 to 222
			NDMA	7.7×10^{-6} to 7.7×10^{-5}	NA
C	1.1E-2	2200	TCE	6.2×10^{-7} to 3.1×10^{-5}	0.04 to 1.8
			Perchlorate	NA	0.22 to 222
			NDMA	7.7×10^{-6} to 7.7×10^{-5}	NA
D	5.1E-3	1600	TCE	3.1×10^{-6} to 3.1×10^{-5}	0.18 to 1.8
			Perchlorate	NA	0.22 to 222
			NDMA	7.7×10^{-6} to 7.7×10^{-4}	NA
E	1.3E-3	46	TCE	3.1×10^{-6} to 3.1×10^{-5}	0.18 to 1.8
			Perchlorate	NA	0.22 to 22
			NDMA	7.7×10^{-6} to 7.7×10^{-5}	NA

NA – Not applicable

For each hydrostratigraphic layer, the total risks and hazard indices for the maximum detected concentration of each CoPC exceed the NCP specified acceptable risk range and hazard index. Comparison of the calculated plume risk to EPA's accepted risk range of 10^{-6} to 10^{-4} for potential additional lifetime cancer risk and a hazard index of 1, indicates

that the TCE plume in the B layer beneath the onsite area exceeds the NCP specified acceptable risk range for both carcinogenic and non-carcinogenic effects. All TCE plume isopleths greater than 5 ug/L exceed the NCP acceptable level for non-carcinogenic effects. NDMA occurrences in Layer D onsite exceed the NCP specified acceptable risk range for carcinogenic effects. Perchlorate levels onsite also have a hazard index greater than one and thus potentially represent an unacceptable risk.

Calculated risks associated with potential future use of groundwater that might be obtained from each of the hydrostratigraphic layers beneath the offsite area were developed as part of the risk characterization effort. The maximum risk values reported below were derived by calculating the risk from the maximum concentration of each CoPC detected over the two-year sampling period and are not indicative of the actual CoPC concentrations that would be expected if the groundwater were extracted. Risks and hazard indices associated with the plumes are also reported. The calculated potential carcinogenic and non-carcinogenic risks associated with each of individual chemicals present in each of the hydrostratigraphic layers beneath the offsite areas were as follows:

Summary of Potential Risks due to Hypothetical Groundwater Use from the Offsite Area

Layer	Total Risk	Total Hazard Index	Plume Chemical	Potential Additional Lifetime Carcinogenic Risk from Plume	Hazard Indices from Plume
C	4.1×10^{-4}	670	TCE	6.2×10^{-7} to 3.1×10^{-5}	0.04 to 1.8
			Perchlorate	NA	0.22 to 222
			NDMA	7.7×10^{-6} to 7.7×10^{-5}	NA
D	4.3×10^{-4}	44	TCE	3.1×10^{-6}	0.18
			Perchlorate	NA	0.22 to 22
			NDMA	7.7×10^{-6} to 7.7×10^{-5}	NA
E	2.5×10^{-4}	36	TCE	3.1×10^{-6} to 3.1×10^{-5}	0.18 to 1.8
			Perchlorate	NA	0.22 to 22
			NDMA	7.7×10^{-6} to 7.7×10^{-5}	NA

NA – Not applicable

For each hydrostratigraphic layer, the total risks and hazard indices for the maximum detected concentration of each CoPC exceed the NCP specified acceptable risk range and hazard index. Comparison of the calculated plume risk to EPA's accepted risk range of 10^{-6} to 10^{-4} for potential additional lifetime cancer risk indicates that carcinogenic risks for individual plumes are within the range of acceptable levels for all carcinogenic CoPCs. Comparison of the calculated risk to the hazard indices, indicates that perchlorate levels offsite in Layers C, D, and E, and TCE in Layers C and E could result in a hazard index greater than one and thus potentially represent an unacceptable risk.

Various uncertainties or possible biases associated with the risk assessment were also identified. Uncertainty or possible bias may be associated with the individual sample analyses and other sampling or measurement uncertainties, unknown future land and groundwater uses, use of maximum detected concentrations as exposure point concentrations, use of upper-bound values for ingestion, inhalation and dermal contact

rates, and use of default values for exposure duration, all which may result in conservative estimates for the exposure point concentrations and intake values. Uncertainties and conservative safety factors associated with the carcinogenic and noncarcinogenic toxicity values developed based on laboratory animal studies were also identified that may result in conservative estimates of the actual toxic effects that may result from potential exposure to the chemicals.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

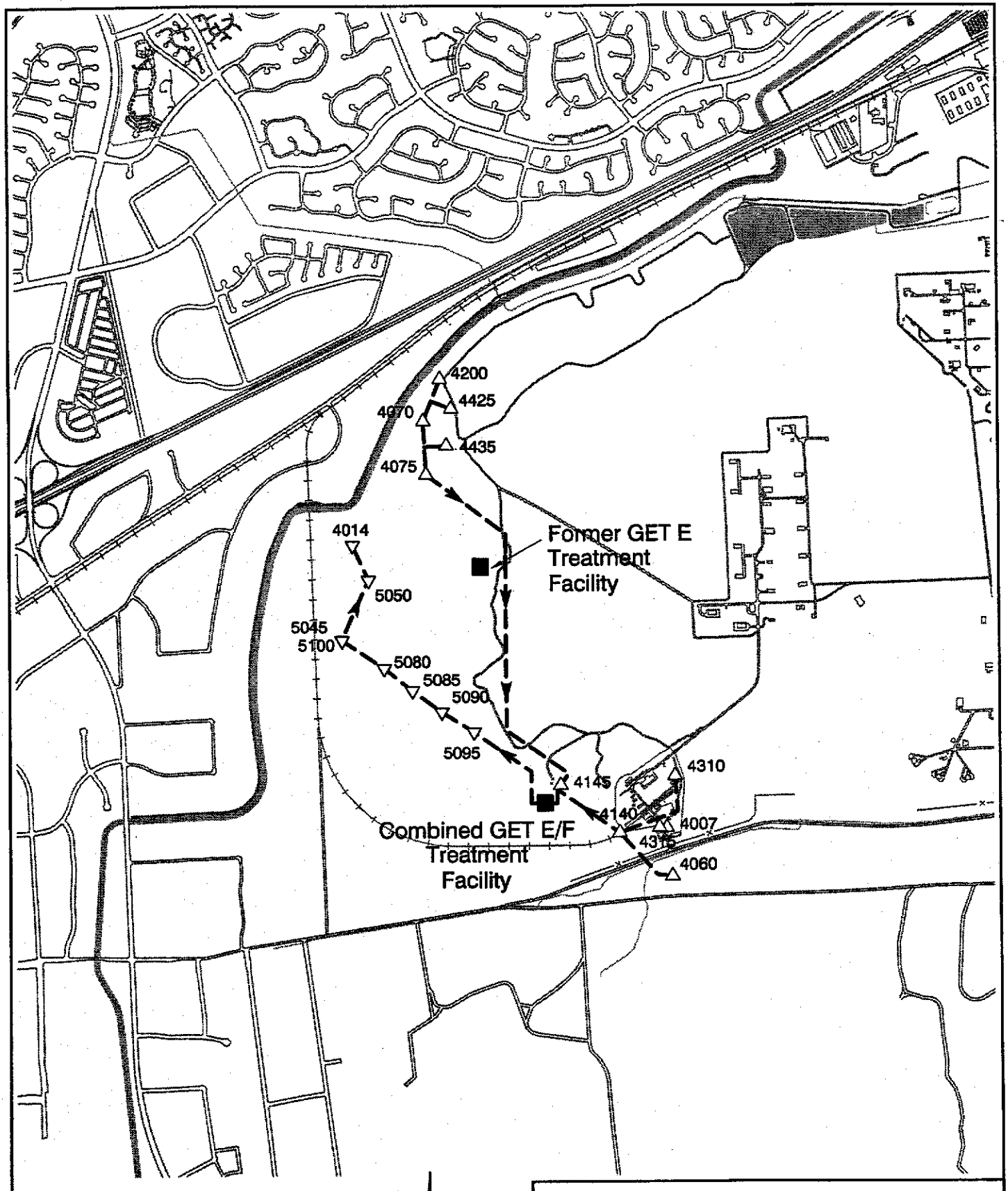

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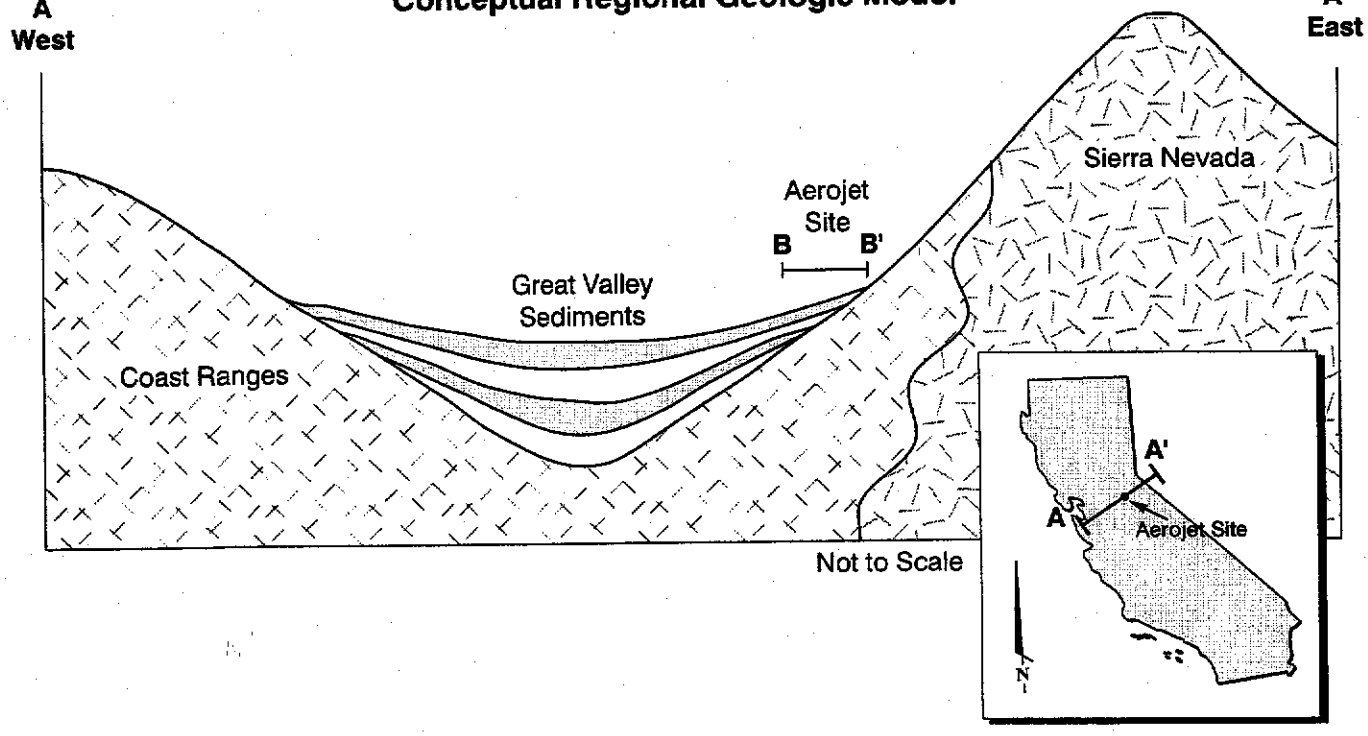
FIGURE 1-2

Western Groundwater Study Area
Existing On-site Containment Facilities

4/13/00 ah SR10109547

Conceptual Regional Geologic Model



Conceptual Regional Hydrogeologic Model

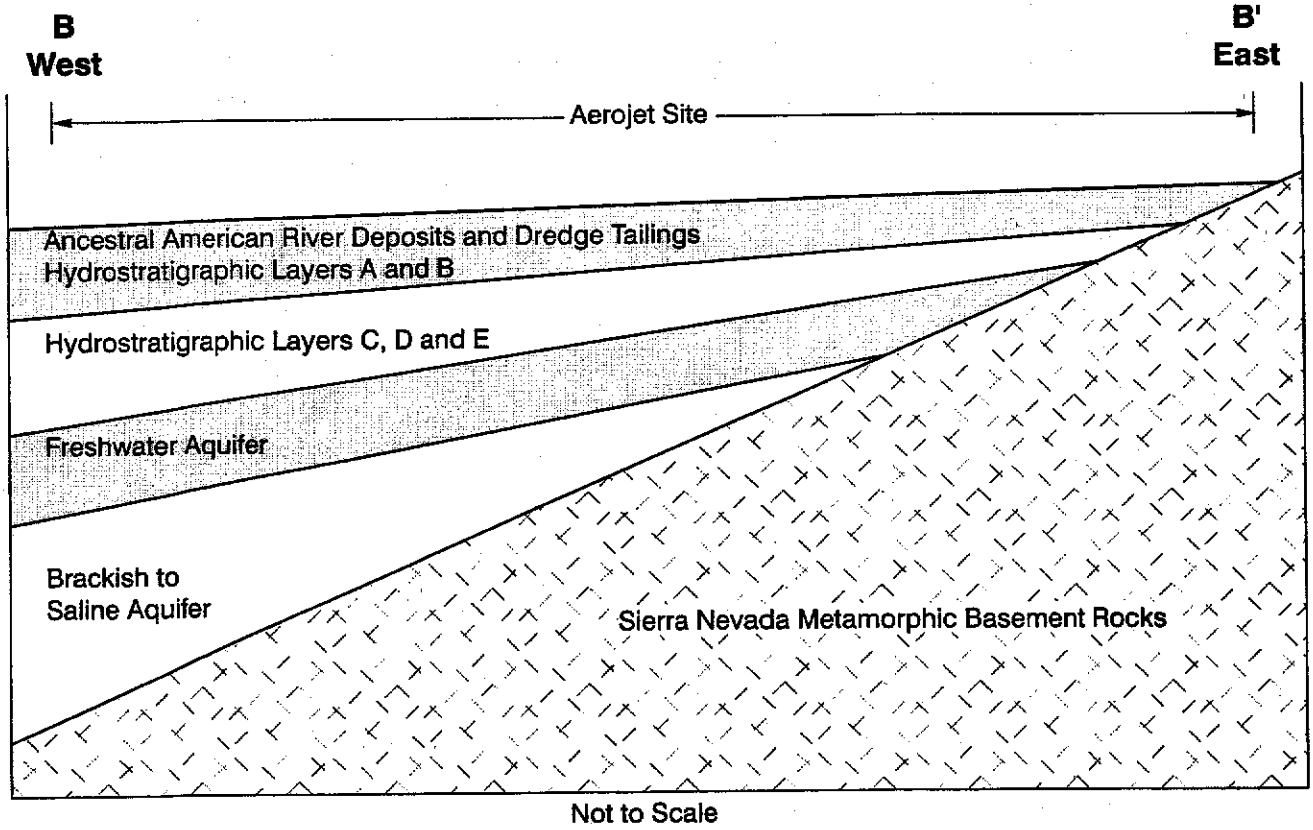


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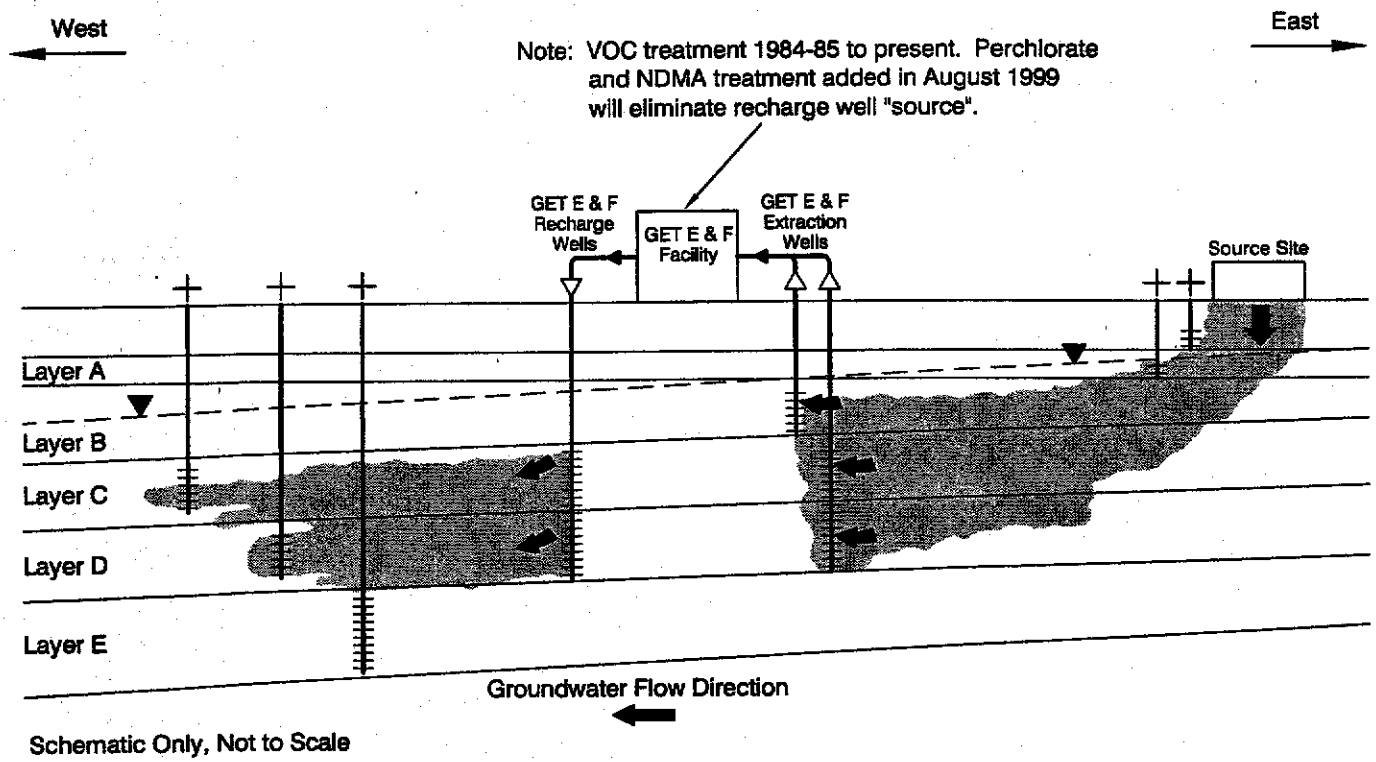
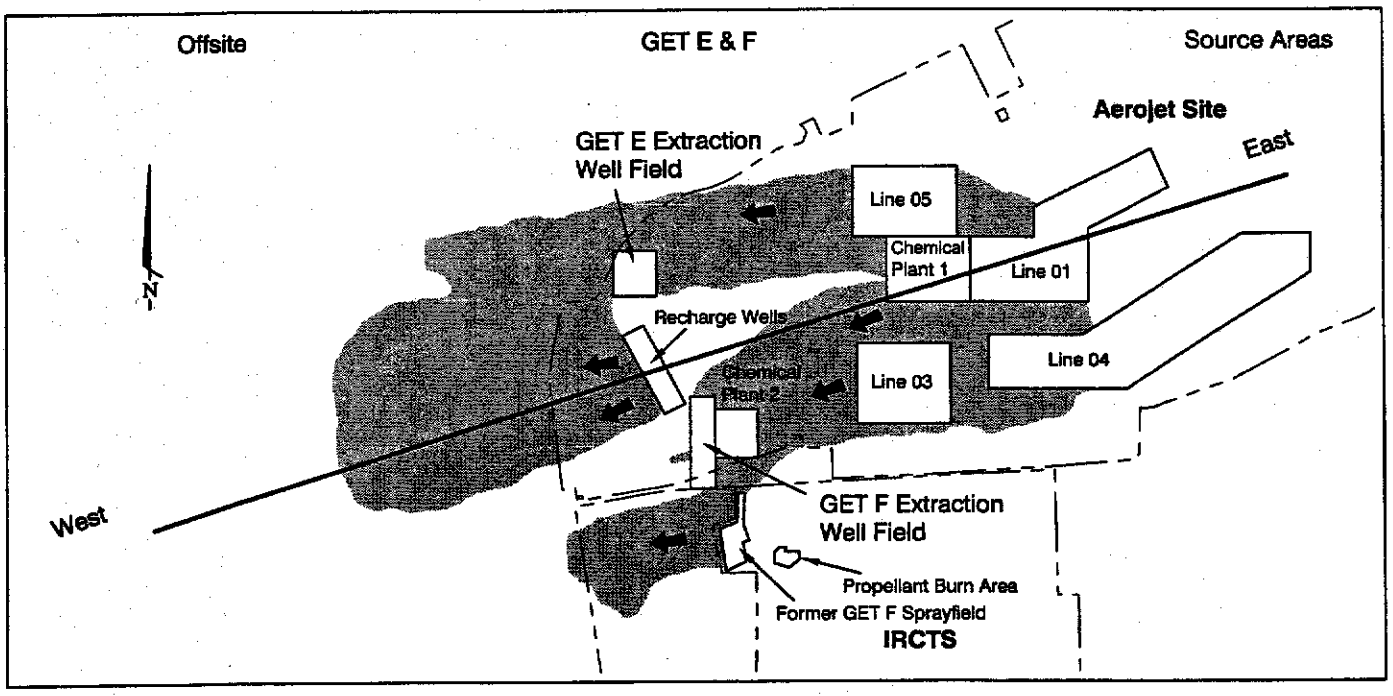
FIGURE 1-3
Western Groundwater Study Area
Conceptual Regional Geologic
and Hydrogeologic Models





Approximate Area of Schematic
(Scale: 1" = 6,000')

EXPLANATION

Dissolved phase contaminants. Shown for illustration purposes only, does not depict contaminant type, concentration, depth, or exact location.

Conceptual Water Table

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FIGURE 1-4

Western Groundwater Study Area
Conceptual Migration of CoPCs
in Groundwater

4/13/00 ah SR10109501

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Page 22, Section 2.1, Remedial Action Objectives. This section discusses the Remedial Action Objectives (RAOs). The Regulatory Agencies have modified the RAOs listed on page 22 for public comment in the Proposed Plan to those contained below:

- Protect human health and the environment from exposure to contaminated groundwater
- Achieve containment of the groundwater contamination to minimize future migration of contaminants until cleanup is accomplished
- Timely protection of public drinking water wells through an acceptable contingency long term alternative water supply plan
- Restore both on-property and off-property to its beneficial uses.

Page 23, Potential ARARs and Table 2-1 through 2-3. Aerojet has provided its interpretation of potential ARARs and listed them in Tables 2-1 through 2-3. Staff of the Regional Board does not agree with Aerojet's interpretation of the ARARs submitted by the Regional Board. A table has been included in the cover pages to Appendix C that provides the Regional Board's interpretation of the Regional Board's ARARs. In particular, Resolution Nos. 68-16 and 92-49, along with the Basin Plan, are ARARs for the development of cleanup requirements. These have been identified as ARARs or potential ARARs in many CERCLA documents developed for cleanup sites in California. The disagreement of ARAR interpretation does not preclude the ability to select a remedy and the differences can be worked our prior to the finalization of an enforcement document for remedy selection. It should be noted that CERCLA requires compliance with State requirements.

Page 24, Section 2.3, Preliminary Remediation Goals (PRAGs) and Tables 2-4 and 2-5. Aerojet attempted to develop Preliminary Remediation Goals using the Baseline Risk Assessment process and Potential Chemical-Specific ARARs or TBCs. The PRAGs listed in Table 2-5 do not incorporate all of the ARARs and TBCs listed in Table 2-4. Using the data supplied in Table 2-4, the PRAGs for 1,1,2-TCA, 1,1-DCA, 1,2-DCA, carbon tetrachloride, chloroform, PCE, TCE, and NDMA would be 0.9 µg/l, 0.06 µg/l, 0.4 µg/l, 0.3 µg/l, 0.16, 0.7 µg/l, 0.8 µg/l, and 0.002 µg/l, respectively. Even if only the values on Table 2-5 were used to develop the PRAGs, the PRAG for NDMA would be 0.004 µg/l (based on the risk-based concentration) and not 0.02 (based on the DHS Interim Action Level).

2 REMEDIAL ACTION OBJECTIVES, POTENTIAL ARARS and PRELIMINARY REMEDIAL ACTION GOALS

This section describes proposed remedial action objectives (RAOs) for the Western Groundwater OU. This section also presents a summary of potentially applicable or relevant and appropriate requirements (ARARs). Preliminary remedial action goals (PRAGs) are developed based on the potential ARARs described below and the risk-based levels presented in the Baseline Risk Assessment.

2.1 Remedial Action Objectives

The initial step in identifying and screening remedial alternatives is to formulate RAOs. RAOs are media-specific goals designed to protect human health and the environment. RAOs specify the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of alternatives to be developed on the basis of chemical-specific ARARs and site-specific risk-related factors.

The only media of concern for the Western Groundwater OU is groundwater. As discussed in the RI and summarized in the previous section of this FS, the contaminants of concern include chlorinated VOCs, perchlorate, NDMA, and nitrate. The only potential future exposure pathways are associated with potential ingestion of contaminated water that may enter drinking water supply wells located downgradient of the Site and inhalation of VOCs that may volatilize from the water.

The overall goal of any remedial alternative is to protect human health and the environment. In order to achieve this goal for the Western Groundwater Study Area, the following RAOs were identified:

- Protect human health and the environment from exposure to contaminated groundwater;
- Minimize offsite migration of CoPCs where practicable to protect long term beneficial uses;
- Reduce contaminant concentrations in already contaminated groundwater in an efficient cost-effective manner; and
- Protect public drinking water wells and provide treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels.

2.2 Potential ARARs

Section 121(d) of CERCLA states that remedial actions on CERCLA sites must attain (or justify the waiver of) any federal or more stringent State environmental standards, requirements, criteria, or limitations that are applicable or relevant and appropriate requirements (ARARs). Applicable requirements are those cleanup standards, criteria, or limitations promulgated under federal or State law that specifically address the type of situation present at a particular CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or State law that while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are well-suited to the conditions of the particular site.

Pursuant to EPA guidance, ARARs generally are classified into three categories: chemical-specific, location-specific, and action-specific requirements. Chemical-specific ARARs include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. Location-specific ARARs are those requirements that relate to the geographical or physical position of the site, rather than the nature of the CoPCs or the proposed site remedial actions. Action-specific ARARs are requirements that define acceptable handling, treatment, and disposal procedures for hazardous substances.

A requirement may not meet the definition of an ARAR, but still may be useful in assessing whether to take action at a site or to what degree action is necessary. This can be particularly true when there are no ARARs for a site, action, or contaminant. Such requirements are called to-be-considered (TBC) criteria. TBC criteria are nonpromulgated advisories or guidance issued by a federal or State government that are not legally binding, but that may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they are considered together with ARARs to establish the required level of cleanup for protection of human health or the environment. The critical difference between a TBC and an ARAR is that one is not required to comply with or meet a TBC when deciding on a remedial action. However, should a TBC be established as a cleanup standard in the ROD, then the TBC effectively produces the same results as an ARAR.

Tables 2-1, 2-2 and 2-3 present a summary of the evaluation of potential chemical-specific, location-specific and action-specific ARARs for the Western Groundwater OU. The complete evaluation of potential ARARs is contained in Appendix C.

2.3 Preliminary Remedial Action Goals

Preliminary Remedial Action Goals (PRAGs) are chemical concentrations in groundwater that, if contained in groundwater extracted by water purveyors, would achieve the levels of protection identified by MCLs or otherwise within risk ranges that have been identified in the risk assessment or through TBCs. PRAGs are termed preliminary remediation goals (PRGs) in EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA". In this FS document, these values are referred to as PRAGs to avoid potential confusion with the EPA Region 9 Preliminary Remediation Goals which represent screening level values for use in scoping or conducting site assessments and risk assessments.

PRAGs for the Western Groundwater OU were developed based on risk-based factors (i.e., exposure pathways, exposure assumptions, and toxicity factors) as presented in the Baseline Risk Assessment (BRA) and/or chemical-specific ARARs or TBCs (Table 2-4). PRAGs do not represent final remediation goals or cleanup levels to be achieved by remedial action. Cleanup levels to be achieved through remedial action will be defined during the remedy selection process.

For evaluating and comparing the alternatives that were developed to address CoPCs in groundwater in the Western Groundwater Study Area, PRAGs were based on risk-based criteria from the BRA and potential chemical-specific ARARs. The risk-based levels were identified using the exposure factors in the BRA and represent the lower of the concentrations reflective of a hazard quotient of 1.0 for noncarcinogenic chemicals or an additional incremental lifetime cancer risk of 1×10^{-6} for carcinogenic chemicals (EPA, 1990b). EPA has established a risk range of between 10^{-4} to 10^{-6} as being within the acceptable risk range with 10^{-6} being used as a point of departure (EPA, 1990b). Selection of risk-based levels for carcinogenic effects was based on an additional incremental lifetime cancer risk of 1×10^{-6}. Although this value is at the lower end of the point of departure used by EPA, it was selected for purposes of assessing alternatives to be more conservative. As discussed more fully in this OU RI/FS, it is not expected that any of the alternatives will result in complete restoration of the aquifer to these levels.

Numerical PRAGs for the Western Groundwater OU are summarized on Table 2-5. Many of the chemicals presented on this table were only detected in a few monitoring wells or were only detected in onsite monitoring wells. As indicated in the BRA, the primary chemicals of concern for the offsite portion of the Western Groundwater OU are perchlorate, NDMA, and TCE.

Table 2-1: Summary of Potential Chemical-Specific Requirements

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Safe Drinking Water Act (40 CFR 141)	Establishes national drinking water standards in the form of Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)	Applicable – at the point groundwater is delivered to a drinking water distribution system.	Applicable to water systems serving over 25 persons. Relevant and appropriate for smaller systems. Establishes MCLs that apply to many of the site-related chemicals (see also Table C-1).
CCR Title 22 Chapter 15, Section 64400 et seq.	Establishes California primary and secondary MCLs	Relevant and Appropriate – for in situ groundwater that is or has a potential to be used for drinking water.	All MCLs (organic, inorganic, etc.) are potentially applicable if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR)	Defines beneficial uses for surface water and groundwater in the basin. Establishes water quality objectives, including narrative and numeric standards, to protect the beneficial uses and water quality objectives (WQOs) of surface and ground waters in the region. Describes implementation plans and other control measures designed to ensure compliance with statewide plans and policies.	Groundwater uses and WQOs are potential TBCs for development of ground-water cleanup levels and remedial actions. These are also potential TBCs if the selected remedial action includes reinjection of treated water. Surface water uses and WQOs are potential TBCs if the selected remedial action includes discharge of treated water to surface water Basin Plan policies and procedures for establishment of cleanup levels are not TBCs as CERCLA sets methods for identification of cleanup levels at NPL sites	Specific portions of the Basin Plan that are TBCs include: • Beneficial uses of waters in the basin including: <u>Ground water</u> – municipal and domestic supply (MUN), – agricultural supply (AGR), – industrial service supply (IND) and – industrial process supply (PRO) <u>Surface water</u> – MUN, AGR, IND, – Recreation (REC) – Freshwater habitat (WARM) and (COLD), Wildlife habitat (WILD), Migration of aquatic organisms (MIGR), and Spawning (SPWN) • Water quality objectives to protect these uses including: <u>Ground water</u> – Numerical standards for bacteria, chemical constituents (MCLs), and radioactivity – Narrative standards for tastes and odors and toxicity <u>Surface water</u> – Numerical limits for bacteria, chemical constituents, dissolved oxygen, pH, radioactivity, salinity, temperature and turbidity – Narrative standards for biostimulatory substances, color, floating material, oil and grease, sediment, settleable material, suspended material, tastes and odor, and toxicity

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR) [cont.]			• Basin Plan also requires that any activity, including, but not limited to, the discharge of contaminated soils or waters or in-situ treatment or containment of contaminated soils or waters, must not result in actual water quality exceeding water quality objectives.
State Water Resources Control Board Resolution No. 88-63 "Sources of Drinking Water Policy" (contained in the RWQCB's Water Quality Control Plan)	Specifies that, with certain exceptions, all ground and surface waters must have the beneficial use of municipal or domestic water supply.	Potential TBC with respect to beneficial uses Potential TBC with respect to basis for exceptions from the general designations of beneficial uses	This policy is used by the Regional Water Board in determining beneficial uses for waters. The beneficial uses established in the Basin Plan are based on this policy. The beneficial uses in the Basin Plan represent a site-specific determination and therefore are more appropriate than this general policy. This policy also establishes the basis for exceptions to the general designation of beneficial uses.
State Water Resources Control Board Resolution No. 68-16 "Statement of Policy With Respect to Maintenance of High Quality of Waters in California " ("Anti-degradation Policy").	Requires that quality of high quality surface and ground waters be maintained to the maximum extent possible. Degradation of waters will be allowed only if : – It is consistent with the maximum benefit to the people of the state, – It does not unreasonably affect present and anticipated beneficial uses, and – It does not result in water quality less than that prescribed in RWQCB and SWRCB policies. If degradation is allowed, the discharge must meet best practicable treatment or control, which must prevent pollution or nuisance and result in the highest water quality consistent with maximum benefit to the people of the state.	–Potential TBC if the selected remedial action includes disposal of wastes into waters of the State	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
RWQCB, CVR Basin Plan "Antidegradation Implementation Policy"	Defines the RWQCB policy with respect to implementation of the SWB Antidegradation Policy contained in SWB Resolution 68-16	Potential TBC for disposal of wastes into waters of the State.	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.
RWQCB, CVR Basin Plan, "Policy for Application of Water Quality Objectives"	This policy requires achievement of water quality objectives at all points within a surface water or groundwater resource for which beneficial uses have been designated rather than just at the points of use. This policy also explains how the Regional Water Board applies numeric and narrative water quality objectives to ensure the reasonable protection of beneficial uses of water. This policy also explains how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high-quality waters.	WQOs are potential TBCs for development of ground-water cleanup levels and remedial actions. Also potential TBCs if the selected remedial action includes reinjection of treated water. Surface water WQOs are potential TBCs if the selected remedial action includes discharge of treated water to surface water	This policy requires maintenance of background water quality to comply with the antidegradation policy. This policy requires WQOs to be the least stringent limits to be imposed on water quality and indicates that background represents the most stringent limits to be imposed on ambient water quality. The Basin Plan includes both numeric and narrative water quality objectives. This policy explains how the RWQCB evaluates compliance with the narrative WQOs through use of other standards, criteria, advisories, etc. as presented in *"A Compilation of Water Quality Goals"*. To the extent that the methodology presented in this policy uses promulgated standards, criteria or limitations, the narrative standards represent potential ARARs. To the extent that the methodology in this policy uses non-promulgated criteria, advisories, or risk-based levels, this policy represents a TBC. This policy also presents a methodology for assessing compliance with the narrative WQO for toxicity. Similar to the other narrative standard, to the extent the toxicity methodology relies on promulgated standards it may be an ARAR and to the extent that it relies on non-promulgated values it is a TBC. Note: The toxicity assessment required by this policy will be addressed in more detail and precision in the Baseline Risk Assessment.

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
State Water Resources Control Board Resolution No. 92-49 (As amended April 21, 1994 and October 2, 1996) "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304" Also Title 23 CCR Chapter 22, Section 2907	Establishes requirements for investigation and cleanup and abatement of discharges. Among other requirements, dischargers must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality, or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of Title 23, CCR, Section 2550.4 requirements to groundwater cleanups.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	These policies and procedures require cleanup of a discharge and abatement of effects of past, current or possible discharges of waste that creates or threatens to create a condition of pollution or nuisance. These policies and procedures establish procedures for investigation, evaluation of cleanup and abatement alternatives, implementation of cleanup and abatement actions including conformance with Resolution No. 68-16. These policies and procedures require cleanup and abatement that promotes attainment of either background water quality, or the best water quality which is reasonable (but not greater than that prescribed in the Water Quality Control Plans and Policies adopted by the State and Regional Water Boards) if background levels cannot be restored. Note: These policies and procedures also address designation and implementation of containment zones, which are discussed in table C-### under potential action-specific requirements.
RWQCB, CVR Basin Plan, "Policy for Investigation and Cleanup of Contaminated Sites."	This policy establishes and describes the RWQCB required procedures for investigation and remediation of contaminated sites. This policy also describes the RWQCB requirements for cleanup levels for groundwater and soil contamination.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	This policy requires establishment of cleanup levels for groundwater based on: – Background concentrations – Water quality objectives – Concentrations that do not pose a significant risk to human health or the environment – Technologic and economic feasibility of attaining background. This policy requires achievement of background levels when feasible. Otherwise, this policy requires achievement of water quality objectives and risk-based levels that do not pose a significant risk to human health or the environment. This policy also requires compliance with groundwater cleanup levels throughout the pollutant plume.

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Title 23, CCR, Chapter 15, Section 2550.4.	This regulation presents procedures for identifying concentration limits for cleanup and abatement of discharges from facilities that treat, store or dispose of hazardous waste at Class I waste management units. SWB Resolution 92-49 also requires use of these regulations for development of cleanup levels other than background.	Potentially applicable for identification of ground water cleanup levels. As this regulation does not contain numeric standards, it is not a chemical-specific ARAR but may be an action-specific ARAR.	This regulation requires cleanup to background concentration levels, or a concentration limit greater than background if – It is technologically and economically infeasible to achieve background, and – The constituent will not pose a substantial present or potential hazard to human health or the environment as long as the concentration limit greater than background is exceeded. This regulation lists the various factors to be considered in setting a concentration limit greater than background. This regulation also requires concentration limits that are greater than background to be set at the lowest levels that are economically and technologically achievable.
"A Compilation of Water Quality Goals"	Provides guidance on selecting numeric values to implement narrative water quality objectives contained in the Basin Plan.	To Be Considered	This document is not a promulgated regulation and therefore in itself is not an ARAR but may be a TBC. This document should be considered in selecting appropriate numeric values to implement the narrative WQOs in the Basin Plan. The numeric values contained in the staff report may be ARARs or TBCs depending on the source of the values.
National Pollutant Elimination Discharge System (NPDES Permit)	These regulations set forth the requirements for discharge to surface water and the Establishment of numeric limits and monitoring requirements for such discharges.	Applicable – if the selected remedial action includes discharge of treated water to surface water.	Discharge of treated groundwater to surface water may require obtaining a new NPDES permit or revision of Aerojet's existing NPDES permit (see also Table C-2). The NPDES permit will specify the numeric standards required to be met in water that is to be discharged to surface water as well as the monitoring requirements for such a discharge.
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) Also Title 22 CCR Chapter 3 Section 12000 et seq.	These regulations identify chemicals known to cause cancer or reproductive toxicity. This act prohibits discharge or release of significant amounts of the identified chemicals.	The numeric limits and notification requirements are potentially relevant and appropriate if the selected remedial action includes use of treated groundwater as drinking water supply.	These regulations make it illegal to expose persons to significant amounts of chemicals known to cause cancer or reproductive toxicity without prior notification, or to discharge significant amounts of these chemicals to sources of drinking water. The numeric limits and notification requirements are applicable to the water suppliers at the point that groundwater is delivered to a water system for public consumption.

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) cont.	Significant amounts are generally defined as levels that pose no significant risk of cancer. For drinking water, significant levels are defined as California MCLs, drinking water action levels when MCLs don't exist, or discharge limits allowed by a Basin Plan or waste discharge permit.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge or reinjection of treated water.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge of treated water to surface water or reinjection of treated groundwater. The numeric limits and notification requirements are applicable to remedial actions, if any, that include use of treated water for municipal or domestic supply.
National Ambient Water Quality Criteria	Establishes water quality criteria, which are non-enforceable guidance developed under CWA §304 and are used by the State, in conjunction with designated use for a stream segment, to establish water quality standards under CWA §303.	Neither applicable nor relevant and appropriate for groundwater. Potentially relevant but likely not appropriate for discharge of treated water to surface water.	These criteria are published by EPA to protect human health and welfare and freshwater and marine aquatic life from pollutants in surface waters and therefore are not applicable to groundwater. Ambient water quality criteria are based on consumption of drinking water and aquatic organisms (primarily fish) and consumption of fish alone and therefore are not relevant to groundwater in the Western Groundwater OU. Although potentially relevant, ambient water quality criteria are not appropriate requirements as the RWQCB has adopted numeric standards for the surface waters in the area which represent site-specific water quality standards which are more appropriate requirements.
US EPA Region 9 Preliminary Remediation Goals (PRGs)	EPA has developed preliminary remediation goals that are risk-based levels that are used to screen sites that may require additional investigation or possible remediation. PRGs are also used to screen lists of site-related chemicals to identify potential chemicals of concern.	To Be Considered	EPA Region 9 PRGs are guidance levels, not promulgated standards, and therefore are not an ARAR; however, the PRGs may be TBCs for identification of potential groundwater cleanup levels.
California Department of Health Services (DHS) Drinking Water Action Levels	DHS has established action levels based mainly on health effects but in some cases based on organoleptic (taste and odor-based) values	To Be Considered	Action levels (ALs) are advisory to water suppliers and therefore would not be ARARs. They are potential TBCs for identifying potential groundwater cleanup levels. Of particular interest in this matter are the ALs for perchlorate and NDMA.

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Public Health Goals (PHGs)	The California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA) has adopted PHGs for chemicals in drinking water. PHGs are levels of drinking water contaminants at which adverse health effects are not expected to occur from a lifetime of exposure.	To Be Considered	PHGs are non-enforceable risk-based goals and therefore are not ARARs but are TBCs for identifying potential groundwater cleanup levels.
EPA Integrated Risk Information System (IRIS)	A non-promulgated database of health effects that may result from exposure to various substances found in the environment.	To be considered	IRIS values were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.
EPA Drinking Water Health Advisories and NAS Suggested No Adverse Response Levels (SNARLs)	Non-promulgated values published by USEPA and the National Academy of Sciences for toxicity other than cancer or incremental cancer risk estimates	To be considered	EPA drinking water health advisories and incremental cancer risk estimates and NAS SNARLs and incremental cancer risk estimates were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.

Table 2-2: Summary of Potential Location-Specific Requirements

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Within floodplain	40 CFR Part 6, Appendix A, Fish and Wildlife Coordination Act (16 USC 661 et seq.), and 40 CFR Part 6.302	Require avoidance of adverse effects, minimization of potential harm, and restoration and preservation of natural and beneficial values of floodplains.	Potentially Applicable to any actions that may be conducted within the floodplain.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within 100-year flood plain	40 CFR 264.18(b) and 22 CCR 66264.18(b)	A RCRA facility located in a 100-year flood plain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	Potentially Applicable if groundwater treatment involves treatment or storage of hazardous wastes.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	National Archaeological and Historical Preservation Act (16 USC Section 469); 36 CFR Part 65	Alteration of terrain that threatens significant scientific, prehistoric, historic, or archaeological data may require actions to recover and preserve artifacts.	Potentially applicable if significant artifacts are encountered during construction	The proposed remedial alternatives will not alter or destroy any known prehistoric or historic archeological features west of the Aerojet Sacramento facility site. Areas west of the Aerojet Sacramento facility are essentially completely developed. However, because there is always a possibility that buried historic or prehistoric remains could be discovered during construction, this regulation would require action to recover and preserve artifacts.
Historic project owned or controlled by a federal agency	National Historic Preservation Act (NHPA) Section 106 (16 USC Section 470 et seq.); 36 CFR Part 800	Property included in or eligible for the National Register of Historic Places may require action to preserve historic properties.	Neither applicable nor relevant and appropriate	The anticipated remedial actions do not include any activities on properties included on, or eligible for inclusion on the National Register of Historic Places. If it is determined that properties subject to NHPA are present and could be impacted during the implementation of the remedial action, these requirements may be applicable and would require mitigation measures to protect or preserve such properties.

Table 2-2: Summary of Potential Location-Specific Requirements (continued)

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Critical habitat upon which endangered species or threatened species depend	Substantive portions of the Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR Part 200, 50 CFR Part 402 Substantive portions of the California Endangered Species Act Substantive portions of the Native Plant Protection Act	Requires action to conserve endangered species or threatened species, including consultation with the Department of the Interior, Fish and Wildlife Service.	Potentially applicable if critical habitat for endangered species could be affected during implementation of the selected remedy	Two endangered floral species are known to occur within Sacramento County: the Sacramento Orcutt grass (Orcuttia Viscida) and the Boggs Lake hedge hyssop (Gratiola Heterosepala). Four endangered wildlife species are expected to occur within 25 miles of the Aerojet Sacramento facility: Bald Eagle, Peregrine Falcon, Giant Garter Snake, and the Valley Elderberry Longhorn Beetle. The Aerojet Sacramento facility may be a habitat for the Burrowing Owl, a species of concern in California. Consultations between Department of Toxic Substances Control (DTSC) and Department of Fish and Game may be conducted if such species are affected by remedial actions.
Wetlands	40 CFR Part 6 Appendix A	Actions must be taken to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	Potentially applicable if any remedial action components are constructed in or otherwise affect wetland areas	Requires actions to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.
	Fish and Game Commission Wetlands Policy (adopted 1987) included in Fish and Game Code Addenda	Actions must be taken to ensure that "no net loss" of wetlands acreage or habitat value occurs. Actions must be taken to restore and enhance California's wetland acreage and habitat value.	TBC	This policy is not a regulatory program but may be considered a TBC criteria.
Areas affecting stream or river	Fish and Wildlife Coordination Act (16 USC 661 et seq.) and 40 CFR Part 6 §302	Restrictions on diversion, channeling or other activity that modifies a stream or river and affects fish or wildlife.	Potentially applicable to any remedial action components that may be constructed in or along a creek or river	Requires action to protect fish or wildlife.

Table 2-3: Summary of Potential Action-Specific Requirements

Action	Potential Requirement	Citation	Description	Preliminary ARAR Determination	Comments
Generation of waste from operation of a groundwater treatment plant	RCRA and State standards for identification and classification of hazardous wastes	40 CFR Part 261 and 22 CCR §66261	Establishes procedures and numeric limits for identification of characteristic hazardous wastes, listed hazardous wastes, and State-only (non-RCRA) hazardous wastes.	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the selected remedial action or operation of a groundwater treatment plant.
	RCRA Generator Standards – hazardous waste determination	40 CFR § 262.11 and 22 CCR §66262.11,	Requires waste generators to determine if wastes are hazardous wastes and establishes procedures for such determinations	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action or operation of a groundwater treatment plant.
Shipment of hazardous wastes for treatment or disposal offsite	RCRA Generator Standards – hazardous waste shipment	40 CFR § 262.30 – 33 and 22 CFR 66262.30 through 66262.33	Prior to transportation, containers should be packaged, labeled, marked, and placarded in accordance with RCRA and Department of Transportation requirements.	Potentially applicable	These requirements are applicable if containers are used to contain hazardous waste to be sent for offsite treatment or disposal.
	RCRA Generator Standards – hazardous waste accumulation	40 CFR § 262.34 and 22 CCR §66262.34	Specifies maximum amounts and maximum periods for accumulation of hazardous waste onsite under generator status	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action and operation of any groundwater treatment plant if these waste materials are hazardous wastes.
Discharge to surface water and/or reinjection of groundwater	Basin Plan – beneficial uses, WQOs and policies and procedures	SWB Resolution 68-16 ("Anti-degradation policy")	Requires maintenance of existing water quality that is better than that required by other policies.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
		SWB Resolution Nos. 68-16 and 92-49	Allow for the use of mixing zones as part of a determination of whether water quality is being maintained in the receiving water.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.

Table 2-3: Summary of Potential Action-Specific Requirements (cont.)

Action	Potential Requirement	Citation	Description	Preliminary ARAR Determination	Comments
	NPDES discharge requirements	40 CFR Parts 122 and 125 and 23 CCR 2235 et seq.	Establishes permit, treatment and monitoring requirements for discharges to surface water	Potentially applicable	This requirement is potentially applicable if the selected remedial action includes discharge of treated water to surface water.
Stormwater management	NPDES stormwater requirements	40 CFR Parts 122.26 23 CCR 2235 et seq.	Establishes permitting, monitoring, and pollutant control requirements for stormwater from industrial activities.	Potentially applicable	These requirements would be applicable if construction activities associated with the remedial action disturb an area of 5 acres.
Groundwater containment	Containment Zone (CZ) requirements	SWB Resolution No. 92-49 and related Containment Zone Application Requirements	Defines requirements to support use of a containment zone and for delineation and implementation of a containment zone for groundwater contamination.	Potential TBC	The SWB Resolution is potential TBC if the selected remedial action includes physical or hydraulic containment of contaminated groundwater. The Containment Zone Application Requirements are a TBC.
Groundwater extraction and treatment	Evaluation of alternatives for reuse of treated water	Basin Plan – wastewater reuse policy	Requires evaluation of potential water reuse options and identifies potential reuse options that should be considered prior to disposal of treated groundwater	Potential TBC	This policy is a potential TBC for remedial actions that include disposal of treated groundwater. This requirement is being addressed through consideration of the various remedial alternatives including potential groundwater reuse options as part the FS evaluation.
Use of treated groundwater for domestic use	Criteria for domestic use of impacted groundwater	DHS Policy Guidance for Direct Domestic Use of Extremely Impaired Source	Sets forth DHS policy for approval of use of treated groundwater for domestic use	TBC	This policy establishes criteria related to use of treated groundwater for domestic supply and is a TBC criteria for remedial actions that include wellhead treatment or other direct use of treated groundwater.

Table 2-4: Summary of Potential Chemical-Specific ARARs and TBCs for Contaminants of Potential Concern in Groundwater

Contaminant of Potential Concern	Federal Primary MCL (mg/L)	Federal MCLG (mg/L)	California Primary MCL (mg/L)	California DHS Action Levels (mg/L)	California Proposition 65 Levels (mg/L)[a]	California PHGs (mg/L)	USEPA Region 9 PRGs (mg/L)[b]
1,1,2-Trichloroethane	0.005	0.003	0.005	NA	0.005	NA	0.0002
1,1-Dichloroethane	NA	NA	0.005	NA	0.05	NA	0.81
1,1-Dichloroethene	0.007	0.007	0.006	NA	NA	0.01	0.000046
1,2-Dichloroethane	0.005	0	0.0005	NA	0.005	0.004	0.00012
1,2-Dichloroethene (cis)	0.07	0.07	0.006	NA	NA	NA	0.061
1,2-Dichloroethene (trans)	0.1	0.1	0.01	NA	NA	NA	0.12
Carbon tetrachloride	0.005	0	0.0005	NA	0.0025	NA	0.00017
Chloroform	0.1 [c]	0	0.1 [c]	NA	0.01	NA	0.00016
Freon-113	NA	NA	1.2	NA	NA	4	59
Tetrachloroethene	0.005	0	0.005	NA	0.007	NA	0.0011
Trichloroethene	0.005	0	0.005	NA	0.025	0.0008	0.0016
Vinyl chloride	0.002	0	0.0005	NA	0.0015	NA	0.00002
Perchlorate	NA	NA	NA	0.0018	NA	NA	0.018
NDMA	NA	NA	NA	0.00002	0.00002	NA	0.0000013
Nitrate [d]	10	NA	45 [e]	NA	NA	NA	NA
Nitrite [d]	1	NA	1	NA	NA	NA	NA
Total Nitrate and Nitrite [d]	10	NA	10	NA	NA	NA	NA

[a] Converted to concentration based on 2 liters per day consumption.
[b] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
[c] For total trihalomethanes (sum of bromoform, bromodichloromethane, chloroform, and dibromochloromethane).
[d] Expressed as N.
[e] Expressed as NO_3.
NA = not available.

Table 2-4: Summary of Potential Chemical-Specific ARARs and TBCs for Contaminants of Potential Concern in Groundwater (cont.)

Contaminant of Potential Concern	IRIS RfD as drinking water levels	IRIS $1x10^{-6}$ incremental cancer risk	EPA DWHAs or SNARLs – non-carcinogenic	EPA DWHAs or SNARLs – carcinogenic	NAS SNARLs – non-carcinogenic	NAS SNARLs - carcinogenic	Taste & odor thresholds
1,1,2-Trichloroethane	2.8	0.6	3				
1,1-Dichloroethane							
1,1-Dichloroethene	6	0.06	7		100		1,500
1,2-Dichloroethane		0.4	700 / 2,600	0.4		0.71	7,000
1,2-Dichloroethene (cis)			70				
1,2-Dichloroethene (trans)	140		100				260
Carbon tetrachloride		0.3	70 / 300	0.3	200	4.5	520
Chloroform		6	100 / 400	6		0.26 / 56	2,400
Freon-113	210,000						
Tetrachloroethene	70		2,000	0.7		3.6	170
Trichloroethene				3		1.5	310
Vinyl chloride			10 / 50	0.015		1.1	3,400
Perchlorate							
NDMA		0.0007					
Nitrate [d]	11,000		10,000				
Nitrite [d]	700		1,000				
Total Nitrate and Nitrite [d]							

Notes:
All values are in units of ug/L
[a] Converted to concentration based on 2 liters per day consumption.
[b] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
[c] For total trihalomethanes (sum of bromoform, bromodichloromethane, chloroform, and dibromochloromethane).
[d] Expressed as N.
NA = not available.

Table 2-5: Preliminary Remedial Action Goals (PRAGs)

Contaminant of Potential Concern	Risk-Based Concentration[1]		Potential Chemical-Specific ARAR or TBC		Preliminary Remedial Action Goal (PRAG)	
	Value[2]	Basis	Value[2]	Source	Value[2]	Comments
1,1,2-Trichloroethane	0.9	C	3	MCLG	0.9	Risk-based value is lower
1,1-Dichloroethane	11.2	C	5	California MCL	5	MCL is lower
1,1-Dichloroethene	0.11	C	6	California MCL	0.11 (0.5)	Risk-based value adjusted for laboratory PQL of 0.5 ug/L
1,2-Dichloroethane	1.4	C	0.5	California MCL	0.5	MCL is lower
1,2-Dichloroethene (cis)	350	NC	6	California MCL	6	MCL is lower
1,2-Dichloroethene (trans)	700	NC	10	California MCL	10	MCL is lower
1,2-DCE (total)	320	NC			320	Only a risk-based level is available
Carbon tetrachloride	0.43	C	0.5	California MCL	0.43 (0.5)	Risk-based value adjusted for laboratory PQL of 0.5 ug/L
Chloroform	2.1	C	10	Proposition 65	2.1	Risk-based value is lower
Freon 113	950,000	NC	1,200	California MCL	1,200	MCL is lower
Tetrachloroethene	1.2	C	5	Federal and California MCL	1.2	Risk-based value is lower
Trichloroethene	5	C	5	Federal and California MCL	5	Risk-based level and MCL are the same
Vinyl chloride	0.24	C	0.5	California MCL	0.24 (0.5)	Risk-based value adjusted for laboratory PQL of 0.5 ug/L
Perchlorate	34	NC	18	DHS Action Level	34	Risk-based value is based on more recent toxicological data than was used for development of the Action Level
NDMA	0.0042	C	0.02	DHS Action Level and Prop 65	0.02	Action level, which equals lab PQL
Nitrate [d]	58,000	NC	10,000	Federal MCL	10,000	MCL is lower
Nitrite [d]	3,700	NC	1,000	Federal MCL	1,000	MCL is lower
Total Nitrate and Nitrite [d]			10,000	Federal MCL	10,000	Only an MCL is available

Notes:
[1]Based on BRA calculations corresponding to an additional lifetime cancer risk of one in one million or a hazard index of 1.0 for non-carcinogens.
[2]All values expressed as ug/L.
[3]C = value based on $1x10^{-6}$ incremental cancer risk. NC = value based on hazard index of 1.0 for non-carcinogenic effects.
[4]PQL = practical quantitation limit.

Page 29, Section 3.3.1 Identification and Screening of Technologies and process Options. Aerojet in the later stages of the RI/FS initiated two filed pilots for groundwater remediation. A field pilot study for *in-situ* biological remediation of both perchlorate and TCE in groundwater is currently being implemented and expected to be completed first quarter 2001. Calcium-magnesium-acetate is used as a food source to enhance bacteria to break perchlorate into chloride and oxygen and TCE into ethene and chloride in the groundwater itself without removal to the surface for treatment. Also a pilot study for ligands applicable to wellhead treatment for perchlorate is pending and is being added as a potential technology for further evaluation. Ligands are molecules that attach themselves to a second molecule by shared electrons. For wastewater treatment, the ligand is the substance being removed from the water (e.g., perchlorate). Ligands could be a cheaper compact wellhead treatment technology.

Page 35, Section 3.3.2.4, Alternate/Replacement Water Supply. This Section provides potential options for replacement of water supplies that are lost prior to, and after, the remedial measures are implemented. The proposals presented in the RI/FS are not of sufficient detail to provide for an effective plan to replace lost water supplies. Most of the options for alternate water discussed in the RI/FS, including, direct reuse of treated groundwater, indirect reuse of treated groundwater, and new surface water supply, have issues that need to be resolved and are not immediately viable as an interim measure for replacing lost water supplies. A water supply contingency plan providing more specifics needs to be developed for interim measures that will replace lost water supplies until final measures for the water replacement can be put in place. The water supply contingency plan can be developed as a separate document to the RI/FS. Aerojet has been requested to develop the contingency plan and the first two versions of the plan have been submitted for agency review and comment. In response to agency comments, a revised contingency plan is currently in development by Aerojet.

3 IDENTIFICATION AND SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGIES

In this section General Response Actions (GRAs), technologies, and process options are described and an overview of the process used to identify and screen technologies is provided. The overview is followed by a detailed discussion of the GRAs, and the identification and screening of technology types and possible process options. Technologies and process options are then used in Section 4 as components of potential OU-wide remedial alternatives.

The process of identifying OU-wide remedial alternatives begins with identification of the potential scope of any remedial action. GRAs that may be applicable to the OU based on the results of the site characterization (Section 1 and Appendix A) and the RAOs established in Section 2 are then identified. Potential remedial action technologies associated with each GRA that may be applicable to the OU and the RAOs are first identified and screened based on technical implementability. The resultant technologies are then evaluated based on anticipated effectiveness, implementability and relative cost to identify the most applicable technologies. These technologies are then combined to develop remedial action alternatives for the Western Groundwater OU. In Section 5 of this RI/FS, the OU-wide remedial action alternatives are subjected to detailed analysis for the various factors required for evaluation in accordance with the NCP (EPA, 1990).

3.1 General Response Actions

After RAOs are established for a site or OU, media-specific GRAs are developed to satisfy the RAOs. The RAOs for the Western Groundwater OU RI/FS are described in Section 2. On the basis of the current understanding of the CoPCs and environmental conditions associated with the Western Groundwater Study Area, the GRAs that could be implemented to achieve these RAOs include the following:

- No-Action: No attempt is made to satisfy the RAOs and no remedial measures are implemented. No-Action is required for consideration by the NCP as a basis against which the other alternatives are compared;
- Institutional controls: Non-engineering methods by which access to contaminated groundwater is physically restricted or regulated, and/or contamination is monitored;
- Monitoring;
- Replacement or substitute water supply;
- Containment of groundwater: Actions that result in contaminated groundwater being contained, thereby minimizing or eliminating the migration of CoPCs and preventing

exposure to contamination. Groundwater containment has a corollary benefit of some mass removal, although mass removal is not the primary objective;

- Treatment of groundwater; and
- Management/reuse of treated groundwater.

A summary of these GRAs is illustrated in Figure 3-1.

3.2 Technologies and Process Options

For each GRA, broad technology groups and specific process options that could be used to implement these actions are identified. Technologies refer to general categories (e.g., chemical treatment or biological treatment). Process options refers to the specific processes within each technology type (e.g., air stripping or cometabolic bioreactors). As discussed in Section 4, the No-Action GRA is included to provide a reference with which to compare the other alternatives that are developed.

Evaluation of potentially applicable technology types and process options is a key step in the FS process. The criteria for identifying potentially applicable technologies are provided in EPA guidance (EPA, 1988a) and in the NCP (EPA, 1990b). A strong statutory preference for remedies that are reliable and provide long-term protection is identified in Section 121 of CERCLA, as amended. The primary requirements for a final remedy are that it be both protective of human health and the environment and cost effective. Hence, candidate technologies and process options need to be capable of satisfying these key factors. A summary of potentially applicable remedial technology types and process options is illustrated in Figure 3-1. Information from the literature, including applicability, performance, removal efficiencies, operation and maintenance (O&M) requirements, implementability, and the relative cost of candidate technologies was considered in preparing the list of technologies and process options provided on Figure 3-1.

3.3 Screening and Evaluation of Groundwater Remediation Technologies and Process Options

The universe of potentially applicable technology types and process options applicable to each identified GRA is initially reduced through screening the options with respect to technical implementability. The results from this initial screening based on technical implementability are also included on Figure 3-1. Technologies and process options considered to be technically implementable are evaluated in greater detail on the basis of effectiveness, implementability (both technical and administrative), and relative cost as defined by the following factors:

- Effectiveness - in terms of protecting human health and the environment in both the short term and the long term;

- Implementability - in terms of technical feasibility, resource availability, and administrative feasibility; and

- Cost - in a comparative manner (i.e., low, moderate, or high) for technologies of similar performance and/or implementability.

These evaluation criteria are applied only to the GRAs and technologies being evaluated for the Western Groundwater OU and not to possible combinations of these technologies and process options that might be combined to form OU-wide remedial alternatives.

Technologies and process options that are not effective in protecting human health and the environment, that cannot be implemented because of the physical characteristics of the site or CoPCs, or that have a cost that is an order of magnitude greater than a similar technology are eliminated during this second evaluation. In accordance with USEPA guidance (1988a), effectiveness is the major emphasis of this second evaluation. Less weight is given to cost and implementability. The technologies and process options that are retained after the effectiveness, implementability, and cost evaluation are assembled into a range of OU-wide remedial alternatives in Section 4.

USEPA presumptive remedy guidance (Presumptive Remedies: Policies and Procedures; USEPA, 1993a) was used where appropriate to identify technologies and process options. Presumptive technologies were used to select ex-situ groundwater treatment process options. Eight presumptive technologies are identified in EPA's guidance document *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (EPA, 1996c.) Four of these technologies are applicable to organic contaminants (air stripping, granular activated carbon, chemical/ultraviolet oxidation, and aerobic biological reactors). When the presumptive technologies are used to treat dissolved contaminants in extracted groundwater, site-specific identification and screening of alternatives is not required. The basis for eliminating these steps is provided in the guidance listed above and EPA's *Analysis of Remedy Selection Experience for Ground Water Treatment Technologies at CERCLA Sites, Draft Final* (USEPA, 1996b). All of the presumptive technologies are well understood and have been used for many years for water, wastewater, and groundwater treatment.

3.3.1 Identification and Screening of Technologies and Process Options

In accordance with USEPA guidance (USEPA, 1988a), technologies and process options for the groundwater GRAs were identified and screened for technical implementability. Screening results are summarized on Figure 3-1.

Process options for groundwater remediation that require excavation to groundwater, placement of a physical barrier in groundwater, or phytoremediation were screened-out

based on various implementability issues discussed under screening comments on Figure 3-1 including the depth to groundwater, the vertical depth of existing or potential occurrences of CoPCs, and the difficulty of constructing a long trench through developed properties containing many buried utilities. These process options are not implementable west of the Aerojet Sacramento facility where the depth to groundwater is approximately 100 feet or greater and the vertical extent of contamination in some areas extends to depths of 300 feet or more. These include all of the process options associated with interceptor trench subsurface drains; vertical physical barriers such as slurry walls, HDPE curtain walls, and reactive in-situ metals walls; and air sparging. Air sparging was also eliminated because two of the CoPCs, perchlorate and NDMA, are not removed by this process.

Presumptive process options for ex-situ treatment of dissolved contaminants in groundwater were identified in USEPA's *Final Guidance: Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (USEPA, 1996c). Screening and evaluation of the presumptive process options is not required. However, the presumptive process options were screened to provide a comparison with other process options that were identified. Several of the presumptive process options (e.g., precipitation, electrochemical processes, and aeration) were screened out because they are not applicable to the CoPCs relative to the Western Groundwater OU.

Several other process options were eliminated in the technical implementability screening process. Electrokinetics is potentially applicable for perchlorate removal but may not be implementable due to well spacing and energy requirements given the depth to water and lateral extent of the Study Area. Membrane separation will remove the CoPCs, but was not considered because of the large flowrate of reject or concentrate sidestream anticipated to be generated (up to 10 percent of the groundwater to-be-treated flowrate). Bench-testing of an above-ground reactive metals reactor conducted by Aerojet indicated that NDMA removal is possible; however, encrustation and clogging of the media occurred, eliminating the process from consideration on a full-scale basis. Deep well injection of treated groundwater was eliminated because the permeability of the deeper groundwater units is not expected to be great enough to support this process option cost-effectively.

It should be noted that two of the CoPCs relative to the Western Groundwater OU, NDMA and perchlorate, have not historically been identified at CERCLA sites as being common CoPCs. Also, numerous presumptive technologies and process options do not exist for removal of these CoPCs from groundwater. A few processes are currently operating on a full-scale basis and several other innovative processes are currently undergoing treatability testing.

For NDMA, although several other process options have been tested (Fleming et al., 1995, and HLA, 1995), really only the ultraviolet irradiation/chemical oxidation (UV/oxidation) process option is available to remove this CoPC to concentration levels of concern in this RI/FS. According to the one manufacturer of UV/oxidation equipment for

removal of NDMA, Calgon Carbon Corporation, there are currently 14 installations in the United States and Canada removing NDMA to below current analytical method detection limits (Crawford, 2000).

For perchlorate removal, there are only two process options that are in a DHS approval review cycle: biological reduction and ion exchange. Aerojet conducted extensive full-scale pilot testing of the biological reduction process in 1997 and 1998 and is currently in full-scale operation of a 3,400 gpm system at the GET F treatment facility. The biological perchlorate removal system consists of four fluidized bed reactors each designed to treat 900 gallons per minute (gpm). During the first six months of operation, Aerojet experienced problems controlling the bed height in one of the two operating reactors. A series of tests were run in the Summer and early Fall of 1999 to control the growth rate of filamentous bacteria that were causing the bed height growth. Bed height growth rates were controlled during these tests and each of the fluidized bed reactors achieved non-detect perchlorate effluent concentrations between October and November 1999 (Harding Lawson Associates, 2000 pending). Aerojet is continuing to monitor and optimize the operation of the fluidized bed reactors.

The second process option for perchlorate removal considered in this RI/FS is ion exchange. This process, specifically the Calgon Ionic SEParation (ISEP®) ion exchange process, has undergone pilot-testing at several sites in the past two years but has yet to be installed full-scale to remove perchlorate from groundwater.

With the exception of horizontal extraction wells and several innovative process options, the majority of the process options retained as a result of the technical implementability screening have been or are currently being used at the Aerojet Sacramento facility. The GETs E/F onsite source containment system includes process options to address the same CoPCs that are found offsite in the Western Groundwater OU. A process flow schematic for this groundwater containment and treatment system is included as Figure 3-2. In August 1999, Aerojet combined the GETs E and F treatment facilities so that groundwater extracted from both of the GETs E and F extraction well systems undergo the same treatment processes. At the same time, UV/oxidation was added to the GET E/F treatment train to remove NDMA. The NDMA removal system is designed to treat NDMA to 0.002 µg/L. On September 26, 1999, the NDMA concentration in the combined GET E/F effluent was below the NDMA method detection limit of 0.0075 µg/L.

Aerojet continues to evaluate innovative treatment process options for treatment of chemicals, including VOCs, NDMA and perchlorate. As discussed previously, to date, Aerojet has demonstrated that a biological reduction process will result in perchlorate removal from groundwater. Aerojet has also identified and pilot tested an innovative NDMA treatment process that is not discussed in detail in this RI/FS because it is Confidential Business Information (CBI). In addition, Aerojet is currently evaluating (including bench and pilot scale testing) two other innovative CBI technologies for the removal of NDMA and perchlorate from groundwater.

The process options that were retained following the technical implementability screening are as follows. If sufficient information from pilot testing is obtained such that a decision can be made regarding use of a process option at full-scale, additional innovative technologies that are currently being pilot-tested may be appropriate for addition and selection in the future during the remedial design phase of any selected remedy.

General Response Action	Remedial Technology	Process Options
No Action	Not applicable	• Not applicable
Institutional Controls	Proprietary Controls	• Land purchase • Deed restrictions • Deed notices • Easements • Covenants
	Governmental Controls	• Land use restrictions • Groundwater use restrictions • Advisories
Monitoring	Monitoring	• Groundwater monitoring

Alternate/Replacement Water Supply	Alternate/Replacement Water Supply	• New water supply well
		• New water supply:
		  • Inter-ties with other water purveyors
		  • Direct reuse of treated groundwater
		  • Indirect reuse of treated groundwater
		  • New surface water supply

Monitored Natural Attenuation	Monitoring/Verification	• Groundwater monitoring
Containment	Hydraulic Barriers	• Vertical extraction wells • Horizontal extraction wells • Recharge wells
Collection	Groundwater Extraction	• Vertical extraction wells • Horizontal extraction wells • Recharge wells
In-Situ Treatment	Stripping	• In-well aeration/stripping
	Biological Treatment	• Enhanced biological reduction

General Response Action	Remedial Technology	Process Options
Liquid Phase Treatment	Ex-situ Physical Treatment	• LPGAC • Air stripping • Filtration
	Ex-situ Chemical Treatment	• Ion exchange • UV/oxidation • pH adjustment
	Ex-situ Biological Treatment	• Aerobic bioreactors • Cometabolic bioreactors • Anaerobic bioreactors
Vapor Phase Treatment for Air Stripping	Ex-situ Physical/ Chemical Treatment	• Direct discharge • VPGAC • Catalytic oxidation • Thermal oxidation
Management/Reuse of Groundwater	Treated Groundwater Management	• Direct potable water supply • Indirect potable supply • Nonpotable water reuse • Streamflow augmentation • Discharge to a Publicly-Owned Treatment Works (POTW) • Groundwater recharge
	Untreated Groundwater Management	• Discharge to POTW

3.3.2 Evaluation of Retained Process Options

The groundwater remediation process options remaining after the initial screening are further evaluated in this section using the criteria of effectiveness, implementability, and cost. The evaluation is presented on Figure 3-3 and discussed in the following sections organized by GRAs.

3.3.2.1 No Action

The No Action GRA is required to be evaluated in the FS and is therefore retained. Evaluation of the No Action alternative serves as a baseline for comparison with other remedial action alternatives. The No Action GRA is not action-based, but rather consists solely of monitoring and activities in support of monitoring.

3.3.2.2 Institutional Controls

The institutional controls process options are nonengineering methods by which federal, state, and local governments or private parties can prevent or limit access to affected environmental media and are applicable in conjunction with other response actions (USEPA 1998b). Institutional controls do not reduce contaminant mobility, toxicity, or volume, but they can reduce the potential for exposure to contaminated material. The NCP contains the following "expectation" regarding the use of institutional controls (USEPA, 1990b):

> "EPA expects to use institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants or contaminants. Institutional controls may be used during the conduct of the remedial investigation/feasibility study (RI/FS) and implementation of the remedial action and, where necessary, as a component of the completed remedy. The use of institutional controls shall not substitute for active response measures (e.g., treatment and/or containment of source material, restoration of ground waters to their beneficial uses) as the sole remedy unless such active measures are determined not to be practicable, based on the balancing of trade-offs among alternatives that is conducted during the selection of remedy."

More commonly, institutional controls are used because treatment and containment measures do not address risks entirely so that the remedy must include activity restrictions to ensure that it is fully protective. For example, over the time that is required to pump and treat contaminated groundwater, other measures may be needed to ensure that residents are not inadvertently exposed by drilling new wells. Containment remedies may have to be supplemented with institutional controls to ensure that future land users are aware of the wastes left on site and that they do not take actions that might interfere with the containment system (USEPA, 1998b).

Institutional control measures that apply solely to groundwater, such as groundwater use restrictions, may be used to prohibit or limit the drilling of new wells, prohibit the temporary use of existing wells, or require the shutdown of public water supply wells if monitoring indicates the presence of CoPCs above enforceable concentrations. While implementation of these process options alone may not attain the RAOs, they will most likely be necessary to maintain the integrity of any active remediation system that may be selected and will therefore be considered in combination with other process options during the development of alternatives.

On the basis of effectiveness, implementability, and cost, the proprietary and governmental institutional controls discussed in the following paragraphs have been retained. Land purchase and land use restrictions were not retained based on effectiveness because they are not appropriate for a groundwater action. High capital cost was also a criterion to screen-out land purchase.

Proprietary controls are based on private property law and include a variety of tools that can be implemented without the intervention of any federal, State, or local regulatory authority. Common examples include covenants or easements restricting future land use or prohibiting activities that may compromise specific engineering remedies. Governmental controls use the regulatory authority of a governmental unit to impose restrictions on citizens or sites under its jurisdiction.

Onsite Institutional Controls. Proprietary controls that can be implemented on the Aerojet property include restrictions on land use including deed restrictions, deed notices, easements, and covenants. There are deed restrictions currently on the Aerojet Site through PCD Paragraph 11. Groundwater use restrictions and advisories are governmental controls that can be implemented onsite.

Offsite Institutional Controls. Offsite institutional controls can include propriety controls such as restrictions on land use through the use of deed restrictions, deed notices, easements, and covenants. Governmental controls can include groundwater use notices/restrictions and advisories, well construction restrictions, zoning, and tailored ordinances.

An easement is a property right conveyed by a landowner to another party, which gives the second party rights with regard to the first party's land. Easements allow access to property, for example, so operation, maintenance, and monitoring can be performed; Easements may be "affirmative" or "negative". An affirmative easement allows the holder of the easement to enter upon or use another's property for a particular purpose (e.g., an access easement). A negative easement imposes limits on how the landowner can use his or her own property. For institutional controls, negative easements are most relevant. A negative easement might, for example, prohibit a particular parcel from being used for residential purposes, or prohibit well-drilling on that parcel.

It is anticipated that easements will be required if an OU-wide alternative requiring offsite construction is selected. Aerojet has attempted to obtain easements for pipelines from private property owners in the past, and has found that they are reluctant to allow the siting of infrastructure designed to carry contaminants on their property. Aerojet has also had past difficulties obtaining easements to use public utility right-of-ways from Sacramento County. Past easements were granted only after the oversight government agencies became involved with the County.

There are several departments within Sacramento County that must approve an easement application. These include the County Departments of Transportation, Water Resources, Water Quality, and Environmental Review and Assessment. The Department of Environmental Review and Assessment will require an evaluation of whether the project is exempt or must complete the California Environmental Quality Act (CEQA) process. Past experience by Aerojet (e.g., ARGET) has shown that the CEQA process may delay implementation of any selected remedy for a year or more.

Easements may also be required from the United States Bureau of Reclamation (USBR) if pipelines conveying groundwater are located adjacent to or cross the Folsom South Canal. The USBR policies for granting easements include fees based on valuing the land at its "best and highest" use. In addition, it is Aerojet's experience that USBR is hesitant to grant easements on federal property.

A covenant is a promise by one landowner to another, made in connection with a conveyance of property. Generally, a covenant is a promise by the holder of a possessory interest in property to use or refrain from using the property in a certain manner. Restrictions such as deed or access restrictions are specific provisions that apply to the use of property; for example, notifying of the potential that groundwater may be contaminated or restrictions on the use of groundwater for certain purposes. Servitudes are specific provisions that apply to the property owner and either oblige or restrict the owner from certain uses of the property that would impair an established easement.

Sacramento County is anticipated to establish a Consultation Zone provision in its existing comprehensive well drilling ordinance. Proposed Chapter 6.28.000(G) of Title 6 of the Sacramento County Code requires: "Consultation Zone. Any application for a well permit within 2000 feet of a known contaminant plume is subject to special review by appropriate regulatory agencies, including but not limited to the Sacramento County Environmental Management Department and the California Regional Water Quality Control Board, Central Valley Region, to evaluate potential impacts to public health and groundwater. The purpose of the proposed "Consultation Zone" provision is to evaluate potential impacts to public health and groundwater quality posed by the regulated activity (i.e., well construction and well decommissioning) and to prescribe appropriate procedures for these activities (based upon site-specific details available to lead regulatory agencies) that are protective of public health and groundwater quality (Sacramento County, 1999).

Descriptions of the institutional controls and the respective enforcement and monitoring activities to be included in each remedial alternative are provided in Section 4.

3.3.2.3 Monitoring

Groundwater monitoring is a process option that is expected to be a component of each remedial alternative in Section 4 and is therefore retained. Groundwater monitoring may serve the purpose of evaluating the migration of CoPCs and, depending upon the remedial alternative selected, to evaluate the effectiveness of any hydraulic containment and of any treatment processes. Groundwater monitoring is integral to monitored natural attenuation, which may be part of a selected remedial alternative.

Monitoring of water supply wells and monitor wells will also be conducted to assess potential impacts to water supply wells. The Exhibit IV process is in currently in place under a PCD for a period of three years beyond completion of the RI/FS. Exhibit IV establishes procedures for monitoring public water supply wells and procedures for

response action in the event that CoPCs are detected and exceed trigger levels. It is anticipated that a process equivalent to the Exhibit IV process would be established if the three year period were exceeded.

3.3.2.4 Alternate/Replacement Water Supply

As more fully discussed in various Water Supply Alternative Reports (Aerojet, 2000b,c) Aerojet has undertaken or paid for several projects to compensate for or replace the loss of water supply wells owned by the Arden Cordova Water Service (ACWS) and the Sacramento County Water Maintenance District (SWMD). Since the Spring of 1997, the following public water supply wells have been closed because concentrations of perchlorate and/or NDMA exceeded provisional or temporary DHS drinking water action levels :

- ACWS wells AC-13, -15, -16, -19, -11, and -14;
- SWMD Sunrise service area wells SWMD-17, and –18;
- Mather AFB wells -2, -3, and -4 (now owned by SWMD in the Mather Field service area); and
- Several privately-owned water supply wells.

In addition, ACWS has closed an additional six water supply wells (AC-1, -5, -7, -10 -12, and -21) because ACWS has analytical data which it believes showed low (i.e., <0.005 µg/L) concentrations of NDMA in these wells. However, current temporary DHS guidelines for NDMA in drinking water require that water purveyors shut down wells when NDMA concentrations exceed 0.2 µg/L. Aerojet has compensated or offered to compensate ACWS for the loss of water from wells AC-11, -13, -15, -16, and –19 as outlined in the Revised Preliminary and Final Water Supply Alternatives Reports for Arden Cordova Water Service Wells #11, 13, 15, 16, and 19 dated March 16, 2000 (Aerojet, 2000b). The lost capacity caused by the closure of AC-14 has not been addressed because the concentrations of NDMA in this well did not exceed the trigger levels specified in the PCD.

In addition, Aerojet has addressed Sacramento County Well #17 in the Preliminary Water Supply Alternative Report prepared for that well (Aerojet, 2000c). The actions financed by Aerojet and documented in this report enable the County to provide water to its Sunrise Service Area through a series of inter-ties, but do not address the question of long-term capacity replacement.

There are various short- and long-term water supply alternatives (i.e., process options) for replacing public and private water supplies that may be impacted in the future as a result of the CoPCs in groundwater in the Study Area. Short-term water replacement may be necessary in the event water supply wells are impacted prior to the implementation of a

remedy identified in the ROD for the Western Groundwater OU. Long-term water supply process options may be a component of each OU-wide alternative that is developed in Section 4 to replace impacted water supply wells or to serve as a new alternate water supply. On the basis of effectiveness, implementability, and cost, the alternate/replacement water supply alternatives of new water supply wells, inter-ties with adjacent water systems, direct reuse of treated groundwater (including wellhead treatment), indirect reuse of treated groundwater, and new surface water supply have been retained as process options.

These various water supply process options could be implemented in both the short- and long-term and could include any one or combination of the following:

- New Water Supply Well. This process option would consist of one or more new water supply wells constructed distant to the area where CoPCs are present in groundwater and transport of groundwater to the water distribution system of the affected water purveyor. The tie-in of the pipeline from the new well would be coordinated with the water purveyor with respect to whether the location of the tie-in within the water distribution system would provide sufficient flow and pressure to replace the capacity of the affected well it would be replacing.

  The construction of a new water supply well is a multi-step process that requires sufficient planning and lead-time. At a minimum, the following steps are typically completed to plan, design, and construct a new water supply well:

  - Evaluate the capacity that needs replacing;
  - Identify locations within the water distribution system where the capacity can be introduced;
  - Evaluate the hydraulic effects on contaminant plumes and existing wells from the selected new well location;
  - Locate property to site the new well;
  - Obtain the necessary permits and property owner approvals;
  - Drill and construct the well;
  - Construct the site improvements necessary to pump, control, and transmit the water to the water distribution system;
  - Conduct aquifer testing to evaluate specific capacity and well yield; and

- Collect the analytical samples required for DHS certification as a drinking water source.

In the past, the local water purveyors have constructed new water supply wells using their personnel and/or consultants and Aerojet has reimbursed them, as appropriate, for their expenses. It is estimated that the time required to conduct the above noted steps would be approximately one year. This time may be shorter in some instances where some of these steps may already be complete (e.g., property is already owned by the water purveyor).

- Inter-ties with Adjacent Water Systems. This process option would consist of water distribution pipelines being constructed between adjacent water systems and one water purveyor providing potable water to another water purveyor on an interim or long-term basis. The construction of inter-ties, if needed, requires that the unaffected water purveyor has sufficient water capacity at a rate that is acceptable to all parties. Rate negotiations and system capacity assessments can be lengthy processes requiring sufficient lead-times. Short-term water replacement may be necessary in the event water supply wells are impacted prior to the implementation of a remedy identified in this FS. Aerojet is in the process of obtaining a commitment from the City of Folsom to provide potable water to ACWS through the existing inter-tie between the two systems. This source would provide approximately 800 to 3,500 gpm for the short-term (two to three years) to ACWS. This City of Folsom commitment and other commitments are also currently being pursued for the long-term.

- Direct Reuse of Treated Groundwater. This process option would consist of placing wellhead treatment facilities on the affected water supply well to address the specific CoPCs, providing treated groundwater from one or more of the Aerojet groundwater extraction and treatment facilities, providing treated groundwater from a groundwater treatment facility that may be part of an OU-wide remedy, or a combination of these three process options. Groundwater would be treated to potable quality and directly reused in the water distribution system. If this process option were to be implemented, the California DHS impaired source issues discussed in DHS's Policy Memo 97-005 must be addressed and the water purveyor must obtain DHS approval to serve the water.

  Aerojet recognizes that there are several administrative and technical issues that must be addressed prior to obtaining DHS approval for direct reuse. The DHS policy Memo 97-005 recognizes that treated groundwater represents "a significant resource that should not be wasted". DHS guidelines also state that the when feasible sources are available, the sources presenting the least risk to public health should be utilized. Therefore, one of the steps required prior to DHS approval is an evaluation of other potential sources of drinking water.

A comprehensive evaluation of surface and ground water supplies in Sacramento County was conducted by the Water Forum and is detailed in the Water Forum Action Plan (Water Forum Proposal, January 1999). It is clear in this evaluation that surface water diversions from the American River are a sensitive issue and that there are very limited opportunities for new surface water diversions. There is a possibility of using Section 215 "spill water" during average or wetter years, however, this water is more available during the winter, when it is least needed. In the Study Area, precipitation has been above-average for the past 3-4 years and the surface water supply has been fairly abundant. However, surface water supplies may not be readily available during years of drought. In addition, currently there do not appear to be sufficient unaffected groundwater resources in the Study Area to support long term supply needs. Therefore, Aerojet believes that treated groundwater may represent the best, if not the only, source of drinking water.

If sufficient alternative drinking water sources are not available, additional steps are required prior to obtaining DHS approval for direct reuse of treated groundwater. Some of these steps have been completed in the Study Area, including a delineation of the source water capture zone, identification of contaminant sources, types, and concentration trends. Additional analytical work will be required for a full characterization of the untreated water quality, including all of the parameters outlined in the DHS guidelines.

In addition to fully characterizing the untreated groundwater, the treatment processes must be commensurate with the degree of risk associated with the contaminants present. This includes using best available treatment technologies defined by the EPA for the contaminants of concern, evaluating the reliability of the treatment systems, establishing performance standards, developing an operations plan, identifying compliance monitoring requirements, and developing a notification plan.

DHS typically approves certain treatment technology processes as acceptable for use in drinking water systems. Once the treatment technology process is accepted by DHS, its use must be approved on a site-specific basis. DHS has recently certified Calgon's ISEP® process for perchlorate removal for direct re-use. Aerojet is currently conducting a pilot test with DHS oversight to demonstrate that the treatment processes utilized at GETs E/F (biological reduction, UV-oxidation, and air-stripping) are acceptable for direct re-use.

The DHS policy memo 97-005 also outlines additional activities that must be completed prior to obtaining direct re-use approval including conducting a risk evaluation, CEQA review, permit application submission, public hearings, and DHS evaluation. Aerojet recognizes that obtaining a direct reuse permit is a necessarily complex process that will require substantial

effort on behalf of all involved parties. Nevertheless, water supply is a critical component of this FS, and direct reuse makes the best use of this resource.

- Indirect Reuse of Treated Groundwater. This process option would involve treated groundwater being piped directly to a surface water treatment facility, or indirectly via discharge to the Upper or Lower American River and exchanged for surface water in the American River that would be diverted via the Folsom South Canal (or via a direct pipeline) to an existing or new SWTP, or a combination of SWTPs. If treated groundwater from all or a portion of water treated at GETs E/F and/or potentially from any offsite remedial alternative where groundwater is extracted is discharged to the American River, this water could be used to replace affected water supplies. Aerojet has recently reached a memorandum of understanding with Sacramento County to sell it treated groundwater from its ARGET facility via discharge to Buffalo Creek and the American River. Because of the lack of available surface water entitlements on the American River, Aerojet believes the discharge of treated water to the American River and subsequent withdrawal at a SWTP clearly represents a viable means for providing replacement water to an affected purveyor.

  Influent water for the SWTP would be obtained either directly (via pipeline) or indirectly (via discharge to the American River and a corresponding diversion at the Folsom South Canal) and could involve multiple parties (e.g., Sacramento County and the Boeing Company) for the construction of the SWTP. This third party involvement would allow the Boeing Company to address its water replacement needs relating to the IRCTS Engineering Evaluation/Cost Analysis (EE/CA), and would allow the County to address water supply needs for new development in eastern Sacramento County. Aerojet and Boeing have met with Sacramento County to explore options with respect to replacement of affected water supply well capacity. Sacramento County is currently conducting an evaluation of replacement water supply options that should be available in April 2000. It is also possible for one or more water purveyors and developers to be involved in the SWTP.

- New Surface Water Supply. This process option would involve diverting Section 215 "spill water" from the Folsom South Canal in average and wetter years, diverting Arden Cordova unused entitlements from the American River, diverting Placer County Water Agency entitlements in excess of their projected long-term needs, and/or diverting other yet-to-be-identified firm upstream entitlements to a new or expanded existing SWTP or combination of SWTPs. Treated surface water would be delivered to the water distribution system of the affected water purveyor.

3.3.2.5 Monitored Natural Attenuation

Monitored natural attenuation refers to the reliance on natural attenuation processes to achieve site-specific remediation objectives within a timeframe that is reasonable compared to that offered by other more active methods. The "natural attenuation processes" that are at work in such a remediation approach include a variety of physical, chemical or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants (USEPA, 1999).

EPA expects that monitored natural attenuation will be most appropriate when used in conjunction with active remediation measures (e.g., source control), or as a follow-up to active remediation measures that have already been implemented. EPA also expects that the potential for creation of transformation products (e.g., degradation of trichloroethylene to vinyl chloride) should be evaluated to assess whether implementation of a monitored natural attenuation remedy is appropriate and protective in the long term (USEPA, 1999). The monitoring program associated with monitored natural attenuation developed for a site should be designed to accomplish the following:

- Demonstrate that natural attenuation is occurring according to expectations;
- Identify any potentially toxic transformation products resulting from biodegradation;
- Evaluate whether a plume is expanding (either downgradient, laterally or vertically);
- Ensure no impact to downgradient receptors;
- Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy;
- Demonstrate the efficacy of institutional controls that were put in place to protect potential receptors;
- Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes; and
- Verify attainment of removal action objectives.

Monitored natural attenuation has been retained to be used in conjunction with active remediation measures (e.g., groundwater containment), or as a follow-up to active

remediation measures that have already been implemented to monitor CoPCs, if any, that may migrate downgradient of any active groundwater remediation measure.

3.3.2.6 Groundwater Containment and Collection

Extraction wells were retained as a representative process option for the potential containment and collection GRAs. This process option involves drilling vertical extraction wells that are screened within the hydrogeologic layer where contamination is known to exist or is projected to be present based on modeling. The wells are pumped and a hydraulic barrier is established to control contaminant migration. If contaminants are present in the groundwater, they are physically removed with the groundwater.

The use of a combination of extraction and recharge wells was also selected as a representative process option for the containment and collection GRAs. Under this process option, the hydraulic containment barrier or collection system would be comprised of a combination of both extraction wells pumping contaminated, or projected to be contaminated groundwater, and injection wells where treated groundwater is recharged to the subsurface. The recharged water can serve as a hydraulic barrier and can direct groundwater to the extraction wells. Public water supply wells can also serve the function of extraction wells for a hydraulic barrier.

Horizontal extraction wells were also retained as a process option to be considered during the remedial design phase of any remedial action. Selection of horizontal extraction wells over vertical wells would be decided during the remedial design phase and would be based on the depth of the CoPCs, the hydrologic and geologic characteristics of the subsurface material, and property access and existing utility limitations. Horizontal wells offer some advantage over vertical wells depending on the subsurface conditions since they allow for recovery in circumstances of limited overlying access, well surface area is maximized, and it is possible to orient well screens in closer proximity to the bulk of the CoPCs in groundwater.

3.3.2.7 In-situ Treatment

All in-situ treatment process options were eliminated during the evaluation process, with the exception of in-well aeration/stripping and enhanced biological reduction innovative process options. While the in-well aeration/stripping in-situ treatment process option only removes VOCs, it was retained after the evaluation because of its potential application with alternatives that might involve groundwater containment or collection using vertical wells. As discussed in Section 1, VOCs are only present in limited areas. Thus, when assembling OU-wide alternatives that might involve extraction of groundwater using vertical wells, from a groundwater treatment perspective it may be desirable to remove the VOCs at the extraction well rather than after the groundwater is blended with groundwater from one or more other wells that may or may not contain VOCs.

The two proprietary in-well aeration or stripping processes are the NoVOCs™ process, which was developed by NoVOCs, Inc. in cooperation with the U.S. Department of Energy's (DOE's) Office of Science and Technology, Stanford University, EG&G Environmental, and the Pacific Northwest National Laboratory (Stanford University owns the patent for NoVOCs™ and has licensed the technology to EG&G), and the Unterdruck-Verdampfer-Brunnen (UVB) process, which was developed in Europe and is licensed to Roy F. Weston, Inc. and IEG Technologies in the United States (Nyer et al., 1996).

NoVOCs™ consists of a well, screened both beneath the water table and in the unsaturated zone. A compressed air line within the well runs from an above-ground supply and extends below the water table. Compressed air injected below the water table aerates the water within the well, creating a density gradient between the aerated water and the more dense water in the surrounding aquifer. As a result, dense water flows in through the lower well screen and forces the aerated water upward within the well, while becoming aerated itself. The result is a rising column of aerated water within the well, or an air-lift pump. Unlike conventional groundwater extraction and treatment systems, in-well aeration does not require ground water to be pumped to the surface for treatment. As the aerated groundwater column rises within the well, VOC mass transfer occurs from the dissolved phase to the vapor phase. Above the water table, a packer, or deflector plate, is installed at the upper screen to prevent the passage of rising water or bubbles. The rising water column hits the packer, the bubbles burst and the entrained VOC vapor is stripped off laterally through the screen by an upper vacuum casing. The VOC-rich vapor is brought to the surface for treatment while the laterally-deflected water circulates back into the aquifer. Re-infiltrating water creates a doughnut-shaped circulation pattern around the well, enabling the ground water to undergo multiple treatment cycles before flowing downgradient.

Limited operational and cost information is available for this process option. Because of the limited cost and performance data available at this time, a representative in-situ treatment process was not selected and the process option is not included in the developed alternatives. However, this innovative process option is not precluded from being implemented during remedial design of any selected remedy in the future if information becomes available to suggest that the technology can achieve significant savings in cost or time to achieve RAOs.

Treatability testing of the in-situ enhanced biological reduction innovative process option is currently being conducted by Aerojet for removal of perchlorate and VOCs. In-situ enhanced biological reduction could offer significant advantages with respect to implementability in the Weatern Groundwater Study Area over more traditional groundwater extraction and treatment technologies.

Within the context of this Western Groundwater OU RI/FS, innovative process options that were retained, but not selected as representative process options, will be considered relative to the representative process option on a case-by-case basis during the remedial

design phase as these technologies become more developed and sufficient information regarding cost and performance is available.

3.3.2.8 Liquid Phase Treatment

For ex-situ treatment of groundwater, LPGAC, air stripping, ion exchange, UV/oxidation, and cometabolic reactors (biological reduction) were retained based on effectiveness, implementability, and cost and were selected as representative process options. Filtration and pH adjustment are also ancillary process options that may be required as part of a liquid phase treatment train, depending on which main process option is, or process options are, selected for removal of the CoPC(s). With the exception of ion exchange, these technologies have been used historically to treat water from water supply wells AC-15 and AC-16 in the Western Ground Water Study Area or are currently used at the Aerojet Sacramento GET facilities to treat contaminated groundwater.

LPGAC. LPGAC is a commonly used method of removing VOCs and other organics. Activated carbon, when contacted with water containing organic material, will remove the organic compounds selectively by a combination of adsorption of the less polar molecules, filtration of the larger particles, and partial deposition of colloidal material on the exterior surface of the activated carbon. The extent of removal of soluble organics by adsorption depends on the diffusion of the particle to the external surface of the carbon and diffusion within the porous adsorbent.

Activated carbon is generally considered to consist of rigid clusters of microcrystallites, with each microcrystallite made up of a stack of graphitic planes. Each carbon atom within a particular plane is bonded to four adjacent carbon atoms, with carbon atoms at the edges of the graphitic planes having highly reactive (active) radical sites. At these sites, which consist of a heterogeneous mix of basal planes and microcrystallite edges, adsorption takes place. The adsorbent capacity of the carbon is reached when the active sites have been filled. As these sites fill, sorption equilibrium is approached, and effluent quality deteriorates to an unacceptable level. Then, the carbon is considered spent and removed for regeneration, typically to a reactivation furnace. Most carbon-adsorption systems utilize granular activated carbon (GAC) in flow through column reactors which can be employed as an upflow-countercurrent type operated with packed or expanded carbon beds or as an upflow or downflow fixed-bed unit having two or three columns in series.

Air Stripping. Air stripping is currently used at GETs A, B, D, and E/F as the main process to remove VOCs or as a VOC-removal polishing step subsequent to UV/oxidation. Air stripping has been retained as it will continue to be used in the Western Groundwater OU Study Area at the GETs E/F groundwater treatment facility and may be considered as a representative process option for VOC removal or as a polishing step for VOC removal for any OU-wide alternative.

Air stripping is a physical unit process in which dissolved molecules are transferred from a liquid, such as groundwater, into a flowing gas or vapor stream, such as air. The

driving force for mass transfer is provided by the concentration gradient between the liquid and gas phases, with solute molecules moving from the liquid to the gas until equilibrium is reached. The governing equilibrium relationship is Henry's Law. VOCs in groundwater having Henry's Law constants above 10 atmospheres (atm) are readily strippable at ambient temperatures. The economic viability of the conventional air stripping process is, however, limited to the VOCs whose Henry's Law constants are more than about 100 atm.

The most common configuration for application of air stripping to groundwater treatment for removal of VOCs is the counter current packed tower air stripper. In countercurrent packed towers, packing materials are used which provide high void volumes and high surface area. The water flows downward by gravity and air is forced upward. The untreated water is usually distributed on the top of the packing with sprays or distribution trays and the air is blown through the tower in forced or induced draft. This design results in continuous and thorough contact of the liquid with the gas and minimizes the thickness of the water layer on the packing, promoting efficient mass transfer. For removal of volatile organic compounds from groundwater, it is economically desirable to operate packed columns with a maximum water flow rate and with the minimum volume of air necessary to achieve the desired concentration of organics in the treated water.

Depending on the air quality requirements where air stripping is to be employed, offgas emissions from the air stripper may require treatment. The process options for air stripper offgas treatment are discussed later in this section.

Ion Exchange. Perchlorate and other anionic CoPCs in groundwater are effectively removed by ion exchange, a process where contaminant anions are exchanged and replaced by an innocuous anion, typically chloride. Ion exchange is an effective method for many groundwater treatment applications due to its efficiency in removing contaminants present in varying concentrations at relatively low costs. Most of the ion exchange resins manufactured are used for water treatment and strong-base anionic resins have been used to remove nitrates from drinking water for several years. Although ion exchange technology is well-known, the effectiveness of an ion exchange process depends, among other factors, on the operational configuration of the process. Key parameters that determine the efficiency and impact the economics of an ion exchange process are treatment ratio and the volume of regeneration waste generated. Treatment ratio refers to the volume of feed water that can be treated before breakthrough of the contaminant(s) is obtained. Regeneration waste volume refers to the volume of waste generated by the ion exchange process while regenerating the ion exchange resin saturated with contaminants. An effective ion exchange process is one that achieves high treatment ratios while producing low regeneration waste volume.

The following reaction is the primary ion-exchange reaction that occurs on the surface of a strong-base anionic exchange resin in the chloride form used for perchlorate removal:

$$R_4N^+Cl^- + ClO_4^- \rightarrow R_4N^+ClO_4^- + Cl^-$$

The chloride ion (Cl^-) on the surface of a quaternary amine group (R_4N^+) is exchanged for the perchlorate ion (ClO_4^-) present in the groundwater. Many other anions commonly present in groundwater will compete with the perchlorate ion for this reaction. These include sulfate (SO_4^{2-}), nitrate (NO_3^-), bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), and bromide (Br-). Other trace ions can also compete with the perchlorate ion for the resin surface (e.g., chlorate).

Ion exchange is reversible. Once the ion exchange resin is loaded with the perchlorate ion, it is regenerated with a sodium chloride salt solution and the perchlorate and other anions are removed. The following reaction illustrates how perchlorate is removed from the ion exchange resin during the regeneration process:

$$R_4N^+ClO_4^- + NaCl \rightarrow R_4N^+ClTC_4N^+Cl^- + NaClO_4$$

However, in order for the chloride to substitute for the perchlorate ion during regeneration, it has to be present at high concentrations in the brine solution. Once the resin is re-loaded with chloride, it is placed back in service, and the ion exchange cycle is repeated.

Several ion exchange equipment designs are currently employed including relatively simple fixed bed downflow or upflow contactor systems that can be operated in either concurrent or countercurrent (service flow in the direction opposite to the regeneration), continuous moving bed systems, and continuous multi-port rotating distributor systems. With respect to regeneration, waste streams generated when the ion exchange media is regenerated include rinse and backwash waters and a concentrated regenerant brine solution that contains perchlorate, nitrate, and sulfate ions in significantly higher concentrations than in the untreated groundwater feed. Depending on the method of ion exchange system operation, the volume of these waste streams can range from 2 to 8 percent of the volume of groundwater treated by ion exchange and must be disposed or reused.

Use of ion exchange for perchlorate removal using the Calgon ISEP® process has undergone recent pilot testing at the Big Dalton Well in the San Gabriel Valley area north of Los Angeles, CA (Calgon, 1998 and Montgomery-Watson, 1998) and at the Jet Propulsion Laboratory in Pasadena, CA (Calgon, 1999). The ISEP® process was recently accepted by DHS as a technology that has demonstrated its ability to remove perchlorate from source waters (DHS, 1999). DHS's acceptance is contingent upon approval by the respective DHS field office for the location where the process is proposed to be installed, conducting additional pilot testing if the water quality of the location is different from that encountered in the pilot testing, and Calgon must obtain National Sanitation Foundation (NSF) approval of the ISEP® components, ion exchange resin, and salt used for regeneration.

In the San Gabriel Valley, California, the regenerate waste streams are being evaluated for discharge to a brine sewer that serves the Los Angeles area. However, for the Western Groundwater OU RI/FS, wastestreams from the ion exchange process must be

collected and treated to remove the concentrated anions because there is no brine sewer. Two methods have been pilot-tested to treat the concentrated brine wastestream: anaerobic biological degradation (Air Force Research Laboratory, 1998) and a catalytic reduction process (Calgon, 1999) that recycles a majority of the wastestream flow. The long-term effectiveness and full-scale operating costs for both of these methods are presently unknown. Since September 1999, Calgon has been conducting pilot-testing of the ISEP® process coupled with the catalytic reduction brine regeneration process using City of Pittsburgh, PA municipal water spiked with approximately 1,200 ug/L of perchlorate (Calgon, 2000). Operating and performance results are expected in mid-2000.

In the catalytic reduction process the spent brine wastestream from the ion exchange system is routed to a catalytic reactor system to which small amounts of a reductant (such as ethanol) are added. Perchlorate and nitrate present in the brine wastestream are reduced to chloride and molecular nitrogen respectively, while the reductant is oxidized to carbon dioxide and water. This reduction-oxidation reaction occurs over a solid catalyst in the reactor at an elevated temperature and pressure. The effluent from the reactor is almost free of perchlorate and nitrate and is passed into a nanofiltration (NF) system where sulfate is removed from the brine into a small purge stream containing high concentrations of sulfate, but no perchlorate and nitrate. This purge stream from the NF system is the only wastestream from the entire brine treatment process and is estimated from pilot studies to be in the range of 0.05-0.2% of the total feed water treated by the ion exchange process. The "purified" brine is recycled back into the regeneration cycle of the ion exchange system along with a small fresh brine make-up stream.

UV/oxidation. UV/oxidation is a generic name for a family of advanced oxidation technologies (AOT) that use ultraviolet light either alone or in conjunction with standard oxidants such as hydrogen peroxide or ozone to achieve greatly increased treatment performance over that obtained with either hydrogen peroxide or ozone alone. The most common UV/oxidation process is the use of UV with hydrogen peroxide. Ultraviolet light is used to split the hydrogen peroxide molecule, producing very reactive hydroxyl radicals ($OH^{\cdot}$). These hydroxyl radicals then quickly react with organic contaminants in the water, eventually breaking them down into carbon dioxide and water. UV/oxidation is currently being used at GET facilities to remove NDMA, VOCs and 1,4 dioxane.

Photolysis involves the interaction of light with molecules to bring about their dissociation into fragments. Light is composed of tiny energy packets called photons, whose energy E is inversely proportional to the wavelength, λ, of the light.

$$E = \frac{hc}{\lambda}$$

where h is Planck's constant and c is the speed of light.

If the absorption of a photon by a molecule is to cause photolysis (dissociation), the photon energy must exceed the energy of the bond to be broken. This requires that the wavelength be in the ultraviolet region of the spectrum for most photolytic reactions. Compounds that absorb UV light and have high quantum yields of photolysis are good candidates for photodegradation using UV light only. Examples of these classes of compounds include NDMA, and various chlorinated alkenes and aromatics.

Oxidation is the chemical conversion of a contaminant to move oxygenated forms by means of reactions with oxidizing agents, such as oxygen (O_2), ozone (O_3), hydrogen peroxide (H_2O_2), or sodium hypochlorite (NaOCl). The following equation represents a general oxidation process:

Chlorinated Organic Molecules	+	O_2, O_3, $\rightarrow\rightarrow\rightarrow$ H_2O_2 or NaOCl	Oxygenated Intermediates
Oxygenated Intermediates		O_2, O_3, $\rightarrow\rightarrow\rightarrow$ H_2O_2 or NaOCl	$CO2 + H2O + Cl^-$

Each of the above reactions are actually multi-step processes. Simple oxidation involves the addition of oxidizing agents such as O_2, O_3, H_2O_2, NaOCl; however , the overall oxidation rates are usually too slow to be applied broadly for groundwater or wastewater treatment.

AOT, the overall rate of oxidation of a contaminant is greatly increased over that obtained by the simple addition of oxidizing agents. The main reason is the much greater involvement of highly reactive initiators (radicals) such as the hydroxyl radical (OH^-) created in AOT. The hydroxyl radical reacts typically a million to a billion times faster than ozone and hydrogen peroxide, aggressively attacking virtually all organic compounds.

Cometabolic Bioreactors (Biological Reduction). The biological reduction process is currently used at the GETs E/F treatment facility to remove perchlorate from GETs E and F groundwater. This technology can be described as a biological reduction process using a fixed-film bioreactor. A fixed-film of biomass is attached to granular activated carbon operated as a fluidized bed (GAC/FB). Groundwater, amended with an organic substrate (e.g., ethanol) and nutrients (nitrogen and phosphorus) is introduced into the influent stream. As groundwater passes through the system, the microorganisms derive energy from the oxidation of the organic substrate, simultaneously destroying the perchlorate, reducing it to chloride and oxygen. In a fluidized-bed bioreactor, flocculated organisms are suspended by drag forces exerted by the rising liquid. By balancing operating conditions and organism characteristics, the flocs are retained in the bioreactor while the medium flows through it continuously. Perchlorate reduction is similar to nitrate reduction. The energy-generated portion of the denitrification reaction with ethanol as the organic substrate (neglecting cell synthesis) is:

$$5C_2H_5OH + 12NO_3^- + 12H^+ \rightarrow 10CO_2 + 6N_2 + 21H_2O$$

The similar reaction for perchlorate during the biological reduction process is:

$$2C_2H_5OH + 4ClO_4^- + 8H^+ \rightarrow 4CO_2 + 4Cl^- + 10H_2O$$

Note that nitrate and perchlorate are completely destroyed, and the carbon substrate (ethanol) is oxidized by bacteria. The end products for the process are biomass (sludge), carbon dioxide, water, chloride, and nitrogen (HLA, 1998). The biomass is typically discharged to a POTW or dewatered and disposed in a non-hazardous landfill.

Aerojet is currently conducting pilot-testing at the GETs E/F groundwater treatment facility of the biological reduction process coupled with the UV/oxidation process for the purpose of obtaining approval of DHS to use the process in a direct reuse application for potable water supply.

Filtration. This ancillary process option is employed to remove particulates that may be generated by other processes and need to be removed prior to the groundwater undergoing treatment by another process or prior to management/reuse of the treated groundwater. There are many common configurations of filters available including dual-media gravity and pressure filters, continuous upflow sand filters, and in-line bag filters. The configuration of filter is selected based on the specific filter application.

pH Adjustment. If necessary, this ancillary process option is used to adjust the pH of groundwater undergoing treatment. An acid (e.g., sulfuric or hydrochloric acid solutions or carbon dioxide gas) or caustic (e.g., sodium hydroxide solution or lime) can be added using chemical metering pumps upstream of another process option to enhance the performance of the process option or downstream of a process option where pH changes through the process option to adjust the pH to within a normal value for water quality (i.e., around 7.0 standard pH units).

3.3.2.9 Vapor Phase Treatment for Air Stripping

Vapor-phase treatment refers to process options to remove VOCs in air stripper offgas in the event that concentrations of contaminants in the offgas warrant emission control. Direct discharge, VPGAC, catalytic oxidation, and thermal oxidation were retained based on effectiveness, implementability, and cost and were selected as the representative vapor-phase treatment process options.

Direct Discharge. Direct discharge of vapors entails releasing the collected vapors to the atmosphere through a stack or other device in such a manner that the resultant vapor concentrations in the atmosphere do not pose a threat to human health or the environment. Direct discharge of vapors is currently being used in conjunction with the existing air strippers at the GETs A, B, D, and E/F groundwater treatment facilities. Use

of direct discharge is a function of the flow rate and VOC concentrations in any vapor stream and the nature of other activities in the vicinity of the discharge.

VPGAC. Granular activated carbon (GAC) is the most common method of vapor phase treatment for removal of VOCs from air stripper gas. VPGAC is popular for several reasons, including its relative ease of implementation and operation, its reputation as a commonly-used treatment, its ability to be regenerated for repeated use, and its applicability to a wide range of contaminants at a wide range of flow rates. As described for the LPGAC process, VPGAC contactors are provided in standard prefabricated units that can contain up to 20,000 pounds of activated carbon. VPGAC contactors are typically operated in series and, when loaded to breakthrough with VOCs, the GAC is either replaced or regenerated onsite using a steam-based desorbing system. The costs are associated with concentrations in the emissions and the volume of air required to be treated.

The adsorption capacity of the carbon depends on several factors, including influent vapor temperature and relative humidity and, most importantly, the influent VOC types and concentrations. Isotherms, which show the mass of contaminants that can be adsorbed per unit mass of carbon, are available to predict the contaminant-specific adsorption capacity for a specific type of carbon.

Catalytic Oxidation. Catalytic oxidation is a variation of the thermal oxidation process which uses catalysts to increase the oxidation rate of contaminant vapors at lower temperature than conventional thermal oxidation processes. A catalytic oxidation process always requires a lower oxidation temperature [less than 1000°F] than thermal oxidation. The products of combustion of a catalytic oxidation reaction are the same as those of thermal oxidation. The heat of oxidation liberated by catalytic oxidation is the same as that of a thermal oxidation. Catalysts are used to increase the oxidation rate at lower temperatures.

The advantages of catalytic oxidation over thermal are the lower fuel requirement because of the lower operating temperature and less severe service requirement for materials of construction.

Thermal Oxidation. In this offgas treatment process, vapors from the air stripping process are preheated and then heated to a high temperature (typically greater than 1,400°F) in a combustion chamber, destroying the contaminant vapors. Thermal oxidation is well-suited to high concentration VOC air streams (i.e., 2,000 to 10,000 ppm; Nyer et al., 1996). Propane or natural gas is typically used as a supplemental fuel to achieve the high temperature levels necessary for thermal oxidation. Thermal oxidation of chlorinated hydrocarbons may result in formation of byproducts and hydrochloric acid, which may necessitate treatment of the combustion gases (i.e., acid scrubber). Depending on the flow rate and VOC concentrations in any vapor stream, a ceramic wheel concentrator may be used to reduce the flow rate and increase the VOC concentrations in the vapor stream directed to the thermal oxidation process.

3.3.2.10 Management/Reuse of Groundwater

Several possible process options have been identified for management and/or possible reuse of untreated or treated groundwater produced by any hydraulic containment or groundwater collection/treatment components that may be part of OU-wide alternatives developed in Section 4. There are several water resource management opportunities and actions that are available in or near the Western Groundwater Study Area in connection with this OU. Regional and local water resource planning includes consideration of the water flows in the American River and the Folsom South Canal, as well as the current and projected future potable and nonpotable water demands of existing development in Sacramento County and various planned development areas in the eastern and southern portions of the County. Quantities of untreated or treated groundwater on an average annual basis that are currently or potentially available vary among each of the OU-wide remedial alternatives described in Section 4. There also may be desirable combinations of the following management/reuse options, as matched to a given remedial alternative.

Possible process options for management or reuse of treated groundwater include direct potable water supply, indirect potable supply, non-potable water reuse, streamflow augmentation, discharge to POTW, and groundwater recharge. On the basis of effectiveness, implementability, and cost all of these possible process options have been retained. At present, the streamflow augmentation and groundwater recharge options are being used to manage treated groundwater from the GET facilities at Aerojet's Sacramento site.

Direct Potable Water Supply. Treated groundwater can be made available to meet urban water supply needs. It can be provided directly under one or more alternatives to local water supplies to a point of use within a water distribution system or directly with wellhead treatment. It can also be provided directly through regional surface water treatment facilities processing treated ground water to meet requirements of DHS. This reuse to provide a potable supply can be implemented if DHS approves the use of treated groundwater for potable use.

Indirect Potable Supply. Indirect potable water use can be achieved through treatment and discharge to surface waters, to the Folsom South Canal, or both. This indirect use would include full water treatment at the point of use by a responsible utility. The treated groundwater could be integrated with proposed residential and commercial development plans in the Eastern Sacramento County area. These development plans include Douglas/Sunrise, the villages of Zinfandel and Rio del Oro, Lewis Homes at Mather, or other proposed developments in the area that are projected to require new water supplies or will have increased water demand.

These growing potable demands can be met through treatment of water from the American River watershed delivered through the Folsom South Canal, but such deliveries are currently inconsistent with the policies of the Water Forum and Sacramento County, which require that water delivered from the American River be diverted at its mouth or from the Sacramento River. Since flows in the American River and, potentially, the

Folsom South Canal can be augmented by approved surface discharges under one or more of the alternatives in the OU, a similar amount of water could be diverted from the system without compromising the local policies with regard to water use.

The use of this water would be subject to conveyance approvals by the US Bureau of Reclamation (BOR) that could be acquired in part to offset any lost groundwater extraction capacity of existing customers. In addition, an evaluation of potential impacts to more senior or environmental rights along the River between the Nimbus Reservoir and the point of treated groundwater discharge would also need to be performed to ensure no adverse impact. Using the treated groundwater in a manner that assists in meeting the growing potable and non-potable water needs in eastern Sacramento County would be consistent with the County policies regarding American River flow management. This approach would allow remediation action efforts to be conducted in concert with water management objectives and provide economic benefits using the most efficient water resource management system possible.

Non-Potable Water Reuse. Another treated groundwater use option would be to supply water for irrigation of golf courses, parks, open space, and residential areas, or other areas currently proposed for development south and west of the OU Study Area. Sacramento has a County policy to install dual systems where economically feasible. These systems can provide different qualities of water from various sources to meet different levels of public health protection.

Treated water could be delivered directly from the OU facilities into a non-potable reuse system, provided that a dual piping system was constructed as part of all new developments that could be economically served. Permitting conditions for this source of non-potable water should be less stringent than water for potable uses and from wastewater sources.

Streamflow Augmentation. The discharge of treated water to surface waters directly or indirectly entering the American River can provide instream and downstream benefits. These discharges would be managed through an existing or new NPDES discharge. One possible process option for the management of treated water would be to discharge the treated water to the American River through the existing Buffalo Creek outlet. The discharge of treated water would need to meet all surface and receiving water requirements. Discharge to the American River would provide for enhancing streamflow for fish or downstream users. Discharge of treated water to the American River also represents an option anticipated to require the least amount of water delivery obligations, including operation and maintenance costs. Such discharge may require a State water right permit if a change of an existing amount or point of diversion for a future use occurs or if new water transfer opportunities are implemented.

Discharge to the American River may be deemed an "offsite" action and therefore requiring permitting through the NPDES program, or possibly the State regulatory activities. The flows in the American River are managed by the BOR under permits issued by the State that have been subject to recent judicial review. State permits may be

necessary to divert water that has been discharged to the American River as part of remedial action. It is also possible that water discharged to the River could be resold downstream under a water marketing/transfer proposal yet to be developed. The extent of federal and state permitting required for long-term augmentation of American River flows depends upon the proposed program and the beneficial use of such waters.

Discharge to POTW. Another management/reuse process option would be to discharge either untreated or treated groundwater to a POTW (i.e., sanitary sewer). Use of this option would depend on the capacity of the sewer in the vicinity of where the groundwater would be discharged and the willingness of the POTW to accept the discharge. This process option could be implemented on both a short-term interim basis or on a long-term basis. Discharge to a POTW of extracted untreated groundwater was retained, as under one or more OU-wide alternatives discussed in Section 4 there may be long periods of time where a containment well may be pumping uncontaminated groundwater (or pumping groundwater that contains CoPC concentrations that are less than POTW influent requirements) to achieve containment and the groundwater could be discharged to a POTW. Discharge to a POTW of treated groundwater was retained and implementability would depend on the capacity of the sanitary sewer in the vicinity of the discharge, the willingness of the POTW to accept the discharge, and the connection and users fees assessed by the POTW.

Groundwater Recharge. The groundwater resource underlying the region is replenished on an annual basis and generally flows from east to west or southwest. While local extraction may affect the performance of nearby remedial extraction facilities, the long-term yield of the basin is unaffected by the extraction and/or recharge of the quantities of water described in this report. The current recharge activities are used as part of the containment strategy. Various alternatives are considered that include recharge. The following options will change the hydrological regime of water in the groundwater basin and could substitute surface water augmentation or satisfy beneficial uses that would or could be supplied from groundwater.

Satisfying Varying Demands. It is expected that various OU-wide remedial alternatives would supply treated groundwater at a steady annual rate. It is likely that the most beneficial uses would accept water at seasonally varying rates. Accommodating this seasonal variation can be accomplished by:

- Varying the operation of extraction and treatment facilities within acceptable limits;
- Discharging increasing quantities of water in the winter months to surface waters for streamflow augmentation or downstream use;
- Providing a combination of recharge and surface water use that optimizes investments and costs; and
- Designing the use facilities to provide for local storage to meet peak demands.

One or more of these options could be employed to optimize the remediation and delivery performance.

Incorporation of the management of the treated groundwater into the overall water supply plans for the eastern portion of the County could be used to minimize potential investment by Sacramento County and would delay if not eliminate the need for a new major Sacramento River diversion and accompanying treatment and pumping facilities at least for service to the portions of eastern Sacramento County that are farthest from the river. It would allow for staged development of water supply facilities meeting all public health and environmental requirements. All costs above the basic remedial action cost would become part of the new development financing program with potentially significant cost savings to both the remediation and development efforts.

Given the benefits of a coordinated approach to the wholesale water supply and development of eastern Sacramento County in conjunction with the requirements and potential beneficial uses associated with groundwater treatment at the Site, all of the possible water management/reuse process options will be retained for consideration in the OU RI/FS. This will allow all of the interested parties to provide input on the possible alternatives for management/reuse of treated groundwater.

3.3.2.11 Results of Evaluation of Groundwater Remediation Process Options

The results of the evaluation of groundwater remediation process options using the criteria of effectiveness, implementability, and cost are shown on Figure 3-3. For some technologies, more than one process option was retained. Examples of multiple representative process options potentially applicable for the Western Groundwater Study Area OU that were retained and were used to assemble OU-wide alternatives are as follows:

Remedial Technology	Multiple Representative Process Options Retained
Proprietary Institutional Controls	• Deed restrictions • Deed notices • Easements • Covenants
Governmental Institutional Controls	• Groundwater use restrictions • Advisories

Alternate/Replacement Water Supply	• New water supply well
	• New water supply:
	  • Inter-ties with adjacent water purveyors
	  • Direct reuse of treated groundwater
	  • Indirect reuse of treated groundwater
	  • New surface water supply

Hydraulic Barriers	• Extraction wells • Extraction and recharge wells

Remedial Technology	Multiple Representative Process Options Retained
Ex Situ Physical/Chemical Treatment	• LPGAC • Air stripping • Filtration • Ion Exchange • UV/oxidation
Vapor-Phase Treatment for Air Stripping (Ex Situ Physical/Chemical/ Biological Treatment	• Direct discharge • VPGAC • Catalytic oxidation • Thermal oxidation
Treated Groundwater Management	• Direct potable water supply • Indirect potable supply • Nonpotable water reuse • Streamflow augmentation • Discharge to POTW (both untreated or treated groundwater) • Groundwater recharge

In accordance with USEPA guidance (USEPA, 1988a), representative process options are selected to simplify the development and evaluation of OU-wide alternatives. However, the specific process option used to implement a remedial action may not be selected until the remedial design phase. Selection of a representative process option for purposes of developing and evaluating OU-wide alternatives in Sections 4 and 5 of this OU RI/FS report does not preclude the application of other retained process options at the site during the remedial design phase.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Page 55, Section 4.1, Remedial Action Objectives. This introduction section lists the Remedial Action Objectives (RAOs). The Regulatory Agencies have modified the RAOs listed on page 22 for public comment in the Proposed Plan to those contained below:

- Protect human health and the environment from exposure to contaminated groundwater
- Achieve containment of the groundwater contamination to minimize future migration of contaminants until cleanup is accomplished
- Timely protection of public drinking water wells through an acceptable contingency long term alternative water supply plan
- Restore both on-property and off-property to its beneficial uses.
  both on-property and off-property to its beneficial uses.

Section 4.2, Description of Alternatives. While Aerojet adequately expanded Section 3.3.2.5 on Monitored Natural Attenuation (MNA) evaluation and implementation, Section 4.2 for Alternatives 3A through 5B was not revised to conform to the MNA evaluation criteria found in Section 3.3.2.5. The Regulatory Agencies cannot accept that contaminants of potential concern will be allowed to migrate, relying on natural attenuation processes to reduce the contaminant concentration over time to acceptable levels unless in each case the Section 3.3.2.5 evaluation criteria has been used and the agencies agree there is adequate protection of human health and the environment.

Page 59, Section 4.2.1, Alternative 1. The listed wells are predicted to be impacted by either perchlorate at 4 µg/l or NDMA at 0.010 µg/l within the 25-year period of study. Under the Partial Consent Decree, the trigger level for NDMA is 0.001 µg/l, with a default to the detection level at the present time of 0.0075 µg/l. Thus, using the lower level of concern, additional wells could be affected by NDMA during the 25-year period of evaluation.

Page 61, Section 4.2.2, Alternative 2A. This section does not clearly state how it is determined when additional water supplies are replaced. Obviously, there is a group of wells that currently require replacement and will be dealt with prior to implementation of the remedy for this operable unit through the Alternate Water Supply provisions of the Partial Consent Decree and an approved Water Supply Contingency Plan. However, as the plumes are allowed to migrate under the 2A Alternative, the criteria to be used to determine when a supply is lost and needs replacement should be clearly stated. This comment also applies to Section 4.2.3 discussing Alternative 2B. However, since the Regulatory Agencies do not believe that Alternatives 2A and 2B comply with ARARs,

this alternative will not be selected for implementation and modification to the report to address this concern is not necessary.

Section 4.2.2 and 4.2.3, Alternatives 2A and 2B. The model predicts that concentrations of contaminants will cause Arden-Cordova Water Service Well Nos. 1, 10, and 20 to be shutdown in 2001. The analysis in the report has Aerojet providing alternate water supply in 2005. This is not acceptable. However, since the Regulatory Agencies do not believe that Alternatives 2A and 2B comply with ARARs, this alternative will not be selected for implementation and modification to the report to address this concern is not necessary for these Alternatives. This issue must be addressed in the water supply contingency plan to be submitted by Aerojet.

Sections 4.2.2 and 4.2.3, Alternatives 2A and 2B. For replacement of alternative water supplies, Aerojet has stated that for costing purposes it is assumed that treated groundwater from GETs A, B, and the American River Study Area would supply flow and the groundwater would be treated with liquid-phase granular activated carbon prior to direct reuse. It is not stated that additional treatment would be needed to further reduce NDMA concentrations in the GET A and B effluents, and there is the potential that perchlorate treatment would be required on the GET B and American River Study Area effluents prior to their use. No cost for the necessary additional treatment is provided in the report. Also, the availability of the American River Study Area GET water is currently uncertain pending negotiations between Aerojet and Sacramento County. A cost for using surface water or groundwater supplies as a replacement should also be included as there is not a guarantee that direct reuse of treated groundwater will be acceptable.

Sections 4.2.4 and 4.2.5, Alternatives 3A and 3B. These alternatives assume that the water supply wells will be operated as before, except that wellhead treatment will be added to remove the contaminants. The Regulatory Agencies believe it may not be possible to place wellhead treatment on all of the wells due to space limitations. Thus, the extraction field may not operate as modeled and the plume capture may not be as extensive as necessary. Selection of either of these alternatives may require some dedicated extraction wells also be included. It should be noted that these two alternatives are the most expensive based on total non-discount cost estimates and would likely not be selected since there are other less expensive alternatives that comply with ARARs.

4 DEVELOPMENT AND SCREENING OF ALTERNATIVES

4.1 Introduction

Technologies and process options retained in Section 3 need to be assembled into OU-wide remedial alternatives. This section describes the remedial alternatives assembled from the technologies and process options. Often, a large number of remedial alternatives are screened against the criteria of overall effectiveness in meeting the RAOs, implementability, and cost in order to screen out certain alternatives, thereby allowing the more detailed evaluation (in Section 5) to be undertaken with a reduced number of alternatives. Here, given the limited remedial actions that are potentially viable for this groundwater system, the number of alternatives assembled are a manageable number (i.e., ten), and additional screening to eliminate alternatives was not required. All of the alternatives have been carried forward to the detailed analysis presented in Section 5.

This OU RI/FS is evaluating a groundwater remedial action for the Western Groundwater OU Study Area. It does not evaluate source control measures for specific onsite source areas. The GETs E and F facilities do provide control with respect to the offsite movement of CoPCs from source areas and are evaluated in this OU RI/FS. As discussed in Section 2, the following RAOs were developed for the Western Groundwater OU:

- Protect human health and the environment from exposure to contaminated groundwater;
- Minimize offsite migration of CoPCs where practicable to protect long term beneficial uses;
- Reduce contaminant concentrations in already contaminated groundwater in an efficient cost-effective manner; and
- Protect public drinking water wells and provide treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels.

The NCP (EPA, 1990b) requires that, at a minimum, the following alternatives be considered during development of remedial alternatives:

- A No-Action alternative;
- A limited number of remedial alternatives that attain site-specific remediation levels within different restoration time periods using one or more technologies; and

- Alternatives that include innovative treatment technologies, if those technologies offer the potential for comparable or superior performance or implementability, fewer or less adverse impacts than other available approaches, or lower costs for levels of performance similar to that of demonstrated treatment technologies.

Using the technologies and representative process options retained in Section 3 and considering the specific RAOs developed for the Western Groundwater OU as well as the alternatives required to be considered by the NCP, remedial alternatives were developed as described in the following sections.

4.2 Description of Alternatives

Figure 4-1 illustrates the assembly of ten remedial alternatives for the Western Groundwater Study Area. The ten remedial alternatives described and screened in this section are as follows:

- Alternative 1 - No Action with Limited Groundwater Monitoring
- Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply
- Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply
- Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells
- Alternative 3B –GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells
- Alternative 4A – GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells
- Alternative 4B – GETs E and F Extraction Wells with Offsite Extraction Wells
- Alternative 4C - GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors
- Alternative 5A – GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells
- Alternative 5B – GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

The following sections describe each of the alternatives. More detailed information is further provided in Section 5 where each alternative is evaluated against the NCP criteria.

All alternatives include groundwater monitoring, including monitoring of public water supply wells and monitor wells in the Study Area. The number of samples collected annually for each alternative would be approximately equivalent to the number of samples currently required by Exhibits IV and VI of the PCD (approximately 530 samples per year) plus samples collected from new monitor wells proposed for each alternative as discussed below.

All Alternatives, except Alternative 1 (No Action) involve operation of the existing GETs E/F boundary containment/source control extraction/treatment system. Each of Alternatives 2 though 5 include an "A" and "B" alternative (e.g., Alternative 2A and Alternative 2B) for purposes of evaluating continued use of GETs E and F recharge wells. Alternative 4 also has a "C" alternative. Each of the "A" alternatives involves continued operation of the GETs E and F recharge wells. Each of the "B" alternatives and the "C" alternative involve shut down of the recharge wells and installation of additional extraction wells to maintain onsite capture. For purposes of costing alternatives, the "B" alternatives and the "C" alternative assume new extraction wells would be added at the Aerojet property boundary downgradient of the shut down recharge wells. The anticipated downgradient location of the replacement extraction wells is shown in figures depicting the "B" alternatives and the "C" alternative. This configuration should enhance onsite capture in layers C, D and E and eliminate the need for offsite containment in layer E and potentially layer D west of the replacement extraction wells.

All of the alternatives except the No Action alternative assume that additional extraction wells will be added to the existing GETs E/F extraction system to enhance capture. Aerojet believes it is advantageous to implement these modifications to GET E/F expeditiously and prior to the likely prolonged period of formal remedy selection and preparation of the ROD. A potential mechanism that could be used for early implementation of these modifications would be the material modification provision within Exhibit VI of the PCD. The modifications will involve additional extraction wells and optimization of extraction rates from existing GETs E/F extraction wells. For purposes of costing alternatives, the following modifications were assumed:

- New GET E and GET F extraction wells will be added as discussed in Section 1. Specifically, a cluster of three extraction wells in the same location, one each screened through the C, D, and E layers would be added to the north of the existing GET E extraction well system. The estimated total extraction rate for these three new GET E wells is approximately 1,000 gpm. Also, a new extraction well screened in layer C will be added to the south of the existing GET F extraction well system. The estimated extraction rate for this new GET F well is approximately 250 gpm; and

- Groundwater modeling for this report indicates that GETs E and F extraction wells can be pumped more efficiently such that the overall existing extraction flow rate can

be reduced by 25 percent while maintaining hydraulic capture: from approximately 3,400 gpm to approximately 2,550 gpm. (Treatment of groundwater from the GETs E and F extraction systems is conducted at the GET F treatment facility, which has a current capacity of approximately 4,000 gpm. Thus, sufficient treatment capacity currently exists at GET F to accommodate the anticipated groundwater flow from the existing GETs E and F extraction wells (2,500 gpm) as well as the added flow from the new GET E and F extraction wells (1,250 gpm) [i.e., a total flow of approximately 3,800 gpm] after these modifications are implemented.)

The detailed description and conceptual design of each of the alternatives described below was based upon the results of the Remedial Investigation (Appendix A) and the results of a numerical groundwater flow model. A description of the model, discussion of model calibration, and the approach/results of the various model simulations for the alternatives described in this section are summarized in Appendix D.

The detailed descriptions and conceptual designs included in this section are FS-level evaluations that provide an adequate basis for evaluation of alternatives. However, it is anticipated that there may be changes to the representative process options during the period of evaluation of this FS and through any remedy design. For example, containment options being evaluated may assume use of new extraction wells, but public water supply wells may be used, as appropriate. Similarly, there may be developments in treatment technologies that will meet performance standards but at lower cost and more advantageous from an implementability perspective. Additional evaluation of design of any remedy, including facility location, actual treatment technologies and the optimal sequence and configuration of these treatment technologies, and the process option or options that will be employed for management/reuse of treated groundwater will be further evaluated in any remedial design activity. Costs of past water supply replacement actions described in Section 3.3.2.4 are not included in the scope of or estimated costs presented in these alternatives.

4.2.1 Alternative 1 - No Action with Limited Groundwater Monitoring

Alternative 1 (No Action) is included as required by the NCP to serve as a baseline for comparison of the other alternatives. For this alternative, GETs E and F extraction, treatment, and treated groundwater recharge facilities would be terminated and no further onsite remedial activities would be implemented. For the No Action alternative there would be no active remediation of groundwater. Groundwater would be monitored under this Alternative, including the lateral and vertical extent of the CoPCs within the study area and downgradient public water supply wells.

For purposes of evaluating potential impact, an FS-level groundwater flow model was used to project particle flow over a 25 year period under assumptions specified in Appendix D. Limitations on the ability of the model to predict outcomes are discussed in that Appendix and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well. The FS-level model simulation

would project for this alternative that the following currently operating regional water supply wells would be impacted by either perchlorate at a concentration of 4 ug/L or NDMA at a concentration of 0.01 ug/L within the 25-year FS evaluation period:

AC-1	Winchester	Nut Plains
AC-10	Rockingham	Countryside
AC-18	AC-6	Mather AFB 4
AC-20	AC-5	
AC-12	AC-22	

4.2.2 Alternative 2A – GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Alternative 2A involves the operation of GETs E and F, including both extraction and recharge wells.

Groundwater would be monitored under this alternative, including the lateral and vertical extent of the CoPCs within the study area and downgradient public water supply wells.

Continued migration of the offsite CoPCs can impact downgradient public water supply wells. This alternative assumes the shutdown of downgradient public water supply wells and the replacement of affected water supply capacity through an alternative water supply. For purposes of evaluating Alternative 2A, it is assumed that the water supply well capacity indicated in Appendix D (Table D8-1) that resulted from the model simulation would require replacement based upon an FS-level groundwater model simulation.

Potential sources of alternate water supply could include treated groundwater from one or more of the Aerojet GET facilities (directly or through surface water conveyance), new water supply wells, or other water sources discussed in Section 3.3.2.4. In order to complete the OU RI/FS screening and evaluation steps and develop the necessary cost estimates, it was assumed that the source of alternate water supply for Alternate 2A would be treated groundwater and surface water.

As illustrated in Figure 4-2, conceptual sources of alternate water supply could consist of one or more of the following:

- Treated groundwater from one or more of the Aerojet GET facilities. Groundwater would be treated to potable quality and introduced to the water distribution system at or near the location of the affected water supply well;

- New water supply well(s) drilled outside of the CoPC plumes along with any necessary modifications to the water distribution system to deliver groundwater from the new well;

- Interties between adjoining water purveyors; and

- Treated surface water. Treated groundwater from one or more of the Aerojet GET facilities could be exchanged for surface water in the American River. Surface water from the American River could be diverted through the Folsom South Canal to one or more surface water treatment facilities that would serve the water distribution system(s) associated with the affected water supply well(s). Depending on which water supply wells are affected, the surface water treatment facilities could consist of the existing Southern California Water Company's (SCWC's) Coloma water treatment plant or one or more new facilities located to serve the water distribution system where water supply well capacity is lost.

In addition, Alternatives 2A and 2B assume the existence of offsite governmental institutional controls; namely, the proposed Consultation Zone provision to the Sacramento County existing comprehensive well drilling ordinance and DHS oversight over public drinking water systems that requires reporting of contaminants to DHS and which establishes obligations on water purveyors to provide potable water supplies to their customers. Aerojet will also request status from the County to be a regular referral entity for any new wells that may be proposed to be drilled in the Study Area.

The specific components that were included in the estimated costs for Alternative 2A are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F groundwater treatment plant (GWTP) are assumed to occur in the year 2001;

- Optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- Continue to treat groundwater at the GET F GWTP at a flow rate of approximately 3,800 gpm (approximately 2,550 gpm from the optimized existing GETs E and F extraction wells and approximately 1,250 gpm from the new GETs E and F extraction wells) using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs. Treated groundwater would continue to be recharged using the existing GETs E and F recharge wells;

- Based on FS-level groundwater model-predicted time projections, Table D8-1 indicates that the following water supply well capacity potentially would require replacement in the following respective years (limitations on the ability of the model

to predict outcomes are discussed in Appendix D and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well):

Year	Estimated Replacement Water Needed (gpm)
2005	4,800
2009	600
2011	900
Total	6,300

Therefore, it is assumed that construction of facilities to deliver replacement water would be completed in mid-year 2004 and beginning in mid-year 2004 replacement water would be provided using a combination of treated groundwater from GETs A (250 gpm), B (3,800 gpm), and ARGET (3,400 gpm) through mid-year 2015. Currently operated GET facilities could not provide adequate water supply, unless modifications were made to current recharge practices to allow water to be discharged, after treatment, to a surface water. For purposes of costing, it was assumed that GETs A, B, and ARGET would provide a total flowrate of approximately 7,450 gpm, which is greater than the 6,300 gpm estimated to be required. The treated groundwater would be polished using LPGAC and conveyed via pipeline to the water distribution system associated with the affected water supply wells. It is assumed that the respective water purveyor would provide disinfection facilities;

- After the year 2015, Table D8-1 indicates that the following additional water supply well capacity potentially would require replacement in the following respective years:

Year	Replacement Water Needed (gpm)
2016	3,700
2019	1,000
2026	200
Total	4,900

Therefore, it is assumed that construction would be completed in mid-year 2015 and beginning in mid-year 2015 replacement water would be provided using a combination of treated groundwater from GETs A, B, and ARGET discussed previously, as well as treated groundwater from GET D (1,000 gpm). The treated groundwater would be polished using LPGAC and conveyed via pipeline to the water distribution system associated with the affected water supply wells. It is assumed that the respective water purveyor would provide disinfection facilities. GETs A, B, D, and ARGET could provide a total flowrate of approximately 8,450 gpm, which is less than the estimated 11,200 gpm to be required for replacement water during the later years of the evaluation period. For purposes of costing, the difference in replacement water estimated to be required and that available from GETs A, B, D, and ARGET, would be provided by a new surface water supply from the American River. It is assumed that unused or other long-term firm entitlements could be purchased, surface

water could be diverted to the Folsom South Canal, and a new 5.8 MGD surface water treatment plant (SWTP) would be constructed at a location west of the Folsom South Canal and south of Highway 50 at a location near the water distribution system associated with the affected water supply wells. It is also assumed that a new raw water transmission pipeline would be constructed from a diversion structure on the Folsom South Canal to the new SWTP; and

- With respect to O&M costs, Alternative 2A would include:
  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and recharge systems;
  - O&M associated with the new GET E and F extraction wells;
  - Beginning in mid-year 2004, additional O&M associated with LPGAC treatment of GETs A, B, and ARGET treated effluents and pumping of treated groundwater as replacement water;
  - Beginning in mid-year 2015, additional O&M associated with LPGAC treatment of GET D treated effluent and pumping of treated groundwater as replacement water; and
  - Beginning in mid-year 2015, additional O&M associated with purchase of surface water and use fees associated with transporting the surface water in the Folsom South Canal.

4.2.3 Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Alternative 2B contains the same components as Alternative 2A with one exception: treated groundwater from the GETs E and F control systems will not be recharged to groundwater. The treated groundwater from the GETs E and F systems will be discharged to surface water and/or reused for potable or non-potable water supply purposes. For purposes of costing Alternative 2B, it is assumed that the water supply well capacity indicated in Appendix D (Table D8-2) will require replacement.

The specific components that were included in the estimated costs for Alternative 2B are as follows:

- Modification in the of the existing GETs E/F boundary containment/source control extraction system to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to

the existing GET E/F groundwater treatment plant (GWTP) are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E layers. The anticipated downgradient location of the replacement extraction wells is shown in figures depicting the "B" alternatives. The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, expand the treatment capacity of the GET F GWTP by approximately 2,225 gpm to accommodate the additional flow from the extraction wells added to replace the GETs E and F recharge wells. The additional flow capacity was derived as follows:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New extraction wells to replace recharge wells	2,425
Subtotal – treatment capacity required	6,225
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	2,225

- Treat groundwater at the GET F GWTP at a flow rate of approximately 6,225 gpm using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs. Groundwater would be treated to NPDES requirements for discharge and discharged to Buffalo Creek for the period from mid-2001 through mid-2004;

- Based on FS-level groundwater model-predicted time projections, Table D8-2 indicates that the following water supply well capacity potentially would require replacement in the following respective years (limitations on the ability of the model to predict outcomes are discussed in Appendix D and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well):

Year	Replacement Water Needed (gpm)
2005	4,800
2009	600
2011	900
Total	6,300

It is assumed that the replacement water would be provided using treated groundwater from the GET F GWTP through the year 2015. The flowrate treated at the GET F facility would be approximately the same as the flowrate of replacement water needed. LPGAC contactors would be constructed at the GET F GWTP location in the year 2004. It is also assumed that in the year 2004, construction of a replacement water transmission pipeline from the Buffalo Creek discharge location to a location within the water distribution system where affected water supply wells are located would be completed. Starting in mid-year 2004, the treated groundwater would be polished using LPGAC and conveyed via pipeline to the water distribution system associated with the affected water supply wells. It is assumed that the respective water purveyor would provide disinfection facilities;

- After the year 2015, Table D8-2 indicates that the following additional water supply well capacity potentially would require replacement in the following respective years:

Year	Replacement Water Needed (gpm)
2016	1,100
2020	1,900
2026	200
Total	3,200

For this estimated replacement water, it is assumed that construction would be completed by mid-year 2015 and beginning in mid-year 2015 replacement water would be provided using treated groundwater from the ARGET GWTP. The treated groundwater would be polished using LPGAC and conveyed via pipeline to the water distribution system associated with the affected water supply wells. It is assumed that the respective water purveyor would provide disinfection facilities; and

- With respect to O&M costs, Alternative 2B would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction and GET F treatment systems;

  - O&M associated with the new extraction wells at GETs E and F and the new extraction wells that will replace the GETs E and F recharge wellfields;

  - Beginning in mid-year 2004, additional O&M associated with LPGAC treatment of GET F treated effluent and pumping of treated groundwater as replacement water; and

- Beginning in mid-year 2015, additional O&M associated with LPGAC treatment of ARGET treated effluent and pumping of treated groundwater as replacement water.

4.2.4 Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Alternative 3A includes continued operation of GETs E and F (extraction and recharge). It also includes monitoring and the institutional controls described previously for Alternative 2A.

Alternative 3A also includes providing wellhead treatment on those existing water supply wells that may become affected by the CoPC plumes over time. If a water supply well becomes impacted by one or more of the CoPCs at concentrations above DHS standards for public water supply systems, treatment facilities would be installed at the wellhead location to treat the respective CoPC. Groundwater from the water supply well would be treated to potable water quality prior to introduction to the water distribution system.

For Alternative 3A, it is assumed that the water supply wells in the vicinity of and downgradient of the CoPC plumes will be continued to be operated by the respective water purveyor in the same manner that they have been operated historically: i.e., based on water demand. Therefore, operation of the wellhead treatment facility(ies) will be tied into the operation of the water supply well pump and also operated based on water demand. For Alternative 3A, the model simulation assumed that all water supply wells would be operated at their historical average pumping rates. The modeled approximate times CoPCs may be present in water supply wells, which is the basis for cost estimates prepared for this alternative, are included in Appendix D (Tables D8-3 through D8-5).

For purposes of this evaluation, the treatment processes assumed to be provided for removal of the respective CoPCs include LPGAC and/or UV/oxidation for VOCs (UV/oxidation would be employed for removal of both VOCs and NDMA if NDMA is present), UV/oxidation for NDMA, and ion exchange for perchlorate. Schematics showing the various wellhead "treatment trains" assumed based on the presence of one or more of the CoPCs are included on Figure 4-3. It is assumed that the existing disinfection system at the water supply well would continue to be operated and the disinfectant added prior to introduction of the treated water to the water distribution system.

Given the location of the public water supply wells and the zones of capture associated with those wells, this alternative provides both protection from exposure to CoPCs and substantial containment of the offsite CoPC plume as more fully discussed in Section 5. CoPCs that are not captured by public water supply wells would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 3A are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F groundwater treatment plant (GWTP) are assumed to occur in the year 2001;

- Optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- Continue to treat groundwater at the GET F GWTP at a flow rate of approximately 3,800 gpm (approximately 2,550 gpm from the optimized existing GETs E and F extraction wells and approximately 1,250 gpm from the new GETs E and F extraction wells) using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs. Treated groundwater would continue to be recharged using the existing GETs E and F recharge wells;

- Based on FS-level groundwater model-predicted time projections CoPCs may be present in water supply wells (see Tables D8-3 through D8-5), capital costs for wellhead treatment were assumed to be expended in the years shown on the following table. Limitations on the ability of the model to predict outcomes are discussed in Appendix D and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well. O&M costs for treatment at the respective wells were also assumed to begin in the years shown on the following table. Based on the CoPCs modeled to be present in the wells, treatment processes are also listed.

Water Supply Well	Year Wellhead Treatment Projected	Assumed Treatment Process(es)
AC-1	2006	Ion exchange
AC-1	2023	UV/oxidation
AC-5	2001	Ion exchange
AC-6	2020	Ion exchange
AC-7	2006	Ion exchange
AC-10	2006	Ion exchange
AC-11	2001	UV/oxidation
AC-11	2017	Ion exchange
AC-13	2009	UV/oxidation
AC-13	2011	Ion exchange

Water Supply Well	Year Wellhead Treatment Projected	Assumed Treatment Process(es)
AC-14	2001	UV/oxidation and ion exchange
AC-15	2001	UV/oxidation and ion exchange
AC-16	2001	UV/oxidation and ion exchange
AC-18	2010	Ion exchange
AC-19	2001	Ion exchange
AC-20	2002	UV/oxidation
AC-20	2006	Additional UV/oxidation added
AC-20	2013	Ion exchange
AC-23	2026	Ion exchange
Chettenham	2014	Ion exchange
Rockingham	2021	Ion exchange
Winchester	2017	Ion exchange
SWMD-17	2001	Ion exchange

- With respect to O&M costs, Alternative 3A would include:
  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and recharge systems;
  - O&M associated with the new GET E and F extraction wells; and
  - O&M associated with wellhead treatment at the water supply wells listed above.

4.2.5 Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Alternative 3B contains the same components as Alternative 3A with one exception: treated groundwater from the GETs E and F control systems will not be recharged to groundwater. The treated groundwater from the GETs E and F systems will be discharged to surface water and/or reused for potable or non-potable water supply purposes.

As with Alternative 3A, the model simulation for 3B assumed that water supply wells would be operated at their historical average pumping rates. The modeled approximate times CoPCs may be present in water supply wells, which is the basis for cost estimates prepared for this alternative, are included in Appendix D (Tables D8-6 through D8-8).

The specific components that were included in the estimated costs for Alternative 3B are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E (cluster locations NEW-1, -2, and –3) layers. The anticipated downgradient locations of the replacement extraction wells are shown in figures depicting the "B" alternatives. The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, expand the treatment capacity of the GET F GWTP by approximately 2,225 gpm to accommodate the additional flow from the extraction wells added to replace the GETs E and F recharge wells. The additional flow capacity was derived as follows:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New extraction wells to replace recharge wells	2,425
Subtotal – treatment capacity required	6,225
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	2,225

- Treat groundwater at the GET F GWTP at a flow rate of approximately 6,225 gpm using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs. Groundwater would be treated to NPDES requirements for discharge and discharged to Buffalo Creek for streamflow augmentation for the evaluation period;

- Based on FS-level groundwater model-predicted time projections CoPCs may be present in water supply wells (see Tables D8-6 through D8-8), capital costs for wellhead treatment were assumed to be expended in the years shown on the following table. Limitations on the ability of the model to predict outcomes are discussed in Appendix D and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well. O&M costs for treatment at the respective wells were also assumed to begin in the years shown on the following table. Based on the CoPCs modeled to be present in the wells, treatment processes are also listed.

Water Supply Well	Year Wellhead Treatment Projected	Assumed Treatment Process(es)
AC-1	2006	Ion exchange
AC-1	2023	UV/oxidation
AC-5	2001	Ion exchange
AC-6	2020	Ion exchange
AC-7	2006	Ion exchange
AC-10	2006	Ion exchange
AC-11	2001	UV/oxidation
AC-11	2017	Ion exchange
AC-13	2009	UV/oxidation
AC-13	2011	Ion exchange
AC-14	2001	UV/oxidation and ion exchange
AC-15	2001	UV/oxidation and ion exchange
AC-16	2001	UV/oxidation and ion exchange
AC-18	2010	Ion exchange
AC-19	2001	Ion exchange
AC-20	2002	UV/oxidation
AC-20	2006	Additional UV/oxidation added
AC-20	2013	Ion exchange
AC-23	2026	Ion exchange
Chettenham	2014	Ion exchange
Rockingham	2021	Ion exchange
Winchester	2017	Ion exchange
SWMD-17	2001	Ion exchange

- With respect to O&M costs, Alternative 3B would include:
  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and discharge systems;
  - O&M associated with the new GET E and F extraction wells; and
  - O&M associated with wellhead treatment at the water supply wells listed above.

4.2.6 Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Alternative 4A involves the continued operation of the GETs E and F systems, in which recharge wells would continue to be used. It also includes monitoring and institutional controls described in Alternative 2A and additional monitoring (approximately 1.5 monitoring wells for each new extraction well).

Alternative 4A also would establish an offsite hydraulic barrier, intended to contain the offsite plume and prevent further migration of CoPCs downgradient of the barrier in concentrations that would impair beneficial uses of the groundwater.

The offsite hydraulic barrier would involve extraction and treatment of groundwater. As evaluated in this OU RI/FS, it would involve using new extraction wells to provide hydraulic containment. A conceptual depiction of the alternative is contained on Figure 4-4. The actual location of groundwater extraction wells will be based upon a combination of factors, including design and construction constraints (e.g., pipeline corridors, public right of ways) and cleanup levels, and may not result in the placement of the hydraulic barrier at or downgradient of the leading edge of the plume.

Based on the model simulation performed for Alternative 4A, a total of 30 new extraction wells would be necessary over time to provide hydraulic containment offsite. Based on modeling, the assumed beginning year of operation, modeled pumping rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-9). Modeled locations of the extraction wells relative to the CoPC plumes are shown on Figure 4-4. More detailed discussion of the modeling and assumptions made are contained in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells.

For purposes of analysis, all extracted water is assumed to be treated at a single treatment location. As previously discussed in Section 3, there are many combinations of process options and technologies that could be developed and analyzed for each alternative that involves extraction of groundwater. For example, groundwater could be treated at the wellhead or at a facility location where groundwater from two or more collection or containment wells is treated. Also, several process options are available for treatment of perchlorate (biological reduction and ion exchange) and any VOCs (LPGAC, air stripping, UV/oxidation) that may be present. UV/oxidation is a proven technology for NDMA removal, but Aerojet is aggressively pursuing other innovative processes. In addition, if groundwater from multiple wells is routed to a central location for treatment, there are many possible pipe routing alternatives to consider taking into account availability of easements and rights-of-way; crossing of major highways and roads such

as US Highway 50, Folsom Boulevard, Sunrise Boulevard, Zinfandel Drive, and White Rock Road; crossing of railroad mainline/spurs and the Folsom South Canal; and the presence of other buried utilities including fiber optic telephone lines, potable water, sanitary and storm sewer, natural gas, and electrical power.

Therefore, in order to complete the OU RI/FS screening and evaluation steps and develop the necessary cost estimates, in addition to the extraction wells proposed for containment, the following offsite representative action components were assumed for Alternative 4A:

- Groundwater collected from all extraction wells would be routed to a central groundwater treatment facility located on Aerojet property adjacent to the existing GETs E/F treatment facility;

- Pipe routing located along a corridor west of the Aerojet site in the vicinity of Zinfandel Drive;

- A representative treatment system consisting of the treatment processes currently employed at the GETs E/F groundwater treatment facility (Figure 3-2) which include biological reduction for perchlorate removal, filtration for solids removal, UV/oxidation for removal of VOCs and NDMA, and air stripping for removal of any remaining VOCs following UV/oxidation; and

- Management/reuse of treated groundwater by delivery via pipeline to a location coincident for discharge to the American River via Buffalo Creek for streamflow augmentation or entry into a public water supply system.

However, inclusion of these offsite action components for Alternative 4A should in no way be construed as precluding consideration or ultimate use of other equivalent technologies during any subsequent remedial design/remedial action activities. Additional evaluation of use of water supply wells or new extraction wells as extraction wells with coincident wellhead treatment and direct reuse of treated groundwater (particularly those water supply wells located north of US Highway 50 downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate), pipe routing, whether one or more treatment facility locations need to be constructed, the actual treatment technologies and the optimal sequence and configuration of these treatment processes, and the process option or options that will be employed for management/reuse of treated groundwater will be performed during the remedial design phase.

CoPCs that are detected downgradient of the offsite hydraulic barrier will be monitored. Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use wellhead treatment. Additional extraction wells may also be added. As discussed in Section D8.3.6, the model simulation for Alternative 4A assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not captured would be

monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 4A are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F groundwater treatment plant (GWTP) are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, complete 12 new extraction wells offsite in the C layer (Figure 4-4 and Table D8-9) and one new extraction well in the D layer (coincident with new extraction well C3) and install conveyance piping from these well locations to the existing GET F GWTP location;

- In the year 2001, expand the treatment capacity of the GET F GWTP using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs by approximately 3,500 gpm to accommodate the following additional flow:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
13 new offsite containment extraction wells (2001)	3,700
Subtotal – treatment capacity required	7,500
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	3,500

Under Alternative 4A, management/reuse of treated groundwater from the onsite and offsite containment systems would involve both (1) recharge, and (2) delivery via pipeline to a location coincident for direct reuse into a public water supply system or streamflow augmentation to the American River via Buffalo Creek. Approximately 3,400 gpm of treated groundwater would continue to be recharged using the existing GETs E and F recharge wells. The remaining approximately 4,100 gpm (year 2001) would be available as long-term replacement water for water supply wells. If a long-term replacement water supply is not necessary, this remaining approximately 4,100 gpm would be discharged to Buffalo Creek for streamflow augmentation.

If the treated groundwater is needed for long-term water replacement, direct reuse is contemplated. As discussed previously regarding replacement water, for direct reuse, treated groundwater from the GETs E/F GWTP would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek. Alternatively, if the treated groundwater is not accepted by DHS for direct reuse, indirect reuse would be employed for long-term water replacement. Under indirect reuse, treated groundwater would be discharged to Buffalo Creek and exchanged for surface water from the American River. Surface water from the American River would be delivered via the Folsom South Canal and a new transmission pipeline to a new or expanded surface water treatment facility to be constructed within the water distribution system of the affected water purveyor.

If treated groundwater is not needed for long-term water replacement, for purposes of comparing costs of OU-wide alternatives on an equivalent basis, treated groundwater from the GETs E/F GWTP would be discharged to Buffalo Creek for streamflow augmentation. The discharge pipeline installed in 2001 from the GET F GWTP to Buffalo Creek would be sized to accommodate the maximum treated groundwater flow anticipated over the evaluation period. Alternatively, treated groundwater in excess of the approximately 3,400 gpm that would be recharged at the GETs E and F recharge fields could be managed/reused by (1) recharge in an area downgradient of the CoPC plume in the western portion of Rancho Cordova, or (2) non-potable reuse for developments south of the Study Area. For purposes of preparing a cost estimate for recharge, it is assumed that a conveyance pipeline would be constructed from the GETs E/F GWTP west along White Rock Road to an area west of Zinfandel Drive and recharge wells with capacities of approximately 500 gpm each would be located approximately 1,000 feet apart. O&M costs for recharge would include pumping costs to deliver the treated water to the recharge wellfield and periodic recharge well rehabilitation costs. Since development plans for non-potable reuse are out of the scope of this FS, for costing purposes, it is assumed that the developer would be responsible for the majority of the capital and O&M costs and that the costs for this option would be similar or less than the costs for offsite recharge.

If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, approximately 3,400 gpm to be discharged to Buffalo Creek may be made available as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. Based on the respective capacities (maximum daily flow) for these wells (AC-1 [400 gpm], AC-10 [700 gpm], and AC-20 [2,300 gpm]) obtained from the Revised Preliminary and Final Water Supply Alternatives Reports for Arden Cordova Water Service Wells #11, 13, 15, 16, and 19 (Aerojet, 2000a), approximately 3,400 gpm of maximum-day capacity would be necessary to replace the combined flows of these wells. Design of and capital cost estimates associated with any facilities that may be constructed relative to replacement water for these wells would likely be based on 3,400 gpm maximum-day flow. Any annual O&M costs, however, would likely be based on the annual average daily flow for these wells of 17 gpm for AC-1, 66 gpm for AC-10,

and 912 gpm for AC-20, for a total of 995 gpm for these wells. On an interim basis, short-term water replacement may be necessary in the event water supply wells are impacted prior to the implementation of a remedy identified in this FS. Aerojet has recently obtained a commitment from the City of Folsom to provide potable water to ACWS through the inter-tie between the two systems. This source would provide up to approximately 3,400 gpm for potential short-term impacts over the next two to three years. Two options would be available to provide replacement water for these water supply wells on a long-term basis: direct reuse of treated groundwater and indirect reuse of treated groundwater. These options are described below:

- Direct Reuse. Under the direct reuse option, treated groundwater from the GETs E/F GWTP would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek. As discussed in Section 3.3.2.4, direct reuse of treated groundwater would be dependent on DHS, water purveyor, and public acceptance. For costing purposes, it is assumed that the LPGAC contactors would be sized for 3,400 gpm and the water purveyor would provide disinfection facilities at the point of introduction to the water distribution system. O&M costs would be based on the 995 gpm annual average daily flow and would include pumping costs to deliver the water to the water distribution system and periodic replacement of the LPGAC.

- Indirect Reuse. Under the indirect reuse option, treated groundwater from the GETs E/F GWTP would be discharged to Buffalo Creek and exchanged for surface water from the American River. Surface water from the American River would be delivered via the Folsom South Canal and a new transmission pipeline to a new or expanded surface water treatment facility to be constructed within the water distribution system of the affected water purveyor. The transmission pipeline and surface water treatment capacity would be sized based on the maximum-day flow of 3,400 gpm. O&M costs would be based on the 995 gpm annual average daily flow and would include use fees for the Folsom South Canal and pumping costs to deliver the water from the Folsom South Canal to the new or expanded surface water treatment facility.

- In the year 2011, complete one new extraction well in the C layer (C11) and two new extraction wells in the D layer coincident with two existing C layer extraction wells (C7 and C10) and add approximately 700 gpm of treatment capacity at the GET F GWTP;

- In the year 2021, complete five new extraction wells (four in the D layer and one in the E layer, all coincident with existing C layer extraction wells) and add approximately 1,300 gpm of treatment capacity at the GET F GWTP; and

- Based on the model simulation performed for Alternative 4A, in years beyond the 25-year evaluation period complete nine new extraction wells (three in the D layer and

six in the E layer, all coincident with existing C layer extraction wells) and add approximately 2,900 gpm of treatment capacity at the GET F GWTP.

- With respect to O&M costs within the evaluation period, Alternative 4A would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and recharge systems;

  - O&M associated with the new GET E and F extraction wells; and

  - Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the 13 new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation;

  - If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing the approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

  - Beginning in mid-year 2011, additional O&M associated with extracting and conveying groundwater from the three new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation; and

  - Beginning in mid-year 2021, additional O&M associated with extracting and conveying groundwater from the five new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation.

4.2.7 Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Alternative 4B contains the same components as Alternative 4A with one exception: treated groundwater from the onsite GETs E and F boundary containment/source control systems would not be recharged to groundwater. The treated groundwater from the GETs E and F systems would be discharged to surface water for streamflow augmentation and/or reused for potable or non-potable water supply purposes.

With respect to the offsite containment component of Alternative 4B, the results of the model simulation indicate that a total of 17 new extraction wells will be necessary over time to provide offsite hydraulic containment. Based on modeling, the assumed beginning year of operation, modeled pumping rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-10). Modeled locations of the extraction wells relative to the CoPC plumes are shown on Figure 4-5. More detailed discussion of the modeling and assumptions made are contained in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells, particularly those locations north of US Highway 50 downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate.
Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use treatment. As discussed in Section D8.3.7, the model simulation for Alternative 4B assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not captured would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 4B are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E layers. The anticipated downgradient locations of the replacement extraction wells are shown in Figure 4-5 (cluster locations NEW-1, -2, and –3). The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, complete 10 new extraction wells offsite in the C layer and one new well in the D layer (Figure 4-5) and install conveyance piping from these well locations to the existing GET F GWTP location;

- In the year 2001, expand the treatment capacity of the GET F GWTP using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs by approximately 5,325 gpm to accommodate the following additional flow:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New extraction wells to replace recharge wells	2,425
11 new offsite containment extraction wells (2001)	3,100
Subtotal – treatment capacity required	9,325
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	5,325

  The entire approximately 9,325 gpm would be discharged to Buffalo Creek for streamflow augmentation. The discharge pipeline installed in 2001 from the GET F GWTP to Buffalo Creek would be sized to accommodate the maximum treated groundwater flow anticipated over the evaluation period.

  If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, a portion of this approximately 9,325 gpm to be discharged to Buffalo Creek may be used as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. As discussed for Alternative 4A, approximately 3,400 gpm would be necessary to replace the combined flows of these wells. This replacement water would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

- In the year 2011, complete one new extraction well in the D layer coincident with existing C layer extraction well C3 and add approximately 200 gpm of treatment capacity at the GET F GWTP;

- In the year 2021, complete two new extraction wells in the D layer coincident with two existing C layer extraction wells (C4 and C5) and add approximately 400 gpm of treatment capacity at the GET F GWTP; and

- Based on the model simulation performed for Alternative 4B, in years beyond the 25-year evaluation period complete three new extraction wells (two in the D layer and one in the E layer, all coincident with existing C layer extraction wells) and add approximately 900 gpm of treatment capacity at the GET F GWTP.

- With respect to O&M costs within the evaluation period, Alternative 4B would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction and treatment systems;

  - O&M associated with the new GET E and F extraction wells and the new extraction wells that will replace the GETs E and F recharge wellfields;

  - Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the 11 new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation;

  - If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

  - Beginning in mid-year 2011, additional O&M associated with extracting and conveying groundwater from the one new offsite containment well, treating the flow associated with this well at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation; and

  - Beginning in mid-year 2021, additional O&M associated with extracting and conveying groundwater from the two new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation.

4.2.8 Alternative 4C - GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors

Alternative 4C would contain the following same components as Alternative 4B:

- Establishment of an offsite hydraulic barrier, intended to contain the offsite plume and prevent further migration of CoPCs downgradient of the barrier in concentrations that would impair beneficial uses of the groundwater; and

- Continued operation of the GETs E and F systems. The treated groundwater from the GETs E and F systems would be discharged to surface water for streamflow augmentation and/or reused for potable or non-potable water supply purposes.

Alternative 4C would also incorporate "multiple containment corridors" by including installation of new extraction wells closer to the estimated leading edge location of the CoPC plume in the D and E layers sooner than planned for the other alternatives. This Alternative 4C was developed in response to USEPA, RWQCB, and DTSC comments on the draft OU RI/FS report. Based on modeling, the assumed beginning year of operation, modeled pumping rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-11). Modeled locations of the extraction wells relative to the CoPC plumes are shown on Figure 4-6.

With respect to the offsite containment component of Alternative 4C, the results of the model simulation indicate that a total of 18 new extraction wells will be necessary over time to provide offsite hydraulic containment. More detailed discussion of the modeling and assumptions made are contained in Section D8.3.8 in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells, particularly those locations north of US Highway 50 downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate.

Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use treatment. As discussed in Section D8.3.8, the model simulation for Alternative 4C assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not captured would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 4C are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E layers. The anticipated downgradient locations of the replacement extraction wells are shown in Figure 4-6 (cluster locations NEW-1, -2, and –3). The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, complete 10 new extraction wells offsite in the C layer, four new extraction wells in the D layer, and two new extraction wells in the E layer and install conveyance piping from these well locations to the existing GET F GWTP location (Figure 4-6);

- In the year 2001, expand the treatment capacity of the GET F GWTP using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs by approximately 5,975 gpm to accommodate the following additional flow:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New extraction wells to replace recharge wells	2,425
16 new offsite containment extraction wells (2001)	3,750
Subtotal – treatment capacity required	9,975
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	5,975

The entire approximately 9,975 gpm would be discharged to Buffalo Creek for streamflow augmentation. The discharge pipeline installed in 2001 from the GET F GWTP to Buffalo Creek would be sized to accommodate the maximum treated groundwater flow anticipated over the evaluation period.

If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, a portion of this approximately 9,975 gpm to be discharged to Buffalo Creek may be used as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. As discussed for Alternative 4A, approximately 3,400 gpm would be necessary to replace the combined flows of these wells. This replacement water would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

- In the year 2011, complete one new extraction well in the D layer coincident with an existing C layer extraction well (C3) and add approximately 200 gpm of treatment capacity at the GET F GWTP; and

- In the year 2021, complete one new extraction well in the D layer coincident with an existing C layer extraction well (C4) and add approximately 200 gpm of treatment capacity at the GET F GWTP.

- With respect to O&M costs within the evaluation period, Alternative 4C would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction and treatment systems;

  - O&M associated with the new GET E and F extraction wells and the new extraction wells that will replace the GETs E and F recharge wellfields;

  - Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the 16 new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation;

  - If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

  - Beginning in mid-year 2011, additional O&M associated with extracting and conveying groundwater from the new offsite containment well, treating the flow associated with this well at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation; and

  - Beginning in mid-year 2021, additional O&M associated with extracting and conveying groundwater from the new offsite containment well, treating the flow associated with this well at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation.

4.2.9 Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Alternative 5A includes continued operation of the GETs E and F control systems and recharge of treated GETs E and F groundwater. It also includes monitoring and the

institutional controls described previously for Alternative 2A. In addition, Alternative 5A would also provide containment of the offsite CoPC plume using a combination of new extraction and recharge wells to provide hydraulic containment.

Modeled locations of extraction and recharge wells downgradient of the CoPC plumes are shown on Figure 4-7. As indicated on Figure 4-7, recharge wells would be located on the periphery to direct the plumes to extraction wells located in the center. The Alternative 5 series evaluates the potential impact of offsite recharge on effectiveness and flow rates of the offsite hydraulic barrier.

Based on the model simulation performed for Alternative 5A, a total of 24 new extraction wells and seven new recharge wells would be necessary to provide hydraulic containment offsite over time. Based on modeling, the assumed beginning year of operation, modeled pumping and recharge rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-12). More detailed discussion of the modeling and assumptions made are contained in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells, particularly those locations north of US Highway 50 downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate.

In addition to the extraction and recharge wells proposed for containment, the following offsite representative action components are included for purposes of preparing estimated costs for Alternative 5A:

- Routing of groundwater collected from extraction wells to a central groundwater treatment facility located southwest of the offsite extraction/recharge wells on or near Mather Field;

- Pipe routing located along a corridor west of the Aerojet site in the vicinity of Zinfandel Drive;

- A representative groundwater treatment system consisting of biological reduction for perchlorate removal, pressure filtration to remove any remaining particulates prior to recharge, UV/oxidation for removal of VOCs and NDMA, air stripping polishing to remove any remaining VOCs following UV/oxidation; and

- Management/reuse of treated groundwater via recharge to maintain a hydraulic barrier in conjunction with the offsite extraction wells.

Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use treatment. As discussed in Section D8.3.9, the model simulation for Alternative 5A assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not

captured would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 5A are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- The existing GET F GWTP will have sufficient capacity accommodate the anticipated flow from the onsite GETs E and F boundary containment/source control systems as indicated below:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
Subtotal – treatment capacity required	3,800
Existing treatment capacity at GET F	4,000

The approximately 3,800 gpm of treated groundwater would continue to be recharged using the existing GETs E and F recharge wells. If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, a portion of this 3,800 gpm to be recharged may be used as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. As discussed for Alternative 4A, approximately 3,400 gpm would be necessary to replace the combined flows of these wells. This replacement water would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek,

- In the year 2001, complete nine new extraction wells offsite in the C layer (Figure 4-7) and one new extraction well in the D layer (coincident with new extraction well C3), install conveyance piping from these well locations to a new offsite GWTP location, and construct a new offsite GWTP to remove perchlorate, NDMA, and any VOCs from groundwater extracted from offsite containment wells. From 2001 to 2011, FS modeling (Table D8-12) indicates that only 3,100 gpm of capacity would be required for the offsite GWTP. However, for purposes of this evaluation, it is

assumed that the offsite GWTP would be sized to accommodate the maximum offsite flow anticipated over the FS evaluation period, which is 4,900 gpm. If Alternative 5A were implemented, the actual initial capacity of the offsite GWTP would be determined during remedial design;

- Also in the year 2001, complete seven offsite recharge wells located where groundwater is not impacted by perchlorate or NDMA and where they can divert impacted groundwater away from operating water supply wells and toward extraction wells (Figure 4-7). Conveyance piping from the new offsite GWTP to these recharge wells would also be constructed in 2001. Groundwater treated at the offsite GWTP would be equally distributed among the seven recharge wells;

- In the year 2011, complete two new extraction wells in the D layer coincident with two existing C layer extraction wells and add 500 gpm of treatment capacity at the offsite GWTP;

- In the year 2021, complete five new extraction wells (four in the D layer and one in the E layer, all coincident with existing C layer extraction wells) and add approximately 1,300 gpm of treatment capacity at the offsite GWTP; and

- Based on the model simulation performed for Alternative 5A, in years beyond the 25-year evaluation period, complete seven new extraction wells (one in the D layer and six in the E layer, all coincident with existing C layer extraction wells) and add approximately 2,200 gpm of treatment capacity at the offsite GWTP.

- With respect to O&M costs within the evaluation period, Alternative 5A would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and recharge systems;

  - O&M associated with the new GETs E and F extraction wells; and

  - If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing the approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

  - Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the 10 new offsite containment wells, treating the flow associated with these wells at a new offsite GWTP, conveying the treated groundwater to the seven new offsite recharge wells, and maintaining the recharge wells;

- Beginning in mid-year 2011, additional O&M associated with extracting, conveying, treating at the offsite GWTP, and recharging groundwater from the two new offsite containment wells; and

- Beginning in mid-year 2021, additional O&M associated with extracting, conveying, treating at the offsite GWTP, and recharging groundwater from the five new offsite containment wells.

4.2.10 Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Alternative 5B contains the same components as Alternative 5A with one exception: treated groundwater from the onsite GETs E/F boundary containment/source control systems would not be recharged to groundwater. The treated groundwater from the GETs E/F systems would be discharged to surface water and/or reused for potable or non-potable water supply purposes.

Similar to Alternative 5A, Alternative 5B includes containment of the offsite CoPC plumes using a combination of new extraction and recharge wells to provide hydraulic containment. Modeled locations of extraction and recharge wells downgradient of the CoPC plumes are shown on Figure 4-8. As indicated on Figure 4-8, recharge wells would be located on the periphery to direct the plumes to extraction wells located in the center.

Based on the model simulation performed for Alternative 5B, a total of 11 new extraction wells and seven new recharge wells would be necessary to provide hydraulic containment offsite over time. Based on modeling, the assumed beginning year of operation, modeled pumping and recharge rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-13). More detailed discussion of the modeling and assumptions made are contained in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells, particularly those locations north of US Highway downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate.

Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use treatment. As discussed in Section D8.3.10, the model simulation for Alternative 5B assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not captured would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 5B are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E layers. The anticipated downgradient locations of the replacement extraction wells are shown in Figure 4-8 (cluster locations NEW-1, -2, and –3). The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, expand the treatment capacity of the GET F GWTP using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs by approximately 2,225 gpm to accommodate the following additional flow:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New clustered extraction wells to replace recharge wells	2,425
Subtotal – treatment capacity required	6,225
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	2,225

The entire approximately 6,225 gpm would be discharged to Buffalo Creek for streamflow augmentation. The discharge pipeline installed in 2001 from the GET F GWTP to Buffalo Creek would be sized to accommodate the maximum treated groundwater flow anticipated over the evaluation period.

If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, a

portion of this approximately 6,225 gpm to be discharged to Buffalo Creek may be used as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. As discussed for Alternative 4A, approximately 3,400 gpm would be necessary to replace the combined flows of these wells. This replacement water would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

- In the year 2001, complete seven new extraction wells offsite in the C layer (Figure 4-8), install conveyance piping from these well locations to a new offsite GWTP location, and construct a new offsite GWTP to remove perchlorate, NDMA, and any VOCs from groundwater extracted from offsite containment wells. From 2001 to 2011, FS modeling (Table D8-13) indicates that only 2,000 gpm of capacity would be required for the offsite GWTP. However, for purposes of this evaluation, it is assumed that the offsite GWTP would be sized to accommodate the maximum offsite flow anticipated over the FS evaluation period, which is 2,600 gpm. If Alternative 5B were implemented, the actual initial capacity of the offsite GWTP would be determined during remedial design;

- Also in the year 2001, complete seven offsite recharge wells located where groundwater is not impacted by perchlorate or NDMA and where they can divert impacted groundwater away from operating water supply wells and toward extraction wells (Figure 4-8). Conveyance piping from the new offsite GWTP to these recharge wells would also be constructed in 2001. Groundwater treated at the offsite GWTP would be equally distributed among the seven recharge wells;

- In the year 2011, complete one new extraction well in the D layer coincident with C layer extraction well C3 and add approximately 200 gpm of treatment capacity at the offsite GWTP; and

- In the year 2021, complete two new extraction wells in the D layer coincident with C layer extraction wells C4 and C5 and add approximately 400 gpm of treatment capacity at the offsite GWTP.

- Based on the model simulation performed for Alternative 5B, in years beyond the 25-year evaluation period, complete one new extraction well in the E layer, coincident with C layer extraction well C5 and add approximately 300 gpm of treatment capacity at the offsite GWTP.

- With respect to O&M costs within the evaluation period, Alternative 5B would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction and treatment systems;

- O&M associated with the new GET E and F extraction wells, the new extraction wells that will replace the GETs E and F recharge wellfields, and the expanded GET F GWTP;

- If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing the approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

- Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the seven new offsite containment wells, treating the flow associated with these wells at a new offsite GWTP, conveying the treated groundwater to the seven new offsite recharge wells, maintaining the recharge wells, and monitoring;

- Beginning in mid-year 2011, additional O&M associated with extracting, conveying, treating at the offsite GWTP, and recharging groundwater from the one new offsite containment well; and

- Beginning in mid-year 2021, additional O&M associated with extracting, conveying, treating at the offsite GWTP, and recharging groundwater from the two new offsite containment wells.

4.3 Screening of Alternatives

In this section, the assembled alternatives are typically screened against the criteria of overall effectiveness in meeting the RAOs, implementability, and cost. The purpose is to reduce the number of alternatives that will undergo a more thorough and extensive analysis during the detailed evaluation of alternatives. This screening process was used, but all alternatives were retained.

Following are descriptions of each of the criteria used in this screening process:

- Effectiveness - The effectiveness criterion measures how well the alternative achieves the RAOs. The effectiveness of each alternative in protecting human health and the environment is a key aspect of the alternative screening evaluation. Each alternative is evaluated in terms of its effectiveness in providing protection and reducing the toxicity, mobility, and volume of contamination. Short-term (during the construction and implementation period) and long-term (after remedial action is complete) effectiveness are evaluated.

- Implementability - The implementability criterion includes evaluating both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative. Technical feasibility refers to the future operation, maintenance, and monitoring of an alternative after the remedial action has been completed. Administrative feasibility refers to the ability to obtain approvals and permits from regulatory agencies; the availability and capacity of treatment, storage, and disposal services; and the requirements for and availability of specialized technicians and equipment.

- Cost - The cost-screening criterion provides a mechanism for comparison of cost estimates among alternatives. However, cost plays a limited role in this screening process. Instead, each alternative is evaluated with respect to whether costs for the alternative are high, low, or medium relative to other alternatives.

At this stage, the screening process focuses on effectiveness factors with less effort directed at the implementability and cost evaluation.

The screened alternatives are assembled from representative technology and process options. However, the specific processes actually used to implement a remedial action may not be selected until the remedial design. At some sites, innovative or non-representative process options may be found to offer significant advantages in the form of treatment performance or implementability, fewer adverse impacts than other available approaches, or lower costs for similar levels of performance.

Because of the use of the representative process option concept for purposes of preparing cost estimates for the various alternatives, the number of alternatives assembled was able to be limited to a manageable number (i.e., ten), additional screening to eliminate alternatives was not required and all of the alternatives have been carried forward to the detailed analysis presented in Section 5.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

It is the Regional Board's belief that Alternatives 1, 2A, and 2B do not comply with the ARARs found in State Water Resources Control Board Resolution Nos. 68-16 and 92-49, or with the Water Quality Control Plan for the Sacramento and San Joaquin River Basins (Basin Plan).

Page 97, Section 5.1.7, Cost. The estimated cost period for the total present worth is required to be 30 years not the 25 years used. The EPA has provided the 30 year cost data in the supplement to Appendix E for Alternatives 3A through 5B which meet EPA's threshold criteria

Page 110, Section 5.2.4.2, Compliance with ARARs. It is stated that groundwater containing concentrations of COPCs greater than PRAGs will be collected and treated. The Regulatory Agencies are not in agreement with the PRAGs presented in the report are cleanup levels. Cleanup levels will be found in the Proposed Plan, and established in the Record of Decision or similar enforcement document

Page 110, Section 5.2.4.2, Compliance with ARARs. The State's interpretation of Resolution No. 68-16 is that the resolution also deals with the migration of existing contamination in groundwater to uncontaminated portions of the aquifer. In addition, the state asserts that State Water Resources Control Board Resolution No. 92-49 not only requires treatment of the extracted groundwater to meet Water Quality Objectives, it requires that the aquifer be restored to meet Water Quality Objectives.

Page 119, Section 5.2.6.2, Compliance with ARARs. Aerojet states that the hydraulic containment system will also consider the substantive requirements of the containment zone provisions of Resolution No. 92-49. However, the State's interpretation of the containment zone provisions of the resolution is that the containment zone deals with designating a portion of the aquifer that will not meet beneficial uses as the "containment zone" and requires that portion of the aquifer be contained. Hydraulic containment of the existing plume will be based on the other provisions of Resolution No. 92-49 and the Basin Plan that have specific requirements for the extent of the plume that must be remediated.

Page 130, Section 5.2.8.5, Short-Term Effectiveness. The EPA estimated the time to complete RAOs and Alternative 4C is expected to achieve RAOs 31% faster than 4B.

Page 130, Section 5.2.8.7, Costs. The total non-discount cost estimate performed by the EPA and contained in Appendix E indicates Alternative 4C to have the lowest cost. Based on the 30 year present worth estimate Alternative 4C is $7.8M or 8% more expensive than 4B, however, not all components of the 4B remedy are installed in the 30 year cost period.

5 DETAILED ANALYSIS OF ALTERNATIVES

In this section, the ten alternatives developed in Section 4 are subjected to detailed analysis. The purpose of this detailed analysis is to provide sufficient information to allow for comparisons among the alternatives based on the standard criteria specified in the NCP.

The detailed evaluation of final alternatives for a remedial action is a two-stage process. During the first stage of evaluation, each of the alternatives is assessed against the individual criteria. This first-stage evaluation of the final remedial action alternatives for the Western Groundwater OU is presented in this section; the evaluation is based on the conceptual descriptions of the final alternatives provided in Section 4. For the second stage of the evaluation process, the criteria are grouped into a tiered system to reflect their interrelationships and different levels of significance. During this second-stage evaluation, the alternatives are initially evaluated according to the threshold criteria, which must be met, and then compared with each other to identify relative advantages and disadvantages and trade-offs among the different balancing criteria. The purpose of the comparative analysis is to provide information for a balanced remedy selection. The second-stage evaluation of final remedial action alternatives is presented in Section 6.

The nine NCP evaluation criteria include:

Threshold Criteria:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

Primary Balancing Criteria:

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

Modifying Criteria:

- State Acceptance
- Community Acceptance

The NCP [40 CFR Section 300.430(e)(9)(iii)] categorizes these nine criteria into three groups: threshold criteria, primary balancing criteria, and modifying criteria. Each type of criteria has its own weight when it is evaluated. Threshold criteria are requirements that each alternative must meet to be eligible for selection as the preferred alternative, and include overall protection of human health and the environment and compliance with ARARs (unless a waiver is obtained).

Primary balancing criteria are used to weigh effectiveness and cost tradeoffs among alternatives. The primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The primary balancing criteria represent the main technical criteria upon which the alternative evaluation is based. Modifying criteria include State acceptance and community acceptance, and may be used to modify aspects of the preferred alternative when preparing the proposed plan.

Modifying criteria are generally evaluated after public comment on the OU RI/FS and the Proposed Plan. Accordingly, only the seven threshold and primary balancing criteria are used in the detailed analysis phase. The following sections provide descriptions of the evaluation criteria and the items considered when assessing alternatives with respect to each criterion.

5.1 Description of Evaluation Criteria

5.1.1 Overall Protection of Human Health and the Environment

This evaluation criterion assesses how each alternative provides and maintains adequate protection of human health and the environment. Alternatives are assessed to determine whether they can adequately protect human health and the environment from unacceptable risks posed by contaminants present at the site, in both the short and long term. This criterion is also used to evaluate how risks would be eliminated, reduced, or controlled through treatment, engineering, institutional controls, or other remedial activities. The considerations evaluated during the analysis of each alternative for overall protection of human health and the environment are presented in below:

Protection of human health:

- Likelihood that the alternative reduces risk to human health to below risk-based levels.

Protection of the environment:

- Likelihood that the alternative reduces the threat to unaffected groundwater by minimizing migration of contaminants. As discussed in the BRA, there are no completed exposure pathways to groundwater for ecological receptors.

5.1.2 Compliance with ARARs

This evaluation criterion is used to evaluate if each alternative would attain federal and State ARARs, or whether invoking waivers to specific ARARs is adequately justified.

Other information, such as advisories, criteria, or guidance, is considered where appropriate during the ARARs analysis. The considerations evaluated during the analysis of the ARARs applicable to each alternative are presented below. Potential action-, location-, and chemical-specific ARARs for the alternatives presented in this OU RI/FS are identified in Appendix C.

Chemical-specific ARARs:

- Likelihood that the alternative will achieve compliance with chemical-specific ARARs (e.g., MCLs) within a reasonable period of time.
- If it appears that compliance with chemical-specific ARARs will not be achieved, then evaluation of whether a waiver is appropriate.

Location-specific ARARs:

- Determination of whether any location-specific ARARs (e.g., whether facilities will be located in a floodplain and preservation of wetlands) apply to the alternative.
- Likelihood that the alternative will achieve compliance with the location-specific ARAR.
- Evaluation of whether a waiver is appropriate if the location-specific ARAR cannot be met.

Action-specific ARARs:

- Likelihood that the alternative will achieve compliance with action-specific ARARs (e.g., new source air emission rules).
- Evaluation of whether a waiver is appropriate if the action-specific ARAR cannot be met.

Other criteria and guidance:

- Likelihood that the alternative will achieve compliance with other criteria, such as risk-based criteria.

5.1.3 Long-Term Effectiveness and Permanence

This evaluation criterion addresses the long-term effectiveness and permanence of maintaining the protection of human health and the environment after implementing the remedial action imposed by the alternative. The primary components of this criterion are the magnitude of residual risk remaining at the site after remedial objectives have been met and the extent and effectiveness of controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The considerations evaluated during the analysis of each alternative for long-term effectiveness and permanence are

presented below. The components addressed for each alternative are described in more detail in the following subsections.

Magnitude of residual risks:

- Identity of remaining risks (risks from treatment residuals) as well as risks from untreated residual contamination.
- Magnitude of the remaining risks.

Adequacy and reliability of controls:

- Likelihood that the technologies will meet required process efficiencies or performance specifications.
- Type and degree of long-term management required.
- Long-term monitoring requirements.
- O&M functions that must be performed.
- Difficulties and uncertainties associated with long-term O&M functions.
- Potential need for technical components replacement.
- Magnitude of threats or risks should the remedial action need replacement.
- Degree of confidence that controls can adequately handle potential problems.
- Uncertainties associated with land disposal of residuals and untreated wastes.

5.1.3.1 Magnitude of Residual Risk

The magnitude of residual risk at the end of remedial activities is measured by numerical standards such as PRGs, or the volume or concentration of CoPCs remaining. The characteristics of the residuals remaining are also evaluated, considering their volume, toxicity, and mobility.

5.1.3.2 Adequacy and Reliability of Controls

The adequacy and reliability of controls that are used to either manage treatment residuals or untreated materials that remain after attaining PRGs are evaluated. This criterion includes an assessment of containment systems and institutional controls to evaluate the degree of confidence that they adequately handle potential problems and provide sufficient protection. The criterion also addresses long-term reliability, the need for long-term management and monitoring, and the potential need to replace technical components of the alternative.

5.1.4 Reduction of Toxicity, Mobility or Volume through Treatment

This evaluation criterion addresses the anticipated performance of the treatment technologies employed by each alternative in permanently and significantly reducing toxicity, mobility, and/or volume of CoPCs associated with the OU. The NCP prefers remedial actions where treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. The considerations evaluated during the analysis of each alternative for reduction of toxicity, mobility, or volume of CoPCs present at a given site are presented below:

Treatment process and remedy:

- Likelihood that the treatment process addresses the principal threat.
- Special requirements for the treatment process.

Relative amount of hazardous material destroyed or treated:

- Portion (mass) of CoPC that is destroyed.
- Portion (mass) of CoPC that is treated.

Reduction in toxicity, mobility, or volume:

- Extent that the total mass of CoPCs is reduced.
- Extent that the mobility of CoPCs is reduced.
- Extent that the volume of CoPCs is reduced.

Irreversibility of treatment:

- Degree that the effects of the treatment are irreversible.

Type and quantity of residuals remaining following treatment:

- Residuals that will remain.
- Quantities and characteristics of the residuals.
- Risk posed by the treatment residuals.

Statutory preference for treatment as a principal element:

- Extent to which the scope of the action covers the principal threats.
- Extent to which the scope of the action reduces the inherent hazards posed by the principal threats at the site.

5.1.5 Short-Term Effectiveness

Short-term effectiveness considers the effect of each remedial alternative on the protection of human health and the environment during the construction and implementation phase. The short-term effectiveness evaluation only addresses protection prior to meeting the RAOs. The considerations evaluated during the analysis of each alternative for short-term effectiveness are presented below:

Protection of the community during any remedial action:

- Risks to the community that must be addressed.
- How the risks will be addressed and mitigated.
- Remaining risks that cannot be readily controlled.

Protection of workers during remedial actions:

- Risks to the workers that must be addressed.
- How the risks will be addressed and mitigated and the effectiveness and reliability of measures to be taken.
- Remaining risks that cannot be readily controlled.

Environmental impacts of any remedial action:

- Environmental impacts that are expected with the construction and implementation of the alternative.
- Mitigation measures that are available and their reliability to minimize potential impacts.
- Impacts that cannot be avoided, should the alternative be implemented.

Time until RAOs are achieved:

- Time to achieve protection against the threats being addressed.
- Time until any remaining threats are addressed.
- Time until RAOs are achieved.

5.1.6 Implementability

Implementability evaluates the technical feasibility and administrative feasibility (i.e., the ease or difficulty) of implementing each alternative and the availability of required services and materials during its implementation. The following considerations are evaluated during the analysis of each alternative for implementability:

Technical Feasibility

Ability to construct and operate the technology:

- Difficulties associated with the construction.
- Uncertainties associated with the construction.

Reliability of the technology:

- Likelihood that technical problems will lead to schedule delays.

Ease of undertaking additional remedial action:

- Likely future remedial actions that may be anticipated.
- Difficulty implementing additional remedial actions.

Monitoring considerations with respect to effectiveness of the remedy:

- Migration or exposure pathways that cannot be monitored adequately.
- Risks of exposure, should the monitoring be insufficient to detect failure.

Administrative Feasibility

Coordination with other agencies:

- Steps required to coordinate with regulatory agencies to implement any remedy.
- Steps required to establish long-term or future coordination among agencies.
- Ease of obtaining permits for offsite activities, if required.

Availability of Services and Materials

Availability of treatment, storage capacity, and disposal services:

- Availability of adequate treatment, storage capacity, and disposal services.
- Additional capacity that is necessary.
- Whether lack of capacity prevents implementation.
- Additional provisions required to ensure that additional capacity is available.

Availability of necessary equipment and specialists:

- Availability of adequate equipment and specialists.
- Additional equipment or specialists that are required.
- Whether there is a lack of equipment or specialists.
- Additional provisions required to ensure that equipment and specialists are available.

Availability of prospective technologies:

- Whether technologies under consideration are generally available and sufficiently demonstrated.
- Further field applications needed to demonstrate that the technologies may be used full-scale to treat CoPCs.
- When technology should be available for full-scale use.
- Whether more than one vendor will be available to provide a competitive bid.

5.1.7 Cost

The estimated costs are presented within the accuracy range stated in RI/FS guidance (USEPA, 1988a). The cost sensitivity analysis represents an evaluation of how sensitive the cost of a given project is to changes in parameters that are not known with certainty.

Capital and O&M costs were prepared using February 1999 dollars. In preparing the capital and O&M cost estimates, a contingency of allowance of 15 percent was included to address unforeseen circumstances such as the ability to estimate the scope of any remedial alternative at this stage of the OU RI/FS, the ability to predict the schedule for implementation of a remedy, the ability to estimate costs of treatment technologies for removal of certain CoPCs, uncertainties associated with the provisional reference dose for perchlorate, and unresolved issues with respect to management of treated groundwater in concert with overall regional water management objectives. With respect to the present worth cost analyses, a discount rate of 7 percent (before taxes and after inflation) [USEPA, 1996e] and a 25 year period of performance for costing purposes were assumed.

For costing all of the alternatives involving groundwater containment or collection (except containment using existing water supply wells), treatment is assumed to occur at a central treatment facility located at the existing GETs E/F treatment facility site or at a new site to be located on or near the former Mather Air Force Base (AFB). For those alternatives involving containment using existing water supply wells, treatment would occur at the well head.

Again, for purposes of costing, the "representative treatment system" approach discussed in Section 3 will be used. Specifically, groundwater treatment processes at a central groundwater treatment facility will involve biological reduction for perchlorate removal, UV/oxidation for VOCs and NDMA removal, and air stripping polishing for removal of any residual VOCs. As to extracted water that is not recharged, the treated groundwater management option for costing purposes is assumed to be discharge to a location coincident with intake of a public water system or to surface water.

5.1.8 State Acceptance

This criterion involves technical and administrative concerns that the State may communicate in its comments concerning each alternative.

5.1.9 Community Acceptance

The preferred alternative for this OU RI/FS will be presented to the public in a Proposed Plan, which will provide a brief summary of all of the alternatives studied in the detailed analysis of alternatives section of the OU RI/FS. In accordance with the NCP, the public will have an opportunity to review and comment on the selected remedial alternative presented in the Proposed Plan. The public's comments will be addressed in the responsiveness summary and ROD for the Western Groundwater OU.

5.2 Results of the Detailed Analysis of Alternatives

The following sections present the detailed analysis of the ten remedial alternatives using the seven threshold and primary balancing criteria.

A numerical groundwater model was used to assist in evaluating the alternatives with respect to the NCP threshold criteria (protectiveness and compliance with ARARs). The model simulated groundwater flow and estimated advective migration of dissolved CoPCs and was used to evaluate the relative merits of the remedial alternatives subsequently described in this section. The groundwater model used to evaluate the remedial alternatives was based on the final site conceptual model as presented in Section 1. A complete description of the groundwater model is presented in Appendix D.

Groundwater flow was simulated using MODFLOW, a modular three-dimensional flow model developed by the United States Geological Survey (USGS). A particle-tracking model, MODPATH, was used to evaluate advective contaminant migration for each of the remedial alternatives as described in Appendix D. This objective was achieved by

starting particles and allowing them to migrate with the advective groundwater flow. Hence, mechanisms such as dispersion, decay, or chemical fate were not considered.

Because of the approximate nature of numerical solutions, the conceptual model, and hydrogeologic parameters, none of the results of the evaluation should be construed as precise predictions of future contaminant distributions. Rather, evaluative results should be viewed as tools for comparing and contrasting the relative merits of each of the remedial alternatives. Analyses were performed to evaluate whether model results were sensitive to uncertainties in various input parameters. These analyses are presented in Appendix D.

5.2.1 Alternative 1: No Action with Limited Groundwater Monitoring

This section presents the description and detailed analysis of the No Action alternative, which serves as the baseline for comparison of the effectiveness of the remaining eight alternatives. Under No Action, the current onsite source containment activities associated with operation of the GETs E and F extraction, treatment, and treated groundwater recharge facilities would be terminated and no further onsite remedial activities would be implemented. For the No Action alternative, there would be no active remediation of groundwater offsite. Also, no institutional controls would be implemented under the No Action alternative. Limited groundwater monitoring, equivalent to that currently being undertaken under Exhibits IV and VI would be undertaken.

Existing water supply wells that may be affected by the migration of CoPC plumes would be shut off, as discussed in Section 4.

5.2.1.1 Overall Protection of Human Health and Environment

Contaminated groundwater is not prevented from migrating further and affecting other groundwater resources. Except to the extent that pre-existing institutional controls prevent exposure, the No Action alternative does not eliminate, reduce, or control the potential consumption of groundwater containing site-related constituents at levels above PRAGs. The No Action alternative (as evaluated in the BRA) assumes that persons will be supplied water containing site-related constituents above risk-based levels either by private or public water providers or through use of individual domestic wells. Therefore, in theory, and for purposes of comparison to the other alternatives, the No Action alternative is assumed to provide inadequate protection to human health and the environment.

In actuality, public water purveyors take action to monitor and shut down wells that they or DHS consider to be inappropriate for service to customers. Further, the anticipated Consultation Zone provision of the Sacramento County comprehensive well drilling

ordinance will restrict drilling of new wells in the area. Consequently, although for purposes of this OU RI/FS it is assumed that the No Action alternative does not include any active or passive means to eliminate, reduce, or control the pathway by which persons could be exposed to contaminated drinking water, there are controls outside the scope of this OU RI/FS that would eliminate, restrict, or control potential use of contaminated drinking water.

Under the No Action alternative, the existing onsite GETs E/F groundwater extraction and treatment facilities that are used to contain and control the source area groundwater would be terminated. Therefore, the No Action alternative would not minimize or control migration from the source area. Similarly, the No Action alternative would not limit further migration of impacted groundwater downgradient of the source. To the extent that it would be practicable to return the regional aquifer to its beneficial uses through cost-effective remediation, the No Action alternative would not achieve the goal of returning the regional aquifer to its expected beneficial use.

As there are no active remediation measures included in the No Action alternative, it does not pose any unacceptable short-term risks or other adverse impacts beyond its theoretical failure to eliminate the use of contaminated groundwater.

5.2.1.2 Compliance with ARARs

Over time, natural flushing of the aquifer will reduce the concentrations of CoPCs in the aquifer; however, this is expected to take a substantial period of time and therefore chemical-specific ARARs will not be met within a reasonable time frame by the No Action Alternative.

As the No Action Alternative does not include any active measures, location- and action-specific ARARs do not apply to this alternative.

5.2.1.3 Long-Term Effectiveness and Permanence

All current and potential future risks remain. Untreated residual CoPCs in groundwater would pose a risk if the residential well or water supply pathways become complete.

Risks posed by CoPCs in groundwater are expected to gradually decrease as contaminant concentrations decrease over time through physical dilution by dispersion and diffusion of all CoPCs and possibly through biodegradation of any VOCs.

5.2.1.4 Reduction of Toxicity, Mobility, and Volume through Treatment

The No Action alternative would not provide any reduction in toxicity beyond the natural attenuation of CoPCs that may occur in the groundwater environment. There would be

no reduction of mobility and volume through treatment because no treatment technologies would be employed. Therefore, the No Action alternative would not address the statutory preference for treatment as a principal element. No treatment residuals would be generated.

5.2.1.5 Short-Term Effectiveness

Because no remedial action would be taken under the No Action alternative, no short-term risks to the community or to workers as a result of implementing the action would occur. Similarly, no environmental impact from construction activities would occur.

The RAOs for protecting human health and the environment from exposure to contaminated groundwater, minimizing offsite migration of CoPCs where practicable to protect long-term beneficial uses, reducing contaminant concentrations in an efficient cost-effective manner would not be met by the No Action alternative as it would not minimize offsite migration. The RAO of protecting public drinking water wells and providing treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels would not be met by the No Action alternative.

5.2.1.6 Implementability

As no active or passive remedial technologies would be implemented under the No Action alternative, there are no implementability concerns or issues associated with the No Action alternative. There are no impediments to implementing the No Action alternative.

5.2.1.7 Costs

Because the No Action alternative only includes limited groundwater monitoring, it is ranked as the least costly alternative. The assumed level of monitoring is equivalent to the current monitoring program under Exhibits IV and VI of the PCD. The annual O&M costs and 25 year present worth costs associated with implementing Alternative 1 are as follows. A present worth summary is included in Appendix E.

Estimated annual Monitoring costs:	$160,000
Estimated 25-year present worth costs:	$2,000,000

5.2.2 Alternative 2A: GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Alternative 2A includes continued operation and improvements to the onsite GETs E and F boundary containment/source control systems and onsite recharge of treated GETs E and F groundwater. A map showing the onsite capture zone is included as Figure 5-1. Alternative 2A also includes monitoring and institutional controls. Offsite, Alternative 2A involves providing an alternate water supply to replace the lost capacity of any existing water supply wells that may become effected by the offsite CoPC plume.

The potential sources of alternate water supply that would be made available by Aerojet to replace lost capacity would include treated groundwater from one or more of the Aerojet GET facilities, new water supply wells located in areas not effected by the CoPC plumes, or surface water that has been exchanged for treated groundwater from one or more of the Aerojet GET facilities.

The assumed level of monitoring is equivalent to the current monitoring program under Exhibits IV and VI of the PCD. Offsite institutional controls (DHS oversight of public drinking water systems and the proposed Consultation Zone provision of the comprehensive Sacramento County well drilling ordinance) are assumed. Aerojet will also request status from the County to be a regular referral entity for any new wells that may be proposed to be drilled in the Study Area.

Under this alternative the offsite CoPC plume will continue to migrate. For purposes of costing, it is assumed that the water supply well capacity resulting from the model simulation (Appendix D, Table D8-1) would require replacement. For purposes of analysis, maximum day water demand is assumed (Fair, Geyer, and Okun, 1966).

There are various replacement/alternative water supplies that are potentially available to replace lost well capacity. For example, treated groundwater from one or more of the existing GET facilities on the Aerojet site may be made available through direct reuse or such GET facility water may become available following discharge to surface water.

Alternative 2A assumes that treated groundwater will be available for direct reuse. Accordingly, costs are associated with piping and transfer to an assumed location in the water distribution system located to the west of the Aerojet site.

5.2.2.1 Overall Protection of Human Health and Environment

By terminating use of impacted groundwater and replacing the supply of potable water with treated groundwater and/or unimpacted surface water and maintaining and/or enhancing existing controls on well drilling and groundwater use in the affected area, Alternative 2 eliminates the potential for consumption of groundwater containing site-related constituents at levels above risk-based criteria. Under Alternative 2A, persons would be provided alternative supplies from treated groundwater or an unimpacted

surface water source. Therefore, Alternative 2A is protective of human health and the environment. Offsite groundwater and water supply well monitoring and institutional controls would contribute to public health protection.

Alternative 2A would eliminate or significantly reduce continued offsite migration offsite of contaminated groundwater from the Aerojet facility. As Alternative 2A does not include any offsite engineered groundwater controls, it would not limit further migration of impacted groundwater downgradient of the GETs E/F systems. Consequently, Alternative 2A would not minimize migration of CoPCs that have already left the Aerojet facility. However, over some very lengthy period of time, natural attenuation processes should eventually result in the restoration of the offsite regional aquifer to its expected beneficial use. As there would be no control of impacted groundwater downgradient of the source area, over the short term, Alternative 2A would allow additional portions of the aquifer to become contaminated and would probably require additional water supply wells to be shut down.

5.2.2.2 Compliance with ARARs

Alternative 2A has the potential to eventually comply with ARARs that pertain to the protection of groundwater resources and the cleanup of releases. At the Aerojet facility, contaminated groundwater captured by the GET E/F extraction wells will be treated prior to management/reuse to concentrations that meet cleanup standards based on risk-based levels and chemical-specific ARARs (e.g., MCLs and PALs if treated water is to be directly reused) where applicable or relevant and appropriate. Over time, all of the onsite groundwater containing CoPCs will be removed by the extraction wells and replaced by natural and/or artificial recharge of uncontaminated water. Thus, the onsite component of Alternative 2A is consistent with protecting the beneficial uses and maintaining the existing quality of receiving waters pursuant to State Water Resources Control Board Resolutions 68-16 and 92-49, and the Basin Plan.

As noted above, Alternative 2A does not include any offsite engineered groundwater controls, and therefore will not limit further migration of impacted groundwater supplies downgradient of the GET E/F systems. Accordingly, it is unlikely that impacted groundwater offsite can attain chemical-specific ARARs within the short term. However, the combined operation of institutional controls (e.g., the proposed Consultation Zone provision to the Sacramento County comprehensive well drilling ordinance and Aerojet's serving as a regular referral entity for any new wells that may be proposed to be drilled in the Study Area), the source control measures at the Aerojet facility, and natural attenuation processes has a reasonable potential to bring about long-term attainment with ARARs.

The GET E/F facilities will be improved and operated in a manner designed to comply with all location- and action-specific ARARs. As no active remediation measures in offsite areas are include in Alternative 2A, location- and action-specific ARARs do not apply to offsite actions under this alternative.

5.2.2.3 Long-Term Effectiveness and Permanence

For Alternative 2A, effective long-term control of the onsite CoPC plume and migration of the plume offsite would be provided through extraction and treatment of groundwater via the GETs E/F containment system. However, potential current and future risks associated with the offsite CoPC plume would remain. Untreated residual CoPCs in groundwater offsite may pose a risk if the groundwater is used as a water supply.

The fate of perchlorate and NDMA in groundwater is not well understood. There is insufficient basis, at present, to conclude that there will be significant degradation of these chemicals in groundwater. Therefore, it is assumed that these CoPCs will migrate downgradient a significant distance, and could impact water supply wells located outside of the Study Area. Offsite, this alternative relies more heavily on institutional controls than other engineered alternatives such as groundwater extraction and treatment.

5.2.2.4 Reduction of Toxicity, Mobility and Volume through Treatment

Under CERCLA guidance for selecting remedial action alternatives, preference is given to remedial technologies that significantly reduce the toxicity, mobility, or volume of the affected media through treatment. This evaluation criterion assesses the degree of reduction in toxicity, mobility, or volume of the CoPCs. Considerations include an analysis of the extent of irreversibility of the treatment and the disposition of treatment materials.

For Alternative 2A, continued operation and upgrading of the onsite GETs E/F boundary control system would capture the CoPCs onsite and prevent them from migrating offsite, reducing the toxicity, mobility, and volume of the CoPCs. VOCs, perchlorate, and NDMA would be destroyed via the UV/oxidation and biological reduction processes, which are irreversible. Use of these treatment processes would satisfy the statutory preference for treatment as a principal element of the remedial action.

Residuals remaining after treatment would include the minor volume of non-hazardous organic sludge that would be generated by the biological reduction process. This sludge would be discharged to the sanitary sewer or dewatered and disposed in a non-hazardous landfill.

Under Alternative 2A, for the portion of the CoPC plume currently offsite, no extraction and treatment of groundwater is planned. To protect human health and the environment, the offsite component of Alternative 2A includes maintaining institutional controls and providing an alternate water supply. Therefore, for the offsite component of the Alternative 2A remedy, no reduction beyond the natural biodegradation of organic compounds that occurs in the groundwater environment and physical dilution by dispersion and diffusion of all CoPCs is projected to take place, the mobility and volume

of the CoPC plume will not be reduced, and the statutory preference for treatment as a principal element will not be addressed. No treatment residuals would be generated from the offsite component of the Alternative 2A remedy.

5.2.2.5 Short-Term Effectiveness

Protection of Community and Workers. The short-term impact on the risks to the community and workers would be minimal during construction of the additional onsite extraction wells and treatment capacity associated with the GETs E/F boundary containment system. Likewise, during construction of any pipelines to convey treated groundwater, surface water treatment facilities, or new water supply wells to replace lost capacity of any existing water supply wells that may become effected, the short-term impact on the risks to the community and workers would be minimal. Workers would be adequately protected during construction by adhering to Occupational Safety and Health Administration (OSHA) practices. Workers would also be protected while operating and maintaining facilities by adhering to appropriate health and safety procedures.

Environmental Impacts. Adverse environmental impacts associated with this alternative include the continued migration of the offsite CoPC plumes.

Time until Response Objectives are Achieved. Minimizing further offsite migration of CoPCs from the Aerojet site is being achieved by the existing GETs E/F boundary control system. Human health risk due to exposure to contaminated groundwater would be eliminated immediately after affected water supply wells are shutdown and alternative water supplies are provided. Minimizing further migration of the offsite CoPC plume would not be achieved under Alternative 2A. Reducing contaminant concentrations in already contaminated groundwater in an efficient cost-effective manner would be achieved immediately for the onsite GETs E/F containment system and would not be achieved for the offsite portion of the CoPC plume.

The RAO of protecting public drinking water wells and providing treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels would be met immediately after affected water supply wells are shutdown and alternative water supplies are provided. During the period between approval of the OU RI/FS and the implementation of this remedial action, should it be selected, it is possible that CoPCs will be detected in additional public water supply wells at unacceptable levels. Public water purveyors would be expected to continue to monitor wells for CoPCs, either directly or by obtaining the results of Aerojet monitoring undertaken pursuant to Exhibit IV of the PCD. Exhibit IV currently requires Aerojet to evaluate the source of the contaminant and recommend alternatives necessary to protect public health, which process is subject to agency review and Court oversight. Such alternatives could include shutting down the well, providing alternative water supplies or providing point of use treatment, all more fully discussed in Section 3 and Section 4 of this OU RI/FS. As part of this alternative, some mechanism for monitoring and

evaluation of interim remedial measures necessary to protect public health would be appropriate, should the provisions of Exhibit IV no longer apply.

5.2.2.6 Implementability

The primary implementability issues associated with Alternative 2A would be (1) for direct reuse of treated groundwater, obtaining DHS approval; and (2) for any alternative water supplies, the routing of water supply conveyance piping from the point of availability to the appropriate pressure zone in the water distribution system.

If treated groundwater is directly used, DHS approval would be required for the water purveyor to use the water. DHS is currently evaluating direct reuse of treated water that had contained the same CoPCs and involving the same types of treatment as existing or projected at GETs E and F. It is possible that DHS will not approve or approve direct reuse only on conditions that raise implementability issues.

If treated groundwater is made available for water purveyor use through discharge to the American River or Folsom South Canal, approvals may be required by other regulatory agencies that can delay the project or impose conditions that can affect implementability.

The only future remedial action that may be necessary under Alternative 2A is the future need to provide additional alternative water supply to offset impacts to wells that may become impacted in the future and/or to provide alternative water supplies to replace wells of water providers whose wells have not been impacted but that may be impacted by further migration of the plume.

Should treated groundwater not be available as an alternative water supply, there may be implementability difficulties due to the potential unavailability of surface water entitlements or long term surface water supplies for such purpose.

As provision of an alternative water supply completely breaks the pathway through which persons could be exposed to contaminated groundwater, monitoring of water quality would not be necessary to insure protection of public health under Alternative 2A. Monitoring downgradient water supply wells that continue to be used would be necessary to identify potential future impacts and insure that contaminated water is not used for potable water supply. This type of monitoring is not expected to be difficult, as water providers are already required to routinely monitor the quality of the water they supply. Monitoring and evaluation of the location of potential new wells would also be necessary to assess and insure the effectiveness of institutional controls on future use of contaminated groundwater. Such monitoring would take the form of continued implementation of the proposed Consultation Zone provision of the Sacramento County comprehensive well ordinance and Aerojet serving in a regular referral entity for any new well that may be proposed in the Study Area. Should the institutional control fail to identify or restrict drilling of a new public water supply well in a contaminated area, it is anticipated that initial sampling of water supplied by a new well would identify the

presence of CoPCs resulting in the hypothetical new well not being used for potable supply.

The primary issues associated with coordination with other agencies would be the need to obtain approval for additional surface water diversion from Nimbus Reservoir via the Folsom South Canal and the need to obtain water purveyor support to shut down affected wells and use the alternate water supply. Coordination with local land planning and land use agencies would be necessary to implement controls on and monitoring of construction of possible new water supply wells in or downgradient of the existing CoPC plume.

Offsite, Alternative 2A does not entail any active treatment, storage or disposal of contaminated water. Therefore, no treatment, storage or disposal facilities would be necessary. The only treatment and storage needs required by this alternative are for treatment, storage and distribution of unaffected surface water supplies. Such treatment, to the extent necessary, is commonly available and routinely used by water suppliers and should require only limited evaluation prior to implementation.

5.2.2.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 2A, assuming direct reuse of GET treated groundwater are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$25,000,000
Estimated annual O&M costs:	$2,100,000-3,900,000
Estimated 25-year present worth costs:	$48,000,000

5.2.3 Alternative 2B: GETs E and F Extraction Wells with Offsite Alternate Water Supply

Alternative 2B differs from Alternative 2A only as to the shutdown of GETs E and F recharge. A map showing the onsite capture zone for this alternative is included as Figure 5-2. The discussion below does not repeat the substance of the discussion as to Alternative 2A, but simply notes any differences between the two alternatives resulting from the change from recharge to extraction onsite.

5.2.3.1 Overall Protection of Human Health and Environment

Alternative 2B is equally as protective as Alternative 2A.

5.2.3.2 Compliance with ARARs

Alternative 2B provides the same level of compliance with ARARs as Alternative 2A.

5.2.3.3 Long-Term Effectiveness and Permanence

As with Alternative 2A, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system. There are some model-projected changes that arise from replacing onsite GETs E/F recharge with extraction wells. First, the extraction wells are currently projected to be placed downgradient of the GETs E/F recharge field and are likely to contain CoPCs in Layer E and substantial portions in Layers C and D that would otherwise migrate off the Aerojet site. Accordingly, there would likely be more mass of chemicals extracted. By extracting, rather than recharging, the hydraulic gradient will decrease locally, thus potentially reducing the offsite movement. Model projections suggest fewer public water supply wells should be impacted over the same period of time.

5.2.3.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 2B is the same as for Alternative 2A discussed in Section 5.2.2.4. The only exception is that by extracting groundwater to implement hydraulic control instead of continued use of recharge wells, Alternative 2B provides greater reduction of mass of CoPCs in groundwater and potentially reduces the mobility and volume of a portion of the offsite plume.

5.2.3.5 Short-Term Effectiveness

Same as Alternative 2A.

5.2.3.6 Implementability

Same as Alternative 2A.

5.2.3.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 2B are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$22,000,000
Estimated annual O&M costs:	$2,500,000-2,800,000
Estimated 25-year present worth costs:	$54,000,000

5.2.4 Alternative 3A: GETs E and F Extraction and Recharge wells with Offsite Wellhead Treatment at Water Supply Wells

Alternative 3A involves operation of the GETs E and F control system onsite. Offsite action is assumed to be wellhead treatment using existing public water supply wells and groundwater monitoring. A map showing both onsite and offsite capture zones is included as Figure 5-3. Figure 5-4 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 3A.

Public water supply wells would be monitored for CoPCs. The assumed level of monitoring is equivalent to the current monitoring program under Exhibits IV and VI of the PCD. If monitoring indicated that a water supply well would become affected by one or more of the CoPCs at concentrations unacceptable for potable use, the well would be shut down until equipped with wellhead treatment. Groundwater from the water supply well would be treated to potable water quality prior to introduction to the water distribution system. The offsite institutional controls would consist of the proposed Consultation Zone provision to the existing comprehensive Sacramento County well drilling ordinance, the DHS groundwater use restriction requiring water purveyors to shut down water supply wells when CoPCs are detected at certain concentrations, and Aerojet serving as a regular referral entity for any new wells that may be proposed to be drilled in the Study Area.

Alternative 3A assumes that any public water supply well that might be impacted based upon FS modeling assumptions is retrofitted for wellhead treatment. This assumption likely overstates the number of wells requiring retrofit, because water purveyors can manage their systems to reduce reliance on any particular well and the decision to retrofit will be based upon water supply needs and containment needs. Public water supply wells act as a hydraulic barrier that modeling suggests can result in containment of the offsite plume.

5.2.4.1 Overall Protection of Human Health and Environment

Existing institutional controls (DHS permitting of public water purveyors and the proposed County Consultation Zone provision to the Sacramento County well ordinance) should provide adequate protection to prevent exposure due to CoPCs in groundwater. Wellhead treatment and the additional monitoring that will be required to evaluate the performance of the wellhead treatment processes will provide an additional level of

protection to prevent potential exposure. Therefore, Alternative 3A is protective of human health and the environment.

Alternative 3A also minimizes migration of CoPCs from the Aerojet facility boundary through the existing GETs E and F control systems, and would provide offsite containment through the use of existing water supply wells. Groundwater modeling suggests that, depending upon the number and location of wells retrofitted with wellhead treatment, the offsite containment of the CoPC plume may be substantial. Alternative 3A could eventually result in restoration of the currently contaminated portion of the offsite regional aquifer. However, given the complexity of the hydrogeology and the fate and effect of the CoPCs in the aquifer, it is uncertain how much restoration will occur and over what period.

5.2.4.2 Compliance with ARARs

All ARARs that pertain to the protection of groundwater resources and the cleanup of releases will be met by Alternative 3A. At the Aerojet facility, contaminated groundwater captured in the GET E/F extraction wells will be treated prior to management/reuse to concentrations that meet standards based on risk-based levels and chemical-specific ARARs where applicable or relevant and appropriate. Beyond the Aerojet facility boundary, contaminated groundwater drawn from existing water supply wells will be treated at those wells before domestic use to meet MCLs, other applicable standards or TBCs such as DHS PALs, and risk-based levels. Over the long term, this alternative will provide a permanent solution by removing CoPCs from groundwater, both at the Aerojet facility and offsite, to concentrations below risk-based criteria and chemical-specific ARARs, and therefore protect the existing beneficial uses of groundwater in the downgradient areas and prevent degradation of the downgradient water quality to the maximum extent feasible.

Water treated at the GET E/F facilities is currently recharged to the groundwater system. Under this alternative, recharge of treated water would continue. The GET E/F facilities are currently operated in accordance with the discharge requirements and effluent limitations set forth in the Partial Consent Decree (PCD). Alternative 3A includes continued characterization and proper management of waste or residual materials produced by operation of the treatment plant, including compliance with the RCRA requirements for identification and characterization of wastes and generator standards.

State Water Board Resolution 68-16 ("Antidegradation Policy") requires that discharges not reduce the quality of surface water or groundwater. Treatment and recharge of treated water under Alternative 3A would be conducted in a manner so as to protect the current beneficial uses of downgradient groundwater and to the extent practical, to avoid an impact to downgradient water. Groundwater containing CoPCs at levels greater than PRAGs will be collected and treated to levels commensurate with how the treated water will be managed/reused (e.g., drinking water standards if the water is to be directly reused). Achievement of these treatment levels will result in compliance with the

substantive requirements of State Water Board Resolution 68-16 and also with State Water Board Resolution 92-49 that requires treatment to WQOs. Design of the use of water supply wells retrofitted with wellhead treatment as a hydraulic containment system will also consider the substantive requirements of the containment zone provisions of Resolution 92-49.

The GET E/F facilities will be improved and operated in a manner designed to comply with all location- and action-specific ARARs. The same will apply to the wellhead treatment retrofitting on offsite water supply wells.

5.2.4.3 Long-Term Effectiveness and Permanence

Alternative 3A provides effective long-term control of onsite and offsite CoPC plumes through extraction and treatment of groundwater using proven or innovative technologies. Over the long term, this alternative will provide a permanent solution by removing CoPCs from groundwater to below risk-based criteria and chemical-specific ARARs.

Residual risk will remain in certain portions of onsite and offsite groundwater until all of the groundwater containing CoPCs has been removed by the extraction wells or water supply wells and has been replaced by natural and/or artificial recharge of uncontaminated water. This risk will be managed through the proposed Consultation Zone provision to the existing comprehensive Sacramento County well drilling ordinance, the DHS groundwater use restriction requiring water purveyors to shut down water supply wells when CoPCs are detected at certain concentrations, and Aerojet serving as a regular referral entity for any new wells that may be proposed to be drilled in the Study Area.

The monitor wells, monitoring equipment, extraction wells and pumps, conveyance piping and transfer pumping, treatment processes for NDMA and VOCs (if any) and associated instrumentation and control systems are common, well established remedy components that have been implemented at the Aerojet Sacramento Site and numerous other sites. The likelihood is high that containment and treatment performance specifications will be met. Equipment and spare parts are readily available. O&M functions should be routine. The only uncertainty that exists with respect to long-term treatment equipment performance and treatment residuals is associated with the ion exchange process.

Perchlorate treatment onsite is assumed to be through biological treatment, which is currently operating at GET F on the Aerojet facility. Perchlorate treatment offsite for this remedy is currently assumed to be ion exchange. The long-term effectiveness of ion exchange, including the regeneration of resins, is currently under evaluation.

5.2.4.4 Reduction of Toxicity, Mobility and Volume through Treatment

For Alternative 3A, the onsite containment system has been discussed under Alternative 2A and is not repeated.

Under Alternative 3A, the offsite portion of the CoPC plume that reaches public water supply wells can be captured by the existing offsite water supply wells in the Study Area. Wellhead treatment can be provided at affected water supply wells, reducing the toxicity, mobility, and volume of the CoPCs. If present in a water supply well, VOCs, perchlorate, and NDMA would be destroyed via the UV/oxidation (VOCs and NDMA), ion exchange (perchlorate), and LPGAC (if only VOCs are present or for VOC polishing) processes, which are irreversible. Use of these treatment processes would satisfy the statutory preference for treatment as a principal element of the remedial action.

Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-4 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-4, modeling indicates that approximately 63 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 63 percent captured, the majority (approximately 59 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 65 percent of the area in Layer E would be captured, this area represents only 9 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	61	59
D (30% of total particles)	68	32
E (9% of total particles)	65	9
Total-all layers	63	100

5.2.4.5 Short-Term Effectiveness

Protection of Community and Workers. The short-term impact on the risks to the community and workers would be minimal during construction of the additional onsite extraction wells and treatment capacity associated with the GETs E/F boundary containment system. Likewise, for this Alternative 3A, during construction of any

wellhead treatment facilities at existing water supply wells that may become effected, the short-term impact on the risks to the community and workers would be minimal. Workers would be adequately protected during construction by adhering to OSHA practices. Workers would also be protected while operating and maintaining facilities by adhering to appropriate health and safety procedures.

Environmental Impacts. There are no adverse environmental impacts associated with this alternative, other than the continued migration of CoPCs until they are extracted by a water supply well.

Time until Response Objectives are Achieved. Human health risk due to exposure to contaminated groundwater has been eliminated and would be managed in the future through monitoring and response at public water supply wells through wellhead treatment. Minimizing further offsite migration of CoPCs from source area groundwater to downgradient areas to the west (source control) is already being achieved by the existing GETs E/F boundary containment/source control system. Further migration of the offsite CoPC plume could be achieved immediately after construction of wellhead treatment facilities is complete.

With respect to the time required to reduce CoPC concentrations in already contaminated groundwater, particle tracking was used in the groundwater flow model to estimate the time required to remove one pore volume of the offsite CoPC plumes as described in Appendix D. It is not possible to accurately predict the time required to reduce CoPC concentrations due to aquifer heterogeneity and fate and transport effects. However, a model simulation of the removal of one pore volume by water supply wells was agreed upon by the Agencies for purposes of comparison among alternatives. For Alternative 3A, the model-predicted time projections are shown on Figure 5-4 and discussed previously in Section 5.2.4.4.

The fourth RAO involves protecting public drinking water wells and providing treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels. During the period between approval of the OU RI/FS and the implementation of this remedial action, should it be selected, it is possible that CoPCs will be detected in additional public water supply wells at unacceptable levels. Public water purveyors would be expected to continue to monitor wells for CoPCs, either directly or by obtaining the results of Aerojet monitoring undertaken pursuant to Exhibit IV of the PCD. Exhibit IV currently requires Aerojet to evaluate the source of the contaminant and recommend replacement water alternatives necessary to protect public health, which process is subject to agency review and Court oversight. Such alternatives could include shutting down the well, providing alternative water supplies or providing point of use treatment, all as more fully discussed in Section 3 and Section 4 of the OU RI/FS. As part of this alternative, some mechanism for monitoring and evaluation of interim remedial measures necessary to protect public health would be appropriate, should the provisions of Exhibit IV no longer apply.

5.2.4.6 Implementability

Alternative 3A is implementable to the extent that the DHS approves wellhead treatment for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. DHS has accepted wellhead treatment at numerous locations throughout the State. If accepted, the well treatment equipment must be capable of fitting in the existing space available at impacted water supply wells, and the treatment processes must be capable of meeting treatment standards in a demonstrable and reliable manner.

Depending upon the well and the type of treatment required, there may be space and other physical impediments to construction and operation. It may be that replacement wells would be constructed in an acceptable location that would support wellhead treatment. Further, wellhead treatment might only be considered on larger pumping wells, thereby reducing the effectiveness of any containment barrier that would otherwise be created by Alternative 3A.

Monitoring of finished water quality would be necessary to insure protection of public health. Monitoring downgradient water supply wells that continue to be used would be necessary to identify potential future impacts and insure that contaminated water is not used for potable water supply without treatment to remove site-related constituents of concern. Monitoring and evaluation of the location of potential new wells would also be necessary to assess and insure the effectiveness of institutional controls on future use of contaminated groundwater. Such monitoring would take the form of implementation of the proposed Consultation Zone provision to the Sacramento County comprehensive well ordinance that would require a consultation zone be established for applications for a well permit in areas within 2,000 feet of a known contaminant plume. Should the institutional control fail to identify or restrict drilling of a new public water supply well in a contaminated area, it is anticipated that initial sampling of water supplied by a new well would identify the presence of CoPCs resulting in the hypothetical new well not being used for potable supply.

The primary issue associated with coordination with other agencies under Alternative 3A is the need to obtain approval from State agencies, water purveyors and the public for use of wellhead treatment. Coordination with local land planning and land use agencies will be necessary to implement controls on and monitoring of construction of possible new water supply wells in or downgradient of the existing plume.

As Alternative 3A does include active treatment of contaminated water, treatment, storage or disposal facilities will be necessary. Technologies necessary to treat the site related constituents (e.g., ion exchange for perchlorate removal and UV/oxidation for NDMA destruction) are not routinely used in the water supply industry. There are only a limited number of vendors who currently provide the equipment to specifically remove the CoPCs using the technologies proposed for wellhead treatment. While ion exchange is used extensively for industrial wastewater treatment and in many instances for removal

of nitrate from drinking water, and UV disinfection is employed routinely for municipal wastewater treatment, these technologies are less commonly employed in the water supply industry. Consequently, additional development and demonstration may be necessary to support the use of the proposed technologies for the specific application of wellhead treatment proposed for Alternative 3A.

Another administrative feasibility issue is that there are no MCLs for perchlorate and NDMA, the two primary CoPCs in the Study Area. EPA has not finalized the Rfd for perchlorate. EPA will release another preliminary Rfd for perchlorate in Fall 2000, host an external peer review, and then issue a final Rfd. It is not currently known how long this process will take. In addition, the DHS has issued a temporary action level for NDMA, primarily due to the uncertainties associated with the analytical detection limits for NDMA. It is not known if or when a permanent action level will be established for NDMA.

5.2.4.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 3A are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$64,000,000
Estimated annual O&M costs:	$3,500,000-5,300,000
Estimated 25-year present worth costs:	$93,000,000

5.2.5 Alternative 3B: GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Alternative 3B differs from Alternative 3A in that GETs E and F no longer recharge water through recharge wells. The specific differences between Alternatives 3A and 3B with respect to the onsite GETs E and F systems were discussed previously in Section 5.2.3 for Alternative 2B. A map showing both onsite and offsite capture zones is included as Figure 5-5. Figure 5-6 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 3B.

5.2.5.1 Overall Protection of Human Health and Environment

Alternative 3B is equally protective as Alternative 3A.

5.2.5.2 Compliance with ARARs

Alternative 3B provides the same level of compliance with ARARs as Alternative 3A.

5.2.5.3 Long-Term Effectiveness and Permanence

As with Alternative 3A, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system. There are some model-projected changes that arise from replacing recharge with extraction wells. First, the extraction wells are currently projected to be placed downgradient of the GETs E/F recharge field and are likely to contain CoPCs in Layer E and substantial portions in Layers C and D of CoPCs that would otherwise migrate off the Aerojet site. Accordingly, there would likely be more mass of chemicals extracted. By extracting, rather than recharging, the hydraulic gradient will decrease locally, thus potentially reducing the offsite movement. Model projections suggest fewer public water supply wells should be impacted over the same period of time.

5.2.5.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 3B is the same as for Alternative 3A discussed in Section 5.2.4.4. The only exception is that for Alternative 3B, treated groundwater from the onsite GETs E/F boundary containment/source control system would not be recharged via the GET E/F recharge field. By extracting groundwater to implement hydraulic control onsite, instead of continued use of recharge wells, Alternative 3B provides greater reduction of mass of CoPCs in groundwater and potentially reduces the mobility and volume of a portion of the offsite plume.

Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-6 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-6, modeling indicates that approximately 60 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 60 percent captured, the majority (approximately 53 percent) of the total CoPCs captured would be from Layer C. Conversely, although the

modeling indicates that 91 percent of the area in Layer E would be captured, this area represents only 14 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	52	53
D (30% of total particles)	69	34
E (9% of total particles)	91	14
Total-all layers	60	100

5.2.5.5 Short-Term Effectiveness

Same as Alternative 3A.

5.2.5.6 Implementability

Same as Alternative 3A.

5.2.5.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 3B are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$77,000,000
Estimated annual O&M costs:	$4,000,000-6,000,000
Estimated 25-year present worth costs:	$115,000,000

5.2.6 Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Alternative 4A involves the continued operation of the GETs E and F systems, in which recharge wells would continue to be used. It also includes monitoring and institutional controls. In addition, Alternative 4A would establish an offsite hydraulic barrier, intended to contain the offsite plume and prevent further migration of CoPCs downgradient of the barrier. A capture zone map for Alternative 4A showing both onsite and offsite capture zones is included as Figure 5-7. Figure 5-8 presents the percent of plume areas captured over time in layers C, D, and E for Alternative 4A.

5.2.6.1 Overall Protection of Human Health and Environment

Protection of human health and the environment would be afforded under Alternative 4A by minimizing offsite migration of CoPCs through the continued operation of the GETs E and F hydraulic containment system. As more fully discussed in Alternative 4B, offsite groundwater containment would be initiated in Layers C and D from the outset. Some CoPCs will migrate through portions of Layers C and D that do not contain CoPCs until they reach the offsite hydraulic barrier. This will occur within individual layers, and for Alternative 4A, will occur in portions of Layers D and E.

Alternative 4A would eventually result in substantial restoration of the currently contaminated portion of the offsite regional aquifer. However, given the complexity of the hydrogeology and the fate of the CoPCs in the aquifer, the extent and overall timing of the eventual restoration of the aquifer is uncertain.

Alternative 4A also relies on monitoring of public water supply wells to ensure that the public is not exposed to CoPCs potentially present above drinking water standards, advisories, or risk-based levels. For areas downgradient of the onsite containment system but upgradient of the offsite containment system where the groundwater has been contaminated, institutional controls would also protect human health until the natural flushing of the aquifer and the result of operating the onsite and offsite containment systems reduces concentrations of CoPCs in these areas. Existing institutional controls (DHS oversight of public water supply systems) should provide adequate protection of public water supplies by establishing MCLs or PALs for CoPCs. Existing public water supplies would be monitored as described in accordance with the procedures outlined in Section 3.3.2.4 to prevent exposure above MCLs or PALs. Although it is considered unlikely that a private party would drill a new water supply well in the Study Area, the proposed Consultation Zone provision to Sacramento County's existing comprehensive well drilling ordinance should provide some level of protection against a party installing a water supply well in contaminated portions of the aquifer. Also, it is recommended that the public be informed of the groundwater contamination and its unsuitability for consumption through EPA's public participation process and periodic fact sheets issued to the community. In addition, Aerojet will request status from the County to be a regular referral entity for any new wells that may be proposed to be drilled in the Study Area. Aerojet will advise the County, and well permit applicant, of any proposed locations that may be located above or near the CoPC plumes.

There are no currently completed exposure pathways for ecological receptors in the Study Area. Potential future impacts to surface water or the aquifer from treated groundwater will be managed by the NPDES permitting process and treatment facility effluent requirements, respectively. As the active remediation measures included in the offsite areas under Alternative 4A are based on standard, accepted treatment practices, this alternative does not pose any unacceptable short-term risks or other adverse impacts.

5.2.6.2 Compliance with ARARs

All ARARs that pertain to the protection of groundwater resources and the cleanup of releases will be met by Alternative 4A. Specifically, water supplied by public or private water purveyors would either be derived from unimpacted surface water or groundwater sources or would be treated to remove or reduce the levels of CoPCs to meet MCLs, other applicable standards or TBCs such as DHS PALs, and risk-based levels. Implementation of the downgradient hydraulic barrier would prevent or greatly reduce further downgradient migration of CoPCs and therefore protect the existing beneficial uses of groundwater in the downgradient areas and prevent degradation of the downgradient water quality to the maximum extent feasible.

At the Aerojet facility, contaminated groundwater captured in the GET E/F extraction wells will be treated prior to management/reuse to concentrations that meet cleanup standards based on risk-based levels and chemical-specific ARARs (e.g., MCLs, PALs if the treated water is to be directly reused) where applicable or relevant and appropriate. Beyond the Aerojet facility boundary, contaminated groundwater drawn from the offsite extraction wells will be conveyed to the onsite GET F groundwater treatment facility and treated prior to management/reuse to meet the same cleanup standards. Over the long term, this alternative will provide a permanent solution by removing CoPCs from groundwater, both at the Aerojet facility and offsite, to concentrations below risk-based criteria and chemical-specific ARARs.

Water treated at the GET E/F facilities is currently recharged to the groundwater system. Under this alternative, recharge of treated water would continue. The GET E/F facilities are currently operated in accordance with the discharge requirements and effluent limitations set forth in the Partial Consent Decree (PCD). Alternative 4A includes continued characterization and proper management of waste or residual materials produced by operation of the treatment plant, including compliance with the RCRA requirements for identification and characterization of wastes and generator standards.

State Water Board Resolution 68-16 ("Antidegradation Policy") requires that discharges not reduce the quality of surface water or groundwater. Treatment and recharge of treated water under Alternative 4A would be conducted in a manner so as to protect the current beneficial uses of downgradient groundwater and to the extent practical, to avoid an impact to downgradient water. Groundwater containing CoPCs at levels greater than PRAGs will be collected and treated to levels commensurate with how the treated water will be managed/reused (e.g., drinking water standards if the water is to be directly reused). Achievement of these treatment levels will result in compliance with the substantive requirements of State Water Board Resolution 68-16 and also with State Water Board Resolution 92-49 that requires treatment to WQOs. Design of the hydraulic containment system will also consider the substantive requirements of the containment zone provisions of Resolution 92-49.

5.2.6.3 Long-Term Effectiveness and Permanence

Alternative 4A provides effective long-term control onsite and offsite of the CoPC plumes through extraction and treatment of groundwater using proven or innovative technologies. The modeled hydraulic capture in layers C, D, and E is shown on Figure 5-8. To the extent feasible, the hydraulic barrier would be designed to contain CoPCs with concentrations exceeding PRAGs. However, due to technical uncertainties, it is likely that some CoPCs will not be contained by the hydraulic barrier. For any CoPCs detected downgradient of the hydraulic barrier, residual risk would be managed by monitoring of water supply and performance monitor wells and implementation of a response action in the event CoPCs are detected and exceed trigger levels.

In addition, it is likely that residual CoPC concentrations will remain in portions of the aquifer for many years. This risk would be managed through monitoring, Aerojet's status as a regular referral entity for the County for any new wells that are proposed to be drilled in the Study Area, the proposed Consultation Zone provisions of the Sacramento County Well Drilling ordinance, and the DHS requirement that water supply wells be shut down if certain concentrations of CoPCs are detected.

With respect to adequacy and reliability of controls, all of the technologies and associated equipment and monitoring facilities proposed for this alternative are proven and reliable. The monitor wells, monitoring equipment, extraction wells and pumps, conveyance piping, transfer pumping, treatment processes for removal of the CoPCs, treated water management facilities, and associated instrumentation and control systems are common, well established, remedy components that have been implemented at the Aerojet Sacramento Site and elsewhere.

Perchlorate treatment onsite is assumed to be through biological treatment, which is currently operating on the Aerojet facility. There are no uncertainties associated with addressing any treatment residuals generated from this remedial technology. The likelihood is high that treatment performance specifications will be met. Equipment and spare parts are readily available. O&M functions should be routine. However, because of the complexity of the hydrogeology and the fate of the CoPCs in the aquifer, the effectiveness of hydraulic containment cannot be assured.

Current and proposed institutional controls (i.e., the proposed well drilling ordinance Consultation Zone, restrictions on operations of potable water suppliers, and Aerojet being a regular referral entity for any new wells that may be proposed to be drilled in the Study Area) are based on programs currently or anticipated to be implemented and managed by Sacramento County and DHS. As these programs are current and are forseen to continue to be operated by government agencies, the long-term permanence of such measures is considered to be high.

5.2.6.4 Reduction of Toxicity, Mobility and Volume through Treatment

The toxicity of perchlorate, NDMA, and nitrate will be irreversibly reduced or eliminated by the treatment process options currently considered for these CoPCs (i.e., biological reduction, UV-oxidation). Use of these treatment processes would satisfy the statutory preference for treatment as a principal element of the remedial action. Residuals remaining after treatment would include the minor volume of non-hazardous organic sludge that would be generated by the biological reduction process. This sludge would be disposed to a sanitary sewer or dewatered and disposed in a non-hazardous landfill. The majority of VOCs will be destroyed through the UV/oxidation process; air stripping will serve as the polishing treatment process for VOCs. The mobility of CoPCs present in groundwater will not be affected by any of the treatment process options considered in this OU RI/FS.

Under Alternative 4A, the CoPCs downgradient of the GETs E/F system are intended to be contained by the offsite hydraulic barrier. Extraction of groundwater containing CoPCs will reduce the overall volume of CoPCs in the onsite and offsite groundwater. It is not possible to accurately predict the time required to reduce CoPC concentrations due to aquifer heterogeneity and fate and transport effects. Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-8 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-8, modeling indicates that approximately 76 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 76 percent captured, the majority (approximately 70 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 21 percent of the area in Layer E would be captured, this area represents only 2 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	87	70
D (30% of total particles)	72	28
E (9% of total particles)	21	2
Total-all layers	76	100

5.2.6.5 Short-Term Effectiveness

Protection of Community and Workers. During construction of the offsite hydraulic barrier it is anticipated that there will be short-term impacts to the community. These impacts could include temporary road/lane closures, traffic detours, noise associated with drilling and pipe laying equipment, and dust. These impacts would be minimized through the implementation of various abatement plans (e.g., traffic controls plans). The short-term impact on the risks to the community and workers would be minimal during construction of the additional onsite extraction wells and treatment capacity associated with the GETs E/F boundary containment system.

Workers should be adequately protected during construction by adhering to OSHA practices. Workers should also be protected while operating and maintaining facilities by adhering to appropriate health and safety procedures.

Possible impacts to existing water supply wells from water table drawdown resulting from operation of the onsite extraction and recharge wells and the offsite extraction wells proposed for Alternative 4A were also evaluated. The modeled maximum drawdowns generated by offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-4). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns in the vicinity of Zinfandel Drive and US Highway 50 are 17, 20, 20, and 15 feet, respectively, for layers AB, C, D, and E.

Environmental Impacts. There are no adverse environmental impacts anticipated to be associated with this alternative other than the temporary traffic disruptions and noise during the offsite hydraulic barrier construction. Depending on where extraction wells are proposed to be located and the groundwater conveyance piping routing, environmental permitting may be required.

Time until Response Objectives are Achieved. Human health risk due to consumption of groundwater has been eliminated and would be managed in the future through monitoring and provision of replacement water. Minimizing further offsite migration of CoPCs from source area groundwater to downgradient areas to the west (source control) is already being achieved by the existing GETs E/F boundary containment/source control system. Minimizing further migration of the offsite contaminant plume will be achieved immediately after construction of offsite extraction wells. However, given the complexity of the hydrogeology and the fate and effect of the CoPCs in the aquifer, it is uncertain how much restoration will occur and over what period.

With respect to the time required to reduce CoPC concentrations in already contaminated groundwater, particle tracking was used in the groundwater flow model to estimate the time required to remove one pore volume of the offsite CoPC plumes as described in Appendix D. It is not possible to accurately predict the time required to reduce CoPC concentrations due to aquifer heterogeneity and fate and transport effects. However, a model simulation of the removal of one pore volume by water supply wells was agreed

upon by the Agencies for purposes of comparison among alternatives. For Alternative 4A, the model-predicted time projections are shown on Figure 5-8 and discussed previously in Section 5.2.6.4.

During the period between approval of the OU RI/FS and the implementation of this remedial action, should it be selected, it is possible that CoPCs will be detected in additional public water supply wells at unacceptable levels. Public water purveyors would be expected to continue to monitor their wells for CoPCs, either directly or by obtaining the results of Aerojet monitoring undertaken pursuant to Exhibit IV of the PCD. Exhibit IV currently requires Aerojet to evaluate the source of the contaminant and recommend alternatives necessary to protect public health, which process is subject to agency review and Court oversight. Such alternatives could include shutting down the well, providing alternative water supplies or providing point of use treatment, all as more fully discussed in Section 3 and Section 4 of this OU RI/FS. As part of this alternative, some mechanism for monitoring and evaluation of interim remedial measures necessary to protect public health would be appropriate, should the provisions of Exhibit IV no longer apply.

5.2.6.6 Implementability

The primary technical implementability issues associated with Alternative 4A will be determining the hydraulic capture of the individual extraction wells and installing significant infrastructure in the offsite areas. The complex hydrogeology of the Study Area will be partially managed by phasing of well construction and pump testing to allow more detailed understanding of aquifer characteristics and chemical distribution. In addition, the performance monitoring wells recommended for this alternative should provide the data necessary to adequately assess hydraulic capture.

There are significant technical and administrative difficulties associated with the construction of the infrastructure associated with the offsite hydraulic barrier, including siting and construction of wells and pipelines. The construction would occur in already developed areas. This will involve securing the necessary easements and/or obtaining title to land required to place the extraction wells and route conveyance piping from the extraction wells to the onsite treatment facility. It will be desirable to locate extraction wells in areas where access can be maintained for future servicing/rehabilitation (i.e., not in a street or sidewalk). Piping will have to be routed through existing streets and inside existing utility easements or rights-of-way. Bridge crossings; tunneling under highways, railroads, the Folsom South Canal, and major roads; utility relocation; extensive traffic control; and night construction will probably be required during construction of the conveyance piping associated with Alternative 4A. A piping alignment engineering study will be required and depending on the proposed piping alignment, environmental permits and/or mitigation may be necessary. Potential delays in the start of implementation of this remedial alternative could result from these issues. Local agency approvals may trigger CEQA evaluation, which can significantly delay project implementation.

There may be technical and administrative implementability difficulties constructing all or portions of the offsite hydraulic barrier at or downgradient of the leading edges of the CoPC plumes. Aquifer and CoPC distribution heterogeneities may result in the discovery of CoPCs beyond the design of the hydraulic barrier. Similarly, there may be access restrictions or legal impediments that preclude the construction of wells or pipelines at the desired locations. In recognition of this fact, CoPCs that are detected downgradient of the offsite hydraulic barrier will be monitored. If the monitoring indicates that public water supply wells may become impacted by CoPC concentrations exceeding PRAGs, additional remedial actions may be warranted. These actions could consist of wellhead treatment, alternate water, or new extraction wells. If monitoring indicates that CoPC concentrations will not impact public water supply wells above PRAGs, the CoPCs will be permitted to disperse through natural attenuation.

Ongoing operation and maintenance requirements in offsite areas would involve coordination with local agencies. Among others, there may be need for traffic control and management of waters used for well rehabilitation.

Additional administrative feasibility issues would be associated with management and/or reuse of treated groundwater associated with Alternative 4A. These issues vary depending on the process option or combination of process options that would be implemented for management and/or reuse of treated groundwater under this alternative. For purposes of costing, groundwater is assumed to be treated on the Aerojet site and then piped to a location where it can either be directly reused in a public water supply system or discharged to surface water for streamflow augmentation. Each process option for management of the treated groundwater raises administrative implementability issues. Therefore, administrative feasibility issues will include short- and long-term coordination with local, State and federal agencies; coordination with local developers and water purveyors; and various probable permitting requirements.

Perchlorate and NDMA treatment processes are undergoing extensive evaluation by Aerojet and regulatory agencies, including DHS (USEPA Region 9, 1999). The technologies for the treatment of perchlorate and NDMA are innovative and will continue to be evaluated. It is assumed that these technologies would be used in this alternative. Currently, there is only one manufacturer for the UV/oxidation equipment that is used for NDMA removal.

Another administrative feasibility issue is that there are no MCLs for perchlorate and NDMA, the two primary CoPCs in the Study Area. EPA has not finalized the Rfd for perchlorate. EPA will release another preliminary Rfd for perchlorate in Fall 2000, host an external peer review, and then issue a final Rfd. It is not currently known how long this process will take. In addition, the DHS has issued a temporary action level for NDMA, primarily due to the uncertainties associated with the analytical detection limits for NDMA. It is not known if or when a permanent action level will be established for NDMA.

5.2.6.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 4A are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$43,000,000
Estimated annual O&M costs:	$3,000,000-3,300,000
Estimated 25-year present worth costs:	$78,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 4A, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 4A in Section 4.2.6 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

5.2.7 Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Offsite, Alternative 4B includes containment of the offsite CoPC plumes using new extraction wells to provide hydraulic containment. Alternative 4B differs from Alternative 4A in that GETs E and F no longer recharge water through recharge wells. The specific differences between Alternatives 4A and 4B with respect to the onsite GETs E and F systems were discussed previously in Section 5.2.3 for Alternative 2B.
A capture zone map for Alternative 4B is included as Figure 5-9. Figure 5-10 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 4B.

5.2.7.1 Overall Protection of Human Health and Environment

Alternative 4B is equally as protective as Alternative 4A.

5.2.7.2 Compliance with ARARs

Alternative 4B provides the same level of compliance with ARARs as Alternative 4A.

5.2.7.3 Long-Term Effectiveness and Permanence

As with Alternative 4A, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system. There are some model-projected changes that arise from replacing recharge with extraction wells. First, the extraction wells are currently projected to be placed downgradient of the GETs E/F recharge field and are likely to contain CoPCs in Layer E and substantial portions in Layers C and D of CoPCs that would otherwise migrate off the Aerojet site. Accordingly, there would likely be more mass of chemicals extracted. By extracting, rather than recharging, the hydraulic gradient will decrease locally, thus potentially reducing the offsite movement. Model projections suggest fewer public water supply wells should be impacted over the same period of time.

5.2.7.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 4B is similar to that for Alternative 4A discussed in Section 5.2.6.4. The only exception is that for Alternative 4B, treated groundwater from the onsite GETs E/F boundary containment/source control system would not be recharged via the GET E/F recharge field. By extracting groundwater to implement hydraulic control onsite, instead of continued use of recharge wells, Alternative 4B provides greater reduction of mass of CoPCs in the E layer, and potentially reduces the mobility and volume of the offsite plume.

For Alternative 4B, CoPCs will be destroyed via the irreversible treatment processes discussed under Alternative 4A, and only minor amounts of treatment residuals will remain following treatment.

Under Alternative 4B, the CoPCs downgradient of the GETs E/F system are intended for capture by the offsite hydraulic barrier. Extraction of groundwater containing CoPCs will reduce the overall volume of CoPCs in the onsite and offsite groundwater. It is not possible to accurately predict the time required to reduce CoPC concentrations due to aquifer heterogeneity and fate and transport effects. Particle tracking was used in the

groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-10and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-10, modeling indicates that approximately 70 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 70 percent captured, the majority (approximately 63 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 52 percent of the area in Layer E would be captured, this area represents only 7 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	72	63
D (30% of total particles)	71	30
E (9% of total particles)	52	7
Total-all layers	70	100

5.2.7.5 Short-Term Effectiveness

Same as Alternative 4A, except the modeled maximum drawdowns generated by offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-5). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns offsite in the vicinity of Zinfandel Drive and Highway 50 are 26, 30, 27, and 25 feet, respectively for layers AB, C, D, and E.

5.2.7.6 Implementability

Same as Alternative 4A.

5.2.7.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 4B are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$38,000,000
Estimated annual O&M costs:	$3,300,000-3,400,000
Estimated 25-year present worth costs:	$77,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 4B, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 4B in Section 4.2.7 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

5.2.8 Alternative 4C - GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors

Onsite, Alternative 4C is the same as Alternative 4B. Similar to Alternative 4B, offsite Alternative 4C includes containment of the offsite CoPC plumes using new extraction wells to provide hydraulic containment. Alternative 4C differs from Alternative 4B in that it would also incorporate "multiple containment corridors" by including installation of new extraction wells closer to the leading edge of the CoPC plume in the D and E layers sooner than planned for the other alternatives. The specific differences between Alternatives 4C and 4B were discussed previously in Section 4.2.8 for Alternative 4C.

A capture zone map for Alternative 4C is included as Figure 5-11. Figure 5-12 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 4C.

5.2.8.1 Overall Protection of Human Health and Environment

Alternative 4C does not provide any additional protection beyond that provided by Alternatives 4A and 4B.

5.2.8.2 Compliance with ARARs

Alternative 4C provides the same level of compliance with ARARs as Alternatives 4A and 4B.

5.2.8.3 Long-Term Effectiveness and Permanence

As with Alternative 4B, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system.

5.2.8.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 4C is similar to that for Alternative 4B discussed in Section 5.2.7.4. The only exception is that Alternative 4C is projected to provide a greater reduction of mass of CoPCs in Layers D and E over the evaluation period and therefore potentially reduces the mobility and volume of the Layer C and D portions of the offsite plume sooner.

Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-12 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-12, modeling indicates that approximately 77 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 77 percent captured, the majority (approximately 61 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 79 percent of the area in Layer E would be captured, this area represents only 9 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	77	61
D (30% of total particles)	77	30
E (9% of total particles)	79	9
Total-all layers	77	100

For Alternative 4C, CoPCs will be destroyed via the irreversible treatment processes discussed under Alternative 4A, and only minor amounts of treatment residuals will remain following treatment.

5.2.8.5 Short-Term Effectiveness

Same as Alternative 4B, except the modeled maximum drawdowns generated by offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-6). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns offsite in the vicinity of Zinfandel Drive and Highway 50 are 31, 35, 33, and 30 feet, respectively for layers AB, C, D, and E.

5.2.8.6 Implementability

Same as Alternative 4B, except additional offsite extraction wells and associated piping in the multiple corridors will render Alternative 4C more difficult to implement than Alternative 4B from both the technical and administrative implementability perspectives.

5.2.8.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 4C are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$42,000,000
Estimated annual O&M costs:	$3,500,000-3,600,000
Estimated 25-year present worth costs:	$85,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 4C, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 4C in Section 4.2.8 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

5.2.9 Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Alternative 5A includes containment of the offsite CoPC plumes using a combination of new extraction and recharge wells to provide hydraulic containment. For costing purposes Alternative 5A extraction wells would be routed to a central groundwater treatment facility located southwest of the offsite extraction/recharge wells on Mather Field. Treated groundwater would be routed back to the recharge wells to maintain a hydraulic barrier in conjunction with the offsite extraction wells.

Onsite, Alternative 5A includes continued operation and improvements to the GET E and F onsite boundary containment/source control systems and recharge of treated GETs E and F groundwater. Alternative 5A also includes monitoring and the institutional controls discussed previously for the other alternatives.

A capture zone map for Alternative 5A is included as Figure 5-13. Figure 5-14 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 5A.

5.2.9.1 Overall Protection of Human Health and Environment

Alternative 5A is equally protective as Alternative 4A.

5.2.9.2 Compliance with ARARs

Alternative 5A provides the same level of compliance with ARARs as Alternative 4A.

5.2.9.3 Long-Term Effectiveness and Permanence

Same as Alternative 4A.

5.2.9.4 Reduction of Toxicity, Mobility and Volume through Treatment

Similar to Alternative 4A. Under Alternative 5A, the CoPCs downgradient of the GETs E/F system are intended for capture by the offsite hydraulic barrier. Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-14 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-14, modeling indicates that approximately 74 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 74 percent captured, the majority (approximately 67 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 27 percent of the area in Layer E would be captured, this area represents only 3 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	81	67
D (30% of total particles)	72	29
E (9% of total particles)	27	3
Total-all layers	74	100

5.2.9.5 Short-Term Effectiveness

Same as Alternative 4A, except the modeled maximum drawdowns generated by the offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-7). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns are 6, 10, 9 and 5 feet, respectively for layers AB, C, D, and E.

5.2.9.6 Implementability

All implementability issues associated with Alternative 4A are associated with Alternative 5A. In addition, using recharge wells as part of the hydraulic barrier requires installation of more wells and piping than extraction alone. Further, it is more difficult to construct and maintain a hydraulic barrier where recharge wells are used as part of the barrier, because maintaining gradients requires more sophisticated groundwater management to optimize system operation and control.

5.2.9.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 5A are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$41,000,000
Estimated O&M costs:	$3,300,000-3,900,000
Estimated 25-year present worth costs:	$78,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 5A, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 5A in Section 4.2.9 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

5.2.10 Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Alternative 5B includes containment of the offsite CoPC plumes using a combination of new extraction and recharge wells to provide hydraulic containment.

Onsite, Alternative 5B includes continued operation and improvements to the GETs E and F onsite boundary containment/source control systems. Treated groundwater from the GETs E and F boundary containment/source control systems will not be recharged onsite to groundwater. The treated groundwater from the GETs E and F systems will be discharged to surface water and/or reused for potable or non-potable purposes. Alternative 5B also includes monitoring and the institutional controls previously discussed for the other alternatives.

A capture zone map for Alternative 5B is included as Figure 5-15. Figure 5-16 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 5B.

5.2.10.1 Overall Protection of Human Health and Environment

Alternative 5B is equally protective as Alternative 4A.

5.2.10.2 Compliance with ARARs

Alternative 5B provides the same level of compliance with ARARs as Alternative 4A.

5.2.10.3 Long-Term Effectiveness and Permanence

As with Alternative 5A, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system. There are some model-projected changes that arise from replacing recharge with extraction wells. First, the extraction wells are currently projected to be placed downgradient of the GETs E/F recharge field and are likely to contain CoPCs in Layer E and substantial portions in Layers C and D of CoPCs that would otherwise migrate off the Aerojet site. Accordingly, there would likely be more mass of chemicals extracted. By extracting, rather than recharging, the hydraulic gradient will decrease locally, thus potentially reducing the offsite movement. Model projections suggest fewer public water supply wells should be impacted over the same period of time.

5.2.10.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 5B is similar to that for Alternative 5A discussed in Section 5.2.9.4. The only exception is that for Alternative 5B, treated groundwater from the onsite GETs E/F boundary containment/source control system would not be recharged via the GET E/F recharge field. By extracting groundwater to implement hydraulic control onsite, instead of continued use of recharge wells, Alternative 5B provides greater reduction of mass of CoPCs in the E layer, and potentially reduces the mobility and volume of a portion of offsite plume.

For Alternative 5B, CoPCs will be destroyed via the irreversible treatment processes discussed under Alternative 4A, and only minor amounts of treatment residuals will remain following treatment.

Under Alternative 5B, the CoPCs downgradient of the GETs E/F system are intended for capture by the offsite hydraulic barrier. Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-16 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-16, modeling indicates that approximately 68 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 68 percent captured, the majority (approximately 61 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 62 percent of the area in Layer E would be captured, this area represents only 8 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	68	61
D (30% of total particles)	72	31
E (9% of total particles)	62	8
Total-all layers	68	100

5.2.10.5 Short-Term Effectiveness

Same as Alternative 5A, except the modeled maximum drawdowns generated by offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-8). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns offsite in the vicinity of Zinfandel Drive and Highway 50 are 18, 22, 22, and 17 feet, respectively for layers AB, C, D, and E.

5.2.10.6 Implementability

Same as Alternative 5A.

5.2.10.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 5B are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$45,000,000
Estimated annual O&M costs:	$3,800,000-4,000,000
Estimated 25-year present worth costs:	$87,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 5B, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 5B in Section 4.2.10 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Alternative 3A Plume Removal

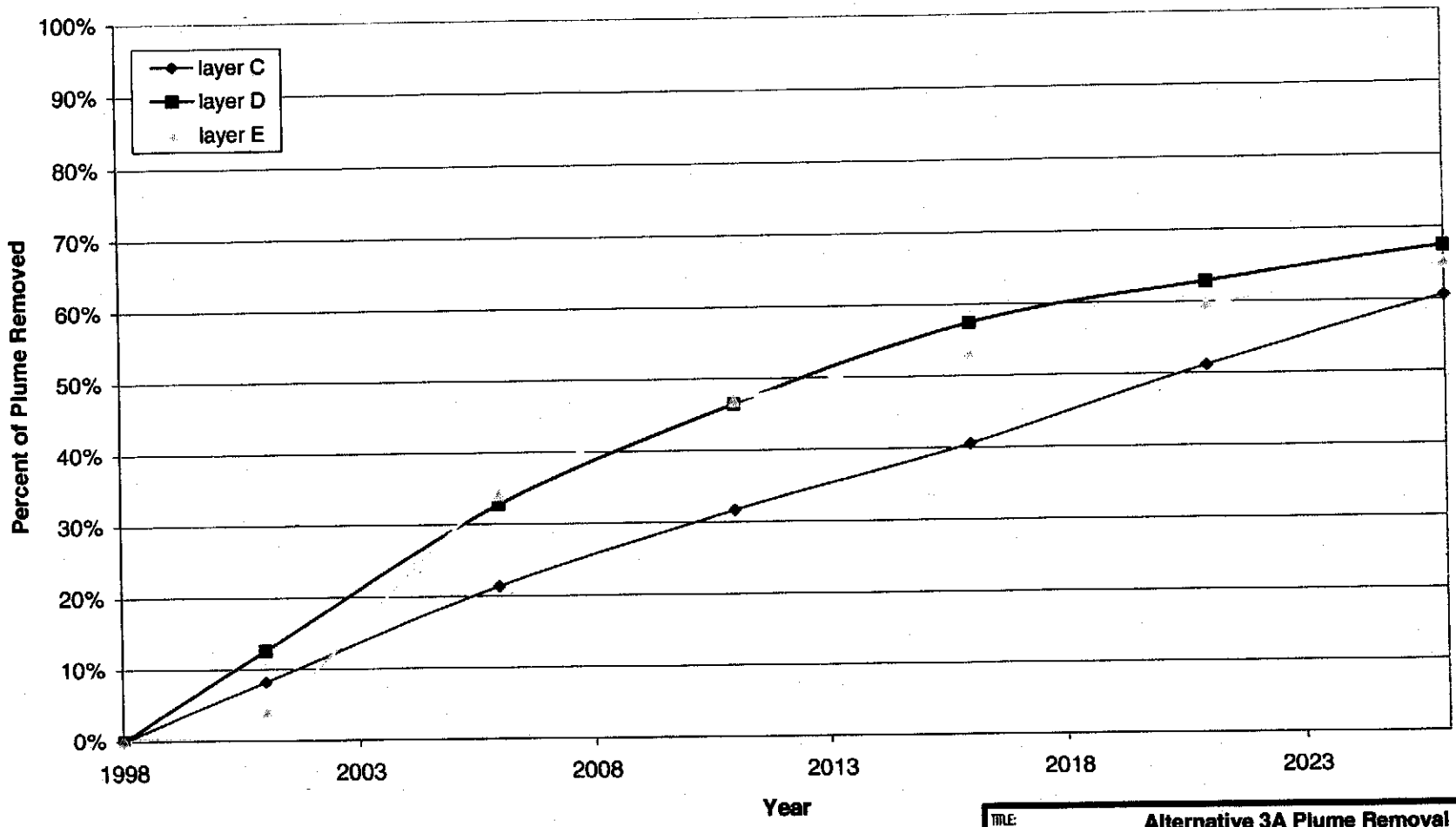

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FIGURE:	5.4

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Alternative 3B Plume Removal

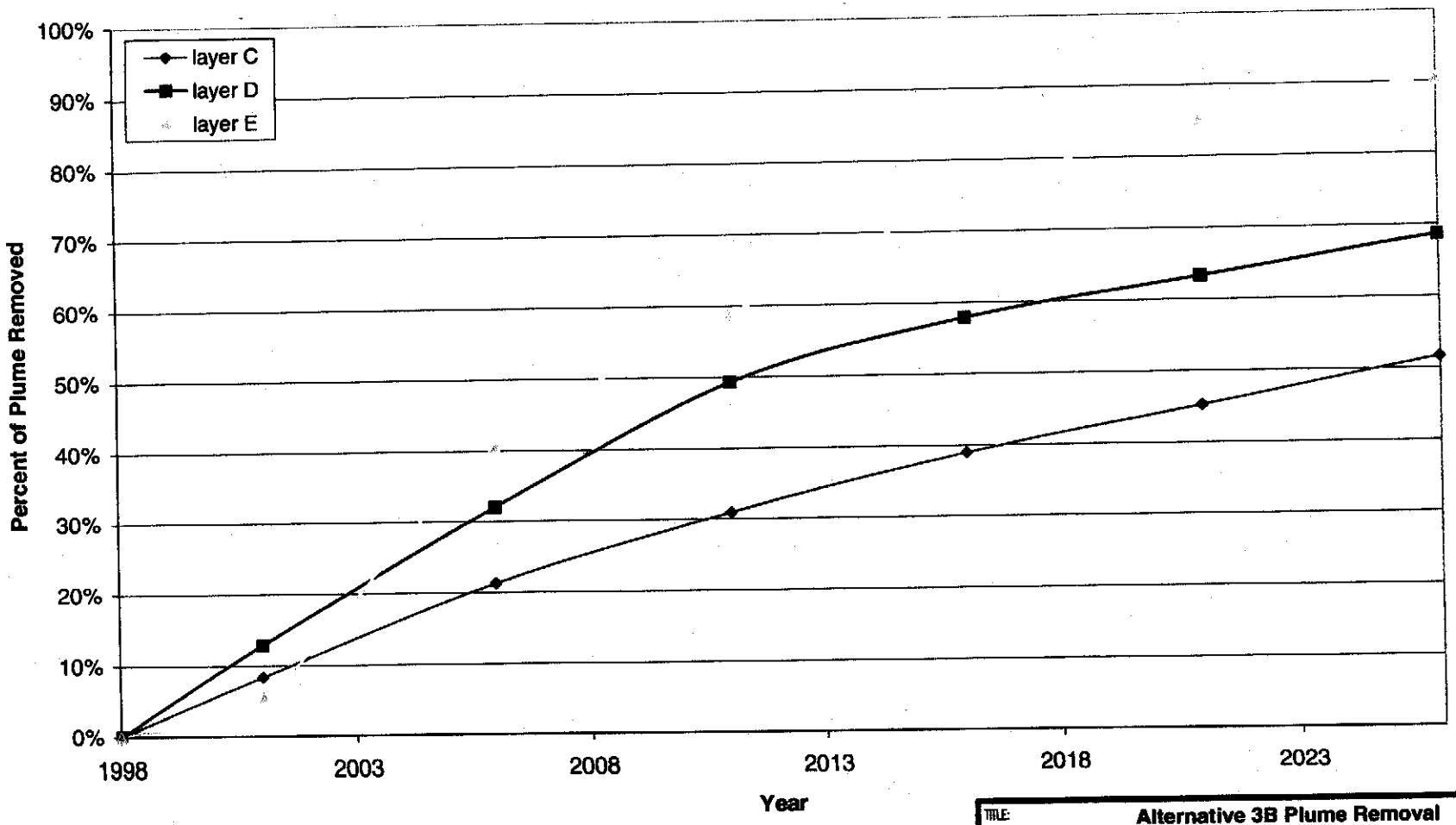

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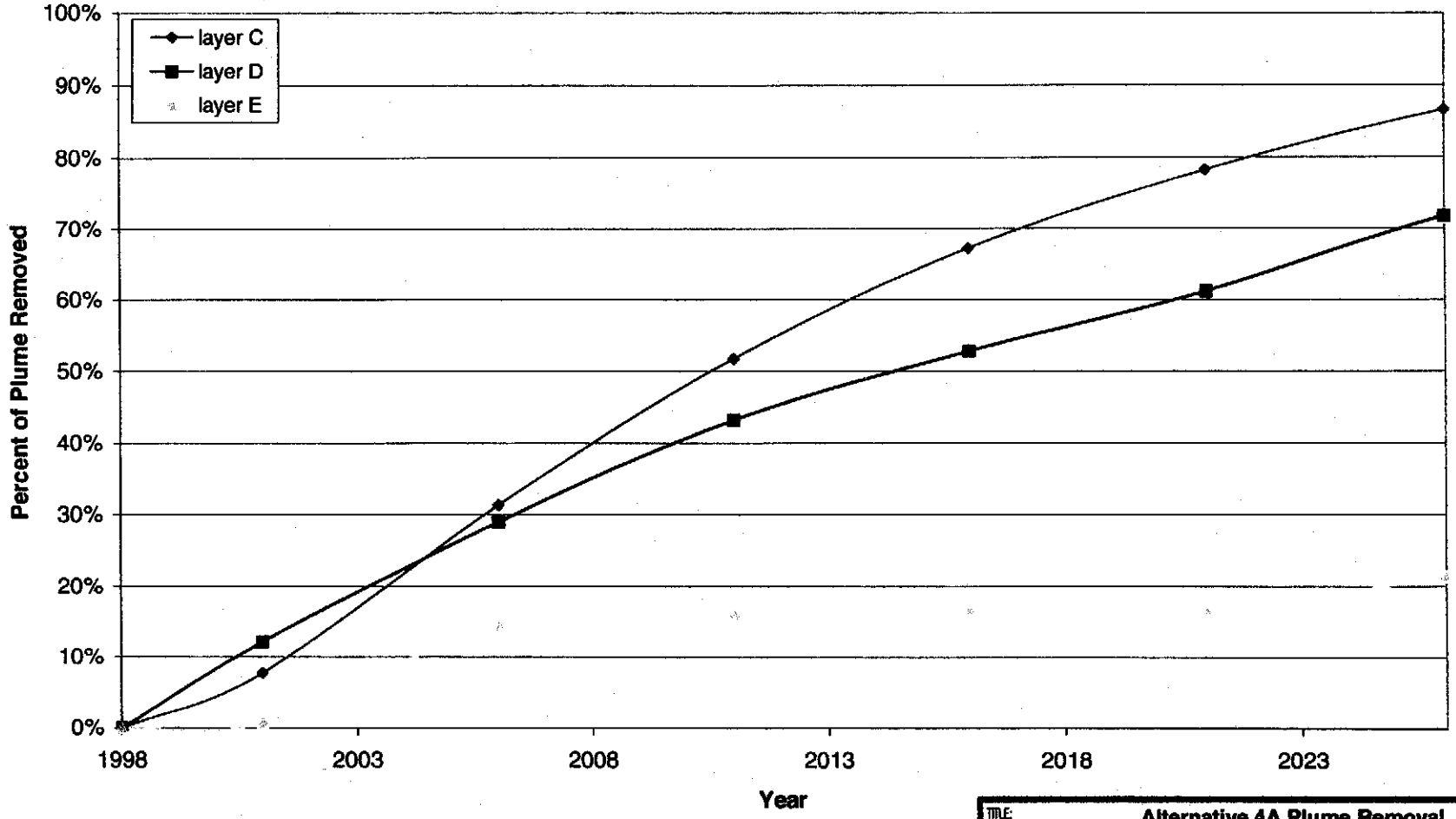
FIGURE: 5.6

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Alternative 4A Plume Removal



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HSI GEOTRANS

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FIGURE: 5.8

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Alternative 4B Plume Removal

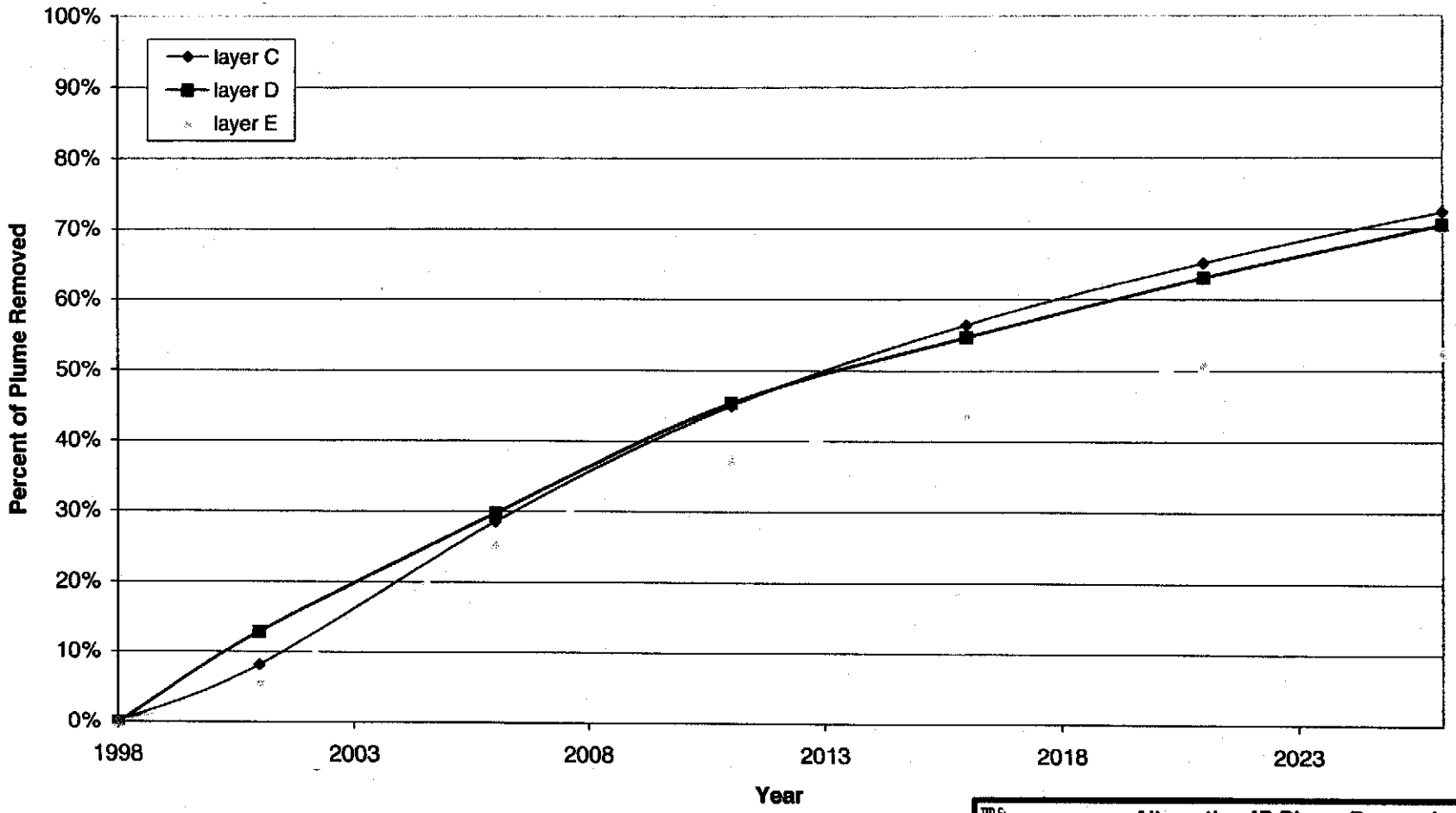

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FIGURE: 5.10

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Alternative 4C Plume Removal

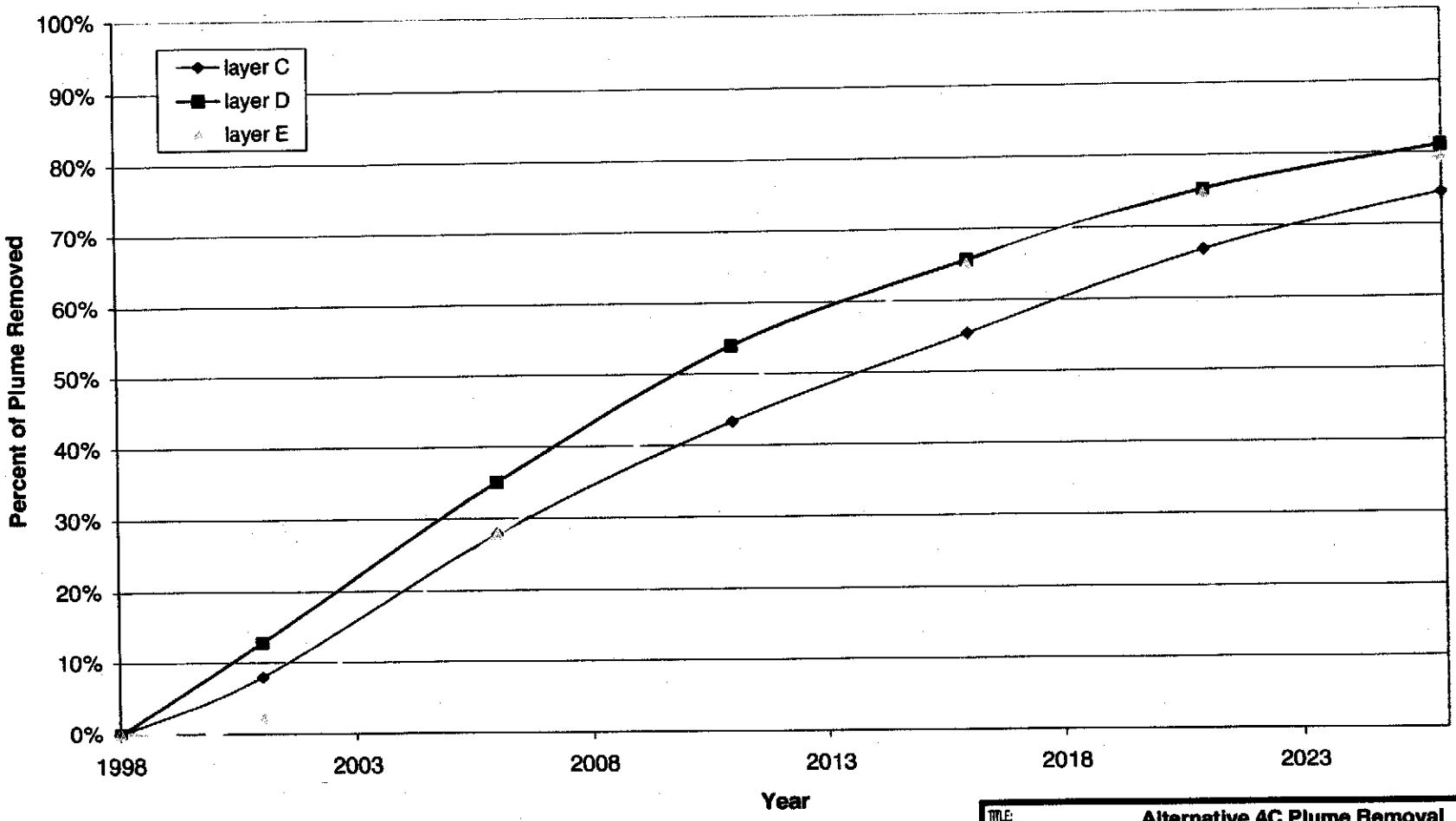

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FIGURE: 5.12

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Alternative 5A Plume Removal

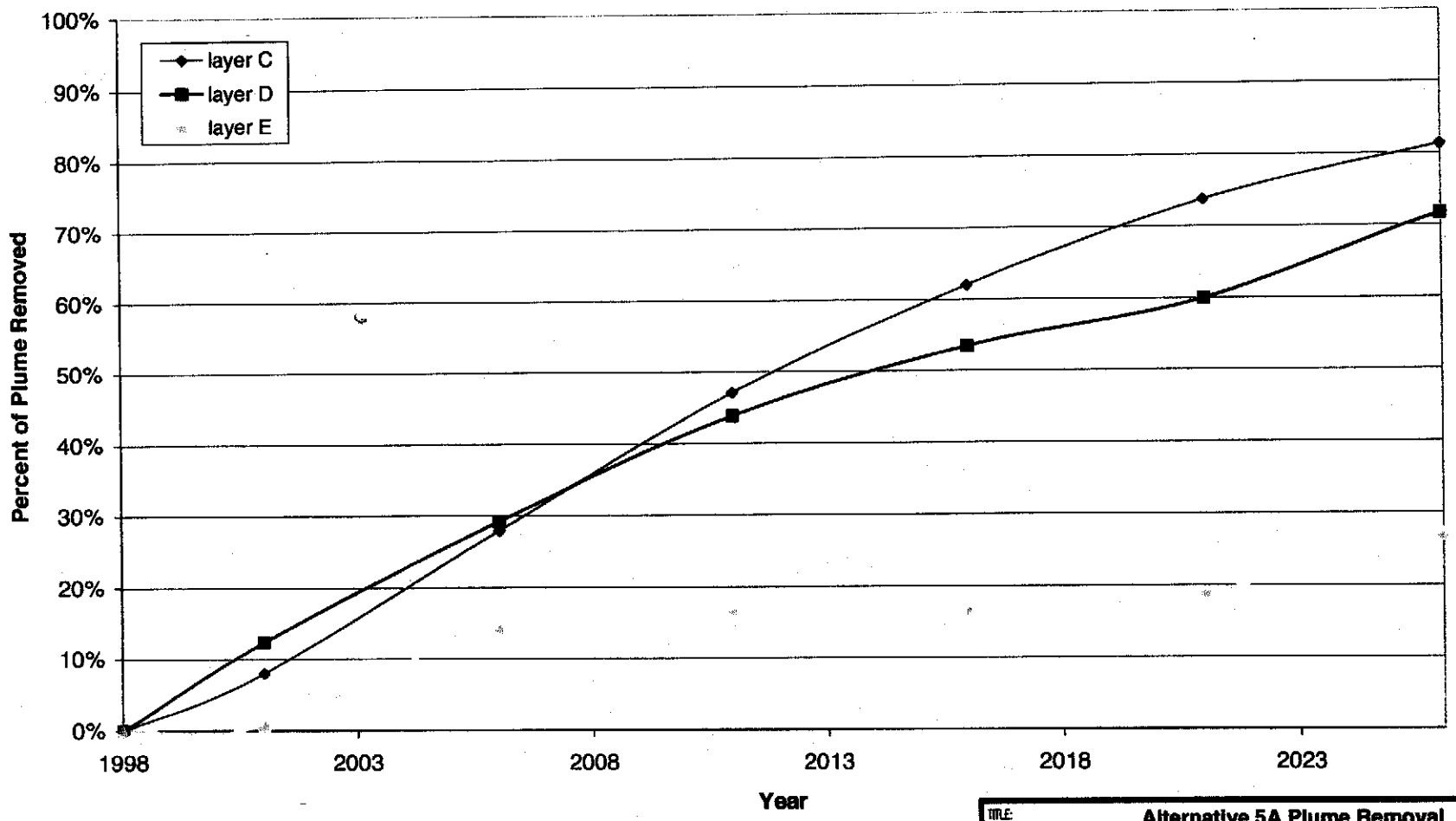

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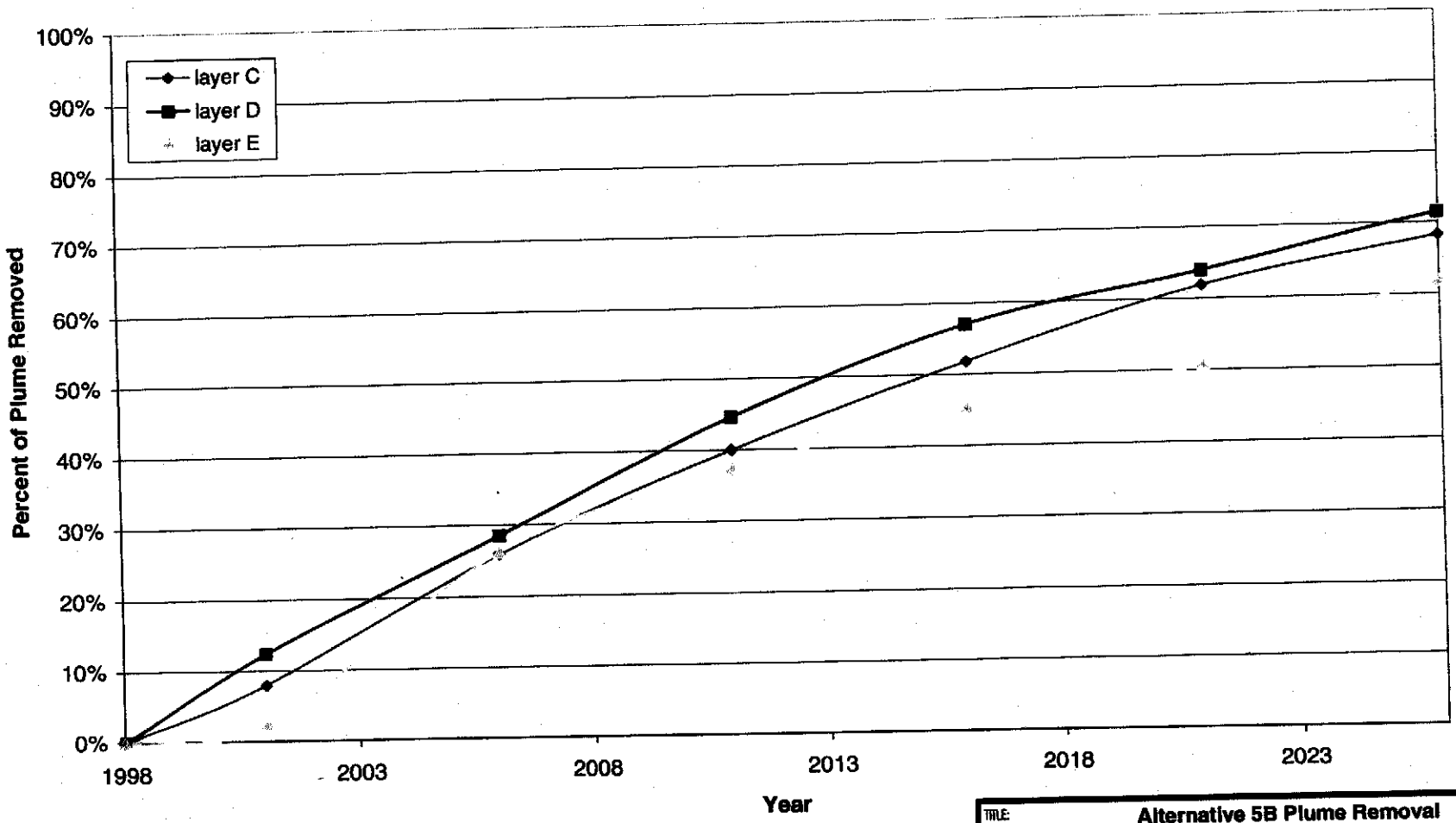
FIGURE:	5.14

PAGES OF OVERSIZED MAPS

(SEE BINDER)



TITLE:	Alternative 5B Plume Removal
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

HSI GEOTRANS

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DATE:	3/29/2000

FIGURE: 5.16

6 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents the comparative analysis for the alternatives that were evaluated in Section 5. The relative performance of each alternative is evaluated against the performance of the other alternatives for each of the threshold and primary balancing criteria. This comparative analysis identifies the advantages and disadvantages of each alternative to assist in the decision making process leading to the Proposed Plan.

6.1 Threshold Criteria

Two of the nine criteria specified in the NCP relate directly to statutory findings that must ultimately be made in the ROD. These two criteria are (1) overall protection of human health and the environment, and (2) compliance with ARARs. They are classified as threshold criteria, as each alternative must meet these two criteria.

6.1.1 Overall Protection of Human Health and the Environment

Alternative 1, which assumes the absence of the onsite GET containment facilities and institutional controls, does not provide adequate protection to human health, because it is assumed that contaminated groundwater continues to migrate offsite and it is assumed that there are no institutional controls to prevent public exposure to the groundwater. As previously discussed, existing (non-CERCLA) regulations related to public and private water supplies prevent the use of contaminated water. Therefore, it is unlikely that contaminated groundwater would be extracted for use. However, for purposes of the FS, it is assumed that under the No Action alternative, contaminated water would be used for potable supply and therefore, this alternative would not be protective of human health.

Each of the remaining alternatives include actions that break the pathway through which contaminated groundwater would be supplied for potable use. First, each of Alternatives 2A through 5B involve operation of GETs E and F at the Aerojet facility boundary, thereby establishing a hydraulic boundary to minimize the risk of the offsite migration of CoPCs. Second, Alternatives 2A through 5B eliminate exposure to unacceptable concentrations of CoPCs through various management options. Alternatives 2A and 2B involve replacement water supplies, Alternatives 3A and 3B involve point of use treatment, and Alternatives 4 and 5 involve a hydraulic barrier. Therefore, Alternatives 2A through 5B are sufficiently protective of public health.

Alternatives 2A and 2B do not prevent the continued migration of CoPCs already offsite and are not protective of the environment in the near-term. Each of Alternatives 3A through 5B involves offsite extraction intended to minimize CoPC migration and protect the environment.

The treated water management/reuse option selected will also be protective of human health and the environment for all alternatives. If wellhead treatment is utilized in all or a portion of the selected remedy, the treated water must meet DHS requirements for a drinking water source. Similarly, if direct reuse of treated groundwater is selected under Alternatives 4A through 5B, the treated water must comply with DHS requirements. Alternatives 4A through 5B must also be protective of the environment if recharge or surface water discharge are selected as treated water management options. This protection will be afforded through the NPDES permitting process for surface water discharge or treatment plant effluent requirements for recharge.

6.1.2 Compliance with ARARs

Compliance with ARARs also serves as a threshold criterion that must be met by any alternative for it to be selected as a remedy, unless an ARARs waiver is obtained. Each alternative, except Alternative 1, has the potential to eventually comply with ARARs.

Chemical-specific ARARs (e.g., MCLs) will be met by Alternatives 3A through 5B, since under each such alternative, impacted groundwater located both on the Aerojet facility and offsite will be treated to concentrations that meet chemical-specific ARARs prior to management/reuse. Alternatives 2A and 2B, which do not include offsite engineered groundwater controls, are less likely to achieve chemical-specific ARARs for offsite groundwater within the short term. However, they have the potential to eventually comply with ARARs through institutional controls, the operation of the GETs E/F extraction and treatment system, and natural attenuation.

Location- and action-specific ARARs do not apply to Alternative 1, the No-Action alternative. The groundwater extraction, conveyance, and treatment systems variously described under Alternatives 3A through 5B will be designed and operated to comply with all location- and action-specific ARARs.

Identified potential ARARs are detailed in Appendix C.

6.2 Primary Balancing Criteria

Alternatives 2A through 5B are comparatively analyzed in this section for the next five of the nine criteria, the primary balancing criteria. (Alternative 1, the No Action alternative, is not evaluated with respect to the primary balancing criteria, as it did not meet the initial threshold criteria.) These five criteria include long-term effectiveness and permanence; reduction of toxicity, mobility and volume through treatment; short-term effectiveness; implementability; and cost. These five criteria are collectively described as the primary balancing criteria as they provide the primary basis for differentiation among the various alternatives.

6.2.1 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence is a measure of the following two principal factors:

- The magnitude of residual risk; and
- The adequacy and reliability of controls.

The Alternative 4 and 5 series would appear to provide greater long-term effectiveness and permanence than the remaining alternatives, with the Alternative 4 series, and particularly 4B, providing the greatest potential for long-term effectiveness and permanence.

Alternative 4C may be less effective at maintaining hydraulic capture than Alternatives 4A and B, and 5A and B. Under Alternative 4C, extraction wells are located in Layers D and E between the Aerojet Site and the offsite hydraulic barrier in Layer C. These extraction wells will decrease the head potential in Layers D and E and may cause the downward migration of CoPCs from Layer C into Layers D and E. If this occurs, some CoPCs located beyond the influence of the extraction wells in Layers D and E will not be captured. The CoPC concentrations are generally an order of magnitude greater in Layer C than in Layers D and E.

The Alternative 4 and 5 series are intended to minimize the migration of CoPCs by establishing onsite and offsite barriers. These barriers will permanently remove and treat CoPCs from affected groundwater, thereby reducing the long-term potential for exposure to CoPCs in offsite groundwater. The potential long-term effectiveness and permanence of the Alternative 4 and 5 series is greater than that for the Alternatives 2 and 3 series because Alternatives 2 and 3 are not specifically designed to remove CoPCs in the offsite areas. It is difficult to accurately predict how far the CoPCs will migrate under Alternatives 2 and 3. However, Alternative 3 does provide a greater degree of long-term effectiveness than Alternative 2 because groundwater modeling indicates that a substantial portion of the offsite CoPCs would be permanently removed and treated through the use of wellhead treatment.

Among the "A", "B" and "C" alternatives, the "B" and "C" alternatives appear to provide the greatest potential to effectively control the migration of CoPCs. Replacing the recharge wells with extraction wells at the western Aerojet boundary enables the "B" and "C" alternatives to remove a greater portion of the CoPCs present in Layers C, D, and E before they migrate offsite. In addition, by eliminating recharge, the "B" and "C" alternatives reduce the total amount of water that must be contained by an offsite hydraulic barrier, thereby increasing the potential effectiveness of the offsite barrier system. Similarly, the Alternative 4 series has a greater potential for long-term

effectiveness than the Alternative 5 series because hydraulic control using only extraction is more attainable than achieving hydraulic control using both extraction and recharge.

The Alternative 4 and 5 series involve more remediation and removal of the offsite portions of the CoPCs than the remaining alternatives, although Alternatives 3A and 3B will remove a substantial portion of the offsite CoPCs. Therefore, the Alternative 4 and 5 series probably have the greatest potential to eventually restore the aquifer to beneficial uses and reduce the magnitude of residual risk. However, given the complexity and heterogeneity of the aquifer system and the unknown fate and transport characteristics of some of the CoPCs (i.e., perchlorate and NDMA), there is no realistic basis for evaluating the extent to which aquifer restoration will occur and over what period of time.

6.2.2 Reduction in Toxicity, Mobility, or Volume through Treatment

This criterion is a measure of the following five principal factors:

- Statutory preference for treatment as a principal element;
- Irreversibility of treatment;
- Type and quantity of treatment residual;
- Amount of hazardous material destroyed or treated; and
- Reduction in toxicity, mobility, or volume.

With respect to offsite CoPCs, except for Alternative 2, each of the alternatives involves management of contaminated groundwater that will achieve reduction in toxicity, mobility or volume through treatment. (A summary of the estimated onsite and offsite extraction flowrates under each alternative is presented in Table 6-1.) The remaining alternatives are equal in their preference for treatment and the irreversibility of treatment processes.

Alternatives 4 and 5 include both onsite and offsite hydraulic boundaries and therefore would be expected to provide greater reduction in toxicity, mobility and volume of the offsite CoPCs than Alternatives 2 and 3, which are not designed to do so (although Alternative 3 does provide containment). Among the "A", "B" and "C" alternatives, the "B" and "C" alternatives would be expected to provide a greater reduction in mobility of CoPCs in the offsite plume than the "A" alternatives because they would not include recharge of the GETs E/F treated groundwater.

Groundwater would be treated using various processes that are irreversible. No residuals are associated with UV/oxidation treatment because contaminants are destroyed. Air strippers produce VOCs in offgas that may require treatment prior to being emitted to the atmosphere. LPGAC does not destroy contaminants but rather collects VOCs within a

carbon vessel. The carbon will periodically require regeneration and offsite treatment or disposal. The groundwater treatment component of Alternatives 3A through 5B meets the statutory preference for treatment to reduce the principal threat because contaminants are destroyed or collected and the total volume of contaminated media is reduced.

The groundwater flow model was used as a basis for comparing the relative amount of the plume area that would be removed by each alternative involving groundwater extraction (i.e., Alternatives 3A through 5B) over the 25-year FS evaluation period. Figures 6-1 to 6-3 present the modeled plume area removed by each alternative in Layers C, D, and E, respectively. Figure 6-4 presents the estimated total plume area removed in all layers by alternative. Table 6-3 summarizes the percent of offsite plume area modeled to be captured under each alternative by layer and by the total plume area for each alternative.

The percent of plume area removed in Layer C ranges from 52 to 87 percent with Alternative 3B removing the least and Alternative 4A providing the most amount of removal (Figure 6-1). The alternatives involving an offsite hydraulic barrier and continued recharge of GETs E/F treated groundwater (i.e., Alternatives 4A and 5A) remove the greatest amount of plume area over the 25-year evaluation period because of the increased hydraulic gradients caused by recharge. Figure 6-2 shows that the plume areas estimated to be removed in Layer D are similar for all alternatives, ranging from approximately 68 to 77 percent. The amount of plume area removed in Layer E has the greatest variability of all layers, ranging from 21 to 91 percent (Figure 6-3, Table 6-2). The modeling indicates that Alternative 3B would remove more plume area from Layer E (91%) than any of the other alternatives because several water supply wells located closest to the Aerojet Site are screened in Layer E. Alternatives 5A and 4A would remove the least amount of plume in Layer E because recharge is continued and portions of the plume in Layer E on the west side of the Aerojet Site are not captured until they reach the offsite hydraulic barrier. Layer E comprises only 9 percent of the total plume area, so hydraulic capture of Layer E may not be a significant benefit.

The modeling indicates that Alternatives 3A and 3B would remove the least amount of the total plume area because they rely on existing water supply wells that are not optimally located for CoPC plume removal (Figure 6-4, Table 6-2). Alternatives 4A through 5B are projected to remove between 68 and 77 percent of the total plume area over 25 years. The approximate 13 percent difference among the alternatives modeled to remove the greatest amount (4A) and least amount (5B) of plume areas is within the range of variability of the model, and suggests that plume area removal is similar for each alternative.

6.2.3 Short-Term Effectiveness

Short-term effectiveness is a measure of the protection afforded by each alternative during the construction and implementation process. As such, the time until RAOs are

achieved is an important component of this criterion. The availability of equipment and specialists to implement the alternative is also a consideration.

This criterion is a measure of the following three principal factors:

- Protection of workers and the community during the remedial action;
- Environmental impacts; and
- Time until RAOs are achieved.

This criterion is typically of greater significance for source control measures. Here, all of the remaining alternatives involve onsite and most involve an offsite response action. Under all alternatives, the community and the environment would be protected during construction and implementation of the remedial action and from potential exposure to CoPCs through existing institutional controls (i.e., DHS drinking water standards).

All remaining alternatives protect offsite human health and the beneficial uses of the aquifer by minimizing the offsite CoPC migration. Alternatives 3A through 5B involve both onsite and offsite groundwater extraction, and are more protective than Alternatives 2A and 2B that rely on natural processes to reduce CoPC concentrations already offsite. Each of the "B" alternatives and Alternative 4C may be more protective than the "A" alternatives because treated groundwater is not recharged. The complex hydrostratigraphy and uneven lateral and vertical contaminant distribution in the Study Area necessitates that some CoPCs will migrate through unaffected portions of the aquifer prior to reaching the extraction or water supply wells. Alternative 4C involves the most aggressive offsite groundwater extraction and will intercept CoPCs in portions of Layers D and E earlier than the other alternatives. The earlier extraction from Layers D and E is unlikely to effect the beneficial use of the aquifer because, until the CoPCs in Layer C are removed, public water supply wells cannot be installed in Layers D and E due to the potential for the downward migration of CoPCs from Layer C into the supply well. Layer C contains the greatest areal extent and highest CoPC concentrations and will likely have the most impact on beneficial use.

The time required to implement Alternatives 2 and 3 would be shorter than Alternatives 4 and 5, because Alternative 2 would not require substantial offsite construction. Alternative 3 would be implemented on a phased basis as public water supply wells become affected. Alternatives 4 and 5 would require significantly more planning, design, and construction activities for the offsite hydraulic containment components. Alternative 4C would probably require the greatest amount of time to implement because it would involve securing the easements and right-of-way access for two offsite pipeline corridors instead of one.

Several of the alternatives involve extraction of groundwater to achieve containment or collection and therefore have the potential to impact the operation of existing or possible future groundwater supply wells. Table 6-1 summarizes the maximum water level

drawdowns estimated to be observed in water supply wells located in the vicinity of the intersection of Zinfandel Drive and U.S. Highway 50 as a result of implementation of Alternatives 4A through 5B. There would appear to be no significant impact on water levels associated with any of the offsite containment alternatives based upon the FS modeling described in Appendix D. The modeling projects potential water level drawdown of approximately 35 feet or less. This is not expected to have any significant impact on the aquifer.

It is anticipated that the necessary equipment and specialists are available to implement all alternatives.

It is not technically feasible to estimate the time required to meet the RAO of reducing CoPC concentrations in already contaminated portions of the groundwater due to the aquifer and contaminant distribution complexities discussed throughout this FS. However, it may be useful to compare the amount of plume area modeled to be removed during the 25-year evaluation period among the alternatives for a relative comparison of time. The alternatives modeled to remove the greatest plume area can reasonably be expected to achieve this RAO more quickly than the other alternatives. As discussed in Sections 5 and 6.2.2, Alternatives 4A through 5B are projected to remove between 68 and 77 percent of the total plume area over 25 years (Table 6-2). The 13 percent difference in estimated plume area removed among the alternatives is probably insignificant for a remedial action that may be implemented for the Western Groundwater OU. Alternative 2 will not attain a reduction in the offsite CoPC concentrations over any meaningful period of time.

6.2.4 Implementability

Implementability evaluates the technical and administrative difficulties associated with implementing each alternative. Each of the alternatives is implementable to varying degrees, as discussed in this section. There are several technical and administrative difficulties associated with each of the alternatives evaluated in this FS. Technical implementability issues include demonstrating hydraulic capture and control of CoPC plumes and demonstrating the ability to treat extracted CoPCs. Administrative difficulties associated with implementing alternatives include obtaining easements and property for wells and pipelines, conducting a large construction project in public roads and neighborhoods, challenges associated with permitting and compliance for wellhead treatment, and exchanging water for potable and nonpotable reuse.

Alternatives 2A and 2B are implementable to the extent that DHS approves treated groundwater for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. If direct reuse is not accepted, and for the projected shortfall of treated water available under Alternative 2A, a surface water treatment plant can be constructed if a suitable location can be found, and if a private or public water purveyor is willing to operate it. It is believed that permission can be

obtained from the USBR to use Folsom South Canal as a raw water conveyance system to a surface water treatment plant, if necessary. Between Alternatives 2A and 2B, Alternative 2A assumes that long-term surface water entitlements would be available on the American River, which may not be the case.

Alternatives 3A and 3B are implementable to the extent that the DHS approves wellhead treatment for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. DHS has accepted wellhead treatment at numerous locations throughout the State. If accepted, the well treatment equipment must be capable of fitting in the existing space available at impacted water supply wells, and the treatment processes must be capable of meeting treatment standards in a demonstrable and reliable manner.

It will be difficult to implement Alternatives 4A through 5B due to the significant amount of offsite infrastructure estimated for these alternatives. Table 6-3 presents the number of wells and lengths of piping estimated for each alternative. Alternatives 4A through 5B are estimated to require from approximately 67,000 to 81,000 feet (approximately 13 to 16 miles) of relatively large diameter piping and from 11 to 30 offsite extraction wells. It will require a substantial effort to identify potential pipeline corridors and secure the necessary permits and easements. This amount of offsite construction may require significant input and participation from Sacramento County and the local community. It is not currently known where extraction wells that require periodic maintenance and monitoring can be located.

In comparing among the "A", "B", and "C" alternatives, the "B" and "C" alternatives should be more implementable, given the preference of using extraction rather than recharge both on and offsite to maintain the hydraulic control, and because the "B" and "C" alternatives involve more containment onsite than the "A" alternatives. With respect to the alternatives that include an offsite hydraulic barrier (Alternatives 4A through 5B), maintaining a hydraulic barrier where recharge wells are used as part of the barrier (Alternatives 5A and 5B) would probably be more difficult to implement as maintaining gradients requires more sophisticated groundwater management to optimize system operation and control

6.2.5 Cost

A summary of the estimated costs associated with each alternative is presented in Table 6-4. The cost estimates for each alternative were prepared in accordance with current EPA guidance with respect to level of accuracy and discount rate (i.e., seven percent). For comparison purposes, the estimated total capital cost, estimated annual O&M costs, and estimated 25-year present worth cost estimates are presented in Table 6-4 for each of the alternatives. Wherever possible, actual capital and O&M costs from the Aerojet GET facilities and local area piping construction projects were used for these cost estimates.

The basis for the costs and the methodology and information used to develop the costs are provided in Appendix E.

6.3 Modifying Criteria

The final two of the nine criteria are state acceptance and community acceptance. These two criteria are evaluated following comment on the FS report and Proposed Plan and as such are termed modifying criteria.

6.3.1 State Acceptance

This criterion addresses the State's apparent preferences among or concerns about the various alternatives. This criterion will be addressed as part of the final decision-making process during the preparation of the ROD.

6.3.2 Community Acceptance

This criterion addresses the community's apparent preferences among or concerns about the various alternatives. This criterion will be addressed as part of the final decision-making process during the preparation of the ROD.

6.4 Sensitivity Analysis

Appendix D addresses the sensitivity of remedial alternatives to modeled parameters, including:

- Effects of changing recharge conditions (i.e., wet and dry years vs. long term average recharge conditions); and
- The effects on capture if hydraulic conductivity values are higher or lower.

The sensitivity evaluation did not indicate that changes in these two conditions substantially impact conclusions reached regarding the relative strengths and weaknesses of the alternatives relative to one another with respect to the various evaluation criteria, including costs.

Table 6-1: Estimated Extraction Flowrates and Anticipated Maximum Drawdowns

Alternative	Description	Estimated Extraction Flowrates (gpm)	Modeled Anticipated Maximum Drawdown Offsite (feet)
1	No Action with Limited Groundwater Monitoring	0	NA
2A	GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply	3,800 Onsite 0 Offsite 3,800 Total	NA
2B	GETs E and F Extraction Wells with Offsite Alternate Water Supply	6,225 Onsite 0 Offsite 6,225 Total	NA
3A	GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells	3,800 Onsite 11,200 Offsite 15,000 Total	NA
3B	GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells	6,225 Onsite 11,200 Offsite 17,425 Total	NA
4A	GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells	3,800 Onsite 3,700-8,600 Offsite 7,500-12,400 Total	20
4B	GETs E and F Extraction Wells with Offsite Extraction Wells	6,225 Onsite 3,100-4,600 Offsite 9,325-10,825 Total	30
4C	GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors	6,225 Onsite 3,750-4,150 Offsite 9,975-10,375 Total	35
5A	GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells	3,800 Onsite 3,200-7,200 Offsite 7,000-11,000 Total	10
5B	GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells	6,225 Onsite 2,000-2,900 Offsite 8,225-9,125 Total	22

Note: NA = not applicable.

Table 6-2: Percent of Offsite Area Modeled to be Captured After 25 Years

Alternative	Description	Layer C (61% of particles)		Layer D (30% of particles)		Layer E (9% of particles)		All Layers (100% of particles)
		Modeled Percent of Layer Area Captured After 25 Years (25%)	Layer Contribution to Total Area Captured (%)	Modeled Percent of Layer Area Captured After 25 Years (25%)	Layer Contribution to Total Area Captured (%)	Modeled Percent of Layer Area Captured After 25 Years (25%)	Layer Contribution to Total Area Captured (%)	Modeled Percent of Layer Area Captured After 25 Years (25%)
1	No Action with Limited Groundwater Monitoring	NA	NA	NA	NA	NA	NA	NA
2A	GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply	NA	NA	NA	NA	NA	NA	NA
2B	GETs E and F Extraction Wells with Offsite Alternate Water Supply	NA	NA	NA	NA	NA	NA	NA
3A	GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells	61	59	68	32	65	9	63
3B	GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells	52	53	69	34	91	14	60
4A	GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells	87	70	72	28	21	2	76
4B	GETs E and F Extraction Wells with Offsite Extraction Wells	72	63	71	30	52	7	70
4C	GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors	77	61	77	30	79	9	77
5A	GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells	81	67	72	29	27	3	74
5B	GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells	68	61	72	31	62	8	68

Table 6-3: Components of Each Alternative

Alternative	Description	Estimated Number of New Wells			Estimated Length of Piping (ft)
		Monitor Wells	Extraction Wells	Recharge Wells	
1	No Action with Limited Groundwater Monitoring	0	0	0	0
2A	GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply	0	4[1]	0	63,000
2B	GETs E and F Extraction Wells with Offsite Alternate Water Supply	0	13[2]	0	32,000
3A	GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells	0	4[1]	0	9,000
3B	GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells	0	13[2]	0	21,000
4A	GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells	45	34[3]	0	79,000
4B	GETs E and F Extraction Wells with Offsite Extraction Wells	26	30[4]	0	67,000
4C	GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors	27	31[5]	0	77,500
5A	GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells	36	28[6]	7	81,000
5B	GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells	17	24[7]	7	79,000

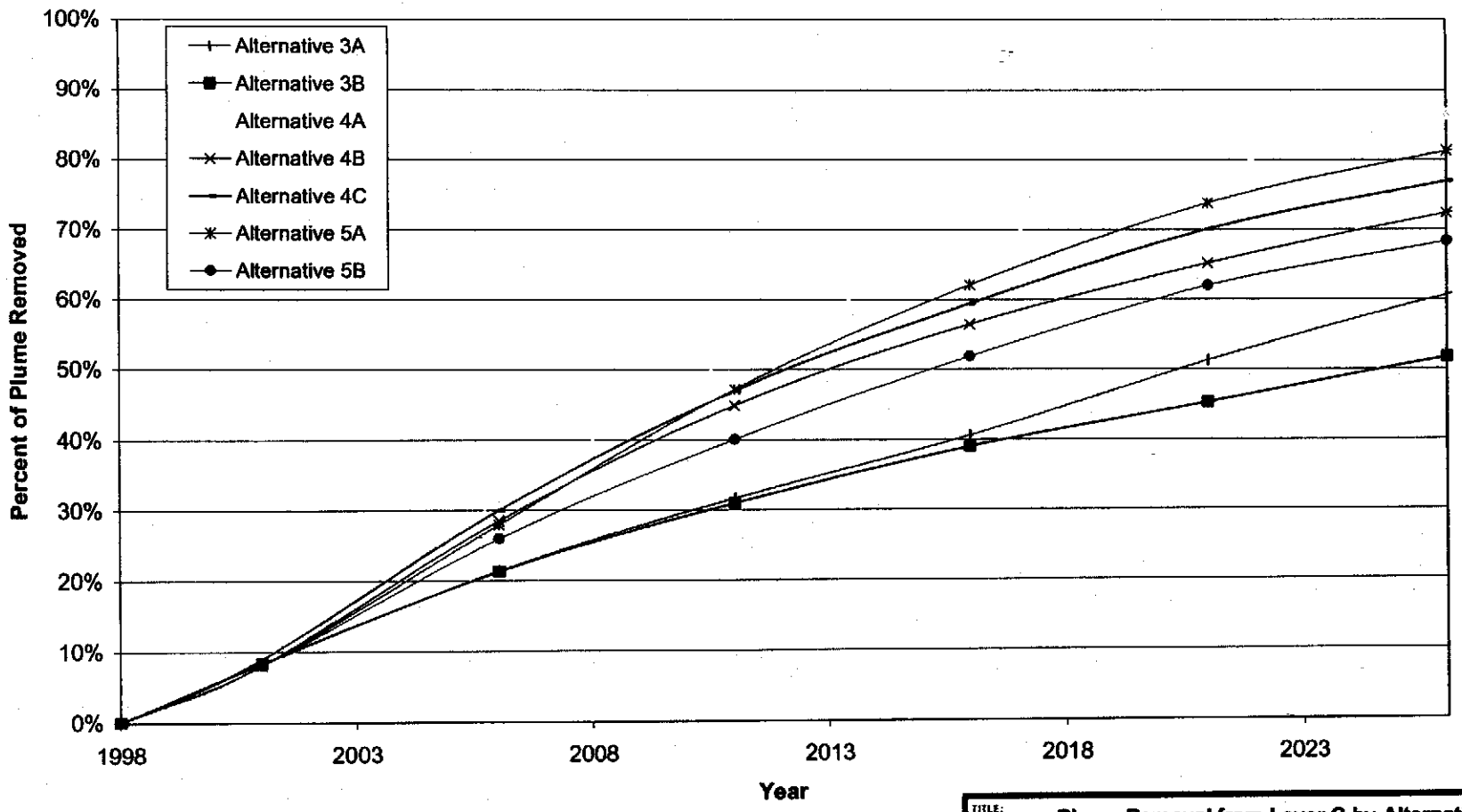
Notes:
1. 4 new extraction wells in 2 locations (all onsite).
2. 13 new extraction wells in 5 locations (all onsite).
3. 34 new extraction wells in 15 (2 onsite, 13 offsite) locations.
4. 30 new extraction wells in 15 (5 onsite, 10 offsite) locations.
5. 31 new extraction wells in 21 (5 onsite, 16 offsite) locations.
6. 28 new extraction wells in 12 (2 onsite, 10 offsite) locations.
7. 24 new extraction wells in 12 (5 onsite, 7 offsite) locations.

Table 6-4: Summary of Estimated Costs

Alternative	Description	Estimated Capital Costs ($M)	Estimated Annual O&M Costs [Range] ($M/year)	Estimated 25-year Present Worth Costs ($M)
1	No Action with Limited Groundwater Monitoring	0	0.16	2
2A	GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply	25	2.1-3.9	48
2B	GETs E and F Extraction Wells with Offsite Alternate Water Supply	22	2.5-2.8	54
3A	GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells	64	3.5-5.3	93
3B	GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells	77	4.0-6.0	115
4A	GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells	43	3.0-3.3	78
4B	GETs E and F Extraction Wells with Offsite Extraction Wells	38	3.3-3.4	77
4C	GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors	42	3.5-3.6	85
5A	GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells	41	3.3-3.9	78
5B	GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells	45	3.8-4.0	87

Notes: Costs include O&M of existing onsite GETs E/F boundary source containment system, improvements to onsite GETs E/F system, and any offsite remedial alternatives.

Plume Removal from Layer C by Alternative



TITLE:	Plume Removal from Layer C by Alternative
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

HSI GEOTRANS

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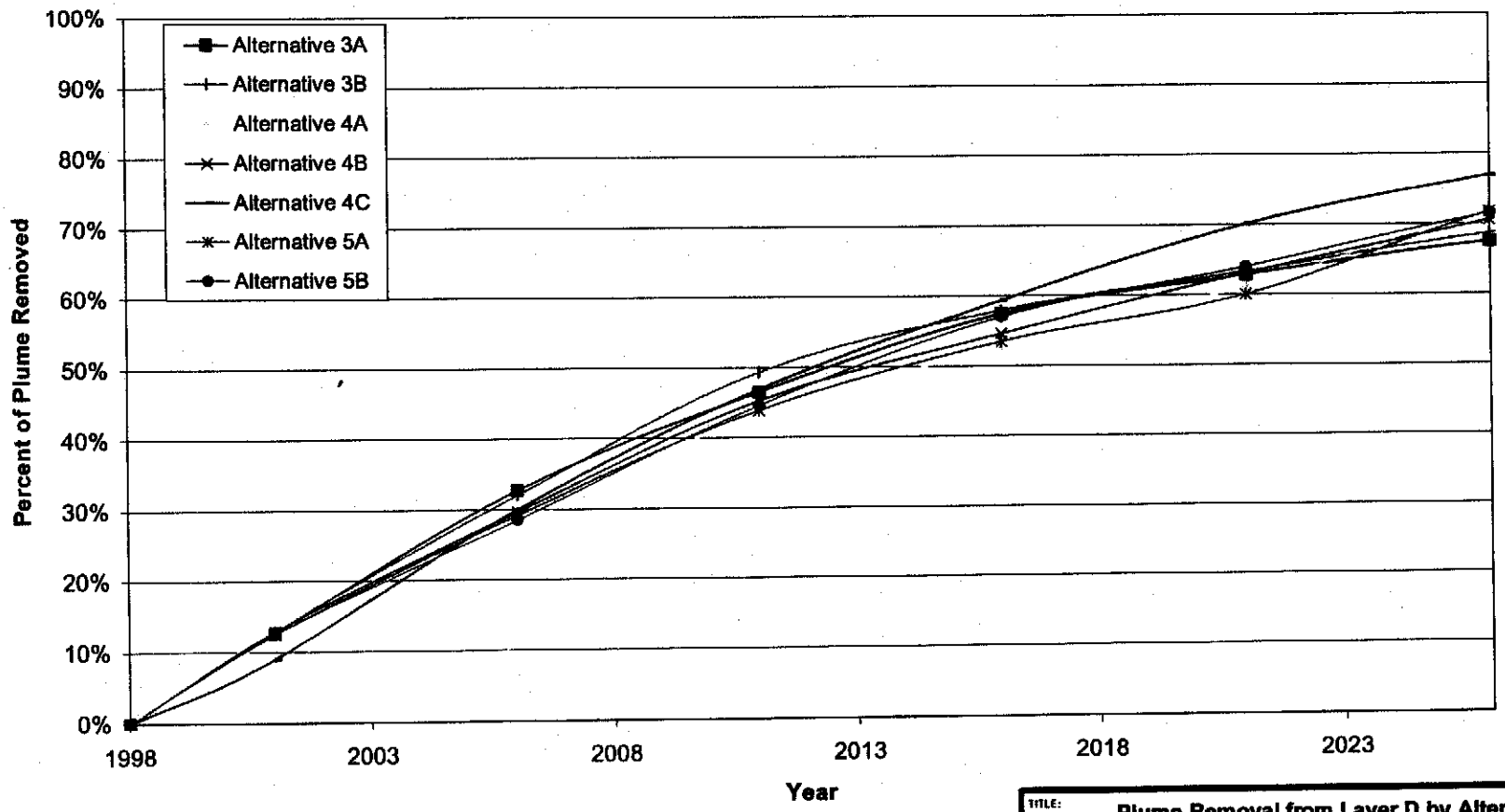
DATE:	3/29/2000

FIGURE: 6.1

Plume Removal from Layer D by Alternative



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LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

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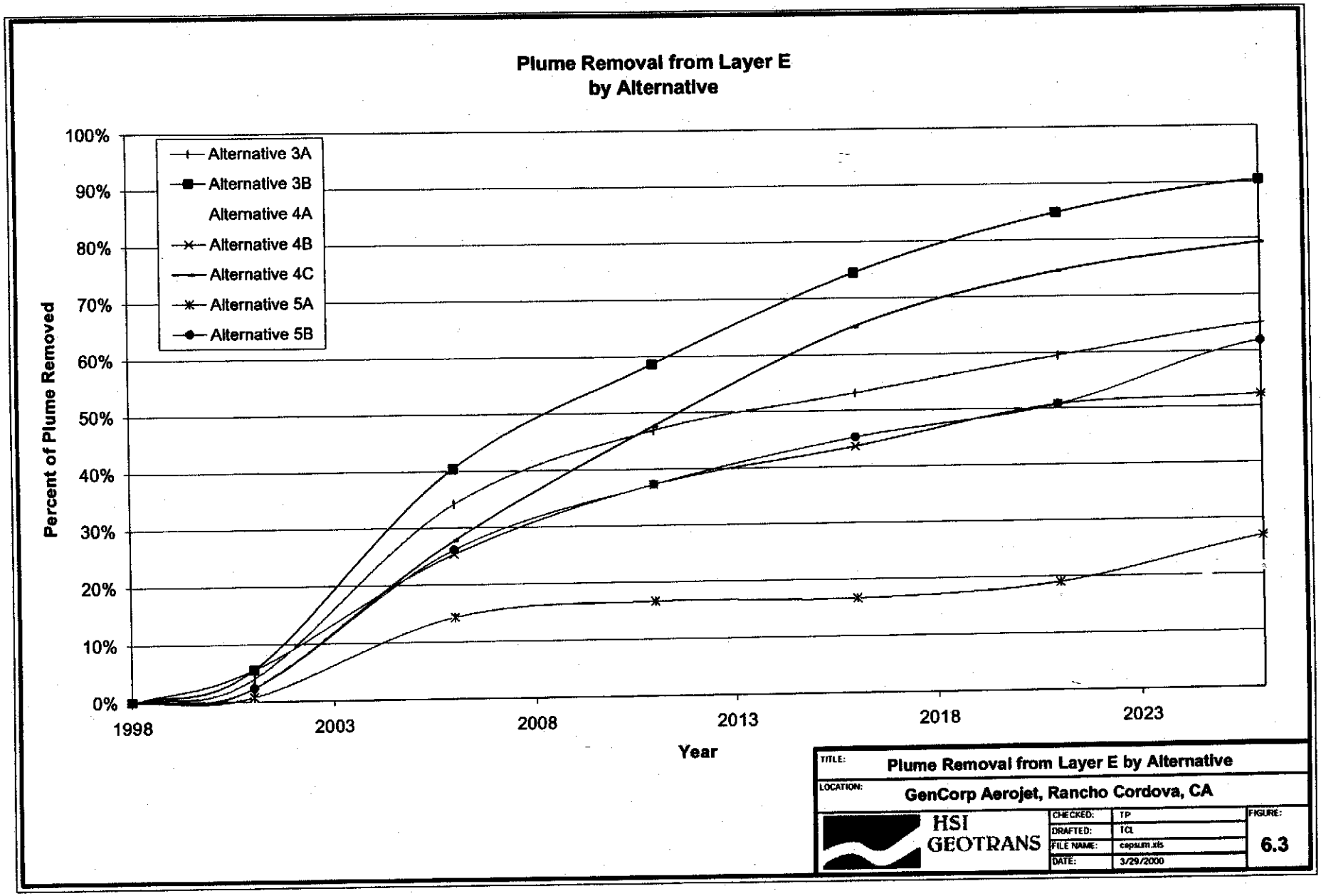
FIGURE: 6.2


Plume Removal from Layer E
by Alternative
Percent of Plume Removed
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1998
2003
2008
2013
2018
2023
Year
Alternative 3A
Alternative 3B
Alternative 4A
Alternative 4B
Alternative 4C
Alternative 5A
Alternative 5B
TITLE: Plume Removal from Layer E by Alternative
LOCATION: GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS
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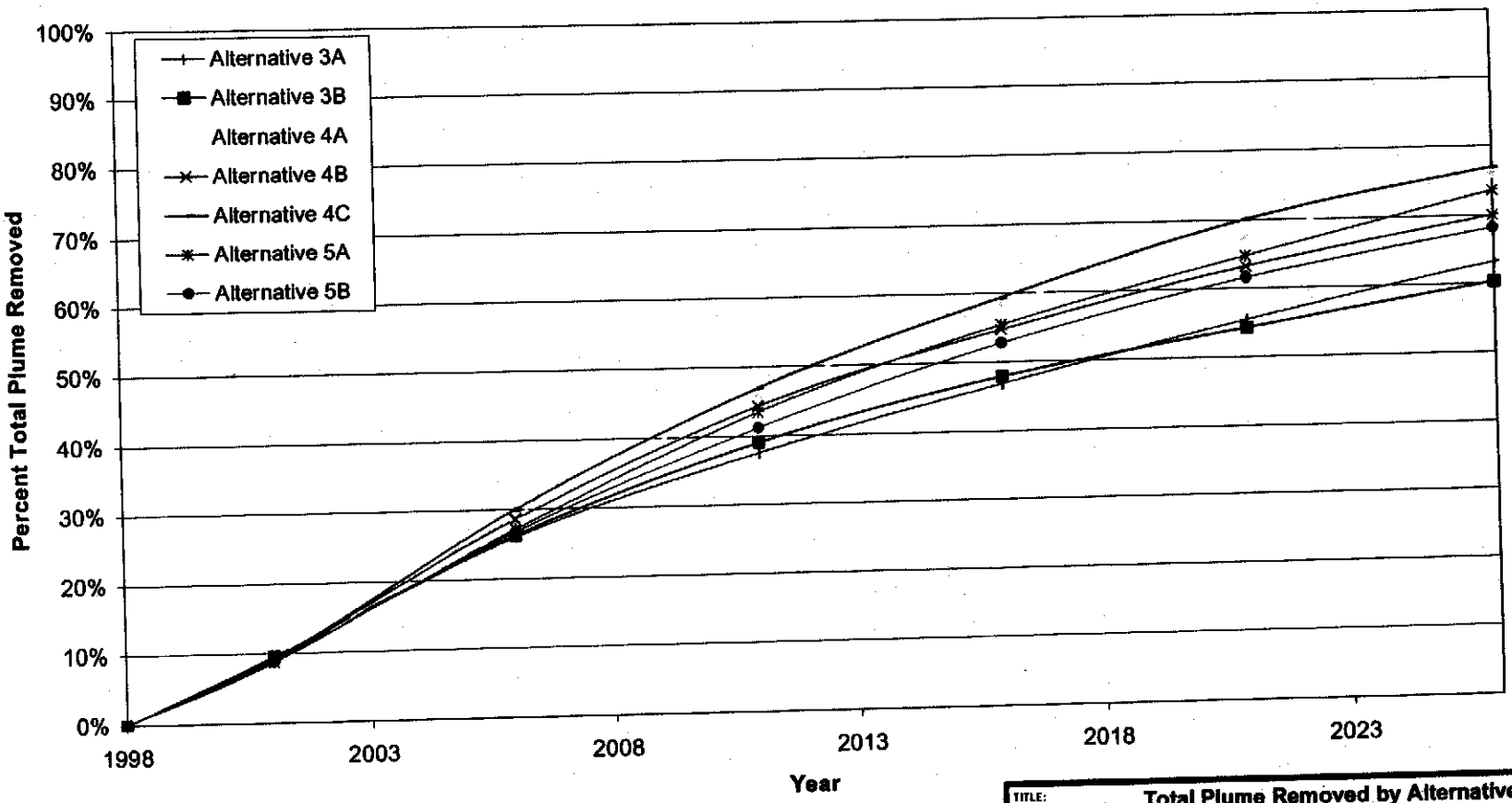
FILE NAME: capsum.xls
DATE: 3/29/2000
FIGURE: 6.3

Total Plume Removed by Alternative



TITLE:	Total Plume Removed by Alternative
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

HSI GEOTRANS

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DATE:	3/29/2000

FIGURE: 6.4

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Remedial Investigation Report

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WESTERN GROUNDWATER OPERABLE UNIT
REMEDIAL INVESTIGATION REPORT

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WESTERN GROUNDWATER OPERABLE UNIT
REMEDIAL INVESTIGATION REPORT

1.0 INTRODUCTION

This remedial investigation (RI) report has been prepared by Aerojet-General Corporation (Aerojet) pursuant to certain requirements of the 1989 Partial Consent Decree (PCD), and pursuant to the schedule submitted in response to the California Regional Water Quality Control Board (CRWQCB) 1996 Cleanup and Abatement Order (CAO) Number 96-259. This report focuses on the groundwater flow conditions and distribution of chemicals in the Western Groundwater Operable Unit (Study Area). The Study Area includes the onsite areas (Aerojet property) around two existing groundwater extraction and treatment (GET) facilities (GETs E and F), the northwestern portion of the Inactive Rancho Cordova Test Site (IRCTS), as well as the western offsite area in the community of Rancho Cordova, California (Figure A-1).

Aerojet site history, chemical use and handling practices, metrology, human populations and land use, and ecological investigations are presented in the Scoping Report (ICF Technology, 1989). The Stage 1 RI Report– Zone 2, presented descriptions of source sites and chemical distributions in the vadose zone and groundwater on the Aerojet Site (ICF Kaiser Engineers, 1993a,b). Findings from these reports are summarized as necessary to explain the interpretations presented in this RI report.

The descriptions of hydrogeologic conditions and chemical distribution in groundwater presented in this report are a culmination of numerous studies conducted since the early 1980s. The nomenclature and interpretation of the hydrostratigraphic units beneath portions of the Study Area were introduced in 1992 in separate GET effectiveness evaluation reports for GETs E and F (Aerojet, 1992a,b). In 1996, the GET E and F effectiveness evaluations were combined and updated to reflect the inter-relationships between the two systems (Aerojet/Hydro-Search, 1996). The combined on- and off-site interpretation of the hydrostratigraphy and descriptions of perchlorate and N-nitrosodimethylamine (NDMA) distributions in groundwater were initially presented in a technical memorandum submitted in December 1998 (Aerojet, 1998).

1.1 Background

Since the early 1950's, the Aerojet Site has been utilized to develop rocket propulsion systems in support of national defense, space exploration, and satellite deployment. Industrial activities have included solid rocket motor manufacturing, testing, and rehabilitation (hogout); liquid rocket engine manufacturing and testing; and chemical manufacturing. Chemicals used in the manufacturing and testing areas included chlorinated solvents, propellants, metals, fuels, oxidizers, and a variety of chemicals produced in the chemical operations areas as described in the Scoping Report (ICF Technology, 1989).

Historical operations at the Aerojet Site have resulted in the discharge of chemicals to the vadose zone and underlying groundwater. Although numerous chemicals were used on the Aerojet Site, trichloroethene (TCE), perchlorate and NDMA are the primary chemicals of potential concern (CoPCs) in groundwater beneath the Study Area. TCE was primarily utilized as a solvent for cleaning and degreasing purposes. Perchlorate (ClO_4^-) was combined with various cations (primarily ammonium or potassium) and utilized as an oxidizer in solid rocket propellants. NDMA is a semi-volatile organic compound (SVOC) that was either an impurity in hydrazine-based liquid rocket fuels or was formed as a combustion product of these fuels.

Offsite source(s) of CoPCs in the Study Area have not been fully evaluated for this RI. TCE is widely used as a solvent, especially for dry cleaning and metal degreasing. Several offsite sources of TCE and/or PCE have been identified and reported to the oversight Agencies by Aerojet, and are noted in the appropriate sections of this report. NDMA is unintentionally formed during various manufacturing processes at many industrial sites and in air, water, and soil from reactions involving other chemicals called alkylamines (ATSDR 1989). According to the ATSDR, the general population may be exposed to NDMA from a variety of sources, including outdoor air. The primary sources of NDMA exposure are tobacco smoke, chewing tobacco, and foods such as cured meats, toiletry and cosmetic products, and various other household goods. In addition, NDMA can form in the stomach during the digestion of alkylamine-containing foods (alkylamines are naturally occurring compounds that are found in some drugs and a variety of foods). Occupational exposures are also possible, such as at tanneries, pesticide manufacturing plants, rubber and tire manufacturing plants, fish processing industries, foundries, and dye manufacturing plants (ATSDR, 1989). The American Water Works Association is funding studies in the year 2000 to study the factors affecting the formation and occurrence of NDMA in water. Perchlorate has recently been detected in many fertilizers (ES&T, 1999).

The presence or potential presence of some of these chemicals in the environment is a significant issue. It can be difficult to distinguish low levels of environmental contamination from low levels of ubiquitous chemicals present as background. This is particularly relevant for NDMA where concentrations in the low parts per trillion can be introduced during sampling and/or analysis. The presence of low levels of NDMA in ultra-pure laboratory grade water has prevented Aerojet's laboratory from being able to achieve California Department of Health Services (DHS) protocols for low-level NDMA analyses. Similarly, if low levels of perchlorate are present in groundwater due to past or present agricultural practices, perchlorate will be difficult to distinguish from environmental contamination. These issues are not relevant in areas of the plumes where the elevated presence of these contaminants is related to activities on the Aerojet Site.

Since the mid-1980's, Aerojet has installed and operated five interim perimeter GET facilities (GETs A, B, D, E, and F) designed to prevent or minimize the offsite migration of volatile organic compounds (VOCs) and NDMA (GETs A and B only) in groundwater. The treated water is recharged to the groundwater system via surface discharge and infiltration, or by recharge wells. A sixth GET facility, the American River Groundwater Extraction and Treatment System (ARGET) began operations in July 1998. Two of these GET facilities, GETs E and F, are located within the Western Groundwater Study Area and are included for evaluation as elements of a Feasibility Study.

1.2 Physical Description of the Study Area

The Study Area encompasses approximately the western one-third of the Aerojet Site, the northwestern corner of the IRCTS, Aerojet-owned land west of the IRCTS, and approximately 10 square miles of commercially and residentially developed areas in the community of Rancho Cordova (Figure A-1). The entire Study Area is comprised of approximately 15 square miles. The western boundary of the Study Area is located at Mather Field Road. The Study Area does not include vadose zone source sites at Chemical Plant 2, the IRCTS, or any of the manufacturing line areas on the Aerojet Site.

The Study Area is characterized by a relatively flat topographic surface gently sloping (less than 1 degree) to the west. Ground surface elevations decrease from approximately 200 feet above mean sea level (MSL) in the east to approximately 60 feet above MSL in the west. The American River meanders in a generally southwesterly direction through the northwest corner of the Study Area. Local topographic features include two ancestral American River terrace scarps that generally trend northeast-southwest

through the Aerojet Site and the IRCTS (Figure A-1). The ground surface elevation decreases 20 to 40 feet from east to west across the terrace scarps.

The majority of the Study Area was dredged for gold beginning in the early 1900's and continued through the 1960's. Evidence of dredging has been obliterated by development in most of the offsite areas. Dredge tailings are evident on the Aerojet Site, the IRCTS, and the land west of the IRCTS. The dredge tailings consist of alternating rows of cobble windrows and low areas ("slickens"). Most cobble windrows are 10 to 20 feet higher in elevation than the intervening slickens areas, although some windrows in the eastern portion of the Study Area are 40 to 60 feet higher than the slickens areas.

1.3 Surface Water Hydrology

1.3.1 Regional Surface Waters

Regional surface water bodies in the vicinity of the Study Area include Folsom Lake, Lake Natoma, the American River, and the Folsom South Canal (Figure A-2). The American River drains a substantial portion of the western Sierra Nevada east of Sacramento County. The American River is used as a municipal and agricultural water supply and provides recreational, fishery, and wildlife uses. The portion of the American River downstream of Lake Natoma serves as spawning ground for salmon, steelhead trout, and shad.

Flows on the American River are controlled by the United States Bureau of Reclamation (USBR) through Folsom Dam, and to a lesser extent, Nimbus Dam. Folsom Dam is located approximately 3.5 miles northeast (upstream) of Lake Natoma. Lake Natoma is formed by Nimbus Dam, and is located approximately ¼ to ½ mile north of Aerojet's northern property boundary. Contours of the potentiometric surface in the vicinity of Lake Natoma indicate the American River is gaining in the vicinity of Lake Natoma (i.e., groundwater discharges to the river). Lake Natoma is located northeast of the Study Area and is generally side-gradient of the Aerojet Site. Downstream of Nimbus Dam, the potentiometric surface ranges from 40 to 125 feet below the base of the American River and river water infiltrates to the groundwater (i.e., losing river)(ICF Kaiser Engineers, 1989).

The Folsom South Canal originates at the southwest end of Lake Natoma, and trends along portions of the northern and western Aerojet boundaries. Folsom South Canal is a concrete-lined canal and was intended to provide cooling water for the Sacramento Municipal Utility District's (SMUD) Rancho Seco Nuclear Power Plant and municipal water for the East Bay Municipal Utility District (EBMUD). The nuclear

power plant is being decommissioned and current use of the canal is limited to relatively small amounts by SMUD, Arden Cordova Water Service, and various agricultural water users. EBMUD maintains, but is not currently using, surface water diversion rights via the Folsom South Canal.

1.3.2 Local Surface Waters

Local surface water features include: Buffalo Creek, the Administration Ditch, West Area Lake, Alder Creek, Rebel Hill Ditch, and various man-made ditches and ponds located throughout the facility (Figure A-2). Most of these features are used to divert and control seasonal storm-water runoff from the Aerojet Site. Alder Creek is located along the northeastern Aerojet boundary and receives a minor amount of storm water runoff from undeveloped areas on and east of Aerojet. Alder Creeks flows west and drains into Lake Natoma.

Most storm-water runoff originating in the northern (Administration Area) and northeastern (Liquid Rocket Test Area) portions of the Aerojet Site flows through the Administration Ditch or Buffalo Creek into the West Area Lakes. Storm-water runoff is staged in the West Area Lakes and discharged to Buffalo Creek, and ultimately the American River. Storm-water discharges to Buffalo Creek/American River are regulated through the National Pollution Discharge Elimination System (NPDES). Aerojet also discharges treated groundwater from the ARGET facility into Buffalo Creek. The ARGET discharge is regulated through a separate NPDES permit. Most storm-water generated on the western half of the Aerojet Site infiltrates locally and does not leave Aerojet property.

Rebel Hill Ditch traverses the facility from northeast to southwest and was constructed to provide water for the gold dredging activities. Aerojet currently discharges treated groundwater from its GET B facility to Rebel Hill Ditch. The treated groundwater from GET B infiltrates into the ground along the southern boundary and does not leave the Aerojet Site. Several lakes, ponds, vernal pools, and wetlands located throughout the Aerojet Site are not differentiated in this report. Most of these features contain water only during the rainy season.

The areas west of the Aerojet Site consist of industrial and residential developments. There are no areas where runoff from the Aerojet Site enters these areas, except for Buffalo and Alder Creeks as noted above. The Sacramento County Department of Public Works - Water Resources Division manages surface water runoff from the developed areas in Rancho Cordova. Storm-water runoff from these areas enters the County's storm-water drainage system and ultimately the American River.

2.0 STUDY AREA GEOLOGY AND HYDROSTRATIGRAPHY

2.1 Regional Geology

The Study Area is located near the eastern edge of the Sacramento Valley near the contact between the Sierra Nevada metamorphic basement rocks and the valley sediments. This area is characterized by shallow-dipping (generally less than 1 degree) Cretaceous-, Tertiary-, and Quaternary-age marine and fluvial sediments overlying steeply dipping Jurassic crystalline basement rocks (Department of Water Resources [DWR], 1974). The erosional surface of the basement rock dips to the west beneath the Study Area at approximately 4 degrees.

The sedimentary sequence includes undifferentiated Quaternary sediments and the Laguna, Mehrten, Valley Springs, Ione, and Chico Formations. These sediments generally strike north-south and form a wedge that thickens from tens of feet at the eastern Aerojet Site boundary to greater than 2,000 feet near the western Aerojet property boundary (Figure A-3). The sediments of interest for this report include the undifferentiated Quaternary sediments, Laguna, Mehrten, and Valley Springs Formations, and contain hydrostratigraphic Layers A through E as described in later sections of this report. Descriptions of each of these geologic formations are provided in the Scoping Report (ICF Technology, 1989) and the GET E and F Effectiveness Evaluation Report (Aerojet/Hydro-Search, 1996).

2.2 Study Area Hydrostratigraphy

The following description of the hydrostratigraphy of the Study Area is based largely on work presented in "Aerojet Site - GET E and F Effectiveness Evaluation Report" (Aerojet/Hydro-Search, 1996b). Six hydrostratigraphic layers (Layers A through F) were defined at GETs E and F based on lithologic descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thickness. Layer F is not addressed in this RI as the deepest observed impact on- or offsite is in the upper portion of Layer E.

Data collected from numerous aquifer tests in the vicinity of GETs E and F were used to confirm and refine the hydrogeologic model on the Aerojet Site. Very few aquifer tests have been conducted in the western offsite areas, and correlation between the on- and offsite hydrostratigraphic layers was based primarily on relative depths, stratigraphy, water levels, and chemical concentrations. Hydrostratigraphic Layers A and B, that appear to be present primarily in the eastern portions of the Study Area, are not

distinct in the western offsite area. Layers C, D, and E appear to be regional features and are more easily correlated between the on- and offsite areas.

The hydrostratigraphic layers discussed in this report do not account for the entire 2,000 feet of sediments present at the western Aerojet Site boundary. The Ione and Chico Formations, estimated at 1,000 to 1,500 feet below ground surface (bgs) in the Study Area, contain saline water that would not yield potable quality. The deepest contamination at the Aerojet Site has been observed in Layer E at depths of approximately 400 to 500 feet bgs. Therefore, there are approximately 500 feet of freshwater sediments below the deepest observed contamination and above the saline formations.

Three cross sections were drawn to depict subsurface conditions in the Study Area (Figures A-4, -5, and -6). The sediments on the cross sections were grouped into relatively higher and lower permeability's to show the overall stratigraphy, potential groundwater flow paths, and the general structural characteristics of the hydrostratigraphic layers. The following sections present brief descriptions of the predominant lithologies and the typical depths and thickness for each of the hydrostratigraphic layers. These descriptions vary locally due to stratigraphic heterogeneity.

2.2.1 Layer A – Hydrostratigraphy

Layer A, the uppermost layer, is located primarily in the GET F area and is composed predominantly of unconsolidated sand and gravel consisting of granitic, metamorphic, and volcanic clasts eroded from the Sierra Nevada. Clast sizes range from large (>1 foot diameter) boulders and cobbles to sands, silt and clay. The primary bedding features have been disturbed to depths of 20 to 80 feet bgs by historic gold dredging activities throughout much of the Study Area. Consequently, precipitation will readily infiltrate into the dredged areas and storm water runoff is minimal compared to undredged areas.

The saturated thickness of Layer A ranges from zero to approximately 20 feet. The depth to the top of Layer A ranges from 40 to 50 feet below ground surface (bgs) near the source areas located in the east to 80 to 100 feet bgs in the central portion of the Study Area near GETs F. Layer A is generally unsaturated on the Aerojet Site to the north, south and west of GET F. At these locations, groundwater from Layer A probably infiltrates downward into Layer B, and does not discharge to surface waters.

2.2.2 Layer B - Hydrostratigraphy

Layer B occurs within the basal sands and gravels of the Quaternary sediments, and appears to be continuous beneath most of the Aerojet Site and the IRCTS. The sediments designated as Layer B grade from relatively coarse-grained materials in the east to relatively finer-grained materials near GET F and in the western offsite area. The westward "fining" of Layer B is coincident with an observed increase in thickness of the B/C aquitard. The B/C aquitard increases in thickness (from tens of feet to over 100 feet) and depth (from 50 to 180 feet bgs) from the western Aerojet Site boundary to the western Study Area boundary. During the recent offsite drilling program, thin (<15 feet) lenses of fine-grained sand were sometimes encountered within the aquitard material overlying Aquifer C at depths ranging from 100 to 180 feet bgs (Figures A-4, -5, and -6). Monitor wells constructed within these sand lenses were tentatively assigned to Layer B based on stratigraphy alone, although it is not clear that these lenses are continuous or are hydraulically connected with the monitoring wells assigned to Layer B on the Aerojet Site or the IRCTS.

2.2.3 Layer C - Hydrostratigraphy

Layer C is composed predominantly of sand, sandstone, and minor gravel with varying degrees of cementation. Thin (1- to 10-foot) interbeds of brown siltstone and clay are common. Layer C ranges in thickness from 50 to 125 feet with an average thickness of approximately 80 feet. It is saturated and continuous throughout the Study Area. The top of Layer C forms a relatively planar surface with a strike of N12°W and a southwesterly dip of approximately 1°. This attitude is consistent with the attitudes of regional geological formations which are reported to strike generally north-south and dip to the west at 1- to 3° (DWR, 1974).

2.2.4 Layer D - Hydrostratigraphy

Layer D is composed of mafic sands and sandstone with some gravel. On the Aerojet Site, Layer D ranges in thickness from 30 to 150 feet. The base of Layer D is present at depths of approximately 360 to 400 feet bgs. Layer D is separated from Layer C by 10- to 45-foot thick clay and siltstone layer.

2.2.5 Layer E - Hydrostratigraphy

Layer E is comprised of sand, sandstone, and some gravel with interbedded silt and clay lenses. In general, the silt and clay lenses are more abundant and are thicker in Layer E than those observed in overlying Layers C and D. The sediments in Layer E are dominantly black or greenish. The top of Layer E occurs at depths of 350 to 400 feet bgs near the western Aerojet boundary. The available data indicate Layer E is at least 100 feet thick.

2.3 Groundwater Flow in the Study Area

Groundwater flow directions and gradients have been studied for many years on the Aerojet Site and on the IRCTS. During the past several years, monitor wells installed in the western offsite areas have provided additional data to interpret groundwater flow in the offsite areas. Potentiometric contour maps dating from April 1991 through March 1998 were reviewed to assess temporal and seasonal trends in the groundwater flow directions (Figures A-7 through A-11).

The maps for each layer vary by both geographic areas covered and the number of wells used to generate the contours. In general, the more recent maps contain more data points over a broader area than the older maps and are probably more indicative of regional groundwater flow patterns. In addition, the maps prepared for April 1991 were based on a similar, but different, set of hydrostratigraphic layers than Layers A through E used on the more recent maps. All potentiometric surface contours were generated by kriging using various software packages. Nevertheless, the various approaches show that groundwater flows toward the west-southwest in each of the layers.

2.3.1 Layer A - Groundwater Flow

The potentiometric surface maps illustrate that Layer A is only present in a relatively small area on the Aerojet Site (Figure A-7). Groundwater is extracted from Layer A by two extraction wells at GET F; Layer A is dry at GET E. Note the map prepared in 1991 represents a theoretical water table map that is not based on the current hydrostratigraphic correlation and is not necessarily a comparison of the same water-bearing strata. The 1991 map does show the general groundwater flow directions for the unconfined aquifer over a much larger area than just the Study Area.

In the West Lake area on the Aerojet Site, the potentiometric surface contour elevations measured in October 1994 are approximately 20 feet lower than those measured in April 1995, suggesting a seasonal fluctuation of the water table in this area. However, the potentiometric surface elevations measured near Chemical Plant 2 are about the same during both periods. This suggests there is more recharge in the vicinity of West Lake, possibly as a result of the retention of storm water in West Lake during the rainy season.

Layer A is not saturated in the northern, southern (IRCTS), and western portions of the Study Area and Layer A is poorly defined west of the Aerojet Site. Where saturated, the groundwater elevations in Layer A range from approximately 90 feet above MSL in the east to approximately 40 feet above MSL in the west (Figure A-7). Groundwater flow directions vary locally, but generally trend to the west-southwest with an average hydraulic gradient of approximately 0.005 foot per foot (25 feet per mile).

2.3.2 Layer B - Groundwater Flow

The four potentiometric surface contour maps for Layer B show similar groundwater flow directions and gradients since 1991 (Figure A-8). Groundwater elevations in Layer B decrease from approximately 100 feet above MSL in the east to approximately 15 feet above MSL in the west. The potentiometric surface map indicates a west to west-southwest direction of groundwater that is locally affected by groundwater extraction at GET F. The groundwater depression near GET F is due to the extraction well in Layer B and probably due to the more significant pumping of Layer C. During 1998, drawdown is apparent in Layer B at GET E and would be caused by pumping in Layer C since none of the extraction wells at GET E are screened in Layer B. On the northwestern portion of the IRCTS, a groundwater mound is coincidentally located at the former GET F Sprayfield, but is probably due to leaking water mains along White Rock Road or possibly related to the dredge tailings, since the use of the sprayfield was terminated in 1990 and water levels have returned to pre-sprayfield conditions. The average hydraulic gradient across the Study Area is 0.004 foot per foot (20 feet per mile). Steeper gradients are present locally in the areas of groundwater extraction.

2.3.3 Layer C - Groundwater Flow

The potentiometric surface maps for Layer C do not show many changes in the groundwater flow directions and gradients from 1991 through 1998 (Figure A-9). Groundwater elevations in Layer C decrease from approximately 75 to -10 feet MSL from east to west across the Study Area. The

groundwater flow direction is generally west-southwest with deviations in the groundwater flow direction evident in the vicinity of the GETs E and F extraction and recharge wells, which are screened primarily within Layer C and to a lesser extent in Layer D. Groundwater elevations are approximately 20 feet higher in the vicinity of the recharge wells than in the vicinity of the GET E and F extraction wells. The groundwater recharge mound dissipates toward the west and is not apparent west of Sunrise Boulevard. The average hydraulic gradient across the Study Area is approximately 0.004 foot per foot (20 feet per mile). In general, the horizontal gradient is steepest in the east and flattens to the west.

2.3.4 Layer D - Groundwater Flow

The potentiometric surface for Layer D has not varied much since 1991 (Figure A-10). The elevation of the potentiometric surface in Layer D decreases from approximately 100 feet above MSL in the eastern portion of the Study Area to 0 feet below MSL in the west. The groundwater flow direction is west-southwest to west across most of the Study Area with deviations in the vicinity of the GET E and F extraction and recharge wells. At GET E, five extraction wells are partially screened through Layer D and create a larger groundwater depression than that observed at GET F, where no extraction wells are screened in Layer D. A groundwater mound is evident in the vicinity of the recharge well field since the recharge wells are also screened in Layer D. The hydraulic gradient averages approximately 0.004 foot per foot or 20 feet per mile across the Study Area. As with Layer C, groundwater gradients are generally steepest in the east and flatten to the west.

2.3.5 Layer E - Groundwater Flow

The potentiometric surfaces for Layer E show a more westerly direction of groundwater flow than the overlying layers (Figure A-11). This difference in the direction of groundwater flow could be due to the pumping of a water-supply wells completed in Layer E or possibly due to the relatively fewer monitor wells in Layer E. The elevation of the potentiometric surface in Layer E decreases from approximately 70 feet above MSL in the east to 10 feet below MSL in the west. The direction of groundwater flow is generally westward in the vicinity of GETs E and F. The hydraulic gradient averages approximately 0.004 foot per foot, or 20 feet per mile.

2.3.6 Vertical Head Differences

The potentiometric surface maps prepared in April 1998 for Layers A through E were compared to assess the potential for vertical migration between the layers. These comparisons were conducted by subtracting the kriged potentiometric surface of the underlying layer from the kriged potentiometric surface of the overlying layer. The resulting differences in the potentiometric surfaces were contoured to provide an aerial view of head differences. Positive numbers on the figures indicate a downward head potential, and negative numbers indicate an upward head potential. The subtraction of the layer surfaces was performed in Surfer® using the GRID, math, subtract functions. Surfer® requires that the aerial coverage for each layer be the same so, because aerial coverage for each layers is different, the grids were re-sized to fit the smallest layer being subtracted. Figures A-12 through A-15 present the contoured potentiometric head differences for Layers AB, BC, CD, and DE, respectively.

Figure A-12 indicates there is a potential for downward vertical migration from Layer A to Layer B wherever Layers A and B co-exist. This potential is greatest in the vicinity of GET F where vertical head differences of up to 34 feet were observed. The strong downward potential in this area is caused by groundwater extraction from Layer B, although a small amount of water (approximately 15 gallons per minute) is also extracted from Layer A. Layer A is dry west and north of GET F, where there are no potentiometric surface difference contours.

Figure A-13 shows the contoured potentiometric surface differences between Layers B and C. There is a potential for downward vertical migration of groundwater from Layer B to Layer C throughout most of the Study Area. The strongest downward head potentials are present in the vicinity of GET E, GET F, and along the northern portion of the IRCTS. A slightly upward potential (-2 feet) exists from Layer C to Layer B on the east and west sides of the recharge well field. As noted in Section 2.2.2, it is not clear that Layer B west of the Aerojet Site is hydraulically connected with Layer B on the Aerojet Site.

The head differences between Layers C and D vary depending on localized pumping (Figure A-14). In the vicinity of GET E, where both Layers C and D are pumped, the potentiometric surface of Layer C ranges from zero to 8 feet above the potentiometric surface of Layer D, indicating the potential for downward migration from Layer C to Layer D. However, in the vicinity of GET F, where only Layer C is pumped, there is a strong upward vertical potential (-16 feet) from Layer D to Layer C. West of the Aerojet site, the vertical head differences between Layers C and D are generally within feet. There is an

exception at one monitor well west of Coloma Road where the potentiometric surface of Layer C is 8 feet higher than the potentiometric surface of Layer D.

Figure A-15 presents the contoured potentiometric surface differences between Layers D and E. There were insufficient monitor wells completed in Layer E west of the Aerojet Site to prepare potentiometric surface contours in this area in April 1998, and the potentiometric surface difference contours between layers D and E do not extend west of Sunrise Boulevard. In the northeastern portions of the Study Area, the potentiometric surface for Layer D is up to 16 feet higher than the potentiometric surface for Layer E, suggesting the potential for downward vertical flow from Layer D to Layer E. However, groundwater extraction from Layer D at GETs E and F causes the vertical head potential to switch from downward to weakly upwards around the GET facilities.

3.0 DISTRIBUTION OF CHEMICALS IN GROUNDWATER

This section describes the types and distributions of chemicals present in groundwater beneath the Study Area. This information will be used to conduct a baseline risk assessment and to prepare engineering costs estimates for the alternatives being evaluated in the feasibility study. The discussions of chemical distribution are presented by hydrostratigraphic layer from the shallowest to the deepest layers (i.e., Layers A to E). The distributions of the various chemical classes (e.g., VOCs, perchlorate) are discussed separately within each layer. The sampling period for this RI ranges from January 1996 through December 1998, although some groundwater data collected before or after these dates are incorporated to fill data gaps as needed and to place contour lines in areas that were not sampled during the sampling period.

3.1 Remedial Investigation Approach

The Sitewide remedial investigation at Aerojet has been ongoing for over 13 years, and has included both vadose zone and groundwater investigations. The RI for the Western Groundwater Study Area is the first in a series of operable unit remedial investigation/feasibility studies for the Aerojet Site. The following sections summarize the results of the relevant site-wide work and provide background information explaining how the RI for the Study Area evolved to its current state.

Section 3.1.1 describes the methodology for placing monitor wells and presents a general chronology of monitor well installation. The development of the analytical program, including discussion of target analytes and specialty chemicals handled at Aerojet are summarized in Section 3.1.2. An approach for handling tentatively identified compounds is presented in Section 3.1.3. Section 3.1.4 describes the geographic distribution of the current data and explains the criteria for posting data on the figures prepared for Sections 3.2 through 3.7.

3.1.1 Development of Groundwater Monitoring Network

Aerojet began installing monitor wells in the Study Area in 1979. The first wells were installed at or near potential source sites east of the Study Area to evaluate whether chemicals had reached groundwater. After confirmation of groundwater contamination, Aerojet installed a series of monitor wells downgradient of the source areas and along its property boundaries from 1980 through 1991. During the

mid- to late-1980's, Aerojet constructed GETs E and F near its northwestern and southwestern property boundaries to control the flow of chemicals off-site. Monitor wells installed during the 1990s were intended to monitor GET effectiveness and for RI groundwater characterization.

In 1997, following the discovery of perchlorate in several public water supply wells, Aerojet installed a series of monitor wells to characterize the vertical and lateral extent of perchlorate west of the Aerojet Site. These wells were also used to evaluate the extent of NDMA when NDMA was discovered at GET E, and subsequently, the GET E recharge wells.

Sections 3.2 through 3.7 describe the distribution of chemicals in groundwater and have incorporated some data from wells located outside of the Study Area. Data collected from at least 483 monitor wells were evaluated, including data collected from 42, 60, 186, 127, and 68 monitor wells completed in Layers A, B, C, D, and E, respectively.

Monitor wells in the Study Area were screened in the most permeable portions of the aquifer based on the premise that the permeable units would act as preferential groundwater and contaminant pathways. These wells have provided the data necessary to construct a reasonably accurate assessment of the lateral and vertical extent of CoPCs. However, there are, and always will be, uncertainties associated with the extent of CoPCs. Some factors contributing to these uncertainties include the heterogeneous distribution of sediments within the aquifer, the large aerial and vertical extent of CoPCs in groundwater, the unknown extent of contributions from off-site sources, and the fate and transport characteristics of some CoPCs. The RI activities in the off-site areas will continue as groundwater containing CoPCs migrates and new information is collected.

3.1.2 Development of Groundwater Analytical Program

The development of an analytical program for a site like Aerojet is very difficult due to the large number of chemicals handled and the complex nature of plant operations. These difficulties are recognized in CERCLA and are addressed by following a systematic process of chemical identification, screening, and assessment. These processes at the Aerojet Site have resulted in the development and/or refinement of analytical methods for identifying unique or specialty chemicals, the formation of Target Analyte Lists (TALs) for the Study Area groundwater, and an approach for handling tentatively identified compounds (TICs).

The Scoping Report and Stage I RI identified over 400 compounds handled at the Aerojet facility based on interviews with Aerojet personnel, reviews of historical data, and reviews of Site documentation related to chemical handling and use (ICF Kaiser Engineers, 1989 and 1993). These 400 compounds were divided into two groups: 1) Chemicals for which there were standard analytical methods and 2) Chemicals for which there were no standard analytical methods. Standard analytical methods were identified for approximately 116 of the chemicals identified in the record search. These chemicals were analyzed as appropriate in soil, soil-gas, and groundwater during the Stage 1 RI.

In addition to the chemicals identified on standard analyte lists, Aerojets analytical laboratory developed methods to detect some unique or specialty chemicals manufactured and/or handled at Aerojet. These compounds include Prowl (pendimethalin), hydrazine, perchlorate, nitroguanadine, NDMA, and 10,10'-oxybisphenoxarsine (OBPA). In addition, the analytical detection limits for perchlorate and NDMA were lowered by two orders of magnitude within the past three years to provide analytical data closer to the perceived risk levels.

The chemicals for which analytical methods did not exist were placed on the non-standard chemical (NSC) list and evaluated following CERCLA and RCRA guidance. These guidance documents recognize that the development of analytical methods to detect all potential NSCs is both time consuming and expensive, and as such can paralyze the CERCLA process. Therefore, the CERCLA process recommends the use of TALs that employ standard analytical methods and look for a wide range of chemicals, but not every known chemical. The use of TALs provides a method for identifying, screening and characterizing chemicals that should be adequate to identify appropriate levels of risk and provide a basis for selection of remedies.

TALs were developed for the Aerojet Site based on historical and Stage 1 analytical data and history of chemical usage (types and volumes). Development of the TALs resulted in the formation of comprehensive analyte lists for groundwater. These lists are zone-specific and are based on chemicals handled and/or chemicals detected in soils and/or groundwater in each zone. The Study Area is located in the western portion of Zone 2. All new monitor wells installed in Zone 2 since 1991 have been initially sampled for the following analytes:

- Volatile organic compounds (VOCs)
- Semi-volatile organic componds (SVOCs)
- Perchlorate
- Metals
- Chromium VI
- Total petroleum hydrocarbons
- Anions
- Field measurements (pH, electrical conductivity, temperature)

Beginning in 1998, NDMA was added to the initial comprehensive analyte list for new monitor wells in Zone 2. Following the initial sampling, each new well is sampled for three quarters. The analyte list for the quarterly sampling is based on the results of the initial sampling, but typically includes VOCs, perchlorate, and any other compounds detected during the initial sampling.

3.1.3 Tentatively Identified Compound (TIC) Approach

Another component of the analytical program plan development was the institution of a formal process for evaluating TICs. Analytical methods utilizing gas-chromatography/mass spectroscopy can tentatively identify compounds through the use of extensive chemical databases. The current TIC databases and those used during the Stage 1 RI included over 150,000 compounds. During Stage 1, TIC data were evaluated based on frequency of detection and repeatability. This evaluation resulted in the addition of 1,4-dioxane, 2-methyl pyrillidanone, and butyl-benzene sulfonamide to the TAL.

During recent negotiations on the Phase I RI/FS Stage 2 Sampling Plans and in response to the Agencies demands, Aerojet developed a TIC approach for use during the OU RI/FS process. For each operable unit the following TIC approach would be applied:

Step 1: Summarize TICs reported in Aerojet site database from RI/FS investigation. Create inventory and map distribution of TICs in groundwater and soil for the OU.

Step 2: Evaluate results from Step 1 and determine data gaps and necessary groundwater and soil sampling. Add sampling to OU RI/FS workplan.

Step 3: Evaluate data collected as part of OU RI/FS workplan and compare to previously existing information. Update inventory and maps.

Step 4: Evaluate retention times and goodness of fit for unknown TICs detected during OU RI/FS in soils and groundwater. For TICs with a possible identification confirmed in either soils and groundwater or in soils or groundwater, examine laboratory TIC results (mass spectra compound fingerprint) from OU RI/FS and attempt to determine probability of correct identification of TICs.

Step 5: TICs for which the mass spectra data have been reviewed and the correct identification confirmed, evaluate toxicity and risk information available.

This TIC approach was developed and approved after the sampling period evaluated for this RI (Spring 1999). However, Aerojet recently conducted an evaluation of TICs in Exhibit IV public, private and monitor wells (Aerojet, 1999). The results from this recently completed analysis are presented in Sections 3.2 to 3.7.

3.1.4 Data Distribution and Posting Criteria

After completion of the initial four quarterly samples from a new monitor well, the well may be added to a Groundwater Monitoring Program. The monitoring frequencies and analytes specified in each Groundwater Monitoring Plan vary, and as a result, the current groundwater data coverage varies throughout the Study Area. In general, the Study Area can be subdivided into four general areas based on the monitoring plan(s) implemented in each area:

1. Source areas on the Aerojet Site
2. GET E and F areas
3. Western offsite area
4. IRCTS

Figure A-16 is a generalized schematic showing the components of the monitoring plans implemented within these areas. Note the IRCTS is not depicted on Figure A-16, but has experienced a similar evolution of monitoring plans, some of which overlap with the monitoring plans implemented on the Aerojet Site (e.g., Stage 1 RI). As shown on Figure A-16, monitor wells sampled under Exhibit VI (GET effectiveness monitoring) are not routinely sampled for semi-volatile organic compounds (SVOCs), metals, or other miscellaneous compounds. Therefore, current data are not available for these analytes in some portions of the Study Area. Nevertheless, sufficient data exists to eliminate these analytes as CoPCs. It is important to note that most of the wells in the western offsite area were installed within the past three years and have been sampled for the comprehensive suite of analytes under the new monitor well sampling program.

The distributions of CoPCs in the Study Area are strongly influenced by the locations of the source areas, the direction of groundwater flow, and the operations of GETs E and F. Figure A-17 presents a conceptual model depicting the potential migration of CoPCs from source areas on the Aerojet Site to the western offsite groundwater. Dissolved CoPCs have generally migrated from source areas located east of the Study Area toward GETs E and F. For the past 12 to 15 years, GETs E and F have treated groundwater for VOCs, but not for perchlorate or NDMA. Most of the water treated at GETs E and F was recharged back into Layers C and D through a series of recharge wells. From December 1984 to February 1990 and in August 1990, groundwater extracted from GET F extraction Wells 4007 and 4060 (formerly GET F South) was treated for VOCs, and then discharged to the GET F Sprayfield located on the IRCTS.

Over forty public and domestic water supply wells are located within the Study Area west of Aerojet and IRCTS (Figure A-18). Some of the wells shown on Figure A-18 are outside (west) of the Study Area boundaries. Aerojet collects water quality samples from many of these wells in accordance with the provisions in Exhibit IV of the PCD. The PCD requires Aerojet and the Agencies to review the Exhibit IV wells, sampling frequencies, and analytes on an annual basis. Data collected from the public and domestic water supply wells (PWSWs) are incorporated into the following discussions and summarized in Section 3.7. Water quality data collected from the PWSWs were posted on the chemical isoconcentration maps for informational purposes. The PWSW data are composite samples collected over relatively long screened intervals (or open borehole), often penetrating multiple hydrostratigraphic layers. These data are not the same as chemical concentrations that are collected from a well screened in a single layer and were not used to prepare the chemical contours.

The data posted on the chemical isoconcentration maps represent the most recent primary sample result collected within the sampling period, unless historical data trends indicated the most recent data was anomalous. Many of the monitor wells in the Study Area were sampled numerous times over periods ranging from 1 to 13 years. During this period, data trends and "representative" chemical concentrations for most locations in the Study Area were evaluated. The current data were compared to previous chemical isoconcentration maps to evaluate the consistency of the data with respect to chemical concentration trends and the well location. In addition, duplicate and replicate sample results were not posted in the tables or on the figures because the results do not vary significantly from the primary sample results.

3.2 Layer A - Distribution of Chemicals in Groundwater

Groundwater chemical data from 43 wells were used in this analysis of Layer A groundwater quality. Groundwater data are presented for some Layer A wells that contained sufficient water when they were sampled, but were dry during the biannual water level measurements. The majority of monitor wells screened in Layer A are located in the eastern portion of the Study Area near source areas on the Aerojet Site. There are also monitor wells screened in Layer A in the vicinity of GETs E and F. Layer A is generally dry west of Aerojet and on the IRCTS.

The last comprehensive sampling of monitor wells screened in Layer A was conducted in 1991-93 during the Stage 1 RI. These data were reviewed to provide additional support for the conclusions reached in this analysis. In the Spring of 1999, perchlorate and TCE samples were collected from eight of the ten wells recommended for sampling in the Evaluation of Perchlorate and NDMA Technical Memorandum (Aerojet, 1998). The remaining two wells (Wells 355 and 1241) were dry or did not contain enough water to sample.

Two existing extraction wells are screened in Layer A in the Study Area (Wells 4007 and 4310) and are part of GET F, located in the southwestern portion of the Aerojet Site near Chemical Plant 2 (Figure A-19). Well 4007 has screened intervals in both Layers A and B. Within the past year, the water level in well 4310 has dropped below the top of the screen and the well has not been operating. Groundwater extracted by these wells was treated for VOCs, and then recharged. Groundwater extraction in the vicinity of GET F is ongoing and the discussion in this area focuses on the chemical distribution upgradient and downgradient of the extraction wells.

3.2.1 Layer A - Distribution of VOCs

VOC analyses were conducted on groundwater samples from 18 monitor wells screened in Layer A from January 1996 through April 1999 (Tables A-1, -2, and -3). The majority of the most recent groundwater sampling in Layer A was conducted in the vicinity of the GET F extraction wells. Many monitor wells located near VOC source sites or in areas with known high concentrations of VOCs in groundwater are not routinely sampled and were last sampled during the Stage 1 RI. These older data were reviewed to supplement the more recent data during the preparation of isoconcentration maps.

Six VOCs: TCE, 1,2-dichloroethene (1,2-DCE), 1,1-dichloroethene (1,1-DCE), vinyl chloride, 1,2-dichloroethane (1,2-DCA), and chloroform were detected above their respective MCLs in Layer A. Three of the VOCs detected above MCLs (TCE, chloroform, and 1,2-DCA) were detected on the Aerojet Site. The remaining three VOCs detected above MCLs (1,2-DCE, 1,1-DCE, and vinyl chloride) were detected off-site in an area unrelated to Aerojet activities. An isoconcentration map was prepared for TCE; the predominant VOC detected in Layer A (Figure A-19). The distribution of all other VOCs detected above their respective MCLs is presented on Figure A-20.

TCE has historically been detected in Layer A at multiple source areas located in the eastern portions of the Study Area on the Aerojet Site. The source areas nearest GETs E and F include Line 01, 03, 04, 05 and Chemical Plants 1 and 2 (Figure A-19). TCE concentrations ranging from 4,000 to 240,000 µg/L have been reported in monitor wells downgradient of Lines 03 and 05 (Aerojet/Hydro-Search, 1996). The TCE emanating from these areas forms a plume that trends roughly southwest and terminates at the GET F extraction wells. TCE concentrations in Layer A average approximately 50 µg/L near GET F. The decrease in TCE concentrations from the source areas to GET F suggests the TCE has migrated downwards into Layer B. As discussed in Section 2.3.6, the potentiometric surface of Layer A near GET F is up to 34 feet higher than the potentiometric surface of Layer B. TCE concentrations in Layer A range from non-detect (<0.5 µg/L) to a maximum of 3 µg/L (Well 75) downgradient of the GET F extraction wells.

Layer A is predominantly dry west of Line 05 and along the northwestern Aerojet Site boundary, and first groundwater is present at depths of approximately 100 feet bgs (Layer B). An area of shallow (Layer A or perched) groundwater is present off-site northeast of Sunrise and Folsom Boulevards. There are several current or former industrial facilities and a former County landfill at this location. The highest concentrations of TCE, 1,2-DCE, 1,1-DCE, and vinyl chloride detected within the sampling period in Layer A were detected in well 30065, located in this vicinity (Figures A-19 and A-20). The relatively high VOC concentrations and shallow depths to water indicate the chemicals detected in this area are emanating from a local off-site source.

Chloroform and 1,2-DCA were the only other VOCs detected above MCLs on the Aerojet Site during the current sampling period (Figure A-20). Chemical Plant 1 was identified as a source of 1,2-DCA and chloroform, and Chemical Plant 2 was identified as a source of 1,2-DCA (ICF Kaiser, 1993). The highest concentrations of 1,2-DCA (480 µg/L) were detected in monitor well 3348 located at Chemical Plant 2. 1,2-DCA was detected in only one monitor well (3.4 µg/L in Well 75) downgradient of the GET F

extraction wells. Chloroform was detected at a maximum concentration of 230 µg/L in Well 22, located west of Line 05 and Chemical Plant 1 (Figure A-20). Chloroform concentrations attenuated to approximately 2 to 10 µg/L in the vicinity of GET F, and chloroform was not detected downgradient of GET F.

3.2.2 Layer A - Distribution of Perchlorate

Perchlorate analyses were conducted on groundwater samples from 15 wells screened in Layer A during the current sampling period (Tables A-3, -4, and -5). These data are presented and contoured on Figure A-21. Several monitor wells shown as not sampled (NS) on Figure A-21 were included within the 400 µg/L contour line based on perchlorate data presented in earlier reports (Aerojet, 1998).

The distribution of perchlorate in Layer A is very similar to that observed for TCE (Figures A-19 and A-21, respectively) because the upgradient source areas in Lines 01, 03, 04, and 05 contain both TCE and perchlorate (ICF Kaiser, 1993). Perchlorate concentrations attenuate from up to 100,000 µg/L detected in Line 03 (Aerojet/Hydro-Search, 1996) to approximately 400 µg/L detected at GET F (Figure A-21). As with TCE, the attenuation of perchlorate in Layer A is probably due to the downward migration of perchlorate from Layer A to Layer B. The concentration of perchlorate downgradient of GET F ranged from non-detect (< 4 µg/L) to 14 µg/L (Well 75).

Perchlorate was detected off-site in Layer A in monitor well 30065, located north of Highway 50 and east of Sunrise Boulevard (Figure A-21). The perchlorate concentrations in this well have declined from 20 µg/L to 6.5 µg/L during the last three sampling events (Table A-4). Well 30065 is screened from 28 to 48 feet bgs in a low-producing, perched groundwater lens. The shallowest water in the vicinity of GET E is present at depths of 90 to 100 feet bgs. The apparent lack of hydraulic connection and the declining perchlorate concentrations in Well 30065 suggest that the perchlorate is likely an artifact from well construction and development.

3.2.3 Layer A - Distribution of NDMA

The investigation of NDMA is ongoing and no clear point source(s) of NDMA have been identified in the Study Area. On the Aerojet facility, NDMA is typically associated with hydrazine-based fuels and liquid rocket engine testing that occurred on the eastern portion of the Aerojet Site. Limited handling of laboratory quantities of hydrazine reportedly occurred just east of the Study Area in the Line 05/Chemical

Plant 1 area (ICF Kaiser, 1993). Several monitor wells located near Chemical Plant 1 are included in this evaluation because they provide additional upgradient information on the NDMA distribution. A summary of the NDMA analyses is presented in Tables A-5 and -6 and shown on Figure A-22.

NDMA was detected in three monitor wells completed in Layer A (Figure A-22). NDMA concentrations ranged from 0.019 to 0.81 µg/L in monitor wells located near Chemical Plant 1 (Tables A-5 and A-6). No sources of NDMA were identified at Chemical Plant 1 during the Stage 1 RI, however, the detection limits attainable during Stage 1 were at least two orders of magnitude higher than the current detection limits (i.e., MDLs of 0.10 versus 0.0075 µg/L). NDMA was not detected in the remaining wells, although, not all on-site wells completed in Layer A have been sampled for NDMA. Additional sampling for NDMA is being evaluated throughout the Study Area.

3.2.4 Layer A - Distribution of SVOCs

Most wells completed in Layer A were sampled for SVOCs during the Stage 1 RI. A summary of the SVOCs detected during the Stage 1 RI and during the current sampling period is presented in Table A-7. Phthalates, common laboratory contaminants, were the only SVOCs detected during Stage 1. The SVOC data collected during Stage 1 indicated that continued monitoring for SVOCs in Layer A was not warranted, and most SVOC sampling was discontinued. In 1996 and 1997, SVOCs were included in the analysis of groundwater samples from off-site wells 30062, 30063, and 30065. SVOCs were not detected in the samples (Table A-7).

3.2.5 Layer A - Distribution of Metals

Most monitor wells completed in Layer A were sampled for metals during the Stage 1 RI. During Stage 1, it was noted that monitor wells were yielding metals in areas where no known metals usage occurred. It was determined that field filtering of the samples was necessary to prevent metals present in sediments from being reported as dissolved metals. Aluminum, barium, cadmium, chromium, lead, and mercury were reported above MCLs in the unfiltered groundwater samples collected in the vicinity of Chemical Plant 1 (ICF Kaiser, 1993). After Aerojet began filtering samples in June 1993, groundwater samples did not yield any metals concentrations exceeding primary or secondary MCLs (ICF Kaiser, 1993). Although all wells with unfiltered metals concentrations exceeding MCLs were not re-sampled, filtered metals data collected from the deeper layers confirm that metals are not a CoPC in the Study Area (Sections 3.3.5, 3.4.5, 3.5.5, and 3.6.5).

During the current sampling period, three new offsite wells north of Highway 50 and east of Sunrise Boulevard were sampled for metals. Two of these wells yielded metals concentrations slightly above primary or secondary MCLs (Table A-8). Well 30063 yielded aluminum (1.1 mg/L) above the primary MCL (1.0 mg/L) and iron (0.32 mg/L) just above the secondary MCL (0.3 mg/L). Well 30065 yielded aluminum (0.68 mg/l) and manganese (0.12 mg/L) above their respective secondary MCLs (0.2 and 0.05 mg/L, respectively). As discussed in Section 3.2.1 it is unlikely that these wells are monitoring chemical impacts associated with the Aerojet Site.

3.2.6 Layer A - Distribution of Miscellaneous Compounds and TICs

During the Stage 1 RI, many monitor wells screened in Layer A were sampled for analytes that are not included in routine monitoring. A target analyte list was developed based on historical uses at the potential source sites, several of which are present in the vicinity of Chemical Plant 2. The target analytes identified for the Chemical Plant 2 area included OBPA and Prowl (a fungicide and herbicide manufactured at Chemical Plant 2), an anion scan, and miscellaneous petroleum hydrocarbons. The anion scan includes chloride, nitrate, total nitrogen (nitrate plus nitrite), and sulfate. The results of the Stage 1 sampling for the anions, OBPA, and Prowl are presented on Table A-9, and the results of the petroleum hydrocarbon sampling a presented on Table A-10.

OBPA and Prowl were not detected in any of the wells sampled (Table A-9). Nitrate was detected above MCLs (45 mg/L) in three of the 32 wells sampled during the Stage 1 RI (Table A-9). Nitrate exceeded MCLs in two wells sampled since the Stage I RI (Wells 3264 and 4310). Petroleum hydrocarbons were detected at 0.3 mg/L in Well 3264 in 1992, but were not detected in two subsequent analyses (Table A-10).

TICs were reported in the SVOCs analyses of three monitor wells in Layer A. Unknown hydrocarbons were detected at estimated concentrations ranging from 280 to 2,300 µg/L in offsite Wells 30062, 30063, and 30065 in 1997 (Table A-10). The presence of TICs in these wells was not confirmed by re-sampling because the Stage 2 TIC approach was developed two years after the wells were sampled. The presence of hydrocarbons in these wells, combined with the atypical suite of VOCs discussed previously, provides further evidence that an offsite source(s)(e.g., a former County Landfill, GZ Plastics) of chemicals exists in the vicinity of these wells.

3.2.7 Layer A - Summary of Chemical Distribution

Three VOCs (TCE, 1,2-DCA, and chloroform), perchlorate, nitrate, and NDMA were detected above their respective regulatory limits in monitor wells completed in Layer A on the Aerojet Site. The sources of these chemicals are located in Lines 01, 03, 04, 05, and Chemical Plants 1 and 2. Near these source areas, the chemical concentrations observed in Layer A were typically several orders of magnitude higher than those observed downgradient near the GET facilities. This is probably primarily due to the downward migration of chemicals and to dilution from recharge, but may be partially due to physical natural attenuation factors.

The offsite migration of chemicals in Layer A has not been observed in the Study Area. Layer A is currently dry along the northwestern and western perimeters of the Aerojet Site and in the vicinity of GET E and the GET E and F recharge fields (Section 2.3.1). TCE, 1,2-DCA, and perchlorate were detected at maximum concentrations of 3, 3.4, and 14 µg/L, respectively, in one monitor well (Well 75) downgradient of the GET F extraction wells; however, none of these compounds were detected in a monitor well (Well 3352) located 700 feet further downgradient. The analytical data show that the chemicals present in Layer A downgradient of the GET F extraction wells are very limited in type, quantity and extent.

North of Highway 50 and east of Sunrise Boulevard, groundwater contains four VOCs (TCE, 1,1-DCE, 1,2-DCE, and vinyl chloride) and several metals above MCLs. This suite of VOCs is suggestive of the reductive dehalogenation of TCE that is not typically observed in groundwater on the Aerojet Site. Petroleum hydrocarbons, which were rarely detected in the Study Area, were detected in this area at concentrations up to 2,300 µg/L. In addition, these chemicals are present in a monitor well (Well 30065) completed at depths of 28 to 48 feet bgs. Monitor wells located upgradient on the Aerojet Site and screened at similar depths are dry. These data indicate the chemical impacts in this area are not associated with activities on the Aerojet Site.

3.3 Layer B - Distribution of Chemicals in Groundwater

Groundwater data from over 80 monitor wells were used in this evaluation of Layer B. Two extraction wells (Wells 4007 and 4315) are screened in Layer B at the GET F facility; no extraction wells are screened in Layer B at GET E. Recharge well 5100, located at the northwest end of the recharge well field, is partially screened in Layer B.

3.3.1 Layer B - Distribution of VOCs

VOC analyses were conducted on 53 monitor wells screened in Layer B from January 1996 through April 1999 (Tables A-2, -3, and -12). Pre-1996 VOC data were reviewed to supplement the more recent data and to prepare the isoconcentration maps. Five VOCs (TCE, 1,1-DCE, 1,2-DCE, carbon tetrachloride, and chloroform) were detected above their respective MCLs in Layer B, although no VOCs were detected above MCLs off of the Aerojet Site or the IRCTS. Well 132, located near GET F, was the only well with VOCs other than TCE exceeding MCLs (Table A-12).

The distribution of TCE, the most commonly detected VOC, is presented on Figure A-23. TCE has been detected in Layer B at concentrations up to 88,000 µg/L near source areas located in Lines 03, 04, 05 and Chemical Plant 1 (Aerojet/Hydro-Search, 1996). The TCE in Layer B extends west from these source areas to GET F (Figure A-23). TCE was detected up to 4,900 µg/L in Well 132, located near GET F extraction well 4315. The lateral extent of TCE in Layer B is similar to that observed for Layer A; however, the TCE concentrations in Layer B near GET F are up to three orders of magnitude higher than those in Layer A (i.e., 50 versus 5,000 µg/L). TCE was not detected in Layer B downgradient of the GET F extraction well (Well 4315), or downgradient of the GET E and F recharge well field (Figure A-23).

TCE concentrations exceeded the MCL (5 µg/L) in four wells located within the Study Area on the northern portion of the IRCTS (Figure A-23). The TCE detected in Wells STSW-21 and STSW-03B may be related to activities at the Aerojet/McDonnell-Douglas propellant burn area (PBA).

TCE was detected at concentrations of 1.2 and 2.0 µg/L to the north and west of the Aerojet Site in Wells 30064 and 30002, respectively (Figure A-23). The TCE detected in Well 30016 is the farthest west detection of TCE in a monitor well in any of the layers. TCE was detected in three public water supply wells located along a southwest trending line roughly parallel to Folsom Boulevard and extending to Mather Field Road (Wells AC1, AC4, and AC5). PCE (Well 1011 at <0.5 to 2.1 µg/L) and chloroform

(Well 1135 at <0.5 to 1.2 µg/L) have also been detected more than one time in two of these three wells (Table A-3).

3.3.2 Layer B – Distribution of Perchlorate

Perchlorate data from 50 monitor wells screened in Layer B were reviewed for this evaluation (Tables A-2, -3, -13 and -14). The distribution of perchlorate shows three main areas of perchlorate within the Study Area. The first area consists of the plume located in Lines 03, 04, and 05 that flows roughly southwest from these source areas toward GET F (Figure A-24). The perchlorate concentrations in this plume attenuate from 100,000 µg/L near the source areas to approximately 5,000 µg/L downgradient at GET F (Aerojet, 1998). Perchlorate was not detected in two monitor wells located west (downgradient) of GET F; however, the sedimentary package designated as Layer B is typically absent west of GET F (Section 2.2.2).

A second area of perchlorate in Layer B is located on the northwestern portion of the IRCTS. The relatively high concentration portion of this plume originates at the former GET F Sprayfield and the joint propellant burn area and extends just beyond the western IRCTS boundary (Figure A-24). Layer B is the upper-most water-bearing zone in this portion of the IRCTS. Perchlorate migrating through Layer B southwest of the GET F appears to co-mingle with the perchlorate originating at the Sprayfield. These two plumes are distinguishable by the relatively higher perchlorate concentrations detected in monitor wells located within the former GET F Sprayfield. Perchlorate concentrations within the Study Area on the IRCTS range from non-detect up to 7,200 µg/L. The extent of perchlorate on the southern portion of the IRCTS appears to be undefined; however, numerous monitor wells are located to the east, south, and west of Well STSW-52A. Aerojet and The Boeing Corporation are jointly investigating this area and plume characterization will be completed under a separate CAO.

The third area of perchlorate in Layer B is located at the GET E and F recharge well field on the Aerojet Site (Figure A-24). Perchlorate concentrations up to 5,200 µg/L have been observed in this area, and are probably the result of recharge through Well 5100. Several attempts to define the western extent of perchlorate at this location yielded no substantial water-bearing units at the depths associated with Layer B in this area (typically 90 to 120 feet bgs).

3.3.3 Layer B – Distribution of NDMA

NDMA was detected in 5 monitor wells and one extraction well sampled in Layer B (Tables A-2, -3, and -15). The majority of NDMA was detected on the Aerojet Site within and downgradient of Line05/Chemical Plant 1 and near the West Lake retention ponds (Figure A-25). Groundwater flow directions indicate that the NDMA detected in well 3447, located north of West Lake, did not originate in the Line 05/Chemical Plant 1 area. There are no known or suspected source areas of NDMA upgradient of well 3447. Not all wells screened in Layer B were sampled for NDMA; however, the distribution of NDMA is scattered and is suggestive of a non-point source. The hydrostratigraphic characteristics of Layer B suggest that NDMA is not flowing offsite through Layer B (Section 2.2.2).

3.3.4 Layer B – Distribution of SVOCs

SVOC analyses were performed on samples from one new well (Well 3591) on the Aerojet Site, one existing well on the IRCTS (Well 1312), and all offsite wells except for Well 1466 (Table A-16). As discussed in Section 3.2.4, very few SVOCs were detected in overlying Layer A, and those that were detected are common laboratory contaminants (i.e., phthalates). Layer A is the primary source of chemicals to Layer B, therefore, the general absence of SVOCs in Layer A suggests that SVOCs should not be present in Layer B.

SVOCs were not detected in the wells located offsite with the exception of 25 µg/L of phenol reported in Well 30075 (Table A-16). Phenol was not detected in previous samples collected from Well 30075, and the one-time detection of 25 µg/L is well below the US EPA's Suggested No-Adverse-Response Level of 4,000 µg/L.

3.3.5 Layer - B – Distribution of Metals

Eight offsite wells west of Aerojet, three wells located on the IRCTS, and one new well located on Aerojet (Well 3591) were sampled for metals since 1996 (Table A-17). Metals concentrations have not exceeded the USEPA primary MCLs. Manganese was detected slightly above the USEPA secondary MCL (0.05 mg/l) at a concentration of 0.065 mg/l at Well 30098, located in the former GET F Sprayfield on the IRCTS.

3.3.6 Layer B – Distribution of Miscellaneous Compounds and TICs

Miscellaneous analyses of groundwater from Layer B included an anion scan that is routinely performed on new monitor wells. The anion scans included chloride, nitrate, total nitrogen (nitrate plus nitrite), and sulfate. Nitrate was not detected above MCLs (Table A-18). Chloride concentrations in Layer B ranged from 5.5 to 75 mg/L and sulfate concentrations ranged from 4.7 to 72 mg/L (Table A-18). Similarly to Layer A, unknown hydrocarbons were detected in three wells located east of Sunrise and Folsom Boulevards. Unknown hydrocarbons were reported at estimated concentrations ranging from 1,100 to 2,200 in Wells 30064, 30066 and 30075 (Table A-11). The presence of TICs in these wells was not confirmed by re-sampling because the Stage 2 TIC approach was developed two years after the wells were sampled. The presence of hydrocarbons in these wells suggests there is vertical hydraulic connection between Layers A and B at this location.

3.3.7 Layer B – Summary of Chemical Distribution

Five VOCs (TCE, 1,1-DCE, 1,2-DCE, carbon tetrachloride, and chloroform), perchlorate, and NDMA were detected above their respective regulatory limits in monitor wells completed in Layer B on the Aerojet Site. The chemicals in Layer B originate from the downward vertical migration of chemicals through overlying Layer A. This downward vertical migration appears to occur relatively close to the source areas, and was observed for TCE and perchlorate, the two most widely detected compounds.

The offsite migration of chemicals west of Aerojet and IRCTS through Layer B has not been observed to date. On the Aerojet Site, groundwater flowing through Layer B is intercepted by one extraction well at GET F. Layer B is generally absent west (downgradient) of GET F. On the IRCTS, chemicals in Layer B (primarily perchlorate and TCE) are not presently controlled by an extraction system. Monitor wells drilled west of the IRCTS to characterize Layer B did not encounter significant water-bearing units at the depths associated with Layer B, similar to the observations west of GET F to the north.

3.4 Layer C - Distribution of Chemicals in Groundwater

Groundwater data from over 190 monitor wells screened in Layer C were evaluated for this RI. Layer C is the shallowest layer present across the entire Study Area and is the most intensely monitored layer. Monitor wells screened in Layer C are utilized to evaluate chemical migration from the source areas, the effectiveness of the GET facilities, offsite plume characterization, and public water supply well

protection. There are five extraction wells at GET E, three extraction wells at GET F, and six recharge wells either entirely or partially screened in Layer C.

3.4.1 Layer C – Distribution of VOCs

VOC analyses were conducted on groundwater samples from over 150 monitor wells screened in Layer C from January 1996 through December 1998 (Tables A-2, -3, and -19). A review of the most recent VOC data from each well shows that four VOCs (TCE, 1,1-DCE, 1,2-DCA, and chloroform) were detected above USEPA and California Department of Health Services (CADHS) primary MCLs, and two VOCs (1,2-DCE and carbon tetrachloride) exceeded the CADHS primary MCL. TCE was the only VOC detected above MCLs west of the Aerojet Site or the IRCTS.

Previous investigations reported TCE concentrations up to 5,000 µg/L in the eastern portion of the Study Area near source areas (i.e., Lines 03, 05, and Chemical Plant 1) located on the Aerojet Site (Aerojet/Hydro-Search, 1996). Most of the wells located in the source areas were not sampled within the sampling period and the data are not included on Figure A-26. However, the contour lines prepared during these investigations were retained on Figure A-26 to illustrate the presence of these source areas. The natural groundwater gradient, combined with the hydraulic mound created by the GET E and F recharge well field, directs the TCE-impacted water from the source areas to the west-northwest and west-southwest towards GETs E and F, respectively. TCE was detected up to 1,000 µg/L in the vicinity of the GET E extraction wells. TCE concentrations in the vicinity of the GET F extraction wells are higher, generally ranging from 1,000 to 6,000 µg/L.

TCE concentrations off-site and downgradient of GETs E and F are substantially lower than those observed on the Aerojet Site (Figure A-26). TCE is present offsite to the north of GET E and extending approximately 12,000 feet southwest to Zinfandel Drive. In this area, TCE was detected in four public water supply wells at concentrations ranging from 1.2 to 97 µg/L. The TCE concentrations observed in well 1014/AC9 and those detected in several nearby monitor wells are higher than the TCE concentrations observed in monitor wells immediately downgradient of GET E and along the northern Aerojet property boundary. These data and groundwater flow directions suggest there may be other off-site sources of TCE in this area.

TCE was detected above the MCL in eleven monitor wells at eight locations downgradient of GET F and south of GET F on the northwestern edge of the IRCTS (Figure A-26). The majority of TCE in this area

is generally confined to the Aerojet Site and the IRCTS, although some TCE may have migrated just beyond the western IRCTS boundary. Potential sources of TCE in this area include the joint propellant burn area and upgradient sources located on Aerojet. The potential source(s) are not differentiated in this analysis. The most recent TCE result for well STSW-03C (810 µg/L) was not posted on Figure A-26 because this result is 7 times higher than any previous result from this well and appears to be anomalous (Table A-19).

TCE was detected at relatively low concentrations (up to 13 µg/L) southwest of the GET E/F recharge wells (Figure A-26). The TCE in this area appears to be limited in aerial and vertical extent.

In addition to TCE, four VOCs were detected above their respective MCLs in monitor wells located on the Aerojet Site (Figure A-27). Chloroform and 1,2-DCA were detected downgradient of Line 05/Chemical Plant 1 as far southwest as Chemical Plant 2. Both compounds were used in these areas and their detections are consistent with the identification of source sites in these areas (ICF Kaiser, 1993). 1,2-DCE and 1,1-DCE, both potential breakdown products of TCE, were also detected downgradient of Chemical Plant 1/Line 05 as far southwest as Chemical Plant 2. These compounds are probably the result of the biological breakdown of TCE that has been documented in groundwater in this area (Beak, 1997).

3.4.2 Layer C – Distribution of Perchlorate

Perchlorate analyses were conducted on groundwater samples collected from over 150 monitor wells screened in Layer C from January 1996 through April 1999 (Tables A-2, -3, -14, and -20). The perchlorate detected in Layer C has the most widespread distribution of any chemical detected in any of the hydrostratigraphic layers (Figure A-28).

On the eastern side of the Study Area, perchlorate in Layer C has "stair-stepped" down from east to west through overlying Layers A and B. Perchlorate concentrations range up to 1,500 and 8,200 µg/L in the vicinity of GETs E and F, respectively (Aerojet, 1998). Groundwater with perchlorate was extracted from Layer C through five extraction wells at GET E and three extraction wells at GET F. Prior to 1999, the extracted groundwater was treated for VOCs then recharged through the GET E and F recharge wells forming the majority of the plume observed west of the Aerojet Site. The irregular shape of the perchlorate plume in the northwestern portion of the Study Area suggests some influence from regional groundwater pumping. The maximum lateral extent of perchlorate downgradient of the recharge well field (defined by the 4 µg/l contour line) may extend west to approximately Zinfandel Drive. Figure A-4

is a cross section showing perchlorate concentrations in monitor wells from the GET F recharge well field to the furthest downgradient monitor well (Well 30116-8). This cross section shows the highest perchlorate concentrations downgradient of the GET F recharge wells are in Layer C.

In the area north of Folsom Boulevard, perchlorate data from the public water supply wells were evaluated to supplement the perchlorate data from monitor wells. In addition, four nested monitor wells were installed in December 1998/January 1999 to assess potential migration pathways for perchlorate and NDMA in this area. Figure A-5 is a cross section constructed generally parallel to Folsom Boulevard from the vicinity of GET E in the east to public water supply well 1011/AC1 in the west. The perchlorate data posted on this cross section shows that perchlorate is present in Layers C and D in the vicinity of public water supply wells 1015/AC15 and 1016/AC16. Perchlorate is present in Layer C in the vicinity of public water supply wells 1013/AC9 and 1014/AC13. Cross section H-H' (Figure A-6) was drawn from the northern end of the recharge well field northwest to the farthest public water supply well with detected perchlorate or NDMA (Wells 1142/AC14 and 1140/AC11)(Figure A-6). This cross section shows perchlorate is present primarily in Layer C.

On the IRCTS, perchlorate was detected up to 2,400 µg/l in the upper portion of Layer C within and generally downgradient of the GET F Sprayfield and the propellant burn area. The lateral extent of perchlorate in this area is relatively well defined by offsite monitoring well 30089-90, where only low concentrations (up to 13 µg/l) of perchlorate were detected (Figure A-28). As with Layer B, the western extent of the southern perchlorate plume on the IRCTS has not been delineated for this report, and is being investigated under a separate program (Aerojet and Boeing, 1998).

3.4.3 Layer C – Distribution of NDMA

The distribution of NDMA in Layer C is presented on Figure A-29 and summarized in Tables A-2, -3, and -21. NDMA was detected on the Aerojet Site near Line 05/Chemical Plant 1, along the northern and northwestern Aerojet Site boundaries, and in one extraction well (4140) located at GET F. NDMA was detected offsite downgradient of the GET E extraction and recharge wells and in two public water supply wells partially screened in Layer C.

The presence of NDMA in Layer C in the West Lake Area suggests NDMA has migrated downward from overlying Layers A and B where NDMA was also detected. Some of the NDMA in these layers has migrated to the GET E extraction wells and was recharged through the recharge well field. Portions of

the NDMA plume north of GET E do not appear to be captured by the extraction wells. The uncaptured and the recharged NDMA form the off-site NDMA plume northwest of GET E.

Characterization of NDMA in the offsite areas is complicated by the very low concentrations (i.e., part per trillion) requiring characterization and the absence of a well-defined source. The majority of NDMA in the off-site wells was detected in Layer C. The western-most detections of NDMA were 0.034 µg/L in Well 30087 and 0.015 µg/L in public water supply well 1140/AC11. NDMA was also reported in two of 20 analyses on Well 1142/AC14 (Table A-3). Nested monitor Wells 30128-30 and 30131-3 were drilled between Wells 1140/AC11 and 1142/AC14 to evaluate the layer(s) through which NDMA was migrating. NDMA was not detected in any of the six well completions (3 in Layer C, 1 in Layer D, and 2 in Layer E) at this location. The absence of NDMA in these wells and upgradient Well 30122-3, combined with the presence of NDMA in Wells 30137-8, 1204, and 1467, suggests the NDMA is present in relatively thin lense(s), probably within Layer C. Additional sampling for NDMA may be warranted, as improved detection limits become available.

3.4.4 Layer C – Distribution of SVOCs

SVOC analyses were conducted on groundwater samples from 55 monitor wells completed in Layer C, including all of the offsite wells (Table A-22). SVOCs were not detected in any of the samples.

3.4.5 Layer C – Distribution of Metals

Metals analyses were conducted on groundwater samples from 50 monitor wells completed in Layer C, including all of the off-site wells (Table A-23). Metals concentrations did not exceed USEPA primary MCLs in any of the samples. Iron was detected above the USEPA secondary MCL (0.3 mg/L) at a concentration of 0.61 mg/L in Well 30059, located on the IRCTS. Manganese was detected above the USEPA secondary MCL (0.05 mg/L) at a concentration of 0.095 mg/L in Well 30123, located north of Folsom Boulevard and west of Sunrise Boulevard.

3.4.6 Layer C – Distribution of Miscellaneous Compounds and TICs

Chloride, nitrate, total nitrogen (nitrate plus nitrite), and sulfate analyses were conducted on groundwater samples from 45 monitor wells completed in Layer C, including all of the off-site monitor wells (Tables A-11 and -24). Chloride concentrations ranged from 3.1 to 86 mg/L. Nitrate concentrations ranged from 0.16 to 9.8 mg/L which are below the USEPA primary MCL of 45 mg/L. Nitrate plus nitrite concentrations (as total nitrogen) exceeded the USEPA primary MCL (1 mg/L) in two wells (2.1 and 2.6 mg/L in Wells 30067 and 30076) located north of Folsom Blvd and east of Sunrise Blvd. Both wells are co-located near a former County landfill and an additional suspected offsite source of solvent. Sulfate concentrations ranged from 2 to 62 mg/L. The two highest sulfate concentrations (62 and 21 mg/L) were also detected in Wells 30067 and 30076.

TICs were reported in the SVOC analyses of four monitor wells completed in Layer C. Unknown hydrocarbons were reported at concentrations ranging from 960 to 1100 ppb in wells 30067 and 30076 (Table A-11). The presence of TICs in these wells was not confirmed by re-sampling because the Stage 2 TIC approach was developed two years after the wells were sampled. These wells are located east of Sunrise and Folsom Boulevards where hydrocarbons were also reported in overlying Layers A and B. The presence of hydrocarbons in Layer C combined with the existence of a local source, indicates there is hydraulic connection between layers A, B, and C in this vicinity.

2-Ethyl-1-hexanol was reported as a TIC at estimated concentrations of 4.6 and 9.5 µg/L in Wells 30122 and 30123, respectively when they were sampled on August 4, 1998 (Table A-11). Confirmation sampling was conducted on December 17, 1998 in accordance with the Stage 2 TIC approach. The reported detection of 2-Ethyl-1-hexanol was not confirmed in either well. However, a different, unknown compound was reported at estimated concentrations of 4.8 and 5.3 µg/L in both wells (Table A-11). TICs were not reported in either well in February 1999, however, PCE was reoprted as a TIC in March 1999 (Table A-11). PCE was not reported in the VOC analysis for either well (Table A-19).

3.4.7 Layer C – Summary of Chemical Distribution

Six VOCs (TCE, 1,2-DCE, 1,1-DCE, carbon tetrachloride, 1,2-DCA, and chloroform), perchlorate, NDMA, and nitrate were detected at concentrations exceeding their respective MCLs/PRGs in monitor wells screened in Layer C. All VOCs detected above MCLs, with the exception to TCE, appear to be

confined within the Aerojet Site boundary. Areas of TCE above MCLs extend from the Aerojet property almost 2 miles to the southwest. In addition, TCE is present downgradient of GET F on the Aerojet Site and on the northwestern corner of the IRCTS.

Perchlorate in Layer C had the most widespread distribution of any chemical in any of the layers. In general, NDMA and TCE were detected within areas impacted by perchlorate. Layer C is not affected by SVOCs, metals, or other anions. A small area with elevated nitrate concentrations was detected northwest of the Aerojet Site near a former County Landfill near Sunrise Boulevard and Highway 50.

3.5 Layer D - Distribution of Chemicals in Groundwater

Groundwater data from over 130 monitor wells screened in Layer D were evaluated for this RI. Layer D underlies Layer C and is present across the entire Study Area. Monitor wells screened in Layer D are utilized to evaluate chemical migration from the source areas, the effectiveness of the GET facilities, offsite plume characterization, and public water-supply well protection. There are five extraction wells at GET E and six recharge wells either entirely or partially screened in Layer D. There are no extraction wells screened in Layer D at GET F.

3.5.1 Layer D - Distribution of VOCs

VOC analyses were conducted on groundwater samples from over 100 monitor wells screened in Layer D from January 1996 to April 1999, including all offsite wells (Tables A-2, -3, and -25). Three VOCs (TCE, 1,1-DCE, and chloroform) were detected at concentrations exceeding USEPA and CADHS primary MCLs and two additional VOCs (1,2-DCE and 1,2-DCA) exceeded only the CADHS primary MCLs. TCE was the only VOC detected above MCLs offsite.

The distribution of TCE, the most commonly detected VOC, is presented on Figure A-30. TCE was detected on the Aerojet Site east of GETs E and F at concentrations up to 620 µg/L. TCE concentrations were relatively higher in the vicinity of GET E, although most wells in the vicinity of GET F were not sampled within the sampling period (Figure A-30). TCE concentrations in monitor wells downgradient (west) of GET E typically ranged from non-detect up to 10 µg/L, with the exception of Well 128 which yielded concentrations up to 280 µg/L. The TCE concentrations in Well 128 have declined three-fold since 1996 that coincides with the initiation of groundwater extraction from upgradient Well 4435 in January 1997 (Table A-25). Continued extraction at Well 4435 is expected to enhance the downward

trend in Well 128. TCE was detected up to 22 µg/L in two wells (Well 421 and 3305) located approximately 1,200 to 2,000 feet north of the northern-most GET E extraction well.

On the southern portion of the Aerojet Site, TCE was detected up to 200 µg/L in Well 401, located adjacent to a GET F extraction well screened in Layer C (Well 4145). Vertical head differences in this area suggest there is the potential for upward groundwater capture from Layer D to Layer C, and Well 401 is in the upper-most lens of Layer D (Section 2.3.6). However, TCE concentrations in Well 401 have increased during the past two years suggesting this well may be monitoring a zone of water that is not hydraulically captured by Extraction Well 4145. TCE was not detected onsite west of Well 401, or in the western offsite area, with the exception of 2.3 µg/L reported in Well 1464 (Figure A-30).

1,1-DCE and chloroform were detected above USEPA Primary MCLs, while 1,2-DCA and 1,2-DCE were detected above CADHS Primary MCLs. The distribution of wells containing one or more of these VOCs above either MCL is presented on Figure A-31. As shown on this figure, the additional VOC concentrations exceeding MCLs were in on-site wells.

3.5.2 Layer D - Distribution of Perchlorate

Perchlorate analyses were conducted on groundwater samples from over 90 monitor wells screened in Layer D from January 1996 to April 1999, including all offsite wells (Table A-2, -3, -14, and -26). The most recent perchlorate results from each well are presented on Figure A-32. The majority of perchlorate in Layer D was detected in wells located on the Aerojet Site. The perchlorate detected in the vicinity of GETs E/F probably originated at the source areas, as TCE is also present in these areas. The relatively higher perchlorate concentrations (up to 7,000 µg/L) observed near the GET E/F recharge well field was probably caused by recharge as indicated by the absence of TCE in this area. The perchlorate emanating from the recharge well field attenuates to less than 600 µg/L within 4,000 feet downgradient (west) of the recharge field. It is not clear if the perchlorate detected in Wells 1464 and 30109 migrated directly through Layer D from the recharge well field, or if it migrated downward from overlying Layer C, which contains perchlorate concentrations greater than 4,000 µg/L in that area. Public water supply well 1030, located just upgradient of Wells 1464 and 30109, may have contributed to the downward migration of perchlorate in this area. On the IRCTS, perchlorate was detected up to 300 µg/L in Wells STSW3C and –52C, located generally downgradient of the former GET F Sprayfield and the Propellant Burn Area.

3.5.3 Layer D - Distribution of NDMA

NDMA analyses were conducted on groundwater samples from over 60 monitor wells screened in Layer D from March 1998 to February 1999, including most offsite wells (Tables A-2, -3, and -27). NDMA was detected just west of West Lake southwest towards GET E and the recharge well field (Figure A-33). Prior to the summer of 1999, the NDMA captured by the GET E extraction wells was partially recharged back into Layer D through the recharge well field. The recharge wells operated as part of GET E are located along the northern portion of the recharge well field (i.e., wells 5045 and 5050 in Layer D). Recharge has formed the portion of the NDMA plume detected along the northwestern Aerojet Site boundary and extending west towards Sunrise Boulevard. Further south, NDMA was detected offsite in Well 1464, which is located just west of Sunrise and north of Folsom Boulevard. Perchlorate and TCE were also detected in this well.

3.5.4 Layer D - Distribution of SVOCs

SVOC analyses were conducted on groundwater samples from 28 monitor wells screened in Layer D from March 1998 January 1996 to February 1999, including most off-site wells (Table A-28). SVOCs were not detected in the samples.

3.5.5 Layer D - Distribution of Metals

Metals analyses were conducted on groundwater samples collected from 25 monitor wells screened in Layer D from March 1998 through April 1999 including most offsite wells (Table A-29). Metals concentrations did not exceed DHS or EPA primary of secondary MCLs in any of the off-site wells. Two wells located on the Aerojet site yielded metals concentrations exceeding secondary MCLs. During the past two years, Well 358, located just south of GET F, has consistently yielded metals concentrations above secondary MCLs. Aluminum (up to 0.39 mg/L), iron (up to 0.88 mg/L), manganese (0.22 mg/L), and zinc (up to 18 mg/L) were reported above secondary MCLs, and lead (0.15 mg/L) was reported one time above the primary MCL. The most recent sample from this well yielded only iron, manganese, and zinc at concentrations exceeding secondary MCLs (Table A-29). Well 358 is screened in blue-green sandy clay which is characteristic of the Valley Springs Formation that has been noted to yield relatively higher metals in groundwater than the overlying geologic formations. One other well screened in Layer D, Well 3593, yielded iron (0.68 mg/L) exceeding EPA's secondary MCL (0.3 mg/L).

3.5.6 Layer D - Distribution of Miscellaneous Compounds and TICs

Chloride, nitrate, nitrate plus nitrite, and sulfate analyses were conducted on groundwater samples from 25 wells completed in Layer D from January 1996 to April 1999 (Table A-30). Chloride concentrations ranged from 4.1 to 29 mg/L. Nitrate concentrations ranged from non-detect (<0.03 mg/L) to 9.4 mg/L which are below the USEPA primary MCL of 10 mg/L. Nitrate plus nitrite (total Nitrogen) was detected in three of the twenty-two wells sampled; however, no concentrations exceeded the EPA Primary MCL of 1 mg/L (Table A-30). Sulfate concentrations ranged from 0.19 to 14 mg/L. One TIC, an unknown hydrocarbon (640 µg/L), was reported in the SVOC analysis conducted on Well 3332 in 1997 (Table A-11). The presence of hydrocarbons in this well was not confirmed by re-sampling because the Stage 2 TIC approach was developed two years after the well was sampled.

3.5.7 Layer D – Summary of Chemical Distribution

Five VOCs (TCE, 1,2-DCE, 1,1-DCE, 1,2-DCA, and chloroform), perchlorate, and NDMA were detected above their respective MCLs/PRGs in monitor wells screened in Layer D. TCE was the only VOC detected above MCLs off-site. Perchlorate, NDMA, and TCE are present in the northwestern portion of the Study Area in the vicinity of GET E and may extend offsite approximately 3000 feet to the west. Perchlorate and NDMA are present west and southwest of the GET E and F recharge well field; however, TCE is not present in this area suggesting the distribution of perchlorate and NDMA is due to the recharge wells. In general, the perchlorate and NDMA may have migrated offsite approximately one-half to one-third the distance in Layer D as they have in overlying Layer C.

3.6 Layer E - Distribution of Chemicals in Groundwater

Groundwater data from approximately 68 monitor wells screened in Layer E were evaluated for this RI. Layer E underlies Layer D and is present across the entire Study Area. For this evaluation, Layer E is considered the lower-most layer. Although Layer F is present beneath Layer E, the few wells screened in Layer F have not shown any chemical impacts. There are no extraction or recharge wells screened in Layer E.

3.6.1 Layer E – Distribution of VOCs

VOC analyses were conducted on groundwater samples from 51 monitor wells screened in Layer E from January 1996 through April 1999, including most offsite wells (Tables A-3 and –31). TCE was the only VOC detected in Layer E at concentrations exceeding MCLs. The majority of TCE in Layer E was detected on the northwestern portion of the Aerojet Site; and may extend approximately 4,000 feet offsite to the west (Figure A-34). Public water supply wells 1015/AC15 and 1016/AC16 are located within this portion of the TCE plume, and public water supply Well 2065/AC20 is relatively close. These wells intersect several hydrostratigraphic layers; the relative contribution from each hydrostratigraphic layer to total production of each public water supply well has not been determined.

3.6.2 Layer E – Distribution of Perchlorate

Perchlorate analyses were conducted on groundwater samples from 49 monitor wells screened in Layer E from January 1996 to April 1999 [including seven new wells installed in early 1999](Tables A-3 and -32). Perchlorate was detected in two apparently separate areas in Layer E (Figure A-35). The first area is located on the Aerojet Site in the vicinity of the GET E extraction wells. The highest perchlorate concentrations in this area (400 µg/L) were detected in well cluster 1437-8.

A second area of perchlorate in Layer E is present in the vicinity of the recharge well field (Figure A-35). The absence of TCE and the presence of perchlorate in this area suggest the perchlorate originated at the recharge well field. There are no recharge wells screened in Layer E, so the perchlorate probably migrated downward from overlying Layer D. Perchlorate was not detected (i.e., <4 µg/L) offsite in monitor wells located west of the recharge well field.

3.6.3 Layer E – Distribution of NDMA

NDMA analyses were conducted on groundwater samples from 26 monitor wells screened in Layer E from March 1998 through May 1999 (Tables A-3 and -33). The distribution of NDMA in Layer E was very similar to the distribution of perchlorate (Figure A-36). NDMA was detected offsite along the northwestern boundary of the Aerojet Site near the GET E extraction wells, and NDMA was detected onsite in two wells located along the western Aerojet boundary west of the recharge well field. NDMA was not detected offsite west of the recharge well field in Layer E.

3.6.4 Layer E – Distribution of SVOCs

SVOC analyses were conducted on groundwater samples from 13 monitor wells screened in Layer E from January 1996 to April 1999 (Table A-34). SVOCs were not detected in the samples.

3.6.5 Layer E – Distribution of Metals

Metals analyses were conducted on groundwater samples from 12 monitor wells screened in Layer E from January 1996 to April 1999 (Table A-35). Lead exceeded the EPA Primary MCLs (0.015 mg/L) in one sample collected from Well 1280 (0.067 mg/L). Lead was not reported in four previous and two subsequent samples collected from this well. Arsenic exceeded the EPA Primary MCL (0.05 mg/L) in the only sample collected from Well 30135 (0.13 mg/L). Aluminum (2 wells), iron (5 wells), manganese (4 wells) and zinc (3 wells) concentrations exceeded EPA Secondary MCLs in several wells. There appears to be a trend of increasing metals concentrations with depth that are caused by geologic conditions and not by site-related activities.

3.6.6 Layer E – Distribution of Miscellaneous Compounds and TICs

Chloride, nitrate, and sulfate analyses were conducted on groundwater samples from 12 wells screened in Layer E from January 1996 through April 1999 (Table A-36). Chloride concentrations ranged from 3.5 to 17 mg/L. Nitrate concentrations ranged from non-detect (<0.03 mg/L) to 7.1 mg/L with no concentrations exceeding EPA Primary MCLs (10 mg/L). Sulfate concentrations ranged from non-detect (<0.05 mg/L) to 20 mg/L. One unknown TIC was reported at an estimated concentration of 4.2 µg/L in the SVOC analysis performed on Well 30126 in 1998 (Table A-11).

3.6.7 Layer E – Summary of Chemical Distribution

TCE, perchlorate, and NDMA were detected above their respective MCLs/PRGs (health-based risk data) in monitor wells screened in Layer E. All three compounds are present on the Aerojet Site in the vicinity of GET E. There are no extraction wells screened in Layer E at GET E, and there are three public water supply wells generally downgradient of GET E screened entirely or partially in Layer E. Perchlorate and NDMA were also detected in several monitor wells located on the Aerojet Site west (downgradient) of the GET E and F recharge well field. The absence of TCE in this area suggests the perchlorate and NDMA

originated at the recharge well field. Neither perchlorate nor NDMA were detected in offsite monitor wells screened in Layer E downgradient of the recharge well field.

3.7 Public Water Supply Wells

This section summarizes the sampling results from public and private water supply wells (PWSWs) in the Study Area. Arden Cordova Water Service (ACWS), Citizens Utilities Company, and the Sacramento County Water Maintenance District (SCWMD) provide water service in the Study Area. The locations of PWSWs and the boundaries of the water purveyor franchise areas are shown on Figure A-37. Most domestic and agricultural water supply wells that were abandoned or are no longer used are not shown on this figure.

This section was updated in October 1999 to incorporate analytical data collected from PWSWs through September 1999. A summary of the VOCs detected and the NDMA and perchlorate analyses from January 1997 through September 1999 are presented in Table A-3. Since March 1997, six PWSWs operated by ACWS (1014/AC13, 1015/AC15, 1016/AC16, 1140/AC11, 1142/AC14, and 1860/AC19) and one PWSW operated by SCWMD (1030/SWMD17) were removed from service because perchlorate and/or NDMA concentrations exceeded public health goals. ACWS has removed three additional wells (1137/AC7, 1141/AC12, and 2066/AC21) from service because they received data suggesting the potential presence of NDMA in these wells that could not be confirmed by Aerojet sampling.

PWSWs were included on the various isoconcentration maps presented in the Sections 3.0 to 3.5 if all or a portion of their screened interval was in the layer being depicted. In many instances, the chemical concentrations reported at the PWSW were higher or lower than isoconcentration contours at that location. This occurs because most PWSWs are screened in multiple layers and draw varying percentages of water from each layer. Figure A-37 shows the chemicals detected in each PWSW regardless of the layer(s) the wells are completed in. The results of sampling at the Mather Air Force Base main wells are not depicted on this figure because it is currently interpreted that chemicals emanating from the IRCTS are responsible for these detections.

Aerojet monitors PWSWs as required by Exhibit IV of the PCD. The Exhibit IV analyte list and sampling frequencies vary based on each wells proximity to known groundwater plumes and previous data. PWSWs in the Study Area are typically sampled for VOCs, perchlorate, and NDMA. PWSWs are periodically screened for a wider range of analytes, most recently in 1998-99. The following sections

summarize the results of the VOC, perchlorate, NDMA, SVOCs, and miscellaneous analyses conducted during the past two years.

3.7.1 Public Water Supply Wells – Distribution of VOCs

Three VOCs, TCE, PCE, and chloroform were detected in PWSWs in the Study Area. Each of these VOCs was used in varying degrees at Aerojet, although TCE appears to have been the most widely used. In some instances, the TCE and/or PCE reported in PWSWs do not appear to be migrating from the Aerojet Site. There are documented releases of TCE and PCE in the western offsite areas that are unrelated to Aerojet activities. Some of these releases are located within several hundred feet of PWSWs where TCE and/or PCE have been detected.

TCE has been reported in up to ten PWSWs in the Study Area (Table A-3). TCE concentrations exceeded MCLs (5 µg/L) in wells 1014/AC13, 1015/AC15, and 1016/AC16. These wells are located within 5,000 feet of the northwestern Aerojet boundary and are also downgradient and sidegradient of an offsite source of TCE located north of Highway 50 and east of Sunrise Boulevard (Figure A-37). Each of these wells was equipped with granular activated carbon filters to remove the TCE in the 1980s. TCE was detected in the remaining seven wells at concentrations up to 1.3 µg/L.

PCE was reported in PWSWs 1011/AC1 and 1137/AC7 at concentrations of 0.96 and 0.68 µg/L, respectively, which are below the MCL for PCE (5 µg/L)(Table A-3). These wells are located between 1.6 and 2.1 miles from the western Aerojet boundary. PCE was not reported in PWSWs located closer to Aerojet, and was rarely detected in offsite monitor wells (Figure A-37). PWSW 1011/AC1 is located within several hundred feet of a dry cleaner with documented PCE releases.

Chloroform was detected in well 1014/AC13 the last time it was sampled (December 1998), and has been historically detected in four other wells (1026, 1140/AC11, 1135AC4, and 1030/SWMD17) (TableA-3). The highest chloroform concentration reported in a PWSW (1.2 µg/L in well 1135/AC4) is well below the MCL of 100 µg/L (RWQCB, 1998). 1,2-DCA was reported one time in well 1142/AC14 at 0.53 µg/L, but was not detected in 18 subsequent samples (Table A-3).

3.7.2 Public Water Supply Wells – Distribution of Perchlorate

Perchlorate was detected in nine PWSWs at concentrations ranging from 5.6 to 410 µg/L. Five PWSWs remain off-line because the perchlorate concentration exceeds the provisional drinking water standard of 18 µg/L (Wells 1014/AC13, 1015/AC15, 1016/AC16, 1030/SWMD17, and 1860/AC19)(RWQCB, 1998). Perchlorate concentrations in the PWSWs downgradient of the closed wells may increase as the perchlorate plume migrates to the west-southwest. Four PWSWs south of the Study Area remain off-line due to perchlorate emanating from the IRCTS.

3.7.3 Public Water Supply Wells – Distribution of NDMA

NDMA has been reported in three PWSWs located within 1.5 miles of the northwestern Aerojet boundary. NDMA concentrations ranged from 0.024 to 0.22 µg/L in Wells 1140/AC11, 1142/AC14, and Well 1016/AC16 (Figure A-37). In March 1998, NDMA was detected twice in Well 1142/AC14, but has not been detected in 17 subsequent samples (Table A-3). NDMA was detected in Well 1140/AC11 in March through September 1998, but was reported in only two of eleven samples collected since (Table A-3).

NDMA characterization is limited by monitor well coverage and the current method detection limits (0.0075 µg/L). Aerojet is evaluating analytical methods to lower the NDMA detection limit to below 0.002 µg/L. The current NDMA plumes north of Highway 50 and west of Sunrise Boulevard are primarily based on data collected from PWSWs. Additional monitor wells are being evaluated in these areas to identify the specific depths and locations where NDMA is present.

3.7.4 Public Water Supply Wells – Distribution of Miscellaneous Constituents

Aerojet recently completed a comprehensive analyses of PWSWs that varied by well location, but generally included SVOCs [including a TIC analysis], hydrazines, metals, organic carbon, total dissolved solids, and pH. The comprehensive analyses did not identify any additional constituents in the PWSWs other than those routinely monitored under Exhibit IV (Aerojet, 1999). TICs were reported in several PWSWs and monitor wells, however, none of the TICs reported in the first samples were confirmed in subsequent sampling events (Table A-11).

4.0 CONTAMINANT FATE AND TRANSPORT

This section discusses the primary processes that affect the fate and transport of contaminants in groundwater. All Study Area contaminants are present in the dissolved-phase and migrate with groundwater through a process referred to as advection. During the advection process, physical, chemical, and/or biological processes act to disperse, retard, or destroy solutes. These processes affect the rate of migration, mobility, concentration and mass of the solutes. The relative effects of each of these processes are determined by the properties of the aquifer and by the properties of each contaminant. Section 4.1 summarizes the work performed to estimate groundwater migration rates (groundwater velocity). Section 4.2 discusses and compares the relative effects of the dispersion, retardation, and destruction processes for solvents, NDMA, and perchlorate.

4.1 Groundwater Advection

Groundwater advection describes the process by which dissolved-phase contaminants are carried in groundwater. The advective process is quantified by estimating the rate of movement for groundwater, or the groundwater velocity. Groundwater velocities are estimated by evaluating aquifer properties and through aquifer testing. The estimated groundwater velocities represent the average linear velocity for all permeable sediments in the aquifer. The aquifer in the Study Area is heterogeneous, and there will be sediments where groundwater velocities are higher or lower than the average linear velocity.

Aquifer testing was conducted on the majority of the GET E and F extraction wells. The extraction wells at GET E are screened in both Layers C and D, and the extraction wells at GET F are individually screened in Layers A, B, and C. The range of results obtained from these tests is representative of the conditions at GETs E and F, but may not necessarily reflect conditions in the western offsite areas. The following chart presents a summary of the hydraulic parameters calculated from the onsite aquifer testing:

Hydraulic Parameter	GET E Area		GET F Area	
	Range	Median	Range	Median
Hydraulic Conductivity (ft/day)	63.5 to 145.6	123.4	7.6 to 38	18.5
Transmissivity (gpd/ft)	49,000 to 156,000	133,000	10,000 to 37,000	21,100

These data show that the median hydraulic conductivities and transmissivities are higher in the GET E area than in the GET F area. This corresponds with field observations that sediments in the vicinity of GET F are generally finer-grained than the sediments observed at GET E.

Arden Cordova Water Service has conducted several aquifer tests in the western offsite area using water supply wells AC19, AC22, and AC23. AC19 and AC22 are screened in Layers C, D, and E, and AC23 is screened in Layer E. Data provided to Aerojet relating to the test performed at well AC22 yielded transmissivities in the range of 210,000 to 252,000 gpd/ft (CH2MHill, 1998). Data collected by Aerojet during the aquifer testing of wells AC19 and AC23 yielded transmissivities of 150,000 and 100,000 gpd/ft, respectively. These data suggest transmissivities in Layers C and D in the western offsite area may be higher than those observed at GETs E and F which is consistent with the observed westward thickening of the layers (Section 2.2).

Estimates of groundwater velocities can be prepared using the following equation:

$$q = k * i / n_e$$

where: q = average groundwater velocity (feet per day)

k = hydraulic conductivity (feet per day)

i = hydraulic gradient (foot/foot), and

n_e = effective porosity

Using an effective porosity value of 0.25 (typical for clean sands), groundwater velocity estimates at GET E range from 372 to 851 feet per year. Groundwater velocity estimates at GET F range from 45 to 222 feet per year.

Estimated groundwater velocities in the Study area are relatively high, and groundwater advection is probably the dominant process affecting contaminant migration rates. Non-reactive contaminants are transported at an average rate equal to the average linear velocity of the groundwater (Freeze and Cherry, 1979). Therefore, estimated migration rates based solely on advection are probably more reasonable for less reactive compounds such as perchlorate, but probably overestimate the migration rates for reactive compounds like TCE.

4.2 Contaminant Dispersion and Retardation

Observed contaminant migration rates are often different than the rates that would be expected based solely on advection. In most cases, contaminant migration rates are slower than groundwater movement, although some processes can cause contaminants to migrate more quickly than groundwater. Some of the processes effecting contaminant migration rates and concentrations include molecular diffusion, mechanical dispersion, retardation, dilution, volatilization, and biological degradation. The effect of each

of these processes can vary significantly from chemical to chemical, and it is difficult to quantify these effects because there are numerous location and chemical specific variables that cannot be practically measured.

It may be necessary to conduct additional studies in the future to provide the data necessary to more accurately gauge contaminant migration rates, groundwater restoration times and natural attenuation rates. Aquifer characterization completed in conjunction with groundwater monitoring and potential remedial design activities should improve the ability to predict the effect of these processes. Although the individual and combined effects of these processes are not well understood, these effects are probably minimal compared to the effects due to the relatively high groundwater velocities in the Study Area. The following paragraphs provide general descriptions of the processes effecting the fate and transport of contaminants in groundwater. Chart A-1 presents a summary of the relative effects of dispersion, retardation, and destruction for solvents, NDMA, and perchlorate.

CHART A-1: Summary of Relative Retardation, Dispersion, and Destruction Effects

	Dispersion Effects		Retardation Effects	Destruction Effects	
CONTAMINANT	Molecular Diffusion	Mechanical Dispersion	Sorption	Volatilization	Biological Degradation
Solvents	√√	√	√√√	√√√	√√
NDMA	√√	√√	√√	√	√
Perchlorate	√√√	√√√	√	√	√

Key: √ = No or uncertain effect
√√ = Moderate effect
√√√ = Greatest effect

Molecular diffusion is the movement of contaminants from areas of higher concentration to areas of lower concentration. Molecular diffusion results in lower contaminant concentrations, although contaminant mass is not changed. Diffusion can cause contaminants to migrate more quickly than the groundwater velocity. However, in areas with high groundwater velocities, the physical dispersion processes tend to dominate over molecular diffusion. Therefore, the effects of molecular diffusion are probably enhanced in the lower permeability aquitards where groundwater velocities are low, and are minimized in the more

transmissive portions of the aquifer. Molecular diffusion into and out of the less permeable sediments will likely increase the time required to achieve groundwater restoration.

Mechanical dispersion is the mixing or dilution of contaminated water with clean water as contaminants flow through porous media at different rates and along different flow paths. The effects of mechanical dispersion vary depending primarily on the pore size, path lengths, and sorting of the aquifer materials. In general, the effects of mechanical dispersion are greatest in fine-grained materials because the contaminants move through more tortuous (and longer) pathways than they do in coarse-grained materials.

Mechanical dispersion primarily dilutes the leading edges of the contaminant plumes and contaminant concentrations in the body of the plume remain relatively unchanged as the aquifer becomes "saturated" with the contaminants. This may be a significant process on the fringes of contaminant plumes, or in plumes where contaminant concentrations are low, and where a small amount of dilution may reduce concentrations below levels of concern. Mechanical dispersion is probably more significant for perchlorate than for the solvents because perchlorate is not retarded and appears to disperse relatively uninhibited.

Evaluation of the off-site portions of the Layer C perchlorate plume may provide some in-sights on the effects of dispersion. The relatively high-concentration portion of this plume is primarily related to the GET F recharge wells, where perchlorate was recharged at average concentrations of approximately 8,000 µg/L. The 4,000µg/L contour shows the approximate distance over which perchlorate concentrations were reduced by ½ of their original concentrations in the aquifer when a continuing source of perchlorate existed. The western edge of the perchlorate plume (between the 4 and 4,000µg/L) contours is an area that has either attenuated due to dispersion, molecular diffusion, dilution, and possible biological breakdown.

Organic chemicals may be sorbed to organic carbon present in the aquifer. Sorption can impede both the migration rates of organic compounds and the time required for remediation of these compounds. The Study Area aquifer has a relatively low organic carbon content and sorption is probably not a significant factor. However, where organic materials are present, the chlorinated solvents will be most affected by sorption, followed by NDMA. Recent work conducted by EPA suggests that perchlorate sorption does occur and is dependent on soil pH and organic content (Susaria, et.al., 1999). The pH (around 7) and low

organic carbon content of the Study Area aquifer are not favorable for perchlorate sorption. There may be exceptions where clays or silts are present in the aquifer.

Volatilization is the transformation of a chemical from the aqueous to the vapor phase. Volatilization only occurs for chemicals with relatively high vapor pressures and low boiling points. Neither perchlorate nor NDMA are volatile under atmospheric conditions. TCE and the solvents may volatilize from the groundwater into the vadose zone. Vapor migration through the vadose zone and into the atmosphere or the foundations of structures is a potential concern. However, the combinations of depth to groundwater (generally over 100 feet), relatively low solvent concentrations observed off-site, and the vadose zone materials, suggest that volatilization from the vadose zone to the atmosphere is highly unlikely. Volatilization may gradually reduce solvent concentrations in groundwater; however, it is not anticipated to be a significant factor.

Biological degradation is a process that, under certain conditions, can reduce contaminant mass in groundwater. A substantial amount of recent research has been devoted to evaluating the biodegradation of chlorinated solvents. Chlorinated solvents can be biodegraded anaerobically in reducing groundwater conditions, and they can be biodegraded aerobically in the presence of a cometabolite (i.e., a carbon source). Both biodegradation processes have been documented at the Aerojet Site. However, the aerobic groundwater conditions present throughout most of the Study Area do not facilitate anaerobic biodegradation and there do not appear to be sufficient carbon sources to stimulate cometabolic biodegradation. An exception occurs at an off-site source of TCE northeast of Sunrise and Folsom Boulevards, where TCE, 1,2-DCE, and vinyl chloride have been observed in groundwater. Once the biodegradation sequence has reached vinyl chloride, it will degrade aerobically to ethene and then carbon dioxide.

Very little research is available documenting the natural biodegradability of perchlorate and NDMA. Aerojet has demonstrated that perchlorate is readily biodegradable in ex-situ bio-reactors, and has recently initiated bench- and pilot-scale testing to evaluate the potential for the in-situ biodegradation of perchlorate. Aerojet conducted some preliminary evaluations on the biodegradability of NDMA in the early 1980's; however, the results were inconclusive. The biodegradability potential for both perchlorate and NDMA will likely be studied in the future as these compounds become recognized at more locations. The in-situ biodegradation of some of the contaminants in the Study Area groundwater may eventually be possible in the future by enhancing naturally occurring processes. However, natural biodegradation

processes occurring today do not sufficiently reduce contaminant concentration or mass below levels of concern.

4.3 Summary of Contaminant Fate and Transport

Groundwater advection is the dominant process governing the fate and transport of the dissolved-phase contaminants in the Study Area groundwater. Relatively high groundwater velocities in the Study Area minimize the effects of dispersion and retardation, although the magnitude of these effects is not clearly understood. Mechanical dispersion appears to dilute the leading edges of the contaminant plumes; however concentrations in the body of the plumes are generally not reduced to below levels of concern. The primary contaminants in the Study Area appear to be chemically and biologically stable and will likely persist in the Study Area groundwater.

5.0 EXPOSURE PATHWAYS ANALYSIS

This section evaluates potential pathways through which human or ecological receptors may be exposed to Study Area contaminants. Figure A-38 shows current and potentially completed exposure pathways for the on- and off-site portions of the Study Area. Human and/or ecological exposure may occur through direct or indirect contact with contaminants prior to treatment, or exposure may occur after groundwater treatment if the treated water contains residual chemicals. Figure A-39 summarizes the results of the exposure pathway analysis.

There are no significant current or future potentially completed exposure pathways on the Aerojet Site (Figure A-39). The City of Folsom supplies potable and non-potable water to Aerojet and direct use of contaminated groundwater is not a current or potentially foreseeable future completed pathway. This potential pathway is also remote for future hypothetical workers on portions of the Aerojet Site that may be sold, as institutional controls (e.g., easements) will limit access to contaminated groundwater. Construction workers excavating on the Aerojet Site will not contact contaminated groundwater because the shallowest groundwater in the Study Area is present at depths (50 feet bgs), well below the construction zone (10 feet bgs). Soil gas samples collected from hundreds of locations across the Aerojet Site have shown that vapor diffusion from groundwater into the vadose zone is negligible in areas where there are no vadose zone source sites, and there are no impacts to indoor air. The potential pathway for industrial workers at GETs E/F is not complete because the treatment plant operates as a "closed system" and there is very limited potential for workers to contact the water.

There are several potentially complete off-site exposure pathways for contaminated and/or treated groundwater (Figure A-39). Groundwater beneath the Study Area is used as a source of potable and non-potable water and the pathway for human and/or ecological receptors is potentially complete. Aerojet, the water purveyors, and the DHS monitor the public and private water supply wells to ensure that chemical concentrations do not exceed acceptable levels. There are no known large-scale agricultural or other uses of groundwater that could result in a potentially significant completed exposure pathway for ecological receptors.

The discharge option(s) selected in the FS will complete one or more potential exposure pathways. Direct potable or non-potable re-use of treated groundwater at a central treatment plant or on an individual well could result in a significant completed pathway to residents and workers. Similarly, if treated groundwater is recharged into the aquifer and subsequently used as a drinking water source, this could result in a significant completed exposure pathway to residents and workers. While both of these pathways are potentially complete, stringent monitoring and adherence to treatment standards will be required, minimizing the potential for exposure to chemicals above levels of concern.

The discharge of treated groundwater to a surface water body could result in a completed pathway for residents and ecological receptors. Residential contact could occur during recreational activities on Buffalo Creek or in the American River, although these exposures are typically limited in duration. In addition, the pathway to various ecological receptors would be complete under a surface water discharge option. The acute and chronic toxicity testing required under the NPDES process would reduce the likelihood that this pathway would result in significant exposure to ecological receptors. In addition, there will be significant dilution of the treated groundwater in the American River, further reducing the likelihood that contaminant concentrations would exceed levels of concern.

5.0 SUMMARY AND CONCLUSIONS

Historical operations on the Aerojet Site have resulted in the release of contaminants to soil and groundwater. The on-site source areas for the CoPCs detected in the Study Area groundwater are primarily located east of the Study Area in the central and eastern portions of the Aerojet Site. VOCs (primarily TCE) and perchlorate have been detected in soil and groundwater beneath a number of these source areas. NDMA, which was known to exist at source areas on the east side of Aerojet, but not known to be present on the west side, was more recently detected in groundwater on the west side of the Aerojet Site.

On the western half of the Aerojet Site, groundwater flows generally to the west-southwest through a complex, heterogeneous aquifer. The aquifer has been subdivided into hydrostratigraphic Layers A through E based on similar lithologic and hydrogeologic properties. These hydrostratigraphic layers are generally tabular bodies that increase in depth and thickness from east to west across the Study Area. Contaminant concentrations in Layers A and B have been observed to decrease significantly within relatively short distances from the source areas. Conversely, contaminant concentrations east of GETs E and F, in underlying Layers C, D, and E, reach their maximum concentrations downgradient of the source areas, and then attenuate with increased distances. This observation, combined with vertical head differences observed from Layers A and B to Layers C, D, and E, suggest vertical groundwater flow is a significant component of contaminant migration in the upper layers. The hydrostratigraphic characteristics of Layers A and B change from east to west and these layers are either dry or not present west of the Aerojet Site.

Since the mid- to late-1980s, contaminants in groundwater flowing west from the source areas were intercepted by two interim perimeter GET facilities. GETs E and F captured and treated groundwater with VOCs at northwestern and southwestern locations along the perimeter of the Aerojet Site, respectively. A relatively small area of groundwater containing VOCs apparently was not captured by the existing GET F extraction wells south of GET F. A series of recharge wells installed in the center of the western perimeter provided a hydraulic barrier to direct contaminants toward the extraction wells. The recharge water was known to contain perchlorate that was not removed since a treatment standard or economic treatment technology had not been established. In early 1998 NDMA was detected at low levels in the water extracted and recharged at GET E using an improved analytical method. Treated groundwater from two of the GET F extraction wells was initially discharged after VOCs were removed

via a sprayfield located within the northwest corner of the IRCTS for a period of approximately 6 years. The treated groundwater discharged to the former sprayfield has percolated beneath the IRCTS and formed a plume of perchlorate-impacted groundwater flowing to the west-southwest. A biological reduction treatment system was added to GET F to remove perchlorate from groundwater in December 1998. In August 1999, the treatment systems at GETs E/F were combined and perchlorate, NDMA and VOC treatment are included in the treatment processes.

The recharge well field water has contributed to the perchlorate and NDMA plumes detected in the western offsite groundwater. The majority of perchlorate and NDMA is present in Layers C and D, although some upward and downward migration into Layers B and E, respectively, has occurred near the western perimeter of the Aerojet Site. The perchlorate in Layer C has been detected up to 9,000 feet west of the western Aerojet perimeter. An area of groundwater containing TCE and NDMA is present in Layers C and D northwest of the Aerojet Site. The TCE and NDMA in this area may have been present before GET E began operating, may represent uncaptured groundwater flowing north of GET E, or may be from offsite sources identified northeast of the intersection of Sunrise and Folsom Boulevards.

The chemicals detected in the Study Area groundwater are physically and chemically stable, and are unlikely to be reduced to concentrations below levels of concern by natural processes within an acceptable time frame. Advective flow is the dominant process affecting contaminant migration, although dispersion, retardation, and biological breakdown may selectively effect some of the contaminants.

There are no significant current or reasonably foreseeable completed exposure pathways on the Aerojet Site. However, off-site exposure pathways are potentially complete where groundwater is used for potable or non-potable use. In addition, the selection of a remedy in the FS may result in the completion of additional exposure pathways if the treated groundwater is directly consumed, recharged back into the aquifer, or discharged to a surface water body.

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TABLE A-1
SUMMARY OF DETECTS - VOC ANALYSES
LAYER A - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	1,1,2-TCA (ug/l)	1,1-DCE (ug/l)	1,2-DCA (ug/l)	1,2-DCE (ug/l)	Chloroform (ug/l)	PCE (ug/l)	TCE (ug/l)	Vinyl Chloride (ug/l)
10	03/19/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
22	03/23/1999	1.3	< 0.5	1.5	10	230	0.82	44	< 0.5
24	02/21/1997	< 5	< 5	< 5	< 5	8.1	< 5	13	< 10
75	05/23/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/23/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/12/1998	< 1	< 1	2.9	< 1	< 1	< 1	< 1	< 1
	03/19/1999	< 0.5	< 0.5	3.4	< 0.5	< 0.5	< 0.5	3	< 0.5
131	05/03/1996	12	< 1	950	2.3	4	< 1	40	< 1
	10/28/1996	6.1	< 1	500	2.8	3.3	< 1	42	< 1
	02/28/1997	< 1	< 1	260	2	2.8	< 1	47	< 1
	09/11/1997	< 2	< 2	530	3.1	3.6	< 2	70	< 2
	03/09/1998	5	< 1	120	2.8	5.4	< 1	68	< 1
307	03/19/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
355	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1203	02/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	9.8	< 1
	08/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	6.7	< 1
	12/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	6.2	< 1
	02/04/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.1	< 0.5
	05/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	6.8	< 1
	01/08/1998	< 1	< 1	< 1	< 1	< 1	< 1	3.6	< 1
	05/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	8.3	< 1
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3	< 0.5
1237	05/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/1996	< 1	< 1	< 1	< 1	< 1	< 1	8.6	< 1
	09/30/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3057	06/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/03/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3348	03/24/1999	< 0.5	< 0.5	480	2.8	< 0.5	< 0.5	82	< 0.5
3352	06/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/23/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3431	03/23/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

TABLE A-1
SUMMARY OF DETECTS - VOC ANALYSES
LAYER A - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	1,1,2-TCA (ug/l)	1,1-DCE (ug/l)	1,2-DCA (ug/l)	1,2-DCE (ug/l)	Chloroform (ug/l)	PCE (ug/l)	TCE (ug/l)	Vinyl Chloride (ug/l)
30062	11/20/1996	< 0.5	< 0.5	0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30063	11/20/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/13/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.65	46	< 0.5
30065	11/21/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	12/13/1996	< 1	2.6	2.9	98	< 1	1.1	400	28
	01/13/1997	< 0.5	4.8	< 0.5	90	< 0.5	0.78	310	29
	01/13/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 10
	04/24/1997	< 0.5	2.8	< 0.5	50	< 0.5	0.59	230	8.4
	07/16/1997	< 0.5	4.1	< 0.5	100	< 0.5	2.8	370	34
	10/31/1997	< 2.5	3.7	< 2.5	190	< 2.5	4.4	630	92
	07/08/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.6	< 0.5
	09/02/1998	< 0.5	7.4	< 0.5	200	< 0.5	1.3	320	110
	09/02/1998	< 0.5	8.7	< 0.5	200	< 0.5	1.4	340	120
	10/30/1998	< 0.5	9	< 0.5	210	< 0.5	1.4	320	130

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4007	01/09/1996	< 1	< 1	< 1	140	1.3	< 1	3	< 1	< 1	40
	02/07/1996	2.3	< 1	< 1	110	1.1	< 1	2.9	< 1	< 1	41
	03/05/1996	< 1	< 1	< 1	95	< 1	< 1	2.4	< 1	< 1	39
	04/02/1996	2.2	< 1	< 1	85	1	< 1	2.6	< 1	< 1	39
	05/07/1996	3.4	< 1	< 1	75	< 1	< 1	2.5	< 1	< 1	38
	06/05/1996	2.7	< 1	< 1	81	< 1	< 1	2.5	< 1	< 1	36
	07/01/1996	1.3	< 1	< 1	75	< 1	< 1	1.7	< 1	< 1	37
	08/07/1996	< 1	< 1	< 1	76	< 1	< 1	2.4	< 1	< 1	43
	09/10/1996	2.4	< 1	< 1	120	< 1	< 1	2.7	< 1	< 1	47
	10/05/1996	1.9	< 1	< 1	71	< 1	< 1	2.7	< 1	< 1	48
	11/02/1996	< 1	< 1	< 1	75	< 1	< 1	2.2	< 1	< 1	46
	12/01/1996	1.8	< 1	< 1	61	< 1	< 1	2.7	< 1	< 1	43
	01/04/1997	1.9	< 1	< 1	65	< 1	< 1	2.8	< 1	< 1	46
	02/01/1997	1.8	< 1	< 1	61	< 1	< 1	2.4	< 1	< 1	43
	04/26/1997	2.2	< 1	< 1	82	< 1	< 1	2.2	< 1	< 1	22
	05/04/1997	1.8	< 1	< 1	120	< 1	< 1	1.9	< 1	< 1	29
	06/01/1997	< 1	< 1	< 1	160	< 1	< 1	2.2	< 1	< 1	35
	07/06/1997	1.9	< 1	< 1	160	1.2	< 1	3	< 1	< 1	43
	08/02/1997	2.6	< 1	< 1	120	< 1	< 1	2.1	< 1	< 1	42
	09/12/1997	2.3	< 1	< 1	53	< 1	< 1	2	< 1	< 1	43
	10/12/1997	2	< 1	< 1	38	< 1	< 1	2	< 1	< 1	40
	11/02/1997	2	< 1	< 1	68	< 1	< 1	2	< 1	< 1	42
	01/24/1998	< 1	< 1	< 1	61	< 1	< 1	2.4	< 1	< 1	43
	04/20/1998	2	< 1	< 1	62	1	< 1	2.5	< 1	< 1	45
	07/26/1998	1.7	< 1	< 1	51	1.1	< 1	2.9	< 1	< 1	46
	10/18/1998	< 0.5	< 0.5	< 0.5	44	1.2	< 0.5	2.4	< 0.5	0.91	49
4060	01/09/1996	< 10	< 10	17	< 10	< 10	< 10	< 10	< 10	< 10	2000
	02/07/1996	< 10	< 10	19	< 10	< 10	< 10	< 10	< 10	< 10	2100
	03/05/1996	< 10	< 10	15	< 10	< 10	< 10	< 10	< 10	< 10	1900
	04/01/1996	< 5	< 5	24	< 5	11	< 5	10	< 5	< 5	2200
	04/02/1996	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	1900

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4060 (cont.)	05/06/1996	< 10	< 10	17	< 10	< 10	< 10	< 10	< 10	< 10	2300
	06/04/1996	< 10	< 10	15	< 10	< 10	< 10	< 10	< 10	< 10	2000
	07/01/1996	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	2000
	08/07/1996	< 10	< 10	16	< 10	< 10	< 10	10	< 10	< 10	2300
	09/10/1996	< 10	< 10	14	< 10	< 10	< 10	< 10	< 10	< 10	2500
	10/05/1996	< 10	< 10	23	< 10	< 10	< 10	11	< 10	< 10	2300
	10/08/1996	< 10	< 10	21	< 10	10	< 10	< 10	< 10	< 10	2500
	11/02/1996	< 10	< 10	22	< 10	< 10	< 10	12	< 10	< 10	2100
	12/01/1996	< 10	< 10	23	< 10	< 10	< 10	12	< 10	< 10	2100
	01/04/1997	< 10	< 10	21	< 10	< 10	< 10	11	< 10	< 10	2100
	02/01/1997	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	2100
	04/26/1997	< 10	< 10	24	< 10	10	< 10	< 10	< 10	< 10	4500
	04/28/1997	< 10	< 10	32	< 10	16	< 10	< 10	< 10	< 10	3700
	05/04/1997	< 10	< 10	20	< 10	< 10	< 10	12	< 10	< 10	4400
	06/01/1997	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3600
	07/06/1997	< 10	< 10	32	< 10	11	< 10	17	< 10	< 10	2600
	08/02/1997	< 10	< 10	12	< 10	< 10	< 10	11	< 10	< 10	2400
	09/12/1997	< 10	< 10	19	< 10	< 10	< 10	11	< 10	< 10	1700
	10/09/1997	< 50	< 50	< 50	< 50	12	< 50	11	< 50	< 50	1800
	10/11/1997	< 10	< 10	21	< 10	< 10	< 10	12	< 10	< 10	2100
	11/02/1997	< 10	< 10	18	< 10	< 10	< 10	12	< 10	< 10	2200
	01/24/1998	< 10	< 10	11	< 10	< 10	< 10	< 10	< 10	< 10	1700
	04/14/1998	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	2000
	04/20/1998	< 10	< 10	14	< 10	< 10	< 10	11	< 10	< 10	2100
	07/25/1998	< 10	< 10	< 10	< 10	< 10	< 10	12	< 10	< 10	2000
	10/18/1998	< 0.5	< 0.5	17	< 0.5	10	< 0.5	17	< 0.5	0.79	420
	10/22/1998	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	2100
4070	01/08/1996	< 5	< 5	9.9	< 5	18	< 5	10	< 5	< 5	1400
	02/07/1996	< 5	< 5	8.3	< 5	16	< 5	9.9	< 5	< 5	1300
	03/05/1996	< 5	< 5	6.9	< 5	14	< 5	8.9	< 5	< 5	1200
	04/02/1996	< 5	< 5	< 5	< 5	13	< 5	8.2	< 5	< 5	1100

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4070	05/07/1996	< 5	< 5	6.1	< 5	14	< 5	9	< 5	< 5	1200
(cont.)	06/05/1996	< 5	< 5	5.7	< 5	13	< 5	9.5	< 5	< 5	1000
	07/02/1996	< 5	< 5	6.3	< 5	16	< 5	9.8	< 5	< 5	1100
	08/07/1996	< 5	< 5	6.7	< 5	15	< 5	9	< 5	< 5	1200
	09/10/1996	< 5	< 5	6.7	< 5	14	< 5	8.2	< 5	< 5	1100
	10/12/1996	< 5	< 5	6	< 5	15	< 5	10	< 5	< 5	1200
	11/02/1996	< 5	< 5	13	< 5	15	< 5	13	< 5	< 5	1200
	12/01/1996	< 5	< 5	9.7	< 5	15	< 5	12	< 5	< 5	1200
	01/11/1997	< 5	< 5	< 5	< 5	14	< 5	13	< 5	< 5	1300
	02/01/1997	< 5	< 5	< 5	< 5	12	< 5	8.3	< 5	< 5	1100
	03/01/1997	< 5	< 5	5.1	6.3	13	< 5	7.8	< 5	< 5	1000
	04/05/1997	< 5	< 5	7.4	< 5	12	< 5	8.2	< 5	< 5	1000
	05/15/1997	< 5	< 5	< 5	< 5	11	< 5	< 5	< 5	< 5	1000
	06/01/1997	< 5	< 5	< 5	< 5	10	< 5	6.9	< 5	< 5	880
	07/06/1997	< 5	< 5	9.5	< 5	9.6	< 5	7.8	< 5	< 5	800
	08/02/1997	< 5	< 5	7.1	< 5	7.6	< 5	7	< 5	< 5	730
	09/12/1997	< 5	< 5	< 5	< 5	5.3	< 5	< 5	< 5	< 5	700
	10/12/1997	< 5	< 5	< 5	< 5	5.9	< 5	< 5	< 5	< 5	670
	11/01/1997	< 5	< 5	< 5	< 5	5.8	< 5	< 5	< 5	< 5	660
	01/05/1998	< 2	< 2	4.4	< 2	5	< 2	4.9	< 2	< 2	510
	04/20/1998	< 2	< 2	< 2	< 2	5	< 2	4.5	< 2	< 2	410
	08/10/1998	< 2	< 2	< 2	< 2	4.8	< 2	3.9	< 2	< 2	380
	10/18/1998	< 0.5	< 0.5	2.1	< 0.5	4.7	< 0.5	4.1	< 0.5	< 0.5	280
4075	01/08/1996	< 2	< 2	5.4	< 2	11	< 2	98	< 2	< 2	590
	02/07/1996	< 2	< 2	< 2	< 2	9.9	< 2	94	< 2	< 2	550
	03/05/1996	< 2	< 2	< 2	< 2	8.6	< 2	95	< 2	< 2	460
	04/02/1996	< 2	< 2	< 2	< 2	8.5	< 2	87	< 2	< 2	450
	05/07/1996	< 2	< 2	4	< 2	9.5	< 2	87	< 2	< 2	530
	06/05/1996	< 2	< 2	3.2	< 2	10	< 2	99	< 2	< 2	450
	07/02/1996	< 2	< 2	2.9	< 2	10	< 2	96	< 2	< 2	460
	08/07/1996	< 2	< 2	3.3	< 2	11	< 2	100	< 2	< 2	530

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4075 (cont.)	09/10/1996	< 2	< 2	3.1	< 2	10	< 2	100	< 2	< 2	480
	10/12/1996	< 2	< 2	5.6	< 2	11	< 2	89	< 2	< 2	550
	11/02/1996	< 2	< 2	5.8	< 2	11	< 2	110	< 2	< 2	550
	12/01/1996	< 2	< 2	5.5	< 2	10	< 2	111	< 2	< 2	570
	01/04/1997	< 2	< 2	4.5	< 2	9	< 2	93	< 2	< 2	490
	02/01/1997	< 2	< 2	< 2	< 2	8.7	< 2	110	< 2	< 2	440
	03/01/1997	< 2	< 2	< 2	< 2	8.8	< 2	110	< 2	< 2	430
	04/05/1997	< 2	< 2	4.1	< 2	8.9	< 2	110	< 2	< 2	410
	05/15/1997	< 2	< 2	3.1	< 2	13	< 2	150	< 2	< 2	550
	06/01/1997	< 2	< 2	3.4	< 2	9.8	< 2	130	< 2	< 2	350
	07/06/1997	< 2	< 2	3.2	3.2	8.6	< 2	110	< 2	< 2	330
	08/02/1997	< 2	< 2	2.8	< 2	8.2	< 2	110	< 2	< 2	310
	09/12/1997	< 1	< 1	< 1	< 1	7.6	< 1	110	< 1	< 1	250
	10/12/1997	< 1	< 1	1.6	1.8	8.5	< 1	110	< 1	< 1	260
	11/01/1997	< 1	< 1	< 1	< 1	7.8	< 1	120	< 1	< 1	270
	01/18/1998	< 1	< 1	< 1	< 1	7.7	< 1	120	< 1	< 1	240
	04/20/1998	< 1	< 1	1.7	2.4	7.3	< 1	130	< 1	< 1	240
	07/25/1998	< 1	< 1	< 1	< 1	8.8	< 1	140	< 1	< 1	220
	10/18/1998	< 0.5	< 0.5	1.2	0.77	8.6	< 0.5	110	< 0.5	< 0.5	230
4140	01/09/1996	< 20	< 20	< 20	67	37	< 20	910	< 20	< 20	5000
	02/07/1996	< 20	< 20	< 20	52	31	< 20	840	< 20	< 20	4800
	03/05/1996	< 20	< 20	< 20	81	27	< 20	870	< 20	< 20	4700
	04/02/1996	< 20	< 20	< 20	78	38	< 20	1100	< 20	< 20	5200
	05/07/1996	< 20	< 20	< 20	32	27	< 20	750	< 20	< 20	4500
	06/05/1996	< 20	< 20	< 20	72	47	< 20	1200	< 20	55	5000
	07/01/1996	< 20	< 20	< 20	60	37	< 20	920	< 20	23	4900
	08/07/1996	< 20	< 20	< 20	47	47	< 20	1200	< 20	< 20	5900
	09/12/1996	< 20	< 20	< 20	31	34	< 20	820	< 20	< 20	4800
	10/05/1996	< 20	< 20	22	28	34	< 20	740	< 20	< 20	4700
	11/02/1996	< 20	< 20	< 20	29	32	< 20	800	< 20	< 20	4500
	12/01/1996	< 20	< 20	< 20	34	26	< 20	720	< 20	< 20	4100

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4140 (cont.)	01/04/1997	< 20	< 20	< 20	32	29	< 20	740	< 20	< 20	4300
	02/01/1997	< 20	< 20	< 20	< 20	35	< 20	950	< 20	25	5400
	04/26/1997	< 20	< 20	< 20	< 20	42	< 20	1100	< 20	< 20	5400
	05/04/1997	< 20	< 20	< 20	< 20	40	< 20	1100	< 20	< 20	6200
	06/01/1997	< 20	< 20	< 20	< 20	44	< 20	990	< 20	26	5200
	07/06/1997	< 20	< 20	< 20	< 20	38	< 20	940	< 20	27	5000
	08/02/1997	< 20	< 20	< 20	< 20	36	< 20	920	< 20	< 20	5300
	09/12/1997	< 20	< 20	< 20	< 20	24	< 20	580	< 20	< 20	4100
	10/12/1997	< 20	< 20	23	< 20	34	< 20	690	< 20	< 20	4700
	11/02/1997	< 20	< 20	< 20	< 20	37	< 20	810	< 20	< 20	5200
	01/24/1998	< 20	< 20	< 20	< 20	< 20	< 20	530	< 20	< 20	4300
	04/20/1998	< 20	< 20	< 20	< 20	27	< 20	570	< 20	< 20	4400
	07/25/1998	< 20	< 20	< 20	< 20	39	< 20	640	< 20	< 20	4800
	10/18/1998	< 0.5	1.2	20	1.3	33	1.4	280	< 0.5	6.7	5000
4145	01/09/1996	< 1	< 1	1.4	< 1	1.2	< 1	74	< 1	< 1	230
	02/07/1996	< 1	< 1	1.4	< 1	1.1	< 1	79	< 1	< 1	240
	03/05/1996	< 1	< 1	1.1	< 1	< 1	< 1	69	< 1	< 1	200
	04/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	69	< 1	< 1	210
	05/07/1996	< 1	< 1	< 1	1.5	< 1	< 1	70	< 1	< 1	180
	06/05/1996	< 1	< 1	< 1	1.7	< 1	< 1	82	< 1	< 1	180
	07/01/1996	< 1	< 1	< 1	< 1	1.1	< 1	74	< 1	1.4	200
	08/07/1996	< 1	< 1	< 1	< 1	1.1	< 1	77	< 1	< 1	190
	09/12/1996	< 1	< 1	< 1	< 1	1.2	< 1	86	< 1	< 1	210
	10/05/1996	< 1	< 1	1.3	< 1	1.3	< 1	80	< 1	< 1	220
	11/02/1996	< 1	< 1	1.4	< 1	1	< 1	81	< 1	< 1	200
	12/01/1996	< 1	< 1	1.5	2.4	1.2	< 1	93	< 1	< 1	240
	01/04/1997	< 1	< 1	1.3	2.2	< 1	< 1	79	< 1	< 1	190
	02/01/1997	< 1	< 1	< 1	< 1	< 1	< 1	85	< 1	< 1	210
	04/26/1997	< 1	< 1	< 1	1.3	< 1	< 1	62	< 1	< 1	120
	05/04/1997	< 1	< 1	< 1	1.4	1.1	< 1	94	< 1	< 1	240
	06/01/1997	< 1	< 1	< 1	2	1.1	< 1	96	< 1	< 1	210

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4200 (cont.)	07/06/1997	< 1	< 1	2.1	3.3	1.8	< 1	120	< 1	< 1	240
	08/02/1997	< 1	< 1	1.9	1.6	1.4	< 1	100	< 1	< 1	240
	09/12/1997	< 1	< 1	1.2	< 1	1.5	< 1	100	< 1	< 1	230
	10/12/1997	< 1	< 1	< 1	< 1	1.1	< 1	95	< 1	< 1	230
	11/02/1997	< 1	< 1	< 1	1.7	1	< 1	94	< 1	< 1	230
	01/24/1998	< 1	< 1	< 1	< 1	< 1	< 1	95	< 1	< 1	260
	04/20/1998	< 1	< 1	< 1	< 1	1.5	< 1	100	< 1	< 1	230
	07/26/1998	< 1	< 1	< 1	< 1	1.3	< 1	89	< 1	< 1	210
	10/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	1.8	< 0.5	90	< 0.5	< 0.5	240
4200	01/08/1996	< 1	< 1	2.7	1.5	3.6	< 1	1.3	< 1	< 1	290
	02/07/1996	< 1	< 1	2.8	< 1	3.1	< 1	1.4	1.4	< 1	280
	03/05/1996	< 1	< 1	1.4	< 1	3.2	< 1	1.1	2.2	1.2	220
	04/02/1996	< 1	< 1	2.4	< 1	3.2	< 1	1.4	1.5	< 1	260
	05/29/1996	< 1	< 1	2.2	< 1	3.6	< 1	1.9	2.4	< 1	230
	06/05/1996	< 1	< 1	2.2	< 1	3.7	< 1	1.7	2.7	< 1	220
	07/01/1996	< 1	< 1	1.8	< 1	3.4	< 1	1.5	2.3	1.3	230
	08/07/1996	< 1	< 1	1.9	< 1	3.3	< 1	1.4	1.8	< 1	250
	09/10/1996	< 1	< 1	1.8	< 1	3.6	< 1	1.4	1.9	1.1	240
	10/12/1996	< 1	< 1	2.8	< 1	3.8	< 1	1.9	1.9	< 1	290
	11/02/1996	< 1	< 1	2.9	< 1	3.4	< 1	2.1	1.8	< 1	260
	12/01/1996	< 1	< 1	2.7	< 1	3.3	< 1	2.1	1.5	< 1	270
	01/04/1997	< 1	< 1	1.7	< 1	2.9	< 1	1.8	1	< 1	230
	02/01/1997	< 1	< 1	< 1	< 1	2.7	< 1	1.1	2	< 1	200
	03/01/1997	< 1	< 1	1.9	< 1	2.4	< 1	1.5	1.7	< 1	200
	04/05/1997	< 1	< 1	2	< 1	2.1	< 1	1.2	1.5	< 1	160
	05/15/1997	< 1	< 1	< 1	< 1	2.1	< 1	< 1	1.2	< 1	150
	06/01/1997	< 1	< 1	< 1	1.5	1.6	< 1	< 1	< 1	< 1	130
	07/06/1997	< 1	< 1	2	< 1	2.4	< 1	1.8	1.9	< 1	140
	08/02/1997	< 1	< 1	1.3	< 1	1.6	< 1	1.1	1.3	< 1	120
	09/12/1997	< 1	< 1	< 1	< 1	1.5	< 1	1.1	1.2	< 1	110
	10/12/1997	< 1	< 1	< 1	< 1	1.5	< 1	< 1	1.9	1.1	110

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4200 (cont.)	11/02/1997	< 1	< 1	1.1	< 1	1.6	< 1	< 1	1.3	< 1	120
	01/18/1998	< 1	< 1	< 1	< 1	1.7	< 1	1.1	2	< 1	110
	04/20/1998	< 1	< 1	< 1	< 1	1.3	< 1	< 1	1.3	< 1	90
	07/25/1998	< 1	1.2	< 1	< 1	1.6	< 1	< 1	1.5	< 1	93
	10/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	1.7	< 0.5	< 0.5	< 0.5	0.56	100
4310	01/09/1996	< 10	< 10	< 10	1400	< 10	< 10	< 10	< 10	< 10	68
	03/05/1996	< 5	< 5	< 5	1100	< 5	< 5	< 5	< 5	< 5	84
	04/02/1996	< 5	< 5	< 5	1100	< 5	< 5	< 5	< 5	< 5	85
	05/07/1996	< 5	< 5	< 5	840	< 5	< 5	< 5	< 5	< 5	83
	06/26/1996	< 5	< 5	< 5	930	< 5	< 5	75	< 5	< 5	55
	07/01/1996	< 5	< 5	< 5	1100	< 5	< 5	< 5	< 5	< 5	63
	08/07/1996	< 5	< 5	< 5	890	< 5	< 5	< 5	< 5	< 5	71
	09/10/1996	< 2	< 2	< 2	370	2.7	< 2	3.9	< 2	< 2	66
	10/05/1996	< 5	< 5	< 5	690	< 5	< 5	< 5	< 5	< 5	52
	11/02/1996	< 5	< 5	< 5	1400	< 5	< 5	7.2	< 5	< 5	72
	12/01/1996	< 5	< 5	< 5	1200	< 5	< 5	6.3	< 5	< 5	68
	01/04/1997	< 5	< 5	< 5	850	< 5	< 5	6	< 5	< 5	64
	02/01/1997	< 5	< 5	< 5	640	< 5	< 5	< 5	< 5	< 5	69
	04/26/1997	< 5	< 5	< 5	850	< 5	< 5	< 5	< 5	< 5	64
	05/04/1997	< 5	< 5	< 5	820	< 5	< 5	< 5	< 5	< 5	62
	06/01/1997	< 5	< 5	< 5	710	< 5	< 5	< 5	< 5	< 5	60
	07/06/1997	< 5	< 5	< 5	650	< 5	< 5	5.6	< 5	< 5	60
	08/02/1997	< 5	< 5	< 5	610	< 5	< 5	< 5	< 5	< 5	58
	09/12/1997	< 5	< 5	< 5	240	< 5	< 5	< 5	< 5	< 5	51
	10/10/1997	1.6	< 1	< 1	38	2.3	< 1	2.4	< 1	< 1	49
	11/07/1997	< 1	< 1	< 1	160	2.7	< 1	2.9	< 1	< 1	48
4315	01/09/1996	< 20	< 20	< 20	31	47	< 20	600	< 20	< 20	5300
	02/07/1996	< 20	< 20	< 20	< 20	45	< 20	540	< 20	< 20	5300
	03/05/1996	< 20	< 20	< 20	< 20	43	< 20	510	< 20	< 20	5100
	04/02/1996	< 20	< 20	< 20	31	60	< 20	740	< 20	< 20	5500
	05/07/1996	< 20	< 20	< 20	29	67	< 20	820	< 20	< 20	5700

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4315 (cont.)	06/05/1996	< 20	< 20	< 20	35	73	< 20	800	< 20	< 20	5600
	07/01/1996	< 20	< 20	< 20	< 20	73	< 20	800	< 20	24	6000
	08/07/1996	< 50	< 50	< 50	< 50	51	< 50	620	< 50	< 50	6300
	09/10/1996	< 20	< 20	< 20	40	76	< 20	740	45	51	5500
	10/05/1996	< 20	< 20	< 20	< 20	53	< 20	520	< 20	< 20	5200
	11/02/1996	< 20	< 20	< 20	25	49	< 20	570	< 20	< 20	5000
	12/01/1996	< 20	< 20	< 20	22	46	< 20	530	< 20	< 20	4900
	01/04/1997	< 20	< 20	< 20	30	42	< 20	480	< 20	< 20	4600
	02/01/1997	< 20	< 20	< 20	49	61	< 20	620	< 20	28	6000
	04/26/1997	< 20	< 20	< 20	72	54	< 20	760	< 20	22	5600
	05/04/1997	< 20	< 20	< 20	< 20	61	< 20	710	< 20	49	5800
	06/01/1997	< 20	< 20	< 20	< 20	63	< 20	650	< 20	57	5500
	07/06/1997	< 20	< 20	< 20	< 20	70	< 20	690	< 20	< 20	5800
	08/02/1997	< 50	< 50	< 50	< 50	< 50	< 50	500	< 50	50	6200
	09/12/1997	< 50	< 50	< 50	< 50	< 50	< 50	460	< 50	< 50	6400
	10/12/1997	< 20	< 20	< 20	< 20	65	< 20	610	< 20	< 20	5600
	11/02/1997	< 50	< 50	< 50	< 50	< 50	< 50	440	< 50	< 50	6000
	01/24/1998	< 20	< 20	< 20	< 20	24	< 20	440	< 20	< 20	5400
	04/20/1998	< 20	< 20	< 20	26	61	< 20	550	< 20	< 20	5100
	07/26/1998	< 20	< 20	< 20	< 20	69	< 20	550	< 20	24	5200
	10/18/1998	4.9	< 1	13	10	66	< 1	420	< 1	10	840
4425	01/18/1997	< 1	< 1	11	< 1	28	< 1	13	6.8	2.6	1900
	02/01/1997	< 10	< 10	< 10	< 10	14	< 10	< 10	< 10	< 10	1500
	03/01/1997	< 5	< 5	5	< 5	16	< 5	8.8	< 5	< 5	1200
	04/05/1997	< 5	< 5	11	< 5	20	< 5	12	< 5	< 5	1300
	05/15/1997	< 5	< 5	< 5	< 5	16	< 5	8.7	< 5	< 5	1200
	06/01/1997	< 5	< 5	< 5	< 5	12	< 5	6.7	< 5	< 5	1000
	07/06/1997	< 5	< 5	11	< 5	15	< 5	9.5	< 5	< 5	1100
	08/02/1997	< 5	< 5	11	< 5	14	< 5	8.9	< 5	< 5	1100
	09/12/1997	< 5	< 5	8.3	< 5	15	< 5	9.7	< 5	< 5	1100
	10/12/1997	< 5	< 5	< 5	< 5	12	< 5	6.9	< 5	< 5	1100

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4425 (cont.)	11/02/1997	< 5	< 5	6.1	< 5	15	< 5	10	< 5	< 5	1300
	01/18/1998	< 5	< 5	< 5	< 5	13	< 5	7.2	< 5	2.6	1100
	04/20/1998	< 5	< 5	6.9	< 5	12	< 5	8.5	< 5	< 5	1000
	07/25/1998	< 5	< 5	< 5	< 5	17	< 5	9.1	< 5	< 5	1100
	10/18/1998	< 0.5	< 0.5	6.3	< 0.5	18	< 0.5	10	4.8	3.1	420
4435	01/18/1997	< 1	< 1	7.4	6.8	28	< 1	74	7.8	2.3	1600
	02/01/1997	< 10	< 10	< 10	< 10	18	< 10	93	< 10	< 10	1600
	03/01/1997	< 10	< 10	< 10	< 10	17	< 10	87	< 10	< 10	1600
	04/05/1997	< 10	< 10	13	< 10	23	< 10	85	< 10	< 10	1700
	05/15/1997	< 10	< 10	< 10	< 10	19	< 10	80	< 10	< 10	1600
	06/01/1997	< 10	< 10	< 10	< 10	21	< 10	80	< 10	< 10	1600
	07/06/1997	< 10	< 10	11	< 10	21	< 10	78	< 10	< 10	1300
	08/02/1997	< 10	< 10	11	< 10	23	< 10	83	< 10	< 10	1500
	09/12/1997	< 10	< 10	< 10	< 10	16	< 10	66	< 10	< 10	1100
	10/12/1997	< 5	< 5	13	< 5	22	< 5	89	< 5	< 5	1200
	11/01/1997	< 5	< 5	< 5	< 5	18	< 5	75	< 5	< 5	1300
	01/18/1998	< 5	< 5	5.2	< 5	12	< 5	78	< 5	< 5	1100
	04/20/1998	< 5	< 5	5.7	< 5	14	< 5	86	< 5	< 5	1000
	08/10/1998	< 5	< 5	< 5	< 5	16	< 5	93	< 5	< 5	1000
	10/18/1998	< 0.5	< 0.5	5.6	4.9	20	< 0.5	83	< 0.5	2	410

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1011	01/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC1)	01/14/1997	-	-	-	-	-	16
	01/27/1997	< 0.5	< 0.5	0.69	< 0.5	-	-
	02/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	04/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/11/1997	< 0.5	< 0.5	0.63	< 0.5	-	-
	07/09/1997	< 0.5	< 0.5	0.52	< 0.5	-	-
	08/13/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	09/10/1997	< 0.5	< 0.5	0.5	< 0.5	-	-
	10/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	11/12/1997	< 0.5	< 0.5	1.6	< 0.5	-	10
	12/11/1997	< 0.5	< 0.5	1.7	< 0.5	-	< 4
	02/11/1998	< 0.5	< 0.5	1.8	< 0.5	-	-
	03/04/1998	< 0.5	< 0.5	1.6	< 0.5	< 0.033	< 4
	03/20/1998	-	-	-	-	< 0.033	-
	04/14/1998	< 0.5	< 0.5	0.59	0.68	< 0.033	-
	05/13/1998	< 0.5	< 0.5	0.99	< 0.5	< 0.033	-
	06/10/1998	< 0.5	< 0.5	1.3	0.67	< 0.0075	< 4
	07/08/1998	< 0.5	< 0.5	1.2	1.1	< 0.0075	< 4
	07/08/1998	-	-	-	-	-	< 4
	08/19/1998	< 0.5	< 0.5	0.69	< 0.5	< 0.0075	4.3
	08/26/1998	-	-	-	-	-	< 4
	08/28/1998	-	-	-	-	-	< 4
	09/01/1998	-	-	-	-	-	< 4
	09/03/1998	-	-	-	-	-	< 4
	09/09/1998	-	-	-	-	-	< 4
	09/10/1998	-	-	-	-	-	< 4
	09/16/1998	< 0.5	< 0.5	2	0.88	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	< 4
	11/18/1998	< 0.5	< 0.5	2	0.99	< 0.0075	< 4
	12/09/1998	< 0.5	< 0.5	1.8	< 0.5	< 0.0075	-
	01/13/1999	< 0.5	< 0.5	2.1	1.2	< 0.0075	-
	02/12/1999	< 0.5	< 0.5	1.3	0.71	< 0.0075	-
	03/10/1999	< 0.5	< 0.5	1.7	0.82	< 0.0075	-
	04/14/1999	< 0.5	< 0.5	2	1.6	< 0.0075	-
	05/19/1999	< 0.5	< 0.5	1.7	0.96	< 0.0075	-
	06/16/1999	< 0.5	< 0.5	< 0.5	1.1	< 0.0075	-
	07/14/1999	< 0.5	< 0.5	0.55	1	-	-
	08/18/1999	< 0.5	< 0.5	< 0.5	0.96	-	-
	09/24/1999	< 0.5	< 0.5	0.73	1	-	5.6

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1012	04/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC5)	03/04/1998	-	-	-	-	-	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	0.59	< 0.0075	< 4
	01/13/1999	< 0.5	< 0.5	< 0.5	1.3	-	-
	01/14/1999	< 0.5	< 0.5	< 0.5	1.3	-	-
	01/20/1999	< 0.5	< 0.5	< 0.5	1.4	-	-
	01/21/1999	< 0.5	< 0.5	< 0.5	1.3	-	-
	01/27/1999	< 0.5	< 0.5	< 0.5	1.5	-	-
	01/28/1999	< 0.5	< 0.5	< 0.5	1.5	-	-
	02/12/1999	< 0.5	< 0.5	< 0.5	0.55	-	-
	03/10/1999	< 0.5	< 0.5	< 0.5	0.62	< 0.0075	< 4
	04/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	07/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	08/18/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	09/28/1999	< 0.5	< 0.5	< 0.5	1	-	-
1014	01/27/1997	< 0.5	0.64	< 0.5	26	-	-
(AC13)	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	300
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	320
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	0.79	< 0.5	97	< 0.0075	350
1015	01/27/1997	< 0.5	< 0.5	< 0.5	9.7	-	-
(AC15)	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	140
	08/19/1998	-	-	-	-	< 0.0075	-
	08/27/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	140
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	18	< 0.0075	150

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1016	01/27/1997	< 0.5	< 0.5	< 0.5	17	-	-
(AC16)	03/24/1998	-	-	-	-	0.21	-
	04/14/1998	-	-	-	-	0.22	-
	05/13/1998	-	-	-	-	0.19	-
	06/10/1998	-	-	-	-	0.19	310
	07/08/1998	-	-	-	-	0.16	-
	08/19/1998	-	-	-	-	0.19	-
	09/16/1998	-	-	-	-	0.17	340
	10/15/1998	-	-	-	-	0.17	-
	11/18/1998	-	-	-	-	0.18	-
	12/09/1998	< 0.5	< 0.5	< 0.5	13	0.18	410
1017	01/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(Mitchell)	02/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	08/13/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	11/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	02/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/19/1998	-	-	-	-	-	5.6
	08/20/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	11/19/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/11/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	06/18/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/23/1999	< 0.5	< 0.5	< 0.5	1.1	-	11
1018	03/03/1998	-	-	-	-	-	< 4
(CUCC 27)	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	03/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	06/17/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1026	01/27/1997	< 0.5	1	< 0.5	0.84	-	-
(Private)	06/05/1998	-	-	-	-	< 0.0075	-
1030	01/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(SWMD 17)	02/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/14/1997	< 0.5	1.6	< 0.5	< 0.5	-	-
	08/13/1997	< 0.5	24	< 0.5	< 0.5	-	-
	04/23/1998	-	-	-	-	< 0.033	18
	06/25/1998	< 1	< 1	< 1	< 1	0.0081	18
	01/22/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	18
1033	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
(CUCC 40)	03/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	06/17/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	-	-	-	-	-	< 4

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1036 (Lonestar)	01/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	04/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	10/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	01/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	10/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	5.3
	01/13/1999	-	-	-	-	-	9.3
	01/14/1999	-	-	-	-	-	6.9
	01/20/1999	-	-	-	-	-	< 4
	01/21/1999	-	-	-	-	-	4
	01/27/1999	-	-	-	-	-	4.4
	01/28/1999	-	-	-	-	-	5
	02/11/1999	-	-	-	-	-	5.9
	03/11/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	04/14/1999	-	-	-	-	-	< 4
	06/18/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	5
	07/14/1999	-	-	-	-	-	< 4
	08/18/1999	-	-	-	-	-	< 4
	09/23/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1037 (Private)	01/27/1997	< 0.5	< 0.5	< 0.5	1.7	-	-
	06/05/1998	-	-	-	-	< 0.0075	-
	12/15/1998	< 0.5	< 0.5	< 0.5	3.8	< 0.0075	< 4
	01/13/1999	< 1.3	< 1.3	< 1.3	3.9	-	-
	01/14/1999	< 1.3	< 1.3	< 1.3	4	-	-
	01/20/1999	< 0.5	< 0.5	< 0.5	4.4	-	-
	01/21/1999	< 0.5	< 0.5	< 0.5	4.5	-	-
	01/27/1999	< 0.5	< 0.5	< 0.5	4.6	-	-
	01/28/1999	< 0.5	< 0.5	< 0.5	4.3	-	-
	02/11/1999	< 0.5	< 0.5	< 0.5	4.7	-	-
	03/11/1999	< 0.5	< 0.5	< 0.5	2.3	< 0.0075	< 4
	04/14/1999	< 0.5	< 0.5	< 0.5	3.6	-	-
	05/19/1999	< 0.5	< 0.5	< 0.5	1.8	-	-
	06/18/1999	< 0.5	< 0.5	< 0.5	0.61	< 0.0075	7.4
	06/29/1999	-	-	-	-	-	6.1
	07/14/1999	< 0.5	< 0.5	< 0.5	0.97	-	-
	08/18/1999	< 0.5	< 0.5	< 0.5	3.1	-	-
	09/23/1999	< 0.5	< 0.5	< 0.5	1.1	-	5.6

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1134	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC3)	03/04/1998	-	-	-	-	-	< 4
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	07/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1135	05/14/1997	< 0.5	< 0.5	< 0.5	1.5	-	-
(AC4)	03/04/1998	-	-	-	-	-	< 4
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	0.69	< 0.0075	< 4
	01/13/1999	< 0.5	1.1	< 0.5	2	-	-
	01/14/1999	< 0.5	1.1	< 0.5	2.1	-	-
	01/20/1999	< 0.5	1.1	< 0.5	2.3	-	-
	01/21/1999	< 0.5	1	< 0.5	2.3	-	-
	01/27/1999	< 0.5	1.2	< 0.5	2.3	-	-
	01/28/1999	< 0.5	1.1	< 0.5	2.2	-	-
	02/12/1999	< 0.5	0.54	0.59	1.7	-	-
	03/10/1999	< 0.5	0.51	< 0.5	1.5	-	-
	03/23/1999	< 0.5	1.1	< 0.5	2.2	-	-
	03/25/1999	< 0.5	0.95	< 0.5	2.2	-	-
	03/31/1999	< 0.5	0.94	< 0.5	2.1	-	-
	04/01/1999	< 0.5	0.95	< 0.5	2.2	-	-
	04/06/1999	< 0.5	1.1	< 0.5	2.1	-	-
	04/08/1999	< 0.5	1	< 0.5	2.1	-	-
	04/14/1999	< 0.5	< 0.5	< 0.5	2	-	-
	05/19/1999	< 0.5	< 0.5	< 0.5	1.6	-	-
	06/16/1999	< 0.5	< 0.5	< 0.5	1.5	-	-
	07/14/1999	< 0.5	< 0.5	< 0.5	1.5	-	< 4
	08/18/1999	< 0.5	< 0.5	< 0.5	1.3	-	-

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1136	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC6)	03/04/1998	-	-	-	-	-	< 4
	03/23/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/14/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	15
	03/31/1999	-	-	-	-	-	< 4
	04/01/1999	-	-	-	-	-	< 4
	04/06/1999	-	-	-	-	-	< 4
	04/08/1999	-	-	-	-	-	< 4
	04/13/1999	-	-	-	-	-	< 4
	04/15/1999	-	-	-	-	-	< 4
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1137	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC7)	03/04/1998	-	-	-	-	-	< 4
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/20/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/10/1999	< 0.5	< 0.5	0.5	< 0.5	< 0.0075	< 4
	05/04/1999	< 0.5	< 0.5	0.66	< 0.5	-	-
	05/06/1999	< 0.5	< 0.5	0.58	< 0.5	-	-
	05/11/1999	< 0.5	< 0.5	0.64	< 0.5	-	-
	05/13/1999	< 0.5	< 0.5	0.66	< 0.5	-	-
	05/18/1999	< 0.5	< 0.5	0.66	< 0.5	-	-
	05/20/1999	< 0.5	< 0.5	0.66	< 0.5	-	-
	06/16/1999	< 0.5	< 0.5	0.53	< 0.5	< 0.0075	< 4
	07/14/1999	< 0.5	< 0.5	0.65	< 0.5	-	-
	08/18/1999	< 0.5	< 0.5	0.68	< 0.5	-	-
	09/28/1999	< 0.5	< 0.5	0.69	< 0.5	-	-

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1138	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC8)	03/04/1998	-	-	-	-	-	< 4
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	07/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1139	03/04/1998	-	-	-	-	-	< 4
(AC10)	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/14/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	01/13/1999	-	-	-	-	< 0.0075	-
	02/12/1999	-	-	-	-	< 0.0075	-
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	04/14/1999	-	-	-	-	< 0.0075	-
	05/19/1999	-	-	-	-	< 0.0075	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1140	01/08/1997	< 0.5	< 0.5	< 0.5	1.6	-	-
(AC11)	02/12/1997	< 0.5	< 0.5	< 0.5	1.5	-	-
	03/12/1997	< 0.5	< 0.5	< 0.5	1.4	-	-
	04/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/11/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/09/1997	< 0.5	0.54	< 0.5	1.5	-	-
	08/13/1997	< 0.5	< 0.5	< 0.5	1.2	-	-
	09/10/1997	< 0.5	< 0.5	< 0.5	1.6	-	-
	10/08/1997	< 0.5	0.7	< 0.5	< 0.5	-	< 4
	11/12/1997	< 0.5	< 0.5	< 0.5	0.95	-	-
	12/11/1997	< 0.5	< 0.5	< 0.5	1.3	-	4.7
	01/14/1998	< 0.5	< 0.5	< 0.5	0.65	-	5.8
	02/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/03/1998	< 0.5	< 0.5	< 0.5	1.2	0.15	< 4
	03/05/1998	-	-	-	-	< 0.033	-

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1140 (cont.)	03/13/1998	-	-	-	-	0.13	-
(AC11)	03/13/1998	-	-	-	-	0.14	-
	03/20/1998	-	-	-	-	< 0.033	-
	03/20/1998	-	-	-	-	0.072	-
	03/30/1998	-	-	-	-	0.055	-
	04/14/1998	< 0.5	< 0.5	< 0.5	0.89	0.057	-
	05/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	0.043	-
	06/10/1998	< 0.5	< 0.5	< 0.5	< 0.5	0.038	< 4
	07/08/1998	< 0.5	< 0.5	< 0.5	0.61	0.034	< 4
	08/20/1998	< 0.5	< 0.5	< 0.5	0.89	0.039	< 4
	08/27/1998	-	-	-	-	0.03	-
	08/28/1998	-	-	-	-	0.039	-
	09/01/1998	-	-	-	-	0.034	-
	09/03/1998	-	-	-	-	0.029	-
	09/09/1998	-	-	-	-	0.037	-
	09/10/1998	-	-	-	-	0.044	-
	09/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	10/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	11/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	0.024	< 4
	01/13/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	01/20/1999	< 0.5	< 0.5	< 0.5	< 0.5	0.03	-
	02/12/1999	< 0.5	< 0.5	0.55	0.51	0.019	-
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	0.011	-
	03/23/1999	< 0.5	0.68	< 0.5	< 0.5	-	-
	03/25/1999	< 0.5	0.6	< 0.5	< 0.5	-	-
	03/31/1999	< 0.5	0.6	< 0.5	< 0.5	-	-
	04/01/1999	< 0.5	0.58	< 0.5	< 0.5	-	-
	04/06/1999	< 0.5	0.57	< 0.5	< 0.5	-	-
	04/08/1999	< 0.5	0.72	< 0.5	< 0.5	-	-
	04/14/1999	< 0.5	< 0.5	< 0.5	0.55	0.015	-
	05/19/1999	-	-	-	-	0.014	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	0.012	-
	07/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	08/18/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	08/26/1999	-	-	-	-	0.017	-
1141	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC12)	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1142 (AC14)	01/08/1997	< 0.5	< 0.5	< 0.5	0.67	-	-
	02/12/1997	< 0.5	< 0.5	< 0.5	1.1	-	-
	03/12/1997	< 0.5	< 0.5	< 0.5	1.3	-	-
	04/09/1997	< 0.5	< 0.5	< 0.5	1.8	-	-
	05/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/03/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/11/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/09/1997	< 0.5	< 0.5	< 0.5	1.2	-	-
	08/04/1997	< 0.5	< 0.5	< 0.5	0.91	-	-
	09/10/1997	< 0.5	< 0.5	< 0.5	1.4	-	-
	10/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	11
	11/12/1997	< 0.5	< 0.5	< 0.5	0.67	-	-
	12/11/1997	< 0.5	< 0.5	< 0.5	0.77	-	4.6
	01/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	5.9
	02/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/03/1998	< 0.5	< 0.5	< 0.5	1.7	< 0.1	4.4
	03/05/1998	-	-	-	-	0.025	-
	03/20/1998	-	-	-	-	0.051	-
	03/30/1998	-	-	-	-	< 0.033	-
	03/30/1998	-	-	-	-	< 0.033	-
	04/14/1998	0.53	< 0.5	< 0.5	< 0.5	< 0.033	-
	04/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/05/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/07/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.033	-
	05/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/19/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/10/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	7.1
	07/08/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	7.8
	08/19/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	9.6
	08/27/1998	-	-	-	-	-	8.6
	08/28/1998	-	-	-	-	-	9.5
	09/01/1998	-	-	-	-	-	9.4
	09/03/1998	-	-	-	-	-	8.4
	09/09/1998	-	-	-	-	-	8.3
	09/10/1998	-	-	-	-	-	6.2
	09/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	8.2
	10/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	8
	11/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	7.7
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	8.6
	01/13/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-
	02/12/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-
	04/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-
	05/19/1999	-	-	-	-	< 0.0075	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1144	03/03/1998	-	-	-	-	-	< 4
(CUCC 32)	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	07/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1148	03/03/1998	-	-	-	-	-	< 4
(CUCC 31)	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
1149	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
(CUCC 26)	03/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	06/17/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1150	03/03/1998	-	-	-	-	-	< 4
(CUCC 38)	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	07/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1151	03/03/1998	-	-	-	-	-	< 4
(CUCC 24)	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	03/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	06/17/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1800	03/24/1998	-	-	-	-	< 0.033	-
(MAFB 1)	04/23/1998	-	-	-	-	< 0.033	-
	05/28/1998	-	-	-	-	< 0.0075	-
	07/30/1998	-	-	-	-	< 0.0075	-
	08/27/1998	-	-	-	-	< 0.0075	-
	09/22/1998	-	-	-	-	< 0.0075	20
	10/14/1998	-	-	-	-	< 0.0075	17
	11/17/1998	-	-	-	-	< 0.0075	16
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	17
	01/11/1999	-	-	-	-	-	16
	02/17/1999	-	-	-	-	-	15
	03/18/1999	-	-	-	-	< 0.0075	13
	04/27/1999	-	-	-	-	-	14
	05/25/1999	-	-	-	-	-	13
	06/24/1999	-	-	-	-	< 0.0075	24
	07/28/1999	-	-	-	-	-	26
	08/25/1999	-	-	-	-	-	22

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1801	03/24/1998	-	-	-	-	< 0.033	-
(MAFB 2)	04/23/1998	-	-	-	-	< 0.033	-
	05/28/1998	-	-	-	-	< 0.0075	-
	07/30/1998	-	-	-	-	< 0.0075	-
	08/27/1998	-	-	-	-	< 0.0075	-
	09/22/1998	-	-	-	-	< 0.0075	< 4
	10/14/1998	-	-	-	-	< 0.0075	< 4
	11/17/1998	-	-	-	-	< 0.0075	< 4
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	01/11/1999	-	-	-	-	-	< 4
	02/17/1999	-	-	-	-	-	< 4
	03/18/1999	-	-	-	-	< 0.0075	< 4
	04/27/1999	-	-	-	-	-	< 4
	05/25/1999	-	-	-	-	-	< 4
	06/29/1999	-	-	-	-	< 0.0075	< 4
	07/30/1999	-	-	-	-	-	< 4
	08/25/1999	-	-	-	-	-	< 4
1860	01/27/1997	< 0.5	< 0.5	0.86	< 0.5	-	-
(AC19)	03/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/20/1998	-	-	-	-	< 0.033	-
	03/27/1998	-	-	-	-	-	19
	04/14/1998	-	-	-	-	< 0.033	-
2003	05/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC18)	03/04/1998	-	-	-	-	-	< 4
	03/23/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/10/1999	< 0.5	< 0.5	< 0.5	0.52	< 0.0075	< 4
	03/25/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/31/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	04/01/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	04/13/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/24/1999	-	-	-	-	-	< 4

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
2065	03/03/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC20)	05/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/04/1998	-	-	-	-	< 0.033	< 4
	03/20/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	01/13/1999	-	-	-	-	< 0.0075	-
	02/12/1999	-	-	-	-	< 0.0075	-
	04/14/1999	-	-	-	-	< 0.0075	-
	05/19/1999	-	-	-	-	< 0.0075	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
2066	01/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC21)	03/26/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/08/1998	-	-	-	-	< 0.0075	-
	06/10/1998	-	-	-	-	-	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/10/1999	< 0.5	< 0.5	< 0.5	0.64	< 0.0075	< 4
	03/25/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/22/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	06/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/29/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/01/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/06/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	09/27/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
2067	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
(AC22)	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/27/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
2068	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
(AC23)	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/27/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-

Note: (-) Equals not analyzed

TABLE A-4
SUMMARY OF PERCHLORATE RESULTS
LAYER A - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/l)
10	03/19/1999	< 4
22	03/23/1999	60
75	03/19/1999	14
303	09/11/1997	< 4
	03/23/1998	4.3
307	03/19/1999	8.5
1203	05/27/1997	< 400
	01/08/1998	< 4
	05/07/1998	6
	03/10/1999	< 4
1237	09/30/1997	< 4
	04/03/1998	< 4
3057	03/19/1999	8.7
3348	03/24/1999	75
3352	03/23/1999	< 4
3431	03/23/1999	< 4
30062	11/20/1996	< 400
	01/14/1997	< 400
	04/24/1997	< 400
	07/16/1997	< 400
	10/30/1997	< 4
	01/30/1998	< 4
	04/15/1998	< 4
	07/16/1998	< 4
	10/29/1998	< 4
30063	11/20/1996	< 400
	01/13/1997	< 400
	04/24/1997	< 400
	07/16/1997	< 400
	10/30/1997	< 4
	01/30/1998	< 4
	04/15/1998	< 4
	07/16/1998	< 4
	10/29/1998	< 4
30065	11/21/1996	< 400
	01/13/1997	< 400
	04/24/1997	< 400
	07/16/1997	< 400
	10/31/1997	20
	09/02/1998	9
	10/30/1998	6.5

TABLE A-7
SUMMARY OF DETECTS - SEMI-VOLATILE ORGANIC COMPOUNDS
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Bis(2-ethylhexyl) phthalate (ppb)	Di-n-octyl phthalate (ppb)
1	09/24/1991	< 10	< 10
	12/19/1991	18.6	< 10
	03/16/1992	< 10	< 10
	05/27/1992	< 10	< 10
	07/13/1992	< 10	< 10
	08/03/1992	< 50	< 10
	10/08/1992	10.3	< 10
	02/17/1993	45.4	< 10
	03/30/1994	< 50	< 10
3	07/15/1992	< 10	< 10
	10/08/1992	< 10	< 10
	03/30/1994	< 50	< 10
4	10/14/1992	< 10.2	< 10.2
22	05/18/1994	< 50	< 10
	03/27/1995	< 50	< 10
24	03/28/1995	< 50	< 10
131	03/26/1994	< 50	< 10
215	04/21/1994	< 50	< 10
307	02/06/1995	< 50	< 10
1203	02/04/1997	< 50	< 10
3221	08/21/1991	< 10	< 10
3264	08/22/1991	< 10	< 10
	11/25/1991	23	2.4
	02/04/1992	20	< 10
	05/04/1992	< 10	< 10
	10/06/1992	15.3	< 10
	04/19/1993	< 50	< 10
	03/30/1994	< 50	< 10
	03/30/1994	< 50	< 10
3352	08/25/1992	< 50	< 10
	03/08/1993	< 50	< 10
3476	09/28/1994	< 50	< 10
30062	11/20/1996	< 50	< 10
	01/14/1997	< 50	< 10
30063	11/20/1996	< 50	< 10
	01/13/1997	< 50	< 10
30065	11/21/1996	< 50	< 10
	01/13/1997	< 50	< 10

TABLE A-8
SUMMARY OF METALS ANALYSES (METHOD 6010)
LAYER A - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	WELL NO. DATE:	30062 11/20/1996	30063 11/20/1996	30065 11/21/1996	30065 07/08/1998
Aluminum	(mg/l)	< 0.2	1.1[1]	0.68[2]	-
Antimony	(mg/l)	< 0.24	< 0.24	< 0.24	-
Arsenic	(mg/l)	< 0.08	< 0.08	< 0.08	-
Barium	(mg/l)	0.029	0.25	0.027	-
Beryllium	(mg/l)	< 0.001	< 0.001	< 0.001	-
Boron	(mg/l)	< 0.04	< 0.04	0.041	0.02
Cadmium	(mg/l)	< 0.004	< 0.004	< 0.004	-
Calcium	(mg/l)	43	340	39	1.5
Chromium	(mg/l)	< 0.008	0.026	0.0084	-
Cobalt	(mg/l)	< 0.008	< 0.008	< 0.008	< 0.002
Copper	(mg/l)	< 0.006	0.0092	< 0.006	-
Iron	(mg/l)	< 0.3	0.32[2]	1.7	-
Lead	(mg/l)	< 0.06	< 0.06	< 0.06	-
Magnesium	(mg/l)	7.4	0.071	14	0.25
Manganese	(mg/l)	< 0.005	< 0.005	0.12[2]	< 0.0012
Molybdenum	(mg/l)	< 0.04	< 0.04	< 0.04	< 0.01
Nickel	(mg/l)	< 0.02	< 0.02	< 0.02	-
Potassium	(mg/l)	3.7	12	3.8	21
Selenium	(mg/l)	< 0.1	< 0.1	< 0.1	-
Silver	(mg/l)	< 0.02	< 0.02	< 0.02	< 0.005
Sodium	(mg/l)	20	60	27	63
Thallium	(mg/l)	< 0.05	< 0.05	< 0.05	-
Vanadium	(mg/l)	0.011	< 0.005	0.014	< 0.0015
Zinc	(mg/l)	< 0.1	0.22	11	< 0.025

Notes: (-) Equals not analyzed
(1) Value exceeds EPA or California DHS Primary Maximum Contaminant Level
(2) Value exceeds EPA or California DHS Secondary Maximum Contaminant Level

TABLE A-9
SUMMARY OF MISCELLANEOUS ANALYSES
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Chloride (ppm)	Nitrate (ppm)	Nitrate + Nitrite (as N) (ppm)	Sulfate (ppm)	OBPA (ppb)	Prowl (ug/l)
1	12/19/1991	13.6	6.08	0.61	16.1	-	-
	03/16/1992	17	6.6	< 0.1	19	-	-
	05/27/1992	12	6.4	< 0.3	22	-	-
	07/13/1992	14	5.7	< 0.1	26	< 10	< 2
	08/03/1992	12	6.1	< 0.1	19	-	-
	10/08/1992	21	5.7	< 0.1	26	< 10	< 2
	02/17/1993	20	5.7	< 0.05	27	-	-
3	07/15/1992	7.9	6.7	< 0.1	41	< 10	< 2
	10/08/1992	6.1	8.3	< 0.1	29	< 10	< 2
	10/23/1992	-	-	-	-	-	< 2
4	07/14/1992	33	6.7	< 0.1	37	< 10	< 2
	10/14/1992	24	6.6	< 0.1	27	< 10	< 2
8	02/10/1993	-	20	< 0.05	-	-	
10	02/08/1993	-	16	< 0.05	-	-	
22	09/22/1991	-	1.9	< 1	-	-	-
	12/13/1991	-	1.79	0.54	-	-	-
	03/09/1992	-	2.5	< 0.1	-	-	-
	05/21/1992	-	2.4	< 1	-	-	-
	11/13/1992	-	2	< 0.2	-	-	-
	05/18/1994	-	-	-	-	< 10	< 0.8
	06/10/1994	-	-	-	-	< 10	-
	12/12/1994	-	-	-	-	< 10	-
	06/07/1995	-	-	-	-	< 10	-
	12/07/1995	-	-	-	-	< 5	-
24	09/22/1991	-	6.2	< 0.1	-	-	-
	12/13/1991	-	3.96	< 0.5	-	-	-
	03/02/1992	-	6	< 0.1	-	-	-
	05/19/1992	-	6.1	< 0.3	-	-	-
	11/12/1992	-	6.2	< 0.1	-	-	-
	06/10/1994	-	-	-	-	< 10	-
	12/09/1994	-	-	-	-	< 10	-
	06/07/1995	-	-	-	-	< 10	-
	12/07/1995	-	-	-	-	< 5	-
25	09/21/1991	-	19	< 0.1	-	-	-
	12/18/1991	-	15.6	< 0.5	-	-	-
	03/06/1992	-	15.1	< 0.5	-	-	-
	06/04/1992	-	17	< 0.1	-	-	-
	11/06/1992	-	23	< 0.1	-	-	-
75	09/18/1991	-	1.1	< 0.1	-	-	-
	12/17/1991	-	0.8	< 0.5	-	-	-
	02/27/1992	-	0.5	< 0.1	-	-	-
	05/26/1992	-	0.4	< 0.3	-	-	-
	11/02/1992	-	0.3	< 0.1	-	-	-
130	08/26/1991	-	1	< 0.1	-	-	-

Note: (-) Equals not analyzed

TABLE A-9
SUMMARY OF MISCELLANEOUS ANALYSES
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Chloride (ppm)	Nitrate (ppm)	Nitrate + Nitrite (as N) (ppm)	Sulfate (ppm)	OBPA (ppb)	Prowl (ug/l)
131	08/26/1991	-	7.3	< 0.5	-	-	-
	11/20/1991	-	1.1	< 0.1	-	-	-
	02/05/1992	-	11	< 0.1	-	-	-
	05/05/1992	-	20	< 0.3	-	-	-
	08/27/1992	-	14	0.2	-	-	-
	03/11/1993	-	2.9	< 1	-	-	-
215	08/21/1991	-	158.415	2.53	-	-	-
	11/20/1991	-	110	8	-	-	-
	02/11/1992	-	58	1.8	-	-	-
	04/30/1992	-	134	2.03	-	-	-
	09/14/1992	-	120	1.4	-	-	-
	03/18/1993	-	110	6	-	-	-
	04/21/1994	-	49	-	-	-	-
	01/27/1995	-	21	-	-	-	-
	06/26/1995	-	13	-	-	-	-
303	09/10/1991	-	1.2	< 0.1	-	-	-
	12/12/1991	-	0.88	< 0.5	-	-	-
	02/24/1992	-	2.8	< 0.1	-	-	-
307	09/12/1991	-	13	< 0.1	-	-	-
	12/06/1991	-	11	< 0.1	-	-	-
	02/26/1992	-	12	< 0.1	-	-	-
	05/29/1992	-	8	< 0.1	-	-	-
	11/03/1992	-	10	< 0.1	-	-	-
	02/25/1994	-	10	-	-	-	-
374	09/16/1991	-	0.7	< 0.1	-	-	-
	12/16/1991	-	2.04	0.6	-	-	-
	03/02/1992	-	0.8	< 0.1	-	-	-
1237	03/25/1991	-	1	< 0.2	-	-	-
	06/17/1991	-	0.8	< 0.2	-	-	-
	09/05/1991	-	1.6	< 0.1	-	-	-
	11/22/1991	-	1.3	< 0.1	-	-	-
	02/04/1992	-	2.1	< 0.1	-	-	-
	04/30/1992	-	3.72	< 0.5	-	-	-
	08/31/1992	-	3.2	< 0.1	-	-	-
	03/11/1993	-	2.1	< 0.05	-	-	-
3043	12/19/1991	-	0.77	< 0.5	-	-	-
3057	02/10/1993	-	11	< 0.05	-	-	-
	04/12/1993	-	8	< 0.05	-	-	-
3221	08/21/1991	-	-	-	-	-	-
	08/21/1991	5.1	0.3	< 0.05	2.8	-	-
3222	08/21/1991	-	85.85	3.28	-	-	-
	11/27/1991	-	89	22	-	-	-
	02/07/1992	-	66.9	10.6	-	-	-
	05/18/1992	-	41	12	-	-	-
	10/08/1992	-	19	21	-	-	-
	04/30/1993	-	9.2	1.6	-	-	-
	03/14/1994	-	0.26	-	-	-	-

Note: (-) Equals not analyzed

TABLE A-9
SUMMARY OF MISCELLANEOUS ANALYSES
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Chloride (ppm)	Nitrate (ppm)	Nitrate + Nitrite (as N) (ppm)	Sulfate (ppm)	OBPA (ppb)	Prowl (ug/l)
3233	09/02/1991	-	8.1	< 0.1	-	-	-
	12/02/1991	-	8.3	< 0.1	-	-	-
	02/07/1992	-	7.73	0.64	-	-	-
	05/15/1992	-	7.9	< 0.1	-	-	-
	09/30/1992	-	7.8	< 0.1	-	-	-
	04/26/1993	-	6.2	< 0.05	-	-	-
3264	08/22/1991	40	219.9	0.46	28.4	-	-
	11/25/1991	-	-	-	-	-	-
	02/04/1992	49	200	< 0.2	32	-	-
	05/04/1992	35.9	189	1.29	36.5	-	-
	10/06/1992	31	85	1.8	28	-	-
	04/19/1993	30	56	0.11	24	-	-
	03/30/1994	-	120	-	-	-	-
	08/09/1995	-	54	-	-	-	-
3292	09/03/1991	-	31	< 0.5	-	-	-
	11/26/1991	-	9.2	0.1	-	-	-
	02/17/1992	-	19	< 0.4	-	-	-
	05/19/1992	-	14	< 0.3	-	-	-
	10/20/1992	-	21	< 0.1	-	-	-
	05/12/1993	-	10	0.07	-	-	-
	04/29/1994	-	20	-	-	-	-
3348	09/13/1991	-	5.2	< 0.1	-	-	-
	09/19/1991	-	5	< 0.1	-	-	-
	12/04/1991	-	1.2	< 0.1	-	-	-
	02/23/1992	-	0.9	< 0.1	-	-	-
	05/14/1992	-	0.8	< 0.1	-	-	-
	10/28/1992	-	0.6	< 0.1	-	-	-
	05/24/1993	-	15	< 0.05	-	-	-
	04/29/1994	-	6.7	-	-	-	-
3352	08/25/1992	12	2.7	< 0.1	7.1	-	-
	02/08/1993	-	1.8	0.19	-	-	-
	03/08/1993	10	2.1	0.1	5.1	-	-
3476	09/28/1994	3	4.2	< 0.05	9	-	-
4007	09/20/1993	33	26	-	82	-	-
4310	05/18/1995	28	47	1.8	500	-	-
30062	11/20/1996	7.4	6.9	0.23	20	-	-
30063	11/20/1996	56	3.5	1.1	2.7	-	-
30065	11/21/1996	13	2.8	0.44	20	-	-
	07/08/1998	8.3	1.3	-	7.5	-	-

Note: (-) Equals not analyzed

TABLE A-10
SUMMARY OF PETROLEUM HYDROCARBON ANALYSES
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Diesel (mg/l)	Gasoline (ppb)	Jet fuels (mg/l)	Kerosene (mg/l)	Stoddard solvent (mg/l)	TPH (mg/l)	TPH (as motor oil) (E5030-8015) (ppb)	Unknown Hydrocarbon (ppb)
1	09/24/1991	-	-	-	-	-	< 0.2	-	-
	12/19/1991	< 300	-	-	-	-	-	-	-
	03/16/1992	-	-	-	-	-	< 0.5	-	-
	05/27/1992	-	-	-	-	-	< 0.2	-	-
	08/03/1992	-	-	-	-	-	< 0.2	-	-
	02/17/1993	-	-	-	-	-	< 0.2	-	-
3221	08/21/1991	-	-	-	-	-	0.2	-	-
3264	08/22/1991	-	-	-	-	-	< 0.2	-	-
	11/25/1991	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 100
	02/04/1992	-	-	-	-	-	0.3	-	-
	05/04/1992	-	-	-	-	-	< 0.2	-	-
	10/06/1992	< 0.05	-	-	-	-	-	-	-
	04/19/1993	-	-	-	-	-	< 0.2	-	-
3352	08/25/1992	-	-	-	-	-	< 0.2	-	-
	03/08/1993	-	-	-	-	-	< 0.2	-	-
3476	09/28/1994	-	-	-	-	-	< 0.2	-	-
30062	01/13/1997	-	< 500	-	-	-	-	-	< 500
	01/14/1997	< 0.05	-	-	-	-	-	< 50	490
30063	01/13/1997	< 0.25	< 500	-	-	-	-	< 250	2300
30065	01/13/1997	< 0.05	< 500	-	-	-	-	< 50	280

Note (-) Equals not analyzed

03/30/2000

TABLE A-11
SUMMARY OF TIC RESULTS - ALL LAYERS
JANUARY 1996 TO MAY 1999

Well Number	Sample Date	Aquifer Designation	Compound	Flag	Retention Time	Estimated Concentration (µg/L)
1011	12/9/98	B,C	*Unknown*			5.4
AC1	3/10/99		No TICs			
	5/19/99		*Unknown*	B	4.30 min	6.7
	5/19/99		*Unknown 1*	B	4.40 min	5.3
	5/19/99		*Unknown 2*	B	4.48 min	5.4
	5/19/99		*Unknown 3*	B	4.95 min	5
1033	12/11/98	C	*Octadecanoic acid*			4.5
Chettenham	3/15/99		No TICs			
	5/19/99		*Unknown*	B	4.30 min	6
	5/19/99		*Unknown 1*	B	4.40 min	4.7
	5/19/99		*Unknown 2*	B	4.48 min	5.1
	5/19/99		*Unknown 3*	B	4.95 min	5
1135	12/9/98	B	*Octadecanoic acid*	B		9.1
AC4	12/9/98		*Unknown*		23.16 min	4.3
	3/10/99		No TICs			
	5/19/99		*Unknown*	B	4.31 min	5.8
	5/19/99		*Unknown 1*	B	4.41 min	4.6
	5/19/99		*Unknown 2*	B	4.49 min	5
	5/19/99		*Unknown 3*	B	4.96 min	5.2
3332	2/3/97	D	*Unknown hydrocarbon*			640
2003	12/9/98	C,D,E	1,2-Benzenedicarboxylic acid, 2-butoxyet			17
AC18	12/9/98		*Octadecanoic acid*	B		4.1
	3/10/99		No TICs			
	5/19/99		*Unknown*	B	4.30 min	4.8
	5/19/99		*Unknown 1*	B	4.40 min	4.9
	5/19/99		*Unknown 2*	B	4.48 min	4.9
	5/19/99		*Unknown 3*	B	4.95 min	5.4
30075	1/9/97	B	*Unknown hydrocarbon*			1100
30067	1/10/97	C	*Unknown hydrocarbon*			1100
30064	1/13/97	B	*Unknown hydrocarbon*			2200
30066	1/10/97	B	*Unknown hydrocarbon*			1100
30076	1/9/97	C	*Unknown hydrocarbon*			960
30114	1/12/99	C	*Unknown 1*	B		6.4
	1/12/99		*Unknown 2*	B		6.7
	1/12/99		*Unknown 3*	B		4.7
	1/12/99		*Unknown 4*		25.27	4
	1/12/99		*Unknown 5*		25.46	5.6
	2/11/99		*Tetrachloroethylene*			5.6
	3/15/99		No TICs			

Notes: "B" Compound detected in method blank

TABLE A-11
SUMMARY OF TIC RESULTS - ALL LAYERS
JANUARY 1996 TO MAY 1999

Well Number	Sample Date	Aquifer Designation	Compound	Flag	Retention Time	Estimated Concentration (µg/L)
30122	8/4/98	C	2-methyl-1hexanol			4.6
	12/17/98		*Unknown*		14.84,14.85	4.8
	2/2/99		No TICs			
	3/16/99		*Tetrachloroethylene*			4.8
30123	8/4/98	C	2-methyl-1hexanol			9.5
	12/17/98		Unknown		14.84,14.85	5.3
	2/2/99		No TICs			
	3/16/99		Dimexano			13
	3/16/99		Tetrachloroethylene			4.1
30124	12/17/98	C	*Unknown*		14.84,14.85	5.5
	2/2/99		No TICs			
	3/16/99		No TICs			
30126	12/18/98	E	*Unknown*			4.2

Notes: "B" Compound detected in method blank

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
132	5/3/96	< 10	< 10	48	< 10	67	< 10	13	< 10	< 10	9400
	10/23/96	< 10	< 10	27	< 10	100	< 10	31	< 10	< 10	7600
	2/28/97	< 5	< 5	13	< 5	78	< 5	350	< 5	< 5	4700
	9/11/97	1.5	1.8	17	< 10	86	1.4	36	< 10	1.2	2800
	3/9/98	< 20	< 20	< 20	< 20	120	< 20	49	< 20	< 20	4900
308	3/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1229	9/9/96	< 1	< 1	< 1	< 1	< 1	< 1	3.1	< 1	< 1	28
	12/13/96	< 1	< 1	< 1	< 1	< 1	< 1	3.1	< 1	< 1	28
	11/11/97	< 1	< 1	< 1	< 1	< 1	< 1	5.8	< 1	< 1	74
	4/10/98	< 1	< 1	< 1	< 1	< 1	< 1	5.6	< 1	< 1	82
1238	5/21/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	16
	4/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1242	6/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/25/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1243	6/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	32
	10/25/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	32
	9/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	27
	4/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	30
1251	1/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.5
	9/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.9
1266	4/25/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/16/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
1267	4/24/96	< 1	< 1	< 1	< 1	< 1	< 1	1.5	1.1	< 1	< 1
	10/16/96	< 1	< 1	< 1	< 1	< 1	< 1	2.1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	1
	10/7/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/20/98	< 1	< 1	< 1	< 1	< 1	< 1	1.1	< 1	< 1	< 1
	6/19/98	< 1	< 1	< 1	< 1	< 1	< 1	6.9	< 1	< 1	40
	12/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.97	< 0.5	< 0.5	1.1
1281	1/2/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1	< 1	3.8	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	7.2	< 1	< 1	< 1
1312	1/11/96	< 1	< 1	< 1	< 1	2.5	< 1	< 1	< 1	< 1	75
	8/20/96	< 1	< 1	< 1	< 1	1.9	< 1	< 1	< 1	< 1	65
	12/11/98	< 0.5	< 0.5	< 0.5	< 0.5	1.9	< 0.5	< 0.5	< 0.5	< 0.5	71
1329	1/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/17/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/13/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/1/98	< 1	< 1	< 1	< 1	< 1	< 1	4.2	< 1	< 1	40
1333	1/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/25/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	8/27/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1	< 1
	10/31/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/16/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1345	1/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.3
	8/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.2
	8/22/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.7
	12/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.7
	6/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.3
	12/17/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.1
	8/5/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.7

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
1466	7/26/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/10/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	5/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/27/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	7/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3044	1/9/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	18	< 1	< 1	47
3113	7/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1
	5/29/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.4
	1/14/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.2
	6/25/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3139	7/8/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/29/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/26/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3145	6/4/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/25/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3160	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/5/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3210	6/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/22/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
3278	6/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/11/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/27/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3351	7/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3409	3/25/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3434	6/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/8/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3441	6/21/96	< 1	< 1	< 1	< 1	< 1	< 1	3.3	< 1	< 1	< 1
	10/24/96	< 1	< 1	< 1	< 1	< 1	< 1	2.9	< 1	< 1	< 1
	10/29/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3591	12/18/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
30002	1/17/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2
	4/29/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	0.89
	7/30/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.2
	11/11/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.3
	12/11/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.1
	1/15/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.2
	4/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.2
	7/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.4
	10/30/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.9
	1/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.7
	4/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.4
	10/26/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
30005	1/18/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5
	4/25/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/29/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/22/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/7/98	< 0.5	-	-	-	-	< 0.5	-	-	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.77	< 0.5
	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	< 0.5
30016	1/25/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5
	4/23/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	0.56
	7/24/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.92
	11/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.71
	12/6/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.83
	1/20/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.3
	4/21/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.78
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.89
	10/27/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.83
	7/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.53
	10/29/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
30020	1/17/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/26/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/29/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/11/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/15/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/18/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
30044	1/19/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/24/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/26/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/21/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/20/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/22/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.91	< 0.5
	7/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.84	< 0.5	0.51	< 0.5
	10/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.69	< 0.5	0.84	< 0.5
30057	10/21/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/29/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	5/5/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/8/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30064	11/20/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.74
	12/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.66
	1/13/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
	4/28/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
	7/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2
	10/30/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.5
	1/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.58
	7/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.74
	10/29/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.2
30066	11/21/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/10/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/24/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/31/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	9/2/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
30075	11/21/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	37
	12/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/9/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/24/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/97	< 0.5	< 0.5	< 0.5	< 0.5	0.59	< 0.5	< 0.5	< 0.5	< 0.5	5.6
	10/31/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	9/2/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30092	5/5/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/6/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/10/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/15/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30095	7/11/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/9/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.5
	6/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30098	7/14/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/9/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30099	7/11/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/9/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30104	12/19/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	3/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30119	6/16/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	9/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
31000	7/21/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	11/19/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
STSW-03B	9/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	12	< 0.5	< 0.5	18
	2/10/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	11	< 0.5	< 0.5	17
	5/6/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	5.9	< 0.24	< 0.2	10
	11/4/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	7.1	< 0.24	< 0.2	9.3
	11/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	7	< 0.5	< 0.5	11
STSW-04B	4/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	9/25/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/11/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	5/2/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	< 0.16
	10/3/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	< 0.16
	5/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-08A	5/1/96	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	12	< 2.5	< 2.5	110
	9/19/96	< 10	< 10	< 10	< 10	< 10	< 10	17	< 10	< 10	410
	2/5/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.5	< 0.5	< 0.5	8.2
	5/14/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	4.8	< 0.24	< 0.2	13
	11/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3.4	< 0.5	< 0.5	4.6
STSW-09A	9/11/96	< 1	< 0.4	< 0.4	< 0.4	< 0.5	< 0.4	< 0.4	< 1	< 0.4	1.5
	6/18/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	0.53
	10/29/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	2.8
	12/9/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
STSW-19	1/26/96	< 0.2	< 1.4	< 0.3	< 0.2	-	< 0.3	< 0.2	-	< 0.4	< 0.3
	9/20/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/6/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	5/12/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	< 0.16
	12/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-20	1/26/96	< 0.2	< 1.4	< 0.3	< 0.2	-	< 0.3	< 0.2	-	< 0.4	4.5
	9/18/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/6/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.7
	5/12/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	1.7
	12/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.7

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
STSW-21	1/26/96	< 1	< 7	< 1.5	< 1	-	< 1.5	52	-	< 2	86
	9/18/96	< 1	< 1	< 1	< 1	< 1	< 1	40	< 1	< 1	60
	2/6/97	< 1	< 1	< 1	< 1	< 1	< 1	32	< 1	< 1	43
	5/12/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	32	< 0.24	< 0.2	52
	11/25/98	< 1	< 1	< 1	< 1	< 1	< 1	33.7	< 1	< 1	57
STSW-22	9/18/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/6/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.51
	5/14/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	1.3
	12/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
STSW-51A	9/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-52A	8/31/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.78	< 0.5	< 0.5	3
	11/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2	< 0.5	< 0.5	3.4

Note: (-) Equals not analyzed

TABLE A-13
SUMMARY OF PERCHLORATE ANALYSES
LAYER B - JANAURY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
235	12/18/1996	5200
304	09/11/1997	15
	03/23/1998	15
305	09/11/1997	990
	03/23/1998	11000
308	03/19/1999	8
1229	11/11/1997	2500
	04/10/1998	2800
1238	09/30/1997	48
	04/02/1998	20
1251	01/03/1996	< 400
	09/06/1996	710
1266	04/25/1996	5500
	10/16/1996	5300
	10/08/1997	4300
	04/20/1998	5200
	06/19/1998	5100
	12/16/1998	4700
1267	04/24/1996	1800
	10/16/1996	2100
	10/07/1997	1800
	04/20/1998	2000
	06/19/1998	1800
	12/16/1998	1900
1281	01/02/1996	3000
	10/15/1996	1300
	10/10/1997	2900
	04/03/1998	3600
	06/24/1998	2200
1312	01/11/1996	< 400
	08/20/1996	< 400
	12/11/1998	60
1329	01/12/1996	< 400
	10/17/1996	< 400
1333	01/18/1996	< 400
	08/27/1996	< 400
	03/10/1997	< 400
1345	01/18/1996	< 400
	08/22/1996	< 400
	06/12/1997	< 400
	12/17/1997	11
	08/05/1998	11
1466	02/10/1997	< 400
	05/28/1997	< 400
	03/27/1998	< 4
	07/02/1998	< 4
3044	01/09/1998	15
3113	05/29/1997	< 400
	03/24/1999	< 4
3139	05/29/1997	< 400
	03/24/1999	310

TABLE A-13
SUMMARY OF PERCHLORATE ANALYSES
LAYER B - JANAURY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
3210	03/10/1997	< 400
3278	03/14/1997	1700
3351	06/04/1997	< 400
3409	03/25/1999	< 4
3434	03/11/1997	5000
3441	10/29/1997	5.5
	03/19/1998	< 4
3591	12/18/1998	< 4
30002	01/15/1997	< 400
	04/23/1997	< 400
	07/16/1997	< 400
	10/30/1997	< 4
	01/30/1998	< 4
	04/13/1998	< 4
	07/14/1998	< 4
	07/14/1998	< 4
	10/26/1998	< 4
30005	01/16/1997	< 400
	04/22/1997	< 400
	07/17/1997	< 400
	10/29/1997	< 4
	01/30/1998	< 4
	04/14/1998	< 4
	07/15/1998	4
	10/28/1998	< 4
30016	01/20/1997	< 400
	04/21/1997	< 400
	07/17/1997	< 400
	10/27/1997	< 20
	01/27/1998	< 4
	04/16/1998	< 4
	10/29/1998	< 4
30020	01/15/1997	< 400
	04/23/1997	< 400
	10/29/1997	< 4
	01/28/1998	< 4
	04/13/1998	< 4
	07/15/1998	< 4
	10/27/1998	< 4
30044	01/20/1997	< 400
	04/22/1997	< 400
	07/17/1997	< 400
	10/28/1997	< 4
	01/28/1998	< 4
	04/14/1998	< 4
	07/17/1998	< 4
	10/27/1998	< 4

TABLE A-13
SUMMARY OF PERCHLORATE ANALYSES
LAYER B - JANAURY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30057	10/21/1996	6100
	10/08/1997	6300
	01/29/1998	6300
	05/05/1998	3100
	10/08/1998	6400
30064	11/20/1996	< 400
	01/13/1997	< 400
	04/28/1997	< 400
	07/16/1997	< 400
	10/30/1997	< 4
	01/30/1998	< 4
	04/15/1998	< 4
	07/16/1998	< 4
	10/29/1998	< 4
30066	11/21/1996	< 400
	01/10/1997	< 400
	04/24/1997	< 400
	07/16/1997	< 400
	10/31/1997	9.3
	09/02/1998	15
	10/30/1998	15
30075	11/21/1996	< 400
	01/09/1997	< 400
	04/24/1997	< 400
	07/15/1997	< 400
	10/31/1997	< 4
	09/02/1998	< 4
	10/30/1998	< 4
30092	05/05/1997	< 400
	10/06/1997	4.1
	02/10/1998	< 4
	12/15/1998	4.2
30095	07/11/1997	3200
	10/09/1997	3500
	02/27/1998	5600
	06/17/1998	4200
30098	07/14/1997	7200
	10/09/1997	6900
	02/04/1998	7100
	12/15/1998	6700
30099	07/11/1997	610
	10/09/1997	7800
	02/04/1998	6100
30104	12/19/1997	< 4
	03/02/1998	< 4
	09/16/1998	< 4
30119	09/21/1998	< 4
31000	07/21/1997	< 400
	11/19/1997	< 4
	02/18/1998	< 4
	05/04/1998	< 4

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

= wells within multiple-completion boring

< PQL of 100 ug/l & > MDL = 35 ug/l.

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 3A	06-May-97				6,300
STSW 3A	04-Nov-97				6,700
STSW 3A	17-Nov-98				1,400
STSW 3B	07-Feb-95		4,000		
STSW 3B	12-Apr-95		2,500		
STSW 3B	16-Jan-97				6,700
STSW 3B	10-Feb-97				7,100
STSW 3B	06-May-97				5,900
STSW 3B	04-Nov-97				5,800
STSW 3B	17-Nov-98				5,200
STSW 3B	12-May-99				4,100
STSW 3C	07-Feb-95	400			
STSW 3C	12-Apr-95	400			
STSW 3C	16-Jan-97				450
STSW 3C	10-Feb-97				470
STSW 3C	06-May-97				320
STSW 3C	17-Nov-98				250
STSW 3C	12-May-99				220
STSW 4B	17-Jan-97			35	
STSW 4B	11-Feb-97			35	
STSW 4B	02-May-97			35	
STSW 4B	03-Oct-97			4	
STSW 4B	15-May-98			4	
STSW 4B	12-Nov-98				4
STSW 4B	23-Apr-99				5
STSW 4B	09-Nov-99			4	
STSW 4C	16-Jan-97				760
STSW 4C	11-Feb-97			35	
STSW 4C	02-May-97			35	
STSW 4C	03-Oct-97				200
STSW 4C	15-May-98				14
STSW 4C	12-Nov-98				1,500
STSW 4C	23-Apr-99				1,600
STSW 4C	09-Nov-99				1,600
STSW 8A	27-Jun-94	400			
STSW 8A	11-Oct-94		1,000		
STSW 8A	16-Feb-95	400			

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

= wells within multiple-completion boring

< PQL of 100 ug/l & > MDL = 35 ug/l.

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 8A	20-Apr-95	400			
STSW 8A	07-Dec-95	400			
STSW 8A	19-Sep-96				1,300
STSW 8A	05-Feb-97			35	
STSW 8A	14-May-97				52
STSW 8A	30-Nov-98				15
STSW 8A	26-May-99				18
STSW 8B	27-Jun-94	400			
STSW 8B	11-Oct-94	400			
STSW 8B	15-Feb-95	400			
STSW 8B	19-Apr-95	400			
STSW 8B	07-Dec-95	400			
STSW 8B	19-Sep-96			35	
STSW 8B	05-Feb-97			35	
STSW 8B	14-May-97			35	
STSW 8B	30-Nov-98			4	
STSW 8B	26-May-99				13
STSW 8C	27-Jun-94	400			
STSW 8C	11-Oct-94	400			
STSW 8C	15-Feb-95	400			
STSW 8C	19-Apr-95	400			
STSW 8C	07-Dec-95	400			
STSW 8C	19-Sep-96			35	
STSW 8C	05-Feb-97			35	
STSW 8C	14-May-97			35	
STSW 8C	30-Nov-98				13
STSW 8C	24-May-99				15
STSW 19	12-Jul-94	400			
STSW 19	13-Oct-94	400			
STSW 19	13-Feb-95	400			
STSW 19	12-Apr-95	400			
STSW 19	26-Jan-96	400			
STSW 19	20-Sep-96			35	
STSW 19	06-Feb-97			35	
STSW 19	12-May-97			35	
STSW 19	01-Dec-98			4	
STSW 19	25-Jun-99				4
STSW 20	14-Jul-94	400			
STSW 20	13-Oct-94	400			
STSW 20	14-Feb-95	400			

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

= wells within multiple-completion boring

< PQL of 100 ug/l & > MDL = 35 ug/l.

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 20	13-Apr-95	400			
STSW 20	26-Jan-96	400			
STSW 20	18-Sep-96			35	
STSW 20	06-Feb-97			35	
STSW 20	12-May-97			35	
STSW 20	01-Dec-98				6
STSW 20	30-Apr-99				5
STSW 21	07-Jul-94	400			
STSW 21	13-Oct-94	400			
STSW 21	14-Feb-95	400			
STSW 21	18-Apr-95	400			
STSW 21	26-Jan-96	400			
STSW 21	18-Sep-96				75
STSW 21	06-Feb-97				50
STSW 21	12-May-97				56
STSW 21	25-Nov-98				330
STSW 21	30-Apr-99				810
STSW 22	07-Jul-94	400			
STSW 22	14-Oct-94		5,300		
STSW 22	14-Feb-95	400			
STSW 22	18-Apr-95	400			
STSW 22	07-Dec-95	400			
STSW 22	18-Sep-96			35	
STSW 22	06-Feb-97			35	
STSW 22	14-May-97			35	
STSW 22	01-Dec-98				8
STSW 22	30-Apr-99				11
STSW 28A	30-Apr-97			35	
STSW 28A	03-Oct-97			4	
STSW 28A	18-May-98			4	
STSW 28A	10-Nov-98			4	
STSW 28A	04-May-99			4	
STSW 28A	08-Nov-99			4	
STSW 28B	30-Apr-97				100
STSW 28B	03-Oct-97				190
STSW 28B	15-May-98				240
STSW 28B	10-Nov-98				350
STSW 28B	04-May-99				420
STSW 28B	08-Nov-99				180
STSW 28C	30-Apr-97			35	

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

= wells within multiple-completion boring

[< PQL of 100 ug/l & > MDL = 35 ug/l.]

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 28C	03-Oct-97			4	
STSW 28C	15-May-98			4	
STSW 28C	10-Nov-98			4	
STSW 28C	04-May-99			4	
STSW 28C	08-Nov-99			4	
STSW 29A	20-Jan-97				1,300
STSW 29A	09-May-97				2,100
STSW 29A	13-Oct-97				1,300
STSW 29A	25-Nov-98				1,000
STSW 29A	25-Jun-99				970
STSW 29B	17-Jan-97				1,000
STSW 29B	08-May-97				920
STSW 29B	13-Oct-97				760
STSW 29B	25-Nov-98				450
STSW 29B	25-Jun-99				370
STSW 29C	17-Jan-97			[35]	
STSW 29C	08-May-97			[35]	
STSW 29C	13-Oct-97			4	
STSW 29C	25-Nov-98			4	
STSW 29C	25-Jun-99			4	
STSW 30A	21-Jan-97			[35]	
STSW 30A	09-May-97			[35]	
STSW 30A	14-Oct-97				24
STSW 30A	24-Nov-98				35
STSW 30A	07-May-99				37
STSW 30B	20-Jan-97			[35]	
STSW 30B	09-May-97			[35]	
STSW 30B	14-Oct-97			4	
STSW 30B	24-Nov-98			4	
STSW 30B	07-May-99			4	
STSW 30C	20-Jan-97			[35]	
STSW 30C	09-May-97			[35]	
STSW 30C	14-Oct-97			4	
STSW 30C	24-Nov-98			4	
STSW 30C	07-May-99			4	

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

[= wells within multiple-completion boring

< PQL of 100 ug/l & > MDL = 35 ug/l.

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 51A	30-Jul-98				6,500
STSW 51A	01-Sep-98				6,400
STSW 51A	13-Nov-98				5,600
STSW 51A	20-Jan-99				6,600
STSW 51A	30-Apr-99				6,800
STSW 51B	30-Jul-98			4	
STSW 51B	01-Sep-98			4	
STSW 51B	13-Nov-98			4	
STSW 51B	20-Jan-99			4	
STSW 51B	30-Apr-99			4	
STSW 51C	30-Jul-98				9
STSW 51C	01-Sep-98			4	
STSW 51C	12-Nov-98			4	
STSW 51C	20-Jan-99				4
STSW 51C	30-Apr-99			4	
STSW 52A	29-Jul-98				2,200
STSW 52A	31-Aug-98				2,100
STSW 52A	16-Nov-98				1,800
STSW 52A	21-Jan-99				2,000
STSW 52A	10-May-99				2,200
STSW 52B	29-Jul-98				4
STSW 52B	31-Aug-98				6
STSW 52B	13-Nov-98			4	
STSW 52B	21-Jan-99				5
STSW 52B	10-May-99				5
STSW 52C	29-Jul-98				300
STSW 52C	31-Aug-98				320
STSW 52C	13-Nov-98				120
STSW 52C	21-Jan-99				440
STSW 52C	10-May-99				430

TABLE A-15
SUMMARY OF NDMA ANALYSES
LAYER B - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
123	05/18/1998	< 0.0075
125	05/20/1998	< 0.0075
169	05/20/1998	< 0.0075
282	05/21/1998	0.32
283	05/21/1998	0.041
291	05/21/1998	< 0.0075
441	05/26/1998	0.17
1212	07/13/1998	< 0.0075
1434	04/30/1998	< 0.02
1466	07/16/1998	< 0.0075
3017	07/09/1998	< 0.0075
3048	05/22/1998	< 0.0075
3351	05/27/1998	< 0.0075
3409	05/28/1998	< 0.0075
3447	06/04/1998	0.081
3457	07/10/1998	< 0.0075
3463	05/29/1998	0.036
30002	04/13/1998	< 0.02
	07/14/1998	< 0.0075
	07/14/1998	< 0.0075
	10/26/1998	< 0.0075
30005	04/14/1998	< 0.02
	07/15/1998	< 0.0075
	10/28/1998	< 0.0075
30016	04/16/1998	< 0.02
	07/16/1998	< 0.0075
	07/16/1998	< 0.0075
	10/29/1998	< 0.0075
30020	04/13/1998	< 0.02
	07/15/1998	< 0.0075
	10/27/1998	< 0.0075
30044	04/14/1998	< 0.02
	07/17/1998	< 0.0075
	10/27/1998	< 0.0075
30064	04/15/1998	< 0.02
	07/16/1998	< 0.0075
	10/29/1998	< 0.0075
30066	09/02/1998	< 0.0075
	10/30/1998	< 0.0075
30075	09/02/1998	< 0.0075
	10/30/1998	< 0.0075
31000	05/06/1998	< 0.02

TABLE A-16
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (METHOD 8270)
LAYER B - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	Well No: / Date:	1312 01/11/1996	3591 12/18/1998	30002 01/15/1997	30057 01/29/1998	30064 11/20/1996	30064 01/13/1997	30066 01/10/1997	30075 11/21/1996
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	-	< 10	< 10	< 10	< 10	< 10	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-16

SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (METHOD 8270)

LAYER B - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	Well No: / Date:	1312 01/11/1996	3591 12/18/1998	30002 01/15/1997	30057 01/29/1998	30064 11/20/1996	30064 01/13/1997	30066 01/10/1997	30075 11/21/1996
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 10	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-16
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (METHOD 8270)
LAYER B - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	Well No: / Date:	30075 01/09/1997	30092 05/05/1997	30095 07/11/1997	30098 07/14/1997	30098 07/14/1997	30099 07/11/1997	30104 12/19/1997	30119 06/16/1998	31000 07/21/1997
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-16
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (METHOD 8270)
LAYER B - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	Well No: / Date:	30075 01/09/1997	30092 05/05/1997	30095 07/11/1997	30098 07/14/1997	30098 07/14/1997	30099 07/11/1997	30104 12/19/1997	30119 06/16/1998	31000 07/21/1997
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	25	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-17
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER B - JANUARY 1996 TO APRIL 1999

Well No. / Sample Date / Compound		30002 7/7/98	30057 1/29/98	30064 11/20/96	30066 11/21/96	30066 7/8/98	30092 5/5/97	30095 7/11/97	30098 7/14/97	30099 7/11/97	30104 12/19/97
Aluminum	(ppm)	< 0.05	< 0.2	< 0.2	< 0.2	-	< 0.2	< 0.2	< 0.2	< 0.2	
Antimony	(ppm)	-	< 0.2	< 0.24	< 0.24	-	< 0.24	< 0.24	< 0.24	< 0.24	
Arsenic	(ppm)	< 0.02	< 0.08	< 0.08	< 0.08	-	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	(ppm)	0.072	0.053	0.032	0.22	-	0.016	0.014	0.015	0.042	0.044
Beryllium	(ppm)	< 0.00025	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	(ppm)	0.16	< 0.04	< 0.04	< 0.04	-	< 0.04	< 0.04	< 0.04	0.19	< 0.04
Cadmium	(ppm)	< 0.001	< 0.004	< 0.004	< 0.004	-	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	(ppm)	-	14	16	110	-	15	43	15	14	14
Chromium	(ppm)	0.0021	< 0.008	< 0.008	< 0.008	-	< 0.008	0.0091	< 0.008	< 0.008	< 0.008
Cobalt	(ppm)	< 0.002	< 0.008	< 0.008	< 0.008	-	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	(ppm)	< 0.0015	0.01	0.016	< 0.006	-	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	(ppm)	< 0.075	< 0.3	< 0.3	< 0.3	-	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	(ppm)	< 0.015	< 0.06	< 0.06	< 0.06	-	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	(ppm)	-	8.4	3.6	0.1	-	3	0.83	9.6	8.2	5
Manganese	(ppm)	-	0.01	< 0.005	< 0.005	-	< 0.005	< 0.005	0.064	1	< 0.005
Molybdenum	(ppm)	< 0.01	< 0.04	< 0.04	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	(ppm)	< 0.005	< 0.02	< 0.02	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	(ppm)	-	< 2	11	11	-	1.8	4	1.7	2.6	2.1
Selenium	(ppm)	< 0.025	< 0.1	< 0.1	< 0.1	< 0.025	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	(ppm)	< 0.005	< 0.02	< 0.02	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	(ppm)	-	8.5	34	47	-	13	21	9.4	20	11
Thallium	(ppm)	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	(ppm)	-	< 0.006	0.0086	< 0.005	-	0.016	0.026	0.005	< 0.005	0.012
Zinc	(ppm)	< 0.025	0.32	< 0.1	< 0.1	-	< 0.1	< 0.1	4	27	< 0.1

Note: (-) Equals not analyzed

TABLE A-17
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER B - JANUARY 1996 TO APRIL 1999

Compound		Well No. 30119 Sample Date 6/16/98	31000 7/21/97	3591 12/18/98
Aluminum	(ppm)	< 0.2	< 0.2	< 0.2
Antimony	(ppm)	< 0.2	< 0.24	< 0.2
Arsenic	(ppm)	< 0.08	< 0.08	< 0.08
Barium	(ppm)	0.11	0.077	0.048
Beryllium	(ppm)	< 0.001	< 0.001	< 0.001
Boron	(ppm)	< 0.04	< 0.04	< 0.04
Cadmium	(ppm)	< 0.004	< 0.004	< 0.004
Calcium	(ppm)	19	20	50
Chromium	(ppm)	< 0.008	< 0.008	< 0.008
Cobalt	(ppm)	< 0.008	< 0.008	< 0.008
Copper	(ppm)	< 0.006	< 0.006	< 0.006
Iron	(ppm)	< 0.3	< 0.3	< 0.3
Lead	(ppm)	< 0.06	< 0.06	< 0.06
Magnesium	(ppm)	2.1	10	7.6
Manganese	(ppm)	< 0.005	< 0.005	< 0.005
Molybdenum	(ppm)	< 0.04	< 0.04	< 0.04
Nickel	(ppm)	< 0.02	< 0.02	< 0.02
Potassium	(ppm)	3.4	2.7	3.6
Selenium	(ppm)	< 0.1	< 0.1	< 0.1
Silver	(ppm)	< 0.02	< 0.02	< 0.02
Sodium	(ppm)	15	13	21
Thallium	(ppm)	< 0.05	< 0.05	< 0.05
Vanadium	(ppm)	0.015	0.0075	0.011
Zinc	(ppm)	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-18
SUMMARY OF ANION ANALYSES
LAYER B - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Chloride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
3591	12/18/1998	75	11	0.56	14
30020	07/07/1998	-	28	-	-
30044	07/07/1998	-	-	-	72
30057	01/29/1998	5.1	2.5	< 0.05	9.9
30064	11/20/1996	24	2	1.8	23
30066	11/21/1996	21	5	2.4	13
30092	05/05/1997	2.9	7.7	< 0.05	4.4
30095	07/11/1997	13	1.1	< 0.25	20
30098	07/14/1997	7.6	1.8	< 0.05	12
30099	07/11/1997	48	0.57	< 0.25	14
30119	06/16/1998	5.5	9.6	< 0.15	4.7
31000	07/21/1997	4.8	5.2	< 0.05	8.9

Notes: (-) Equals not analyzed

TABLE [redacted]
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
124	03/23/1999	0.67	11	0.94	32	0.66	12	2.6	< 0.5	2.8	830
127	06/27/1996	< 1	2.5	< 1	6.3	< 1	7.1	< 1	< 1	< 1	380
	11/15/1996	< 1	1.2	< 1	2.6	< 1	3.7	< 1	< 1	< 1	190
	05/16/1997	< 1	< 1	< 1	1.7	< 1	4.3	< 1	< 1	< 1	150
	01/06/1998	< 1	1	< 1	1.7	< 1	4.9	< 1	< 1	< 1	160
	06/19/1998	< 1	< 1	< 1	1.2	< 1	3.4	< 1	< 1	< 1	110
134	06/27/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/16/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
135	06/27/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
138	06/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/14/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
139	12/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
357	06/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/25/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
399	05/20/1996	< 1	< 1	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.1
	10/29/1996	< 1	< 1	< 1	< 1	< 1	1.8	< 1	< 1	< 1	1.3
	02/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.4
	09/25/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.5
	03/30/1998	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	3.1

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
420	07/01/1996	< 1	< 1	< 1	1.2	< 1	< 1	1.5	< 1	< 1	11
	11/20/1996	1.2	< 1	< 1	2.1	< 1	< 1	3	< 1	1.1	12
	02/03/1997	1.2	< 0.5	< 0.5	2	< 0.5	0.88	< 3.1	< 0.5	1.1	16
	05/21/1997	1.3	< 1	< 1	2.5	< 1	< 1	3.5	< 1	< 1	15
	01/07/1998	1.2	< 1	< 1	1.5	< 1	< 1	2.6	< 1	< 1	16
	05/20/1998	1	< 1	< 1	2	< 1	< 1	1.7	< 1	< 1	13
437	06/28/1996	< 1	< 1	< 1	1.2	< 1	1	< 1	< 1	< 1	120
	11/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	100
	05/22/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	32
	01/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	13
	06/29/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	20
438	06/28/1996	< 1	3.7	< 1	7.2	< 1	3.4	2.1	< 1	1.1	590
	11/20/1996	< 1	7.6	< 1	9.8	< 1	5.2	2.8	< 1	1.6	680
	05/22/1997	< 1	< 1	< 1	2.2	< 1	< 1	1.4	< 1	< 1	170
	01/07/1998	< 1	1.5	< 1	1.1	< 1	< 1	< 1	< 1	< 1	140
	06/29/1998	< 1	< 1	< 1	2.1	< 1	1	1.4	< 1	< 1	140
447	06/28/1996	< 1	< 1	< 1	1.2	< 1	3.3	< 1	< 1	< 1	130
	11/19/1996	< 1	< 1	< 1	< 1	< 1	2.6	< 1	< 1	< 1	69
	05/28/1997	< 1	< 1	< 1	< 1	< 1	1.4	< 1	< 1	< 1	31
	01/08/1998	< 1	< 1	< 1	< 1	< 1	1.4	< 1	< 1	< 1	16
	06/23/1998	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	< 1	13
494	05/23/1996	< 1	< 1	1.4	< 1	< 1	41	< 1	< 1	< 1	13
	10/25/1996	< 1	< 1	2.1	< 1	< 1	39	< 1	< 1	< 1	9.1
	09/12/1997	< 1	< 1	1.5	< 1	< 1	24	< 1	< 1	< 1	13
	03/13/1998	< 1	< 1	1.5	< 1	< 1	25	< 1	< 1	< 1	17
495	05/23/1996	< 1	2.1	< 1	< 1	< 1	7.9	< 1	< 1	< 1	190
	10/25/1996	< 1	3.5	< 1	< 1	< 1	10	< 1	< 1	< 1	200
	09/12/1997	< 1	< 1	< 1	< 1	< 1	34	< 1	< 1	< 1	140
	03/13/1998	< 1	1.2	< 1	< 1	< 1	26	< 1	< 1	< 1	130

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1169	01/11/1996	< 0.5	< 0.5	< 0.25	1.6	< 0.5	< 0.5	< 0.5	< 0.5	0.74	42
	04/03/1996	< 0.5	< 0.5	< 0.25	1.5	< 0.25	< 0.5	< 0.5	< 0.5	0.79	53
	07/02/1996	< 0.5	0.56	< 0.25	0.74	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	38
	01/03/1997	< 0.5	< 0.5	< 0.5	0.83	< 0.5	< 0.5	< 0.5	< 0.5	0.99	41
	02/05/1997	< 0.5	0.96	< 0.5	0.97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	39
	04/02/1997	< 0.5	< 0.5	< 0.5	0.87	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	36
	07/25/1997	< 0.5	< 0.5	< 0.5	0.83	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	36
	10/03/1997	< 0.5	< 0.5	< 0.5	0.71	< 0.5	< 0.5	< 0.5	< 0.5	0.51	40
	01/19/1998	< 0.5	1.4	< 0.5	1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	54
	06/23/1998	< 0.5	0.97	< 0.5	1.6	< 0.5	0.54	< 0.5	< 0.5	0.67	55
	07/17/1998	< 0.5	1	< 0.5	1.7	< 0.5	0.57	< 0.5	< 0.5	0.66	56
	10/09/1998	< 0.5	3.4	< 0.5	3.3	< 0.5	0.79	< 0.5	< 0.5	0.81	80
1204	02/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	07/30/1996	< 1	< 1	< 1	1.8	< 1	< 1	< 1	< 1	< 1	14
	12/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.7
	02/04/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.52
	05/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	15
	01/08/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.7
1231	12/13/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.2
	11/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	86
	04/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	77
1239	05/20/1996	< 1	< 1	< 1	3	< 1	< 1	< 1	< 1	< 1	68
	11/01/1996	< 1	< 1	< 1	3.5	< 1	< 1	< 1	< 1	< 1	22
	03/05/1997	< 1	< 1	< 1	1.8	< 1	< 1	< 1	< 1	< 1	88
	09/30/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	260
	04/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	260
1240	05/20/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	190
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	98
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	110
	09/30/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	200
	04/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	240

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1244	06/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.3
	09/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1245	06/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1252	01/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	6.2
	09/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	12
1253	01/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4
	09/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10
1268	04/24/1996	< 1	< 1	< 1	< 1	< 1	9.7	< 1	< 1	< 1	15
	10/16/1996	< 1	< 1	< 1	< 1	< 1	9	< 1	< 1	< 1	25
	10/29/1996	< 1	< 1	< 1	< 1	< 1	9.1	< 1	< 1	< 1	23
	10/07/1997	< 1	< 1	< 1	< 1	< 1	7.2	< 1	< 1	< 1	35
	04/20/1998	< 1	< 1	< 1	< 1	< 1	7.2	< 1	< 1	< 1	40
	06/19/1998	< 1	< 1	< 1	< 1	< 1	1.2	< 1	< 1	< 1	1.2
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.1	< 0.5	< 0.5	< 0.5	44
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6	< 0.5	< 0.5	< 0.5	47
1272	07/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/03/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/06/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/29/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1273	07/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/03/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/29/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.7

Note: (-) Equals not analyzed

TABLE 9
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1277	05/24/1996	< 1	1.4	< 1	< 1	< 1	9.1	< 1	< 1	< 1	140
	10/18/1996	< 1	< 1	< 1	< 1	< 1	8	< 1	< 1	< 1	130
	10/30/1996	< 1	< 1	< 1	< 1	< 1	8.5	< 1	< 1	< 1	130
	03/07/1997	< 1	< 1	< 1	< 1	< 1	8	< 1	< 1	< 1	94
	10/09/1997	< 1	1.1	< 1	< 1	< 1	7.8	< 1	< 1	< 1	180
	04/16/1998	< 1	< 1	< 1	< 1	< 1	6	< 1	< 1	< 1	100
1278	05/24/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/07/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/09/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1282	06/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.6
	10/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3
	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.1
	03/07/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.2
	10/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.8
	04/03/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1
1283	06/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1294	01/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/04/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.67
1295	01/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/04/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1313	01/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/20/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.8
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.7

Note: (-) Equals not analyzed

TABLE 9
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1330	01/12/1996	< 1	< 1	< 1	< 1	< 1	3.9	< 1	1.3	< 1	81
	06/14/1996	< 1	< 1	< 1	< 1	< 1	6.7	< 1	< 1	< 1	97
	10/17/1996	< 1	1.4	< 1	< 1	< 1	6.3	< 1	< 1	< 1	130
	10/30/1996	< 1	< 1	< 1	< 1	< 1	6.3	< 1	< 1	< 1	130
	10/13/1997	< 1	< 1	< 1	< 1	< 1	4.8	< 1	< 1	< 1	69
	04/01/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1331	06/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/13/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/01/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1334	01/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/24/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/26/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1335	01/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/25/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/28/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1346	01/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.3
	08/14/1996	< 1	1.1	< 1	< 1	< 1	< 1	< 1	< 1	1.1	8.2
	08/22/1996	< 1	1.4	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.4
	12/09/1996	< 1	2.1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.6
	06/12/1997	< 1	1.9	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.8
	12/17/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.5
	08/05/1998	< 1	1.1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.6

Note: (-) Equals not analyzed

TABLE 9
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1347	01/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.1	< 1
	08/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.2	< 1
	12/09/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/17/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1350	01/16/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.9
	05/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.8
	09/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	5.2
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.3
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4
	10/20/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.7
	04/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.3
1351	01/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.9
	05/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	6.2
	09/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	5.8
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.7
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.8
	10/17/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.3
1352	01/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/16/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1353	01/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3
	06/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	16
	09/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	19
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	17
	03/13/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	19
	10/21/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	19
	04/02/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	36

Note: (-) Equals not analyzed

TABLE 19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1354	01/12/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	43
	06/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	62
	09/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	64
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	53
	03/13/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	42
	10/21/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	44
	04/02/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.8
1355	01/12/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/13/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/21/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/02/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1435	07/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	4.6
	11/27/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.1
	05/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	1.2	< 1	< 1	3.2
	01/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	1.5	< 1	< 1	5
1457	01/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.1
	06/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/03/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/20/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1460	07/10/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1463	09/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE 9
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1467	07/26/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	20
	11/27/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	19
	02/07/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.66	< 0.5	< 0.5	< 0.5	19
	05/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	17
	03/27/1998	< 1	2.4	< 1	< 1	< 1	< 1	< 1	< 1	< 1	51
	07/02/1998	< 1	3.9	< 1	< 1	< 1	< 1	< 1	< 1	< 1	67
1484	09/24/1996	< 1	1.4	< 1	1.6	< 1	< 1	1.8	< 1	< 1	40
	11/22/1996	< 1	1.1	< 1	1.8	< 1	< 1	< 1	< 1	< 1	47
	02/03/1997	0.94	1.5	< 0.5	2.2	< 0.5	< 0.5	1.1	< 0.5	1.2	55
	06/03/1997	< 1	1.6	< 1	1.8	< 1	< 1	< 1	< 1	< 1	46
	01/08/1998	< 1	1.3	< 1	2.1	< 1	< 1	< 1	< 1	< 1	55
	04/30/1998	< 1	3	< 1	2.2	< 1	< 1	< 1	< 1	< 1	61
3049	05/22/1998	< 1	< 1	160	8.9	< 1	400	< 1	2.1	2.8	380
3050	05/22/1998	< 1	< 1	< 1	6.3	< 1	420	< 1	< 1	2.6	370
3058	05/31/1996	1.1	63	2.8	41	< 1	200	< 1	< 1	1.6	4200
	11/01/1996	< 5	43	< 5	21	< 5	99	< 5	< 5	5.9	5300
	02/27/1997	< 5	39	< 5	21	< 5	92	< 5	< 5	< 5	4700
	10/03/1997	< 2	< 20	4	< 20	< 20	130	< 20	< 20	< 2	4500
	03/16/1998	< 2	38	4.4	36	< 2	190	< 2	< 2	< 2	780
3059	05/31/1996	< 1	< 1	< 1	< 1	< 1	25	< 1	< 1	< 1	62
	11/01/1996	< 1	< 1	< 1	< 1	< 1	22	< 1	< 1	< 1	58
	02/27/1997	< 1	< 1	1.3	< 1	< 1	65	< 1	< 1	< 1	160
	10/03/1997	< 1	< 1	< 1	< 1	< 1	9.7	< 1	< 1	< 1	36
	03/16/1998	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	< 1	28
3060	05/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.2
	11/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/24/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3114	07/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/14/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/25/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE 19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3124	05/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.4
	11/04/1996	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	< 1	7
	03/03/1997	< 1	< 1	< 1	< 1	< 1	1.2	< 1	< 1	< 1	5.6
	10/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1
3125	05/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.3
3126	05/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	11
	11/04/1996	< 1	< 1	< 1	< 1	< 1	9	< 1	< 1	< 1	71
	02/28/1997	< 1	< 1	< 1	< 1	< 1	9.9	< 1	< 1	< 1	90
	10/12/1997	< 1	< 1	< 1	< 1	< 1	8.4	< 1	< 1	< 1	93
	03/18/1998	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	< 1	120
3140	07/08/1996	< 1	< 1	< 1	< 1	< 1	3.9	< 1	< 1	< 1	1.9
	12/03/1996	< 1	< 1	< 1	< 1	< 1	4.3	< 1	< 1	< 1	2.7
	05/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/26/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3141	07/08/1996	< 1	< 1	< 1	< 1	< 1	2.5	< 1	< 1	< 1	2
	12/03/1996	< 1	< 1	< 1	< 1	< 1	2.8	< 1	< 1	< 1	1.8
	05/28/1997	< 1	< 1	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.1
	01/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/26/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3146	06/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/03/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/25/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE 19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3147	06/03/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/03/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/24/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3161	06/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/04/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/14/1997	< 1	< 1	< 1	< 1	< 1	1.2	< 1	< 1	< 1	1.7
	03/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3211	06/12/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/22/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/17/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3228	06/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/23/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3279	06/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/14/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3280	06/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/14/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3304	01/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.1
3323	05/28/1998	< 5	< 5	< 5	< 5	< 5	670	< 5	< 5	< 5	330

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3335	07/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/02/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/27/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3341	05/24/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.9
	10/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3342	05/29/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.7
3353	07/17/1996	< 1	8.2	< 1	11	< 1	4.7	3.6	< 1	2.4	990
	11/26/1996	< 1	7.9	< 1	10	< 1	5.5	2.7	< 1	1.1	750
	06/04/1997	< 1	< 1	1.1	2	< 1	< 1	< 1	< 1	< 1	160
	01/16/1998	< 1	< 1	< 1	1.1	< 1	< 1	< 1	< 1	< 1	72
	06/26/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	11
3403	07/17/1996	< 1	< 1	< 1	1.1	< 1	< 1	1.3	< 1	< 1	7.5
	11/25/1996	< 1	< 1	< 1	1.1	< 1	< 1	1.5	< 1	< 1	7.3
	02/05/1997	0.72	< 0.5	1.4	1.1	< 0.5	< 0.5	1.6	< 0.5	< 0.5	8.1
	06/03/1997	< 1	< 1	< 1	1.1	< 1	< 1	< 1	< 1	< 1	6.6
	01/14/1998	< 1	< 1	< 1	1.2	< 1	< 1	< 1	< 1	< 1	7.1
	05/28/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.1
3406	08/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/26/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/04/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/24/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE 19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3435	06/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/08/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3436	06/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/08/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3438	06/13/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1
	10/25/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.3
	10/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2
	03/20/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1
3441	06/21/1996	< 1	< 1	< 1	< 1	< 1	3.3	< 1	< 1	< 1	< 1
	10/24/1996	< 1	< 1	< 1	< 1	< 1	2.9	< 1	< 1	< 1	< 1
	10/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3442	06/13/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3448	02/10/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.9
3517	03/19/1997	< 1	< 1	< 1	21	< 1	< 1	< 1	< 1	< 1	1200
	07/07/1997	< 1	6.6	3.5	16	< 1	6.5	< 1	< 1	2.2	1100
	10/31/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.1	610
	02/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	540
3518	03/19/1997	< 1	< 1	< 1	24	< 1	70	< 1	< 1	< 1	1000
	07/07/1997	< 1	3.7	4.7	17	< 1	72	< 1	< 1	1.1	820
	10/31/1997	< 1	< 1	< 1	< 1	< 1	77	5.4	< 1	< 1	690
	02/18/1998	< 1	< 1	< 1	< 1	< 1	45	< 1	< 1	< 1	460

Note: (-) Equals not analyzed

TABLE 9
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3547	11/18/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/17/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	07/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3552	11/14/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/23/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/03/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3553	11/13/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/23/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/02/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/27/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3555	09/25/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3556	11/12/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/25/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3592	12/18/1998	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5
30003	01/16/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/29/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/30/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/07/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.91
	12/11/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/16/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/23/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/26/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE 19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30006	01/18/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/25/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/26/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6
	12/09/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/22/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/07/1998	-	-	< 0.5	-	-	-	-	-	-	-
	07/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30008	01/23/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/24/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/25/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.4
	12/09/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.96
	01/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/18/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABL 9

SUMMARY OF DETECTS - VOC ANALYSES

LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30009	01/24/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/23/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/25/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.2
	12/09/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/18/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30017	01/25/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/22/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/24/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
	12/10/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/20/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE 19

SUMMARY OF DETECTS - VOC ANALYSES

LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30018	01/25/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/22/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/22/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	28
	12/10/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/20/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30021	01/17/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/26/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/29/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/11/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.8
	12/09/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/23/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/18/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE 19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30045	01/22/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/24/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/26/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/21/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.2
	12/11/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/22/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30050	09/12/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	03/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/08/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/01/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30058	10/21/1996	< 1	< 1	< 1	< 1	< 1	6.5	< 1	< 1	< 1	68
	10/08/1997	< 1	1.2	< 1	< 1	< 1	7.1	< 1	< 1	< 1	82
	01/29/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	28
	05/05/1998	< 1	< 1	< 1	< 1	< 1	4.8	< 1	< 1	< 1	51
	10/08/1998	< 0.5	< 0.5	0.56	< 0.5	< 0.5	4.8	< 0.5	< 0.5	< 0.5	34
30059	10/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/08/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/29/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/08/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE 9
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30067	11/21/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/10/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	9.4
	04/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	8.6
	07/16/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	7
	10/31/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.8
	09/02/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.7
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.3
30076	11/20/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.1
	12/12/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.2
	01/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.7
	04/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.2
	07/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.6
	10/31/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.5
	07/08/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	170
	09/02/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.1
	10/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.2
	12/17/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6
30077	04/09/1997	< 5	< 5	< 5	< 5	< 5	5.8	< 5	< 5	< 5	< 5
	10/01/1997	< 1	< 1	< 1	< 1	< 1	2.5	< 1	< 1	< 1	1.8
	02/09/1998	< 1	< 1	< 1	< 1	< 1	2.8	< 1	< 1	< 1	2.3
	05/13/1998	< 1	< 1	< 1	< 1	< 1	2.6	< 1	< 1	< 1	1.6
30078	04/09/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.3
	02/09/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30079	04/09/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.2
	02/09/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.4
	05/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.8

Note: (-) Equals not analyzed

TABLE 19

SUMMARY OF DETECTS - VOC ANALYSES

LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30080	04/10/1997	< 5	< 5	< 5	< 5	< 5	6.1	< 5	< 5	< 5	< 5
	09/30/1997	< 1	< 1	< 1	< 1	< 1	4.4	< 1	< 1	< 1	3.4
	02/12/1998	< 1	< 1	< 1	< 1	< 1	4.8	< 1	< 1	< 1	3.9
	05/12/1998	< 1	< 1	< 1	< 1	< 1	4.5	< 1	< 1	< 1	3
30081	04/10/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/30/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/12/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/12/1998	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	< 1	1.1
30083	04/10/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/01/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/11/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30084	04/11/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/01/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/11/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30085	04/11/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/01/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/11/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/11/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30086	04/30/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30087	05/01/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.4
	02/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.5
	05/19/1998	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	< 1	3.8

Note: (-) Equals not analyzed

TABL[illegible]9

SUMMARY OF DETECTS - VOC ANALYSES

LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30089	05/06/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/07/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/22/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30090	05/05/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/07/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/22/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30093	05/06/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/06/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.53	< 0.5	< 0.5	< 0.5	< 0.5
30094	05/05/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/06/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30096	07/14/1997	< 5	< 5	< 5	< 5	< 5	11	< 5	< 5	< 5	18
	10/08/1997	< 1	< 1	< 1	< 1	< 1	14	< 1	< 1	< 1	23
	06/17/1998	< 1	< 1	< 1	< 1	< 1	13	< 1	< 1	< 1	38
30097	07/14/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/08/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/27/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/17/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30105	12/19/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30106	12/19/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30107	01/06/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30108	12/18/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/18/1998	< 1	< 1	< 1	< 1	< 1	3.8	< 1	< 1	< 1	4
	09/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.9	< 0.5	< 0.5	< 0.5	6.6
30110	01/27/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	04/06/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/21/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30113	01/30/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30114	01/30/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30116	01/28/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/14/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30117	01/28/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/14/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30120	06/16/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/21/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30121	06/16/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/21/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30122	08/04/1998	< 5	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5
	12/17/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30123	08/04/1998	< 5	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5
	12/17/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30131	01/14/1999	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5
30132	01/14/1999	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5

Note: (-) Equals not analyzed

TABLE 9
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30133	01/14/1999	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5
30137	02/04/1999	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	7
30138	02/04/1999	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	88
31001	07/21/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	11/19/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
31002	07/21/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	11/19/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
31003	07/22/1997	< 5	< 5	< 5	< 5	< 5	23	< 5	< 5	< 5	19
	11/18/1997	< 1	< 1	< 1	< 1	< 1	28	< 1	< 1	< 1	18
	02/18/1998	< 1	< 1	< 1	< 1	< 1	19	< 1	< 1	< 1	15
	05/05/1998	< 1	< 1	< 1	< 1	< 1	18	< 1	< 1	< 1	13
31004	07/22/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	11/18/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/17/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
STSW-04C	04/12/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	13	< 0.5	< 1	< 0.5	3.2
	09/30/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	14	< 0.5	< 1	< 0.5	4.7
	02/11/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	10	< 0.5	< 1	< 0.5	4.2
	05/02/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	8.3	< 0.24	< 0.1	< 0.2	4.9
	10/03/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	9.2	< 0.24	< 0.1	< 0.2	7
	05/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.5	< 0.5	< 0.5	< 0.5	3.2
	11/12/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	12.1	< 0.5	< 0.5	< 0.5	17.8
STSW-08B	05/01/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	09/19/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	02/05/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	05/14/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	1.1	< 0.1	< 0.2	0.99
	11/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE 9
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
STSW-28A	03/13/1996	< 0.12	< 0.066	< 0.042	< 0.048	< 0.06	< 0.041	0.36	< 0.08	< 0.046	< 0.11
	04/05/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	10/01/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	01/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	04/30/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16
	10/03/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16
	05/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/10/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-28B	03/12/1996	< 0.12	< 0.066	< 0.042	< 0.048	< 0.06	< 0.041	0.34	< 0.08	< 0.046	< 0.11
	04/04/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	1.1
	09/30/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	1.1
	01/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	1.4
	04/30/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	0.82
	10/03/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	1.4
	05/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6	< 0.5	< 0.5	< 0.5	1.7
	11/10/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.6	< 0.5	< 0.5	< 0.5	2.1
STSW-29B	10/02/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	< 0.5	< 1	< 0.5	3
	01/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.3	< 0.5	< 1	< 0.5	3
	05/08/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	1.6	< 0.24	< 0.1	< 0.2	5.4
	10/13/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	2.6
	11/25/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1	< 0.5	< 0.5	< 0.5	1.9
STSW-30A	10/03/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	40
	01/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	22
	05/09/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	0.82
	10/14/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	17
	11/24/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	9.5
STSW-30B	10/03/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	01/20/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	05/09/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16
	10/14/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16
	11/24/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STS51B	09/01/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.88
	11/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
STS52B	08/31/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.56	< 0.5	< 0.5	< 0.5	1.64
	11/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.68	< 0.5	< 0.5	< 0.5	1.68

Note: (-) Equals not analyzed

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
124	3/23/99	700
127	5/16/97	1500
134	5/16/97	7200
135	5/15/97	6400
138	3/14/97	< 400
227	5/20/98	1200
228	5/20/98	1000
236	12/18/96	2000
292	1/8/98	820
	5/21/98	770
293	1/8/98	240
	5/21/98	260
306	9/12/97	260
	3/25/98	130
357	11/24/97	< 4
	3/27/98	< 4
399	3/30/98	< 4
420	2/3/97	< 400
	5/21/97	< 400
	5/20/98	5.7
437	5/22/97	< 400
438	5/22/97	< 400
447	5/28/97	920
1169	2/5/97	< 400
	7/25/97	< 400
	10/3/97	< 4
	1/19/98	6.4
	6/23/98	5.8
	7/17/98	7.3
1204	2/4/97	< 400
	5/27/97	210[1]
1205	5/7/98	8.3
1231	11/11/97	880
	4/10/98	2000
1239	3/5/97	< 400
	9/30/97	2400
	4/13/98	2200
1240	3/5/97	1700
	9/30/97	2900
	4/13/98	2900
1244	3/5/97	< 400
1245	3/5/97	< 400
1252	1/2/96	< 400
	9/6/96	< 400
1253	1/2/96	< 400
	9/6/96	< 400

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
1268	4/24/96	1600
	10/16/96	1800
	10/7/97	1700
	4/20/98	1800
	6/19/98	1600
	12/16/98	1500
1277	10/18/96	2700
	3/7/97	2400
	10/9/97	4100
	4/16/98	2700
1278	10/17/96	< 400
	3/7/97	< 400
	10/9/97	< 4
	4/16/98	< 4
1282	10/15/96	530
	3/7/97	< 400
	10/10/97	90
	4/3/98	70
1283	3/11/97	< 400
	10/10/97	5.8
	4/3/98	< 4
1294	1/4/96	400
	10/15/96	< 400
	2/4/97	< 400
	10/14/97	190
	4/10/98	97
	12/15/98	130
1295	1/4/96	< 400
	10/11/96	< 400
	2/4/97	< 400
	10/14/97	< 4
	4/10/98	< 4
	12/15/98	< 4
1313	1/11/96	< 400
	8/20/96	< 400
	12/11/98	9.4
1330	1/12/96	< 400
	10/17/96	2100
1334	1/17/96	< 400
	8/26/96	< 400
	3/10/97	< 400
1335	1/17/96	< 400
	8/28/96	< 400
	3/10/97	< 400

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
1346	1/18/96	< 400
	8/22/96	< 400
	6/12/97	< 400
	12/17/97	32
	8/5/98	33
1347	1/18/96	< 400
	8/21/96	< 400
	6/12/97	< 400
	12/17/97	< 4
	8/5/98	< 4
1350	1/16/96	< 400
	9/4/96	< 400
	3/11/97	< 400
	3/11/97	< 400
1351	1/15/96	< 400
	9/4/96	< 400
	3/11/97	< 400
1352	1/15/96	< 400
	9/4/96	< 400
	3/11/97	< 400
1353	1/15/96	720
	9/5/96	1300
	3/13/97	1300
1354	1/12/96	2900
	9/6/96	2800
	3/13/97	2300
1355	1/12/96	< 400
	9/6/96	< 400
	3/13/97	< 400
1435	5/27/97	< 400
	4/21/98	11
1457	1/15/96	< 400
	9/3/96	< 400
	3/12/97	< 400
1460	5/29/97	490
	5/4/98	540
1463	9/24/97	2000
1467	2/7/97	< 400
	5/29/97	< 400
	3/27/98	110
	7/2/98	160
1484	2/3/97	< 400
	6/3/97	< 400
	1/8/98	24
	4/30/98	17

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
3049	5/22/98	3600
3114	5/28/97	< 400
3140	5/29/97	2000
	3/24/99	1200
3141	5/28/97	2300
3211	3/10/97	7300
3228	3/12/97	7400
3279	3/14/97	7400
3280	3/14/97	7500
3304	1/15/98	< 4
3323	5/28/98	2000
3335	7/18/96	810
	12/2/96	1000
	6/2/97	680
3341	10/24/97	< 4
	3/18/98	< 4
3342	10/24/97	< 4
	3/18/98	< 4
3353	6/4/97	< 400
	1/16/98	24
	6/26/98	16
3403	2/5/97	< 400
	6/3/97	8.1
	1/14/98	8.6
	5/28/98	9.5
3406	6/4/97	< 400
	1/16/98	82
3435	3/10/97	7600
3436	3/11/97	7800
3438	10/27/97	5900
	3/20/98	5500
3441	10/29/97	5.5
	3/19/98	< 4
3442	10/29/97	< 4
	3/19/98	< 4
3448	2/10/97	< 400
3517	3/19/97	540
	7/7/97	470
	10/31/97	310
	2/18/98	270
3518	3/19/97	410
	7/7/97	< 400
	10/31/97	420
	2/18/98	300
3547	11/18/96	3200
	9/15/97	4200
	7/15/98	5500

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
3552	11/14/96	7100
	9/23/97	5800
	2/3/98	7200
3553	11/13/96	8100
	9/23/97	7000
	2/2/98	140
3555	6/3/97	6000
	9/25/97	7000
	2/4/98	6900
3556	11/12/96	8000
	9/25/97	5900
	2/4/98	7200
3592	12/18/98	4000
30003	1/16/97	< 400
	4/23/97	< 400
	7/16/97	< 400
	10/30/97	< 4
	1/30/98	< 4
	4/13/98	< 4
	7/14/98	< 4
	10/26/98	< 4
30006	1/21/97	< 400
	4/22/97	< 400
	7/17/97	< 400
	10/29/97	< 4
	1/30/98	< 4
	4/14/98	< 4
	7/15/98	< 4
	10/28/98	< 4
30008	1/17/97	< 400
	4/21/97	< 400
	7/18/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/15/98	< 4
	7/15/98	< 4
	10/28/98	< 4
30009	1/17/97	< 400
	4/21/97	< 400
	7/18/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/15/98	< 4
	7/15/98	< 4
	10/28/98	< 4

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30017	1/20/97	< 400
	4/21/97	< 400
	7/17/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/16/98	< 4
	7/16/98	< 4
	10/29/98	< 4
30018	1/20/97	< 400
	4/21/97	< 400
	7/17/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/16/98	< 4
	7/16/98	< 4
	10/29/98	< 4
30021	1/15/97	< 400
	4/23/97	< 400
	7/18/97	< 400
	10/28/97	< 4
	1/28/98	< 4
	4/13/98	< 4
	7/15/98	< 4
	10/27/98	< 4
30045	1/17/97	< 400
	4/22/97	< 400
	7/17/97	< 400
	10/28/97	< 4
	1/28/98	< 4
	4/16/98	< 4
	7/17/98	< 4
	10/27/98	< 4
30050	9/12/96	540
	3/24/97	510
	8/8/97	540
	11/14/97	720
	5/1/98	560
30058	10/21/96	1100
	10/8/97	1100
	1/29/98	2400
	5/5/98	1600
	10/8/98	600

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30059	10/21/96	< 400
	10/8/97	< 4
	1/29/98	< 4
	5/5/98	< 4
	10/8/98	< 4
30067	11/21/96	< 400
	1/10/97	< 400
	4/24/97	< 400
	7/16/97	400
	10/31/97	440
	9/2/98	390
	10/30/98	320
	12/11/98	330
30076	11/20/96	< 400
	1/9/97	< 400
	4/24/97	< 400
	7/15/97	< 400
	10/31/97	270
	9/2/98	150
	10/30/98	170
	12/17/98	180
30077	4/9/97	3700
	10/1/97	2700
	2/9/98	3000
	5/13/98	2800
30078	4/9/97	1200
	9/29/97	1400
	2/9/98	1200
	5/13/98	1200
30079	4/9/97	< 400
	9/29/97	160
	2/9/98	180
	5/13/98	180
30080	4/10/97	6700
	9/30/97	7700
	2/12/98	7500
	5/12/98	7200
30081	4/10/97	7700
	9/30/97	8700
	2/12/98	7600
	5/12/98	8000

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30083	4/10/97	6500
	10/1/97	7200
	2/11/98	7300
	5/18/98	6100
30084	4/11/97	8100
	10/1/97	8300
	2/11/98	8600
	5/18/98	7500
30085	4/11/97	5400
	10/1/97	6400
	2/11/98	6100
	5/18/98	5200
30086	4/30/97	< 400
	9/26/97	73
	2/10/98	39
	5/19/98	14
	12/11/98	7.9
30087	5/1/97	500
	9/26/97	590
	2/10/98	1100
30089	5/6/97	< 400
	10/7/97	7.4
	2/5/98	7.2
	6/22/98	< 4
	12/16/98	< 4
30090	5/5/97	< 400
	10/7/97	4
	2/5/98	< 4
	6/22/98	4.9
	12/16/98	13
30093	5/6/97	< 400
	10/6/97	24
	2/10/98	27
	12/15/98	58
30094	5/5/97	< 400
	10/6/97	< 4
	2/10/98	< 4
	12/15/98	< 4
30096	7/14/97	1800
	10/8/97	1600
	2/27/98	2200
	6/17/98	2600
30097	7/14/97	< 400
	10/8/97	< 4
	2/27/98	< 4

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30105	12/19/97	< 4
	5/7/98	< 4
	9/16/98	23
	12/16/98	46
30106	12/19/97	4
	5/7/98	4
	9/16/98	15
	12/16/98	25
30107	1/6/98	11
	5/18/98	87
30108	12/18/97	310
	5/18/98	680
	9/15/98	1200
30110	1/27/98	4700
	4/6/98	6000
	9/21/98	6900
30113	1/30/98	4.9
	5/15/98	20
	9/18/98	77
	1/12/99	100
30114	1/30/98	< 4
	5/15/98	< 4
	9/18/98	4.5
	1/12/99	4.9
30116	1/28/98	< 4
	5/14/98	< 4
30117	1/28/98	< 4
	5/14/98	< 4
30120	9/21/98	67
30121	6/16/98	17
	9/21/98	19
30122	8/4/98	< 4
	12/17/98	< 4
30123	8/4/98	< 4
	12/17/98	< 4
30131	1/14/99	< 4
30132	1/14/99	5.2
30133	1/14/99	< 4
30137	2/4/99	400
30138	2/4/99	340
31001	7/21/97	< 400
	11/19/97	16
	2/18/98	11
	5/4/98	8.7

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
31002	7/21/97	< 400
	11/19/97	21
	2/18/98	81
	5/4/98	69
31003	7/22/97	4300
	11/18/97	4300
	2/18/98	5300
	5/5/98	5500
31004	7/22/97	< 400
	11/18/97	7.1
	2/17/98	10
	5/5/98	14

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-21
SUMMARY OF NDMA ANALYSES
LAYER C - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
61	5/11/98	0.041
64	5/19/98	< 0.0075
104	7/7/98	< 0.0075
170	5/20/98	0.17
227	5/20/98	< 0.0075
228	5/20/98	< 0.0075
287	5/21/98	< 0.0075
289	5/21/98	< 0.0075
292	5/21/98	< 0.0075
293	5/21/98	< 0.0075
420	5/20/98	0.25
1169	4/29/98	< 0.0075
1204	3/10/99	0.037
1212	7/13/98	< 0.0075
1435	4/30/98	0.39
1460	5/4/98	0.16
1463	5/5/98	< 0.0075
	6/15/98	< 0.0075
1467	7/16/98	0.016
1484	4/30/98	0.25
3018	7/9/98	0.024
3049	5/22/98	< 0.0075
3050	5/22/98	< 0.0075
3082	5/22/98	< 0.0075
3083	5/22/98	0.21
3304	5/26/98	< 0.0075
3323	5/28/98	< 0.0075
3335	5/27/98	0.16
3403	5/28/98	0.25
3447	6/4/98	0.081
3448	6/4/98	< 0.0075
3453	7/10/98	< 0.0075
3552	5/27/98	< 0.0075
3553	5/27/98	< 0.0075
3555	5/27/98	< 0.0075
3556	5/27/98	< 0.0075
3592	12/18/98	< 0.0075
30003	7/14/98	< 0.0075
	10/26/98	< 0.0075
	1/13/99	< 0.0075
	3/23/99	< 0.0075

TABLE A-21
SUMMARY OF NDMA ANALYSES
LAYER C - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
30006	7/15/98	< 0.0075
	10/28/98	< 0.0075
30008	10/28/98	< 0.0075
30009	7/15/98	< 0.0075
	10/28/98	< 0.0075
30017	7/16/98	< 0.0075
	10/29/98	< 0.0075
30018	7/16/98	< 0.0075
	10/29/98	< 0.0075
30021	7/15/98	< 0.0075
	10/27/98	< 0.0075
	1/13/99	< 0.0075
	3/23/99	< 0.0075
30045	7/17/98	< 0.0075
	10/27/98	< 0.0075
30050	5/1/98	0.13
30067	9/2/98	0.17
	10/30/98	0.2
	12/11/98	0.18
	3/23/99	0.16
30076	9/2/98	0.12
	10/30/98	0.16
	12/17/98	0.15
	3/23/99	0.14
30077	5/13/98	0.1
30078	5/13/98	0.061
30079	5/13/98	< 0.0075
30083	5/18/98	< 0.0075
30084	5/18/98	< 0.0075
30085	5/18/98	< 0.0075
30086	5/19/98	< 0.0075
	12/11/98	< 0.0075
	3/17/99	< 0.0075
30087	5/19/98	0.034
30089	12/16/98	< 0.0075
30090	12/16/98	< 0.0075
30105	12/16/98	< 0.0075
30106	12/16/98	< 0.0075
30110	5/6/98	< 0.0075
30113	1/12/99	< 0.0075
30114	1/12/99	< 0.0075
30120	6/16/98	< 0.0075
30121	6/16/98	< 0.0075

TABLE A-21
SUMMARY OF NDMA ANALYSES
LAYER C - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
30122	8/4/98	< 0.0075
	12/17/98	< 0.0075
	3/16/99	< 0.0075
30123	8/4/98	< 0.0075
	12/17/98	< 0.0075
	3/16/99	< 0.0075
30131	1/14/99	< 0.0075
30132	1/14/99	< 0.0075
30133	1/14/99	< 0.0075
30137	2/4/99	0.14
30138	2/4/99	0.024
31001	5/6/98	< 0.0075
31002	5/6/98	< 0.0075
31003	5/5/98	< 0.0075
31004	5/5/98	< 0.0075

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	SITE: / DATE:	420 2/3/97	1169 1/5/96	1169 2/5/97	1169 7/25/97	1169 7/17/98	1204 2/4/97	1330 1/12/96	1484 2/3/97	3403 2/5/97	3517 3/19/97	3518 3/19/97	3547 11/18/96
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	(ppb)	-	-	-	-	< 10	-	-	-	-	-	-	-
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	SITE: / DATE:	420 2/3/97	1169 1/5/96	1169 2/5/97	1169 7/25/97	1169 7/17/98	1204 2/4/97	1330 1/12/96	1484 2/3/97	3403 2/5/97	3517 3/19/97	3518 3/19/97	3547 11/18/96
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	150	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	3552 11/14/96	3553 11/13/96	3556 11/12/96	3592 12/18/98	30003 1/16/97	30050 9/12/96	30058 1/29/98	30059 1/29/98	30067 11/21/96	30076 11/20/96	30076 1/9/97	30077 4/9/97
1,2,4-Trichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	< 10	< 10	< 10	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	-	-	-	< 10	-	-	-	-	-	-	-	-
4-Chlorophenyl phenyl ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	3552 11/14/96	3553 11/13/96	3556 11/12/96	3592 12/18/98	30003 1/16/97	30050 9/12/96	30058 1/29/98	30059 1/29/98	30067 11/21/96	30076 11/20/96	30076 1/9/97	30077 4/9/97
Dimethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	< 20	< 20	< 20	< 10	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30078 4/9/97	30079 4/9/97	30080 4/10/97	30081 4/10/97	30083 4/10/97	30084 4/11/97	30085 4/11/97	30086 4/30/97	30087 5/1/97	30089 5/6/97	30090 5/5/97	30093 5/6/97	30094 5/5/97	30096 7/14/97
1,2,4-Trichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Chlorophenyl phenyl ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30078 4/9/97	30079 4/9/97	30080 4/10/97	30081 4/10/97	30083 4/10/97	30084 4/11/97	30085 4/11/97	30086 4/30/97	30087 5/1/97	30089 5/6/97	30090 5/5/97	30093 5/6/97	30094 5/5/97	30096 7/14/97
Dimethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30097 7/14/97	30105 12/19/97	30105 12/16/98	30106 12/19/97	30106 12/16/98	30107 1/6/98	30108 12/18/97	30110 1/27/98	30113 1/30/98	30114 1/30/98	30116 1/28/98
1,2,4-Trichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	< 10	< 10	-	< 10	-	< 10	< 10	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	-	-	< 10	-	< 10	-	-	-	-	-	< -
4-Chlorophenyl phenyl ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30097 7/14/97	30105 12/19/97	30105 12/16/98	30106 12/19/97	30106 12/16/98	30107 1/6/98	30108 12/18/97	30110 1/27/98	30113 1/30/98	30114 1/30/98	30116 1/28/98
Dimethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	< 20	< 20	< 10	< 20	< 10	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30117 1/28/98	30120 6/16/98	30121 6/16/98	30122 8/4/98	30122 12/17/98	30123 8/4/98	30123 12/17/98	30133 1/14/99	30137 2/4/99	30138 2/4/99	31001 7/21/97	31002 7/21/97	31003 7/22/97	31004 7/22/97
1,2,4-Trichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	< 10	< 10	< 10	-	-	-	-	-	-	-	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	-	-	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	-	-	-
4-Chlorophenyl phenyl ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30117 1/28/98	30120 6/16/98	30121 6/16/98	30122 8/4/98	30122 12/17/98	30123 8/4/98	30123 12/17/98	30133 1/14/99	30137 2/4/99	30138 2/4/99	31001 7/21/97	31002 7/21/97	31003 7/22/97	31004 7/22/97
Dimethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	< 20	< 20	< 20	< 20	< 10	< 20	< 10	< 10	< 10	< 10	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE:	3517	3518	3547	3552	3553	3556	3592	30008	30009	30058	30059	30067
(Units in mg/l) DATE:	3/19/97	3/19/97	11/18/96	11/14/96	11/13/96	11/12/96	12/18/98	7/7/98	7/7/98	1/29/98	1/29/98	11/21/96
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.05	-	< 0.2	< 0.2	< 0.2
Antimony	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.2	-	-	< 0.2	< 0.2	< 0.24
Arsenic	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.02	-	< 0.08	< 0.08	< 0.08
Barium	0.1	0.1	0.044	0.065	0.082	0.082	0.057	0.061	-	0.1	0.052	0.014
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.00025	< 0.001	< 0.001	< 0.001
Boron	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-	-	< 0.04	< 0.04	< 0.04
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	-	-	< 0.004	< 0.004	< 0.004
Calcium	24	25	35	26	29	29	32	-	-	18	14	20
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	-	-	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	-	-	< 0.008	< 0.008	< 0.008
Copper	< 0.006	< 0.006	< 0.006	0.0065	< 0.006	< 0.006	< 0.006	-	-	< 0.006	< 0.006	< 0.006
Iron	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	-	-	< 0.3	0.61	< 0.3
Lead	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	-	-	< 0.06	< 0.06	< 0.06
Magnesium	12	12	3.5	14	15	11	8.4	-	-	11	8.1	0.26
Manganese	< 0.005	< 0.005	< 0.005	0.013	< 0.005	< 0.005	< 0.005	-	-	0.0076	0.08	< 0.005
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-	-	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	-	< 0.02	< 0.02	< 0.02
Potassium	2.9	3.1	6	2.8	1.9	2.4	5	-	-	3.1	2.9	14
Selenium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-	-	< 0.1	< 0.1	< 0.1
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	-	< 0.02	< 0.02	< 0.02
Sodium	12	12	17	12	13	16	14	-	-	10	9.6	81
Thallium	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-	-	< 0.05	< 0.05	< 0.05
Vanadium	0.0067	0.0061	0.022	0.0078	0.0095	0.0099	0.014	-	-	0.0091	< 0.006	0.012
Zinc	< 0.1	< 0.1	< 0.1	0.4	< 0.1	< 0.1	< 0.1	-	-	0.16	0.11	< 0.1

Note: (-) Equals not analyzed

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE:	30067	30067	30076	30076	30077	30078	30079	30080	30081	30083	30084	30085	30086
(Units in mg/l) DATE:	7/8/98	12/11/98	11/20/96	12/17/98	4/9/97	4/9/97	4/9/97	4/10/97	4/10/97	4/10/97	4/11/97	4/11/97	4/30/97
Aluminum	-	< 0.05	< 0.2	< 0.05	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	-	< 0.05	< 0.24	< 0.05	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24
Arsenic	-	< 0.02	< 0.08	< 0.02	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	-	0.089	0.0063	0.12	0.089	0.078	0.1	0.081	0.097	0.081	0.094	0.068	0.067
Beryllium	-	< 0.00025	< 0.001	< 0.00025	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	-	0.012	< 0.04	0.014	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	-	< 0.001	< 0.004	< 0.001	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	-	24	2.7	29	26	27	54	28	27	26	29	25	18
Chromium	-	< 0.002	< 0.008	< 0.002	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	-	< 0.002	< 0.008	< 0.002	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	-	0.0021	< 0.006	< 0.0015	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	-	< 0.075	< 0.3	< 0.075	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	-	< 0.015	< 0.06	< 0.015	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	-	9.1	0.49	12	13	11	5.1	13	16	15	15	14	8.7
Manganese	-	< 0.0012	< 0.005	< 0.0012	0.01	0.0063	< 0.005	0.0052	0.0099	0.0058	< 0.005	0.016	< 0.005
Molybdenum	-	< 0.01	< 0.04	< 0.01	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.005	< 0.005	< 0.02	< 0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	-	2.7	16	2.8	2.2	3.4	14	4.8	3.1	2.8	4	3.1	8.8
Selenium	-	< 0.025	< 0.1	< 0.025	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	-	< 0.005	< 0.02	< 0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	-	11	54	11	12	12	21	15	13	13	13	13	20
Thallium	-	< 0.012	< 0.05	< 0.012	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	-	0.0047	< 0.005	0.0051	0.0066	0.0071	0.0088	0.0083	0.0081	0.0073	0.0099	0.0096	0.0079
Zinc	-	< 0.025	< 0.1	< 0.025	0.23	< 0.1	< 0.1	0.14	0.4	0.34	0.16	0.37	0.1

Note: (-) Equals not analyzed

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE:	30086	30087	30089	30089	30090	30090	30093	30094	30096	30097	30105	30106	30107
(Units in mg/l) DATE:	12/11/98	5/1/97	5/6/97	12/16/98	5/5/97	12/16/98	5/6/97	5/5/97	7/14/97	7/14/97	12/19/97	12/19/97	1/6/98
Aluminum	< 0.05	< 0.2	< 0.2	< 0.05	< 0.2	< 0.05	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.05	< 0.24	< 0.24	< 0.05	< 0.24	< 0.05	< 0.24	< 0.24	< 0.24	< 0.24	< 0.2	< 0.2	< 0.2
Arsenic	< 0.02	< 0.08	< 0.08	< 0.02	< 0.08	< 0.02	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.1	0.074	0.034	0.028	0.05	0.041	0.051	0.033	0.028	0.032	0.063	< 0.006	0.057
Beryllium	< 0.00025	< 0.001	< 0.001	< 0.00025	< 0.001	< 0.00025	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	< 0.01	< 0.04	< 0.04	0.015	< 0.04	0.01	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	< 0.001	< 0.004	< 0.004	< 0.001	< 0.004	< 0.001	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	25	23	28	15	24	14	20	23	15	20	19	0.19	21
Chromium	< 0.002	< 0.008	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.002	< 0.008	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.0015	< 0.006	< 0.006	< 0.0015	< 0.006	< 0.0015	< 0.006	< 0.006	0.006	< 0.006	0.0067	< 0.006	< 0.006
Iron	< 0.075	< 0.3	< 0.3	< 0.075	< 0.3	< 0.075	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	< 0.015	< 0.06	< 0.06	< 0.015	< 0.06	< 0.015	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	9.5	10	0.52	2.5	2.3	4.2	7.2	4.2	9.2	2.4	9.5	< 0.05	8.3
Manganese	< 0.0012	0.0078	< 0.005	< 0.0012	< 0.005	0.0042	< 0.005	< 0.005	0.0055	< 0.005	0.0067	< 0.005	< 0.005
Molybdenum	< 0.01	< 0.04	< 0.04	< 0.01	< 0.04	< 0.01	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.005	< 0.02	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	3.2	4.6	10	2.6	5.8	2.2	3.1	3.6	2	5.5	3.5	< 2	2.5
Selenium	< 0.025	< 0.1	< 0.1	< 0.025	< 0.1	< 0.025	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.005	< 0.02	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	13	13	24	8.2	19	8.8	14	11	9.7	12	12	< 0.8	13
Thallium	< 0.012	< 0.05	< 0.05	< 0.012	< 0.05	< 0.012	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	0.006	0.0081	0.019	0.011	0.016	0.011	0.014	0.011	0.013	0.021	0.011	< 0.006	0.011
Zinc	< 0.025	0.1	< 0.1	< 0.025	< 0.1	< 0.025	< 0.1	0.15	0.31	< 0.1	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE: (Units in mg/l) DATE:	30108 12/18/97	30110 1/27/98	30113 1/30/98	30114 1/30/98	30116 1/28/98	30117 1/28/98	30120 6/16/98	30121 6/16/98	30122 8/4/98	30123 8/4/98	30133 1/14/99	30137 2/4/99	30138 2/4/99
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Arsenic	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.076	0.068	0.044	0.043	0.044	0.045	0.03	0.059	0.046	0.091	0.06	0.089	0.091
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	21	27	20	18	21	20	12	19	19	28	20	28	39
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.006	< 0.006	0.01	0.0082	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	10	8.3	10	7.1	0.88	4.9	4	3.3	6.7	11	7.5	11	6.4
Manganese	< 0.005	< 0.005	0.011	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.025	0.095	0.016	0.0069	< 0.005
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	4.1	4.7	3.1	2.9	< 4.3	3.6	2.6	3.6	6.6	7	4.9	2.7	8
Selenium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	12	18	10	13	18	10	10	17	18	16	16	15	24
Thallium	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	0.012	0.018	0.0079	0.015	< 0.02	0.015	0.015	0.022	< 0.006	< 0.006	0.0093	< 0.006	0.0074
Zinc	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.21	< 0.1	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE:	31001	31002	31003	31004
(Units in mg/l) DATE:	7/21/97	7/21/97	7/22/97	7/22/97
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.24	< 0.24	< 0.24	< 0.24
Arsenic	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.078	0.075	0.095	0.049
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001
Boron	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	22	23	23	15
Chromium	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.006	< 0.006	< 0.006	< 0.006
Iron	< 0.3	< 0.3	< 0.3	< 0.3
Lead	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	9.6	8.9	11	7.7
Manganese	< 0.005	< 0.005	< 0.005	0.0087
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	3.5	4.3	3	3.6
Selenium	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	12	13	12	10
Thallium	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	0.0095	0.011	0.011	0.009
Zinc	< 0.1	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-24
SUMMARY OF ANION ANALYSES (EPA 300)
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Chloride (mg/l)	Fluoride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
3517	3/19/97	5.8	-	6.3	< 0.05	12
3518	3/19/97	5.5	-	6.6	< 0.05	14
3547	11/18/96	9.5	-	7	< 0.05	9.8
3552	11/14/96	9.8	-	7.8	< 0.05	13
3553	11/13/96	11	-	7.3	< 0.05	17
3556	11/12/96	11	-	7.2	< 0.15	17
3592	12/18/98	23	-	6	0.08	9.8
30050	9/12/96	6.4	-	6.4	< 0.05	11
30058	1/29/98	8.9	-	5.4	< 0.05	4.4
30059	1/29/98	9.4	-	0.25	< 0.05	15
30067	11/21/96	60	-	4.7	2.1	62
30076	11/20/96	8.3	-	0.89	2.6	21
30077	4/9/97	8.8	-	7.2	< 0.05	13
30078	4/9/97	7.5	-	7.5	< 0.05	10
30079	4/9/97	86	-	7.7	< 0.05	8.2
30080	4/10/97	15	-	7.6	< 0.05	15
30081	4/10/97	13	-	7.7	< 0.05	16
30083	4/10/97	22	-	8.1	< 0.05	15
30084	4/11/97	14	-	7.9	< 0.5	18
30085	4/11/97	11	-	6.9	< 0.5	13
30086	4/30/97	5.7	-	7.4	0.07	7.9
30087	5/1/97	8.2	-	7.9	< 0.05	9.5
30089	5/6/97	3.1	-	7.5	0.16	5
30090	5/5/97	26	-	7.9	< 0.5	6.1
30093	5/6/97	9.2	-	5	< 0.15	6.3
30094	5/5/97	11	-	0.16	< 0.05	5.7
30096	7/14/97	6	-	7.6	< 0.05	4.7
30097	7/14/97	5.2	-	6.5	< 0.05	6.7
30107	1/6/98	6.4	-	12	< 0.05	5.1
30110	1/27/98	11	-	6.8	< 0.25	13
30113	1/30/98	4.2	-	7.2	< 0.25	6.6
30114	1/30/98	6.6	-	8.1	0.07	7.8
30116	1/28/98	9.1	-	8.2	0.16	2.8

TABLE A-24
SUMMARY OF ANION ANALYSES (EPA 300)
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Chloride (mg/l)	Fluoride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
30117	1/28/98	7.4	-	9.8	< 0.5	3.7
30120	6/16/98	4.2	-	12	< 0.15	2
30121	6/16/98	8.6	-	9.5	0.097	4.6
30131	1/14/99	20	-	5.6	0.063	13
30132	1/14/99	10	-	5.1	< 0.25	16
30133	1/14/99	5.3	-	2.7	< 0.05	9.6
30137	2/4/99	6.5	-	7.4	0.06	12
30138	2/4/99	57	-	5.8	< 0.05	8.9
31001	7/21/97	5.5	-	7.1	< 0.05	10
31002	7/21/97	4.9	-	7.3	< 0.05	10
31003	7/22/97	12	-	7.5	< 0.05	11
31004	7/22/97	5.2	-	3.9	< 0.05	4.8

Notes: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
88	5/31/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/27/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
128	6/26/96	< 1	< 1	1.9	< 1	2.6	5	< 1	< 1	< 1	280	< 1
	11/15/96	< 1	< 1	1.6	< 1	2.6	5.8	< 1	< 1	< 1	200	< 1
	5/16/97	< 1	< 1	< 1	< 1	2.3	5.2	< 1	< 1	< 1	170	< 1
	1/6/98	< 1	< 1	< 1	< 1	< 1	4.4	< 1	< 1	< 1	110	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1	3.7	< 1	< 1	< 1	85	< 1
136	6/27/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
137	6/27/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
140	6/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/15/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
172	7/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/20/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/5/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
358	4/2/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/9/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/15/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	10/27/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	11/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/27/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/14/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	7/7/98	< 0.5	-	-	-	-	-	-	-	4.1	-	-
	10/28/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
401	5/17/96	< 1	< 1	< 1	< 1	< 1	18	< 1	< 1	< 1	91	< 1
	10/28/96	< 1	< 1	< 1	1.2	< 1	23	< 1	< 1	< 1	100	< 1
	2/26/97	< 1	< 1	< 1	1.3	< 1	26	< 1	< 1	< 1	120	< 1
	9/25/97	< 1	< 1	< 1	< 1	< 1	2.9	< 1	< 1	< 1	22	< 1
	3/30/98	< 1	< 1	< 1	1.2	< 1	47	< 1	< 1	< 1	200	< 1
402	5/17/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/25/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/30/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
421	6/28/96	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	33	< 1
	11/20/96	< 1	< 1	< 1	< 1	< 1	< 1	1.7	< 1	< 1	28	< 1
	2/3/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.57	1.4	< 0.5	0.69	29	< 0.5
	5/23/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	22	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1	< 1	1.7	< 1	< 1	20	< 1
422	6/27/96	< 1	< 1	< 1	< 1	< 1	< 1	1.8	< 1	< 1	6.9	< 1
	11/19/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	5.5	< 1
	2/3/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.68	1.9	< 0.5	0.6	8.3	< 0.5
	5/23/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	6.9	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1	< 1	2.7	< 1	< 1	7	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
439	6/28/96	< 1	< 1	7.2	< 1	14	5.3	3.6	< 1	1.3	870	< 1
	11/20/96	< 1	< 1	8.6	< 1	15	4.4	2.9	< 1	2.3	1000	< 1
	5/21/97	< 1	< 1	7.2	< 1	14	4.2	3.6	< 1	1.6	860	< 1
	1/7/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	690	< 1
	6/26/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	570	< 1
446	6/28/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	11	< 1
	11/19/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	12	< 1
	5/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.8	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.6	< 1
	6/23/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4	< 1
476	7/1/96	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	< 1	54	< 1
	11/21/96	< 1	< 1	< 1	< 1	< 1	1.9	< 1	< 1	< 1	50	< 1
	5/21/97	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	33	< 1
	1/19/98	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	< 1	23	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1	1.4	< 1	< 1	< 1	19	< 1
1206	2/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	7/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/22/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/7/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1232	9/9/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/10/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1269	4/23/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/1/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/7/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1270	4/23/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/1/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/7/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
1274	7/19/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/2/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/6/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.5	< 1
	6/29/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1
1279	10/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1284	6/17/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1296	1/4/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/11/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1314	1/11/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	8/20/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1332	6/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/13/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/1/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1336	6/24/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/1/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1348	6/6/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1356	6/20/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
1436	7/9/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	14	< 1
	11/27/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	12	< 1
	5/23/97	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	11	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1	< 1	1.4	< 1	< 1	8.4	< 1
	4/30/98	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	8.4	< 1
1458	1/16/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/20/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/20/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/9/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1461	7/9/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/2/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	12	< 1
	5/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	15	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.8	< 1
	5/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.2	< 1
1464	9/24/97	< 1	< 1	< 1	< 1	< 1	0.81	< 1	< 1	< 1	2.3	< 1
1465	9/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1485	7/26/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/22/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/4/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	6/2/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/30/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3045	1/9/98	< 1	< 1	< 1	< 1	< 1	460	< 1	< 1	< 1	840	< 1
	6/24/98	< 1	< 1	< 1	4.6	1.9	280	< 1	< 1	1.7	350	< 1
3046	1/9/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3050	5/22/98	< 1	< 1	< 1	< 1	6.3	420	< 1	< 1	2.6	370	< 1
3051	5/22/98	< 1	< 1	< 1	< 1	5.8	320	< 1	3.8	2.4	340	< 1
3052	5/22/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3061	5/31/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/27/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3116	7/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/4/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.4	< 1
	5/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.2	< 1
	1/14/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.9	< 1
	6/25/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.2	< 1
3127	5/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	5.5	< 1
	10/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10	< 1
3128	5/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	11	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/25/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3142	7/8/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/26/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3148	6/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3149	6/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3150	6/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3162	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3164	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3165	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3212	6/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/22/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3213	6/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3229	6/4/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/23/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3246	6/6/96	< 1	< 1	< 1	< 1	< 1	1**	< 1	< 1	< 1	< 1	< 1
	11/8/96	< 1	< 1	< 1	< 1	< 1	12	< 1	< 1	< 1	< 1	< 1
	3/13/97	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	< 1	< 1	< 1
	10/29/97	< 1	< 1	< 1	< 1	< 1	8	< 1	< 1	< 1	< 1	< 1
	3/25/98	< 1	< 1	< 1	< 1	< 1	7.3	< 1	< 1	< 1	< 1	< 1
3247	6/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3281	6/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/13/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3305	1/15/98	< 1	1.7	< 1	< 1	3	1	< 1	< 1	< 1	19	< 1
	5/26/98	< 1	1.6	< 1	2.7	2.8	1.9	< 1	< 1	< 1	22	< 1
3306	1/15/98	< 1	1.1	< 1	< 1	1.2	1.1	3.2	< 1	1.2	9.3	< 1
	5/26/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.1	< 1
3324	5/28/98	< 1	< 1	< 1	< 1	< 1	170	< 1	< 1	< 1	53	< 1
3332	7/8/96	< 1	< 1	12	< 1	21	6.1	5	< 1	2.7	1400	< 1
	11/27/96	< 1	< 1	14	< 1	17	8.7	4.5	< 1	2.8	1200	< 1
	2/3/97	< 2.5	< 2.5	14	< 2.5	25	4.4	5.3	< 2.5	5	1500	< 2.5
	6/2/97	< 1	< 1	13	1.5	12	6.4	4.2	< 1	2.3	1300	< 1
	1/9/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	640	< 10
	6/25/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	620	< 10
3336	12/2/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/2/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3407	8/1/96	< 1	< 1	< 1	2.8	5.4	130	< 1	< 1	< 1	110	< 1
	11/26/96	< 1	< 1	< 1	2.4	4.8	120	< 1	< 1	< 1	100	< 1
	6/3/97	< 1	< 1	< 1	3.9	6.1	130	< 1	< 1	< 1	100	< 1
	1/16/98	< 1	< 1	< 1	< 1	6.7	160	< 1	< 1	< 1	120	< 1
	6/24/98	< 1	< 1	< 1	< 1	6.1	140	< 1	< 1	< 1	110	< 1
3415	6/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3416	6/10/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3439	6/13/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3517	3/19/97	< 10	< 10	< 10	< 10	21	< 10	< 10	< 10	< 10	1200	< 20
	7/7/97	< 10	< 10	6.6	3.5	16	6.5	< 10	< 10	2.2	1100	< 10
	10/31/97	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	1.1	610	< 10
	2/18/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	540	< 10
3518	3/19/97	< 10	< 10	< 10	< 10	24	70	< 10	< 10	< 10	1000	< 20
	7/7/97	< 10	< 10	3.7	4.7	17	72	< 10	< 10	1.1	820	< 10
	10/31/97	< 10	< 10	< 10	< 10	< 10	77	5.4	< 10	< 10	690	< 10
	2/18/98	< 10	< 10	< 10	< 10	< 10	45	< 10	< 10	< 10	460	< 10
3548	11/14/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/19/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	7/15/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3549	11/14/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/19/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3554	11/13/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/19/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3557	11/12/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/25/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/3/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3564	3/4/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	6/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3565	3/4/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	6/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3593	12/18/98	< 5	< 5	< 5		< 5	< 5	< 5	< 5	< 5	< 5	< 1
30004	1/16/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/29/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	7/30/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/14/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/5/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/26/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
30007	1/19/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/25/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/26/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.52	< 0.5
	12/9/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/22/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30010	1/24/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/23/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	7/25/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/21/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/18/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
30022	1/18/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/26/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/29/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/11/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1	< 0.5
	12/9/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/15/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/18/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30046	1/22/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/24/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/25/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.82	< 0.5
	12/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/21/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/22/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/7/98	-	< 0.5	< 0.5	< 0.5	23	< 0.5	< 0.5	< 0.5	-	-	1.8
	7/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30051	9/10/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	1	< 1
	3/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.6	< 1
	8/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1
	11/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.4	< 1
	5/1/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.7	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
30052	9/11/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	5.2	< 1
	3/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.2	< 1
	8/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.8	< 1
	11/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.1	< 1
	5/1/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.2	< 1
30082	4/10/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/12/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/12/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30088	5/1/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/10/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30091	5/5/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 10
	10/7/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/5/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30109	12/18/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	5/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	12/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30111	1/27/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	4/6/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/21/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30112	1/26/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	4/6/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/21/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30115	1/30/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	5/15/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
30118	1/28/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	5/14/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30124	8/4/98	< 5	< 5	< 5	< 5	-	< 5	< 5	< 10	< 5	< 5	< 10
	12/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5
	3/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5
30125	12/18/98	< 5	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	4/22/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5
30128	1/13/99	< 5	< 5	< 5	-	< 5	< 5	< 5	< 10	< 5	< 5	< 10
	5/17/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5
30139	2/4/99	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 10	< 5	< 5	< 10
31005	7/22/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	11/18/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-03C	9/13/96	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	14	< 2.5	< 5	< 2.5	110	< 2.5
	2/10/97	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	14	< 2.5	< 5	< 2.5	120	< 2.5
	5/6/97	< 0.36	< 0.36	< 0.58	< 0.22	< 0.28	15	< 0.48	< 0.2	< 0.4	68	< 0.52
	11/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	11	< 0.5	< 5	< 0.5	810	< 1
STSW-08C	5/1/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	1.1	< 0.5
	9/19/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	2.5	< 0.5
	2/5/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	2.9	< 0.5
	5/14/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	2.4	< 0.26
	11/30/98	< 0.5	< 0.5	0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3.4	< 0.5
STSW-28C	3/12/96	< 0.12	< 0.12	< 0.066	< 0.042	< 0.048	< 0.041	0.32	< 0.08	< 0.046	< 0.11	< 0.079
	4/8/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	9/30/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	1/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	4/30/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	10/3/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	5/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
STSW-29C	10/2/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	1/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	5/8/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	10/13/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	11/25/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-30C	10/3/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	1/20/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	5/9/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	10/14/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	11/24/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-51C	9/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-52C	8/31/98	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	25.6	< 2.5	< 2.5	< 2.5	57.3	< 2.5
	11/13/98	< 1	< 1	< 1	< 1	< 1	19.4	< 1	< 1	< 1	45.3	< 1

Note: (-) Equals not analyzed

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
128	5/16/97	1100
136	5/15/97	2300
137	5/15/97	< 400
172	5/20/97	580
229	5/20/98	830
230	5/20/98	580
237	12/18/96	< 400
238	12/18/96	< 400
242	1/9/98	580
	5/19/98	570
243	1/8/98	480
	5/19/98	500
244	1/8/98	510
	5/19/98	640
358	11/24/97	< 4
	3/27/98	< 4
421	2/3/97	< 400
	5/23/97	< 400
	5/20/98	22
422	2/3/97	< 400
	5/23/97	< 400
	5/20/98	17
439	5/21/97	< 400
446	5/28/97	690
476	5/21/97	1000
	1/19/98	810
	6/22/98	820
1206	5/22/97	< 400
	1/8/98	< 4
	5/7/98	< 4
1232	11/11/97	< 4
	4/10/98	< 4
1269	4/23/96	< 100
	10/7/97	< 4
	4/20/98	< 4
1270	4/23/96	< 100
	10/7/97	< 4
	4/17/98	27
1279	10/8/97	< 4
1284	3/11/97	< 400
	10/10/97	< 4
	4/3/98	< 4

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
1296	1/4/96	< 400
	10/11/96	< 400
	2/4/97	< 400
	10/14/97	7.1
	4/9/98	4.7
1297	10/14/97	< 4
	4/13/98	< 4
1314	1/11/96	< 400
	8/20/96	< 400
	12/11/98	< 4
1336	3/11/97	< 400
1348	6/6/97	< 400
1356	3/11/97	< 400
1436	5/23/97	< 400
	4/21/98	13
1458	1/16/96	< 400
	9/3/96	< 400
	3/12/97	< 400
1461	5/30/97	< 400
	5/4/98	500
1464	9/24/97	420
1465	9/24/97	< 4
1485	2/4/97	< 400
	6/2/97	< 400
	1/8/98	< 4
	4/30/98	< 4
3045	1/9/98	3700
3046	1/9/98	< 4
3116	5/28/97	710
3142	5/28/97	550
3212	3/10/97	7900
3213	3/10/97	8700
3229	3/12/97	7000
3246	3/13/97	< 400
3247	3/12/97	< 400
3281	3/13/97	< 400
3305	1/15/98	32
3306	1/15/98	18
3324	5/28/98	420
3332	2/3/97	590
	6/2/97	500
	1/9/98	290
	6/25/98	290

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
3336	12/2/96	620
	6/2/97	580
	1/13/98	730
3407	6/3/97	< 400
	1/16/98	520
3415	9/12/97	< 4
	3/19/98	< 4
3416	9/15/97	< 4
	3/18/98	< 4
3439	3/10/97	1900
	10/28/97	2100
	3/20/98	2000
3517	3/19/97	540
	7/7/97	470
	10/31/97	310
	2/18/98	270
3518	3/19/97	410
	7/7/97	< 400
	10/31/97	420
	2/18/98	300
3548	11/14/96	< 400
	9/19/97	< 4
	7/15/98	< 4
3549	11/14/96	< 400
	9/19/97	< 4
	7/14/98	< 4
3554	11/13/96	< 400
	9/19/97	580
	2/2/98	530
3557	11/12/96	600
	9/25/97	710
	2/3/98	570
3564	3/5/97	640
	6/30/97	550
	11/3/97	620
	2/13/98	760
3565	3/4/97	610
	6/30/97	550
	11/3/97	620
	2/13/98	550
3593	12/18/98	27

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
30004	1/14/97	< 400
	4/23/97	< 400
	7/16/97	< 400
	10/30/97	< 4
	1/5/98	< 4
	4/13/98	< 4
	7/14/98	< 4
	10/26/98	< 4
30007	1/16/97	< 400
	4/22/97	< 400
	7/17/97	< 400
	10/29/97	< 4
	1/30/98	< 4
	4/15/98	< 4
	7/15/98	< 4
	10/28/98	< 4
30010	1/17/97	< 400
	4/21/97	< 400
	7/18/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/15/98	< 4
	7/15/98	< 4
	10/28/98	< 4
30022	1/15/97	< 400
	4/23/97	< 400
	7/18/97	< 400
	10/28/97	< 4
	1/28/98	< 4
	4/13/98	< 4
	7/15/98	< 4
	10/27/98	< 4
30046	1/21/97	< 400
	4/22/97	< 400
	7/17/97	< 400
	10/28/97	< 4
	1/28/98	< 4
	4/14/98	< 4
	7/17/98	< 4
	10/27/98	< 4
30051	9/10/96	600
	3/24/97	510
	8/8/97	580
	11/14/97	820
	5/1/98	550

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
30052	9/11/96	410
	3/24/97	< 400
	8/8/97	500
	11/14/97	590
	5/1/98	400
30082	4/10/97	500
	9/30/97	440
	2/12/98	590
	5/12/98	590
30088	5/1/97	< 400
	9/26/97	< 4
	2/10/98	< 4
	5/19/98	< 4
	12/11/98	< 4
30091	5/5/97	< 400
	10/7/97	4.1
	2/5/98	< 4
	6/22/98	< 4
	12/15/98	< 4
30109	12/18/97	5.5
	5/18/98	14
	9/15/98	12
	12/17/98	22
30111	1/27/98	< 4
	4/6/98	< 4
	9/21/98	< 4
30112	1/26/98	< 4
	4/6/98	< 4
30115	1/30/98	< 4
	5/15/98	< 4
	9/18/98	< 4
	1/12/99	< 4
30118	1/28/98	< 4
	5/14/98	< 4
30124	8/4/98	< 4
	12/17/98	< 4
30125	12/18/98	570
30128	1/13/99	< 4
30139	2/4/99	15
31005	7/22/97	< 400
	11/18/97	< 4
	2/13/98	< 4
	5/4/98	< 4
	12/17/98	< 4

TABLE A-27
SUMMARY OF NDMA ANALYSES
LAYER D - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
171	3/16/98	0.16
	5/20/98	0.15
172	5/20/98	0.17
229	5/20/98	< 0.0075
230	5/20/98	< 0.0075
242	5/19/98	< 0.0075
243	5/19/98	< 0.0075
244	5/19/98	< 0.0075
284	5/21/98	< 0.0075
285	5/21/98	< 0.0075
288	5/21/98	< 0.0075
421	5/20/98	0.57
422	5/20/98	0.52
442	5/26/98	1.3
443	5/22/98	0.26
448	5/21/98	< 0.0075
1206	5/7/98	< 0.02
	3/10/99	< 0.0075
1212	7/13/98	< 0.0075
1436	4/30/98	0.43
1461	5/4/98	0.082
1464	5/5/98	0.021
	5/13/98	0.022
	6/15/98	0.023
1465	5/5/98	< 0.02
	6/15/98	< 0.02
1485	4/30/98	< 0.02
3019	7/9/98	< 0.0075
3020	7/9/98	0.028
3050	5/22/98	< 0.0075
3051	5/22/98	< 0.0075
3052	5/22/98	< 0.0075
3084	5/22/98	< 0.0075
3305	5/26/98	0.37
3306	5/26/98	0.74
3324	5/28/98	< 0.0075
3336	5/27/98	0.14
3410	5/28/98	0.41
3449	6/4/98	< 0.0075
3454	7/10/98	< 0.0075
3458	7/10/98	< 0.0075
3464	5/29/98	< 0.0075
3554	5/27/98	0.15
3557	5/27/98	0.16
3564	5/29/98	0.18
3565	5/29/98	0.19

TABLE A-27
SUMMARY OF NDMA ANALYSES
LAYER D - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
3593	12/18/98	< 0.0075
30004	4/13/98	< 0.02
	7/14/98	< 0.0075
	10/26/98	< 0.0075
30007	4/14/98	< 0.02
	7/15/98	< 0.0075
	10/28/98	< 0.0075
30010	4/15/98	< 0.02
	7/15/98	< 0.0075
	10/28/98	< 0.0075
30022	4/13/98	< 0.02
	7/15/98	< 0.0075
	10/27/98	< 0.0075
30046	4/14/98	< 0.02
	7/17/98	< 0.0075
	10/27/98	< 0.0075
30051	5/1/98	0.13
30052	5/1/98	0.036
30082	5/12/98	0.18
30088	5/19/98	< 0.0075
	12/11/98	< 0.0075
	3/17/99	< 0.0075
30091	12/15/98	< 0.0075
30109	12/17/98	< 0.0075
30111	5/6/98	< 0.02
30112	5/6/98	< 0.02
30115	1/12/99	< 0.0075
30125	12/18/98	0.18
30128	1/13/99	< 0.0075
30139	2/4/99	< 0.0075
31005	5/5/98	< 0.02
	12/17/98	< 0.0075
	3/17/99	< 0.0075

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	421 2/3/97	422 2/3/97	3332 2/3/97	3517 3/19/97	3518 3/19/97	3548 11/14/96	3549 11/14/96	3554 11/13/96	3557 11/12/96	3564 3/4/97	3565 3/4/97	3593 12/18/98
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
4-Bromophenyl phenyl ether	(ppb)	-	-	-	-	-	-	-	-	-	-	-	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

	SITE:	421	422	3332	3517	3518	3548	3549	3554	3557	3564	3565	3593
CONSTITUENT:	DATE:	2/3/97	2/3/97	2/3/97	3/19/97	3/19/97	11/14/96	11/14/96	11/13/96	11/12/96	3/4/97	3/4/97	12/18/98
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 10
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butylbenzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	1485 2/4/97	30004 1/14/97	30051 9/10/96	30052 9/11/96	30082 4/10/97	30088 5/1/97	30091 5/5/97	30109 12/18/97	30111 1/27/98	30115 1/30/98	30115 1/12/99	30118 1/28/98
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	< 10
4-Bromophenyl phenyl ether	(ppb)	-	-	-	-	-	-	-	-	-	-	< 10	-
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	1485 2/4/97	30004 1/14/97	30051 9/10/96	30052 9/11/96	30082 4/10/97	30088 5/1/97	30091 5/5/97	30109 12/18/97	30111 1/27/98	30115 1/30/98	30115 1/12/99	30118 1/28/98
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 10	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butylbenzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	30124 8/4/98	30124 12/17/98	30124 2/2/99	30124 3/16/99	30125 12/18/98	30128 1/13/99	30139 2/4/99	31005 7/22/97
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	-	-	-	-	-	-	-	< 10
4-Bromophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

	SITE:	30124	30124	30124	30124	30125	30128	30139	31005
CONSTITUENT:	DATE:	8/4/98	12/17/98	2/2/99	3/16/99	12/18/98	1/13/99	2/4/99	7/22/97
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 10	< 10	< 10	< 10	< 10	< 10	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butylbenzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-29
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT: SITE:	358	358	358	358	358	358	3517	3518	3548	3549	3554	3557
(Units in mg/l) DATE:	4/2/96	10/9/96	4/15/97	10/27/97	4/14/98	10/28/98	3/19/97	3/19/97	11/14/96	11/14/96	11/13/96	11/12/96
Aluminum	< 0.22	< 0.2	< 0.2	< 0.2	0.39	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.44	< 0.24	< 0.24	< 0.2	< 0.2	< 0.2	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24
Arsenic	< 0.089	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.013	0.048	0.052	0.055	0.054	0.049	0.1	0.1	0.037	0.042	0.026	0.091
Beryllium	0	0	0	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	0.047	< 0.001	< 0.001	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	< 0.0044	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	20	14	12	13	13	12	24	25	20	19	23	26
Chromium	< 0.004	< 0.004	< 0.004	0.015	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	0	0	0	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.008	0.18	0.31	0.47	0.46	0.19	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	< 0.33	< 0.3	0.42	1.2	0.88	0.32	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	< 0.067	< 0.06	< 0.06	0.15	0.066	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	6.5	6.4	6.7	6.9	6.7	6.3	12	12	4.3	6.1	7.3	9.9
Manganese	0.021	0.1	0.14	0.22	0.13	0.1	< 0.005	< 0.005	0.013	0.028	< 0.005	< 0.005
Molybdenum	< 0.044	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	2.2	2.9	2.1	2.7	3.5	2	2.9	3.1	5.1	2.9	4.6	4.6
Selenium	< 0.11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	15	8.7	8.8	9.6	9	8.9	12	12	12	10	19	15
Thallium	< 0.056	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	< 0.0056	< 0.005	< 0.005	< 0.006	< 0.006	< 0.006	0.0067	0.0061	0.0057	< 0.005	0.014	0.0089
Zinc	< 0.006	2.1	0.8	18	5.1	5.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-29
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT: SITE:	3564	3565	3593	30004	30010	30082	30088	30088	30091	30091	30109	30109	30111
(Units in mg/l) DATE:	3/5/97	3/4/97	12/18/98	7/7/98	7/7/98	4/10/97	5/1/97	12/11/98	5/5/97	12/15/98	12/18/97	12/17/98	1/27/98
Aluminum	< 0.2	< 0.2	< 0.2	-	-	< 0.2	< 0.2	< 0.05	< 0.2	< 0.05	< 0.2	< 0.05	< 0.2
Antimony	< 0.24	< 0.24	< 0.2	-	-	< 0.24	< 0.24	< 0.05	< 0.24	< 0.05	< 0.2	< 0.05	< 0.2
Arsenic	< 0.08	< 0.08	< 0.08	-	-	< 0.08	< 0.08	< 0.02	< 0.08	< 0.02	< 0.08	< 0.02	< 0.08
Barium	0.087	0.053	0.029	-	-	0.066	0.088	0.09	0.03	0.037	0.071	0.063	0.06
Beryllium	< 0.001	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.00025	< 0.001	< 0.00025	< 0.001	< 0.00025	< 0.001
Boron	< 0.04	< 0.04	< 0.04	-	-	< 0.04	< 0.04	0.012	< 0.04	0.011	< 0.04	0.011	< 0.04
Cadmium	< 0.004	< 0.004	< 0.004	-	< 0.001	< 0.004	< 0.004	< 0.001	< 0.004	< 0.001	< 0.004	< 0.001	< 0.004
Calcium	26	24	22	27	-	25	23	22	17	11	23	19	24
Chromium	< 0.008	< 0.008	< 0.008	-	-	< 0.008	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	-	-	< 0.008	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008
Copper	< 0.006	< 0.006	0.008	-	-	< 0.006	< 0.006	< 0.0015	< 0.006	< 0.0015	< 0.006	< 0.0015	< 0.006
Iron	< 0.3	< 0.3	0.68	-	-	< 0.3	< 0.3	< 0.075	< 0.3	< 0.075	< 0.3	0.14	< 0.3
Lead	< 0.06	< 0.06	< 0.06	-	-	< 0.06	< 0.06	< 0.015	< 0.06	< 0.015	< 0.06	< 0.015	< 0.06
Magnesium	11	9.5	8.7	21	-	12	6.3	8.5	4.6	5.5	9.6	9.8	7.1
Manganese	0.0066	0.0061	0.021	< 0.0012	-	0.0051	< 0.005	< 0.0012	< 0.005	0.0039	< 0.005	0.011	0.039
Molybdenum	< 0.04	< 0.04	< 0.04	-	-	< 0.04	< 0.04	< 0.01	< 0.04	< 0.01	< 0.04	< 0.01	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	-	-	< 0.02	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02
Potassium	2.7	4.8	4.2	0.75	-	3.1	5.5	4.3	1.9	1.9	4.5	2.8	4.6
Selenium	< 0.1	< 0.1	< 0.1	-	-	< 0.1	< 0.1	< 0.025	< 0.1	< 0.025	< 0.1	< 0.025	< 0.1
Silver	< 0.02	< 0.02	< 0.02	-	-	< 0.02	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02
Sodium	12	18	12	35	-	13	17	11	11	8.1	12	9.7	11
Thallium	< 0.05	< 0.05	< 0.05	-	-	< 0.05	< 0.05	< 0.012	< 0.05	< 0.012	< 0.05	< 0.012	< 0.05
Vanadium	< 0.005	0.0052	< 0.006	0.0038	-	0.0072	0.0092	0.0059	0.016	0.011	0.012	0.0094	< 0.006
Zinc	< 0.1	0.16	< 0.1	-	-	< 0.1	< 0.1	< 0.025	0.17	0.045	< 0.1	0.038	< 0.1

Note: (-) Equals not analyzed

TABLE A-29
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT: SITE:	30112	30115	30118	30124	30125	30128	30139	31005	31005
(Units in mg/l) DATE:	1/26/98	1/30/98	1/28/98	8/4/98	12/18/98	1/13/99	2/4/99	7/22/97	12/17/98
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.05
Antimony	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.24	< 0.05
Arsenic	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.02
Barium	0.056	0.032	0.032	0.036	0.026	0.051	0.054	0.056	0.066
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.00025
Boron	< 0.04	< 0.04	< 0.04	< 0.04	0.044	< 0.04	< 0.04	< 0.04	0.017
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.001
Calcium	19	19	11	20	19	17	22	19	22
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.002
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.002
Copper	< 0.006	0.01	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.0015
Iron	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.075
Lead	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.015
Magnesium	6	2.2	5	5.2	5.5	3.8	8.3	9	9.2
Manganese	0.054	< 0.005	0.0088	0.067	0.02	< 0.005	< 0.005	0.01	< 0.0012
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.01
Nickel	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.005
Potassium	3	4.1	2.8	6.3	< 2	6.3	3.8	3.7	4
Selenium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.025
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.005
Sodium	9.6	14	9.5	21	12	26	19	15	9.3
Thallium	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.012
Vanadium	< 0.006	0.017	0.013	0.0072	< 0.006	0.0068	0.006	0.008	0.0069
Zinc	0.24	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.025

Note: (-) Equals not analyzed

TABLE 10
SUMMARY OF ANION ANALYSES (EPA 300)
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Chloride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
358	4/2/96	4.6	0.091	-	5.2
	10/9/96	4.2	< 0.03	-	4.4
	4/15/97	4.9	0.068	-	5.7
	10/27/97	4.3	0.08	-	5.1
	4/14/98	4.1	< 0.03	-	5.1
	10/28/98	4.4	< 0.03	-	5
3517	3/19/97	5.8	6.3	< 0.05	12
3518	3/19/97	5.5	6.6	< 0.05	14
3548	11/14/96	5.6	< 0.03	< 0.05	6.3
3549	11/14/96	5.3	< 0.03	< 0.05	4
3554	11/13/96	7	6.3	< 0.05	9.1
3557	11/12/96	8.1	6.5	< 0.05	11
3564	3/5/97	6.6	6.7	< 0.05	11
3565	3/4/97	6.4	6	< 0.05	12
3593	12/18/98	9.4	6.1	-	7.6
30022	7/7/98	8.2		-	-
30051	9/10/96	8.2	6.8	< 0.05	11
30052	9/11/96	7.7	5.7	< 0.05	9.1
30082	4/10/97	6.7	7.2	< 0.05	11
30088	5/1/97	6.5	9.4	< 0.05	6.9
30091	5/5/97	5.2	7.5	< 0.05	5.2
30111	1/27/98	29	< 0.03	< 0.05	5.5
30112	1/26/98	4.7	< 0.03	< 0.05	2.9
30112	1/26/98	4.8	< 0.03	< 0.05	2.9
30115	1/30/98	7.1	2	0.11	11
30118	1/28/98	4.8	6	< 0.1	5.5
30125	12/18/98	5.2	< 0.1	< 0.05	0.19
30128	1/13/99	7.9	1.4	0.062	8.1
30139	2/4/99	-	1.3	0.12	9.9
30139	2/4/99	11	-	-	-
31005	7/22/97	8.6	7.9	< 0.05	6.4

Notes: (-) equals not analyzed

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
141	6/7/96	< 1	< 1	< 1	< 1	< 1
	10/28/96	< 1	< 1	< 1	< 1	< 1
	11/15/96	< 1	< 1	< 1	< 1	< 1
	3/14/97	< 1	< 1	< 1	< 1	< 1
	9/11/97	< 1	< 1	< 1	< 1	< 1
142	4/9/96	< 5	< 5	< 5	< 5	< 5
208	4/2/96	< 5	< 5	< 5	< 5	< 5
	10/8/96	< 5	< 5	< 5	< 5	< 5
	4/14/97	< 5	< 5	< 5	< 5	< 5
	10/9/97	< 5	< 5	< 5	< 5	< 5
	4/15/98	< 5	< 5	< 5	< 5	< 5
	7/7/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/26/98	< 5	< 5	< 5	< 5	< 5
403	4/1/96	< 5	< 5	< 5	< 5	< 5
	5/17/96	< 1	< 1	< 1	< 1	< 1
	10/10/96	< 5	< 5	< 5	< 5	< 5
	4/16/97	< 5	< 5	< 5	< 5	< 5
	9/25/97	< 1	< 1	< 1	< 1	< 1
	10/27/97	< 5	< 5	< 5	< 5	< 5
	4/17/98	< 5	< 5	< 5	< 5	< 5
	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
478	7/1/96	< 1	< 1	< 1	< 1	< 1
	11/21/96	< 1	< 1	< 1	< 1	< 1
	5/21/97	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1
479	7/1/96	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1
	5/19/97	< 1	< 1	< 1	< 1	< 1
	1/14/98	< 1	< 1	< 1	< 1	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1
1170	1/9/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/3/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/3/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/8/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/2/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/4/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/2/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/29/97	< 0.5	< 0.5	< 0.5	< 0.5	0.92
	10/6/97	< 0.5	< 0.5	< 0.5	< 0.5	2
	1/19/98	< 0.5	< 0.5	< 0.5	< 0.5	1.8
	6/22/98	< 0.5	< 0.5	< 0.5	< 0.5	4.4
	7/17/98	< 0.5	< 0.5	< 0.5	< 0.5	4
	10/12/98	< 0.5	< 0.5	< 0.5	< 0.5	1.1

Note: (-) Equals not analyzed

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
1207	2/14/96	< 1	< 1	< 1	< 1	< 1
	7/30/96	< 1	< 1	< 1	< 1	< 1
	12/3/96	< 1	< 1	< 1	< 1	< 1
	5/22/97	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1
	5/7/98	< 1	< 1	< 1	< 1	< 1
1233	9/9/96	< 1	< 1	< 1	< 1	< 1
	12/12/96	< 1	< 1	< 1	< 1	< 1
	11/11/97	< 1	< 1	< 1	< 1	2.4
	4/10/98	< 1	< 1	< 1	< 1	2.7
1234	9/9/96	< 1	< 1	< 1	< 1	< 1
	12/12/96	< 1	< 1	< 1	< 1	< 1
	11/11/97	< 1	< 1	< 1	< 1	< 1
	4/10/98	< 1	< 1	< 1	< 1	< 1
1280	4/1/96	< 5	< 5	< 5	< 5	< 5
	10/10/96	< 5	< 5	< 5	< 5	< 5
	4/15/97	< 5	< 5	< 5	< 5	< 5
	10/28/97	< 5	< 5	< 5	< 5	< 5
	4/16/98	< 5	< 5	< 5	< 5	< 5
	10/29/98	< 5	< 5	< 5	< 5	< 5
1285	6/17/96	< 1	< 1	< 1	< 1	< 1
	10/31/96	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1
1286	6/17/96	< 1	< 1	< 1	< 1	< 1
	10/31/96	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1
1349	8/14/96	< 1	< 1	< 1	< 1	< 1
	12/6/96	< 1	< 1	< 1	< 1	< 1
	6/6/97	< 1	< 1	< 1	< 1	< 1
	12/17/97	< 1	< 1	< 1	< 1	< 1
	8/5/98	< 1	< 1	< 1	< 1	< 1
1437	7/9/96	< 1	< 1	< 1	< 1	150
	11/27/96	< 1	< 1	< 1	< 1	110
	5/23/97	< 1	< 1	< 1	< 1	69
	1/7/98	< 1	< 1	< 1	< 1	190
	5/4/98	2.3	1	< 1	< 1	220
1438	7/9/96	< 1	< 1	< 1	< 1	91
	11/26/96	< 1	4.5	< 1	< 1	47
	5/23/97	< 1	7.8	< 1	< 1	84
	1/7/98	< 1	< 1	< 1	< 1	37
	5/4/98	< 1	< 1	< 1	< 1	150
1439	7/9/96	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1
	5/23/97	< 1	< 1	< 1	< 1	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1
	4/30/98	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
1459	1/16/96	< 1	< 1	< 1	< 1	1.4
	6/20/96	< 1	< 1	< 1	< 1	< 1
	9/3/96	< 1	< 1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
	10/20/97	< 1	< 1	< 1	< 1	< 1
	4/9/98	< 1	< 1	< 1	< 1	< 1
1462	7/9/96	< 1	< 1	< 1	< 1	< 1
	11/27/96	< 1	< 1	< 1	< 1	< 1
	5/30/97	< 1	< 1	< 1	< 1	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1
	5/4/98	< 1	< 1	< 1	< 1	< 1
1468	7/26/96	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1
	2/6/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	5/29/97	< 1	< 1	< 1	< 1	< 1
	3/27/98	< 1	< 1	< 1	< 1	< 1
	7/2/98	< 1	< 1	< 1	< 1	< 1
1486	7/26/96	< 1	< 1	< 1	< 1	< 1
	11/22/96	< 1	< 1	< 1	< 1	< 1
	2/4/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	6/2/97	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1
	4/30/98	< 1	< 1	< 1	< 1	< 1
3047	1/9/98	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1
3053	5/22/98	< 1	< 1	< 1	< 1	< 1
3214	6/12/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1
3215	6/12/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1
3230	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
3231	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
3232	6/4/96	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
3248	6/6/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1
3249	6/6/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1
3282	6/7/96	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/13/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	4/17/98	< 1	< 1	< 1	< 1	< 1
3283	6/7/96	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/13/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	4/17/98	< 1	< 1	< 1	< 1	< 1
3307	1/15/98	< 1	< 1	< 1	< 1	3.1
	5/26/98	< 1	< 1	1.6	< 1	5.4
3325	5/28/98	< 1	< 1	< 1	< 1	< 1
3333	7/8/96	< 1	< 1	< 1	< 1	45
	11/27/96	< 1	< 1	< 1	< 1	52
	2/3/97	< 0.5	< 0.5	< 0.5	< 0.5	61
	5/30/97	< 1	< 1	< 1	< 1	63
	1/9/98	< 1	< 1	< 1	< 1	71
	6/26/98	< 1	< 1	< 1	< 1	84
3334	7/8/96	< 1	< 1	< 1	< 1	18
	11/27/96	< 1	< 1	< 1	< 1	11
	2/3/97	< 0.5	< 0.5	< 0.5	< 0.5	11
	5/30/97	< 1	< 1	< 1	< 1	8.3
	6/25/98	< 1	< 1	< 1	< 1	7.9
3337	12/2/96	< 1	< 1	< 1	< 1	< 1
	6/2/97	< 1	< 1	< 1	< 1	< 1
3343	5/29/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/5/97	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1
3404	7/15/96	< 1	< 1	< 1	< 1	18
	11/22/96	< 1	< 1	< 1	1.3	18
	2/4/97	< 0.5	< 0.5	< 0.5	1.1	17
	6/3/97	< 1	< 1	< 1	< 1	17
	1/15/98	< 1	< 1	< 1	< 1	27
	5/28/98	< 1	< 1	< 1	< 1	30

Note: (-) Equals not analyzed

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
3405	7/17/96	< 1	< 1	< 1	< 1	44
	11/25/96	< 1	< 1	< 1	< 1	35
	2/4/97	< 0.5	< 0.5	< 0.5	< 0.5	24
	6/4/97	< 1	< 1	< 1	< 1	9.9
	1/13/98	< 1	< 1	< 1	< 1	12
	5/28/98	< 1	< 1	< 1	< 1	14
3408	7/29/96	< 1	< 1	< 1	< 1	< 1
	11/25/96	< 1	< 1	< 1	< 1	< 1
	6/3/97	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1
3417	6/10/96	< 1	< 1	< 1	< 1	< 1
	11/8/96	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1
	9/15/97	< 1	< 1	< 1	< 1	< 1
	3/18/98	< 1	< 1	< 1	< 1	< 1
3566	2/28/97	< 5	< 5	< 5	< 5	< 5
	6/30/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	2/13/98	< 1	< 1	< 1	< 1	< 1
30126	12/18/98	< 5	< 5	< 5	< 5	< 5
30127	12/18/98	< 5	< 5	< 5	< 5	< 5
30129	1/13/99	< 5	< 5	< 5	< 5	< 5
30130	1/13/99	< 5	< 5	< 5	< 5	< 5
30134	2/4/99	< 5	< 5	< 5	< 5	< 5
30135	2/3/99	< 5	< 5	< 5	< 5	< 5
30136	2/3/99	< 5	< 5	< 5	< 5	22

Note: (-) Equals not analyzed

TABLE A-32
SUMMARY OF PERCHLORATE ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
141	03/14/1997	< 35*
403	10/28/1998	< 4
478	05/21/1997	< 400
	01/08/1998	< 4
	06/22/1998	< 4
479	05/19/1997	< 400
	01/14/1998	< 4
	06/22/1998	< 4
1170	02/04/1997	< 400
	07/29/1997	< 400
	10/06/1997	< 4
	01/19/1998	< 4
	07/17/1998	< 4
1207	05/22/1997	< 400
	01/08/1998	< 4
	05/07/1998	< 4
1233	11/11/1997	< 4
	04/10/1998	< 4
1234	11/11/1997	< 4
	04/10/1998	< 4
1280	10/28/1997	< 4
	04/16/1998	< 4
	10/29/1998	< 4
1285	03/11/1997	< 400
	10/10/1997	4.8
	04/03/1998	< 4
1286	03/11/1997	< 400
	10/10/1997	< 4
	04/03/1998	< 4
1349	06/06/1997	< 400
	12/17/1997	< 4
	08/05/1998	< 4
1437	05/23/1997	< 400
	04/21/1998	390
1438	05/23/1997	< 400
	04/21/1998	400
1439	05/23/1997	< 400
	04/21/1998	< 4
1459	01/16/1996	< 400
	09/03/1996	< 400
	03/12/1997	< 35*
1462	05/30/1997	< 400
	05/04/1998	22
1468	02/06/1997	< 400
	05/29/1997	< 400
	03/27/1998	< 4
	07/02/1998	< 4

Notes: (*) Equals value reported between PQL and MDL

TABLE A-32
SUMMARY OF PERCHLORATE ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
1486	02/04/1997	< 400
	06/02/1997	< 400
	01/08/1998	< 4
	04/30/1998	< 4
3047	01/09/1998	< 4
3214	03/10/1997	< 120*
3215	03/10/1997	< 35*
3230	03/12/1997	< 35*
3231	03/12/1997	< 35*
3232	03/12/1997	< 35*
3248	03/12/1997	< 35*
3249	03/12/1997	< 35*
3282	03/13/1997	< 35*
3283	03/13/1997	< 35*
3307	01/15/1998	10
3308	01/15/1998	< 4
3309	01/15/1998	< 4
3325	05/28/1998	< 4
3333	02/03/1997	< 400
	05/30/1997	< 400
	01/09/1998	160
	06/26/1998	180
3334	02/03/1997	< 400
	05/30/1997	590
	06/25/1998	28
3337	12/02/1996	< 400
	06/02/1997	< 35*
3343	10/24/1997	< 4
	03/18/1998	< 4
3404	02/04/1997	< 400
	06/03/1997	< 400
	01/15/1998	40
	05/28/1998	37
3405	02/04/1997	< 400
	06/04/1997	< 400
	01/13/1998	23
	05/28/1998	22
3408	06/03/1997	< 400
	01/15/1998	< 4
3417	09/15/1997	< 4
	03/18/1998	< 4
3566	02/28/1997	580
	06/30/1997	510
	11/03/1997	610
	02/13/1998	500
30126	12/18/1998	< 4
30127	12/18/1998	< 4
30129	01/13/1999	< 4
30130	01/13/1999	< 4
30134	02/04/1999	< 4
30135	02/03/1999	< 4
30136	02/03/1999	< 4

Notes: (*) Equals value reported between PQL and MDL

TABLE A-33
SUMMARY OF NDMA ANALYSES
LAYER E - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
1170	04/29/1998	< 0.02
1171	04/29/1998	< 0.02
1207	05/07/1998	< 0.02
	03/10/1999	< 0.0075
1437	05/04/1998	0.015
1438	05/04/1998	0.08
1439	04/30/1998	< 0.02
1462	05/04/1998	0.024
1468	07/16/1998	< 0.0075
1486	04/30/1998	< 0.02
3021	07/09/1998	0.0098
3307	05/26/1998	0.38
3325	05/28/1998	< 0.0075
3337	05/26/1998	< 0.0075
3404	05/28/1998	0.26
3411	05/28/1998	< 0.0075
3455	07/10/1998	< 0.0075
3459	07/09/1998	0.035
3465	05/29/1998	< 0.0075
3566	05/29/1998	0.18
30126	12/18/1998	< 0.0075
30127	12/18/1998	< 0.0075
30129	01/13/1999	< 0.0075
30130	01/13/1999	< 0.0075
30134	02/04/1999	< 0.0075
30135	02/03/1999	< 0.0075
30136	02/03/1999	< 0.0075

TABLE A-34
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER E - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	1486 2/4/97	3333 2/3/97	3334 2/3/97	3404 2/4/97	3405 2/4/97	3566 2/28/97	30126 12/18/98	30127 12/18/98	30129 1/13/99	30129 1/13/99	30130 1/13/99	30134 2/4/99
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	-	-	-	-	-	-
4-Bromophenyl phenyl ether	(ppb)	-	-	-	-	-	-	< 10	< 10	< 10	< 10	< 10	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-34
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER E - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	1486 2/4/97	3333 2/3/97	3334 2/3/97	3404 2/4/97	3405 2/4/97	3566 2/28/97	30126 12/18/98	30127 12/18/98	30129 1/13/99	30129 1/13/99	30130 1/13/99	30134 2/4/99
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-benzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-34
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER E - JANUARY 1996 TO APRIL 1999

	SITE:	30135	30136	30136
CONSTITUENT:	DATE:	2/3/99	2/3/99	2/3/99
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	-	-	-
4-Bromophenyl phenyl ether	(ppb)	< 10	< 10	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-34
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER E - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	30135 2/3/99	30136 2/3/99	30136 2/3/99
Dibenzofuran	(ppb)	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 10	< 10	< 10
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10
N-Butyl-benzenesulfonamide	(ppb)	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-35
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER E - JANUARY 1996 TO DECEMBER 1998

SITE:	142	208	208	208	208	208	208	208	208	403	403	403	403
CONSTITUENT: DATE: (Units in mg/l)	4/9/96	4/2/96	10/8/96	4/14/97	4/14/97	10/9/97	4/15/98	10/26/98	10/26/98	4/1/96	10/10/96	4/16/97	10/27/97
Aluminum	0.3	< 0.22	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.23	0.4	< 0.2	< 0.2
Antimony	< 0.44	< 0.44	< 0.24	< 0.24	< 0.24	< 0.2	< 0.2	< 0.2	< 0.2	< 0.44	< 0.24	< 0.24	< 0.2
Arsenic	< 0.089	< 0.089	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.089	< 0.08	< 0.08	< 0.08
Barium	0.034	0.055	0.013	0.014	0.01	0.013	0.014	0.013	0.013	0.051	0.053	0.045	0.049
Beryllium	< 0.0011	-	-	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-	-	< 0.001
Boron	0.047	< 0.001	0.057	0.054	0.05	0.047	0.054	0.044	0.045	< 0.001	< 0.001	< 0.001	< 0.04
Cadmium	< 0.0044	-	-	-	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.0044	< 0.004	< 0.004	< 0.004
Calcium	19	14	20	20	19	19	19	18	17	22	17	19	20
Chromium	< 0.0089	< 0.004	< 0.004	< 0.004	< 0.01	< 0.008	< 0.008	< 0.008	< 0.008	< 0.004	< 0.004	< 0.004	< 0.008
Cobalt	< 0.0089	< 0.008	< 0.008	< 0.008	< 0.01	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	0.14	0.23	< 0.008	< 0.008	< 0.01	< 0.006	< 0.006	< 0.006	< 0.006	0.33	0.7	0.22	0.29
Iron	0.6	< 0.33	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.64	0.7	< 0.3	0.47
Lead	< 0.067	< 0.067	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.067	< 0.06	< 0.06	< 0.06
Magnesium	5.8	6.7	6	6.4	6.2	6.2	6	6	5.7	7.2	5.2	6.8	7
Manganese	0.1	0.13	0.021	0.023	0.02	0.025	0.028	0.028	0.026	0.065	0.054	0.066	0.062
Molybdenum	< 0.044	-	-	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-	-	-	< 0.04
Nickel	< 0.022	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.022	< 0.02	< 0.02	< 0.02
Potassium	2.5	1.1	2.2	1.7	1.6	< 2	2.3	2.2	< 2	3.5	4	2.6	2.8
Selenium	< 0.11	< 0.11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.11	< 0.1	< 0.1	< 0.1
Silver	< 0.022	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.022	< 0.02	< 0.02	< 0.02
Sodium	14	9	14	14	14	14	14	14	13	10	7.8	9.3	10
Thallium	< 0.056	< 0.056	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.056	< 0.05	< 0.05	< 0.05
Vanadium	< 0.0056	< 0.006	< 0.006	< 0.006	< 0.01	< 0.006	< 0.006	< 0.006	< 0.006	< 0.0056	< 0.005	< 0.005	< 0.006
Zinc	8.8	1.2	< 0.006	0.71	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	4.2	3.8	0.5	8

TABLE A-35
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER E - JANUARY 1996 TO DECEMBER 1998

SITE:	403	403	403	1280	1280	1280	1280	1280	1280	3566	30126	30127
CONSTITUENT: DATE: (Units in mg/l)	4/17/98	7/7/98	10/28/98	4/1/96	10/10/96	4/15/97	10/28/97	4/16/98	10/29/98	2/28/97	12/18/98	12/18/98
Aluminum	< 0.2	< 0.05	< 0.2	< 0.22	< 0.2	< 0.2	< 0.2	0.25	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.2	-	< 0.2	< 0.44	< 0.24	< 0.24	< 0.2	< 0.2	< 0.2	< 0.24	< 0.2	< 0.2
Arsenic	< 0.08	-	< 0.08	< 0.089	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.046	-	0.048	0.059	0.051	0.06	0.057	0.06	0.057	0.06	0.07	0.02
Beryllium	< 0.001	-	< 0.001	-	-	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	< 0.04	-	< 0.04	< 0.001	< 0.001	< 0.001	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.25
Cadmium	< 0.004	-	< 0.004	< 0.0044	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	20	-	20	17	16	18	16	17	16	23	26	13
Chromium	< 0.008	-	< 0.008	< 0.004	< 0.004	< 0.004	0.0084	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	-	< 0.008	-	-	-	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	0.22	-	0.25	0.28	0.39	0.48	0.45	0.36	0.18	< 0.006	< 0.006	< 0.006
Iron	< 0.3	-	< 0.3	< 0.33	< 0.3	< 0.3	0.48	0.5	< 0.3	< 0.3	0.51	< 0.3
Lead	< 0.06	-	< 0.06	< 0.067	< 0.06	< 0.06	0.067	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	6.8	-	7.1	0.067	0.067	0.067	6.9	6.6	6.6	9.5	9.6	1.9
Manganese	0.052	-	0.056	0.19	0.12	0.18	0.19	0.21	0.17	0.012	0.014	0.053
Molybdenum	< 0.04	-	< 0.04	< 0.044	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	-	< 0.02	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	2.7	-	2.8	2.9	2.9	2.9	2.5	3.1	2.4	5.8	3.2	2.6
Selenium	< 0.1	-	< 0.1	< 0.11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.02	-	< 0.02	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	9.4	-	10	9.3	9.1	8.1	9.2	9	9.2	12	15	30
Thallium	< 0.05	-	< 0.05	< 0.056	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	< 0.006	-	< 0.006	< 0.0056	< 0.005	< 0.005	< 0.006	< 0.006	< 0.006	0.005	0.0081	< 0.006
Zinc	2.8	-	3.8	1.6	2	1.3	12	7.2	6.4	< 0.1	< 0.1	< 0.1

TABLE A-35
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER E - JANUARY 1996 TO DECEMBER 1998

SITE: / CONSTITUENT: DATE: (Units in mg/l)	30129 1/13/99	30130 1/13/99	30134 2/4/99	30135 2/3/99	30136 2/3/99
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Arsenic	< 0.08	< 0.08	< 0.08	0.13	< 0.08
Barium	0.043	0.038	0.064	0.033	0.045
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	0.046	0.3	< 0.04	0.045	0.06
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	16	22	21	20	23
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	< 0.3	< 0.3	0.43	< 0.3	0.3
Lead	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	6	7.8	6.7	6.8	8.2
Manganese	0.015	0.027	0.0057	0.0099	0.02
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	4.4	3.7	3.9	6.2	5.3
Selenium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	19	16	21	14	14
Thallium	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	< 0.006	< 0.006	0.018	0.0062	< 0.006
Zinc	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

TABLE A-36
SUMMARY OF ANION ANALYSES (EPA 300)
LAYER E - JANUARY 1996 TO DECEMBER 1999

Well No.	Sample Date	Chloride (mg/l)	Fluoride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
142	4/9/96	5.5	0.045	< 0.03	-	1.1
208	4/2/96	6.2	0.059	< 0.03	-	0.15
	10/8/96	6.3	0.033	< 0.03	-	0.2
	4/14/97	6	0.064	0.31	-	0.82
	4/14/97	6.2	0.06	< 0.03	-	0.32
	10/9/97	6.2	0.14	< 0.03	-	0.36
	4/15/98	5.8	< 0.15	< 0.03	-	0.37
403	4/1/96	6.1	0.085	< 0.03	-	1.4
	10/10/96	4.5	0.093	< 0.03	-	1.3
	4/16/97	6.6	0.063	< 0.03	-	2
	10/27/97	6.7	0.075	< 0.03	-	1.9
	4/17/98	6.2	0.067	< 0.03	-	1.8
	10/28/98	6.5	0.047	< 0.03	-	2.1
1280	4/1/96	3.8	0.1	< 0.03	-	0.11
	10/10/96	4.1	0.12	< 0.03	-	< 0.05
	4/15/97	3.5	0.088	< 0.03	-	2.4
	10/28/97	4.7	0.065	< 0.03	-	0.085
	4/16/98	4.5	0.076	< 0.03	-	0.1
	10/29/98	4.6	0.078	< 0.03	-	0.09
3566	2/28/97	8.7	-	6.6	< 0.05	12
30126	12/18/98	6.7	-	7.1	-	12
30127	12/18/98	11	-	< 0.1	-	3.8
30129	1/13/99	13	-	< 0.1	-	2.2
30130	1/13/99	17	-	< 0.1	-	0.19
30134	2/4/99	8.7	-	1	-	15
30135	2/3/99	7.6	-	< 0.1	-	14
30136	2/3/99	6.5	-	< 0.1	-	20

Notes: (-) equals Not Analyzed

PAGES OF OVERSIZED MAPS

(SEE BINDER)

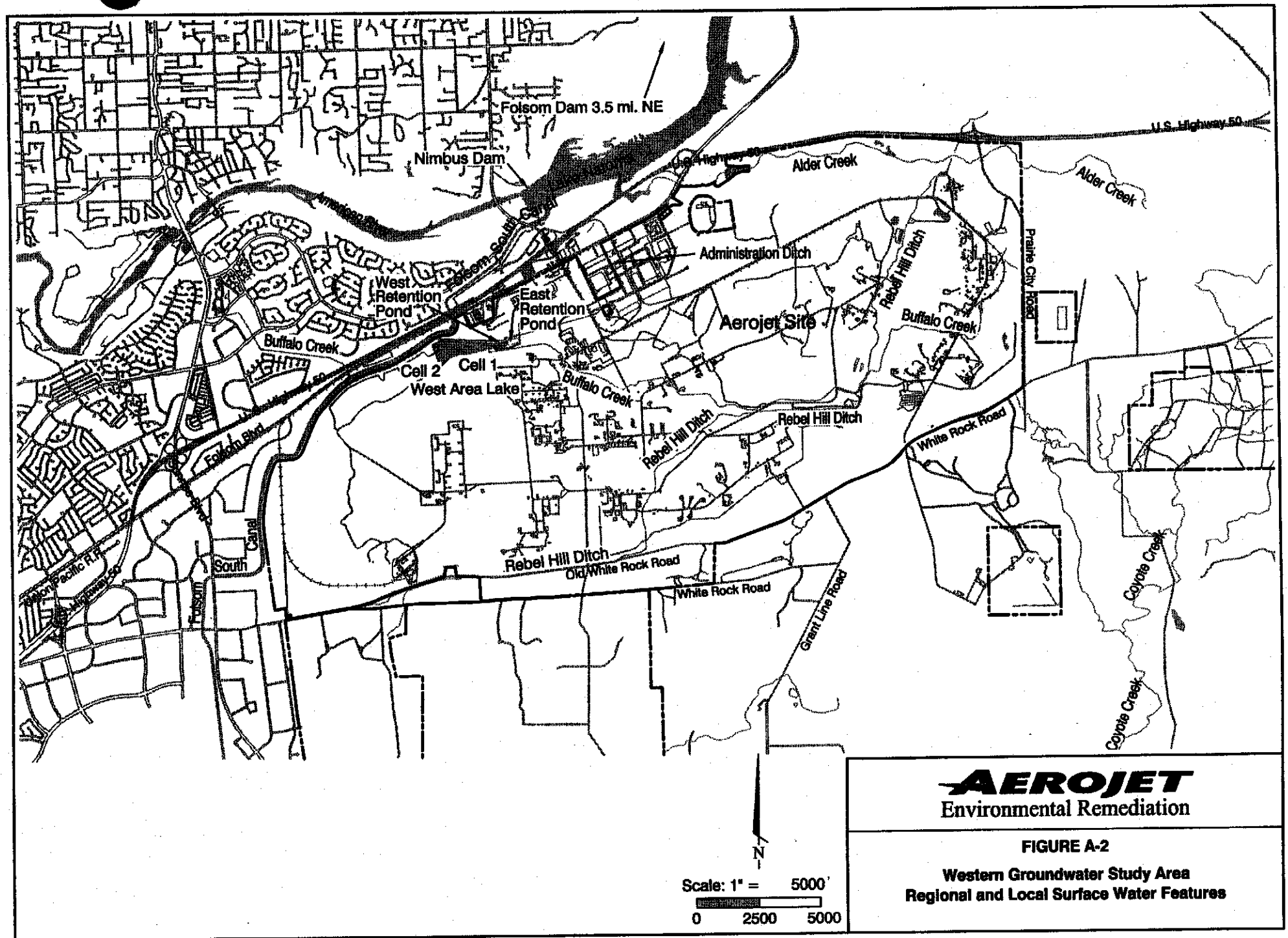

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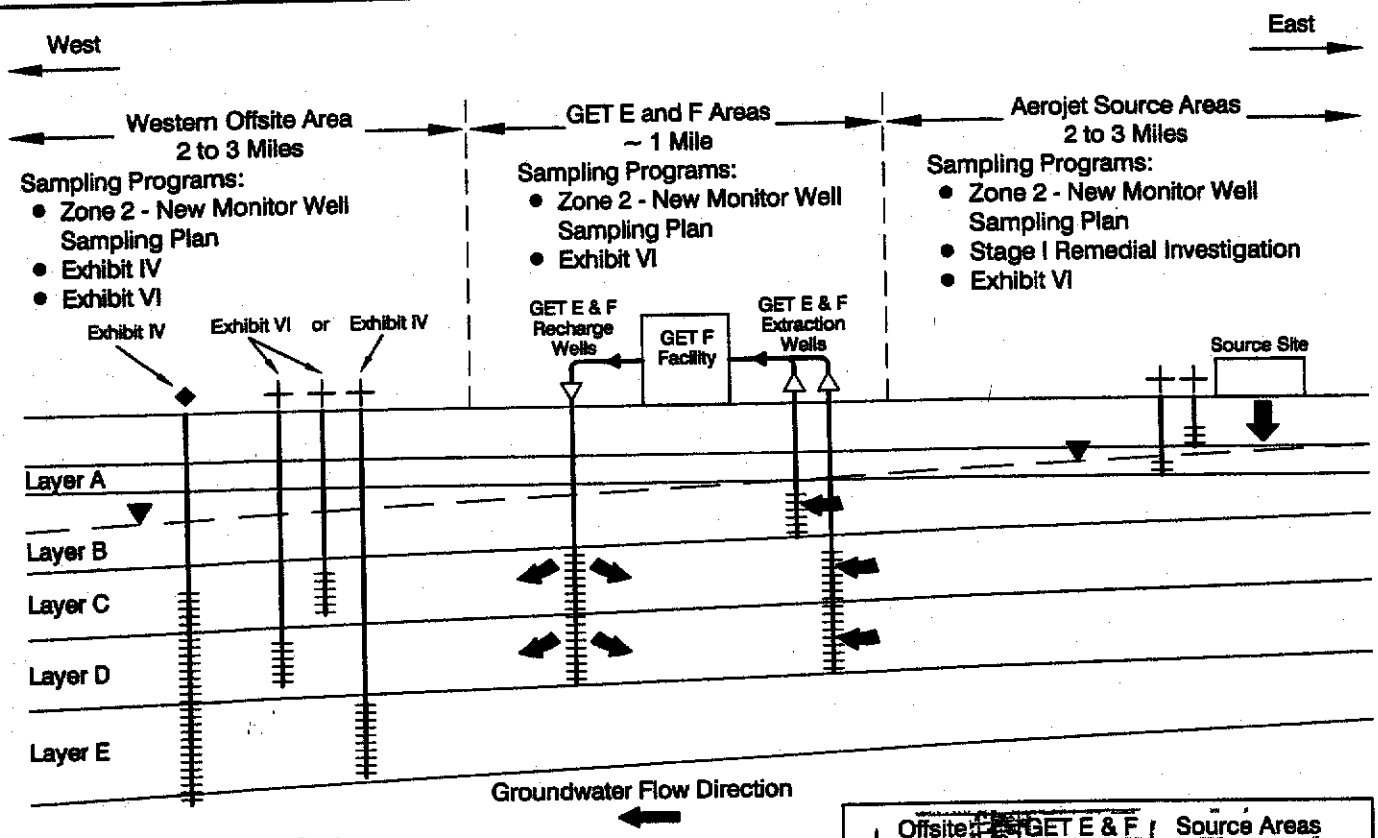
FIGURE A-2

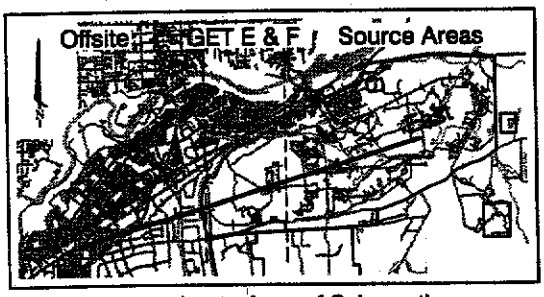
Western Groundwater Study Area
Regional and Local Surface Water Features

4/14/00 ah SR10109267

PAGES OF OVERSIZED MAPS

(SEE BINDER)





Approximate Area of Schematic
(Scale: 1" = 20,000')

Zone 2 - New Monitor Well Sampling Plan	
Frequency	**Analytes**
First Quarter	VOCs, Perchlorate, SVOCs, Metals, Chromium VI, TPH, Anions, NDMA, Field Parameters
Second Quarter Third Quarter Fourth Quarter	• VOCs and Perchlorate • Miscellaneous Compounds Detected in Initial Sampling

Exhibit VI Monitoring Plan (GET Effectiveness)	
Frequency	**Analytes**
• Quarterly • Semi-annually • Annually	Dependent on Well History, Typically: • VOCs • Perchlorate

Exhibit IV Monitoring Plan (Public Water Supply Wells)	
Frequency	**Analytes**
• Monthly • Quarterly • Semi-annually • Annually	• Initial Comprehensive Sampling • VOCs, Perchlorate, NDMA

Stage 1 RI Monitoring Plan (1991 - 1993)	
Vadose Zone	**Shallow Groundwater**
VOCs - Soil Gas Non-VOCs - Soil Samples Source Site Specific: • Perchlorate • TPH • Metals • SVOCs • OBPA • Prowl • Miscellaneous	4 Quarters Zone 2 Comprehensive Analysis • VOCs • SVOCs • Perchlorate • TPH • Metals • Anions • Misc. Compounds Detected in Vadose Zone

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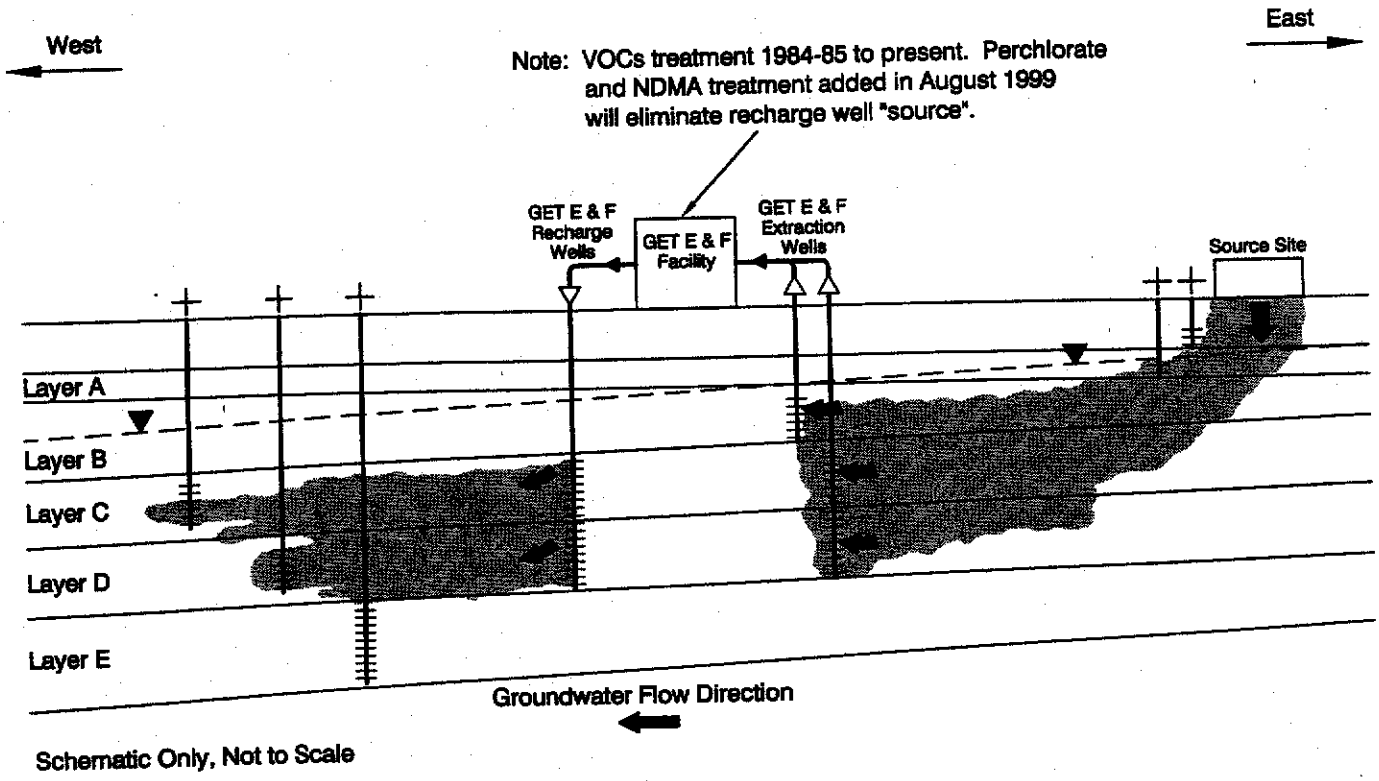
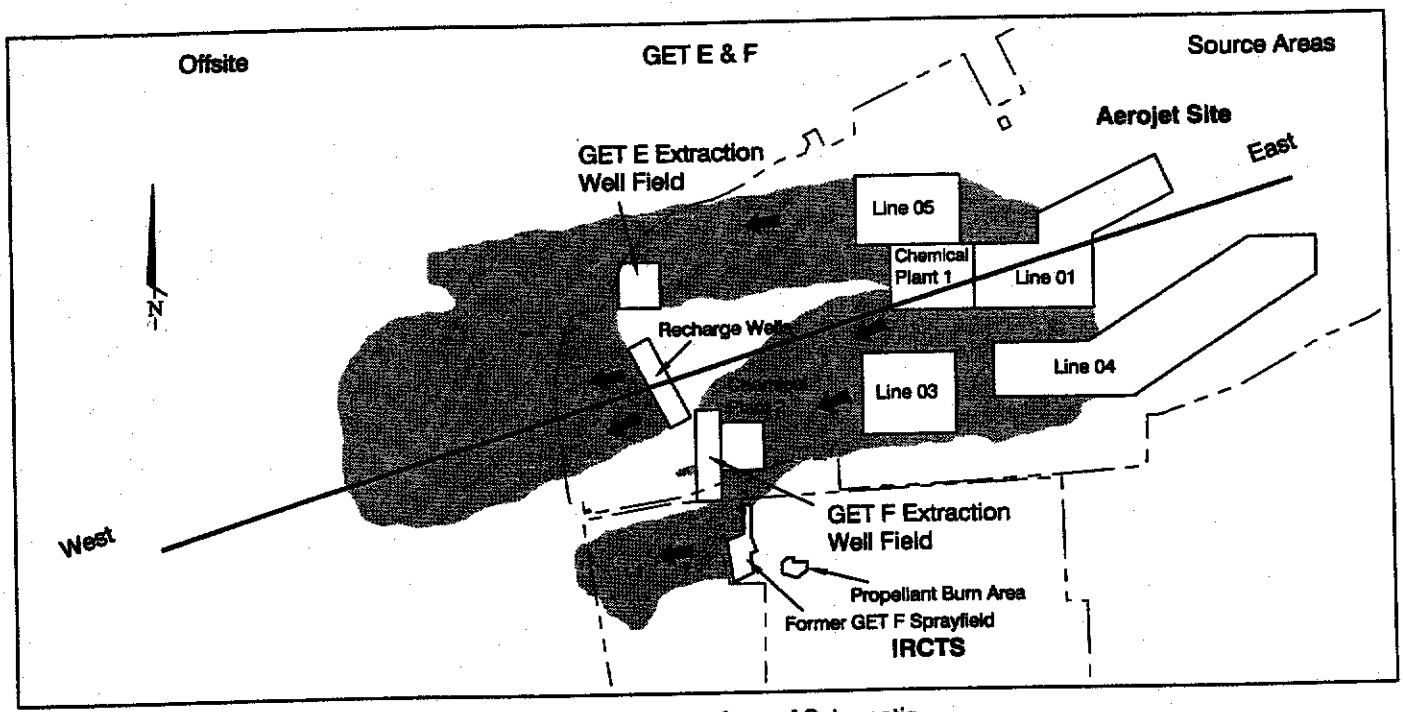
FIGURE A-16

Western Groundwater Study Area
Composite Schematic of
Aerojet Groundwater Monitoring

3/8/00 ah SR10109433





Approximate Area of Schematic
(Scale: 1" = 6,000')

EXPLANATION

Dissolved phase contaminants. Shown for illustration purposes only, does not depict contaminant type, concentration, depth, or exact location.

Conceptual Water Table

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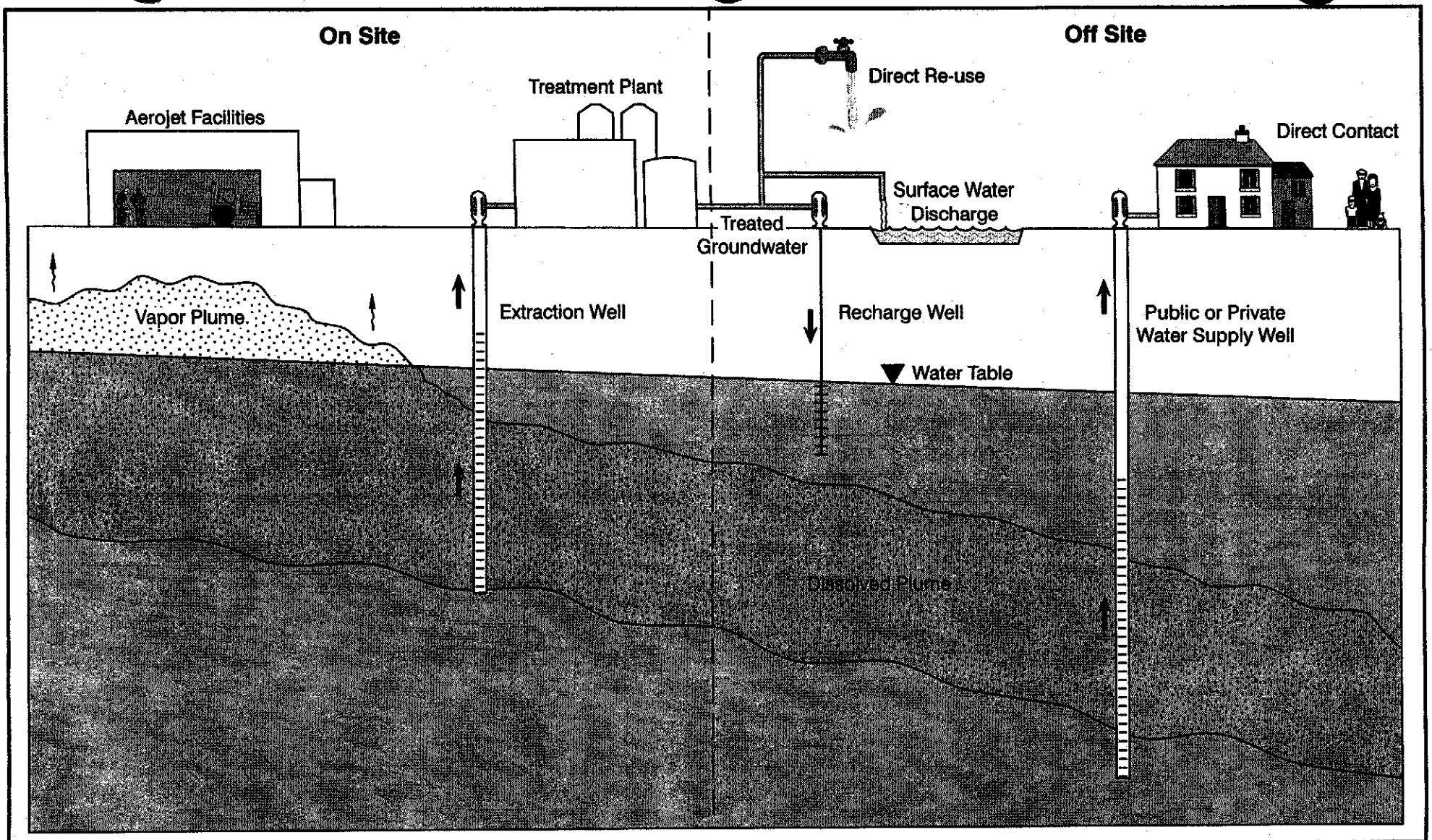
FIGURE A-17

Western Groundwater Study Area Conceptual Migration of CoPCs in Groundwater

4/14/00 ah SR10109445

PAGES OF OVERSIZED MAPS

(SEE BINDER)



Not to Scale

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FIGURE A-38
Western Groundwater Study Area
Current and Future Potentially Complete Exposure Pathways

4/15/00 ah SR10109482

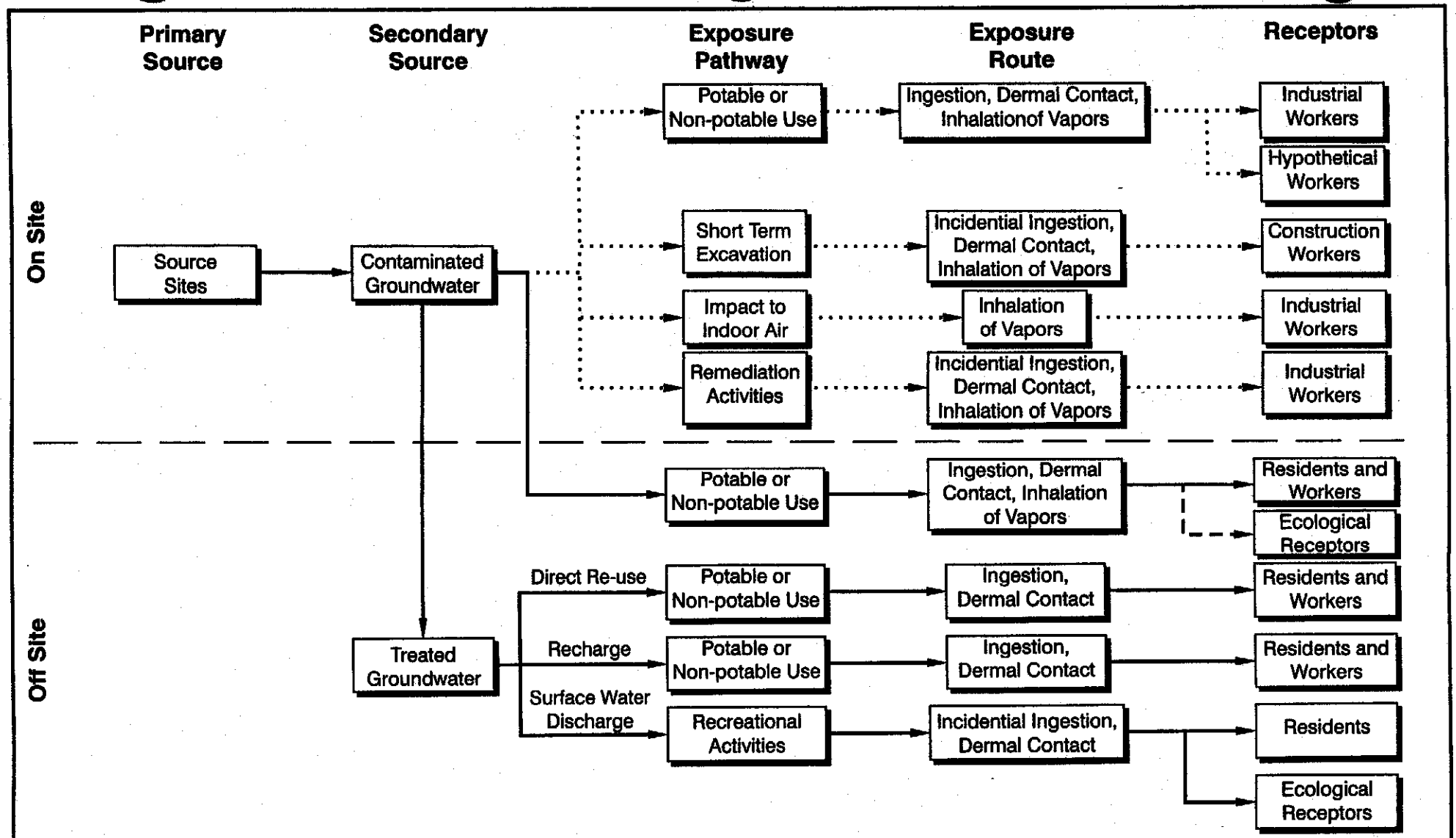

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FIGURE A-39
Western Groundwater Study Area
Potential Exposure Pathways

4/15/00 ah SR10109489

Western Groundwater Operable Unit
Baseline Risk Assessment

April 14, 2000

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Western Groundwater Operable Unit
Baseline Risk Assessment

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Western Groundwater Operable Unit i

Executive Summary

This executive summary presents the purpose of the Human Health Risk Assessment (HHRA) performed for the Western Groundwater Operable Unit Study Area and provides a summary of the HHRA results.

ES-1 Purpose

The purpose of this baseline risk assessment (BRA) is to evaluate potential site-specific human health risks associated with hypothetical exposure to chemicals detected in groundwater in the Western Groundwater Study Area. The risk assessment was conducted assuming that future residents could contact this water through its use as a private domestic water supply from an individual well. Current hypothetical risks were calculated assuming residential exposure to water from public water purveyor supply wells. The concentrations used in the risk assessment are those that represent the current state of the plumes as well as maximum detected concentrations over the past 2 years of sampling, without regard to future mitigation activities.

This BRA was completed according to the DTSC *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities Guidance Manual* (DTSC 1992) and U.S. Environmental Protection Agency's (EPA) *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Part A* (EPA 1989). Exposure assumptions for estimates of chemical intake were based on information presented in these documents as well as: *DTSC Preliminary Endangerment Assessment* (DTSC 1994); *Exposure Factors Handbook* (EPA 1997a); *EPA Region IX Preliminary Remediation Goals (PRGs)* (EPA 1999); and *Risk Assessment Guidance for Superfund, Volume I, Part B* (EPA 1991). Information on chemical toxicity was obtained from *Integrated Risk Information System* (IRIS) (EPA 2000), EPA Region 9 PRGs (EPA 1999) and the *Toxicity Criteria Database* from the Office of Environmental Health and Hazard Assessment (OEHHA), California EPA (OEHHA 2000).

The Western Groundwater Study area is comprised of 6 hydrostratigraphic layers (Layers A through F) that are a minimum depth below ground surface of approximately 60 feet (Layer A) to over 400 feet (Layer F). Layer F has not been impacted by site release and is not included in the

BRA or remedial investigation. Layers A through E are discussed separately, and risks in each layer are described separately for off-site and on-site areas.

ES-2 Data, Exposure Assessment, and Toxicity Assessment

The chemicals of potential concern (CoPCs) for the BRA included all chemicals detected in the last 2 years of groundwater monitoring in the Western Groundwater Study Area, with the exception of metals. The RI has concluded that metals in the study area groundwater are naturally occurring and are not the result of site-related activities. The maximum detected concentration of each COPC from the past 2 years of groundwater monitoring was used to assess risks to on- and off-site future receptors. For current off-site receptors, the COPC list from the water supply well with the highest number of CoPCs was used; for those chemicals, the exposure point concentration was conservatively assumed to be equivalent to the maximum contaminant level (MCL), even though actual detected concentrations were far below MCL concentrations. Additionally, plume maps have been drawn for three CoPCs: n-nitrosodimethylamine (NDMA), trichloroethene (TCE), and perchlorate. For these three chemicals, risks and hazard indices keyed to the plume isopleth concentrations were also provided.

The exposure pathways included in the risk assessment were ingestion of groundwater; dermal contact with groundwater; and inhalation of vapors from groundwater use. In addition, an analysis of inhalation of vapors from groundwater through the subsurface was included for future off-site receptors. This pathway was not evaluated for on-site receptors because soil gas sampling has shown it to be nonexistent. All exposure parameters used in the intake equations were for residential receptors. Exposure parameters were consistent with those used in the EPA Region 9 PRGS, with the addition of dermal exposure and the use of both adult and child exposure parameters for all pathways and all chemicals.

Toxicity values used were consistent with EPA Region 9 PRGs, with one modification. EPA Region 9 PRGs and other databases do not list a carcinogenic toxicity value for 1,1-dichloroethane, but California EPA has developed a carcinogenic slope factor for this possible human carcinogen. To be conservative, 1,1-dichloroethane was evaluated as both a noncarcinogen (using EPA toxicity values) and a carcinogen (using California EPA toxicity values).

ES-3 Results

Layer A

On-site Layer A risks total 9.4E-3 and are attributable mainly to 1,2-dichloroethane (1,2-DCA) through ingestion and inhalation pathways; chloroform through the inhalation of vapors pathway; and NDMA through the ingestion pathway. Other chemicals posing individual risks greater than 1E-6 were 1,1,2-trichloroethane and TCE. The total hazard index was 610, again due mainly to 1,2-DCA (ingestion and inhalation pathways) and chloroform (from inhalation). Perchlorate posed a hazard index of 5.3, while nitrate and nitrite posed hazard indices of 4.8 and 7.7, respectively. The hazard indices for these chemicals were due to the ingestion of groundwater exposure pathway.

Risks associated with the on-site Layer A plume of TCE ranged from 3.1E-6 to 3.1 E-5 (concentrations of 5 ug/L to 50 ug/L). Hazard indices associated with the isopleths were 0.18 and 1.8 for the 5 ug/L and 50 ug/L plumes, respectively. Risks are associated mainly with the ingestion and inhalation exposure pathways. The Layer A perchlorate plume was associated with hazard indices of 0.22 at 4 ug/L to 22 at 400 ug/L. Again, the results are due to the groundwater ingestion pathway. Risks from NDMA associated with isopleth concentrations of 0.01 and 0.1 ug/L were 7.7E-6 and 7.7E-5, respectively.

Off-site exposure to Layer A was not assessed because off-site Layer A is not hydrologically connected to the on-site areas.

In summary, for Layer A, results show that areas of the plume that exceeded generally acceptable levels of risk and hazard are limited to perchlorate at concentrations of 40 ug/L and higher. TCE and NDMA plumes in Layer A were within the acceptable risk range of 1E-6 to 1E-4, even when summed across the highest plume concentrations of each chemical. The 50 ug/L plume of TCE slightly exceeds the acceptable hazard index of 1.0. The maximum concentration of each COPC causes exceedance of both the acceptable risk range and target hazard index. The risks are generally due to NDMA, 1,2-DCA, chloroform, 1,1,2-trichloroethane and TCE and hazard indices are related mainly to 1,2-DCA, chloroform, perchlorate, nitrate, and nitrite.

Layer B

On-site Layer B risks total 9.4E-3 and total hazard index is 1800. The risks are attributable mainly to the groundwater ingestion and inhalation pathways and are associated with TCE, NDMA, 1,1-DCE, carbon tetrachloride, chloroform, PCE, and 1,1,2-trichloroethane. Chemical-specific hazard indices above 1.0 are from chloroform (716), TCE (332) and perchlorate (775). These risks and hazard indices are based on the maximum detected concentration of each chemical and require direct use of the groundwater.

Risks associated with the on-site Layer B plume of TCE ranged from 3.1E-6 to 3.1 E-3 (concentrations of 5 ug/L to 5,000 ug/L). Hazard indices associated with the isopleths were 0.18 and 180 for the 5 and 5,000 ug/L plumes, respectively. Risks are associated mainly with the ingestion and inhalation exposure pathways. All isopleths are within the Aerojet site boundary. The Layer B perchlorate plumes were associated with hazard indices of 0.22 at 4 ug/L to 222 at 4,000 ug/L. Again, the results are due to the groundwater ingestion pathway. Risks from NDMA associated with the 5 small isopleths with concentrations of 0.01 and 0.1 ug/L were 7.7E-6 and 7.7E-5, respectively.

Risks associated with off-site Layer B are not assessed because off-site and on-site Layer B are not hydrologically connected.

In conclusion, for Layer B, results show that areas of the plume that exceeded generally acceptable levels of hazard are limited to perchlorate at concentrations of 40 ug/L and higher, and TCE at concentration of 50 ug/L and above. Acceptable risk levels are exceeded at the TCE plume isopleths of 500 ug/L and higher. NDMA plumes in Layer B were within the acceptable risk range of 1E-6 to 1E-4, except when summed with the highest plume concentrations of TCE chemical. The maximum concentration of each COPC cause exceedance of both the acceptable risk range and target hazard index, although the risks are generally due to NDMA and TCE (and infrequently detected carbon tetrachloride, chloroform, 1,1,2-trichloroethane and 1,1-DCE) and hazard indices are related mainly to perchlorate, TCE, and chloroform.

Layer C

Risks from on-site Layer C maximum concentrations totaled 1.1E-2, due mostly to 1,1-DCE, 1,2-DCA, chloroform, TCE, and NDMA. Total hazard index was 2200, due mainly to perchlorate (581), TCE (192), chloroform (1402), and 1,2-DCA (20). Hazard indices and risks were driven mainly by ingestion and inhalation pathways, which require direct contact with groundwater.

The on-site TCE plume for Layer C had concentrations ranging from 1 ug/L to 50 ug/L, corresponding to risks of 6.2E-7 to 3.1E-5 and hazard indices of 0.04 to 1.8. The higher plume concentrations are on the east side of Aerojet property, with lower plume concentrations as the isopleths approach the western site boundary. The perchlorate plume for on-site Layer C ranged in concentration form 4 ug/L to 4,000 ug/L, corresponding to hazard indices of 0.22 to 222. The hazard indices for perchlorate are due to the ingestion exposure pathway. NDMA plumes for Layer C are generally to the western side of the Aerojet site, and travel off-site to the northwest of GET E. The on-site plume concentrations range from 0.01 ug/L to 0.1 ug/L, corresponding to risks of 7.7E-6 to 7.7E-5. The risks are due to groundwater ingestion.

The off-site maximum concentrations of all CoPCs in Layer C have a total risk of 4.1E-4 and total hazard index of 670. The chemicals contributing significantly to the total risk are 1,1-DCE, chloroform, TCE, and NDMA. NDMA itself exceeds the upper end of the target risk range, with a chemical-specific risk of 1.9E-4. Hazard indices are due mainly to chloroform (57) and perchlorate (611). Off-site plume concentrations for TCE range from 1 to 5 ug/L, with one small area having a concentration of 50 ug/L. The risk at 1 ug/L is 6.2E-7, at 5 ug/L is 3.1E-6, and at 50 ug/L is 3.1E-5. These risks are within the acceptable risk range of 1E-6 to 1E-4. The hazard indices associated with these concentrations are 0.04 (1 ug/L), 0.18 (5 ug/L) and 1.8 (50 ug/L). All are below or just slightly above the target hazard index of 1.0. The off-site perchlorate plume ranges in concentration from 4 ug/L to 4,000 ug/L, corresponding to hazard indices of 0.22 to 222, respectively. The NDMA plume in off-site Layer C is generally to the west of the Aerojet boundary, and ranges in concentration from 0.01 ug/L to 0.1 ug/L, corresponding to risks of 7.7E-6 and 7.7E-5, respectively.

For Layer C, areas of the plume that exceeded generally acceptable levels of hazard are limited to perchlorate at concentrations of 40 ug/L and higher and TCE at a concentration of 50 ug/L. TCE and NDMA plumes in Layer C were within the acceptable risk range of 1E-6 to 1E-4, except when summed across the highest plume concentrations of each chemical. The maximum

concentrations of each COPC cause exceedance of both the acceptable risk range and target hazard index, although the risks are generally due to NDMA and TCE (and infrequently detected chloroform and 1,1-DCE) and hazard indices are related mainly to perchlorate and TCE (and infrequently detected chloroform).

Layer D

Risks from on-site Layer D maximum concentrations totaled 5.1E-3, due mostly to 1,1-DCE, 1,2-DCA, chloroform, TCE, and NDMA. Total hazard index was 1600, due mainly to perchlorate (610), TCE (53), and chloroform (942). Hazard indices and risks were driven mainly by ingestion and inhalation pathways, which require direct contact with groundwater.

The on-site TCE plume for Layer D had concentrations ranging from 5 ug/L to 50 ug/L, corresponding to risks of 3.1E-6 to 3.1E-5 and hazard indices of 0.18 to 1.8. The perchlorate plume for on-site Layer D ranged in concentration form 4 ug/L to 4,000 ug/L, corresponding to hazard indices of 0.22 to 222. The hazard indices for perchlorate are due to the ingestion exposure pathway. NDMA plumes for Layer D on-site had concentrations range from 0.01 ug/L to 1.0 ug/L, corresponding to risks of 7.7E-6 to 7.7E-4. The risks are due to groundwater ingestion.

The off-site maximum concentrations of all CoPCs in Layer D have a total risk of 4.3E-4 and total hazard index of 44. The chemicals contributing significantly to the total risk are vinyl chloride, TCE, and NDMA. NDMA itself exceeds the upper end of the target risk range, with a chemical-specific risk of 3.3E-4. Hazard indices are due mainly to perchlorate (43), as all other CoPCs have hazard indices below 1.0. Off-site plume concentrations for TCE range from 5 to 50 ug/L corresponding to risks of 3.1E-6 and 3.1E-5, respectively. These risks are within the acceptable risk range of 1E-6 to 1E-4. The hazard indices associated with these concentrations are 0.18 (5 ug/L) and 1.8 (50 ug/L), which are below to slightly above the target hazard index of 1.0. The off-site perchlorate plume ranges in concentration from 4 ug/L to 4,000 ug/L, corresponding to hazard indices of 0.22 to 222, respectively. The NDMA plume in off-site Layer D ranges in concentration from 0.01 ug/L to 0.1 ug/L, corresponding to risks of 7.7E-6 and 7.7E-5, respectively. Higher concentrations of NDMA are found in the on-site plume.

For Layer D, the plume concentrations that exceed the target hazard index are limited to perchlorate at concentrations of 40 ug/L and above, and TCE concentrations of 50 ug/L and above. The acceptable risk range is exceeded in the on-site NDMA plume area at concentrations of 1.0 ug/L. The maximum concentrations (both on- and off-site) of each COPC cause exceedance of both the acceptable risk range and target hazard index, although the risks are generally due to NDMA and TCE (and infrequently detected vinyl chloride) and hazard indices are related mainly to perchlorate.

Layer E

Risks from on-site Layer E maximum concentrations totaled 1.3E-3, due to chloroform, TCE, and NDMA. Both TCE and NDMA individual risks exceeded 1E-4 (TCE at 2.9E-4 and NDMA at 1.0E-3). Total hazard index was 46, due to perchlorate (43) and TCE (3.0). Hazard indices and risks were driven mainly by ingestion and inhalation pathways, which require direct contact with groundwater.

The on-site TCE plume for Layer E had concentrations ranging from 5 ug/L to 50 ug/L, corresponding to risks of 3.1E-6 to 3.1E-5 and hazard indices of 0.18 to 1.8. The perchlorate plume for on-site Layer E ranged in concentration form 4 ug/L to 400 ug/L, corresponding to hazard indices of 0.22 to 22.2. The hazard indices for perchlorate are due to the ingestion exposure pathway. NDMA plumes for Layer E on-site had concentrations range from 0.01 ug/L to 0.1 ug/L, corresponding to risks of 7.7E-6 to 7.7E-5. The risks are due to groundwater ingestion.

The off-site maximum concentrations of all CoPCs in Layer E have a total risk of 2.5E-4 and total hazard index of 36. The chemicals contributing significantly to the total risk are 1,1-DCE, TCE, and NDMA. Hazard indices are due mainly to perchlorate (28) and TCE (7.7), as all other CoPCs have hazard indices far below 1.0. Off-site plume concentrations for TCE range from 5 to 50 ug/L corresponding to risks of 3.1E-6 and 3.1E-5, respectively. These risks are within the acceptable risk range of 1E-6 to 1E-4. The hazard indices associated with these concentrations are 0.18 (5 ug/L) and 1.8 (50 ug/L), which are below to slightly above the target hazard index of 1.0. The off-site perchlorate plumes range in concentration from 4 ug/L to 400 ug/L, corresponding to hazard indices of 0.22 to 22.2, respectively. The NDMA plume in off-site

Layer E ranges in concentration from 0.01 ug/L to 0.1 ug/L, corresponding to risks of 7.7E-6 and 7.7E-5, respectively.

For Layer E, the plume concentrations that exceed the target hazard index are limited to perchlorate at concentrations of 40 ug/L and above and TCE at concentrations of 50 ug/L. The acceptable risk range is not exceeded by the plume isopleths. The maximum concentrations (both on- and off-site) of each COPC cause exceedance of both the acceptable risk range and target hazard index, although the risks are generally due to NDMA and TCE (and infrequently detected 1,1-DCE) and hazard indices are related mainly to perchlorate and TCE.

ES-4 Uncertainty

Uncertainty and variability are inherent to risk assessments. According to EPA guidance (1989), "it is important to fully specify assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective." DTSC guidance also recommends a qualitative discussion of uncertainty (1992 and 1994). Uncertainty exists in the exposure assessment, toxicity values, and the hence, the risk characterization. In this human health risk assessment, the exposure assessment and the toxicity assessment are the largest sources of uncertainty and variability.

The maximum concentration was used for simplicity and to address concerns regarding the "maximally exposed" individual. It is important to note, though, that the maximum concentrations of each COPC did not always occur at the same well. Further, actual groundwater use would result in mixing of highly impacted groundwater with less impacted groundwater, lowering the maximum exposure point (particularly over a 30-year period). The use of groundwater would have a larger sphere of influence, and water from nearby areas with potentially lower concentrations of chemicals would be mixed with the concentrations detected. All exposure point concentrations are probably overestimated because this was not considered in determining exposure point concentrations.

Use of default exposure duration values in the risk assessment also overestimate risk because they do not to account for site-specific variability. Default parameters often used in intake equations are based on nationally averaged data and may not reflect the more active lifestyle typical of residents in states with temperate climates (EPA 1997a). Although they were not used in this risk

assessment, EPA has developed revised exposure parameters based on California-specific data and regional variability that appear to be more realistic (that is, lower), while still being conservative (EPA 1997a).

For the toxicity assessment, uncertainties are inherent to the carcinogenic and noncarcinogenic toxicity values, which are based on laboratory animal studies. Specifically, uncertainties arise from the extrapolation of results from animals dosed at high concentrations to human exposures at low concentrations. Scientists also debate the validity of the critical underlying assumptions in the dose-response model for carcinogens (linearized multistage model). This model is based on the assumption that any dose of a carcinogen is associated with a risk of cancer and that a carcinogenic response is linear at low doses (EPA 1996). The results of this modeling may result in varying toxicity values, depending on the studies used as inputs to the model and interpretations of results.

The provisional cancer slope factors for PCE and TCE are associated with the uncertainties described above, and the EPA cancer classification of these chemicals is also currently undecided. Only provisional slope factors are available from EPA at this time (EPA 1998) pending a decision as to whether PCE and TCE are possible carcinogens (classification "C") or probable carcinogens based on results of animal studies (classification "B2"). Both chemicals were considered carcinogenic in this assessment, but it is important to note that the current classification and toxicity values are provisional.

The reference dose for perchlorate is perhaps the most uncertain toxicity value used in this assessment. An external review draft value was available from EPA, but is still under review and subject to change (EPA 1998). In addition, reviews of toxicity data for perchlorate were decided by independent reviewers to not be definitive enough to calculate a toxicity value (TERA 1997). The current range of appropriate oral reference doses (RfDs) is 0.0001 to 0.0005 mg/kg-day, according to EPA's Office of Research and Development (ORD, EPA 1999b). However, EPA's National Center for Environmental Assessment (NCEA) has posted a less conservative provisional oral RfD (EPA 1998, available at www.epa.gov/ncea). The critical effect of perchlorate is assumed to be related to thyroid function, but the effects to other organs, developmental toxicity, reproductive toxicity, and carcinogenicity are as yet unknown. Multiple studies are underway, and some have been completed, to address these issues and will generate data necessary to produce a final toxicity value.

Further, this BRA used toxicity values as presented in the EPA Region PRG document of October 1999. EPA Region 9 and California EPA have different toxicity values for many carcinogens. The most important difference in this assessment is the CSF value for NDMA. California EPA lists a CSF of 16 $(mg/kg\text{-}day)^{-1}$ and has based some state health standards on this value. EPA Region 9 uses a CSF of 51 $(mg/kg\text{-}day)^{-1}$ which is nearly three times higher (more conservative). Use of the California EPA CSF would reduce the risks associated with NDMA by approximately two-thirds. As an example, the risk associated with the NDMA plume of 0.1 ug/L is 7.7E-5 using the EPA Region 9 toxicity value; the risk would be 2.4E-5 using the California EPA toxicity value. If less conservative exposure parameters were also used, the risk would be below 1E-5.

Western Groundwater Operable Unit
Baseline Risk Assessment

B.1 INTRODUCTION

HSI GeoTrans (HSIG) conducted this Baseline Risk Assessment (BRA) of the Western Groundwater Study Area (Study Area) of the Aerojet Sacramento Site (Site) on behalf of Aerojet-General Corporation (AGC). The BRA was based on groundwater investigations and analytical groundwater sampling results collected over a period of about 15 years, up to the current time. During this sampling, chemical propellants and solvents were detected in groundwater samples collected from on- and off-site wells. These chemicals are the focus of this BRA.

This BRA addresses human health risks from hypothetical exposure to groundwater by future residential receptors. Ecological risks are not evaluated, as there are no completed exposure pathways to groundwater for ecological receptors. Groundwater does not surface within the Study Area nor does it discharge to the American River.

B.1.1 Purpose and Scope

The purpose of this BRA is to evaluate potential site-specific human health risks associated with hypothetical exposure to chemicals detected in groundwater in the Western Plume area, as depicted in the plume maps shown on Figures B- 5 through B- 19. The risk assessment was conducted assuming that future residents could contact this water through its use as a private domestic water supply from an individual well. Current hypothetical risks were calculated assuming residential exposure to water from public water purveyor supply wells. The concentrations used in the risk assessment are those that represent the current state of the plumes as well as maximum detected concentrations over the past 2 years of sampling, without regard to future mitigation activities.

This assessment was completed according to the DTSC *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities Guidance Manual* (DTSC 1992) and U.S. Environmental Protection Agency's (EPA) *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Part A* (EPA 1989). Exposure assumptions for estimates of chemical intake were based on information

presented in those documents as well as: *DTSC Preliminary Endangerment Assessment* (DTSC 1994); *Exposure Factors Handbook* (EPA 1997a); *EPA Region IX Preliminary Remediation Goals (PRGs)* (EPA 1999); and *Risk Assessment Guidance for Superfund, Volume I, Part B* (EPA 1991). Information on chemical toxicity was obtained from *Integrated Risk Information System* (IRIS) (EPA 2000), EPA Region 9 PRGS (EPA 1999) and the *Toxicity Criteria Database* from the Office of Environmental Health and Hazard Assessment (OEHHA), California EPA (OEHHA 2000). The exposure pathways are identified in "Table 1", which also appears as Table B.3-1.

The baseline human health risk assessment follows the EPA risk assessment paradigm (EPA 1989) and consists of the following components:

1. data evaluation and identification of chemicals;
2. exposure assessment;
3. toxicity assessment; and
4. risk characterization.

B.1.2 Study Area Description

The Study Area encompasses approximately the western one-third of the Aerojet Site, the northwestern corner of the Inactive Rancho Cordova Test Site (IRCTS), the Aerojet-owned land west of the IRCTS, and approximately 10 square miles of commercially and residentially developed areas in the community of Rancho Cordova (Figure B-1). The entire Study Area is comprised of approximately 15 square miles. The western boundary of the Study Area is located at Mather Field Road, however, this boundary is artificial and is intended to be flexible in the event CoPCs are detected west of this location.

Descriptions of the Study Area geology and hydrogeology are contained within the RI report (Appendix A). In addition, information on public and private water supply wells is provided in Section 3.7 of the RI report (Appendix A) and Section B.3.1 of this assessment.

B.2 DATA COLLECTION AND EVALUATION

This section presents a brief summary of the data and plume maps used as the basis for exposure point concentrations used in this risk assessment. A detailed description of groundwater data and nature and extent of CoPCs in the Study Area are contained in Section 3.0 of the RI report (Appendix A). Data used in this report to characterize the groundwater were collected from monitoring wells and other wells, both on-site and off-site, for the past 15 years as described in the RI report. Data validation is an ongoing process at a site with as extensive an amount of data as has been collected at Aerojet. Data validation is conducted on 10% of the samples in accordance with the EPA-approved Quality Assurance Project Plan prepared for the Aerojet Site (Aerojet, 1998). Most of the data presented in this RI/FS are relatively recent and the formal data validation process has not been completed. The most recent data validation report was prepared during the Phase I Remedial Investigation in 1993 (ICF Kaiser, 1993). Data validation has been ongoing since that time and data qualifiers generated as a result of the validation process are entered into the Aerojet database.

In addition to the formal data validation process, data quality is informally assessed by comparing the most recent data with historical results and trends from individual wells, and by comparing the data to results from nearby wells.

Briefly, six hydrostratigraphic layers (Layers A through F) have been identified at the Study Area based on lithologic descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thicknesses. Layer F is not addressed in this RI as the deepest observed impacts on- or off-site are in the upper portion of Layer E. Layers A through E are evaluated for on-site areas, while Layers C through E were evaluated for off-site areas because chemical and hydraulic data indicate that CoPCs are not flowing off of the Aerojet Site in Layers A and B. A small area of groundwater containing CoPCs is present northeast of the intersection of Highway 50 and Sunrise Boulevard. Four monitor wells constructed in this area are assigned to Layer A, but are probably completed in perched groundwater. The depth to groundwater in these wells is approximately 30 to 40 feet below ground surface (bgs). The regional water table is typically encountered at depths of 100 feet bgs in this area. These hydrostratigraphic conditions, the

unique suite of chemicals found in these wells, and the presence of several documented potential sources of industrial chemicals in this area support the conclusions that they are not related to activities on the Aerojet Site, and they are not evaluated in this BRA. However, these chemicals may have mixed with chemicals emanating from the Aerojet Site in the deeper hydrostratigraphic layers (i.e., Layers B, C, D, and E). All chemicals in the deeper layers are evaluated in this BRA regardless of their potential sources.

Remedial investigations performed for the Aerojet Site as a whole and for this particular operable unit have concluded that most inorganic chemicals are not site-related. Soil sampling and shallow groundwater sampling conducted in source areas on the interior of the Aerojet Site have shown very limited, if any, impacts due to metals contamination (ICF Kaiser, 1993). Metals were not included in this BRA due to the general absence of elevated metals concentrations in source area soils, the absence of industrial metals above drinking water standards, and unfavorable solute transport conditions for most metals in the Study Area (neutral pH, travel distances of several miles). Inorganic chemicals that were retained in this BRA include perchlorate, nitrate, and nitrite.

The RI report in Sections 3.2.5, 3.3.5, 3.4.5, 3.5.5, and 3.6.5 describe the distribution of metals in Layers A, B, C, D, and E, respectively. All organic chemicals were retained as CoPCs. The maximum concentration of each chemical retained as a COPC was used as the exposure point concentration. These chemicals were evaluated for each hydrostratigraphic layer using the maximum detected concentrations from the most recent 2 years of monitoring. The following chemicals were evaluated in this manner: 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichoroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), carbon tetrachloride, chloroform, freon-113, NDMA, perchlorate, nitrate, nitrite, tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride. Data are summarized in Tables B.2-1 through B.2-10, organized by on- and off-site hydrostratigraphic layer. Although data are presented for off-site Layers A and B, these layers are not associated with Aerojet activities and are not further evaluated, as described in the RI text (see Appendix A, Sections 3.2 and 3.3).

The plume maps were also used as the representative exposure concentrations for the hypothetical residential receptor. In general, plume maps of select CoPCs were developed using the most recent data available. In some areas, data were not available for the current sampling period (January 1996 to December 1998) and historical data were utilized. Risks were calculated based

on the concentrations of each chemical as depicted by the plume isopleths. Chemicals for which a plume map was created were those most frequently detected, and that were not laboratory contaminants. Therefore, plume maps were created for TCE, NDMA, and perchlorate. The plume maps were used as the exposure point concentrations for TCE, NDMA, and perchlorate in addition to the maximum detected concentration of each chemical detected in each hydrostratigraphic layer.

B.3 EXPOSURE ASSESSMENT

An exposure assessment includes an evaluation of potential human receptors that could contact site-related chemicals, as well as routes, magnitude, frequency, and duration of exposure. An evaluation of all possible human exposures is necessary to identify receptors that could contact impacted groundwater in the future. The principal objective of this evaluation is to identify exposures that represent reasonable maximum (RME) for groundwater contact. The concept of reasonable scenarios underlies the RME concept developed by EPA. As defined by EPA (1989), the RME is the maximum exposure that is reasonably expected to occur at a site. It should be emphasized, however, that the RME exposure is for the same receptor and that, before risks are calculated, it must be determined whether "it is likely that the same individual would consistently face the 'reasonable maximum exposure (RME)'"(EPA 1989, emphasis not added).

It is also important that intake variable values for each RME exposure pathway should be "selected so that the combination of all intake variables results in an estimate of the reasonable maximum exposure for that pathway" (EPA 1989). In other words, the most conservative intake variables for each parameter for a given pathway are not used exclusively. A combination of average and upper-bound values should be combined to estimate exposures that are meaningful and represent the actual reasonable maximum exposure for the site.

The exposure assessment for the western groundwater plumes included the following steps:

- Characterization of the exposure setting(s) and identification of potential future receptors
- Identification of exposure pathways and exposure routes
- Estimation of exposure point concentrations, and
- Quantification of chemical intake for pathway specific exposures for each potential receptor

Following EPA guidance (1989), all complete exposure pathways were selected for evaluation unless:

- Exposure from the pathway is likely to be much less than that from another pathway involving the same medium of the same exposure point

- The potential magnitude of exposure from a pathway is likely to be very low
- The probability of the exposure occurring is very low and the risks associated with the pathway are low.

B.3.1 Exposure Pathways and Exposure Routes

According to EPA guidance (1989a), an exposure pathway consists of four elements:

- A source and mechanism of chemical release
- A retention or transport medium (or media in cases involving transfer of chemicals)
- A point of potential human contact with the contaminated medium (referred to as the exposure point)
- An exposure route (such as ingestion) at the contact point

Eliminating any of these elements (except in a case where the source itself is the point of exposure) results in an incomplete exposure pathway. Therefore, if no receptors exist that would contact the source or transport medium, the pathway is incomplete and is not evaluated.

For the purposes of this evaluation, the exposure and risk discussions are presented for on-site and off-site exposure. The conceptual site model is presented in graph form in Figure B-2, and pictorially in Figure B-3. The selection of exposure pathways is shown in Table B.3-1. As shown in Figure B.2, current on-site exposures are incomplete because groundwater is not used. Water is supplied to the Aerojet facilities by the City of Folsom. Further, there are no current on-site residents. Current and future on-site exposure via inhalation of vapors in indoor air from volatilization of chemicals through the subsurface is not quantitatively evaluated in the BRA. Soil gas samples collected from hundreds of locations across the Aerojet site have shown that vapor diffusion from groundwater into the vadose zone is negligible in areas where there are no vadose zone source sites; and that there are no impacts to indoor air. Future on-site exposures are evaluated assuming that the land has been residentially developed and an individual installs a private well on their property for domestic use. The residential scenario represents the most conservative exposure setting because it involves ingestion, dermal contact, and inhalation of volatile chemicals from the impacted groundwater over a lifetime. Since the residential scenario provides a more conservative exposure estimate, the future worker scenario was not quantitatively evaluated.

The off-site area above the plume has been residentially and commercially developed. The off-site groundwater has been used as a water supply source for residences, as supplied by water purveyors in the area. Three water purveyors supply industrial and residential water in the Study Area (Figure B-4). The Arden-Cordova Water Service (ACWS) provides water to approximately 40,000 residents and workers in Rancho Cordova. Sacramento County Sunrise District provides water to approximately 2,000 to 3,000 people working in their service area, but no residences. Citizens Utilities Company, which is located just west of the Study Area, supplies water to approximately 33,600 people.

Current potential exposure to groundwater supplied by these water purveyors is assessed by monitoring water quality pursuant to the Partial Consent Decree, Exhibit IV monitoring plan. This plan includes provisions for evaluating replacement water supply should wells become affected above State of California DHS of Federal drinking water action levels. This monitoring program has resulted in the closure of six water supply wells in the ACWS franchise area, one well located in Sacramento County's franchise area, and several private water supply wells. Alternate sources of water have been provided for the affected wells (e.g., bottled water, new wells, etc.). Four additional Sacramento County wells were closed south of the Study Area due to perchlorate emanating from a separate source located south of the Study Area that is being evaluated under a separate program.

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted Health Consultations for ACWS, Citizens, and the Sacramento County Sunrise District to evaluate perchlorate exposure and potential Health effects (ATSDR 1998a, 1998b, and 1998c). These studies concluded that it was unlikely that any non-cancer health effects had occurred in the study area.

Current potential exposure to groundwater supplied by water purveyors is assessed by monitoring water quality pursuant to the Partial Consent Decree Exhibit IV monitoring plan. The water purveyors, in conjunction with the California DHS, determine when a well should be taken out of service. Private wells do exist in the off-site areas, although most are not used as domestic water supply wells; they are used for industrial or agricultural purposes (as presented on Figure A-13 of the RI report, also included as Figure B-4).

Current exposures for off-site residents were assessed assuming exposure to the most impacted public water supply well still in use (Well 1011). That well had the most number of chemicals detected (specifically, PCE, TCE and perchlorate). As a conservative measure, each chemical detected in that well was assumed to be present at its MCL (for perchlorate, the current health-based concentration of 18 ug/L was used). Additionally, NDMA was assumed to be present at its detection limit of 0.0075 ug/L, although this chemical has not been detected in Well 1011. Again, although the off-site public supply water may be used by workers, only residential exposure was quantitatively evaluated because it involves a greater extent and duration of groundwater use.

Future use of off-site groundwater was evaluated assuming an individual installed a private well on their property for domestic use. This residential scenario represents the most conservative exposure setting because it involves ingestion, dermal contact, and inhalation of volatile chemicals from the impacted groundwater over a lifetime. Although future off-site workers may also be exposed to impacted groundwater, the residential scenario presents the most conservative risk estimate. Therefore, the worker scenario was not quantitatively assessed. Note that Figure B-2 also includes surface water discharge. Surface water discharge may result in recreational and ecological receptor exposure to treated groundwater. This pathway would only be complete if particular remediation technologies are used off-site. This is not a currently complete pathway and may not occur in the future. Therefore, it is not evaluated in this risk assessment.

The exposure pathways selected for inclusion in this risk assessment include ingestion of and dermal contact with groundwater for all chemicals. In addition, the exposure pathway of inhalation of volatile chemicals from groundwater use was included for volatile chemicals. These pathways are consistent with EPA guidance (1989), EPA Region IX PRGs (EPA 1999) and DTSC guidance (1992, 1994). Additionally, a quantitative evaluation of potential off-site risk from inhalation of vapors from groundwater volatilizing through the subsurface is described in the risk characterization (detailed results are presented in Attachment B). This pathway is negligible due to depth to groundwater and lithology of the area, which prevent or significantly diffuse volatilization. While other exposure pathways may be possible, these pathways represent the most likely to be complete and that would involve exposures for the longest duration and greatest quantity extent. In particular, use of water for irrigation and watering of livestock were not evaluated because potential exposure from these pathways would be significantly lower than direct ingestion, dermal contact, and inhalation pathways.

Because these pathways are based on future exposures, they are considered potentially complete and evaluated to provide a conservative estimate of risk. Not all of these pathways may actually be complete for all receptors in the future, and exposure may differ from the parameters used here to estimate risk. At the direction of EPA Region IX, conservative exposure parameters were used for all pathways; lower exposure estimates may be achieved using more site-specific or average exposure parameters.

B.3.2 Exposure Point Concentrations

All chemicals detected in each hydrostratigraphic layer (except metals) were retained as CoPCs. The exposure point concentrations were set equal to the maximum detected concentration from the most recent 2 years of sampling results. These chemicals and the exposure point concentrations used are presented in Tables B.2-1 through B.2-10, related to the hydrostratigraphic layer in which each was detected for on- and off-site areas.

Exposure point concentrations for NDMA, perchlorate, and TCE in the western plume area were estimated from the plume maps. The plume maps were used to generate isopleths of risks corresponding to the concentration gradients measured from monitoring wells and modeled to future receptors. For perchlorate, these concentrations ranged from 4 µg/L to 4,000 µg/L. For NDMA, the concentration range was 0.01 µg/L to 1.0 µg/L. For TCE, the plume concentrations ranged from 5 to 5000 µg/L. Plume maps were prepared for each hydrostratigraphic layer. As described above, the maximum detected concentrations of NDMA, perchlorate, and TCE detected in each hydrostratigraphic layer over the past 2 years of monitoring were also included in the estimate of the maximum risk to receptors. Use of the maximum detected concentrations to estimate risks is a conservative measure. Per EPA and DTSC guidance (EPA 1989, DTSC 1992), baseline risk assessments typically use the upper 95th percent confidence limit of the mean concentration (95UCL) as the exposure point concentration. The 95UCL is a measure of the average concentration rather than the maximum detected value.

Current hypothetical exposure to impacted groundwater was estimated using the CoPC list of the off-site well with the greatest variety of CoPCs (Well 1011). TCE, PCE, and perchlorate have been detected in this well at concentrations below MCLs. As a conservative measure, current exposure was assessed using the MCL as the exposure point concentration for these chemicals. Additionally, hypothetical current exposure to NDMA was estimated at the detection limit of 0.0075 ug/L. Although this chemicals has not been detected in Well 1011, the detection limit is

associated with a risk above 1E-6. Therefore NDMA was assumed to be present at its detection limit as a conservative measure.

B.3.3 Quantification of Chemical Intake

To estimate the intake of chemicals contained in the plumes and the risks associated with that intake, exposure equations with appropriate exposure parameters were selected for hypothetical residential receptors. Exposure, or intake, is defined as the mass of chemical taken into the body per unit body weight per unit time. Intake of a chemical from groundwater is the product of the exposure point concentration for a plume area, the frequency and duration of exposure, and contact rate, all divided by the product of body weight and averaging time. The general equation for intake is

$$\text{Intake (mg/kg-day)} = \frac{C \times CR \times EF \times ED \times CV}{BW \times AT}$$

where

C = Exposure point concentration (milligram per liter [mg/L])

CR = Contact rate (liters per day, cubic meters per hour)

EF = Exposure frequency (days per year)

ED = Exposure duration (years)

CV = Conversion factors (L/cm^3, for example)

BW = Body weight (kg)

AT = Averaging time (days)

For this baseline risk assessment, the general equation was modified specifically for the ingestion, dermal contact and inhalation of vapors from groundwater exposure pathways. The complete equations and input parameters are presented in Tables B.3-1 and B.3-2 for residential exposures.

As shown in these tables, the contact rate is more specifically defined for exposure pathway. Exposure parameters for the intake calculations were selected from the *PEA Guidance* (DTSC 1994); the *Supplemental Guidance for Human Health Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (DTSC 1992); *EPA Region 9 PRGs* (EPA 1999); the *Exposure Factors*

Handbook (EPA 1997a); *Risk Assessment Guidance for Superfund, Volume I; Part A* (EPA 1989); and *Risk Assessment Guidance for Superfund, Volume I, Part B* (EPA 1991).

For residential RME exposure, the exposure frequency was assumed to be 350 days per year and the exposure duration was set at 30 years, the default upper-bound value for the number of years people live at one residence in the entire United States (EPA 1997a, EPA 1999). For groundwater ingestion, values of 2 liters per day (L/day) for adults and 1 L/day for children were used. The surface area for dermal contact was set at 23,000 square centimeters (cm^2/event) for adults and 7,200 cm^2/event for children. Inhalation exposures assumed a 24-hour per day exposure, at inhalation rates of 20 cubic meters per day (m^3/day) for adults and 10 m^3/day for children. All exposure parameters used are referenced in Tables B.3-2 and B.3-3.

B.4 TOXICITY ASSESSMENT

The toxicity assessment focuses on the chemicals presented in groundwater plume maps or otherwise included in the HHRA: carbon tetrachloride, chloroform, 1,1-DCA, 1,2-DCA, 1,1-DCE, 1,2-DCE, freon-113, NDMA, perchlorate, PCE, 1,1,2-trichloroethane, TCE, vinyl chloride, and nitrates. Standard toxicological methodologies for assessing the toxicity of chemicals involve quantifying dose-response relationships for adverse human health effects associated with exposure to specific chemicals.

Qualitative and quantitative toxicity information and EPA- and DTSC-derived toxicity values are included in the toxicity profiles provided as an attachment to this appendix, for the chemicals in the Study Area groundwater. Sources of information included IRIS (EPA 2000), OEHHA's Toxicity Criteria Database (OEHHA 2000), EPA Region IX PRGs (1999), and the Superfund Technical Support Center (1998). Carcinogenic chemicals and associated risks are evaluated and presented separately from noncarcinogenic chemicals; however, noncarcinogenic effects of carcinogenic chemicals were also evaluated.

For carcinogenic health effects, carcinogenic slope factors (CSFs) are used to estimate the additional lifetime cancer risk corresponding to chemical intake. CSFs correspond to specific routes of exposure. The current CSF from DTSC and EPA and the weight of evidence classification is provided in the toxicity profiles for each carcinogenic chemical. CSFs are expressed in units of (milligrams per kilogram-day)$^{-1}$ [(mg/kg-day)$^{-1}$].

Carcinogenic risk is the product of the calculated intake multiplied by the CSF for the pathway of interest. Risk is a statistical measure of an individual's increased probability of developing cancer over a lifetime from exposure to chemicals at a site, under the assumptions used to calculate intake (EPA 1989).

The following information was gathered from all available sources and presented for noncarcinogenic chemicals:

1. The current reference dose (RfD) and the reference concentration (RfC) and the basis for these values;

2. Critical study on which the toxicity value is based;
3. Target organs and uncertainty factors; and
4. Possible biochemical mechanisms of toxicity.

The potential for noncarcinogenic adverse health effects for ingestion is typically evaluated by comparing estimated daily intakes with RfDs. RfDs represent daily intakes at which no adverse health effects are expected to occur to even sensitive receptors (EPA 1989). RfCs represent the equivalent value for inhalation exposures. RfCs are typically presented in units of milligrams per cubic meter (mg/m^3), but can be converted to inhalation RfDs and expressed in units of milligrams per kilogram-day (mg/kg-day) to be consistent with the units of intake calculations.

Noncarcinogens are assessed in terms of hazard quotients rather than risk. A hazard quotient is the ratio of a chemical-specific intake to the RfD. Hazard quotients are summed across chemicals and exposure pathways to produce hazard indices (HIs) for a specific exposure scenario (residential, occupational, agricultural, or recreational). This is a conservative approach because it sums non-cancer risks that may not be additive or associated with the same target organ and is used for screening purposes.

Toxicity profiles for CoPCs are presented as an attachment to this appendix. Toxicity values are presented in Tables B.4-1 through B.4-4.

B.5 RISK CHARACTERIZATION

The risk characterization combines exposure and toxicity information to estimate human health carcinogenic risks and noncarcinogenic hazard indices. For the Study Area, the risk characterization is described for on- and off-site areas by hydrostratigraphic layer in subsections B.5.1 and B.5.2. The risk characterizations for perchlorate, NDMA, and TCE are keyed to the plume maps, presented in this section by hydrostratigraphic layer. Additionally, the maximum detected concentrations of NDMA, TCE, perchlorate, and any other detected chemical selected as a CoPC are included in the risk assessment.

The risks and hazard indices are characterized in reference to the criteria established in the National Contingency Plan. Specifically, "for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound life-time cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response" [40CFR§340.430(e)(2)(i)(A)(2)]. For hazard indices, the acceptable level is 1.0.

B.5.1 On-site Areas

The following subsections describe risk assessment results for on-site areas. Because there are no currently complete exposure pathways on-site, only future potential exposures are addressed. Total risks and hazard indices (based on maximum detected concentrations of all chemicals) are described first, followed by a discussion of risks and hazard indices associated with the plumes of TCE, NDMA, and perchlorate.

B.5.1.1 Layer A

All volatile organic chemicals (VOCs) that were detected in Layer A were selected as CoPCs in addition to TCE, NDMA, and perchlorate. The total risk associated with the maximum detected concentration of each chemical in on-site Layer A is 9.4E-3; the total hazard index is 610. The risk is due mainly to NDMA via groundwater ingestion, and to 1,2-DCA and chloroform via inhalation of vapors from groundwater use. Chloroform, at a concentration of 230 µg/L, is associated with a risk of 1.4E-3 and hazard index of 470. 1,2-DCA was detected at a maximum

concentration of 950 µg/L. The risk from 1,2-DCA is 7.8E-3. The maximum concentration was at Well 131, which overlaps the TCE isopleth of 50 µg/L. The hazard index of 1,2-DCA is 121 at 950 µg/L, related mainly to inhalation of vapors from groundwater use.

Other chemicals detected in Layer A on-site were 1,1,2-trichloroethane (1,1,2-TCA), 1,2-DCE, PCE, TCE, perchlorate, NDMA, nitrate and nitrite. The risks and hazard indices associated with the maximum detected concentrations of these chemicals are:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1,2-TCA	1.3	6.6E-6	0.068
1,2-DCA	950	7.8E-3	121
1,2-DCE	10	NA	0.24
Chloroform	230	1.4E-3	470
PCE	0.82	8.2E-7	0.045
TCE	82	5.1E-5	2.9
Perchlorate	75	NA	5.3
NDMA	0.16	1.2E-4	NA
Nitrate	219 ppm	NA	4.8
Nitrite	22 ppm	NA	7.7
	TOTAL	9.4E-3	610

Note that inhalation of volatilized chemicals from groundwater through the subsurface is not a significant pathway, because on-site soil gas samples have shown that such volatilization occurs only at source areas with vadose zone impacts (ICF Kaiser Engineers 1993).

Figures B-5 through B-7 show the plume maps for Layer A. As shown on Figure B-5, the TCE plume is drawn at concentrations of 5 to 50 µg/L, which corresponds to risks of 3.1E-6 to 3.1E-5, respectively (the off-site plume of 50 µg/L is unrelated to the Aerojet Site and is not further discussed in this risk assessment). These risks are related almost entirely to groundwater ingestion and inhalation. Risks from dermal contact with groundwater is insignificant for this chemical, posing risks less than 1E-7 even at 50 µg/L. The hazard index associated with a concentration of 5 µg/L is 0.18 and is 1.8 at a concentration of 50 µg/L, based on ingestion, dermal contact, and inhalation pathways. The risks from exposure to these plume concentrations are within the NCP acceptable range of 1.0E-6 to 1.0E-4, and are below to slightly above the

level of concern of 1.0 for hazard indices. The maximum detected concentration of TCE on-site in Layer A was at Well 3348 at 82 µg/L. This corresponds to a risk of 5.1E-5 and hazard index of 2.9.

Perchlorate was detected in Layer A and plumes were drawn at isopleths of 4 to 400 µg/L as shown on Figure B-6. The hazard index corresponding to 4 µg/L is 0.22, and increases to 22 at 400 µg/L. Where the perchlorate plume overlaps with the TCE plume, the hazard index rises to 22.42 (perchlorate at 400 µg/L and TCE at 50 µg/L). As described above, the maximum detected concentration of perchlorate in on-site Layer A is 75 µg/L, which corresponds to a hazard index of 5.3. Perchlorate is evaluated only as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are also protective against potential carcinogenic effects.

The NDMA plume in Layer A is drawn at isopleths of 0.01 µg/L and 0.1 µg/L at a single on-site area (Figure B-7). The risks associated with these concentrations are 7.7E-6 at 0.01 µg/L and 7.7E-5 at 0.1 µg/L. These risks are related primarily to ingestion of groundwater, and to a much lesser degree, dermal contact with groundwater. The risks from exposure to these plume concentrations are within the NCP acceptable range of 1.0E-6 to 1.0E-4. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical. The maximum concentration of NDMA of 0.16 µg/L is associated with a risk of 1.2E-4. The maximum concentration was detected in Well 22.The TCE plume, shown on Figure B-5, overlaps the NDMA plume in certain areas. If risks from these two chemicals are added at the points where the plumes overlap, the highest risk is 8.0E-6, which is within the NCP acceptable risk range of 1E-6 to 1E-4.

B.5.1.2 Layer B

NDMA, TCE, and perchlorate were selected as CoPCs for on-site Layer B in addition to all detected VOCs, nitrate, and nitrite. CoPCs in on-site Layer B hydrostratigraphic layer are associated with the following risks and hazards:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1,2-TCA	1.5	7.6E-6	0.08

1,1-DCA	1.8	9.2E-7	0.00085
1,1-DCE	48	1.1E-3	1.1
1,2-DCE	120	NA	2.8
Carbon Tetrachloride	1.4	8.4E-6	0.43
Chloroform	350	2.1E-3	716
Freon-113	1.1	NA	2.4E-5
PCE	2.1	2.1E-6	0.011
TCE	9,400	5.8E-3	332
NDMA	0.32	2.5E-4	NA
Perchlorate	11,000	NA	775
Nitrate	11 ppm	NA	0.24
Nitrite	0.56 ppm	NA	0.2
	TOTAL	9.4E-3	1800

Risks and hazard indices from TCE are attributable to ingestion and inhalation exposures. Risks from 1,1-DCE are due mainly to inhalation and ingestion exposures and, to a lesser extent, dermal contact. The risks and hazard indices from exposure to chloroform are related to inhalation exposure, and to a lesser extent, ingestion exposure. Risk from NDMA is due entirely to ingestion of groundwater. The hazard index from perchlorate is also due mainly to ingestion exposure. Note that inhalation of volatilized chemicals from groundwater through the subsurface is not a significant pathway, because on-site soil gas samples have shown that such volatilization occurs only at source areas with vadose zone impacts (ICF Kaiser Engineers 1993).

Described below, The plume isopleth concentrations of TCE and NDMA are within the acceptable risk range of 1E-6 to 1E-4, except at the 5,000 ug/L isopleth for TCE. Hazard indices at each isopleth concentration for perchlorate are also below the level of concern of 1.0. However, the total risks and hazard indices for the maximum detected concentration of each of these chemicals exceed acceptable levels, as do the total risk and hazard index for all CoPCs in on-site Layer B. The total risk from the maximum detected concentrations of all CoPCs is 9.4E-3 and the total HI is 1800, as shown in Table B.5-3 and B.5-4. These results are extremely conservative because they assume a maximum exposure for a 30-year period. The plume maps, described below, provide more average exposure concentrations, although it is unlikely that a water supply well would obtain its water from a single layer, based on water purveyor practice.

Figure B-8 shows two on-site TCE plumes in the Layer B hydrostratigraphic unit. The isopleths ranged from 5 µg/L to 5,000 µg/L in the larger plume. At 5 µg/L, the risk is 3.1E-6 and the hazard index is 0.18; at 5,000 µg/L, the risk is 3.1E-3 and the hazard index is 180. The maximum concentration was detected in Well 132 (9,400 µg/L). The smaller plume has concentrations of 5 to 50 µg/L, which correspond to risks of 3.1E-6 and 3.1E-5, respectively. All isopleths are within the Aerojet property boundary. The risks of the smaller plume are within the NCP acceptable risk range of 1E-6 to 1E-4, and most of the larger plume falls in that range as well. Only at the 500 µg/L isopleth does the risk exceed that range. The hazard indices are above the level of concern at the isopleths of 50, 500, and 5,000 µg/L (hazard indices of 1.8, 18, and 180, respectively). The maximum detected concentration of TCE of 9,400 µg/L in well 132 is associated with a risk of 5.8E-3 and hazard index of 332.

Perchlorate is also found in two plumes in Layer B, as shown on Figure B-9. In the smaller plume, the concentrations range from 0.4 µg/L to 4,000 µg/L. The hazard indices corresponding to these concentrations are 0.022 and 222. The larger plume also has isopleths of up to 4,000 µg/L. The TCE plume overlaps the larger perchlorate plume. The highest isopleths of both chemicals results in a hazard index of 264, due mainly to perchlorate. The maximum detected concentration of perchlorate in Layer B on-site was 11,000 µg/L at Well 305, which corresponds to a hazard index of 775.

Five small on-site NDMA isopleths were drawn for Layer B, involving 5 separate wells (Figure B-10). The NDMA concentrations exceeded 0.01 µg/L at each of the five wells and NDMA concentrations exceeded 0.1 µg/L at two wells. The concentration of 0.01 µg/L corresponds to a risk of 7.7E-6, and 0.1 µg/L corresponds to a risk of 7.7E-5. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical. The maximum detected concentration was 0.32 µg/L at Well 282. The risk of NDMA at 0.32 µg/L is 2.5E-4.

The NDMA and TCE plumes overlap at two points: the Magazine Area (Wells 282 and 283) and Well 4315. The total risk from the combined effects of these chemicals at the Magazine Area is 1.1E-4, due mainly to NDMA. At Well 4315, the combined risk is 3.1E-3, due mainly to TCE.

B.5.1.3 Layer C

Tables B.5-5 and B.5-6 present the risks and hazard indices for all CoPCs in on-site Layer C. The chemical-specific risks and hazard indices are as follows:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1-DCA	1.3	6.7E-7	0.0017
1,1-DCE	63	1.4E-3	1.4
1,2-DCA	160	1.3E-3	20
1,2-DCE	41	NA	0.96
Carbon Tetrachloride	0.66	4.0E-6	0.20
Chloroform	670	4.2E-3	1402
Freon-114	5.4	NA	0.00011
PCE	5.9	5.9E-6	0.032
TCE	5,300	3.3E-3	192
NDMA	0.39	3.0E-4	NA
Perchlorate	8,200	NA	581
	TOTAL	1.1E-2	2200

In general the ingestion and inhalation of vapors pathways posed the greatest risks and hazard indices. For perchlorate and NDMA, the ingestion pathway contributed the overwhelming majority of the total risk or hazard index. For 1,1-DCE, 1,2-DCA, chloroform and TCE, both ingestion and inhalation pathways posed risks greater than 1E-6. Hazard indices for 1,2-DCA, chloroform and TCE were also driven by these two exposure pathways. The maximum detected concentrations of all CoPCs detected in on-site Layer C have a total risk of 1.1E-2 and hazard index of 2200, which are above acceptable limits. These risks are likely overestimates of actual risks because maximum concentrations were used as exposure concentrations for long-term exposure. Additionally, a substantial portion of the risk is attributable to infrequently detected chemicals. Note that inhalation of volatilized chemicals from groundwater through the subsurface is not a significant pathway, because on-site soil gas samples have shown that such volatilization occurs only at source areas with vadose zone impacts (ICF Kaiser Engineers 1993).

The TCE plume for Layer C is shown on Figure B- 11. In the on-site areas, the plume isopleths range from 1 µg/L to 50 µg/L. At 1 µg/L, the risk is 6.2E-7 and the hazard index is 0.04. At 50 µg/L, the risk is 3.1E-5 and the hazard index is 1.8. The 50 µg/L plume is mainly on the east side of the facility, with the lower plume concentrations approaching the western boundary. Even at 50 µg/L, the risks are within the NCP acceptable risk range of 1.0E-6 to 1.0E-4, and hazard indices are only slightly above 1.0. The maximum concentration of TCE in on-site layer C is 5,300 µg/L at well 3058, which corresponds to a risk of 3.3E-3 and a hazard index of 192.

Perchlorate was also detected in Layer C, and isopleths were drawn for concentrations of 4 µg/L, 40 µg/L, 400 µg/L and 4,000 µg/L (Figure B-12). Perchlorate is evaluated as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are protective against potential carcinogenic effects as well. At a concentration of 4 µg/L, the hazard index is 0.22, lower than the NCP level of concern of 1.0. The concentration of 40 µg/L corresponds to a hazard index of 2.2; at 400 µg/L, the hazard index is 22.2. The highest hazard index of 222 is associated with the concentration isopleth of 4,000 µg/L, which occurs in three areas. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate. The maximum detected concentration of perchlorate in on-site Layer C was 8,200 µg/L at well 4140. This concentration corresponds to a hazard index of 581.

NDMA in Layer C is generally present on the western side of the Aerojet Site and off-site northwest of GET E (Figure B-13). In the on-site areas, the concentration isopleths of 0.01 µg/L to 0.1 µg/L exist in around Wells 3083, 3018, and 4140 and in the northwest portion of the site. The risk associated with a concentration of 0.1 µg/L is 7.7E-5 and the risk associated with a concentration of 0.01 µg/L is 7.7E-6. The maximum detected concentration of NDMA in on-site layer C is 0.39 µg/L at Well 1435, which corresponds to a risk of 3.0E-4. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical.

The NDMA plumes overlap with the TCE plume at all points. The maximum risk from exposure to these two plumes at their highest concentrations is 3.3E-4, with a maximum hazard index of 1.8. The perchlorate and TCE plumes also overlap, although the hazard indices associated with TCE in this layer are very low and do not contribute significantly to the total hazard index.

For Layer C, the areas of the plumes that exceed generally acceptable levels of risk and hazard are limited to perchlorate at concentrations of 40 µg/L or higher. TCE and NDMA in Layer C of the western plume area were found at concentrations that correspond to risks within the acceptable risk range of 1E-6 to 1E-4, even when risks are summed for these chemicals. At isopleth concentrations of 50 ug/L and higher of TCE, the hazard index exceeds 1.0.

B.5.1.4 Layer D

Risks and hazard indices associated with CoPCs in on-site Layer D are presented in Tables B.5-7 and B.5-8. The following chemical-specific risks are based on maximum detected concentrations of each CoPCs:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1-DCA	1.7	8.8E-7	0.003
1,1-DCE	14	3.2E-4	0.82
1,2-DCA	4.7	3.8E-5	0.6
1,2-DCE	25	NA	0.6
Chloroform	460	2.8E-3	942
Freon-113	5.4	NA	0.0001
PCE	5	5.0E-6	0.03
TCE	1,500	9.4E-4	53
NDMA	1.3	1.0E-3	NA
Perchlorate	8,700	NA	610
Nitrate	6.7 ppm	NA	0.15
	TOTAL	5.1E-3	1600

CoPCs exceeding the acceptable risk range or hazard index criteria are 1,1-DCE, chloroform, TCE, NDMA, and perchlorate. These are conservative estimates of risks because the maximum detected concentration was used as the exposure point concentration. It is unlikely that an individual would be exposed to the maximum concentration of each COPC on a daily basis for 30 years, because actual groundwater use would result in mixing of highly impacted water with less impacted groundwater, lowering the exposure point concentration (particularly over a 30 year period). Note that inhalation of volatilized chemicals from groundwater through the subsurface is not a significant pathway, because on-site soil gas samples have shown that such volatilization occurs only at source areas with vadose zone impacts (ICF Kaiser Engineers 1993).

The TCE plume is shown on Figure B-14, and is drawn in concentration isopleths of 5 and 50 µg/L. The risks associated with these concentrations are 3.1E-6 and 3.1E-5, respectively. Hazard indices are 0.18 and 1.8, respectively. These risks are within or below the NCP acceptable range, and are based on hypothetical use of the groundwater as a domestic water supply for future on-site residential receptors. The hazard index slightly exceeds the acceptable standard at 50 ug/L. The maximum detected concentration of TCE was 1,500 µg/L at Well 3332, which corresponds to a risk of 9.4E-4 and hazard index of 53.

As shown on Figure B-15, the NDMA plume is drawn in isopleths of 0.01 µg/L, 0.1 µg/L and 1.0 µg/L in three areas. The risks associated with these concentrations are 7.7E-6 at 0.01 µg/L and 7.7E-5 at 0.1 µg/L. At 1.0 µg/L, the risk is 7.7E-4. This concentration was detected only within the Aerojet property boundary. These risks are related primarily to ingestion of groundwater and, to a much lesser degree, dermal contact with groundwater. The risks from exposure to these plume concentrations are within the NCP acceptable range of 1.0E-6 to 1.0E-4, with the exception of the plume isopleth of 1.0 µg/L. The maximum detected concentration of NDMA was 1.3 µg/L at Well 442, corresponding to a risk of 1.0E-3. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical.

Perchlorate was detected in a wider area, and plume isopleths were drawn corresponding to concentrations of 4 µg/L, 40 µg/L, 400 µg/L and 4,000 µg/L (Figure B-16). Perchlorate is evaluated as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are also protective against potential carcinogenic effects. The results were similar to those of the Layer C risk characterization. At a concentration of 4 µg/L, the hazard index is 0.22, lower than the NCP level of concern of 1.0. The concentration of 40 µg/L corresponds to a hazard index of 2.2; at 400 µg/L, the hazard index is 22.2. The highest hazard index of 222 is associated with the concentration isopleth of 4,000 µg/L, which occurs in one area within the Aerojet property boundary. The maximum detected concentration of perchlorate was 8,700 µg/L at Well 3213, which corresponds to a hazard index of 611. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate.

The points at which the NDMA and TCE plumes overlap result in a maximum risk of 7.7E-4; this occurs at the northwest boundary of the Aerojet site and is due mainly to NDMA.

Therefore, for Layer D, plume concentrations that exceed the NCP acceptable risk range and hazard index criteria are perchlorate at concentrations of 40 µg/L or above, and NDMA at concentrations of 1.0 µg/L or above. The 50 µg/L TCE isopleth exceeds the acceptable target hazard index of 1.0. Plume concentrations may represent more realistic exposure concentrations because they represent an average of concentrations over an area, rather than a maximum detection at on well.

B.5.1.5 Layer E

As shown in Tables B.5-9 and B.5—10, risks and hazard indices associated with on-site Layer E total 1.3E-3 and 46, respectively. Chemical-specific risks for each COPC are as follows:

Chemical	Concentration (ug/L)	Risk	Hazard
Chloroform	1.6	9.9E-6	0.034
Freon-113	1.3	NA	0.00003
TCE	84	2.9E-4	3.0
Perchlorate	610	NA	43
NDMA	0.38	1.0E-3	NA
Nitrate	6.6 ppm	NA	0.15
	TOTAL	1.3E-3	46

The groundwater ingestion pathway contributes the majority of the risks and hazard indices. These are conservative estimates of risk, based on the maximum detected concentration of each COPC and default exposure parameters. It is unlikely that an individual would be exposed to the maximum concentration of each COPC on a daily basis for 30 years because actual groundwater use would result in mixing of highly impacted water with less impacted groundwater, lowering the exposure point concentration (particularly over a 30 year period). Note that inhalation of volatilized chemicals from groundwater through the subsurface is not a significant pathway, because on-site soil gas samples have shown that such volatilization occurs only at source areas with vadose zone impacts.

Although plume maps for TCE, NDMA, and perchlorate were developed for Layer E, the extent of the plumes is far more limited and concentrations are lower than those in Layers C and D.

For TCE, as shown on Figure B-17, the plume is limited to the northwest corner of the Aerojet Site. Two isopleths were drawn, 5 µg/L and 50 µg/L, that correspond to risks of 3.1E-6 and 3.1E-5, respectively. Hazard indices are 0.18 and 1.8 at these concentrations, respectively. The maximum detected value of TCE was 84 µg/L at Well 3333, corresponding to risks of 2.9E-4 and a hazard index of 3.0.

The two perchlorate plumes for Layer E are located in close proximity to each other, with concentrations ranging from 4 µg/L to 400 µg/L (Figure B-18). At 4 µg/L, the hazard index associated with perchlorate is 0.22, below the NCP level of concern. At 40 µg/L, the hazard index is 2.2 µg/L; at 400 µg/L, the hazard index is 22. The maximum detected concentration of perchlorate of 610 µg/L in Well 3566 corresponds to a hazard index of 43. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate.

The NDMA plumes were drawn at concentrations of 0.01 µg/L and 0.1 µg/L (Figure B-19). The plumes are present in three areas. At a concentration of 0.01 µg/L, the risk from NDMA exposure is estimated at 7.7E-6; the risk is estimated at 7.7E-5 at a concentration of 0.1 µg/L. These risks are within the NCP acceptable risk range of 1.0E-6 to 1.0E-4. The maximum detected concentration of NDMA of 0.38 µg/L in Well 3307 corresponds to a risk of 1.0E-3. The risks are attributable to groundwater ingestion, as dermal contact with groundwater contributes an insignificant amount to the total risk.

TCE and NDMA overlap at the northwest corner of the site, with a maximum risk totaling 1.1E-4. The hazard index of 1.8 for TCE remains unchanged, because NDMA is not evaluated for noncarcinogenic effects. The perchlorate plume overlaps both the NDMA and TCE plumes. However, the hazard index for perchlorate is greater than that for TCE, and the addition of hazard indices for these two chemicals does not significantly change the perchlorate plume hazard index of 22.

In conclusion, for Layer E, the risks associated with TCE and NDMA plume concentrations fall slightly above the NCP acceptable risk range of 1.0E-6 to 1.0E-4, at the highest plume concentrations. The TCE plume of 50 µg/L is associated with a hazard index of 1.8, slightly above the target level of 1.0. For perchlorate, plume concentrations of 40 µg/L or above cause the hazard index to exceed the acceptable level of 1.0. The maximum detected concentrations of

all CoPCs are associated with a total risk of 1.3E-3 and total hazard index of 46, as shown in Tables B.5-9 and B.5-10.

B.5.2 Off-site Areas

Two assessments were performed to estimate risks to off-site receptors from exposure to CoPCs in groundwater. First, potential current exposures were assessed using a list of CoPCs detected at a water supply well, assuming that they were present at their MCL. Second, for hydrostratigraphic layers C through E, potential future risks and hazard indices corresponding to the maximum detected concentrations of each CoPC were calculated. Risks and hazard indices were also calculated for plume isopleths for these layers to present the areal extent of potential human health impacts. Only Layers C through E are considered for off-site areas because Layers A and B are not flowing off-site, as described in Appendix A, Section 3.2 and 3.3.

B.5.2.1 Potential Current Exposures

Well 1011 was selected as the "most impacted" water supply well because the greatest number of CoPCs have been detected in that well. Specifically, TCE, PCE and perchlorate have been detected at concentrations of 0.55, 0.96, and 5.6 ug/L respectively. To be conservative, it was assumed that each of these chemicals was present at their MCL (for perchlorate, the health-based level of 18 ug/L was used). As an additional conservative measure, it was assumed that NDMA was also present at its detection limit of 0.0075 ug/L, NDMA has not been detected in this well. However, the health-based screening concentration for NDMA is below the currently achievable detection limit. Therefore, NDMA was included in the potential current exposure assessment to provide a conservative risk estimate. The results (also presented in Table B.5-11 and B.5-12) are as follows:

Chemical	Concentration (ug/L)	Risk	Hazard Index
TCE	5	3.1E-6	0.18
PCE	5	5.0E-6	0.03
Perchlorate	18	NA	1.3
NDMA	0.0075	5.8E-6	NA
	TOTAL	1.4E-5	1.5

The total risk is within the acceptable risk range of 1.0E-4 to 1.0E-6, but slightly exceeds the target hazard index of 1.0. However, these are hypothetical risks, based solely on the potential for these chemicals to appear in off-site groundwater supply wells at their respective MCLs, health-based level or detection limit. Aerojet cannot direct water purveyors on the use of their wells, but it would be unlikely that a receptor would be exposed to these chemicals for the amount of time assumed in this assessment once a water purveyor and DHS have been informed of the presence of these chemicals in a well at these concentrations.

B.5.2.2 Layer C: Potential Future Exposures

Risks and hazard indices associated with CoPCs selected for off-site Layer C are presented in Tables B.5-13 and B.5-14, respectively. The chemical-specific results using maximum detected concentrations of each CoPC are as follows:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1-DCE	3.9	8.9E-5	0.022
1,2-DCA	0.56	NA	0.0071
Chloroform	28	4.3E-5	57
TCE	88	8.1E-5	3.1
Perchlorate	8,700	NA	611
NDMA	0.25	1.9E-4	NA
Nitrate	12 ppm	NA	0.26
Nitrite	2.6 ppm	NA	0.91
	TOTAL	4.1E-4	670

The risks and hazard indices are due mainly to groundwater ingestion and secondarily, to inhalation of vapors through groundwater use. These are conservative estimates of exposure based on the maximum detected concentration of each CoPC and conservative default exposure parameters.

An assessment of exposure through volatilization of chemicals from groundwater through the subsurface was also performed for off-site Layer C. Detailed results are included as Attachment B to this appendix. The maximum concentration of each VOC (TCE, 1,2-DCA, 1,1-DCE, and

chloroform) was used, along with simplified conservative assumptions regarding soil type. The total risk posed by this exposure is 3.4E-7 based on the assumptions made for this assessment. The results are likely overestimated because the lithology of the subsurface soil is more complex than the inputs used.

The TCE plume for Layer C is shown on Figure B-11. In the off-site areas, the plume isopleths range from 1 µg/L to 5 µg/L, with one small area to the north of the Aerojet Site having a plume of 50 µg/L. At 1 µg/L, the risk is 6.2E-7 and the hazard index is 0.04. At 50 µg/L, the risk is 3.1E-5 and the hazard index is 1.8. Even at 50 µg/L, the plume risks are within the NCP acceptable risk range of 1.0E-6 to 1.0E-4; the hazard index is slightly above 1.0. The maximum detected concentration of TCE was 88 µg/L in Well 30138, which corresponds to a risk of 8.1E-5 and hazard index of 3.1.

Perchlorate was also detected in Layer C, and isopleths were drawn at concentrations of 4 µg/L, 40 µg/L, 400 µg/L and 4,000 µg/L (Figure B-12). Perchlorate is evaluated as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are protective against potential carcinogenic effects as well. At a concentration of 4 µg/L, the hazard index is 0.22, lower than the NCP level of concern of 1.0. The concentration of 40 µg/L corresponds to a hazard index of 2.2; at 400 µg/L the hazard index is 22.2. The highest hazard index of 222 is associated with the concentration isopleth of 4,000 µg/L, which occurs in three areas. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate. The maximum detected concentration of perchlorate of 8,700 µg/L from Well 30081 is associated with a hazard index of 611

NDMA in Layer C is generally to the western side of the Aerojet Site, and most of the plume is off-site (Figure B-13). The concentration isopleths of 0.01 µg/L to 0.1 µg/L exist off the northwest portion of the site. The risk associated with a concentration of 0.1 µg/L is 7.7E-5 and with 0.01 µg/L is 7.7E-6. The maximum concentration of NDMA was 0.25 µg/L in Well 1484, which corresponds to a risk of 1.9E-4. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical.

The NDMA plume overlaps with the TCE plume at all points of the off-site NDMA plume. The maximum risk from exposure to these two plumes at their highest concentrations is 1.1E-4, with a

maximum hazard index of 1.8. The perchlorate and TCE plumes also overlap, although the hazard indices associated with TCE in this layer are low and do not contribute significantly to the total hazard index for the plumes.

For Layer C, areas of the plume that exceed generally acceptable levels of risk and hazard are limited to perchlorate at concentrations of 40 µg/L or higher and (for hazard indices only) TCE at concentrations of 50 µg/L. Trichloroethene and NDMA in Layer C of the western plume area were found at concentrations that correspond to risks within the acceptable risk range of 1E-6 to 1E-4, except when risks are summed across these two plumes at their highest concentrations. The maximum concentrations of each CoPC are associated with a total risk of 4.1E-4 and total hazard index of 670 as shown in Tables B.5-13 and B.5-14. The majority of the total hazard index is due to perchlorate and the majority of the risk is due NDMA and TCE as well as infrequently detected chloroform and 1,1-DCE.

B.5.2.3 Layer D: Potential Future Exposures

Tables B.5-15 and B.5-16 present risks and hazard indices associated with the maximum detected concentrations of all chemicals in off-site Layer D. The total risk is 4.3E-4 and total hazard index is 44, based on the assumptions used for this BRA. The chemical-specific results are as follows:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,2-DCE	23	NA	0.53
Perchlorate	600	NA	42
TCE	15	9.4E-6	0.53
NDMA	0.43	3.3E-4	NA
Vinyl Chloride	1.8	9.3E-5	NA
Nitrate	9.4 ppm	NA	0.21
Nitrite	0.12 ppm	NA	0.042
	TOTAL	4.3E-4	44

Risks are due mainly to ingestion of NDMA in groundwater; hazard indices are due to ingestion of perchlorate in groundwater. The dermal exposure pathway was insignificant. TCE and vinyl chloride chemical-specific risks are within the acceptable range of 1E-4 to 1E-6, but NDMA and

the total risk exceed that range. Similarly, only perchlorate exceeds the target hazard index of 1.0; no other chemical contributes significantly to the total hazard index.

An assessment of exposure through volatilization of chemicals from groundwater through the subsurface was also performed for off-site Layer D. Detailed results are included as Attachment B to this appendix. The maximum concentration of each VOC (TCE, 1,2-DCE, and vinyl chloride) was used, along with simplified conservative assumptions regarding soil type. The total risk posed by this exposure is 1.5E-7 and total hazard index is 0.00013, based on the assumptions made for this assessment. The results are likely overestimated because the lithology of the subsurface soil is more complex than the inputs used.

TCE, NDMA, and perchlorate were detected Layer D and plume maps were drawn for these chemicals.

The TCE plume is shown on Figure B-14, and was drawn at concentration isopleths of 5 and 50 µg/L. However, only the 5 µg/L isopleth extends to off-site areas. The risk associated with this concentration is 3.1E-6. The hazard index is 0.18. The maximum detected concentration of TCE of 15 µg/L in Well 1461 corresponds to a risk of 9.4E-6 and hazard index of 0.53. These risks and hazard indices are within or below the NCP acceptable range, and are based on hypothetical use of the groundwater as a domestic water supply for future residential receptors.

As shown in Figure B-15, the NDMA plume is drawn in isopleths of 0.01 µg/L, 0.1 µg/L and 1.0 µg/L in three areas, but the 1.0 µg/L isopleth does not extend off-site. The risk associated with the off-site concentrations is 7.7E-6 at 0.01 µg/L and 7.7E-5 at 0.1 µg/L. These risks are related primarily to ingestion of groundwater and, to a much lesser degree, dermal contact with groundwater. The risks from exposure to these plume concentrations are within the NCP acceptable range of 1.0E-6 to 1.0E-4. The maximum concentration of NDMA of 0.43 µg/L was detected in Well 1436 and corresponds to a risk of 3.3E-4. The risks were calculated conservatively assuming an extensive exposure to groundwater, specifically, a 2 L/day ingestion (adults) and 1 L/day (children) for 350 days per year for a total of 30 years. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical.

Perchlorate was detected in a wider area, and plume isopleths were drawn corresponding to concentrations of 4 µg/L, 40 µg/L, 400 µg/L and 4,000 µg/L (Figure B-16) but the 4,000 µg/L isopleth does not extend off-site. Perchlorate is evaluated as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are protective against carcinogenic effects as well. The results were similar to those of the Layer C risk characterization. At a concentration of 4 µg/L, the hazard index is 0.22, lower than the NCP level of concern of 1.0. The concentration of 40 µg/L corresponds to a hazard index of 2.2; at 400 µg/L the hazard index is 22.2. The maximum detected concentration of perchlorate was 600 µg/L in Well 30051, which corresponds to a total hazard index of 42. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate.

The points at which the NDMA and TCE plumes overlap off-site result in a risk of 8.0E-5; this occurs over the northwest boundary of the Aerojet site. The perchlorate and TCE plumes also overlap in this area, with total hazard indices of 0.40 to 24.0, due mainly to perchlorate at a concentration of 400 µg/L.

Therefore, for Layer D, the plume concentrations that exceed the NCP acceptable risk range and hazard index criteria are limited to perchlorate at concentrations of 40 µg/L or above, and NDMA at 1.0 µg/L in the on-site area. The total risk from the maximum detected concentrations of each CoPC was 4.3E-4 and the total hazard index was 44.0, as shown in Tables B.5-15 and B.5-16.

B.5.2.4 Layer E: Potential Future Exposures

Tables B.5-17 and B.5-18 present risks and hazard indices associated with the maximum detected concentrations of all chemicals in off-site Layer E. The total risk is 1.3E-4 and the total hazard index is 30. The chemical-specific results are as follows:

Chemical	Concentration (ug/L)	Risk	Hazard Index
1,1-DCE	2.3	5.3E-5	0.054
1,2-DCE	7.8	NA	0.18
TCE	220	1.4E-4	7.7
Perchlorate	400	NA	28
NDMA	0.08	6.1E-5	NA

Nitrate	7.1 ppm	NA	0.16
	TOTAL	2.5E-4	36

An assessment of exposure through volatilization of chemicals from groundwater through the subsurface was also performed for off-site Layer E. Detailed results are included as Attachment B to this appendix. The maximum concentration of each VOC (TCE, 1,2-DCE, and 1,1-DCE) was used, along with simplified conservative assumptions regarding soil type. The total risk posed by this exposure is 1.3E-7 and total hazard index is 0.000035, based on the assumptions made for this assessment. The results are likely overestimated because the lithology of the subsurface soil is more complex than the inputs used.

Although plume maps for TCE, NDMA, and perchlorate were developed for Layer E, the extent of the plumes is far more limited and concentrations are lower than those in Layers C and D.

For TCE, as shown on Figure B-17, the plume is limited to the northwest corner of the Aerojet site and adjacent off-site areas. Two isopleths were drawn, of 5 µg/L and 50 µg/L, corresponding to risks of 3.1E-6 and 3.1E-5, respectively. Hazard indices are 0.18 and 1.8 at these concentrations, respectively. The maximum concentration of TCE of 220 µg/L in Well 1437 is associated with a risk of 1.4E-4 and hazard index of 7.7.

The two perchlorate plumes for Layer E are located in close proximity to each other, with concentrations ranging from 4 µg/L to 400 µg/L (Figure B-18). At 4 µg/L, the hazard index associated with perchlorate is 0.22, below the NCP level of concern. At 40 µg/L, the hazard index is 2.2 µg/L; at 400 µg/L, the hazard index is 22. The isopleth of 400 µg/L, however, is mostly on-site; in general, concentrations between 4 and 40 µg/L comprise the larger part of the off-site plume. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate.

For NDMA, as shown on Figure B-19, the plumes were drawn at concentrations of 0.01 µg/L and 0.1 µg/L. One plume is present off-site at the northwestern boundary of the Site. The NDMA isopleths in this plume are 0.01 µg/L (with a risk of 7.7E-6) and 0.1 µg/L (with a risk of 7.7E-5). The maximum concentration of NDMA of 0.08 in Well 1438 corresponds to a risk of 6.1E-5. These risks are within the NCP acceptable risk range of 1.0E-6 to 1.0E-4. The risks are

attributable to groundwater ingestion, as dermal contact with groundwater contributes an insignificant amount to the total risk.

TCE and NDMA overlap off-site, past the northwest boundary of the site, with a maximum risk totaling 1.0E-4. The hazard index of 1.8 for TCE remains unchanged, because NDMA is not evaluated for noncarcinogenic effects. The perchlorate plume overlaps both the NDMA and TCE plumes. However, the hazard index for perchlorate is far greater than that of TCE and the addition of hazard indices for these two plumes does not change the conclusions regarding total plume hazard indices.

In conclusion, for Layer E, the off-site risks associated with TCE and NDMA plumes fall within the NCP acceptable risk range of 1.0E-6 to 1.0E-4, when considered separately or together. The isopleth concentrations of 50 µg/L for TCE slightly exceeds the target hazard index of 1.0. For perchlorate, concentrations of 40 µg/L or above cause the hazard index to exceed the acceptable level of 1.0. The total risk based on the maximum concentrations of each CoPC is 2.5E-4 and total hazard index is 36. The total risk is due mainly to NDMA, TCE, and 1,1-DCE. The total hazard index is associated mainly with perchlorate; the maximum detected concentration of TCE contributes a hazard index of 7.7. These risks and hazard indices are overestimated because maximum concentrations are not representative of actual exposure concentrations for long-term exposure.

B.6 UNCERTAINTY AND VARIABILITY

Uncertainty and variability are inherent to risk assessments. According to EPA guidance (1989), "it is important to fully specify assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective." DTSC guidance also recommends a qualitative discussion of uncertainty (1992 and 1994). Uncertainty exists in the exposure assessment, toxicity values, and the hence, the risk characterization. In this human health risk assessment, the exposure assessment and the toxicity assessment are the largest sources of uncertainty and variability.

EPA defines uncertainty as a "lack of knowledge about specific factors, parameters, or models" (1997b) including:

1. parameter uncertainty (measurement errors, sampling errors, and systematic errors);
2. model uncertainty (uncertainty due to necessary simplification of real-world processes, mis-specification of the model structure, model misuse, use of inappropriate surrogate variables); and
3. scenario uncertainty (descriptive errors, aggregation errors, errors in professional judgment, incomplete analysis).

Variability is defined as "observed differences attributable to true heterogeneity or diversity in a population or exposure parameter" (EPA 1997b). Variability is the result of natural random process, such as variations in body weight, breathing rate, or drinking water rates. Variability cannot be reduced by further study, but may be better characterized through further measurements.

For the exposure assessment, uncertainty may influence the risk estimates because of:

1. the use of the maximum detected concentrations for all CoPCs in each hydrostratigraphic layer over the past 2 years of monitoring;
2. unknown future land and groundwater use;
3. the use of upper-bound values for ingestion, inhalation, and dermal contact rates; and
4. the use of default values for exposure duration that are likely to overestimate exposures.

The maximum concentration was used for simplicity and to address concerns regarding the "maximally exposed" individual. It is important to note, though, that the maximum concentrations of each COPC did not always occur at the same well. Further, actual groundwater use would result in mixing of highly impacted groundwater with less impacted groundwater, lowering the maximum exposure point (particularly over a 30-year period). The use of groundwater would have a larger sphere of influence, and water from nearby areas with potentially lower concentrations of chemicals would be mixed with the concentrations detected. It is likely that all exposure point concentrations are overestimated because this was not considered in determining exposure point concentrations

The use of the Johnson and Ettinger model to estimate exposure and risk from volatilization of chemicals from groundwater through the subsurface provides conservative results that are not likely to underestimate exposures. The lithology of the off-site Western Plume study area is more complex than the simplifying assumptions used in the model and actual exposures would likely be lower than those estimated. On-site soil vapor measurements have shown that this pathway is incomplete even over plumes with higher VOC concentrations.

As recommended by EPA (1999a) and DTSC guidance (1992 and 1994), upper-bound exposure parameters were selected for groundwater ingestion, dermal contact and inhalation rates. These default values tend to overestimate expected exposures, and are representative of the maximally exposed individual. Use of default exposure duration values in the risk assessment may also overestimate risk because they do not to account for site-specific variability. Default parameters often used in intake equations are based on nationally averaged data and may not reflect the more active lifestyle typical of residents in states with temperate climates (EPA 1997a). Although they were not used in this risk assessment, EPA has developed revised exposure parameters based on California-specific data and regional variability that appear to be more realistic (that is, lower), while still being conservative (EPA 1997a).

For the toxicity assessment, uncertainties are inherent to the carcinogenic and noncarcinogenic toxicity values, which are based on laboratory animal studies. Specifically, uncertainties arise from the extrapolation of results from animals dosed at high concentrations to human exposures at low concentrations. Scientists also debate the validity of the critical underlying assumptions in the dose-response model for carcinogens (linearized multistage model). This model is based on the assumption that any dose of a carcinogen is associated with a risk of cancer and that a

carcinogenic response is linear at low doses (EPA 1996). The results of this modeling may result in varying toxicity values, depending on the studies used as inputs to the model and interpretations of results.

The provisional cancer slope factors for PCE and TCE are associated with the uncertainties described above, and the EPA cancer classification of these chemicals is also currently undecided. Only provisional slope factors are available from EPA at this time (EPA 1998) pending a decision as to whether PCE and TCE are possible carcinogens (classification "C") or probable carcinogens based on results of animal studies (classification "B2"). Both chemicals were considered carcinogenic in this assessment, but it is important to note that the current classification and toxicity values are provisional.

The reference dose for perchlorate is perhaps the most uncertain toxicity value used in this assessment. An external review draft value was available from EPA, but is still under review and subject to change (EPA 1998). In addition, reviews of toxicity data for perchlorate were decided by independent reviewers to not be definitive enough to calculate a toxicity value (TERA 1997). The current range of appropriate oral RfDs is 0.0001 to 0.0005 mg/kg-day, according to EPA's Office of Research and Development (ORD, EPA 1999b). However, EPA's National Center for Environmental Assessment (NCEA) has posted a less conservative provisional oral RfD (www.epa.gov/ncea, EPA 1998). The critical effect of perchlorate is assumed to be related to thyroid function, but the effects to other organs, developmental toxicity, reproductive toxicity, and carcinogenicity are as yet unknown. Multiple studies are underway, and some have been completed, to address these issues and will generate data necessary to produce a final toxicity value.

Further, this BRA used toxicity values as presented in the EPA Region PRG document of October 1999. EPA Region 9 and California EPA have different toxicity values for many carcinogens. The most important difference in this assessment is the CSF value for NDMA. California EPA lists a CSF of 16 $(mg/kg\text{-}day)^{-1}$ and has based some state health standards on this value. EPA Region 9 uses a CSF of 51 $(mg/kg\text{-}day)^{-1}$ which is nearly three times higher (more conservative). Use of the California EPA CSF would reduce the risks associated with NDMA by approximately two-thirds. As an example, the risk associated with the NDMA plume of 0.1 ug/L is 7.7E-5 using the EPA Region 9 toxicity value; the risk would be 2.4E-5 using the California EPA toxicity value. If less conservative exposure parameters were also used, the risk would be below 1E-5.

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ATTACHMENT A
TOXICITY PROFILES

Carbon Tetrachloride

Carbon tetrachloride is a clear, heavy aromatic liquid with a sweet odor. It is distributed throughout the environment due to its extensive human production and use. Carbon tetrachloride may currently be used as a refrigerant and propellant (MDEQ 1994) but most uses are currently banned and it is used only in some industrial applications (ATSDR 1995). It is also used as a solvent for oil, fats, lacquers, varnishes, rubber, waxes, and resins. Until the 1960's it was also used as an industrial degreaser, household spot remover, and a fire-extinguishing agent. Carbon tetrachloride is relatively persistent in the environment and is stable in the atmosphere (ATSDR 1995, MDEQ 1994).

Carbon tetrachloride is readily absorbed when ingested or inhaled but is poorly absorbed through the skin. Carbon tetrachloride is metabolized in the liver. It is known that the metabolism of carbon tetrachloride plays an important role in its toxicity, although the specific mechanism relating the metabolites to toxicity has not been determined to date. Unmetabolized carbon tetrachloride is removed from the body by expired air and in the feces and urine. Acute exposure to large doses of carbon tetrachloride is associated with central nervous system depression, gastrointestinal effects, and liver and kidney damage (ATSDR 1995, MDEQ 1994). However, carbon tetrachloride does not bioaccumulate in animals (ATSDR 1995).

EPA classifies carbon tetrachloride as a probable human carcinogen (class B2) based on carcinogenicity in laboratory animals. Human data are inadequate. The oral CSF developed by EPA is 0.13 $(mg/kg\text{-}day)^{-1}$ (EPA 2000), while OEHHA lists an oral CSF of 0.15 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000). The inhalation CSF from EPA is 0.05 $(mg/kg\text{-}day)^{-1}$ (EPA 2000) and from Cal/EPA is 0.15 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000).

EPA has also developed an oral RfD of 0.0007 mg/kg-day for carbon tetrachloride, based on development of liver lesions in laboratory animals. The oral RfD is associated with an uncertainty factor of 1,000 based on interspecies and intrahuman variability and extrapolation from subchronic to chronic duration of exposure. An inhalation RfD has not been developed for

carbon tetrachloride, but EPA Region 9 recommends using the oral CSF to assess inhalation exposures for organic chemicals.

Chloroform

Chloroform is used as a grain fumigant; as a solvent for pesticides, adhesives, fats, oils, rubbers, alkaloids, and waxes; as a chemical intermediate for dyes and pesticides; and as a component of cough syrups, toothpastes, and liniments. It is also an environmental degradation product of carbon tetrachloride, and is formed from the interaction of chlorine with organic material in drinking water as a by-product of chlorination.

Chloroform is well absorbed by all routes: oral, inhalation, and dermal. Once absorbed, it is widely distributed throughout the body, with high concentrations accumulating in adipose tissue and in organs with high fat content, particularly the brain. Some chloroform is exhaled unchanged, but most is oxidized primarily in the liver to the intermediate phosgene, then to carbon dioxide, which is subsequently exhaled. The ratio between metabolized and unmetabolized excretion is difficult to predict because it varies with species, sex, amount of body fat, dose, and other factors.

The primary adverse effect noted after single doses of chloroform is CNS depression, which can proceed to the level of anesthesia with extensive exposure to high concentrations. Chloroform was used as a general anesthetic for decades until studies revealed that single doses were capable of causing serious and even fatal liver and kidney damage in some patients. It also occasionally caused cardiac arrest. Acute exposure via inhalation can result in disruption of body temperature regulation and respiration, as well as cardiovascular and vasomotor functions. The major target organs with repeated doses are the liver and kidneys.

Chloroform is a class B2 carcinogen based on its ability to induce liver and kidney tumors in rats and mice (EPA 2000). The EPA and Cal/EPA oral CSFs are 0.0061 and 0.031 $(mg/kg\text{-}day)^{-1}$, respectively (EPA 2000, OEHHA 2000). Numerous studies of humans have found evidence of increased cancer rates in persons drinking chlorinated drinking water, but a direct correlation between chloroform and tumor formation has not been established. In several animal reproductive toxicity studies, chloroform affected the neonates only at doses that had significant

adverse effects on the mothers. The EPA and Cal/EPA inhalation CSFs are 0.081 and 0.019 $(mg/kg\text{-}day)^{-1}$, respectively (EPA 2000, OEHHA 2000).

The oral RfD for chloroform is 0.01 mg/kg-day with an uncertainty factor of 1,000 (EPA 2000). The critical effect for this RfD is fatty cyst formation in livers of experimental animals. EPA Region 9 (EPA 1999) lists an inhalation RfD of 8.6E-5 mg/kg-day that was used in this assessment.

1,1-Dichloroethane

The compound 1,1-DCA, known commercially as either ethylidene chloride and ethylidene dichloride, is a volatile compound with limited use as a solvent and chemical intermediate.

It is apparently absorbed by inhalation, ingestion, and through the skin, and is excreted in exhaled air. No metabolic data are available.

Most of the available information describes adverse effects from acute exposure. The major effects include local irritation and central nervous system depression. It once had limited therapeutic use as an anesthetic. High doses produce minor pathological changes in the liver and kidneys. In experimental studies, repeated doses did not produce specific toxic effects, but did result in decreased weight gain and an increased death rate. The unavailable reproductive toxicity study found limited, nonspecific adverse effects at high doses.

The 1,1-DCA compound is a class C carcinogen which does not have an oral CSF (EPA 2000). The California oral and inhalation CSFs are 5.7E-3 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000). The oral RfD for 1,1-DCA is 0.1 mg/kg-day with an uncertainty factor of 1,000 (HEAST 1997). This RfD is based on the no observed adverse effects level (NOAEL). The inhalation RfD is 0.14 with an uncertainty factor of 1,000, based on effects to kidneys (HEAST 1997).

1,2-Dichloroethane (1,2-DCA)

The compound 1,2-DCA, known commercially as ethylene dichloride, is a chemical intermediate in the production of vinyl chloride and other chemicals, and a solvent. It is absorbed by all routes: oral, inhalation, and dermal. In experimental animals, 1,2-DCA is metabolized in the liver

through a number of pathways, leading to myriad metabolic products. Unmetabolized 1,2-DCA is exhaled, while other chemical intermediates are primarily excreted in the urine. Metabolism has not been studied in man, making extrapolation of data from laboratory animals to humans highly uncertain.

Acute doses cause irritation at the site of contact and central nervous system depression. Large doses also produce lesions in the liver, kidney, and adrenals. Repeated doses affect the same organs causing similar lesions. Reproductive studies have reported no adverse effects.

The compound 1,2-DCA is a class B2 carcinogen (EPA 2000). The EPA and California oral CSFs for 1,2-DCA are 0.091 and 0.07 $(mg/kg\text{-}day)^{-1}$, respectively, and are based on the induction of blood vessel tumors (EPA 2000, OEHHA 2000). Federal EPA has not derived an oral or inhalation RfD for 1,2-DCA, but EPA Region 9 lists an oral RfD of 0.03 mg/kg-day and inhalation RfD of 0.0014 mg/kg-day (EPA 1999) that were used in this assessment.

1,1-Dichloroethene (1,1-DCE)

The compound 1,1-DCE, commonly known as vinylidene chloride, is used as a chemical intermediate, primarily for polymers such as modacrylic and saran fibers.

The compound 1,1-DCE is readily absorbed with oral, inhalation, and dermal exposures. It is oxidized and conjugated in the liver to metabolites that are excreted in the urine. Some of the parent compound, however, is exhaled unchanged. Metabolism appears to produce toxic derivatives, since experimental animals that readily metabolize 1,1-DCE are more sensitive to its toxic effects.

The primary effect of acute exposure to 1,1-DCE is fully reversible CNS depression. As a liquid, it is quite irritating to the skin, respiratory tract, and eyes. Repeated doses produce a variety of liver and kidney lesions. There have been numerous carcinogenicity studies, but the findings remain inconclusive. Reproductive toxicity is observed only at doses that produced maternal

toxicity. Exposure to high concentrations via inhalation sensitizes the myocardium to arrhythmias by epinephrine injection.

The compound 1,1-DCE is a class C carcinogen based on the induction of several types of tumors in experimental animals. The EPA oral and inhalation CSFs are 0.6 and 0.18 $(mg/kg\text{-}day)^{-1}$, respectively (EPA 2000). OEHHA does not list alternate CSFs for this chemical.

The oral RfD for 1,1-DCE is 0.009 mg/kg-day with an uncertainty factor of 1,000 (EPA 2000). This RfD is based on the critical effect of hepatic lesions in experimental animals. Federal EPA has not developed an inhalation RfD for this chemical, but EPA Region 9 uses the oral toxicity values to assess inhalation exposures (EPA 1999).

1,2-Dichloroethene (1,2-DCE)

The compound 1,2-DCE exists in two isometric forms: cis and trans. Neither form has wide industrial use because they are very flammable and volatile, but the trans isomer is used as a solvent in materials such as dyes, perfume, waxes, resins, and thermoplastics. Both cis-1,2-DCE and trans-1,2-DCE are degradation products of the solvents tetrachloroethene and trichloroethene.

1,2-DCE is absorbed by all routes but has little potential to bioaccumulate. Due to the lipophilic nature of 1,2-DCE, tissues with a high lipid content would likely have the highest levels of 1,2-DCE in exposed receptors. ATSDR (1989a) reports that 1,2-DCE is metabolized in the body to chloroethylene epoxides; excretion of 1,2-DCE and its metabolites has not been well characterized.

This compound was once used as anesthetic in humans but there are no reports of long-term exposure to 1,2-DCE isomers. Acute exposure to concentrations in air of 1,2-DCE at 2,000 parts per million (ppm) causes burning of the eyes, vertigo, and nausea.

The oral RfD for trans-1,2-DCE is 0.02 mg/kg-day based on increased serum alkaline phosphatase levels in laboratory animals. The uncertainty factor associated with this RfD is 1,000 (EPA 2000). The oral RfD for cis-1,2-DCE is 0.01 mg/kg-day (EPA 2000) based on decreased hematocrit and hemoglobin levels in laboratory animals. The oral RfD for total 1,2-DCE (both isomers) is 0.009 mg/kg-day with an uncertainty factor of 1,000. This value is

derived from the oral RfD for 1,1-DCE (EPA 2000), which is based on hepatic lesions in experimental animals. The value of 0.009 mg/kg-day was also used to assess inhalation exposure to 1,1-DCE, per EPA Region 9 protocol (EPA 1999)

Carcinogenicity data are not available for 1,2-DCE. Neither isomer appears to induce genotoxic effects (EPA 2000).

Freon-113

Freon-113 belongs to a class of chemicals known as chlorofluorocarbons (CFCs), odorless, colorless gases that are extremely stable. The chemical name for Freon –113 is 1,1,2-trichloro-1,2,2-trifluoroethane. CFCs were developed in 1930 as a refrigerant. CFCs are used today as solvents and aerosol propellants, for foam production, sterilization and in fire-fighting agents. CFCs are believed to be the cause of depletion of the stratospheric ozone layer and contribute to global warming. Due to these concerns, CFCs are being phased out of many products and in the United States, aerosol propellants containing CFCs have been banned.

CFCs are widely distributed in the atmosphere. Although most refrigerators contain CFCs as the working fluid, most CFC use is related to foam production, vehicle air conditioning, and solvent applications.

Acute exposures to high concentrations of CFCs may cause depression of the central nervous system, heart palpitations, and death due to heart failure.

Freon-113 is not listed as a carcinogen. EPA has developed an oral RfD of 30 mg/kg-day for Freon-113 based on psychomotor impairment in humans (EPA 2000). The uncertainty factor of 10 is based on expected interhuman variability in response to exposure to Freon-113. EPA Region 9 uses an inhalation RfD of 8.6 mg/kg-day (EPA 1999).

Nitrate and Nitrites

Nitrate is the chemically stable form of inorganic nitrogen. Nitrates can occur naturally in water supplies throughout the United States, and are also associated with the use of inorganic fertilizers,

explosives, and glassmaking. Naturally occurring nitrate is the result of the decay of organic matter (such as leaves) which are taken up by plants as they grow. Nitrites are manufactured primarily for use in food preservation, and the human body will convert nitrate to nitrite.

Exposure to nitrates occurs through ingestion of food and water that contains nitrates. Vegetables such as beets, celery, lettuce, parsely, radishes, rhubarb, spinach and turnip greens naturally contain high levels of nitrates. Exposure to nitrites occurs through the same pathways, due to nitrites that have been added to food as a preservative, and the conversion of nitrates to nitrite by the body (Harte et al, 1991).

Nitrates are not considered particularly toxic, but nitrites are associated with methemoglobinemia, a condition in which the blood loses its normal ability to carry oxygen. Drinking water high in nitrates can cause high nitrite levels in the blood, leading to this condition. It is most significant for infants, because nitrates are more readily converted to nitrites in infants, infant hemoglobin is more susceptible to methemoglobinemia, and infants consume a mostly liquid diet. If infant formula is made using water that is high in nitrates (more than 100 mg/L), the infant is at greater risk of methemoglobinemia. If methemoglobinemia occurs, it can be treated with no lasting effects if diagnosed promptly (Harte et al, 1991).

EPA has developed oral RfDs for both nitrates and nitrites. For nitrate, the oral RfD is 1.6 mg/kg-day, with an uncertainty factor of 1, based on early clinical signs of methemoglobinemia. For nitrites, the oral RfD is 0.1 mg/kg-day, with an uncertainty factor of 10, based on methemoglobinemia (EPA 2000). There are no inhalation RfDs for these chemicals and they have not been evaluated for carcinogenicity by EPA.

N-Nitrosodimethyl amine (NDMA)

N-Nitrosodimethylamine is commonly known as NDMA. It is a yellow liquid with no distinct odor and belongs to a class of chemicals known as nitrosamines. It was historically used as a component of rocket fuel, but is also unintentionally formed during various manufacturing processes at many industrial sites and in air, water, and soil from reactions involving other chemicals called alkylamines (ATSDR 1989b). NDMA decomposes when exposed to sunlight, but the rate of decomposition in groundwater is unknown.

According to the ATSDR, the general population may be exposed to NDMA from a variety of sources, including outdoor air. The primary sources of NDMA exposure are tobacco smoke, chewing tobacco, and foods such as cured meats, toiletry and cosmetic products, and various other household goods. In addition, NDMA can form in the stomach during the digestion of alkylamine-containing foods (alkylamines are naturally occurring compounds that are found in some drugs and a variety of foods). Occupational exposures are also possible, such as at tanneries, pesticide manufacturing plants, rubber and tire manufacturing plants, fish processing industries, foundries, and dye manufacturing plants (ATSDR 1989b).

NDMA is readily absorbed when ingested and distributed through the bloodstream to many organs. In the liver, it is metabolized into other substances, most of which leave the body within 24 hours in expired air or in urine. NDMA may also be absorbed through the skin or inhaled, but little is known about the fate of NDMA contacted via these routes.

According to EPA, human exposure to nitrosamines results from contact with mixtures containing these compounds (such as tobacco products). Data from human exposure is therefore of limited use in the evaluation of carcinogenicity of individual nitrosamines because of potential confounding by other substances in these mixtures (EPA 2000). Nonetheless, NDMA is classified as a probable human carcinogen (class B2) based on induction of tumors at multiple sites in laboratory animals exposed by various routes. It has also been found to be mutagenic in bacterial cultures. EPA lists an oral CSF of 51 $(mg/kg\text{-}day)^{-1}$, while Cal/EPA has developed an oral CSF of 16 $(mg/kg\text{-}day)^{-1}$. The inhalation CSFs are listed as 49 $(mg/kg\text{-}day)^{-1}$ and 16 $(mg/kg\text{-}day)^{-1}$ by EPA and Cal/EPA respectively. The Cal/EPA values were used in this assessment.

No RfDs have been developed for NDMA.

Perchlorate

Perchlorate, an inorganic anion, is found in compounds with numerous inorganic cations such as ammonium or potassium. Ammonium perchlorate has been widely used as an oxidizer in solid rocket propellants. Potassium perchlorate was used therapeutically as a treatment for Graves' disease (hyperthyroidism), an autoimmune disorder which produces elevated levels of thyroid

hormones. Perchlorate blocks iodine uptake, returning thyroid hormone levels to normal and controlling the symptoms of hyperthyroidism (TERA 1997).

Animal studies of perchlorate have also focused on effects to the thyroid. Short-term studies in rats have identified a No Observed Adverse Effects Level (NOAEL) and a Lowest Observed Adverse Effects Level (LOAEL) based on increased relative thyroid weight, increased thyroid stimulating hormone (TSH), and decreased levels of T3 and T4 thyroid hormones.

In 1992, EPA Office of Research and Development (ORD) initiated internal study of perchlorate toxicity and derived a provisional RfD of 0.0001 mg/kg-day, based on an acute, single dose (potassium perchlorate) study of Grave's disease patients by Stanbury and Wyngaarden (1952). The EPA ORD identified a NOAEL of 0.14 mg/kg-day and applied an uncertainty factor of 1,000 to derive the RfD. The uncertainty factor included a value of 10 for the use of an acute study instead of a chronic study, 10 to protect sensitive individuals, and 10 to account for database deficiencies.

In 1995, EPA's National Center for Environmental Assessment (NCEA) evaluated available information on perchlorate toxicity and stated that "... the appropriate provisional RfD for perchlorate appears to be in the range of 1 to 5 x 10^{-4} mg/kg-day" pending the availability of adequate chronic exposure data. The latter RfD was derived from different NOAEL values based on three studies and uncertainty factors that utilized a value of 3 for database deficiencies; 10 for the use of an acute instead of chronic study; and 10 to protect sensitive individuals (example: NOAEL of 0.14 mg/kg-day divided by 300).

Starting in 1998, EPA Region IX provided a provisional oral RfD of 0.0005 mg/kg-day (EPA 1999). EPA Region IX did not provide any data for cancer risk, although the EPA ORD (1992) labeled perchlorate as a probable human carcinogen (B2) based on thyroid tumors in mice and rats following long-term administration of sodium or potassium perchlorate.

The 1992/95 toxicological characterization of perchlorate was not subject to internal EPA review and external peer review; and therefore was labeled provisional. An external peer review was conducted in 1997 by Toxicological Excellence in Risk Assessment (TERA), a non-profit organization dedicated to the best use of toxicity data in risk assessment, which concluded that the available data were insufficient and recommended further animal studies. Comprehensive

studies are on-going, as listed below, and are expected to produce an RfD that is protective of human health in early 1999:

1. 90-day Subchronic Oral Bioassay
2. Neurobehavioral Development Study
3. Segment II Developmental Study
4. 2-Generation reproductive Toxicity Study
5. Adsorption, Distribution, Metabolism, and elimination Studies
6. Perchlorate Mechanism Studies
7. Genotoxicity Assays
8. Immunotoxicity Studies

Currently, the NCEA has posted a provisional RfD for external review that is less conservative than the RfD currently used (www.epa.gov/ncea, EPA 1998). This value was based on a mode-of-action modeling approach that harmonizes noncarcinogenic and carcinogenic approaches to derive a single oral risk benchmark based on the established adverse effects on the thyroid. The oral RfD is proposed as protective of potential cancer and noncancer effects. A composite uncertainty factor of 100 was used. This RfD results in a revised risk-based groundwater action level of 32 µg/L, which is above the previous provisional values (EPA 1998).

The oral RfD value of 0.0005 mg/kg-day was used in this risk assessment at the request of EPA Region 9. However, the more recent value of 0.0009 mg/kg-day was used for developing clean-up goals

Tetrachloroethene (PCE)

PCE is a commonly used industrial solvent for degreasing processes. PCE is well absorbed from the lung, but less so from the gastrointestinal tract and through the skin. It is widely distributed throughout the body, with most deposition in adipose tissue. PCE is primarily exhaled unchanged, but some is metabolized in the liver, and excreted in the urine. The amount of this metabolism varies greatly among species. The metabolites, especially the highly reactive epoxide, are believed responsible for the compound's carcinogenicity and some other toxic effects.

The major acute toxic effect of PCE is central nervous system depression. It can also irritate tissues, particularly mucous membranes, and produce lesions in the liver and kidneys. PCE's former usage in the treatment of hookworms suggests that it is not highly toxic when given orally to humans.

Repeated doses produce considerable hepatotoxicity and often nephrotoxicity. Pulmonary edema, although rare, can be produced after inhalation and dermatitis can develop after prolonged contact with skin. No evidence of teratogenicity exists in the few available studies.

PCE is a class B2 to C carcinogen (possible to probable human carcinogen) based on the induction of liver tumors in animal studies. Limited human studies have found no carcinogenicity. The Cal/EPA oral CSF is 0.051 $(mg/kg\text{-}day)^{-1}$; the inhalation CSF is 0.021 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000). The provisional oral CSF for PCE from the Superfund Technical Support Center is 0.052 $(mg/kg\text{-}day)^{-1}$ and the inhalation CSF is 0.002 $(mg/kg\text{-}day)^{-1}$ (STSC 1998).

The oral RfD for PCE is 0.01 mg/kg-day with an uncertainty factor of 1,000. This oral RfD is based on the effects of hepatotoxicity and weight gain in experimental animals (EPA 2000). An inhalation RfD of 0.11 mg/kg-day, as listed in EPA Region 9 PRGs (EPA 1999) was used in this risk assessment.

1,1,2-Trichloroethane (1,1,2-TCA)

The compound 1,1,2-TCA, also known as beta-trichloroethane, is used as a nonflammable solvent and is used mostly where 1,1-dichloroethene is made (ATSDR 1989c). The compound 1,1,2-TCA can enter the body through all routes and is readily excreted or metabolized. It is completely absorbed after ingestion, well absorbed after inhalation, and slowly absorbed through the skin. This compound is concentrated in fat and in organs with high levels of fat, such as the brain. Most is exhaled unchanged, but small amounts are metabolized and subsequently excreted in the urine.

The primary effects of acute toxicity are CNS depression and mild skin irritation if contact with skin occurs. Chronic toxicity, which is rarely reported in humans, usually involves kidney and

liver lesions. Based on limited information, 1,1,2-TCA does not appear to cause birth defects or otherwise inhibit normal development (ATSDR 1989c).

1,1,2-Trichloroethane is a class C carcinogen, based on liver tumors in laboratory animals. EPA lists an oral CSF of 0.057 $(mg/kg\text{-}day)^{-1}$ and an inhalation CSF of 0.056 $(mg/kg\text{-}day)^{-1}$ (EPA 2000). Cal/EPA has developed an oral cancer slope factor of 0.072 $(mg/kg\text{-}day)^{-1}$ (and an inhalation slope factor of 0.057 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000). The oral RfD for 1,1,1-TCA is 0.004 mg/kg-day with an uncertainty factor of 1,000 (EPA 2000). This RfD is based on the critical effect of changes in clinical serum chemistry of laboratory animals. No inhalation RfD has been established for 1,1,2-TCA by federal EPA but EPA Region 9 lists an inhalation toxicity value of 0.004 mg/kg-day, based on route-to-route extrapolation.

Trichloroethene (TCE)

TCE is widely used as a solvent, especially for dry cleaning and metal degreasing. TCE is well absorbed after inhalation, ingestion, and to some extent through skin. It tends to collect in fat because it is lipophilic. The compound is metabolized in the liver to a variety of metabolites, which are responsible for much of the TCE toxicity. Metabolites are excreted primarily in the urine. TCE can potentiate the toxicity of other compounds including ethanol and increase the toxicity of both compounds.

Acute exposures cause CNS depression and TCE was once used as a surgical anesthetic. Chronic dosing produces liver and kidney lesions as well as a peripheral neuritis. The chemical was found to be carcinogenic in some animal tests, but no human data are available. No evidence of reproductive toxicity exists in the few tests available.

TCE is a class B2 carcinogen based on the induction of hepatomas. The Cal/EPA oral CSF is 0.015 $(mg/kg\text{-}day)^{-1}$ and the inhalation CSF is 0.01 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000).

The provisional EPA oral CSF is 0.011 $(mg/kg\text{-}day)^{-1}$ and the inhalation CSF is 0.006 $(mg/kg\text{-}day)^{-1}$ according to information from the Superfund Technical Support Center (STSC 1998).

The provisional oral RfD for TCE is 0.006 mg/kg-day according to information from the Superfund Technical Support Center (STSC 1998). EPA Region 9 uses the oral RfD for

trichloroethene to assess inhalation exposures as well, although federal EPA has not developed an inhalation RfD for this chemical.

Vinyl Chloride

Vinyl chloride, or chloroethene, was of little toxicological interest until 1974 when it was first reported as a human carcinogen. Since then there have been many human and animal studies summarized in various reviews.

Vinyl chloride may enter the body through various routes. Once in the body, it is metabolized and excreted. The compound is fully absorbed after inhalation and ingestion, but little is absorbed by the skin. Vinyl chloride is concentrated in the liver (site of metabolism) and kidney (site of excretion). Vinyl chloride is oxidized to an exposed and other reactive intermediates, which react further. These intermediates are generally believed to be the active chemical species for the specific toxic effects of vinyl chloride. Excretion is primarily in the urine as conjugates of metabolites with sulfur-containing compounds. Very small amounts are exhaled unchanged.

Vinyl chloride produces both acute and chronic effects. Large single doses of vinyl chloride produce CNS depression. Early studies of its anesthetic potential found cardiac and circulatory disturbances. Chronic exposure to low concentrations in workers produce a syndrome called "vinyl chloride disease". This includes acroosteolysis, Raynaud's disease, scleroderma, lung toxicity, thrombocytopenia, and liver toxicity. Chromosomal abnormalities have been reported in workers.

The most striking effect of vinyl chloride toxicity is the production of hemangiosarcomas, which are extremely rare tumors. These occur in the liver and occasionally elsewhere. Since this has been repeatedly confirmed in worker exposure studies and animal studies, vinyl chloride is a confirmed human carcinogen. Some studies have also reported vinyl chloride-induced tumors at other sites, especially the brain and, after inhalation, the lungs.

There have been reports of reproductive toxicity in exposed workers, but no adverse effects have been seen in animal studies except at high doses that produce nonspecific toxic effects. Epidemiological studies in residential neighborhoods near vinyl chloride production plants have been inconclusive.

Vinyl chloride is a class A carcinogen. The EPA and California oral CSFs are 1.9 and 0.27 $(mg/kg\text{-}day)^{-1}$, respectively, and are based on the induction of tumors in the liver and lung (EPA 2000, OEHHA 2000). The EPA and California inhalation CSFs are 0.3 and 0.27 $(mg/kg\text{-}day)^{-1}$, respectively. No RfDs for vinyl chloride have been established (EPA 2000).

TABLE 1
SELECTION OF EXPOSURE PATHWAYS
AEROJET WESTERN PLUME STUDY AREA

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Groundwater	Groundwater	Layers A, B, C, D, and E	Occupational	Adult	Dermal Ingestion	On-Site	None	Groundwater is not currently used on-site.
			Layers C, D, and E	Residential	Adult	Dermal Ingestion	Off-Site	Quantitative	Water purveyors use these aquifers to supply water to off-site residents. Off-site Layers A and B are unimpacted or not related to Aerojet
					Child	Dermal Ingestion	Off-site	Quantitative	Water purveyors use these aquifers to supply water to off-site residents. Off-site Layers A and B are unimpacted or not related to Aerojet
		Air	Layers A, B, C, D, and E Volatilization through Subsurface	Occupational	Adult	Inhalation	On-Site	Qualitiative	Flux sampling on-site has not detected volatiles in or near buildings
			Layers C, D, and E Water Vapors from Groundwater Use	Residential	Adult	Inhalation	Off-Site	Quantitative	Water purveyors use these aquifers to supply water to off-site residents. Off-site Layers A and B are unimpacted or not related to Aerojet
					Child	Inhalation	Off-Site	Quantitative	Water purveyors use these aquifers to supply water to off-site residents. Off-site Layers A and B are unimpacted or not related to Aerojet
			Layers C, D, and E Volatilization through Subsurface	Residential	Adult	Inhalation	Off-site	Quantitative	Potentially complete but likely insignificant given depth and geology
					Child	Inhalation	Off-site	Quantitative	Potentially complete but likely insignificant given depth and geology
Future	Groundwater	Groundwater	Layers A, B, C, D, and E	Residential	Adult	Dermal Ingestion	On-site	Quantitative	Default assumption for future exposure
					Child	Dermal Ingestion	On-site	Quantitative	Default assumption for future exposure
			Layers C, D, and E	Residential	Adult	Dermal Ingestion	Off-Site	Quantitative	Default assumption for future exposure; Off-site Layers A and B are unimpacted or not related to Aerojet
					Child	Dermal Ingestion	Off-Site	Quantitative	Default assumption for future exposure Off-site Layers A and B are unimpacted or not related to Aerojet
		Air	Layers A, B, C, D, and E Water Vapors from Groundwater Use	Residential	Adult	Inhalation	On-site	Quantitative	Default assumption for future exposure
					Child	Inhalation	On-site	Quantitative	Default assumption for future exposure
			Layers C, D, and E Water Vapors from Groundwater Use	Residential	Adult	Inhalation	Off-Site	Quantitative	Default assumption for future exposure. Off-site Layers A and B are unimpacted or not related to Aerojet
					Child	Inhalation	Off-Site	Quantitative	Default assumption for future exposure Off-site Layers A and B are unimpacted or not related to Aerojet
			Layers A, B, C, D, and E Volatilization through Subsurface	Residential	Adult	Inhalation	On-site	Quantitative	Potentially complete but likely insignificant given depth and geology
					Child	Inhalation	On-site	Quantitative	Potentially complete but likely insignificant given depth and geology
			Layers C, D, and E Volatilization through Subsurface	Residential	Adult	Inhalation	Off-Site	Quantitative	Potentially complete but likely insignificant given depth and geology Off-site Layers A and B are unimpacted or not related to Aerojet
					Child	Inhalation	Off-site	Quantitative	Potentially complete but likely insignificant given depth and geology Off-site Layers A and B are unimpacted or not related to Aerojet

09/11/2000

TABLE B.5-1
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer A onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	1.96E-05	mg/kg-day	0.057	(mg/kg-day)-1	1.1E-06
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	1.43E-02	mg/kg-day	0.091	(mg/kg-day)-1	1.3E-03
	1,2-Dichloroethene	10	ug/L	10	ug/L	10	1.51E-04	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	230	ug/L	230	ug/L	230	3.47E-03	mg/kg-day	0.006	(mg/kg-day)-1	2.1E-05
	Tetrachloroethene	0.82	ug/L	0.82	ug/L	0.82	1.24E-05	mg/kg-day	0.052	(mg/kg-day)-1	6.4E-07
	Trichloroethene	82	ug/L	82	ug/L	82	1.24E-03	mg/kg-day	0.011	(mg/kg-day)-1	1.4E-05
	Perchlorate	75	ug/L	75	ug/L	75	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.16	ug/L	0.16	ug/L	0.16	2.41E-06	mg/kg-day	51	(mg/kg-day)-1	1.2E-04
	Nitrate	219	mg/L	219	mg/L	219	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	22	mg/L	22	mg/L	22	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	3.22E-07	mg/kg-day	0.057	(mg/kg-day)-1	1.8E-08
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	1.49E-04	mg/kg-day	0.091	(mg/kg-day)-1	1.4E-05
	1,2-Dichloroethene	10	ug/L	10	ug/L	10	2.95E-06	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	230	ug/L	230	ug/L	230	6.04E-05	mg/kg-day	0.006	(mg/kg-day)-1	3.7E-07
	Tetrachloroethene	0.82	ug/L	0.82	ug/L	0.82	1.16E-06	mg/kg-day	0.052	(mg/kg-day)-1	6.0E-08
	Trichloroethene	82	ug/L	82	ug/L	82	3.87E-05	mg/kg-day	0.011	(mg/kg-day)-1	4.3E-07
	Perchlorate	75	ug/L	75	ug/L	75	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.16	ug/L	0.16	ug/L	0.16	3.78E-09	mg/kg-day	51	(mg/kg-day)-1	1.9E-07
	Nitrate	219	mg/L	219	mg/L	219	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	22	mg/L	22	mg/L	22	NA	mg/kg-day	NA	(mg/kg-day)-1	NA

TABLE B.5-1
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer A onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Inhalation via Groundwater Use	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	9.79E-05	mg/kg-day	0.056	(mg/kg-day)-1	5.5E-06
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	7.16E-02	mg/kg-day	0.091	(mg/kg-day)-1	6.5E-03
	1,2-Dichloroethene	10	ug/L	10	ug/L	10	7.53E-04	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	230	ug/L	230	ug/L	230	1.73E-02	mg/kg-day	0.081	(mg/kg-day)-1	1.4E-03
	Tetrachloroethene	0.82	ug/L	0.82	ug/L	0.82	6.18E-05	mg/kg-day	0.002	(mg/kg-day)-1	1.2E-07
	Trichloroethene	82	ug/L	82	ug/L	82	6.18E-03	mg/kg-day	0.006	(mg/kg-day)-1	3.7E-05
	Perchlorate	75	ug/L	75	ug/L	75	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.16	ug/L	0.16	ug/L	0.16	NA	mg/kg-day	49	(mg/kg-day)-1	NA
	Nitrate	219	mg/L	219	mg/L	219	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	22	mg/L	22	mg/L	22	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	9.4E-03

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

NA = Not Applicable

TABLE B.5-2
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer A onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	4.57E-05	mg/kg-day	0.004	mg/kg-day		mg/kg-day	1.1E-02
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	3.34E-02	mg/kg-day	0.030	mg/kg-day		mg/kg-day	1.1E+00
	1,2-Dichloroethene	10	ug/L	10	ug/L	10	3.52E-04	mg/kg-day	0.009	mg/kg-day		mg/kg-day	3.9E-02
	Chloroform	230	ug/L	230	ug/L	230	8.09E-03	mg/kg-day	0.010	mg/kg-day		mg/kg-day	8.1E-01
	Tetrachloroethene	0.82	ug/L	0.82	ug/L	0.82	2.88E-05	mg/kg-day	0.010	mg/kg-day		mg/kg-day	2.9E-03
	Trichloroethene	82	ug/L	82	ug/L	82	2.88E-03	mg/kg-day	0.006	mg/kg-day		mg/kg-day	4.8E-01
	Perchlorate	75	ug/L	75	ug/L	75	2.64E-03	mg/kg-day	0.0005	mg/kg-day		mg/kg-day	5.3E+00
	NDMA	0.16	ug/L	0.16	ug/L	0.16	5.63E-06	mg/kg-day	NA	mg/kg-day		mg/kg-day	NA
	Nitrate	219	mg/L	219	mg/L	219	7.70E+00	mg/kg-day	1.6	mg/kg-day		mg/kg-day	4.8E+00
	Nitrite	22	mg/L	22	mg/L	22	7.74E-01	mg/kg-day	0.1	mg/kg-day		mg/kg-day	7.7E+00
Dermal Contact	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	7.52E-07	mg/kg-day	0.004	mg/kg-day		mg/kg-day	1.9E-04
	1.2-Dichloroethane	950	ug/L	950	ug/L	950	3.47E-04	mg/kg-day	0.030	mg/kg-day		mg/kg-day	1.2E-02
	1,2-Dichloroethene	10	ug/L	10	ug/L	10	6.88E-06	mg/kg-day	0.009	mg/kg-day		mg/kg-day	7.6E-04
	Chloroform	230	ug/L	230	ug/L	230	1.41E-04	mg/kg-day	0.010	mg/kg-day		mg/kg-day	1.4E-02
	Tetrachloroethene	0.82	ug/L	0.82	ug/L	0.82	2.71E-06	mg/kg-day	0.010	mg/kg-day		mg/kg-day	2.7E-04
	Trichloroethene	82	ug/L	82	ug/L	82	9.03E-05	mg/kg-day	0.006	mg/kg-day		mg/kg-day	1.5E-02
	Perchlorate	75	ug/L	75	ug/L	75	4.13E-06	mg/kg-day	0.0005	mg/kg-day		mg/kg-day	8.3E-03
	NDMA	0.16	ug/L	0.16	ug/L	0.16	8.81E-09	mg/kg-day	NA	mg/kg-day		mg/kg-day	NA
	Nitrate	219	mg/L	219	mg/L	219	NA	mg/kg-day	1.6	mg/kg-day		mg/kg-day	NA
	Nitrite	22	mg/L	22	mg/L	22	NA	mg/kg-day	0.1	mg/kg-day		mg/kg-day	NA

TABLE B.5-2
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer A onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Inhalation via Groundwat Use	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	2.29E-04	mg/kg-day		mg/kg-day	0.004	mg/kg-day	5.7E-02
	1.2-Dichloroethane	950	ug/L	950	ug/L	950	1.67E-01	mg/kg-day		mg/kg-day	0.0014	mg/kg-day	1.2E+02
	1,2-Dichloroethene	10	ug/L	10	ug/L	10	1.76E-03	mg/kg-day		mg/kg-day	0.009	mg/kg-day	2.0E-01
	Chloroform	230	ug/L	230	ug/L	230	4.04E-02	mg/kg-day		mg/kg-day	0.000086	mg/kg-day	4.7E+02
	Tetrachloroethene	0.82	ug/L	0.82	ug/L	0.82	1.44E-04	mg/kg-day		mg/kg-day	0.11	mg/kg-day	1.3E-03
	Trichloroethene	82	ug/L	82	ug/L	82	1.44E-02	mg/kg-day		mg/kg-day	0.006	mg/kg-day	2.4E+00
	Perchlorate	75	ug/L	75	ug/L	75	NA	mg/kg-day		mg/kg-day	NA	mg/kg-day	NA
	NDMA	0.16	ug/L	0.16	ug/L	0.16	NA	mg/kg-day		mg/kg-day	NA	mg/kg-day	NA
	Nitrate	219	mg/L	219	mg/L	219	NA	mg/kg-day		mg/kg-day	NA	mg/kg-day	NA
	Nitrite	22	mg/L	22	mg/L	22	NA	mg/kg-day		mg/kg-day	NA	mg/kg-day	NA
												Total Hazard Across All Exposure Routes/Pathways	6.1E+02

NA = Not Applicable

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic Values

(3) Reference concentrations converted to reference doses

TABLE B.5-3
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer B onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	2.26E-05	mg/kg-day	0.057	(mg/kg-day)-1	1.3E-06
	1,1-Dichloroethane	1.8	ug/L	1.8	ug/L	1.8	2.71E-05	mg/kg-day	0.006	(mg/kg-day)-1	1.5E-07
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	7.23E-04	mg/kg-day	0.600	(mg/kg-day)-1	4.3E-04
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	2.11E-05	mg/kg-day	0.130	(mg/kg-day)-1	2.7E-06
	Chloroform	350	ug/L	350	ug/L	350	5.27E-03	mg/kg-day	0.006	(mg/kg-day)-1	3.2E-05
	Freon-113	1.1	ug/L	1.1	ug/L	1.1	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	3.16E-05	mg/kg-day	0.052	(mg/kg-day)-1	1.6E-06
	Trichloroethene	9400	ug/L	9400	ug/L	9400	1.42E-01	mg/kg-day	0.011	(mg/kg-day)-1	1.6E-03
	Perchlorate	11000	ug/L	11000	ug/L	11000	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.32	ug/L	0.32	ug/L	0.32	4.82E-06	mg/kg-day	51	(mg/kg-day)-1	2.5E-04
	Nitrate	11	mg/L	11	ug/L	11	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	0.56	mg/L	0.56	ug/L	0.56	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	3.72E-07	mg/kg-day	0.057	(mg/kg-day)-1	2.1E-08
	1,1-Dichloroethane	1.8	ug/L	1.8	ug/L	1.8	4.73E-07	mg/kg-day	0.006	(mg/kg-day)-1	2.7E-09
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	2.27E-05	mg/kg-day	0.600	(mg/kg-day)-1	1.4E-05
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	9.08E-07	mg/kg-day	0.130	(mg/kg-day)-1	1.2E-07
	Chloroform	350	ug/L	350	ug/L	350	9.19E-05	mg/kg-day	0.006	(mg/kg-day)-1	5.6E-07
	Freon-113	1.1	ug/L	1.1	ug/L	1.1	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	2.97E-06	mg/kg-day	0.052	(mg/kg-day)-1	1.5E-07
	Trichloroethene	9400	ug/L	9400	ug/L	9400	4.44E-03	mg/kg-day	0.011	(mg/kg-day)-1	4.9E-05
	Perchlorate	11000	ug/L	11000	ug/L	11000	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.32	ug/L	0.32	ug/L	0.32	7.55E-09	mg/kg-day	51	(mg/kg-day)-1	3.9E-07
	Nitrate	11	mg/L	11	ug/L	11	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	0.56	mg/L	0.56	ug/L	0.56	NA	mg/kg-day	NA	(mg/kg-day)-1	NA

TABLE B.5-3
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer B onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Inhalation via Groundwater Use	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	1.13E-04	mg/kg-day	0.056	(mg/kg-day)-1	6.3E-06
	1,1-Dichloroethane	1.8	ug/L	1.8	ug/L	1.8	1.36E-04	mg/kg-day	0.0057	(mg/kg-day)-1	7.7E-07
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	3.62E-03	mg/kg-day	0.18	(mg/kg-day)-1	6.5E-04
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	1.05E-04	mg/kg-day	0.053	(mg/kg-day)-1	5.6E-06
	Chloroform	350	ug/L	350	ug/L	350	2.64E-02	mg/kg-day	0.081	(mg/kg-day)-1	2.1E-03
	Freon-113	1.1	ug/L	1.1	ug/L	1.1	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	1.58E-04	mg/kg-day	0.002	(mg/kg-day)-1	3.2E-07
	Trichloroethene	9400	ug/L	9400	ug/L	9400	7.08E-01	mg/kg-day	0.006	(mg/kg-day)-1	4.2E-03
	Perchlorate	11000	ug/L	11000	ug/L	11000	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.32	ug/L	0.32	ug/L	0.32	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrate	11	mg/L	11	ug/L	11	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	0.56	mg/L	0.56	ug/L	0.56	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	9.4E-03

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-4
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer B onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	5.27E-05	mg/kg-day	0.004	mg/kg-day			1.32E-02
	1,1-Dichloroethane	1.8	ug/L	1.8	ug/L	1.8	6.33E-05	mg/kg-day	0.100	mg/kg-day			6.33E-04
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	1.69E-03	mg/kg-day	0.009	mg/kg-day			1.88E-01
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	4.22E-03	mg/kg-day	0.009	mg/kg-day			4.69E-01
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	4.92E-05	mg/kg-day	0.001	mg/kg-day			7.03E-02
	Chloroform	350	ug/L	350	ug/L	350	1.23E-02	mg/kg-day	0.010	mg/kg-day			1.23E+00
	Freon-113	1.1	ug/L	1.1	ug/L	1.1	3.87E-05	mg/kg-day	30.000	mg/kg-day			1.29E-06
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	7.38E-05	mg/kg-day	0.01	mg/kg-day			7.38E-03
	Trichloroethene	9400	ug/L	9400	ug/L	9400	3.31E-01	mg/kg-day	0.006	mg/kg-day			5.51E+01
	Perchlorate	11000	ug/L	11000	ug/L	11000	3.87E-01	mg/kg-day	0.0005	mg/kg-day			7.74E+02
	NDMA	0.32	ug/L	0.32	ug/L	0.32	1.13E-05	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	11	mg/L	11	ug/L	11	3.87E-01	mg/kg-day	1.6	mg/kg-day			2.42E-01
	Nitrite	0.56	mg/L	0.56	ug/L	0.56	1.97E-02	mg/kg-day	0.1	mg/kg-day			1.97E-01
Dermal Contact	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	8.67E-07	mg/kg-day	0.004	mg/kg-day			2.17E-04
	1,1-Dichloroethane	1.8	ug/L	1.8	ug/L	1.8	1.10E-06	mg/kg-day	0.100	mg/kg-day			1.10E-05
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	5.29E-05	mg/kg-day	0.009	mg/kg-day			5.87E-03
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	8.26E-05	mg/kg-day	0.009	mg/kg-day			9.18E-03
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	2.12E-06	mg/kg-day	0.001	mg/kg-day			3.03E-03
	Chloroform	350	ug/L	350	ug/L	350	2.14E-04	mg/kg-day	0.010	mg/kg-day			2.14E-02
	Freon-113	1.1	ug/L	1.1	ug/L	1.1	1.29E-06	mg/kg-day	30.000	mg/kg-day			4.29E-08
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	6.94E-06	mg/kg-day	0.01	mg/kg-day			6.94E-04
	Trichloroethene	9400	ug/L	9400	ug/L	9400	1.04E-02	mg/kg-day	0.006	mg/kg-day			1.73E+00
	Perchlorate	11000	ug/L	11000	ug/L	11000	6.06E-04	mg/kg-day	0.0005	mg/kg-day			1.21E+00
	NDMA	0.32	ug/L	0.32	ug/L	0.32	1.76E-08	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	11	mg/L	11	ug/L	11	NA	mg/kg-day	1.6	mg/kg-day			NA
	Nitrite	0.56	mg/L	0.56	ug/L	0.56	NA	mg/kg-day	0.1	mg/kg-day			NA

TABLE B.5-4
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer B onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Inhalation via Groundwater Use	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	2.64E-04	mg/kg-day			0.004	mg/kg-day	6.59E-02
	1,1-Dichloroethane	1.8	ug/L	1.8	ug/L	1.8	3.16E-04	mg/kg-day			0.14	mg/kg-day	2.26E-03
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	8.44E-03	mg/kg-day			0.009	mg/kg-day	9.38E-01
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	2.11E-02	mg/kg-day			0.009	mg/kg-day	2.34E+00
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	2.46E-04	mg/kg-day			0.0007	mg/kg-day	3.52E-01
	Chloroform	350	ug/L	350	ug/L	350	6.15E-02	mg/kg-day			0.000086	mg/kg-day	7.15E+02
	Freon-113	1.1	ug/L	1.1	ug/L	1.1	1.93E-04	mg/kg-day			8.6	mg/kg-day	2.25E-05
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	3.69E-04	mg/kg-day			0.11	mg/kg-day	3.36E-03
	Trichloroethene	9400	ug/L	9400	ug/L	9400	1.65E+00	mg/kg-day			0.006	mg/kg-day	2.75E+02
	Perchlorate	11000	ug/L	11000	ug/L	11000	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	0.32	ug/L	0.32	ug/L	0.32	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrate	11	mg/L	11	ug/L	11	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrite	0.56	mg/L	0.56	ug/L	0.56	NA	mg/kg-day			NA	mg/kg-day	NA
												Total Hazard Across All Exposure Routes/Pathways	1.8E+03

NA = Not Applicable

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic Values

(3) Reference concentrations converted to reference doses

TABLE B.5-5

CALCULATION OF CANCER RISKS

REASONABLE MAXIMUM EXPOSURE

AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1-Dichloroethane	1.3	ug/L	1.3	ug/L	1.3	1.96E-05	mg/kg-day	0.006	(mg/kg-day)-1	1.1E-07
	1,1-Dichoroethene	63	ug/L	63	ug/L	63	9.49E-04	mg/kg-day	0.600	(mg/kg-day)-1	5.7E-04
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	2.41E-03	mg/kg-day	0.091	(mg/kg-day)-1	2.2E-04
	1,2-Dichloroethene	41	ug/L	41	ug/L	41	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	9.95E-06	mg/kg-day	0.130	(mg/kg-day)-1	1.3E-06
	Chloroform	670	ug/L	670	ug/L	670	1.01E-02	mg/kg-day	0.006	(mg/kg-day)-1	6.2E-05
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	8.89E-05	mg/kg-day	0.052	(mg/kg-day)-1	4.6E-06
	Trichloroethene	5300	ug/L	5300	ug/L	5300	7.99E-02	mg/kg-day	0.011	(mg/kg-day)-1	8.8E-04
	Perchlorate	8200	ug/L	8200	ug/L	8200	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.39	ug/L	0.39	ug/L	0.39	5.88E-06	mg/kg-day	51	(mg/kg-day)-1	3.0E-04
	Nitrate	7.8	mg/L	7.8	mg/l	7.8	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	0.08	mg/L	0.08	mg/l	0.08	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,1-Dichloroethane	1.3	ug/L	1.3	ug/L	1.3E+00	3.41E-07	mg/kg-day	0.006	(mg/kg-day)-1	1.9E-09
	1,1-Dichoroethene	63	ug/L	63	ug/L	6.3E+01	2.97E-05	mg/kg-day	0.600	(mg/kg-day)-1	1.8E-05
	1,2-Dichloroethane	160	ug/L	160	ug/L	1.6E+02	2.50E-05	mg/kg-day	0.091	(mg/kg-day)-1	2.3E-06
	1,2-Dichloroethene	41	ug/L	41	ug/L	4.10E+01	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	6.6E-01	4.28E-07	mg/kg-day	0.130	(mg/kg-day)-1	5.6E-08
	Chloroform	670	ug/L	670	ug/L	6.7E+02	1.76E-04	mg/kg-day	0.006	(mg/kg-day)-1	1.1E-06
	Freon-113	5.4	ug/L	5.4	ug/L	5.4E+00	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9E+00	8.35E-06	mg/kg-day	0.052	(mg/kg-day)-1	4.3E-07
	Trichloroethene	5300	ug/L	5300	ug/L	5.3E+03	2.50E-03	mg/kg-day	0.011	(mg/kg-day)-1	2.8E-05
	Perchlorate	8200	ug/L	8200	ug/L	8.2E+03	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.39	ug/L	0.39	ug/L	3.9E-01	9.20E-09	mg/kg-day	51	(mg/kg-day)-1	4.7E-07
	Nitrate	7.8	mg/L	7.8	mg/l	7.8E+00	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	0.08	mg/L	0.08	mg/l	8.0E-02	NA	mg/kg-day	NA	(mg/kg-day)-1	NA

TABLE B.5-5

CALCULATION OF CANCER RISKS

REASONABLE MAXIMUM EXPOSURE

AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Inhalation via Groundwater Use	1,1-Dichloroethane	1.3	ug/L	1.3	ug/L	1.3	9.79E-05	mg/kg-day	0.0057	(mg/kg-day)-1	5.6E-07
	1,1-Dichoroethene	63	ug/L	63	ug/L	63	4.75E-03	mg/kg-day	0.18	(mg/kg-day)-1	8.5E-04
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	1.21E-02	mg/kg-day	0.091	(mg/kg-day)-1	1.1E-03
	1,2-Dichloroethene	41	ug/L	41	ug/L	41	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	4.97E-05	mg/kg-day	0.053	(mg/kg-day)-1	2.6E-06
	Chloroform	670	ug/L	670	ug/L	670	5.05E-02	mg/kg-day	0.081	(mg/kg-day)-1	4.1E-03
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	4.45E-04	mg/kg-day	0.002	(mg/kg-day)-1	8.9E-07
	Trichloroethene	5300	ug/L	5300	ug/L	5300	3.99E-01	mg/kg-day	0.006	(mg/kg-day)-1	2.4E-03
	Perchlorate	8200	ug/L	8200	ug/L	8200	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.39	ug/L	0.39	ug/L	0.39	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrate	7.8	mg/L	7.8	mg/l	7.8	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	0.08	mg/L	0.08	mg/l	0.08	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	1.1E-02

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

E B.5-6
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1-Dichloroethane	1.3	ug/L	1.3	ug/L	1.3	4.57E-05	mg/kg-day	0.100	mg/kg-day			4.6E-04
	1,1-Dichoroethene	63	ug/L	63	ug/L	63	2.22E-03	mg/kg-day	0.009	mg/kg-day			2.5E-01
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	5.63E-03	mg/kg-day	0.030	mg/kg-day			1.9E-01
	1,2-Dichloroethene	41	ug/L	41	ug/L	41	1.44E-03	mg/kg-day	0.009	mg/kg-day			1.6E-01
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	2.32E-05	mg/kg-day	0.001	mg/kg-day			3.3E-02
	Chloroform	670	ug/L	670	ug/L	670	2.36E-02	mg/kg-day	0.010	mg/kg-day			2.4E+00
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	1.90E-04	mg/kg-day	30.000	mg/kg-day			6.3E-06
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	2.07E-04	mg/kg-day	0.010	mg/kg-day			2.1E-02
	Trichloroethene	5300	ug/L	5300	ug/L	5300	1.86E-01	mg/kg-day	0.006	mg/kg-day			3.1E+01
	Perchlorate	8200	ug/L	8200	ug/L	8200	2.88E-01	mg/kg-day	0.0005	mg/kg-day			5.8E+02
	NDMA	0.39	ug/L	0.39	ug/L	0.39	1.37E-05	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	7.8	mg/L	7.8	mg/l	7.8	2.74E-01	mg/kg-day	1.6	mg/kg-day			1.7E-01
	Nitrite	0.08	mg/L	0.08	mg/l	0.08	2.81E-03	mg/kg-day	0.1	mg/kg-day			2.8E-02
Dermal Contact	1,1-Dichloroethane	1.3	ug/L	1.3	ug/L	1.3	7.96E-07	mg/kg-day	0.100	mg/kg-day			8.0E-06
	1,1-Dichoroethene	63	ug/L	63	ug/L	63	6.94E-05	mg/kg-day	0.009	mg/kg-day			7.7E-03
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	5.84E-05	mg/kg-day	0.030	mg/kg-day			1.9E-03
	1,2-Dichloroethene	41	ug/L	41	ug/L	41	2.82E-05	mg/kg-day	0.009	mg/kg-day			3.1E-03
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	9.99E-07	mg/kg-day	0.001	mg/kg-day			1.4E-03
	Chloroform	670	ug/L	670	ug/L	670	4.10E-04	mg/kg-day	0.010	mg/kg-day			4.1E-02
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	6.32E-06	mg/kg-day	30.000	mg/kg-day			2.1E-07
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	1.95E-05	mg/kg-day	0.010	mg/kg-day			1.9E-03
	Trichloroethene	5300	ug/L	5300	ug/L	5300	5.84E-03	mg/kg-day	0.006	mg/kg-day			9.7E-01
	Perchlorate	8200	ug/L	8200	ug/L	8200	4.51E-04	mg/kg-day	0.0005	mg/kg-day			9.0E-01
	NDMA	0.39	ug/L	0.39	ug/L	0.39	2.15E-08	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	7.8	mg/L	7.8	mg/l	7.8	NA	mg/kg-day	1.6	mg/kg-day			NA
	Nitrite	0.08	mg/L	0.08	mg/l	0.08	NA	mg/kg-day	0.1	mg/kg-day			NA

TABLE B.5-6
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Inhalation via Groundwat Use	1,1-Dichloroethane	1.3	ug/L	1.3	ug/L	1.3	2.29E-04	mg/kg-day			0.14	mg/kg-day	1.6E-03
	1,1-Dichoroethene	63	ug/L	63	ug/L	63	1.11E-02	mg/kg-day			0.009	mg/kg-day	1.2E+00
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	2.81E-02	mg/kg-day			0.0014	mg/kg-day	2.0E+01
	1,2-Dichloroethene	41	ug/L	41	ug/L	41	7.21E-03	mg/kg-day			0.009	mg/kg-day	8.0E-01
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	1.16E-04	mg/kg-day			0.0007	mg/kg-day	1.7E-01
	Chloroform	670	ug/L	670	ug/L	670	1.18E-01	mg/kg-day			0.000086	mg/kg-day	1.4E+03
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	9.49E-04	mg/kg-day			8.6	mg/kg-day	1.1E-04
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	1.04E-03	mg/kg-day			0.11	mg/kg-day	9.4E-03
	Trichloroethene	5300	ug/L	5300	ug/L	5300	9.32E-01	mg/kg-day			0.006	mg/kg-day	1.6E+02
	Perchlorate	8200	ug/L	8200	ug/L	8200	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	0.39	ug/L	0.39	ug/L	0.39	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrate	7.8	mg/L	7.8	mg/l	7.8	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrite	0.08	mg/L	0.08	mg/l	0.08	NA	mg/kg-day			NA	mg/kg-day	NA
													2.2E+03

NA = Not Applicable

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic Values

(3) Reference concentrations converted to reference doses

TABLE B.5-7
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer D onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1-Dichloroethane	1.7	ug/L	1.7	ug/L	1.7	2.56E-05	mg/kg-day	0.0057	(mg/kg-day)-1	1.5E-07
	1,1-Dichloroethene	14	ug/L	14	ug/L	14	2.11E-04	mg/kg-day	0.600	(mg/kg-day)-1	1.3E-04
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	7.08E-05	mg/kg-day	0.091	(mg/kg-day)-1	6.4E-06
	1,2-Dichloroethene	25.0	ug/L	25.0	ug/L	25.0	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	460	ug/L	460	ug/L	460	6.9E-03	mg/kg-day	0.006	(mg/kg-day)-1	4.2E-05
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Tetrachloroethene	5	ug/L	5	ug/L	5	7.5E-05	mg/kg-day	0.052	(mg/kg-day)-1	3.9E-06
	Trichloroethene	1500	ug/L	1500	ug/L	1500	2.3E-02	mg/kg-day	0.011	(mg/kg-day)-1	2.5E-04
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	1.3	ug/L	1.3	ug/L	1.3	2.0E-05	mg/kg-day	51	(mg/kg-day)-1	1.0E-03
	Nitrate	6.7	mg/L	6.7	mg/L	6.7	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,1-Dichloroethane	1.7	ug/L	1.7	ug/L	1.7	4.46E-07	mg/kg-day	0.0057	(mg/kg-day)-1	2.5E-09
	1,1-Dichloroethene	14	ug/L	14	ug/L	14	6.61E-06	mg/kg-day	0.600	(mg/kg-day)-1	4.0E-06
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	7.35E-07	mg/kg-day	0.091	(mg/kg-day)-1	6.7E-08
	1,2-Dichloroethene	25	ug/L	25	ug/L	25	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	460	ug/L	460	ug/L	460	1.21E-04	mg/kg-day	0.006	(mg/kg-day)-1	7.4E-07
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Tetrachloroethene	5	ug/L	5	ug/L	5	7.08E-06	mg/kg-day	0.052	(mg/kg-day)-1	3.7E-07
	Trichloroethene	1500	ug/L	1500	ug/L	1500	7.08E-04	mg/kg-day	0.011	(mg/kg-day)-1	7.8E-06
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	1.3	ug/L	1.3	ug/L	1.3	3.07E-08	mg/kg-day	51	(mg/kg-day)-1	1.6E-06
	Nitrate	6.7	mg/L	6.7	mg/L	6.7	NA	mg/kg-day	NA	(mg/kg-day)-1	NA

TABLE B.5-7
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer D onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Inhalation via Groundwater Use	1,1-Dichloroethane	1.7	ug/L	1.7	ug/L	1.7	1.28E-04	mg/kg-day	0.0057	(mg/kg-day)-1	7.3E-07
	1,1-Dichloroethene	14	ug/L	14	ug/L	14	1.05E-03	mg/kg-day	0.18	(mg/kg-day)-1	1.9E-04
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	3.54E-04	mg/kg-day	0.091	(mg/kg-day)-1	3.2E-05
	1,2-Dichloroethene	25.0	ug/L	25.0	ug/L	25.0	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	460	ug/L	460	ug/L	460	3.47E-02	mg/kg-day	0.081	(mg/kg-day)-1	2.8E-03
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Tetrachloroethene	5	ug/L	5	ug/L	5	3.77E-04	mg/kg-day	0.002	(mg/kg-day)-1	7.5E-07
	Trichloroethene	1500	ug/L	1500	ug/L	1500	1.13E-01	mg/kg-day	0.006	(mg/kg-day)-1	6.8E-04
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	1.3	ug/L	1.3	ug/L	1.3	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrate	6.7	mg/L	6.7	mg/L	6.7	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	5.1E-03

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-8
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer D onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1-Dichloroethane	1.7	ug/L	1.7	ug/L	1.7	5.98E-05	mg/kg-day	0.100	mg/kg-day			6.0E-04
	1,1-Dichloroethene	14	ug/L	14	ug/L	14	4.92E-04	mg/kg-day	0.009	mg/kg-day			5.5E-02
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	1.65E-04	mg/kg-day	0.030	mg/kg-day			5.5E-03
	1,2-Dichloroethene	25.0	ug/L	25.0	ug/L	25.0	8.79E-04	mg/kg-day	0.009	mg/kg-day			9.8E-02
	Chloroform	460	ug/L	460	ug/L	460	1.62E-02	mg/kg-day	0.010	mg/kg-day			1.6E+00
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	1.90E-04	mg/kg-day	30.000	mg/kg-day			6.3E-06
	Tetrachloroethene	5	ug/L	5	ug/L	5	1.76E-04	mg/kg-day	0.010	mg/kg-day			1.8E-02
	Trichloroethene	1500	ug/L	1500	ug/L	1500	5.27E-02	mg/kg-day	0.006	mg/kg-day			8.8E+00
	Perchlorate	8700	ug/L	8700	ug/L	8700	3.06E-01	mg/kg-day	0.001	mg/kg-day			6.1E+02
	NDMA	1.3	ug/L	1.3	ug/L	1.3	4.57E-05	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	6.7	mg/L	6.7	mg/L	6.7	2.36E-01	mg/kg-day	1.6	mg/kg-day			1.5E-01
Dermal Contact	1,1-Dichloroethane	1.7	ug/L	1.7	ug/L	1.7	1.04E-06	mg/kg-day	0.100	mg/kg-day			1.0E-05
	1,1-Dichloroethene	14	ug/L	14	ug/L	14	1.54E-05	mg/kg-day	0.009	mg/kg-day			1.7E-03
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	1.71E-06	mg/kg-day	0.030	mg/kg-day			5.7E-05
	1,2-Dichloroethene	25.0	ug/L	25.0	ug/L	25.0	1.72E-05	mg/kg-day	0.009	mg/kg-day			1.9E-03
	Chloroform	460	ug/L	460	ug/L	460	2.82E-04	mg/kg-day	0.010	mg/kg-day			2.8E-02
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	6.32E-06	mg/kg-day	30.000	mg/kg-day			2.1E-07
	Tetrachloroethene	5	ug/L	5	ug/L	5	1.65E-05	mg/kg-day	0.010	mg/kg-day			1.7E-03
	Trichloroethene	1500	ug/L	1500	ug/L	1500	1.65E-03	mg/kg-day	0.006	mg/kg-day			2.8E-01
	Perchlorate	8700	ug/L	8700	ug/L	8700	4.79E-04	mg/kg-day	0.001	mg/kg-day			9.6E-01
	NDMA	1.3	ug/L	1.3	ug/L	1.3	7.16E-08	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	6.7	mg/L	6.7	mg/L	6.7	NA	mg/kg-day	1.6	mg/kg-day			NA

TABLE B.5-8
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer D onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Inhalation via Groundwate Use	1,1-Dichloroethane	1.7	ug/L	1.7	ug/L	1.7	2.99E-04	mg/kg-day			0.14	mg/kg-day	2.1E-03
	1,1-Dichloroethene	14	ug/L	14	ug/L	14	2.46E-03	mg/kg-day			0.009	mg/kg-day	2.7E-01
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	8.26E-04	mg/kg-day			0.0014	mg/kg-day	5.9E-01
	1,2-Dichloroethene	25.0	ug/L	25.0	ug/L	25.0	4.39E-03	mg/kg-day			0.009	mg/kg-day	4.9E-01
	Chloroform	460	ug/L	460	ug/L	460	8.09E-02	mg/kg-day			8.60E-05	mg/kg-day	9.4E+02
	Freon-113	5.4	ug/L	5.4	ug/L	5.4	9.49E-04	mg/kg-day			8.60E+00	mg/kg-day	1.1E-04
	Tetrachloroethene	5	ug/L	5	ug/L	5	8.79E-04	mg/kg-day			1.10E-01	mg/kg-day	8.0E-03
	Trichloroethene	1500	ug/L	1500	ug/L	1500	2.64E-01	mg/kg-day			6.00E-03	mg/kg-day	4.4E+01
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	1.3	ug/L	1.3	ug/L	1.3	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrate	6.7	mg/L	6.7	mg/L	6.7	NA	mg/kg-day			NA	mg/kg-day	NA
												Total Risk Across All Exposure Routes/Pathways	1.6E+03

NA = Not Applicable

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic Values

(3) Reference concentrations converted to reference doses

TABLE B.5-9
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timefram	Future
Medium:	Layer E onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Populatio	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Chloroform	1.6	ug/L	1.6	ug/L	1.6	2.41E-05	mg/kg-day	0.0061	(mg/kg-day)-1	1.5E-07
	Freon-113	1.3	ug/L	1.3	ug/L	1.3	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Trichloroethene	84	ug/L	84	ug/L	84.0	2.3E-02	mg/kg-day	0.011	(mg/kg-day)-1	2.5E-04
	Perchlorate	610	ug/L	610	ug/L	610	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.38	ug/L	0.38	ug/L	0.38	2.0E-05	mg/kg-day	51	(mg/kg-day)-1	1.0E-03
	Nitrate	6.6	mg/L	6.6	mg/L	6.6	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal	Chloroform	1.6	ug/L	1.6	ug/L	1.6	4.20E-07	mg/kg-day	0.0061	(mg/kg-day)-1	2.6E-09
	Freon-113	1.3	ug/L	1.3	ug/L	1.3	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Contact	Trichloroethene	84	ug/L	84	ug/L	84.0	3.96E-05	mg/kg-day	0.011	(mg/kg-day)-1	4.4E-07
	Perchlorate	610	ug/L	610	ug/L	610	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.38	ug/L	0.38	ug/L	0.38	8.97E-09	mg/kg-day	51	(mg/kg-day)-1	4.6E-07
	Nitrate	6.6	mg/L	6.6	mg/L	6.6	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Inhalation	Chloroform	1.6	ug/L	1.6	ug/L	1.6	1.21E-04	mg/kg-day	0.081	(mg/kg-day)-1	9.8E-06
via	Freon-113	1.3	ug/L	1.3	ug/L	1.3	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Groundwater	Trichloroethene	84	ug/L	84	ug/L	84.0	6.33E-03	mg/kg-day	0.006	(mg/kg-day)-1	3.8E-05
Use	Perchlorate	610	ug/L	610	ug/L	610	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.38	ug/L	0.38	ug/L	0.38	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrate	6.6	mg/L	6.6	mg/L	6.6	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	1.3E-03

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-10
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timefram	Future
Medium:	Layer E onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Populatio	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	Chloroform	1.6	ug/L	1.6	ug/L	1.6	5.63E-05	mg/kg-day	0.010	mg/kg-day			5.6E-03
	Freon-113	1.3	ug/L	1.3	ug/L	1.3	4.57E-05	mg/kg-day	30	mg/kg-day			1.5E-06
	Trichloroethene	84	ug/L	84	ug/L	84.0	2.95E-03	mg/kg-day	0.006	mg/kg-day			4.9E-01
	Perchlorate	610	ug/L	610	ug/L	610	2.14E-02	mg/kg-day	0.001	mg/kg-day			4.3E+01
	NDMA	0.38	ug/L	0.38	ug/L	0.38	1.34E-05	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	6.6	mg/L	6.6	mg/L	6.6	2.32E-01	mg/kg-day	1.6	mg/kg-day			1.5E-01
Dermal	Chloroform	1.6	ug/L	1.6	ug/L	1.6	9.80E-07	mg/kg-day	0.010	mg/kg-day			9.8E-05
	Freon-113	1.3	ug/L	1.3	ug/L	1.3	1.52E-06	mg/kg-day	30.000	mg/kg-day			5.1E-08
Contact	Trichloroethene	84	ug/L	84	ug/L	84.0	9.25E-05	mg/kg-day	0.006	mg/kg-day			1.5E-02
	Perchlorate	610	ug/L	610	ug/L	610	3.36E-05	mg/kg-day	0.001	mg/kg-day			6.7E-02
	NDMA	0.38	ug/L	0.38	ug/L	0.38	2.09E-08	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	6.6	mg/L	6.6	mg/L	6.6	NA	mg/kg-day	1.6	mg/kg-day			NA
Inhalation	Chloroform	1.6	ug/L	1.6	ug/L	1.6	2.81E-04	mg/kg-day			1.00E-02	mg/kg-day	2.8E-02
via	Freon-113	1.3	ug/L	1.3	ug/L	1.3	2.29E-04	mg/kg-day			8.60E+00	mg/kg-day	2.7E-05
Groundwate	Trichloroethene	84	ug/L	84	ug/L	84.0	1.48E-02	mg/kg-day			6.00E-03	mg/kg-day	2.5E+00
Use	Perchlorate	610	ug/L	610	ug/L	610	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	0.38	ug/L	0.38	ug/L	0.38	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrate	6.6	mg/L	6.6	mg/L	6.6	NA	mg/kg-day			NA	mg/kg-day	NA
												Total Risk Across All Exposure Routes/Pathways	4.6E+01

NA = Not Applicable

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic Values

(3) Reference concentrations converted to reference doses

TABLE B.5-11
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Current
Medium:	Off-Site Water Supply Well
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Trichloroethene	5	ug/L	5	ug/L	5	7.53E-05	mg/kg-day	0.011	(mg/kg-day)-1	8.3E-07
	Tetrachloroethene	5	ug/L	5	ug/L	5	7.53E-05	mg/kg-day	0.052	(mg/kg-day)-1	3.9E-06
	Perchlorate	18	ug/L	18	ug/L	18	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.0075	ug/L	0.0075	ug/L	0.0075	1.13E-07	mg/kg-day	51	(mg/kg-day)-1	5.8E-06
Dermal Contact	Trichloroethene	5	ug/L	5	ug/L	5	2.36E-06	mg/kg-day	0.011	(mg/kg-day)-1	2.6E-08
	Tetrachloroethene	5	ug/L	5	ug/L	5	7.08E-06	mg/kg-day	0.052	(mg/kg-day)-1	3.7E-07
	Perchlorate	18	ug/L	18	ug/L	18	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.0075	ug/L	0.0075	ug/L	0.0075	1.77E-10	mg/kg-day	51	(mg/kg-day)-1	9.0E-09
Inhalation via Groundwater Use	Trichloroethene	5	ug/L	5	ug/L	5	3.77E-04	mg/kg-day	0.006	(mg/kg-day)-1	2.3E-06
	Tetrachloroethene	5	ug/L	5	ug/L	5	3.77E-04	mg/kg-day	0.002	(mg/kg-day)-1	7.5E-07
	Perchlorate	18	ug/L	18	ug/L	18	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.0075	ug/L	0.0075	ug/L	0.0075	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	1.4E-05

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-12
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Off-site Supply Wells
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	Trichloroethene	5	ug/L	5	ug/L	5	1.76E-04	mg/kg-day	0.006	mg/kg-day			2.9E-02
	Tetrachloroethene	5	ug/L	5	ug/L	5	1.76E-04	mg/kg-day	0.010	mg/kg-day			1.8E-02
	Perchlorate	18	ug/L	18	ug/L	18	6.33E-04	mg/kg-day	0.0005	mg/kg-day			1.3E+00
	NDMA	0.0075	ug/L	0.0075	ug/L	0.0075	2.64E-07	mg/kg-day	NA	mg/kg-day			NA
Dermal Contact	Trichloroethene	5	ug/L	5	ug/L	5	5.51E-06	mg/kg-day	0.006	mg/kg-day			9.2E-04
	Tetrachloroethene	5	ug/L	5	ug/L	5	1.65E-05	mg/kg-day	0.010	mg/kg-day			1.7E-03
	Perchlorate	18	ug/L	18	ug/L	18	9.91E-07	mg/kg-day	0.001	mg/kg-day			2.0E-03
	NDMA	0.0075	ug/L	0.0075	ug/L	0.0075	4.13E-10	mg/kg-day	NA	mg/kg-day			NA
Inhalation via Groundwate Use	Trichloroethene	5	ug/L	5	ug/L	5	8.79E-04	mg/kg-day			0.006	mg/kg-day	1.5E-01
	Tetrachloroethene	5	ug/L	5	ug/L	5	8.79E-04	mg/kg-day			0.11	mg/kg-day	8.0E-03
	Perchlorate	18	ug/L	18	ug/L	18	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	0.0075	ug/L	0.0075	ug/L	0.0075	NA	mg/kg-day			NA	mg/kg-day	NA
												Total Risk Across All Exposure Routes/Pathways	1.5E+00

NA = Not Applicable

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic Values

(3) Reference concentrations converted to reference doses

TABLE B.5-13
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C Off site Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	5.88E-05	mg/kg-day	0.6	(mg/kg-day)-1	3.5E-05
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	28	ug/L	28	ug/L	28	4.22E-04	mg/kg-day	0.0061	(mg/kg-day)-1	2.6E-06
	Trichloroethene	88	ug/L	88	ug/L	88	1.33E-03	mg/kg-day	0.011	(mg/kg-day)-1	1.5E-05
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.25	ug/L	0.25	ug/L	0.25	3.77E-06	mg/kg-day	51	(mg/kg-day)-1	1.9E-04
	Nitrate	12	mg/L	12	mg/L	12	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,1-Dichloroethene	4E+00	ug/L	4E+00	ug/L	4E+00	1.84E-06	mg/kg-day	0.6	(mg/kg-day)-1	1.1E-06
	1,2-Dichloroethane	6E-01	ug/L	6E-01	ug/L	6E-01	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	3E+01	ug/L	3E+01	ug/L	3E+01	7.35E-06	mg/kg-day	0.0061	(mg/kg-day)-1	4.5E-08
	Trichloroethene	9E+01	ug/L	9E+01	ug/L	9E+01	4.15E-05	mg/kg-day	0.011	(mg/kg-day)-1	4.6E-07
	Perchlorate	9E+03	ug/L	9E+03	ug/L	9E+03	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	3E-01	ug/L	3E-01	ug/L	3E-01	5.90E-09	mg/kg-day	51	(mg/kg-day)-1	3.0E-07
	Nitrate	1E+01	mg/L	1E+01	mg/L	1E+01	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	3E+00	mg/L	3E+00	mg/L	3E+00	NA	mg/kg-day	NA	(mg/kg-day)-1	NA

TABLE B.5-13
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C Off site Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Inhalation via Groundwater Use	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	2.94E-04	mg/kg-day	0.18	(mg/kg-day)-1	5.3E-05
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	28	ug/L	28	ug/L	28	2.11E-03	mg/kg-day	0.019	(mg/kg-day)-1	4.0E-05
	Trichloroethene	88	ug/L	88	ug/L	88	6.63E-03	mg/kg-day	0.01	(mg/kg-day)-1	6.6E-05
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.25	ug/L	0.25	ug/L	0.25	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrate	12	mg/L	12	mg/L	12	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	4.1E-04

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-14
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C Off site Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	1.37E-04	mg/kg-day	0.009	mg/kg-day			1.5E-02
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	1.97E-05	mg/kg-day	0.030	mg/kg-day			6.6E-04
	Chloroform	28	ug/L	28	ug/L	28	9.84E-04	mg/kg-day	0.010	mg/kg-day			9.8E-02
	Trichloroethene	88	ug/L	88	ug/L	88	3.09E-03	mg/kg-day	0.006	mg/kg-day			5.2E-01
	Perchlorate	8700	ug/L	8700	ug/L	8700	3.06E-01	mg/kg-day	0.001	mg/kg-day			6.1E+02
	NDMA	0.25	ug/L	0.25	ug/L	0.25	8.79E-06	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	12	mg/L	12	mg/L	12	4.22E-01	mg/kg-day	1.6	mg/kg-day			2.6E-01
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	9.14E-02	mg/kg-day	0.1	mg/kg-day			9.1E-01
Dermal Contact	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	4.29E-06	mg/kg-day	0.009	mg/kg-day			4.8E-04
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	2.04E-07	mg/kg-day	0.030	mg/kg-day			6.8E-06
	Chloroform	28	ug/L	28	ug/L	28	1.72E-05	mg/kg-day	0.010	mg/kg-day			1.7E-03
	Trichloroethene	88	ug/L	88	ug/L	88	9.69E-05	mg/kg-day	0.006	mg/kg-day			1.6E-02
	Perchlorate	8700	ug/L	8700	ug/L	8700	4.79E-04	mg/kg-day	0.001	mg/kg-day			9.6E-01
	NDMA	0.25	ug/L	0.25	ug/L	0.25	1.38E-08	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	12	mg/L	12	mg/L	12	NA	mg/kg-day	1.6	mg/kg-day			NA
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	NA	mg/kg-day	0.1	mg/kg-day			NA

TABLE B.5-14
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C Off site Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Inhalation via Groundwate Use	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	6.86E-04	mg/kg-day			0.009	mg/kg-day	7.6E-02
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	9.84E-05	mg/kg-day			0.0014	mg/kg-day	7.0E-02
	Chloroform	28	ug/L	28	ug/L	28	4.92E-03	mg/kg-day			0.000086	mg/kg-day	5.7E+01
	Trichloroethene	88	ug/L	88	ug/L	88	1.55E-02	mg/kg-day			0.006	mg/kg-day	2.6E+00
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	0.25	ug/L	0.25	ug/L	0.25	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrate	12	mg/L	12	mg/L	12	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	NA	mg/kg-day			NA	mg/kg-day	NA
												Total Risk Across All Exposure Routes/Pathways	6.7E+02

NA = Not Applicable

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic Values

(3) Reference concentrations converted to reference doses

TABLE B.5-15
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timefram	Future
Medium:	Layer D off site Groundwate
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Populatio	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,2-Dichloroethene	23	ug/L	23	ug/L	23	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Perchlorate	600.0	ug/L	600.0	ug/L	600.0	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Trichloroethene	15	ug/L	15	ug/L	15	2.26E-04	mg/kg-day	0.011	(mg/kg-day)-1	2.5E-06
	NDMA	0.43	ug/L	0.4	ug/L	0.4	6.48E-06	mg/kg-day	51	(mg/kg-day)-1	3.3E-04
	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	2.71E-05	mg/kg-day	1.9	(mg/kg-day)-1	5.2E-05
	Nitrate	9.4	mg/L	9.4	mg/L	9.4	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	0.12	mg/L	0.12	mg/L	0.12	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,2-Dichloroethene	23	ug/L	23	ug/L	23	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Perchlorate	600.0	ug/L	600.0	ug/L	600.0	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Trichloroethene	15	ug/L	15	ug/L	15	7.08E-06	mg/kg-day	0.011	(mg/kg-day)-1	7.8E-08
	NDMA	0.43	ug/L	0.4	ug/L	0.4	1.01E-08	mg/kg-day	51	(mg/kg-day)-1	5.2E-07
	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	3.88E-07	mg/kg-day	1.9	(mg/kg-day)-1	7.4E-07
	Nitrate	9.4	mg/L	9.4	mg/L	9.4	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	0.12	mg/L	0.12	mg/L	0.12	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Inhalation via Groundwater Use	1,2-Dichloroethene	23	ug/L	23	ug/L	23	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Perchlorate	600.0	ug/L	600.0	ug/L	600.0	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Trichloroethene	15	ug/L	15	ug/L	15	1.13E-03	mg/kg-day	0.006	(mg/kg-day)-1	6.8E-06
	NDMA	0.43	ug/L	0.4	ug/L	0.4	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	1.36E-04	mg/kg-day	0.3	(mg/kg-day)-1	4.1E-05
	Nitrate	9.4	mg/L	9.4	mg/L	9.4	NA	mg/kg-day	16	(mg/kg-day)-1	NA
	Nitrite	0.12	mg/L	0.12	mg/L	0.12	NA	mg/kg-day	0.01	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	4.3E-04

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-16
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timefram Future
Medium: Layer D off site Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Populatic Residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentratio Units	Hazard Quotient
Ingestion	1,2-Dichloroethene	23	ug/L	23	ug/L	23	8.09E-04	mg/kg-day	0.01	mg/kg-day			8.1E-02
	Perchlorate	600.0	ug/L	600.0	ug/L	600.0	2.11E-02	mg/kg-day	0.0005	mg/kg-day			4.2E+01
	Trichloroethene	15	ug/L	15	ug/L	15	5.27E-04	mg/kg-day	0.006	mg/kg-day			8.8E-02
	NDMA	0.43	ug/L	0.4	ug/L	0.4	1.51E-05	mg/kg-day	NA	mg/kg-day			NA
	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	6.33E-05	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	9.4	mg/L	9.4	mg/L	9.4	3.31E-01	mg/kg-day	1.6	mg/kg-day			2.1E-01
	Nitrite	0.12	mg/L	0.12	mg/L	0.12	4.22E-03	mg/kg-day	0.1	mg/kg-day			4.2E-02
Dermal Contact	1,2-Dichloroethene	23	ug/L	23	ug/L	23	1.58E-05	mg/kg-day	0.01	mg/kg-day			1.6E-03
	Perchlorate	600.0	ug/L	600.0	ug/L	600.0	3.30E-05	mg/kg-day	0.0005	mg/kg-day			6.6E-02
	Trichloroethene	15	ug/L	15	ug/L	15	1.65E-05	mg/kg-day	0.006	mg/kg-day			2.8E-03
	NDMA	0.43	ug/L	0.4	ug/L	0.4	2.37E-08	mg/kg-day	NA	mg/kg-day			NA
	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	9.04E-07	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	9.4	mg/L	9.4	mg/L	9.4	NA	mg/kg-day	1.6	mg/kg-day			NA
	Nitrite	0.12	mg/L	0.12	mg/L	0.12	NA	mg/kg-day	0.1	mg/kg-day			NA
Inhalation via Groundwater Use	1,2-Dichloroethene	23	ug/L	23	ug/L	23	4.04E-03	mg/kg-day			9.00E-03	mg/kg-day	4.5E-01
	Perchlorate	600.0	ug/L	600.0	ug/L	600.0	1.05E-01	mg/kg-day			NA	mg/kg-day	NA
	Trichloroethene	15	ug/L	15	ug/L	15	2.64E-03	mg/kg-day			6.00E-03	mg/kg-day	4.4E-01
	NDMA	0.43	ug/L	0.4	ug/L	0.4	NA	mg/kg-day			NA	mg/kg-day	NA
	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	3.16E-04	mg/kg-day			NA	mg/kg-day	NA
	Nitrate	9.4	mg/L	9.4	mg/L	9.4	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrite	0.12	mg/L	0.12	mg/L	0.12	NA	mg/kg-day			NA	mg/kg-day	NA
												Total Risk Across All Exposure Routes/Pathways	4.4E+01

NA = Not Applicable

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic Values

(3) Reference concentrations converted to reference doses

TABLE B.5-17
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer E Off site Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	3.47E-05	mg/kg-day	0.6	(mg/kg-day)-1	2.1E-05
	1,2-Dichloroethene	7.8	ug/L	7.8	ug/L	7.8	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Trichloroethene	220	ug/L	220	ug/L	220	3.32E-03	mg/kg-day	0.011	(mg/kg-day)-1	3.6E-05
	Perchlorate	400	ug/L	400	ug/L	400	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.08	ug/L	0.08	ug/L	0.08	1.21E-06	mg/kg-day	51	(mg/kg-day)-1	6.1E-05
	Nitrate	7.10	mg/L	7.10	mg/L	7.10	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	1.09E-06	mg/kg-day	0.6	(mg/kg-day)-1	6.5E-07
	1,2-Dichloroethene	7.8	ug/L	7.8	ug/L	7.8	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Trichloroethene	220	ug/L	220	ug/L	220	1.04E-04	mg/kg-day	0.011	(mg/kg-day)-1	1.1E-06
	Perchlorate	400	ug/L	400	ug/L	400	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.08	ug/L	0.08	ug/L	0.08	1.89E-09	mg/kg-day	51	(mg/kg-day)-1	9.6E-08
	Nitrate	7.10	mg/L	7.10	mg/L	7.10	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Inhalation via Groundwater Use	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	1.73E-04	mg/kg-day	0.18	(mg/kg-day)-1	3.1E-05
	1,2-Dichloroethene	7.8	ug/L	7.8	ug/L	7.8	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Trichloroethene	220	ug/L	220	ug/L	220	1.66E-02	mg/kg-day	0.006	(mg/kg-day)-1	9.9E-05
	Perchlorate	400	ug/L	400	ug/L	400	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.08	ug/L	0.08	ug/L	0.08	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrate	7.10	mg/L	7.10	mg/L	7.10	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	2.5E-04

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-18
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer E Off site Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	8.09E-05	mg/kg-day	0.009	mg/kg-day			9.0E-03
	1,2-Dichloroethene	7.8	ug/L	7.8	ug/L	7.8	2.74E-04	mg/kg-day	0.009	mg/kg-day			3.0E-02
	Trichloroethene	220	ug/L	220	ug/L	220	7.74E-03	mg/kg-day	0.006	mg/kg-day			1.3E+00
	Perchlorate	400	ug/L	400	ug/L	400	1.41E-02	mg/kg-day	0.001	mg/kg-day			2.8E+01
	NDMA	0.08	ug/L	0.08	ug/L	0.08	2.81E-06	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	7.10	mg/L	7.10	mg/L	7.10	2.50E-01	mg/kg-day	1.6	mg/kg-day			1.6E-01
Dermal Contact	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	2.53E-06	mg/kg-day	0.009	mg/kg-day			2.8E-04
	1,2-Dichloroethene	7.8	ug/L	7.8	ug/L	7.8	5.37E-06	mg/kg-day	0.009	mg/kg-day			6.0E-04
	Trichloroethene	220	ug/L	220	ug/L	220	2.42E-04	mg/kg-day	0.006	mg/kg-day			4.0E-02
	Perchlorate	400	ug/L	400	ug/L	400	2.20E-05	mg/kg-day	0.001	mg/kg-day			4.4E-02
	NDMA	0.08	ug/L	0.08	ug/L	0.08	4.40E-09	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	7.10	mg/L	7.10	mg/L	7.10	NA	mg/kg-day	1.6	mg/kg-day			NA
Inhalation via Groundwate Use	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	4.04E-04	mg/kg-day			0.009	mg/kg-day	4.5E-02
	1,2-Dichloroethene	7.8	ug/L	7.8	ug/L	7.8	1.37E-03	mg/kg-day			0.009	mg/kg-day	1.5E-01
	Trichloroethene	220	ug/L	220	ug/L	220	3.87E-02	mg/kg-day			0.006	mg/kg-day	6.4E+00
	Perchlorate	400	ug/L	400	ug/L	400	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	0.08	ug/L	0.08	ug/L	0.08	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrate	7.10	mg/L	7.10	mg/L	7.10	NA	mg/kg-day			NA	mg/kg-day	NA
												Total Risk Across All Exposure Routes/Pathways	3.6E+01

NA = Not Applicable

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic Values

(3) Reference concentrations converted to reference doses

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Appendix C Addendum 9/26/00

The following section presents Aerojet's interpretation of ARARs for the Western Groundwater Operable Unit. The Regulatory Agencies have significant disagreement on the assessment of the ARARs/TBCs and how they are designated an ARAR or TBC. The table supplied to Aerojet listing ARARs and TBCs for the Regional Water Quality Control Board was significantly altered by Aerojet to designate most of the ARARs as TBCs and potential TBCs. The State maintains its position on the ARARs found in the attached table to be the current ARARs and TBCs for the Regional Board for cleanup of contaminated groundwater at the Aerojet site. Though there is disagreement, the disagreement does not effect the selection of the alternative. The final list of ARARs will be provided in the decision document for the operable unit, thus providing time to resolve any disagreement on ARARs.

#	Source	Standard, Requirement, Criterion, or Limitation	Description	ARARs, or To Be Considered	Comments
1	Porter-Cologne Water Quality Control Act (California Water Code Section 13000 et seq.)	California Water Code Section 13243	The RWQCB may specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted.	Applicable	Applies to groundwater remedial action.
2	Porter-Cologne Water Quality Control Act (California Water Code Sections 13240, 13241, 13242, 13243)	Water Quality Control Plan (Basin Plan) for the RWQCB, CVR [SITE PAGES WITH BENEFICIAL USES AND WATER QUALITY OBJECTIVES.]	Establishes water quality objectives, including narrative and numerical standards, that protect the beneficial uses and water quality objectives of surface and ground waters in the region. Describes implementation plans and other control measures designed to ensure compliance with statewide plans and policies and provide comprehensive water quality planning. [ADD LIST OF SPECIFIC BENEFICIAL USES AND WATER QUALITY OBJECTIVES FOR WATERS SUBJECT TO ROD.]	Applicable	Specific applicable portions of the Basin Plan include beneficial uses of affected water bodies and water quality objectives to protect those uses. Any activity, including, but not limited to, the discharge of contaminated soils or waters or in-situ treatment or containment of contaminated soils or waters, must not result in actual water quality exceeding water quality objectives.
3	Porter-Cologne Water Quality Control Act (California Water Code Sections 13000, 13304, 13240, 13241, 13242, 13243)	RWQCB, CVR Basin Plan, "Policy for Investigation and Cleanup of Contaminated Sites." [CHECK REGION'S BASIN PLAN FOR SIMILAR PROVISIONS AND REPLACE THIS LISTING.]	Establishes and describes policy for investigation and remediation of contaminated sites. Also includes implementation actions for setting groundwater and soil cleanup standard.	Applicable	Cleanup standards for water should be equal to background concentrations unless such levels are technically and economically infeasible to achieve. In such cases, cleanup standards should not exceed applicable water quality objectives.

#	Source	Standard, Requirement, Criterion, or Limitation	Description	ARARs, or To Be Considered	Comments
4	Porter-Cologne Water Quality Control Act (California Water Code Sections 13240, 13241, 13242, 13243)	RWQCB, CVR Basin Plan, "Policy for Application of Water Quality Objectives" [CHECK REGION'S BASIN PLAN FOR SIMILAR POLICY AND REPLACE THIS LISTING.]]	This policy defines water quality objectives and explains how the Regional Water Board applies numerical and narrative water quality objectives to ensure the reasonable protection of beneficial uses of water and how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high-quality waters.	Applicable	Applies to groundwater remedial actions.
5	Porter-Cologne Water Quality Control Act (California Water Code Sections 13240, 13241, 13242, 13243)	RWQCB, CVR Basin Plan, "Wastewater Reuse Policy" [CHECK REGION'S BASIN PLAN FOR SIMILAR POLICY AND REPLACE THIS LISTING.]	Requires applicants for waste discharge requirements and discharge permits to evaluate land disposal as an alternative to discharge to surface waters.	Applicable	Applies to groundwater extracted by groundwater treatment system.
6	Porter-Cologne Water Quality Control Act (California Water Code Sections 13000, 13140, 13263, 13304)	State Water Resources Control Board Resolution No. 68-16 ("Anti-degradation Policy").	Requires that high quality surface and ground waters be maintained to the maximum extent possible. Degradation of waters will be allowed (or allowed to remain) only if it is consistent with the maximum benefit to the people of the state, does not unreasonably affect present and anticipated beneficial uses, and does not result in water quality less than that prescribed in RWQCB and SWRCB policies. If degradation is allowed, the discharge must meet best practicable treatment or control, which must prevent pollution or nuisance and result in the highest water quality consistent with maximum benefit to the people of the state.	Applicable	Applies to discharges of waste to waters, including discharges to soil that may affect surface or ground waters. In-situ cleanup levels for contaminated ground waters must be set at background level, unless allowing continued degradation is consistent with the maximum benefit of the people of the state. If degradation of waters is allowed, or allowed to remain, the discharge must meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state. In no case may water quality objectives be exceeded.

#	Source	Standard, Requirement, Criterion, or Limitation	Description	ARARs, or To Be Considered	Comments
7	Porter-Cologne Water Quality Control Act (California Water Code Sections 13000, 13140, 13240, 13260, 13263, 13267, 13300, 13304, 13307)	State Water Resources Control Board Resolution No. 92-49 (As amended April 21, 1994)	Establishes requirements for investigation and cleanup and abatement of discharges. Among other requirements, dischargers must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality, or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of Title 23, CCR, Section 2550.4, requirements to cleanups.	Applicable	Applies to groundwater remedial actions.
8	Porter-Cologne Water Quality Control Act (California Water Code Sections 13000, 13140, 13240)	State Water Resources Control Board Resolution No. 88-63 ("Sources of Drinking Water Policy") (as contained in the RWQCB's Water Quality Control Plan)	Specifies that, with certain exceptions, all ground and surface waters must have the beneficial use of municipal or domestic water supply.	Applicable	Applies in determining beneficial uses for waters that may be affected by discharges of waste.
9	Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267, 13304)	Title 27, CCR, Division 2, Subdivision 1(Section 20080 et seq.) Title 23, CCR, Division 3, Chapter 15 (Section 2510 et seq.).	Establishes waste and siting classification systems and minimum waste management standards for discharges of waste to land for treatment, storage, and disposal. Engineered alternatives that are consistent with Title 27/Title 23 performance goals may be considered. Establishes corrective action requirements for responding to discharges to land, including spills and leaks and other unauthorized discharges.	Applicable	The Application of specific sections of Title 27/ Title 23 is discussed below. Provisions of Title 23 apply to hazardous waste and provisions of Title 27 apply to designated and nonhazardous solid waste.
10	Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267,	Title 27, CCR, Section 20090(d) Title 23, CCR. Section 2511 (d)	Action taken by public agencies to clean up unauthorized releases are exempt from Title 27/ Title 23 accept that wastes removed from immediate place of release and discharged to land must be managed in accordance with classification (Title 27, CCR, Section 20200/ Title 23, CCR, Section 2520) and siting requirements of Title 27 or Title 23 and	Applicable	Applies to remediation and monitoring of sites.

#	Source	Standard, Requirement, Criterion, or Limitation	Description	ARARs, or To Be Considered	Comments
	13304).		wastes contained or left in place must comply with Title 27 or Title 23 to the extent feasible.		
11	Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267, 13304).	Title 27, CCR, Section 20400 Title 23, CCR, Section 2550.4.	Concentration limits must be established for groundwater, surface water, and the unsaturated zone. Must be based on background, equal to background, or for corrective actions, may be greater than background, not to exceed the lower of the applicable water quality objective or the concentration technologically or economically achievable. Specific factors must be considered in setting cleanup standards above background levels.	Applicable	Applies in setting ground water cleanup levels for all discharges of waste to land.
12	Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267, 13304).	Title 27, CCR, Section 20410 Title 23, CCR, Section 2550.6	Requires monitoring for compliance with remedial action objectives for three years from the date of achieving cleanup standards.	Applicable	Applies to groundwater remedial actions.

#	Source	Standard, Requirement, Criterion, or Limitation	Description	ARARs, or To Be Considered	Comments
13	Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267, 13304).	Title 27, CCR, Section 20415 Title 23, CCR, Section 2550.7.	Requires general soil, surface water, and ground water monitoring.	Applicable	Applies to all areas at which waste has been discharged to land.
14	Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267, 13304).	Title, 27, CCR, Section 20425 Title, 23, CCR, Section 2550.9.	Requires an assessment of the nature and extent of the release, including a determination of the spatial distribution and concentration of each constituent.	Applicable	Applies to areas at which monitoring results show statistically significant evidence of a release.
15	Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267 13304).	Title 27, CCR, Section 20430 Title 23, CCR Section 2550.10	Requires implementation of corrective action measures that ensure that cleanup levels are achieved throughout the zone affected by the release by removing the waste constituents or treating them in place. Source control may be required. Also requires monitoring to determine the effectiveness of the corrective actions.	Applicable	Applies to groundwater remedial acations.

#	Source	Standard, Requirement, Criterion, or Limitation	Description	ARARs, or To Be Considered	Comments
16	Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267 13304).	Title 27, CCR, Section 21090	Requires a final cover constructed in accordance with specific prescriptive standards, to be maintained as long as wastes pose a threat to water quality.	Applicable Relevant & Appropriate	Applies to wastes contained or left in place at the end of remedial actions that could affect water quality. Includes closure of landfills and other areas where wastes have been discharged to land. Relevant and appropriate for "closed, abandoned, or inactive" landfills and other areas where wastes have been discharged to land and water quality is threatened.
17	California Safe Drinking Water Act (California Health & Safety Code Section 4010 et seq.)	Title 22, CCR, Section 64400 et seq.	Requirements for public water systems. Includes Maximum Contaminant Levels (MCLs) and Secondary Maximum Contaminant Levels (SMCLs). State MCLS which are more stringent than the federal MCLs, or not addressed by federal MCLs are [LIST SPECIFIC CONSTITUENTS, e.g., BENZENE.]	Applicable	The act is legally applicable for an aquifer and associated distribution and pre-treatment system that is currently defined as "public water system" If it is only a potential "Public water system," then the act is relevant and appropriate.
18	Staff Report of the RWQCB, CVR	"A Compilation of Water Quality Goals"	Provides guidance on selecting numerical values to implement narrative water quality objectives contained in the Basin Plan.	To Be Considered	Performance Standard. To be considered in selecting appropriate numerical values to implement the Basin Plan for setting cleanup levels and discharge limits. The numerical values contained in the staff report may be ARAR's, or Performance Standards, depending on the source of the values.

Appendix C

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR WESTERN GROUNDWATER OU RI/FS

This appendix presents an evaluation of requirements established under federal or State environmental laws that may represent potentially applicable or relevant and appropriate requirements (ARARs) for remedial actions that may be conducted for the Western Groundwater OU. EPA will select ARARs and cleanup standards and document that selection in the Record of Decision. This FS evaluates potential ARARs to assist in the development and evaluation of alternatives in accordance with the requirements set forth in the National Contingency Plan (40 CFR 300.430).

C.1 Introduction

The development and evaluation of potential ARARs is based primarily on the following information:

- Requirements set forth in the NCP;
- EPA's guidance document "CERCLA Compliance with Other Laws Manual" (EPA, 1988) and related guidance;
- The Central Valley Regional Water Quality Control Board's May 7, 1998 general listing of ARARs for Groundwater Remediation;
- EPA, RWQCB, and DTSC comments on Aerojet's 11-23-99 draft Western Groundwater OU RI/FS; and
- The State Water Resources Control Board's July 14, 1992 Memorandum regarding "Applicable or Relevant and Appropriate Requirements (ARARs), To-Be-Considered Requirements (TBCs), and Permit Requirements of CERCLA."

This OU is focused solely on groundwater contamination in the Western Groundwater Study Area. This OU does not include investigation of potential or actual source areas and internal groundwater control on property not within the Western Groundwater Study Area, or an evaluation of potential remedial alternatives for these areas. Source areas and onsite groundwater will be addressed as part of future OU RI/FS efforts. Consequently, this ARARs evaluation does not identify or evaluate potential ARARs for source areas, even if a possible source area is located within the Western Groundwater Study Area.

The potential ARARs identified in this appendix were used in Section 2 of the FS to identify Preliminary Remedial Action Goals (PRAGs) and remedial action objectives. The evaluation of potential ARARs presented in this section does take into account the

potential remedial alternatives presented in the FS. However, the detailed evaluation of how each ARAR may potentially be applicable or relevant and appropriate for each remedial alternative and how each alternative complies with ARARs is presented as part of the detailed evaluation of the alternatives in Section 5 of the FS.

C.2 Identification and Evaluation of ARARs

Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) states that remedial actions on CERCLA sites must attain (or justify the waiver of) any federal or more stringent State environmental standards, requirements, criteria, or limitations that are determined to be ARARs. Applicable requirements are those cleanup standards, criteria, or limitations promulgated under federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site. All jurisdictional prerequisites must be met in order for the requirement to be applicable.

If a requirement is not legally applicable, the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or State law that, while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are well suited to the conditions of the site. The criteria for determining relevance and appropriateness are listed in Title 40, Code of Federal Regulations (CFR), Section 300.400(g)(2) {40 CFR 300.400(g)(2)}.

ARARs are concerned only with substantive, not administrative, requirements of a statute or regulation. The substantive portions of the regulation are those requirements that pertain directly to actions or conditions in the environment. Examples of substantive requirements include quantitative health- or risk-based restrictions upon exposure to types of hazardous substances (e.g., maximum contaminant levels [MCLs]). Administrative requirements are the mechanisms that facilitate implementation of the substantive requirements. Administrative requirements include issuance of permits, documentation, reporting, recordkeeping, and enforcement. Thus, in determining the extent to which onsite CERCLA response actions must comply with environmental laws, a distinction should be made between substantive requirements, which may be ARARs, and administrative requirements, which are not.

Furthermore, the ARARs provision in CERCLA applies to onsite actions. "Onsite" is defined as the areal extent of contamination and includes the groundwater plumes to be remediated. According to CERCLA Section 121(e), a remedial response action that takes place entirely onsite may proceed without obtaining permits. This permit exemption applies to all administrative requirements, as well as to permits. Offsite actions must comply with the substantive as well as the administrative requirements of all applicable regulations.

Pursuant to U.S. Environmental Protection Agency (EPA) guidance, ARARs generally are classified into three categories: chemical-specific, location-specific, and action-specific requirements. These classification categories were developed to help identify ARARs, some of which do not fall precisely into one group or another. These categories of ARARs are defined below:

- Chemical-Specific ARARs include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. If, in a specific situation, a chemical is subject to more than one discharge or exposure limit, the more stringent of the requirements should generally be applied.

- Location-Specific ARARs are those requirements that relate to the geographical or physical position of the site, rather than the nature of the contaminants or the proposed site remedial actions. These requirements may limit the placement of remedial action, and may impose additional constraints on the cleanup action.

- Action-Specific ARARs are requirements that define acceptable handling, treatment, and disposal procedures for hazardous substances. These ARARs generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities related to management of hazardous substances or pollutants. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Because a remedial site usually involves several alternative actions, very different action-specific requirements can apply.

Agency policies and guidance may not meet the definition of ARARs as defined above, but still may be useful in determining whether to take action at a site or to what degree action is necessary. This can be particularly true when there are no ARARs for a site, action, or contaminant (e.g., contaminants that do not have MCLs). Such agency policies and guidance that are not promulgated regulations (that is, those policies and guidance that are not formally adopted as state-wide regulations of general applicability following public notice and comment and do not appear in the California Code of Regulations) are called to-be-considered (TBC) criteria. TBC criteria may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they may be considered when developing the required level of cleanup for protection of health or the environment. The critical difference between a TBC and an ARAR is that one is not required to comply with or meet a TBC when deciding on a remedial action.

ARARS and TBCs are identified at various points throughout the CERCLA process. These criteria are identified on a site-specific basis. Therefore, as additional information is developed about the site, including special features of the site location, the specific chemicals at the site, and the actions that are being considered as remedies, more ARARs

may be identified, and the list of potential ARARs further refined. Potential ARARs are usually identified in the FS, and the final list of ARARs that any remedy must meet is established in the ROD.

C.3 Waivers of ARARs

CERCLA Section 121 provides that, under certain circumstances, an otherwise applicable or relevant and appropriate requirement may be waived. These waivers apply only to the attainment of the ARAR. Other statutory requirements, such as the requirement that remedies be protective of human health and the environment, cannot be waived. The waivers provided by CERCLA Section 121(d)(4) are listed below:

- Interim Remedy--The remedial action selected is only part of a total remedial action that will attain such a level or standard of control when completed.
- Greater Risk to Human Health or the Environment--Compliance with the requirement at the site will result in greater risk to human health and the environment than alternative options.
- Technical Impracticability--Compliance with the requirement is technically impracticable from an engineering perspective.
- Equivalent Standard of Performance--The remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation through use of another method or approach.
- Inconsistent Application of State Requirements--With respect to a State standard, requirement, criterion, or limitation, the State has not consistently applied (or demonstrated the intention to consistently apply) the standard, requirement, criterion, or limitation in similar circumstances at other remedial actions.
- Fund Balancing--In the case of a remedial action to be undertaken solely under Section 104 using the Fund, selection of a remedial action that attains the level or standard of control in the requirement will not provide a balance between the need for protection of public health and welfare and the environment at the site under consideration, and the availability of amounts from the Fund to respond to other sites that present or may present a threat to public health or welfare or the environment, taking into consideration the relative immediacy of such threats.

C.4 Potential Chemical-Specific ARARs

Chemical-specific ARARs are usually health- or risk-based numeric values or methodologies which, when applied to site-specific conditions result in the establishment

of numeric values (EPA, 1998). This section focuses on those standards, criteria or limitations that, considering site-specific conditions, contain numeric values establishing acceptable amounts or concentrations of a chemical that may be found in or discharged to the environment.

C.4.1 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) establishes national primary drinking water standards (Maximum Contaminant Levels or MCLs) to protect the quality of water in public water systems. MCLs are enforceable standards and represent the maximum concentrations of contaminants permissible in a water system delivered to the public. Because MCLs are enforced at the point where water is delivered to the public, MCLs are rarely applicable to cleanup of groundwater at Superfund sites (55 Federal Register 8750). However, MCLs are generally relevant and appropriate when determining acceptable exposure limits for groundwater that is a current or potential source of drinking water [40 CFR 300.430(e)(2)(i) (B)]. The National Contingency Plan (NCP) states that maximum contaminant level goals (MCLGs) that are set at levels above zero should also be considered to be relevant and appropriate requirements for groundwater that is a potential source of drinking water [40 CFR 300.430 (e)(2)(i)(B)].

California drinking water standards (Title 22 CCR Chapter 15, Section 64400 et seq.) establish primary MCLs for contaminants that cannot be exceeded in water supplied to the public. As with the federal drinking water standards, the California MCLs are applicable at the point where water is delivered to the public and therefore are not applicable to cleanup of groundwater. However, to the extent that the State MCLs are more stringent than the federal limits, the State requirements may be relevant and appropriate for groundwater that is, or may be, a potential source of drinking water. The California drinking water MCLs are, in some cases, more stringent than the federal MCLs and, in other cases, less stringent than the national standards. Thus, the more stringent limit is determined on a chemical-by-chemical basis.

Table C-1 presents a listing of potential CoPCs of concern for the Western Groundwater OU and their federal and state MCLs and the federal MCLGs. The MCLs are potentially applicable at the point where water is delivered to the public. MCLs are applicable to the Western Groundwater OU at the point any withdrawn groundwater is placed in a water distribution system used for drinking water supply. MCLs and non-zero MCLGs are potentially relevant and appropriate for in-place groundwater that is or may be a potential source of drinking water and therefore, are relevant and appropriate for the Western Groundwater OU.

Only the MCLs and non-zero MCLGs for the site-specific organic chemicals of concern and nitrate and nitrite are relevant and appropriate as potential cleanup levels for the Western Groundwater OU. However, these and other MCLs, such as those established for inorganic constituents, could also become applicable if the selected remedial action includes use of treated water as part of a public water supply.

C.4.2 Water Quality Control Plan (Basin Plan)

The California Water Code requires Regional Water Quality Control Boards to prepare and periodically update Water Quality Control Plans, also known as Basin Plans. The Porter-Cologne Water Quality Control Act states that basin plans consist of beneficial uses, water quality objectives and a program of implementation for achieving their water quality objectives [California Water Code Section 12050(j)].

The Basin Plan for the Sacramento and San Joaquin River Basins, dated September 15, 1998, designates beneficial uses for waters, and contains numeric and narrative water quality objectives (WQOs) to protect those beneficial uses. The Basin Plan also contains policies and procedures intended to protect beneficial uses. The Basin Plan is not a promulgated regulation. As discussed below, the policies and procedures contained in the Basin Plan may be TBCs for the Western Groundwater OU.

C.4.2.1 Beneficial Uses

State Water Board Resolution No. 88-63 specifies that all surface and ground waters of the State are considered to be suitable, or potentially suitable, for municipal or domestic water supply and should be so designated by the Regional Boards unless the water meets certain exceptions. Beneficial uses of ground water in the Sacramento and San Joaquin basin are designated in the Basin Plan. The Basin Plan states that unless otherwise designated by the Regional Water Board, all ground waters in the Region are considered as suitable or potentially suitable, at a minimum, for municipal and domestic supply (MUN), agricultural supply (AGR), industrial service supply (IND), and industrial process supply (PRO).

In making exceptions to the beneficial uses designation of municipal and domestic supply (MUN), the Regional Water Board applies the criteria in State Water Board Resolution No. 88-63, "Sources of Drinking Water Policy". One of the criteria for exceptions is stated as follows:

> "There is contamination, either by natural processes or by human activity (unrelated to the specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices..."

Based on the Basin Plan, the highest beneficial use of ground water within the Western Groundwater Study Area is MUN.

Although the Regional Water Board has not made a specific exception with respect to the current area of the contaminant plumes beneath the Western Groundwater Study Area, the presence of perchlorate and NDMA provides a basis for a possible exception to the

MUN use. Aerojet and others are currently involved in developing and demonstrating treatment technologies for these constituents that may be used to treat contaminated water to a level suitable for drinking water supplies. Treatment methods for perchlorate are currently in the demonstration phase. While treatment of perchlorate and NDMA have been effectively demonstrated, DHS has not yet certified these technologies for treatment of drinking water supplies in the Western Groundwater Study Area. Therefore, these technologies do not yet represent BMP or best economically achievable treatment practices for potential drinking water in the Study Area. Consequently, water containing perchlorate or NDMA above risk-based levels in the Western Groundwater Study Area currently is not suitable for municipal or domestic supply.

The beneficial uses for groundwater identified in the Basin Plan are TBCs with respect to the Western Groundwater OU, subject to the potential exception identified in State Water Board Resolution 88-63. The beneficial uses for surface water identified in the Basin Plan are potential TBCs with respect to any remedial action that includes discharge of treated water to surface water.

C.4.2.2 Water Quality Objectives

The Porter-Cologne Water Quality Control Act defines water quality objectives as "... the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or prevention of nuisance within a specific area [Water Code Section 13050(h)]." The Basin Plan includes water quality objectives for groundwater that apply to all groundwaters of the Sacramento and San Joaquin River Basins. The Basin Plan states that water quality objectives are relevant to the protection of designated beneficial uses. The plan also states that these objectives do not require improvement over naturally occurring background concentrations. The Plan further states that the groundwater objectives contained in the Plan are not required by the federal Clean Water Act.

The Basin Plan identifies water quality objectives for groundwater for bacteria, chemical constituents, radioactivity, tastes and odors, and toxicity. Specific numeric standards are defined for bacteria, chemical constituents and radioactivity. Narrative standards are provided for tastes, odors and toxicity.

The water quality objective for chemical constituents in groundwaters state that "Ground waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses." This objective further states, that:

> "At a minimum, ground waters designated for domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs). Specifically, the Basin Plan references the MCLs specified in the following provisions of Title 22 of the California Code of Regulations: Tables 64431-A (Inorganic Chemicals) and 64431-B (Fluoride) of Section 64431. Table 64444-A (Organic Chemicals) of Section 64444, and

Tables 64449-A (Secondary Maximum Contaminant Levels –Consumer Acceptance Limits) and 64449-B (Secondary Maximum Contaminant Levels-Ranges) of Section 64449."

MCLs were discussed in the previous section of this appendix and are summarized on Table C-1.

Only a narrative statement is provided for the water quality objectives in groundwater relative to toxicity. This objective states that "Ground waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life associated with beneficial use(s)."

Water quality objectives for groundwater presented in the Basin Plan that are not MCLs or are not otherwise promulgated standards are TBCs with respect to the Western Groundwater OU.

Water quality objectives have also been developed for surface water. Although surface water is not included within the scope of the Western Groundwater OU, it is possible that groundwater collected and treated as part of a selected remedial action for the Western Groundwater OU may be discharged to surface water. Water quality objectives for surface water that are not MCLs or are not otherwise promulgated standards would represent potential TBCs for such a discharge.

C.4.2.3 State Water Board and Regional Water Board Policies and Plans

There are several State Water Board water quality control policies and three State Water Board water quality control plans to which Regional Water Board actions must conform. These are not promulgated regulations. Several of these may represent TBCs for potential remedial actions for the Western Groundwater OU.

C.4.2.3.1 State Water Board Resolution No. 68-16, Statement of Policy with Respect to Maintaining High Quality of Water in California

This policy was adopted by the State Water Board to maintain high quality waters of the State. This resolution is also referred to as the "Anti-degradation Policy". It is not a promulgated regulation. This policy generally restricts the discharge of contaminants that reduces the water quality of surface or ground waters, even though such a reduction in water quality might still result in protection of beneficial uses Specifically this policy requires existing high quality waters to be maintained unless it is demonstrated that a change is consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses and will not result in water quality less than that prescribed in the policies. If discharge is allowed, the discharge must meet best practical treatment or control necessary to prevent pollution or a nuisance and maintain the highest water quality with maximum benefit to the people of the State.

EPA has developed specific guidance related to evaluation of state anti-degradation requirements as potential ARARs (EPA, 1989a, 1989b, 1990 and 1991). EPA considers anti-degradation requirements for groundwater to generally be prospective in nature, designed to prevent further degradation of water quality. EPA thus concludes that these requirements may potentially be ARARs for CERCLA remedial actions that involve injection of partially treated water into a pristine aquifer. EPA has determined that anti-degradation requirements would not require cleanup to the aquifer's original quality prior to contamination.

Resolution 68-16 addresses the disposal of wastes into waters of the State and therefore is a potential TBC with regard to a remedial action involving reinjection of treated groundwater or discharge of treated water to surface water. This policy does not contain any numeric standards, but does provide procedures for establishment of numeric values. Thus, to the extent this policy leads to the establishment of numeric values, it is a potential TBC with respect to addressing the existing groundwater contamination.

C.4.2.3.2 Regional Water Board Policy for Application of Water Quality Objectives

This policy was adopted by the Central Valley Regional Water Board to define the least stringent standards that the Regional Water Board will apply to regional waters in order to protect beneficial uses. This policy was also adopted to explain how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high quality waters. It is not a promulgated regulation.

Water quality objectives are defined as "the limits or levels of water quality constituents or characteristics which are established for reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." Water quality objectives may be stated in either numeric or narrative form. This policy states that "Where numerical water quality objectives are listed, these are the limits necessary for the reasonable protection of beneficial uses of the water." The Regional Water Board has not adopted numeric water quality objectives for many constituents or parameters and instead has adopted narrative water quality objectives.

To evaluate compliance with narrative water quality objectives, the Regional Water Board considers, on a case-by-case basis, direct evidence of beneficial use impacts, material and relevant information submitted by the discharger and other interested parties, and relevant information and numeric criteria and guidelines developed and/or published by other agencies and organizations. The Regional Water Board will, on a case-by-case basis, adopt numeric limitations which will implement the narrative objectives. To assist dischargers and other interested parties, the Regional Board staff have compiled many of the numeric water quality criteria from other appropriate agencies and organizations in the Central Valley Regional Water Board staff report, *A Compilation of Water Quality Goals* (see Section C.4.2.5 below).

As previously discussed, water quality objectives presented in the Basin Plan that are not MCLs or are not otherwise promulgated standards are potential TBCs with respect to the Western Groundwater OU. Narrative standards that do not contain numeric limits, but do provide procedures for establishment of numeric values, represent potential TBCs

C.4.2.3.3 State Water Board Resolution No. 92-49, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304

This resolution establishes policies and procedures that the State and Regional Water Boards follow in conducting oversight of investigations and cleanup and abatement activities resulting from discharge of hazardous substances. The principles described in this resolution reflect the requirements set forth in CCR Title 23 Division 3 Chapter 22 Section 2907.

With respect to cleanup levels, this resolution requires cleanup and abatement of the effects of discharges in a manner that promotes attainment of either background water quality, or the best water quality which is reasonable if background levels of water quality cannot be restored. Use of cleanup levels less stringent than background requires consideration of all demands being made and to be made on the waters and the beneficial, detrimental, economic, social, tangible and intangible values involved. This resolution also requires application of Section 2550.4 of Chapter 15 of the California Code of Regulations in setting alternative cleanup levels.

This resolution also requires that any

"...alternative cleanup level shall:

1. Be consistent with maximum benefit to the people of the State;

2. Not unreasonably affect present and anticipated beneficial use of such water; and

3. Not result in water quality less than that prescribed in the Water Quality Control Plans and Policies adopted by the State and Regional Boards; and

H. Consider the designation of containment zones notwithstanding any other provision of this or other policies or regulations which require cleanup to water quality objectives."

Policies and procedures related to designation of containment zones are discussed in Section C.6.4.2 as part of the evaluation of potential action-specific ARARs.

As this resolution does not contain numeric standards but rather presents policies and procedures for investigation and remediation of contaminated sites, it does not represent a

chemical-specific ARAR. As this resolution does present procedures for identification of cleanup levels, it is considered to be a TBC for the Western Groundwater OU.

Under this policy, the Regional Board could require cleanup of groundwater to background levels or alternatively could require particular evaluations to support CoPC levels greater than background. Narrative goals that require cleanup to zero are generally not considered to be chemical-specific ARARs (see previous discussion in Section C.4.2.3.1). For example, EPA has determined that MCLGs that are set at zero would not be appropriate for setting cleanup levels and therefore would not be ARARs. Consequently, although the procedures for establishment of cleanup levels established under Resolution 92-49 may potentially be relevant to the Western Groundwater OU, these procedures are not appropriate as the procedures for establishing cleanup levels under CERCLA Section 121(d) and 40 CFR 300.430 are the required and more appropriate procedures for establishment of cleanup standards at National Priority List (NPL) sites. The policies and procedures set forth in Resolution 92-49 are considered to be TBCs for the Western Groundwater OU.

Evaluation of the potential applicability or relevance and appropriateness of those portions of this resolution related to containment zones are discussed as part of the evaluation of potential action-specific requirements.

C.4.2.3.4 Regional Water Board Policy for Investigation and Cleanup of Contaminated Sites

This policy describes the Regional Water Board's strategy for managing contaminated sites and in particular describes the basis for establishing ground water (and soil) cleanup levels. It is not a promulgated regulation. Specifically this policy states that

> "Ground water cleanup levels shall be established based on
>
> *i.* background concentrations of individual pollutants;
>
> *ii.* applicable water quality objectives to protect designated beneficial uses of the water body as listed in Chapters II and III;
>
> *iii.* concentrations which do not pose a significant risk to human health or the environment, considering risks from toxic constituents to be additive across all media of exposure and, in the absence of scientifically valid data to the contrary, additive for all constituents having similar toxicological effects or having carcinogenic effects; and
>
> *iv.* technologic and economic feasibility of attaining background concentrations and of attaining concentrations lower than defined in (*ii*) and (*iii*) above.

Factors in (*i*) through (*iii*) above are used to establish ground water cleanup levels according to the following principles:

v. Pursuant to 23 CCR Section 2550.4, the Regional Water Board establishes cleanup levels that are protective of human health, the environment and beneficial uses of waters of the state, as measured by compliance with (*ii*) and (*iii*) above, and are equal to background concentrations if background levels are technologically and economically feasible to achieve. If background levels are infeasible to achieve, cleanup levels are set between background concentrations and concentrations that meet all criteria in (*ii*) and (*iii*) above. Within this concentration range, cleanup levels must be set at the lowest concentrations that are technologically and economically achievable. In no case are cleanup levels established below natural background concentrations.

vi. Technologic feasibility is determined by assessing the availability of technologies which have been shown to be effective in reducing the concentrations of the constituents of concern to the established cleanup levels. Bench-scale and/or pilot-scale studies may be necessary to make this feasibility assessment in the context of constituent, hydrogeologic, and other site-specific factors. Economic feasibility does not refer to the subjective measurement of the ability of the discharger to pay the cost of cleanup, but rather to the objective balancing of the incremental benefit of attaining more stringent levels of constituents of concern as compared with the incremental cost of achieving those levels. Factors to be considered in the establishment of cleanup levels greater than background are listed in 23 CCR, Section 2550.4(d). The discharger's ability to pay is one factor to be considered in determining whether the cleanup level is *reasonable*. However, availability of economic resources to the discharger is primarily considered in establishing reasonable schedules for compliance with cleanup levels.

vii. Compliance with (*iii*) above shall be determined through risk assessments performed by the discharger, using most current procedures authorized by the Department of Toxic Substances Control, the Office of Environmental Health Hazard Assessment, or the USEPA."

This policy sets forth procedures to be used for establishing groundwater cleanup levels at a contaminated site. This policy is a TBC for the Western Groundwater OU.

C.4.2.4 Title 23 Chapter 15 Section 2550.4 – Concentration Limits

Section 2550.4 of Chapter 15 of Title 23 of the California Code of Regulations specifies that one of the following concentration limits shall be proposed by the discharger for each hazardous constituent for each medium:

1. A concentration limit not to exceed the background value of that constituent;

2. A concentration limit equal to background; or

3. A concentration limit greater than background established pursuant to this section for a corrective action program.

Concentrations limits greater than background shall be established only if it is technologically or economically infeasible to achieve the background value for a particular constituent and the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the concentration limit greater than background is not exceeded. This regulation also specifies the factors to be considered by the Regional Board in establishing a concentration limit greater than background. Concentration limits greater than background shall not exceed the lowest concentration that is technologically and economically feasible. This regulation is not intended to allow a concentration limit to exceed the maximum concentration allowed under other applicable statutes or regulations such as the federal MCLs established under the Safe Drinking Water Act.

Although these regulations were established to address hazardous waste management, pursuant to State Board Resolution 92-49 and Section 2550.0 of these regulations, these requirements are applicable to cleanup and abatement activities. Specifically, 23 CCR 2550.0 states *"Furthermore, §2550.4 of this article also applies to all determinations of alternative cleanup levels for unpermitted discharges to land of hazardous waste pursuant to ¶III.G. of SWRCB Resolution 92-49 (Section 2907, Title 23 of this code) [§20400 of Title 27 of this code serves a similar function for unpermitted discharges to land of solid waste]."*

Therefore, Section 2550.4 may potentially be applicable to the Western Groundwater OU. As these regulations do not contain specific numeric criteria, they are not chemical specific ARARs but may potentially be applicable or relevant and appropriate action specific requirements.

C.4.2.5 Compilation of Water Quality Goals

As previously indicated, the Regional Board staff have developed a compilation of numeric water quality criteria from other appropriate agencies and organizations in the Central Valley Regional Water Board staff report, *A Compilation of Water Quality Goals.* The intent of this compilation is to provide numeric water quality limits from literature sources that may be used to ascertain compliance with water quality standards. This compilation includes promulgated standards such as MCLs as well as non-promulgated advisories such as Suggested No-Adverse-Response Levels (SNARLs). *A Compilation of Water Quality Goals* is not a promulgated regulation or standard. Moreover, many of the numeric values cited in *A Compilation of Water Quality Goals* are promulgated

values such as MCLs or are health-based criteria such as values from USEPA Integrated Risk Information System that are potential TBCs, the majority of which are addressed elsewhere in this ARARS evaluation. The only numeric values in *A Compilation of Water Quality Goals* that may be TBCs that are not otherwise addressed in this evaluation are the values for taste and odor thresholds. The taste and odor threshold values are summarized on Table C-2. As these values are not promulgated standards, they are not ARARs; however, they may be TBCs and may need to be considered to address the WQOs for taste and odor in the Basin Plan.

C.4.3 NPDES Program and Permit

New discharges of treated groundwater to the American River, Buffalo Creek, Alder Creek, or the Folsom South Canal must comply with the substantive portions of the National Pollutant Discharge Elimination System (NPDES) permit program. These requirements may include monitoring of discharges and meeting discharge requirements that have previously been issued for the existing Aerojet Site and American River GET treatment facilities by the Regional Water Quality Control Board. The numeric limits established for the American River GET facility under the NPDES program are listed in Table C-3. There are also specific requirements for inorganic constituents and other parameters in the existing discharge requirements.

An NPDES permit may be required for remedial actions that include discharge of treated groundwater to surface water. If treated groundwater from this OU is discharged to surface water as part of Aerojet's current NPDES permit, the requirements of this permit and any modifications or additions to this permit are applicable requirements.

C.4.4 California Safe Drinking Water and Toxic Enforcement Act (Proposition 65) Levels

The California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) prohibits the knowing discharge or release to a source (or potential source) of drinking water of a significant amount of a chemical which the State has identified under Proposition 65 as causing cancer or reproductive harm. Chemicals known to cause cancer or reproductive toxicity are identified in 23 CCR §12000. CoPCs identified for the Western Groundwater OU that are included on the list of chemicals known to the State to cause cancer are identified on Table C-4. None of the Western Groundwater OU CoPCs has been identified by the State as being known to cause reproductive harm.

For chemicals identified as carcinogens, a "significant amount" of that chemical means a level in a source of drinking water above which poses a significant risk of cancer, assuming lifetime exposure at the level in question. Proposition 65 sets a "no significant risk" level for carcinogenic compounds as that level which is calculated to result in not more than one excess case of cancer in an exposed population of 100,000. The "default" values are summarized on Table C-4. For drinking water, Proposition 65 also provides

that the following levels shall be deemed to be "no significant risk" levels: (1) California MCLs, if they exist for the chemical in question; (2) drinking water action levels set by the State Department of Health Services, for chemicals for which there are no California MCLs; or (3) specific numeric levels of concentration which are permitted to be discharged or released into sources of drinking water by a Regional Water Quality Control Board in a Basin Plan or in waste discharge requirements, if such levels are based on considerations of minimizing carcinogenic risk associated with such discharges or releases.

The numeric limits established under Proposition 65 are not applicable, as more appropriate standards such as MCLs exist, but the Proposition 65 limits may be relevant and appropriate if a remedial action involves supplying treated groundwater to the water system for public consumption. The identification of chemicals known to cause cancer or reproductive toxicity and the numeric limits and default values for identifying "significant amounts" are potentially applicable if the selected remedial action includes reinjection of treated water or discharge to surface water.

C.4.5 National Ambient Water Quality Criteria

USEPA has published ambient water quality criteria under section 304(a) of the Clean Water Act (CWA) to protect human health and welfare and freshwater and marine aquatic life from pollutants in surface waters. Ambient water quality criteria for human health have been developed for drinking of water and consumption of aquatic organisms and for consumption of aquatic organisms alone. Typically, ambient water quality criteria are used by the states to develop water quality standards for surface waters pursuant to section 303(c) of the CWA. They may also be used as a basis to develop numeric limits for NPDES permits. Although ambient water quality criteria are not enforceable standards, CERCLA and the NCP identified these criteria as potential ARARs.

Ambient water quality criteria were developed to protect human health and welfare and freshwater and marine aquatic life in surface water, and therefore are not applicable to groundwater. As the numeric limits contained in the water quality criteria address combined exposures from both drinking water and ingestion of aquatic organisms, they are not considered relevant to groundwater. In addition, more appropriate criteria such as MCLs exist for groundwater. Therefore, ambient water quality criteria are neither applicable nor relevant and appropriate to groundwater in the Western Groundwater OU.

Ambient water quality criteria may represent relevant and possibly appropriate requirements for discharge of treated groundwater to surface waters. EPA recently published updates to the ambient water quality criteria As discharge of treated water to surface waters is necessary to trigger consideration of ambient water quality criteria, these requirements are addressed further under potential action-specific requirements.

C.4.6 USEPA Region 9 Preliminary Remediation Goals

Region 9 of U.S. EPA has established preliminary remediation goals (PRGs) as risk-based tools for evaluating and cleaning up contaminated sites. These PRGs incorporate current toxicity values with standard exposure factors to provide estimates of contaminant concentrations in environmental media that are considered to be protective of humans over a lifetime. PRGs are intended for use in screening pollutants in environmental media, triggering further investigation and providing an initial cleanup goal if applicable.

U.S. EPA Region 9 PRGs for the Western Groundwater OU are summarized on Table C-5. The Region 9 PRGs are guidance and not promulgated standards. Consequently, the EPA Region 9 PRGs for groundwater are TBCs for the Western Groundwater OU.

C.4.7 DHS Drinking Water Action Levels

The California Department of Health Services has established health-based advisory levels (ALs) for chemicals for which primary maximum contaminant levels (MCLs) have not been adopted. An AL is a level of a contaminant in drinking water that is considered not to pose a significant health risk to people ingesting water on a daily basis. ALs are calculated using typical exposure assumptions (two-liter per day ingestion rate, a 70 kilogram adult body weight, and a 70-year lifetime) and standard federal and state assessment methodologies for noncarcinogens and carcinogens. Often the basis for an AL is an evaluation previously completed by USEPA or the Cal EPA's Office of Environmental Health Hazard Assessment (OEHHA).

ALs are advisory levels and are not enforceable standards. When an AL is exceeded, suppliers of drinking water are required to notify local governing agencies. DHS also recommends that utilities notify their customers and consumers as soon as feasible about the presence of the contaminant and its potential for adverse health effects. DHS also recommends that drinking water utilities take the source of the chemical out of service if a contaminant is present at more than 10 times the AL for ALs based on noncarcinogenic effects and 100 times the AL for those based on potential carcinogenic risk.

ALs have been established for two of the chemicals of concern for the Western Groundwater OU. An AL of 18 parts per billion (ppb) was established in 1997 for perchlorate based on a provisional oral reference dose established by USEPA for noncarcinogenic effects. EPA has subsequently revised the RfD upward to a level equivalent to 32 ppb. An AL of 0.002 ppb was established in 1998 for N-nitrosodimethylamine (NDMA) which corresponds to a theoretical 10^{-6} cancer risk; however, this level was below the detection limits of most laboratories. Because of the potential for production of NDMA in drinking water treatment processes, DHS subsequently established a temporary AL of 0.02 ppb for NDMA. The ALs and the USEPA RfD are TBCs for the Western Groundwater OU.

C.4.8 California Public Health Goals

At the end of 1997, OEHAA adopted a set of Public Health Goals (PHGs) for chemicals in drinking water. PHGs are levels of drinking water contaminants at which adverse health effects are not expected to occur from a lifetime of exposure. They are based on a 10^{-6} incremental cancer risk estimate for carcinogens and a threshold toxicity limit for other contaminants. The PHGs for the Western Groundwater OU CoPCs are summarized on Table C-6. As PHGs are only non-promulgated goals, they are not ARARs but represent potential TBCs for the Western Groundwater OU.

C.4.9 Integrated Risk Information System

The Integrated Risk Information System (IRIS) is a database prepared and maintained by the U.S. EPA of human health effects that may result from exposure to various substances found in the environment. The database includes oral reference doses and inhalation reference concentrations for chronic non-carcinogenic health effects and hazard identification, oral slope factors and oral and inhalation unit risk for carcinogenic effects. The oral reference doses (RfDs) for non-carcinogenic health effects and oral unit risk values for potential carcinogenic effects associated with the Western Groundwater OU CoPCs are summarized on Table C-7.

As IRIS is a non-promulgated database, it is not an ARAR but may potentially be a TBC. Typically, IRIS information is used in the development of toxicity data and the estimation of potential risks in a Baseline Risk Assessment. IRIS values along with other non-promulgated risk-based values were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.

C.4.10 Drinking Water Health Advisories and Suggested No-Adverse Response Levels

USEPA has published drinking water health advisories for toxicity other than cancer risk that were previously referred to as Suggested No-Adverse Response Levels (SNARLs). EPA has also published one-in-a-million incremental cancer risk estimates for various chemicals that may be present in drinking water. The National Academy of Sciences(NAS) has also published SNARLs and one-in-a-million incremental cancer risk levels for drinking water. None of the health advisories, SNARLs or incremental cancer risk estimates are promulgated standards and thus are not ARARs. These values are considered TBCs. Published drinking water health advisories, SNARLs and incremental cancer risk estimates for the CoPCs in the Western Groundwater OU are summarized on Table C-8.

C.4.11 Summary of Potential Chemical-Specific ARARs and TBCs

Table C-9 presents a summary of potential chemical-specific ARARs. Numerical limits associated with potential ARARs or TBCs for chemical occurrences in groundwater are summarized on Table C-10.

Several regulations contain numeric limits for which consideration as potential ARARs would only be triggered by particular actions. For example, consideration of the surface water WQOs would only be triggered by a remedial action that included discharge of treated water to surface water. Numeric limits associated with potential ARARs or TBCs related to discharge of treated groundwater to surface water are discussed further under potential action-specific ARARs. Similarly, consideration of numeric limits promulgated under the Clean Air Act or State air quality regulations would only be considered if the treatment process to be employed result in emissions of regulated substances. Consequently, numeric limits established for surface water, air emissions, hazardous waste management and other regulations that would only be potential ARARs if the selected remedy includes a particular action(s) or results in a generation or discharge that is covered by these regulations, are discussed further as part of the evaluation of potential action-specific requirements.

C.5 Potential Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations. Location-specific ARARs differ from chemical-specific or action-specific ARARs in that they are not closely related to the chemicals of concern or the specific remedial alternative under consideration. Location-specific ARARs are concerned with the area in which the site or remedial action component is located. To the extent that the remedial action will affect historical resources, streams, flood plains, or wetlands, EPA requires that the potential remedial alternatives comply with the location-specific requirements. Potential location-specific ARARs and TBC criteria for the Aerojet Western Groundwater OU RI/FS are summarized in Table C-11.

C.6 Potential Action-Specific ARARs

Action-specific requirements are usually technology or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved.

For the Western Groundwater OU, one of the primary potential action-specific ARARs includes the Resource Conservation and Recovery Act (RCRA) and the California hazardous waste management regulations. The Basin Plan, including beneficial uses, water quality objectives, and policies and procedures for implementation of the Plan, also contains requirements that may potentially be action-specific requirements. Some of the State and Regional Water Board policies and procedures along with DHS policies may be applicable or relevant and appropriate if treated water is discharged or reused. The National Pollutant Discharge Elimination System (NPDES) and the Underground Injection Control (UIC) regulations may potentially be action-specific ARARs depending upon the method used to discharge treated water. In addition, as previously indicated, several of the chemical-specific requirements previously discussed may also be potential ARARs for reinjection or discharge of treated water.

In addition to the various potential action-specific requirements addressed below, regulations related to air quality and control of air emissions promulgated under the federal Clean Air Act and the Sacramento Metropolitan Air Quality Management District (SMAQMD) may also represent potential chemical-specific (numeric limits) or action-specific ARARs. As currently envisioned, treatment of groundwater will either not include processes that result in air emissions or the emissions from the groundwater treatment processes will be so low so as to be exempt from the new source review requirements. In addition, construction activities associated with installation of extraction wells and conveyance piping, construction of a treatment facility, and installation of recharge wells or construction of a surface water discharge system are not anticipated to disturb an area over 5 acres, but more likely will disturb an area less than 1 acre. Consequently, requirements of the Clean Air Act, the California Air Pollution Control Laws, and the SMAQMD rules and regulations are not expected to be potential action-specific ARARs. Therefore, these requirements have not been evaluated as part of this ARARs analysis. If the nature of the selected remedial action entails air emissions at levels that would be subject to these regulations, then they could potentially be considered action-specific ARARs.

C.6.1 Resource Conservation and Recovery Act (RCRA)

Regulations (40 CFR 260 et seq.) promulgated under Subtitle C of the Resource Conservation and Recovery Act (RCRA) and the California Hazardous Waste Act (CCR Title 22 Division 4.5) contain requirements for management of hazardous wastes. Specifically, these regulations contain requirements related to the identification and classification of hazardous wastes, generator standards for management of hazardous wastes and standards for storage, treatment and disposal of hazardous wastes.

RCRA requirements are generally applicable under two scenarios: (1) sites where hazardous wastes were treated, stored, or disposed of after the effective date of RCRA; and (2) a CERCLA activity involving treatment, storage, or disposal of hazardous wastes. These two scenarios are contingent upon a determination that RCRA hazardous waste is present and on identification of the period of waste management. As previously

indicated, source areas will be addressed as part of future OU RI/FS efforts. Therefore, this FS evaluates potential action-specific requirements under RCRA with regard to wastes that potentially may be generated, stored, treated or disposed in conjunction with remedial actions for the Western Groundwater OU.

At this time, the anticipated treatment processes that may be used for treatment of groundwater from the Western Groundwater OU are not expected to entail generation or accumulation of hazardous waste, or are not expected to result in generation of hazardous wastes in amounts or for periods of accumulation greater than that allowed under the standards for generators. Consequently, the RCRA standards for treatment, storage and disposal (TSD) facilities are not expected to be action-specific ARARs for any of the remedial actions that may be taken for the Western Groundwater OU. If the selected treatment processes do result in generation of sidestreams or other residuals that are a hazardous waste and if operation of the treatment system entails treatment, storage or disposal of such hazardous wastes onsite beyond the limits allowed under generator status, then portions of the RCRA TSD standards may potentially be applicable.

C.6.1.1 Identification and Classification of RCRA Hazardous Wastes and State Hazardous Wastes

Treatment of water or air can generate waste material that must be managed before its disposal or regeneration. If the material generated is a solid waste that meets the definition of a hazardous waste, substantive requirements of the Resource Conservation and Recovery Act and Title 22 of the California Code of Regulations, Division 4.5, Chapter 11 for the management of hazardous wastes may potentially be applicable.

Specifically those portions of these regulations that require testing and characterization of wastes prior to disposal or treatment would potentially be applicable to the management of residuals. These include testing and definitions related to the characteristics of ignitability, corrosivity, reactivity, and toxicity. The numeric limits for identification of toxicity characteristic hazardous waste (40 CFR Part 261 and Title 22 CCR Chapter 11, §66261) resulting from the presence of site-related constituents such as carbon tetrachloride, chloroform, 1,2-dichloroethane, 1,1-dichloroethylene, tetrachloroethylene, and trichloroethylene or other chemicals that may be encountered, used or generated during water treatment process, are potentially applicable. Along with the numeric limits for identification of characteristic hazardous wastes, RCRA regulations related to identification and classification of listed hazardous wastes are also potential action-specific ARARs.

Operation of a groundwater treatment facility could result in production of side-streams, by-products or waste material that could potentially be hazardous wastes. Wastes that may be produced by a facility used to treat contaminated groundwater could potentially include ion exchange regeneration brine solutions, biological treatment sludges, spent granular activated carbon, or other treatment residuals or sidestreams. To the extent that any of these materials are a hazardous waste, they would have to be handled and treated

or disposed in accordance with the RCRA standards for management of hazardous wastes. The requirements in these sections of the RCRA regulations (40 CFR Parts 261 and Title 22 CCR Chapter 11, §66261.10 et seq.) are applicable in determining whether wastes materials produced through treatment of contaminated water are potentially RCRA hazardous waste.

California has adopted in entirety the federal RCRA regulations related to the identification and classification of hazardous wastes. In addition, California has developed additional regulations (Title 22 CCR Chapter 11, §66261.24) related to identification of State-only (non-RCRA) hazardous wastes. All of these requirements are potentially applicable to wastes generated during treatment of contaminated groundwater.

Requirements and numeric standards related to identification of characteristic or listed RCRA hazardous or State-only (non-RCRA) hazardous wastes are potential action-specific requirements for management of byproduct materials and wastes generated by treatment of contaminated groundwater. The numeric limits for identification of characteristic hazardous wastes and State hazardous wastes are summarized on Table C-12.

C.6.1.2 RCRA Generator Standards

RCRA regulations (40 CFR Parts 262 and Title 22 CCR Chapter 12, §66262) related to management of hazardous wastes by generators of hazardous wastes (generator standards) are also potentially applicable to management of hazardous wastes, if any, generated at a groundwater treatment facility. The substantive portions of these standards (40 CFR § 262.11 and § 262.30-34) establish minimum requirements for testing to determine whether a waste is hazardous, storage and inspection requirements, and maximum periods of accumulation of hazardous wastes for generators. Specifically, the RCRA (40 CFR §262.11) and State hazardous waste management (Title 22 CCR Chapter 12, §66262.11) regulations requiring generators to determine if a waste is hazardous, are potentially applicable. Similarly, regulations related to identification of characteristic or listed RCRA hazardous wastes (40 CFR §261.24 and Title 22 CCR Chapter 12 §66261.24) are potentially applicable to waste materials that may be generated from treatment of contaminated groundwater.

These regulations also establish minimum standards for management and storage of hazardous wastes by generators and maximum amounts and periods of accumulation for different types of generators. Specifically, these regulations establish the minimum requirements for packaging, labeling, marking and placarding of hazardous waste containers prior to shipment offsite for treatment or disposal. These regulations also establish the requirements and maximum duration over which hazardous wastes may be accumulated onsite prior to shipment without requiring permitting as a hazardous waste storage facility.

C.6.2 NPDES Regulations

The National Pollutant Discharge Elimination System (NPDES) regulations (40 CFR Parts 122 and 125) established under the Federal Water Pollution Control Act (FWPCA) and the equivalent waste discharge permit regulations established under the RWQCB Basin Plan are potential action-specific requirements. Specifically, substantive portions of the NPDES and Waste Discharge Permit requirements related to discharge of treated water would potentially be applicable if the selected remedy includes discharge of treated groundwater to surface water. The substantive portions of the NPDES stormwater regulations may also be potential action-specific requirements for the design and operation of any groundwater treatment facility.

C.6.2.1 NPDES Discharge Permits

New discharges of treated groundwater to the American River, Buffalo Creek, Alder Creek or the Folsom South Canal must comply with the National Pollutant Discharge Elimination System (NPDES) permit program. To the extent that discharge of treated water occurs onsite, as the term site is defined under CERCLA, only the substantive portions of the NPDES regulations need to be met by the selected remedial action. To the extent that discharge of treated water occurs offsite, both the substantive and administrative requirements (e.g., permitting) may apply.

NPDES requirements include monitoring of discharges and numeric limits on the quality of the discharge. Requirements for discharge of treated groundwater from the existing Aerojet American River GET treatment facility have previously been issued by the Regional Water Quality Control Board. The numeric limits established for the American River GET facility under the NPDES program are listed in Table C-3. The monitoring requirements established under the existing NPPDES permit are described on Table C-13.

An NPDES or waste discharge permit may be required for remedial actions that include discharge of treated groundwater to surface water. If treated groundwater from this OU is discharged to surface water as part of Aerojet's current NPDES permit, the requirements of this permit and any modifications or additions to this permit are applicable requirements. Alternatively, a new permit, with similar or different requirements may be issued for surface water discharge of treated groundwater if this option is included in the selected remedial action. If discharge of treated water occurs entirely onsite, only the substantive portions of these regulations may need to be met. Specifically, discharge limitations will be developed using the procedures set forth in these regulations; however, permits are not required for onsite actions.

C.6.2.2 NPDES Stormwater Regulations

The NPDES permit and stormwater regulations (40 CFR Part 122.26) promulgated under the Federal Water Pollution Control Act, as amended by the Clean Water Act are

potential action-specific ARARs. These regulations establish requirements for stormwater discharges from industrial activities.

NPDES stormwater regulations may be applicable to construction projects involving disturbance of areas of one acre or more and therefore may be potential action-specific ARARs for construction of any groundwater treatment facility. The primary substantive requirement of these regulations is the use of best management practices to control surface water runoff.

C.6.3 RWQCB Basin Plan and Related Policies and Procedures

As previously discussed, the Basin Plan establishes beneficial uses for surface water and groundwater along with water quality objectives (WQOs) to protect the beneficial uses. The State and Regional Water Quality Control Boards have adopted various policies and procedures to protect the beneficial uses. These are not promulgated regulations. WQOs and related policies and procedures established under the Basin Plan were previously discussed as potential TBCs (Section C.4.2).

C.6.3.1 State Water Board Resolution No. 68-16, Statement of Policy with Respect to Maintaining High Quality of Water in California

This policy is discussed in Section C.4.2.3.1.This policy addresses disposal of wastes into waters of the State and therefore is a TBC with regard to a remedial action involving reinjection of treated groundwater or discharge of treated groundwater to surface water.

C.6.3.2 State Water Board Resolution No. 92-49, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304

This resolution is discussed in Section C.4.2.3.3. It contains policies and procedures to address sites where waste discharges have caused or threaten to cause pollution of the waters of the state. These policies require cleanup of groundwater and soils that threaten to pollute groundwater to the extent that beneficial uses of the water are restored and protected. To comply with this resolution, pollutant concentrations must be reduced to levels that at a minimum comply with water quality objectives.

This resolution was amended in 1996 to include provision for designation of a containment zone (CZ) where compliance with water quality objectives for groundwater cannot reasonably be achieved within a reasonable period of time Requirements associated with establishing the rationale for support of a CZ, delineation of the CZ, development of a management plan for the CZ, and implementation of the CZ, are set forth in Section III.H of this resolution.

This resolution does not contain standards of performance or design criteria but rather defines the criteria that the RWQCB may consider in selecting a containment zone action. Thus, these policies and procedures are not action-specific ARARs. However, as several of the alternatives for the Western Groundwater OU may entail use of hydraulic containment to prevent further CoPC migration, the provisions of this resolution are potential TBCs.

C.6.3.3 State Water Resources Control Board Resolutions 68-16 and 92-49

In addition to the previous discussions related to the potential applicability of these resolutions to groundwater actions, these resolutions also have been evaluated with respect to the discharge of treated water to surface water. These resolutions do not set a zero-discharge standard, but rather express the State's policy that existing water quality must be maintained where it is reasonable to do so. The policy expressed in Resolutions 68-16 and 92-49, as well as the Central Valley Regional Water Quality Control Board's Water Quality Control Plan (Basin Plan) (see previous Section C.4.5) further allow the use of mixing zones when determining whether water quality is being maintained in the receiving water. These requirements are potential TBCs for discharge of treated water to surface waters.

C.6.3.4 Wastewater Reuse Policy

The Regional Board has established a policy to encourage the reclamation and reuse of wastewater, including treated groundwater from cleanup actions, where practicable. This is not a promulgated regulation. This policy requires an evaluation of reuse and land disposal options as alternative disposal methods to surface water discharge. Specific types of reuse that should be considered, depending upon the quality of the treated water and the required quality for the specific reuses, include industrial and municipal supply, crop irrigation, landscape irrigation, groundwater recharge and wetland restoration. Both year round and partial year reuse options should be examined. The requirement for evaluation of potential reuse options is a potential TBC and is addressed as part of the development of the various remedial action alternatives for the Western Groundwater OU.

C.6.4 DHS Policy Guidance for Direct Domestic Use of Extremely Impaired Sources

The California Department of Health Services (DHS) has developed a policy that potentially restricts direct domestic use of contaminated water. This is a developing policy that is not uniformly applied and is site-specific. It is not a promulgated regulation.

DHS Policy Memo 97-005 "Policy Guidance for Direct Domestic Use of Extremely Impaired Sources" states the following:

"Extremely impaired sources that contain or are likely to contain high concentrations of contaminants, multiple contaminants, or unknown contaminants (such as groundwater subject to contamination from a hazardous waste disposal site) should not be considered for direct human consumption where alternatives are available."

DHS has developed criteria for identifying an extremely impaired source. Per the DHS policy, an extremely impaired groundwater source meets one or more of the following criteria:

- exceeds 10 times an MCL or action level (AL) based on chronic health effects;
- exceeds 3 times an MCL or action level (AL) based on acute health effects;
- is extremely threatened with contamination due to proximity to known contaminating activities;
- contains a mixture of contaminants of health concern; or
- is designed to intercept known contaminants of health concern.

Although portions of the groundwater plumes in the Western Groundwater OU Study Area may meet these criteria, groundwater in portions of the area contains CoPCs at concentrations below these levels. Groundwater with concentrations less than those specified in this policy are being considered for potential use for domestic supply in the form of the wellhead treatment options. This policy is considered a TBC for the evaluation of those alternatives that include use of treated groundwater for domestic or municipal supply.

C.6.5 Summary of Potential Action-Specific ARARs

The federal and State potential action-specific ARARs for the alternatives discussed in the Western Groundwater OU RI/FS are summarized in Table C-14.

Table C-1: Primary Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) for Contaminants of Potential Concern

Contaminant of Potential Concern	Federal Primary MCL (mg/L)	Federal MCLG (mg/L)	California Primary MCL (mg/L)
1,1,2-Trichloroethane	0.005	0.003	0.005
1,1-Dichloroethane			0.005
1,1-Dichloroethene	0.007	0.007	0.006
1,2-Dichloroethane	0.005	0	0.0005
cis-1,2-Dichloroethene	0.007	0.007	0.006
trans-1,2-Dichloroethene	0.1	0.1	0.01
Carbon tetrachloride	0.005	0	0.0005
Chloroform	0.080 [a]		
Freon-113			1.2
Tetrachloroethene	0.005	0	0.005
Trichloroethene	0.005	0	0.005
Vinyl chloride	0.002	0	0.0005
Perchlorate			
NDMA			
Nitrate (as N)	10		45 [b]
Nitrite (as N)	1		1
Total Nitrate and Nitrite (as N)	10		10

[a] For total trihalomethanes (TTHM).
[b] As NO_3.
Lack of an entry denotes that MCLs or MCLGs are not available for the constituent.

Table C-2: Taste and Odor Threshold Values

Contaminant of Potential Concern	Taste & Odor Thresholds
1,1,2-Trichloroethane	NA
1,1-Dichloroethane	NA
1,1-Dichloroethene	1,500
1,2-Dichloroethane	7,000
1,2-Dichloroethene (cis)	NA
1,2-Dichloroethene (trans)	260
Carbon tetrachloride	520
Chloroform	2,400
Freon-113	NA
Tetrachloroethene	170
Trichloroethene	310
Vinyl chloride	3,400
Perchlorate	NA
NDMA	NA
Nitrate	NA
Nitrite	NA
Total Nitrate and Nitrite	NA

Notes:
All values are in units of ug/L.
NA = not available.

Table C-3: Effluent Limitations for American River Study Area Interim Groundwater Extraction and Treatment System

Constituent	Units	Daily Maximum	Monthly Average
Copper (total)	ug/L	17	11
Lead (total)	ug/L	15	2.5
Zinc (total)	ug/L	110	100
Volatile organics [a]	ug/L	0.5 [b]	
Perchlorate	ug/L	18	18
1,4-dioxane	ug/L	15	10

[a] Includes all volatile organics constituents listed in EPA Methods 8010 and 8020.
[b] The concentration of each constituent shall not exceed 0.5 ug/L.

Table C-4: California Proposition 65 "No Significant Risk" Levels

Contaminant of Potential Concern	California Proposition 65 Levels (ug/day)	California Proposition 65 Levels [a] (ug/L)
1,1,2-Trichloroethane	10	5
1,1-Dichloroethane	100	50
1,1-Dichloroethene	NA	NA
1,2-Dichloroethane	10	5
1,2-Dichloroethene (cis)	NA	NA
1,2-Dichloroethene (trans)	NA	NA
Carbon tetrachloride	5	2.5
Chloroform	20	10
Freon-113	NA	NA
Tetrachloroethene	14	7
Trichloroethene	50	25
Vinyl chloride	3	1.5
Perchlorate	NA	NA
NDMA	0.04	0.02
Nitrate	NA	NA
Nitrite	NA	NA
Total Nitrate and Nitrite	NA	NA

Notes:

[a] Converted to concentration based on 2 liters per day consumption.
NA = not available.
None of the Western Groundwater CoPCs have been identified as known to cause reproductive toxicity.

Table C-5: EPA Region 9 Preliminary Remediation Goals

Contaminant of Potential Concern	USEPA Region 9 PRGs [a]
1,1,2-Trichloroethane	0.2
1,1-Dichloroethane	810
1,1-Dichloroethene	0.046
1,2-Dichloroethane	0.12
1,2-Dichloroethene (cis)	61
1,2-Dichloroethene (trans)	120
Carbon tetrachloride	0.17
Chloroform	0.16
Freon-113	59,000
Tetrachloroethene	1.1
Trichloroethene	1.6
Vinyl chloride	0.02
Perchlorate	18
NDMA	0.0013
Nitrate	NA
Nitrite	NA
Total Nitrate and Nitrite	NA

Notes:

All values are in units of ug/L
[a] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
NA = not available.

Table C-6: California Public Health Goals

Contaminant of Potential Concern	California PHGs
1,1,2-Trichloroethane	NA
1,1-Dichloroethane	NA
1,1-Dichloroethene	10
1,2-Dichloroethane	4
1,2-Dichloroethene (cis)	NA
1,2-Dichloroethene (trans)	NA
Carbon tetrachloride	NA
Chloroform	NA
Freon-113	4,000
Tetrachloroethene	NA
Trichloroethene	0.8
Vinyl chloride	NA
Perchlorate	NA
NDMA	NA
Nitrate	NA
Nitrite	NA
Total Nitrate and Nitrite	NA

Notes:
All values are in units of ug/L
NA = not available.

Table C-7: USEPA Integrated Risk Information System (IRIS) RfDs and Incremental Cancer Risk Values

Contaminant of Potential Concern	IRIS RfDs as drinking water levels	IRIS $1x10^{-6}$ incremental cancer risk as drinking water levels
1,1,2-Trichloroethane	2.8	0.6
1,1-Dichloroethane		
1,1-Dichloroethene	6	0.06
1,2-Dichloroethane		0.4
1,2-Dichloroethene (cis)		
1,2-Dichloroethene (trans)	140	
Carbon tetrachloride		0.3
Chloroform		6
Freon-113	210,000	
Tetrachloroethene	70	
Trichloroethene		
Vinyl chloride		
Perchlorate		
NDMA		0.0007
Nitrate [a]	11,000	
Nitrite [a]	700	
Total Nitrate and Nitrite [a]		

Notes:
All values are in units of ug/L.
All values are based on consumption of 2 liters of water per day.
[a] Expressed as N.
NA = not available.

Table C-8: USEPA and NAS Drinking Water Health Advisories and Suggested No-Adverse Response Levels

Contaminant of Potential Concern	EPA DWHAs or SNARLs – non-carcinogenic	EPA DWHAs or SNARLs – carcinogenic	NAS SNARLs – non-carcinogenic	NAS SNARLs - carcinogenic
1,1,2-Trichloroethane	3			
1,1-Dichloroethane				
1,1-Dichloroethene	7		100	
1,2-Dichloroethane	700 / 2,600	0.4		0.71
1,2-Dichloroethene (cis)	70			
1,2-Dichloroethene (trans)	100			
Carbon tetrachloride	70 / 300	0.3	200	4.5
Chloroform	100 / 400	6		0.26 / 56
Freon-113				
Tetrachloroethene	2,000	0.7		3.6
Trichloroethene		3		1.5
Vinyl chloride	10 / 50	0.015		1.1
Perchlorate				
NDMA				
Nitrate [a]	10,000			
Nitrite [a]	1,000			
Total Nitrate and Nitrite [a]				

Notes:
All values are in units of ug/L
[a] Expressed as N.
NA = not available.

Table C-9: Summary of Potential Chemical-Specific Requirements

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Safe Drinking Water Act (40 CFR 141)	Establishes national drinking water standards in the form of Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)	Applicable – at the point groundwater is delivered to a drinking water distribution system.	Applicable to water systems serving over 25 persons. Relevant and appropriate for smaller systems. Establishes MCLs that apply to many of the site-related chemicals (see also Table C-1).
CCR Title 22 Chapter 15, Section 64400 et seq.	Establishes California primary and secondary MCLs	Relevant and Appropriate – for in situ groundwater that is or has a potential to be used for drinking water .	All MCLs (organic, inorganic, etc.) are potentially applicable if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR)	Defines beneficial uses for surface water and groundwater in the basin. Establishes water quality objectives, including narrative and numeric standards, to protect the beneficial uses and water quality objectives (WQOs) of surface and ground waters in the region. Describes implementation plans and other control measures designed to ensure compliance with statewide plans and policies.	Groundwater uses and WQOs are potential TBCs for development of ground-water cleanup levels and remedial actions. These are also potential TBCs if the selected remedial action includes reinjection of treated water. Surface water uses and WQOs are potential TBCs if the selected remedial action includes discharge of treated water to surface water Basin Plan policies and procedures for establishment of cleanup levels are not TBCs as CERCLA sets methods for identification of cleanup levels at NPL sites	Specific portions of the Basin Plan that are TBCs include: • Beneficial uses of waters in the basin including: <u>Ground water</u> – municipal and domestic supply (MUN), – agricultural supply (AGR), – industrial service supply (IND) and – industrial process supply (PRO) <u>Surface water</u> – MUN, AGR, IND, – Recreation (REC) – Freshwater habitat (WARM) and (COLD), Wildlife habitat (WILD), Migration of aquatic organisms (MIGR), and Spawning (SPWN) • Water quality objectives to protect these uses including: <u>Ground water</u> – Numerical standards for bacteria, chemical constituents (MCLs), and radioactivity – Narrative standards for tastes and odors and toxicity <u>Surface water</u> – Numerical limits for bacteria, chemical constituents, dissolved oxygen, pH, radioactivity, salinity, temperature and turbidity – Narrative standards for biostimulatory substances, color, floating material, oil and grease, sediment, settleable material, suspended material, tastes and odor, and toxicity

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR) cont.			• Basin Plan also requires that any activity, including, but not limited to, the discharge of contaminated soils or waters or in-situ treatment or containment of contaminated soils or waters, must not result in actual water quality exceeding water quality objectives.
State Water Resources Control Board Resolution No. 88-63 "Sources of Drinking Water Policy" (contained in the RWQCB's Water Quality Control Plan)	Specifies that, with certain exceptions, all ground and surface waters must have the beneficial use of municipal or domestic water supply.	Potential TBC with respect to beneficial uses Potential TBC with respect to basis for exceptions from the general designations of beneficial uses	This policy is used by the Regional Water Board in determining beneficial uses for waters. The beneficial uses established in the Basin Plan are based on this policy. The beneficial uses in the Basin Plan represent a site-specific determination and therefore are more appropriate than this general policy. This policy also establishes the basis for exceptions to the general designation of beneficial uses.
State Water Resources Control Board Resolution No. 68-16 "Statement of Policy With Respect to Maintenance of High Quality of Waters in California " ("Anti-degradation Policy").	Requires that quality of high quality surface and ground waters be maintained to the maximum extent possible. Degradation of waters will be allowed only if : – It is consistent with the maximum benefit to the people of the state, – It does not unreasonably affect present and anticipated beneficial uses, and – It does not result in water quality less than that prescribed in RWQCB and SWRCB policies. If degradation is allowed, the discharge must meet best practicable treatment or control, which must prevent pollution or nuisance and result in the highest water quality consistent with maximum benefit to the people of the state.	–Potential TBC if the selected remedial action includes disposal of wastes into waters of the State	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
RWQCB, CVR Basin Plan "Antidegradation Implementation Policy"	Defines the RWQCB policy with respect to implementation of the SWB Antidegradation Policy contained in SWB Resolution 68-16	–Potential TBC for disposal of wastes into waters of the State	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.
RWQCB, CVR Basin Plan, "Policy for Application of Water Quality Objectives"	This policy requires achievement of water quality objectives at all points within a surface water or groundwater resource for which beneficial uses have been designated rather than just at the points of use. This policy also explains how the Regional Water Board applies numeric and narrative water quality objectives to ensure the reasonable protection of beneficial uses of water. This policy also explains how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high-quality waters.	WQOs are potential TBCs for development of ground-water cleanup levels and remedial actions. Also potential TBCs if the selected remedial action includes reinjection of treated water. Surface water WQOs are potential TBCs if the selected remedial action includes discharge of treated water to surface water	This policy requires maintenance of background water quality to comply with the antidegradation policy. This policy requires WQOs to be the least stringent limits to be imposed on water quality and indicates that background represents the most stringent limits to be imposed on ambient water quality. The Basin Plan includes both numeric and narrative water quality objectives. This policy explains how the RWQCB evaluates compliance with the narrative WQOs through use of other standards, criteria, advisories, etc. as presented in *"A Compilation of Water Quality Goals"*. To the extent that the methodology presented in this policy uses promulgated standards, criteria or limitations, the narrative standards represent potential ARARs. To the extent that the methodology in this policy uses non-promulgated criteria, advisories, or risk-based levels, this policy represents a TBC. This policy also presents a methodology for assessing compliance with the narrative WQO for toxicity. Similar to the other narrative standard, to the extent the toxicity methodology relies on promulgated standards it may be an ARAR and to the extent that it relies on non-promulgated values it is a TBC. Note: The toxicity assessment required by this policy will be addressed in more detail and precision in the Baseline Risk Assessment.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
State Water Resources Control Board Resolution No. 92-49 (As amended April 21, 1994 and October 2, 1996) "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304" Also Title 23 CCR Chapter 22, Section 2907	Establishes requirements for investigation and cleanup and abatement of discharges. Among other requirements, dischargers must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality, or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of Title 23, CCR, Section 2550.4 requirements to groundwater cleanups.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	These policies and procedures require cleanup of a discharge and abatement of effects of past, current or possible discharges of waste that creates or threatens to create a condition of pollution or nuisance. These policies and procedures establish procedures for investigation, evaluation of cleanup and abatement alternatives, implementation of cleanup and abatement actions including conformance with Resolution No. 68-16. These policies and procedures require cleanup and abatement that promotes attainment of either background water quality, or the best water quality which is reasonable (but not greater than that prescribed in the Water Quality Control Plans and Policies adopted by the State and Regional Water Boards) if background levels cannot be restored. Note: These policies and procedures also address designation and implementation of containment zones, which are discussed in table C-### under potential action-specific requirements.
RWQCB, CVR Basin Plan, "Policy for Investigation and Cleanup of Contaminated Sites."	This policy establishes and describes the RWQCB required procedures for investigation and remediation of contaminated sites. This policy also describes the RWQCB requirements for cleanup levels for groundwater and soil contamination.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	This policy requires establishment of cleanup levels for groundwater based on: – Background concentrations – Water quality objectives – Concentrations that do not pose a significant risk to human health or the environment – Technologic and economic feasibility of attaining background. This policy requires achievement of background levels when feasible. Otherwise, this policy requires achievement of water quality objectives and risk-based levels that do not pose a significant risk to human health or the environment. This policy also requires compliance with groundwater cleanup levels throughout the pollutant plume.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Title 23, CCR, Chapter 15, Section 2550.4.	This regulation presents procedures for identifying concentration limits for cleanup and abatement of discharges from facilities that treat, store or dispose of hazardous waste at Class I waste management units. SWB Resolution 92-49 also requires use of these regulations for development of cleanup levels other than background.	Potentially Applicable for identification of ground water cleanup levels. As this regulation does not contain numeric standards, it is not a chemical-specific ARAR but may be an action-specific ARAR.	This regulation requires cleanup to background concentration levels, or a concentration limit greater than background if – It is technologically and economically infeasible to achieve background, and – The constituent will not pose a substantial present or potential hazard to human health or the environment as long as the concentration limit greater than background is exceeded. This regulation lists the various factors to be considered in setting a concentration limit greater than background. This regulation also requires concentration limits that are greater than background to be set at the lowest levels that are economically and technologically achievable.
"A Compilation of Water Quality Goals"	Provides guidance on selecting numeric values to implement narrative water quality objectives contained in the Basin Plan.	To Be Considered	This document is not a promulgated regulation and therefore in itself is not an ARAR but may be a TBC. This document should be considered in selecting appropriate numeric values to implement the narrative WQOs in the Basin Plan. The numeric values contained in the staff report may be ARARs or TBCs depending on the source of the values.
National Pollutant Elimination Discharge System (NPDES Permit)	These regulations set forth the requirements for discharge to surface water and the Establishment of numeric limits and monitoring requirements for such discharges.	Applicable – if the selected remedial action includes discharge of treated water to surface water.	Discharge of treated groundwater to surface water may require obtaining a new NPDES permit or revision of Aerojet's existing NPDES permit (see also Table C-2). The NPDES permit will specify the numeric standards required to be met in water that is to be discharged to surface water as well as the monitoring requirements for such a discharge.
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) Also Title 22 CCR Chapter 3 Section 12000 et seq.	These regulations identify chemicals known to cause cancer or reproductive toxicity. This act prohibits discharge or release of significant amounts of the identified chemicals.	The numeric limits and notification requirements are potentially relevant and appropriate if the selected remedial action includes use of treated groundwater as drinking water supply..	These regulations make it illegal to expose persons to significant amounts of chemicals known to cause cancer or reproductive toxicity without prior notification, or to discharge significant amounts of these chemicals to sources of drinking water. The numeric limits and notification requirements are applicable to the water suppliers at the point that groundwater is delivered to a water system for public consumption.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) cont.	Significant amounts are generally defined as levels that pose no significant risk of cancer. For drinking water, significant levels are defined as California MCLs, drinking water action levels when MCLs don't exist, or discharge limits allowed by a Basin Plan or waste discharge permit.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge or reinjection of treated water.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge of treated water to surface water or reinjection of treated groundwater. The numeric limits and notification requirements are applicable to remedial actions, if any, that include use of treated water for municipal or domestic supply.
National Ambient Water Quality Criteria	Establishes water quality criteria, which are non-enforceable guidance developed under CWA §304 and are used by the State, in conjunction with designated use for a stream segment, to establish water quality standards under CWA §303.	Neither applicable nor relevant and appropriate for groundwater. Potentially relevant but likely not appropriate for discharge of treated water to surface water.	These criteria are published by EPA to protect human health and welfare and freshwater and marine aquatic life from pollutants in surface waters and therefore are not applicable to groundwater. Ambient water quality criteria are based on consumption of drinking water and aquatic organisms (primarily fish) and consumption of fish alone and therefore are not relevant to groundwater in the Western Groundwater OU. Although potentially relevant, ambient water quality criteria are not appropriate requirements as the RWQCB has adopted numeric standards for the surface waters in the area which represent site-specific water quality standards which are more appropriate requirements.
US EPA Region 9 Preliminary Remediation Goals (PRGs)	EPA has developed preliminary remediation goals that are risk-based levels that are used to screen sites that may require additional investigation or possible remediation. PRGs are also used to screen lists of site-related chemicals to identify potential chemicals of concern.	To Be Considered	EPA Region 9 PRGs are guidance levels, not promulgated standards, and therefore are not an ARAR; however, the PRGs may be TBCs for identification of potential groundwater cleanup levels.
California Department of Health Services (DHS) Drinking Water Action Levels	DHS has established action levels based mainly on health effects but in some cases based on organoleptic (taste and odor-based) values	To Be Considered	Action levels (ALs) are advisory to water suppliers and therefore would not be ARARs. They are potential TBCs for identifying potential groundwater cleanup levels. Of particular interest in this matter are the ALs for perchlorate and NDMA.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Public Health Goals (PHGs)	The California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA) has adopted PHGs for chemicals in drinking water. PHGs are levels of drinking water contaminants at which adverse health effects are not expected to occur from a lifetime of exposure.	To Be Considered	PHGs are non-enforceable risk-based goals and therefore are not ARARs but are TBCs for identifying potential groundwater cleanup levels.
EPA Integrated Risk Information System (IRIS)	A non-promulgated database of health effects that may result from exposure to various substances found in the environment.	To be considered	IRIS values were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.
EPA Drinking Water Health Advisories and NAS Suggested No Adverse Response Levels (SNARLs)	Non-promulgated values published by USEPA and the National Academy of Sciences for toxicity other than cancer or incremental cancer risk estimates	To be considered	EPA drinking water health advisories and incremental cancer risk estimates and NAS SNARLs and incremental cancer risk estimates were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.

Table C-10: Summary of Potential Chemical-Specific ARARs and TBCs for Contaminants of Potential Concern in Groundwater

Contaminant of Potential Concern	Federal Primary MCL (mg/L)	Federal MCLG (mg/L)	California Primary MCL (mg/L)	California DHS Action Levels (mg/L)	California Proposition 65 Levels (mg/L)[a]	California PHGs (mg/L)	USEPA Region 9 PRGs (mg/L)[b]
1,1,2-Trichloroethane	0.005	0.003	0.005	NA	0.005	NA	0.0002
1,1-Dichloroethane	NA	NA	0.005	NA	0.05	NA	0.81
1,1-Dichloroethene	0.007	0.007	0.006	NA	NA	0.01	0.000046
1,2-Dichloroethane	0.005	0	0.0005	NA	0.005	0.004	0.00012
1,2-Dichloroethene (cis)	0.07	0.07	0.006	NA	NA	NA	0.061
1,2-Dichloroethene (trans)	0.1	0.1	0.01	NA	NA	NA	0.12
Carbon tetrachloride	0.005	0	0.0005	NA	0.0025	NA	0.00017
Chloroform	0.1 [c]	0	0.1 [c]	NA	0.01	NA	0.00016
Freon-113	NA	NA	1.2	NA	NA	4	59
Tetrachloroethene	0.005	0	0.005	NA	0.007	NA	0.0011
Trichloroethene	0.005	0	0.005	NA	0.025	0.0008	0.0016
Vinyl chloride	0.002	0	0.0005	NA	0.0015	NA	0.00002
Perchlorate	NA	NA	NA	0.0018	NA	NA	0.018
NDMA	NA	NA	NA	0.00002	0.00002	NA	0.0000013
Nitrate [d]	10	NA	45 [e]	NA	NA	NA	NA
Nitrite [d]	1	NA	1	NA	NA	NA	NA
Total Nitrate and Nitrite [d]	10	NA	10	NA	NA	NA	NA

Table C-10: Summary of Potential Chemical-Specific ARARs and TBCs for Contaminants of Potential Concern in Groundwater (cont.)

Contaminant of Potential Concern	IRIS RfD as drinking water levels	IRIS $1x10^{-6}$ incremental cancer risk	EPA DWHAs or SNARLs – non-carcinogenic	EPA DWHAs or SNARLs – carcinogenic	NAS SNARLs – non-carcinogenic	NAS SNARLs - carcinogenic	Taste & Odor thresholds
1,1,2-Trichloroethane	2.8	0.6	3				
1,1-Dichloroethane							
1,1-Dichloroethene	6	0.06	7		100		1,500
1,2-Dichloroethane		0.4	700 / 2,600	0.4		0.71	7,000
1,2-Dichloroethene (cis)			70				
1,2-Dichloroethene (trans)	140		100				260
Carbon tetrachloride		0.3	70 / 300	0.3	200	4.5	520
Chloroform		6	100 / 400	6		0.26 / 56	2,400
Freon-113	210,000						
Tetrachloroethene	70		2,000	0.7		3.6	170
Trichloroethene				3		1.5	310
Vinyl chloride			10 / 50	0.015		1.1	3,400
Perchlorate							
NDMA		0.0007					
Nitrate [d]	11,000		10,000				
Nitrite [d]	700		1,000				
Total Nitrate and Nitrite [d]							

Notes: NA = not available.
All values are in units of ug/L
[a] Converted to concentration based on 2 liters per day consumption.
[b] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
[c] For total trihalomethanes (sum of bromoform, bromodichloromethane, chloroform, and dibromochloromethane).
[d] Expressed as N.
[e] Expressed as NO_3.

Table C-11: Potential Location-Specific Requirements

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Within floodplain	40 CFR Part 6, Appendix A, Fish and Wildlife Coordination Act (16 USC 661 et seq.), and 40 CFR Part 6.302	Require avoidance of adverse effects, minimization of potential harm, and restoration and preservation of natural and beneficial values of floodplains.	Potentially Applicable to any actions that may be conducted within the floodplain.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within 100-year flood plain	40 CFR 264.18(b) and 22 CCR 66264.18(b)	A RCRA facility located in a 100-year flood plain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	Potentially Applicable if groundwater treatment involves treatment or storage of hazardous wastes.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	National Archaeological and Historical Preservation Act (16 USC Section 469); 36 CFR Part 65	Alteration of terrain that threatens significant scientific, prehistoric, historic, or archaeological data may require actions to recover and preserve artifacts.	Potentially applicable if significant artifacts are encountered during construction	The proposed remedial alternatives will not alter or destroy any known prehistoric or historic archeological features west of the Aerojet Sacramento facility site. Areas west of the Aerojet Sacramento facility are essentially completely developed. However, because there is always a possibility that buried historic or prehistoric remains could be discovered during construction, this regulation would require action to recover and preserve artifacts.
Historic project owned or controlled by a federal agency	National Historic Preservation Act (NHPA) Section 106 (16 USC Section 470 et seq.); 36 CFR Part 800	Property included in or eligible for the National Register of Historic Places may require action to preserve historic properties.	Neither applicable nor relevant and appropriate	The anticipated remedial actions do not include any activities on properties included on, or eligible for inclusion on the National Register of Historic Places. If it is determined that properties subject to NHPA are present and could be impacted during the implementation of the remedial action, these requirements may be applicable and would require mitigation measures to protect or preserve such properties.

Table C-11: Potential Location-Specific Requirements (continued)

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Critical habitat upon which endangered species or threatened species depend	Substantive portions of the Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR Part 200, 50 CFR Part 402 Substantive portions of the California Endangered Species Act Substantive portions of the Native Plant Protection Act	Requires action to conserve endangered species or threatened species, including consultation with the Department of the Interior, Fish and Wildlife Service.	Potentially applicable if critical habitat for endangered species could be affected during implementation of the selected remedy	Two endangered floral species are known to occur within Sacramento County: the Sacramento Orcutt grass (Orcuttia Viscida) and the Boggs Lake hedge hyssop (Gratiola Heterosepala). Four endangered wildlife species are expected to occur within 25 miles of the Aerojet Sacramento facility: Bald Eagle, Peregrine Falcon, Giant Garter Snake, and the Valley Elderberry Longhorn Beetle. The Aerojet Sacramento facility may be a habitat for the Burrowing Owl, a species of concern in California. Consultations between Department of Toxic Substances Control (DTSC) and Department of Fish and Game may be conducted if such species are affected by remedial actions.
Wetlands	40 CFR Part 6 Appendix A	Actions must be taken to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	Potentially applicable if any remedial action components are constructed in or otherwise affect wetland areas	Requires actions to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.
	Fish and Game Commission Wetlands Policy (adopted 1987) included in Fish and Game Code Addenda	Actions must be taken to ensure that "no net loss" of wetlands acreage or habitat value occurs. Actions must be taken to restore and enhance California's wetland acreage and habitat value.	TBC	This policy is not a regulatory program but may be considered a TBC criteria.
Areas affecting stream or river	Fish and Wildlife Coordination Act (16 USC 661 et seq.) and 40 CFR Part 6 §302	Restrictions on diversion, channeling or other activity that modifies a stream or river and affects fish or wildlife.	Potentially applicable to any remedial action components that may be constructed in or along a creek or river	Requires action to protect fish or wildlife.

Table C-12: Summary of Numerical Limits for Identification of RCRA Characteristic and State (Non-RCRA) Hazardous Waste

Contaminant of Potential Concern	RCRA TCLP Level (ug/L)	State STLC Level (mg/L)	State TTLC Level (mg/kg)
1,1,2-Trichloroethane			
1,1-Dichloroethane			
1,1-Dichloroethene	700		
1,2-Dichloroethane	500		
1,2-Dichloroethene (cis)			
1,2-Dichloroethene (trans)			
Carbon tetrachloride	500		
Chloroform	6,000		
Freon-113			
Tetrachloroethene	700		
Trichloroethene	500	204	2,040
Vinyl chloride	200		
Perchlorate			
NDMA			

Notes:
TCLP = Toxicity Characteristic Leaching Procedure
STLC = Soluble Threshold Limit Concentration
TTLC = Total Threshold Limit Concentration
Lack of an entry denotes that no standard is available for the constituent.

Table C-13: Discharge Limitations for American River Study Area Interim Groundwater Extraction and Treatment System

Groundwater Treatment System (Inlet and Outlet) Monitoring

Constituents	Units	Type of Sample	Sampling Frequency
Electrical Conductivity @25°C[1]	umhos/cm	Grab	Weekly
Flow	MGD	Meter	Continuous
Total Dissolved Solids	mg/l	Grab	Monthly
Acute Toxicity[2,3]	% survival	Grab	Monthly
Volatile Organics[4]	ug/l	Grab	Weekly
Semi-volatile Organics[5]	ug/l	Grab	Monthly
1,4-dioxane[6]	ug/l	Grab	Monthly
Perchlorate[7]	ug/l	Grab	Monthly
Total Copper	mg/l	Grab	Quarterly
Total Lead	mg/l	Grab	Quarterly
Total Zinc	mg/l	Grab	Quarterly
Hardness (as $CaCO_3$)	mg/l	Grab	Quarterly
Temperature	°F/°C	Grab	Weekly
Dissolved Oxygen	mg/l	Grab	Quarterly
pH[1]	pH units	Grab	Weekly
NDMA[8]	ug/l	Grab	Monthly

Receiving Water Monitoring[9,10]

Constituents	Units	Type of Sample	Sampling Frequency
Dissolved Oxygen	mg/l	R-1,R-2	Monthly
pH	pH units	R-1,R-2	Monthly
Turbidity	NTU	R-1,R-2	Monthly
Temperature	°F/°C	R-1,R-2	Monthly
Electrical Conductivity	umhos/cm	R-1,R-2	Monthly
Total Copper	mg/l	R-1,R-2	Quarterly
Total Lead	mg/l	R-1,R-2	Quarterly
Total Zinc	mg/l	R-1,R-2	Quarterly
NDMA[8]	ug/l	R-2	Monthly
Perchlorate[7]	ug/l	R-2	Monthly
Volatile Organics[4]	ug/l	R-1,R-2	Monthly
Hardness (as $CaCO_3$)	mg/l	R-1,R-2	Monthly

Table C-13: Discharge Limitations for American River Study Area Interim Groundwater Extraction and Treatment System (continued)

Three Species Chronic Toxicity Monitoring

Chronic toxicity monitoring shall be conducted to determine whether the effluent is contributing to toxicity in the American River. The testing shall be conducted as specified in EPA 600/4-89-001. Chronic toxicity samples shall be collected at the discharge of the Ground Water Treatment Plant prior to entering Buffalo Creek. Samples collected from the outlet of the treatment unit shall be representative of the volume and quality of the discharge. The time of collection for samples shall be recorded. Chronic toxicity monitoring shall include the following:

Species:	*Pimephales promelas, Ceriodaphnia dubia, Selenastrum capriocornutum*
Frequency:	Once per Quarter for one year
Dilution Series:	100 percent effluent

Monitoring of Discharge to Sailor Bar Park

The Discharger shall sample the discharge to pond in Sailor Bar Park for volatile organic constituents and NDMA as listed above in the table for the groundwater treatment system monitoring. The sample shall be collected and analyzed on a monthly basis from the discharge prior to it entering the pond.

Table C-13: Discharge Limitations for American River Study Area Interim Groundwater Extraction and Treatment System (continued)

Notes:
All Metals analyses shall be by atomic adsorption methods or a method with an equivalent practical quantitation limit. In addition, chronic toxicity monitoring for the treatment system is also required, and detailed below.

1 Field measurements.
2 The analyses shall be performed in accordance with EPA/600/4-90/027, *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*
3 Sampling of effluent only.
4 Test method to be by EPA Methods 601 and 602, or 8010 and 8020, or 500 series with a practical quantitation level no greater than 0.5 ug/l. All concentrations between the detection level and practical quantitation level shall be reported as trace.
5 Test method to be EPA Method 8270 or equivalent. All peaks shall be reported and tentatively identified. All concentrations between the detection limit and the practical quantitation limit shall be reported as trace values.
6 A practical quantitation level of 10 ug/l. All concentrations between the detection level and quantitation level shall be reported as trace.
7 A practical quantitation level of 4 ug/l. All concentrations between the detection level and quantitation level shall be reported as trace.
8 NDMA analysis with a minimum practical quantitation level of 0.033 ug/l. All concentrations between the detection level and quantitation level shall be reported as trace.
9 All receiving water samples shall be grab samples. Receiving water monitoring shall include at least the following:

Station	Description
R-1	At least 100 feet upstream on the American River from the confluence with Buffalo Creek.
R-2	Downstream on the American River at the pedestrian bridge crossing just downstream of the Sunrise Bridge overcrossing.

10 In conducting the receiving water sampling, a log shall be kept of the receiving water conditions in the American River. Attention shall be given to the presence or absence of:

a. Floating or suspended matter
b. Discoloration
c. Bottom Deposits
d. Aquatic life
e. Visible films, sheens or coatings
f. Fungi, slimes, or objectionable growths
g. Potential nuisance conditions

Notes on receiving water conditions shall be summarized in the monitoring report.

Table C-14: Potential Action-Specific Requirements

Action	Potential Requirement	Citation	Description	Preliminary ARAR Determination	Comments
Generation of waste from operation of a groundwater treatment plant	RCRA and State standards for identification and classification of hazardous wastes	40 CFR Part 261 and 22 CCR §66261	Establishes procedures and numeric limits for identification of characteristic hazardous wastes, listed hazardous wastes, and State-only (non-RCRA) hazardous wastes.	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the selected remedial action or operation of a groundwater treatment plant.
	RCRA Generator Standards – hazardous waste determination	40 CFR § 262.11 and 22 CCR §66262.11,	Requires waste generators to determine if wastes are hazardous wastes and establishes procedures for such determinations	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action or operation of a groundwater treatment plant.
Shipment of hazardous wastes for treatment or disposal offsite	RCRA Generator Standards – hazardous waste shipment	40 CFR § 262.30 – 33 and 22 CFR 66262.30 through 66262.33	Prior to transportation, containers should be packaged, labeled, marked, and placarded in accordance with RCRA and Department of Transportation requirements.	Potentially applicable	These requirements are applicable if containers are used to contain hazardous waste to be sent for offsite treatment or disposal.
	RCRA Generator Standards – hazardous waste accumulation	40 CFR § 262.34 and 22 CCR §66262.34	Specifies maximum amounts and maximum periods for accumulation of hazardous waste onsite under generator status	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action and operation of any groundwater treatment plant if these waste materials are hazardous wastes.
Discharge to surface water and/or reinjection of groundwater	Basin Plan – beneficial uses, WQOs and policies and procedures	SWB Resolution 68-16 ("Anti-degradation policy")	Requires maintenance of existing water quality that is better than that required by other policies.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
		SWB Resolution Nos. 68-16 and 92-49	Allow for the use of mixing zones as part of a determination of whether water quality is being maintained in the receiving water.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.

Table C-14: Potential Action-Specific Requirements (cont.)

Action	Potential Requirement	Citation	Description	Preliminary ARAR Determination	Comments
	NPDES discharge requirements	40 CFR Parts 122 and 125 and 23 CCR 2235 et seq.	Establishes permit, treatment and monitoring requirements for discharges to surface water	Potentially applicable	This requirement is potentially applicable if the selected remedial action includes discharge of treated water to surface water.
Stormwater management	NPDES stormwater requirements	40 CFR Parts 122.26 23 CCR 2235 et seq.	Establishes permitting, monitoring, and pollutant control requirements for stormwater from industrial activities.	Potentially applicable	These requirements would be applicable if construction activities associated with the remedial action disturb an area of 5 acres.
Groundwater containment	Containment Zone (CZ) requirements	SWB Resolution No. 92-49 and related Containment Zone Application Requirements	Defines requirements to support use of a containment zone and for delineation and implementation of a containment zone for groundwater contamination.	Potential TBC	The SWB Resolution is potential TBC if the selected remedial action includes physical or hydraulic containment of contaminated groundwater. The Containment Zone Application Requirements are a TBC.
Groundwater extraction and treatment	Evaluation of alternatives for reuse of treated water	Basin Plan – wastewater reuse policy	Requires evaluation of potential water reuse options and identifies potential reuse options that should be considered prior to disposal of treated groundwater	Potential TBC	This policy is a potential TBC for remedial actions that include disposal of treated groundwater. This requirement is being addressed through consideration of the various remedial alternatives including potential groundwater reuse options as part the FS evaluation.
Use of treated groundwater for domestic use	Criteria for domestic use of impacted groundwater	DHS Policy Guidance for Direct Domestic Use of Extremely Impaired Source	Sets forth DHS policy for approval of use of treated groundwater for domestic use	TBC	This policy establishes criteria related to use of treated groundwater for domestic supply and is a TBC criteria for remedial actions that include wellhead treatment or other direct use of treated groundwater.

Appendix D

Western Groundwater OU RI/FS

Groundwater Flow Model

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D1.0 INTRODUCTION

The purpose of this report is to document the groundwater flow model used to develop and analyze the remedial alternatives evaluated in the Western Groundwater Operable Unit Remedial Investigation/Feasibility Study (OU RI/FS).

D1.1 Objectives

The objectives of the groundwater flow model used in this OU RI/FS are to: 1) simulate groundwater flow conditions within and around the Rancho Cordova area and 2) simulate the effects of remedial alternatives under assumed future hydrologic conditions to allow further evaluation of alternatives using CERCLA criteria.

D1.2 Approach

The steps used to evaluate remedial alternatives using the groundwater flow model for this OU RI/FS consisted of: 1) development of an approximation of the hydrogeologic conceptual model; 2) transient calibration of the groundwater flow model; and 3) particle tracking to delineate capture zones and evaluate advective migration of chemical plumes.

Following this introduction, Section D2.0 describes the conceptual model of the hydrogeologic setting, Section D3.0 describes the configuration of the groundwater flow model used to incorporate the elements of the conceptual model, Sections D3.0, D4.0 and D5.0 summarize the configuration, parameters, and stresses of the numerical groundwater flow model. Model calibration is presented in Section D6.0. Section D7.0 describes model sensitivity. Section D8.0 summarizes simulations of remedial alternatives. Section D9.0 provides a list of references cited in the report.

D2.0 CONCEPTUAL MODEL

The conceptual hydrogeologic model provides an interpretation of the groundwater flow system that is simulated by the groundwater flow model. Figure D2-1 shows the region included in the groundwater flow model and pertinent features such as model boundaries, the American River, Lake Natoma, and areas of dredge tailings. The model is approximately 83 square miles in area.

The following Subsections describe the conceptual model boundaries, regional geology, and the interpretation of the groundwater occurrence and movement.

D2.1 Boundaries

The easternmost boundary of the model coincides with the contact between sedimentary formations and the basement complex comprised of metamorphosed igneous and sedimentary rocks. Mountain-front recharge to the groundwater flow system within the sedimentary formations is assumed to occur as a result of precipitation runoff from the surrounding hills.

The northeastern and southeastern boundaries represent regional flow lines and are considered as no-flow boundaries.

The western, northwestern and southern boundaries represent water-level conditions to the west of the OU RI/FS model and allows the OU RI/FS model to be hydrologically connected to the remainder of the Central Valley groundwater basin surrounding the model. This boundary allows groundwater to flow into and out of the model depending on differences in water levels at the model boundary and water levels in wells located 20,000 feet west of the model boundary and an assumed conductance of the sediments west of the model boundary.

The American River and Lake Natoma are internal boundaries that act as regions of groundwater recharge or discharge. Flows between groundwater and surface water depend on the differences in their respective water levels and the vertical hydraulic conductivity of the river and lake beds.

D2.2 Regional Geology

The Aerojet site and the Western Groundwater OU RI/FS site are located near the edge of the Sacramento Valley at the contact between the Sierra Nevada metamorphic basement rocks and valley sediments. This area is characterized by shallow-dipping (generally less than one degree) Cretaceous, Tertiary and Quaternary marine and fluvial sediments overlying a steeply dipping contact with Jurassic crystalline basement rocks (DWR, 1974). The sedimentary sequence includes undifferentiated Quaternary sediment and the Laguna, Mehrten, Valley Springs, Ione and Chico Formations. These sediments generally strike north-south and form a wedge that thickens from tens of feet at the eastern Aerojet site boundary to greater than 2,000 feet near the western Aerojet property boundary, a distance of about six miles. The sediments of interest for the groundwater flow model include the undifferentiated Quaternary, Laguna and Mehrten formations. These sediments contain water-bearing zones identified as subsurface layers A through E.

Quaternary Sediments

The uppermost sedimentary sequence consists of Quaternary-age sediments deposited in southwesterly trending channels of the ancestral American River (Shlemon, 1995). Geologic formations present within this sequence include the Modesto, Riverbank, Fair Oaks/Turlock Lake/Laguna complex, Arroyo Seco gravels, and Victor Formations. These formations are not differentiated in this report because they are unsaturated throughout most of the area, and because historic gold dredging has obliterated much of the evidence required to make the distinctions. The

Quaternary sediments were deposited during the glacial and inter-glacial periods during the Pleistocene, and clast size range from clays and fine silts to cobbles and boulders. Locally, the sequence ranges from zero to 125 feet in thickness.

Laguna Formation

The late Pliocene to early Pleistocene Laguna Formation underlies the Quaternary formations. Sediments of the Laguna Formation were derived primarily from granitic and metamorphic parent rocks and were deposited in a low-energy fluvial environment (DWR, 1974). It is primarily composed of tan and brown interbedded silts and clays with less common interbeds of poorly-sorted sands and gravels. The Laguna forms a wedge which thickens from east to west with reported thicknesses ranging from 125 to 400 feet (DWR, 1974).

Mehrten Formation

The middle Miocene to middle Pliocene Mehrten Formation underlies the Laguna Formation. The Mehrten sediments are derived primarily from andesitic lavas and mudflows and are generally darker in color than the overlying Laguna Formation. The contact between the Laguna and Mehrten is not always distinct and is informally referred to as the Laguna-Mehrten transition zone. This transition zone is characterized by relatively clean andesitic sands and interbedded silt and clay lenses. Below the transition zone, the Mehrten is characterized by two types of deposits. The most common deposits are well-sorted black sand, sandstone and gravels. These deposits are loose to weakly-cemented and generally yield abundant quantities of water. Locally, less common deposits consist of a generally non-water bearing tuff-breccia with a well-cemented andesite lapilli and ash matrix. The Mehrten thickens from a few tens of feet in the eastern portions of the Aerojet Site to over 1,300 feet in the Sacramento-San Joaquin Delta (DWR, 1974).

D2.2.1 Hydrostratigraphy

The following description of the hydrostratigraphy within the OU RI/FS area is based largely on the work presented in "Aerojet Site - GET E and F Effectiveness Evaluation Report, April 1996" (Aerojet and Hydro-Search, 1996). The hydrostratigraphic units (layers A through F) were defined at GETs E and F based on lithologic descriptions, water levels, geophysical data, pumping test data, and relative depths and thicknesses. The general descriptions presented below may vary locally due to stratigraphic heterogeneities. Layers A through F do not necessarily correlate with regional geologic formations discussed above.

Layer A

Layer A, the uppermost water bearing unit, is predominantly composed of unconsolidated sand and gravel. Much of Layer A has been disturbed by dredging in the eastern and central portions of the model area. In addition, large areas of Rancho Cordova were dredged prior to development. The saturated thickness of layer A ranges from zero to approximately 20 feet. The depth to the top of layer A ranges from 40 to 50 feet below ground surface (bgs) in the east to 80 to 100 feet in the central portion of the model area. The depth to water increases to the west and layer A is generally

unsaturated on the Aerojet Site to the north, south and west of GET F. The sediments that contain Layer A are present and may be saturated to the west of the Aerojet Site, however, the available data suggest that they are not hydraulically connected with Layer A on the Aerojet Site.

Layer B

On the Aerojet Site, layer B occurs within the basal sands and gravels of the Quaternary sediments, and appears to be continuous beneath most of the Aerojet Site. Layer B is generally unsaturated west of GET F. A relatively low permeability unit comprised of predominantly silt and clay underlies Layer B west of the Aerojet Site. This low permeability unit increases in thickness (from tens of feet to over 100 feet) and depth (from zero to 300 feet bgs) from east to west. During recent off-site drilling, thin (less than 15 feet) lenses of sand were sometimes encountered within the low permeability unit at depths of 100 to 200 feet bgs. Monitor wells constructed in these lenses were assigned to Layer B, although it is not clear that these lenses are continuous or are hydraulically connected with the monitoring wells assigned to layer B on the Aerojet Site.

Layer C

Layer C is composed primarily of mafic sand, sandstone and minor gravel with varying degrees of cementation. Interbeds of brown siltstone and clay are common and vary in thickness from one to 10 feet. Layer C ranges in thickness from 50 to 125 feet with an average thickness of approximately 80 feet. It is saturated and continuous throughout the OU RI/FS study area. The top of Layer C forms a relatively planar surface with a strike of N12°W and a southwesterly dip of approximately 1°. This attitude is consistent with the attitudes of regional geologic formations.

Layer D

Layer D is composed of sands and sandstone with some gravel. On the Aerojet Site. Layer D ranges in thickness from 30 to 150 feet. For the most part, the base of Layer D has not been reached west of the Aerojet Site. Layer D is separated from Layer C by a discontinuous 10- to 45-foot thick clay and siltstone layer.

Layer E

Layer E consists of sand, sandstone and some gravel with interbedded silt and clay. It occurs at depths of 350 to 400 feet bgs near the western Aerojet property boundary. Layer E has not been well characterized in the western portions of the Aerojet Site and there are no wells screened in Layer E west of Sunrise Boulevard. The available data indicate that Layer E is at least 100 feet thick.

Layer F

Layer F consists of similar geologic material as Layer E. The hydrostratigraphy of Layer F is not well known, as very few monitor wells have been completed in this Layer.

D2.3 Groundwater Occurrence and Movement

This section describes regional flow directions, water level differences between layers, groundwater

inflows, groundwater outflows, and historical changes in water levels.

D2.3.1 Water Levels

Groundwater flows generally from east to west. The highest groundwater elevations are found in the eastern portion of the Aerojet Site. Flowpaths radiate north, west and south from this portion of the Aerojet site.

Figure D2-2 shows 1996 water levels for each hydrostratigraphic layer. Because hydrostratigraphic layers dip at an angle steeper than the regional groundwater gradient, layers A through E all intersect the water table at different locations (see the cross-sections in Section D3.2). Water levels for layers A and B are combined. The effects of extraction and recharge at GETs E and F are evident in Layers A through D.

Figure D2-3 shows water level differences between layers AB and C, C and D, and D and E. Positive differences indicate downward vertical gradients. Negative differences indicate upward vertical gradients. Water level differences denote areas of active areal recharge and the effects of pumping and recharge at GETs E and F. Recharge areas tend to generate vertical gradients downward. Vertical gradients also are generated by pumping from selected layers.

Figure D2-4 shows a long-term water level hydrograph for well 9N6E34R1M. The long-term water level decline observed at well 9N6E34R1M is representative of water-level conditions over much of the Western Groundwater OU RI/FS area. This is likely due to increased regional groundwater pumping removing water from storage throughout the greater Sacramento Valley. Short term changes in water levels represent seasonal changes due to increased rainfall in winter months and dryer conditions in the summer months. Increased groundwater pumping occurs during summer months, which would also tend to decrease water levels. Water levels increase in the early 1980's in response to increased precipitation, and thus recharge, within the modeled area. Water levels decline between approximately 1985 and 1995 because of the combination of drought conditions and increased groundwater extractions. Water levels increased after 1995 due to increased precipitation.

D2.3.2 Groundwater Inflows

Groundwater enters the model area through infiltration of precipitation, mountain-front recharge, recharge wells, and to a lesser extent from the American River.

The amount of recharge to the groundwater system from precipitation is dependent on the spatial variability of long-term precipitation patterns, year-to-year changes in precipitation, interception by impervious surfaces, evapotranspiration and soil infiltration capacity.

Mountain-front recharge occurs as runoff from nearby highlands which infiltrates into the adjacent alluvium of the groundwater basin. Mountain-front recharge may also occur as groundwater inflow

from adjacent bedrock areas.

Recharge wells operated by Aerojet as part of the GETs E and F systems began operating in the 1980s. Water is recharged directly to Layers C and D through a series of six wells.

In areas where groundwater levels are lower than the water levels in the American River, recharge of river water may occur. The amount of recharge is dependent on the permeability of the riverbed.

D2.3.3 Groundwater Outflows

Groundwater leaves the model area through extraction wells, subsurface groundwater outflow, and to a lesser extent through the American River.

The number of extraction wells in the model area has increased steadily from the 1960s to the present as a response to development in the area. Water supply wells operated by Arden Cordova Water Service, Citizen's Utility Company, Mather Air Force Base and Sacramento County are located in the model area. Groundwater extraction and recharge wells operated by Aerojet are also located in the model area.

Subsurface groundwater outflow occurs in all layers along the western boundary of the model area. This subsurface flow occurs as groundwater flows from recharge areas near the highlands to the east toward large pumping centers located to the west of the model area.

Discharge to the American River occurs when groundwater levels are higher than the river level. Consistently this occurs in the vicinity of Lake Natoma. Discharge to other parts of the American River has decreased with time as regional water levels have declined.

D2.3.4 Changes in Groundwater Storage

Water levels have decreased approximately 40 feet between 1956 and 1980 (see Figure D2-4). This decline in water level and the corresponding decrease in storage is the result of increased groundwater extractions within the area as well as regional water level declines experienced by the larger groundwater basin in the Sacramento area.

D3.0 GROUNDWATER FLOW MODEL CONFIGURATION

The groundwater flow model is based on the U.S. Geological Survey (USGS) finite difference MODFLOW code (McDonald and Harbaugh, 1988). GWVISTAS (Environmental Simulations, Inc., 1996) was used as both a preprocessor and postprocessor in the construction and development of the model.

D3.1 Model Grid

The model grid has 92 rows and 64 columns. Grid spacings in both the X and Y directions range from 500 to 3,200 feet. Adjacent row and column dimensions do not differ by more than a factor of 1.5. Figure D3-1 shows the configuration of the model grid.

D3.2 Model Layers

The model layers are generalized representations of the complex hydrostratigraphy described in Section D2.2.1 above (Figures D3-2 through D3-4). More emphasis was placed on the representation of Layers C, D and E because NDMA and perchlorate are found in these layers within the Western Groundwater OU RI/FS area. Layers A and B are grouped into the first layer of the groundwater model and is referred to as layer AB. Model layers 2, 3, 4 and 5 generally correspond to hydrostratigraphic layers C, D, E and F, respectively. All layers dip towards the west at an angle of one degree.

Further simplification of the hydrostratigraphy occurs as uniform thicknesses are applied to each layer throughout the model area. Model layer 1 (layer AB) varies in thickness from zero at the Aerojet Site to approximately 300 feet at the western model boundary. Figure D3-5 shows an isopach map for model layer 1 for 1996. Layers 2 and 3 are each 80 feet thick. Layers 4 and 5 are each 175 feet thick.

D3.3 Parameter Zones

Hydraulic parameter zones (such as hydraulic conductivity, vertical leakance and storativity) are based on lithologic descriptions obtained from each layer and aquifer testing.

Well drillers reports and lithologic logs were reviewed to calculate the percentage of fine-grained material in layers 1 through 4. At each well site, the percentage of fine-grained material was determined by the ratio of the combined thickness of silt and clay layers to total layer thickness. Table D3-1 summarizes the results. Figure D3-6 shows the distribution of fine-grained material in layers 1 through 4. These distributions were used to aid in assigning preliminary horizontal and vertical hydraulic conductivities at the beginning of the calibration process. In general, areas of relatively high percentages of fine-grained material (>75%) were assigned relatively low values of hydraulic conductivity (5 - 30 ft/d). Likewise, areas of relatively low percentages of fine-grained material (<25%) were assigned relatively high values of hydraulic conductivity (75 - 150 ft/d). The hydraulic conductivity distribution was then modified to reflect values obtained from aquifer tests.

Specific capacity and aquifer test data also were used to aid in assigning hydraulic conductivity values. Specific capacity data from Arden Cordova Water Service and Citizen Utility Company water supply wells were used to calculate transmissivity (Figure D3-7). Aquifer test data from testing extraction wells at GET D, GET E, GET F, and ARGET as well as aquifer test data from Arden

Cordova Water Service wells 19 and 23 were also reviewed to aid in assigning hydraulic conductivity values. These aquifer tests were also reviewed to aid in assigning storativity values. Figure D3-6 shows the locations of wells for which transmissivity data were available.

D3.4 Boundary Conditions

Figure D3-8 shows the location of model boundaries within and around the model area.

Flow across the easternmost boundary is applied as areal recharge to simulate mountain-front recharge. This recharge is applied to model layer 4 because this is the highest saturated layer in this area.

The northeastern and southeastern boundaries are no-flow boundaries simulating groundwater flowpaths originating from the recharge area along the eastern boundary. The base of the model is a no-flow boundary as well and is located within the Mehrten Formation (see Figure D3-2).

The western, northwestern and southwestern boundaries are general head boundaries that are applied to all five model layers. The prescribed water levels of the general head boundary change with time.

River cells within the model area act as internal boundaries that input or remove groundwater based on the water level differences. Figure D3-8 shows river cells for each model layer. These are represented by the RIV package in MODFLOW. River cells are assigned to the uppermost saturated model layer.

The water table forms the upper boundary of the model.

D4.0 MODEL PARAMETERS

With the aid of hydrogeologic data and through the calibration process described in Section D6.0, hydrogeologic parameter values were selected for the groundwater flow model.

D4.1 Horizontal Hydraulic Conductivity

Figures D4-1 through D4-5 illustrate the zoned values of hydraulic conductivity calibrated for each model layer. Below is a summary of horizontal and vertical hydraulic conductivities in the model area.

Model Layer	Hydraulic Conductivity Horizontal (ft/d)	Vertical (ft/d)
1	30 - 300	0.04 - 2.0
2	2 - 400	0.01 - 2.0
3	2 - 150	0.001 - 2.0
4	2 - 75	0.005 - 0.2
5	2 - 60	0.005 - 0.2

Transmissivities for model layers 2 through 5 are calculated within the MODFLOW code by multiplying zoned hydraulic conductivities by the model cell layer thickness. Transmissivity for model layer 1 is determined as a function of layer saturated thickness.

Transmissivities shown in Figure D3-6 were incorporated into hydraulic conductivity zonation. The resultant model transmissivities are typically within 10 percent of observed values.

D4.2 Vertical Conductance

Vertical conductance (leakance) between model layers is calculated internally within MODFLOW as:

$$VCONT = \frac{1}{\frac{z_1/2}{K_{v1}} + \frac{z_2/2}{K_{v2}}}$$

where z is the model layer thickness and K_v is the vertical hydraulic conductivity for each pair of model layers.

Figures D4-6 through D4-9 shows the generalized distribution of vertical conductance between model layers. The values shown in Figures D4-6 through D4-9 are not input into the model because, as stated above, vertical conductance is calculated internally to MODFLOW. Internally calculated vertical conductance is much more variable than what is shown in the figures. Figures D4-6 through D4-9 are included to provide a general understanding of the spatial distribution of vertical conductance within the model area.

D4.3 Specific Yield and Storativity

Figures D4-10 through D4-13 show the distribution of specific yield and storativity for model layers

1 through 4, respectively. Values for specific yield and storativity were obtained from representative values from Freeze and Cherry (1979) and from aquifer tests conducted at GETs E and F extraction wells (Aerojet and Hydrosearch, 1996). These values were adjusted during the calibration process. Layer 5 is confined and was assigned a uniform value of storativity of $1x10^{-6}$. Calibrated specific yield values range from 0.07 to 0.15. Higher values of specific yield are assigned to areas of dredge tailings. In areas where model layers are confined, storativity values range from $1x10^{-4}$ to $1x10^{-6}$.

D4.4 Riverbed Conductance

River bed conductance is calculated by multiplying the assumed vertical hydraulic conductivity of the river bed by the estimated channel area in each river cell. Vertical hydraulic conductivity values of 0.1 to 0.2 ft/day were used for cells simulating Lake Natoma. Values of 0.07 and 0.09 ft/day were used in river cells approximately two miles downstream of Nimbus Dam. River cells farther downstream and within model layer 1 were assigned vertical hydraulic conductivity values of 0.025 ft/day. River bed conductance ranges from approximately 180 ft^2/day for the American River to 10,000 ft^2/day for Lake Natoma. Conductances differ for the two bodies of water because Lake Natoma is much wider than the American River.

D4.5 General Head Boundary Conductance

The general head boundary conductance is a function of boundary cross-sectional area, horizontal hydraulic conductivity, and the distance to an assumed water level. The distance to an assumed water level is the same for all model layers (20,000 feet). General head boundary cells in model layer 1 typically have a cross-sectional area of 200,000 ft^2 (400 ft x 500 ft) and have a hydraulic conductivity of 23 ft/day. The conductance for these cells in layer 1 is 230 ft^2/day. General head boundaries in layers 2 and 3 have cross-sectional areas of 40,000 ft^2 (80 ft x 500 ft) and have a hydraulic conductivity of 53 ft/day. General head boundaries in layers 4 and 5 have cross-sectional areas of 87,500 ft^2 (175 ft x 500 ft) and have a hydraulic conductivity of 23 ft/day. In layers 2 through 5 these cells have conductances of approximately 100 ft^2/day.

D5.0 MODEL STRESSES

Model stresses include prescribed groundwater inflows and outflows during set periods of time (stress periods). Model stresses may change from stress period to stress period. Stress periods used in the OU RI/FS model are set at five years and one year.

D5.1 Groundwater Inflows

Prescribed groundwater inflows include mountain-front recharge, areal recharge and river recharge.

D5.1.1 Areal Recharge

Areal recharge is applied to the uppermost saturated layer in the model. This may be layer 1, 2, 3 or 4. The amount of recharge applied to the model varies spatially as well as with time.

The areal distribution of recharge is based on factors such as areal distribution of precipitation, soil infiltration capacity, interception by impervious surfaces, and evapotranspiration. Figure D5-1 shows the distribution of long-term (50-yr) averages of precipitation within the model area. On average, more precipitation falls closer to the highlands to the east than in the west.

Soil infiltration capacity, interception by impervious surfaces, and evapotranspiration are accounted for in a modifying factor applied to the areal distribution of precipitation. In general, in areas disturbed by dredging it is assumed that precipitation will recharge readily. A modifying factor of 70 to 95 percent is applied to precipitation in these areas. This indicates that 70 to 95 percent of the precipitation falling in areas of dredge tailings will recharge the groundwater system. In undisturbed areas, it is assumed that soil infiltration capacity is lower, interception by impervious surfaces is higher and evapotranspiration is higher than in disturbed areas. Therefore, a low modifying factor (10 percent) is applied to these areas.

Precipitation totals for each model stress period have been recorded at a precipitation gage at Folsom Dam (Figure D5-2). The average yearly rainfall at this station since 1955 is approximately 23 inches. The equation to evaluate recharge as a function of time and location is:

$$R = P_{sp}/P_a \times P_l \times F$$

where R is the recharge rate (time and location dependent); P_{sp} is the precipitation observed at Folsom Dam for a given stress period (P_{sp} varies with time); P_a is the long-term average precipitation at Folsom Dam (23 inches); P_l is the value of long-term precipitation at a given location from Figure D5-1; and F is the modifying factor governing the amount of precipitation reaching the groundwater. The modifying factor F was adjusted during calibration.

Figure D5-2 shows annual precipitation at the Folsom Dam station and the amount of recharge applied to the model during the calibration period. Model recharge varies from 25,000 ac-ft/yr to 52,000 ac-ft/yr. These values are consistent with values presented in DWR (1964). Figure D5-3 shows the recharge zonation applied to the model. This zonation also is used during predictive simulations.

D5.1.2 Mountain-Front Recharge

Mountain-front recharge enters the model area along a portion of the eastern boundary and is applied as high areal recharge in a number of model cells along the boundary. It is assumed that mountain-front recharge originates as runoff from precipitation falling on adjacent highlands as well as

subsurface flow along the bedrock-basin boundary (see Section D6.2). Minor adjustments to this value were made during the calibration process and found to be a constant 3,600 acre-feet/year (ac-ft/yr). This value is consistent with the amount of runoff expected from the watersheds adjacent to the eastern boundary of the model area. The model cells for which mountain-front recharge is applied as areal recharge are shown in Figure D5-2.

D5.1.3 River Leakage

River stages do not change with time but vary along the stretch of the American River. A constant water level elevation of 126 feet mean sea level (ft msl) is applied to the stretch of river occupied by Lake Natoma. This is the normal pool elevation of Lake Natoma (USGS, 1980a). Downstream of Lake Natoma, water levels of the American River range from 82 ft msl just downstream of Nimbus dam to 30 ft msl near the western boundary of the model area (USGS, 1980a, 1980b). Although it is recognized that water levels of the American River change within a given year, the values used in the model represent annual averages, as do other model parameters such as pumping and areal recharge.

Leakage from the American River varies along the length of the river and is dependent on the head difference between river stage and groundwater levels. Total leakage from the river increases throughout the calibration period because groundwater levels decline. Leakage, as calculated by the groundwater flow model, increases from about 4,000 ac-ft/yr in 1980 to 6,000 ac-ft/year in 1998.

D5.1.4 Recharge Wells

Recharge wells located at the GETs D, E and F facilities began recharging water into the groundwater system in the early 1980s to offset groundwater extractions at those facilities. The majority of the recharge wells are screened in layers C and D with only a few screened in layer E at the GET D facility. The amount of recharge through wells changed on a yearly basis. Based on data collected by Aerojet, recharge ranged from a low of 3,500 ac-ft/yr in 1985 to a high of 6,700 ac-ft/yr in 1996.

D5.2 Groundwater Outflows

Extractions through pumping wells, discharge to the river and subsurface flow comprise groundwater outflows from the model.

D5.2.1 Wells

Figure D5-4 shows the location of extraction and recharge wells within the model area. Pumping data were obtained from Southern California Water Company, Citizens Utilities Company, Mather AFB, Sacramento County Water Maintenance District, and Aerojet. Figure D5-5 shows the total amount of groundwater pumping from the model area during the calibration period. Total pumping

from within the model area ranges from a low of 700 ac-ft/yr to a high of 31,000 ac-ft/yr.

Each well screened across more than one layer is weighted twice to distribute pumping among the layers. Pumping is first distributed based on the length of perforated interval in each model layer. Pumping is then weighted by the hydraulic conductivity of each model layer screened by the well.

D5.2.2 River Leakage

Discharge to the American River is dependent on water level differences between groundwater and river stage. More discharge of groundwater to the river occurred in the past when groundwater levels were higher. Discharge to the river, as calculated by the groundwater flow model, has ranged from a high of approximately 5,000 ac-ft/yr in the past to a low of 800 ac-ft/yr in recent years.

D5.2.3 Boundary Subsurface Flow

Simulated groundwater flow out of the model area is determined by the boundary conductance and the difference in water levels simulated by the model at the boundary and water levels assumed downgradient of the boundary.

The general head boundary along the western edge of the model area is divided into three sections, A, B and C (see Figure D3-7). Each section is associated with a monitor well located approximately 20,000 feet west of the boundary. Section A is associated with well 9N5E12J1M, Section B is associated with well 8N5E16C1 and Section C is associated with well 8N5E30C1

Figure D5-6 Shows the relationship between water levels in the wells and those applied to the general head boundaries. Between 1970 and 1987, water levels at 8N5E16C1 are based on observed water levels at 8N5E30C1. Between 1955 and 1965, water levels are assumed to decline by 20 to 30 feet in keeping with reported levels in DWR (1964). Initial water levels are based on those reported by DWR (1964).

D6.0 GROUNDWATER MODEL CALIBRATION

Calibration of the Western Groundwater OU RI/FS model emphasizes a match to transient groundwater levels for years 1984 to 1996. The model, however, begins simulating groundwater flow in 1956 with initial conditions derived from steady-state simulations.

Model calibration is an ongoing process as interpretations of the hydrogeologic conceptual model evolve with the availability of new data. This section presents a level of calibration judged sufficient to meet the objects of the model.

D6.1 Approach

The calibration of the Western Groundwater OU RI/FS model involved:

- Steady-state simulations to obtain initial conditions.
- Establishing five-year stress periods between 1956 and 1981 and one-year stress periods between 1981 and 1998.
- Transient, trial and error calibration to simulate water levels observed between 1984 and 1998.

D6.2 Steady-State Simulations

The objective of steady-state simulations was to provide initial conditions for the transient calibration, not to generate a calibrated steady-state model. The initial incorporation of parameters into the steady-state model was based on assumed 1960 conditions. This was a period of little groundwater development in the area. Initial model parameter estimates were derived from:

- The distribution of long-term precipitation and recharge capacities as described in Section D5.1.2.
- The distribution of hydraulic conductivity based on aquifer tests and distribution of fine grained sediments.
- Assumed water levels to the west of the model boundary and conductances based on model hydraulic conductivity adjacent to the boundary.
- Assumed river bed conductance based on silty material.
- A gross estimate of mountain-front recharge based on 27 inches of rainfall falling on a catchment area of 1200 acres (approximately 3,000 acre-ft/yr).
- Increased recharge in the vicinity of Aerojet property to account for infiltration of unused imported water.

Thirteen wells were operating during the steady-state simulations. Two of these wells were operated by Arden Cordova Water Service, seven were operated by Mather Air Force Base and four were operated by Aerojet. These wells, the layers in which they were screened and their pumping rates are summarized below:

Summary of Steady-State Extraction Wells

Well	Layers Screened	Pumping Rate (ac-ft/yr)
AC-1	1	229
AC-4	1,2	74
Aerojet No. 1	3,4	280
Aerojet No. 2	3,4	280
Aerojet No. 3	3,4	280
Aerojet No. 4	3,4	280
Mather No. 1	1,2,3	242
Mather No. 2	1,2,3,4	242
Mather No. 3	2,3	242
Family Housing No. 1	2	296
Family Housing No. 2	3,4	296
Family Housing No. 3	1,2,3	296
Family Housing No. 4	2,3	296

Figure D6-1 shows the distribution of recharge for the steady-state. Steady-state recharge reflects infiltration of unused water imported by Aerojet. The amount of unused imported water recharging to the groundwater is not well documented in DWR (1964). This amount was adjusted during the calibration process. The final value is approximately 3,700 ac-ft/yr.

Parameters in the steady-state model were updated after each transient calibration run as adjustments became necessary to achieve a transient match to water levels. This made for an iterative process that provided consistency between the two models.

Steady-state water levels were qualitatively compared to 1962 water levels presented in DWR (1964). Simulated water levels were judged to be appropriate if the following criteria were met: 1) water levels across the model area ranged from approximately 250 ft msl in the east to 30 ft msl in the west; 2) radial flow away from the vicinity of Aerojet property; and 3) water levels remain below ground surface. Figure D6-2 shows the final steady-state water level conditions.

D6.3 Transient Trial-and-Error Calibration

The period from 1984 to 1998 was selected for transient calibration because:

- It contains a suitable variability in groundwater levels.
- Its later years are representative of current conditions and expected conditions in the near future.
- There are many water level measurements from discretely-screened monitor wells.
- Relatively detailed pumping data are available.

Zone parameters were adjusted on a trial and error basis in an effort to match selected well hydrographs and water level contour plots. The parameters adjusted during the calibration process included, in order of frequency changed: horizontal hydraulic conductivity, vertical hydraulic conductivity, areal recharge distribution, storage, river bed conductance, mountain-front recharge and general head boundary conductance.

D6.4 Match to Observed Groundwater levels

The Western Groundwater OU RI/FS groundwater model is calibrated to observed water levels between 1984 and 1998 to within ± 6 feet.

D6.4.1 Calibration Limitations

Calibration to observed water levels is limited by the available data, model assumptions and the numerical discretization of space and time. These limiting factors include:

- Water level data from discretely screened wells are not available prior to the early 1980s and are relatively sparse in 1984 and 1986.
- Data supporting model input, such as pumping rates and screened intervals, may not be complete or are inexact.
- Parameters specified for a model cell represent an approximation to the heterogeneity of the hydrostratigraphic layers. Actual water levels may show confined responses to stresses in areas represented by an unconfined model cell. Vertical water level differences may occur over short distances but are averaged over the thickness of a model cell.

- Actual water levels may change in response to stresses that occur over a shorter time period than the length of a model stress period (one year). This is particularly true for wells screened in confined layers.

- Changes in groundwater levels over a short distances may not be well represented by the water level averaging within a model cell

D6.3.1 Map Calibration

Figures D6-3 through D6-10 show the distribution of water level residuals (simulated water levels minus observed water levels) for the years 1984, 1986, 1988, 1990, 1992, 1994, 1996 and 1998, respectively. At locations where two wells are screened in a model layer, the observed water level is the average of both water levels. Furthermore, the majority of observed water levels are averages of spring and fall water level measurements.

Large residuals within the first model layer (layer AB) result from model cell averaging of relatively small-scale heterogeneities within layers A and B. Water levels in layer A and B monitor wells exhibit large variations over short distances due to discontinuous stratigraphy that promote perched conditions and significant vertical gradients. Because more emphasis has been placed on simulating groundwater conditions in deeper layers, layers A and B have been grouped together and treated as one model layer. Large residuals in model layer 1 are not considered significant.

Large residuals in layers 2, 3, and 4 result from calibration limitations listed above. Residuals may be greater in 1984 because of rapid rise in water levels due to short-lived recharge events that are averaged over the one-year stress periods. Large residuals also occur in areas of steep gradients because model cell averaging cannot reproduce significant water level changes over short distances.

Figure D6-11 shows 1996 simulated water level differences between layers. A comparison of Figure D6-11 to D2-3 shows that the positive head difference dominating much of the Aerojet site, indicative of a downward hydraulic gradient, is reproduced by the model. Positive and negative differences produced by extractions and recharge around the GETs E and F facilities are also reproduced.

Table D6-1 summarizes statistics describing the calibration. The mean absolute error (MAE) is highest for layer 1 for reasons discussed above. The MAE values for layers 2 through 4 show the model's ability to match observed water levels within ± 6 feet. The goodness-of-fit of the model is a statistical parameter taken from trend surface analysis (Davis, 1973) and its calculation is shown on Table D6-1. Goodness-of-fit is a measure of how well the model can reproduce the variability (or range) in observed water levels. A high goodness-of-fit value, one that is close to unity (>0.95), indicates an overall significant match to observed conditions and that the difference between simulated and observed water levels is nearly a constant value, in this case 6 feet.

How well the model fits observed water levels is also displayed in the scatter plots shown in Figures D6-12 though D6-19. The MAE is a measure of the deviation from the diagonal line representing the condition when simulated water levels equal observed water levels (MAE=0). The goodness-of-fit is a measure of how closely the data points in the scatter plots follow a trend. Ideally, that trend should be represented by the diagonal line in the figures.

D6.3.2 Hydrograph Calibration

Monitor wells having hydrographs to be used for comparison during calibration were chosen to provide a widespread distribution and because they generally have a long history of record. Figures D6-20 through D6-23 show simulated and observed hydrographs for layers AB through E, respectively.

In general, simulated hydrographs match observed hydrographs well. However, where differences in simulated and observed hydrographs occur it is for one or more of the following reasons:

1. Observed water levels may respond to stresses, such as pumping or recharge, that occur over a shorter time period than the length of a model stress period (one year). Therefore, the change in water levels cannot be simulated by the model.

2. Because model layers simplify complex hydrostratigraphy, several discrete, water-bearing layers may be represented by a single model cell. The model cell may be unconfined, however a monitor well within the model cell may be screened in a discrete layer that id confined. Therefore, simulated water levels in the model cell (unconfined) may not closely match the observed water level in the monitor well (confined).

3. Pumping rates and screened intervals of some wells are estimates because complete data were not available. Water level hydrographs at monitor wells near these pumping wells may be affected by pumping conditions that are not well represented by the model. Therefore, the simulated hydrograph cannot show the same effects of pumping as the observed hydrograph.

4. The size of model cells are too large to represent steep horizontal hydraulic gradients. Therefore, although a simulated hydrograph may appropriately represent relative changes in water levels over time, it may not match the observed water level.

D6.3.3 Groundwater Balance

The simulated groundwater balance for the calibration period is summarized in Table D6-2. The table shows all inflow to and outflow from the model as well as the change in storage (inflow - outflow) for each stress period. The simulated groundwater balance is presented to illustrate the magnitude

of changes in all the flow components during the calibration process.

D7.0 SENSITIVITY ANALYSIS

Groundwater models produce a solution dependent upon all input parameters. Because of the complexity of this groundwater flow model, many combinations of input parameters could produce reasonable results. That is, no unique solution may exist based on the information available at this time. Section D6.0 described a set of input parameters that produce a calibrated model in terms of representing observed water levels and their fluctuations through time. Other combinations of input parameters could produce similar results. This section describes analyses to evaluate the sensitivity of model results to various input parameters.

The sensitivity analysis proceeded by changing one model parameter while keeping all other input parameters the same in the calibrated model. No attempt was made to change other model input parameters to maintain model calibration during sensitivity trials. The sensitivity analysis is divided into two sections. The first section assesses the sensitivity of the groundwater flow model calibration by evaluating how changes in one parameter cause changes in computed water levels. The second section assesses the sensitivity of the effectiveness of a selected remedial alternative by evaluating how changes in one input parameter cause changes in the placement of wells and the amount of extracted water.

D7.1 Groundwater Flow Model Sensitivity Analysis

The sensitivity of the groundwater flow model was assessed by changing one parameter by one order of magnitude or less, keeping all other parameters unchanged, and computing water levels during the calibration period. The computed water levels were compared to observed water levels and the mean absolute error was determined for selected stress periods. The sensitivity of the model calibration to the parameter was judge by comparison of the MAE to those generated by the calibrated model. Parameters that were changed during the sensitivity analysis include areal recharge, horizontal hydraulic conductivity and vertical hydraulic conductivity. For each simulation of the sensitivity analysis, only one parameter was changed while all other parameters in the model remained the same. Figure D7-1 summarizes the results of each of the sensitivity analysis runs on water levels in layers 1 through 4. The results of each separate sensitivity run are shown for comparison purposes.

D7.1.1 Sensitivity to Areal Recharge

The sensitivity of the model calibration to areal recharge was investigated by varying areal recharge by factors of 0.5 and 2. Doubling areal recharge produce the greatest change in water levels by increasing water levels significantly thereby generating a large MAE. Reducing areal recharge by one half decreased water levels almost to the same degree.

D7.1.2 Sensitivity to Horizontal Hydraulic Conductivity

The sensitivity of model calibration to horizontal hydraulic conductivity was investigated by varying the horizontal hydraulic conductivity of all layers by a factor of 0.5 and 2. In general, increasing horizontal hydraulic conductivity by a factor of two caused computed heads to decrease at about the same magnitude as the increased when values were decreased by one half.

D7.1.3 Sensitivity to Vertical Hydraulic Conductivity

The sensitivity of model calibration to vertical hydraulic conductivity was assessed by varying the vertical hydraulic conductivity of all layers by an order of magnitude. Variations in this parameter produced the least effect on computed water levels. Comparatively more changes were brought about in Layers 1 and 2 than in layers 3 and 4.

D7.1.4 Summary

Model calibration is least sensitive to changes in vertical hydraulic conductivities. This implies that uncertainty in this parameter does not significantly affect the groundwater flow solution produced by the model. Vertical hydraulic conductivity could increase or decrease by one order of magnitude and still produce similar model results for the given suite of other model parameters.

Model calibration is most sensitive to areal recharge. This implies that calibration is dependent, to some extent, on the value of areal recharge. Given that there is some uncertainty in areal recharge values, it follows that different flow models may exist that have differing suites of parameters.

D8.0 REMEDIAL ALTERNATIVE EVALUATIONS USING THE GROUNDWATER FLOW MODEL

The following section describes alternative evaluations using the calibrated model.

D8.1 Transient Simulations

The calibrated model is used to perform predictive, transient simulations to evaluate remedial alternatives. All model parameters, such as horizontal and vertical hydraulic conductivity, storativity, specific yield, and river conductance remain the same for predictive uses of the model. The following parameters were changed:

- Water levels at the end of the calibration period (1998) are used as initial conditions for the predictive trials.
- Areal recharge was set to a long-term average (based on calibration results)

of approximately 33,600 ac-ft/yr. This value did not change throughout the predictive period.

- Water levels at the general head boundary decrease at a rate 0.5 feet per year.
- Regional extraction wells operate at their long-term average pumping rates.

D8.2 Particle Tracking

Particle tracking was used to evaluate groundwater flowpaths, advective migration of conservative contaminants and groundwater capture for each transient simulation. However, there are limitations to using particle tracking to evaluate contaminant migration. One limitation is that physical processes such as retardation, degradation, and dispersion are not simulated. These limitations, however, do not preclude the use of particle tracking for a comparative analysis of remedial alternatives.

MODPATH (Pollock, 1994) was used to estimate travel times of particles along transient groundwater flowpaths for each alternative. Particles in MODPATH represent conservative contaminants, not subject to retardation or degradation, and travel times predicted by the code represent the advective migration of these contaminants through the groundwater flow regime.

For each alternative, overall migration of perchlorate and NDMA plumes was simulated by tracking particles located along concentration contours. Figures 1-10, 1-12, and 1-14 show perchlorate and NDMA plumes in 1998 for layers C, D and E, respectively. For each layer, particles were placed at approximately 100 ft intervals along the 4, 40, 400, and 4,000 µg/l perchlorate contours and along the 0.01 and 0.1 µg/l NDMA contours. Each particle was located at the midpoint of the layer. The movement of each concentration contour was simulated by MODPATH. Figures D8-1 and D8-2 show the projected location of these perchlorate and NDMA contours, respectively, in 2001. The time for each concentration contour to reach each extraction well was evaluated using this methodology and the results are summarized in the descriptions of the remedial alternatives presented in this section.

Particle tracking was also used to evaluate capture zones generated by remedial alternatives. Clouds of particles located in the centers of model layers 2, 3, and 4 were released at the beginning of remedial alternative simulations and allowed to migrate forward toward the extraction wells for the period over which the alternative was simulated. Figure D8-3 shows the starting locations of particles for capture zone evaluation. These locations were used for each layer and the particles were placed at the midpoint of the layer. A map showing which particles in Figure D8-3 are captured by extraction wells (either GET E and F, remedial or regional) in each alternative represents the capture zone for the specified remedial alternative. The capture zones for the remedial alternatives are presented in Section 5.0 of Volume I of this report. The capture zones define regions of groundwater within Layers C, D and E that are removed by offsite extraction wells (remedial and/or regional water

supply wells) and GET E and F wells.

Particle tracking was also used to evaluate the percent of plume area captured by each alternative. In each layer, particles were located in the center of each model cell within the perimeter of the combined extent of CoPCs shown in Figures 1-10, 1-12, and 1-14. Particles were located at the midpoint of the layer. For each alternative, a series of MODPATH simulations were run to evaluate the number of particles, which define the extent of the combined CoPCs, that are captured by remedial extraction wells for a given time period. The length of each sequential simulation is increased by five years. The first MODPATH simulation runs from 1998 to 2006, the second runs from 1998 to 2011, the third runs from 1998 to 2016, and so forth until all particles have been removed. In this way the cumulative capture of CoPC plumes by each alternative can be evaluated. The cumulative capture of the CoPC plumes, in terms of the percentage of CoPC area captured over time, by each alternative is presented in Sections 5.0 and 6.0 of this report.

MODPATH uses hydraulic head output from MODFLOW along with effective porosities to calculate flow directions and velocities from which particle flow paths and travel times are computed. A uniform value of 0.25 was used for effective porosity for each layer in the flow model. This value is based on groundwater velocities calculated from observed migration of perchlorate from GETs E and F recharge wells.

For all MODPATH simulations, particles are specified to stop as they enter a weak sink cell. These are cells that represent low-yielding pumping wells.

D8.3 Analysis of Alternatives

The following sections describe how each alternative was modeled and present modeling results for each alternative.

D8.3.1 Alternative 1 - No Action with Limited Groundwater monitoring

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping and recharge at GETs E and F facilities stop.

2. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

3. Just prior to contacting the 4 µg/l perchlorate contour or the 0.01 µg/l contour regional water supply wells are turned off.

D8.3.2 Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternative Water Supply

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping from GETs E and F remains the same as in 1997. Recharge through GETs E and F recharge wells remains the same as in 1997. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001.

2. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

3. Just prior to contacting the 4 µg/l perchlorate contour or the 0.01 µg/l contour regional water supply wells are turned off.

4. Water not impacted by perchlorate or NDMA is recharged through the GETs E and F recharge well field beginning in 2001.

Groundwater capture maps for Alternative 2A are included as Figure 5-1 in Section 5.0 of Volume I of this report.

Under this alternative the CoPCs plume will continue to migrate. Table D8-1 summarizes the water supply well capacity that will require replacement during this alternative. The implications of water supply well capacity replacement is described in more detail in Sections 4.0 and 5.0.

D8.3.3 Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. In 2001, all pumping from GETs E and F wells is reduced by 25 percent and recharge is turned off. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001. Three new cluster wells, located between GETs E and F and west of the existing

recharge well field are screened in layers C, D and E, pump at 725 to 850 gpm per cluster well and also begin operation in 2001.

2. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

3. Just prior to contacting the 4 µg/l perchlorate contour or the 0.01 µg/l contour regional water supply wells are turned off.

Groundwater capture maps for Alternative 2A are included as Figure 5-2 in Section 5.0 of Volume I of this report.

Under this alternative the CoPCs plume will continue to migrate. Table D8-2 summarizes the water supply well capacity that will require replacement during this alternative. The implications of water supply well capacity replacement is described in more detail in Sections 4.0 and 5.0.

D8.3.4 Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping from GETs E and F remains the same as in 1997. Recharge through GETs E and F recharge wells remains the same as in 1997. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001.

2. Starting in 2001, all regional wells not in operation in 1998 begin operation again and pump at their long-term average rates. These include all wells operated by Southern California Water Company, Citizens Utilities, Sacramento County and Mather Air Force base. All regional wells remain in operation throughout the simulation.

3. Water not impacted by perchlorate or NDMA is recharged through the GETs E and F recharge well field beginning in 2001.

Groundwater capture maps for Alternative 3A are included as Figure 5-3 in Section 5.0 of Volume I of this report. The percent of plume area captured over time by this alternative is presented in Figure 5-4.

Tables D8-3, D8-4 and D8-5 indicate the approximate times resulting from the model simulation that various concentrations of NDMA and perchlorate may be present in regional water supply wells. The various CoPC concentrations shown on Tables D8-3 through D8-5 are based on multiples of the respective detection limits for NDMA and perchlorate. Table D8-3 shows the average pumping rates and modeled approximate times that CoPCs may be present in Layer C if containment of the offsite CoPC plumes is provided by existing water supply wells and wellhead treatment is added. Tables D8-4 and D8-5 indicate the model simulation results for Layers D and E, respectively.

D8.3.5 Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment of Water Supply Wells

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. In 2001, all pumping from GETs E and F wells is reduced by 25 percent and recharge is turned off. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001. Three new cluster wells, located between GETs E and F and west of the existing recharge well field are screened in layers C, D and E, pump at 725 to 850 gpm per cluster well and also begin operation in 2001.

2. Starting in 2001, all regional wells not in operation in 1998 begin operation again and pump at their long-term average rates. These include all wells operated by Southern California Water Company, Citizens Utilities, Sacramento County and Mather Air Force base. All regional wells remain in operation throughout the simulation.

Groundwater capture maps for Alternative 3B are included as Figure 5-5 in Section 5.0 of Volume I of this report. The percent of plume area captured over time by this alternative is presented in Figure 5-6.

Tables D8-6, D8-7 and D8-8 indicate the approximate times resulting from the model simulation that various concentrations of NDMA and perchlorate may be present in regional water supply wells for Alternative 3B. The various CoPC concentrations shown on Tables D8-6 through D8-8 are based on multiples of the respective detection limits for NDMA and perchlorate. Table D8-6 shows the average pumping rates and modeled approximate times that CoPCs may be present in Layer C if containment of the offsite CoPC plumes is provided by existing water supply wells and wellhead treatment is added. Tables D8-7 and D8-8 indicate the model simulation results for Layers D and E, respectively.

D8.3.6 Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Offsite extraction wells were located at the perimeters of the perchlorate and NDMA plumes in layer C at their projected locations in 2001 (Figures D8-1 and D8-2). Extraction wells were spaced along this perimeter to capture and remove particles migrating between the wells.

Pumping rates assigned to the offsite extraction wells were proportional to the hydraulic conductivity of the layers in which they were screened. Lower pumping rates (100 to 200 gpm) were assigned to wells screened where hydraulic conductivity values were relatively low (30 to 50 ft/d). Likewise, higher pumping rates (400 to 500 gpm) were assigned to wells screened where hydraulic conductivity values were relatively high (75 to 150 ft/d).

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping from GETs E and F remains the same as in 1997. Recharge through GETs E and F recharge wells remains the same as in 1997. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001.

2. All layer C wells begin operation in 2001.

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Water not impacted by perchlorate or NDMA is recharged through the GETs E and F recharge well field beginning in 2001.

6. Wells screened in Layer D are located within the same model cells as Layer C wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

7. Wells screened in Layer E are located within the same model cells as Layer C and D wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

8. Operation of individual offsite extraction wells was stopped when layers were no longer impacted by chemicals.

Groundwater capture maps for Alternative 4A are included as Figure 5-7 in Section 5.0 of Volume I of this report. The percent of plume area captured over time by this alternative is presented in Figure 5-8. Figure D8-4 shows the modeled maximum drawdown generated by offsite extraction wells in Layers C, D and E.

Based on the model simulation performed for Alternative 4A, a total of 30 new extraction wells will be necessary to provide hydraulic containment offsite in Layers C, D and E. Thirteen of the new wells will be constructed in 2001, three in 2011, five in 2021, two in 2031, and seven in later years. Table D8-9 was generated from the model simulation and summarizes the periods of operation, estimated pumping rates and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells.

D8.3.7 Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Offsite extraction wells were located at the perimeters of the perchlorate and NDMA plumes in layer C at their projected locations in 2001 (Figures D8-1 and D8-2). Extraction wells were spaced along this perimeter to capture and remove particles migrating between the wells.

Pumping rates assigned to the offsite extraction wells were proportional to the hydraulic conductivity of the layers in which they were screened. Lower pumping rates (100 to 200 gpm) were assigned to wells screened where hydraulic conductivity values were relatively low (30 to 50 ft/d). Likewise, higher pumping rates (400 to 500 gpm) were assigned to wells screened where hydraulic conductivity values were relatively high (75 to 150 ft/d).

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. In 2001, all pumping from GETs E and F wells is reduced by 25 percent and recharge is turned off. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001. Three new cluster wells, located between GETs E and F and west of the existing recharge well field are screened in layers C, D and E, pump at 725 to 850 gpm per cluster well and also begin operation in 2001.

2. All layer C wells begin operation in 2001.

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Wells screened in Layer D are located within the same model cells as Layer C wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

6. Wells screened in Layer E are located within the same model cells as Layer C and D wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

7. Operation of individual offsite extraction wells was stopped when layers were no longer impacted by chemicals.

Groundwater capture maps for Alternative 4B are included as Figure 5-9 in Section 5.0 of Volume I of this report. The percentage of plume area captured over time by this alternative is presented in Figure 5-10. Figure D8-5 shows the modeled maximum drawdown generated by offsite extraction wells in Layers C, D and E.

Based on the model simulation performed for Alternative 4B, a total of 17 new extraction wells will be necessary to provide hydraulic containment offsite in Layers C, D and E. Eleven of the new wells will be constructed in 2001, one will be constructed in 2011, two in 2021, one in 2031 and two will be constructed in later years. Table D8-10 was generated from the model simulation and summarizes the periods of operation, estimated pumping rates and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells.

D8.3.8 Alternative 4C - GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors

Offsite extraction wells were located at the perimeters of the perchlorate and NDMA plumes in layers C, D and E at their projected locations in 2001 (Figures D8-1 and D8-2). Extraction wells were spaced along the perimeters of these plumes in each layer to capture and remove particles migrating between the wells.

Pumping rates assigned to the offsite extraction wells were proportional to the hydraulic conductivity of the layers in which they were screened. Lower pumping rates (100 to 200 gpm) were assigned to wells screened where hydraulic conductivity values were relatively low (30 to 50 ft/d). Likewise, higher pumping rates (400 to 500 gpm) were assigned to wells screened where hydraulic conductivity

values were relatively high (75 to 150 ft/d).

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. In 2001, all pumping from GETs E and F wells is reduced by 25 percent and recharge is turned off. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001. Three new cluster wells, located between GETs E and F and west of the existing recharge well field are screened in layers C, D and E, pump at 725 to 850 gpm per cluster well and also begin operation in 2001.

2. All layer C wells begin operation in 2001.

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Wells screened in Layer D are located along the perimeters of the perchlorate and NDMA plumes in layer D and begin pumping in 2001.

6. Wells screened in Layer E are located along the perimeters of the perchlorate and NDMA plumes in layer E and begin pumping in 2001.

7. Operation of individual offsite extraction wells was stopped when layers were no longer impacted by chemicals.

Groundwater capture maps for Alternative 4C are included as Figure 5-11 in Section 5.0 of Volume I of this report. The percentage of plume area captured over time by this alternative is presented in Figure 5-12. Figure D8-6 shows the modeled maximum drawdown generated by offsite extraction wells in Layers C, D and E.

Based on the model simulation performed for Alternative 4C, a total of 18 new extraction wells will be necessary to provide hydraulic containment offsite in Layers C, D and E. Sixteen of the new wells will be constructed in 2001, one will be constructed in 2011, and one will be constructed in 2021. Table D8-11 was generated from the model simulation and summarizes the periods of operation, estimated pumping rates and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells.

D8.3.9 Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells and Recharge Wells

Offsite extraction wells were located at the perimeters of the perchlorate and NDMA plumes in layer C at their projected locations in 2001 (Figures D8-1 and D8-2). Extraction wells were spaced along this perimeter to capture and remove particles migrating between the wells.

Offsite recharge wells were located where groundwater is not impacted by perchlorate or NDMA in 2001 and where they can divert impacted groundwater away from operating water supply wells and toward extraction wells. The spacing of the offsite recharge wells is such that impacted groundwater would not migrate between them.

Pumping rates assigned to the offsite extraction wells were proportional to the hydraulic conductivity of the layers in which they were screened. Lower pumping rates (100 to 200 gpm) were assigned to wells screened where hydraulic conductivity values were relatively low (30 to 50 ft/d). Likewise, higher pumping rates (400 to 500 gpm) were assigned to wells screened where hydraulic conductivity values were relatively high (75 to 150 ft/d).

All recharge wells are located in areas of relatively high hydraulic conductivity and therefore have been assigned relatively high recharge rates (up to 500 gpm).

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping from GETs E and F remains the same as in 1997. Recharge through GETs E and F recharge wells remains the same as in 1997. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001.

2. All Layer C wells begin operation in 2001.

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Water not impacted by perchlorate or NDMA is recharged through the GETs E and F recharge well field beginning in 2001.

6. Wells screened in Layer D are located within the same model cells as Layer C wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

7. Wells screened in Layer E are located within the same model cells as Layer C and D wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

8. Offsite recharge wells are screened in layers C and D and recharge an equivalent amount of water as extracted by the offsite extraction wells.

9. The total amount of water to be recharged offsite is equally distributed among the recharge wells.

10. Operation of individual offsite extraction wells was stopped when layers were no longer impacted by chemicals.

Groundwater capture maps for Alternative 5A are included as Figure 5-13 in Section 5.0 of Volume I of this report. The percent of plume area captured over time by this alternative is presented in Figure 5-14. Figure D8-7 shows the modeled maximum drawdown generated by offsite extraction wells in Layers C, D and E.

Based on the model simulation performed for Alternative 5A, a total of 24 new extraction wells and seven new recharge wells will be necessary to provide hydraulic containment. Ten of the extraction wells and all of the recharge wells will be constructed in 2001, with the remainder constructed in 2011, 2012, 2031, and later. Table D8-12 was generated from the model simulation and summarizes the periods of operation, estimated pumping and recharge rates and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells.

D8.3.10 Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction Wells and Recharge Wells

Offsite extraction wells were located at the perimeters of the perchlorate and NDMA plumes in layer C at their projected locations in 2001 (Figures D8-1 and D8-2). Extraction wells were spaced along this perimeter to capture and remove particles migrating between the wells.

Offsite recharge wells were located where groundwater is not impacted by perchlorate or NDMA in 2001 and where they can divert impacted groundwater away from operating water supply wells

and toward extraction wells. The spacing of the offsite recharge wells is such that impacted groundwater would not migrate between them.

Pumping rates assigned to the offsite extraction wells were proportional to the hydraulic conductivity of the layers in which they were screened. Lower pumping rates (100 to 200 gpm) were assigned to wells screened where hydraulic conductivity values were relatively low (30 to 50 ft/d). Likewise, higher pumping rates (400 to 500 gpm) were assigned to wells screened where hydraulic conductivity values were relatively high (75 to 150 ft/d).

All recharge wells are located in areas of relatively high hydraulic conductivity and therefore have been assigned relatively high recharge rates (up to 500 gpm).

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. In 2001, all pumping from GETs E and F wells is reduced by 25 percent and recharge is turned off. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001. Three new cluster wells, located between GETs E and F and west of the existing recharge well field are screened in layers C, D and E, pump at 725 to 850 gpm per cluster well and also begin operation in 2001.

2. All Layer C wells begin operation in 2001

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Wells screened in Layer D are located within the same model cells as Layer C wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

6. Wells screened in Layer E are located within the same model cells as Layer C and D wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

7. Offsite recharge wells are screened in layers C and D and recharge an equivalent amount of water as extracted by the offsite extraction wells.

8. The total amount of water to be recharged offsite is equally distributed among the recharge wells.

9. Operation of individual offsite extraction wells was stopped when layers were no longer impacted by chemicals.

Groundwater capture maps for Alternative 5B are included as Figure 5-15 in Section 5.0 of Volume I of this report. The percent of plume area captured over time by this alternative is presented in Figure 5-16. Figure D8-8 shows the modeled maximum drawdowns generated by offsite extraction wells in Layers C, D and E.

Based on the model simulation performed for Alternative 5A, a total of 11 new extraction wells and seven new recharge wells will be necessary to provide hydraulic containment. Seven of the extraction wells and all of the recharge wells will be constructed in 2001, with the remainder of the extraction wells constructed in 2011 and 2012. Table D8-13 was generated from the model simulation and summarizes the periods of operation, estimated pumping and recharge rates and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells.

D8.4 Sensitivity of Remedial Alternative Effectiveness

Sensitivity of remedial alternative effectiveness was investigated by determining how changes in hydrologic parameters affect groundwater capture, pumping rates, travel time and cost. Areal recharge and hydraulic conductivity were changed during the simulation of Remedial Alternative 4A to investigate the effects on groundwater capture, pumping rates, perchlorate and NDMA travel time and costs generated by this scenario. The assumptions used during the simulation of Remedial Alternative 4A are described in Section D8.3.6 above. The sensitivity analyses simulated conditions over a 30-year period.

D8.4.1 Sensitivity to Areal Recharge

The amount of areal recharge applied to the model area was varied by a factor of ± 25 percent for periods of ten years during the 30-year simulation. This simulated extended periods of either increased precipitation or drought. Six simulations were performed in all. In simulations one through three, recharge was increased by 25 percent in the first, second and third 10-year periods, respectively. In simulations four through six, recharge was increased by 25 percent in the first, second and third 10-year periods, respectively. Varying which 10-year period in the 30-year simulation received increased or decreased areal recharge tested the sensitivity of remedial effectiveness to the timing of hydrologic changes.

After each of the six simulations, particle tracking was used to evaluate capture of perchlorate and NDMA plumes as well as travel times of concentrations to the offsite remedial wells.

Results show that changing areal recharge conditions, regardless of which 10-year period they occur, have little effect on the remedial effectiveness of Remedial Alternative 4A. That is, groundwater capture, pumping rates, travel times and, therefore, costs would not be impacted by future changes in this hydrologic parameter.

D8.4.2 Sensitivity to Hydraulic Conductivity

The sensitivity of remedial effectiveness to hydraulic conductivity was investigated in two simulations.

In the first simulation, horizontal hydraulic conductivity was increased by a factor of two (2X) over an 18 square mile region surrounding the offsite extraction wells in Remedial Alternative 4A. No other hydrologic parameters were changed during the 30-year simulation. Particle tracking was used to evaluate capture and travel times of perchlorate and NDMA plumes to the offsite remedial extraction wells.

Results show that changes to pumping rates at the offsite extraction wells were not required to maintain groundwater capture of the chemical plumes. Travel times were decreased, however, because of the increase in hydraulic conductivity. Table D8-14 shows the results of this sensitivity analysis.

In the second simulation, horizontal hydraulic conductivity was decreased by a factor of two (0.5X) over the 18 square mile region surrounding the offsite extraction wells in Remedial Alternative 4A. No other hydrologic parameters were changed during the 30-year simulation. Particle tracking was used to evaluate capture and travel times of perchlorate and NDMA plumes to the offsite remedial extraction wells.

Results show that pumping rates at some offsite extraction wells could be reduced to maintain groundwater capture of the chemical plumes. Travel times of chemicals moving to the extraction wells increased because of the decrease in hydraulic conductivity. Table D8-15 shows the results of this sensitivity analysis.

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Table D3-1 Summary of Fine-Grained Material by Model Layer

Well	Percent Fines by Model Layer				Well	Percent Fines by Model Layer				Well	Percent Fines by Model Layer			
	layer 1	layer 2	layer 3	layer 4		layer 1	layer 2	layer 3	layer 4		layer 1	layer 2	layer 3	layer 4
Aerojet					Aerojet					Aerojet				
51A,B,C	78	32	NS	NS	3071	NS	0	62	NS	STSW-7	NS	55	100	NS
101	NS	NS	33	52	3270	NS	0	26	NS	STSW-8	NS	2	40	NS
145	NS	NS	50	81	3332-4	73	33	36	30	STSW-9	NS	43	81	NS
177	0	13	91	25	3335-7	26	23	29	44	STSW-12	NS	21	100	NS
223	NS	39	83	68	3338-40	100	27	50	72	STSW-13	100	38	49	NS
286	34	63	63	52	3363-5	29	45	58	76	STSW-14	NS	100	81	NS
294	NS	10	75	80	3388-90	NS	NS	20	15	STSW-15	100	38	81	NS
453	NS	NS	NS	68	3404-5	62	19	65	57	SCWC				
484	18	59	78	57	3408	40	25	25	42	AC-1	84	NS	NS	NS
1169	68	14	63	27	3434-6	93	27	28	NS	AC-5	90	94	45	NS
1203-8	93	69	19	63	3450-52	NS	5	41	54	AC-6	78	58	NS	NS
1246	NS	34	71	13	3453-55	NS	63	68	37	AC-8	81	73	NS	NS
1259-60	NS	16	92	27	3503-05	NS	NS	NS	100	AC-9	53	0	0	NS
1280	100	26	60	NS	3547-9	95	13	15	NS	AC-10	73	81	51	NS
1292-3	56	40	31	NS	3552-54	88	70	56	NS	AC-11	75	18	40	25
1307	NS	29	33	23	3555-57	71	30	38	20	AC-12	75	10	0	NS
1310-11	NS	6	46	19	3564-66	0	11	18	12	AC-13	91	66	50	81
1315-16	NS	36	85	73	5085-7	76	15	47	NS	AC-14	76	10	55	NS
1322-3	NS	53	48	48	30002-4	60	38	48	NS	AC-15	7	0	69	98
1327-8	NS	40	42	39	30005-07	80	25	NS	NS	AC-16	0	14	89	95
1336	NS	24	60	NS	30008-10	77	NS	NS	NS	AC-17	0	6	0	0
1375	NS	0	64	71	30016-18	70	NS	NS	NS	AC-18	62	0	0	NS
1385	NS	100	36	65	30020-22	61	23	31	NS	AC-19	72	20	18	50
1395	61	38	51	76	30044-46	71	NS	NS	NS	AC-20	80	28	78	39
1400	NS	20	21	79	30077-79	66	21	41	NS	AC-22	95	13	0	3
1406	32	33	13	33	30080-82	57	18	NS	NS	AC-23	95	13	40	9
1434-9	92	0	75	19	30083-85	65	32	NS	NS	Citizens Utility Company				
1445	NS	NS	60	19	30086-8	70	37	NS	NS	Chettenham	82	0	NS	NS
1451	NS	0	10	51	30089-91	62	48	NS	NS	Chicago	100	64	65	51
1457-9	36	12	3	51	30092-94	31	42	NS	NS	Countryside	38	19	31	NS
1460-2	48	38	41	40	30095-97	29	39	NS	NS	Explorer	70	NS	NS	NS
1463-5	91	13	8	50	30104-06	85	33	NS	NS	Folsom	70	NS	NS	NS
1466-8	63	34	51	31	30107-9	72	35	18	NS	Gould	39	NS	NS	NS
1475-7	NS	33	66	NS	30110-2	66	10	35	NS	Malaga	79	NS	NS	NS
1487	37	39	64	26	30113-15	71	21	14	NS	New York	31	13	70	NS
1506	24	66	70	64	30116-8	84	33	33	NS	Nutplains	61	56	56	NS
1509	47	18	91	42	30119-21	50	32	NS	NS	Rockingham	72	90	85	NS
1596	NS	9	46	NS	30122-24	55	0	22	NS	Swansea	62	NS	NS	NS
3005	NS	NS	NS	NS	31000-02	55	24	14	NS	Town	56	6	0	63
3026	NS	32	50	54	31003-05	41	0	5	NS	West La Loma	87	39	46	NS
3048	56	29	19	50	STSW-5	NS	70	88	NS	Winchester	75	NS	NS	NS
3067	0	29	52	33	STSW-6	NS	80	100	NS					

NS = model layer not screened by well

Table D6-1 Summary of Calibration Statistics

	Layer AB		Layer C		Layer D		Layer E	
year	MAE	Fit	MAE	Fit	MAE	Fit	MAE	Fit
1984	10.14	0.92	6.14	0.97	5.11	0.97	5.90	0.98
1986	8.53	0.90	4.86	0.99	5.05	0.97	7.75	0.97
1988	7.43	0.89	5.10	0.98	5.16	0.97	6.76	0.97
1990	9.79	0.82	5.30	0.98	5.24	0.98	6.27	0.98
1992	10.53	0.80	5.10	0.98	5.05	0.98	5.77	0.98
1994	11.32	0.78	5.85	0.98	5.51	0.98	5.40	0.99
1996	11.75	0.81	4.69	0.99	4.52	0.99	5.46	0.98
1998	11.51	0.80	5.06	0.98	3.77	0.99	6.11	0.98

MAE (Mean Absolute Error) = $\frac{1}{n} \Sigma \left| (Y_o - Y_s) \right|$

Fit = SS_s / SS_o

With: $$SS_s = \Sigma Y_s^2 - \frac{(\Sigma Y_s)^2}{n}$$

$$SS_o = \Sigma Y_o^2 - \frac{(\Sigma Y_o)^2}{n}$$

Where:
Y_s = simulated water level
Y_o = observed water level
n = number of monitor wells with observed water levels
SS_s = sum of squares of simulated water levels
SS_o = sum of squares of observed water levels

Table D6-2 Simulated Groundwater Balance

Time Step	Year	INFLOW (acre-ft/year)			OUTFLOW (acre-feet/year)			Change in Storage (acre-ft)/year
		Recharge	River	Wells	Wells	River	GHB	
1	1956-60	39,061	453		712	5,191	27,857	5,755
2	1961-65	32,941	1,281		19,136	3,298	28,759	-16,972
3	1966-70	35,781	2,863		13,413	2,427	30,174	-7,370
4	1971-75	32,810	3,887		9,689	1,960	30,808	-5,761
5	1976-80	31,841	4,640		9,736	1,565	29,812	-4,631
6	1981	35,078	4,851		11,685	1,504	29,545	-2,805
7	1982	43,618	4,722		11,249	1,678	30,303	5,110
8	1983	52,938	4,387	311	13,223	2,140	28,444	13,830
9	1984	25,666	4,660	943	17,883	1,830	27,502	-15,946
10	1985	28,811	5,067	3,496	23,485	1,499	26,653	-14,263
11	1986	36,501	5,303	3,577	26,860	1,430	24,954	-7,862
12	1987	31,635	5,533	4,072	27,388	1,311	23,691	-11,151
13	1988	25,092	5,840	3,688	27,571	1,104	25,849	-19,905
14	1989	29,821	6,189	5,970	28,788	944	24,174	-11,925
15	1990	27,043	6,416	6,760	28,329	840	22,980	-11,929
16	1991	33,792	6,531	6,051	25,436	817	23,485	-3,363
17	1992	34,252	6,430	5,489	27,227	806	22,268	-4,130
18	1993	38,177	6,678	5,452	25,574	856	21,947	1,931
19	1994	28,444	6,697	5,783	28,053	781	21,534	-9,444
20	1995	50,230	6,529	6,678	26,607	937	22,773	13,120
21	1996	46,028	6,361	6,708	28,535	1,100	24,816	4,646
22	1997	32,392	6,504	6,600	28,237	1,001	22,498	-6,240
23	1998	52,824	6,504	6,313	31,405	1,127	20,684	12,424

Table D8-1: Water Supply Well Capacity Projected to Require Replacement - Alternative 2A

Year	Capacity Projected to Require Replacement [gpm]
2005	4,800
2009	600
2011	900
2016	3,700
2019	1,000
2026	200
Total	11,200

Table D8-2: Water Supply Well Capacity Projected to Require Replacement - Alternative 2B

Year	Capacity Projected to Require Replacement [gpm]
2005	4,800
2009	600
2013	900
2016	1,100
2020	1,900
2026	200
Total	9,500

Table D8-3: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer C) - Alternative 3A

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1	17	2001	2023	2031			2006	2011	2011	2016	2016	2019	2019	2031
AC 5	27	2001					2016	2023	2023	2031				
AC 6	113	2001					2020	2026	2026	2031				
AC 7	268	2001					2006	2015						
AC 8	25	2001												
AC 9	114	2001	2008	2019	2019	2031					2001	2027	2027	2031
AC 10	44	2001					2006	2012	2012	2023	2023	2031		
AC 11	50	2001	2001	2019	2019	2031	2001	2016	2016	2019	2019	2031		
AC 12	74	2001					2011	2020						
AC 13	71	2001	2002	2011	2011	2020					2001	2020		
AC 14	212	2001	2004	2031			2001	2004	2004	2031				
AC 15														
AC 16														
AC 17	266	2001												
AC 18	627	2001					2006	2008	2008	2009	2009	2026	2026	2031
AC 19														
AC 20														
AC 21														
AC 22														
AC 23														
Chettenham	260	2001					2012	2013	2013	2019	2019	2022	2022	2031
Countryside	520	2001												
Malaga	118	2001												
Nut Plains	535	2001												
Rockingham	71	2001					2015	2016	2016	2020	2020	2031		
West Laloma														
Winchester	173	2001					2015	2016	2016	2019	2019	2026	2026	2031
SWMD-17	57	2001											2001	2017
SWMD-18	52	2001												

Table D8-4: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be present (Layer D) - Alternative 3A

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1														
AC 5	45	2001												
AC 6														
AC 7	108	2001												
AC 8	63	2001												
AC 9	114	2001	2011	2012	2012	2024	2012	2015	2015	2016	2016	2020	2020	2024
AC 10	22	2001												
AC 11	298	2001												
AC 12	74	2001												
AC 13	118	2001	2009	2013	2013	2026	2012	2013	2013	2015	2015	2023	2023	2027
AC 14	85	2001												
AC 15	75	2001			2001	2008			2001	2002	2002	2008		
AC 16	74	2001			2001	2009	2001	2002	2002	2004	2004	2009		
AC 17	320	2001												
AC 18	196	2001												
AC 19	464	2001									2017	2020	2020	2028
AC 20														
AC 21														
AC 22	476	2001												
AC 23														
Countryside														
Nut Plains														
Rockingham	348	2001												
West Laloma	623	2001												
Winchester														
SWMD-17	95	2001					2001	2015	2015	2023	2023	2026	2026	2031
SWMD-18	131	2001												

Table D8-5: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer E) - Alternative 3A

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present									
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1												
AC 5												
AC 6												
AC 7												
AC 8												
AC 9	28	2001										
AC 10												
AC 11	66	2001										
AC 12	28	2001										
AC 13	155	2001					2024	2030	2030	2031		
AC 14	29	2001										
AC 15	164	2001					2001 2017	2005 2031	2005 2015	2006 2017	2006	2015
AC 16	163	2001	2009	2020	2001	2009			2001 2004	2002 2031	2002	2004
AC 17	120	2001										
AC 18	91	2001										
AC 19	365	2001										
AC 20	912	2001	2002	2005	2005	2031	2009	2012	2012	2015	2015	2031
AC 21	312	2001										
AC 22	416	2001										
AC 23	1071	2001							2026	2030	2030	2031
Countryside												
Nut Plains												
Rockingham												
West Laloma												
Winchester												
SWMD-17												
SWMD-18												

Table D8-6: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer C) - Alternative 3B

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1	17	2001					2006	2016	2016	2022	2022	2026	2026	2031
AC 5	27	2001					2022	2031						
AC 6	113	2001					2022	2031						
AC 7	268	2001					2020	2023						
AC 8	25	2001												
AC 9	114	2001	2011	2030	2030	2031					2001	2031		
AC 10	44	2001					2008	2020	2020	2031				
AC 11	50	2001	2001	2005			2001	2002						
AC 12	74	2001					2012	2026						
AC 13	71	2001	2002	2020							2001	2031		
AC 14	212	2001	2004	2015			2001	2004	2004	2015				
AC 15														
AC 16														
AC 17	266	2001												
AC 18	627	2001					2006	2008	2008	2020	2020	2031		
AC 19														
AC 20														
AC 21														
AC 22														
AC 23														
Chettenham	260	2001					2015	2017	2017	2023	2023	2028	2028	2031
Countryside	520	2001												
Malaga	118	2001												
Nut Plains	535	2001												
Rockingham	71	2001					2017	2020	2020	2024	2024	2031		
West Laloma														
Winchester	173	2001					2026	2031						
SWMD-17	57	2001											2001	2023
SWMD-18	52	2001												

Table D8-7: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer D) - Alternative 3B

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present									
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1												
AC 5	45	2001										
AC 6												
AC 7	108	2001										
AC 8	63	2001										
AC 9	114	2001	2016	2017	2017	2031	2012	2016	2016	2019	2019	2031
AC 10	22	2001										
AC 11	298	2001										
AC 12	74	2001										
AC 13	118	2001	2013	2020	2020	2031	2013	2019	2019	2023	2023	2031
AC 14	85	2001										
AC 15	75	2001			2001	2015			2001	2002	2002	2012
AC 16	74	2001			2001	2015	2001	2002	2002	2005	2005	2031
AC 17	320	2001										
AC 18	196	2001										
AC 19	464	2001									2017	2031
AC 20												
AC 21												
AC 22	476	2001										
AC 23												
Countryside												
Nut Plains												
Rockingham	348	2001 - 2031										
West Laloma	623	2001 - 2031										
Winchester												
SWMD-17	95	2001 - 2031										
SWMD-18	131	2001 - 2031										

Table D8-8: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer E) - Alternative 3B

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present									
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L	
			Begin Yea	End Year	Begin Yea	End Year	Begin Yea	End Year	Begin Yea	End Year	Begin Yea	End Year
AC 1												
AC 5												
AC 6												
AC 7												
AC 8												
AC 9	28	2001										
AC 10												
AC 11	66	2001										
AC 12	28	2001										
AC 13	155	2001										
AC 14	29	2001										
AC 15	164	2001	2009	2017			2001 2020	2006 2031	2006 2019	2008 2020	2008	2019
AC 16	163	2001	2023	2026	2001	2023			2001 2015	2004 2031	2004	2015
AC 17	120	2001										
AC 18	91	2001										
AC 19	365	2001										
AC 20	912	2001	2002	2005	2005	2031	2012	2028	2028	2031		
AC 21	312	2001										
AC 22	416	2001										
AC 23	1071	2001										
Countryside												
Nut Plains												
Rockingham												
West Laloma												
Winchester												
SWMD-17												
SWMD-18												

Table D8-9: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present - Alternative 4A

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	400	2001					2001	2004	2004	2009	2009	2020		
									2020	2080				
C2	500	2001					2001	2004	2004	2009	2009	2023	2023	2050
C3	400	2001					2001	2002	2002	2004	2004	2006	2006	2022
							2022	2042						
C4	300	2001					2001	2002	2002	2005	2005	2008	2008	2022
							2022	2031						
C5	200	2001					2001	2002	2002	2005	2005	2006	2006	2022
							2022	2042						
C6	200	2001	2016	2022			2001	2004	2005	2011	2008	2011	2011	2031
							2031	2050						
C7	200	2001	2012	2015	2015	2042	2001	2005	2005	2006	2006	2011	2011	2042
C8	200	2001	2013	2024	2024	2042	2001	2002	2002	2005	2005	2042		
C9	200	2001	2015	2035	2035	2042	2001	2005	2005	2034	2034	2042		
			2042	2050			2042	2050						
C10	300	2001	2009	2022			2001	2008	2008	2022				
C11	300	2011	2011	2017	2017	2031	2011	2012	2012	2017	2017	2031		
C12	300	2001	2004	2005	2005	2022	2001	2004	2004	2006	2006	2022		
C13	300	2001	2004	2006	2006	2022	2001	2004	2004	2009				
							2009	2022						
D1	200	2001	2017	2022			2009	2012	2012	2013	2013	2016	2037	2119
							2020	2022	2018	2020	2034	2037		
							2028	2033	2033	2034				
D2	200	2021	2027	2028	2028	2050	2019	2027	2027	2030	2030	2031	2031	2050
D3	200	2021	2023	2024	2024	2031	2017	2019	2019	2023	2023	2027	2027	2031
D4	200	2021	2019	2020	2020	2042	2016	2017	2016	2019	2019	2023	2023	2031
D5	200	2011	2015	2016	2016	2042	2013	2015	2015	2016	2016	2023	2023	2042
D6	200	2031	2034	2035	2035	2042	2028	2030	2030	2031	2031	2042		
D7	200	2021	2042	2061			2042	2043	2028	2030	2030	2042		
D8	200	2051	2022	2042			2017	2026	2042	2045	2045	2061		
D9	200	2021	2028	2030	2030	2042	2027	2028	2028	2030	2030	2042		
			2042	2061			2042	2061						
D10	200	2011	2022	2061			2017	2026	2026	2031	2031	2042		
							2042	2061						
E1	500	2021	2022	2023	2023	2050	2022	2026	2026	2028	2028	2039		
			2050	2061					2039	2061				
E2	500	2031	2037	2048			2031	2038	2038	2039	2039	2053		
							2056	2061	2053	2056				
E3	500	2051					2050	2122						
E4	400	2061	2072	2080			2061	2067	2067	2072	2072	2083		
							2089	2122	2083	2089				
E5	300	2061	2069	2080			2061	2067	2067	2072	2072	2083		
							2089	2122	2083	2089				
E6	300	2061	2067	2069	2069	2080	2061	2067	2067	2072	2072	2083		
			2080	2122			2089	2122	2083	2089				
E7	300	2061	2080	2083	2083	2097	2061	2083	2083	2086	2086	2100		
			2097	2122			2105	2122	2100	2105				

Table D8-10: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present - Alternative 4B

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	300	2001					2001	2006	2006	2015	2015	2050		
									2050	2089				
C2	400	2001					2001	2004	2004	2006	2006	2034	2034	2048
											2048	2069		
C3	400	2001					2001	2002	2002	2005	2005	2008	2008	2064
											2064	2089		
C4	300	2001					2001	2002	2002	2006	2006	2008	2008	2064
											2064	2089		
C5	200	2001	2019	2026	2026	2039	2001	2002	2002	2008	2008	2009	2009	2069
			2039	2042										
C6	300	2001	2016	2034	2034	2069	2001	2004	2004	2009	2009	2069		
C7	200	2001	2019	2031			2001	2004	2004	2008	2008	2031		
C8	200	2001	2012	2022			2001	2006	2006	2012				
							2012	2017						
C9	200	2001	2001	2017	2017	2031	2001	2005	2005	2023	2023	2031		
C10	300	2001	2004	2008	2008	2022	2001	2005	2005	2022				
D1	200	2011	2020	2026	2011	2015	2015	2017	2017	2024				
					2026	2050	2024	2026						
							2050	2089						
D2	200	2021	2034	2041	2041	2056	2022	2026	2026	2037	2037	2048	2048	2061
			2056	2061										
D3	200	2021	2023	2024	2024	2050	2022	2023	2023	2024	2024	2035	2035	2061
			2050	2061			2061	2171						
D4	200	2041	2034	2035	2035	2067	2031	2039	2039	2042	2042	2069		
			2067	2069			2069	2171						
D5	200	2041	2050	2059	2059	2067	2041	2080						
			2067	2080										
D6	300	2001					2001	2005	2005	2022				
E1	500	2041	2042	2045	2045	2072	2045	2050	2050	2056	2056	2080		

Table D8-11: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present - Alternative 4C

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	200	2001					2001	2006	2006	2016	2016	2050		
									2050	2152				
C2	350	2001					2001	2004	2004	2011	2011	2097		
C3	300	2001					2001	2002	2002	2005	2002	2008	2008	2064
											2064	2097		
C4	200	2001					2001	2002	2002	2006	2006	2008	2008	2064
											2064	2097		
C5	200	2001	2023	2042			2001	2002	2002	2009	2009	2012	2010	2069
C6	200	2001	2020	2031			2001	2004	2004	2008	2008	2031		
C7	100	2001	2017	2031			2001	2004	2004	2009	2009	2031		
C8	200	2001	2012	2031			2001	2006	2006	2012				
							2012	2031						
C9	300	2001	2001	2017	2017	2031	2001	2012	2012	2023	2023	2031		
C10	350	2001	2004	2008	2008	2022	2001	2005	2005	2022				
D1	150	2001					2001	2031						
D2	200	2001	2004	2008	2008	2042			2001	2004	2004	2042		
D3	200	2001	2004	2004	2004	2050			2001	2004	2004	2037	2037	2152
D4	200	2001	2007	2011	2011	2050	2001	2007	2007	2023	2023	2152		
D5	200	2011					2012	2020	2020	2026				
							2026	2031						
D6	200	2021					2023	2026	2026	2045	2045	2097		
E1	300	2001	2012	2015	2015	2042								
E2	300	2001	2001	2023	2023	2061	2001	2045	2005	2020	2020	2031		
									2031	2061				

Table D8-12: Modeled Pumping and Recharge Rates and Modeled Approximate Times CoPCs may be Present - Alternative 5A

Extraction Wells

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	400	2001							2001	2011	2011	2050		
									2050	2122				
C2	500	2001					2001	2002	2002	2004	2004	2017	2017	2037
C3	400	2001					2001	2002	2002	2005	2005	2006	2006	2020
C4	300	2001					2001	2002	2002	2006	2006	2008	2008	2020
C5	200	2001	2019	2022	2020	2027	2001	2002	2002	2006	2006	2009	2009	2031
C6	200	2001	2017	2022	2022	2034	2001	2004	2004	2011	2011	2013	2013	2017
											2017	2037		
C7	200	2001	2013	2030	2030	2042	2001	2004	2004	2006	2006	2042		
C8	200	2001	2016	2034	2034	2050	2001	2002	2002	2017	2037	2050		
							2017	2028	2028	2005				
C9	400	2001	2004	2008	2008	2031	2005	2006	2006	2012	2012	2031		
D1	300	2011	2034	2042			2015	2017	2017	2034	2034	2037	2037	2050
D2	300	2001	2016	2024	2024	2031	2006	2012	2012	2015	2015	2020	2027	2039
									2020	2023	2023	2027		
D3	200	2021	2023	2024	2024	2031	2020	2022	2022	2023	2023	2027	2027	2039
D4	200	2021	2023	2024	2024	2031	2020	2022	2022	2023	2023	2027	2027	2039
D5	200	2021	2023	2024	2024	2031	2023	2024	2024	2026	2026	2027	2027	2050
D6	200	2021	2023	2026	2026	2050	2024	2026	2026	2027	2027	2050		
D7	200	2031	2042	2045	2045	2122	2039	2041	2041	2042	2042	2122		
D8	200	2011	2023	2026	2026	2034	2017	2024	2024	2028	2028	2034		
E1	500	2021					2050	2060						
							2072	2122						
E2	300	2051	2064	2069			2050	2060	2060	2067	2067	2069		
							2072	2122	2069	2072				
E3	300	2051	2064	2086			2050	2064	2064	2069	2069	2080		
							2089	2122	2080	2089				
E4	300	2051	2072	2075	2075	2083	2050	2069	2069	2075	2075	2102		
			2083	2086			2105	2122	2102	2105				
E5	300	2081	2083	2086	2086	2089	2080	2086	2086	2087	2087	2105		
			2089	2091			2108	2122	2105	2108				
E6	300	2081	2083	2089			2080	2086	2086	2087	2087	2102		
							2105	2122	2102	2105				
E7	500	2021	2022	2024	2024	2122	2026	2031	2031	2037	2037	2039		

Recharge Wells

Recharge Well	Layers Screened	Recharge Rate (gpm)					
		2001 - 2011	2011 - 2021	2021 - 2031	2031 - 2041	2041 - 2051	2051 - 2061
I1	C,D	443	514	600	443	286	229
I2	C,D	443	514	600	443	286	229
I3	C,D	443	514	600	443	286	229
I4	C,D	443	514	600	443	286	229
I5	C,D	443	514	600	443	286	229
I6	C,D	443	514	600	443	286	229
I7	C,D	443	514	600	443	286	229

Table D8-13: Alternative 5B - Modeled Pumping and Recharge Rates and Modeled Approximate Times CoPCs may be Present

Extraction Wells

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	300	2001					2001	2004	2004	2015	2015	2050		
									2050	2111				
C2	400	2001					2001	2004	2004	2011	2011	2034	2034	2056
									2056	2111				
C3	400	2001					2001	2004	2004	2005	2005	2008	2008	2061
									2056	2111				
C4	300	2001	2023	2031	2031	2072	2001	2004	2004	2006	2006	2008	2008	2061
									2061	2111				
C5	200	2001	2022	2023	2023	2072	2001	2002	2002	2009	2009	2012	2012	2072
									2072	2111				
C6	200	2001	2017	2039	2039	2072	2001	2004	2004	2012	2008	2026		
									2026	2050				
C7	200	2001	2017	2026			2001	2004	2004	2009	2009	2015		
									2015	2050				
D1	200	2011	2019	2022	2039	2045	2012	2015	2015	2020	2020	2026	2048	2072
			2035	2039					2026	2027	2042	2048		
									2039	2042				
D2	200	2021	2030	2031	2031	2072	2023	2028	2028	2034	2034	2042	2042	2072
			2072	2231										
D3	200	2021	2026	2028	2031	2072	2023	2030	2030	2034	2034	2072		
			2072	2231										
E1	300	2111	2111	2119	2119	2179	2023	2030	2160	2231				
			2179	2231										

Recharge Wells

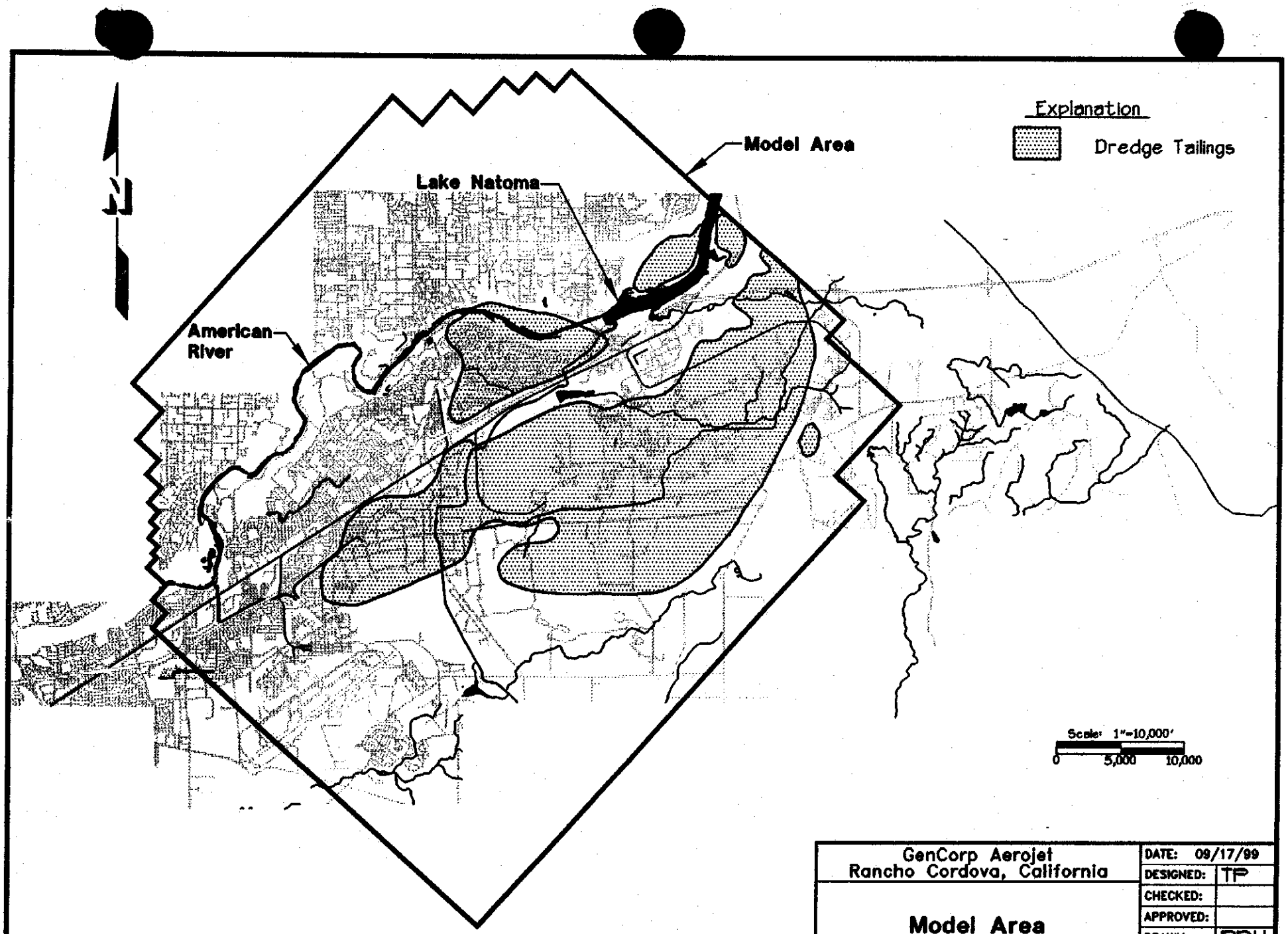
Recharge Well	Layers Screened	Recharge Rate (gpm)		
		2001 - 2011	2011 - 2021	2021 - 2071
I1	C,D	286	314	371
I2	C,D	286	314	371
I3	C,D	286	314	371
I4	C,D	286	314	371
I5	C,D	286	314	371
I6	C,D	286	314	371
I7	C,D	286	314	371

Table D8-14 Modeled Pumping Rates and Approximate Times CoPCs may be Present when Hydraulic Conductivity is High (2X)

Offsite Extraction Barrier Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Approximate Times CoPCs may be Present											
			NDMA				Perchlorate							
			0.01 ug/l		0.1 ug/l		4 ug/l		40 ug/l		400 ug/l		4000 ug/l	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	400	2001					2001	2002	2002	2008	2008	2038		
									2038	2061				
C2	500	2001					2001	2002	2002	2005	2005	2017	2017	2042
							2042	2050						
C3	400	2001					2001	2001	2001	2003	2003	2005	2005	2022
							2022	2031						
C4	300	2001					2001	2002	2002	2004	2004	2006	2006	2022
							2022	2031						
C5	200	2001					2001	2001	2001	2005	2005	2006	2006	2022
							2022	2050						
C6	200	2001	2013	2022			2001	2002	2002	2007	2007	2009	2009	2031
							2031	2050						
C7	200	2001	2010	2014	2014	2042	2001	2003	2003	2006	2006	2042		
C8	200	2001	2011	2017	2017	2042	2001	2002	2002	2005	2005	2042		
C9	200	2001	2012	2035	2035	2042	2001	2003	2003	2028	2028	2042		
			2042	2050			2042	2050						
C10	300	2001	2007	2022			2001	2006	2006	2022				
C11	300	2011	2009	2017	2017	2031	2011	2012	2012	2016	2016	2031		
C12	300	2001	2004	2004	2004	2022	2001	2003	2003	2006	2006	2206		
C13	300	2001	2004	2012			2001	2011						
D1	200	2001	2016	2018			2006	2011	2011	2012	2012	2017	2048	2061
							2018	2031	2017	2018	2040	2048		
									2031	2040				
D2	200	2011	2025	2027	2027	2050	2013	2015	2015	2016	2016	2018	2030	2045
							2020	2026	2018	2020	2028	2030		
									2026	2028				
D3	200	2011	2022	2023	2023	2031	2015	2017	2017	2019	2019	2026	2026	2031
D4	200	2011	2017	2018	2018	2031	2013	2014	2014	2016	2016	2020	2020	2031
D5	200	2011	2012	2014	2014	2042	2012	2014	2014	2016	2016	2019	2019	2037
D6	200	2031	2028	2035	2035	2042	2028	2030	2030	2031	2031	2042		
D7	200	2021	2031	2035	2035	2042	2031	2032	2032	2033	2033	2061		
			2042	2061										
D8	200	2011	2030	2034	2034	2061	2032	2035	2035	2041	2041	2061		
D9	200	2041	2052	2061			2045	2048	2048	2049	2049	2061		
D10	200	2051	2057	2061			2056	2057	2057	2058	2058	2061		
									2001					
E1	500	2021	2022	2023	2023	2050	2022	2026	2026	2028	2028	2039		
			2050	2061					2039	2061				
E2	500	2031	2037	2048			2031	2038	2038	2039	2039	2053		
							2056	2061	2053	2056				
E3	500	2051					2050	?						

Table D8-15 Modeled Pumping Rates and Approximate Times CoPCs may be Present when Hydraulic Conductivity is Low (0.5X)

Offsite Extraction Barrier Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Approximate Times CoPCs may be Present											
			NDMA				Perchlorate							
			0.01 ug/l		0.1 ug/l		4 ug/l		40 ug/l		400 ug/l		4000 ug/l	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	400	2001					2002	2003	2003	2009	2010	2045		
									2045	2069				
C2	500	2001					2002	2003	2003	2008	2008	2027	2027	2058
							2031	2042						
C3	300	2001					2001	2002	2002	2005	2005	2009	2009	2031
C4	225	2001					2003	2003	2003	2007	2007	2009	2009	2031
							2031	2042						
C5	150	2001					2001	2003	2003	2008	2008	2010	2010	2031
							2031	2050						
C6	150	2001	2019	2031			2001	2004	2004	2012	2012	2014	2014	2031
C7	150	2001	2015	2019	2019	2042	2002	2006	2006	2010	2010	2016	2016	2042
C8	200	2001	2017	2029	2029	2042	2001	2003	2003	2007	2007	2042		
C9	150	2001	2022	2037	2037	2050	2002	2006	2006	2034	2034	2042		
							2042	2050						
C10	225	2001	2012	2022		2001	2002	2009	2009	2022				
C11	300	2011	2011	2020	2020	2042	2009	2013	2014	2021	2021	2031		
							2031	2042						
C12	300	2001	2004	2005	2005	2022	2002	2004	2004	2006	2006	2022		
C13	300	2001	2004	2006	2006	2022	2001	2004	2004	2011				
							2009	2022						
D1	200	2001	2018	2023			2008	2013	2013	2015	2015	2021	2037	2061
							2023	2034	2021	2023	2037	2037		
							2028	2032	2034	2037				
							2061	2080						
D2	150	2021	2031	2033	2033	2037	2017	2032	2032	2033	2033	2037	2037	2050
			2037	2050										
D3	150	2021	2027	2001	2030	2038	2019	2022	2022	2025	2025	2034	2034	2037
							2037	2050						
D4	150	2021	2020	2021	2021	2028	2016	2018	2018	2023	2023	2028	2028	2031
							2031	2042						
D5	150	2011	2018	2019	2019	2034	2015	2018	2018	2023	2023	2027	2027	2037
							2037	2042						
D6	200	2031	2032	2032	2032	2042	2032	2032	2032	2034	2034	2042		
D7	150	2021	2026	2030	2030	2042	2027	2028	2028	2030	2030	2042		
			2042	2061			2042	2061						
D8	200	2011	2025	2061			2017	2026	2026	2031	2031	2042		
							2042	2061						
D9	150	2041	2052	2061			2053	2054	2054	2055	2055	2061		
D10	150	2051	2058	2080			2058	2060	2060	2061	2061	2064		
							2064	2080						
E1	500	2021	2022	2023	2023	2050	2022	2026	2026	2028	2028	2039		
			2050	2061										
E2	500	2031	2037	2048			2034	2038	2038	2039	2039	2053		
							2056	2061	2053	2056				
E3	375	2051					2058	?						



GenCorp Aerojet Rancho Cordova, California	DATE: 09/17/99 DESIGNED: TP CHECKED: APPROVED: DRAWN: RDH PROJ.: N940-104
Model Area	
HSI GEOTRANS A TETRA TECH COMPANY	Figure D2-1

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PAGES OF OVERSIZED MAPS

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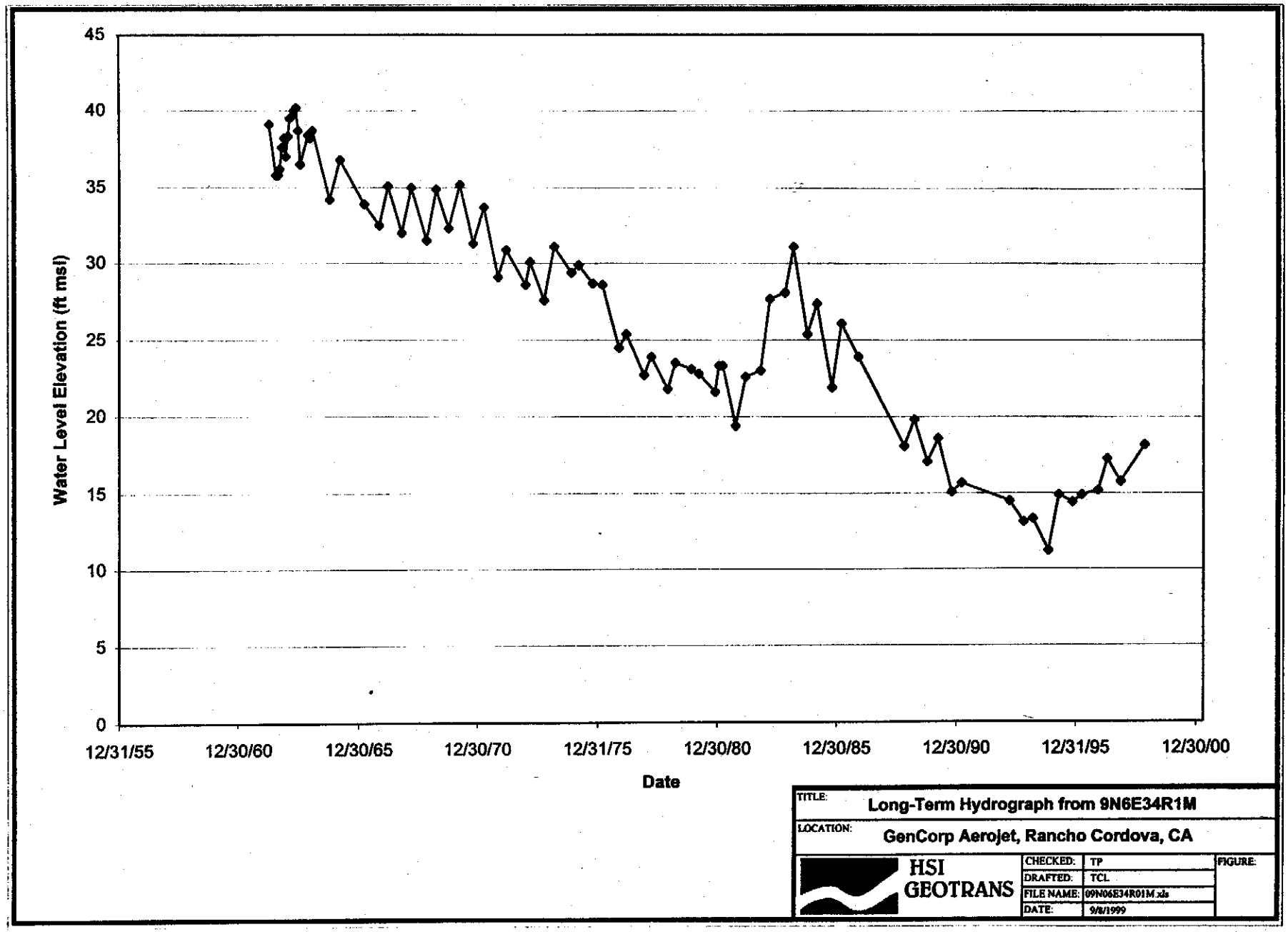
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25
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15
10
5
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12/31/55
12/30/60
12/30/65
12/30/70
12/31/75
12/30/80
12/30/85
12/30/90
12/31/95
12/30/00
Date
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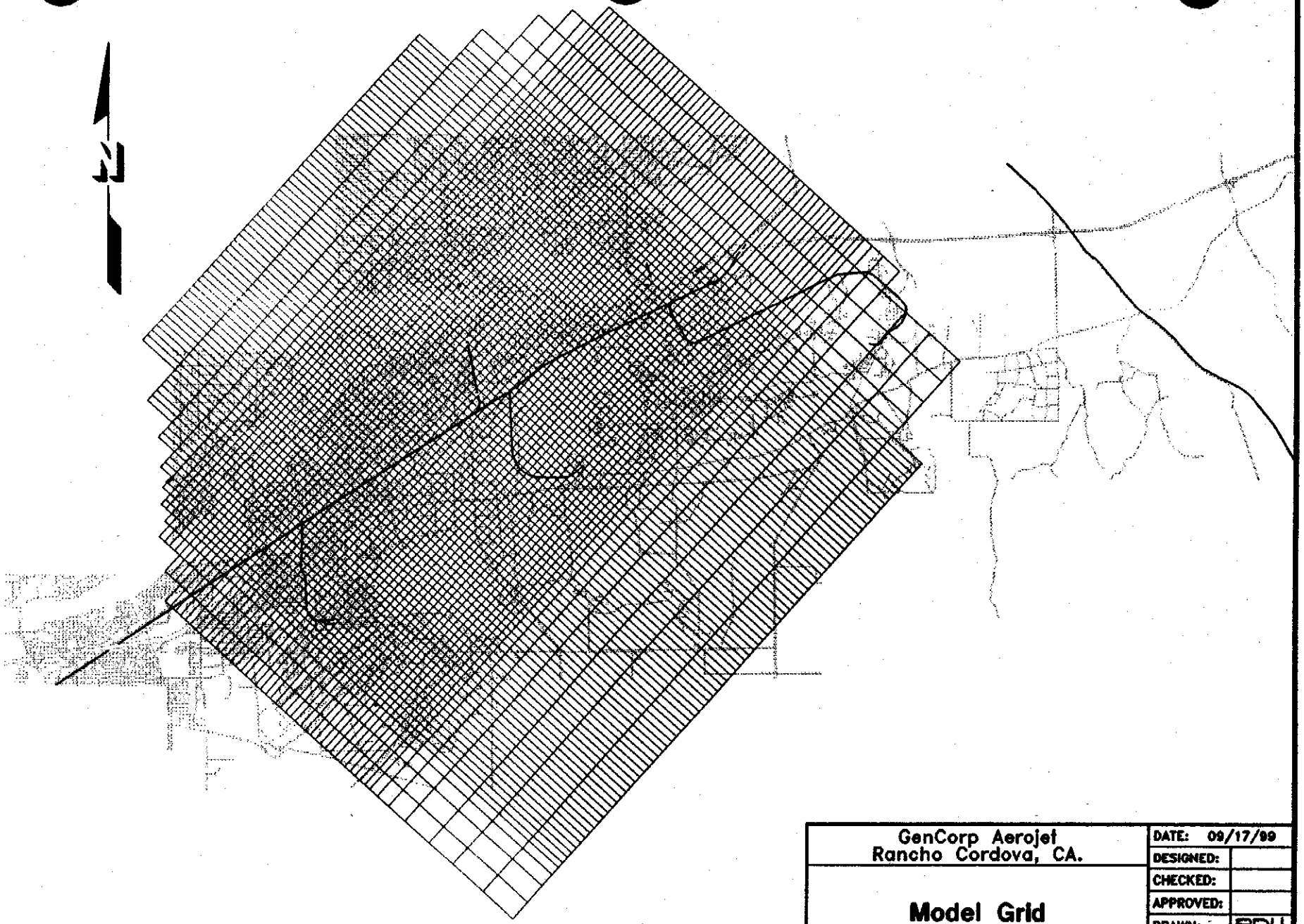
DATE: 9/8/1999
FIGURE:

Figure D2-4



GenCorp Aerojet
Rancho Cordova, CA.

Model Grid

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DESIGNED:	
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

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Figure D3-1

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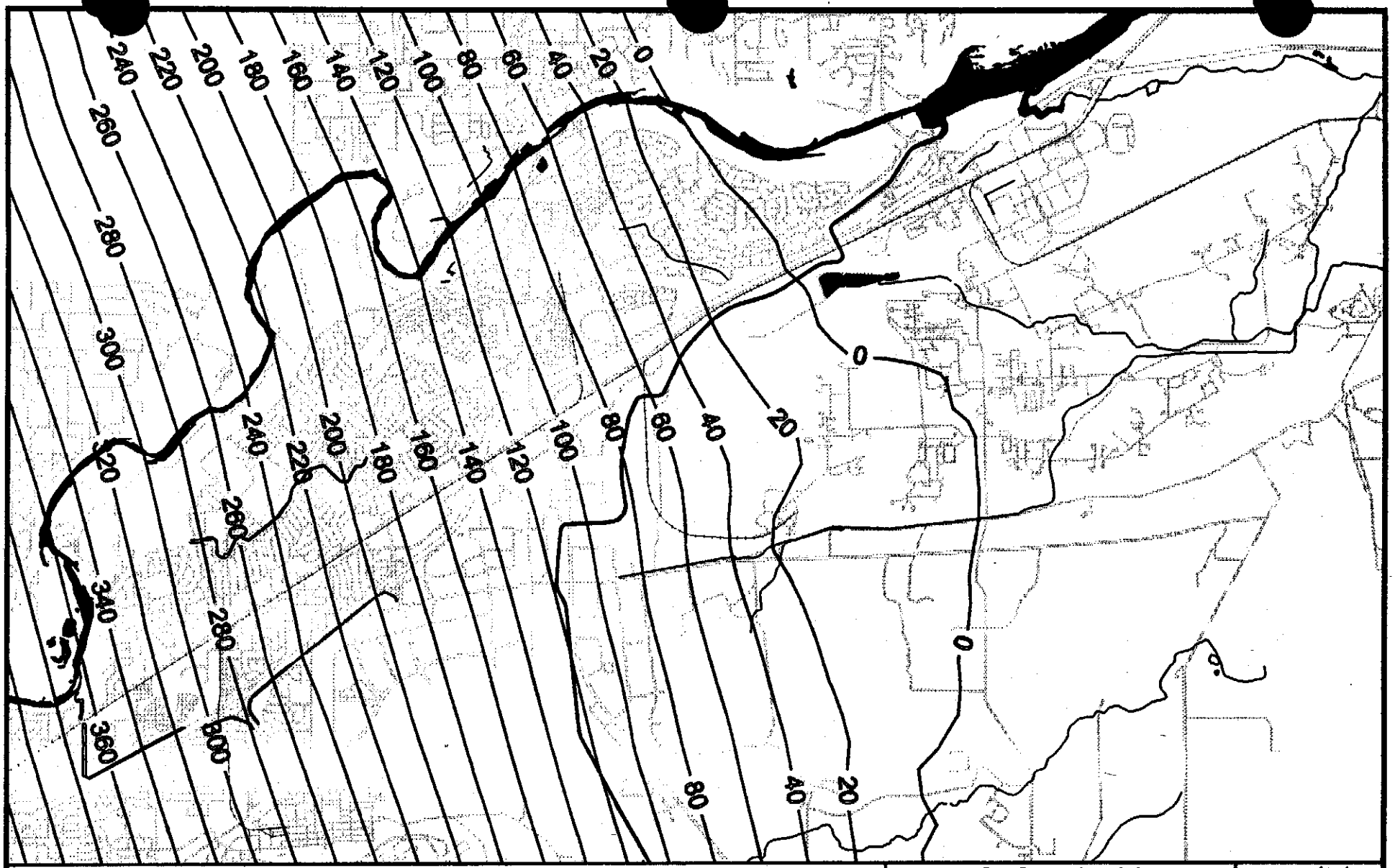

Explanation

—100— Line of Equal Thickness (ft.)

Note: Simulated 1996 Water Levels Used to Calculate Layer Thickness

Scale: 1"=5000'

0 2500' 5000'

GenCorp Aerojet
Rancho Cordova, CA.

Layer AB Isopach

DATE:	03/31/00
DESIGNED:	
CHECKED:	TP
APPROVED:	TP
DRAWN:	RDH
PROJ.:	N940-102

HSI GEOTRANS
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Figure D3-5

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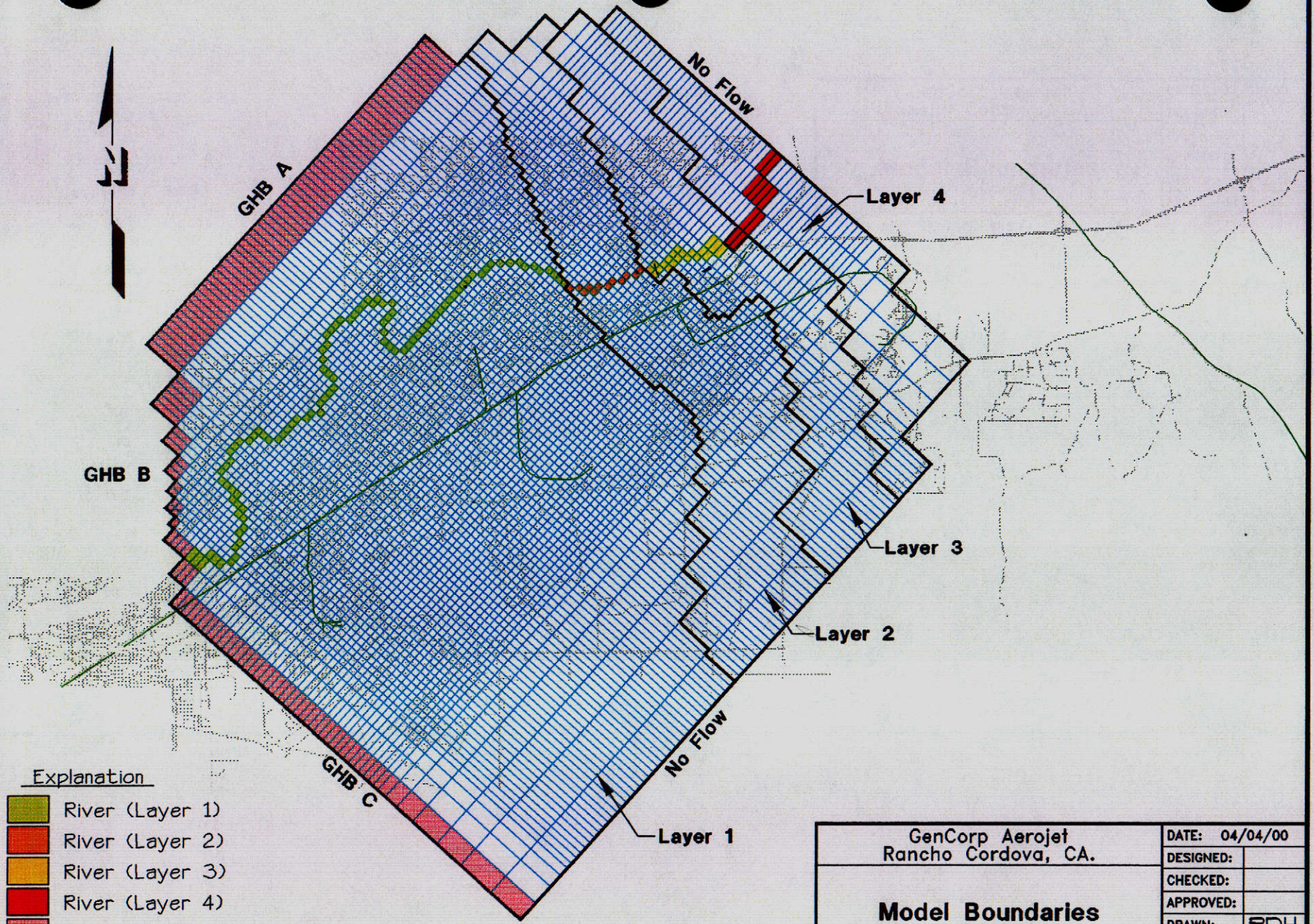
PAGES OF OVERSIZED MAPS

(SEE BINDER)



GenCorp Aerojet
Rancho Cordova, CA.

Model Boundaries

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CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

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Figure D3-8

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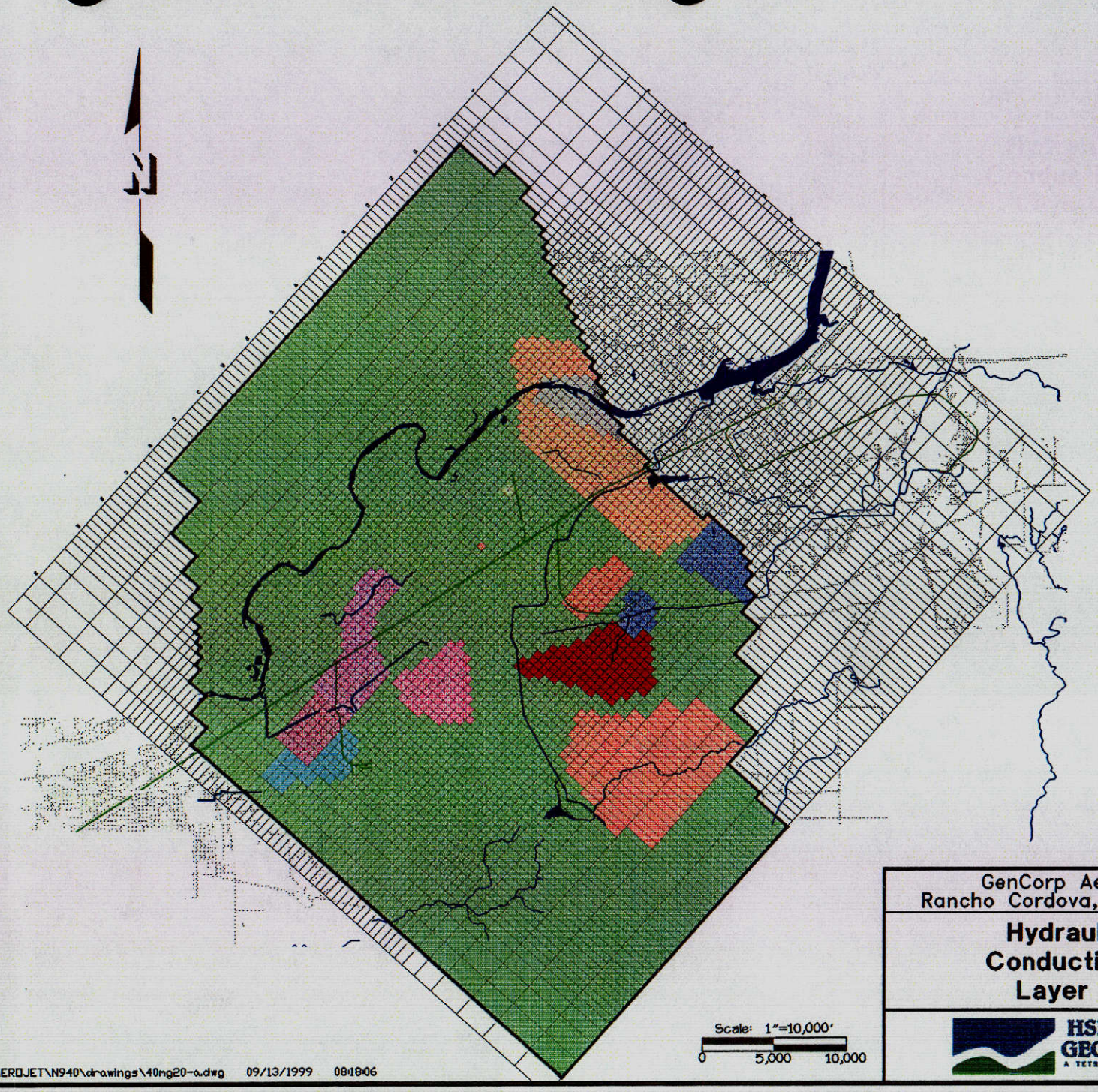

GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 1

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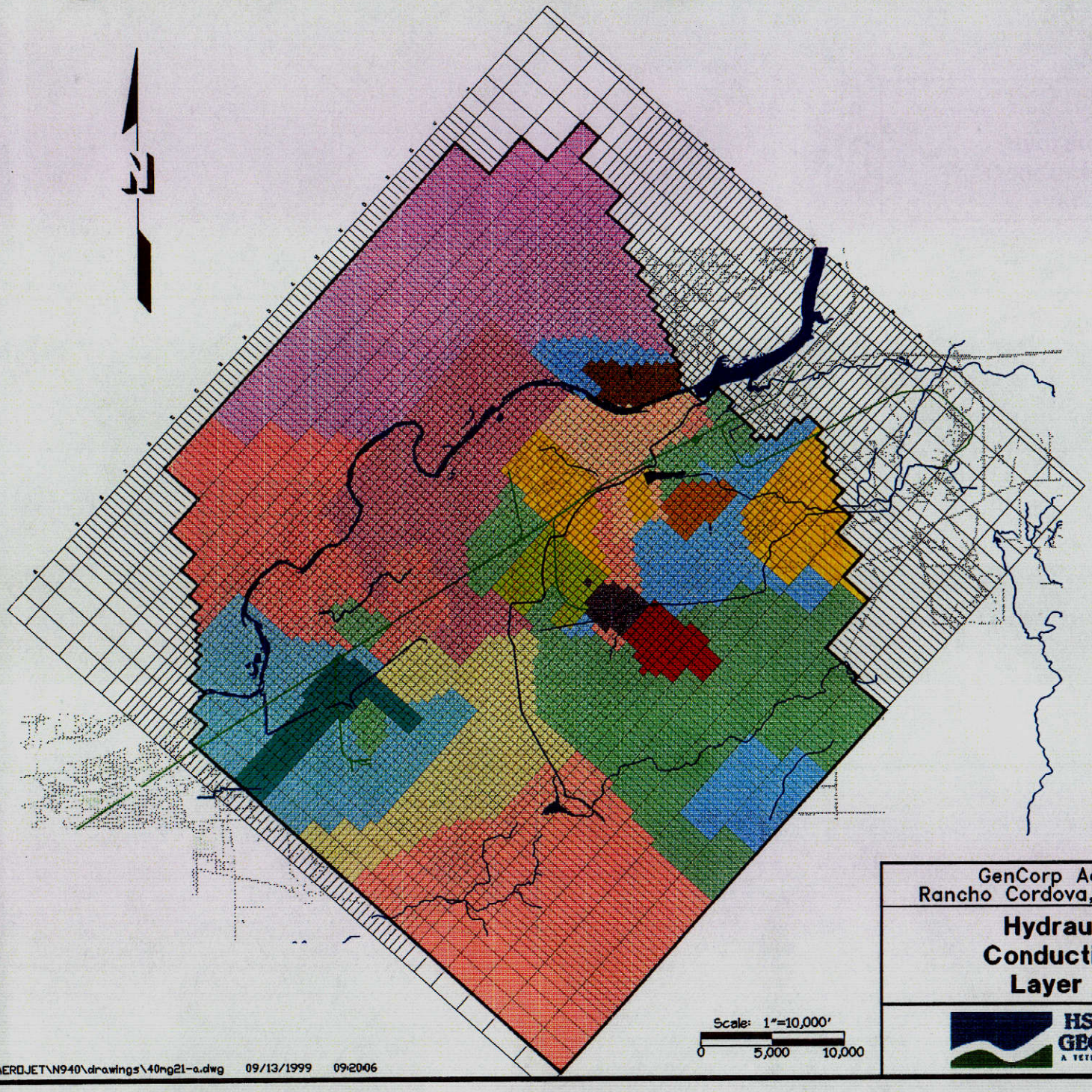
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-1



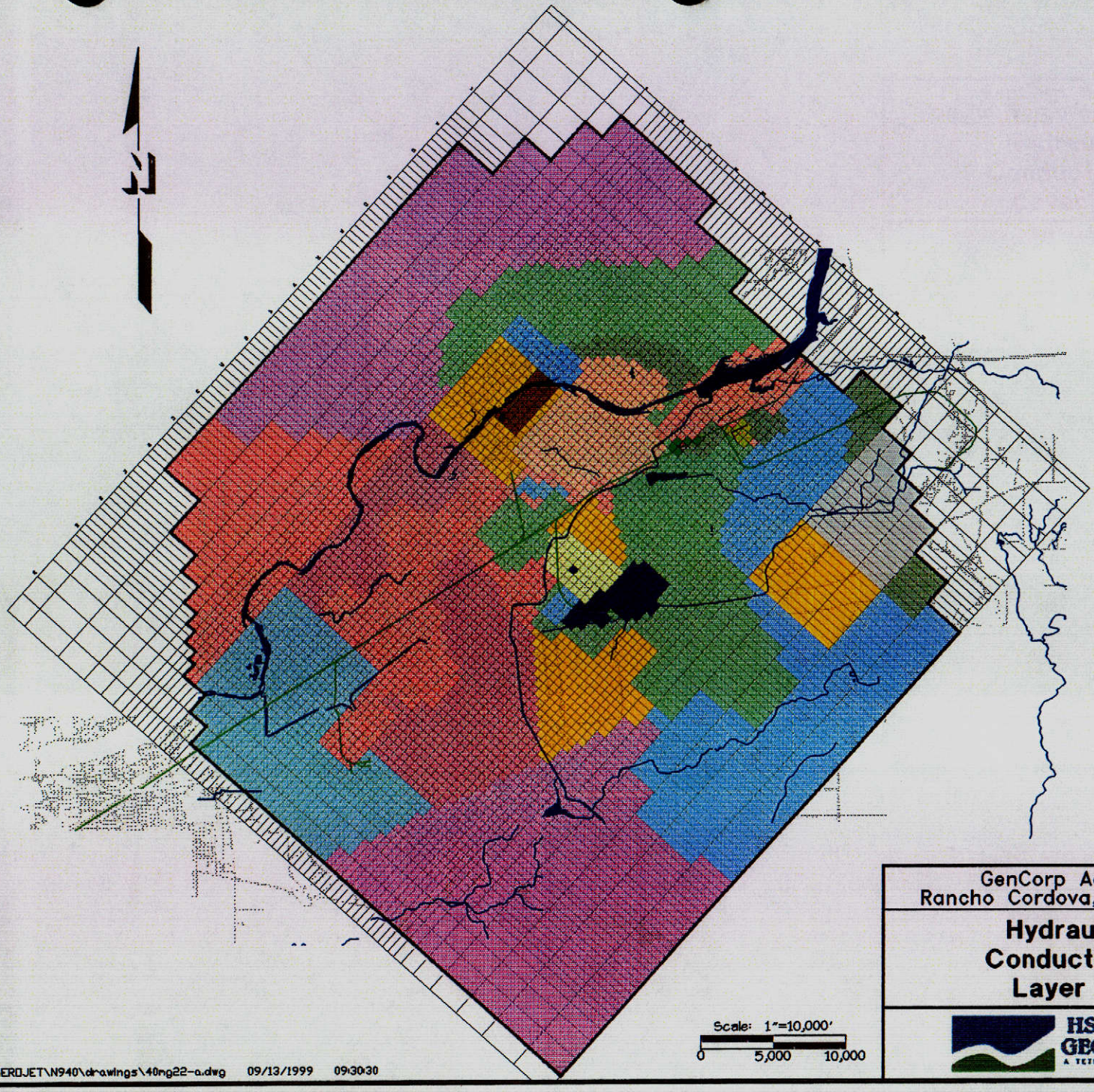
GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 2

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-2



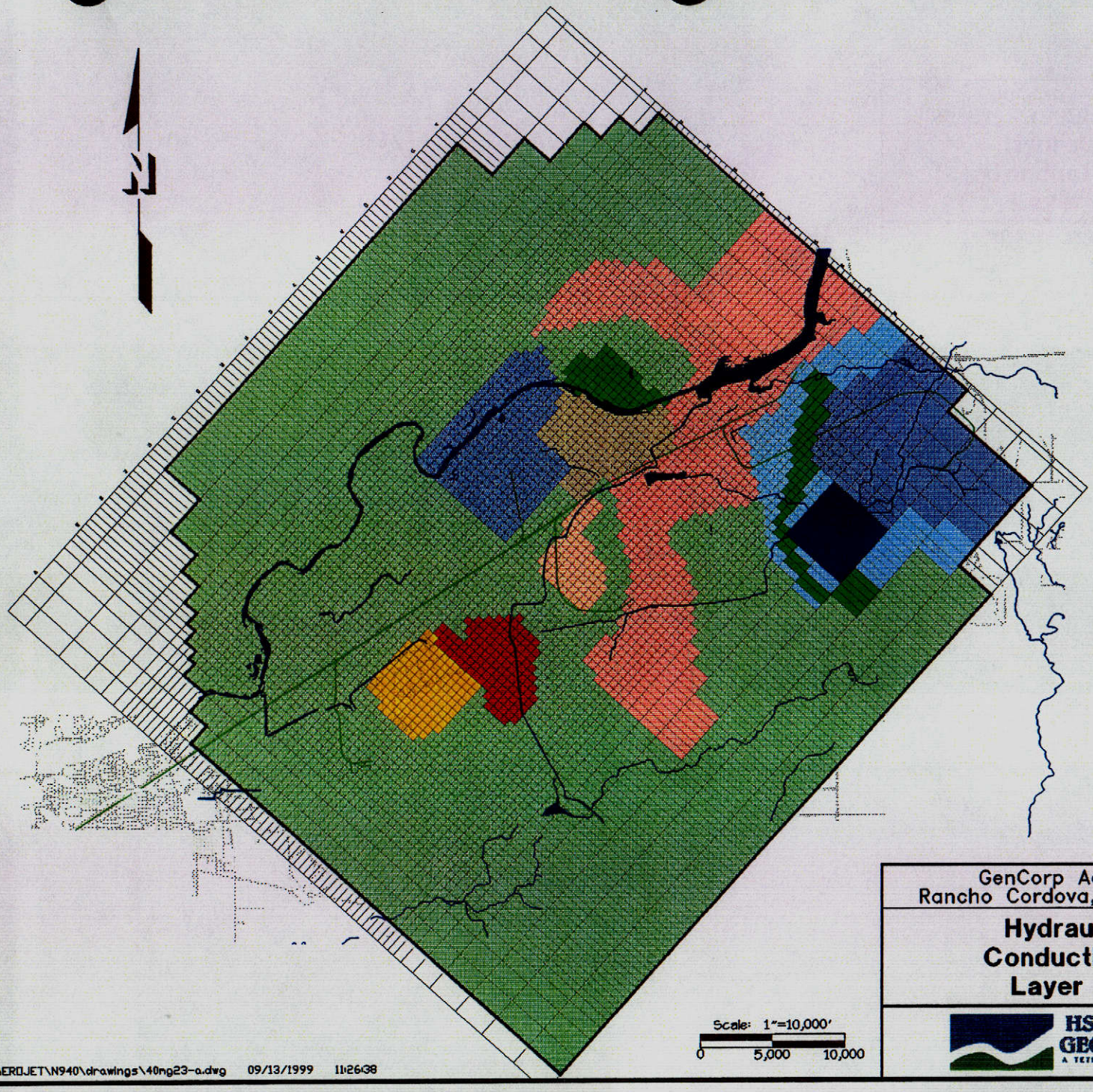
GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 3

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-3



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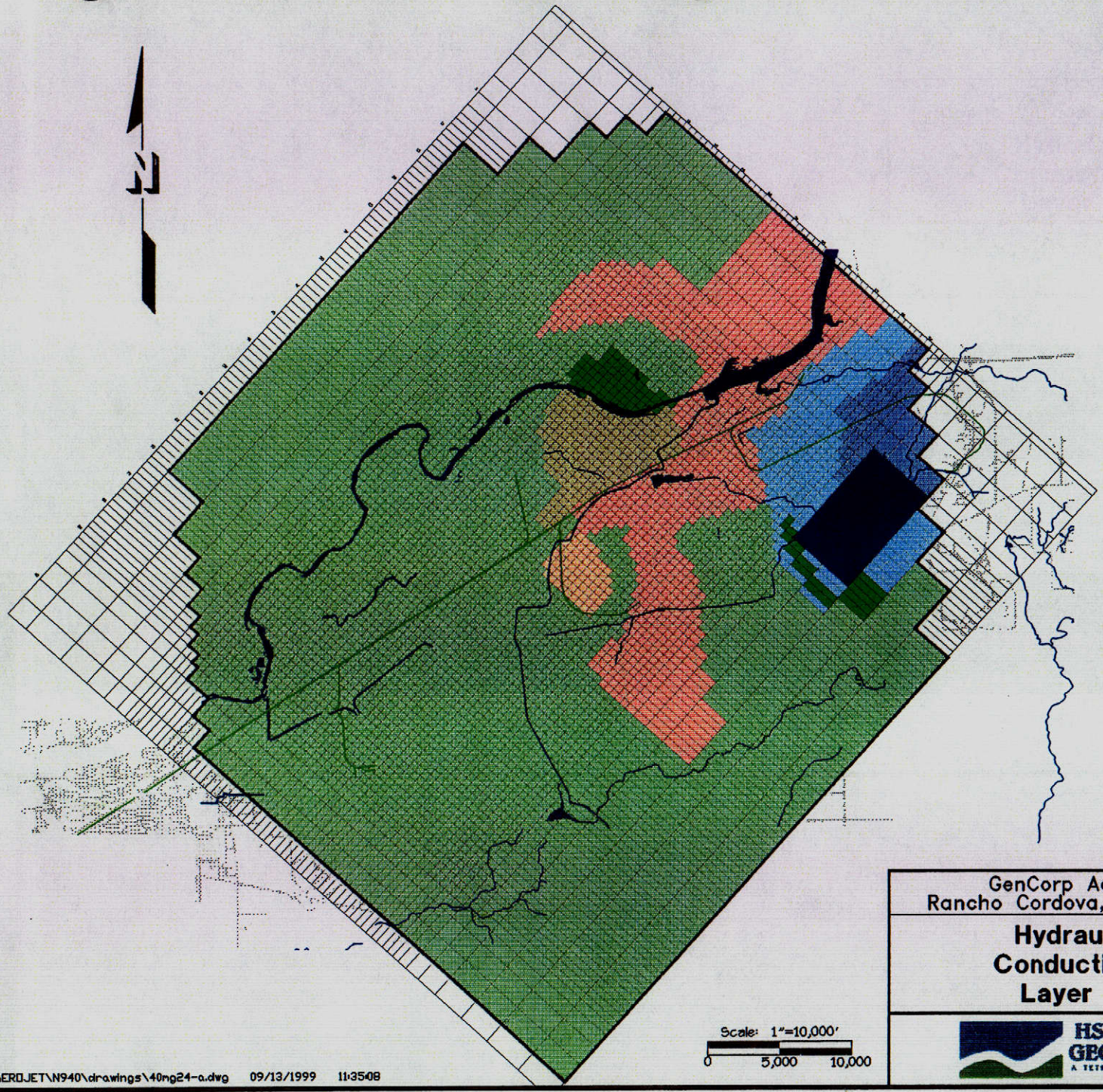
GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 4

HSI GEOTRANS
A TETRA TECH COMPANY

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

Figure D4-4



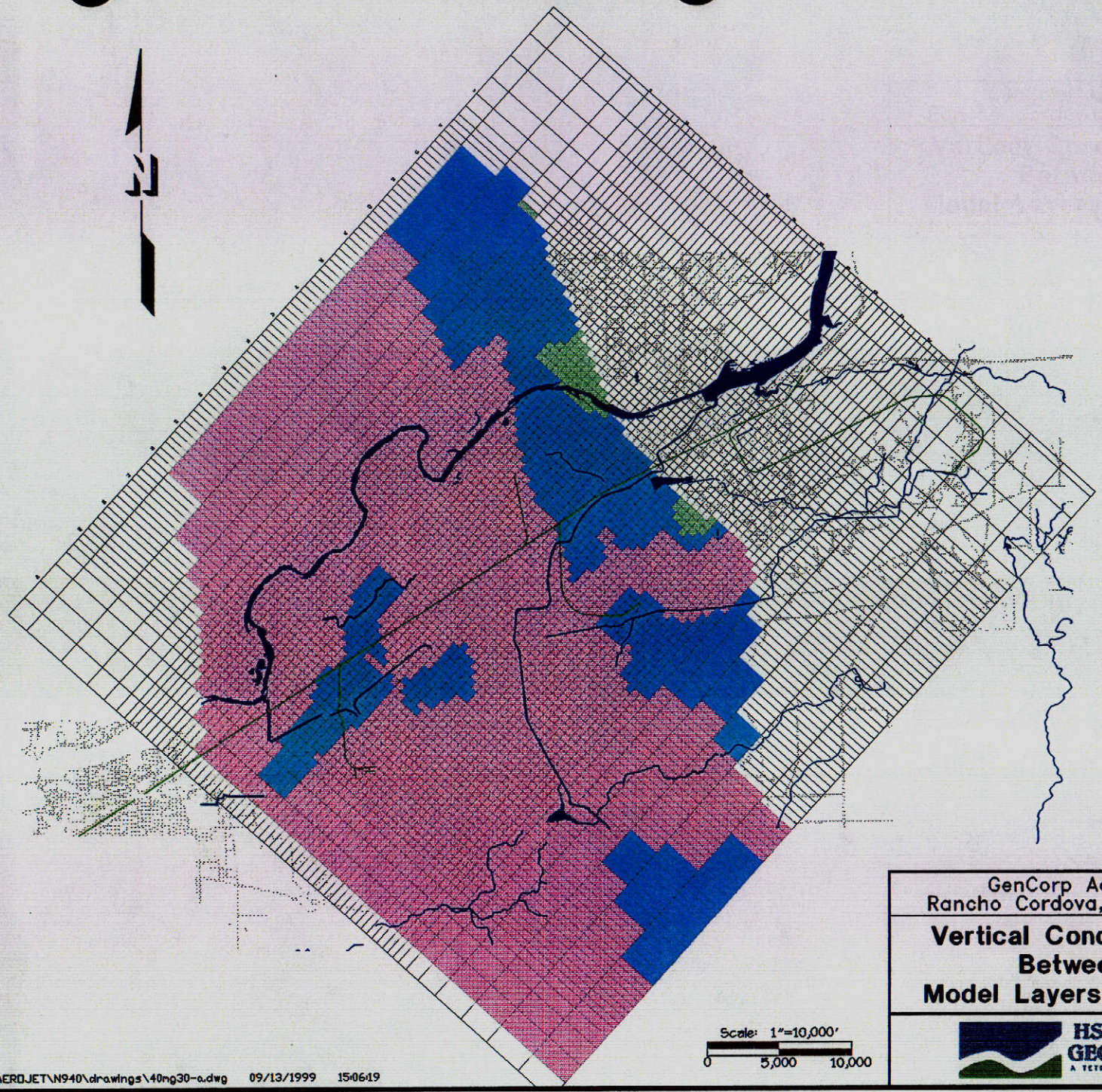
GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 5

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-5



GenCorp Aerojet
Rancho Cordova, California

Vertical Conductance Between Model Layers 1 and 2

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-6

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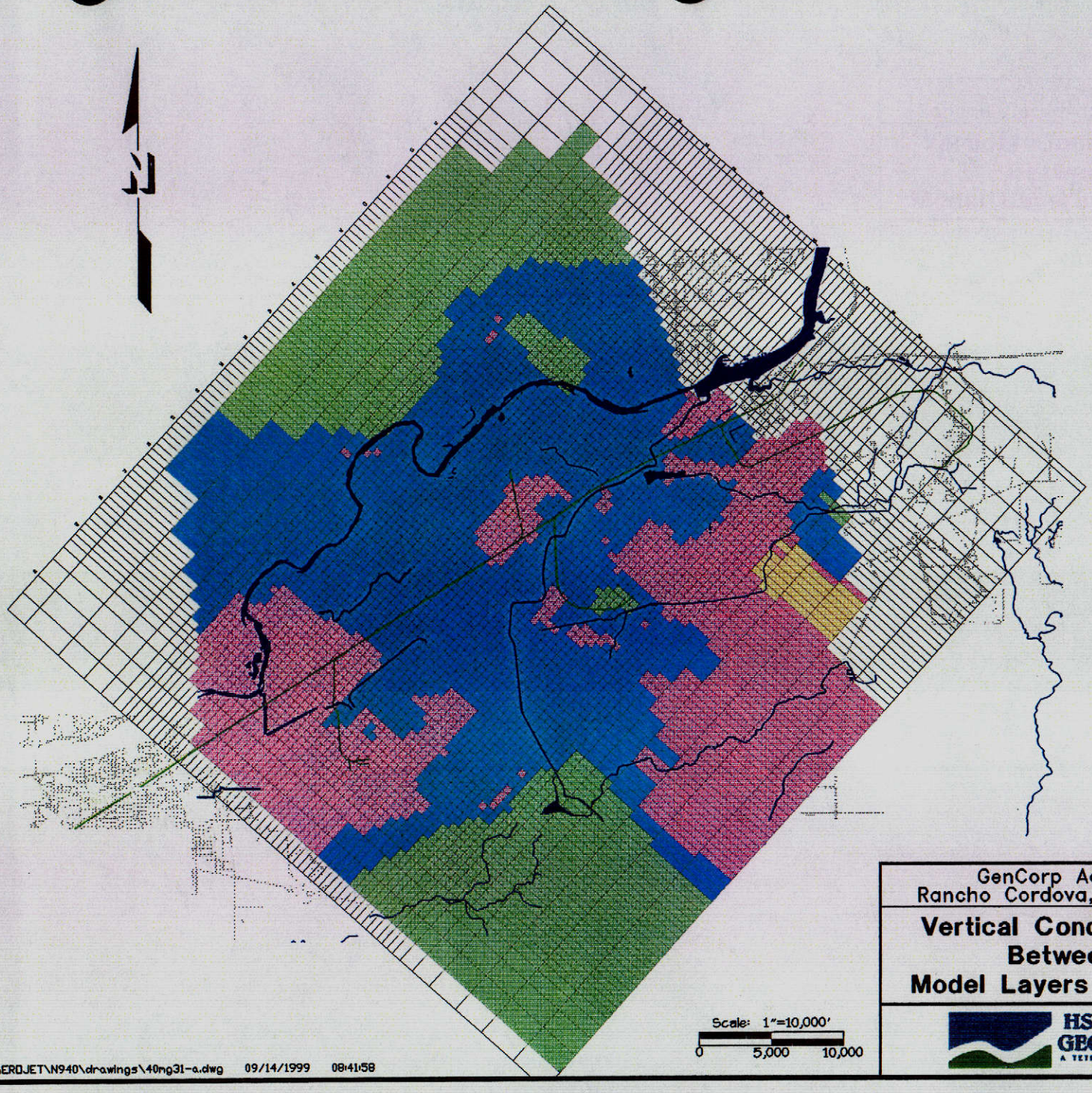

GenCorp Aerojet
Rancho Cordova, California

Vertical Conductance Between Model Layers 2 and 3

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-7

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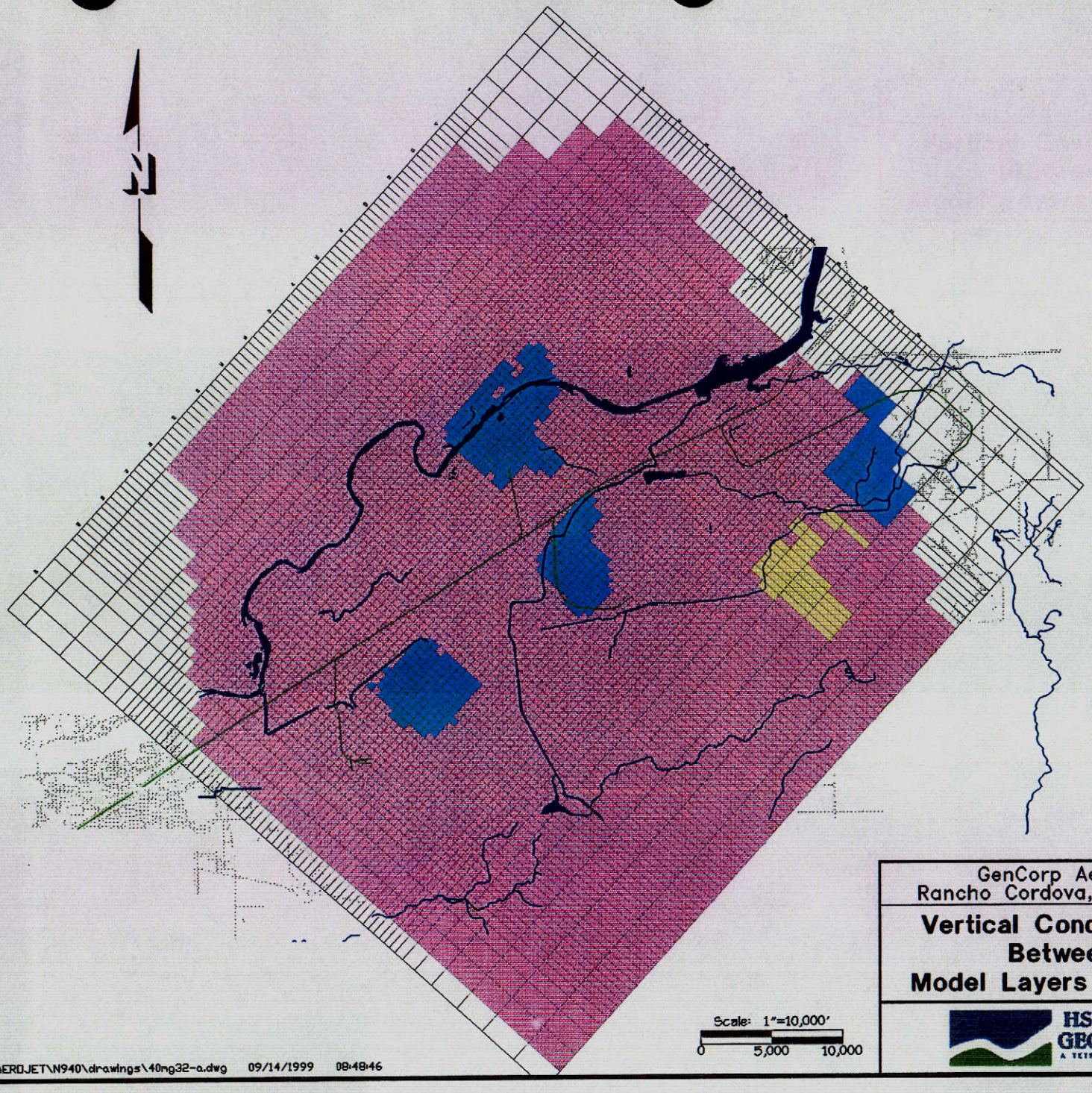


GenCorp Aerojet
Rancho Cordova, California

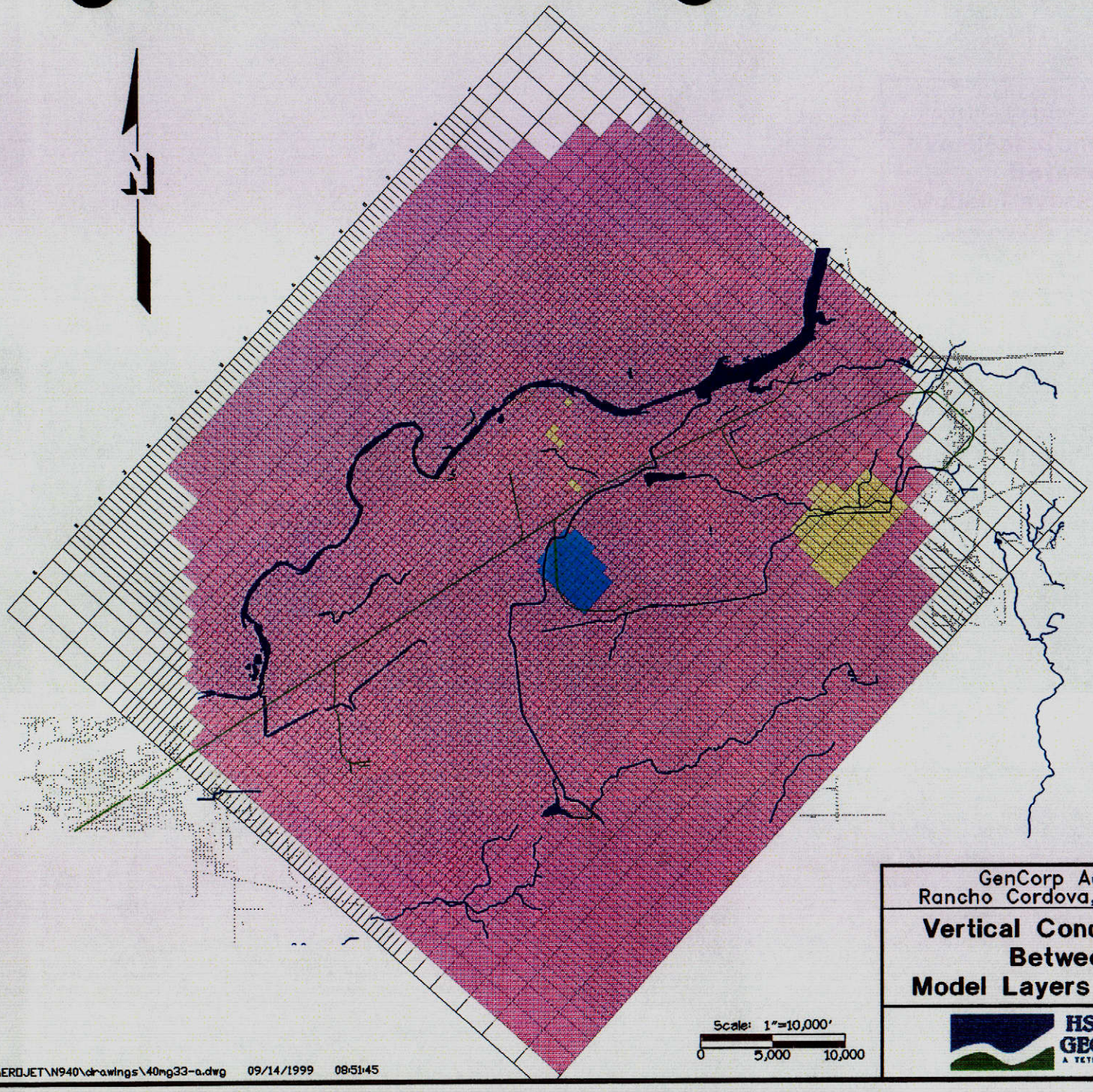
Vertical Conductance Between Model Layers 3 and 4

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-8

D:\AEROJET\N940\drawings\40mg32-a.dwg 09/14/1999 08:48:46



GenCorp Aerojet
Rancho Cordova, California

Vertical Conductance Between Model Layers 4 and 5

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-9

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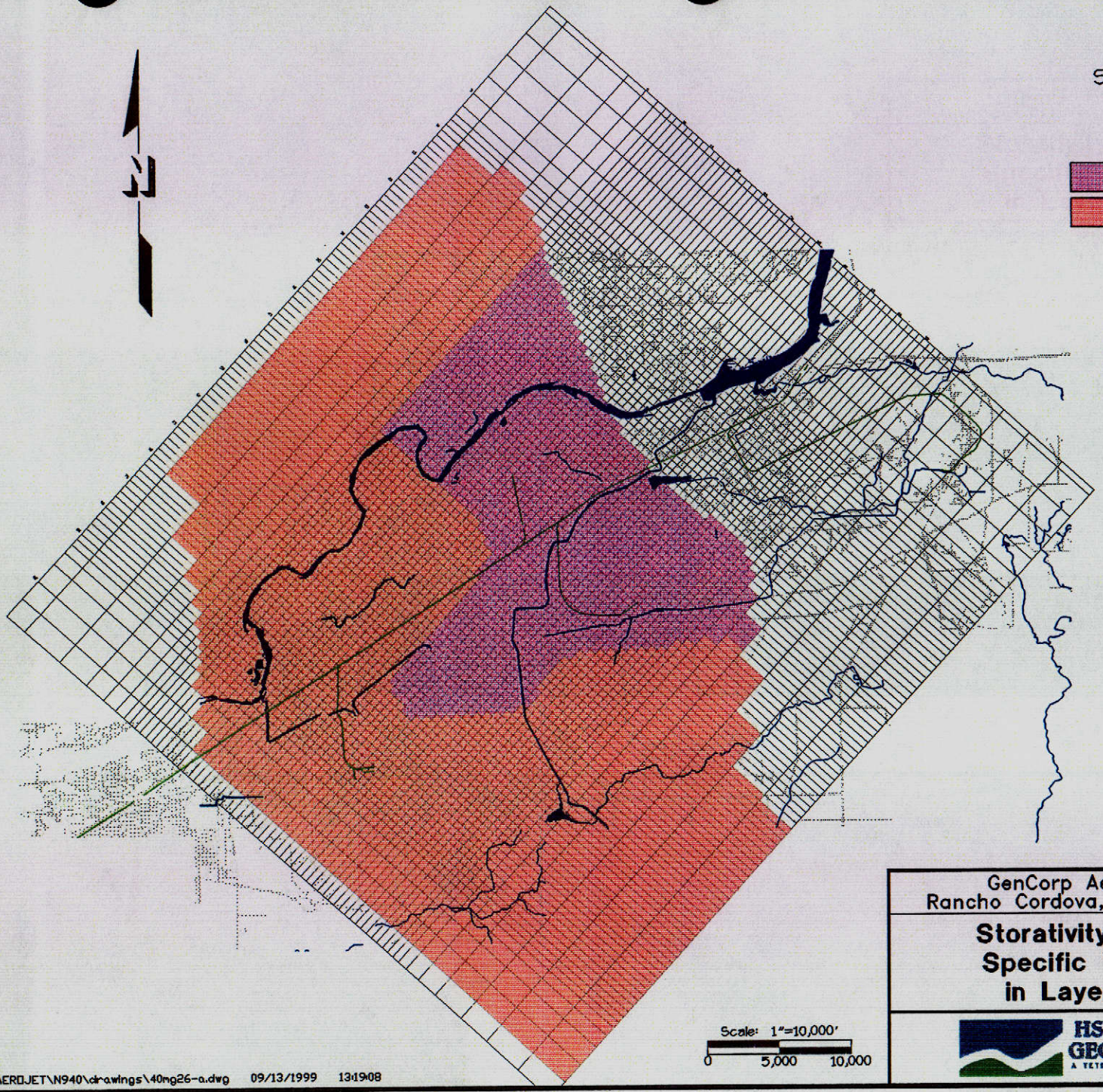

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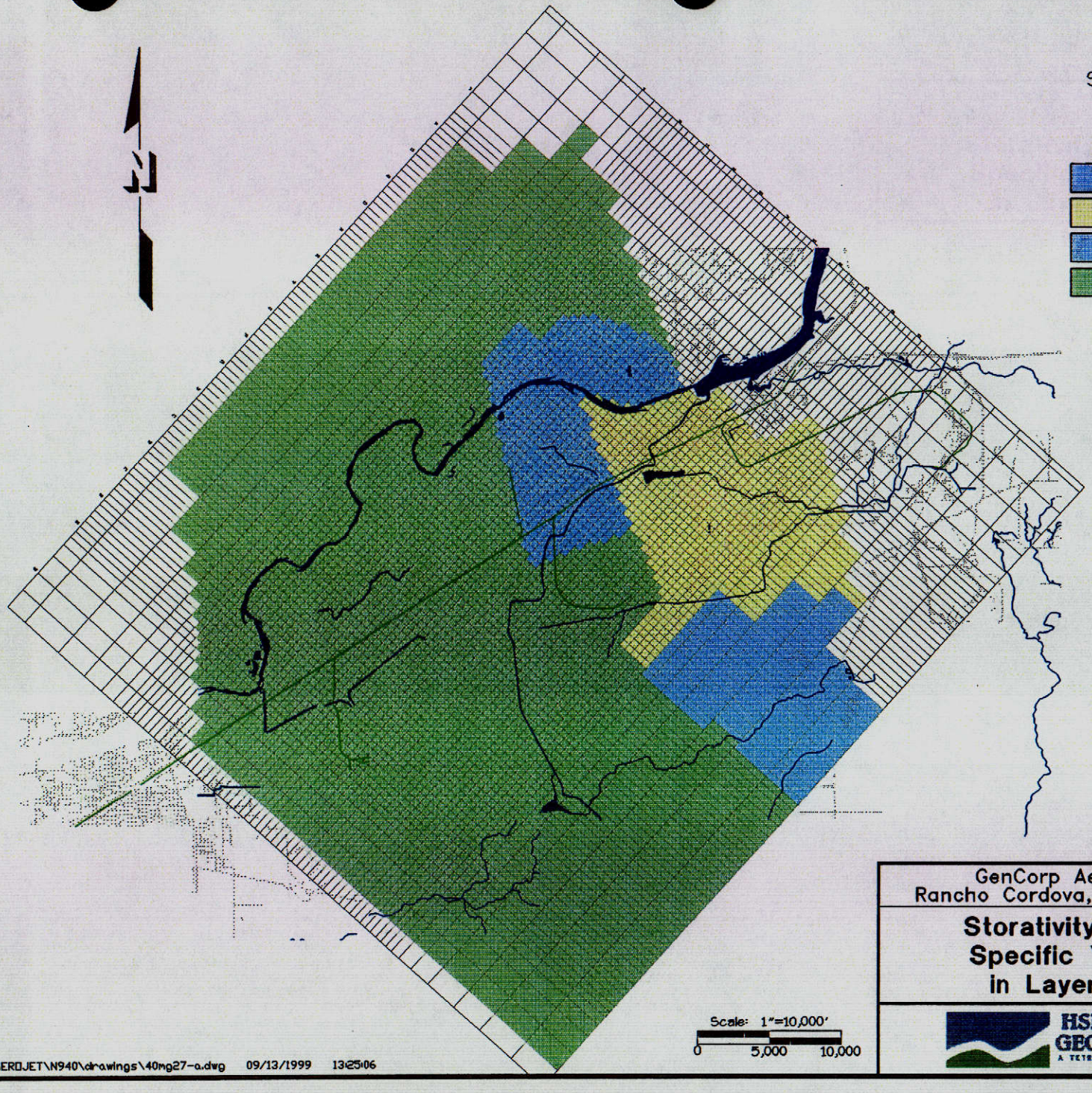
GenCorp Aerojet
Rancho Cordova, California

Storativity and Specific Yield in Layer 1

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-10



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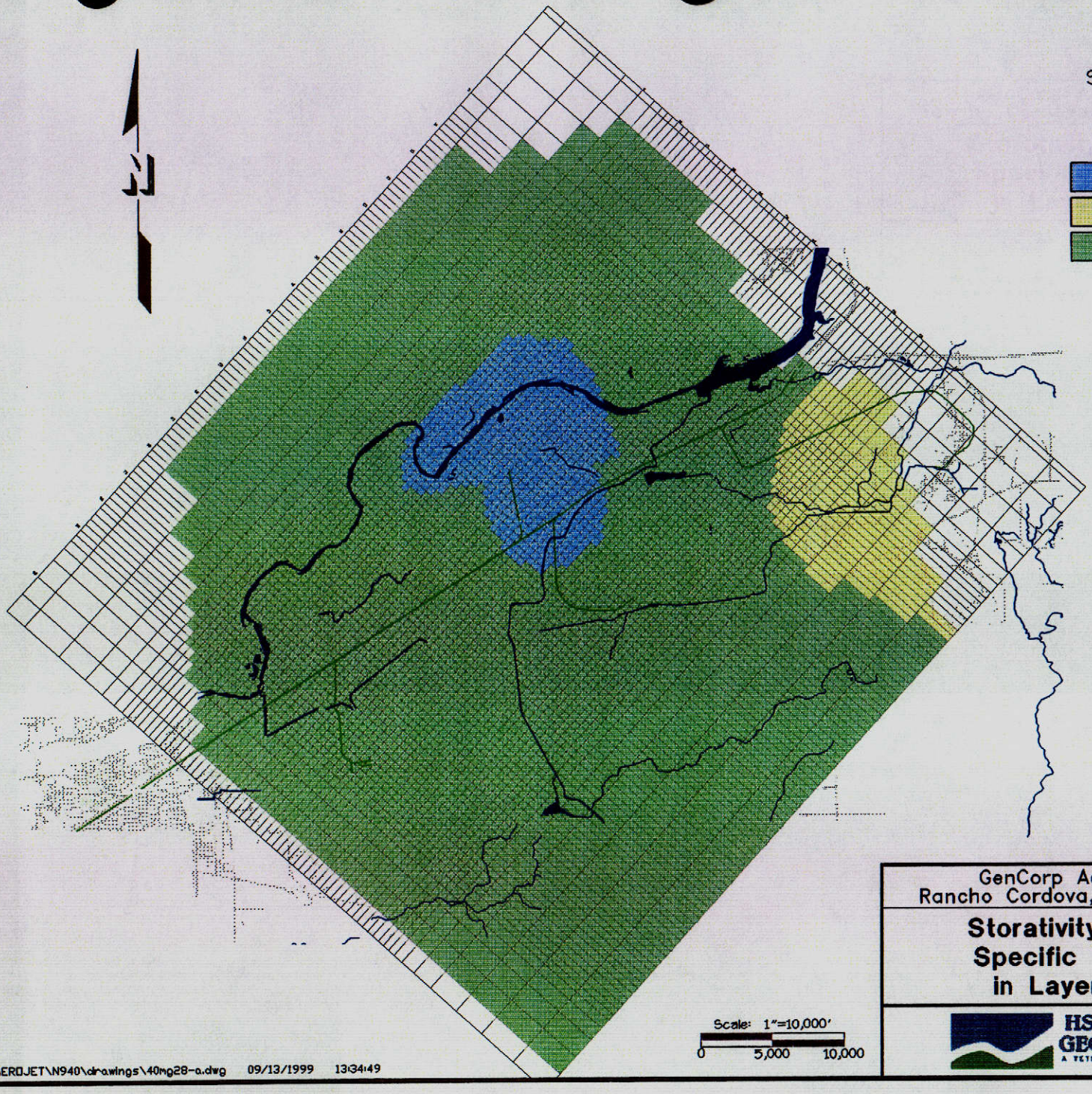
GenCorp Aerojet
Rancho Cordova, California

Storativity and Specific Yield in Layer 2

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-11



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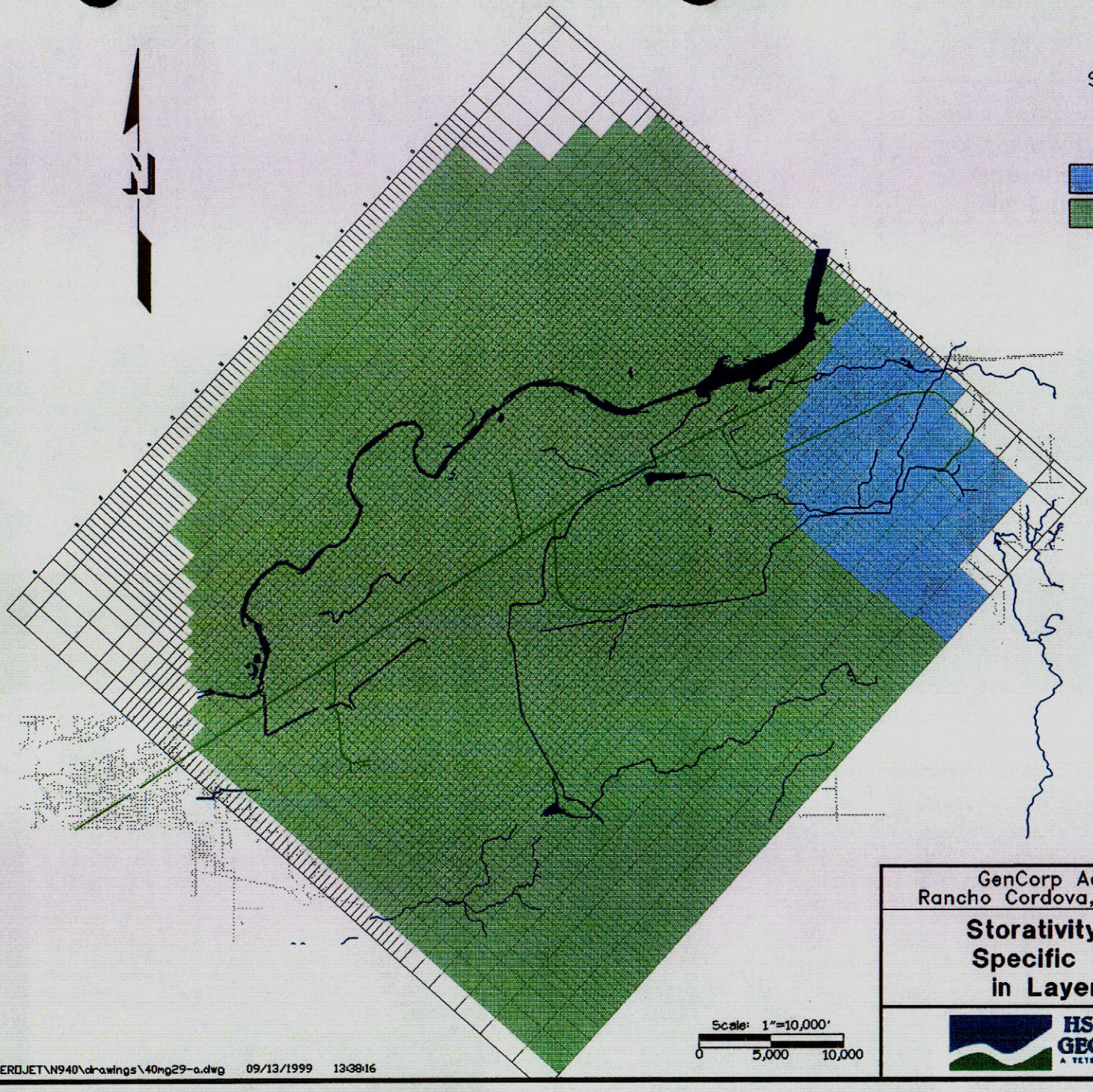
GenCorp Aerojet
Rancho Cordova, California

Storativity and Specific Yield in Layer 3

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-12



GenCorp Aerojet
Rancho Cordova, California

Storativity and Specific Yield in Layer 4

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-13

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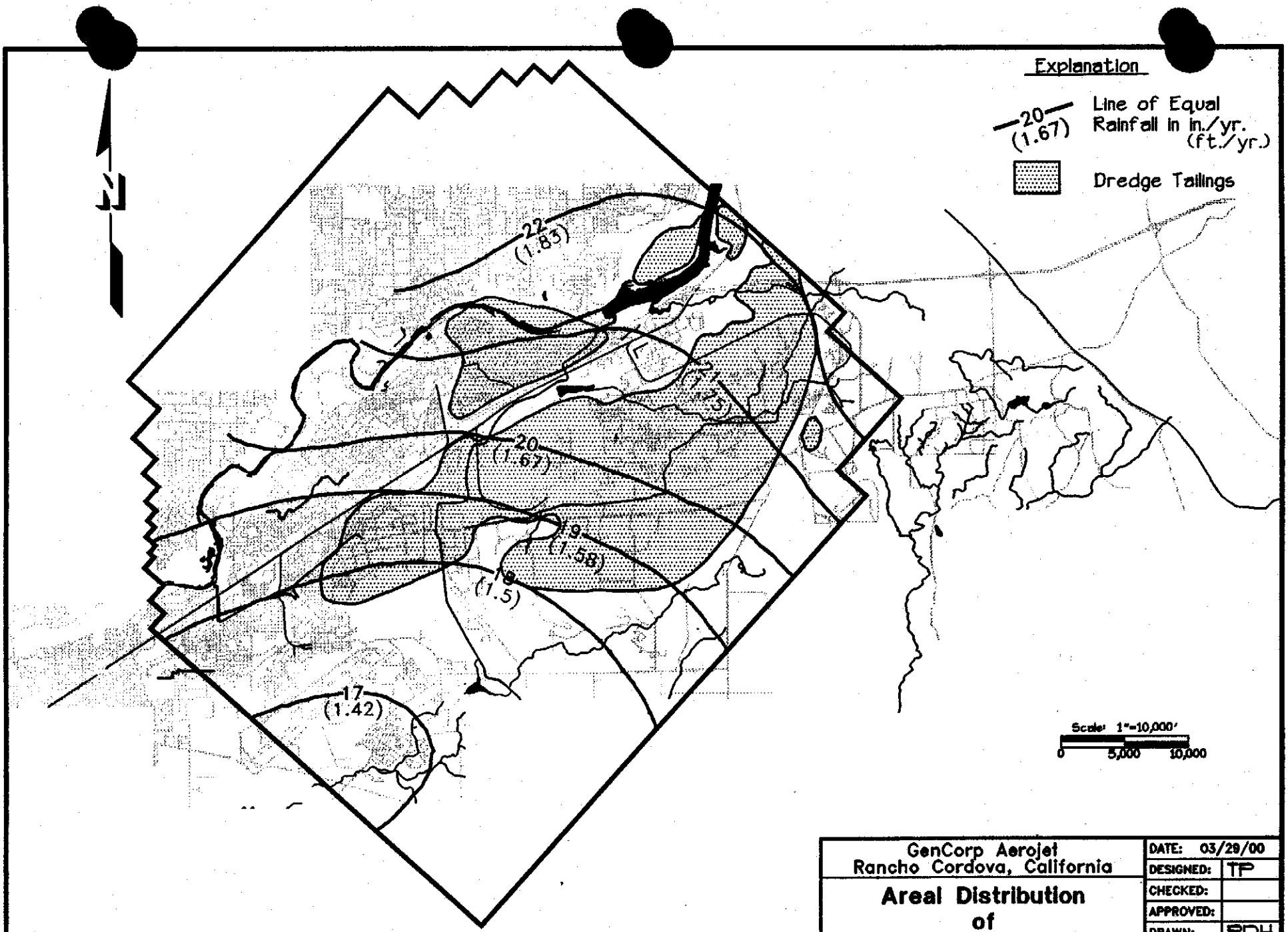

From DWR (1964)

GenCorp Aerojet Rancho Cordova, California	DATE: 03/29/00
	DESIGNED: TP
Areal Distribution of Average Precipitation	CHECKED:
	APPROVED:
	DRAWN: RDH
	PROJ.: N940-104
HSI GEOTRANS A TETRA TECH COMPANY	Figure D5-1

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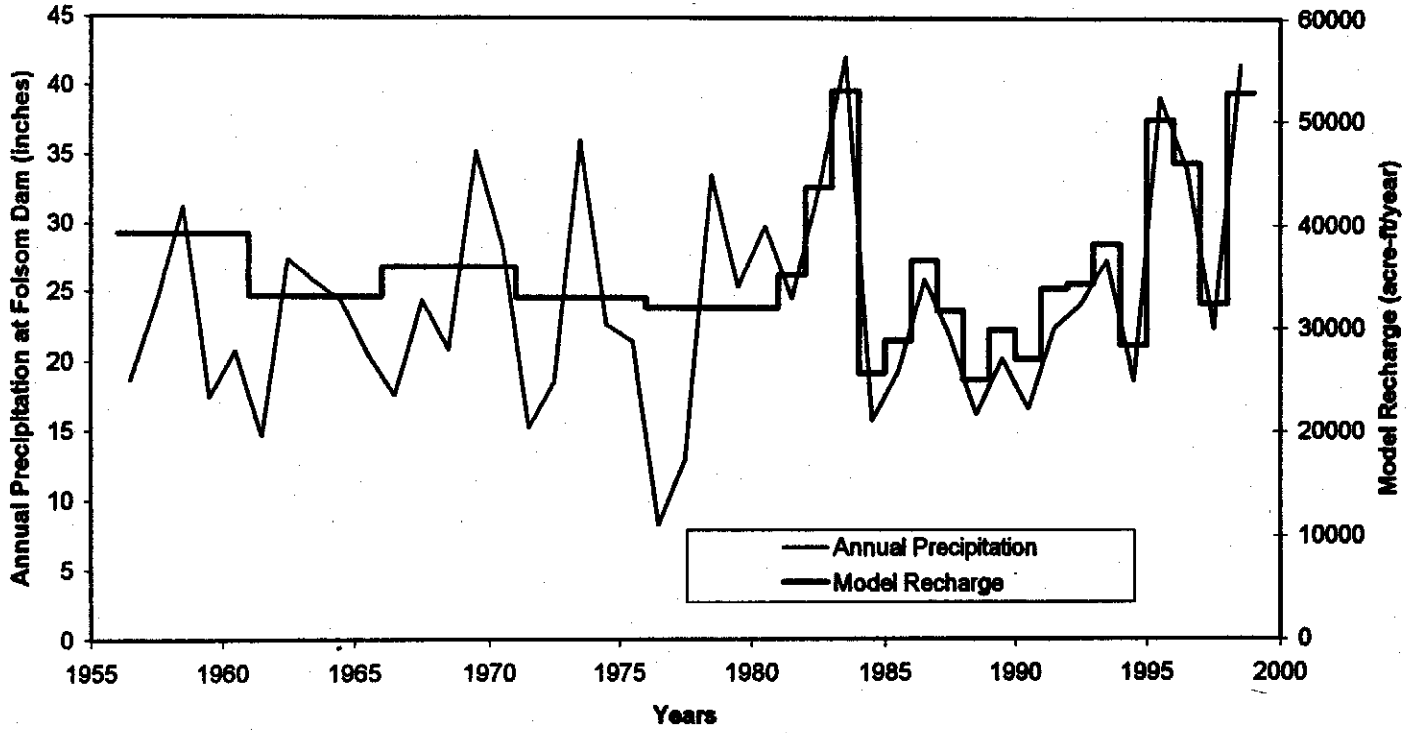


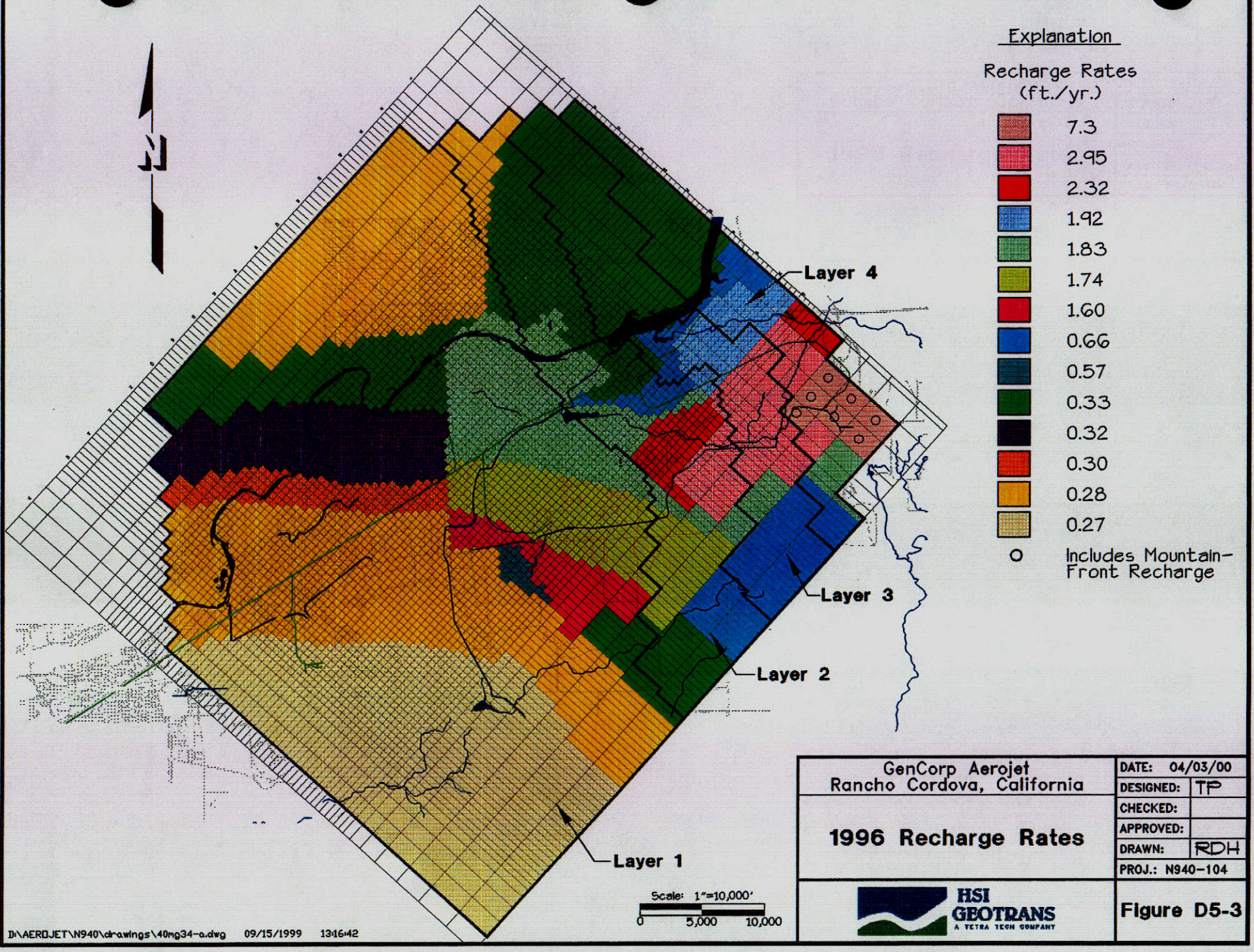
TITLE:	Annual Precipitation and Model Recharge
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

HSI GEOTRANS

CHECKED:	TP
DRAFTED:	TCL
FILE NAME:	ScatterPlot.xls
DATE:	9/8/1999

FIGURE:

Figure D5-2



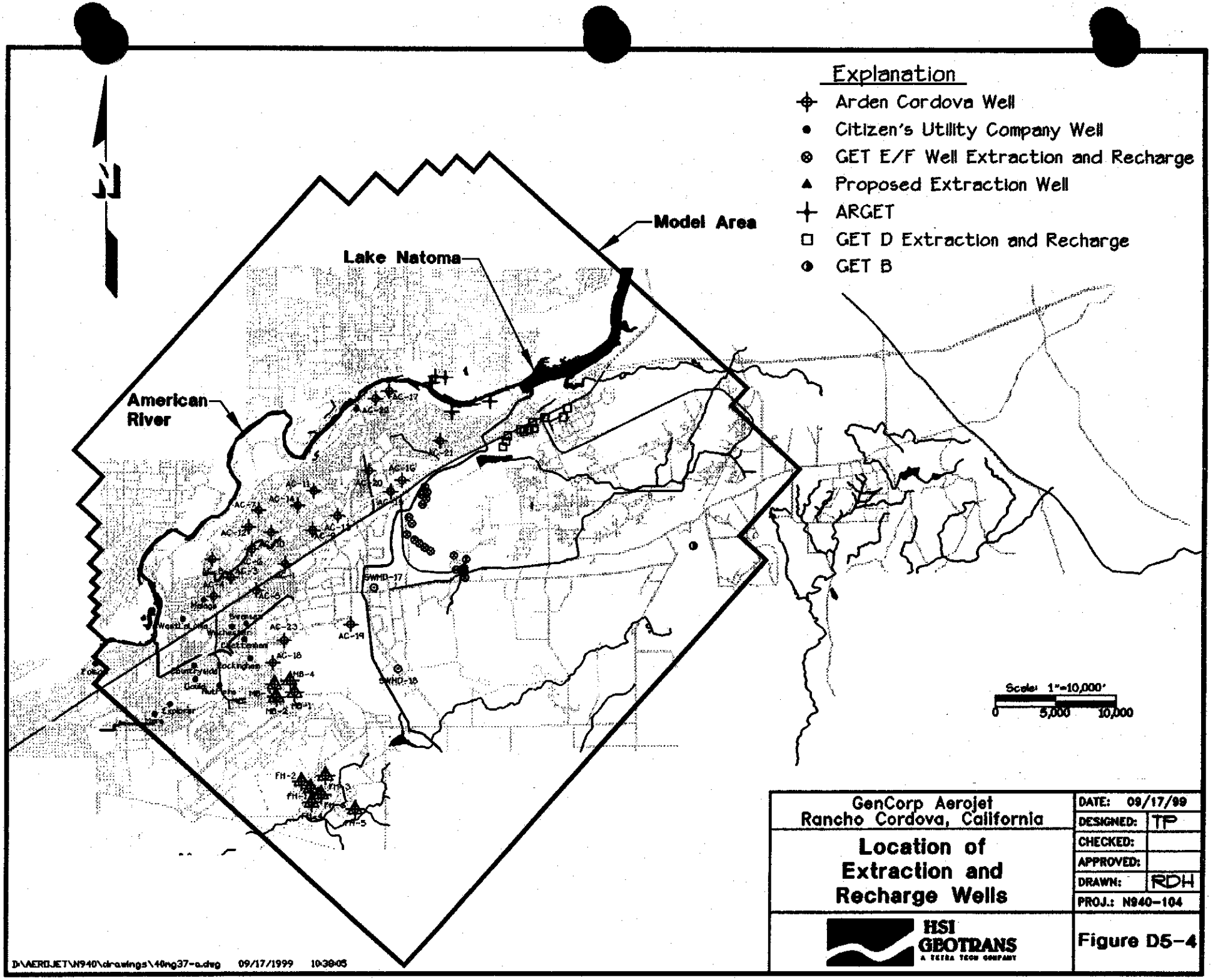
GenCorp Aerojet
Rancho Cordova, California

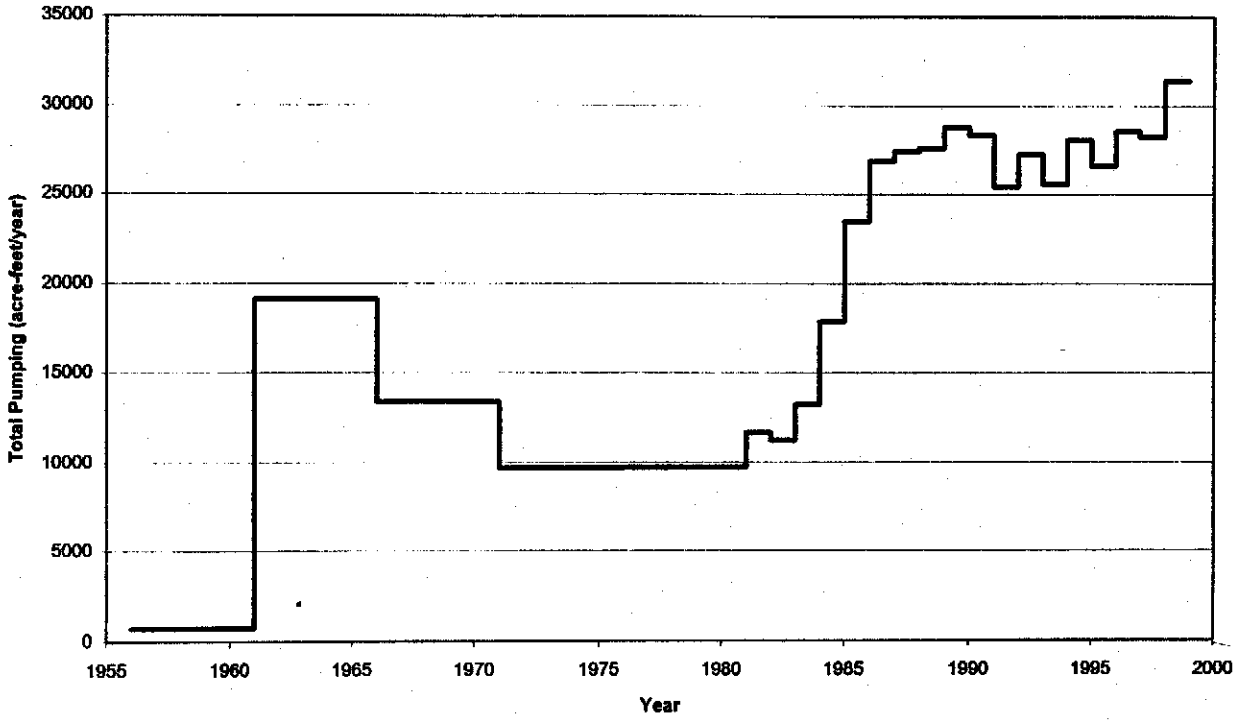
1996 Recharge Rates

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

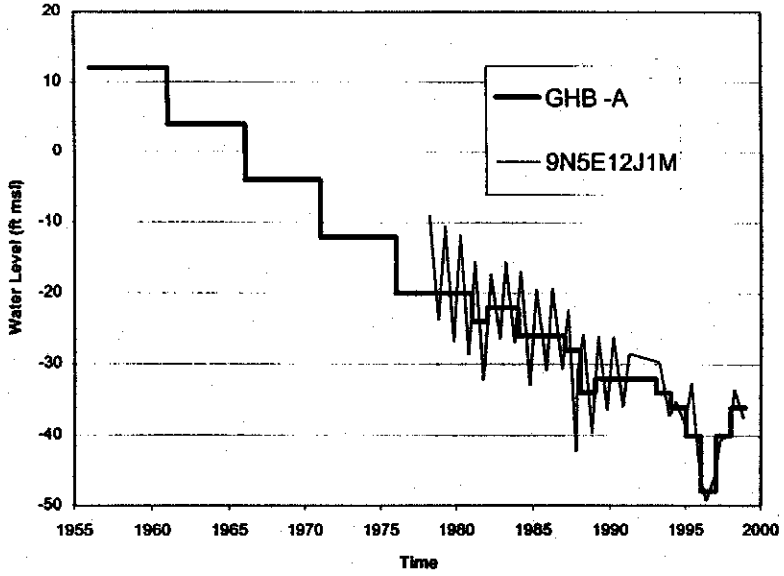
Figure D5-3

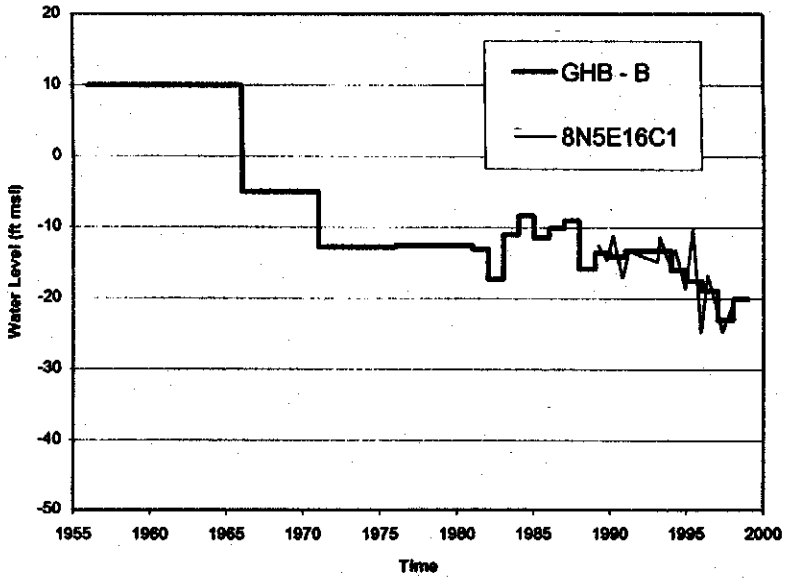

Explanation
Arden Cordova Well
Citizen's Utility Company Well
GET E/F Well Extraction and Recharge
Proposed Extraction Well
ARGET
GET D Extraction and Recharge
GET B
Model Area
Lake Natoma
American River
N
Scale: 1"=10,000'
0
5,000
10,000
GenCorp Aerojet
Rancho Cordova, California
Location of Extraction and Recharge Wells
DATE: 09/17/99
DESIGNED: TP
CHECKED:
APPROVED:
DRAWN: RDH
PROJ.: N940-104
HSI GEOTRANS
A TETRA TECH COMPANY
Figure D5-4
D:\AEROJET\N940\drawings\40ng37-a.dwg 09/17/1999 10:38:05

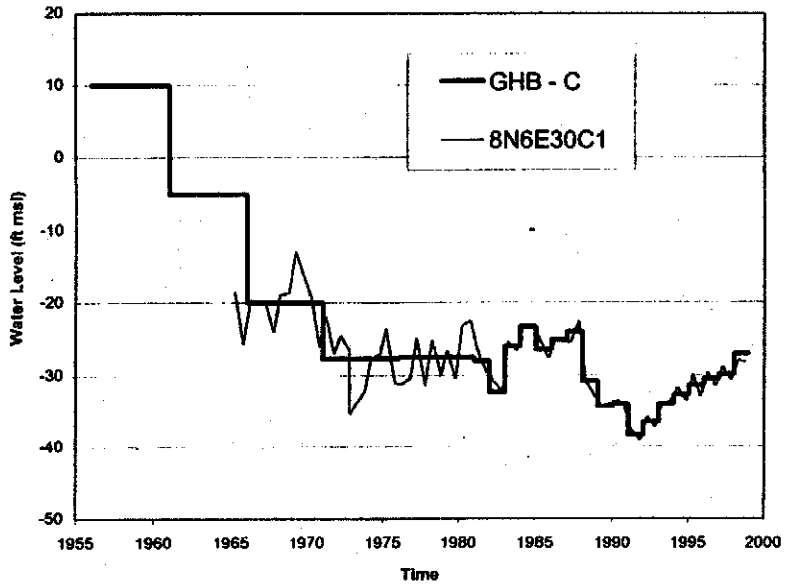


TITLE:	Total Groundwater Extractions
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS	CHECKED: IP
	DRAFTED: ICL
	FILE NAME: ScatterPlots.xls
	DATE: 9/8/1999
	FIGURE:

Figure D5-5

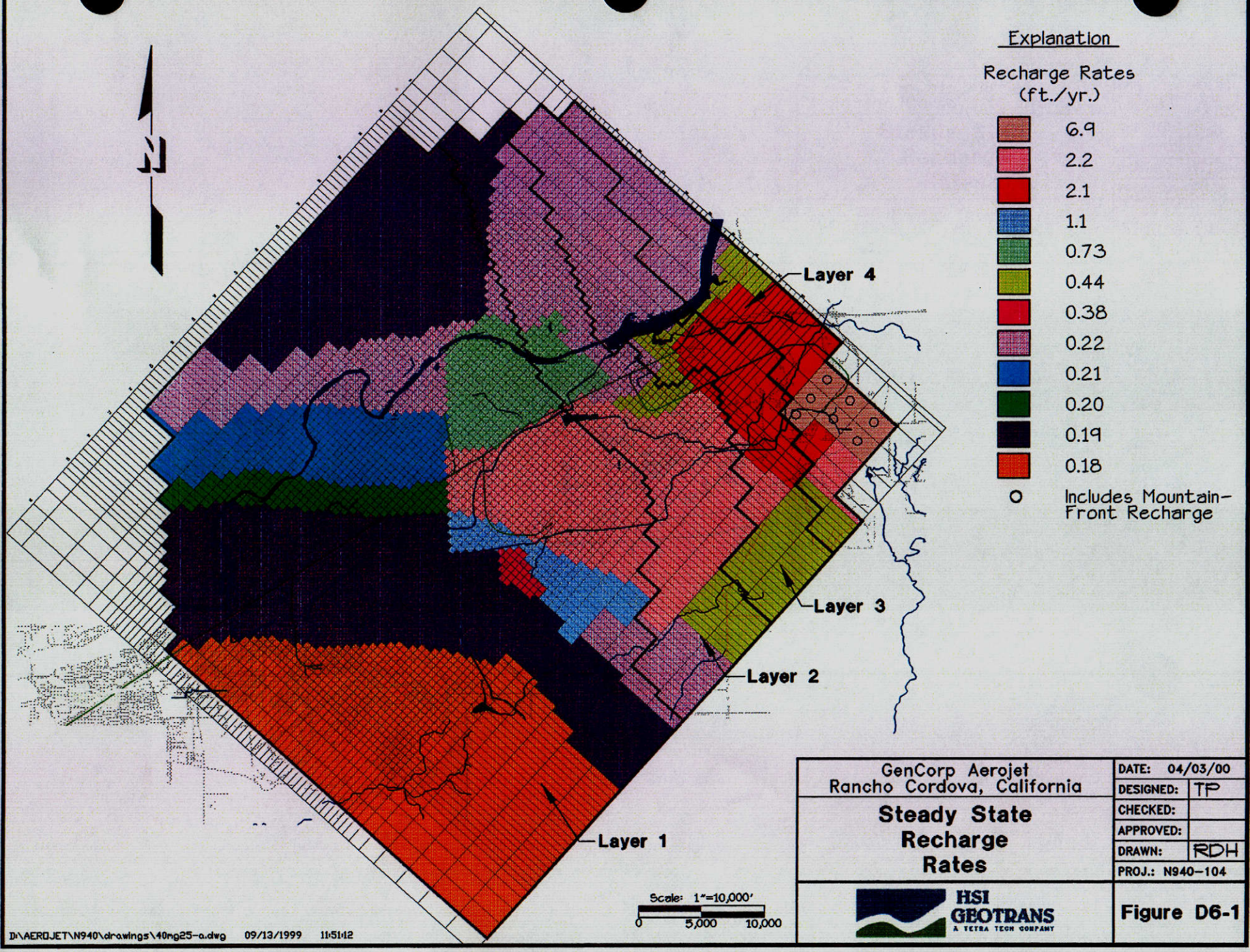






TITLE:	General Head Boundary Time Series		
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA		
HSI GEOTRANS	CHECKED:	TP	FIGURE:
	DRAFTED:	TCI	
	FILE NAME:	ScatterPlots.xls	
	DATE:	9/8/1999	

Figure D5-6



GenCorp Aerojet
Rancho Cordova, California

Steady State Recharge Rates

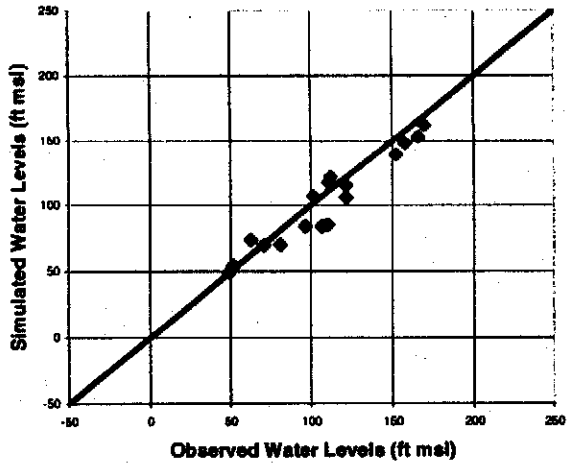
DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

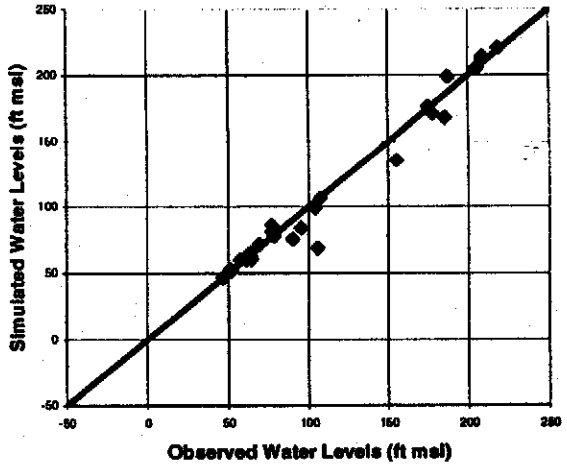
HSI GEOTRANS
A TETRA TECH COMPANY

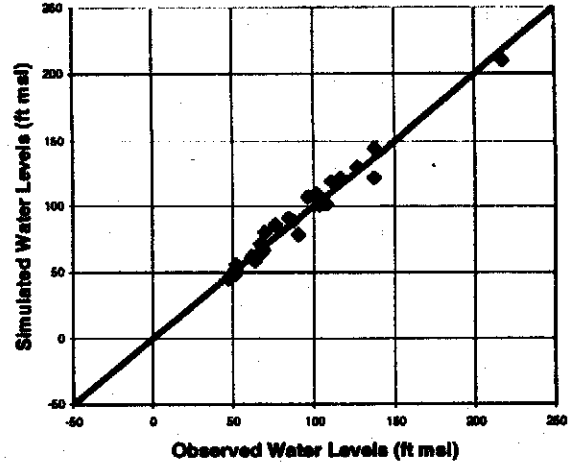
Figure D6-1

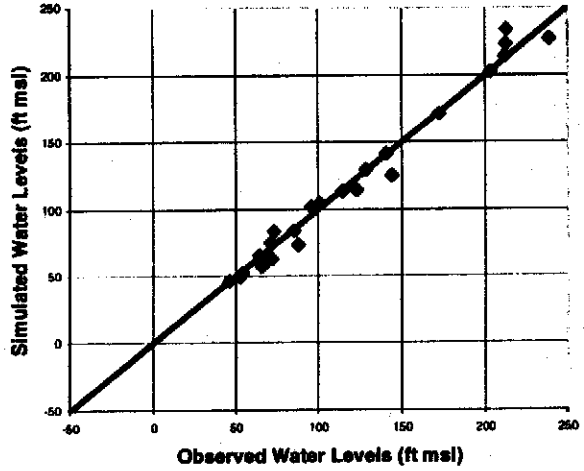
PAGES OF OVERSIZED MAPS

(SEE BINDER)









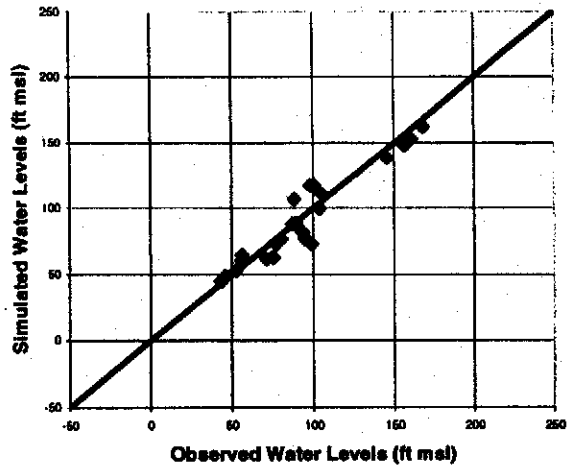
TITLE:	1984 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

HSI GEOTRANS

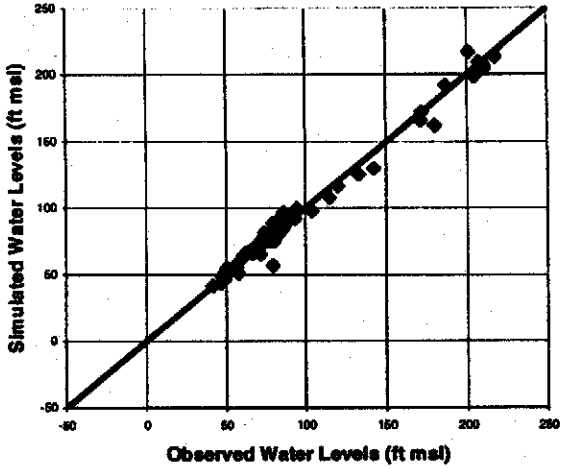
CHECKED:	TP	FIGURE:
DRAFTED:	TCL	
FILE NAME:	Scatter2.xls	
DATE:	10/26/1999	

Figure D8-12

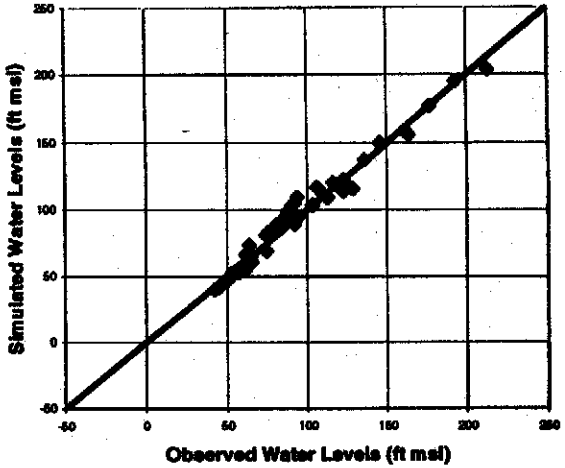
layer AB



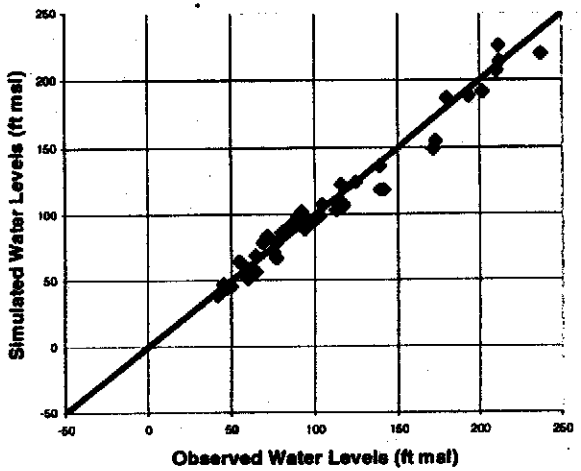
layer C



layer D



layer E



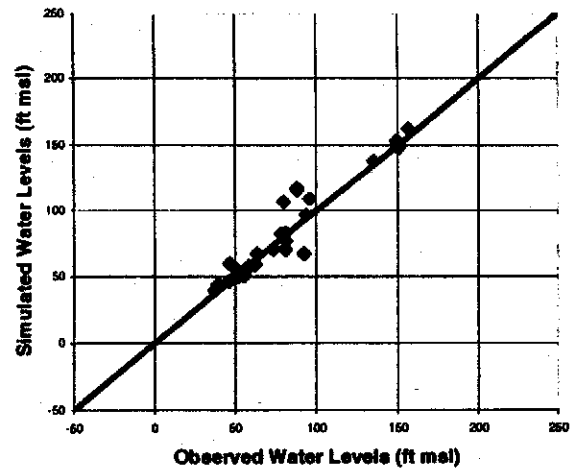
TITLE:	1986 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

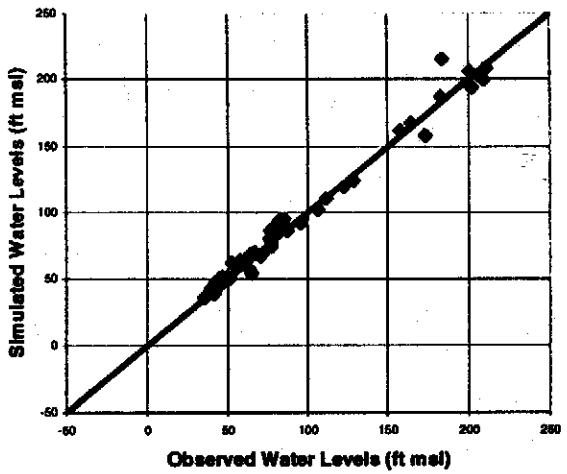
HSI GEOTRANS

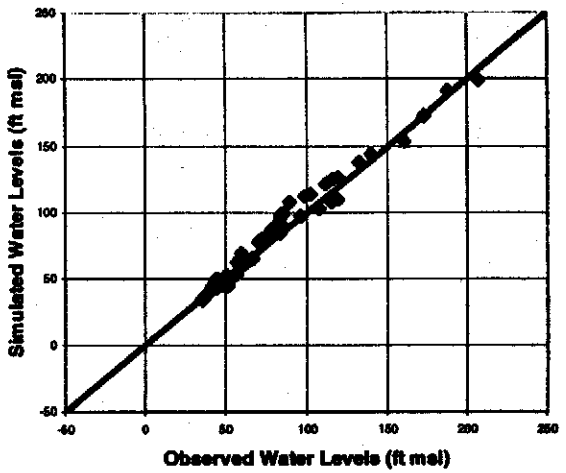
CHECKED:	TP
DRAFTED:	TCL
FILE NAME:	Scatter2.xls
DATE:	10/26/1998

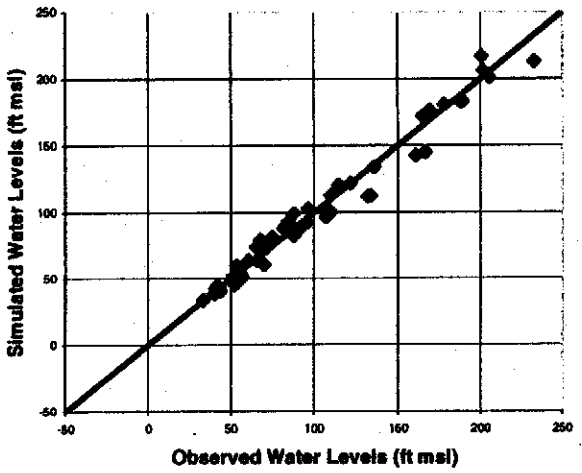
FIGURE:

Figure D6-13







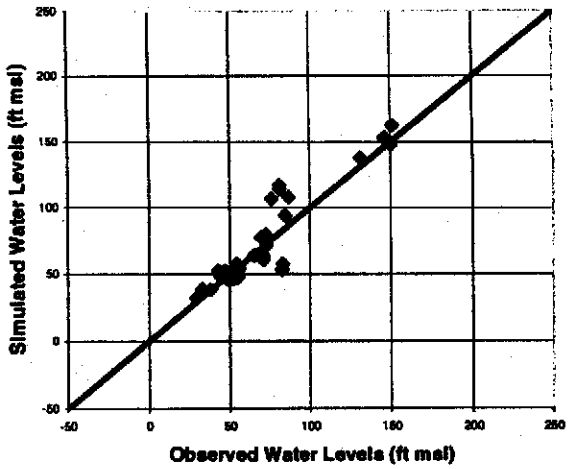


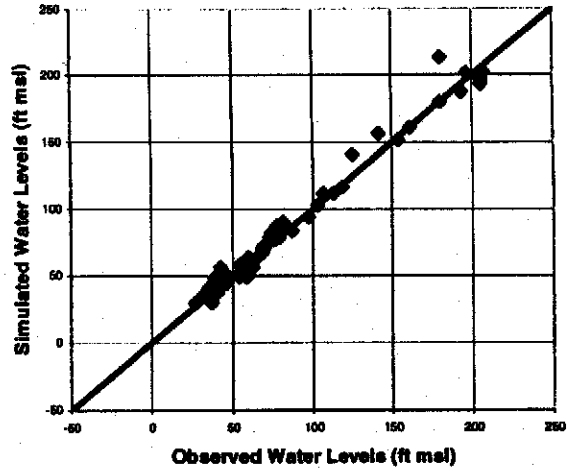
TITLE:	1988 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

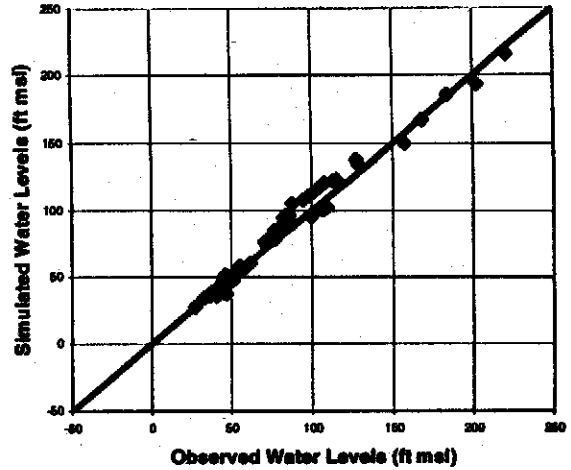
HSI GEOTRANS

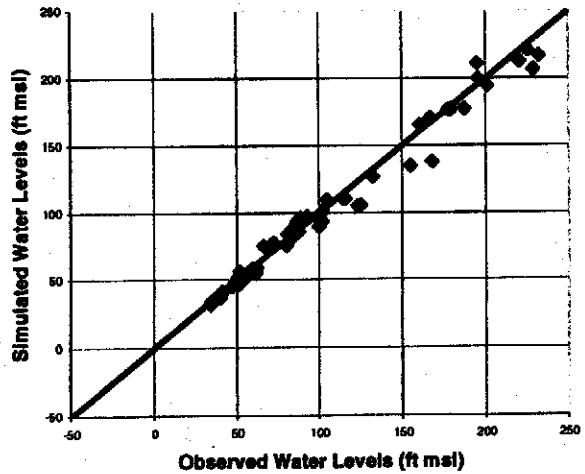
CHECKED:	TP	FIGURE:
DRAFTED:	TCL	
FILE NAME:	Scatter2.xls	
DATE:	10/26/1999	

Figure D6-14









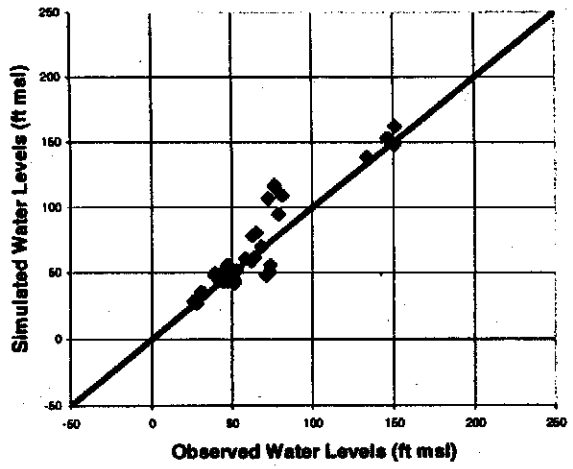
TITLE:	1990 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

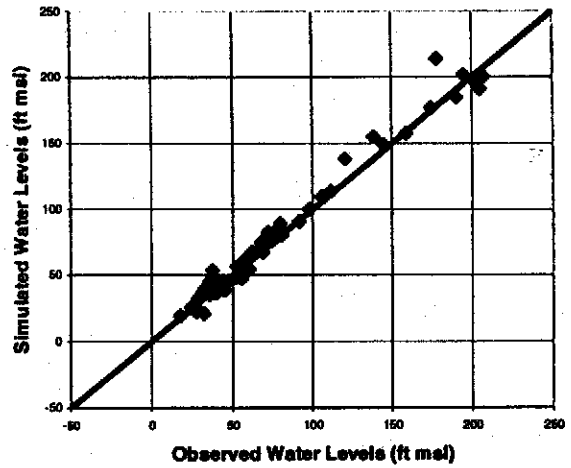
HSI GEOTRANS

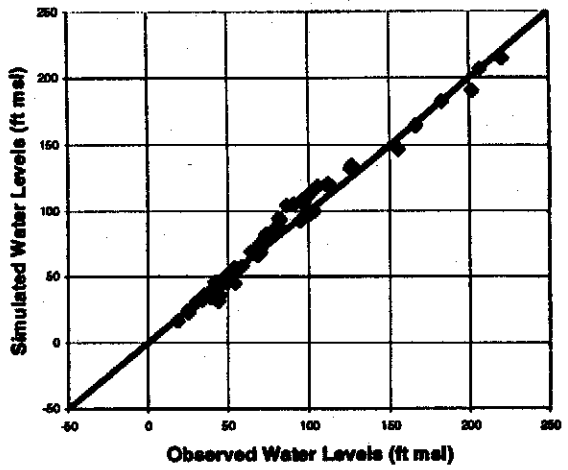
CHECKED:	TP
DRAFTED:	TCL
FILE NAME:	Scatter2.xls
DATE:	10/26/1998

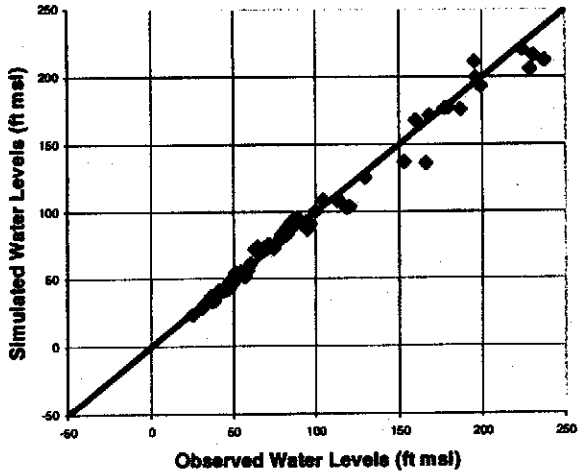
FIGURE:

Figure D6-15









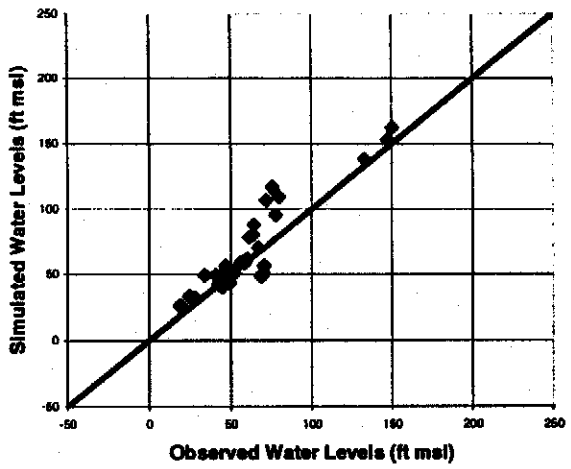
TITLE:	1992 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

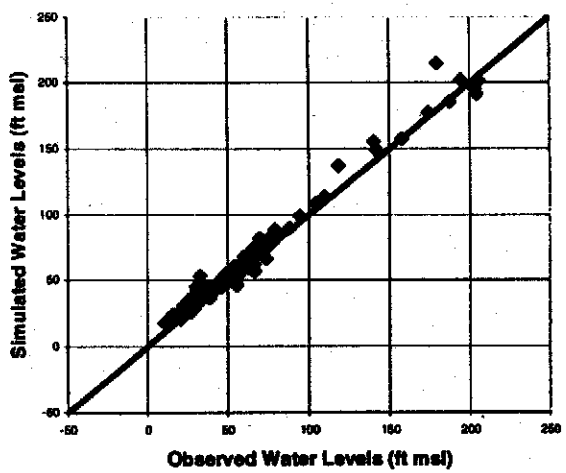
HSI GEOTRANS

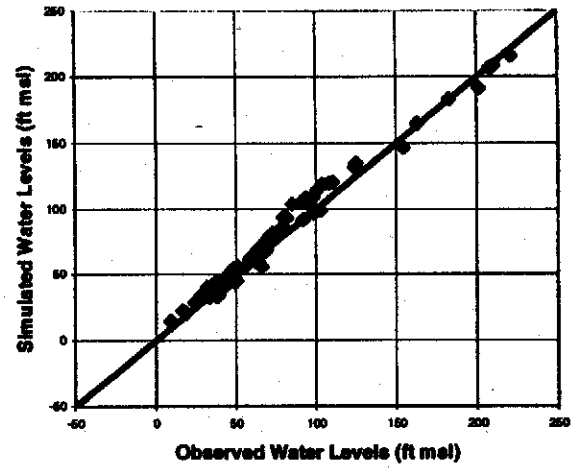
CHECKED:	TP
DRAFTED:	TCL
FILE NAME:	Scatter2.xls
DATE:	10/26/1999

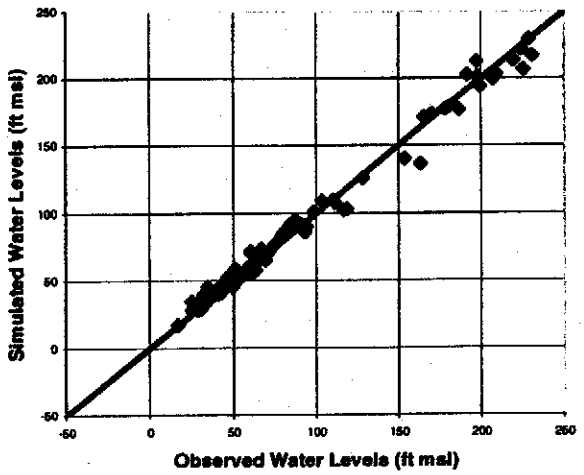
FIGURE:

Figure D6-16









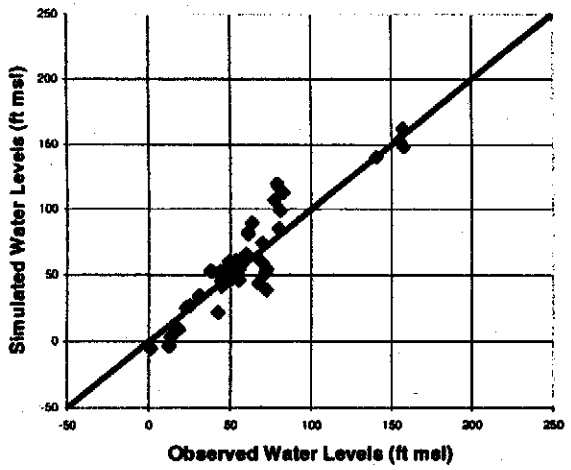
TITLE:	1994 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

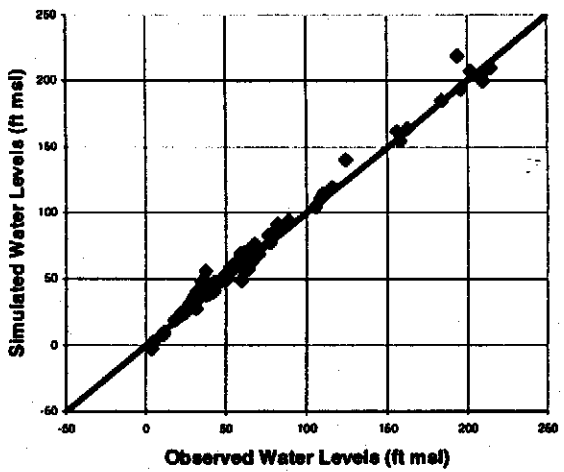
HSI GEOTRANS

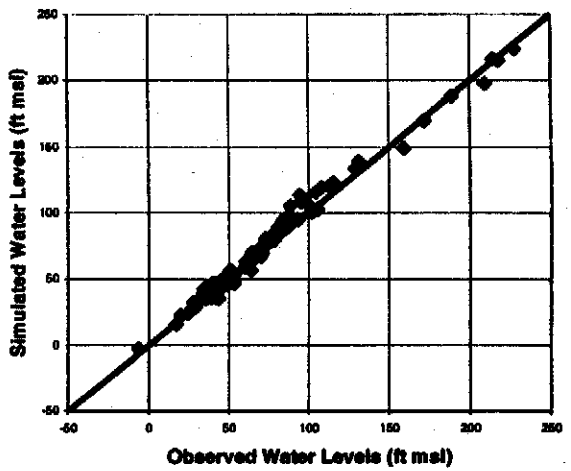
CHECKED:	TP
DRAFTED:	TCL
FILE NAME:	Scatter2.ai
DATE:	10/26/1999

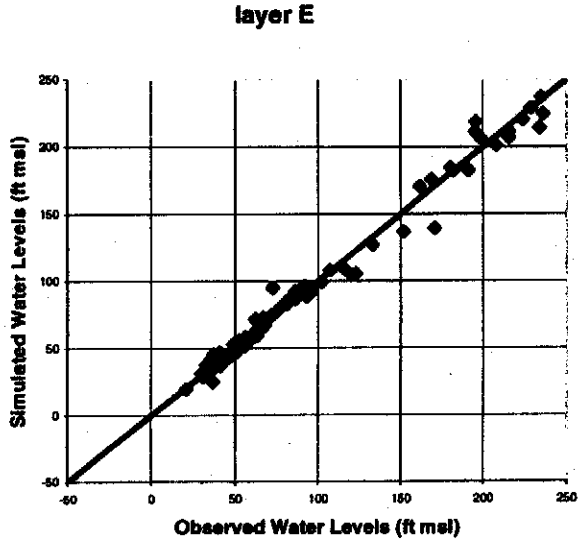
FIGURE:

Figure D8-17









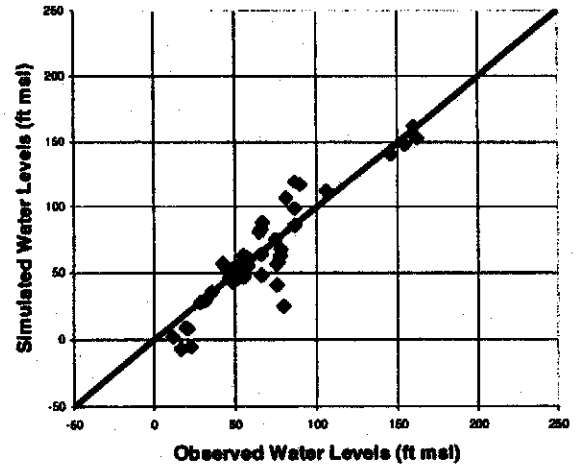
TITLE:	1996 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

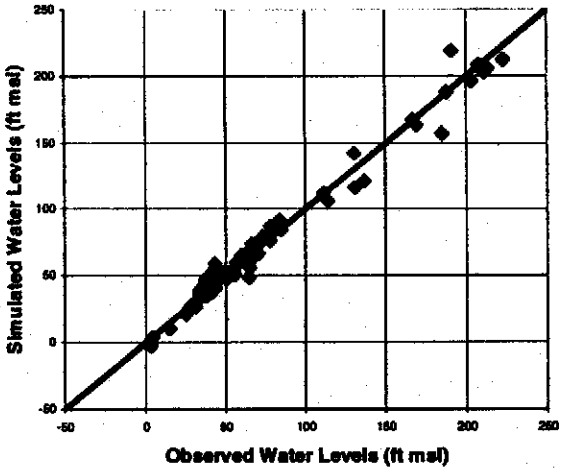
HSI GEOTRANS

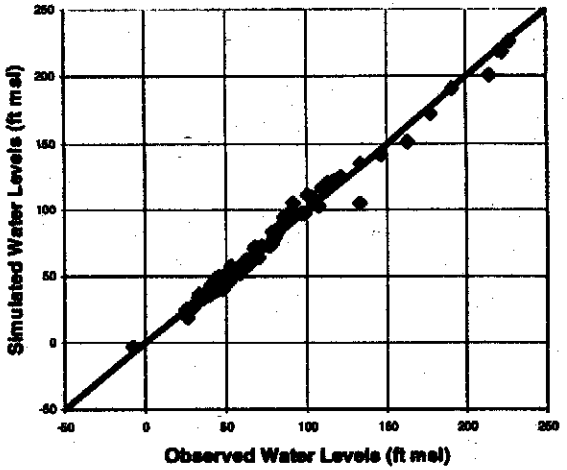
CHECKED:	TP
DRAFTED:	TCL
FILE NAME:	Scatter2.xls
DATE:	10/26/1999

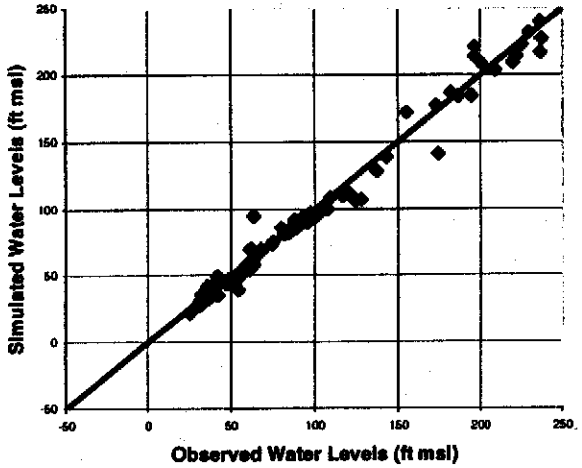
FIGURE:

Figure D6-16









TITLE:	1998 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

HSI GEOTRANS

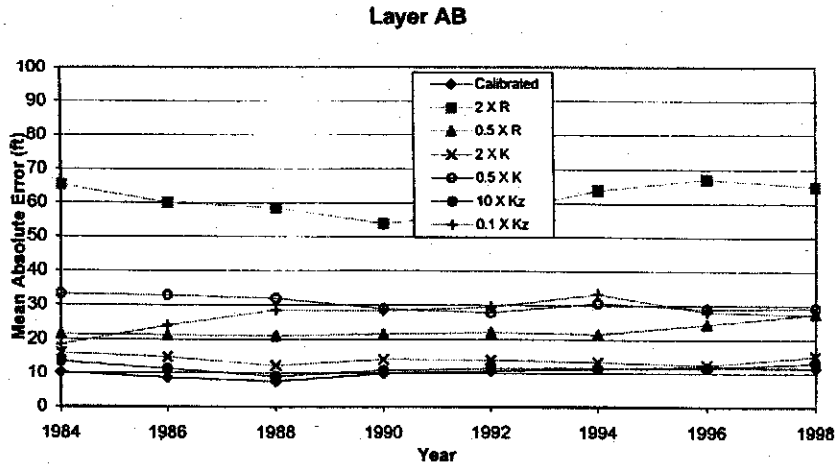
CHECKED:	TP
DRAFTED:	TCL
FILE NAME:	Scatter2.xls
DATE:	10/26/1999

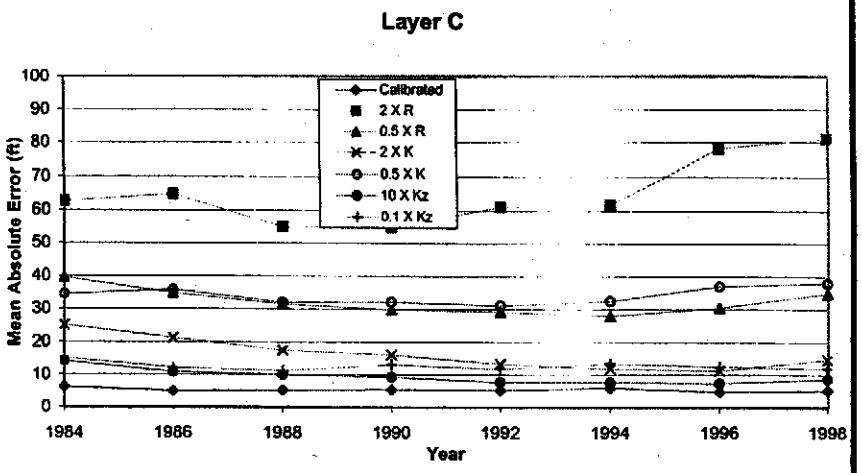
FIGURE:

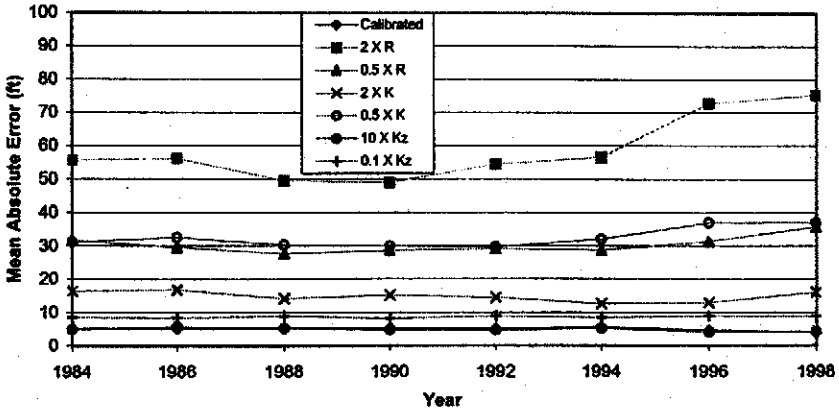
Figure D6-19

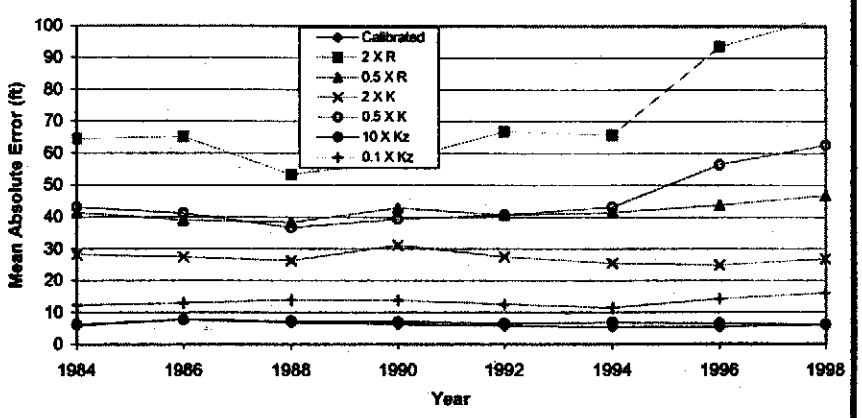
PAGES OF OVERSIZED MAPS

(SEE BINDER)



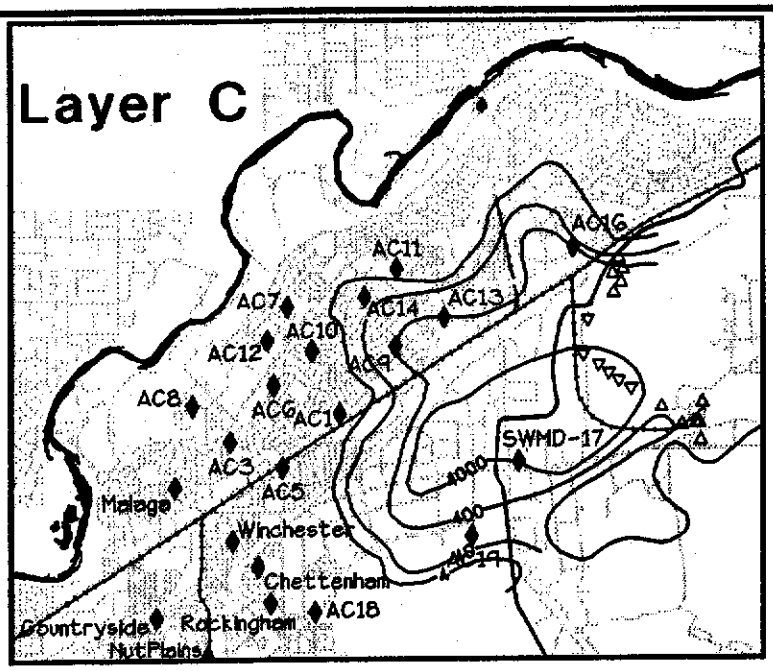


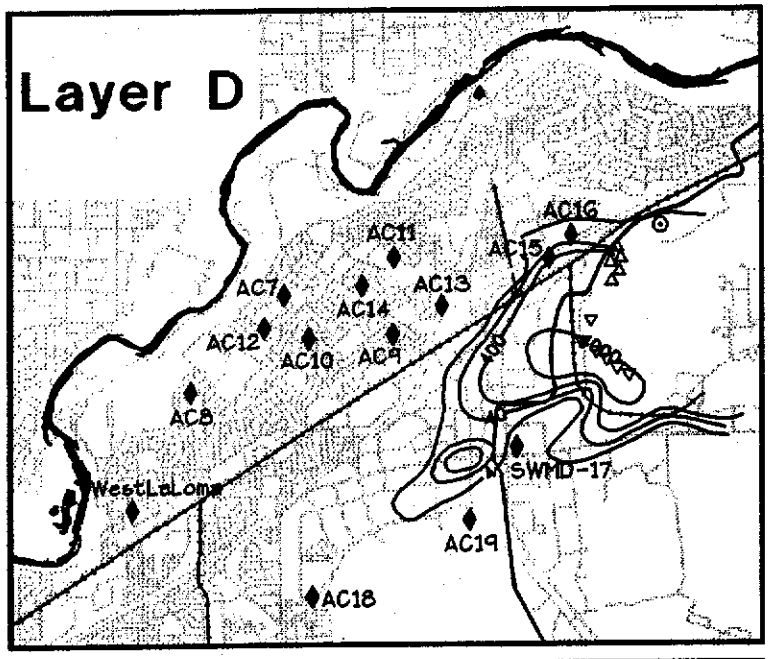


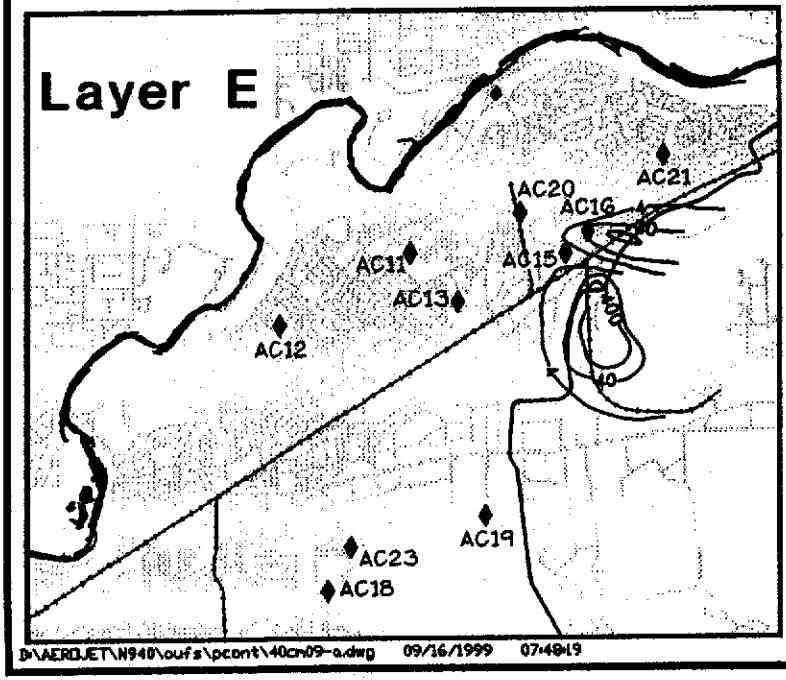


TITLE:	Sensitivity Analysis Results
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS	CHECKED: TP; DRAFTED: TCL; FILE NAME: sensitivity.xls; DATE: 9/8/1999; FIGURE:

Figure D7-1







Explanation

- Water Supply Wells
- GET E/F Extraction Wells
- GET E/F Recharge Wells
- —40— Perchlorate Concentration (µg/l)

N

Scale: 1"=8000'

0 4000' 8000'

D:\AEROJET\N940\oufs\pcont\40cn09-a.dwg 09/16/1999 07:49:19

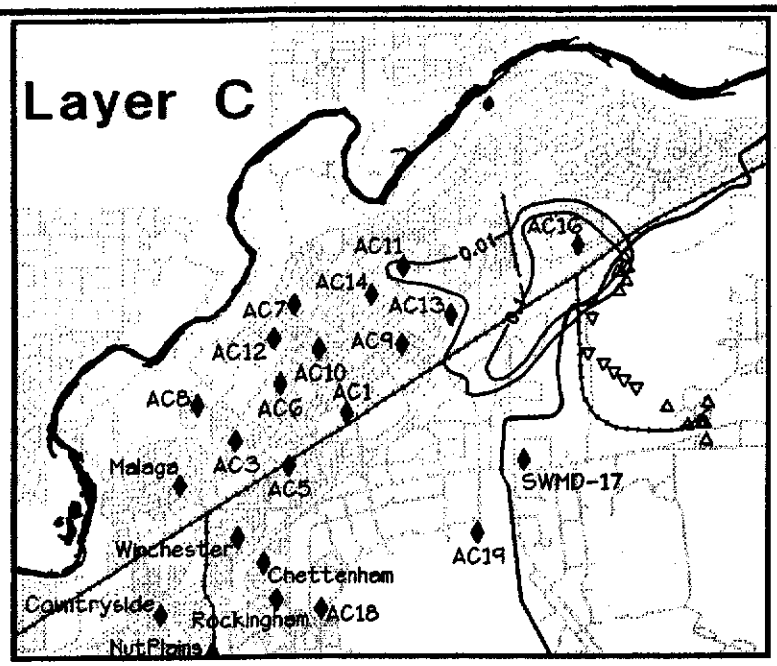
GenCorp Aerojet
Rancho Cordova, California

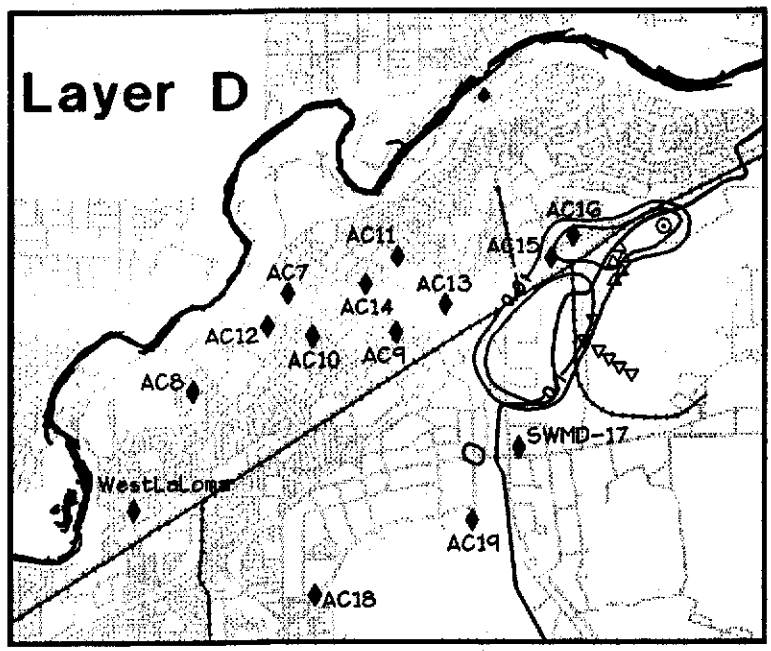
Projected Perchlorate Migration in 2001

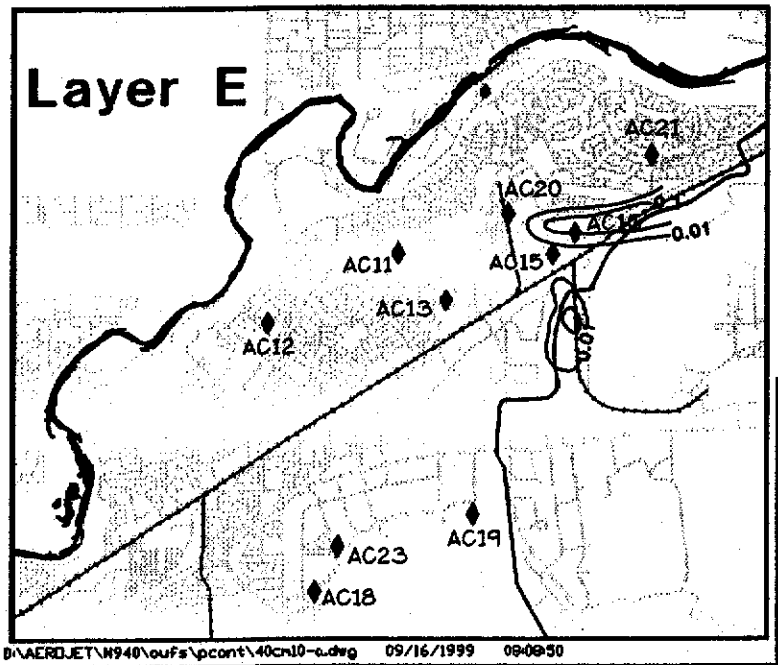
DATE:	04/06/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D8-1

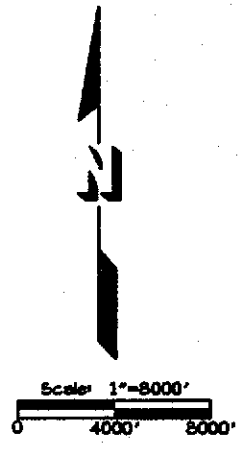






Explanation

- Water Supply Wells
- GET E/F Extraction Wells
- GET E/F Recharge Wells
- —0.1— NDMA Concentration (µg/l)



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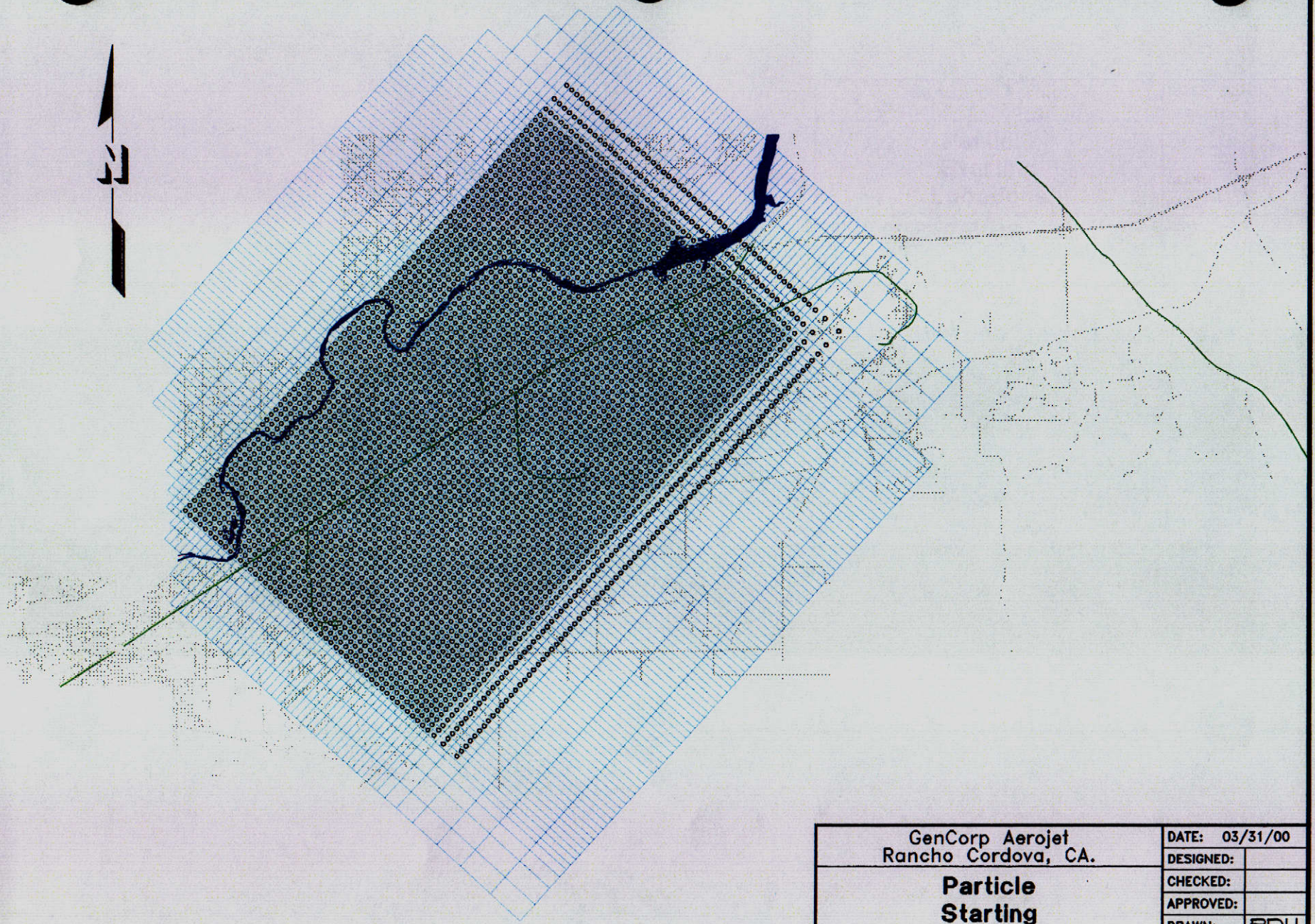
GenCorp Aerojet
Rancho Cordova, California

Projected NDMA Migration in 2001

DATE:	04/06/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D8-2



GenCorp Aerojet
Rancho Cordova, CA.

Particle Starting Locations

DATE:	03/31/00
DESIGNED:	
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-102

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D8-3

Scale: 1"=10,000'
0 5,000 10,000

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PAGES OF OVERSIZED MAPS

(SEE BINDER)

The cost estimates presented by Aerojet are for only a 25-year period. The USEPA has provided the standard 30 year total present worth cost estimate for Alternatives 3A through 5B which meet the CERCLA threshold criteria using a discount rate of 7%. Also in accordance with EPA guidance a total non-discount cost estimate was calculated for the life of the remedy for each Alternatives 3A through 5B which meet the CERCLA threshold criteria.

PRESENT WORTH COST ESTIMATE 30 YEARS

ALTERNATIVE 3A COST ITEMS

ITEM	**COST (M$)**
GET E and F Upgrade (Capital Costs)	
Onsite Extraction Wells	1.058
Untreated Groundwater Piping	0.702
Markup, Mob/Demob, Insurance	0.176
Engineering, Permitting, Construction Mgmt.	0.264
Regulatory Oversight	0.044
Contingency	0.337
TOTAL	2.581
Wellhead Treatment (Capital Costs)	
Monitor Wells	2.906
Wellhead Treatment (18 wells)	38.980
Markup, Mob/demob, Insurance	4.188
Engineering, Permitting, Construction Mgmt.	6.284
Regulatory Oversight	1.048
Contingency	8.012
TOTAL	61.418
TOTAL CAPITAL COSTS	64.000
O&M Costs (per year)	1.677 - 5.389
TOTAL COST	$97.30 M

ALTERNATIVE 3B COST ITEMS

ITEM	COST (M$)
GET E and F Upgrade (Capital Costs)	
Onsite Extraction Wells	3.530
Monitor Wells	0.784
Untreated Groundwater Piping	1.101
Treatment Facilities	4.719
Treated Groundwater Piping	1.437
Markup, Mob/demob, Insurance	1.157
Engineering, Permitting, Construction Mgmt.	1.736
Regulatory Oversight	0.289
Contingency	2.213
TOTAL	16.966
Wellhead Treatment (Capital Costs)	
Monitor Wells	2.906
Wellhead Treatment (18 wells)	38.721
Markup, Mob/demob, Insurance	4.163
Engineering, Permitting, Construction Mgmt.	6.244
Regulatory Oversight	1.041
Contingency	7.961
TOTAL	61.034
TOTAL CAPITAL COSTS	78.000
O&M Costs (per year)	1.677-6.038
TOTAL COST	$119.8M

ALTERNATIVE 4A CAPITAL COST ITEMS

ITEM	COST (M$)	2006 Effectiveness Mod. (M$)
Extraction Wells	7.427	1.293
Monitor Wells	1.460	0.320
Untreated GW Piping	13.528	1.000
Treatment Facilities	7.506	1.500
Discharge Facilities	1.861	
Markup, Mob/Demob, Insurance	3.171	0.411
Eng., Permits, Const. Mgmt.	4.768	0.617
Regulatory Oversight	0.795	0.103
Contingency	6.078	0.787
TOTAL CAPITAL COSTS	46.594	6.031
O&M Costs (per year)***	1.505 - 3.780	
TOTAL COST	88.300*	
Replacement Water - Direct Reuse**	3.909 (O&M 0.133/yr)	
Replacement Water - Indirect Reuse**	6.895 (O&M 0.044/yr)	
TOTAL COST Direct Reuse	$93.9M	
TOTAL COST Indirect Reuse	$95.8M	

* In addition, 1 layer D extraction well and 1 layer E extraction well must be installed in 2051 (700 gpm total) and 4 layer E extraction wells must be installed in 2061 (1300 gpm total).

** One of these costs will apply.

*** Reflects different O&M costs that occur in different yrs.

ALTERNATIVE 4B CAPITAL COST ITEMS

ITEM	COST (M$)	2006 Effectiveness Mod. (M$)
Extraction Wells	7.288	1.842
Monitor Wells	0.845	0.440
Untreated GW Piping	8.945	1.425
Treatment Facilities	6.991	2.100
Discharge Facilities	1.866	
Markup, Mob/Demob, Insurance	2.594	0.581
Eng., Permits, Const. Mgmt.	3.890	0.871
Regulatory Oversight	0.648	0.145
Contingency	4.960	1.111
TOTAL CAPITAL COSTS	38.027	8.515
O&M Costs (per year)***	1.624 - 4.085	
TOTAL COST	87.700*	
Replacement Water - Direct Reuse**	3.909 (O&M 0.133/yr)	
Replacement Water - Indirect Reuse**	6.895 (O&M 0.044/yr)	
TOTAL COST Direct Reuse	$92.9M	
TOTAL COST Indirect Reuse	$94.8	

* In addition, 2 D layer extraction wells and 1 E layer extraction well must be installed in 2041 (900 gpm).
** One of these costs will apply.
*** Reflects different)&M costs that occur in different years.

ALTERNATIVE 4C CAPITAL COST ITEMS

ITEM	COST (M$)	2006 Effectiveness Mod. (M$)
Extraction Wells	8.707	1.540
Monitor Wells	1.087	0.360
Untreated GW Piping	9.261	1.210
Treatment Facilities	7.997	1.800
Discharge Facilities	1.866	
Markup, Mob/Demob, Insurance	2.892	0.491
Eng., Permits, Const. Mgmt.	4.339	0.736
Regulatory Oversight	0.723	0.123
Contingency	5.531	0.929
TOTAL CAPITAL COSTS	42.403	6.463
O&M Costs (per year)**	1.774 - 3.944	
TOTAL COST	95.400	
Replacement Water - Direct Reuse*	3.909 (O&M 0.133/yr)	
Replacement Water - Indirect Reuse*	6.895 (O&M 0.044/yr)	
TOTAL COST Direct Reuse	$101M	
TOTAL COST Indirect Reuse	$102.6M	

* One of these costs will apply.
** Reflects different)&M costs that occur in different years.

ALTERNATIVE 5A CAPITAL COST ITEMS

ITEM	COST (M$)	2006 Effectiveness Mod. (M$)
Extraction Wells	6.144	1.705
Monitor Wells	1.345	0.360
Untreated GW Piping	6.807	1.100
Treatment Facilities	7.209	1.800
Recharge Wells	1.950	
Treated Groundwater Piping	7.212	
Markup, Mob/Demob, Insurance	3.267	0.496
Eng., Permits, Const. Mgmt.	4.600	0.745
Regulatory Oversight	0.767	0.124
Contingency	5.866	0.950
TOTAL CAPITAL COSTS	45.167	7.280
O&M Costs (per year)***	1.640 - 4.134	
TOTAL COST	94.000*	
Replacement Water - Direct Reuse**	3.909 (O&M 0.133/yr)	
Replacement Water - Indirect Reuse**	6.895 (O&M 0.044/yr)	
TOTAL COST Direct Reuse	$99.6M	
TOTAL COST Indirect Reuse	$101.5M	

* In addition, 3 E layer extraction wells must be installed in 2051 (900 gpm total) and 2 E layer extraction wells must be installed in 2061 (600 gpm total).
** One of these costs will apply.
*** Reflects different)&M costs that occur in different years.

ALTERNATIVE 5B CAPITAL COST ITEMS

ITEM	COST (M$)	2006 Effectiveness Mod. (M$)
Extraction Wells	6.268	1.705
Monitor Wells	0.603	0.360
Untreated GW Piping	4.727	1.280
Treatment Facilities	9.484	1.800
Recharge Wells	1.950	
Treated Groundwater Piping	8.135	
Markup, Mob/Demob, Insurance	3.117	0.514
Eng., Permits, Const. Mgmt.	4.675	0.772
Regulatory Oversight	0.779	0.129
Contingency	5.961	0.984
TOTAL	45.699	7.544
O&M Costs (per year)***	1.794 - 4.274	
TOTAL COST	100.000*	
Replacement Water - Direct Reuse**	3.909 (O&M 0.133/yr)	
Replacement Water - Indirect Reuse**	6.895 (O&M 0.044/yr)	
TOTAL COST Direct Reuse	$105.6M	
TOTAL COST Indirect Reuse	$107.5M	

* In addition, 1 E layer extraction well must be installed in 2111 (300 gpm).
** One of these costs will apply.
*** Reflects different)&M costs that occur in different years.

ALTERNATIVE COST SUMMARY TOTAL NON-DISCOUNT COST ESTIMATE
AFTER 6 PORE VOLUMES (Remedy Completion)

Alternative	Year 6 Pore Volume Completed	Non-Discounted Alternative Cost ($)	Non-Discounted Indirect Reuse ($)	Non-Discounted Direct Use ($)	Total Non-Discounted Cost ($)
3A	2330	2,177,929,000	-	-	2,177,929,000
3B	2480	2,994,785,000	-	-	2,994,785,000
4A	2234	1,469,197,000	51,688,000	54,650,000	1,520,885,000 - 1,523,846,000
4B	2348	1,731,570,000	77,389,000	81,531,000	1,808,959,000 - 1,813,101,000
4C	2240	1,085,824,000	51,908,000	55,440,000	1,137,732,000 - 1,141,364,000
5A	2258	1,826,912,000	59,595,000	61,611,000	1,886,507,000 - 1,888,523,000
5B	2348	1,859,747,000	77,389,000	81,531,000	1,937,136,000 - 1,941,288,000

Appendix E

DETAILED COST ESTIMATES

Capital, operation and maintenance (O&M), and present worth cost estimates for each alternative are presented in this Appendix. A summary table of these costs for each alternative are provided at the beginning and detailed cost estimates for the components of each alternative are presented following the summary table. The summary table and detailed estimates for each alternative are provided at the end of this Appendix. Detailed costs are broken down by the various components of each alternative: groundwater monitoring, providing alternate water supply, wellhead treatment, groundwater extraction, groundwater conveyance, groundwater treatment and treated water management/reuse. Capital cost details are provided for the years in which capital costs are projected to occur. A representative O&M cost detail is included for one of the years over the 25-year period for which present worth costs are estimated.

In accordance with EPA guidance, the cost estimates for each alternative are order-of-magnitude estimates and are generally accurate within the range specified in the guidance. The accuracy of the estimates is subject to substantial variation because details of the specific design will not be known until any remedy is implemented. For example, the actual site conditions, project scope and schedule, design details, competitive market conditions, changes during construction, labor and equipment rates, and other variables are not known.

Furthermore, the selection of technologies or process options is not intended to limit flexibility during remedial design. The selection provides a basis for estimating costs. Remedial design efforts might reveal possible cost savings as a result of value engineering studies and reduce the cost of implementing the remedy. In addition treatment technologies for removal of NDMA and perchlorate that were in the developmental and full scale testing phases during preparation of this OU RI/FS may be substantially more proven at the time of design, incorporated into the remedy and provide significant cost savings.

Wherever possible, actual capital and O&M costs from construction and operation of existing monitor wells, extraction and recharge wells, conveyance piping - both onsite and offsite, groundwater treatment facilities, recharge wells, and treated groundwater recharge and surface water discharge facilities for the GET systems at Aerojet were used for these cost estimates. Construction industry standard cost estimating cost guides (RS Means *Heavy Construction Cost Data,* 13th Annual Edition, 1999, and Dodge Unit Cost Guide 2000) were also consulted. The basis for the costs is stated in the sections that follow and in the detailed tables provided at the end of this appendix.

E-1 Summary of Estimated Alternative Costs

Estimated costs for Alternatives 1 through 5B are included. The tables show the capital and O&M cost estimates for monitoring, alternate water supply, wellhead treatment, groundwater extraction, groundwater treatment, and treated water management/reuse. Costs to maintain institutional controls were assumed to be negligible. All cost estimates are shown in 1999 dollars and include a 15 percent contingency. Present worth cost estimates (assuming a 7 percent discount rate in accordance with the most recent EPA guidance [USEPA, 1996e]) are also provided.

E-2 Capital and O&M Cost Detail

E-2.1 Extraction Wells and Conveyance Piping Capital Cost Estimates

Costs for extraction wells were based on a total depth of 300 feet below ground surface (bgs) for wells screened in Layer C, a depth of 400 feet bgs for wells screened in Layer D, and 500 feet bgs for wells screened in Layer E. Several of the extraction wells that would be installed onsite would be multiple-completion wells installed in one location. These wells are designated as New GET E, New-1, New-2, and New-3 on the various figures that are referenced with respect to the various alternatives in Section 4. For monitor well capital costs, it was assumed that 1.5 monitor wells would be constructed for each extraction well. Percentage costs for contractor markup, mobilization/demobilization, insurance, engineering, construction management, regulatory oversight, and contingency are also included.

Conveyance piping costs were estimated on a per lineal foot basis based on actual groundwater and water piping project construction costs for piping associated with the Aerojet GETs E and F and ARGET facilities, recent piping projects in the Sacramento area, and recent Means and Dodge construction cost estimating guides. The per lineal foot piping construction cost estimates varied depending on the pipe diameter and whether the installation was estimated to occur in existing streets/rights-of-way or in undeveloped land within the Aerojet property boundary.

For several of the remedial alternatives, it is estimated that an extensive conveyance piping array will be required in the Study Area west of the Aerojet site. If such a piping system were to be implemented as part of a remedy for the Western Groundwater OU, a preliminary alignment study, any environmental permitting, and final alignment study would probably have to be prepared. The conveyance piping cost estimates do not reflect that an alignment study was performed, assume that piping would be constructed within existing easements and/or rights-of-way and streets, assume that parcels of land will not be taken through imminent domain, and do not include allowances for utility relocation, extensive traffic control, night construction, or bridge crossings. It is further assumed that conveyance piping would be constructed as single-walled pipe. An allowance of $20 per inch diameter of pipe was estimated for jack/bore crossings of US Highway 50,

Folsom Boulevard and associated main rail lines and spurs, and the Folsom South Canal. Following is a listing of the unit prices used to estimate conveyance piping construction costs:

Pipe Diameter (inches)	Estimated Construction Cost ($/lineal foot)
6 and 8	100
10 and 12	140
16	175
20	225
24	260
30	300
Open field areas on Aerojet site	$8 per inch-diameter

E-2.2 Extraction Wells and Conveyance Piping O&M Cost Estimates

An allowance per extraction well per year was included for extraction well O&M and includes labor and repair and replacement supplies. Electrical utility costs vary by extraction well and are based on the estimated extraction flowrate and total dynamic head estimated for each extraction well pump and the current electrical utility rate paid by Aerojet of $0.05 per kilowatt-hour (kWh). Pipeline maintenance was estimated at $10,000 per year for the alternatives that included an offsite conveyance piping system.

Costs for monitoring are based on current Aerojet-Sacramento facility costs for the PCD Exhibit IV and VI requirements for the Western Groundwater Study Area groundwater monitoring program on a per-sample basis for labor and equipment ($110 per well completion), and the following per sample analytical costs: VOCs ($50 each), SVOCs ($225 each), perchlorate ($50 each), and NDMA ($60 each). Since most samples would be analyzed for VOCs, perchlorate, and NDMA, an average per sample cost of $300 was used in the detailed cost estimates. For this cost estimate it is assumed that the per-sample costs would be the same and that the number of samples collected annually for each alternative would to be approximately equivalent to the number of samples currently required by Exhibits IV and VI of the PCD plus samples collected from new monitor wells proposed for each alternative as discussed in Section 4. The numbers of extraction and monitor wells used to calculate the monitoring costs for each alternative are shown on the detailed cost estimates that follow.

E-2.3 Alternate Water Supply Cost Estimates

Capital and O&M costs for LPGAC treatment were developed using estimates from Calgon Carbon Corporation of $140,000 for each 2-20,000 pound (operated in series) contactor system, which is capable of treating an incremental flow of approximately 750

gpm. O&M costs for LPGAC were estimated at $0.75 per pound of GAC and assuming GAC is replaced at a frequency of once every two years.

For construction of surface water treatment capacity, the HDR/CWC Water Cost Manual, Estimating Costs for Treatment Plant Construction (Qasim et. al., 1992), and EPA's Estimating Water Treatment Costs Volume 2: Cost Curves Applicable to 1 to 200 mgd Treatment Plants (USEPA, 1979) were used for a typical surface water treatment facility employing the raw water pumping, coagulation/flocculation, filtration, disinfection, and treated water storage unit processes. Costs were escalated to February 1999 dollars. From the costing model the capital costs for a 10 million gallon per day (MGD) surface water treatment facility were estimated to be $5.5 million. Water treatment O&M costs were estimated at $0.074 per 1,000 gallons. Capital costs for water treatment facilities with flowrates greater or less than 10 MGD were estimated using the capital cost estimate and the following exponential cost correlation (Perry and Green, 1984):

$$\text{Capital Cost}_{\text{Flow B}} = \text{Capital Cost}_{\text{Flow A}} (\text{Flow}_B/\text{Flow}_A)^{0.6}$$

E-2.4 Groundwater Treatment Cost Estimates

Groundwater treatment capital costs were estimated using actual equipment and installation costs for recent construction of the ARGET facility and expansions to the GET B and GET F groundwater treatment facilities. Capital and O&M costs for the biological reduction process were estimated using cost curves developed in February 1997 by EarthTech for Aerojet and escalated to 1999 dollars using the Engineering News Record Construction Cost Index (ENR, 1999). Capital and O&M cost estimates for the UV/oxidation process were obtained from preliminary quotes from Calgon Carbon Corporation for their 30 kW and 276 kW AOT units and from preliminary O&M cost estimates for an innovative NDMA removal process currently undergoing full-scale testing at Aerojet. With respect to perchlorate removal costs using ion exchange in the wellhead treatment scenario, capital and O&M costs were estimated using preliminary quotes from Calgon Carbon Corporation for their ISEP ion exchange system and perchlorate and nitrate destruction module (PNDM) regenerant brine recycling system.

O&M costs for treatment include electric utility costs at $0.05 per kWh for transfer pumping and treatment equipment, chemicals required to operate the biological reduction and UV/oxidation processes, UV bulb replacement, equipment maintenance at three percent of equipment capital costs per year, operator and management oversight labor, and monitoring of various locations within the treatment system.

For purposes of costing, it was assumed that treatment of offgas emissions from any air stripping polishing unit process for removal of any VOCs remaining after the UV/oxidation process would not be required. Specifically, it was assumed that the initial emission rate for any VOCs from the air stripping process following the UV/oxidation process would not result in a residential 70-year maximum exposed individual (MEI)

cancer risk value above the 0.1×10^{-6} *deminimus* level referenced in SMAQMD new source review air quality rules.

E-2.5 Management/Reuse of Treated Groundwater Cost Estimates

Capital costs for management/reuse of treated groundwater include estimated costs for piping to convey treated groundwater to a water distribution system to deliver treated groundwater for direct reuse (Alternatives 2A and 2B). For Alternatives 3A and 3B, it was assumed that the existing piping at the various wellhead locations could be used to convey the treated water to the water distribution system. For purposes of costing the direct reuse of treated groundwater component of Alternatives 2A and 2B, it was assumed that the groundwater treatment process train described previously with the addition of the LPGAC unit process would be sufficient. Also for the direct reuse option it was assumed that the water purveyor would provide the disinfection process.

O&M costs for management/reuse of treated groundwater include estimates of electric utility costs to convey the treated water for those alternatives where the water is conveyed to a water distribution system under the direct reuse option, discharged to surface water, or recharged. Maintenance costs associated with recharge well maintenance and monitoring costs were also included.

If the treated water management/reuse options of (1) discharge to the American River to offset surface water exchange, or (2) use for irrigation or other non-potable purposes as implemented, there may be additional capital costs associated with dual distribution system piping that may have to be shared between Aerojet and the user of the non-potable water. O&M costs and revenues associated with these options might include a difference in value between exchanged surface water and treated groundwater in the Folsom South Canal, costs to convey and store treated groundwater for irrigation or other non-potable purposes, and revenue associated with the value of treated groundwater when the groundwater is exchanged or sold for irrigation or other non-potable purposes.

Detailed Cost Estimates

Alternative 1

Present Worth Cost Estimate

Alternative 1 - No Action

Year	*n*	P/F(*i*=7%)	Estimated Monitoring Costs ($/year)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	80,000	80,000	80,000
2002	1	0.93458	160,000	149,533	230,000
2003	2	0.87344	160,000	139,750	370,000
2004	3	0.81630	160,000	130,608	500,000
2005	4	0.76290	160,000	122,063	620,000
2006	5	0.71299	160,000	114,078	730,000
2007	6	0.66634	160,000	106,615	840,000
2008	7	0.62275	160,000	99,640	940,000
2009	8	0.58201	160,000	93,121	1,030,000
2010	9	0.54393	160,000	87,029	1,120,000
2011	10	0.50835	160,000	81,336	1,200,000
2012	11	0.47509	160,000	76,015	1,280,000
2013	12	0.44401	160,000	71,042	1,350,000
2014	13	0.41496	160,000	66,394	1,420,000
2015	14	0.38782	160,000	62,051	1,480,000
2016	15	0.36245	160,000	57,991	1,540,000
2017	16	0.33873	160,000	54,198	1,590,000
2018	17	0.31657	160,000	50,652	1,640,000
2019	18	0.29586	160,000	47,338	1,690,000
2020	19	0.27651	160,000	44,241	1,730,000
2021	20	0.25842	160,000	41,347	1,770,000
2022	21	0.24151	160,000	38,642	1,810,000
2023	22	0.22571	160,000	36,114	1,850,000
2024	23	0.21095	160,000	33,752	1,880,000
2025	24	0.19715	160,000	31,543	1,910,000
2026	25	0.18425	80,000	14,740	1,920,000
	Total Estimated Costs:				2,000,000

Detailed Cost Estimates

Alternative 2A

Present Worth Cost Estimate

Alternative 2A - GETs E and F Extraction Wells with Offsite Alternate Water Supply

			Existing GETs E/F Estimated Costs			Additional Alternative 2A Estimated Costs					Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	2,579,000	229,000	2,808,000	2,808,000	2,800,000	2,579,000	1,029,000	3,608,000	3,800,000	3,600,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		458,000	458,000	428,000	3,200,000	0	2,058,000	2,058,000	1,900,000	5,500,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		458,000	458,000	400,000	3,600,000	0	2,058,000	2,058,000	1,800,000	7,300,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000	12,168,000	664,000	12,832,000	10,475,000	14,100,000	12,168,000	2,264,000	14,432,000	11,800,000	19,100,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		664,000	664,000	507,000	14,600,000	0	2,264,000	2,264,000	1,700,000	20,800,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		664,000	664,000	473,000	15,100,000	0	2,264,000	2,264,000	1,600,000	22,400,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		664,000	664,000	442,000	15,500,000	0	2,264,000	2,264,000	1,500,000	23,900,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		664,000	664,000	414,000	15,900,000	0	2,264,000	2,264,000	1,400,000	25,300,000
2009	8	0.58201	1,600,000	936,000	10,300,000		664,000	664,000	386,000	16,300,000	0	2,264,000	2,264,000	1,300,000	26,600,000
2010	9	0.54393	1,600,000	870,000	11,200,000		664,000	664,000	361,000	16,700,000	0	2,264,000	2,264,000	1,200,000	27,800,000
2011	10	0.50835	1,600,000	810,000	12,000,000		664,000	664,000	338,000	17,000,000	0	2,264,000	2,264,000	1,200,000	29,000,000
2012	11	0.47509	1,600,000	760,000	12,800,000		664,000	664,000	315,000	17,300,000	0	2,264,000	2,264,000	1,100,000	30,100,000
2013	12	0.44401	1,600,000	710,000	13,500,000		664,000	664,000	295,000	17,600,000	0	2,264,000	2,264,000	1,000,000	31,100,000
2014	13	0.41496	1,600,000	660,000	14,200,000		664,000	664,000	276,000	17,900,000	0	2,264,000	2,264,000	900,000	32,000,000
2015	14	0.38782	1,600,000	620,000	14,800,000	9,707,000	2,284,000	11,991,000	4,650,000	22,600,000	9,707,000	3,884,000	13,591,000	5,300,000	37,300,000
2016	15	0.36245	1,600,000	580,000	15,400,000		2,284,000	2,284,000	828,000	23,400,000	0	3,884,000	3,884,000	1,400,000	38,700,000
2017	16	0.33873	1,600,000	540,000	15,900,000		2,284,000	2,284,000	774,000	24,200,000	0	3,884,000	3,884,000	1,300,000	40,000,000
2018	17	0.31657	1,600,000	510,000	16,400,000		2,284,000	2,284,000	723,000	24,900,000	0	3,884,000	3,884,000	1,200,000	41,200,000
2019	18	0.29586	1,600,000	470,000	16,900,000		2,284,000	2,284,000	676,000	25,600,000	0	3,884,000	3,884,000	1,100,000	42,300,000
2020	19	0.27651	1,600,000	440,000	17,300,000		2,284,000	2,284,000	632,000	26,200,000	0	3,884,000	3,884,000	1,100,000	43,400,000
2021	20	0.25842	1,600,000	410,000	17,700,000		2,284,000	2,284,000	590,000	26,800,000	0	3,884,000	3,884,000	1,000,000	44,400,000
2022	21	0.24151	1,600,000	390,000	18,100,000		2,284,000	2,284,000	552,000	27,300,000	0	3,884,000	3,884,000	900,000	45,300,000
2023	22	0.22571	1,600,000	360,000	18,500,000		2,284,000	2,284,000	516,000	27,900,000	0	3,884,000	3,884,000	900,000	46,200,000
2024	23	0.21095	1,600,000	340,000	18,800,000		2,284,000	2,284,000	482,000	28,300,000	0	3,884,000	3,884,000	800,000	47,000,000
2025	24	0.19715	1,600,000	320,000	19,100,000		2,284,000	2,284,000	450,000	28,800,000	0	3,884,000	3,884,000	800,000	47,800,000
2026	25	0.18425	800,000	160,000	19,300,000		1,142,000	1,142,000	210,000	29,000,000	0	1,942,000	1,942,000	400,000	48,200,000
	Total Estimated Costs:				19,000,000	24,000,000				29,000,000	24,000,000				48,000,000

Capital Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Onsite Extraction Wells (year 2001)	**[4 onsite, 2 locations]**				
Surveying		1	day	1,000	1,000
Extraction wells (drilling and development)	Depth				
C	300	2	ft	550	330,000
D	400	1	ft	550	220,000
E	500	1	ft	550	275,000
Development (incl. above)		4	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		3	ea	29,000	87,000
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	3	lin ft	100	60,000
Installation (pump, wellhead, I&C)		4	LS	5,000	20,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		4	ea	2,000	8,000
Instrumentation and control/telemetry		4	ea	2,000	8,000
Subtotal - Extraction Wells (yr 2001)					1,058,000
Untreated Groundwater Piping GETs E and F to GETs E/F GWTP (year 2001)					
Surveying		2	day	1,000	2,000
Single-walled piping system (in field)					
8"		1,300	lin ft	64	83,200
10"		7,700	lin ft	80	616,000
Subtotal - Untreated Groundwater Piping (yr 2001)		9,000			701,000
Estimated Construction Costs - Subtotal (year 2001)					1,759,000
Contractor Markup, Mob/demob, Insurance			%	10	176,000
Engineering, Permitting and Construction Management			%	15	264,000
Regulatory Oversight			%	2.5	44,000
Estimated Project Capital Costs - Subtotal (year 2001)					2,243,000
Contingency			%	15	336,000
Estimated Project Capital Costs - Total (year 2001)					**2,579,000**

Capital Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2004)					
GETs GWTP Additions and Treated Groundwater Piping to Water Distribution System					
GET A					
LPGAC polishing contactors 750 gpm each (incl. GAC)		1	ea	140,000	140,000
General contractor installation @ % of equipment		140,000	%	20	28,000
Chlorine disinfection (assumed provided by water purveyor)					
GET B					
LPGAC polishing contactors 750 gpm each (incl. GAC)		5	ea	140,000	700,000
General contractor installation @ % of equipment		700,000	%	20	140,000
Chlorine disinfection (assumed provided by water purveyor)					
ARGET					
LPGAC polishing contactors 750 gpm each (incl. GAC)		4	ea	140,000	560,000
General contractor installation @ % of equipment		560,000	%	20	112,000
Chlorine disinfection (assumed provided by water purveyor)					
Secure easements		1	LS	20,000	20,000
Surveying		5	day	1,000	5,000
Treated groundwater piping to Water Distribution System					0
8" from GET A to GET B (onsite)		9,800	lin ft	64	627,200
20" from GET B to Line 01 (onsite)		11,700	lin ft	160	1,872,000
24" from Line 01 to Buffalo Creek		18,100	lin ft	192	3,475,000
20" from ARGET discharge to water distribution system		500	lin ft	160	80,000
Jack and bore:	No:				
30" under Folsom South Canal	1	200	lin ft	600	120,000
30" under railroad and Folsom Blvd	1	200	lin ft	600	120,000
30" under Hwy 50	1	500	lin ft	600	300,000
Subtotal					8,299,000
Estimated Construction Costs - Subtotal (year 2004)					8,299,000
Contractor Markup, Mob/demob, Insurance			%	10	830,000
Engineering, Permitting and Construction Management			%	15	1,245,000
Regulatory Oversight			%	2.5	207,000
Estimated Project Capital Costs - Subtotal (year 2004)					10,581,000
Contingency			%	15	1,587,000
Estimated Project Capital Costs - Total (year 2004)					**12,168,000**

Capital Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description	Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2015)				
GETs GWTP Additions and Treated Groundwater Piping to Water Distribution System				
GET D				
LPGAC polishing contactors 750 gpm each (incl. GAC)	2	ea	140,000	280,000
General contractor installation @ % of equipment	280,000	%	20	56,000
Chlorine disinfection (assumed provided by water purveyor)				
Treated groundwater piping to Water Distribution System				
10" from GET D to Line 01 (onsite)	7,900	lin ft	80	632,000
Subtotal				968,000
Surface Water Treatment Facilities (New 5.8 MGD [4,000 gpm] facility offsite) and Piping [year 2015]				
Secure easements	1	LS	10,000	10,000
Land purchase	2	acre	20,000	40,000
Surveying	2	day	1,000	2,000
Incoming high voltage power	1,000	ft	20	20,000
Inlet structure at Folsom South Canal	1	ea	20,000	20,000
Raw water piping from Folsom South Canal				
20"	6,000	lin ft	260	1,560,000
Surface water treatment facility (5.8 MGD)	1	ea	4,000,000	4,000,000
Subtotal				5,652,000
Estimated Construction Costs - Subtotal (year 2015)				6,620,000
Contractor Markup, Mob/demob, Insurance		%	10	662,000
Engineering, Permitting and Construction Management		%	15	993,000
Regulatory Oversight		%	2.5	166,000
Estimated Project Capital Costs - Subtotal (year 2015)				8,441,000
Contingency		%	15	1,266,000
Estimated Project Capital Costs - Total (year 2015)				**9,707,000**

Operation and Maintenance Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**			
Extraction well maintenance		4	ea	1,000	4,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
UV/oxidation	51	446,760	kwh	0.050	22,000
Effluent pumping - GET A	19	122,338	kwh	0.050	6,000
Effluent pumping - GET B	262	1,712,732	kwh	0.050	86,000
Effluent pumping - GET D	0	0	kwh	0.050	0
Effluent pumping - ARGET	101	660,625	kwh	0.050	33,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement		600	85 w bulb	35	21,000
LPGAC replacement			pound	0.75	
Equip Maintenance (@ % of equip capital)		121,000	%	3	4,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qrtrs.				
Extraction wells	4	4	ea	300	4,800
Monitor wells	4	6	ea	300	7,200
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)		4	ea	300	0
GWTP effluent (incl in exist. GET F O&M)		4	ea	300	0
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Sidestreams (incl in exist. GET F O&M)		2	ea	300	0
Folsom South Canal Use Fee		0	ac ft	15	0
Estimated Project O&M Costs - Subtotal Year 2001					398,000
Contingency			%	15	60,000
Estimated Project O&M Costs - Total Year 2001					458,000

Operation and Maintenance Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2004**			
Extraction well maintenance		4	ea	1,000	4,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
UV/oxidation	51	446,760	kwh	0.050	22,000
Effluent pumping - GET A	19	122,338	kwh	0.050	6,000
Effluent pumping - GET B	262	1,712,732	kwh	0.050	86,000
Effluent pumping - GET D	0	0	kwh	0.050	0
Effluent pumping - ARGET	101	660,625	kwh	0.050	33,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement		600	85 w bulb	35	21,000
LPGAC replacement		200,000	pound	0.75	150,000
Equip Maintenance (@ % of equip capital)		121,000	%	3	4,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qrtrs.				
Extraction wells	4	4	ea	300	4,800
Monitor wells	4	6	ea	300	7,200
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP effluent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Sidestreams (incl in exist. GET F O&M)		2	ea	300	0
Folsom South Canal Use Fee		0	ac ft	10	0
Estimated Project O&M Costs - Subtotal Year 2004					577,000
Contingency			%	15	87,000
Estimated Project O&M Costs - Total Year 2004					664,000

Operation and Maintenance Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2015**				
Extraction well maintenance		4	ea	1,000	4,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
UV/oxidation			kwh	0.050	22,000
Effluent pumping - GET A	19	122,338	kwh	0.050	6,000
Effluent pumping - GET B	262	1,712,732	kwh	0.050	86,000
Effluent pumping - GET D	75	489,352	kwh	0.050	24,000
Effluent pumping - ARGET	101	660,625	kwh	0.050	33,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement			-		21,000
LPGAC replacement		240,000	pound	0.75	180,000
Equip Maintenance (@ % of equip capital)		121,000	%	3	4,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qrtrs.				
Extraction wells	4	4	ea	300	4,800
Monitor wells	4	6	ea	300	7,200
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP effluent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Sidestreams (incl in exist. GET F O&M)		2	ea	300	0
Raw water purchase		6,452	ac ft	200	1,290,000
Folsom South Canal Use Fee		6,452	ac ft	10	65,000
Estimated Project O&M Costs - Subtotal Year 2015					1,986,000
Contingency			%	15	298,000
Estimated Project O&M Costs - Total Year 2015					**2,284,000**

Detailed Cost Estimates

Alternative 2B

Present Worth Cost Estimate

Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

			Existing GETs E/F Estimated Costs			Additional Alternative 2B Estimated Costs					Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	15,954,000	453,500	16,407,500	16,408,000	16,400,000	15,954,000	1,253,500	17,207,500	17,200,000	17,200,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		907,000	907,000	848,000	17,300,000	0	2,507,000	2,507,000	2,300,000	19,500,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		907,000	907,000	792,000	18,000,000	0	2,507,000	2,507,000	2,200,000	21,700,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000	5,104,000	1,096,000	6,200,000	5,061,000	23,100,000	5,104,000	2,696,000	7,800,000	6,400,000	28,100,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,096,000	1,096,000	836,000	23,900,000	0	2,696,000	2,696,000	2,100,000	30,200,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,096,000	1,096,000	781,000	24,700,000	0	2,696,000	2,696,000	1,900,000	32,100,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,096,000	1,096,000	730,000	25,500,000	0	2,696,000	2,696,000	1,800,000	33,900,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,096,000	1,096,000	683,000	26,100,000	0	2,696,000	2,696,000	1,700,000	35,600,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,096,000	1,096,000	638,000	26,800,000	0	2,696,000	2,696,000	1,600,000	37,200,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,096,000	1,096,000	596,000	27,400,000	0	2,696,000	2,696,000	1,500,000	38,700,000
2011	10	0.50835	1,600,000	810,000	12,000,000		1,096,000	1,096,000	557,000	27,900,000	0	2,696,000	2,696,000	1,400,000	40,100,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,096,000	1,096,000	521,000	28,500,000	0	2,696,000	2,696,000	1,300,000	41,400,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,096,000	1,096,000	487,000	28,900,000	0	2,696,000	2,696,000	1,200,000	42,600,000
2014	13	0.41496	1,600,000	660,000	14,200,000		1,096,000	1,096,000	455,000	29,400,000	0	2,696,000	2,696,000	1,100,000	43,700,000
2015	14	0.38782	1,600,000	620,000	14,800,000	2,406,000	1,228,000	3,634,000	1,409,000	30,800,000	2,406,000	2,828,000	5,234,000	2,000,000	45,700,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,228,000	1,228,000	445,000	31,200,000	0	2,828,000	2,828,000	1,000,000	46,700,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,228,000	1,228,000	416,000	31,700,000	0	2,828,000	2,828,000	1,000,000	47,700,000
2018	17	0.31657	1,600,000	510,000	16,400,000		1,228,000	1,228,000	389,000	32,100,000	0	2,828,000	2,828,000	900,000	48,600,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,228,000	1,228,000	363,000	32,400,000	0	2,828,000	2,828,000	800,000	49,400,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,228,000	1,228,000	340,000	32,800,000	0	2,828,000	2,828,000	800,000	50,200,000
2021	20	0.25842	1,600,000	410,000	17,700,000		1,228,000	1,228,000	317,000	33,100,000	0	2,828,000	2,828,000	700,000	50,900,000
2022	21	0.24151	1,600,000	390,000	18,100,000		1,228,000	1,228,000	297,000	33,400,000	0	2,828,000	2,828,000	700,000	51,600,000
2023	22	0.22571	1,600,000	360,000	18,500,000		1,228,000	1,228,000	277,000	33,600,000	0	2,828,000	2,828,000	600,000	52,200,000
2024	23	0.21095	1,600,000	340,000	18,800,000		1,228,000	1,228,000	259,000	33,900,000	0	2,828,000	2,828,000	600,000	52,800,000
2025	24	0.19715	1,600,000	320,000	19,100,000		1,228,000	1,228,000	242,000	34,100,000	0	2,828,000	2,828,000	600,000	53,400,000
2026	25	0.18425	800,000	150,000	19,300,000		614,000	614,000	113,000	34,300,000	0	1,414,000	1,414,000	300,000	53,700,000
Total Estimated Costs:					19,000,000	23,000,000				34,300,000	23,000,000				54,000,000

Capital Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Onsite Extraction Wells (year 2001)	[13 onsite, 5 locations]				
Surveying		2	day	1,000	2,000
Extraction wells (drilling and development)	Depth				
C	300	5	ft	550	825,000
D	400	4	ft	550	880,000
E	500	4	ft	550	1,100,000
Development (incl. above)		13	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		9	ea	26,000	234,000
500 gpm, 300' TDH, 60 hp, 8" disch		4	ea	29,000	116,000
Discharge piping, 3" SS threaded	200	9	lin ft	40	72,000
Discharge piping, 8" SS threaded	200	4	lin ft	100	80,000
Installation (pump, wellhead, I&C)		13	LS	5,000	65,000
Incoming service power	5	500	ft	15	37,500
Pump control power and control		13	ea	2,000	26,000
Instrumentation and control/telemetry		13	ea	2,000	26,000
Subtotal - Extraction Wells (yr 2001)					3,464,000
Untreated Groundwater Piping GETs E and F, New-1 thru New-3 Wells to GET F GWTP (year 2001)					
Onsite:					
Surveying		4	day	1,000	4,000
Single-walled piping system (in field)					
10"		9,300	lin ft	80	744,000
12"		3,200	lin ft	96	307,200
16"		700	lin ft	128	89,600
Subtotal - Untreated Groundwater Piping (yr 2001)		13,200			1,145,000
Treatment Facilities - GET F (additional 2,225 gpm capacity) [year 2001]					
Surveying		1	day	1,000	1,000
Equalization tankage	2	66,750	gal	1.00	133,500
Transfer pumping	42 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		2	ea	85,000	170,000
Offgas treatment (assume not required)		0	ea	200,000	0
Perchlorate removal (biological reduction)	2,225 gpm	1	ea	2,869,000	2,869,000
UV/oxidation (KW)			ea		800,000
Transfer pumping	42 hp	3	ea	10,000	30,000
Electrical wiring		1	LS	50,000	50,000
Instrumentation and control		1	LS	50,000	50,000
Treatment building		800	sq ft	100	80,000
General contractor installation @ % of equipment		1,263,500	%	40	505,400
Subtotal - Additional Treatment at GET F (yr 2001)					4,719,000
Treated Groundwater Piping GET F GWTP to Buffalo Creek (year 2001)					
Onsite:					
Surveying		2	day	1,000	2,000
Single-walled piping system (in field)					
24"		8,000	lin ft	192	1,536,000
Monitoring manhole and facilities		1.0	ea	5,000	5,000
Discharge structure		1.0	LS	10,000	10,000
Subtotal - Untreated Groundwater Piping (yr 2001)		8,000			1,553,000
Estimated Construction Costs - Subtotal (year 2001)					10,881,000
Contractor Markup, Mob/demob, Insurance			%	10	1,088,000
Engineering, Permitting and Construction Management			%	15	1,632,000
Regulatory Oversight			%	2.5	272,000
Estimated Project Capital Costs - Subtotal (year 2001)					13,873,000
Contingency			%	15	2,081,000
Estimated Project Capital Costs - Total (year 2001)					**15,954,000**

Capital Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2004)					
GETs E/F GWTP Additions and Treated Groundwater Piping to Water Distribution System					
LPGAC polishing contactors 750 gpm each (incl. GAC)		9	ea	140,000	1,260,000
General contractor installation @ % of equipment		1,260,000	%	20	252,000
Chlorine disinfection (assumed provided by water purveyor)					
Secure easements		1	LS	20,000	20,000
Surveying		5	day	1,000	5,000
Treated groundwater piping from Buffalo Creek Discharge to Water Distribution System					
24" on-site open field		700	lin ft	192	134,400
24" in street		5,300	lin ft	260	1,378,000
Jack and bore:					
24" under Folsom South Canal	1	200	lin ft	480	96,000
24" under railroad and Folsom Blvd	1	200	lin ft	480	96,000
24" under Hwy 50	1	500	lin ft	480	240,000
Subtotal					3,481,000
Estimated Construction Costs - Subtotal (year 2004)					3,481,000
Contractor Markup, Mob/demob, Insurance			%	10	348,000
Engineering, Permitting and Construction Management			%	15	522,000
Regulatory Oversight			%	2.5	87,000
Estimated Project Capital Costs - Subtotal (year 2004)					4,438,000
Contingency			%	15	666,000
Estimated Project Capital Costs - Total (year 2004)					**5,104,000**

Draft O&M Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**			
Extraction well maintenance		13	ea	1,000	13,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
New-1	68	444,070	kwh	0.050	22,000
New-2	80	520,633	kwh	0.050	26,000
New-3	80	520,633	kwh	0.050	26,000
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:					
Air stripping	30	196,312	kwh	0.050	10,000
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps	50	326,642	kwh	0.050	16,000
Effluent pumping - 6,225 gpm to discharge	233	1,523,108	kwh	0.050	76,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement					21,000
Perchlorate biological reduction system O&M in add'n to existing		1	LS	265,000	265,000
LPGAC replacement			pound	0.75	
Onsite VPGAC regeneration system			ccf	0.5	0
Equip Maintenance (@ % of equip capital)		1,430,000	%	3	43,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qrtrs.				
Extraction wells	4	13	ea	300	15,600
Monitor wells	4	20	ea	300	23,400
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)		4	ea	300	0
GWTP effluent (incl in exist. GET F O&M)		4	ea	300	0
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Sidestreams (incl in exist. GET F O&M)		2	ea	300	0
Estimated Project O&M Costs - Subtotal Year 2001					789,000
Contingency (%)			%	15	118,000
Estimated Project O&M Costs - Total Year 2001					**907,000**

Capital Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description	Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2015)				
ARGET GWTP Additions and Treated Groundwater Piping to Water Distribution System (3,200 gpm)				
LPGAC polishing contactors 750 gpm each (incl. GAC)	5	ea	140,000	700,000
General contractor installation @ % of equipment	700,000	%	20	140,000
Chlorine disinfection (assumed provided by water purveyor)				
Surveying	1	day	1,000	1,000
Treated groundwater piping from ARGET Discharge to Water Distribution System				
20" on-site open field	5,000	lin ft	160	800,000
Subtotal				1,641,000
Estimated Construction Costs - Subtotal (year 2015)				1,641,000
Contractor Markup, Mob/demob, Insurance		%	10	164,000
Engineering, Permitting and Construction Management		%	15	246,000
Regulatory Oversight		%	2.5	41,000
Estimated Project Capital Costs - Subtotal (year 2015)				2,092,000
Contingency		%	15	314,000
Estimated Project Capital Costs - Total (year 2015)				**2,406,000**

Draft O&M Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2015**				
Extraction well maintenance		13	ea	1,000	13,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
New-1	68	444,070	kwh	0.050	22,000
New-2	80	520,633	kwh	0.050	26,000
New-3	80	520,633	kwh	0.050	26,000
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:					
Air stripping	30	196,312	kwh	0.050	10,000
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps	50	326,642	kwh	0.050	16,000
Effluent pumping - 9,500 gpm to water distribution system	356	2,324,421	kwh	0.050	116,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement					21,000
Perchlorate biological reduction system O&M in add'n to existing		1	LS	265,000	265,000
UV service contract		0	LS	5,000	0
LPGAC replacement		280,000	pound	0.75	210,000
Onsite VPGAC regeneration system			ccf	0.5	0
Equip Maintenance (@ % of equip capital)		1,430,000	%	3	43,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qrtrs.				
Extraction wells	4	13	ea	300	15,600
Monitor wells	4	20	ea	300	23,400
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP effluent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Estimated Project O&M Costs - Subtotal Year 2015					1,068,000
Contingency (%)			%	15	160,000
Estimated Project O&M Costs - Total Year 2015					**1,228,000**

Detailed Cost Estimates

Alternative 3A

Present Worth Cost Estimate

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 3A Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	23,537,000	877,000	24,414,000	24,414,000	24,414,000	23,537,000	1,677,000	25,214,000	25,210,000	25,210,000
2002	1	0.93458	1,600,000	1,495,000	2,295,000	682,000	1,903,000	2,585,000	2,416,000	26,830,000	682,000	3,503,000	4,185,000	3,910,000	29,120,000
2003	2	0.87344	1,600,000	1,398,000	3,693,000	0	1,903,000	1,903,000	1,662,000	28,492,000	0	3,503,000	3,503,000	3,060,000	32,180,000
2004	3	0.81630	1,600,000	1,306,000	4,999,000	0	1,903,000	1,903,000	1,553,000	30,045,000	0	3,503,000	3,503,000	2,860,000	35,040,000
2005	4	0.76290	1,600,000	1,221,000	6,220,000	0	1,903,000	1,903,000	1,452,000	31,497,000	0	3,503,000	3,503,000	2,670,000	37,710,000
2006	5	0.71299	1,600,000	1,141,000	7,361,000	8,643,000	2,169,000	10,812,000	7,709,000	39,206,000	8,643,000	3,769,000	12,412,000	8,850,000	46,560,000
2007	6	0.66634	1,600,000	1,066,000	8,427,000	0	2,372,000	2,372,000	1,581,000	40,787,000	0	3,972,000	3,972,000	2,650,000	49,210,000
2008	7	0.62275	1,600,000	996,000	9,423,000	0	2,362,000	2,362,000	1,471,000	42,258,000	0	3,962,000	3,962,000	2,470,000	51,680,000
2009	8	0.58201	1,600,000	931,000	10,354,000	426,000	2,398,000	2,824,000	1,644,000	43,902,000	426,000	3,998,000	4,424,000	2,570,000	54,250,000
2010	9	0.54393	1,600,000	870,000	11,224,000	4,974,000	2,645,000	7,619,000	4,144,000	48,046,000	4,974,000	4,245,000	9,219,000	5,010,000	59,260,000
2011	10	0.50835	1,600,000	813,000	12,037,000	1,605,000	2,954,000	4,559,000	2,318,000	50,364,000	1,605,000	4,554,000	6,159,000	3,130,000	62,390,000
2012	11	0.47509	1,600,000	760,000	12,797,000	0	3,045,000	3,045,000	1,447,000	51,811,000	0	4,645,000	4,645,000	2,210,000	64,600,000
2013	12	0.44401	1,600,000	710,000	13,507,000	4,111,000	3,293,000	7,404,000	3,287,000	55,098,000	4,111,000	4,893,000	9,004,000	4,000,000	68,600,000
2014	13	0.41496	1,600,000	664,000	14,171,000	3,382,000	3,545,000	6,927,000	2,874,000	57,972,000	3,382,000	5,145,000	8,527,000	3,540,000	72,140,000
2015	14	0.38782	1,600,000	621,000	14,792,000	0	3,321,000	3,321,000	1,288,000	59,260,000	0	4,921,000	4,921,000	1,910,000	74,050,000
2016	15	0.36245	1,600,000	580,000	15,372,000	0	3,097,000	3,097,000	1,122,000	60,382,000	0	4,697,000	4,697,000	1,700,000	75,750,000
2017	16	0.33873	1,600,000	542,000	15,914,000	6,177,000	3,427,000	9,604,000	3,253,000	63,635,000	6,177,000	5,027,000	11,204,000	3,800,000	79,550,000
2018	17	0.31657	1,600,000	507,000	16,421,000	0	3,427,000	3,427,000	1,085,000	64,720,000	0	5,027,000	5,027,000	1,590,000	81,140,000
2019	18	0.29586	1,600,000	473,000	16,894,000	0	3,427,000	3,427,000	1,014,000	65,734,000	0	5,027,000	5,027,000	1,490,000	82,630,000
2020	19	0.27651	1,600,000	442,000	17,336,000	2,500,000	3,426,000	5,926,000	1,639,000	67,373,000	2,500,000	5,026,000	7,526,000	2,080,000	84,710,000
2021	20	0.25842	1,600,000	413,000	17,749,000	3,148,000	3,785,000	6,933,000	1,792,000	69,165,000	3,148,000	5,385,000	8,533,000	2,210,000	86,920,000
2022	21	0.24151	1,600,000	386,000	18,135,000	0	3,785,000	3,785,000	914,000	70,079,000	0	5,385,000	5,385,000	1,300,000	88,220,000
2023	22	0.22571	1,600,000	361,000	18,496,000	202,000	3,789,000	3,991,000	901,000	70,980,000	202,000	5,389,000	5,591,000	1,260,000	89,480,000
2024	23	0.21095	1,600,000	338,000	18,834,000	0	3,789,000	3,789,000	799,000	71,779,000	0	5,389,000	5,389,000	1,140,000	90,620,000
2025	24	0.19715	1,600,000	315,000	19,149,000	0	3,789,000	3,789,000	747,000	72,526,000	0	5,389,000	5,389,000	1,060,000	91,680,000
2026	25	0.18425	800,000	147,000	19,296,000	4,606,000	2,395,000	7,001,000	1,290,000	73,816,000	4,606,000	3,195,000	7,801,000	1,440,000	93,120,000
		Total Estimated Costs:			19,300,000	64,000,000				74,000,000	64,000,000				93,000,000

Present Worth Cost Estimate

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Year	Well AC-1 Capital Costs ($)	O&M Costs ($/yr)	Well AC-5 Capital Costs ($)	O&M Costs ($/yr)	Well AC-6 Capital Costs ($)	O&M Costs ($/yr)	Well AC-7 Capital Costs ($)	O&M Costs ($/yr)	Well AC-10 Capital Costs ($)	O&M Costs ($/yr)	Well AC-11 Capital Costs ($)	O&M Costs ($/yr)
2001			2,500,000	63,500							551,000	53,000
2002				127,000								106,000
2003				127,000								106,000
2004				127,000								106,000
2005				127,000								106,000
2006	2,514,000	37,000		127,000			3,093,000	106,500	2,500,000	60,000		106,000
2007		74,000		127,000				213,000		120,000		106,000
2008		74,000		127,000				213,000		120,000		106,000
2009		74,000		127,000				213,000		120,000		106,000
2010		74,000		127,000				213,000		120,000		106,000
2011		74,000		127,000				213,000		120,000		106,000
2012		74,000		127,000				213,000		120,000		106,000
2013		74,000		127,000				213,000		120,000		106,000
2014		74,000		127,000				213,000		120,000		106,000
2015		74,000		127,000				106,500		120,000		106,000
2016		74,000		127,000						120,000		106,000
2017		74,000		127,000						120,000	2,795,000	250,000
2018		74,000		127,000						120,000		250,000
2019		74,000		127,000						120,000		250,000
2020		74,000		127,000	2,500,000	82,000				120,000		250,000
2021		74,000		127,000		164,000				120,000		250,000
2022		74,000		127,000		164,000				120,000		250,000
2023	202,000	78,000		127,000		164,000				120,000		250,000
2024		78,000		127,000		164,000				120,000		250,000
2025		78,000		127,000		164,000				120,000		250,000
2026		39,000		63,500		82,000				60,000		125,000

Present Worth Cost Estimate

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Year	Well AC-13 Capital Costs ($)	Well AC-13 O&M Costs ($/yr)	Well AC-14 Capital Costs ($)	Well AC-14 O&M Costs ($/yr)	Well AC-15 Capital Costs ($)	Well AC-15 O&M Costs ($/yr)	Well AC-16 Capital Costs ($)	Well AC-16 O&M Costs ($/yr)	Well AC-18 Capital Costs ($)	Well AC-18 O&M Costs ($/yr)	Well AC-19 Capital Costs ($)	Well AC-19 O&M Costs ($/yr)	Well AC-20 Capital Costs ($)	Well AC-20 O&M Costs ($/yr)
2001			3,242,000	102,500	3,294,000	127,500	3,257,000	91,000			4,966,000	200,000		
2002				205,000		255,000		182,000				400,000	682,000	150,000
2003				205,000		255,000		182,000				400,000		150,000
2004				205,000		255,000		182,000				400,000	-	150,000
2005				205,000		255,000		182,000				400,000		150,000
2006				205,000		255,000		182,000				400,000	536,000	212,000
2007				205,000		255,000		182,000				400,000		212,000
2008				205,000		245,000		182,000				400,000		212,000
2009	426,000	45,500		205,000		235,000		182,000				400,000		212,000
2010		91,000		205,000		235,000		166,000	4,974,000	218,000		400,000		212,000
2011	1,605,000	182,000		205,000		235,000		166,000		436,000		400,000		212,000
2012		273,000		205,000		235,000		166,000		436,000		400,000		212,000
2013		273,000		205,000		235,000		166,000		436,000		400,000	4,111,000	460,000
2014		273,000		205,000		235,000		166,000		436,000		400,000		460,000
2015		273,000		205,000		117,500		166,000		436,000		400,000		460,000
2016		273,000		205,000				166,000		436,000		400,000		460,000
2017		273,000		205,000				166,000		436,000		400,000		460,000
2018		273,000		205,000				166,000		436,000		400,000		460,000
2019		273,000		205,000				166,000		436,000		400,000		460,000
2020		273,000		205,000				83,000		436,000		400,000		460,000
2021		273,000		205,000						436,000		486,000		460,000
2022		273,000		205,000						436,000		486,000		460,000
2023		273,000		205,000						436,000		486,000		460,000
2024		273,000		205,000						436,000		486,000		460,000
2025		273,000		205,000						436,000		486,000		460,000
2026		136,500		102,500						218,000		243,000		230,000

Present Worth Cost Estimate

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

	Well AC-23		Chettenham		Rockingham		Winchester		SWMD-17		GETs E/F Extract Wells	
Year	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)
2001									3,148,000	85,000	2,579,000	154,000
2002										170,000		308,000
2003										170,000		308,000
2004										170,000		308,000
2005										170,000		308,000
2006										170,000		308,000
2007										170,000		308,000
2008										170,000		308,000
2009										170,000		308,000
2010										170,000		308,000
2011										170,000		308,000
2012										170,000		308,000
2013										170,000		308,000
2014			3,382,000	252,000						170,000		308,000
2015				252,000						170,000		308,000
2016				252,000						170,000		308,000
2017				252,000			3,382,000	186,000		170,000		308,000
2018				252,000				186,000		170,000		308,000
2019				252,000				186,000		170,000		308,000
2020				252,000				186,000		170,000		308,000
2021				294,000	3,148,000	232,000		186,000		170,000		308,000
2022				294,000		232,000		186,000		170,000		308,000
2023				294,000		232,000		186,000		170,000		308,000
2024				294,000		232,000		186,000		170,000		308,000
2025				294,000		232,000		186,000		170,000		308,000
2026	4,606,000	500,000		147,000		116,000		93,000		85,000		154,000

Capital and O&M Cost Estimate for GETs E and F Extraction Wells

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Onsite Extraction Wells (year 2001)	**[4 onsite, 2 locations]**				
Surveying		1	day	1,000	1,000
Extraction wells (drilling and development)	Depth				
C	300	2	ft	550	330,000
D	400	1	ft	550	220,000
E	500	1	ft	550	275,000
Development (incl. above)		4	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		3	ea	29,000	87,000
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	3	lin ft	100	60,000
Installation (pump, wellhead, I&C)		4	LS	5,000	20,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		4	ea	2,000	8,000
Instrumentation and control/telemetry		4	ea	2,000	8,000
Subtotal - Extraction Wells (yr 2001)					1,058,000
Untreated Groundwater Piping GETs E and F to GETs E/F GWTP (year 2001)					
Surveying		2	day	1,000	2,000
Single-walled piping system (in field)					
8"		1,300	lin ft	64	83,200
10"		7,700	lin ft	80	616,000
Subtotal - Untreated Groundwater Piping (yr 2001)		9,000			701,000
Estimated Construction Costs - Subtotal (year 2001)					1,759,000
Contractor Markup, Mob/demob, Insurance			%	10	176,000
Engineering, Permitting and Construction Management			%	15	264,000
Regulatory Oversight			%	2.5	44,000
Estimated Project Capital Costs - Subtotal (year 2001)					2,243,000
Contingency			%	15	336,000
Estimated Project Capital Costs - Total (year 2001)					**2,579,000**

Preliminary Capital and O&M Cost Estimate for Water Supply Well AC-14
Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at well = historical average flow = 326 **gpm**

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	2001				
Monitor Wells	2001				
Secure permit		2	ea	100	200
Surveying		0.5	day	1,000	500
Monitor wells		2	ea	40,000	80,000
Subtotal - Monitor Wells	2001				80,700
Treatment Facilities at Wellhead	2001				
Secure easements		0	LS	5,000	0
Land purchase		0.25	acre	200,000	50,000
Surveying		0.5	day	1,000	500
Perchlorate removal via ion exchange		1	ea	980,000	980,000
Perchlorate destruction module		1	ea	805,000	805,000
UV/oxidation (KW)	16.7	1	ea	90,000	90,000
Incoming high voltage power		300	ft	20	6,000
Backup generator (not for UV)		1	ea	5,000	5,000
Electrical wiring		1	LS	10,000	10,000
Instrumentation and control		1	LS	10,000	10,000
Treatment building		600	sq ft	100	60,000
Sitework and access road		1	LS	5,000	5,000
Area lighting		1	LS	2,000	2,000
Security fencing/gates		420	lin ft	15	6,300
General contractor installation		1	LS	100,000	100,000
Subtotal - Treatment	2001				2,130,000
Estimated Construction Costs - Subtotal	2001				2,210,700
Contractor Markup, Mob/demob, Insurance			%	10	221,000
Engineering, Permitting and Construction Management			%	15	332,000
Regulatory Oversight			%	2.5	55,000
Estimated Project Capital Costs - Subtotal	2001				2,818,700
Contingency			%	15	423,000
Estimated Project Capital Costs - Total	2001				**3,242,000**

Capital and O&M Cost Estimate for GETs E and F Extraction Wells

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs: (Years 2001 to 2026)					
Extraction well maintenance		4	ea	1,000	4,000
Pipeline maintenance		1	LS	1,000	1,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,007,733	kwh	0.050	50,000
South of F	23	150,506	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
UV/oxidation			kwh	0.050	22,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement					21,000
Equip Maintenance (@ % of equip capital)		113,000	%	3	3,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Monitoring - in addition to existing GETs E/F monitoring:					
Quarterly:	# qrtrs.				
Extraction wells	4	4	ea	300	4,800
Monitor wells	4	6	ea	300	7,200
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Estimated Project O&M Costs - Subtotal					268,000
Contingency			%	15	40,000
Estimated Project O&M Costs - Total					308,000

Preliminary Capital and O&M Cost Estimate for Water Supply Well AC-14
Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at well = historical average flow = 326 **gpm**

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2001**				
Monitor Wells	**2001**				
Secure permit		2	ea	100	200
Surveying		0.5	day	1,000	500
Monitor wells		2	ea	40,000	80,000
Subtotal - Monitor Wells	2001				80,700
Treatment Facilities at Wellhead	**2001**				
Secure easements		0	LS	5,000	0
Land purchase		0.25	acre	200,000	50,000
Surveying		0.5	day	1,000	500
Perchlorate removal via ion exchange		1	ea	980,000	980,000
Perchlorate destruction module		1	ea	805,000	805,000
UV/oxidation (KW)		1	ea	90,000	90,000
Incoming high voltage power		300	ft	20	6,000
Backup generator (not for UV)		1	ea	5,000	5,000
Electrical wiring		1	LS	10,000	10,000
Instrumentation and control		1	LS	10,000	10,000
Treatment building		600	sq ft	100	60,000
Sitework and access road		1	LS	5,000	5,000
Area lighting		1	LS	2,000	2,000
Security fencing/gates		420	lin ft	15	6,300
General contractor installation		1	LS	100,000	100,000
Subtotal - Treatment	2001				2,130,000
Estimated Construction Costs - Subtotal	**2001**				2,210,700
Contractor Markup, Mob/demob, Insurance			%	10	221,000
Engineering, Permitting and Construction Management			%	15	332,000
Regulatory Oversight			%	2.5	55,000
Estimated Project Capital Costs - Subtotal	**2001**				2,818,700
Contingency			%	15	423,000
Estimated Project Capital Costs - Total	**2001**				**3,242,000**

Preliminary Capital and O&M Cost Estimate for Water Supply Well AC-14
Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at well = historical average flow = 326 gpm

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs			**(2001-2026)**			
Water supply well maintenance			1	ea	4,000	4,000
Electric utilities:						
Well pump:	(hp	49	319,485	kwh	0.050	16,000
Treatment equipment:						
UV/oxidation	(kw)		146,361	kwh	0.050	7,000
Ion exchange - ISEP facility			171,346	1,000 gal	0.020	3,400
Perchlorate destruction module (IE regeneration)			171,346	1,000 gal	0.070	12,000
Pressure drop makeup			171,346	1,000 gal	0.020	3,400
Misc. lighting and power			15,000	kwh	0.050	1,000
Chemicals						
Salt/brine			171,346	1,000 gal	0.010	1,700
Ion exchange resin			171,346	1,000 gal	0.0038	700
Ammonium			171,346	1,000 gal	0.0029	500
Catalyst			171,346	1,000 gal	0.030	5,100
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement					2,500	1,400
Waste disposal						
Brine disposal costs			171,346	1,000 gal	0.06	10,300
UV Equip Maintenance (@ 3% of equip capital)			90,000	%	3	2,700
Ion exchange maintenance labor and material			171,346	1,000 gal	0.25	42,800
Labor (incl. fringe benefits):						
Ion exchange operator labor			171,346	1,000 gal	0.13	22,000
Management oversight and reporting			0.010	yr	100,000	1,000
Monitoring:						
Quarterly:		No.				
Monitor wells		4	2	ea	500	4,000
Weekly/Monthly:						
Water supply well		1	12	ea	500	6,000
Treated water at wellhead		1	52	ea	500	26,000
Intermediate location in wellhead treatment train		1	12	ea	500	6,000
IE brine		1	12	ea	100	1,200
Estimated Project O&M Costs - Subtotal (2001-2026)						178,000
Contingency				%	15	27,000
Estimated Project O&M Costs - Total (2001-2026)						**205,000**

Present Worth Cost Estimate

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 3B Estimated Costs					Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	37,924,000	1,201,000	39,125,000	39,125,000	39,125,000	37,924,000	2,001,000	39,925,000	39,930,000	39,930,000
2002	1	0.93458	1,600,000	1,495,000	2,295,000	682,000	2,477,000	3,159,000	2,952,000	42,077,000	682,000	4,077,000	4,759,000	4,450,000	44,380,000
2003	2	0.87344	1,600,000	1,398,000	3,693,000	0	2,552,000	2,552,000	2,229,000	44,306,000	0	4,152,000	4,152,000	3,630,000	48,010,000
2004	3	0.81630	1,600,000	1,306,000	4,999,000	0	2,552,000	2,552,000	2,083,000	46,389,000	0	4,152,000	4,152,000	3,390,000	51,400,000
2005	4	0.76290	1,600,000	1,221,000	6,220,000	0	2,552,000	2,552,000	1,947,000	48,336,000	0	4,152,000	4,152,000	3,170,000	54,570,000
2006	5	0.71299	1,600,000	1,141,000	7,361,000	8,643,000	2,818,000	11,461,000	8,172,000	56,508,000	8,643,000	4,418,000	13,061,000	9,310,000	63,880,000
2007	6	0.66634	1,600,000	1,066,000	8,427,000	0	3,021,000	3,021,000	2,013,000	58,521,000	0	4,621,000	4,621,000	3,080,000	66,960,000
2008	7	0.62275	1,600,000	996,000	9,423,000	0	3,011,000	3,011,000	1,875,000	60,396,000	0	4,611,000	4,611,000	2,870,000	69,830,000
2009	8	0.58201	1,600,000	931,000	10,354,000	426,000	3,047,000	3,473,000	2,021,000	62,417,000	426,000	4,647,000	5,073,000	2,950,000	72,780,000
2010	9	0.54393	1,600,000	870,000	11,224,000	4,974,000	3,294,000	8,268,000	4,497,000	66,914,000	4,974,000	4,894,000	9,868,000	5,370,000	78,150,000
2011	10	0.50835	1,600,000	813,000	12,037,000	1,605,000	3,603,000	5,208,000	2,647,000	69,561,000	1,605,000	5,203,000	6,808,000	3,460,000	81,610,000
2012	11	0.47509	1,600,000	760,000	12,797,000	0	3,694,000	3,694,000	1,755,000	71,316,000	0	5,294,000	5,294,000	2,520,000	84,130,000
2013	12	0.44401	1,600,000	710,000	13,507,000	4,111,000	3,942,000	8,053,000	3,576,000	74,892,000	4,111,000	5,542,000	9,653,000	4,290,000	88,420,000
2014	13	0.41496	1,600,000	664,000	14,171,000	3,382,000	4,068,000	7,450,000	3,091,000	77,983,000	3,382,000	5,668,000	9,050,000	3,760,000	92,180,000
2015	14	0.38782	1,600,000	621,000	14,792,000	0	3,970,000	3,970,000	1,540,000	79,523,000	0	5,570,000	5,570,000	2,160,000	94,340,000
2016	15	0.36245	1,600,000	580,000	15,372,000	0	3,746,000	3,746,000	1,358,000	80,881,000	0	5,346,000	5,346,000	1,940,000	96,280,000
2017	16	0.33873	1,600,000	542,000	15,914,000	6,177,000	3,983,000	10,160,000	3,442,000	84,323,000	6,177,000	5,583,000	11,760,000	3,980,000	100,260,000
2018	17	0.31657	1,600,000	507,000	16,421,000	0	4,076,000	4,076,000	1,290,000	85,613,000	0	5,676,000	5,676,000	1,800,000	102,060,000
2019	18	0.29586	1,600,000	473,000	16,894,000	0	4,076,000	4,076,000	1,206,000	86,819,000	0	5,676,000	5,676,000	1,680,000	103,740,000
2020	19	0.27651	1,600,000	442,000	17,336,000	2,500,000	4,075,000	6,575,000	1,818,000	88,637,000	2,500,000	5,675,000	8,175,000	2,260,000	106,000,000
2021	20	0.25842	1,600,000	413,000	17,749,000	3,148,000	4,318,000	7,466,000	1,929,000	90,566,000	3,148,000	5,918,000	9,066,000	2,340,000	108,340,000
2022	21	0.24151	1,600,000	386,000	18,135,000	0	4,434,000	4,434,000	1,071,000	91,637,000	0	6,034,000	6,034,000	1,460,000	109,800,000
2023	22	0.22571	1,600,000	361,000	18,496,000	202,000	4,438,000	4,640,000	1,047,000	92,684,000	202,000	6,038,000	6,240,000	1,410,000	111,210,000
2024	23	0.21095	1,600,000	338,000	18,834,000	0	4,438,000	4,438,000	936,000	93,620,000	0	6,038,000	6,038,000	1,270,000	112,480,000
2025	24	0.19715	1,600,000	315,000	19,149,000	0	4,438,000	4,438,000	875,000	94,495,000	0	6,038,000	6,038,000	1,190,000	113,670,000
2026	25	0.18425	800,000	147,000	19,296,000	4,606,000	2,469,000	7,075,000	1,304,000	95,799,000	4,606,000	3,269,000	7,875,000	1,450,000	115,120,000
			Total Estimated Costs:		19,300,000	78,000,000				96,000,000	78,000,000				115,000,000

Summary of Capital and O&M Cost Estimates

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Year	Well AC-1 Capital Costs ($)	Well AC-1 O&M Costs ($/yr)	Well AC-5 Capital Costs ($)	Well AC-5 O&M Costs ($/yr)	Well AC-6 Capital Costs ($)	Well AC-6 O&M Costs ($/yr)	Well AC-7 Capital Costs ($)	Well AC-7 O&M Costs ($/yr)	Well AC-10 Capital Costs ($)	Well AC-10 O&M Costs ($/yr)	Well AC-11 Capital Costs ($)	Well AC-11 O&M Costs ($/yr)
2001			2,500,000	63,500							551,000	53,000
2002				127,000								106,000
2003				127,000								106,000
2004				127,000								106,000
2005				127,000								106,000
2006	2,514,000	37,000		127,000			3,093,000	106,500	2,500,000	60,000		106,000
2007		74,000		127,000				213,000		120,000		106,000
2008		74,000		127,000				213,000		120,000		106,000
2009		74,000		127,000				213,000		120,000		106,000
2010		74,000		127,000				213,000		120,000		106,000
2011		74,000		127,000				213,000		120,000		106,000
2012		74,000		127,000				213,000		120,000		106,000
2013		74,000		127,000				213,000		120,000		106,000
2014		74,000		127,000				213,000		120,000		106,000
2015		74,000		127,000				106,500		120,000		106,000
2016		74,000		127,000						120,000		106,000
2017		74,000		127,000						120,000	2,795,000	250,000
2018		74,000		127,000						120,000		250,000
2019		74,000		127,000						120,000		250,000
2020		74,000		127,000	2,500,000	82,000				120,000		250,000
2021		74,000		127,000		164,000				120,000		250,000
2022		74,000		127,000		164,000				120,000		250,000
2023	202,000	78,000		127,000		164,000				120,000		250,000
2024		78,000		127,000		164,000				120,000		250,000
2025		78,000		127,000		164,000				120,000		250,000
2026		39,000		63,500		82,000				60,000		125,000

Summary of Capital and O&M Cost Estimates

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Year	Well AC-13 Capital Costs ($)	Well AC-13 O&M Costs ($/yr)	Well AC-14 Capital Costs ($)	Well AC-14 O&M Costs ($/yr)	Well AC-15 Capital Costs ($)	Well AC-15 O&M Costs ($/yr)	Well AC-16 Capital Costs ($)	Well AC-16 O&M Costs ($/yr)	Well AC-18 Capital Costs ($)	Well AC-18 O&M Costs ($/yr)	Well AC-19 Capital Costs ($)	Well AC-19 O&M Costs ($/yr)	Well AC-20 Capital Costs ($)	Well AC-20 O&M Costs ($/yr)
2001			3,242,000	102,500	3,294,000	127,500	3,257,000	91,000			4,966,000	200,000		
2002				205,000		255,000		182,000				400,000	682,000	75,000
2003				205,000		255,000		182,000				400,000		150,000
2004				205,000		255,000		182,000				400,000		150,000
2005				205,000		255,000		182,000				400,000		150,000
2006				205,000		255,000		182,000				400,000	536,000	212,000
2007				205,000		255,000		182,000				400,000		212,000
2008				205,000		245,000		182,000				400,000		212,000
2009	426,000	45,500		205,000		235,000		182,000				400,000		212,000
2010		91,000		205,000		235,000		166,000	4,974,000	218,000		400,000		212,000
2011	1,605,000	182,000		205,000		235,000		166,000		436,000		400,000		212,000
2012		273,000		205,000		235,000		166,000		436,000		400,000		212,000
2013		273,000		205,000		235,000		166,000		436,000		400,000	4,111,000	460,000
2014		273,000		205,000		235,000		166,000		436,000		400,000		460,000
2015		273,000		205,000		117,500		166,000		436,000		400,000		460,000
2016		273,000		205,000				166,000		436,000		400,000		460,000
2017		273,000		205,000				166,000		436,000		400,000		460,000
2018		273,000		205,000				166,000		436,000		400,000		460,000
2019		273,000		205,000				166,000		436,000		400,000		460,000
2020		273,000		205,000				83,000		436,000		400,000		460,000
2021		273,000		205,000						436,000		486,000		460,000
2022		273,000		205,000						436,000		486,000		460,000
2023		273,000		205,000						436,000		486,000		460,000
2024		273,000		205,000						436,000		486,000		460,000
2025		273,000		205,000						436,000		486,000		460,000
2026		136,500		102,500						218,000		243,000		230,000

Summary of Capital and O&M Cost Estimates

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

	Well AC-23		Chettenham		Rockingham		Winchester		SWMD-17		GETs E/F Extract Wells	
Year	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)
2001									3,148,000	85,000	16,966,000	478,500
2002										170,000		957,000
2003										170,000		957,000
2004										170,000		957,000
2005										170,000		957,000
2006										170,000		957,000
2007										170,000		957,000
2008										170,000		957,000
2009										170,000		957,000
2010										170,000		957,000
2011										170,000		957,000
2012										170,000		957,000
2013										170,000		957,000
2014			3,382,000	126,000						170,000		957,000
2015				252,000						170,000		957,000
2016				252,000						170,000		957,000
2017				252,000			3,382,000	93,000		170,000		957,000
2018				252,000				186,000		170,000		957,000
2019				252,000				186,000		170,000		957,000
2020				252,000				186,000		170,000		957,000
2021				294,000	3,148,000	116,000		186,000		170,000		957,000
2022				294,000		232,000		186,000		170,000		957,000
2023				294,000		232,000		186,000		170,000		957,000
2024				294,000		232,000		186,000		170,000		957,000
2025				294,000		232,000		186,000		170,000		957,000
2026	4,606,000	250,000		147,000		116,000		93,000		85,000		478,500

Capital and O&M Cost Estimate for GETs E and F Extraction Wells

Alternative 3B - GETs E and F Extraction with Offsite Wellhead Treatment at Water Supply Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Onsite Extraction Wells (year 2001)	**[13 onsite, 4 locations]**				
Surveying		1	day	1,000	1,000
Extraction wells (drilling and development)	Depth				
C	300	5	ft	550	825,000
D	400	4	ft	550	880,000
E	500	4	ft	550	1,100,000
Development (incl. above)		13	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		4	ea	26,000	104,000
500 gpm, 300' TDH, 60 hp, 8" disch		9	ea	29,000	261,000
Discharge piping, 3" SS threaded	200	4	lin ft	40	32,000
Discharge piping, 8" SS threaded	200	9	lin ft	100	180,000
Installation (pump, wellhead, I&C)		13	LS	5,000	65,000
Incoming service power	4	500	ft	15	30,000
Pump control power and control		13	ea	2,000	26,000
Instrumentation and control/telemetry		13	ea	2,000	26,000
Subtotal - Extraction Wells (yr 2001)					3,530,000
Monitor Wells (year 2001)					
Secure permit		20	ea	100	1,950
Surveying		2.0	day	1,000	2,000
Monitor wells		20	ea	40,000	780,000
Subtotal - Monitor Wells (yr 2001)					783,950
Untreated Groundwater Piping GETs E and F to GETs E/F GWTP (year 2001)					
Surveying		2	day	1,000	2,000
Single-walled piping (open field)					
8"		1,300	lin ft	64	83,200
10"		9,300	lin ft	80	744,000
12"		1,900	lin ft	96	182,400
16"		700	lin ft	128	89,600
Subtotal - Untreated Groundwater Piping (yr 2001)		13,200			1,101,000
Treatment Facilities (2,225 gpm expanded capacity at Get F) [year 2001]					
Surveying		1	day	1,000	1,000
Equalization tankage	2	66,750	gal	1.00	133,500
Transfer pumping	42 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		2	ea	85,000	170,000
Offgas treatment (assumed not required)		0	ea		0
Perchlorate removal (biological reduction)	2,225 gpm	1	ea	2,869,000	2,869,000
UV/oxidation (KW)		2	ea	400,000	800,000
Transfer pumping	42 hp	3	ea	10,000	30,000
Electrical wiring		1	LS	50,000	50,000
Instrumentation and control		1	LS	50,000	50,000
Treatment building		800	sq ft	100	80,000
General contractor installation @ % of equipment		1,263,500	%	40	505,400
Subtotal - Treatment at GET F (yr 2001)					4,719,000

Capital and O&M Cost Estimate for GETs E and F Extraction Wells

Alternative 3B - GETs E and F Extraction with Offsite Wellhead Treatment at Water Supply Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treated Groundwater Piping from GET F to Discharge at Buffalo Creek (year 2001)					
Surveying		1	day	1,000	1,000
Single-walled piping system (open field)					
24"		7,400	lin ft	192	1,420,800
Monitoring manhole and facilities		1	ea	5,000	5,000
Discharge structure		1	LS	10,000	10,000
Subtotal - Treated Groundwater to Discharge		7,400			1,437,000
Estimated Construction Costs - Subtotal (year 2001)					11,571,000
Contractor Markup, Mob/demob, Insurance			%	10	1,157,000
Engineering, Permitting and Construction Management			%	15	1,736,000
Regulatory Oversight			%	2.5	289,000
Estimated Project Capital Costs - Subtotal (year 2001)					14,753,000
Contingency			%	15	2,213,000
Estimated Project Capital Costs - Total (year 2001)					**16,966,000**

Estimated Annual Operation & Maintenance Costs: (Years 2001 to 2026)

Extraction well maintenance		13	ea	1,000	13,000
Pipeline maintenance		1	LS	1,000	1,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,007,733	kwh	0.050	50,000
South of F	23	150,506	kwh	0.050	8,000
New-1	68	444,973	kwh	0.050	22,000
New-2	80	523,498	kwh	0.050	26,000
New-3	80	523,498	kwh	0.050	26,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
Air stripping	30	196,312	kwh	0.050	10,000
UV/oxidation			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps (GET F)	50	326,642	kwh	0.050	16,000
Effluent pumping - add'l 2,225 gpm to discharge	25	163,321	kwh	0.050	8,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
Perchlorate biological reduction system O&M in add'n to exist:		1	LS	255,000	255,000
UV bulb replacement				35	21,000
Equip Maintenance (@ % of equip capital)		1,415,000	%	3	42,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Monitoring - in addition to existing GETs E/F monitoring:					
Quarterly:	# qrtrs.				
Extraction wells	13	13	ea	300	50,700
Monitor wells	20	20	ea	300	114,100
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Estimated Project O&M Costs - Subtotal					832,000
Contingency			%	15	125,000
Estimated Project O&M Costs - Total					**957,000**

Capital and O&M Cost Estimate for Water Supply Well AC-19

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at each well = historical average flow = 829 gpm

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	2001				
Monitor Wells	2001				
Secure permit		2	ea	100	200
Surveying		0.5	day	1,000	500
Monitor wells		2	ea	40,000	80,000
Subtotal - Monitor Wells	2001				80,700
Treatment Facilities at Wellhead	2001				
Secure easements		1	LS	5,000	5,000
Land purchase		0.25	acre	200,000	50,000
Surveying		0.5	day	1,000	500
Perchlorate removal via ion exchange		1	ea	1,500,000	1,500,000
Perchlorate destruction module		1	ea	1,431,000	1,431,000
UV/oxidation (KW)		0	ea	90,000	0
Backup generator (not for UV)		1	ea	5,000	5,000
Electrical wiring		1	LS	20,000	20,000
Instrumentation and control		1	LS	20,000	20,000
Treatment building		600	sq ft	100	60,000
Sitework and access road		1	LS	5,000	5,000
Area lighting		1	LS	2,000	2,000
Security fencing/gates		420	lin ft	15	6,300
General contractor installation		1	LS	200,000	200,000
Subtotal - Treatment	2001				3,305,000
Estimated Construction Costs - Subtotal	2001				**3,385,700**
Contractor Markup, Mob/demob, Insurance			%	10	339,000
Engineering, Permitting and Construction Management			%	15	508,000
Regulatory Oversight			%	2.5	85,000
Estimated Project Capital Costs - Subtotal	2001				4,317,700
Contingency			%	15	648,000
Estimated Project Capital Costs - Total	2001				**4,966,000**

Capital and O&M Cost Estimate for Water Supply Well AC-19

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at each well = historical average flow = 829 **gpm**

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs		**(2001 to 2020)**			
Water supply well maintenance		1	ea	4,000	4,000
Electric utilities:					
Well pump:	124	812,433	kwh	0.050	41,000
Treatment equipment:					
Ion exchange - ISEP facility		435,722	1,000 gal	0.020	8,714
Perchlorate destruction module (IE regeneration)		435,722	1,000 gal	0.120	52,287
Pressure drop makeup		435,722	1,000 gal	0.020	8,700
Misc. lighting and power		15,000	kwh	0.050	750
Chemicals					
Salt/brine		435,722	1,000 gal	0.020	8,714
Ion exchange resin		435,722	1,000 gal	0.010	4,357
Ammonium		435,722	1,000 gal	0.0033	1,438
Catalyst		435,722	1,000 gal	0.050	21,786
Treatment equipment (besides utilities and maintenance)					
UV bulb replacement		0	30 kw bulb	2,500	0
Waste disposal					
Truck IE regen brine to central regeneration facility			round trip	200	0
Brine disposal costs		435,722	1,000 gal	0.10	43,572
Ion exchange maintenance labor and material		435,722	1,000 gal	0.19	82,787
Labor (incl. fringe benefits):					
Ion exchange operator labor		435,722	1,000 gal	0.06	26,000
Management oversight and reporting		0.010	yr	100,000	1,000
Monitoring:					
Quarterly:	No.				
Monitor wells	4	2	ea	500	4,000
Weekly/Monthly:					
Water supply well	1	12	ea	500	6,000
Treated water at wellhead	1	52	ea	500	26,000
Intermediate location in wellhead treatment train	1	12	ea	500	6,000
IE brine	1	12	ea	100	1,200
Estimated Project O&M Costs - Subtotal (2001 to 2020)					348,000
Contingency			%	15	52,000
Estimated Project O&M Costs - Total (2001 to 2020)					**400,000**

Capital and O&M Cost Estimate for Water Supply Well AC-19

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at each well = historical average flow = 829 gpm

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs		**(2021 to 2026)**			
Water supply well maintenance		1	ea	4,000	4,000
Electric utilities:					
Well pump:	124	812,433	kwh	0.050	41,000
Treatment equipment:					
Ion exchange - ISEP facility		435,722	1,000 gal	0.020	8,714
Perchlorate destruction module (IE regeneration)		435,722	1,000 gal	0.180	78,430
Pressure drop makeup		435,722	1,000 gal	0.020	8,700
Misc. lighting and power		15,000	kwh	0.050	750
Chemicals					
Salt/brine		435,722	1,000 gal	0.03	13,072
Ion exchange resin		435,722	1,000 gal	0.0082	3,573
Ammonium		435,722	1,000 gal	0.0063	2,745
Catalyst		435,722	1,000 gal	0.08	34,858
Treatment equipment (besides utilities and maintenance)					
UV bulb replacement		0	30 kw bulb	2,500	0
Waste disposal					
Brine disposal costs		435,722	1,000 gal	0.16	69,716
Ion exchange maintenance labor and material		435,722	1,000 gal	0.20	87,144
Labor (incl. fringe benefits):					
Ion exchange operator labor		435,722	1,000 gal	0.06	26,143
Management oversight and reporting		0.010	yr	100,000	1,000
Monitoring:					
Quarterly:	No.				
Monitor wells	4	2	ea	500	4,000
Weekly/Monthly:					
Water supply well	1	12	ea	500	6,000
Treated water at wellhead	1	52	ea	500	26,000
Intermediate location in wellhead treatment train	1	12	ea	500	6,000
IE brine	1	12	ea	100	1,200
Estimated Project O&M Costs - Subtotal (2021 to 2026)					423,000
Contingency			%	15	63,000
Estimated Project O&M Costs - Total (2021 to 2026)					**486,000**

Detailed Cost Estimates

Alternative 4A

Present Worth Cost Estimate

Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 4A Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	38,413,000	705,000	39,118,000	39,118,000	39,100,000	38,413,000	1,505,000	39,918,000	39,900,000	39,900,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		1,410,000	1,410,000	1,318,000	40,400,000	0	3,010,000	3,010,000	2,800,000	42,700,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,410,000	1,410,000	1,232,000	41,700,000	0	3,010,000	3,010,000	2,600,000	45,300,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,410,000	1,410,000	1,151,000	42,800,000	0	3,010,000	3,010,000	2,500,000	47,800,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,410,000	1,410,000	1,076,000	43,900,000	0	3,010,000	3,010,000	2,300,000	50,100,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,410,000	1,410,000	1,005,000	44,900,000	0	3,010,000	3,010,000	2,100,000	52,200,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,410,000	1,410,000	940,000	45,800,000	0	3,010,000	3,010,000	2,000,000	54,200,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,410,000	1,410,000	878,000	46,700,000	0	3,010,000	3,010,000	1,900,000	56,100,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,410,000	1,410,000	821,000	47,500,000	0	3,010,000	3,010,000	1,800,000	57,900,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,410,000	1,410,000	767,000	48,300,000	0	3,010,000	3,010,000	1,600,000	59,500,000
2011	10	0.50835	1,600,000	810,000	12,000,000	1,550,000	1,641,000	3,191,000	1,622,000	49,900,000	1,550,000	3,241,000	4,791,000	2,400,000	61,900,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,641,000	1,641,000	780,000	50,700,000	0	3,241,000	3,241,000	1,500,000	63,400,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,641,000	1,641,000	729,000	51,400,000	0	3,241,000	3,241,000	1,400,000	64,800,000
2014	13	0.41496	1,600,000	660,000	14,200,000		1,641,000	1,641,000	681,000	52,100,000	0	3,241,000	3,241,000	1,300,000	66,100,000
2015	14	0.38782	1,600,000	620,000	14,800,000		1,641,000	1,641,000	636,000	52,800,000	0	3,241,000	3,241,000	1,300,000	67,400,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,641,000	1,641,000	595,000	53,300,000	0	3,241,000	3,241,000	1,200,000	68,600,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,641,000	1,641,000	556,000	53,900,000	0	3,241,000	3,241,000	1,100,000	69,700,000
2018	17	0.31657	1,600,000	510,000	16,400,000		1,641,000	1,641,000	519,000	54,400,000	0	3,241,000	3,241,000	1,000,000	70,700,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,641,000	1,641,000	486,000	54,900,000	0	3,241,000	3,241,000	1,000,000	71,700,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,641,000	1,641,000	454,000	55,400,000	0	3,241,000	3,241,000	900,000	72,600,000
2021	20	0.25842	1,600,000	410,000	17,700,000	2,797,000	1,758,000	4,555,000	1,177,000	56,500,000	2,797,000	3,358,000	6,155,000	1,600,000	74,200,000
2022	21	0.24151	1,600,000	390,000	18,100,000		1,758,000	1,758,000	425,000	57,000,000	0	3,358,000	3,358,000	800,000	75,000,000
2023	22	0.22571	1,600,000	360,000	18,500,000		1,758,000	1,758,000	397,000	57,400,000	0	3,358,000	3,358,000	800,000	75,800,000
2024	23	0.21095	1,600,000	340,000	18,800,000		1,758,000	1,758,000	371,000	57,700,000	0	3,358,000	3,358,000	700,000	76,500,000
2025	24	0.19715	1,600,000	320,000	19,100,000		1,758,000	1,758,000	347,000	58,100,000	0	3,358,000	3,358,000	700,000	77,200,000
2026	25	0.18425	800,000	150,000	19,300,000		1,758,000	1,758,000	324,000	58,400,000	0	2,558,000	2,558,000	500,000	77,700,000
	Total Estimated Costs:				19,000,000	43,000,000				58,400,000	43,000,000				78,000,000

Capital Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	[13 offsite, 4 onsite in 2 locations]				
Secure easements		13	ea	2,000	26,000
Land purchase (1/8th acre ea wellhead)		1.625	acre	200,000	325,000
Surveying		6.5	day	1,000	6,500
Extraction wells - drilling and development	Depth				
C	300	14	ft	550	2,310,000
D	400	2	ft	550	440,000
E	500	1	ft	550	275,000
Wellhead vault: H-20 traffic rated		13	ea	5,000	65,000
Development (included with drilling)		17			
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		7	ea	26,000	182,000
500 gpm, 300' TDH, 60 hp, 8" disch		10	ea	29,000	290,000
Discharge piping, 3" SS threaded	200	7	lin ft	40	56,000
Discharge piping, 8" SS threaded	200	10	lin ft	100	200,000
Installation (pump, wellhead, I&C)		17	LS	5,000	85,000
Incoming service power	15	500	ft	15	112,500
Pump control power and control		17	ea	2,000	34,000
Instrumentation and control/telemetry		17	ea	2,000	34,000
Subtotal - Extraction Wells (yr 2001)					4,441,000
Monitor Wells (year 2001)					
Secure permit		20	ea	100	2,000
Surveying		10	day	1,000	10,000
Monitor wells		20	ea	40,000	800,000
Subtotal - Monitor Wells (yr 2001)					812,000
Untreated Groundwater Piping (year 2001)					
Secure easements		1	LS	100,000	100,000
Land purchase		1	acre	200,000	200,000
Surveying		20	day	1,000	20,000
Jack and bore	No.				
8" under railroad and Folsom Blvd	1	200	lin ft	160	32,000
20" under railroad	1	200	lin ft	400	80,000
20" under Sunrise Blvd	1	500	lin ft	400	200,000
20" under Folsom S. Canal	2	300	lin ft	400	240,000
Single-walled piping system (open field)					
8"		1,400	lin ft	64	89,600
10"		4,600	lin ft	80	368,000
12"			lin ft	96	0
16"			lin ft	128	0
20"		1,000	lin ft	160	160,000
24"		8,800	lin ft	192	1,689,600
30"			lin ft	240	0
Single-walled piping system (in street)					
8"		8,000	lin ft	100	800,000
10"		5,600	lin ft	140	784,000
12"		7,500	lin ft	140	1,050,000
16"		11,300	lin ft	175	1,977,500
20"		21,500	lin ft	225	4,837,500
24"			lin ft	280	0
30"			lin ft	300	0
Subtotal - Untreated Groundwater Piping (yr 2001)		69,700			12,628,000

Capital Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities (new 4,100 gpm facility at Get F) [year 2001]					
Surveying		1	day	1,000	1,000
Equalization tankage	2	136,500	gal	1.00	273,000
Transfer pumping	75 hp	4	ea	10,000	40,000
VOC removal					
Air stripping		4	ea	85,000	340,000
Offgas treatment (assumed not required)		0	ea		0
Perchlorate removal (biological reduction)	4,100 gpm	1	ea	3,780,000	3,780,000
UV/oxidation					800,000
Transfer pumping	75 hp	0	ea	10,000	0
Backup generator (not for UV)		1	ea	20,000	20,000
Electrical wiring		1	LS	150,000	150,000
Instrumentation and control		1	LS	150,000	150,000
Treatment building		1,600	sq ft	100	160,000
Sitework and access road		1	LS	10,000	10,000
Area lighting		1	LS	5,000	5,000
Security fencing/gates		1,200	lin ft	15	18,000
General contractor installation @ % of equipment		1,773,000	%	40	709,200
Subtotal - Treatment at GET F					6,456,000
Discharge Facilities (from GWTP at GET F to Buffalo Creek)					
Surveying		2.5	day	1,000	2,500
Single-walled piping system (open field)					
24"		9,600	lin ft	192	1,843,200
Monitoring manhole and facilities		1	ea	5,000	5,000
Discharge structure		1	LS	10,000	10,000
Subtotal - Discharge Facilities from GET F					1,881,000
Estimated Construction Costs - Subtotal (year 2001)					26,198,000
Contractor Markup, Mob/demob, Insurance			%	10	2,620,000
Engineering, Permitting and Construction Management			%	15	3,930,000
Regulatory Oversight			%	2.5	655,000
Estimated Project Capital Costs - Subtotal (year 2001)					33,403,000
Contingency			%	15	5,010,000
Estimated Project Capital Costs - Total (year 2001)					38,413,000

Capital Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2011)					
Extraction Wells					
Secure easements		3	ea	2,000	6,000
Land purchase (1/8th acre ea wellhead)		0.375	acre	200,000	75,000
Surveying		1.5	day	1,000	1,500
Extraction wells - drilling and development	Depth				
C	300	1	ft	550	165,000
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		3	ea	5,000	15,000
Development (included with drilling)		3			
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		3	ea	26,000	78,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	3	lin ft	40	24,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		3	LS	5,000	15,000
Incoming service power	3	500	ft	15	22,500
Pump control power and control		3	ea	2,000	6,000
Instrumentation and control/telemetry		3	ea	2,000	6,000
Subtotal - Extraction Wells					854,000
Monitor Wells					
Secure permit		5	ea	100	500
Surveying		2.5	day	1,000	2,500
Monitor wells		5	ea	40,000	200,000
Subtotal - Monitor Wells					203,000
Estimated Construction Costs - Subtotal	**2011**				1,057,000
Contractor Markup, Mob/demob, Insurance			%	10	106,000
Engineering, Permitting and Construction Management			%	15	159,000
Regulatory Oversight			%	2.5	26,000
Estimated Project Capital Costs - Subtotal	**2011**				1,348,000
Contingency			%	15	202,000
Estimated Project Capital Costs - Total	**2011**				**1,550,000**

Capital Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2021)					
Extraction Wells					
Secure easements		5	ea	2,000	10,000
Land purchase (1/8th acre ea wellhead)		0.625	acre	200,000	125,000
Surveying		2.5	day	1,000	2,500
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	4	ft	550	880,000
E	500	1	ft	550	275,000
Wellhead vault: H-20 traffic rated		5	ea	5,000	25,000
Development (included with drilling)		5			
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		5	ea	26,000	130,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	4	lin ft	40	32,000
Discharge piping, 8" SS threaded	200	1	lin ft	100	20,000
Installation (pump, wellhead, I&C)		5	LS	5,000	25,000
Incoming service power	5	500	ft	15	37,500
Pump control power and control		5	ea	2,000	10,000
Instrumentation and control/telemetry		5	ea	2,000	10,000
Subtotal - Extraction Wells					1,582,000
Monitor Wells					
Secure permit		8	ea	100	800
Surveying		4	day	1,000	4,000
Monitor wells		8	ea	40,000	320,000
Subtotal - Monitor Wells					324,800
Estimated Construction Costs - Subtotal	**2021**				1,906,800
Contractor Markup, Mob/demob, Insurance			%	10	191,000
Engineering, Permitting and Construction Management			%	15	286,000
Regulatory Oversight			%	2.5	48,000
Estimated Project Capital Costs - Subtotal	**2021**				2,431,800
Contingency			%	15	365,000
Estimated Project Capital Costs - Total	**2021**				**2,797,000**

Operation and Maintenance Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**				
Extraction well maintenance			17	ea	1,000	17,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		37	245,004	kwh	0.050	12,000
C2		47	306,255	kwh	0.050	15,000
C3		37	245,004	kwh	0.050	12,000
C4		28	183,753	kwh	0.050	9,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		19	122,502	kwh	0.050	6,000
C8		19	122,502	kwh	0.050	6,000
C9		9	61,251	kwh	0.050	3,000
C10		28	183,753	kwh	0.050	9,000
C11		28	183,753	kwh	0.050	9,000
C12		28	183,753	kwh	0.050	9,000
C13		28	183,753	kwh	0.050	9,000
D1		25	161,703	kwh	0.050	8,000
D2		0	0	kwh	0.050	0
D3		0	0	kwh	0.050	0
D4		0	0	kwh	0.050	0
D5		0	0	kwh	0.050	0
D6		0	0	kwh	0.050	0
D7		0	0	kwh	0.050	0
D8		0	0	kwh	0.050	0
D9		0	0	kwh	0.050	0
D10		0	0	kwh	0.050	0
E1		0	0	kwh	0.050	0
E2		0	0	kwh	0.050	0
E3		0	0	kwh	0.050	0
New GET E containment extraction well		154	1,004,516	kwh	0.050	50,000
New GET F containment extraction well		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping	hp:	60	392,623	kwh	0.050	19,600
UV/oxidation	kw:			kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
VPGAC booster fans				kwh	0.050	0
Intermediate transfer pumps (GET F)		127	831,898	kwh	0.050	42,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf		0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Acid				gal		0
Base				gal		0
Carbon dioxide				ccf		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)						21,000
Perchlorate biological reduction system O&M			1	LS	574,000	574,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. below)				lb		0
Equip Maintenance (@ % of equip capital)			1,856,000	%	3	56,000
Labor (incl. fringe benefits):						
Operator labor (assume 1 FTE in bio. red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	17	ea	300	20,400
Monitor wells		4	20	ea	300	24,000
PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2001						1,226,000
Contingency				%	15	184,000
Estimated Project O&M Costs - Total Year 2001						1,410,000

Operation and Maintenance Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2015**				
Extraction well maintenance			20	ea	1,000	20,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		37	245,004	kwh	0.050	12,000
C2		47	306,255	kwh	0.050	15,000
C3		37	245,004	kwh	0.050	12,000
C4		28	183,753	kwh	0.050	9,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		19	122,502	kwh	0.050	6,000
C8		19	122,502	kwh	0.050	6,000
C9		9	61,251	kwh	0.050	3,000
C10		28	183,753	kwh	0.050	9,000
C11		28	183,753	kwh	0.050	9,000
C12		28	183,753	kwh	0.050	9,000
C13		28	183,753	kwh	0.050	9,000
D1		25	161,703	kwh	0.050	8,000
D2			0	kwh	0.050	0
D3			0	kwh	0.050	0
D4			0	kwh	0.050	0
D5		25	161,703	kwh	0.050	8,000
D6			0	kwh	0.050	0
D7			0	kwh	0.050	0
D8		25	161,703	kwh	0.050	8,000
D9		25	161,703	kwh	0.050	8,000
D10		25	161,703	kwh	0.050	8,000
E1		77	502,258	kwh	0.050	25,000
E2		77	502,258	kwh	0.050	25,000
E3		77	502,258	kwh	0.050	25,000
New GET E containment extraction well		154	1,004,516	kwh	0.050	50,000
New GET F containment extraction well		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	19,600
UV/oxidation	kw:			kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
VPGAC booster fans				kwh	0.050	0
Intermediate transfer pumps (GET F)		154	1,003,171	kwh	0.050	50,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system (assumed not required)				ccf		0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Acid				gal		0
Base				gal		0
Carbon dioxide				ccf		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)						21,000
Perchlorate biological reduction system O&M			1	LS	653,000	653,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. below)				lb		0
Equip Maintenance (@ % of equip capital)			1,856,000	%	3	56,000
Labor (incl. fringe benefits):						
Operator labor (assume 1 FTE in bio. red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	20	ea	300	24,000
Monitor wells		4	20	ea	300	24,000
PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2015						1,427,000
Contingency				%	15	214,000
Estimated Project O&M Costs - Total Year 2015						**1,641,000**

Detailed Cost Estimates

Alternative 4B

Present Worth Cost Estimate

Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 4B Estimated Costs					Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	35,900,000	824,500	36,724,500	36,725,000	37,000,000	35,900,000	1,624,500	37,524,500	37,500,000	37,500,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		1,708,000	1,708,000	1,596,000	38,000,000	0	3,308,000	3,308,000	3,100,000	40,600,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,708,000	1,708,000	1,492,000	40,000,000	0	3,308,000	3,308,000	2,900,000	43,500,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,708,000	1,708,000	1,394,000	41,000,000	0	3,308,000	3,308,000	2,700,000	46,200,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,708,000	1,708,000	1,303,000	43,000,000	0	3,308,000	3,308,000	2,500,000	48,700,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,708,000	1,708,000	1,218,000	44,000,000	0	3,308,000	3,308,000	2,400,000	51,100,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,708,000	1,708,000	1,138,000	45,000,000	0	3,308,000	3,308,000	2,200,000	53,300,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,708,000	1,708,000	1,064,000	46,000,000	0	3,308,000	3,308,000	2,100,000	55,400,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,708,000	1,708,000	994,000	47,000,000	0	3,308,000	3,308,000	1,900,000	57,300,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,708,000	1,708,000	929,000	48,000,000	0	3,308,000	3,308,000	1,800,000	59,100,000
2011	10	0.50835	1,600,000	810,000	12,000,000	1,066,000	1,796,000	2,862,000	1,455,000	49,000,000	1,066,000	3,396,000	4,462,000	2,300,000	61,400,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,796,000	1,796,000	853,000	50,000,000	0	3,396,000	3,396,000	1,600,000	63,000,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,796,000	1,796,000	797,000	51,000,000	0	3,396,000	3,396,000	1,500,000	64,500,000
2014	13	0.41496	1,600,000	660,000	14,200,000		1,796,000	1,796,000	745,000	52,000,000	0	3,396,000	3,396,000	1,400,000	65,900,000
2015	14	0.38782	1,600,000	620,000	14,800,000		1,796,000	1,796,000	697,000	52,000,000	0	3,396,000	3,396,000	1,300,000	67,200,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,796,000	1,796,000	651,000	53,000,000	0	3,396,000	3,396,000	1,200,000	68,400,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,796,000	1,796,000	608,000	54,000,000	0	3,396,000	3,396,000	1,200,000	69,600,000
2018	17	0.31657	1,600,000	510,000	16,400,000		1,796,000	1,796,000	569,000	54,000,000	0	3,396,000	3,396,000	1,100,000	70,700,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,796,000	1,796,000	531,000	55,000,000	0	3,396,000	3,396,000	1,000,000	71,700,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,796,000	1,796,000	497,000	55,000,000	0	3,396,000	3,396,000	900,000	72,600,000
2021	20	0.25842	1,600,000	410,000	17,700,000	1,066,000	1,855,000	2,921,000	755,000	56,000,000	1,066,000	3,455,000	4,521,000	1,200,000	73,800,000
2022	21	0.24151	1,600,000	390,000	18,100,000		1,803,000	1,803,000	435,000	56,000,000	0	3,403,000	3,403,000	800,000	74,600,000
2023	22	0.22571	1,600,000	360,000	18,500,000		1,803,000	1,803,000	407,000	57,000,000	0	3,403,000	3,403,000	800,000	75,400,000
2024	23	0.21095	1,600,000	340,000	18,800,000		1,803,000	1,803,000	380,000	57,000,000	0	3,403,000	3,403,000	700,000	76,100,000
2025	24	0.19715	1,600,000	320,000	19,100,000		1,803,000	1,803,000	355,000	58,000,000	0	3,403,000	3,403,000	700,000	76,800,000
2026	25	0.18425	800,000	150,000	19,300,000		901,500	901,500	166,000	58,000,000	0	1,701,500	1,701,500	300,000	77,100,000
	Total Estimated Costs:				19,000,000	38,000,000				58,000,000	38,000,000		122,000,000		77,000,000

Capital Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	**[10 offsite; 13 onsite in 5 locations]**				
Secure easements		10	ea	2,000	20,000
Land purchase (1/8th acre ea wellhead)		1.250	acre	200,000	250,000
Surveying		5.0	day	1,000	5,000
Extraction wells - drilling and development	Depth				
C	300	15	ft	550	2,475,000
D	400	4	ft	550	880,000
E	500	4	ft	550	1,100,000
Wellhead vault: H-20 traffic rated		10	ea	5,000	50,000
Development (included with drilling)		23	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		9	ea	26,000	234,000
500 gpm, 300' TDH, 60 hp, 8" disch		14	ea	29,000	406,000
Discharge piping, 3" SS threaded	200	9	lin ft	40	72,000
Discharge piping, 8" SS threaded	200	14	lin ft	100	280,000
Installation (pump, wellhead, I&C)		23	LS	5,000	115,000
Incoming service power	15	500	ft	15	112,500
Pump control power and control		23	ea	2,000	46,000
Instrumentation and control/telemetry		15	ea	2,000	30,000
Subtotal - Extraction Wells (yr 2001)					6,076,000
Monitor Wells (year 2001)					
Secure permit		15	ea	100	1,500
Surveying		1.88	day	1,000	1,875
Monitor wells		15	ea	40,000	600,000
Subtotal - Monitor Wells (yr 2001)					603,000
Untreated Groundwater Piping (year 2001)					
Secure easements		1	LS	100,000	100,000
Land purchase		1	acre	200,000	200,000
Surveying		20	day	1,000	20,000
Jack and bore					
10" under railroad and Folsom Blvd	0	200	lin ft	150	0
12" under railroad and Folsom Blvd	1	200	lin ft	240	48,000
8" under Sunrise Blvd	0	500	lin ft	120	0
16" under Hwy 50	1	500	lin ft	320	160,000
16" under Folsom S. Canal	0	300	lin ft	240	0
20" under Folsom S. Canal	1	300	lin ft	400	120,000
Single-walled piping system (open field)					
8"			lin ft	64	0
10"		9,300	lin ft	80	744,000
12"		3,200	lin ft	96	307,200
16"		700	lin ft	128	89,600
20"		5,000	lin ft	160	800,000
24"			lin ft	192	0
30"			lin ft	240	0
Single-walled piping system (in street)					
6"			lin ft	100	0
8"		18,000	lin ft	100	1,800,000
10"		2,500	lin ft	140	350,000
12"		1,400	lin ft	140	196,000
16"		5,300	lin ft	175	927,500
20"		13,700	lin ft	225	3,082,500
30"			lin ft	300	0
Subtotal - Untreated Groundwater Piping (yr 2001)		59,100			8,945,000

Capital Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities (new 5,325 gpm facility [in addition to existing 4,000 gpm] at Get F) [year 2001]						
Secure easements			0	LS	5,000	0
Land purchase			0	acre	200,000	0
Surveying			1	day	1,000	1,000
Equalization tankage		2	159,750	gal	1.00	319,500
Transfer pumping	hp:	55	3	ea	10,000	30,000
VOC removal						
Air stripping			4	ea	85,000	340,000
Offgas treatment			0	ea	1,000,000	0
pH adjustment			0	ea		0
Transfer pumping			0	ea	10,000	0
Perchlorate removal (biological reduction)		5,325 gpm	1	ea	4,250,000	4,250,000
Regenerant bioreduction plant, incl. general contractor			0	ea		0
Chemical feed facilities			0	ea		0
UV/oxidation			2	ea	400,000	800,000
Transfer pumping	hp:	55	3	ea	10,000	30,000
Filtration and backwash facilities			0	ea		0
Liquid phase GAC contactors			0	ea		0
Disinfection, if necessary			0	ea		0
Transfer pumping			0	ea	10,000	0
Incoming high voltage power			0	ft	20	0
Backup generator (not for UV)			1	ea	50,000	50,000
Electrical wiring			1	LS	100,000	100,000
Instrumentation and control			1	LS	150,000	150,000
Treatment building			1,600	sq ft	100	160,000
Sitework and access road			1	LS	10,000	10,000
Area lighting			1	LS	5,000	5,000
Security fencing/gates			1,200	lin ft	15	18,000
General contractor installation @ % of equipment			1,819,500	%	40	727,800
Subtotal - Treatment at GET F (yr 2001)						6,991,000
Discharge Facilities (from 9,325 gpm GWTP at GET F to Buffalo Creek) [yr 2001]						
Surveying			2.5	day	1,000	2,500
Single-walled piping system (open field)						
30"			7,700	lin ft	240	1,848,000
Monitoring manhole and facilities			1	ea	5,000	5,000
Discharge structure			1	LS	10,000	10,000
Subtotal - Discharge Facilities from GET F (yr 2001)						1,866,000
Estimated Construction Costs - Subtotal (year 2001)						24,481,000
Contractor Markup, Mob/demob, Insurance				%	10	2,448,000
Engineering, Permitting and Construction Management				%	15	3,672,000
Regulatory Oversight				%	2.5	612,000
Estimated Project Capital Costs - Subtotal (year 2001)						31,213,000
Contingency				%	15	4,682,000
Estimated Project Capital Costs - Total (year 2001)						**35,900,000**

Capital Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**(mid 2011)**				
Extraction Wells					
Secure easements		2	ea	2,000	4,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		2	ea	5,000	10,000
Development (included with drilling)		2	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		2	ea	26,000	52,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	2	lin ft	40	16,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		2	LS	5,000	10,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		2	ea	2,000	4,000
Instrumentation and control/telemetry		2	ea	2,000	4,000
Subtotal - Extraction Wells					606,000
Monitor Wells					
Secure permit		3	ea	100	300
Surveying		0.38	day	1,000	375
Monitor wells		3	ea	40,000	120,000
Subtotal - Monitor Wells					121,000
Estimated Construction Costs - Subtotal (mid 2011)					727,000
Contractor Markup, Mob/demob, Insurance			%	10	73,000
Engineering, Permitting and Construction Management			%	15	109,000
Regulatory Oversight			%	2.5	18,000
Estimated Project Capital Costs - Subtotal (mid 2011)					927,000
Contingency			%	15	139,000
Estimated Project Capital Costs - Total (mid 2011)					**1,066,000**

Capital Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	(mid 2021)				
Extraction Wells					
Secure easements		2	ea	2,000	4,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		2	ea	5,000	10,000
Development (included with drilling)		2	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		2	ea	26,000	52,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	2	lin ft	40	16,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		2	LS	5,000	10,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		2	ea	2,000	4,000
Instrumentation and control/telemetry		2	ea	2,000	4,000
Subtotal - Extraction Wells					606,000
Monitor Wells (year 2001)					
Secure permit		3	ea	100	300
Surveying		0.50	day	1,000	500
Monitor wells		3	ea	40,000	120,000
Subtotal - Monitor Wells	(mid 2021)				121,000
Estimated Construction Costs - Subtotal					**727,000**
Contractor Markup, Mob/demob, Insurance			%	10	73,000
Engineering, Permitting and Construction Management			%	15	109,000
Regulatory Oversight			%	2.5	18,000
Estimated Project Capital Costs - Subtotal	**(mid 2021)**				927,000
Contingency			%	15	139,000
Estimated Project Capital Costs - Total	**(mid 2021)**				**1,066,000**

Operation and Maintenance Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**				
Extraction well maintenance			23	ea	1,000	23,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		28	183,753	kwh	0.050	9,000
C2		37	245,004	kwh	0.050	12,000
C3		37	245,004	kwh	0.050	12,000
C4		28	183,753	kwh	0.050	9,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		19	122,502	kwh	0.050	6,000
C8		19	122,502	kwh	0.050	6,000
C9		19	122,502	kwh	0.050	6,000
C10		28	183,753	kwh	0.050	9,000
D1			0	kwh	0.050	0
D2			0	kwh	0.050	0
D3			0	kwh	0.050	0
D4			0	kwh	0.050	0
D5			0	kwh	0.050	0
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)	hp:	111	723,017	kwh	0.050	36,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	715,000	715,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,070,000	%	3	62,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	23	ea	300	27,600
Monitor wells		4	35	ea	300	41,400
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2001						1,434,000
Contingency				%	15	215,000
Estimated Project O&M Costs - Total Year 2001						**1,649,000**

Operation and Maintenance Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2015**				
Extraction well maintenance			25	ea	1,000	25,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		28	183,753	kwh	0.050	9,000
C2		37	245,004	kwh	0.050	12,000
C3		37	245,004	kwh	0.050	12,000
C4		28	183,753	kwh	0.050	9,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		19	122,502	kwh	0.050	6,000
C8		19	122,502	kwh	0.050	6,000
C9		19	122,502	kwh	0.050	6,000
C10		28	183,753	kwh	0.050	9,000
D1		25	161,703	kwh	0.050	8,000
D2			0	kwh	0.050	0
D3			0	kwh	0.050	0
D4			0	kwh	0.050	0
D5		25	161,703	kwh	0.050	8,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		111	723,017	kwh	0.050	36,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	768,000	768,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,070,000	%	3	62,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	25	ea	300	30,000
Monitor wells		4	38	ea	300	45,000
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2015						1,562,000
Contingency				%	15	234,000
Estimated Project O&M Costs - Total Year 2015						**1,796,000**

Operation and Maintenance Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2026**				
Extraction well maintenance			27	ea	1,000	27,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		28	183,753	kwh	0.050	9,000
C2		37	245,004	kwh	0.050	12,000
C3		37	245,004	kwh	0.050	12,000
C4		28	183,753	kwh	0.050	9,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		19	122,502	kwh	0.050	6,000
C8		19	122,502	kwh	0.050	6,000
C9		19	122,502	kwh	0.050	6,000
C10		28	183,753	kwh	0.050	9,000
D1		25	161,703	kwh	0.050	8,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4			0	kwh	0.050	0
D5		25	161,703	kwh	0.050	8,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		111	723,017	kwh	0.050	36,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	750,000	750,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,070,000	%	3	62,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	27	ea	300	32,400
Monitor wells		4	41	ea	300	49,600
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2026						1,568,000
Contingency				%	15	235,000
Estimated Project O&M Costs - Total Year 2026						**1,803,000**

Detailed Cost Estimates

Alternative 4C

Present Worth Cost Estimate

Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

			Existing GETs E/F Estimated Costs			Additional Alternative 4C Estimated Costs					Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	41,260,000	974,500	42,234,500	42,235,000	42,200,000	41,260,000	1,774,500	43,034,500	43,000,000	43,000,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		1,949,000	1,949,000	1,821,000	44,100,000	0	3,549,000	3,549,000	3,300,000	46,300,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,949,000	1,949,000	1,702,000	45,800,000	0	3,549,000	3,549,000	3,100,000	49,400,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,949,000	1,949,000	1,591,000	47,300,000	0	3,549,000	3,549,000	2,900,000	52,300,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,949,000	1,949,000	1,487,000	48,800,000	0	3,549,000	3,549,000	2,700,000	55,000,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,949,000	1,949,000	1,390,000	50,200,000	0	3,549,000	3,549,000	2,500,000	57,500,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,949,000	1,949,000	1,299,000	51,500,000	0	3,549,000	3,549,000	2,400,000	59,900,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,949,000	1,949,000	1,214,000	52,700,000	0	3,549,000	3,549,000	2,200,000	62,100,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,949,000	1,949,000	1,134,000	53,900,000	0	3,549,000	3,549,000	2,100,000	64,200,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,949,000	1,949,000	1,060,000	54,900,000	0	3,549,000	3,549,000	1,900,000	66,100,000
2011	10	0.50835	1,600,000	810,000	12,000,000	573,000	1,994,000	2,567,000	1,305,000	56,200,000	573,000	3,594,000	4,167,000	2,100,000	68,200,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,994,000	1,994,000	947,000	57,200,000	0	3,594,000	3,594,000	1,700,000	69,900,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,994,000	1,994,000	885,000	58,100,000	0	3,594,000	3,594,000	1,600,000	71,500,000
2014	13	0.41498	1,600,000	660,000	14,200,000		1,994,000	1,994,000	827,000	58,900,000	0	3,594,000	3,594,000	1,500,000	73,000,000
2015	14	0.38782	1,600,000	620,000	14,800,000		1,994,000	1,994,000	773,000	59,700,000	0	3,594,000	3,594,000	1,400,000	74,400,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,994,000	1,994,000	723,000	60,400,000	0	3,594,000	3,594,000	1,300,000	75,700,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,994,000	1,994,000	675,000	61,100,000	0	3,594,000	3,594,000	1,200,000	76,900,000
2018	17	0.31657	1,600,000	510,000	16,400,000		1,994,000	1,994,000	631,000	61,700,000	0	3,594,000	3,594,000	1,100,000	78,000,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,994,000	1,994,000	590,000	62,300,000	0	3,594,000	3,594,000	1,100,000	79,100,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,994,000	1,994,000	551,000	62,800,000	0	3,594,000	3,594,000	1,000,000	80,100,000
2021	20	0.25842	1,600,000	410,000	17,700,000	573,000	2,008,000	2,581,000	667,000	63,500,000	573,000	3,608,000	4,181,000	1,100,000	81,200,000
2022	21	0.24151	1,600,000	390,000	18,100,000		1,970,000	1,970,000	476,000	64,000,000	0	3,570,000	3,570,000	900,000	82,100,000
2023	22	0.22571	1,600,000	360,000	18,500,000		1,970,000	1,970,000	445,000	64,400,000	0	3,570,000	3,570,000	800,000	82,900,000
2024	23	0.21095	1,600,000	340,000	18,800,000		1,970,000	1,970,000	416,000	64,800,000	0	3,570,000	3,570,000	800,000	83,700,000
2025	24	0.19715	1,600,000	320,000	19,100,000		1,970,000	1,970,000	388,000	65,200,000	0	3,570,000	3,570,000	700,000	84,400,000
2026	25	0.18425	800,000	150,000	19,300,000		985,000	985,000	181,000	65,400,000	0	1,785,000	1,785,000	300,000	84,700,000
	Total Estimated Costs:				19,000,000	42,000,000				65,400,000	42,000,000		131,734,500		85,000,000

Capital Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	**[16 offsite; 13 onsite in 5 locations]**				
Secure easements		16	ea	2,000	32,000
Land purchase (1/8th acre ea wellhead)		2.000	acre	200,000	400,000
Surveying		8.0	day	1,000	8,000
Extraction wells - drilling and development	Depth				
C	300	15	ft	550	2,475,000
D	400	8	ft	550	1,760,000
E	500	6	ft	550	1,650,000
Wellhead vault: H-20 traffic rated		16	ea	5,000	80,000
Development (included with drilling)		29	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		12	ea	26,000	312,000
500 gpm, 300' TDH, 60 hp, 8" disch		17	ea	29,000	493,000
Discharge piping, 3" SS threaded	200	12	lin ft	40	96,000
Discharge piping, 8" SS threaded	200	17	lin ft	100	340,000
Installation (pump, wellhead, I&C)		29	LS	5,000	145,000
Incoming service power	21	500	ft	15	157,500
Pump control power and control		29	ea	2,000	58,000
Instrumentation and control/telemetry		21	ea	2,000	42,000
Subtotal - Extraction Wells (yr 2001)					8,049,000
Monitor Wells (year 2001)					
Secure permit		24	ea	100	2,400
Surveying		3.00	day	1,000	3,000
Monitor wells		24	ea	40,000	960,000
Subtotal - Monitor Wells (yr 2001)					965,000
Untreated Groundwater Piping (year 2001)					
Secure easements		1	LS	100,000	100,000
Land purchase		1	acre	200,000	200,000
Surveying		20	day	1,000	20,000
Jack and bore					
8" under railroad and Folsom Blvd	1	200	lin ft	160	32,000
8" under Hwy 50	1	500	lin ft	160	80,000
20" under Folsom S. Canal	1	300	lin ft	400	120,000
10" under railroad and Folsom Blvd	1	200	lin ft	200	40,000
10" under RR	1	200	lin ft	200	40,000
8" under Sunrise Blvd	1	300	lin ft	160	48,000
Single-walled piping system (open field)					
8"		900	lin ft	64	57,600
10"		9,000	lin ft	80	720,000
12"		2,000	lin ft	96	192,000
16"			lin ft	128	0
20"		4,800	lin ft	160	768,000
24"			lin ft	192	0
30"			lin ft	240	0
Single-walled piping system (in street)					
6"			lin ft	100	0
8"		31,600	lin ft	100	3,160,000
10"		7,000	lin ft	140	980,000
12"		1,700	lin ft	140	238,000
16"		8,300	lin ft	175	1,452,500
20"		4,500	lin ft	225	1,012,500
30"			lin ft	300	0
Subtotal - Untreated Groundwater Piping (yr 2001)		69,800			9,261,000

Capital Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities (new 6,175 gpm facility [in addition to existing 4,000 gpm] at Get F) [year 2001]						
Secure easements			0	LS	5,000	0
Land purchase			0	acre	200,000	0
Surveying			1	day	1,000	1,000
Equalization tankage		2	198,750	gal	1.00	397,500
Transfer pumping	hp:	67	3	ea	15,000	45,000
VOC removal						
Air stripping			4	ea	100,000	400,000
Offgas treatment			0	ea	1,000,000	0
pH adjustment			0	ea		0
Transfer pumping			0	ea	10,000	0
Perchlorate removal (biological reduction)		6,175 gpm	1	ea	4,660,000	4,660,000
Regenerant bioreduction plant, incl. general contractor			0	ea		0
Chemical feed facilities			0	ea		0
UV/oxidation			2	ea	400,000	800,000
Transfer pumping	hp:	67	3	ea	15,000	45,000
Filtration and backwash facilities			0	ea		0
Liquid phase GAC contactors			0	ea		0
Disinfection, if necessary			0	ea		0
Transfer pumping			0	ea	10,000	0
Incoming high voltage power			0	ft	20	0
Backup generator (not for UV)			1	ea	50,000	50,000
Electrical wiring			1	LS	200,000	200,000
Instrumentation and control			1	LS	250,000	250,000
Treatment building			2,400	sq ft	100	240,000
Sitework and access road			1	LS	10,000	10,000
Area lighting			1	LS	5,000	5,000
Security fencing/gates			1,200	lin ft	15	18,000
General contractor installation @ % of equipment			2,187,500	%	40	875,000
Subtotal - Treatment at GET F (yr 2001)						7,997,000
Discharge Facilities (from GWTP at GET F to Buffalo Creek) [yr 2001]						
Surveying			2.5	day	1,000	2,500
Single-walled piping system (open field)						
30"			7,700	lin ft	240	1,848,000
Monitoring manhole and facilities			1	ea	5,000	5,000
Discharge structure			1	LS	10,000	10,000
Subtotal - Discharge Facilities from GET F (yr 2001)						1,866,000
Estimated Construction Costs - Subtotal (year 2001)						28,138,000
Contractor Markup, Mob/demob, Insurance				%	10	2,814,000
Engineering, Permitting and Construction Management				%	15	4,221,000
Regulatory Oversight				%	2.5	703,000
Estimated Project Capital Costs - Subtotal (year 2001)						35,876,000
Contingency				%	15	5,381,000
Estimated Project Capital Costs - Total (year 2001)						**41,260,000**

Capital Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**(mid 2011)**				
Extraction Wells					
Secure easements		1	ea	2,000	2,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	1	ft	550	220,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		1	ea	5,000	5,000
Development (included with drilling)		1	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		1	LS	5,000	5,000
Incoming service power	1	500	ft	15	7,500
Pump control power and control		1	ea	2,000	2,000
Instrumentation and control/telemetry		1	ea	2,000	2,000
Subtotal - Extraction Wells					329,000
Monitor Wells					
Secure permit		2	ea	100	150
Surveying		0.50	day	1,000	500
Monitor wells		2	ea	40,000	60,000
Subtotal - Monitor Wells					61,000
Estimated Construction Costs - Subtotal (mid 2011)					390,000
Contractor Markup, Mob/demob, Insurance			%	10	39,000
Engineering, Permitting and Construction Management			%	15	59,000
Regulatory Oversight			%	2.5	10,000
Estimated Project Capital Costs - Subtotal (mid 2011)					498,000
Contingency			%	15	75,000
Estimated Project Capital Costs - Total (mid 2011)					**573,000**

Capital Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**(mid 2021)**				
Extraction Wells					
Secure easements		1	ea	2,000	2,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	1	ft	550	220,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		1	ea	5,000	5,000
Development (included with drilling)		1	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		1	LS	5,000	5,000
Incoming service power	1	500	ft	15	7,500
Pump control power and control		1	ea	2,000	2,000
Instrumentation and control/telemetry		1	ea	2,000	2,000
Subtotal - Extraction Wells					329,000
Monitor Wells (year 2001)					
Secure permit		2	ea	100	150
Surveying		0.50	day	1,000	500
Monitor wells		2	ea	40,000	60,000
Subtotal - Monitor Wells	(mid 2021)				61,000
Estimated Construction Costs - Subtotal					**390,000**
Contractor Markup, Mob/demob, Insurance			%	10	39,000
Engineering, Permitting and Construction Management			%	15	59,000
Regulatory Oversight			%	2.5	10,000
Estimated Project Capital Costs - Subtotal	**(mid 2021)**				498,000
Contingency			%	15	75,000
Estimated Project Capital Costs - Total	**(mid 2021)**				**573,000**

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**				
Extraction well maintenance			29	ea	1,000	29,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		19	122,502	kwh	0.050	6,000
C2		33	214,378	kwh	0.050	11,000
C3		28	183,753	kwh	0.050	9,000
C4		19	122,502	kwh	0.050	6,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		9	61,251	kwh	0.050	3,000
C8		19	122,502	kwh	0.050	6,000
C9		28	183,753	kwh	0.050	9,000
C10		33	214,378	kwh	0.050	11,000
D1		19	121,277	kwh	0.050	6,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4		25	161,703	kwh	0.050	8,000
D5			0	kwh	0.050	0
D6			0	kwh	0.050	0
E1		46	301,355	kwh	0.050	15,000
E2		46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,833	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,833	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)	hp:	134	877,163	kwh	0.050	44,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	803,000	803,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,437,000	%	3	73,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.5	yr	54,000	81,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	29	ea	300	34,800
Monitor wells		4	44	ea	300	52,200
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2001						1,695,000
Contingency				%	15	254,000
Estimated Project O&M Costs - Total Year 2001						**1,949,000**

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells
with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2015**				
Extraction well maintenance			30	ea	1,000	30,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		19	122,502	kwh	0.050	6,000
C2		33	214,378	kwh	0.050	11,000
C3		28	183,753	kwh	0.050	9,000
C4		19	122,502	kwh	0.050	6,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		9	61,251	kwh	0.050	3,000
C8		19	122,502	kwh	0.050	6,000
C9		28	183,753	kwh	0.050	9,000
C10		33	214,378	kwh	0.050	11,000
D1		19	121,277	kwh	0.050	6,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4		25	161,703	kwh	0.050	8,000
D5		25	161,703	kwh	0.050	8,000
D6			0	kwh	0.050	0
E1		46	301,355	kwh	0.050	15,000
E2		46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		134	877,163	kwh	0.050	44,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	830,000	830,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,437,000	%	3	73,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.5	yr	54,000	81,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	30	ea	300	36,000
Monitor wells		4	45	ea	300	54,000
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2015						1,734,000
Contingency				%	15	260,000
Estimated Project O&M Costs - Total Year 2015						**1,994,800**

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2021**				
Extraction well maintenance			31	ea	1,000	31,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		19	122,502	kwh	0.050	6,000
C2		33	214,378	kwh	0.050	11,000
C3		28	183,753	kwh	0.050	9,000
C4		19	122,502	kwh	0.050	6,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		9	61,251	kwh	0.050	3,000
C8		19	122,502	kwh	0.050	6,000
C9		28	183,753	kwh	0.050	9,000
C10		33	214,378	kwh	0.050	11,000
D1		19	121,277	kwh	0.050	6,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4		25	161,703	kwh	0.050	8,000
D5		25	161,703	kwh	0.050	8,000
D6		25	161,703	kwh	0.050	8,000
E1		46	301,355	kwh	0.050	15,000
E2		46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		134	877,163	kwh	0.050	44,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	830,000	830,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,437,000	%	3	73,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.5	yr	54,000	81,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	31	ea	300	37,200
Monitor wells		4	47	ea	300	55,800
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2021						1,746,000
Contingency				%	15	262,000
Estimated Project O&M Costs - Total Year 2021						**2,008,000**

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells
with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2022**				
Extraction well maintenance			30	ea	1,000	30,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		19	122,502	kwh	0.050	6,000
C2		33	214,378	kwh	0.050	11,000
C3		28	183,753	kwh	0.050	9,000
C4		19	122,502	kwh	0.050	6,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		9	61,251	kwh	0.050	3,000
C8		19	122,502	kwh	0.050	6,000
C9		28	183,753	kwh	0.050	9,000
C10			0	kwh	0.050	0
D1		19	121,277	kwh	0.050	6,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4		25	161,703	kwh	0.050	8,000
D5		25	161,703	kwh	0.050	8,000
D6		25	161,703	kwh	0.050	8,000
E1		46	301,355	kwh	0.050	15,000
E2		46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		134	877,163	kwh	0.050	44,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	812,000	812,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,437,000	%	3	73,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.5	yr	54,000	81,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	30	ea	300	36,000
Monitor wells		4	45	ea	300	54,000
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2022						1,713,000
Contingency				%	15	257,000
Estimated Project O&M Costs - Total Year 2022						**1,970,000**

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells
with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2026**				
Extraction well maintenance			30	ea	1,000	30,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		19	122,502	kwh	0.050	6,000
C2		33	214,378	kwh	0.050	11,000
C3		28	183,753	kwh	0.050	9,000
C4		19	122,502	kwh	0.050	6,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		9	61,251	kwh	0.050	3,000
C8		19	122,502	kwh	0.050	6,000
C9		28	183,753	kwh	0.050	9,000
C10			0	kwh	0.050	0
D1		19	121,277	kwh	0.050	6,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4		25	161,703	kwh	0.050	8,000
D5		25	161,703	kwh	0.050	8,000
D6		25	161,703	kwh	0.050	8,000
E1		46	301,355	kwh	0.050	15,000
E2		46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		134	877,163	kwh	0.050	44,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	812,000	812,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,437,000	%	3	73,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.5	yr	54,000	81,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	30	ea	300	36,000
Monitor wells		4	45	ea	300	54,000
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2026						1,713,000
Contingency				%	15	257,000
Estimated Project O&M Costs - Total Year 2026						**1,970,000**

Detailed Cost Estimates

Alternative 5A

Present Worth Cost Estimate

Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 5A Estimated Costs					Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	35,407,000	839,500	36,246,500	36,247,000	36,200,000	35,407,000	1,639,500	37,046,500	37,000,000	37,000,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		1,738,000	1,738,000	1,624,000	37,900,000	0	3,338,000	3,338,000	3,100,000	40,100,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,738,000	1,738,000	1,518,000	39,400,000	0	3,338,000	3,338,000	2,900,000	43,000,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,738,000	1,738,000	1,419,000	40,800,000	0	3,338,000	3,338,000	2,700,000	45,700,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,738,000	1,738,000	1,326,000	42,100,000	0	3,338,000	3,338,000	2,500,000	48,200,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,738,000	1,738,000	1,239,000	43,400,000	0	3,338,000	3,338,000	2,400,000	50,600,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,738,000	1,738,000	1,158,000	44,500,000	0	3,338,000	3,338,000	2,200,000	52,800,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,738,000	1,738,000	1,082,000	45,600,000	0	3,338,000	3,338,000	2,100,000	54,900,000
2009	8	0.58201	1,600,000	930,000	10,300,000	812,000	1,793,000	2,605,000	1,516,000	47,100,000	812,000	3,393,000	4,205,000	2,400,000	57,300,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,793,000	1,793,000	975,000	48,100,000	0	3,393,000	3,393,000	1,800,000	59,100,000
2011	10	0.50835	1,600,000	810,000	12,000,000	1,022,000	1,880,000	2,902,000	1,475,000	49,600,000	1,022,000	3,480,000	4,502,000	2,300,000	61,400,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,880,000	1,880,000	893,000	50,500,000	0	3,480,000	3,480,000	1,700,000	63,100,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,880,000	1,880,000	835,000	51,300,000	0	3,480,000	3,480,000	1,500,000	64,600,000
2014	13	0.41496	1,600,000	660,000	14,200,000		1,880,000	1,880,000	780,000	52,100,000	0	3,480,000	3,480,000	1,400,000	66,000,000
2015	14	0.38782	1,600,000	620,000	14,800,000		1,880,000	1,880,000	729,000	52,800,000	0	3,480,000	3,480,000	1,300,000	67,300,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,880,000	1,880,000	681,000	53,500,000	0	3,480,000	3,480,000	1,300,000	68,600,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,906,000	1,906,000	646,000	54,100,000	0	3,506,000	3,506,000	1,200,000	69,800,000
2018	17	0.31657	1,600,000	510,000	16,400,000	812,000	1,906,000	2,718,000	860,000	55,000,000	812,000	3,506,000	4,318,000	1,400,000	71,200,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,906,000	1,906,000	564,000	55,600,000	0	3,506,000	3,506,000	1,000,000	72,200,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,906,000	1,906,000	527,000	56,100,000	0	3,506,000	3,506,000	1,000,000	73,200,000
2021	20	0.25842	1,600,000	410,000	17,700,000	2,499,000	2,094,000	4,593,000	1,187,000	57,300,000	2,499,000	3,694,000	6,193,000	1,600,000	74,800,000
2022	21	0.24151	1,600,000	390,000	18,100,000		2,044,000	2,044,000	494,000	57,800,000	0	3,644,000	3,644,000	900,000	75,700,000
2023	22	0.22571	1,600,000	360,000	18,500,000		2,044,000	2,044,000	461,000	58,200,000	0	3,644,000	3,644,000	800,000	76,500,000
2024	23	0.21095	1,600,000	340,000	18,800,000		2,044,000	2,044,000	431,000	58,700,000	0	3,644,000	3,644,000	800,000	77,300,000
2025	24	0.19715	1,600,000	320,000	19,100,000		2,044,000	2,044,000	403,000	59,100,000	0	3,644,000	3,644,000	700,000	78,000,000
2026	25	0.18425	800,000	150,000	19,300,000		1,022,000	1,022,000	188,000	59,300,000	0	1,822,000	1,822,000	300,000	78,300,000
Total Estimated Costs:					19,000,000	41,000,000				59,000,000	41,000,000				78,000,000

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	**[10 offsite, 4 onsite in 2 locations]**				
Secure easements		10	ea	2,000	20,000
Land purchase (1/8th acre ea wellhead)		1.25	acre	200,000	250,000
Surveying		5	day	1,000	5,000
Extraction wells - drilling and development	Depth				
C	300	11	ft	550	1,815,000
D	400	2	ft	550	440,000
E	500	1	ft	550	275,000
Wellhead vault: H-20 traffic rated		10	ea	5,000	50,000
Development (included with drilling)		14	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		4	ea	26,000	104,000
500 gpm, 300' TDH, 60 hp, 8" disch		10	ea	29,000	290,000
Discharge piping, 3" SS threaded	200	4	lin ft	40	32,000
Discharge piping, 8" SS threaded	200	10	lin ft	100	200,000
Installation (pump, wellhead, I&C)		14	LS	5,000	70,000
Incoming service power	14	500	ft	15	105,000
Pump control power and control		14	ea	2,000	28,000
Instrumentation and control/telemetry		14	ea	2,000	28,000
Subtotal - Extraction Wells (yr 2001)					3,712,000
Monitor Wells (year 2001)					
Secure permit		14	ea	100	1,400
Surveying		2.0	day	1,000	2,000
Monitor wells		21	ea	40,000	840,000
Subtotal - Monitor Wells (yr 2001)					843,400
Untreated Groundwater Piping (year 2001)					
Offsite Extraction Well Piping:					
Secure easements		1	LS	50,000	50,000
Land purchase		0.0	acre	200,000	0
Surveying		20	day	1,000	20,000
Jack and bore					
12" under railroad and Folsom Blvd	1	200	lin ft	240	48,000
16" under Hwy 50	1	500	lin ft	320	160,000
Single-walled piping system (in street)					
8"		9,500	lin ft	100	950,000
10"		10,200	lin ft	140	1,428,000
12"		4,000	lin ft	140	560,000
16"		5,800	lin ft	175	812,000
20"		2,100	lin ft	225	472,500
24"		3,500	lin ft	260	910,000
Onsite:					
Single-walled piping system (open field)					
8"		1,200	lin ft	64	76,800
10"		9,000	lin ft	80	720,000
Subtotal - Untreated Groundwater Piping (yr 2001)		45,300			6,207,000

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities at GET F (4,000 gpm capacity is adequate for 3,800 gpm projected) [year 2001]					
Treatment Facilities (New 4,900 gpm facility offsite) [year 2001]					
Secure easements		1	LS	10,000	10,000
Land purchase		2	acre	20,000	40,000
Surveying		2	day	1,000	2,000
Equalization tankage	2	147,000	gal	1.00	294,000
Transfer pumping	92 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		4	ea	85,000	340,000
Offgas treatment (assumed not required)		0	ea	400,000	0
Perchlorate removal (biological reduction)	4,900 gpm	1	ea	4,118,000	4,118,000
Transfer pumping	92 hp	3	ea	10,000	30,000
Incoming high voltage power		1,000	ft	20	20,000
Backup generator (not for UV)		1	ea	50,000	50,000
Electrical wiring		1	LS	100,000	100,000
Instrumentation and control		1	LS	100,000	100,000
Treatment building		1,600	sq ft	100	160,000
Sitework and access road		1	LS	30,000	30,000
Area lighting		1	LS	5,000	5,000
Security fencing/gates		1,200	lin ft	15	18,000
General contractor installation @ % of equipment		964,000	%	40	386,000
Subtotal - Treatment Offsite (yr 2001)					5,733,000
Recharge Wells (yr 2001)					
Secure easements		7	ea	10,000	70,000
Land purchase		0.875	acre	200,000	175,000
Surveying		4	day	1,000	3,500
Recharge wells	Number:				
C		400	ft	550	0
D	7	400	ft	550	1,540,000
E			ft	550	0
Wellheads/vaults		7	ea	5,000	35,000
Development		7	ea	10,000	70,000
Installation		7	LS	5,000	35,000
Instrumentation and control (w/ 500' conduit)		7	LS	3,000	21,000
Subtotal - Recharge Wells (yr 2001)					1,950,000

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treated Groundwater Piping to Recharge Wells (year 2001)					
Secure easements		1	LS	50,000	50,000
Land purchase		0.0	acre	200,000	0
Surveying		20	day	1,000	20,000
Jack and bore					
20" under railroad and Folsom Blvd	1	200	lin ft	400	80,000
16" under Sunrise Blvd	1	300	lin ft	320	96,000
20" under Hwy 50	1	500	lin ft	400	200,000
Single-walled piping system (in street - separate trench)					
8"		3,800	lin ft	100	380,000
10"		1,200	lin ft	140	168,000
12"		500	lin ft	140	70,000
16"		12,500	lin ft	175	2,187,500
20"		17,600	lin ft	225	3,960,000
Subtotal - Treated Groundwater Piping to Recharge		35,600			7,212,000
Estimated Construction Costs - Subtotal (year 2001)					25,657,000
Contractor Markup, Mob/demob, Insurance			%	10	2,566,000
Engineering, Permitting and Construction Management			%	10	2,566,000
Regulatory Oversight			%	2.5	641,000
Estimated Project Capital Costs - Subtotal (year 2001)					30,789,000
Contingency			%	15	4,618,000
Estimated Project Capital Costs - Total (year 2001)					**35,407,000**

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2009**				
Treatment Facilities Offsite					
UV/oxidation					400,000
Electrical wiring		1	LS	10,000	10,000
Instrumentation and control		1	LS	10,000	10,000
General contractor installation @ % of equipment		420,000	%	40	168,000
Subtotal - Treatment					588,000
Estimated Construction Costs - Subtotal	**2009**				588,000
Contractor Markup, Mob/demob, Insurance			%	10	59,000
Engineering, Permitting and Construction Management			%	10	59,000
Regulatory Oversight			%	2.5	15,000
Estimated Project Capital Costs - Subtotal	**2009**				706,000
Contingency			%	15	106,000
Estimated Project Capital Costs - Total	**2009**				**812,000**

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2011**				
Extraction Wells					
Secure easements		2	ea	2,000	4,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		2	ea	5,000	10,000
Development (included with drilling)		2	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		1	ea	29,000	29,000
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	1	lin ft	100	20,000
Installation (pump, wellhead, I&C)		2	LS	5,000	10,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		2	ea	2,000	4,000
Instrumentation and control/telemetry		2	ea	2,000	4,000
Subtotal - Extraction Wells					621,000
Monitor Wells					
Secure permit		2	ea	100	200
Surveying		0.25	day	1,000	250
Monitor wells		3	ea	40,000	120,000
Subtotal - Monitor Wells					120,000
Estimated Construction Costs - Subtotal	**2011**				741,000
Contractor Markup, Mob/demob, Insurance			%	10	74,000
Engineering, Permitting and Construction Management			%	10	74,000
Regulatory Oversight			%	2.5	19,000
Estimated Project Capital Costs - Subtotal	**2011**				889,000
Contingency			%	15	133,000
Estimated Project Capital Costs - Total	**2011**				**1,022,000**

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2017**				
Treatment Facilities Offsite					
UV/oxidation		1	ea	400,000	400,000
Electrical wiring		1	LS	10,000	10,000
Instrumentation and control		1	LS	10,000	10,000
General contractor installation @ % of equipment		420,000	%	40	168,000
Subtotal - Treatment					588,000
Estimated Construction Costs - Subtotal	**2017**				588,000
Contractor Markup, Mob/demob, Insurance			%	10	59,000
Engineering, Permitting and Construction Management			%	10	59,000
Regulatory Oversight			%	2.5	15,000
Estimated Project Capital Costs - Subtotal	**2017**				706,000
Contingency			%	15	106,000
Estimated Project Capital Costs - Total	**2017**				**812,000**

Capital Cost Estimate

Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2021**				
Extraction Wells					
Secure easements		5	ea	2,000	10,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	4	ft	550	880,000
E	500	1	ft	550	275,000
Wellhead vault: H-20 traffic rated		5	ea	5,000	25,000
Development (included with drilling)		5	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		4	ea	26,000	104,000
500 gpm, 300' TDH, 60 hp, 8" disch		1	ea	29,000	29,000
Discharge piping, 3" SS threaded	200	4	lin ft	40	32,000
Discharge piping, 8" SS threaded	200	1	lin ft	100	20,000
Installation (pump, wellhead, I&C)		5	LS	5,000	25,000
Incoming service power	5	500	ft	15	37,500
Pump control power and control		5	ea	2,000	10,000
Instrumentation and control/telemetry		5	ea	2,000	10,000
Subtotal - Extraction Wells					1,509,000
Monitor Wells					
Secure permit		5	ea	100	500
Surveying		1.0	day	1,000	1,000
Monitor wells		8	ea	40,000	300,000
Subtotal - Monitor Wells					301,500
Estimated Construction Costs - Subtotal	**2021**				1,811,000
Contractor Markup, Mob/demob, Insurance			%	10	181,000
Engineering, Permitting and Construction Management			%	10	181,000
Regulatory Oversight			%	2.5	45,000
Estimated Project Capital Costs - Subtotal	**2021**				2,173,000
Contingency			%	15	326,000
Estimated Project Capital Costs - Total	**2021**				**2,499,000**

Operation and Maintenance Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2001**				
Extraction Wells and Pipeline:					
Extraction well maintenance		14	ea	1,000	14,000
Recharge well maintenance		7	ea	50,000	350,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	37	245,004	kwh	0.050	12,000
C2	47	306,255	kwh	0.050	15,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
C8	19	122,502	kwh	0.050	6,000
C9	37	245,004	kwh	0.050	12,000
D1		0	kwh	0.050	0
D2	28	183,753	kwh	0.050	9,000
D3		0	kwh	0.050	0
D4		0	kwh	0.050	0
D5		0	kwh	0.050	0
D6		0	kwh	0.050	0
D7		0	kwh	0.050	0
D8		0	kwh	0.050	0
E1		0	kwh	0.050	0
E2		0	kwh	0.050	0
GET E North of E	154	1,004,516	kwh	0.050	50,000
GET F South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GET F) in addition to existing:					
Electric utilities:					
UV/oxidation	kw:		kwh	0.050	22,000
Treatment equipment (GET F) besides utilities and maintenance:					
UV bulb replacement (GET F)					21,000
Equip Maintenance (@ % of equip capital)		400,000	%	3	12,000

Operation and Maintenance Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment equipment (Offsite GWTP):						
Electric utilities:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	0	0	kwh	0.050	0
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps		70	455,097	kwh	0.050	23,000
Effluent pumping		58	379,248	kwh	0.050	19,000
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system (assumed not required)			0	ccf	2.0	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement			0			0
Perchlorate biological reduction system O&M			1	LS	539,000	539,000
Waste disposal						
Sludge from biological reduction (incl. in bio. red'n)				lb		0
Equip Maintenance (@ % of equip capital)			860,000	%	3	26,000
Labor (incl. fringe benefits):						
Operator labor (1 FTE incl. in biological red'n)			0.5	yr	54,000	27,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	14	ea	300	16,800
Monitor wells		4	21	ea	300	25,200
Equivalent to PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2001						1,460,000
Contingency				%	15	219,000
Estimated Project O&M Costs - Total Year 2001						**1,679,000**

Operation and Maintenance Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2015**			
Extraction Wells and Pipeline:					
Extraction well maintenance		14	ea	1,000	14,000
Recharge well maintenance		7	ea	50,000	350,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	37	245,004	kwh	0.050	12,000
C2	47	306,255	kwh	0.050	15,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
C8	19	122,502	kwh	0.050	6,000
C9	37	245,004	kwh	0.050	12,000
D1	28	183,753	kwh	0.050	9,000
D2	28	183,753	kwh	0.050	9,000
D3		0	kwh	0.050	0
D4		0	kwh	0.050	0
D5		0	kwh	0.050	0
D6		0	kwh	0.050	0
D7		0	kwh	0.050	0
D8	19	122,502	kwh	0.050	6,000
E1		0	kwh	0.050	0
E2		0	kwh	0.050	0
GET E North of E	154	1,004,516	kwh	0.050	50,000
GET F South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GET F) in addition to existing:					
Electric utilities:					
UV/oxidation	kw:		kwh	0.050	22,000
Treatment equipment (GET F) besides utilities and maintenance:					
UV bulb replacement (GET F)					21,000
Equip Maintenance (@ % of equip capital)		400,000	%	3	12,000

Operation and Maintenance Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment equipment (Offsite GWTP):						
Electric utilities:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:			kwh	0.050	11,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps		70	455,097	kwh	0.050	23,000
Effluent pumping		58	379,248	kwh	0.050	19,000
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system (assumed not required)			0	ccf	2.0	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement						10,500
Perchlorate biological reduction system O&M			1	LS	600,000	600,000
Waste disposal						
Sludge from biological reduction (incl. in bio. red'n)				lb		0
Equip Maintenance (@ % of equip capital)			860,000	%	3	26,000
Labor (incl. fringe benefits):						
Operator labor (1 FTE incl. in biological red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	14	ea	300	16,800
Monitor wells		4	21	ea	300	25,200
Equivalent to PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2015						1,635,000
Contingency				%	15	245,000
Estimated Project O&M Costs - Total Year 2015						**1,880,000**

Detailed Cost Estimates

Alternative 5B

Present Worth Cost Estimate

Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 5B Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	43,179,000	993,500	44,172,500	44,173,000	44,200,000	43,179,000	1,793,500	44,972,500	45,000,000	45,000,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		1,987,000	1,987,000	1,857,000	46,000,000	0	3,587,000	3,587,000	3,400,000	48,400,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,987,000	1,987,000	1,736,000	47,800,000	0	3,587,000	3,587,000	3,100,000	51,500,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,987,000	1,987,000	1,622,000	49,400,000	0	3,587,000	3,587,000	2,900,000	54,400,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,987,000	1,987,000	1,516,000	50,900,000	0	3,587,000	3,587,000	2,700,000	57,100,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,987,000	1,987,000	1,417,000	52,300,000	0	3,587,000	3,587,000	2,600,000	59,700,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,987,000	1,987,000	1,324,000	53,600,000	0	3,587,000	3,587,000	2,400,000	62,100,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,987,000	1,987,000	1,237,000	54,900,000	0	3,587,000	3,587,000	2,200,000	64,300,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,987,000	1,987,000	1,156,000	56,000,000	0	3,587,000	3,587,000	2,100,000	66,400,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,987,000	1,987,000	1,081,000	57,100,000	0	3,587,000	3,587,000	2,000,000	68,400,000
2011	10	0.50835	1,600,000	810,000	12,000,000	573,000	2,015,000	2,588,000	1,316,000	58,400,000	573,000	3,615,000	4,188,000	2,100,000	70,500,000
2012	11	0.47509	1,600,000	760,000	12,800,000		2,015,000	2,015,000	957,000	59,400,000	0	3,615,000	3,615,000	1,700,000	72,200,000
2013	12	0.44401	1,600,000	710,000	13,500,000		2,015,000	2,015,000	895,000	60,300,000	0	3,615,000	3,615,000	1,600,000	73,800,000
2014	13	0.41496	1,600,000	660,000	14,200,000		2,015,000	2,015,000	836,000	61,100,000	0	3,615,000	3,615,000	1,500,000	75,300,000
2015	14	0.38782	1,600,000	620,000	14,800,000		2,015,000	2,015,000	781,000	61,900,000	0	3,615,000	3,615,000	1,400,000	76,700,000
2016	15	0.36245	1,600,000	580,000	15,400,000		2,015,000	2,015,000	730,000	62,600,000	0	3,615,000	3,615,000	1,300,000	78,000,000
2017	16	0.33873	1,600,000	540,000	15,900,000		2,015,000	2,015,000	683,000	63,300,000	0	3,615,000	3,615,000	1,200,000	79,200,000
2018	17	0.31657	1,600,000	510,000	16,400,000	882,000	2,071,000	2,953,000	935,000	64,300,000	882,000	3,671,000	4,553,000	1,400,000	80,600,000
2019	18	0.29586	1,600,000	470,000	16,900,000		2,071,000	2,071,000	613,000	64,900,000	0	3,671,000	3,671,000	1,100,000	81,700,000
2020	19	0.27651	1,600,000	440,000	17,300,000		2,071,000	2,071,000	573,000	65,400,000	0	3,671,000	3,671,000	1,000,000	82,700,000
2021	20	0.25842	1,600,000	410,000	17,700,000	1,065,000	2,139,000	3,204,000	828,000	66,300,000	1,065,000	3,739,000	4,804,000	1,200,000	83,900,000
2022	21	0.24151	1,600,000	390,000	18,100,000		2,139,000	2,139,000	517,000	66,800,000	0	3,739,000	3,739,000	900,000	84,800,000
2023	22	0.22571	1,600,000	360,000	18,500,000		2,139,000	2,139,000	483,000	67,300,000	0	3,739,000	3,739,000	800,000	85,600,000
2024	23	0.21095	1,600,000	340,000	18,800,000		2,139,000	2,139,000	451,000	67,700,000	0	3,739,000	3,739,000	800,000	86,400,000
2025	24	0.19715	1,600,000	320,000	19,100,000		2,139,000	2,139,000	422,000	68,100,000	0	3,739,000	3,739,000	700,000	87,100,000
2026	25	0.18425	800,000	150,000	19,300,000		1,069,500	1,069,500	197,000	68,300,000	0	1,869,500	1,869,500	300,000	87,400,000
Total Estimated Costs:					19,000,000	46,000,000				68,000,000	46,000,000				87,000,000

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	**[7 offsite, 13 onsite in 5 locations]**				
Secure easements		7	ea	2,000	14,000
Land purchase (1/8th acre ea wellhead)		0.875	acre	200,000	175,000
Surveying		3.5	day	1,000	3,500
Extraction wells - drilling and development	Depth				
C	300	12	ft	550	1,980,000
D	400	4	ft	550	880,000
E	500	4	ft	550	1,100,000
Wellhead vault: H-20 traffic rated		7	ea	5,000	35,000
Development (included with drilling)		20	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		7	ea	26,000	182,000
500 gpm, 300' TDH, 60 hp, 8" disch		13	ea	29,000	377,000
Discharge piping, 3" SS threaded	200	7	lin ft	40	56,000
Discharge piping, 8" SS threaded	200	13	lin ft	100	260,000
Installation (pump, wellhead, I&C)		20	LS	5,000	100,000
Incoming service power	12	500	ft	15	90,000
Pump control power and control		20	ea	2,000	40,000
Instrumentation and control/telemetry		20	ea	2,000	40,000
Subtotal - Extraction Wells (yr 2001)					5,333,000
Monitor Wells (year 2001)					
Secure permit		7	ea	100	700
Surveying		1.0	day	1,000	1,000
Monitor wells		11	ea	40,000	420,000
Subtotal - Monitor Wells (yr 2001)					422,000
Untreated Groundwater Piping (year 2001)					
Offsite:					
Secure easements		1	LS	50,000	50,000
Land purchase		0.0	acre	200,000	0
Surveying		20	day	1,000	20,000
Jack and bore	No.				
8" and 20" under railroad and Folsom Blvd	1	200	lin ft	160	32,000
16" under Sunrise Blvd	1	500	lin ft	320	160,000
10" and 20" under Hwy 50	1	500	lin ft	400	200,000
Single-walled piping (in street)					
8"		9,400	lin ft	100	940,000
10"		600	lin ft	140	84,000
Single-walled piping (in street)					
8"		2,400	lin ft	100	240,000
10"		4,900	lin ft	140	686,000
12"		2,900	lin ft	140	406,000
20"		3,600	lin ft	225	810,000
Onsite:					
Single-walled piping (open field)					
8"		1,300	lin ft	64	83,200
10"		9,300	lin ft	80	744,000
12"		1,900	lin ft	96	182,400
16"		700	lin ft	128	89,600
Subtotal - Untreated Groundwater Piping (yr 2001)		37,000			4,727,000
Treatment Facilities (2,225 gpm expanded capacity at Get F) [year 2001]					
Surveying		1	day	1,000	1,000
Equalization tankage	2	66,750	gal	1.00	133,500
Transfer pumping	42 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		2	ea	85,000	170,000
Offgas treatment (assumed not required)		0	ea		0
Perchlorate removal (biological reduction)	2,225 gpm	1	ea	2,869,000	2,869,000
UV/oxidation (KW)					800,000
Transfer pumping	42 hp	3	ea	10,000	30,000
Electrical wiring		1	LS	50,000	50,000
Instrumentation and control		1	LS	50,000	50,000
Treatment building		800	sq ft	100	80,000
General contractor installation @ % of equipment		1,263,500	%	40	505,400
Subtotal - Treatment at GET F (yr 2001)					4,719,000

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities (New 2,600 gpm facility offsite) [year 2001]					
Secure easements		1	LS	10,000	10,000
Land purchase		2	acre	200,000	400,000
Surveying		2	day	1,000	2,000
Equalization tankage	2	78,000	gal	1.00	156,000
Transfer pumping	50 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		2	ea	85,000	170,000
Offgas treatment (assumed not required)		0	ea		0
Perchlorate removal (biological reduction)	2,600 gpm	1	ea	3,038,000	3,038,000
UV/oxidation (KW)		0	ea		0
Transfer pumping	50 hp	3	ea	10,000	30,000
Incoming high voltage power		1,000	ft	20	20,000
Backup generator (not for UV)		1	ea	50,000	50,000
Electrical wiring (most incl. in bio. red'n)		1	LS	10,000	10,000
Instrumentation and control (most incl. in bio. red'n)		1	LS	20,000	20,000
Treatment building		0	sq ft	100	0
Sitework and access road		1	LS	10,000	10,000
Area lighting		1	LS	5,000	5,000
Security fencing/gates		1,200	lin ft	15	18,000
General contractor installation @ % of equipment		486,000	%	40	194,400
Subtotal - Treatment Offsite (yr 2001)					4,163,000
Recharge Wells (yr 2001)					
Secure easements		7	ea	10,000	70,000
Land purchase		0.875	acre	200,000	175,000
Surveying		4	day	1,000	3,500
Recharge wells	Number:				
C		400	ft	550	0
D	7	400	ft	550	1,540,000
E			ft	550	0
Wellheads/vaults		7	ea	5,000	35,000
Development		7	ea	10,000	70,000
Installation		7	LS	5,000	35,000
Instrumentation and control (w/ 500' conduit)		7	LS	3,000	21,000
Subtotal - Recharge Wells (yr 2001)					1,950,000
Treated Groundwater Piping to Recharge Wells (year 2001)					
Secure easements		1	LS	50,000	50,000
Land purchase		0.0	acre	200,000	0
Surveying		20	day	1,000	20,000
Jack and bore - see untreated groundwater piping					
Single-walled piping system (in street)					
8"		4,000	lin ft	100	400,000
10"		1,200	lin ft	140	168,000
12"		500	lin ft	140	70,000
16"		11,600	lin ft	175	2,030,000
20"		3,800	lin ft	225	855,000
Single-walled piping system (in street)					
20"		13,800	lin ft	225	3,105,000
Subtotal - Treated Groundwater Piping to Recharge		34,900			6,698,000
Treated Groundwater Piping from GET F to Discharge at Buffalo Creek (year 2001)					
Surveying		1	day	1,000	1,000
Single-walled piping system (open field)					
24"		7,400	lin ft	192	1,420,800
Monitoring manhole and facilities		1	ea	5,000	5,000
Discharge structure		1	LS	10,000	10,000
Subtotal - Treated Groundwater to Discharge		7,400			1,437,000
Estimated Construction Costs - Subtotal (year 2001)					29,449,000
Contractor Markup, Mob/demob, Insurance			%	10	2,945,000
Engineering, Permitting and Construction Management			%	15	4,417,000
Regulatory Oversight			%	2.5	736,000
Estimated Project Capital Costs - Subtotal (year 2001)					37,547,000
Contingency			%	15	5,632,000
Estimated Project Capital Costs - Total (year 2001)					**43,179,000**

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2011**				
Extraction Wells					
Secure easements		1	ea	2,000	2,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	1	ft	550	220,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		1	ea	5,000	5,000
Development (included with drilling)		1	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		1	LS	5,000	5,000
Incoming service power	1	500	ft	15	7,500
Pump control power and control		1	ea	2,000	2,000
Instrumentation and control/telemetry		1	ea	2,000	2,000
Subtotal - Extraction Wells					329,000
Monitor Wells					
Secure permit		1	ea	100	100
Surveying		0.50	day	1,000	500
Monitor wells		2	ea	40,000	60,000
Subtotal - Monitor Wells					61,000
Estimated Construction Costs - Subtotal	**2011**				390,000
Contractor Markup, Mob/demob, Insurance			%	10	39,000
Engineering, Permitting and Construction Management			%	15	59,000
Regulatory Oversight			%	2.5	10,000
Estimated Project Capital Costs - Subtotal	**2011**				498,000
Contingency			%	15	75,000
Estimated Project Capital Costs - Total	**2011**				**573,000**

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2018**				
Treatment Facilities Offsite					
UV/oxidation					400,000
Electrical wiring		1	LS	20,000	20,000
Instrumentation and control		1	LS	10,000	10,000
General contractor installation @ % of equipment		430,000	%	40	172,000
Subtotal - Treatment					602,000
Estimated Construction Costs - Subtotal	**2018**				602,000
Contractor Markup, Mob/demob, Insurance			%	10	60,000
Engineering, Permitting and Construction Management			%	15	90,000
Regulatory Oversight			%	2.5	15,000
Estimated Project Capital Costs - Subtotal	**2018**				767,000
Contingency			%	15	115,000
Estimated Project Capital Costs - Total	**2018**				**882,000**

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2021**				
Extraction Wells					
Secure easements		2	ea	2,000	4,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		2	ea	5,000	10,000
Development (included with drilling)		2	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		2	ea	26,000	52,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	2	lin ft	40	16,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		2	LS	5,000	10,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		2	ea	2,000	4,000
Instrumentation and control/telemetry		2	ea	2,000	4,000
Subtotal - Extraction Wells					606,000
Monitor Wells					
Secure permit		2	ea	100	200
Surveying		0.25	day	1,000	250
Monitor wells		3	ea	40,000	120,000
Subtotal - Monitor Wells					120,000
Estimated Construction Costs - Subtotal	**2021**				**726,000**
Contractor Markup, Mob/demob, Insurance			%	10	73,000
Engineering, Permitting and Construction Management			%	15	109,000
Regulatory Oversight			%	2.5	18,000
Estimated Project Capital Costs - Subtotal	**2021**				926,000
Contingency			%	15	139,000
Estimated Project Capital Costs - Total	**2021**				**1,065,000**

Operation and Maintenance Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2001**				
Extraction Wells and Pipeline:					
Extraction well maintenance		20	ea	1,000	20,000
Recharge well maintenance		7	ea	50,000	350,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	28	183,753	kwh	0.050	9,000
C2	37	245,004	kwh	0.050	12,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
D1		0	kwh	0.050	0
D2		0	kwh	0.050	0
D3		0	kwh	0.050	0
New-1 (replace E/F recharge)	68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GET F) in addition to existing:					
Electric utilities:					
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps (GET F)	50	326,642	kwh	0.050	16,000
Effluent pumping - add'l 2,225 gpm to discharge	25	163,321	kwh	0.050	8,000
Treatment equipment (GET F) besides utilities and maintenance:					
UV bulb replacement (GET F)					21,000
Perchlorate biological reduction system O&M in add'n to exist:		1	LS	255,000	255,000
Equip Maintenance (@ % of equip capital)		1,639,000	%	3	49,000
Labor (incl. fringe benefits) - included in existing:					
Operator labor		0.5	yr	54,000	27,000
Management oversight and reporting		0.00	yr	100,000	0

Operation and Maintenance Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment equipment (Offsite):						
Electric utilities:						
Air stripping		30	196,312	kwh	0.050	10,000
UV/oxidation	kw:	0	0	kwh	0.050	0
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps		45	293,611	kwh	0.050	15,000
Effluent pumping				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system (assumed not required)				ccf		0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement						0
Perchlorate biological reduction system O&M			1	LS	441,000	441,000
UV service contract			0	LS	5,000	0
Waste disposal						
Biological sludge disposal (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			697,000	%	3	21,000
Labor (incl. fringe benefits):						
Operator labor (in additon to 1 FTE in bio. red'n)			0.5	yr	54,000	27,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	20	ea	300	24,000
Monitor wells		4	30	ea	300	36,000
Equivalent to PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2001						1,728,000
Contingency				%	15	259,000
Estimated Project O&M Costs - Total Year 2001						**1,987,000**

Operation and Maintenance Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2015**				
Extraction Wells and Pipeline:					
Extraction well maintenance		21	ea	1,000	21,000
Recharge well maintenance		7	ea	50,000	350,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	28	183,753	kwh	0.050	9,000
C2	37	245,004	kwh	0.050	12,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
D1	19	122,502	kwh	0.050	6,000
D2		0	kwh	0.050	0
D3		0	kwh	0.050	0
New-1 (replace E/F recharge)	68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GET F) in addition to existing:					
Electric utilities:					
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps (GET F)	50	326,642	kwh	0.050	16,000
Effluent pumping - add'l 2,225 gpm to discharge	25	163,321	kwh	0.050	8,000
Treatment equipment (GET F) besides utilities and maintenance:					
UV bulb replacement (GET F)					21,000
Perchlorate biological reduction system O&M in add'n to exist:		1	LS	255,000	255,000
Equip Maintenance (@ % of equip capital)		1,639,000	%	3	49,000
Labor (incl. fringe benefits) - included in existing:					
Operator labor		0.5	yr	54,000	27,000
Management oversight and reporting		0.00	yr	100,000	0

Operation and Maintenance Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment equipment (Offsite):						
Electric utilities:						
Air stripping		30	196,312	kwh	0.050	10,000
UV/oxidation	kw:	0	0	kwh	0.050	0
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps		45	293,611	kwh	0.050	15,000
Effluent pumping				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system (assumed not required)				ccf		0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement						0
Perchlorate biological reduction system O&M			1	LS	455,000	455,000
UV service contract			0	LS	5,000	0
Waste disposal						
Biological sludge disposal (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			697,000	%	3	21,000
Labor (incl. fringe benefits):						
Operator labor (in additon to 1 FTE in bio. red'n)			0.5	yr	54,000	27,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	21	ea	300	25,200
Monitor wells		4	32	ea	300	37,800
Equivalent to PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2015						1,752,000
Contingency				%	15	263,000
Estimated Project O&M Costs - Total Year 2015						**2,015,000**

Detailed Cost Estimates

Potential Estimated Additional Costs for Replacement Water for Direct Reuse and Indirect Reuse

Present Worth Cost Estimate

Replacement Water - Direct Reuse

			Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	3,909,000	66,500	3,975,500	3,976,000	3,976,000
2002	1	0.93458		133,000	133,000	124,000	4,100,000
2003	2	0.87344		133,000	133,000	116,000	4,216,000
2004	3	0.81630		133,000	133,000	109,000	4,325,000
2005	4	0.76290		133,000	133,000	101,000	4,426,000
2006	5	0.71299		133,000	133,000	95,000	4,521,000
2007	6	0.66634		133,000	133,000	89,000	4,610,000
2008	7	0.62275		133,000	133,000	83,000	4,693,000
2009	8	0.58201		133,000	133,000	77,000	4,770,000
2010	9	0.54393		133,000	133,000	72,000	4,842,000
2011	10	0.50835		133,000	133,000	68,000	4,910,000
2012	11	0.47509		133,000	133,000	63,000	4,973,000
2013	12	0.44401		133,000	133,000	59,000	5,032,000
2014	13	0.41496		133,000	133,000	55,000	5,087,000
2015	14	0.38782		133,000	133,000	52,000	5,139,000
2016	15	0.36245		133,000	133,000	48,000	5,187,000
2017	16	0.33873		133,000	133,000	45,000	5,232,000
2018	17	0.31657		133,000	133,000	42,000	5,274,000
2019	18	0.29586		133,000	133,000	39,000	5,313,000
2020	19	0.27651		133,000	133,000	37,000	5,350,000
2021	20	0.25842		133,000	133,000	34,000	5,384,000
2022	21	0.24151		133,000	133,000	32,000	5,416,000
2023	22	0.22571		133,000	133,000	30,000	5,446,000
2024	23	0.21095		133,000	133,000	28,000	5,474,000
2025	24	0.19715		133,000	133,000	26,000	5,500,000
2026	25	0.18425		66,500	66,500	12,000	5,512,000
	Total Estimated Costs:		3,900,000				5,500,000

Capital Cost Estimate
Replacement Water - Direct Reuse

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2001)					
Polishing Treatment and Treated Groundwater Piping to Water Distribution System					
GETs E/F GWTP					
LPGAC polishing contactors 750 gpm each (incl. GAC)		5	ea	140,000	700,000
General contractor installation @ % of equipment		700,000	%	20	140,000
Slab-on-grade for LPGAC contactors	5	800	sq ft	20	80,000
Transfer pumps (incl. in GET F GWTP)		0	ea	1	0
Electrical		1	ea	5,000	5,000
Instrumentation and control		1	ea	10,000	10,000
Chlorine disinfection (assumed provided by water purveyor)					
Secure easements		1	LS	20,000	20,000
Surveying		5	day	1,000	5,000
Treated groundwater piping to Water Distribution System					0
20" from GETs E/F to water distribution system (field)		8,000	lin ft	160	1,280,000
20" from GETs E/F to water distribution system (street)		1,000		225	225,000
Jack and bore:	No:				
20" under Hwy 50	1	500	lin ft	400	200,000
Subtotal					2,665,000
Estimated Construction Costs - Subtotal (year 2004)					2,665,000
Contractor Markup, Mob/demob, Insurance			%	10	267,000
Engineering, Permitting and Construction Management			%	15	400,000
Regulatory Oversight			%	2.5	67,000
Estimated Project Capital Costs - Subtotal (year 2004)					3,399,000
Contingency			%	15	510,000
Estimated Project Capital Costs - Total (year 2004)					**3,909,000**

Operation and Maintenance Cost Estimate
Replacement Water - Direct Reuse

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**			
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Treated GW pumping-GET F GWTP to water system (995 gpm annual avg) hp	37	243,453	kwh	0.050	12,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
LPGAC replacement (2 year frequency)		100,000	pound	0.75	75,000
Equip Maintenance (@ % of equip capital)		10,000	%	3	0
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F GWTP O&M)		0.00	yr	54,000	0
Management oversight and reporting (incl. in exist. GET F GWTP O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Monthly:	# mos.				
LPGAC influent	12	4	ea	500	24,000
GWTP effluent (incl in exist. GET F O&M)	12	0	ea	300	0
Estimated Project O&M Costs - Subtotal Year 2001					116,000
Contingency			%	15	17,000
Estimated Project O&M Costs - Total Year 2001					133,000

Present Worth Cost Estimate

Replacement Water - Indirect Reuse

			Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	6,895,000	22,000	6,917,000	6,917,000	6,917,000
2002	1	0.93458		44,000	44,000	41,000	6,958,000
2003	2	0.87344		44,000	44,000	38,000	6,996,000
2004	3	0.81630		44,000	44,000	36,000	7,032,000
2005	4	0.76290		44,000	44,000	34,000	7,066,000
2006	5	0.71299		44,000	44,000	31,000	7,097,000
2007	6	0.66634		44,000	44,000	29,000	7,126,000
2008	7	0.62275		44,000	44,000	27,000	7,153,000
2009	8	0.58201		44,000	44,000	26,000	7,179,000
2010	9	0.54393		44,000	44,000	24,000	7,203,000
2011	10	0.50835		44,000	44,000	22,000	7,225,000
2012	11	0.47509		44,000	44,000	21,000	7,246,000
2013	12	0.44401		44,000	44,000	20,000	7,266,000
2014	13	0.41496		44,000	44,000	18,000	7,284,000
2015	14	0.38782		44,000	44,000	17,000	7,301,000
2016	15	0.36245		44,000	44,000	16,000	7,317,000
2017	16	0.33873		44,000	44,000	15,000	7,332,000
2018	17	0.31657		44,000	44,000	14,000	7,346,000
2019	18	0.29586		44,000	44,000	13,000	7,359,000
2020	19	0.27651		44,000	44,000	12,000	7,371,000
2021	20	0.25842		44,000	44,000	11,000	7,382,000
2022	21	0.24151		44,000	44,000	11,000	7,393,000
2023	22	0.22571		44,000	44,000	10,000	7,403,000
2024	23	0.21095		44,000	44,000	9,000	7,412,000
2025	24	0.19715		44,000	44,000	9,000	7,421,000
2026	25	0.18425		22,000	22,000	4,000	7,425,000
	Total Estimated Costs:		6,900,000				7,400,000

Capital Cost Estimate
Replacement Water - Indirect Reuse

Description	Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2001)				
Surface Water Treatment Facilities (New or expanded existing 4.9 MGD [3,400 gpm] facility) and Piping				
Secure easements for piping and Canal use	1	LS	50,000	50,000
Land purchase	2	acre	200,000	400,000
Surveying for piping	3	day	1,000	3,000
Inlet structure at Folsom South Canal	1	ea	20,000	20,000
Raw water piping from Folsom South Canal				
20"	6,000	lin ft	225	1,350,000
Surface water treatment facility (4.9 MGD max day flow)	1	ea	2,880,000	2,880,000
Subtotal				4,703,000
Estimated Construction Costs - Subtotal (year 2001)				4,703,000
Contractor Markup, Mob/demob, Insurance		%	10	470,000
Engineering, Permitting and Construction Management		%	15	705,000
Regulatory Oversight		%	2.5	118,000
Estimated Project Capital Costs - Subtotal (year 2001)				5,996,000
Contingency		%	15	899,000
Estimated Project Capital Costs - Total (year 2001)				**6,895,000**

Operation and Maintenance Cost Estimate
Replacement Water - Indirect Reuse

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**			
Pipeline maintenance		1	LS	2,000	2,000
Electric utilities:					
Raw water pumping - Folsom South Canal to Surface WTP	37	243,453	kwh	0.050	12,000
Treatment (by water purveyor)					
Equipment Maintenance (by water purveyor)					
Labor (by water purveyor)					
Monitoring (by water purveyor)					
Folsom South Canal Use Fee		1,605	ac ft	15	24,000
Estimated Project O&M Costs - Subtotal Year 2001					38,000
Contingency			%	15	6,000
Estimated Project O&M Costs - Total Year 2001					44,000

RESPONSE TO COMMENTS
Aerojet Site
Engineering Evaluation and Cost Analysis

Draft Revised Engineering Evaluation/Cost Analysis for the American River Study Area, Aerojet, Rancho Cordova, California Regional Water Quality Control Board (RB) Comments, Dated 4 June 1996. (Attachment 1.)

Comment:

1. There should be some minor discussion of the environmental impacts associated with the construction of the pipeline and treatment facilities. The discussion can be brief and refer the reader to the development of the CEQA document that will address the issues in greater detail.

Response:

A discussion of the environmental impacts associated with the construction of the pipeline and treatment facilities has been added to Section 5.0 of the Final Revised EE/CA and will be further defined in the environmental document currently in progress pursuant to the California Environmental Quality Act (CEQA)..

Comment:

2. An analysis of the concentrations of n-butyl-benzene sulfonamide that are expected to enter the extraction field and the treatment system and be discharged in the final effluent needs to be included. This analysis should be similar to that conducted for 1,4-dioxane. This analysis is needed to provide a basis for establishing effluent limitations for the chemical. Initially, the concentrations would be set at background in the receiving water (non-detect) and an allowance for increased concentrations as justified would be made. The same comment applies to any pollutant that will be discharged from the treatment system. Additional analysis can also be performed when developing the CEQA document.

Response:

A discussion of n-butyl-benzene-sulfonamide results has been added to Section 2.4.2 of the Final Revised EE CA..

Comment:

3. The reasoning behind adding the UV/peroxide treatment system to the treatment train should be clarified. It would appear from the discussion provided that the reason is to reduce the concentrations of 1,4-dioxane in the effluent from the

reduce the high concentrations of VOCs entering the air stripper and thus eliminate the need for an air treatment system for the off-gas from the air stripper. The reduction in estimated worst-case 1,4-dioxane concentrations (from 6 ug/l down to 4.3 ug/l) is not significant. The added expense of the water treatment train, thereby eliminating the need for air treatment appears to be justified.

Response:

The conclusion in the Final Revised EE/CA now clearly states that the UV/Oxidation treatment system was selected to reduce the total emission rate from the air stripper thereby eliminating the need for an air emission control device.

Comment:

4. The estimated zone of capture for the extraction wells should be delineated on the appropriate figures.

Response:

Figure 2-12 has been added which provides an estimate of the predicted drawdown and capture zone anticipated from the existing extraction wells. The capture zones have also been added to the TCE distribution maps, Figures 2-14, 2-15 and 2-16.

Comment:

5. The data presented in Table 2-2 shows the need for better decontamination procedures and/or the use of dedicated samplers in the wells. In the future, Regional Board staff would like to split samples on the wells listed in this table and selected wells screened below the deep aquifer.

Response:

Aerojet has implemented stricter adherence to the existing decontamination procedures and has installed dedicated purge/sampling pumps in key wells. Aerojet will gladly provide the Regional Board the opportunity to split samples.

Comment:

6. It appears that this EE/CA addresses only the upper three designated aquifers. Monitor wells 1408, 1527, 1480, 1471, and 1489 are screened below the lowest of those three aquifers and have been found to contain concentrations of TCE up to 290 ug/l. The presence and extent of VOCs in those lower water bearing zones needs to be determined. It may be desirable to size the conveyance piping for

flows exceeding that anticipated to be extracted from the upper three aquifers in case extraction from these lower zones are required. The treatment facility should also be designed to allow expansion, if necessary.

Response:

The EE/CA and the recommended action do focus on the upper aquifers. In addition, distribution maps of chemicals in the deeper aquifers are included in Figures 2-14, 2-15, 2-16 and Appendix F. Continued groundwater monitoring will be conducted to evaluate the presence and distribution of chemicals in the Deeper aquifers. In addition, the pipeline and the treatment facility were designed to allow for expansion, if determined necessary. Information related to the groundwater collection system hydraulics, specifically design and maximum flow rates, is presented in Figure 1 attached to this Response document.

Comment:

7. TCE appears in ground water monitor wells located north of the American River along Hazel Avenue (MWs 1529 and 1530). Similar to comment 6, above, it is not certain that the proposed extraction field covers this portion of the plume of contaminants. The EE/CA need not address the entire plume of contamination, but it should be stated what the goal of the EE/CA action is.

Response:

The full impact of the existing extraction field on the northern portion of the groundwater plume is not known at this time. Once the recommended interim action is implemented, additional evaluation of the impacts of the extraction and treatment system will be conducted and additional actions recommended, as necessary. However, please note, the installation of additional extraction wells to the north is potentially infeasible due to the presence of residential neighborhoods. Aerojet will continue to work with the RB to determine the most feasible, cost-effective, and appropriate actions for the ARSA.

Comment:

8. Appendix J. The assumptions/algorithms used to produce the results found in this appendix should be specified.

Response:

The assumptions for determining the system parameters for the air stripping system are provided in Appendix J. These calculations were primarily performed to determine the required air stripping system flow rate. The value was used

to determine the required air stripping system flow rate. The value was used within the air risk assessment model and to evaluate emission control equipment type and cost. Copies of the algorithms used for both the air stripping system and UV/Oxidation system are provided as Attachment 3 and 4 to this Response and a copy of the UV/Oxidation Handbook provided by the vendor is provided as Attachment 5.

Comment:

9. An evaluation of metals to be extracted and discharged needs to be made to allow development of effluent limitations for the discharge of the treated water. Effluent limitations for metals will be based on protection of the American River as a source of drinking water and an aquatic habitat.

Response:

An evaluation of metals and minerals that may be in the influent to the treatment facility has been added to Section 4.1 of the Final Revised EE/CA. Also included are typical values for COD, TDS, pH and conductivity.

Comment:

10. Initially, it appears that the discharge of the treated ground water to Buffalo Creek is the preferred option. Aerojet will be requested to periodically evaluate other disposal options that may provide alternative uses of the water.

Response:

Aerojet has revised the Final EE/CA to include discharge to Buffalo Creek, Alder Creek or Folsom South Canal as the preferred discharge alternatives. Aerojet will work with the RB to periodically evaluate other, more beneficial uses of the water as they become available.

Comment:

11. Page 18, paragraph 2, last sentence. The interpretation here for the non-degradation policy is not correct. Water quality standards will be set to protect the beneficial uses of the receiving water. In the case of 1,4-dioxane, the allowable concentration is well less than the detection level of 10 ug/l. If it is assumed that the treated ground water is consumed directly from the treatment unit, the effluent limit would be that lower value and the treatment system designed to achieve that value. There would not be allowed to detectable concentrations of 1,4-dioxane in the effluent and the treatment system operated in such a manner to achieve reduction to the lower value. However, there can be some allowance for dilution in the receiving water if it is technically and economically justified. Aerojet has

dioxane at the estimated worst-case concentrations. This case would satisfy the requirement of Resolution 68-16. The same process is pertinent for any pollutant discharged from the treatment unit in the water discharge.

Response:

The applicable, relevant and appropriate requirements section of the Final Revised EE/CA was modified to reflect this comment.

Draft Revised Engineering Evaluation/Cost Analysis for the American River Study Area, Aerojet, Rancho Cordova, Department of Toxic Substances Control Comments, Dated 2 July 1996 (Attachment 2).

Comment:

12. The Department of Toxic Substances Control (DTSC) has received and reviewed the subject plan. Combining the American River North and South actions, in addition to the State assuming the lead regulatory role for those actions, has led us to conclude that this action should be considered as a remedial action rather than a removal action. We note that Chapter 6.8 of the Health and Safety Code limits the cost of removal action covered by a Removal Action Workplan to $1 million and Chapter 6.8 Section 25256.1(b) requires the preparation of a Remedial Action Plan (RAP). Therefore, Aerojet should revise the Engineering Evaluation/Cost Analysis (EE/CA) to conform with the requirements of a Remedial Investigation/Feasibility Study (RI/FS).

Response:

The California Regional Water Quality Control Board (RB) has assumed the lead oversight role for the American River Study Area. Pursuant to their direction and in that the initial groundwater treatment facility is an interim action, Aerojet has revised and resubmitted an EE/CA for RB approval. The RB Cleanup and Abatement Order governing this action requires the preparation and submittal of the necessary documents for an approved removal action and anticipates completion and submittal at a later date of a RAP to implement the final remedial action on the plume.

Comment:

13. The RI/FS could be prepared in support of a RAP for a final remedy or, alternatively, in support of a RAP for an interim action. We expect that in terms of implementing one of the plans proposed in the draft EE/CA, an interim RAP may prove to be more expedient. If it is decided to proceed towards an interim RAP, Aerojet will be required to prepare another RI/FS and RAP in support of a final remedy for the American River Study Area (ARSA). The final remedy selection will be based upon the performance of the interim remedial measure and will examine a larger number of remedial alternatives such as in-situ bioremediation, in-well air stripping, etc. Also the proposed pipeline between the ARSA and Aerojet must be large enough to accommodate any additional groundwater flows which may be added in the final remedial action. It will be necessary to quickly replace the interim treatment plant in Sailor Bar Park whether either the interim or final action approach is taken. We would like to discuss these two proposals with

Aerojet and reach agreement on the appropriate approach. If the interim approach is chosen, the revised document should be entitled "Interim RI/FS".

Response:

See response to Comment #13 above.

Comment:

14. In accordance with 40 CFR 300.430(d)(4), Aerojet must also prepare a baseline risk assessment. As a part of the risk evaluation of remedial alternatives where treatment plant effluent will be discharged to drinking water supplies, Aerojet must demonstrate that all contaminants which may be present in the ARSA groundwaters have been accounted for and that the constituents will either be removed by treatment or will not otherwise present a significant threat to human health or the environment. Aerojet should also include in its analysis of treatment plant effluent discharge alternatives consideration of reinjection upgradient of the extraction wells, i.e., back into the plume area.

Response:

The risk assessment requirements will be met within the preparation of the RAP and other support documents. In addition, a streamlined risk evaluation was prepared on the ARSA by the US EPA and provided in an Action Memorandum dated 30 June 1994.

Additional evaluation of metals, minerals and semi-volatile organic compounds that may be present in the influent to the treatment facility has been incorporated into the Final Revised EE/CA.

Reinjection upgradient of the extraction wells is part of the effluent discharge alternatives considered in the Final Revised EE/CA.

Comment:

15. The draft EE/CA lacks an analysis of the expected effectiveness of the proposed remedial action in capturing the groundwater plume. This analysis is necessary for determining adequacy of the extraction rates and locations to achieve plume capture and to ensure that the conveyance and treatment systems are properly sized. Updated diagrams, similar to those provided in the original EE/CA, should be provided.

Response:

Figures 2-12, 2-14, 2-15, 2,16 have been added to the Final Revised EE/CA.

Comment:

16. This analysis should include the expected effects of the groundwater extraction and treated water discharge systems on the regional aquifers.

Response:

Figures 2-12, 2-14, 2-15, 2,16 have been added to the Final Revised EE/CA.

Comment:

17. Pump test results should be compared with previous or expected results.

Response:

A brief statement has been added to Section 2.4.2 of the Final Revised EE/CA.

Comment:

18. More information and description of the portion of the pipeline crossing under the American River is needed.

Response:

The American River Crossing Project Plan has been provided as Appendix P to the Final Revised EE/CA..

Comment:

19. The EE/CA indicates that another Ultra Violet (UV) treatment system will be added if the air stream from the stripping tower exceeds 10 pounds per day. At start-up, the emission rate is expected to be less than five pounds per day. What would emission rates be for worst case conditions? If those rates necessitate an additional UV treatment unit, a cost estimate comparing the various treatment options for worst case influent concentrations should be prepared.

Response:

Worst-case concentrations and associated emission rates at startup have been included in the analysis contained in the Final Revised EE/CA.

Comment:

20. Current uses of the Buffalo Creek and the potential impacts of using the creek for effluent discharge (potential to effect natural use as a drainage ditch, rate of

infiltration, potential for erosion, safety considerations, etc.) should be discussed. Circumstances which prevent or limit the discharge to the American River or Folsom Canal, such as maintenance, construction activities or flooding, should be discussed.

Response:

A brief description of the uses of Buffalo Creek has been provided in the Final Revised EE/CA in Section 4.5.1. Additional information will be provided in the environmental documentation prepared pursuant to CEQA.

Comment:

21. We disagree with your statement that Proposition 65 establishes "levels at which the State has determined that concentrations below those levels do not constitute significant risks." Statements about risk ranges associated with the discharge of various constituents would be more appropriate. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) risk goals (a discussion of which should be included in this section) are less that the Proposition 65 levels and as such, we consider levels less than the Proposition 65 levels to be significant.

Response:

See response to Comment #11 above.

Comment:

22. More information on the acquisition of permits, particularly from the County and other government agencies should be provided.

Response:

This information will be provided in the environmental documentation prepared pursuant to CEQA.

Comment:

23. We believe that a key aspect to the proposed plan is acceptance from the community, and in particular those who make use the American River and Folsom Canal waters downstream from Aerojet's treatment plant discharge locations. The document should contain more information about those uses.

Response:

Sections 4.5.1 and 4.5.2 briefly describe uses of the American River and Folsom South canal which would be downstream from Aerojet's discharge location. As any proposed discharge to either the American River or Folsom South Canal will be pursuant to a NPDES permit issued by the RB, the standards which are established will be protective of these resources.

Comment:

24. The Community Relations Plan (CRP) should be updated for this site specific action. The updated CRP should be submitted under separate cover for approval and placement in the Administrative Record.

Response:

Aerojet is working with the Agencies to update the Community Relations Plan. Once updated, it will be submitted for Agency review and approval.

Comment:

25. The plan contains no citations to reference material or other documents. Reference to appropriate guidance documents, relevant materials, and reports should be included.

Response:

Section 6.0, References, has been added to the Final Revised EE/CA.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

ATTACHMENT 1

STATE OF CALIFORNIA - Environmental Protection Agency
PETE WILSON, Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

[redacted] Routier Road, Suite A
[redacted]mento, CA 95827-3098
[redacted]NE: (916) 255-3000
FAX: (916) 255-3015

RECEIVED

JUN 05 1996

AEROJET-GENERAL SACRAMENTO
ENVIRONMENTAL OPERATIONS

4 June 1996

Ms. Cindy Caulk
Program Coordinator
GenCorp Aerojet
P.O. Box 13222
Sacramento, CA 95813-6000

DRAFT REVISED ENGINEERING EVALUATION/COST ANALYSIS FOR THE AMERICAN RIVER STUDY AREA, AEROJET, RANCHO CORDOVA

Thank you for the opportunity to review the subject plan. Regional Board staff have completed their initial review and we present the following comments for a basis of discussion at the upcoming meeting on **6 June 1996:**

1. There should be some minor discussion of the environmental impacts associated with the construction of the pipeline and treatment facilities. The discussion can be brief and refer the reader to the development of the CEQA document that will address the issues in greater detail.

2. An analysis of the concentrations of n-butyl-benzene sulfonamide that are expected to enter the extraction field and the treatment system and be discharge in the final effluent needs to be included. This analysis should be similar to that conducted for 1,4-dioxane. This analysis is needed to provide a basis for establishing effluent limitations for the chemical. Initially, the concentrations would be set at background in the receiving water (non-detect) and an allowance for increased concentrations as justified would be made. The same comment applies to any pollutant that will be discharged from the treatment system. Additional analysis can also be performed when developing the CEQA document.

3. The reasoning behind adding the UV/peroxide treatment system to the treatment train should be clarified It would appear from the discussion provided that the reason is to reduce the concentrations of 1,4-dioxane in the effluent from the treatment plant. In reality, the reason for the treatment unit in question is to reduce the high concentrations of VOCs entering the air stripper and thus eliminate the need for an air treatment system for the off-gas from the air stripper. The reduction in estimated worst-case 1,4-dioxane concentrations (from 6 µg/l down to 4.3 µg/l) is not significant. The added expense of the water treatment train, thereby eliminating the need for air treatment appears to be justified.

4. The estimated zone of capture for the extraction wells should be delineated on the appropriate figures.

5. The data presented in Table 2-2 shows the needed for better decontamination procedures and/or the use of dedicated samplers in the wells. In the future, Regional Board staff would like to split samples on the wells listed in this table and selected wells screened below the deep aquifer.

6. It appears that this EE/CA addresses only the upper three designated aquifers. Monitor wells 1408, 1527, 1480, 1471, and 1489 are screened below the lowest of those three aquifers and have been found to contain concentrations of TCE up to 290 µg/l. The presence and extent of VOCs in those lower water bearing zones needs to be determined. It may be desirable to size the conveyance piping for flows exceeding that anticipated to be extracted from the upper three aquifers in case extraction from these lower zones are required. The treatment facility should also be designed to allow expansion, if necessary.

7. TCE appears in ground water monitor wells located north of the American River along Hazel Avenue (MWs 1529 and 1530). Similar to comment 6, above, it is not certain that the proposed extraction field covers this portion of the plume of contaminants. The EE/CA need not address the entire plume of contamination, but it should be stated what the goal of the EE/CA action is.

8. Appendix J. The assumptions/algorithms used to produce the results found in this appendix should be specified.

9. An evaluation of metals to be extracted and discharged needs to be made to allow development of effluent limitations for the discharge of the treated water. Effluent limitations for metals will be based on protection of the American River as a source of drinking water and an aquatic habitat.

10. Initially, it appears that the discharge of the treated ground water to Buffalo Creek is the preferred option, Aerojet will be requested to periodically evaluate other disposal options that may provide alternative uses of the water.

11. Page 18, paragraph 2, last sentence. The interpretation here is for the non-degradation policy is not correct. Water quality standards will be set to protect the beneficial uses of the receiving water. In the case of 1,4-dioxane, the allowable concentration is well less than the detection level of 10 µg/l. If it is assumed that the treated ground water is consumed directly from the treatment unit, the effluent limit would be that lower value and the treatment system designed to achieve that value. There would not be allowed to detectable concentrations of 1,4-dioxane in the effluent and the treatment system operated in such a manner to achieve reduction to the lower value. However, there can be some allowance for dilution in the receiving water if it is technically and economically justified. Aerojet has made a case for not requiring specific treatment solely for the reduction of 1,4-dioxane at the estimated worst-case concentrations. This case would satisfy the requirement of Resolution 68-16. The same process is pertinent for any pollutant discharged from the treatment unit in the water discharge.

These comments should be considered for discussion at the upcoming meeting. Additional comments may be supplied after additional review of the document. The above have also been briefly discussed with Mr. Craig Fegan of your office.

If you have any questions regarding this matter, please call me at (916) 255-3025.

ALEXANDER MACDONALD
Project Coordinator

cc: Ms. JoAnn Cola, U.S. Environmental Protection Agency (H-7-3), San Francisco
Mr. Duncan Austin, Department of Toxic Substances Control, Sacramento

ATTACHMENT 2

STATE OF CALIFORNIA—ENVIRONMENTAL PROTECTION AGENCY

PETE WILSON, Governor

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

REGION 1
1151 CROYDON WAY, SUITE 3
SACRAMENTO, CA 95827-2106

(916) 255-3545

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JUL 08 1996

AEROJET-GENERAL SACRAMENTO
ENVIRONMENTAL OPERATIONS

July 2, 1996

Ms. Cindy Caulk
Program Coordinator
Gen Corp Aerojet
P.O. Box 13222
Sacramento, California 95813-6000

DRAFT REVISED ENGINEERING EVALUATION/COST ANALYSIS FOR THE AMERICAN RIVER STUDY AREA, AEROJET, RANCHO CORDOVA

Dear Ms. Caulk:

The Department of Toxic Substances Control (DTSC) has received and reviewed the subject plan. Combining the American River North and South actions, in addition to the State assuming the lead regulatory role for those actions, has led us to conclude that this action should be considered as a remedial action rather than a removal action. We note that Chapter 6.8 of the Health and Safety Code limits the cost of removal actions covered by a Removal Action Workplan to $1 million and Chapter 6.8 Section 25256.1(b) requires the preparation of a Remedial Action Plan (RAP). Therefore, Aerojet should revise the Engineering Evaluation/Cost Analysis (EE/CA) to conform with the requirements of a Remdial Investigation/ Feasibility Study (RI/FS).

The RI/FS could be prepared in support of a RAP for a final remedy or, alternatively, in support of a RAP for an interim action. We expect that in terms of implementing one of the plans proposed in the draft EE/CA, an interim RAP may prove to be more expedient. If it is decided to proceed towards an interim RAP, Aerojet will be required to prepare another RI/FS and RAP in support of a final remedy for the American River Study Area (ARSA). The final remedy selection will be based upon the performance of the interim remedial measure and will examine a larger number of remedial alternatives such as in-situ bioremediation, in-well air stripping, etc. Also, the proposed pipeline between the ARSA and Aerojet must be large enough to accomodate any additional groundwater flows which may be added in the final remedial action. It will be necessary to quickly replace the interim treatment plant in Sailor Bar Park whether either the interim or final action approach is taken. We would like to discuss these two proposals with Aerojet and reach agreement on the appropriate approach. If the interim approach is chosen, the revised document should be entitled "Interim RI/FS".

In accordance with 40 CFR 300.430(d)(4), Aerojet must also prepare a baseline risk assessment. As a part of the risk evaluation of remedial alternatives where treatment plant effluent will be discharged to drinking water supplies, Aerojet must demonstrate that all contaminants which may be present in the ARSA groundwaters have been accounted for and that the constituents will either be removed by treatment or will not otherwise present a significant threat to human health or the environment. Aerojet should also include in its analysis of treatment plant effluent discharge alternatives consideration of reinjection upgradient of the extraction wells, i.e., back into the plume area.

Additional information needs to be included in the plan as follows:

1. Hydrogeologic Analysis

   The draft EE/CA lacks an analysis of the expected effectiveness of the proposed remedial action in capturing the groundwater plume. This analysis is necessary for determining adequacy of the extraction rates and locations to achieve plume capture and to ensure that the conveyance and treatment systems are properly sized. Updated diagrams, similar to those provided in the original EE/CA, should be provided.

   This analysis should include the expected effects of the groundwater extraction and treated water discharge systems on the regional aquifers.

   Pump test results should be compared with previous or expected results.

2. Engineering Options Analysis

   More information and description of the portion of the pipeline crossing under the American River is needed.

   The EE/CA indicates that another Ultra Violet (UV) treatment system will be added if the air stream from the stripping tower exceeds 10 pounds per day. At start-up, the emission rate is expected to be less than five pounds per day. What would emission rates be for worst case concentrations? If those rates necessitate an additional UV treatment unit, a cost estimate comparing the various treatment options for worst case influent concentrations should be prepared.

   Current uses of the Buffalo Creek and the potential impacts of using the creek for effluent discharge (potential to

effect natural use as a drainage ditch, rate of infiltration, potential for erosion, safety considerations, etc.) should be discussed. Circumstances which prevent or limit the discharge to the American River or Folsom Canal, such as maintenance, construction activities or flooding, should be discussed.

3. Analysis of Applicable or Relevant and Appropriate Requirement (ARARs) and To Be Considered's

We disagree with your statement that Proposition 65 establishes "levels at which the State has determined that concentrations below those levels do not constitute significant risks." Statements about risk ranges associated with the discharge of various constituents would be more appropriate. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) risk goals (a discussion of which should be included in this section) are less than the Proposition 65 levels and as such, we consider levels less than the Proposition 65 levels to be significant.

More information on the acquisition of permits, particularly from the County and other government agencies should be provided.

4. Community Concerns

We believe that a key aspect to the proposed plan is acceptance from the community, and in particular those who make use the American River and Folsom Canal waters downstream from Aerojet's treatment plant discharge locations. The document should contain more information about those uses.

The Community Relations Plan (CRP) should be updated for this site specific action. The updated CRP should be submitted under separate cover for approval and placement in the Administrative Record.

5. References and Citations to Other Works

The plan contains no citations to reference material or other documents. Reference to appropriate guidance documents, relevant materials, and reports should be included.

If you have any questions, please call me at (916) 255-3706.

Sincerely,

Duncan Austin, P.E.
Remedial Project Manager

cc: Mr. Alex MacDonald
Central Valley Regional Water
Quality Control Board
3443 Routier Road, Suite A
Sacramento, California 95827-3098

Ms. JoAnn Cola, H-7-A
US Environmental Protection Agency,
Region IX
75 Hawthorne Street
San Francisco, California 94105-3901

ATTACHMENT 3

	A
53	
54	ENVIRONMENTAL OPERATIONS, DEPT 0330
55	DESIGN AND CONSTRUCTION
56	ARGET
57	=A4
58	
59	OPTION: TREATMENT BY AIR STRIPPING
60	
61	SUBJECT:TOWER SPECIFICATIONS (cont.)
62	
63	Find:
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99	
100	
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104	

	B
53	Air Flow =
54	
55	
56	
57	
58	
59	
60	
61	
62	
63	
64	
65	**Number of Transfer Units Required for Removal (volumetric)**
66	
67	R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))
68	
69	R =
70	
71	NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)
72	
73	NTU =
74	
75	**Number of Transfer Units Required for Removal (stripping factor)**
76	
77	NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)
78	
79	NTU =
80	
81	
82	**Input Information to Flooding Correlation Graphs**
83	
84	x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5
85	
86	x-axis (vol.) =
87	
88	x-axis (R) =
89	
90	y-axis =
91	
92	Tower Dia.(ft)
93	8
94	9
95	10
96	11
97	12
98	
99	Tower Dia.(ft)
100	8
101	9
102	10
103	11
104	12

	C	D
53	=(D24*D37*E12)/D20	cfm
54		
[redacted]		
[redacted]		
[redacted]		
58		
59		
60		
61		
62		
63		
64		
65		
66		
67		
68		
69	=(D20*C46)/(D24*E12)	
70		
71		
72		
73	=C69/(C69-1)*LN((((D26/D28)*(C69-1))+1)/C69	
74		
75		
76		
77		
[redacted]		
[redacted]	=D37/(D37-1)*LN((((D26/D28)*(D37-1))+1)/D3	
[redacted]		
81		
82		
83		
84		
85		
86	=(D12/E46)*((D16/D14)^0.5)	
87		
88	=(D12/E53)*((D16/D14)^0.5)	
89		
90		
91		
92	G'(vol)	G'(R)
93	=(E46/3600)/(3.14159*(B93^2)/4)	=(E53/3600)/(3.14159*(B93^2)/4)
94	=(E46/3600)/(3.14159*(B94^2)/4)	=(E53/3600)/(3.14159*(B94^2)/4)
95	=(E46/3600)/(3.14159*(B95^2)/4)	=(E53/3600)/(3.14159*(B95^2)/4)
96	=(E46/3600)/(3.14159*(B96^2)/4)	=(E53/3600)/(3.14159*(B96^2)/4)
97	=(E46/3600)/(3.14159*(B97^2)/4)	=(E53/3600)/(3.14159*(B97^2)/4)
98		
99	y-axis(vol)	y-axis(R)
100	=(D30*(E93^2)*(D18^0.1))/(D14-D16)	=(D30*(F93^2)*(D18^0.1))/(D14-D16)
[redacted]	=(D30*(E94^2)*(D18^0.1))/(D14-D16)	=(D30*(F94^2)*(D18^0.1))/(D14-D16)
[redacted]	=(D30*(E95^2)*(D18^0.1))/(D14-D16)	=(D30*(F95^2)*(D18^0.1))/(D14-D16)
[redacted]	=(D30*(E96^2)*(D18^0.1))/(D14-D16)	=(D30*(F96^2)*(D18^0.1))/(D14-D16)
104	=(D30*(E97^2)*(D18^0.1))/(D14-D16)	=(D30*(F97^2)*(D18^0.1))/(D14-D16)

	E	F
53	=C53*60*D16	lbs/hr
54		
55		
56		
57		
58		
59		
60		
61		
62		
63		
64		
65		
66		
67		
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80		
81		
82		
83		
84		
85		
86		
87		
88		
89		
90		
91		
92	Cap. Fact.(vol.)	Cap. Fact.(R.)
93	=C93/D16^0.5	=D93/D16^0.5
94	=C94/D16^0.5	=D94/D16^0.5
95	=C95/D16^0.5	=D95/D16^0.5
96	=C96/D16^0.5	=D96/D16^0.5
97	=C97/D16^0.5	=D97/D16^0.5
98		
99		
100		
101		
102		
103		
104		

	A	B	C
1	1,4-DIOXANE COST TREATMENT COST EVALUATION		
2	AEROJET ENVIRONMENTAL OPERATIONS		
3	DEPARTMENT 0330		
4	ARGET		
5	33706		
6			
7	GIVEN:		
8			
9	1,4-DIOXANE INFLUENT CONCENTRATION (PPB)		
10			
11	1,4-DIOXANE EFFLUENT CONCENTRATION (PPB)		
12			
13			
14			
15	GROUNDWATER FLOW RATE (GPM)		
16			
17	ELECTRICAL POWER COST PER KWH ($/KWH)		
18			
19	HYDROGEN PEROXIDE DOSE (PPM)		
20			
21	ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)		
22			
23	OPERATING HOURS PER YEAR		
24			
25	HYDROGEN PEROXIDE COST ($/POUND)		
26			
27	HYDROGEN PEROXIDE STRENGTH (%/100)		
28			
29			
30	ASSUMPTIONS:		
31			
32	UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS		
33			
34			
35	FIND:		
36			
37	KILOWATTS REQUIRED FOR TREATMENT		
38			
39	ELECTRICAL COST PER YEAR		
40			
41	LAMP REPLACEMENT COST		
42			
43	HYDROGEN PEROXIDE COST PER YEAR		
44			
45	TOTAL ANNUAL OPERATING COST		

	D	E
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8		
9		6
10		
11		1.25
12		
13		
14		
15		3445
16		
17		0.08
18		
19		25
20		
21		3.85
22		
23		8400
24		
25		0.32
26		
27		0.5
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		=(E21*60*E15*(LOG(E9/E11)))/1000
38		
39		=E37*E23*E17
40		
41		=(E37/30)*E23/3500*2500
42		
43		=((E15*60*E23)/1000000)*(E19/E27)*8.34*E25
44		
45		=SUM(E39:E43)

	A
1	ENVIRONMENTAL OPERATIONS, DEPT 0330
2	DESIGN AND CONSTRUCTION
3	ARGET
4	33706
5	
6	OPTION: TREATMENT BY AIR STRIPPING
7	
8	SUBJECT:TOWER SPECIFICATIONS
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33	Assumptions:
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40	Find:
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	B
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12	Liquid Rate (lb / hr) =
13	
14	Liquid Density (lb / cuft) =
15	
16	Gas Density (lb / cuft) =
17	
18	Liquid Viscosity (cp) =
19	
20	Henry Constant 15°C (PCE) =
21	
22	Cuft per Gallon (liquid) =
23	
24	Molar Flowrate Conv. =
25	
26	Influent Conc. (ppb) =
27	
28	Effluent Conc. (ppb) =
29	
30	Packing Factor (F) =
31	
32	
33	
34	
35	Volumetric Flowrate Ratio (L/G) =
36	
37	Stripping Factor (R) =
38	
39	
40	
41	
42	**Air Flow Requirements (volumetric)**
43	
44	(liquid flowrate) (cuft / gal.) (volumetric ratio)
45	
46	Air Flow =
47	
48	
49	**Air Flow Requirements (stripping factor))**
50	
51	((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant
52	

	C	D
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		=E12*60*8.34
13		
14		62.4
15		
16		0.073
17		
18		1
19		
20		628
21		
22		0.1337
23		
24		177.5
25		
26		3.9
27		
28		0.25
29		
30		30
31		
32		
33		
34		
35		60
36		
37		4
38		
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42		
43		
44		
45		
46	=E12*D22*D35	cfm
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	E	F
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45		
46	=C46*60*D16	lbs/hr
47		
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Aerojet Sacramento Site

Final Revised Engineering Evaluation and Cost Analysis for the American River Study Area

Prepared by:

Gencorp Aerojet
Sacramento, California

September 1996

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1.0 INTRODUCTION

In May 1993, Aerojet revised and submitted an Engineering Evaluation/Cost Analysis (1993 EE/CA) for the American River Study Area (ARSA) which recommended that a groundwater extraction/treatment facility be located on the north side of the American River to minimize the downgradient migration of chemicals in groundwater. Subsequently, US EPA issued Unilateral Order No. 95-16 (EPA Order) governing the remediation of the plume on both sides of the American River. The EPA Order included a program for completion of the remedial action on the north side of the American River and development of an EE/CA for the plume on the south side of the American River. During design and the associated public comment period, the public expressed substantial concerns regarding the siting of a treatment plant in Sailor Bar Park which resulted in a delay of the project and a reevaluation of the siting of the treatment facilities. EPA rescinded the EPA Order and the Central Valley Regional Water Quality Control Board issued a Cleanup and Abatement Order requesting implementation of an interim action for the ARSA and development of a revised EE/CA which would evaluate extraction of the groundwater and transport back to the Aerojet Sacramento facility for treatment. Accordingly, this EE/CA provides such an evaluation and recommends construction of a groundwater treatment system on the Aerojet site which combines UV/Oxidation and Air Stripping treatment technologies with disposal of the treated groundwater to Buffalo Creek, Alder Creek or Folsom South Canal.

2.0 SITE CHARACTERIZATION

2.1 Site Description

The Aerojet Sacramento facility is located south of US Highway 50 in Rancho Cordova, California approximately 15 miles east of downtown Sacramento (see Figure 2-1). The ARSA, as shown on Figure 2-2, is located north of Highway 50, and west of Hazel Avenue, approximately 0.5 mile north of the Aerojet facility boundary. North of the American River, the ARSA includes Sacramento County's Sailor Bar Park and the surrounding residential properties of Fair Oaks. Most of the investigation north of the river has been conducted within the park area which encompasses approximately 375 acres. South of the river, the study area includes federal lands of the American River and Nimbus fish hatcheries, state properties, various commercial properties and is bounded to the southwest by the community of Gold River.

Illinois Avenue provides access to the most eastern end of Sailor Bar Park and is one of two vehicular entrances. Located north of this entrance is a small, man-made fishing pond fed by a groundwater well which is used to maintain the pond's water and to provide a source of water for fire control.

The ARSA was the site of placer and gold dredging operations in the late 1800's and currently provides recreational opportunities including, but not limited to hiking, horseback riding, fishing, boating and picnicking.

2.2 Site Background

Since the early 1950's, the Aerojet Sacramento facility has been devoted to the development of propulsion systems to support national defense, space exploration, and satellite deployment. Industrial activities at the Aerojet site have included solid rocket motor manufacturing and testing, liquid rocket engine manufacturing and testing, and chemical manufacturing. Chemicals used in the manufacturing and production areas on the Aerojet site included chlorinated solvents, propellants, metals, oxidizers, and a variety of chemicals produced in the chemical manufacturing areas as described in the Scoping Report (1989).

2.3 Recent Investigations and Field Work

Since submittal of the 1993 EE/CA, additional investigation and field work have been completed to further evaluate the hydrogeologic conditions in the study area. This work includes the installation of ten triple-completion monitor wells, four single-completion monitor wells, fifteen groundwater extraction wells and three groundwater recharge wells. This brings the total number of wells in the ARSA to 158 wells at 62 locations, including monitor, extraction, recharge and water supply wells. Table 2-1 identifies the new wells and lists their depths, dates drilled, aquifers etc. The locations of the new wells are shown on Figure 2-3 and well construction diagrams are included in Appendix A. Aquifer pumping tests were performed on the new extraction wells and aquifer recharge tests were performed on the three recharge wells. Several rounds of groundwater sampling and chemical analyses have also been completed on new and existing monitor wells since submittal of the 1993 EE/CA.

2.3.1 Monitor Wells

One triple-completion and one single-completion monitor well were installed south of the American River; the remaining 12 monitor wells were installed north of the river. Two of the triple-completion wells (wells 1588-90 and 1591-93) were installed to monitor groundwater conditions in the vicinity of the recharge wells located at the far western end of Sailor Bar Park. Three of the triple-completion wells (1556-58, 1559-61 and 1594-96) were installed in the community of Fair Oaks, north of the western end of the park, between the park and a water supply well owned by the Fair Oaks Water District known as the Chicago Well (Aerojet well number 1049). These wells were installed to monitor groundwater conditions downgradient of Sailor Bar Park and to serve as sentinel wells for the Chicago Well. One of the completions (well 1556) was not installed properly and has never provided reliable water level measurements or groundwater samples and is usually dry. This completion was replaced by the uppermost completion of well 1594-96. The remaining triple-completion monitor wells were installed to better define the distribution of chemicals in groundwater in the study area. The single-completion wells were installed adjacent to new or existing triple-completion wells where additional water-bearing zones were present which warranted investigation.

2.3.2 Extraction Wells

Five sets of three extraction wells were installed in the ARSA, three north of the river and two south of the river. The extraction well sets consist of three wells, each screened in one of the three aquifer units containing significant quantities of chemicals of concern in the study area. The aquifer units were screened individually to assure that groundwater would be extracted from each unit at each location and to allow variation of the pumping rates in each unit. One set of wells (4325, 4330 and 4335) was placed in the area of highest chemical concentrations located south of the American River. This set of wells is located on the Nimbus Fish Hatchery property. The intent of these wells is to expedite removal of chemical mass from the subsurface. The other four sets of extraction wells were located along the downgradient extent of the chemical plumes and placed to attempt to maximize the zone of capture created by the groundwater extraction system. The locations of the downgradient extraction wells were somewhat controlled by the geography and land use in the study area. The extraction wells north of the river were all placed on County land within Sailor Bar Park. It was not feasible to locate extraction wells in the residential areas nor the heavily wooded ravines north of the river.

Aquifer pumping tests were performed on each of the ARSA extraction wells. These tests were performed to determine design parameters (flow rate and initial influent chemical concentration) for the ARSA groundwater treatment system and to evaluate the hydraulic characteristics of the aquifer units in the study area. Based on the tests, the nine wells north of the river are expected to pump a total volume of 2,030 gallons per minute (gpm) or 2.9 million gallons per day (mgd) and the six wells south of the river are expected to pump a total of 1,415 gpm or 2.0 mgd when the American River groundwater extraction and treatment system is in full-scale operation. Further details and results of the aquifer pumping tests are described below in section 2.4.2.

2.3.3 Recharge Wells

Three recharge wells (5110, 5115 and 5120) were installed at the far western end of Sailor Bar Park to evaluate groundwater recharge as a method for disposing of treated groundwater. The wells were located at the western end of the park in order to be placed downgradient of the chemicals in groundwater; and screened in aquifer units below the three aquifer units of concern in the study area. There is virtually no other location within the park that would be appropriate for the installation of recharge wells without risking aquifer cross-contamination or adversely modifying the flow of groundwater in the overlying aquifers.

The recharge wells were tested by injecting groundwater pumped from the fire protection well located in Sailor Bar Park. The water was injected at a constant rate for approximately eight hours. Water levels were monitored during the tests using data loggers and pressure transducers placed in the recharge wells and in nearby groundwater monitoring wells. The maximum capacities for the three recharge wells injected individually is 320, 365 and 140 gpm. The actual capacity of the three wells would be somewhat lower when they are pumped concurrently due to interference effects between the three wells. Therefore, the total recharge capacity of this set of three recharge wells would be somewhat less than 825 gpm or 1.2 mgd. This is only approximately 40 percent of the expected extraction rate for the nine northern extraction wells. Due to geographic limitations on potential locations for recharge wells and the relatively low recharge capacity of the deeper aquifers, recharge within Sailor Bar Park did not prove to be a viable option for disposal of treated groundwater. A description of the recharge well tests and graphs of water level response during the tests is presented in Appendix B.

2.4 Hydrogeology

Figure 2-4 shows the monitor, extraction, recharge and water supply wells from which data were collected for the evaluation of subsurface conditions for this project. Evaluation of lithologic and geophysical logs shows that the sediments consist of Tertiary- and Quaternary-age alluvial deposits from previous courses of the American River. Historic gold-dredging operations have disturbed the shallow sediments in the area.

2.4.1 Groundwater Flow System

Lithologic and geophysical logs of monitor, extraction, recharge and public water supply wells were used to construct six hydrogeologic cross-sections through the area (Figures 2-5, 2-6, and 2-7). Finer-grained materials (silts, clays, siltstones, claystones) were grouped together as aquitards while the coarser-grained materials (sands, gravels, sandstones) were grouped together as aquifers. The interpretation of the continuity of lenses and layers shown on the cross-sections is based on geophysical logs, lithologic descriptions, and the response of water levels to pumping. In general, lateral variations in stratigraphy are greater in the north-south direction than in the east-west direction. This configuration is consistent with the depositional patterns expected from the ancestral American River which flowed westward.

The upper hydrostratigraphy has been divided into three main aquifer units (Upper, Middle, and Lower Aquifers) which contain the majority of the chemical mass in the study area addressed by this report. Below the Lower Aquifer is a relatively continuous aquitard as well as additional water-bearing units, identified as a group as the Deeper Aquifer unit. The three aquifers of concern tend to be thicker in the eastern portion of the study area near the fish hatcheries and become thinner to the west. Conversely, the Deeper Aquifer unit below the Lower Aquifer becomes thicker and more prevalent than aquitard materials to the west, while aquitard materials are more prevalent in the eastern portion of the study area.

Upper Aquifer

The Upper Aquifer consists of higher permeability sands and gravels with lenses of interbedded sediments of lower permeability and extends to a depth of approximately 25 to 100 feet below ground surface. Figures 2-8 and 2-9 present groundwater elevation contour maps of the Upper, Middle, Lower and Deeper Aquifers based upon data collected during plant-wide soundings conducted in April and October 1995, respectively. The Upper Aquifer

maps indicate that groundwater flows generally to the west-northwest under a gradient of approximately 0.01 feet per foot (56 feet per mile) in the eastern portion of the study area and under a gradient of approximately 0.004 to 0.006 feet per foot (20 to 33 feet per mile) in the central and western portion of the study area. The average gradient across the study area is approximately 0.005 feet per foot (29 feet per mile). Groundwater in the Upper Aquifer exists under both unconfined and semi-confined conditions as determined by local stratigraphy.

Although the unconfined to semi-confined nature of the Upper Aquifer suggests that some hydraulic connection between the American River and the Upper Aquifer exists, the presence of chemicals in the Upper Aquifer on the north side of the river and the configuration of the potentiometric surface of the Upper Aquifer indicate that the river is not a significant barrier to chemical migration or groundwater flow.

Middle Aquifer

The Middle Aquifer is separated from the Upper Aquifer by a relatively continuous aquitard ranging from approximately 10 to 55 feet in thickness. In general, the Middle Aquifer consists of sands, gravels, and silty sands ranging in thickness between 10 and 70 feet. In the central and western portions of the study area the Middle Aquifer is bifurcated into two water bearing units as shown on cross-sections B-B' and E-E' on Figures 2-6 and 2-7, respectively. The Middle Aquifer groundwater elevation contour maps presented on Figures 2-8 and 2-9 indicate that groundwater flows generally to the west-northwest under a gradient of approximately 0.009 feet per foot (45 feet per mile) in the eastern portion of the study area and gradient of approximately 0.004 to 0.006 feet per foot (22 to 32 feet per mile) in the western portion of the study area. The average gradient across the study area is approximately 0.005 feet per foot (29 feet per mile). Groundwater in the Middle Aquifer exists under confined to semi-confined conditions.

Lower Aquifer

The Lower Aquifer is separated from the Middle Aquifer by an aquitard ranging in thickness from approximately 15 to 50 feet. The Lower Aquifer groundwater elevation contour maps presented on Figures 2-8 and 2-9 indicate that groundwater flows generally to the west-northwest under a gradient of approximately 0.011 feet per foot (61 feet per mile) in the eastern portion of the study area and under a gradient of approximately 0.004 to 0.007 feet

per foot (22 to 39 feet per mile) in the western portion of the study area. In the central portion of the study area, there is an area with a relatively flat gradient, 0.001 feet per foot (7 to 8 feet per mile). The average gradient across the study area is approximately 0.005 feet per foot (26 feet per mile). Groundwater in the Lower Aquifer exists under confined to semi-confined conditions.

Deeper Aquifer

The water-bearing zones below the Lower Aquifer are grouped together as the Deeper Aquifer. The Deeper Aquifer is separated from the Lower Aquifer by an aquitard ranging in thickness from approximately 15 to 100 feet. The Deeper Aquifer groundwater elevation contour maps presented on Figures 2-8 and 2-9 indicate that groundwater flows generally to the west under a gradient of approximately 0.011 feet per foot (61 feet per mile) in the eastern portion of the study area, approximately 0.002 feet per foot (10 feet per mile) in the central portion of the study area and 0.006 to 0.008 feet per foot (34 to 43 feet per mile) in the western portion of the study area. The average gradient across the study area is approximately 0.006 feet per foot (34 feet per mile). Groundwater in the Deeper Aquifer exists under confined to semi-confined conditions.

Water Level Fluctuations

Water levels are measured twice annually (in April and October) in all monitor wells in the ARSA. Figures 2-10 and 2-11 are representative hydrographs of monitor wells in the southern portion of the study area. Hydrographs for the remaining wells are presented in Appendix C. Water levels in all aquifers have generally declined between 1986, a year of above normal rainfall, and April 1993, when increasing water levels were observed. Water levels declined again between April 1993 and October 1994 and then increased again during the 1995 water level soundings. The regional changes in water levels are due to variations in climatic conditions from year to year. Since there is currently no significant pumping from the Upper, Middle, Lower and Deeper Aquifers, the regional fluctuations are not a result of aquifer overdraft. Seasonal fluctuations of water levels in water levels have also been observed. Between April and October of 1995 water levels declined an average of 3.3 feet in the Upper Aquifer, 2.9 feet in the Middle Aquifer, 3.0 feet in the Lower Aquifer and 2.3 feet in the Deeper Aquifer. The lower rate of water level decline in the Deeper Aquifer relative to the three overlying aquifer units suggests that this unit may be more confined and more hydraulically isolated from the other three. This is also indicated by water levels in the Deeper

Aquifer which are often higher than one or more of the overlying aquifers, as shown on the hydrographs presented in Figures 2-10 and 2-11. In general, there is a downward gradient from the Upper to the Middle to the Lower Aquifers and an upward gradient from the Deeper Aquifer to the overlying Lower Aquifer. This has helped to limit the downward migration of chemicals to the Deeper Aquifer.

2.4.2 Aquifer Pumping Tests

Aquifer pumping tests were performed on the 15 extraction wells installed in the ARSA. The purpose of these tests was to determine the approximate quantity of water each well would produce under full-scale operating conditions and to evaluate the hydrologic characteristics of the aquifers being pumped. Table 2-3 presents a summary of the aquifer testing and analyses including test dates, duration, pumping rates, drawdown, distance to pumping wells, transmissivity and storage coefficient. Descriptions of the aquifer testing and analysis procedures and graphs of time versus water level and/or drawdown are presented in Appendix G. In general, the results of the aquifer tests are similar to those of other aquifer tests performed on the Aerojet site. The results are consistent with the nature of the aquifer materials present in the study area.

Drawdown measurements were compiled and summed for each of the extraction and monitor wells for data collected during the 15 single-well pumping tests conducted between November 1993 and August 1995 to represent the cumulative drawdown that might occur during full-scale pumping. These drawdown data are presented on Table G-2 in Appendix G. Figure 2-12 presents contour maps of the predicted groundwater elevation and capture zones for the Upper, Middle, and Lower aquifers based on the total drawdown data. No extraction wells are screened in the Deeper aquifer.

The maps were created by using the *Surfer for Windows* software package to grid and contour the drawdown data using the Kriging algorithm. This same approach was used to contour the groundwater elevation data as presented on Figures 2-8 and 2-9. Using *Surfer's* grid math functions, the drawdown grid was subtracted from the groundwater elevation grid for the April 1995 water level data from each aquifer, resulting in the contour maps shown on Figure 2-12. The capture zones were then drawn by hand based on the resulting groundwater elevation contours. The capture zones were reduced in size in order to compensate for *Surfer's* tendency to spread out the contours where data is sparse. The somewhat smaller

capture zones are more conservative estimates than would occur from strict adherence to the contour lines.

2.4.3 Distribution of Chemicals in Groundwater

Chemicals, primarily volatile organic compounds (VOCs), have been identified in groundwater at depths of approximately 50 to 250 feet below ground surface within portions of the study area. Results for samples collected between January 1990 and April 1993 were presented in Appendix D of the 1993 EE/CA. Results for samples collected between January 1993 and January 1996 are presented in Appendix D of this report. The five most common VOCs account for approximately 99% of the VOC mass present and are as follows; trichloroethylene (TCE), Freon-113, cis- and/or trans-1,2-dichloroethylene (c/t-1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and perchloroethylene (PCE). Based on the concentrations of these five compounds for all groundwater samples collected between January 1990 and December 1995, the average composition of VOCs is: 85% TCE, 6% Freon-113; 4% c/t-1,2-DCE; 3% 1,1-DCE; and 1% PCE. The graph presented in Figures 2-13 shows the composition and trend of these five compounds since January 1990 for well 1405 which is located in the more highly concentrated portion of the plume on the south side of the American River. Chemical trend graphs for the remaining wells are presented in Appendix E. Because TCE is the most prevalent chemical and its distribution encompasses that of the other chemicals, TCE has been chosen as the indicator to define the configuration of the VOC plume in the groundwater.

The chemical distribution maps for TCE and the other VOCs, discussed below, were based upon data collected from monitor, extraction and water supply wells between July and December 1995. The period encompasses two quarterly sampling events. Figure 2-14 presents the distribution of TCE in the Upper, Middle, Lower and Deeper Aquifers for the July through September, 1995 quarterly sampling, Figure 2-15 presents the TCE distribution for the October through December quarterly sampling, and Figure 2-16 presents the TCE distribution for the January through March, 1996 quarterly sampling . Chemical distribution maps for the first two sampling periods for Freon-113, c/t-1,2-DCE, 1,1-DCE, PCE and 1,4-Dioxane are presented in Appendix F.

The highest TCE concentrations in each aquifer (greater than 1,000 micrograms per liter (ug/l) in the upper three aquifers) are located in a relatively small area in the central part of the study area under the western portion of the fish hatchery property south of the American

River. The highest concentrations and widest distribution of chemicals are within the Middle Aquifer.

Three previously tentatively identified compounds (TICs) that were identified in the 1993 EE/CA are 1,4-dioxane, n-butyl-benzene-sulfonamide, and 1-methyl-2-pyrrolidinone. These compounds are now routinely analyzed for in the Aerojet Analytical Laboratory EPA 8270 analysis. Of these, 1,4-dioxane is the most commonly detected in the study area. The 1-methyl-2-pyrrolidinone compound has only been identified above detection limits in two samples and n-butyl-benzene-sulfonamide continues to be identified sporadically and with inconsistent results , but does not show any significant distribution in the study area. N-butyl-benzene-sulfonamide has been identified in 20 of the approximately 150 wells sampled in the study area. It has been identified above detection limits in 45 samples out of a total of 438 samples analyzed. Thirteen of the wells containing n-butyl-benzene-sulfonamide are one-inch completions and this appears to be consistent with reports that it may be a remnant of well construction. Nine of the wells are completed in the Deeper aquifer, below the aquifers screened by the extraction wells. Therefore, no significant concentrations of n-butyl-benzene-sulfonamide are expected to be introduced into the groundwater treatment facility.

Distribution maps for 1,4-dioxane in the Upper, Middle, Lower and Deeper Aquifers are included in Appendix F. These maps indicate that 1,4-dioxane is present above the detection limit of 10 ug/l in some of the wells located south of the American River with the highest concentration detected of 29 ug/l in wells 1307 and 1404. 1,4-dioxane was not detected in any of the wells north of the river above the laboratory detection limit of 10 ug/l.

Fair Oaks Water District Water Supply Wells

The Fair Oaks Water District owns and operates two water supply wells in the ARSA. The Chicago Well (well 1049) is located approximately 3,400 feet north of the western end of Sailor Bar Park. The Town Well (well 1047) is located approximately 3,500 feet west of the western boundary of the park (Figure 2-4). These wells are used for pressure control during times of high demand and as a backup water supply in case of a failure of the surface water distribution system, and therefore do not operate year-round. Aerojet has sampled and analyzed 15 groundwater samples from the Town Well and 21 samples from the Chicago Well since September 1993. No VOCs were identified in these samples above the laboratory detection limit of 0.5 ug/l.

Samples from the multiple-completion monitor wells installed in Fair Oaks to serve as sentinel wells for the Chicago Well have shown anomalous results for TCE. The first few samples from wells 1557-8 and 1559-61 (installed in 1993) contained no VOCs above laboratory detection limits. Starting with the July 1994 samples, TCE was identified sporadically in wells 1557 and 1558. Low concentrations of TCE were then identified in March and April 1995 samples from wells 1559, 1560 and 1561. The initial samples from wells 1594, 1595 and 1596 (installed in 1995) also contained low concentrations of TCE. All of these positive results for TCE were considered anomalous because they did not fit the general distribution of TCE in groundwater and they were very inconsistent. Contaminated purging and/or sampling equipment was suspected as the source of the TCE in these wells. Rinse blanks from the purge pump and hose used to sample these wells showed significant concentrations of TCE. In order to eliminate the possibility of false positive results from the purging/sampling equipment, dedicated purge/sampling pumps were installed in the eight well completions in November 1995. No VOCs have been identified above the laboratory detection limit of 0.5 ug/l in the eight samples collected from each of these wells since installation of the dedicated pumps. Table 2-2 presents the analytical results for TCE for all samples collected from these eight completions from the date of their installation through July 1996.

2.5 Summary of Site Conditions That Justify A Removal Action

TCE concentrations greater than 1,000 ug/l of VOCs have been identified in groundwater samples from certain monitoring wells in the American River study area. Site investigations have revealed that the leading edge of the plume is on the north side of the river in the vicinity of the northern boundary of Sailor Bar County Park. Residents in the surrounding areas are predominantly served by public water supplies with water quality that meets all drinking water standards. The recommended removal action is justified because groundwater extracted from the ARSA will reduce or eliminate potential degradation of downgradient water supplies.

3.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

3.1 Removal Action Objectives and Scope

The objective of the removal action is to implement a groundwater extraction/treatment facility to control the migration of chemicals in groundwater and remove chemicals from the extracted groundwater. The extraction wells are intended to control further downgradient chemical migration and to remove the highest concentrations of chemicals. By doing so, the removal action should significantly reduce the risk to public health and the environment and contribute to the goal of final remedy by significantly reducing cleanup time and costs.

3.2 Removal Action Schedule

Once the EE/CA and associated CEQA documentation has been reviewed by the public and approved by the Agencies, Aerojet anticipates approximately 6 months for design, 1 month for procurement and 8 months for construction of the removal action assuming expeditious Agency review of deliverables and that property access and permits can be obtained.

3.3 Applicable or Relevant and Appropriate Requirements (ARARs)

Under CERCLA a removal action that involves extraction and treatment of groundwater above or in proximity of a contaminated aquifer should ARARs to the extent practicable, considering the exigencies of the situation. A requirement under federal or state environmental laws may be either "applicable" or "relevant and appropriate". "Applicable" requirements are:

> those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site.

For a standard to be "applicable", all of the jurisdictional prerequisites must exist, such that the requirement would apply if the action were not undertaken pursuant to CERCLA. "Relevant and appropriate" requirements are promulgated federal or state requirements which

are not "applicable" but which address problems sufficiently similar to those encountered in the contemplated removal action that their use is well suited to the particular site.

Under CERCLA, only promulgated state standards more stringent than federal requirements can be considered potential ARARs. Promulgated requirements are laws imposed by state legislative bodies and regulations developed by state agencies that are of general applicability and are legally enforceable. Policy or guidance documents issued by federal or state agencies that are not legally binding are not ARARs.

Section 121 (d) (4) of CERCLA, as amended by SARA, provides that a cleanup standard that assures protection of human health and the environment, but does not achieve a level of control equivalent to an ARAR, may be selected if:

1. The action is only part of the total action that will ultimately attain ARARs;

2. Compliance with the ARAR will result in greater risk to human health and the environment than alternative options;

3. Compliance is not feasible from an engineering perspective;

4. The action selected will achieve the same level of cleanup through another method or approach;

5. A state has not consistently applied a state ARAR in similar circumstances in connection with other actions within the state; or

6. The ARAR would require too great an expenditure from the "Superfund".

There are three separate categories of ARARs: (1) ambient or chemical-specific requirements that set health or risk-based concentration limits or ranges for particular chemicals; (2) performance, design, or action-specific requirements that govern particular activities, such as Clean Water Act pre-treatment standards for discharges to publicly owned treatment works (POTW); and (3) location-specific requirements, such as facility siting restrictions.

3.3.1 Ambient or Chemical Specific Requirements

Maximum contaminant levels (MCLs) under the Safe Drinking Water Act and Title 22 of the California Code of Regulations establish health based concentration limits for water provided as a part of a public water supply. The California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) prohibits the discharge of the significant amount of a chemical which State has identified under Proposition 65 as causing cancer or other reproductive effects.

3.3.2 Performance, Design or Action Specific Requirements

The removal actions being considered by this EE/CA involve the extraction and transport of groundwater, treatment of the extracted groundwater, and discharge of the treated water.

ARARs are addressed in the Recommended Removal Action section (5.0).

3.3.2.1 Treatment of Groundwater

3.3.2.1.1 Air Emissions

If the facility uses a treatment technology that will result in air emissions, then the substantive requirements of the Sacramento Metropolitan Air Quality Management District (SMAQMD) must be evaluated.

Under SMAQMD regulations, new sources that emit reactive organic compounds (ROCs) which exceed 10 pounds per day are required to meet best available control technology (BACT).

SMAQMD has not promulgated a rule for discharge of toxic chemicals into the atmosphere. It does have a toxics guidance which, while not an ARAR, is to be considered. Essentially, a risk assessment is undertaken to determine theoretically increased risks associated with the proposed project. If risks are within an unacceptable range, the SMAQMD will require the applicant to evaluate further risk reduction.

3.3.2.1.2 Management of Treatment Residuals

Treatment of the water or the air can generate material that must be managed before disposal or regeneration. If the material generated is a solid waste that meets the characteristics for a hazardous waste, substantive requirements of the Resource Conservation Recovery Act (RCRA) of 1976 as amended by the Hazardous and Solid Waste Amendments of 1984 and Title 22 of the California Code of Regulations, Division 4.5, Chapter 11 for the management of hazardous waste may be ARARs.

3.3.2.2 Discharge Options

3.3.2.2.1 Discharge to the Aquifer Through Recharge or On-Site Percolation

The Federal Safe Drinking Water Act mandates the establishment of an Underground Injection Control (UIC) program in states where injection may cause a risk to drinking water. The UIC program for California is administered by the U.S. EPA. The UIC program exempts injection of treated groundwater into the aquifer from which it was drawn pursuant to a CERCLA cleanup.

California's Toxic Injection Well Control Act of 1985 (Health and Safety Code Sections 25159.10 et seq.) is not applicable because it is limited to hazardous waste and otherwise exempts groundwater cleanups and therefore, is not relevant and appropriate to the evaluation.

The Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code); California Code of Regulations, Title 23, Division 3, Chapter 15; the Regional Water Quality Control Board's, Central Valley Region Basin Plan; apply to discharge of treated groundwater to the waters of the State that are potential sources of drinking water. The Regional Board has identified State Water Resource Control Board Resolution Nos. 68-16, 88-63, and 92-49 as potentially applicable or relevant and appropriate requirements.

3.3.2.2.2 Discharge to Buffalo Creek, Alder Creek or Folsom South Canal

If the chosen remedial alternative requires discharge to a surface water, the discharge must meet the substantive requirements of the National Pollutant Discharge Elimination System (NPDES) and the federal Clean Water Act antidegradation policy requirement which is

satisfied by the State Water Board Resolution No. 68-16. If the receiving stream is an aquatic and wildlife habitat, Ambient Water Quality Criteria (AWQC) are appropriate standards for protection of aquatic life.

Discharges to surface water under the Clean Water Act must, at a minimum, meet BACT requirements for toxic pollutants and Best Conventional Control Technology (BCCT) for conventional pollutants. More stringent effluent limits based upon Best Available Demonstrated Control Technology (BADCT) may be promulgated for new sources. Effluent limitations are developed specifically based on knowledge of available technology and cost-effectiveness.

California's "Statement of Policy With Respect to Maintaining High Quality of Water in California," (Resolution 68-16) has also been evaluated as a potential ARAR. The policy requires maintenance of existing water quality unless it is demonstrated that a change will benefit the people of the state, will not unreasonably affect present or potential beneficial uses, and will not result in water quality less than prescribed by other state policies. Resolution 68-16 is not a zero-discharge standard, but rather a policy statement that existing quality be maintained when it is reasonable to do so. The policy specified in Resolution 68-16 and the Basin Plan allows for the use of mixing zones when determining whether water quality is being maintained in the receiving water.

3.3.3 Location Specific Requirements

The removal action being considered involves extraction wells and piping on the north and south sides of the American River and a treatment facility on Aerojet. The treatment facility would be located outside the 100 year flood plain and outside of any wetland. An extraction well is located within the 100 year flood plain. There is no prohibition on placement of the well and pipeline within the flood plain, although such facilities may require special design considerations. Aerojet is unaware of any location specific ARAR or siting requirement for this removal action other than the State has identified a threatened species, the Valley Elderberry Longhorn Beetle, which resides in blue elderberry shrubs found in the American River Parkway.

Aerojet contracted with *biota biological consulting* to conduct a Natural Environment Study (NES), assessing potential impacts to biological resources associated with the five GET facility alternatives, the proposed pipeline alignment and the recharge wells. The NES, the

Valley Elderberry Longhorn Beetle Habitat Mitigation & Monitoring Plan and related information are included within this report as Appendix H.

3.3.4 Other

The State has identified that CEQA is an ARAR and has requested that Aerojet have the necessary CEQA documents prepared.

4.0 IDENTIFICATION AND EVALUATION OF REMOVAL ACTION ALTERNATIVES

4.1 Pipeline Routing

As part of preliminary planning to prepare the EE/CA, the "SARGET Facility - Pipeline Alternatives Nimbus Fish Hatchery to Aerojet", dated September 19, 1995 (Appendix I) was completed. Based on this report, and considering the anticipated location of the groundwater treatment facility, pipeline Alternative 5 from Appendix I was retained for further evaluation and is included within this report. Figure 4-1 shows this pipeline route along with the property parcels and ownership.

Aerojet is in the process of obtaining all easements necessary to utilize the pipeline alignments detailed as part of this route. To date, preliminary request for easements have been made to all agencies along this pipeline route. Currently , the easements being secured are under the jurisdiction of the Federal, State and Local Government agencies.

4.2 Influent Chemical Concentration Treatment Design Assumptions

Table 4-1 presents the basis for determining which chemicals would be subject to treatment due to exceedance of applicable water quality standards. The values in this table were derived from flow rates determined during aquifer testing of the fifteen extraction wells, actual average chemical concentrations present in groundwater in the fish hatchery extraction wells (4325, 4330 and 4335), and predictions of chemical concentrations in groundwater that could occur in the future in the remaining wells. The chemical concentrations used during this evaluation for groundwater produced from the western wells located on the south side of the American River (4370, 4375 and 4380) were assumed to be 10% of the chemical concentrations present in wells located at the fish hatchery (4325, 4330 and 4335). The

chemical concentrations assumed in groundwater from wells located on the north side of the American River in Sailor Bar Park are based on predictions of future increases in concentration due to continued downgradient chemical migration but also limited by initiation of groundwater extraction from the wells located on the south side of the American River. The calculated worst case influent chemical concentrations are a flow-weighted average from all fifteen groundwater extraction wells with a total anticipated groundwater extraction rate of 3,445 gallons per minute. Figure 4-2, American River GET Collection System, provides information related to: well location, expected extraction flow rate, chemicals present, and worst-case anticipated chemical concentrations for the fifteen groundwater extraction wells along with a calculated worst-case flow weighted influent concentration which was then used as the basis for evaluation of the treatment alternatives.

Table 4-1 compares the estimated influent concentration for both organic and inorganic constituents with applicable regulatory standards such as the Federal and State maximum contaminant levels (MCLs), RWQCB non-degradation policy, and Ambient Water Quality Criteria. The table also shows which chemicals have to be treated to meet these individual standards. These chemical concentrations for VOCs are a conservative estimate of the maximum concentration expected to be encountered during the life of this project and are significantly higher than those expected during project startup. The values used for inorganic constitiuents or other physical parameters are based on water quality data collected during aquifer testing from selected extraction wells located in the area of the highest organic chemical concentration (4325, 4330 and 4335) along with extraction wells located in the side gradient portion of the groundwater plume that contain significantly lower chemical concentrations (4370, 4375 and 4380).

As Table 4-1 displays, the only chemicals exceeding published standards are organic chemicals, primarily VOCs. Based on this, treatment will be designed to remove VOCs present in the influent groundwater such that the effluent would contain no detectable concentrations of any VOC using a practical quantification limit (PQL) of 0.5 ppb. The anticipated influent concentrations of the compound 1,4-dioxane are below the Proposition 65 limit of 15 ppb according to water quality results obtained using EPA 8270 analytical techniques with a PQL of 10 ppb.

4.3 Analysis of Groundwater Treatment Technologies

General Response Actions are defined as those measures which will satisfy the Remedial Action Objectives and Scope described in Section 3.1. The basic General Response Actions for remediation of groundwater containing chemicals in the American River Study Area are no action, point of use treatment, and groundwater extraction and treatment. The no action alternative does not require evaluation as part of an EE/CA and is therefore, not included in this submittal. There is no need for point of use treatment at the present time as chemicals have not been detected in the analysis of water quality samples from the nearest downgradient public water supply wells.

The extraction and treatment of groundwater will reduce and potentially eliminate the mobility and volume of the chemicals present. Groundwater pumping would inhibit continued chemical migration. Due to the hydrogeologic conditions and the depth of the groundwater containing chemicals, pumping from extraction wells for above-ground treatment is the only commercially proven and feasible option for control of chemical migration. Existing, commercially demonstrated technologies for treatment of groundwater containing VOCs and SVOCs include physical and advanced oxidation treatments methods. Physical treatment processes that are applicable for treating groundwater and which are included in this EE/CA are air stripping and carbon adsorption. UV/Oxidation is considered an advanced oxidation process and is also included in this evaluation.

This section provides an initial screening of those remedial action alternatives that may be feasible for the General Response Actions identified above. Consistent with U.S. EPA guidance documents, the evaluation factors used to screen each alternative on a preliminary basis are effectiveness, implementability and cost. These evaluation factors are defined as follows:

Effectiveness - Protection of human health and the environment; reduction of toxicity, mobility and volume.

Implementability - Technical and administrative feasibility of constructing, operating and maintaining the removal action.

Cost - Costs are evaluated qualitatively in the initial screening.

4.3.1 Air Stripping

Description

Air stripping, using counter-current, packed towers, has been effective in removing VOCs from groundwater at Aerojet since 1981. Air stripping is a common technology at many sites in the nation for treatment of VOCs. Aerojet operates five air stripping systems at the Sacramento site at a combined flow rate of approximately 5,000 gpm. Each plant is a two-stage system, operating in series flow, with the first tower providing primary treatment and the second tower(s) performing polishing treatment. Effluent quality remains below discharge limitations established in the Decree, and is generally below 0.5 ug/l for each of the VOCs targeted for treatment. The systems operated by Aerojet are extremely reliable with interlocking controls which ensure the blower system is operating and provides the correct air volume while water is being pumped through the treatment towers. This prevents the discharge of untreated groundwater from the treatment facility.

In the air stripping process, influent groundwater is pumped to the top of the first tower and flows down the tower through packing material that possesses a large surface area. The flow is evenly distributed throughout the cross-sectional area of the circular tower by the use of liquid distributor troughs. Air is then either forced or induced upward through the tower counter-current or cross-current to the cascading water, at a mass flow rate designed to transfer the VOCs from the aqueous phase to the air phase. The treated water is collected in a reservoir at the base of the first tower for final polishing treatment in the second tower in a similar manner.

Effectiveness

Air stripping systems will adequately reduce the concentrations of VOCs in groundwater to meet ARARs, and are technically feasible and reliable. Air emissions control must be evaluated for each system based on emissions rate of reactive organic compounds, cancer risk, and chronic and acute hazard indices. Air stripping technology is not effective for the removal of 1,4-dioxane from groundwater.

Implementability

Air Stripping systems have been successfully implemented on the Aerojet site.

Cost

Air Stripping is a relatively low cost alternative. However, control of VOCs in the off-gas could require the installation of control equipment resulting in significant impacts to both capital and operation and maintenance (O & M) costs.

4.3.2 Granular Activated Carbon Adsorption

Description

Aerojet has operated three aqueous phase granular activated carbon (GAC) adsorption systems which were installed on local municipal water supply wells beginning approximately 10 years ago. Each system is composed of two 20,000 pound carbon filter beds operated in series. The carbon media is replaced once VOC breakthrough occurs above 4.5 ug/l in the primary GAC adsorber vessel. The polishing adsorber vessel is used as a redundant treatment module to assure potability of the water supplied for human consumption.

These systems remove 10 to 25 ug/l VOCs with only one or two vessels requiring carbon replacement per year. As the VOC loading increases, the carbon usage rate increases proportionately, thereby shortening the carbon replacement period.

Effectiveness

Carbon adsorption transfers the contamination from the aqueous phase to the surface of the GAC. No contamination is released to the air phase. Spent carbon, replaced with virgin carbon, is removed and shipped to an offsite facility, where it is thermally regenerated and recycled for reuse in other applications. Thermal regeneration of the carbon destroys the adsorbates. Carbon Adsorption would provide a significant level in reduction of toxicity, mobility and volume. Carbon adsorbtion is not effective for the removal of 1,4-dioxane from groundwater.

Implementability

Aqueous phase carbon adsorption is a technically feasible alternative; however, it is typically limited to relatively low VOC concentrations. The technology has greater potential implementability as secondary treatment or polishing instead of providing complete treatment due to high operational cost caused by excessive GAC usage.

Cost

The estimated annual operating cost for carbon replacement is the main criteria used to evaluate whether or not carbon adsorption is a feasible alternative. Capital costs are low; however, O&M costs are moderate to high depending on GAC usage rates.

4.3.3 UV/Oxidation

Description

UV/Oxidation is a two step treatment process for removal of VOCs in an aqueous stream. In the first step, an oxidizer, such as hydrogen peroxide or ozone, is introduced into the aqueous stream. The second step is to expose the aqueous stream containing the previously introduced oxidizer to UV energy. The reaction of UV energy with oxidizer in the aqueous stream produces an oxidizing hydroxyl radical which reacts and breaks down the oxidizable contaminants (VOCs). Under optimum conditions, the targeted VOCs will oxidize and break down into water, carbon dioxide and chloride ion.

Effectiveness

UV/Oxidation has the capability to consistently remove certain VOCs from an aqueous stream to less than detectable levels at 0.5 ug/l. However, UV/Oxidation alone for the ARSA project would not be effective due to the groundwater containing several VOCs not amenable to effective or efficient treatment by this technology. UV/Oxidation is a technology that is typically more applicable to lower volume or more concentrated waste streams rather than high volume, dilute applications; and therefore, UV/Oxidation is a treatment technology that is primarily suitable for pretreatment to reduce total VOC mass. Treatment to MCLs requires numerous treatment units resulting in excessive electrical consumption. UV/Oxidation or other advanced oxidation processes such as ozonation are the only commercially proven and effective treatment methods to treat 1,4-dioxane.

Implementability

UV/Oxidation is a commercially proven treatment alternative if used as a pretreatment system, followed by polishing treatment, such as air stripping or aqueous phase carbon or a combination of the two technologies particularly when dealing with groundwater that contains Freon, chloroform and assorted chlorinated ethanes.

Cost

Capital costs are moderate. O&M costs are high due to the considerable electrical power consumption of the treatment system.

4.3.4 Summary of Applicable Technologies Versus Target Chemicals

Table 4-2 lists the relative performance of the technologies for each of the chemical compounds anticipated to be present in the groundwater influent. These are subjective ratings meant only for comparison between technologies.

Due to the elevated VOC concentrations and the high flow rate, GAC is not recommended because carbon usage rates would be excessive and therefore, O&M costs would be very high. GAC is considered economically infeasible and will not be further considered in this evaluation. UV/Oxidation alone is not recommended due to the presence of certain VOCs in the influent which are not amenable to treatment by this method. Air stripping is by far the most efficient and cost effective method to remove VOCs. Accordingly, air stripping alone or in combination with UV/Oxidation will be carried forward in this analysis.

4.4 Detailed Analysis of Groundwater Treatment Alternatives

The following sections present two different alternatives for the treatment of groundwater produced from the fifteen existing extraction wells in the ARSA. Each treatment alternative evaluation was based on the flow rate, and chemical constituents and associated concentrations presented in Section 4.2.

4.4.1 Groundwater Treatment Alternative 1

Groundwater Treatment Alternative 1 (Figure 4-3) combines UV/Oxidation and air stripping technologies (Appendix J). Initially this alternative would include treatment of the groundwater produced from extraction wells 4325, 4330 and 4335 using a 180 KW UV/Oxidation treatment system. Even though these wells produce only 23% of the total extracted volume, these wells contain approximately 91% of the total chemical mass projected to be encountered during system startup. After pre-treatment, the partially treated groundwater would be combined with the groundwater produced from the other twelve extraction wells for removal of the remaining VOCs utilizing an air stripping system.

The initial system results in emissions. Total and reactive organic compounds (ROCs) emissions at system start-up are calculated to be 1.9 and 1.7 pounds per day respectively. According to SMAQMD Rule 202, Section 301.1 since the ROCs emissions do not exceed the 10 pounds per day limit, (SMAQMD, Procedure for Permit Processing) the application of BACT would typically not be required. In addition, the off-gas from the air stripper will also contain compounds regulated as toxic organics. Since the initial emission rate for these compounds would result in a residential 70-year maximum exposed individual (MEI) cancer risk value below the 0.1×10^{-6} deminimus level, the application of T-BACT would not typically be required. In the event that future influent groundwater chemical concentrations increase to a point where the limit for ROCs or the cancer risk deminimus value might be exceeded, the treatment system will be modified, including installation of additional UV/Oxidation equipment, to maintain ROCs emissions to levels below 10 lbs/day and toxic risk values below the deminimus levels. The resultant emissions at the worst-case influent groundwater concentrations would result in total and ROCs emissions of 15.2 and 14.3 pounds per day respectively, and a residential 70-year maximum exposed individual (MEI) cancer risk value of 0.30×10^{-6} (Appendix K scenario 1).

4.4.2 Groundwater Treatment Alternative 2

Groundwater Treatment Alternative 2 (Figure 4-5) provides for the removal of VOCs from the total groundwater flow utilizing an air stripping system (Appendix J) with control of the resultant emissions by a combination concentrator thermal oxidation system (Appendix M).

The air stripping system utilized as part of Groundwater Treatment Alternative 2 would result in emissions. Total and ROCs emissions are projected to be 11.8 and 11.6 pounds per day at system startup and 25.1 and 24.1 pounds per day at worst-case conditions. (Appendix K, scenario 2.) According to SMAQMD Rule 202, Section 301.1 since the emissions exceed the 10 pounds per day limit for ROCs (SMAQMD, Procedure for Permit Processing) the application of BACT would be required. Also, since the emission rate at start-up would exceed the deminimus residential 70-year maximum exposed individual (MEI) cancer risk value of 0.1×10^{-6} , the application of T-BACT regulation would typically apply requiring the installation of an emission control device (Appendix L). An air emission control device would have a typical control efficiency of 95% reducing the ROCs below the 10 pound per day level and the residential 70-year maximum exposed individual (MEI) cancer risk value below the 0.1×10^{-6} deminimus level.

4.4.3 Summary of Detailed Groundwater Treatment Alternatives

Table 4-3 provides information related to estimated costs associated with construction of the two treatment system alternatives. Appendix L - Air Stripper T-BACT - Review of Candidate Technologies and Appendix M- Cost Estimation for Concentration and Thermal Destruction of a Dilute Air Stream Containing Halogenated Compounds, provide information related to the costs associated with the control of air emissions generated by the air stripping scenarios considered in this evaluation. Table 4-4 provides information related to the estimated O&M costs associated with the two treatment alternatives. Analysis of net present value (NPV) for the pipeline configuration alternatives versus the two treatment alternatives are provided in Tables 4-5. Information related to the calculated effluent concentration (ppb) for each individual targeted compound and 1,4-dioxane based on expected worst case influent concentrations versus the two treatment alternatives is provided in Table 4-8. In all cases, targeted VOCs are removed from the groundwater to non-detectable concentrations at a PQL of 0.5 ppb. In the case of 1,4-dioxane, calculated effluent concentrations for this compound range from a calculated value of 1.3 ppb at startup to 6.0 ppb at worst-case conditions depending on the treatment alternative, and are never anticipated to exceed the PQL of 10 ppb.

4.5 Analysis of Treated Groundwater Discharge

4.5.1 Treated Groundwater Disposal Option 1-Discharge to Buffalo Creek or Alder Creek

Treated Groundwater Discharge Alternative 1 utilizes Buffalo Creek (Figure 4-5), or Alder Creek, waterways that begin on the Aerojet property and ultimately discharge into the American River, to dispose of the treated groundwater. Buffalo Creek and Alder Creek are main drainage courses on the Aerojet site and as such, discharges into these waterways are subject to NPDES requirements. Regardless of which Groundwater Treatment Alternative is selected, effluent from the treatment facility in all cases will be free of all targeted regulated VOCs based on a PQL of 0.5 ppb. The effluent may contain 1,4-dioxane below the PQL of 10 ppb. Based on the most conservative circumstances, the 1,4-dioxane concentration in the effluent is not expected to exceed a calculated 6 ppb. Given that the effluent flow rate of the treatment system is estimated to be 3,445 gpm or approximately 7.7 cubic feet per second (CFS) and a minimum flow rate in the American River of 250 CFS, there would be more than a 30 fold reduction in the 1,4-dioxane concentration in the River after an appropriate mixing interval. (Appendix N provides Flow Rate Information for the Lower American River and the Folsom South Canal.) In addition, Buffalo Creek and Alder Creek have no known uses as water supplies or recreational water bodies.

4.5.2 Treated Groundwater Disposal Option 2 - Discharge to Folsom South Canal

Option 2 (Figure 4-6) discharges the treated groundwater to Folsom South Canal, located on the western and northern border of the Aerojet site. This canal is owned and operated by the United States Bureau of Reclamation (USBR). Current uses of this canal include: drinking water supply for the Arden Cordova Water Service, irrigation supply for the Omochumnee-Hartnell and Clay Water Districts, SMUD (Rancho Seco) among others. According to data provided by USBR, surface water diversion from the American River to the Folsom South Canal varies between 1,000-2,600 acre-ft per month or approximately 7,440-19,340 gpm. Treated groundwater would be discharged into the Canal down stream of the surface water intake of the Arden Cordova Water Service. Given the estimated effluent flow rate of the treatment system of 3,445 gpm and the flow rate of the Folsom South Canal at a minimum of 7,440 gpm, there would be more than a two-fold reduction in the 1,4-dioxane concentration in the Canal after an appropriate mixing interval. (See Appendix N.)

4.5.3 Treated Groundwater Disposal Option 3 - Discharge to Recharge Wells

Option 3 (Figure 4-7) discharges the treated groundwater to the aquifers utilizing a series of recharge wells located on the northern boundary of Aerojet in the vicinity of the proposed treatment facility. The cost estimate was developed based on a recharge rate per well typical of that currently achieved in the GET D area recharge field, approximately 225 gpm on average. Using this recharge rate as a guide, 15 recharge wells would be required for the discharge of groundwater at a flow rate of 3445 gpm. This option would result in localized mounding in the vicinity of the recharge.

4.5.4 Treated Groundwater Disposal Option 4 - On-Site Percolation Discharge

Option 4 (Figure 4-8) discharges the treated groundwater to land, applied through an irrigation system using impact type sprinklers. The area required to percolate a flow rate of 3445 gpm without ponding, is approximately 142 acres. This surface area requirement is based on a groundwater application rate of 0.8 gpd per ft^2 which is a typical application rate for the soil type expected to be encountered in the percolation area. This option would also result in localized mounding in the vicinity of the recharge.

4.5.5 Summary of Treated Groundwater Discharge Options

Table 4-7 provides information related to construction and O&M costs along with an analysis of NPV of each of the four discharge options.

5.0 Recommended Removal Action

The EE/CA has assessed alternatives to implement a groundwater extraction/treatment facility to control the migration of chemicals. The following paragraphs summarize the recommended alternative and the rationale behind the recommendation.

Aerojet's recommendation for groundwater extraction, treatment and discharge combines Groundwater Treatment Alternative 1 (Figure 4-1) and Treated Groundwater Discharge Alternative 1 (Figure 4-5).

This project includes the outfitting of 15 extraction wells, installation of 3,000 lineal feet of 8-inch diameter pipe, 3,350 lineal feet of 16-inch diameter pipe, 9,900 lineal feet of 10-inch diameter pipe, and 11,300 lineal feet of 20-inch diameter pipe. This project also includes a 2,000 foot, directionally drilled river crossing. (See Appendix P, American River Crossing Project Plan.)

This recommendation includes the installation of dual groundwater conveyance pipelines. The installation of the dual pipelines will allow the groundwater from Extraction Wells 4325, 4330 and 4335 (located near the Fish Hatchery) to be isolated from the groundwater from the remaining twelve extraction wells for pretreatment using an UV/Oxidation system. After pretreatment, effluent from the UV/Oxidation system will be combined with the groundwater produced from the other twelve wells for removal of the remaining VOCs using a conventional air stripping system. Pretreatment of the Fish Hatchery wells using this UV/Oxidation system would significantly reduce the total mass of chemical that would require further treatment by the air stripping system. In addition, UV/Oxidation would also significantly reduce the concentration of 1,4-dioxane concentrations present in the groundwater from these wells. This approach would not result in emissions of toxic or ROCs above regulatory limits, and therefore, the installation of an emission control device for the off-gas produced by the air stripping system is not required.

Table 4-8 provides an estimate of the flow weighted influent chemical concentrations that could be expected to be encountered during the treatment system start-up. These estimates are based on water quality information obtained from extraction and monitor wells presented in an ARSA water quality report for the monitoring period October thru December, 1995. Table 4-9 provides information related to influent and effluent chemical concentrations for both start-up and worst case conditions. Table 4-9 also provides the estimated air emission rates at start-up.

After treatment, the groundwater will be discharged to Buffalo Creek or Alder Creek as described previously in Section 4.5.1 Treated Groundwater Disposal Option 1. At this time, discharge to Buffalo Creek appears to be the most logical alternative. In the future, periodic evaluation will be performed to assess alternative disposal or reuse options that may be identified in the future. The construction, operation and maintenance, and NPV costs of this recommendation are presented in Table 4-10.

The recommended alternative will meet ARARs. The effluent will be at limits consistent with the Clean Water Act NPDES requirements. Air emissions will be managed consistent with SMAQMD regulations.

An Initial Study and Negative Declaration are being prepared for this project under Sections 15063 and 15070 of the CEQA Guidelines. The Initial Study and Negative Declaration include a project description, Initial Study checklist, discussion of potential environmental effects, and mitigation measures that will be incorporated into the project description and construction specifications in order to avoid or mitigate environmental effects to a point where no significant effects would occur.

The Initial Study will contain a discussion of all checklist items, with an emphasis on the following environmental issue areas:

- Compatibility with surrounding land uses along the pipeline alignment and along the American River Parkway;
- Air quality and public health effects from pipeline construction and operation of the air stripper system;
- Historic and prehistoric cultural resources;
- Surface and groundwater quality and quantity;
- Biologic resources along the pipeline alignment and along the American River Parkway;
- Noise from construction and operation of the pipelines and treatment facility; and,
- Construction traffic effects on local roadways.

6.0 References

CERCLA, Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986.

City of Sacramento Department of Planning and Development, American River Parkway Plan, December 1985.

Gencorp Aerojet, Engineering Evaluation and Cost Analysis for the American River Study Area, Aerojet Sacramento Site, May 1993.

Gencorp Aerojet, Scoping Report, December 1989.

RCRA, Resource Conservation Recovery Act of 1976, as amended by the Hazardous and Solid Waste Amendments of 1984.

US EPA, Outline of EE/CA Guidance, 30 March 1988.

Table 2-1
New Wells in the American River Study Area

Well Number	Cluster Name	Well Type*	Date Completed	Top of Perforations (feet, MSL)	Bottom of Perforations (feet, MSL)	Aquifer Designation
1538	1538-40	MC	06/21/93	57.3	41.3	Upper
1539	1538-40	MC	06/21/93	-3.7	-14.7	Middle
1540	1538-40	MC	06/21/93	-44.7	-56.7	Lower
1556	1556-8	MC	10/21/93	9.3	-3.7	Upper
1557	1556-8	MC	10/21/93	-51.2	-67.2	Middle
1558	1556-8	MC	10/21/93	-100.7	-113.7	Lower
1559	1559-61	MC	10/30/93	10.2	-7.8	Upper
1560	1559-61	MC	10/30/93	-40.9	-50.9	Middle
1561	1559-61	MC	10/30/93	-76.9	-86.9	Lower
1562	1562	SC	04/07/94	13.8	-1.2	Middle
1563	1563	SC	04/12/94	-9.4	-14.4	Middle
1564	1564-6	MC	04/21/94	39.7	23.7	Upper
1565	1564-6	MC	04/21/94	-16.3	-26.3	Middle
1566	1564-6	MC	04/21/94	-48.3	-58.3	Lower
1567	1567-9	MC	04/29/94	50.8	34.8	Upper
1568	1567-9	MC	04/29/94	11.8	-2.2	Middle
1569	1567-9	MC	04/29/94	-38.2	-48.2	Lower
1570	1570	SC	05/03/94	-14.1	-22.1	Middle
1571	1571-3	MC	05/09/94	38.9	24.9	Upper
1572	1571-3	MC	05/09/94	-21.1	-36.1	Middle
1573	1571-3	MC	05/09/94	-79.1	-87.1	Lower
1574	1574	SC	05/11/94	0.9	-4.1	Middle
1585	1585-7	MC	05/01/95	18.7	-2.3	Upper
1586	1585-7	MC	05/01/95	-44.3	-51.3	Middle
1587	1585-7	MC	05/01/95	-70.3	-76.3	Lower
1588	1588-90	MC	05/17/95	-195.3	-210.3	Deeper
1589	1588-90	MC	05/17/95	-237.3	-251.3	Deeper
1590	1588-90	MC	05/17/95	-283.3	-303.3	Deeper
1591	1591-3	MC	05/23/95	6.5	-14.5	Upper
1592	1591-3	MC	05/23/95	-53.5	-64.5	Middle
1593	1591-3	MC	05/23/95	-81.5	-101.5	Lower
1594	1594-6	MC	06/12/95	-1.0	-13.0	Upper
1595	1594-6	MC	06/12/95	-123.0	-133.0	Deeper
1596	1594-6	MC	06/12/95	-150.0	-160.0	Deeper

Well Number	Cluster Name	Well Type*	Date Completed	Top of Perforations (feet, MSL)	Bottom of Perforations (feet, MSL)	Aquifer Designation
4300	4300	EW	08/05/93	43.2	13.2	Upper
4301	4301	EW	08/10/93	2.9	-7.1	Middle
4302	4302	EW	08/02/93	-46.8	-66.8	Lower
4325	4325	EW	08/15/94	36.0	20.0	Upper
4330	4330	EW	08/09/94	6.7	-1.3	Middle
	Second Screen			-9.3	-29.3	
4335	4335	EW	08/24/94	-61.7	-76.7	Lower
4340	4340	EW	09/21/94	37.6	17.6	Upper
4345	4345	EW	10/03/94	-15.7	-28.7	Middle
4350	4350	EW	09/14/94	-45.2	-49.2	Lower
	Second Screen			-58.2	-65.2	
4355	4355	EW	10/24/94	31.1	24.1	Upper
	Second Screen			17.1	9.1	
4360	4360	EW	10/18/94	2.6	-1.4	Middle
	Second Screen			-9.4	-21.4	
4365	4365	EW	10/11/94	-32.7	-38.7	Lower
	Second Screen			-47.7	-54.7	
4370	4370	EW	12/07/94	31.8	21.8	Upper
4375	4375	EW	12/22/94	6.0	-18.0	Middle
	Second Screen			-27.0	-34.0	
4380	4380	EW	11/28/94	-86.3	-104.3	Lower
5110	5110	RW	10/28/94	-178.2	-230.2	Deeper
	Second Screen			-280.2	-304.2	
5115	5115	RW	11/08/94	-169.6	-205.6	Deeper
	Second Screen			-253.6	-303.6	
5120	5120	RW	12/07/94	-181.8	-214.8	Deeper
	Second Screen			-238.8	-263.8	
	Third Screen			-283.8	-310.8	

* MC - Multiple Completion Monitor Well
SC - Single Completion Monitor Well
EW - Extraction Well
RW - Recharge Well

Table 2-2
Fair Oaks Groundwater Monitor Wells
Analytical Results for TCE

Well Number	Sample Date	Sampling Method	TCE
1557	11/05/93	Purge Pump/Bailer	<0.5
	11/22/93	Purge Pump/Bailer	<0.5
	12/13/93	Purge Pump/Bailer	<5
	02/16/94	Purge Pump/Bailer	<1
	05/10/94	Purge Pump/Bailer	<1
	07/05/94	Purge Pump/Bailer	11
	02/08/95	Purge Pump/Bailer	<1
	03/07/95	Purge Pump/Bailer	3.1
	04/14/95	Purge Pump/Bailer	8
	06/28/95	Purge Pump/Bailer	9.8
	07/31/95	Purge Pump/Bailer	4.2
	08/21/95	Purge Pump/Bailer	<0.5
	09/29/95	Purge Pump/Bailer	14
	10/13/95	Purge Pump/Bailer	11
	12/11/95	Dedicated Pump	<0.5
	01/25/96	Dedicated Pump	<0.5
	02/27/96	Dedicated Pump	<0.5
	03/26/96	Dedicated Pump	<0.5
	04/18/96	Dedicated Pump	<0.5
	05/28/96	Dedicated Pump	<0.5
	06/25/96	Dedicated Pump	<0.5
	07/31/96	Dedicated Pump	<0.5
1558	11/05/93	Purge Pump/Bailer	<0.5
	11/22/93	Purge Pump/Bailer	<0.5
	12/13/93	Purge Pump/Bailer	<5
	02/16/94	Purge Pump/Bailer	<1
	05/10/94	Purge Pump/Bailer	<1
	07/05/94	Purge Pump/Bailer	36
	02/08/95	Purge Pump/Bailer	1.3
	03/07/95	Purge Pump/Bailer	1.7
	04/13/95	Purge Pump/Bailer	4.6
	06/28/95	Purge Pump/Bailer	11
	07/31/95	Purge Pump/Bailer	<0.5
	08/21/95	Purge Pump/Bailer	<0.5
	09/27/95	Purge Pump/Bailer	4.2
	10/13/95	Purge Pump/Bailer	1.2
	12/11/95	Dedicated Pump	<0.5
	01/25/96	Dedicated Pump	<0.5
	02/27/96	Dedicated Pump	<0.5
	03/26/96	Dedicated Pump	<0.5
	04/18/96	Dedicated Pump	<0.5
	05/28/96	Dedicated Pump	<0.5
	06/25/96	Dedicated Pump	<0.5
	07/31/96	Dedicated Pump	<0.5
1559	11/22/93	Purge Pump/Bailer	<0.5
	12/13/93	Purge Pump/Bailer	<5
	02/15/94	Purge Pump/Bailer	<1
	05/10/94	Purge Pump/Bailer	<1
	09/02/94	Purge Pump/Bailer	<1
	03/08/95	Purge Pump/Bailer	1
	04/11/95	Purge Pump/Bailer	2.5
	06/28/95	Purge Pump/Bailer	<0.5
	07/31/95	Purge Pump/Bailer	<0.5
	08/23/95	Purge Pump/Bailer	<0.5
	09/29/95	Purge Pump/Bailer	<0.5
	10/12/95	Purge Pump/Bailer	1.9
	12/11/95	Dedicated Pump	<0.5
	01/25/96	Dedicated Pump	<0.5
	02/23/96	Dedicated Pump	<0.5
	03/25/96	Dedicated Pump	<0.5
	04/18/96	Dedicated Pump	<0.5
	05/28/96	Dedicated Pump	<0.5
	06/25/96	Dedicated Pump	<0.5
	07/31/96	Dedicated Pump	<0.5

Well Number	Sample Date	Sampling Method	TCE
1560	11/22/93	Purge Pump/Bailer	<0.5
	12/13/93	Purge Pump/Bailer	<5
	02/15/94	Purge Pump/Bailer	<1
	05/10/94	Purge Pump/Bailer	<1
	09/02/94	Purge Pump/Bailer	<1
	03/07/95	Purge Pump/Bailer	<1
	04/13/95	Purge Pump/Bailer	3.1
	06/28/95	Purge Pump/Bailer	<0.5
	07/31/95	Purge Pump/Bailer	<0.5
	08/23/95	Purge Pump/Bailer	1.4
	09/29/95	Purge Pump/Bailer	<0.5
	10/12/95	Purge Pump/Bailer	<0.5
	10/12/95	Purge Pump/Bailer	<0.5
	12/11/95	Dedicated Pump	<0.5
	01/25/96	Dedicated Pump	<0.5
	02/23/96	Dedicated Pump	<0.5
	03/25/96	Dedicated Pump	<0.5
	04/18/96	Dedicated Pump	<0.5
	05/28/96	Dedicated Pump	<0.5
	06/25/96	Dedicated Pump	<0.5
	07/31/96	Dedicated Pump	<0.5
1561	11/22/93	Purge Pump/Bailer	<0.5
	12/13/93	Purge Pump/Bailer	<5
	02/15/94	Purge Pump/Bailer	<1
	05/10/94	Purge Pump/Bailer	<1
	09/02/94	Purge Pump/Bailer	<1
	03/07/95	Purge Pump/Bailer	<1
	04/13/95	Purge Pump/Bailer	2.5
	06/28/95	Purge Pump/Bailer	<0.5
	07/31/95	Purge Pump/Bailer	<0.5
	08/23/95	Purge Pump/Bailer	<0.5
	09/29/95	Purge Pump/Bailer	0.8
	10/12/95	Purge Pump/Bailer	0.6
	12/11/95	Dedicated Pump	<0.5
	01/25/96	Dedicated Pump	<0.5
	02/23/96	Dedicated Pump	<0.5
	03/25/96	Dedicated Pump	<0.5
	04/18/96	Dedicated Pump	<0.5
	05/28/96	Dedicated Pump	<0.5
	06/25/96	Dedicated Pump	<0.5
	07/31/96	Dedicated Pump	<0.5
1594	08/14/95	Purge Pump/Bailer	1.8
	08/30/95	Purge Pump/Bailer	<0.5
	11/13/95	Purge Pump/Bailer	<0.5
	12/14/95	Dedicated Pump	<0.5
	01/01/96	Dedicated Pump	<0.5
	02/27/96	Dedicated Pump	<0.5
	03/25/96	Dedicated Pump	<0.5
	04/18/96	Dedicated Pump	<0.5
	05/28/96	Dedicated Pump	<0.5
	06/25/96	Dedicated Pump	<0.5
	07/30/96	Dedicated Pump	<0.5
1595	08/14/95	Purge Pump/Bailer	2.6
	08/30/95	Purge Pump/Bailer	<0.5
	11/13/95	Purge Pump/Bailer	<0.5
	12/14/95	Dedicated Pump	<0.5
	01/01/96	Dedicated Pump	<0.5
	02/27/96	Dedicated Pump	<0.5
	03/25/96	Dedicated Pump	<0.5
	04/18/96	Dedicated Pump	<0.5
	05/28/96	Dedicated Pump	<0.5
	06/25/96	Dedicated Pump	<0.5
	07/30/96	Dedicated Pump	<0.5
1596	08/14/95	Purge Pump/Bailer	6.3
	08/30/95	Purge Pump/Bailer	0.7
	11/13/95	Purge Pump/Bailer	<0.5
	12/14/95	Dedicated Pump	<0.5
	01/01/96	Dedicated Pump	<0.5
	02/27/96	Dedicated Pump	<0.5
	03/25/96	Dedicated Pump	<0.5
	04/18/96	Dedicated Pump	<0.5
	05/28/96	Dedicated Pump	<0.5
	06/25/96	Dedicated Pump	<0.5
	07/30/96	Dedicated Pump	<0.5

OVERSIZED TABLE

(SEE BINDER)

TABLE 4-1

CALCULATED WORST-CASE INFLUENT CHEMICAL CONCENTRATIONS

ORGANICS

CHEMICAL	INFL. CONC. (PPB)	MCL (PPB)	NPDES/ 68-16 (PPB)	TRMT REQ (POTABLE)	TRMT REQ (NPDES/ 68-16)
TRICHLOROETHYLENE	514.1	5.0	<0.5	Yes	Yes
1,2-DICHLOROETHYLENE	42.8	6.0	<0.5	Yes	Yes
FREON 113	23.3	1200	<0.5	No	Yes
1,1-DICHLOROETHYLENE	19.7	6.0	<0.5	Yes	Yes
1,4-DIOXANE	<10 (6.0)[1]	15[2]	<10[3]	No	No
TETRACHLOROETHYLENE	3.9	5.0	<0.5	No	Yes
CHLOROFORM	1.7	100	<0.5	No	Yes
1,1-DICHLOROETHANE	0.8	5.0	<0.5	No	Yes
1,2-DICHLOROETHANE	<0.5 (0.5)[1]	0.5	<0.5	Yes	Yes
1,1,1-TRICHLOROETHANE	<0.5 (0.3)[1]	200	<0.5	No	No
CARBON TETRACHLORIDE	<0.5 (0.1)[1]	0.5	<0.5	No	No

(1) Calculated concentration.

(2) Proposition 65 concentration limit.

(3) Effluent will not contain detectable concentrations of 1,4-dioxane based on the EPA analytical method 8270 with a practical quantitation limit (PQL) of 10 ppb.

TABLE 4-1

CALCULATED WORST CASE INFLUENT CHEMICAL CONCENTRATIONS
(Continued)

INORGANICS

CHEMICAL	INFL. CONC.- (PPB)[4]	MCL (PPB)	AMBIENT WATER QUAL. CRITERIA (PPB)	TRMT REQ (POTABLE)	TRMT REQ (AWQ. CRIT.)
ALUMINUM	0.0	1000.	NA	NO	NO
ANTIMONY	0.0	6.0	NA	NO	NO
ARSENIC	0.672	50.0	190.0	NO	NO
BARIUM	91.485	1000.	NA	NO	NO
BERYLLIUM	0.0	4.0	NA	NO	NO
BORON	0.0	NA[5]	NA	NO	NO
CADMIUM	0.0	10.0	1.5	NO	NO
CALCIUM	40,545.35	NA	NA	NO	NO
CHLORIDE	40,392.46	NA	NA	NO	NO
CHROMIUM	2.430	50.0	11.0	NO	NO
COBALT	0.0	NA	NA	NO	NO
COD	0.0	NA	NA	NO	NO
CONDUCTANCE	385.9658	NA	NA	NO	NO
COPPER	1.577	1000.	16.0	NO	NO
IRON	0.0	NA	4.9	NO	NO
LEAD	0.0	50.0	NA	NO	NO
MAGNESIUM	15,624.5	NA	NA	NO	NO
MANGANESE	1.003	NA	NA	NO	NO
MERCURY	0.0	0.012	NA	NO	NO

(4) Concentration based on average from extraction wells 4225, 4330, 4335, 4370, 4375, and 4380.

(5) Not applicable.

TABLE 4-1

CALCULATED WORST CASE INFLUENT CHEMICAL CONCENTRATIONS
(Continued)

INORGANICS

CHEMICAL	INFL. CONC.- (PPB)[4]	MCL (PPB)	AMBIENT WATER QUAL. CRITERIA (PPB)	TRMT REQ (POTABLE)	TRMT REQ (AWQ. CRI.)
MOLYBDENUM	0.0	NA	NA	NO	NO
NICKEL	0.0	600.0	210.0	NO	NO
NITRATE	9,231.92	NA	NA	NO	NO
NITRITE	0.0	NA	NA	NO	NO
PERCHLORATE	0.0	NA	NA	NO	NO
pH	7.5901	NA	NA	NO	NO
PHOSPHATE	608.351	NA	NA	NO	NO
POTASSIUM	3,824.499	NA	NA	NO	NO
SELENIUM	0.0	10.0	5.0	NO	NO
SODIUM	21,936.4	NA	NA	NO	NO
SILVER	0.0	NA	NA	NO	NO
SULFATE	12,653.24	NA	NA	NO	NO
SULFITE	0.0	NA	NA	NO	NO
TDS	259,399.3	NA	NA	NO	NO
THALLIUM	0.0	2.0	NA	NO	NO
VANADIUM	8.725	NA	NA	NO	NO
ZINC	0.0	NA	140.0	NO	NO

(4) Concentration based on average from extraction wells 4225, 4330, 4335, 4370, 4375, and 4380.

(5) Not applicable.

TABLE 4-2

TECHNOLOGY COMPARISON

CHEMICAL	AIR STRIPPING	ADVANCED OXIDATION (UV/H2O2)	GRANULAR ACTIVATED CARBON
TRICHLOROETHYLENE	good	good	good
1,2-DICHLOROETHYLENE	fair	good	fair
FREON 113	good	poor	good
1,4-DIOXANE	not applicable	good	not applicable
1,1-DICHLOROETHYLENE	good	good	good
TETRACHLOROETHYLENE	good	good	good
CHLOROFORM	fair	poor	poor
1,1-DICHLOROETHANE	fair	poor	poor
1,2-DICHLOROETHANE	poor	poor	poor
1,1,1-TRICHLOROETHANE	good	poor	fair
CARBON TETRACHLORIDE	good	poor	fair

TABLE 4-3

ESTIMATED CONSTRUCTION COST ($ THOUSAND) AT STARTUP
TREATMENT SYSTEM AND INFLUENT PIPING ONLY

ALTERNATIVE	COLLECTION ALTERNATIVE CONFIG.	COLLECTION PIPELINE COST (APPENDIX O)	TREATMENT SYSTEM COST (APPENDIX O)	EMISSION CONTROL COSTS (APPENDIX M)	PROJECT TOTAL
1	Dual	$6,217	$1,905	N/A	$8,122
2	Single	$5,723	$1,415	$1,600	$8,738

TABLE 4-4

ESTIMATED OPERATION AND MAINTENANCE COSTS AT STARTUP
TREATMENT SYSTEM ONLY ($ THOUSAND)

ALTERNATIVE	TREATMENT SYSTEM COST	O&M COSTS (5% OF TREATMENT SYSTEM)	UV/H2O2 COSTS (APPENDIX J)	EMISSION CONTROL O&M COSTS (APPENDIX M)	TOTAL ANNUAL O&M
1	$1,905	$95	$210	NA	$305
2	$1,415	$71	NA	$416	$487

TABLE 4-5

NET PRESENT VALUE ANALYSIS (NPV) AT STARTUP
TREATMENT SYSTEM AND COLLECTION SYSTEM ONLY ($ THOUSAND)

ALTERNATIVE	PROJECT COST TOTAL	ANNUAL O&M	NPV (20 YR @5%)
1	$8,122	$542	$14,876
2	$8,738	$719	$17,698

Pumping cost: 130K (Appendix J)
O&M Extraction Well: 10% of Construction Cost
O&M Pipelines/River Crossing: 1% of Construction Cost
O&M Basic Treatment System: 5% of Construction Cost
O&M UV/Oxidation System (Appendix J): 210K

TABLE 4-6

WORST-CASE CALCULATED EFFLUENT CONCENTRATIONS

CHEMICAL	INFLUENT CONCENTRATION	NPDES/ 68-16	ALTERNATIVE 1	ALTERNATIVE 2
TRICHLOROETHYLENE	514.1	<0.5	0.25	0.25
1,2-DICHLOROETHYLENE	42.8	<0.5	0.25	0.25
FREON 113	23.3	<0.5	0.25	0.25
1,1-DICHLOROETHYLENE	19.7	<0.5	0.25	0.25
1,4-DIOXANE	<10 (6.0)[1]	<10	<10(3.5)[1]	<10 (6.0)[1]
TETRACHLOROETHYLENE	3.9	<0.5	0.25	0.25
CHLOROFORM	1.7	<0.5	0.25	0.25
1,1-DICHLOROETHANE	0.8	<0.5	0.25	0.25
1,2-DICHLOROETHANE	<0.5 (0.5)[1]	<0.5	0.25	0.25
1,1,1-TRICHLOROETHANE	<0.5 (0.3)[1]	<0.5	0.25	0.25
CARBON TETRACHLORIDE	<0.5 (0.1)[1]	<0.5	-	-

[1] Calculated concentration.

TABLE 4-7

ESTIMATED COSTS ($ THOUSAND)
EFFLUENT DISCHARGE OPTIONS
(Appendix O)

ALTERNATIVE	EFFLUENT PIPELINE COSTS	DISCHARGE STRUCTURE COSTS	TOTAL CONSTRUCTION COSTS	ANNUAL O&M COSTS	NPV COSTS 20 YRS @5%
Buffalo Creek	$165	$28	$233	$2(1)	$258
Folsom South Canal	$450	$58	$601	$6(1)	$676
Recharge Wells (15 wells)	$550	$1,456	$2,371	$99(2)	$3,605
Percolation Field (142 acres)	$1,560	$143	$1,970	$39 (3)	$2,456

(1) Annual O&M costs assumed to be 1% of construction cost due to the relative simplicity of this discharge option.
(2) Annual O&M costs include provision for the rehabilitation of half the recharge wells annually (7.5 wells/yr) at a unit well cost of $10, 000 plus 1% of the construction costs.
(3) Annual O&M costs assumed to be 2% of construction cost due to the size of the percolation area and associated water application system.

TABLE 4-8

CALCULATED STARTUP INFLUENT CHEMICAL CONCENTRATIONS

CHEMICAL	INFLUENT CONCENTRATION (PPB)	EFFLUENT LIMITS MCL (PPB)	EFFLUENT LIMITS (PPB)
TRICHLOROETHYLENE	249.8	5.0	<0.5
1,2-DICHLOROETHYLENE	13.4	6.0	<0.5
1,1-DICHLOROETHYLENE	10.0	6.0	<0.5
FREON 113	4.7	1200	<0.5
TETRACHLOROETHYLENE	3.7	5.0	<0.5
1,4-DIOXANE	<10 (2.8)[1]	15[2]	<10[3]
CHLOROFORM	1.6	100	<0.5
1,1-DICHLOROETHANE	0.8	5.0	<0.5
1,2-DICHLOROETHANE	<0.5 (0.5)[1]	0.5	<0.5
1,1,1-TRICHLOROETHANE	<0.5 (0.3)[1]	200	<0.5
CARBON TETRACHLORIDE	<0.5 (0.1)[1]	0.5	<0.5

(1) Calculated concentration below PQL of 10 ug/l.
(2) Proposition 65 concentration limit; no MCL for 1,4-dioxane.
(3) Effluent would not contain detectable concentrations of 1,4-dioxane using EPA 8270 analytical method with a PQL of 10 ppb.

TABLE 4-9
RECOMMENDED TREATMENT ALTERNATIVE
CHEMICAL SUMMARY INFORMATION

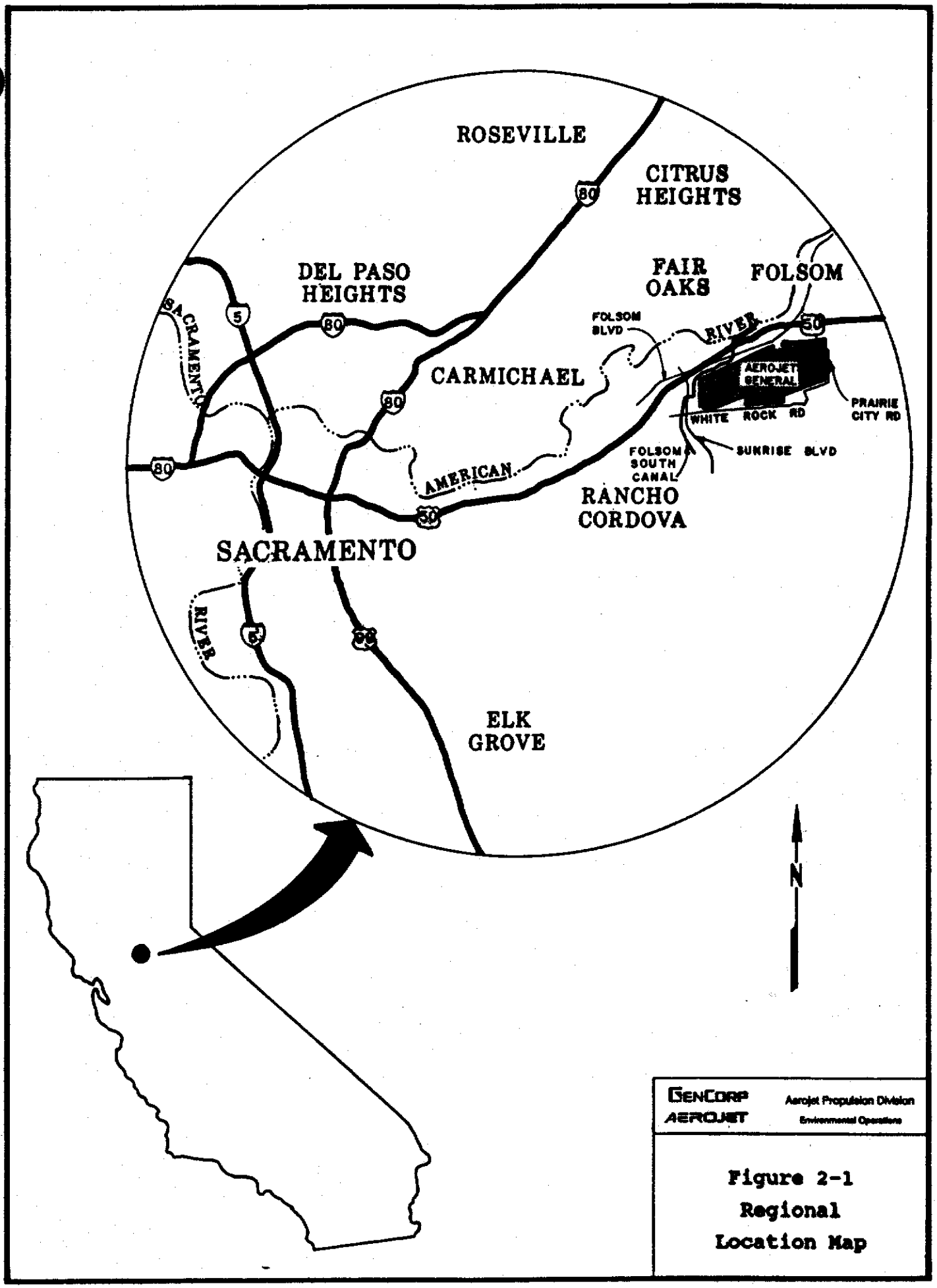
CHEMICAL	INFLUENT CONC. (PPB) STARTUP	INFLUENT CONC. (PPB) WORST-CASE	EFFLUENT CONC. (PPB) STARTUP	EFFLUENT CONC. (PPB) WORST-CASE	EMISSION RATES STARTUP LBS/DAY
1,4-DIOXANE	<10 (2.8)[1]	<10 (6.0)[1]	<10 (0.3)[1]	<10 (3.5)[1]	NA
TRICHLOROETHYLENE	249.8	514.1	<0.5	<0.5	1.48×10^{0}
1,2-DICHLOROETHYLENE	13.4	42.8	<0.5	<0.5	6.09×10^{-1}
1,1-DICHLOROETHYLENE	10.0	19.7	<0.5	<0.5	4.06×10^{-1}
FREON 113	4.7	23.3	<0.5	<0.5	1.46×10^{-1}
TETRACHLOROETHYLENE	3.7	3.9	<0.5	<0.5	3.19×10^{-2}
CHLOROFORM	1.6	1.7	<0.5	<0.5	4.84×10^{-2}
1,1-DICHLOROETHANE	0.8	0.8	<0.5	<0.5	1.74×10^{-2}
1,2-DICHLOROETHANE	0.5	0.5	<0.5	<0.5	1.12×10^{-2}
1,1,1-TRICHLOROETHANE	<0.5 (0.3)[1]	<0.5(0.3)[1]	<0.5	<0.5	8.28×10^{-3}
CARBON TETRACHLORIDE	<0.5 (0.1)[1]	<0.5 (0.1)[1]	<0.5	<0.5	2.07×10^{-3}
TOTALS VOCS	285.2	607.2			
AIR EMISSION RATE					1.85×10^{0}
TOTALS ROCs (LBS/DAY)					1.70×10^{0}

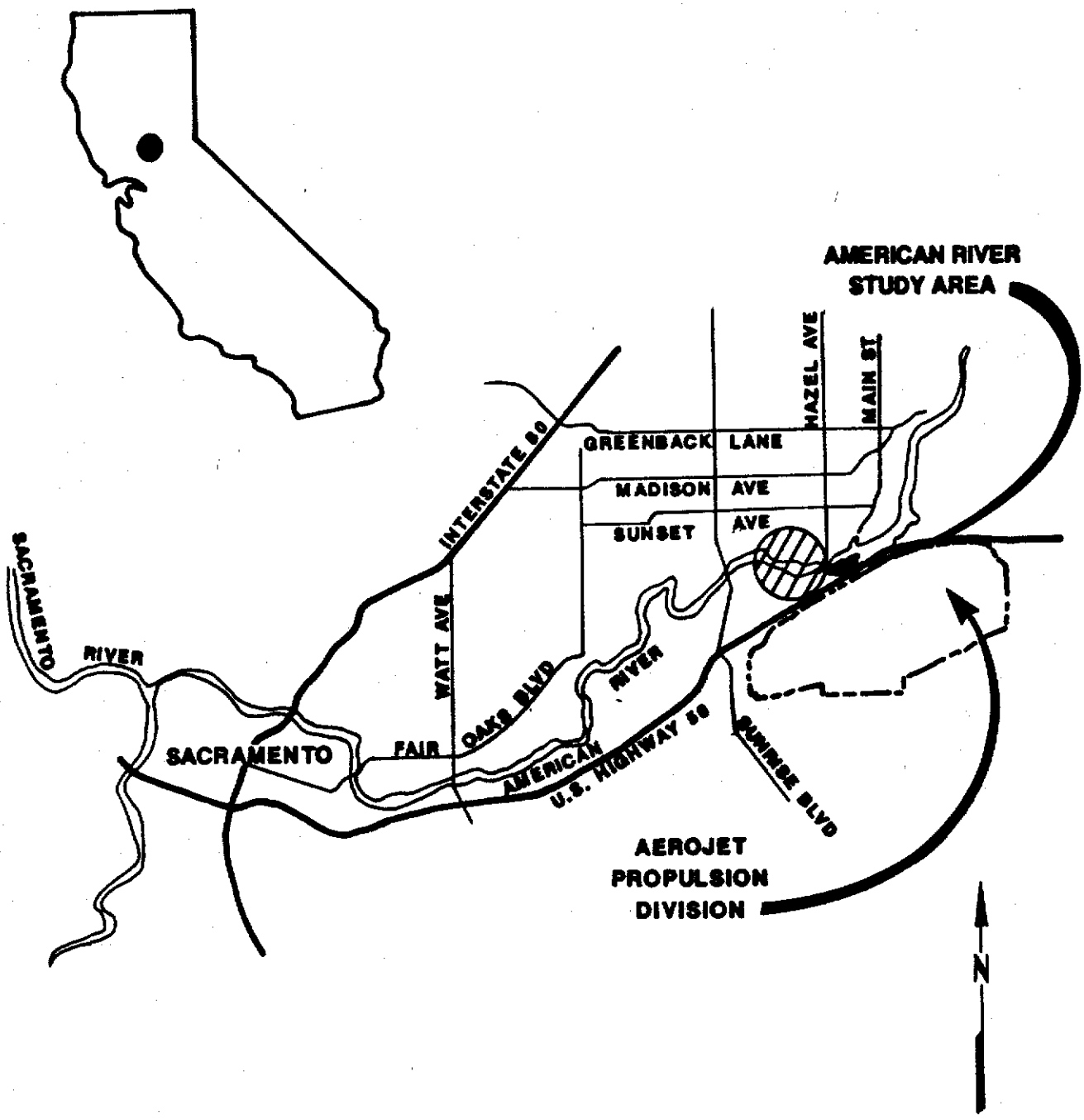
(1) Calculated concentration.

TABLE 4-10

COSTS SUMMARY ($ THOUSAND) AT STARTUP
FINAL RECOMMENDATION

ALTERNATIVE	CONSTRUCTION COSTS	ANNUAL O&M COSTS	NPV COSTS
Collection Route 1, Dual Pipeline	$6,217	$237	$9,170
Treatment Alternative 1 (UV/Oxidation)	$1,905	$305	$5,706
Discharge Buffalo Creek	$233	$2	$258
Total	$8,355	$449	$15,134

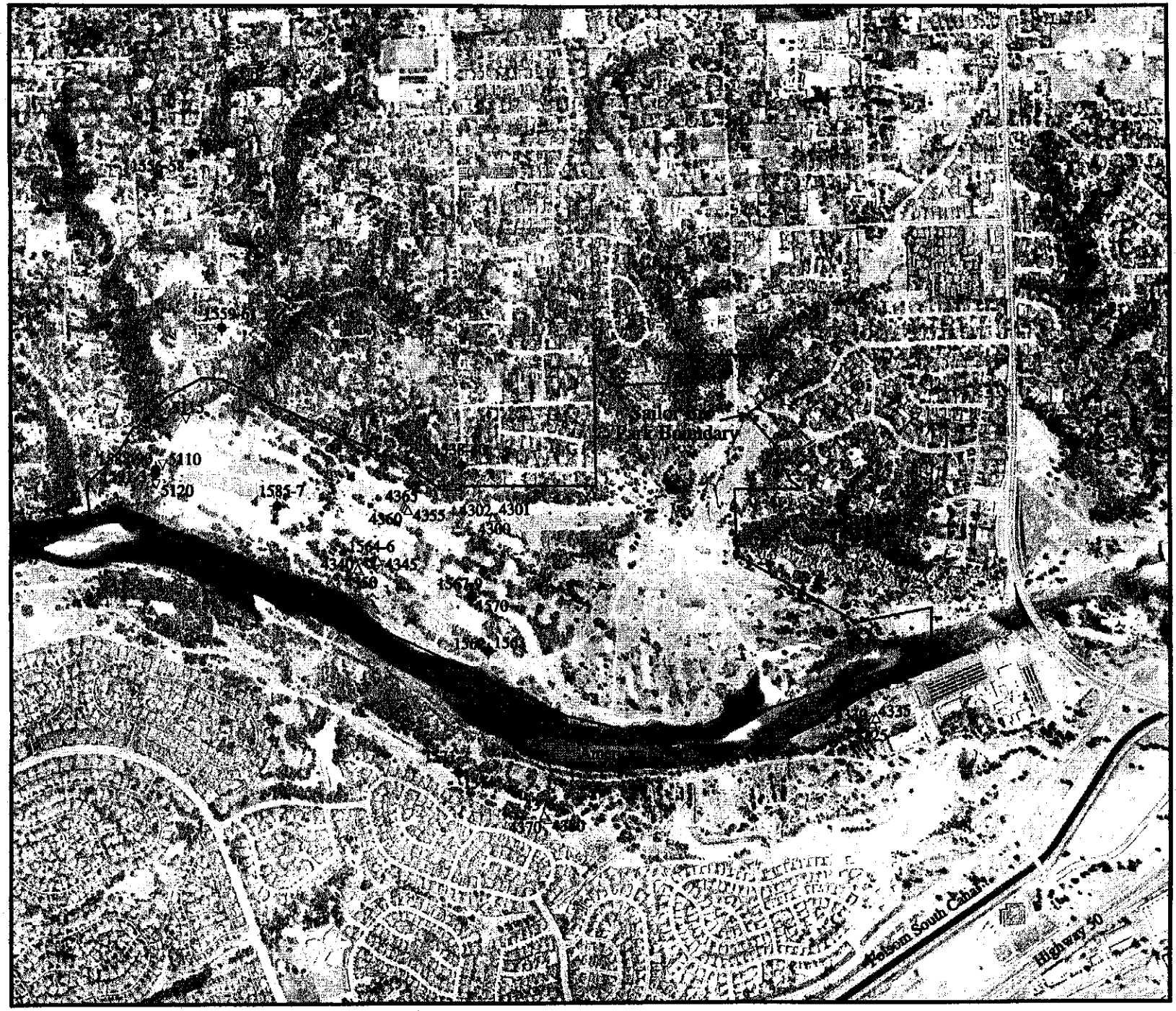

ROSEVILLE
CITRUS HEIGHTS
DEL PASO HEIGHTS
FAIR OAKS
FOLSOM
CARMICHAEL
FOLSOM BLVD
AMERICAN RIVER
AEROJET GENERAL
WHITE ROCK RD
PRAIRIE CITY RD
SUNRISE BLVD
FOLSOM SOUTH CANAL
AMERICAN
RANCHO CORDOVA
SACRAMENTO
SACRAMENTO RIVER
ELK GROVE
80
5
50
99
N
GENCORP AEROJET
Aerojet Propulsion Division
Environmental Operations
Figure 2-1
Regional
Location Map



NOT TO SCALE

GenCorp Aerojet — Aerojet Propulsion Division, Environmental Operations

Figure 2-2
Location Map



LEGEND

- ♦ Monitor Well
- △ Extraction Well
- ▽ Recharge Well

N

0 500 1000 2000

Scale in Feet

GENCORP
AEROJET

American River Study Area

Figure 2-3

Location Map of
New Wells

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Figure 2-10

Hydrograph - Well 1357-1360

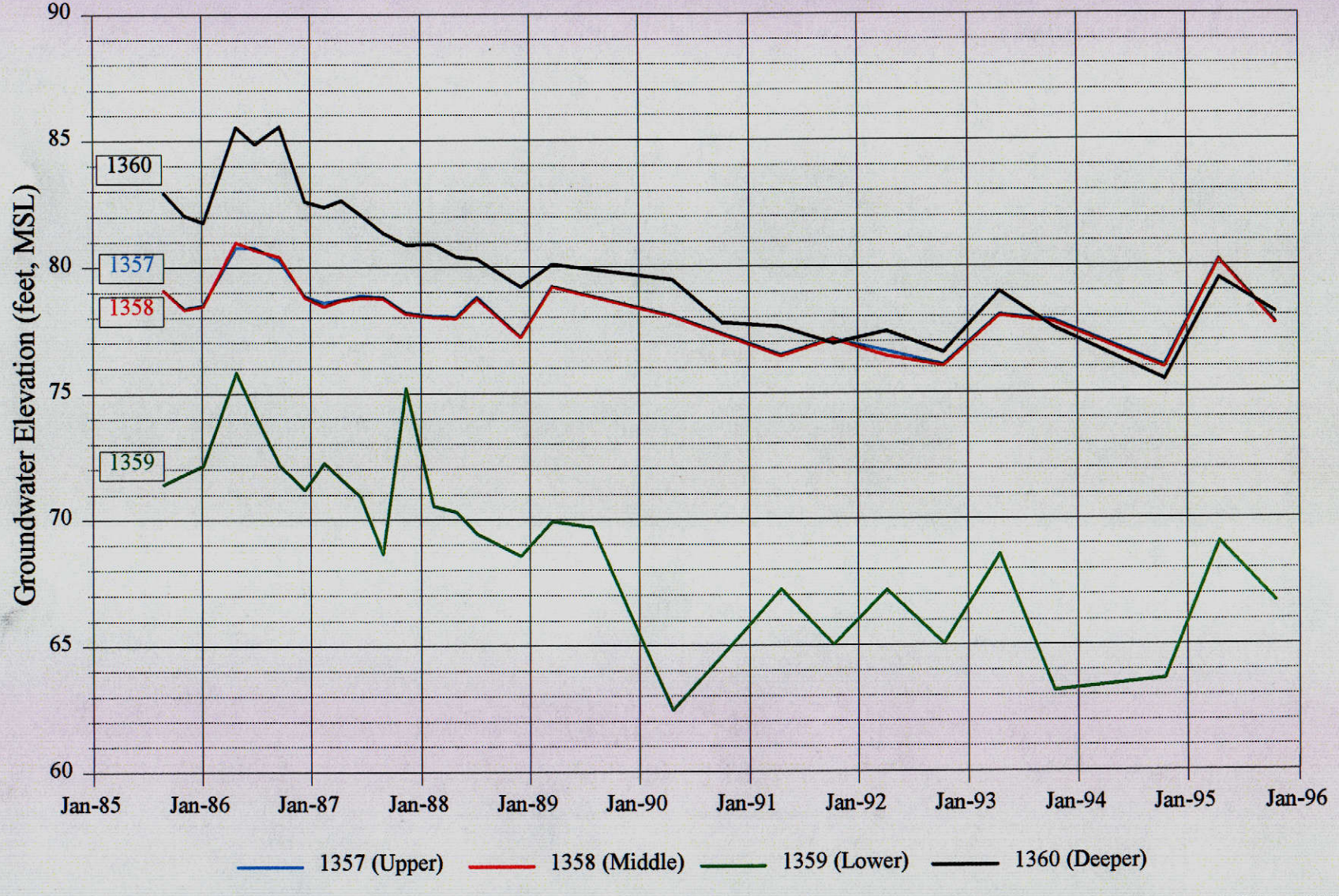
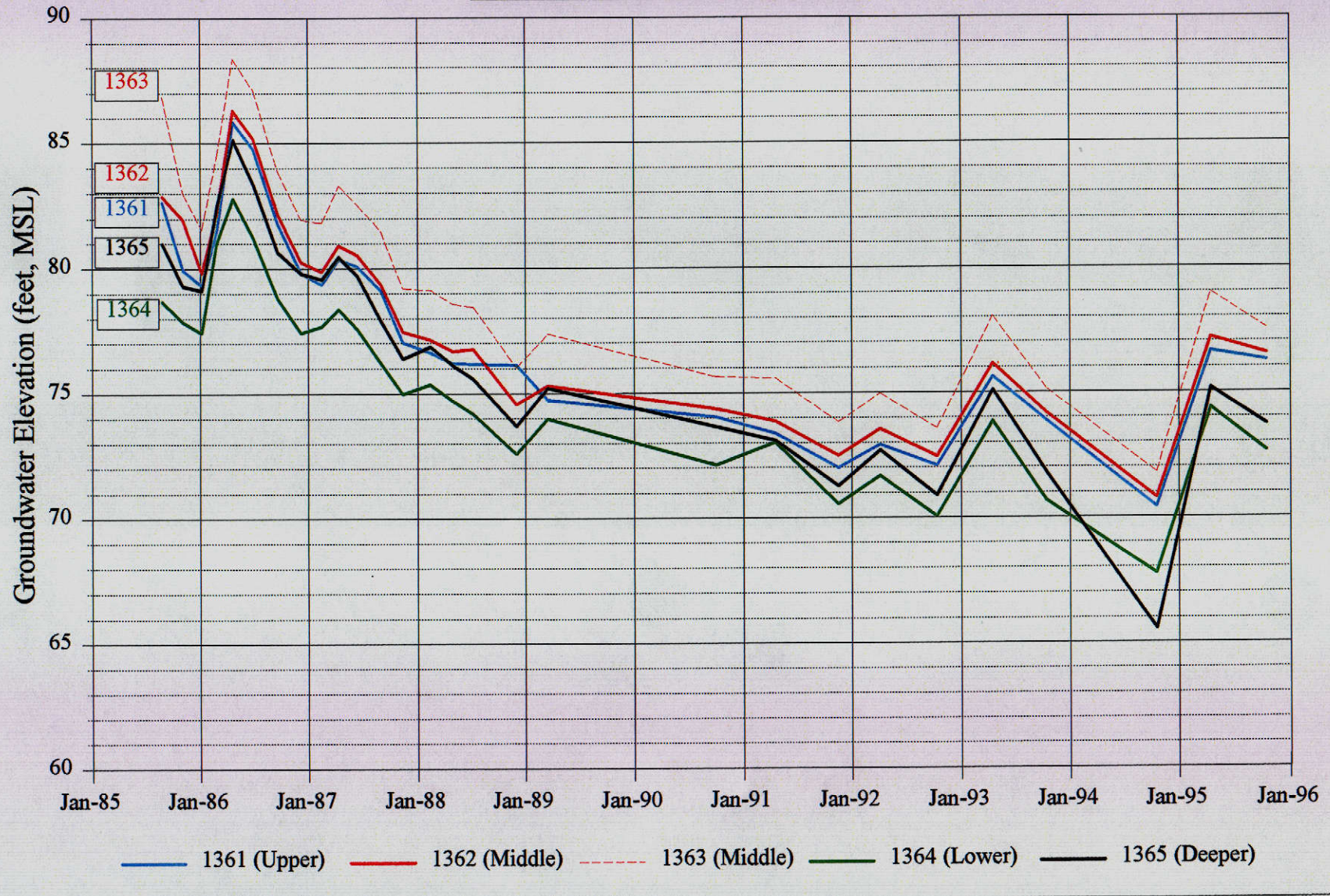


Figure 2-11

Hydrograph - Well 1361-65

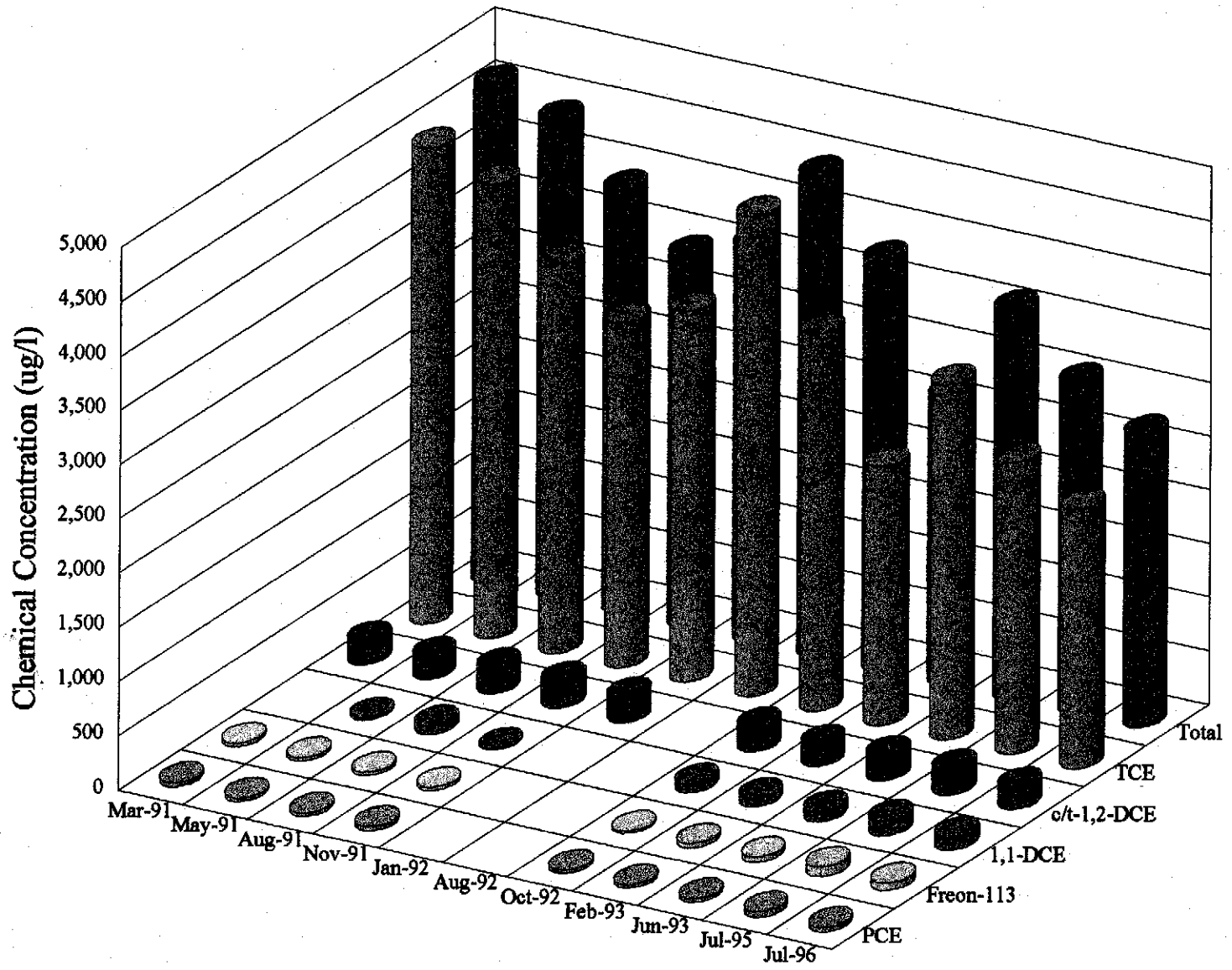


PAGES OF OVERSIZED MAPS

(SEE BINDER)

Figure 2-13

Well 1405 - VOC Trend in Groundwater



PAGES OF OVERSIZED MAPS

(SEE BINDER)

APPENDIX A

New Well Construction Diagrams

AEROJET

LEGEND FOR LITHOLOGY/WELL CONSTRUCTION LOGS

GENERAL LITHOLOGY

Clay

Silt

Sand

Gravel

WELL CONSTRUCTION

Blank pipe with well centralizer

Shutter screen

Wire-wrapped screen

2.5" ID slotted (1/8" x 3") Schedule 40, threaded and coupled steel pipe

9-sack cement seal

Neat cement seal

Number 60 sand

Sand pack

Gravel pack

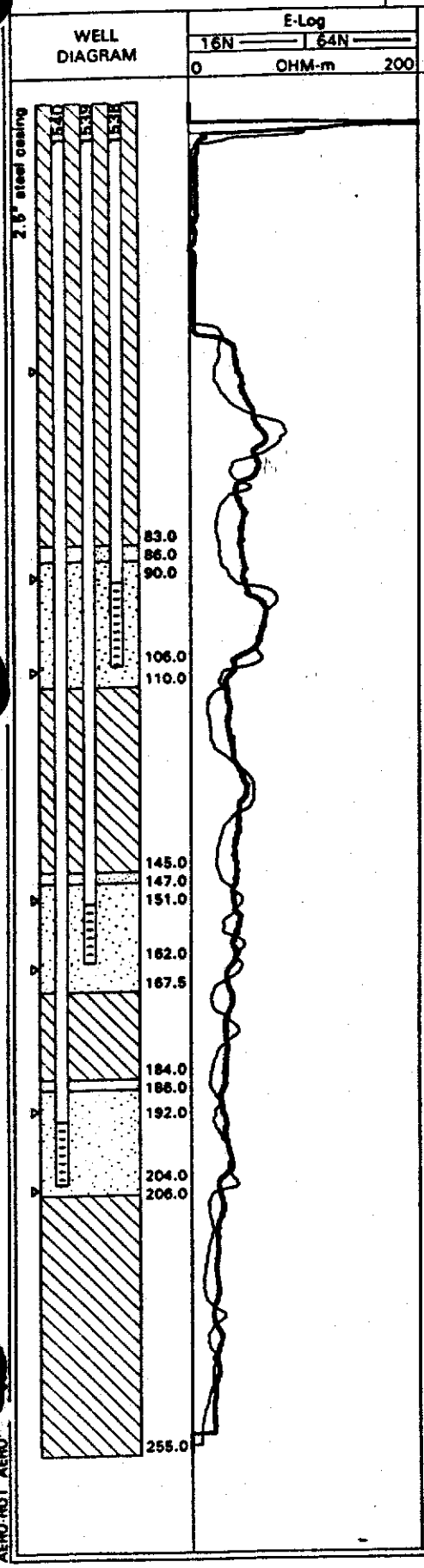
Bentonite chips or pellets

Slough

HSI AEROLGND

AEROJET

TOTAL DEPTH BORING ft: 255.0	WELL ID: 1538-40 Page 1 of 1
TOTAL DEPTH WELL ft: 106, 162, 204	SITE: Northwest of Emperor Drive, Boring: ED-1
SURFACE ELEVATION ft MSL: 147.3	EAST = 2216224.7 NORTH = 355378.5
TOC ELEVATION ft MSL: 147.32	DATE COMPLETED: 6/17/93 LOGGED BY: B.Honea
BOREHOLE DIAMETER: 10.6"	



DEPTH (FT) | GRAPHIC LOG

DESCRIPTION

0 to 9' [SM]: SILTY SAND; brown, fine-grained, medium dense, trace clay to occasional gravel, dry to moist.

9' to 13' [SP]: GRAVELLY SAND; brown, fine to medium sand and approximately 20% fine to medium gravel, medium dense, minor clay, moist.

13' to 29' [ML]: SANDY SILT; brown, medium dense, moist. Increasing fine sandstone interbeds.

29' to 46' [SM]: SANDSTONE; brown, fine to medium, moderate to well cemented, minor gravel interbeds, common mica and quartz.

46' to 57' [ML/SM]: SILTSTONE/SANDSTONE, INTERBEDDED; brown, moderately cemented, common mica.

57' to 62' [ML]: CLAYEY SILT; light brown, slightly plastic.

62' to 74' [SP]: SANDSTONE; dark brown, fine to medium, moderately cemented grading to strongly cemented.

74' to 78' [ML/SM]: SILTSTONE/SANDSTONE, INTERBEDDED; light brown/dark brown.

78' to 97' [SP]: SANDSTONE; light brown, fine, moderate to well cemented.

97' to 108' [SP]: SANDSTONE; black to darkly variegated, medium to coarse, angular, well indurated.

108' to 122' [ML]: SILTSTONE; light brown, moderate to poorly cemented.

122' to 136' [SP]: SANDSTONE; dark brown (variegated), medium to coarse, subangular to subrounded, moderately cemented. Grades to include siltstone interbeds.

136' to 147' [ML]: SILTSTONE; light brown, moderate to well cemented.

147' to 157' [ML/SM]: SANDSTONE/SILTSTONE, INTERBEDDED; light brown to dark brown, subangular, moderately cemented.

157' to 166' [SP]: SANDSTONE; dark brown (variegated), well cemented, minor siltstone.

166' to 178' [ML]: SILTSTONE; light brown, trace of slightly plastic clay.

178' to 184' [SP]: SANDSTONE; dark brown (variegated), moderate to well cemented.

184' to 194' [ML/CL]: CLAYEY SILT; light brown to tan, moderate plasticity, soft to medium stiff.

194' to 204' [SP]: SANDSTONE; light tan to white, rounded, poorly cemented, quartzose.

204' to 226' [CL]: SILTY CLAY; tan, moderate plasticity.

226' to 231' [SP]: SANDSTONE; white to tan, coarse, rounded, quartzose.

231' to 254' [CL]: SILTY CLAY; light brown, moderate plasticity, minor fine sand lenses from 1' to 2' thick.

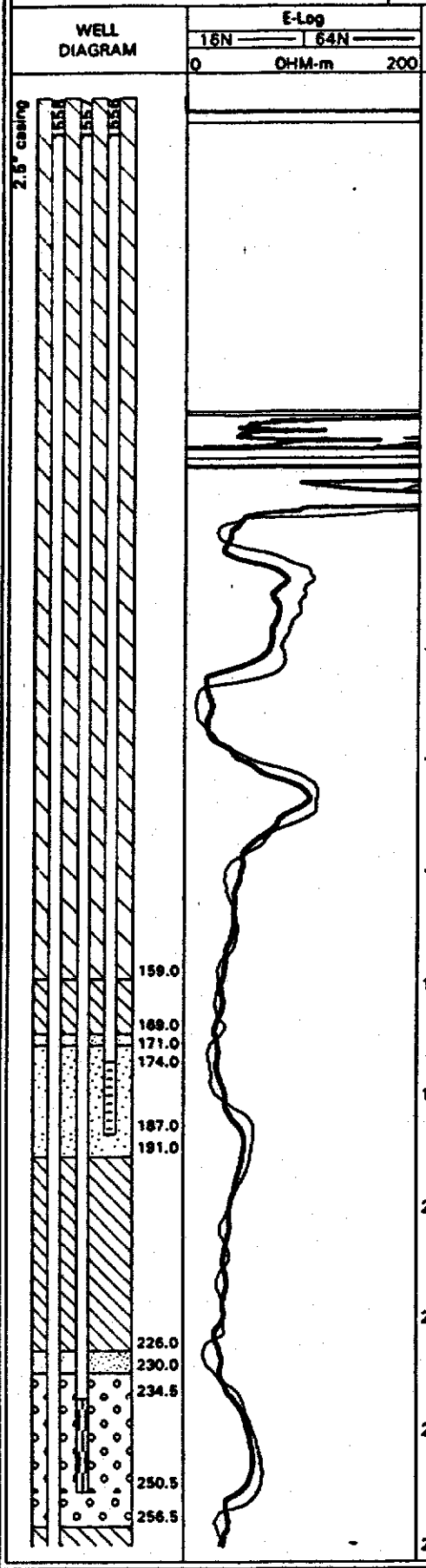
254' to 255' [CH]: CLAY; gray, high plasticity, medium stiff.

Total Depth of Borehole: 255 feet

AERO-ROT AERO

AEROJET

TOTAL DEPTH BORING ft: 300.0	WELL ID: 1556-58 Page 1 of 2
TOTAL DEPTH WELL ft: 187, 250.5, 292	SITE: 06-1, Oakglen Way at Maverick Court
SURFACE ELEVATION ft MSL: 183.3	EAST = 2213540.0 NORTH = 358450.0
TOC ELEVATION ft MSL: 183.3	DATE COMPLETED: 10/21/93 LOGGED BY: B. Honea
BOREHOLE DIAMETER: 10.6"	



DESCRIPTION

0 to 1' [AC]: ASPHALT; 3.5" asphalt with 5" aggregate base.

1' to 11' [SM]: SILTY SAND; dark gray with some fine to medium gravel, dry to moist.

11' to 15' [CL]: SANDY CLAY; dark gray, moderate to high plasticity, stiff, moist.

15' to 18' [SM]: SILTY SAND; brown, fine, dense, moist.

18' to 23' [ML]: SANDY SILT; yellow brown, medium dense, moist.

23' to 27' [SC]: CLAYEY SAND; light red-brown, medium grained, medium dense.

27' to 44' [SM]: SILTY SAND; light red-brown, fine, medium dense.

44' to 60' [CL]: SANDY CLAY; light brown, fine, medium plasticity.

Grades to a silty clay, gray-brown to brown, with fine sand interbeds.

60' to 64' [SP]: SAND; light brown and white, medium to coarse, subrounded to subangular.

64' to 68' [CL]: SILTY CLAY; light brown, medium to high plasticity.

68' to 81' [SP]: SAND; light brown variegated, moderately indurated, medium to coarse, quartz common.

81' to 84' [ML]: SILT; light brown with some fine sand.

84' to 105' [SP]: SAND; darkly variegated, moderately indurated, medium to coarse, quartz and mafics common, with some fine gravel and silty fine sand interbeds.

105' to 117' [CL]: SILTY CLAY; gray, high plasticity, medium stiff.

117' to 124' [ML]: SILTSTONE; brown, well indurated, with interbedded clayey silt, soft.

124' to 138' [SP/SM]: SAND with some silt; darkly variegated, medium with well indurated, fine interbeds.

Grades to [SP] sand.

138' to 142' [ML]: CLAYEY SILT; light brown to brown, soft.

142' to 159' [SM]: SILTY SAND; brown to chocolate brown, moderately to poorly indurated, fine.

159' to 162' [ML]: SILT with some fine sand; light brown, poorly to moderately indurated.

162' to 171' [SM]: SILTY SAND; dark brown, poorly indurated, fine.

171' to 174' [SP]: SAND; dark brown, moderately to well indurated, fine to medium.

174' to 182' [ML]: SANDY SILT; light brown to brown, fine, with minor siltstone lenses.

182' to 202' [SP]: SAND; dark brown, poor to moderately indurated, fine to medium.

202' to 230' [ML]: SANDY SILT; light brown, fine with trace to some clay, soft.

230' to 266' [GP]: GRAVEL; gray-brown variegated, medium to coarse, loose, well sorted.
Note: Description based on e-log and rig attitude. No cuttings, no circulation.

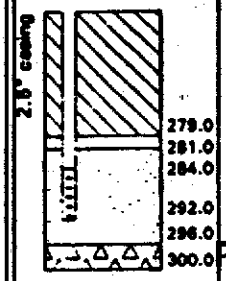
Cobbles (heavy chatter).

AERO-ROT AERO 4/23/96

AEROJET

TOTAL DEPTH BORING ft: 300.0	WELL ID: 1556-58 Page 2 of 2
TOTAL DEPTH WELL ft: 187, 250.5, 292	SITE: 06-1, Oakglen Way at Maverick Court
SURFACE ELEVATION ft MSL: 183.3	EAST = 2213540.0 NORTH = 358450.0
TOC ELEVATION ft MSL: 183.3	DATE COMPLETED: 10/21/93 LOGGED BY: B. Hones
BOREHOLE DIAMETER: 10.6"	

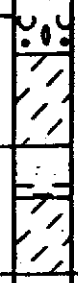
WELL DIAGRAM



E-Log

DEPTH (FT)

GRAPHIC LOG



260
280
300
320
340
360
380
400
420
440
460
480
500
520

DESCRIPTION

266' to 280' (CL/ML): CLAY and SILT mixture; light brown, soft.

280' to 288' (SM): SILTY SAND; brown, moderately indurated, fine.

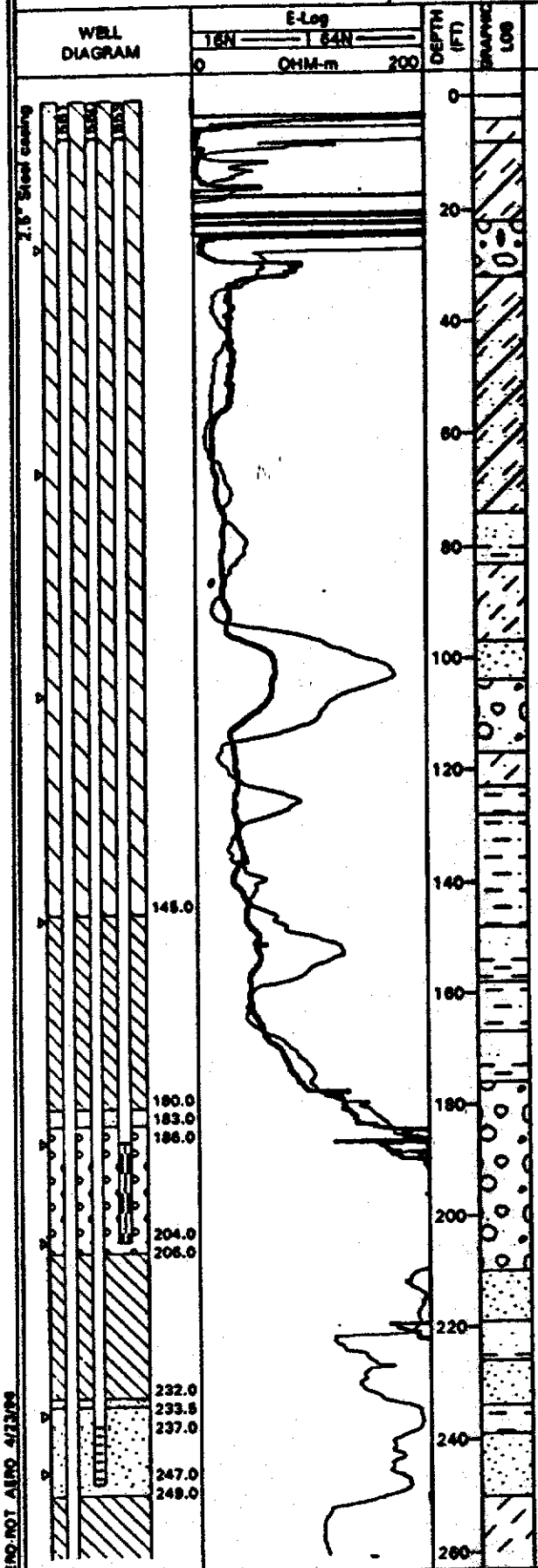
288' to 300' (CL): SILTY CLAY; light brown to dark green-gray, high plasticity.

Total Depth of Borehole: 300 feet

ENG-ROT AERO

AEROJET

TOTAL DEPTH BORING ft: 303.0	WELL ID: 1559-61 Page 1 of 2
TOTAL DEPTH WELL ft: 204, 247, 283	SITE: Neigh Bord Well, Greenvale Road, American River
SURFACE ELEVATION ft MSL: 196.2	EAST = 2213870.0 NORTH = 356750.0
TOC ELEVATION ft MSL: 196.16	DATE COMPLETED: 10/30/93 LOGGED BY: S. Hones
BOREHOLE DIAMETER: 10.6"	



DESCRIPTION

0 to 4' [SM]: SILTY SAND; brown, fine, medium dense, moist.

4' to 8' [ML]: CLAYEY SILT; light red-brown, dense, moist.

8' to 22' [SC]: CLAYEY SAND; fine sand with trace gravel to 1", coarsening from fine to medium, mica and quartz common (decomposed granite).

22' to 32' [GP]: GRAVEL; gray, mafic with some medium sand, quartz common, some mica, moist to wet.

32' to 74' [CL]: SANDY CLAY; light brown, medium plasticity, stiff, induration increases with depth, pieces of sandstone present.

74' to 83' [ML]: SANDY SILT; light brown, moderately indurated, fine.

83' to 97' [CL]: CLAYEY SILT; gray-brown, slight plasticity, soft.

97' to 104' [SP]: SAND; darkly variegated, moderately indurated, medium to coarse, quartz common.

104' to 117' [GP]: SANDY GRAVEL; darkly variegated, fine gravel, medium to coarse sand, quartz common.

117' to 123' [CL]: SILTY CLAY; gray-brown, medium to high plasticity, medium stiff.

123' to 128' [ML]: SILTSTONE; light brown with some fine sand.

128' to 148' [ML]: SILT with some medium-grained sand; brown, interbedded poorly to well indurated, dense.

148' to 158' [SM]: SILTY SANDSTONE; dark brown, moderately to well indurated, fine sand.

158' to 167' [ML]: SILT; light brown to tan, soft to medium stiff.

167' to 176' [SM]: SAND/SILTSTONE; light brown to tan, moderately indurated, fine sand.

176' to 210' [GP/SP]: SANDY GRAVEL; darkly variegated, loose, sand coarse, poorly sorted.

Increasing sandstone, darkly variegated, fine.

210' to 219' [SP]: SANDSTONE; black, moderately indurated, fine.

219' to 226' [ML/SM]: SILTSTONE/SANDSTONE; light brown to tan, moderately indurated, fine sandstone.

226' to 234' [SP]: SANDSTONE; darkly variegated, well indurated.

234' to 239' [ML]: SILTSTONE; light brown, indurated and soft interbeds.

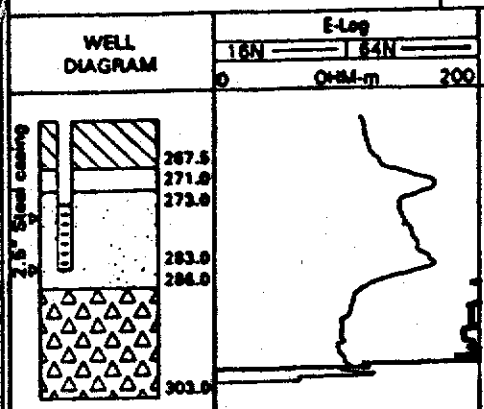
239' to 250' [SP]: SANDSTONE; black, well indurated, angular, mafic (no quartz).

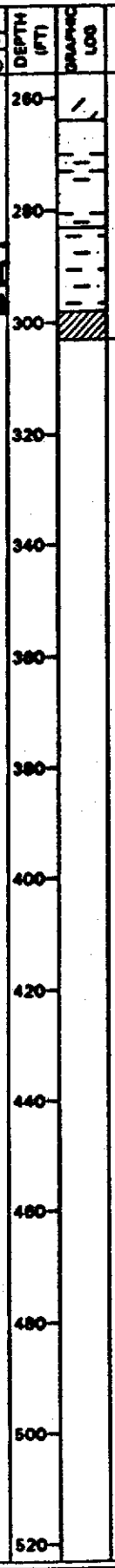
250' to 264' [ML/CL]: CLAYEY SILT; light brown, moderate to high plasticity, soft.

AERO-NOT AERO 4/23/96

AEROJET

TOTAL DEPTH BORING ft: 303.0	WELL ID: 1559-61 Page 2 of 2
TOTAL DEPTH WELL ft: 204, 247, 283	SITE: Neigh Bord Well, Greenvale Road, American River
SURFACE ELEVATION ft MSL: 196.2	EAST = 2213870.0 NORTH = 358750.0
TOC ELEVATION ft MSL: 196.15	DATE COMPLETED: 10/30/93 LOGGED BY: B. Hones
BOREHOLE DIAMETER: 10.6"	





DESCRIPTION

264' to 283' [SM]: SILTY SAND; light brown to brown, moderately indurated with well indurated siltstone stringers, fine sand.

283' to 298' [ML]: SILT; light brown to tan, soft to medium stiff.

Grades to greenish-tan.

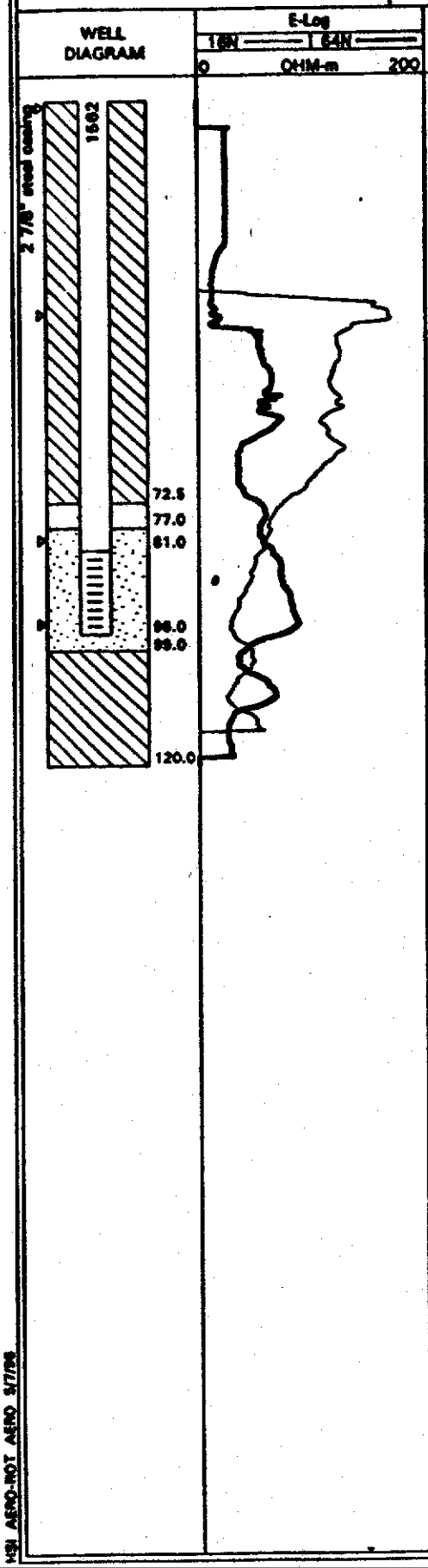
298' to 303' [CL/CH]: CLAY; dark green to gray, moderate to high plasticity, soft to medium stiff.

Total Depth of Borehole: 303 feet

AERO-ROT AERO

AEROJET

TOTAL DEPTH BORING ft: 120.0	WELL ID: 1562 Page 1 of 1
TOTAL DEPTH WELL ft: 96.0	SITE: AR-94-2
SURFACE ELEVATION ft MSL: 94.8	EAST = 2216484.0 NORTH = 353675.0
TOC ELEVATION ft MSL: 94.84	DATE COMPLETED: 4/7/84 LOGGED BY: D. Dettloff
BOREHOLE DIAMETER: 9" / 6"	



DESCRIPTION

0 to 17' [GW]: GRAVEL; very dark gray (N, 3/), well indurated, moderately sorted, subrounded to rounded, dry.

17' to 20' [SP]: SAND; dark yellowish-brown (10YR, 4/6), poorly indurated, well sorted, subangular to rounded, dry.

20' to 25' [ML]: SANDY SILT; brown (10YR, 4/3), moderate to poorly indurated (in pods), moderately sorted, subangular to rounded, 15% to 20% sand, moist.

25' to 60' [SW]: SAND; dark grayish-brown (2.5Y, 4/2), poorly indurated, moderately to poorly sorted, subangular to rounded, dry.

60' to 70' [SW]: SILTY SAND; brown (10YR, 4/3), moderately to well indurated, moderately to poorly sorted, subangular to subrounded, 40% silt, wet.

70' to 90' [SW]: SILTY SAND; sand: dark grayish-brown (10YR, 4/2), well indurated, well to moderately sorted, subangular to subrounded, wet; siltstone: brown (7.5YR, 4/4), well indurated, 5% to 10% siltstone (decreasing with depth), wet.

90' to 115' [SW]: SAND; dark brown (7.5YR, 3/2), poorly to well indurated, moderately to poorly sorted, subangular to rounded, wet.

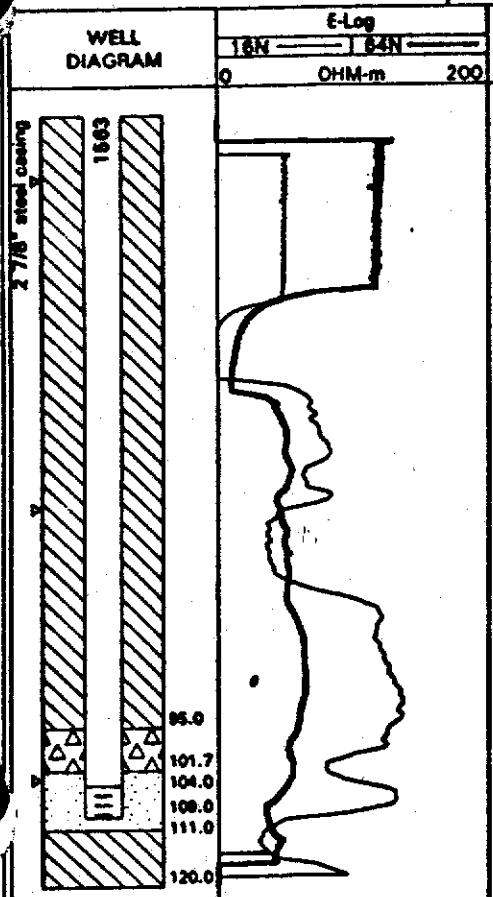
115' to 120' [SW]: SILTY SAND; dark yellowish-brown (10YR, 4/4), moderately to poorly indurated, poorly sorted, angular to subrounded, 40% to 45% silt, wet.

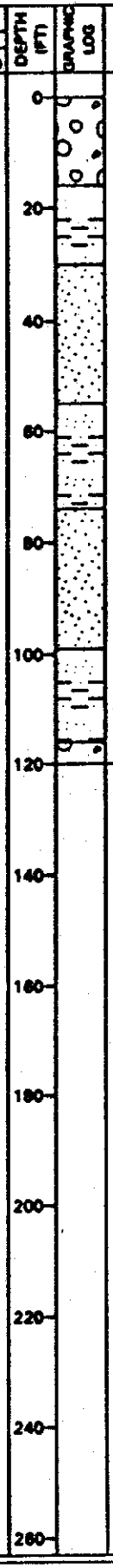
Total Depth of Borehole: 120 feet

HSI AERO-NOT AERO 5/7/86

AEROJET

TOTAL DEPTH BORING ft: 120.0	WELL ID: 1563 Page 1 of 1
TOTAL DEPTH WELL ft: 109.0	SITE: AR-94-3
SURFACE ELEVATION ft MSL: 94.6	EAST= 2216496.0 NORTH= 353585.0
TOC ELEVATION ft MSL: 94.60	DATE COMPLETED: 4/13/94 LOGGED BY: D. Dettloff
BOREHOLE DIAMETER: 9" / 6"	





DESCRIPTION

0 to 16' [GW]: SANDY GRAVEL; dark greenish-gray (5YR, 4/1), poorly indurated, poorly sorted, subangular to rounded, 10% to 15% sand, dry.

16' to 25' [SM]: SILTY SAND; very dark grayish-brown (10YR, 3/2), poorly indurated, moderately sorted, subangular to well rounded, 30% to 35% silt, dry.

25' to 30' Same as above, sand size increasing.

30' to 35' [SP]: SAND; dark brown (10YR, 3/3), poorly indurated, well sorted, subangular to subrounded, moist.

35' to 55' [SP]: SAND; brown (7.5YR, 4/3), poorly indurated, coarse, well sorted, angular to subrounded, wet.

55' to 74' [SM]: SILTY SAND; brown (10YR, 4/3), poorly indurated, poorly sorted, subangular to subrounded, 25% to 30% silt, wet.

74' to 99' [SW]: SAND; brown (7.5YR, 4/3), well indurated (in clods), poorly sorted, angular to subrounded, wet.

99' to 103' [ML]: SANDY SILT; brown (10YR, 4/3), poor to moderately indurated, poorly sorted, subangular to rounded, 40% to 45% sand, wet.

103' to 109' [SM]: SILTY SAND; very dark brown (10YR, 2/2), poor to moderately indurated, poorly sorted, subangular to rounded, 40% to 45% silt, wet.

109' to 116' [ML]: SANDY SILT; brown (10YR, 4/3), moderately indurated, poorly sorted, subangular to rounded, 35% to 40% sand, wet.

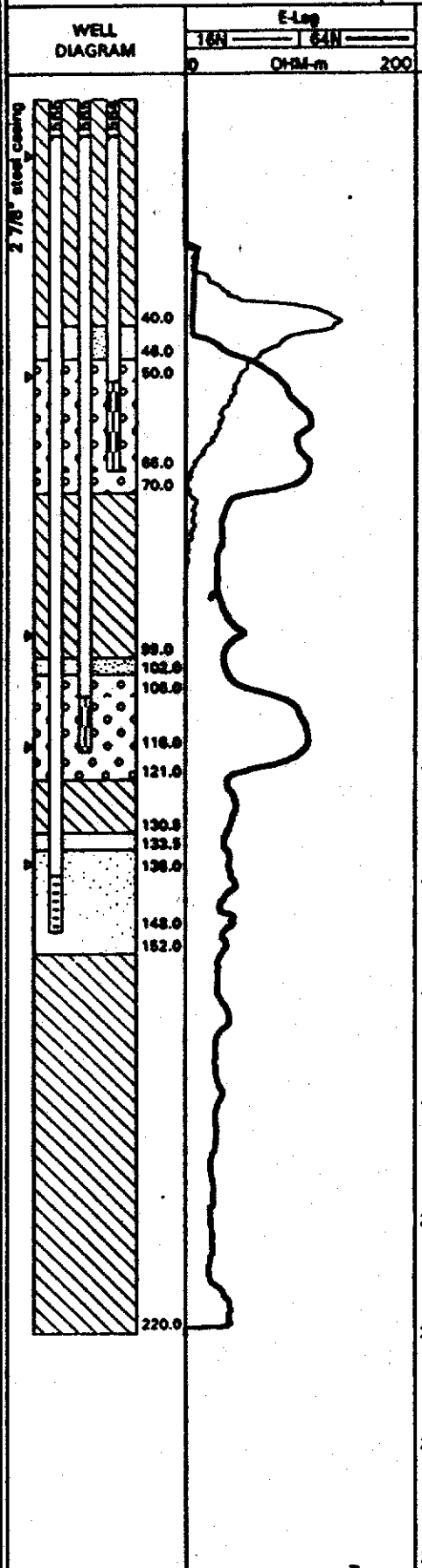
116' to 120' [GW]: SANDY GRAVEL; yellowish-brown (10YR, 5/4), poorly indurated, poorly sorted, subangular to rounded, 30% to 35% sand, wet.

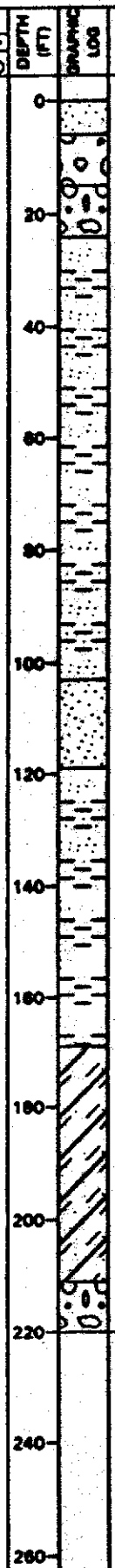
Total Depth of Borehole: 120 feet

HSI_AERO_RDT

AEROJET

TOTAL DEPTH BORING ft: 220.0	WELL ID: 1564-66 Page 1 of 1
TOTAL DEPTH WELL ft: 66, 116, 148	SITE: AR-94-4
SURFACE ELEVATION ft MSL: 89.7	EAST = 2216374.0 NORTH = 364453.0
TOC ELEVATION ft MSL: 89.70	DATE COMPLETED: 4/20/94 LOGGED BY: D. Dertloft
BOREHOLE DIAMETER: 12"/ 10"	





DESCRIPTION

0 to 6' [SP]: SAND; brownish-yellow (10YR, 6/6), poorly indurated, well sorted, subangular to rounded, dry.

6' to 16' [GW]: SANDY GRAVEL; brownish-yellow (10YR, 6/6), poorly indurated, poorly sorted, subangular to rounded, dry, sand decreases with depth.

16' to 24' [GP]: GRAVEL; black (10YR, 2/1), poorly indurated, well sorted, subrounded to well rounded, dry.

24' to 35' [SM]: SILTY SAND; dark yellowish-brown (10YR, 4/4), poor to moderately indurated, poorly sorted, subangular to rounded, 35% to 40% silt, moist, sand decreasing in size with depth.

35' to 40' [GM]: GRAVELLY SANDY SILT; dark yellowish-brown (10YR, 4/4), poor to moderately indurated, poorly sorted, angular to subrounded, 20% gravel and 30% sand, wet.

40' to 70' [SM]: SILTY SAND; brown (7.5YR, 4/3), poorly indurated, moderately sorted, subangular to subrounded, 0 to 5% silt, wet.

70' to 103' [ML]: SANDY SILT; dark yellowish-brown (10YR, 4/4), moderately indurated, well sorted, soft, subrounded to rounded, 10 to 15% sand, wet.

90' to 98' increasing sand content, 30% to 25% sand.

103' to 119' [SP]: SAND; black (10YR, 2/1), poorly indurated, well sorted, subangular to subrounded, wet.

119' to 169' [SM]: SILTY SAND; brown (10YR, 5/3), moderately to well indurated, moderately sorted, dense, subangular to subrounded, 30% to 35% silt, wet.

169' to 211' [CL]: SANDY CLAY; light yellowish-brown (10YR, 6/4), poorly indurated, poorly sorted, soft, subangular to subrounded, 25% to 30% sand, wet.

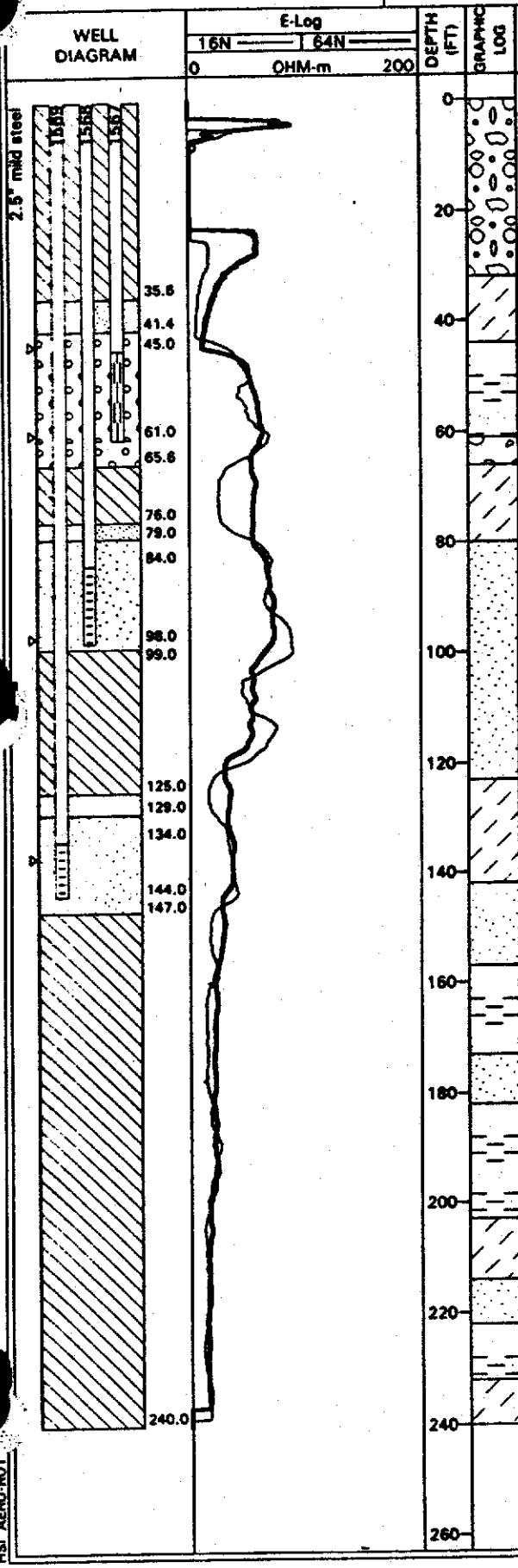
211' to 220' [GP]: GRAVEL; gray (7.5YR, 5/1), poorly indurated, well sorted, rounded to well rounded, wet.

Total Depth of Borehole: 220 feet

H:\ AERO-ROT AERO 9/7/96

AEROJET

TOTAL DEPTH BORING ft: 240.0	WELL ID: 1567-69 Page 1 of 1
TOTAL DEPTH WELL ft: 61, 98, 144	
SURFACE ELEVATION ft MSL: 95.8	SITE: AR-94-5
TOC ELEVATION ft MSL: 95.76	EAST= 2216309.0 NORTH= 354113.0
BOREHOLE DIAMETER: 10 7/8"	DATE COMPLETED: 4/29/94 LOGGED BY: F. Forsgren



DESCRIPTION

0 to 1' CRUSHED ROCK and GRAVEL

1' to 32' [GP]: GRAVEL (Dredge tails, boulders, cobbles, and gravels with little fines); dark gray, poorly indurated, well sorted, angular to subangular, dry; subequal Tertiary volcanics and Paleozoic metavolcanics and sediments. Paleozoics increasing with depth.

32' to 44' [ML]: CLAYEY SILT; red-brown, occasional sand unit, 70% silt, 30% clay, wet.

44' to 61' [ML]: SILTY SANDSTONE; red-brown, moderately indurated, well sorted, subangular to subrounded, 60% to 80% sand, 20% to 40% silt, occasional gravel, wet.

61' to 66' [GW]: SANDY GRAVEL; dark gray, poorly indurated, poorly sorted, subangular to rounded, wet.

66' to 80' [ML/CL]: CLAYEY SILT/SILTY CLAY; red-brown, poorly to moderately indurated, wet.

80' to 123' [SP]: SAND; red-brown, poorly indurated, well sorted, subangular to subrounded, 80% fine to coarse sand, 20% silt with occasional gravel, wet.

123' to 142' [ML/CL]: CLAYEY SILT/SILTY CLAY; red-brown, poorly to moderately indurated, with some fine interbedded sands.

142' to 157' [SP]: SANDSTONE; gray, moderately indurated, well sorted, subangular to rounded, fine grained, wet.

157' to 173' [ML]: SANDY SILT; brown (7.5YR, 5/3), poorly indurated, moderately sorted, subangular to rounded, 60% to 80% silt, 20% to 40% fine sand, wet.

173' to 182' [SP]: SAND; red-brown, moderately indurated, fine, well sorted, subangular to rounded, minor silt, wet.

182' to 203' [ML]: SANDY SILT; brown to red-brown, poorly indurated, well sorted, subangular to rounded, 60% to 80% silt, 20% to 40% fine sand, wet.

203' to 214' [CL/ML]: SILTY CLAY/ CLAYEY SILT; light gray, poorly indurated, occasional sand, wet.

214' to 222' [SW]: SAND; brown (7.5YR, 5/3), poorly indurated, fine to coarse, angular to rounded, 15% silt, wet.

222' to 232' [GP]: SILTY SAND; green, moderately indurated, moderately sorted, subangular to rounded, 60% to 80% fine to coarse sand, 20% to 40% silt, wet.

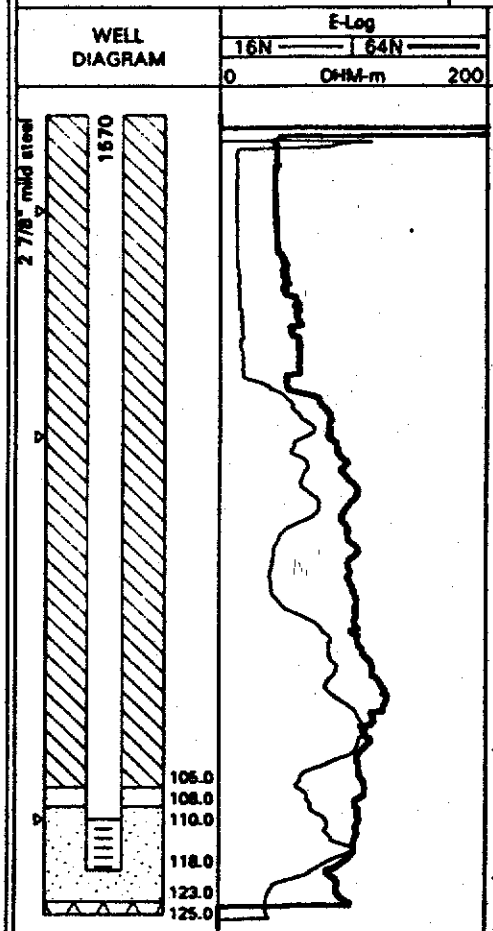
232' to 240' [CL/ML]: SILTY CLAY/CLAYEY SILT; light green, poorly indurated, 15% fine to coarse sand, decreasing with depth.

Total Depth of Borehole: 240 feet

HSI AERO.ROT

AEROJET

TOTAL DEPTH BORING ft: 126.0	WELL ID: 1570 Page 1 of 1
TOTAL DEPTH WELL ft: 118	
SURFACE ELEVATION ft MSL: 95.9	SITE: AR-94-6
TOC ELEVATION ft MSL: 95.88	EAST = 2216328.0 NORTH = 354104.0
BOREHOLE DIAMETER: 9" / 6"	DATE COMPLETED: 5/3/94 LOGGED BY: J. Thornb



DESCRIPTION

0 to 25' [GW]: DREDGE TAILS; very pale brown (10YR, 7/3), boulders, cobbles, and gravels with little fines, poorly sorted, subrounded to well rounded, dry.

25' to 35' [SC]: CLAYEY SAND; reddish-brown (5YR, 4/4), fine to medium, 30% silty clay, dry.

35' to 65' [SW]: SAND; very dark brown (10YR, 2/2), fine to coarse, moderately well sorted, subangular to rounded, predominantly lithic fragments, wet.

65' to 77' [CL]: SILTY CLAY; reddish-brown (5YR, 4/4), poorly indurated, abundant sand, fine to coarse, wet.

77' to 120' [SW]: SAND; very dark brown (10YR, 2/2), poorly indurated, moderately well sorted, subangular to rounded, fine to coarse, mostly lithic fragments, wet.

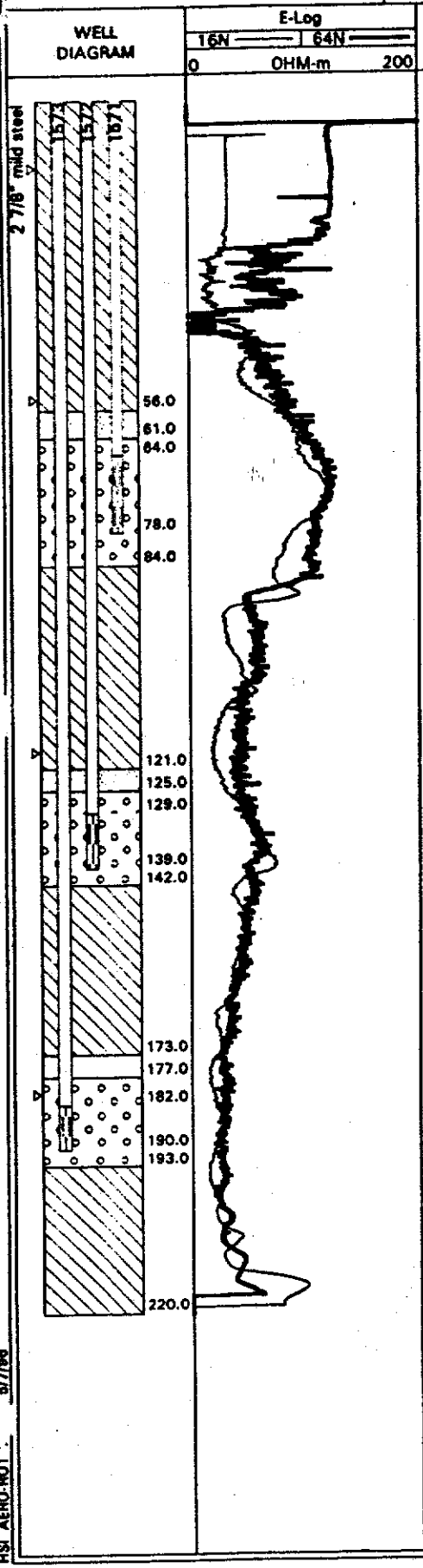
120' to 125' [CL]: CLAY; light reddish-brown (5YR, 6/3), moderately indurated, wet.

Total Depth of Borehole: 125 feet

HSI AERO-RDT AERO 9/7/96

AEROJET

TOTAL DEPTH BORING ft: 220.0	WELL ID: 1571-73 Page 1 of 1
TOTAL DEPTH WELL ft: 78, 139, 190	SITE: AR-94-7
SURFACE ELEVATION ft MSL: 102.9	EAST = 2216182.0 NORTH = 352433.0
TOC ELEVATION ft MSL: 102.90	DATE COMPLETED: 5/9/94 LOGGED BY: J. Thornburg
BOREHOLE DIAMETER: 10 5/8"	



DESCRIPTION

0 to 15' [GW]: COBBLES; light yellowish-brown (10YR, 6/4), moderately sorted, subrounded to rounded, dry.

15' to 37' [CL]: CLAY; brown (7.5YR, 5/3), soft, 20% fine to medium sand, dry to slightly moist.

37' to 47' [SP]: SAND; light brownish-gray (2.5YR, 6/2), well sorted, subangular to rounded, predominantly volcanic lithic fragments, wet.

47' to 55' [SP]: SANDSTONE; reddish-brown (5YR, 4/3), poorly indurated, well sorted, subrounded, fine to medium, predominantly feldspar, 20% mafic and lithic fragments, 10% clay, wet.

55' to 92' [GW]: SANDY GRAVEL; very dark gray (10YR, 3/1), poorly sorted, lithic fragments (volcanics and metavolcanics), 30% fine to coarse sand, wet.

92' to 100' [CL]: SANDY CLAY; reddish-brown (5YR, 4/3), poorly indurated, 30% fine to medium sand, wet.

100' to 127' [CL]: CLAYSTONE; reddish-brown (5YR, 4/4), moderately indurated, wet.

127' to 142' [GW]: SANDY GRAVEL; brown (7.5YR, 4/3), poorly sorted, lithic fragments (volcanics and metavolcanics), 20% fine to coarse sand, wet.

142' to 164' [SP]: SANDSTONE; brown (7.5YR, 4/3), moderately well indurated, well sorted, rounded, predominantly feldspar, 10% mafic and lithic fragments, very fine, wet.

164' to 178' [CL]: CLAY; dark grayish-brown (10YR, 4/2), poorly indurated.

178' to 192' [GW]: SANDY GRAVEL; brown (7.5YR, 5/3), slightly indurated, lithic fragments (volcanics and metavolcanics), 20% sandstone, very fine, wet.

192' to 212' [CL]: CLAY; brown (7.5YR, 5/3), poorly indurated, wet.

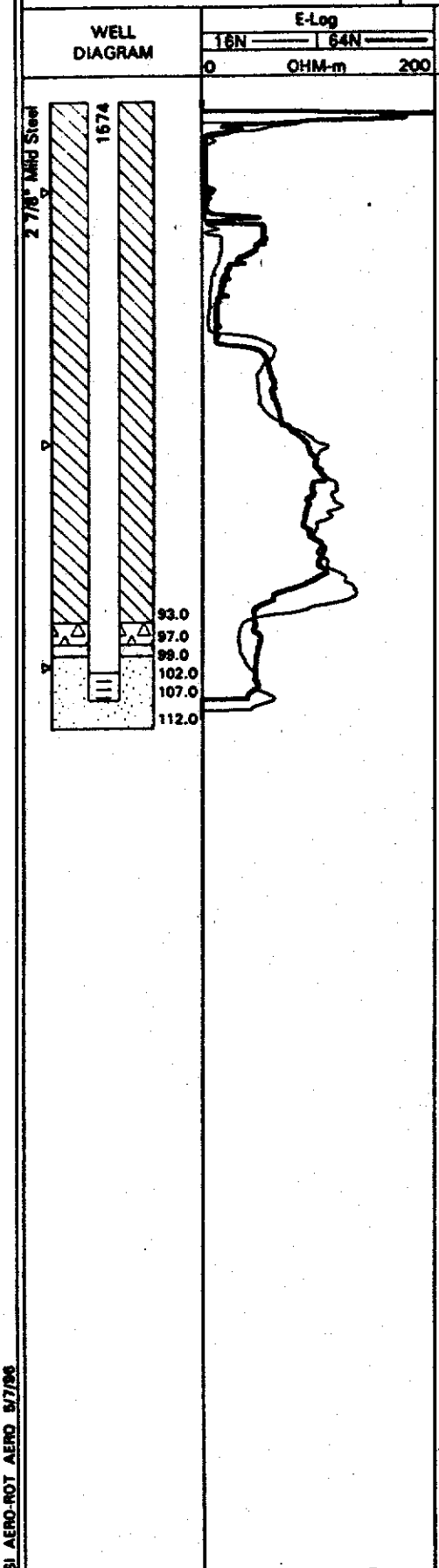
212' to 220' [GP]: GRAVEL; very dark brown (10YR, 2/2), well sorted, subangular to rounded, lithic fragments, wet.

Total Depth of Borehole: 220 feet

HSI_AERO.ROT 6/7/94

AEROJET

TOTAL DEPTH BORING ft: 112.0	WELL ID: 1574
TOTAL DEPTH WELL ft: 107	
SURFACE ELEVATION ft MSL: 102.9	SITE: AR-94-8
TOC ELEVATION ft MSL: 102.90	EAST = 2216195.0 NORTH = 352425.0
BOREHOLE DIAMETER: 6 1/2"	DATE COMPLETED: 5/11/94 LOGGED BY: J.Thornbur



DESCRIPTION

0 to 15' [GW]: COBBLES; light yellowish brown (10YR, 6/4), moderately sorted, subrounded to rounded, dry.

15' to 37' [CL]: CLAY; brown (7.5 YR, 5/3), soft, 20% fine to medium sand, dry to slightly moist.

37' to 47' [SP]: SAND; light brownish gray (2.5 YR, 6/2), well sorted, subangular to rounded, predominantly feldspar, 20% mafic and lithic fragments, 10% clay, wet.

47' to 55' Color change to reddish brown (5YR, 4/3), becomes poorly indurated.

55' to 92' [GW]: SANDY GRAVEL; very dark gray (10YR, 3/1), poorly sorted, lithic fragments (volcanics and metavolcanics), 30% fine to coarse sand, wet.

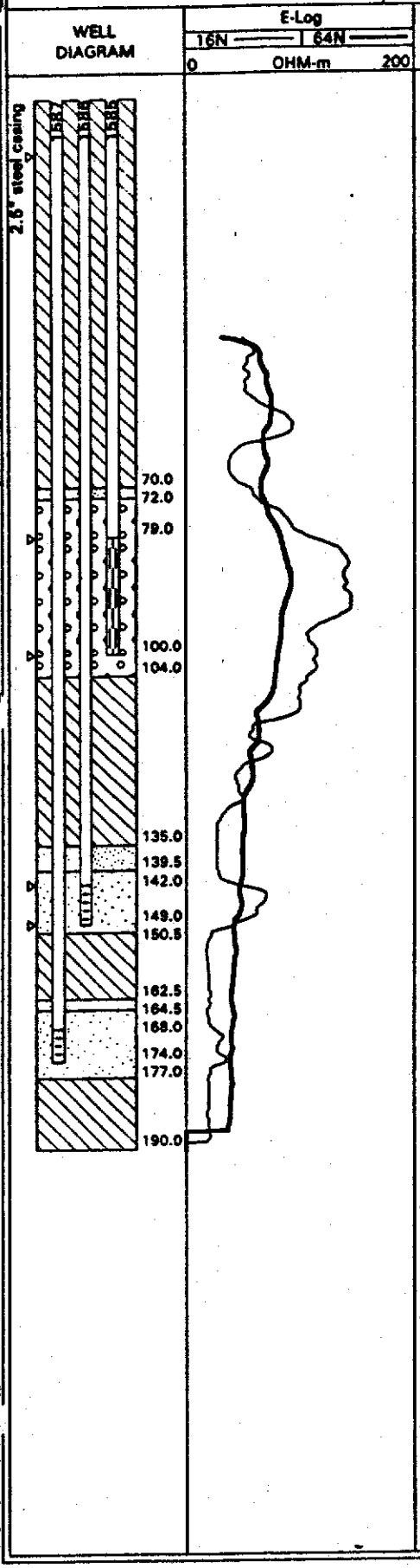
92' to 100' [CL]: SANDY CLAY; reddish brown (5YR, 4/3), poorly indurated, 30% fine to medium sand, wet.

100' to 112' [CL]: CLAYSTONE; reddish brown (5YR, 4/4), moderately indurated, wet.

Total Depth of Borehole: 112 feet

AEROJET

TOTAL DEPTH BORING ft: 190.0	WELL ID: 1585-87 Page 1 of 1
TOTAL DEPTH WELL ft: 100, 149, 174	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 97.7	EAST = 2214365.5 NORTH = 355141.5
TOC ELEVATION ft MSL: 97.68	DATE COMPLETED: 5/1/95 LOGGED BY: C.M. Cochrane
BOREHOLE DIAMETER: 10 5/8"	



DESCRIPTION

0 to 8' [GM]: SILTY GRAVEL; pale brown (10YR 6/3), 60-70% gravel up to cobble size, 10-20% fine to medium, angular to subrounded sand, 10-20%silt, loose, dry.

8 to 33' [GW]: SANDY GRAVEL; yellowish-brown (10YR 5/4), fine, poorly sorted, subangular to rounded gravel, damp.

Large cobbles
20 feet; becomes dry.
22 feet; hard andesite cobbles.

29 feet; becomes damp.

33 to 60' [SM]: SILTY SAND; brown (7.5YR 5/4), 60-70% fine to medium, subangular to rounded sand, 30-40% silt, poorly to moderately indurated, some organic flecks.

60 to 105' [SW]: SAND; very dark grayish brown (10YR 3/2), angular to subangular, poorly sorted sand, less than 10% gravels.

105 to 140' [ML]: SANDY SILT; dark brown (10YR 3/3), 70-90% silt, low plasticity, fine to very fine sand.

140 to 150' [SM]: SILTY SAND; dark brown (10YR 3/3), 60-90% subangular to subrounded, coarse to very coarse sand, 10-40% silt.

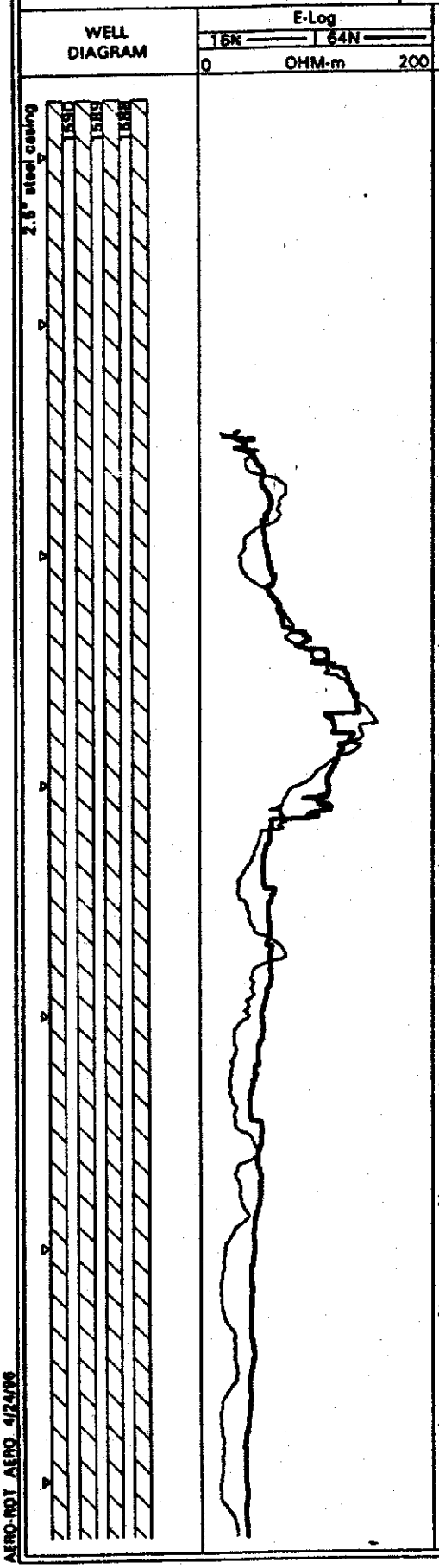
150 to 190' [ML]: SANDY SILT; yellowish brown (10YR 5/4), 70-90% silt, low plasticity, 10-30% fine to very fine sand.

Total Depth of Borehole: 190 feet

AERO-ROT AERL

AEROJET

TOTAL DEPTH BORING ft: 411.0	WELL ID: 1588-90 Page 1 of 2
TOTAL DEPTH WELL ft: 307, 348, 400	
SURFACE ELEVATION ft MSL: 97.6	SITE: Sailor Bar Park
TOC ELEVATION ft MSL: 97.58	EAST = 2213262.0 NORTH = 355415.5
BOREHOLE DIAMETER: 10 5/8"	DATE COMPLETED: 5/17/95 LOGGED BY: C.M. Cochr



DESCRIPTION

0 to 5' [AC]: Asphalt and roadbase, light grey (10YR 7/2).

5 to 20' [GP]: COBBLES; light gray (10YR 7/1).

20 to 40' [GW]: SANDY GRAVEL; brown (10YR 4/3), 60-70% subangular to rounded gravel, 30-40% fine to very coarse sand.

40 to 45' [GM]: SILTY GRAVEL; dark brown (10YR 3/3), 50-60% subrounded to rounded gravel, 40-50% silt.

45 to 100' [ML]: SANDY SILT; very pale brown (10YR 8/3), indurated, 60-90% silt, 10-40% very fine to fine sand.

100 to 120' [SM]: SILTY SAND; very dark gray (10YR 3/1), 60-90% angular to subangular, coarse sand.

120 to 130' [GW]: GRAVEL; black (10YR 2/1), subangular to rounded.

130 to 175' [ML]: SANDY SILT; brown (10YR 4/3), indurated, 60-80% silt, 20-40% fine sand.

175 to 190' [ML]: SANDY SILT; pale brown (10YR 6/3), 70-90% silt, 10-30% fine to very fine sand.

190 to 205' [GM]: SILTY GRAVEL; (10YR 6/1), 60-90% angular to rounded gravel, 10-40% silt.

205 to 215' [ML]: SILT; pale brown (10YR 6/3), indurated.

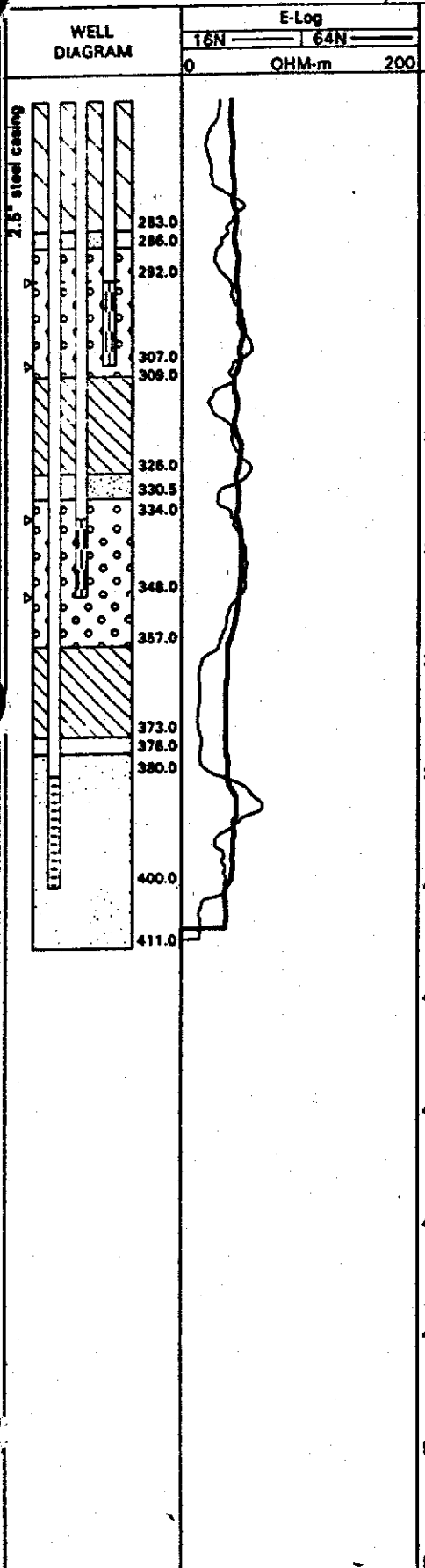
215 to 255' [ML]: SANDY SILT; greenish gray (5GY 5/1), 60-90% silt, 10-40% fine sand.

255 to 315' [SP]: SAND; very dark grayish brown (10YR 3/2), medium to very

AERO-ROT AERO_4/24/96

AEROJET

TOTAL DEPTH BORING ft: 411.0	WELL ID: 1588-90 Page 2 of 2
TOTAL DEPTH WELL ft: 307, 348, 400	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 97.6	EAST = 2213262.0 NORTH = 355415.5
TOC ELEVATION ft MSL: 97.58	DATE COMPLETED: 5/17/95 LOGGED BY: C.M. Cochrane
BOREHOLE DIAMETER: 10 5/8"	



DESCRIPTION

coarse sand.

315 to 325' [ML]: SANDY SILT; pale brown (10YR 6/3), 70-90% silt, low plasticity, 10-30% very fine sand.

325 to 360' [SM]: SILTY SAND; dark yellowish brown (10YR 4/4), 60-90% medium to coarse, angular to subangular sand, 10-40% silt.

360 to 382' [ML]: SANDY SILT; greenish gray (5GY 6/1), 80-90% silt, low plasticity, 10-20% fine sand.

382 to 400' [SP]: SAND; light greenish gray (5GY 7/1), coarse to very coarse, angular to subangular sand.

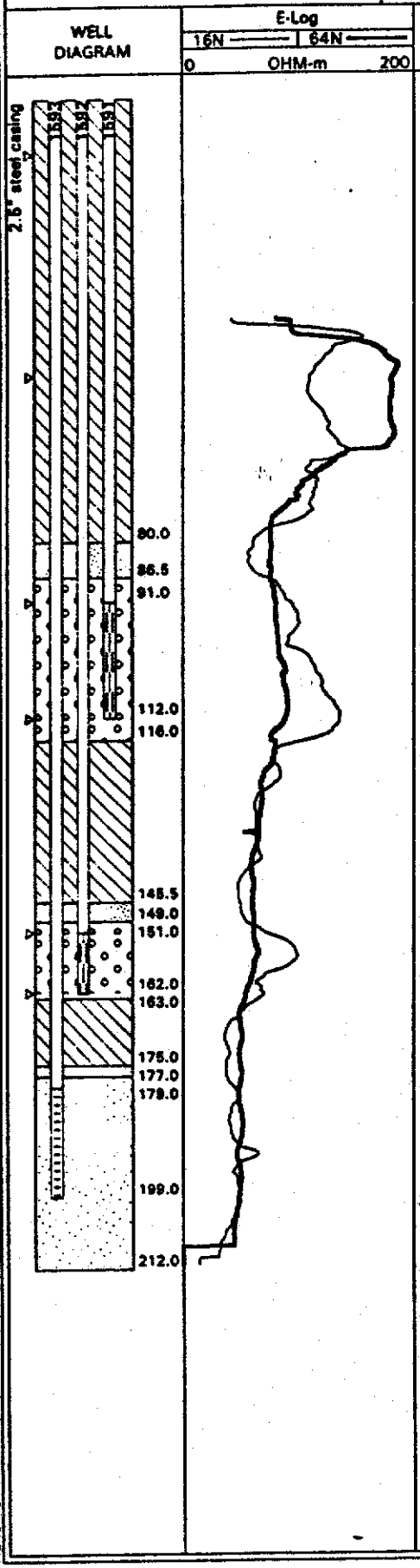
400 to 411' [ML]: SANDY SILT; greenish gray (5GY 6/1), 80-90% silt, low plasticity, 10-20% fine sand.

Total Depth of Borehole: 411 feet

AERO-ROT AERO

AEROJET

TOTAL DEPTH BORING ft: 212.0	WELL ID: 1591-93 Page 1 of 1
TOTAL DEPTH WELL ft: 112, 162, 199	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 97.5	EAST = 2213296.3 NORTH = 355381.0
TOC ELEVATION ft MSL: 97.49	DATE COMPLETED: 5/23/95 LOGGED BY: C.M. Coch
BOREHOLE DIAMETER: 10 5/8"	



DESCRIPTION

0 to 15' [GP]: SANDY GRAVEL; light gray (10YR 7/1), 70-90% gravel up to cobble size, 10-30% fine to medium, angular to subrounded sand.

15 to 80' [ML]: SANDY SILT; brown (10YR 5/2), 60-90% silt, 10-40% very fine sand.
20' becomes wet

80 to 95' [SM]: SILTY SAND; very dark gray (10YR 3/1), 70-90% angular to subangular, medium to very coarse sand.

95 to 175' [SP]: SAND; black (10YR 2.5/1), angular to subrounded, medium to very coarse.

175 to 188' [ML]: SANDY SILT; pinkish gray (10YR 6/2), 60-90% silt, 10-40% very fine sand.

188 to 205' [SM]: SILTY SAND; brown (10YR 5/3), 70-90% angular to subrounded, medium to very coarse sand, 10-30% silt.

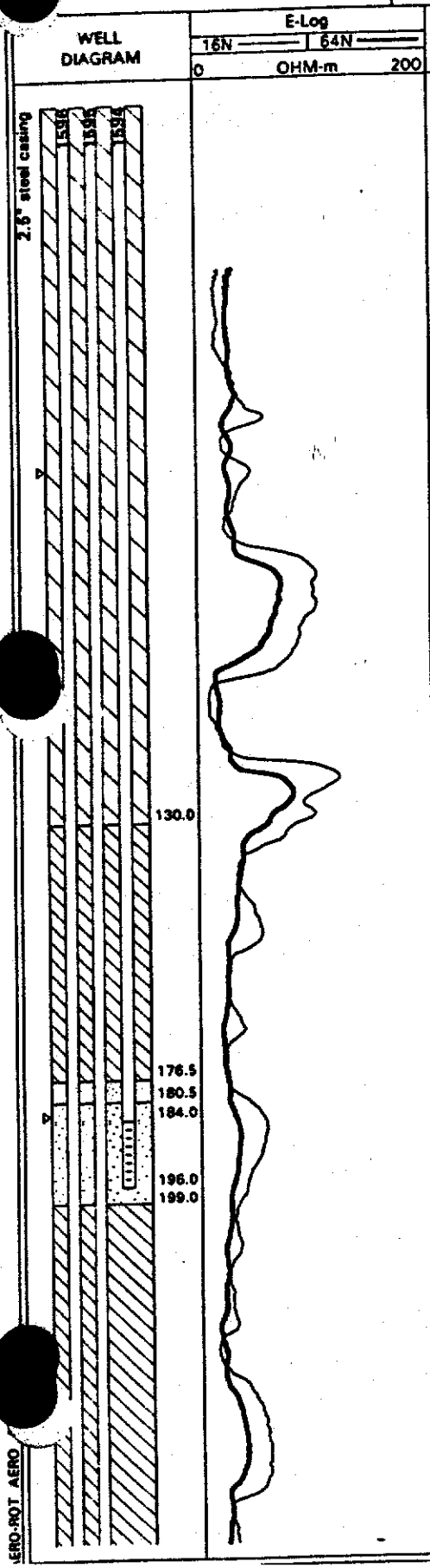
205 to 212' [ML]: SANDY SILT; pinkish gray (10YR 6/2), 70-90% silt, 10-30% very fine sand.

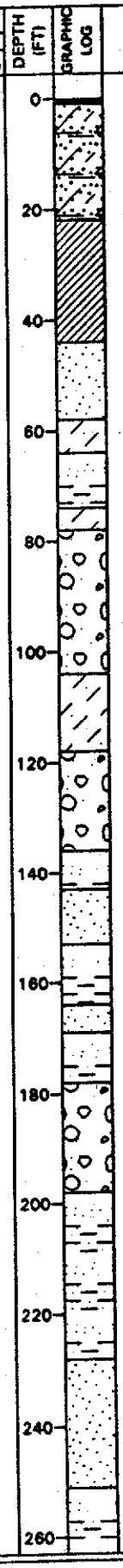
Total Depth of Borehole: 212 feet

AERO-ROT AERO 4/24/96

AEROJET

TOTAL DEPTH BORING ft: 400.0	WELL ID: 1594-6
TOTAL DEPTH WELL ft: 196, 316, 343	
SURFACE ELEVATION ft MSL: 183.0	SITE: Oak Glen Way
TOC ELEVATION ft MSL: 182.99	EAST = 2213605.2 NORTH = 358397.5
BOREHOLE DIAMETER: 10 5/8"	DATE COMPLETED: 6/12/95 LOGGED BY: D. Dettloff





DESCRIPTION

0 to 1' [AS]: 3" of asphalt with 5" of road base.

1 to 22' [CL]: SANDY SILTY CLAY; variegated, medium brown, gray, and white, well indurated, clay and silt: firm, sand: fine, well sorted, subrounded to rounded, dry. Sand and silt decreasing with depth.

22 to 44' [CL/CH]: CLAY; light yellowish-brown (10YR, 6/4), firm, dry, with a lens of coarse sand from 37' to 40' bgs.

44 to 58' [SP]: SAND; dark brown (10YR, 4/1), poorly indurated, coarse, well sorted, angular to subrounded, dry.

58 to 64' [CL/ML]: SILTY CLAY/CLAYEY SILT; pale yellow (2.5Y, 7/3), firm, dry.

64 to 74' [SM]: SILTY SAND; variegated, gray, white, and tan, poorly to moderately indurated, sand: fine to coarse, moderately sorted, subangular to subrounded, silt: very soft to soft, dry to slightly moist.

74 to 78' [CL/ML]: SILTY CLAY/CLAYEY SILT; same as 58' to 64' above.

78 to 104' [SW]: GRAVELLY SAND; dark gray (2.5Y, 4/1), poorly indurated, fine to coarse, poorly sorted, angular to subrounded, dry, with gravel up to 9.0 mm.

104 to 118' [ML]: CLAYEY SILT; pale brown (10YR, 6/3), firm, dry.

118 to 136' [SW]: GRAVELLY SAND; very dark gray (10YR, 3/1), poorly indurated, fine to coarse, poorly sorted, subangular to subrounded, dry to moist, with gravel up to 7.0 mm.

136 to 143' [SM]: SILTY SAND; light yellowish-brown (2.5Y, 6/3), poorly indurated, sand: medium to coarse, moderately sorted, subangular to subrounded, silt: soft, dry.

143 to 153' [SP]: SAND; variegated, brown to dark gray, poorly indurated, medium, well sorted, subangular to subrounded, dry.

153 to 164' [SM]: SILTY SAND; very dark gray (10YR, 3/1), poorly indurated, sand: fine to coarse, poorly sorted, subangular to subrounded, silt: soft, moist.

164 to 169' [SW]: SAND; brown (10YR, 4/3), poorly indurated, fine to coarse, poorly sorted, subangular to subrounded, dry to slightly moist.

169 to 178' [SM]: SILTY SAND; variegated, black, gray, and brown, poorly indurated, sand: fine to coarse, poorly sorted, angular to subrounded, silt: soft to firm, moist.

178 to 198' [SW]: GRAVELLY SAND; variegated, black, gray, and tan, poorly indurated, fine to coarse, poorly sorted, subangular to subrounded, moist.

198 to 222' [SM/ML]: SILTY SAND/SANDY SILT; light brownish-gray (10YR, 6/2), sand: poorly indurated, fine to coarse, poorly sorted, subangular to subrounded, silt: soft, slightly moist.

222 to 228' [ML]: SANDY SILT; pale yellow (5Y, 7/3), poorly indurated, sand: fine to coarse, poorly sorted, subangular to subrounded, dry.

228 to 251' [SP]: SAND; light olive brown (2.5Y, 5/3), poorly indurated, coarse, well sorted, subangular to subrounded, moist, with a trace of silt.

251 to 258' [SM/ML]: SILTY SAND/SANDY SILT; dark yellowish-brown (10YR, 4/4), poorly indurated, sand: fine to coarse, poorly sorted, subangular to

AERO-ROT AERO

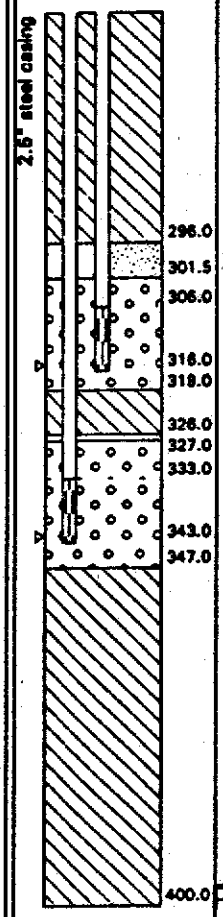
AEROJET

TOTAL DEPTH BORING ft: 400.0
TOTAL DEPTH WELL ft: 196, 316, 343
SURFACE ELEVATION ft MSL: 183.0
TOC ELEVATION ft MSL: 182.89
BOREHOLE DIAMETER: 10 5/8"

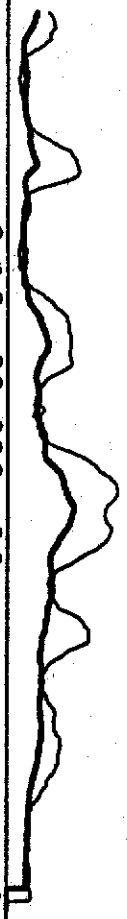
WELL ID: 1594-6

SITE: Oak Glen Way
EAST = 2213605.2 NORTH = 358397.5
DATE COMPLETED: 6/12/95 LOGGED BY: D. Dettlo

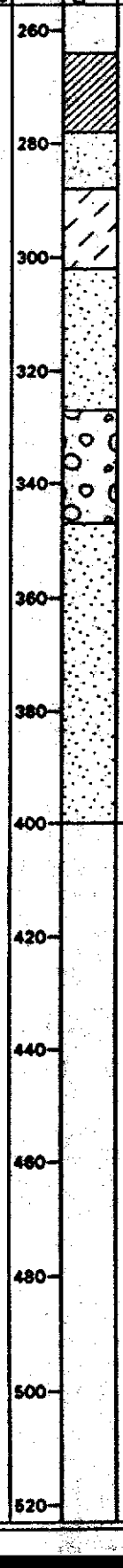
WELL DIAGRAM



E-Log
16N — 64N
0 OHM-m 200



DEPTH (FT)



GRAPHIC LOG

DESCRIPTION

subrounded, silt: soft to firm, moist.

258 to 264' [SM]: SILTY SAND; dark yellowish-brown (10YR, 4/4), poorly indurated, sand: fine to coarse, poorly sorted, subangular to subrounded, silt: soft, moist.

264 to 278' [CL]: CLAY; olive (5Y, 5/3), soft to firm, moist.

278 to 288' [SP]: SAND; dark gray (2.5Y, 4/1), moderately indurated, fine to medium, moderately sorted, subangular to subrounded, moist.

288 to 302' [CL]: SILTY CLAY; gray (2.5Y, 5/1), soft to firm, moist.

302 to 327' [SP]: SAND; variegated, black, gray, and white, poorly indurated, fine to medium, moderately sorted, angular to subrounded, dry to slightly moist.

327 to 347' [GP]: SANDY GRAVEL; black (10YR, 2/1), poorly indurated, well sorted, angular to subangular, moist.

347 to 400' [SW]: SAND; black (10YR, 2/1), poorly indurated, fine to coarse, poorly sorted, subangular to subrounded, moist.

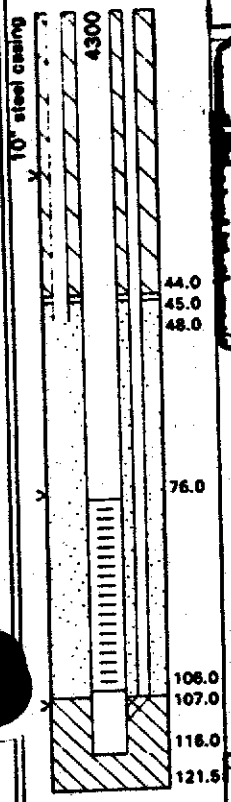
Total Depth of Borehole: 400 feet

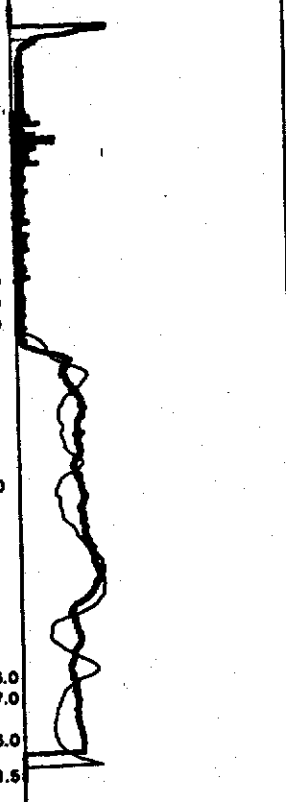
AERO-ROT AERO 4/24/96

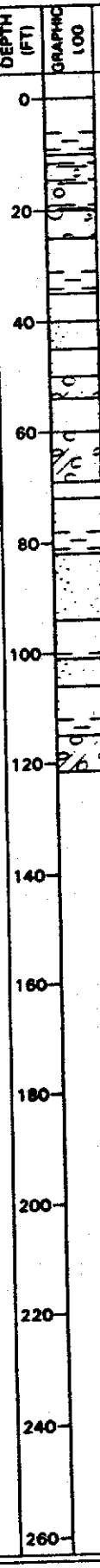
AEROJET

TOTAL DEPTH BORING ft: 121.5	WELL ID: 4300
TOTAL DEPTH WELL ft: 116	
SURFACE ELEVATION ft MSL: 119.2	SITE: Sailor Bar Park, Borehole: AREW-T-3
TOC ELEVATION ft MSL: 119.17	EAST = 2216492.3 NORTH = 354856.7
BOREHOLE DIAMETER: 22"	DATE COMPLETED: 8/5/93 LOGGED BY: D. Dettloff

WELL DIAGRAM







DESCRIPTION

0 to 10' [SM]: SANDY SILT; dark brown (10YR, 3/3), poorly sorted, poorly indurated, angular to subrounded, trace mica and gravel.

10' to 20' [SM/SP]: GRAVELLY SILTY SAND; dark yellowish-brown (10YR, 3/4), poorly sorted, angular to rounded, up to 10% gravel.

20' to 25' [SP]: GRAVELLY SAND; dark brown (10YR, 3/3), moderately sorted, poorly indurated, subangular to rounded, 35-40% gravel.

25' to 35' [SM]: SILTY SAND; dark yellowish-brown (10YR, 3/4), moderately sorted, angular to rounded, 30% soft silt.

35' to 40' [SM/ML]: CLAYEY SILTY SAND; brown (7.5YR, 4/3), moderately sorted, moderately indurated when dry, subangular to rounded, 25% soft silt, trace clay.

40' to 45' [SP]: SAND; very dark brown (10YR, 2/2), moderately sorted, poorly indurated, angular to rounded, trace silt.

45' to 50' [SM]: SILTY SAND; brown (7.5YR, 4/3), well sorted, subangular to rounded, well indurated, 20-25% silt.

50' to 54' [GC]: CLAYEY GRAVEL; brown (7.5YR, 4/2), extremely poorly sorted, poorly indurated, angular to subrounded, 30-35% clay.

54' to 60' [SM]: SANDY SILT; brown (7.5YR, 4/2), 35-40% sand: poorly sorted, silt well indurated, angular to subrounded.

60' to 69' [CL]: GRAVELLY CLAY; brown (7.5 YR, 5/3), 30-35% gravel: extremely poorly sorted, moderately indurated, angular to subrounded.

69' to 72' [SM]: SILTY SAND; brown (7.5 YR, 4/2), extremely poorly sorted, well indurated, angular to rounded, 40-45% silt.

72' to 82' [SM]: SILTY SAND; brown (7.5YR, 4/3), poorly sorted, well indurated (when dry), angular to subrounded, 30% silt and fine sand, trace mica. Grain size increases with depth.

82' to 94' [SW]: SAND; brown (7.5YR, 4/3), poorly sorted, well indurated, subangular to rounded.

94' to 101' [SM]: SILTY SAND; brown (7.5YR, 4/3), poorly sorted, well indurated, subangular to rounded, 40% silt. Sand size decreasing with depth.

101' to 106' [SP]: SAND; brown (7.5 YR, 4/3), moderately sorted, extremely well indurated, subangular to rounded.

106' to 115' [SM]: SILTY SAND; dark yellowish-brown (10YR, 3/4), poorly sorted, moderately indurated, subangular to rounded, trace mica.

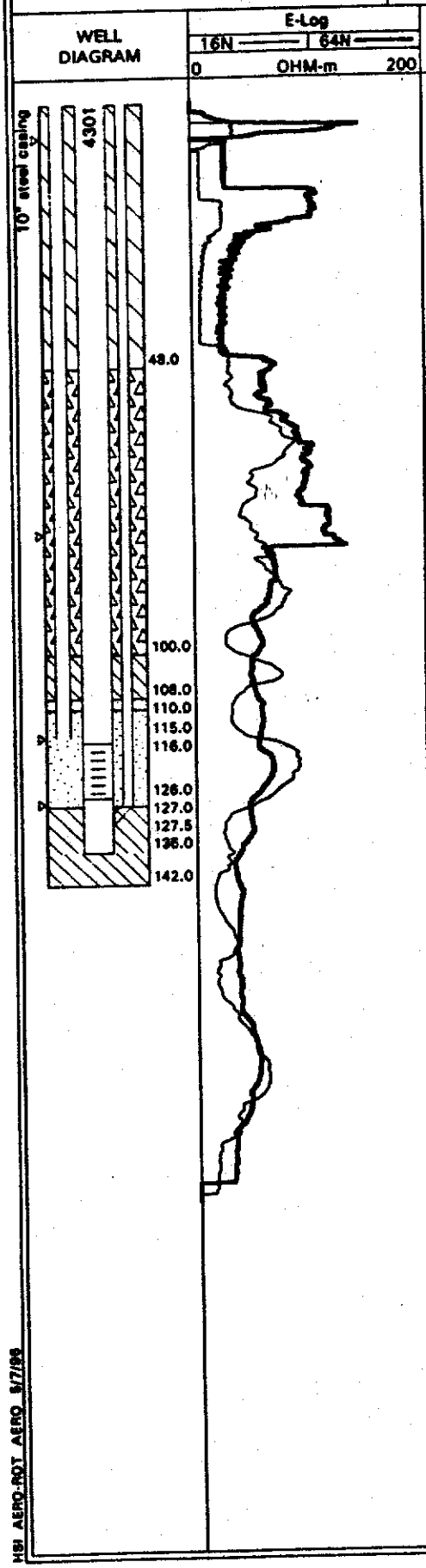
115' to 121.5' [GC]: CLAYEY GRAVEL; brown (7.5 YR, 3/2), poorly sorted, poorly indurated, subangular to well rounded, 30-40% clay, trace mica. Clay content increases with depth.

Total Depth of Borehole: 121.5 feet
E-log from borehole: AREW-T-3
24" surface casing installed to a depth of 50 feet.
Oct-93 land-surface elevations (ft-msl) for:
10" well casing at 119.17..
Well screen: 0.045" stainless steel wirewrap.
Gravel: 8 x 16

HSI AERO.ROT AL

AEROJET

TOTAL DEPTH BORING ft: 142.0	WELL ID: 4301 Page 1 of 1
TOTAL DEPTH WELL ft: 136	SITE: Sailor Bar Park, Borehole: AREW-T-2
SURFACE ELEVATION ft MSL: 118.9	EAST = 2216512.3 NORTH = 354859.5
TOC ELEVATION ft MSL: 118.92	DATE COMPLETED: 8/10/93 LOGGED BY: D. Dettloff
BOREHOLE DIAMETER: 22"	



DESCRIPTION

0 to 5' [ML]: SILT; very dark grayish-brown (10YR, 3/2), well sorted, well indurated, very soft, subangular to subrounded, trace mica, trace clay.

5' to 10' [GW]: SILTY GRAVEL; dark brown (10YR, 3/3), poorly sorted, poorly indurated, very loose, angular to rounded 10-15% silt.

10' to 15' [SP]: GRAVELLY SAND; dark brown (10YR, 3/3), moderately well sorted, poorly indurated, loose, angular to rounded, 10% gravel.

15' to 35' [GW]: SILTY GRAVEL; dark brown (10YR, 3/3), poorly sorted, poorly indurated, very loose, angular to rounded, 10-15% silt.

35' to 45' [SP]: SAND; very dark grayish-brown (10YR, 3/2), fine, moderately indurated, soft, angular to rounded, 5% gravel.

45' to 50' [SP]: SAND; black (10YR, 2/1), well sorted, poorly indurated, loose, subangular to angular.

50' to 65' [CL]: GRAVELLY CLAY; dark grayish-brown (10YR, 4/2) grading to very dark grayish-brown (10YR, 3/2) with depth, poorly sorted, well indurated, soft, angular to subrounded, 35-40% gravel.

65' to 69' [GM]: GRAVELLY SILT; brown (10YR, 4/3), poorly sorted, moderately indurated, soft, angular to rounded, 35-40% gravel.

69' to 72' [SP]: SAND; black (10YR, 2/1), moderately sorted, moderately indurated, subangular to well rounded.

72' to 80' [SC]: SANDY CLAY; brown (10YR, 4/3), poorly sorted, moderately indurated, angular to subrounded, 30-35% sand, trace mica.

80' to 82' [GC]: CLAYEY GRAVEL; brown (10YR, 4/3), poorly sorted, moderately indurated, angular to subrounded, 40-45% clay, trace mica.

82' to 95' [GW]: SANDY GRAVEL; very dark gray (10YR, 3/1), poorly sorted, poorly indurated, angular to rounded, 40-45% sand.

95' to 100' [CL]: SANDY CLAY; brown (10YR, 5/3), poorly sorted, moderately indurated, subangular to well rounded, 40-45% sand.

100' to 108' [SC]: CLAYEY SAND; brown (10YR, 5/3), poorly sorted, well indurated, subangular to rounded, 35-40% clay.

108' to 115' [CL]: SANDY CLAY; brown (10YR, 5/3), poorly sorted, moderately indurated, subangular to rounded, 30% sand.

115' to 127' [SW]: GRAVELLY SAND; black (10YR, 2/1), poorly sorted, poorly indurated, subangular to rounded, 15-20% gravel.

127' to 134' [CL]: SANDY CLAY; brown (10YR, 5/3), poorly sorted, moderately indurated, angular to subrounded, 15-20% sand.

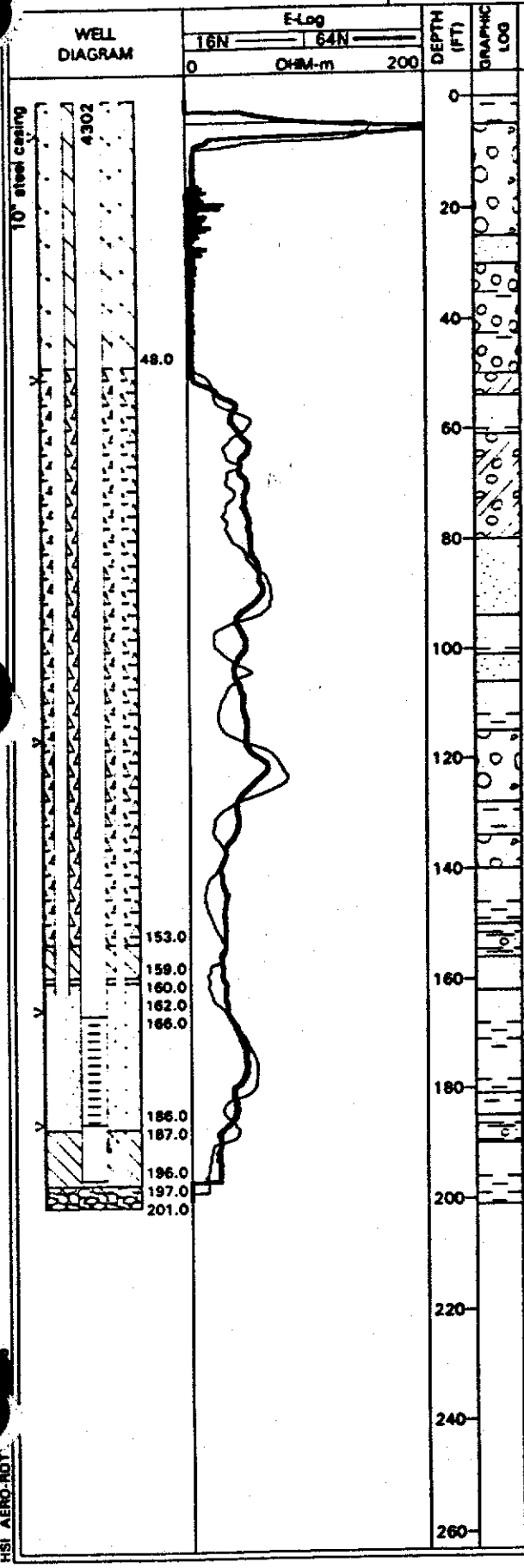
134' to 142' [SC]: CLAYEY SAND; brown (10YR, 5/3), moderately sorted, moderately indurated, angular to subrounded, 35-40% clay.

Total Depth of Borehole: 142 feet
E-log from borehole: AREW-T-2
24" surface casing installed to a depth of 50 feet.
Oct-93 land-surface elevations (ft-msl) for:
10" well casing at 118.92.
Well screen: 0.045" stainless steel wirewrap
Gravel: 8 x 16

HSI AERO-ROT AERO 8/7/96

AEROJET

TOTAL DEPTH BORING ft: 201.0	WELL ID: 4302 Page 1 of 1
TOTAL DEPTH WELL ft: 196	SITE: Sailor Bar Park, Borehole: AREW-T-4
SURFACE ELEVATION ft MSL: 119.2	EAST = 2216473.5 NORTH = 354853.5
TOC ELEVATION ft MSL: 119.22	DATE COMPLETED: 8/2/93 LOGGED BY: D. Dettloff
BOREHOLE DIAMETER: 22"	



DESCRIPTION

0 to 5' [ML]: SILT; very dark grayish-brown (10YR, 3/2), well sorted, well indurated, soft, subangular to subrounded, trace clay, trace mica.

5' to 25' [SW]: GRAVELLY SAND; dark brown (10YR, 3/3), poorly sorted, poorly indurated, loose when dry, angular to subrounded, 5-10% gravel. Gravel increases with depth, 30-35% gravel at 25 feet.

25' to 30' [SP]: SAND; dark brown (10YR, 3/3), well sorted, poorly indurated, loose, subangular to rounded.

30' to 50' [GM]: GRAVELLY SILT; brown (10YR, 4/3), poorly sorted, moderate to well indurated, angular to subrounded, 10% gravel.

50' to 54' [GC]: CLAYEY GRAVEL; brown (7.5YR, 4/2), extremely poorly sorted, poorly indurated, angular to subrounded, 30-35% clay.

54' to 61' [SM]: SANDY SILT; brown (7.5YR, 4/2), poorly sorted, silt well indurated, angular to subrounded, 35-40% sand.

61' to 80' [CL]: GRAVELLY CLAY; brown (7.5YR, 5/3), extremely poorly sorted, moderately indurated, angular to subrounded, 30-35% gravel.

80' to 94' [SW]: SAND; brown (7.5YR, 4/3), poorly sorted, well indurated, subangular to rounded.

94' to 101' [SM]: SILTY SAND; brown (7.5YR, 4/3), poorly sorted, well indurated, subangular to rounded, 40% silt. Grain size decreasing with depth.

101' to 106' [SP]: SAND; brown (7.5YR, 4/3), moderately sorted, extremely well indurated, subangular to rounded.

106' to 115' [SM]: SILTY SAND; dark yellowish-brown (10YR, 3/4), poorly sorted, moderately indurated, subangular to rounded, trace mica.

115' to 128' [GW]: SANDY GRAVEL; brown (7.5YR, 4/2), poorly sorted, angular to subrounded, sand well indurated, trace mica. Gravel increases with depth.

128' to 134' [ML]: SILT; brown (7.5YR, 4/4), well sorted, moderately indurated, subangular to rounded, soft.

134' to 140' [SW]: GRAVELLY SAND; brown (7.5YR, 4/2), poorly sorted, moderately indurated, subangular to rounded, 10-15% gravel.

140' to 150' [SM]: SILTY SAND; brown (10YR, 4/3), moderately sorted, well indurated, angular to rounded, 35-40% silt.

150' to 156' [SM]: GRAVELLY SILTY SAND; pinkish-gray silt (7.5YR, 7.2), and brown sand (7.5YR, 4/2), poorly sorted, well indurated, subangular to rounded, 10% gravel. Silt in well indurated chips.

156' to 162' [ML]: SANDY SILT; pinkish-gray silt (7.5YR, 7/2), and brown sand (7.5YR, 4/2), poorly sorted, well indurated, angular to subrounded, trace gravel, 15-20% sand. Sand increasing with depth.

162' to 181' [SM]: SILTY SAND; pinkish-gray silt (7.5YR, 7.2), and brown sand (7.5YR, 4/2), poorly sorted, well indurated, angular to subrounded. Silt in well indurated chips. Silt decreasing with depth.

181' to 185' [ML]: SILT; dark gray (10YR, 4/1), well sorted, moderately indurated, angular to subrounded.

185' to 190' [SM]: GRAVELLY SILTY SAND; brown (7.5YR, 5/2), poorly sorted, moderately indurated, subangular to rounded, 10% gravel, 10-15% silt.

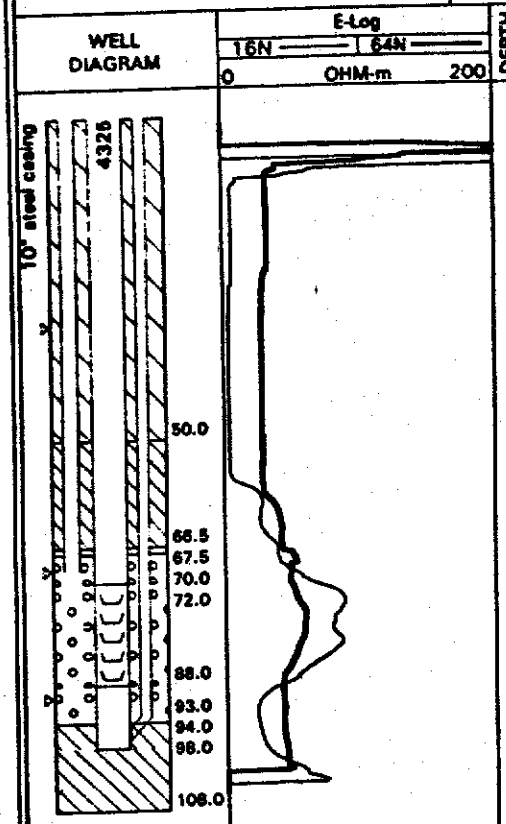
190' to 201' [SM]: SILTY SAND; gray (7.5YR, 5/1), moderately sorted, well indurated, subangular to rounded, 35-40% silt. Silt decreasing with depth.

Total Depth of Borehole: 201 feet
E-log from borehole: AREW-T-4
24" surface casing installed to a depth of 50 feet.
Oct-93 land-surface elevations (ft-msl) for:
10" well casing at 119.22.
Well screen: 0.045" stainless steel wirewrap
Gravel: 8 x 16

HSI AERO-ROT

AEROJET

TOTAL DEPTH BORING ft: 108.0	WELL ID: 4325 Page 1 of 1
TOTAL DEPTH WELL ft: 98.0	
SURFACE ELEVATION ft MSL: 108.0	SITE: Nimbus Fish Hatchery
TOC ELEVATION ft MSL: 108.03	EAST = 2220257.3 NORTH = 352888.5
BOREHOLE DIAMETER: 42"/22"	DATE COMPLETED: 8/15/94 LOGGED BY: D. Dentloff



DESCRIPTION

0 to 5' [GP]: BOULDERS (Dredge Tailings), loose, well sorted, well rounded, dry.

5' to 32' [SP]: GRAVELLY SAND; very dark gray brown (10YR, 3/4), loose, well sorted, coarse, angular to subrounded, dry.

32' to 34' [CH]: CLAY; yellowish-brown (10YR, 5/4), soft, sticky, plastic.

34' to 36' [SP]: SAND; dark grayish-brown (10YR, 4/2), loose, well sorted, subangular to rounded, dry.

36' to 42' [SM]: SANDY SILT; dark yellowish-brown (10YR, 4/4), loose, 60% to 80% silt, 20% to 40% fine to very fine sand, moist.

42' to 68' [SP]: SAND; very dark gray (10YR, 3/1), moderately sorted, angular to subrounded, predominantly metamorphics and volcanics, micaceous, wet.

68' to 88' [GP]: SANDY GRAVEL; black (10YR, 2/1), poorly sorted, angular to subangular, predominantly metamorphics and volcanics with some granite, quartz, and feldspar, 60% gravel, 40% coarse sand, micaceous, wet.

88' to 98' [SP/SW]: SAND; very dark gray (10YR, 3/1), moderately sorted, angular to rounded, predominantly metamorphics and volcanics, micaceous, wet.

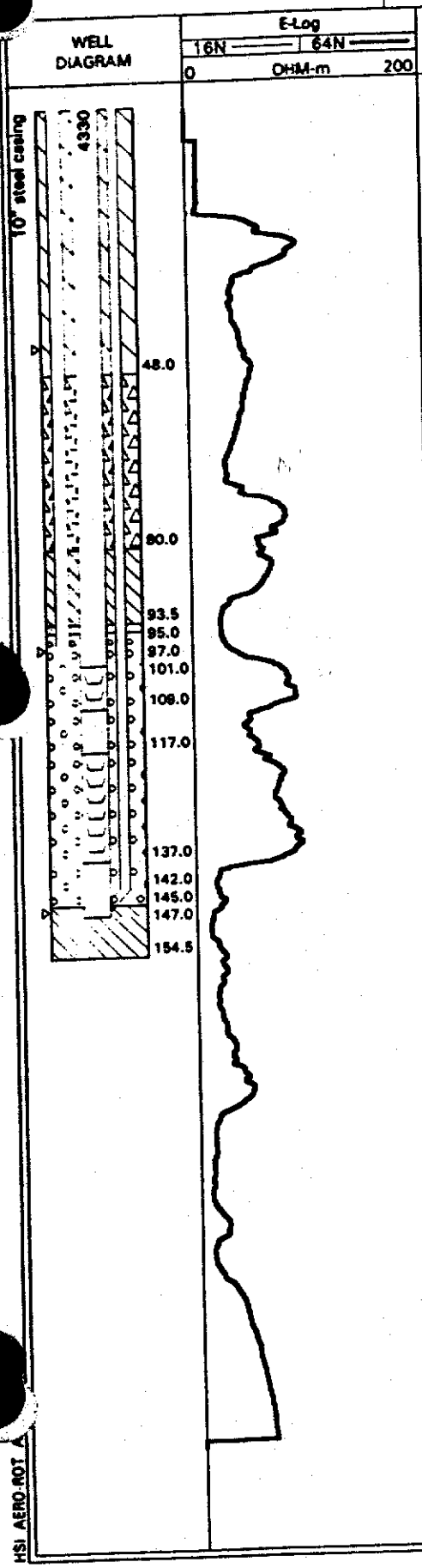
98' to 108' [GW]: SANDY GRAVEL; very dark gray (10YR, 3/1), poorly sorted, angular to subangular, predominantly metamorphics and volcanics, micaceous, wet.

Total Depth of Borehole: 108 feet
24" surface casing installed to a depth of 56 feet.
Dec-94 land-surface elevations (ft-msl) for:
10" well casing at 108.03,
3" gravel fill tube at 108.02,
2" sounding tube at 108.03.
Well screen: 0.125" core-10 shutter
Well casing: 4325
Sounding tube: 4326
Gravel fill tube: 4327
Gravel: RMC Special Blend

HSI A/NO-NOT A/NO 8/18/95

AEROJET

TOTAL DEPTH BORING ft: 154.5	WELL ID: 4330 Page 1 of 1
TOTAL DEPTH WELL ft: 147	SITE: Nimbus Fish Hatchery
SURFACE ELEVATION ft MSL: 107.7	EAST = 2220258.3 NORTH = 352911.0
TOC ELEVATION ft MSL: 107.67	DATE COMPLETED: 8/9/94 LOGGED BY: D. Dettloff
BOREHOLE DIAMETER: 42"/22"	



DESCRIPTION

0 to 5' [GP]: BOULDERS (Dredge tailings); loose, well sorted, well rounded, dry.

5' to 32' [SP]: GRAVELLY SAND; very dark gray brown (10YR, 3/4), loose, well sorted, angular to subrounded, coarse, dry.

32' to 34' [CH]: CLAY; yellowish-brown (10YR, 5/4), soft, sticky, plastic.

34' to 36' [SP]: SAND; dark grayish-brown (10YR, 4/2), loose, well sorted, subangular to rounded, dry.

36' to 42' [SM]: SANDY SILT; dark yellowish-brown (10YR, 4/4), loose, 60% to 80% silt and 20% to 40% fine to very fine sand, moist.

42' to 70' [SP]: SAND; dark brown (10YR, 4/3), slightly indurated, moderately sorted, subangular to rounded, moist.

70' to 88' [SW]: GRAVELLY SAND; dark brown (10YR, 4/3), poorly sorted, subangular to rounded, 75% sand and 25% gravel, moist.

88' to 99' [GW]: SANDY GRAVEL; black (10YR, 2/1), poorly sorted, subangular to subrounded, 70% gravel and 30% sand, moist.

99' to 125' [SP]: SAND; very dark gray (10YR, 3/1), well sorted, coarse, angular to very angular, micaceous, wet.
Bit chattering from 101' to 139'.

125' to 139' [GP]: GRAVEL; very dark gray (10YR, 3/1), well sorted, angular to subangular, micaceous, wet.

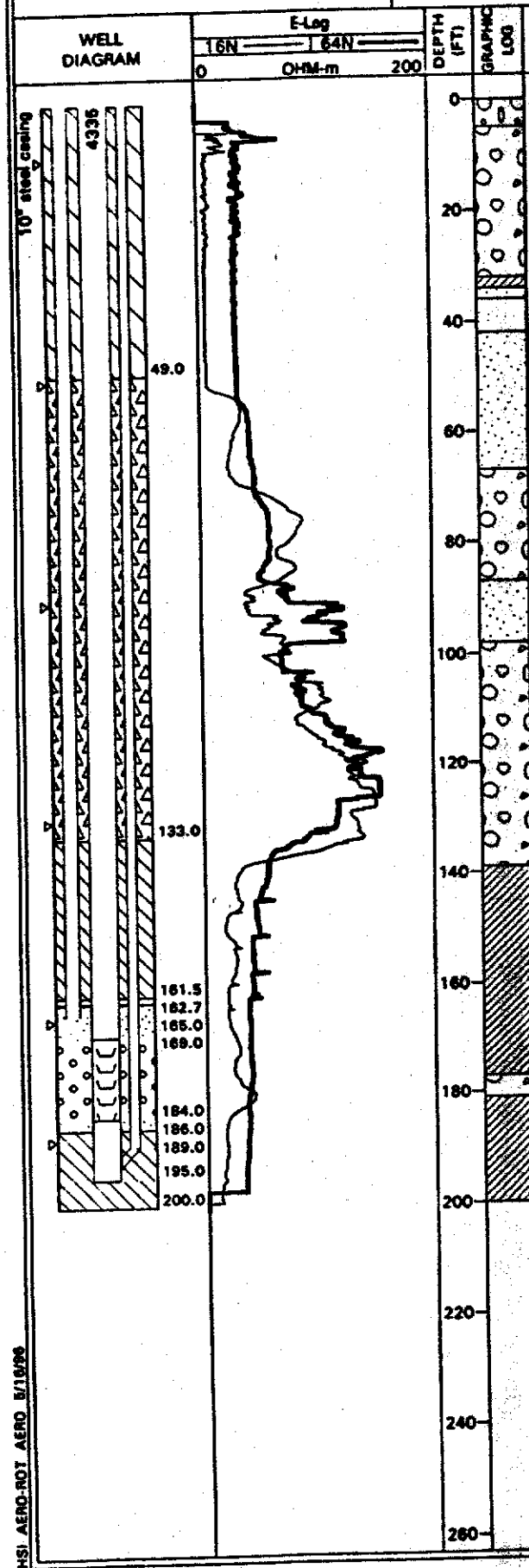
139' to 160' [CL]: SANDY CLAY; pale olive (5Y, 6/4), soft, 5% to 10% fine to coarse sand, moist.

Total Depth of Borehole: 154.5 feet
E-log from Corehole, ARCH-94-2
24" surface casing installed to depth of 50 feet.
Dec-94 land-surface elevations (ft-msl) for:
10" well casing at 107.7,
3" gravel fill tube at 107.73,
2" sounding tube at 107.67.
Well screen: 0.125" core-10 shutter
Well casing: 4330
Sounding tube: 4331
Gravel fill tube: 4332
Gravel: RMC Special Blend

HSI AERO.ROT

AEROJET

TOTAL DEPTH BORING ft: 200.0	**WELL ID: 4335** Page 1 of 1
TOTAL DEPTH WELL ft: 195.0	SITE: Nimbus Fish Hatchery
SURFACE ELEVATION ft MSL: 107.3	EAST = 2220278.2 NORTH = 352917.4
TOC ELEVATION ft MSL: 107.23	DATE COMPLETED: 8/24/94 LOGGED BY: D. Dettloff
BOREHOLE DIAMETER: 42"/22"	



DESCRIPTION

0 to 5' [GP]: BOULDERS (Dredge tailings); loose, well sorted, well rounded, dry.

5' to 32' [SP]: GRAVELLY SAND; very dark gray-brown (10YR, 3/4), loose, well sorted, coarse, angular to subrounded, dry.

32' to 34' [CH]: CLAY; yellowish-brown (10YR, 5/4), soft, sticky, plastic.

34' to 36' [SP]: SAND; dark grayish-brown (10YR, 4/2), loose, well sorted, subangular to rounded, dry.

36' to 42' [SM]: SANDY SILT; dark yellowish-brown (10YR, 4/4), loose, 60% to 80% silt and 20% to 40% fine to very fine sand, moist.

42' to 67' [SP]: SAND; very dark gray (10YR, 3/1), loose, well sorted, angular to rounded, predominantly volcanics and metamorphics, micaceous, wet.

67' to 87' [GW]: SANDY GRAVEL; black (10YR, 2/1), loose, poorly sorted, extremely angular to subrounded, 60% to 65% gravel and 35% to 40% coarse sand, predominantly volcanics with some quartz, feldspar, and metamorphics, wet.

87' to 98' [SP]: SAND; black (10YR, 2/1), loose, well sorted, angular to rounded, predominantly volcanics, micaceous, wet.

98' to 139' [GW]: SANDY GRAVEL; very dark gray (10YR, 3/1), loose, poorly sorted, extremely angular to rounded, 60% to 75% gravel (increasing with depth) and 25% to 40% coarse sand, predominantly volcanics and metamorphics, micaceous, wet.

139' to 177' [CL]: CLAY; brown (10YR, 5/3), moderately indurated, stiff, wet.

177' to 181' [GW]: SANDY GRAVEL; very dark gray (10YR, 3/1), loose, poorly sorted, angular to subrounded, 60% gravel and 40% coarse sand, predominantly volcanics and metamorphics, micaceous, wet.

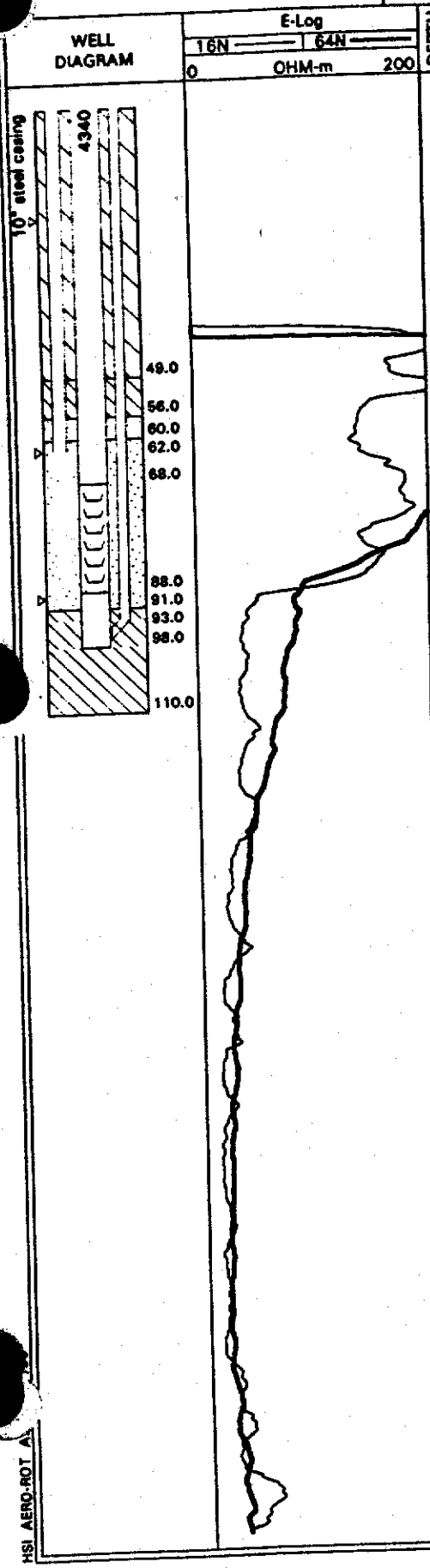
181' to 200' [CL]: CLAY; brown (10YR, 5/3), poorly indurated, very soft, wet.

Total Depth of Borehole: 200 feet
24" surface casing installed to a depth of 50 feet.
Dec-94 land surface elevations (ft-msl) for:
10" well casing at 107.23,
3" gravel fill tube at 107.28,
2" sounding tube at 107.27.
Well screen: 0.045" core-10 shutter
Well casing: 4335
Sounding tube: 4336
Gravel fill tube: 4337
Gravel: 8 x 16

HSI AERO-ROT AERO 5/19/95

AEROJET

TOTAL DEPTH BORING ft: 110.0	WELL ID: 4340 — Page 1 of 1
TOTAL DEPTH WELL ft: 98	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 106.6	EAST = 2215209.7 NORTH = 354367.5
TOC ELEVATION ft MSL: 106.9	DATE COMPLETED: 9/21/94 LOGGED BY: D. Dettloff
BOREHOLE DIAMETER: 22"	



DESCRIPTION

0 to 6' [GP]: COBBLES (Dredge Tailings); light gray (2.5Y, 7/2), well sorted, well rounded, loose, dry.

6' to 30' [GP]: GRAVEL; bluish-gray (5B, 6/1), well sorted, angular to subrounded, loose, dry.

30' to 40' [SM]: SILTY SAND; yellowish-brown (10YR, 3/4), moderately sorted, fine to medium, angular to subrounded, medium dense, moist, micaceous, trace gravel, 35% to 40% silt, and 60% to 65% sand.

40' to 61' [SP]: SAND; brown (10YR, 4/3), moderately indurated, well sorted, subangular to rounded, loose, wet.
47' to 50' Cemented gravel?

61' to 62' [ML]: CLAY; brown (10YR, 5/3), poorly indurated, soft, wet.

62' to 80' [SP]: SAND; dark gray (10YR, 4/1), medium to coarse, moderately sorted, angular to subrounded, loose, wet. Predominantly volcanics with some feldspar and quartz.

80' to 98' [SM]: SILTY SAND; dark yellowish-brown (10YR, 4/6), coarse, angular to subrounded, loose, wet, 75% to 80% sand and 20% to 25% silt.

98' to 104' [SP]: SAND; very dark gray (10YR, 3/1), coarse, well sorted, angular to subrounded, loose, wet. Predominantly volcanics with some feldspar.

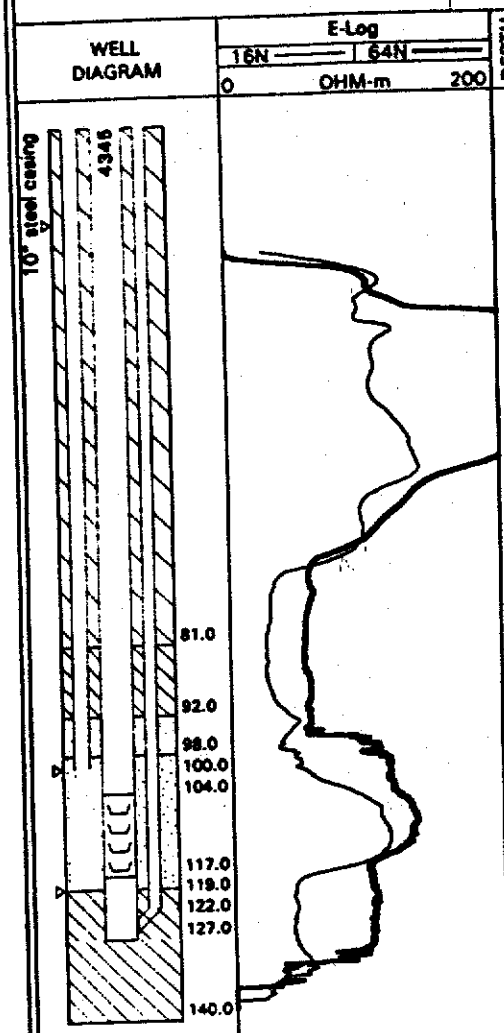
104' to 110' [SM]: SILTY SAND; yellowish-brown (10YR, 5/6), poorly sorted, angular to subrounded, loose, wet, 65% to 70% sand and 30% to 35% silt.

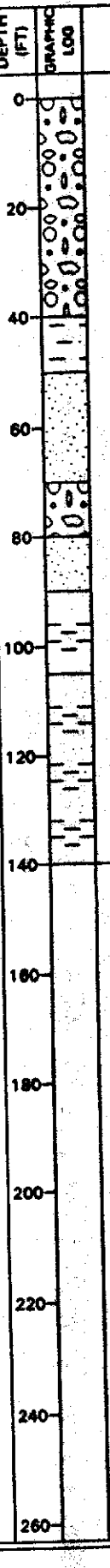
Total Depth of Borehole: 110 feet
E-log from Core Hole: ARCH-94-3
24" Surface Casing installed to a depth of 50' bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing at 105.82,
10" well casing at 106.90,
3" gravel fill tube at 105.88,
and 2" sounding tube at 106.58.
Well Screen: 0.045" shutter.
Well Casing: 4340
Sounding Tube: 4341
Gravel Fill Tube: 4342
Gravel: 8 x 16

HSI AERO-ROT A

AEROJET

TOTAL DEPTH BORING ft: 140.0	WELL ID: 4345 Page 1 of 1
TOTAL DEPTH WELL ft: 127	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 88.3	EAST = 2215402.7 NORTH = 354448.2
TOC ELEVATION ft MSL: 90.80	DATE COMPLETED: 10/3/94 LOGGED BY: C. Cochrane
BOREHOLE DIAMETER: 14"	





DESCRIPTION

0 to 40' [GP]: COBBLES (Dredge Tailings); gray (10YR, 6/1), loose, dry.

40' to 50' [ML]: SILT; yellowish-brown (10YR, 5/4), low plasticity, soft, dry.

50' to 70' [SW]: SAND; dark brown (10YR, 3/2), well graded, subangular to rounded, loose, wet.

70' to 80' [GP]: GRAVEL; black (10YR, 2/1), 8-10mm gravel, subangular to rounded, loose, wet.

80' to 90' [SP]: SAND; very dark grayish-brown (10YR, 3/1), subrounded to rounded, fine to medium, wet.

90' to 105' [ML]: SANDY SILT; dark yellowish-brown (10YR, 3/4), 10% to 30% sand, fine, subangular to subrounded, soft, wet.

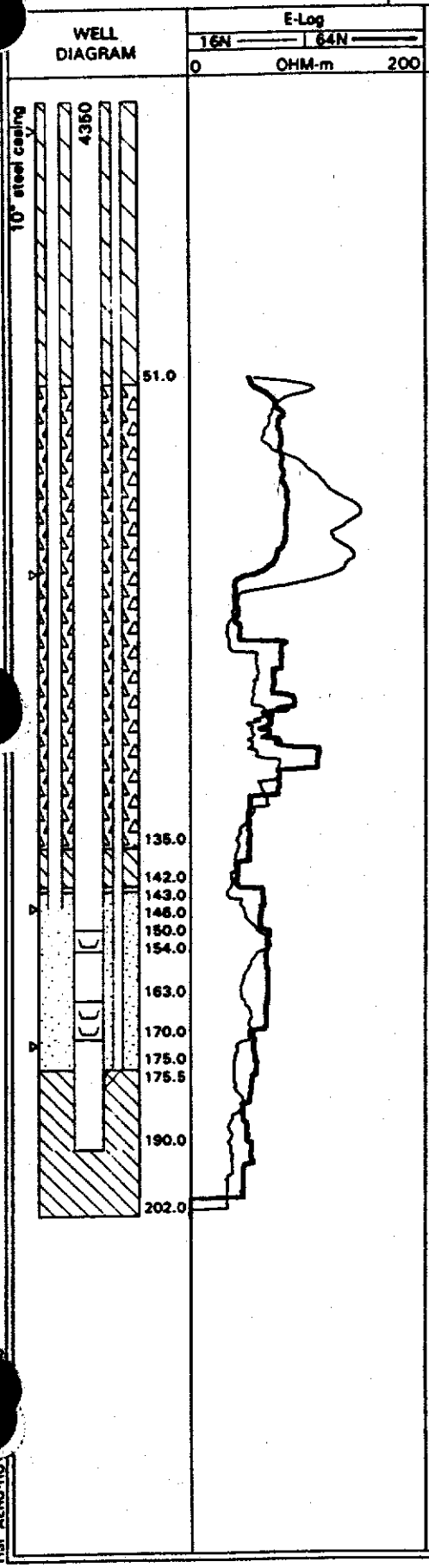
105' to 140' [SM]: SILTY SAND; dark yellowish-brown (10YR, 4/6), 70% to 80% sand, very fine, subrounded to rounded, loose, moist.

Total Depth of Borehole: 140 feet
24" Surface Casing installed to a depth of 19' bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing at 89.90,
8" well casing at 90.80,
2" gravel fill tube at 90.83,
and 1" sounding tube at 90.65.
Well Screen: 0.050" shutter.
Well Casing: 4345
Sounding Tube: 4346
Gravel Fill Tube: 4347
Gravel: 8 x 16

HSI AERO-ROT AERO 5/7/96

AEROJET

TOTAL DEPTH BORING ft: 202.0	WELL ID: 4350 Page 1 of 1
TOTAL DEPTH WELL ft: 190	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 104.8	EAST = 2215226.7 NORTH = 354351.7
TOC ELEVATION ft MSL: 106.42	DATE COMPLETED: 9/14/94 LOGGED BY: D. Dettloff
BOREHOLE DIAMETER: 22"	



DESCRIPTION

0 to 6' [GP]: COBBLES (Dredge Tailings); light gray (2.5Y, 7/2), well sorted, well rounded, dry.

6' to 30' [GP]: GRAVEL; bluish-gray (5B, 6/1), well sorted, angular to subrounded, loose, dry.

30' to 40' [SM]: SILTY SAND; dark yellowish-brown (10YR, 3/4), moderately sorted, fine to medium, angular to subrounded, medium dense, moist, micaceous, trace gravel, 35% to 40% silt and 60% to 65% sand.

40' to 56' [SP]: SAND; very dark gray (10YR, 3/1), well sorted, subangular to rounded, loose, moist.

56' to 62' [SM]: SILTY SANDSTONE; brown (10YR, 4/3), well indurated, well sorted, fine to medium, angular to subrounded, moist, 40% to 45% silt and 55% to 60% sand.

62' to 88' [SP]: SAND; very dark brown (10YR, 2/2), well sorted, angular to rounded, loose, moist.

88' to 99' [ML]: SILT; dark yellowish-brown (10YR, 4/4), moderately indurated, moist.

99' to 118' [SM]: SILTY SAND; dark brown (10YR, 3/3), moderately sorted, medium to coarse, angular to subrounded, loose, wet, 35% to 40% silt and 60% to 65% sand.

118' to 130' [SP]: SAND; dark gray (10YR, 4/1), well sorted, subangular to rounded, loose, wet.

130' to 144' [ML]: SILT; dark yellowish-brown (10YR, 4/6), moderately indurated, dry.

144' to 158' [SP]: SAND; dark gray (10YR, 4/1), well sorted, subangular to rounded, loose, moist.

158' to 162' [CL]: CLAY; brown (10YR, 5/3), soft, wet.

162' to 170' [SP]: SAND; gray (10YR, 5/1), well sorted, angular to subrounded, loose, wet.

170' to 178' [CL]: CLAY; brown (10YR, 5/3), medium plasticity, soft, wet.

178' to 184' [SP]: SAND; brown (10YR, 4/3), well sorted, subangular to rounded, loose, wet.

184' to 202' [CL]: CLAY; brown (10YR, 5/3), medium plasticity, soft, wet.

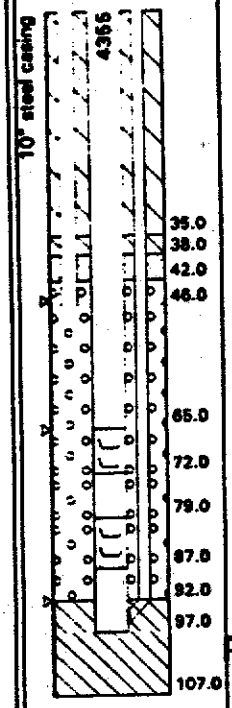
Total Depth of Borehole: 202 feet
24" Surface Casing installed to depth of 50' bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing at 104.95,
10" well casing at 106.42,
3" gravel fill tube at 105.58,
and 2" sounding tube at 105.52.
Well Screen: 0.030" shutter.
Well Casing: 4350
Sounding Tube: 4351
Gravel Fill Tube: 4352
Gravel: 8 x 20

HSI AERO-RO

AEROJET

TOTAL DEPTH BORING ft: 107.0	WELL ID: 4355 Page 1 of 1
TOTAL DEPTH WELL ft: 97	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 96.1	EAST = 2215697.8 NORTH = 354926.9
TOC ELEVATION ft MSL: 97.67	DATE COMPLETED: 10/24/94 LOGGED BY: C. Cochran
BOREHOLE DIAMETER: 22"	

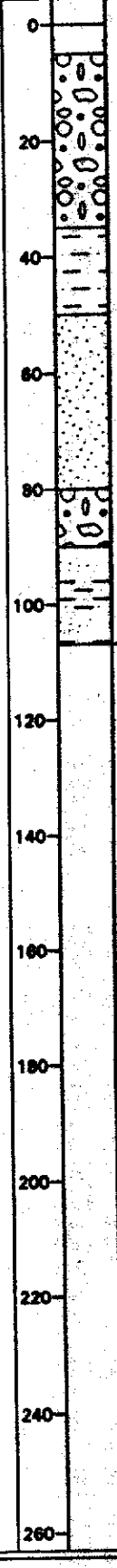
WELL DIAGRAM



E-Log

DEPTH (FT)

GRAPHIC LOG



DESCRIPTION

0 to 5' [SM]: SILTY SAND; brown (10YR, 5/3), well graded, angular to subrounded sand, loose, dry, some cobble.

5' to 35' [GP]: COBBLES; gray (10YR, 6/1), loose, dry.

35' to 50' [ML]: SILT; yellowish-brown (10YR, 5/4), low plasticity, soft, dry.

50' to 80' [SW]: SAND; dark brown (10YR, 3/2), well graded, subangular to rounded, loose, moist.

80' to 90' [GP]: GRAVEL; black (10YR, 2/1), 8-10mm gravel, subangular to rounded, loose, wet.

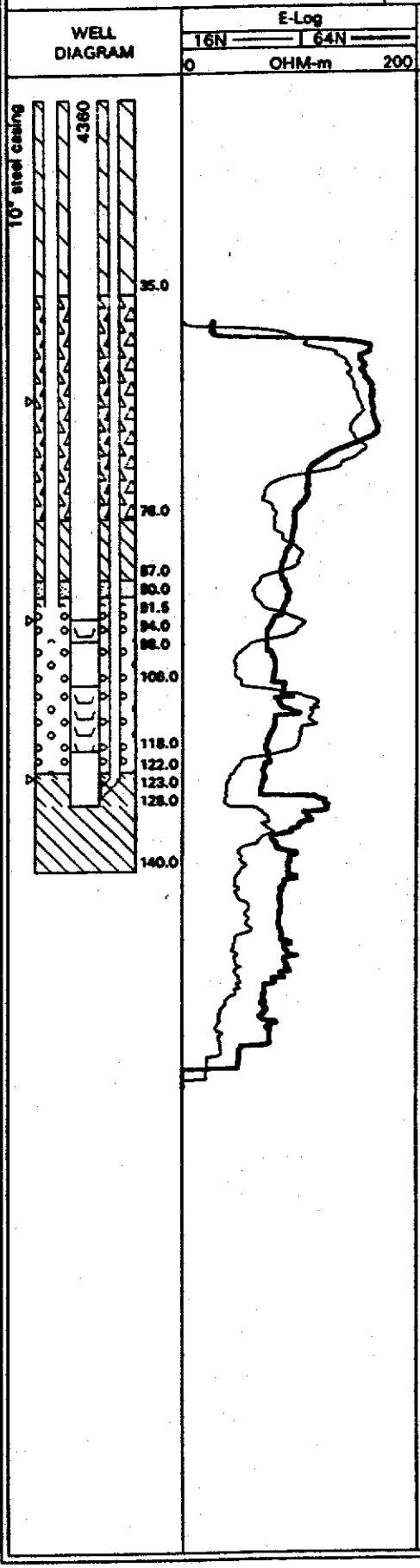
90' to 107' [ML]: SANDY SILT; dark yellowish-brown (10YR, 3/4), 10% to 30% subangular to subrounded, fine sand, soft, wet.

Total Depth of Borehole: 107 feet
24" Surface Casing installed to a depth of 50' bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing at 96.42,
10" well casing at 97.67,
2" gravel fill tube at 97.59,
and 1" sounding tube at 97.40.
Well Screen: 0.10" shutter.
Well Casing: 4355
Sounding Tube: 4356
Gravel Fill Tube: 4357
Gravel: 3/8 x 6

HSI AERO-ROT AERO 5/1/96

AEROJET

TOTAL DEPTH BORING ft: 140.0	WELL ID: 4360
TOTAL DEPTH WELL ft: 128	
SURFACE ELEVATION ft MSL: 96.6	SITE: Sailor Bar Park
TOC ELEVATION ft MSL: 97.67	EAST = 2215677.7 NORTH = 354946.3
BOREHOLE DIAMETER: 22"	DATE COMPLETED: 10/18/94 LOGGED BY: C. Cochrane



DESCRIPTION

0 to 5' [SM]: SILTY SAND; brown (10YR, 5/3), well graded, angular to subrounded, loose, dry, some cobbles.

5' to 40' [GP]: COBBLES; gray (10YR, 6/1), loose, dry.

40' to 50' [ML]: SANDY SILT; dark yellowish-brown (10YR, 3/4), 10% to 30% very fine to fine, subangular to rounded sand, damp.

50' to 80' [SW]: SAND; dark brown (10YR, 3/2), well graded, subangular to rounded, loose, moist.

80' to 90' [GP]: GRAVEL; black (10YR, 2/1), 8-10mm gravel, subangular to rounded, loose, wet.

90' to 100' [SW]: SAND; dark brown (10YR, 3/3), subangular to rounded, well graded, loose, wet.

100' to 130' [ML]: SANDY SILT; dark yellowish-brown (10YR, 3/4), 10% to 30% fine, subangular to subrounded sand, soft, wet.

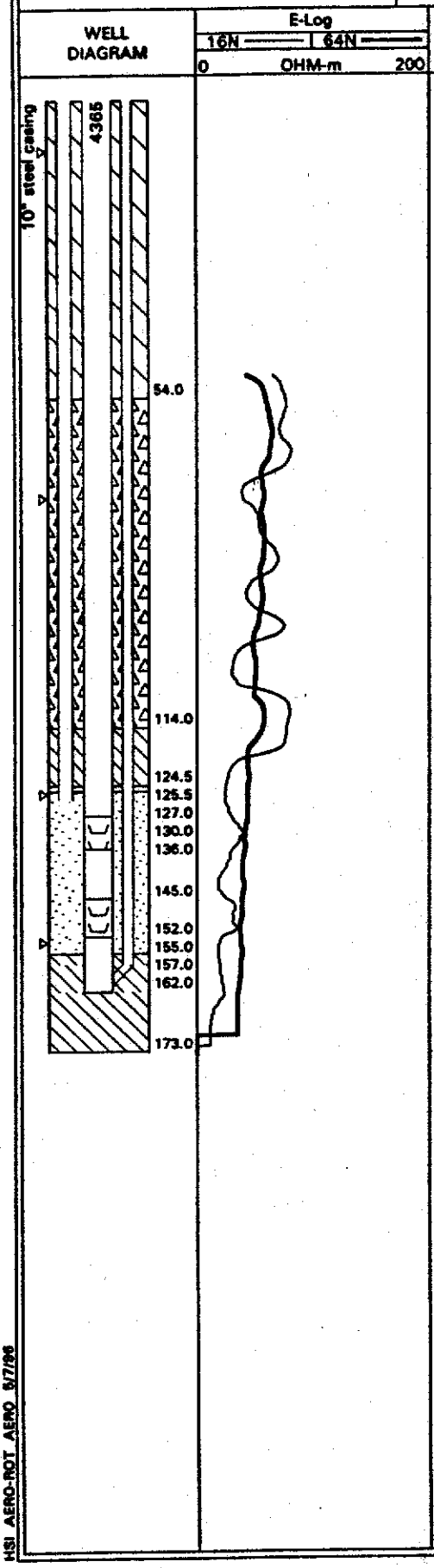
130' to 140' [SP]: SAND; very dark grayish-brown (10YR, 3/2), fine, subangular to rounded, loose, wet.

Total Depth of Borehole: 140 feet
E-log from Core Hole: ARCH-94-7
24" Surface Casing installed to a depth of 40' bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing at 97.28,
10" well casing at 97.67,
2" gravel fill tube at 97.62,
and 1" sounding tube at 97.35.
Well Screen: 0.060" shutter.
Well Casing: 4360
Sounding Tube: 4361
Gravel Fill Tube: 4362
Gravel: 4 x 12

HSI AERO-ROT AERO 97/06

AEROJET

TOTAL DEPTH BORING ft: 173.0	WELL ID: 4365 Page 1 of 1
TOTAL DEPTH WELL ft: 162	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 97.3	EAST = 2215662.3 NORTH = 354964.1
TOC ELEVATION ft MSL: 99.7	DATE COMPLETED: 10/11/94 LOGGED BY: D. Dettl
BOREHOLE DIAMETER: 22"	



DESCRIPTION

0 to 5' [SW]: SILTY SAND; brown (10YR, 5/3), angular to subrounded, poorly sorted, loose, dry, some cobbles.

5' to 35' [GP]: COBBLES; gray (10YR, 6/1), loose, dry.

35' to 38' [ML]: SILT; yellowish-brown (10YR, 5/4), slight plasticity, soft, dry.

38' to 45' [CL]: CLAY; brown (7.5YR, 4/3), medium plasticity, soft, damp.

45' to 68' [SW]: GRAVELLY SAND; very dark gray (5YR, 3/1), 10% to 15% gravel and 85% to 90% sand, poorly sorted, angular (due to drilling) to rounded, loose, wet.

68' to 98' [SP]: SAND; very dark gray (5YR, 3/1), well sorted, fine to medium, subangular to rounded, loose, wet.
73' to 86' Grades to coarse sand.

86' to 92' Grades to medium sand.

92' to 98' Grades to coarse sand.

98' to 119' [SP]: SAND; brown (7.5YR, 4/3), well sorted, fine to medium, angular to rounded, loose, wet.
105' to 119' Grades to coarse sand.

119' to 130' [ML]: SILT; brown (10YR, 5/3), moderately to well indurated, firm, wet.

130' to 137' [SP]: SAND; very dark gray (5YR, 3/1), well sorted, medium, angular to subrounded, loose, wet.

137' to 144' [CL]: SANDY CLAY; light yellowish-brown (10YR, 6/4), 25% to 30% sand and 70% to 75% clay; sand: well sorted, fine, subangular to rounded, wet; clay: soft, sticky, wet.

144' to 152' [SP]: SAND; brown (10YR, 4/3), well sorted, fine to medium, subangular to rounded, loose, wet.

152' to 157' [CL]: SANDY CLAY; light yellowish-brown (10YR, 6/4), 70% to 75% clay and 25% to 30% sand; sand: well sorted, subangular to rounded, wet; clay: soft, sticky, wet.

157' to 165' [SP]: SAND; brown (10YR, 4/3), well sorted, fine, subangular to rounded, loose, wet.

165' to 173' [CL]: SANDY CLAY; light yellowish-brown (10YR, 6/4), 55% to 60% clay and 40% to 45% sand; sand: well sorted, subangular to rounded, wet; clay: soft, wet.

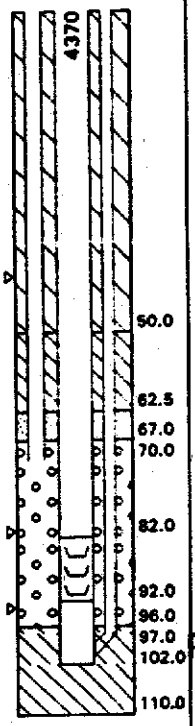
Total Depth of Borehole: 173 feet
24" Surface Casing installed to depth of 50' bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing at 98.29,
10" well casing at 99.70,
3" gravel fill tube at
and 2" sounding tube at 98.41.
Well Screen: 0.030" shutter.
Well Casing: 4365
Sounding Tube: 4366
Gravel Fill Tube: 4367
Gravel: 8 x 20

HSI AERO-ROT AERO 9/7/96

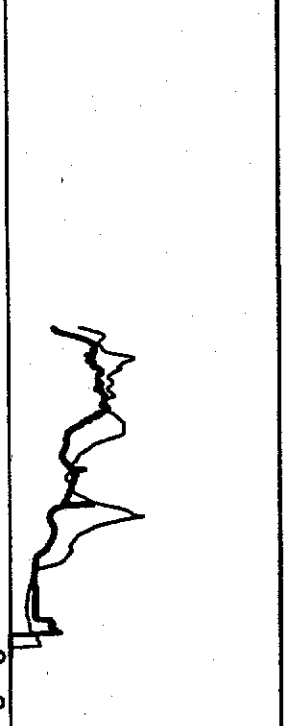
AEROJET

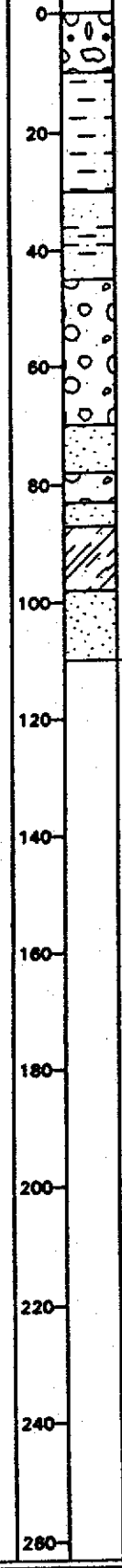
TOTAL DEPTH BORING ft: 110.0	WELL ID: 4370 Page 1 of 1
TOTAL DEPTH WELL ft: 110	SITE: Sunrise Park
SURFACE ELEVATION ft MSL: 113.8	EAST = 2217046.9 NORTH = 351986.2
TOC ELEVATION ft MSL:	DATE COMPLETED: 12/7/94 LOGGED BY: D.Dettloff
BOREHOLE DIAMETER: 22"	

WELL DIAGRAM



E-Log





DESCRIPTION

0 to 10' [GW]: COBBLES; gray (7.5YR 6/1), well rounded, poorly sorted, dry.

10 to 30' [ML]: SILT; dark yellowish brown (10YR 4/4), low plasticity, pyrite, soft, moist.

30 to 45' [SM]: SILTY SAND; yellowish brown (10YR 5/6), loose, 80-90% subangular to rounded, medium to coarse sand, and 10-20% silt, few pyrites, moist.

45 to 70' [GW]: SANDY GRAVEL; dark bluish gray (10B 3/1), loose, extremely angular (due to drilling) to subrounded, poorly sorted, moist. 25-30% coarse sand and 70-75% gravel. Lenses of black sand (10YR 2/1), loose, subangular to rounded, well sorted, wet from 59-61' and from 62-65' bgs.

70 to 78' [SP]: SAND; very dark grayish brown (10YR 3/2), loose, angular to subrounded, well sorted, wet.

78 to 83' [GW]: SANDY GRAVEL; dark bluish gray (10B 3/1), loose, extremely angular (due to drilling) to subrounded, poorly sorted, wet. 20-25% coarse sand and 75-80% gravel.

83 to 87' [SP]: SAND; dark brown (10YR 3/3), loose, subangular to rounded, well sorted, wet.

87 to 98' [SC]: SANDY CLAY; dark yellowish brown (10YR 4/4), moderately indurated, soft, moist. 10-15% fine sand and 85-90% clay.

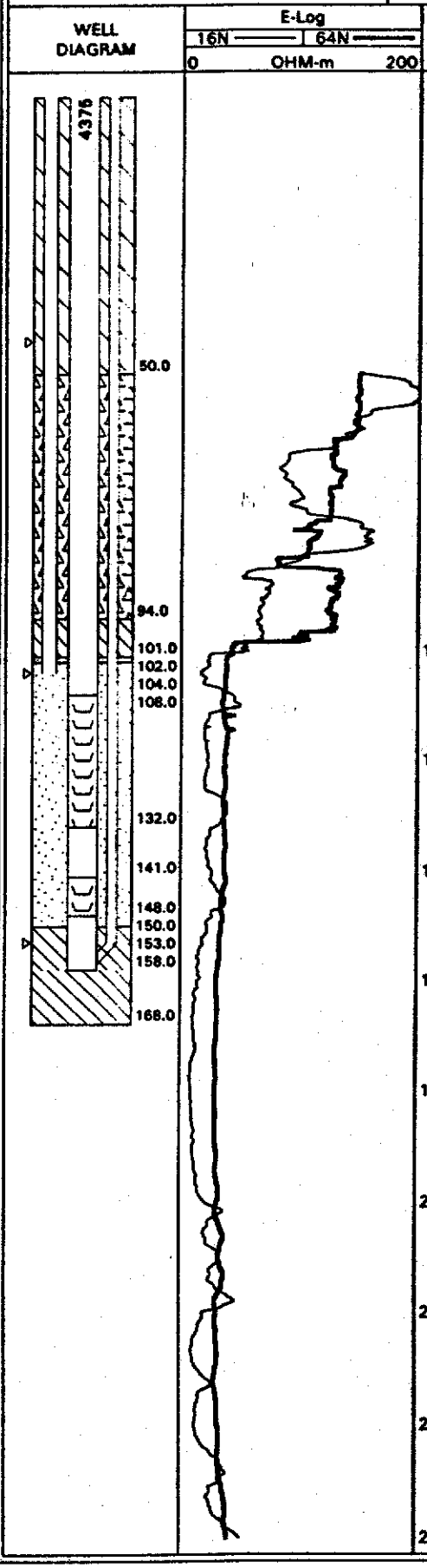
98 to 110' [SP]: SAND; dark brown (10YR 3/3), loose, subangular to well rounded, well sorted, wet.

Total Depth of Borehole: 110 feet
24" Surface Casing installed to a depth of 50' bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing (plate) at 114.75.
Well Screen: 0.125" shutter.
Well Casing: 4370
Sounding Tube: 4371
Gravel Fill Tube: 4372
Gravel: 3/8 x 6

H9I_AERO-ROT_AERO_9/7/96

AEROJET

TOTAL DEPTH BORING ft: 168.0	WELL ID: 4375 Page 1 of 1
TOTAL DEPTH WELL ft: 168	SITE: Sunrise Park
SURFACE ELEVATION ft MSL: 114.0	EAST = 2217035.5 NORTH = 352010.7
TOC ELEVATION ft MSL: 113.87	DATE COMPLETED: 12/22/94 LOGGED BY: D.Dettloff
BOREHOLE DIAMETER: 22"	



DESCRIPTION

0 to 10' [GW]: COBBLES; gray (7.5YR 6/1), loose, well rounded, poorly sorted, dry.

10 to 30' [ML]: SILT; dark yellowish brown (10YR 4/4), low plasticity, pyrite, soft, moist.

30 to 45' [SM]: SILTY SAND; yellowish brown (10YR 5/6), loose, 80-90% subangular to rounded, medium to coarse sand, and 10-20% silt, few pyrites, moist.

45 to 64' [GW]: SANDY GRAVEL; dark bluish gray (10B 3/1), loose, extremely angular (due to drilling) to subrounded, poorly sorted, moist. 25-30% coarse sand and 70-75% gravel. Lens of black sand (10YR 2/1), loose, subangular to rounded, well sorted, wet from 59-61' bgs.

64 to 75' [SP]: GRAVELLY SAND; brown (10YR 4/3), loose, angular to subrounded, moderately sorted, wet. 25-30% gravel and 70-75% medium to coarse sand.

75 to 83' [GP]: GRAVEL; dark brown (10YR 3/3), loose, subrounded to rounded, well sorted, wet.

83 to 100' [SP]: SAND; very dark gray (10YR 3/1), loose, angular to subrounded, well sorted, wet. Predominantly feldspar and metavolcanics.

100 to 106' [CL]: SANDY CLAY; dark grayish brown (10YR 4/2), firm, sand: angular to subrounded, well sorted, wet; clay: poorly indurated, wet, 30-35% fine sand and 65-70% clay.

106 to 111' [SP]: SAND; dark grayish brown (10YR 4/2), loose, angular to subrounded, well sorted, wet.

111 to 125' [CL]: CLAY; brown (10YR 5/3), soft, wet.

125 to 132' [SP]: SAND; brown (10YR 5/3), poorly to moderately indurated, subangular to rounded, well sorted, wet.

132 to 142' [SC]: CLAYEY SAND; brown (10YR 5/3), clay: soft, wet; sand: medium dense, angular to subrounded, well sorted, wet. 30-35% clay and 65-70% fine sand.

142 to 147' [SP]: SAND; grayish brown (10YR 5/2), loose, angular to subrounded, well sorted, wet.

147 to 160' [ML]: SILT; pale brown (10YR 6/3), well indurated (in chips), moist.

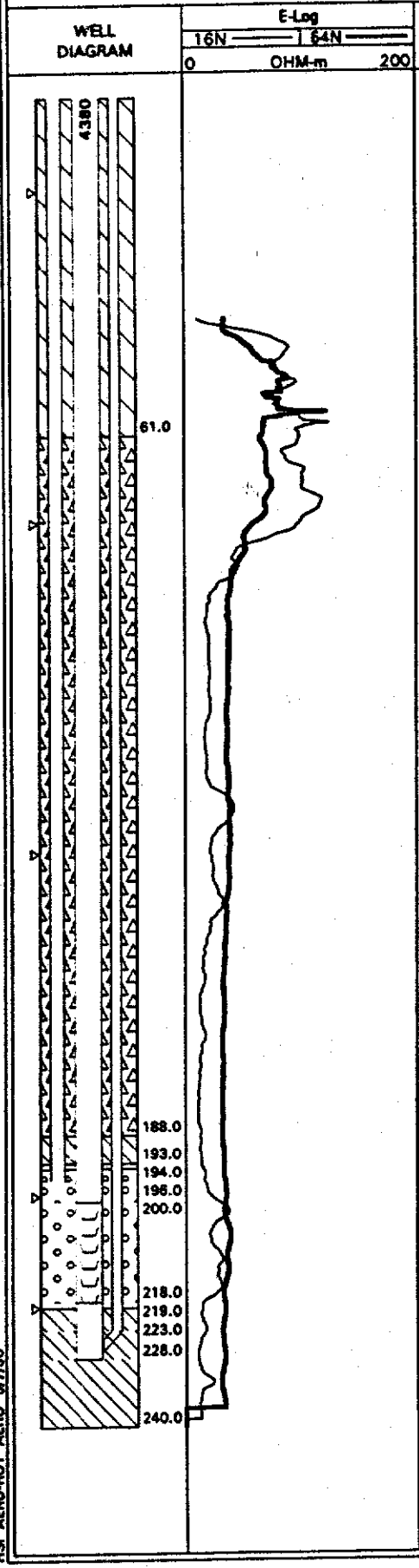
160 to 168' [CL]: CLAY; brown (10YR 5/3), soft, wet.

Total Depth of Borehole: 168 feet
E-log from Core Hole ARCH-94-9
24" Surface Casing installed to a depth of 50' bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing at 114.02,
10" well casing at 113.87,
3" gravel fill tube at 113.78,
and 2" sounding tube at 113.71.
Well Screen: 0.045" shutter.
Well Casing: 4375
Sounding Tube: 4376
Gravel Fill Tube: 4377
Gravel: 8 x 20

HSI AERO-ROT AERO 5/7/96

AEROJET

TOTAL DEPTH BORING ft: 240.0	WELL ID: 4380 Page 1 of 2
TOTAL DEPTH WELL ft: 228	
SURFACE ELEVATION ft MSL: 113.7	SITE: Sunrise Park
TOC ELEVATION ft MSL:	EAST = 2217070.9 NORTH = 351961.8
BOREHOLE DIAMETER: 22"	DATE COMPLETED: 11/28/94 LOGGED BY: D.Dettloff



DESCRIPTION

0 to 10' [GW]: COBBLES; gray (7.5YR 6/1), loose, well rounded, poorly sorted, dry.

10 to 30' [ML]: SILT; dark yellowish brown (10YR 4/4), low plasticity, pyrite, soft, damp.

30 to 45' [SM]: SILTY SAND; yellowish brown (10YR 5/6), loose, 80-90% subangular to rounded, medium to coarse sand, and 10-20% silt, few pyrites, moist.

45 to 80' [GP]: SANDY GRAVEL; black (10YR 2/1), loose, well sorted, subangular to rounded, wet.

80 to 88' [SP]: SAND; black (10YR 2/1), loose, well sorted, angular to subrounded, wet. Predominantly volcanic and metamorphic.

88 to 96' [ML]: SANDY SILT; brown (10YR 4/3), silt: well indurated, hard (in chips), wet; sand: loose, well sorted, angular to subrounded, wet. 40-45% coarse sand and 55-60% silt.

96 to 112' [SM]: SILTY SAND; brown (10YR 4/3), sand: loose, well sorted, angular to rounded, wet; silt: well indurated, hard (in chips), wet. 45-50% silt and 50-55% coarse sand.

112 to 123' [ML]: SILT; brown (10YR 5/3), well indurated (in chips), wet.

123 to 134' [SW]: SAND; dark grayish brown (10YR 4/2), loose, poorly sorted (fine to coarse), angular to rounded, wet.

134 to 142' [SM]: SILTY SAND; very dark grayish brown (10YR 3/2), sand: loose, poorly sorted (fine to coarse), angular to subrounded, moist; silt: well indurated, hard (in chips), moist. 35/40% silt and 60-65% sand.

142 to 148' [SW]: SAND; dark brown (10YR 3/3), loose, poorly sorted (fine to coarse), angular to subrounded, wet.

148 to 170' [SM/ML]: SILTY SAND/SANDY SILT; brown (10YR 5/3), sand: loose, poorly sorted (fine to coarse), angular to subrounded, wet; silt: well indurated (in chips), wet.

170 to 199' [CL]: CLAY; pale brown (10YR 6/3), soft, slow dilatancy, medium toughness, wet.

199 to 217' [SP]: SAND; brown (10YR 5/3); moderately indurated, moderately sorted, angular to rounded, wet.

217 to 221' [CL]: CLAY; pale brown (10YR 6/3), soft, slow dilatancy, no toughness, wet.

221 to 224' [ML]: SILT; light yellowish brown (10YR 6/4), well indurated (in chips), wet.

224 to 230' [CL]: CLAY; brown (10YR 5/3), slightly indurated, slow dilatancy, low toughness.

230 to 233' [SP]: SAND; grayish brown (10YR 5/2), well to poorly indurated, well sorted (fine), subangular to rounded, wet.

233 to 239' [CL]: CLAY; light brownish gray (10YR 6/2), slightly indurated, slow dilatancy, low toughness, wet.

239 to 240' [GP]: GRAVEL; gray (10YR 5/1), loose, well sorted, angular (due to

HSI AERO-ROT AERO 8/7/96

AEROJET

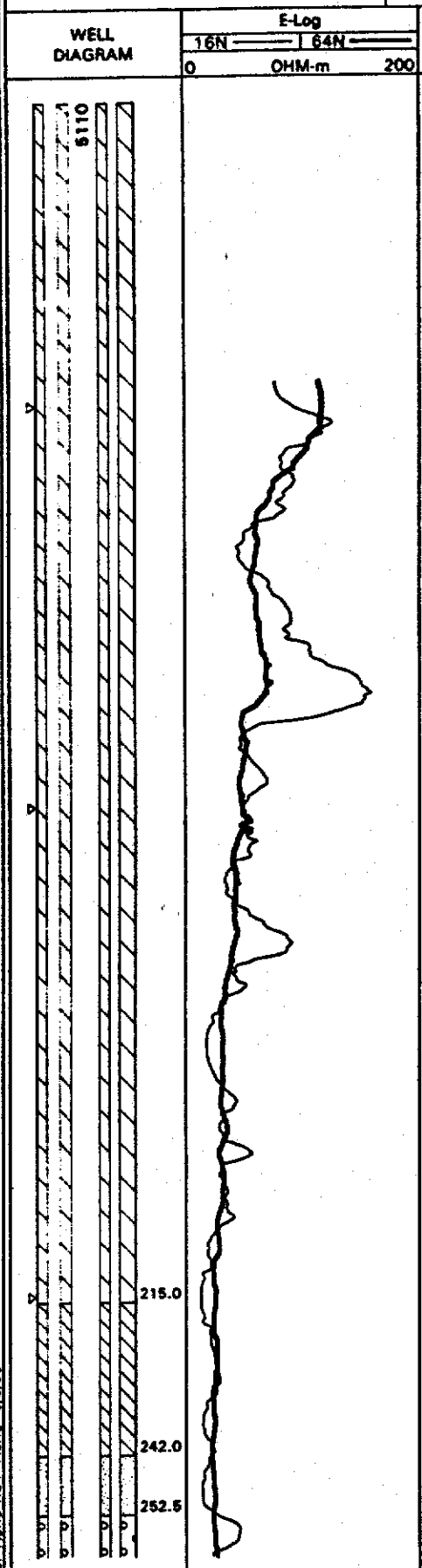
TOTAL DEPTH BORING ft: 240.0	WELL ID: 4380
TOTAL DEPTH WELL ft: 226	
SURFACE ELEVATION ft MSL: 113.7	SITE: Sunrise Park
TOC ELEVATION ft MSL:	EAST = 2217070.9 NORTH = 351961.8
BOREHOLE DIAMETER: 22"	DATE COMPLETED: 11/28/94 LOGGED BY: D.Dettle

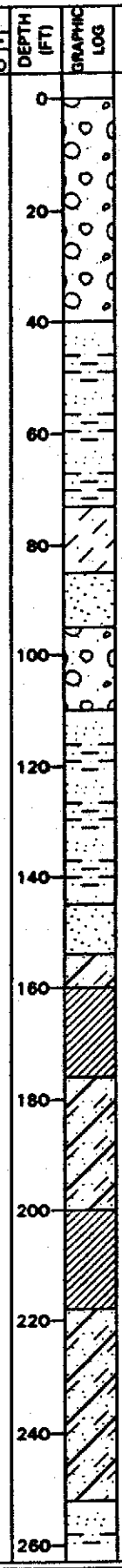
WELL DIAGRAM	E-Log 16N — 64N 0 OHM-m 200	DEPTH (FT)	GRAPHIC LOG	DESCRIPTION
		260		drilling) to rounded, wet.
		280		Total Depth of Borehole: 240 feet 24" Surface Casing installed to a depth of 40' bgs The 1/94 land survey elevations (ft-msl) for: 24" surface casing (plate) at 114.21. Well Screen: 0.050" shutter. Well Casing: 4380 Sounding Tube: 4381 Gravel Fill Tube: 4382 Gravel: 8 x 16
		300		
		320		
		340		
		360		
		380		
		400		
		420		
		440		
		460		
		480		
		500		
		520		

HSI_AERO-ROT_AERO_5/7/96

AEROJET

TOTAL DEPTH BORING ft: 430.0	WELL ID: 5110
TOTAL DEPTH WELL ft: 422	
SURFACE ELEVATION ft MSL: 97.8	SITE: Sailor Bar Park
TOC ELEVATION ft MSL: 100.48	EAST = 2213308.9 NORTH = 355415.2
BOREHOLE DIAMETER: 22"	DATE COMPLETED: 10/28/94 LOGGED BY: D. Dettloff





DESCRIPTION

0 to 40' [GP]: SANDY GRAVEL; gray (7.5YR, 6/1), 35% to 40% medium to coarse sand and 60% to 65% gravel, subrounded to well rounded, loose, dry.

40' to 73' [SM]: SILTY SAND; dark brown (7.5YR, 3/3), 40% to 45% silt and 55% to 60% fine sand, angular to subrounded, medium dense, micaceous, moist.

73' to 85' [ML]: CLAYEY SILT; pale brown (10YR, 6/3), poorly to moderately indurated, dry.

85' to 95' [SP]: SAND; very dark gray (10YR, 3/1), poorly graded, angular to subrounded, loose, moist.

95' to 110' [GW]: SANDY GRAVEL; black (10YR, 2/1), well graded, angular to subrounded, loose, wet.

110' to 145' [SM]: SILTY SAND; very pale brown (10YR, 7/3), 35% to 40% silt and 60% to 65% coarse sand, subangular to subrounded, very loose, dry.

145' to 154' [SP]: SAND; dark yellowish brown (10YR, 3/4), poorly graded, angular to subrounded, loose, moist.

154' to 160' [CL]: SANDY CLAY; dark yellowish brown (10YR, 3/4), clay: soft, 55% to 60% clay, moderate plasticity; sand: 40% to 45% medium sand, angular to subrounded, moist.

160' to 176' [CL]: CLAY; grayish brown (10YR, 5/2), soft, slow dilatancy, low toughness, moist.

176' to 200' [SC]: CLAYEY SAND; grayish brown (10YR, 5/2), sand: 70% to 75% medium to coarse sand, angular to rounded; clay: soft, slow dilatancy, low toughness, 25% to 30% clay, moist.

200' to 218' [CL]: CLAY; light gray (5Y, 7/2), soft, rapid dilatancy, low toughness, wet.

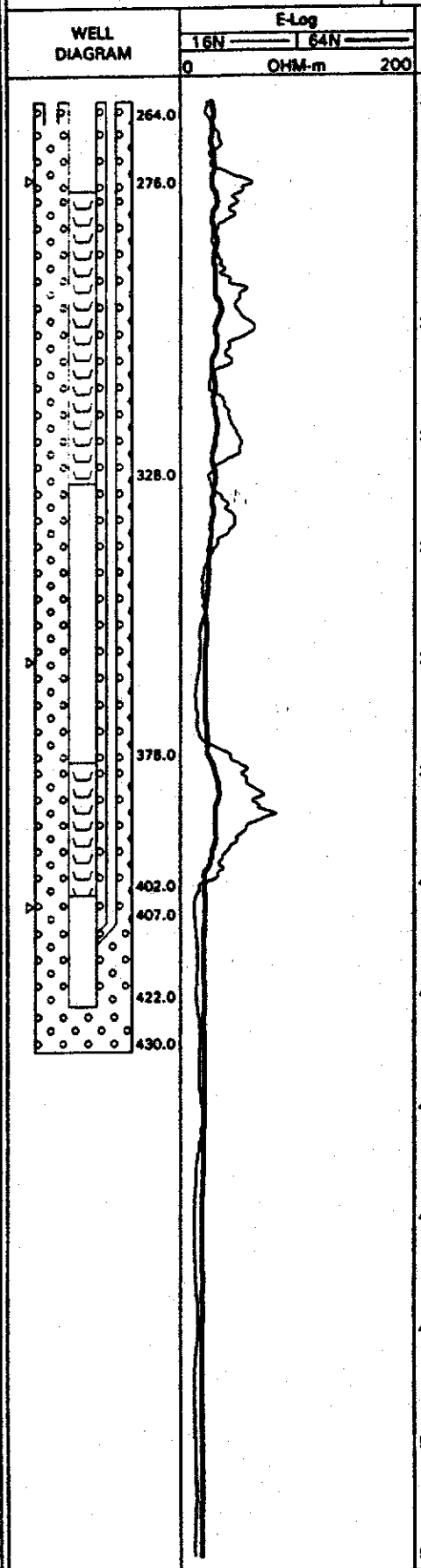
218' to 252' [CL]: SANDY CLAY; dark grayish brown (2.5Y, 3/2), clay: firm, 50% to 55% clay; sand: 45% to 50% medium sand, subangular to rounded, dry.

252' to 270' [SM]: SILTY SAND; brown (10YR, 5/3), well to moderately indurated, 35% to 40% silt and 60% to 65% fine to medium sand, angular to

HSI AERO.ROT AERO 5/5/98

AEROJET

TOTAL DEPTH BORING ft: 430.0	WELL ID: 5110
TOTAL DEPTH WELL ft: 422	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 97.8	EAST = 2213308.9 NORTH = 355415.2
TOC ELEVATION ft MSL: 100.48	DATE COMPLETED: 10/28/94 LOGGED BY: D. Dettl
BOREHOLE DIAMETER: 22"	

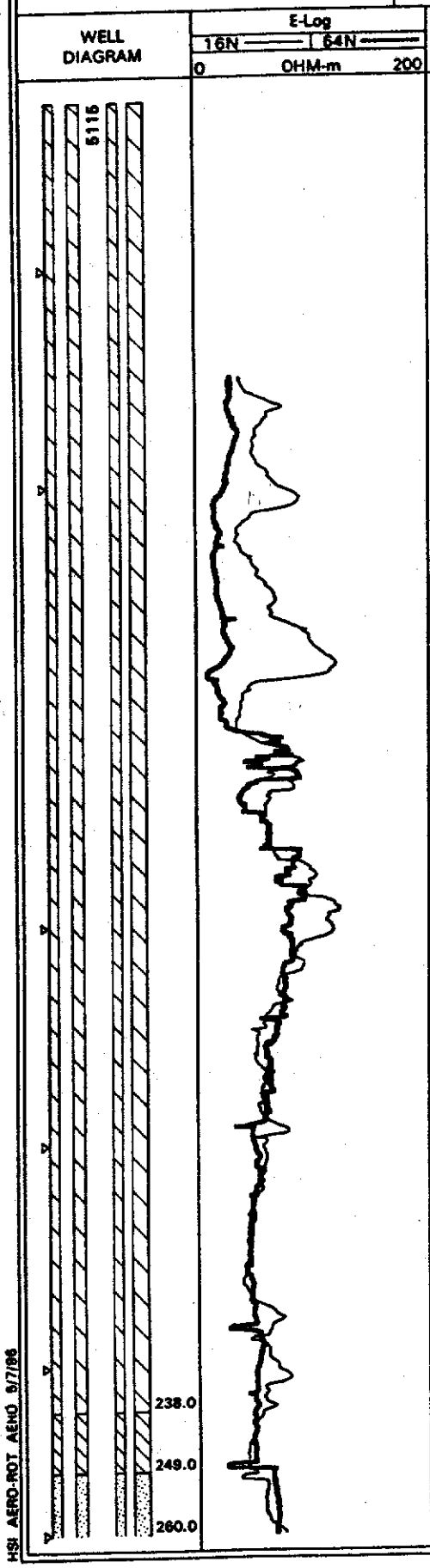


DEPTH (FT)	GRAPHIC LOG	DESCRIPTION
260		subrounded, slightly moist.
		270' to 280' [SP]: SAND; brown (10YR, 4/3), moderately graded, angular to subrounded, loose, wet.
280		280' to 292' [CL]: CLAY; very pale brown (10YR, 8/2), well to moderately indurated, dry.
		292' to 304' [SP]: SAND; brown (10YR, 4/3), poorly graded, angular to subrounded, loose, moist.
300		304' to 314' [CL]: CLAY; yellowish brown (10YR, 5/4), soft, rapid dilatancy, low toughness, moist.
		314' to 324' [SP]: SAND; very dark grayish brown (10YR, 3/2), poorly graded, angular to subangular, loose, wet.
320		324' to 329' [CL]: CLAY; yellowish brown (10YR, 5/4), poorly indurated, dry.
		329' to 337' [SP]: SAND; greenish gray (10GY, 4/1), poorly graded, angular to subangular, (pelecypod shell), loose, wet.
340		337' to 375' [CH]: CLAY; pale olive (5Y, 6/3), soft, high toughness, high dry strength, moist.
360		
		375' to 430' [SP]: SAND; light gray (5Y, 7/1), poorly graded, mostly angular to subrounded, loose, wet. 80% to 85% quartz, 10% to 15% feldspar, and 5% to 10% lithic fragments.
380		
400		
420		
440		Total Depth of Borehole: 430 feet 24" Surface Casing installed to 50'bgs E-log from Corehole ARCH-94-6 The 1/94 land survey listed elevations (ft-msl) for: 24" surface casing (plate) at 97.94, 10" well casing at 100.48, 3" gravel fill tube at 98.20, 2" sounder tube at 98.05. Well Screens: 0.060" shutter. Well Casing: 5110 Sounding Tube: 5111 Gravel Fill Tube: 5112 Gravel: 6 x 16
460		
480		
500		
520		

HSI AERO-ROT AERO 8/8/96

AEROJET

TOTAL DEPTH BORING ft: 434.0	WELL ID: 5115
TOTAL DEPTH WELL ft: 424	
SURFACE ELEVATION ft MSL: 100.4	SITE: Sailor Bar Park
TOC ELEVATION ft MSL: 102.65	EAST = 2213617.8 NORTH = 355785.0
BOREHOLE DIAMETER: 22"	DATE COMPLETED: 11/8/94 LOGGED BY: C.M. Cochrane



DEPTH (FT) | GRAPHIC LOG

DESCRIPTION

0 to 15' [GW]: GRAVEL; gray (7.5YR, 6/1), 70% to 80% gravel in chips, dry.

15' to 20' [SM]: SILTY SAND; brown (7.5YR, 5/3), 70% to 90% fine to medium sand, 10% to 30% silt , loose, dry.

20' to 40' [GW]: GRAVEL; gray (7.5YR, 6/1), 70% to 90% gravel in chips, dry.

40' to 53' [ML]: SANDY SILT; brown (7.5YR, 5/3), 5% to 20% very fine sand, soft, moist.

53' to 58' [SM]: SILTY SAND; dark brown (10YR, 3/3), fine to medium sand, dense, moist.
54' to 58' Becomes loose with cobbles up to 1.5" in diameter.

58' to 67' [ML]: SANDY SILT; brown (7.5YR, 4/2), 10% to 30% very fine sand, soft, moist.

67' to 74.5' [SM]: SILTY SAND; very dark brown (10YR, 2/2), 70% to 90% medium to coarse sand, 10% to 30% silt, loose, moist.
69' to 74.5' Becomes wet.

74.5' to 83' [ML]: SANDY SILT; brown (10YR, 4/3), moderately indurated, 60% to 80% silt, 20% to 40% very fine sand, moist.

83' to 88' [SM]: SILTY SAND; very dark grayish brown (10YR, 3/2), indurated, well graded sand, moist .
87' to 88' Becomes very dark gray (10YR, 3/1), loose.

88' to 107' [SW]: SAND; very dark grayish brown (10YR, 3/2), well graded, loose, wet.

107' to 115' [ML]: SANDY SILT; dark brown (7.5YR, 3/2), 10% to 30% very fine sand, 70% to 90% silt, hard, moist.

115' to 121.5' [SM]: SILTY SAND; very dark grayish brown (10YR, 3/2), 60% to 80% fine to medium sand, 20% to 40% silt, dense, moist.

121.5' to 127.5' [ML]: SANDY SILT; dark grayish brown (10YR, 3/2), 70% to 90% silt, 10% to 30% very fine sand, hard, moist.

127.5' to 154.5' [SM]: SILTY SAND; very dark grayish brown (10YR, 3/2), 70% to 80% fine to medium sand, 20% to 30% silt, loose, moist.
129' to 231' Becomes dark yellowish brown (10YR, 4/6), dense.

154.5' to 156.5' [ML]: SANDY SILT; dark yellowish brown (10YR, 3/6), 10% to 30% very fine to fine sand, 70% to 90% silt, firm, moist.

156.5' to 159' [SW]: SAND; very dark brown (10YR, 2/2), well graded, loose, moist.

159' to 163' [ML]: SANDY SILT; dark yellowish brown (10YR, 3/4), indurated, 85% to 95% silt, 5% to 15% very fine sand, moist.

163' to 166' [SW]: SAND; very dark brown (10YR, 2/2), well graded, loose, moist.

166' to 175.5' [ML]: SANDY SILT; brown (10YR, 4/3), 70% to 90% silt, 10% to 30% very fine sand, hard, moist.

175.5' to 186' [SM]: SILTY SAND; yellowish brown (10YR, 5/4), well graded, loose, moist.

186' to 203' [SM]: SILTY SAND; very dark grayish brown (10YR, 3/2), 70% to 90% fine sand, 10% to 30% silt, loose, moist.

203' to 208' [CL]: SILTY CLAY; grayish brown (10YR, 5/2), 10% to 20% silt, moist.

208' to 213' [SM]: SILTY SAND; light yellowish brown (10YR, 6/4), 80% to 90% well graded sand, 10% to 20% silt, loose, moist.

213' to 219' [CL]: SILTY CLAY; very pale brown (10YR, 7/3), indurated, damp.

219' to 225' [SW]: SAND; pale olive (5YR, 6/3), well graded, loose, wet.

225' to 229' [CL]: SILTY CLAY; dark brown (10YR, 3/3), indurated, 10% to 40% silt, moist.

229' to 234' [SW]: SAND; very dark gray (10YR, 3/1), well graded, loose, wet.

234' to 235' [CL]: SILTY CLAY; brown (10YR, 5/3), 10% to 40% silt, soft, moist.

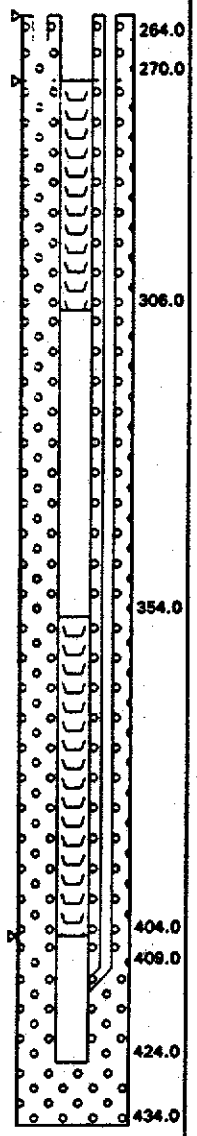
235' to 245' [SW]: SAND; pale olive (5YR, 6/4), well graded, loose, wet.

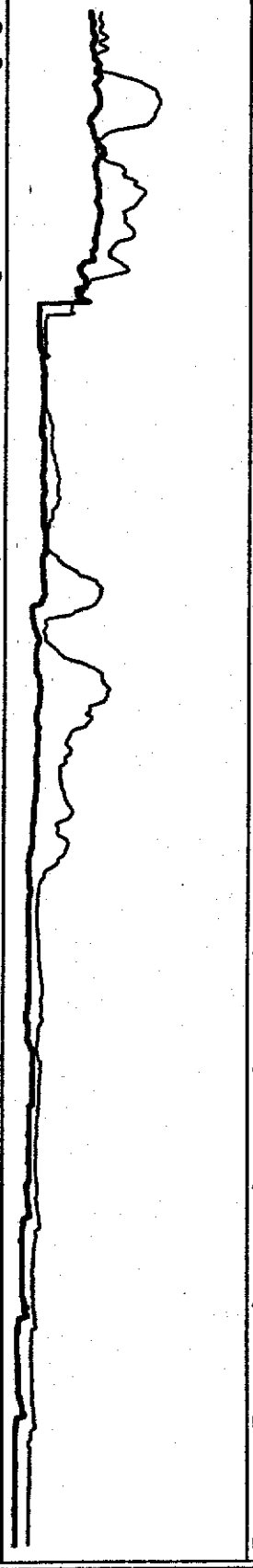
245' to 259' [ML]: SANDY SILT; yellowish brown (10YR, 5/4), 60% to 90% silt, 10% to 40% very fine sand, hard, moist.

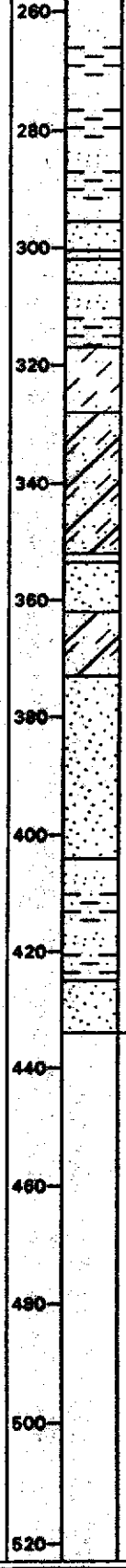
AEROJET

TOTAL DEPTH BORING ft: 434.0	WELL ID: 5115
TOTAL DEPTH WELL ft: 424	Page 2 of 2
SURFACE ELEVATION ft MSL: 100.4	SITE: Sailor Bar Park
TOC ELEVATION ft MSL: 102.65	EAST = 2213517.8 NORTH = 355785.0
BOREHOLE DIAMETER: 22"	DATE COMPLETED: 11/8/94 LOGGED BY: C.M. C

WELL DIAGRAM







DESCRIPTION

259' to 263' [SM]: SILTY SAND; dark yellowish brown (10YR, 3/4), 60% to 80% fine to medium sand, 20% to 40% silt, loose, moist.

263' to 265' [ML]: SANDY SILT; light yellowish brown (10YR, 6/4), 60% to 90% silt, 10% to 40% fine sand, firm, moist.

265' to 268' [SM]: SILTY SAND; very dark grayish brown (10YR, 3/2), 60% to 85% fine to medium sand, loose, moist.

268' to 270' [ML]: SANDY SILT; yellowish brown (10YR, 5/4), 60% to 90% silt and 10% to 40% very fine sand, firm, moist.

270' to 281.5' [SM]: SILTY SAND; very dark grayish brown (10YR, 3/2), 60% to 80% fine sand, 20% to 40% silt, loose, moist to wet.

281.5' to 286' [ML]: SANDY SILT; yellowish brown (10YR, 5/6), 70% to 90% silt, 10% to 30% fine sand, firm, moist.

286' to 295.5' [SM]: SILTY SAND; very dark gray (7.5YR, 3/1), 60% to 90% well graded sand, 10% to 30% silt, dense, moist.

295.5' to 300.5' [SW]: SAND; dark gray (10YR, 4/1), indurated, well graded, moist.

300.5' to 302' [CL]: SILTY CLAY; gray (5Y, 5/1), low to medium plasticity, 10% to 30% silt, 5% to 10% very fine sand, firm, moist.

302' to 306' [SW]: SAND; dark gray (10YR, 4/1), indurated, well graded, wet.

306' to 317' [SM]: SILTY SAND; gray (5Y, 5/1), indurated, 50% to 80% fine to medium sand, 30% to 50% silt, moist.

317' to 328' [CL]: SILTY CLAY; light greenish gray (5G, 7/1), plastic, 10% to 20% silt, <5% very fine sand, firm, moist.

328' to 352' [SC]: CLAYEY SAND: light greenish gray (5G, 7/1), 60% to 80% fine to medium sand, medium dense, moist.

352' to 353.5' [SM]: SILTY SAND; greenish gray (5BG, 6/1), 70% to 90% fine to medium sand, 10% to 30% silt, loose, moist.

353.5' to 362' [SP]: SAND; greenish gray (5BG, 6/1), medium, loose, moist.

362' to 373' [CL]: SANDY CLAY; greenish gray (5BG, 5/1), 10% to 30% fine sand, firm, moist.

373' to 404' [SW]: SAND; greenish gray (5G, 6/1), subangular to subrounded, well graded, loose, moist.

404' to 425' [SM]: SILTY SAND; dark greenish gray (5G, 4/1), 80% to 90% well graded sand, 10% to 20% silt, loose, moist.

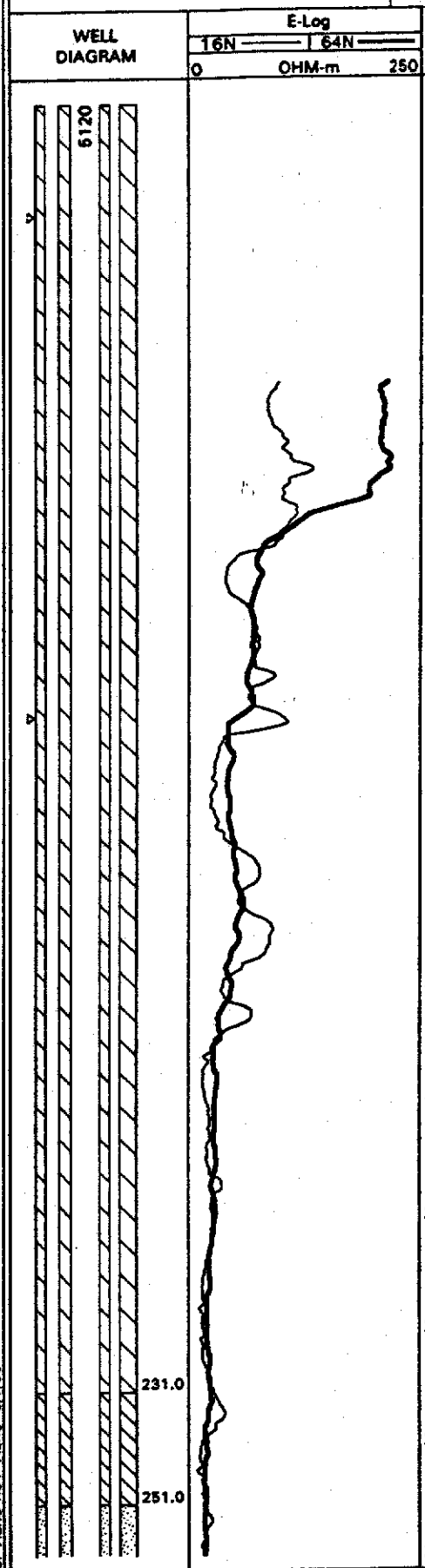
425' to 434' [SP]: SAND; dark black gray (5B, 4/1), subangular to subrounded, very fine to medium, medium dense, moist.

Total Depth of Borehole: 434 feet
E-log from Core Hole: ARCH-94-5
Lithologic Description from Core Hole: ARCH-94-5
24" Surface Casing installed to a depth of 50'bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing at 100.68,
10" well casing at 102.65,
and 2" sounder tube at 101.59.
Well Screens: 0.045" shutter.
Well Casing: 5115
Sounding Tube: 5116
Gravel Fill Tube: 5117
Gravel: 8 x 16

HSI AERO-ROT AERO 9/7/96

AEROJET

TOTAL DEPTH BORING ft: 440.0	WELL ID: 5120
TOTAL DEPTH WELL ft: 429	
SURFACE ELEVATION ft MSL: 98.2	SITE: Sailor Bar Park
TOC ELEVATION ft MSL: 99.69	EAST = 2213261.3 NORTH = 355179.9
BOREHOLE DIAMETER: 22"	DATE COMPLETED: 12/7/94 LOGGED BY: C. M. Cochrane



DESCRIPTION

0 to 20' [GW]: COBBLES; bluish gray (5B, 6/1), loose, dry.

20' to 50' [SP]: GRAVELLY SAND; brown (10YR, 5/3), sand: coarse, subangular to rounded; gravel: up to 15mm, loose, dry. 20% to 40% gravel.

50' to 70' [ML]: SILT; yellowish brown (10YR, 5/4), soft, slight plasticity, moist.

70' to 105' [SM]: SILTY SAND; very dark gray (10YR, 3/1), very fine to coarse, subrounded to rounded, loose, moist. 10% to 20%.

105' to 115' [SP]: SAND; very dark brown (7.5YR, 2.5/2), medium to very coarse, subangular, loose, wet.

115' to 140' [ML]: SANDY SILT; dark yellowish brown (10YR, 4/6), medium dense, damp. 30% to 40% very fine sand.

140' to 175' [SM]: SILTY SAND; very dark grayish brown (10YR, 3/2), fine to medium, subangular to subrounded, loose, moist. 10% to 20% silt.

175' to 190' [ML]: SILT; brown (10YR, 4/3), firm, slight plasticity, damp.

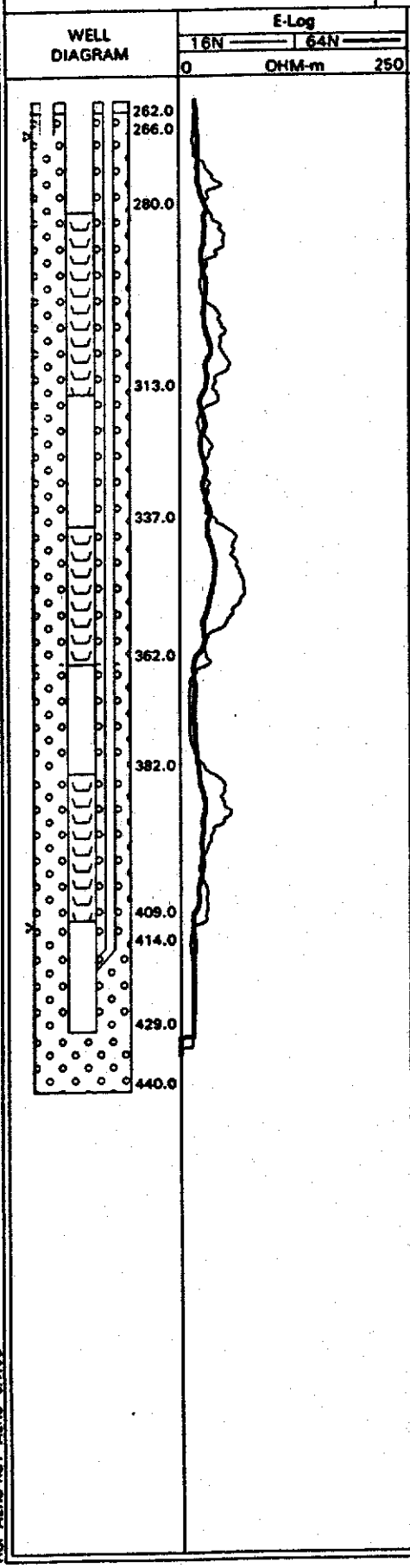
190' to 225' [SM]: SILTY SAND; greenish gray (5BG, 5/1), medium, subangular to rounded, loose, moist.

225' to 330' [SW]: SAND; yellowish brown (10YR, 5/6), fine to coarse, subangular to rounded, loose, moist.

HSI AERO-ROT Acru 5/7/96

AEROJET

TOTAL DEPTH BORING ft: 440.0	WELL ID: 5120 Page 2 of 2
TOTAL DEPTH WELL ft: 429	SITE: Sailor Bar Park
SURFACE ELEVATION ft MSL: 98.2	EAST = 2213261.3 NORTH = 355179.9
TOC ELEVATION ft MSL: 99.69	DATE COMPLETED: 12/7/94 LOGGED BY: C. M. Ce
BOREHOLE DIAMETER: 22"	



DESCRIPTION

330' to 380' [ML]: SILT; very dark grayish brown (10YR, 3/2), soft, slight plasticity, damp.

380' to 420' [SW]: SAND; pale olive (5Y, 6/4), fine to coarse, subrounded to rounded, loose, moist.

420' to 440' [ML]: SILT; dark greenish gray (5G, 4/1), soft, slight plasticity, damp, with <10% very fine sand.

Total Depth of Borehole: 440 feet
E-log from Core Hole: ARCH-94-8
24" Surface Casing installed to a depth of 50'bgs
The 1/94 land survey elevations (ft-msl) for:
24" surface casing at 98.25,
10" well casing at 99.69,
3" gravel fill tube was not surveyed,
2" sounder tube at 98.67.
Well Screens: 0.060" shutter.
Well Casing: 5120
Sounding Tube: 5121
Gravel Fill Tube: 5122
Gravel: 6 x 16

AEROJET

TOTAL DEPTH BORING ft: 120.0	**BORING: 10000** Page 1 of 1
TOTAL DEPTH WELL ft:	SITE: Sailor Bar Park, Boring AR-94-1
SURFACE ELEVATION ft MSL: 96.1	EAST = 2216517.0 NORTH = 353526.0
TOC ELEVATION ft MSL:	DATE COMPLETED: 4/5/94 LOGGED BY: D. Dettloff
BOREHOLE DIAMETER: 6.5"	

WELL DIAGRAM

Volclay from 0 to 120 feet bgs.

120.0

E-Log

16N — 64N

0 OHM-m 200

DEPTH (FT)

GRAPHIC LOG

0
20
40
60
80
100
120
140
160
180
200
220
240
260

DESCRIPTION

0 to 20' [GW]: SANDY GRAVEL; dark greenish-gray (5G, 4/1), poorly sorted, poorly indurated, extremely angular (due to drilling), 20-30% sand, dry.

Angular to subrounded from 15 to 20 feet.

20' to 25' [SW]: GRAVELLY SAND; brown (10YR, 4/3), poorly sorted, poorly indurated, subangular to rounded, 20-25% gravel, dry.

25' to 30' [SP]: SAND; olive-brown (2.5YR, 4/3), coarse, moderately well sorted, poorly indurated, subangular to rounded, dry.
Includes lenses of well indurated sandstones from 30 to 40 feet.

Color change to very dark grayish-brown (2.5YR, 3/2), angular to subangular, wet.
Includes lenses of well indurated sandstone from 46 to 51 feet.

51' to 68' [SM]: SILTY SAND; grayish-brown (10YR, 5/2), moderately sorted, well to moderately indurated, subangular to subrounded, micaceous, 40% silt, wet.

68' to 71' [SW]: GRAVELLY SAND; sand: very dark grayish-brown (10YR, 4/2), well to moderately sorted, well indurated, angular to subrounded, wet micaceous; gravel: dark gray (N, 4/1), well sorted, poorly indurated, subangular to rounded, wet.

71' to 105' [ML]: SANDY SILT; brown (7.5YR, 4/4), moderately sorted, poorly indurated, subangular to subrounded, 30% sand, wet.

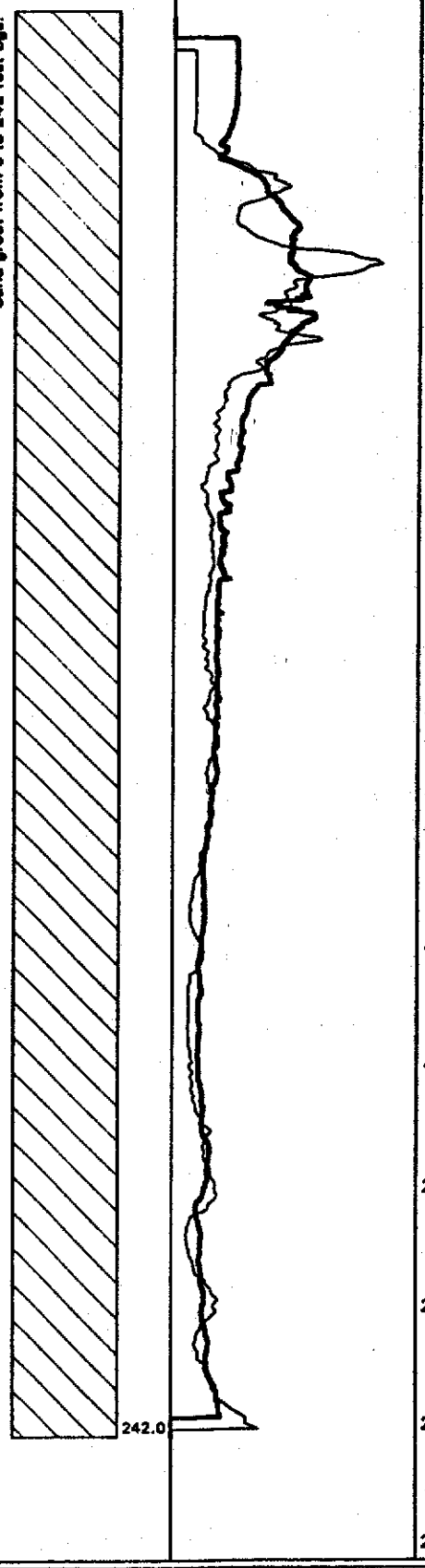
105' to 120' [SM]: SILTY SAND; gray (10YR, 5/1), poor to moderately sorted, poor to moderately indurated, subangular to rounded, micaceous, 35-40% silt, wet.

Total Depth of Borehole: 120 feet

HSI AERO-ROT AERO 5/7/96

AEROJET

TOTAL DEPTH BORING ft: 242.0	BORING: 10001 Page 1 of 2
TOTAL DEPTH WELL ft:	
SURFACE ELEVATION ft MSL: 106.7	SITE: Upper Sunrise Park, Boring: ARCH 94-1
TOC ELEVATION ft MSL:	EAST = 2217461.2 NORTH = 351986.2
BOREHOLE DIAMETER: 5.25"	DATE COMPLETED: 7/8/94 LOGGED BY: R. Atkin[redacted]



DESCRIPTION

0 to 8' [GP]: COBBLES, SAND, and SILT; loose, predominantly volcanics.

8' to 22' [CH]: CLAY; reddish gray (5YR, 5/2), high plasticity, 5% to 10% very fine sand.

22' to 25.5' [SW]: SAND; light olive brown (2.5Y, 5/3).

25.5' to 31' [GW]: GRAVEL; dark gray (10YR, 4/1), rounded, coarse, matrix of coarse sand.

31' to 39.5' [SM]: SILTY SAND; variegated; light olive brown (2.5Y, 5/4), with yellow brown (2.5Y, 8/6), reddish brown (2.5YR, 4/4), and strong brown (7.5YR, 5/6), fine to medium, 20% silt.

39.5' to 58' [GW]: GRAVEL; dark grayish brown (10YR, 4/2), coarse gravel to boulders, thin interbeds of clayey sand.

58' to 77' [SC]: CLAYEY SAND; reddish brown (5YR, 4/4), medium to coarse, subangular to subrounded, micaceous, 30% clay.

68' to 69' [CH]: CLAY; reddish brown (5YR, 4/4), high plasticity, 10% very fine sand.

72' to 74' [CH]: CLAY; reddish brown (5YR, 4/4), high plasticity, 10% very fine sand.

77' to 84' [CL]: SILTY CLAY; reddish brown (5YR, 4/4), with rare black partings.
79' white cemented layer. 79' to 80' Very fine grained silty sand bed.
80' to 81' Clay very plastic.
81' to 84' Increasing very fine sand.

84' to 103' [SM]: SILTY SAND; yellowish brown (10YR, 5/4), very fine, subangular to subrounded, 30% silt and 10% clay.

103' to 108' [CL]: SILTY CLAY; light yellowish brown (10YR, 6/4), some mottled areas, weathering around grains, rare gypsum nodules, 10% fine to medium sand.
107.5' to 108' weakly indurated.

108' to 115' [SC]: CLAYEY SAND; light yellowish brown (10YR, 6/4), very fine, 20% silty clay.

110' to 111' [CH]: Clay; reddish yellow (5YR, 6/6), laminated, high plasticity.

115' to 119' [CH]: CLAY; yellowish brown (10YR, 5/4).
118.5' to 119' Becomes pink.

119' to 126' [SM]: SILTY SAND; brown (10YR, 5/3), fine to very fine coarsening with depth, with 10% silt.

126' to 131' [CL]: SILTY CLAY; brown (10YR, 5/3), 10% very fine sand.

131' to 140.5' [SM]: SILTY SAND; brown (10YR, 5/3), very fine, subangular to subrounded, 20% to 40% silt.
137' to 140.5' Local thin beds of hard clay.
138' to 138.5' Spots of red-orange, iron oxide cement.

140.5' to 148' [ML]: SANDY SILT; brown (10YR, 5/3), 20% to 40% very fine sand, rare thin black partings.
145' Gravel clasts to 1 inch.

148' to 156.5' [ML]: CLAYEY SILT; brown (7.5YR, 5/3), micaceous, local thin (1/16") hard clay partings, locally up to 20% very fine sand.

156.5' to 162.8' [SW]: SAND; brown (7.5YR, 4/3), fine to coarse, angular to subrounded, loose, approximately 50% rock fragments.

162.8' to 166' [SC]: CLAYEY SAND; reddish brown (2.5YR, 5/4), medium to coarse, subangular to rounded, 30% to 40% clay and silt.

166' to 173.5' [ML]: CLAYEY SILT; reddish brown (2.5YR, 5/3), micaceous, with < 10% very fine sand.

173.5' to 178' [SM]: SILTY SAND; reddish brown (5YR, 4/4), fine to medium, angular to subrounded, 20% to 30% silt.

178' to 181' [SP]: SAND; yellowish red (5YR, 5/6), fine to medium, subangular to rounded, loose, moist.

181' to 198.5' [ML]: CLAYEY SILT; brown (10YR, 5/3), damp, with < 10% medium to coarse sand lenses.
185' to 185.5' [CH]: CLAY; plastic.
192' to 192.5' [CH]: CLAY; plastic.
192.5' to 198.5' Up to 20% fine, micaceous sand.

198.5' to 207' [SP]: SAND; brown (10YR, 4/3), fine to medium, subangular to rounded, loose, damp, silt.

207' to 209' [CL]: SILTY CLAY; brown (10YR, 5/3), micaceous, moist rare white clay partings.

209' to 223' [ML/SM]: SANDY SILT/SILTY SAND; brown (10YR, 5/3), 40% to 60% very fine sand, micaceous.

HBI_AERO.PGT AERO 9/7/99

AEROJET

TOTAL DEPTH BORING ft: 242.0
TOTAL DEPTH WELL ft:
SURFACE ELEVATION ft MSL: 106.7
TOC ELEVATION ft MSL:
BOREHOLE DIAMETER: 5.25"

BORING: 10001

SITE: Upper Sunrise Park, Boring: ARCH 94-1
EAST = 2217461.2 NORTH = 351986.2
DATE COMPLETED: 7/8/94 LOGGED BY: R. Atkin

WELL DIAGRAM	E-Log 16N / 64N, 0 OHM-m 200	DEPTH (FT)	GRAPHIC LOG	DESCRIPTION
Sand grout from 0 to 242 feet bgs.		260, 280, 300, 320, 340, 360, 380, 400, 420, 440, 460, 480, 500, 520		218' to 220' Greater than 50% very fine sand. 223' to 231.5' [ML]: CLAYEY SILT; light olive brown (2.5Y, 5/3), hard, brittle, 10% very fine sand. 231.5' to 234' No core recovered. 234' to 239.5' [SP]: SAND; very dark grayish brown (10YR, 3/2), fine, subangular, to rounded, loose, wet, 10% iron oxide and 25% mafic grains. 239.5' to 242' [GP]: COBBLE-BOULDER GRAVEL; unable to core. Total Depth of Borehole: 242 feet

AEROJET

TOTAL DEPTH BORING ft: 280.0	BORING: 10002 Page 1 of 2
TOTAL DEPTH WELL ft:	SITE: Sailor Bar Park, Boring: ARCH-94-4
SURFACE ELEVATION ft MSL: 97.6	EAST = NORTH =
TOC ELEVATION ft MSL:	DATE COMPLETED: 8/11/94 LOGGED BY: C. Cochra[redacted]
BOREHOLE DIAMETER: 94mm	

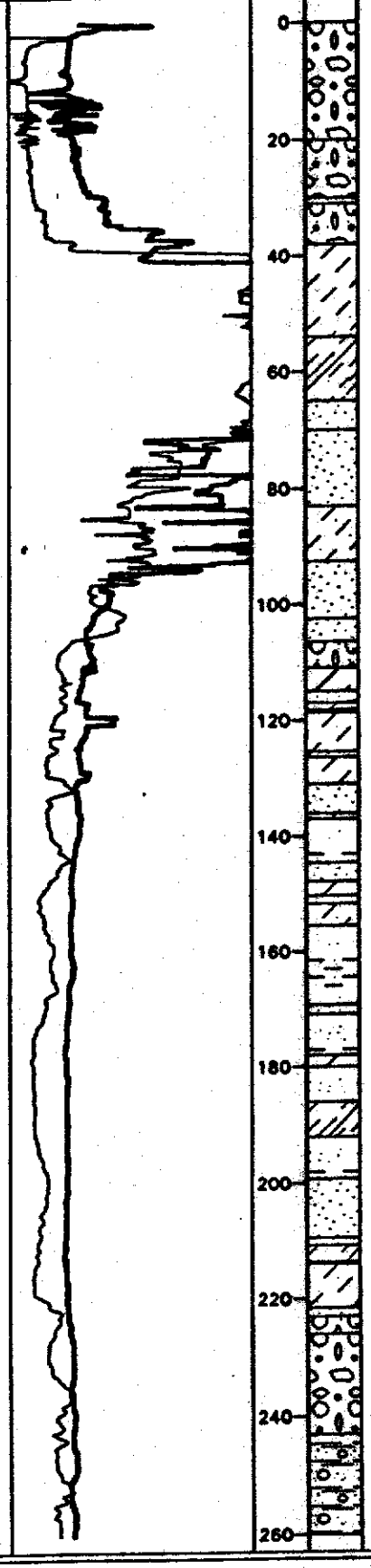
WELL DIAGRAM

Velcity from 0 to 280 feet bgs.

E-Log
16N | 64N
0 OHM-m 200

DEPTH (FT)

GRAPHIC LOG



DESCRIPTION

0 to 20' [GP]: COBBLES

20' to 30' [GP]: SANDY GRAVEL: poorly sorted, subrounded, clasts 1/4" to 1/2", with medium to coarse sand, rare cobble fragments.

30' to 31' [SW]: SAND; brown (10YR, 5/3), subangular to subrounded.

31' to 38' [GW]: SANDY GRAVEL

38' to 54' [CL]: Silty Clay; brown (10YR 5/3), low to medium plasticity, soft, damp, 10 to 20% fine sand.

At 49', Becomes moist, 5 to 10% very fine sand.

54' to 65' [CL]: SANDY CLAY; dark yellowish brown (10YR 4/4), medium plastic, dense, moist.
At 56.5' Becomes dark grayish brown (10YR 4/2), 20 - 30% sand, less than 5% silt.

65' to 70' [SP]: SAND; very dark grayish brown (10YR 3/2), loose, 10 to 15% silt, moist.

70' to 83' [SW]: SAND; well graded, indurated, less than 5% gravel, moist.
72' to 83'; Becomes loose.

83' to 92.5' [CL]: SILTY CLAY; strong brown (7.5YR 4/6), medium plasticity, soft, damp, iron staining.
85' to 92.5', Becomes brown (7.5YR 4/3), no iron staining, root holes.

92.5' to 102.5 [SP]: SAND; dark brown (10YR 3/3), fine grained, loose, few indurated lenses, 10% silt, moist.
101.3' to 101.8, Becomes very dark grayish brown (10YR 3/2), dense to loose.

102.5' to 106.5' [SW]: SAND; very dark greyish brown (10YR 3/2), fine to coarse grained, well graded, loose, 5 to 10% silt, wet.

106.5' to 111' [GP]: SANDY GRAVEL; very dark brown (10YR 2/2), subrounded, clasts to 1.5", loose, 20 to 30% medium to coarse sand, wet.

111' to 115' [SC]: CLAYEY SAND; dark yellowish brown (10YR 4/4) with minor greenish yellow mottling, fine grained, indurated, 30 to 40% clay, few gravels, moist.

115' to 117' [SP]: SAND; dark brown (10YR 3/3), fine grained, loose, 5 to 10% silt, wet.
116.3' to 117' Becomes dark yellowish brown (10YR 3/4).

117' to 118.2' [CL]: SILTY CLAY; dark yellowish brown (10YR 3/4), indurated, moist

118.2' to 118.7' [SW]: SAND; very dark brown (10YR 2/2), well graded, loose, wet.

118.7' to 125.3' [CL]: SILTY CLAY; brown (10YR 5/3), slight plasticity, stiff, 10 to 20% fine sand, damp.

125.3' to 126.3' [SP]: SAND; very dark grayish brown (10YR 3/2), very fine grained, loose, wet.

126.3 to 130.9' [CL]: SILTY CLAY; light brown (7.5yr 6/3), slight plasticity, weak induration, stiff, damp.

130.9' to 136.0 [SP]: SAND; brown (10YR 5/3), very fine grained, loose, wet.

136' to 137' [CL]: SILTY CLAY; light brown (7.5YR 6/3), slight plasticity, weak induration, stiff, damp.

137' to 144.6' [ML]: SANDY SILT; brown (10YR 4/3), stiff, 40 to 50% very fine sand, moist.

144.6' TO 147.8' [SP]: SAND; very dark grayish brown (10YR 3/2), fine to medium grained, loose, wet.
146.5' to 147.8' Becomes fine sand.

147.8' to 150.3' [CL]: SILTY CLAY; brown (10YR 5/3), low plasticity, soft, damp.

150.3' to 151.7' [SM]: SILTY SAND; dark grayish brown (10YR 4/2), very fine grained, loose, 40 to 50% silt, wet.

151.7' to 155.5' [CL]: SILTY CLAY; light brown (7.5YR 6/3), indurated, low plasticity, damp.

155.5' to 169.3' [ML]: SANDY SILT; yellowish brown (10YR 5/4)slight plasticity, 40 to 50% very fine sand, moist.

169.3' to 171.0 [SW]: SAND; brown (10YR 4/3) well graded, loose, wet.

171.0' to 178.0 [SM]: SILTY SAND; brown (10YR 5/3), fine to medium grained, loose to dense, 40 to 50% silt, damp.
176' to 178', Strong iron staining.

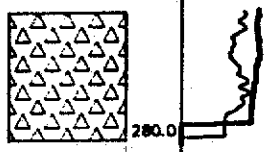
178' to 180' [CL]: SILTY CLAY; brown (10YR 4.3), low plasticity, 5 to 10% very fine sand, iron staining, damp.

HSI AERO-ROT AtHO 5/7/96

AEROJET

TOTAL DEPTH BORING ft: 280.0	**BORING: 10002** Page 2 of 2
TOTAL DEPTH WELL ft:	
SURFACE ELEVATION ft MSL: 97.6	SITE: Sailor Bar Park, Boring: ARCH-94-4
TOC ELEVATION ft MSL:	EAST = NORTH =
BOREHOLE DIAMETER: 94mm	DATE COMPLETED: 8/11/94 LOGGED BY: C. Cochrane

WELL DIAGRAM



E-Log
16N — 64N
0 OHM-m 200

DEPTH (FT)	GRAPHIC LOG
260	
280	
300	
320	
340	
360	
380	
400	
420	
440	
460	
480	
500	
520	

DESCRIPTION

180' to 186' [SM]: SILTY SAND; brown (7.5YR 4/4), very fine grained, 40 to 50% silt, damp.

186' to 192' [CL]: SANDY CLAY; brown (10YR 4/3), medium plasticity, 20 to 30% fine sand, damp.
188' to 192' White sand lenses.

192' to 199.2' [SM]: SILTY SAND; brown (7.5YR 4/3), loose, 30 to 40% silt, wet.
198' to 199.2' Becomes yellowish brown (10YR 5/4), damp.

199.2' to 209.5' [SW]: SAND; dark grayish brown (10YR 4.2), well graded, indurated, wet.

209.5' to 210.8' [ML]: SANDY SILT; brown (10YR 4/3), low plasticity, soft, 30 to 40% very fine sand, wet.

210.8' to 213.6' [CL]: SANDY CLAY; brown (10YR 4/3), low plasticity, soft, 40 to 50% fine sand, wet.

213.6' to 214' [SM]: SILTY SAND; dark yellowish brown (10YR 4/4), fine to medium grained, 20 to 30% silt, wet.

214' to 221.5' [CL]: SILTY CLAY; brown (10YR 4/3), medium plasticity, stiff, 5 to 10% very fine sand, wet.
218' to 219' Becomes gray (10YR 6/1).
219' to 220.3 Becomes brown (10YR 5/3).
220.3' to 221.5 Becomes gray (10YR 5/1).

221.5' to 223' [SP]: SAND; grayish brown (10YR 5/2), subrounded, medium to coarse grained, indurated, 5 to 10% silt, few 1/16" lenses of white sand, moist.

223' to 226' [GW]: SANDY GRAVEL; grayish brown (10YR 5/2), subrounded, clasts 1/4 to 2 inch, locally cemented, 20 to 30% subangular, coarse to very coarse sand, 5 to 10% silt, wet.

226' to 243' [GW]: COBBLES; GRAY (10YR 5/1).

243' to 260' [GW/CL]: SANDY GRAVEL/SILTY CLAY; grayish brown (10YR 5/3), sandy gravel, clasts to cobble; interbedded with brown (10YR 5/3), silty clay.

260' to 280' [CL]: SILTY CLAY; brown (10YR 4/3), weathered rock chips present, may be claystone.

Total Depth of Borehole: 280 feet

HSI AERO-ROT AERO 5/7/96

AEROJET

TOTAL DEPTH BORING ft: 335.0	**BORING: 10003** Page 1 of 2
TOTAL DEPTH WELL ft:	SITE: Sailor Bar Park, Boring: AR-95-2
SURFACE ELEVATION ft MSL: 97.6	EAST = 2213260.0 NORTH = 355390.0
TOC ELEVATION ft MSL:	DATE COMPLETED: 5/2/95 LOGGED BY: C.M. Co
BOREHOLE DIAMETER: 10 5/8"	

WELL DIAGRAM

Sand grout from 0 to 335 feet bgs.

E-Log
16N — 64N
0 OHM-m 200

DEPTH (FT)

GRAPHIC LOG

DESCRIPTION

0 to 5' [AC]: Asphalt and roadbase, gray (7.5YR 6/1).

5 to 15' [GP]: COBBLES; light gray (10YR 7/1), dry.

15 to 20' [GW]: SANDY GRAVEL; brown (10YR 5/3), 60-80% gravel up to 15mm, 20-40% medium sand, dry.

20 to 25' [SP]: SAND; very dark gray (10YR 3/1).

25 to 65' [SM]: SILTY SAND; dark grayish-brown (10YR 4/2), 60-80% medium to coarse, angular to subrounded sand, 20-40% silt.

65 to 80' [SP]: SAND; dark grayish-brown (10YR 4/2), fine to medium, subangular to rounded, minor silt.

80 to 105' [ML]: SANDY SILT; brown (10YR 5/3), 70-85% silt, low plasticity 15-30% fine to coarse sand.

90 to 105' Sand increases to 30-40%

105 to 175' [SW]: SAND; very dark grayish-brown (10YR 3/2), poorly sorted, angular to rounded.

175 to 215' [ML]: SANDY SILT; brown (10YR 5/3), 70-80% silt, low plasticity, 20-30% medium to coarse sand.

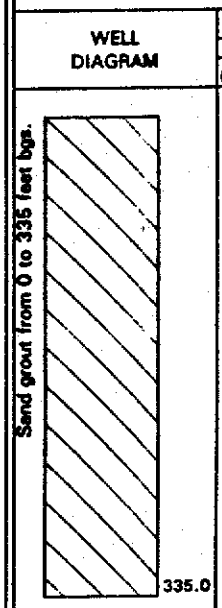
215 to 240' [ML]: SANDY SILT; yellowish-brown (10YR 5/4), 80-90% silt, 10-20% very fine sand.

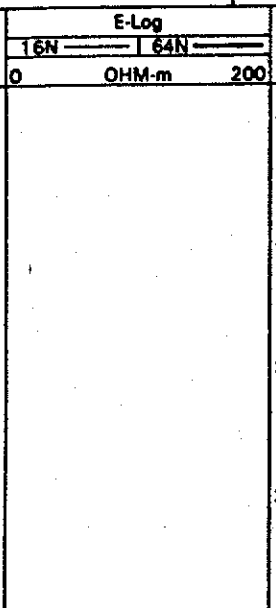
240 to 335' [SM]: SILTY SAND; pale brown (10YR 6/3), 60-90% medium to coarse sand, 10-40% silt.

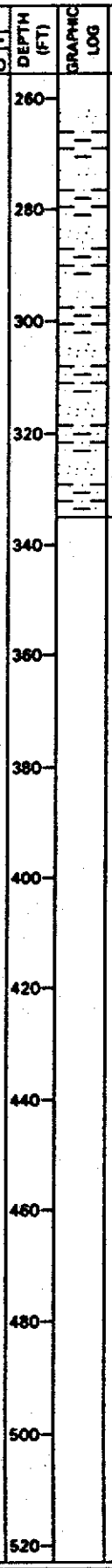
HSI AERO-ROT AERO 5/7/96

AEROJET

TOTAL DEPTH BORING ft: 335.0	**BORING: 10003**
TOTAL DEPTH WELL ft:	SITE: Sailor Bar Park, Boring: AR-95-2
SURFACE ELEVATION ft MSL: 97.6	EAST = 2213260.0 NORTH = 355390.0
TOC ELEVATION ft MSL:	DATE COMPLETED: 5/2/95 LOGGED BY: C.M. Cochrane
BOREHOLE DIAMETER: 10 5/8"	







DESCRIPTION

315 to 335' Sand becomes medium to very coarse

Total Depth of Borehole: 335 feet

HSI AERO-ROT AERO 5/7/96

APPENDIX B

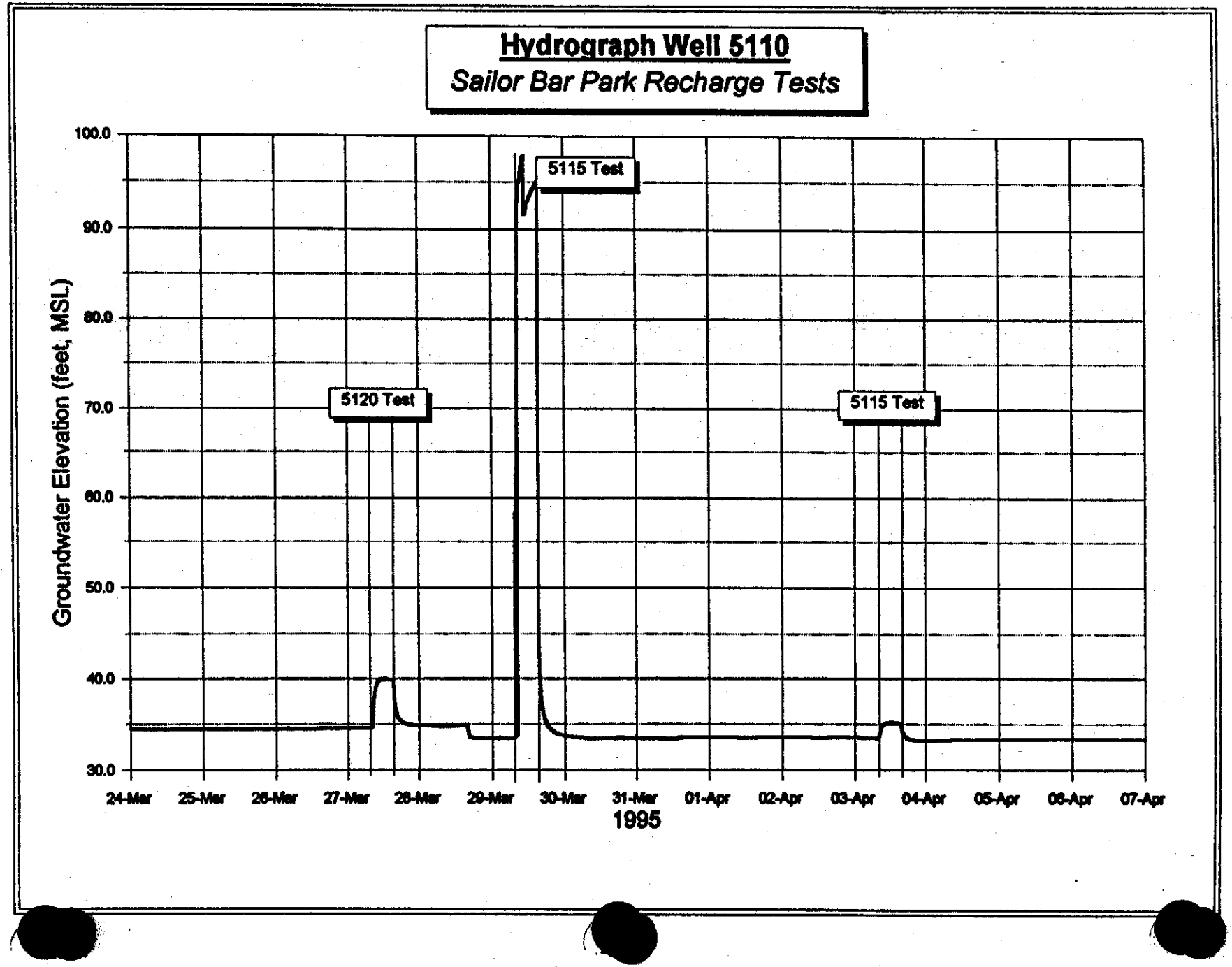
Recharge Well Tests

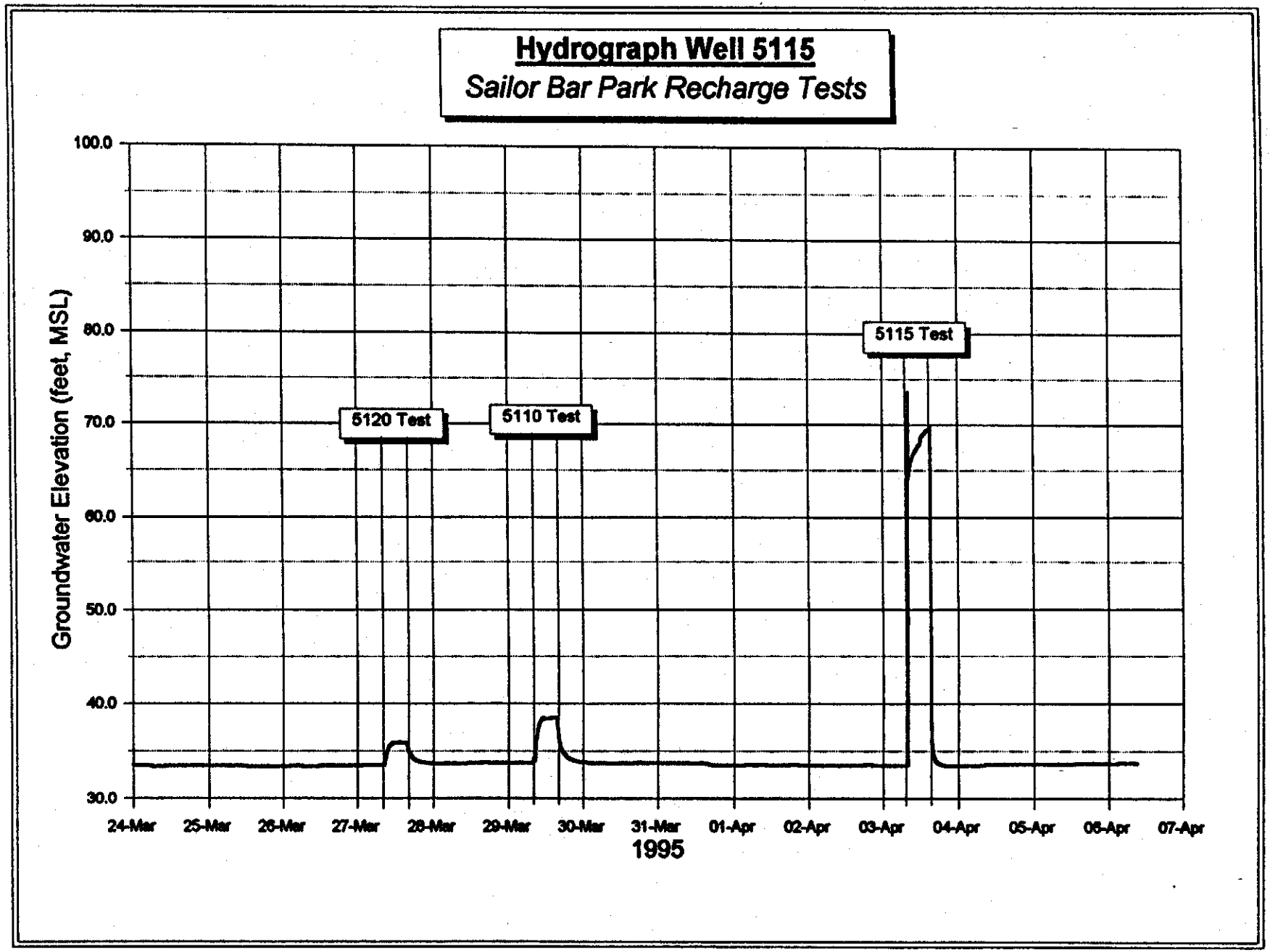
Appendix B

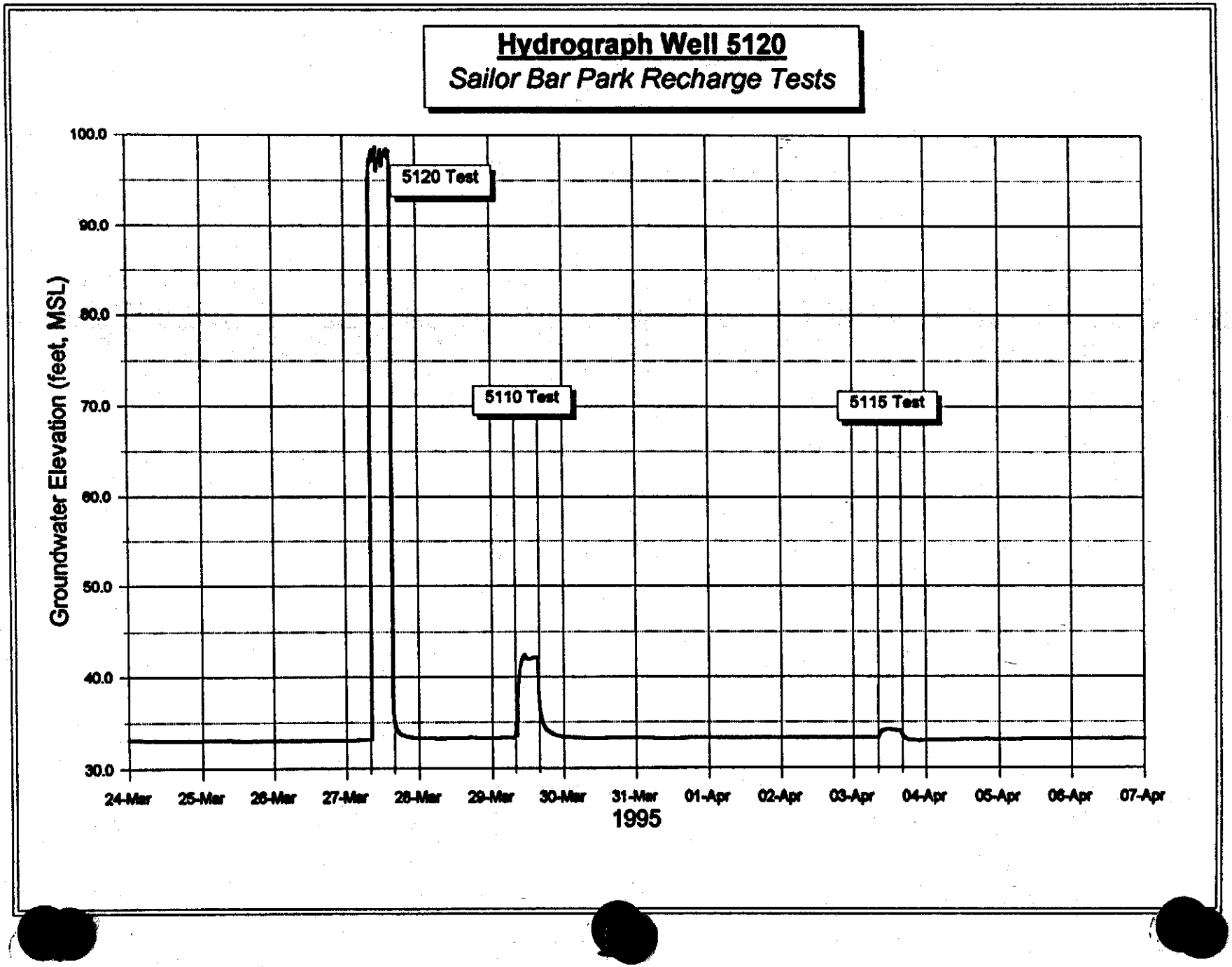
Recharge Well Tests

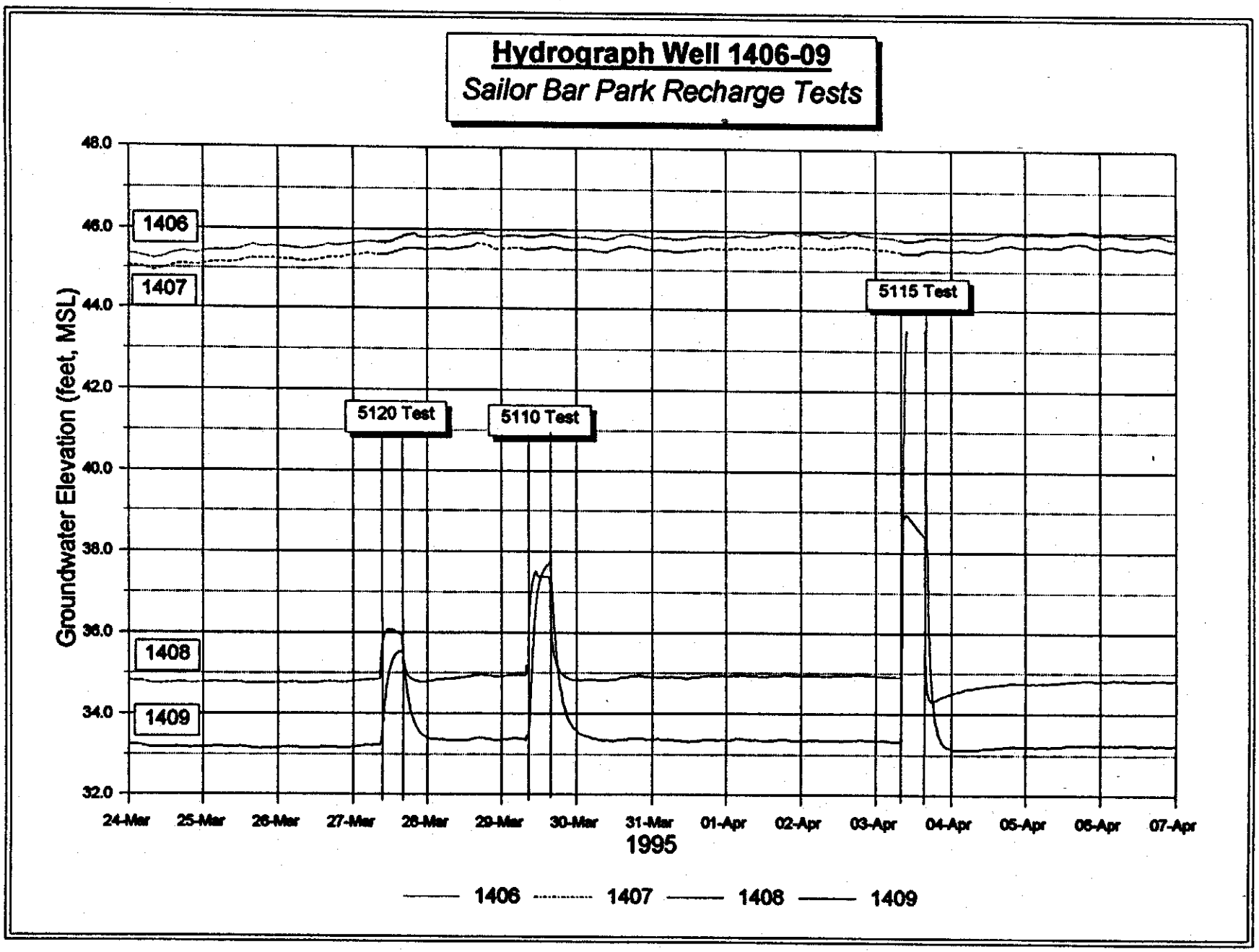
The recharge wells were tested by injecting groundwater pumped from the fire protection well located in Sailor Bar Park. The tests were performed between March 27 and April 4, 1995. Water was injected into each well through a drop pipe at a constant rate for approximately eight hours. Water levels were monitored during the tests using data loggers and pressure transducers placed in the recharge wells and in nearby groundwater monitoring wells. The following hydrographs present the transducer data collected during the tests for recharge wells 5110, 5115 and 5120 and monitor wells 1406, 1407, 1408 and 1409.

The maximum capacities for the wells 5110, 5115 and 5120 tested individually is 320, 365 and 140 gpm, respectively. The actual capacity of the three wells would be somewhat lower when they are being used concurrently due to interference effects between the three wells. Therefore, the total recharge capacity of this set of three recharge wells would be somewhat less than 825 gpm or 1.2 mgd.


Hydrograph Well 5110
Sailor Bar Park Recharge Tests
Groundwater Elevation (feet, MSL)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
5115 Test
5120 Test
5115 Test
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
1995


Hydrograph Well 5115
Sailor Bar Park Recharge Tests
Groundwater Elevation (feet, MSL)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
5120 Test
5110 Test
5115 Test
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
1995

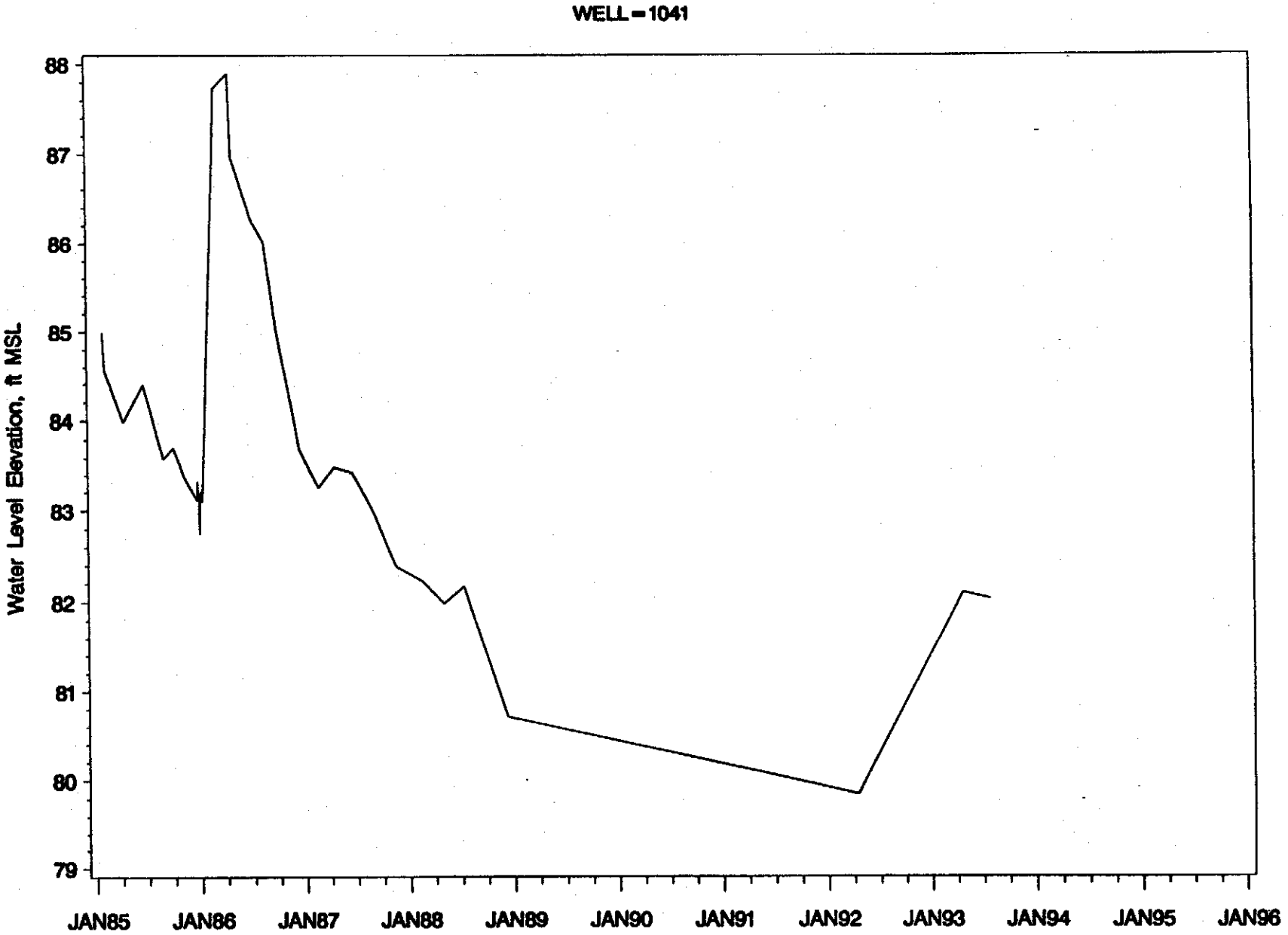

Hydrograph Well 5120
Sailor Bar Park Recharge Tests
Groundwater Elevation (feet, MSL)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
5120 Test
5110 Test
5115 Test
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
1995


Hydrograph Well 1406-09
Sailor Bar Park Recharge Tests
Groundwater Elevation (feet, MSL)
48.0
46.0
44.0
42.0
40.0
38.0
36.0
34.0
32.0
1406
1407
1408
1409
5120 Test
5110 Test
5115 Test
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
1995
1406
1407
1408
1409

APPENDIX C

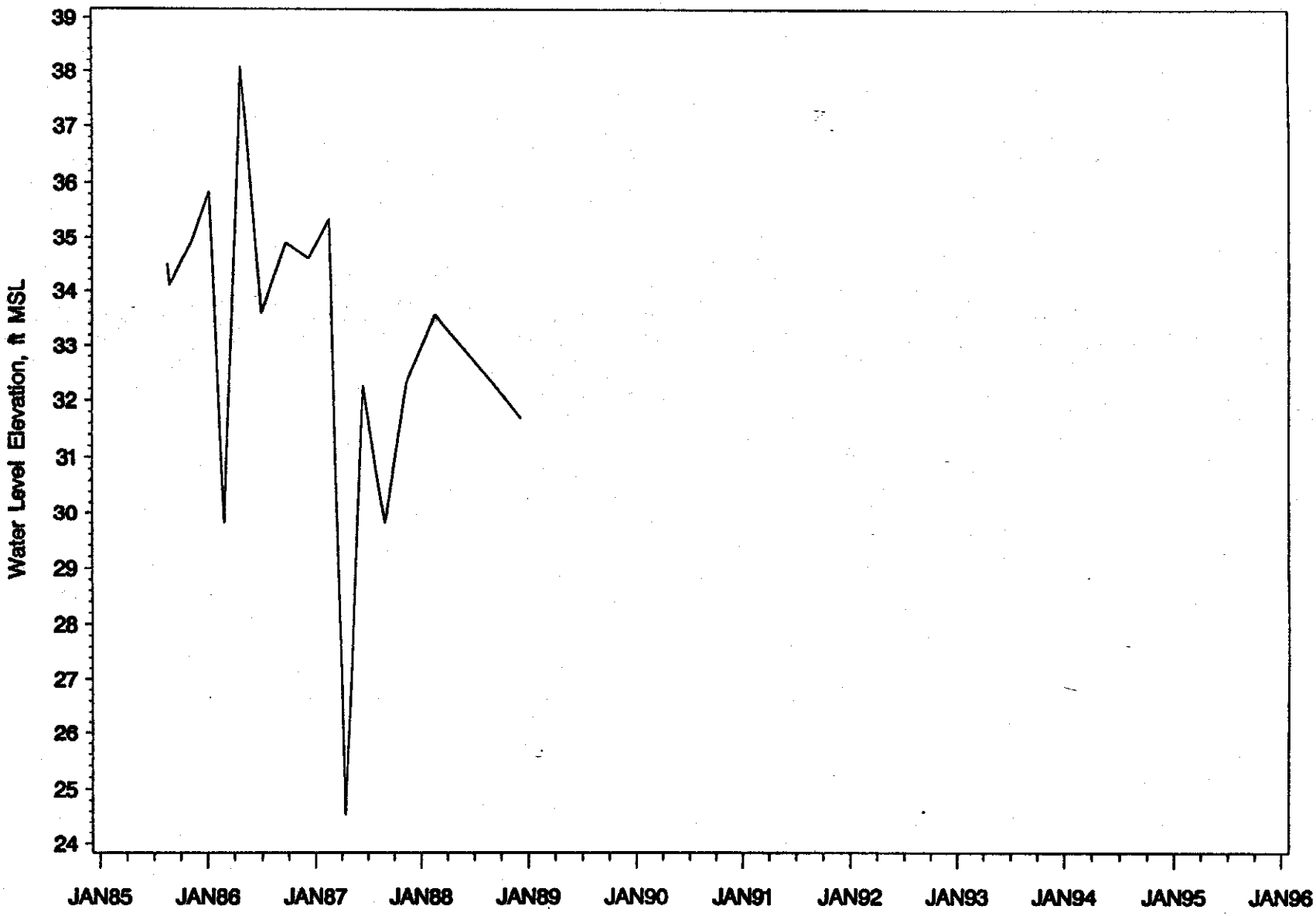
Hydrographs of Wells Within the American River Study Area

HYDROGRAPH


WELL=1041
Water Level Elevation, ft MSL
88
87
86
85
84
83
82
81
80
79
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96

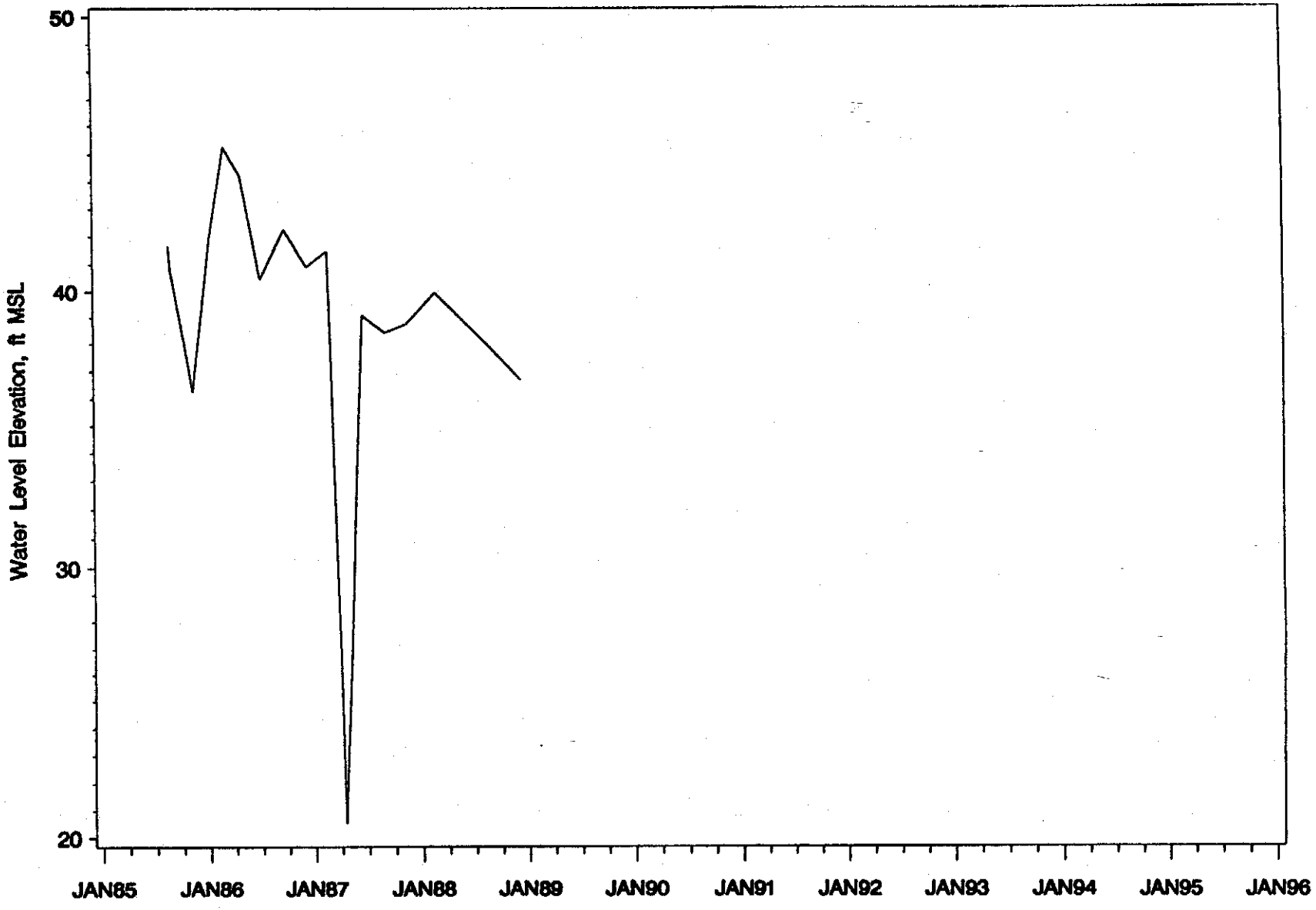
HYDROGRAPH

WELL = 1047



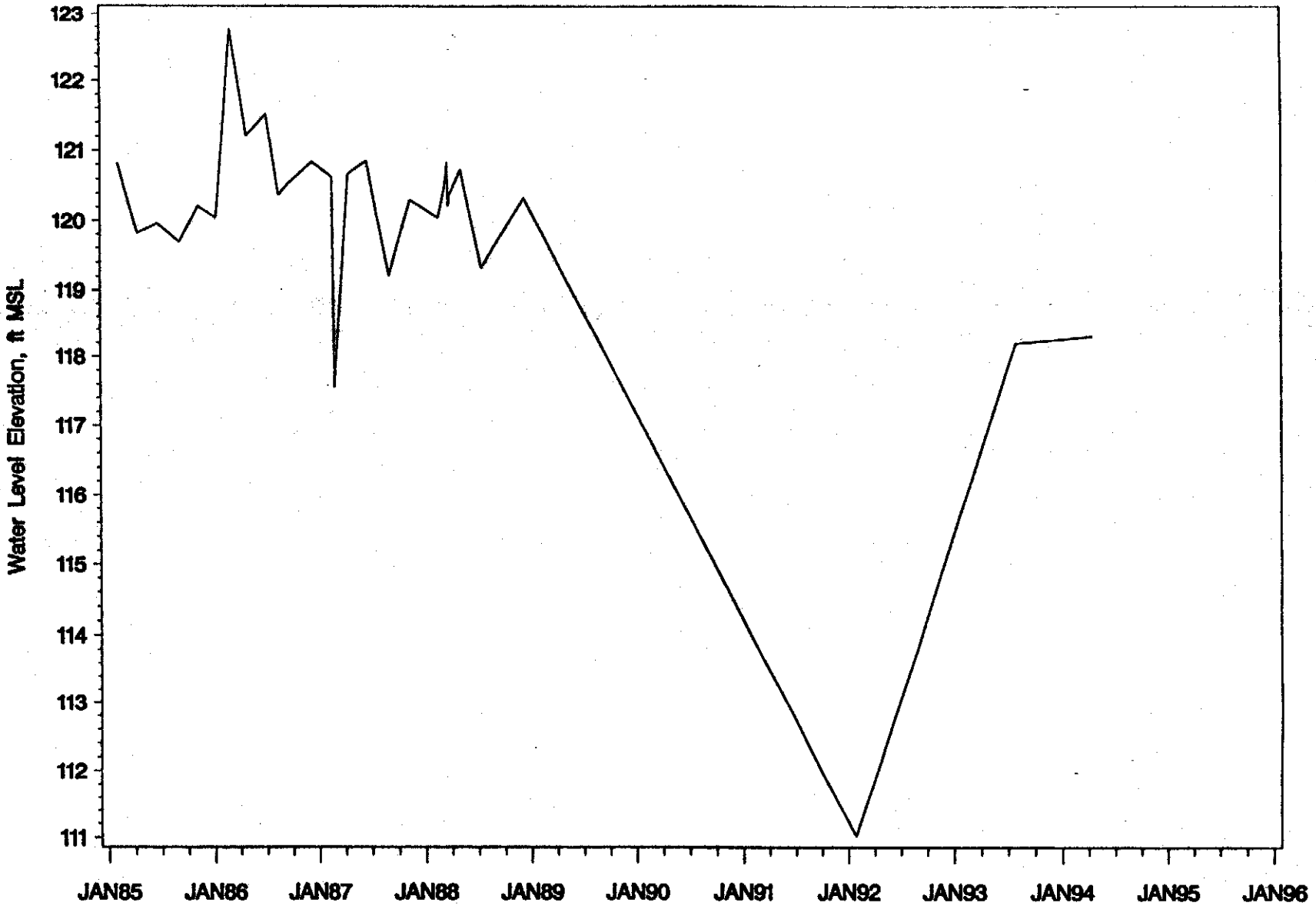
HYDROGRAPH

WELL = 1049



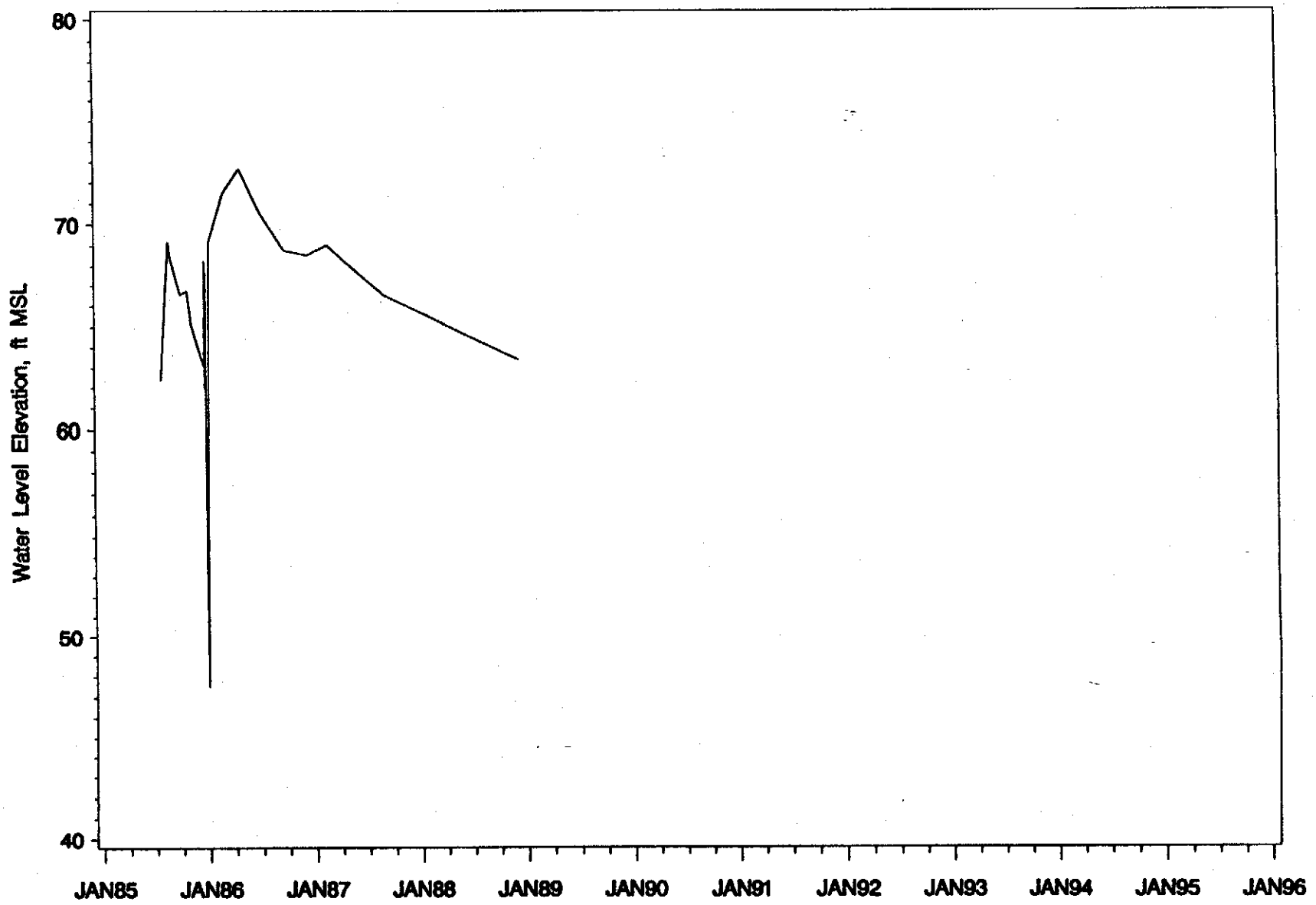
HYDROGRAPH

WELL = 1154

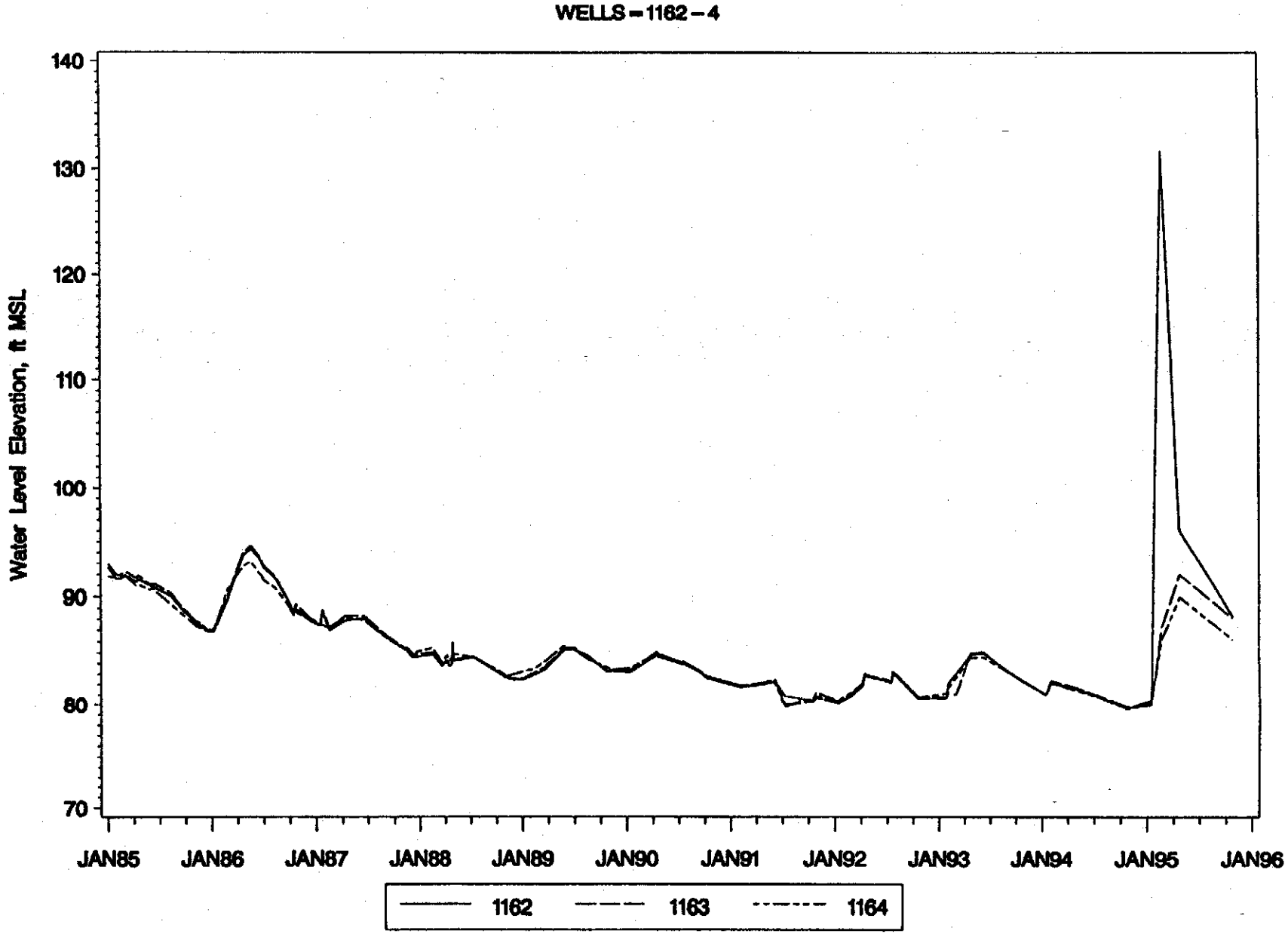


HYDROGRAPH

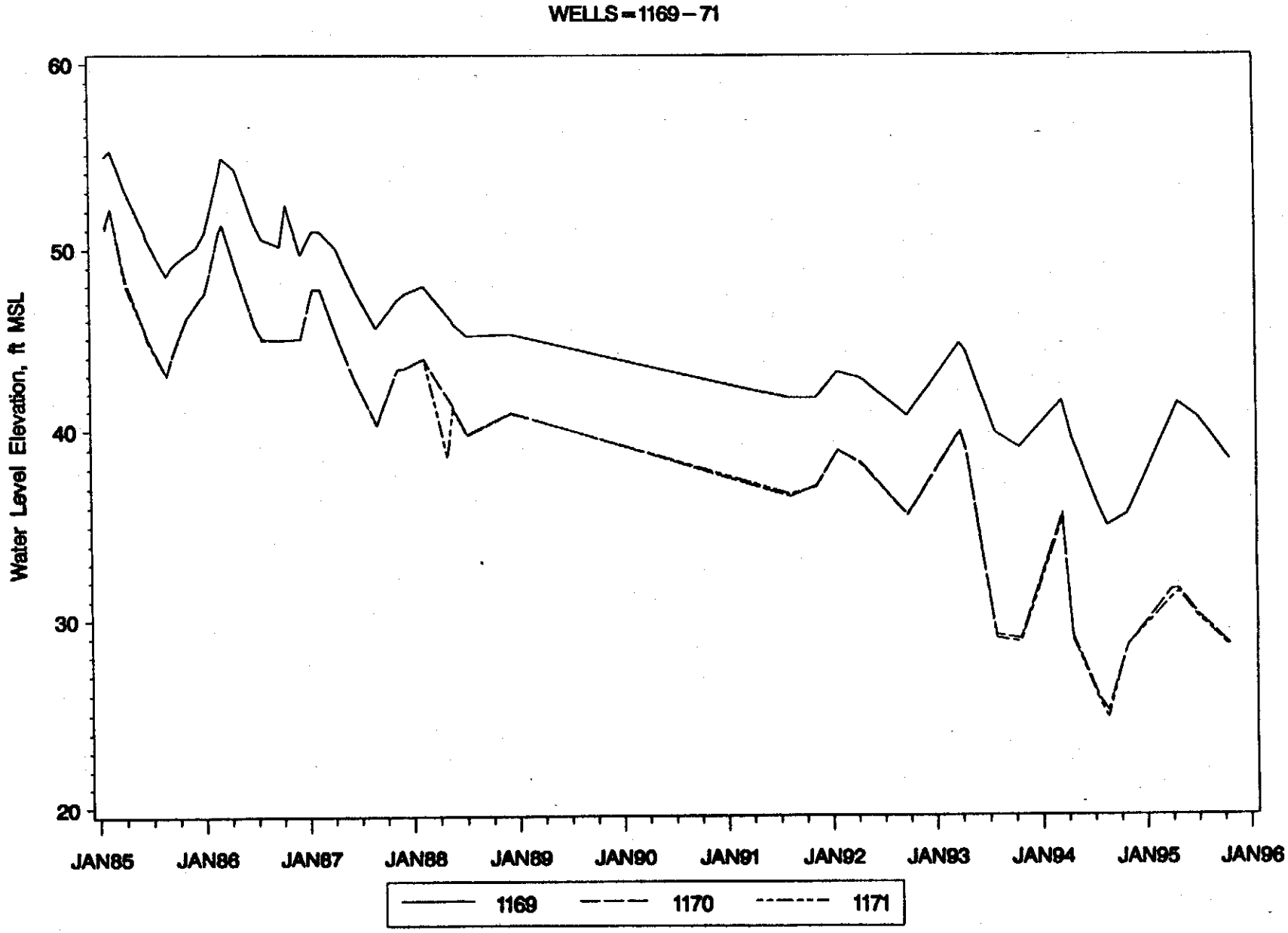
WELL = 1156



HYDROGRAPH

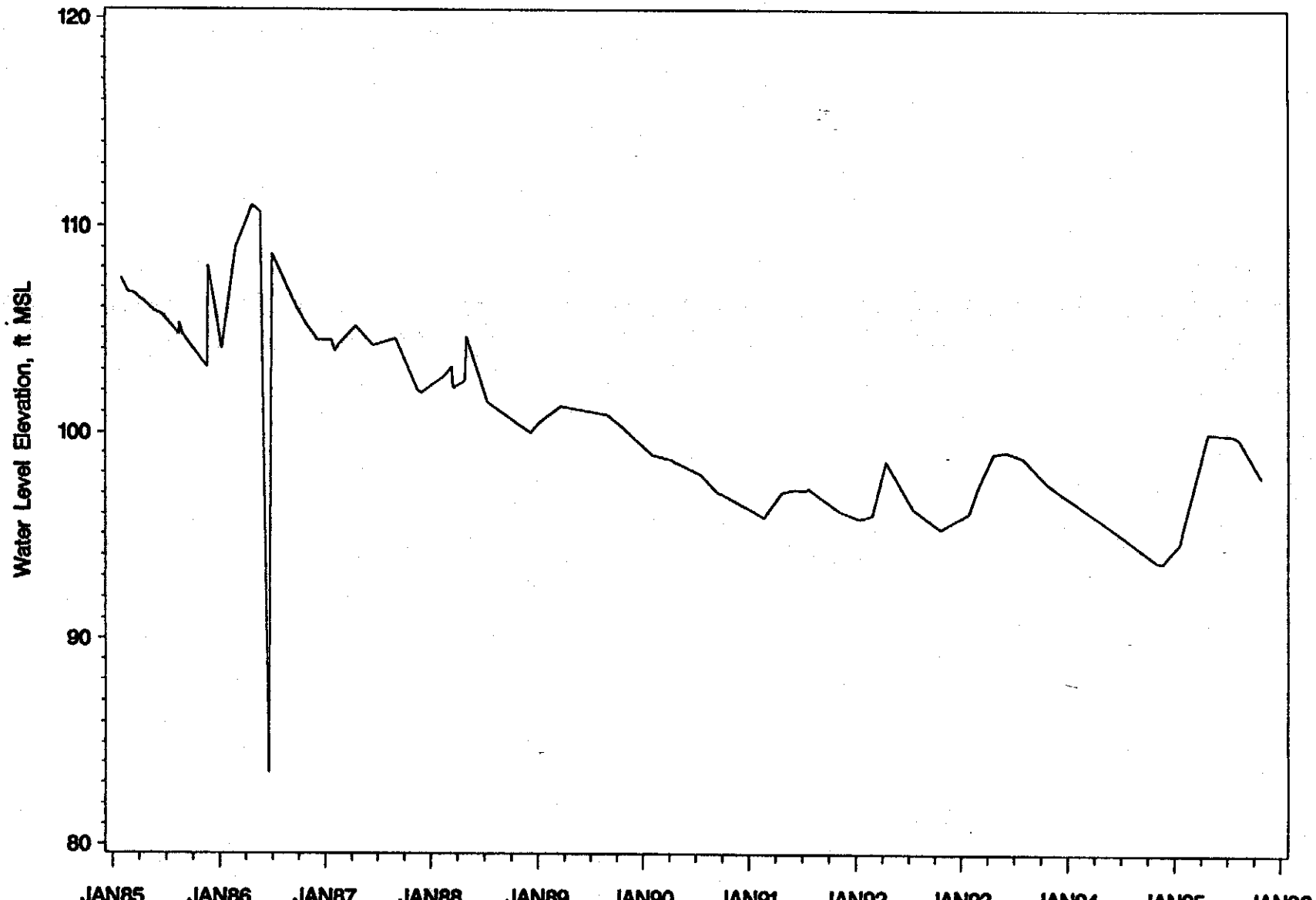

WELLS = 1162 – 4
Water Level Elevation, ft MSL
140
130
120
110
100
90
80
70
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1162
1163
1164

HYDROGRAPH


WELLS=1169-71
Water Level Elevation, ft MSL
60
50
40
30
20
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1169
1170
1171

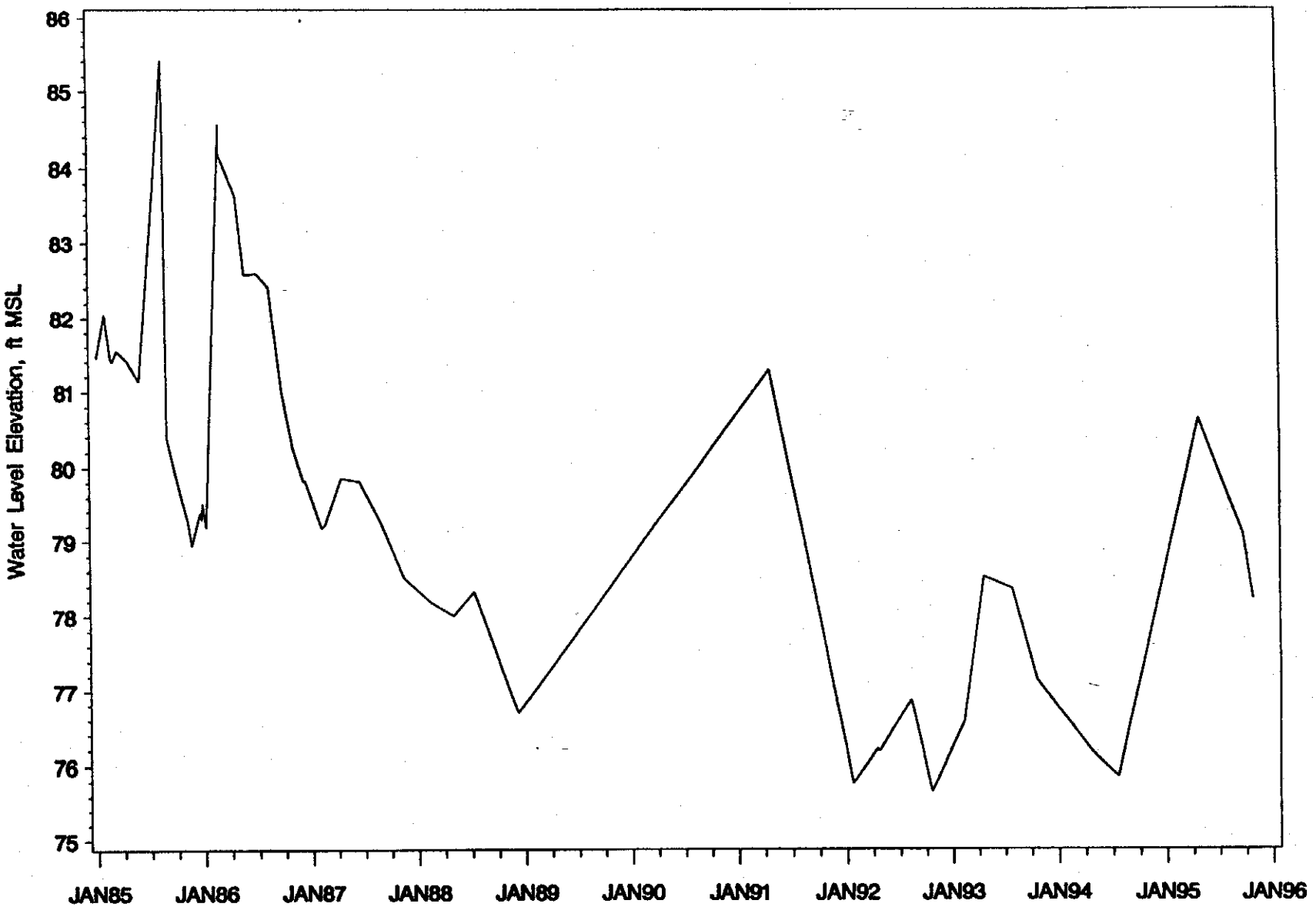
HYDROGRAPH

WELL = 1211

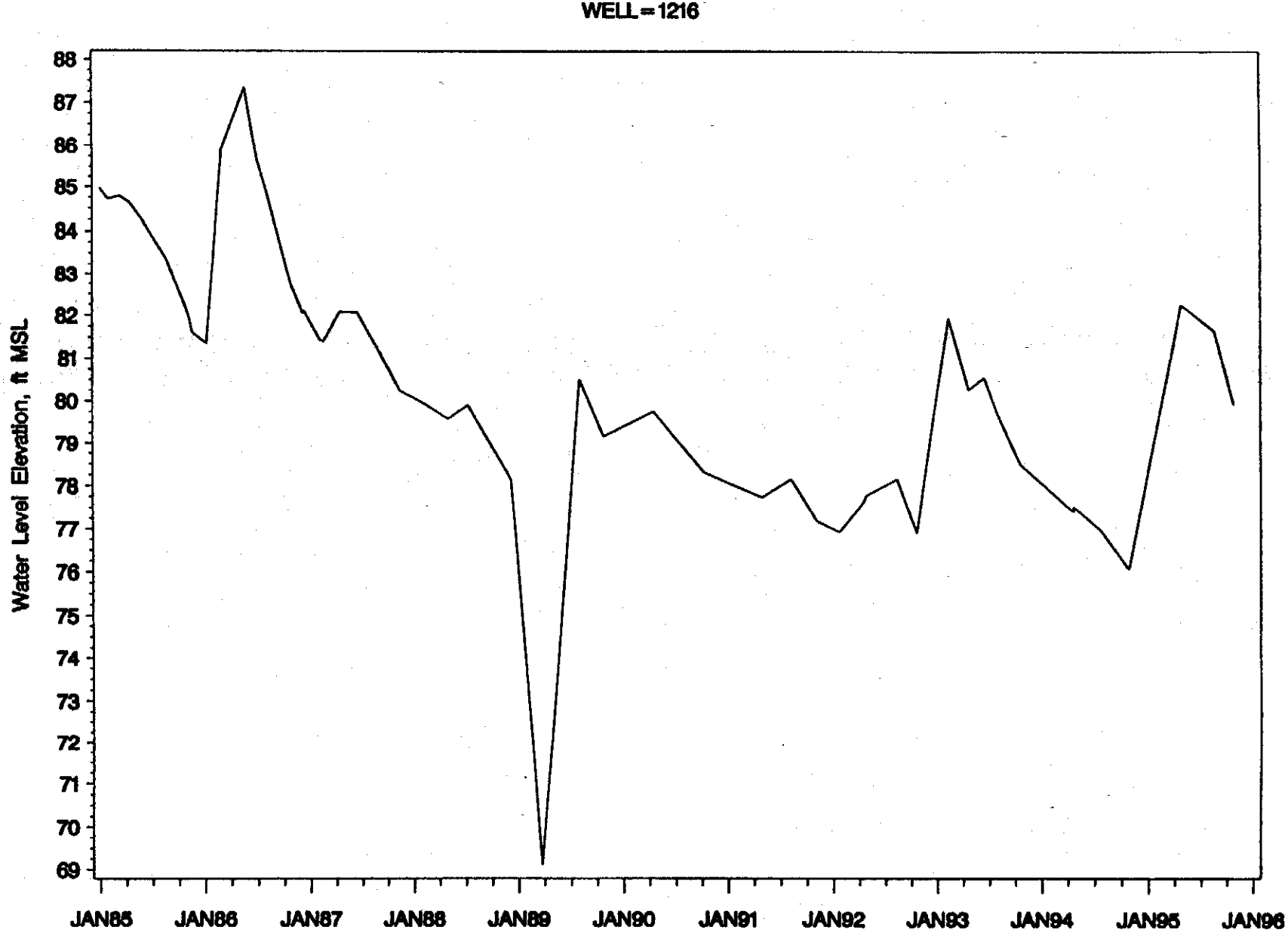


HYDROGRAPH

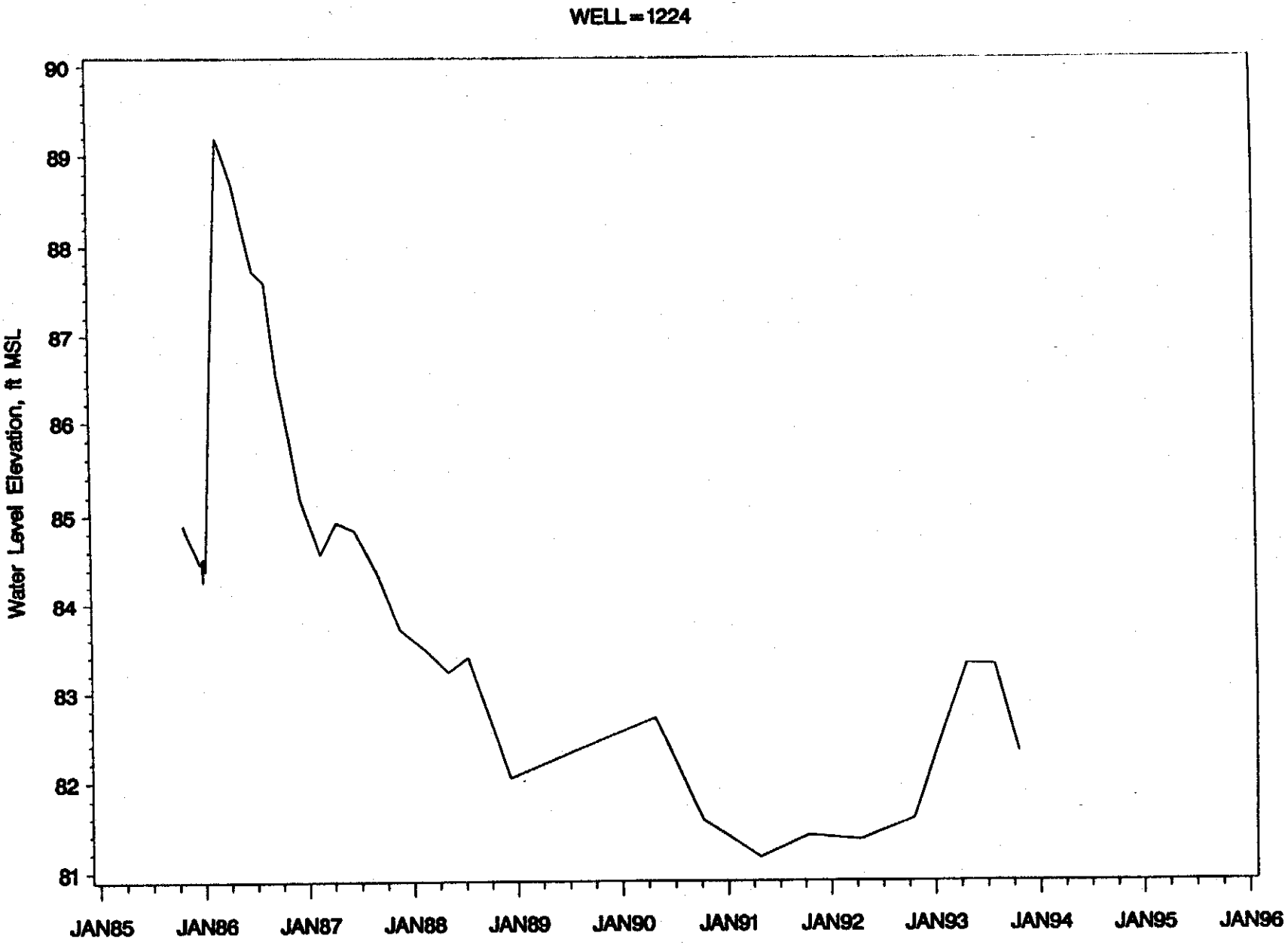
WELL = 1214



HYDROGRAPH

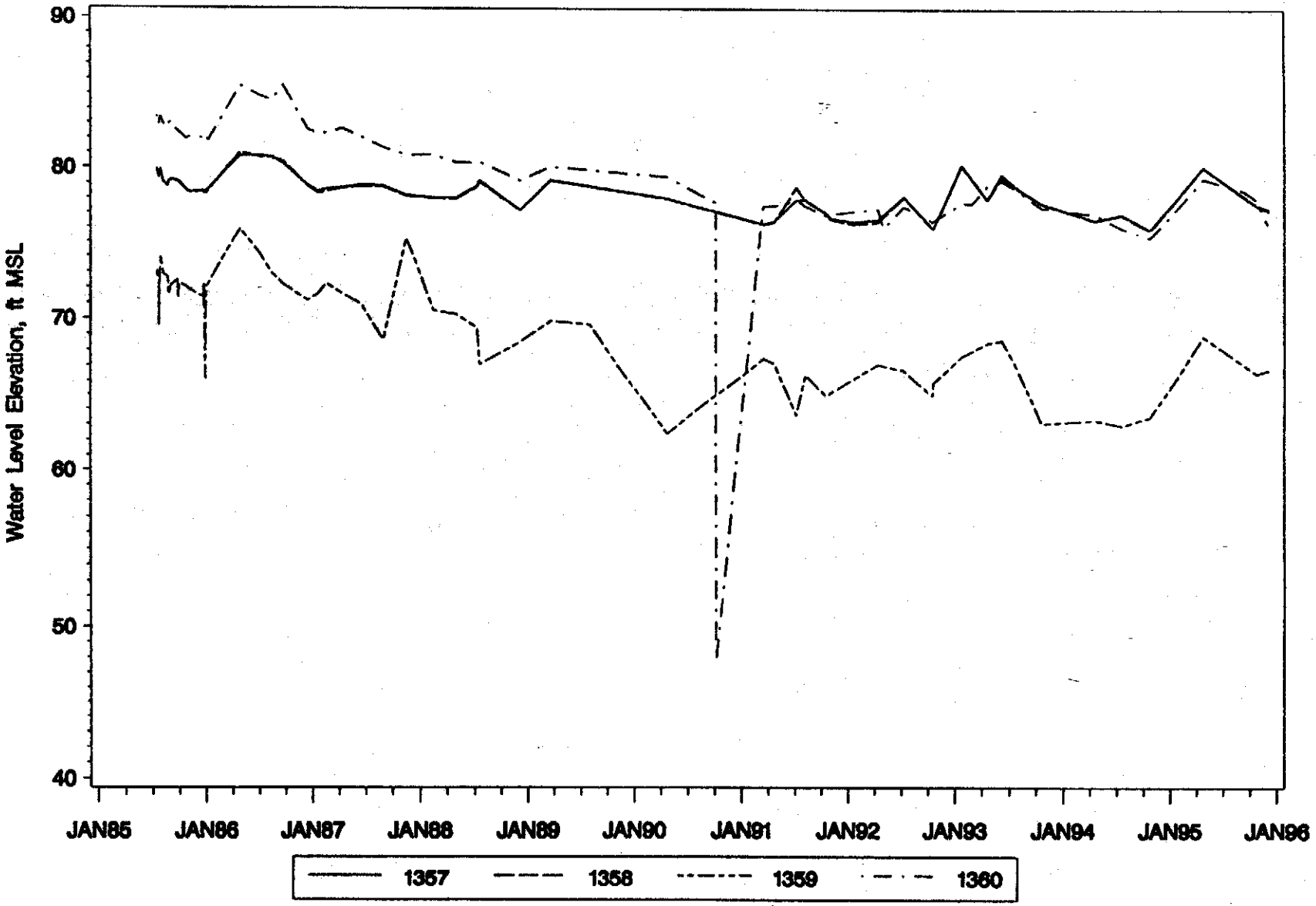

WELL=1216
Water Level Elevation, ft MSL
88
87
86
85
84
83
82
81
80
79
78
77
76
75
74
73
72
71
70
69
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96

HYDROGRAPH

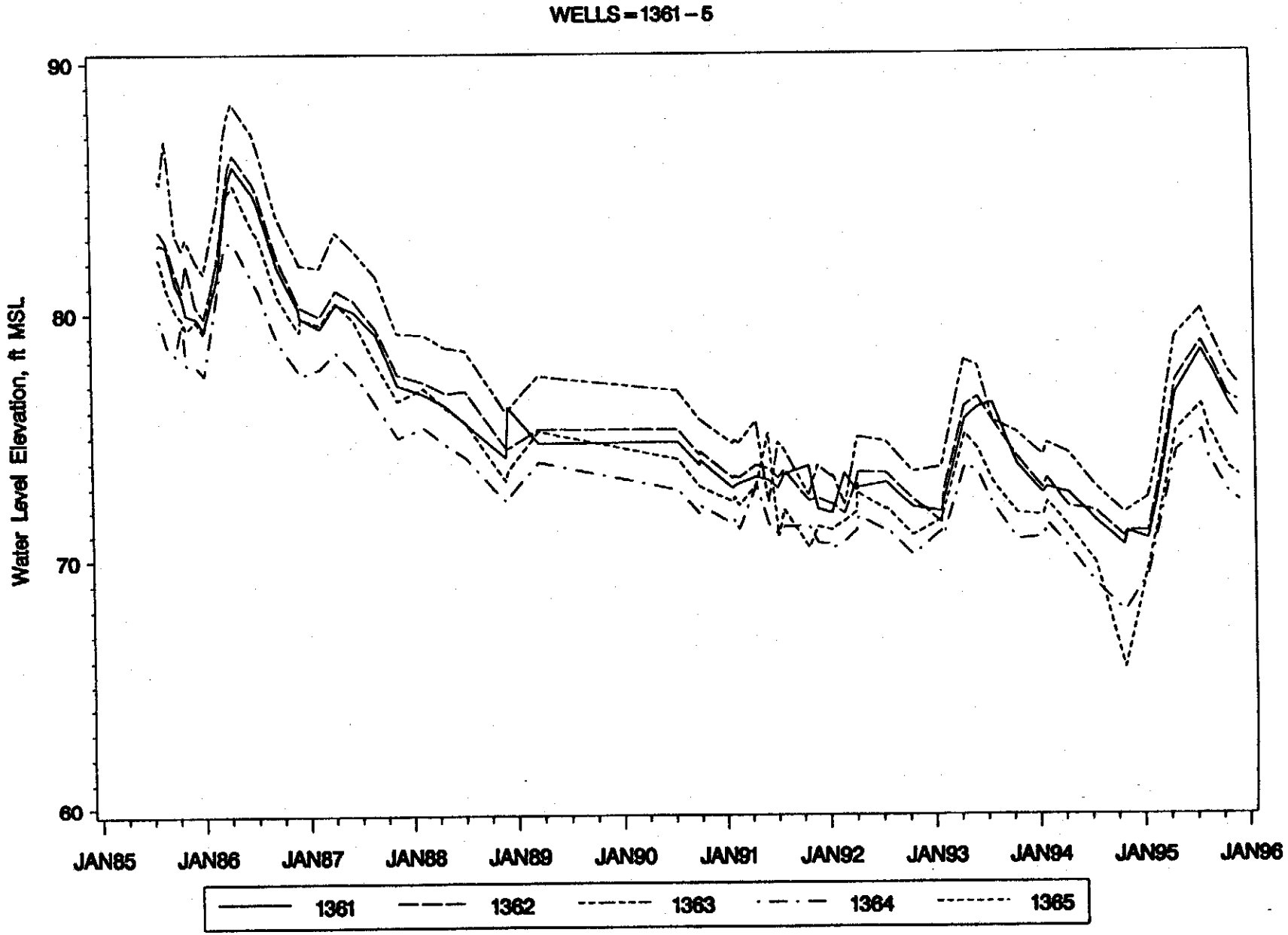

WELL=1224
Water Level Elevation, ft MSL
90
89
88
87
86
85
84
83
82
81
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96

HYDROGRAPH

WELLS = 1357 – 60

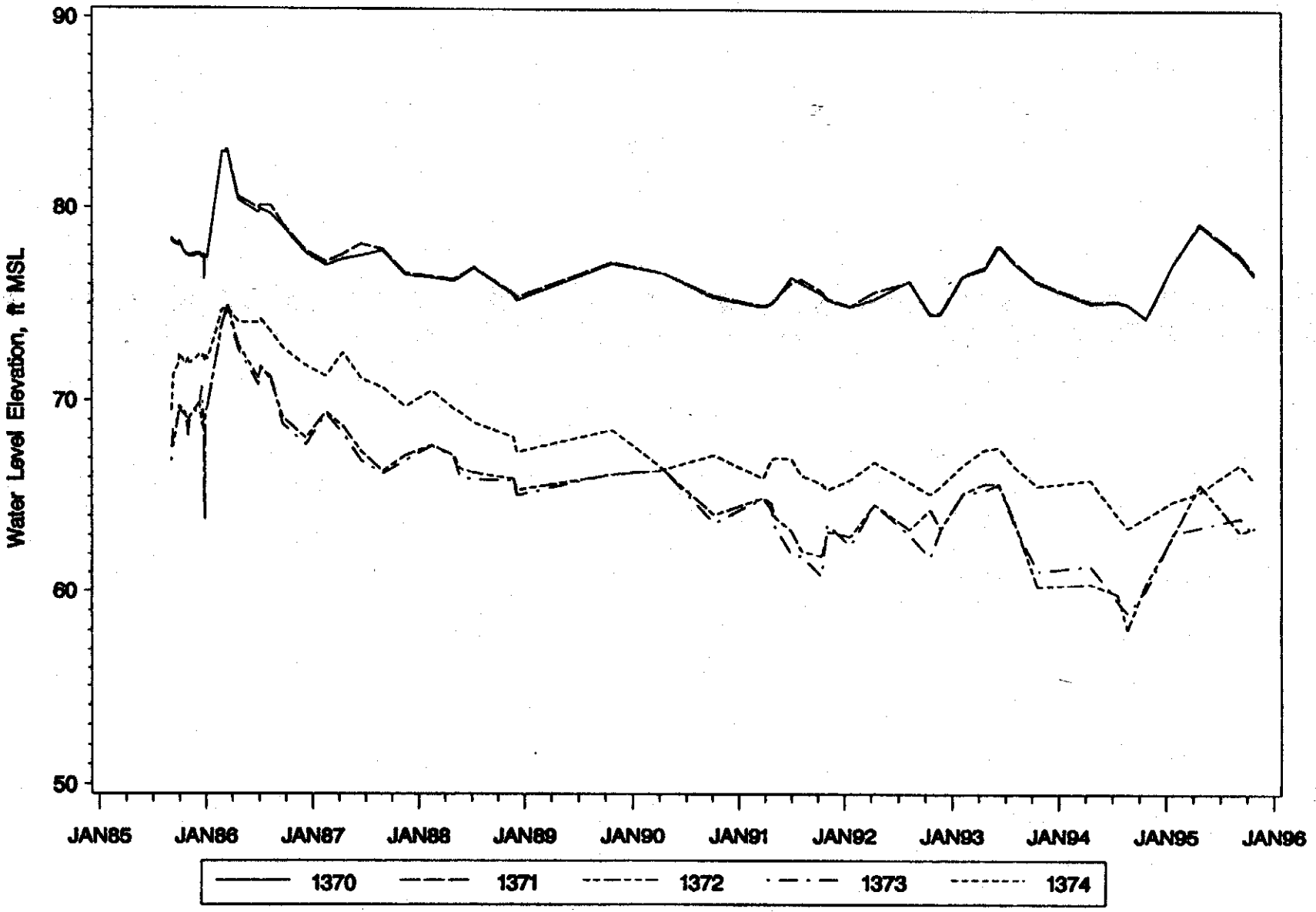


HYDROGRAPH

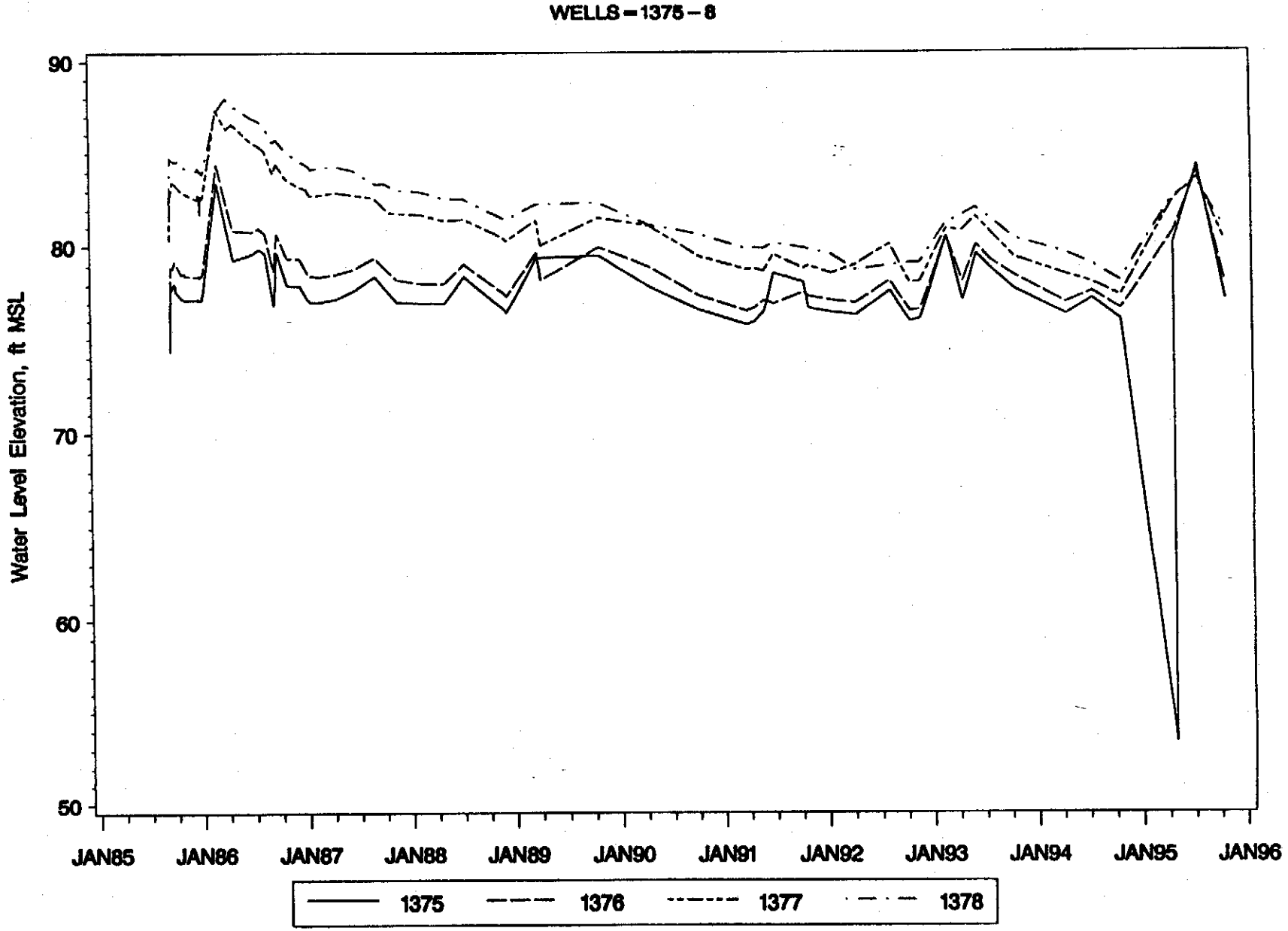

WELLS = 1361 – 5
Water Level Elevation, ft MSL
90
80
70
60
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1361
1362
1363
1364
1365

HYDROGRAPH

WELLS = 1370 – 4

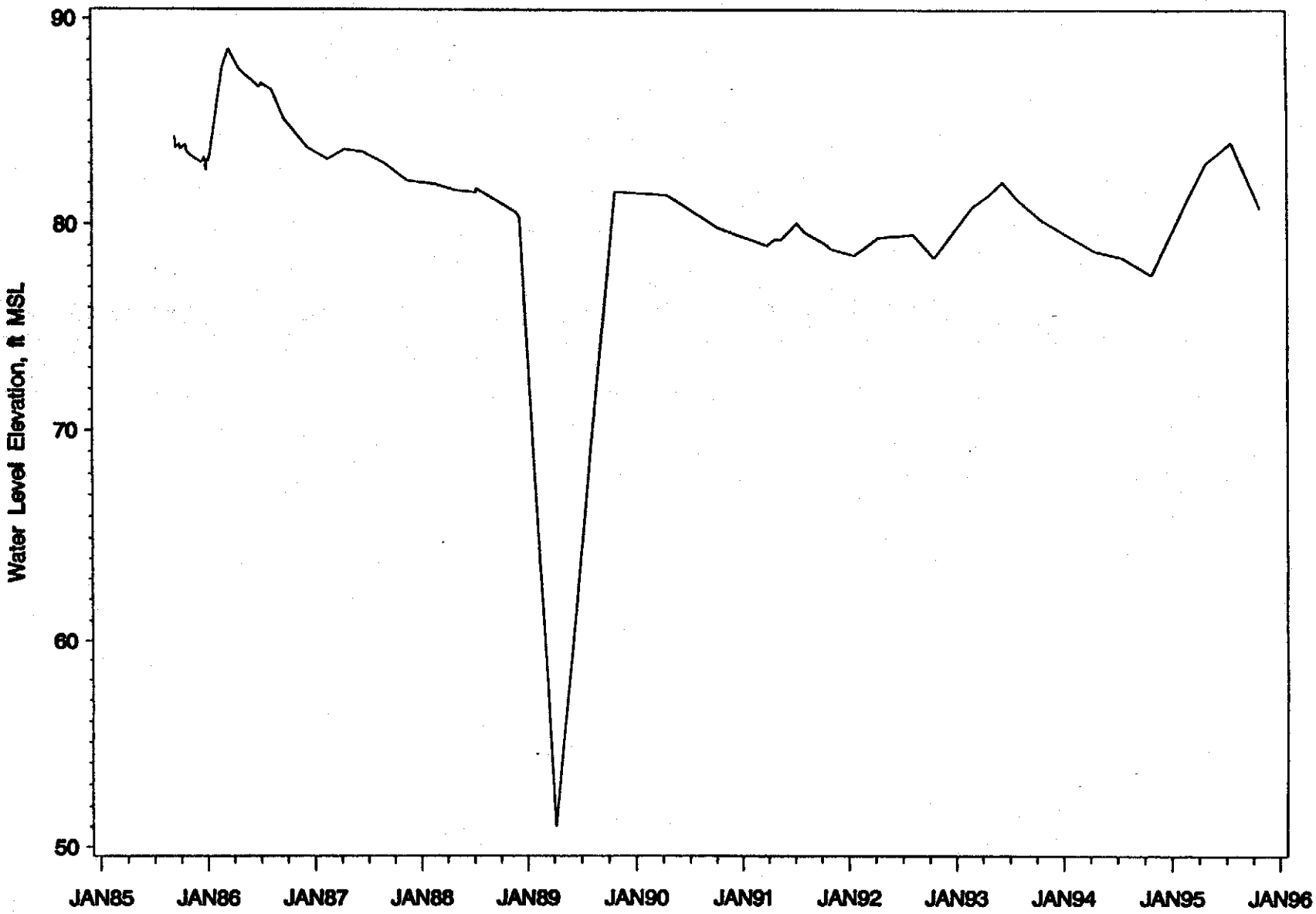


HYDROGRAPH

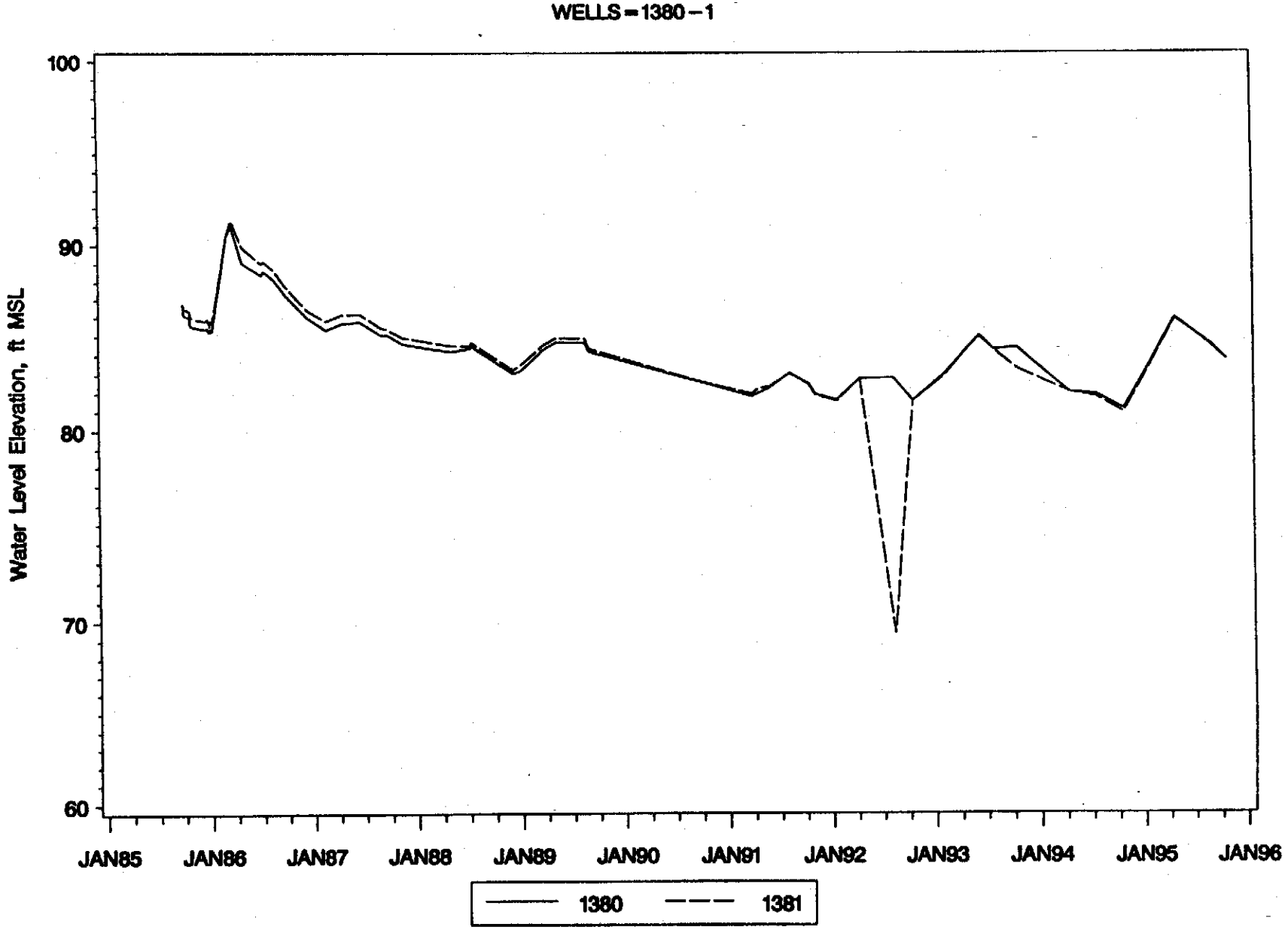

WELLS = 1375 – 8
Water Level Elevation, ft MSL
90
80
70
60
50
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1375
1376
1377
1378

HYDROGRAPH

WELL=1379

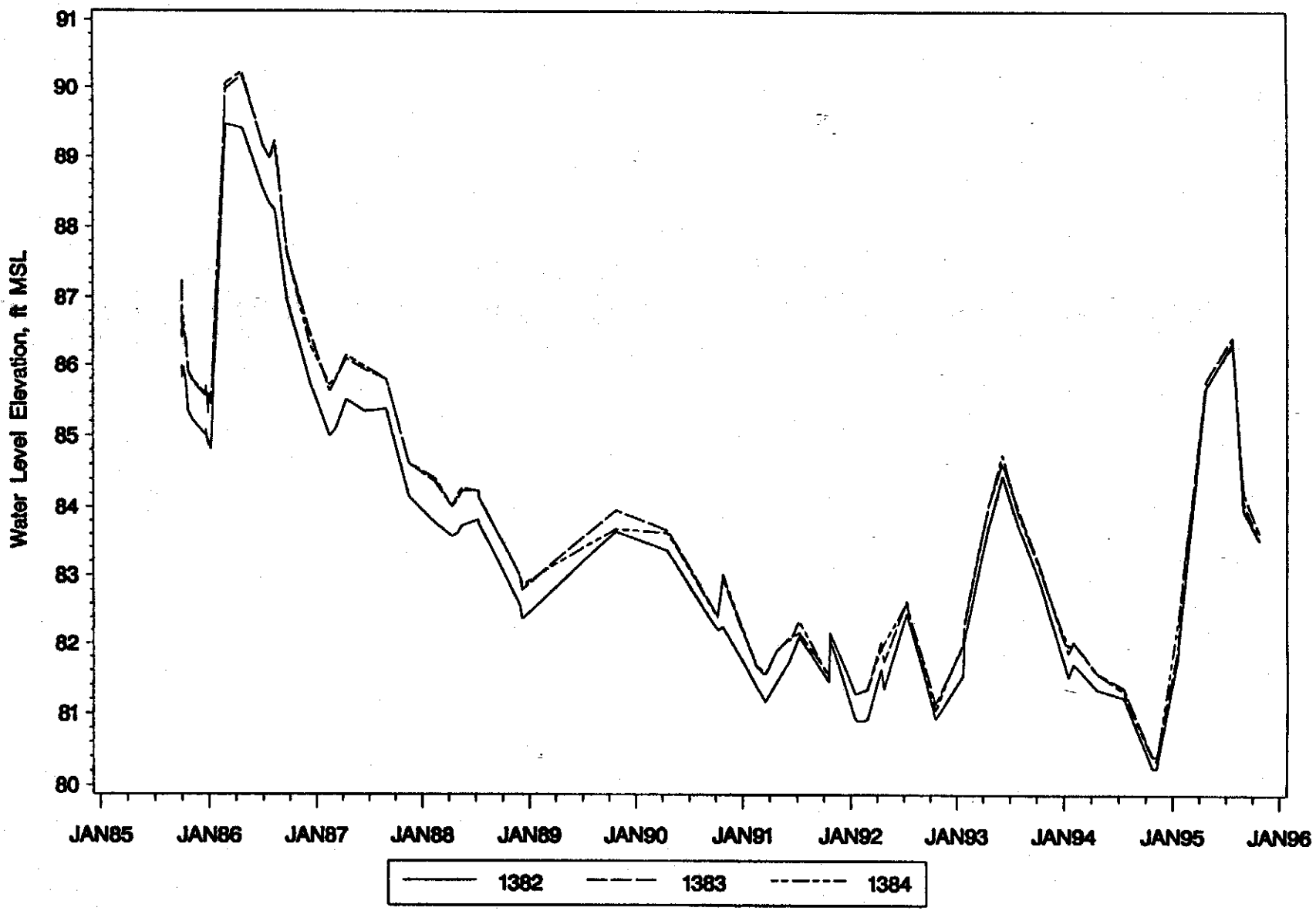


HYDROGRAPH

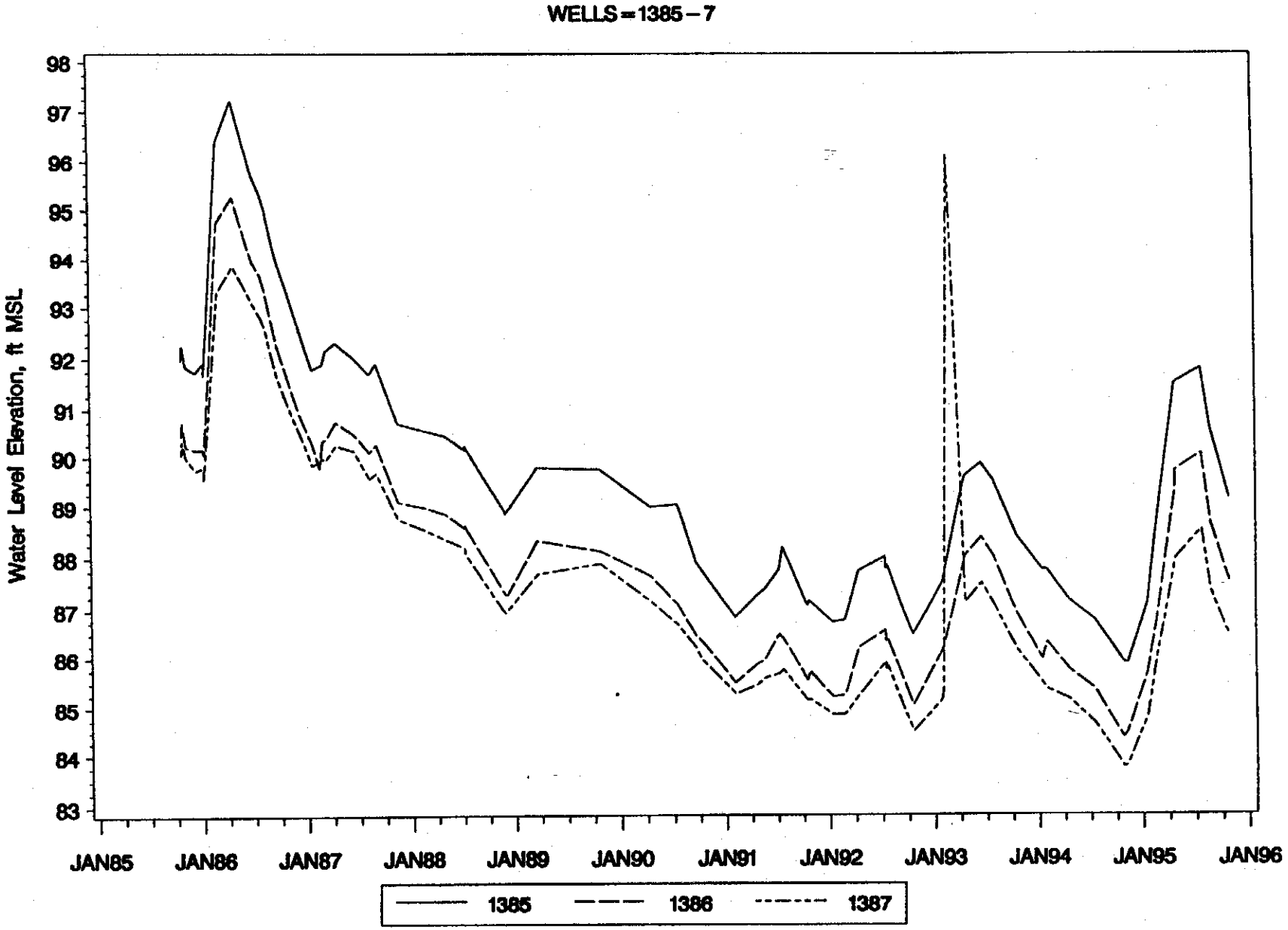

WELLS = 1380 – 1
Water Level Elevation, ft MSL
100
90
80
70
60
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1380
1381

HYDROGRAPH

WELLS=1382-4

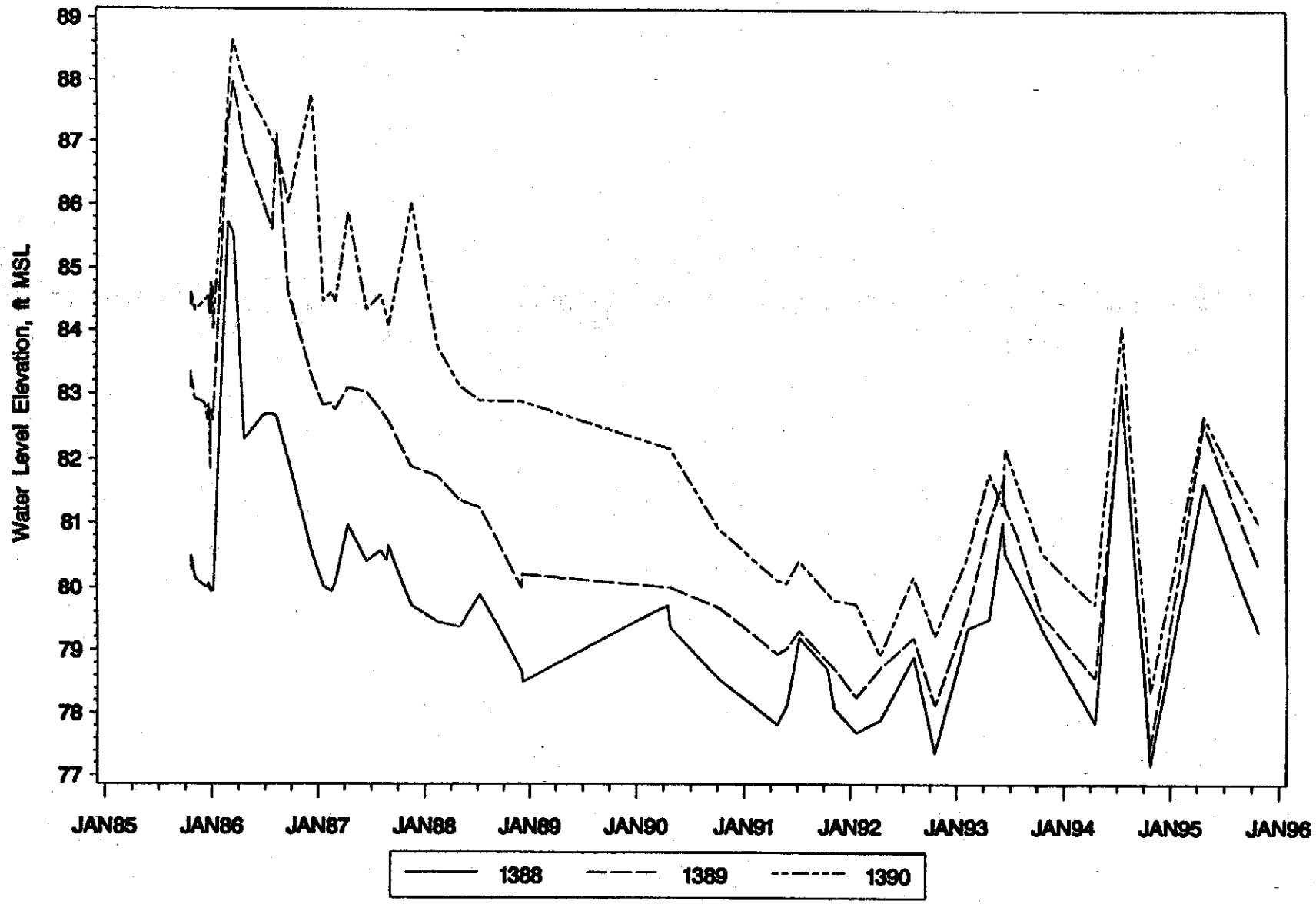


HYDROGRAPH

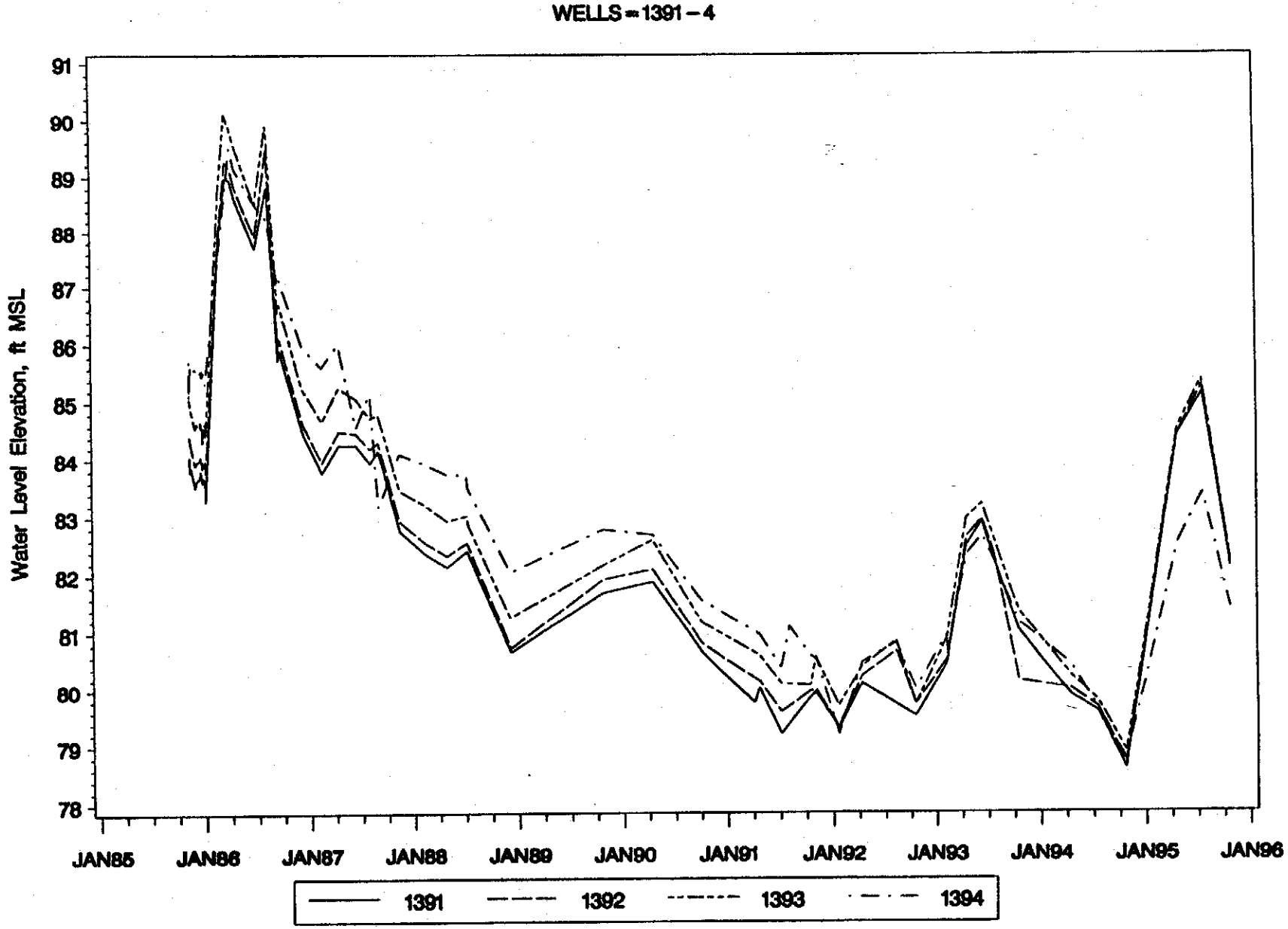

WELLS = 1385 – 7
Water Level Elevation, ft MSL
98
97
96
95
94
93
92
91
90
89
88
87
86
85
84
83
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1385
1386
1387

HYDROGRAPH

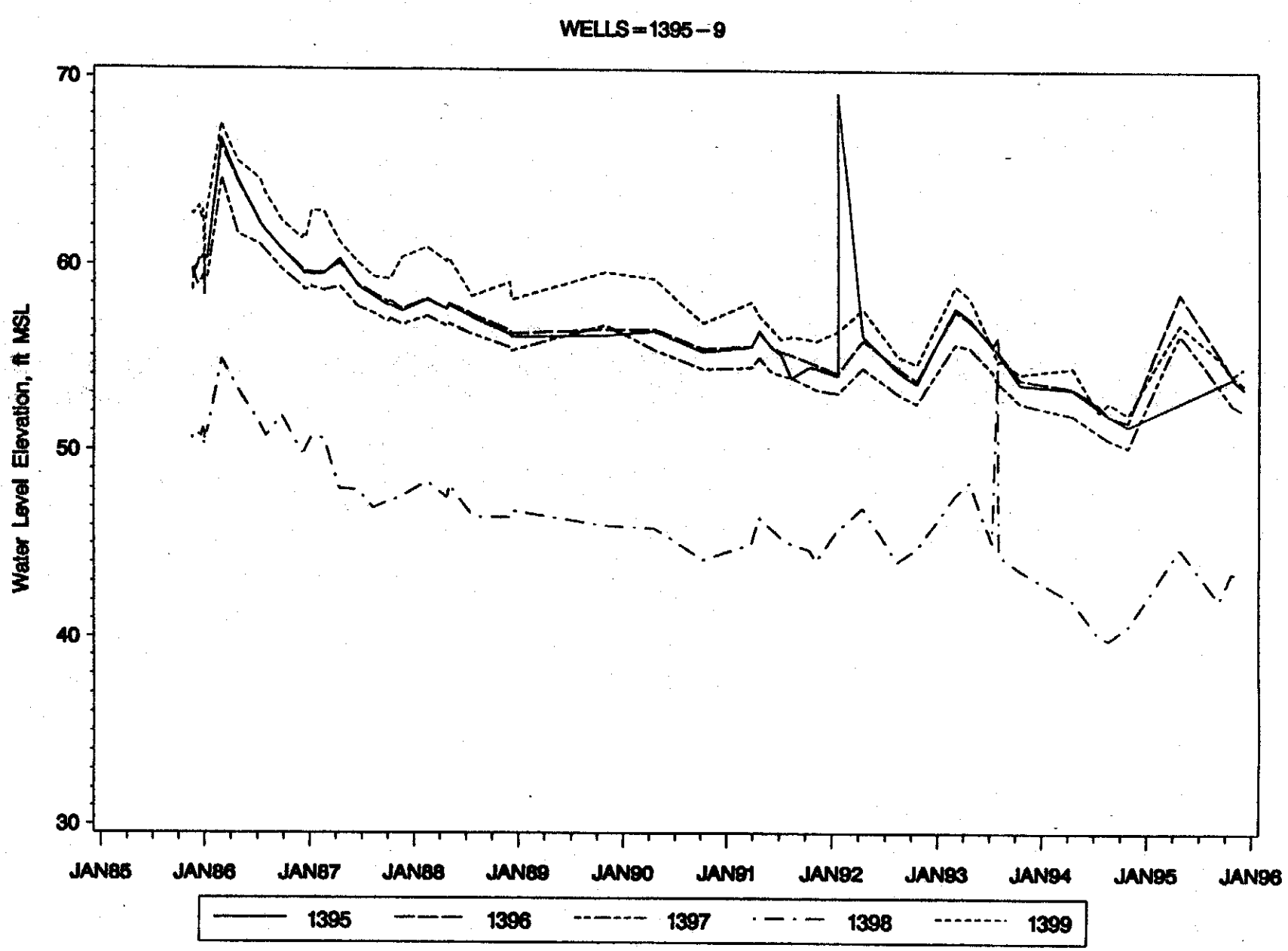
WELLS = 1388 – 90



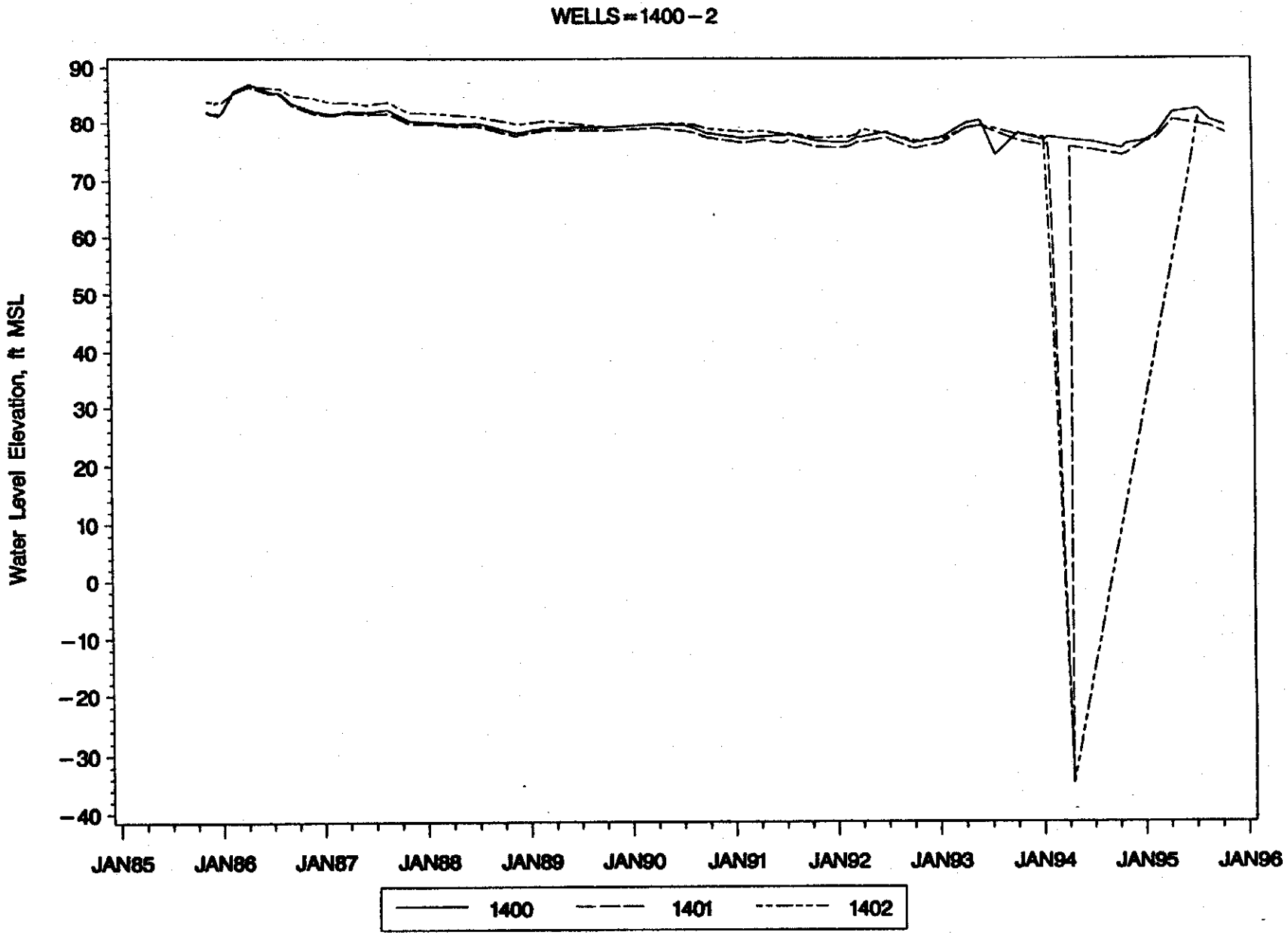
HYDROGRAPH


WELLS = 1391 – 4
Water Level Elevation, ft MSL
91
90
89
88
87
86
85
84
83
82
81
80
79
78
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1391
1392
1393
1394

HYDROGRAPH

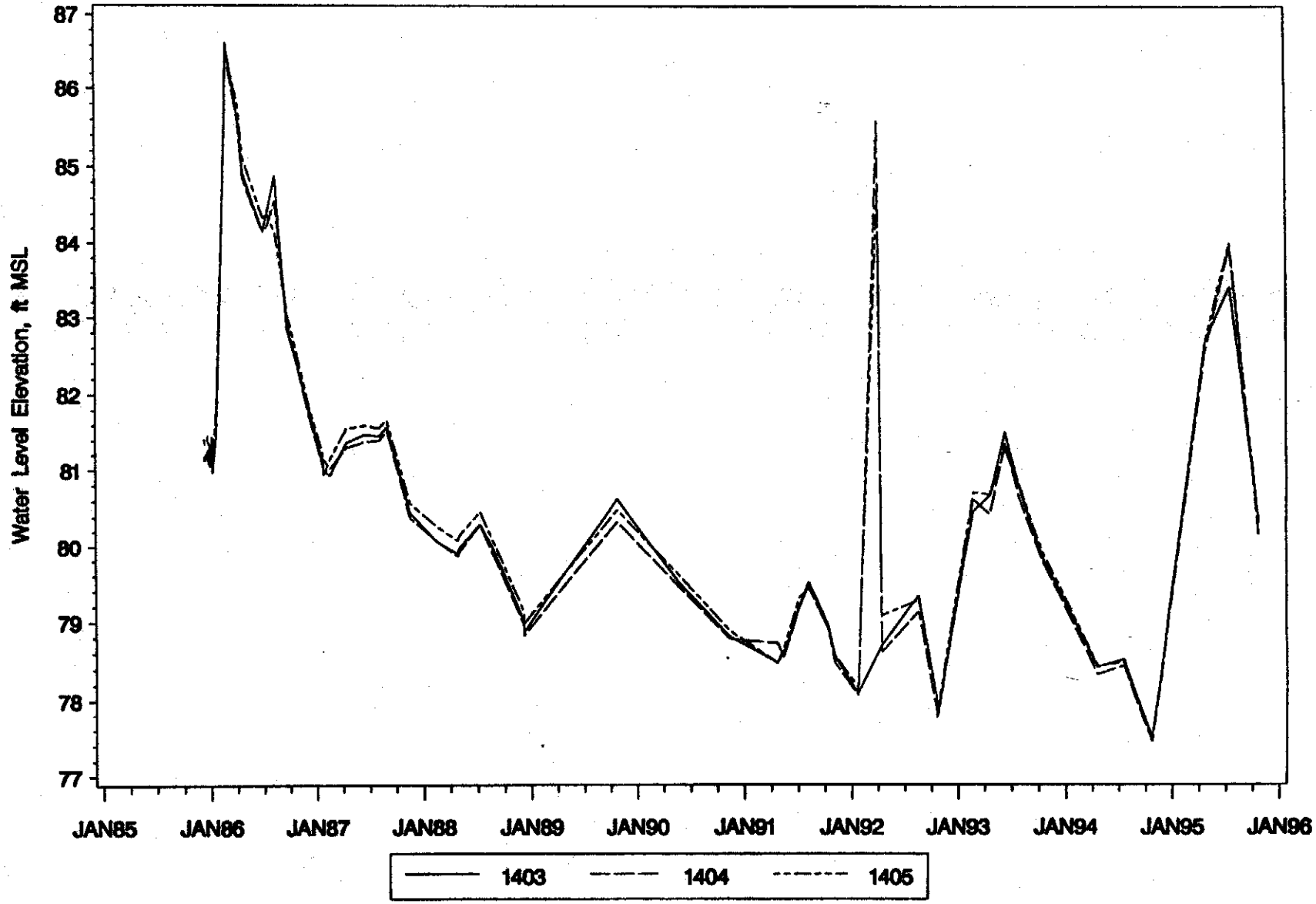

WELLS=1395-9
Water Level Elevation, ft MSL
70
60
50
40
30
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1395
1396
1397
1398
1399

HYDROGRAPH

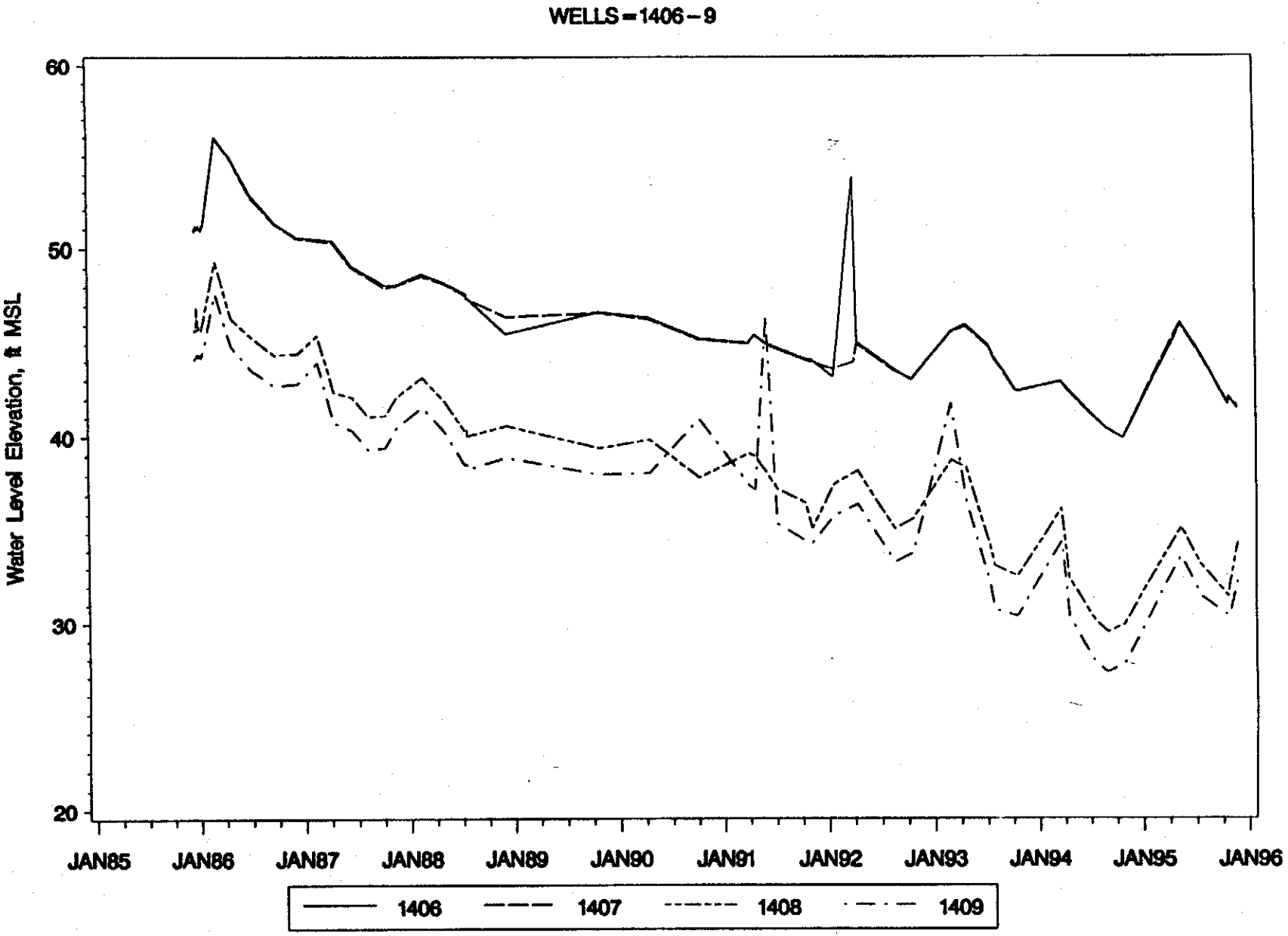

WELLS=1400-2
Water Level Elevation, ft MSL
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1400
1401
1402

HYDROGRAPH

WELLS = 1403 – 5

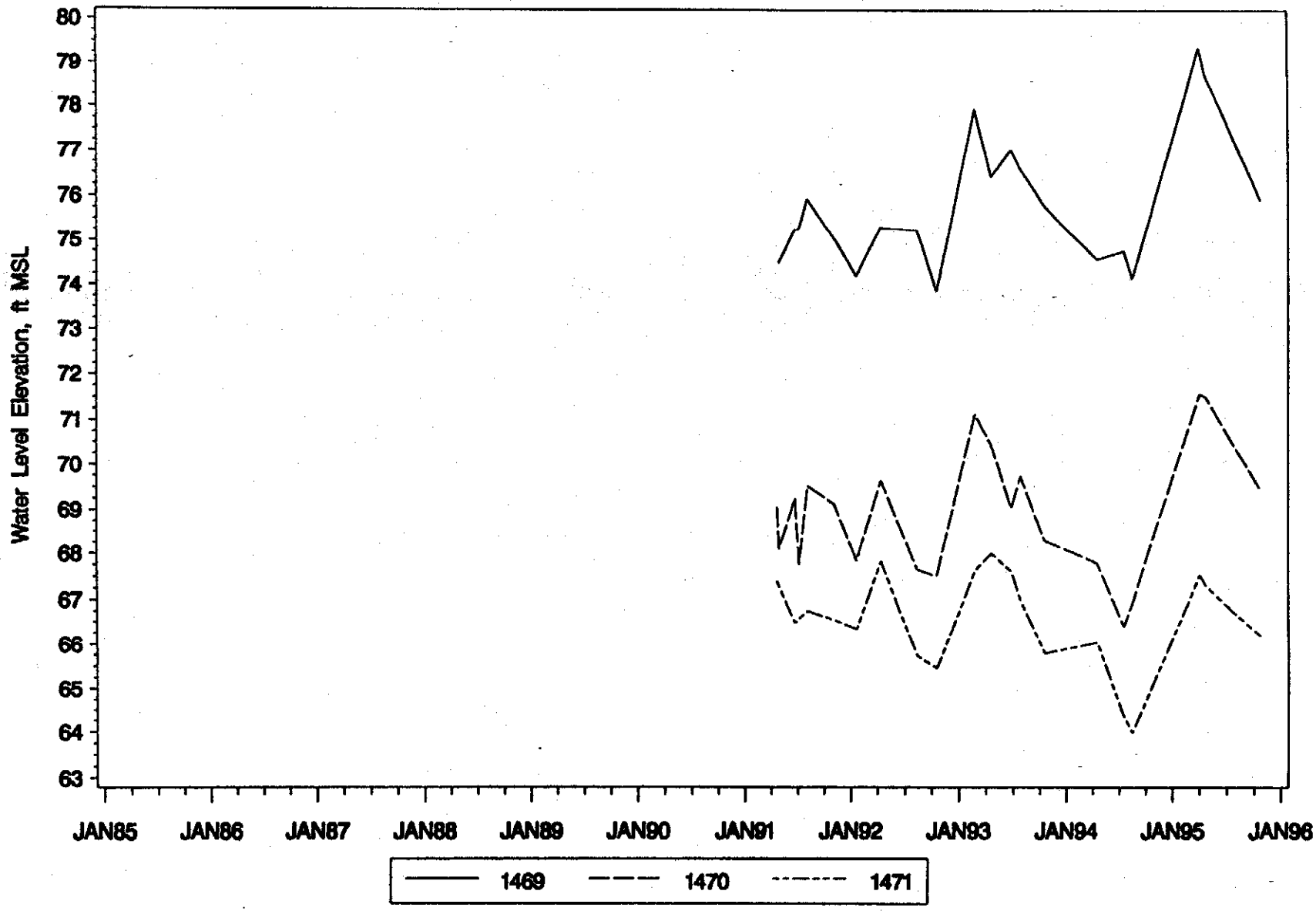


HYDROGRAPH

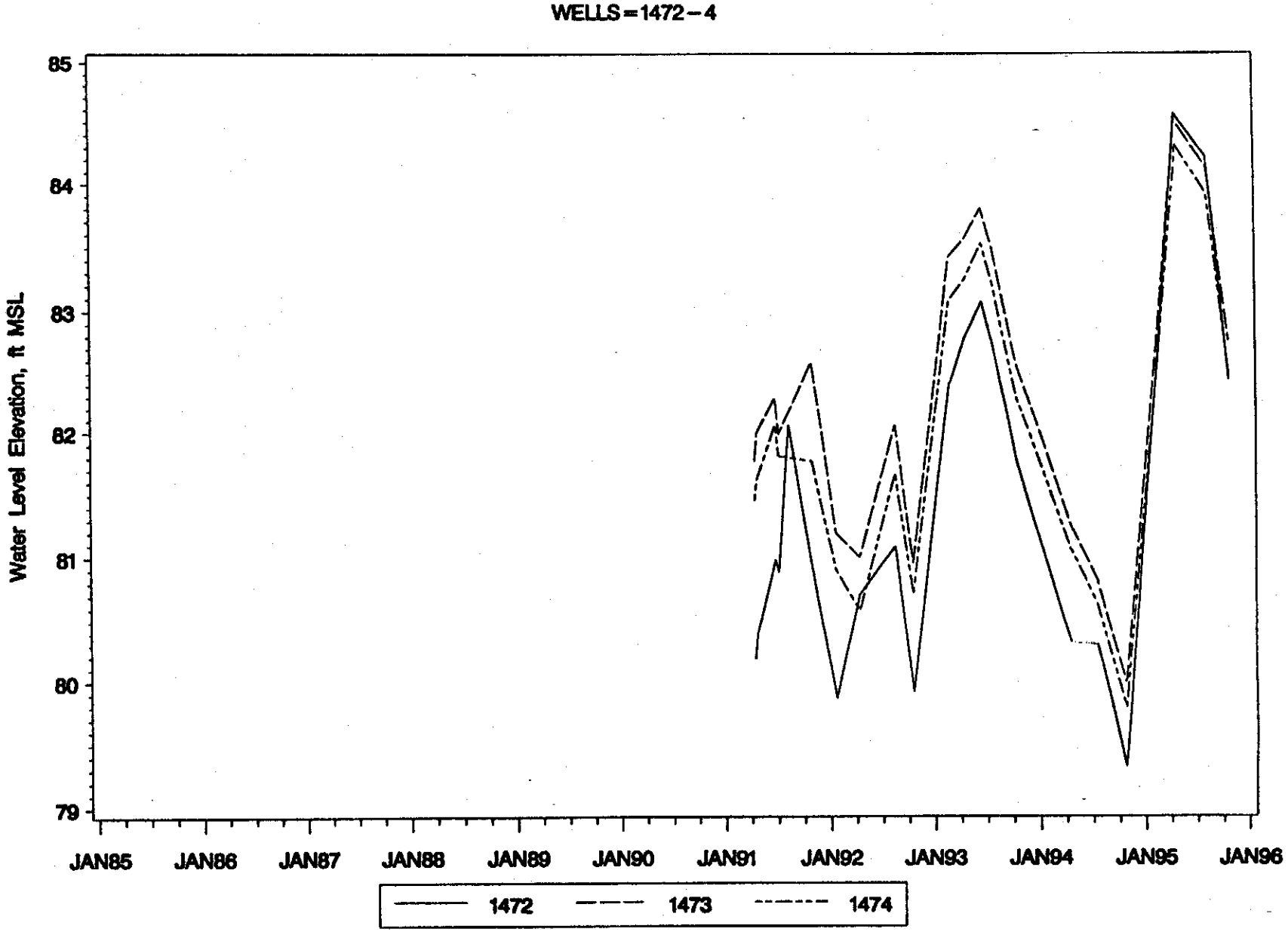

WELLS = 1406 – 9
Water Level Elevation, ft MSL
60
50
40
30
20
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1406
1407
1408
1409

HYDROGRAPH

WELLS = 1469 – 71

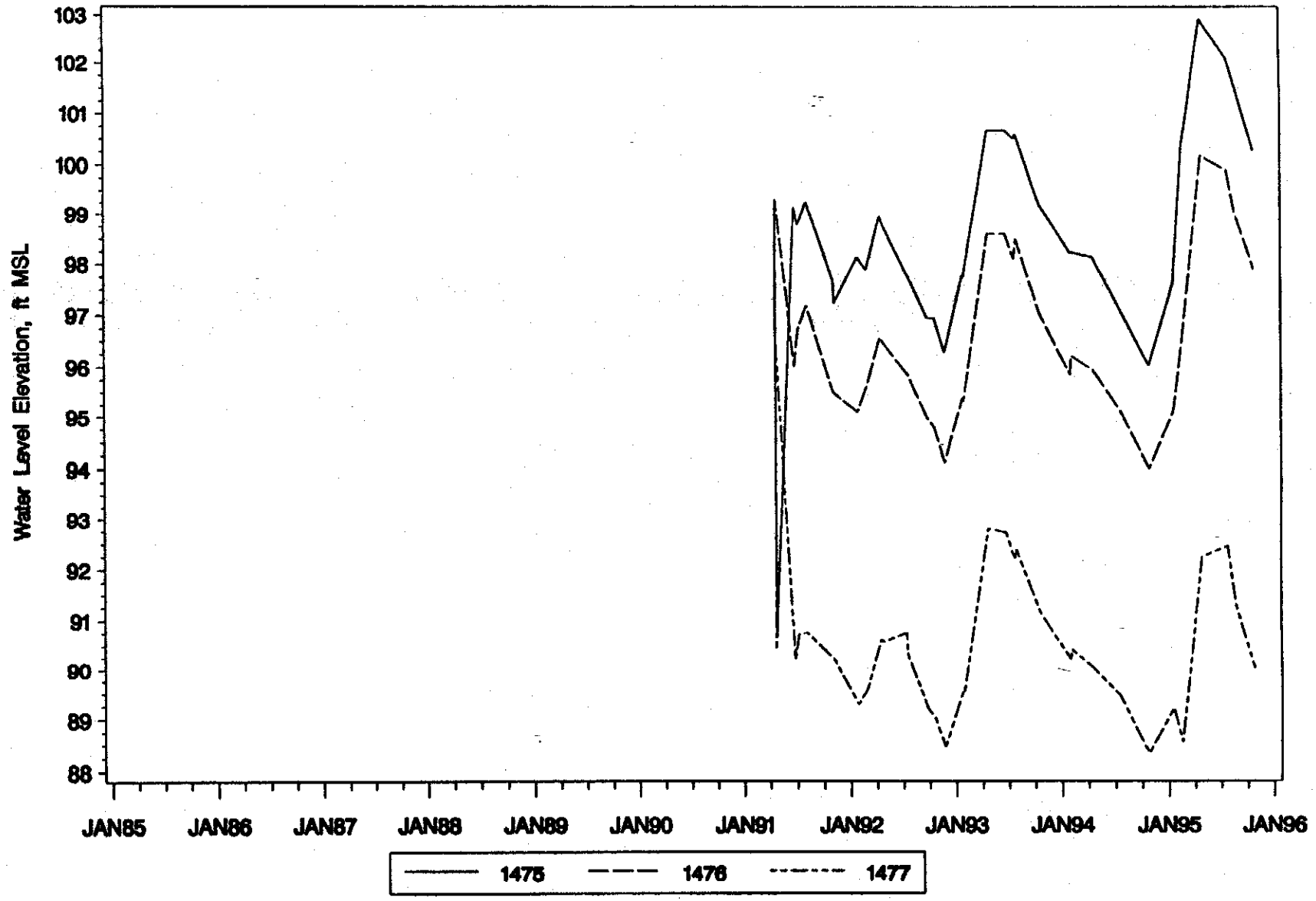


HYDROGRAPH

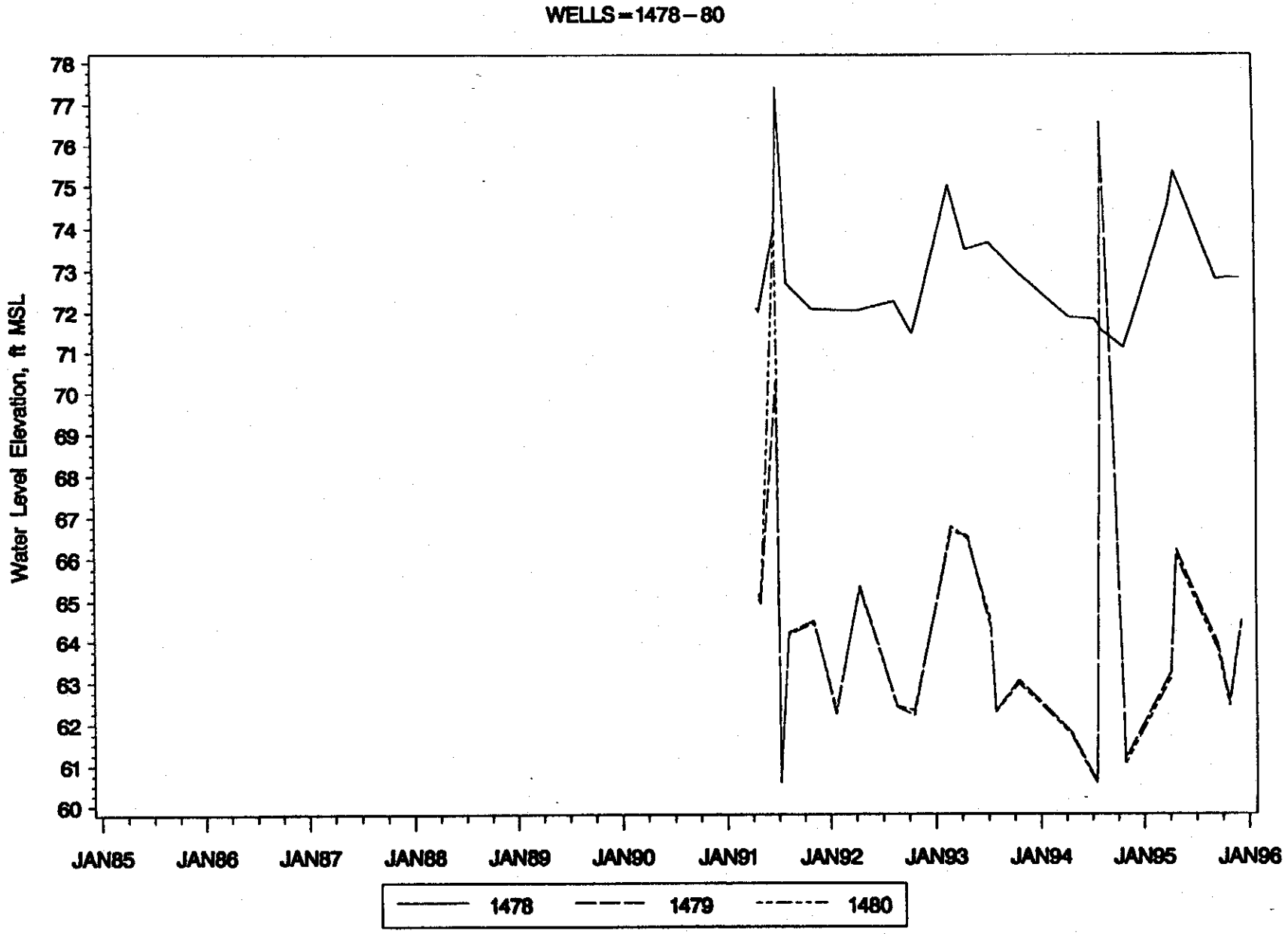

WELLS=1472-4
Water Level Elevation, ft MSL
85
84
83
82
81
80
79
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1472
1473
1474

HYDROGRAPH

WELLS = 1475 – 7

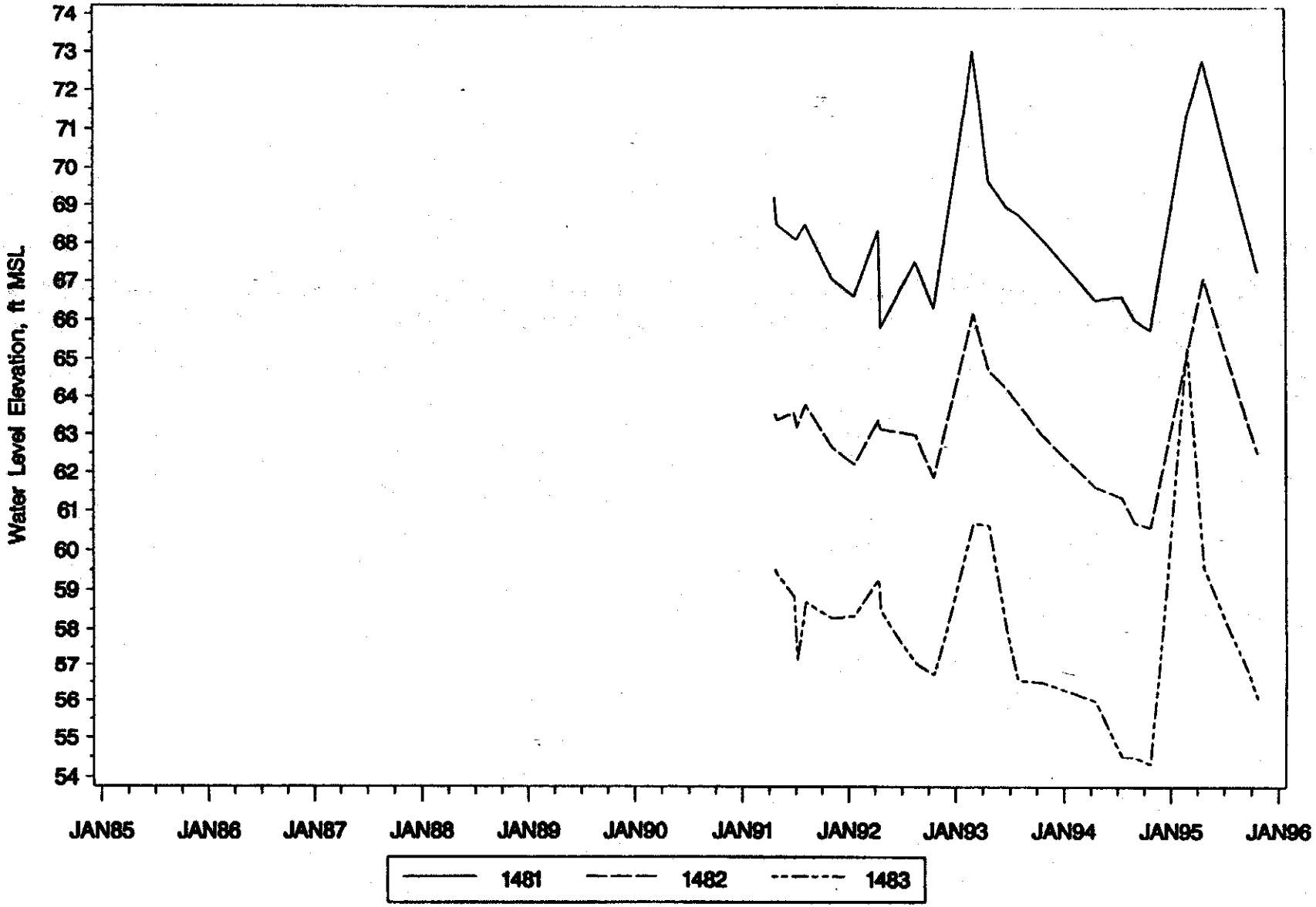


HYDROGRAPH

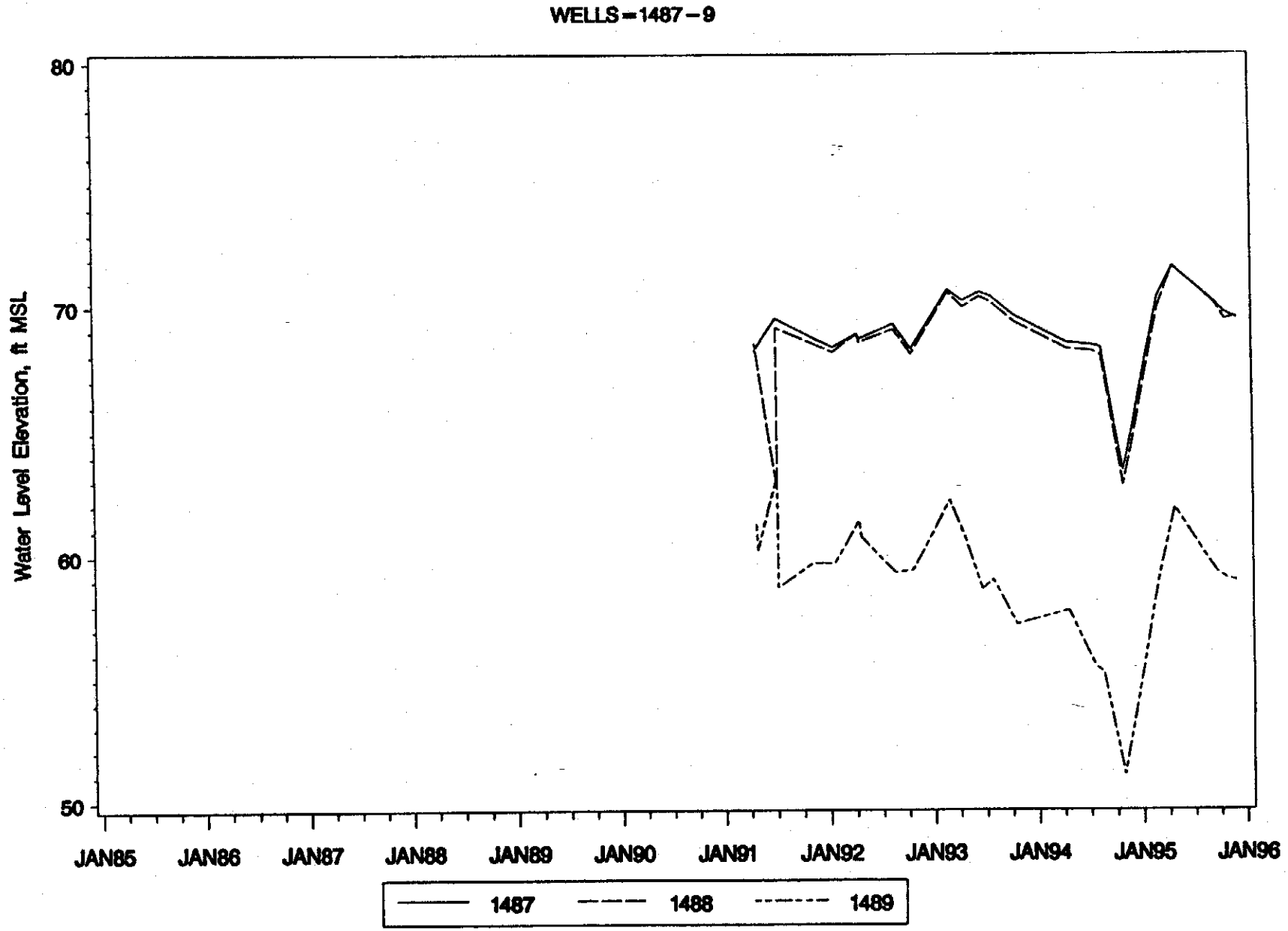

WELLS=1478-80
Water Level Elevation, ft MSL
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
63
62
61
60
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1478
1479
1480

HYDROGRAPH

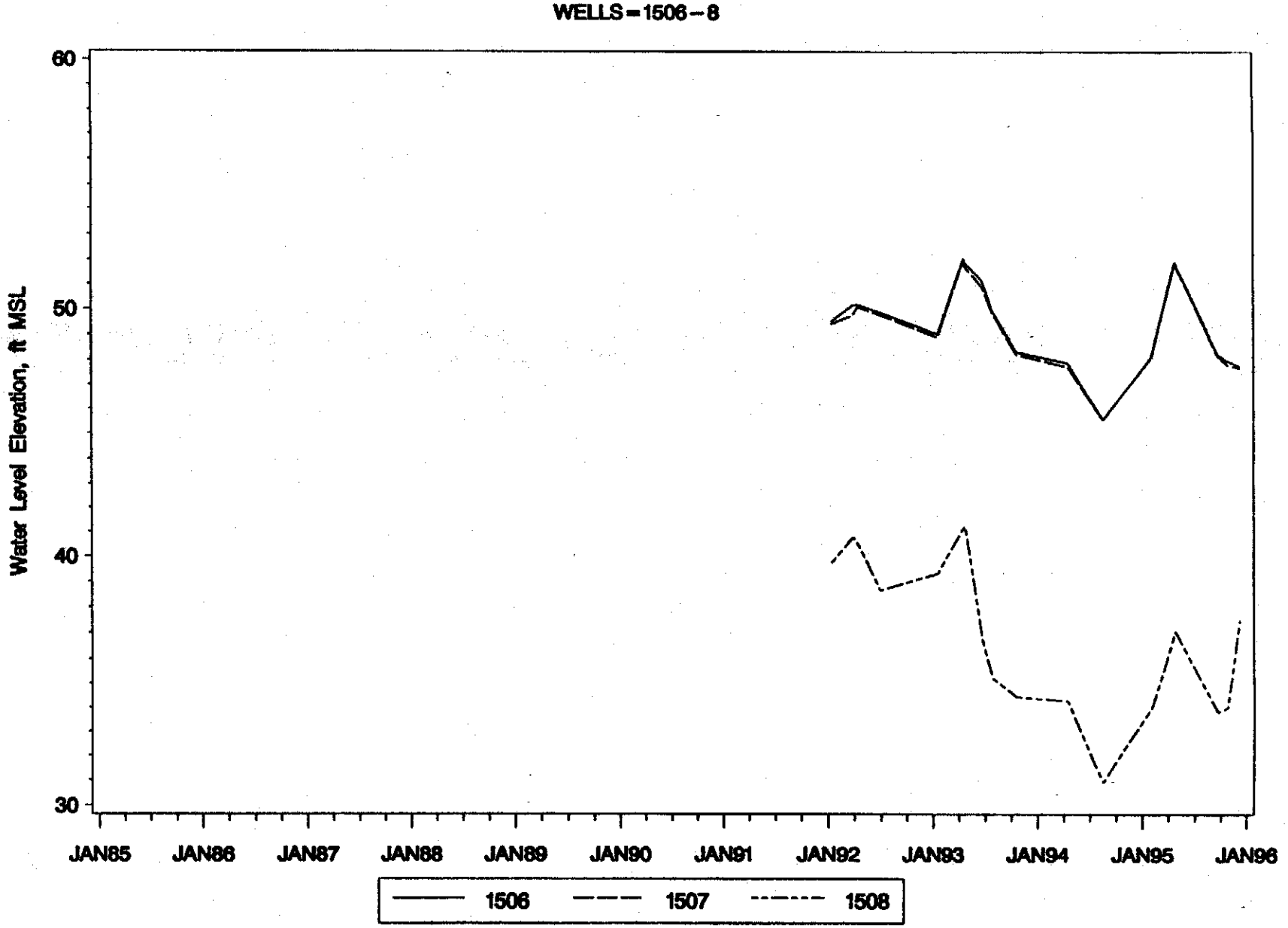
WELLS = 1481 – 3



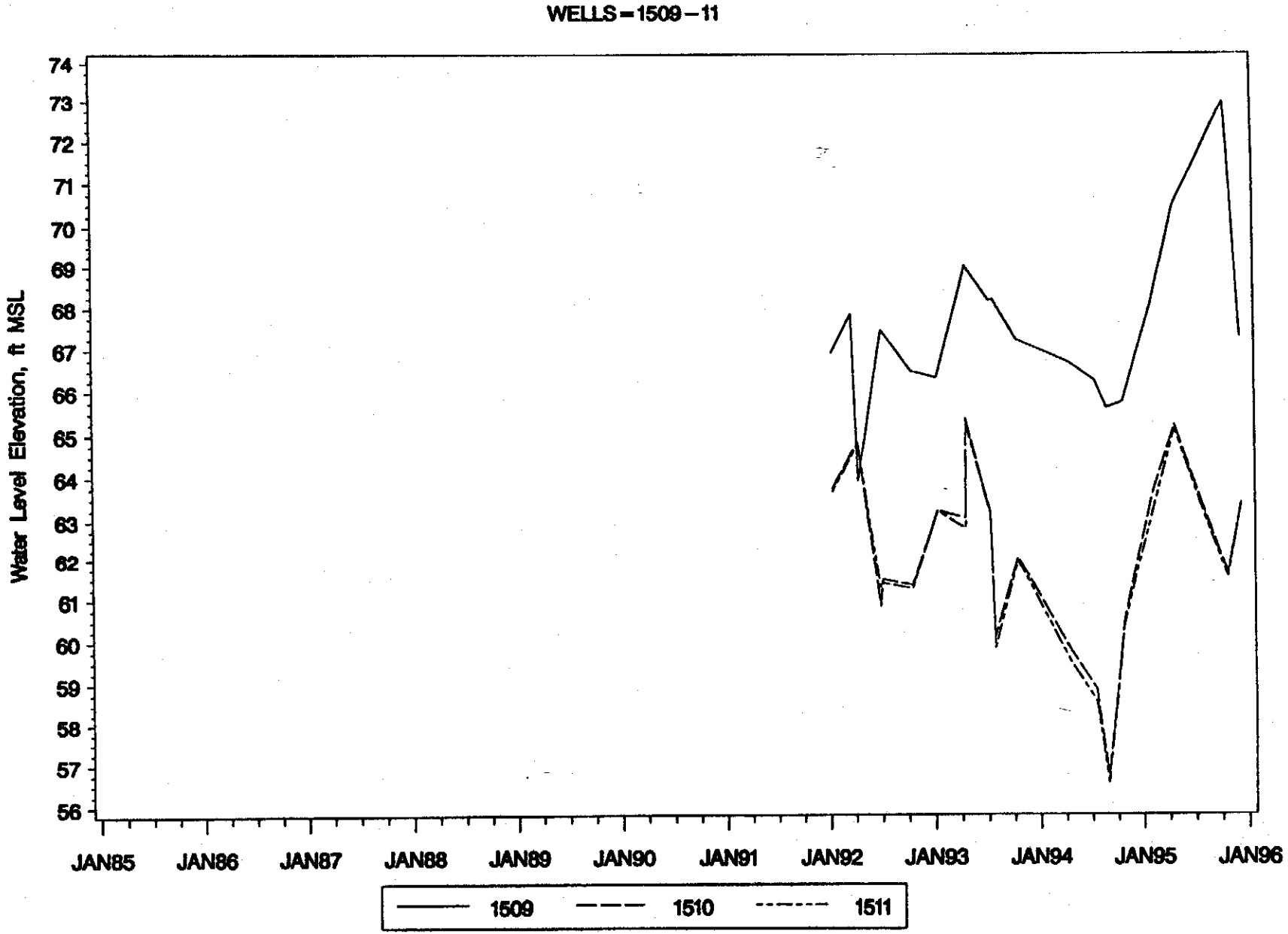
HYDROGRAPH


WELLS=1487-9
Water Level Elevation, ft MSL
80
70
60
50
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1487
1488
1489

HYDROGRAPH

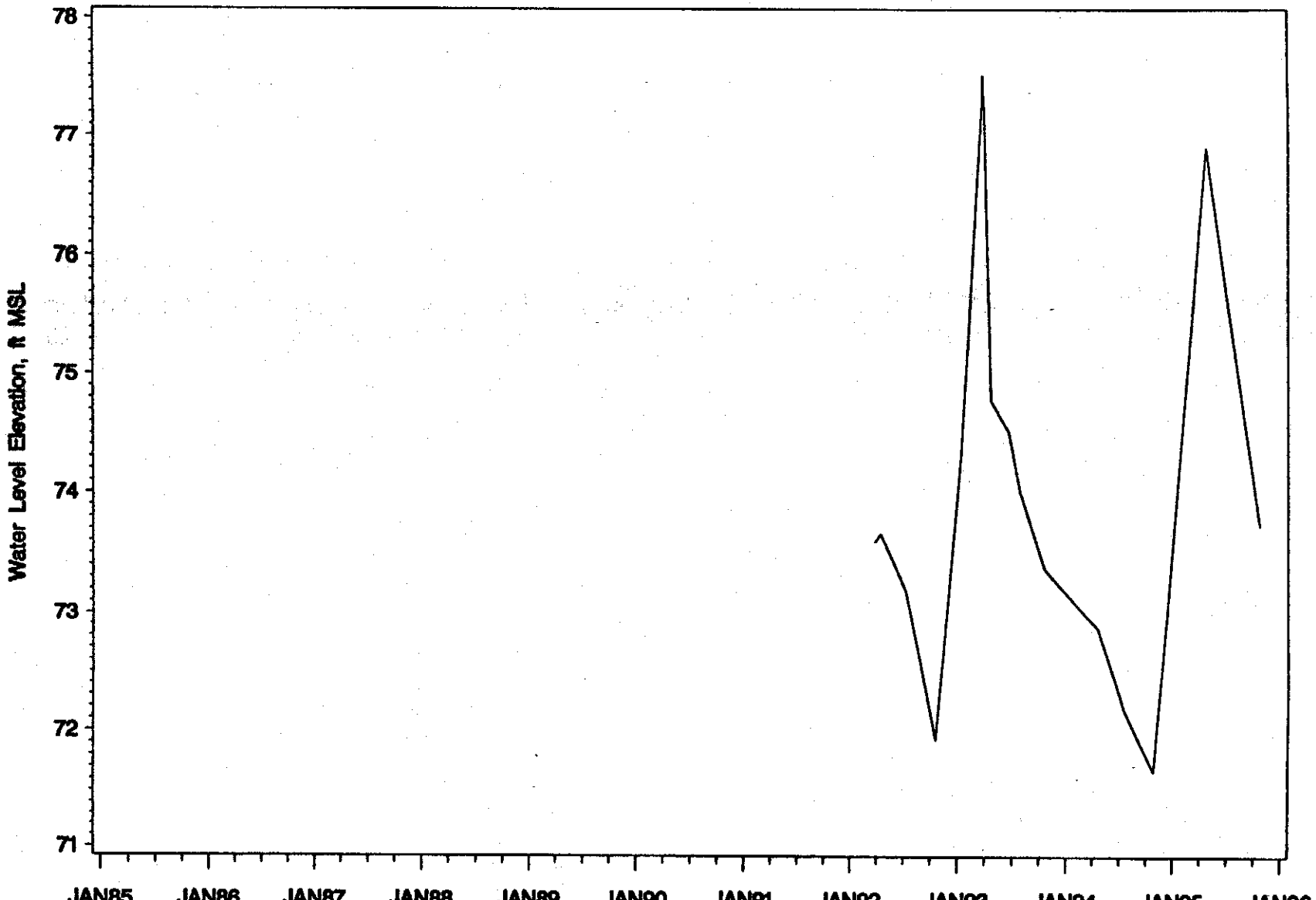

WELLS = 1506 – 8
Water Level Elevation, ft MSL
60
50
40
30
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1506
1507
1508

HYDROGRAPH


WELLS = 1509 – 11
Water Level Elevation, ft MSL
74
73
72
71
70
69
68
67
66
65
64
63
62
61
60
59
58
57
56
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1509
1510
1511

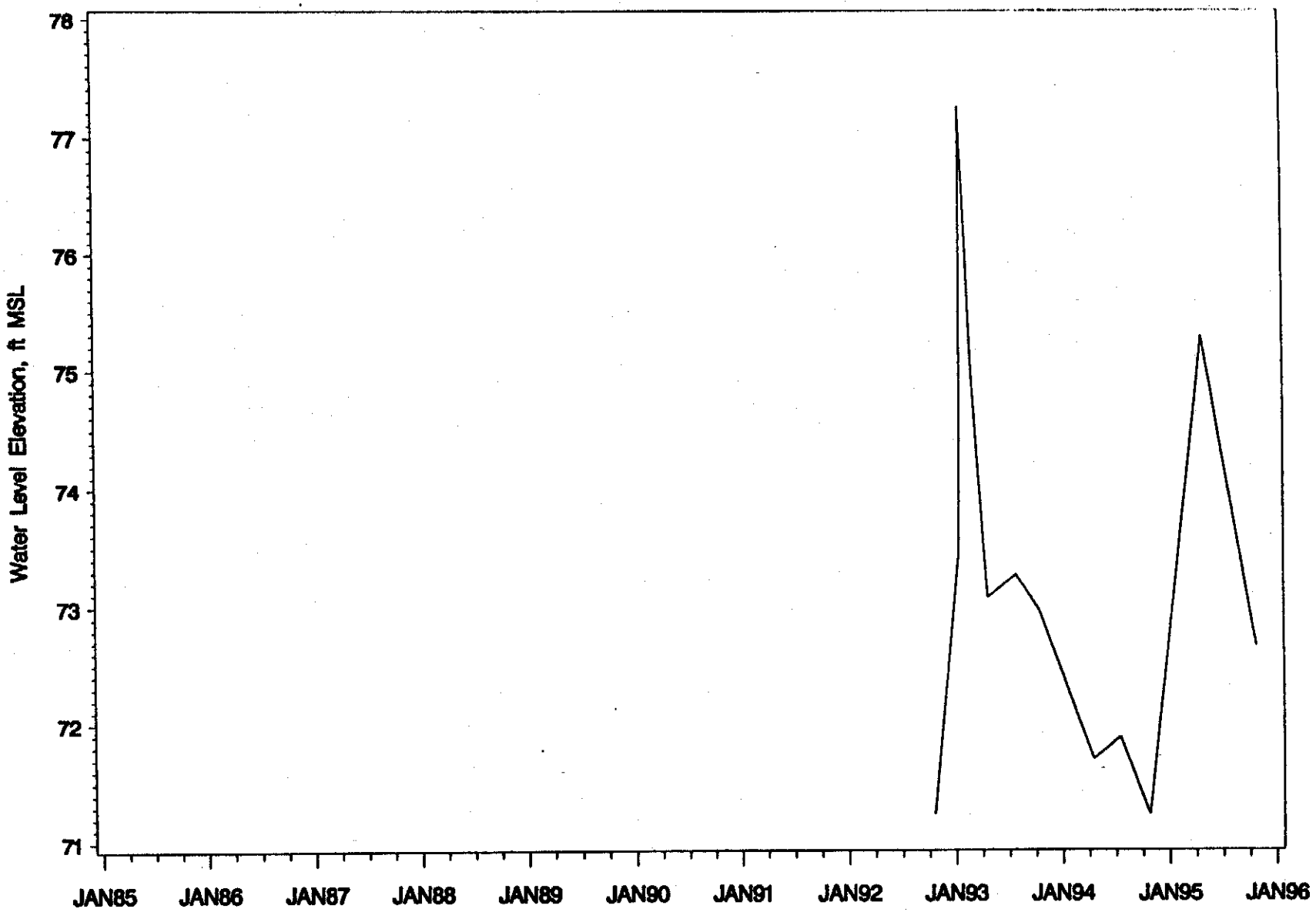
HYDROGRAPH

WELL = 1516



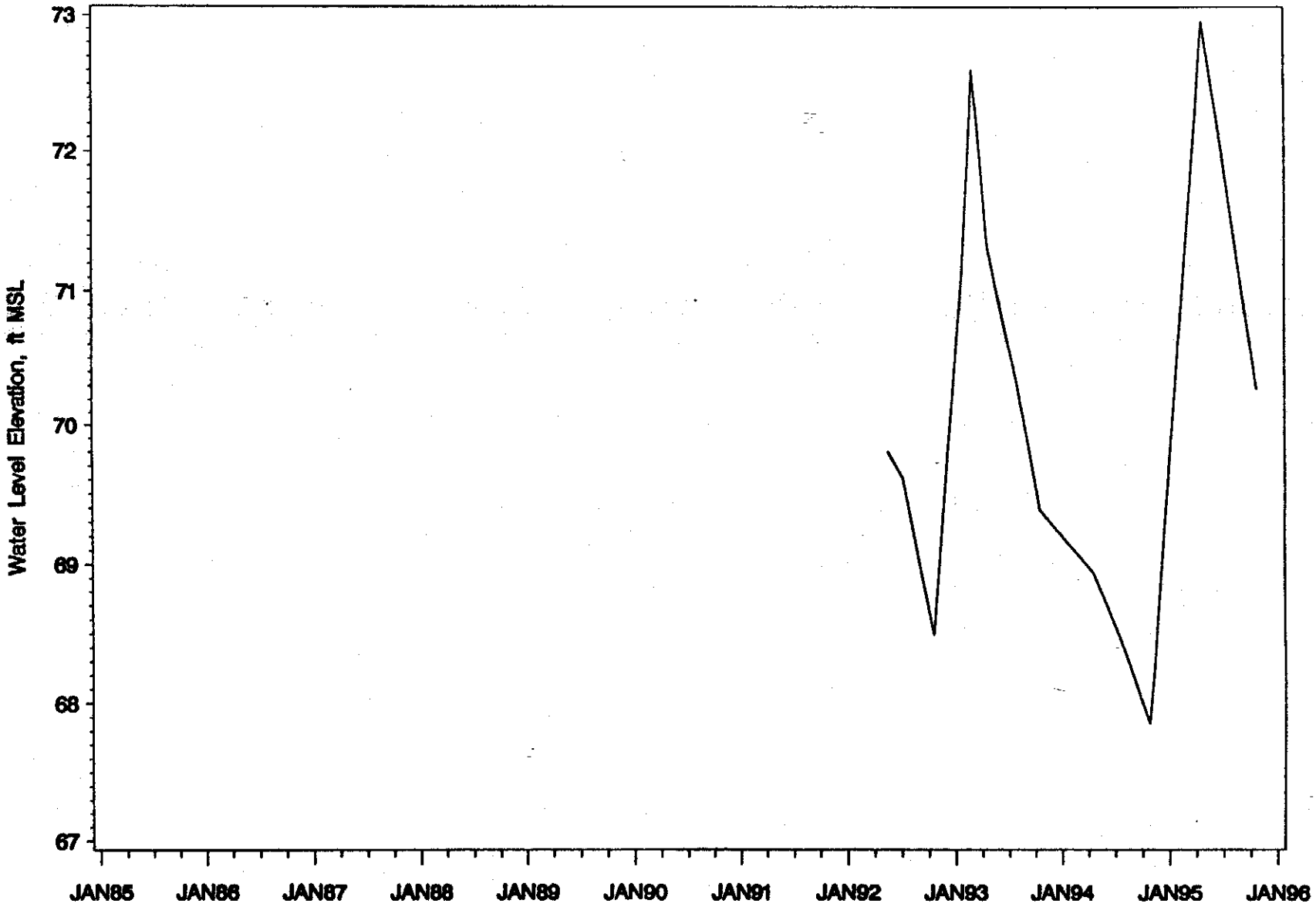
HYDROGRAPH

WELL=1517

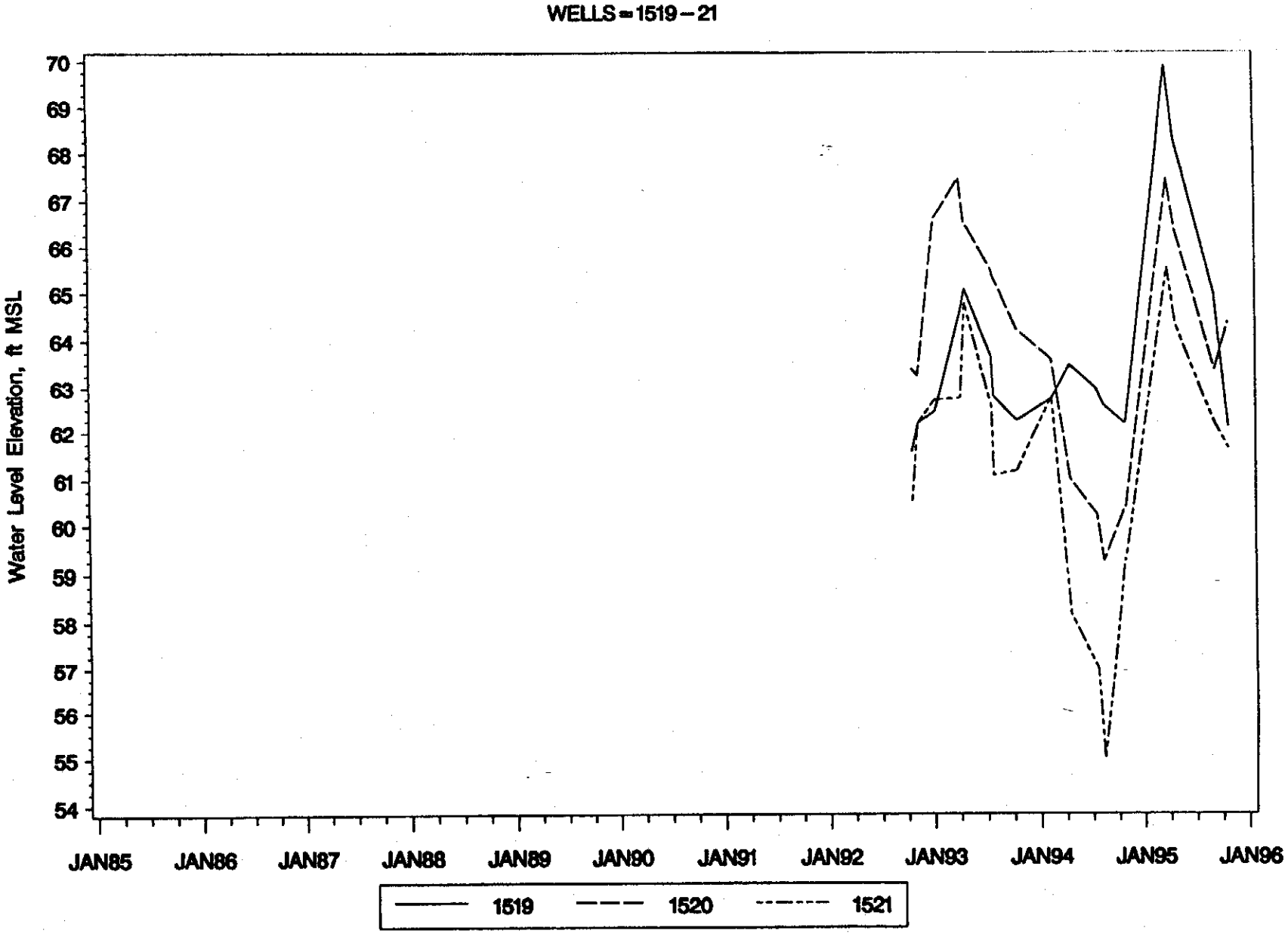


HYDROGRAPH

WELL = 1518

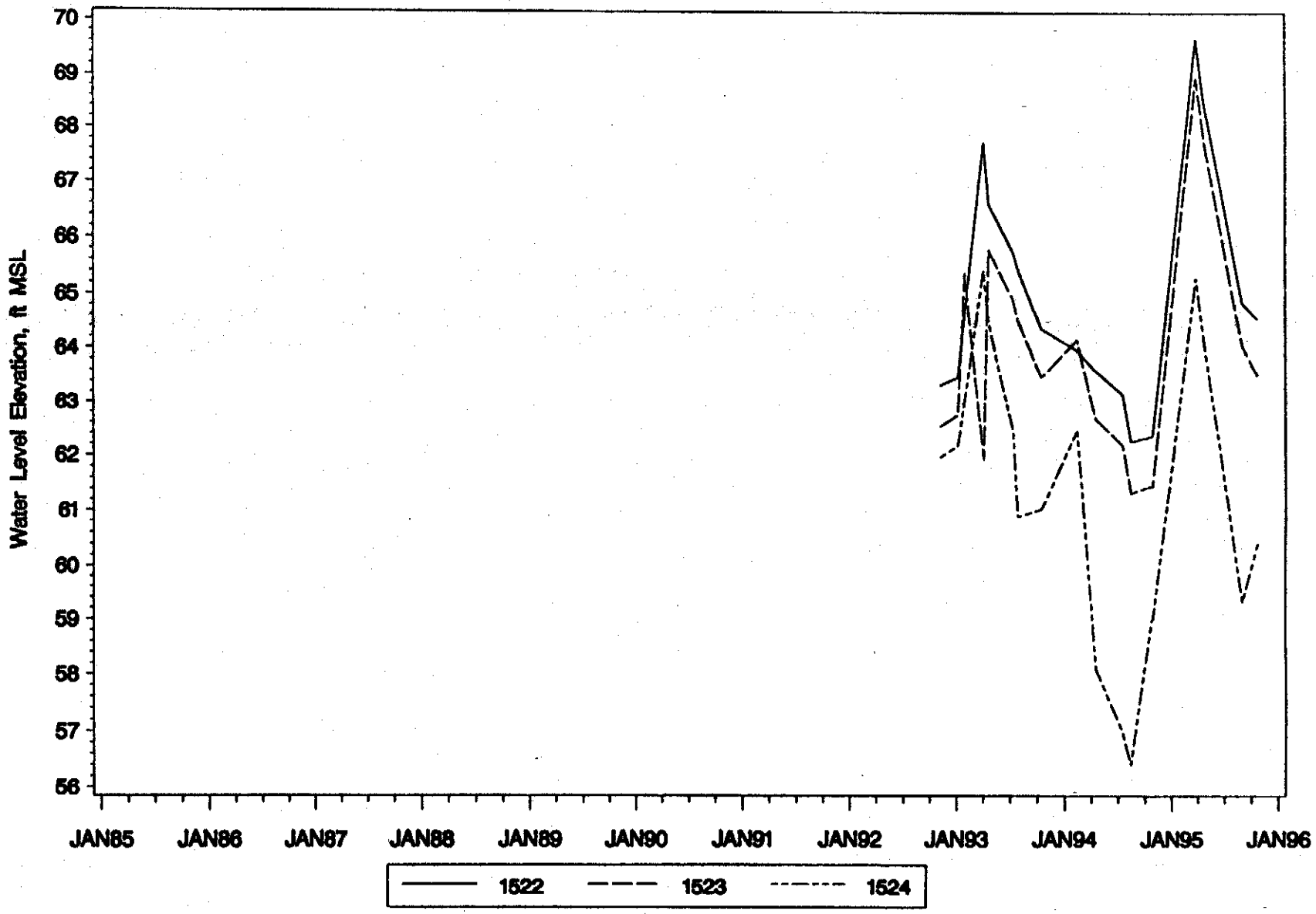


HYDROGRAPH


WELLS = 1519 – 21
Water Level Elevation, ft MSL
70
69
68
67
66
65
64
63
62
61
60
59
58
57
56
55
54
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1519
1520
1521

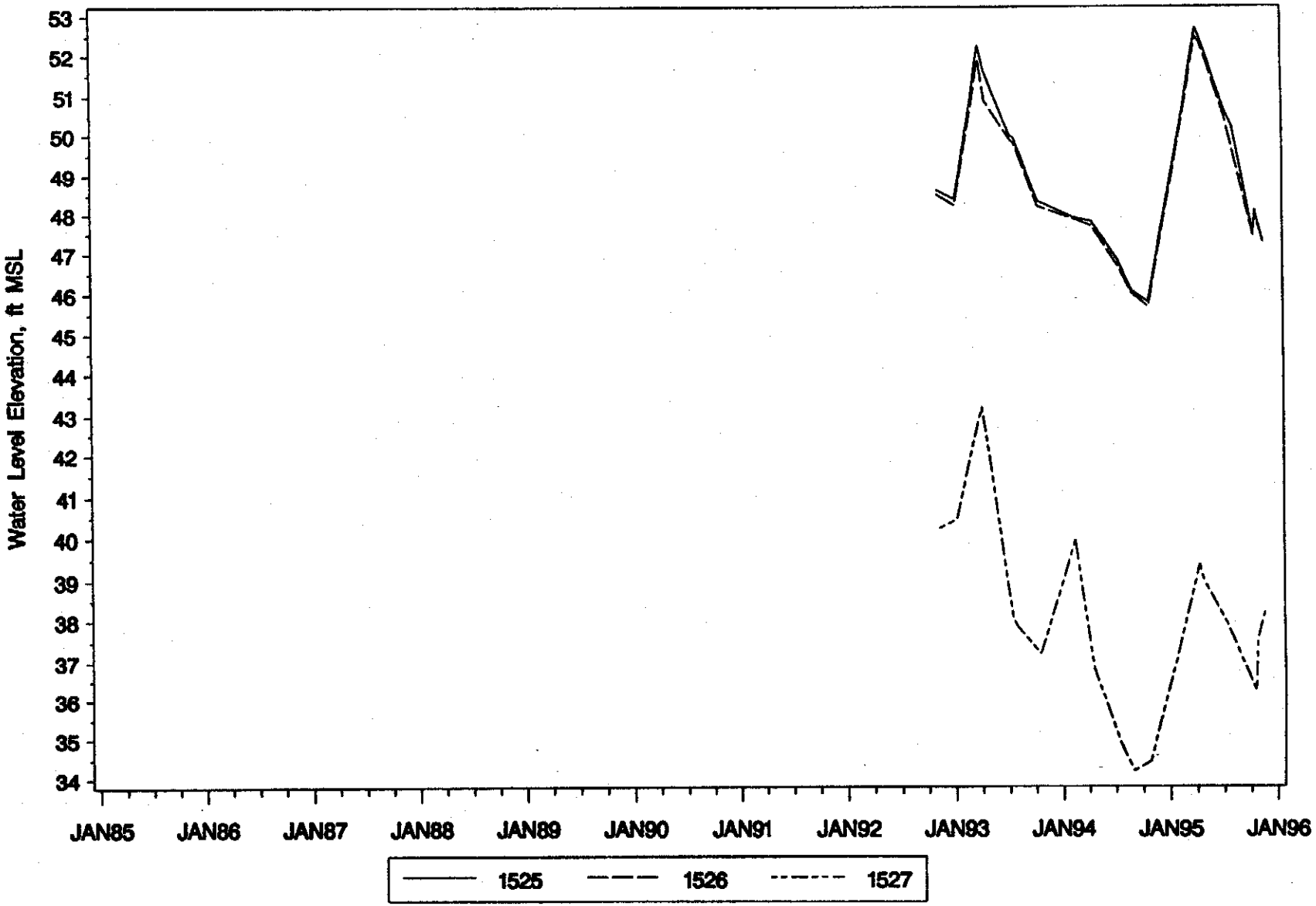
HYDROGRAPH

WELLS = 1522 – 4



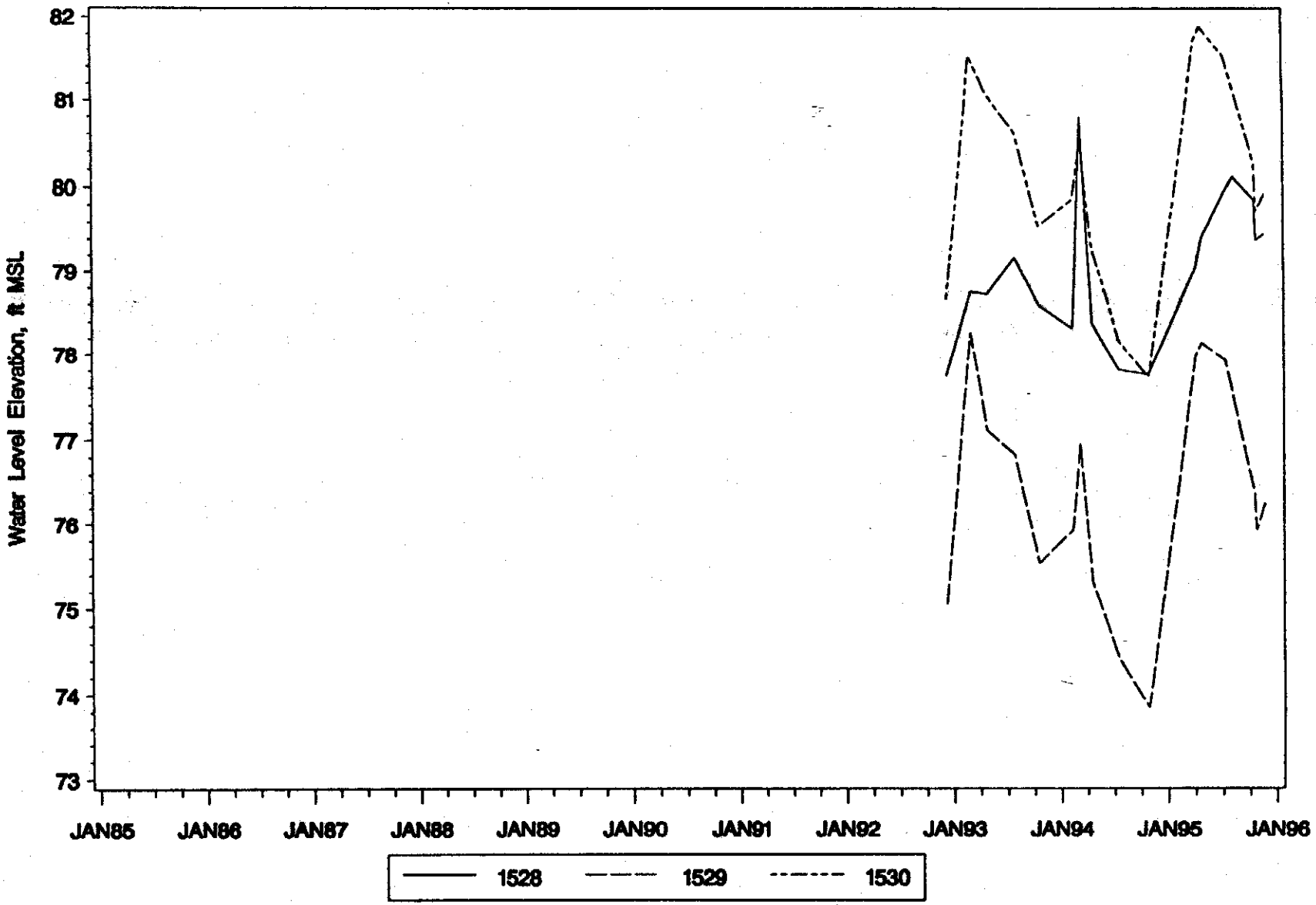
HYDROGRAPH

WELLS = 1525 – 7

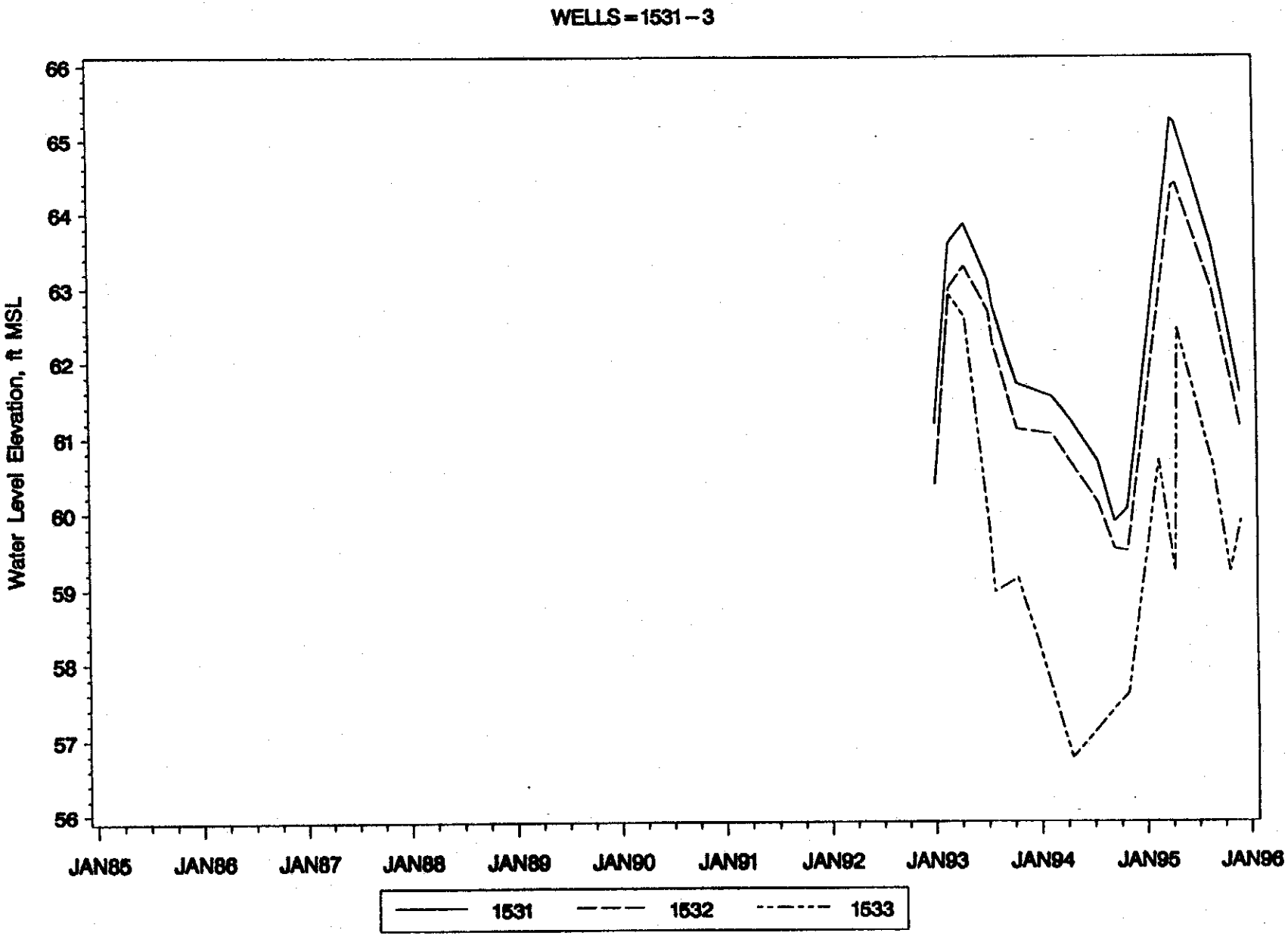


HYDROGRAPH

WELLS=1528-30

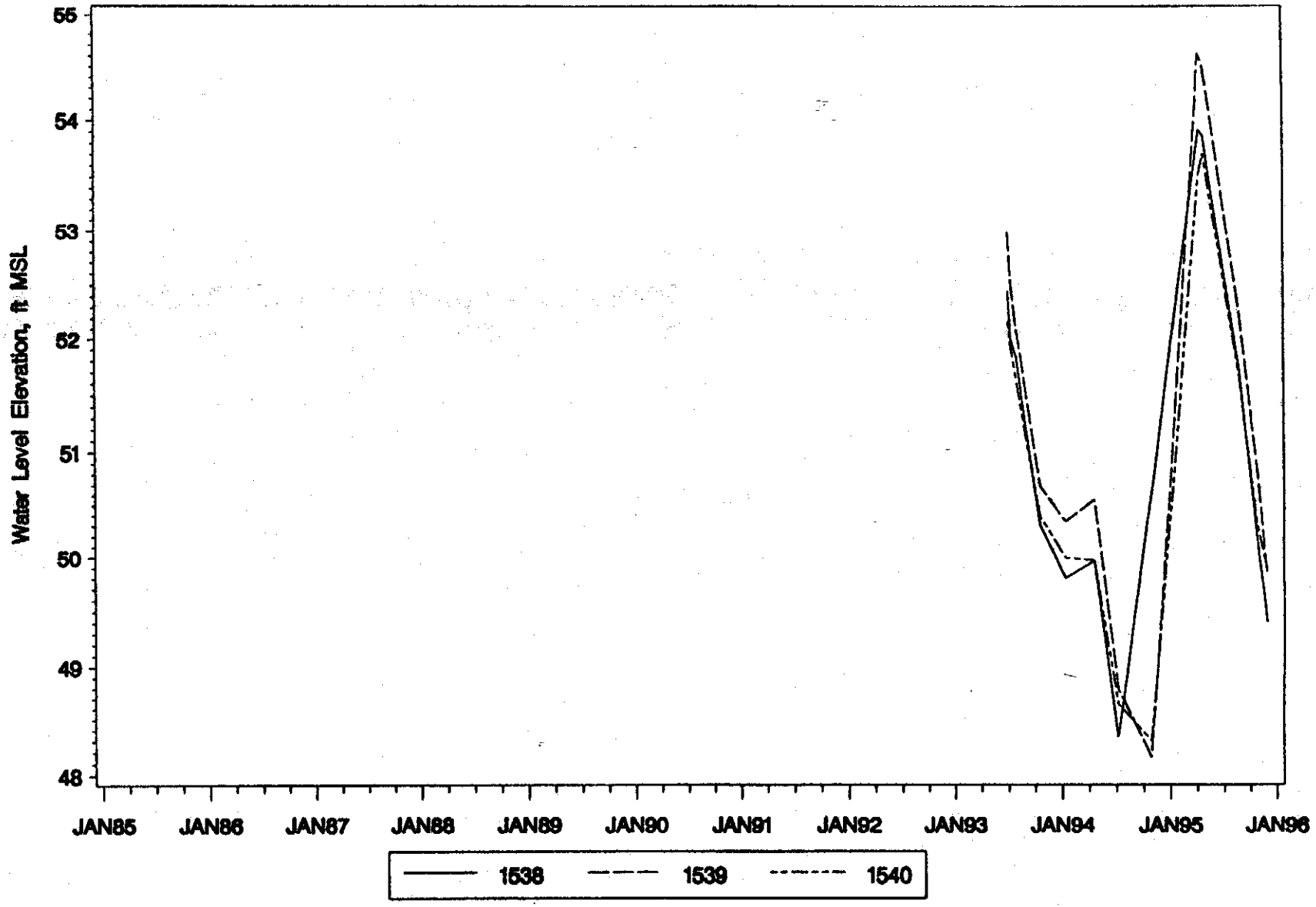


HYDROGRAPH


WELLS = 1531 – 3
Water Level Elevation, ft MSL
66
65
64
63
62
61
60
59
58
57
56
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1531
1532
1533

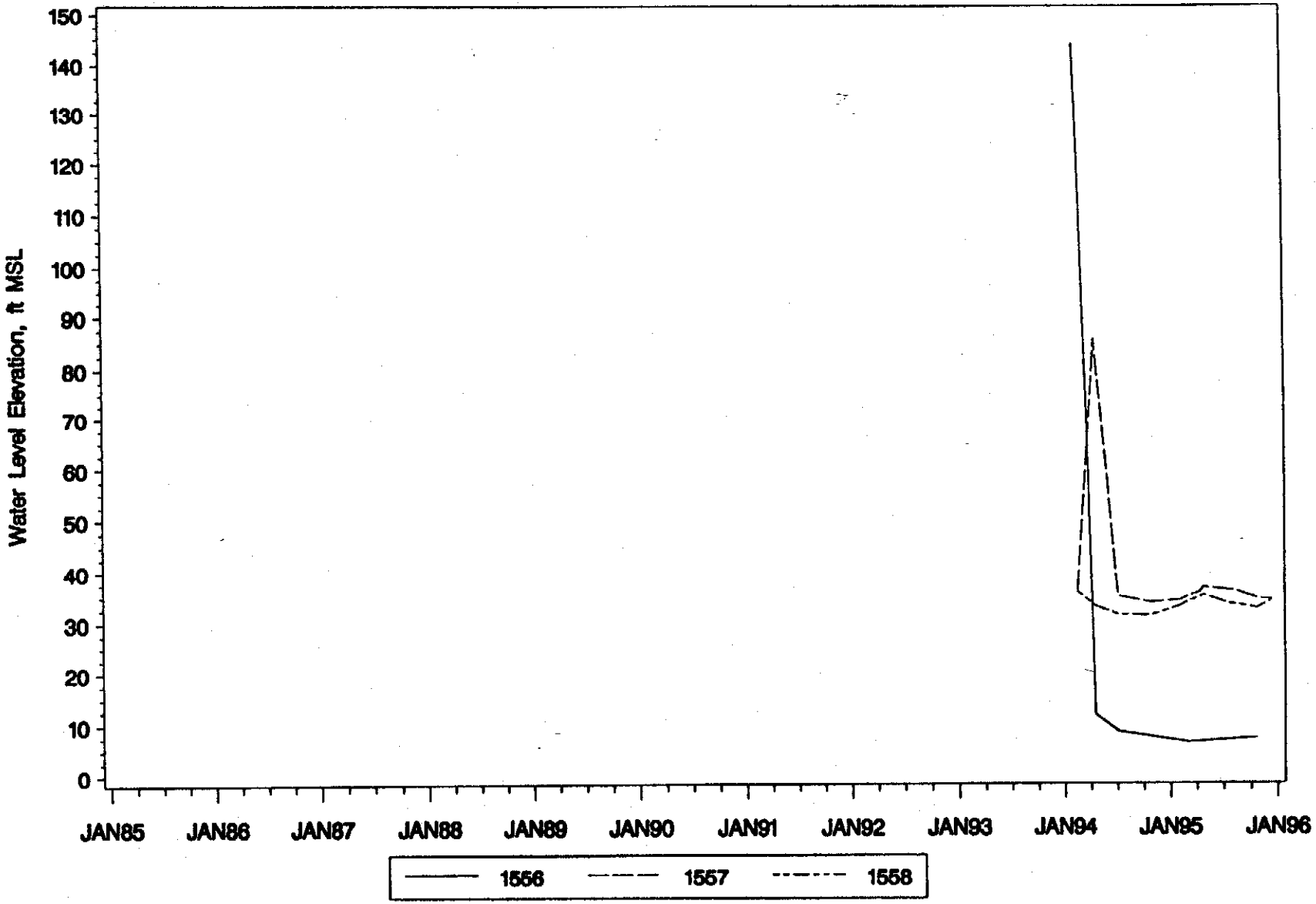
HYDROGRAPH

WELLS = 1538 – 40



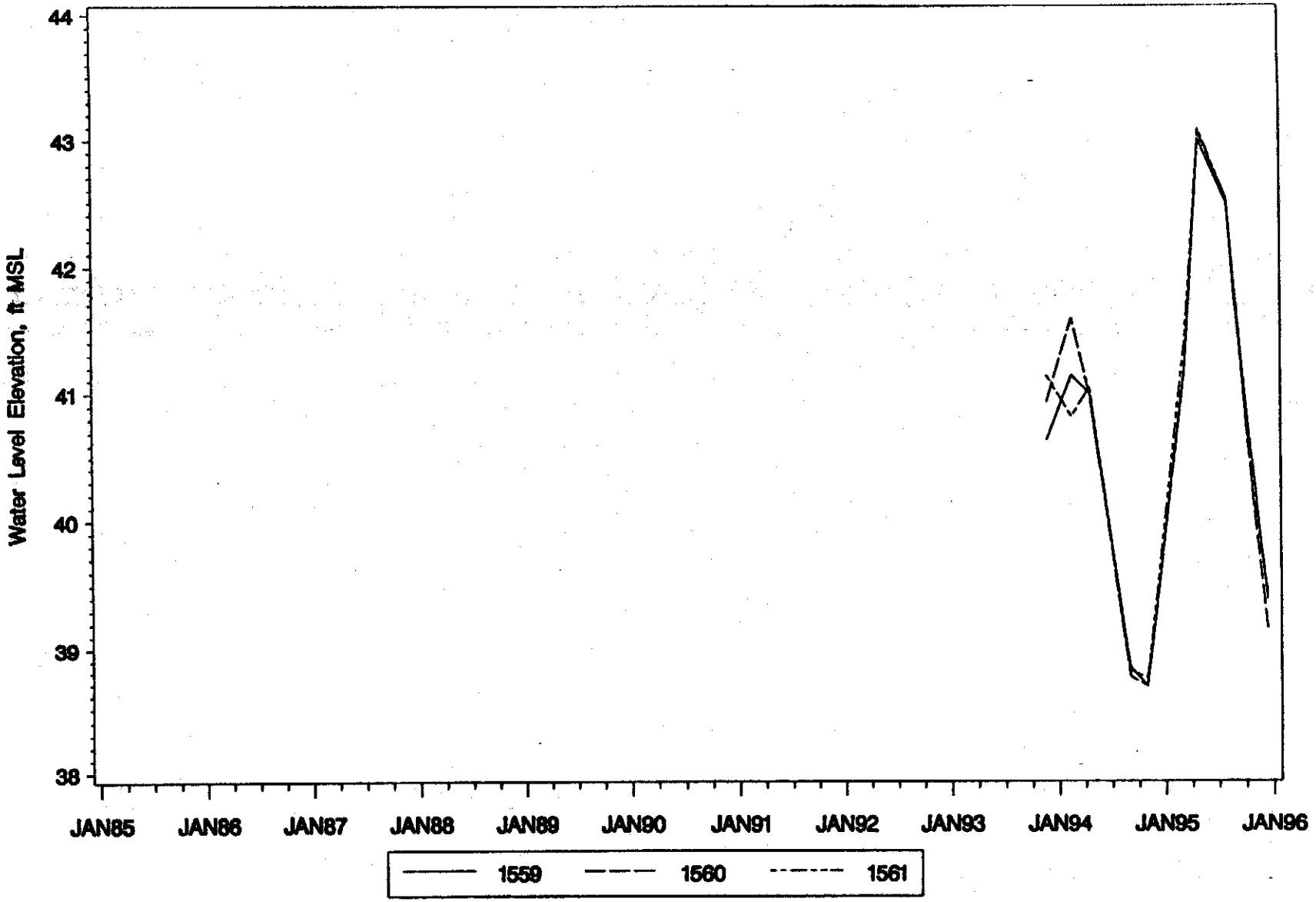
HYDROGRAPH

WELLS=1556-8



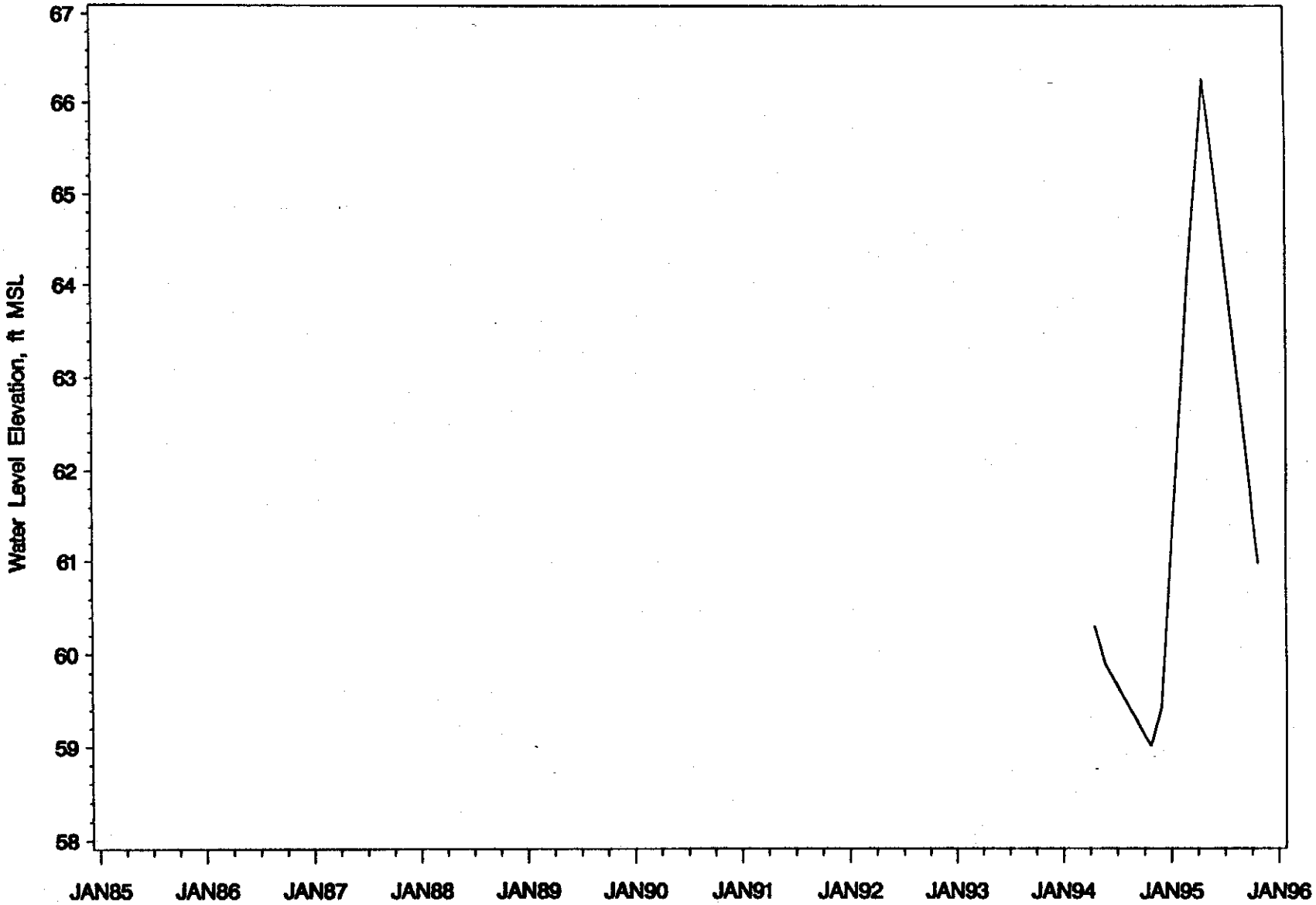
HYDROGRAPH

WELLS = 1559 – 61



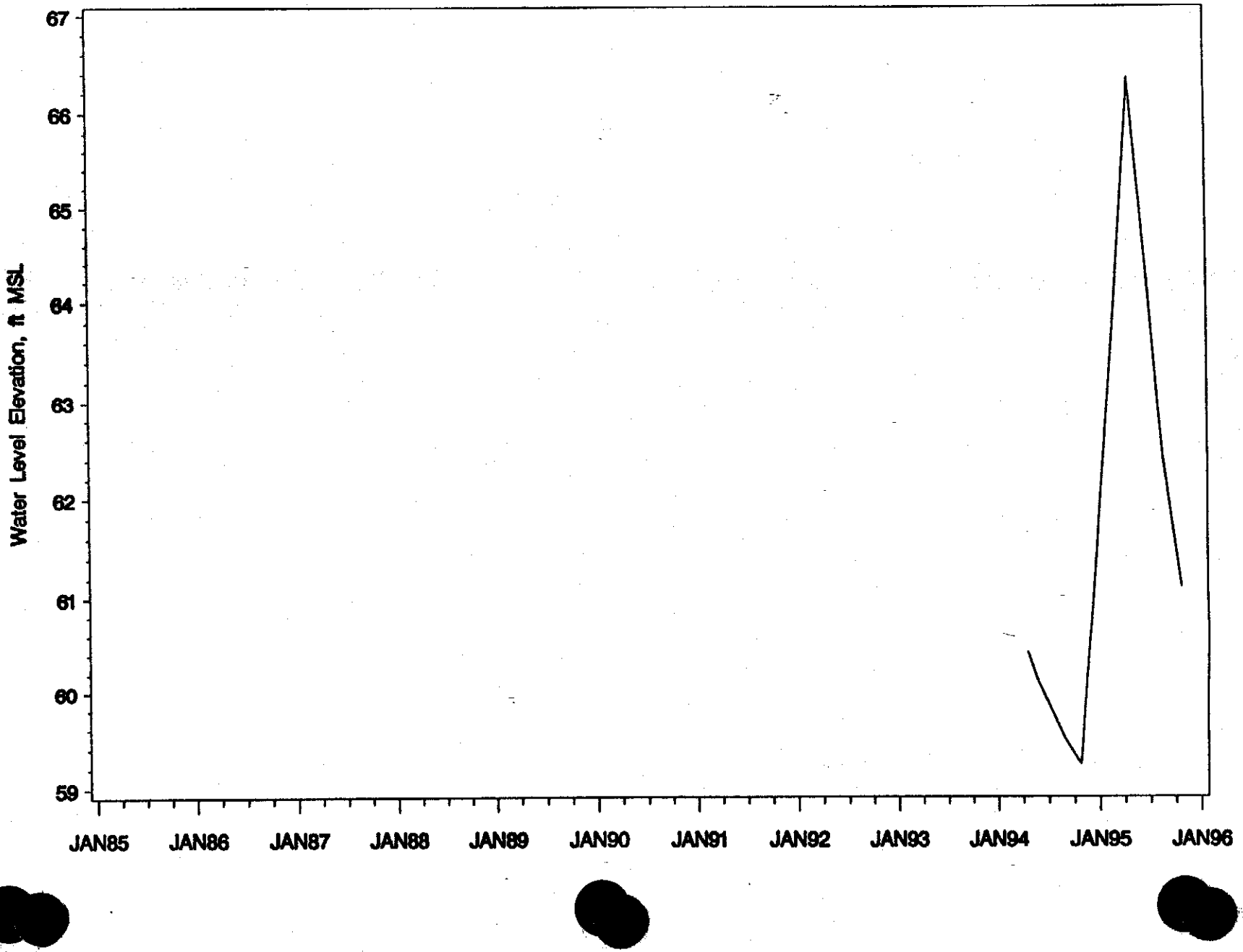
HYDROGRAPH

WELL=1562



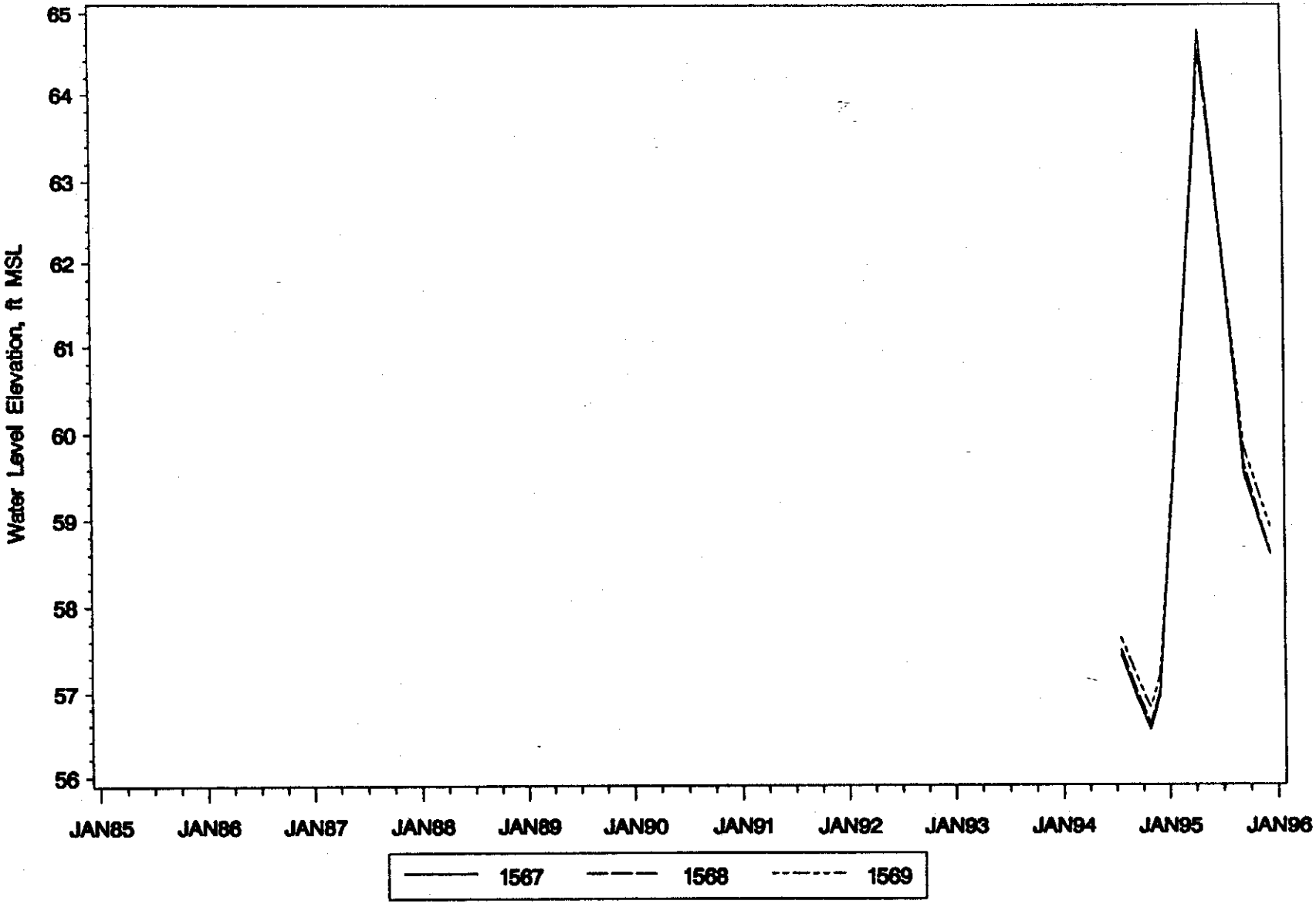
HYDROGRAPH

WELL = 1563



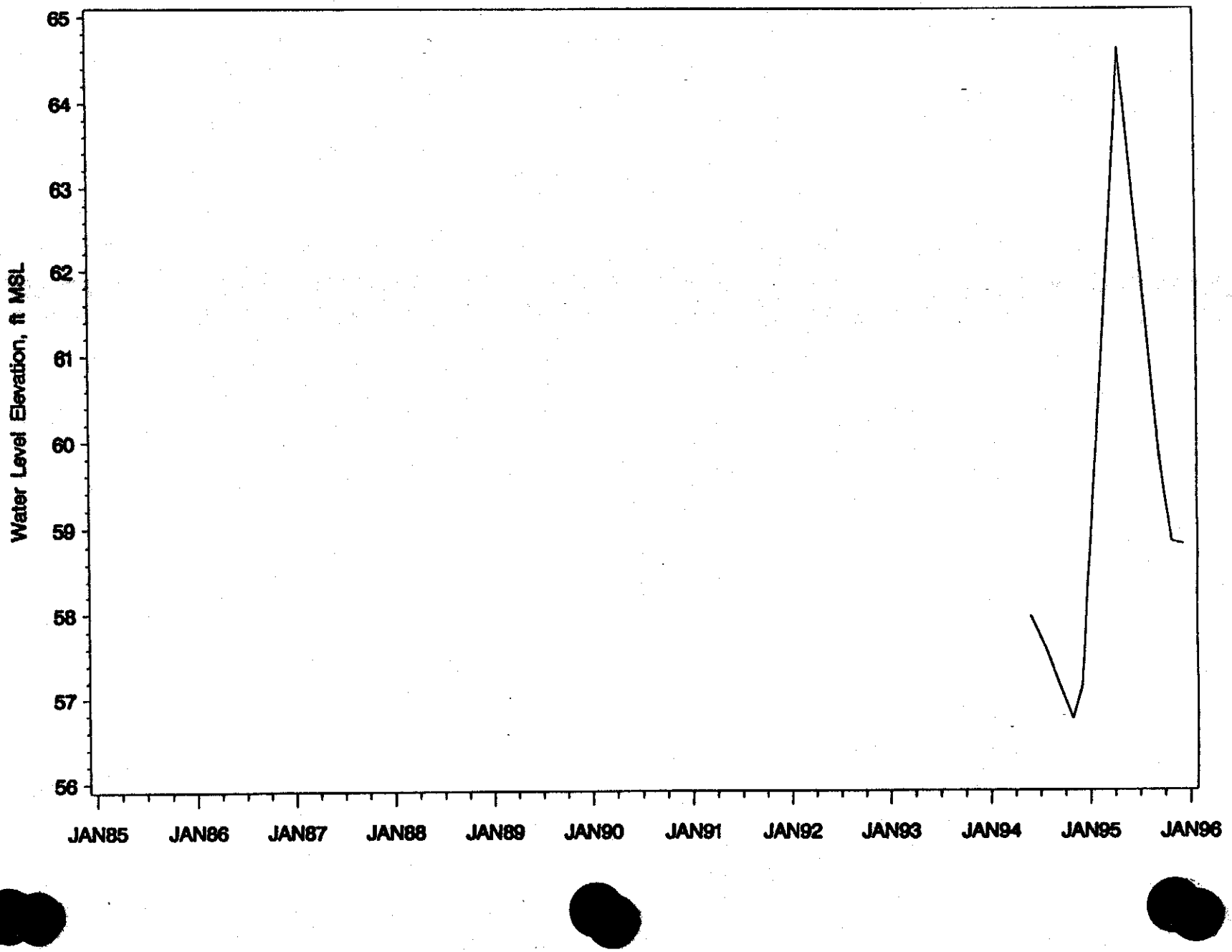
HYDROGRAPH

WELLS = 1567 – 9

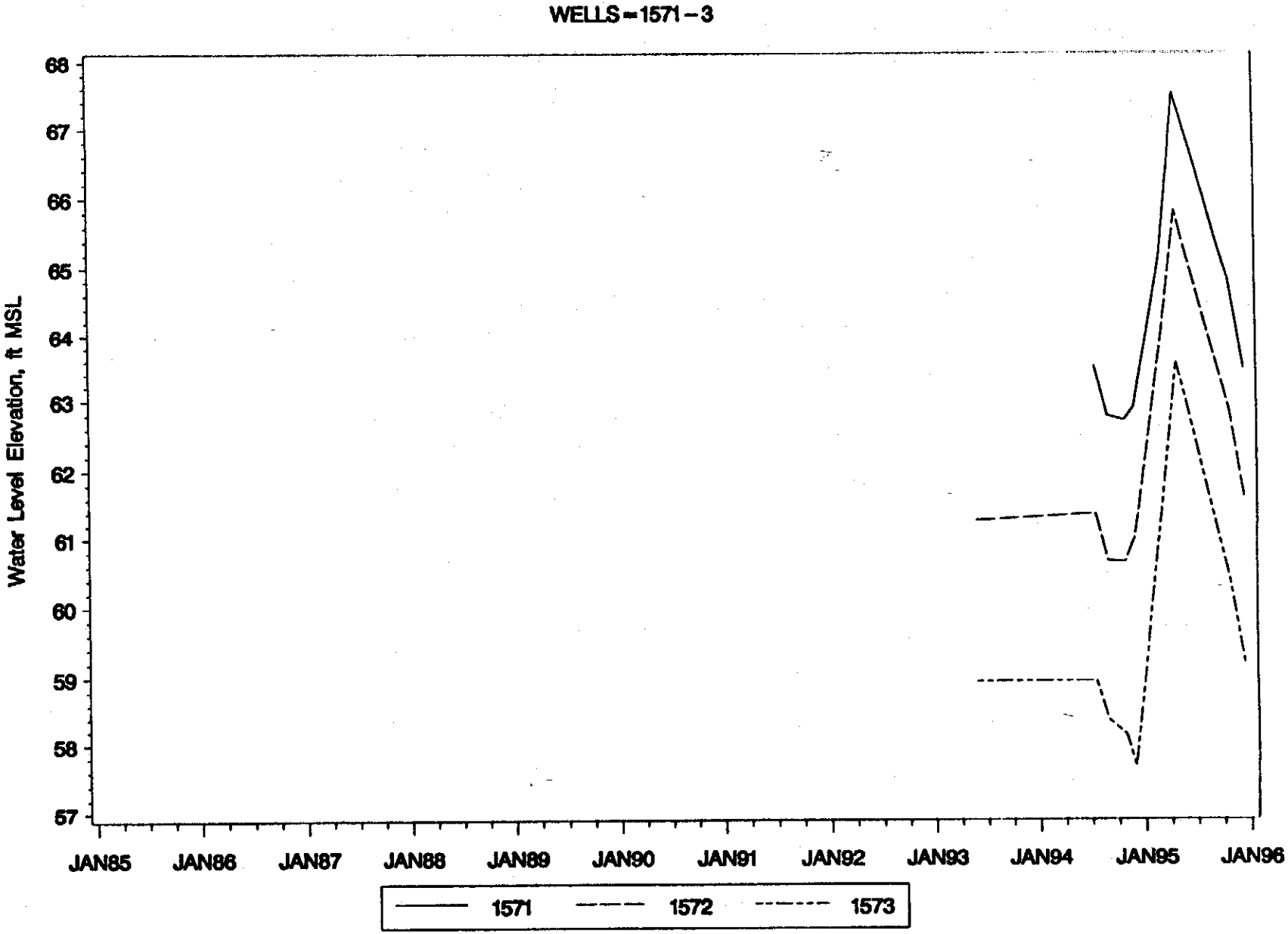


HYDROGRAPH

WELL = 1570

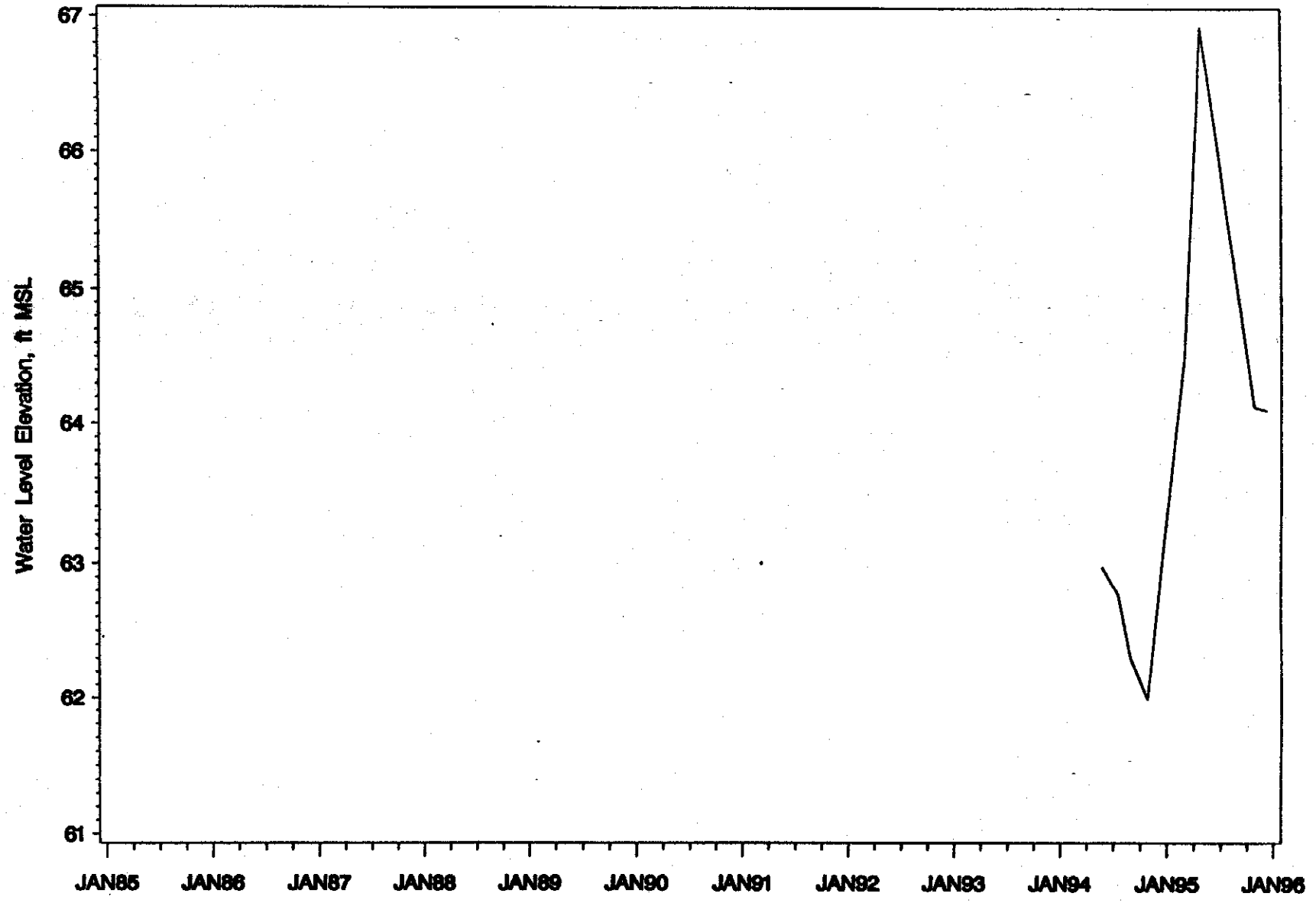


HYDROGRAPH

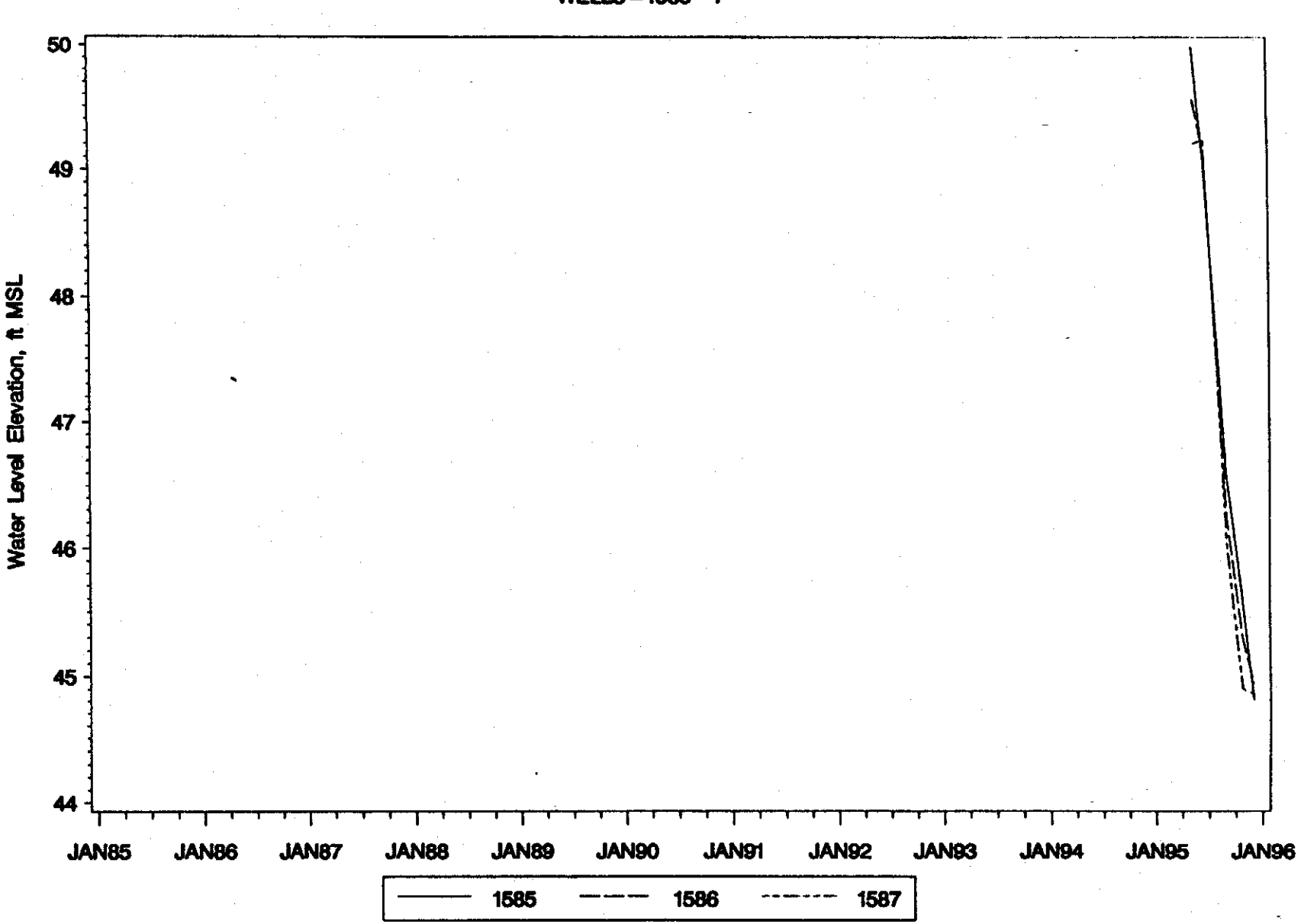

WELLS = 1571 - 3
Water Level Elevation, ft MSL
68
67
66
65
64
63
62
61
60
59
58
57
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1571
1572
1573

HYDROGRAPH

WELL=1574

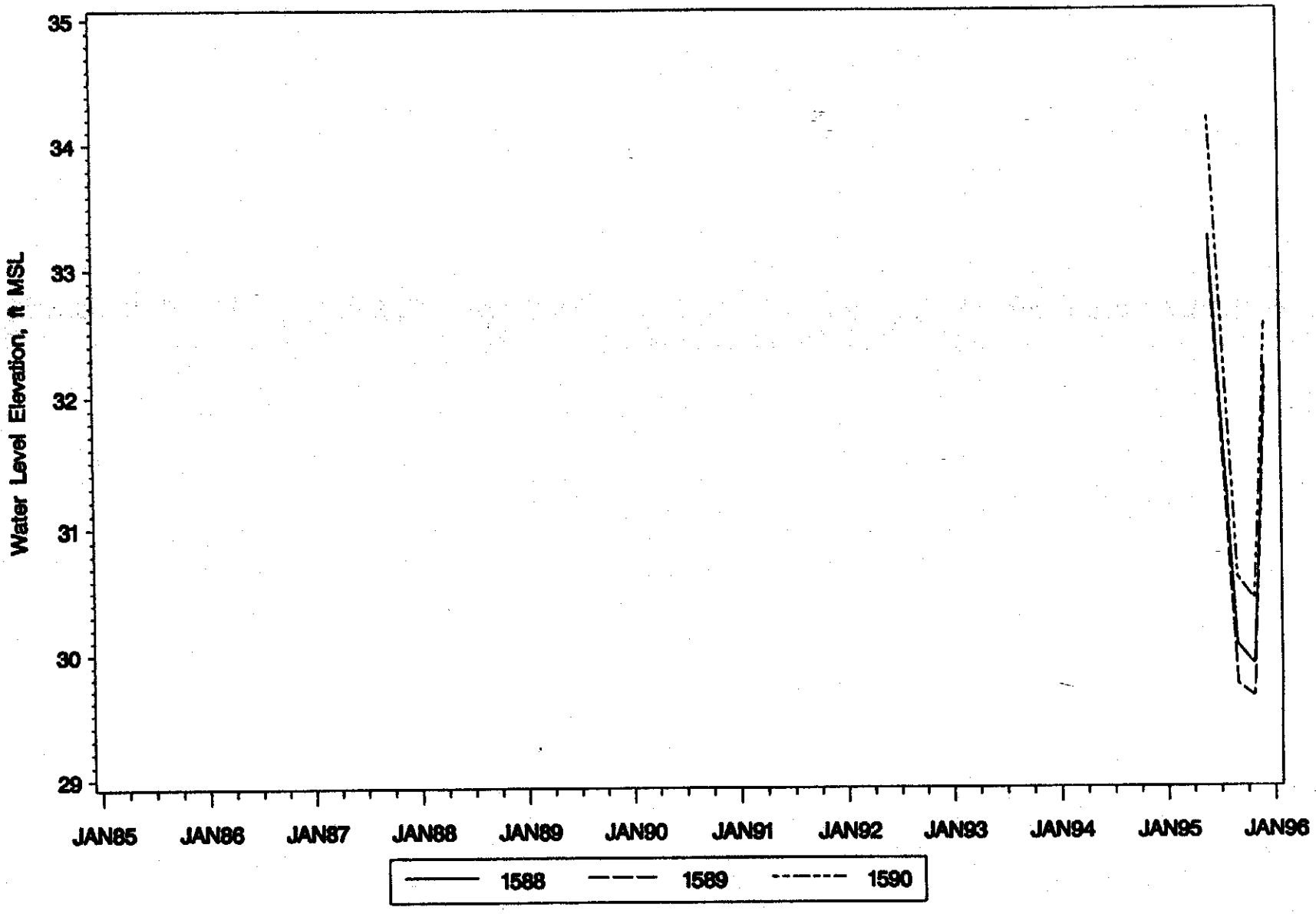


HYDROGRAPH

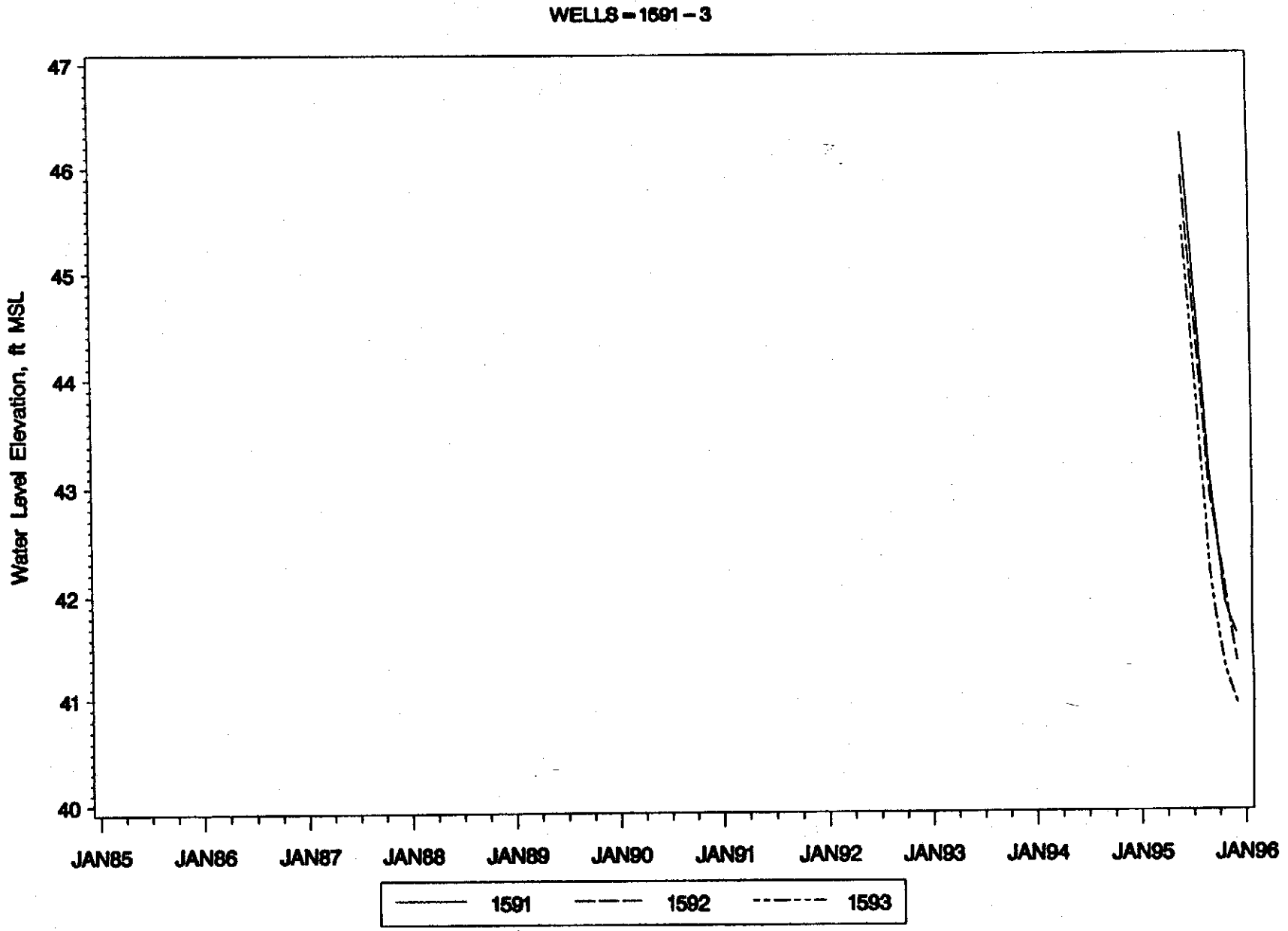

WELLS = 1585 – 7
Water Level Elevation, ft MSL
50
49
48
47
46
45
44
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1585
1586
1587

HYDROGRAPH

WELLS = 1588 – 90

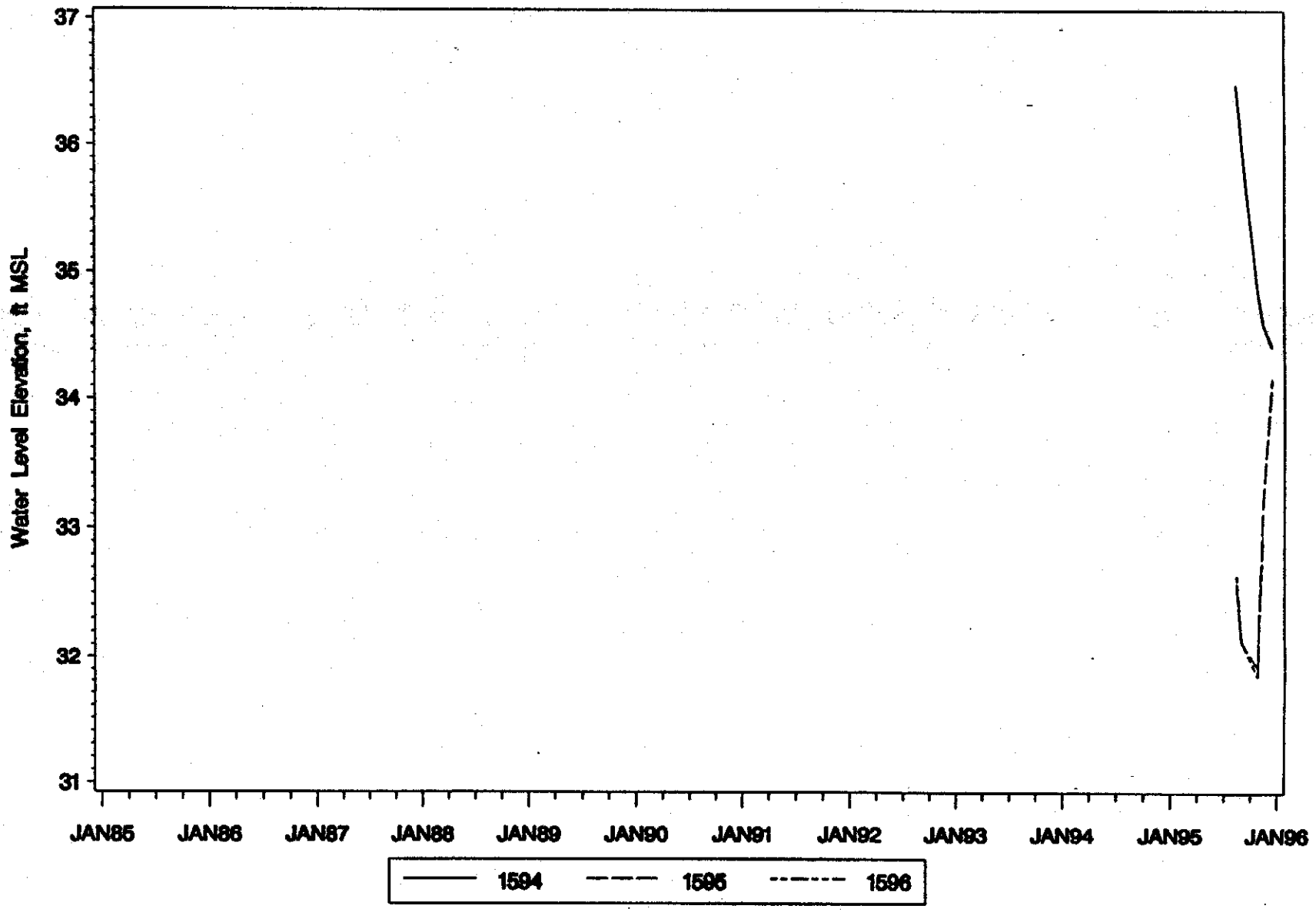


HYDROGRAPH

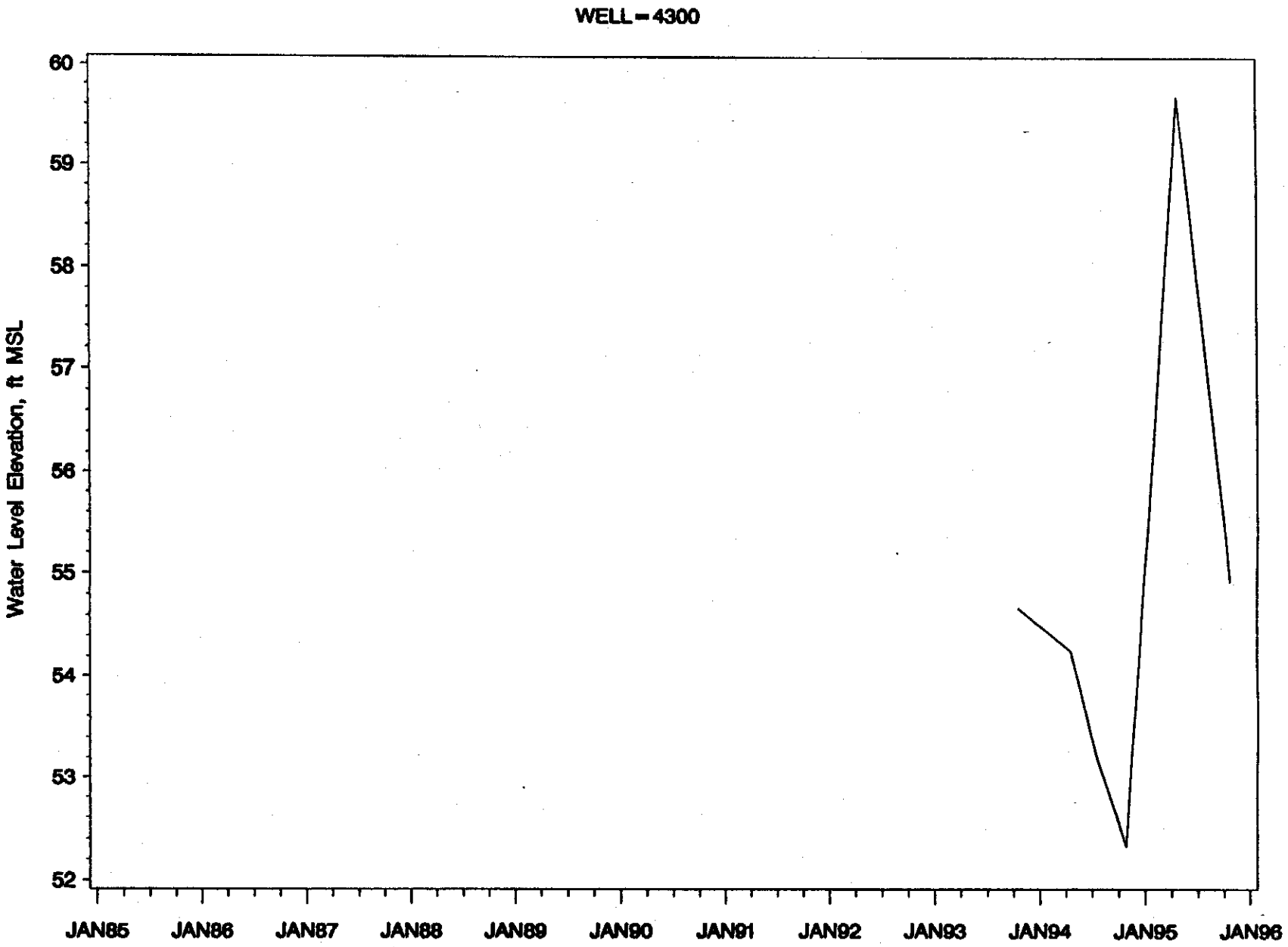

WELLS = 1591 – 3
Water Level Elevation, ft MSL
47
46
45
44
43
42
41
40
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
1591
1592
1593

HYDROGRAPH

WELLS = 1594 – 6

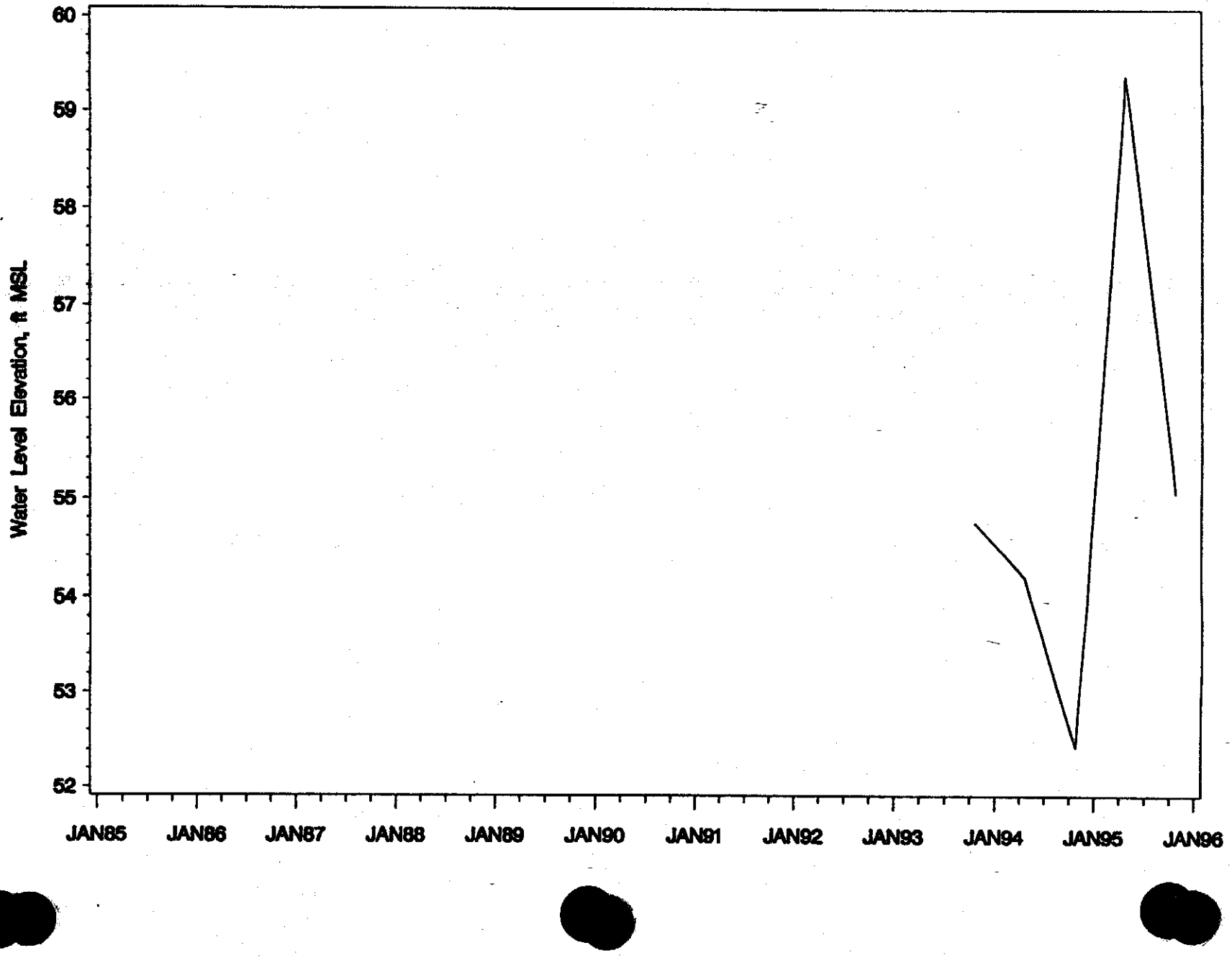


HYDROGRAPH


WELL = 4300
Water Level Elevation, ft MSL
60
59
58
57
56
55
54
53
52
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96

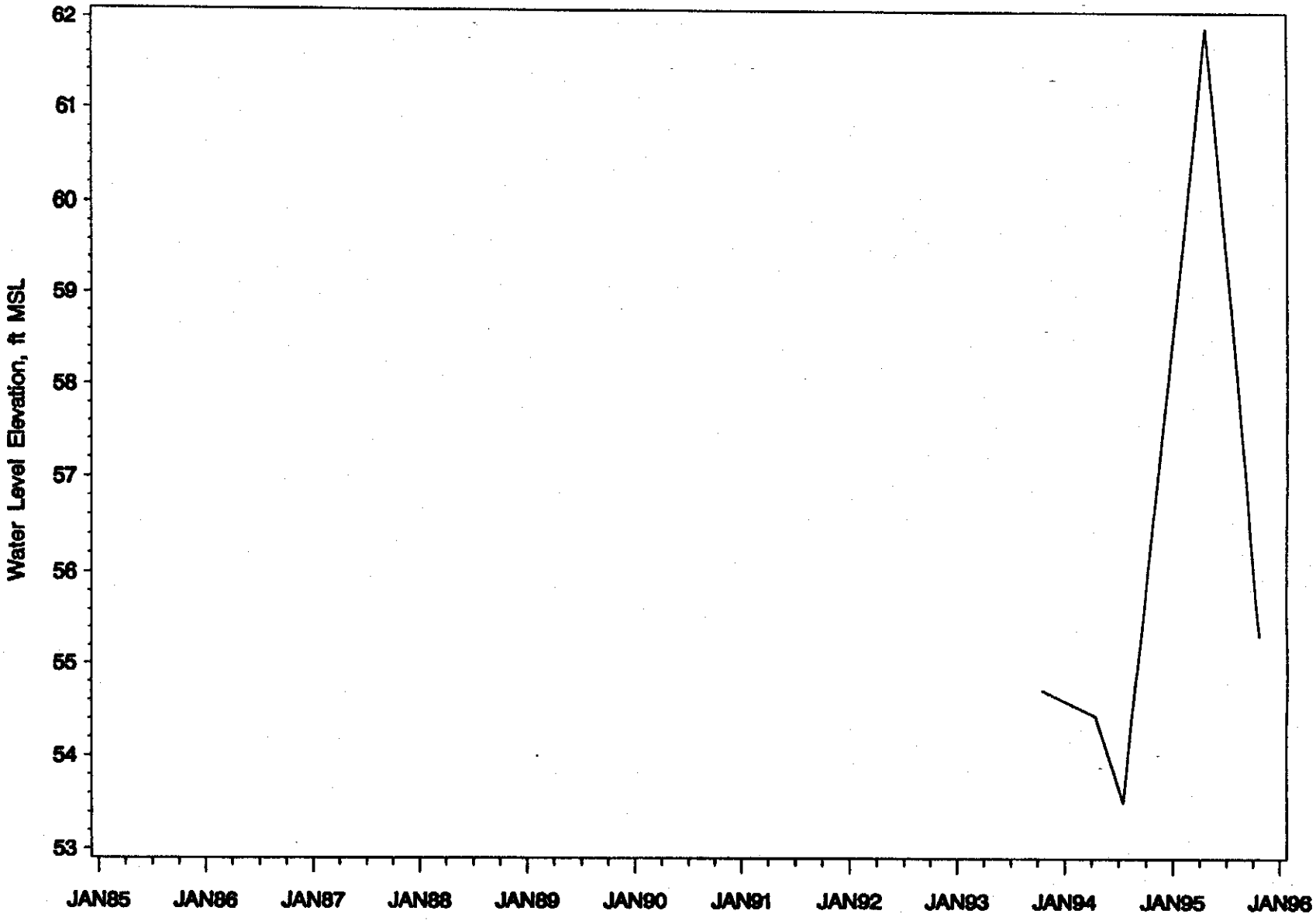
HYDROGRAPH

WELL=4301



HYDROGRAPH

WELL = 4302



APPENDIX D

Chemical Analytical Results

Table D-1. Summary of Semi Volatile Analyses. All data are listed for 1,4-dioxane. Only results above the detection limit are listed for other analytes. See Table D-2 for a list of detection limits.

Well Number	Date	1,4-Dioxane	1-Methyl-2-pyrroli-dinone	Bis(2-ethyl-hexyl) phthalate	di-n-Butyl phthalate	di-n-Octyl phthalate	n-Butyl-benzene-sulfonamide	Phenol	All Other Semi-Volatiles Measured
1041	NS								
1047	09/29/93	<3							ND
	09/13/95	<10							ND
1049	09/29/93	<3							ND
	09/13/95	<10							ND
1154	08/30/95	<10							ND
1158	09/06/95	<10							ND
1162	02/01/93	7							NM
	06/07/93	<10							ND
	02/21/95	<10		60					ND
	10/02/95	<10							ND
1163	02/01/93	<3							NM
	03/01/93	<3							NM
	06/07/93	<10							ND
	02/21/95	<10		90					ND
	10/02/95	<10							ND
1164	02/03/93	25		NM					NM
	06/07/93	20							ND
	01/14/94	20							ND
	02/21/95	10							ND
	10/02/95	13		70					ND
1169	03/17/94	<10							ND
	07/06/95	<10	60					10	ND
1170	03/17/94	120						10	ND
	07/06/95	<10							ND
1171	03/16/94	<10	30						ND
	07/05/95	<10							ND
1211	02/24/93	49							NM
	08/09/95	<10							ND
1214	09/21/95	13							ND
1216	08/16/95	11							ND
1224	NS								
1357	01/25/93	53							ND
	06/09/93	30							ND
	09/15/95	25							ND
1358	01/26/93	34							NM
	06/09/93	30							ND
	09/18/95	25							ND
1359	01/26/93	14							NM
	09/15/95	23							ND
1360	01/26/93	<3							NM
	03/01/93	<3							NM
	07/27/93	<10		51			110		ND
	09/11/95	<10					1200		ND
1361	02/03/93	<3							NM
	06/08/93	<10							ND
	01/02/95	<10					110		ND
	08/17/95	<10							ND
1362	02/03/93	3							NM
	02/06/95	<10							ND
	08/17/95	<10							ND
1363	02/03/93	6							NM
	06/07/93	<10							ND
	02/06/95	<10		90	50				ND
	08/17/95	<10							ND

Well Number	Date	1,4-Dioxane	1-Methyl-2-pyrroli-dinone	Bis(2-ethyl-hexyl) phthalate	di-n-Butyl phthalate	di-n-Octyl phthalate	n-Butyl-benzene-sulfonamide	Phenol	All Other Semi-Volatiles Measured
1364	02/03/93	<3							NM
	02/06/96	<10					360		ND
	08/30/95	<10					1100		ND
1365	02/03/93	<3							NM
	02/06/95	<10					230		ND
	08/30/95	<10					1200		ND
1370	02/06/93	31							NM
	06/23/94	30							ND
	01/23/95	30		70					ND
	09/08/95	29							ND
1371	02/06/93	9							NM
	06/23/94	<10							ND
	01/23/95	10							ND
	09/08/95	<10							ND
1372	02/06/93	<3							NM
	06/23/94	<10							ND
	01/23/95	<10							ND
	09/08/95	<10							ND
1373	02/09/93	<3							NM
	06/23/94	<10					370		ND
	01/25/95	<10					350		ND
	09/08/95	<10					1400		ND
1374	02/09/93	<3							NM
	06/23/94	<10					3000	10	ND
	01/25/95	<10					410		ND
	09/08/95	<10					1000		ND
1375	02/26/93	<3							NM
	07/20/95	<10							ND
1376	02/26/93	47							NM
	07/20/95	16							ND
1377	02/26/93	6							NM
	07/20/95	<10							ND
1378	02/26/93	<3							NM
	07/12/95	<10					44		ND
1379	02/26/93	36							NM
	07/19/95	22							ND
1380	02/10/93	32							NM
	08/24/95	16					770		ND
1381	02/10/93	9							NM
	08/24/95	<10					990		ND
1382	01/25/93	36							ND
	07/22/93	20							ND
	08/30/95	13							ND
1383	08/01/93	40							NM
	06/07/93	30							ND
	08/30/95	24							ND
1384	02/01/93	26							NM
	06/07/93	20							ND
	08/29/95	<10							ND
1385	02/01/93	23							NM
	02/16/95	<10		60					ND
	08/23/95	<10							ND
1386	02/01/93	7							NM
	02/16/95	<10							ND
	08/23/95	<10					14		ND

Table D-1 Continued. Summary of Semi Volatile Analyses.

Well Number	Date	1,4-Dioxane	1-Methyl-2-pyrroli-dinone	Bis(2-ethyl-hexyl) phthalate	di-n-Butyl phthalate	di-n-Octyl phthalate	n-Butyl-benzene-sulfonamide	Phenol	All Other Semi-Volatiles Measured
1387	02/01/93	<3							NM
	03/01/93	<3							NM
	02/16/95	<10					260		ND
	08/23/95	<10					1300		ND
1388	02/09/93	36							NM
	08/21/95	23							ND
1389	02/09/93	8							NM
	08/21/95	23							ND
1390	02/09/93	<3							NM
	08/18/95	<10							ND
1391	02/09/93	20							NM
	07/21/95	12							ND
1392	02/08/93	27							NM
	07/20/95	16							ND
1393	02/09/93	39							NM
	07/20/95	23							ND
1394	02/10/93	<3							NM
	07/21/95	<10					40		ND
1395	03/03/93	<3							NM
	07/12/93	<10							ND
	08/04/93	<3							NM
	08/22/94	<10							ND
	04/05/95	<10							ND
	09/07/95	<10							ND
1396	03/03/93	<3							NM
	07/12/93	<10							ND
	08/04/93	<3							NM
	08/22/94	<10							ND
	04/05/95	<10							ND
	09/07/95	<10							ND
1397	03/03/93	<3							NM
	07/12/93	<10							ND
	08/04/93	<3							NM
	08/22/94	<10							ND
	04/05/95	<10							ND
	09/07/95	<10							ND
1398	03/09/93	<3							NM
	07/12/93	<10					100		ND
	08/04/93	<3							NM
	08/22/94	<10					450		ND
	04/06/95	<10					80		ND
	09/11/95	<10		57			1200		ND
1399	03/09/93	<3							NM
	07/12/93	<10					2000		ND
	08/04/93	<3							NM
	08/22/94	<10					230		ND
	04/06/95	<10					80		ND
	09/06/95	<10					1600		ND
1400	02/03/93	10							NM
	08/31/95	11		61					ND
1401	02/04/93	8							NM
	08/31/95	11		82					ND
1402	02/04/93	<3							NM
1403	02/25/93	27							NM
	[redacted]	20							ND

Well Number	Date	1,4-Dioxane	1-Methyl-2-pyrroli-dinone	Bis(2-ethyl-hexyl) phthalate	di-n-Butyl phthalate	di-n-Octyl phthalate	n-Butyl-benzene-sulfonamide	Phenol	All Other Semi-Volatiles Measured
1403	07/18/95	<10							ND
1404	02/25/93	34							NM
	08/14/93	40							ND
	07/18/95	25							ND
1405	02/25/93	32							NM
	07/18/95	19							ND
1406	03/03/93	<3							NM
	07/14/93	<3							NM
1407	03/03/93	<3							NM
	07/14/93	<3							NM
	07/11/95	<10							ND
1408	03/03/93	<3							NM
	07/13/93	<3							NM
1409	03/03/93	<3							NM
	08/05/93	<3							NM
1469	02/26/93	14							NM
	09/08/95	11							ND
1470	02/26/93	7							NM
	09/11/95	<10							ND
1471	02/26/93	10							NM
	09/12/95	10							ND
1472	03/02/93	17							NM
	08/11/95	<10							ND
1473	02/26/93	<3							NM
	08/16/95	<10							ND
1474	02/26/93	<3							NM
	08/11/95	<10							ND
1475	01/25/93	15							ND
	07/22/93	10							ND
	02/06/95	<10							ND
	08/21/95	<10							ND
1476	01/25/93	8							ND
	08/23/93	<10							ND
	02/06/95	<10							ND
	08/23/95	<10							ND
1477	01/25/93	31							ND
	07/22/93	30							ND
	02/06/95	20							ND
	08/23/95	14							ND
1478	02/25/93	<3							NM
	07/13/93	<3							ND
	08/11/94	<10							ND
	04/04/95	<10							ND
	09/14/95	<10							ND
1479	02/25/93	<3							NM
	07/12/93	<3							ND
	08/11/94	<10							ND
	04/04/95	<10							ND
	09/14/95	<10							ND
1480	02/25/93	<3							NM
	07/12/93	<10							ND
	08/04/93	<3							NM
	08/11/94	<10							ND
	04/04/95	<10							ND
	09/14/95	<10							ND

Table D-1 Continued. Summary of Semi Volatile Analyses.

Well Number	Date	1,4-Dioxane	1-Methyl-2-pyrroli-dinone	Bis(2-ethyl-hexyl) phthalate	di-n-Butyl phthalate	di-n-Octyl phthalate	n-Butyl-benzene-sulfonamide	Phenol	All Other Semi-Volatiles Measured
1481	03/04/93	<3							NM
	09/19/95	<10							ND
1482	03/02/93	<3							NM
	09/18/95	<10							ND
1483	03/02/93	<3							NM
	09/18/95	<10							ND
1487	03/01/93	<3							NM
	08/15/94	<10							ND
	01/19/95	<10		190		30			ND
	09/20/95	<10			33		12		ND
1488	03/01/93	<3							NM
	08/15/94	<10							ND
	01/19/95	<10		340					ND
	09/20/95	<10							ND
1489	03/01/93	<3							NM
	06/23/94	<10							ND
	01/19/96	<10		140		30			ND
	09/19/95	<10							ND
1506	01/18/93	<3							NM
	04/20/93	<3							ND
	09/20/95	<10							ND
1507	01/18/93	<3							NM
	04/20/93	<3							ND
	09/21/95	<10							ND
1508	01/18/93	<3							NM
	04/20/93	<3							ND
	09/21/95	<10							ND
1509	01/14/93	<3							NM
	04/20/93	<3							ND
	07/15/93	<3							NM
	09/22/95	<10							ND
1510	01/14/93	<3							NM
	04/20/93	<3							ND
	07/15/93	<3							NM
	09/22/95	<10							ND
1511	01/15/93	<3							NM
	04/20/93	<3							ND
	07/15/93	<3							NM
	09/22/95	<10							ND
1516	01/14/93	<3							NM
	03/30/93	<3							ND
	06/21/93	<10							ND
	08/14/95	<10							ND
1517	01/26/93	<3							ND
	03/02/93	<3							NM
	08/24/95	<10							ND
1518	01/25/93	<3							ND
	03/02/93	<3							NM
	08/25/95	<10							ND
1519	01/06/93	<10							ND
	04/07/93	<3							NM
	07/23/93	<3							NM
	02/14/94	<3							NM
	08/12/94	<10							ND
	03/27/95	<10							ND
	09/06/95	<10							ND

Well Number	Date	1,4-Dioxane	1-Methyl-2-pyrroli-dinone	Bis(2-ethyl-hexyl) phthalate	di-n-Butyl phthalate	di-n-Octyl phthalate	n-Butyl-benzene-sulfonamide	Phenol	All Other Semi-Volatiles Measured
1520	01/06/93	<10							ND
	04/07/93	<3							NM
	07/23/93	<3							NM
	02/14/94	<3							NM
	03/27/95	<10		60	-				ND
	09/06/95	<10							ND
1521	01/06/93	<10							ND
	04/07/93	<3							NM
	07/23/93	<3							NM
	02/14/94	<3							NM
	08/12/94	<10							ND
	03/27/95	<10							ND
	09/06/95	<10							ND
1522	01/06/93	<10							ND
	04/06/93	<3							NM
	07/15/93	<3							NM
	09/15/94	<3							NM
	08/15/94	<10							ND
	03/27/95	<10							ND
	09/01/95	<10							ND
1523	01/06/93	<10							ND
	04/06/93	3							NM
	07/15/93	<3							NM
	02/14/94	<3							NM
	08/15/94	<10							ND
	03/27/95	<10							ND
	09/01/95	<10							ND
1524	01/06/93	<10							ND
	04/06/93	<3							NM
	07/15/93	<3							NM
	02/14/94	<3							NM
	08/15/94	<10							ND
	03/27/95	<10							ND
	09/01/95	<10							ND
1525	01/06/93	<10							ND
	04/05/93	<3							NM
	07/16/93	<3							NM
	02/15/94	<3							NM
	07/06/95	<10							ND
1526	01/06/93	<10							ND
	04/06/93	<3							NM
	07/16/93	<3							NM
	02/15/94	<3							NM
	07/11/95	<10							ND
1527	01/06/93	<10		120					ND
	04/06/93	<3							NM
	07/16/93	<3							NM
	02/15/94	<3							NM
	07/11/95	<10							ND
1528	03/01/93	<3							NM
	02/11/94	<3							NM
	07/10/95	<10		50					ND
1529	03/01/93	<3							NM
	02/11/94	<3							NM
	07/10/95	<10		56					ND
1530	03/01/93	<3							NM

Table D-1 Continued. Summary of Semi Volatile Analyses.

Well Number	Date	1,4-Dioxane	1-Methyl-2-pyrroli-dinone	Bis(2-ethyl-hexyl) phthalate	di-n-Butyl phthalate	di-n-Octyl phthalate	n-Butyl-benzene-sulfonamide	Phenol	All Other Semi-Volatiles Measured
1530	02/11/94	<3							NM
	07/10/95	<10							ND
1531	01/05/93	<10							ND
	03/01/93	<3							NM
	07/14/93	<3							NM
	02/15/94	<3							NM
	06/25/94	<10							ND
1532	01/05/93	<10							ND
	03/01/93	<3							NM
	07/15/93	<3							NM
	02/15/94	<3							NM
	06/25/94	<10							ND
1533	01/05/93	<10		80					ND
	03/01/93	<3							NM
	07/15/93	<3							NM
	02/15/94	<3							NM
	06/24/94	<10							ND
1536	07/02/93	<3							ND
	04/20/94	<10							ND
	06/23/95	<10							ND
1539	07/02/93	<3							ND
	06/25/95	<10							ND
1540	07/02/93	<3							ND
	04/20/94	<10							ND
	06/25/95	<10							ND
1556	NS								
1557	12/13/93	<10							ND
	06/21/95	<10							ND
1558	12/13/93	<10							ND
	06/21/95	<10							ND
1559	12/13/93	<10							ND
	06/23/95	<10							ND
1560	12/13/93	<10		70					ND
	06/23/95	<10							ND
1561	12/13/93	<10							ND
	06/23/95	<10							ND
1562	06/28/94	<10							ND
	06/18/95	<10							ND
1563	05/25/94	<10							ND
	06/18/95	<10							ND
1564	05/24/94	<10							ND
1565	05/24/94	<10							ND
	07/13/95	<10							ND
1566	05/25/94	<10							ND
	07/13/95	<10							ND
1567	05/24/94	<10							ND
	09/12/95	<10							ND
1568	05/24/94	<10							ND
	09/12/95	<10							ND
1569	05/24/94	<10							ND
	09/12/95	<10							ND
1570	05/24/94	<10							ND
	09/11/95	<10							ND
1571	05/26/94	<10							ND
	[illegible]	<10							ND
1572	[illegible]	<10							ND
	[illegible]	<10							ND

Well Number	Date	1,4-Dioxane	1-Methyl-2-pyrroli-dinone	Bis(2-ethyl-hexyl) phthalate	di-n-Butyl phthalate	di-n-Octyl phthalate	n-Butyl-benzene-sulfonamide	Phenol	All Other Semi-Volatiles Measured
1573	05/26/94	<10							ND
	09/26/95	<10							ND
1574	05/26/94	<10							ND
	09/26/95	<10							ND
1585	05/16/95	<10							ND
	08/31/95	<10							ND
1586	05/17/95	<10							ND
	08/31/95	<10							ND
1587	05/16/95	<10							ND
	08/31/95	<10							ND
1588	06/01/95	<10							ND
	08/29/95	<10							ND
1589	06/01/95	<10							ND
1590	06/02/95	<10							ND
	08/28/95	<10							ND
1591	06/06/95	<10							ND
	09/01/95	<10							ND
1592	06/06/95	<10							ND
	09/01/95	<10							ND
1593	06/06/95	<10							ND
	09/01/95	<10							ND
1594	06/14/95	<10							ND
1595	06/14/95	<10							ND
1596	06/14/95	<10							ND
4300	11/08/93	<5							NM
	11/08/93	<5							NM
	11/10/93	<5							NM
	11/10/93	<5							NM
	11/12/93	<5							NM
	11/12/93	<5							NM
4301	11/15/93	<5							NM
	11/15/93	<5							NM
	11/16/93	<5							NM
	11/17/93	<5							NM
	11/19/93	<5							NM
	11/19/93	<5							NM
4302	11/03/93	<5							NM
	11/05/93	<5							NM
	11/05/93	<5							NM
	11/05/93	<5							NM
4325	08/29/95	11							ND
4330	08/24/95	14							ND
4335	08/22/95	<10							ND
4340	NS								
4345	NS								
4350	NS								
4355	NS								
4360	NS								
4365	NS								
4370	08/04/95	<10							ND
4375	08/02/95	<10							ND
4380	07/17/95	<10							ND

NM Not measured
NS Not sampled
ND Not detected at or above method detection limit
See Table D-2 for method detection limits

Table D-2. Detection Limits for EPA Method 8270 Analytes

Compound	Detection Limit (ppb)
1,2,4-TRICHLOROBENZENE	< 10
1,2-DICHLOROBENZENE	< 10
1,2-DIPHENYLHYDRAZINE/AZOBENZENE	< 10
1,3-DICHLOROBENZENE	< 10
1,4-DICHLOROBENZENE	< 10
1,4-DIOXANE	< 10
1-METHYL-2-PYRROLIDINONE	< 10
2,4,5-TRICHLOROPHENOL	< 10
2,4,6-TRICHLOROPHENOL	< 10
2,4-DICHLOROPHENOL	< 10
2,4-DIMETHYLPHENOL	< 10
2,4-DINITROPHENOL	< 50
2,4-DINITROTOLUENE	< 10
2,6-DINITROTOLUENE	< 10
2-CHLORONAPHTHALENE	< 10
2-CHLOROPHENOL	< 10
2-METHYL-4,6-DINITROPHENOL	< 50
2-METHYLNAPHTHALENE	< 10
2-METHYLPHENOL	< 10
2-NITROANILINE	< 50
2-NITROPHENOL	< 10
3-DICHLOROBENZIDINE	< 10
3-NITROANILINE	< 50
4-BROMOPHENOXYBENZENE	< 10
4-CHLOROANILINE	< 10
4-CHLOROPHENYL PHENYL ETHER	< 10
4-METHYLPHENOL	< 10
4-NITROANILINE	< 50
4-NITROPHENOL	< 50
ACENAPHTHENE	< 10
ACENAPHTHYLENE	< 10
ANILINE	< 10
ANTHRACENE	< 10
BENZIDINE	< 50
BENZO(A)ANTHRACENE	< 10
BENZO(A)PYRENE	< 10
BENZO(B)FLUORANTHENE	< 10
BENZO(G,H,I)PERYLENE	< 10
BENZO(K)FLUORANTHENE	< 10
BENZOIC ACID	< 50
BENZYL ALCOHOL	< 10
BIS(2-CHLOROETHOXY)METHANE	< 10
BIS(2-CHLOROETHYL) ETHER	< 10
BIS(2-CHLOROISOPROPYL) ETHER	< 10
BIS(2-ETHYLHEXYL) PHTHALATE	< 50
BUTYL BENZYL PHTHALATE	< 10
CHRYSENE	< 10
DI-N-BUTYL PHTHALATE	< 20

Compound	Detection Limit (ppb)
DI-N-OCTYL PHTHALATE	< 10
DIBENZO(A,H)ANTHRACENE	< 10
DIBENZOFURAN	< 10
DIETHYLPHTHALATE	< 10
DIMETHYL PHTHALATE	< 10
FLUORANTHENE	< 10
FLUORENE	< 10
HEXACHLOROBENZENE	< 10
HEXACHLOROBUTADIENE	< 20
HEXACHLOROCYCLOPENTADIENE	< 10
HEXACHLOROETHANE	< 10
INDENO(1,2,3-CD)PYRENE	< 10
ISOPHORONE	< 10
N-BUTYL-BENZENESULFONAMIDE	< 10
N-NITROSODI-N-PROPYLAMINE	< 10
N-NITROSODIPHENYLAMINE	< 10
NAPHTHALENE	< 10
NITROBENZENE	< 10
P-CHLORO-M-CRESOL	< 20
PENTACHLOROPHENOL	< 50
PHENANTHRENE	< 10
PHENOL	< 10
PYRENE	< 10

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

ell: 1047 9N/6E-12Q1 TOWN Well Type: WS Zone: 2 Sector: E GSE: 187.25 TOC: 188.1 TOP: BOP: TD: 600

	Sample Date:	09/29/93	12/15/93	03/09/94	06/08/94	09/14/94	12/14/94	03/08/95	05/11/95	06/15/95
	Time:	09:25	07:40	08:05	08:15	13:30	08:10	08:15	08:15	08:05
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
IISCELLANEOUS	(Units)									
:ONDUCTANCE	(UMHOS/CM)	NM	NM	NM	NM	NM	NM	NM	NM	NM
I-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
'H	(PH)	NM	NM	NM	NM	NM	NM	NM	NM	NM
'EMPERATURE	(DEGREES C.)	NM	NM	NM	NM	NM	NM	NM	NM	NM
/OLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
1,1-DICHLOROETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROPROPANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
BROMOFORM	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
DIBROMOCHLOROMETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
DICHLOROMETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1047 9N/6E-12Q1 TOWN Well Type: WS Zone: 2 Sector: E GSE: 187.25 TOC: 188.1 TOP: BOP: TD: 600

		Sample Date:	07/12/95	08/10/95	09/13/95	10/11/95	12/13/95
		Time:	08:15	08:10	08:25	08:05	08:20
		Sample Type:					
		Lab:	EL	EL	EL	EL	EL
MISCELLANEOUS	(Units)						
CONDUCTANCE	(UMHOS/CM)		NM	NM	120.	NM	120.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	NM	NM
PH	(PH)		NM	NM	7.8	NM	6.6
TEMPERATURE	(DEGREES C.)		NM	NM	16.9	NM	15.
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)		NM	NM	< 0.5	NM	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)		NM	NM	< 0.5	NM	< 0.5
1,1-DICHLOROETHANE	(PPB)		NM	NM	< 0.5	NM	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	0.5	< 0.5	< 0.25	< 0.5	< 0.5
1,2-DICHLOROPROPANE	(PPB)		NM	NM	< 0.5	NM	< 0.5
2-BUTANONE (MEK)	(PPB)		NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)		NM	NM	NM	NM	NM
2-HEXANONE	(PPB)		NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)		NM	NM	NM	NM	NM
ACETONE	(PPB)		NM	NM	NM	NM	NM
BENZENE	(PPB)		NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)		NM	NM	< 0.5	NM	< 0.5
BROMOFORM	(PPB)		NM	NM	< 0.5	NM	< 0.5
BROMOMETHANE	(PPB)		NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)		NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	<	0.5	< 0.5	< 0.25	< 0.5	< 0.5
CHLOROBENZENE	(PPB)		NM	NM	< 0.5	NM	< 0.5
CHLOROETHANE	(PPB)		NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)		NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)		NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		NM	NM	< 0.5	NM	< 0.5
DIBROMOCHLOROMETHANE	(PPB)		NM	NM	< 0.5	NM	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)		NM	NM	< 0.5	NM	< 0.5
DICHLOROMETHANE	(PPB)		NM	NM	< 0.5	NM	< 0.5
ETHYLBENZENE	(PPB)		NM	NM	NM	NM	NM
FREON 113	(PPB)		NM	NM	< 0.5	NM	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)		NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)		NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)		NM	NM	< 0.5	NM	< 0.5
VINYL ACETATE	(PPB)		NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	<	0.5	< 0.5	< 0.25	< 0.5	< 0.5
XYLENES (TOTAL)	(PPB)		NM	NM		NM	NM

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1049 9N/7E-7F1 CHICAGO Well Type: WS Zone: 2 Sector: E GSE: 204.26 TOC: 204.26 TOP: 472 BOP: 600 TD: 600

	Sample Date:	09/29/93	12/15/93	03/09/94	06/08/94	09/14/94	12/14/94	01/25/95	03/08/95	05/11/95
	Time:	09:00	08:05	08:33	08:35	13:10	08:45	09:30	08:25	08:50
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MISCELLANEOUS	(Units)									
CONDUCTANCE	(UMHOS/CM)	NM	NM	NM	NM	NM	NM	NM	NM	NM
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	NM	< 10.	NM	NM
PH	(PH)	NM	NM	NM	NM	NM	NM	NM	NM	NM
TEMPERATURE	(DEGREES C.)	NM	NM	NM	NM	NM	NM	NM	NM	NM
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NM	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
1,1-DICHLOROETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NM	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NM	< 0.5	< 0.5
1,2-DICHLOROPROPANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
BROMOFORM	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NM	< 0.5	< 0.5
CHLOROBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NM	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
DIBROMOCHLOROMETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
DICHLOROMETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NM	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NM	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	NM	< 0.5	< 0.5
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1049 9N/7E-7F1 CHICAGO Well Type: WS Zone: 2 Sector: E GSE: 204.26 TOC: 204.26 TOP: 472 BOP: 600 TD: 600

		Sample Date:	06/15/95	06/20/95	07/12/95	08/10/95	09/13/95	10/11/95	11/16/95	12/13/95	12/14/95
		Time:	07:55	08:10	08:45	08:25	08:45	08:30	08:20	08:35	08:35
		Sample Type:									
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MISCELLANEOUS	(Units)										
CONDUCTANCE	(UMHOS/CM)	NM	NM	NM	NM	310.	NM	NM	NM	250.
N-NITROSODIMETHYLAMINE	(PPB)	NM	NM	NM	NM	< 10.	NM	NM	NM	NM
PH	(PH)	NM	NM	NM	NM	7.8	NM	NM	NM	7.2
TEMPERATURE	(DEGREES C.)	NM	NM	NM	NM	18.4	NM	NM	NM	16.6
VOLATILE ORGANICS											
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
1,1-DICHLOROETHANE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
BROMOFORM	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
BROMOMETHANE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
CHLOROETHANE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	0.62	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
DICHLOROMETHANE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
ETHYLBENZENE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	NM	NM	NM	NM	< 0.5	NM	NM	NM	< 0.5
VINYL ACETATE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< [redacted]	< 0.25
XYLENES (TOTAL)	(PPB)	NM	NM	[redacted]	NM	NM	NM	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1154 NIMBUS FLAT PARK #1 Well Type: DW Zone: 1 Sector: D GSE: 131.2 TOC: 131.72 TOP: BOP: TD: 130

	Sample Date:	01/13/93	02/03/93	04/14/93	07/14/93	10/13/93	01/12/94	04/13/94	07/13/94	10/12/94
	Time:	13:50	12:15	13:50	11:05	10:48	11:30	11:10	12:15	11:30
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)									
NITRATE	(MG/L)	NM	1.6	NM	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)	NM	250.	NM	330.	NM	NM	NM	NM	NM
N-NITROSODIMETHYLAMINE	(PPB)	NM	NM	NM	NM	NM	NM	NM	NM	NM
PH	(PH)	NM	7.1	NM	7.2	NM	NM	NM	NM	NM
TEMPERATURE	(DEGREES C.)	NM	17.9	NM	21.2	NM	NM	NM	NM	NM
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	NM	NM	NM	< 0.2	NM	NM	NM	NM	NM
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 1.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
1,1,2-TRICHLOROETHANE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
1,1-DICHLOROETHANE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 1.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.5	< 1.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROPROPANE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
BROMOFORM	(PPB)	NM	< 2.	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.5	< 1.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROBENZENE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 0.5	< 1.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
DIBROMOCHLOROMETHANE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
DICHLORODIFLUOROMETHANE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
DICHLOROMETHANE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 1.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)	< 0.5	< 1.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.5	< 1.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1154 NIMBUS FLAT PARK #1 Well Type: DW Zone: 1 Sector: D GSE: 131.2 TOC: 131.72 TOP: BOP: TD: 130

		Sample Date:	01/11/95	04/12/95	07/12/95	08/30/95	10/11/95
		Time:	12:10	11:30	11:45	12:44	11:45
		Sample Type:					
		Lab:	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		NM	NM	NM	NM	NM
NITRITE	(MG/L)		NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)		NM	NM	NM	NM	NM
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		NM	NM	NM	300.	NM
N-NITROSODIMETHYLANINE	(PPB)		NM	NM	NM	< 10.	NM
PH	(PH)		NM	NM	NM	7.3	NM
TEMPERATURE	(DEGREES C.)		NM	NM	NM	21.1	NM
TOTAL PETROLEUM HYDROCARBONS	(MG/L)		NM	NM	NM	NM	NM
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)		NM	NM	NM	< 0.5	NM
1,1,2-TRICHLOROETHANE	(PPB)		NM	NM	NM	< 0.5	NM
1,1-DICHLOROETHANE	(PPB)		NM	NM	NM	< 0.5	NM
1,1-DICHLOROETHYLENE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.25	< 0.5
1,2-DICHLOROPROPANE	(PPB)		NM	NM	NM	< 0.5	NM
BROMODICHLOROMETHANE	(PPB)		NM	NM	NM	< 0.5	NM
BROMOFORM	(PPB)		NM	NM	NM	< 0.5	NM
CARBON TETRACHLORIDE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.25	< 0.5
CHLOROBENZENE	(PPB)		NM	NM	NM	< 0.5	NM
CHLOROFORM	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		NM	NM	NM	< 0.5	NM
DIBROMOCHLOROMETHANE	(PPB)		NM	NM	NM	< 0.5	NM
DICHLORODIFLUOROMETHANE	(PPB)		NM	NM	NM	< 0.5	NM
DICHLOROMETHANE	(PPB)		NM	NM	NM	< 0.5	NM
FREON 113	(PPB)		NM	NM	NM	< 0.5	NM
TETRACHLOROETHYLENE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)		NM	NM	NM	< 0.5	NM
VINYL CHLORIDE	(PPB)	<	0.5	< 0.5	< 0.5	< 0.25	< 0.5

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1156 SAILOR BAR Well Type: WS Zone: 1 Sector: D GSE: TOC: 130.39 TOP: BOP: TD: 250

	Sample Date:		02/22/93		09/06/95		12/05/95	
	Time:		09:55		13:22		13:32	
	Sample Type:							
	Lab:		EL		EL		EL	
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		3.9		NM		NM	
NITRITE	(MG/L)	<	0.05		NM		NM	
PERCHLORATE	(MG/L)	<	0.4		NM		NM	
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		200.		250.		210.	
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.		NM	
PH	(PH)		7.8		7.6		7.6	
TEMPERATURE	(DEGREES C.)		16.		23.9		16.7	
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	0.5	<	0.5	
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	0.5	<	0.5	
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	0.5	<	0.5	
1,1-DICHLOROETHANE	(PPB)	<	1.	<	0.5	<	0.5	
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	0.5	<	0.5	
1,2-DICHLOROETHANE	(PPB)	<	1.	<	0.25	<	0.25	
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	0.5	<	0.5	
BROMODICHLOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
BROMOFORM	(PPB)	<	2.	<	0.5	<	0.5	
CARBON TETRACHLORIDE	(PPB)	<	1.	<	0.25	<	0.25	
CHLOROBENZENE	(PPB)	<	1.	<	0.5	<	0.5	
CHLOROFORM	(PPB)	<	1.	<	0.5	<	0.5	
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	0.5	<	0.5	
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
DICHLOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
FREON 113	(PPB)	<	1.	<	0.5	<	0.5	
TETRACHLOROETHYLENE	(PPB)	<	1.	<	0.5	<	0.5	
TRICHLOROETHYLENE	(PPB)		12.		21.		29.	
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
VINYL CHLORIDE	(PPB)	<	1.	<	0.25	<	0.25	

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1162 OFFSITE-NW-F Well Type: MC Zone: 1 Sector: D GSE: 137.87 TOC: 137.87 TOP: 95 BOP: 105 TD: 105

	Sample Date:	02/01/93		06/07/93		01/14/94		11/10/94		02/21/95		10/02/95	
	Time:	15:26		12:07		10:07		16:39		11:34		13:59	
	Sample Type:												
	Lab:	EL		EL		EL		EL		EL		EL	
MINERALS, INORGANICS	(Units)												
NITRATE	(MG/L)		8.8		NM		NM		NM		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM		NM		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM		NM		NM
MISCELLANEOUS													
CONDUCTANCE	(UMHOS/CM)		310.		310.		290.		270.		280.		220.
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.		NM		NM	<	10.	<	10.
PH	(PH)		7.9		7.7		8.		8.1		8.7		8.8
TEMPERATURE	(DEGREES C.)		19.5		20.9		15.5		15.5		22.4		23.5
VOLATILE ORGANICS													
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)	<	1.		1.		1.1		1.6	<	1.	<	0.5
1,1-DICHLOROETHYLENE	(PPB)		4.		6.		2.3		3.2	<	1.	<	0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	1.		1.		1.		1.9	<	0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.		1.1	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
FREON 113	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
TRICHLOROETHYLENE	(PPB)		54.		82.		37.		27.		27.		12.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1163 OFFSITE-NW-F Well Type: MC Zone: 1 Sector: D GSE: 137.87 TOC: 137.87 TOP: 130 BOP: 151 TD: 151

	Sample Date:	02/01/93	06/07/93	01/14/94	11/10/94	02/21/95	10/02/95
	Time:	15:01	11:41	09:49	15:40	11:00	12:19
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)	15.	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	0.5	NM	NM	NM	NM	< 0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)	310.	330.	300.	240.	290.	210.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	< 10.	< 10.
PH	(PH)	8.	7.7	8.2	7.9	8.3	9.
TEMPERATURE	(DEGREES C.)	19.7	21.1	15.2	15.6	22.7	21.9
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	1.	2.	< 0.5
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	1.	< 1.	1.6	2.4	< 1.	0.77
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	22.	6.	25.	29.	26.	21.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
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May 23, 1996

Well: 1164 OFFSITE-MW-F Well Type: MC Zone: 1 Sector: D GSE: 137.87 TOC: 137.87 TOP: 210 BOP: 231 TD: 231

		Sample Date:	02/03/93	06/07/93	01/14/94	11/10/94	02/21/95	10/02/95
		Time:	10:14	10:58	09:00	14:31	10:08	10:37
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		10.	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		360.	360.	340.	220.	340.	340.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	< 10.	NM	< 10.	< 10.
PH	(PH)		7.8	7.6	8.2	7.8	8.	7.6
TEMPERATURE	(DEGREES C.)		17.1	19.6	14.1	16.4	19.5	21.
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		2.	3.	2.8	1.8	1.7	1.4
1,1-DICHLOROETHYLENE	(PPB)		60.	60.	50.	39.	34.	44.
1,2-DICHLOROETHANE	(PPB)		7.	9.	8.4	5.1	5.6	4.8
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)		1.	1.	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		2.	2.	1.8	1.7	1.7	1.3
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)		4.	3.	3.5	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)		47.	51.	46.	33.	32.	43.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1169 OFFSITE-NW-C Well Type: MC Zone: 2 Sector: E GSE: 111.57 TOC: 111.57 TOP: 115 BOP: 162 TD: 162

	Sample Date:	03/31/93		03/17/94		08/18/94		03/30/95		06/08/95		07/06/95		10/17/95	
	Time:	13:32		11:06		10:27		13:22		09:48		13:21		09:19	
	Sample Type:														
	Lab:	EL		EL		EL		EL		EDL		EL		EL	
MINERALS, INORGANICS	(Units)														
NITRATE	(MG/L)		3.9		NM		NM		NM		NM		NM		NM
NITRITE	(MG/L)		0.07		NM		NM		NM		NM		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM		NM		NM		NM
MISCELLANEOUS															
CONDUCTANCE	(UMHOS/CM)		320.		230.		260.		NM		NM		240.		230.
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.		NM		NM		NM	<	10.		NM
PH	(PH)		8.9		9.7		8.2		NM		NM		8.1		7.9
TEMPERATURE	(DEGREES C.)		18.6		17.1		18.7		NM		NM		20.6		16.8
VOLATILE ORGANICS															
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	<	2.	<	1.	<	0.5	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.	<	1.		2.	<	0.5	<	0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		3.		2.		2.6		3.8		NM		0.71		0.64
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.		NM	<	0.5	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.		NM	<	0.5	<	0.5
FREON 113	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
T-1,2-DICHLOROETHYLENE	(PPB)		NM		NM		NM		NM		2.		NM		NM
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
TRICHLOROETHYLENE	(PPB)		80.		31.		50.		39.		8.		45.		73.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1170 OFFSITE-NW-C Well Type: MC Zone: 2 Sector: E GSE: 111.57 TOC: 111.57 TOP: 379 BOP: 421 TD: 421

		Sample Date:	03/31/93	03/17/94	08/18/94	03/30/95	07/06/95	10/16/95
		Time:	12:59	10:22	09:37	12:43	12:39	13:25
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS -	(Units)							
NITRATE	(MG/L)		3.2	NM	NM	NM	NM	NM
NITRITE	(MG/L)		0.48	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		240.	230.	240.	NM	240.	240.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	NM	NM	< 10.	NM
PH	(PH)		8.6	8.9	7.9	NM	7.8	7.7
TEMPERATURE	(DEGREES C.)		19.1	16.6	19.	NM	21.1	20.9
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)		1.	< 1.	1.3	1.1	1.1	76.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
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May 23, 1996

Well: 1171 OFFSITE-NW-C Well Type: MC Zone: 2 Sector: E GSE: 111.57 TOC: 111.57 TOP: 470 BOP: 512 TD: 512

	Sample Date:	03/31/93		03/16/94		08/17/94		03/30/95		07/05/95		10/16/95					
	Time:	11:22		14:08		14:33		11:24		14:08		10:36					
	Sample Type:																
	Lab:	EL		EL		EL		EL		EL		EL					
MINERALS, INORGANICS *	(Units)																
NITRATE	(MG/L)		0.2		NM		NM		NM		NM		NM				
NITRITE	(MG/L)	<	0.05		NM		NM		NM		NM		NM				
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM		NM		NM				
MISCELLANEOUS																	
CONDUCTANCE	(UMHOS/CM)		260.		250.		250.		NM		260.		250.				
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.		NM		NM	<	10.		NM				
PH	(PH)		8.		7.9		7.5		NM		7.9		7.7				
TEMPERATURE	(DEGREES C.)		19.1		17.		24.2		NM		22.		17.9				
VOLATILE ORGANICS																	
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25				
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	<	2.	<	0.5	<	0.5				
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25				
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
FREON 113	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
TRICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.		1.5		4.7		33.				
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25				

AEROJET Environmental Operations
Water Quality Information

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Well: 1211 STATE WELLS-LS-2 MW Well Type: SW Zone: 1 Sector: D GSE: 135.6 TOC: 135.34 TOP: 80 BOP: 155 TD: 160

	Sample Date:	02/24/93		06/07/93		11/18/94		02/03/95		08/09/95					
	Time:	16:09		14:25		12:31		14:09		14:30					
	Sample Type:														
	Lab:	EL		EL		EL		EL		EL					
MINERALS, INORGANICS	(Units)														
NITRATE	(MG/L)		12.		NM		NM		NM		NM				
NITRITE	(MG/L)		0.08		NM		NM		NM		NM				
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM	<	0.4				
MISCELLANEOUS															
CONDUCTANCE	(UMHOS/CM)		420.		400.		370.		110.		370.				
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM		NM		NM	<	10.				
PH	(PH)		7.		7.3		8.4		7.2		7.2				
TEMPERATURE	(DEGREES C.)		17.3		21.5		17.2		20.2		24.5				
VOLATILE ORGANICS															
1,1,1-TRICHLOROETHANE	(PPB)		4.		4.	<	1.	<	1.		0.76				
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
1,1-DICHLOROETHANE	(PPB)		6.		6.		3.4	<	1.		2.8				
1,1-DICHLOROETHYLENE	(PPB)		69.		58.		18.		6.6		29.				
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25				
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	<	2.	<	0.5				
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25				
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.	<	1.		1.7				
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		47.		46.		48.		9.1		36.				
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
FREON 113	(PPB)		14.		11.		1.3		2.1		8.8				
TETRACHLOROETHYLENE	(PPB)		14.		14.		7.6		2.7		12.				
TRICHLOROETHYLENE	(PPB)		300.		300.		220.		62.		250.				
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25				

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Well: 1214 STATE WELLS-LS-4 MW Well Type: SW Zone: 1 Sector: D GSE: 131.9 TOC: 131.45 TOP: 70 BOP: 165 TD: 170

		Sample Date:	02/10/93		09/21/95
		Time:	12:47		14:32
		Sample Type:			
		Lab:	EL		EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)		12.		NM
NITRITE	(MG/L)	<	0.2		NM
PERCHLORATE	(MG/L)	<	0.4		NM
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		580.		420.
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.
PH	(PH)		7.8		7.7
TEMPERATURE	(DEGREES C.)		17.6		21.2
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)		5.		0.74
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)		15.		3.9
1,1-DICHLOROETHYLENE	(PPB)		64.		29.
1,2-DICHLOROETHANE	(PPB)	<	1.		0.35
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	0.5
CHLOROFORM	(PPB)		2.		4.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		82.		42.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	0.5
FREON 113	(PPB)		13.		7.
TETRACHLOROETHYLENE	(PPB)		14.		9.1
TRICHLOROETHYLENE	(PPB)		1300.		580.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	0.25

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May 22, 1996

Well: 1216 STATE WELLS-LS-6 MW Well Type: SW Zone: 1 Sector: D GSE: 124.8 TOC: 127.96 TOP: 60 BOP: 80 TD: 80

		Sample Date:	02/10/93	06/16/93	08/18/95
		Time:	10:45	14:28	10:46
		Sample Type:			
		Lab:	EL	EL	EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)		12.	NM	NM
NITRITE	(MG/L)	<	0.3	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		740.	700.	1100.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.
PH	(PH)		7.	7.	7.
TEMPERATURE	(DEGREES C.)		18.2	23.	20.
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)		6.	4.	0.58
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		12.	14.	2.2
1,1-DICHLOROETHYLENE	(PPB)		63.	52.	16.
1,2-DICHLOROETHANE	(PPB)		1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 0.5
CHLOROFORM	(PPB)		4.	2.	1.1
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		61.	59.	17.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
FREON 113	(PPB)		4.	2.	< 0.5
TETRACHLOROETHYLENE	(PPB)		16.	13.	4.2
TRICHLOROETHYLENE	(PPB)		1300.	1200.	290.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1357 NFH-MW2 Well Type: MC Zone: 1 Sector: D GSE: 97.92 TOC: 94.1 TOP: 60 BOP: 68 TD: 68

		Sample Date:	01/25/93		06/09/93		09/15/95	12/05/95
		Time:	09:42		14:18		11:04	10:13
		Sample Type:						
		Lab:	EL		EL		EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)		0.36	<	0.05		NM	NM
ANTIMONY	(MG/L)	<	0.3		NM		NM	NM
ARSENIC	(MG/L)	<	0.1	<	0.1		NM	NM
BARIUM	(MG/L)		0.15		0.12		NM	NM
BERYLLIUM	(MG/L)	<	0.002	<	0.002		NM	NM
BORON	(MG/L)	<	0.1		NM		NM	NM
CADMIUM	(MG/L)	<	0.02	<	0.02		NM	NM
CHROMIUM	(MG/L)	<	0.04	<	0.04		NM	NM
COBALT	(MG/L)	<	0.02		NM		NM	NM
COPPER	(MG/L)	<	0.05	<	0.05		NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.04		NM		NM	NM
IRON	(MG/L)		1.1	<	0.1		NM	NM
LEAD	(MG/L)	<	0.1	<	0.1		NM	NM
MERCURY	(MG/L)	<	0.0002		NM		NM	NM
MOLYBDENUM	(MG/L)	<	0.04		NM		NM	NM
NICKEL	(MG/L)	<	0.04	<	0.04		NM	NM
SELENIUM	(MG/L)	<	0.4	<	0.4		NM	NM
SILVER	(MG/L)	<	0.01	<	0.01		NM	NM
THALLIUM	(MG/L)	<	0.4	<	0.4		NM	NM
VANADIUM	(MG/L)	<	0.02		NM		NM	NM
ZINC	(MG/L)		1.5		0.3		NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)		85.		NM		NM	NM
CHLORIDE	(MG/L)		100.		NM		NM	NM
MAGNESIUM	(MG/L)		31.		NM		NM	NM
MANGANESE	(MG/L)		0.016		NM		NM	NM
NITRATE	(MG/L)		11.		NM		NM	NM
NITRITE	(MG/L)	<	0.3		NM		NM	NM
PERCHLORATE	(MG/L)		0.6		NM	<	0.4	NM
POTASSIUM	(MG/L)		5.5		NM		NM	NM
SODIUM, TOTAL	(MG/L)		19.		NM		NM	NM
SULFATE	(MG/L)		23.		NM		NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	<	1.		NM		NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	<	3.		NM		NM	NM
CONDUCTANCE	(UMHOS/CM)		750.		670.		430.	450.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	<	10.	<	10.	NM
PH	(PH)		7.6		7.6		7.7	7.8
TEMPERATURE	(DEGREES C.)		10.6		18.5		21.3	15.8
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.2		NM		NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1357 NFH-MW2 Well Type: MC Zone: 1 Sector: D GSE: 97.92 TOC: 94.1 TOP: 60 BOP: 68 TD: 68

		Sample Date:	01/25/93	06/09/93	09/15/95	12/05/95
		Time:	09:42	14:18	11:04	10:13
		Sample Type:				
		Lab:	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)					
1,1,1-TRICHLOROETHANE	(PPB)		5.	< 5.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	5.	< 5.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	5.	< 5.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)		6.	7.	1.	3.2
1,1-DICHLOROETHYLENE	(PPB)		57.	60.	6.8	20.
1,2-DICHLOROETHANE	(PPB)	<	5.	< 5.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	5.	< 5.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	<	20.	< 20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	<	10.	< 10.	NM	NM
2-HEXANONE	(PPB)	<	20.	< 20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	<	10.	< 10.	NM	NM
ACETONE	(PPB)	<	20.	< 20.	NM	NM
BENZENE	(PPB)	<	5.	< 5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	<	5.	< 5.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	5.	< 5.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	<	10.	< 10.	NM	NM
CARBON DISULFIDE	(PPB)	<	5.	< 5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	<	5.	< 5.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	5.	< 5.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	<	10.	< 10.	NM	NM
CHLOROFORM	(PPB)	<	5.	< 5.	2.	4.6
CHLOROMETHANE	(PPB)	<	10.	< 10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	< 5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		61.	68.	23.	63.
DIBROMOCHLOROMETHANE	(PPB)	<	5.	< 5.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	10.	< 10.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	5.	< 5.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	<	5.	< 5.	NM	NM
FREON 113	(PPB)		6.	8.	2.1	5.6
T-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	< 5.	NM	NM
TETRACHLOROETHYLENE	(PPB)		20.	17.	1.7	9.2
TOLUENE	(PPB)	<	5.	< 5.	NM	NM
TRICHLOROETHYLENE	(PPB)		760.	630.	100.	350.
TRICHLOROFLUOROMETHANE	(PPB)	<	5.	< 5.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	<	10.	< 10.	NM	NM
VINYL CHLORIDE	(PPB)	<	10.	< 10.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	<	5.	< 5.	NM	NM

AEROJET Environmental Operations
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May 22, 1996

Well: 1358 NFH-MW2 Well Type: MC Zone: 1 Sector: D GSE: 97.92 TOC: 94.1 TOP: 103 BOP: 113 TD: 113

		Sample Date:	01/26/93	06/09/93	09/18/95	12/05/95
		Time:	13:06	12:40	09:05	11:15
		Sample Type:				
		Lab:	EL	EL	EL	EL
METALS	(Units)					
ALUMINUM	(MG/L)		NM	< 0.05	NM	NM
ARSENIC	(MG/L)		NM	< 0.1	NM	NM
BARIUM	(MG/L)		NM	0.09	NM	NM
BERYLLIUM	(MG/L)		NM	< 0.002	NM	NM
CADMIUM	(MG/L)		NM	< 0.02	NM	NM
CHROMIUM	(MG/L)		NM	< 0.04	NM	NM
COPPER	(MG/L)		NM	< 0.05	NM	NM
IRON	(MG/L)		NM	< 0.1	NM	NM
LEAD	(MG/L)		NM	< 0.1	NM	NM
NICKEL	(MG/L)		NM	< 0.04	NM	NM
SELENIUM	(MG/L)		NM	< 0.4	NM	NM
SILVER	(MG/L)		NM	< 0.01	NM	NM
THALLIUM	(MG/L)		NM	< 0.4	NM	NM
ZINC	(MG/L)		NM	< 0.1	NM	NM
MINERALS, INORGANICS						
NITRATE	(MG/L)		9.8	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4	NM
MISCELLANEOUS						
CONDUCTANCE	(UMHOS/CM)		420.	440.	410.	400.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	< 10.	NM
PH	(PH)		8.1	7.9	7.8	8.
TEMPERATURE	(DEGREES C.)		13.2	19.	19.	15.6
VOLATILE ORGANICS						
1,1,1-TRICHLOROETHANE	(PPB)		9.	< 20.	0.6	1.1
1,1,2,2-TETRACHLOROETHANE	(PPB)		12.	< 20.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)		7.	< 20.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)		15.	< 20.	3.8	5.4
1,1-DICHLOROETHYLENE	(PPB)		100.	100.	33.	41.
1,2-DICHLOROETHANE	(PPB)		10.	< 20.	1.3	2.3
1,2-DICHLOROPROPANE	(PPB)	<	5.	< 20.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)		NM	< 80.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)		NM	< 40.	NM	NM
2-HEXANONE	(PPB)		NM	< 80.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)		NM	< 40.	NM	NM
ACETONE	(PPB)		NM	< 80.	NM	NM
BENZENE	(PPB)		NM	< 20.	NM	NM
BROMODICHLOROMETHANE	(PPB)	<	5.	< 20.	< 0.5	< 0.5

AEROJET Environmental Operations
Water Quality Information

Well: 1358 NFH-MW2 Well Type: MC Zone: 1 Sector: D GSE: 97.92 TOC: 94.1 TOP: 103 BOP: 113 TD: 113

	Sample Date:	01/26/93	06/09/93	09/18/95	12/05/95
	Time:	13:06	12:40	09:05	11:15
	Sample Type:				
	Lab:	EL	EL	EL	EL
VOLATILE ORGANICS (cont'd)	(Units)				
BROMOFORM	(PPB)	< 10.	< 20.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 40.	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 20.	NM	NM
CARBON TETRACHLORIDE	(PPB)	7.	< 20.	< 0.25	1.3
CHLOROBENZENE	(PPB)	< 5.	< 20.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 40.	NM	NM
CHLOROFORM	(PPB)	14.	< 20.	6.5	7.6
CHLOROMETHANE	(PPB)	NM	< 40.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 20.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	270.	200.	61.	95.
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 20.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 5.	< 40.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 20.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 20.	NM	NM
FREON 113	(PPB)	54.	40.	14.	20.
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 20.	NM	NM
TETRACHLOROETHYLENE	(PPB)	38.	30.	6.	15.
TOLUENE	(PPB)	NM	< 20.	NM	NM
TRICHLOROETHYLENE	(PPB)	4600.	3200.	670.	1000.
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 20.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 40.	NM	NM
VINYL CHLORIDE	(PPB)	< 5.	< 40.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 20.	NM	NM

AEROJET Environmental Operations
Water Quality Information

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Well: 1359 NFH-MW2 Well Type: MC Zone: 1 Sector: D GSE: 97.92 TOC: 94.1 TOP: 153 BOP: 163 TD: 163

		Sample Date:	01/26/93		06/09/93		09/15/95		12/04/95	
		Time:	12:26		11:27		13:46		:	
		Sample Type:								
		Lab:	EL		EL		EL		EL	
METALS	(Units)									
ALUMINUM	(MG/L)		NM	<	0.05		NM		NM	
ARSENIC	(MG/L)		NM	<	0.1		NM		NM	
BARIUM	(MG/L)		NM		0.088		NM		NM	
BERYLLIUM	(MG/L)		NM	<	0.002		NM		NM	
CADMIUM	(MG/L)		NM	<	0.02		NM		NM	
CHROMIUM	(MG/L)		NM	<	0.04		NM		NM	
COPPER	(MG/L)		NM	<	0.05		NM		NM	
IRON	(MG/L)		NM	<	0.1		NM		NM	
LEAD	(MG/L)		NM	<	0.1		NM		NM	
NICKEL	(MG/L)		NM	<	0.04		NM		NM	
SELENIUM	(MG/L)		NM	<	0.4		NM		NM	
SILVER	(MG/L)		NM	<	0.01		NM		NM	
THALLIUM	(MG/L)		NM	<	0.4		NM		NM	
ZINC	(MG/L)		NM	<	0.1		NM		NM	
MINERALS, INORGANICS										
NITRATE	(MG/L)		9.2		NM		NM		NM	
NITRITE	(MG/L)	<	0.05		NM		NM		NM	
PERCHLORATE	(MG/L)	<	0.4		NM	<	0.4		NM	
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)		410.		410.		400.		380.	
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.		NM	
PH	(PH)		7.9		7.9		7.7		7.4	
TEMPERATURE	(DEGREES C.)		14.3		19.1		21.9		16.1	
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)		1.	<	10.		1.1		1.	
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	10.	<	0.5	<	0.5	
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	10.		0.9	<	0.5	
1,1-DICHLOROETHANE	(PPB)		10.		10.		10.		9.2	
1,1-DICHLOROETHYLENE	(PPB)		71.		70.		83.		74.	
1,2-DICHLOROETHANE	(PPB)		6.	<	10.		4.3		4.8	
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	10.	<	0.5	<	0.5	
2-BUTANONE (MEK)	(PPB)		NM	<	40.		NM		NM	
2-CHLOROETHYL VINYL ETHER	(PPB)		NM	<	20.		NM		NM	
2-HEXANONE	(PPB)		NM	<	40.		NM		NM	
4-METHYL-2-PENTANONE (MIBK)	(PPB)		NM	<	20.		NM		NM	
ACETONE	(PPB)		NM	<	40.		NM		NM	
BENZENE	(PPB)		NM	<	10.		NM		NM	
BROMODICHLOROMETHANE	(PPB)	<	1.	<	10.	<	0.5	<	0.5	

AEROJET Environmental Operations
Water Quality Information

Well: 1359 NFH-MW2 Well Type: MC Zone: 1 Sector: D GSE: 97.92 TOC: 94.1 TOP: 153 BOP: 163 TD: 163

	Sample Date:	01/26/93	06/09/93	09/15/95	12/04/95
	Time:	12:26	11:27	13:46	:
	Sample Type:				
	Lab:	EL	EL	EL	EL
VOLATILE ORGANICS - (cont'd)	(Units)				
BROMOFORM	(PPB)	< 2.	< 10.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 20.	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 10.	NM	NM
CARBON TETRACHLORIDE	(PPB)	6.	< 10.	2.8	3.2
CHLOROBENZENE	(PPB)	< 1.	< 10.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 20.	NM	NM
CHLOROFORM	(PPB)	7.	< 10.	14.	10.
CHLOROMETHANE	(PPB)	NM	< 20.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 10.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	96.	100.	110.	120.
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 10.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 20.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 10.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 10.	NM	NM
FREON 113	(PPB)	24.	20.	40.	31.
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 10.	NM	NM
TETRACHLOROETHYLENE	(PPB)	14.	10.	18.	18.
TOLUENE	(PPB)	NM	< 10.	NM	NM
TRICHLOROETHYLENE	(PPB)	2200.	1900.	1500.	1500.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 10.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 20.	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 20.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 10.	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1360 NFH-MW2 Well Type: MC Zone: 1 Sector: D GSE: 97.92 TOC: 94.1 TOP: 270 BOP: 290 TD: 290

		Sample Date:	01/26/93	07/27/93	09/11/95	11/30/95
		Time:	13:37	14:46	11:36	13:22
		Sample Type:				
		Lab:	EL	EL	EL	EL
METALS	(Units)					
ALUMINUM	(MG/L)		NM	0.15	NM	NM
ARSENIC	(MG/L)		NM	< 0.1	NM	NM
BARIUM	(MG/L)		NM	0.019	NM	NM
BERYLLIUM	(MG/L)		NM	< 0.002	NM	NM
CADMIUM	(MG/L)		NM	< 0.02	NM	NM
CHROMIUM	(MG/L)		NM	< 0.04	NM	NM
COPPER	(MG/L)		NM	< 0.05	NM	NM
IRON	(MG/L)		NM	< 0.1	NM	NM
LEAD	(MG/L)		NM	< 0.1	NM	NM
NICKEL	(MG/L)		NM	< 0.04	NM	NM
SELENIUM	(MG/L)		NM	< 0.4	NM	NM
SILVER	(MG/L)		NM	< 0.01	NM	NM
THALLIUM	(MG/L)		NM	< 0.4	NM	NM
ZINC	(MG/L)		NM	0.4	NM	NM
MINERALS, INORGANICS						
NITRATE	(MG/L)	<	0.1	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4	NM
MISCELLANEOUS						
CONDUCTANCE	(UMHOS/CM)		430.	380.	380.	340.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	< 10.	NM
PH	(PH)		11.5	11.	10.9	11.1
TEMPERATURE	(DEGREES C.)		14.	19.1	26.2	18.7
VOLATILE ORGANICS						
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 5.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 5.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 5.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 5.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 5.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 5.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 5.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)		NM	< 20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)		NM	< 10.	NM	NM
2-HEXANONE	(PPB)		NM	< 20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)		NM	< 10.	NM	NM
ACETONE	(PPB)		NM	< 20.	NM	NM
BENZENE	(PPB)		NM	< 5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	<	1.	< 5.	< 0.5	< 0.5

AEROJET Environmental Operations
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Well: 1360 NFH-MW2 Well Type: MC Zone: 1 Sector: D GSE: 97.92 TOC: 94.1 TOP: 270 BOP: 290 TD: 290

		Sample Date:	01/26/93	07/27/93	09/11/95	11/30/95
		Time:	13:37	14:46	11:36	13:22
		Sample Type:				
		Lab:	EL	EL	EL	EL
VOLATILE ORGANICS (cont'd)	(Units)					
BROMOFORM	(PPB)	< 2.	< 5.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM

AEROJET Environmental Operations
Water Quality Information

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Well: 1361 NFH-MW4 Well Type: MC Zone: 1 Sector: D GSE: 122.05 TOC: 122.05 TOP: 84 BOP: 94 TD: 94

		Sample Date:	02/03/93	06/08/93	01/18/94	11/07/94	01/02/95	02/06/95	08/17/95	11/27/95
		Time:	12:10	13:45	14:44	12:06	:	:	12:45	13:45
		Sample Type:								
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)									
NITRATE	(MG/L)		10.	NM	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)		0.5	NM	NM	NM	NM	NM	< 0.4	NM
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)		280.	290.	300.	230.	NM	270.	340.	330.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	NM	NM	< 10.	NM	< 10.	NM
PH	(PH)		8.3	8.2	8.3	7.9	NM	8.2	8.1	7.8
TEMPERATURE	(DEGREES C.)		17.9	20.6	21.3	18.9	NM	17.9	20.1	19.4
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	0.8	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	0.43	0.55
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	NM	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	0.56	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	0.58	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)		120.	120.	81.	1.8	NM	52.	60.	37.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1362 NFH-MW4 Well Type: MC Zone: 1 Sector: D GSE: 122.05 TOC: 122.05 TOP: 122 BOP: 132 TD: 132

		Sample Date:	02/03/93	06/08/93	01/18/94	11/07/94	02/06/95	08/17/95	11/27/95
		Time:	12:46	12:51	14:16	11:01	:	12:18	14:32
		Sample Type:							
		Lab:	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)								
NITRATE	(MG/L)		7.7	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	< 0.4	NM
MISCELLANEOUS									
CONDUCTANCE	(UMHOS/CM)		310.	350.	320.	280.	190.	340.	340.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	NM	NM	< 10.	< 10.	NM
PH	(PH)		8.1	8.	7.9	7.8	7.9	7.9	8.
TEMPERATURE	(DEGREES C.)		17.7	20.2	22.7	18.4	18.3	20.2	19.2
VOLATILE ORGANICS									
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	0.72	1.1
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)		21.	25.	1.4	1.1	< 1.	37.	28.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

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Well: 1363 NFH-MW4 Well Type: MC Zone: 1 Sector: D GSE: 122.05 TOC: 122.05 TOP: 161 BOP: 171 TD: 171

		Sample Date:	02/03/93	06/07/93	06/07/93	01/18/94	11/07/94	02/06/95	08/17/95	11/27/95
		Time:	11:40	11:39	11:44	13:33	11:29	:	11:37	15:20
		Sample Type:								
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)									
NITRATE	(MG/L)		9.3	NM	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)		330.	NM	260.	340.	290.	170.	340.	330.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	NM	NM	< 10.	< 10.	NM
PH	(PH)		8.1	NM	7.9	8.2	7.8	7.6	7.8	8.1
TEMPERATURE	(DEGREES C.)		18.1	NM	19.9	21.5	18.4	21.4	21.	19.1
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	1.5	1.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	NM	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	1.4	2.1
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	0.84	0.83
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)		5.	1.	NM	3.3	24.	3.5	24.	22.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	NM	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1364 NFH-MW4 Well Type: MC Zone: 1 Sector: D GSE: 122.05 TOC: 122.05 TOP: 194 BOP: 204 TD: 204

		Sample Date:	02/03/93	06/08/93	01/18/94	11/11/94	02/06/95	08/30/95	11/30/95
		Time:	13:47	11:39	12:27	12:52	:	11:30	11:50
		Sample Type:							
		Lab:	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)								
NITRATE	(MG/L)		8.5	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)		0.1	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)		0.6	NM	NM	NM	NM	< 0.4	NM
MISCELLANEOUS									
CONDUCTANCE	(UMHOS/CM)		300.	330.	310.	230.	320.	320.	290.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	NM	NM	< 10.	< 10.	NM
PH	(PH)		8.7	10.7	8.	8.2	8.5	7.9	8.4
TEMPERATURE	(DEGREES C.)		17.6	22.	20.3	16.3	17.3	25.	18.8
VOLATILE ORGANICS									
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)	<	1.	< 1.	1.9	< 1.	2.7	2.3	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1365 NFH-MW4 Well Type: MC Zone: 1 Sector: D GSE: 122.05 TOC: 122.05 TOP: 230 BOP: 240 TD: 240

	Sample Date:	02/03/93		06/08/93		01/18/94		11/11/94		02/06/95		08/30/95		11/30/95	
	Time:	13:19		10:23		12:04		14:06		:		09:34		11:22	
	Sample Type:														
	Lab:	EL		EL		EL		EL		EL		EL		EL	
MINERALS, INORGANICS	(Units)														
NITRATE	(MG/L)		5.		NM		NM		NM		NM		NM		NM
NITRITE	(MG/L)		1.3		NM		NM		NM		NM		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM		NM	<	0.4		NM
MISCELLANEOUS															
CONDUCTANCE	(UMHOS/CM)		380.		310.		380.		210.		320.		360.		250.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM		NM		NM	<	10.	<	10.		NM
PH	(PH)		11.1		8.3		11.1		8.1		10.7		10.4		10.8
TEMPERATURE	(DEGREES C.)		17.6		21.8		22.2		16.5		18.5		22.7		18.8
VOLATILE ORGANICS															
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	<	2.	<	2.	<	0.5	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
FREON 113	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
TRICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1370 NFH-MW3 Well Type: MC Zone: 1 Sector: D GSE: 115.26 TOC: 115.26 TOP: 80 BOP: 90 TD: 90

Sample Date:		02/08/93		06/10/93		08/23/94		01/24/95		09/08/95	
Time:		12:23		11:15		12:19		10:50		10:45	
Sample Type:											
Lab:		EL		EL		EL		EL		EL	
MINERALS, INORGANICS	(Units)										
NITRATE	(MG/L)		2.1		NM		NM		NM		NM
NITRITE	(MG/L)		1.9		NM		NM		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM	<	0.4
MISCELLANEOUS											
CONDUCTANCE	(UMHOS/CM)		870.		990.		710.		1000.		870.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.	<	10.	<	10.
PH	(PH)		7.7		7.8		8.		7.6		7.8
TEMPERATURE	(DEGREES C.)		17.7		20.7		21.3		16.5		20.9
VOLATILE ORGANICS											
1,1,1-TRICHLOROETHANE	(PPB)		3.		12.		2.4		9.5		1.6
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)		9.		12.		9.4		17.		11.
1,1-DICHLOROETHYLENE	(PPB)		79.		120.		70.		150.		95.
1,2-DICHLOROETHANE	(PPB)		1.		1.	<	1.		1.9		0.66
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		2.		4.		2.1		5.9		4.2
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		80.		110.		63.		95.		57.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)		2.	<	1.	<	1.	<	1.	<	0.5
FREON 113	(PPB)		4.		8.		3.5		9.	<	0.5
TETRACHLOROETHYLENE	(PPB)		12.		26.		11.		28.		5.2
TRICHLOROETHYLENE	(PPB)		1100.		1700.		1000.		1800.		530.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1371 NFH-MW3 Well Type: MC Zone: 1 Sector: D GSE: 115.26 TOC: 115.26 TOP: 128 BOP: 138 TD: 138

		Sample Date:	02/08/93	06/10/93	08/23/94	01/23/95	09/08/95
		Time:	13:09	10:54	11:45	12:47	10:01
		Sample Type:					
		Lab:	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		8.	NM	NM	NM	NM
NITRITE	(MG/L)		0.13	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	< 0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		390.	410.	380.	380.	360.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	< 10.	< 10.
PH	(PH)		8.	8.	7.9	8.2	8.1
TEMPERATURE	(DEGREES C.)		17.8	19.9	20.4	16.7	21.4
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)		2.	3.	< 1.	3.2	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		3.	6.	2.2	9.5	2.7
1,1-DICHLOROETHYLENE	(PPB)		23.	48.	17.	76.	27.
1,2-DICHLOROETHANE	(PPB)		1.	1.	< 1.	2.4	0.79
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)		2.	2.	< 1.	4.5	2.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		36.	60.	25.	89.	27.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)		3.	4.	58.	9.8	< 0.5
TETRACHLOROETHYLENE	(PPB)		6.	12.	2.7	19.	2.7
TRICHLOROETHYLENE	(PPB)		590.	1300.	330.	1500.	270.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1372 NFH-MW3 Well Type: MC Zone: 1 Sector: D GSE: 115.26 TOC: 115.26 TOP: 180 BOP: 190 TD: 190

	Sample Date:	02/08/93		06/10/93		08/23/94		01/23/95		09/08/95					
	Time:	14:13		10:17		11:05		12:00		08:55					
	Sample Type:														
	Lab:	EL		EL		EL		EL		EL					
MINERALS, INORGANICS	(Units)														
NITRATE	(MG/L)		7.1		NM		NM		NM		NM				
NITRITE	(MG/L)		0.83		NM		NM		NM		NM				
PERCHLORATE	(MG/L)		0.7		NM		NM		NM	<	0.4				
MISCELLANEOUS															
CONDUCTANCE	(UMHOS/CM)		410.		420.		420.		400.		460.				
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.	<	10.	<	10.				
PH	(PH)		7.9		7.8		8.5		8.9		8.8				
TEMPERATURE	(DEGREES C.)		18.		20.7		20.2		17.4		19.1				
VOLATILE ORGANICS															
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.		1.2		0.55				
1,1-DICHLOROETHYLENE	(PPB)		3.		3.		8.6		11.		8.1				
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.		0.3				
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	<	2.	<	0.5				
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25				
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.	<	1.		0.68				
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		10.		16.		13.		19.		9.7				
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
FREON 113	(PPB)		1.	<	1.	<	1.		1.2	<	0.5				
TETRACHLOROETHYLENE	(PPB)		2.		3.		1.5		3.	<	0.5				
TRICHLOROETHYLENE	(PPB)		250.		400.		210.		340.		110.				
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5				
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25				

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1373 NFH-MW3 Well Type: MC Zone: 1 Sector: D GSE: 115.26 TOC: 115.26 TOP: 215 BOP: 224.6 TD: 224.6

		Sample Date:	02/09/93	06/10/93	08/23/94	01/25/95	09/08/95
		Time:	10:33	11:56	18:11	09:25	10:40
		Sample Type:					
		Lab:	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)	<	0.1	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	< 0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		870.	890.	590.	720.	730.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	< 10.	< 10.
PH	(PH)		11.8	11.6	11.2	11.7	11.4
TEMPERATURE	(DEGREES C.)		15.	22.2	19.9	15.7	22.9
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	<	1.	3.	< 1.	< 1.	2.4
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25

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Well: 1374 NFH-MW3 Well Type: MC Zone: 1 Sector: D GSE: 115.26 TOC: 115.26 TOP: 272 BOP: 282 TD: 282

		Sample Date:	02/09/93	06/10/93	08/23/94	01/25/95	09/08/95
		Time:	09:50	11:42	16:36	11:28	09:44
		Sample Type:					
		Lab:	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		< 0.1	NM	NM	NM	NM
NITRITE	(MG/L)		< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)		< 0.4	NM	NM	NM	NM
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		200.	190.	180.	210.	210.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	< 10.	< 10.
PH	(PH)		10.1	10.1	9.1	10.1	9.5
TEMPERATURE	(DEGREES C.)		16.2	23.	21.4	17.9	22.3
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)		< 2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)		< 1.	1.	< 1.	< 1.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)		< 1.	< 1.	< 1.	< 1.	< 0.25

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Well: 1375 NFH-MW1 Well Type: MC Zone: 1 Sector: D GSE: 101.96 TOC: 101.77 TOP: 32 BOP: 42 TD: 42

		Sample Date:	02/26/93	06/10/93	07/20/95
		Time:	10:35	11:38	11:31
		Sample Type:			
		Lab:	EL	EL	EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)		2.1	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		120.	280.	220.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.
PH	(PH)		7.8	7.2	7.2
TEMPERATURE	(DEGREES C.)		11.4	17.4	17.7
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	3.	0.94
1,1-DICHLOROETHYLENE	(PPB)	<	1.	15.	10.
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 0.5
CHLOROFORM	(PPB)	<	1.	1.	1.1
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	19.	14.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
FREON 113	(PPB)		2.	37.	21.
TETRACHLOROETHYLENE	(PPB)	<	1.	8.	8.7
TRICHLOROETHYLENE	(PPB)		7.	110.	92.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 0.25

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Well: 1376 NFH-MW1 Well Type: MC Zone: 1 Sector: D GSE: 101.96 TOC: 101.77 TOP: 80 BOP: 101 TD: 101

		Sample Date:	02/26/93		06/10/93		07/20/95
		Time:	10:20		10:48		11:09
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		8.		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM	<	0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		440.		420.		400.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.
PH	(PH)		7.8		7.7		7.7
TEMPERATURE	(DEGREES C.)		13.3		19.7		19.
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)		2.		2.		1.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.		0.6
1,1-DICHLOROETHANE	(PPB)		9.		12.		12.
1,1-DICHLOROETHYLENE	(PPB)		55.		64.		87.
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)		2.	<	1.		0.33
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		6.		5.		7.4
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		35.		29.		35.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
FREON 113	(PPB)		330.		280.		280.
TETRACHLOROETHYLENE	(PPB)		28.		42.		47.
TRICHLOROETHYLENE	(PPB)		660.		440.		620.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25

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Well: 1377 NFH-MW1 Well Type: MC Zone: 1 Sector: D GSE: 101.96 TOC: 101.77 TOP: 164 BOP: 174 TD: 174

		Sample Date:	02/26/93	06/10/93	07/20/95
		Time:	09:55	09:46	10:34
		Sample Type:			
		Lab:	EL	EL	EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)		4.3	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		400.	410.	390.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.
PH	(PH)		7.8	7.8	7.7
TEMPERATURE	(DEGREES C.)		13.7	19.4	18.4
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		2.	3.	3.5
1,1-DICHLOROETHYLENE	(PPB)		15.	19.	33.
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 0.5
CHLOROFORM	(PPB)		3.	3.	4.4
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		5.	7.	13.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
FREON 113	(PPB)		153.	220.	270.
TETRACHLOROETHYLENE	(PPB)		5.	7.	18.
TRICHLOROETHYLENE	(PPB)		180.	260.	490.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 0.25

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Well: 1378 NFH-MW1 Well Type: MC Zone: 1 Sector: D GSE: 101.96 TOC: 101.77 TOP: 230 BOP: 250 TD: 250

	Sample Date:		02/26/93		07/12/95	
	Time:		11:00		15:02	
	Sample Type:					
	Lab:		EL		EL	
MINERALS, INORGANICS	(Units)					
NITRATE	(MG/L)	<	0.1		NM	
NITRITE	(MG/L)	<	0.05		NM	
PERCHLORATE	(MG/L)	<	0.4	<	0.4	
MISCELLANEOUS						
CONDUCTANCE	(UMHOS/CM)		820.		770.	
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.	
PH	(PH)		11.9		11.4	
TEMPERATURE	(DEGREES C.)		13.7		20.7	
VOLATILE ORGANICS						
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	0.5	
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	0.5	
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	0.5	
1,1-DICHLOROETHANE	(PPB)	<	1.	<	0.5	
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	0.5	
1,2-DICHLOROETHANE	(PPB)	<	1.	<	0.25	
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	0.5	
BROMODICHLOROMETHANE	(PPB)	<	1.	<	0.5	
BROMOFORM	(PPB)	<	2.	<	0.5	
CARBON TETRACHLORIDE	(PPB)	<	1.	<	0.25	
CHLOROBENZENE	(PPB)	<	1.	<	0.5	
CHLOROFORM	(PPB)	<	1.	<	0.5	
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	0.5	
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	0.5	
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	0.5	
DICHLOROMETHANE	(PPB)	<	1.	<	0.5	
FREON 113	(PPB)	<	1.	<	0.5	
TETRACHLOROETHYLENE	(PPB)	<	1.	<	0.5	
TRICHLOROETHYLENE	(PPB)	<	1.	<	0.5	
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	0.5	
VINYL CHLORIDE	(PPB)	<	1.	<	0.25	

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Well: 1379 NFH-MW7 Well Type: SC Zone: 1 Sector: D GSE: 134.71 TOC: 134.51 TOP: 200 BOP: 221 TD: 221

		Sample Date:	02/26/93		06/08/93		07/19/95
		Time:	14:20		09:33		13:24
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		8.3		NM		NM
NITRITE	(MG/L)		0.05		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM	<	0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		410.		490.		440.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.
PH	(PH)		8.1		7.7		7.8
TEMPERATURE	(DEGREES C.)		14.5		19.3		21.6
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.		0.75
1,1-DICHLOROETHANE	(PPB)		11.		13.		15.
1,1-DICHLOROETHYLENE	(PPB)		76.		91.		120.
1,2-DICHLOROETHANE	(PPB)		8.		3.	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)		7.		9.		6.1
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		8.		8.		11.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		50.		42.		64.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
FREON 113	(PPB)		39.		36.		66.
TETRACHLOROETHYLENE	(PPB)		5.		5.		8.7
TRICHLOROETHYLENE	(PPB)		700.		820.		890.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25

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Well: 1380 NFH-MW8 Well Type: MC Zone: 1 Sector: D GSE: 114.86 TOC: 114.88 TOP: 110 BOP: 120 TD: 120

		Sample Date:	02/10/93		06/10/93		08/24/95
		Time:	11:15		13:22		11:05
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS -	(Units)						
NITRATE	(MG/L)		12.		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM	<	0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		370.		380.		400.
N-NITROSODIMETHYLAMINE	(UG/L)		NM		NM	<	0.1
PH	(PH)		7.4		7.4		7.5
TEMPERATURE	(DEGREES C.)		16.2		23.3		23.5
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)		2.		1.	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)		9.		11.		5.1
1,1-DICHLOROETHYLENE	(PPB)		66.		55.		22.
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)		1.		2.		0.53
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		8.		8.		6.8
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		35.		34.		24.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
FREON 113	(PPB)		830.		670.		250.
TETRACHLOROETHYLENE	(PPB)		85.		99.		55.
TRICHLOROETHYLENE	(PPB)		590.		780.		530.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25

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Well: 1381 NFH-MW8 Well Type: MC Zone: 1 Sector: D GSE: 114.86 TOC: 114.88 TOP: 168 BOP: 178 TD: 178

		Sample Date:	02/10/93		06/10/93		08/24/95
		Time:	10:42		13:01		10:12
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS -	(Units)						
NITRATE	(MG/L)		5.8		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM	<	0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		400.		410.		410.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.
PH	(PH)		7.8		7.8		7.7
TEMPERATURE	(DEGREES C.)		15.4		23.2		23.3
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)		3.		3.		4.8
1,1-DICHLOROETHYLENE	(PPB)		34.		15.		16.
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)		1.	<	1.		0.7
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		3.		2.		5.4
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		9.		5.		13.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
FREON 113	(PPB)		280.		120.		230.
TETRACHLOROETHYLENE	(PPB)		10.		7.		20.
TRICHLOROETHYLENE	(PPB)		350.		240.		480.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1382 NFH-MW9 Well Type: MC Zone: 1 Sector: D GSE: 132.16 TOC: 132.24 TOP: 109 BOP: 119 TD: 119

		Sample Date:	01/25/93	06/07/93	07/22/93	01/15/94	11/07/94	02/03/95	08/30/95
		Time:	09:46	10:39	11:14	11:54	13:41	09:38	12:52
		Sample Type:							
		Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)								
ALUMINUM	(MG/L)		0.17	NM	< 0.05	NM	NM	NM	NM
ANTIMONY	(MG/L)	<	0.3	NM	< 0.5	NM	NM	NM	NM
ARSENIC	(MG/L)	<	0.1	NM	< 0.1	NM	NM	NM	NM
BARIUM	(MG/L)		0.071	NM	0.07	NM	NM	NM	NM
BERYLLIUM	(MG/L)	<	0.002	NM	< 0.002	NM	NM	NM	NM
BORON	(MG/L)	<	0.1	NM	< 0.1	NM	NM	NM	NM
CADMIUM	(MG/L)	<	0.02	NM	< 0.01	NM	NM	NM	NM
CHROMIUM	(MG/L)	<	0.04	NM	< 0.01	NM	NM	NM	NM
COBALT	(MG/L)	<	0.02	NM	< 0.02	NM	NM	NM	NM
COPPER	(MG/L)	<	0.05	NM	< 0.01	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM
IRON	(MG/L)		0.5	NM	< 0.1	NM	NM	NM	NM
LEAD	(MG/L)	<	0.1	NM	< 0.1	NM	NM	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	<	0.04	NM	< 0.04	NM	NM	NM	NM
NICKEL	(MG/L)	<	0.04	NM	< 0.04	NM	NM	NM	NM
SELENIUM	(MG/L)	<	0.4	NM	< 0.2	NM	NM	NM	NM
SILVER	(MG/L)	<	0.01	NM	< 0.01	NM	NM	NM	NM
THALLIUM	(MG/L)	<	0.4	NM	< 0.05	NM	NM	NM	NM
VANADIUM	(MG/L)	<	0.02	NM	< 0.02	NM	NM	NM	NM
ZINC	(MG/L)		2.4	NM	1.5	NM	NM	NM	NM
MINERALS, INORGANICS									
CALCIUM	(MG/L)		37.	NM	33.	NM	NM	NM	NM
CHLORIDE	(MG/L)		12.	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		15.	NM	14.	NM	NM	NM	NM
MANGANESE	(MG/L)		0.007	NM	< 0.005	NM	NM	NM	NM
NITRATE	(MG/L)		8.	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)		0.6	NM	NM	NM	NM	NM	< 0.4
POTASSIUM	(MG/L)		2.9	NM	2.	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		18.	NM	16.	NM	NM	NM	NM
SULFATE	(MG/L)		14.	NM	NM	NM	NM	NM	NM
MISCELLANEOUS									
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		5.	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		34.	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		360.	380.	380.	380.	380.	340.	370.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	< 10.	NM	NM	NM	< 10.
PH	(PH)		7.4	7.2	7.4	7.6	7.4	7.5	7.5
TEMPERATURE	(DEGREES C.)		18.9	17.6	24.5	20.1	18.1	16.	22.5
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.2	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1382 NFH-MW9 Well Type: MC Zone: 1 Sector: D GSE: 132.16 TOC: 132.24 TOP: 109 BOP: 119 TD: 119

	Sample Date:	01/25/93	06/07/93	07/22/93	01/15/94	11/07/94	02/03/95	08/30/95
	Time:	09:46	10:39	11:14	11:54	13:41	09:38	12:52
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	4.	< 5.	3.7	3.	2.5	1.6
1,1-DICHLOROETHYLENE	(PPB)	25.	21.	28.	21.	24.	12.	14.
1,2-DICHLOROETHANE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	< 20.	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	< 20.	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	< 20.	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 5.	< 4.	< 5.	< 2.	< 2.	< 2.	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 2.	< 5.	2.	1.8	1.8	3.3
CHLOROMETHANE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	100.	95.	120.	86.	59.	64.	47.
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 2.	< 10.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	3.	< 5.	6.9	6.2	4.9	3.2
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	7.	7.	7.	8.2	6.6	6.	5.8
TOLUENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	450.	400.	430.	390.	270.	340.	250.
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 2.	< 5.	< 1.	< 1.	< 1.	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 2.	< 10.	< 1.	< 1.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1383 NFH-MW9 Well Type: MC Zone: 1 Sector: D GSE: 132.16 TOC: 132.24 TOP: 147 BOP: 157 TD: 157

	Sample Date:	02/01/93	06/07/93	01/15/94	11/07/94	02/03/95	08/30/95
	Time:	10:00	11:35	11:18	13:48	09:10	13:41
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)	8.5	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	< 0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)	390.	400.	400.	380.	370.	390.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	< 10.
PH	(PH)	7.7	7.6	7.7	7.2	7.7	7.6
TEMPERATURE	(DEGREES C.)	18.5	20.	19.4	21.5	16.2	22.3
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	8.	9.	8.8	7.7	7.1	6.6
1,1-DICHLOROETHYLENE	(PPB)	44.	49.	44.	54.	45.	52.
1,2-DICHLOROETHANE	(PPB)	2.	< 2.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 4.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	1.	< 2.	1.3	< 1.	< 1.	0.37
CHLOROBENZENE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	4.	4.	4.1	4.1	4.1	5.6
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	33.	34.	34.	33.	32.	30.
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	180.	230.	220.	250.	240.	180.
TETRACHLOROETHYLENE	(PPB)	13.	17.	17.	14.	15.	18.
TRICHLOROETHYLENE	(PPB)	310.	440.	440.	440.	410.	400.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 2.	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1384 NFH-MW9 Well Type: MC Zone: 1 Sector: D GSE: 132.16 TOC: 132.24 TOP: 188 BOP: 209 TD: 209

		Sample Date:	02/01/93	06/07/93	01/15/94	11/07/94	02/03/95	08/29/95
		Time:	11:03	12:50	12:52	14:33	10:20	12:53
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		6.4	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	< 0.4
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		440.	460.	450.	440.	410.	440.
N-NITROSODIMETHYLAMINE	(UG/L)		NM	< 10.	NM	NM	NM	< 0.1
PH	(PH)		8.	8.	8.1	8.2	8.1	8.
TEMPERATURE	(DEGREES C.)		19.	19.3	21.5	17.9	16.8	21.4
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		6.	7.	6.7	5.6	5.6	4.
1,1-DICHLOROETHYLENE	(PPB)		32.	40.	37.	35.	36.	31.
1,2-DICHLOROETHANE	(PPB)		1.	< 1.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)		2.	3.	2.4	1.4	1.7	0.72
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)		4.	4.	3.6	3.5	3.6	3.9
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		19.	20.	20.	16.	16.	12.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)		71.	100.	100.	100.	130.	68.
TETRACHLOROETHYLENE	(PPB)		3.	3.	4.	2.6	4.2	3.7
TRICHLOROETHYLENE	(PPB)		240.	270.	260.	140.	250.	210.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1385 NFH-MW11 Well Type: MC Zone: 1 Sector: D GSE: 127.62 TOC: 127.77 TOP: 94 BOP: 115 TD: 115

		Sample Date:	02/01/93	06/18/93	01/15/94	11/08/94	02/16/95	08/23/95
		Time:	13:32	13:45	09:45	10:25	13:30	15:26
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		8.7	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	< 0.4
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		400.	360.	380.	220.	280.	360.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	NM	NM	< 10.	< 10.
PH	(PH)		7.6	7.3	7.6	8.2	7.7	8.2
TEMPERATURE	(DEGREES C.)		17.1	24.1	17.8	18.1	20.1	24.7
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		5.	7.	4.5	4.7	1.1	< 0.5
1,1-DICHLOROETHYLENE	(PPB)		37.	40.	26.	34.	9.2	4.3
1,2-DICHLOROETHANE	(PPB)		2.	< 1.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)		2.	3.	1.6	1.8	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)		8.	7.	4.2	4.6	1.2	0.67
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		17.	19.	13.	13.	3.4	1.3
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	2.4	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)		330.	410.	220.	220.	59.	19.
TETRACHLOROETHYLENE	(PPB)		49.	57.	39.	31.	9.	5.2
TRICHLOROETHYLENE	(PPB)		710.	650.	390.	450.	120.	73.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1386 NFH-MW11 Well Type: MC Zone: 1 Sector: D GSE: 127.62 TOC: 127.77 TOP: 152 BOP: 169 TD: 169

		Sample Date:	02/01/93	06/18/93	01/15/94	11/08/94	02/16/95	08/23/95
		Time:	13:00	13:19	09:15	10:32	14:12	14:50
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		3.9	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		300.	340.	230.	170.	220.	200.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	NM	NM	< 10.	< 10.
PH	(PH)		7.4	7.7	9.5	9.6	9.	9.3
TEMPERATURE	(DEGREES C.)		17.5	25.5	14.7	19.2	18.9	27.3
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)		13.	13.	5.5	4.6	4.5	0.89
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)		1.	1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		1.	1.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)		20.	22.	9.1	7.5	7.6	1.5
TETRACHLOROETHYLENE	(PPB)		2.	2.	1.5	1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)		91.	99.	55.	30.	38.	20.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25

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Well: 1387 NFH-MW11 Well Type: MC Zone: 1 Sector: D GSE: 127.62 TOC: 127.77 TOP: 224 BOP: 234 TD: 234

		Sample Date:	02/01/93	06/18/93	11/23/94	02/16/95	08/23/95
		Time:	13:58	14:15	14:50	14:30	13:33
		Sample Type:					
		Lab:	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)	<	0.1	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)		0.6	NM	NM	NM	< 0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		210.	220.	250.	210.	290.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	NM	< 10.	< 10.
PH	(PH)		7.9	7.7	8.2	7.7	7.2
TEMPERATURE	(DEGREES C.)		17.4	27.6	14.5	17.2	27.5
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25

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Well: 1388 NFH-MW6 Well Type: MC Zone: 1 Sector: D GSE: 104.42 TOC: 106.13 TOP: 88 BOP: 109 TD: 109

		Sample Date:	02/09/93	06/08/93	08/21/95
		Time:	13:00	11:23	10:15
		Sample Type:			
		Lab:	EL	EL	EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)		0.7	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		430.	440.	240.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.
PH	(PH)		8.	7.8	9.
TEMPERATURE	(DEGREES C.)		18.2	21.	20.7
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	2.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		11.	14.	6.1
1,1-DICHLOROETHYLENE	(PPB)		75.	80.	21.
1,2-DICHLOROETHANE	(PPB)		2.	1.	1.3
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	3.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 0.5
CHLOROFORM	(PPB)		4.	6.	1.6
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		77.	79.	38.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	1.8
DICHLOROMETHANE	(PPB)		4.	< 1.	< 0.5
FREON 113	(PPB)		35.	120.	22.
TETRACHLOROETHYLENE	(PPB)		9.	16.	4.1
TRICHLOROETHYLENE	(PPB)		740.	940.	250.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 0.25

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Well: 1389 NFH-MW6 Well Type: MC Zone: 1 Sector: D GSE: 104.42 TOC: 106.13 TOP: 171 BOP: 192 TD: 192

		Sample Date:	02/09/93	06/08/93	08/21/95
		Time:	14:12	10:54	09:24
		Sample Type:			
		Lab:	EL	EL	EL
MINERALS, INORGANICS -	(Units)				
NITRATE	(MG/L)		0.4	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		480.	NM	340.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.
PH	(PH)		7.9	NM	8.3
TEMPERATURE	(DEGREES C.)		18.2	NM	19.8
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		8.	13.	4.2
1,1-DICHLOROETHYLENE	(PPB)		56.	79.	11.
1,2-DICHLOROETHANE	(PPB)		2.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	11.	0.3
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 0.5
CHLOROFORM	(PPB)		1.	8.	0.76
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		21.	30.	9.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)		9.	< 1.	3.
FREON 113	(PPB)		3.	41.	8.6
TETRACHLOROETHYLENE	(PPB)		2.	4.	0.59
TRICHLOROETHYLENE	(PPB)		450.	830.	140.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 0.25

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Well: 1390 NFH-MW6 Well Type: MC Zone: 1 Sector: D GSE: 104.42 TOC: 106.13 TOP: 247 BOP: 268 TD: 268

		Sample Date:	02/09/93	06/16/93	08/18/95
		Time:	12:21	12:15	14:39
		Sample Type:			
		Lab:	EL	EL	EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)	<	0.1	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		580.	560.	540.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.
PH	(PH)		11.5	11.3	11.2
TEMPERATURE	(DEGREES C.)		18.8	23.1	23.3
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)		3.	< 1.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 0.25

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Well: 1391 NFH-MW10 Well Type: MC Zone: 1 Sector: D GSE: 126.09 TOC: 126.1 TOP: 75 BOP: 85 TD: 85

		Sample Date:	02/09/93		06/17/93		07/21/95
		Time:	12:49		09:08		10:07
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		6.8		NM		NM
NITRITE	(MG/L)	<	0.2		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM	<	0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		460.		540.		580.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.
PH	(PH)		8.		7.5		7.4
TEMPERATURE	(DEGREES C.)		14.7		19.5		18.8
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)		3.		2.		1.
1,1,2,2-TETRACHLOROETHANE	(PPB)		1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)		6.		9.		7.3
1,1-DICHLOROETHYLENE	(PPB)		47.		61.		47.
1,2-DICHLOROETHANE	(PPB)		1.	<	1.	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.25
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	0.5
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		3.		2.		4.7
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		55.		89.		120.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
FREON 113	(PPB)		4.		3.		7.5
TETRACHLOROETHYLENE	(PPB)		10.		16.		15.
TRICHLOROETHYLENE	(PPB)		480.		700.		720.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25

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Well: 1392 NFH-MW10 Well Type: MC Zone: 1 Sector: D GSE: 126.09 TOC: 126.1 TOP: 129 BOP: 150 TD: 150

		Sample Date:	02/09/93		06/17/93		07/20/95
		Time:	12:20		09:58		14:41
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		10.		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM	<	0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		360.		390.		370.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.
PH	(PH)		8.1		7.8		7.7
TEMPERATURE	(DEGREES C.)		15.9		19.6		21.3
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)		6.		5.		1.6
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)		8.		9.		6.7
1,1-DICHLOROETHYLENE	(PPB)		88.		87.		73.
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)		1.	<	1.	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		6.		3.		8.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		150.		160.		150.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
FREON 113	(PPB)		37.		28.		30.
TETRACHLOROETHYLENE	(PPB)		20.		22.		22.
TRICHLOROETHYLENE	(PPB)		1500.		1800.		1200.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25

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Well: 1393 NFH-MW10 Well Type: MC Zone: 1 Sector: D GSE: 126.09 TOC: 126.1 TOP: 188 BOP: 209 TD: 209

		Sample Date:	02/09/93		06/17/93		07/20/95
		Time:	11:24		12:22		14:04
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		7.2		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM	<	0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		380.		440.		390.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.
PH	(PH)		8.4		7.8		7.8
TEMPERATURE	(DEGREES C.)		15.2		24.8		21.4
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.		0.82
1,1-DICHLOROETHANE	(PPB)		12.		16.		12.
1,1-DICHLOROETHYLENE	(PPB)		83.		82.		91.
1,2-DICHLOROETHANE	(PPB)		7.		7.		6.5
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)		5.		5.		1.5
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		6.		8.		10.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		59.		71.		94.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
FREON 113	(PPB)		72.		73.		91.
TETRACHLOROETHYLENE	(PPB)		6.		7.		16.
TRICHLOROETHYLENE	(PPB)		550.		440.		1100.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25

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Water Quality Information

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Well: 1394 NFH-MW10 Well Type: MC Zone: 1 Sector: D GSE: 126.09 TOC: 126.1 TOP: 304 BOP: 314 TD: 314

		Sample Date:	02/10/93	06/17/93	07/21/95
		Time:	14:50	08:07	10:47
		Sample Type:			
		Lab:	EL	EL	EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)	<	0.1	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		180.	180.	180.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.
PH	(PH)		8.7	8.6	8.5
TEMPERATURE	(DEGREES C.)		16.4	19.7	22.
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.25
BROMOFORM	(PPB)	<	2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 0.5
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1395 GARN-MW1 Well Type: MC Zone: 1 Sector: D GSE: 116.19 TOC: 116.19 TOP: 83 BOP: 93 TD: 93

		Sample Date:	03/03/93	07/12/93	08/22/94	04/05/95	09/07/95	12/05/95
		Time:	12:36	15:54	14:02	12:57	11:38	12:45
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		2.7	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	< 0.4	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		260.	260.	220.	140.	160.	260.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	< 10.	< 10.	< 10.	NM
PH	(PH)		7.2	7.1	7.2	8.3	7.5	7.3
TEMPERATURE	(DEGREES C.)		18.1	20.7	19.8	19.	22.2	15.6
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)		2.	< 1.	1.3	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1396 OARN-MW1 Well Type: MC Zone: 1 Sector: D GSE: 116.19 TOC: 116.19 TOP: 126 BOP: 136 TD: 136

	Sample Date:	03/03/93		07/12/93		08/22/94		04/05/95		09/07/95		12/05/95					
	Time:	11:44		15:30		13:26		12:13		10:59		11:40					
	Sample Type:																
	Lab:	EL		EL		EL		EL		EL		EL					
MINERALS, INORGANICS	(Units)																
NITRATE	(MG/L)		0.6		NM		NM		NM		NM		NM				
NITRITE	(MG/L)	<	0.05		NM		NM		NM		NM		NM				
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM	<	0.4		NM				
MISCELLANEOUS																	
CONDUCTANCE	(UMHOS/CM)		270.		210.		180.		150.		150.		150.				
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.	<	10.	<	10.	<	10.		NM				
PH	(PH)		8.9		8.7		8.3		9.6		8.6		8.				
TEMPERATURE	(DEGREES C.)		16.9		20.3		20.4		19.3		25.5		15.5				
VOLATILE ORGANICS																	
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25				
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	<	2.	<	0.5	<	0.5				
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25				
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		5.		2.		2.4		1.1	<	0.5		0.67				
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
FREON 113	(PPB)	<	1.	<	1.		6.2	<	1.	<	0.5	<	0.5				
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
TRICHLOROETHYLENE	(PPB)		130.		74.		77.		39.		26.		40.				
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.5	<	0.5				
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	1.	<	0.25	<	0.25				

AEROJET Environmental Operations
Water Quality Information

Well: 1397 OARN-MW1 Well Type: MC Zone: 1 Sector: D GSE: 116.19 TOC: 116.19 TOP: 174 BOP: 192 TD: 192

		Sample Date:	03/03/93	07/12/93	08/22/94	04/05/95	09/07/95	12/05/95
		Time:	10:43	14:57	12:54	11:22	09:56	10:22
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)	1.6	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	< 0.4	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)	210.	240.	240.	230.	240.	230.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	< 10.	< 10.	< 10.	NM
PH	(PH)	8.7	8.9	8.2	9.1	8.3	8.4
TEMPERATURE	(DEGREES C.)	17.7	21.	20.3	19.5	25.2	15.4
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	2.	3.8	3.5	3.4	3.8
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	0.92	1.1
TRICHLOROETHYLENE	(PPB)	48.	77.	130.	130.	140.	160.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1398 OARN-MW1 Well Type: MC Zone: 1 Sector: D GSE: 116.19 TOC: 116.19 TOP: 228 BOP: 238 TD: 238

		Sample Date:	03/09/93	07/12/93	08/22/94	04/06/95	09/11/95	11/30/95
		Time:	17:12	17:03	19:36	13:17	09:24	15:25
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS -	(Units)							
NITRATE	(MG/L)		3.4	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	< 0.4	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		250.	240.	240.	270.	250.	180.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	< 10.	< 10.	< 10.	NM
PH	(PH)		8.2	8.3	8.3	8.4	7.1	8.8
TEMPERATURE	(DEGREES C.)		17.9	21.7	18.	16.	19.3	20.3
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	6.4	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	1.9	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1399 OARN-MW1 Well Type: MC Zone: 1 Sector: D GSE: 116.19 TOC: 116.19 TOP: 278 BOP: 288 TD: 288

		Sample Date:	03/09/93	07/12/93	08/22/94	04/06/95	09/08/95	12/04/95
		Time:	15:59	16:26	16:52	11:54	12:56	:
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM	
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	< 0.4	NM	
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)	260.	240.	250.	240.	260.	260.	
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	< 10.	< 10.	< 10.	NM	
PH	(PH)	8.	8.4	8.	8.2	7.7	8.1	
TEMPERATURE	(DEGREES C.)	18.4	22.8	18.9	16.2	28.2	23.2	
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5	
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
TRICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1400 NFH-MW12 Well Type: MC Zone: 1 Sector: D GSE: 125.75 TOC: 125.79 TOP: 134 BOP: 155 TD: 155

		Sample Date:	02/03/93	06/10/93	01/17/94	11/08/94	02/06/95	08/31/95
		Time:	13:42	10:24	13:44	13:00	:	12:23
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		13.	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.1	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	< 0.4
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		360.	380.	380.	350.	380.	380.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	NM	NM	NM	< 10.
PH	(PH)		7.8	7.9	7.9	8.1	7.8	7.9
TEMPERATURE	(DEGREES C.)		18.5	19.	19.5	18.9	15.4	21.6
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		3.	4.	4.9	4.8	5.9	6.2
1,1-DICHLOROETHYLENE	(PPB)		16.	23.	24.	38.	22.	28.
1,2-DICHLOROETHANE	(PPB)		2.	2.	3.1	4.8	2.6	1.7
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 4.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 2.	1.4	1.2	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)		2.	< 2.	2.8	2.5	2.9	4.6
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		31.	33.	38.	22.	37.	45.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)		5.	5.	8.5	7.5	13.	16.
TETRACHLOROETHYLENE	(PPB)		4.	4.	5.4	3.2	7.4	8.5
TRICHLOROETHYLENE	(PPB)		520.	580.	690.	350.	550.	560.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 2.	< 1.	< 1.	< 1.	< 0.25

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Well: 1401 NFH-MW12 Well Type: MC Zone: 1 Sector: D GSE: 125.75 TOC: 125.79 TOP: 186 BOP: 196 TD: 196

		Sample Date:	02/04/93	06/10/93	01/17/94	11/08/94	02/06/95	08/31/95
		Time:	13:11	09:29	12:22	12:20	:	10:51
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		9.	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	< 0.4
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		340.	340.	380.	350.	340.	340.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	NM	NM	NM	< 10.
PH	(PH)		8.	8.2	7.7	8.1	8.6	8.5
TEMPERATURE	(DEGREES C.)		19.1	18.1	21.6	18.6	15.5	18.9
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		2.	3.	4.1	4.8	5.7	4.7
1,1-DICHLOROETHYLENE	(PPB)		22.	23.	31.	35.	43.	38.
1,2-DICHLOROETHANE	(PPB)		2.	3.	3.9	4.8	4.8	3.4
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	1.3	1.2	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)		1.	2.	2.2	2.5	3.8	4.4
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		12.	15.	19.	22.	23.	19.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)		4.	3.	6.3	7.7	7.	7.4
TETRACHLOROETHYLENE	(PPB)		2.	2.	2.7	2.7	3.2	2.3
TRICHLOROETHYLENE	(PPB)		230.	270.	320.	370.	360.	270.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 0.25

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Well: 1402 NFH-MW12 Well Type: MC Zone: 1 Sector: D GSE: 125.75 TOC: 125.79 TOP: 330 BOP: 340 TD: 340

	Sample Date:		02/04/93		06/08/93
	Time:		15:25		13:35
	Sample Type:				
	Lab:		EL		EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)		0.3		NM
NITRITE	(MG/L)	<	0.05		NM
PERCHLORATE	(MG/L)		0.6		NM
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		190.		150.
PH	(PH)		8.9		8.4
TEMPERATURE	(DEGREES C.)		19.5		22.9
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(UG/L)	<	1.	<	1.
1,1,2,2-TETRACHLOROETHANE	(UG/L)	<	1.	<	1.
1,1,2-TRICHLOROETHANE	(UG/L)	<	1.	<	1.
1,1-DICHLOROETHANE	(UG/L)	<	1.	<	1.
1,1-DICHLOROETHYLENE	(UG/L)	<	1.	<	1.
1,2-DICHLOROETHANE	(UG/L)	<	1.	<	1.
1,2-DICHLOROPROPANE	(UG/L)	<	1.	<	1.
BROMODICHLOROMETHANE	(UG/L)	<	1.	<	1.
BROMOFORM	(UG/L)	<	2.	<	2.
CARBON TETRACHLORIDE	(UG/L)	<	1.	<	1.
CHLOROBENZENE	(UG/L)	<	1.	<	1.
CHLOROFORM	(UG/L)	<	1.	<	1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(UG/L)	<	1.	<	1.
DIBROMOCHLOROMETHANE	(UG/L)	<	1.	<	1.
DICHLORODIFLUOROMETHANE	(UG/L)	<	1.	<	1.
DICHLOROMETHANE	(UG/L)	<	1.	<	1.
FREON 113	(UG/L)	<	1.	<	1.
TETRACHLOROETHYLENE	(UG/L)	<	1.	<	1.
TRICHLOROETHYLENE	(UG/L)		4.		1.
TRICHLOROFLUOROMETHANE	(UG/L)	<	1.	<	1.
VINYL CHLORIDE	(UG/L)	<	1.	<	1.

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Well: 1403 NFH-MW5 Well Type: MC Zone: 1 Sector: D GSE: 133.02 TOC: 133.1 TOP: 68 BOP: 78 TD: 78

		Sample Date:	02/25/93		06/14/93		07/18/95
		Time:	11:46		14:52		13:51
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		7.9		NM		NM
NITRITE	(MG/L)	<	1.		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM	<	0.4
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		1500.		1200.		890.
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.	<	10.
PH	(PH)		6.9		7.2		7.1
TEMPERATURE	(DEGREES C.)		16.5		26.2		20.7
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)		4.		5.		1.8
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)		6.		6.		4.3
1,1-DICHLOROETHYLENE	(PPB)		40.		50.		46.
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		3.		2.		4.1
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		50.		46.		54.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
FREON 113	(PPB)		3.		6.		11.
TETRACHLOROETHYLENE	(PPB)		14.		14.		16.
TRICHLOROETHYLENE	(PPB)		380.		450.		440.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25

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Well: 1404 NFH-MW5 Well Type: MC Zone: 1 Sector: D GSE: 133.02 TOC: 133.1 TOP: 125 BOP: 135 TD: 135

		Sample Date:	02/25/93	06/14/93	07/18/95
		Time:	11:17	12:49	13:18
		Sample Type:			
		Lab:	EL	EL	EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)		10.	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		400.	420.	420.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	< 10.
PH	(PH)		7.7	7.8	7.8
TEMPERATURE	(DEGREES C.)		17.9	24.1	20.7
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)		6.	3.	2.7
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 2.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 2.	1.2
1,1-DICHLOROETHANE	(PPB)		13.	15.	15.
1,1-DICHLOROETHYLENE	(PPB)		96.	110.	140.
1,2-DICHLOROETHANE	(PPB)		6.	2.	2.8
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 2.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 2.	< 0.5
BROMOFORM	(PPB)	<	2.	< 4.	< 0.5
CARBON TETRACHLORIDE	(PPB)		5.	5.	4.5
CHLOROBENZENE	(PPB)	<	1.	< 2.	< 0.5
CHLOROFORM	(PPB)		13.	11.	17.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		240.	220.	160.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 2.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 2.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 2.	< 0.5
FREON 113	(PPB)		57.	77.	120.
TETRACHLOROETHYLENE	(PPB)		36.	34.	34.
TRICHLOROETHYLENE	(PPB)		3100.	4100.	2100.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 2.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 2.	< 0.25

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Well: 1405 NFH-MW5 Well Type: MC Zone: 1 Sector: D GSE: 133.02 TOC: 133.1 TOP: 158 BOP: 168 TD: 168

		Sample Date:	02/25/93		06/16/93		07/18/95
		Time:	10:39		13:35		12:12
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		9.1		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		380.		400.		390.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.
PH	(PH)		7.6		8.		7.8
TEMPERATURE	(DEGREES C.)		18.1		24.7		22.7
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)		4.		3.	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	2.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	2.		1.3
1,1-DICHLOROETHANE	(PPB)		10.		12.		14.
1,1-DICHLOROETHYLENE	(PPB)		78.		97.		140.
1,2-DICHLOROETHANE	(PPB)		4.		2.	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	2.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	2.	<	0.5
BROMOFORM	(PPB)	<	2.	<	4.	<	0.5
CARBON TETRACHLORIDE	(PPB)		4.		3.		3.
CHLOROBENZENE	(PPB)	<	1.	<	2.	<	0.5
CHLOROFORM	(PPB)		10.		5.		19.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		190.		220.		230.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	2.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	2.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	2.	<	0.5
FREON 113	(PPB)		33.		43.		86.
TETRACHLOROETHYLENE	(PPB)		26.		31.		43.
TRICHLOROETHYLENE	(PPB)		2400.		3300.		2700.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	2.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	2.	<	0.25

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Well: 1406 OARN-MW2 Well Type: MC Zone: 1 Sector: D GSE: 102.73 TOC: 102.73 TOP: 95 BOP: 105 TD: 105

	Sample Date:	03/03/93	07/14/93	03/23/94	08/29/94	04/06/95	05/11/95	10/20/95
	Time:	10:51	12:21	12:08	11:40	12:15	13:06	14:44
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)	0.2	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)	84.	100.	NM	100.	100.	140.	99.
PH	(PH)	9.6	9.1	NM	9.1	7.6	7.6	7.4
TEMPERATURE	(DEGREES C.)	15.6	19.	NM	17.	15.9	17.9	19.
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 0.5	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	< 1.	1.	< 0.5	< 1.	< 1.	1.	1.9
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.25

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Well: 1407 OARN-MW2 Well Type: MC Zone: 1 Sector: D GSE: 102.73 TOC: 102.73 TOP: 150 BOP: 160 TD: 160

		Sample Date:	03/03/93	07/14/93	03/23/94	08/29/94	04/10/95	05/11/95	07/11/95	10/20/95	11/21/95
		Time:	10:21	11:10	11:50	11:13	13:10	13:49	14:30	13:21	10:37
		Sample Type:									
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS -	(Units)										
NITRATE	(MG/L)		0.2	NM	NM	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS											
CONDUCTANCE	(UMHOS/CM)		97.	130.	NM	120.	110.	120.	130.	100.	110.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	NM	NM	NM	NM	< 10.	NM	NM
PH	(PH)		9.2	8.3	NM	9.2	9.3	7.9	8.1	7.6	6.4
TEMPERATURE	(DEGREES C.)		14.8	18.9	NM	16.2	20.4	17.3	19.	19.3	15.3
VOLATILE ORGANICS											
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 0.5	< 2.	< 2.	< 2.	< 0.5	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)		2.	9.	5.	2.2	7.9	5.7	9.1	47.	17.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1408 OARN-MW2 Well Type: MC Zone: 1 Sector: D GSE: 102.73 TOC: 102.73 TOP: 280 BOP: 301 TD: 301

Sample Date:		03/03/93		07/13/93		03/23/94		08/29/94		04/10/95		05/11/95		10/20/95		11/21/95	
Time:		09:36		17:04		11:01		10:30		12:18		12:36		11:15		09:31	
Sample Type:																	
Lab:		EL		EL		EL		EL		EL		EL		EL		EL	
MINERALS, INORGANICS	(Units)																
NITRATE	(MG/L)		0.6		NM		NM		NM		NM		NM		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM		NM		NM		NM		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM		NM		NM		NM		NM
MISCELLANEOUS																	
CONDUCTANCE	(UMHOS/CM)		120.		170.		NM		110.		140.		190.		110.		130.
PH	(PH)		8.9		9.5		NM		9.8		9.5		8.		9.4		9.
TEMPERATURE	(DEGREES C.)		14.5		19.7		NM		17.4		18.9		18.2		18.5		15.7
VOLATILE ORGANICS																	
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.25	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5	<	2.	<	2.	<	2.	<	0.5	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.25	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
CHLOROFORM	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
FREON 113	(PPB)		2.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
TRICHLOROETHYLENE	(PPB)		12.	<	1.		1.4	<	1.	<	1.	<	1.		33.		23.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.5	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.5	<	1.	<	1.	<	1.	<	0.25	<	0.25

AEROJET Environmental Operations
Water Quality Information

Well: 1409 OARN-MW2 Well Type: MC Zone: 1 Sector: D GSE: 102.73 TOC: 102.82 TOP: 348 BOP: 358 TD: 358

	Sample Date:	03/03/93	08/05/93	03/23/94	08/30/94	04/11/95	05/11/95	12/07/95
	Time:	14:12	08:29	09:23	17:08	17:05	11:18	12:38
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)	< 0.1	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)	180.	190.	NM	220.	230.	170.	160.
PH	(PH)	10.2	10.1	NM	10.3	7.8	9.8	10.5
TEMPERATURE	(DEGREES C.)	15.2	18.5	NM	18.6	15.8	20.1	15.4
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 0.5	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 1.	9.3	< 1.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 0.5	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1469 D-OFFSITE-NW-ARI Well Type: MC Zone: 1 Sector: D GSE: 115.74 TOC: 115.74 TOP: 42 BOP: 52 TD: 52

		Sample Date:	02/26/93		06/28/93		04/03/95		09/08/95
		Time:	14:15		16:24		11:55		13:40
		Sample Type:							
		Lab:	EL		EL		EL		EL
MINERALS, INORGANICS	(Units)								
NITRATE	(MG/L)		6.2		NM		NM		NM
NITRITE	(MG/L)	<	3.		NM		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM
MISCELLANEOUS									
CONDUCTANCE	(UMHOS/CM)		1600.		1900.		1000.		2000.
N-NITROSODIMETHYLAMINE	(UG/L)		NM		NM		NM	<	0.1
PH	(PH)		7.6		7.2		7.3		7.
TEMPERATURE	(DEGREES C.)		16.5		20.4		20.5		22.3
VOLATILE ORGANICS									
1,1,1-TRICHLOROETHANE	(PPB)		2.		4.	<	1.		3.9
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)	<	1.		2.	<	1.		2.
1,1-DICHLOROETHYLENE	(PPB)		24.		39.		6.3		84.
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.		0.41
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)		1.		1.	<	1.		5.6
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		30.		46.		10.		59.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	0.5
FREON 113	(PPB)	<	1.	<	1.	<	1.	<	0.5
TETRACHLOROETHYLENE	(PPB)		8.		12.		2.5		22.
TRICHLOROETHYLENE	(PPB)		940.		1300.		220.		1400.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	<	0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1470 D-OFFSITE-NW-ARI Well Type: MC Zone: 1 Sector: D GSE: 115.74 TOC: 115.74 TOP: 158 BOP: 168 TD: 168

	Sample Date:	02/26/93	06/28/93	04/04/95	09/11/95
	Time:	13:45	18:05	08:20	12:45
	Sample Type:				
	Lab:	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)	5.4	NM	NM	NM
NITRITE	(MG/L)	0.22	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)	390.	1900.	4400.	1000.
N-NITROSODIMETHYLAMINE	(PPB)	NM	NM	NM	< 10.
PH	(PH)	9.6	11.9	12.5	12.1
TEMPERATURE	(DEGREES C.)	16.8	20.9	16.	22.1
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	2.3	0.66
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	1.	< 1.	6.8	2.2
1,1-DICHLOROETHYLENE	(PPB)	10.	< 1.	60.	25.
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	17.	2.	36.	15.
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	< 1.	< 1.	2.8	< 0.5
TETRACHLOROETHYLENE	(PPB)	3.	< 1.	11.	4.6
TRICHLOROETHYLENE	(PPB)	300.	29.	730.	260.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1471 D-OFFSITE-NW-ARI Well Type: MC Zone: 1 Sector: D GSE: 115.74 TOC: 115.74 TOP: 285 BOP: 295 TD: 295

		Sample Date:	02/26/93	06/28/93	09/12/95
		Time:	13:28	17:28	12:30
		Sample Type:			
		Lab:	EL	EL	EL
MINERALS, INORGANICS	(Units)				
NITRATE	(MG/L)	<	0.1	NM	NM
NITRITE	(MG/L)	<	0.3	NM	NM
PERCHLORATE	(MG/L)		0.5	NM	< 0.4
MISCELLANEOUS					
CONDUCTANCE	(UMHOS/CM)		2000.	1500.	1000.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.
PH	(PH)		12.	11.7	12.
TEMPERATURE	(DEGREES C.)		17.4	22.9	19.1
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)		1.	1.	0.84
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		1.	1.	2.8
1,1-DICHLOROETHYLENE	(PPB)		16.	18.	44.
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		16.	13.	19.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)		3.	4.	6.1
TRICHLOROETHYLENE	(PPB)		230.	220.	290.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

Well: 1472 D-NFH-MW11-AR3 Well Type: MC Zone: 1 Sector: D GSE: 133.09 TOC: 133.09 TOP: 45 BOP: 65 TD: 65

		Sample Date:	03/02/93		06/28/93		08/11/95
		Time:	09:15		15:23		13:35
		Sample Type:					
		Lab:	EL		EL		EL
MINERALS, INORGANICS	(Units)						
NITRATE	(MG/L)		1.3		NM		NM
NITRITE	(MG/L)	<	0.5		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM
MISCELLANEOUS							
CONDUCTANCE	(UMHOS/CM)		870.		920.		840.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.
PH	(PH)		7.3		7.2		7.2
TEMPERATURE	(DEGREES C.)		15.1		21.1		22.3
VOLATILE ORGANICS							
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5
1,1-DICHLOROETHANE	(PPB)		4.		2.		1.4
1,1-DICHLOROETHYLENE	(PPB)		15.		11.		11.
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5
CHLOROFORM	(PPB)	<	1.	<	1.		1.3
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		30.		13.		22.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
FREON 113	(PPB)		7.		2.		3.6
TETRACHLOROETHYLENE	(PPB)		7.		5.		6.8
TRICHLOROETHYLENE	(PPB)		160.		98.		180.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1473 D-NFH-MW11-AR3 Well Type: MC Zone: 1 Sector: D GSE: 133.09 TOC: 133.09 TOP: 262 BOP: 272 TD: 272

	Sample Date:	02/26/93	06/21/93	08/15/95
	Time:	13:07	17:22	15:25
	Sample Type:			
	Lab:	EL	EL	EL
MINERALS, INORGANICS	(Units)			
NITRATE	(MG/L)	< 0.1	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM
MISCELLANEOUS				
CONDUCTANCE	(UMHOS/CM)	210.	230.	230.
N-NITROSODIMETHYLAMINE	(PPB)	NM	NM	< 10.
PH	(PH)	8.3	7.9	7.7
TEMPERATURE	(DEGREES C.)	15.4	21.7	24.2
VOLATILE ORGANICS				
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	< 1.	< 1.	7.3
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1474 D-NFH-MW11-AR3 Well Type: MC Zone: 1 Sector: D GSE: 133.09 TOC: 133.09 TOP: 335 BOP: 345 TD: 345

	Sample Date:	02/26/93		06/21/93		08/11/95		
	Time:	11:20		15:52		13:57		
	Sample Type:							
	Lab:	EL		EL		EL		
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)	<	0.1	NM		NM		
NITRITE	(MG/L)	<	0.05	NM		NM		
PERCHLORATE	(MG/L)	<	0.4	NM		NM		
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		190.		200.		190.	
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM	<	10.	
PH	(PH)		9.1		8.8		8.6	
TEMPERATURE	(DEGREES C.)		14.7		22.9		21.7	
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5	
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5	
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5	
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.5	
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	0.5	
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	0.25	
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	0.5	
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	
BROMOFORM	(PPB)	<	2.	<	2.	<	0.5	
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	0.25	
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	0.5	
CHLOROFORM	(PPB)	<	1.	<	1.	<	0.5	
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	0.5	
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	
FREON 113	(PPB)	<	1.	<	1.	<	0.5	
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	0.5	
TRICHLOROETHYLENE	(PPB)	<	1.	<	1.		3.4	
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	0.5	
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	0.25	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1475 D-OFFSITE-NW-Q2 Well Type: MC Zone: 1 Sector: D GSE: 135.42 TOC: 135.42 TOP: 70 BOP: 80 TD: 80

		Sample Date:	01/25/93	06/23/93	07/22/93	02/03/94	11/09/94	02/06/95	08/21/95
		Time:	11:30	13:18	14:24	10:53	15:42	:	13:41
		Sample Type:							
		Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)								
ALUMINUM	(MG/L)		0.13	NM	< 0.05	NM	NM	NM	< 0.16
ANTIMONY	(MG/L)	<	0.3	NM	NM	NM	NM	NM	< 0.44
ARSENIC	(MG/L)	<	0.1	NM	< 0.1	NM	NM	NM	< 0.088
BARIUM	(MG/L)		0.073	NM	0.055	NM	NM	NM	0.034
BERYLLIUM	(MG/L)	<	0.002	NM	< 0.002	NM	NM	NM	< 0.0011
BORON	(MG/L)	<	0.1	NM	NM	NM	NM	NM	< 0.044
CADMIUM	(MG/L)	<	0.02	NM	< 0.02	NM	NM	NM	< 0.0044
CHROMIUM	(MG/L)	<	0.04	NM	< 0.04	NM	NM	NM	< 0.0088
COBALT	(MG/L)	<	0.02	NM	NM	NM	NM	NM	< 0.0088
COPPER	(MG/L)	<	0.05	NM	0.06	NM	NM	NM	< 0.0066
HEXAVALENT CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM
IRON	(MG/L)		26.	NM	0.5	NM	NM	NM	< 0.33
LEAD	(MG/L)	<	0.1	NM	< 0.1	NM	NM	NM	< 0.066
MERCURY	(MG/L)	<	0.0002	NM	NM	NM	NM	NM	< 0.0002
MOLYBDENUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	< 0.044
NICKEL	(MG/L)	<	0.04	NM	< 0.04	NM	NM	NM	< 0.022
SELENIUM	(MG/L)	<	0.4	NM	< 0.4	NM	NM	NM	< 0.11
SILVER	(MG/L)	<	0.01	NM	< 0.01	NM	NM	NM	< 0.022
THALLIUM	(MG/L)	<	0.4	NM	< 0.4	NM	NM	NM	< 0.055
VANADIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	< 0.0055
ZINC	(MG/L)		0.4	NM	0.2	NM	NM	NM	< 0.11
MINERALS, INORGANICS									
CALCIUM	(MG/L)		35.	NM	NM	NM	NM	NM	11.
CHLORIDE	(MG/L)		12.	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		13.	NM	NM	NM	NM	NM	12.
MANGANESE	(MG/L)		0.1	NM	NM	NM	NM	NM	0.015
NITRATE	(MG/L)		1.8	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)		3.1	NM	NM	NM	NM	NM	4.5
SODIUM, TOTAL	(MG/L)		12.	NM	NM	NM	NM	NM	13.
SULFATE	(MG/L)		14.	NM	NM	NM	NM	NM	NM
MISCELLANEOUS									
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	<	1.	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	<	3.	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		350.	360.	240.	210.	280.	180.	280.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	< 10.	NM	NM	< 10.	< 10.
PH	(PH)		7.4	7.4	8.3	8.1	8.5	9.	7.4
TEMPERATURE	(DEGREES C.)		19.	21.6	29.	17.3	15.6	18.7	24.9
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.2	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1475 D-OFFSITE-NW-Q2 Well Type: MC Zone: 1 Sector: D GSE: 135.42 TOC: 135.42 TOP: 70 BOP: 80 TD: 80

	Sample Date:	01/25/93	06/23/93	07/22/93	02/03/94	11/09/94	02/06/95	08/21/95
	Time:	11:30	13:18	14:24	10:53	15:42	:	13:41
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	3.	< 5.	1.7	1.2	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	8.	6.	10.	3.1	2.5	1.5	1.
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	< 20.	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	< 20.	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	< 20.	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	1.	< 5.	< 1.	< 1.	< 1.	0.61
CHLOROMETHANE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	20.	18.	33.	14.	10.	7.9	5.1
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	4.	< 5.	2.2	1.5	< 1.	1.5
TOLUENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	510.	390.	490.	210.	110.	70.	93.
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1476 D-OFFSITE-NW-02 Well Type: MC Zone: 1 Sector: D GSE: 135.42 TOC: 135.42 TOP: 112 BOP: 127 TD: 127

	Sample Date:	01/25/93	06/23/93	02/03/94	11/09/94	02/06/95	08/23/95
	Time:	10:48	12:13	10:29	14:51	:	12:51
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)						
ALUMINUM	(MG/L)	0.15	NM	NM	NM	NM	< 0.16
ANTIMONY	(MG/L)	< 0.3	NM	NM	NM	NM	< 0.44
ARSENIC	(MG/L)	< 0.1	NM	NM	NM	NM	< 0.088
BARIUM	(MG/L)	0.032	NM	NM	NM	NM	0.029
BERYLLIUM	(MG/L)	< 0.002	NM	NM	NM	NM	< 0.0011
BORON	(MG/L)	< 0.1	NM	NM	NM	NM	< 0.044
CADMIUM	(MG/L)	< 0.02	NM	NM	NM	NM	< 0.0044
CHROMIUM	(MG/L)	< 0.04	NM	NM	NM	NM	< 0.0088
COBALT	(MG/L)	< 0.02	NM	NM	NM	NM	< 0.0088
COPPER	(MG/L)	< 0.05	NM	NM	NM	NM	< 0.0066
HEXAVALENT CHROMIUM	(MG/L)	< 0.04	NM	NM	NM	NM	NM
IRON	(MG/L)	14.	NM	NM	NM	NM	< 0.33
LEAD	(MG/L)	< 0.1	NM	NM	NM	NM	< 0.066
MERCURY	(MG/L)	< 0.0002	NM	NM	NM	NM	< 0.0002
MOLYBDENUM	(MG/L)	< 0.04	NM	NM	NM	NM	< 0.044
NICKEL	(MG/L)	< 0.04	NM	NM	NM	NM	< 0.022
SELENIUM	(MG/L)	< 0.4	NM	NM	NM	NM	< 0.11
SILVER	(MG/L)	< 0.01	NM	NM	NM	NM	< 0.022
THALLIUM	(MG/L)	< 0.4	NM	NM	NM	NM	< 0.055
VANADIUM	(MG/L)	< 0.02	NM	NM	NM	NM	< 0.0055
ZINC	(MG/L)	0.3	NM	NM	NM	NM	< 0.11
MINERALS, INORGANICS							
CALCIUM	(MG/L)	17.	NM	NM	NM	NM	9.6
CHLORIDE	(MG/L)	11.	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	12.	NM	NM	NM	NM	12.
MANGANESE	(MG/L)	0.09	NM	NM	NM	NM	0.023
NITRATE	(MG/L)	1.	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	3.3	NM	NM	NM	NM	3.6
SODIUM, TOTAL	(MG/L)	13.	NM	NM	NM	NM	13.
SULFATE	(MG/L)	6.9	NM	NM	NM	NM	NM
MISCELLANEOUS							
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	7.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	310.	320.	240.	260.	270.	200.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	< 10.	NM	NM	< 10.	< 10.
PH	(PH)	7.3	7.4	7.8	8.4	7.4	8.4
TEMPERATURE	(DEGREES C.)	18.7	22.6	17.4	15.7	19.2	24.7
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.2	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1476 D-OFFSITE-NW-Q2 Well Type: MC Zone: 1 Sector: D GSE: 135.42 TOC: 135.42 TOP: 112 BOP: 127 TD: 127

	Sample Date:	01/25/93	06/23/93	02/03/94	11/09/94	02/06/95	08/23/95
	Time:	10:48	12:13	10:29	14:51	:	12:51
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 2.	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	7.	2.	2.5	< 1.	1.9	1.
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1477 D-OFFSITE-NW-Q2 Well Type: MC Zone: 1 Sector: D GSE: 135.42 TOC: 135.42 TOP: 210 BOP: 220 TD: 220

	Sample Date:	01/25/93	06/23/93	07/22/93	02/03/94	11/09/94	02/06/95	08/23/95
	Time:	10:14	11:08	13:48	09:45	14:01	:	10:45
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	0.17	NM	NM	NM	NM	NM	< 0.16
ANTIMONY	(MG/L)	< 0.3	NM	NM	NM	NM	NM	< 0.44
ARSENIC	(MG/L)	< 0.1	NM	NM	NM	NM	NM	< 0.088
BARIUM	(MG/L)	0.094	NM	NM	NM	NM	NM	0.066
BERYLLIUM	(MG/L)	< 0.002	NM	NM	NM	NM	NM	< 0.0011
BORON	(MG/L)	< 0.1	NM	NM	NM	NM	NM	< 0.044
CADMIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM	< 0.0044
CHROMIUM	(MG/L)	< 0.04	NM	NM	NM	NM	NM	< 0.0088
COBALT	(MG/L)	< 0.02	NM	NM	NM	NM	NM	< 0.0088
COPPER	(MG/L)	< 0.05	NM	NM	NM	NM	NM	< 0.0066
HEXAVALENT CHROMIUM	(MG/L)	< 0.04	NM	NM	NM	NM	NM	NM
IRON	(MG/L)	26.	NM	NM	NM	NM	NM	< 0.33
LEAD	(MG/L)	< 0.1	NM	NM	NM	NM	NM	< 0.066
MERCURY	(MG/L)	< 0.0002	NM	NM	NM	NM	NM	< 0.0002
MOLYBDENUM	(MG/L)	< 0.04	NM	NM	NM	NM	NM	< 0.044
NICKEL	(MG/L)	< 0.04	NM	NM	NM	NM	NM	< 0.022
SELENIUM	(MG/L)	< 0.4	NM	NM	NM	NM	NM	< 0.11
SILVER	(MG/L)	< 0.01	NM	NM	NM	NM	NM	< 0.022
THALLIUM	(MG/L)	< 0.4	NM	NM	NM	NM	NM	< 0.055
VANADIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM	< 0.0055
ZINC	(MG/L)	0.3	NM	NM	NM	NM	NM	< 0.11
MINERALS, INORGANICS								
CALCIUM	(MG/L)	22.	NM	NM	NM	NM	NM	13.
CHLORIDE	(MG/L)	51.	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	9.2	NM	NM	NM	NM	NM	2.3
MANGANESE	(MG/L)	0.078	NM	NM	NM	NM	NM	< 0.0055
NITRATE	(MG/L)	1.3	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	7.4	NM	NM	NM	NM	NM	9.6
SODIUM, TOTAL	(MG/L)	17.	NM	NM	NM	NM	NM	22.
SULFATE	(MG/L)	11.	NM	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	1.	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	4.	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	370.	370.	250.	300.	200.	240.	240.
N-NITROSODIMETHYLAMINE	(UG/L)	< 10.	NM	< 10.	NM	NM	< 10.	< 0.1
PH	(PH)	7.5	8.	9.3	9.4	8.1	9.1	9.6
TEMPERATURE	(DEGREES C.)	18.8	21.9	26.1	17.4	16.2	18.4	23.7
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.2	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1477 D-OFFSITE-NW-Q2 Well Type: MC Zone: 1 Sector: D GSE: 135.42 TOC: 135.42 TOP: 210 BOP: 220 TD: 220

	Sample Date:	01/25/93	06/23/93	07/22/93	02/03/94	11/09/94	02/06/95	08/23/95
	Time:	10:14	11:08	13:48	09:45	14:01	:	10:45
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	8.	9.	9.	7.8	5.1	2.8	4.
1,1-DICHLOROETHYLENE	(PPB)	47.	49.	49.	38.	23.	9.8	27.
1,2-DICHLOROETHANE	(PPB)	< 5.	2.	< 5.	5.7	3.1	2.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	< 20.	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	< 20.	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	< 20.	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	4.	< 5.	2.7	1.5	< 1.	2.3
CHLOROMETHANE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	28.	26.	32.	21.	14.	8.4	13.
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
FREON 113	(PPB)	180.	160.	160.	85.	13.	5.9	39.
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	16.	19.	14.	14.	2.9	1.4	10.
TOLUENE	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	360.	370.	320.	240.	95.	54.	150.
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	< 10.	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	< 5.	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1478 OARN-MW4-AR4 Well Type: MC Zone: 1 Sector: D GSE: 90.55 TOC: 90.55 TOP: 52 BOP: 62 TD: 62

	Sample Date:	02/25/93			07/13/93			08/11/94			04/04/95			09/14/95			12/05/95						
	Time:	13:22			09:37			12:21			11:11			13:29			12:42						
	Sample Type:																						
	Lab:	EL			EL			EL			EL			EL			EL						
MINERALS, INORGANICS	(Units)																						
NITRATE	(MG/L)		0.7			NM			NM			NM			NM			NM					
NITRITE	(MG/L)	<	0.05			NM			NM			NM			NM			NM					
PERCHLORATE	(MG/L)	<	0.4			NM			NM			NM			NM			NM					
MISCELLANEOUS																							
CONDUCTANCE	(UMHOS/CM)		110.			87.			110.			110.			130.			110.					
N-NITROSODIMETHYLAMINE	(PPB)		NM		<	10.		<	10.		<	10.		<	10.			NM					
PH	(PH)		7.9			8.			7.8			9.1			7.1			7.2					
TEMPERATURE	(DEGREES C.)		15.1			20.2			22.7			19.3			21.5			19.3					
VOLATILE ORGANICS																							
1,1,1-TRICHLOROETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
1,1,2-TRICHLOROETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
1,1-DICHLOROETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
1,1-DICHLOROETHYLENE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
1,2-DICHLOROETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.25		<	0.25					
1,2-DICHLOROPROPANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
BROMODICHLOROMETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
BROMOFORM	(PPB)	<	2.		<	2.			NM		<	2.		<	0.5		<	0.5					
CARBON TETRACHLORIDE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.25		<	0.25					
CHLOROBENZENE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
CHLOROFORM	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.			1.			NM		<	1.		<	0.5			0.64					
DIBROMOCHLOROMETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
DICHLORODIFLUOROMETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
DICHLOROMETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
FREON 113	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
TETRACHLOROETHYLENE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5			0.53					
TRICHLOROETHYLENE	(PPB)		77.			60.			NM			22.			6.4			28.					
TRICHLOROFLUOROMETHANE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.5		<	0.5					
VINYL CHLORIDE	(PPB)	<	1.		<	1.			NM		<	1.		<	0.25		<	0.25					

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1479 OARN-MW4-AR4 Well Type: MC Zone: 1 Sector: D GSE: 90.55 TOC: 90.55 TOP: 141 BOP: 162 TD: 162

		Sample Date:	02/25/93	07/12/93	08/11/94	04/04/95	09/14/95	12/05/95
		Time:	12:01	13:55	11:31	10:42	11:49	11:40
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		1.8	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		250.	270.	210.	220.	290.	210.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	< 10.	< 10.	< 10.	NM
PH	(PH)		8.7	8.8	10.1	9.4	8.8	9.1
TEMPERATURE	(DEGREES C.)		15.7	22.6	22.5	20.1	20.7	17.5
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	0.5	1.
1,1-DICHLOROETHYLENE	(PPB)	<	1.	6.	5.4	5.5	6.1	13.
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	1.3	1.6	2.1
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		7.	19.	12.	18.	13.	26.
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	1.	1.	< 1.	1.6	1.8
TETRACHLOROETHYLENE	(PPB)		2.	7.	4.3	4.6	3.1	8.6
TRICHLOROETHYLENE	(PPB)		230.	760.	450.	560.	360.	700.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1480 OARN-MW4-AR4 Well Type: MC Zone: 1 Sector: D GSE: 90.55 TOC: 90.55 TOP: 211 BOP: 232 TD: 232

		Sample Date:	02/25/93	07/12/93	08/11/94	04/04/95	09/14/95	12/05/95
		Time:	10:39	13:02	10:10	09:46	09:52	10:08
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		2.6	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		280.	270.	200.	140.	180.	150.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	< 10.	< 10.	< 10.	NM
PH	(PH)		8.4	9.3	9.8	10.2	9.6	9.6
TEMPERATURE	(DEGREES C.)		16.	23.8	20.8	19.1	18.9	17.1
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	NM	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)		6.	6.	NM	11.	32.	45.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	NM	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1481 OARN-MW3-AR2 Well Type: MC Zone: 1 Sector: D GSE: 95.84 TOC: 95.84 TOP: 48 BOP: 62 TD: 62

	Sample Date:	03/04/93		06/22/93		08/31/94		01/19/95		09/19/95					
	Time:	09:03		12:02		13:14		:		09:14					
	Sample Type:														
	Lab:	EL		EL		EL		EL		EL					
MINERALS, INORGANICS	(Units)														
NITRATE	(MG/L)		2.9		NM		NM		NM		NM				
NITRITE	(MG/L)	<	0.05		NM		NM		NM		NM				
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM		NM				
MISCELLANEOUS															
CONDUCTANCE	(UMHOS/CM)		280.		220.		160.		130.		220.				
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM		NM		NM	<	10.				
PH	(PH)		7.5		8.3		8.6		9.		8.1				
TEMPERATURE	(DEGREES C.)		17.2		19.7		21.1		16.4		19.4				
VOLATILE ORGANICS															
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.25				
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
BROMOFORM	(PPB)	<	2.	<	2.	<	2.		NM	<	0.5				
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.25				
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
FREON 113	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
TRICHLOROETHYLENE	(PPB)		2.	<	1.	<	1.		NM	<	0.5				
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.5				
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.		NM	<	0.25				

AEROJET Environmental Operations
Water Quality Information

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Well: 1482 OARN-MW3-AR2 Well Type: MC Zone: 1 Sector: D GSE: 95.84 TOC: 95.84 TOP: 130 BOP: 140 TD: 140

		Sample Date:	03/02/93		06/22/93		09/01/94		01/19/95		09/18/95
		Time:	13:53		10:23		13:38		:		13:41
		Sample Type:									
		Lab:	EL		EL		EL		EL		EL
MINERALS, INORGANICS	(Units)										
NITRATE	(MG/L)		0.6		NM		NM		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM		NM		NM
MISCELLANEOUS											
CONDUCTANCE	(UMHOS/CM)		150.		95.		150.		120.		93.
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM		NM		NM	<	10.
PH	(PH)		8.3		9.2		8.1		8.8		8.5
TEMPERATURE	(DEGREES C.)		17.2		18.1		19.8		16.8		23.3
VOLATILE ORGANICS											
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	NM		<	0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.25
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
FREON 113	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
TRICHLOROETHYLENE	(PPB)		1.		1.	<	1.	NM		<	0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.25

AEROJET Environmental Operations
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Well: 1483 OARN-MW3-AR2 Well Type: MC Zone: 1 Sector: D GSE: 95.84 TOC: 95.84 TOP: 245 BOP: 255 TD: 255

Sample Date:		03/02/93		06/22/93		09/01/94		02/28/95		09/18/95					
Time:		12:40		09:07		13:01		08:53		11:56					
Sample Type:															
Lab:		EL		EL		EL		EL		EL					
MINERALS, INORGANICS	(Units)														
NITRATE	(MG/L)	<	0.1	NM		NM		NM		NM					
NITRITE	(MG/L)	<	0.05	NM		NM		NM		NM					
PERCHLORATE	(MG/L)	<	0.4	NM		NM		NM		NM					
MISCELLANEOUS															
CONDUCTANCE	(UMHOS/CM)		270.		270.		260.		140.		140.				
N-NITROSODIMETHYLAMINE	(PPB)		NM		NM		NM		NM	<	10.				
PH	(PH)		7.8		7.7		7.7		9.7		9.2				
TEMPERATURE	(DEGREES C.)		18.		18.8		20.5		16.3		22.2				
VOLATILE ORGANICS															
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
1,1-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
1,2-DICHLOROETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.25				
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
BROMODICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
BROMOFORM	(PPB)	<	2.	<	2.	<	2.	NM		<	0.5				
CARBON TETRACHLORIDE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.25				
CHLOROBENZENE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
CHLOROFORM	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
DICHLOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
FREON 113	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
TETRACHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
TRICHLOROETHYLENE	(PPB)	<	1.	<	1.	<	1.	NM			1.				
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.5				
VINYL CHLORIDE	(PPB)	<	1.	<	1.	<	1.	NM		<	0.25				

AEROJET Environmental Operations
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Well: 1487 D-OFFSITE-NW-AR5 Well Type: MC Zone: 1 Sector: D GSE: 108.66 TOC: 108.66 TOP: 54 BOP: 75 TD: 75

		Sample Date:	03/01/93	06/21/93	08/15/94	01/19/95	09/20/95	12/11/95
		Time:	12:31	14:36	12:13	:	10:59	:
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		0.9	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		130.	150.	100.	94.	87.	81.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	< 10.	< 10.	NM
PH	(PH)		9.2	9.3	8.8	9.9	9.3	8.3
TEMPERATURE	(DEGREES C.)		15.7	18.6	21.6	16.1	22.	16.2
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)		3.	19.	2.9	4.1	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1488 D-OFFSITE-MW-AR5 Well Type: MC Zone: 1 Sector: D GSE: 108.66 TOC: 108.66 TOP: 124 BOP: 134 TD: 134

		Sample Date:	03/01/93	06/21/93	08/15/94	01/19/95	09/20/95	12/11/95
		Time:	12:10	13:27	11:46	:	08:23	:
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		4.2	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.3	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		580.	530.	300.	280.	370.	290.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	< 10.	< 10.	NM
PH	(PH)		8.3	8.4	8.9	9.8	8.1	8.8
TEMPERATURE	(DEGREES C.)		16.2	18.2	20.1	16.9	18.1	14.9
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		5.	4.	1.2	2.2	1.8	1.8
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)		120.	120.	19.	51.	58.	54.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
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May 22, 1996

Well: 1489 D-OFFSITE-NW-AR5 Well Type: MC Zone: 1 Sector: D GSE: 108.66 TOC: 108.66 TOP: 239 BOP: 260 TD: 260

		Sample Date:	03/01/93	06/21/93	08/23/94	01/19/95	09/19/95	12/11/95
		Time:	11:41	12:12	09:41	:	12:24	:
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)		5.2	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)		300.	300.	290.	260.	270.	180.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	< 10.	< 10.	NM
PH	(PH)		8.3	8.6	9.	10.8	8.6	10.1
TEMPERATURE	(DEGREES C.)		16.7	19.1	17.3	18.3	21.6	15.1
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	1.1	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	1.1	0.63	< 0.5
TRICHLOROETHYLENE	(PPB)		30.	37.	86.	88.	120.	94.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
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Well: 1506 DOSNW-AR6 Well Type: MC Zone: 1 Sector: D GSE: 104.2 TOC: 104.24 TOP: 94 BOP: 104 TD: 104

		Sample Date:	01/18/93	04/20/93	06/23/93	08/29/94	02/01/95	09/20/95	12/07/95
		Time:	13:22	14:19	10:10	08:20	11:31	13:16	14:05
		Sample Type:							
		Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)								
ALUMINUM	(MG/L)		NM	< 0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)		NM	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)		NM	0.005	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)		NM	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)		NM	< 0.02	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)		NM	< 0.04	NM	NM	NM	NM	NM
COBALT	(MG/L)		NM	< 0.02	NM	NM	NM	NM	NM
COPPER	(MG/L)		NM	< 0.05	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)		NM	< 0.04	NM	NM	NM	NM	NM
IRON	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
LEAD	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)		NM	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)		NM	< 0.04	NM	NM	NM	NM	NM
NICKEL	(MG/L)		NM	< 0.04	NM	NM	NM	NM	NM
SELENIUM	(MG/L)		NM	< 0.4	NM	NM	NM	NM	NM
SILVER	(MG/L)		NM	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)		NM	< 0.4	NM	NM	NM	NM	NM
VANADIUM	(MG/L)		NM	< 0.02	NM	NM	NM	NM	NM
ZINC	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS									
CALCIUM	(MG/L)		NM	4.8	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)		NM	3.7	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		NM	0.93	NM	NM	NM	NM	NM
MANGANESE	(MG/L)		NM	< 0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)		0.2	0.1	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)		NM	2.	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		NM	7.1	NM	NM	NM	NM	NM
SULFATE	(MG/L)		NM	3.4	NM	NM	NM	NM	NM
MISCELLANEOUS									
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		NM	< 1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		NM	5.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		110.	86.	110.	110.	68.	110.	82.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)		8.5	9.3	7.3	8.2	10.1	7.8	8.1
TEMPERATURE	(DEGREES C.)		15.6	18.6	[redacted]	16.9	17.1	23.6	16.1
TOTAL PETROL[redacted]RBONS	(MG/L)		NM	< 0.2	[redacted]	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1506 DOSNW-AR6 Well Type: MC Zone: 1 Sector: D GSE: 104.2 TOC: 104.24 TOP: 94 BOP: 104 TD: 104

	Sample Date:	01/18/93	04/20/93	06/23/93	08/29/94	02/01/95	09/20/95	12/07/95
	Time:	13:22	14:19	10:10	08:20	11:31	13:16	14:05
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1507 DOSNW-AR6 Well Type: MC Zone: 1 Sector: D GSE: 104.2 TOC: 104.24 TOP: 177 BOP: 187 TD: 187

	Sample Date:	01/18/93	04/20/93	06/23/93	08/20/94	02/01/95	09/21/95	12/08/95
	Time:	12:48	12:57	09:39	08:34	12:17	08:17	09:05
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	0.013	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)	NM	4.5	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	2.5	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	0.97	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	< 0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)	0.1	0.2	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	2.	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	5.8	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	2.5	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	7.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	94.	77.	93.	65.	74.	80.	78.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)	9.	9.6	8.9	8.9	10.	9.6	8.5
TEMPERATURE	(DEGREES C.)	15.5	18.8	[redacted]	16.8	17.8	17.1	15.6
TOTAL PETRO[redacted]RBONS	(MG/L)	NM	< 0.2	[redacted]	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1507 DOSNW-AR6 Well Type: MC Zone: 1 Sector: D GSE: 104.2 TOC: 104.24 TOP: 177 BOP: 187 TD: 187

	Sample Date:	01/18/93	04/20/93	06/23/93	08/20/94	02/01/95	09/21/95	12/08/95
	Time:	12:48	12:57	09:39	08:34	12:17	08:17	09:05
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	4.6	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 150B DOSNW-AR6 Well Type: MC Zone: 1 Sector: D GSE: 104.2 TOC: 104.24 TOP: 266 BOP: 276 TD: 276

	Sample Date:	01/18/93	04/20/93	06/23/93	08/18/94	02/01/95	09/21/95	12/11/95
	Time:	12:17	11:18	08:44	15:05	13:20	10:16	:
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	0.027	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)	NM	18.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	4.1	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	0.73	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	< 0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)	1.1	0.8	NM	NM	NM	NM	NM
NITRITE	(MG/L)	0.05	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	4.	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	7.3	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	2.9	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	3.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	210.	170.	170.	360.	140.	210.	180.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)	10.4	10.5	10.3	10.8	10.4	10.9	9.8
TEMPERATURE	(DEGREES C.)	16.6	18.9	17.5	21.	18.7	19.8	15.9
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	NM	< 0.2		NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1508 DOSNW-AR6 Well Type: MC Zone: 1 Sector: D GSE: 104.2 TOC: 104.24 TOP: 266 BOP: 276 TD: 276

	Sample Date:	01/18/93	04/20/93	06/23/93	08/18/94	02/01/95	09/21/95	12/11/95
	Time:	12:17	11:18	08:44	15:05	13:20	10:16	:
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	4.1	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	5.	< 5.	< 1.	1.4	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1509 OARN-MW5-AR7 Well Type: MC Zone: 1 Sector: D GSE: 155.81 TOC: 155.81 TOP: 131 BOP: 152 TD: 152

		Sample Date:	01/14/93	04/20/93	07/15/93	08/29/94	02/02/95	09/22/95	12/13/95
		Time:	15:12	12:13	12:07	12:50	11:07	13:56	12:39
		Sample Type:							
		Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)								
ALUMINUM	(MG/L)		NM	< 0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)		NM	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)		NM	0.052	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)		NM	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)		NM	< 0.02	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)		NM	< 0.04	NM	NM	NM	NM	NM
COBALT	(MG/L)		NM	< 0.02	NM	NM	NM	NM	NM
COPPER	(MG/L)		NM	< 0.05	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)		NM	< 0.04	NM	NM	NM	NM	NM
IRON	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
LEAD	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)		NM	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)		NM	< 0.04	NM	NM	NM	NM	NM
NICKEL	(MG/L)		NM	< 0.04	NM	NM	NM	NM	NM
SELENIUM	(MG/L)		NM	< 0.4	NM	NM	NM	NM	NM
SILVER	(MG/L)		NM	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)		NM	< 0.4	NM	NM	NM	NM	NM
VANADIUM	(MG/L)		NM	< 0.02	NM	NM	NM	NM	NM
ZINC	(MG/L)		NM	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS									
CALCIUM	(MG/L)		NM	21.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)		NM	7.7	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		NM	4.	NM	NM	NM	NM	NM
MANGANESE	(MG/L)		NM	< 0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)		0.4	1.7	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	0.56	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)		NM	7.	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		NM	10.	NM	NM	NM	NM	NM
SULFATE	(MG/L)		NM	5.	NM	NM	NM	NM	NM
MISCELLANEOUS									
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		NM	< 1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		NM	5.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		210.	240.	270.	220.	300.	360.	170.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)		8.4	10.3	10.8	10.9	11.4	11.1	8.9
TEMPERATURE	(DEGREES C.)		19.	24.	[redacted]	22.9	18.3	23.1	17.8
TOTAL PETROLE[redacted]BONS	(MG/L)		NM	< 0.2	[redacted]	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1509 OARN-MW5-AR7 Well Type: MC Zone: 1 Sector: D GSE: 155.81 TOC: 155.81 TOP: 131 BOP: 152 TD: 152

	Sample Date:	01/14/93	04/20/93	07/15/93	08/29/94	02/02/95	09/22/95	12/13/95
	Time:	15:12	12:13	12:07	12:50	11:07	13:56	12:39
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	< 20.	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	< 20.	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	< 20.	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 5.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 10.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	3.8	1.7	1.1	8.8
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 10.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1510 OARN-MW5-AR7 Well Type: MC Zone: 1 Sector: D GSE: 155.81 TOC: 155.81 TOP: 212 BOP: 232 TD: 232

	Sample Date:	01/14/93	04/20/93	07/15/93	08/30/94	02/02/95	09/22/95	12/08/95
	Time:	15:49	10:58	11:14	09:25	10:30	12:06	12:23
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	0.057	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)	NM	13.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	23.	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	5.8	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	< 0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)	2.3	0.5	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	6.	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	12.	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	3.7	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	7.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	260.	190.	200.	170.	210.	210.	190.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)	8.3	9.3	9.	10.1	9.7	9.6	9.6
TEMPERATURE	(DEGREES C.)	19.2	22.	23.3	19.2	18.2	21.	17.7
TOTAL PETROL[redacted]ARBONS	(MG/L)	NM	< 0.2	[redacted]	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1510 OARN-MW5-AR7 Well Type: MC Zone: 1 Sector: D GSE: 155.81 TOC: 155.81 TOP: 212 BOP: 232 TD: 232

	Sample Date:	01/14/93	04/20/93	07/15/93	08/30/94	02/02/95	09/22/95	12/08/95
	Time:	15:49	10:58	11:14	09:25	10:30	12:06	12:23
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	< 20.	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	< 20.	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	< 20.	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 5.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 10.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	1.	< 5.	< 5.	< 1.	1.2	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 10.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1511 OARN-MW5-AR7 Well Type: MC Zone: 1 Sector: D GSE: 155.81 TOC: 155.81 TOP: 290 BOP: 300 TD: 300

	Sample Date:	01/15/93	04/20/93	07/15/93	08/30/94	02/02/95	09/22/95	12/08/95
	Time:	12:18	09:40	09:45	08:44	09:28	09:51	11:16
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	0.038	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	0.2	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)	NM	15.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	21.	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	4.2	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	< 0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)	0.3	0.8	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	7.	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	13.	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	11.	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	5.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	260.	220.	240.	220.	200.	260.	190.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)	8.1	8.5	8.2	10.3	9.9	8.	7.3
TEMPERATURE	(DEGREES C.)	19.4	18.2	19.8	18.7	18.	19.4	17.6
TOTAL PETROLE[redacted]ARBONS	(MG/L)	NM	< 0.2	[redacted]	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1511 OARN-MW5-AR7 Well Type: MC Zone: 1 Sector: D GSE: 155.81 TOC: 155.81 TOP: 290 BOP: 300 TD: 300

	Sample Date:	01/15/93	04/20/93	07/15/93	08/30/94	02/02/95	09/22/95	12/08/95
	Time:	12:18	09:40	09:45	08:44	09:28	09:51	11:16
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	< 20.	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	< 20.	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	< 20.	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 5.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 10.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	5.	< 5.	< 5.	< 1.	1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 5.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	< 10.	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 10.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	< 5.	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1516 OSAR-4A Well Type: SC Zone: 1 Sector: D GSE: 88.3 TOC: 88.38 TOP: 13 BOP: 33 TD: 33

		Sample Date:	01/14/93		03/30/93		06/21/93		08/24/95
		Time:	14:16		08:30		12:04		10:36
		Sample Type:							
		Lab:	EL		EL		EL		EL
METALS	(Units)								
ALUMINUM	(MG/L)		NM	<	0.05		NM		NM
ANTIMONY	(MG/L)		NM	<	0.3		NM		NM
ARSENIC	(MG/L)		NM	<	0.1		NM		NM
BARIUM	(MG/L)		NM		0.031		NM		NM
BERYLLIUM	(MG/L)		NM	<	0.002		NM		NM
BORON	(MG/L)		NM	<	0.1		NM		NM
CADMIUM	(MG/L)		NM	<	0.02		NM		NM
CHROMIUM	(MG/L)		NM	<	0.04		NM		NM
COBALT	(MG/L)		NM	<	0.02		NM		NM
COPPER	(MG/L)		NM	<	0.05		NM		NM
HEXAVALENT CHROMIUM	(MG/L)		NM	<	0.04		NM		NM
IRON	(MG/L)		NM		0.9		NM		NM
LEAD	(MG/L)		NM	<	0.1		NM		NM
MERCURY	(MG/L)		NM	<	0.0002		NM		NM
MOLYBDENUM	(MG/L)		NM	<	0.04		NM		NM
NICKEL	(MG/L)		NM	<	0.04		NM		NM
SELENIUM	(MG/L)		NM	<	0.4		NM		NM
SILVER	(MG/L)		NM	<	0.01		NM		NM
THALLIUM	(MG/L)		NM	<	0.4		NM		NM
VANADIUM	(MG/L)		NM	<	0.02		NM		NM
ZINC	(MG/L)		NM		3.1		NM		NM
MINERALS, INORGANICS									
CALCIUM	(MG/L)		NM		14.		NM		NM
CHLORIDE	(MG/L)		NM		2.1		NM		NM
MAGNESIUM	(MG/L)		NM		5.4		NM		NM
MANGANESE	(MG/L)		NM		0.2		NM		NM
NITRATE	(MG/L)		0.1		0.5		NM		NM
NITRITE	(MG/L)	<	0.05	<	0.05		NM		NM
PERCHLORATE	(MG/L)	<	0.4	<	0.4		NM		NM
POTASSIUM	(MG/L)		NM	<	1.		NM		NM
SODIUM, TOTAL	(MG/L)		NM		5.		NM		NM
SULFATE	(MG/L)		NM		3.1		NM		NM
MISCELLANEOUS									
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		NM	<	1.		NM		NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		NM	<	3.		NM		NM
CONDUCTANCE	(UMHOS/CM)		160.		160.		180.		200.
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.	<	10.	<	10.
PH	(PH)		6.7		6.9		6.7		6.7
TEMPERATURE	(DEGREES C.)		18.3		15.		19.		19.7
TOTAL PETROL[redacted]ARBONS	(MG/L)		NM	<	0.2		[redacted]		NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1516 OSAR-4A Well Type: SC Zone: 1 Sector: 0 GSE: 88.3 TOC: 88.38 TOP: 13 BOP: 33 TD: 33

	Sample Date:	01/14/93	03/30/93	06/21/93	08/24/95
	Time:	14:16	08:30	12:04	10:36
	Sample Type:				
	Lab:	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)				
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM
TRICHLOROETHYLENE	(PPB)	2.	11.	< 1.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1517 OSAR-AR9 Well Type: SC Zone: 1 Sector: D GSE: 89.5 TOC: 89.58 TOP: 17 BOP: 30 TD: 30

		Sample Date:	01/25/93		06/21/93		08/24/95
		Time:	10:57		13:38		13:30
		Sample Type:					
		Lab:	EL		EL		EL
METALS	(Units)						
ALUMINUM	(MG/L)		25.		NM	<	0.16
ANTIMONY	(MG/L)	<	0.3		NM	<	0.44
ARSENIC	(MG/L)	<	0.1		NM	<	0.088
BARIUM	(MG/L)		0.14		NM		0.034
BERYLLIUM	(MG/L)	<	0.002		NM	<	0.0011
BORON	(MG/L)	<	0.1		NM	<	0.044
CADMIUM	(MG/L)	<	0.02		NM	<	0.0044
CHROMIUM	(MG/L)	<	0.04		NM	<	0.0088
COBALT	(MG/L)	<	0.02		NM	<	0.0088
COPPER	(MG/L)	<	0.05		NM	<	0.0066
HEXAVALENT CHROMIUM	(MG/L)	<	0.04		NM		NM
IRON	(MG/L)		24.		NM	<	0.33
LEAD	(MG/L)	<	0.1		NM	<	0.066
MERCURY	(MG/L)	<	0.0002		NM	<	0.0002
MOLYBDENUM	(MG/L)	<	0.04		NM	<	0.044
NICKEL	(MG/L)	<	0.04		NM	<	0.022
SELENIUM	(MG/L)	<	0.4		NM	<	0.11
SILVER	(MG/L)	<	0.01		NM	<	0.022
THALLIUM	(MG/L)	<	0.4		NM	<	0.055
VANADIUM	(MG/L)		0.02		NM		0.0065
ZINC	(MG/L)		3.		NM		0.23
MINERALS, INORGANICS							
CALCIUM	(MG/L)		24.		NM		20.
CHLORIDE	(MG/L)		11.		NM		NM
MAGNESIUM	(MG/L)		10.		NM		8.8
MANGANESE	(MG/L)		0.81		NM		0.091
NITRATE	(MG/L)		7.6		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM
PERCHLORATE	(MG/L)		0.5		NM	<	0.4
POTASSIUM	(MG/L)		1.7		NM		3.4
SODIUM, TOTAL	(MG/L)		7.6		NM		7.8
SULFATE	(MG/L)		12.		NM		NM
MISCELLANEOUS							
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		1.		NM		NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		28.		NM		NM
CONDUCTANCE	(UMHOS/CM)		160.		180.		180.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.		NM	<	10.
PH	(PH)		7.2		7.		6.8
TEMPERATURE	(DEGREES C.)		14.7		23.6		24.3
TOTAL PETROLE[redacted]RBONS	(MG/L)	<	0.2		NM		[redacted]

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1517 OSAR-AR9 Well Type: SC Zone: 1 Sector: D GSE: 89.5 TOC: 89.58 TOP: 17 BOP: 30 TD: 30

		Sample Date:	01/25/93	06/21/93	08/24/95
		Time:	10:57	13:38	13:30
		Sample Type:			
		Lab:	EL	EL	EL
VOLATILE ORGANICS	(Units)				
1,1,1-TRICHLOROETHANE	(PPB)	<	5.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	5.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	5.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	5.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	5.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	5.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	5.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	<	20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	<	10.	NM	NM
2-HEXANONE	(PPB)	<	20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	<	10.	NM	NM
ACETONE	(PPB)	<	20.	NM	NM
BENZENE	(PPB)	<	5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	<	5.	< 1.	< 0.5
BROMOFORM	(PPB)	<	5.	< 2.	< 0.5
BROMOMETHANE	(PPB)	<	10.	NM	NM
CARBON DISULFIDE	(PPB)	<	5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	<	5.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	5.	< 1.	< 0.5
CHLOROETHANE	(PPB)	<	10.	NM	NM
CHLOROFORM	(PPB)	<	5.	< 1.	< 0.5
CHLOROMETHANE	(PPB)	<	10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	5.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	5.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	10.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	5.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	<	5.	NM	NM
FREON 113	(PPB)	<	5.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	NM	NM
TETRACHLOROETHYLENE	(PPB)	<	5.	< 1.	< 0.5
TOLUENE	(PPB)	<	5.	NM	NM
TRICHLOROETHYLENE	(PPB)	<	5.	< 1.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	5.	< 1.	< 0.5
VINYL ACETATE	(PPB)	<	10.	NM	NM
VINYL CHLORIDE	(PPB)	<	10.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	<	5.	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1518 OSAR-AR8 Well Type: SC Zone: 1 Sector: D GSE: 130.7 TOC: 130.71 TOP: 55 BOP: 75 TD: 75

		Sample Date:	01/25/93		06/22/93		08/25/95
		Time:	11:59		13:05		09:30
		Sample Type:					
		Lab:	EL		EL		EL
METALS	(Units)						
ALUMINUM	(MG/L)		14.		NM	<	0.16
ANTIMONY	(MG/L)	<	0.3		NM	<	0.44
ARSENIC	(MG/L)	<	0.1		NM	<	0.088
BARIUM	(MG/L)		0.12		NM		0.023
BERYLLIUM	(MG/L)	<	0.002		NM	<	0.0011
BORON	(MG/L)	<	0.1		NM	<	0.044
CADMIUM	(MG/L)	<	0.02		NM	<	0.0044
CHROMIUM	(MG/L)	<	0.04		NM	<	0.0088
COBALT	(MG/L)	<	0.02		NM	<	0.0088
COPPER	(MG/L)		0.15		NM	<	0.0066
HEXAVALENT CHROMIUM	(MG/L)	<	0.04		NM		NM
IRON	(MG/L)		61.		NM	<	0.33
LEAD	(MG/L)	<	0.1		NM	<	0.066
MERCURY	(MG/L)	<	0.0002		NM		0.0004
MOLYBDENUM	(MG/L)	<	0.04		NM	<	0.044
NICKEL	(MG/L)	<	0.04		NM	<	0.022
SELENIUM	(MG/L)	<	0.4		NM	<	0.11
SILVER	(MG/L)	<	0.01		NM	<	0.022
THALLIUM	(MG/L)	<	0.4		NM	<	0.055
VANADIUM	(MG/L)		0.06		NM	<	0.0055
ZINC	(MG/L)		2.4		NM		0.16
MINERALS, INORGANICS							
CALCIUM	(MG/L)		17.		NM		19.
CHLORIDE	(MG/L)		3.5		NM		NM
MAGNESIUM	(MG/L)		7.3		NM		7.5
MANGANESE	(MG/L)		0.55		NM		0.14
NITRATE	(MG/L)		1.4		NM		NM
NITRITE	(MG/L)	<	0.05		NM		NM
PERCHLORATE	(MG/L)	<	0.4		NM		NM
POTASSIUM	(MG/L)		2.4		NM		1.4
SODIUM, TOTAL	(MG/L)		6.9		NM		5.
SULFATE	(MG/L)		4.		NM		NM
MISCELLANEOUS							
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		2.		NM		NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		5.		NM		NM
CONDUCTANCE	(UMHOS/CM)		150.		230.		200.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.		NM	<	10.
PH	(PH)		7.3		7.2		7.
TEMPERATURE	(DEGREES C.)		14.9		20.6		18.8
TOTAL PETROLE[redacted]RBONS	(MG/L)	<	0.2		NM		[redacted]

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1518 OSAR-AR8 Well Type: SC Zone: 1 Sector: D GSE: 130.7 TOC: 130.71 TOP: 55 BOP: 75 TD: 75

	Sample Date:	01/25/93	06/22/93	08/25/95
	Time:	11:59	13:05	09:30
	Sample Type:			
	Lab:	EL	EL	EL
VOLATILE ORGANICS	(Units)			
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM
ACETONE	(PPB)	< 20.	NM	NM
BENZENE	(PPB)	< 5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM
TRICHLOROETHYLENE	(PPB)	11.	< 1.	0.96
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1519 OSAR-AR10 Well Type: MC Zone: 1 Sector: D GSE: 102.19 TOC: 102.19 TOP: 90 BOP: 95 TD: 95

	Sample Date:	01/08/93	04/07/93	07/23/93	02/14/94	08/12/94	03/27/95	09/06/95
	Time:	11:33	12:05	11:30	13:05	11:09	09:54	11:43
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)	1.7	3.8	3.4	NM	NM	NM	NM
NITRITE	(MG/L)	0.12	< 0.05	< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	0.5	< 0.4	< 0.4	NM	NM	NM	< 0.4
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)	230.	210.	210.	NM	110.	NM	100.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	< 10.	< 10.	< 10.
PH	(PH)	10.	8.4	8.4	NM	8.7	NM	8.4
TEMPERATURE	(DEGREES C.)	13.6	19.2	22.2	NM	20.2	NM	23.2
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	NM	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	2.2	NM	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	1.	< 1.	< 1.	70.	NM	9.	3.1
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1520 OSAR-AR10 Well Type: MC Zone: 1 Sector: D GSE: 102.19 TOC: 102.19 TOP: 155 BOP: 165 TD: 165

	Sample Date:	01/08/93	04/07/93	07/23/93	02/14/94	08/12/94	03/27/95	09/06/95
	Time:	10:46	11:41	11:07	11:50	10:33	10:36	11:10
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)	1.1	1.2	0.9	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)	180.	180.	170.	NM	230.	NM	210.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	< 10.	< 10.
PH	(PH)	9.2	8.9	8.8	NM	10.5	NM	9.3
TEMPERATURE	(DEGREES C.)	14.	18.5	20.4	NM	20.7	NM	21.8
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	NM	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	4.	2.	3.	< 1.	NM	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	90.	50.	59.	< 1.	NM	5.7	7.9
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	< 1.	< 0.25

AEROJET Environmental Operations
Water Quality Information

Well: 1521 Well Type: MC Zone: 1 Sector: D GSE: 102.19 TOC: 102.19 TOP: 226 BOP: 246 TD: 246

	Sample Date:	01/08/93	04/07/93	07/23/93	02/14/94	08/12/94	03/27/95	09/06/95
	Time:	09:35	10:59	10:32	10:24	09:40	09:13	10:12
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)	< 0.1	< 0.1	< 0.1	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	< 0.4	NM	NM	NM	< 0.4
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)	230.	260.	250.	NM	230.	NM	240.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	< 10.	< 10.	< 10.
PH	(PH)	9.8	9.1	9.1	NM	9.7	NM	10.4
TEMPERATURE	(DEGREES C.)	13.5	20.5	21.8	NM	19.	NM	20.9
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
1,2-DICHLOROETHANE	(PPB)	1.	< 1.	< 1.	< 1.	NM	NM	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	NM	NM	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
TRICHLOROETHYLENE	(PPB)	2.	< 1.	< 1.	6.9	NM	NM	5.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	NM	NM	< 0.25

AEROJET Environmental Operations
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May 22, 1996

Well: 1522 OSAR AR WB Well Type: MC Zone: 1 Sector: D GSE: 101.9 TOC: 101.9 TOP: 77 BOP: 82 TD: 82

	Sample Date:	01/08/93	04/06/93	07/15/93	02/15/94	08/15/94	03/27/95	09/01/95
	Time:	10:11	10:34	13:45	17:29	09:11	13:12	13:38
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)							
NITRATE	(MG/L)	0.2	1.1	0.4	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM
MISCELLANEOUS								
CONDUCTANCE	(UMHOS/CM)	150.	200.	160.	NM	280.	NM	150.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	< 10.	< 10.	< 10.
PH	(PH)	10.1	9.1	9.	NM	7.5	NM	8.4
TEMPERATURE	(DEGREES C.)	14.5	17.9	20.1	NM	20.1	NM	21.2
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	2.	2.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	29.	52.	30.	31.	35.	15.	1.9
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
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May 22, 1996

Well: 1523 OSAR AR WB Well Type: MC Zone: 1 Sector: D GSE: 101.9 TOC: 101.9 TOP: 108 BOP: 124 TD: 124

	Sample Date:	01/08/93	02/01/93	04/06/93	07/15/93	02/14/94	08/15/94	03/27/95	09/01/95
	Time:	10:09	11:51	10:11	12:57	16:37	08:42	12:40	13:04
	Sample Type:								
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)								
NITRATE	(MG/L)	0.6	NM	2.8	1.8	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	< 0.05	< 0.5	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	< 0.4	< 0.4	NM	NM	NM	NM
MISCELLANEOUS									
CONDUCTANCE	(UMHOS/CM)	450.	NM	430.	430.	NM	550.	NM	1000.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	< 10.	< 10.	< 10.
PH	(PH)	10.	NM	8.2	8.3	NM	7.9	NM	8.7
TEMPERATURE	(DEGREES C.)	14.9	NM	17.4	20.4	NM	19.3	NM	20.
VOLATILE ORGANICS									
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	4.	2.	2.	< 2.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 4.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	< 1.	1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	4.	19.	13.	13.	11.	6.5	2.7	1.7
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	< 1.	1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	5.	4.	3.	3.8	1.5	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)	100.	710.	350.	320.	420.	190.	70.	62.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
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Well: 1524 OSAR AR WB Well Type: MC Zone: 1 Sector: D GSE: 101.9 TOC: 101.9 TOP: 197 BOP: 207 TD: 207

		Sample Date:	01/08/93	04/06/93	07/15/93	02/14/94	08/15/94	03/27/95	09/01/95
		Time:	09:32	11:25	11:50	15:11	08:05	12:07	12:14
		Sample Type:							
		Lab:	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)								
NITRATE	(MG/L)		1.5	5.	4.9	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	< 0.05	< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	< 0.4	< 0.4	NM	NM	NM	NM
MISCELLANEOUS									
CONDUCTANCE	(UMHOS/CM)		220.	280.	280.	NM	250.	NM	250.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	NM	NM	< 10.	< 10.	< 10.
PH	(PH)		8.8	8.2	8.	NM	8.1	NM	8.
TEMPERATURE	(DEGREES C.)		14.9	18.9	20.5	NM	18.9	NM	20.3
VOLATILE ORGANICS									
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25
BROMODICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	<	2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5
CARBON TETRACHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROFORM	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
FREON 113	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
TETRACHLOROETHYLENE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
TRICHLOROETHYLENE	(PPB)		6.	11.	14.	24.	24.	41.	39.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL CHLORIDE	(PPB)	<	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25

AEROJET Environmental Operations
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Well: 1525 OSAR AR12 Well Type: MC Zone: 1 Sector: D GSE: 97.87 TOC: 97.87 TOP: 85 BOP: 90 TD: 90

	Sample Date:	01/08/93	04/05/93	07/16/93	02/15/94	08/31/94	04/11/95	07/06/95	08/08/95	10/18/95
	Time:	12:52	12:23	10:09	13:41	11:44	10:25	:	13:05	13:59
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)									
NITRATE	(MG/L)	0.1	2.5	1.2	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	0.5	< 0.4	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)	75.	220.	140.	NM	150.	910.	220.	NM	200.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	NM	< 10.	NM	NM
PH	(PH)	9.5	8.3	9.	NM	8.8	9.8	8.	NM	7.8
TEMPERATURE	(DEGREES C.)	14.6	19.2	16.9	NM	20.4	16.7	16.9	NM	18.5
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)	1.	< 1.	< 1.	< 1.	< 1.	1.	13.	0.61	16.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25

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Well: 1525 OSAR AR12 Well Type: MC Zone: 1 Sector: D GSE: 97.87 TOC: 97.87 TOP: 85 BOP: 90 TD: 90

	Sample Date:	11/20/95	
	Time:	12:51	
	Sample Type:		
	Lab:	EL	
MINERALS, INORGANICS	(Units)		
NITRATE	(MG/L)		NM
NITRITE	(MG/L)		NM
PERCHLORATE	(MG/L)		NM
MISCELLANEOUS			
CONDUCTANCE	(UMHOS/CM)		180.
N-NITROSODIMETHYLAMINE	(PPB)		NM
PH	(PH)		7.8
TEMPERATURE	(DEGREES C.)		18.3
VOLATILE ORGANICS			
1,1,1-TRICHLOROETHANE	(PPB)	<	0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	0.5
1,1-DICHLOROETHANE	(PPB)	<	0.5
1,1-DICHLOROETHYLENE	(PPB)	<	0.5
1,2-DICHLOROETHANE	(PPB)	<	0.25
1,2-DICHLOROPROPANE	(PPB)	<	0.5
BROMODICHLOROMETHANE	(PPB)	<	0.5
BROMOFORM	(PPB)	<	0.5
CARBON TETRACHLORIDE	(PPB)	<	0.25
CHLOROBENZENE	(PPB)	<	0.5
CHLOROFORM	(PPB)	<	0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	0.5
DIBROMOCHLOROMETHANE	(PPB)	<	0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	0.5
DICHLOROMETHANE	(PPB)	<	0.5
FREON 113	(PPB)	<	0.5
TETRACHLOROETHYLENE	(PPB)	<	0.5
TRICHLOROETHYLENE	(PPB)		22.
TRICHLOROFLUOROMETHANE	(PPB)	<	0.5
VINYL CHLORIDE	(PPB)	<	0.25

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Well: 1526 OSAR AR12 Well Type: MC Zone: 1 Sector: D GSE: 97.87 TOC: 97.87 TOP: 119 BOP: 129 TD: 129

	Sample Date:	01/08/93	04/05/93	07/16/93	02/15/94	08/31/94	04/11/95	07/11/95	10/18/95	11/20/95
	Time:	13:56	10:49	09:23	12:44	11:19	10:03	12:21	07:35	12:06
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)									
NITRATE	(MG/L)	0.3	0.2	0.7	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)	110.	140.	150.	NM	200.	1100.	190.	150.	140.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	NM	< 10.	NM	NM
PH	(PH)	9.8	8.9	8.7	NM	8.	9.5	8.2	8.7	6.6
TEMPERATURE	(DEGREES C.)	12.7	20.3	17.6	NM	18.	17.	17.9	18.	18.2
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	1.5	< 1.	< 1.	1.2	47.	51.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25

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Well: 1527 OSAR AR12 Well Type: MC Zone: 1 Sector: D GSE: 97.87 TOC: 97.87 TOP: 241 BOP: 262 TD: 262

	Sample Date:	01/08/93	04/05/93	07/16/93	02/15/94	08/31/94	04/11/95	07/11/95	10/17/95	11/20/95
	Time:	13:31	09:41	10:57	11:30	10:41	09:22	11:31	13:02	11:10
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)									
NITRATE	(MG/L)	0.2	2.6	< 0.1	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)	120.	260.	160.	NM	100.	580.	250.	140.	160.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	NM	< 10.	NM	NM
PH	(PH)	9.4	8.	9.3	NM	9.7	9.3	7.9	8.3	8.8
TEMPERATURE	(DEGREES C.)	12.5	17.1	18.5	NM	18.8	16.2	19.	18.5	16.8
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	1.7	< 1.	2.5	26.	23.	15.
TRICHLOROETHYLENE	(PPB)	2.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.5	< 0.25
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.			

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Well: 1528 OSAR-AR13 Well Type: MC Zone: 1 Sector: D GSE: 233.29 TOC: 233.29 TOP: 156 BOP: 177 TD: 177

	Sample Date:	03/01/93	07/22/93	02/11/94	03/09/94	08/29/94	04/04/95	07/10/95	08/02/95	10/19/95
	Time:	14:05	15:29	13:47	14:20	21:20	11:20	12:49	14:40	09:50
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)									
NITRATE	(MG/L)	0.6	< 0.1	1.	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.3	< 0.5	< 0.15	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)	1800.	1400.	930.	NM	970.	800.	410.	NM	670.
N-NITROSODIMETHYLAMINE	(PPB)	NM	NM	NM	NM	NM	NM	< 10.	NM	NM
PH	(PH)	11.9	11.6	11.9	NM	11.3	11.5	11.1	NM	11.4
TEMPERATURE	(DEGREES C.)	19.2	20.8	17.3	NM	20.	20.6	20.4	NM	19.2
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	0.55	0.65	< 0.5
TRICHLOROETHYLENE	(PPB)	1.	< 1.	< 1.	1.8	< 1.	< 1.	14.	3.7	1.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25

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Water Quality Information

May 22, 1996

Well: 1529 OSAR-AR13 Well Type: MC Zone: 1 Sector: D GSE: 233.29 TOC: 233.29 TOP: 292 BOP: 313 TD: 313

	Sample Date:	03/01/93	07/22/93	02/11/94	03/10/94	08/29/94	04/04/95	07/10/95	10/18/95	11/27/95
	Time:	11:47	13:54	12:44	08:53	21:04	09:55	11:27	10:58	10:48
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)									
NITRATE	(MG/L)	2.1	1.6	1.7	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)	210.	200.	210.	NM	140.	170.	240.	160.	150.
N-NITROSODIMETHYLAMINE	(PPB)	NM	NM	NM	NM	NM	NM	< 10.	NM	NM
PH	(PH)	9.1	8.7	9.4	NM	10.	10.2	8.3	8.4	8.4
TEMPERATURE	(DEGREES C.)	22.7	22.4	17.2	NM	20.1	19.5	21.	19.7	19.3
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	0.56
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)	1.	< 1.	14.	< 1.	< 1.	< 1.	2.2	46.	41.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1530 OSAR-AR13 Well Type: MC Zone: 1 Sector: 0 GSE: 233.29 TOC: 233.29 TOP: 345 BOP: 366 TD: 366

	Sample Date:	03/01/93	07/22/93	02/11/94	03/10/94	08/29/94	04/04/95	07/10/95	10/18/95	11/21/95
	Time:	13:10	11:53	10:58	11:31	18:40	11:10	13:28	12:40	13:52
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
MINERALS, INORGANICS	(Units)									
NITRATE	(MG/L)	< 0.1	< 0.1	0.3	NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
CONDUCTANCE	(UMHOS/CM)	200.	180.	180.	NM	140.	180.	190.	170.	160.
N-NITROSODIMETHYLAMINE	(PPB)	NM	NM	NM	NM	NM	NM	< 10.	NM	NM
PH	(PH)	9.7	9.3	9.4	NM	9.2	8.6	8.6	8.3	7.7
TEMPERATURE	(DEGREES C.)	20.4	20.2	17.7	NM	20.8	21.6	20.8	20.2	19.3
VOLATILE ORGANICS										
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5	< 0.5
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TRICHLOROETHYLENE	(PPB)	< 1.	< 1.	19.	< 1.	< 1.	< 1.	< 0.5	4.3	3.9
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1531 OSAR-AR11 Well Type: MC Zone: 1 Sector: D GSE: 181.2 TOC: 181.2 TOP: 148 BOP: 153 TD: 153

		Sample Date:	01/05/93	03/01/93	07/14/93	02/15/94	09/13/94	04/11/95	08/24/95	11/28/95
		Time:	15:10	12:45	17:00	18:09	11:50	11:45	12:58	13:00
		Sample Type:								
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)		1.3	NM	NM	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	<	0.3	NM	NM	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM	NM
BARIUM	(MG/L)		0.031	NM	NM	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	<	0.002	NM	NM	NM	NM	NM	NM	NM
BORON	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
COBALT	(MG/L)	<	0.02	NM	NM	NM	NM	NM	NM	NM
COPPER	(MG/L)	<	0.05	NM	NM	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
IRON	(MG/L)		32.	NM	NM	NM	NM	NM	NM	NM
LEAD	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
NICKEL	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	NM	NM
SILVER	(MG/L)	<	0.01	NM	NM	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	NM	NM
ZINC	(MG/L)		0.6	NM	NM	NM	NM	NM	NM	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)		30.	NM	NM	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)		12.	NM	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		4.5	NM	NM	NM	NM	NM	NM	NM
MANGANESE	(MG/L)		0.13	NM	NM	NM	NM	NM	NM	NM
NITRATE	(MG/L)		3.9	6.9	5.1	3.9	NM	NM	NM	NM
NITRITE	(MG/L)		0.11	< 0.05	< 0.05	0.059	NM	NM	NM	NM
PERCHLORATE	(MG/L)		0.4	< 0.4	< 0.4	< 0.4	NM	NM	< 0.4	NM
POTASSIUM	(MG/L)		5.2	NM	NM	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		14.	NM	NM	NM	NM	NM	NM	NM
SULFATE	(MG/L)		14.	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		2.	NM	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		9.	NM	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		220.	270.	250.	250.	230.	1700.	250.	210.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	NM	NM	NM	NM	< 10.	NM
PH	(PH)		8.9	7.9	7.8	8.6	8.2	9.	7.5	7.3
TEMPERATURE	(DEGREES C.)		11.7	17.5	23.6	14.9	22.1	19.1	22.1	17.5
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.2	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1531 OSAR-AR11 Well Type: MC Zone: 1 Sector: D GSE: 181.2 TOC: 181.2 TOP: 148 BOP: 153 TD: 153

	Sample Date:	01/05/93	03/01/93	07/14/93	02/15/94	09/13/94	04/11/95	08/24/95	11/28/95
	Time:	15:10	12:45	17:00	18:09	11:50	11:45	12:58	13:00
	Sample Type:								
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)								
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
STYRENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TOTAL XYLENES	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	1.	3.	6.7	1.6	< 1.	5.2	3.6
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1532 OSAR-AR11 Well Type: MC Zone: 1 Sector: D GSE: 181.2 TOC: 181.2 TOP: 184 BOP: 198 TD: 198

		Sample Date:	01/05/93	03/01/93	07/15/93	02/15/94	09/13/94	04/11/95	08/24/95	11/29/95
		Time:	16:49	11:47	14:22	17:09	11:10	12:21	12:21	14:25
		Sample Type:								
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)		0.2	NM	NM	NM	NM	NM	< 0.16	NM
ANTIMONY	(MG/L)	<	0.3	NM	NM	NM	NM	NM	< 0.44	NM
ARSENIC	(MG/L)	<	0.1	NM	NM	NM	NM	NM	< 0.088	NM
BARIUM	(MG/L)		0.043	NM	NM	NM	NM	NM	0.074	NM
BERYLLIUM	(MG/L)	<	0.002	NM	NM	NM	NM	NM	< 0.0011	NM
BORON	(MG/L)	<	0.1	NM	NM	NM	NM	NM	< 0.044	NM
CADMIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	< 0.0044	NM
CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	< 0.0088	NM
COBALT	(MG/L)	<	0.02	NM	NM	NM	NM	NM	< 0.0088	NM
COPPER	(MG/L)	<	0.05	NM	NM	NM	NM	NM	< 0.0066	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
IRON	(MG/L)		18.	NM	NM	NM	NM	NM	< 0.33	NM
LEAD	(MG/L)	<	0.1	NM	NM	NM	NM	NM	< 0.066	NM
MERCURY	(MG/L)		0.0008	NM	NM	NM	NM	NM	< 0.0002	NM
MOLYBDENUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	< 0.044	NM
NICKEL	(MG/L)	<	0.04	NM	NM	NM	NM	NM	< 0.022	NM
SELENIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	< 0.11	NM
SILVER	(MG/L)	<	0.01	NM	NM	NM	NM	NM	< 0.022	NM
THALLIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	< 0.055	NM
VANADIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	0.0073	NM
ZINC	(MG/L)	<	0.1	NM	NM	NM	NM	NM	< 0.11	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)		14.	NM	NM	NM	NM	NM	24.	NM
CHLORIDE	(MG/L)		15.	NM	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		3.9	NM	NM	NM	NM	NM	8.2	NM
MANGANESE	(MG/L)		0.17	NM	NM	NM	NM	NM	< 0.0055	NM
NITRATE	(MG/L)		1.6	4.4	4.8	5.1	NM	NM	NM	NM
NITRITE	(MG/L)		0.06	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM
POTASSIUM	(MG/L)		6.4	NM	NM	NM	NM	NM	7.1	NM
SODIUM, TOTAL	(MG/L)		13.	NM	NM	NM	NM	NM	10.	NM
SULFATE	(MG/L)		11.	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		3.	NM	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		13.	NM	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		170.	210.	220.	240.	370.	4300.	250.	240.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	NM	NM	NM	NM	< 10.	NM
PH	(PH)		9.5	8.4	8.4	9.2	10.1	10.6	8.8	8.7
TEMPERATURE	(DEGREES C.)		13.1	17.2	23.3	15.	21.8	19.2	21.8	18.9
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.2	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1532 OSAR-AR11 Well Type: MC Zone: 1 Sector: D GSE: 181.2 TOC: 181.2 TOP: 184 BOP: 198 TD: 198

	Sample Date:	01/05/93	03/01/93	07/15/93	02/15/94	09/13/94	04/11/95	08/24/95	11/29/95
	Time:	16:49	11:47	14:22	17:09	11:10	12:21	12:21	14:25
	Sample Type:								
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)								
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
STYRENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TOTAL XYLENES	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	4.2	< 1.	< 1.	0.69	5.4
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1533 OSAR-AR11 Well Type: MC Zone: 1 Sector: D GSE: 181.2 TOC: 181.2 TOP: 247 BOP: 257 TD: 257

		Sample Date:	01/05/93	03/01/93	07/15/93	02/15/94	09/13/94	04/11/95	08/24/95	11/29/95
		Time:	16:30	10:29	13:26	15:53	10:06	13:10	11:25	13:26
		Sample Type:								
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)		2.	NM	NM	NM	NM	NM	< 0.16	NM
ANTIMONY	(MG/L)	<	0.3	NM	NM	NM	NM	NM	< 0.44	NM
ARSENIC	(MG/L)	<	0.1	NM	NM	NM	NM	NM	< 0.088	NM
BARIUM	(MG/L)		0.066	NM	NM	NM	NM	NM	0.036	NM
BERYLLIUM	(MG/L)	<	0.002	NM	NM	NM	NM	NM	< 0.0011	NM
BORON	(MG/L)	<	0.1	NM	NM	NM	NM	NM	< 0.044	NM
CADMIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	< 0.0044	NM
CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	< 0.0088	NM
COBALT	(MG/L)	<	0.02	NM	NM	NM	NM	NM	< 0.0088	NM
COPPER	(MG/L)		0.06	NM	NM	NM	NM	NM	< 0.0066	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
IRON	(MG/L)		48.	NM	NM	NM	NM	NM	< 0.33	NM
LEAD	(MG/L)	<	0.1	NM	NM	NM	NM	NM	< 0.066	NM
MERCURY	(MG/L)	<	0.0002	NM	NM	NM	NM	NM	< 0.0002	NM
MOLYBDENUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	< 0.044	NM
NICKEL	(MG/L)	<	0.04	NM	NM	NM	NM	NM	< 0.022	NM
SELENIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	< 0.11	NM
SILVER	(MG/L)	<	0.01	NM	NM	NM	NM	NM	< 0.022	NM
THALLIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	< 0.055	NM
VANADIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	0.0065	NM
ZINC	(MG/L)		0.2	NM	NM	NM	NM	NM	< 0.11	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)		19.	NM	NM	NM	NM	NM	25.	NM
CHLORIDE	(MG/L)		13.	NM	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		4.3	NM	NM	NM	NM	NM	8.8	NM
MANGANESE	(MG/L)		0.25	NM	NM	NM	NM	NM	0.018	NM
NITRATE	(MG/L)		2.3	5.1	4.9	4.8	NM	NM	NM	NM
NITRITE	(MG/L)		0.07	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM
POTASSIUM	(MG/L)		6.3	NM	NM	NM	NM	NM	5.4	NM
SODIUM, TOTAL	(MG/L)		13.	NM	NM	NM	NM	NM	11.	NM
SULFATE	(MG/L)		12.	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		2.	NM	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		30.	NM	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		230.	250.	250.	250.	220.	2700.	240.	230.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	NM	NM	NM	NM	< 10.	NM
PH	(PH)		8.9	8.3	8.	7.7	7.1	8.4	7.6	7.8
TEMPERATURE	(DEGREES C.)		15.2	18.	23.1	15.4	19.1	19.2	21.4	20.
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.2	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1533 OSAR-AR11 Well Type: MC Zone: 1 Sector: D GSE: 181.2 TOC: 181.2 TOP: 247 BOP: 257 TD: 257

	Sample Date:	01/05/93	03/01/93	07/15/93	02/15/94	09/13/94	04/11/95	08/24/95	11/29/95
	Time:	16:30	10:29	13:26	15:53	10:06	13:10	11:25	13:26
	Sample Type:								
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)								
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
STYRENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TOTAL XYLENES	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1538 AR ED-1 Well Type: MC Zone: 1 Sector: D GSE: 147.3 TOC: 147.3 TOP: 90 BOP: 106 TD: 106

		Sample Date:	07/02/93	07/12/93	01/14/94	04/20/94	07/07/94	08/25/95	11/28/95
		Time:	12:33	09:43	11:49	20:12	08:40	11:54	09:45
		Sample Type:							
		Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)								
ALUMINUM	(MG/L)		0.35	NM	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	<	0.3	NM	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM
BARIUM	(MG/L)		0.029	NM	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	<	0.002	NM	NM	NM	NM	NM	NM
BORON	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM
COBALT	(MG/L)	<	0.02	NM	NM	NM	NM	NM	NM
COPPER	(MG/L)	<	0.05	NM	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM
IRON	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM
LEAD	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM
NICKEL	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	NM
SILVER	(MG/L)	<	0.01	NM	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	NM
ZINC	(MG/L)		0.1	NM	NM	NM	NM	NM	NM
MINERALS, INORGANICS									
CALCIUM	(MG/L)		54.	NM	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)		33.	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		0.21	NM	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	<	0.005	NM	NM	NM	NM	NM	NM
NITRATE	(MG/L)		3.2	NM	4.6	2.	NM	NM	NM
NITRITE	(MG/L)		0.28	NM	0.2	0.97	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4	< 0.4	NM	NM	NM
POTASSIUM	(MG/L)		11.	NM	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		24.	NM	NM	NM	NM	NM	NM
SULFATE	(MG/L)		12.	NM	NM	NM	NM	NM	NM
MISCELLANEOUS									
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	<	1.	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		3.	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		400.	340.	240.	1010.	270.	240.	270.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	NM	< 10.	NM	< 10.	NM
PH	(PH)		10.6	10.6	10.	11.8	9.6	9.9	8.3
TEMPERATURE	(DEGREES C.)		27.	20.7	18.8	15.6	18.1	22.5	16.2
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.2	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1538 AR ED-1 Well Type: MC Zone: 1 Sector: D GSE: 147.3 TOC: 147.3 TOP: 90 BOP: 106 TD: 106

	Sample Date:	07/02/93	07/12/93	01/14/94	04/20/94	07/07/94	08/25/95	11/28/95
	Time:	12:33	09:43	11:49	20:12	08:40	11:54	09:45
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	5.	< 1.	18.	2.	1.1	2.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1539 ER ED-1 Well Type: MC Zone: 1 Sector: D GSE: 147.3 TOC: 147.3 TOP: 151 BOP: 162 TD: 162

		Sample Date:	07/02/93	07/12/93	01/14/94	04/20/94	07/07/94	04/10/95	08/25/95	11/28/95
		Time:	11:08	09:07	11:15	19:21	09:25	10:21	12:32	10:25
		Sample Type:								
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)	< 0.05	NM	NM	NM	NM	NM	NM	NM	
ANTIMONY	(MG/L)	< 0.3	NM	NM	NM	NM	NM	NM	NM	
ARSENIC	(MG/L)	< 0.1	NM	NM	NM	NM	NM	NM	NM	
BARIUM	(MG/L)	0.068	NM	NM	NM	NM	NM	NM	NM	
BERYLLIUM	(MG/L)	< 0.002	NM	NM	NM	NM	NM	NM	NM	
BORON	(MG/L)	< 0.1	NM	NM	NM	NM	NM	NM	NM	
CADMIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM	NM	NM	
CHROMIUM	(MG/L)	< 0.04	NM	NM	NM	NM	NM	NM	NM	
COBALT	(MG/L)	< 0.02	NM	NM	NM	NM	NM	NM	NM	
COPPER	(MG/L)	< 0.05	NM	NM	NM	NM	NM	NM	NM	
HEXAVALENT CHROMIUM	(MG/L)	< 0.04	NM	NM	NM	NM	NM	NM	NM	
IRON	(MG/L)	< 0.1	NM	NM	NM	NM	NM	NM	NM	
LEAD	(MG/L)	< 0.1	NM	NM	NM	NM	NM	NM	NM	
MERCURY	(MG/L)	< 0.0002	NM	NM	NM	NM	NM	NM	NM	
MOLYBDENUM	(MG/L)	< 0.04	NM	NM	NM	NM	NM	NM	NM	
NICKEL	(MG/L)	< 0.04	NM	NM	NM	NM	NM	NM	NM	
SELENIUM	(MG/L)	< 0.4	NM	NM	NM	NM	NM	NM	NM	
SILVER	(MG/L)	< 0.01	NM	NM	NM	NM	NM	NM	NM	
THALLIUM	(MG/L)	< 0.4	NM	NM	NM	NM	NM	NM	NM	
VANADIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM	NM	NM	
ZINC	(MG/L)	< 0.1	NM	NM	NM	NM	NM	NM	NM	
MINERALS, INORGANICS										
CALCIUM	(MG/L)	33.	NM	NM	NM	NM	NM	NM	NM	
CHLORIDE	(MG/L)	54.	NM	NM	NM	NM	NM	NM	NM	
MAGNESIUM	(MG/L)	3.6	NM	NM	NM	NM	NM	NM	NM	
MANGANESE	(MG/L)	< 0.005	NM	NM	NM	NM	NM	NM	NM	
NITRATE	(MG/L)	3.1	NM	2.2	3.1	NM	NM	NM	NM	
NITRITE	(MG/L)	< 0.2	NM	0.29	< 0.15	NM	NM	NM	NM	
PERCHLORATE	(MG/L)	< 0.4	NM	< 0.4	0.4	NM	NM	< 0.4	NM	
POTASSIUM	(MG/L)	14.	NM	NM	NM	NM	NM	NM	NM	
SODIUM, TOTAL	(MG/L)	20.	NM	NM	NM	NM	NM	NM	NM	
SULFATE	(MG/L)	8.9	NM	NM	NM	NM	NM	NM	NM	
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	< 1.	NM	NM	NM	NM	NM	NM	NM	
CHEM. OXYGEN DEMAND (COD)	(MG/L)	3.	NM	NM	NM	NM	NM	NM	NM	
CONDUCTANCE	(UMHOS/CM)	570.	580.	1200.	280.	420.	1000.	320.	680.	
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	NM	< 10.	NM	
PH	(PH)	10.9	11.3	11.8	10.2	10.9	11.6	9.4	11.4	
TEMPERATURE	(DEGREES C.)	24.9	19.5	16.8	16.4	19.1	22.5	23.	16.9	
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	0.3	NM	NM	NM	NM	NM	NM	NM	

AEROJET Environmental Operations
Water Quality Information

Well: 1539 ER ED-1 Well Type: NC Zone: 1 Sector: D GSE: 147.3 TOC: 147.3 TOP: 151 BOP: 162 TD: 162

	Sample Date:	07/02/93	07/12/93	01/14/94	04/20/94	07/07/94	04/10/95	08/25/95	11/28/95
	Time:	11:08	09:07	11:15	19:21	09:25	10:21	12:32	10:25
	Sample Type:								
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)								
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	2.	2.2	3.7	4.6	4.2	3.5	4.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	1.1	1.6	1.5	1.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	93.	93.	100.	140.	180.	130.	170.	140.
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1540 AR ED-1 Well Type: MC Zone: 1 Sector: D GSE: 147.3 TOC: 147.3 TOP: 192 BOP: 204 TD: 204

		Sample Date:	07/02/93	07/12/93	01/14/94	04/20/94	07/07/94	04/10/95	08/25/95	11/28/95
		Time:	09:45	08:19	10:08	18:22	10:31	09:27	11:30	11:31
		Sample Type:								
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)		0.23	NM	NM	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	<	0.3	NM	NM	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM	NM
BARIUM	(MG/L)		0.097	NM	NM	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	<	0.002	NM	NM	NM	NM	NM	NM	NM
BORON	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
COBALT	(MG/L)	<	0.02	NM	NM	NM	NM	NM	NM	NM
COPPER	(MG/L)	<	0.05	NM	NM	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
IRON	(MG/L)		0.6	NM	NM	NM	NM	NM	NM	NM
LEAD	(MG/L)	<	0.1	NM	NM	NM	NM	NM	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
NICKEL	(MG/L)	<	0.04	NM	NM	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	NM	NM
SILVER	(MG/L)	<	0.01	NM	NM	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	<	0.4	NM	NM	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM	NM	NM
ZINC	(MG/L)		0.1	NM	NM	NM	NM	NM	NM	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)		81.	NM	NM	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)		83.	NM	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		1.1	NM	NM	NM	NM	NM	NM	NM
MANGANESE	(MG/L)		0.012	NM	NM	NM	NM	NM	NM	NM
NITRATE	(MG/L)		4.2	NM	4.2	4.5	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.3	NM	0.4	< 0.15	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	< 0.4	< 0.4	NM	NM	NM	NM
POTASSIUM	(MG/L)		18.	NM	NM	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		27.	NM	NM	NM	NM	NM	NM	NM
SULFATE	(MG/L)		11.	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	<	1.	NM	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		10.	NM	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		920.	840.	520.	230.	540.	560.	440.	260.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	NM	< 10.	NM	NM	< 10.	NM
PH	(PH)		11.4	11.6	11.3	9.8	11.2	11.3	11.	10.2
TEMPERATURE	(DEGREES C.)		20.6	18.8	15.6	17.1	19.6	20.4	22.2	17.5
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.2	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1540 AR ED-1 Well Type: MC Zone: 1 Sector: D GSE: 147.3 TOC: 147.3 TOP: 192 BOP: 204 TD: 204

	Sample Date:	07/02/93	07/12/93	01/14/94	04/20/94	07/07/94	04/10/95	08/25/95	11/28/95
	Time:	09:45	08:19	10:08	18:22	10:31	09:27	11:30	11:31
	Sample Type:								
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)								
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	2.	9.1	7.2	8.6	4.4	6.1	24.
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1556 06-1 (OAKGLEN) Well Type: MC Zone: 1 Sector: D GSE: 183.3 TOC: 183.3 TOP: 174 BOP: 187 TD: 187

	Sample Date:		05/10/94		07/05/94	
	Time:		12:50		14:00	
	Sample Type:					
	Lab:		EL		EL	
MINERALS, INORGANICS	(Units)					
NITRATE	(MG/L)	<	0.03		NM	
NITRITE	(MG/L)	<	0.05		NM	
PERCHLORATE	(MG/L)	<	0.4		NM	
MISCELLANEOUS						
CONDUCTANCE	(UMHOS/CM)		520.		920.	
PH	(PH)		11.		11.	
TEMPERATURE	(DEGREES C.)		19.6		21.2	
VOLATILE ORGANICS						
1,1,1-TRICHLOROETHANE	(UG/L)	<	1.	<	1.	
1,1,2,2-TETRACHLOROETHANE	(UG/L)	<	1.	<	1.	
1,1,2-TRICHLOROETHANE	(UG/L)	<	1.	<	1.	
1,1-DICHLOROETHANE	(UG/L)	<	1.	<	1.	
1,1-DICHLOROETHYLENE	(UG/L)	<	1.	<	1.	
1,2-DICHLOROETHANE	(UG/L)	<	1.	<	1.	
1,2-DICHLOROPROPANE	(UG/L)	<	1.	<	1.	
BROMODICHLOROMETHANE	(UG/L)	<	1.	<	1.	
BROMOFORM	(UG/L)	<	2.	<	2.	
CARBON TETRACHLORIDE	(UG/L)	<	1.	<	1.	
CHLOROBENZENE	(UG/L)	<	1.	<	1.	
CHLOROFORM	(UG/L)		4.2		2.4	
CIS/TRANS-1,2-DICHLOROETHYLENE	(UG/L)	<	1.	<	1.	
DIBROMOCHLOROMETHANE	(UG/L)	<	1.	<	1.	
DICHLORODIFLUOROMETHANE	(UG/L)	<	1.	<	1.	
DICHLOROMETHANE	(UG/L)		1.4		1.2	
FREON 113	(UG/L)	<	1.	<	1.	
TETRACHLOROETHYLENE	(UG/L)		4.5		2.8	
TRICHLOROETHYLENE	(UG/L)		4.9		3.5	
TRICHLOROFLUOROMETHANE	(UG/L)	<	1.	<	1.	
VINYL CHLORIDE	(UG/L)	<	1.	<	1.	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1557 06-1 (OAKGLEN) Well Type: MC Zone: 1 Sector: D GSE: 183.3 TOC: 183.3 TOP: 234.5 BOP: 250.5 TD: 250.5

	Sample Date:	11/05/93	11/22/93	12/13/93	02/16/94	05/10/94	07/05/94	02/08/95	03/07/95	04/14/95
	Time:	12:39	12:20	15:57	10:02	11:46	11:23	10:05	10:58	14:17
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)	NM	NM	< 0.05	NM	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	NM	< 0.5	NM	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	NM	< 0.1	NM	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	NM	0.064	NM	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	NM	< 0.002	NM	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	NM	< 0.1	NM	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	NM	< 0.01	NM	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	NM	< 0.01	NM	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	NM	< 0.02	NM	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	NM	< 0.01	NM	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	NM	< 0.02	NM	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	NM	< 0.1	NM	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	NM	< 0.1	NM	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	NM	< 0.0002	NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	NM	< 0.04	NM	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	NM	< 0.04	NM	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	NM	< 0.2	NM	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	NM	< 0.01	NM	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	NM	< 0.05	NM	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	NM	< 0.02	NM	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	NM	< 0.1	NM	NM	NM	NM	NM	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)	NM	NM	23.	NM	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	NM	10.	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	NM	5.9	NM	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	NM	0.009	NM	NM	NM	NM	NM	NM
NITRATE	(MG/L)	NM	NM	5.1	0.83	< 0.03	NM	NM	NM	NM
NITRITE	(MG/L)	NM	NM	0.17	< 0.05	< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	NM	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	NM	5.8	NM	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	NM	12.	NM	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	NM	9.	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	NM	1.	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	NM	6.1	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	NM	NM	230.	170.	200.	200.	160.	130.	100.
N-NITROSODIMETHYLAMINE	(PPB)	NM	NM	< 10.	NM	NM	NM	NM	NM	NM
PH	(PH)	NM	NM	9.2	9.7	9.6	9.6	8.6	9.4	9.9
TEMPERATURE	(DEGREES C.)	NM	NM	15.	18.	19.2	20.6	18.2	[redacted]	20.
TOTAL PETROLE[redacted]ARBONS	(MG/L)	NM	NM	< [redacted]	NM	NM	NM	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1557 06-1 (OAKGLEN) Well Type: MC Zone: 1 Sector: D GSE: 183.3 TOC: 183.3 TOP: 234.5 BOP: 250.5 TD: 250.5

VOLATILE ORGANICS	(Units)	Sample Date:	11/05/93	11/22/93	12/13/93	02/16/94	05/10/94	07/05/94	02/08/95	03/07/95	04/14/95
		Time:	12:39	12:20	15:57	10:02	11:46	11:23	10:05	10:58	14:17
		Sample Type:									
		Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
1,1,1-TRICHLOROETHANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	0.67
1,2-DICHLOROPROPANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)		NM	NM	< 20.	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)		NM	NM	< 10.	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)		NM	NM	< 20.	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)		NM	NM	< 10.	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)		NM	NM	< 20.	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)		NM	NM	< 5.	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)		< 0.5	< 0.5	< 5.	< 2.	< 2.	< 2.	< 2.	< 2.	< 1.
BROMOMETHANE	(PPB)		NM	NM	< 10.	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)		NM	NM	< 5.	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROBENZENE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROETHANE	(PPB)		NM	NM	< 10.	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	2.7
CHLOROMETHANE	(PPB)		NM	NM	< 10.	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)		NM	NM	< 5.	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)		< 0.5	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLOROMETHANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
ETHYLBENZENE	(PPB)		NM	NM	< 5.	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)		NM	NM	< 5.	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
TOLUENE	(PPB)		NM	NM	< 5.	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	11.	< 1.	3.1	8.
TRICHLOROFLUOROMETHANE	(PPB)		< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL ACETATE	(PPB)		NM	NM	< 10.	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)		< 0.5	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
XYLENES (TOTAL)	(PPB)		NM	NM	< 5.	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1557 06-1 (OAKGLEN) Well Type: MC Zone: 1 Sector: D GSE: 183.3 TOC: 183.3 TOP: 234.5 BOP: 250.5 TD: 250.5

		Sample Date:	06/28/95	07/31/95	08/21/95	09/29/95	10/13/95	12/11/95
		Time:	:	10:14	13:05	08:40	12:15	09:45
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)		NM	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)		NM	NM	NM	NM	NM	NM
ARSENIC	(MG/L)		NM	NM	NM	NM	NM	NM
BARIUM	(MG/L)		NM	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)		NM	NM	NM	NM	NM	NM
BORON	(MG/L)		NM	NM	NM	NM	NM	NM
CADMIUM	(MG/L)		NM	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)		NM	NM	NM	NM	NM	NM
COBALT	(MG/L)		NM	NM	NM	NM	NM	NM
COPPER	(MG/L)		NM	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)		NM	NM	NM	NM	NM	NM
IRON	(MG/L)		NM	NM	NM	NM	NM	NM
LEAD	(MG/L)		NM	NM	NM	NM	NM	NM
MERCURY	(MG/L)		NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)		NM	NM	NM	NM	NM	NM
NICKEL	(MG/L)		NM	NM	NM	NM	NM	NM
SELENIUM	(MG/L)		NM	NM	NM	NM	NM	NM
SILVER	(MG/L)		NM	NM	NM	NM	NM	NM
THALLIUM	(MG/L)		NM	NM	NM	NM	NM	NM
VANADIUM	(MG/L)		NM	NM	NM	NM	NM	NM
ZINC	(MG/L)		NM	NM	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)		NM	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)		NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		NM	NM	NM	NM	NM	NM
MANGANESE	(MG/L)		NM	NM	NM	NM	NM	NM
NITRATE	(MG/L)		NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)		NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)		NM	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)		NM	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		NM	NM	NM	NM	NM	NM
SULFATE	(MG/L)		NM	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		87.	110.	240.	160.	170.	240.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	NM	NM	NM
PH	(PH)		10.	9.4	8.1	8.2	8.2	8.
TEMPERATURE	(DEGREES C.)		22.3	22.6	22.	17.4	20.7	18.1
TOTAL PETROLE[redacted]ARBONS	(MG/L)		NM	NM	[redacted]	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1557 06-1 (OAKGLEN) Well Type: MC Zone: 1 Sector: D GSE: 183.3 TOC: 183.3 TOP: 234.5 BOP: 250.5 TD: 250.5

	Sample Date:	06/28/95	07/31/95	08/21/95	09/29/95	10/13/95	12/11/95
	Time:	:	10:14	13:05	08:40	12:15	09:45
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.5	0.54	< 0.25	< 0.25	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.5	< 0.25	< 0.25	< 0.25	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 0.5	< 0.5	< 0.5	2.8	2.6	< 0.5
CHLOROMETHANE	(PPB)	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	9.8	4.2	< 0.5	14.	11.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.5	< 0.25	< 0.25	< 0.25	< 0.5	< 0.25
XYLENES (TOTAL)	(PPB)	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1558 06-1 (OAKGLEN) Well Type: MC Zone: 1 Sector: D GSE: 183.3 TOC: 183.3 TOP: 284 BOP: 297 TD: 292

	Sample Date:	11/05/93	11/22/93	12/13/93	02/16/94	05/10/94	07/05/94	02/08/95	03/07/95	04/13/95
	Time:	13:54	11:20	15:15	09:12	10:25	15:08	11:08	12:26	16:00
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)	NM	NM	< 0.05	NM	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	NM	< 0.5	NM	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	NM	< 0.1	NM	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	NM	0.17	NM	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	NM	< 0.002	NM	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	NM	< 0.1	NM	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	NM	< 0.01	NM	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	NM	< 0.01	NM	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	NM	< 0.02	NM	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	NM	< 0.01	NM	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	NM	< 0.02	NM	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	NM	< 0.1	NM	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	NM	< 0.1	NM	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	NM	< 0.0002	NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	NM	< 0.04	NM	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	NM	< 0.04	NM	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	NM	< 0.2	NM	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	NM	< 0.01	NM	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	NM	< 0.05	NM	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	NM	< 0.02	NM	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	NM	0.19	NM	NM	NM	NM	NM	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)	NM	NM	48.	NM	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	NM	290.	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	NM	7.9	NM	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	NM	0.22	NM	NM	NM	NM	NM	NM
NITRATE	(MG/L)	NM	NM	0.063	< 0.03	< 0.03	NM	NM	NM	NM
NITRITE	(MG/L)	NM	NM	< 1.3	< 0.05	< 0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	NM	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	NM	26.	NM	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	NM	89.	NM	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	NM	12.	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	NM	4.6	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	NM	10.	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	NM	NM	890.	760.	420.	740.	130.	280.	350.
N-NITROSODIMETHYLAMINE	(PPB)	NM	NM	< 10.	NM	NM	NM	NM	NM	NM
PH	(PH)	NM	NM	7.7	11.8	9.8	8.6	9.8	8.9	8.3
TEMPERATURE	(DEGREES C.)	NM	NM	16.3	16.8	20.	23.4	18.8	21.6	19.7
TOTAL PETROLE[redacted]RBONS	(MG/L)	NM	NM	< [redacted]	NM	NM	NM	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1558 06-1 (OAKGLEN) Well Type: MC Zone: 1 Sector: D GSE: 183.3 TOC: 183.3 TOP: 284 BOP: 297 TD: 292

	Sample Date:	11/05/93	11/22/93	12/13/93	02/16/94	05/10/94	07/05/94	02/08/95	03/07/95	04/13/95
	Time:	13:54	11:20	15:15	09:12	10:25	15:08	11:08	12:26	16:00
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)									
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROPROPANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	NM	< 20.	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	NM	< 10.	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	NM	< 20.	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	NM	< 10.	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	NM	< 20.	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	NM	< 5.	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 0.5	< 0.5	< 5.	< 2.	< 2.	< 2.	< 2.	< 2.	< 1.
BROMOMETHANE	(PPB)	NM	NM	< 10.	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	NM	< 5.	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROBENZENE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROETHANE	(PPB)	NM	NM	< 10.	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
CHLOROMETHANE	(PPB)	NM	NM	< 10.	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	< 5.	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	NM	NM	< 5.	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	< 5.	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
TOLUENE	(PPB)	NM	NM	< 5.	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	36.	1.3	1.7	4.6
TRICHLOROFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
VINYL ACETATE	(PPB)	NM	NM	< 10.	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.5	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5
XYLENES (TOTAL)	(PPB)	NM	NM	< 5.	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1558 06-1 (OAKGLEN) Well Type: MC Zone: 1 Sector: D GSE: 183.3 TOC: 183.3 TOP: 284 BOP: 297 TD: 292

		Sample Date:	06/28/95	07/31/95	08/21/95	09/27/95	10/13/95	12/11/95
		Time:	:	11:28	11:59	09:57	09:32	08:13
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)		NM	NM	< 0.16	NM	NM	NM
ANTIMONY	(MG/L)		NM	NM	< 0.44	NM	NM	NM
ARSENIC	(MG/L)		NM	NM	< 0.088	NM	NM	NM
BARIUM	(MG/L)		NM	NM	0.075	NM	NM	NM
BERYLLIUM	(MG/L)		NM	NM	< 0.0011	NM	NM	NM
BORON	(MG/L)		NM	NM	< 0.044	NM	NM	NM
CADMIUM	(MG/L)		NM	NM	< 0.0044	NM	NM	NM
CHROMIUM	(MG/L)		NM	NM	< 0.0088	NM	NM	NM
COBALT	(MG/L)		NM	NM	< 0.0088	NM	NM	NM
COPPER	(MG/L)		NM	NM	< 0.0066	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)		NM	NM	NM	NM	NM	NM
IRON	(MG/L)		NM	NM	< 0.33	NM	NM	NM
LEAD	(MG/L)		NM	NM	< 0.066	NM	NM	NM
MERCURY	(MG/L)		NM	NM	< 0.0002	NM	NM	NM
MOLYBDENUM	(MG/L)		NM	NM	< 0.044	NM	NM	NM
NICKEL	(MG/L)		NM	NM	< 0.022	NM	NM	NM
SELENIUM	(MG/L)		NM	NM	< 0.11	NM	NM	NM
SILVER	(MG/L)		NM	NM	< 0.022	NM	NM	NM
THALLIUM	(MG/L)		NM	NM	< 0.055	NM	NM	NM
VANADIUM	(MG/L)		NM	NM	< 0.0055	NM	NM	NM
ZINC	(MG/L)		NM	NM	< 0.11	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)		NM	NM	34.	NM	NM	NM
CHLORIDE	(MG/L)		NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		NM	NM	5.	NM	NM	NM
MANGANESE	(MG/L)		NM	NM	0.1	NM	NM	NM
NITRATE	(MG/L)		NM	NM	NM	NM	NM	NM
NITRITE	(MG/L)		NM	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)		NM	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)		NM	NM	10.	NM	NM	NM
SODIUM, TOTAL	(MG/L)		NM	NM	22.	NM	NM	NM
SULFATE	(MG/L)		NM	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		120.	370.	350.	340.	350.	370.
N-NITROSODIMETHYLAMINE	(PPB)		NM	NM	< 10.	NM	NM	NM
PH	(PH)		9.8	8.	7.8	8.4	7.9	7.2
TEMPERATURE	(DEGREES C.)		22.7	24.8	23.5	19.5	18.8	17.2
TOTAL PETROLE[redacted]ARBONS	(MG/L)		NM	NM	[redacted]	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1558 06-1 (OAKGLEN) Well Type: MC Zone: 1 Sector: D GSE: 183.3 TOC: 183.3 TOP: 284 BOP: 297 TD: 292

	Sample Date:	06/28/95	07/31/95	08/21/95	09/27/95	10/13/95	12/11/95
	Time:	:	11:28	11:59	09:57	09:32	08:13
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.5	< 0.25	< 0.25	< 0.25	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.5	< 0.25	< 0.25	< 0.25	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	11.	< 0.5	< 0.5	4.2	1.2	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.5	< 0.25	< 0.25	< 0.25	< 0.5	< 0.25
XYLENES (TOTAL)	(PPB)	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1559 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 186 BOP: 204 TD: 204

	Sample Date:	11/22/93	12/13/93	02/15/94	05/10/94	09/02/94	03/08/95	04/11/95	06/28/95	07/31/95
	Time:	14:35	12:57	13:17	18:03	11:18	14:50	14:25	:	13:44
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)	NM	0.057	NM	NM	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	< 0.5	NM	NM	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	0.072	NM	NM	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	0.22	NM	NM	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	< 0.2	NM	NM	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)	NM	25.	NM	NM	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	6.6	NM	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	9.3	NM	NM	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	0.043	NM	NM	NM	NM	NM	NM	NM
NITRATE	(MG/L)	NM	4.1	0.74	< 0.03	NM	NM	NM	NM	NM
NITRITE	(MG/L)	NM	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	3.	NM	NM	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	7.6	NM	NM	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	9.8	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	< 3.	NM	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	NM	240.	210.	170.	170.	150.	260.	150.	170.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
PH	(PH)	NM	7.7	9.	8.9	8.8	9.2	7.8	9.2	8.8
TEMPERATURE	(DEGREES C.)	NM	15.	16.9	17.8	18.1	17.7	15.8	[redacted]	22.5
TOTAL PETROLE[redacted]ARBONS	(MG/L)	NM	< 0.2	[redacted]	NM	NM	NM	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1559 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 186 BOP: 204 TD: 204

	Sample Date:	11/22/93	12/13/93	02/15/94	05/10/94	09/02/94	03/08/95	04/11/95	06/28/95	07/31/95
	Time:	14:35	12:57	13:17	18:03	11:18	14:50	14:25	:	13:44
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)									
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 0.5	< 5.	< 2.	< 2.	< 2.	< 2.	< 1.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	1.	2.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1559 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 186 BOP: 204 TD: 204

	Sample Date:	08/23/95	09/29/95	10/12/95	12/11/95
	Time:	11:54	14:26	14:02	11:53
	Sample Type:				
	Lab:	EL	EL	EL	EL
METALS	(Units)				
ALUMINUM	(MG/L)	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	NM	NM	NM
BARIUM	(MG/L)	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	NM	NM	NM
BORON	(MG/L)	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	NM	NM	NM
COBALT	(MG/L)	NM	NM	NM	NM
COPPER	(MG/L)	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	NM	NM	NM
IRON	(MG/L)	NM	NM	NM	NM
LEAD	(MG/L)	NM	NM	NM	NM
MERCURY	(MG/L)	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	NM	NM	NM
NICKEL	(MG/L)	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	NM	NM	NM
SILVER	(MG/L)	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	NM	NM	NM
ZINC	(MG/L)	NM	NM	NM	NM
MINERALS, INORGANICS					
CALCIUM	(MG/L)	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	NM	NM	NM
NITRATE	(MG/L)	NM	NM	NM	NM
NITRITE	(MG/L)	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	NM	NM	NM
SULFATE	(MG/L)	NM	NM	NM	NM
MISCELLANEOUS					
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	220.	200.	200.	230.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM
PH	(PH)	7.7	8.4	8.1	7.7
TEMPERATURE	(DEGREES C.)	18.4	19.3	18.6	15.3
TOTAL PETROLE[redacted]RBONS	(MG/L)	NM	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1559 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 186 BOP: 204 TD: 204

	Sample Date:	08/23/95	09/29/95	10/12/95	12/11/95
	Time:	11:54	14:26	14:02	11:53
	Sample Type:				
	Lab:	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)				
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.25	< 0.25	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	NM	NM	NM
ACETONE	(PPB)	NM	NM	NM	NM
BENZENE	(PPB)	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.25	< 0.25	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	NM	NM	NM
FREON 113	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	1.9	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.25	< 0.25	< 0.5	< 0.25
XYLENES (TOTAL)	(PPB)	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1560 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 237 BOP: 247 TD: 247

	Sample Date:	11/22/93	12/13/93	02/15/94	05/10/94	09/02/94	03/07/95	04/13/95	06/28/95	07/31/95
	Time:	13:20	11:45	12:36	17:01	10:28	15:28	13:15	:	15:20
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	< 0.5	NM	NM	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	0.063	NM	NM	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	0.012	NM	NM	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	0.2	NM	NM	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	< 0.2	NM	NM	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)	NM	23.	NM	NM	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	6.2	NM	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	8.	NM	NM	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	0.028	NM	NM	NM	NM	NM	NM	NM
NITRATE	(MG/L)	NM	2.4	0.1	< 0.03	NM	NM	NM	NM	NM
NITRITE	(MG/L)	NM	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	3.1	NM	NM	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	6.6	NM	NM	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	10.	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	< 3.	NM	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	NM	230.	220.	180.	130.	130.	220.	130.	150.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
PH	(PH)	NM	8.2	9.1	8.9	9.5	9.6	7.5	9.6	9.3
TEMPERATURE	(DEGREES C.)	NM	15.7	17.	18.6	17.1	17.8	16.	[redacted]	21.6
TOTAL PETROL[redacted]BONS	(MG/L)	NM	< 0.2	[redacted]	NM	NM	NM	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1560 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 237 BOP: 247 TD: 247

	Sample Date:	11/22/93	12/13/93	02/15/94	05/10/94	09/02/94	03/07/95	04/13/95	06/28/95	07/31/95
	Time:	13:20	11:45	12:36	17:01	10:28	15:28	13:15	:	15:20
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)									
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 0.5	< 5.	< 2.	< 2.	< 2.	< 2.	< 1.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	3.1	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1560 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 237 BOP: 247 TD: 247

		Sample Date:	08/23/95	09/29/95	10/12/95	12/11/95
		Time:	11:17	12:20	11:51	11:30
		Sample Type:				
		Lab:	EL	EL	EL	EL
METALS	(Units)					
ALUMINUM	(MG/L)		NM	NM	NM	NM
ANTIMONY	(MG/L)		NM	NM	NM	NM
ARSENIC	(MG/L)		NM	NM	NM	NM
BARIUM	(MG/L)		NM	NM	NM	NM
BERYLLIUM	(MG/L)		NM	NM	NM	NM
BORON	(MG/L)		NM	NM	NM	NM
CADMIUM	(MG/L)		NM	NM	NM	NM
CHROMIUM	(MG/L)		NM	NM	NM	NM
COBALT	(MG/L)		NM	NM	NM	NM
COPPER	(MG/L)		NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)		NM	NM	NM	NM
IRON	(MG/L)		NM	NM	NM	NM
LEAD	(MG/L)		NM	NM	NM	NM
MERCURY	(MG/L)		NM	NM	NM	NM
MOLYBDENUM	(MG/L)		NM	NM	NM	NM
NICKEL	(MG/L)		NM	NM	NM	NM
SELENIUM	(MG/L)		NM	NM	NM	NM
SILVER	(MG/L)		NM	NM	NM	NM
THALLIUM	(MG/L)		NM	NM	NM	NM
VANADIUM	(MG/L)		NM	NM	NM	NM
ZINC	(MG/L)		NM	NM	NM	NM
MINERALS, INORGANICS						
CALCIUM	(MG/L)		NM	NM	NM	NM
CHLORIDE	(MG/L)		NM	NM	NM	NM
MAGNESIUM	(MG/L)		NM	NM	NM	NM
MANGANESE	(MG/L)		NM	NM	NM	NM
NITRATE	(MG/L)		NM	NM	NM	NM
NITRITE	(MG/L)		NM	NM	NM	NM
PERCHLORATE	(MG/L)		NM	NM	NM	NM
POTASSIUM	(MG/L)		NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		NM	NM	NM	NM
SULFATE	(MG/L)		NM	NM	NM	NM
MISCELLANEOUS						
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		220.	220.	210.	220.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	NM	NM
PH	(PH)		8.1	8.1	8.2	8.1
TEMPERATURE	(DEGREES C.)		19.6	20.1	[redacted]	15.4
TOTAL PETROL[redacted]RBONS	(MG/L)		NM	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1560 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 237 BOP: 247 TD: 247

	Sample Date:	08/23/95	09/29/95	10/12/95	12/11/95
	Time:	11:17	12:20	11:51	11:30
	Sample Type:				
	Lab:	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)				
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.25	< 0.25	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	NM	NM	NM
ACETONE	(PPB)	NM	NM	NM	NM
BENZENE	(PPB)	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.25	< 0.25	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	NM	NM	NM
FREON 113	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	1.4	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 0.5	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.25	< 0.25	< 0.5	< 0.25
XYLENES (TOTAL)	(PPB)	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1561 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 273 BOP: 283 TD: 283

	Sample Date:	11/22/93	12/13/93	02/15/94	05/10/94	09/02/94	03/07/95	04/13/95	06/28/95	07/31/95
	Time:	10:15	10:11	11:07	15:41	09:15	16:15	11:53	:	16:20
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	< 0.5	NM	NM	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	0.062	NM	NM	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	0.2	NM	NM	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	< 0.2	NM	NM	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	0.26	NM	NM	NM	NM	NM	NM	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)	NM	19.	NM	NM	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	6.2	NM	NM	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	7.	NM	NM	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	0.17	NM	NM	NM	NM	NM	NM	NM
NITRATE	(MG/L)	NM	1.8	1.	< 0.03	NM	NM	NM	NM	NM
NITRITE	(MG/L)	NM	< 0.05	< 0.05	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	< 0.4	< 0.4	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	3.4	NM	NM	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	16.	NM	NM	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	10.	NM	NM	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	< 3.	NM	NM	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	NM	230.	210.	200.	220.	200.	190.	210.	220.
N-NITROSODIMETHYLAMINE	(UG/L)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
PH	(PH)	NM	7.7	8.6	8.7	7.7	8.3	7.5	8.7	8.1
TEMPERATURE	(DEGREES C.)	NM	14.2	16.7	18.2	16.6	17.5	15.9	18.5	23.5
TOTAL PETROLE[redacted]ARBONS	(MG/L)	NM	< 0.2	[redacted]	NM	NM	NM	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1561 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 273 BOP: 283 TD: 283

	Sample Date:	11/22/93	12/13/93	02/15/94	05/10/94	09/02/94	03/07/95	04/13/95	06/28/95	07/31/95
	Time:	10:15	10:11	11:07	15:41	09:15	16:15	11:53	:	16:20
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)									
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)	< 0.5	< 5.	< 2.	< 2.	< 2.	< 2.	< 1.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	2.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 0.5	< 5.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 0.5	< 10.	< 1.	< 1.	< 1.	< 1.	< 0.5	< 0.5	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1561 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 273 BOP: 283 TD: 283

		Sample Date:	08/23/95	09/29/95	10/12/95	12/11/95
		Time:	10:16	10:26	09:29	10:58
		Sample Type:				
		Lab:	EL	EL	EL	EL
METALS	(Units)					
ALUMINUM	(MG/L)		NM	NM	NM	NM
ANTIMONY	(MG/L)		NM	NM	NM	NM
ARSENIC	(MG/L)		NM	NM	NM	NM
BARIUM	(MG/L)		NM	NM	NM	NM
BERYLLIUM	(MG/L)		NM	NM	NM	NM
BORON	(MG/L)		NM	NM	NM	NM
CADMIUM	(MG/L)		NM	NM	NM	NM
CHROMIUM	(MG/L)		NM	NM	NM	NM
COBALT	(MG/L)		NM	NM	NM	NM
COPPER	(MG/L)		NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)		NM	NM	NM	NM
IRON	(MG/L)		NM	NM	NM	NM
LEAD	(MG/L)		NM	NM	NM	NM
MERCURY	(MG/L)		NM	NM	NM	NM
MOLYBDENUM	(MG/L)		NM	NM	NM	NM
NICKEL	(MG/L)		NM	NM	NM	NM
SELENIUM	(MG/L)		NM	NM	NM	NM
SILVER	(MG/L)		NM	NM	NM	NM
THALLIUM	(MG/L)		NM	NM	NM	NM
VANADIUM	(MG/L)		NM	NM	NM	NM
ZINC	(MG/L)		NM	NM	NM	NM
MINERALS, INORGANICS						
CALCIUM	(MG/L)		NM	NM	NM	NM
CHLORIDE	(MG/L)		NM	NM	NM	NM
MAGNESIUM	(MG/L)		NM	NM	NM	NM
MANGANESE	(MG/L)		NM	NM	NM	NM
NITRATE	(MG/L)		NM	NM	NM	NM
NITRITE	(MG/L)		NM	NM	NM	NM
PERCHLORATE	(MG/L)		NM	NM	NM	NM
POTASSIUM	(MG/L)		NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		NM	NM	NM	NM
SULFATE	(MG/L)		NM	NM	NM	NM
MISCELLANEOUS						
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		230.	220.	220.	220.
N-NITROSODIMETHYLAMINE	(UG/L)	<	0.1	NM	NM	NM
PH	(PH)		7.6	8.1	8.	8.
TEMPERATURE	(DEGREES C.)		19.	20.	16.6	15.6
TOTAL PETROL[redacted]RBONS	(MG/L)		NM	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1561 AMERICAN RIVER NEIGHBORD WELL Well Type: MC Zone: 1 Sector: D GSE: 196.15 TOC: 196.15 TOP: 273 BOP: 283 TD: 283

		Sample Date:	08/23/95	09/29/95	10/12/95	12/11/95
		Time:	10:16	10:26	09:29	10:58
		Sample Type:				
		Lab:	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)					
1,1,1-TRICHLOROETHANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)		< 0.25	< 0.25	< 0.5	< 0.25
1,2-DICHLOROPROPANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)		NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)		NM	NM	NM	NM
2-HEXANONE	(PPB)		NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)		NM	NM	NM	NM
ACETONE	(PPB)		NM	NM	NM	NM
BENZENE	(PPB)		NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
BROMOFORM	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
BROMOMETHANE	(PPB)		NM	NM	NM	NM
CARBON DISULFIDE	(PPB)		NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)		< 0.25	< 0.25	< 0.5	< 0.25
CHLOROBENZENE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)		NM	NM	NM	NM
CHLOROFORM	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)		NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)		NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)		NM	NM	NM	NM
FREON 113	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)		NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)		NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)		< 0.5	0.79	0.6	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)		< 0.5	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)		NM	NM	NM	NM
VINYL CHLORIDE	(PPB)		< 0.25	< 0.25	< 0.5	< 0.25
XYLENES (TOTAL)	(PPB)		NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1562 AR94-2 Well Type: SC Zone: 1 Sector: D GSE: 94.8 TOC: 94.84 TOP: 81 BOP: 96 TD: 96

Sample Date:	05/12/94		05/25/94		08/26/94		11/28/94		02/20/95		08/18/95	
Time:	17:11		10:50		12:52		09:06		:		12:06	
Sample Type:												
Lab:	EL		EL		EL		EL		EL		EL	
METALS	(Units)											
ALUMINUM	(MG/L)	NM	<	0.05	NM		NM		NM		NM	
ANTIMONY	(MG/L)	NM	<	0.3	NM		NM		NM		NM	
ARSENIC	(MG/L)	NM	<	0.1	NM		NM		NM		NM	
BARIUM	(MG/L)	NM		0.019	NM		NM		NM		NM	
BERYLLIUM	(MG/L)	NM	<	0.002	NM		NM		NM		NM	
BORON	(MG/L)	NM	<	0.1	NM		NM		NM		NM	
CADMIUM	(MG/L)	NM	<	0.01	NM		NM		NM		NM	
CHROMIUM	(MG/L)	NM	<	0.04	NM		NM		NM		NM	
COBALT	(MG/L)	NM	<	0.01	NM		NM		NM		NM	
COPPER	(MG/L)	NM	<	0.05	NM		NM		NM		NM	
HEXAVALENT CHROMIUM	(MG/L)	NM	<	0.02	NM		NM		NM		NM	
IRON	(MG/L)	NM	<	0.1	NM		NM		NM		NM	
LEAD	(MG/L)	NM	<	0.1	NM		NM		NM		NM	
MERCURY	(MG/L)	NM	<	0.0002	NM		NM		NM		NM	
MOLYBDENUM	(MG/L)	NM	<	0.02	NM		NM		NM		NM	
NICKEL	(MG/L)	NM	<	0.03	NM		NM		NM		NM	
SELENIUM	(MG/L)	NM	<	0.4	NM		NM		NM		NM	
SILVER	(MG/L)	NM	<	0.01	NM		NM		NM		NM	
THALLIUM	(MG/L)	NM	<	0.4	NM		NM		NM		NM	
VANADIUM	(MG/L)	NM	<	0.01	NM		NM		NM		NM	
ZINC	(MG/L)	NM		0.2	NM		NM		NM		NM	
MINERALS, INORGANICS												
CALCIUM	(MG/L)	NM		11.	NM		NM		NM		NM	
CHLORIDE	(MG/L)	NM		2.4	NM		NM		NM		NM	
MAGNESIUM	(MG/L)	NM		4.2	NM		NM		NM		NM	
MANGANESE	(MG/L)	NM		0.007	NM		NM		NM		NM	
NITRATE	(MG/L)	NM		0.19	NM		NM		NM		NM	
NITRITE	(MG/L)	NM	<	0.05	NM		NM		NM		NM	
PERCHLORATE	(MG/L)	NM	<	0.4	NM		NM		NM		NM	
POTASSIUM	(MG/L)	NM		1.6	NM		NM		NM		NM	
SODIUM, TOTAL	(MG/L)	NM		3.	NM		NM		NM		NM	
SULFATE	(MG/L)	NM		2.8	NM		NM		NM		NM	
MISCELLANEOUS												
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM		1.2	NM		NM		NM		NM	
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM		7.4	NM		NM		NM		NM	
CONDUCTANCE	(UMHOS/CM)	NM		140.	89.		91.		77.		130.	
N-NITROSODIMETHYLAMINE	(PPB)	NM	<	10.	NM		NM		NM	<	10.	
PH	(PH)	NM		8.4	8.		8.9		9.6		7.2	
TEMPERATURE	(DEGREES C.)	NM		18.6	20.2		12.9		16.3		18.3	
TOTAL PETROLE[redacted]ARBONS	(MG/L)	NM	<	0.2	[redacted]		NM		NM		NM	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1562 AR94-2 Well Type: SC Zone: 1 Sector: D GSE: 94.8 TOC: 94.84 TOP: 81 BOP: 96 TD: 96

	Sample Date:	05/12/94	05/25/94	08/26/94	11/28/94	02/20/95	08/18/95
	Time:	17:11	10:50	12:52	09:06	:	12:06
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1563 AR94-3 Well Type: SC Zone: 1 Sector: D GSE: 94.6 TOC: 94.6 TOP: 104 BOP: 109 TD: 109

		Sample Date:	05/11/94		05/25/94	08/26/94	11/28/94	02/20/95	08/18/95
		Time:	15:21		12:15	12:15	09:14	:	11:34
		Sample Type:							
		Lab:	EL		EL	EL	EL	EL	EL
METALS	(Units)								
ALUMINUM	(MG/L)	NM	<	0.05	NM	NM	NM	NM	
ANTIMONY	(MG/L)	NM	<	0.3	NM	NM	NM	NM	
ARSENIC	(MG/L)	NM	<	0.1	NM	NM	NM	NM	
BARIUM	(MG/L)	NM		0.026	NM	NM	NM	NM	
BERYLLIUM	(MG/L)	NM	<	0.002	NM	NM	NM	NM	
BORON	(MG/L)	NM	<	0.1	NM	NM	NM	NM	
CADMIUM	(MG/L)	NM	<	0.01	NM	NM	NM	NM	
CHROMIUM	(MG/L)	NM	<	0.04	NM	NM	NM	NM	
COBALT	(MG/L)	NM	<	0.01	NM	NM	NM	NM	
COPPER	(MG/L)	NM	<	0.05	NM	NM	NM	NM	
HEXAVALENT CHROMIUM	(MG/L)	NM	<	0.02	NM	NM	NM	NM	
IRON	(MG/L)	NM	<	0.1	NM	NM	NM	NM	
LEAD	(MG/L)	NM	<	0.1	NM	NM	NM	NM	
MERCURY	(MG/L)	NM	<	0.0002	NM	NM	NM	NM	
MOLYBDENUM	(MG/L)	NM	<	0.02	NM	NM	NM	NM	
NICKEL	(MG/L)	NM	<	0.03	NM	NM	NM	NM	
SELENIUM	(MG/L)	NM	<	0.4	NM	NM	NM	NM	
SILVER	(MG/L)	NM	<	0.01	NM	NM	NM	NM	
THALLIUM	(MG/L)	NM	<	0.4	NM	NM	NM	NM	
VANADIUM	(MG/L)	NM	<	0.01	NM	NM	NM	NM	
ZINC	(MG/L)	NM	<	0.1	NM	NM	NM	NM	
MINERALS, INORGANICS									
CALCIUM	(MG/L)	NM		22.	NM	NM	NM	NM	
CHLORIDE	(MG/L)	NM		3.1	NM	NM	NM	NM	
MAGNESIUM	(MG/L)	NM		3.	NM	NM	NM	NM	
MANGANESE	(MG/L)	NM	<	0.005	NM	NM	NM	NM	
NITRATE	(MG/L)	NM		0.087	NM	NM	NM	NM	
NITRITE	(MG/L)	NM		0.096	NM	NM	NM	NM	
PERCHLORATE	(MG/L)	NM	<	0.4	NM	NM	NM	NM	
POTASSIUM	(MG/L)	NM		3.	NM	NM	NM	NM	
SODIUM, TOTAL	(MG/L)	NM		5.2	NM	NM	NM	NM	
SULFATE	(MG/L)	NM		7.8	NM	NM	NM	NM	
MISCELLANEOUS									
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM		2.2	NM	NM	NM	NM	
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM		6.6	NM	NM	NM	NM	
CONDUCTANCE	(UMHOS/CM)	NM		140.	120.	130.	230.	120.	
N-NITROSODIMETHYLAMINE	(UG/L)	NM	<	10.	NM	NM	NM	< 0.1	
PH	(PH)	NM		9.7	9.6	10.7	11.1	8.6	
TEMPERATURE	(DEGREES C.)	NM		17.6	20.	14.4	16.2	17.9	
TOTAL PETROL[redacted]CARBONS	(MG/L)	NM	<	0.2	[redacted]	NM	NM	NM	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1563 AR94-3 Well Type: SC Zone: 1 Sector: D GSE: 94.6 TOC: 94.6 TOP: 104 BOP: 109 TD: 109

	Sample Date:	05/11/94	05/25/94	08/26/94	11/28/94	02/20/95	08/18/95
	Time:	15:21	12:15	12:15	09:14	:	11:34
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	1.	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1564 AR94-4 Well Type: MC Zone: 1 Sector: D GSE: 89.7 TOC: 89.7 TOP: 50 BOP: 66 TD: 66

	Sample Date:	05/12/94		05/24/94	08/26/94	11/21/94	05/22/95	10/20/95
	Time:	12:51		14:15	10:39	:	13:38	08:07
	Sample Type:							
	Lab:	EL		EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	NM	<	0.05	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	<	0.3	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	<	0.1	NM	NM	NM	NM
BARIUM	(MG/L)	NM		0.009	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	<	0.002	NM	NM	NM	NM
BORON	(MG/L)	NM	<	0.1	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	<	0.01	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	<	0.04	NM	NM	NM	NM
COBALT	(MG/L)	NM	<	0.01	NM	NM	NM	NM
COPPER	(MG/L)	NM		0.057	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	<	0.02	NM	NM	NM	NM
IRON	(MG/L)	NM	<	0.1	NM	NM	NM	NM
LEAD	(MG/L)	NM	<	0.1	NM	NM	NM	NM
MERCURY	(MG/L)	NM	<	0.0002	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	<	0.02	NM	NM	NM	NM
NICKEL	(MG/L)	NM	<	0.03	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	<	0.4	NM	NM	NM	NM
SILVER	(MG/L)	NM	<	0.01	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	<	0.4	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	<	0.01	NM	NM	NM	NM
ZINC	(MG/L)	NM	<	0.1	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)	NM		14.	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM		7.8	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM		3.6	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	<	0.005	NM	NM	NM	NM
NITRATE	(MG/L)	NM		0.63	NM	NM	NM	NM
NITRITE	(MG/L)	NM	<	0.05	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM		0.44	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM		6.4	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM		11.	NM	NM	NM	NM
SULFATE	(MG/L)	NM		4.2	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM		2.4	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	<	3.	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	NM		150.	160.	160.	240.	160.
N-NITROSODIMETHYLAMINE	(PPB)	NM	<	10.	NM	NM	NM	NM
PH	(PH)	NM		8.9	9.6	10.6	10.2	6.8
TEMPERATURE	(DEGREES C.)	NM		24.2	[illegible]	15.2	16.4	14.6
TOTAL PETROLEU[illegible]RBONS	(MG/L)	NM	<	0.2	[illegible]	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1564 AR94-6 Well Type: MC Zone: 1 Sector: D GSE: 89.7 TOC: 89.7 TOP: 50 BOP: 66 TD: 66

	Sample Date:	05/12/94	05/24/94	08/26/94	11/21/94	05/22/95	10/20/95
	Time:	12:51	14:15	10:39	:	13:38	08:07
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	< 5.	1.4	< 1.	15.	0.7
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1565 AR94-5 Well Type: MC Zone: 1 Sector: 0 GSE: 89.7 TOC: 89.7 TOP: 106 BOP: 116 TD: 116

	Sample Date:	05/12/94	05/24/94	08/26/94	11/21/94	05/22/95	07/13/95	10/19/95
	Time:	12:01	15:20	10:23	:	13:20	13:27	13:56
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	0.023	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	0.15	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	< 0.03	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)	NM	17.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	8.7	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	4.	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	< 0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)	NM	0.072	NM	NM	NM	NM	NM
NITRITE	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	0.54	NM	NM	NM	< 0.4	NM
POTASSIUM	(MG/L)	NM	2.1	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	5.9	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	5.6	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	7.7	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	NM	140.	97.	110.	100.	140.	100.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)	NM	8.9	9.4	10.4	9.6	8.3	8.2
TEMPERATURE	(DEGREES C.)	NM	20.2	17.6	15.9	17.7	18.2	20.1
TOTAL PETROLE[redacted]RBONS	(MG/L)	NM	< 0.2	[redacted]	NM	NM	NM	NM

AEROJET Environmental Operations
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May 22, 1996

Well: 1565 AR94-5 Well Type: MC Zone: 1 Sector: D GSE: 89.7 TOC: 89.7 TOP: 106 BOP: 116 TD: 116

	Sample Date:	05/12/94	05/24/94	08/26/94	11/21/94	05/22/95	07/13/95	10/19/95
	Time:	12:01	15:20	10:23	:	13:20	13:27	13:56
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
/OLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	10.	9.6	9.9	3.3	2.3	7.	26.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1566 AR94-4 Well Type: MC Zone: 1 Sector: D GSE: 89.7 TOC: 89.7 TOP: 138 BOP: 148 TD: 148

	Sample Date:	05/12/94	05/25/94	08/26/94	11/21/94	05/22/95	07/13/95	10/19/95
	Time:	10:45	09:30	09:51	:	12:47	12:36	12:09
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	NM	0.094	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	NM	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)	NM	0.036	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM
COBALT	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
COPPER	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
NICKEL	(MG/L)	NM	< 0.03	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)	NM	40.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	NM	14.	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	1.9	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	NM	< 0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)	NM	0.55	NM	NM	NM	NM	NM
NITRITE	(MG/L)	NM	0.25	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	4.6	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	NM	10.2	NM	NM	NM	NM	NM
SULFATE	(MG/L)	NM	5.7	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	5.6	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	NM	250.	150.	67.	100.	160.	130.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)	NM	10.8	10.3	9.9	9.3	8.8	9.
TEMPERATURE	(DEGREES C.)	NM	15.8	18.2	18.3	15.7	19.2	17.6
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	NM	< 0.2	[redacted]	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1566 AR94-4 Well Type: MC Zone: 1 Sector: D GSE: 89.7 TOC: 89.7 TOP: 138 BOP: 148 TD: 148

	Sample Date:	05/12/94	05/25/94	08/26/94	11/21/94	05/22/95	07/13/95	10/19/95
	Time:	10:45	09:30	09:51	:	12:47	12:36	12:09
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	13.	15.	11.	4.7	2.1	18.	21.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1567 AR94-5 Well Type: MC Zone: 1 Sector: D GSE: 95.8 TOC: 95.76 TOP: 45 BOP: 61 TD: 61

	Sample Date:	05/12/94	05/25/94	08/24/94	11/28/94	02/20/95	09/12/95	12/08/95
	Time:	17:04	12:31	18:38	10:32	:	11:45	11:55
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	NM	< 0.05	NM	NM	NM	< 0.17	NM
ANTIMONY	(MG/L)	NM	< 0.3	NM	NM	NM	< 0.44	NM
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	< 0.088	NM
BARIUM	(MG/L)	NM	0.06	NM	NM	NM	0.11	NM
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	< 0.0011	NM
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	< 0.044	NM
CADMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	< 0.0044	NM
CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	< 0.0088	NM
COBALT	(MG/L)	NM	< 0.01	NM	NM	NM	< 0.0088	NM
COPPER	(MG/L)	NM	< 0.05	NM	NM	NM	< 0.0066	NM
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM
IRON	(MG/L)	NM	< 0.1	NM	NM	NM	< 0.33	NM
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	< 0.066	NM
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	< 0.0002	NM
MOLYBDENUM	(MG/L)	NM	< 0.02	NM	NM	NM	< 0.044	NM
NICKEL	(MG/L)	NM	< 0.03	NM	NM	NM	< 0.022	NM
SELENIUM	(MG/L)	NM	< 0.4	NM	NM	NM	< 0.11	NM
SILVER	(MG/L)	NM	0.048	NM	NM	NM	< 0.022	NM
THALLIUM	(MG/L)	NM	< 0.4	NM	NM	NM	< 0.055	NM
VANADIUM	(MG/L)	NM	< 0.01	NM	NM	NM	< 0.0055	NM
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	< 0.11	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)	NM	30.	NM	NM	NM	25.	NM
CHLORIDE	(MG/L)	NM	8.8	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	NM	5.9	NM	NM	NM	11.	NM
MANGANESE	(MG/L)	NM	< 0.005	NM	NM	NM	0.034	NM
NITRATE	(MG/L)	NM	2.3	NM	NM	NM	NM	NM
NITRITE	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	NM	3.	NM	NM	NM	2.4	NM
SODIUM, TOTAL	(MG/L)	NM	9.4	NM	NM	NM	7.8	NM
SULFATE	(MG/L)	NM	11.	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	< 3.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	NM	220.	220.	120.	240.	240.	210.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)	NM	7.1	7.7	9.7	7.6	7.2	7.2
TEMPERATURE	(DEGREES C.)	NM	18.1	[illegible]	11.8	16.	19.3	14.4
TOTAL PETROLEU[illegible]BONS	(MG/L)	NM	< 0.2	[illegible]	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1567 AR94-5 Well Type: MC Zone: 1 Sector: D GSE: 95.8 TOC: 95.76 TOP: 45 BOP: 61 TD: 61

	Sample Date:	05/12/94	05/25/94	08/24/94	11/28/94	02/20/95	09/12/95	12/08/95
	Time:	17:04	12:31	18:38	10:32	:	11:45	11:55
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	9.3	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1568 AR94-5 Well Type: MC Zone: 1 Sector: D GSE: 95.8 TOC: 95.76 TOP: 84 BOP: 98 TD: 98

		Sample Date:	05/12/94		05/24/94	08/24/94	11/28/94	02/20/95	09/12/95	12/08/95
		Time:	16:11		15:56	17:51	10:52	:	10:25	10:57
		Sample Type:								
		Lab:	EL		EL	EL	EL	EL	EL	EL
METALS	(Units)									
ALUMINUM	(MG/L)		NM	<	0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)		NM	<	0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)		NM	<	0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)		NM		0.032	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)		NM	<	0.002	NM	NM	NM	NM	NM
BORON	(MG/L)		NM	<	0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)		NM	<	0.01	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)		NM	<	0.04	NM	NM	NM	NM	NM
COBALT	(MG/L)		NM	<	0.01	NM	NM	NM	NM	NM
COPPER	(MG/L)		NM	<	0.05	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)		NM	<	0.02	NM	NM	NM	NM	NM
IRON	(MG/L)		NM		0.13	NM	NM	NM	NM	NM
LEAD	(MG/L)		NM	<	0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)		NM	<	0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)		NM	<	0.02	NM	NM	NM	NM	NM
NICKEL	(MG/L)		NM	<	0.03	NM	NM	NM	NM	NM
SELENIUM	(MG/L)		NM	<	0.4	NM	NM	NM	NM	NM
SILVER	(MG/L)		NM	<	0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)		NM	<	0.4	NM	NM	NM	NM	NM
VANADIUM	(MG/L)		NM	<	0.01	NM	NM	NM	NM	NM
ZINC	(MG/L)		NM	<	0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS										
CALCIUM	(MG/L)		NM		22.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)		NM		4.	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		NM		5.1	NM	NM	NM	NM	NM
MANGANESE	(MG/L)		NM	<	0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)		NM		0.73	NM	NM	NM	NM	NM
NITRITE	(MG/L)		NM	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)		NM	<	0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)		NM		2.3	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		NM		4.	NM	NM	NM	NM	NM
SULFATE	(MG/L)		NM		4.5	NM	NM	NM	NM	NM
MISCELLANEOUS										
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		NM	<	1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		NM	<	3.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		NM		160.	130.	97.	140.	130.	110.
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.	NM	NM	NM	< 10.	NM
PH	(PH)		NM		7.2	8.3	9.4	8.1	9.	7.4
TEMPERATURE	(DEGREES C.)		NM		18.4	14.3	12.6	16.	19.5	14.9
TOTAL PETROLE[redacted]ARBONS	(MG/L)		NM	<	0.2	[redacted]	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1568 AR94-5 Well Type: MC Zone: 1 Sector: D GSE: 95.8 TOC: 95.76 TOP: 84 BOP: 98 TD: 98

	Sample Date:	05/12/94	05/24/94	08/24/94	11/28/94	02/20/95	09/12/95	12/08/95
	Time:	16:11	15:56	17:51	10:52	:	10:25	10:57
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	5.2	< 1.	1.1	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1569 AR94-5 Well Type: MC Zone: 1 Sector: D GSE: 95.8 TOC: 95.76 TOP: 134 BOP: 144 TD: 144

		Sample Date:	05/12/94	05/24/94	08/24/94	11/28/94	02/20/95	09/12/95	12/08/95
		Time:	15:05	14:29	16:59	11:22	:	12:24	09:40
		Sample Type:							
		Lab:	EL	EL	EL	EL	EL	EL	EL
METALS	(Units)								
ALUMINUM	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM	
ANTIMONY	(MG/L)	NM	< 0.3	NM	NM	NM	NM	NM	
ARSENIC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	
BARIUM	(MG/L)	NM	0.031	NM	NM	NM	NM	NM	
BERYLLIUM	(MG/L)	NM	< 0.002	NM	NM	NM	NM	NM	
BORON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	
CADMIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	
CHROMIUM	(MG/L)	NM	< 0.04	NM	NM	NM	NM	NM	
COBALT	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	
COPPER	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM	
HEXAVALENT CHROMIUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	
IRON	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	
LEAD	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	
MERCURY	(MG/L)	NM	< 0.0002	NM	NM	NM	NM	NM	
MOLYBDENUM	(MG/L)	NM	< 0.02	NM	NM	NM	NM	NM	
NICKEL	(MG/L)	NM	< 0.03	NM	NM	NM	NM	NM	
SELENIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM	
SILVER	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	
THALLIUM	(MG/L)	NM	< 0.4	NM	NM	NM	NM	NM	
VANADIUM	(MG/L)	NM	< 0.01	NM	NM	NM	NM	NM	
ZINC	(MG/L)	NM	< 0.1	NM	NM	NM	NM	NM	
MINERALS, INORGANICS									
CALCIUM	(MG/L)	NM	32.	NM	NM	NM	NM	NM	
CHLORIDE	(MG/L)	NM	11.	NM	NM	NM	NM	NM	
MAGNESIUM	(MG/L)	NM	4.1	NM	NM	NM	NM	NM	
MANGANESE	(MG/L)	NM	< 0.005	NM	NM	NM	NM	NM	
NITRATE	(MG/L)	NM	0.63	NM	NM	NM	NM	NM	
NITRITE	(MG/L)	NM	< 0.05	NM	NM	NM	NM	NM	
PERCHLORATE	(MG/L)	NM	0.42	NM	NM	NM	< 0.4	NM	
POTASSIUM	(MG/L)	NM	2.6	NM	NM	NM	NM	NM	
SODIUM, TOTAL	(MG/L)	NM	4.8	NM	NM	NM	NM	NM	
SULFATE	(MG/L)	NM	4.1	NM	NM	NM	NM	NM	
MISCELLANEOUS									
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	< 1.	NM	NM	NM	NM	NM	
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	< 3.	NM	NM	NM	NM	NM	
CONDUCTANCE	(UMHOS/CM)	NM	180.	160.	160.	180.	160.	140.	
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM	NM	NM	< 10.	NM	
PH	(PH)	NM	7.4	10.	10.	9.9	9.5	9.3	
TEMPERATURE	(DEGREES C.)	NM	19.5	15.2	14.	16.4	20.9	14.5	
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	NM	< 0.2	NM	NM	NM	NM	NM	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1569 AR94-5 Well Type: MC Zone: 1 Sector: D GSE: 95.8 TOC: 95.76 TOP: 134 BOP: 144 TD: 144

	Sample Date:	05/12/94	05/24/94	08/24/94	11/28/94	02/20/95	09/12/95	12/08/95
	Time:	15:05	14:29	16:59	11:22	:	12:24	09:40
	Sample Type:							
	Lab:	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)							
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	NM	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	1.3	< 5.	< 1.	1.3	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	NM	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	46.	60.	40.	42.	36.	25.	32.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	NM	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	NM	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1570 AR94-6 Well Type: SC Zone: 1 Sector: D GSE: 95.9 TOC: 95.88 TOP: 110 BOP: 118 TD: 118

		Sample Date:	05/24/94	08/24/94	11/28/94	02/20/95	09/11/95	12/07/95
		Time:	14:45	19:44	11:52	:	14:32	13:46
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)	< 0.05	NM	NM	NM	NM	NM	
ANTIMONY	(MG/L)	< 0.3	NM	NM	NM	NM	NM	
ARSENIC	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
BARIUM	(MG/L)	0.028	NM	NM	NM	NM	NM	
BERYLLIUM	(MG/L)	< 0.002	NM	NM	NM	NM	NM	
BORON	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
CADMIUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM	
CHROMIUM	(MG/L)	< 0.04	NM	NM	NM	NM	NM	
COBALT	(MG/L)	< 0.01	NM	NM	NM	NM	NM	
COPPER	(MG/L)	< 0.05	NM	NM	NM	NM	NM	
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM	
IRON	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
LEAD	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
MERCURY	(MG/L)	< 0.0002	NM	NM	NM	NM	NM	
MOLYBDENUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM	
NICKEL	(MG/L)	< 0.03	NM	NM	NM	NM	NM	
SELENIUM	(MG/L)	< 0.4	NM	NM	NM	NM	NM	
SILVER	(MG/L)	< 0.01	NM	NM	NM	NM	NM	
THALLIUM	(MG/L)	< 0.4	NM	NM	NM	NM	NM	
VANADIUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM	
ZINC	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
MINERALS, INORGANICS								
CALCIUM	(MG/L)	44.	NM	NM	NM	NM	NM	
CHLORIDE	(MG/L)	6.4	NM	NM	NM	NM	NM	
MAGNESIUM	(MG/L)	0.9	NM	NM	NM	NM	NM	
MANGANESE	(MG/L)	< 0.005	NM	NM	NM	NM	NM	
NITRATE	(MG/L)	0.21	NM	NM	NM	NM	NM	
NITRITE	(MG/L)	0.058	NM	NM	NM	NM	NM	
PERCHLORATE	(MG/L)	0.54	NM	NM	NM	< 0.4	NM	
POTASSIUM	(MG/L)	6.5	NM	NM	NM	NM	NM	
SODIUM, TOTAL	(MG/L)	16.3	NM	NM	NM	NM	NM	
SULFATE	(MG/L)	5.6	NM	NM	NM	NM	NM	
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	< 1.	NM	NM	NM	NM	NM	
CHEM. OXYGEN DEMAND (COD)	(MG/L)	8.6	NM	NM	NM	NM	NM	
CONDUCTANCE	(UMHOS/CM)	200.	130.	100.	150.	120.	83.	
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	< 10.	NM	
PH	(PH)	10.3	9.1	9.4	8.9	9.4	9.1	
TEMPERATURE	(DEGREES C.)	19.1	14.9	14.7	16.2	21.3	14.4	
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.2	NM	[redacted]	NM	NM	NM	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1570 AR94-6 Well Type: SC Zone: 1 Sector: D GSE: 95.9 TOC: 95.88 TOP: 110 BOP: 118 TD: 118

	Sample Date:	05/24/94	08/24/94	11/28/94	02/20/95	09/11/95	12/07/95
	Time:	14:45	19:44	11:52	:	14:32	13:46
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	3.	7.4
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1571 AR94-7 Well Type: MC Zone: 1 Sector: D GSE: 102.9 TOC: 102.9 TOP: 64 BOP: 78 TD: 78

Sample Date:		05/26/94	08/30/94	11/28/94	02/28/95	09/26/95	12/14/95	
Time:		08:56	12:35	14:10	11:29	13:51	12:32	
Sample Type:								
Lab:		EL	EL	EL	EL	EL	EL	
METALS	(Units)							
ALUMINUM	(MG/L)	< 0.05	NM	NM	NM	NM	NM	
ANTIMONY	(MG/L)	< 0.3	NM	NM	NM	NM	NM	
ARSENIC	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
BARIUM	(MG/L)	0.017	NM	NM	NM	NM	NM	
BERYLLIUM	(MG/L)	< 0.002	NM	NM	NM	NM	NM	
BORON	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
CADMIUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM	
CHROMIUM	(MG/L)	< 0.04	NM	NM	NM	NM	NM	
COBALT	(MG/L)	< 0.01	NM	NM	NM	NM	NM	
COPPER	(MG/L)	< 0.05	NM	NM	NM	NM	NM	
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM	
IRON	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
LEAD	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
MERCURY	(MG/L)	< 0.0002	NM	NM	NM	NM	NM	
MOLYBDENUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM	
NICKEL	(MG/L)	< 0.03	NM	NM	NM	NM	NM	
SELENIUM	(MG/L)	< 0.4	NM	NM	NM	NM	NM	
SILVER	(MG/L)	< 0.01	NM	NM	NM	NM	NM	
THALLIUM	(MG/L)	< 0.4	NM	NM	NM	NM	NM	
VANADIUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM	
ZINC	(MG/L)	< 0.1	NM	NM	NM	NM	NM	
MINERALS, INORGANICS								
CALCIUM	(MG/L)	8.9	NM	NM	NM	NM	NM	
CHLORIDE	(MG/L)	2.7	NM	NM	NM	NM	NM	
MAGNESIUM	(MG/L)	2.8	NM	NM	NM	NM	NM	
MANGANESE	(MG/L)	< 0.005	NM	NM	NM	NM	NM	
NITRATE	(MG/L)	0.9	NM	NM	NM	NM	NM	
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM	
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	NM	
POTASSIUM	(MG/L)	1.3	NM	NM	NM	NM	NM	
SODIUM, TOTAL	(MG/L)	3.2	NM	NM	NM	NM	NM	
SULFATE	(MG/L)	3.2	NM	NM	NM	NM	NM	
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	< 1.	NM	NM	NM	NM	NM	
CHEM. OXYGEN DEMAND (COD)	(MG/L)	< 3.	NM	NM	NM	NM	NM	
CONDUCTANCE	(UMHOS/CM)	95.	77.	67.	79.	63.	62.	
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	< 10.	NM	
PH	(PH)	7.9	9.6	9.5	9.6	9.2	9.	
TEMPERATURE	(DEGREES C.)	17.7	21.1	18.3	17.4	19.1	15.2	
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.2	NM		NM	NM	NM	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1571 AR94-7 Well Type: MC Zone: 1 Sector: D GSE: 102.9 TOC: 102.9 TOP: 64 BOP: 78 TD: 78

	Sample Date:	05/26/94	08/30/94	11/28/94	02/28/95	09/26/95	12/14/95
	Time:	08:56	12:35	14:10	11:29	13:51	12:32
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.25
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	NM	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.25	< 0.5
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	NM	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	9.	< 1.	< 1.	NM	1.4	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	NM	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	NM	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1572 AR94-7 Well Type: MC Zone: 1 Sector: D GSE: 102.9 TOC: 102.9 TOP: 124 BOP: 139 TD: 139

		Sample Date:	05/26/94	08/30/94	11/28/94	02/28/95	09/26/95	12/14/95
		Time:	11:55	12:15	13:17	11:04	12:06	11:57
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)		0.11	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	<	0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	<	0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)		0.027	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	<	0.002	NM	NM	NM	NM	NM
BORON	(MG/L)	<	0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	<	0.01	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	<	0.01	NM	NM	NM	NM	NM
COBALT	(MG/L)	<	0.01	NM	NM	NM	NM	NM
COPPER	(MG/L)	<	0.01	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM
IRON	(MG/L)	<	0.1	NM	NM	NM	NM	NM
LEAD	(MG/L)	<	0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM
NICKEL	(MG/L)	<	0.03	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	<	0.2	NM	NM	NM	NM	NM
SILVER	(MG/L)	<	0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	<	0.05	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	<	0.01	NM	NM	NM	NM	NM
ZINC	(MG/L)	<	0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)		34.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)		32.	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		0.88	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	<	0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)		0.18	NM	NM	NM	NM	NM
NITRITE	(MG/L)		0.18	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)		6.1	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		13.	NM	NM	NM	NM	NM
SULFATE	(MG/L)		5.3	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	<	1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		9.5	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		220.	180.	120.	110.	110.	87.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	NM	NM	< 10.	NM
PH	(PH)		10.6	10.6	10.6	10.2	9.6	9.3
TEMPERATURE	(DEGREES C.)		17.4	19.6	16.9	17.5	18.9	15.6
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.2	NM	[redacted]	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1572 AR94-7 Well Type: MC Zone: 1 Sector: D GSE: 102.9 TOC: 102.9 TOP: 124 BOP: 139 TD: 139

	Sample Date:	05/26/94	08/30/94	11/28/94	02/28/95	09/26/95	12/14/95
	Time:	11:55	12:15	13:17	11:04	12:06	11:57
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.25
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.5
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1573 AR94-7 Well Type: MC Zone: 1 Sector: D GSE: 102.9 TOC: 102.9 TOP: 182 BOP: 190 TD: 190

	Sample Date:	05/26/94	08/30/94	11/28/94	02/28/95	09/26/95	12/14/95
	Time:	13:20	11:38	13:24	10:32	09:59	11:14
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)						
ALUMINUM	(MG/L)	0.06	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)	0.021	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)	< 0.1	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM
COBALT	(MG/L)	< 0.01	NM	NM	NM	NM	NM
COPPER	(MG/L)	< 0.01	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM
IRON	(MG/L)	0.13	NM	NM	NM	NM	NM
LEAD	(MG/L)	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM
NICKEL	(MG/L)	< 0.03	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	< 0.2	NM	NM	NM	NM	NM
SILVER	(MG/L)	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	< 0.05	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	0.011	NM	NM	NM	NM	NM
ZINC	(MG/L)	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS							
CALCIUM	(MG/L)	19.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	20.	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	1.4	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	< 0.005	NM	NM	NM	NM	NM
NITRATE	(MG/L)	0.41	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	6.	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	17.	NM	NM	NM	NM	NM
SULFATE	(MG/L)	3.6	NM	NM	NM	NM	NM
MISCELLANEOUS							
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	< 1.	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	< 3.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	190.	140.	110.	120.	120.	100.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)	9.8	9.4	9.4	10.1	9.4	7.1
TEMPERATURE	(DEGREES C.)	17.8	20.5	16.6	16.8	17.5	14.8
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.2	NM	[redacted]	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1573 AR94-7 Well Type: MC Zone: 1 Sector: D GSE: 102.9 TOC: 102.9 TOP: 182 BOP: 190 TD: 190

	Sample Date:	05/26/94	08/30/94	11/28/94	02/28/95	09/26/95	12/14/95
	Time:	13:20	11:38	13:24	10:32	09:59	11:14
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.25
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.5
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	< 1.	1.4	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1574 AR94-B Well Type: SC Zone: 1 Sector: D GSE: 102.9 TOC: 102.9 TOP: 102 BOP: 107 TD: 112

	Sample Date:	05/26/94	08/30/94	11/28/94	02/28/95	09/26/95	12/08/95
	Time:	10:25	13:20	12:22	12:20	15:47	14:10
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)						
ALUMINUM	(MG/L)	< 0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	< 0.3	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	< 0.1	NM	NM	NM	NM	NM
BARIUM	(MG/L)	0.013	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	< 0.002	NM	NM	NM	NM	NM
BORON	(MG/L)	< 0.1	NM	NM	NM	NM	NM
CADNIUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM
COBALT	(MG/L)	< 0.01	NM	NM	NM	NM	NM
COPPER	(MG/L)	< 0.01	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM
IRON	(MG/L)	< 0.1	NM	NM	NM	NM	NM
LEAD	(MG/L)	< 0.1	NM	NM	NM	NM	NM
MERCURY	(MG/L)	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM
NICKEL	(MG/L)	< 0.03	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	< 0.2	NM	NM	NM	NM	NM
SILVER	(MG/L)	< 0.01	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	< 0.05	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM
ZINC	(MG/L)	< 0.1	NM	NM	NM	NM	NM
MINERALS, INORGANICS							
CALCIUM	(MG/L)	7.5	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	3.2	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	1.9	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	0.0056	NM	NM	NM	NM	NM
NITRATE	(MG/L)	0.55	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	2.4	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	10.	NM	NM	NM	NM	NM
SULFATE	(MG/L)	4.1	NM	NM	NM	NM	NM
MISCELLANEOUS							
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	1.4	NM	NM	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	4.9	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	110.	90.	79.	93.	110.	79.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	< 10.	NM
PH	(PH)	8.8	9.8	10.2	10.3	10.	7.4
TEMPERATURE	(DEGREES C.)	16.2	20.5	16.7	17.7	20.7	15.4
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.2	NM	[redacted]	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1574 AR94-B Well Type: SC Zone: 1 Sector: D GSE: 102.9 TOC: 102.9 TOP: 102 BOP: 107 TD: 112

	Sample Date:	05/26/94	08/30/94	11/28/94	02/28/95	09/26/95	12/08/95
	Time:	10:25	13:20	12:22	12:20	15:47	14:10
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 5.	< 2.	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 1.	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 1.	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1585 Well Type: MC Zone: 1 Sector: D GSE: 97.68 TOC: 97.68 TOP: 79 BOP: 100 TD: 100

	Sample Date:	05/16/95	06/20/95	08/31/95	11/30/95
	Time:	13:54	10:51	12:16	14:12
	Sample Type:				
	Lab:	EL	EL	EL	EL
METALS	(Units)				
ALUMINUM	(MG/L)	< 0.22	NM	NM	NM
ANTIMONY	(MG/L)	< 0.44	NM	NM	NM
ARSENIC	(MG/L)	< 0.088	NM	NM	NM
BARIUM	(MG/L)	0.018	NM	NM	NM
BERYLLIUM	(MG/L)	< 0.0011	NM	NM	NM
BORON	(MG/L)	< 0.044	NM	NM	NM
CADMIUM	(MG/L)	< 0.0044	NM	NM	NM
CHROMIUM	(MG/L)	< 0.0088	NM	NM	NM
COBALT	(MG/L)	< 0.0088	NM	NM	NM
COPPER	(MG/L)	< 0.0066	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM	NM
IRON	(MG/L)	< 0.33	NM	NM	NM
LEAD	(MG/L)	< 0.066	NM	NM	NM
MERCURY	(MG/L)	< 0.0002	NM	NM	NM
MOLYBDENUM	(MG/L)	< 0.044	NM	NM	NM
NICKEL	(MG/L)	< 0.022	NM	NM	NM
SELENIUM	(MG/L)	< 0.11	NM	NM	NM
SILVER	(MG/L)	< 0.022	NM	NM	NM
THALLIUM	(MG/L)	< 0.055	NM	NM	NM
VANADIUM	(MG/L)	< 0.0055	NM	NM	NM
ZINC	(MG/L)	< 0.11	NM	NM	NM
MINERALS, INORGANICS					
CALCIUM	(MG/L)	16.	NM	NM	NM
CHLORIDE	(MG/L)	3.1	NM	NM	NM
MAGNESIUM	(MG/L)	2.9	NM	NM	NM
MANGANESE	(MG/L)	< 0.0055	NM	NM	NM
NITRATE	(MG/L)	0.45	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM
POTASSIUM	(MG/L)	2.9	NM	NM	NM
SODIUM, TOTAL	(MG/L)	4.8	NM	NM	NM
SULFATE	(MG/L)	3.	NM	NM	NM
MISCELLANEOUS					
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	< 1.	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	< 3.	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	130.	110.	200.	190.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	< 10.	NM
PH	(PH)	9.4	8.4	8.3	8.7
TEMPERATURE	(DEGREES C.)	18.	20.	20.8	17.
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.1	NM	NM	NM

[redacted] [redacted] [redacted]

AEROJET Environmental Operations
Water Quality Information

May 23, 1996

Well: 1585 Well Type: MC Zone: 1 Sector: D GSE: 97.68 TOC: 97.68 TOP: 79 BOP: 100 TD: 100

		Sample Date:	05/16/95	06/20/95	08/31/95	11/30/95
		Time:	13:54	10:51	12:16	14:12
		Sample Type:				
		Lab:	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)					
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.25	< 0.25	
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	
ACETONE	(PPB)	< 20.	NM	NM	NM	
BENZENE	(PPB)	< 5.	NM	NM	NM	
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
BROMOFORM	(PPB)	< 2.	< 2.	< 0.5	< 0.5	
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 0.25	< 0.25	
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	
CHLOROFORM	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	
FREON 113	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
TOLUENE	(PPB)	< 5.	NM	NM	NM	
TRICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5	
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 0.25	< 0.25	
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1586 Well Type: MC Zone: 1 Sector: D GSE: 97.68 TOC: 97.68 TOP: 142 BOP: 149 TD: 149

	Sample Date:	05/17/95	06/20/95	08/31/95	11/06/95
	Time:	13:21	13:50	11:41	:
	Sample Type:				
	Lab:	EL	EL	EL	EL
METALS	(Units)				
ALUMINUM	(MG/L)	< 0.22	NM	NM	NM
ANTIMONY	(MG/L)	< 0.44	NM	NM	NM
ARSENIC	(MG/L)	< 0.088	NM	NM	NM
BARIUM	(MG/L)	0.023	NM	NM	NM
BERYLLIUM	(MG/L)	< 0.0011	NM	NM	NM
BORON	(MG/L)	< 0.044	NM	NM	NM
CADMIUM	(MG/L)	< 0.0044	NM	NM	NM
CHROMIUM	(MG/L)	< 0.0088	NM	NM	NM
COBALT	(MG/L)	< 0.0088	NM	NM	NM
COPPER	(MG/L)	< 0.0066	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM	NM
IRON	(MG/L)	< 0.33	NM	NM	NM
LEAD	(MG/L)	< 0.066	NM	NM	NM
MERCURY	(MG/L)	< 0.0002	NM	NM	NM
MOLYBDENUM	(MG/L)	< 0.044	NM	NM	NM
NICKEL	(MG/L)	< 0.022	NM	NM	NM
SELENIUM	(MG/L)	< 0.11	NM	NM	NM
SILVER	(MG/L)	< 0.022	NM	NM	NM
THALLIUM	(MG/L)	< 0.055	NM	NM	NM
VANADIUM	(MG/L)	< 0.0055	NM	NM	NM
ZINC	(MG/L)	< 0.11	NM	NM	NM
MINERALS, INORGANICS					
CALCIUM	(MG/L)	19.	NM	NM	NM
CHLORIDE	(MG/L)	7.6	NM	NM	NM
MAGNESIUM	(MG/L)	5.	NM	NM	NM
MANGANESE	(MG/L)	0.0056	NM	NM	NM
NITRATE	(MG/L)	0.78	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM
POTASSIUM	(MG/L)	9.8	NM	NM	NM
SODIUM, TOTAL	(MG/L)	12.	NM	NM	NM
SULFATE	(MG/L)	5.1	NM	NM	NM
MISCELLANEOUS					
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	8.4	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	9.2	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	270.	170.	190.	250.
N-NITROSODIMETHYLAMINE	(UG/L)	< 10.	NM	< 0.1	NM
PH	(PH)	9.	8.5	8.5	8.9
TEMPERATURE	(DEGREES C.)	18.4	19.8	19.2	17.3
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.1	NM	[redacted]	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1586 Well Type: MC Zone: 1 Sector: D GSE: 97.68 TOC: 97.68 TOP: 142 BOP: 149 TD: 149

		Sample Date:	05/17/95	06/20/95	08/31/95	11/06/95
		Time:	13:21	13:50	11:41	:
		Sample Type:				
		Lab:	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)					
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM
FREON 113	(PPB)	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	2.4	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	15.	13.	11.	12.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1587 Well Type: MC Zone: 1 Sector: D GSE: 97.68 TOC: 97.68 TOP: 168 BOP: 174 TD: 174

		Sample Date:	05/18/95	06/20/95	08/31/95	11/30/95
		Time:	13:04	12:47	10:52	12:38
		Sample Type:				
		Lab:	EL	EL	EL	EL
METALS	(Units)					
ALUMINUM	(MG/L)	<	0.22	NM	NM	NM
ANTIMONY	(MG/L)	<	0.44	NM	NM	NM
ARSENIC	(MG/L)	<	0.088	NM	NM	NM
BARIUM	(MG/L)		0.046	NM	NM	NM
BERYLLIUM	(MG/L)	<	0.0011	NM	NM	NM
BORON	(MG/L)	<	0.044	NM	NM	NM
CADMIUM	(MG/L)	<	0.0044	NM	NM	NM
CHROMIUM	(MG/L)		0.015	NM	NM	NM
COBALT	(MG/L)	<	0.0088	NM	NM	NM
COPPER	(MG/L)	<	0.0066	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.02	NM	NM	NM
IRON	(MG/L)	<	0.33	NM	NM	NM
LEAD	(MG/L)	<	0.066	NM	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM	NM
MOLYBDENUM	(MG/L)	<	0.044	NM	NM	NM
NICKEL	(MG/L)	<	0.022	NM	NM	NM
SELENIUM	(MG/L)	<	0.11	NM	NM	NM
SILVER	(MG/L)	<	0.022	NM	NM	NM
THALLIUM	(MG/L)	<	0.055	NM	NM	NM
VANADIUM	(MG/L)		0.0087	NM	NM	NM
ZINC	(MG/L)	<	0.11	NM	NM	NM
MINERALS, INORGANICS						
CALCIUM	(MG/L)		55.	NM	NM	NM
CHLORIDE	(MG/L)		52.	NM	NM	NM
MAGNESIUM	(MG/L)		0.5	NM	NM	NM
MANGANESE	(MG/L)	<	0.0055	NM	NM	NM
NITRATE	(MG/L)		1.9	NM	NM	NM
NITRITE	(MG/L)	<	0.15	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM
POTASSIUM	(MG/L)		9.	NM	NM	NM
SODIUM, TOTAL	(MG/L)		18.	NM	NM	NM
SULFATE	(MG/L)		12.	NM	NM	NM
MISCELLANEOUS						
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		1.4	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)		4.6	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		350.	270.	240.	190.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	< 10.	NM
PH	(PH)		10.4	10.4	10.1	9.4
TEMPERATURE	(DEGREES C.)		2.	19.5	18.2	17.1
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.1	NM		NM

AEROJET Environmental Operations
Water Quality Information

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Well: 1587 Well Type: MC Zone: 1 Sector: D GSE: 97.68 TOC: 97.68 TOP: 168 BOP: 174 TD: 174

	Sample Date:	05/18/95	06/20/95	08/31/95	11/30/95
	Time:	13:04	12:47	10:52	12:38
	Sample Type:				
	Lab:	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)				
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM
CHLOROFORM	(PPB)	< 1.	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM
FREON 113	(PPB)	< 1.	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	3.1	5.1	12.	12.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1588 Well Type: MC Zone: 1 Sector: D GSE: 97.58 TOC: 97.58 TOP: 292 BOP: 307 TD: 307

			Sample Date:	06/01/95	08/29/95	12/04/95
			Time:	11:25	12:35	12:36
			Sample Type:			
			Lab:	EL	EL	EL
METALS	(Units)					
ALUMINUM	(MG/L)	<	0.22	NM	NM
ANTIMONY	(MG/L)	<	0.44	NM	NM
ARSENIC	(MG/L)	<	0.088	NM	NM
BARIUM	(MG/L)		0.043	NM	NM
BERYLLIUM	(MG/L)	<	0.0011	NM	NM
BORON	(MG/L)		0.085	NM	NM
CADMIUM	(MG/L)	<	0.0044	NM	NM
CHROMIUM	(MG/L)	<	0.0088	NM	NM
COBALT	(MG/L)	<	0.0088	NM	NM
COPPER	(MG/L)		0.0071	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.02	NM	NM
IRON	(MG/L)	<	0.33	NM	NM
LEAD	(MG/L)	<	0.066	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM
MOLYBDENUM	(MG/L)	<	0.044	NM	NM
NICKEL	(MG/L)	<	0.022	NM	NM
SELENIUM	(MG/L)	<	0.11	NM	NM
SILVER	(MG/L)	<	0.022	NM	NM
THALLIUM	(MG/L)	<	0.055	NM	NM
VANADIUM	(MG/L)		0.011	NM	NM
ZINC	(MG/L)	<	0.11	NM	NM
MINERALS, INORGANICS					
CALCIUM	(MG/L)		26.	NM	NM
CHLORIDE	(MG/L)		17.	NM	NM
MAGNESIUM	(MG/L)		4.6	NM	NM
MANGANESE	(MG/L)	<	0.0055	NM	NM
NITRATE	(MG/L)		1.3	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM
POTASSIUM	(MG/L)		6.8	NM	NM
SODIUM, TOTAL	(MG/L)		17.	NM	NM
SULFATE	(MG/L)		9.7	NM	NM
MISCELLANEOUS					
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		1.3	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	<	3.	NM	NM
CONDUCTANCE	(UMHOS/CM)		240.	230.	200.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	< 10.	NM
PH	(PH)		9.5	8.8	8.9
TEMPERATURE	(DEGREES C.)		19.6	17.9	14.9
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.1	NM	[redacted]

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1588 Well Type: MC Zone: 1 Sector: D GSE: 97.58 TOC: 97.58 TOP: 292 BOP: 307 TD: 307

	Sample Date:	06/01/95	08/29/95	12/04/95
	Time:	11:25	12:35	12:36
	Sample Type:			
	Lab:	EL	EL	EL
VOLATILE ORGANICS	(Units)			
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM
ACETONE	(PPB)	< 20.	NM	NM
BENZENE	(PPB)	< 5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 5.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM
CHLOROFORM	(PPB)	< 5.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM
FREON 113	(PPB)	< 5.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	< 0.5	0.75
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1589 Well Type: MC Zone: 1 Sector: D GSE: 97.58 TOC: 97.58 TOP: 334 BOP: 348 TD: 348

		Sample Date:	06/02/95	08/29/95	12/04/95
		Time:	11:57	11:20	11:08
		Sample Type:			
		Lab:	EL	EL	EL
METALS	(Units)				
ALUMINUM	(MG/L)	<	0.22	NM	NM
ANTIMONY	(MG/L)	<	0.44	NM	NM
ARSENIC	(MG/L)	<	0.088	NM	NM
BARIUM	(MG/L)		0.03	NM	NM
BERYLLIUM	(MG/L)	<	0.0011	NM	NM
BORON	(MG/L)		0.11	NM	NM
CADMIUM	(MG/L)	<	0.0044	NM	NM
CHROMIUM	(MG/L)	<	0.0088	NM	NM
COBALT	(MG/L)	<	0.0088	NM	NM
COPPER	(MG/L)	<	0.0066	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.02	NM	NM
IRON	(MG/L)	<	0.33	NM	NM
LEAD	(MG/L)	<	0.066	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM
MOLYBDENUM	(MG/L)	<	0.044	NM	NM
NICKEL	(MG/L)	<	0.022	NM	NM
SELENIUM	(MG/L)	<	0.11	NM	NM
SILVER	(MG/L)	<	0.022	NM	NM
THALLIUM	(MG/L)	<	0.055	NM	NM
VANADIUM	(MG/L)	<	0.0055	NM	NM
ZINC	(MG/L)	<	0.11	NM	NM
MINERALS, INORGANICS					
CALCIUM	(MG/L)		22.	NM	NM
CHLORIDE	(MG/L)		21.	NM	NM
MAGNESIUM	(MG/L)		4.6	NM	NM
MANGANESE	(MG/L)	<	0.0055	NM	NM
NITRATE	(MG/L)		0.54	NM	NM
NITRITE	(MG/L)	<	0.15	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM
POTASSIUM	(MG/L)		6.5	NM	NM
SODIUM, TOTAL	(MG/L)		29.	NM	NM
SULFATE	(MG/L)		10.	NM	NM
MISCELLANEOUS					
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		2.9	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	<	3.	NM	NM
CONDUCTANCE	(UMHOS/CM)		260.	260.	260.
N-NITROSODIMETHYLAMINE	(PPB)		NM	< 10.	NM
PH	(PH)		9.2	8.2	8.6
TEMPERATURE	(DEGREES C.)		17.1	19.3	14.6
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.1	NM	[redacted]

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1589 Well Type: MC Zone: 1 Sector: D GSE: 97.58 TOC: 97.58 TOP: 334 BOP: 348 TD: 348

	Sample Date:	06/02/95	08/29/95	12/04/95
	Time:	11:57	11:20	11:08
	Sample Type:			
	Lab:	EL	EL	EL
VOLATILE ORGANICS	(Units)			
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM
ACETONE	(PPB)	< 20.	NM	NM
BENZENE	(PPB)	< 5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM
CHLOROFORM	(PPB)	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM
FREON 113	(PPB)	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	< 0.5	1.2
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1590 Well Type: MC Zone: 1 Sector: D GSE: 97.58 TOC: 97.58 TOP: 380 BOP: 400 TD: 400

		Sample Date:	06/02/95	08/28/95	12/04/95
		Time:	10:14	11:31	09:32
		Sample Type:			
		Lab:	EL	EL	EL
METALS	(Units)				
ALUMINUM	(MG/L)	<	0.22	NM	NM
ANTIMONY	(MG/L)	<	0.44	NM	NM
ARSENIC	(MG/L)	<	0.088	NM	NM
BARIUM	(MG/L)		0.028	NM	NM
BERYLLIUM	(MG/L)	<	0.0011	NM	NM
BORON	(MG/L)		0.38	NM	NM
CADMIUM	(MG/L)	<	0.0044	NM	NM
CHROMIUM	(MG/L)	<	0.0088	NM	NM
COBALT	(MG/L)	<	0.0088	NM	NM
COPPER	(MG/L)	<	0.0066	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.02	NM	NM
IRON	(MG/L)	<	0.33	NM	NM
LEAD	(MG/L)	<	0.066	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM
MOLYBDENUM	(MG/L)	<	0.044	NM	NM
NICKEL	(MG/L)	<	0.022	NM	NM
SELENIUM	(MG/L)	<	0.11	NM	NM
SILVER	(MG/L)	<	0.022	NM	NM
THALLIUM	(MG/L)	<	0.055	NM	NM
VANADIUM	(MG/L)	<	0.0055	NM	NM
ZINC	(MG/L)		0.49	NM	NM
MINERALS, INORGANICS					
CALCIUM	(MG/L)		20.	NM	NM
CHLORIDE	(MG/L)		58.	NM	NM
CHLORINE RESIDUAL	(MG/L)		1.	NM	NM
MAGNESIUM	(MG/L)		6.4	NM	NM
MANGANESE	(MG/L)		0.1	NM	NM
NITRATE	(MG/L)	<	0.03	NM	NM
NITRITE	(MG/L)	<	0.1	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM
POTASSIUM	(MG/L)		5.1	NM	NM
SODIUM, TOTAL	(MG/L)		52.	NM	NM
SULFATE	(MG/L)		1.5	NM	NM
MISCELLANEOUS					
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		2.5	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	<	3.	NM	NM
CONDUCTANCE	(UMHOS/CM)		380.	370.	340.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	< 10.	NM
PH	(PH)		8.6	8.	8.6
TEMPERATURE	(DEGREES C.)		15.4	18.5	

[redacted] [redacted] [redacted]

AEROJET Environmental Operations
Water Quality Information

Well: 1590 Well Type: MC Zone: 1 Sector: D GSE: 97.58 TOC: 97.58 TOP: 380 BOP: 400 TD: 400

	Sample Date:	06/02/95		08/28/95		12/04/95		
	Time:	10:14		11:31		09:32		
	Sample Type:							
	Lab:	EL		EL		EL		
MISCELLANEOUS (cont'd)	(Units)							
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	<	0.1	NM		NM		
VOLATILE ORGANICS								
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	<	0.5	<	0.5	
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	<	0.5	<	0.5	
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	<	0.5	<	0.5	
1,1-DICHLOROETHANE	(PPB)	<	1.	<	0.5	<	0.5	
1,1-DICHLOROETHYLENE	(PPB)	<	1.	<	0.5	<	0.5	
1,2-DICHLOROETHANE	(PPB)	<	1.	<	0.25	<	0.25	
1,2-DICHLOROPROPANE	(PPB)	<	1.	<	0.5	<	0.5	
2-BUTANONE (MEK)	(PPB)	<	20.	NM		NM		
2-CHLOROETHYL VINYL ETHER	(PPB)	<	10.	NM		NM		
2-HEXANONE	(PPB)	<	20.	NM		NM		
4-METHYL-2-PENTANONE (MIBK)	(PPB)	<	10.	NM		NM		
ACETONE	(PPB)	<	20.	NM		NM		
BENZENE	(PPB)	<	5.	NM		NM		
BROMODICHLOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
BROMOFORM	(PPB)	<	2.	<	0.5	<	0.5	
BROMOMETHANE	(PPB)	<	10.	NM		NM		
CARBON DISULFIDE	(PPB)	<	5.	NM		NM		
CARBON TETRACHLORIDE	(PPB)	<	1.	<	0.25	<	0.25	
CHLOROBENZENE	(PPB)	<	1.	<	0.5	<	0.5	
CHLOROETHANE	(PPB)	<	10.	NM		NM		
CHLOROFORM	(PPB)	<	1.	<	0.5	<	0.5	
CHLOROMETHANE	(PPB)	<	10.	NM		NM		
CIS-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	NM		NM		
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	<	0.5	<	0.5	
DIBROMOCHLOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
DICHLOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
ETHYLBENZENE	(PPB)	<	5.	NM		NM		
FREON 113	(PPB)	<	1.	<	0.5	<	0.5	
T-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	NM		NM		
TETRACHLOROETHYLENE	(PPB)	<	1.	<	0.5	<	0.5	
TOLUENE	(PPB)	<	5.	NM		NM		
TRICHLOROETHYLENE	(PPB)	<	1.	<	0.5	<	0.5	
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	<	0.5	<	0.5	
VINYL ACETATE	(PPB)	<	10.	NM		NM		
VINYL CHLORIDE	(PPB)	<	1.	<	0.25	<	0.25	
XYLENES (TOTAL)	(PPB)	<	5.	NM		NM		

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1591 Well Type: MC Zone: 1 Sector: D GSE: 97.49 TOC: 97.49 TOP: 91 BOP: 112 TD: 112

	Sample Date:	06/06/95	09/01/95	12/01/95
	Time:	10:08	12:35	11:36
	Sample Type:			
	Lab:	EL	EL	EL
METALS	(Units)			
ALUMINUM	(MG/L)	< 0.22	NM	NM
ANTIMONY	(MG/L)	< 0.44	NM	NM
ARSENIC	(MG/L)	< 0.088	NM	NM
BARIUM	(MG/L)	0.054	NM	NM
BERYLLIUM	(MG/L)	< 0.0011	NM	NM
BORON	(MG/L)	< 0.044	NM	NM
CADMIUM	(MG/L)	< 0.0044	NM	NM
CHROMIUM	(MG/L)	< 0.0088	NM	NM
COBALT	(MG/L)	< 0.0088	NM	NM
COPPER	(MG/L)	< 0.0066	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM
IRON	(MG/L)	< 0.33	NM	NM
LEAD	(MG/L)	< 0.066	NM	NM
MERCURY	(MG/L)	< 0.0002	NM	NM
MOLYBDENUM	(MG/L)	< 0.044	NM	NM
NICKEL	(MG/L)	< 0.022	NM	NM
SELENIUM	(MG/L)	< 0.11	NM	NM
SILVER	(MG/L)	< 0.022	NM	NM
THALLIUM	(MG/L)	< 0.055	NM	NM
VANADIUM	(MG/L)	0.0074	NM	NM
ZINC	(MG/L)	< 0.11	NM	NM
MINERALS, INORGANICS				
CALCIUM	(MG/L)	23.	NM	NM
CHLORIDE	(MG/L)	6.1	NM	NM
MAGNESIUM	(MG/L)	6.	NM	NM
MANGANESE	(MG/L)	< 0.0055	NM	NM
NITRATE	(MG/L)	2.3	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM
POTASSIUM	(MG/L)	4.	NM	NM
SODIUM, TOTAL	(MG/L)	9.4	NM	NM
SULFATE	(MG/L)	9.4	NM	NM
MISCELLANEOUS				
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	< 1.	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	< 3.	NM	NM
CONDUCTANCE	(UMHOS/CM)	190.	190.	160.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	< 10.	NM
PH	(PH)	8.1	7.7	8.8
TEMPERATURE	(DEGREES C.)	17.2	18.3	15.3
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.1	NM	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1591 Well Type: MC Zone: 1 Sector: D GSE: 97.49 TOC: 97.49 TOP: 91 BOP: 112 TD: 112

		Sample Date:	06/06/95	09/01/95	12/01/95
		Time:	10:08	12:35	11:36
		Sample Type:			
		Lab:	EL	EL	EL
VOLATILE ORGANICS	(Units)				
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	<	20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	<	10.	NM	NM
2-HEXANONE	(PPB)	<	20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	<	10.	NM	NM
ACETONE	(PPB)	<	20.	NM	NM
BENZENE	(PPB)	<	5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	<	10.	NM	NM
CARBON DISULFIDE	(PPB)	<	5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	<	1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	<	10.	NM	NM
CHLOROFORM	(PPB)	<	1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	<	10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	<	5.	NM	NM
FREON 113	(PPB)	<	1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	NM	NM
TETRACHLOROETHYLENE	(PPB)	<	1.	< 0.5	< 0.5
TOLUENE	(PPB)	<	5.	NM	NM
TRICHLOROETHYLENE	(PPB)	<	1.	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	<	10.	NM	NM
VINYL CHLORIDE	(PPB)	<	1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	<	5.	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1592 Well Type: MC Zone: 1 Sector: D GSE: 97.49 TOC: 97.49 TOP: 151 BOP: 162 TD: 162

	Sample Date:	06/05/95	09/01/95	12/01/95
	Time:	14:42	12:00	10:49
	Sample Type:			
	Lab:	EL	EL	EL
METALS	(Units)			
ALUMINUM	(MG/L)	< 0.22	NM	NM
ANTIMONY	(MG/L)	< 0.44	NM	NM
ARSENIC	(MG/L)	< 0.088	NM	NM
BARIUM	(MG/L)	0.025	NM	NM
BERYLLIUM	(MG/L)	< 0.0011	NM	NM
BORON	(MG/L)	< 0.044	NM	NM
CADMIUM	(MG/L)	< 0.0044	NM	NM
CHROMIUM	(MG/L)	< 0.0088	NM	NM
COBALT	(MG/L)	< 0.0088	NM	NM
COPPER	(MG/L)	< 0.0066	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM
IRON	(MG/L)	< 0.33	NM	NM
LEAD	(MG/L)	< 0.066	NM	NM
MERCURY	(MG/L)	< 0.0002	NM	NM
MOLYBDENUM	(MG/L)	< 0.044	NM	NM
NICKEL	(MG/L)	< 0.022	NM	NM
SELENIUM	(MG/L)	< 0.11	NM	NM
SILVER	(MG/L)	< 0.022	NM	NM
THALLIUM	(MG/L)	< 0.055	NM	NM
VANADIUM	(MG/L)	0.006	NM	NM
ZINC	(MG/L)	< 0.11	NM	NM
MINERALS, INORGANICS				
CALCIUM	(MG/L)	13.	NM	NM
CHLORIDE	(MG/L)	3.9	NM	NM
MAGNESIUM	(MG/L)	3.3	NM	NM
MANGANESE	(MG/L)	< 0.0055	NM	NM
NITRATE	(MG/L)	0.18	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM
POTASSIUM	(MG/L)	3.2	NM	NM
SODIUM, TOTAL	(MG/L)	5.5	NM	NM
SULFATE	(MG/L)	3.3	NM	NM
MISCELLANEOUS				
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	< 1.	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	< 3.	NM	NM
CONDUCTANCE	(UMHOS/CM)	120.	110.	91.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	< 10.	NM
PH	(PH)	9.	8.4	8.9
TEMPERATURE	(DEGREES C.)	16.8	18.7	14.9
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	< 0.1	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1592 Well Type: MC Zone: 1 Sector: D GSE: 97.49 TOC: 97.49 TOP: 151 BOP: 162 TD: 162

		Sample Date:	06/05/95	09/01/95	12/01/95
		Time:	14:42	12:00	10:49
		Sample Type:			
		Lab:	EL	EL	EL
VOLATILE ORGANICS	(Units)				
1,1,1-TRICHLOROETHANE	(PPB)	<	1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	<	1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	<	1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	<	1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	<	1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	<	1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	<	20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	<	10.	NM	NM
2-HEXANONE	(PPB)	<	20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	<	10.	NM	NM
ACETONE	(PPB)	<	20.	NM	NM
BENZENE	(PPB)	<	5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
BROMOFORM	(PPB)	<	2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	<	10.	NM	NM
CARBON DISULFIDE	(PPB)	<	5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	<	1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	<	1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	<	10.	NM	NM
CHLOROFORM	(PPB)	<	1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	<	10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	<	5.	NM	NM
FREON 113	(PPB)	<	1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	<	5.	NM	NM
TETRACHLOROETHYLENE	(PPB)	<	1.	< 0.5	< 0.5
TOLUENE	(PPB)	<	5.	NM	NM
TRICHLOROETHYLENE	(PPB)	<	1.	< 0.5	0.99
TRICHLOROFLUOROMETHANE	(PPB)	<	1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	<	10.	NM	NM
VINYL CHLORIDE	(PPB)	<	1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	<	5.	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1593 Well Type: MC Zone: 1 Sector: D GSE: 97.49 TOC: 97.49 TOP: 179 BOP: 199 TD: 199

		Sample Date:	06/06/95	09/01/95	12/01/95
		Time:	12:10	11:14	10:01
		Sample Type:			
		Lab:	EL	EL	EL
METALS	(Units)				
ALUMINUM	(MG/L)	<	0.22	NM	NM
ANTIMONY	(MG/L)	<	0.44	NM	NM
ARSENIC	(MG/L)	<	0.088	NM	NM
BARIUM	(MG/L)		0.031	NM	NM
BERYLLIUM	(MG/L)	<	0.0011	NM	NM
BORON	(MG/L)	<	0.044	NM	NM
CADMIUM	(MG/L)	<	0.0044	NM	NM
CHROMIUM	(MG/L)	<	0.0088	NM	NM
COBALT	(MG/L)	<	0.0088	NM	NM
COPPER	(MG/L)	<	0.0066	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.02	NM	NM
IRON	(MG/L)		0.36	NM	NM
LEAD	(MG/L)	<	0.066	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM
MOLYBDENUM	(MG/L)	<	0.044	NM	NM
NICKEL	(MG/L)	<	0.022	NM	NM
SELENIUM	(MG/L)	<	0.11	NM	NM
SILVER	(MG/L)	<	0.022	NM	NM
THALLIUM	(MG/L)	<	0.055	NM	NM
VANADIUM	(MG/L)	<	0.0055	NM	NM
ZINC	(MG/L)		0.25	NM	NM
MINERALS, INORGANICS					
CALCIUM	(MG/L)		17.	NM	NM
CHLORIDE	(MG/L)		3.5	NM	NM
MAGNESIUM	(MG/L)		6.2	NM	NM
MANGANESE	(MG/L)		0.016	NM	NM
NITRATE	(MG/L)		1.1	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM
POTASSIUM	(MG/L)		3.6	NM	NM
SODIUM, TOTAL	(MG/L)		8.3	NM	NM
SULFATE	(MG/L)		7.	NM	NM
MISCELLANEOUS					
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	<	1.	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	<	3.	NM	NM
CONDUCTANCE	(UMHOS/CM)		170.	170.	140.
N-NITROSODIMETHYLAMINE	(UG/L)	<	10.	< 0.1	NM
PH	(PH)		8.2	7.7	8.2
TEMPERATURE	(DEGREES C.)		16.1	18.8	14.3
TOTAL PETROLEU[redacted]ARBONS	(MG/L)	<	0.1	NM	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1593 Well Type: MC Zone: 1 Sector: D GSE: 97.49 TOC: 97.49 TOP: 179 BOP: 199 TD: 199

Sample Date:	06/06/95	09/01/95	12/01/95
Time:	12:10	11:14	10:01
Sample Type:			
Lab:	EL	EL	EL

VOLATILE ORGANICS	(Units)					
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 1.	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 1.	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM
ACETONE	(PPB)	< 20.	NM	NM
BENZENE	(PPB)	< 5.	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
BROMOFORM	(PPB)	< 2.	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 1.	< 0.25	< 0.25
CHLOROBENZENE	(PPB)	< 1.	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM
CHLOROFORM	(PPB)	< 1.	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM
FREON 113	(PPB)	< 1.	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 1.	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM
TRICHLOROETHYLENE	(PPB)	< 1.	< 0.5	1.8
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM
VINYL CHLORIDE	(PPB)	< 1.	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1594 Well Type: MC Zone: 1 Sector: D GSE: 182.99 TOC: 182.99 TOP: 184 BOP: 196 TD: 196

	Sample Date:	08/14/95	08/14/95	08/30/95	11/13/95	12/14/95	01/01/96
	Time:	14:46	16:36	11:57	09:50	09:45	:
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)						
ALUMINUM	(MG/L)	< 0.16	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	< 0.44	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	< 0.088	NM	NM	NM	NM	NM
BARIUM	(MG/L)	0.056	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	< 0.0011	NM	NM	NM	NM	NM
BORON	(MG/L)	< 0.044	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	< 0.0044	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	< 0.0088	NM	NM	NM	NM	NM
COBALT	(MG/L)	< 0.0088	NM	NM	NM	NM	NM
COPPER	(MG/L)	< 0.0066	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM
IRON	(MG/L)	< 0.33	NM	NM	NM	NM	NM
LEAD	(MG/L)	< 0.066	NM	NM	NM	NM	NM
MERCURY	(MG/L)	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	< 0.044	NM	NM	NM	NM	NM
NICKEL	(MG/L)	< 0.022	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	< 0.11	NM	NM	NM	NM	NM
SILVER	(MG/L)	< 0.022	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	< 0.055	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	0.0072	NM	NM	NM	NM	NM
ZINC	(MG/L)	0.17	NM	NM	NM	NM	NM
MINERALS, INORGANICS							
CALCIUM	(MG/L)	34.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	11.	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	11.	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	0.011	NM	NM	NM	NM	NM
NITRATE	(MG/L)	6.9	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	5.3	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	12.	NM	NM	NM	NM	NM
SULFATE	(MG/L)	9.1	NM	NM	NM	NM	NM
MISCELLANEOUS							
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	NM	< 1.	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	< 3.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	290.	NM	NM	290.	290.	290.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	NM
PH	(PH)	8.	NM	NM	7.5	8.	7.9
TEMPERATURE	(DEGREES C.)	21.7	NM	NM	19.1	15.7	16.2
TOTAL PETROLEU[redacted]BONS	(MG/L)	< 0.1	NM	[redacted]	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

Well: 1594 Well Type: MC Zone: 1 Sector: D GSE: 182.99 TOC: 182.99 TOP: 184 BOP: 196 TD: 196

	Sample Date:	08/14/95	08/14/95	08/30/95	11/13/95	12/14/95	01/01/96
	Time:	14:46	16:36	11:57	09:50	09:45	:
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5
BROMOFORM	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 0.25	< 0.25	< 0.25	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	1.8	< 0.5	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1595 Well Type: MC Zone: 1 Sector: D GSE: 182.99 TOC: 182.99 TOP: 306 BOP: 316 TD: 316

		Sample Date:	08/14/95	08/14/95	08/30/95	11/13/95	12/14/95	01/01/96
		Time:	13:51	16:43	11:17	10:23	09:26	:
		Sample Type:						
		Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)							
ALUMINUM	(MG/L)		0.09	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	<	0.1	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	<	0.02	NM	NM	NM	NM	NM
BARIUM	(MG/L)		0.032	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	<	0.00025	NM	NM	NM	NM	NM
BORON	(MG/L)		0.025	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	<	0.001	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	<	0.002	NM	NM	NM	NM	NM
COBALT	(MG/L)	<	0.002	NM	NM	NM	NM	NM
COPPER	(MG/L)		0.0051	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	<	0.02	NM	NM	NM	NM	NM
IRON	(MG/L)		0.1	NM	NM	NM	NM	NM
LEAD	(MG/L)	<	0.015	NM	NM	NM	NM	NM
MERCURY	(MG/L)	<	0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	<	0.01	NM	NM	NM	NM	NM
NICKEL	(MG/L)	<	0.005	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	<	0.025	NM	NM	NM	NM	NM
SILVER	(MG/L)		0.061	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	<	0.013	NM	NM	NM	NM	NM
VANADIUM	(MG/L)		0.0062	NM	NM	NM	NM	NM
ZINC	(MG/L)		0.041	NM	NM	NM	NM	NM
MINERALS, INORGANICS								
CALCIUM	(MG/L)		19.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)		23.	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)		3.4	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	<	0.0013	NM	NM	NM	NM	NM
NITRATE	(MG/L)	<	0.03	NM	NM	NM	NM	NM
NITRITE	(MG/L)	<	0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	<	0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)		12.	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)		16.	NM	NM	NM	NM	NM
SULFATE	(MG/L)		17.	NM	NM	NM	NM	NM
MISCELLANEOUS								
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)		NM	NM	< 1.	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	<	3.	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)		230.	NM	NM	220.	200.	200.
N-NITROSODIMETHYLAMINE	(PPB)	<	10.	NM	NM	NM	NM	NM
PH	(PH)		9.3	NM	NM	8.2	8.3	8.
TEMPERATURE	(DEGREES C.)		21.9	NM	NM	19.7	16.9	16.9
TOTAL PETROLE[redacted]BONS	(MG/L)		0.1	NM	[redacted]	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1595 Well Type: MC Zone: 1 Sector: D GSE: 182.99 TOC: 182.99 TOP: 306 BOP: 316 TD: 316

	Sample Date:	08/14/95	08/14/95	08/30/95	11/13/95	12/14/95	01/01/96
	Time:	13:51	16:43	11:17	10:23	09:26	:
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5
BROMOFORM	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 0.25	< 0.25	< 0.25	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	2.6	< 0.5	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1596 Well Type: MC Zone: 1 Sector: D GSE: 182.99 TOC: 182.99 TOP: 333 BOP: 343 TD: 343

	Sample Date:	08/14/95	08/14/95	08/30/95	11/13/95	12/14/95	01/01/96
	Time:	12:11	16:49	10:01	10:55	08:47	:
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
METALS	(Units)						
ALUMINUM	(MG/L)	< 0.05	NM	NM	NM	NM	NM
ANTIMONY	(MG/L)	< 0.1	NM	NM	NM	NM	NM
ARSENIC	(MG/L)	< 0.02	NM	NM	NM	NM	NM
BARIUM	(MG/L)	0.047	NM	NM	NM	NM	NM
BERYLLIUM	(MG/L)	< 0.00025	NM	NM	NM	NM	NM
BORON	(MG/L)	0.031	NM	NM	NM	NM	NM
CADMIUM	(MG/L)	< 0.001	NM	NM	NM	NM	NM
CHROMIUM	(MG/L)	< 0.002	NM	NM	NM	NM	NM
COBALT	(MG/L)	< 0.002	NM	NM	NM	NM	NM
COPPER	(MG/L)	0.0067	NM	NM	NM	NM	NM
HEXAVALENT CHROMIUM	(MG/L)	< 0.02	NM	NM	NM	NM	NM
IRON	(MG/L)	< 0.075	NM	NM	NM	NM	NM
LEAD	(MG/L)	0.017	NM	NM	NM	NM	NM
MERCURY	(MG/L)	< 0.0002	NM	NM	NM	NM	NM
MOLYBDENUM	(MG/L)	< 0.01	NM	NM	NM	NM	NM
NICKEL	(MG/L)	< 0.005	NM	NM	NM	NM	NM
SELENIUM	(MG/L)	< 0.025	NM	NM	NM	NM	NM
SILVER	(MG/L)	< 0.005	NM	NM	NM	NM	NM
THALLIUM	(MG/L)	< 0.013	NM	NM	NM	NM	NM
VANADIUM	(MG/L)	0.0061	NM	NM	NM	NM	NM
ZINC	(MG/L)	0.05	NM	NM	NM	NM	NM
MINERALS, INORGANICS							
CALCIUM	(MG/L)	20.	NM	NM	NM	NM	NM
CHLORIDE	(MG/L)	7.7	NM	NM	NM	NM	NM
MAGNESIUM	(MG/L)	5.8	NM	NM	NM	NM	NM
MANGANESE	(MG/L)	0.063	NM	NM	NM	NM	NM
NITRATE	(MG/L)	< 0.03	NM	NM	NM	NM	NM
NITRITE	(MG/L)	< 0.05	NM	NM	NM	NM	NM
PERCHLORATE	(MG/L)	< 0.4	NM	NM	NM	NM	NM
POTASSIUM	(MG/L)	7.3	NM	NM	NM	NM	NM
SODIUM, TOTAL	(MG/L)	11.	NM	NM	NM	NM	NM
SULFATE	(MG/L)	17.	NM	NM	NM	NM	NM
MISCELLANEOUS							
BIOCHEMICAL OXYGEN DEMAND, TOTAL	(MG/L)	NM	NM	< 1.	NM	NM	NM
CHEM. OXYGEN DEMAND (COD)	(MG/L)	6.6	NM	NM	NM	NM	NM
CONDUCTANCE	(UMHOS/CM)	220.	NM	NM	210.	200.	190.
N-NITROSODIMETHYLAMINE	(PPB)	< 10.	NM	NM	NM	NM	NM
PH	(PH)	8.5	NM	NM	8.3	7.4	7.6
TEMPERATURE	(DEGREES C.)	21.6	NM	NM	19.4	17.8	7.5
TOTAL PETROLEU[redacted]BONS	(MG/L)	0.12	NM	[redacted]	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 1596 Well Type: MC Zone: 1 Sector: D GSE: 182.99 TOC: 182.99 TOP: 333 BOP: 343 TD: 343

	Sample Date:	08/14/95	08/14/95	08/30/95	11/13/95	12/14/95	01/01/96
	Time:	12:11	16:49	10:01	10:55	08:47	:
	Sample Type:						
	Lab:	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)						
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-DICHLOROETHANE	(PPB)	< 5.	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-BUTANONE (MEK)	(PPB)	< 20.	NM	NM	NM	NM	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	< 10.	NM	NM	NM	NM	NM
2-HEXANONE	(PPB)	< 20.	NM	NM	NM	NM	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	< 10.	NM	NM	NM	NM	NM
ACETONE	(PPB)	< 20.	NM	NM	NM	NM	NM
BENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5
BROMOFORM	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
BROMOMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CARBON DISULFIDE	(PPB)	< 5.	NM	NM	NM	NM	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 0.25	< 0.25	< 0.25	< 0.5	< 0.25
CHLOROBENZENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CHLOROFORM	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CHLOROMETHANE	(PPB)	< 10.	NM	NM	NM	NM	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLORODIFLUOROMETHANE	(PPB)	< 10.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
DICHLOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
ETHYLBENZENE	(PPB)	< 5.	NM	NM	NM	NM	NM
FREON 113	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TETRACHLOROETHYLENE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE	(PPB)	< 5.	NM	NM	NM	NM	NM
TRICHLOROETHYLENE	(PPB)	< 5.	6.3	0.71	< 0.5	< 0.5	< 0.5
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
VINYL ACETATE	(PPB)	< 10.	NM	NM	NM	NM	NM
VINYL CHLORIDE	(PPB)	< 10.	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
XYLENES (TOTAL)	(PPB)	< 5.	NM	NM	NM	NM	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4300 SAILOR BAR NORTH EXTRACTION WE Well Type: EW Zone: 1 Sector: D GSE: TOC: 118.9 TOP: BOP: TD:

	Sample Date:	10/28/93	10/28/93	10/28/93	11/08/93	11/08/93	11/10/93	11/10/93	11/12/93	11/12/93
	Time:	10:45	13:30	15:30	14:00	22:00	10:00	22:00	11:44	22:06
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)									
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
CHLOROFORM	(PPB)	2.3	1.8	1.4	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	1.1	< 1.	< 1.	< 1.
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
TRICHLOROETHYLENE	(PPB)	4.1	5.3	5.6	4.7	5.8	8.2	8.	8.2	7.8
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4300 SAILOR BAR NORTH EXTRACTION WE Well Type: EW Zone: 1 Sector: D OSE: TOC: 118.9 TOP: BOP: TD:

	Sample Date:	11/29/93	11/30/93	12/01/93	12/04/93	12/05/93	12/06/93	12/07/93	12/08/93
	Time:	:	22:00	22:00	22:00	22:00	22:00	22:00	22:00
	Sample Type:								
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)								
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
CHLOROFORM	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	3.4
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	2.8	2.7	2.6	2.8	3.1	2.7	3.3	< 1.
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	1.	1.1	1.6	1.1
TRICHLOROETHYLENE	(PPB)	120.	110.	100.	120.	130.	110.	130.	140.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4301 SAILOR BAR NORTH EXTRACTION WE Well Type: EW Zone: 1 Sector: D GSE: TOC: 119.2 TOP: BOP: TD:

	Sample Date:	10/29/93	10/29/93	10/29/93	10/29/93	11/15/93	11/15/93	11/16/93	11/17/93	11/19/93
	Time:	10:00	12:00	14:18	16:00	14:00	22:00	22:00	22:00	11:44
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)									
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 4.	< 2.	< 2.	< 2.	< 2.
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
CHLOROFORM	(PPB)	4.8	3.1	2.4	1.9	< 2.	1.1	1.7	< 1.	< 1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	7.7	7.3	7.6	6.6	8.6	9.	5.8	6.1	5.5
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
TETRACHLOROETHYLENE	(PPB)	2.3	2.2	2.3	2.1	2.5	2.8	1.7	2.2	2.1
TRICHLOROETHYLENE	(PPB)	280.	270.	270.	250.	330.	300.	210.	210.	190.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 2.	< 1.	< 1.	< 1.	< 1.

AEROJET Environmental Operations
Water Quality Information

Well: 4301 SAILOR BAR NORTH EXTRACTION WE Well Type: EW Zone: 1 Sector: D GSE: TOC: 119.2 TOP: BOP: TD:

Sample Date: 11/19/93
Time: 22:00
Sample Type:
Lab: EL

VOLATILE ORGANICS	(Units)		
1,1,1-TRICHLOROETHANE	(PPB)	<	1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.
1,1,2-TRICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHYLENE	(PPB)	<	1.
1,2-DICHLOROETHANE	(PPB)	<	1.
1,2-DICHLOROPROPANE	(PPB)	<	1.
BROMODICHLOROMETHANE	(PPB)	<	1.
BROMOFORM	(PPB)	<	2.
CARBON TETRACHLORIDE	(PPB)	<	1.
CHLOROBENZENE	(PPB)	<	1.
CHLOROFORM	(PPB)	<	1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		5.7
DIBROMOCHLOROMETHANE	(PPB)	<	1.
DICHLORODIFLUOROMETHANE	(PPB)	<	1.
DICHLOROMETHANE	(PPB)	<	1.
FREON 113	(PPB)	<	1.
TETRACHLOROETHYLENE	(PPB)		1.7
TRICHLOROETHYLENE	(PPB)		200.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.
VINYL CHLORIDE	(PPB)	<	1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4302 SAILOR BAR NORTH EXTRACTION WE Well Type: EW Zone: 1 Sector: D GSE: TOC: 119.2 TOP: BOP: TD:

	Sample Date:	10/26/93	10/26/93	10/26/93	10/26/93	11/02/93	11/03/93	11/03/93	11/05/93	11/05/93
	Time:	11:00	13:02	14:58	16:58	12:55	13:00	17:00	01:00	11:00
	Sample Type:									
	Lab:	EL	EL	EL	EL	EL	EL	EL	EL	EL
VOLATILE ORGANICS	(Units)									
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
BROMODICHLOROMETHANE	(PPB)	1.3	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
BROMOFORM	(PPB)	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
CHLOROFORM	(PPB)	15.	11.	7.6	4.9	1.7	< 1.	3.8	< 1.	< 1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	3.5	2.8	2.6	2.	2.8	2.4	2.7	1.9	1.9
DIBROMOCHLOROMETHANE	(PPB)	1.1	1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
TETRACHLOROETHYLENE	(PPB)	1.	< 1.	< 1.	< 1.	1.1	< 1.	1.2	< 1.	< 1.
TRICHLOROETHYLENE	(PPB)	150.	120.	110.	98.	98.	90.	98.	84.	82.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.

AEROJET Environmental Operations
Water Quality Information

Well: 4302 SAILOR BAR NORTH EXTRACTION WE Well Type: EW Zone: 1 Sector: D GSE: TOC: 119.2 TOP: BOP: TD:

	Sample Date:	11/05/93	11/22/93	11/22/93	11/23/93	11/24/93
	Time:	14:45	14:02	22:00	22:01	11:55
	Sample Type:					
	Lab:	EL	EL	EL	EL	EL
VOLATILE ORGANICS -	(Units)					
1,1,1-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
1,1,2-TRICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
1,1-DICHLOROETHYLENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
1,2-DICHLOROPROPANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
BROMODICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
BROMOFORM	(PPB)	< 2.	< 1.	< 2.	< 2.	< 2.
CARBON TETRACHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
CHLOROBENZENE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
CHLOROFORM	(PPB)	< 1.	1.3	< 1.	< 1.	< 1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	2.3	2.2	1.9	1.9	2.2
DIBROMOCHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLORODIFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
DICHLOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
FREON 113	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
TETRACHLOROETHYLENE	(PPB)	< 1.	< 1.	1.	< 1.	< 1.
TRICHLOROETHYLENE	(PPB)	86.	100.	88.	81.	89.
TRICHLOROFLUOROMETHANE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.
VINYL CHLORIDE	(PPB)	< 1.	< 1.	< 1.	< 1.	< 1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4325 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:	08/29/95	08/29/95
	Time:	08:20	15:02
	Sample Type:		
	Lab:	EL	EL
METALS	(Units)		
ALUMINUM	(MG/L)	NM	< 0.16
ANTIMONY	(MG/L)	NM	< 0.44
ARSENIC	(MG/L)	NM	< 0.088
BARIUM	(MG/L)	NM	0.17
BERYLLIUM	(MG/L)	NM	< 0.0011
BORON	(MG/L)	NM	< 0.044
CADMIUM	(MG/L)	NM	< 0.0044
CHROMIUM	(MG/L)	NM	< 0.0088
COBALT	(MG/L)	NM	< 0.0088
COPPER	(MG/L)	NM	< 0.0066
IRON	(MG/L)	NM	< 0.33
LEAD	(MG/L)	NM	< 0.066
MERCURY	(MG/L)	NM	< 0.0002
MOLYBDENUM	(MG/L)	NM	< 0.044
NICKEL	(MG/L)	NM	< 0.022
SELENIUM	(MG/L)	NM	< 0.11
SILVER	(MG/L)	NM	< 0.022
THALLIUM	(MG/L)	NM	< 0.055
VANADIUM	(MG/L)	NM	0.009
ZINC	(MG/L)	NM	< 0.11
MINERALS, INORGANICS			
BICARBONATE	(MG/L)	NM	240.
CALCIUM	(MG/L)	NM	69.
CARBONATE	(MG/L)	NM	0.
CHLORIDE	(MG/L)	NM	140.
MAGNESIUM	(MG/L)	NM	28.
MANGANESE	(MG/L)	NM	< 0.0055
NITRATE	(MG/L)	NM	21.
NITRITE	(MG/L)	NM	< 0.25
O-PHOSPHATE	(MG/L)	NM	0.4
PERCHLORATE	(MG/L)	NM	< 0.4
POTASSIUM	(MG/L)	NM	3.6
SODIUM, TOTAL	(MG/L)	NM	64.
SULFATE	(MG/L)	NM	20.
SULFITE	(MG/L)	NM	< 10.
TOTAL ALKALINITY AS CACO3	(MG/L)	NM	240.
TOTAL SOLIDS	(MG/L)	NM	530.
MISCELLANEOUS			
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	< 3.
CONDUCTANCE	(UMHOS/CM)	NM	780.

[redacted] [redacted] [redacted]

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4325 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:		08/29/95		08/29/95	
	Time:		08:20		15:02	
	Sample Type:					
	Lab:		EL		EL	
MISCELLANEOUS (cont'd)	(Units)					
HYDROXIDE	(MG/L)		NM		0.	
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.	
PH	(PH)		NM		7.	
TEMPERATURE	(DEGREES C.)		NM		19.9	
TOTAL DISSOLVED SOLIDS	(MG/L)		NM		490.	
TOTAL PETROLEUM HYDROCARBONS	(MG/L)		NM	<	0.1	
VOLATILE DISSOLVED SOLIDS	(MG/L)		NM		86.	
VOLATILE ORGANICS						
1,1,1-TRICHLOROETHANE	(PPB)		1.5	<	5.	
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	0.5	<	5.	
1,1,2-TRICHLOROETHANE	(PPB)	<	0.5	<	5.	
1,1-DICHLOROETHANE	(PPB)		1.4	<	5.	
1,1-DICHLOROETHYLENE	(PPB)		30.		35.	
1,2-DICHLOROETHANE	(PPB)	<	0.5	<	5.	
1,2-DICHLOROPROPANE	(PPB)	<	0.5	<	5.	
2-BUTANONE (MEK)	(PPB)		NM	<	20.	
2-CHLOROETHYL VINYL ETHER	(PPB)		NM	<	10.	
2-HEXANONE	(PPB)		NM	<	20.	
4-METHYL-2-PENTANONE (MIBK)	(PPB)		NM	<	10.	
ACETONE	(PPB)		NM	<	20.	
BENZENE	(PPB)		NM	<	5.	
BROMODICHLOROMETHANE	(PPB)	<	0.5	<	5.	
BROMOFORM	(PPB)	<	0.5	<	5.	
BROMOMETHANE	(PPB)		NM	<	10.	
CARBON DISULFIDE	(PPB)		NM	<	5.	
CARBON TETRACHLORIDE	(PPB)	<	0.5	<	5.	
CHLOROBENZENE	(PPB)	<	0.5	<	5.	
CHLOROETHANE	(PPB)		NM	<	10.	
CHLOROFORM	(PPB)		2.5	<	5.	
CHLOROMETHANE	(PPB)		NM	<	10.	
CIS-1,3-DICHLOROPROPYLENE	(PPB)		NM	<	5.	
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		18.		35.	
DIBROMOCHLOROMETHANE	(PPB)	<	0.5	<	5.	
DICHLORODIFLUOROMETHANE	(PPB)	<	0.5	<	10.	
DICHLOROMETHANE	(PPB)	<	0.5	<	5.	
ETHYLBENZENE	(PPB)		NM	<	5.	
FREON 113	(PPB)		5.5	<	5.	
META-XYLENE	(PPB)		NM	<	0.5	
ORTHO-XYLENE	(PPB)		NM	<	0.5	
PARA-XYLENE	(PPB)		NM	<	0.5	
T-1,3-DICHLOROPROPYLENE	(PPB)		NM	<	5.	
TETRACHLOROETHYLENE	(PPB)		10.		12.	

AEROJET Environmental Operations
Water Quality Information

Well: 4325 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

		Sample Date:	08/29/95		08/29/95
		Time:	08:20		15:02
		Sample Type:			
		Lab:	EL		EL
VOLATILE ORGANICS (cont'd)	(Units)				
TOLUENE	(PPB)		NM	<	5.
TRICHLOROETHYLENE	(PPB)		280.		440.
TRICHLOROFLUOROMETHANE	(PPB)	<	0.5	<	5.
VINYL ACETATE	(PPB)		NM	<	10.
VINYL CHLORIDE	(PPB)	<	0.5	<	10.
XYLENES (TOTAL)	(PPB)		NM	<	5.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4330 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

Sample Date:		08/24/95	08/24/95	08/25/95	
Time:		08:10	15:05	15:05	
Sample Type:					
Lab:		EL	EL	EL	
METALS	(Units)				
ALUMINUM	(MG/L)	NM	NM	<	0.16
ANTIMONY	(MG/L)	NM	NM	<	0.44
ARSENIC	(MG/L)	NM	NM	<	0.088
BARIUM	(MG/L)	NM	NM		0.14
BERYLLIUM	(MG/L)	NM	NM	<	0.0011
BORON	(MG/L)	NM	NM	<	0.044
CADMIUM	(MG/L)	NM	NM	<	0.0044
CHROMIUM	(MG/L)	NM	NM	<	0.0088
COBALT	(MG/L)	NM	NM	<	0.0088
COPPER	(MG/L)	NM	NM	<	0.0066
IRON	(MG/L)	NM	NM	<	0.33
LEAD	(MG/L)	NM	NM	<	0.066
MERCURY	(MG/L)	NM	NM	<	0.0002
MOLYBDENUM	(MG/L)	NM	NM	<	0.044
NICKEL	(MG/L)	NM	NM	<	0.022
SELENIUM	(MG/L)	NM	NM	<	0.11
SILVER	(MG/L)	NM	NM	<	0.022
THALLIUM	(MG/L)	NM	NM	<	0.055
VANADIUM	(MG/L)	NM	NM		0.0076
ZINC	(MG/L)	NM	NM	<	0.11
MINERALS, INORGANICS					
BICARBONATE	(MG/L)	NM	NM		200.
CALCIUM	(MG/L)	NM	NM		62.
CARBONATE	(MG/L)	NM	NM		0.
CHLORIDE	(MG/L)	NM	NM		52.
MAGNESIUM	(MG/L)	NM	NM		25.
MANGANESE	(MG/L)	NM	NM	<	0.0055
NITRATE	(MG/L)	NM	NM		13.
NITRITE	(MG/L)	NM	NM	<	0.15
O-PHOSPHATE	(MG/L)	NM	NM		0.32
PERCHLORATE	(MG/L)	NM	NM	<	0.4
POTASSIUM	(MG/L)	NM	NM		4.3
SODIUM, TOTAL	(MG/L)	NM	NM		18.
SULFATE	(MG/L)	NM	NM		20.
SULFITE	(MG/L)	NM	NM	<	10.
TOTAL ALKALINITY AS CACO3	(MG/L)	NM	NM		200.
TOTAL SOLIDS	(MG/L)	NM	NM		360.
MISCELLANEOUS					
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	NM	<	3.
CONDUCTANCE	(UMHOS/CM)	NM	NM		530.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4330 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:	08/24/95	08/24/95	08/25/95
	Time:	08:10	15:05	15:05
	Sample Type:			
	Lab:	EL	EL	EL
MISCELLANEOUS (cont'd)	(Units)			
HYDROXIDE	(MG/L)	NM	NM	0.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM
PH	(PH)	NM	NM	7.5
TEMPERATURE	(DEGREES C.)	NM	NM	22.3
TOTAL DISSOLVED SOLIDS	(MG/L)	NM	NM	360.
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	NM	< 0.1	NM
VOLATILE DISSOLVED SOLIDS	(MG/L)	NM	NM	67.
VOLATILE ORGANICS				
1,1,1-TRICHLOROETHANE	(PPB)	< 5.	< 10.	NM
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 5.	< 10.	NM
1,1,2-TRICHLOROETHANE	(PPB)	< 5.	< 10.	NM
1,1-DICHLOROETHANE	(PPB)	5.4	< 10.	NM
1,1-DICHLOROETHYLENE	(PPB)	51.	74.	NM
1,2-DICHLOROETHANE	(PPB)	< 5.	< 10.	NM
1,2-DICHLOROPROPANE	(PPB)	< 5.	< 10.	NM
2-BUTANONE (MEK)	(PPB)	NM	< 40.	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 20.	NM
2-HEXANONE	(PPB)	NM	< 40.	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 20.	NM
ACETONE	(PPB)	NM	< 40.	NM
BENZENE	(PPB)	NM	< 10.	NM
BROMODICHLOROMETHANE	(PPB)	< 5.	< 10.	NM
BROMOFORM	(PPB)	< 10.	< 10.	NM
BROMOMETHANE	(PPB)	NM	< 20.	NM
CARBON DISULFIDE	(PPB)	NM	< 10.	NM
CARBON TETRACHLORIDE	(PPB)	< 5.	< 10.	NM
CHLOROBENZENE	(PPB)	< 5.	< 10.	NM
CHLOROETHANE	(PPB)	NM	< 20.	NM
CHLOROFORM	(PPB)	9.6	< 10.	NM
CHLOROMETHANE	(PPB)	NM	< 20.	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 10.	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	94.	120.	NM
DIBROMOCHLOROMETHANE	(PPB)	< 5.	< 10.	NM
DICHLORODIFLUOROMETHANE	(PPB)	< 5.	< 20.	NM
DICHLOROMETHANE	(PPB)	< 5.	< 10.	NM
ETHYLBENZENE	(PPB)	NM	< 10.	NM
FREON 113	(PPB)	33.	23.	NM
META-XYLENE	(PPB)	NM	< 0.5	NM
ORTHO-XYLENE	(PPB)	NM	< 0.5	NM
PARA-XYLENE	(PPB)	NM	< 0.5	NM
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 10.	NM
TETRACHLOROETHYLENE	(PPB)	22.	22.	[redacted]

AEROJET Environmental Operations
Water Quality Information

Well: 4330 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

		Sample Date:	08/24/95	08/24/95	08/25/95
		Time:	08:10	15:05	15:05
		Sample Type:			
		Lab:	EL	EL	EL
VOLATILE ORGANICS (cont'd)	(Units)				
TOLUENE	(PPB)		NM	< 10.	NM
TRICHLOROETHYLENE	(PPB)		1500.	2000.	NM
TRICHLOROFLUOROMETHANE	(PPB)	<	5.	< 10.	NM
VINYL ACETATE	(PPB)		NM	< 20.	NM
VINYL CHLORIDE	(PPB)	<	5.	< 20.	NM
XYLENES (TOTAL)	(PPB)		NM	< 10.	NM

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4335 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:	08/22/95	08/22/95
	Time:	08:25	15:00
	Sample Type:		
	Lab:	EL	EL
METALS	(Units)		
ALUMINUM	(MG/L)	NM	< 0.17
ANTIMONY	(MG/L)	NM	< 0.44
ARSENIC	(MG/L)	NM	< 0.088
BARIUM	(MG/L)	NM	0.14
BERYLLIUM	(MG/L)	NM	< 0.0011
BORON	(MG/L)	NM	< 0.044
CADMIUM	(MG/L)	NM	< 0.0044
CHROMIUM	(MG/L)	NM	< 0.0088
COBALT	(MG/L)	NM	< 0.0088
COPPER	(MG/L)	NM	< 0.0066
IRON	(MG/L)	NM	< 0.33
LEAD	(MG/L)	NM	< 0.066
MERCURY	(MG/L)	NM	< 0.0002
MOLYBDENUM	(MG/L)	NM	< 0.044
NICKEL	(MG/L)	NM	< 0.022
SELENIUM	(MG/L)	NM	< 0.11
SILVER	(MG/L)	NM	< 0.022
THALLIUM	(MG/L)	NM	< 0.055
VANADIUM	(MG/L)	NM	< 0.0055
ZINC	(MG/L)	NM	< 0.11
MINERALS, INORGANICS			
BICARBONATE	(MG/L)	NM	170.
CALCIUM	(MG/L)	NM	50.
CARBONATE	(MG/L)	NM	0.
CHLORIDE	(MG/L)	NM	17.
MAGNESIUM	(MG/L)	NM	17.
MANGANESE	(MG/L)	NM	< 0.0055
NITRATE	(MG/L)	NM	9.5
NITRITE	(MG/L)	NM	< 0.05
O-PHOSPHATE	(MG/L)	NM	1.8
PERCHLORATE	(MG/L)	NM	< 0.4
POTASSIUM	(MG/L)	NM	4.9
SODIUM, TOTAL	(MG/L)	NM	17.
SULFATE	(MG/L)	NM	15.
SULFITE	(MG/L)	NM	< 10.
TOTAL ALKALINITY AS CACO3	(MG/L)	NM	170.
TOTAL SOLIDS	(MG/L)	NM	290.
MISCELLANEOUS			
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	< 3.
CONDUCTANCE	(UMHOS/CM)	NM	380.

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AEROJET Environmental Operations
Water Quality Information

Well: 4335 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

		Sample Date:	08/22/95		08/22/95
		Time:	08:25		15:00
		Sample Type:			
		Lab:	EL		EL
MISCELLANEOUS (cont'd)	(Units)				
HYDROXIDE	(MG/L)		NM		0.
N-NITROSODIMETHYLAMINE	(PPB)		NM	<	10.
PH	(PH)		NM		7.5
TEMPERATURE	(DEGREES C.)		NM		21.3
TOTAL DISSOLVED SOLIDS	(MG/L)		NM		270.
TOTAL PETROLEUM HYDROCARBONS	(MG/L)		NM	<	0.1
VOLATILE DISSOLVED SOLIDS	(MG/L)		NM		43.
VOLATILE ORGANICS					
1,1,1-TRICHLOROETHANE	(PPB)	<	5.	<	5.
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	5.	<	5.
1,1,2-TRICHLOROETHANE	(PPB)	<	5.	<	5.
1,1-DICHLOROETHANE	(PPB)		7.2		7.8
1,1-DICHLOROETHYLENE	(PPB)		48.	<	5.
1,2-DICHLOROETHANE	(PPB)		6.9		6.1
1,2-DICHLOROPROPANE	(PPB)	<	5.	<	5.
2-BUTANONE (MEK)	(PPB)		NM	<	20.
2-CHLOROETHYL VINYL ETHER	(PPB)		NM	<	10.
2-HEXANONE	(PPB)		NM	<	20.
4-METHYL-2-PENTANONE (MIBK)	(PPB)		NM	<	10.
ACETONE	(PPB)		NM	<	20.
BENZENE	(PPB)		NM	<	5.
BROMODICHLOROMETHANE	(PPB)	<	5.	<	5.
BROMOFORM	(PPB)	<	10.	<	5.
BROMOMETHANE	(PPB)		NM	<	10.
CARBON DISULFIDE	(PPB)		NM	<	5.
CARBON TETRACHLORIDE	(PPB)	<	5.		5.1
CHLOROBENZENE	(PPB)	<	5.	<	5.
CHLOROETHANE	(PPB)		NM	<	10.
CHLOROFORM	(PPB)		9.5		7.8
CHLOROMETHANE	(PPB)		NM	<	10.
CIS-1,3-DICHLOROPROPYLENE	(PPB)		NM	<	5.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)		50.		58.
DIBROMOCHLOROMETHANE	(PPB)	<	5.	<	5.
DICHLORODIFLUOROMETHANE	(PPB)	<	5.	<	10.
DICHLOROMETHANE	(PPB)	<	5.	<	5.
ETHYLBENZENE	(PPB)		NM	<	5.
FREON 113	(PPB)		18.		13.
META-XYLENE	(PPB)		NM	<	0.5
ORTHO-XYLENE	(PPB)		NM	<	0.5
PARA-XYLENE	(PPB)		NM	<	0.5
T-1,3-DICHLOROPROPYLENE	(PPB)		NM	<	5.
TETRACHLOROETHYLENE	(PPB)		9.1		8.2

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4335 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:	08/22/95		08/22/95		
	Time:	08:25		15:00		
	Sample Type:					
	Lab:	EL		EL		
VOLATILE ORGANICS (cont'd)	(Units)					
TOLUENE	(PPB)	NM	<	5.		
TRICHLOROETHYLENE	(PPB)	1100.		1100.		
TRICHLOROFLUOROMETHANE	(PPB)	< 5.	<	5.		
VINYL ACETATE	(PPB)	NM	<	10.		
VINYL CHLORIDE	(PPB)	< 5.	<	10.		
XYLENES (TOTAL)	(PPB)	NM	<	5.		

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4340 Well Type: SC Zone: 22Sector: GSE: TOC: TOP: BOP: TD:

Sample Date: 03/06/95
Time: 16:50
Sample Type:
Lab: EL

VOLATILE ORGANICS	(Units)		
1,1,1-TRICHLOROETHANE	(PPB)	<	1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.
1,1,2-TRICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHYLENE	(PPB)	<	1.
1,2-DICHLOROETHANE	(PPB)	<	1.
1,2-DICHLOROPROPANE	(PPB)	<	1.
BROMODICHLOROMETHANE	(PPB)	<	1.
BROMOFORM	(PPB)	<	2.
CARBON TETRACHLORIDE	(PPB)	<	1.
CHLOROBENZENE	(PPB)	<	1.
CHLOROFORM	(PPB)		2.2
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.
DIBROMOCHLOROMETHANE	(PPB)	<	1.
DICHLORODIFLUOROMETHANE	(PPB)	<	1.
DICHLOROMETHANE	(PPB)	<	1.
FREON 113	(PPB)	<	1.
TETRACHLOROETHYLENE	(PPB)	<	1.
TRICHLOROETHYLENE	(PPB)	<	1.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.
VINYL CHLORIDE	(PPB)	<	1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4345 Well Type: SC Zone: 22Sector: GSE: TOC: TOP: BOP: TD:

Sample Date: 12/12/94
Time: 15:19
Sample Type:
Lab: EL

VOLATILE ORGANICS	(Units)		
1,1,1-TRICHLOROETHANE	(PPB)	<	1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.
1,1,2-TRICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHYLENE	(PPB)	<	1.
1,2-DICHLOROETHANE	(PPB)	<	1.
1,2-DICHLOROPROPANE	(PPB)	<	1.
BROMODICHLOROMETHANE	(PPB)	<	1.
BROMOFORM	(PPB)	<	2.
CARBON TETRACHLORIDE	(PPB)	<	1.
CHLOROBENZENE	(PPB)	<	1.
CHLOROFORM	(PPB)	<	1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.
DIBROMOCHLOROMETHANE	(PPB)	<	1.
DICHLORODIFLUOROMETHANE	(PPB)	<	1.
DICHLOROMETHANE	(PPB)	<	1.
FREON 113	(PPB)	<	1.
TETRACHLOROETHYLENE	(PPB)	<	1.
TRICHLOROETHYLENE	(PPB)		6.1
TRICHLOROFLUOROMETHANE	(PPB)	<	1.
VINYL CHLORIDE	(PPB)	<	1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4350 Well Type: SC Zone: 22Sector: GSE: TOC: TOP: BOP: TD:

Sample Date: 12/19/94
Time: 15:20
Sample Type:
Lab: EL

VOLATILE ORGANICS	(Units)		
1,1,1-TRICHLOROETHANE	(PPB)	<	1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.
1,1,2-TRICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHYLENE	(PPB)	<	1.
1,2-DICHLOROETHANE	(PPB)	<	1.
1,2-DICHLOROPROPANE	(PPB)	<	1.
BROMODICHLOROMETHANE	(PPB)	<	1.
BROMOFORM	(PPB)	<	2.
CARBON TETRACHLORIDE	(PPB)	<	1.
CHLOROBENZENE	(PPB)	<	1.
CHLOROFORM	(PPB)	<	1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.
DIBROMOCHLOROMETHANE	(PPB)	<	1.
DICHLORODIFLUOROMETHANE	(PPB)	<	1.
DICHLOROMETHANE	(PPB)	<	1.
FREON 113	(PPB)	<	1.
TETRACHLOROETHYLENE	(PPB)	<	1.
TRICHLOROETHYLENE	(PPB)		13.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.
VINYL CHLORIDE	(PPB)	<	1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4355 Well Type: SC Zone: 22Sector: GSE: TOC: TOP: BOP: TD:

Sample Date: 11/23/94
Time: 13:05
Sample Type:
Lab: EL

VOLATILE ORGANICS	(Units)		
1,1,1-TRICHLOROETHANE	(PPB)	<	1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.
1,1,2-TRICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHYLENE	(PPB)	<	1.
1,2-DICHLOROETHANE	(PPB)	<	1.
1,2-DICHLOROPROPANE	(PPB)	<	1.
BROMODICHLOROMETHANE	(PPB)	<	1.
BROMOFORM	(PPB)	<	2.
CARBON TETRACHLORIDE	(PPB)	<	1.
CHLOROBENZENE	(PPB)	<	1.
CHLOROFORM	(PPB)	<	1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.
DIBROMOCHLOROMETHANE	(PPB)	<	1.
DICHLORODIFLUOROMETHANE	(PPB)	<	1.
DICHLOROMETHANE	(PPB)	<	1.
FREON 113	(PPB)	<	1.
TETRACHLOROETHYLENE	(PPB)	<	1.
TRICHLOROETHYLENE	(PPB)	<	1.
TRICHLOROFLUOROMETHANE	(PPB)	<	1.
VINYL CHLORIDE	(PPB)	<	1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4360 Well Type: SC Zone: 22Sector: GSE: TOC: TOP: BOP: TD:

Sample Date: 12/01/94
Time: 14:14
Sample Type:
Lab: EL

VOLATILE ORGANICS	(Units)		
1,1,1-TRICHLOROETHANE	(PPB)	<	1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.
1,1,2-TRICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHYLENE	(PPB)	<	1.
1,2-DICHLOROETHANE	(PPB)	<	1.
1,2-DICHLOROPROPANE	(PPB)	<	1.
BROMODICHLOROMETHANE	(PPB)	<	1.
BROMOFORM	(PPB)	<	2.
CARBON TETRACHLORIDE	(PPB)	<	1.
CHLOROBENZENE	(PPB)	<	1.
CHLOROFORM	(PPB)	<	1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.
DIBROMOCHLOROMETHANE	(PPB)	<	1.
DICHLORODIFLUOROMETHANE	(PPB)	<	1.
DICHLOROMETHANE	(PPB)	<	1.
FREON 113	(PPB)	<	1.
TETRACHLOROETHYLENE	(PPB)	<	1.
TRICHLOROETHYLENE	(PPB)		1.6
TRICHLOROFLUOROMETHANE	(PPB)	<	1.
VINYL CHLORIDE	(PPB)	<	1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4365 Well Type: SC Zone: 22Sector: GSE: TOC: TOP: BOP: TD:

Sample Date: 12/07/94
Time: 16:15
Sample Type:
Lab: EL

VOLATILE ORGANICS	(Units)		
1,1,1-TRICHLOROETHANE	(PPB)	<	1.
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	1.
1,1,2-TRICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHANE	(PPB)	<	1.
1,1-DICHLOROETHYLENE	(PPB)	<	1.
1,2-DICHLOROETHANE	(PPB)	<	1.
1,2-DICHLOROPROPANE	(PPB)	<	1.
BROMODICHLOROMETHANE	(PPB)	<	1.
BROMOFORM	(PPB)	<	2.
CARBON TETRACHLORIDE	(PPB)	<	1.
CHLOROBENZENE	(PPB)	<	1.
CHLOROFORM	(PPB)	<	1.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	1.
DIBROMOCHLOROMETHANE	(PPB)	<	1.
DICHLORODIFLUOROMETHANE	(PPB)	<	1.
DICHLOROMETHANE	(PPB)	<	1.
FREON 113	(PPB)	<	1.
TETRACHLOROETHYLENE	(PPB)	<	1.
TRICHLOROETHYLENE	(PPB)		3.1
TRICHLOROFLUOROMETHANE	(PPB)	<	1.
VINYL CHLORIDE	(PPB)	<	1.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4370 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

		Sample Date:	08/04/95		08/04/95
		Time:	08:22		14:17
		Sample Type:			
		Lab:	EL		EL
VOLATILE ORGANICS - (cont'd)	(Units)				
TOLUENE	(PPB)		NM	<	5.
TRICHLOROETHYLENE	(PPB)	<	0.5	<	5.
TRICHLOROFLUOROMETHANE	(PPB)	<	0.5	<	5.
VINYL ACETATE	(PPB)		NM	<	10.
VINYL CHLORIDE	(PPB)	<	0.25	<	10.
XYLENES (TOTAL)	(PPB)		NM	<	5.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4375 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:	08/02/95	08/02/95
	Time:	08:38	15:26
	Sample Type:		
	Lab:	EL	EL

METALS	(Units)			
ALUMINUM	(MG/L)	NM		0.24
ANTIMONY	(MG/L)	NM	<	0.44
ARSENIC	(MG/L)	NM	<	0.089
BARIUM	(MG/L)	NM		0.041
BERYLLIUM	(MG/L)	NM	<	0.0011
BORON	(MG/L)	NM	<	0.044
CADMIUM	(MG/L)	NM	<	0.0044
CHROMIUM	(MG/L)	NM	<	0.0089
COBALT	(MG/L)	NM	<	0.0089
COPPER	(MG/L)	NM	<	0.0067
IRON	(MG/L)	NM	<	0.33
LEAD	(MG/L)	NM	<	0.067
MERCURY	(MG/L)	NM		0.0002
MOLYBDENUM	(MG/L)	NM	<	0.044
NICKEL	(MG/L)	NM	<	0.022
SELENIUM	(MG/L)	NM	<	0.11
SILVER	(MG/L)	NM	<	0.022
THALLIUM	(MG/L)	NM	<	0.056
VANADIUM	(MG/L)	NM		0.0081
ZINC	(MG/L)	NM	<	0.11
MINERALS, INORGANICS				
BICARBONATE	(MG/L)	NM		73.
CALCIUM	(MG/L)	NM		18.
CARBONATE	(MG/L)	NM		0.
CHLORIDE	(MG/L)	NM		9.1
MAGNESIUM	(MG/L)	NM		6.3
MANGANESE	(MG/L)	NM	<	0.0056
NITRATE	(MG/L)	NM		2.5
NITRITE	(MG/L)	NM	<	0.05
O-PHOSPHATE	(MG/L)	NM		0.39
PERCHLORATE	(MG/L)	NM	<	0.4
POTASSIUM	(MG/L)	NM		3.1
SODIUM, TOTAL	(MG/L)	NM		10.
SULFATE	(MG/L)	NM		5.7
SULFITE	(MG/L)	NM	<	10.
TOTAL ALKALINITY AS CACO3	(MG/L)	NM		73.
TOTAL SOLIDS	(MG/L)	NM		130.
MISCELLANEOUS				
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	<	3.
CONDUCTANCE	(UMHOS/CM)	NM		180.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4370 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:	08/04/95		08/04/95	
	Time:	08:22		14:17	
	Sample Type:				
	Lab:	EL		EL	
METALS	(Units)				
ALUMINUM	(MG/L)	NM	<	0.22	
ANTIMONY	(MG/L)	NM	<	0.44	
ARSENIC	(MG/L)	NM	<	0.089	
BARIUM	(MG/L)	NM		0.015	
BERYLLIUM	(MG/L)	NM	<	0.0011	
BORON	(MG/L)	NM	<	0.044	
CADMIUM	(MG/L)	NM	<	0.0044	
CHROMIUM	(MG/L)	NM	<	0.0089	
COBALT	(MG/L)	NM	<	0.0089	
COPPER	(MG/L)	NM	<	0.0067	
IRON	(MG/L)	NM	<	0.33	
LEAD	(MG/L)	NM	<	0.067	
MERCURY	(MG/L)	NM	<	0.0002	
MOLYBDENUM	(MG/L)	NM	<	0.044	
NICKEL	(MG/L)	NM	<	0.022	
SELENIUM	(MG/L)	NM	<	0.11	
SILVER	(MG/L)	NM	<	0.022	
THALLIUM	(MG/L)	NM	<	0.056	
VANADIUM	(MG/L)	NM		0.0076	
ZINC	(MG/L)	NM	<	0.11	
MINERALS, INORGANICS					
BICARBONATE	(MG/L)	NM		42.	
CALCIUM	(MG/L)	NM		6.2	
CARBONATE	(MG/L)	NM		0.	
CHLORIDE	(MG/L)	NM		3.4	
MAGNESIUM	(MG/L)	NM		2.2	
MANGANESE	(MG/L)	NM	<	0.0056	
NITRATE	(MG/L)	NM		1.2	
NITRITE	(MG/L)	NM	<	0.05	
O-PHOSPHATE	(MG/L)	NM		0.51	
PERCHLORATE	(MG/L)	NM	<	0.4	
POTASSIUM	(MG/L)	NM		1.3	
SODIUM, TOTAL	(MG/L)	NM		4.1	
SULFATE	(MG/L)	NM		3.6	
SULFITE	(MG/L)	NM	<	10.	
TOTAL ALKALINITY AS CACO3	(MG/L)	NM		42.	
TOTAL SOLIDS	(MG/L)	NM		95.	
MISCELLANEOUS					
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	<	3.	
CONDUCTANCE	(UMHOS/CM)	NM		97.	

AEROJET Environmental Operations
Water Quality Information

Well: 4370 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

		Sample Date:	08/04/95	08/04/95
		Time:	08:22	14:17
		Sample Type:		
		Lab:	EL	EL
MISCELLANEOUS - (cont'd)	(Units)			
HYDROXIDE	(MG/L)	NM		0.
N-NITROSODIMETHYLAMINE	(PPB)	NM	<	10.
PH	(PH)	NM		7.7
TEMPERATURE	(DEGREES C.)	NM		19.7
TOTAL DISSOLVED SOLIDS	(MG/L)	NM		83.
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	NM	<	0.1
VOLATILE DISSOLVED SOLIDS	(MG/L)	NM		28.
VOLATILE ORGANICS				
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	<	5.
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	<	5.
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	<	5.
1,1-DICHLOROETHANE	(PPB)	< 0.5	<	5.
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	<	5.
1,2-DICHLOROETHANE	(PPB)	< 0.25	<	5.
1,2-DICHLOROPROPANE	(PPB)	< 0.5	<	5.
2-BUTANONE (MEK)	(PPB)	NM	<	20.
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	<	10.
2-HEXANONE	(PPB)	NM	<	20.
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	<	10.
ACETONE	(PPB)	NM	<	20.
BENZENE	(PPB)	NM	<	5.
BROMODICHLOROMETHANE	(PPB)	< 0.5	<	5.
BROMOFORM	(PPB)	< 0.5	<	5.
BROMOMETHANE	(PPB)	NM	<	10.
CARBON DISULFIDE	(PPB)	NM	<	5.
CARBON TETRACHLORIDE	(PPB)	< 0.25	<	5.
CHLOROBENZENE	(PPB)	< 0.5	<	5.
CHLOROETHANE	(PPB)	NM	<	10.
CHLOROFORM	(PPB)	1.	<	5.
CHLOROMETHANE	(PPB)	NM	<	10.
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	<	5.
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	<	5.
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	<	5.
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	<	10.
DICHLOROMETHANE	(PPB)	< 0.5	<	5.
ETHYLBENZENE	(PPB)	NM	<	5.
FREON 113	(PPB)	< 0.5	<	5.
META-XYLENE	(PPB)	NM	<	0.5
ORTHO-XYLENE	(PPB)	NM	<	0.5
PARA-XYLENE	(PPB)	NM	<	0.5
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	<	5.
TETRACHLOROETH[redacted]	(PPB)	< 0.5	<	5.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4375 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:	08/02/95		08/02/95		
	Time:	08:38		15:26		
	Sample Type:					
	Lab:	EL		EL		
MISCELLANEOUS (cont'd)	(Units)					
HYDROXIDE	(MG/L)	NM		0.		
N-NITROSODIMETHYLAMINE	(PPB)	NM	<	10.		
PH	(PH)	NM		7.9		
TEMPERATURE	(DEGREES C.)	NM		28.2		
TOTAL DISSOLVED SOLIDS	(MG/L)	NM		120.		
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	NM	<	0.1		
VOLATILE DISSOLVED SOLIDS	(MG/L)	NM		19.		
VOLATILE ORGANICS						
1,1,1-TRICHLOROETHANE	(PPB)	<	0.5	<	5.	
1,1,2,2-TETRACHLOROETHANE	(PPB)	<	0.5	<	5.	
1,1,2-TRICHLOROETHANE	(PPB)	<	0.5	<	5.	
1,1-DICHLOROETHANE	(PPB)	<	0.5	<	5.	
1,1-DICHLOROETHYLENE	(PPB)	<	0.5	<	5.	
1,2-DICHLOROETHANE	(PPB)	<	0.25	<	5.	
1,2-DICHLOROPROPANE	(PPB)	<	0.5	<	5.	
2-BUTANONE (MEK)	(PPB)	NM		<	20.	
2-CHLOROETHYL VINYL ETHER	(PPB)	NM		<	10.	
2-HEXANONE	(PPB)	NM		<	20.	
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM		<	10.	
ACETONE	(PPB)	NM		<	20.	
BENZENE	(PPB)	NM		<	5.	
BROMODICHLOROMETHANE	(PPB)	<	0.5	<	5.	
BROMOFORM	(PPB)	<	0.5	<	5.	
BROMOMETHANE	(PPB)	NM		<	10.	
CARBON DISULFIDE	(PPB)	NM		<	5.	
CARBON TETRACHLORIDE	(PPB)	<	0.25	<	5.	
CHLOROBENZENE	(PPB)	<	0.5	<	5.	
CHLOROETHANE	(PPB)	NM		<	10.	
CHLOROFORM	(PPB)	<	0.5	<	5.	
CHLOROMETHANE	(PPB)	NM		<	10.	
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM		<	5.	
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	<	0.5	<	5.	
DIBROMOCHLOROMETHANE	(PPB)	<	0.5	<	5.	
DICHLORODIFLUOROMETHANE	(PPB)	<	0.5	<	10.	
DICHLOROMETHANE	(PPB)	<	0.5	<	5.	
ETHYLBENZENE	(PPB)	NM		<	5.	
FREON 113	(PPB)	<	0.5	<	5.	
META-XYLENE	(PPB)	NM		<	0.5	
ORTHO-XYLENE	(PPB)	NM		<	0.5	
PARA-XYLENE	(PPB)	NM		<	0.5	
T-1,3-DICHLOROPROPYLENE	(PPB)	NM		<	5.	
TETRACHLOROETHYLENE	(PPB)	<	0.5	<	5.	

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4375 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

		Sample Date:	08/02/95		08/02/95
		Time:	08:38		15:26
		Sample Type:			
		Lab:	EL		EL
VOLATILE ORGANICS (cont'd)	(Units)				
TOLUENE	(PPB)		NM	<	5.
TRICHLOROETHYLENE	(PPB)		9.7		14.
TRICHLOROFLUOROMETHANE	(PPB)	<	0.5	<	5.
VINYL ACETATE	(PPB)		NM	<	10.
VINYL CHLORIDE	(PPB)	<	0.25	<	10.
XYLENES (TOTAL)	(PPB)		NM	<	5.

AEROJET Environmental Operations
Water Quality Information

May 22, 1996

Well: 4380 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

		Sample Date:	07/17/95		07/17/95		08/29/95
		Time:	10:10		15:20		15:02
		Sample Type:					
		Lab:	EL		EL		EL
METALS	(Units)						
ALUMINUM	(MG/L)	NM			0.28	<	0.16
ANTIMONY	(MG/L)	NM	<		0.44	<	0.44
ARSENIC	(MG/L)	NM	<		0.089	<	0.088
BARIUM	(MG/L)	NM			0.054		0.17
BERYLLIUM	(MG/L)	NM	<		0.0011	<	0.0011
BORON	(MG/L)	NM	<		0.044	<	0.044
CADMIUM	(MG/L)	NM	<		0.0044	<	0.0044
CHROMIUM	(MG/L)	NM	<		0.0089	<	0.0088
COBALT	(MG/L)	NM	<		0.0089	<	0.0088
COPPER	(MG/L)	NM	<		0.0067	<	0.0066
IRON	(MG/L)	NM	<		0.33	<	0.33
LEAD	(MG/L)	NM	<		0.067	<	0.066
MERCURY	(MG/L)	NM	<		0.0002	<	0.0002
MOLYBDENUM	(MG/L)	NM	<		0.044	<	0.044
NICKEL	(MG/L)	NM	<		0.022	<	0.022
SELENIUM	(MG/L)	NM	<		0.11	<	0.11
SILVER	(MG/L)	NM	<		0.022	<	0.022
THALLIUM	(MG/L)	NM	<		0.056	<	0.055
VANADIUM	(MG/L)	NM			0.0096		0.0084
ZINC	(MG/L)	NM	<		0.11	<	0.11
MINERALS, INORGANICS							
BICARBONATE	(MG/L)	NM			110.		240.
CALCIUM	(MG/L)	NM			27.		69.
CARBONATE	(MG/L)	NM			0.		0.
CHLORIDE	(MG/L)	NM			7.5		140.
MAGNESIUM	(MG/L)	NM			9.5		28.
MANGANESE	(MG/L)	NM			0.0068	<	0.0055
NITRATE	(MG/L)	NM			6.		21.
NITRITE	(MG/L)	NM	<		0.05	<	0.25
O-PHOSPHATE	(MG/L)	NM			0.26		0.46
PERCHLORATE	(MG/L)	NM	<		0.4	<	0.4
POTASSIUM	(MG/L)	NM			3.9		4.
SODIUM, TOTAL	(MG/L)	NM			13.		64.
SULFATE	(MG/L)	NM			8.2		20.
SULFITE	(MG/L)	NM	<		10.	<	10.
TOTAL ALKALINITY AS CACO3	(MG/L)	NM			110.		240.
TOTAL SOLIDS	(MG/L)	NM			190.		540.
MISCELLANEOUS							
CHEM. OXYGEN DEMAND (COD)	(MG/L)	NM	<		3.	<	3.
CONDUCTANCE	(UMHOS/CM)	NM			230.		770.

AEROJET Environmental Operations
Water Quality Information

Well: 4380 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:	07/17/95	07/17/95	08/29/95
	Time:	10:10	15:20	15:02
	Sample Type:			
	Lab:	EL	EL	EL
MISCELLANEOUS (cont'd)	(Units)			
HYDROXIDE	(MG/L)	NM	0.	0.
N-NITROSODIMETHYLAMINE	(PPB)	NM	< 10.	NM
PH	(PH)	NM	8.	7.1
TEMPERATURE	(DEGREES C.)	NM	20.3	19.7
TOTAL DISSOLVED SOLIDS	(MG/L)	NM	190.	490.
TOTAL PETROLEUM HYDROCARBONS	(MG/L)	NM	< 0.1	NM
VOLATILE DISSOLVED SOLIDS	(MG/L)	NM	24.	76.
VOLATILE ORGANICS				
1,1,1-TRICHLOROETHANE	(PPB)	< 0.5	< 5.	NM
1,1,2,2-TETRACHLOROETHANE	(PPB)	< 0.5	< 5.	NM
1,1,2-TRICHLOROETHANE	(PPB)	< 0.5	< 5.	NM
1,1-DICHLOROETHANE	(PPB)	< 0.5	< 5.	NM
1,1-DICHLOROETHYLENE	(PPB)	< 0.5	< 5.	NM
1,2-DICHLOROETHANE	(PPB)	< 0.25	< 5.	NM
1,2-DICHLOROPROPANE	(PPB)	< 0.5	< 5.	NM
2-BUTANONE (MEK)	(PPB)	NM	< 20.	NM
2-CHLOROETHYL VINYL ETHER	(PPB)	NM	< 10.	NM
2-HEXANONE	(PPB)	NM	< 20.	NM
4-METHYL-2-PENTANONE (MIBK)	(PPB)	NM	< 10.	NM
ACETONE	(PPB)	NM	< 20.	NM
BENZENE	(PPB)	NM	< 5.	NM
BROMODICHLOROMETHANE	(PPB)	< 0.5	< 5.	NM
BROMOFORM	(PPB)	< 0.5	< 5.	NM
BROMOMETHANE	(PPB)	NM	< 10.	NM
CARBON DISULFIDE	(PPB)	NM	< 5.	NM
CARBON TETRACHLORIDE	(PPB)	< 0.25	< 5.	NM
CHLOROBENZENE	(PPB)	< 0.5	< 5.	NM
CHLOROETHANE	(PPB)	NM	< 10.	NM
CHLOROFORM	(PPB)	< 0.5	< 5.	NM
CHLOROMETHANE	(PPB)	NM	< 10.	NM
CIS-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM
CIS/TRANS-1,2-DICHLOROETHYLENE	(PPB)	< 0.5	< 5.	NM
DIBROMOCHLOROMETHANE	(PPB)	< 0.5	< 5.	NM
DICHLORODIFLUOROMETHANE	(PPB)	< 0.5	< 10.	NM
DICHLOROMETHANE	(PPB)	< 0.5	< 5.	NM
ETHYLBENZENE	(PPB)	NM	< 5.	NM
FREON 113	(PPB)	< 0.5	< 5.	NM
META-XYLENE	(PPB)	NM	< 0.5	NM
ORTHO-XYLENE	(PPB)	NM	< 0.5	NM
PARA-XYLENE	(PPB)	NM	< 0.5	NM
T-1,3-DICHLOROPROPYLENE	(PPB)	NM	< 5.	NM
TETRACHLOROETHYLENE	(PPB)	< 0.5	< 5.	NM

AEROJET Environmental Operations
Water Quality Information

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Well: 4380 Well Type: EW Zone: 1 Sector: D GSE: TOC: TOP: BOP: TD:

	Sample Date:	07/17/95		07/17/95		08/29/95			
	Time:	10:10		15:20		15:02			
	Sample Type:								
	Lab:	EL		EL		EL			
VOLATILE ORGANICS (cont'd)	(Units)								
TOLUENE	(PPB)	NM		<	5.		NM		
TRICHLOROETHYLENE	(PPB)	<	0.5	<	5.		NM		
TRICHLOROFLUOROMETHANE	(PPB)	<	0.5	<	5.		NM		
VINYL ACETATE	(PPB)	NM		<	10.		NM		
VINYL CHLORIDE	(PPB)	<	0.25	<	10.		NM		
XYLENES (TOTAL)	(PPB)	NM		<	5.		NM		

APPENDIX E

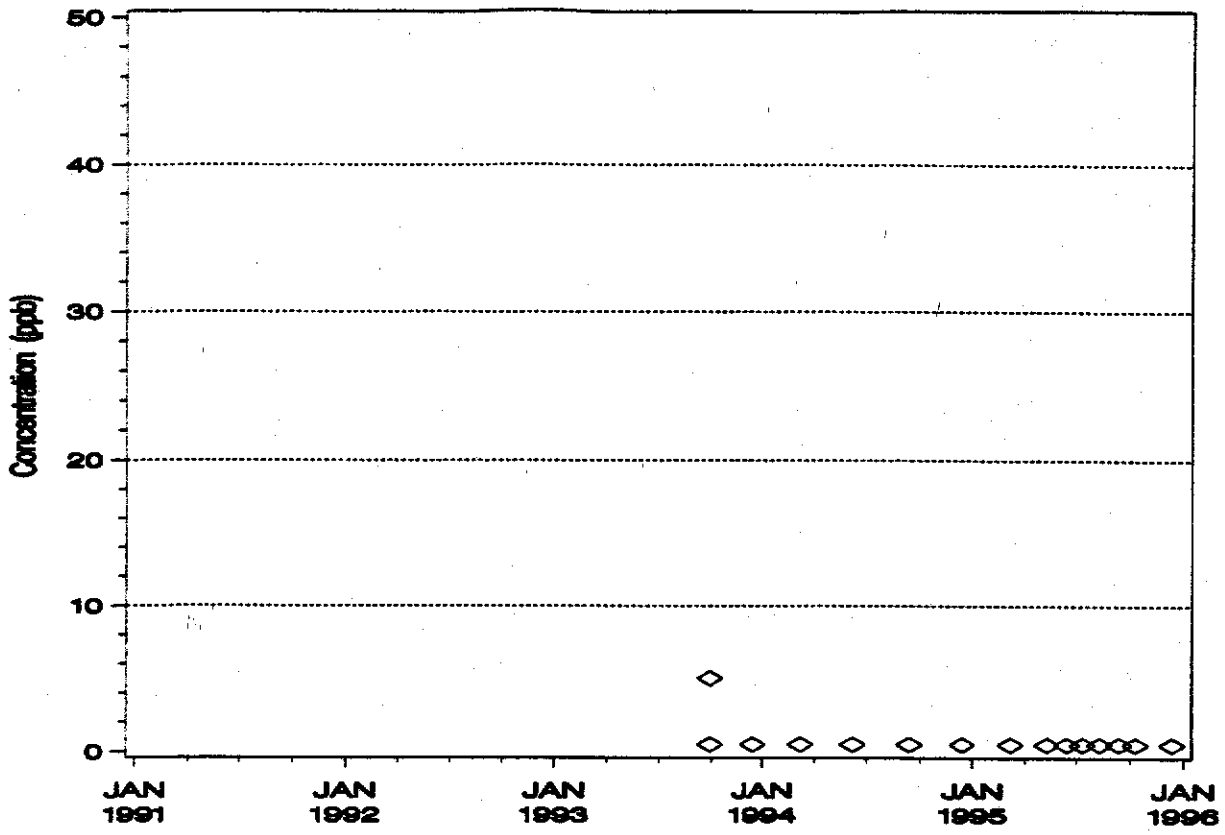
Chemical Trend Graphs

LEGEND

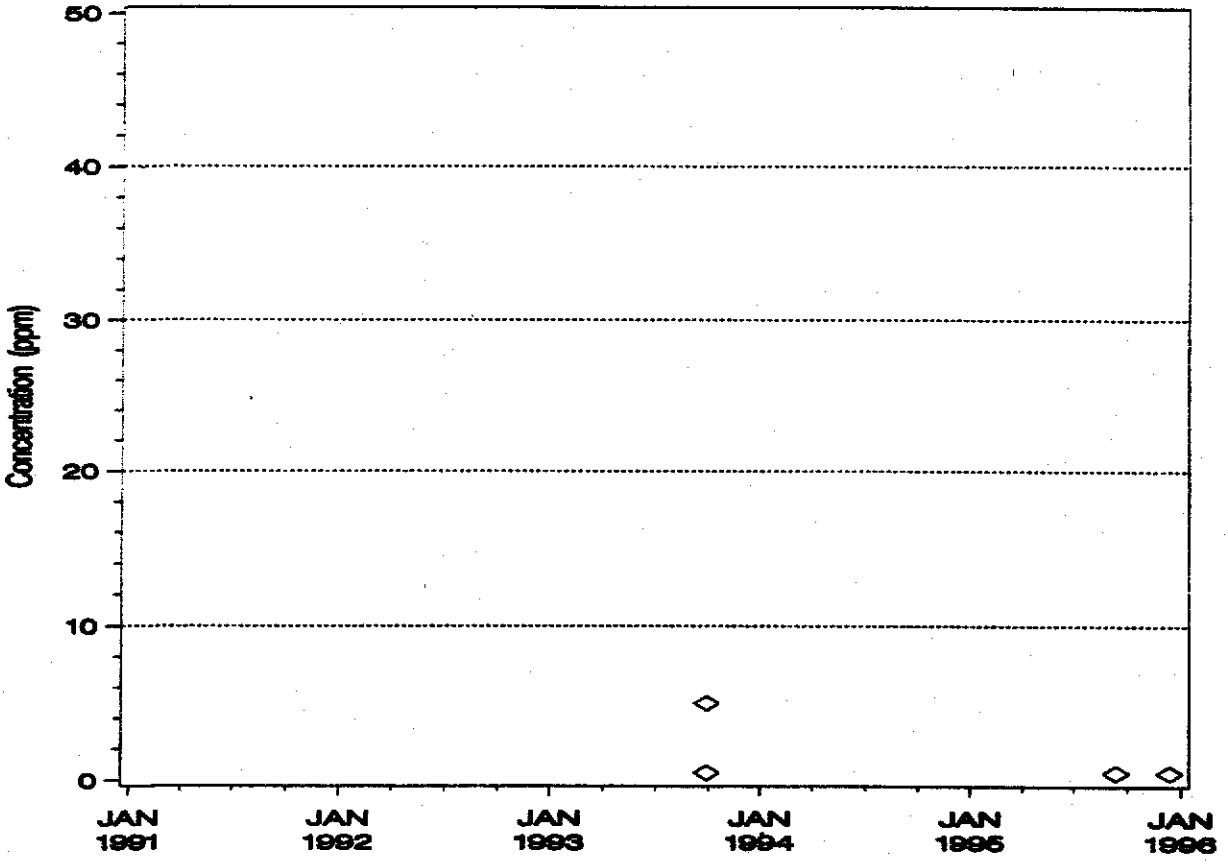
+	Chemical value less than detection limit
<>	Chemical value greater than or equal to detection limit

No data was available during the reporting period for Well 1041. All other wells are reported.

WELL 1047
TRICHLOROETHYLENE Trend

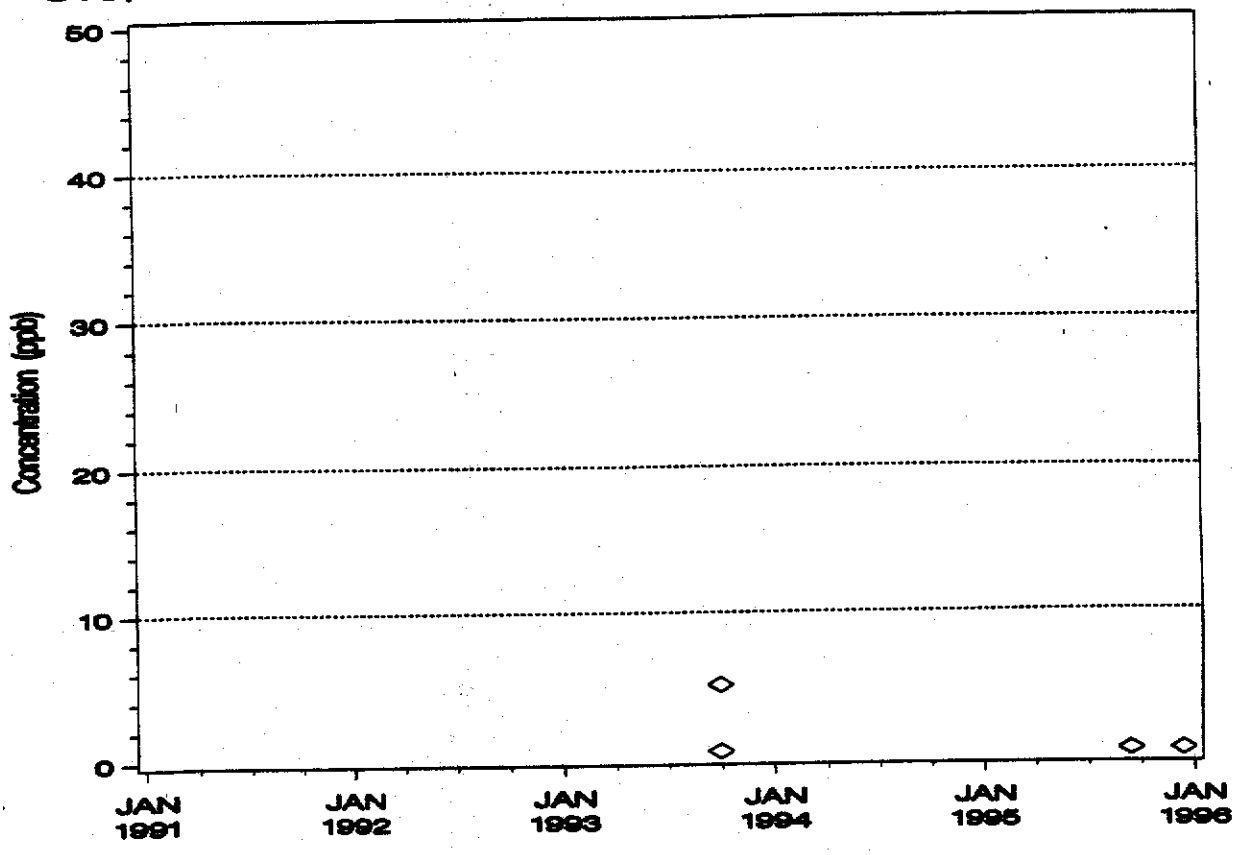


FREON 113 Trend

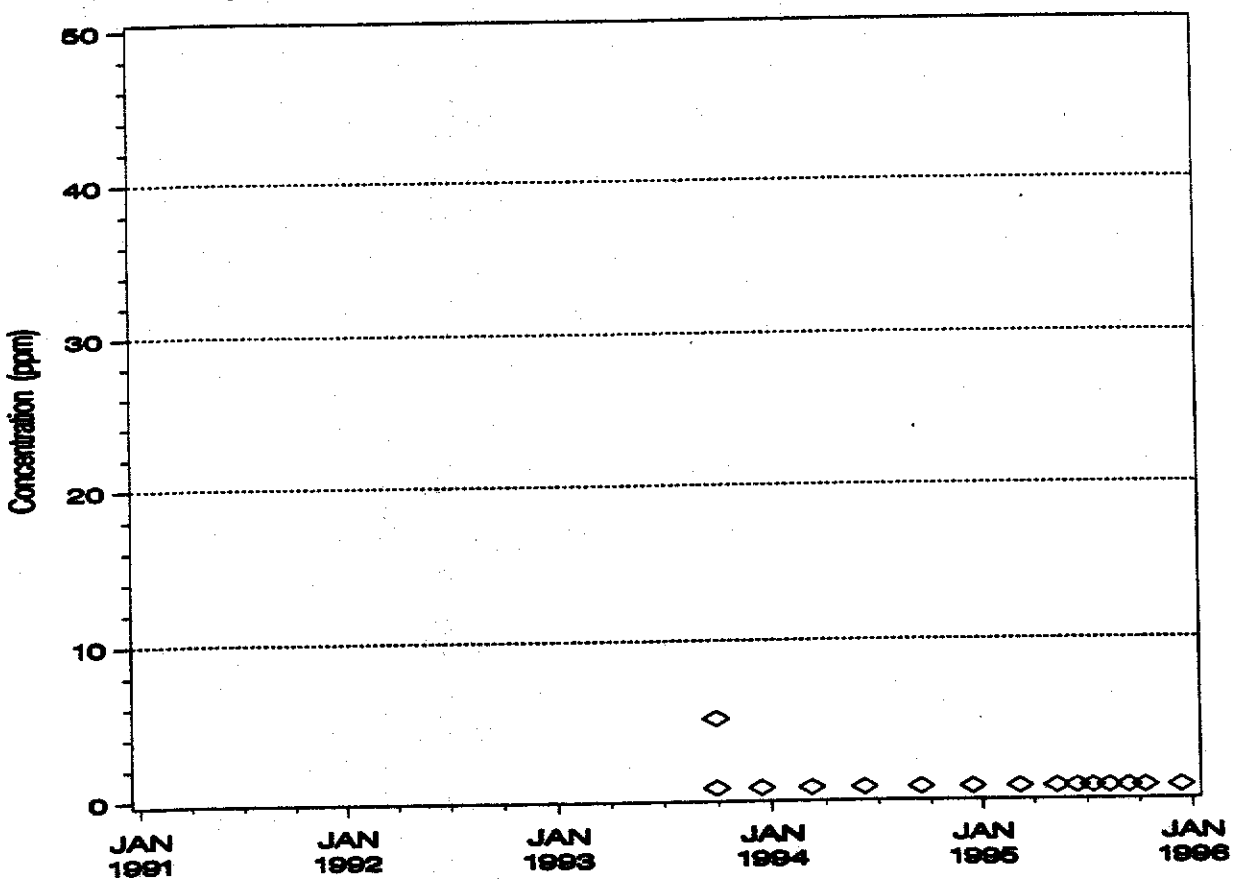


WELL 1047

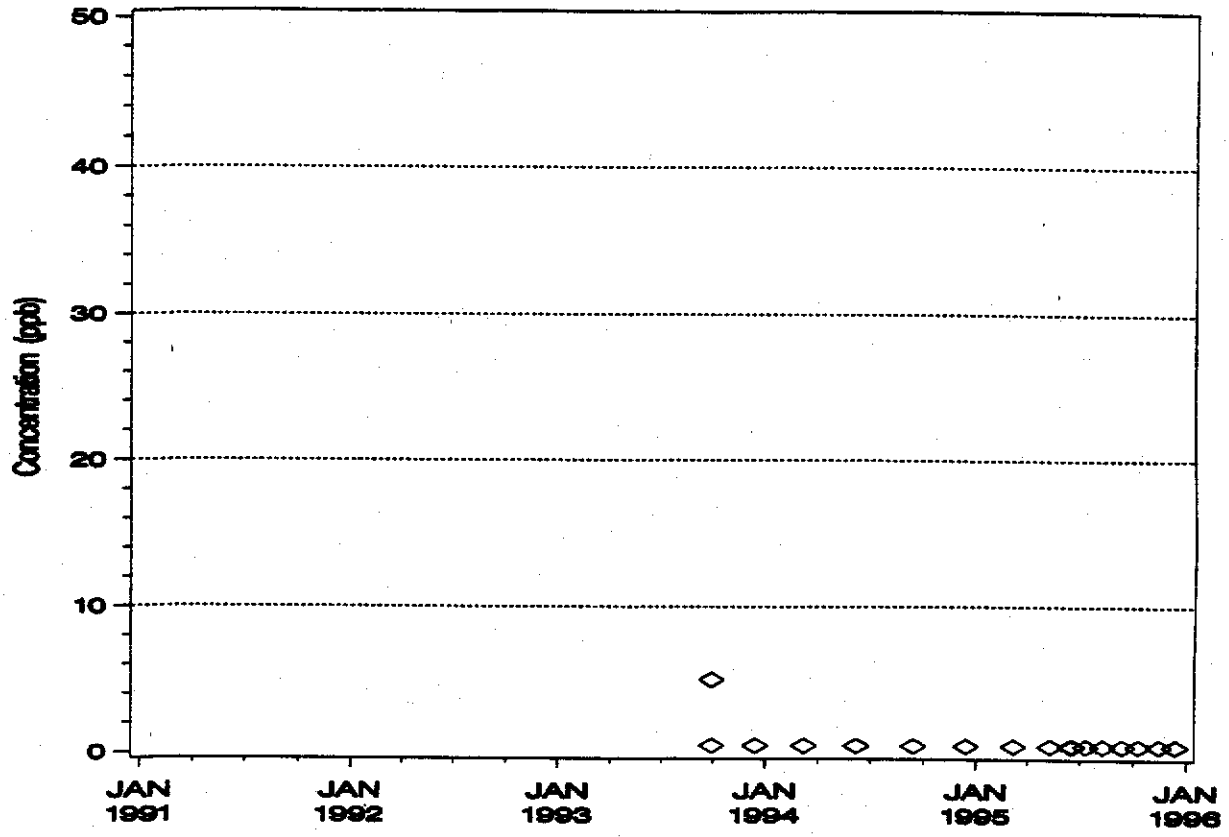
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



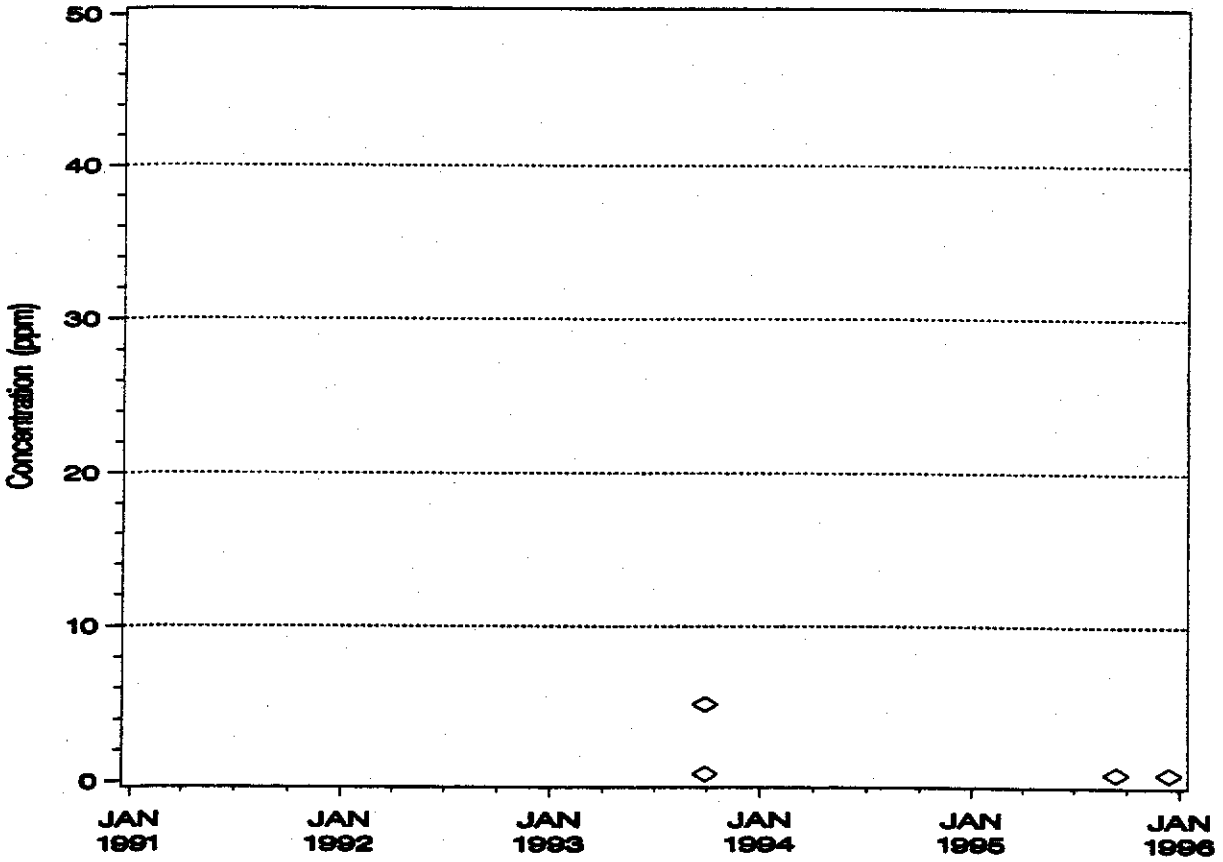
1,1 – DICHLOROETHYLENE Trend



WELL 1049
TRICHLOROETHYLENE Trend

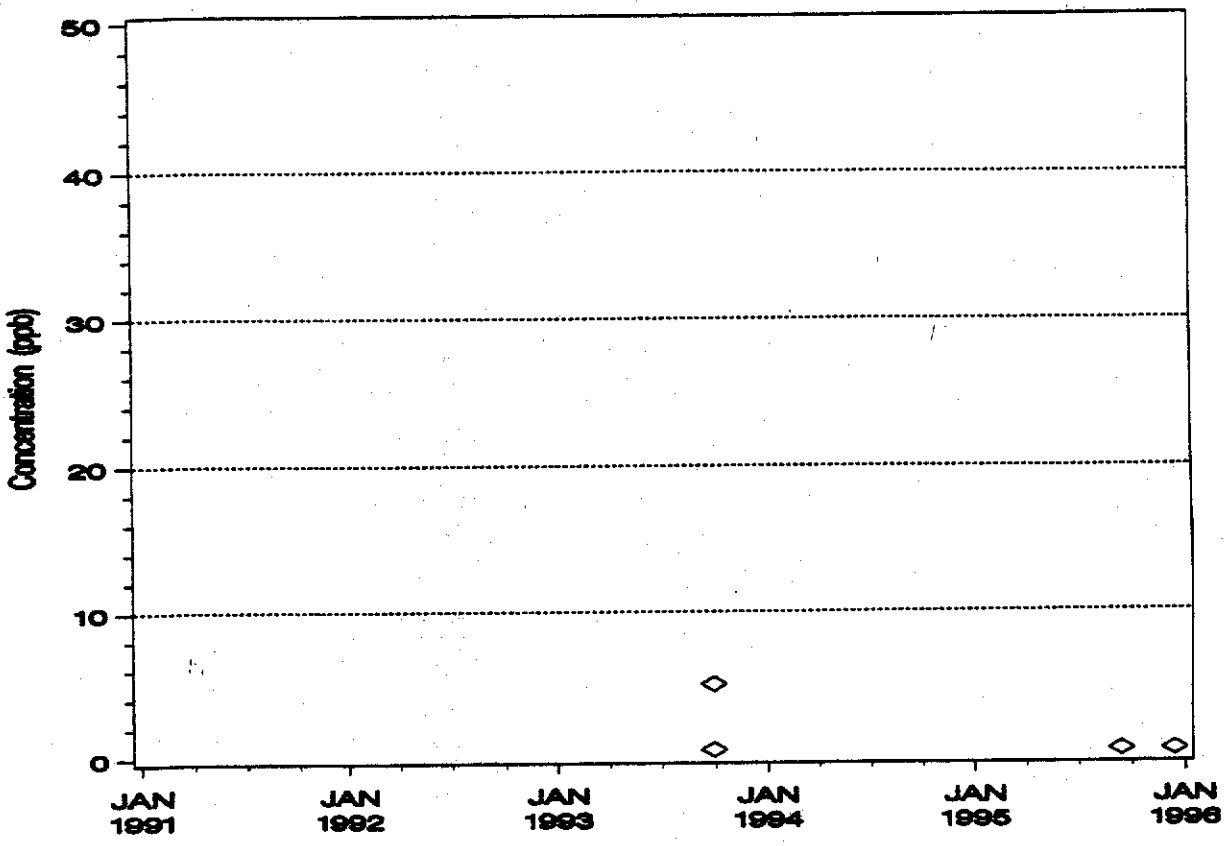


FREON 113 Trend

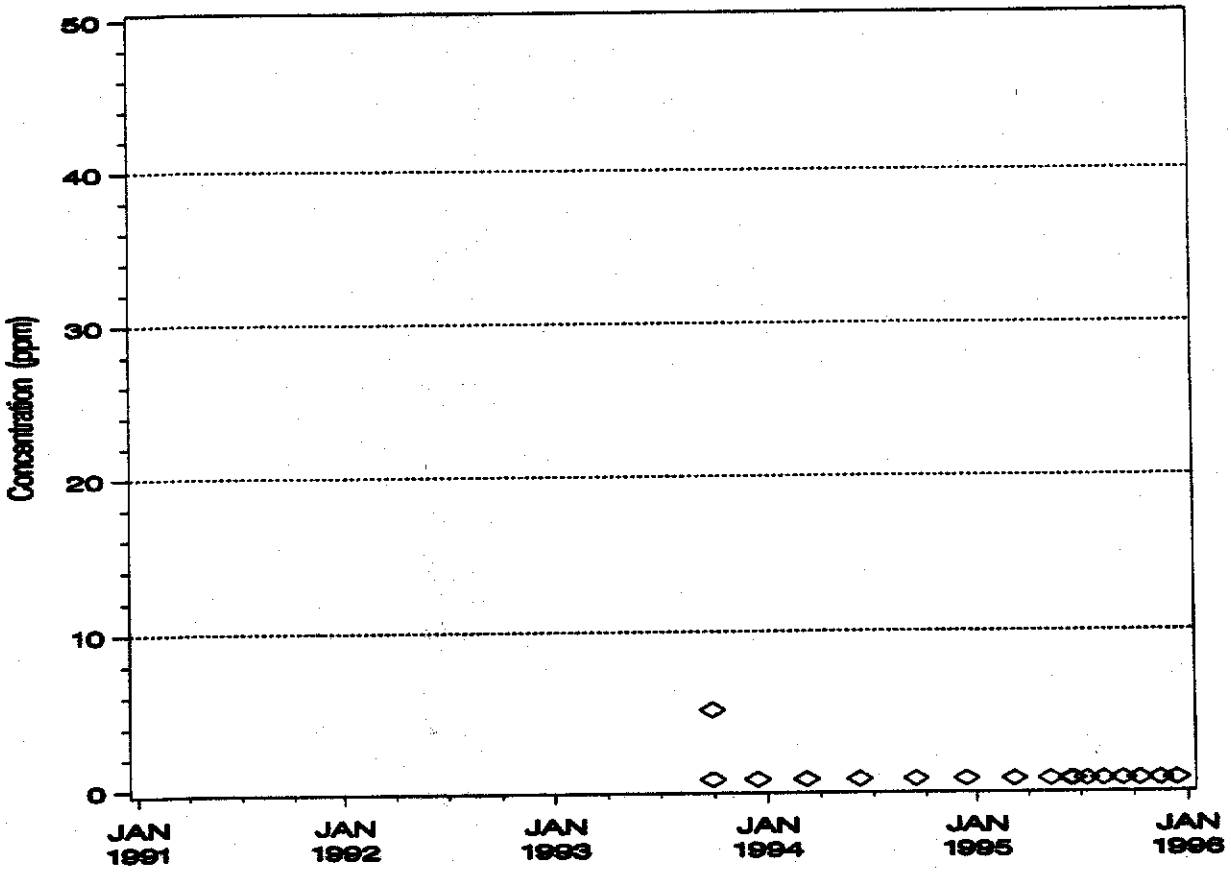


WELL 1049

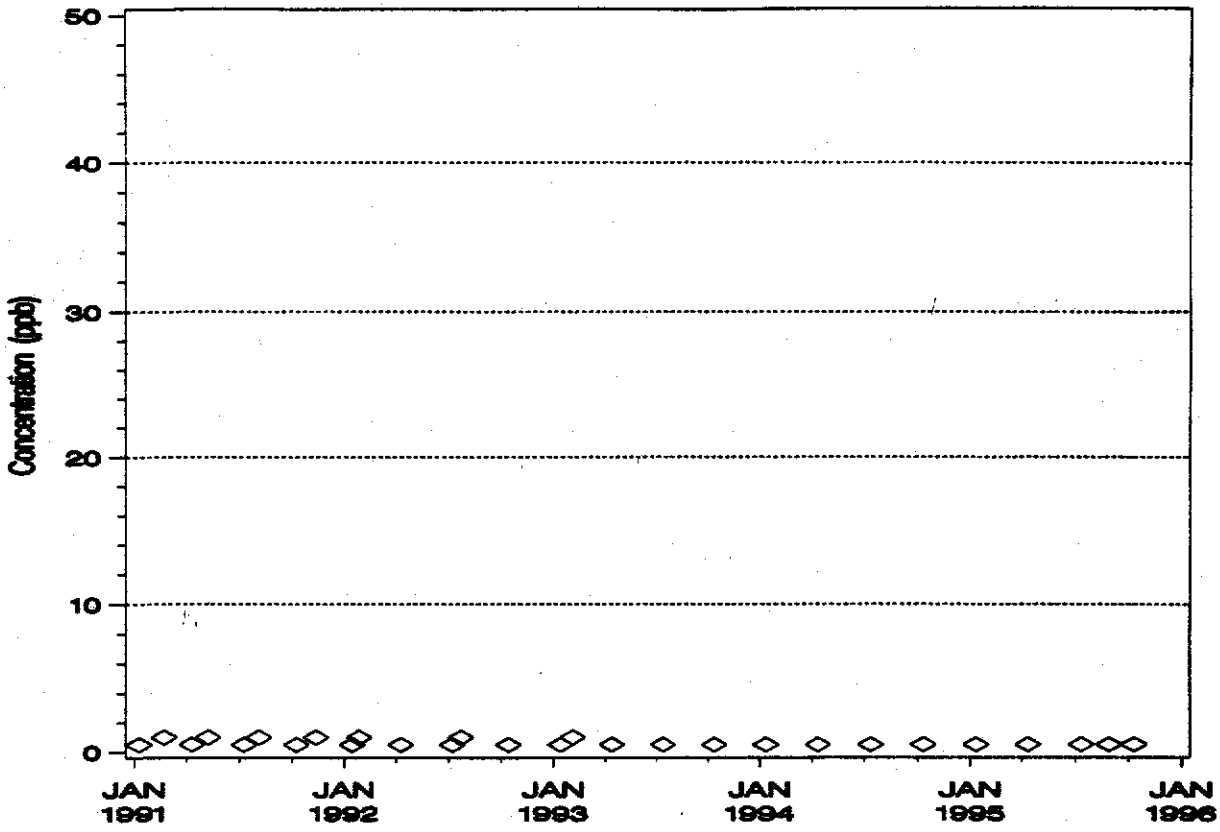
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



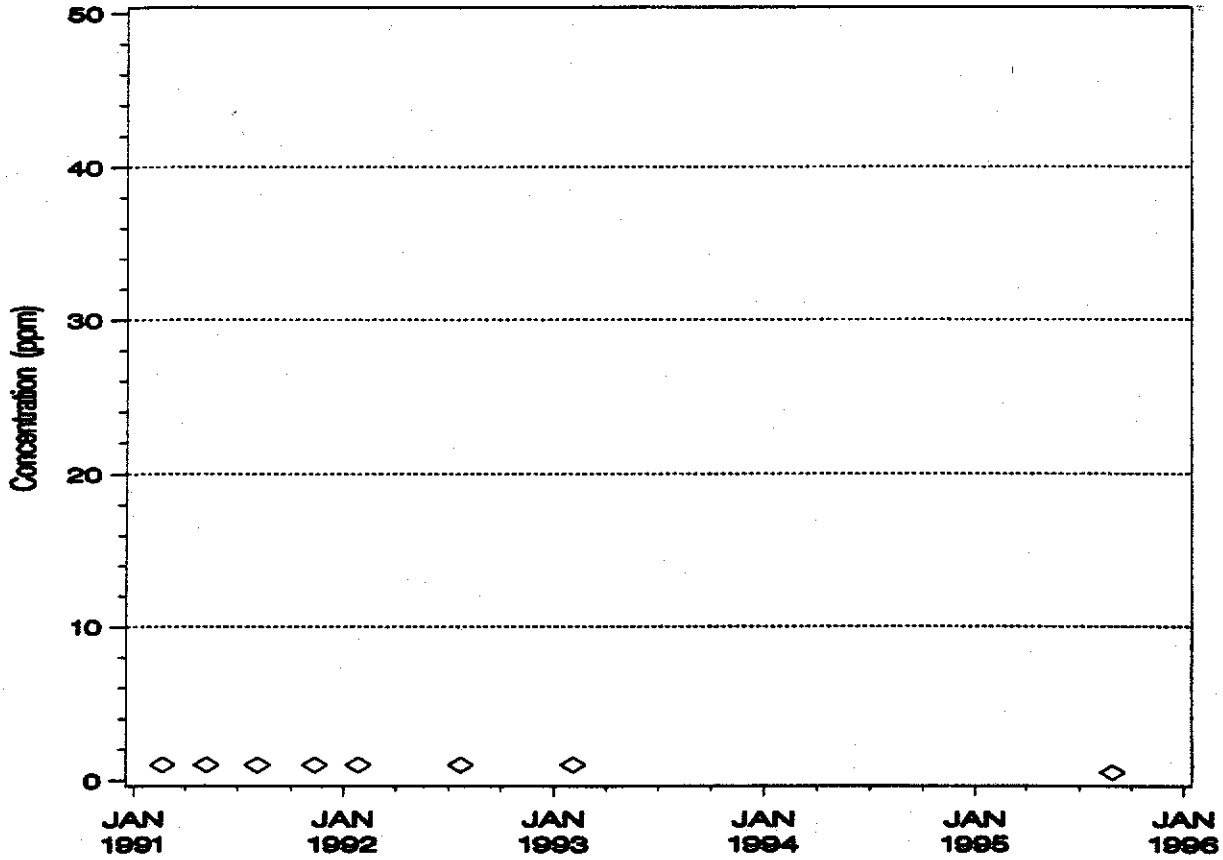
1,1 – DICHLOROETHYLENE Trend



WELL 1154
TRICHLOROETHYLENE Trend

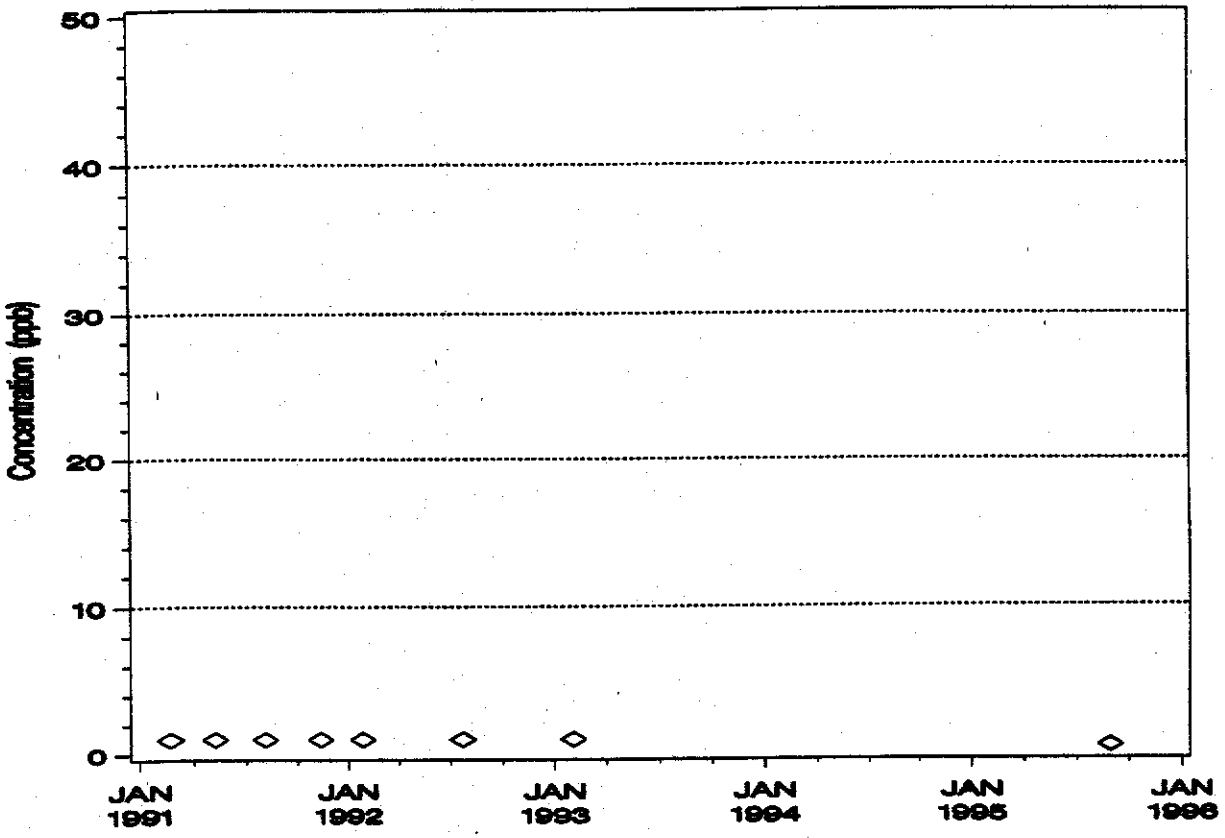


FREON 113 Trend

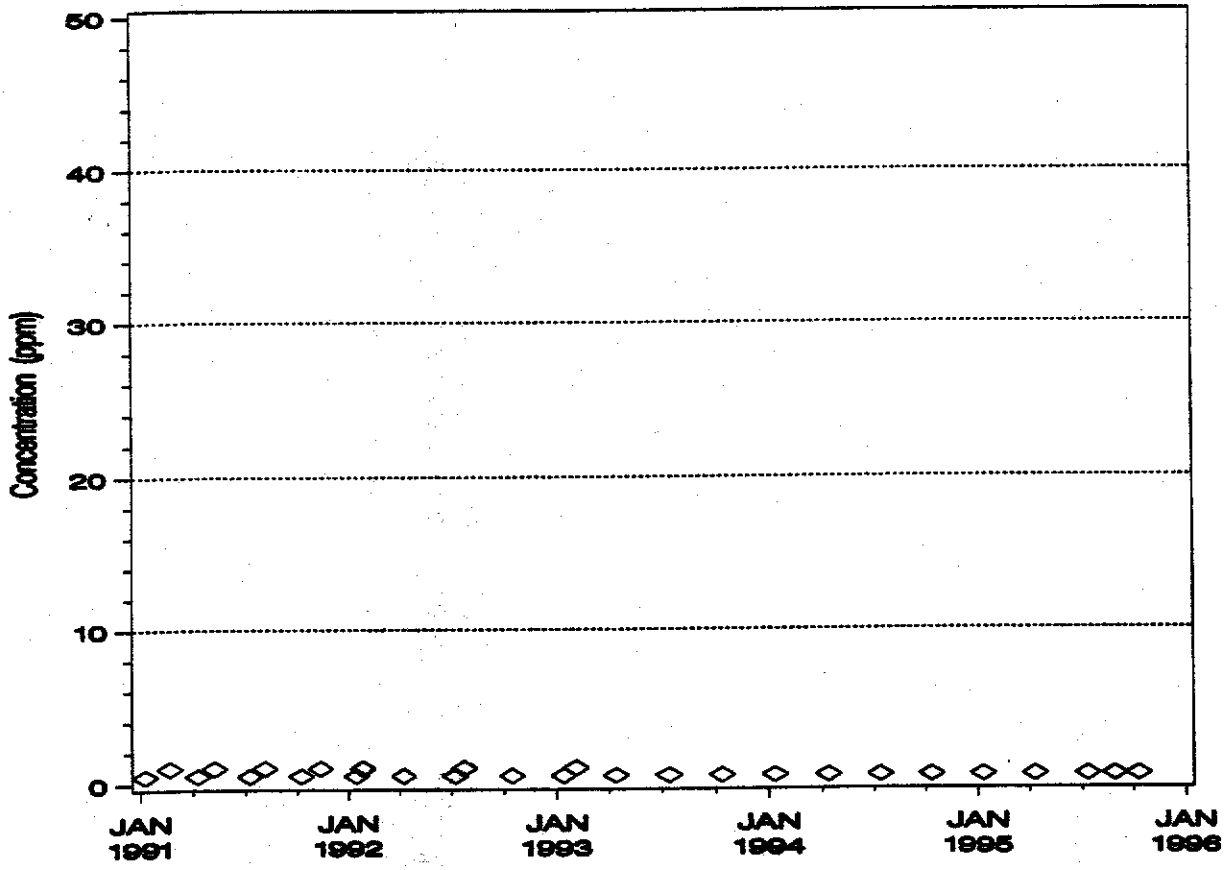


WELL 1154

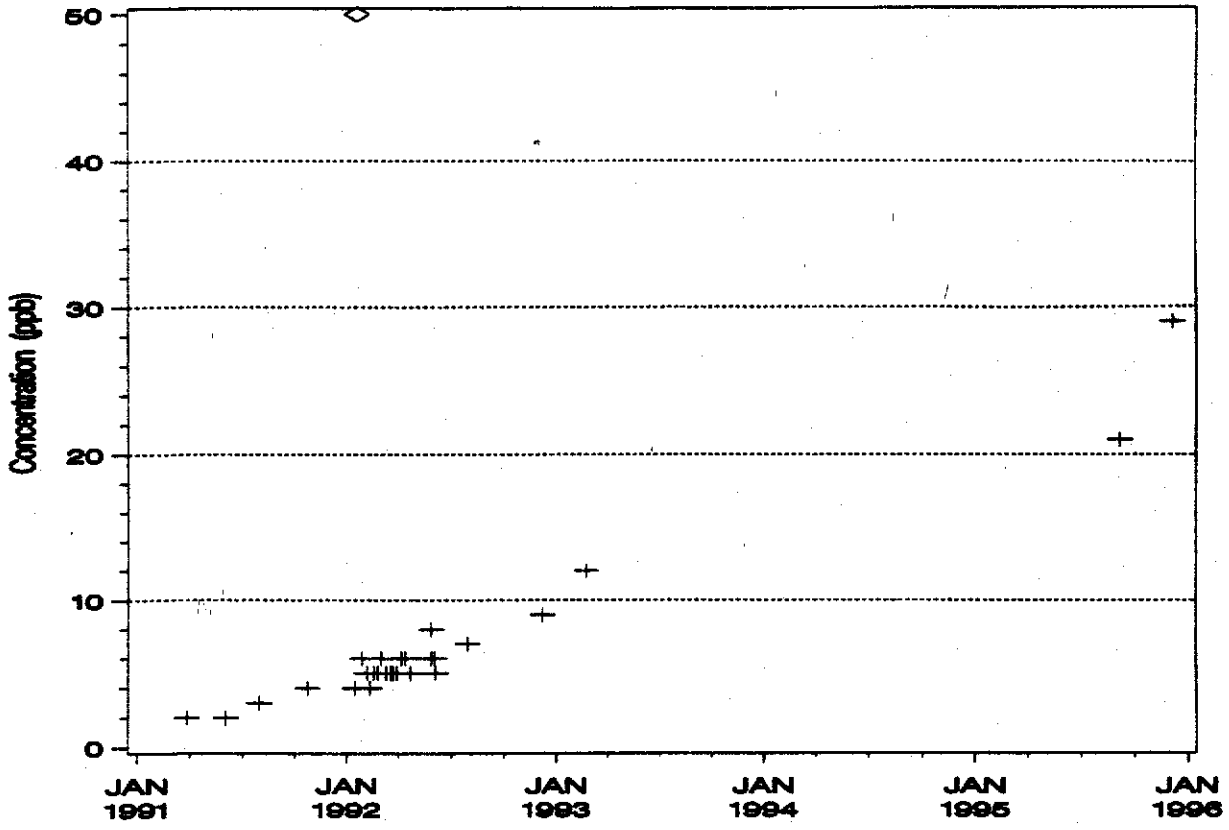
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



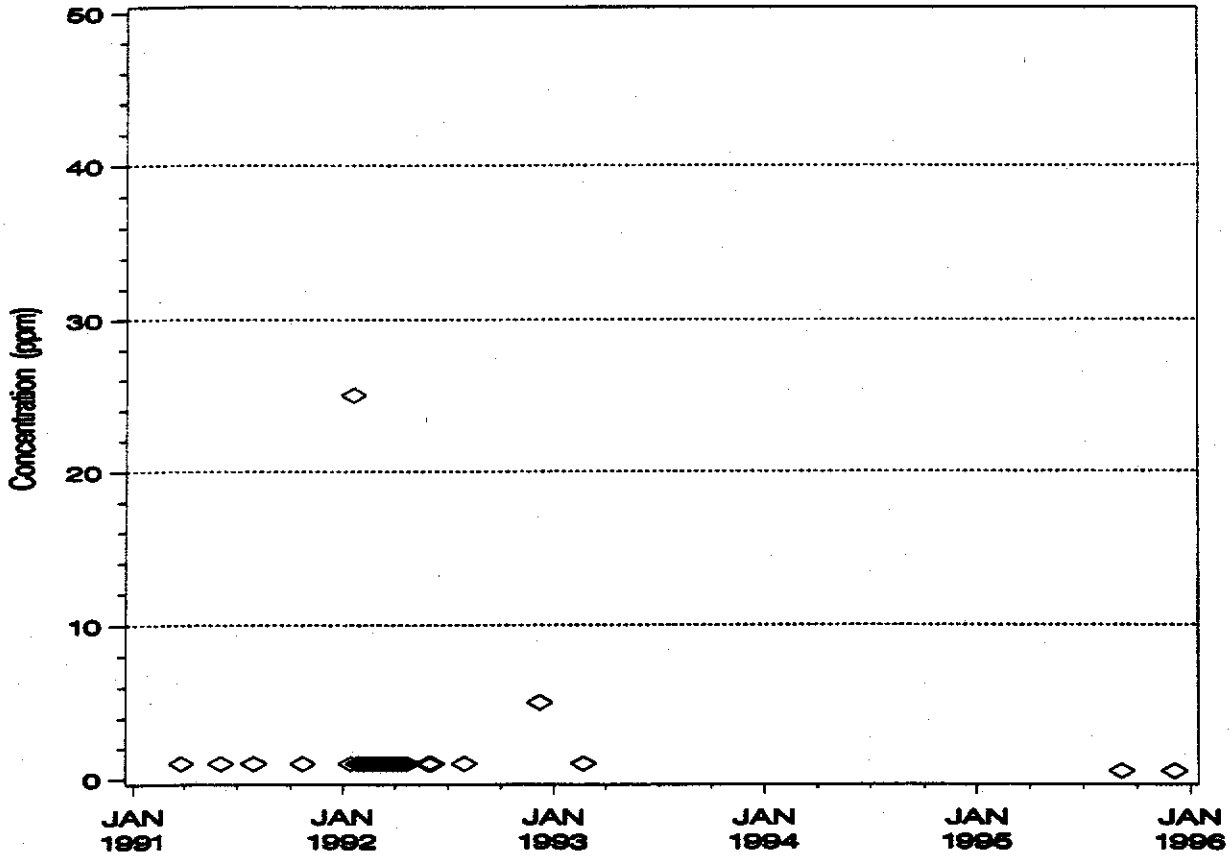
1,1 – DICHLOROETHYLENE Trend



WELL 1156
TRICHLOROETHYLENE Trend

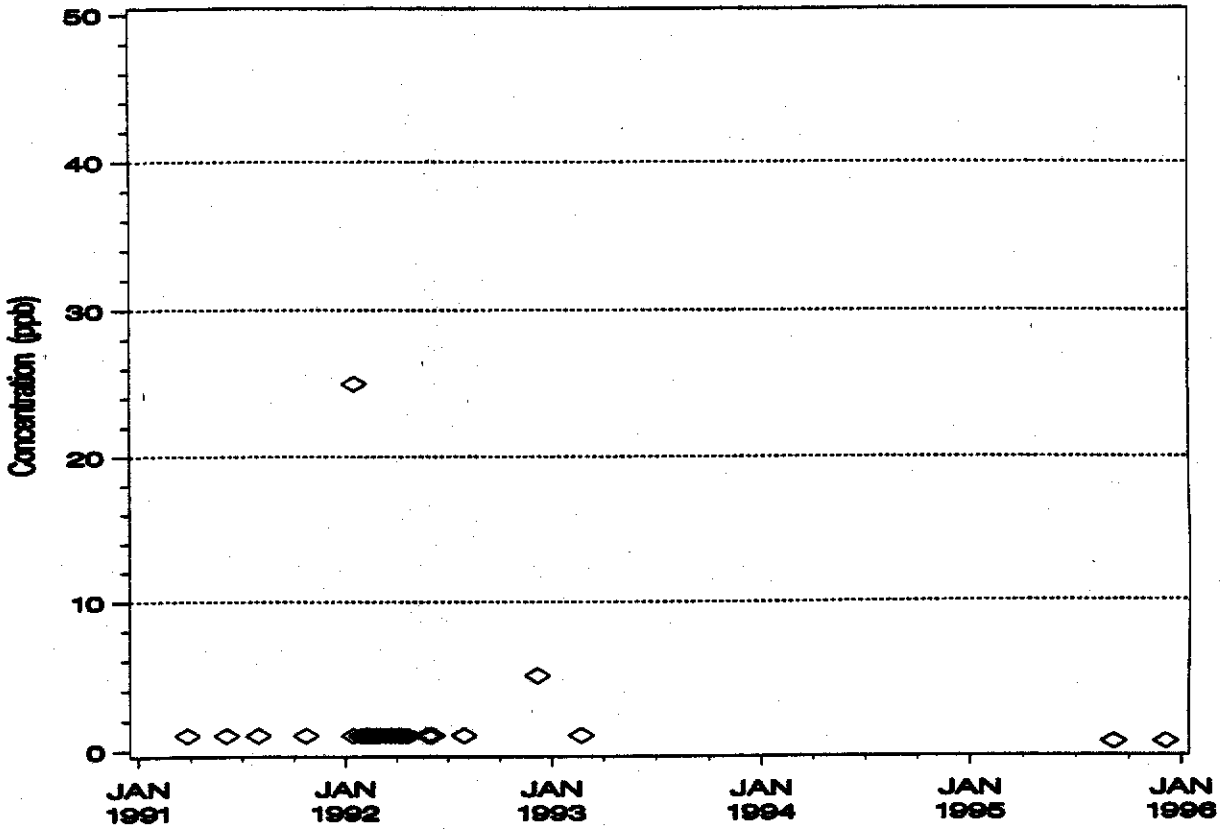


FREON 113 Trend

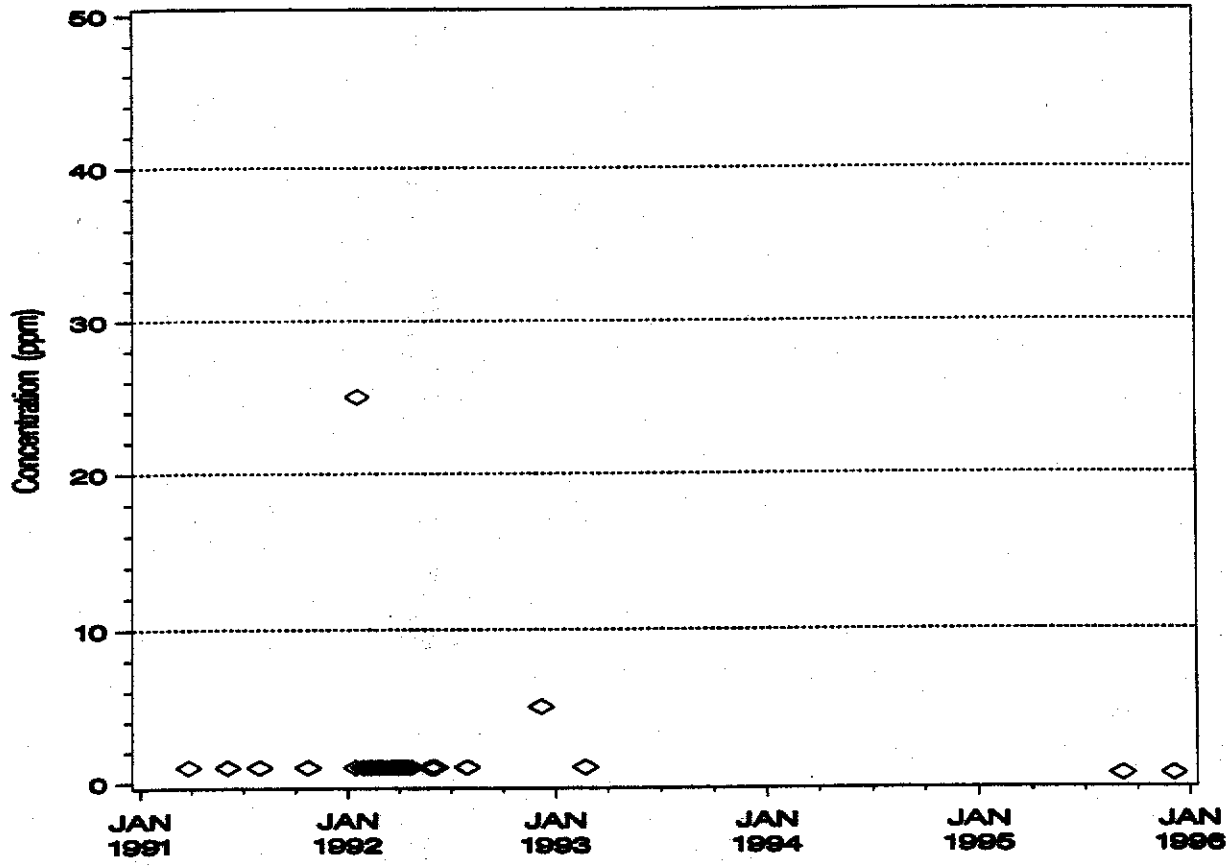


WELL 1156

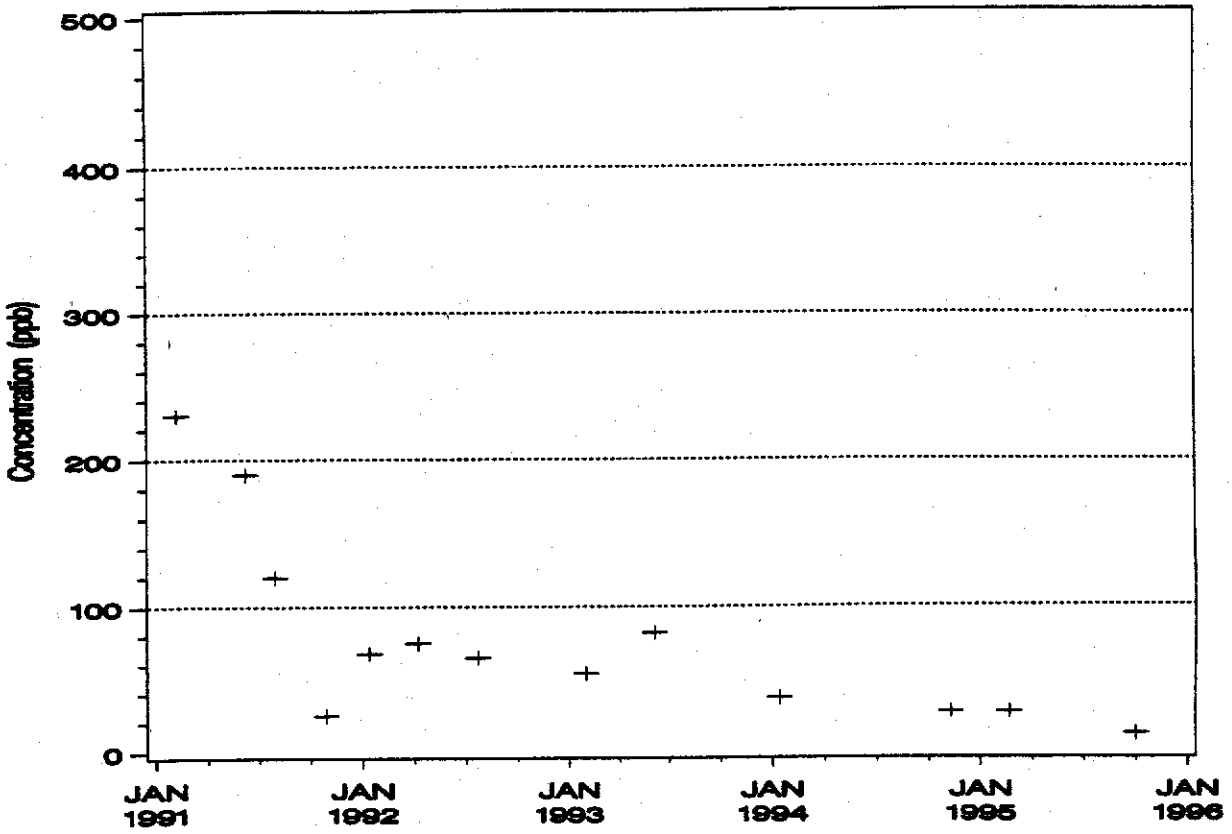
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



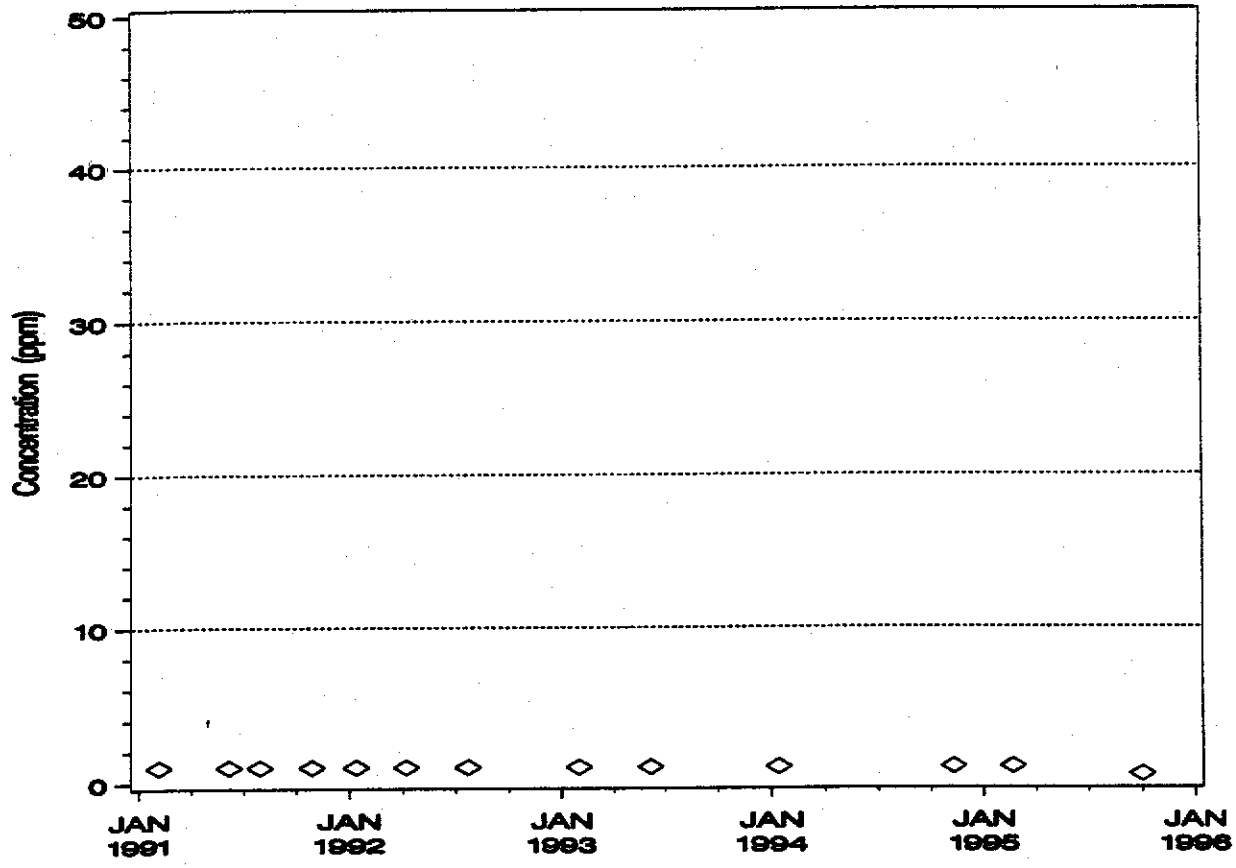
1,1 – DICHLOROETHYLENE Trend



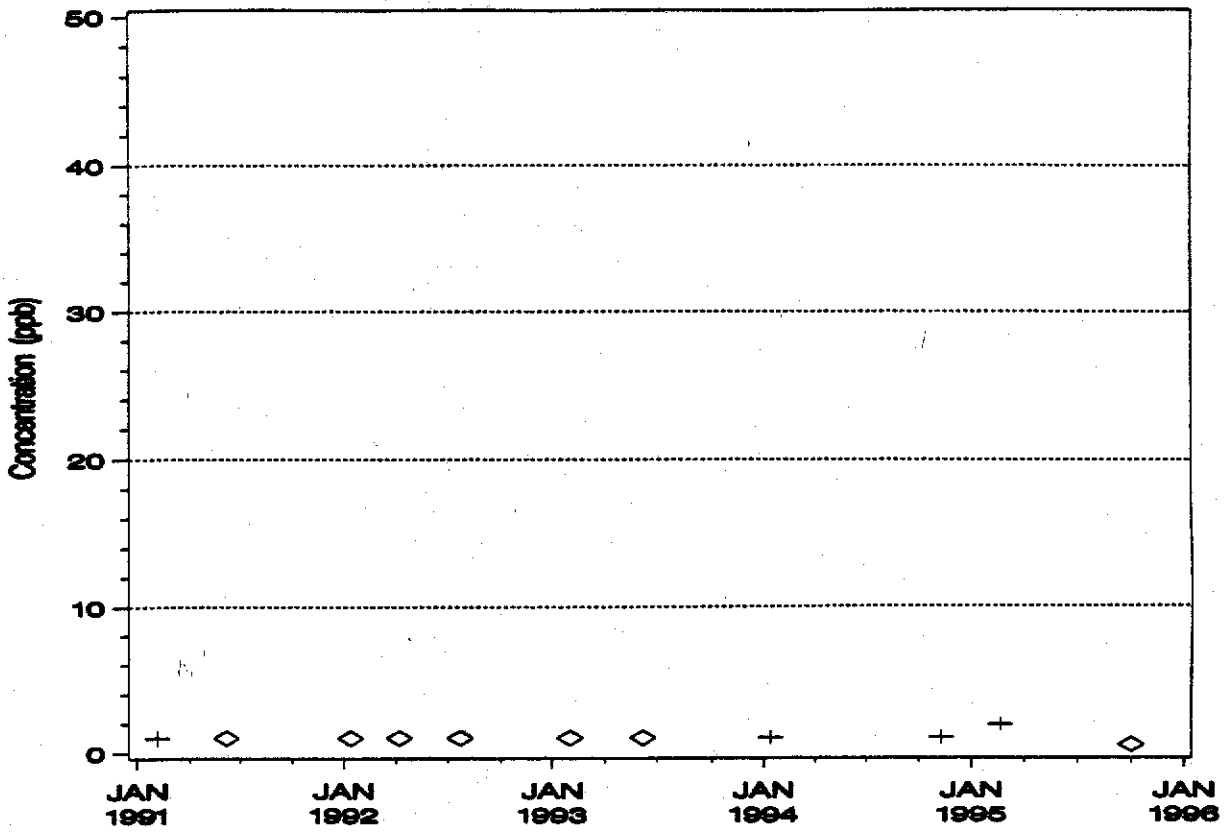
WELL 1162
TRICHLOROETHYLENE Trend



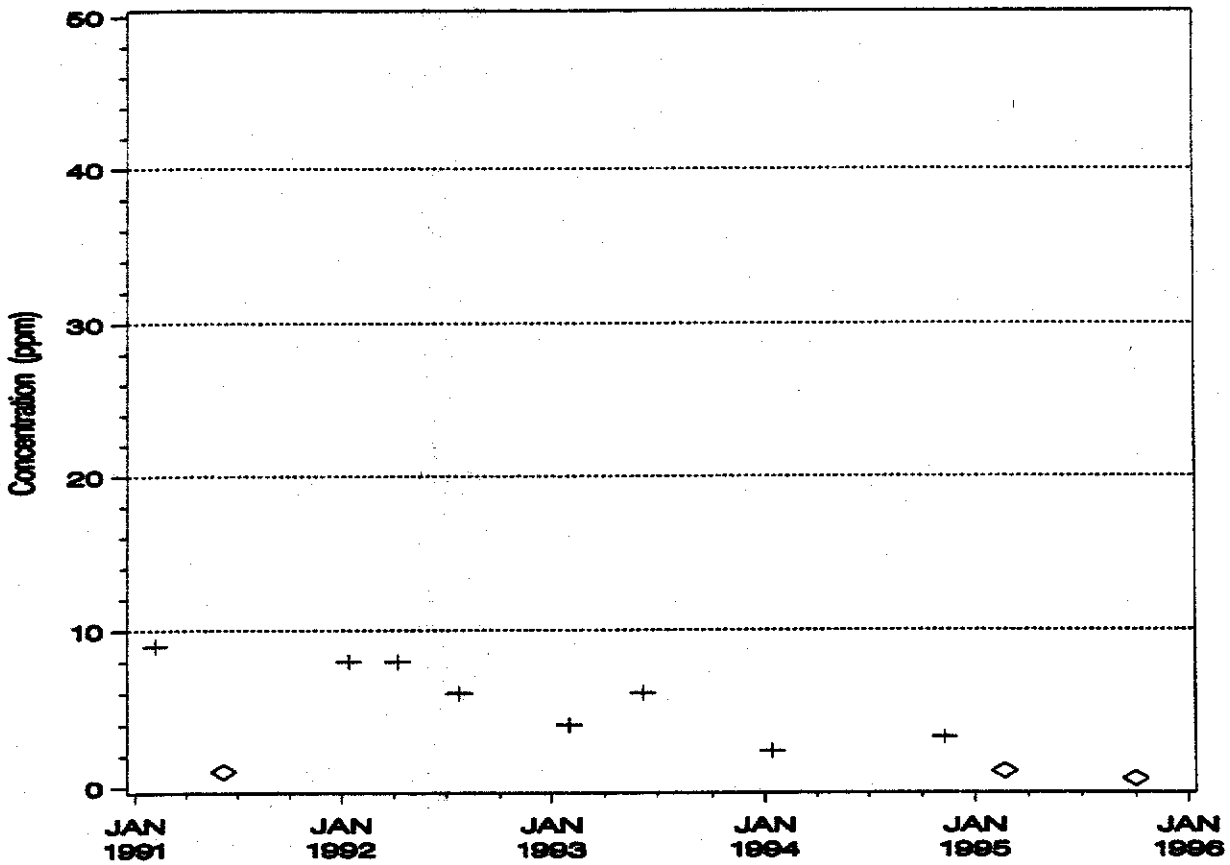
FREON 113 Trend



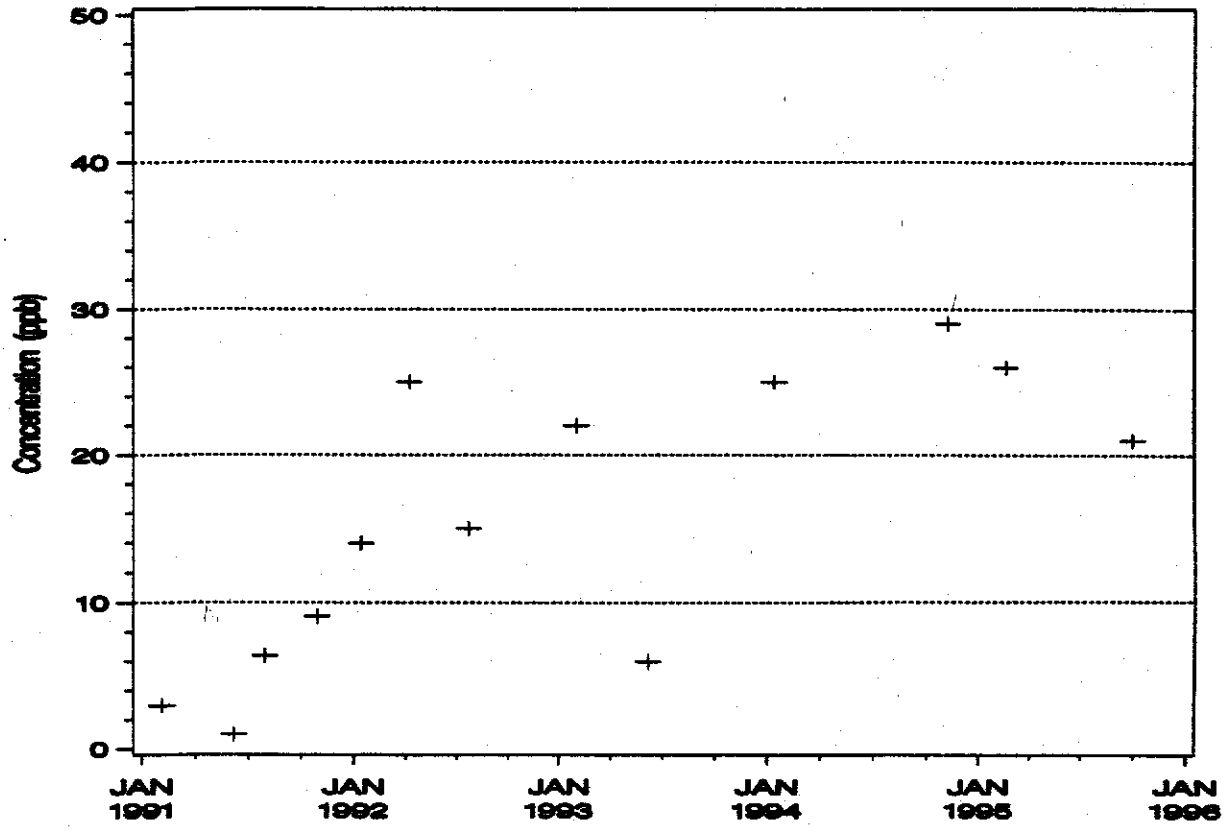
WELL 1162
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



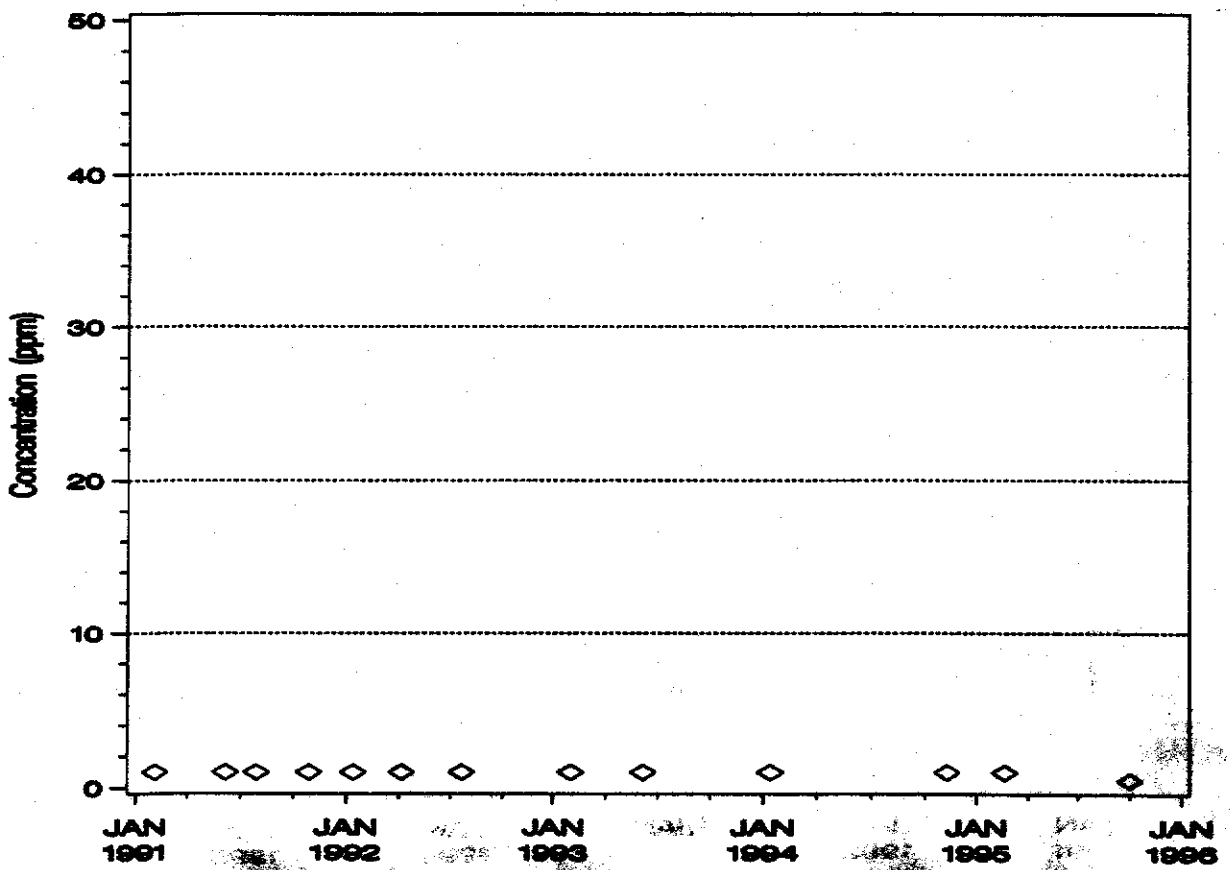
1,1 – DICHLOROETHYLENE Trend



WELL 1163
TRICHLOROETHYLENE Trend

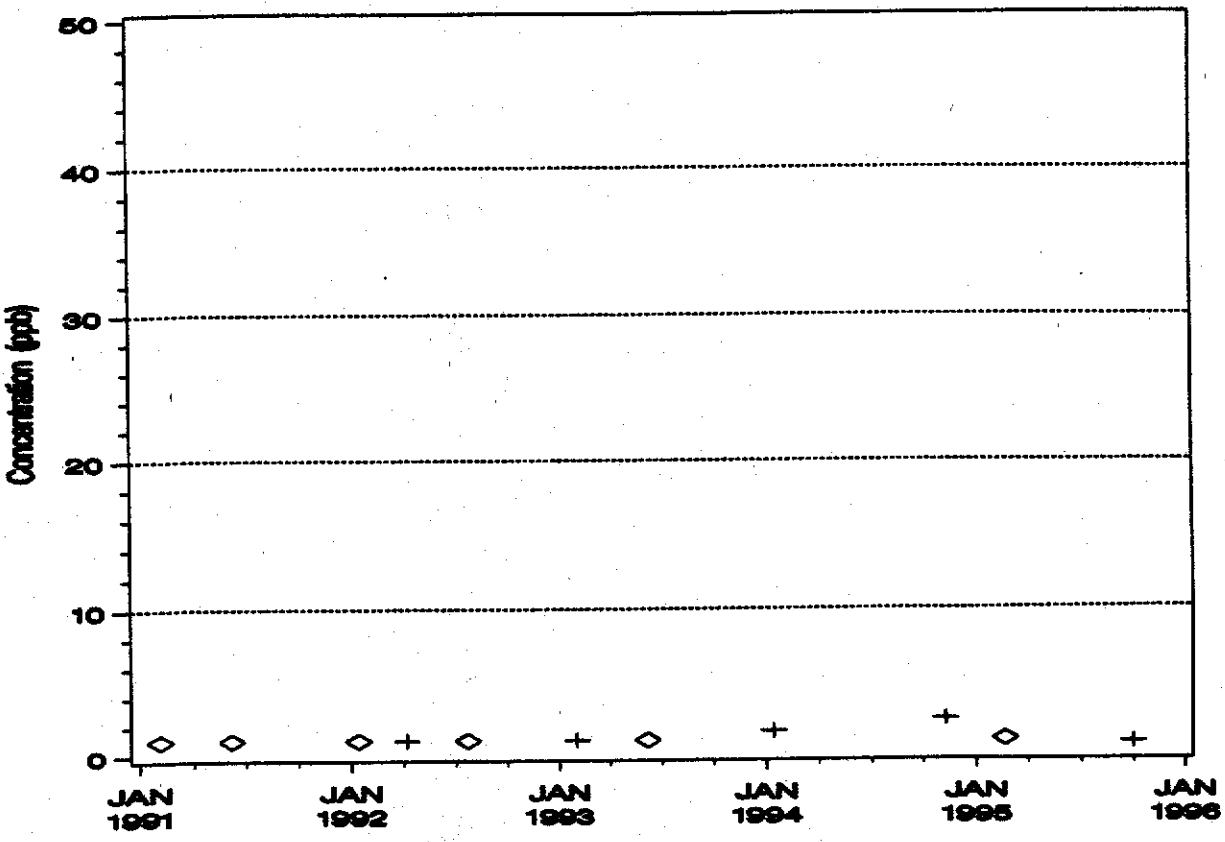


FREON 113 Trend

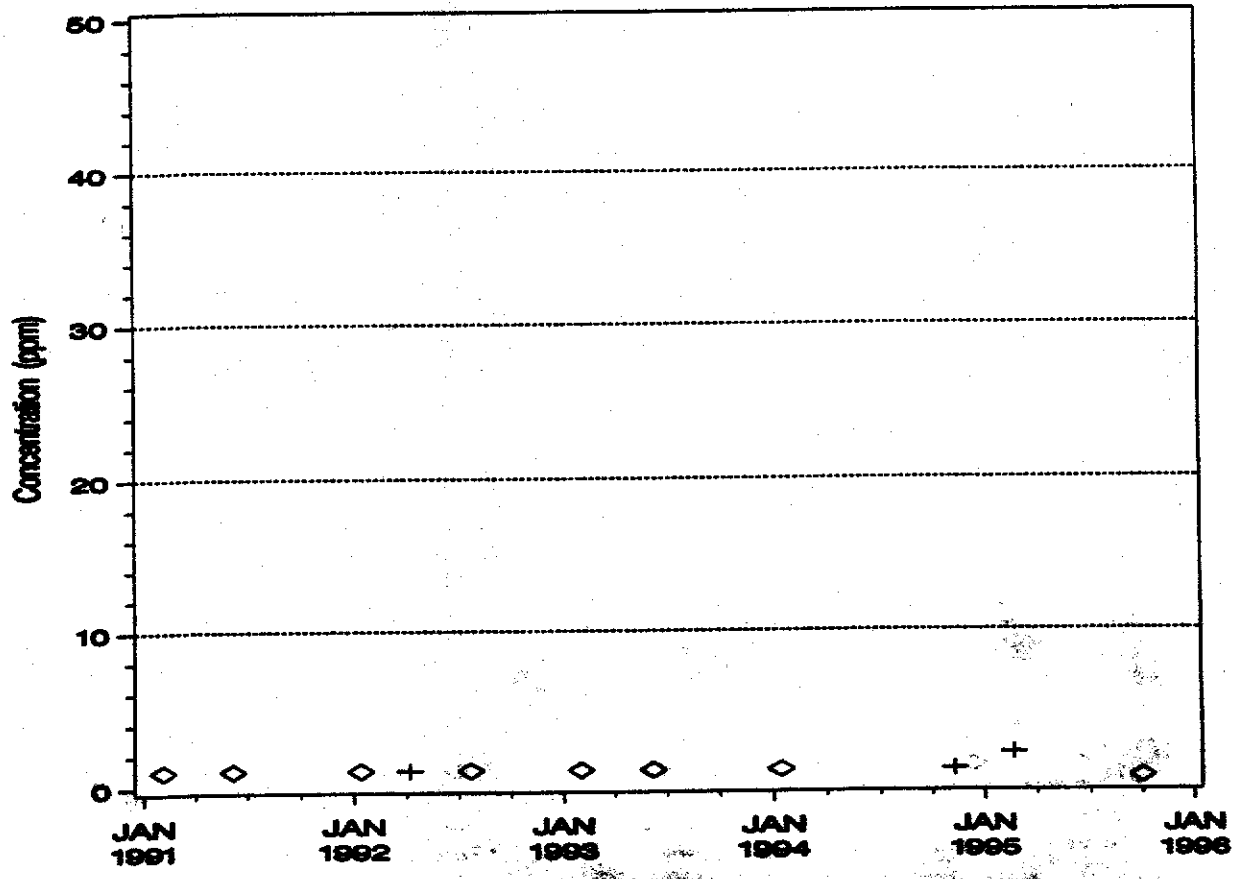


WELL 1163

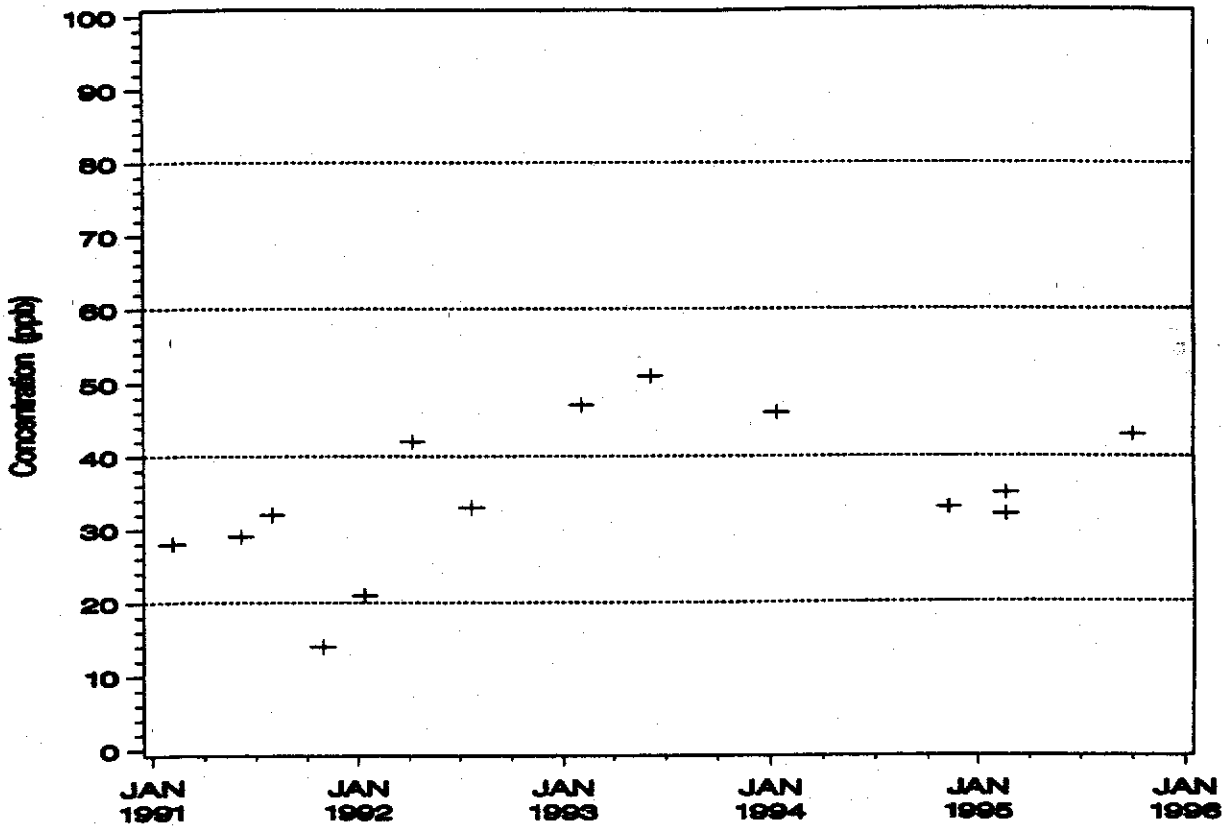
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



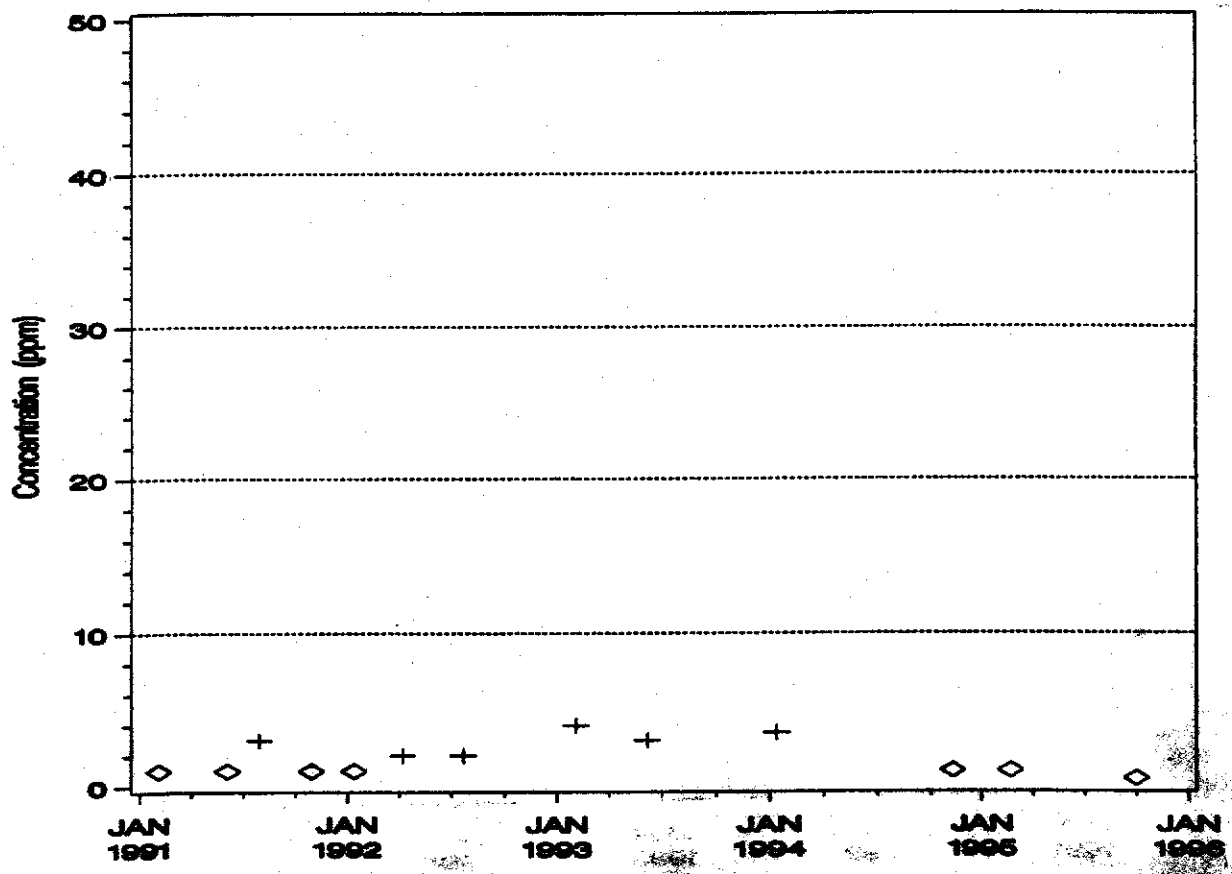
1,1 – DICHLOROETHYLENE Trend



WELL 1164
TRICHLOROETHYLENE Trend

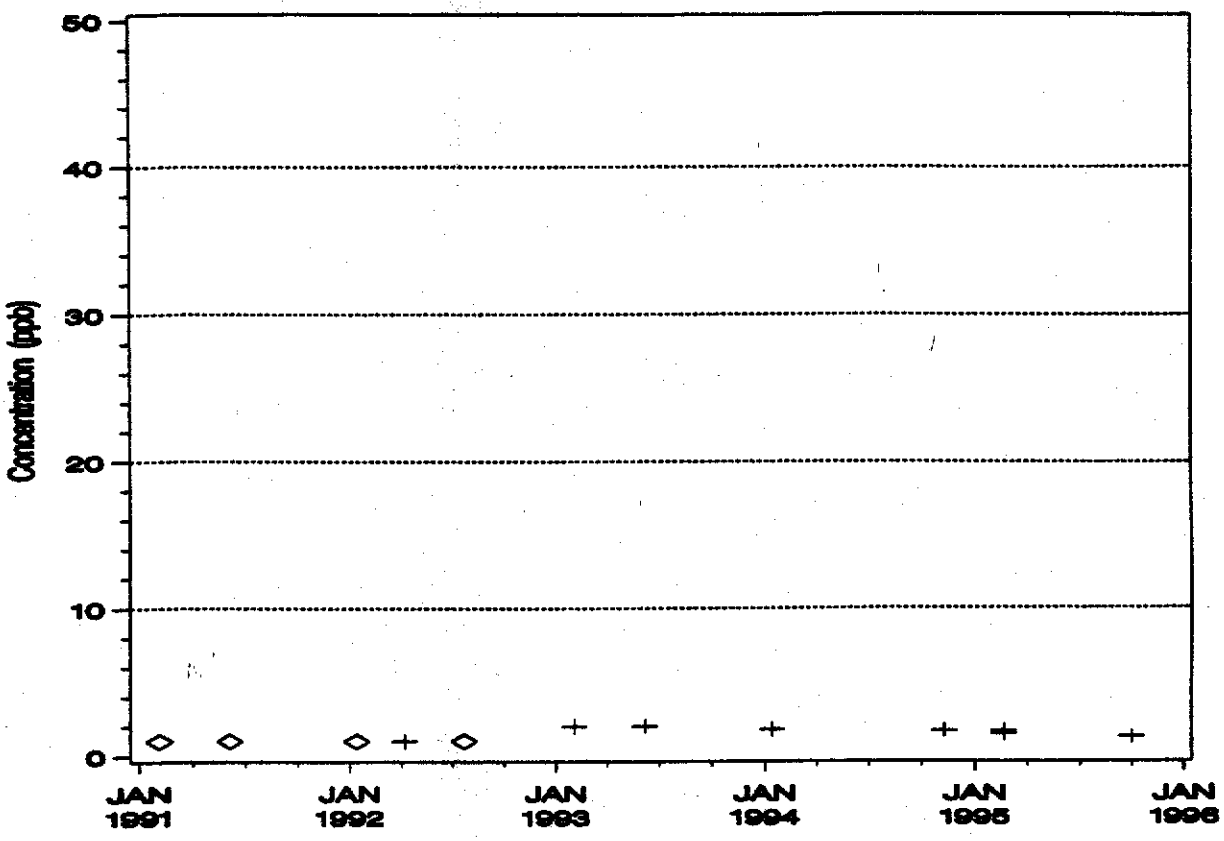


FREON 113 Trend

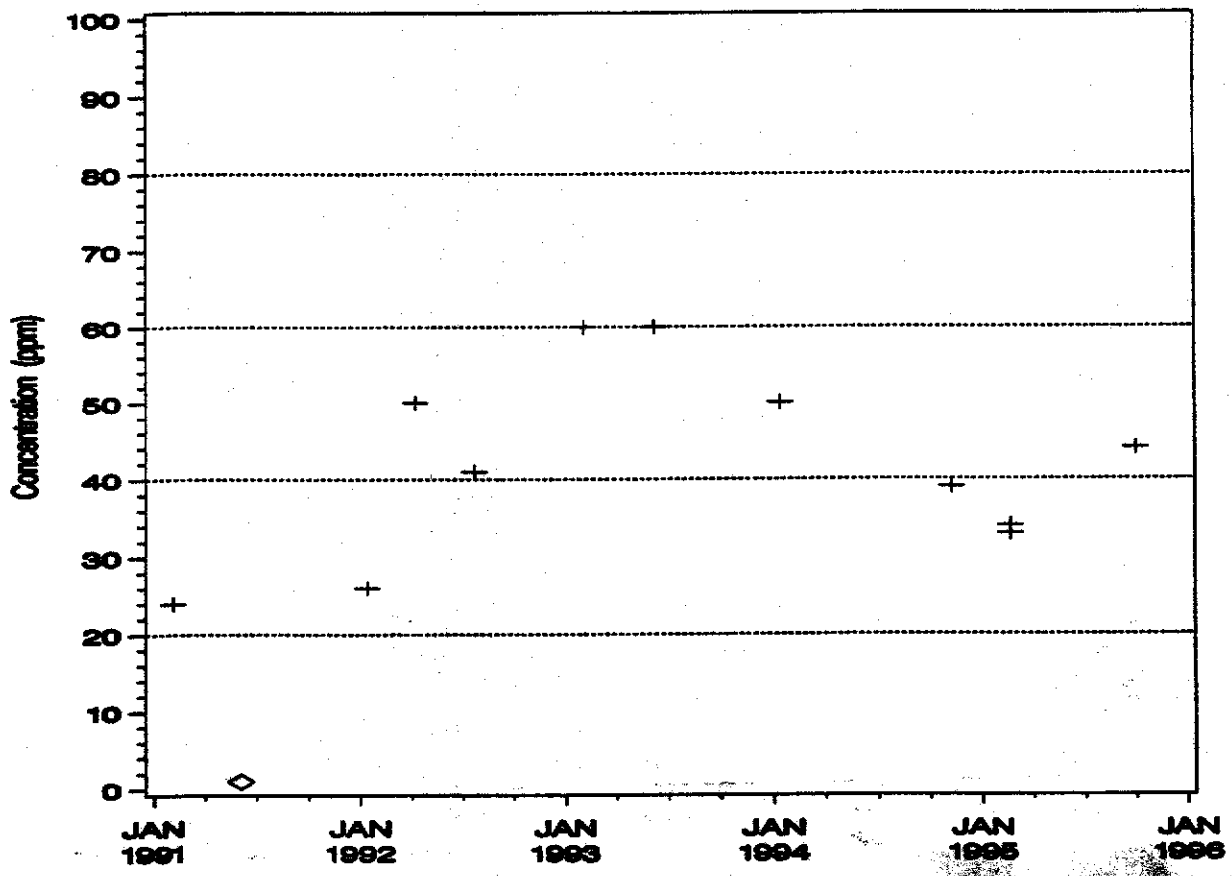


WELL 1164

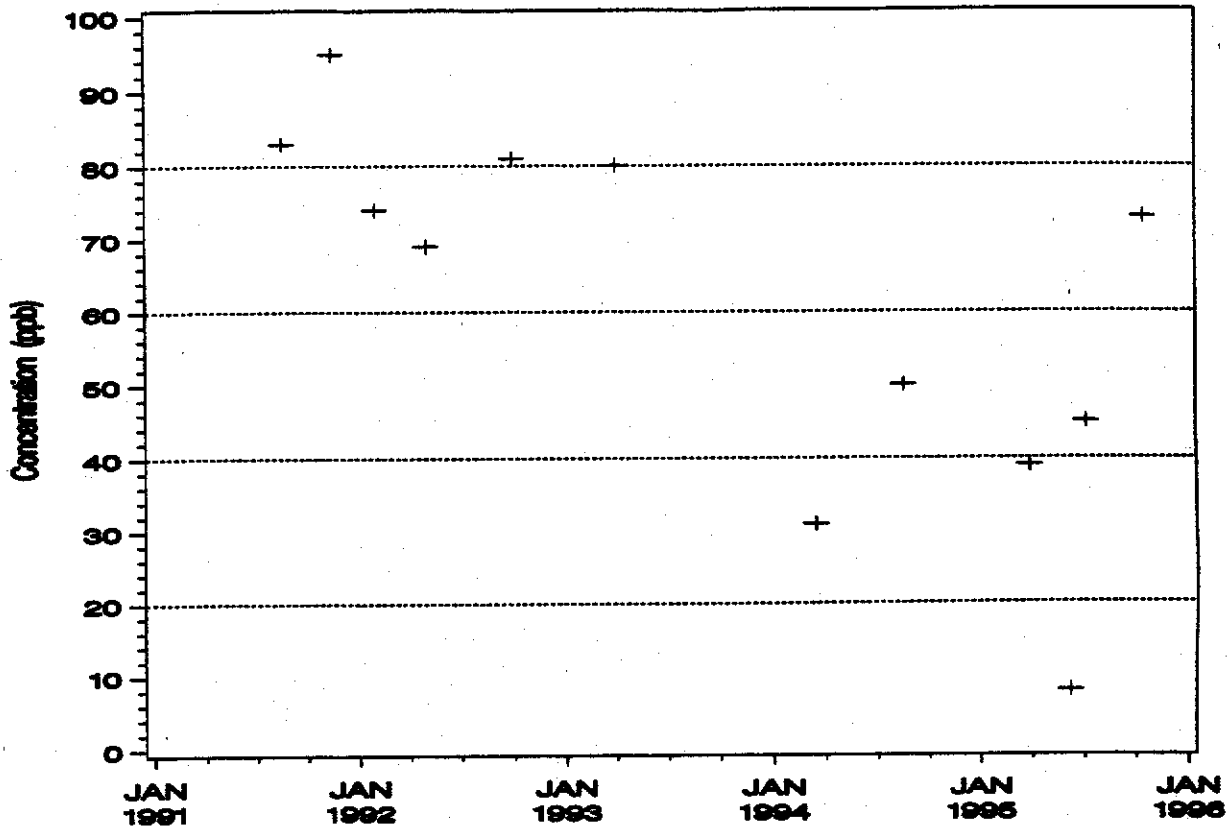
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



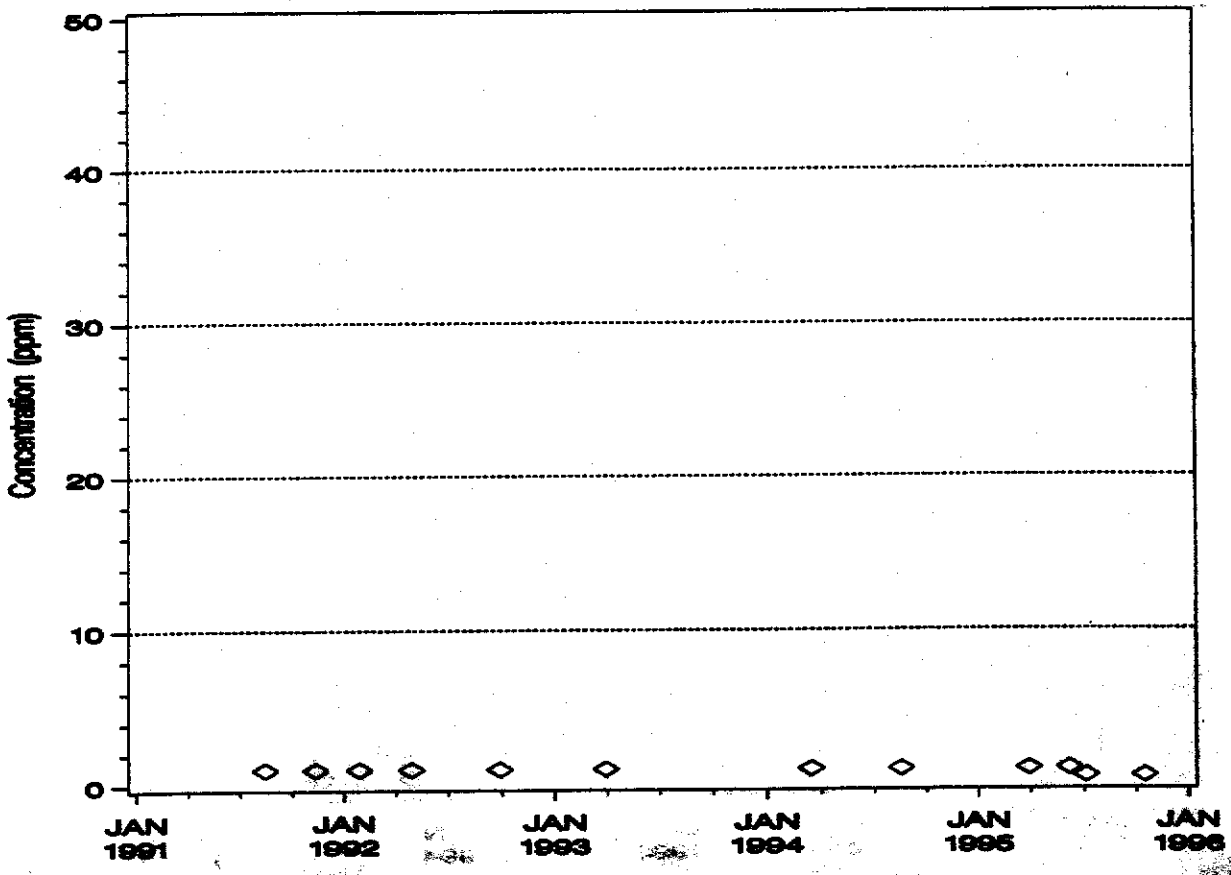
1,1 – DICHLOROETHYLENE Trend



WELL 1169
TRICHLOROETHYLENE Trend

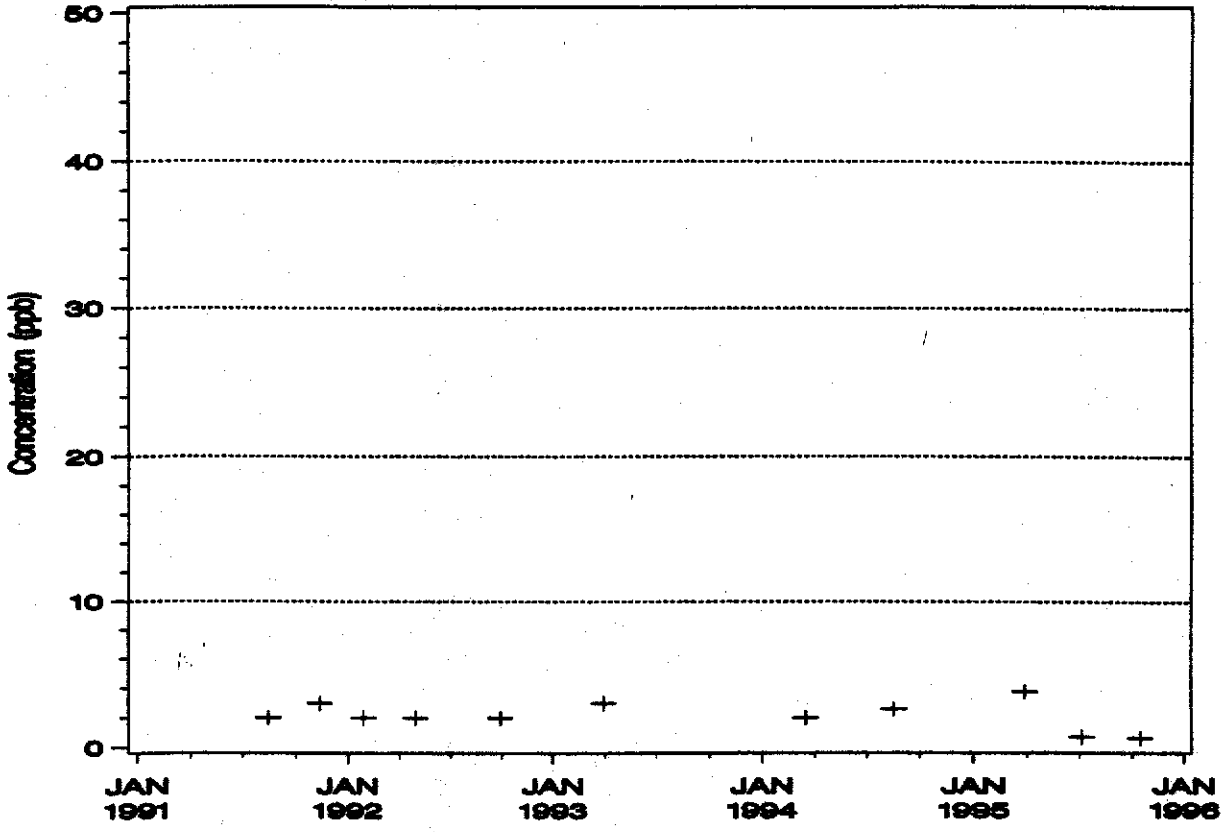


FREON 113 Trend

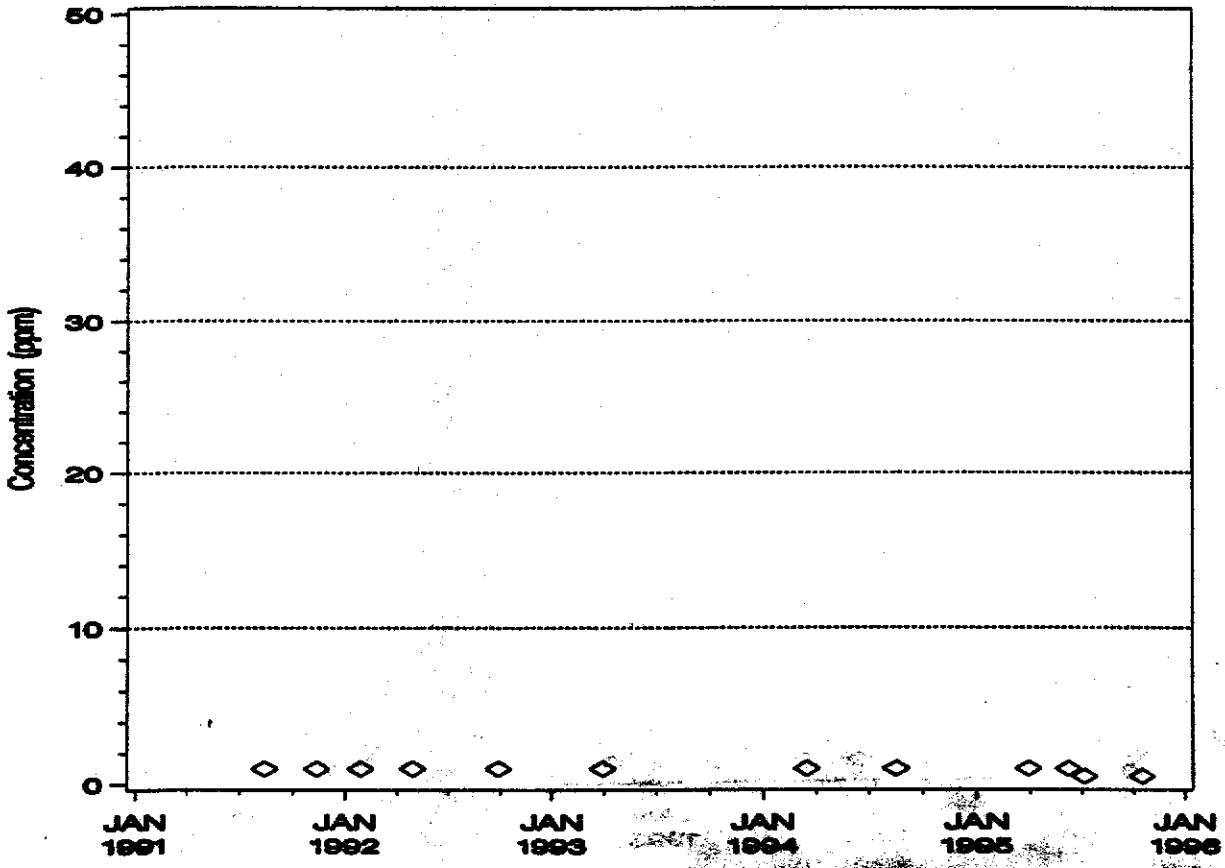


WELL 1169

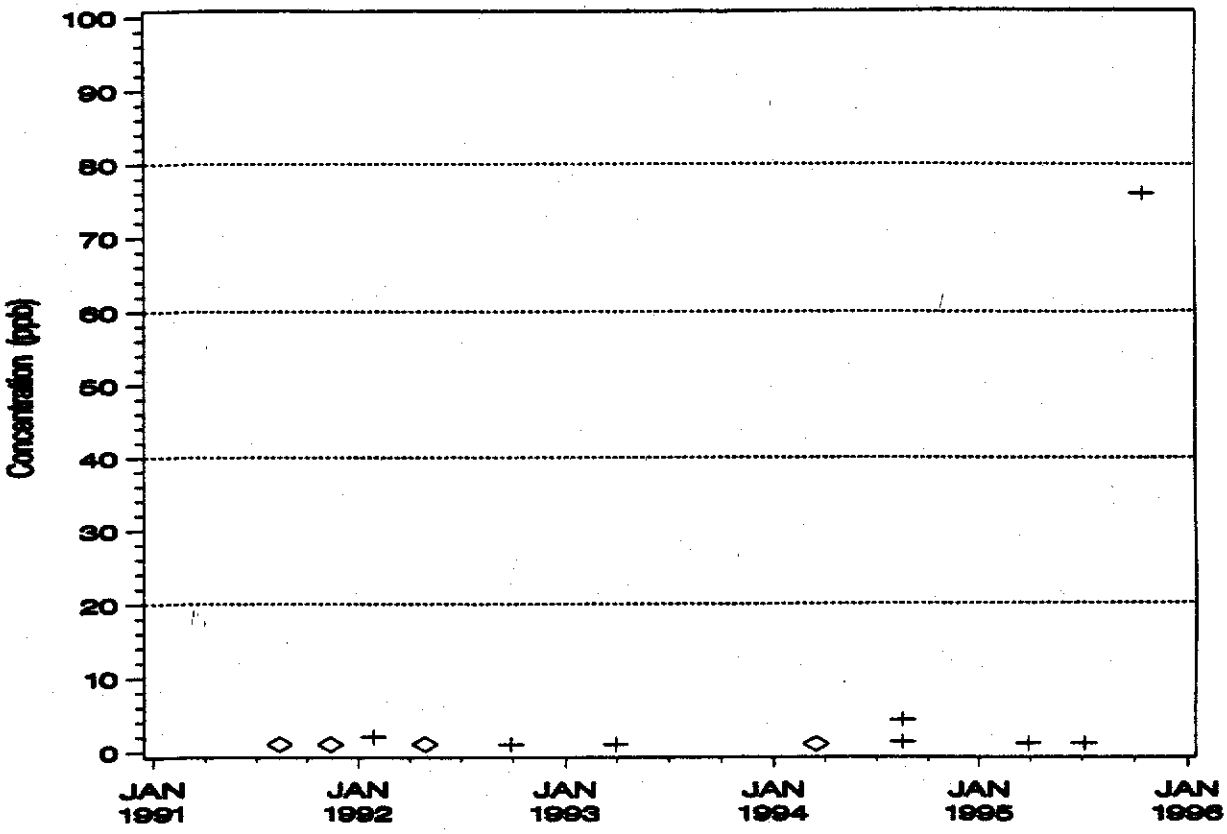
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



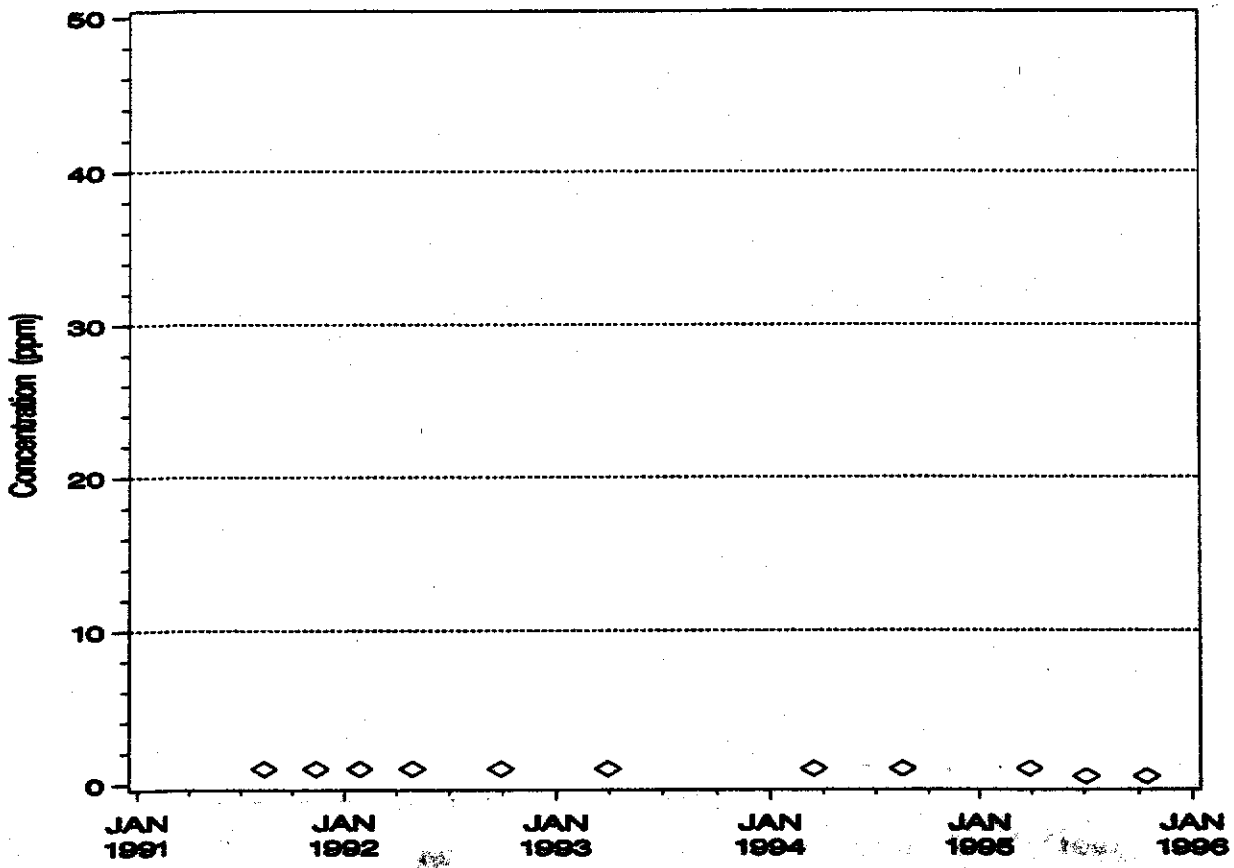
1,1 – DICHLOROETHYLENE Trend



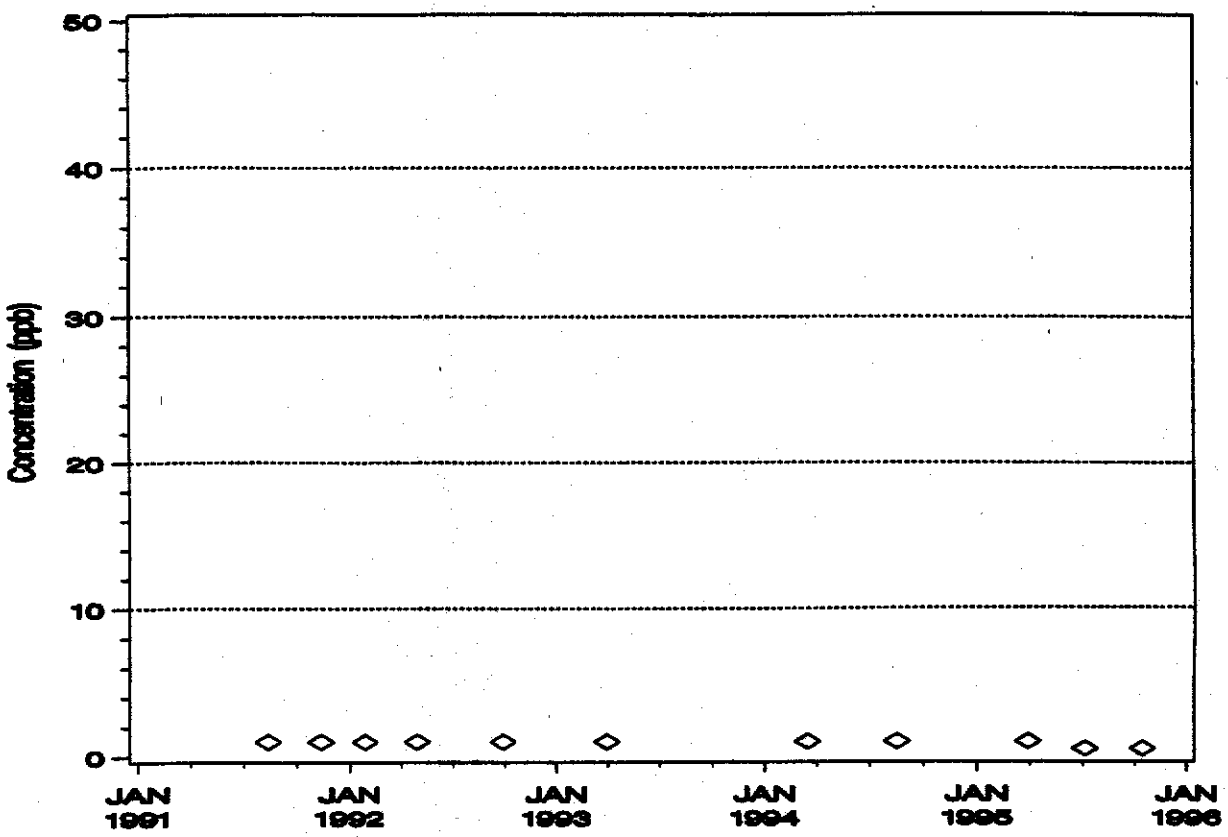
WELL 1170
TRICHLOROETHYLENE Trend



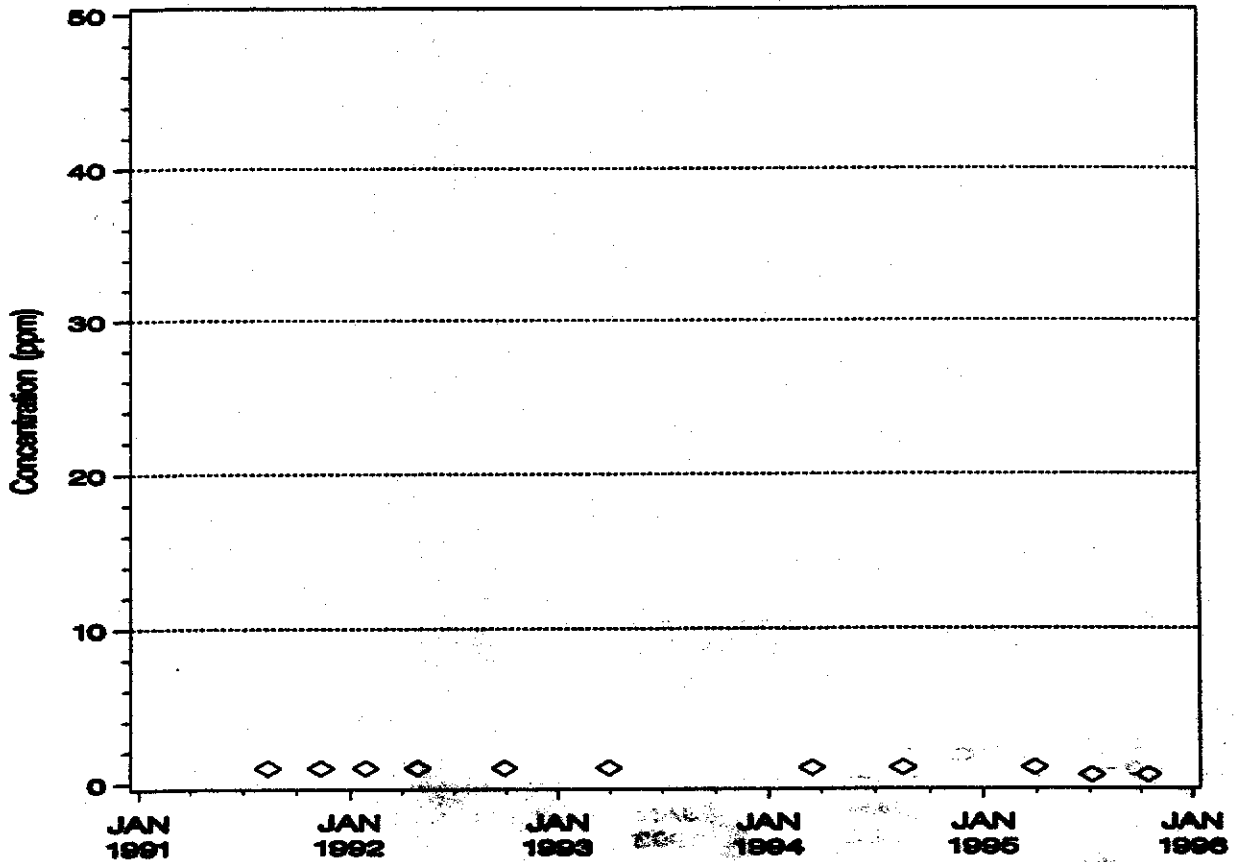
FREON 113 Trend



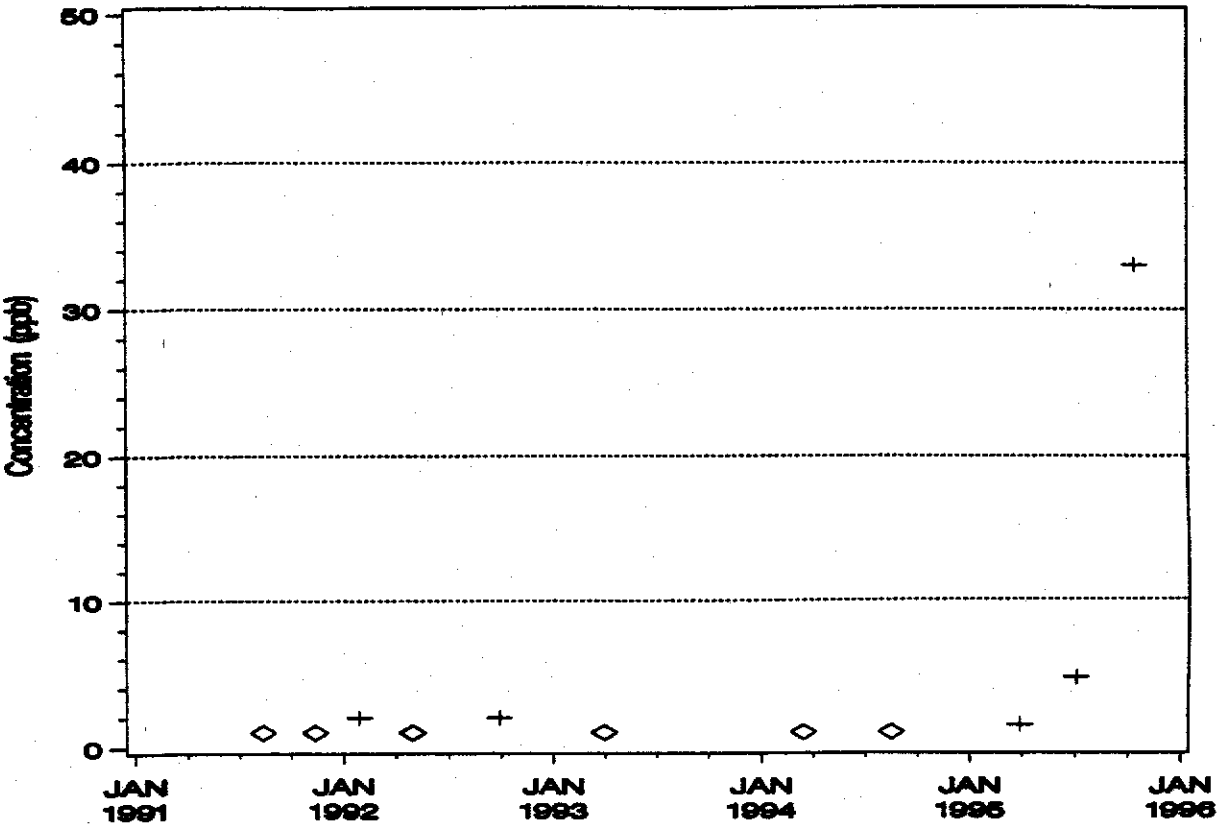
WELL 1170
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



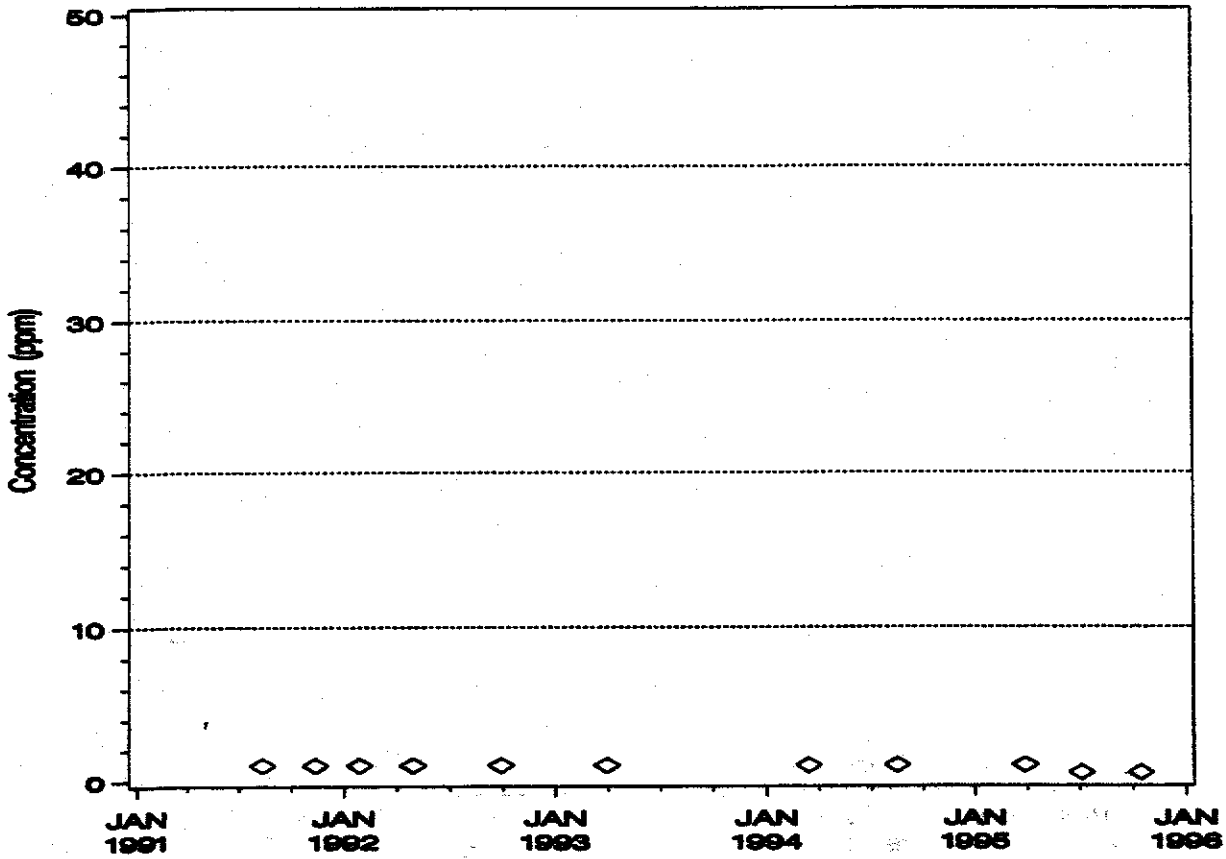
1,1 – DICHLOROETHYLENE Trend



WELL 1171
TRICHLOROETHYLENE Trend

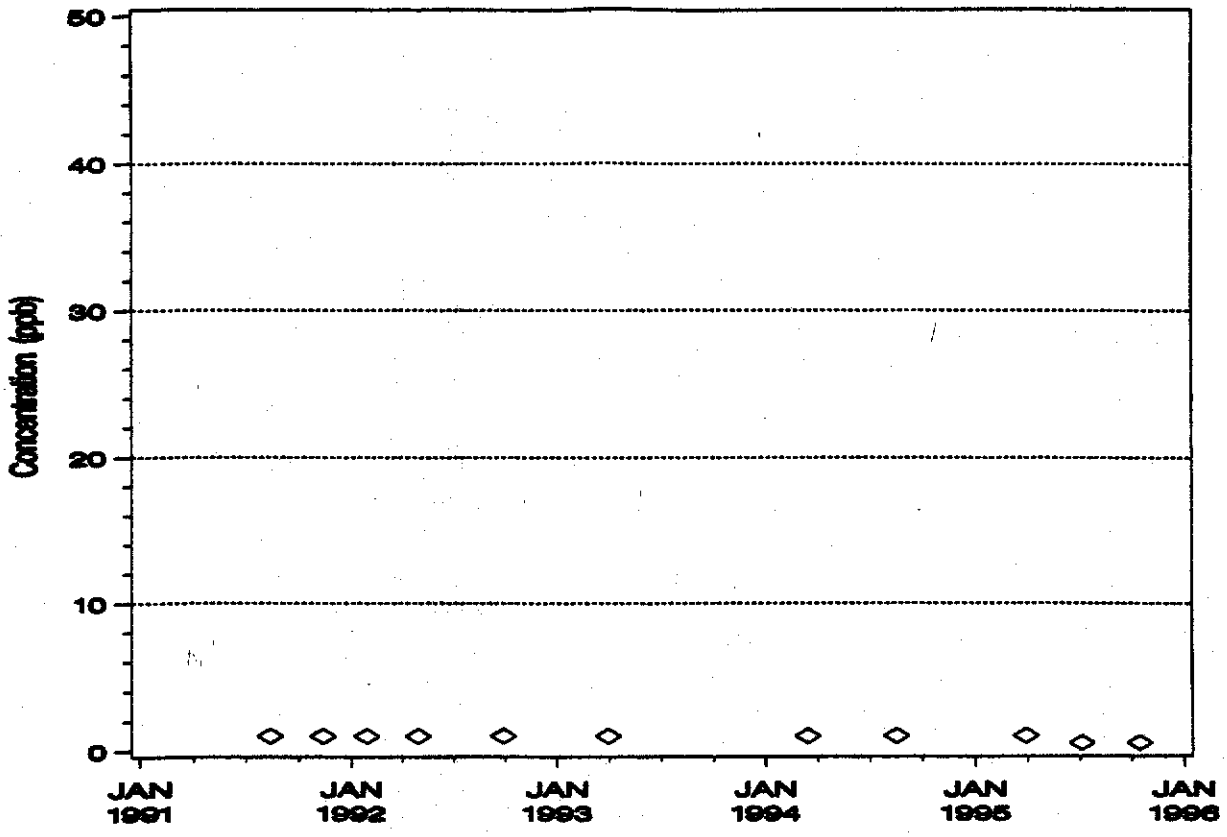


FREON 113 Trend

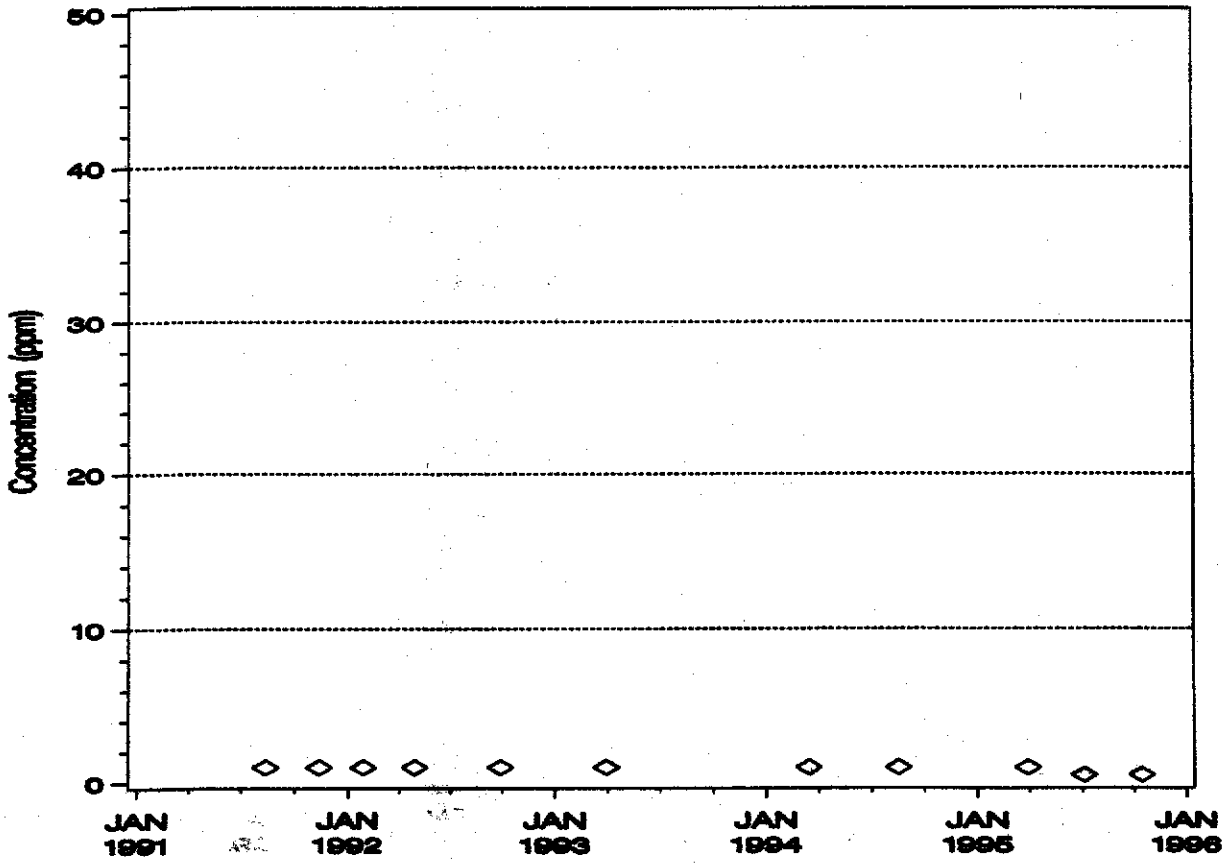


WELL 1171

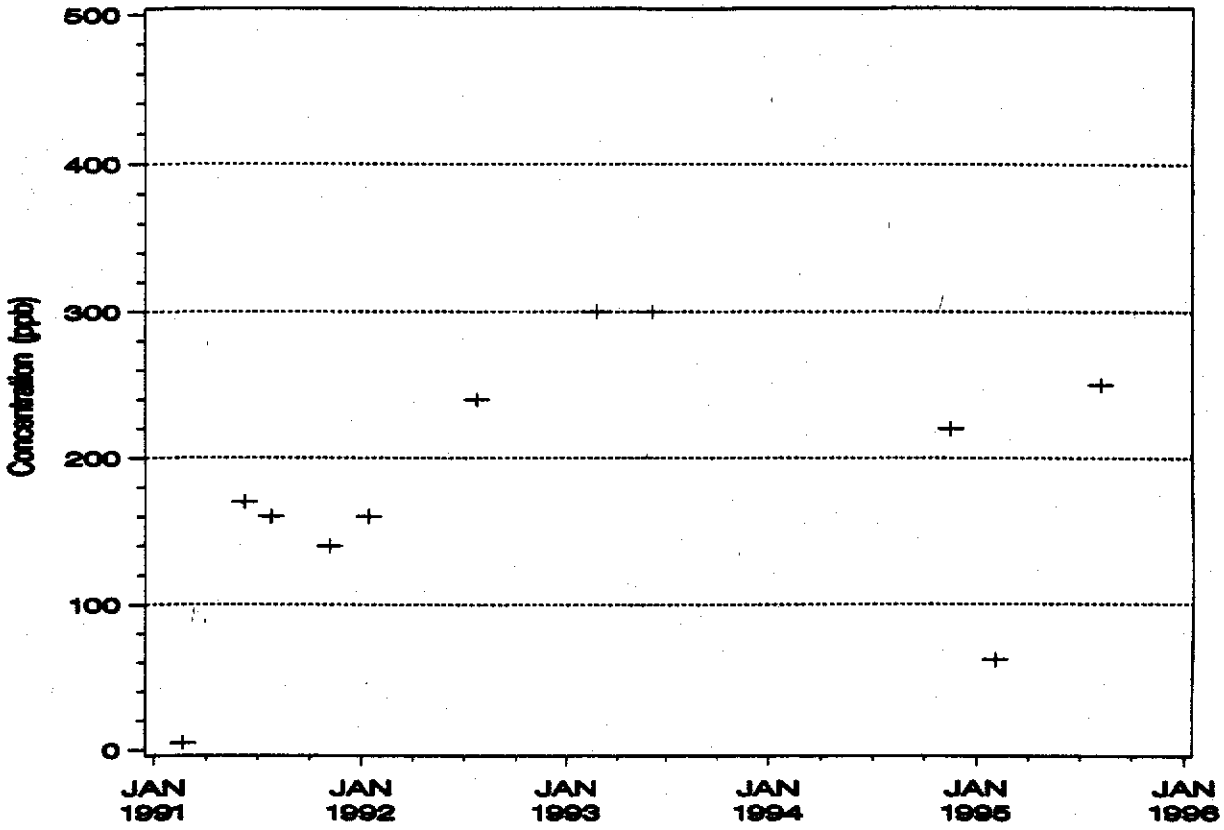
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



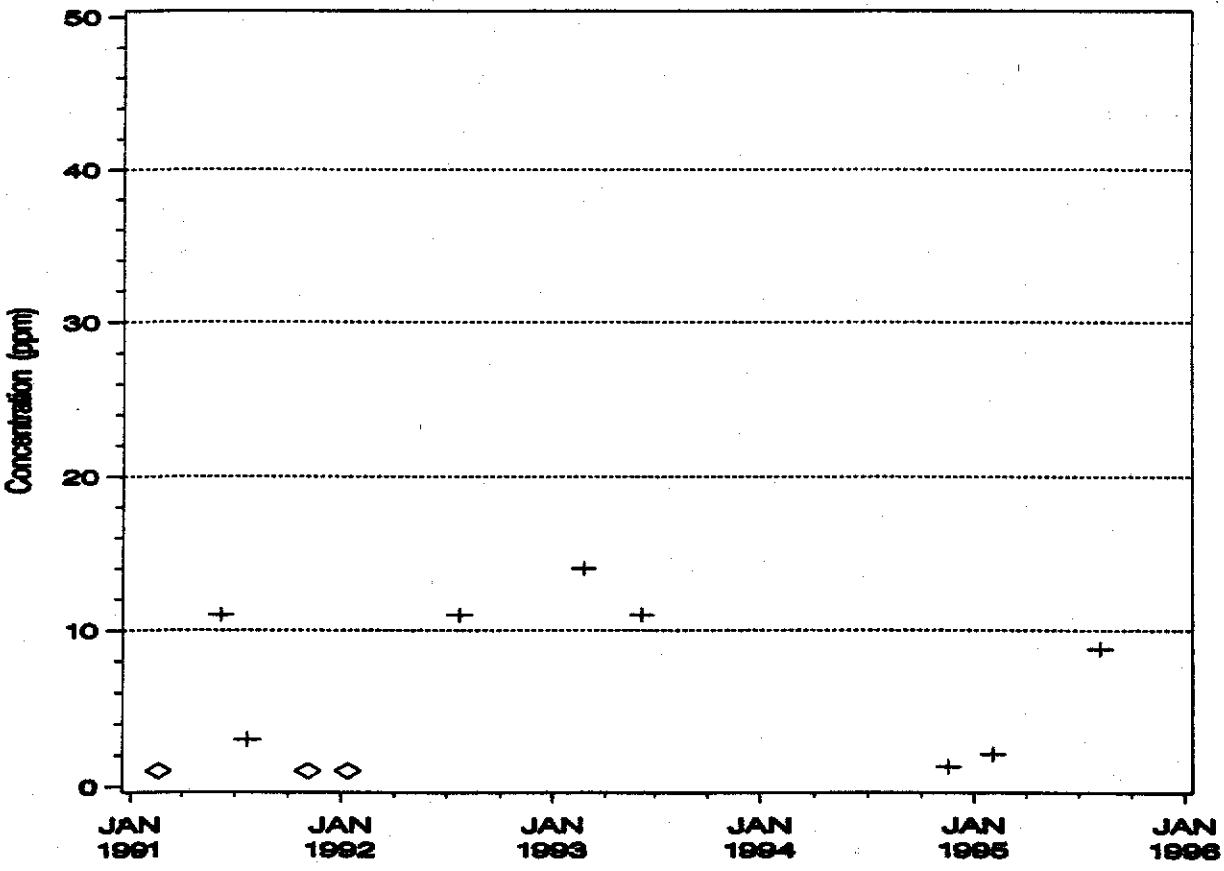
1,1 – DICHLOROETHYLENE Trend



WELL 1211
TRICHLOROETHYLENE Trend

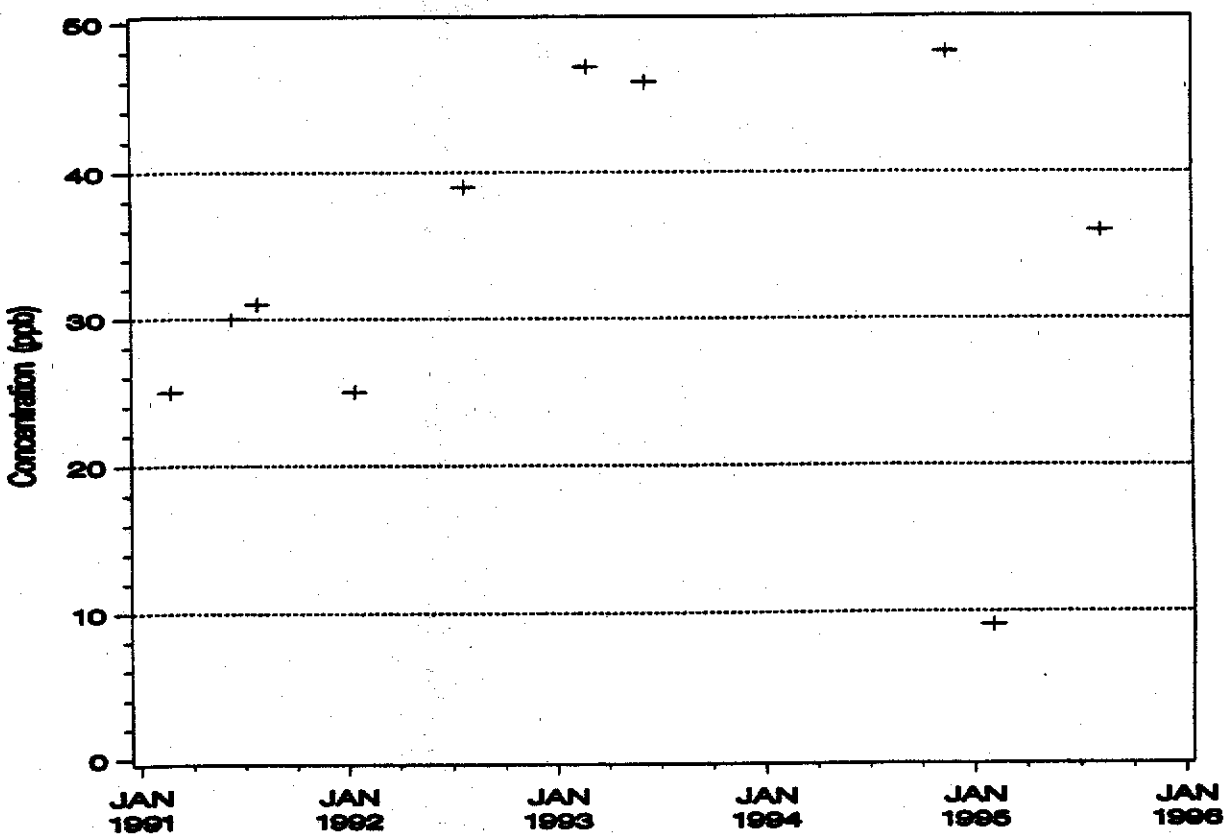


FREON 113 Trend

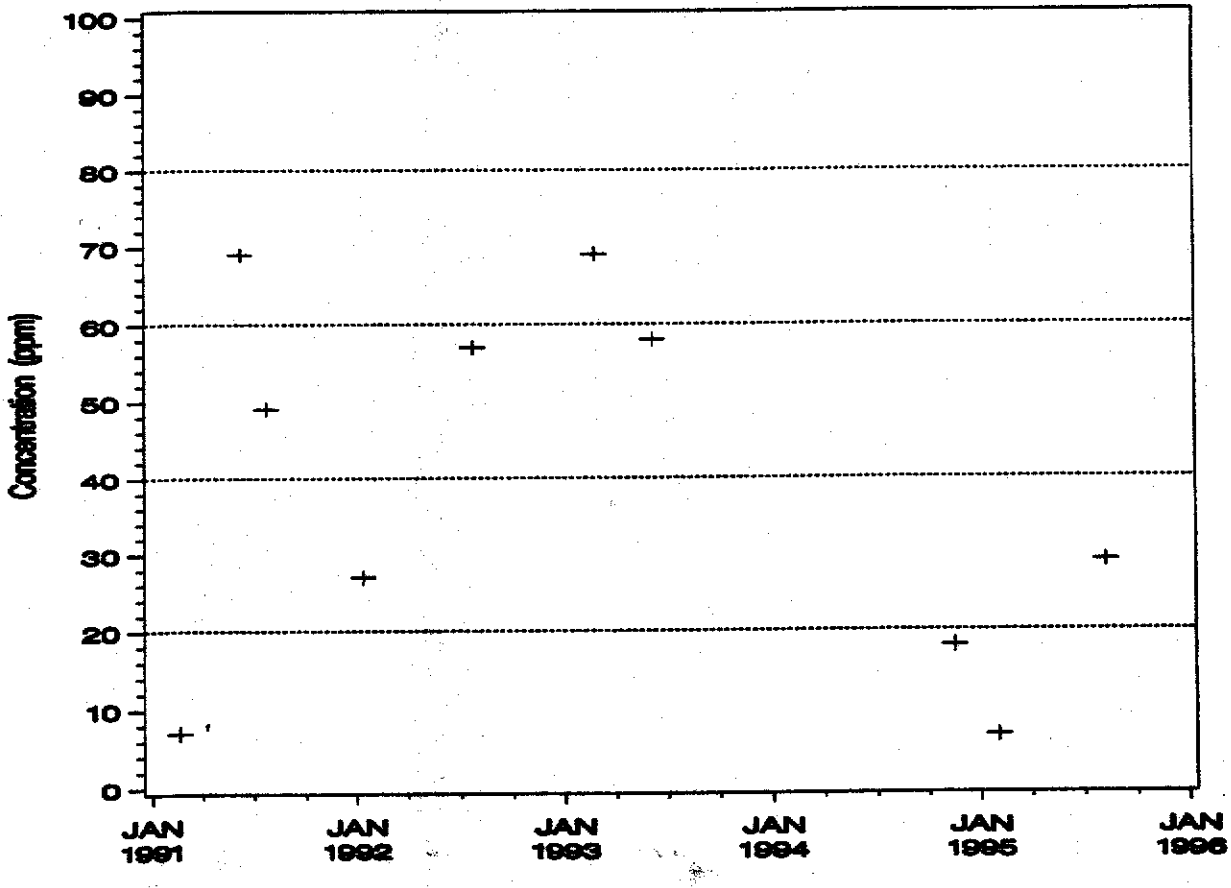


WELL 1211

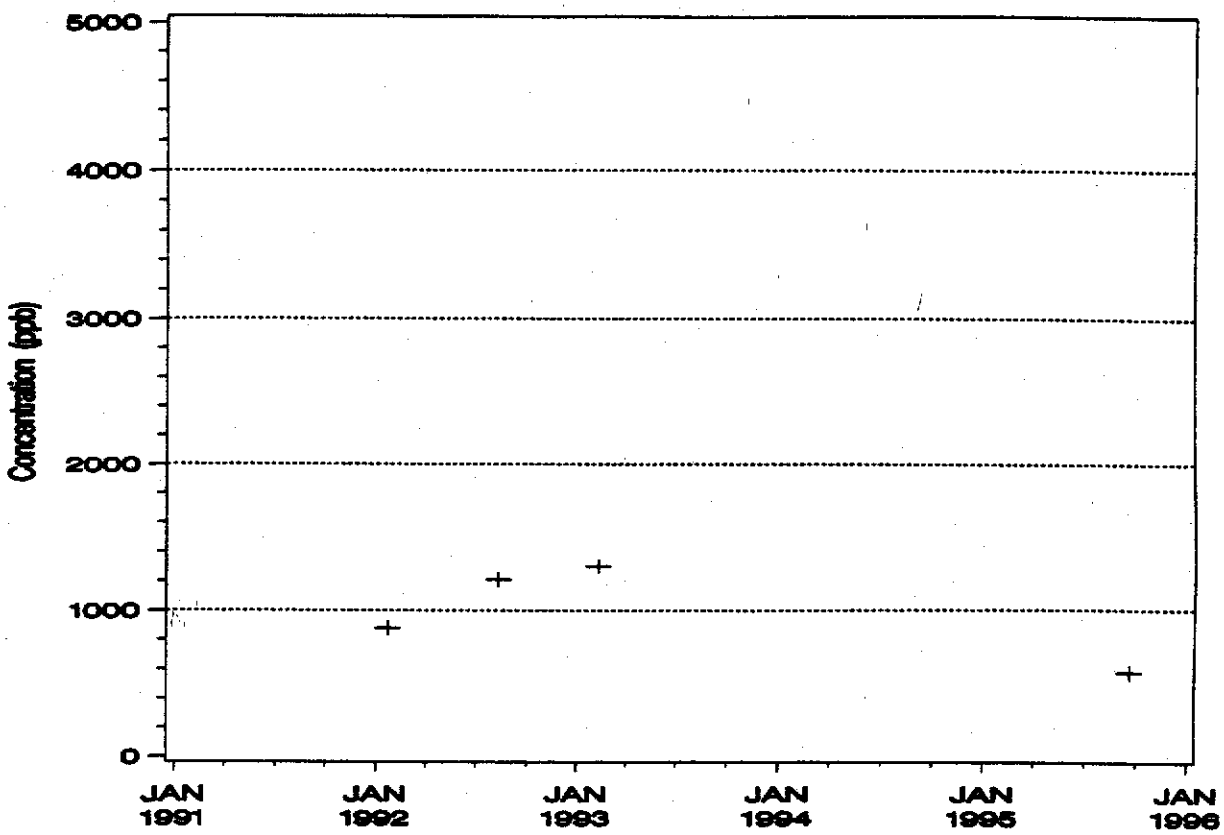
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



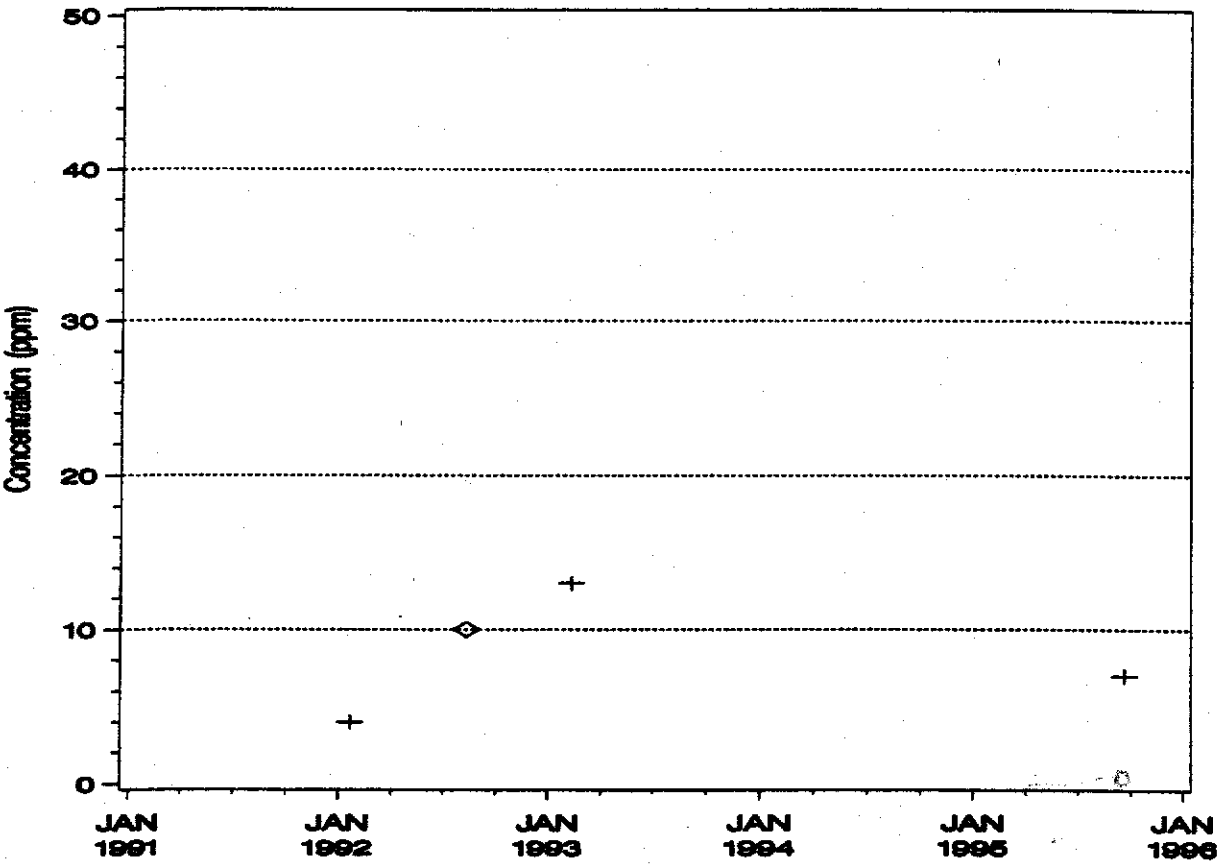
1,1 – DICHLOROETHYLENE Trend



WELL 1214
TRICHLOROETHYLENE Trend

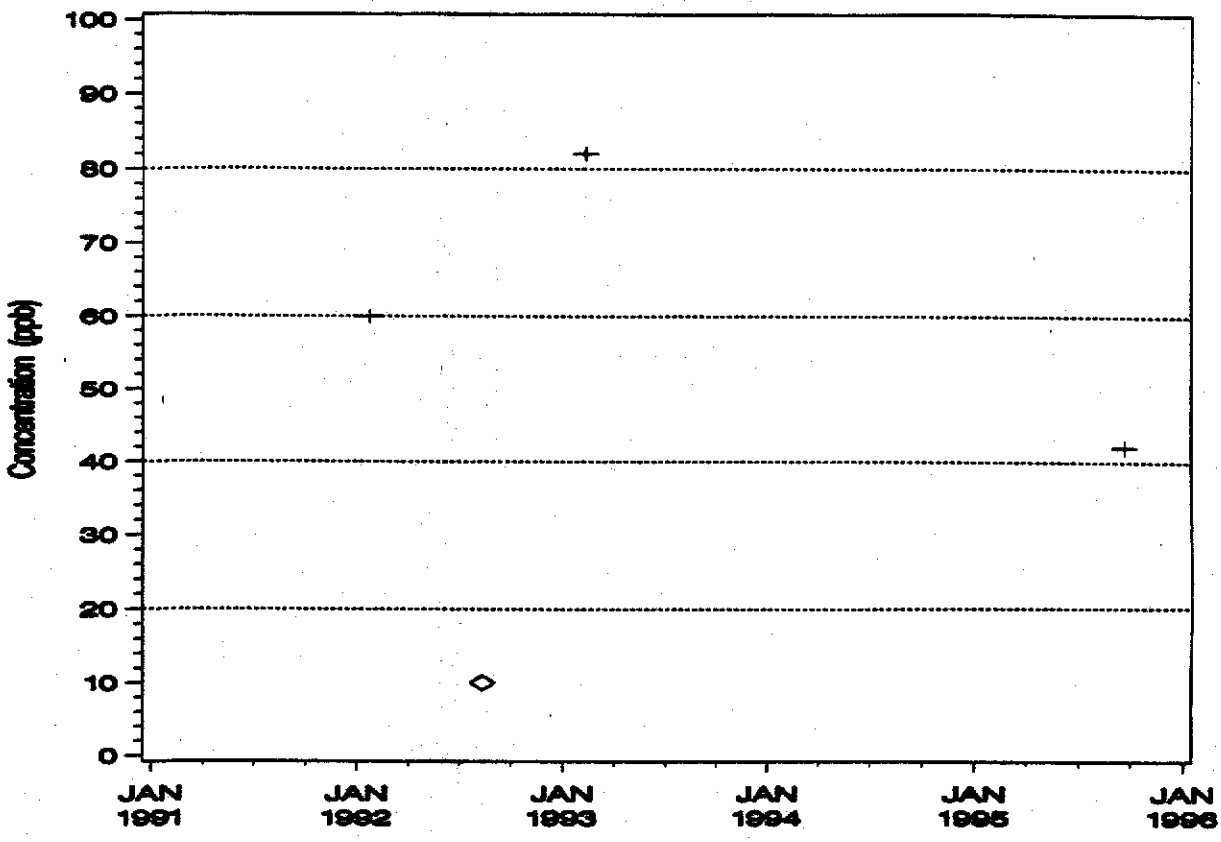


FREON 113 Trend

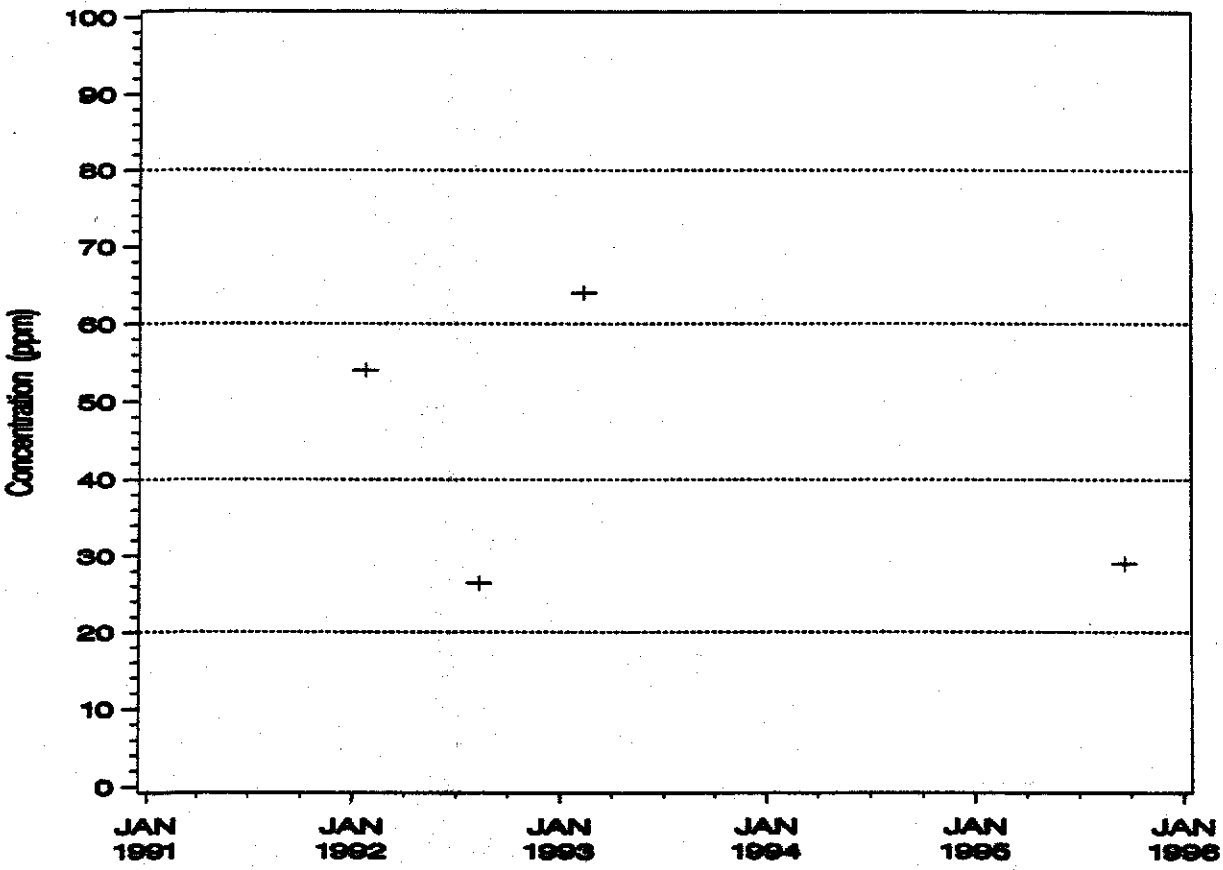


WELL 1214

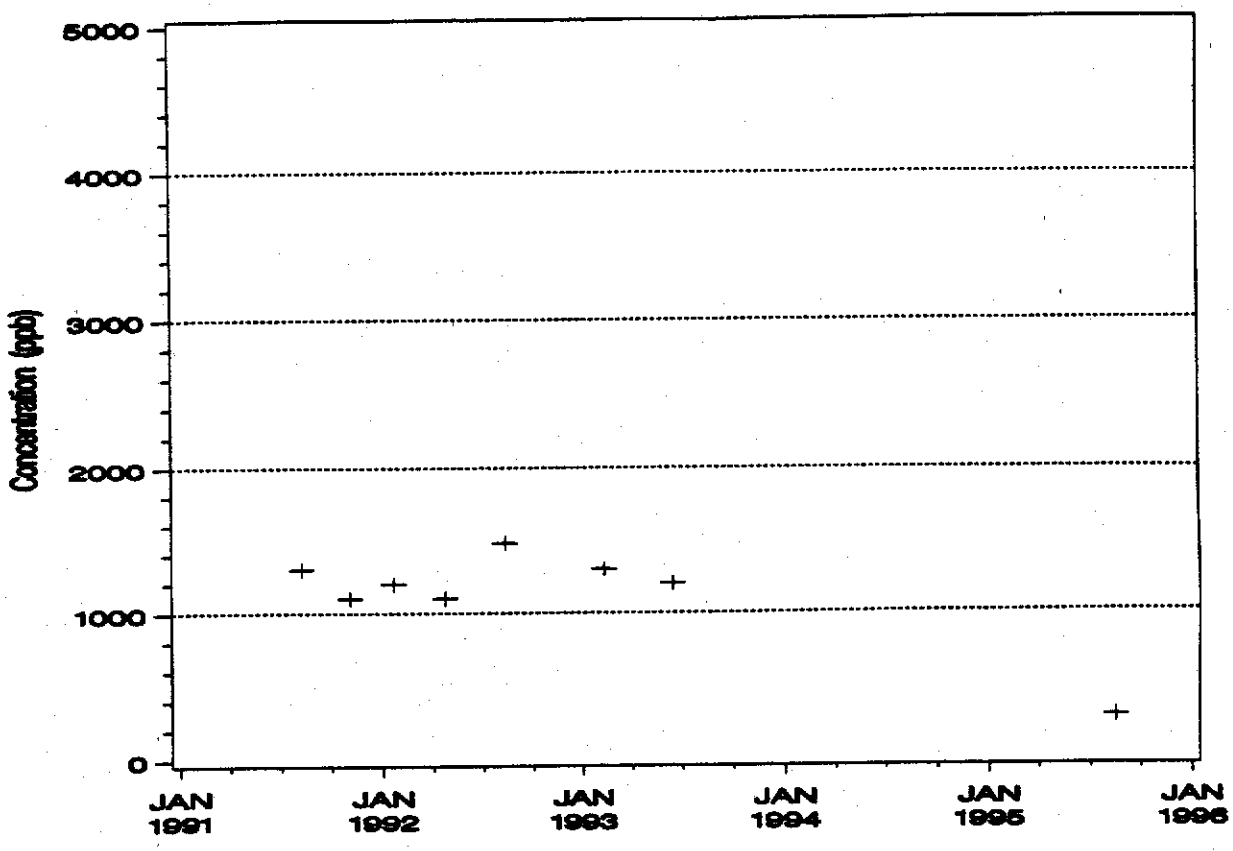
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



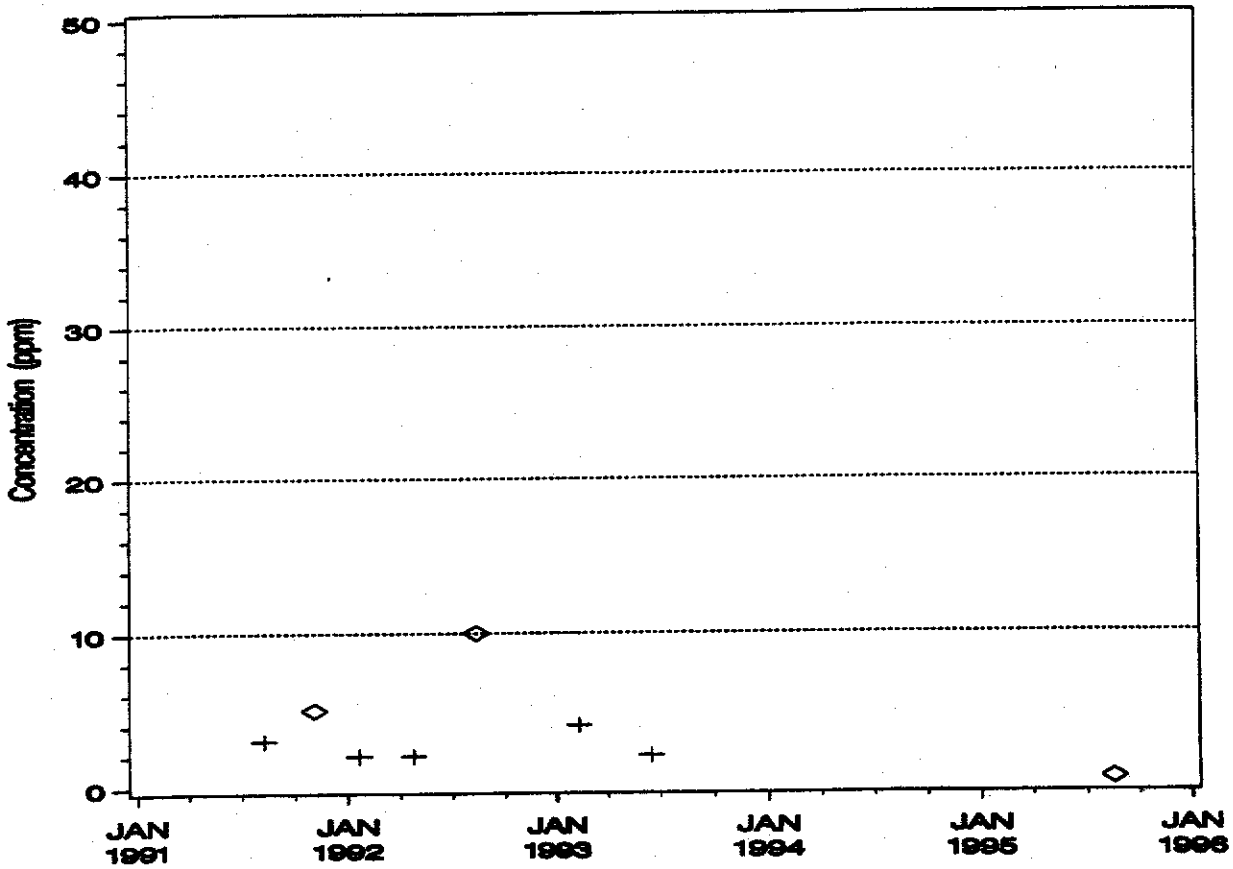
1,1 – DICHLOROETHYLENE Trend



WELL 1216
TRICHLOROETHYLENE Trend

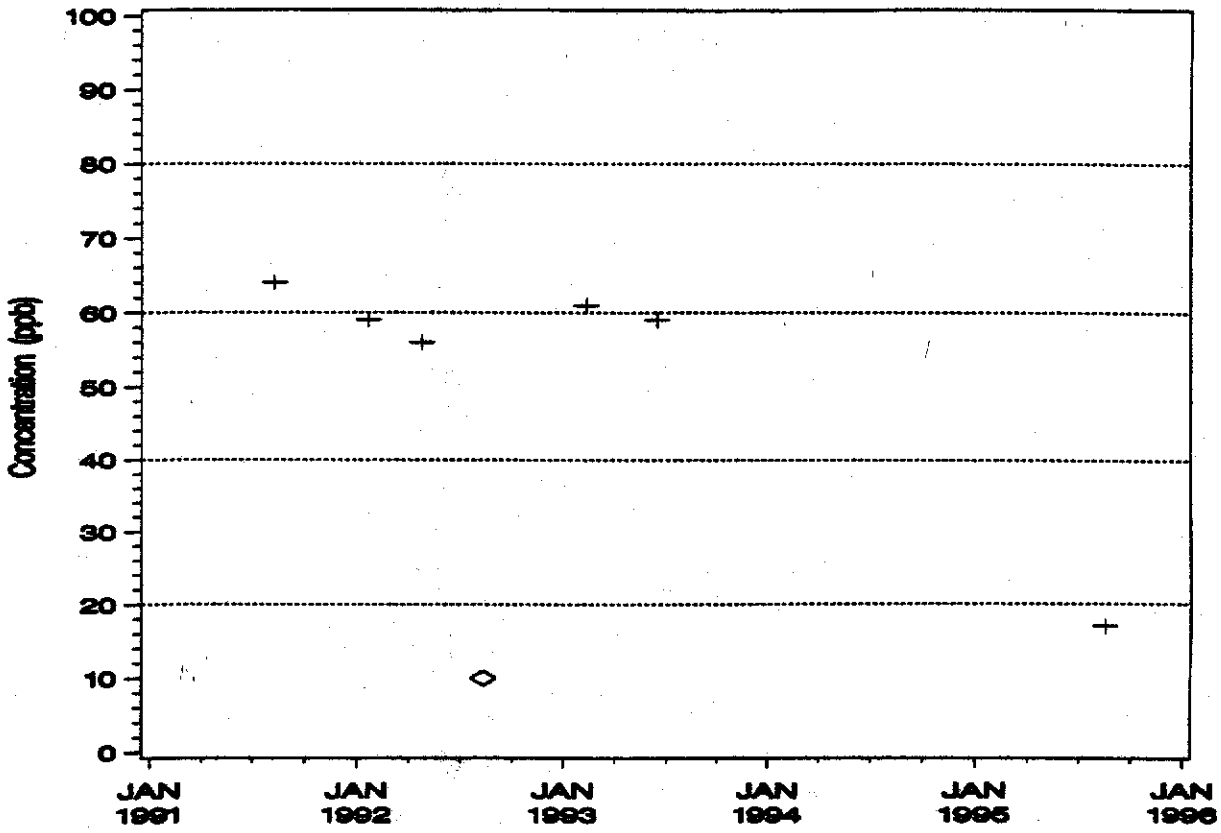


FREON 113 Trend

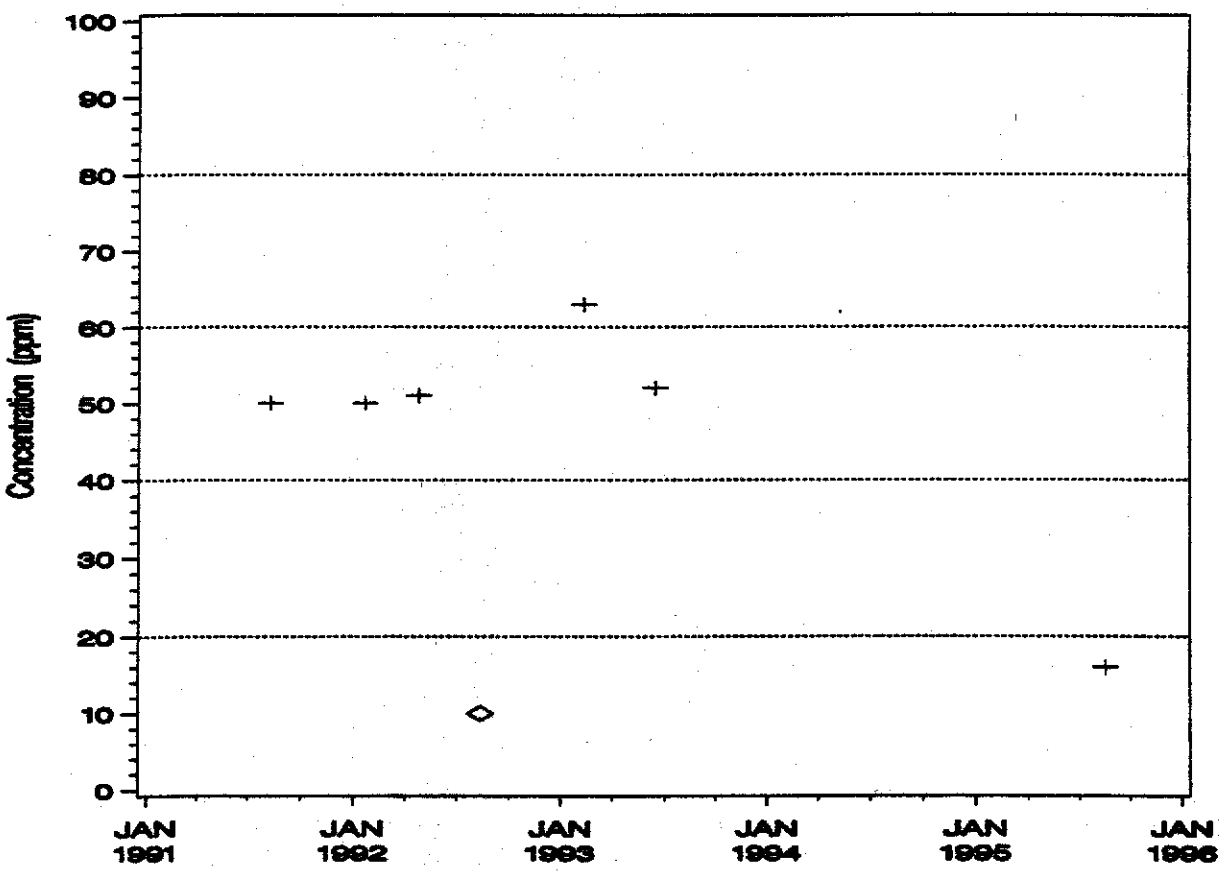


WELL 1216

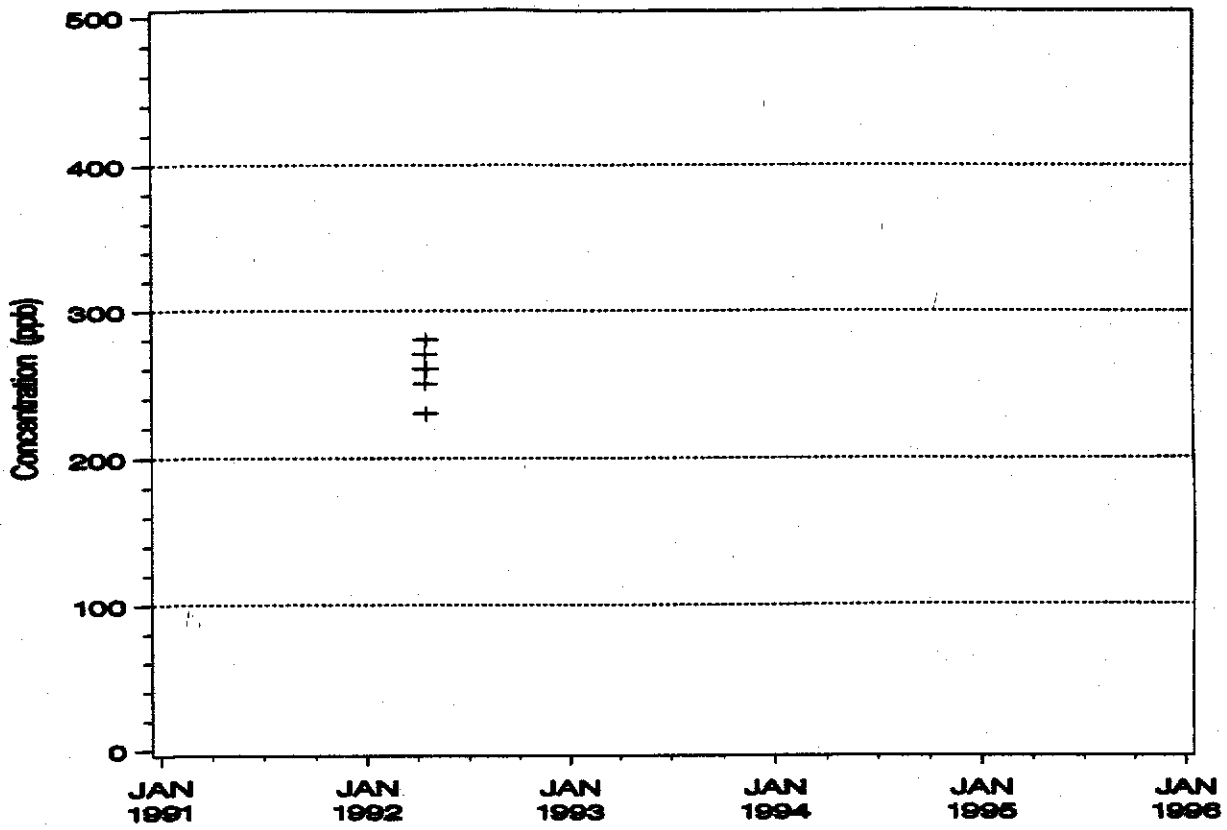
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



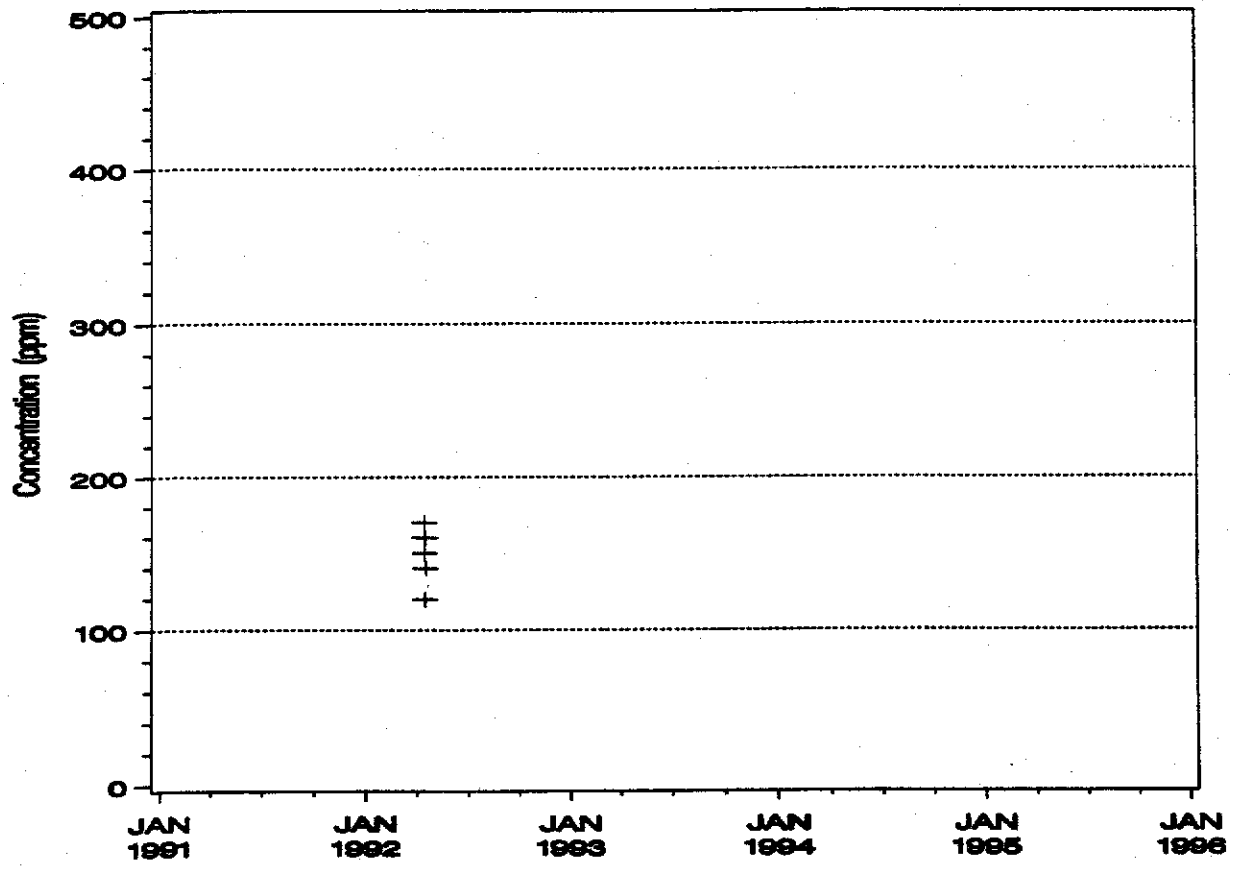
1,1 — DICHLOROETHYLENE Trend



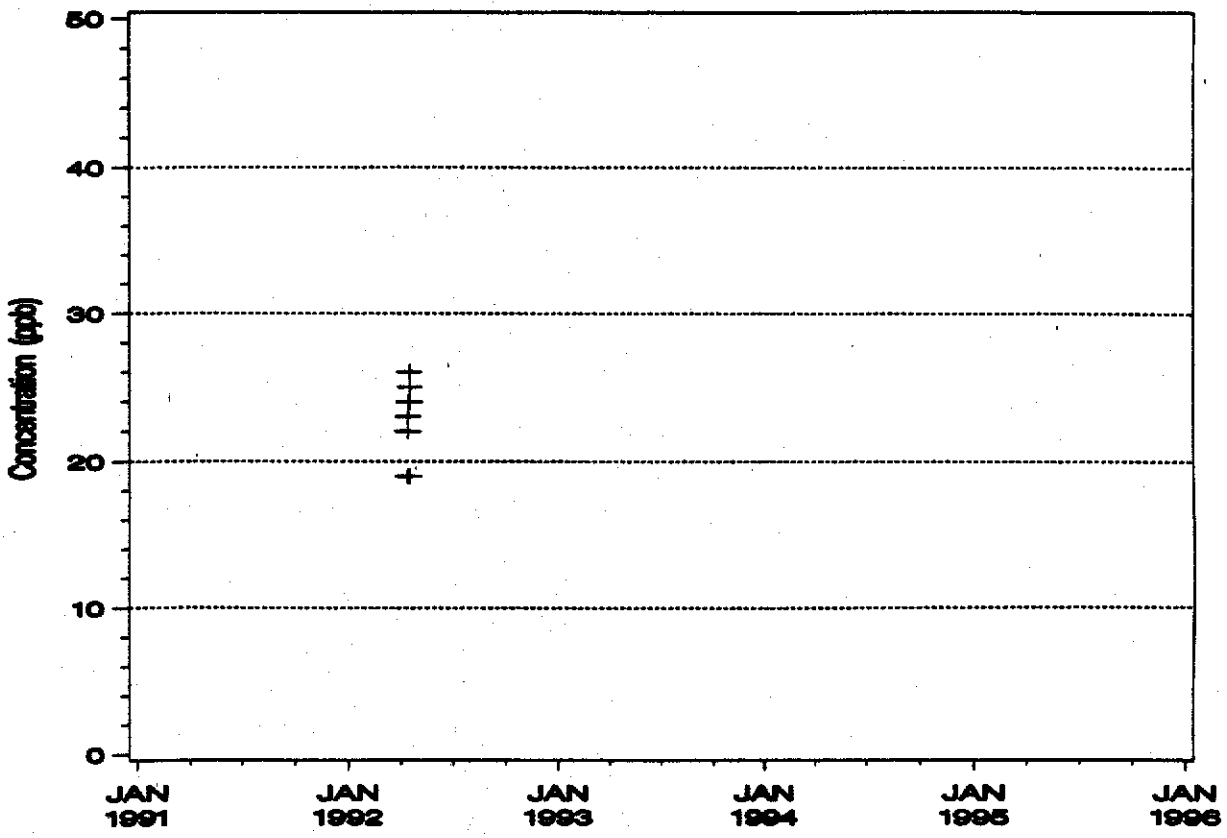
WELL 1224
TRICHLOROETHYLENE Trend



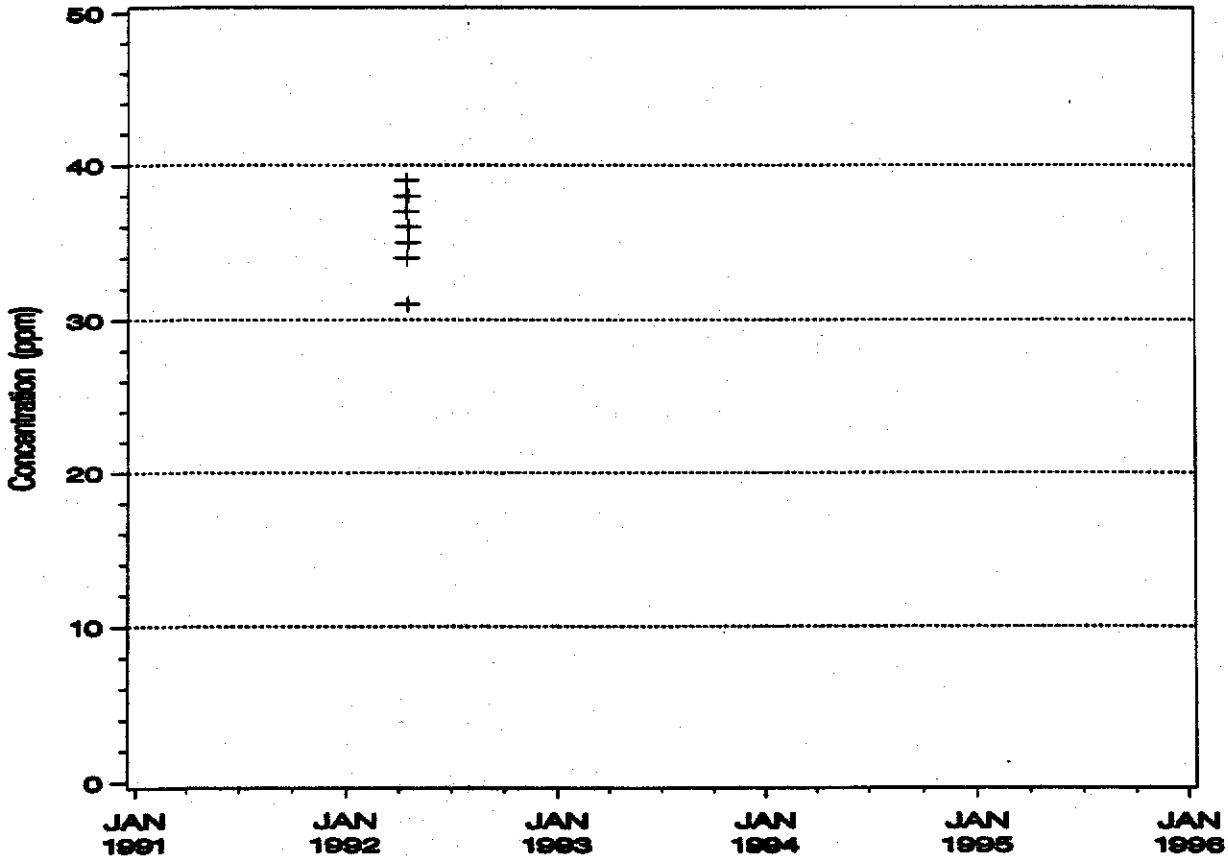
FREON 113 Trend



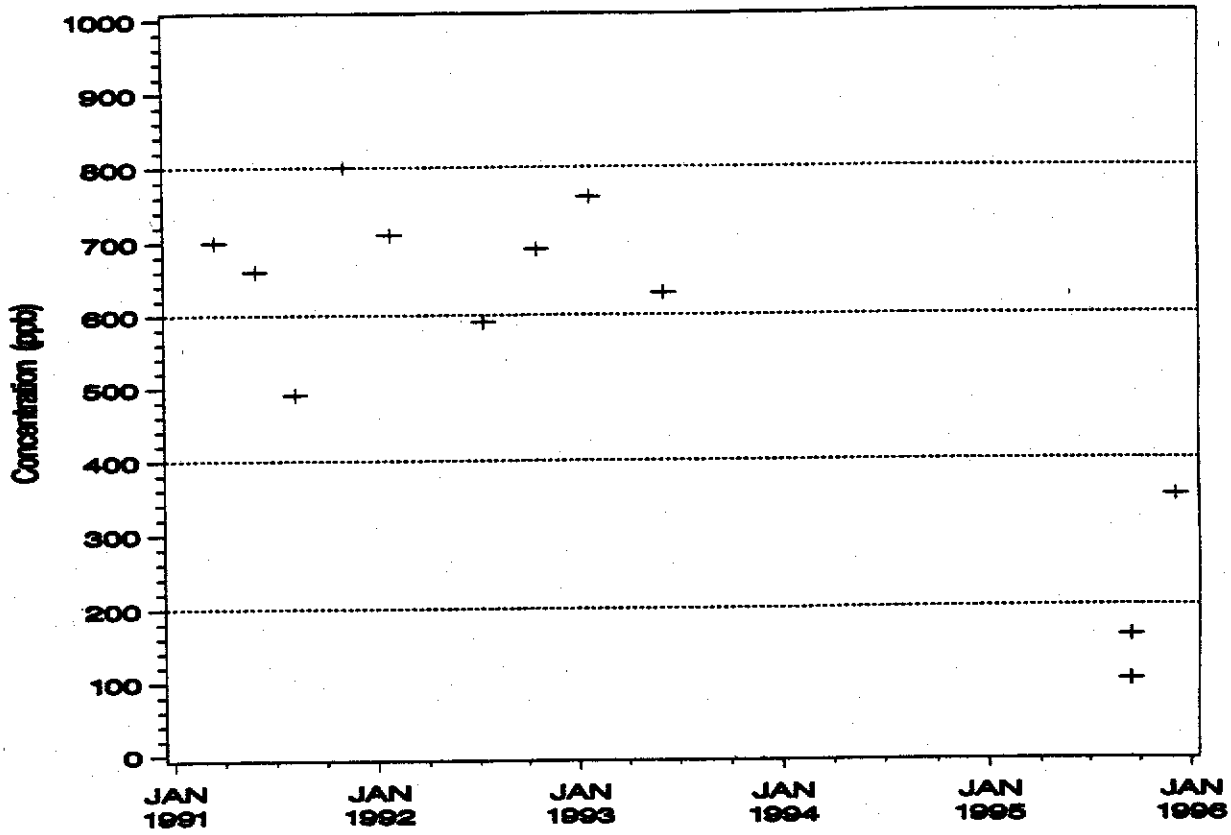
WELL 1224
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



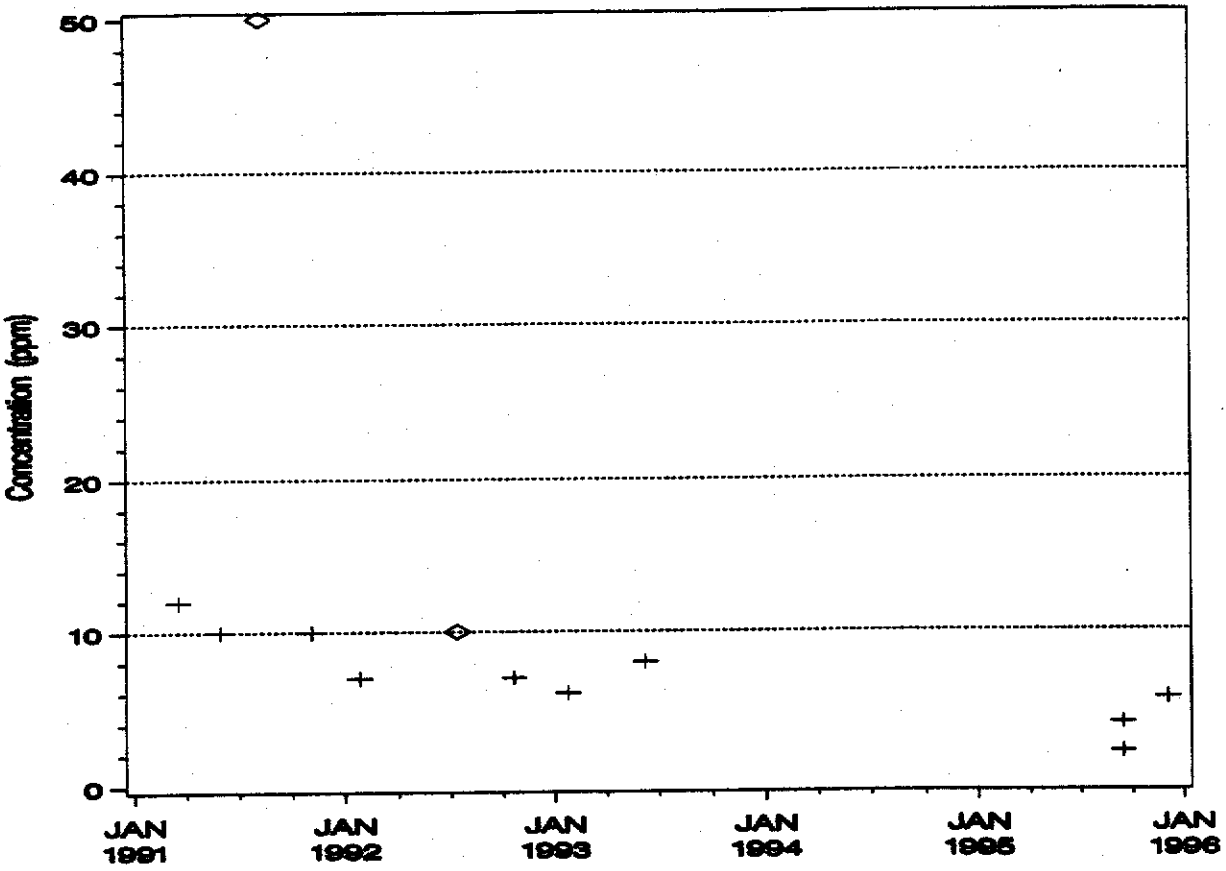
1,1 — DICHLOROETHYLENE Trend



WELL 1357
TRICHLOROETHYLENE Trend

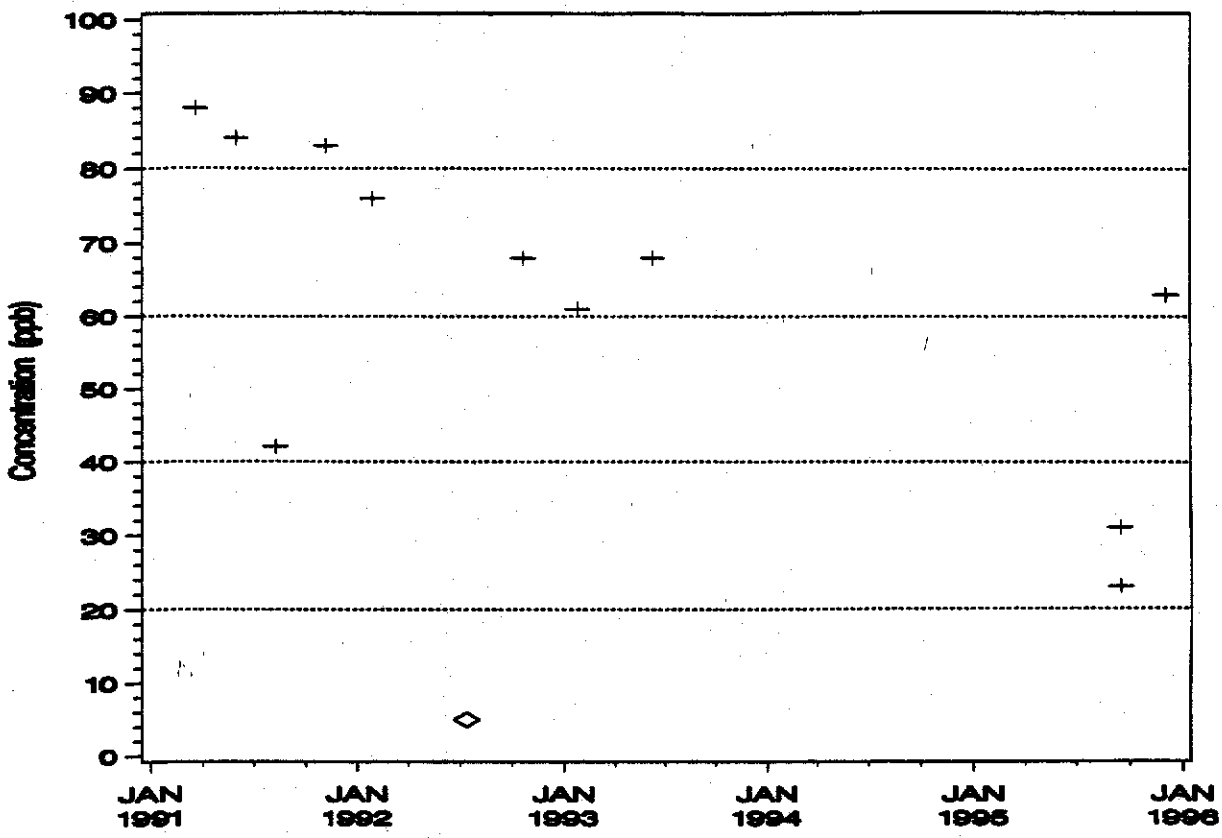


FREON 113 Trend

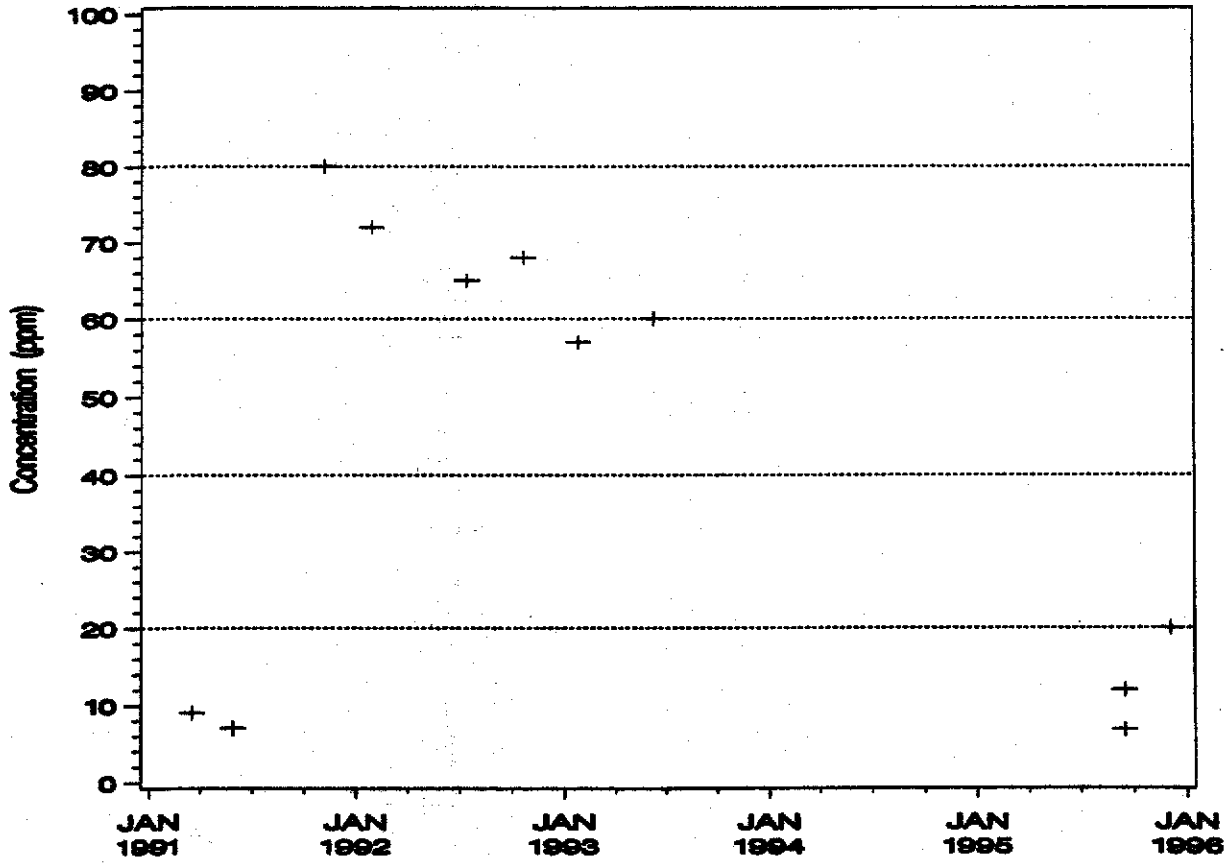


WELL 1357

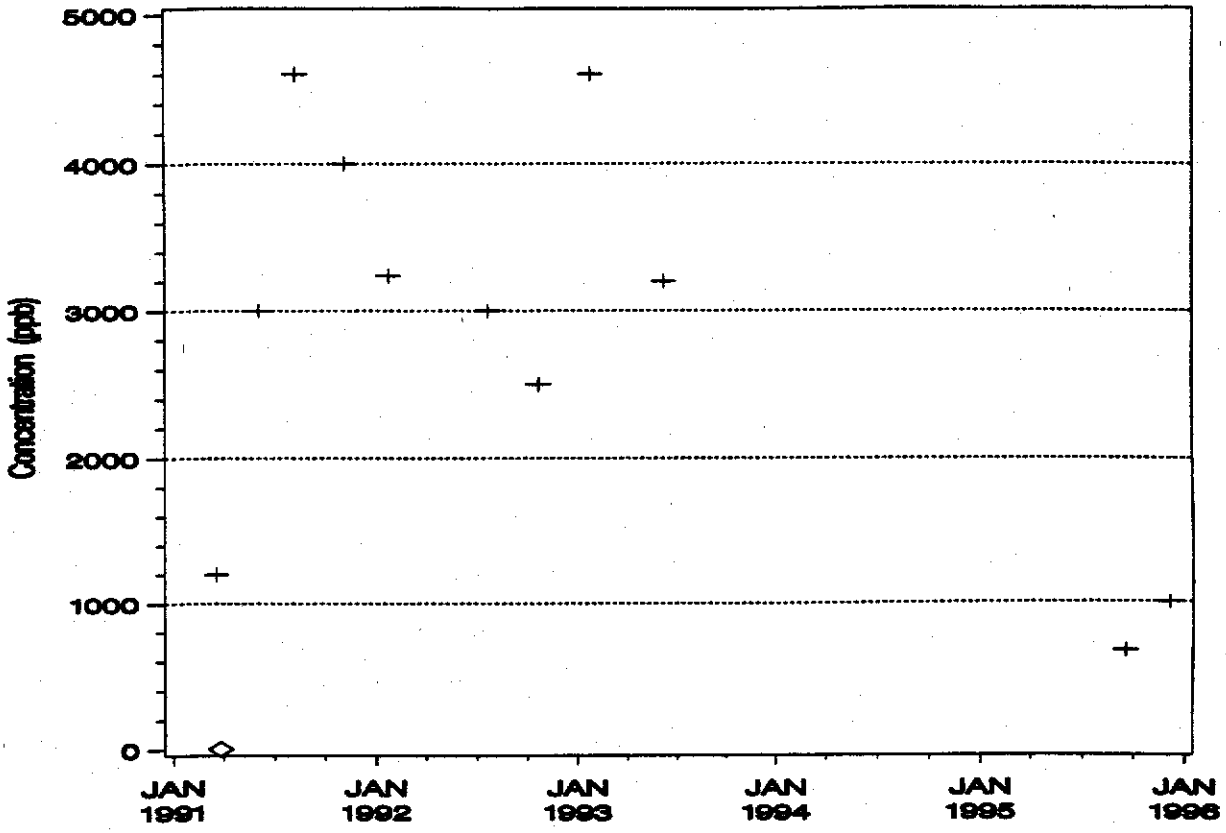
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



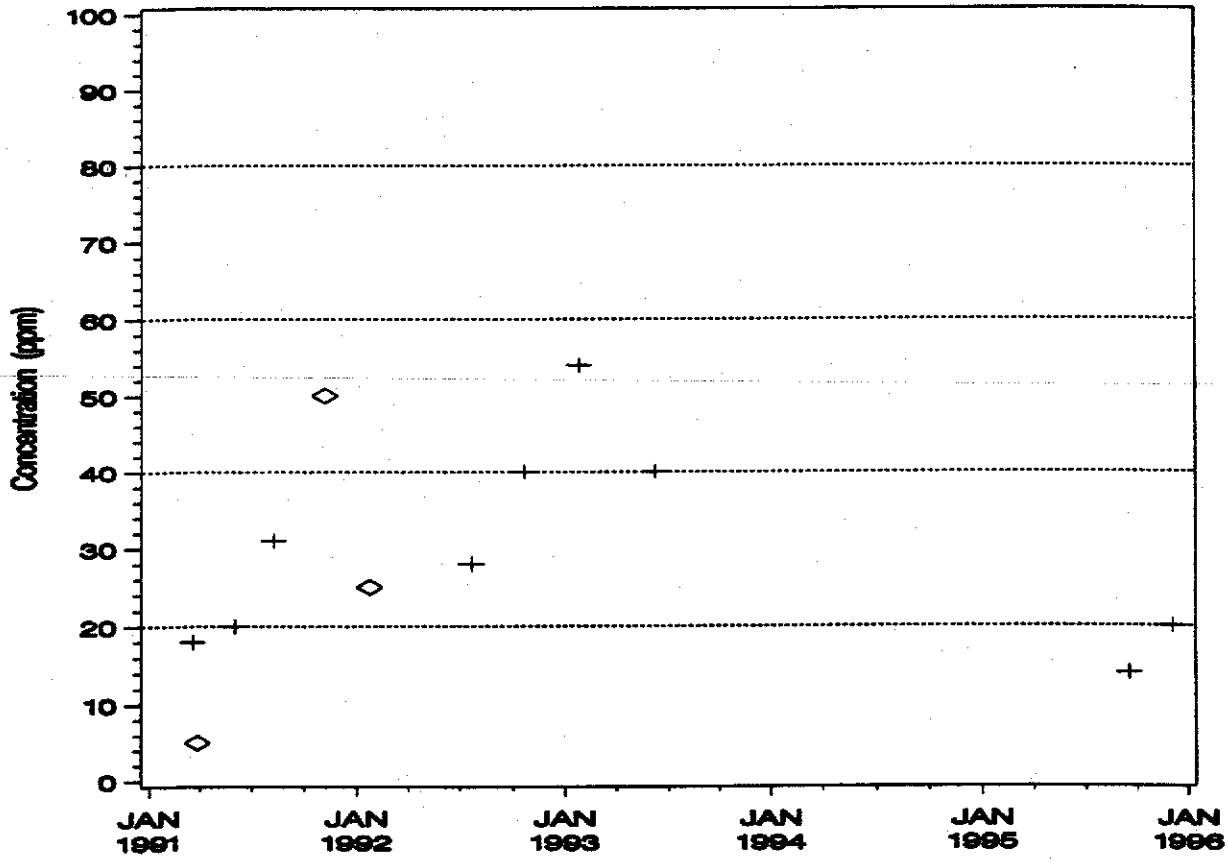
1,1 – DICHLOROETHYLENE Trend



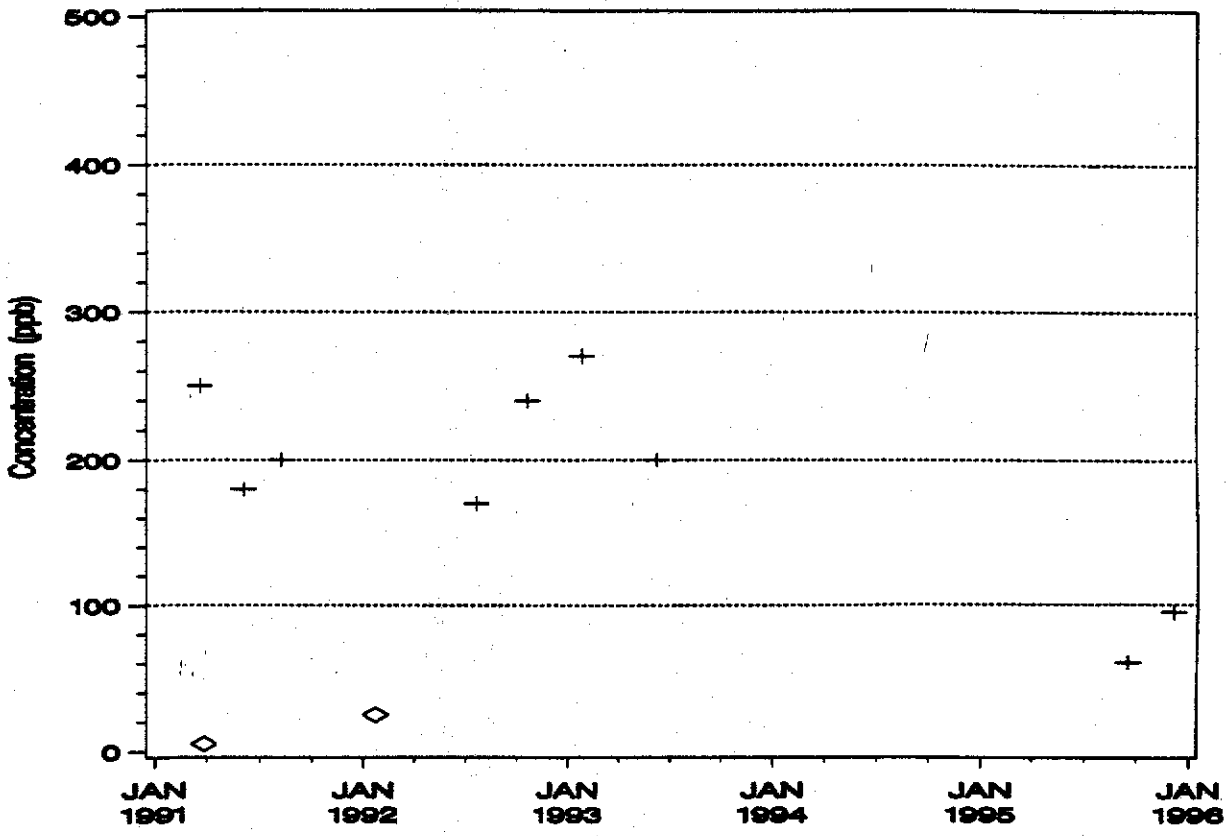
WELL 1358
TRICHLOROETHYLENE Trend



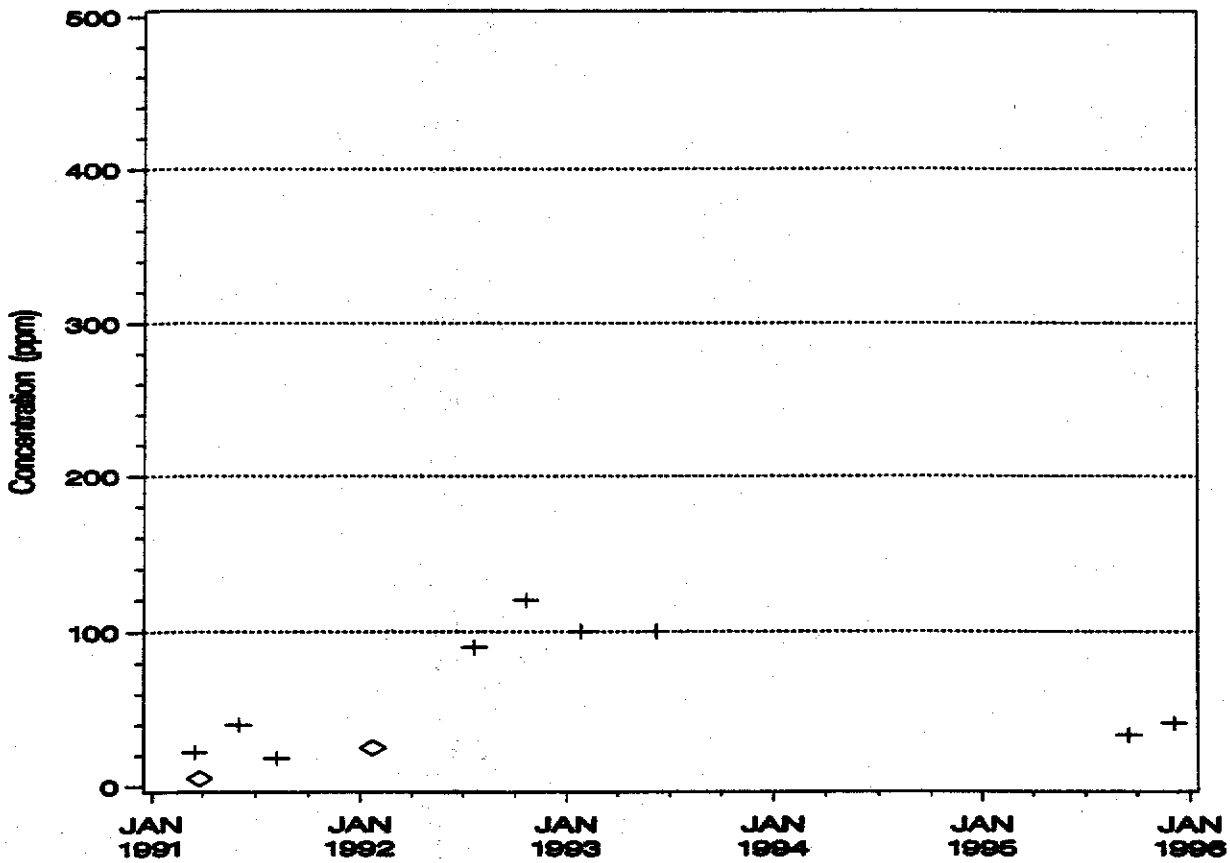
FREON 113 Trend



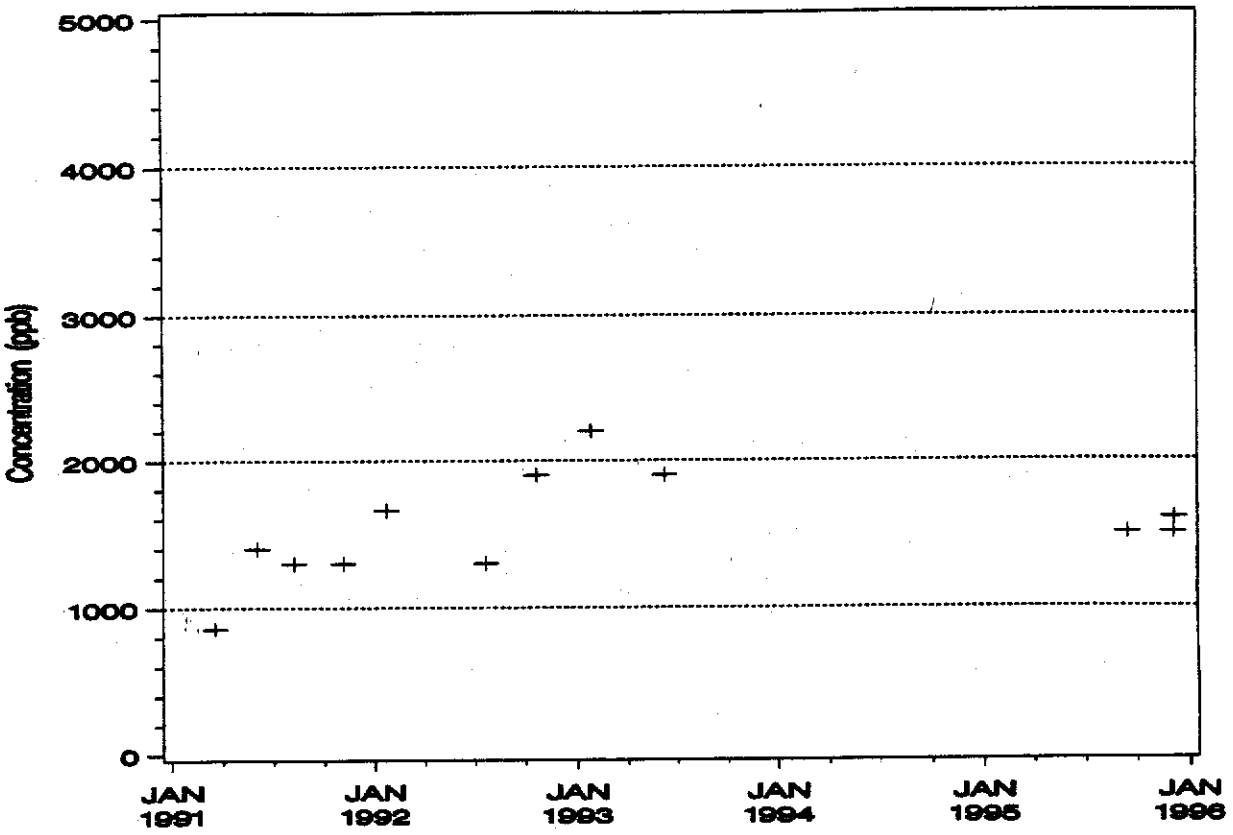
WELL 1358
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



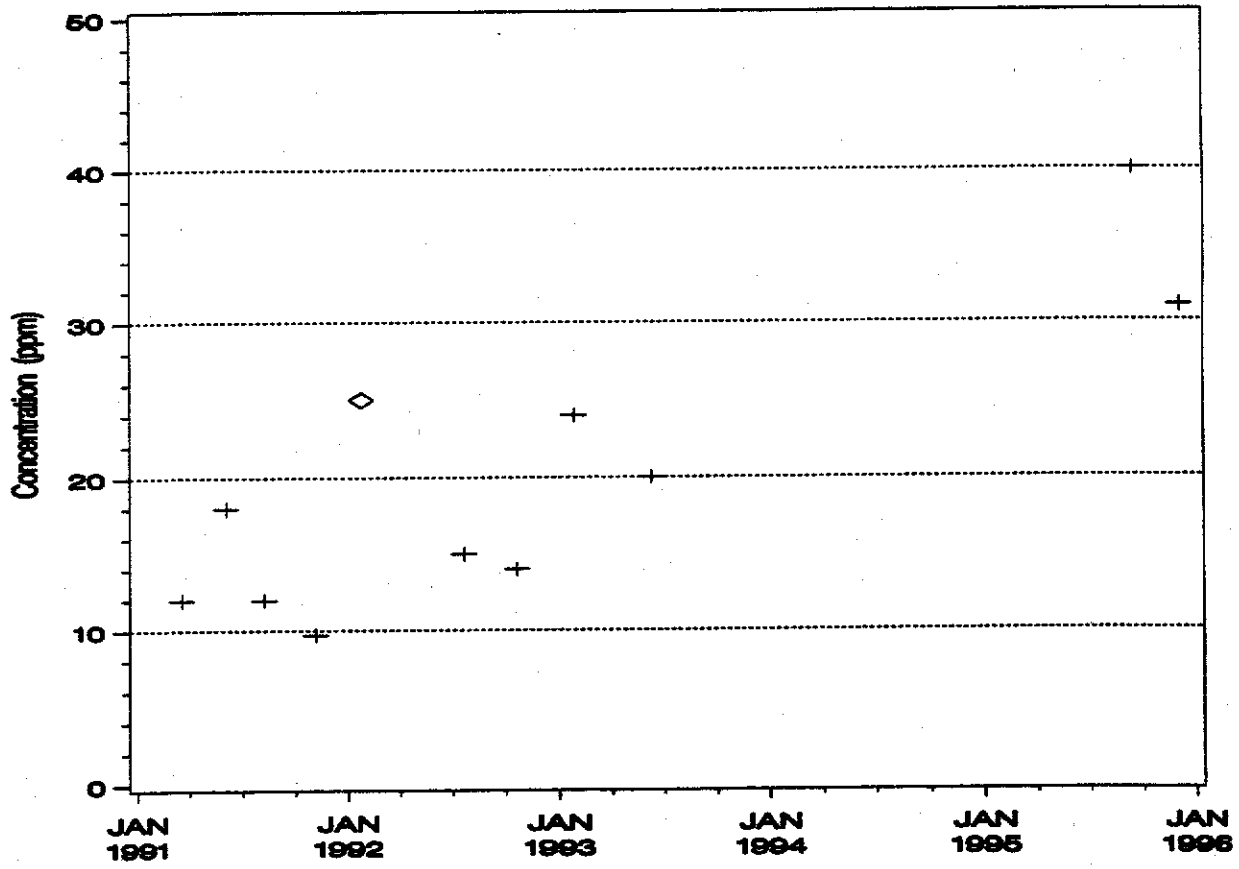
1,1 – DICHLOROETHYLENE Trend



WELL 1359
TRICHLOROETHYLENE Trend

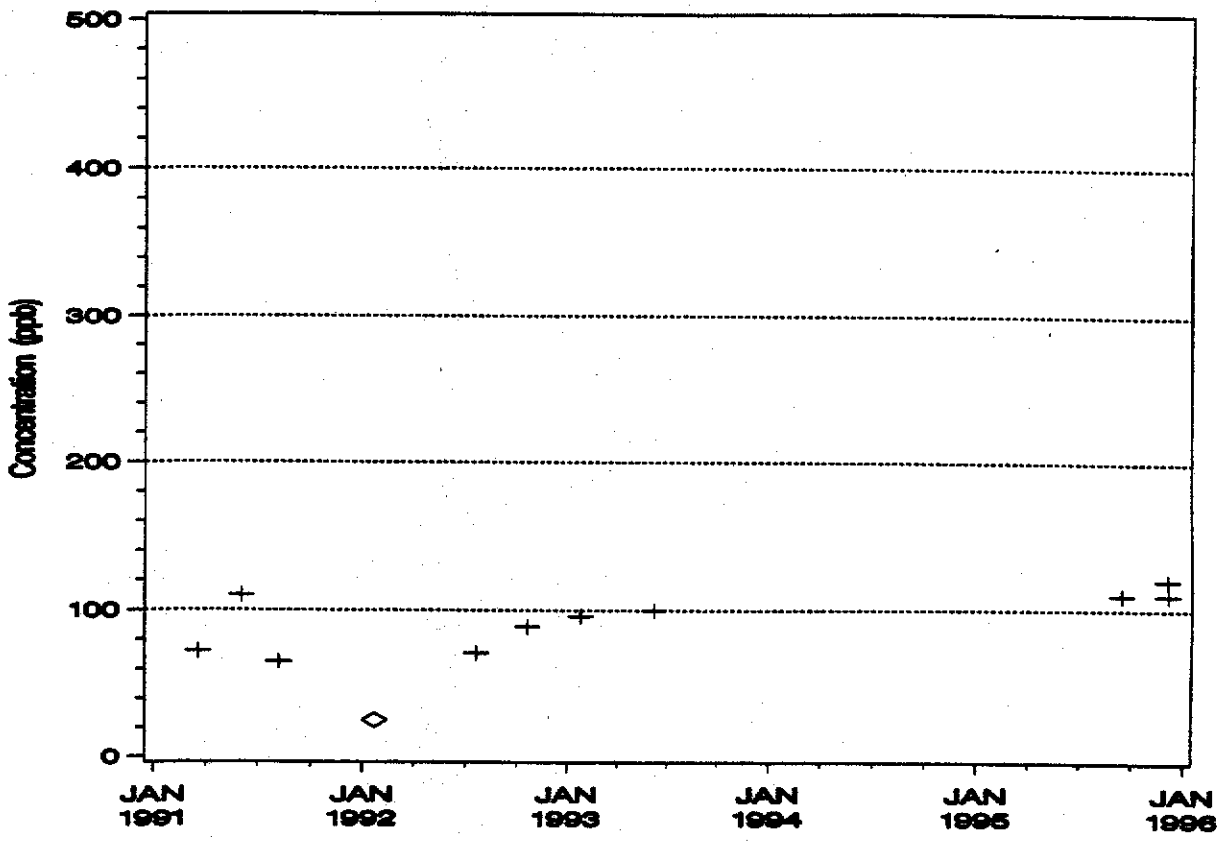


FREON 113 Trend

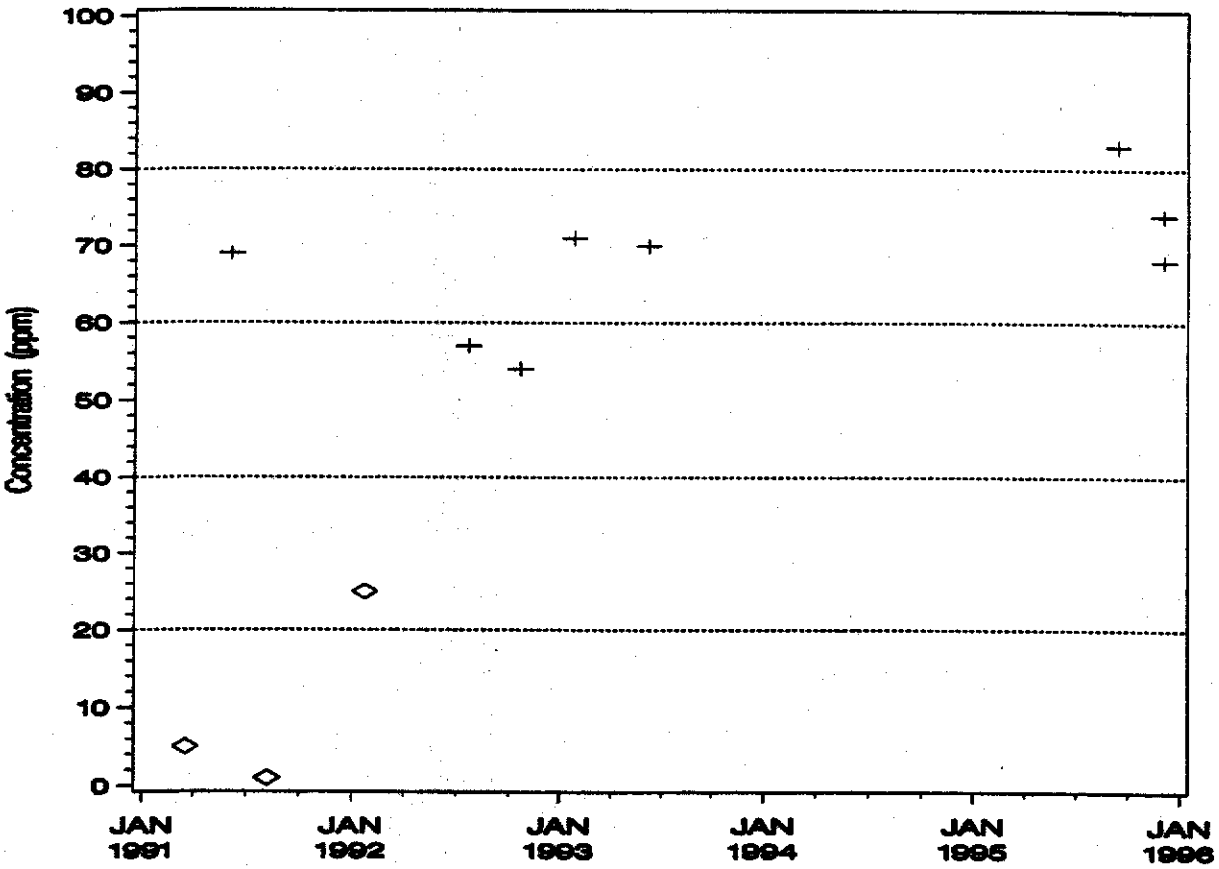


WELL 1359

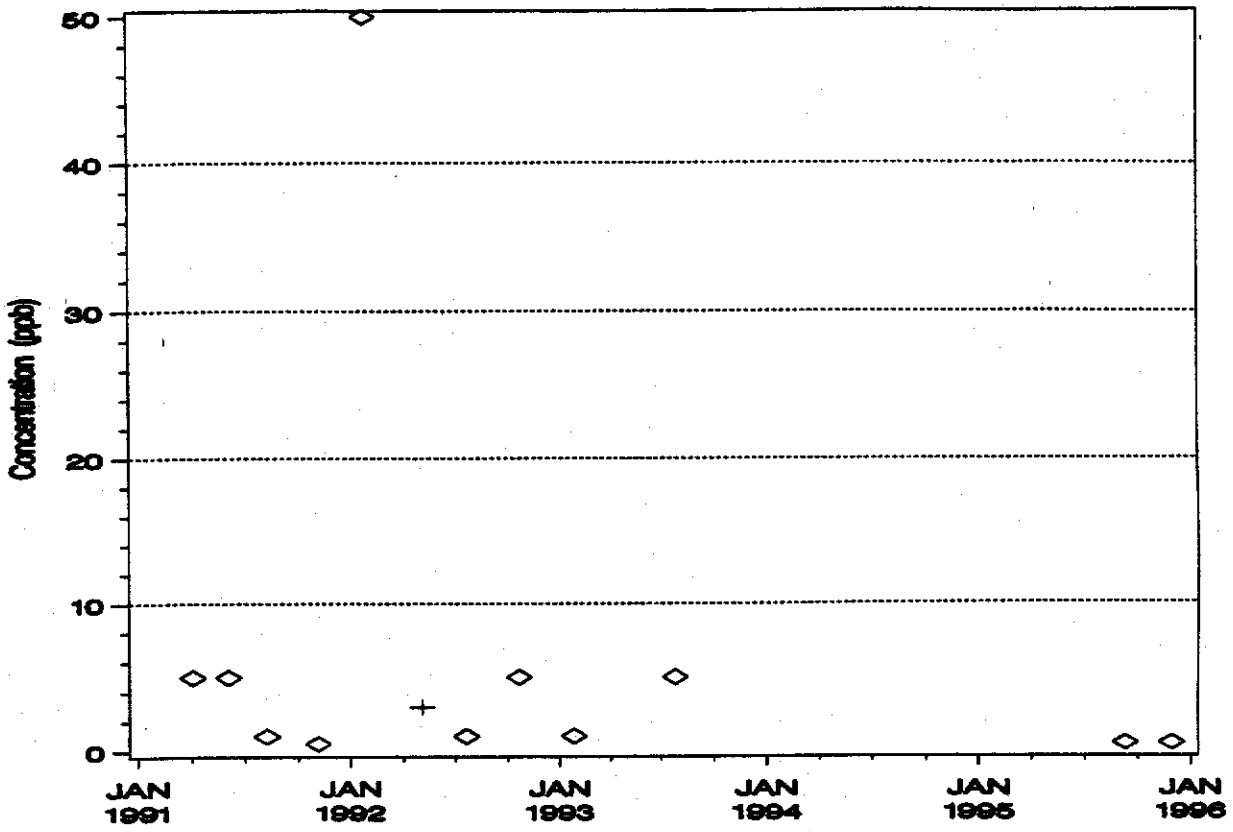
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



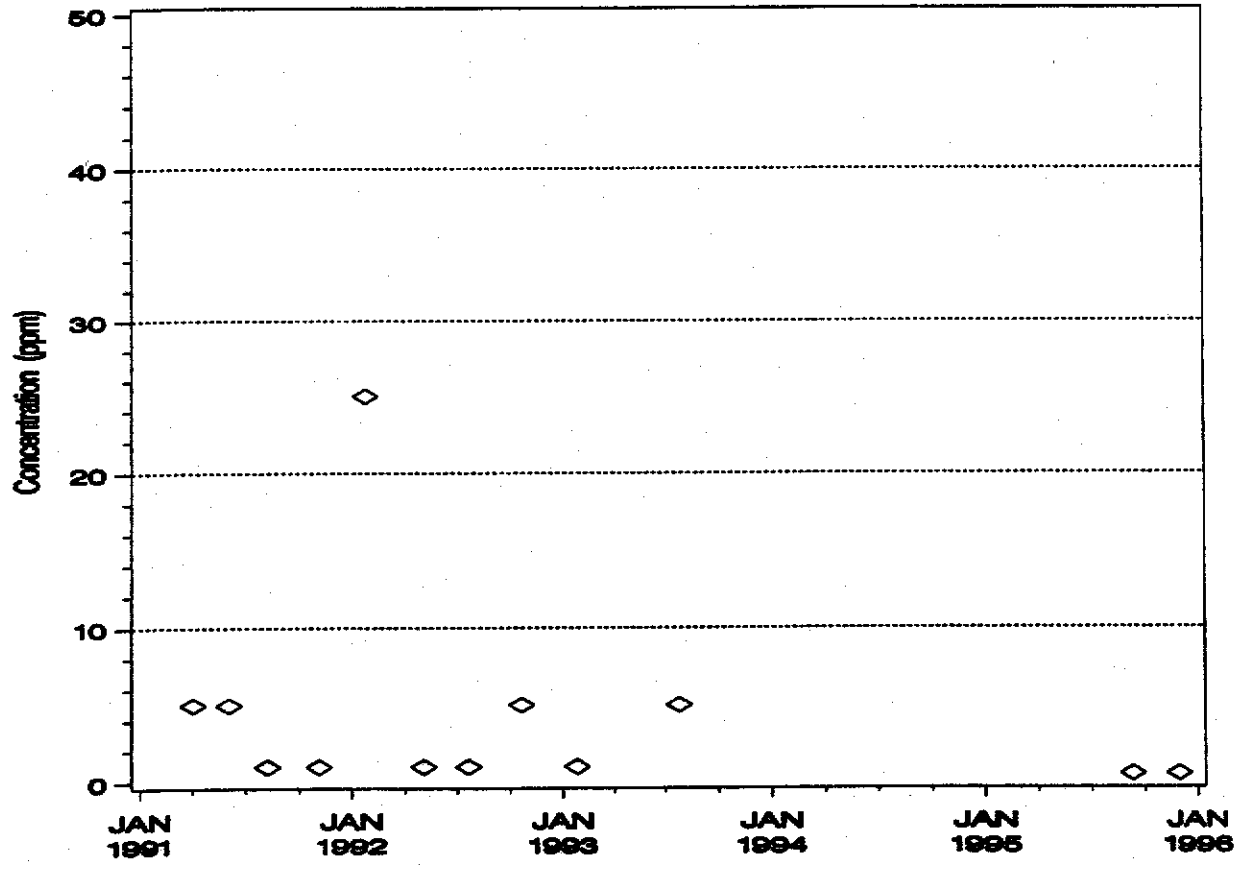
1,1 – DICHLOROETHYLENE Trend



WELL 1360
TRICHLOROETHYLENE Trend

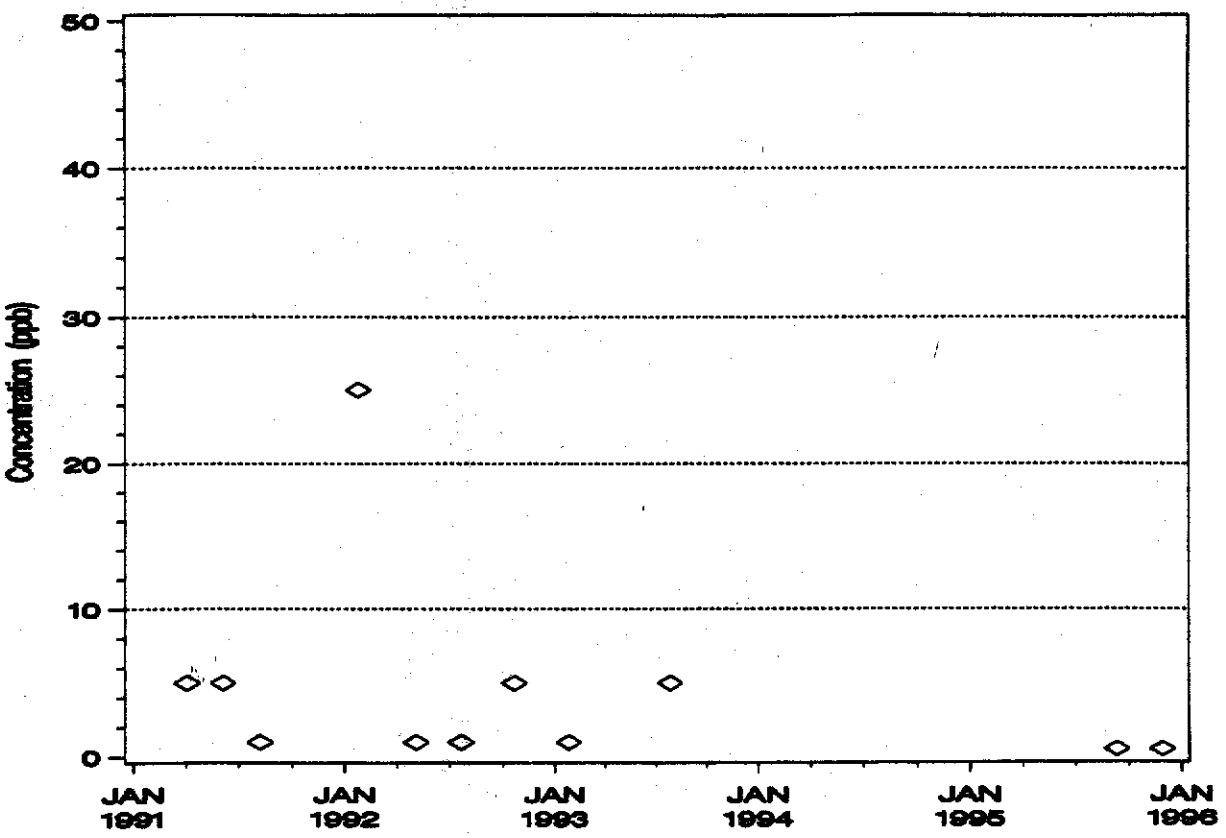


FREON 113 Trend

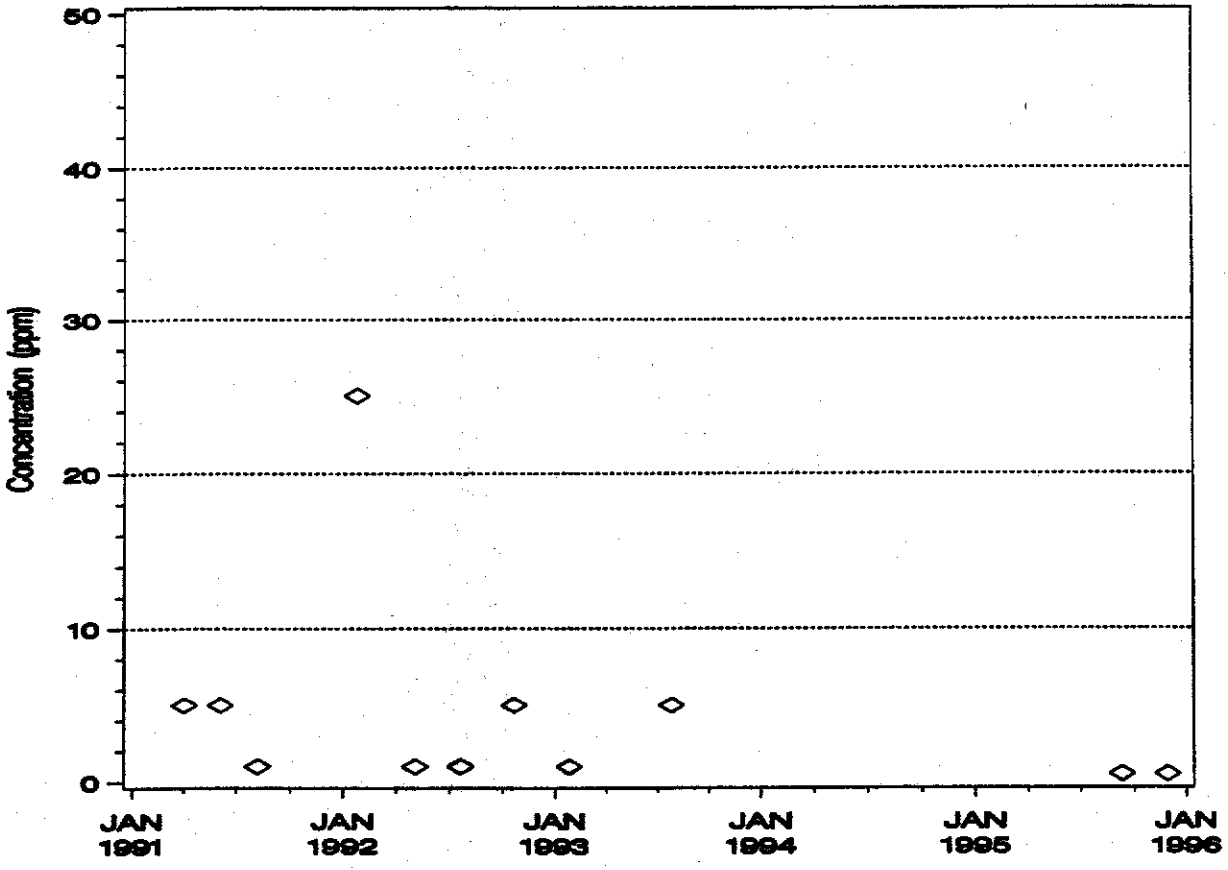


WELL 1360

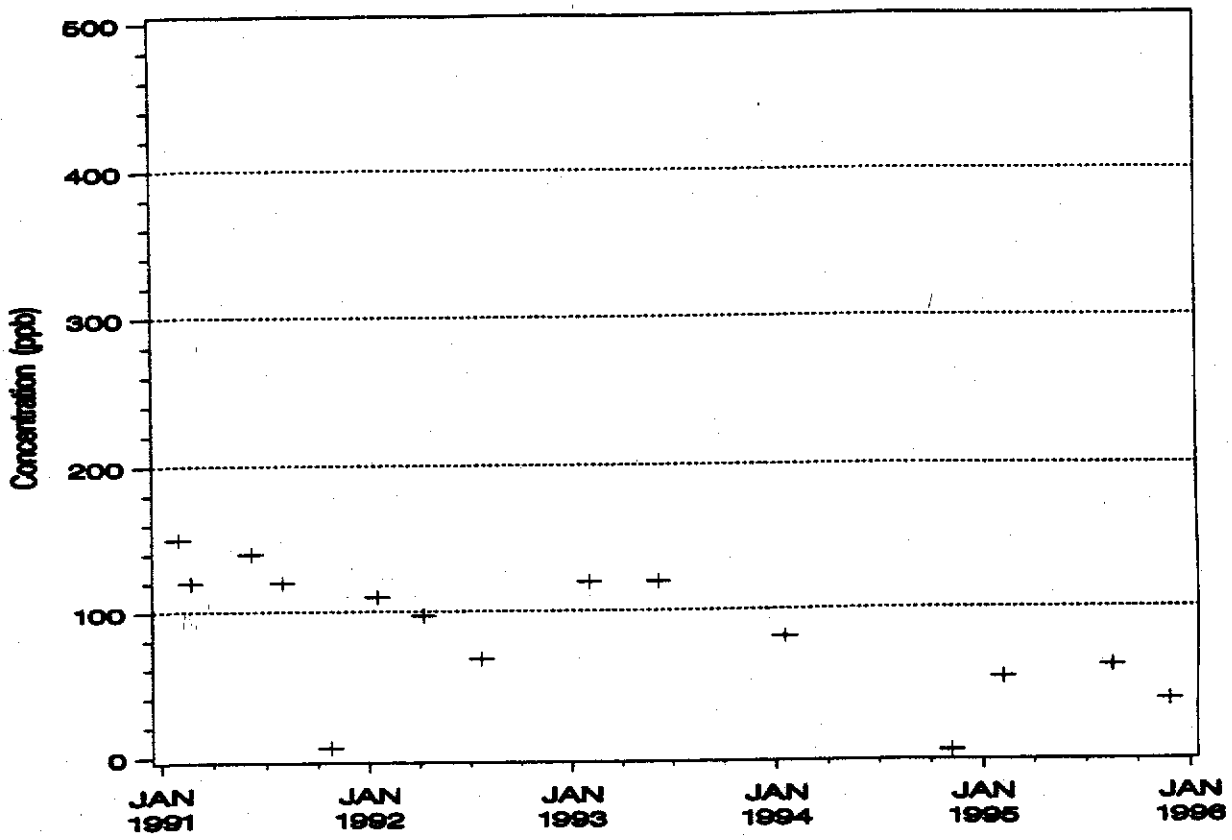
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



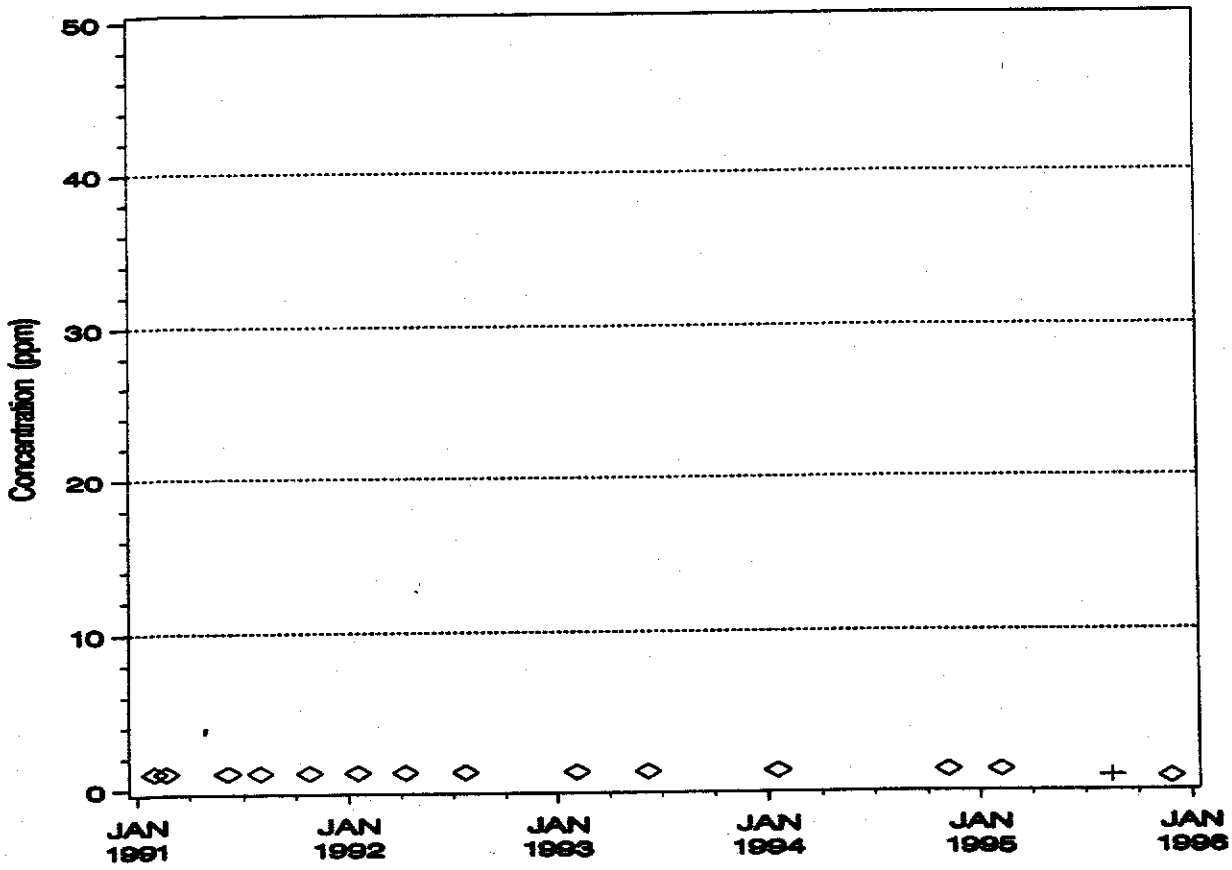
1,1 – DICHLOROETHYLENE Trend



WELL 1361
TRICHLOROETHYLENE Trend

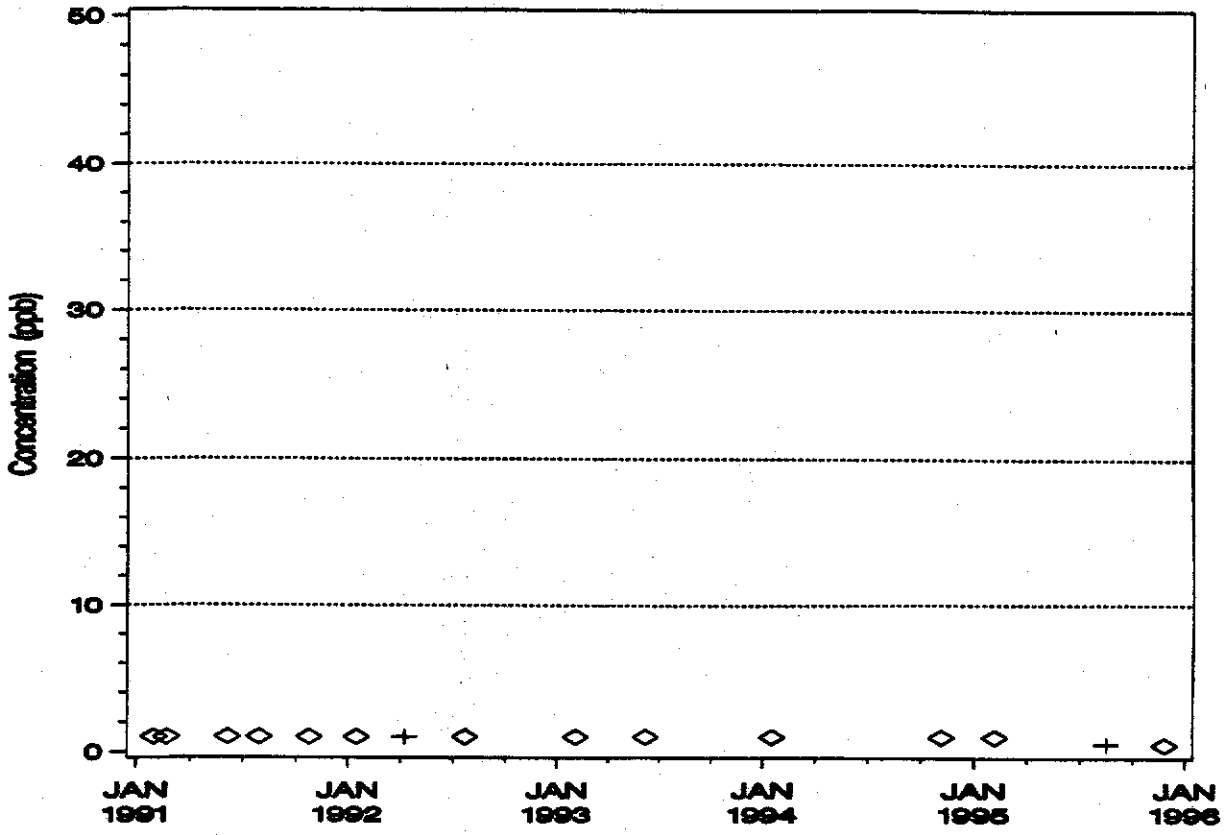


FREON 113 Trend

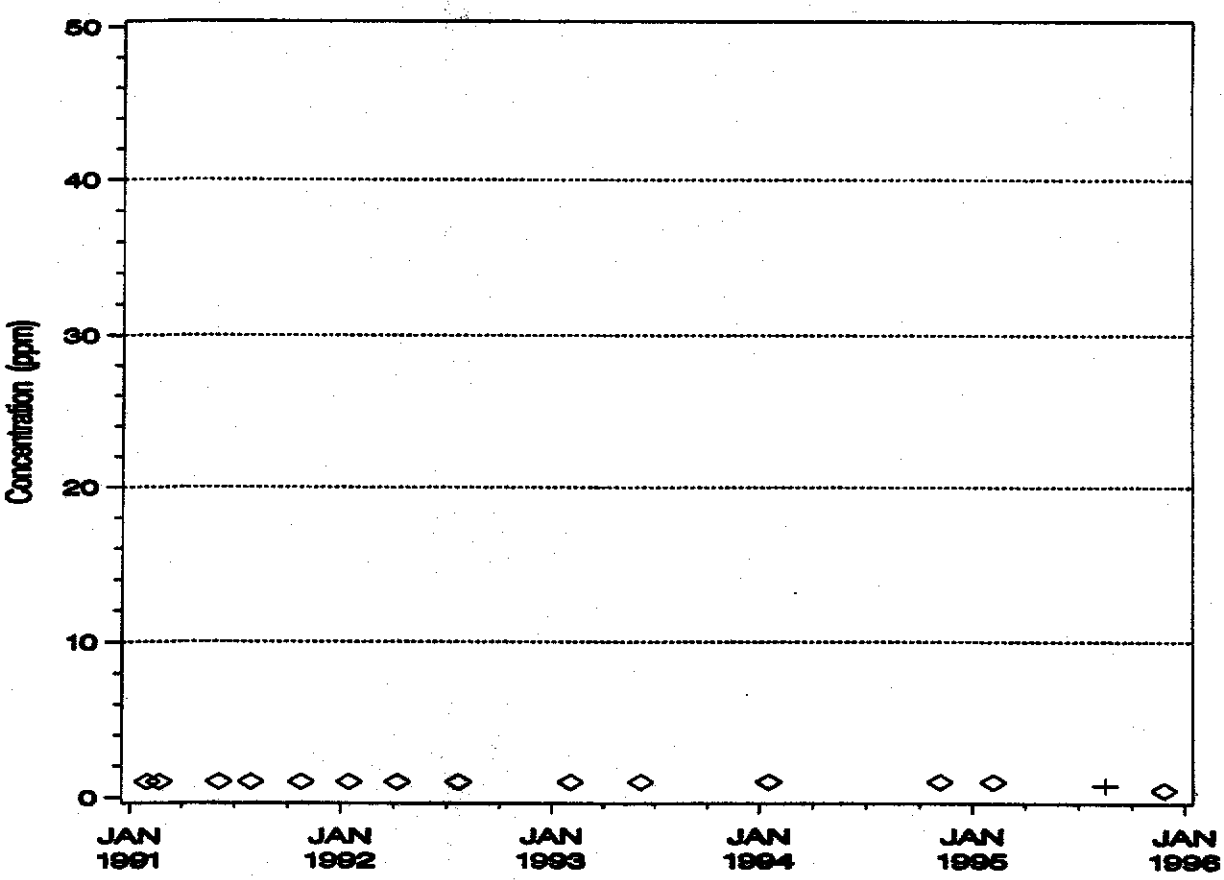


WELL 1361

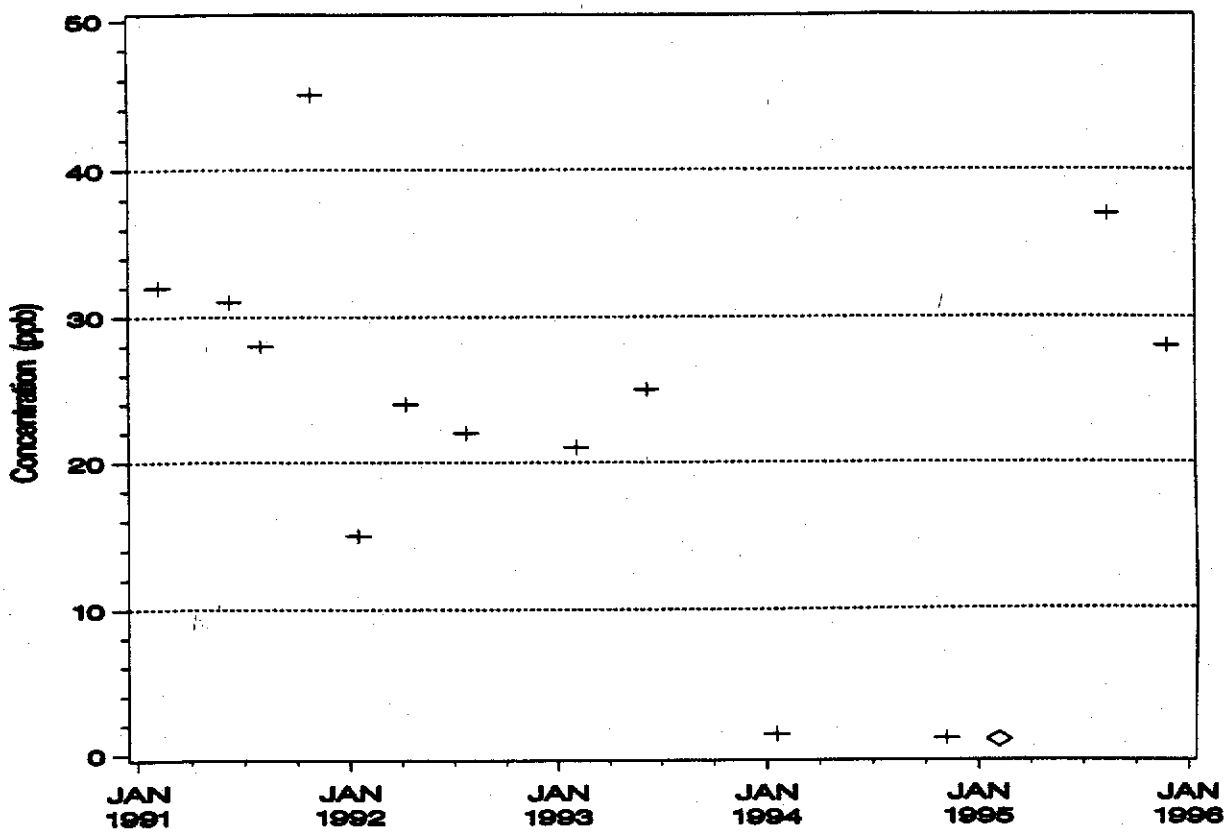
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



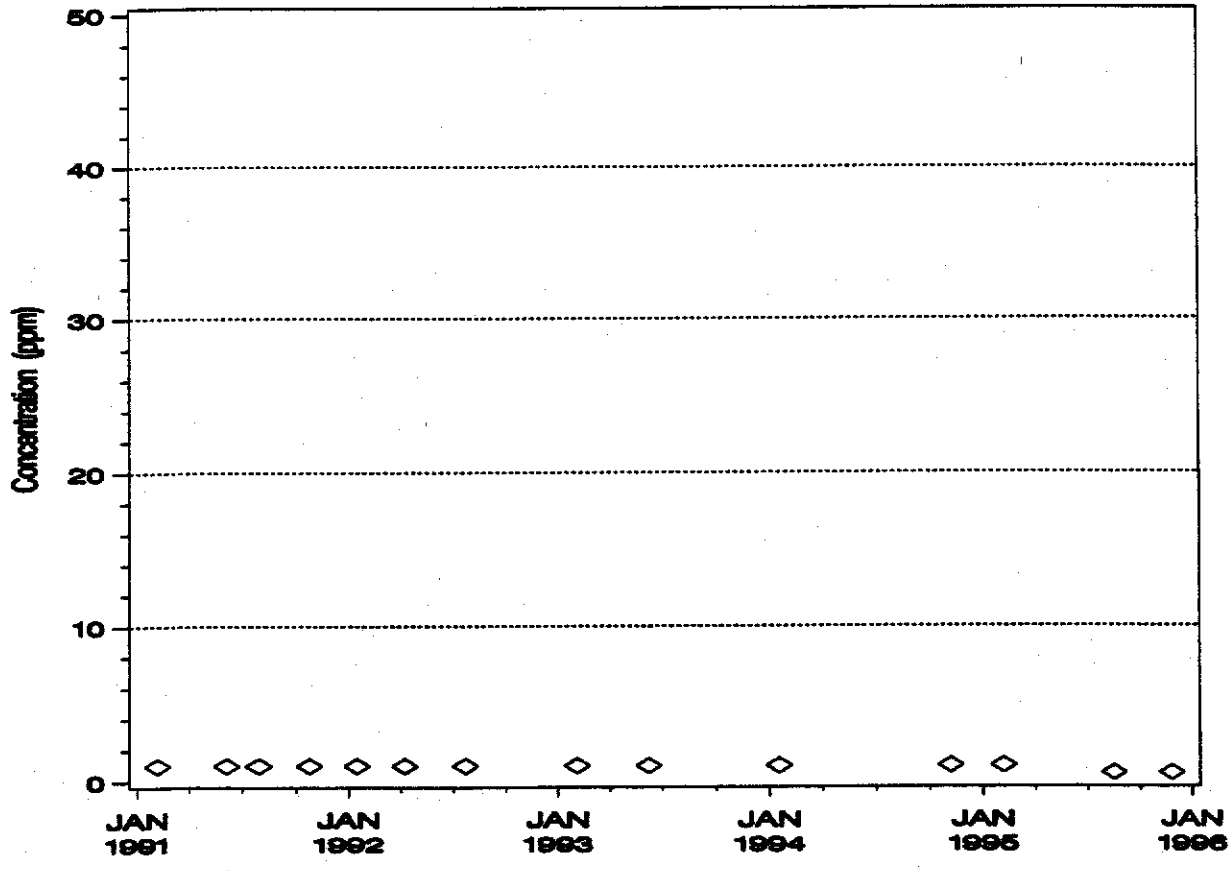
1,1 – DICHLOROETHYLENE Trend



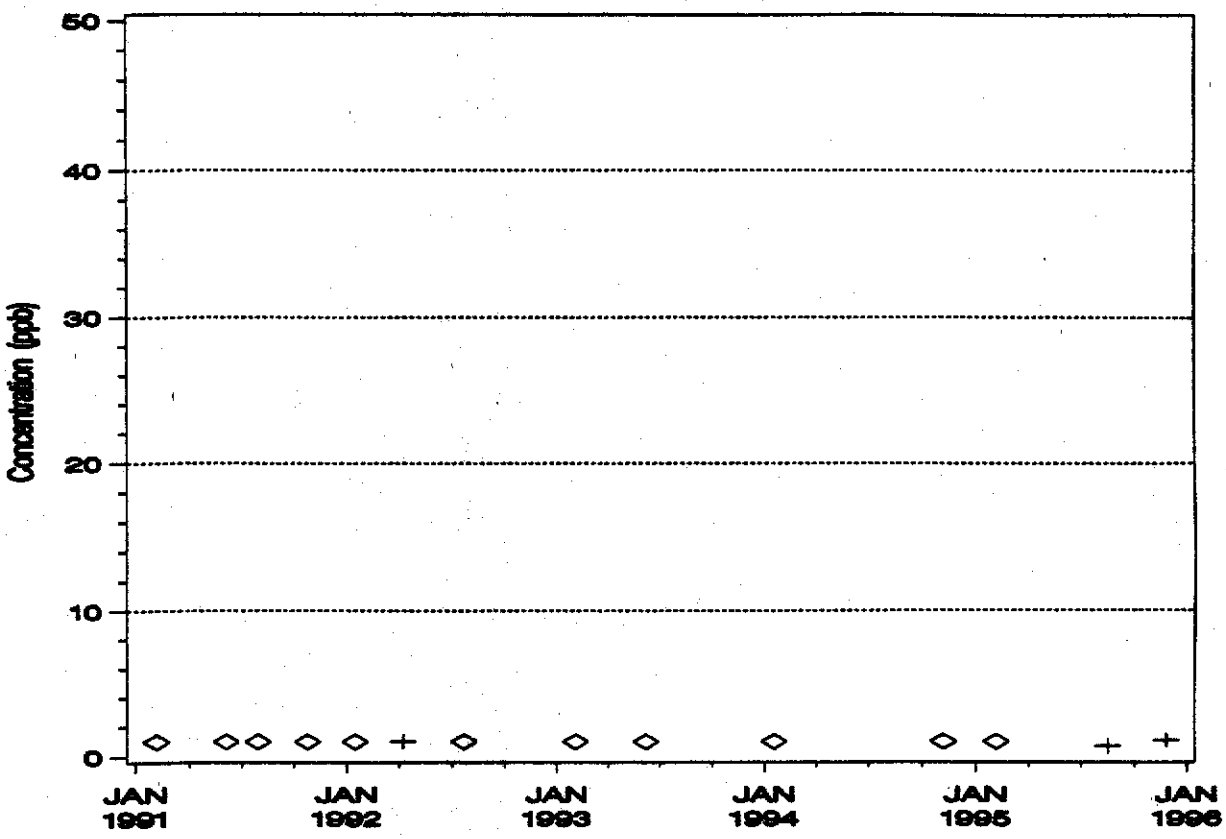
WELL 1362
TRICHLOROETHYLENE Trend



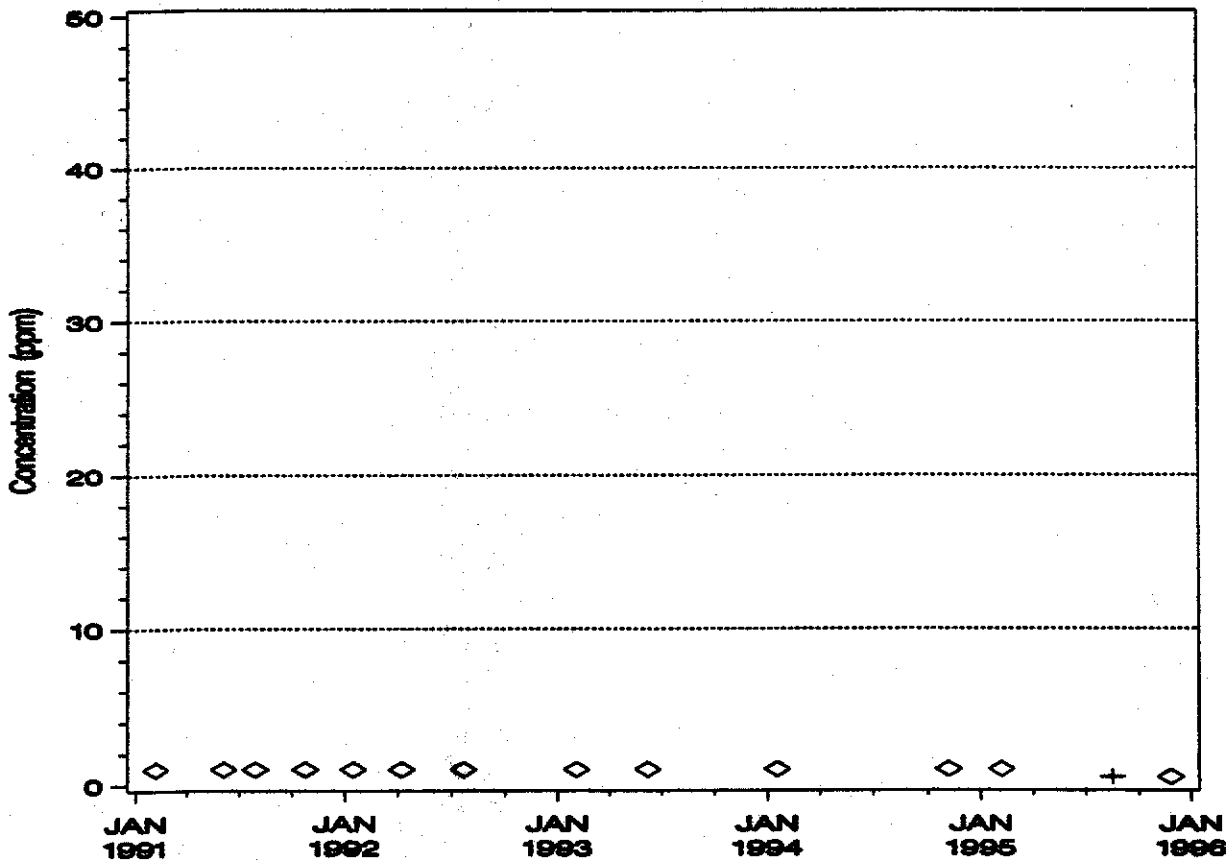
FREON 113 Trend



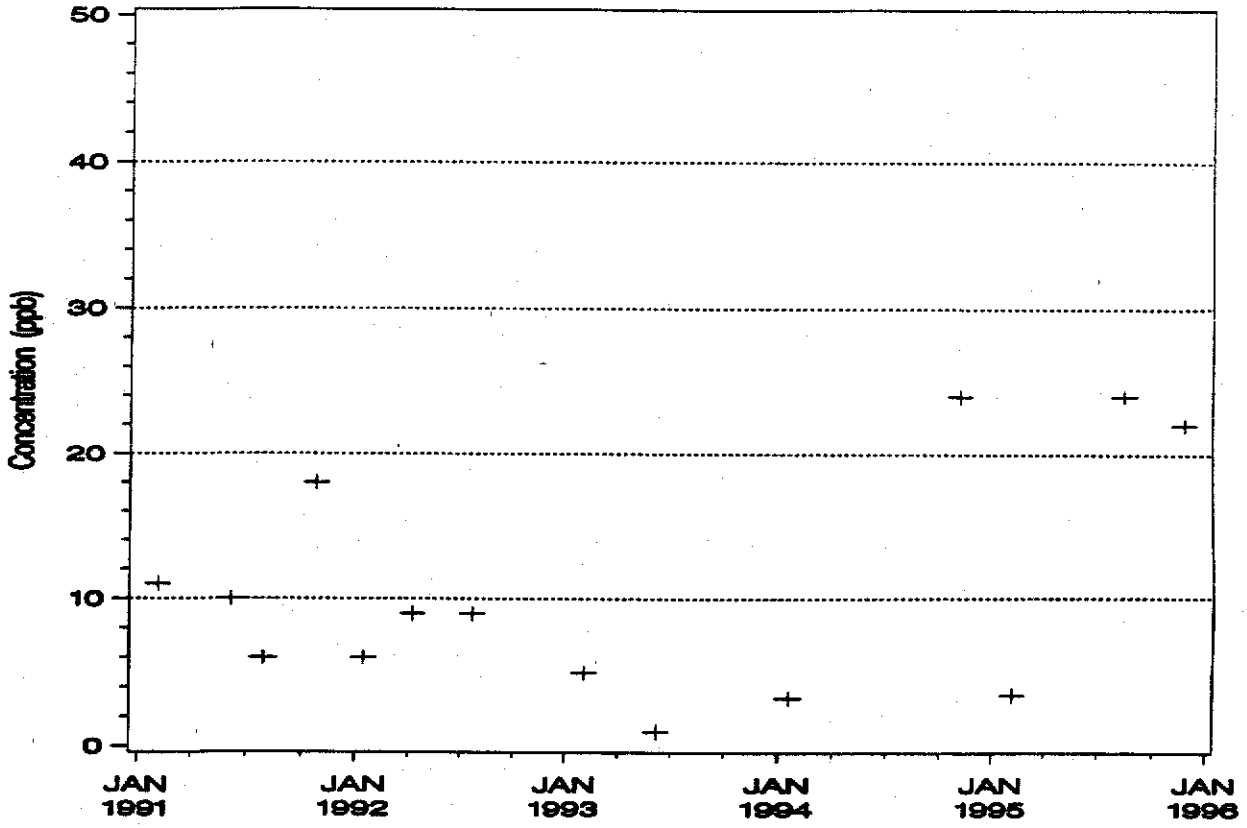
WELL 1362
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



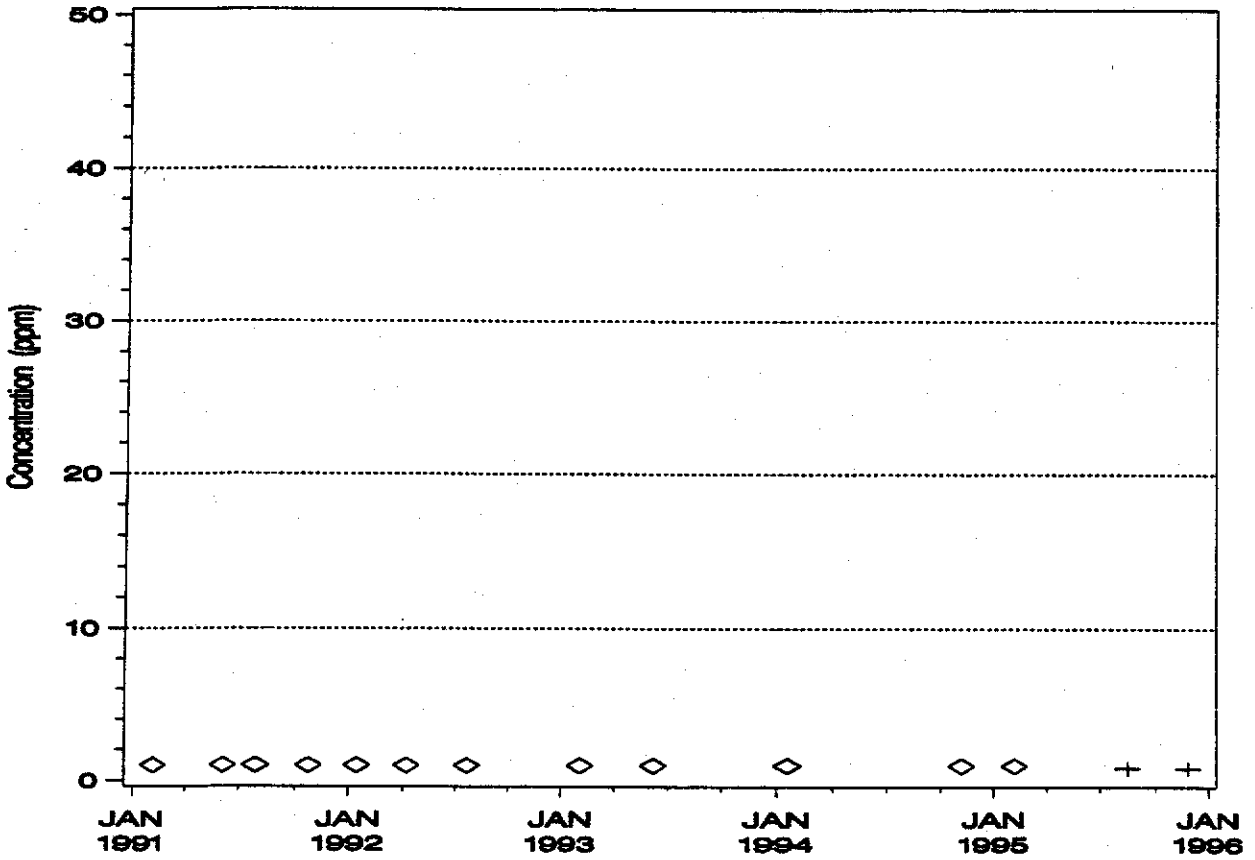
1,1 – DICHLOROETHYLENE Trend



WELL 1363
TRICHLOROETHYLENE Trend

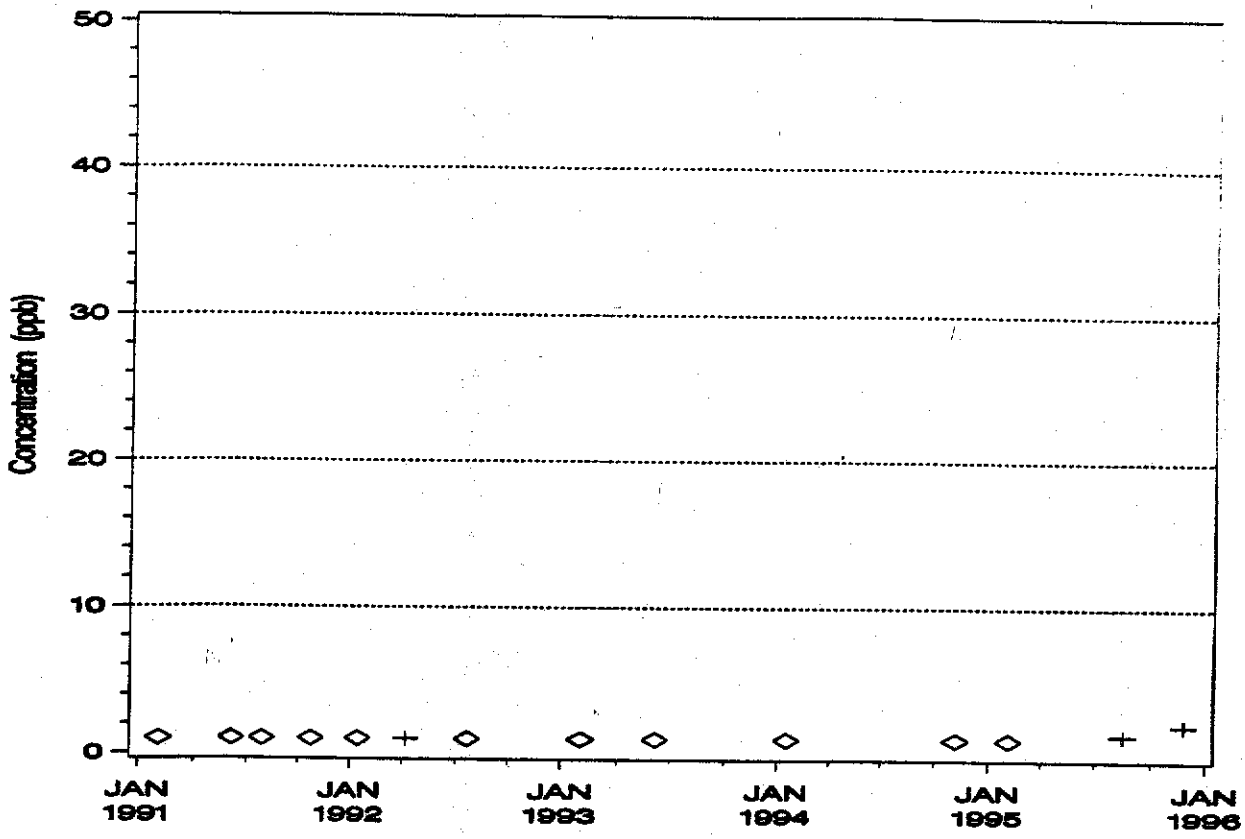


FREON 113 Trend

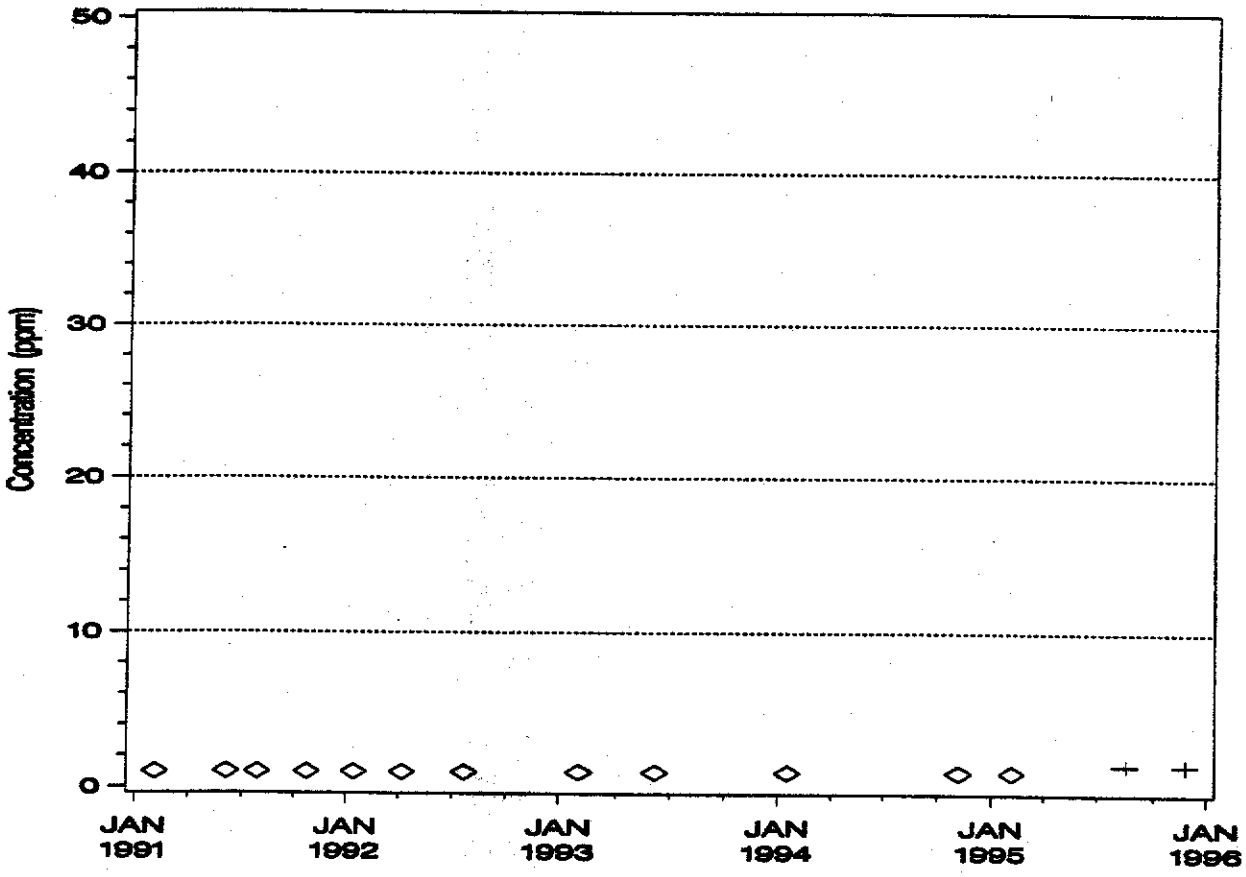


WELL 1363

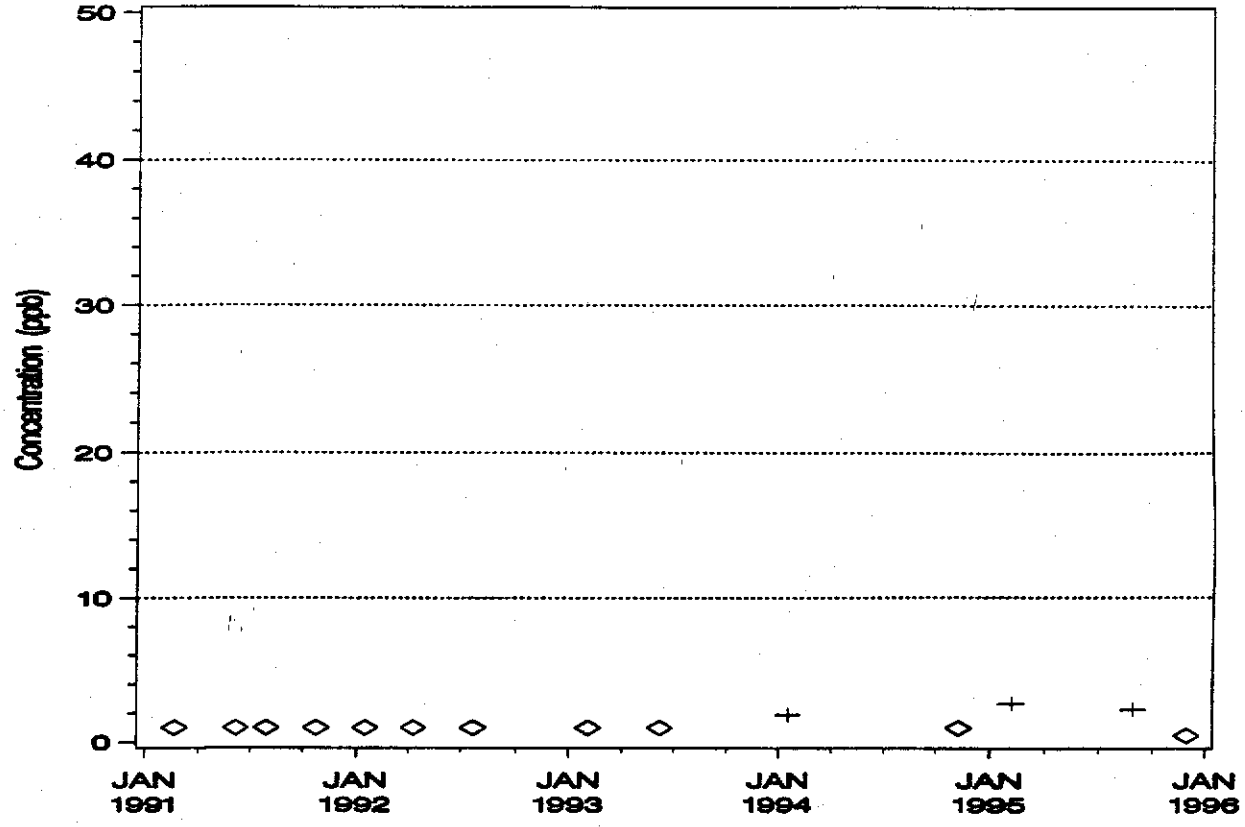
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



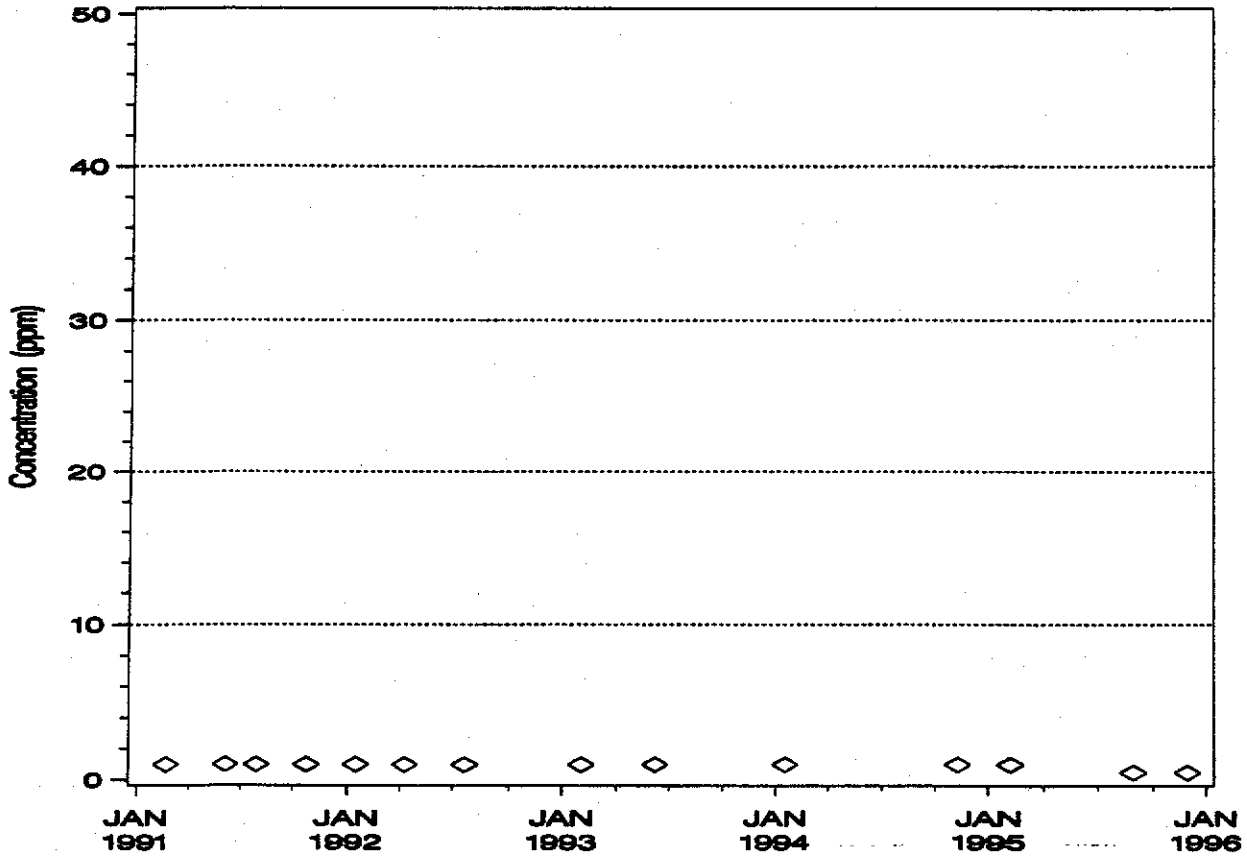
1,1 – DICHLOROETHYLENE Trend



WELL 1364
TRICHLOROETHYLENE Trend

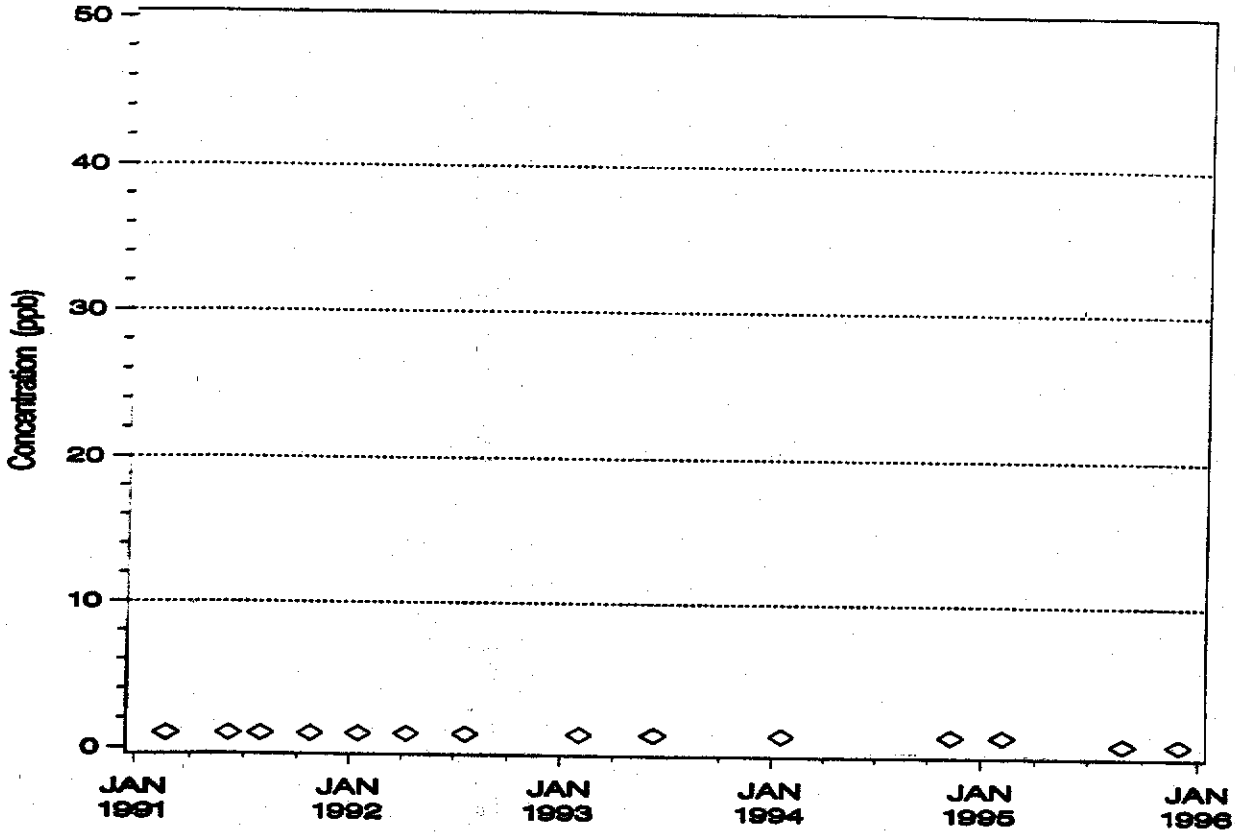


FREON 113 Trend

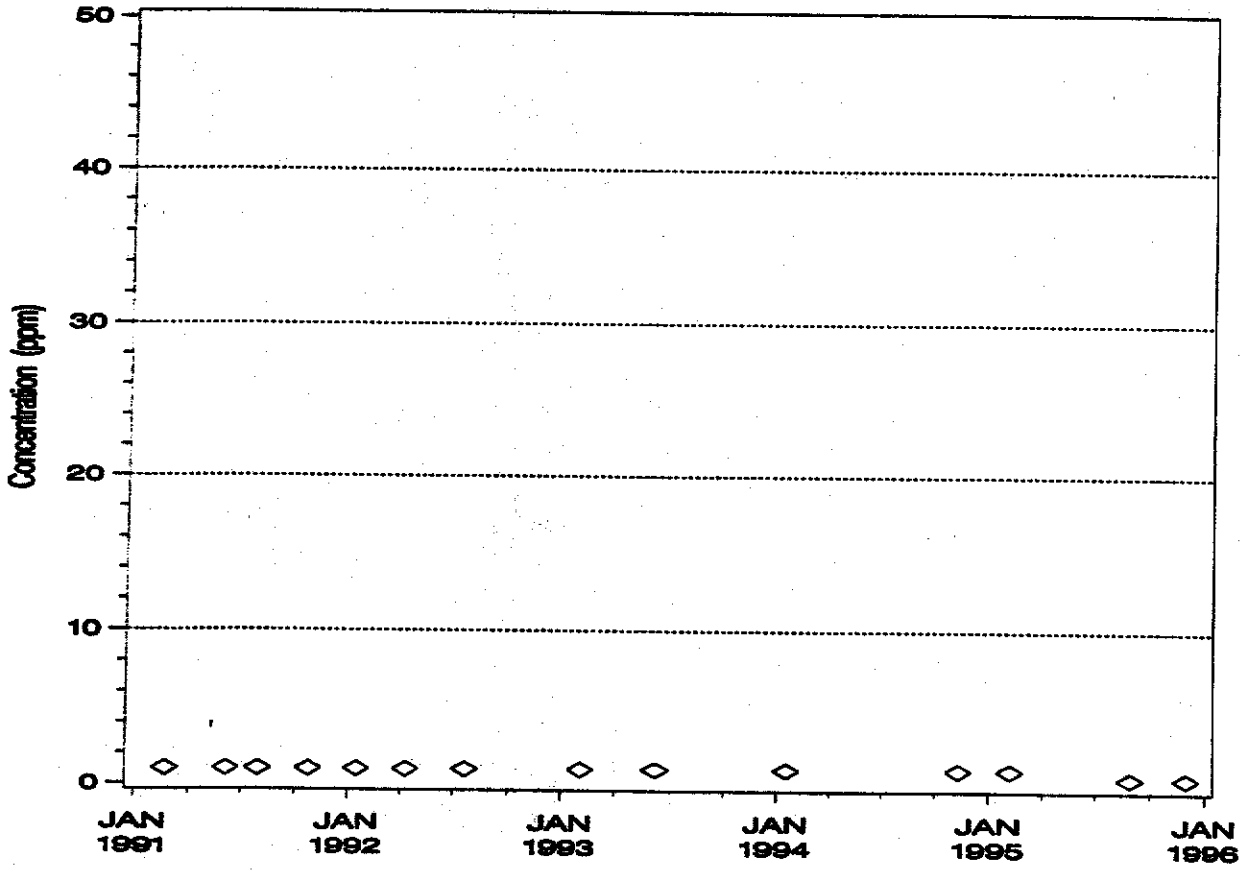


WELL 1364

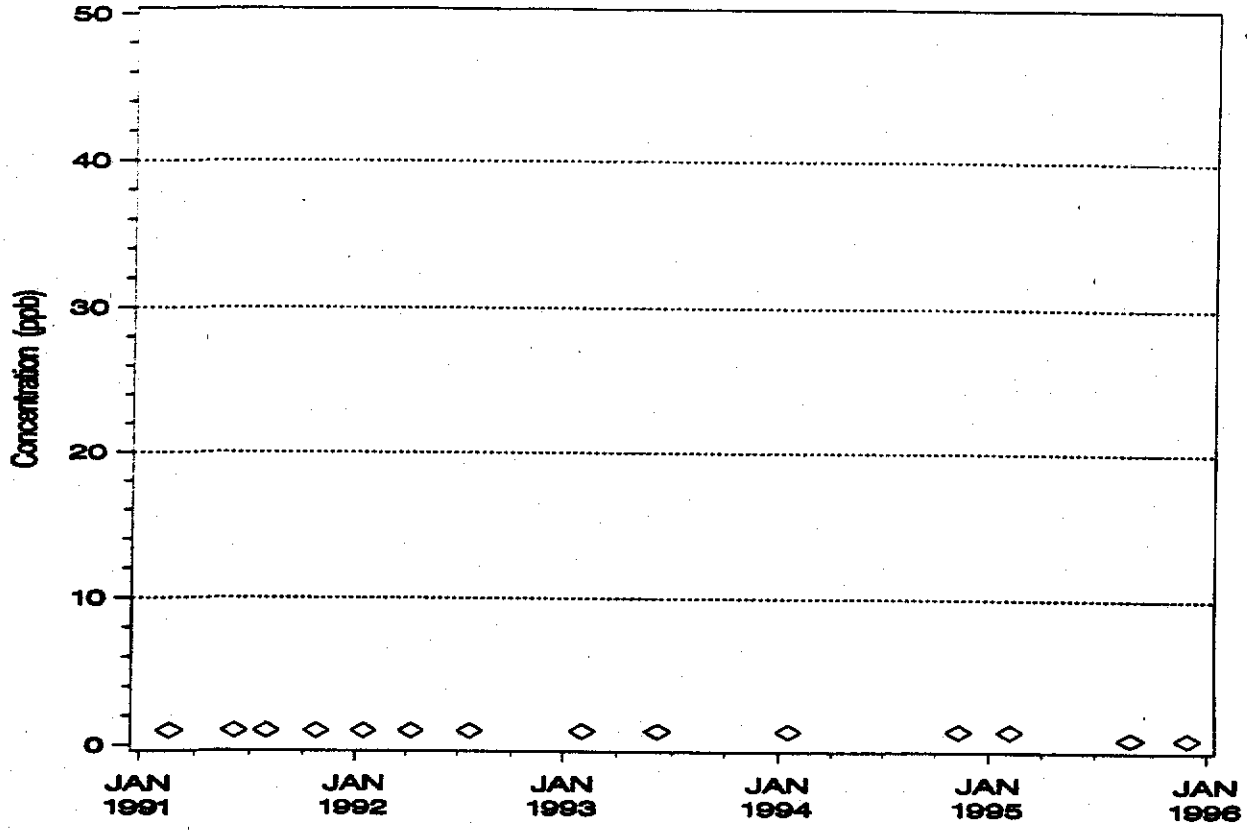
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



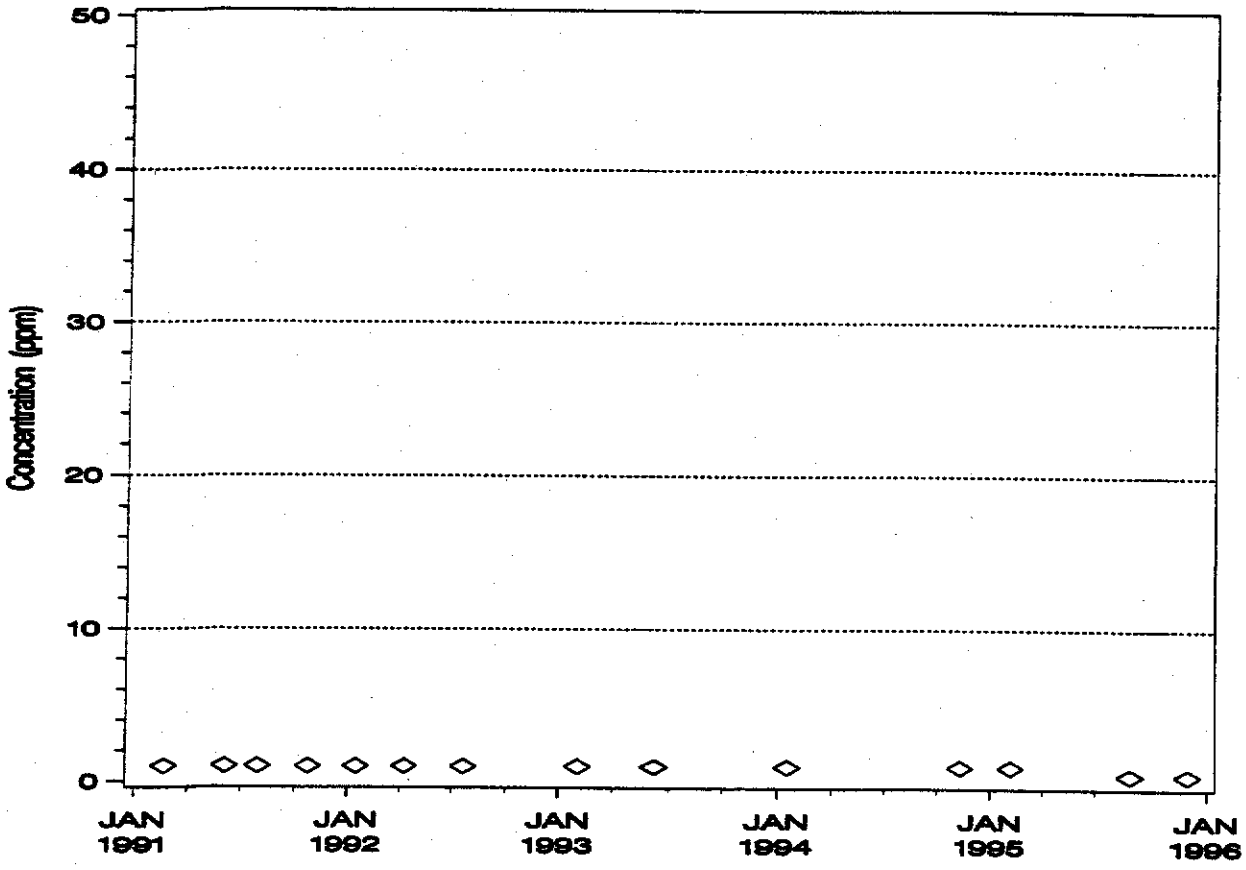
1,1 – DICHLOROETHYLENE Trend



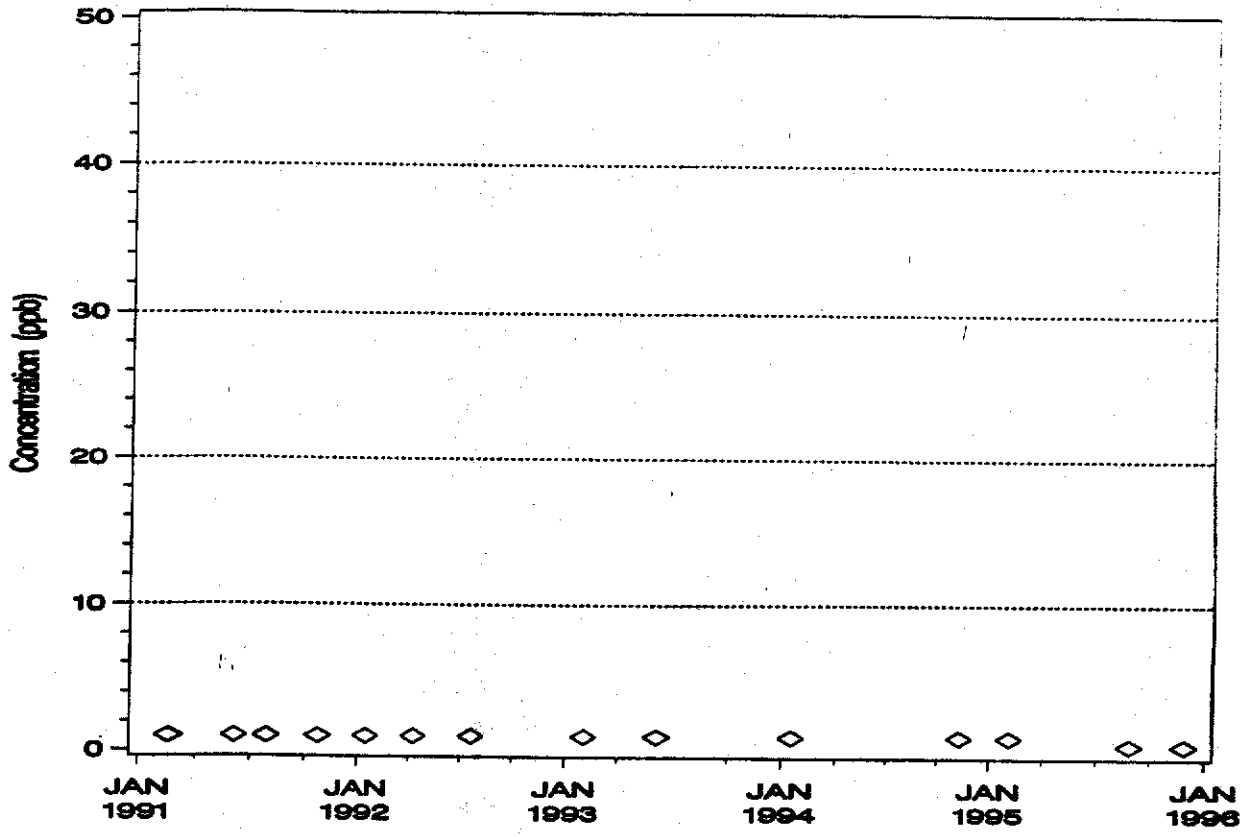
WELL 1365
TRICHLOROETHYLENE Trend



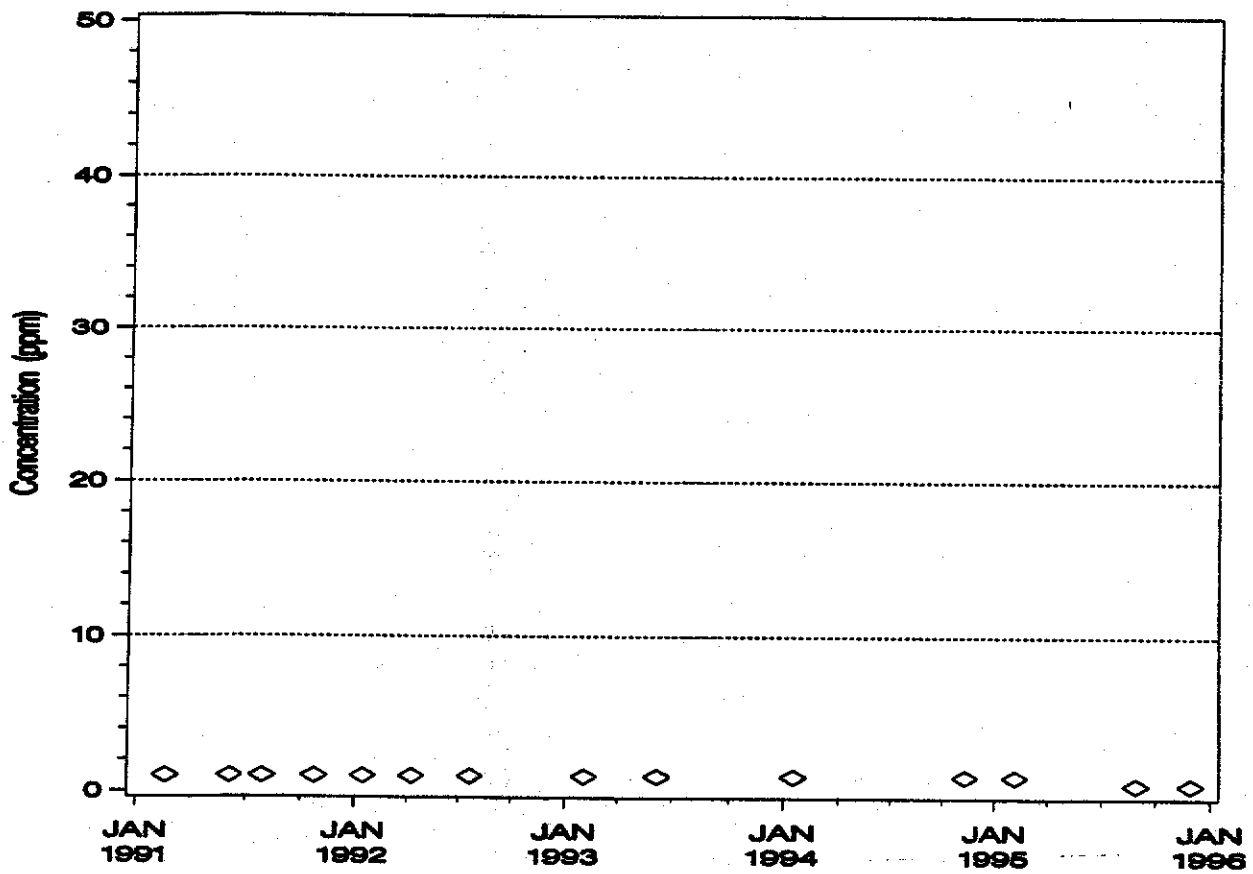
FREON 113 Trend



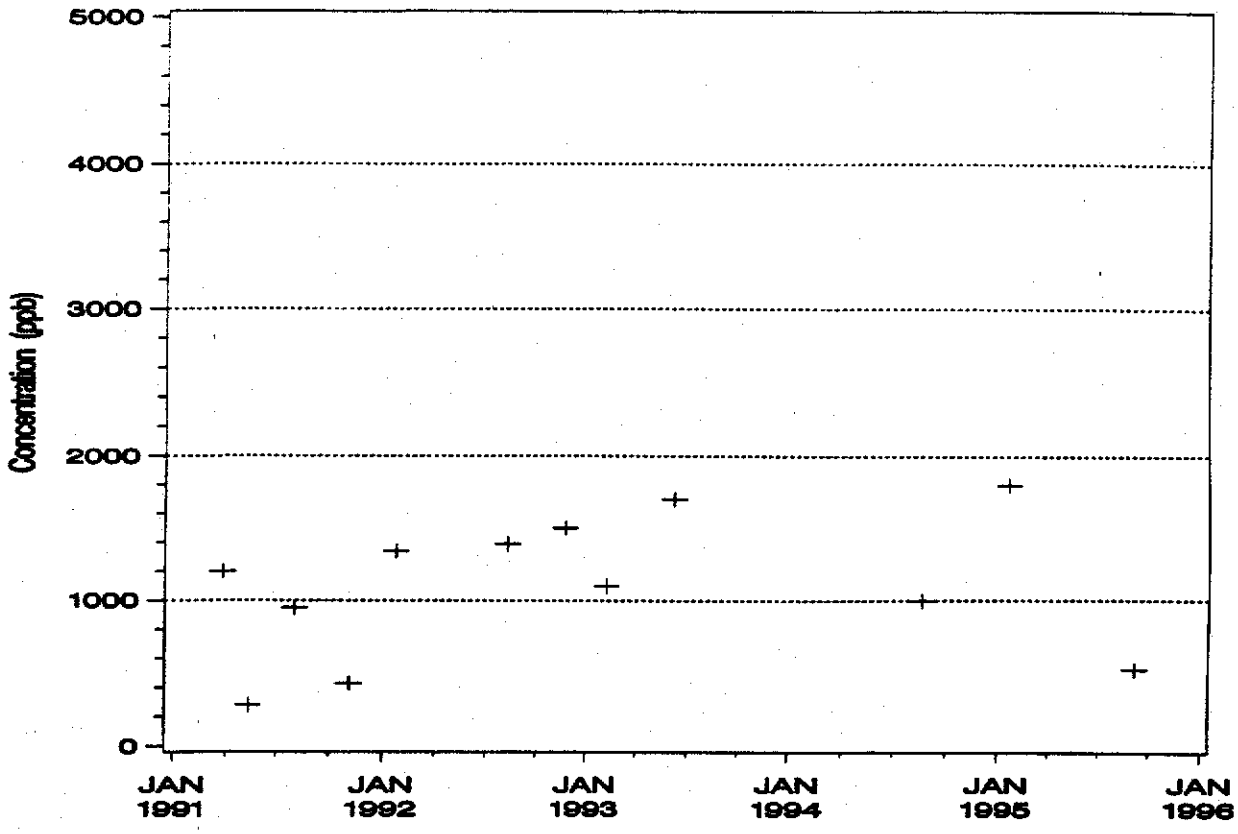
WELL 1365
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



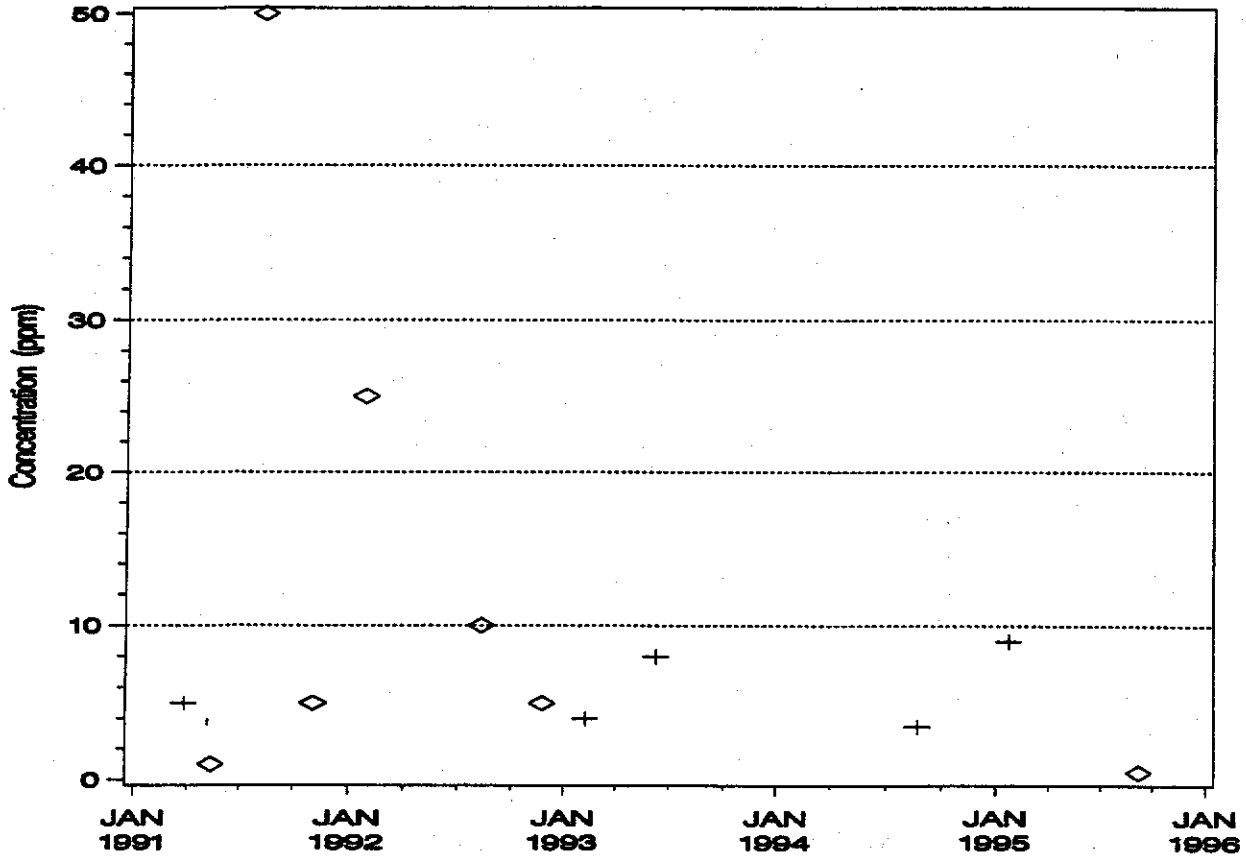
1,1 – DICHLOROETHYLENE Trend



WELL 1370
TRICHLOROETHYLENE Trend

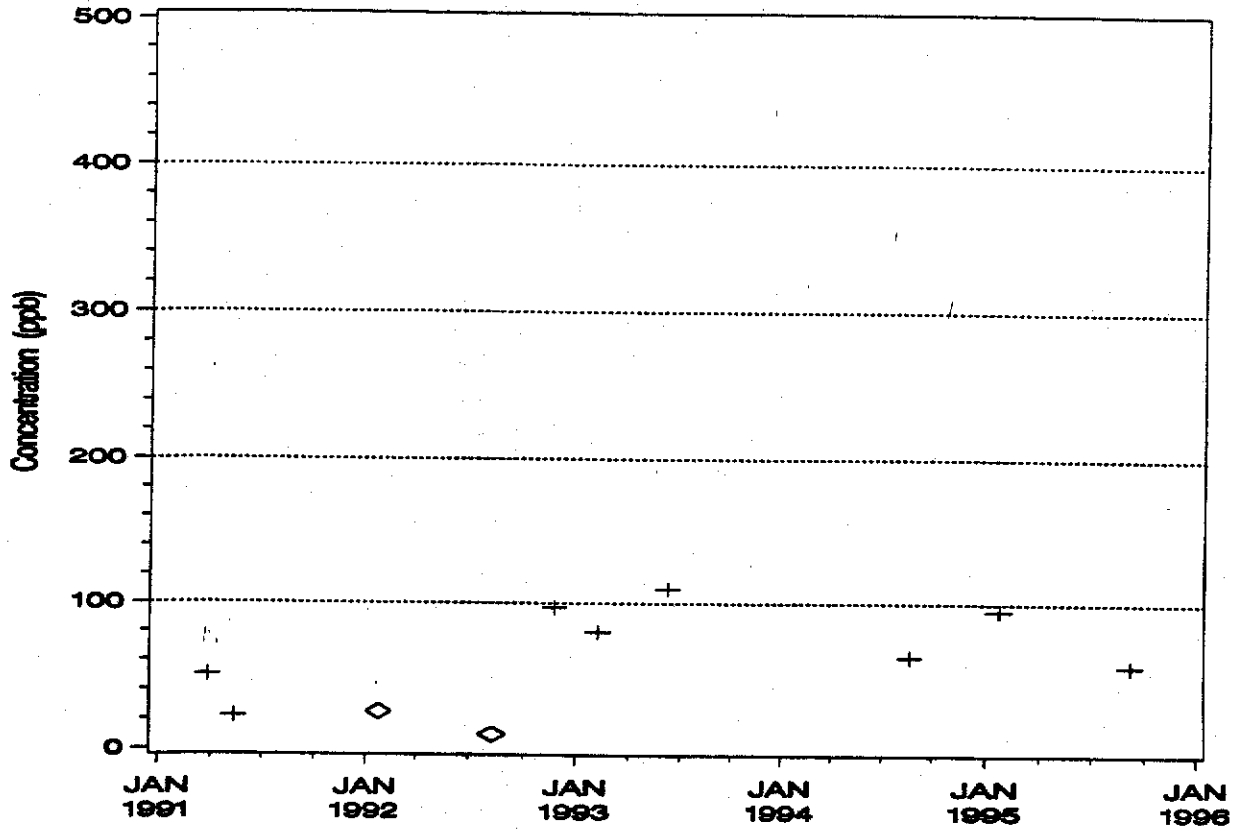


FREON 113 Trend

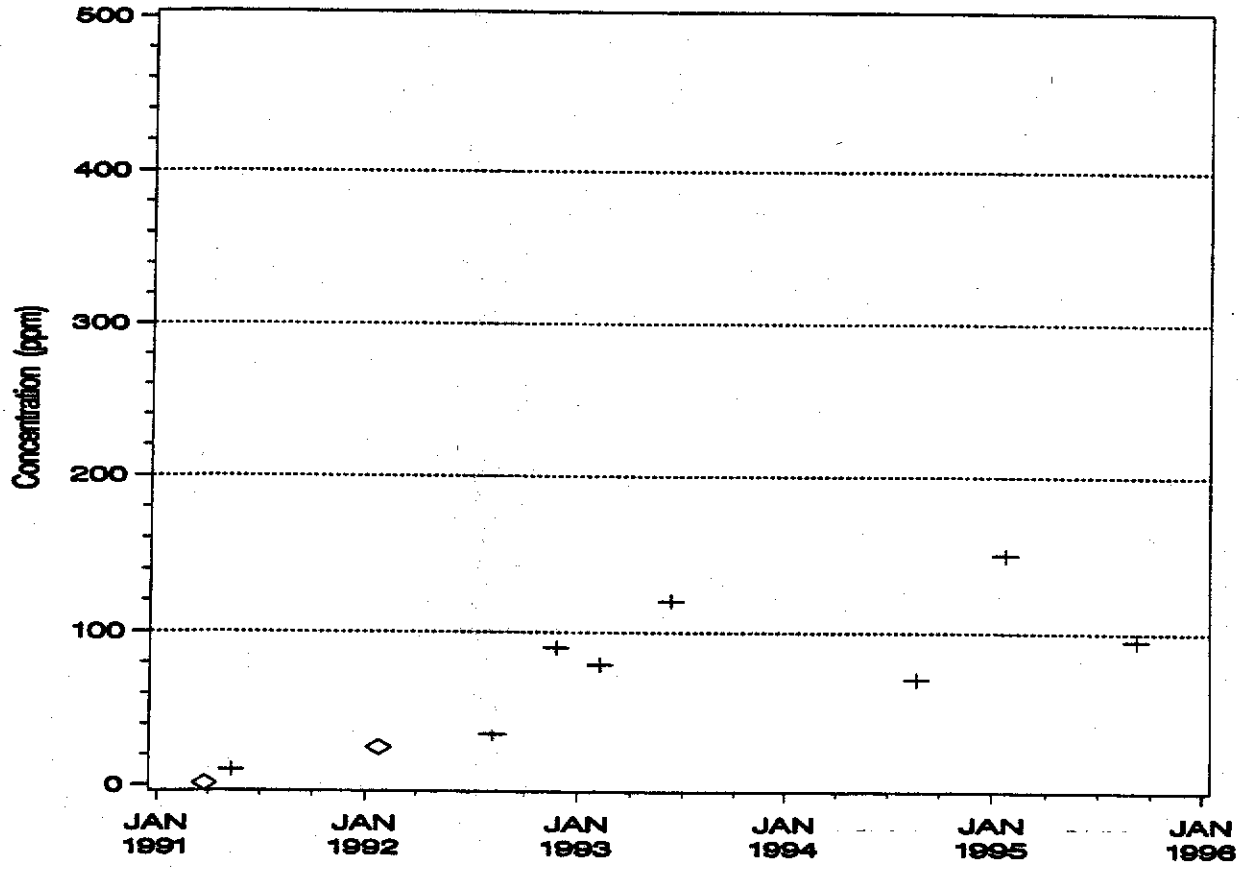


WELL 1370

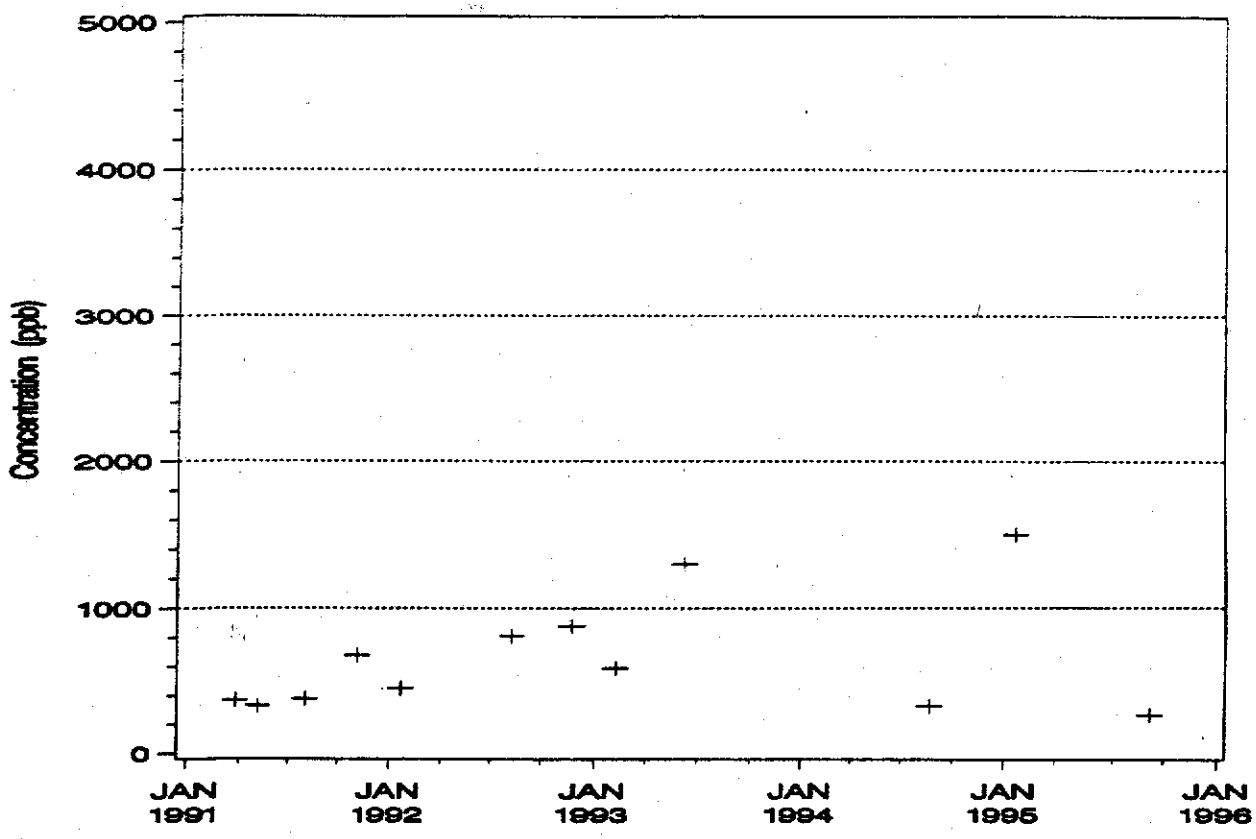
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



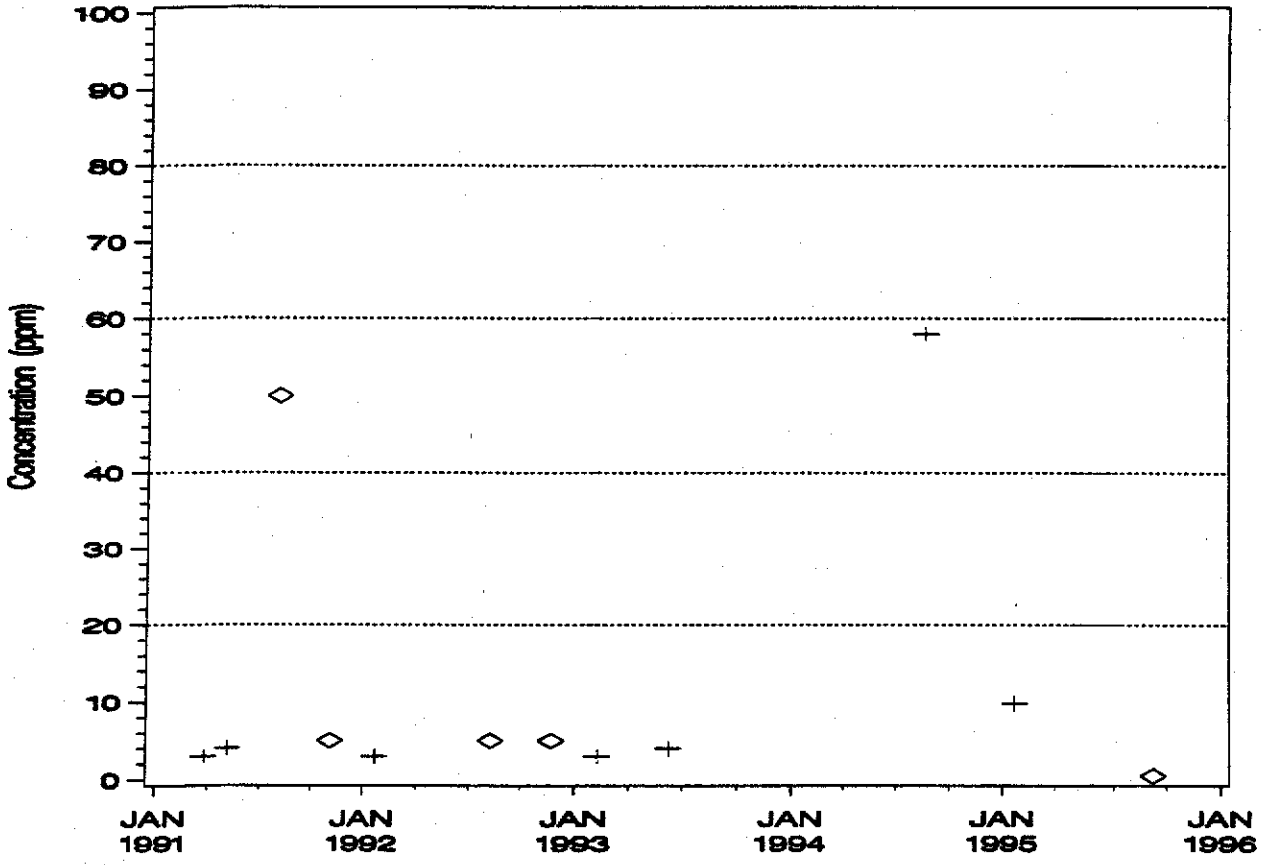
1,1 – DICHLOROETHYLENE Trend



WELL 1371
TRICHLOROETHYLENE Trend

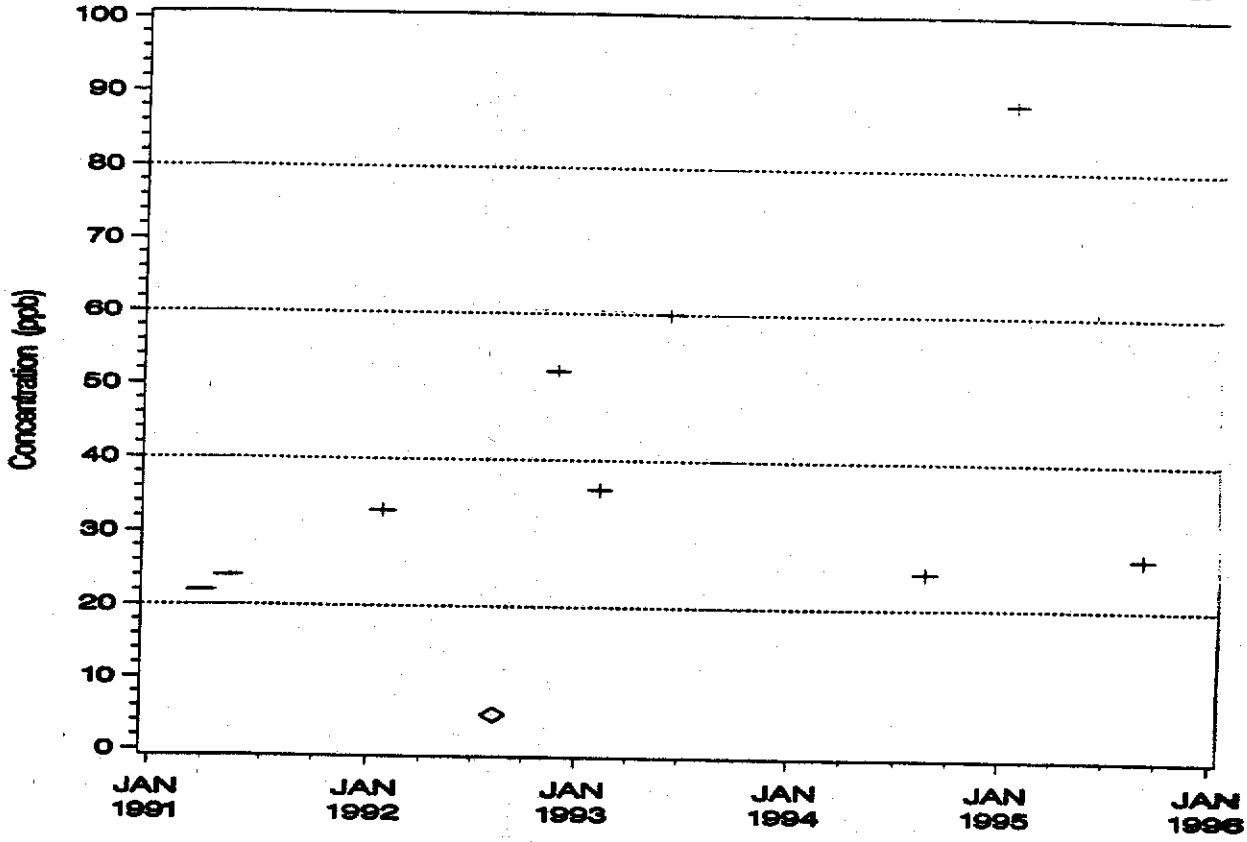


FREON 113 Trend

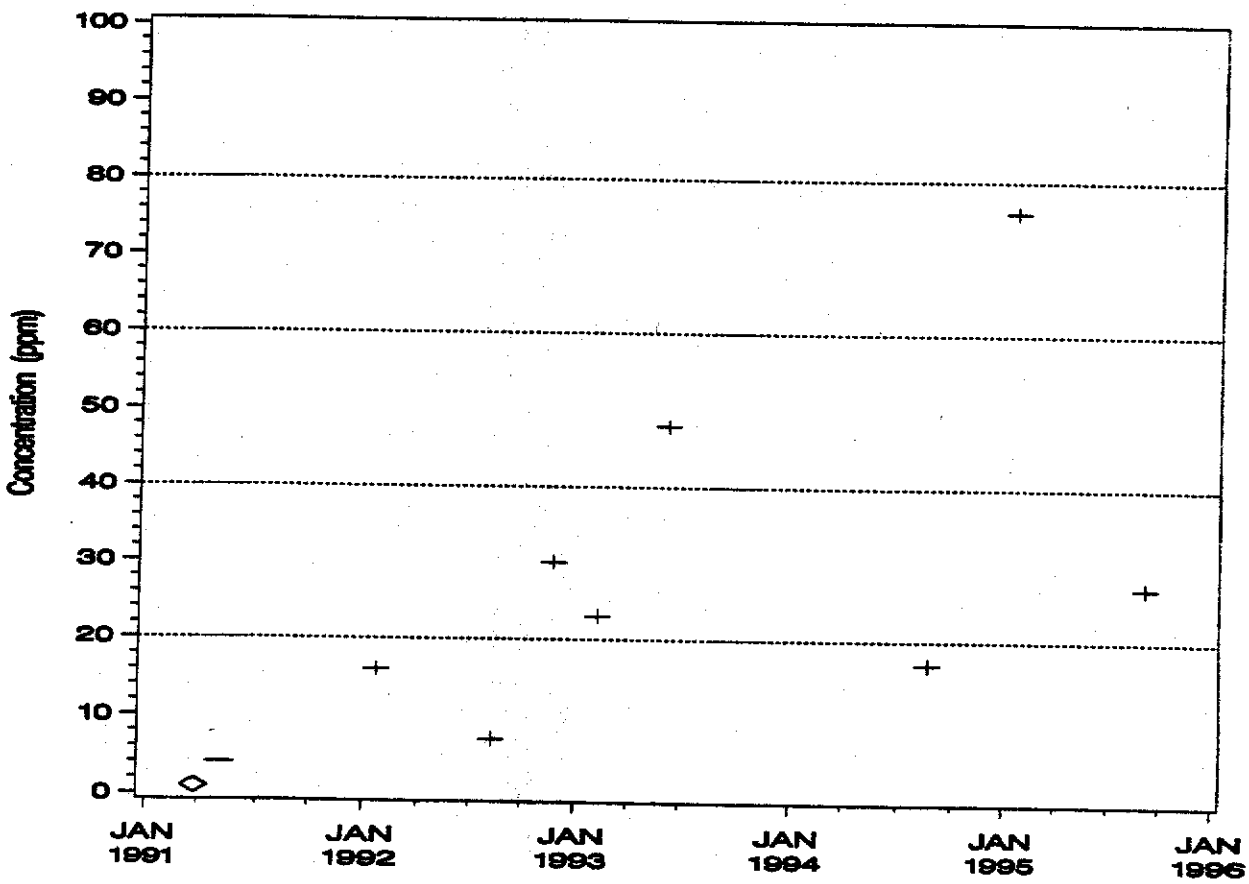


WELL 1371

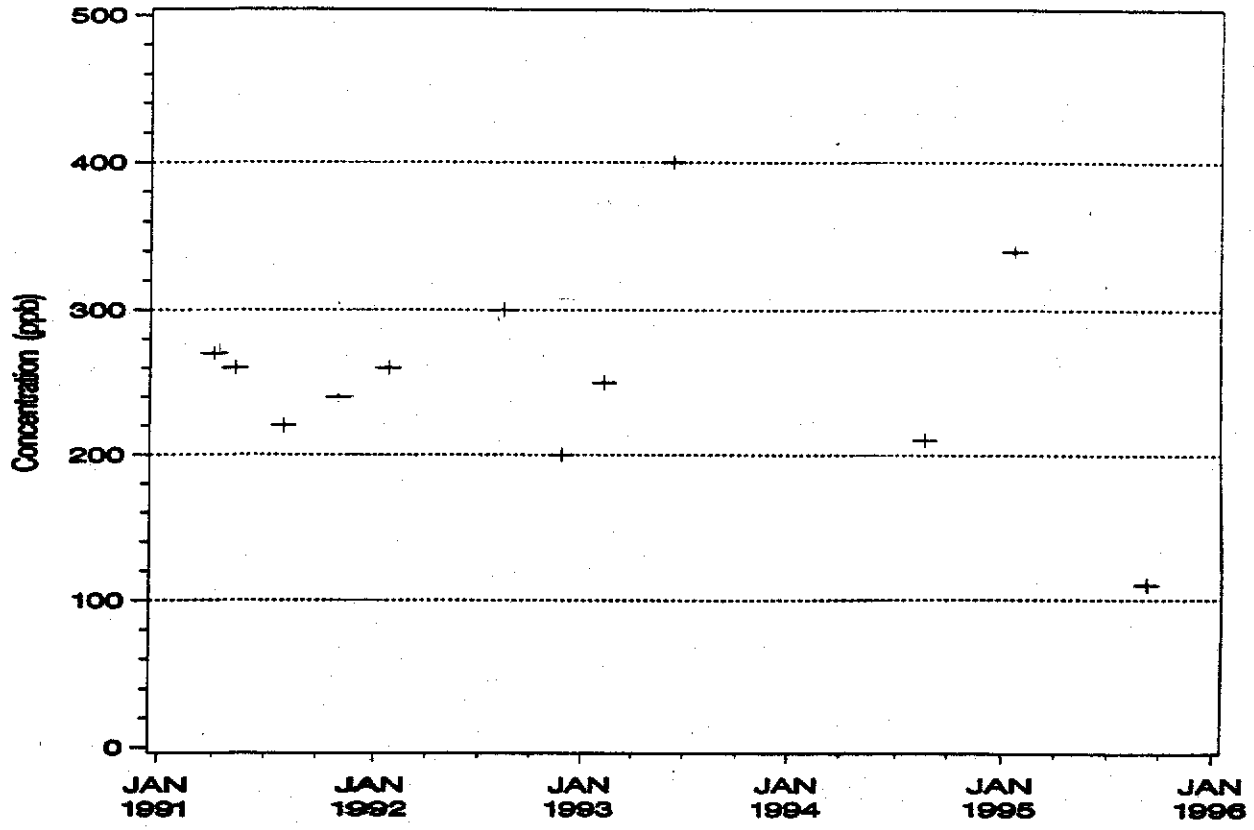
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



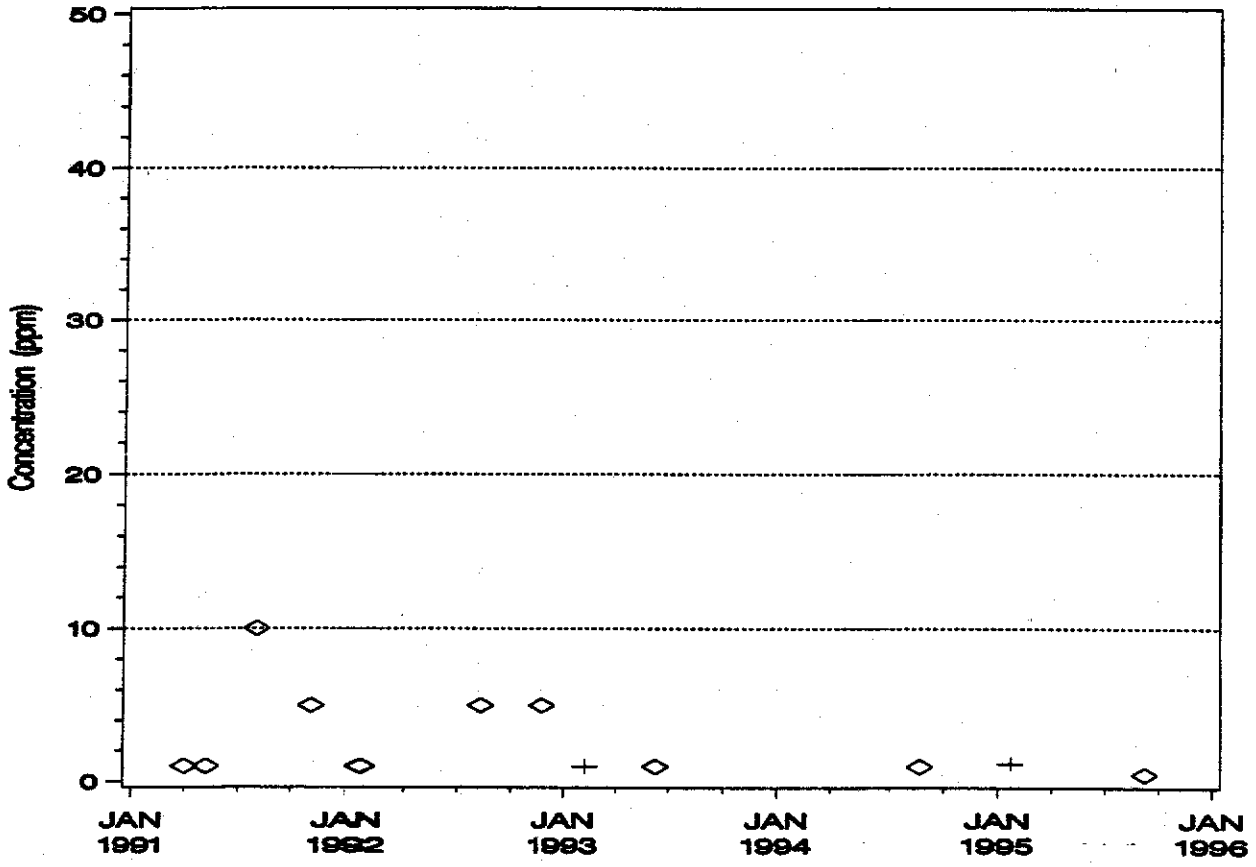
1,1 – DICHLOROETHYLENE Trend



WELL 1372
TRICHLOROETHYLENE Trend

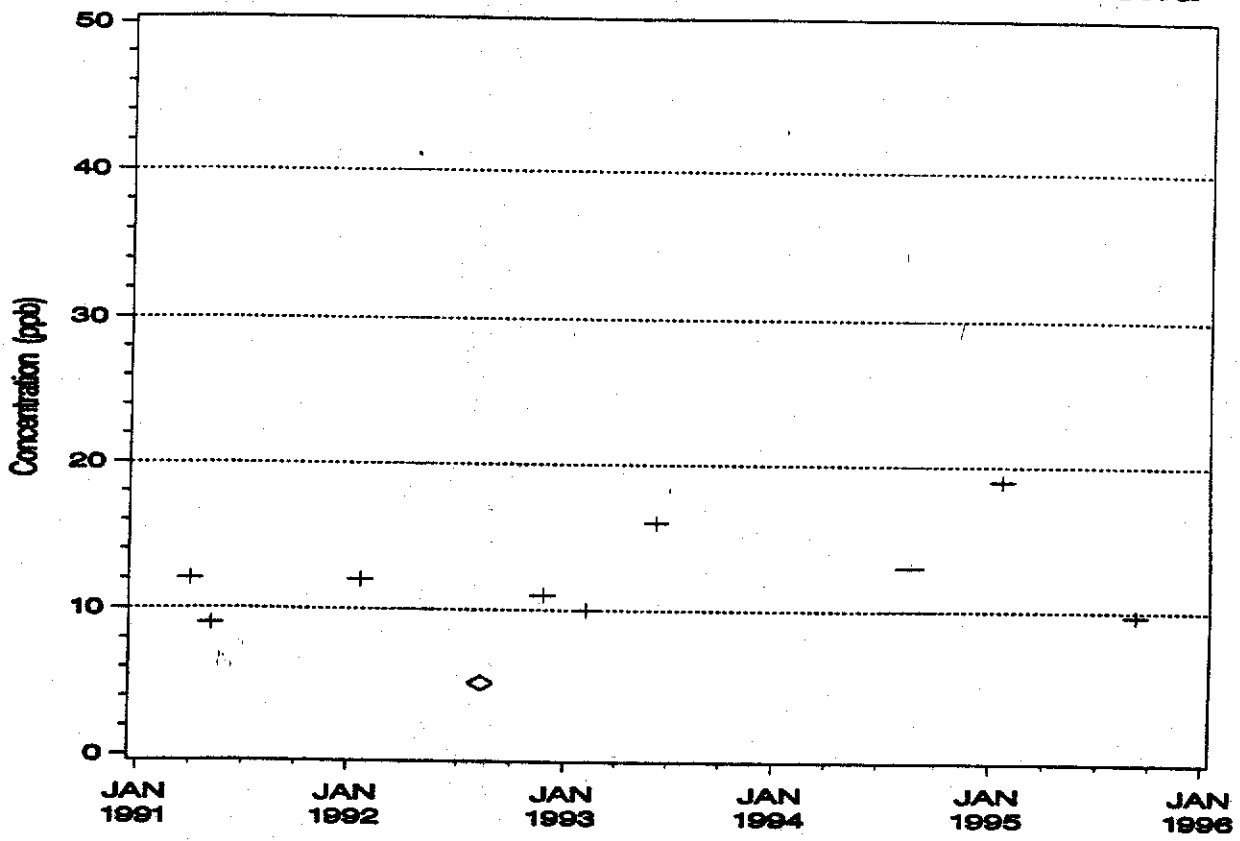


FREON 113 Trend

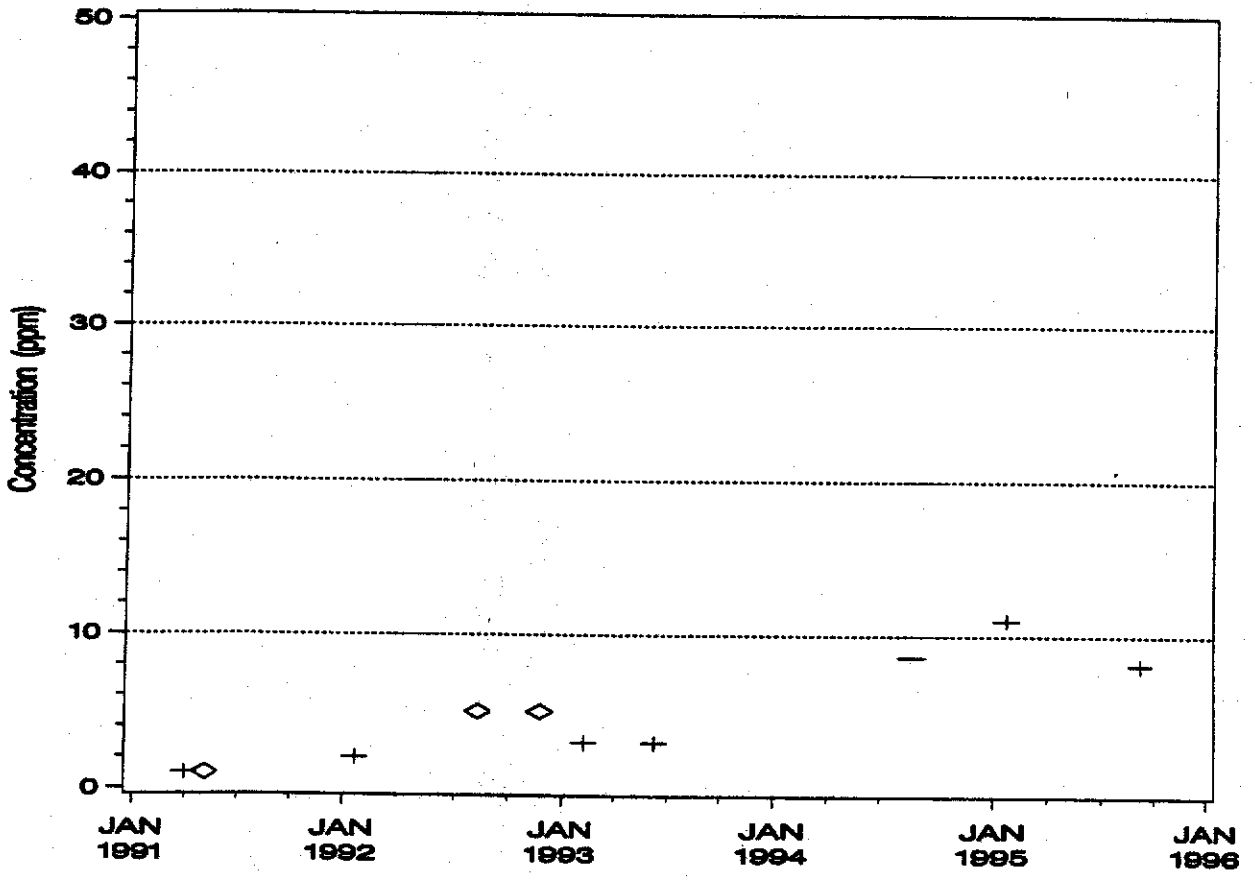


WELL 1372

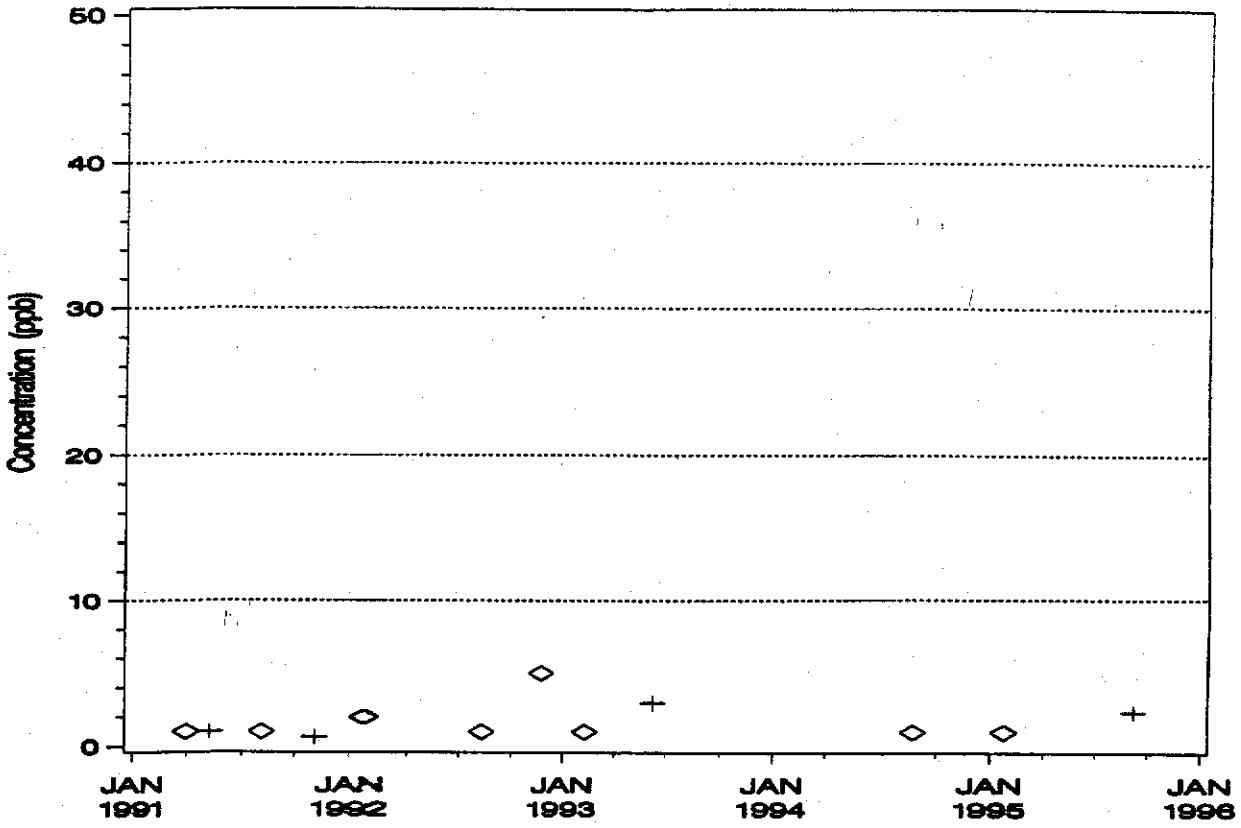
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



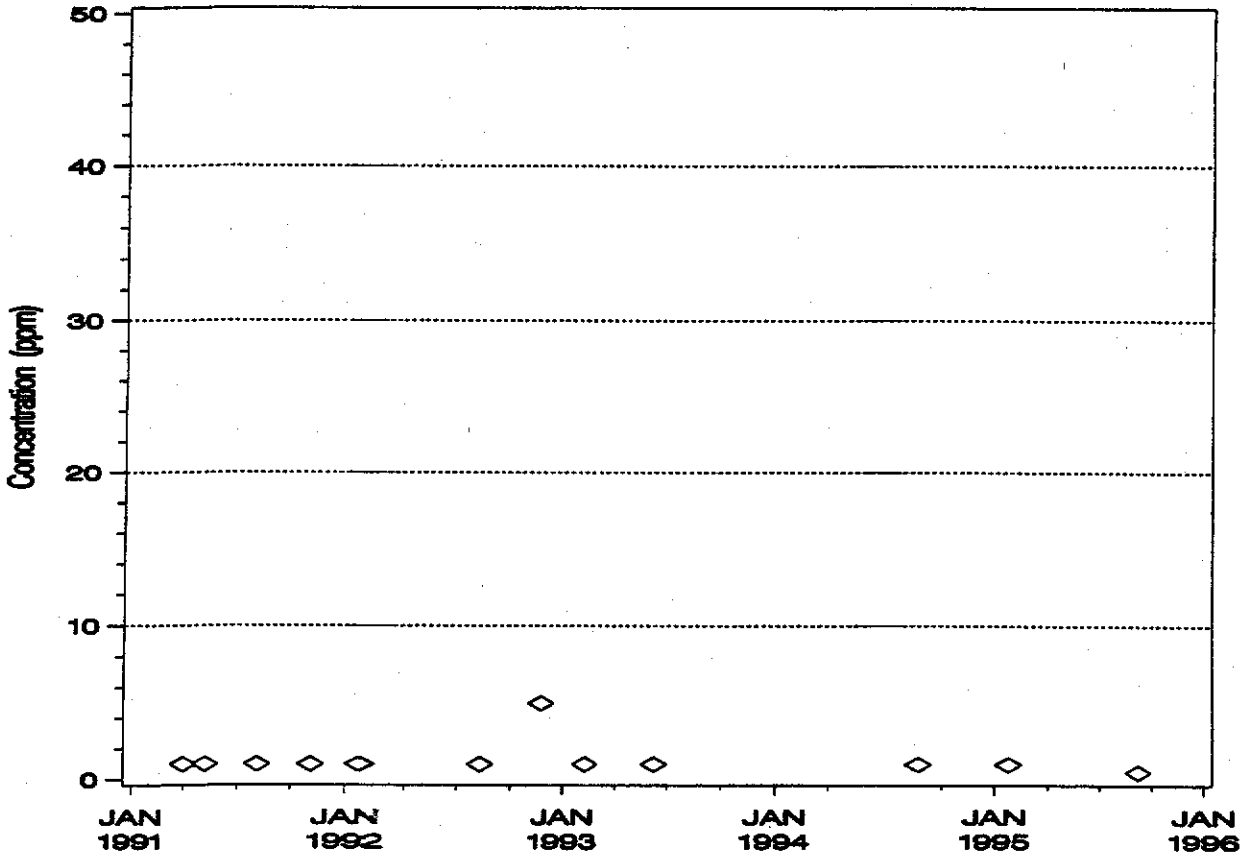
1,1 – DICHLOROETHYLENE Trend



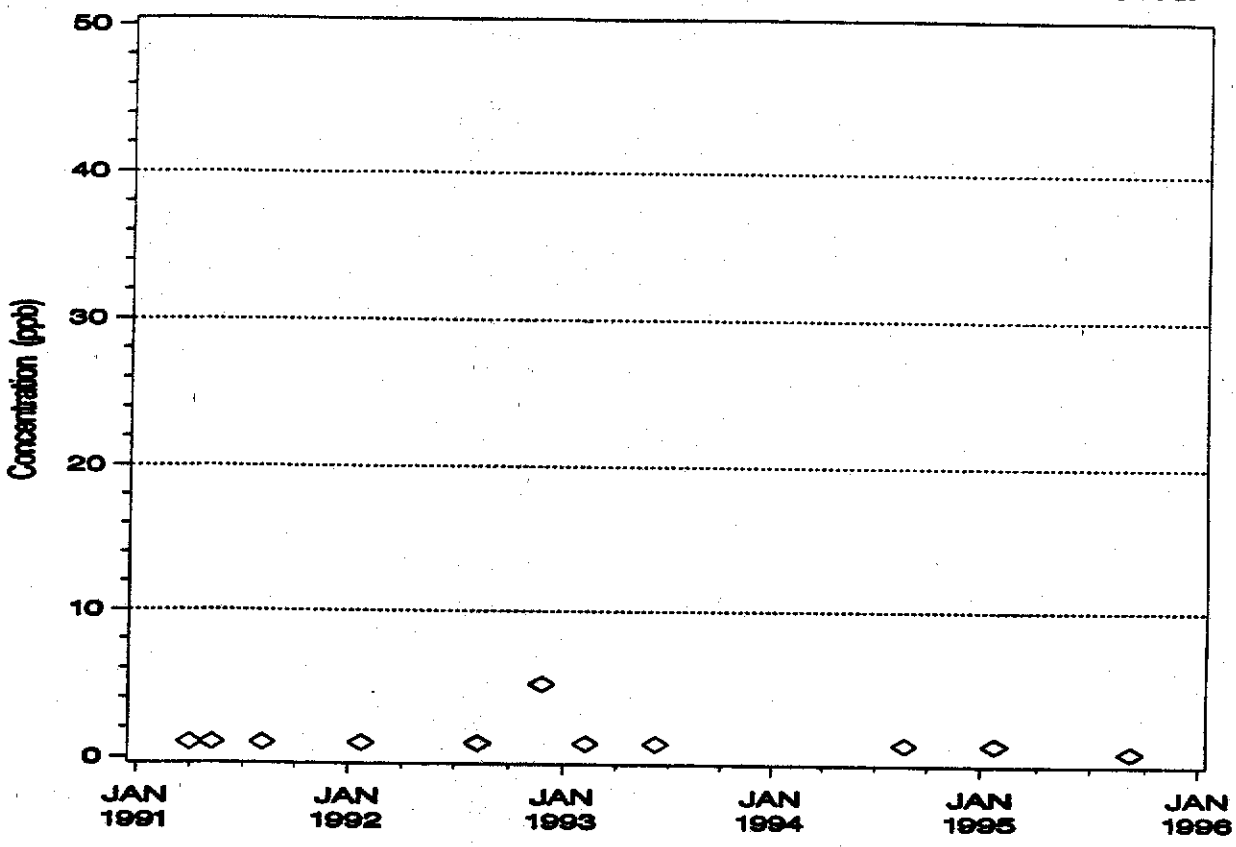
WELL 1373
TRICHLOROETHYLENE Trend



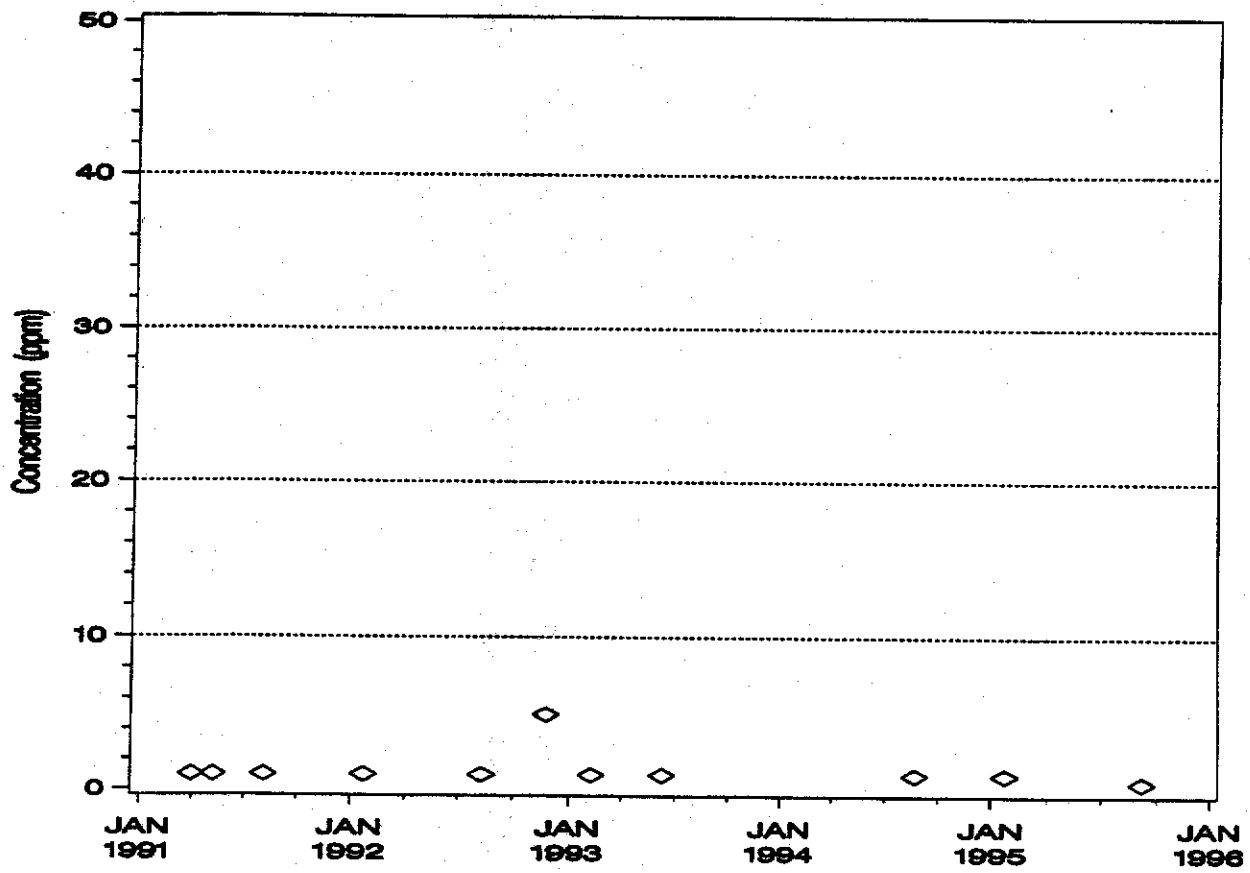
FREON 113 Trend



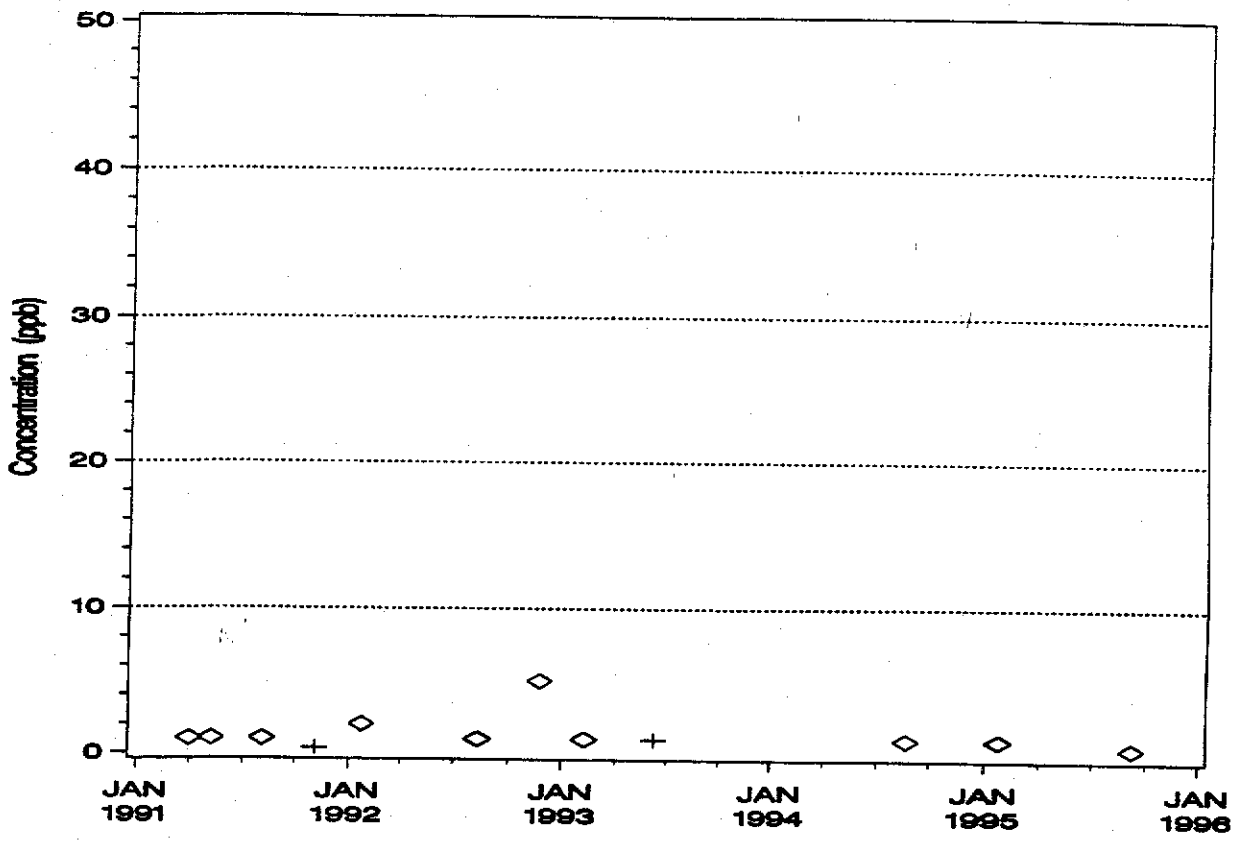
WELL 1373
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



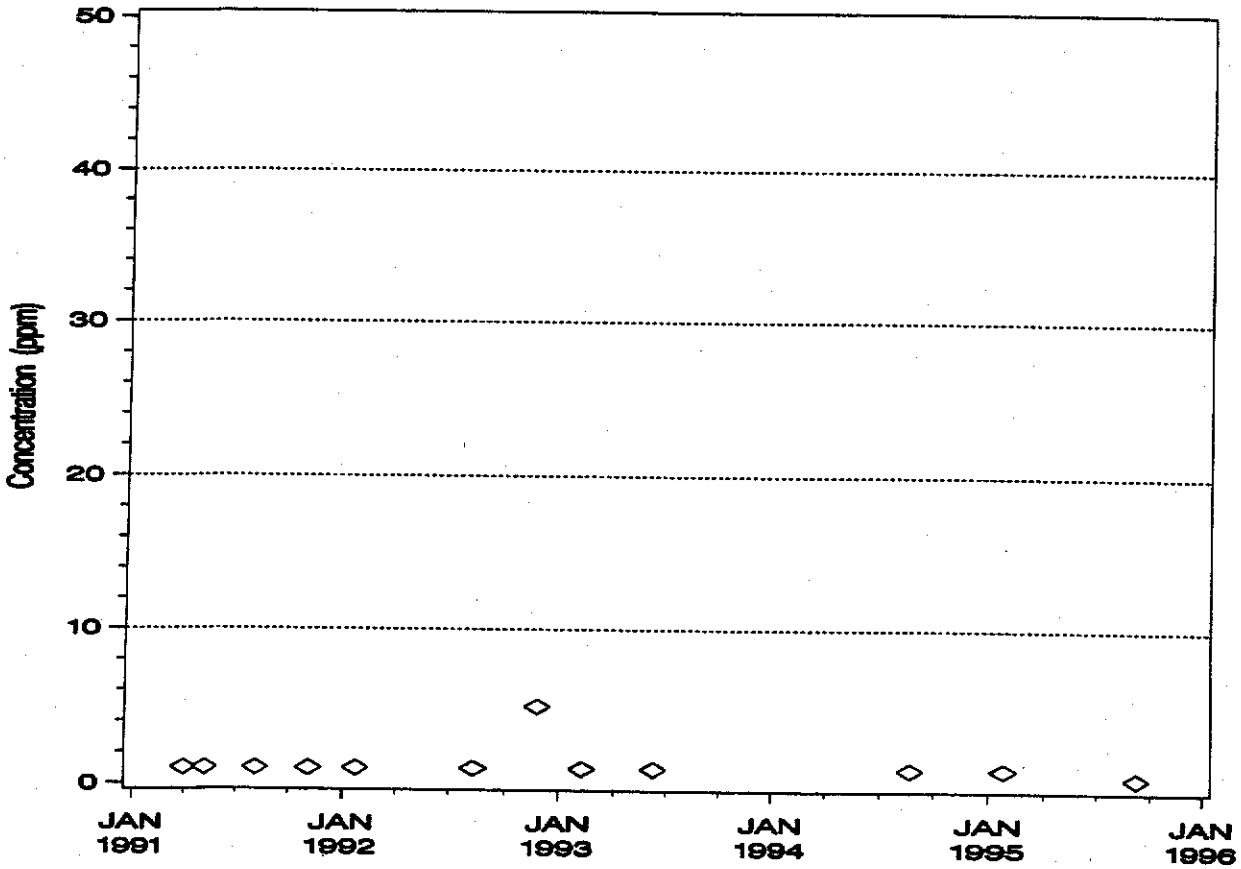
1,1 – DICHLOROETHYLENE Trend



WELL 1374
TRICHLOROETHYLENE Trend

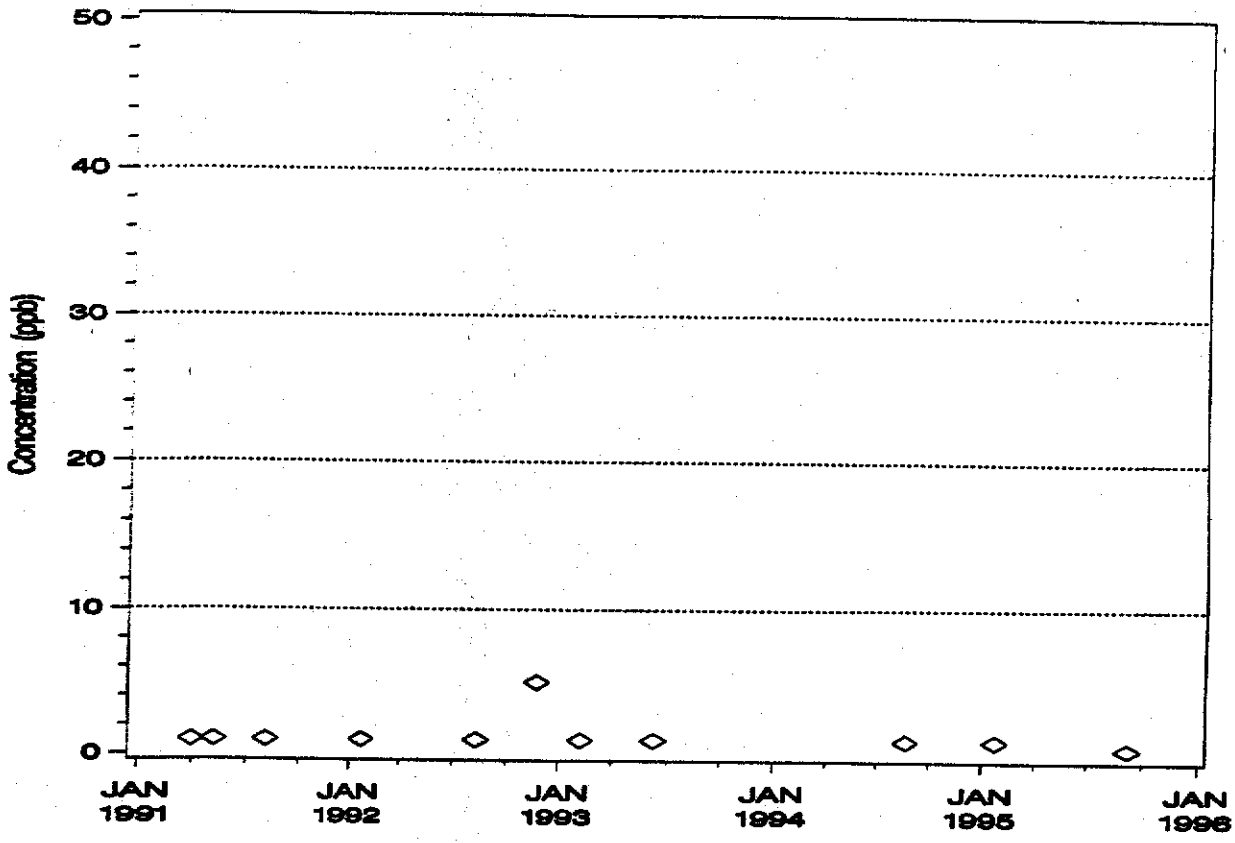


FREON 113 Trend

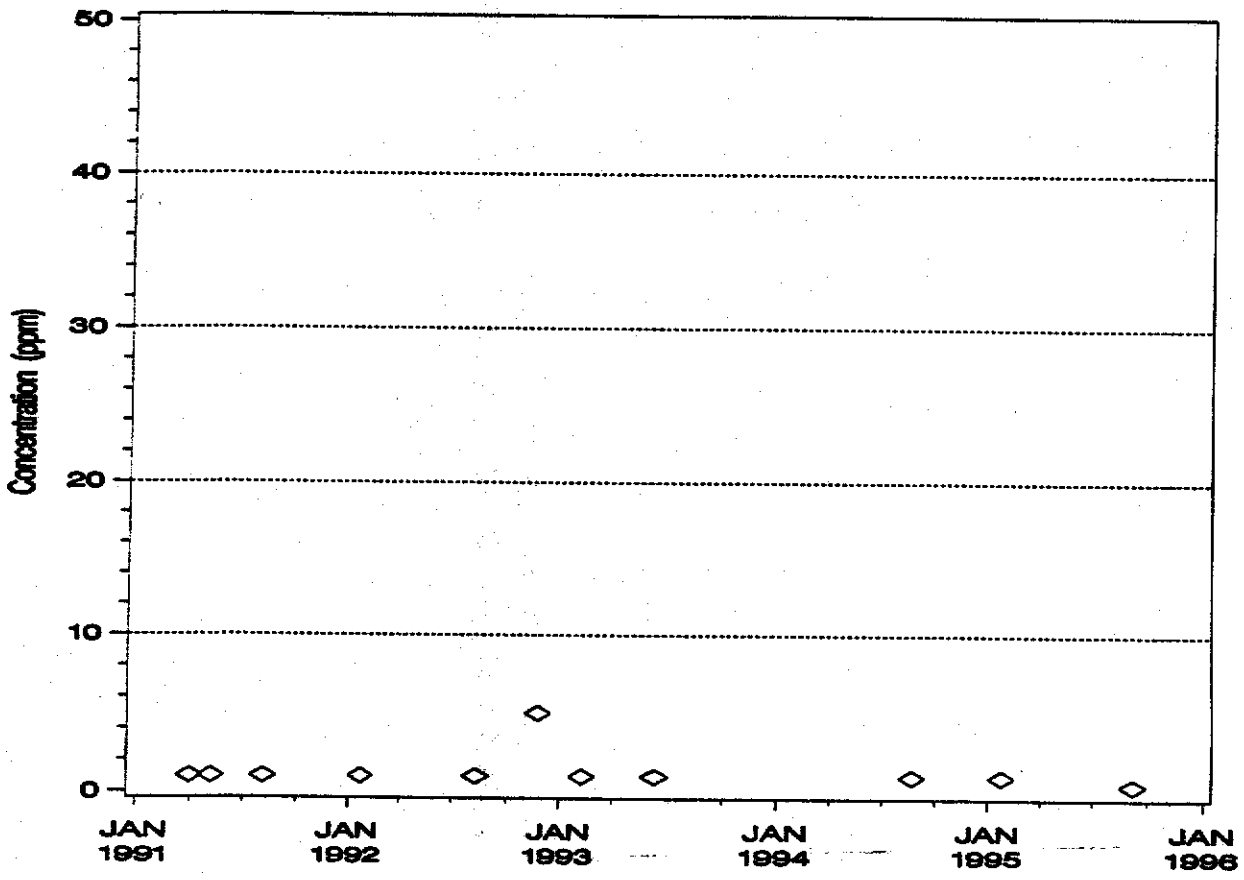


WELL 1374

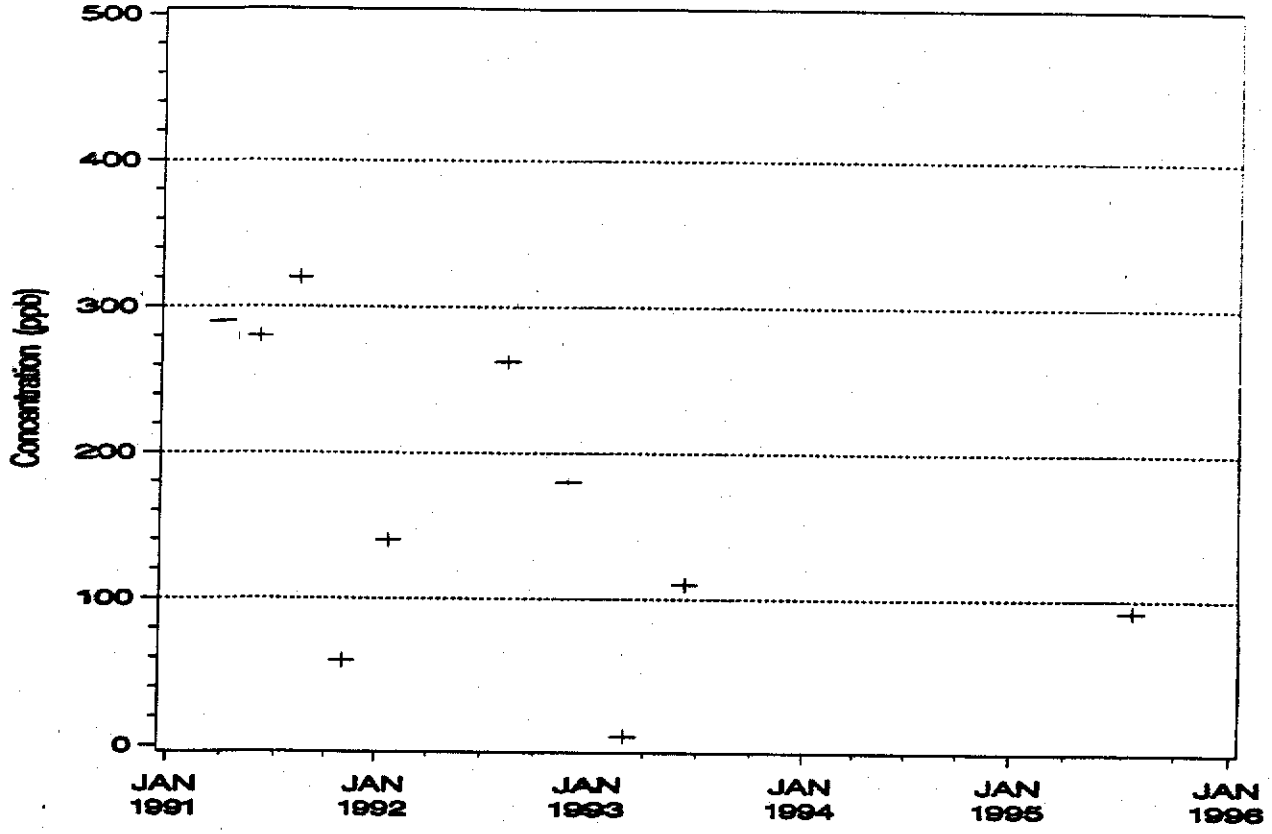
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



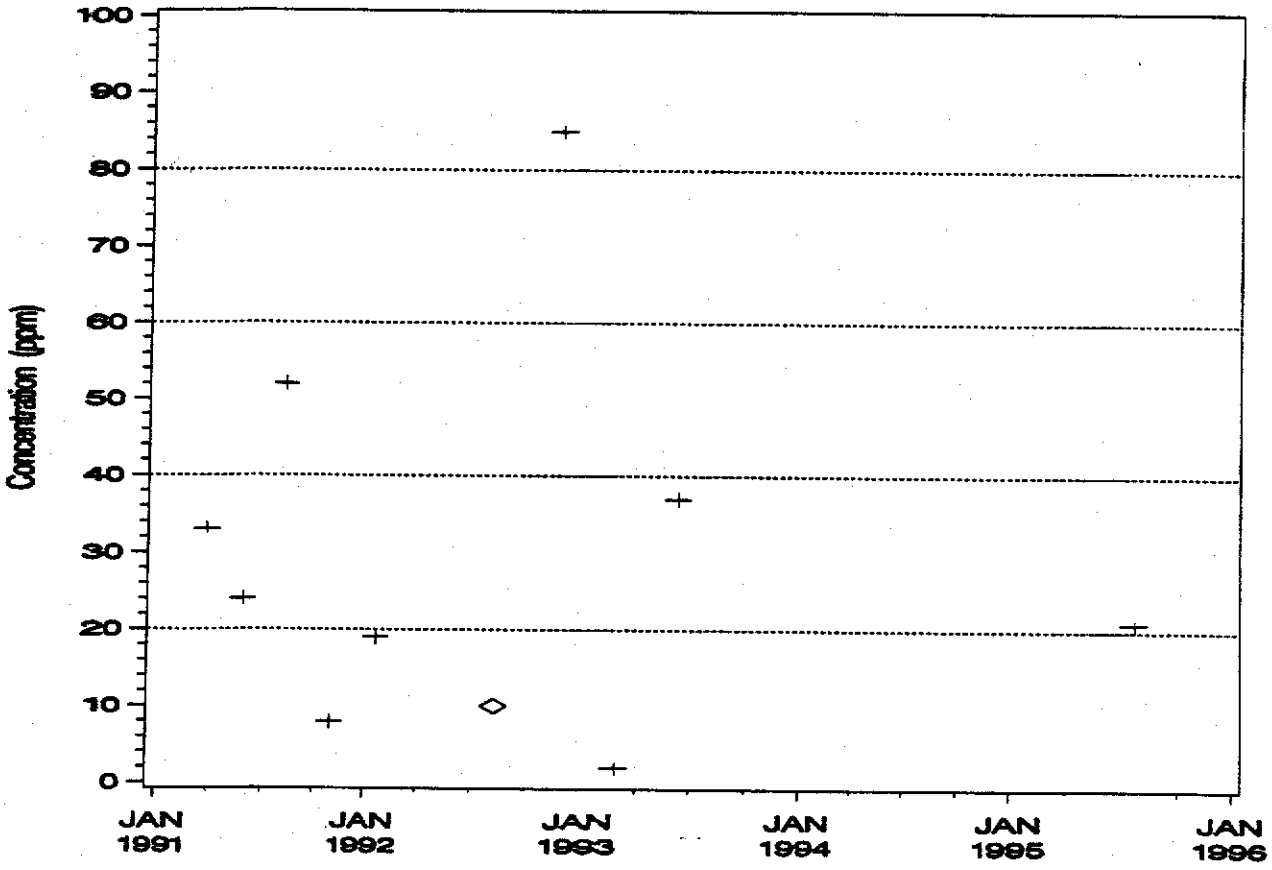
1,1 – DICHLOROETHYLENE Trend



WELL 1375
TRICHLOROETHYLENE Trend

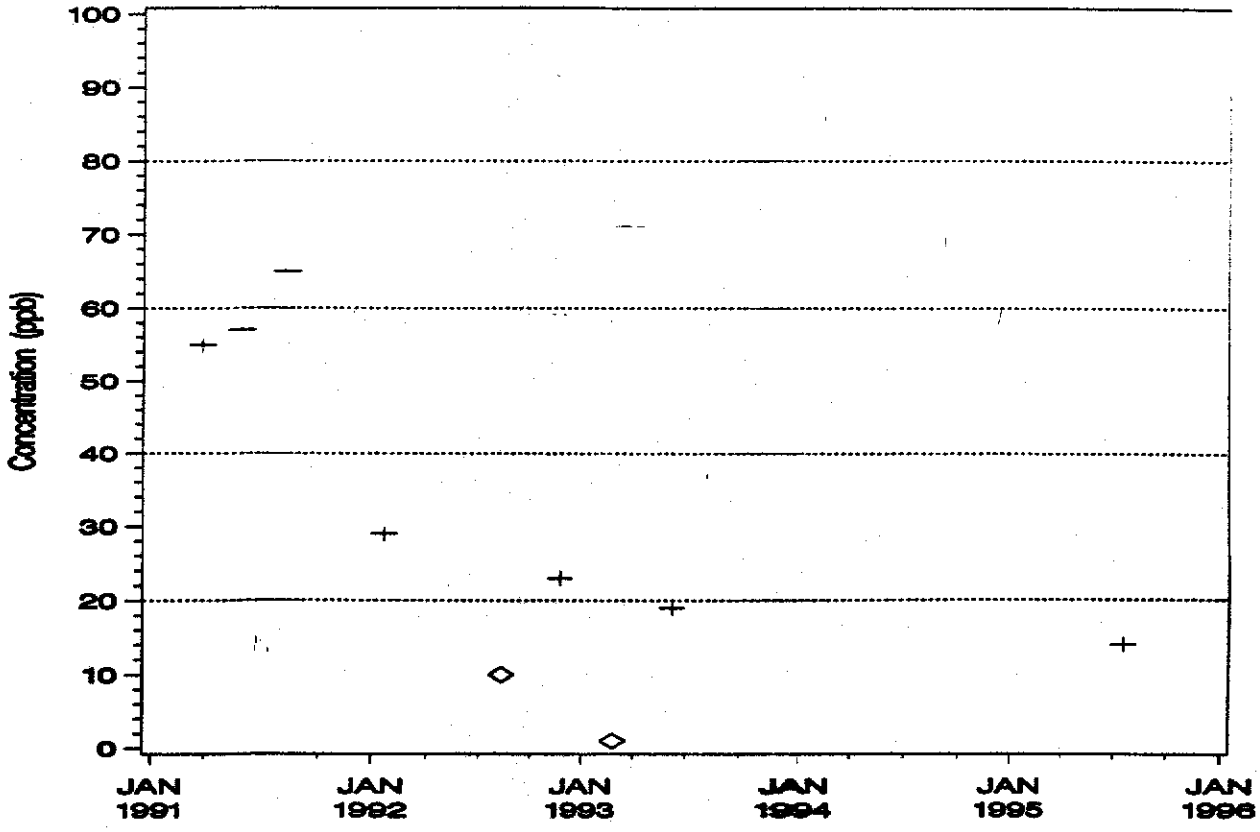


FREON 113 Trend

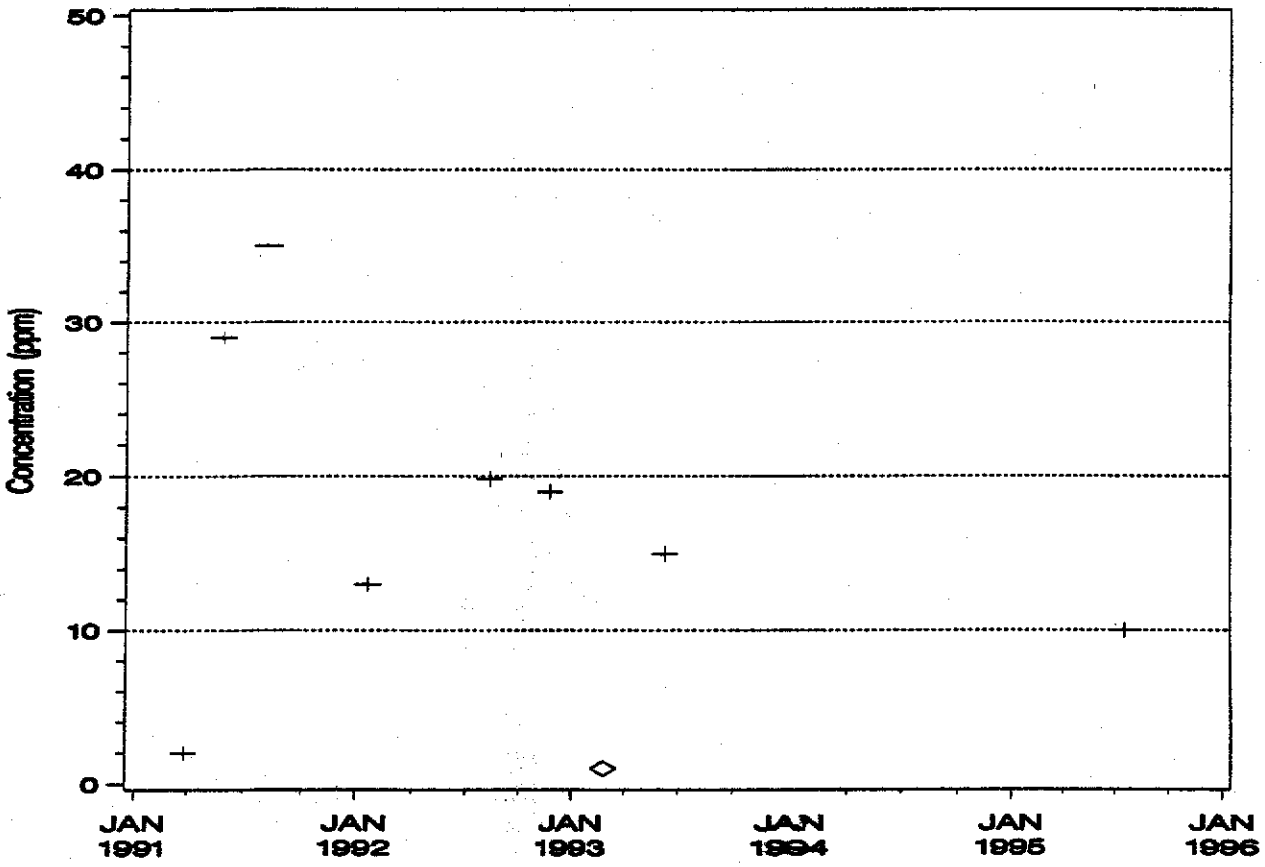


WELL 1375

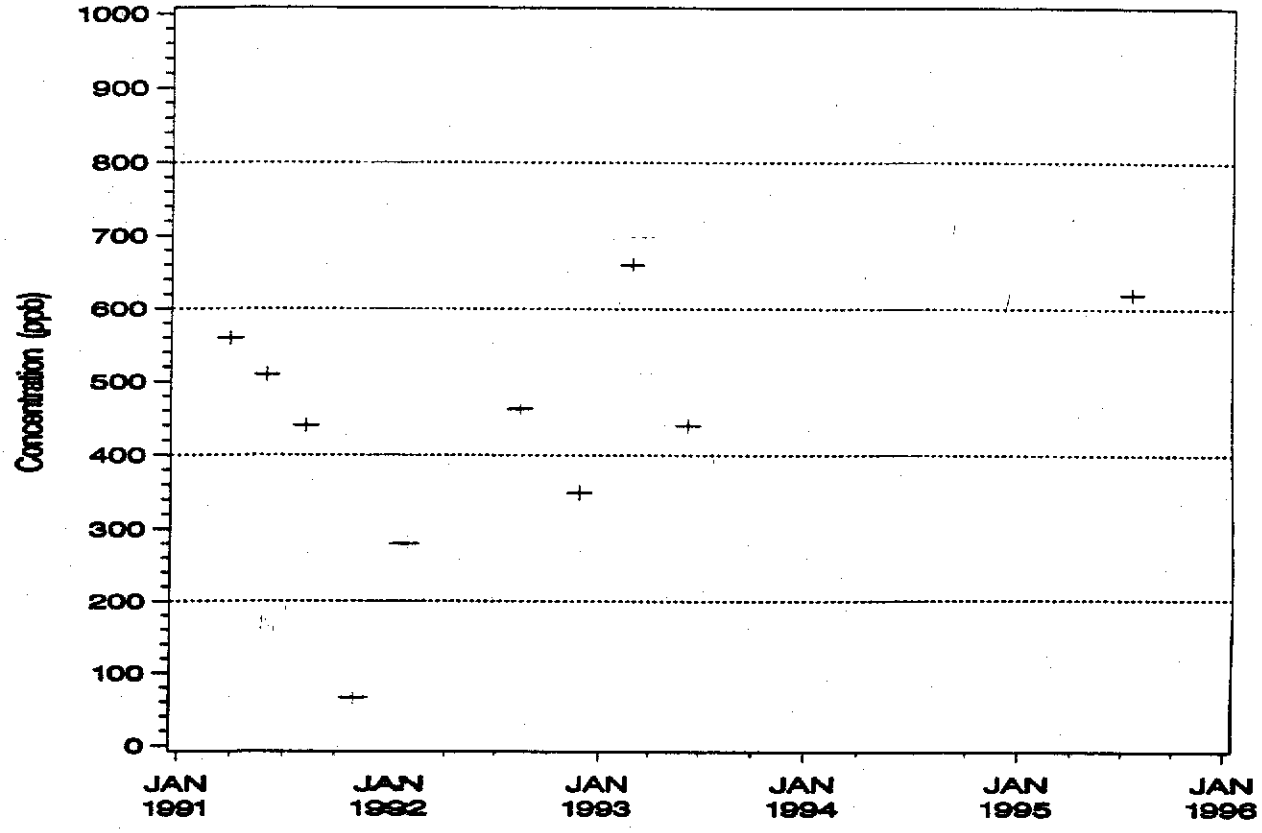
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



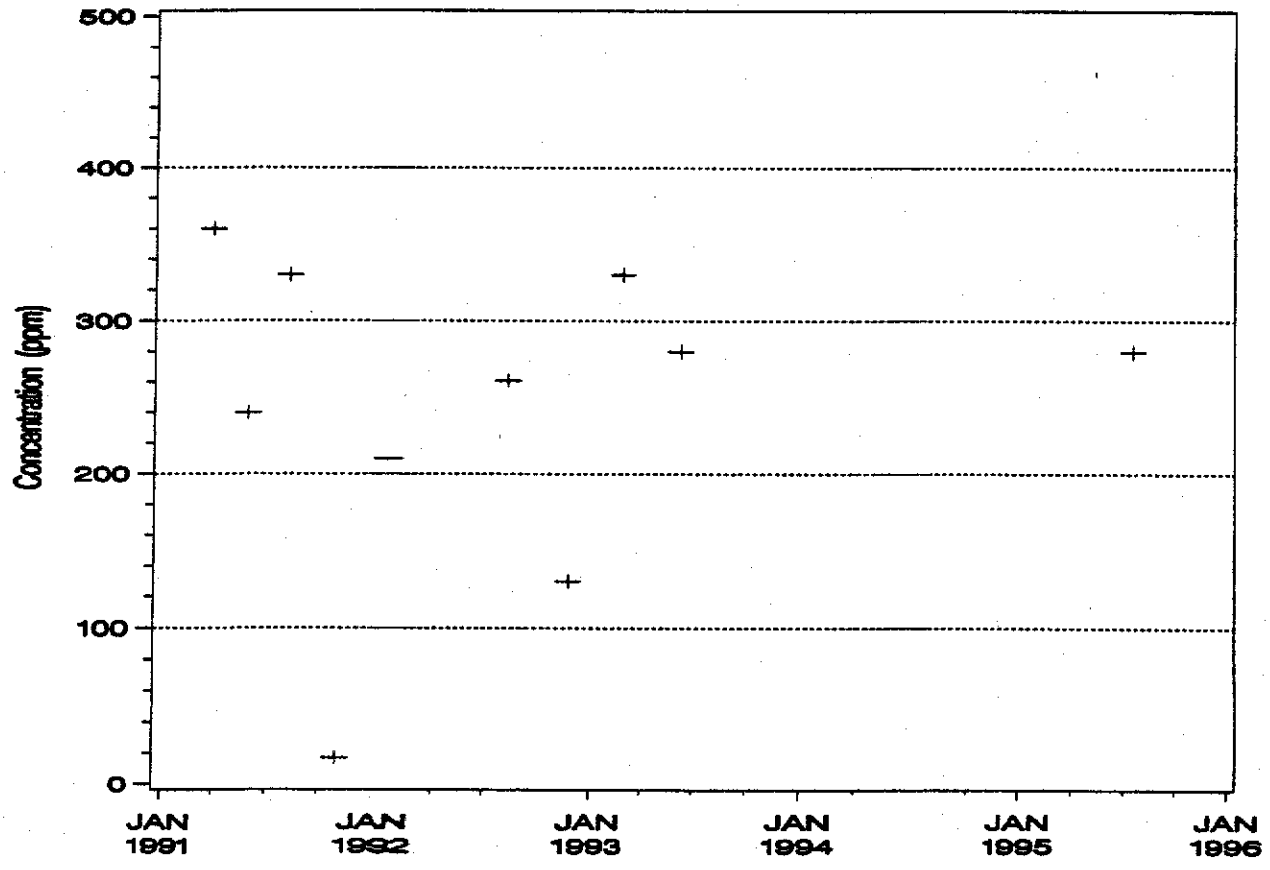
1,1 — DICHLOROETHYLENE Trend



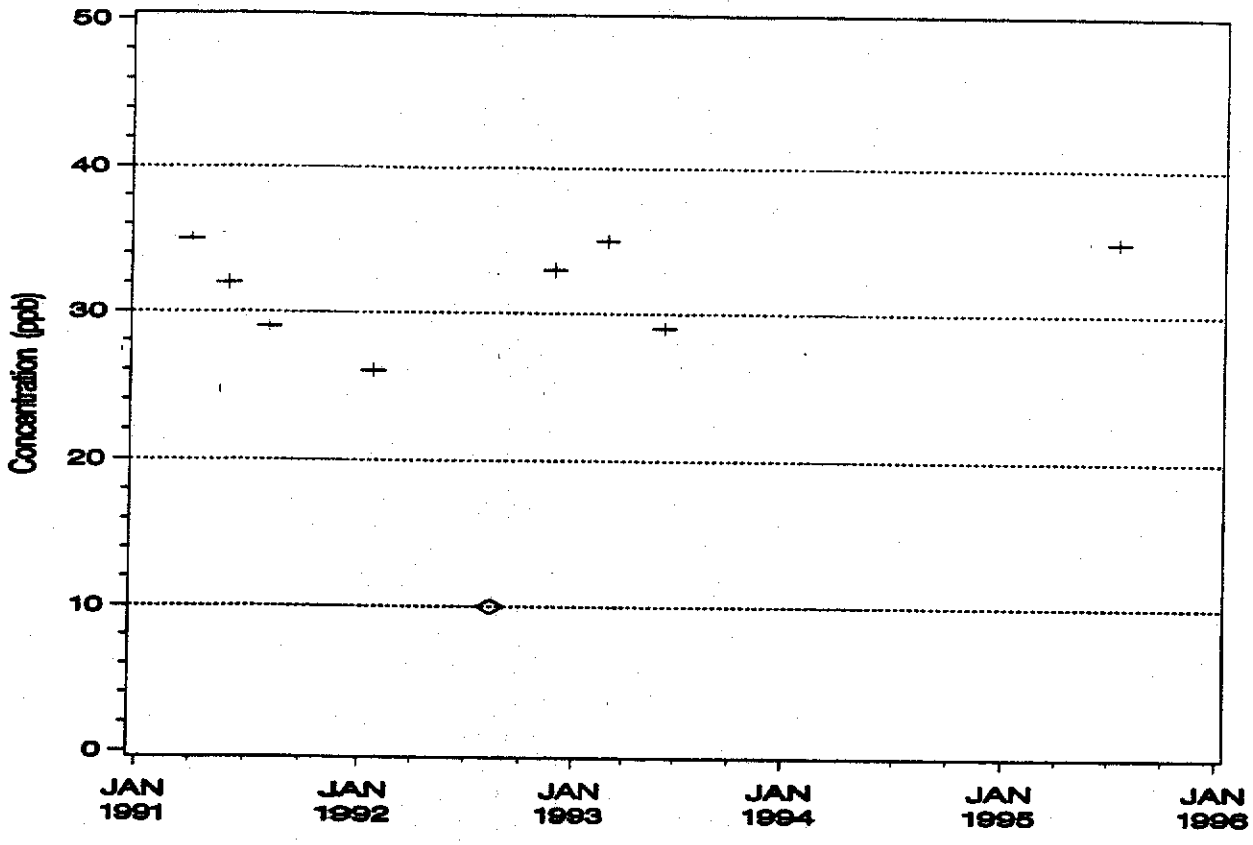
WELL 1376
TRICHLOROETHYLENE Trend



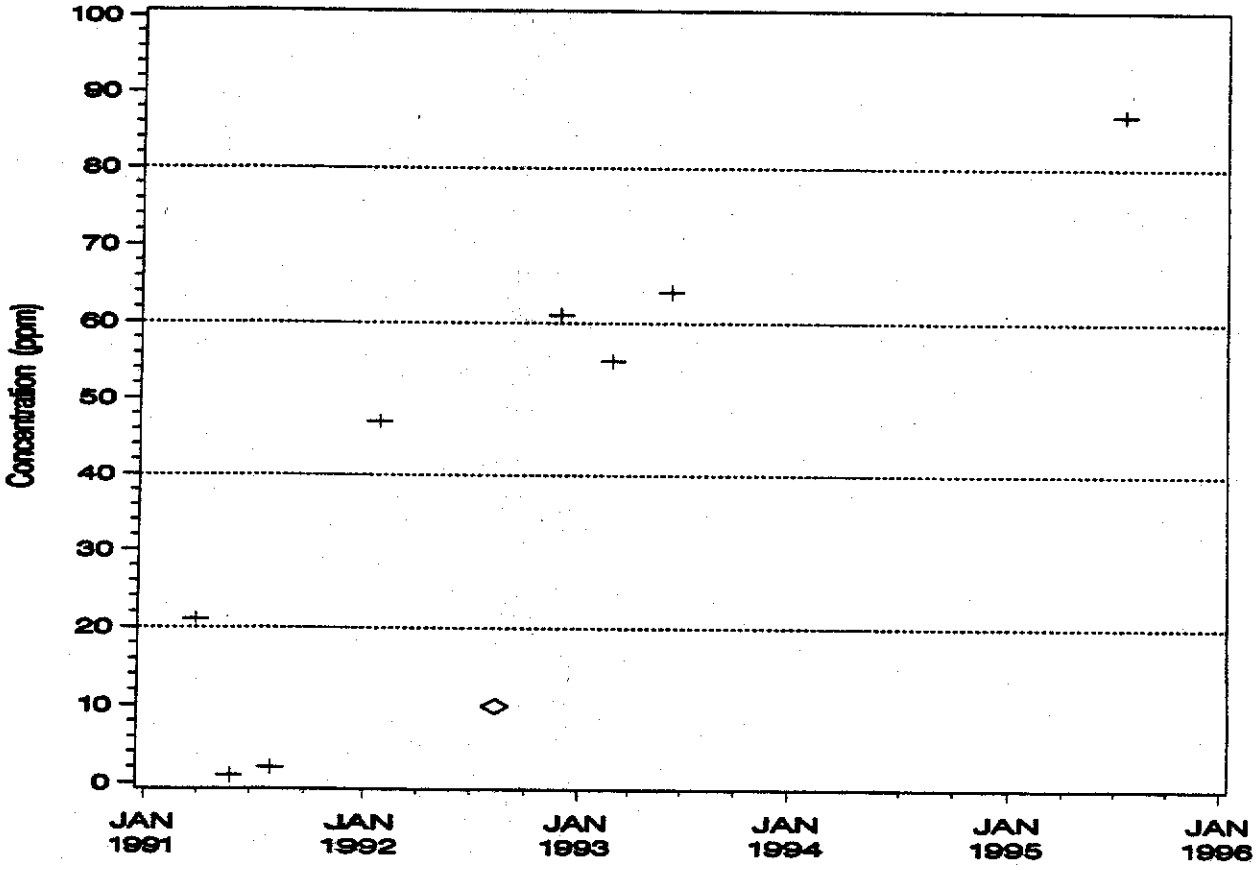
FREON 113 Trend



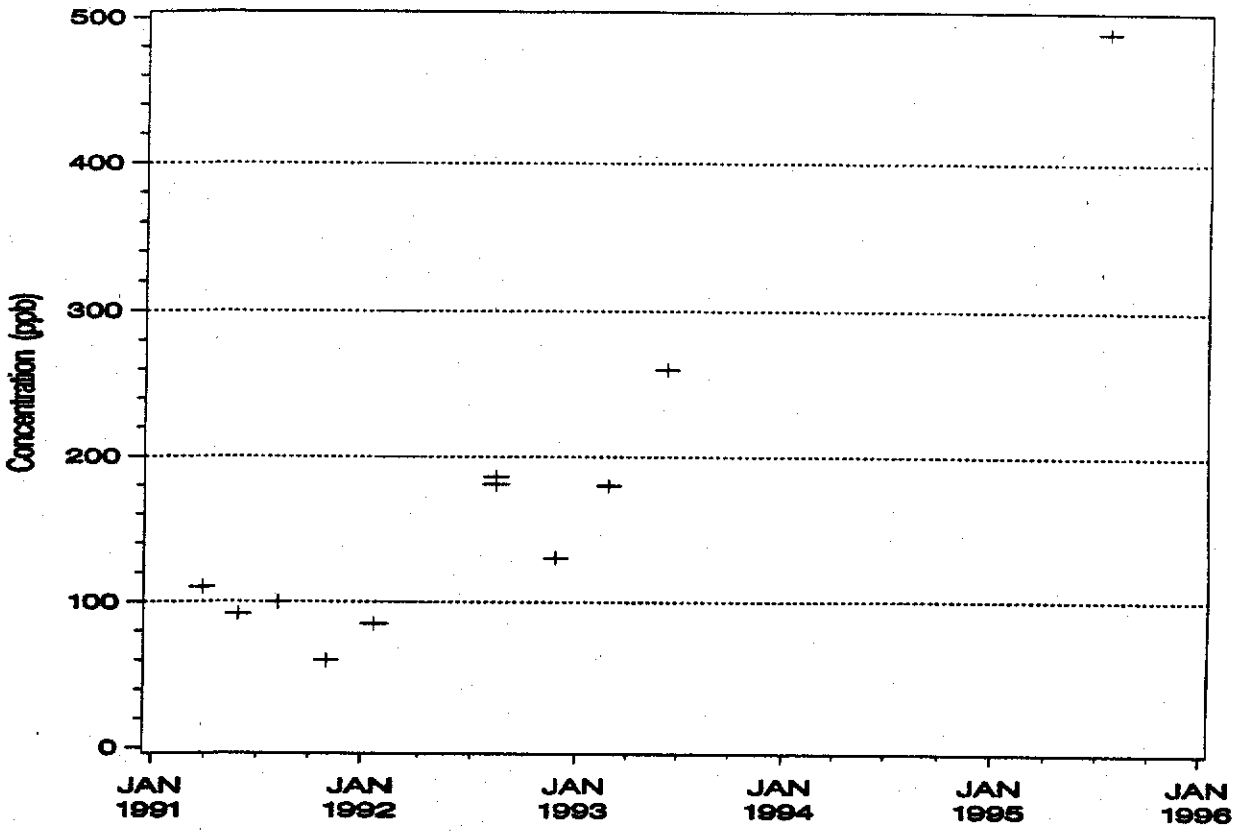
WELL 1376
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



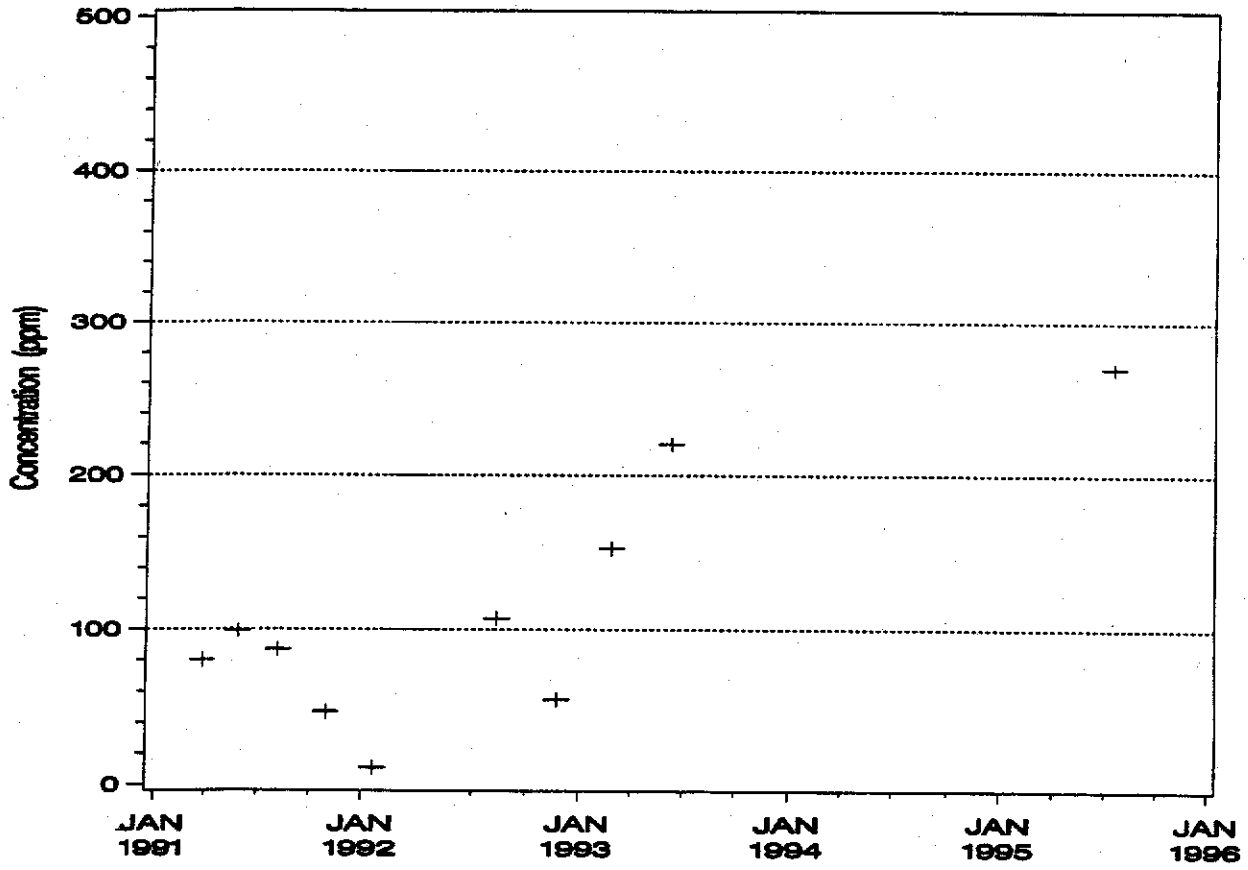
1,1 — DICHLOROETHYLENE Trend



WELL 1377
TRICHLOROETHYLENE Trend

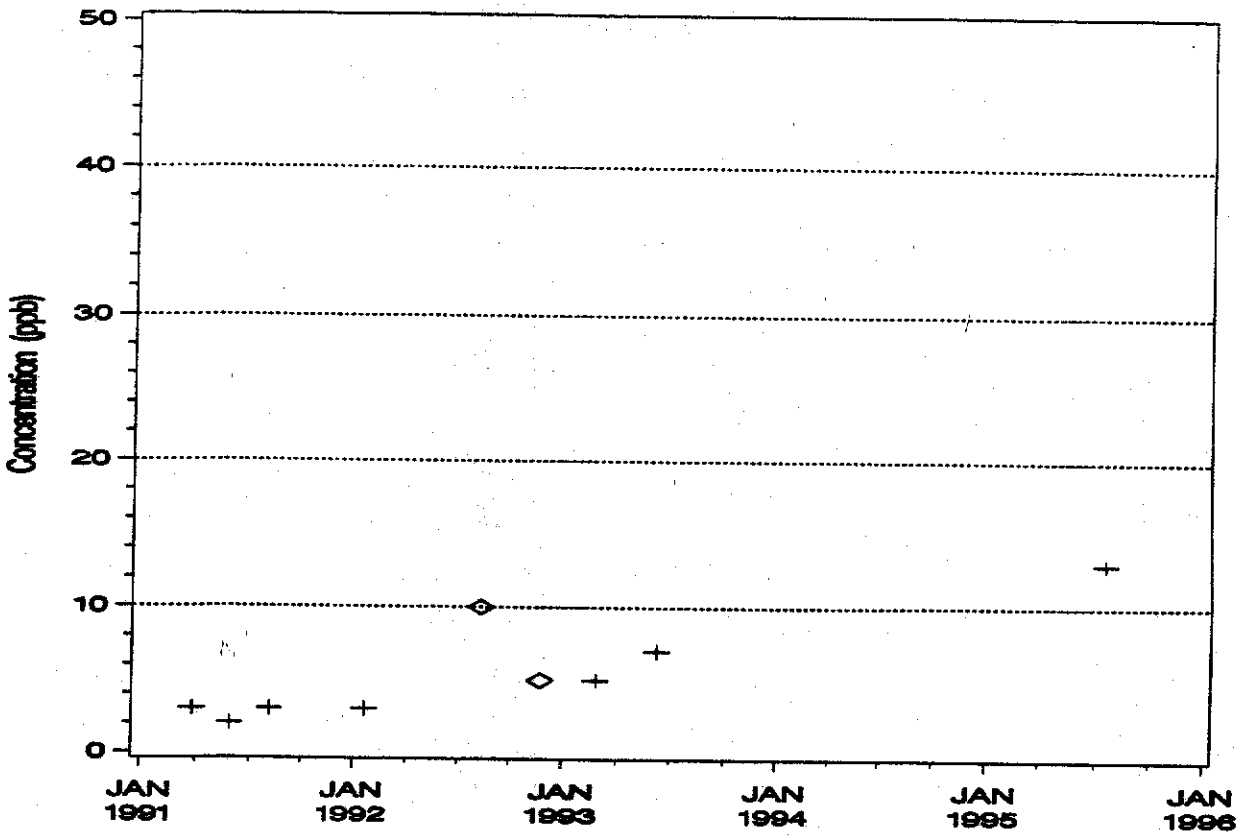


FREON 113 Trend

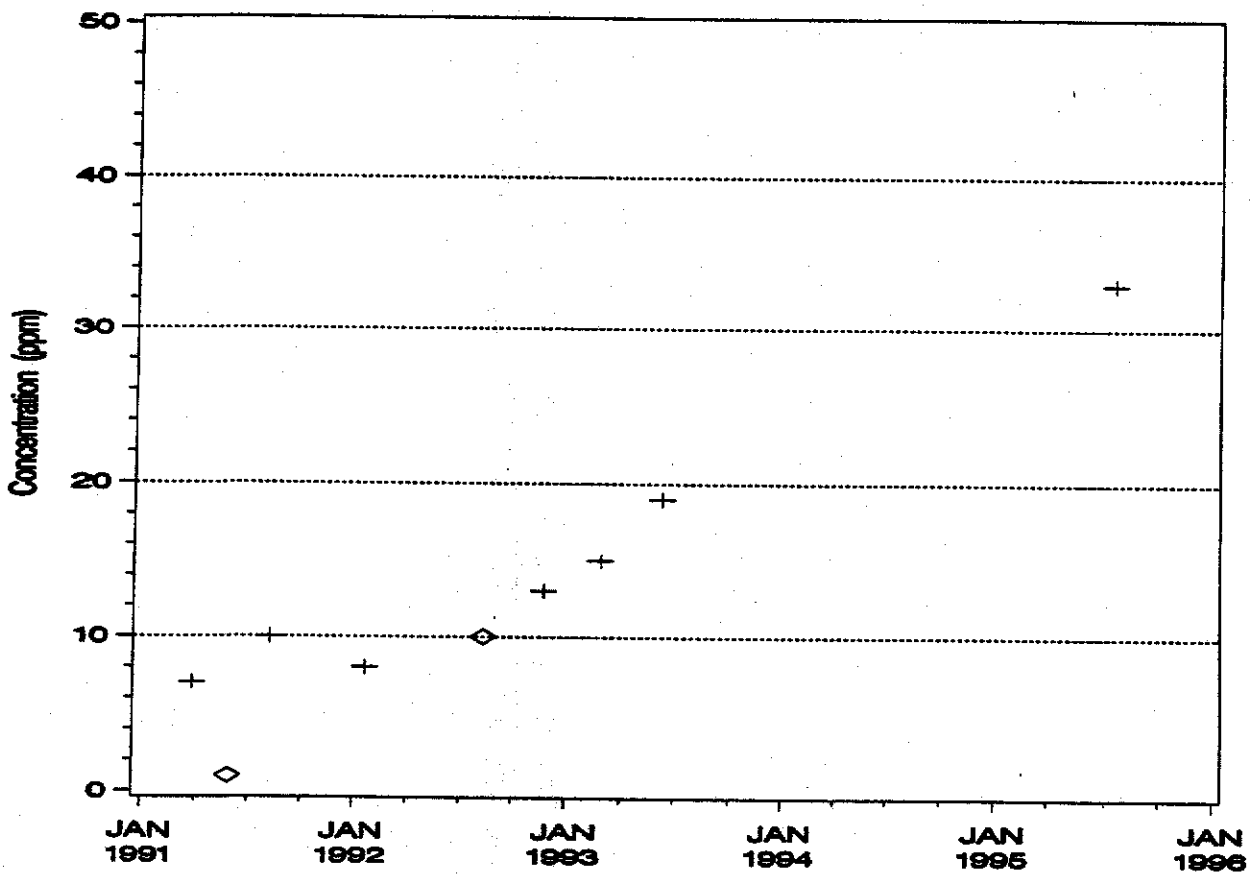


WELL 1377

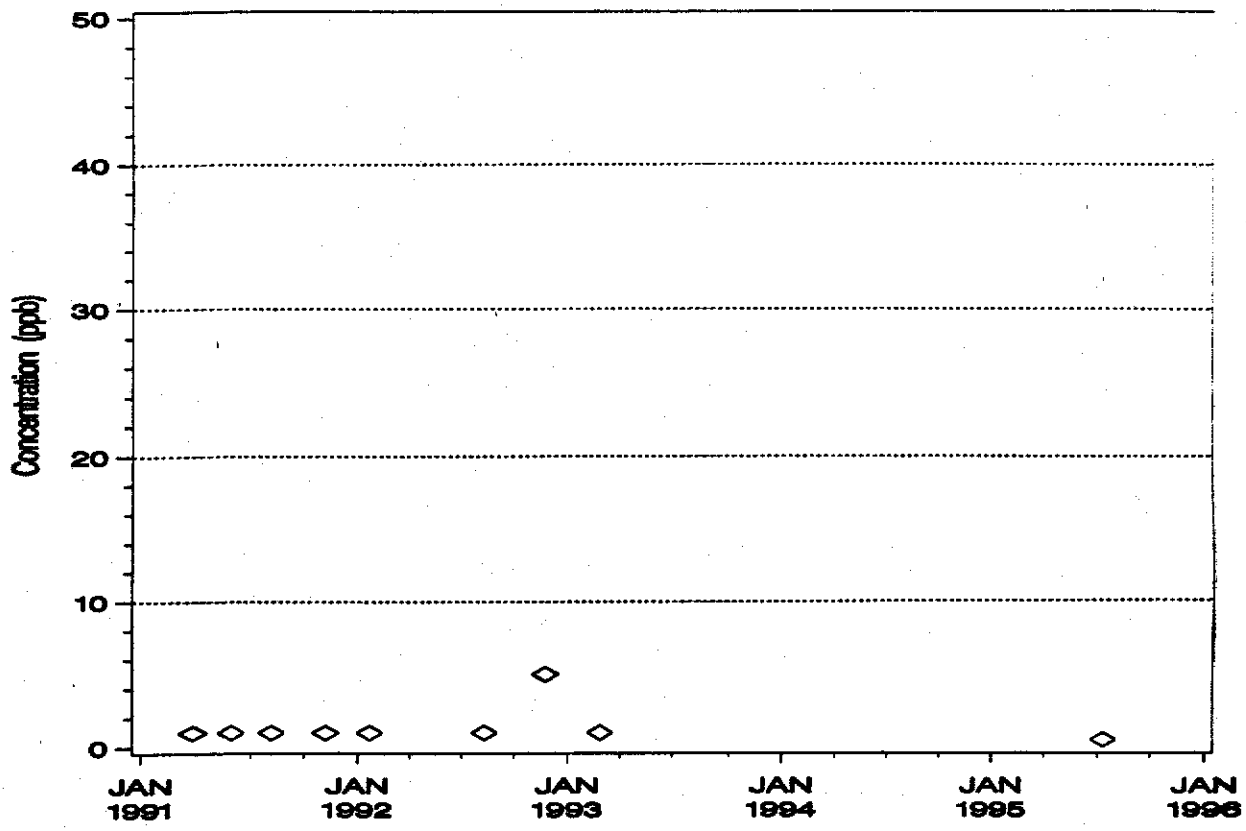
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



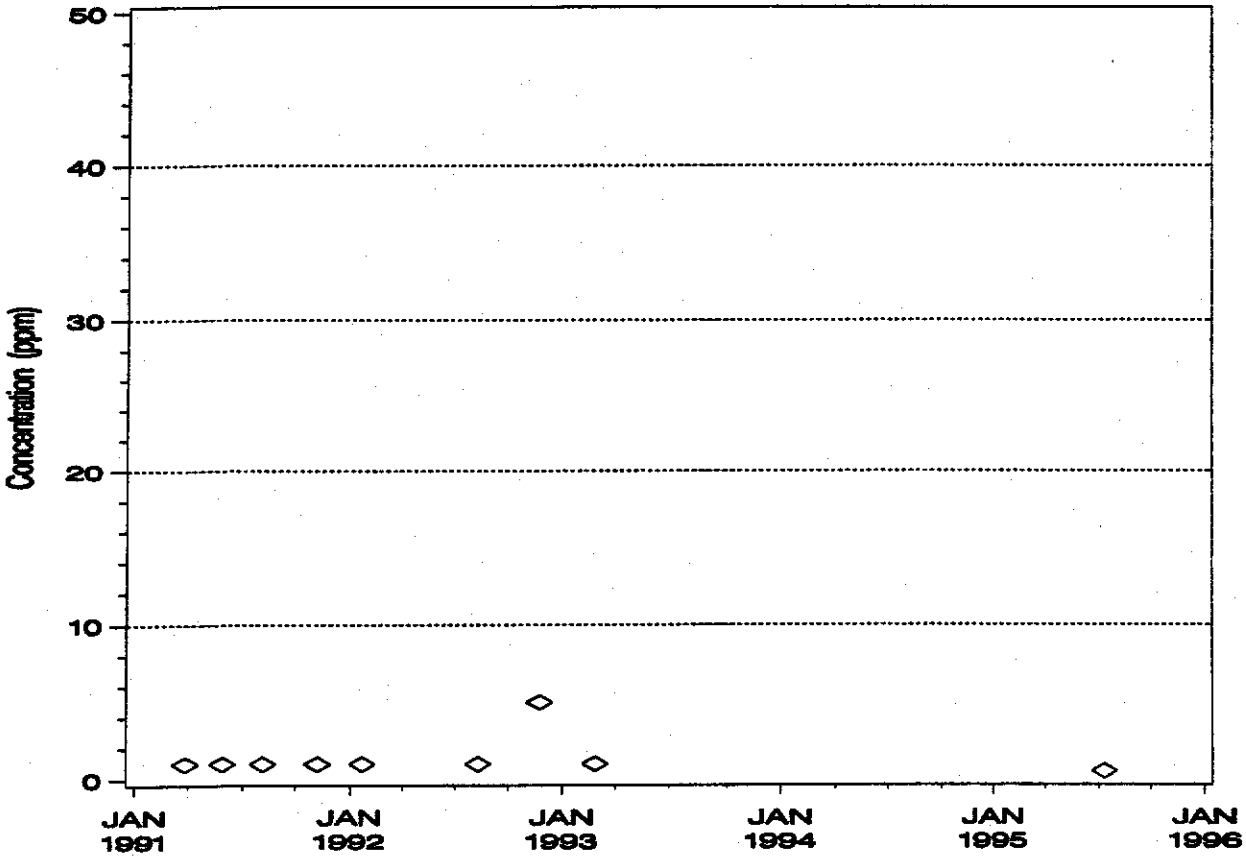
1,1 – DICHLOROETHYLENE Trend



WELL 1378
TRICHLOROETHYLENE Trend

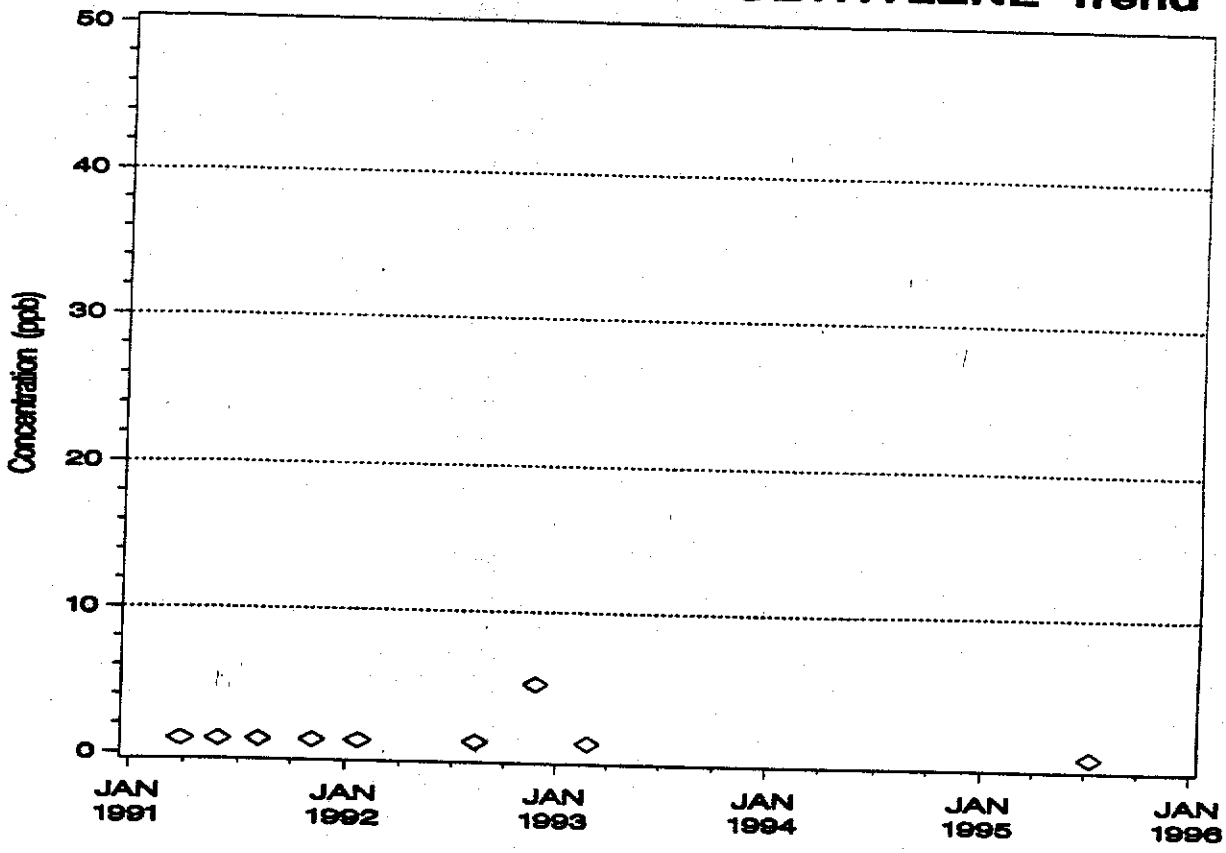


FREON 113 Trend

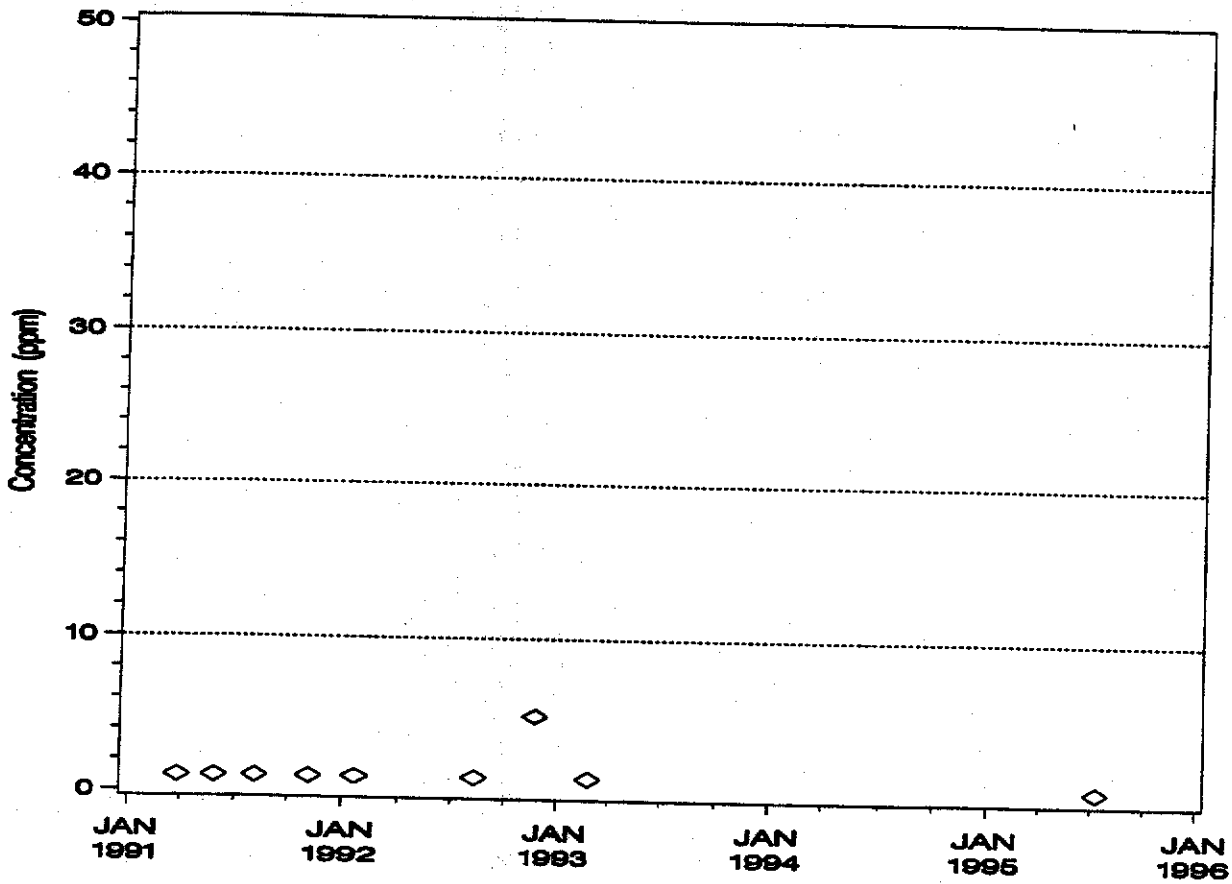


WELL 1378

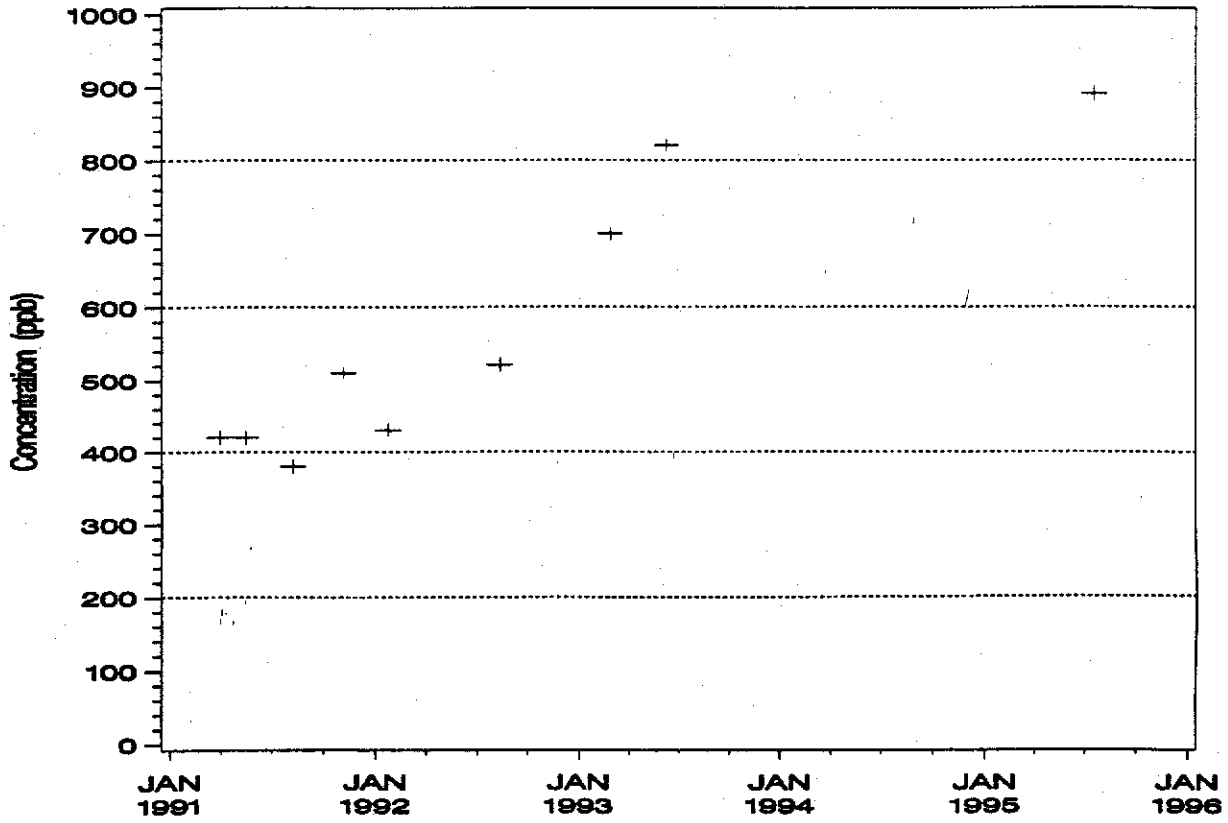
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



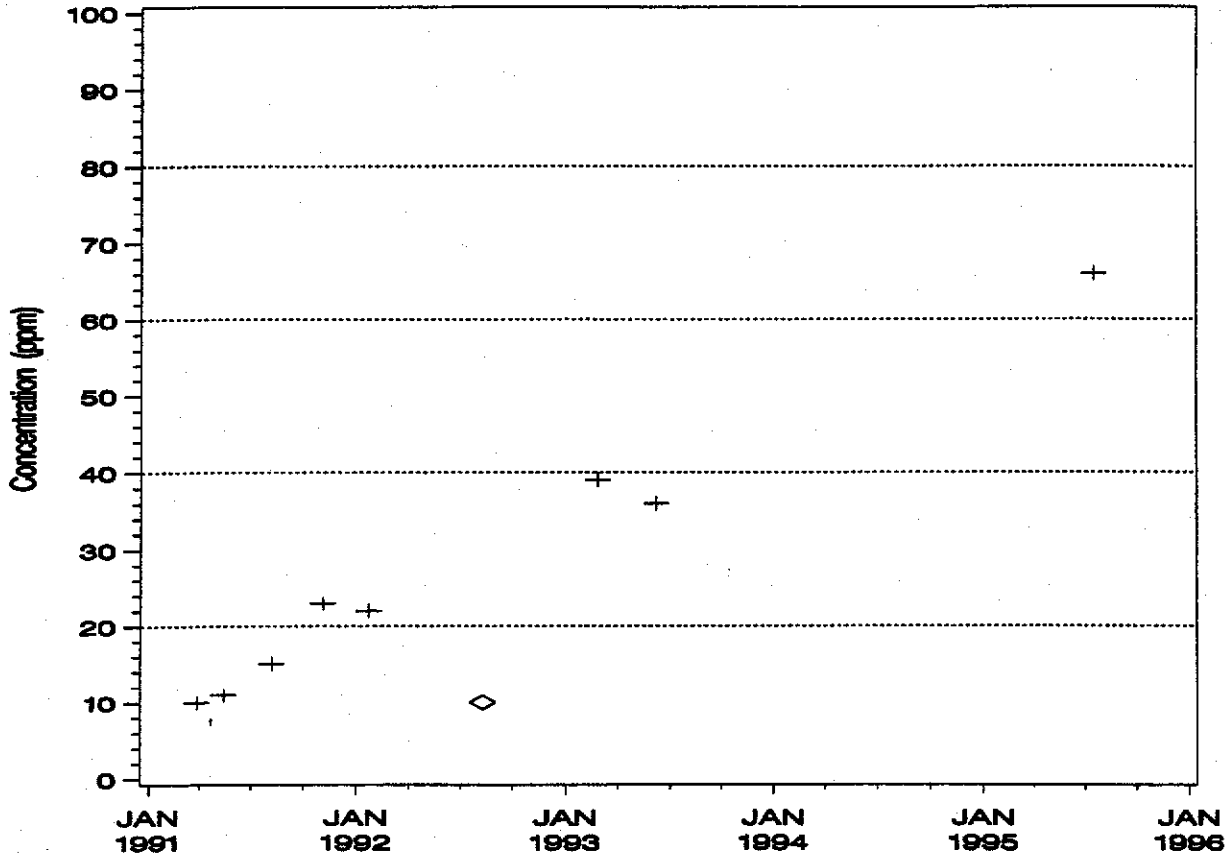
1,1 – DICHLOROETHYLENE Trend



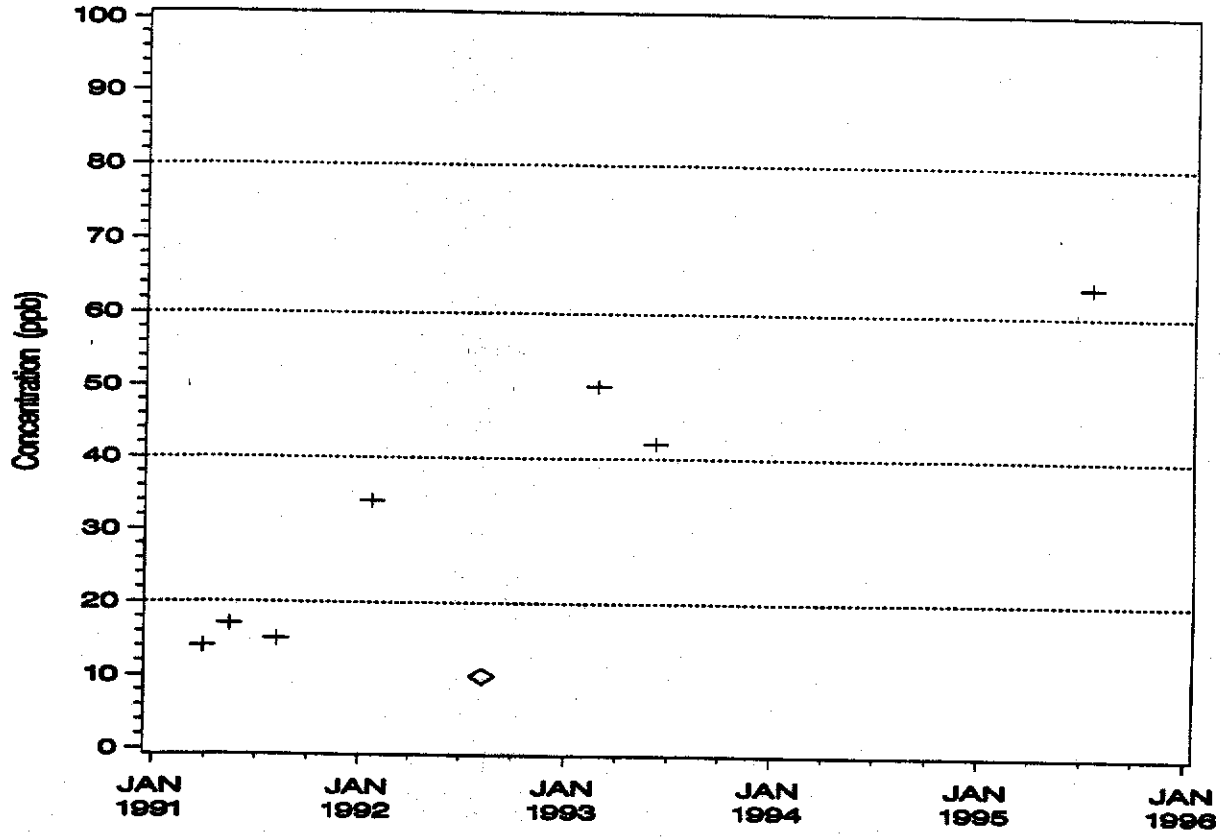
WELL 1379
TRICHLOROETHYLENE Trend



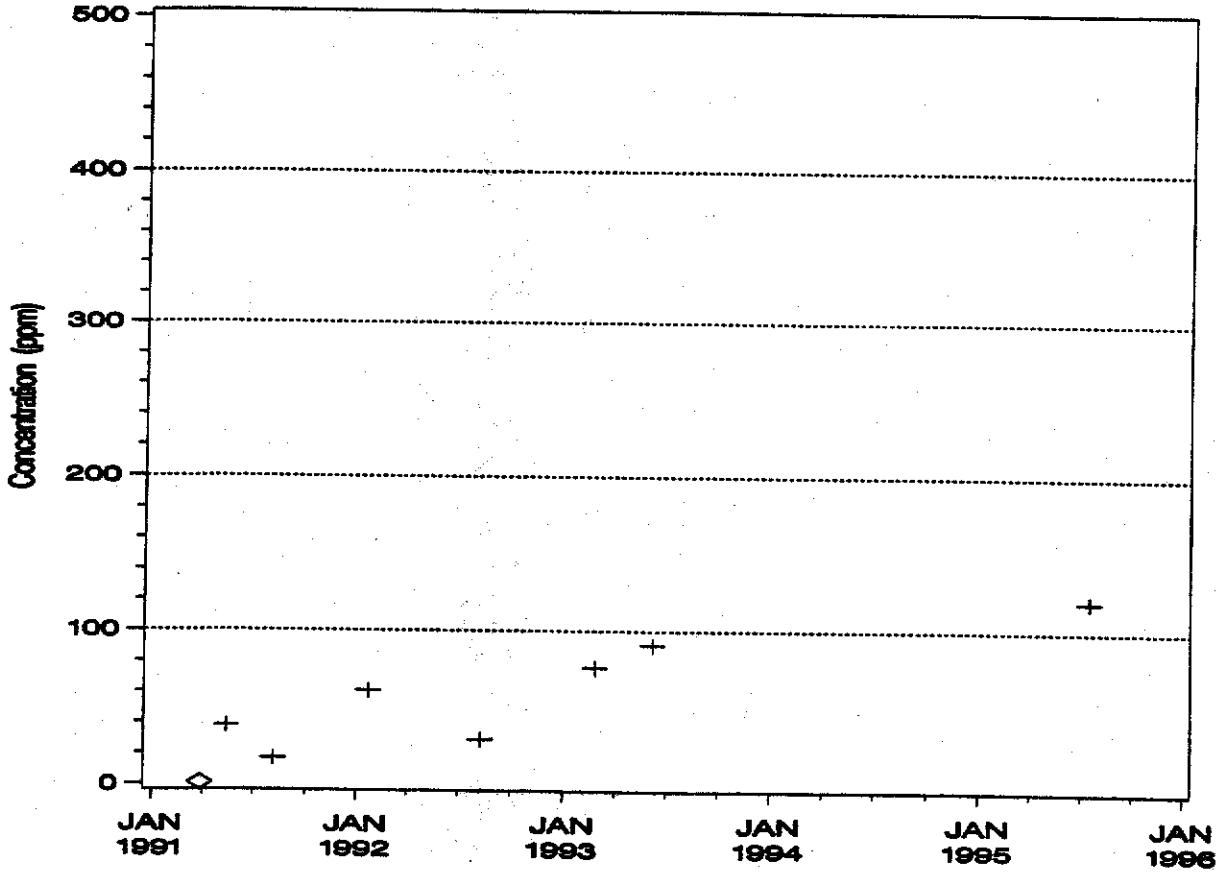
FREON 113 Trend



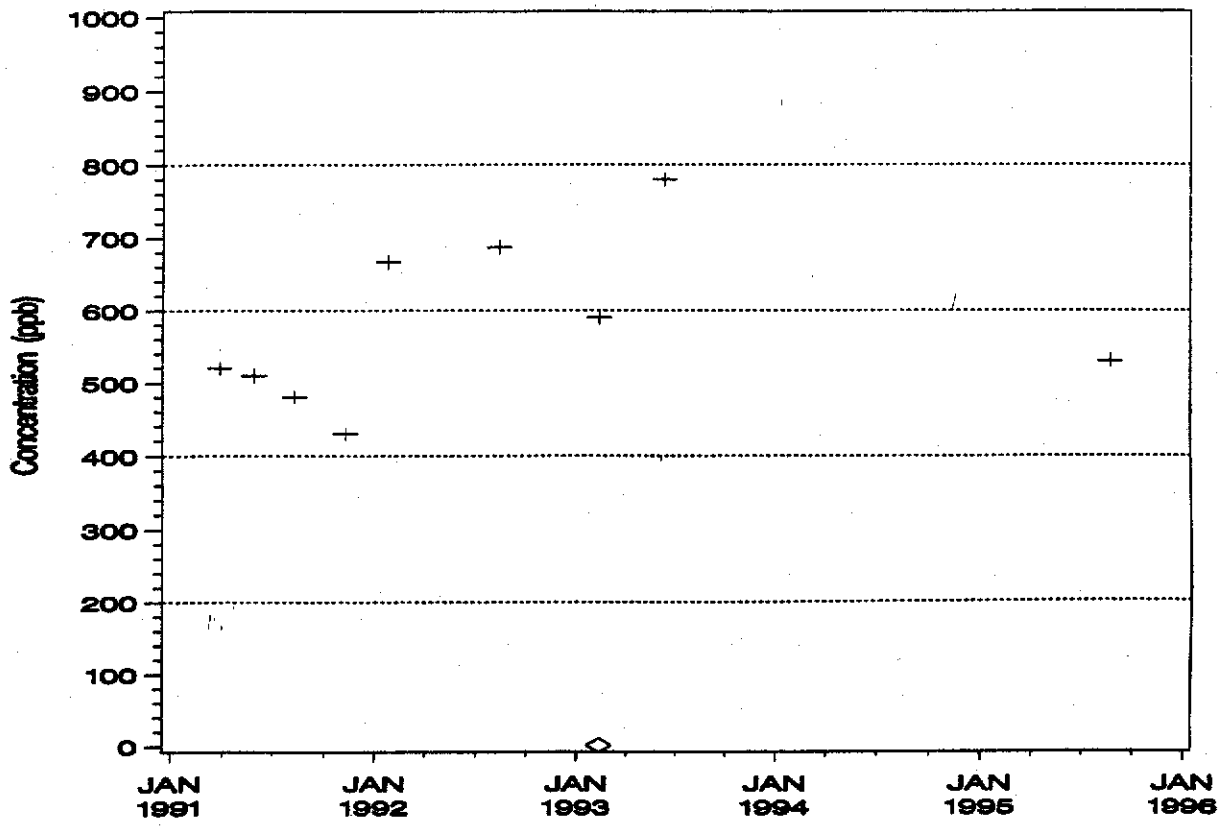
WELL 1379
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



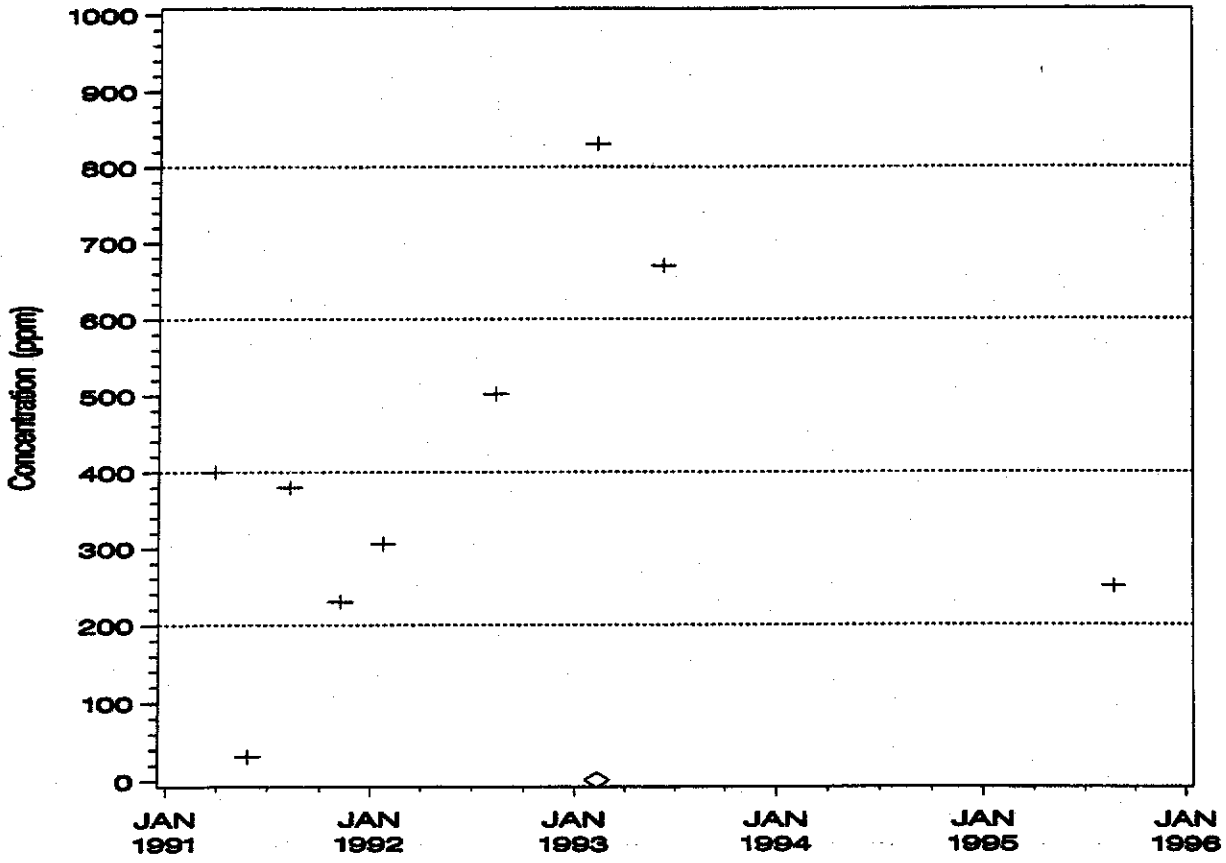
1,1 – DICHLOROETHYLENE Trend



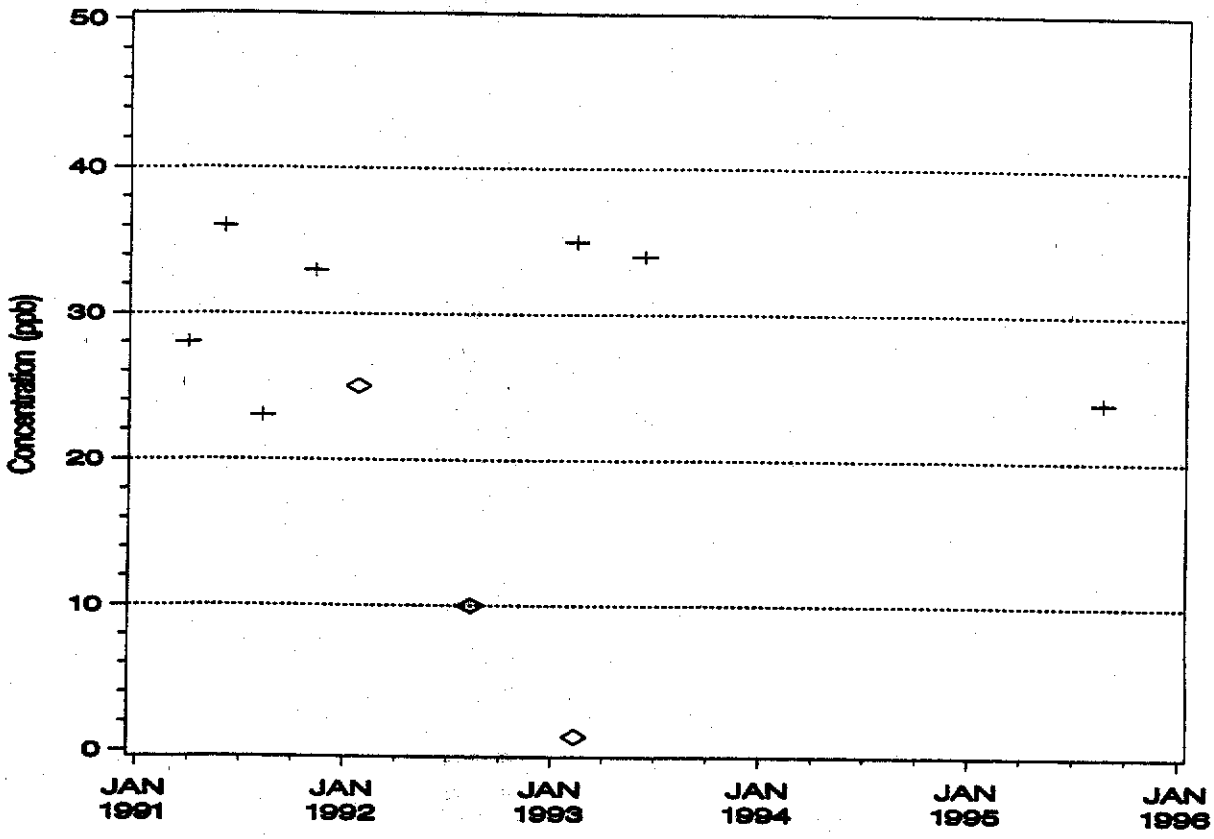
WELL 1380
TRICHLOROETHYLENE Trend



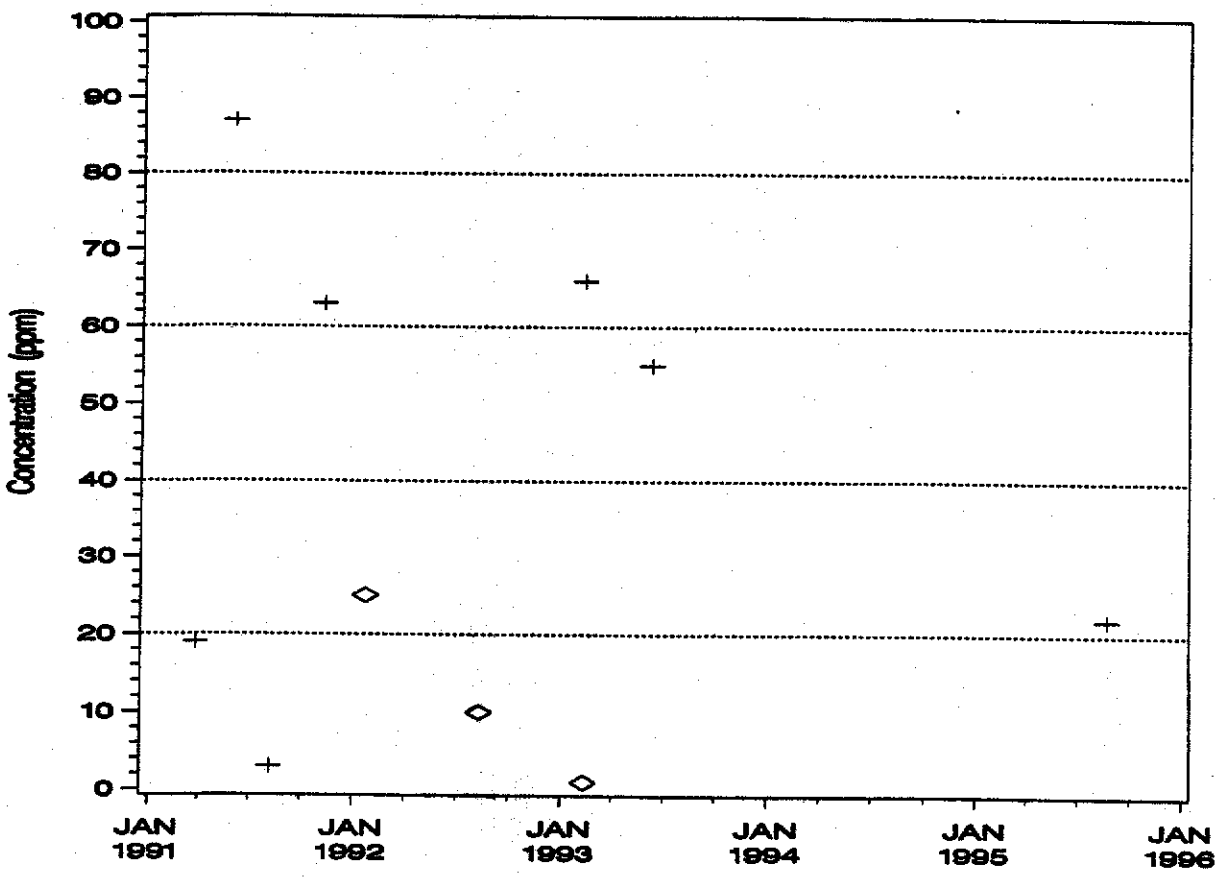
FREON 113 Trend



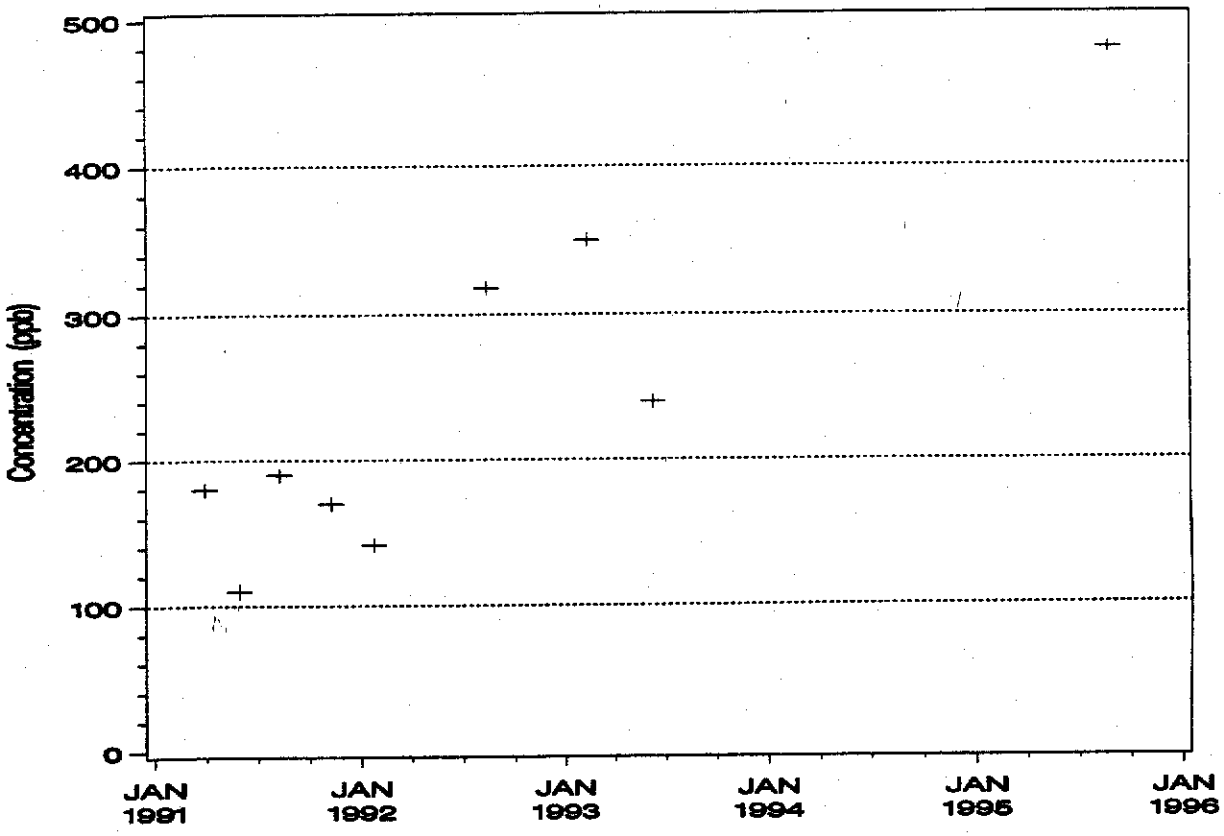
WELL 1380
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



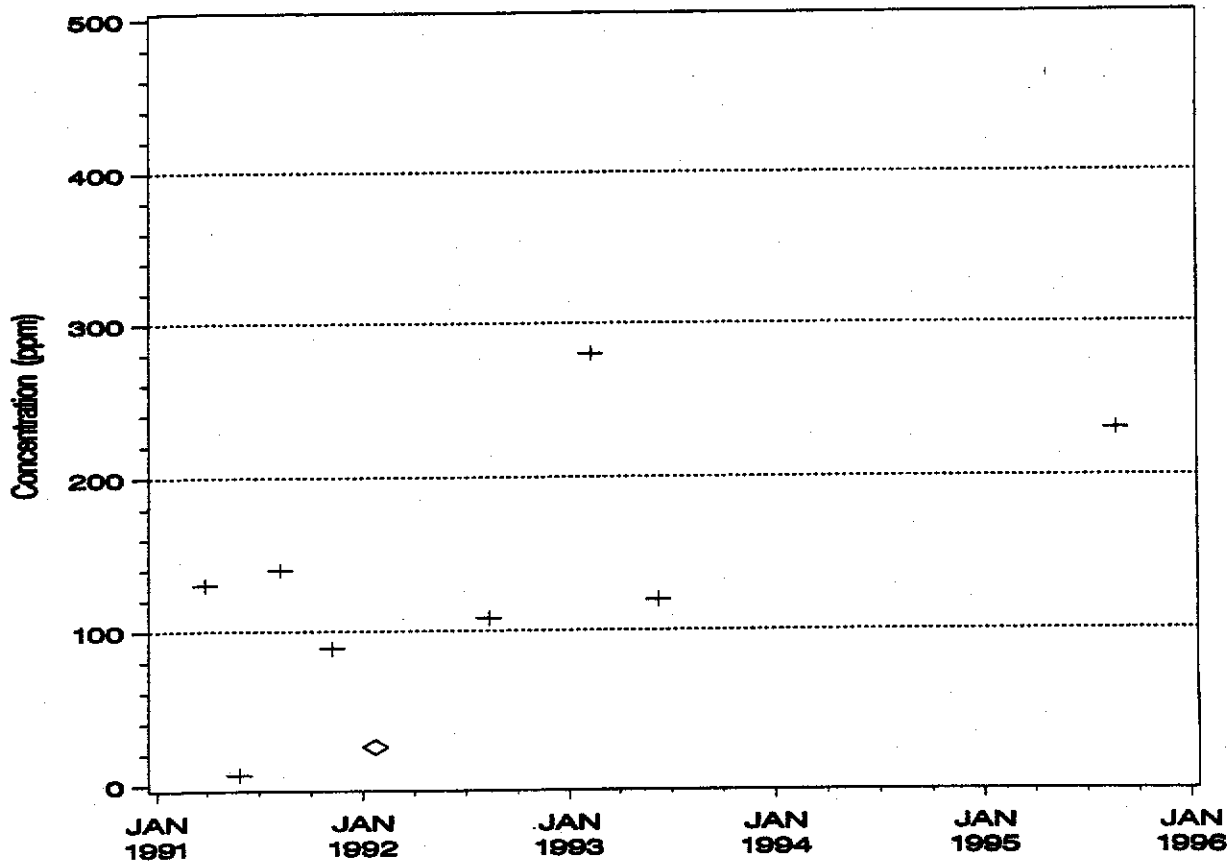
1,1 – DICHLOROETHYLENE Trend



WELL 1381
TRICHLOROETHYLENE Trend

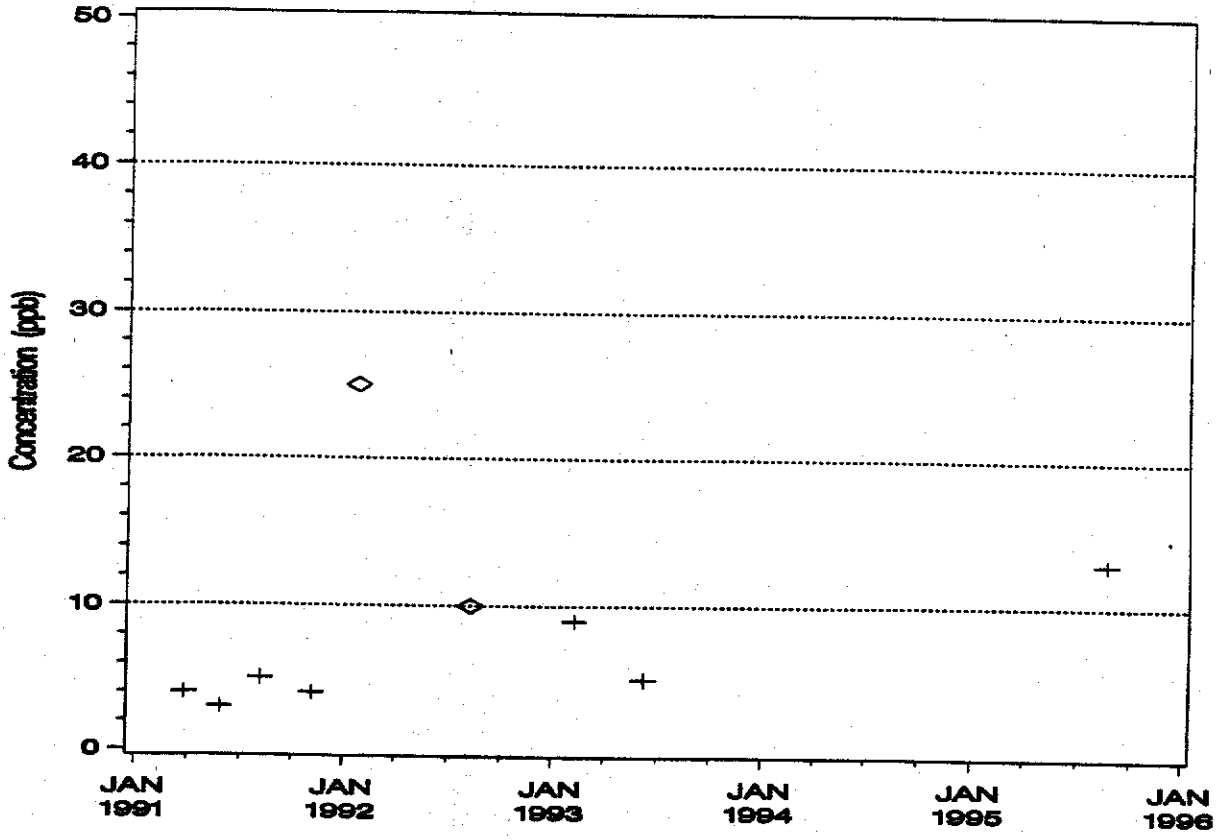


FREON 113 Trend

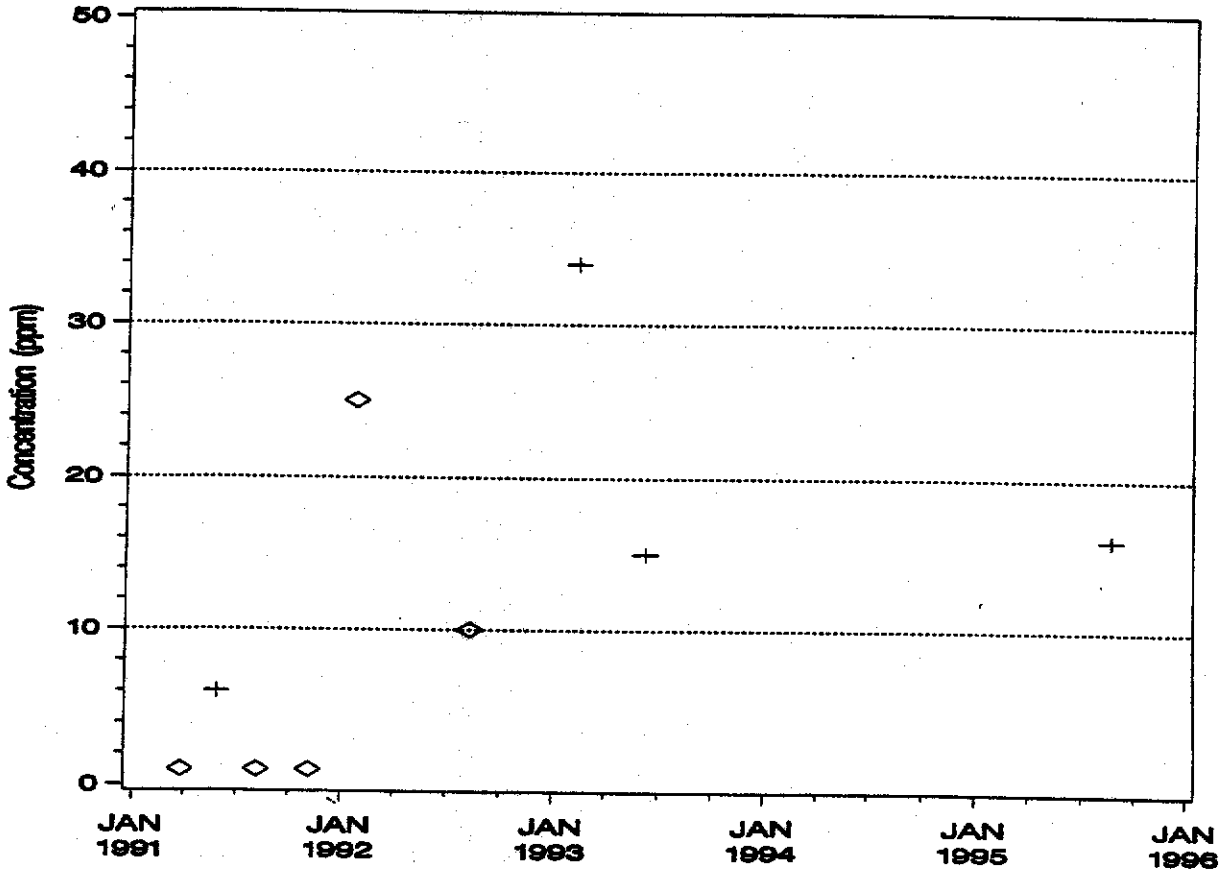


WELL 1381

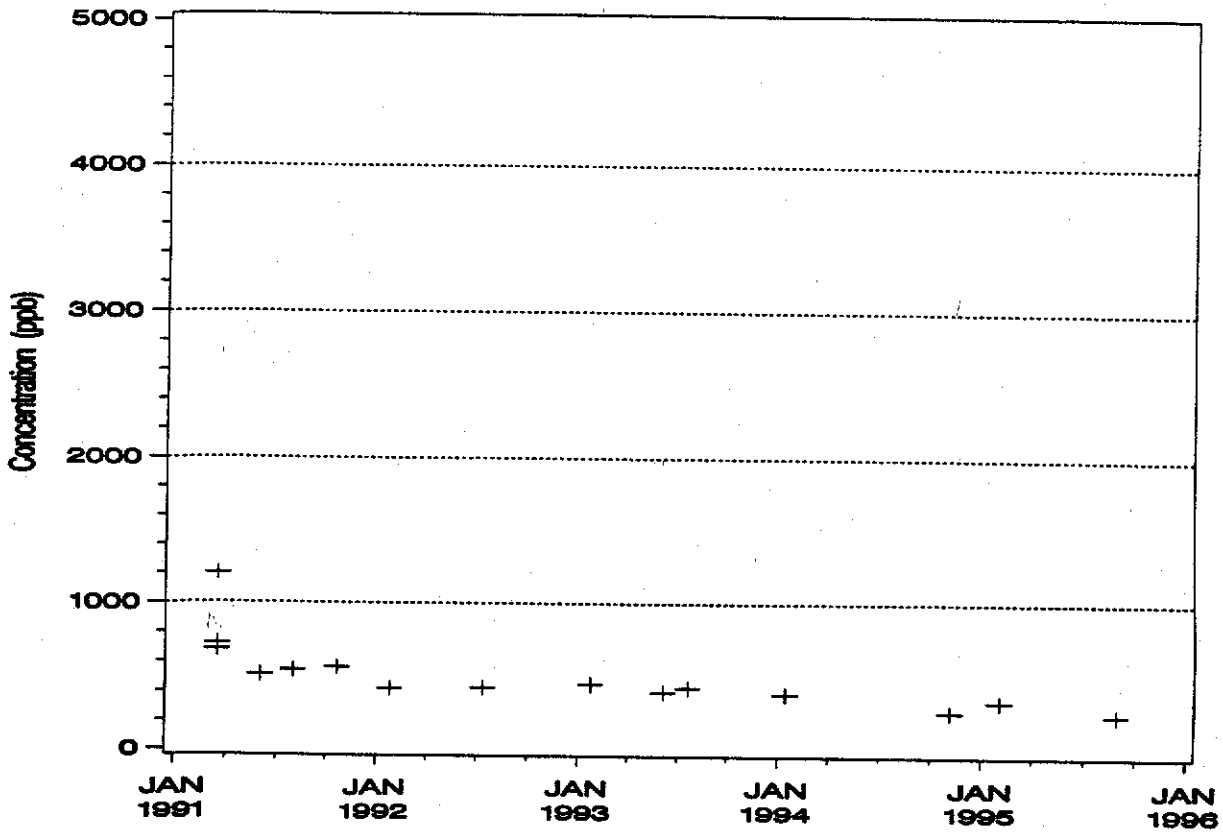
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



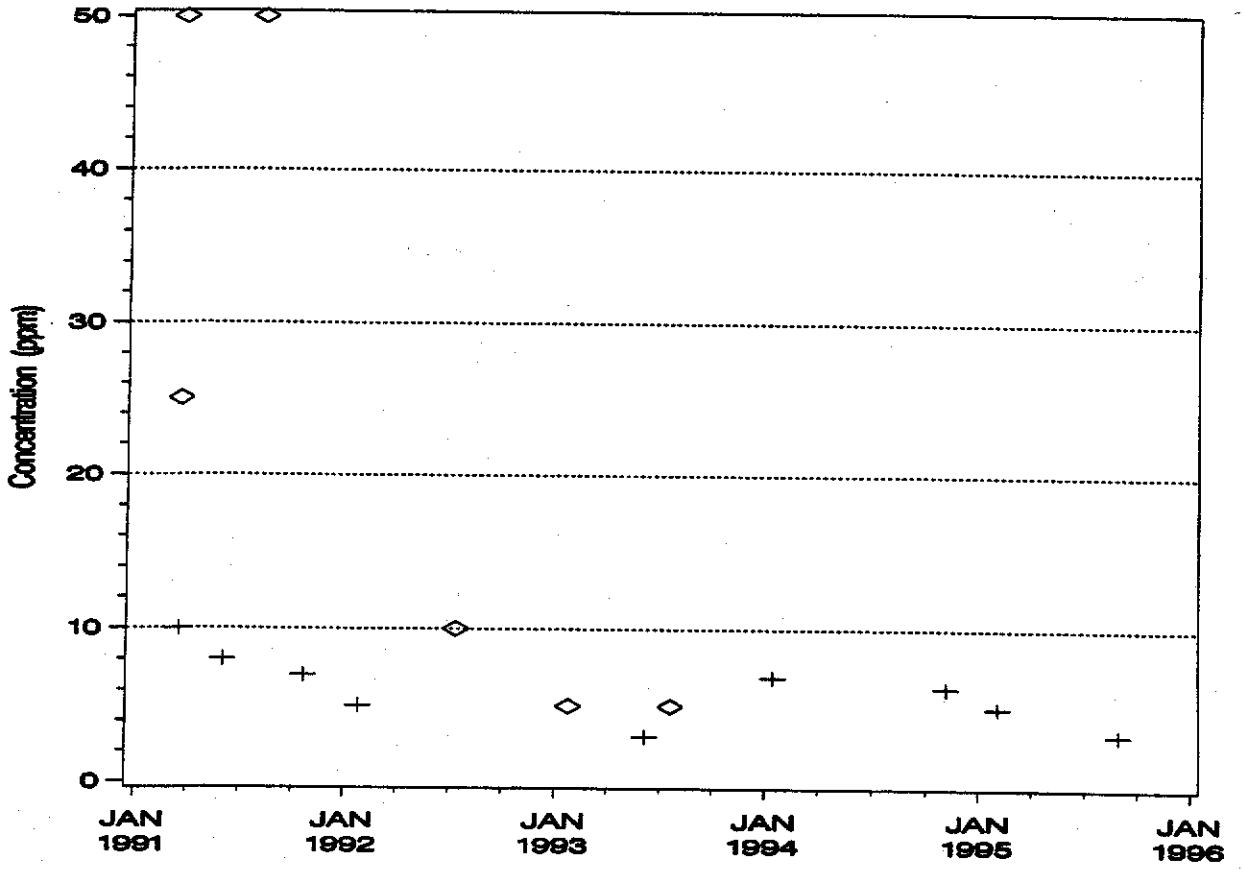
1,1 – DICHLOROETHYLENE Trend



WELL 1382
TRICHLOROETHYLENE Trend

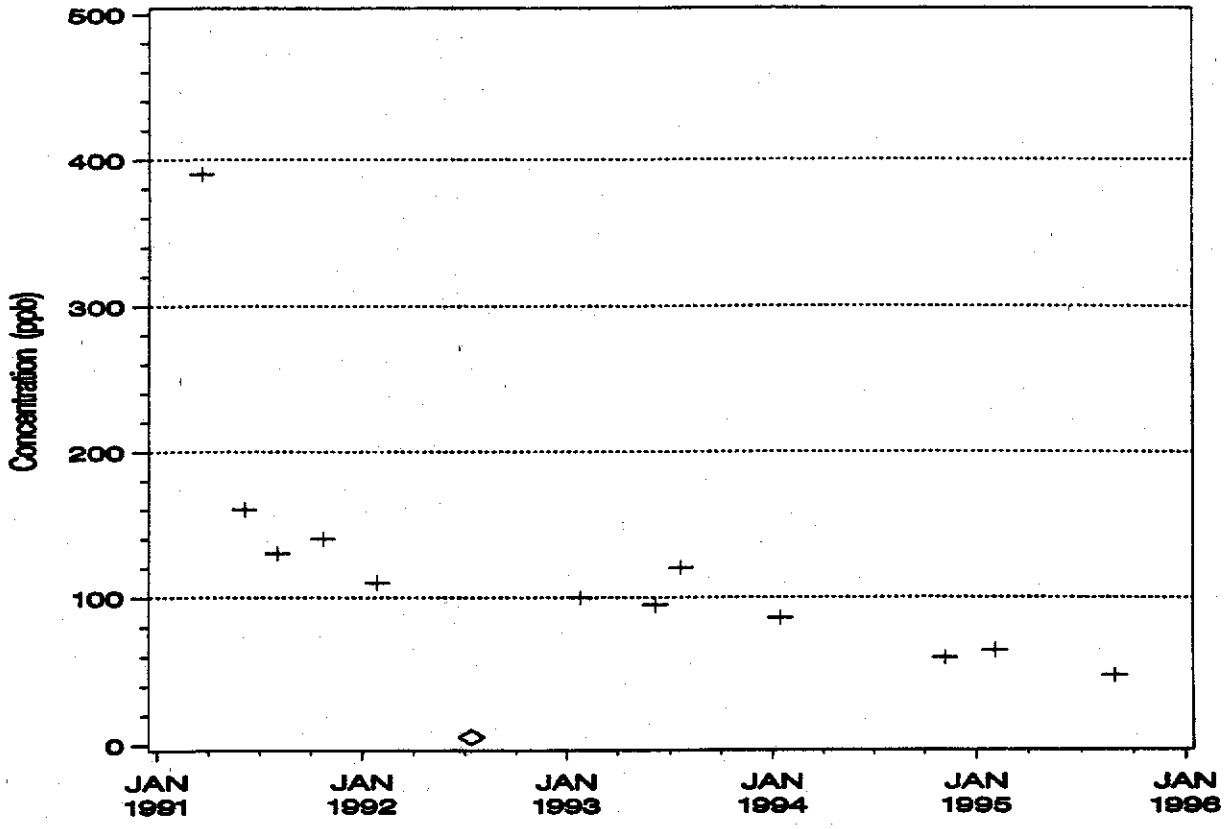


FREON 113 Trend

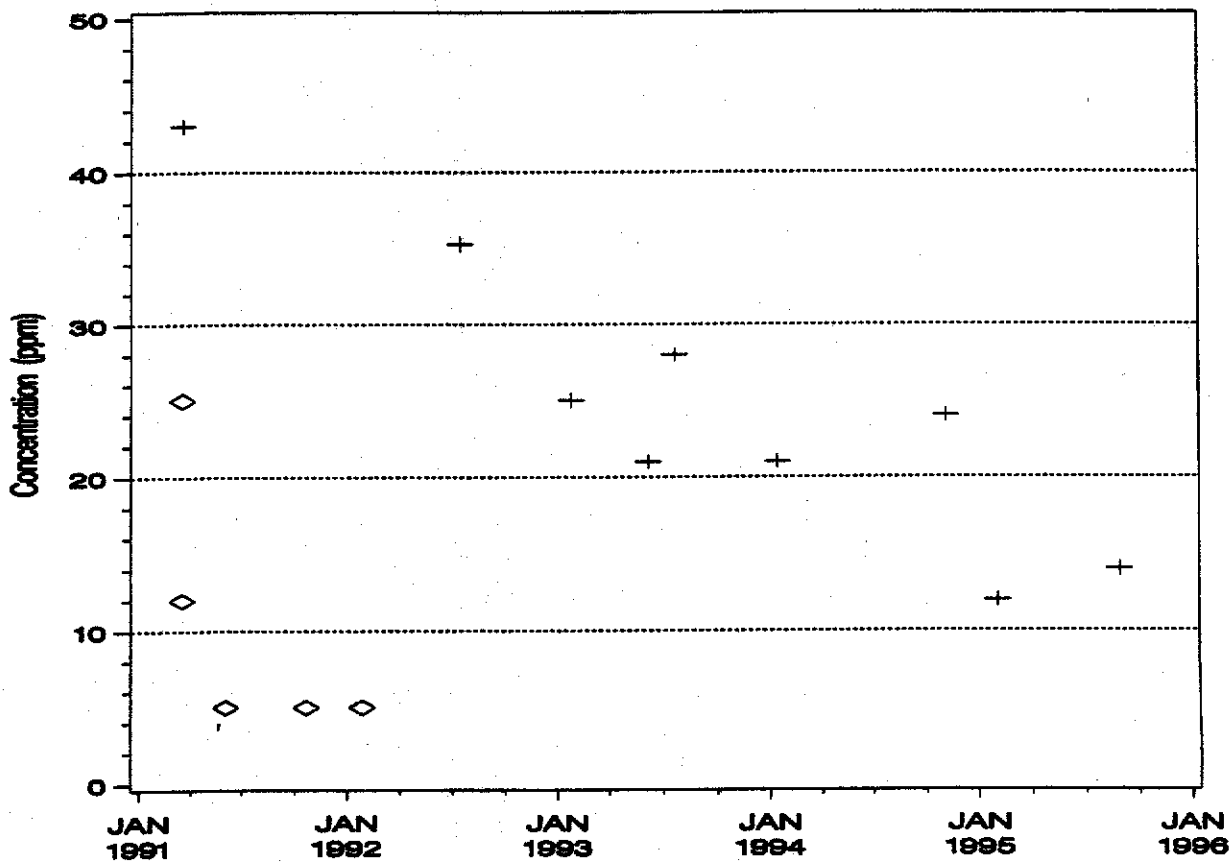


WELL 1382

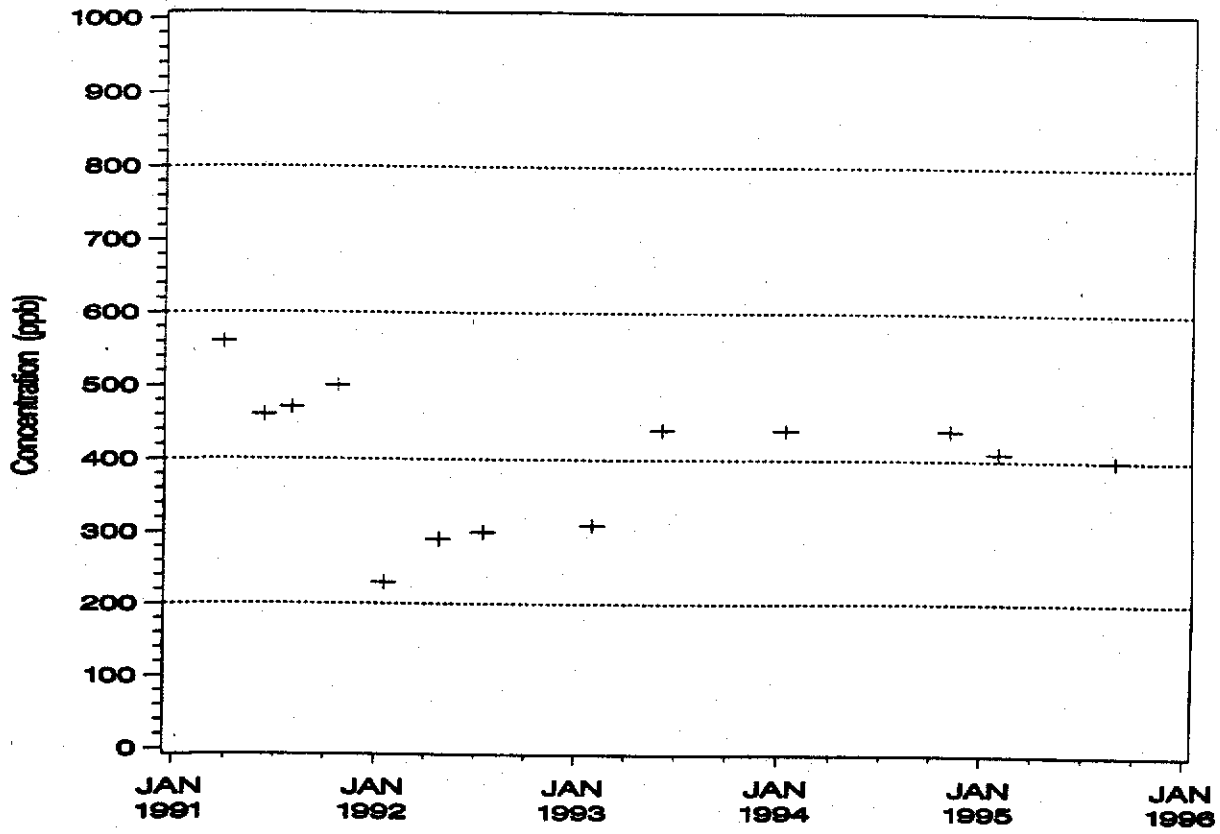
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



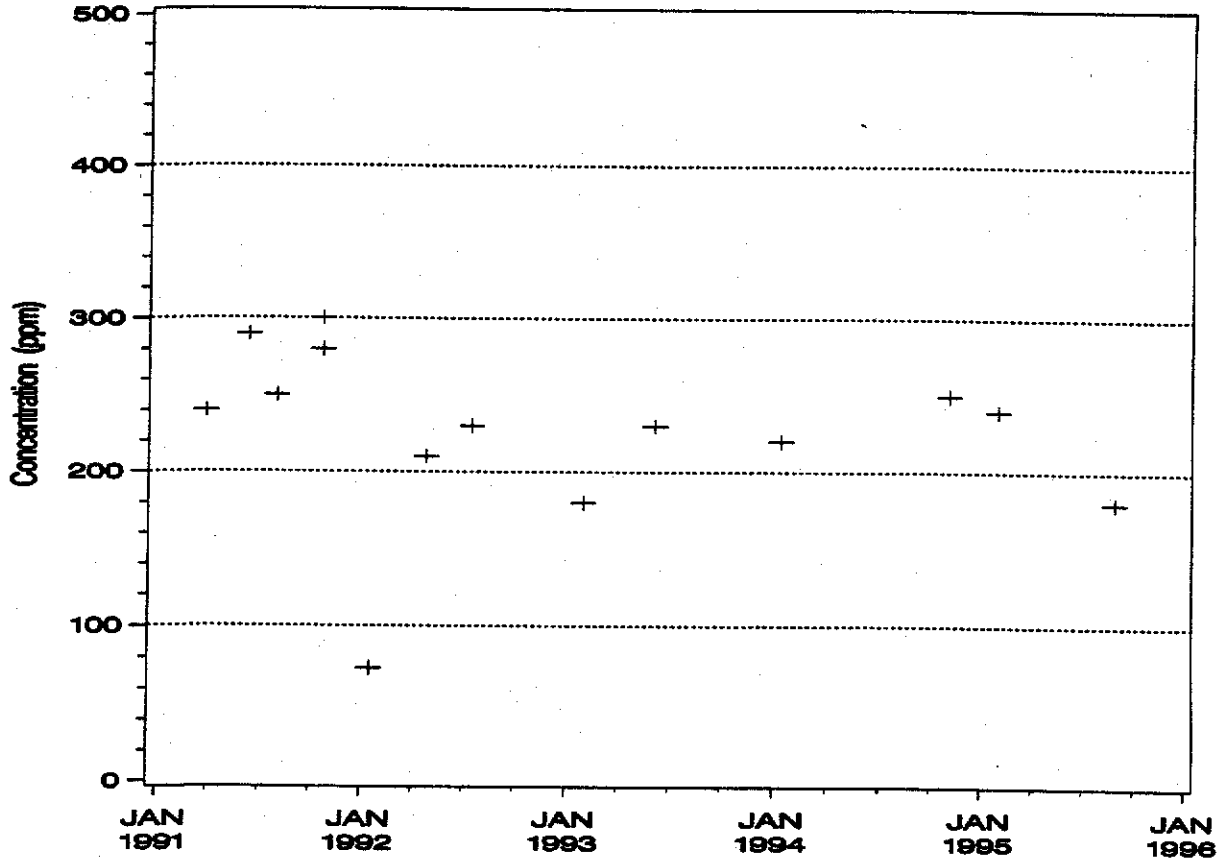
1,1 – DICHLOROETHYLENE Trend



WELL 1383
TRICHLOROETHYLENE Trend

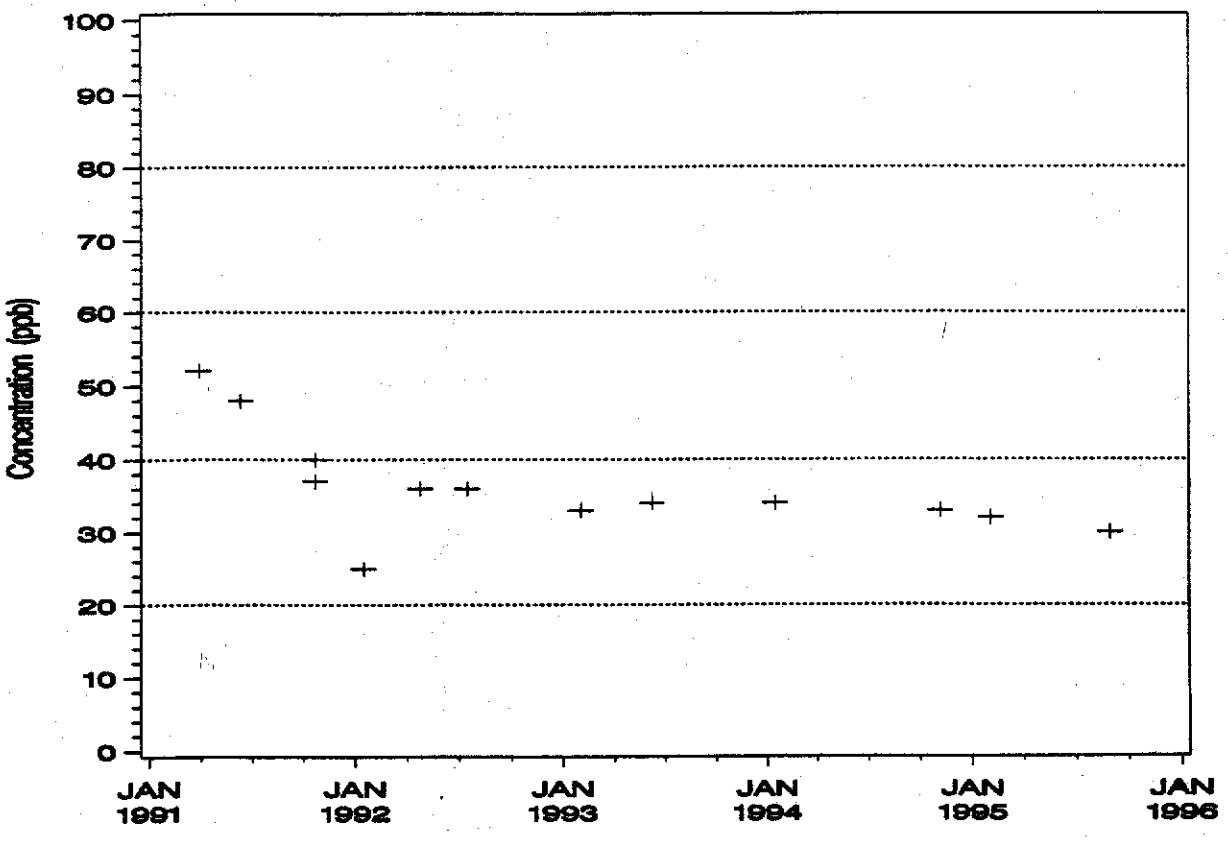


FREON 113 Trend

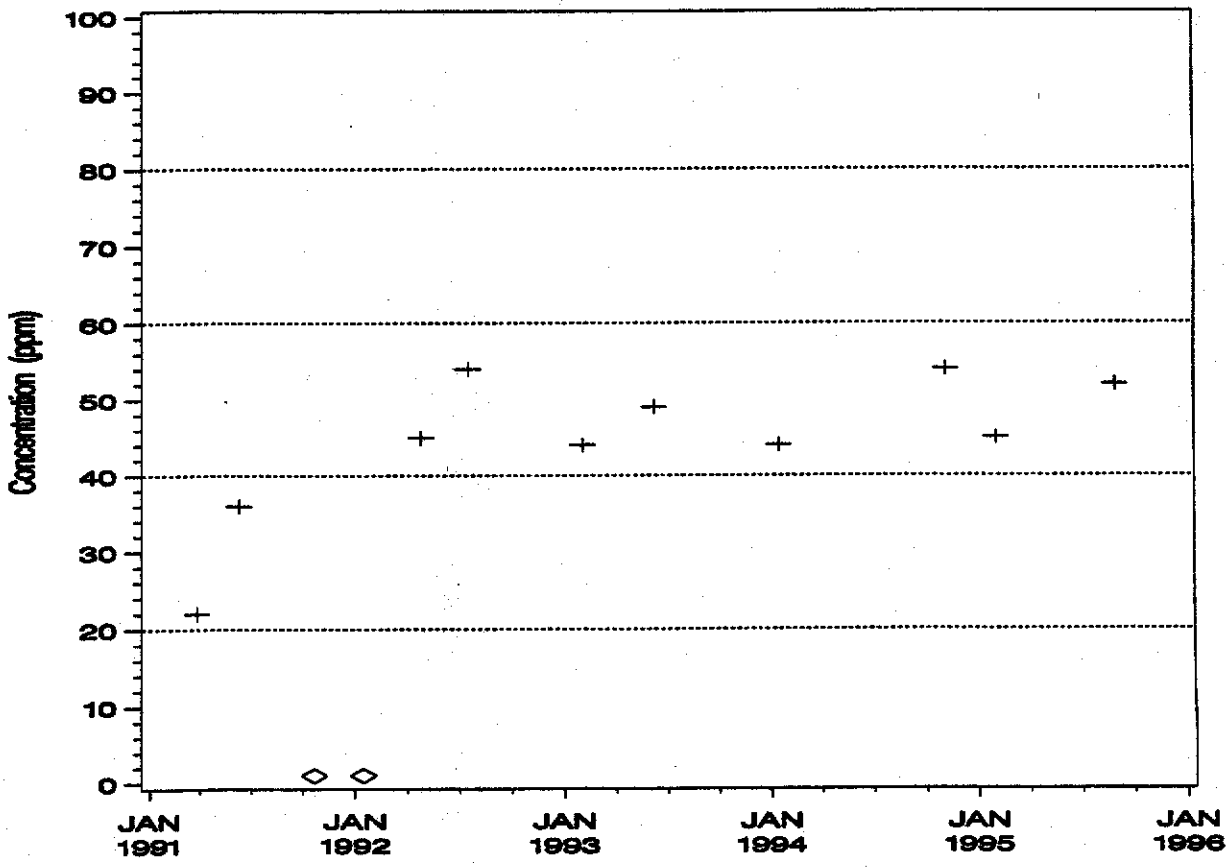


WELL 1383

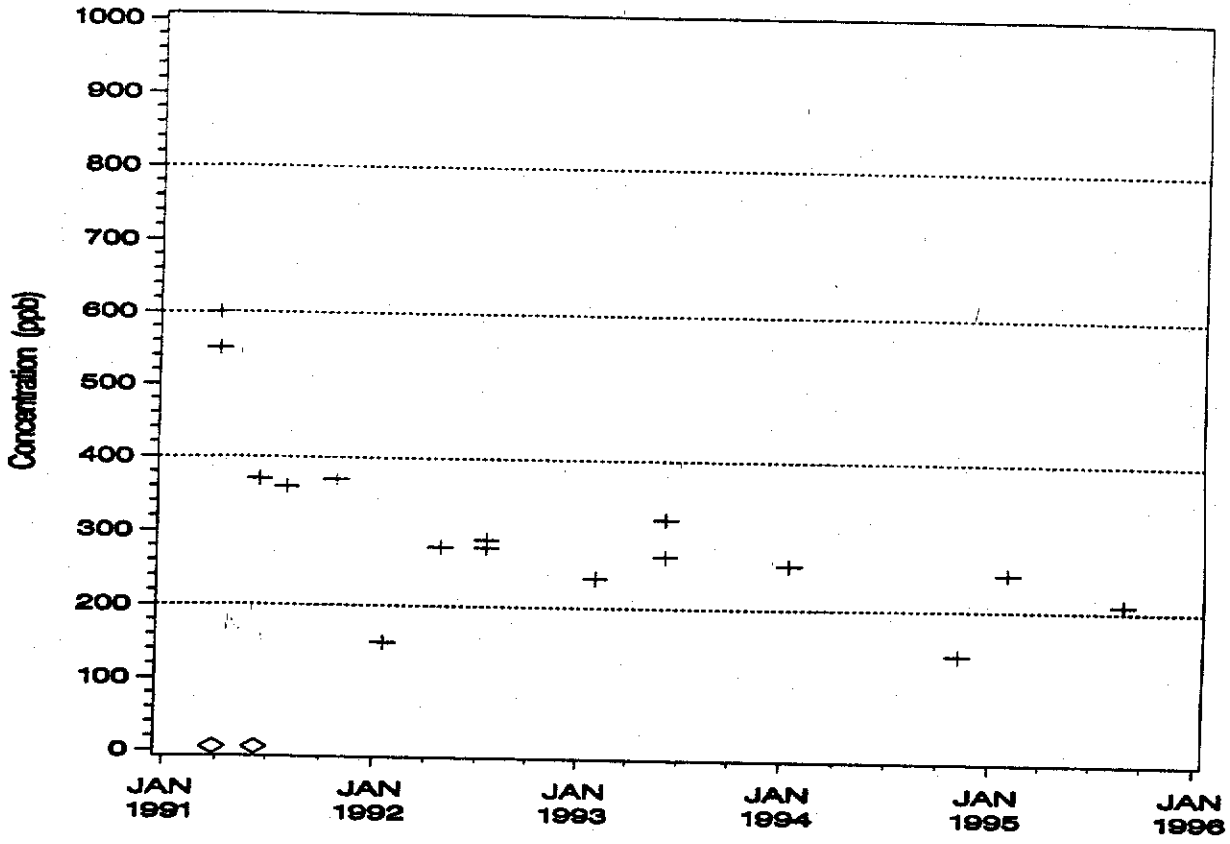
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



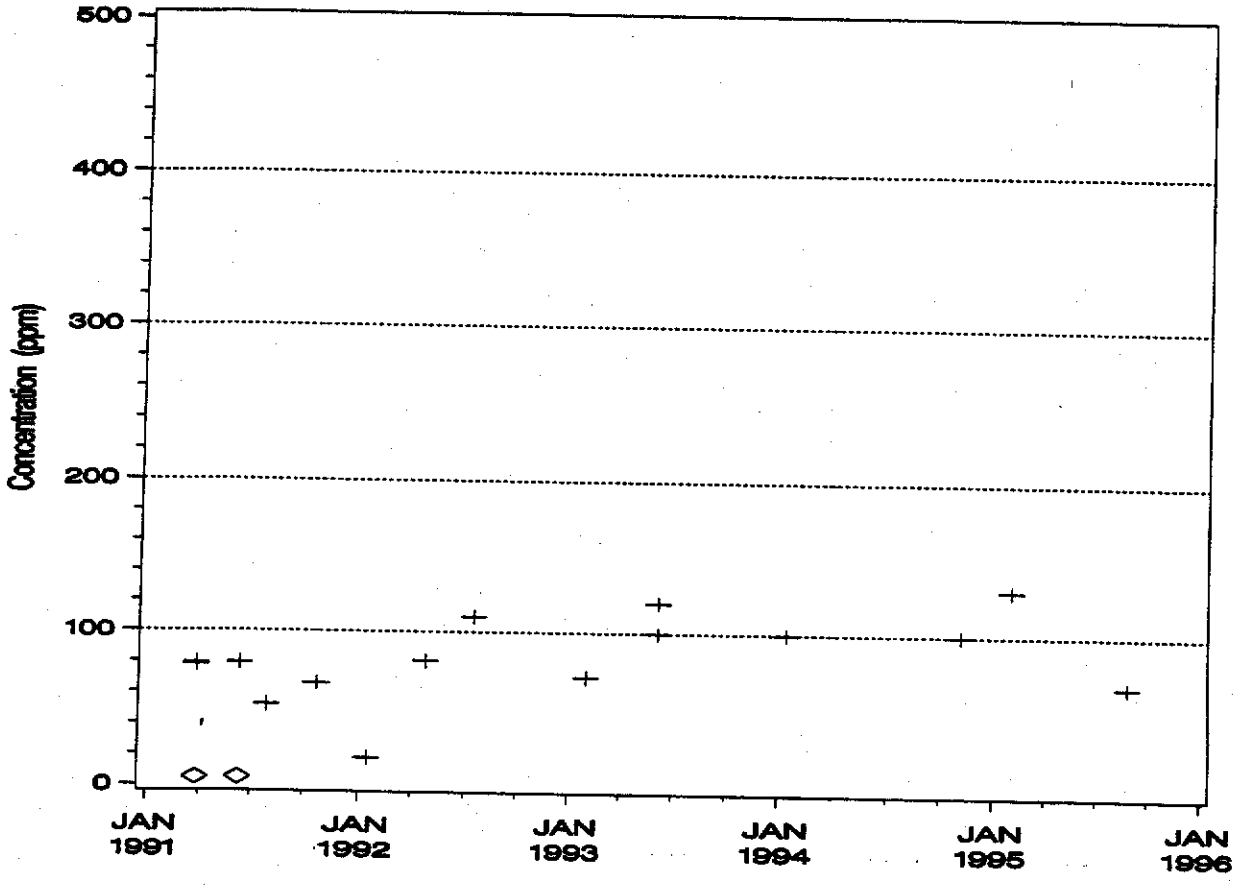
1,1 – DICHLOROETHYLENE Trend



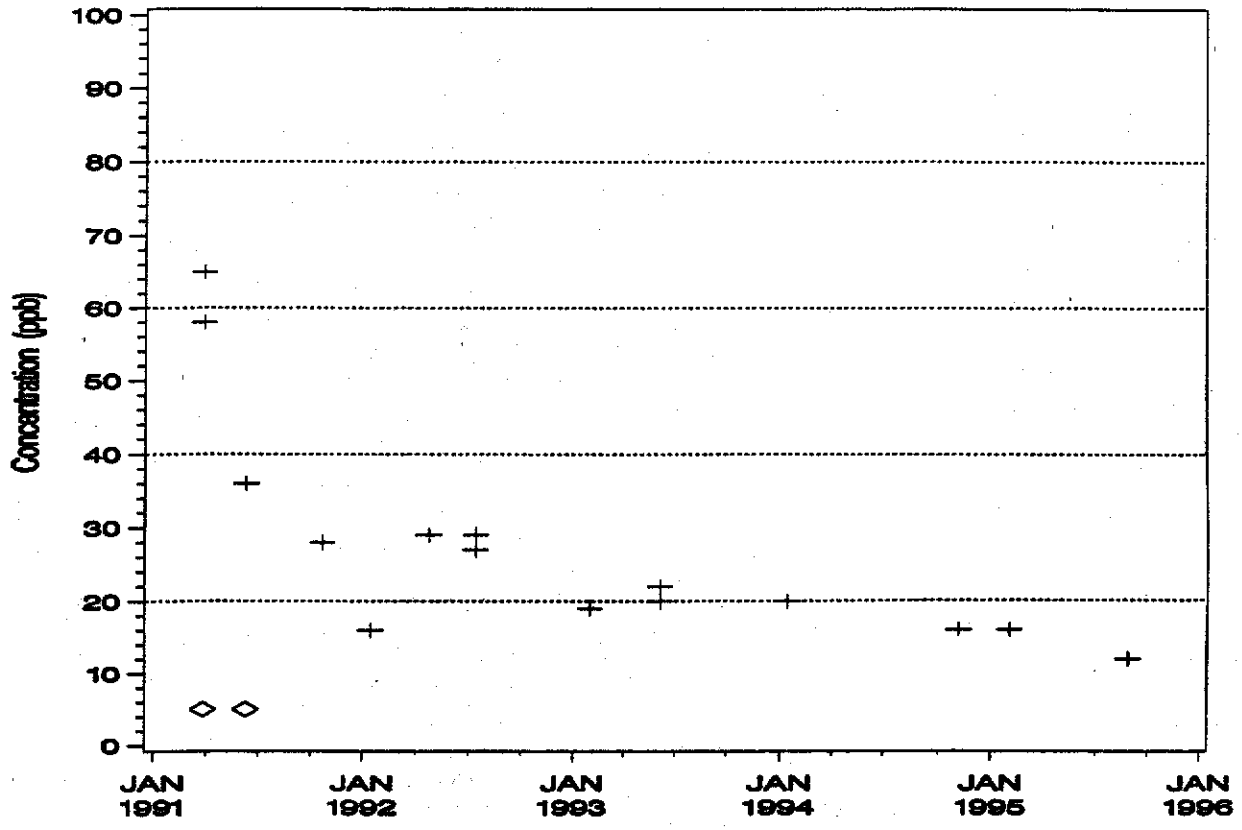
WELL 1384
TRICHLOROETHYLENE Trend



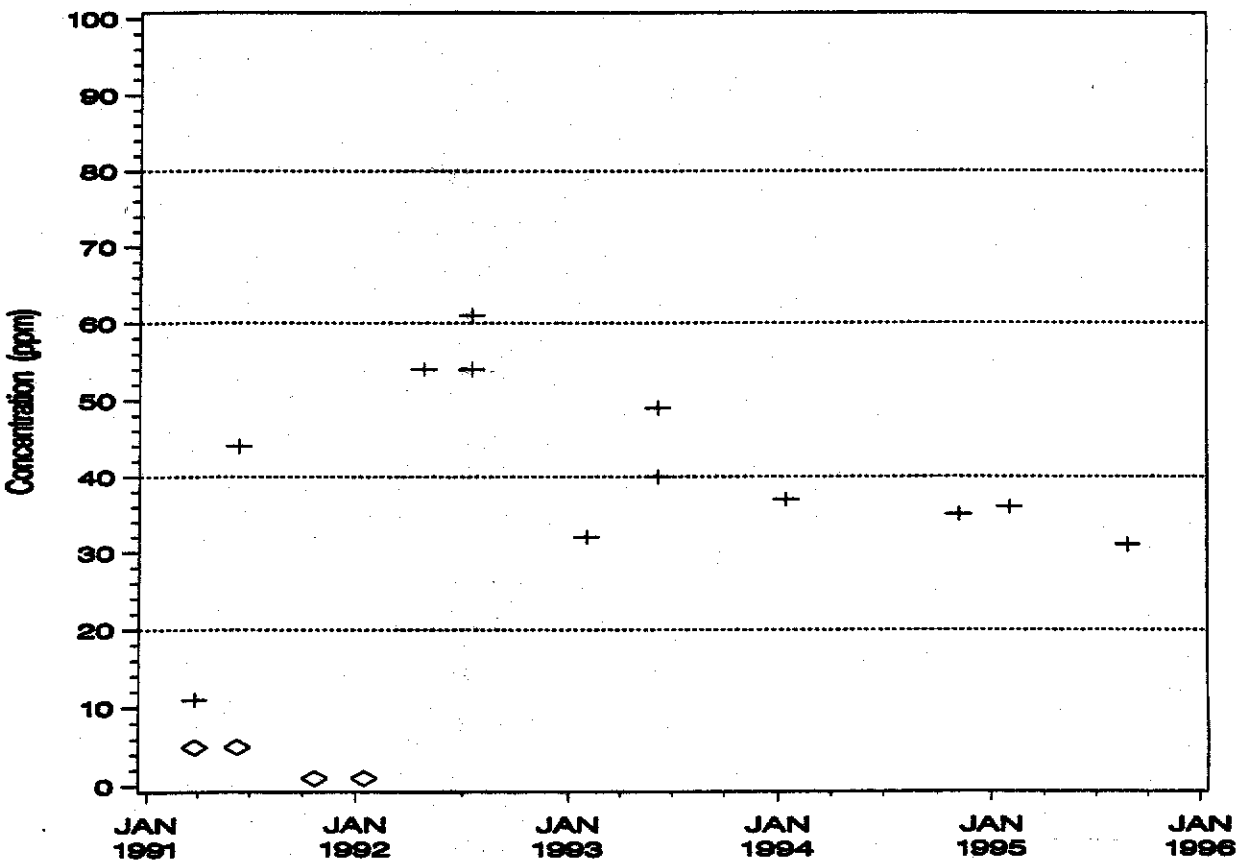
FREON 113 Trend



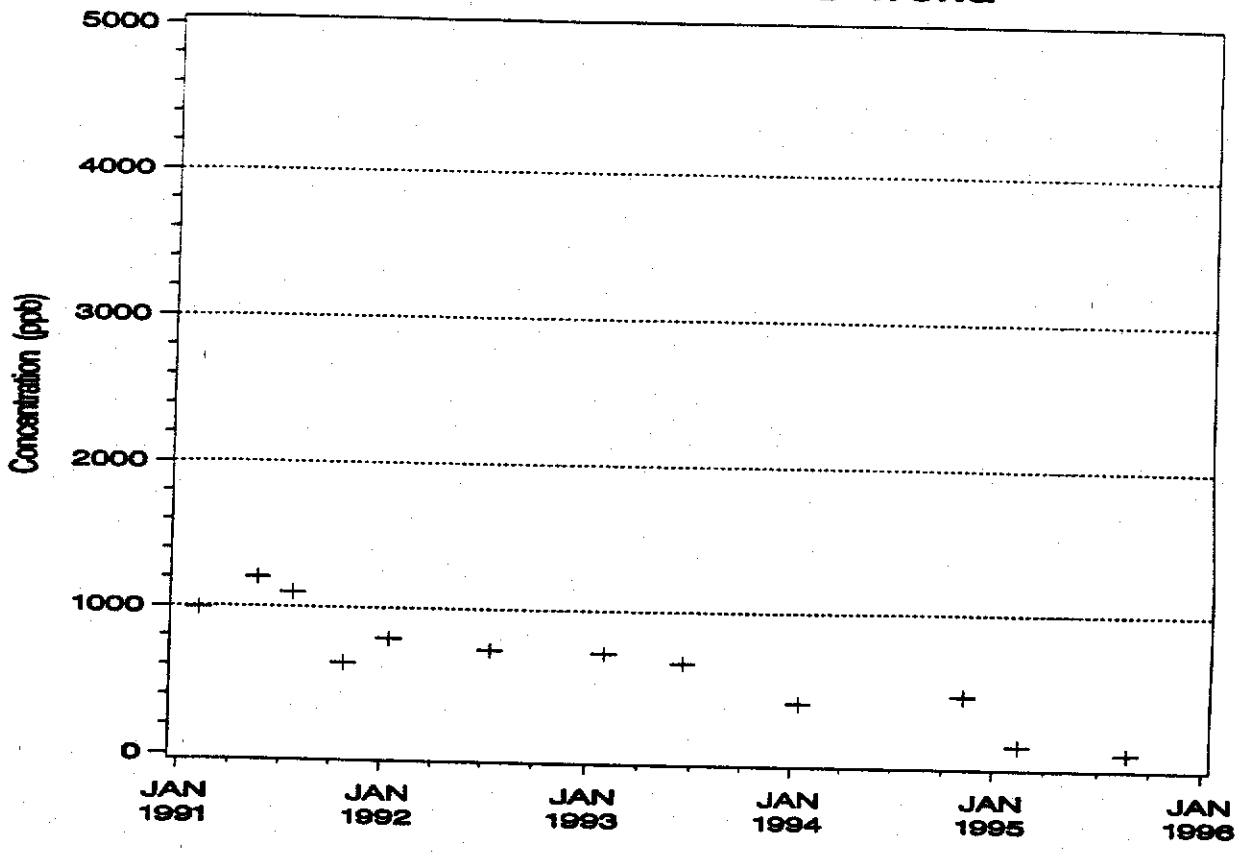
WELL 1384
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



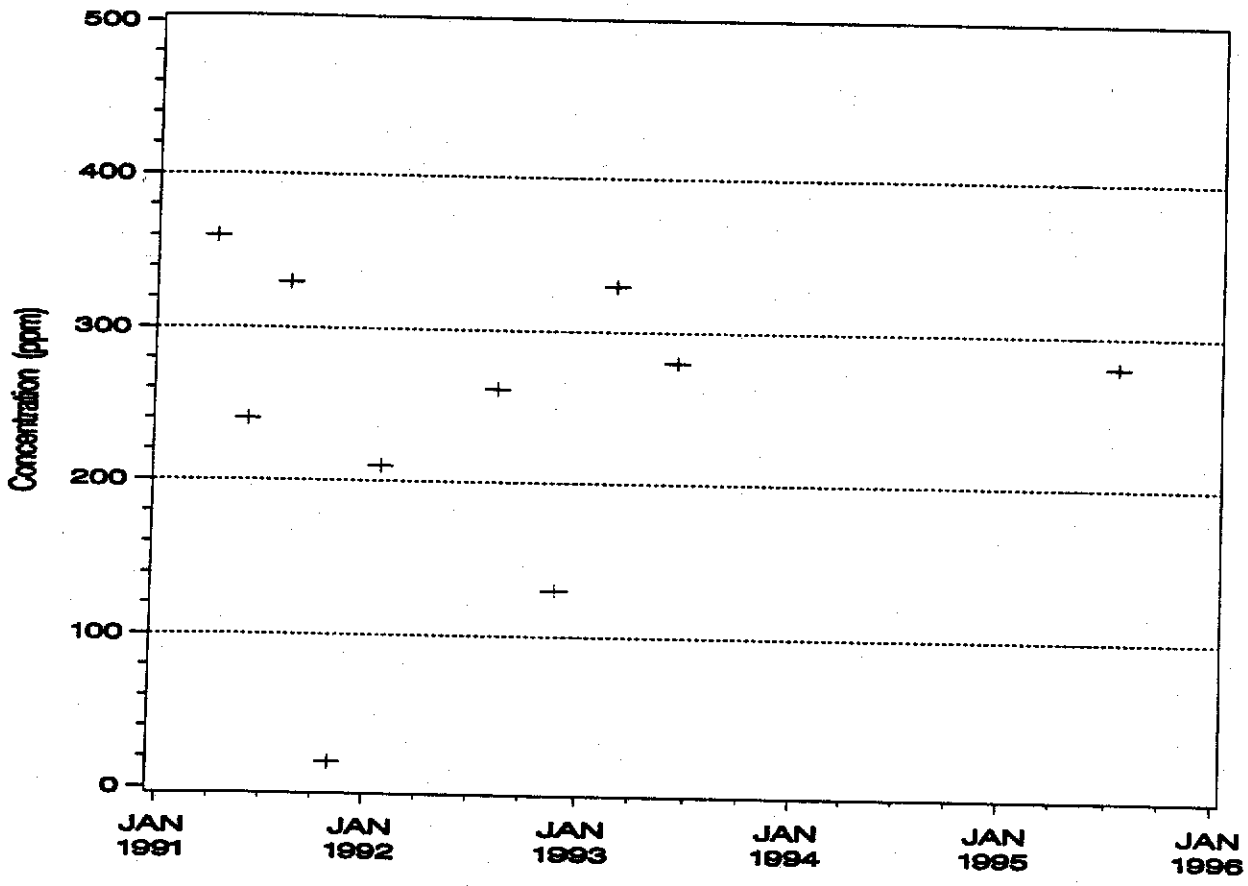
1,1 – DICHLOROETHYLENE Trend



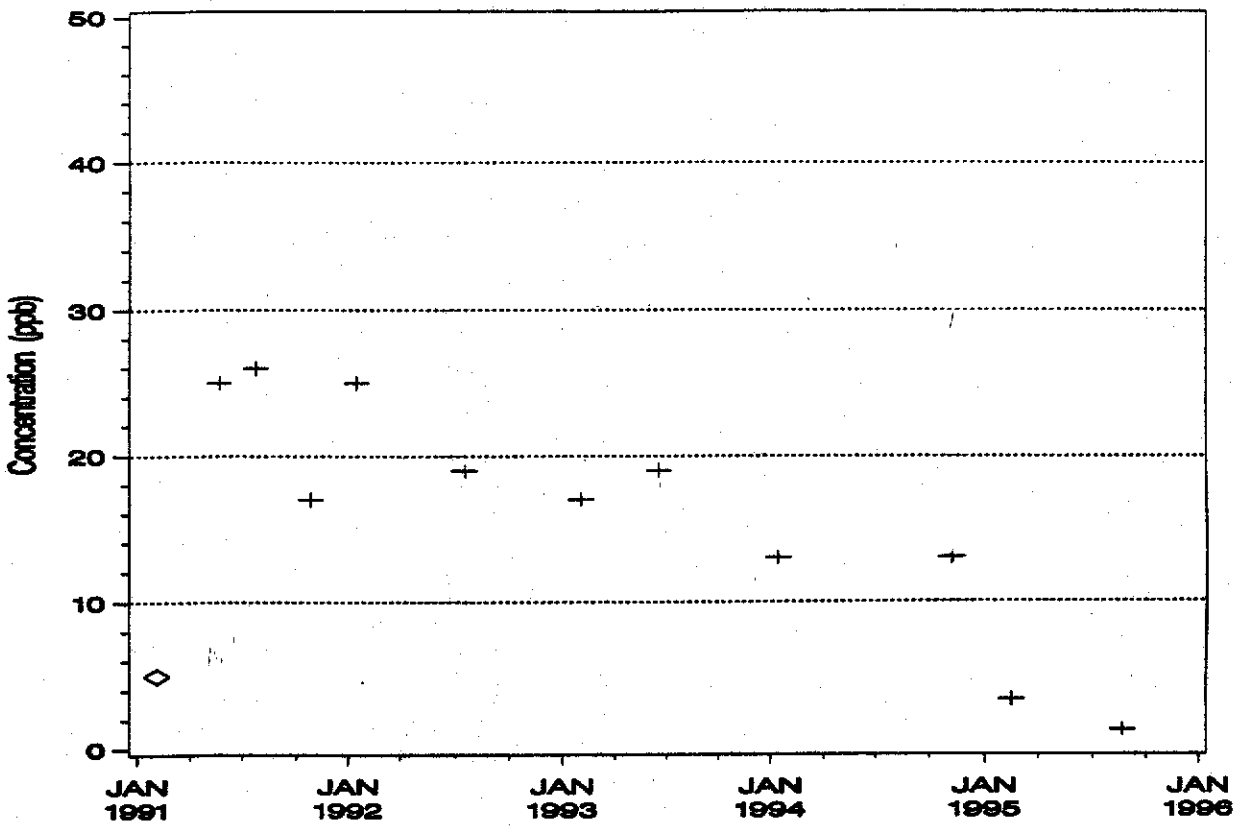
WELL 1385
TRICHLOROETHYLENE Trend



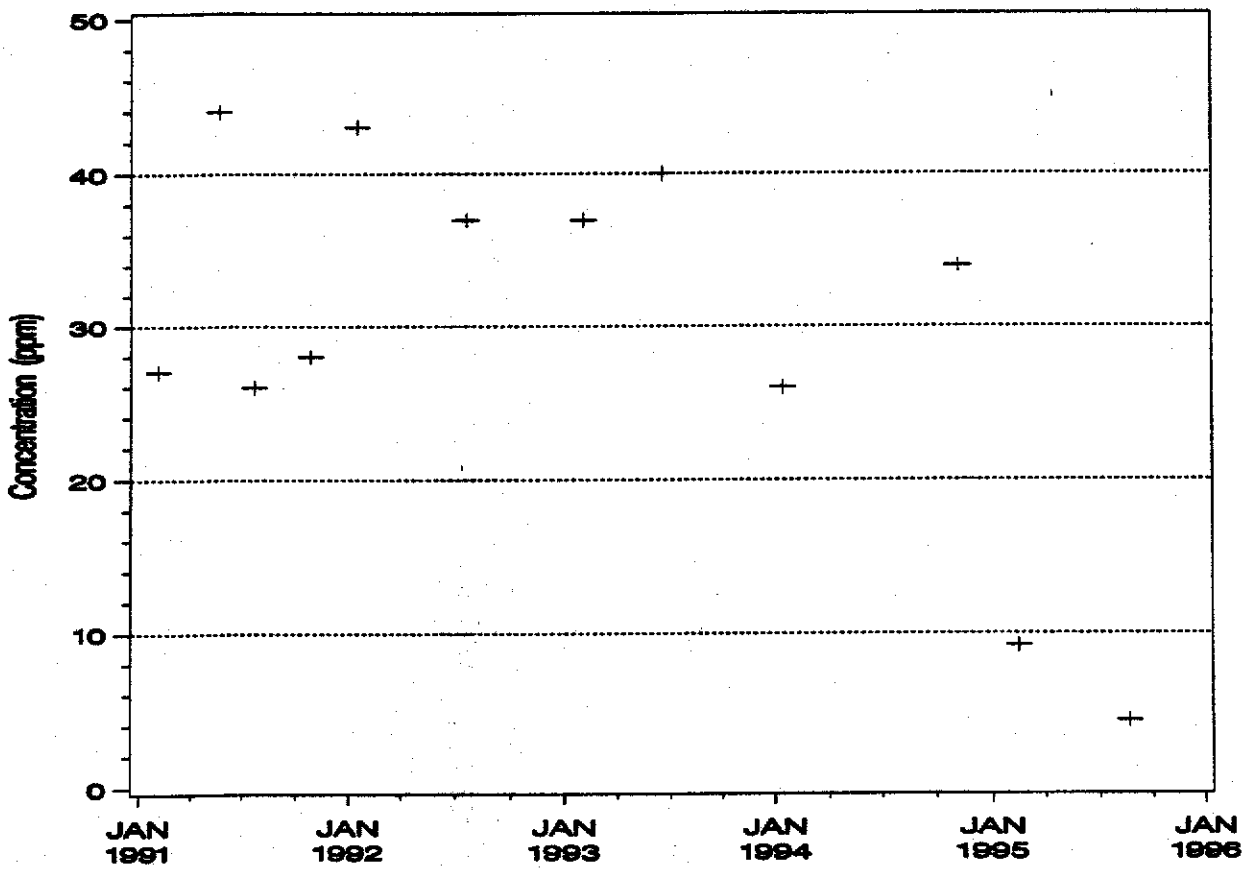
FREON 113 Trend



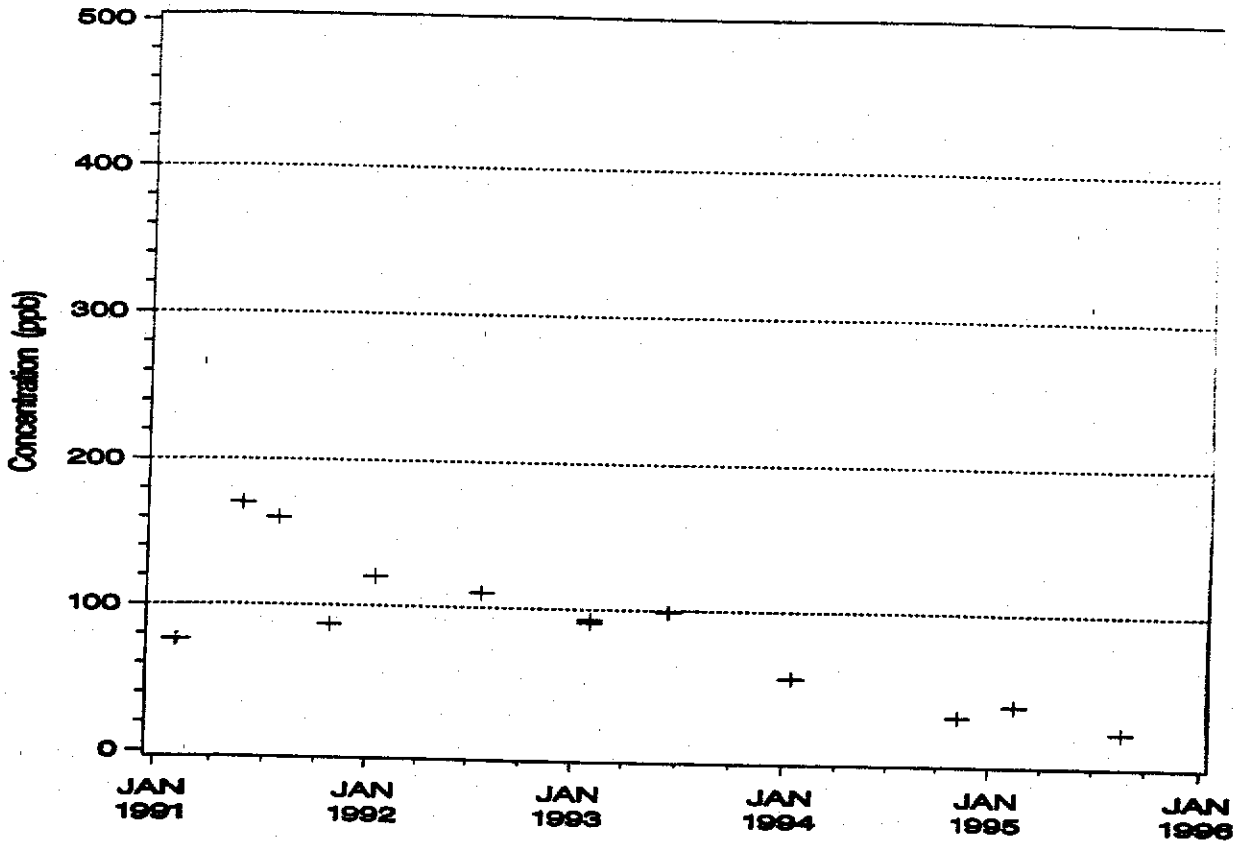
WELL 1385
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



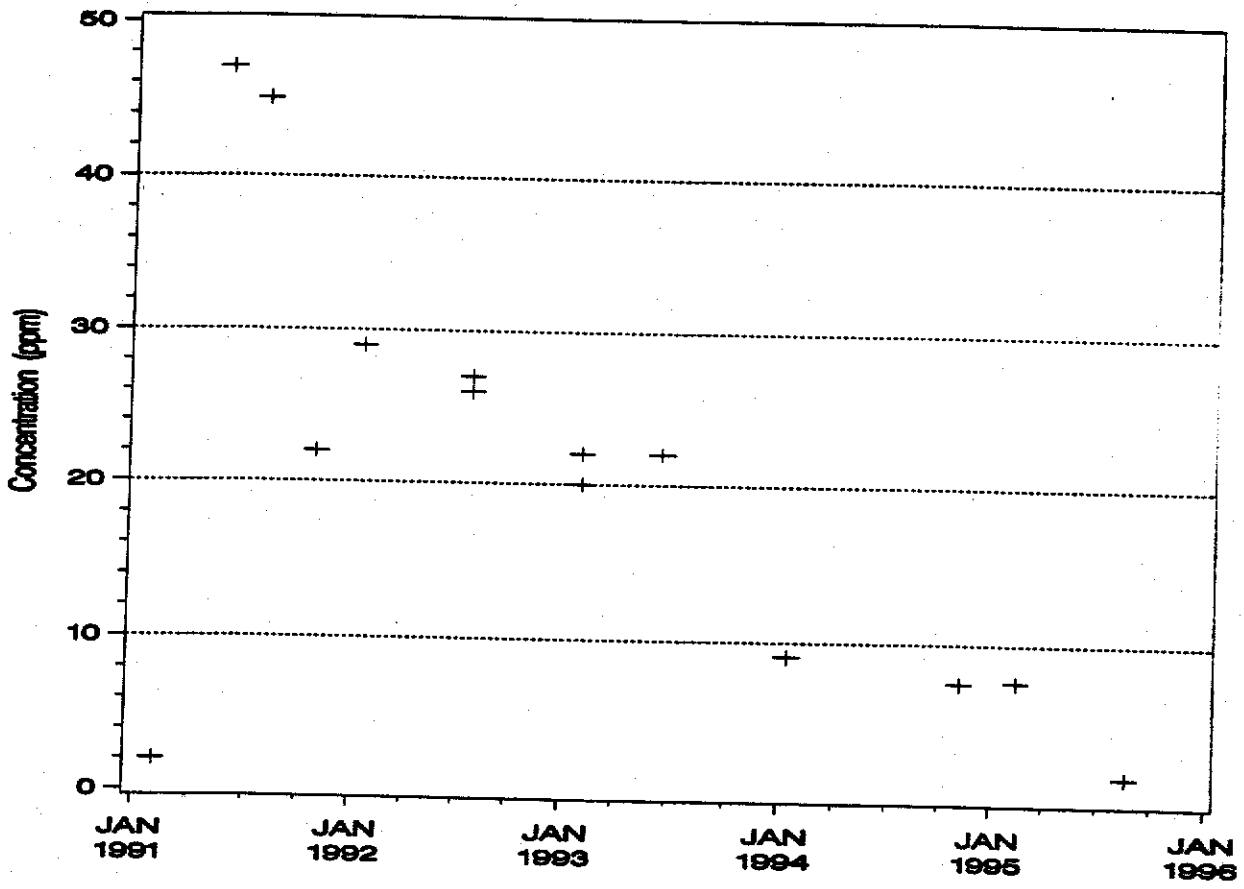
1,1 – DICHLOROETHYLENE Trend



WELL 1386
TRICHLOROETHYLENE Trend

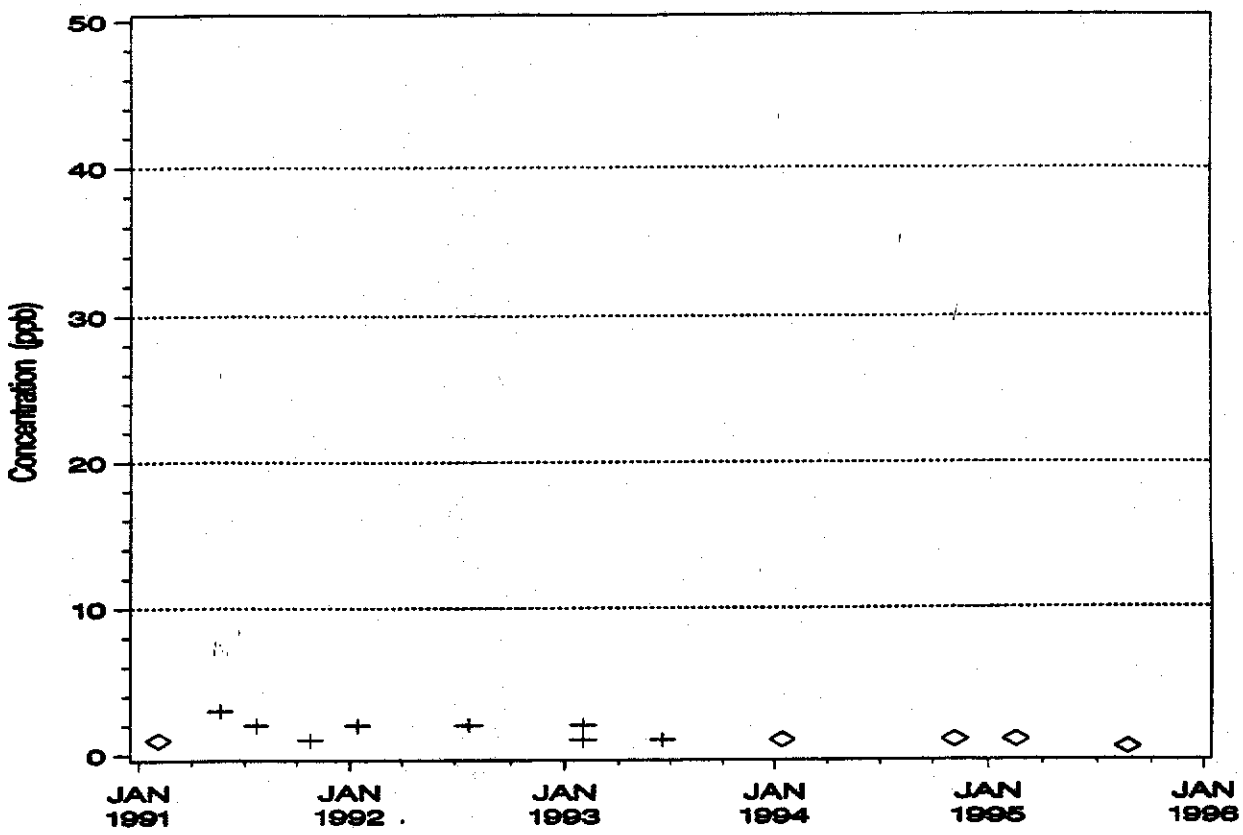


FREON 113 Trend

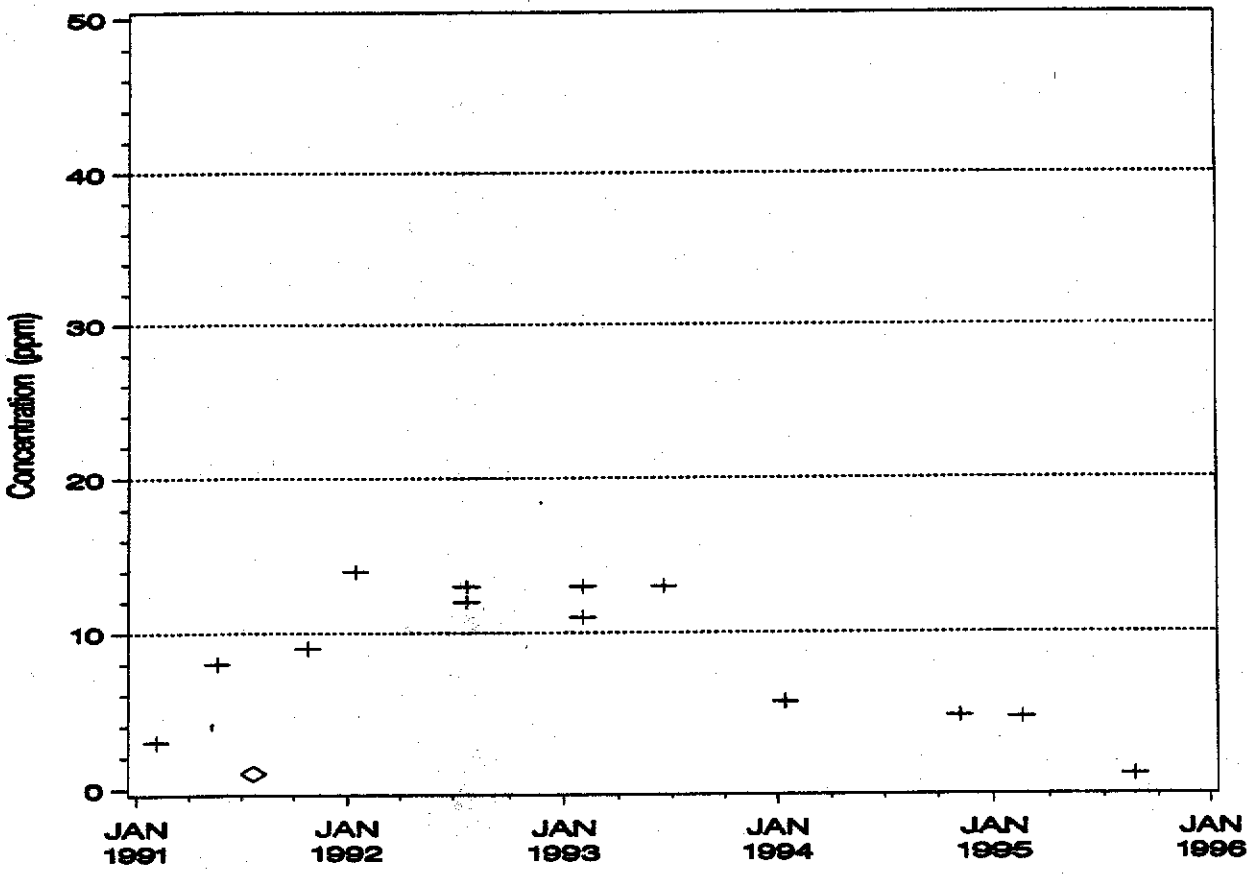


WELL 1386

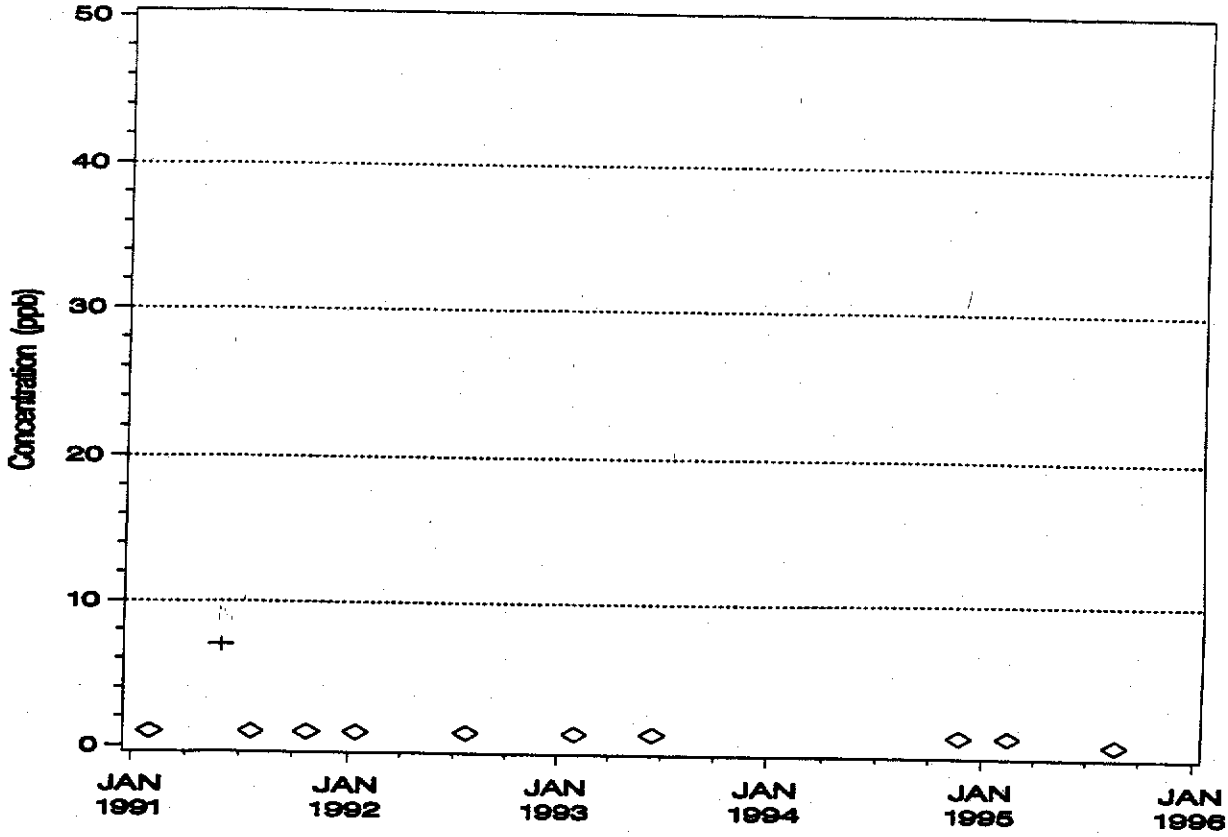
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



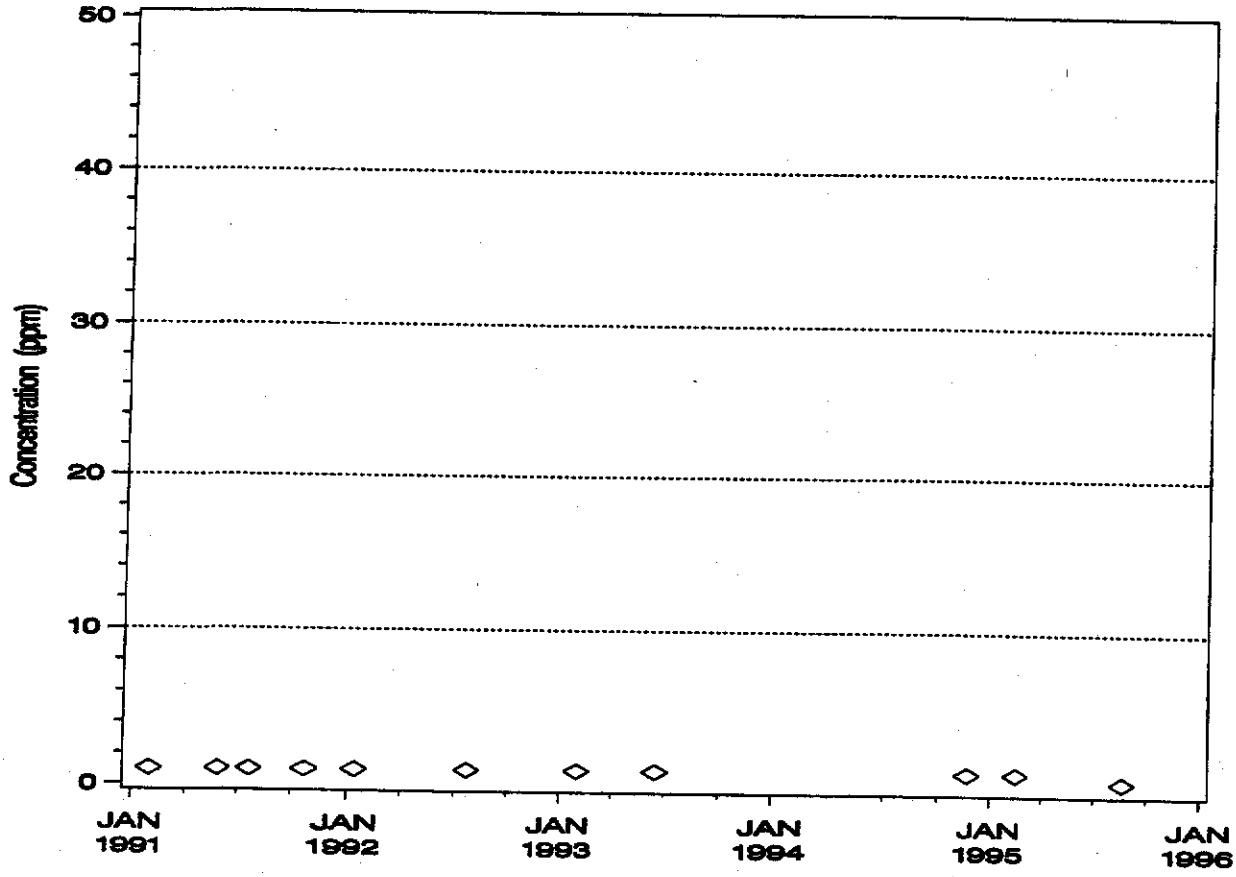
1,1 – DICHLOROETHYLENE Trend



WELL 1387
TRICHLOROETHYLENE Trend

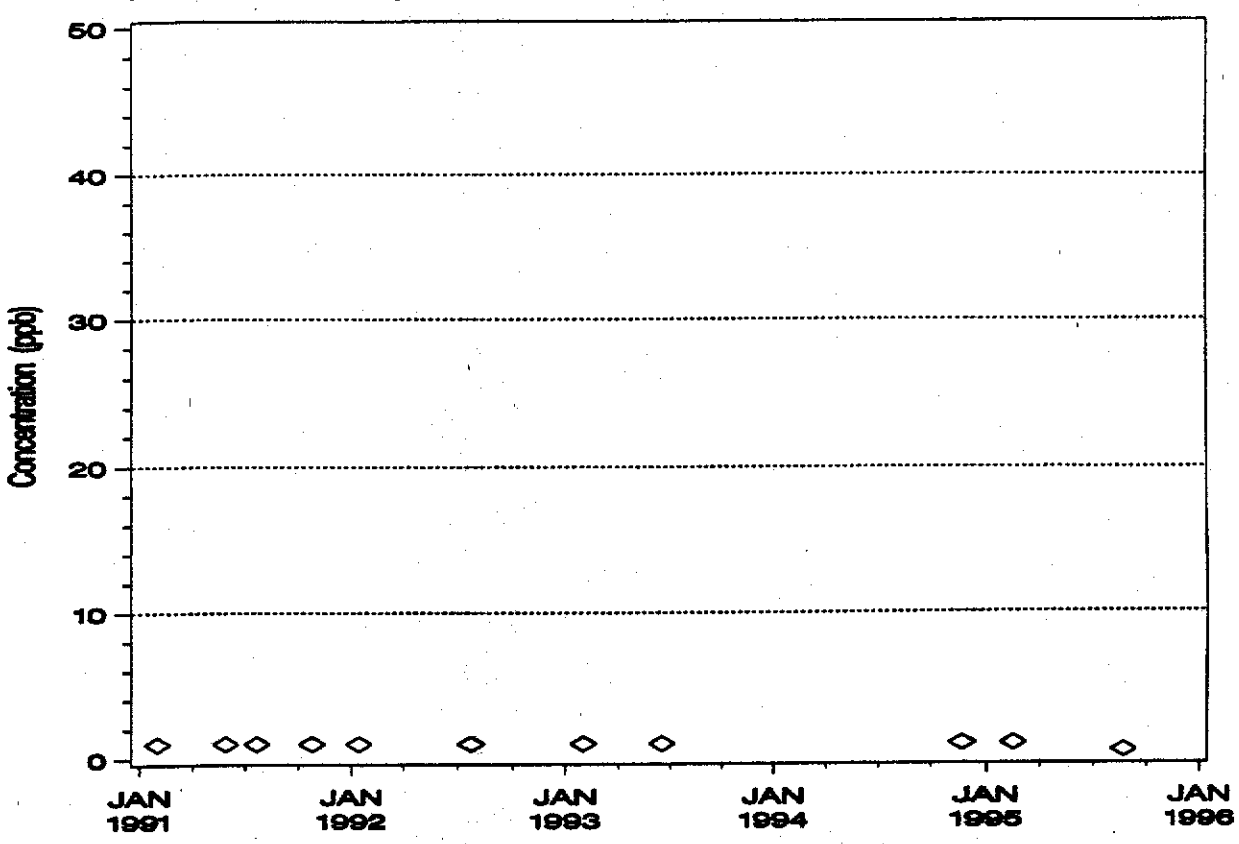


FREON 113 Trend

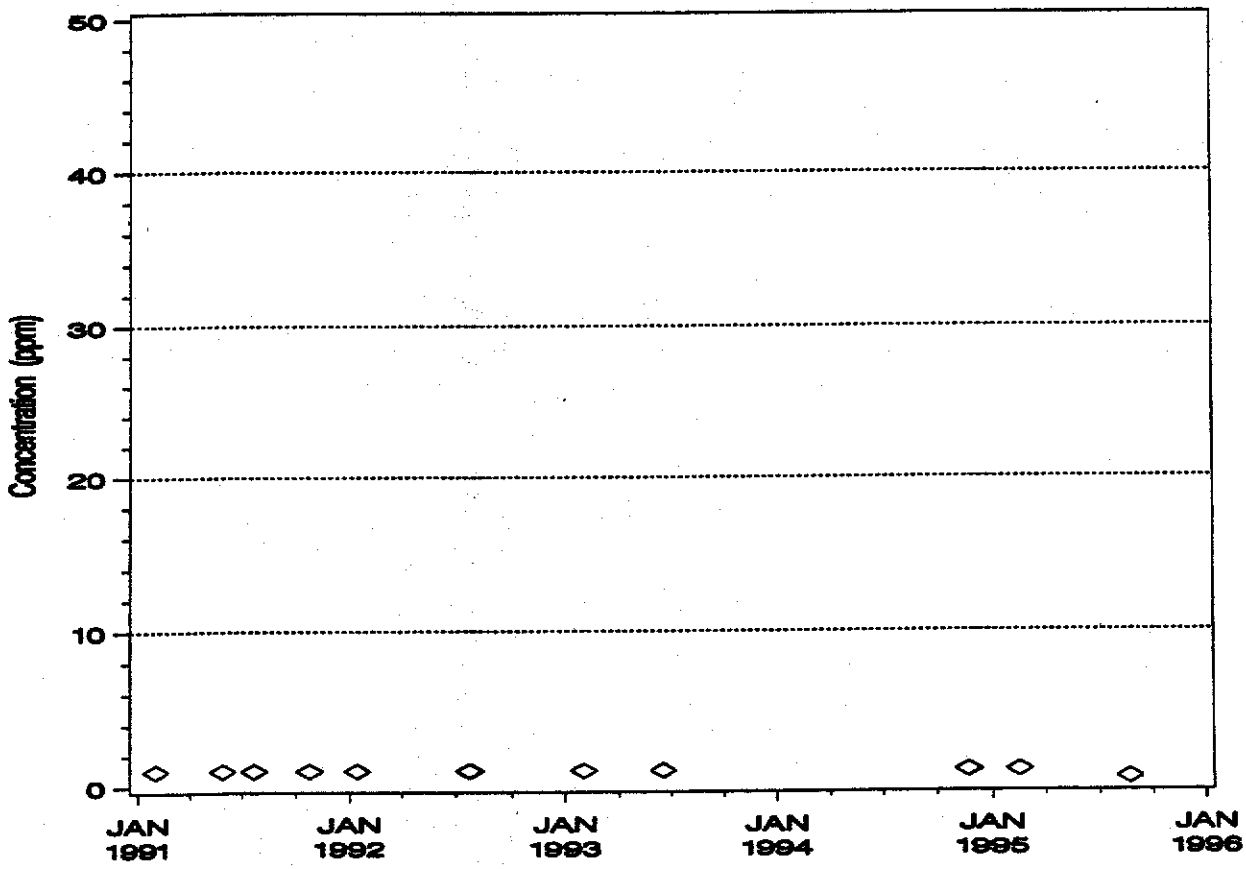


WELL 1387

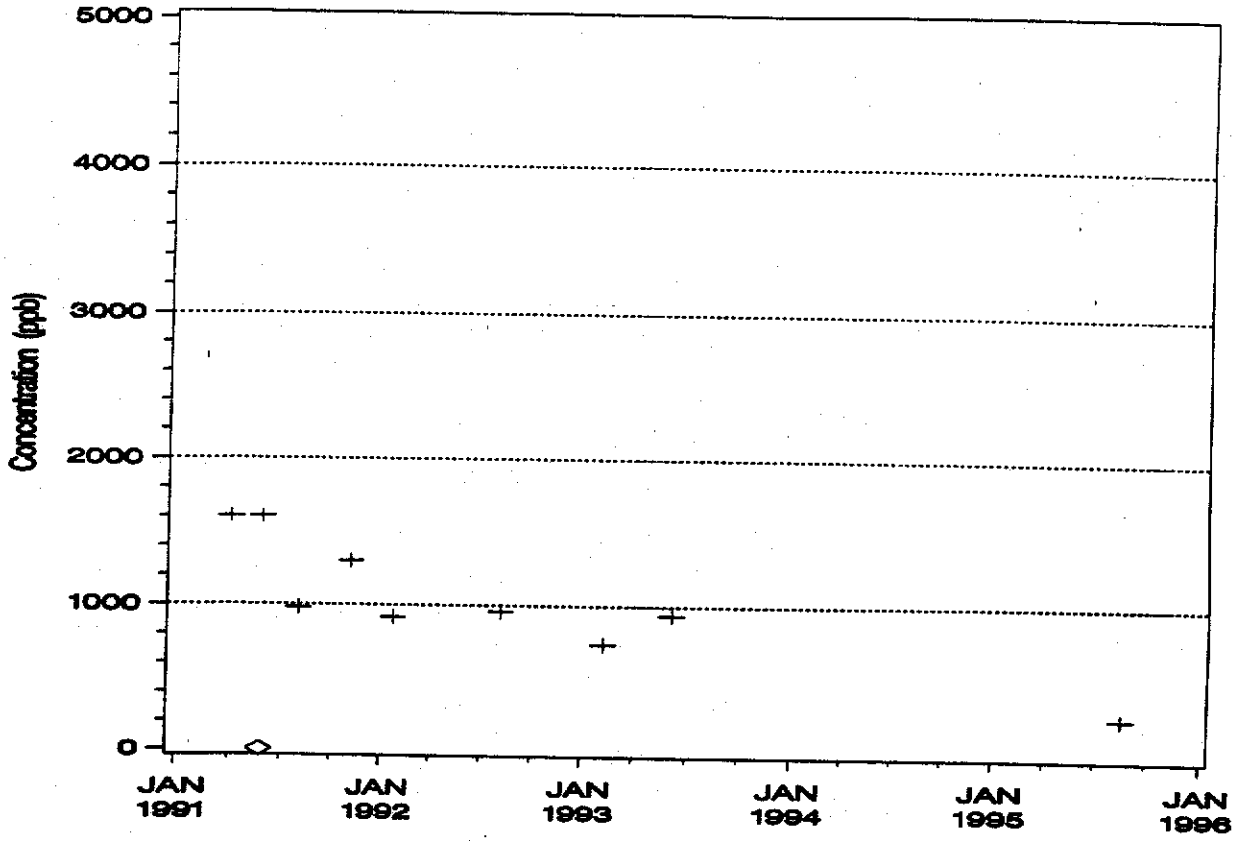
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



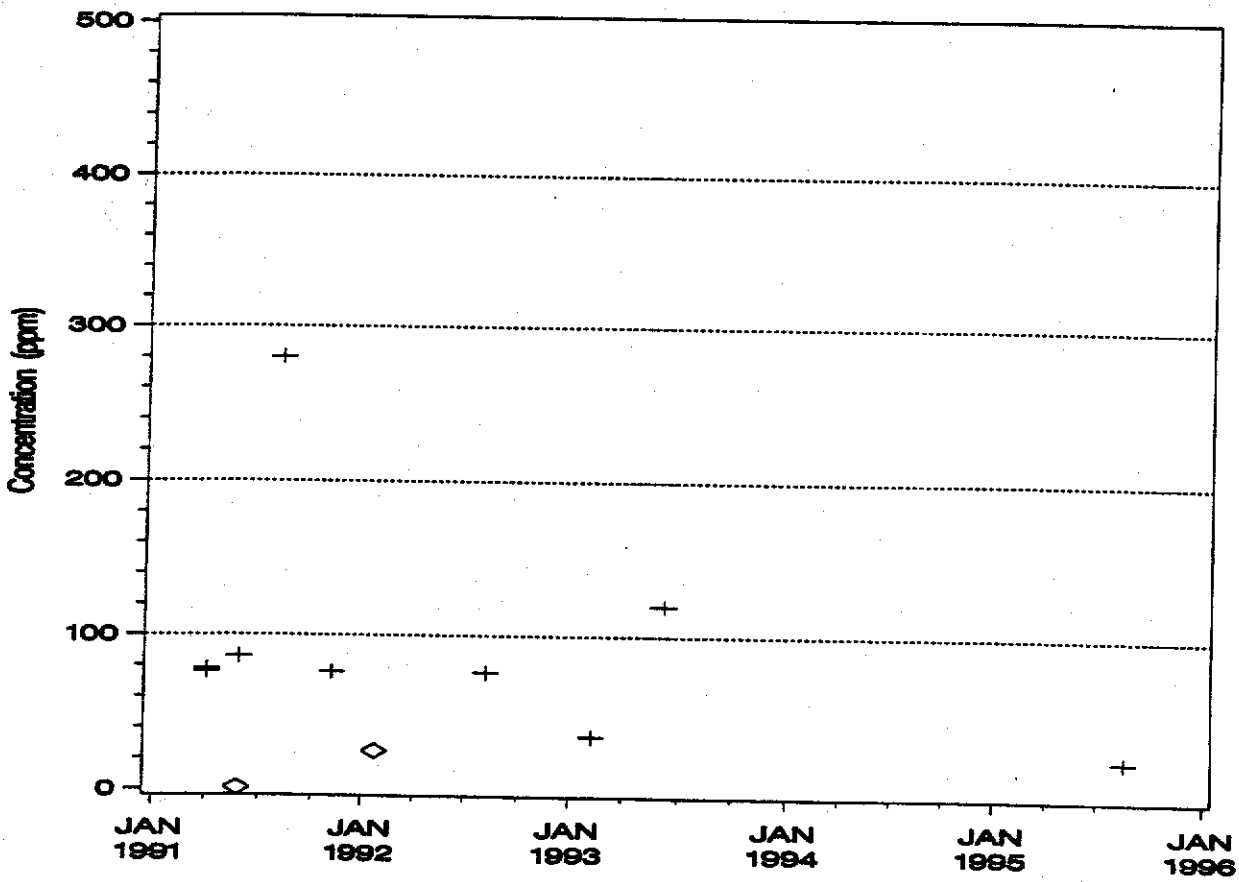
1,1 – DICHLOROETHYLENE Trend



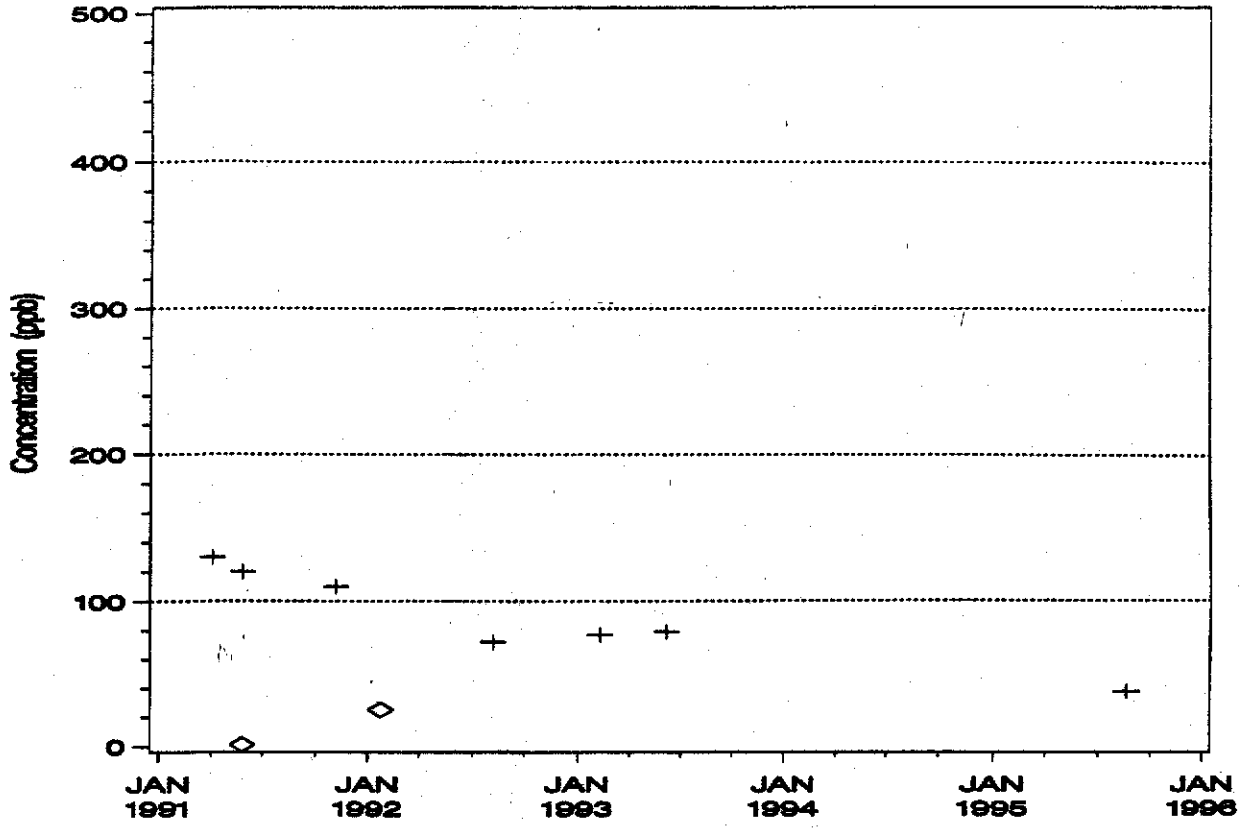
WELL 1388
TRICHLOROETHYLENE Trend



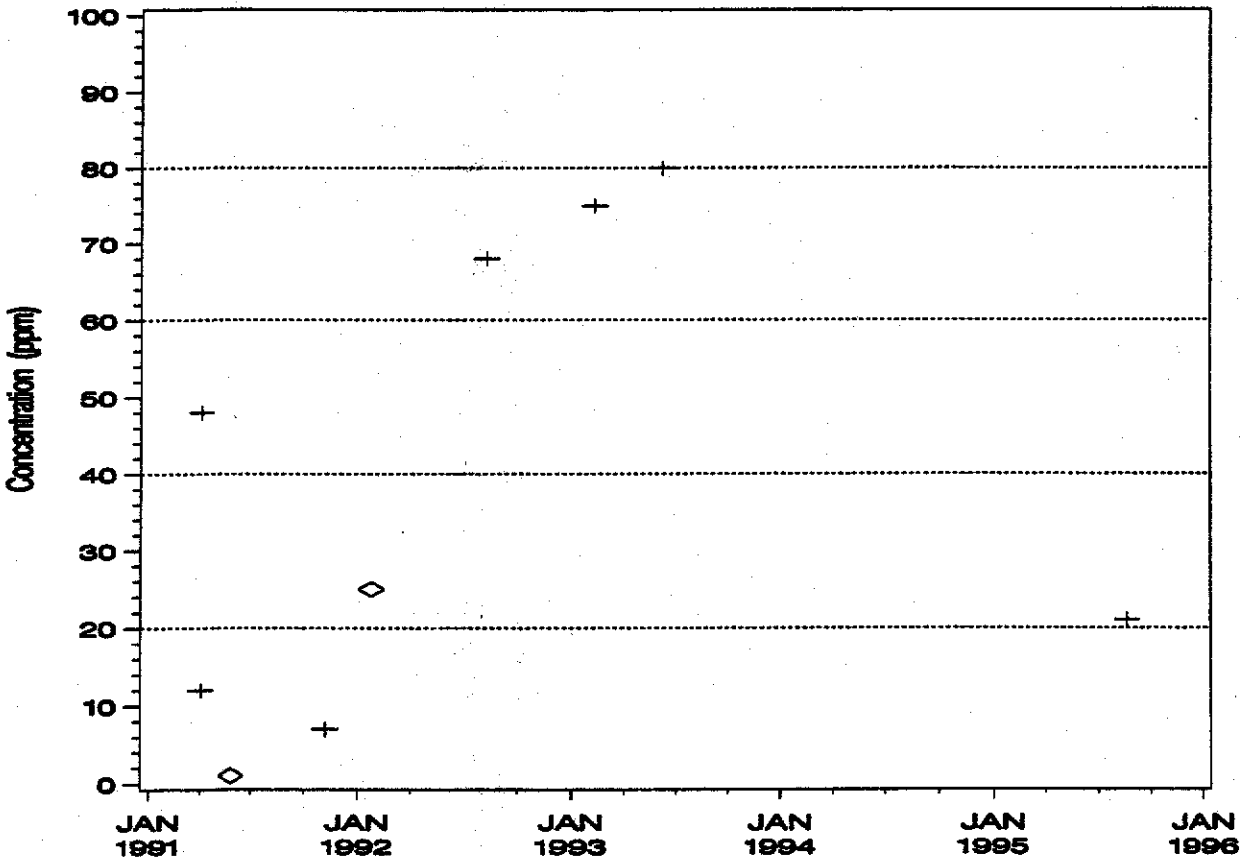
FREON 113 Trend



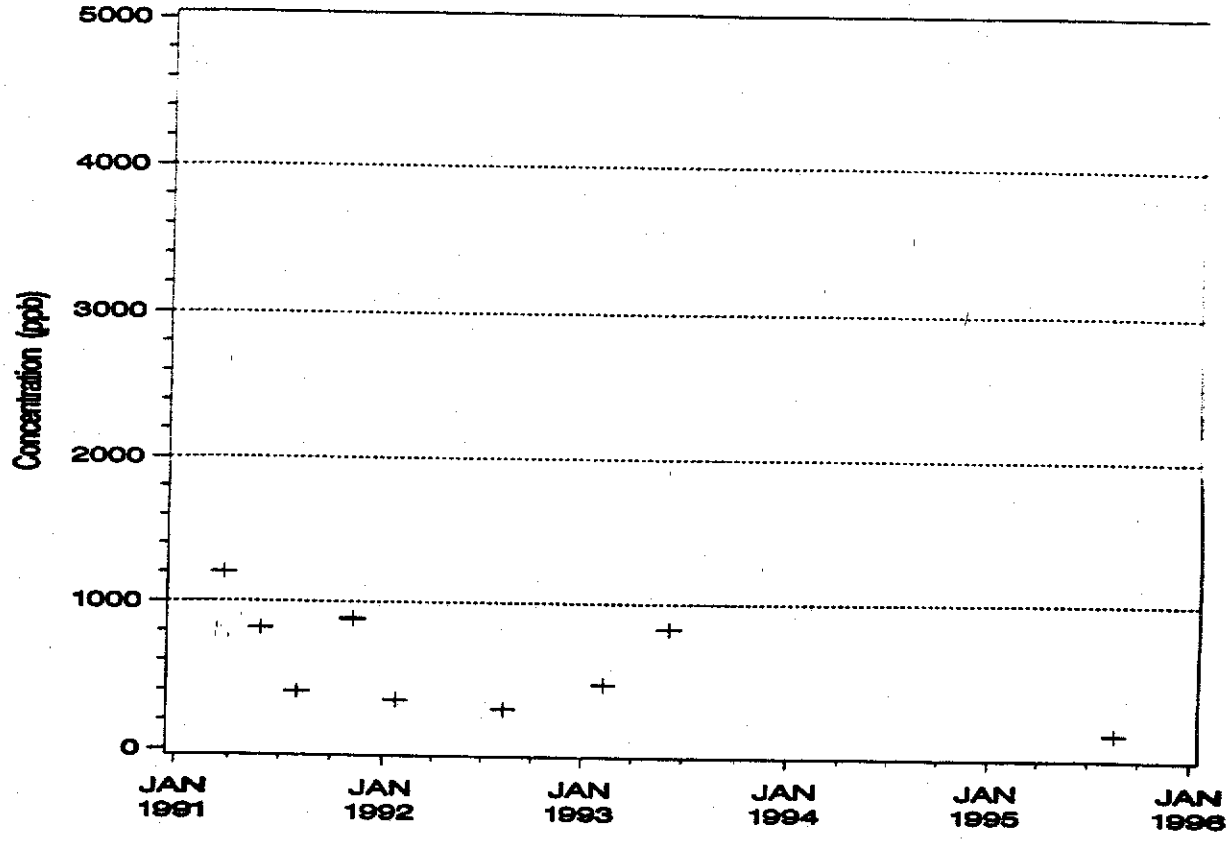
WELL 1388
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



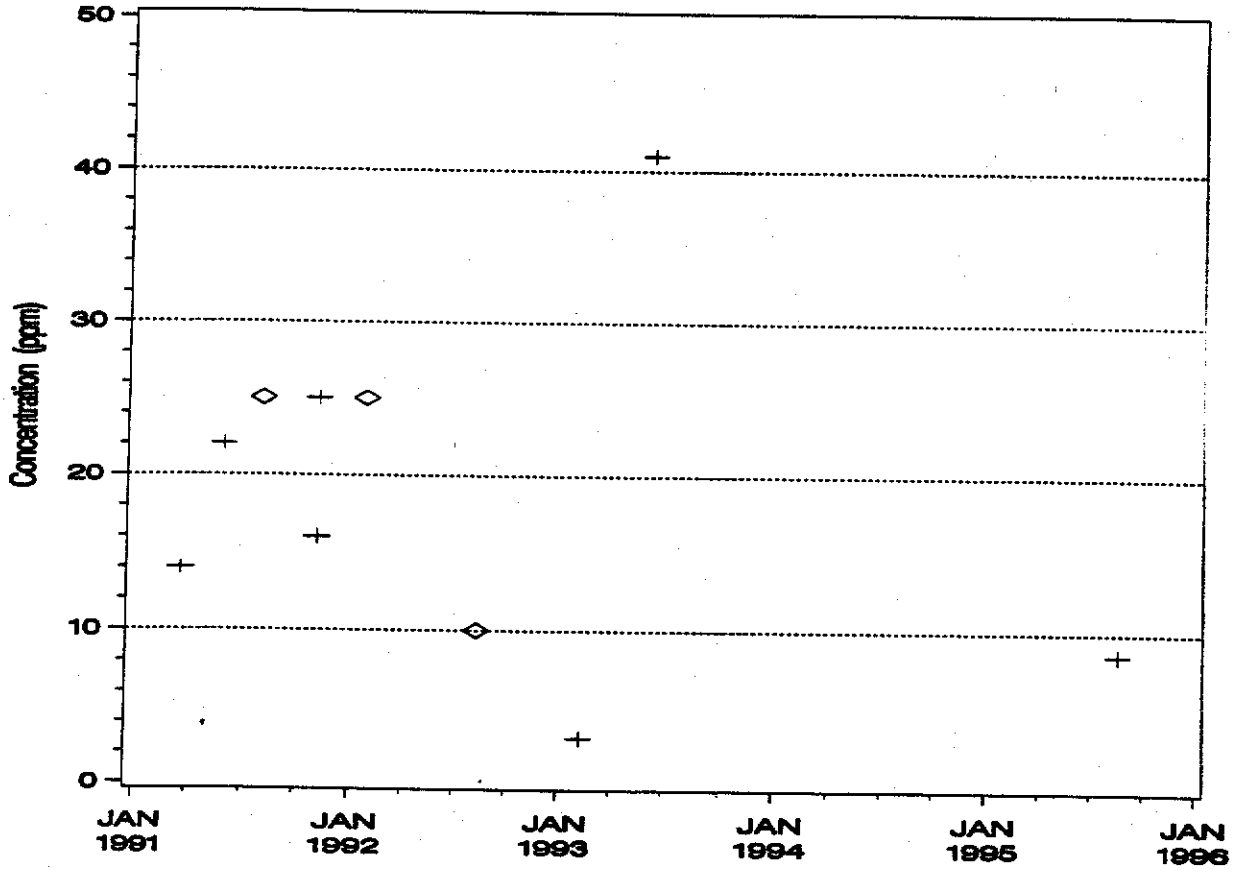
1,1 – DICHLOROETHYLENE Trend



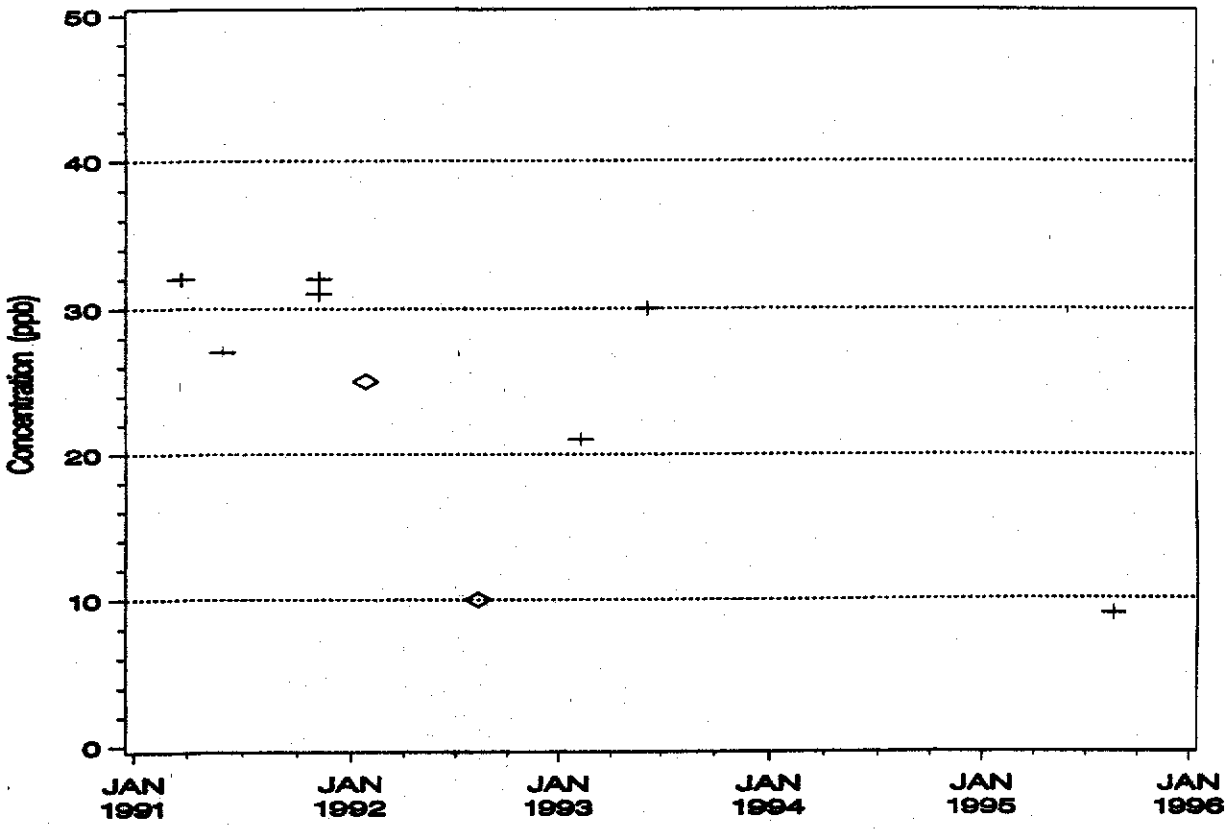
WELL 1389
TRICHLOROETHYLENE Trend



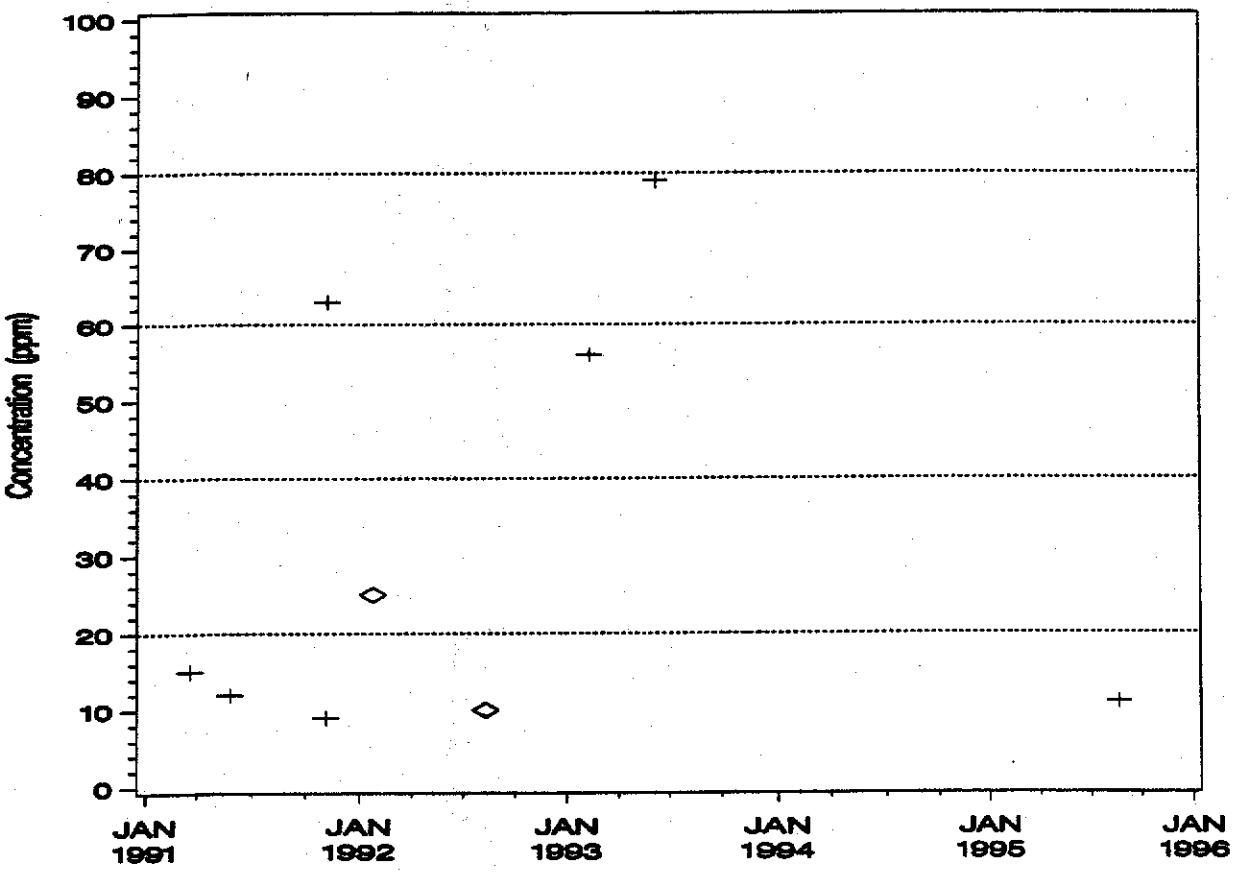
FREON 113 Trend



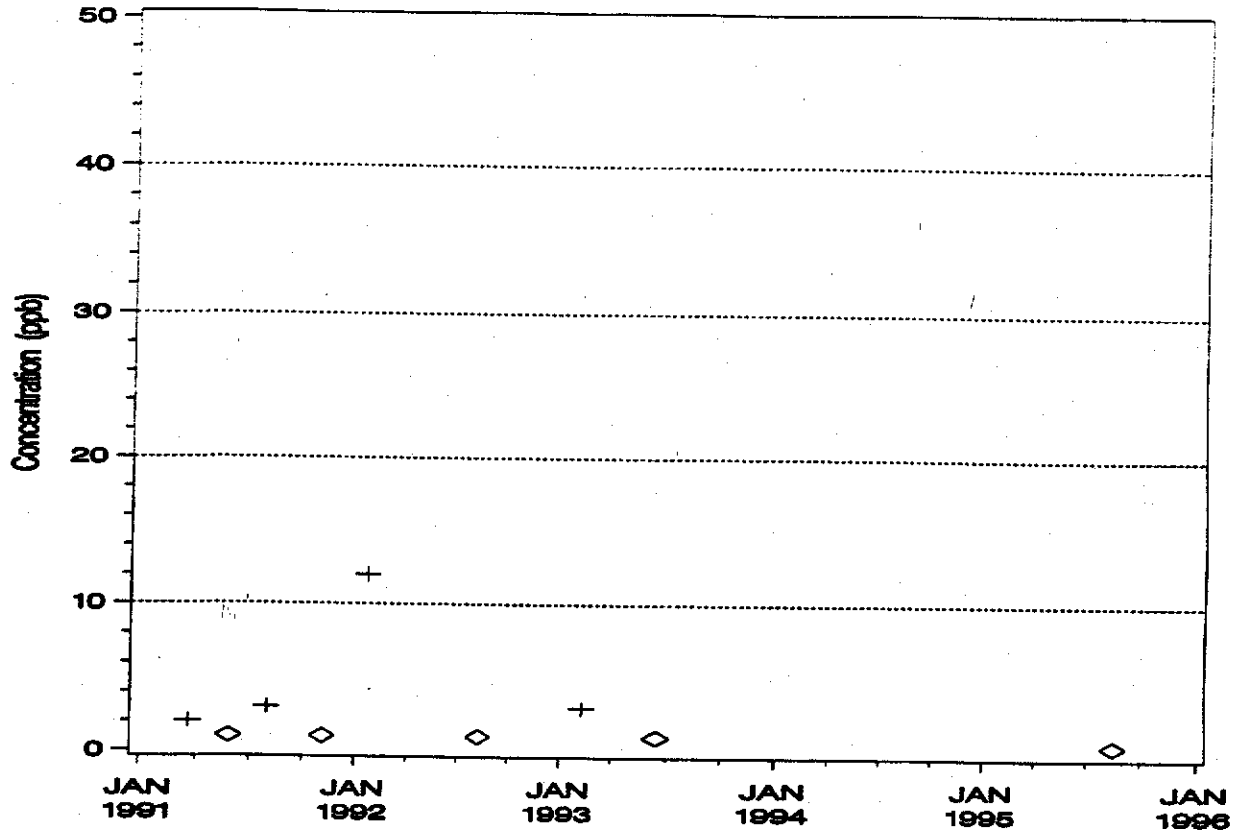
WELL 1389
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



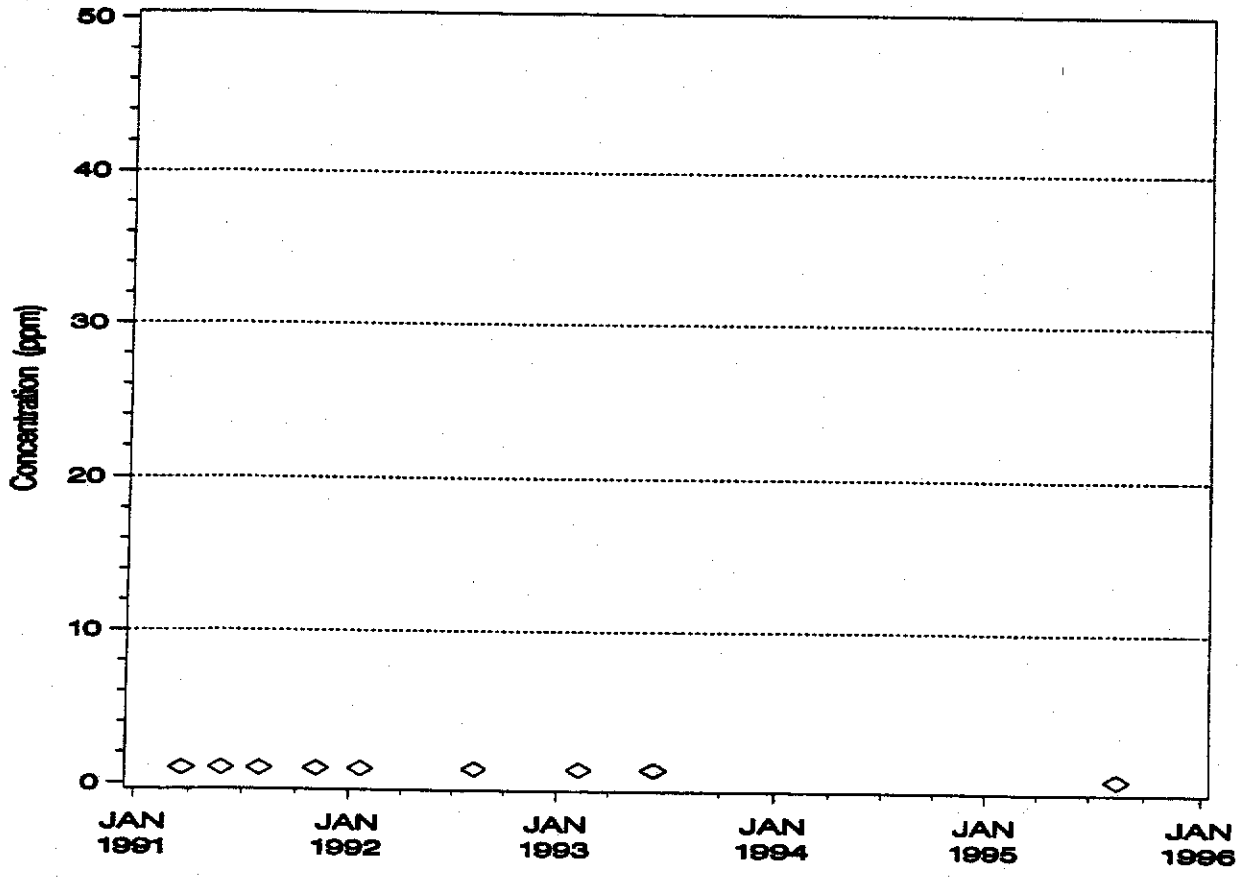
1,1 – DICHLOROETHYLENE Trend



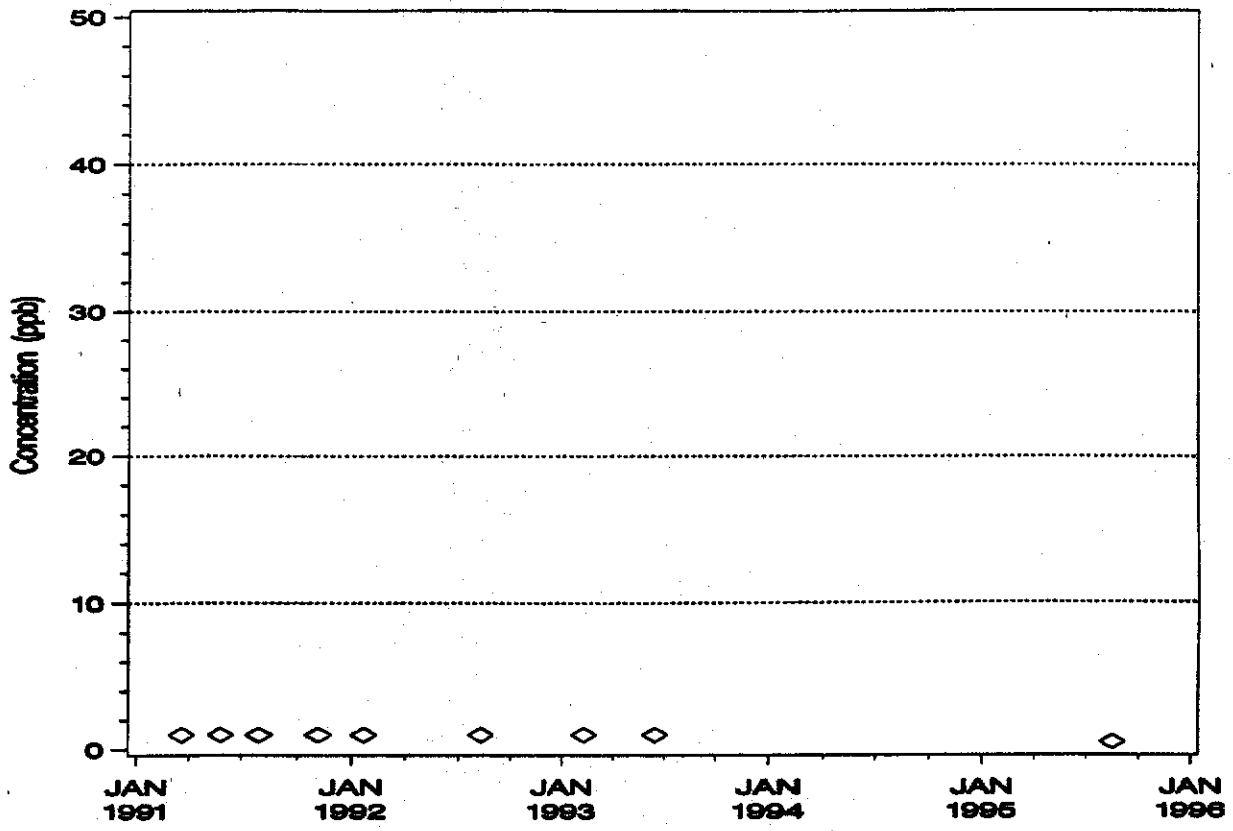
WELL 1390
TRICHLOROETHYLENE Trend



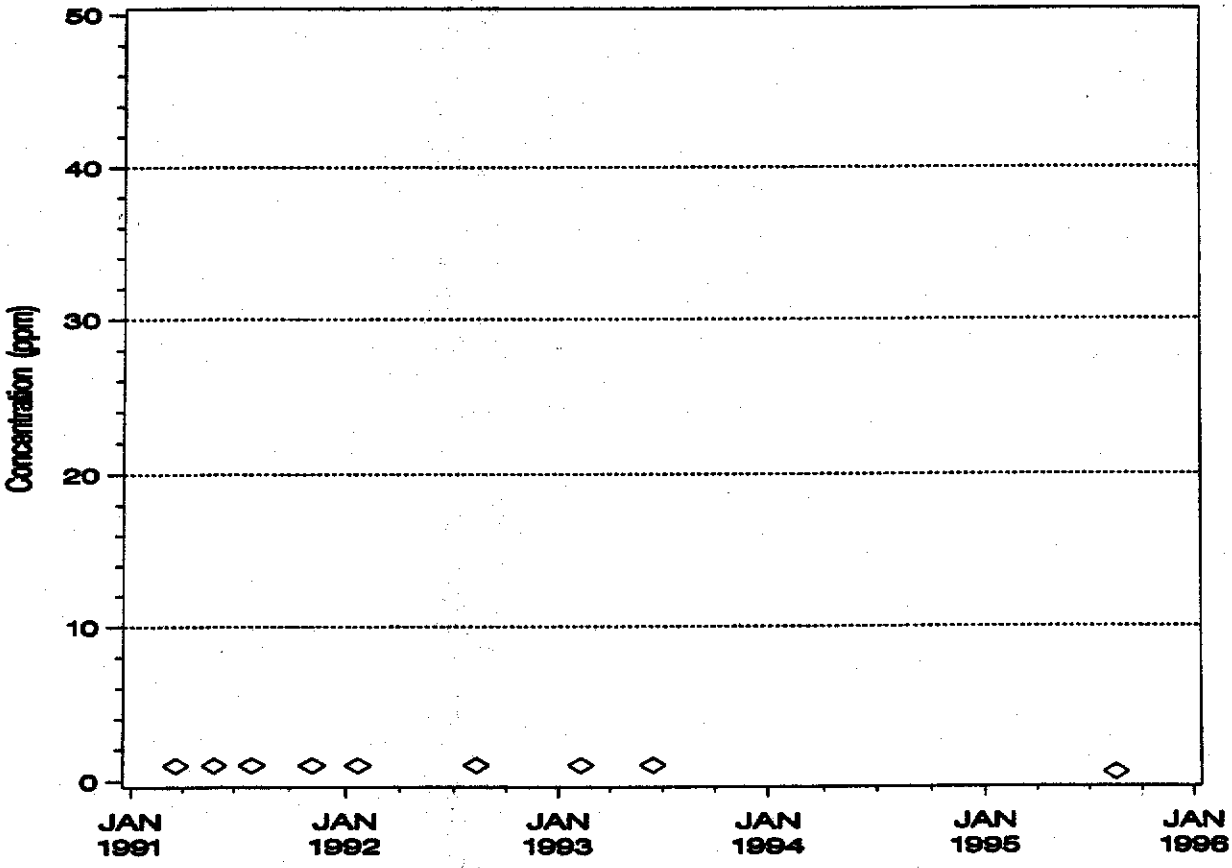
FREON 113 Trend



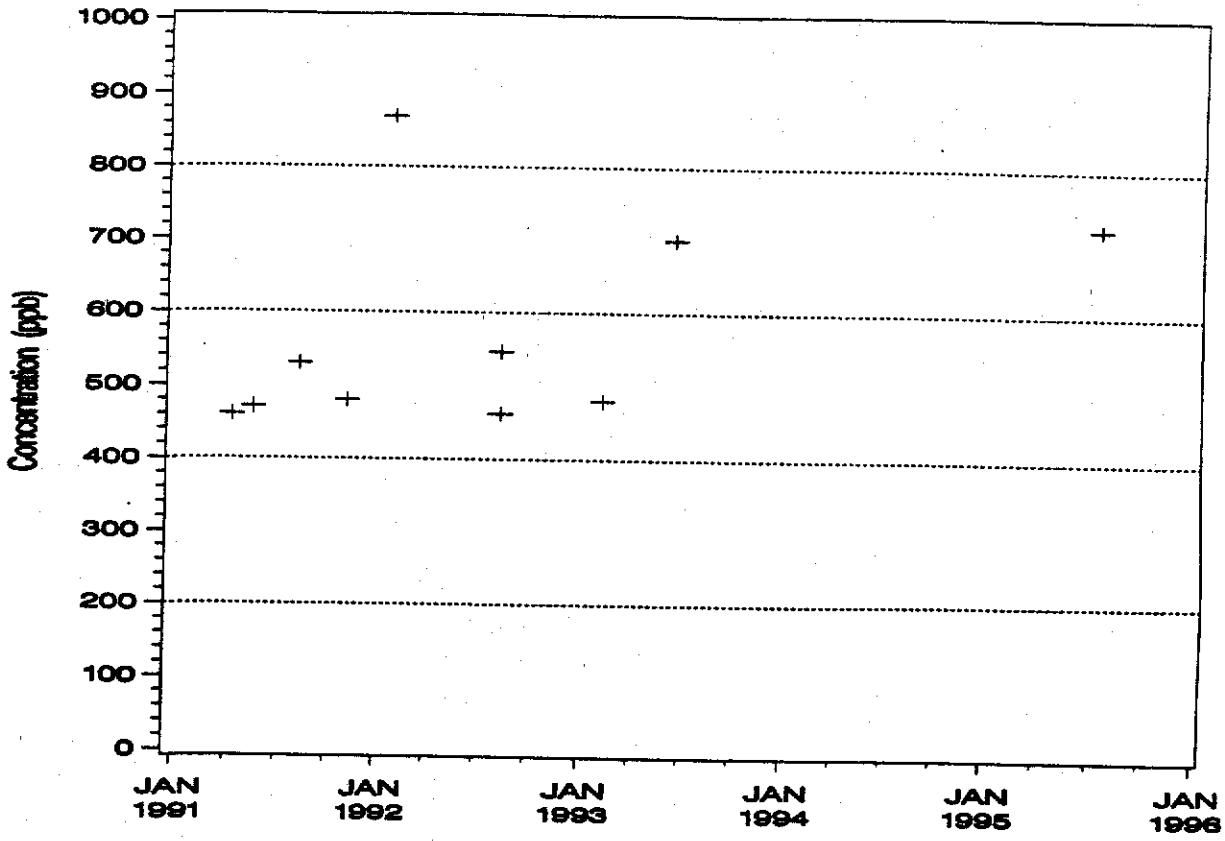
WELL 1390
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



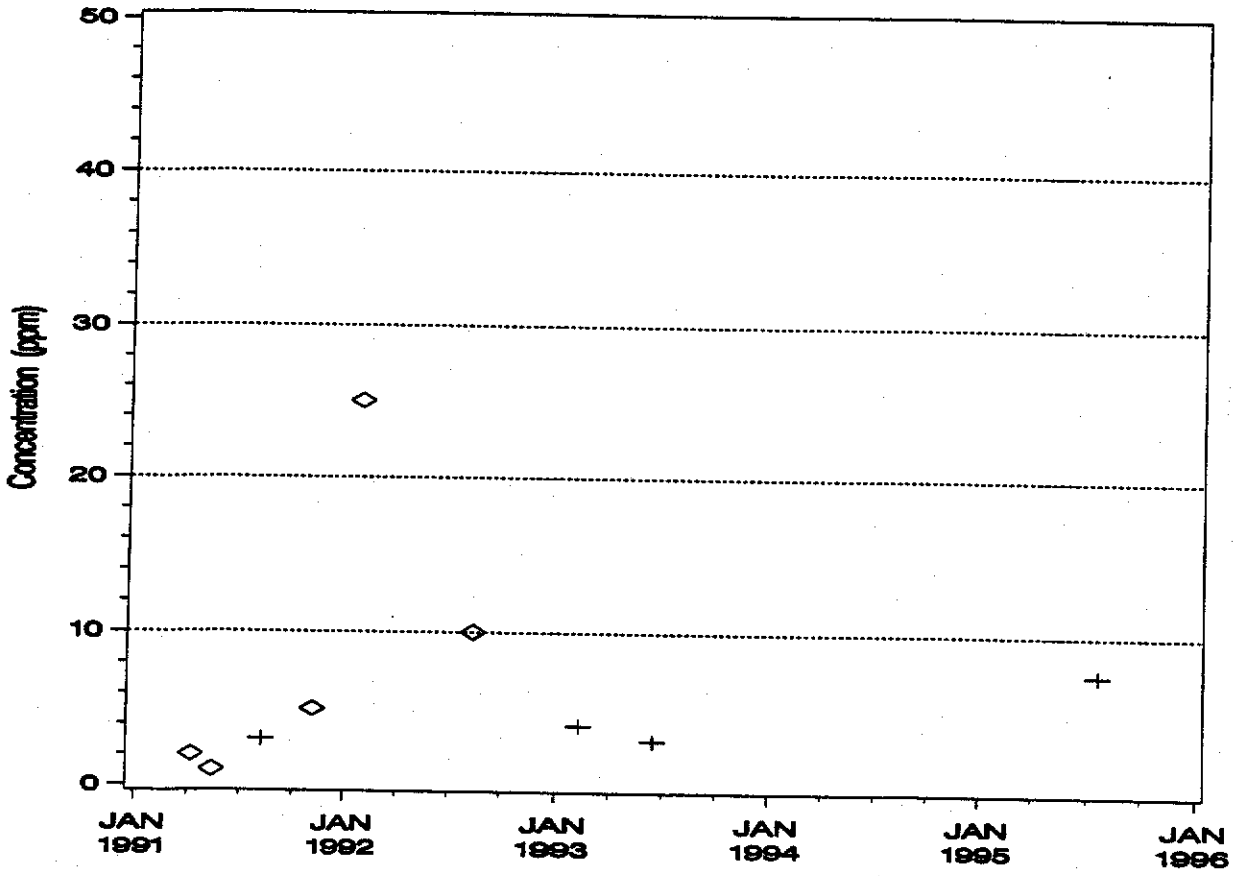
1,1 – DICHLOROETHYLENE Trend



WELL 1391
TRICHLOROETHYLENE Trend

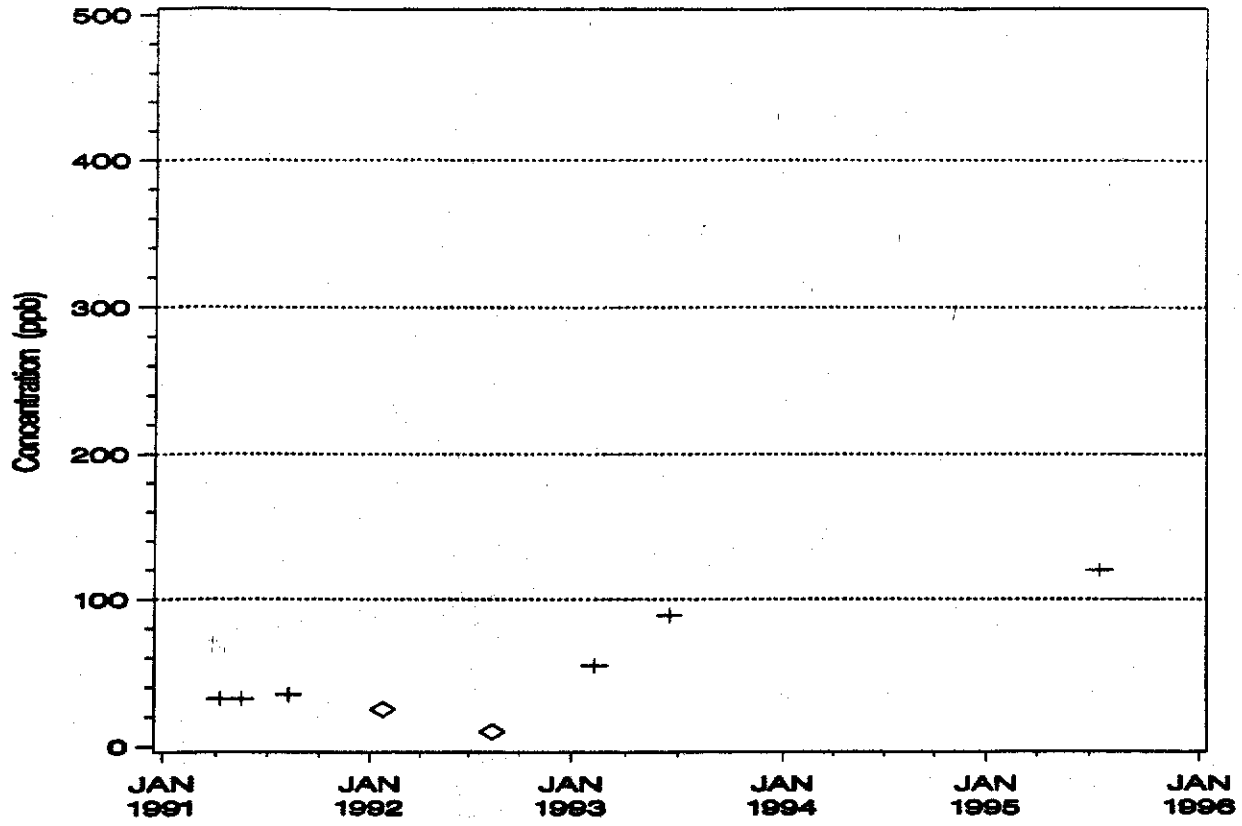


FREON 113 Trend

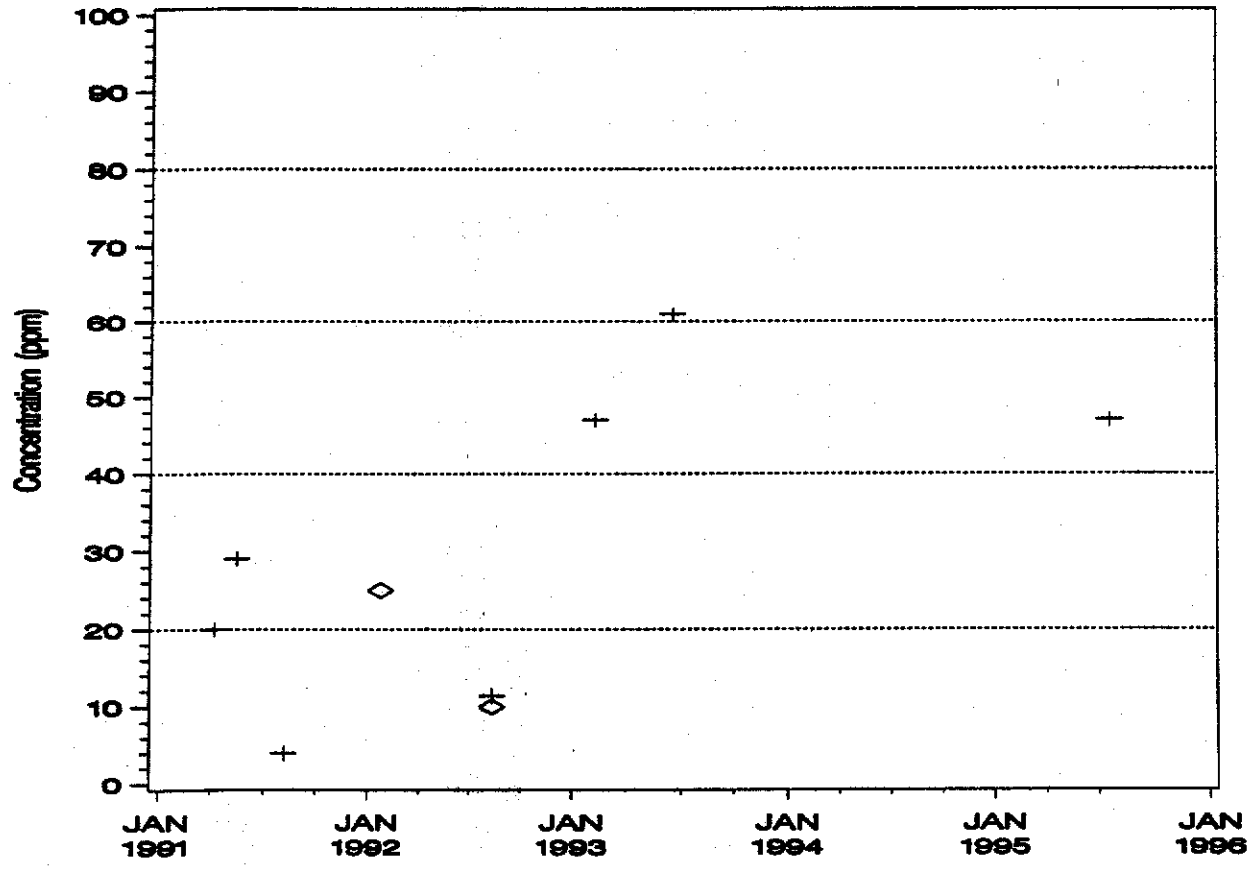


WELL 1391

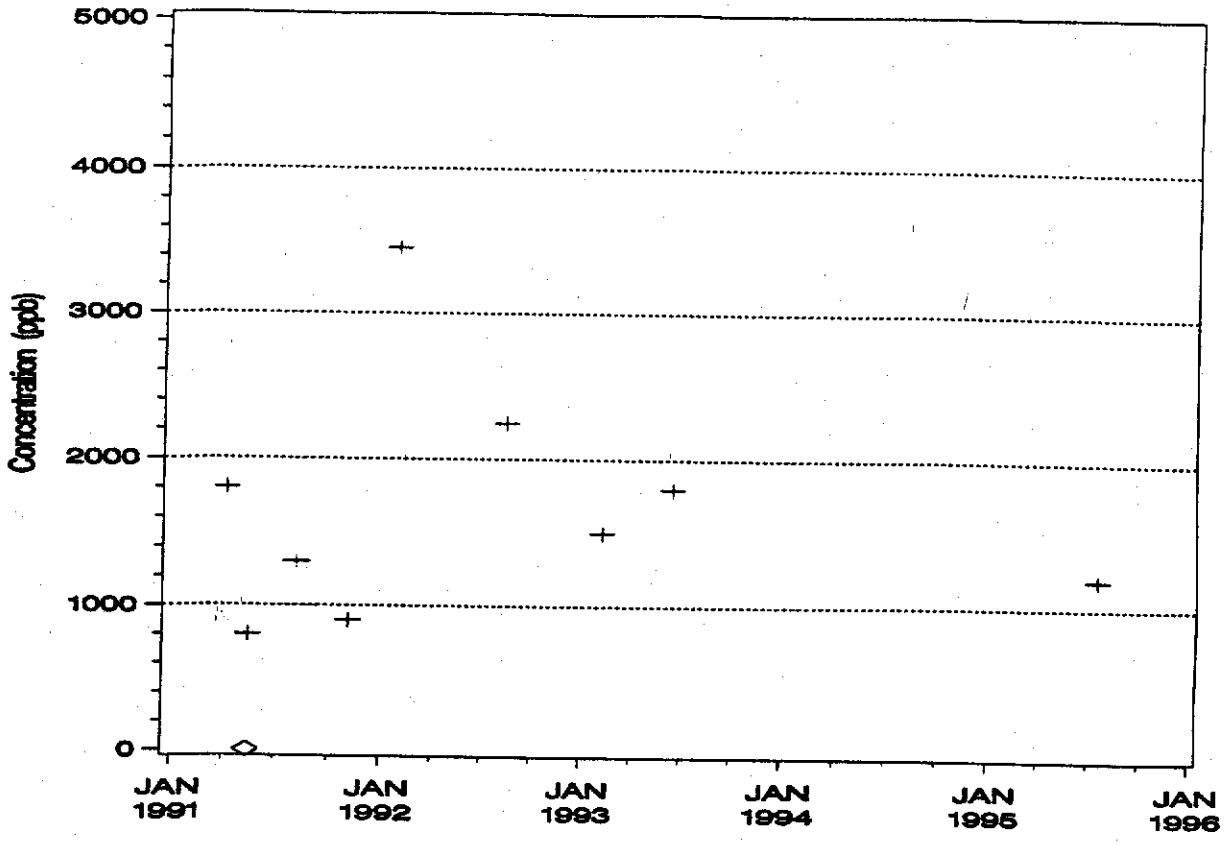
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



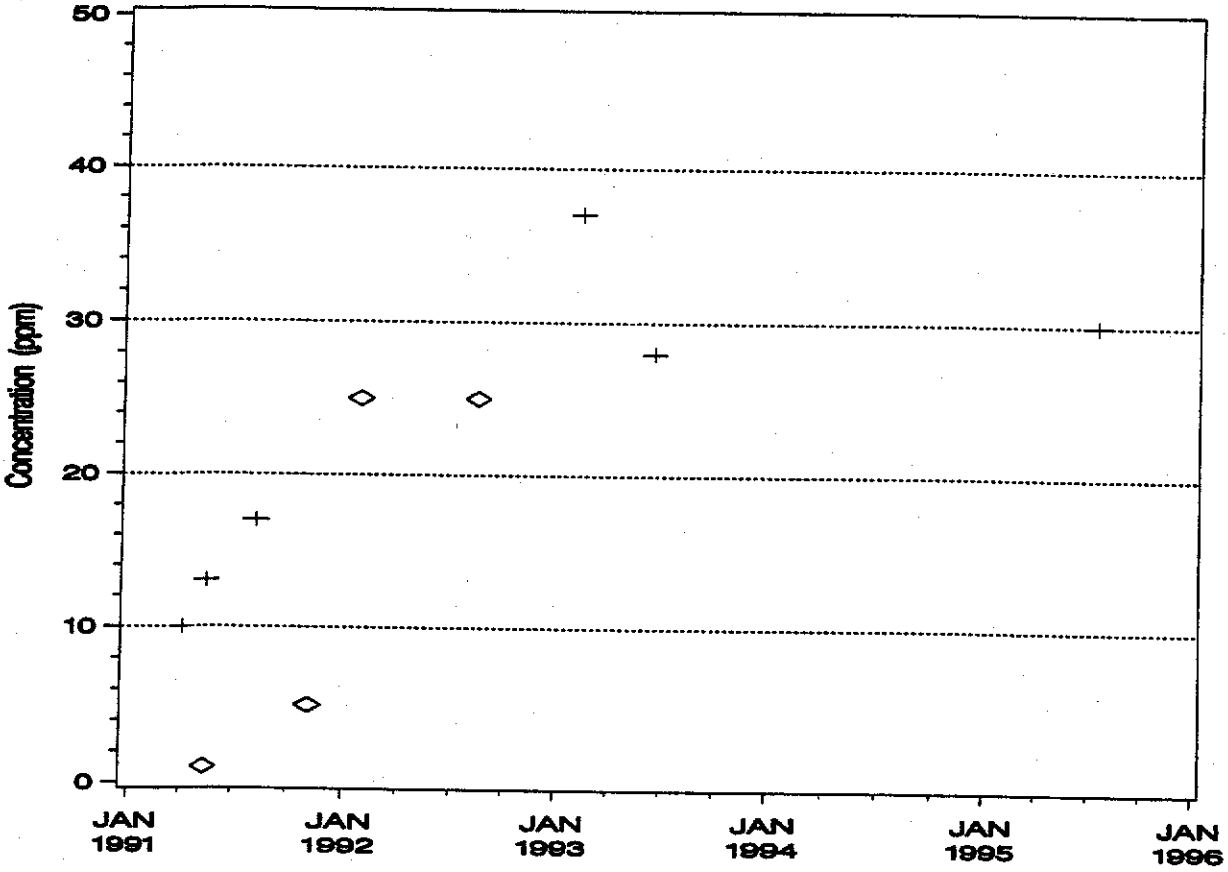
1,1 – DICHLOROETHYLENE Trend



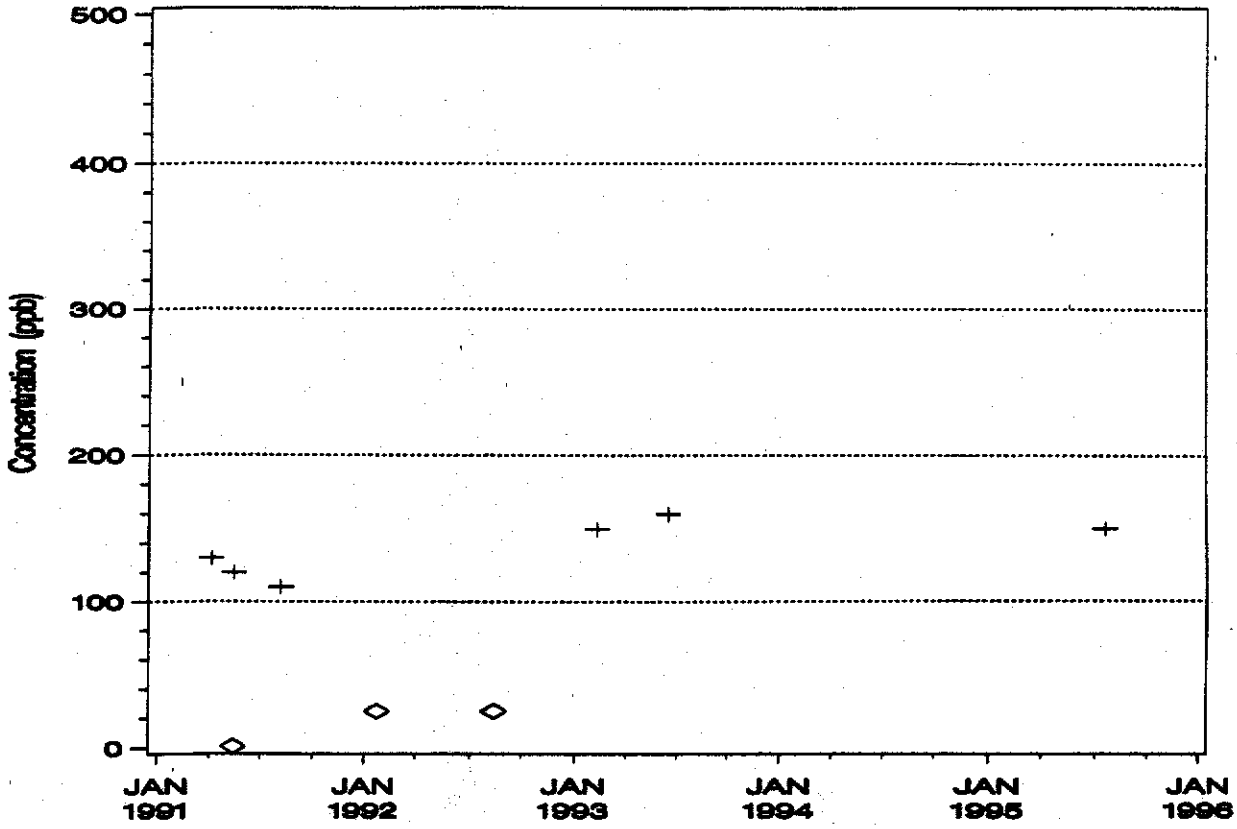
WELL 1392
TRICHLOROETHYLENE Trend



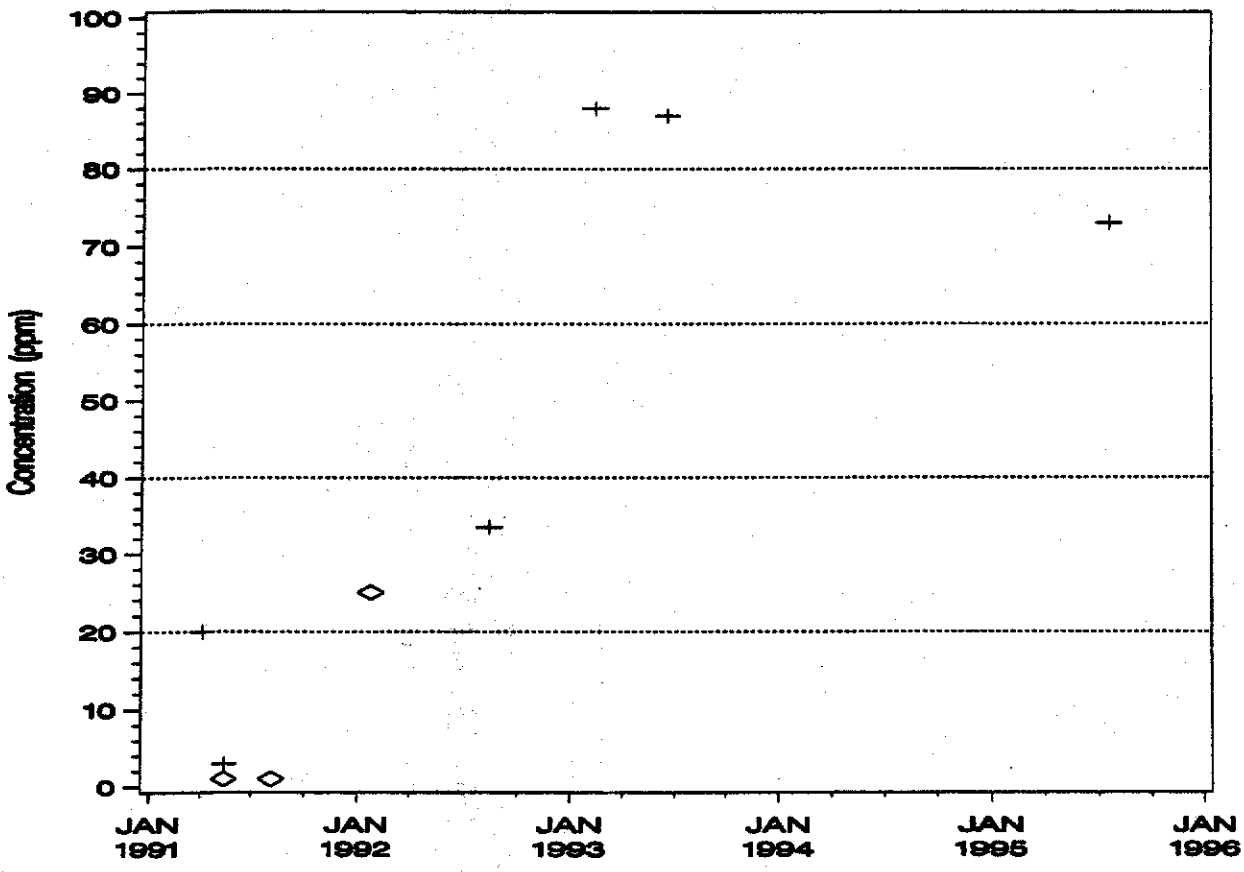
FREON 113 Trend



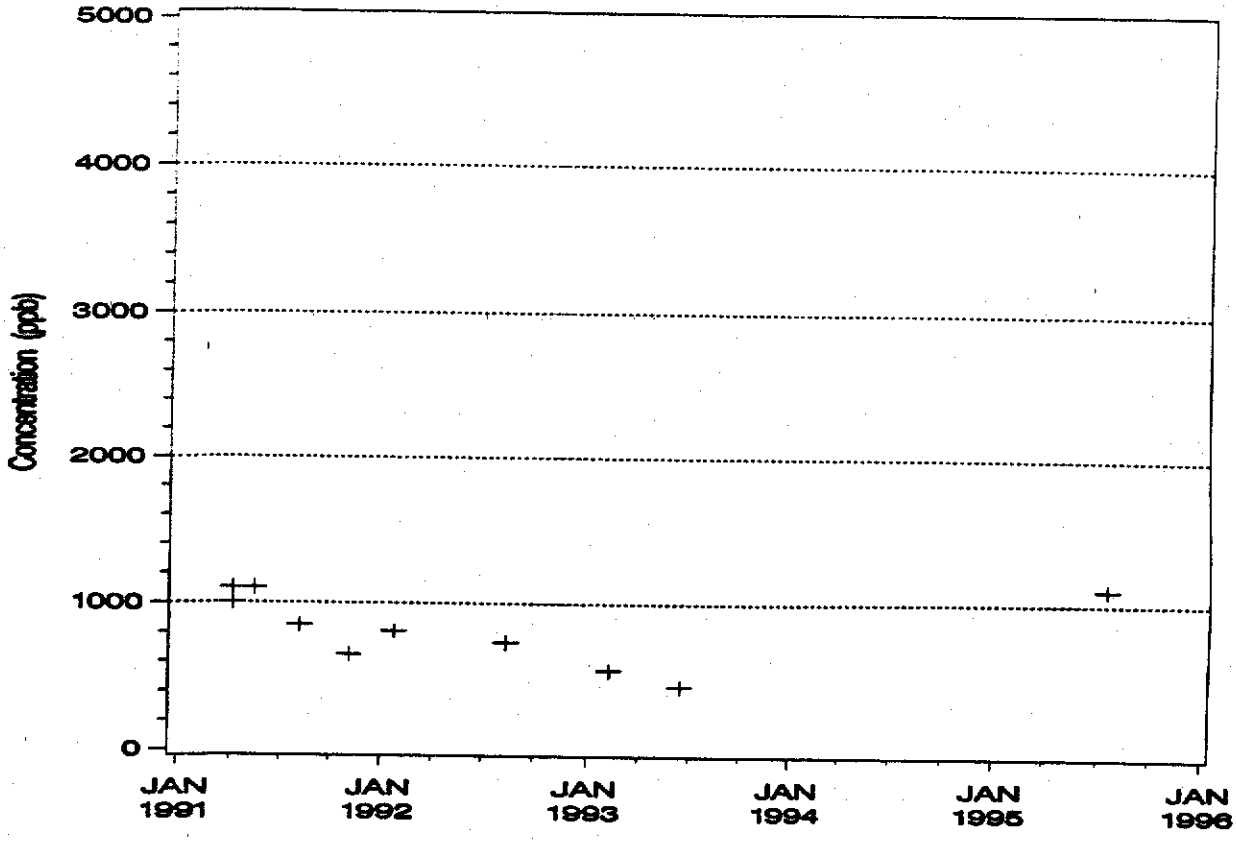
WELL 1392
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



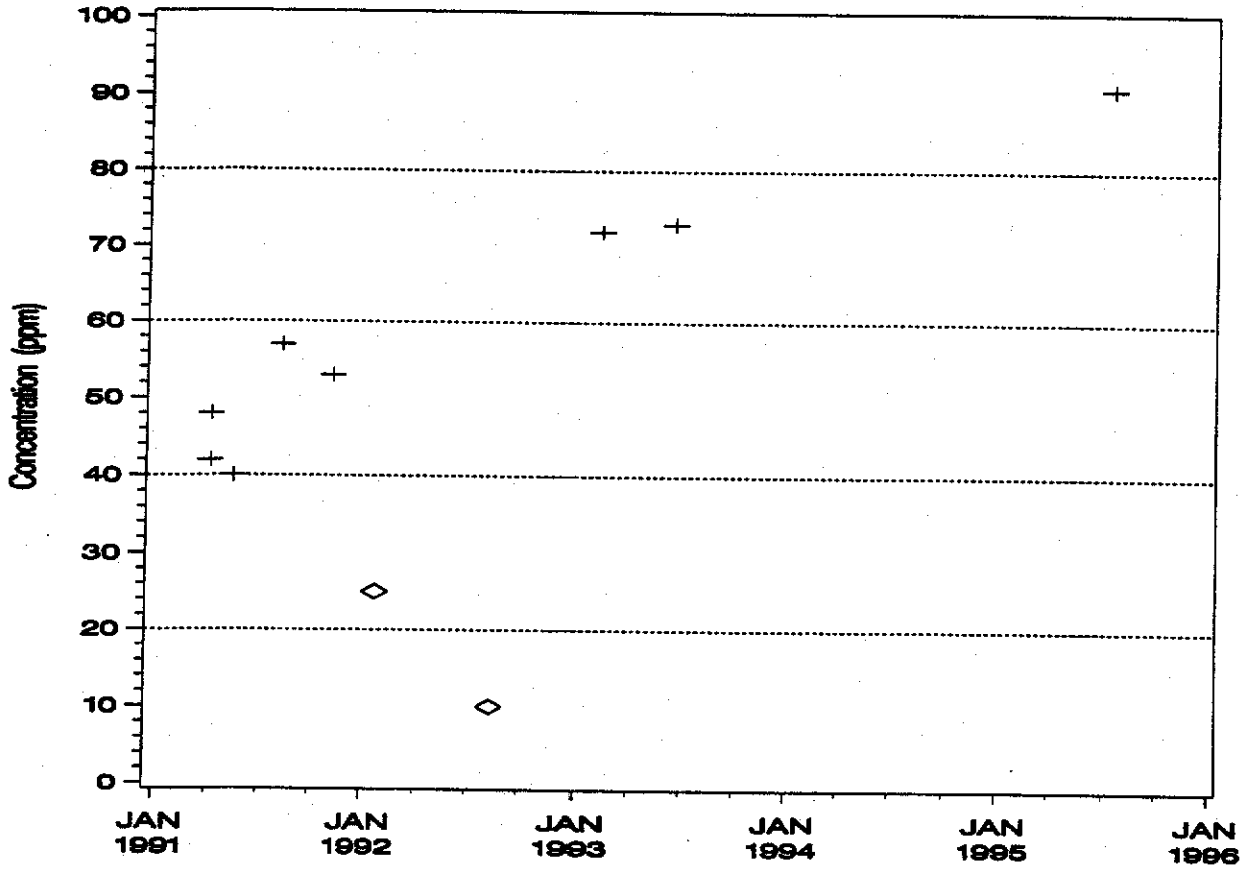
1,1 – DICHLOROETHYLENE Trend



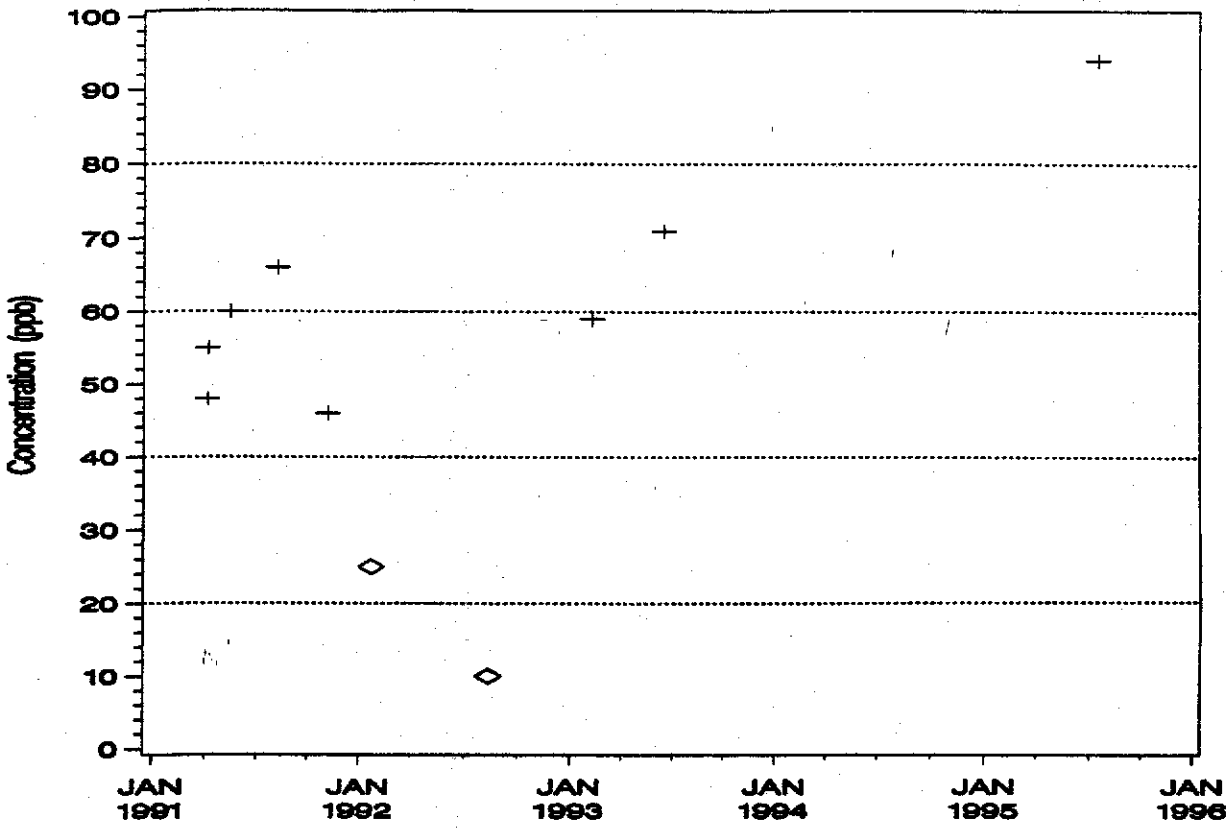
WELL 1393
TRICHLOROETHYLENE Trend



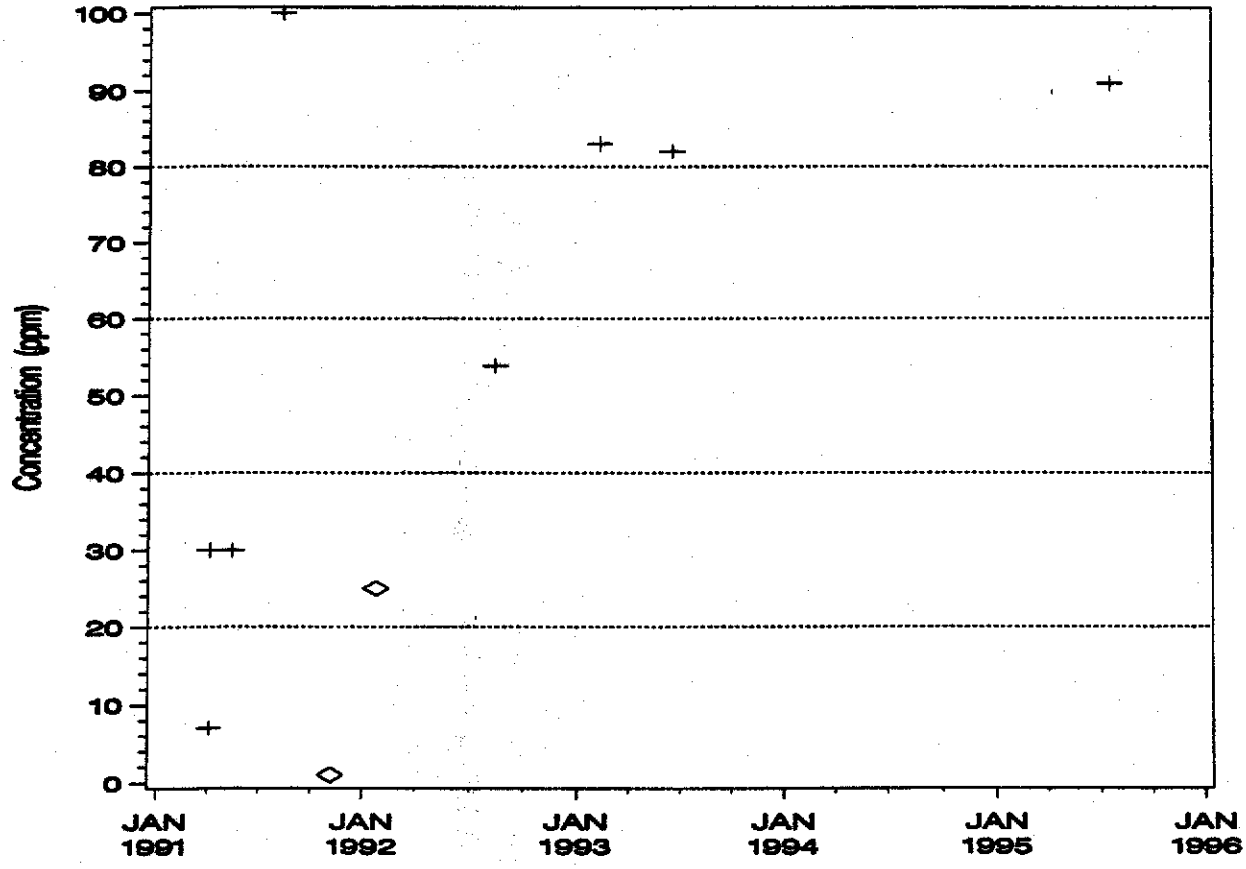
FREON 113 Trend



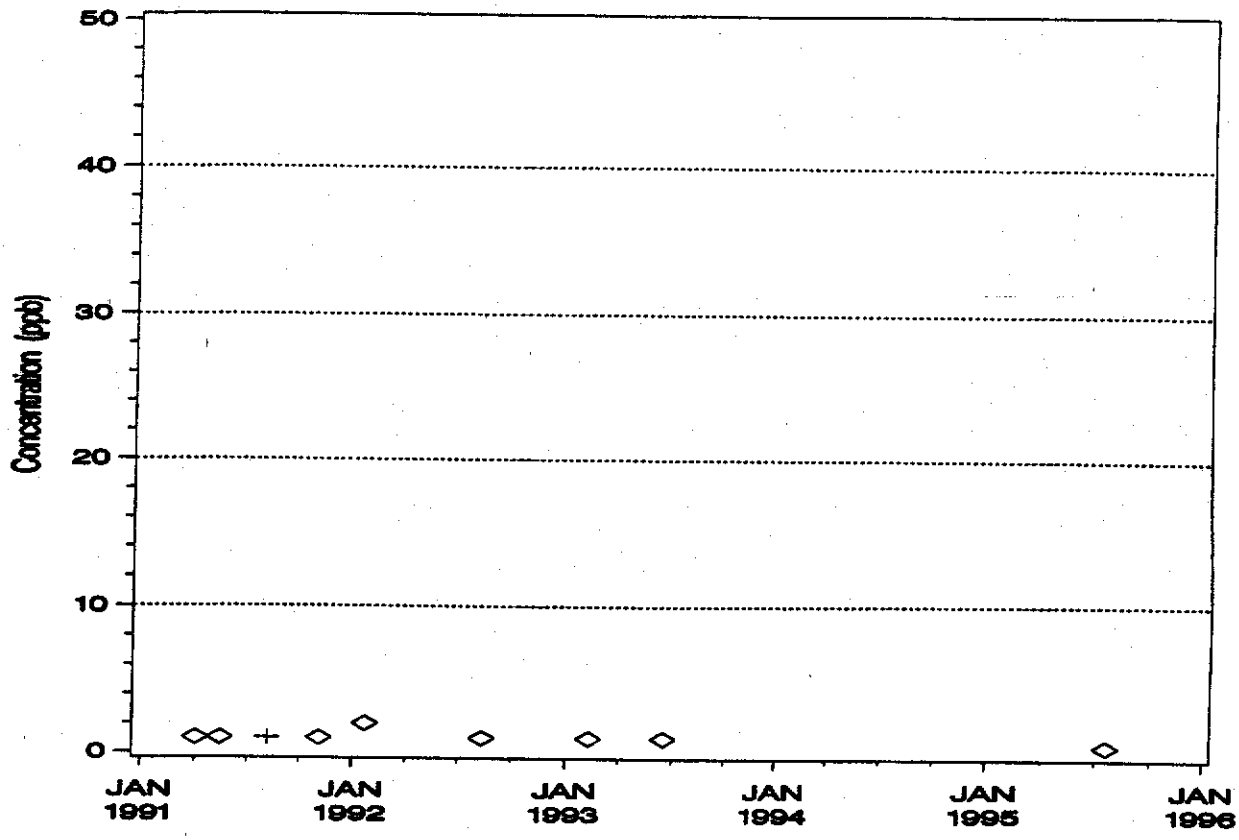
WELL 1393
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



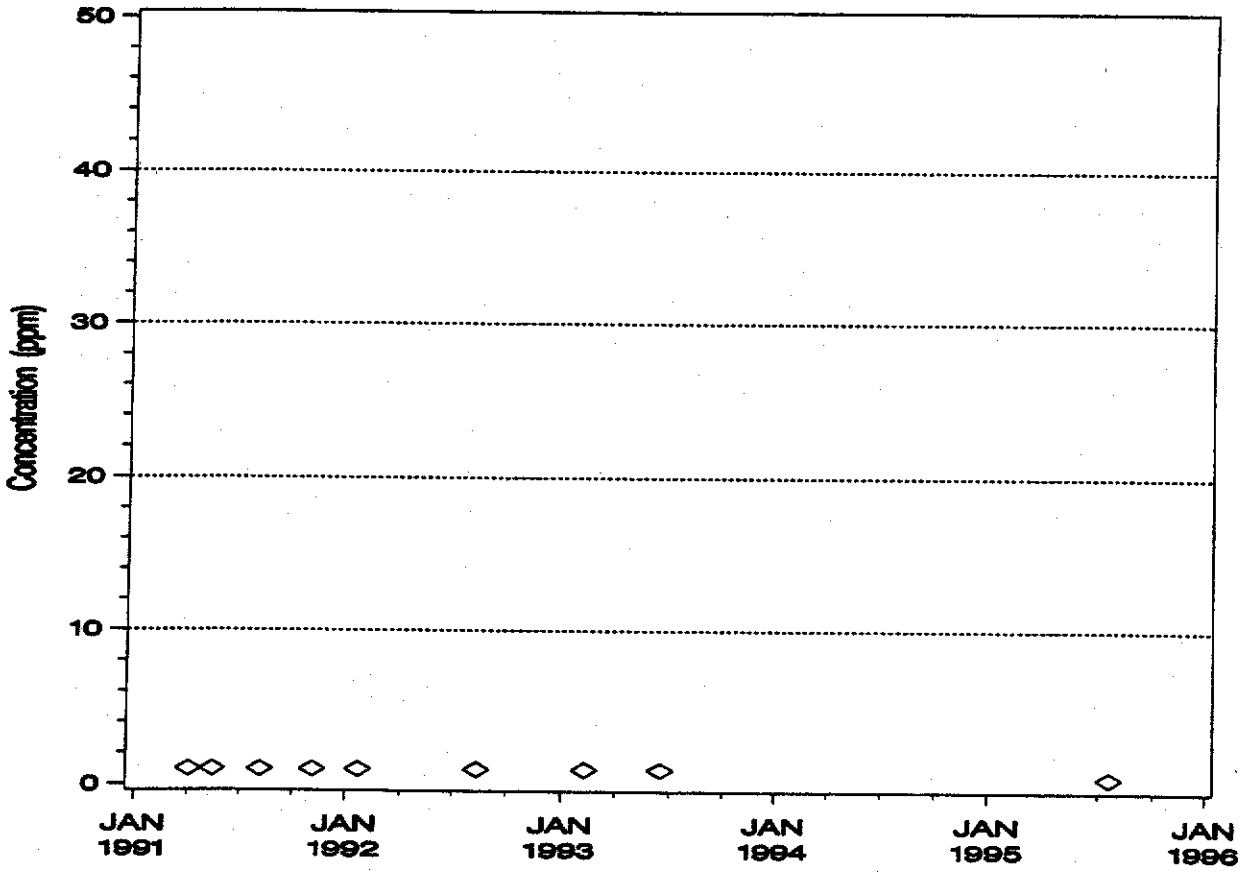
1,1 – DICHLOROETHYLENE Trend



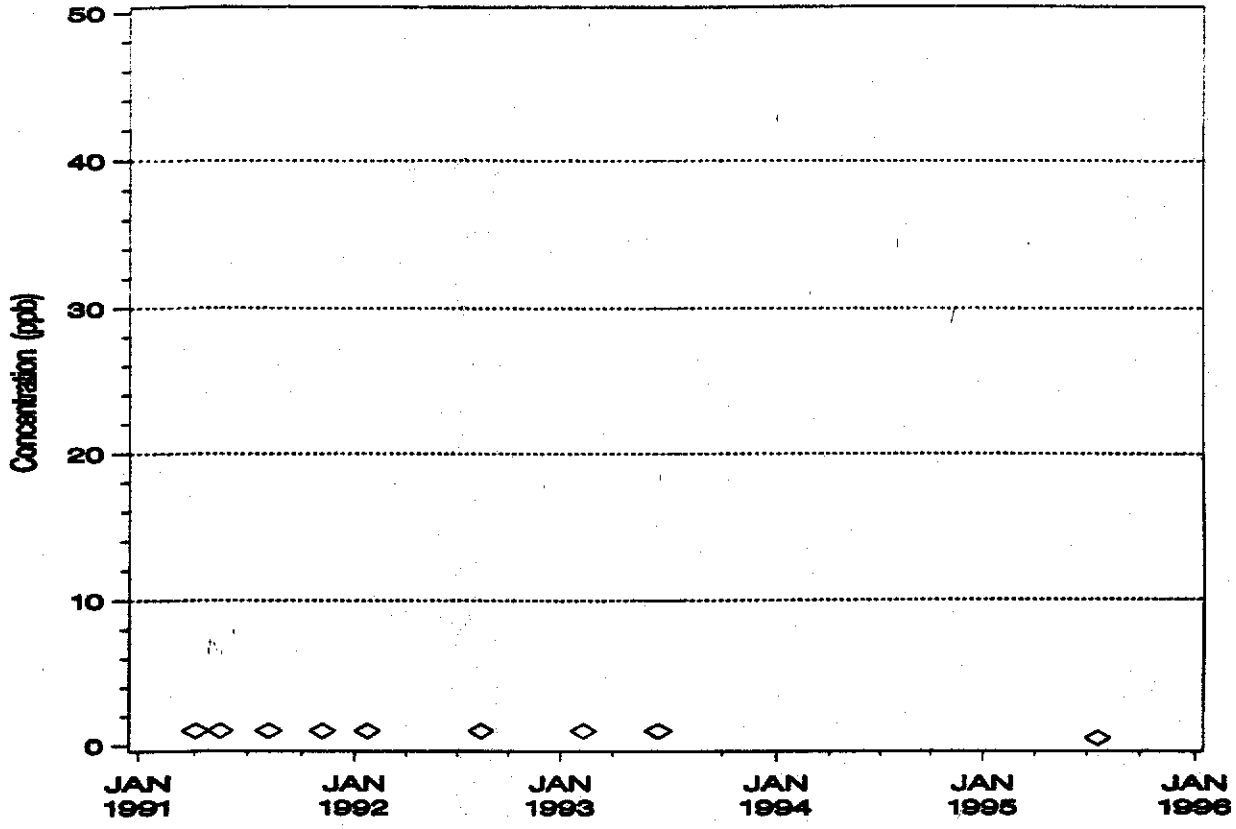
WELL 1394
TRICHLOROETHYLENE Trend



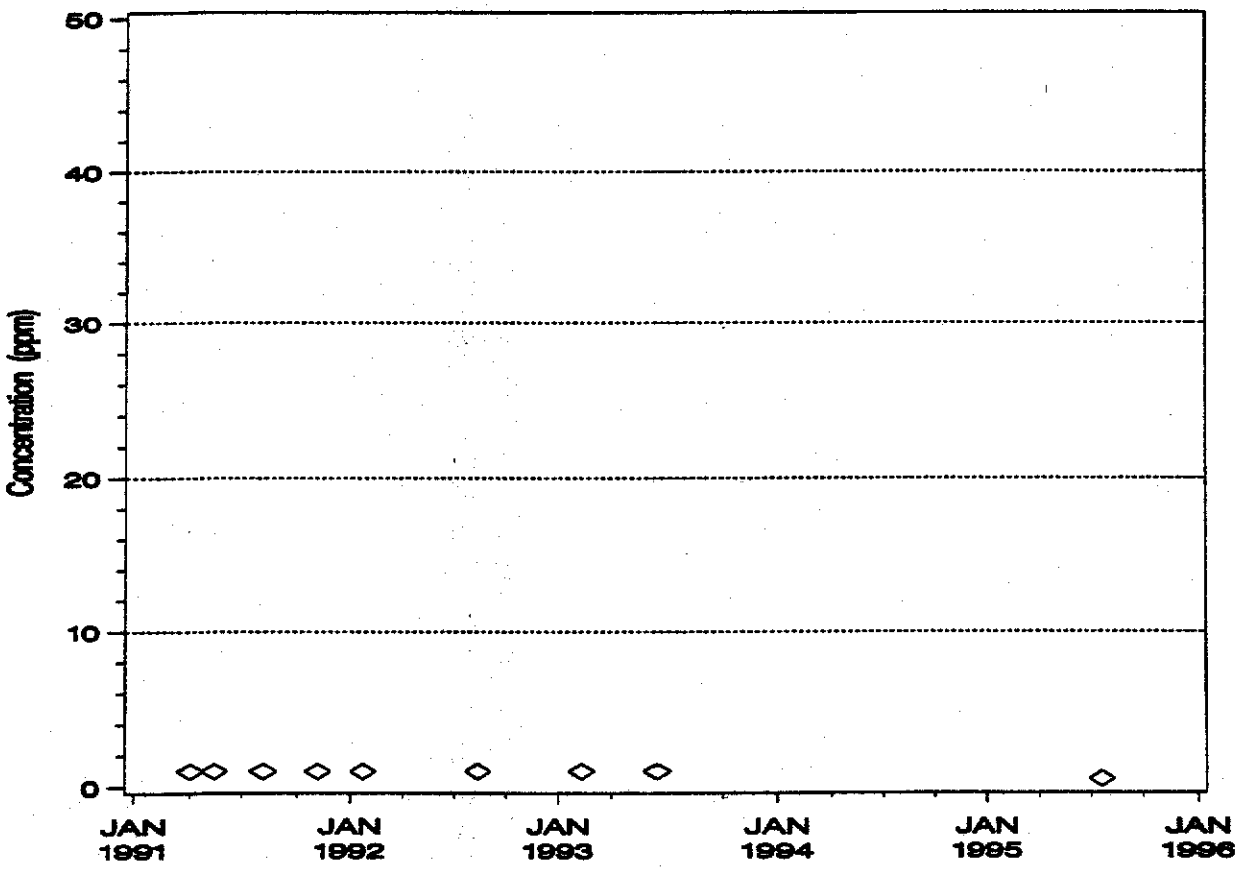
FREON 113 Trend



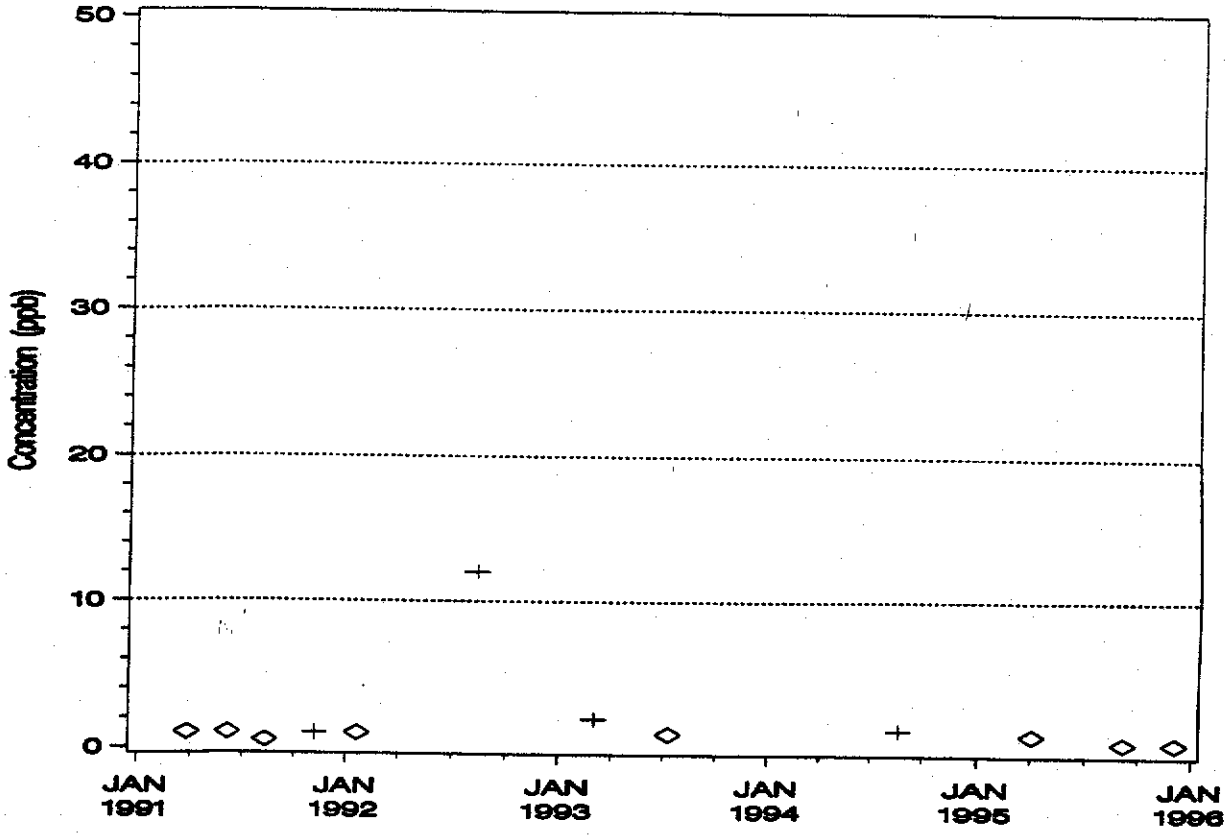
WELL 1394
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



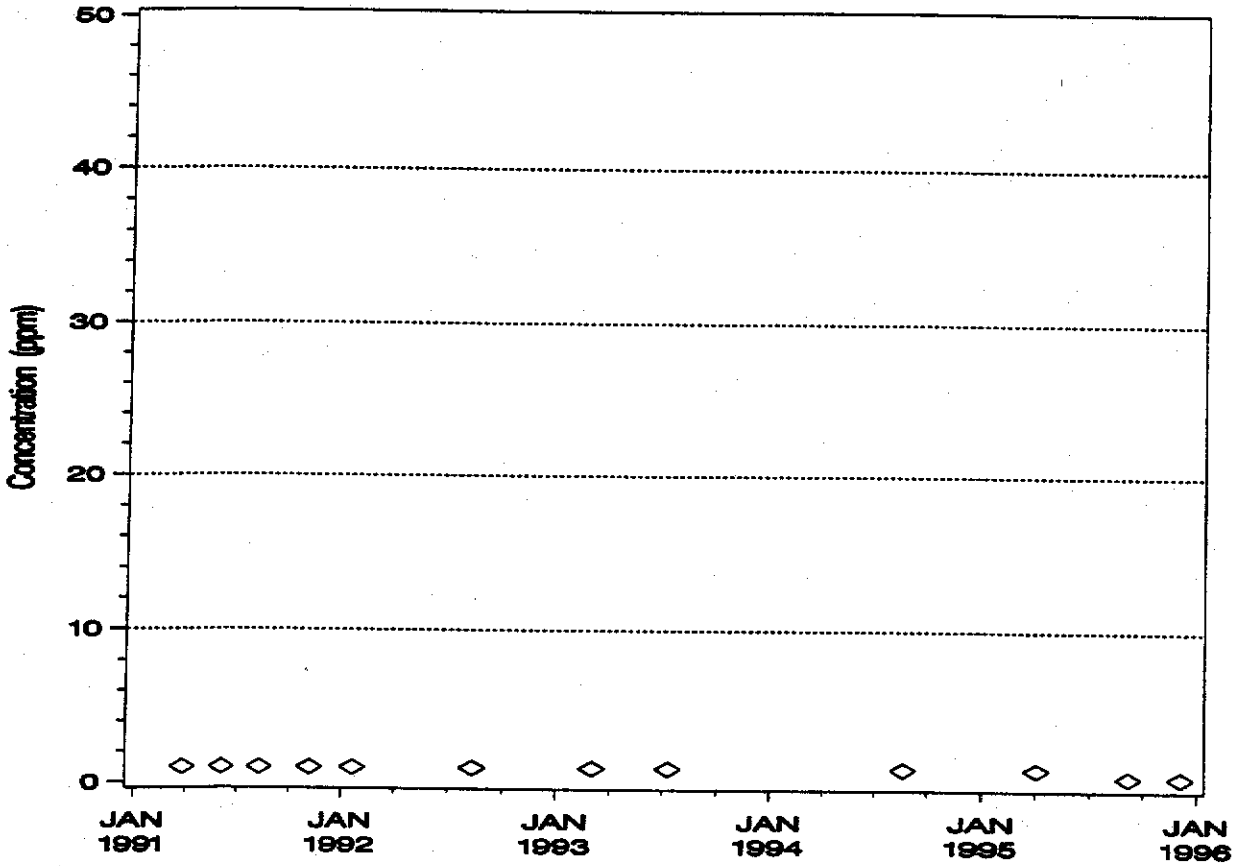
1,1 – DICHLOROETHYLENE Trend



WELL 1395
TRICHLOROETHYLENE Trend

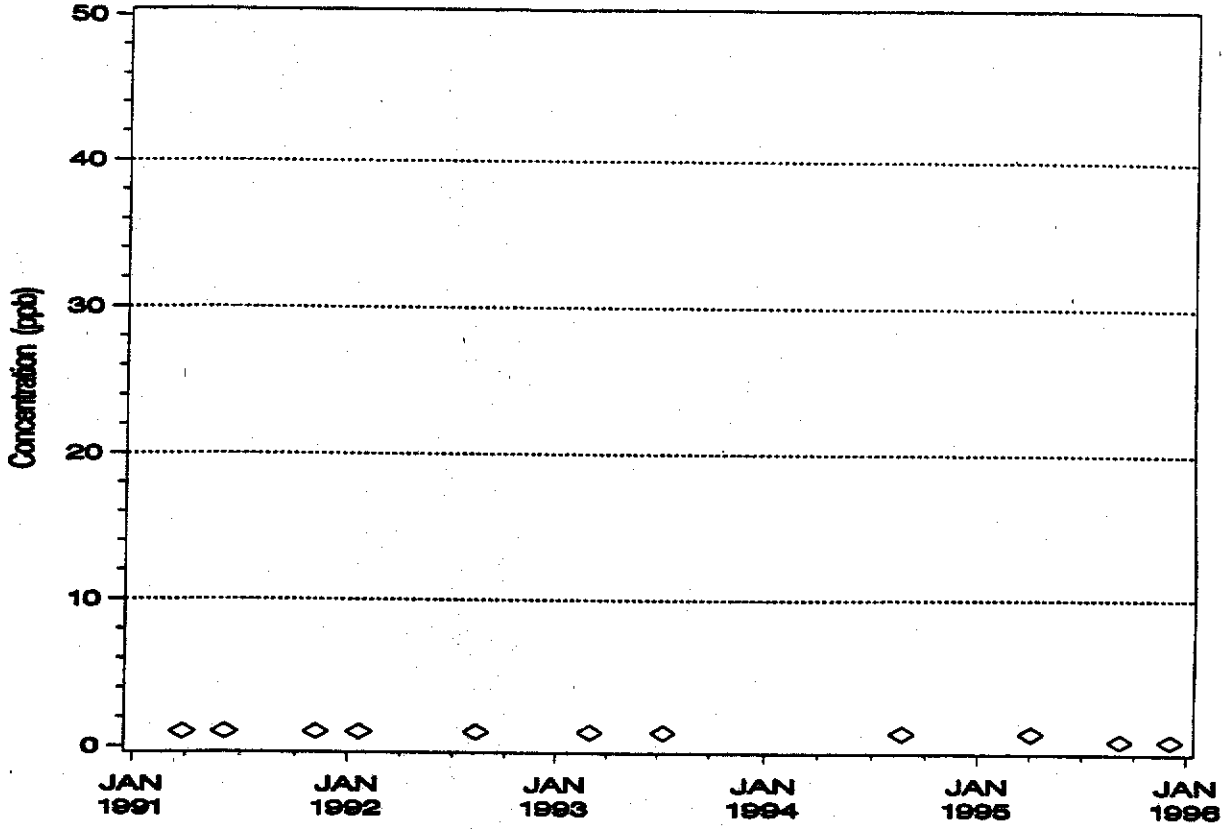


FREON 113 Trend

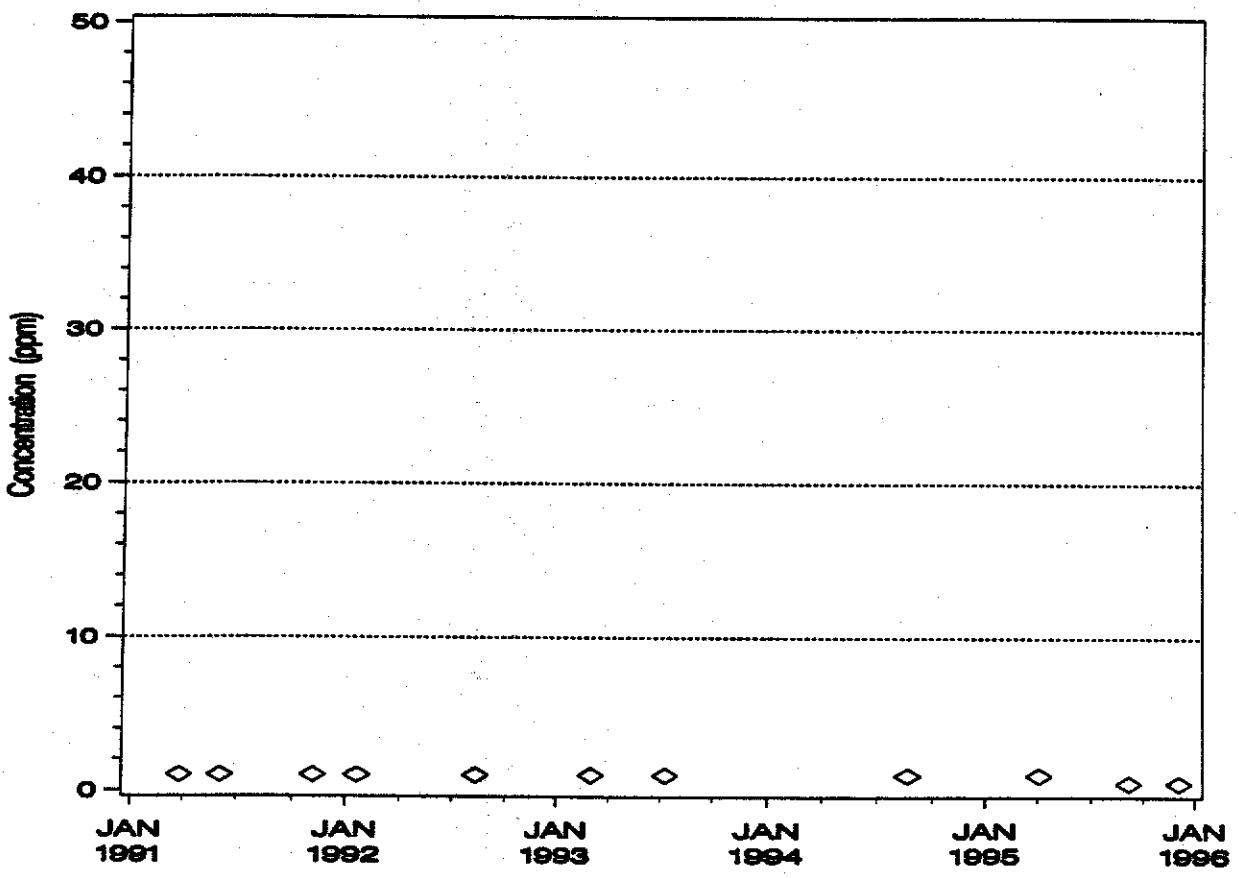


WELL 1395

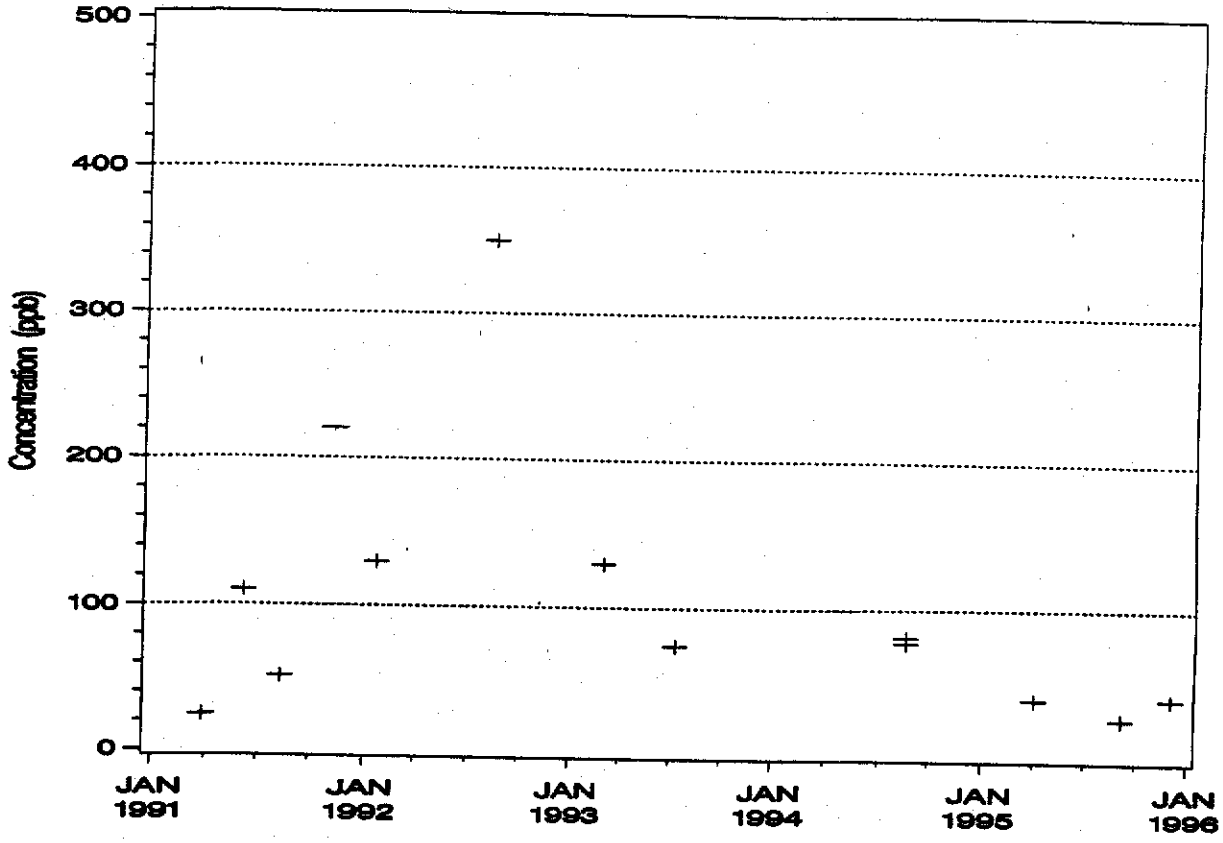
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



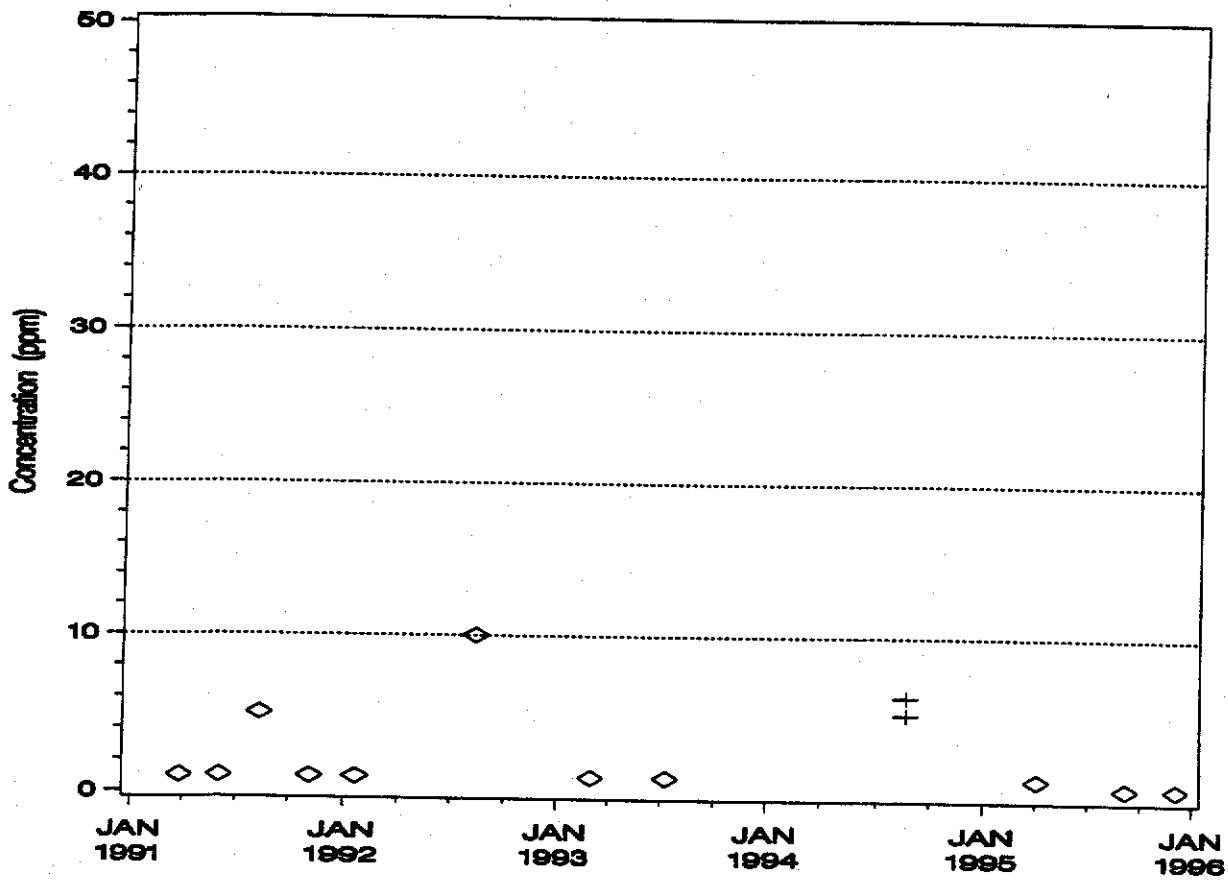
1,1 – DICHLOROETHYLENE Trend



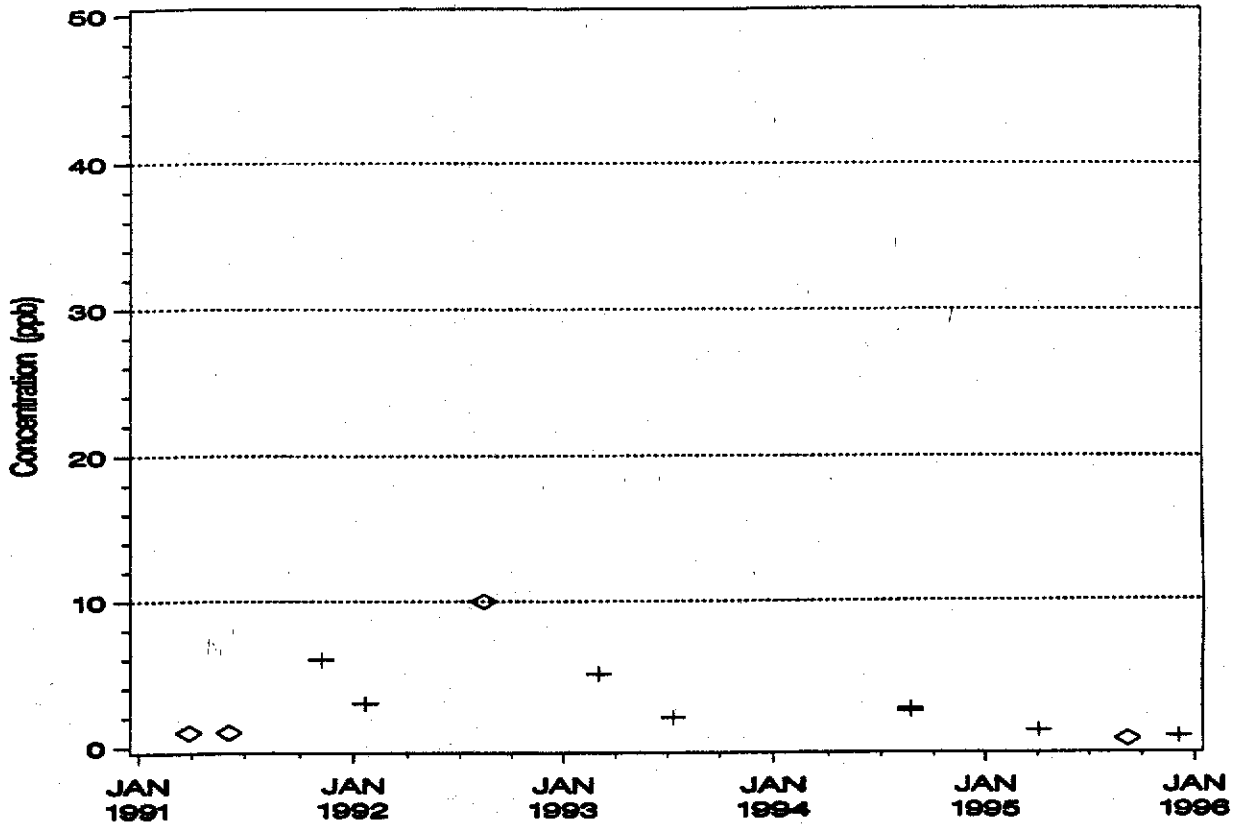
WELL 1396
TRICHLOROETHYLENE Trend



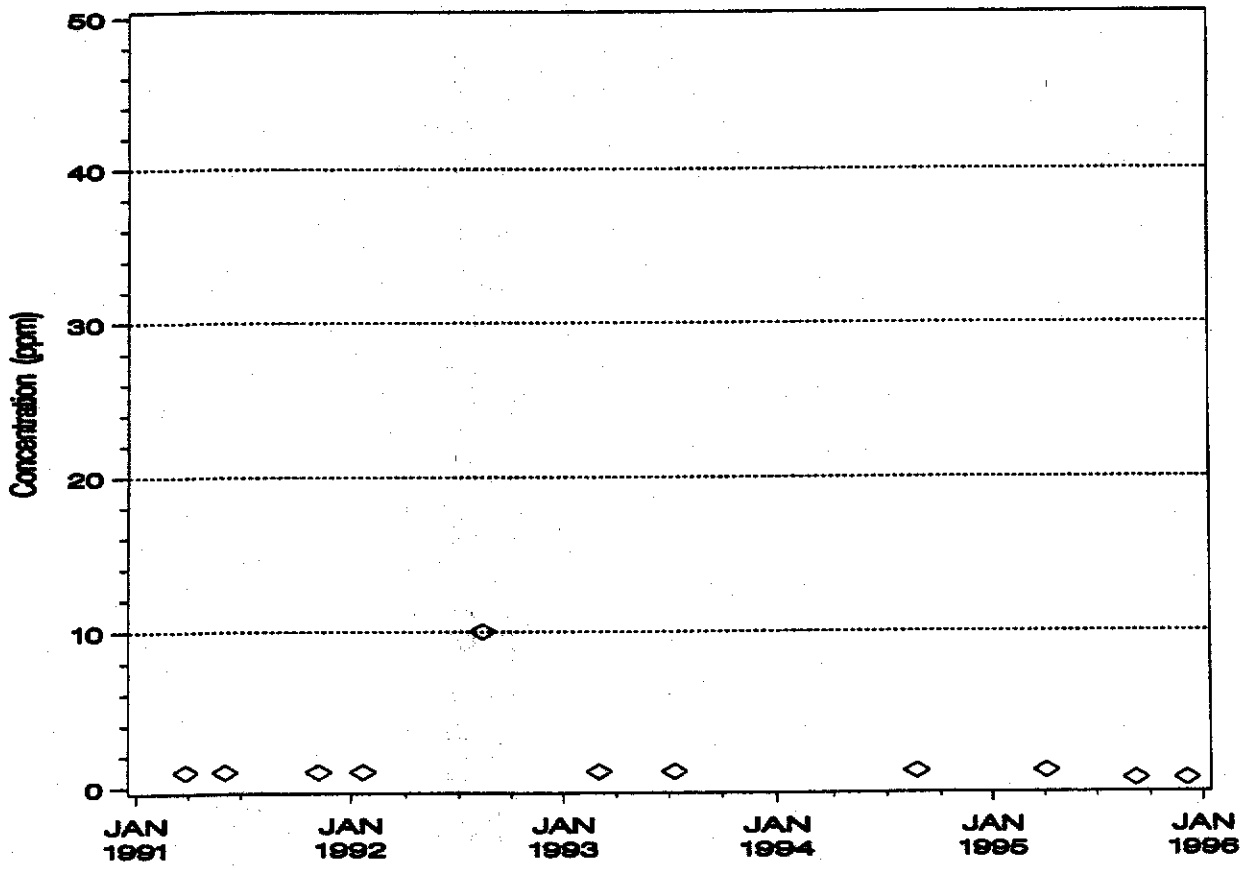
FREON 113 Trend



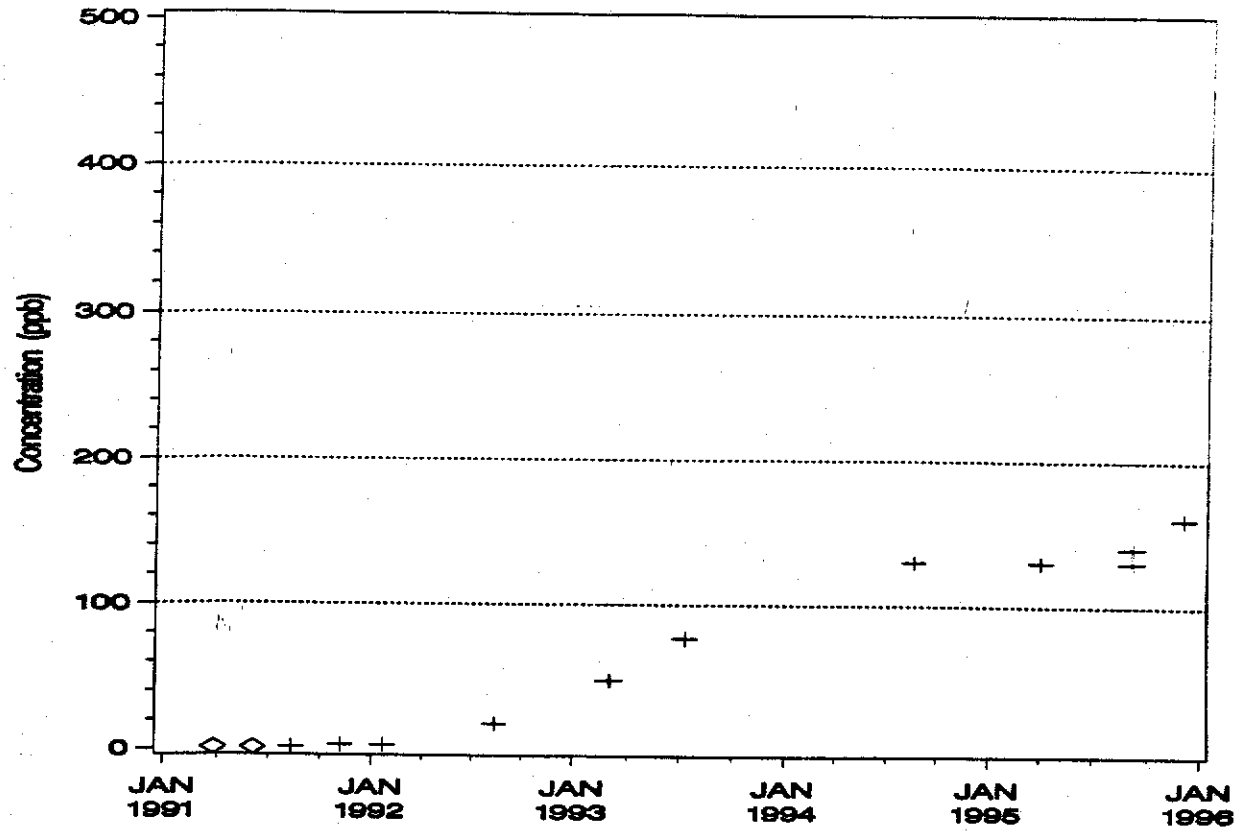
WELL 1396
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



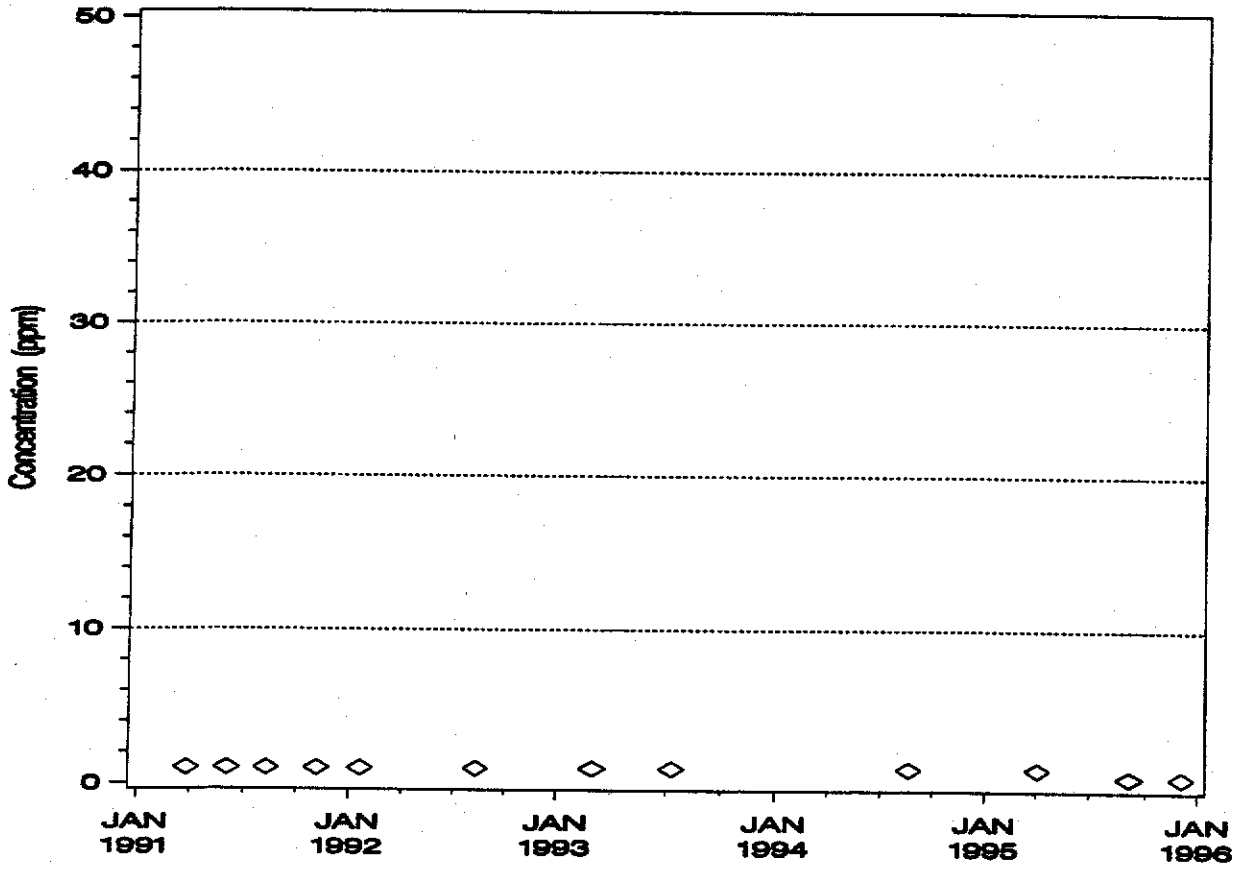
1,1 – DICHLOROETHYLENE Trend



WELL 1397
TRICHLOROETHYLENE Trend

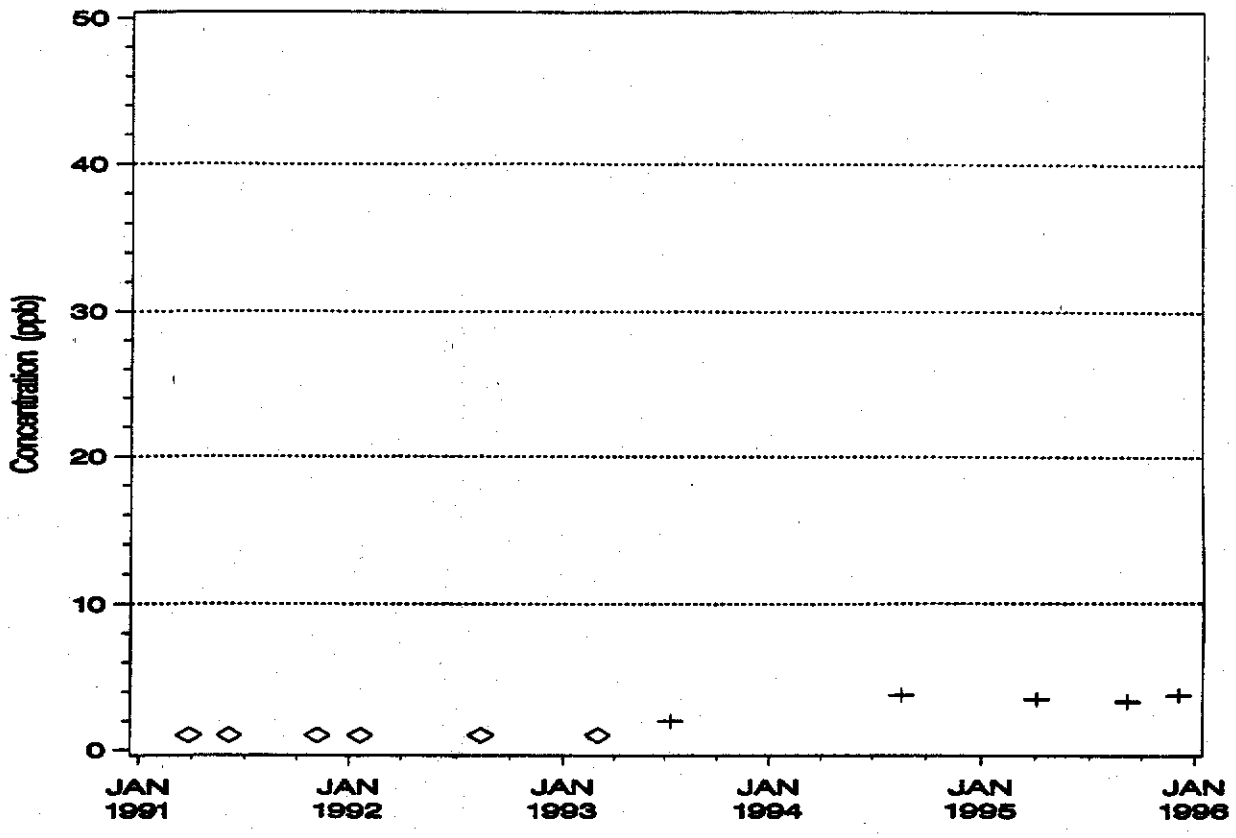


FREON 113 Trend

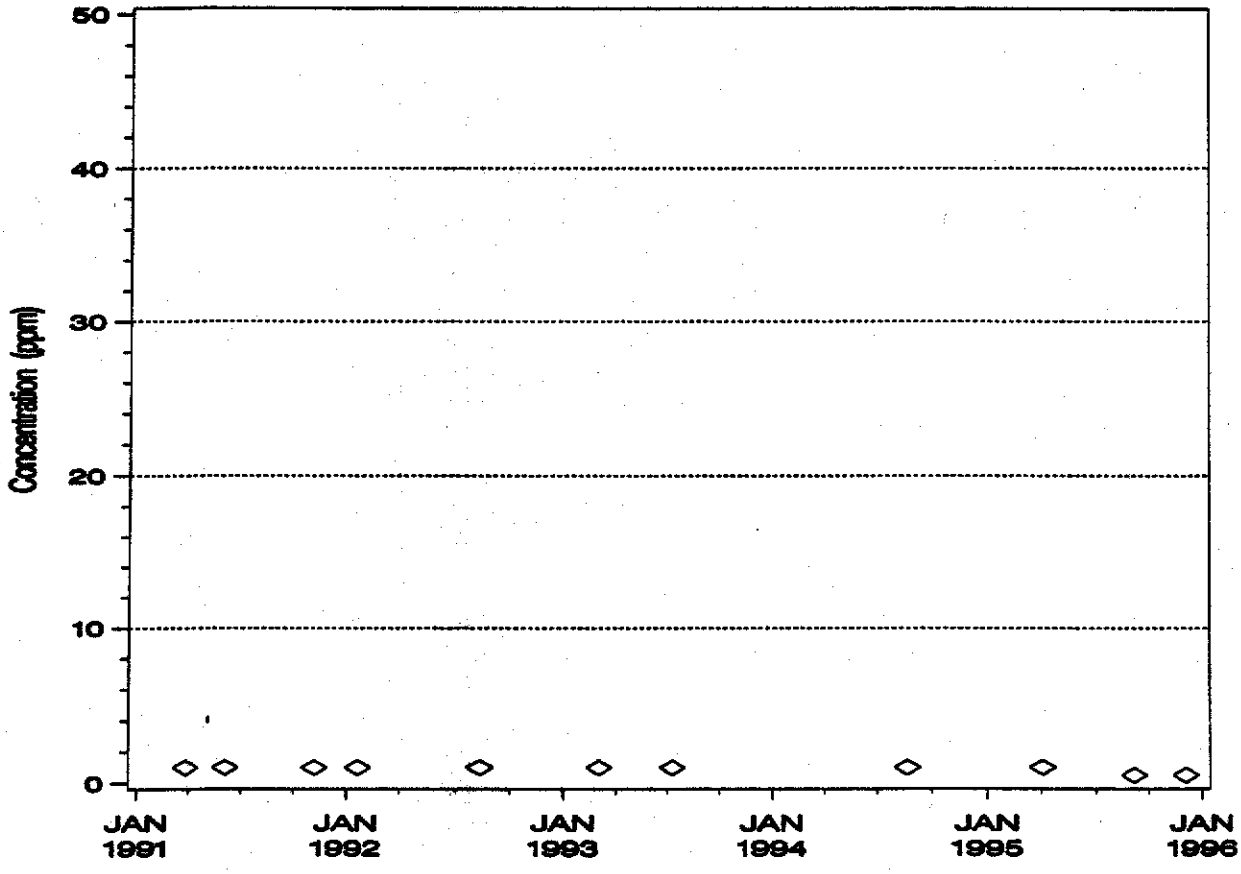


WELL 1397

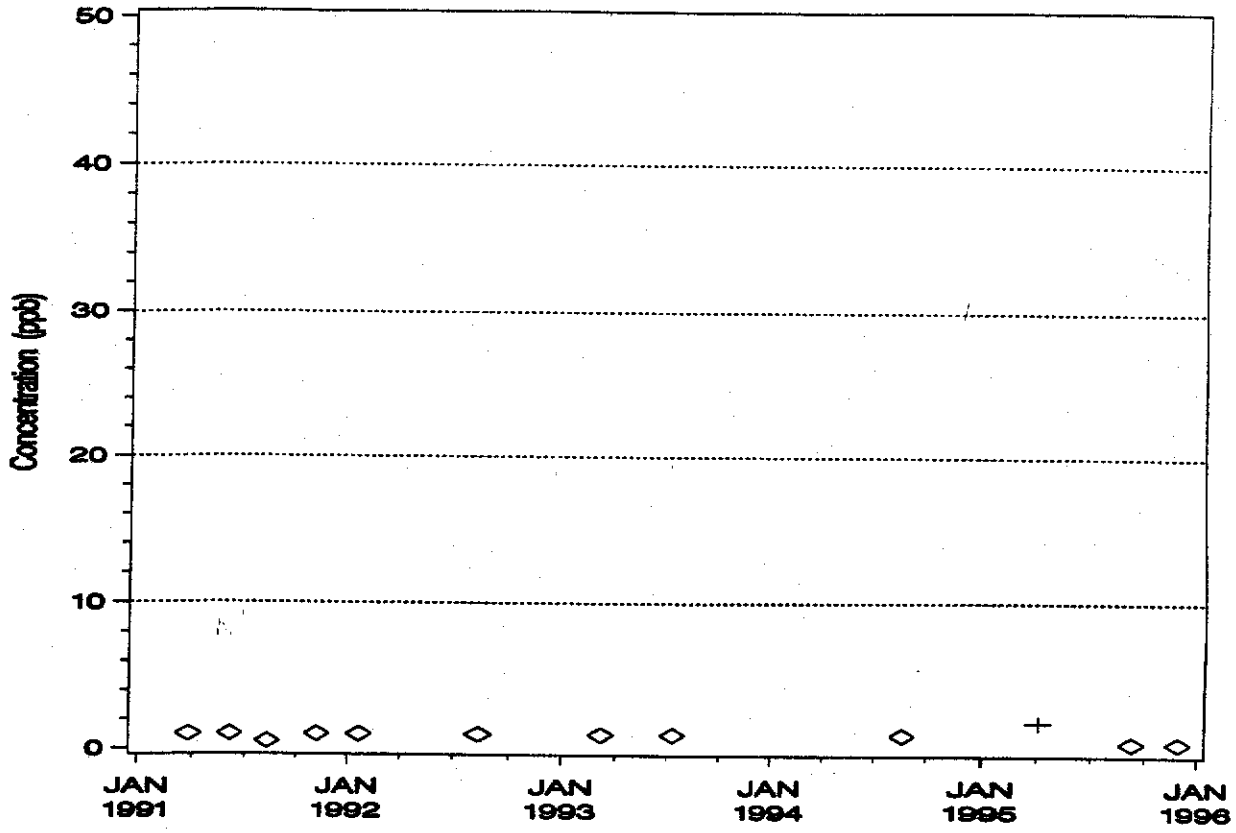
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



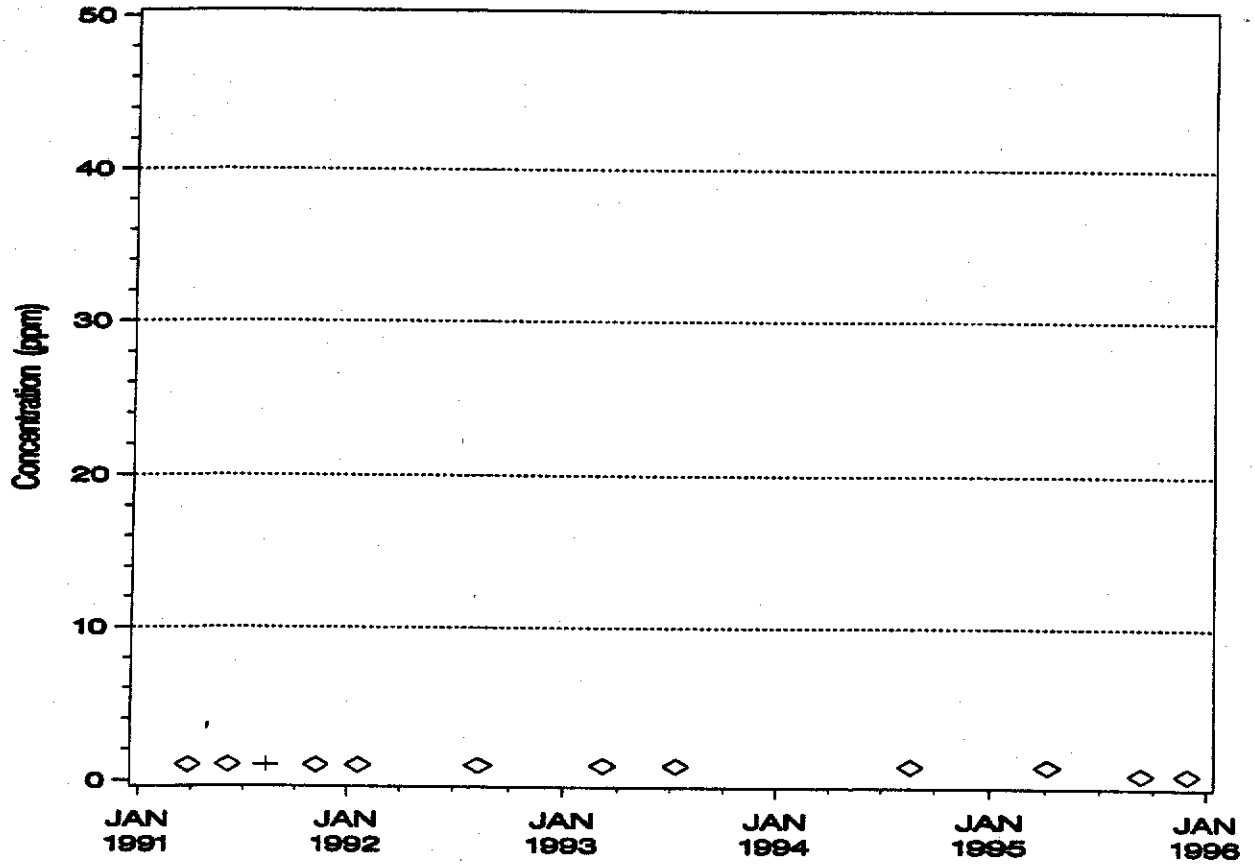
1,1 – DICHLOROETHYLENE Trend



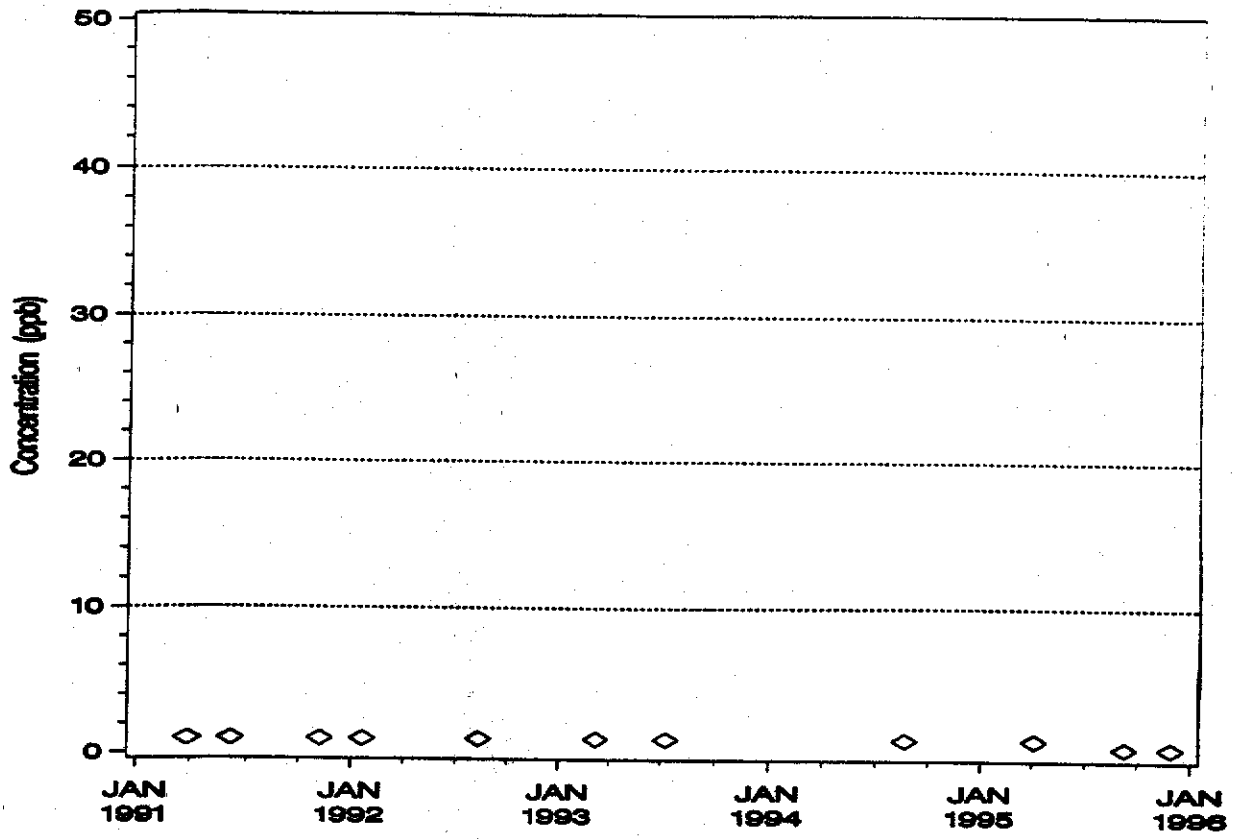
WELL 1398
TRICHLOROETHYLENE Trend



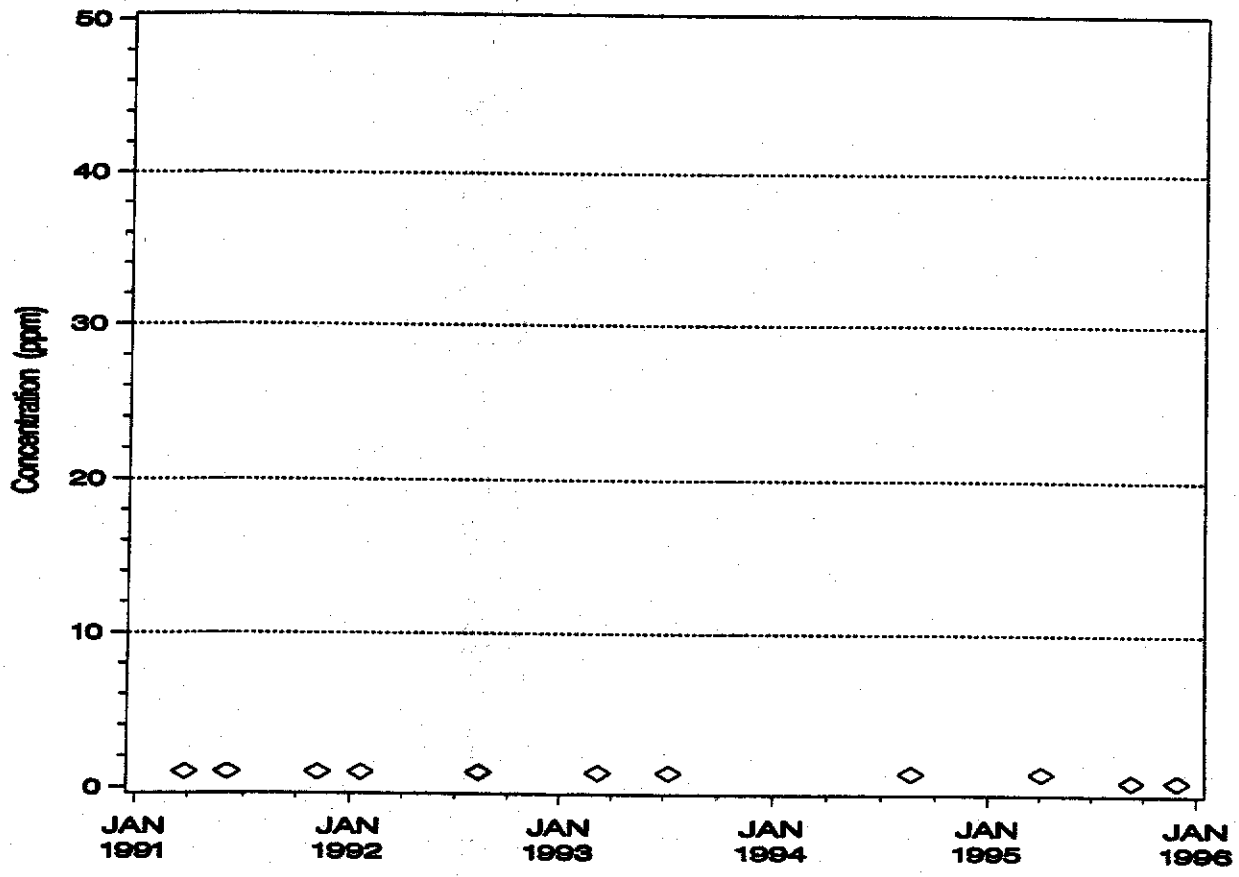
FREON 113 Trend



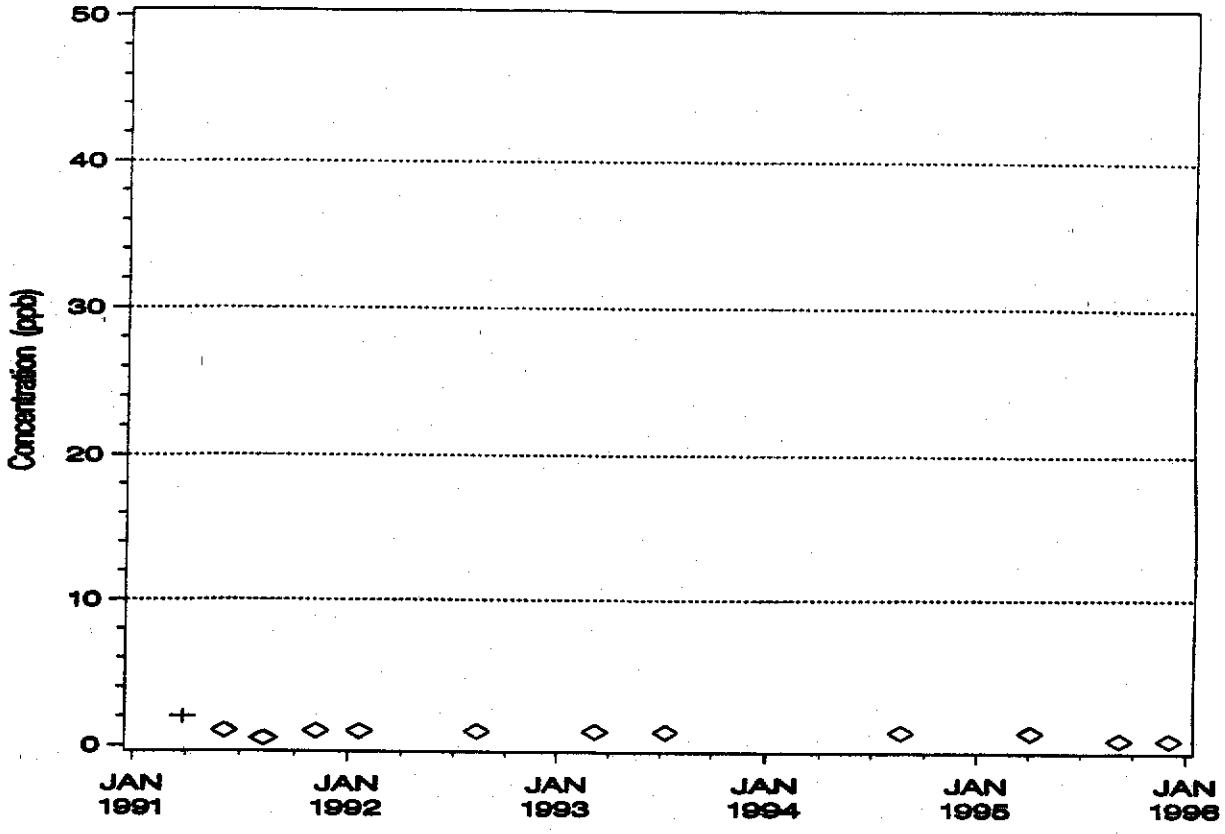
WELL 1398
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



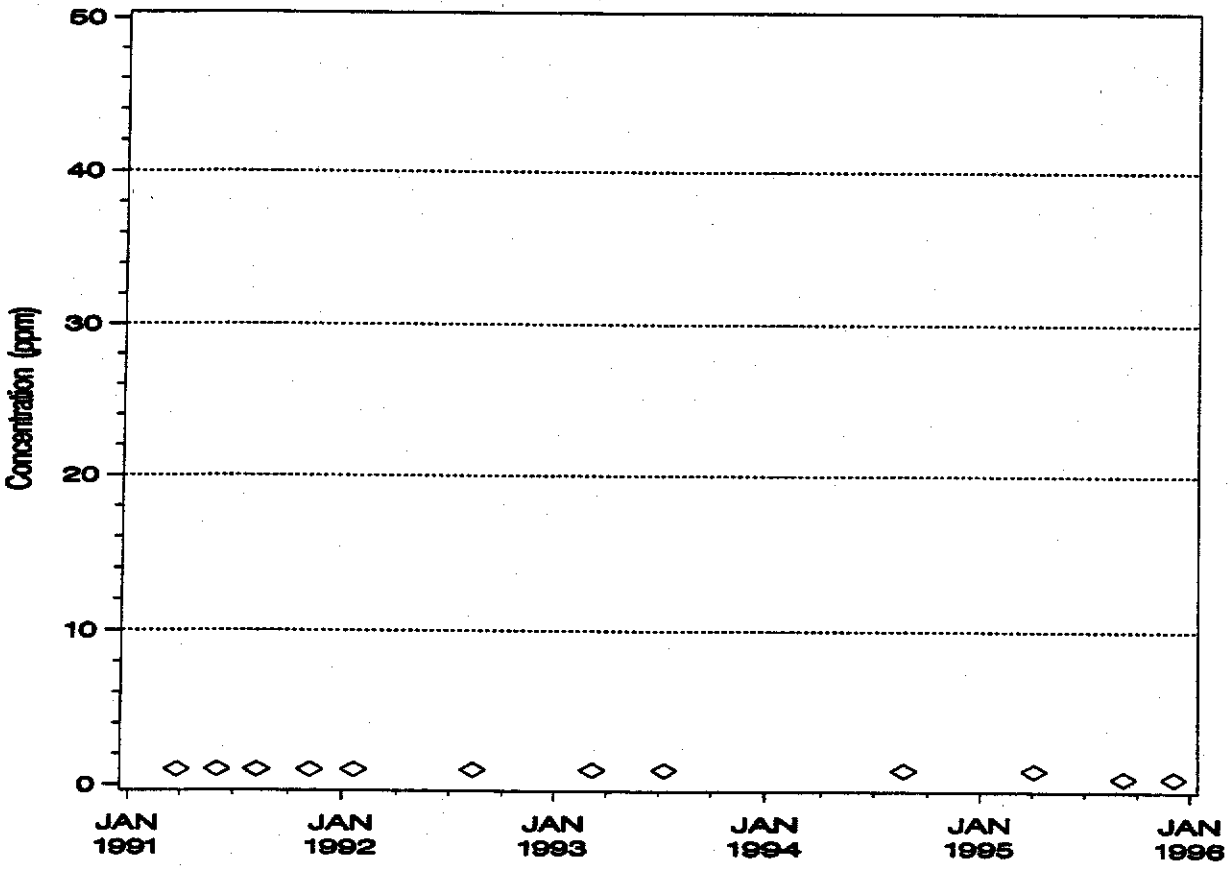
1,1 – DICHLOROETHYLENE Trend



WELL 1399
TRICHLOROETHYLENE Trend

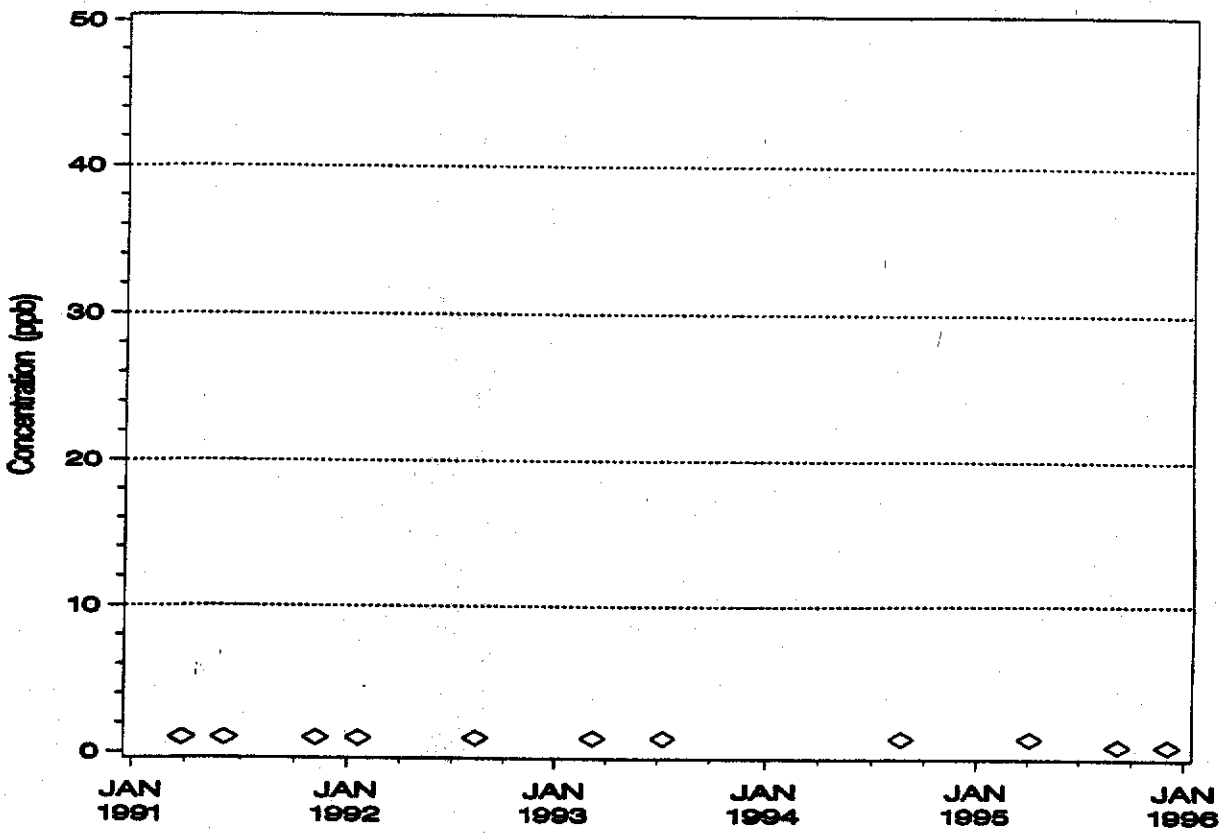


FREON 113 Trend

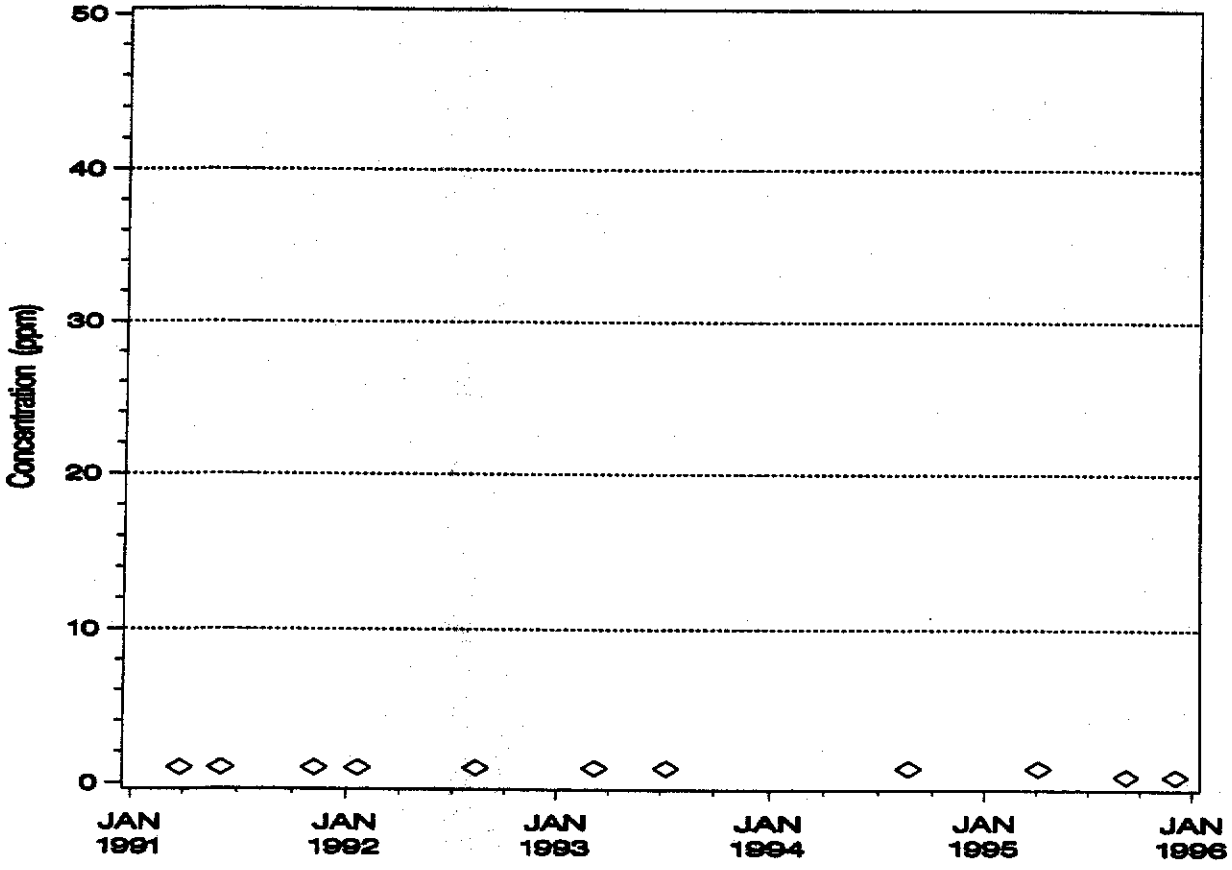


WELL 1399

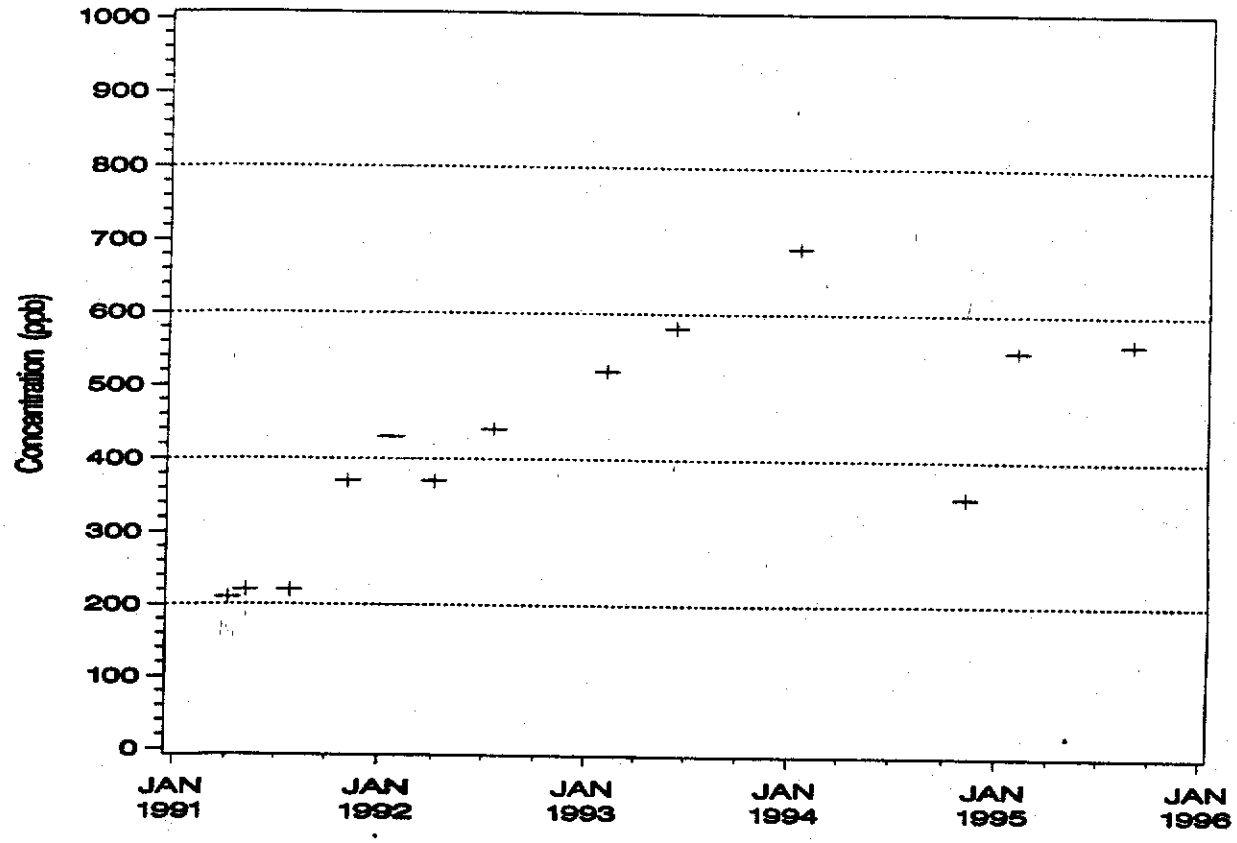
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



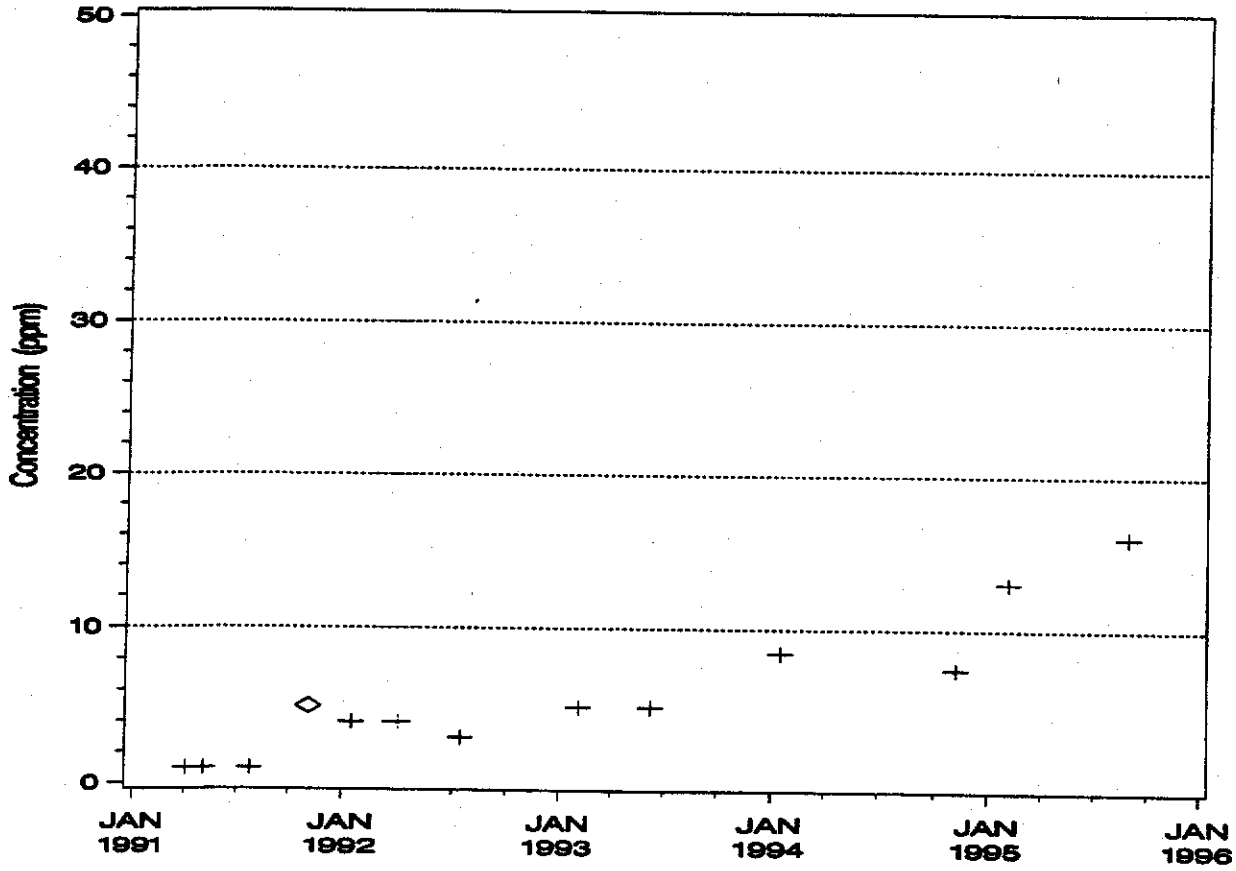
1,1 – DICHLOROETHYLENE Trend



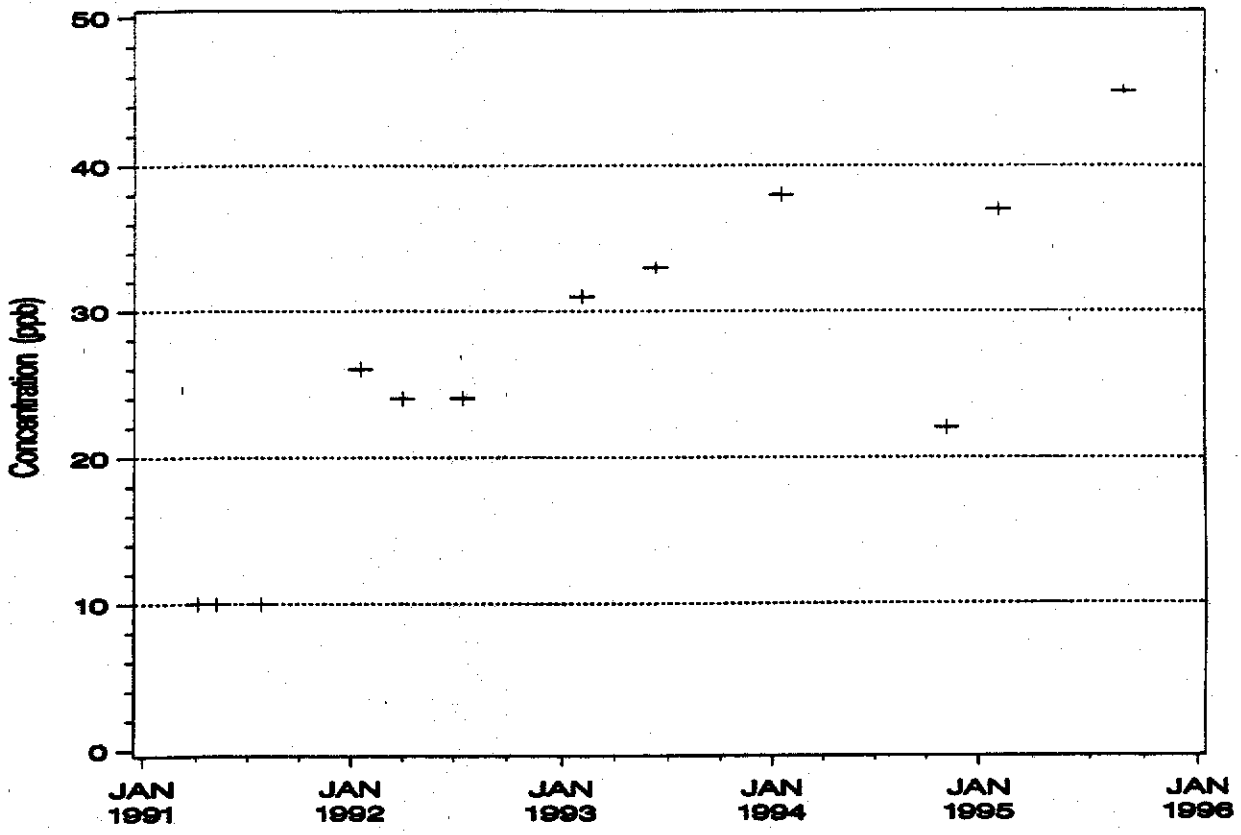
WELL 1400
TRICHLOROETHYLENE Trend



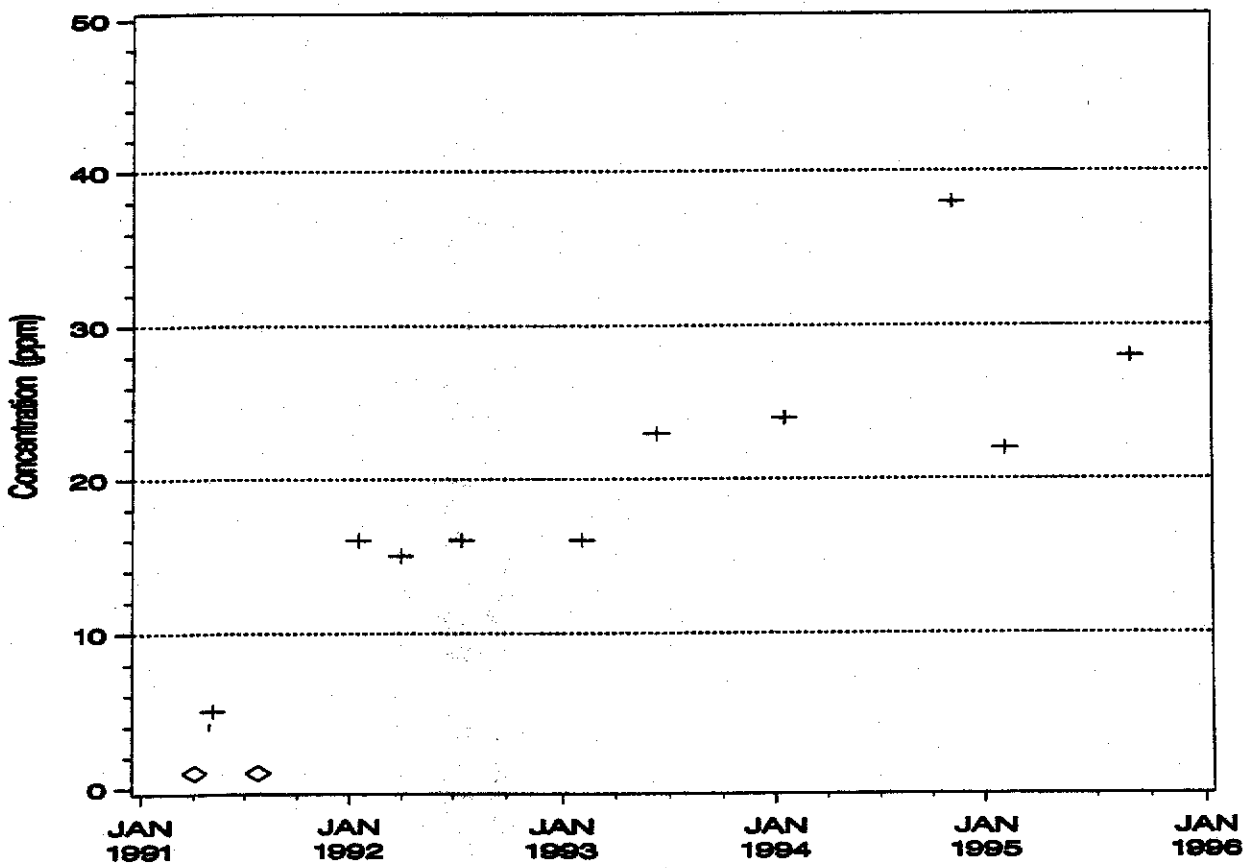
FREON 113 Trend



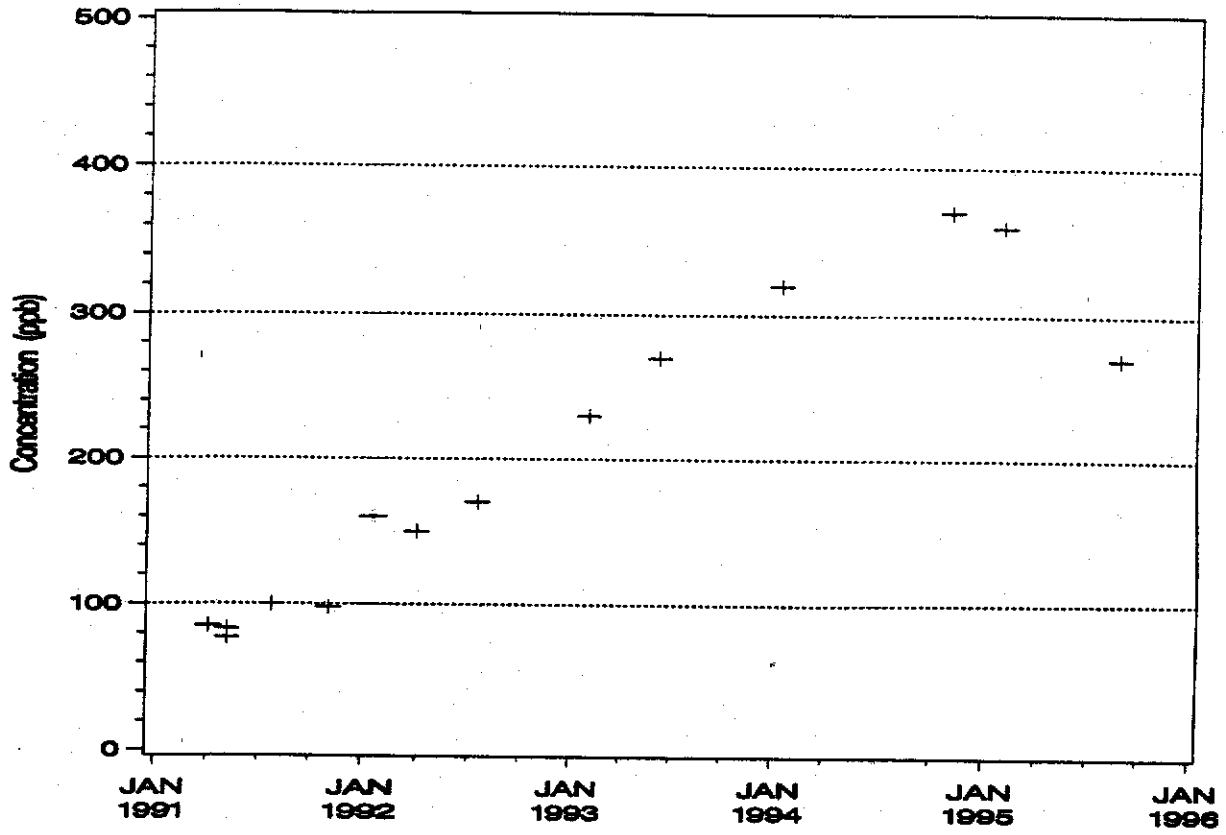
WELL 1400
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



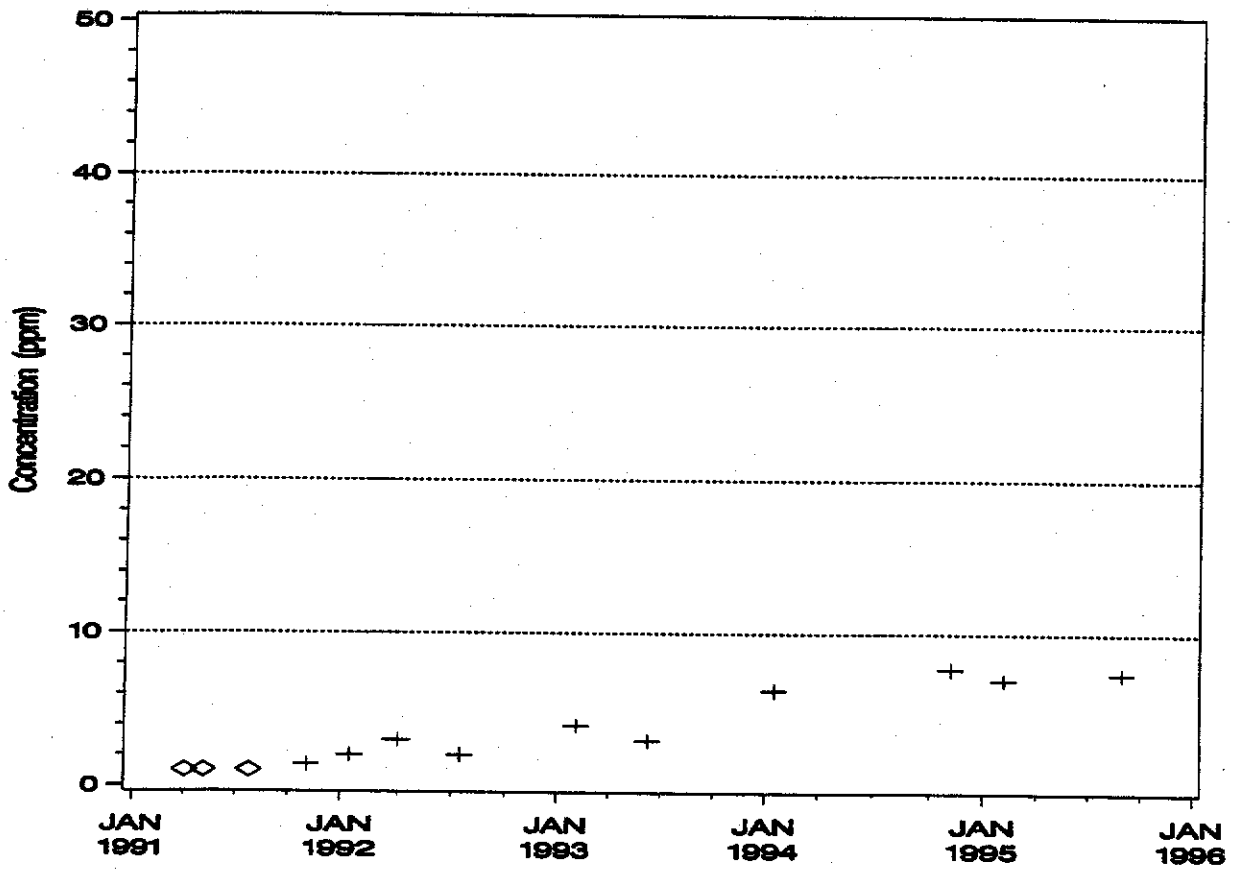
1,1 – DICHLOROETHYLENE Trend



WELL 1401
TRICHLOROETHYLENE Trend

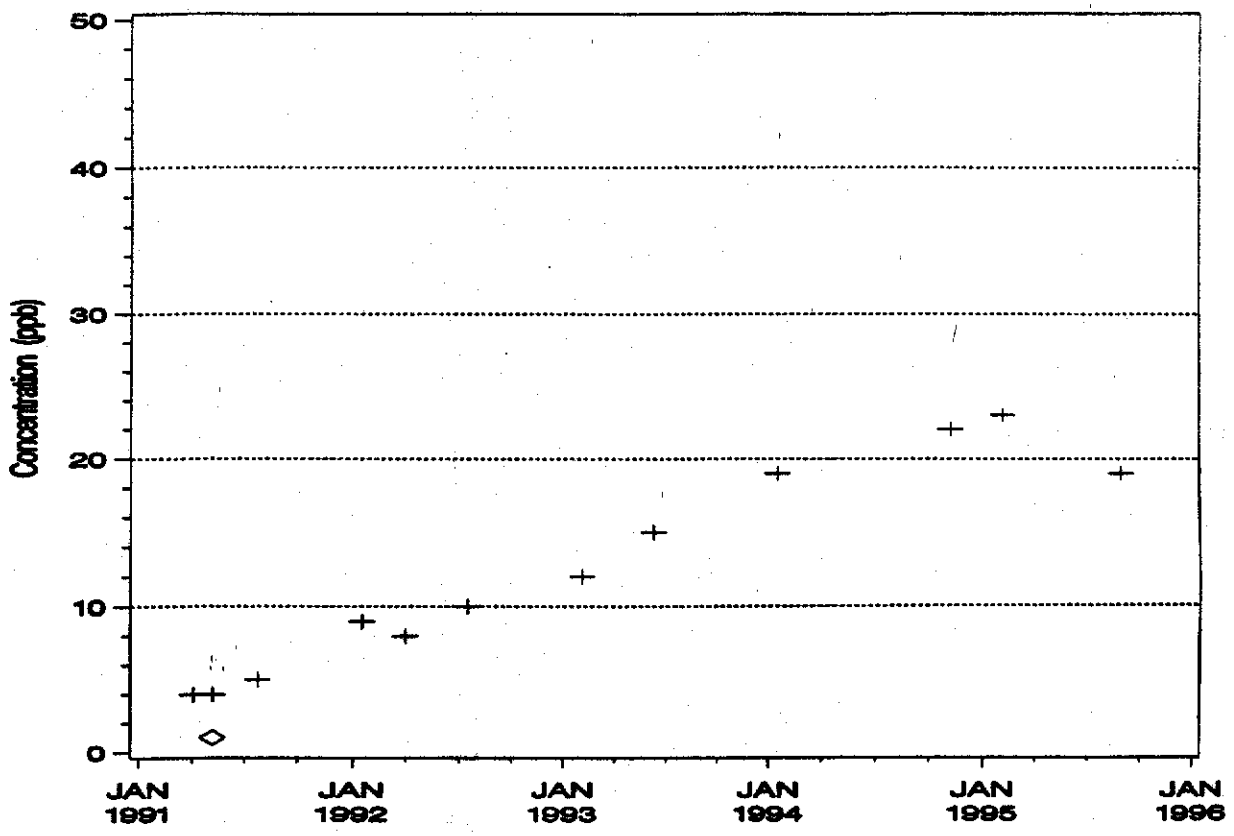


FREON 113 Trend

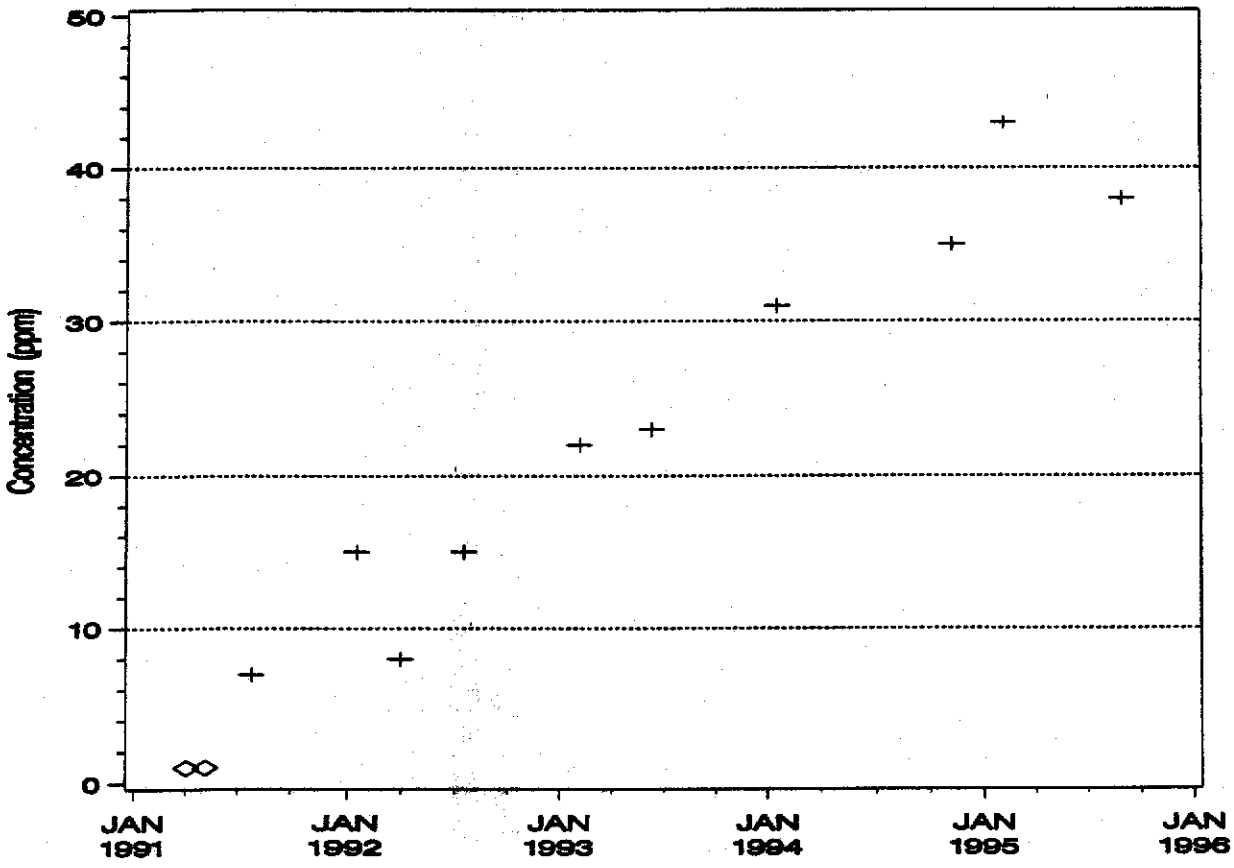


WELL 1401

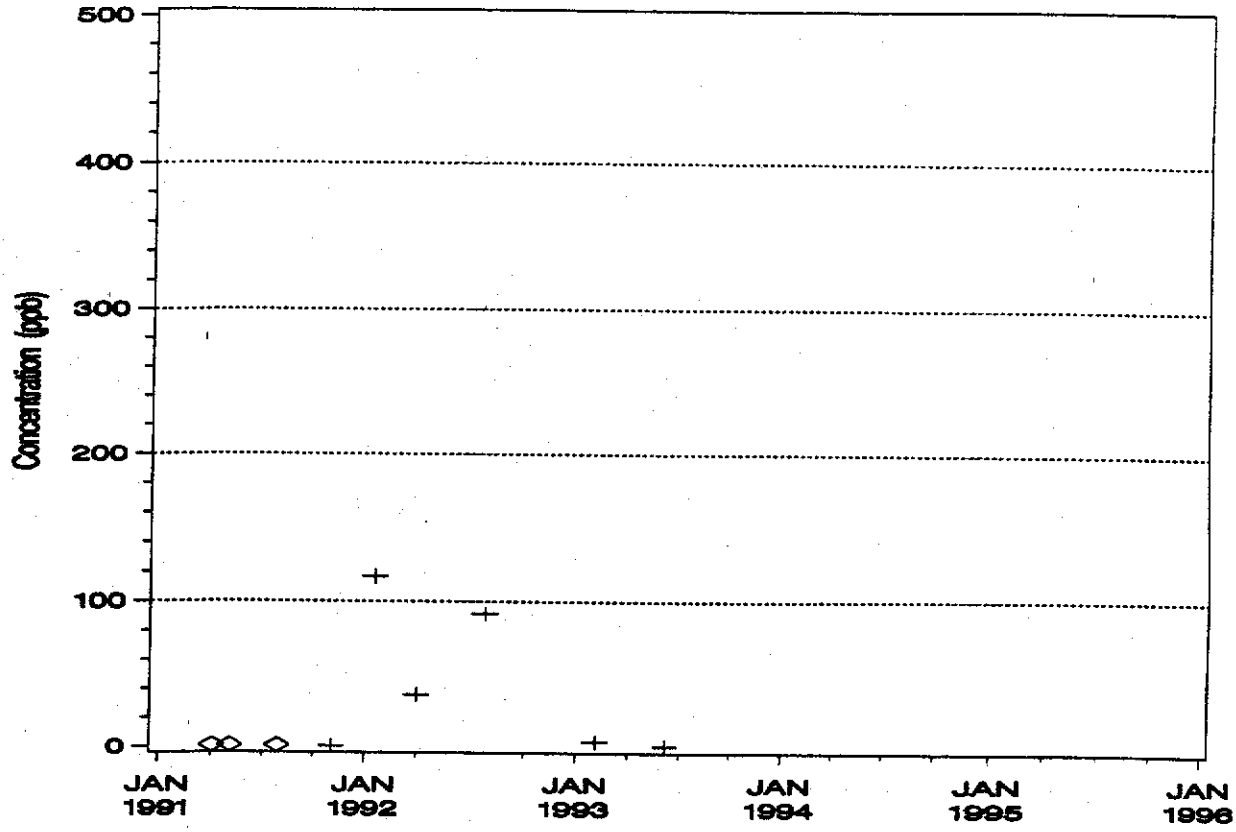
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



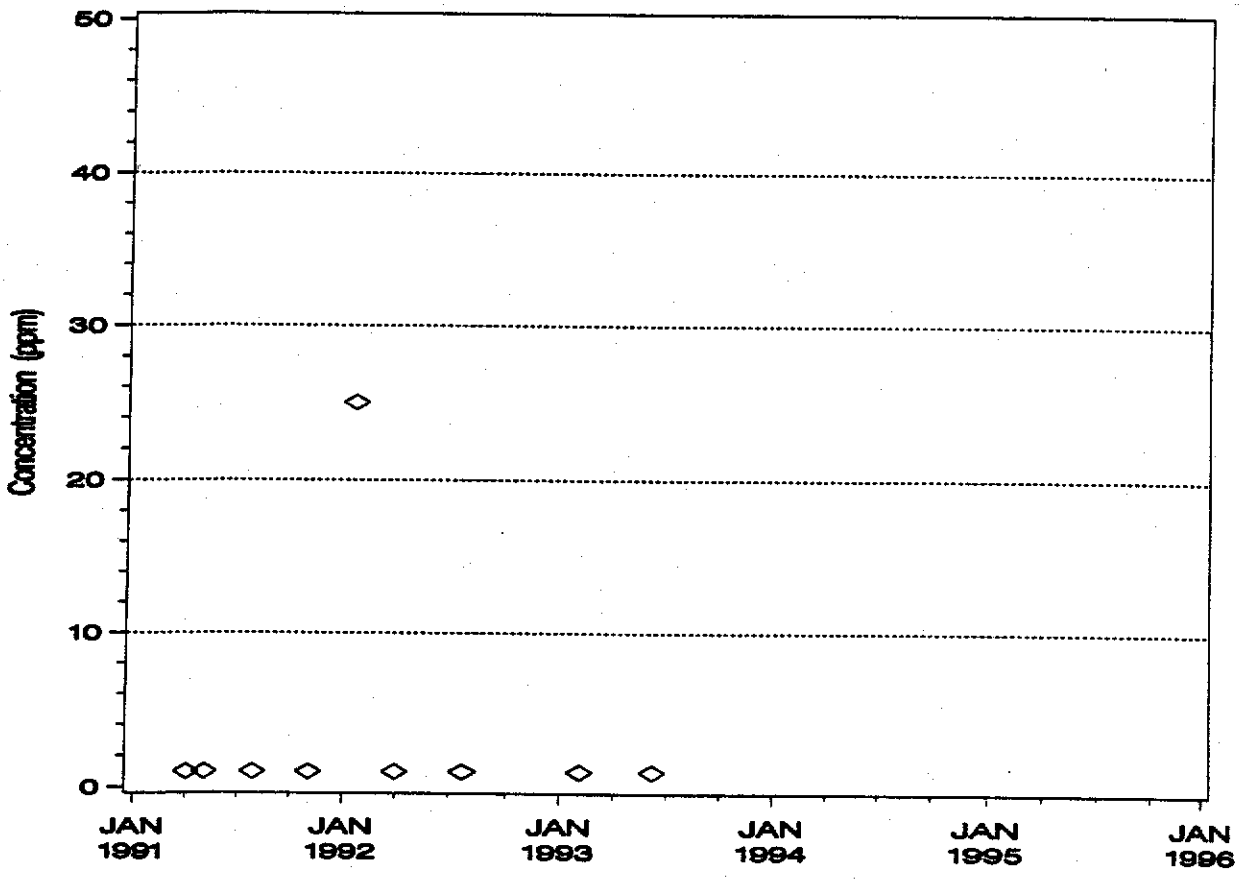
1,1 – DICHLOROETHYLENE Trend



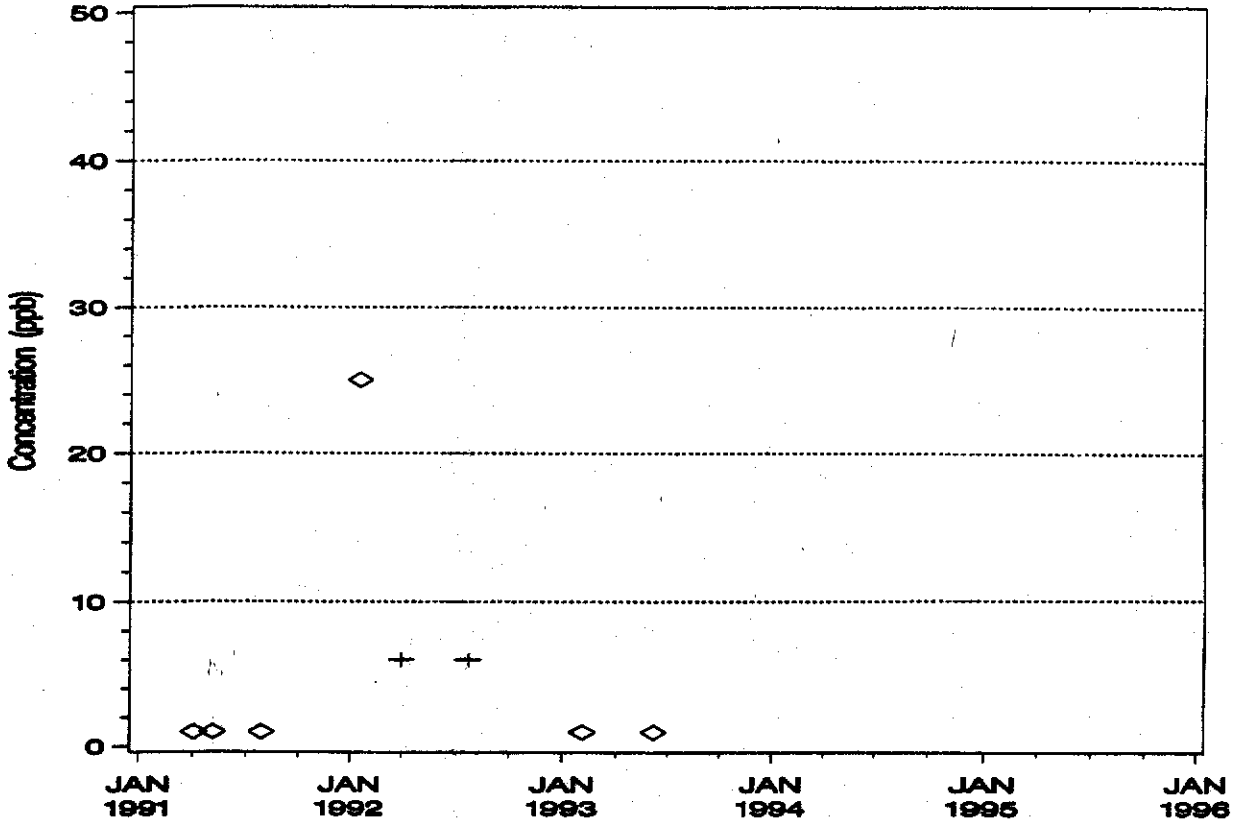
WELL 1402
TRICHLOROETHYLENE Trend



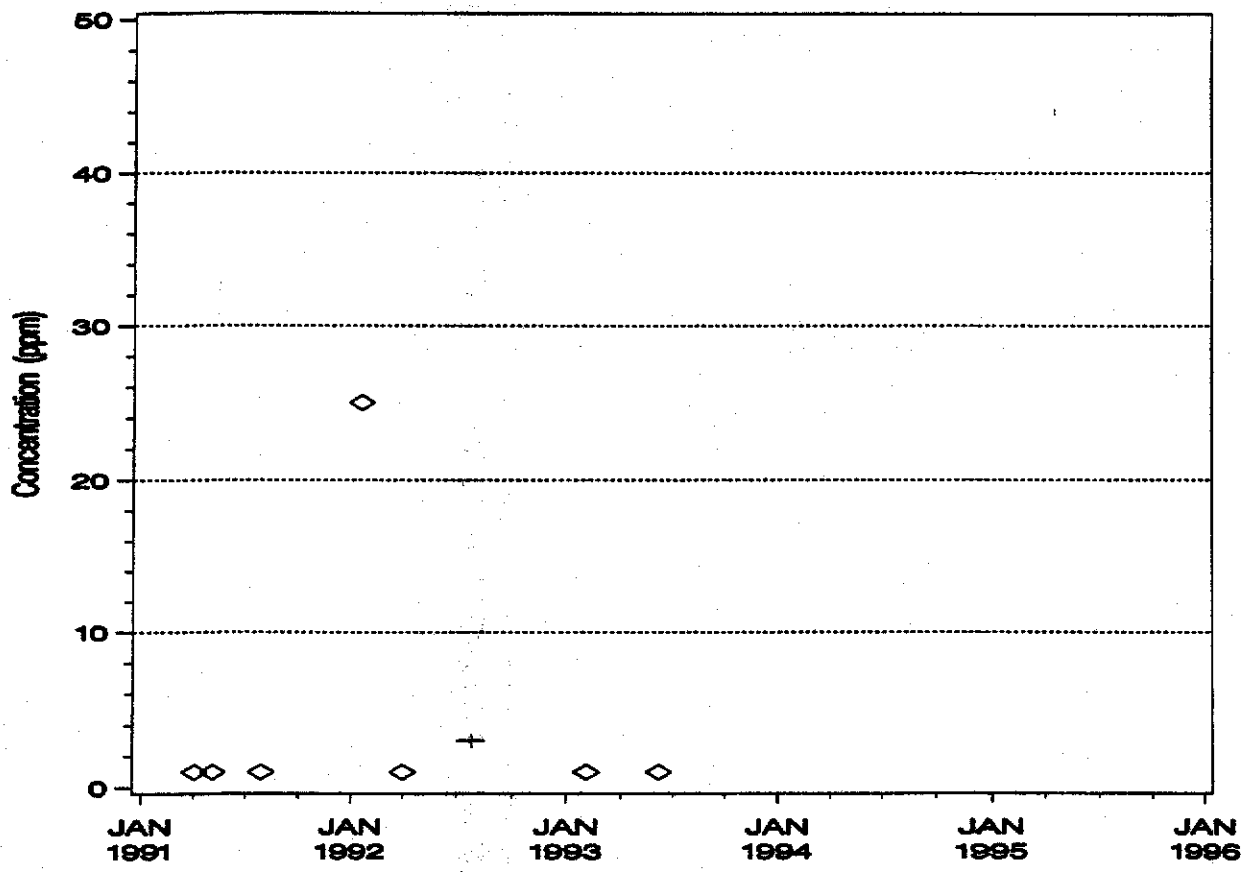
FREON 113 Trend



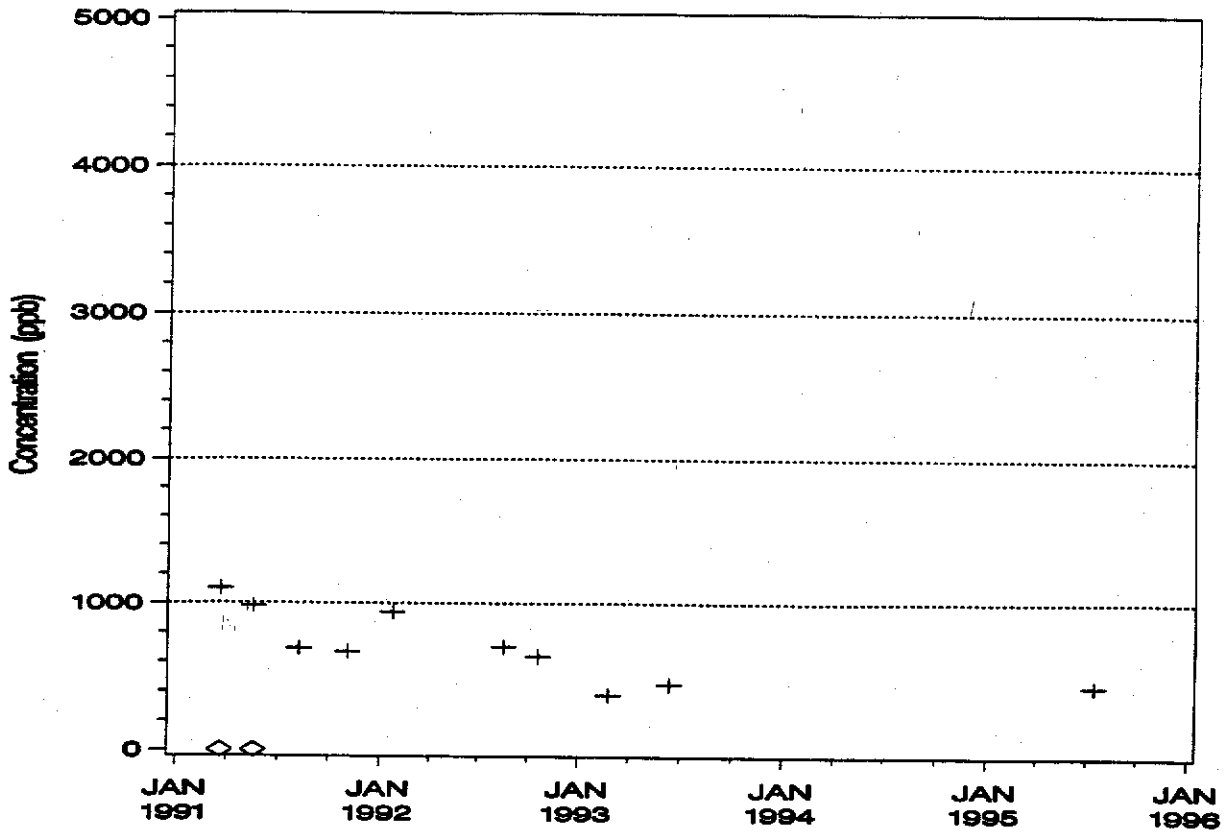
WELL 1402
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



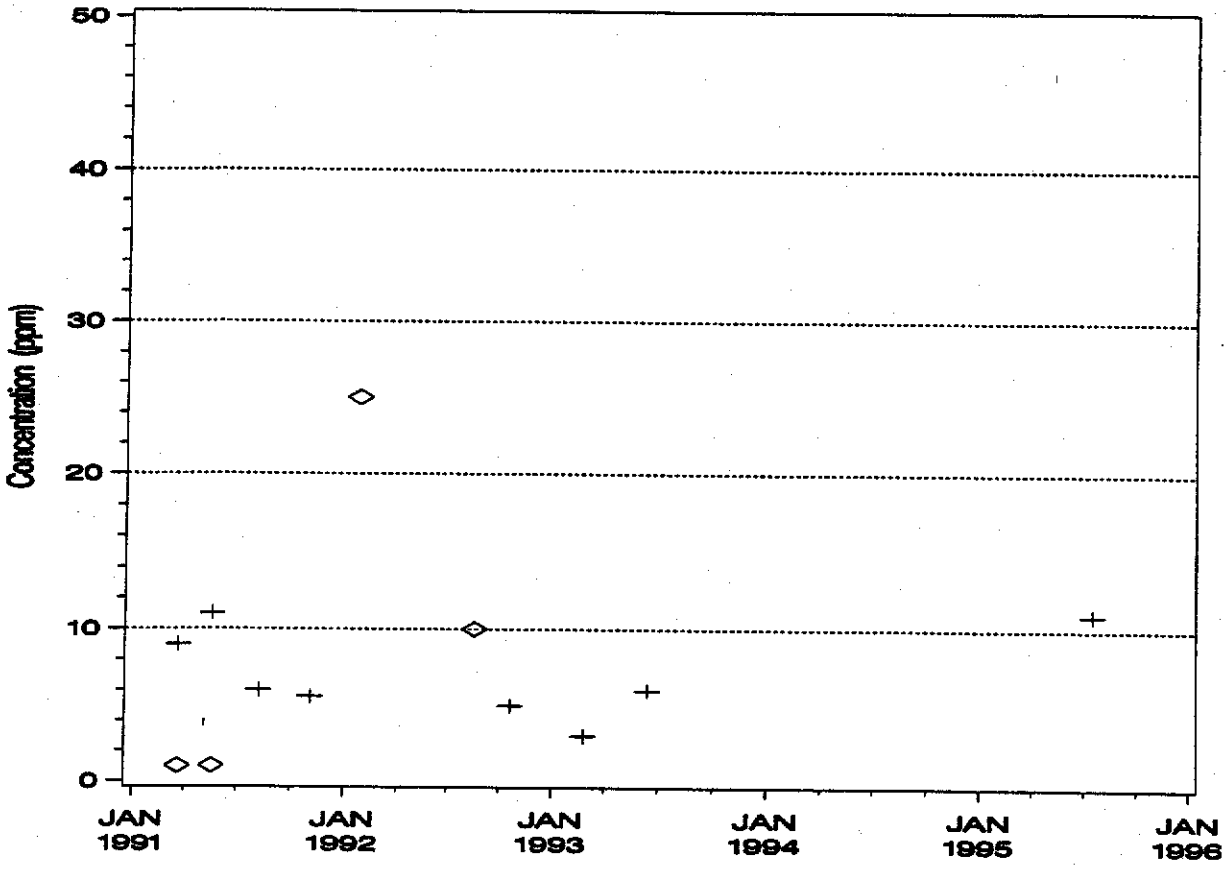
1,1 – DICHLOROETHYLENE Trend



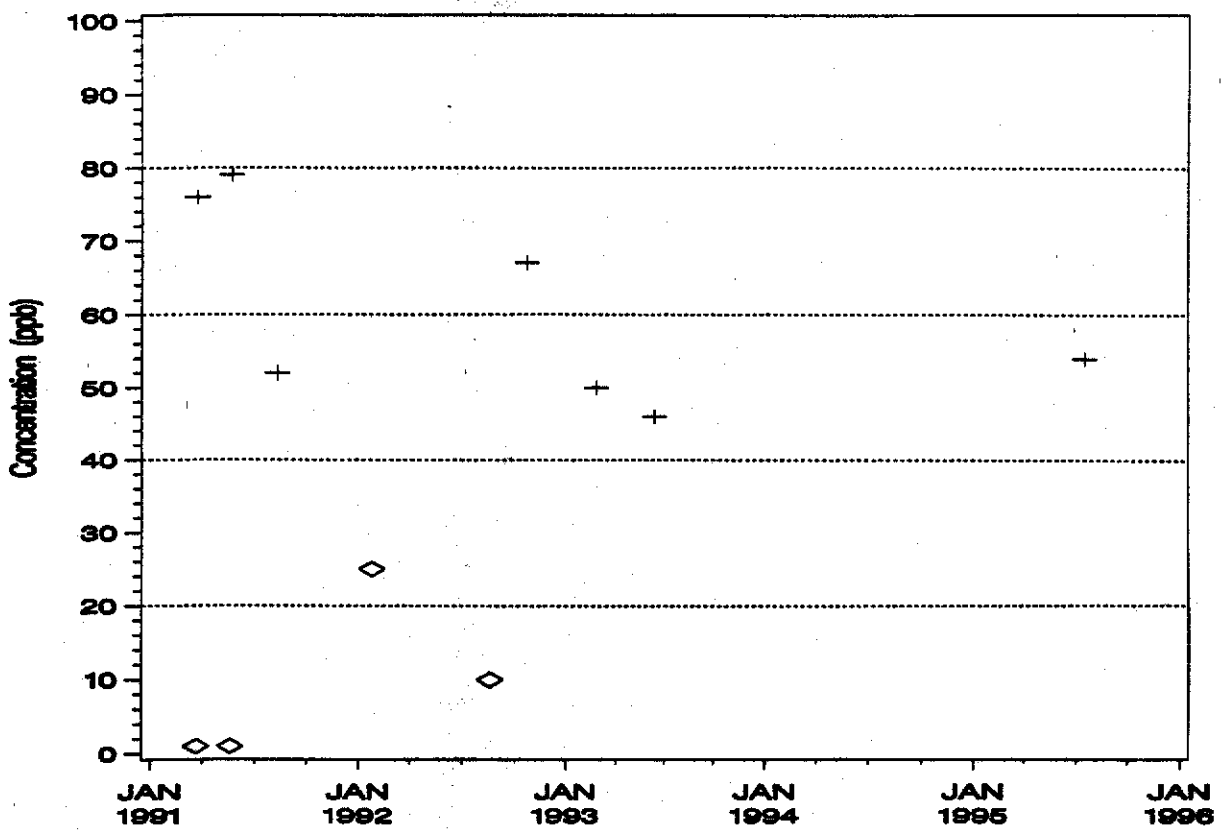
WELL 1403
TRICHLOROETHYLENE Trend



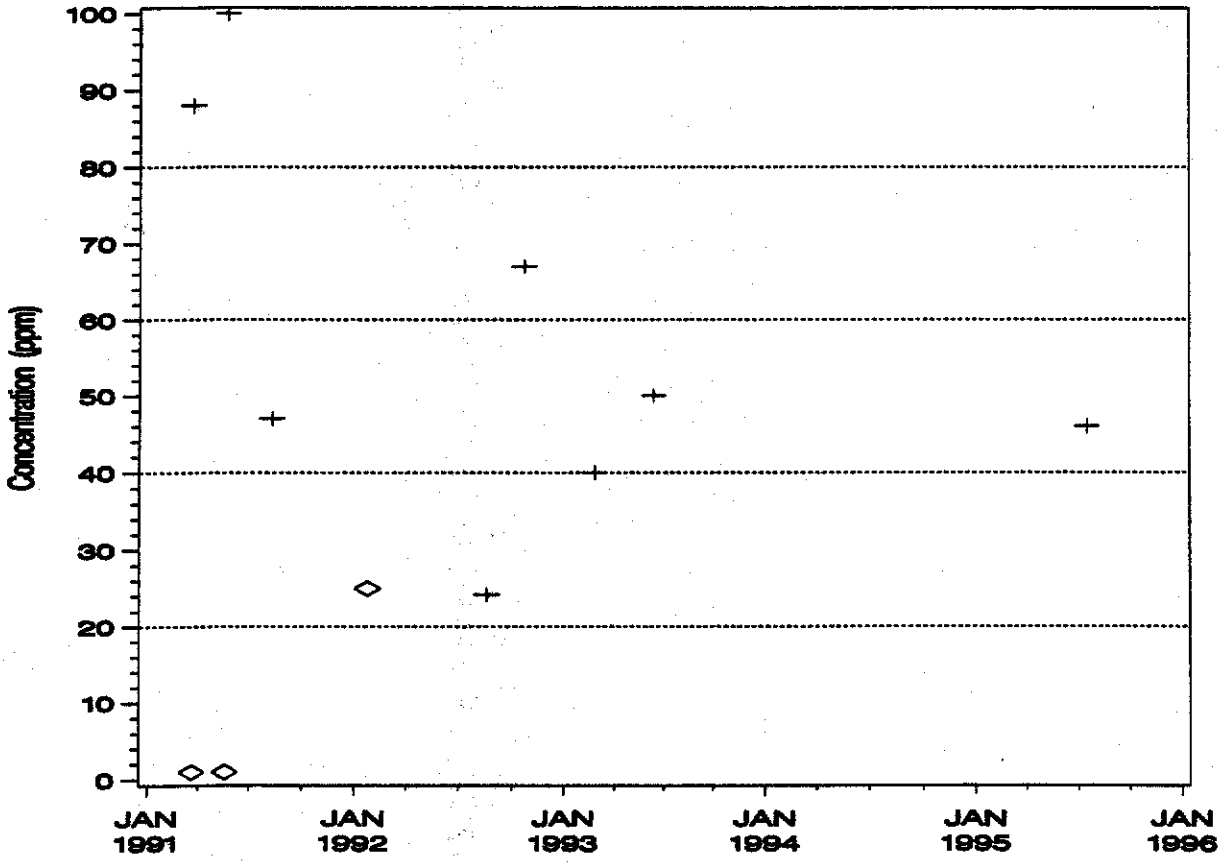
FREON 113 Trend



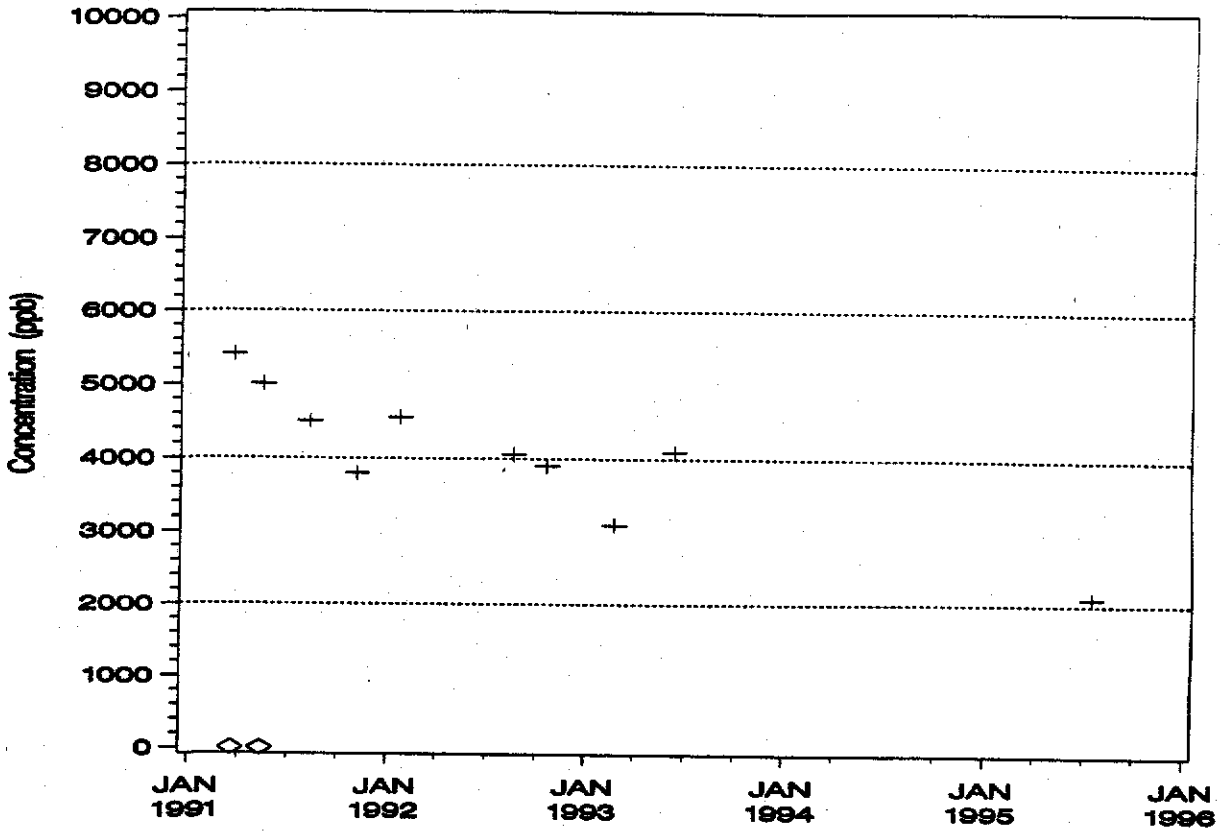
WELL 1403
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



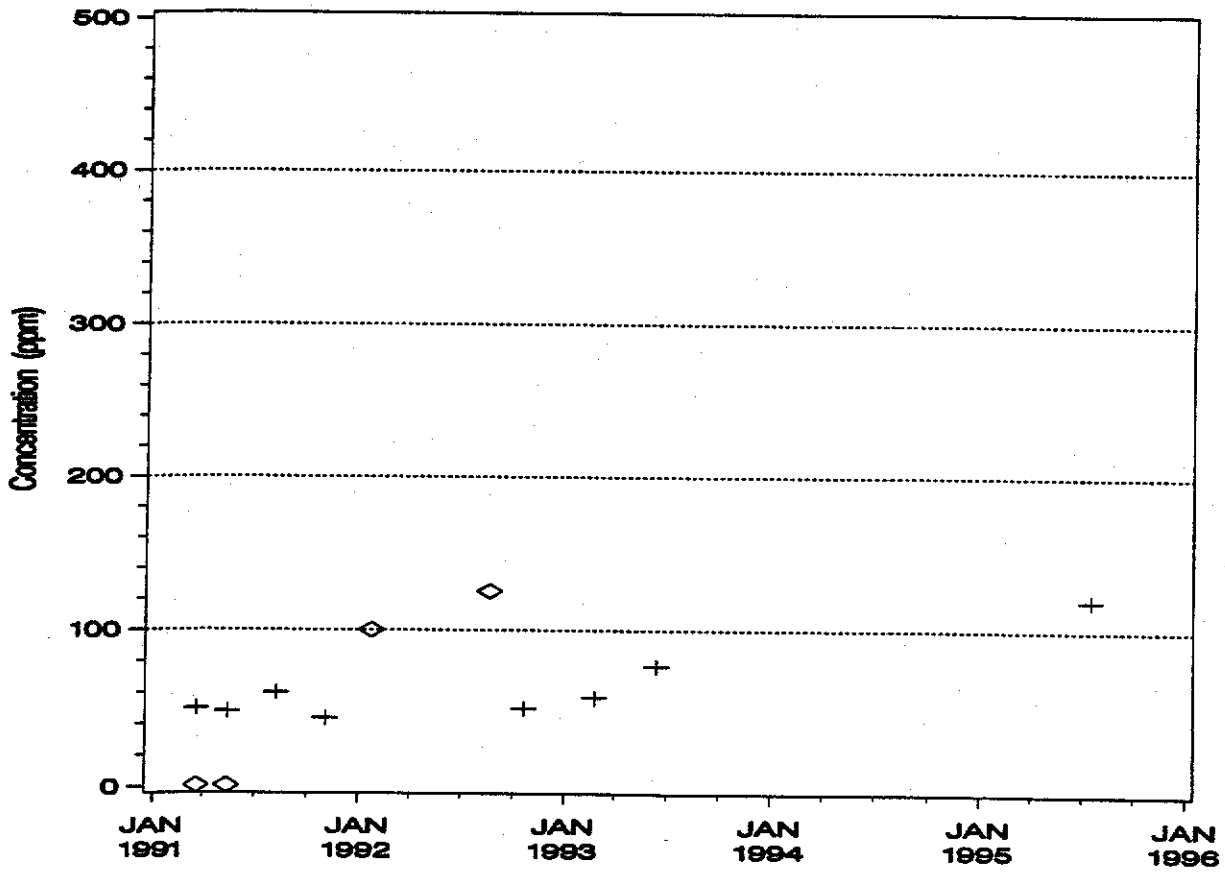
1,1 — DICHLOROETHYLENE Trend



WELL 1404
TRICHLOROETHYLENE Trend

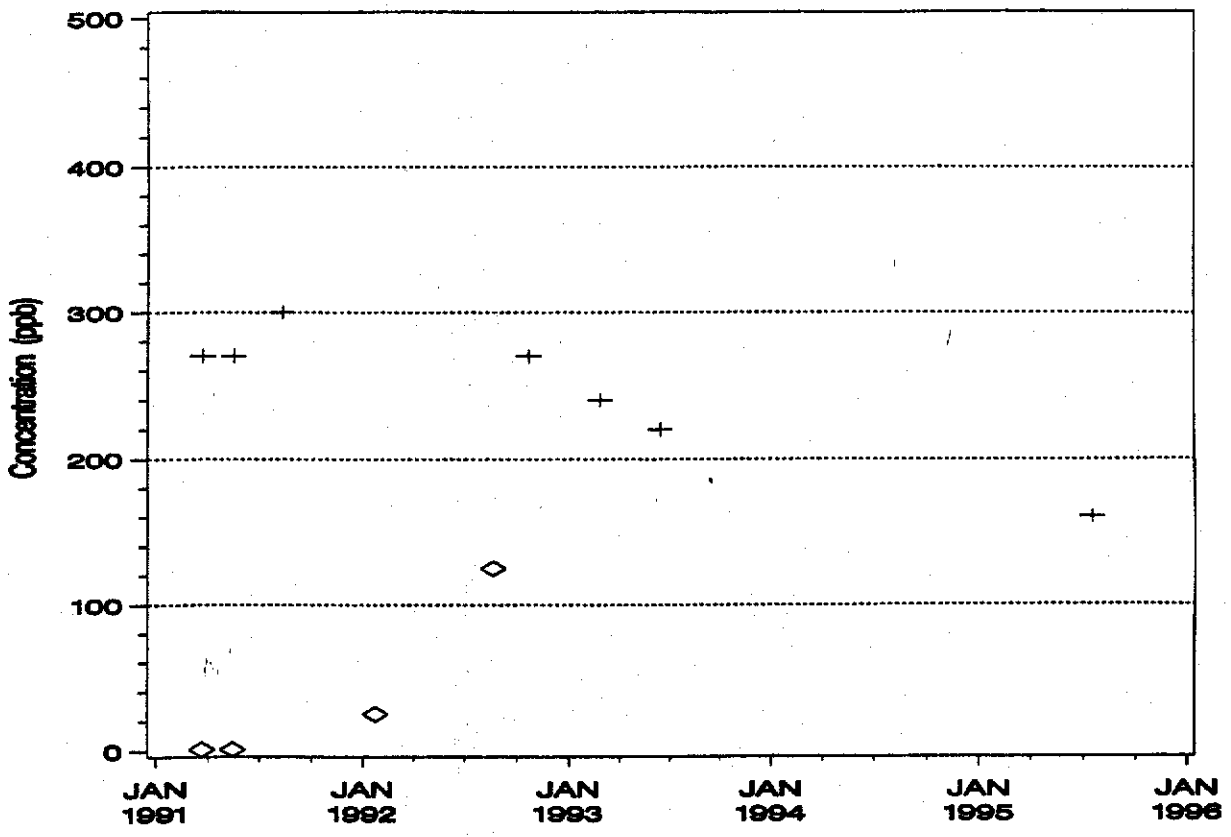


FREON 113 Trend

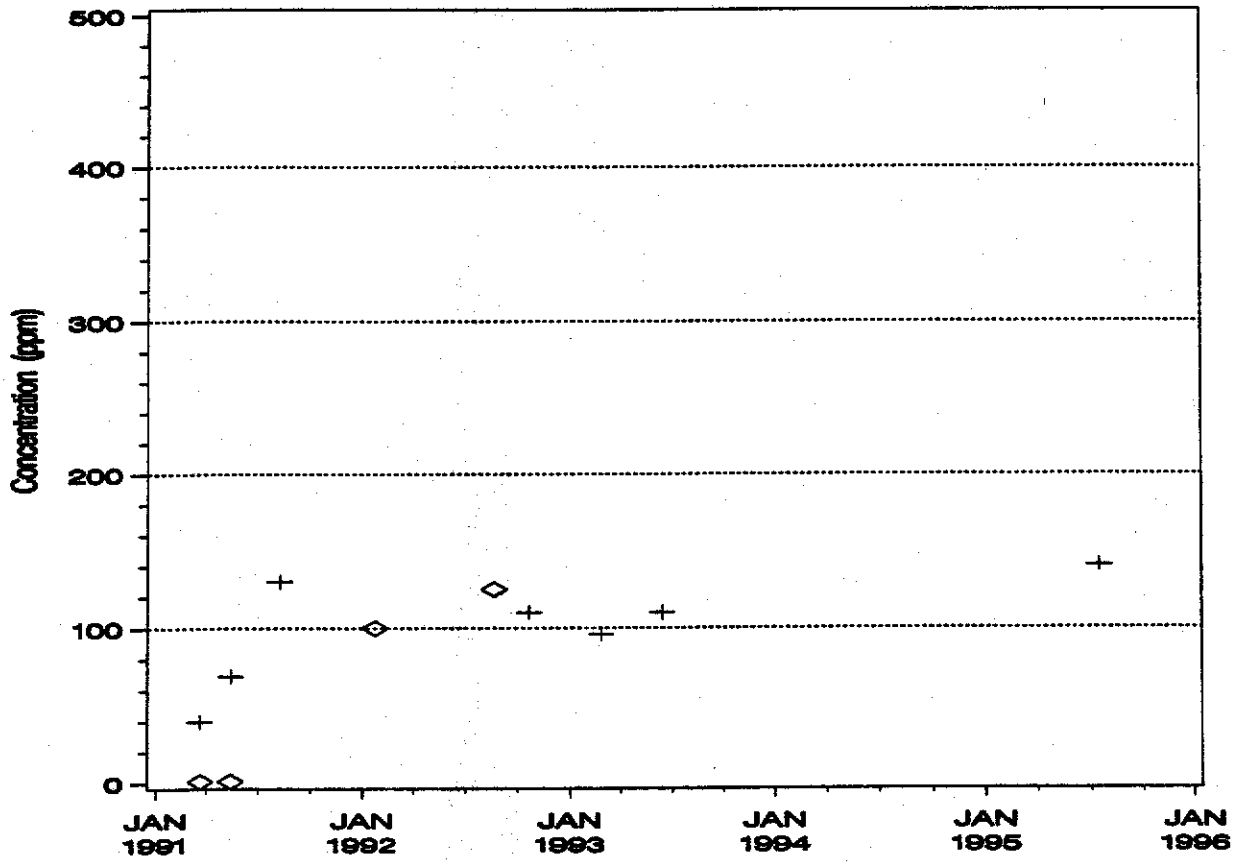


WELL 1404

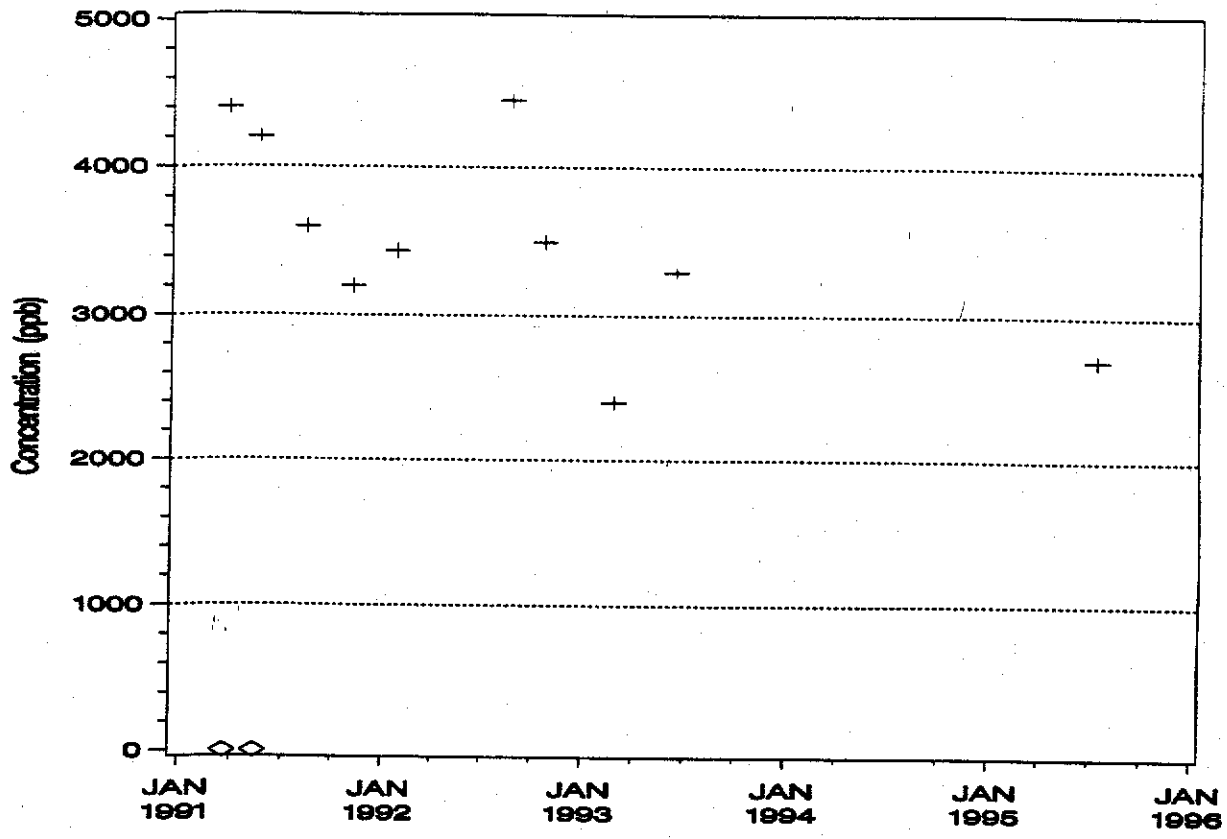
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



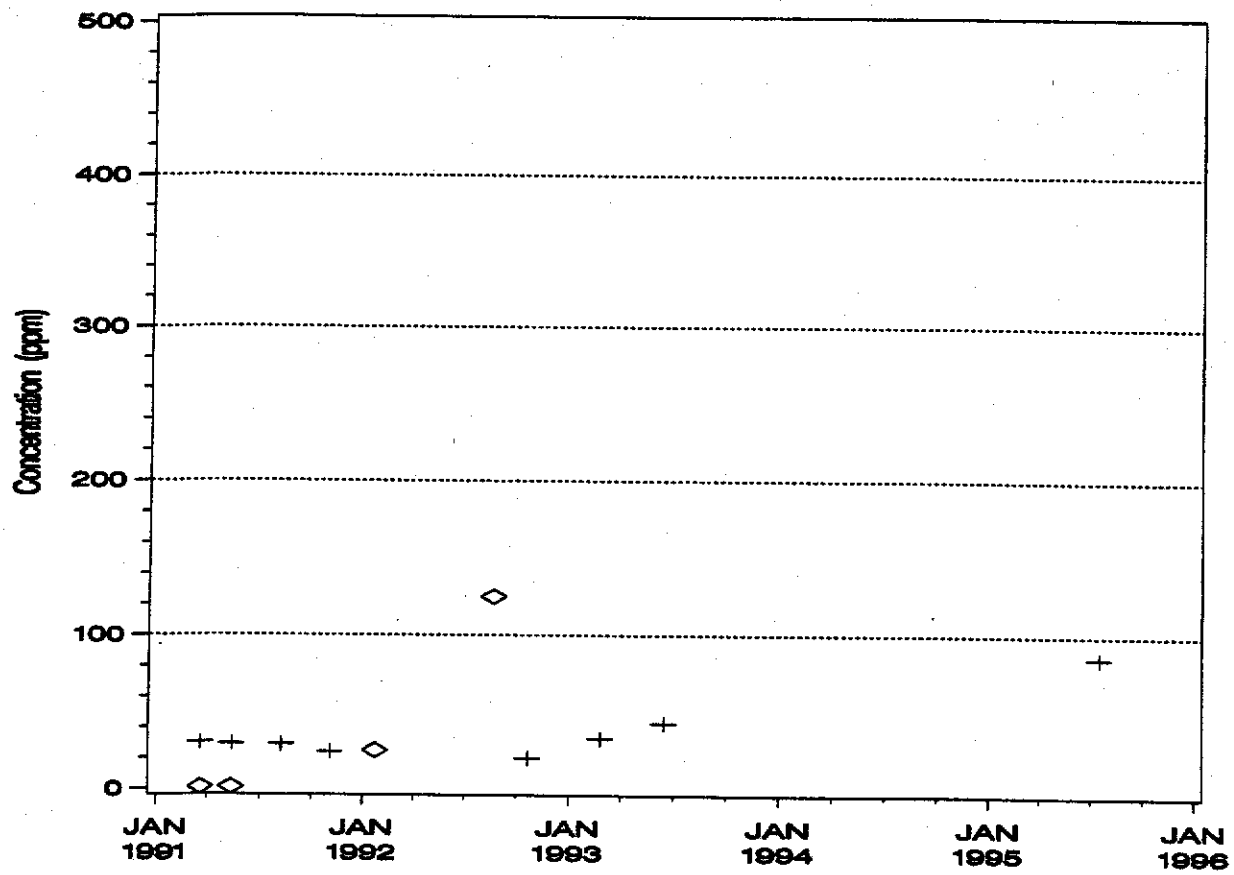
1,1 – DICHLOROETHYLENE Trend



WELL 1405
TRICHLOROETHYLENE Trend

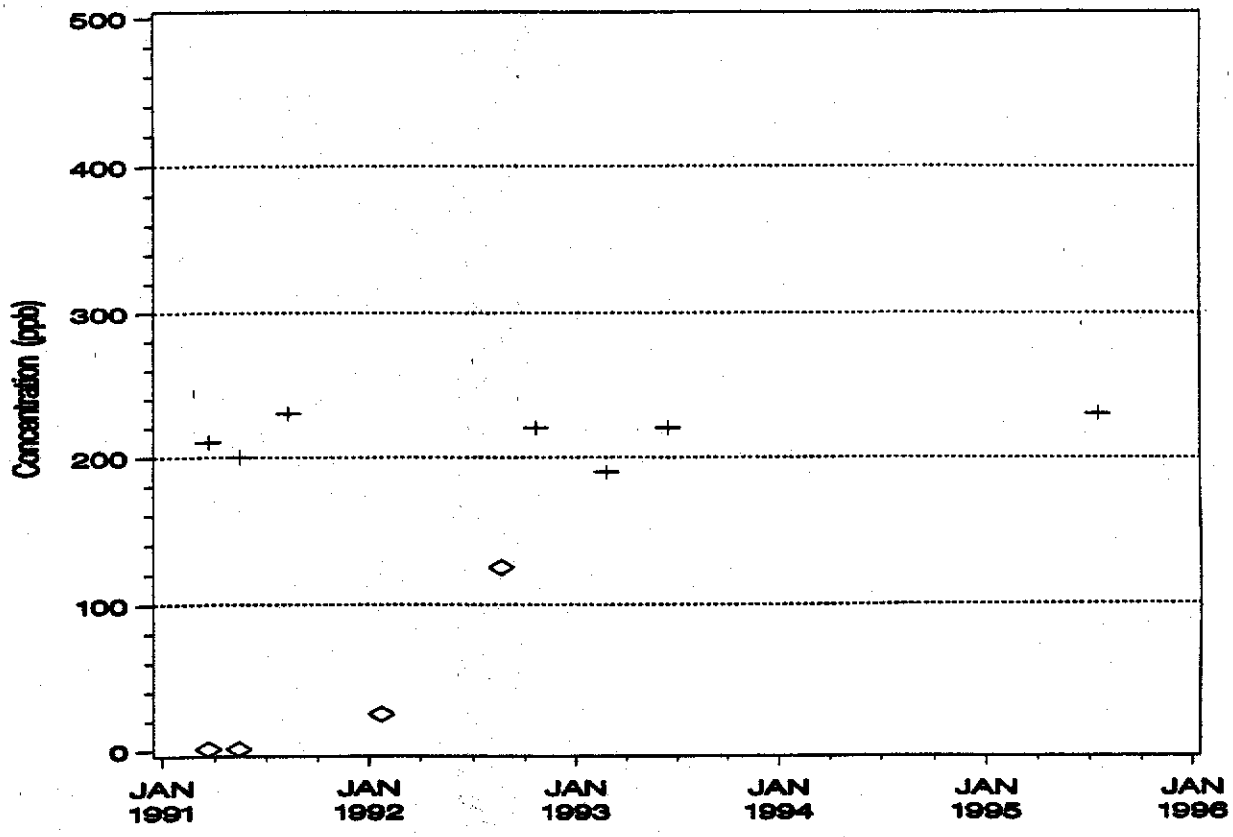


FREON 113 Trend

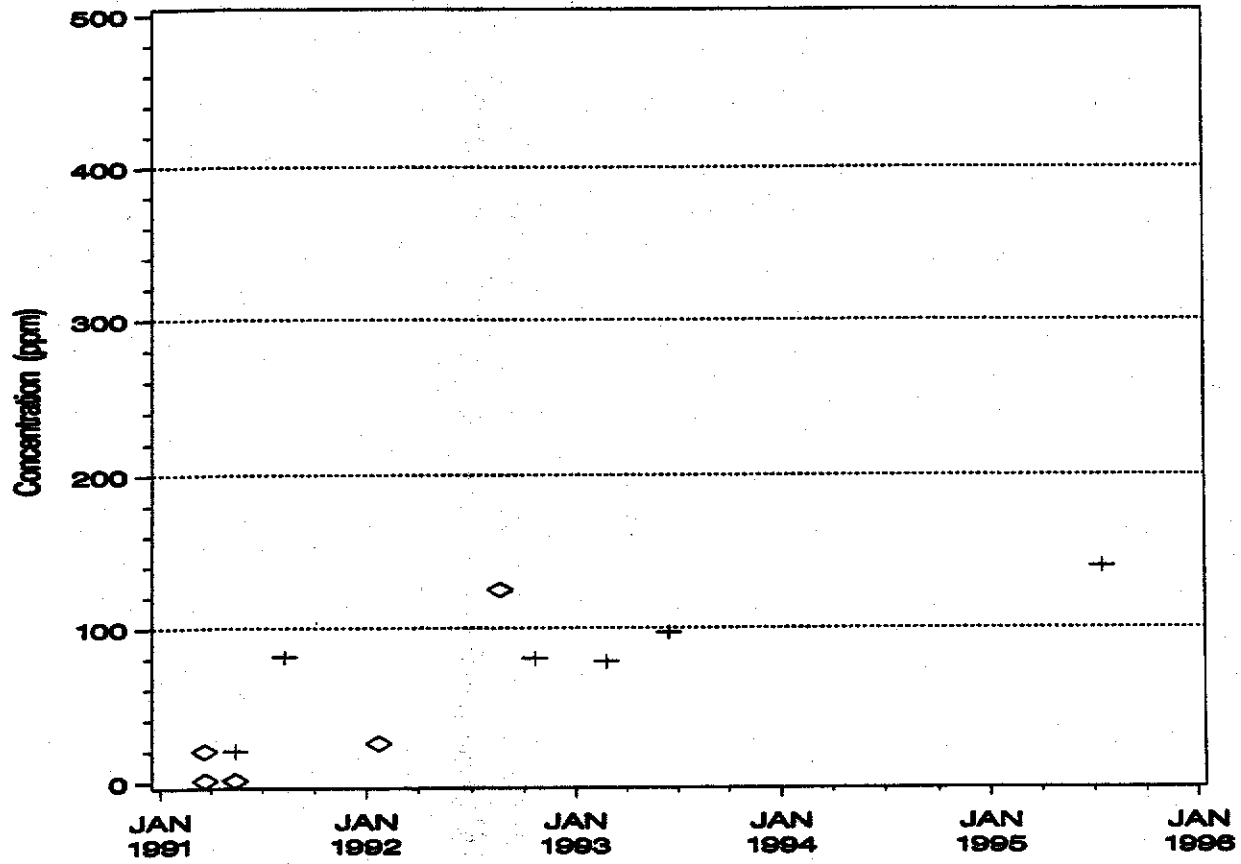


WELL 1405

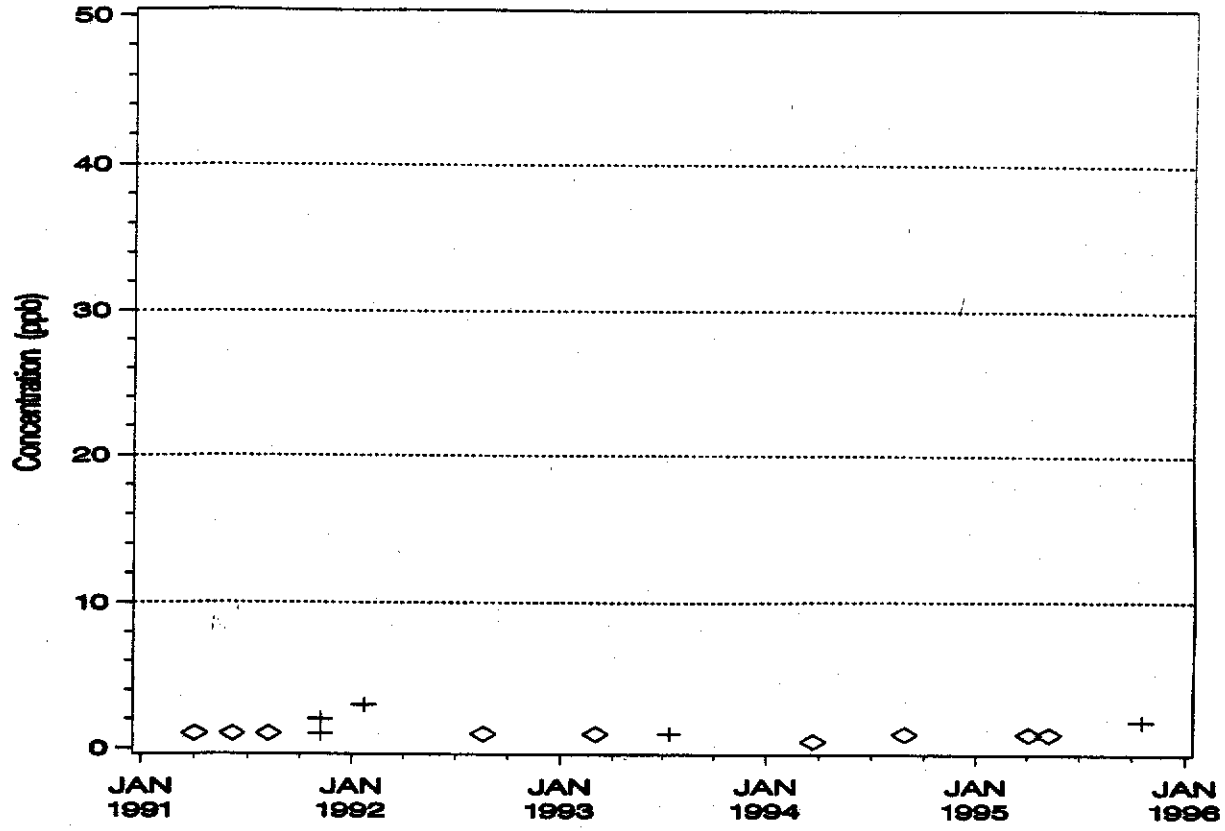
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



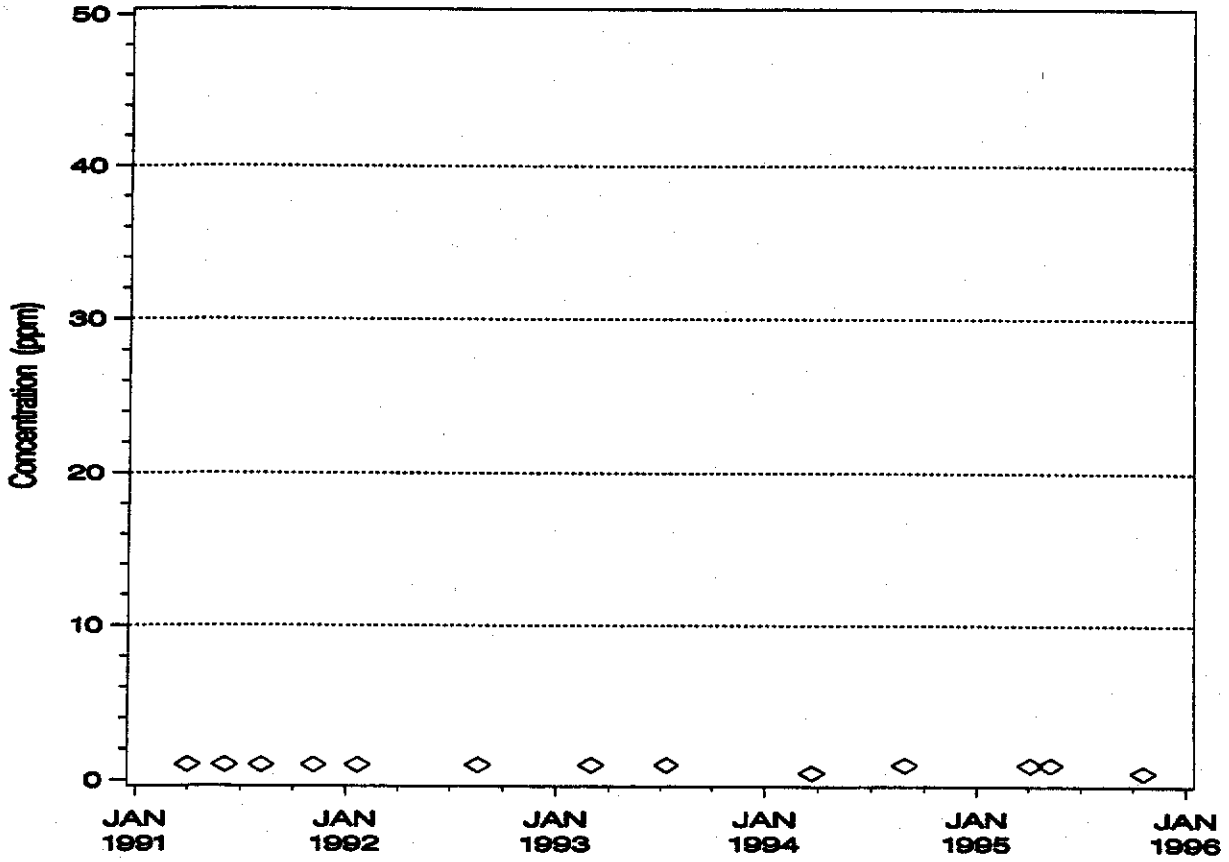
1,1 – DICHLOROETHYLENE Trend



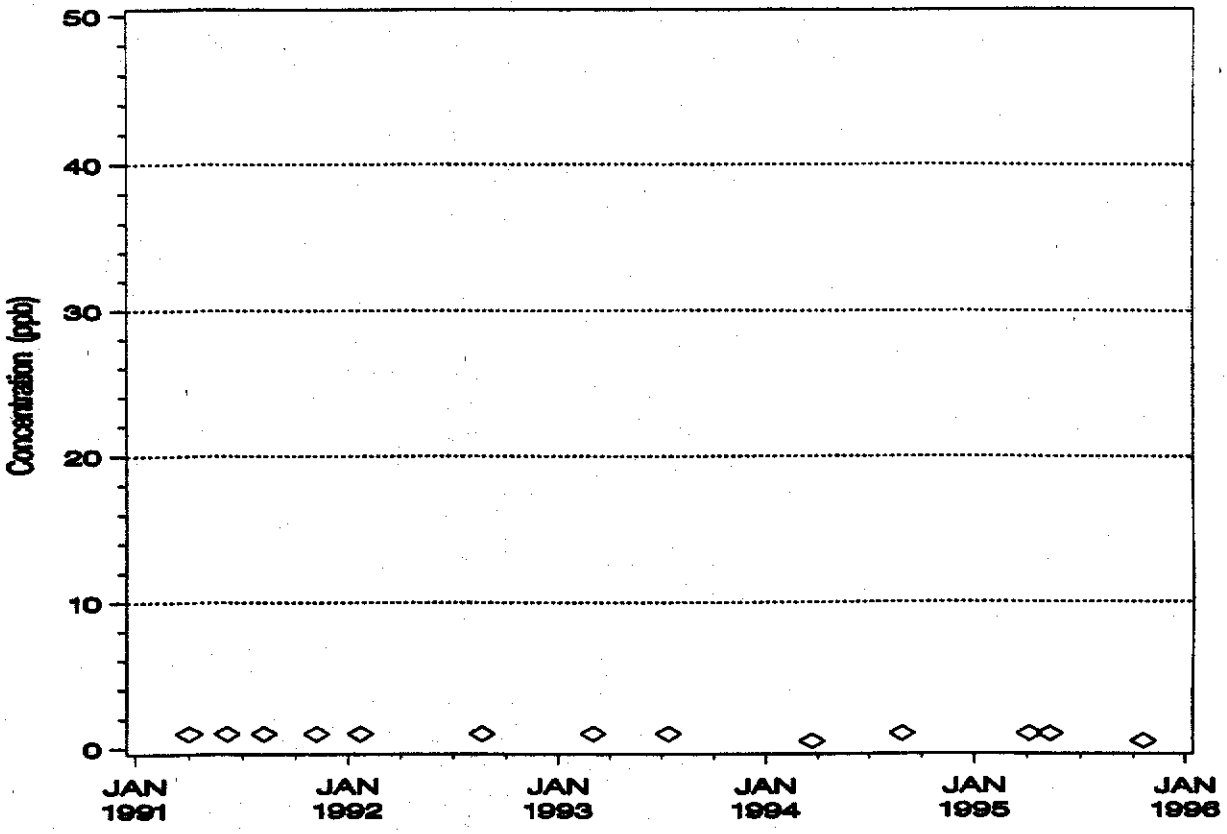
WELL 1406
TRICHLOROETHYLENE Trend



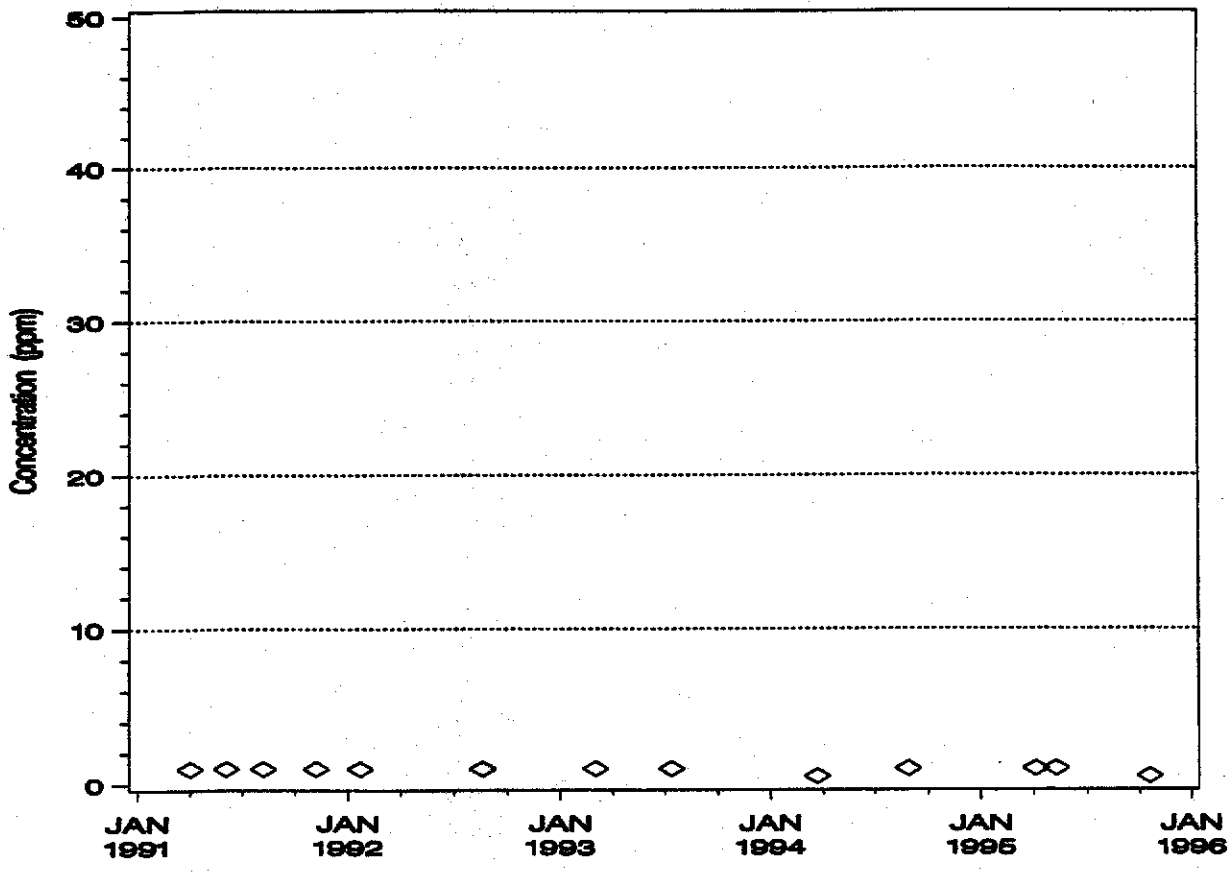
FREON 113 Trend



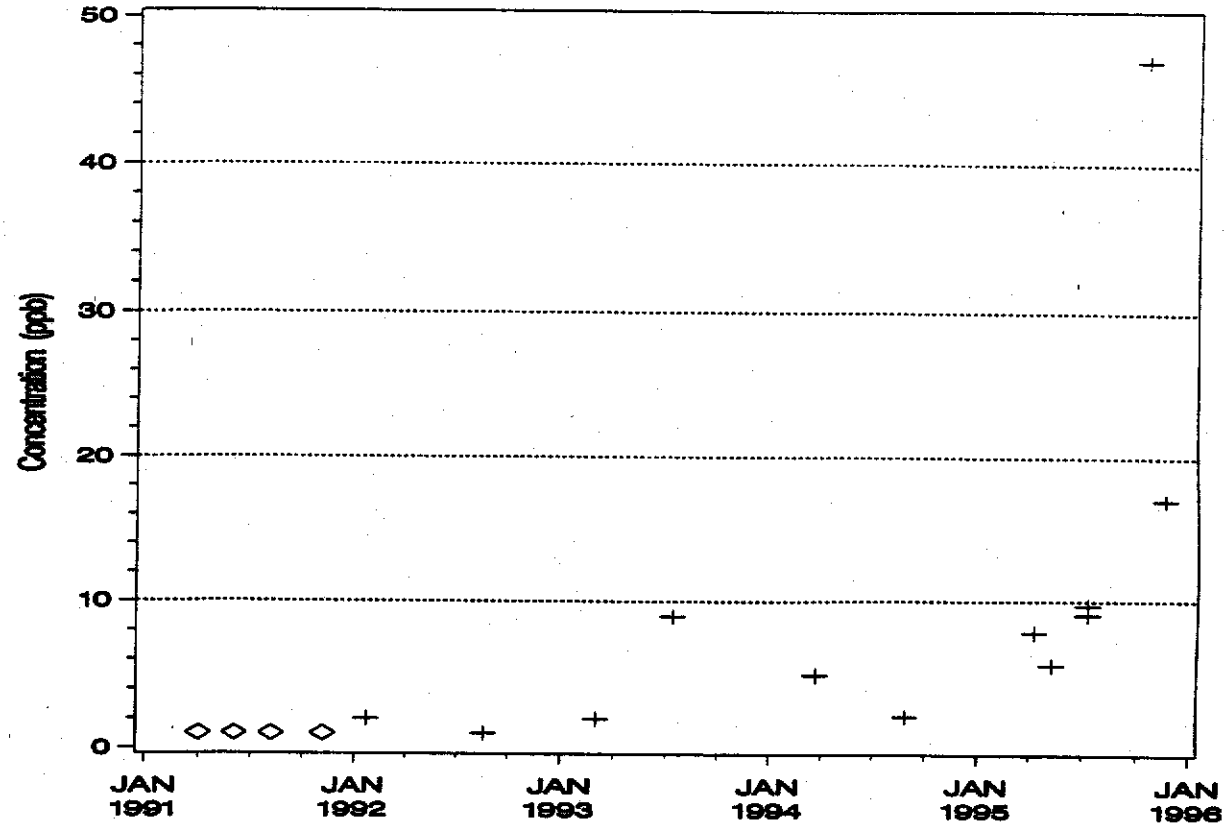
WELL 1406
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



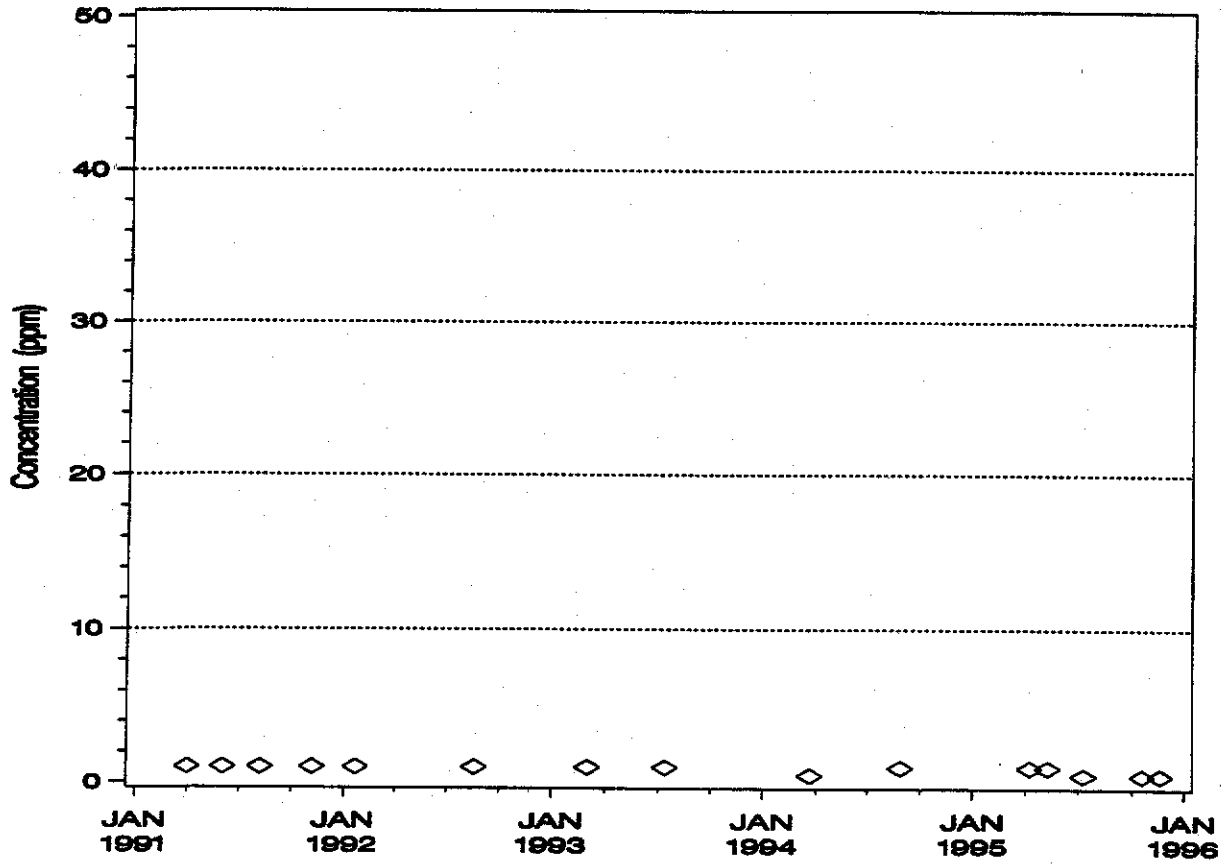
1,1 – DICHLOROETHYLENE Trend



WELL 1407
TRICHLOROETHYLENE Trend

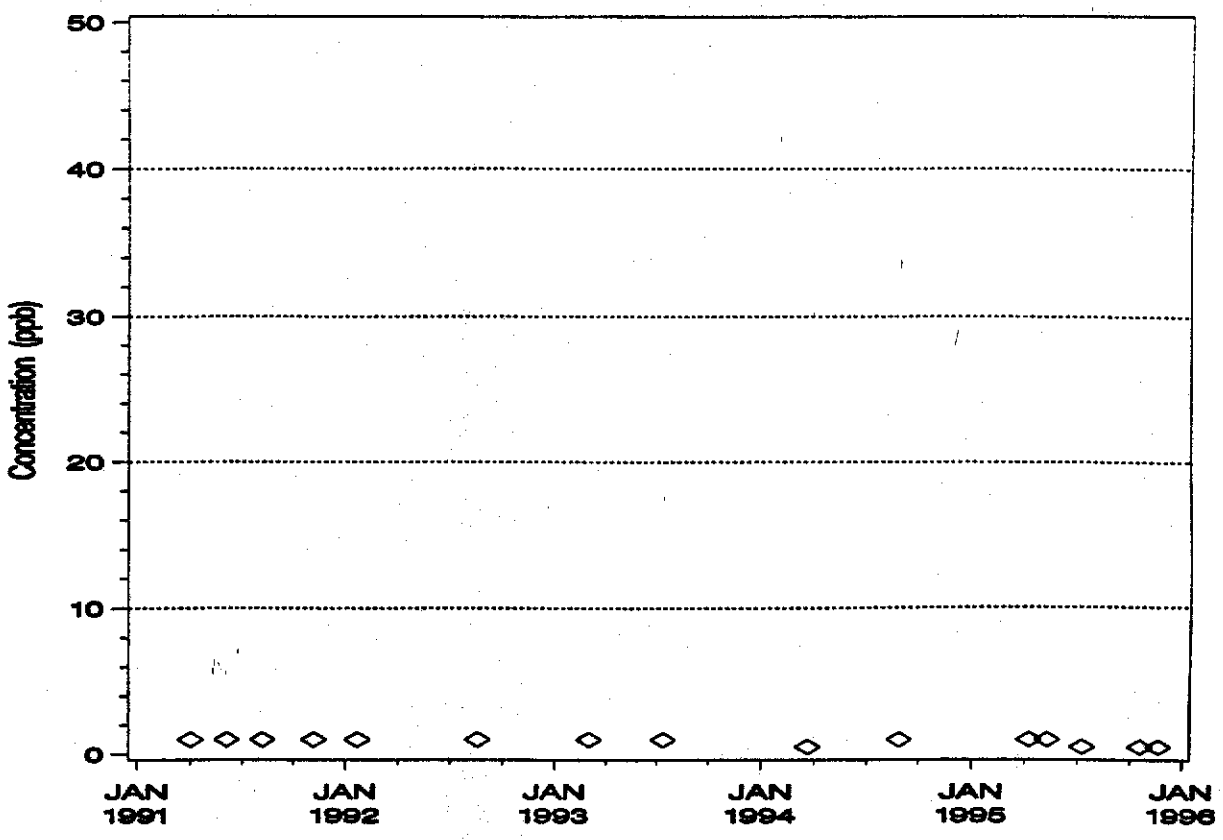


FREON 113 Trend

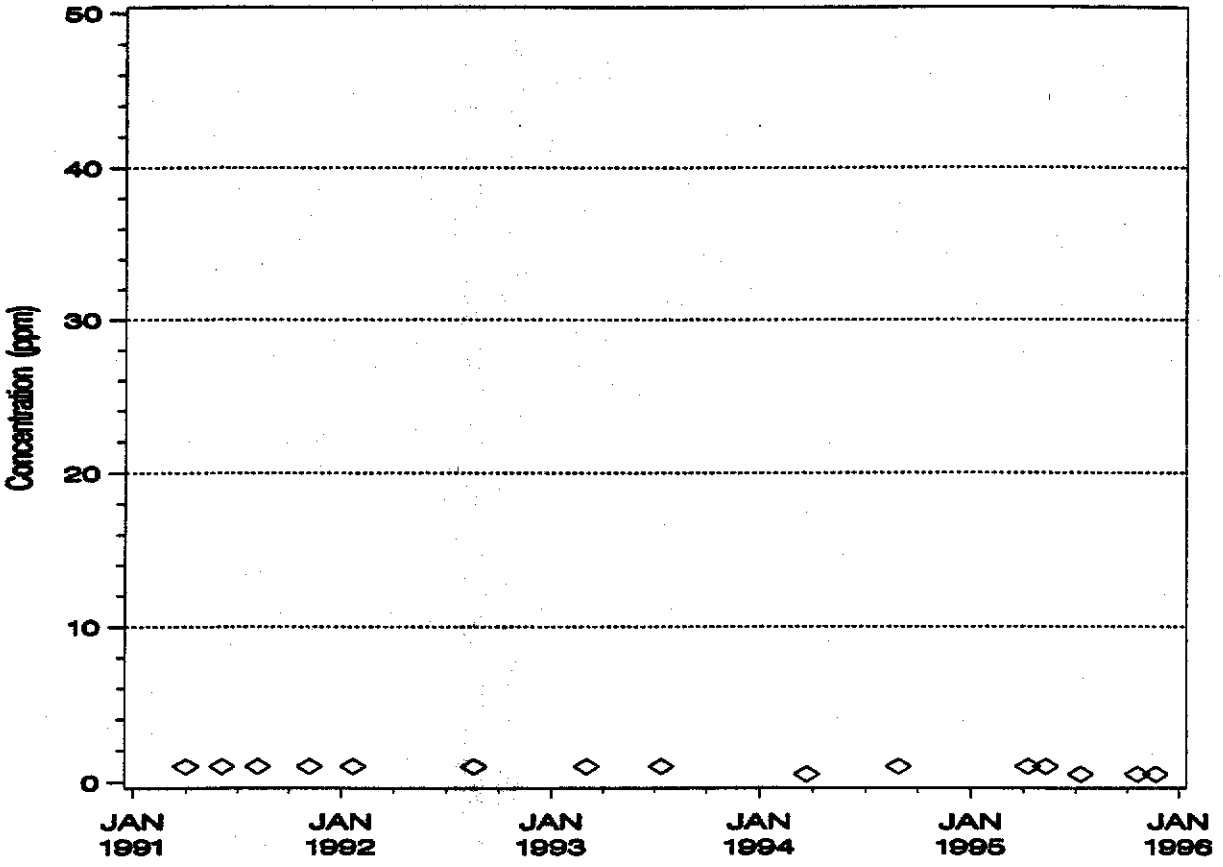


WELL 1407

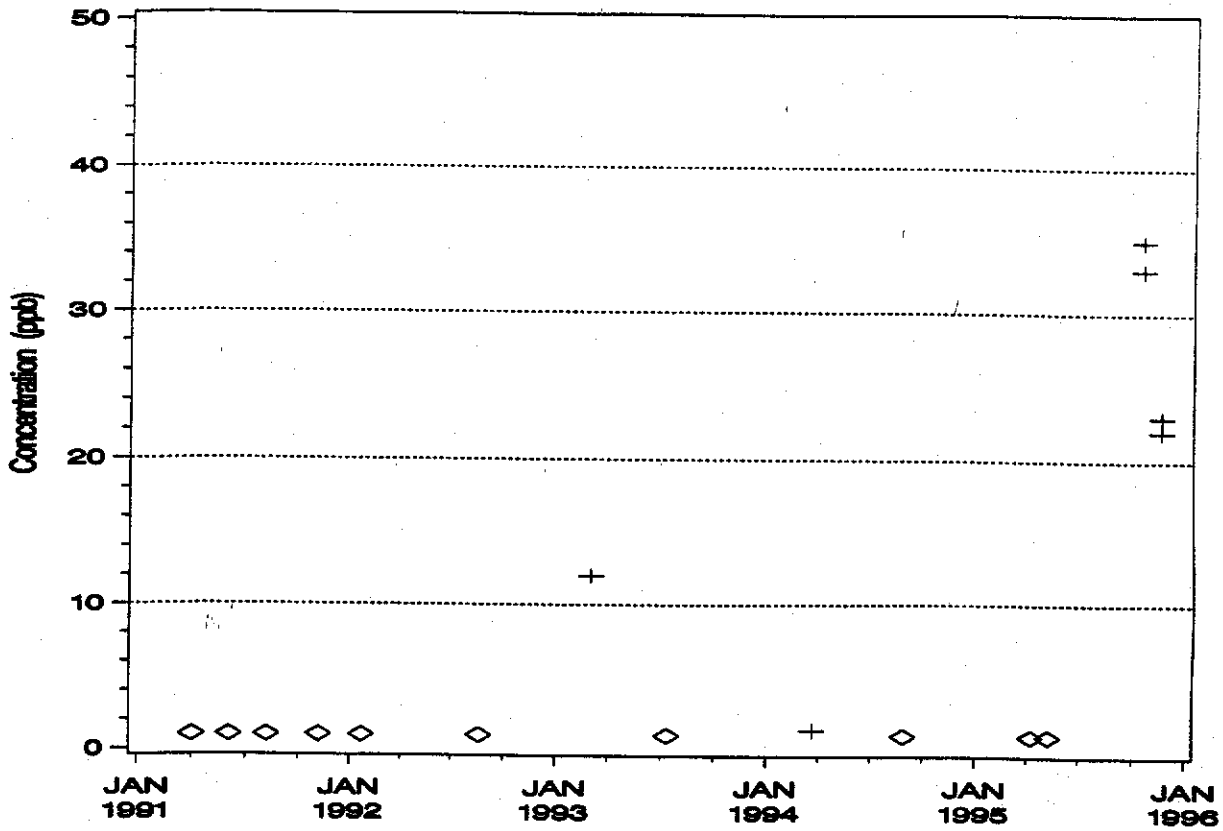
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



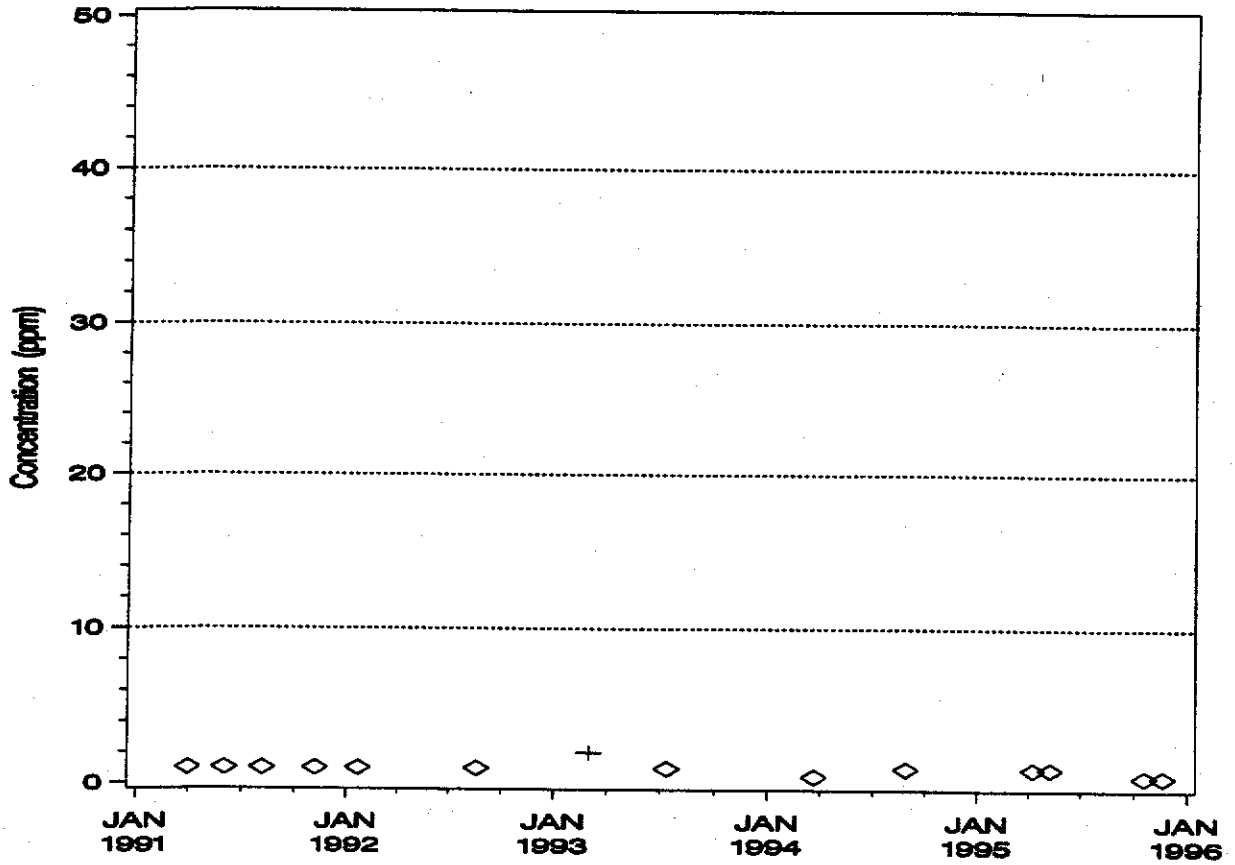
1,1 – DICHLOROETHYLENE Trend



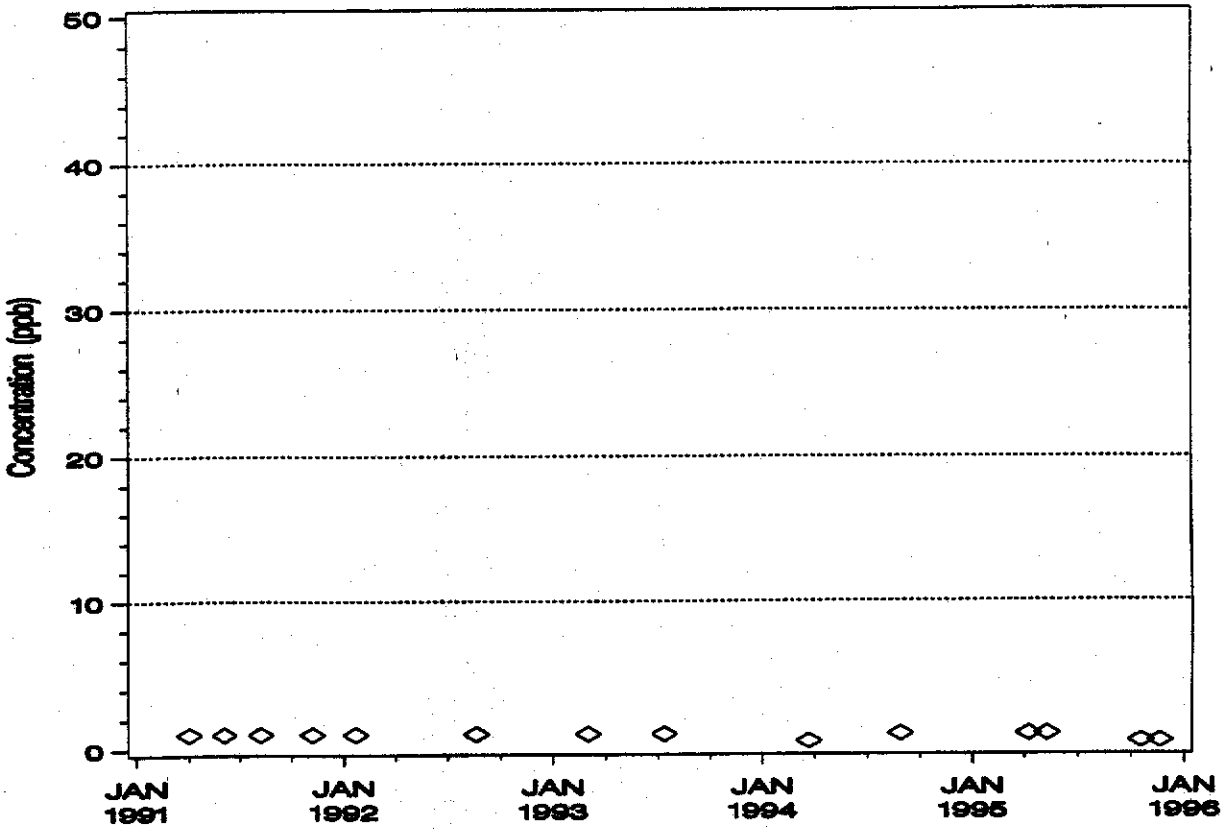
WELL 1408
TRICHLOROETHYLENE Trend



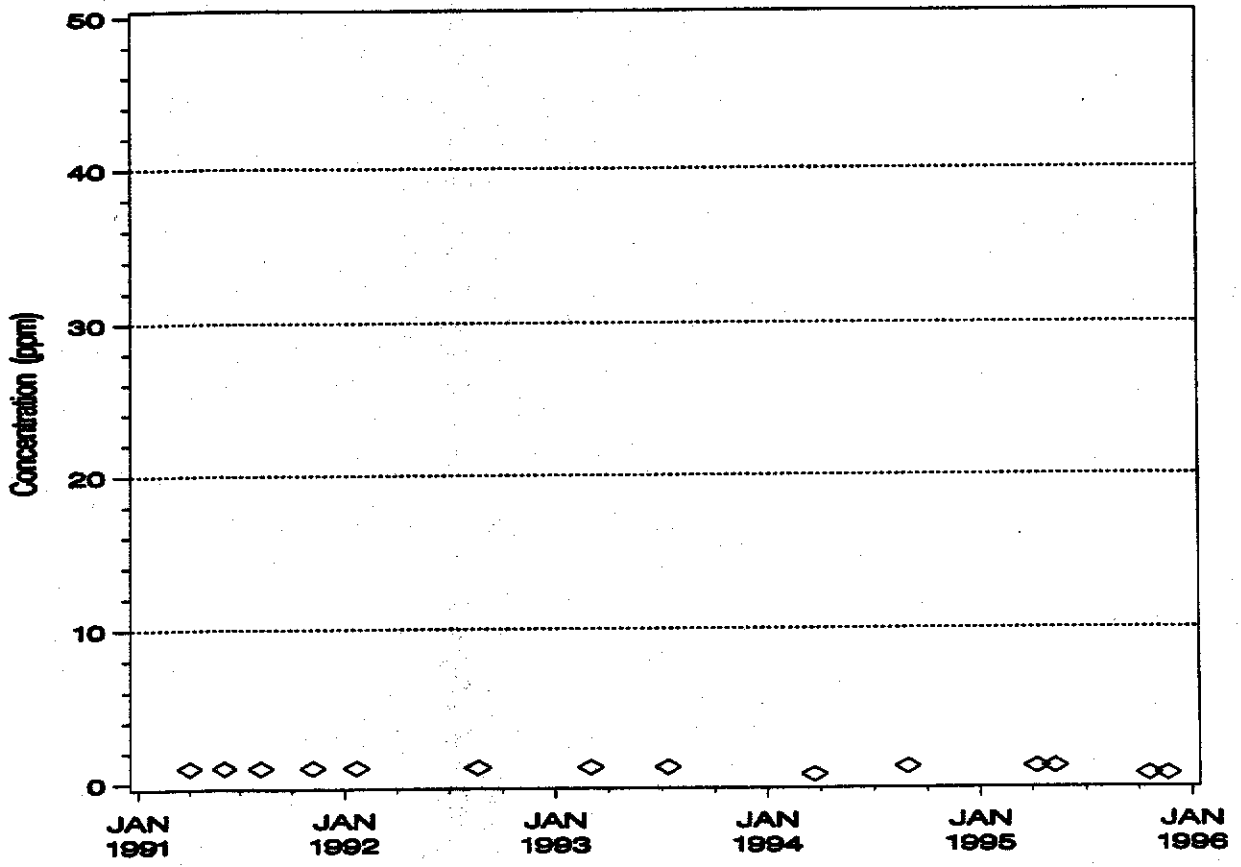
FREON 113 Trend



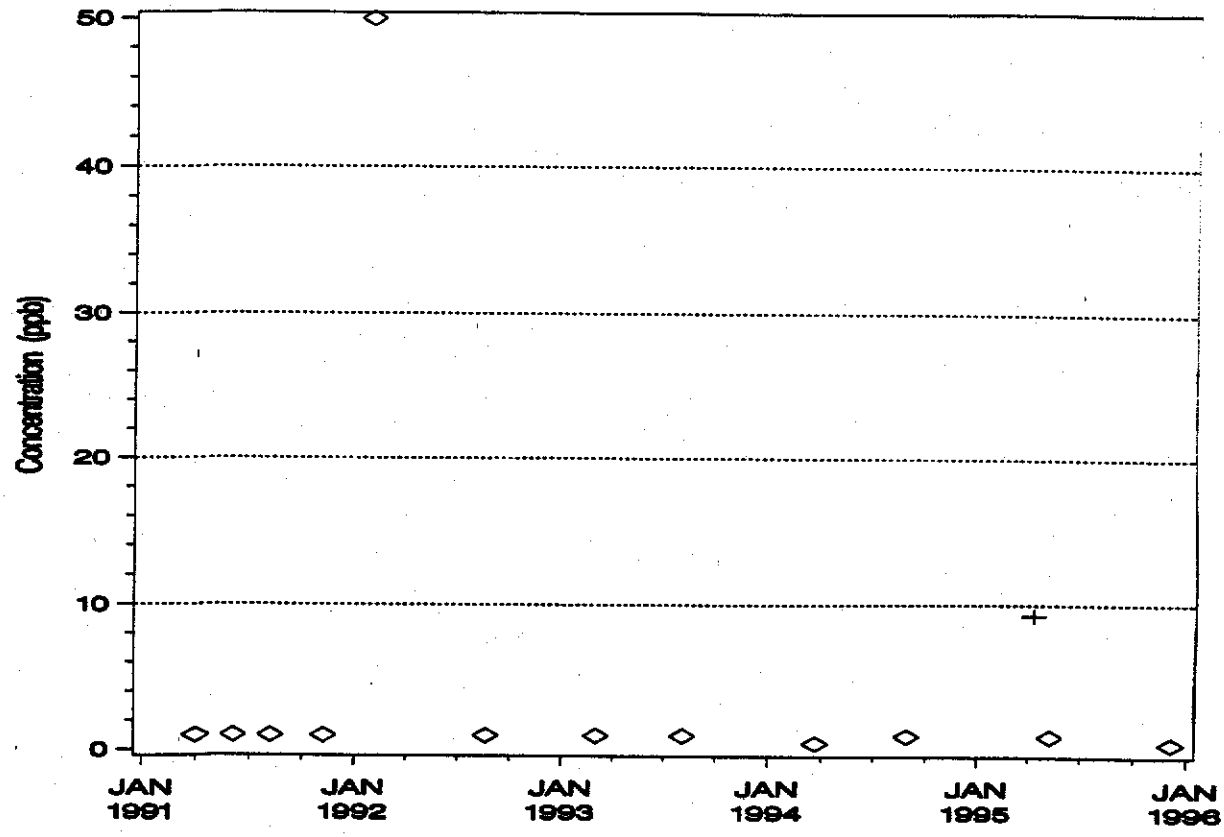
WELL 1408
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



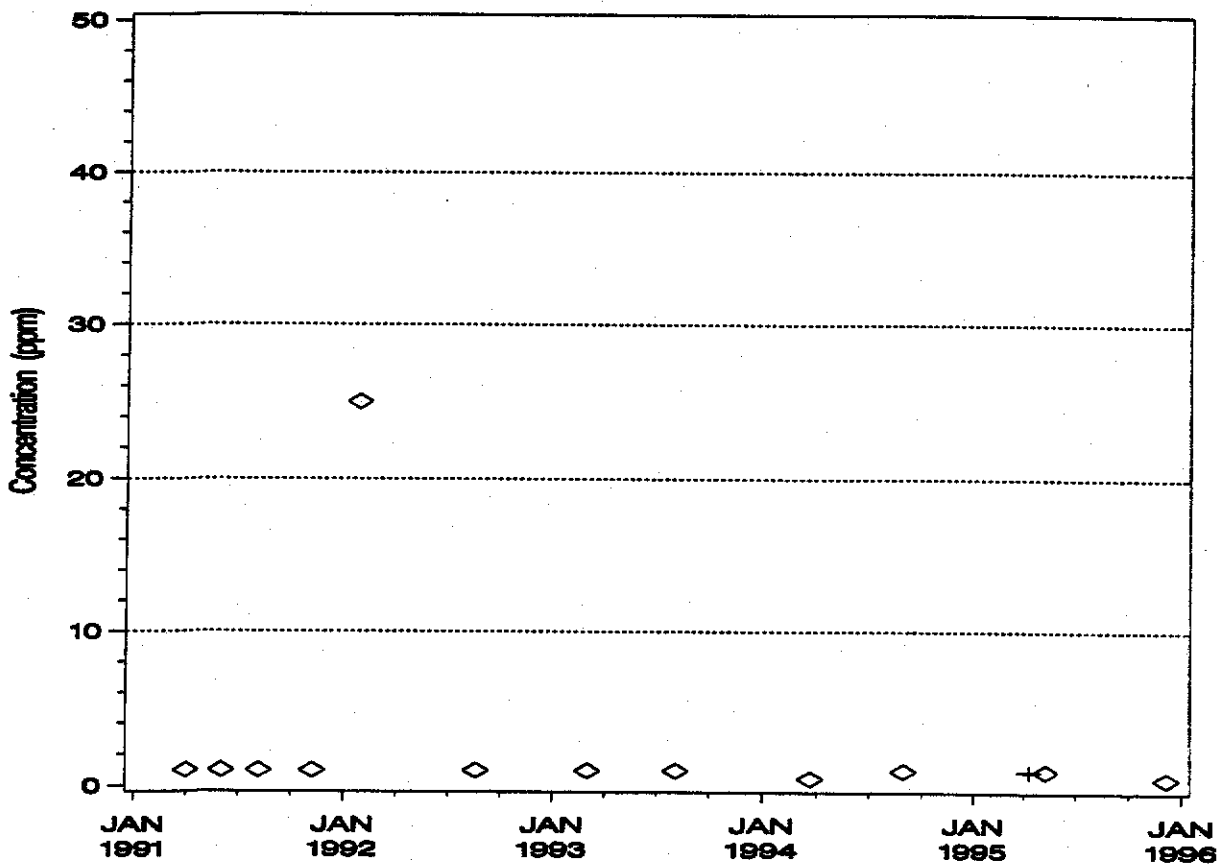
1,1 – DICHLOROETHYLENE Trend



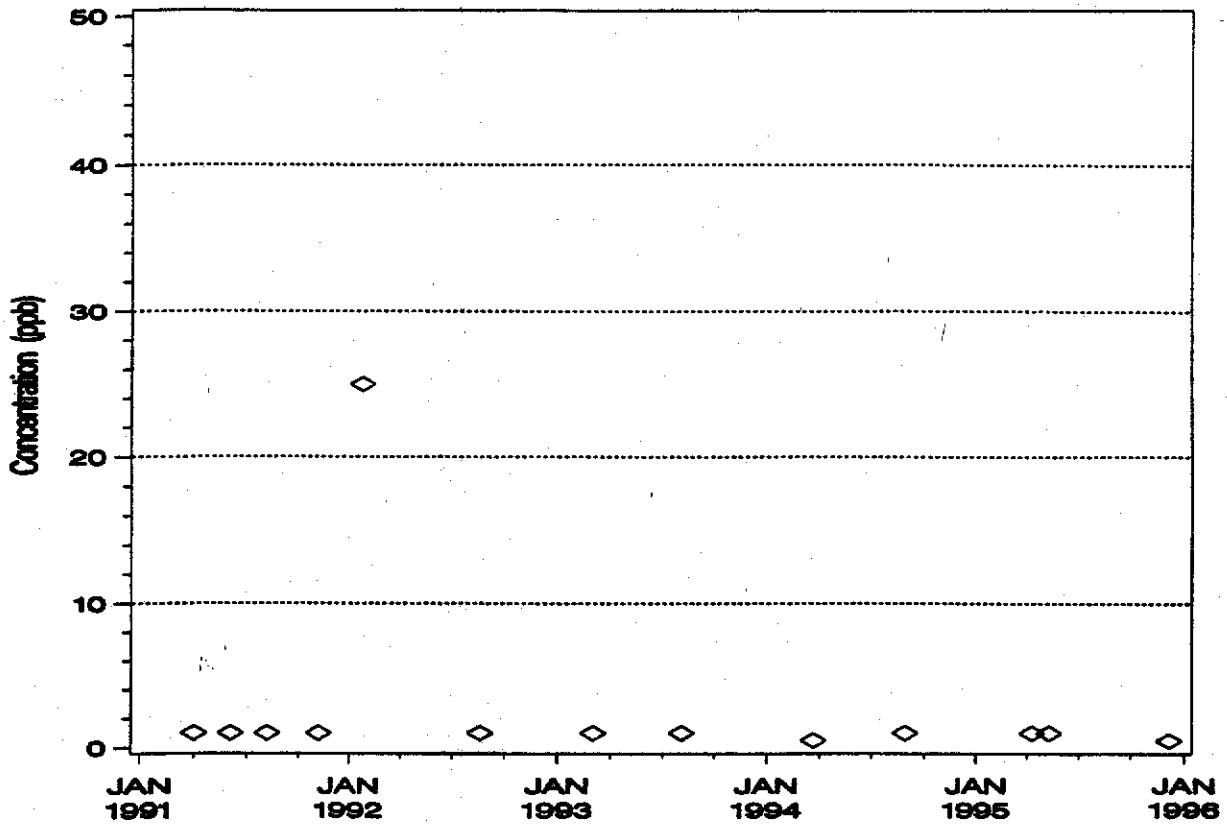
WELL 1409
TRICHLOROETHYLENE Trend



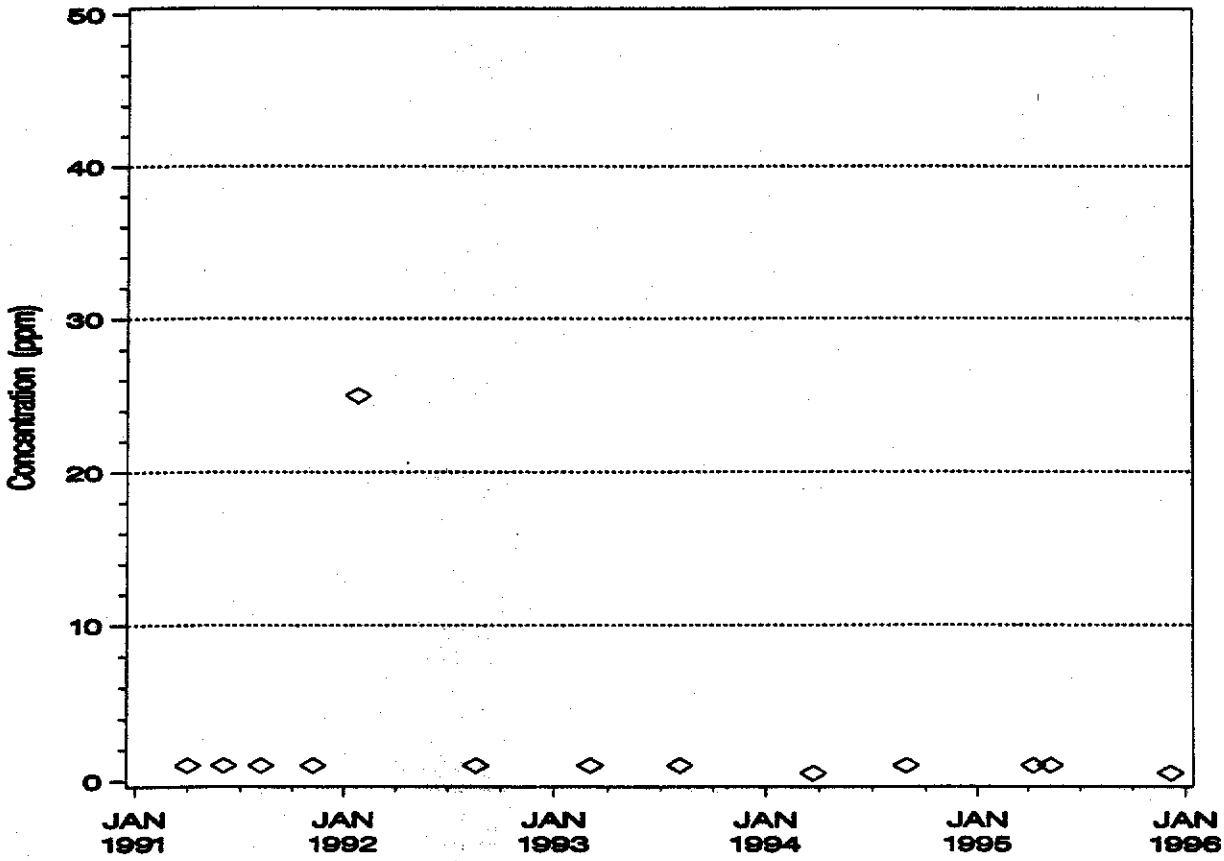
FREON 113 Trend



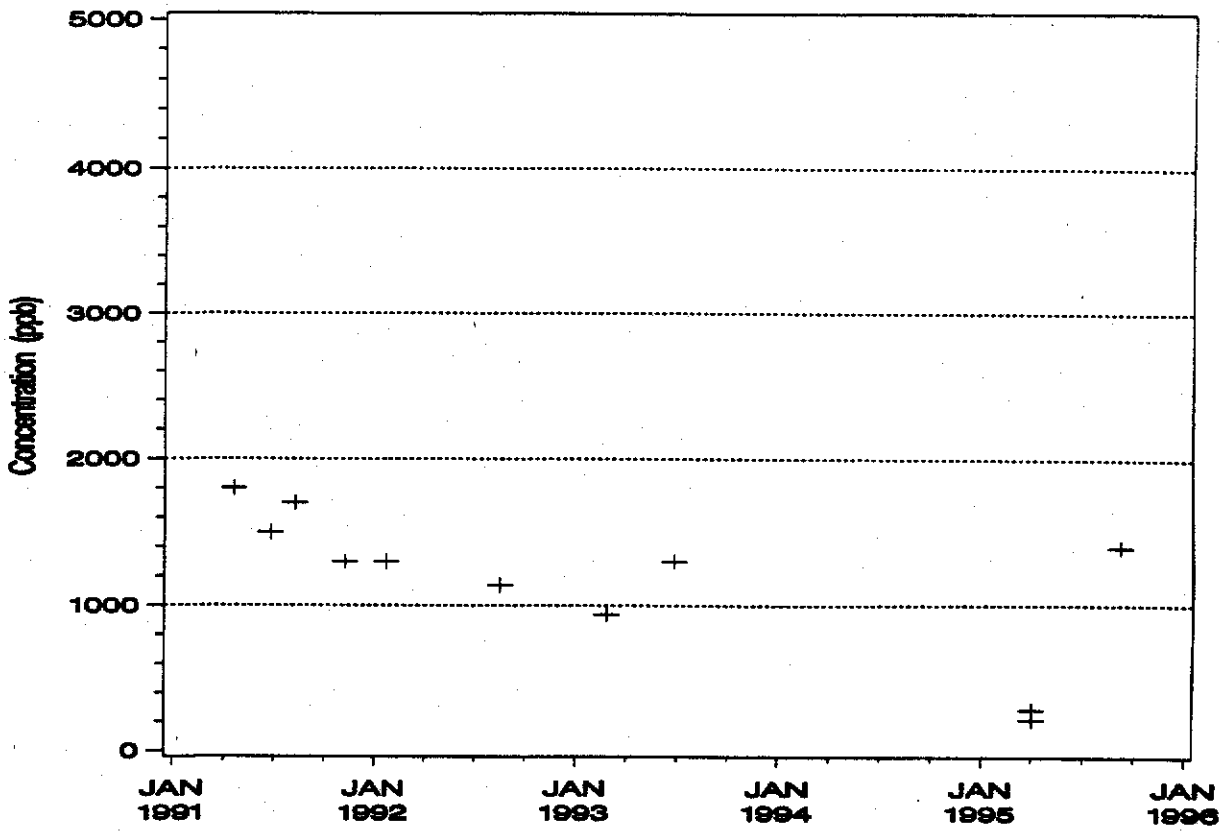
WELL 1409
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



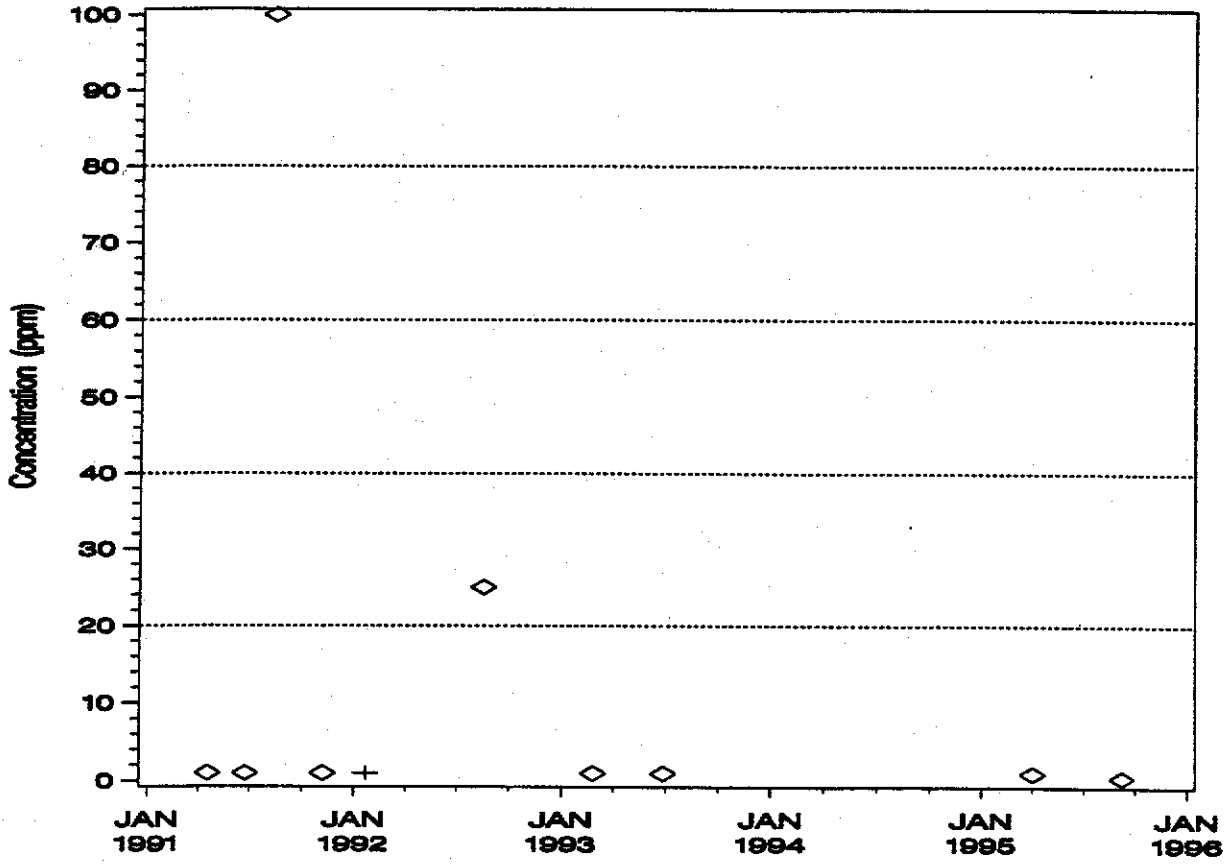
1,1 – DICHLOROETHYLENE Trend



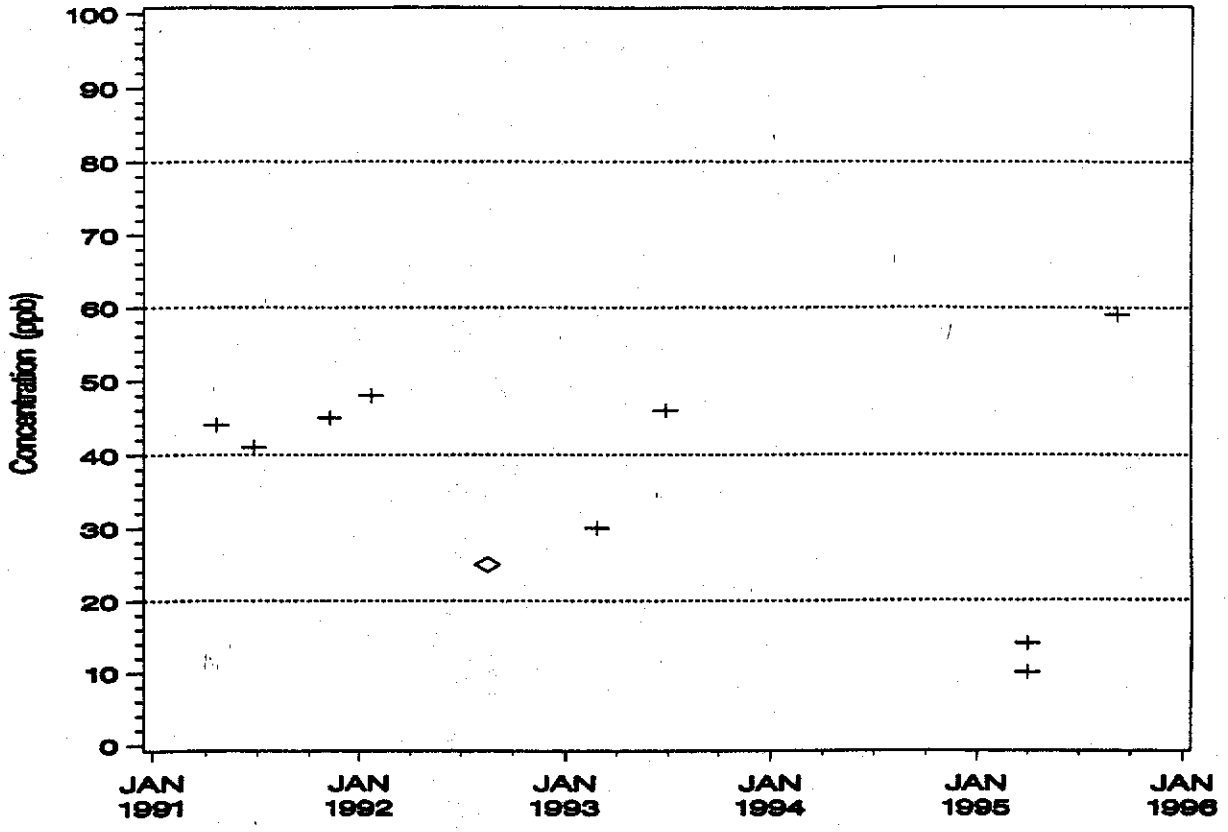
WELL 1469
TRICHLOROETHYLENE Trend



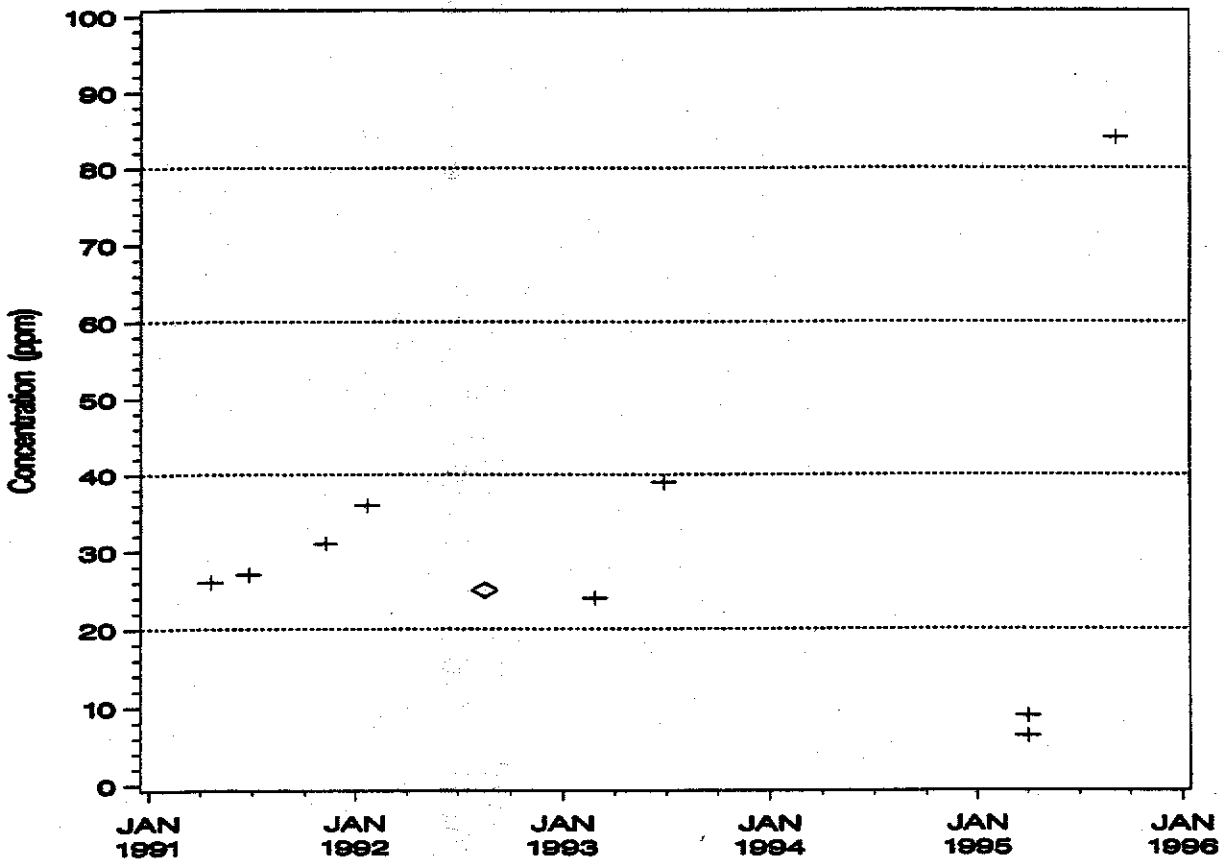
FREON 113 Trend



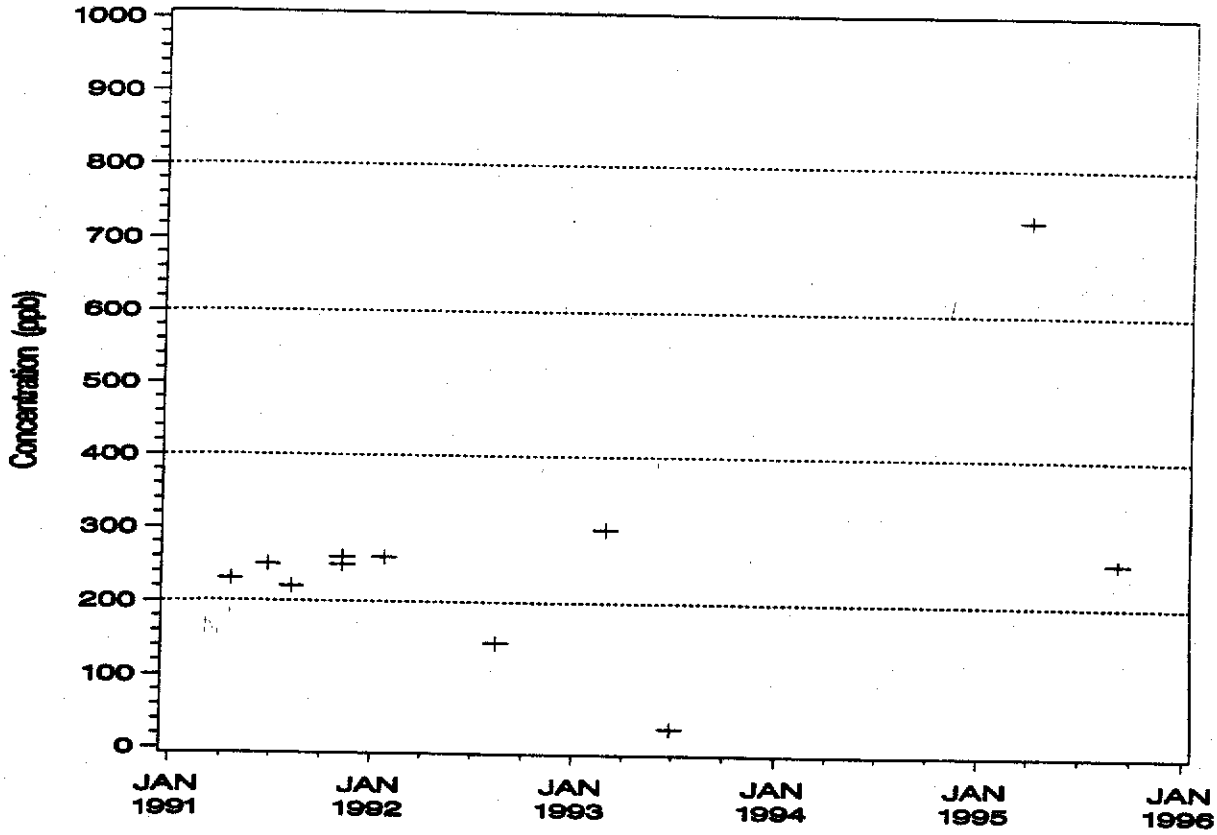
WELL 1469
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



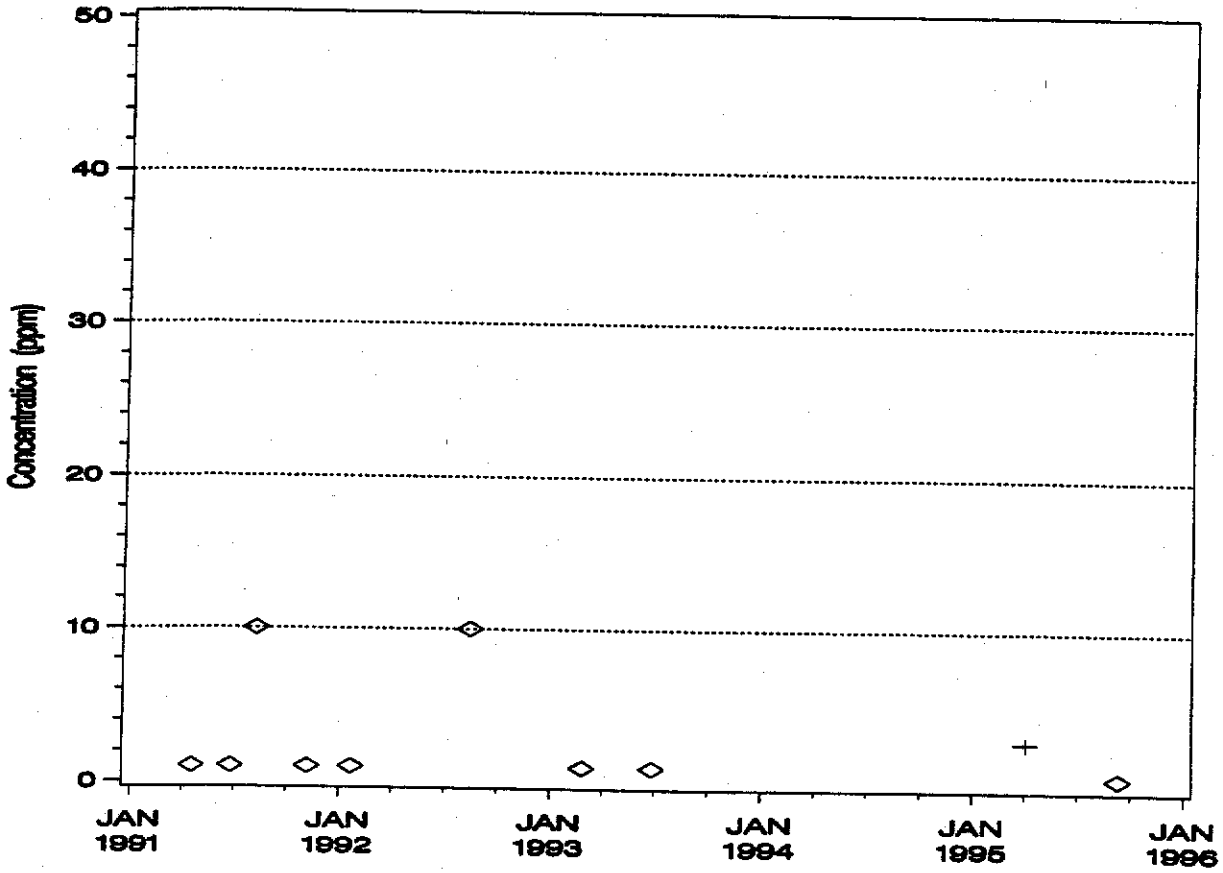
1,1 – DICHLOROETHYLENE Trend



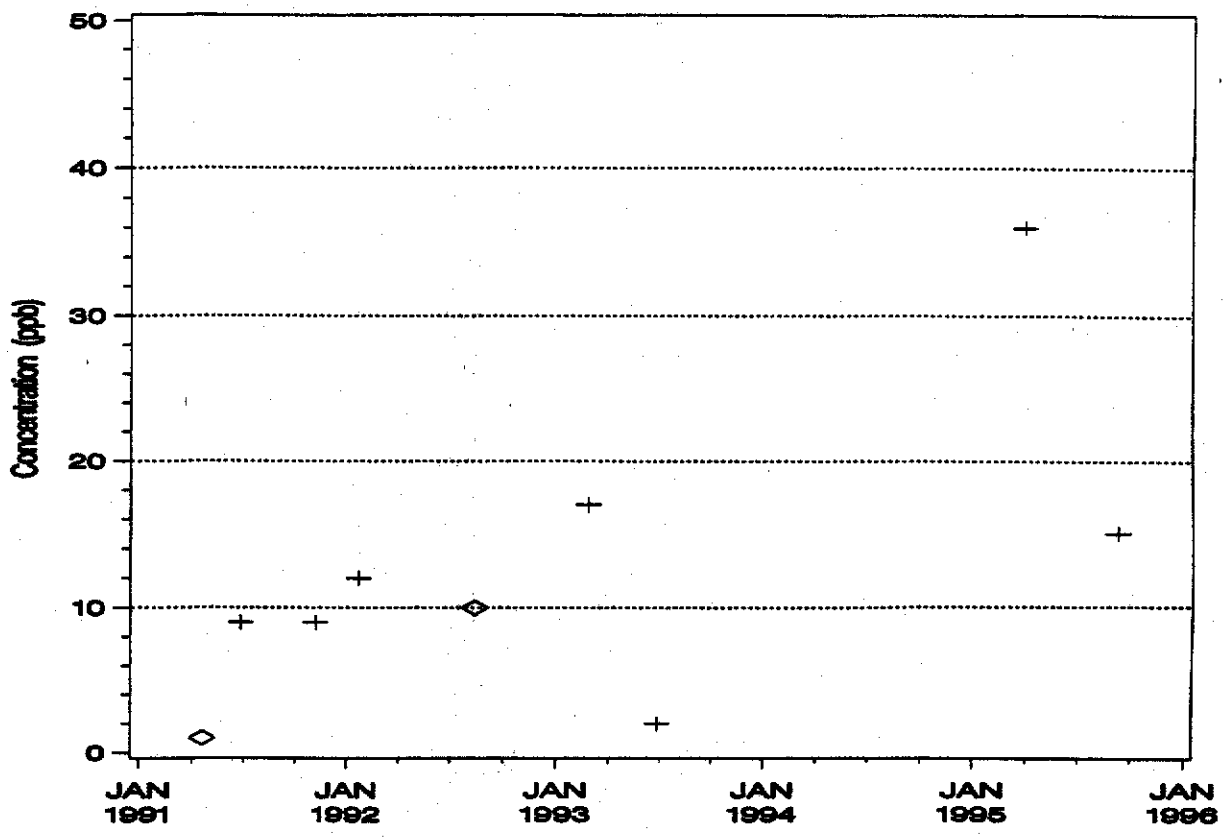
WELL 1470
TRICHLOROETHYLENE Trend



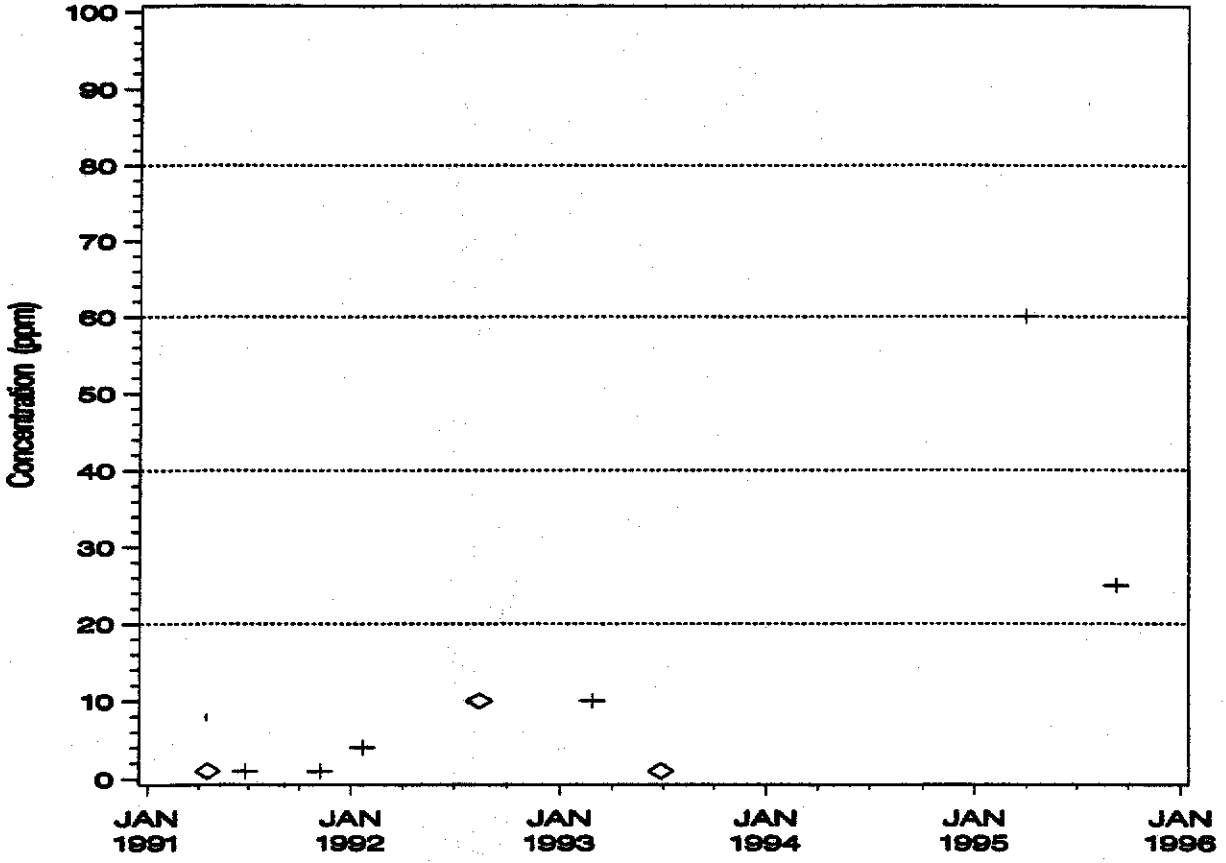
FREON 113 Trend



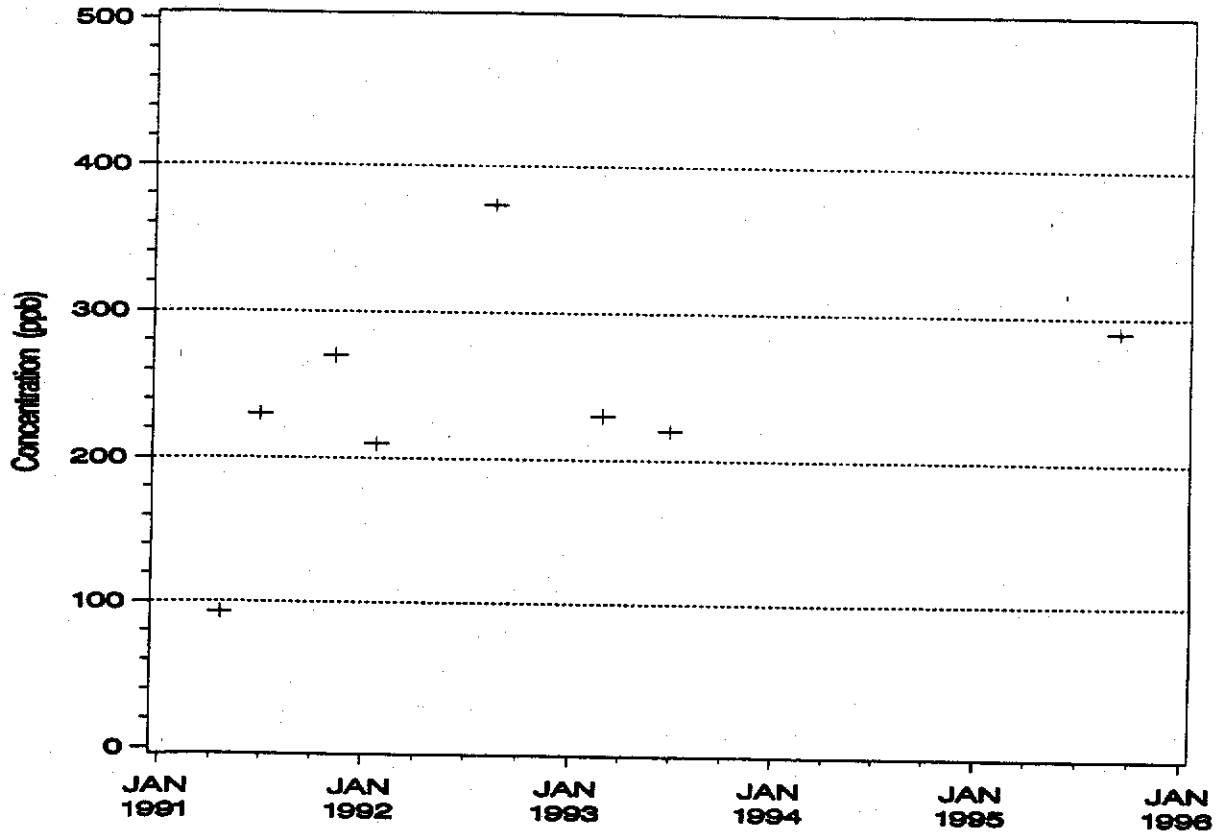
WELL 1470
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



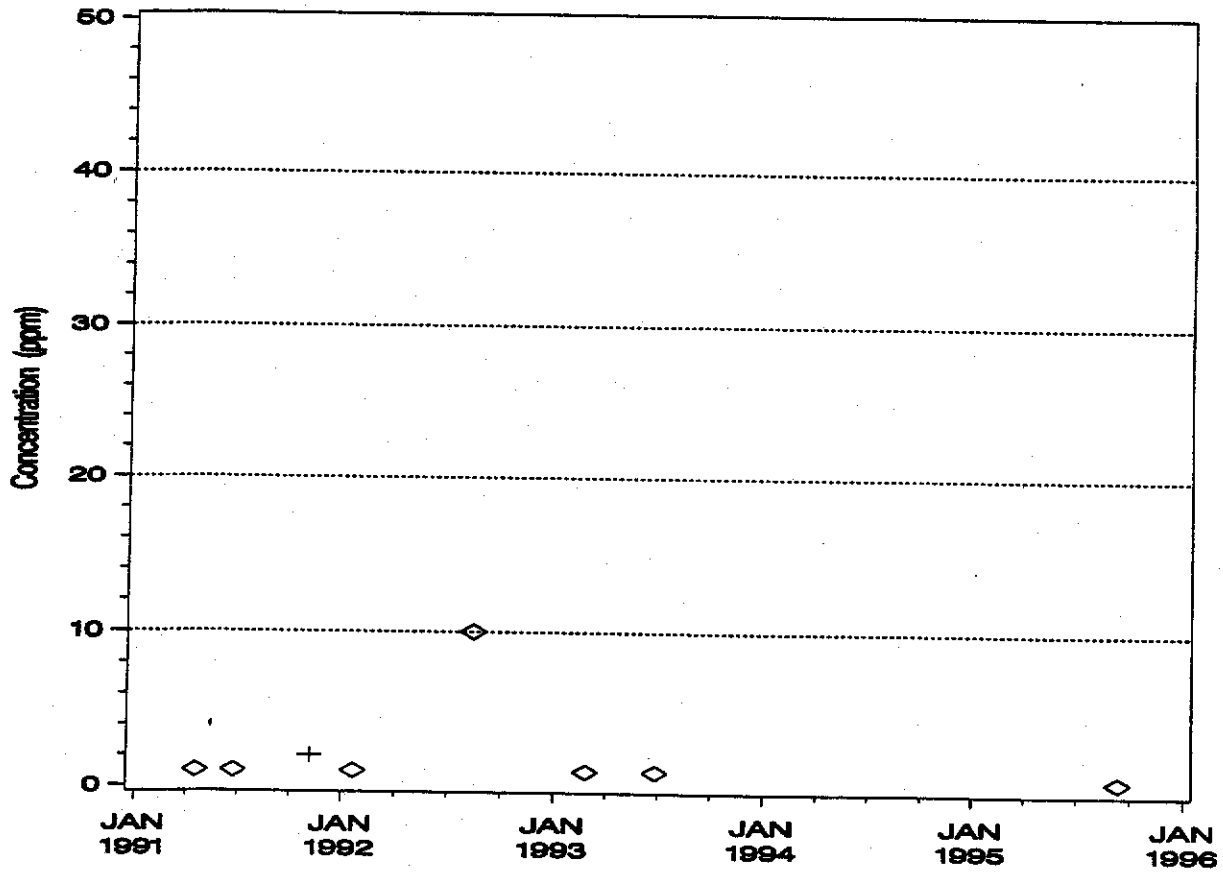
1,1 — DICHLOROETHYLENE Trend



WELL 1471
TRICHLOROETHYLENE Trend

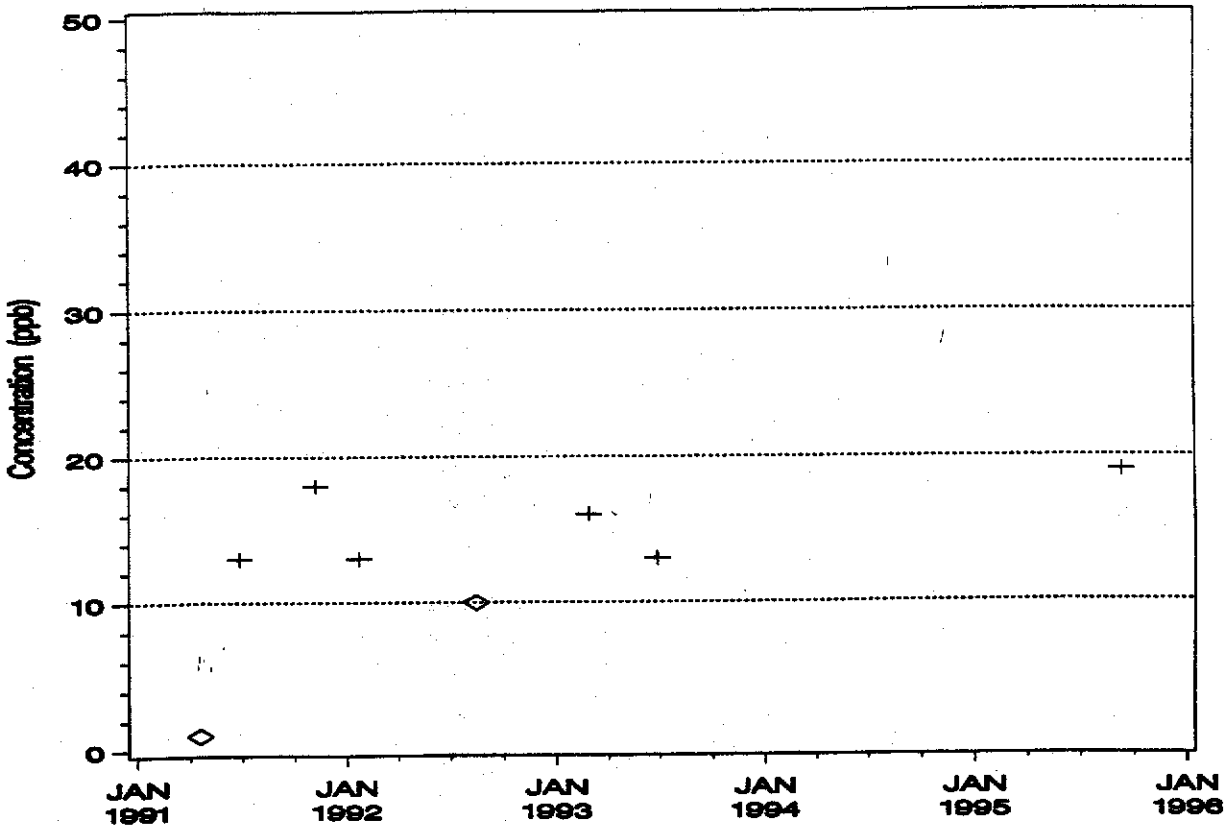


FREON 113 Trend

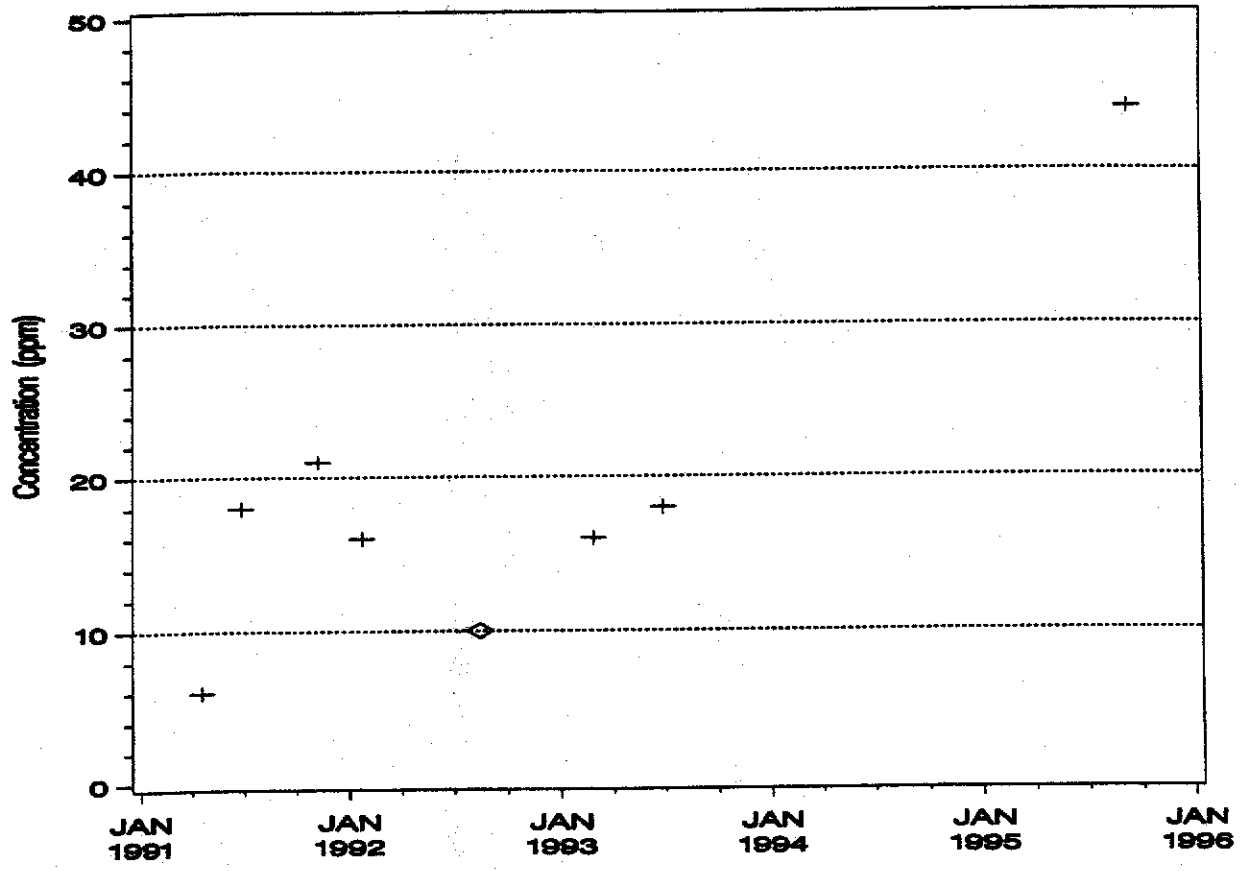


WELL 1471

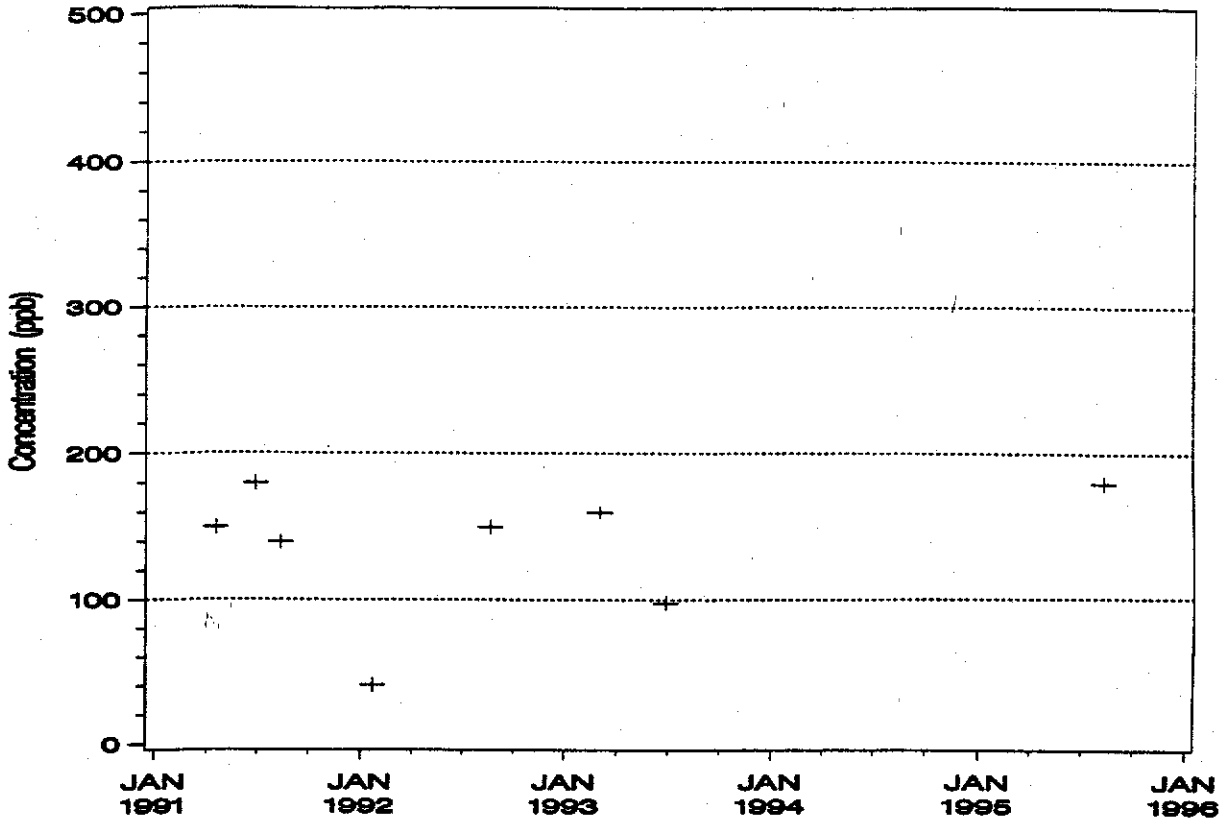
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



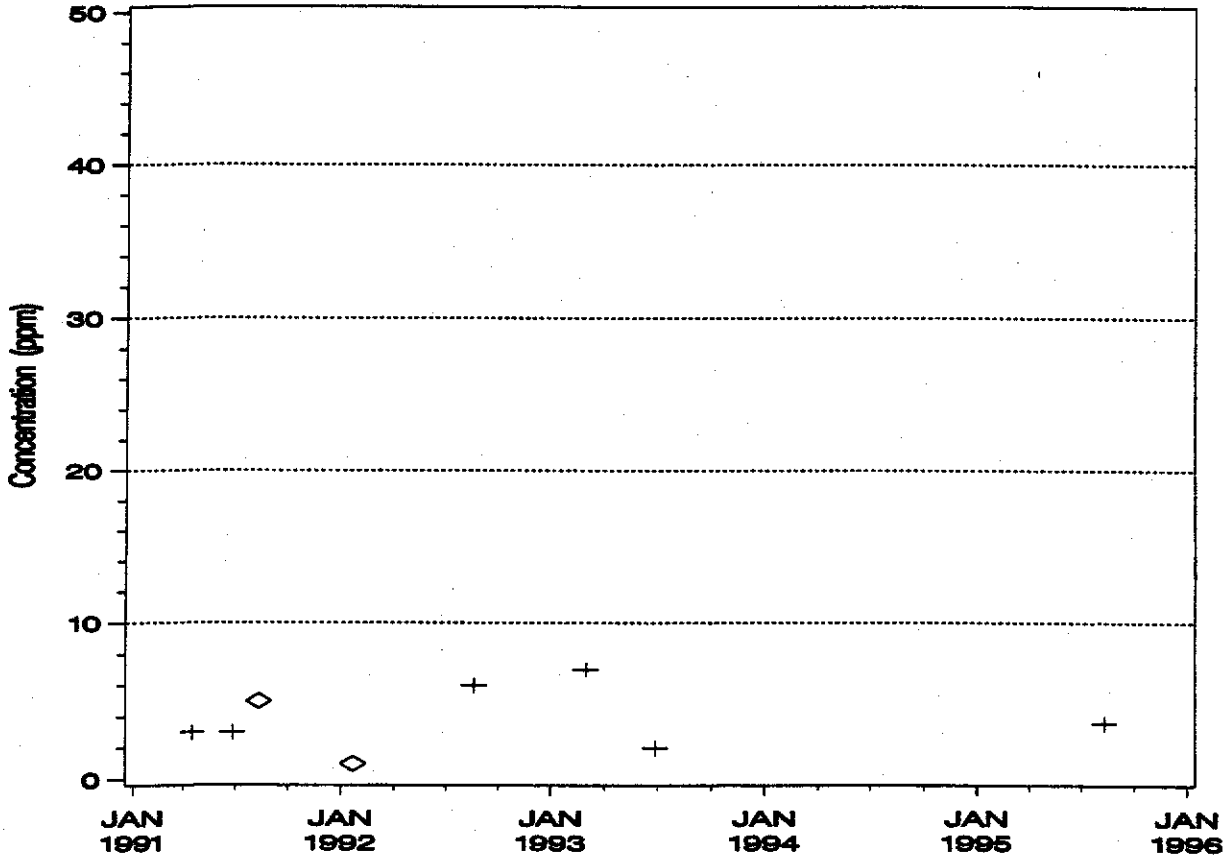
1,1 – DICHLOROETHYLENE Trend



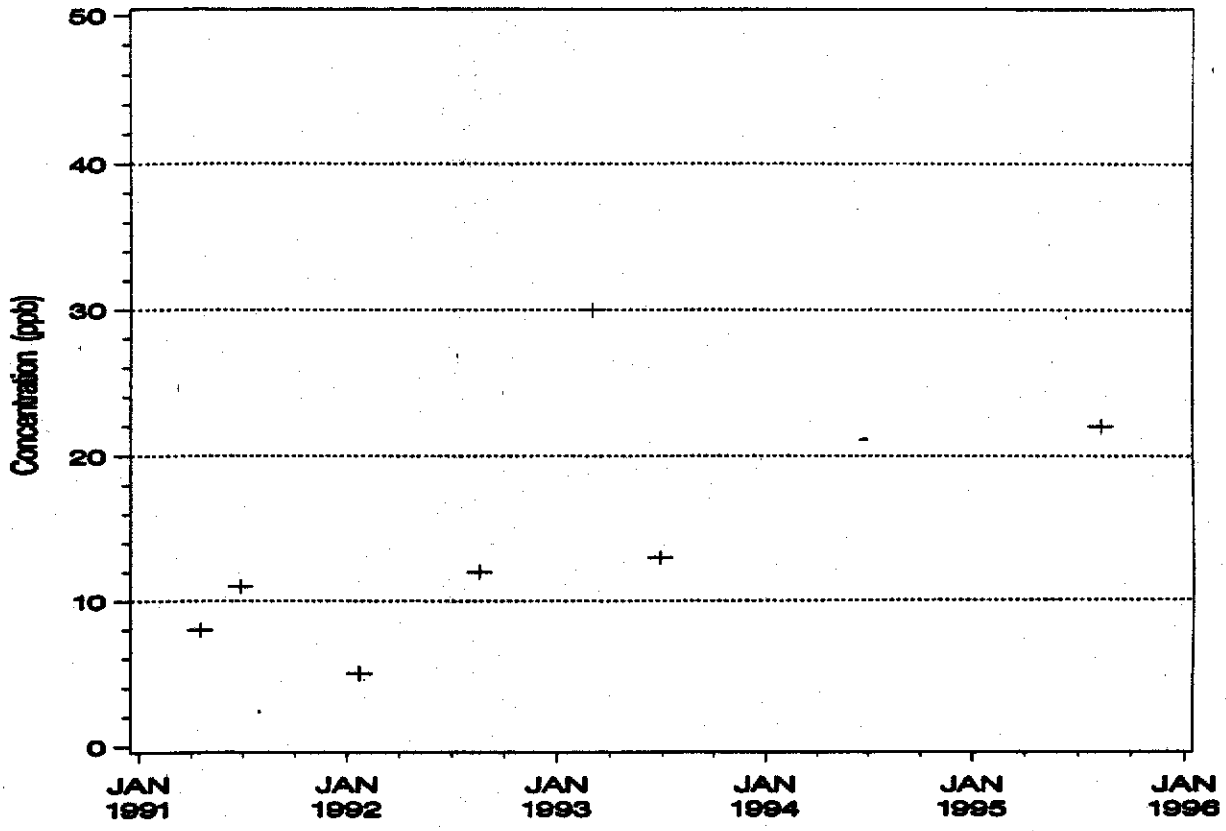
WELL 1472
TRICHLOROETHYLENE Trend



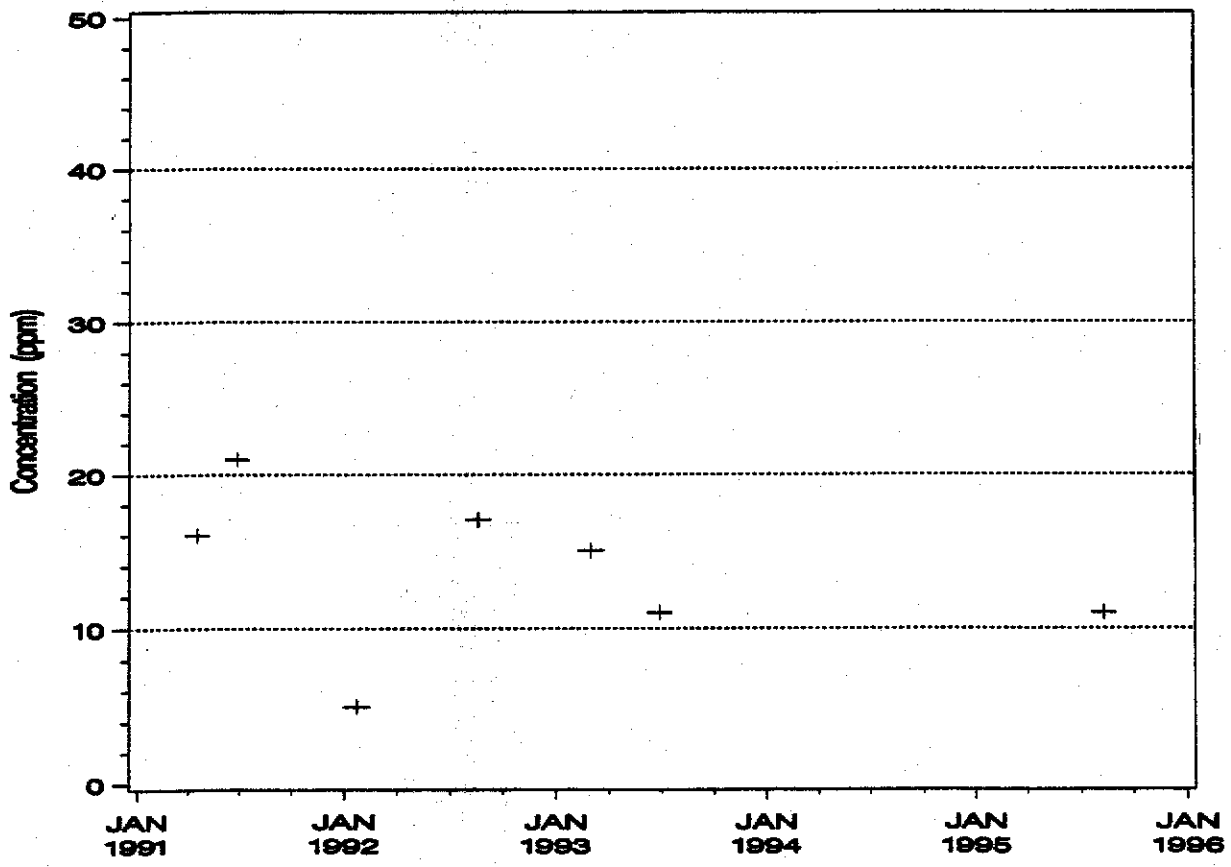
FREON 113 Trend



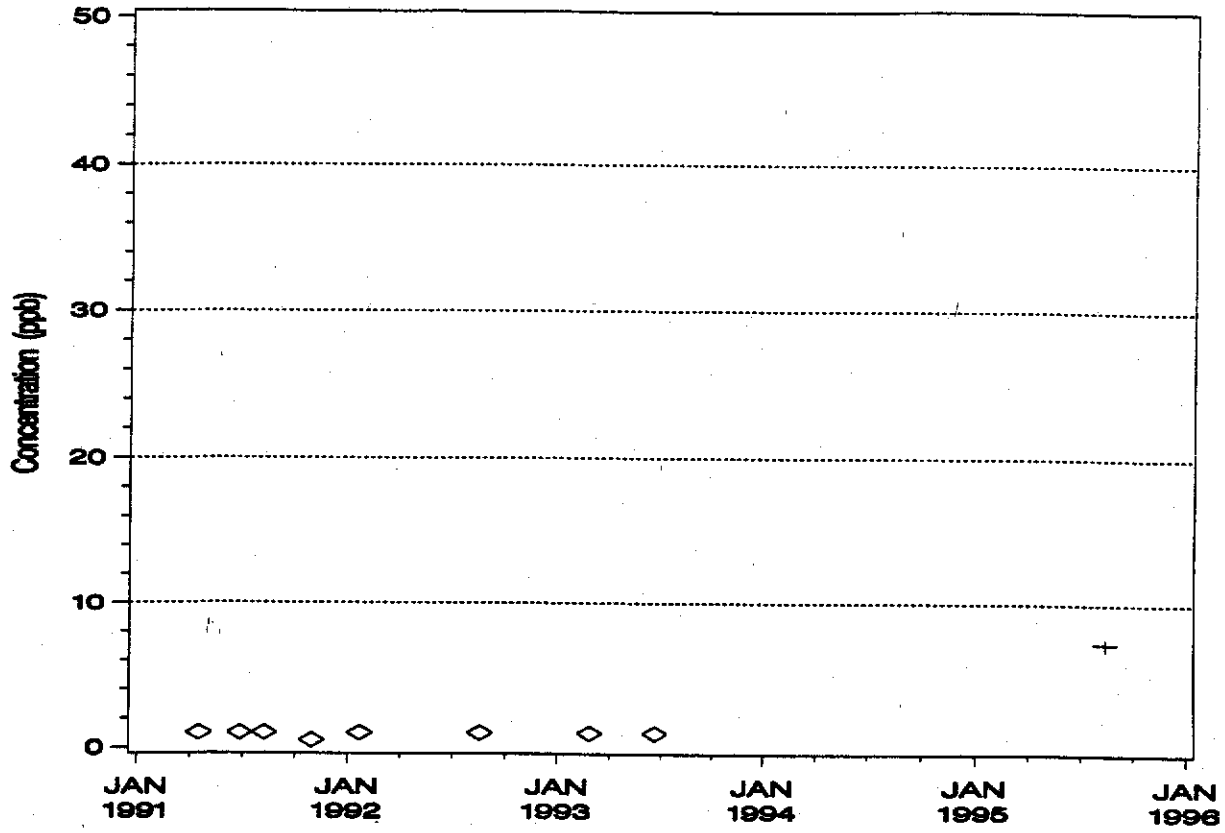
WELL 1472
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



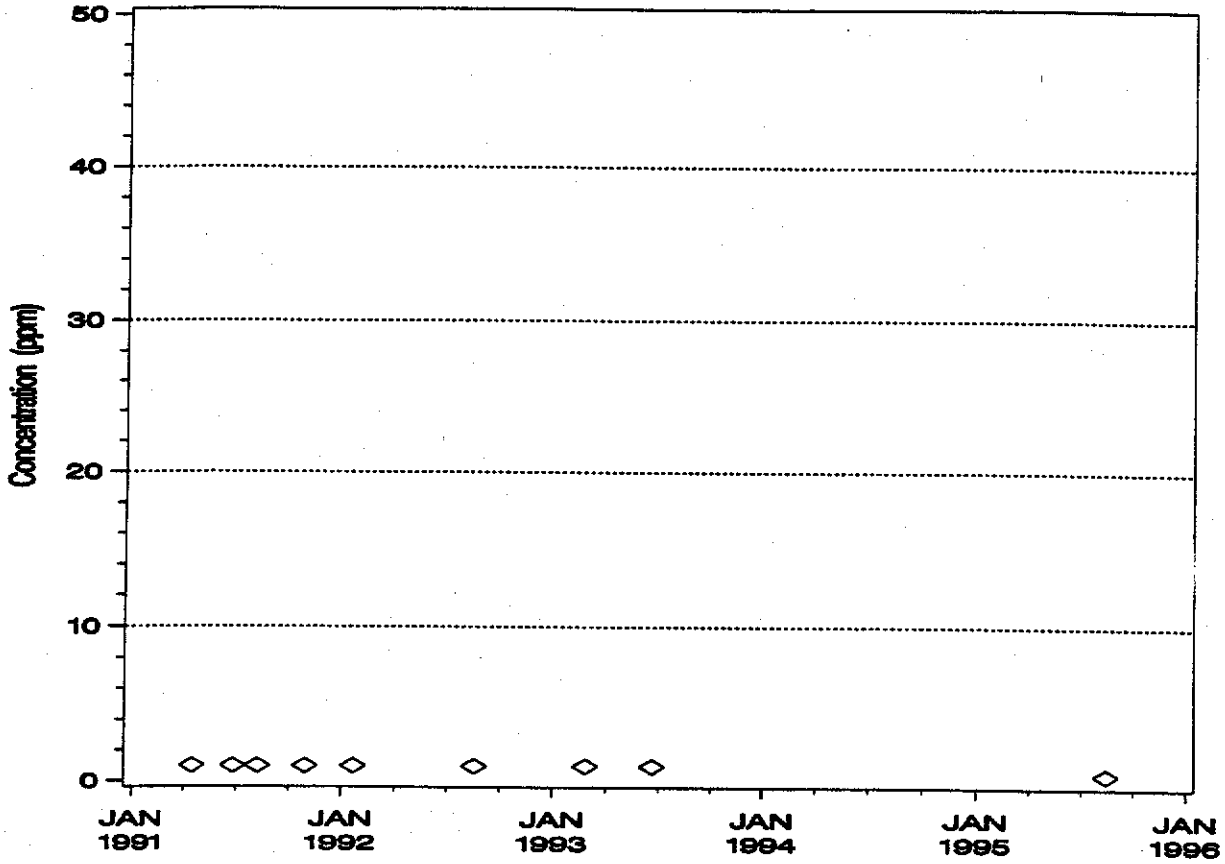
1,1 — DICHLOROETHYLENE Trend



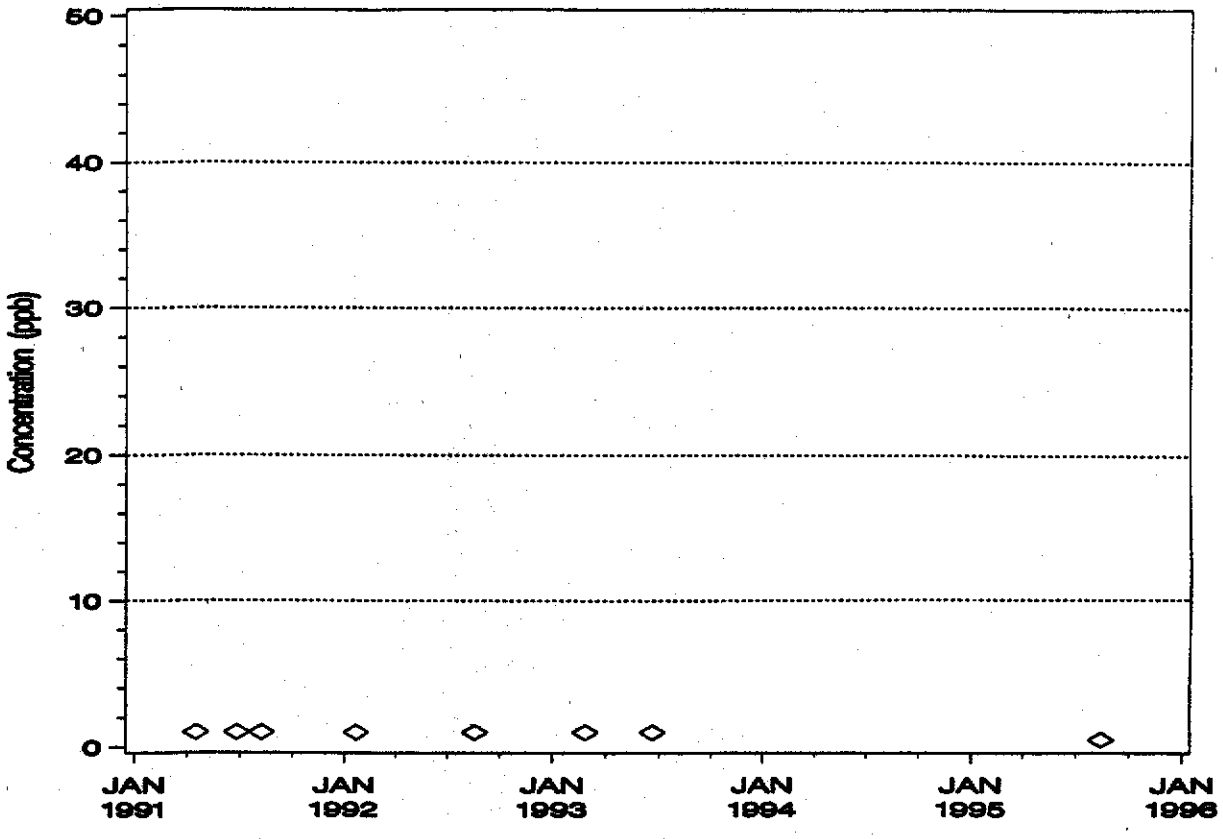
WELL 1473
TRICHLOROETHYLENE Trend



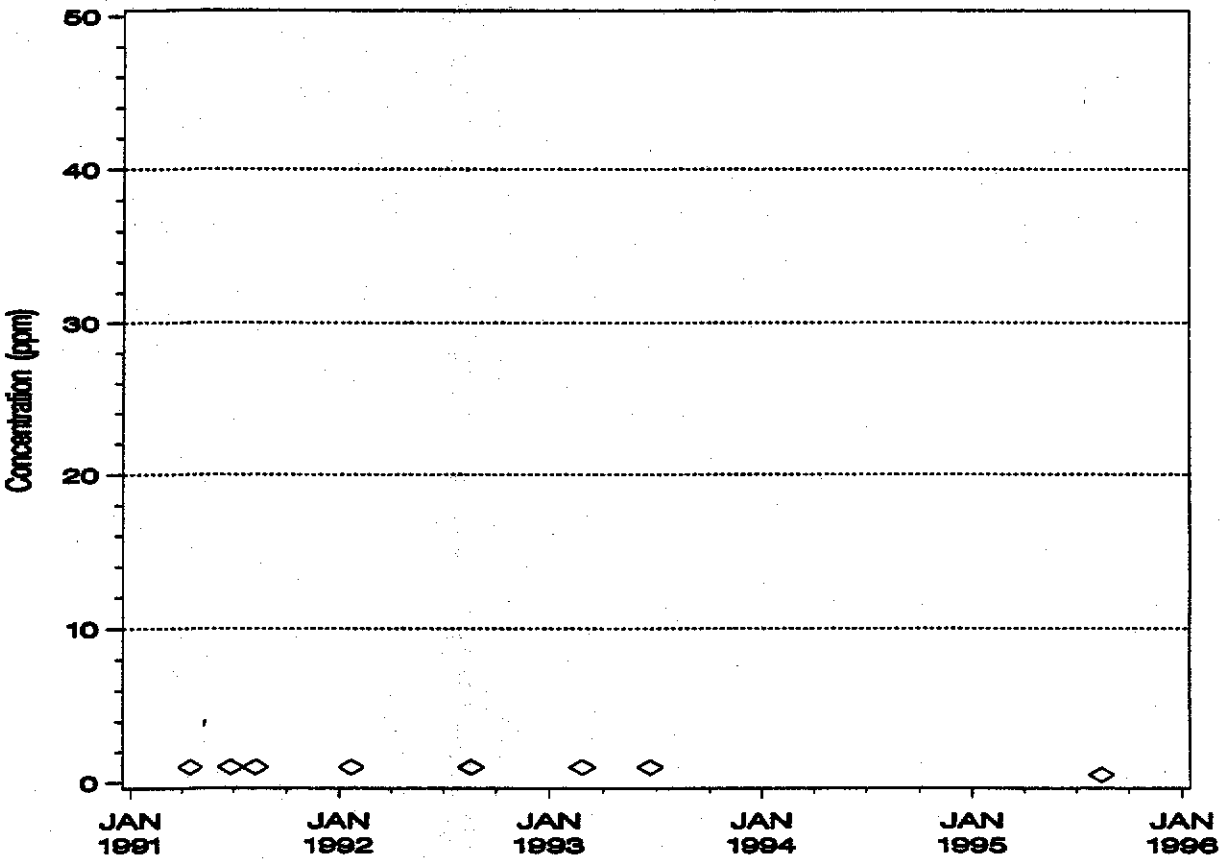
FREON 113 Trend



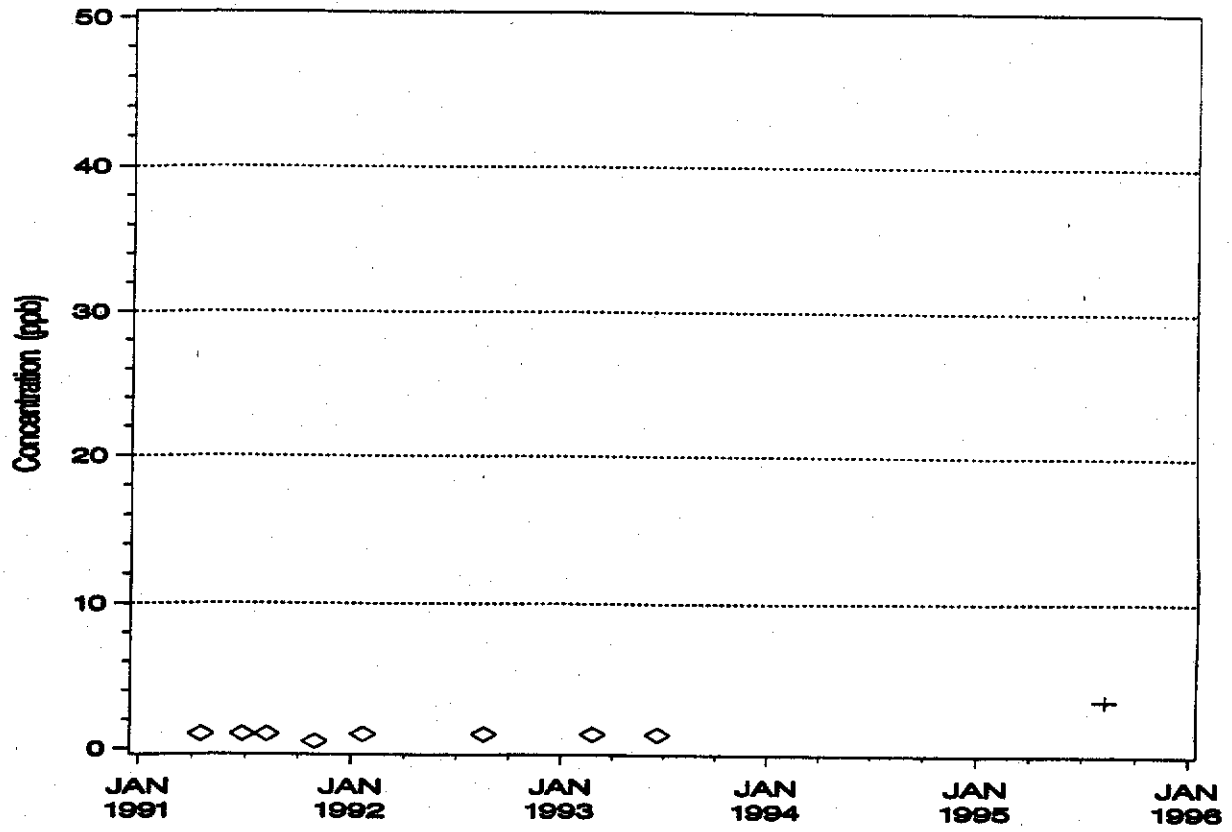
WELL 1473
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



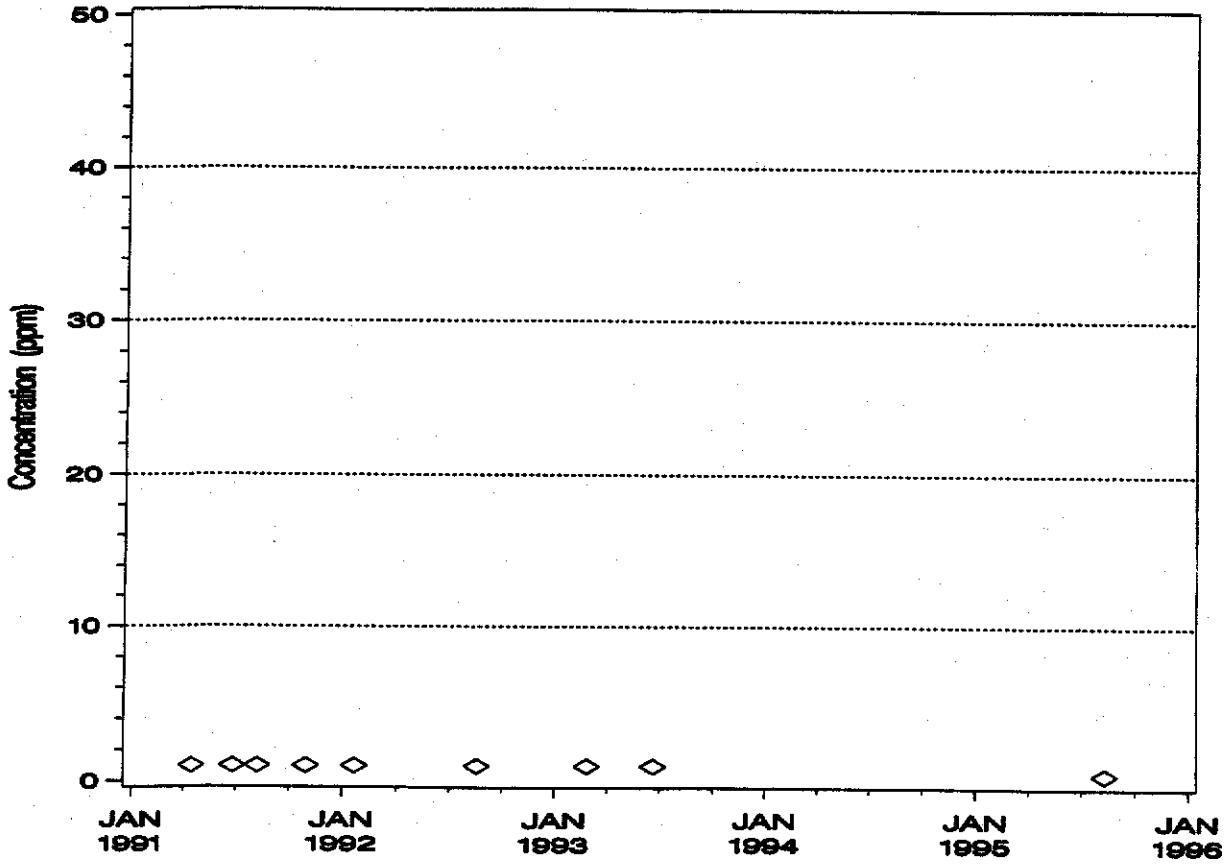
1,1 – DICHLOROETHYLENE Trend



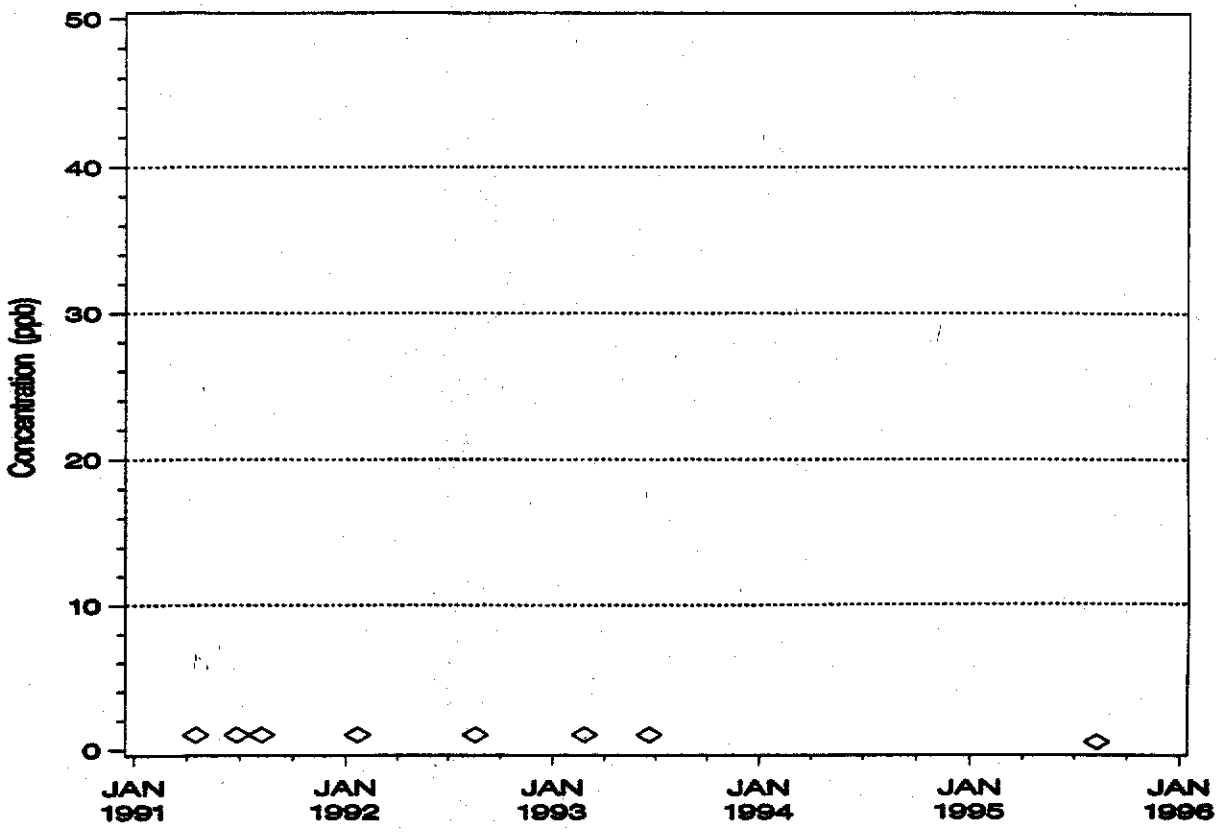
WELL 1474
TRICHLOROETHYLENE Trend



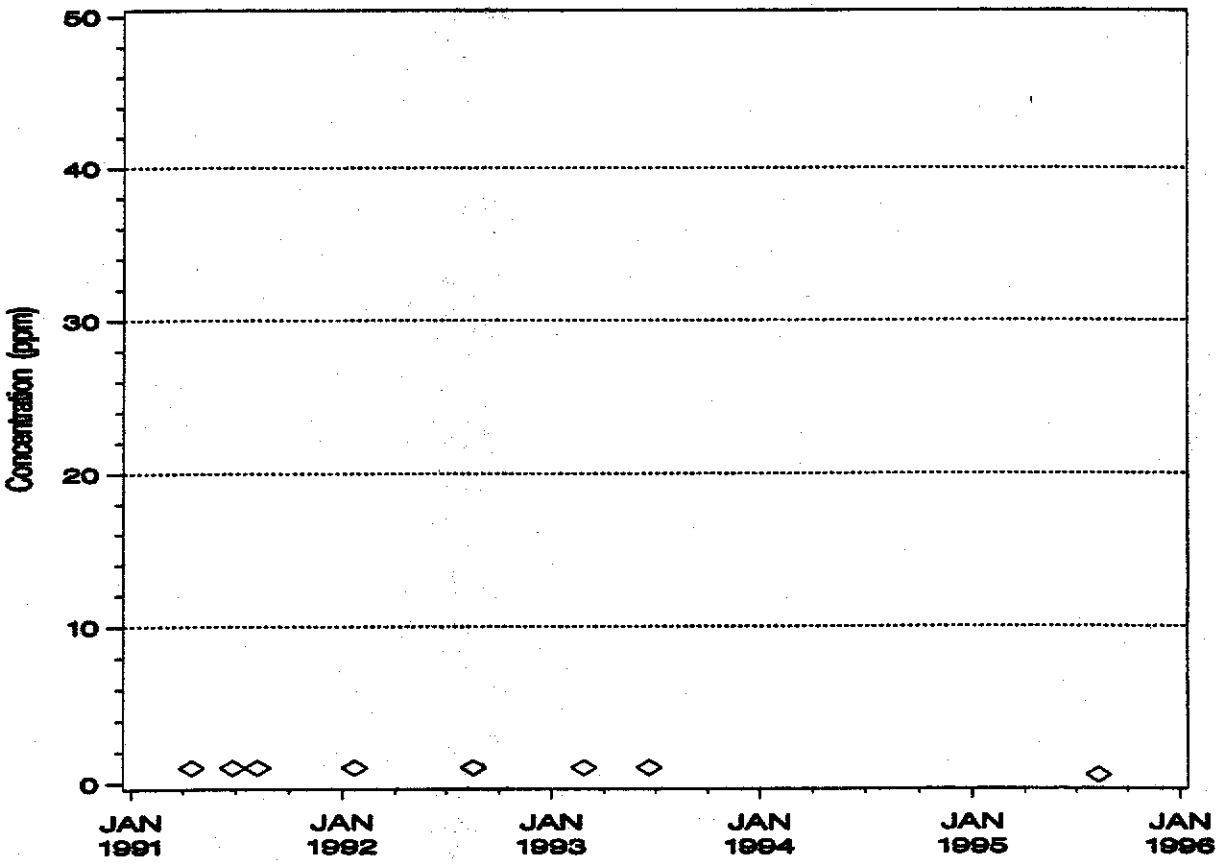
FREON 113 Trend



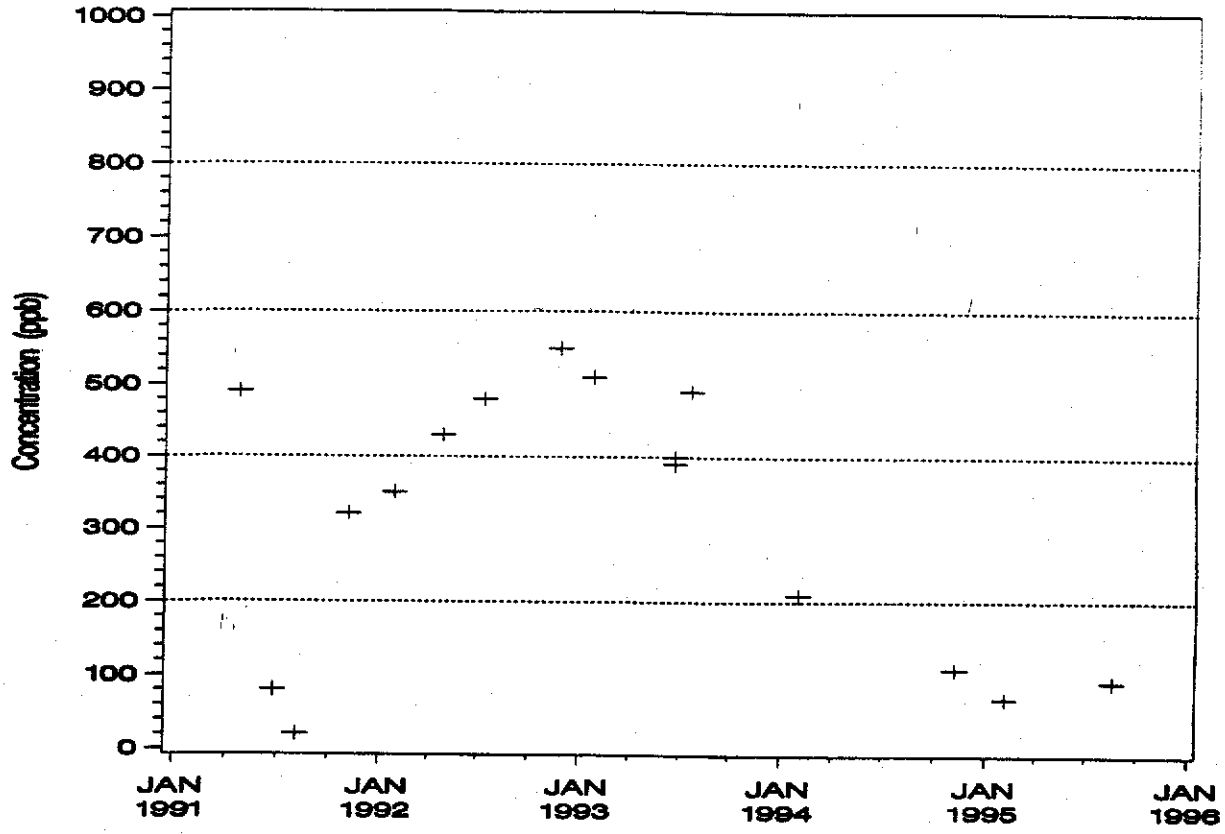
WELL 1474
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



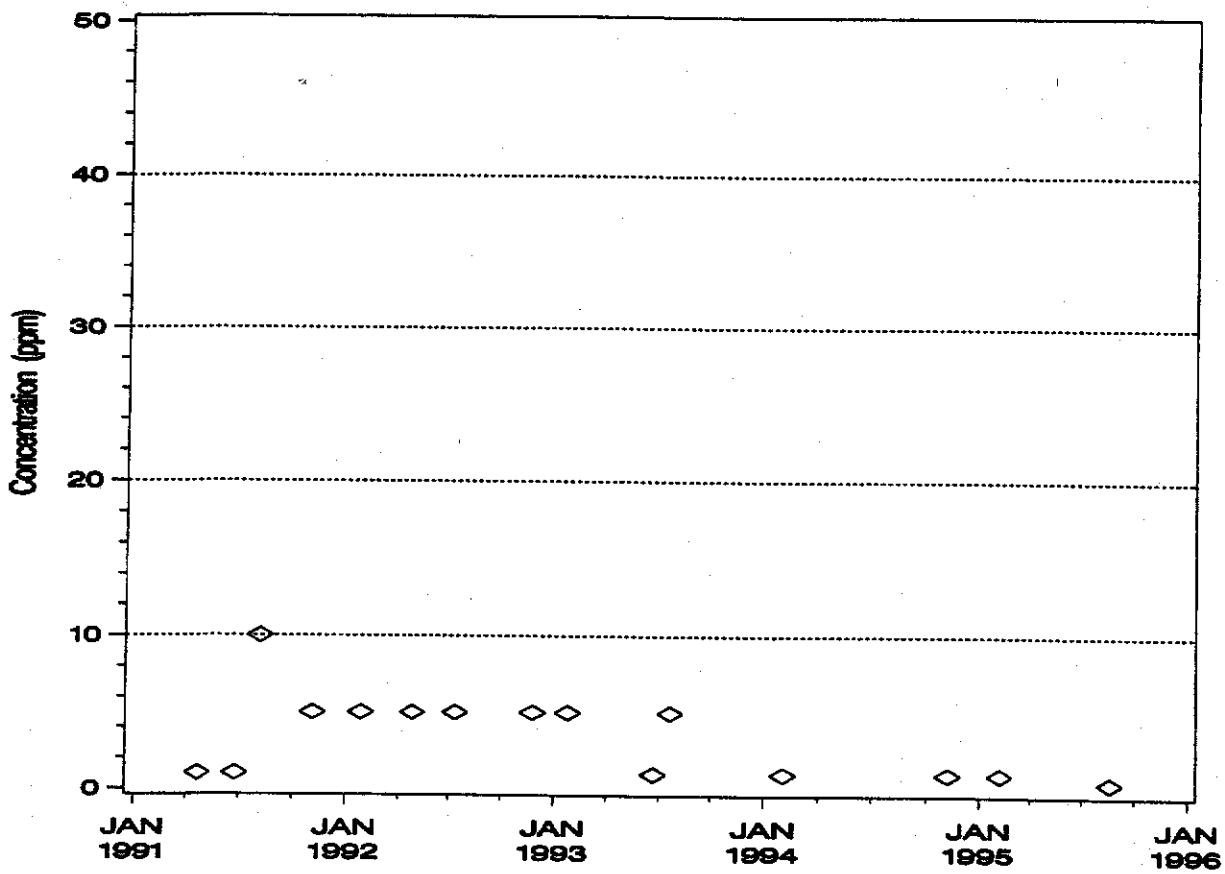
1,1 — DICHLOROETHYLENE Trend



WELL 1475
TRICHLOROETHYLENE Trend

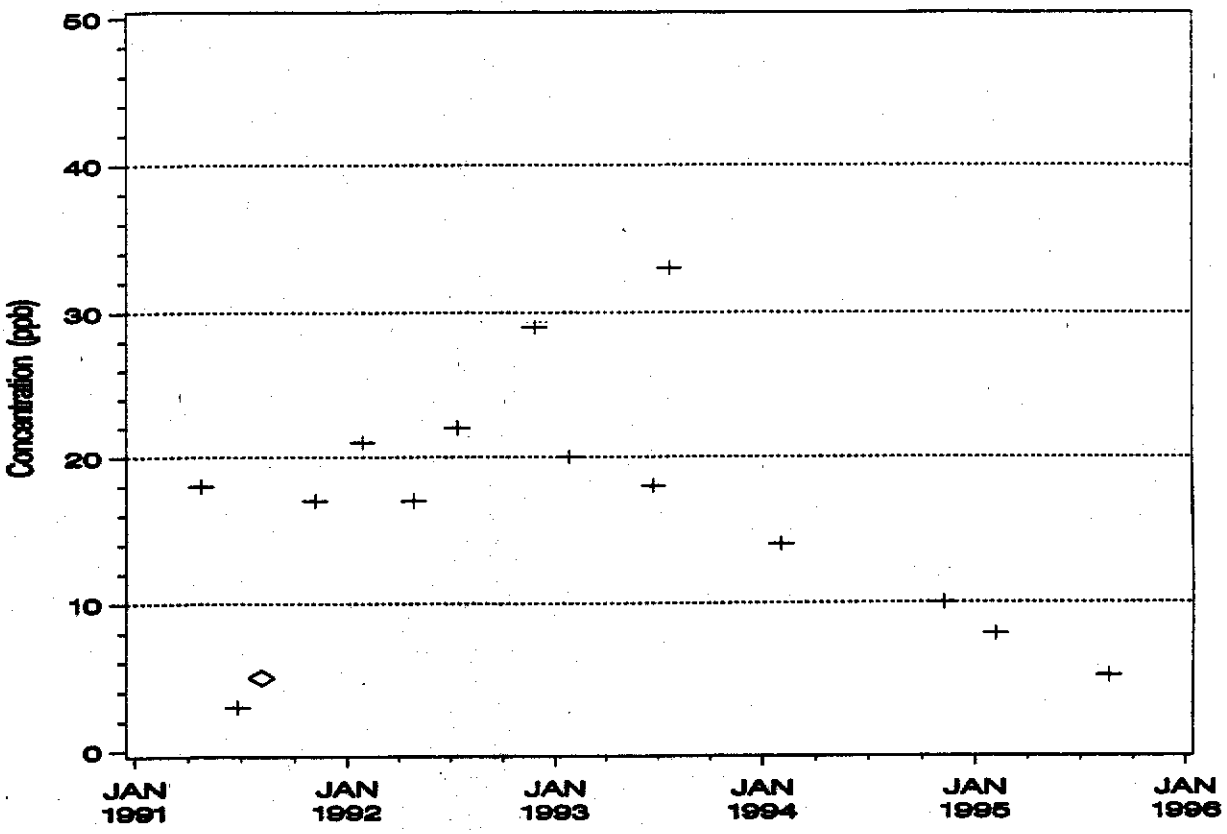


FREON 113 Trend

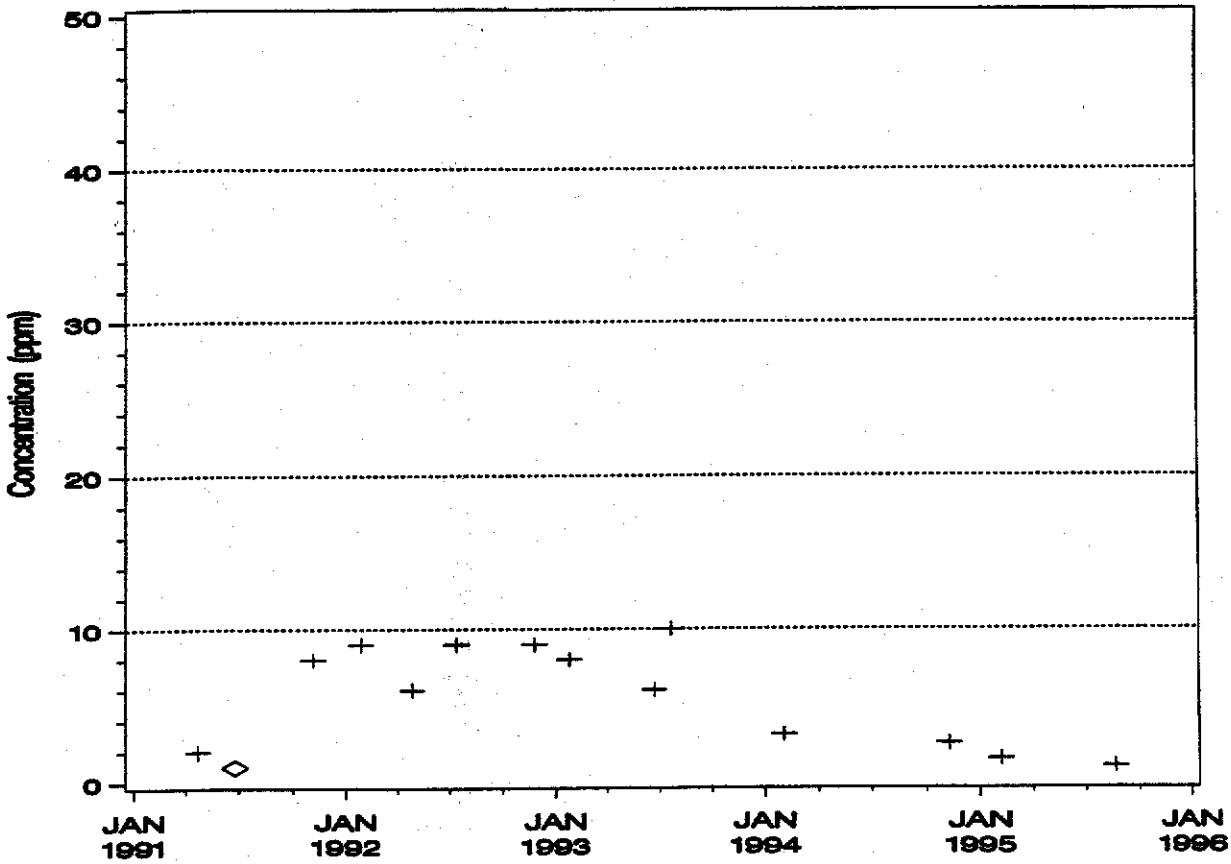


WELL 1475

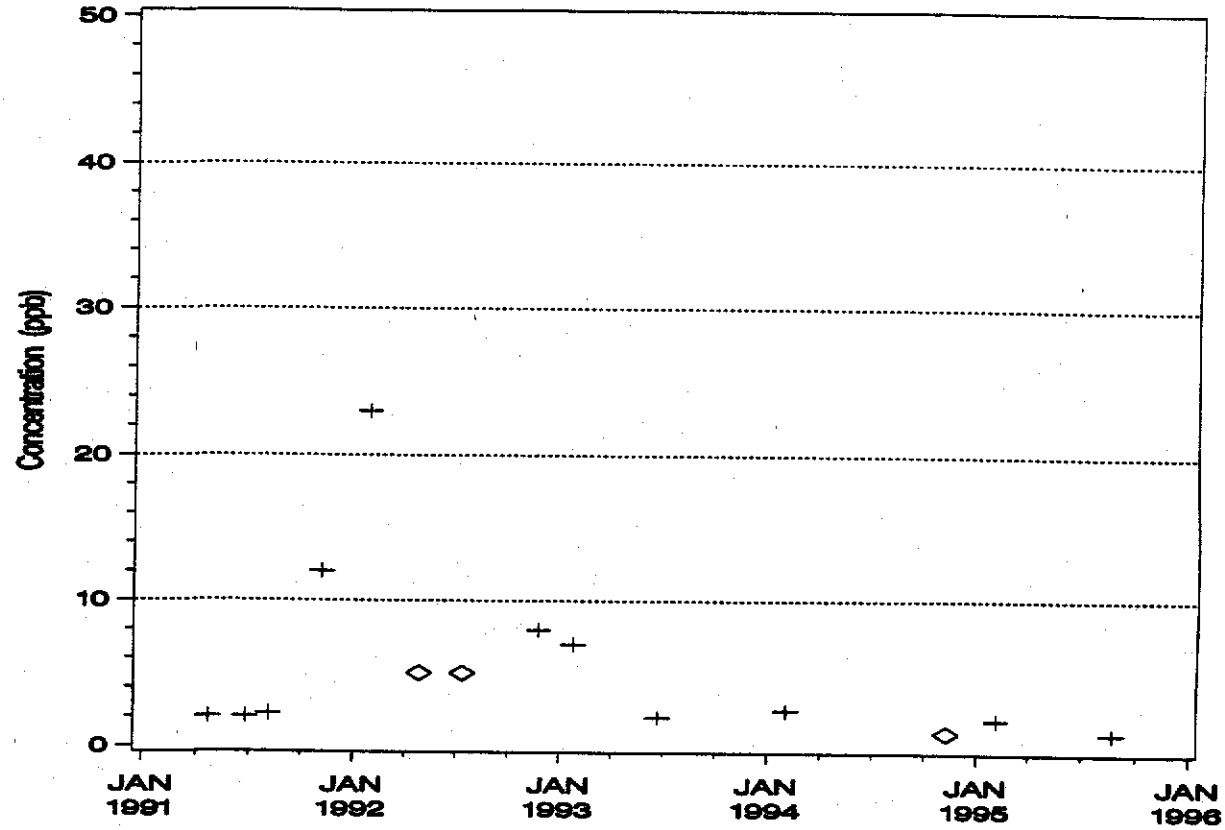
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



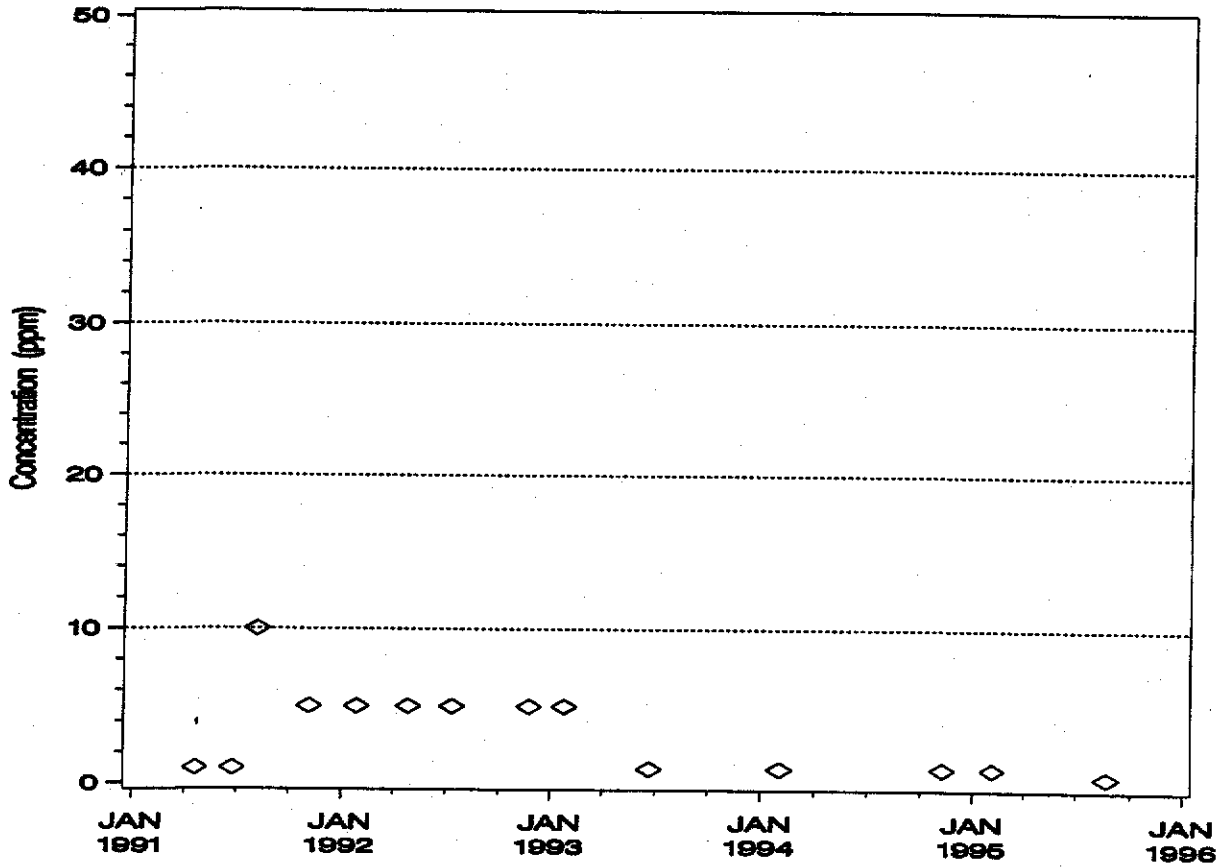
1,1 – DICHLOROETHYLENE Trend



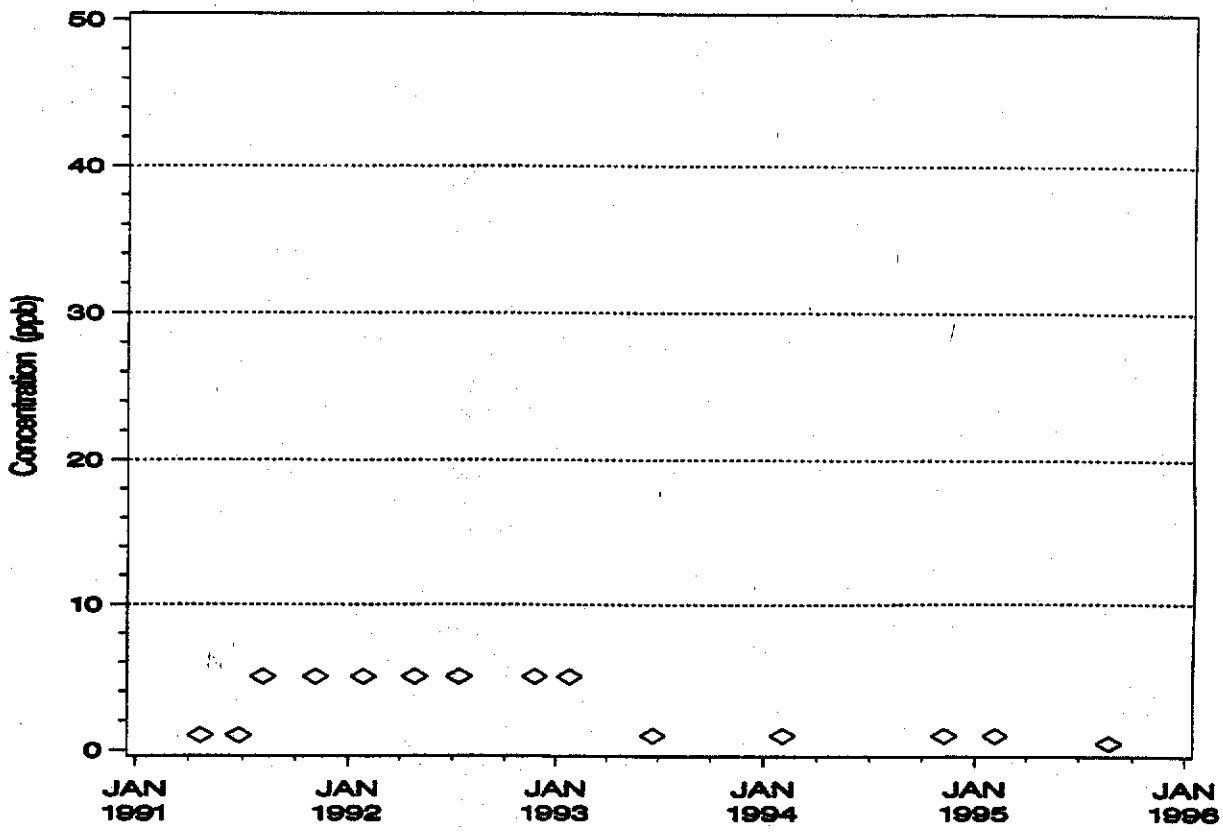
WELL 1476
TRICHLOROETHYLENE Trend



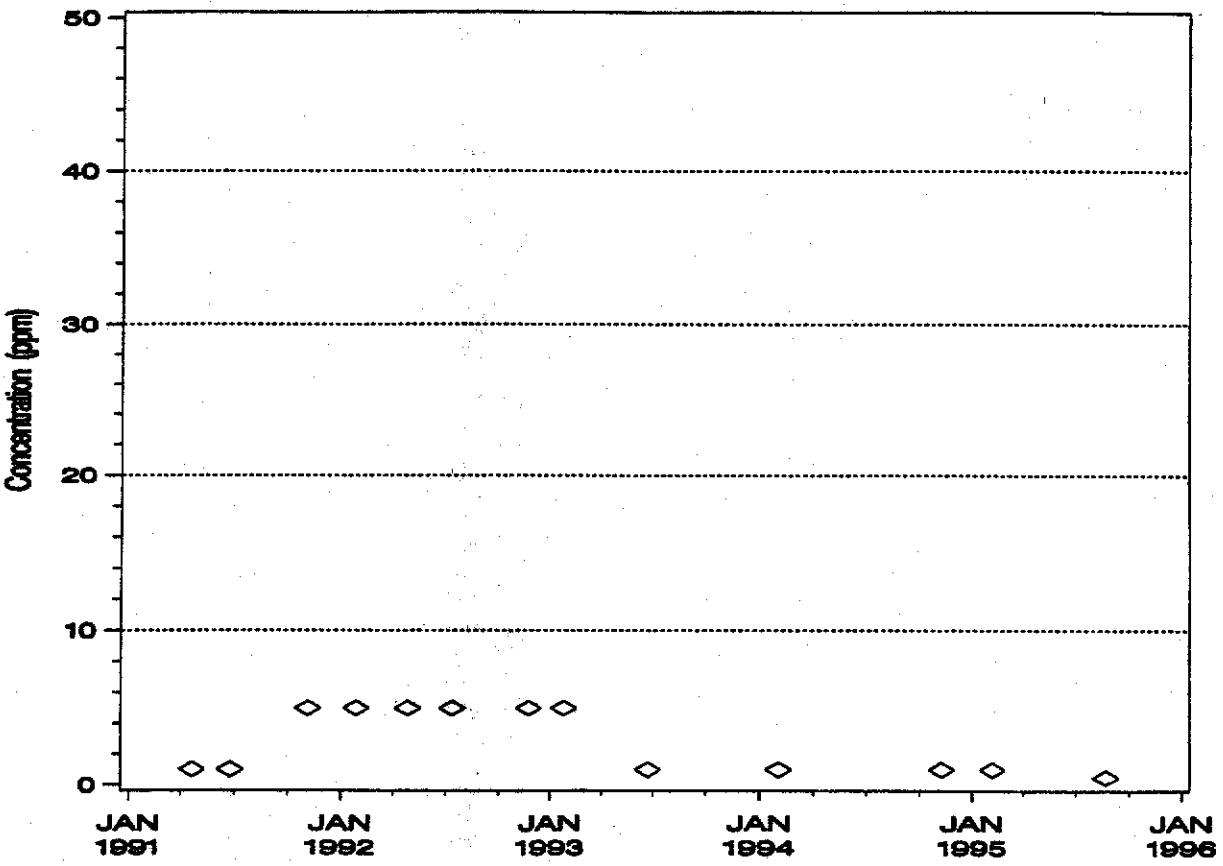
FREON 113 Trend



WELL 1476
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend

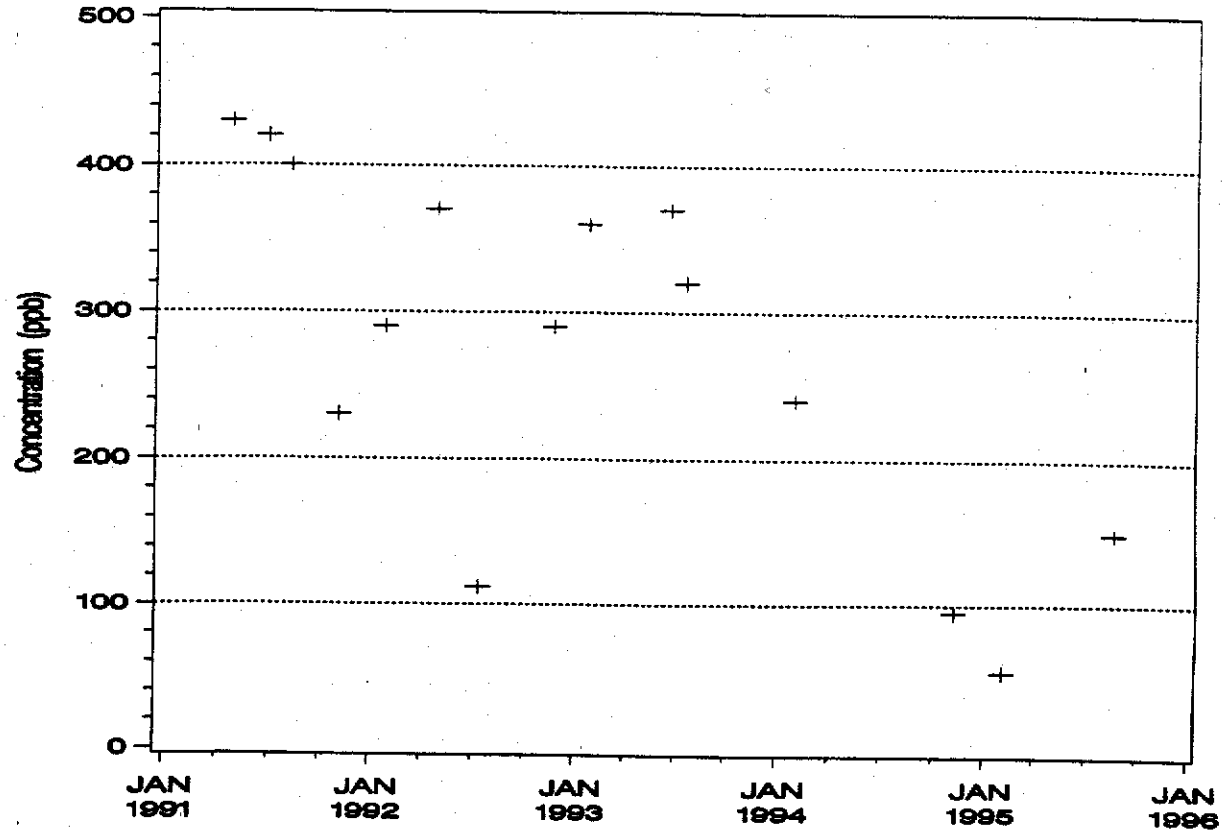


1,1 – DICHLOROETHYLENE Trend

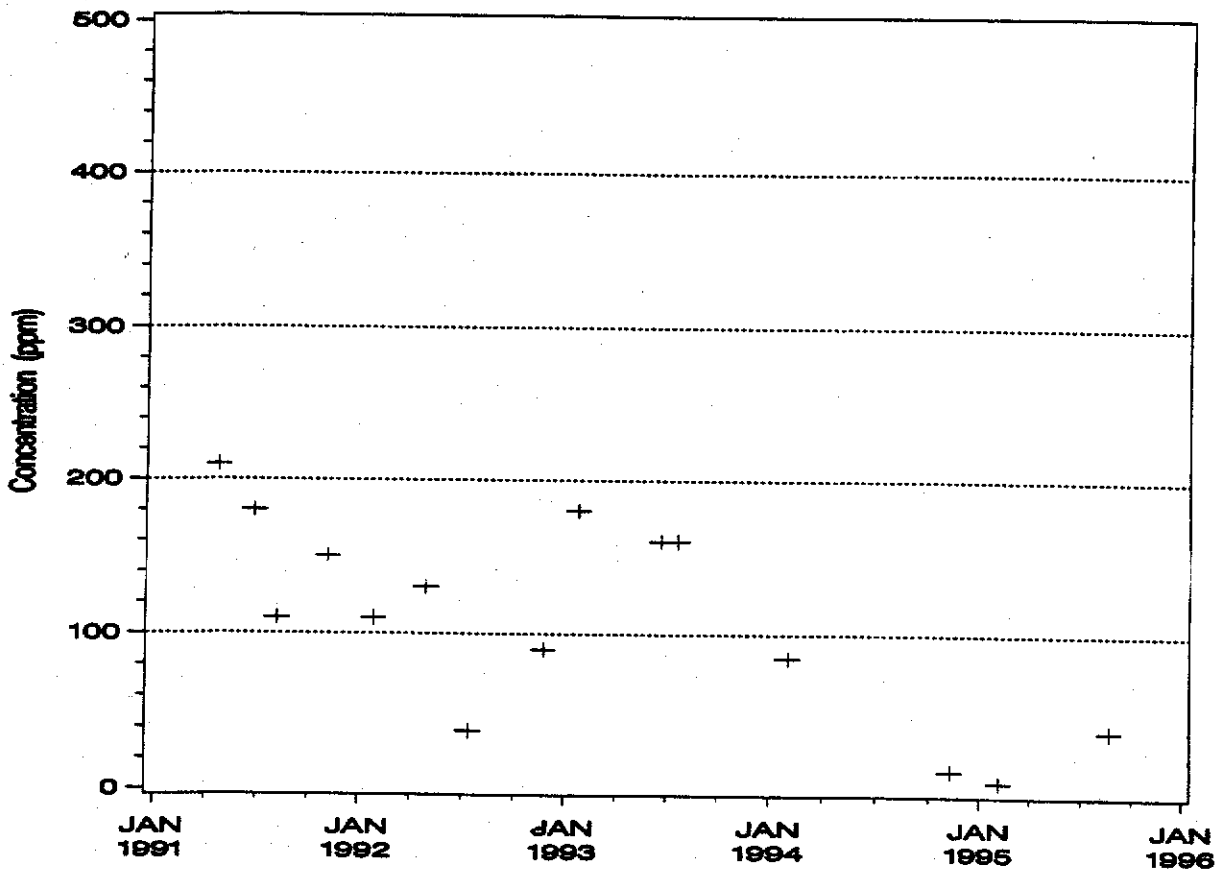


WELL 1477

TRICHLOROETHYLENE Trend

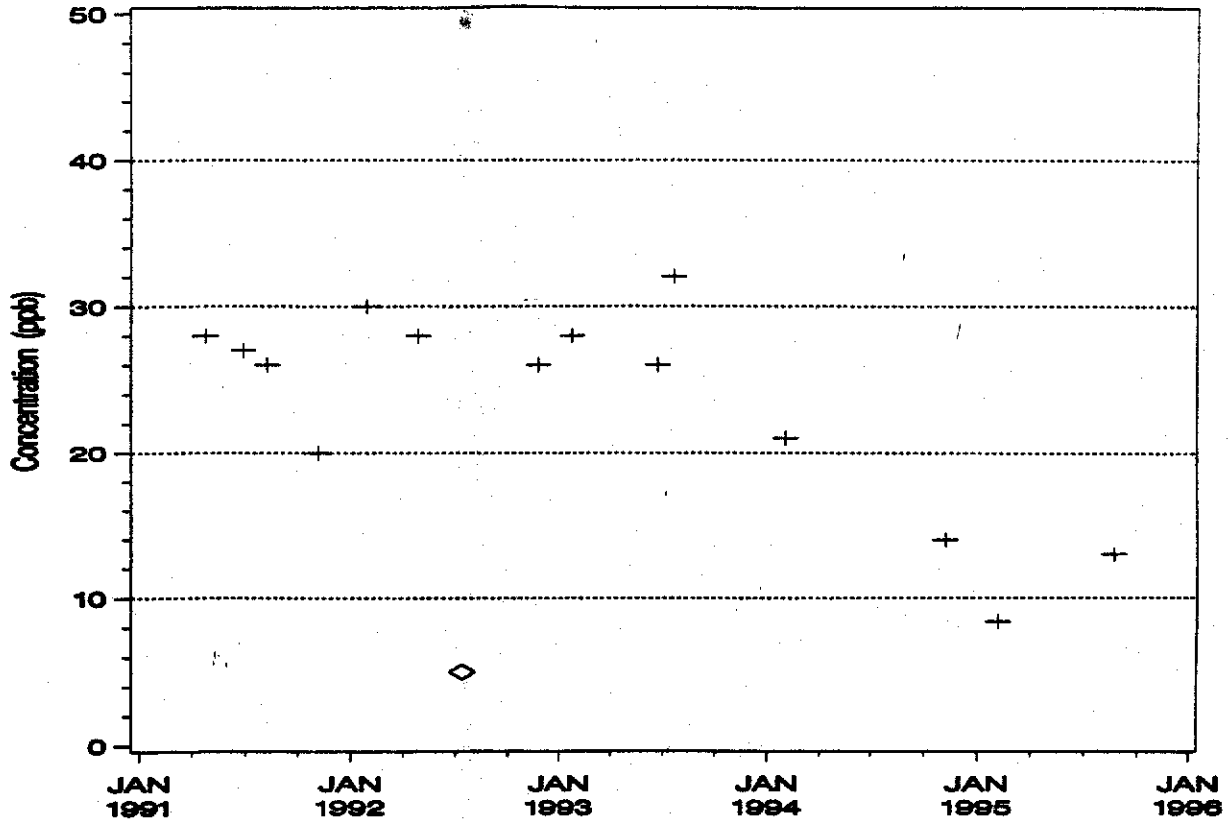


FREON 113 Trend

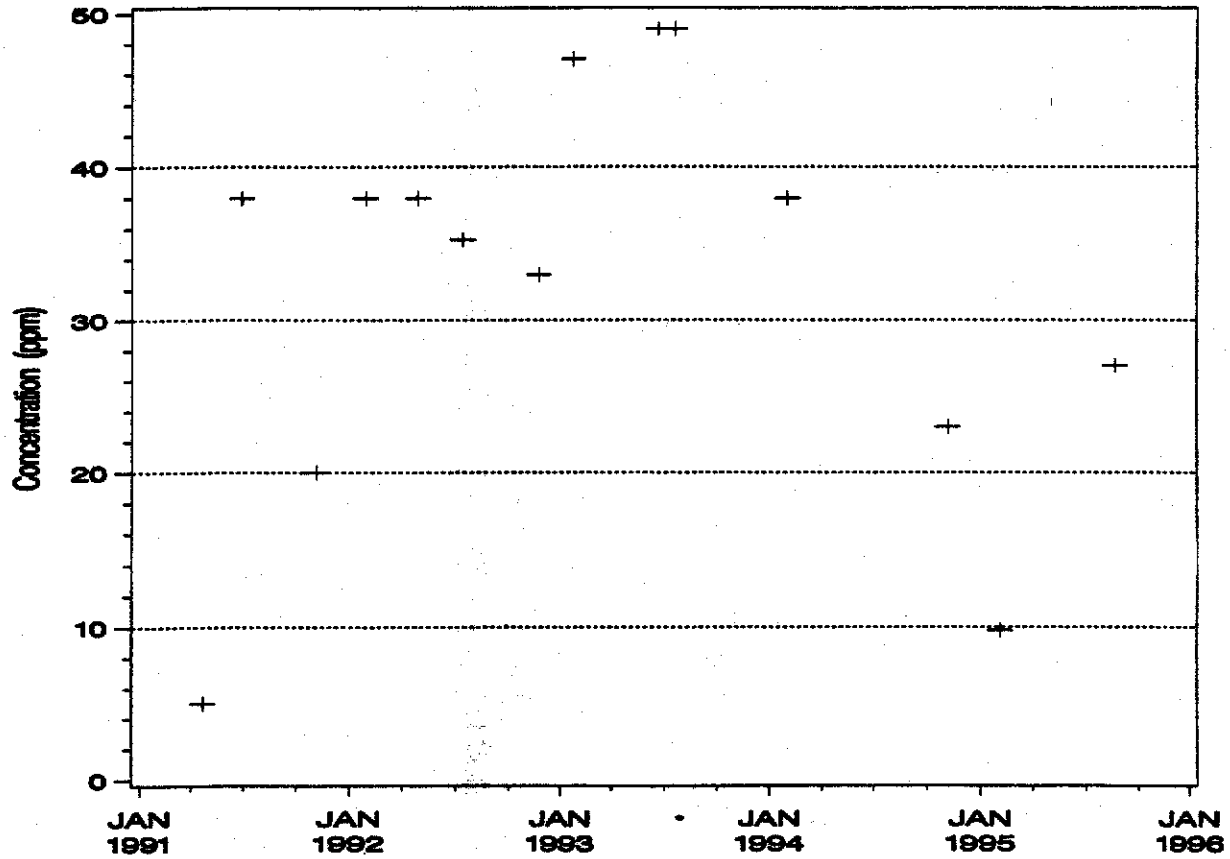


WELL 1477

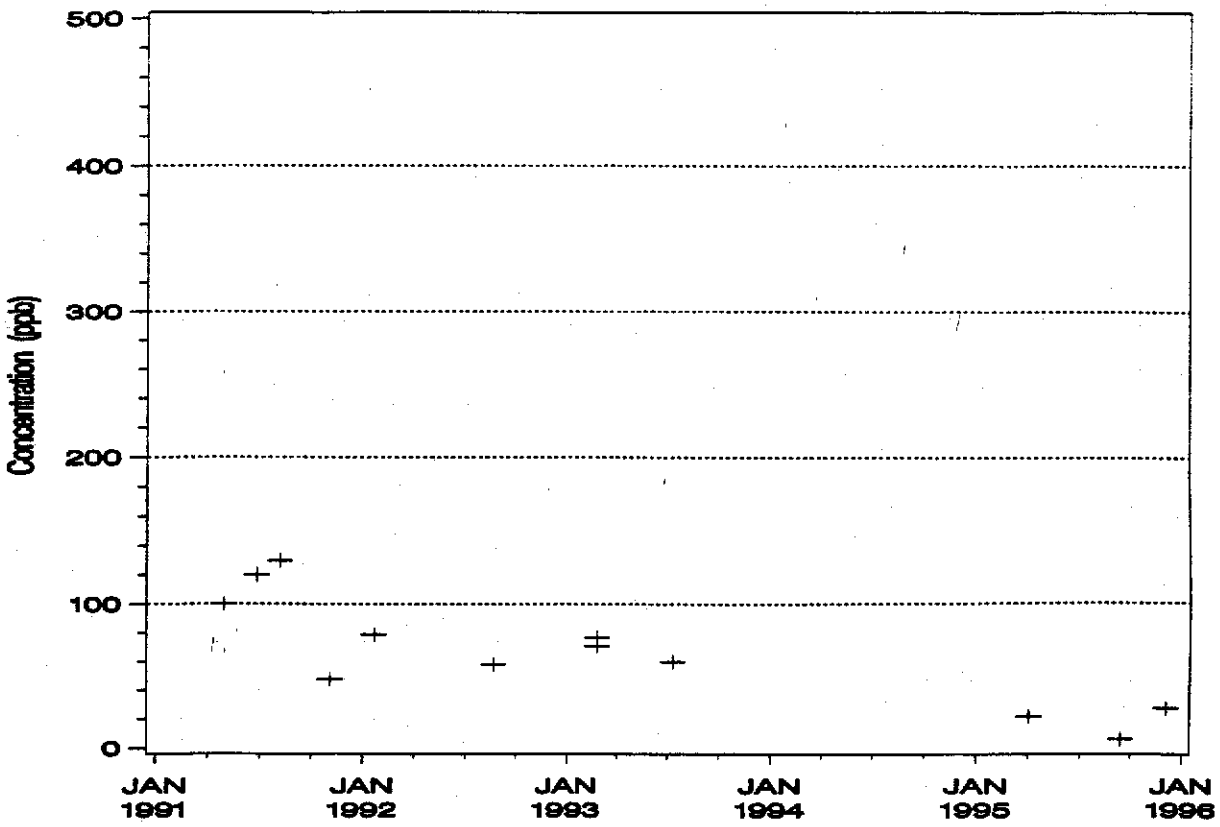
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



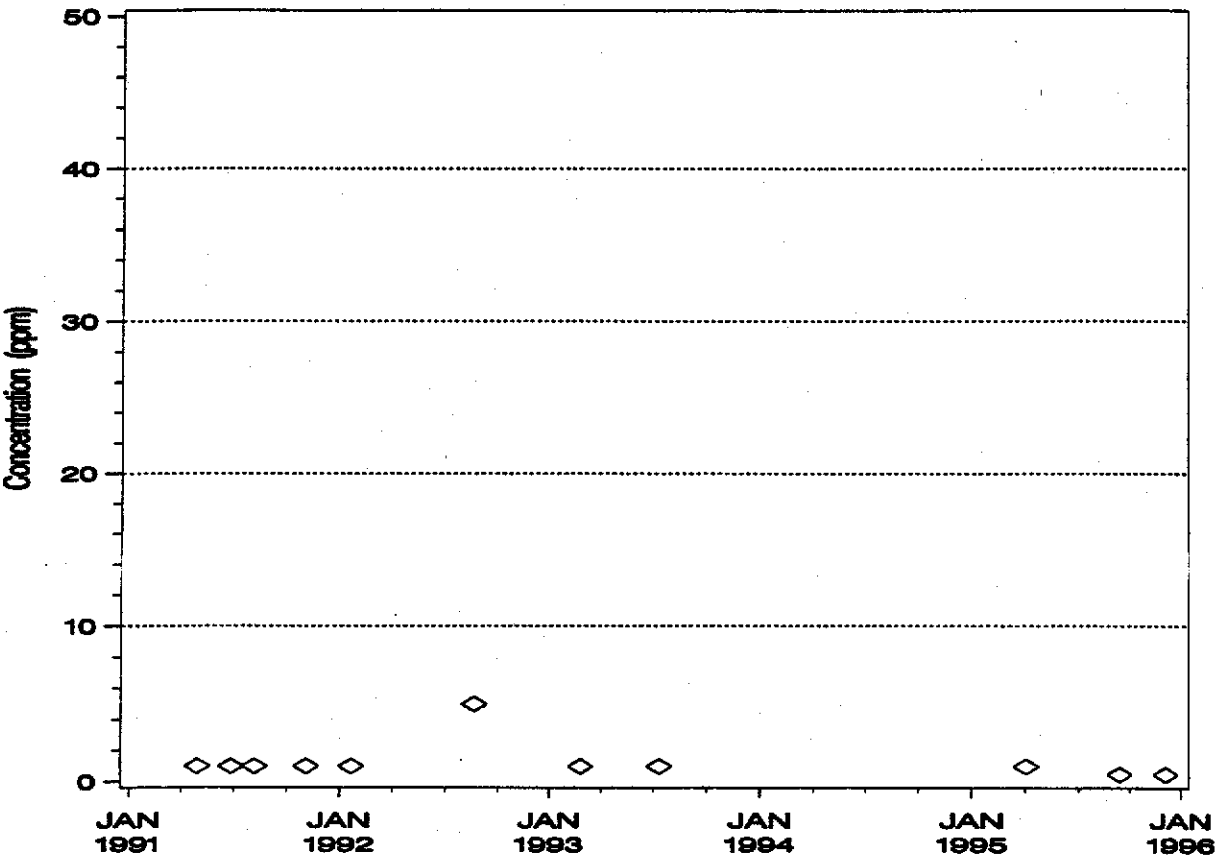
1,1 – DICHLOROETHYLENE Trend



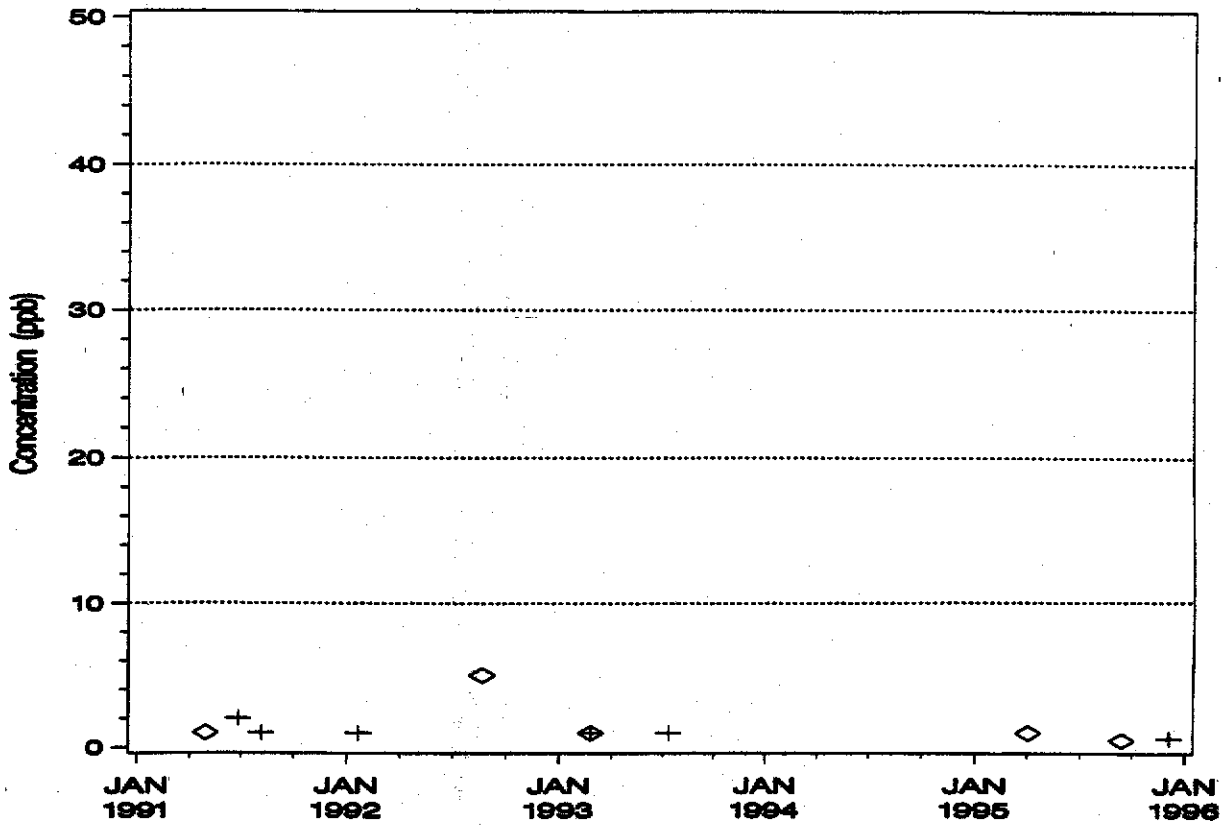
WELL 1478
TRICHLOROETHYLENE Trend



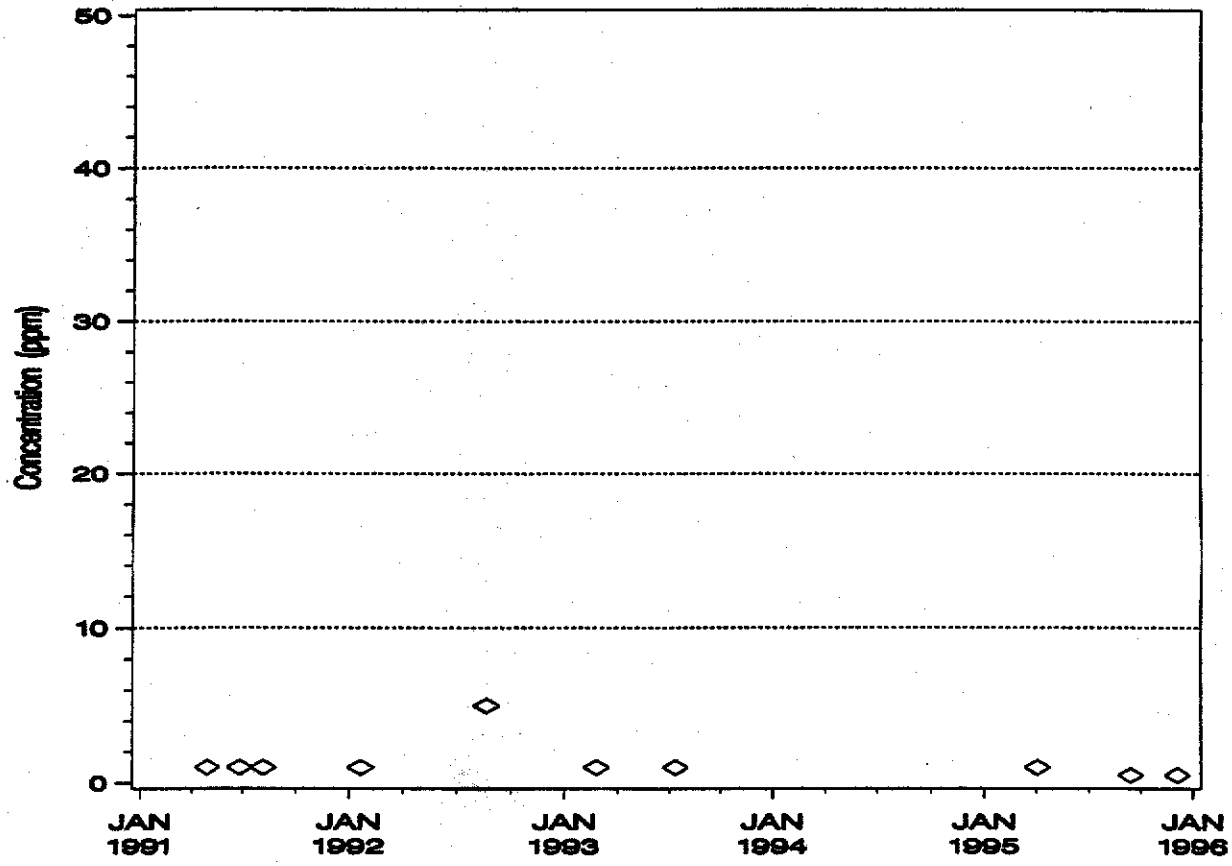
FREON 113 Trend



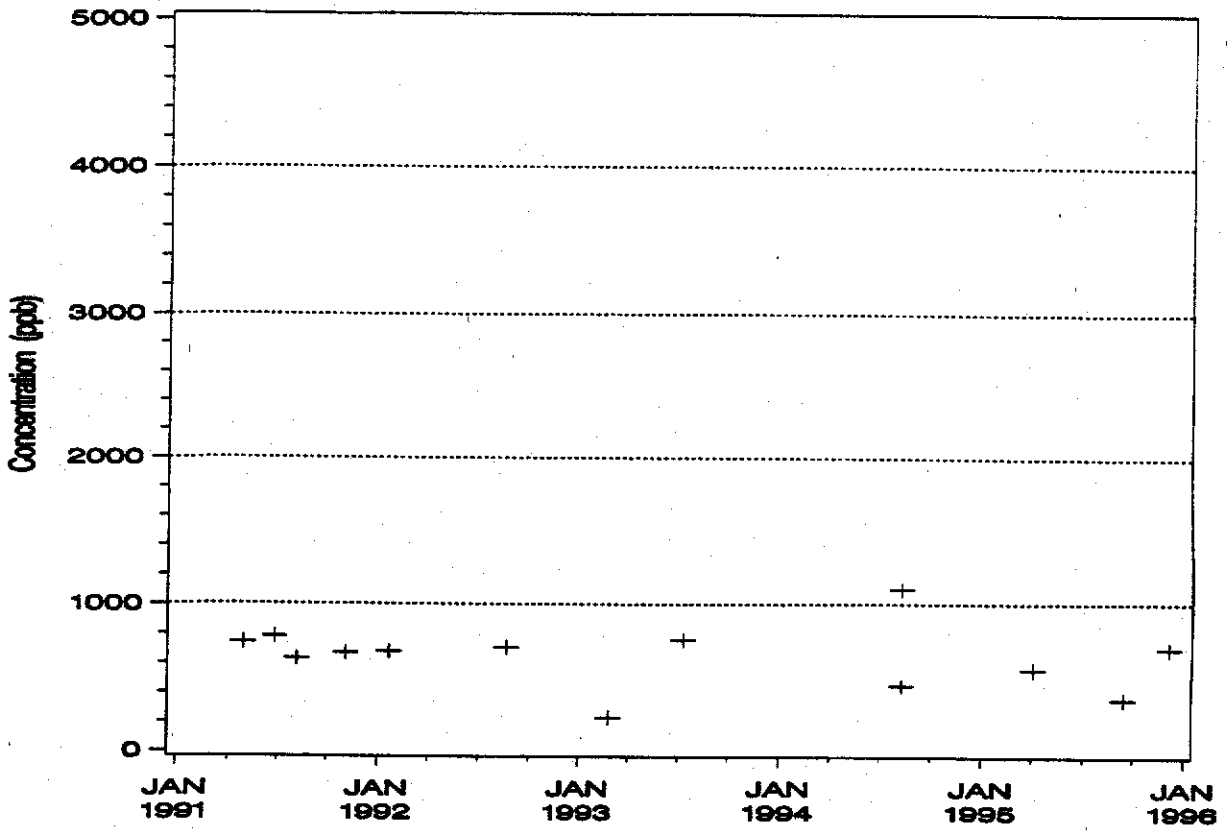
WELL 1478
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



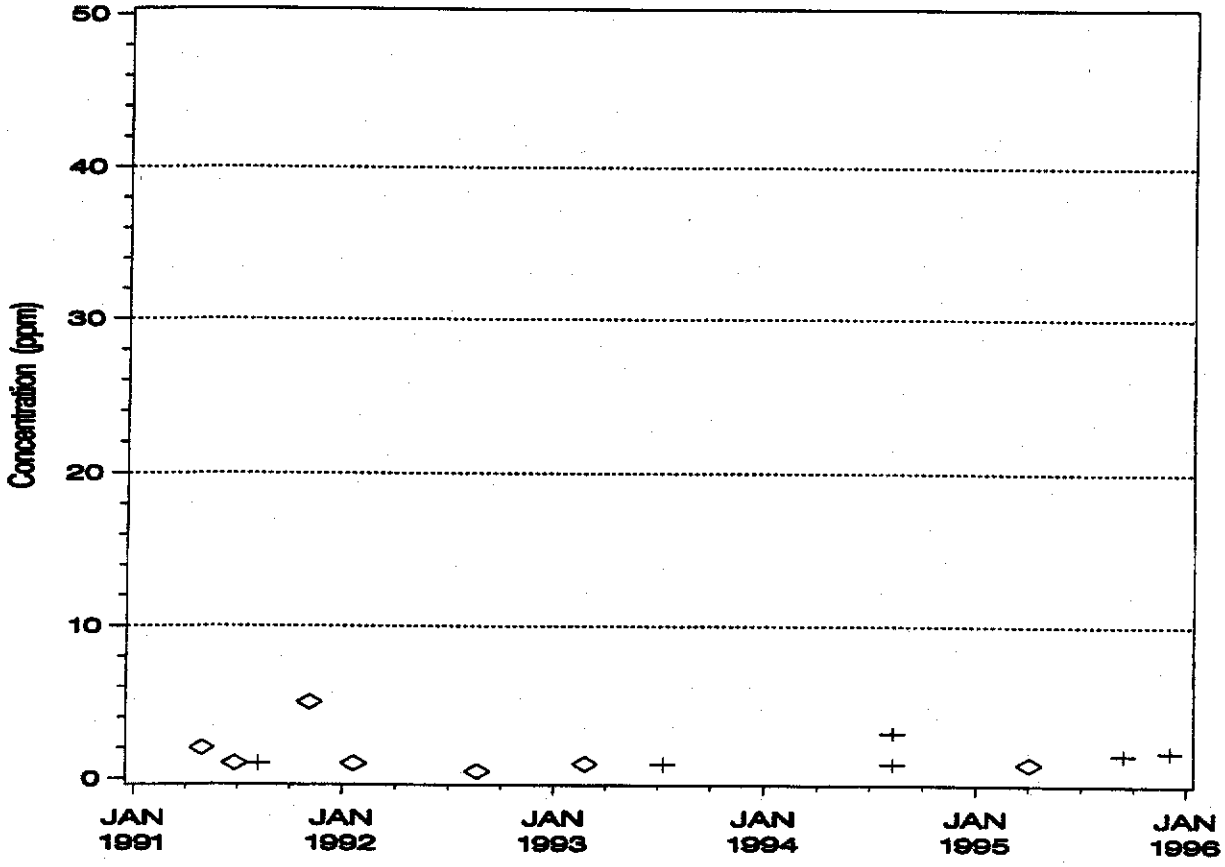
1,1 – DICHLOROETHYLENE Trend



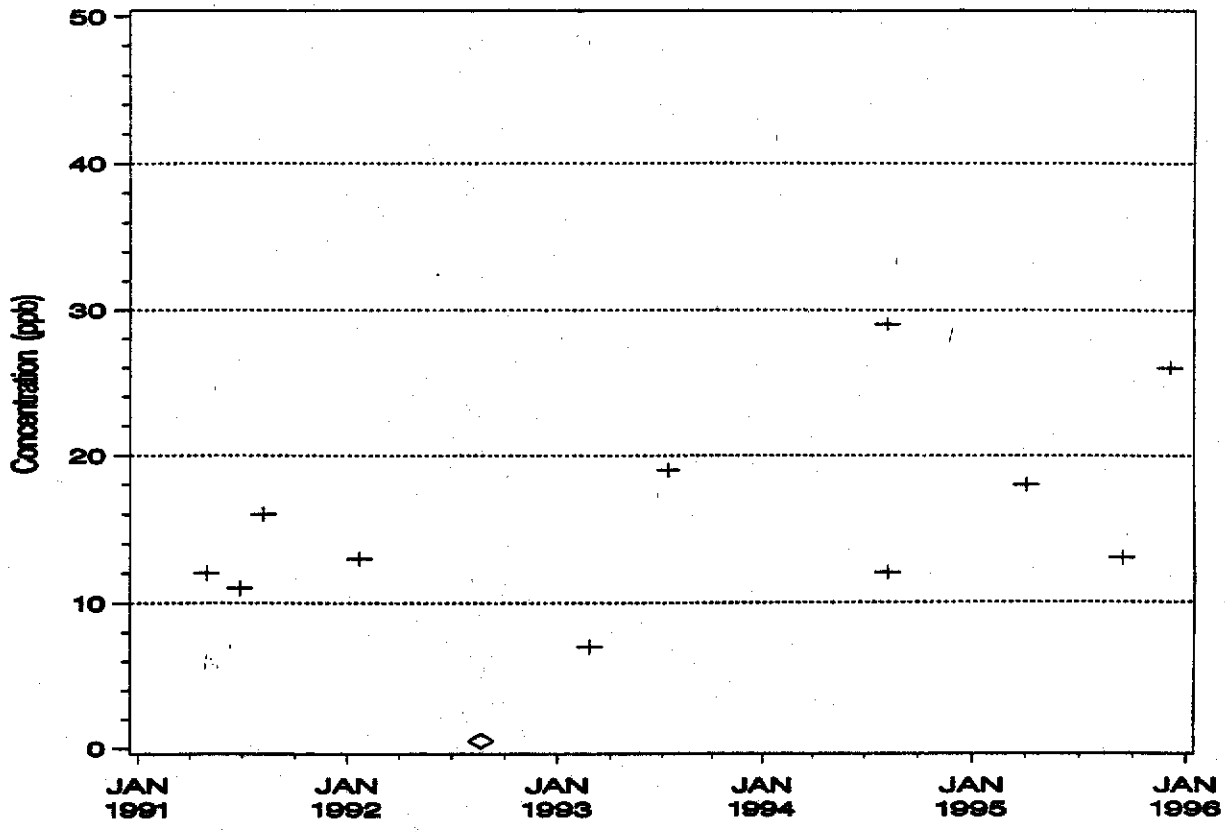
WELL 1479
TRICHLOROETHYLENE Trend



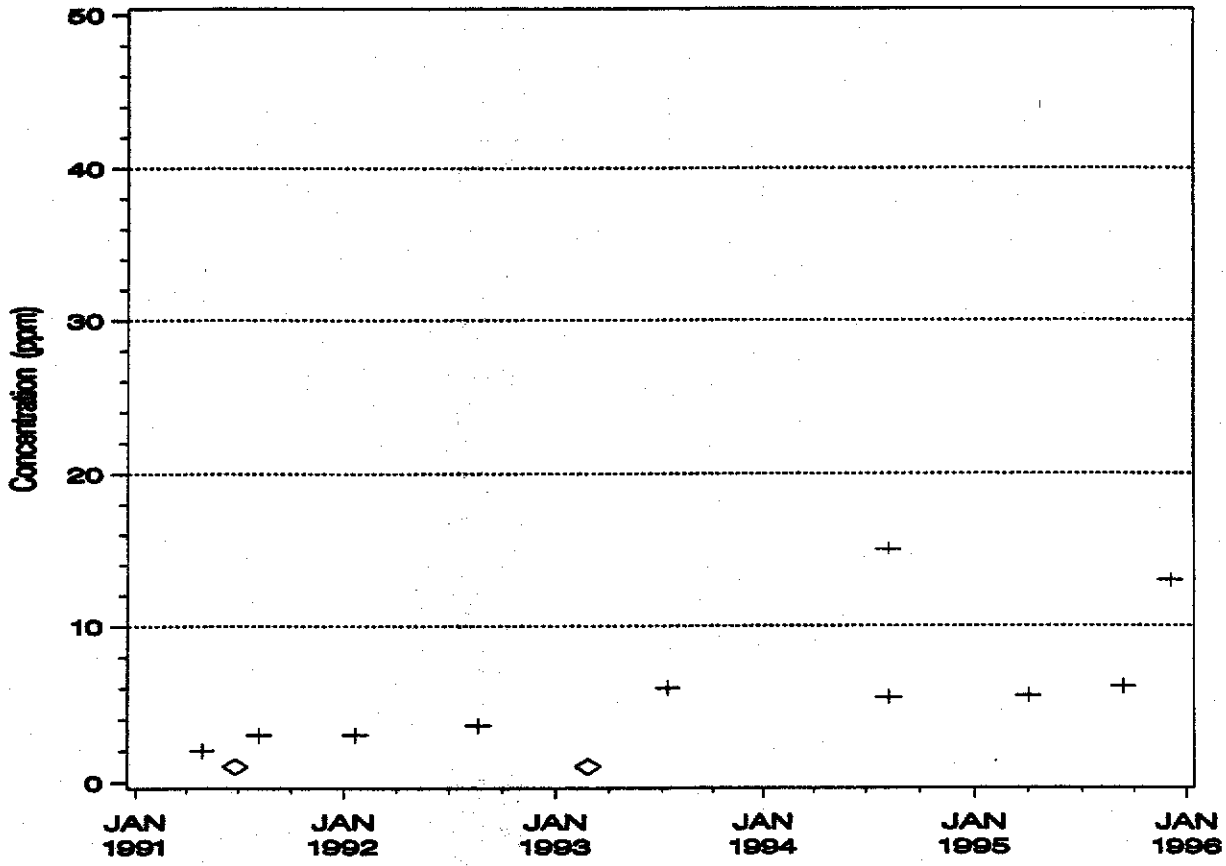
FREON 113 Trend



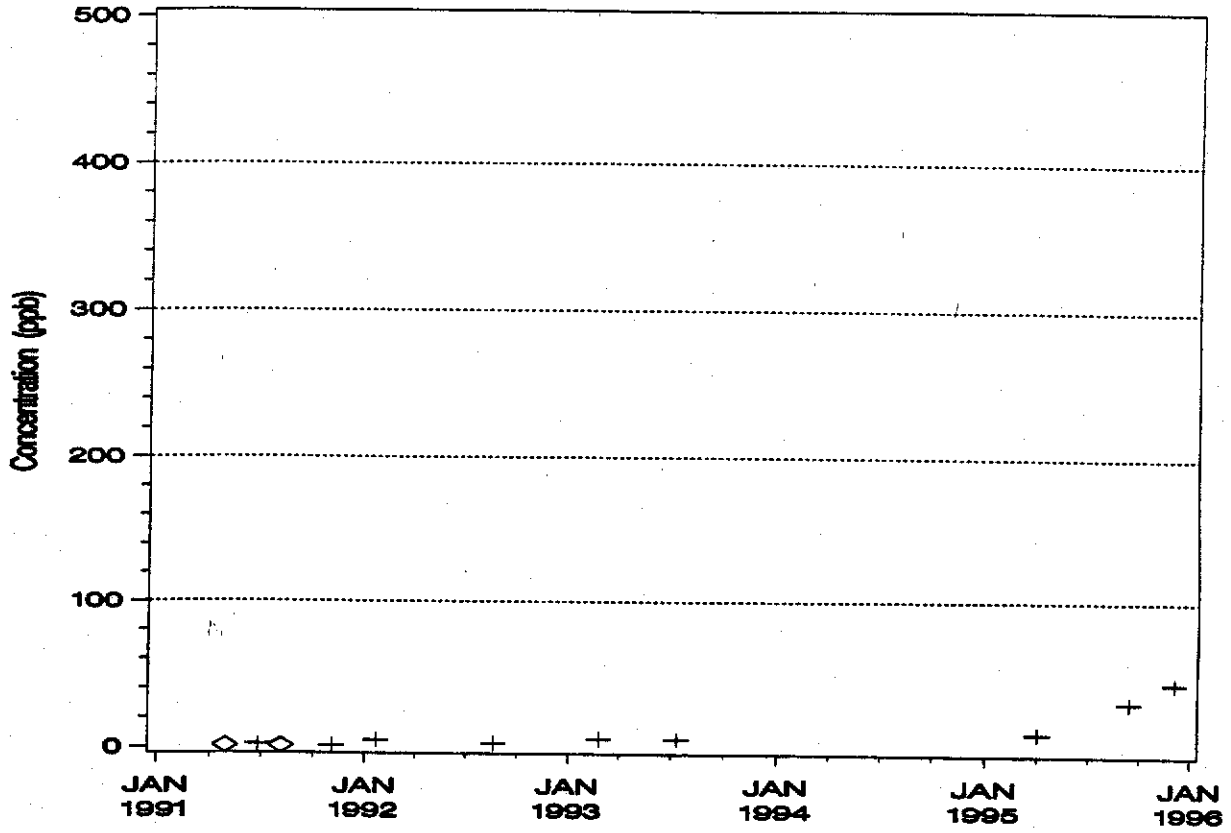
WELL 1479
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



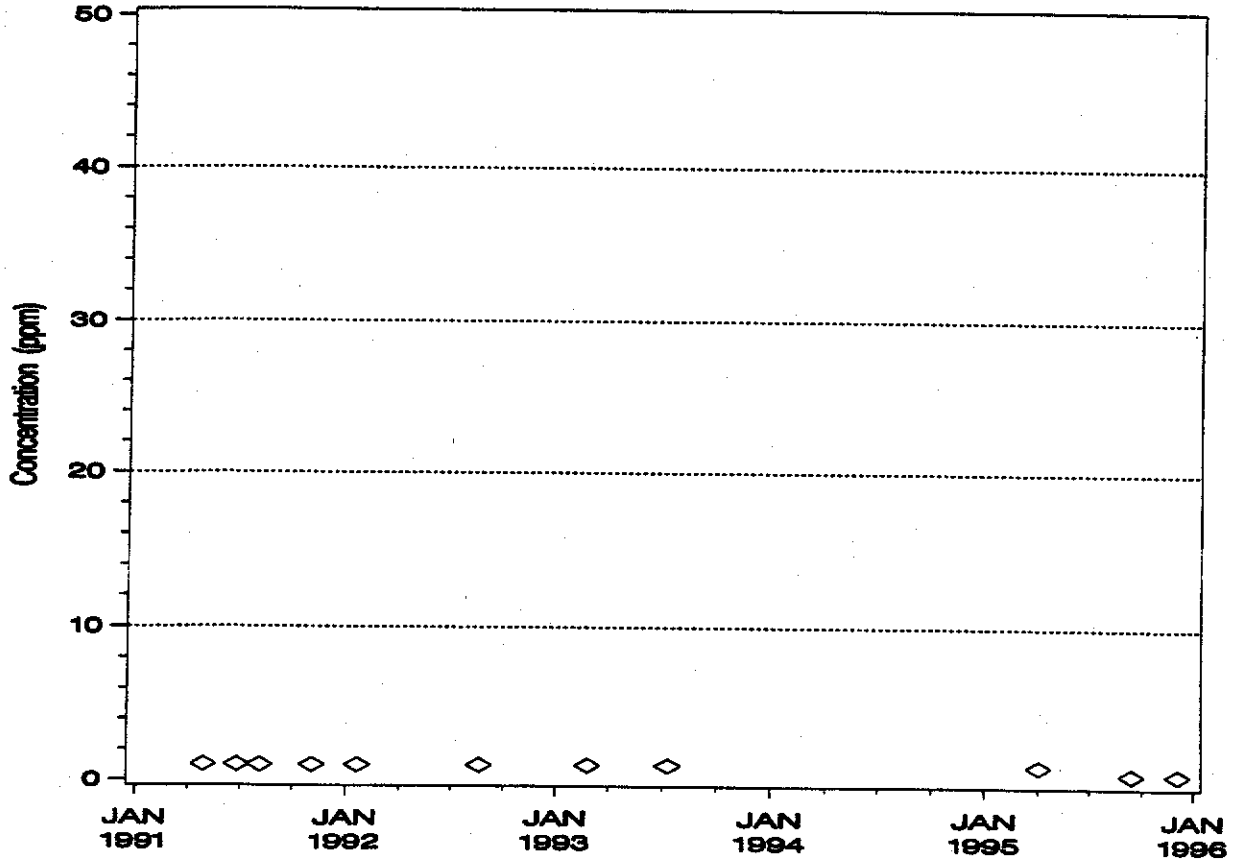
1,1 – DICHLOROETHYLENE Trend



WELL 1480
TRICHLOROETHYLENE Trend

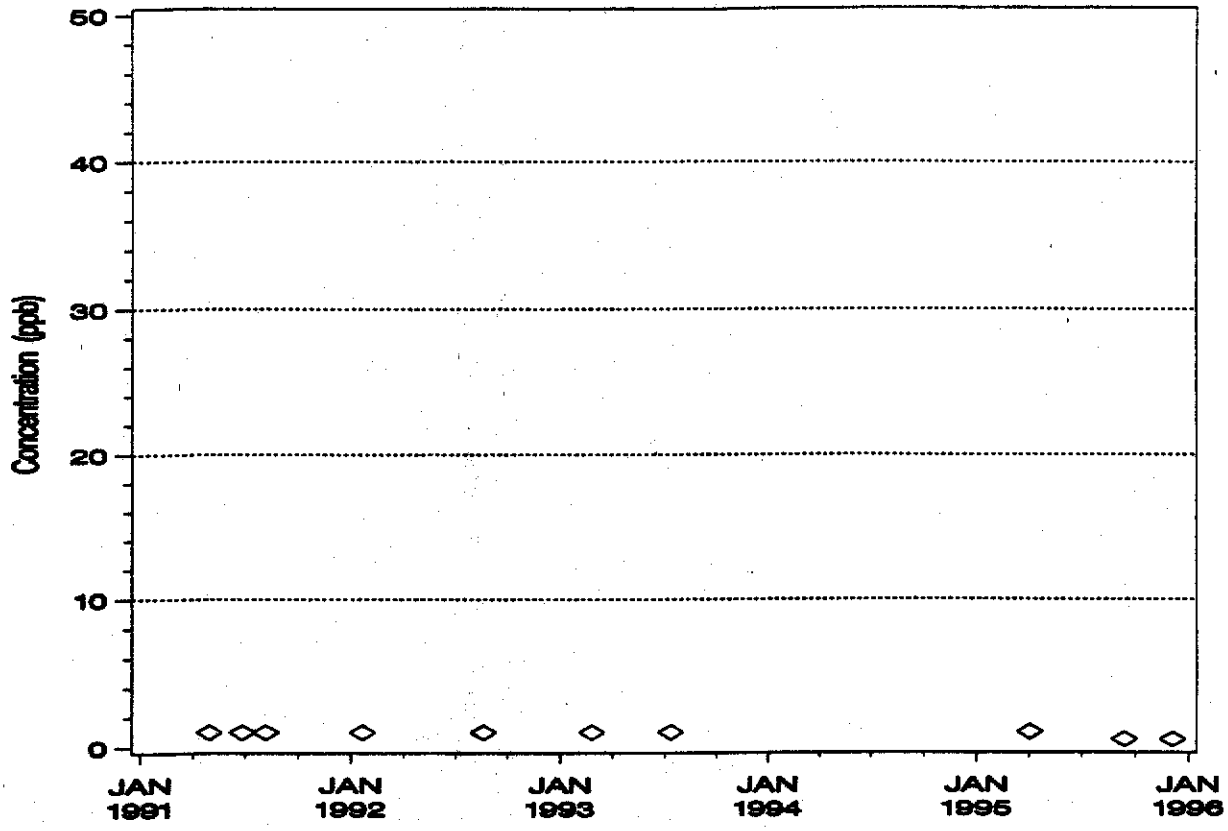


FREON 113 Trend

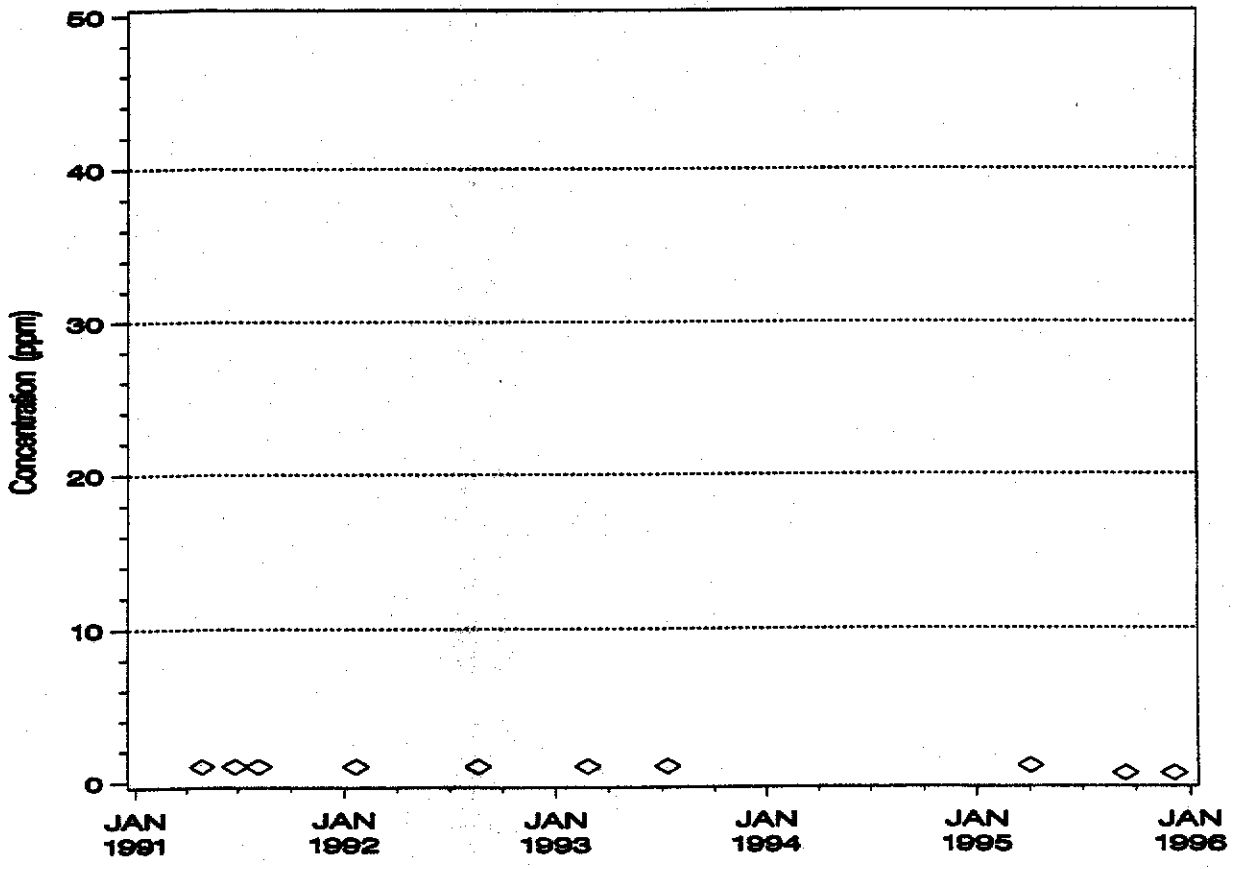


WELL 1480

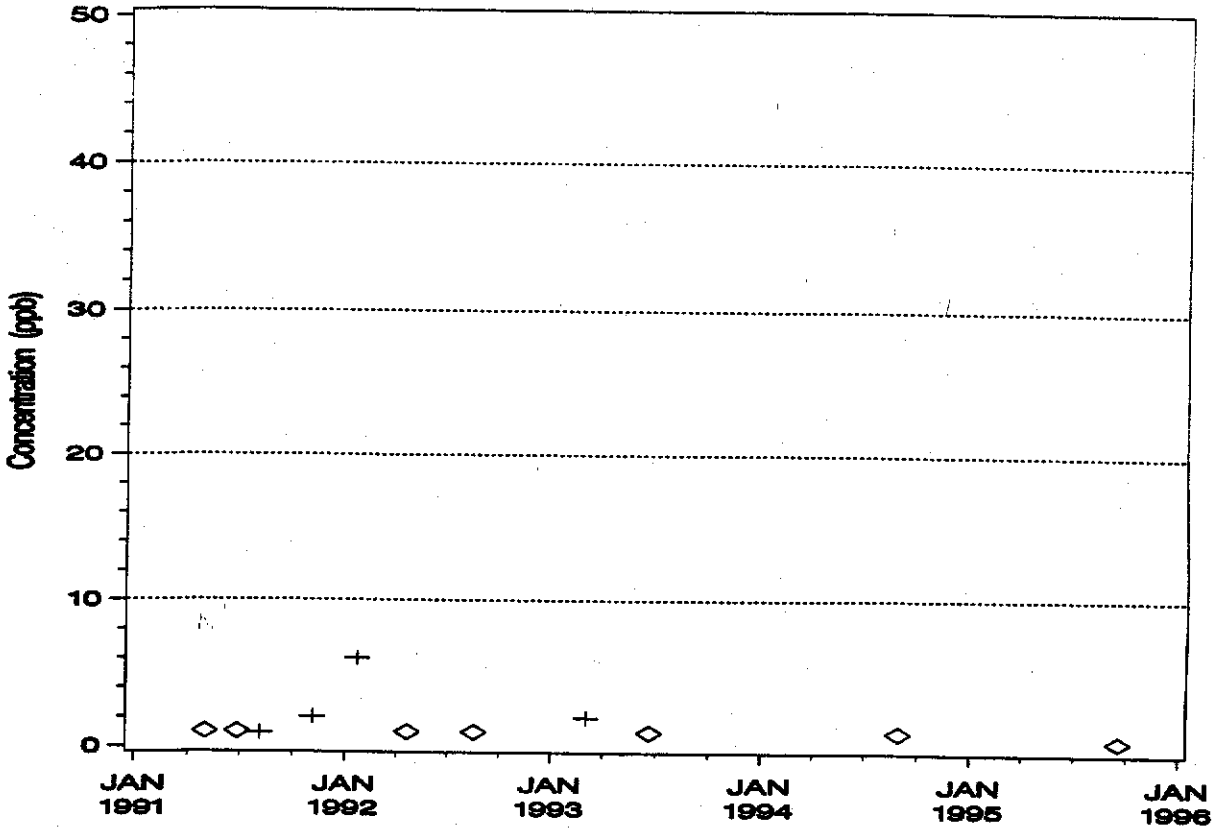
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



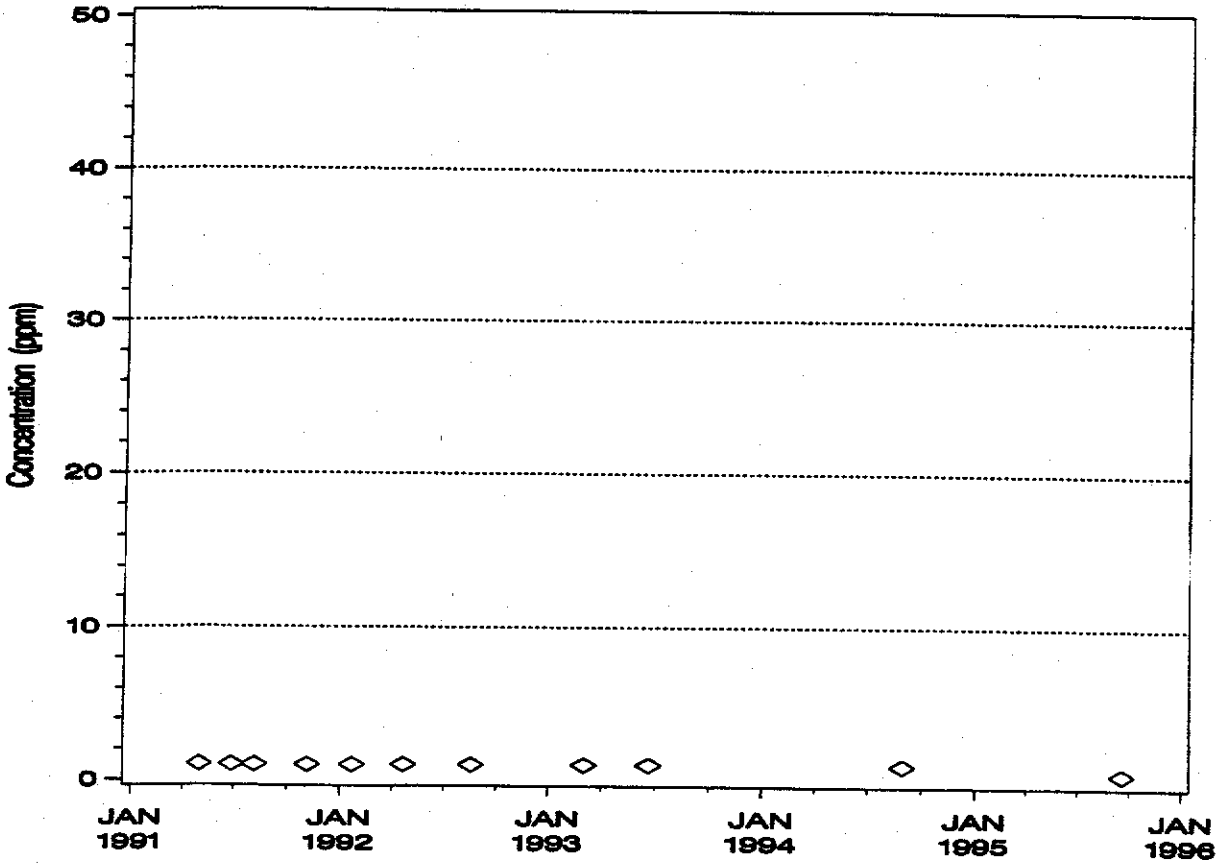
1,1 – DICHLOROETHYLENE Trend



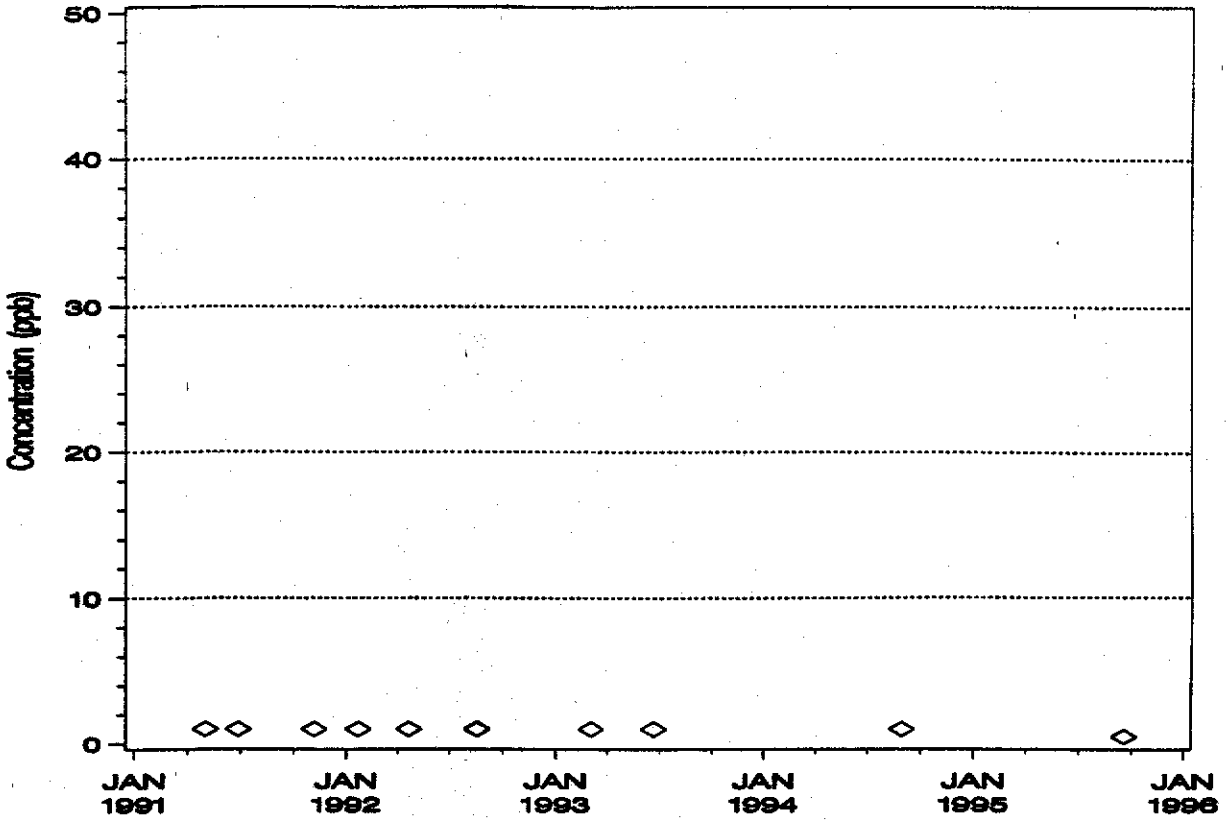
WELL 1481
TRICHLOROETHYLENE Trend



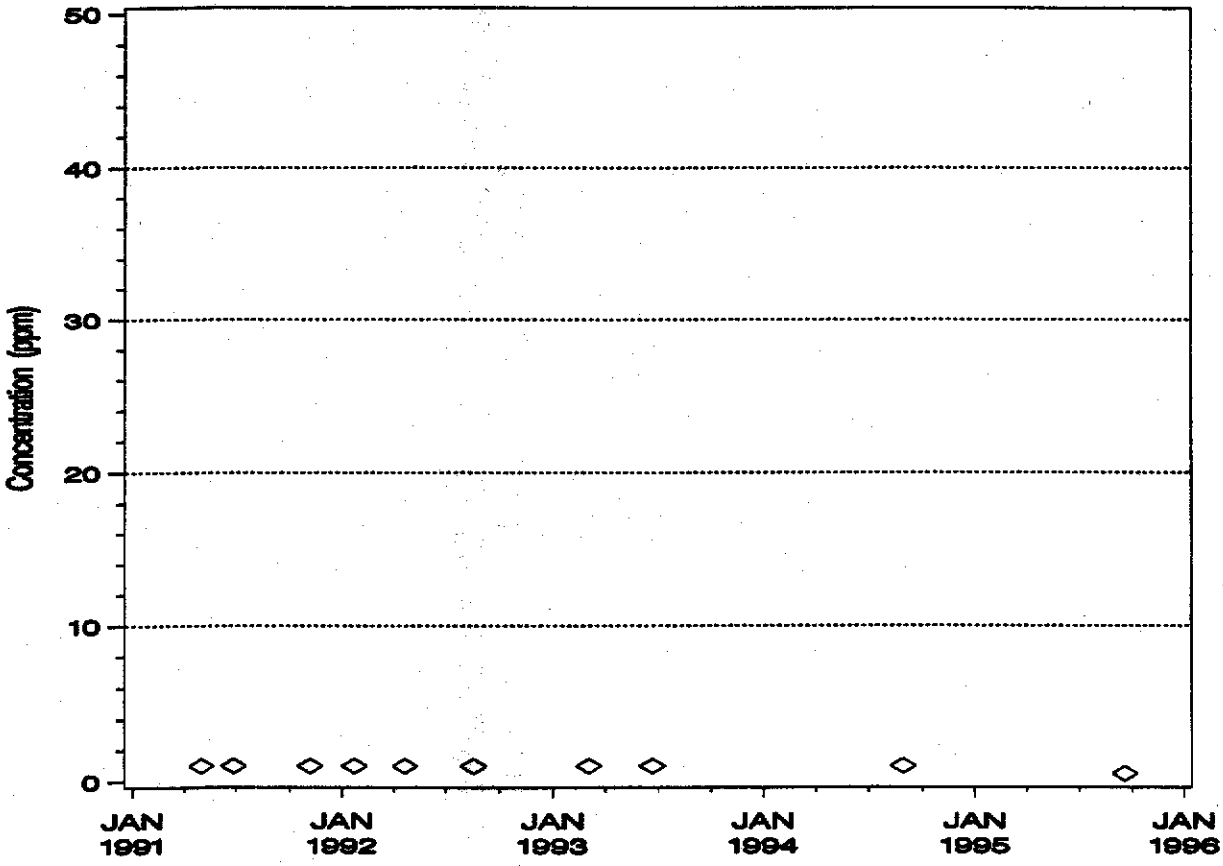
FREON 113 Trend



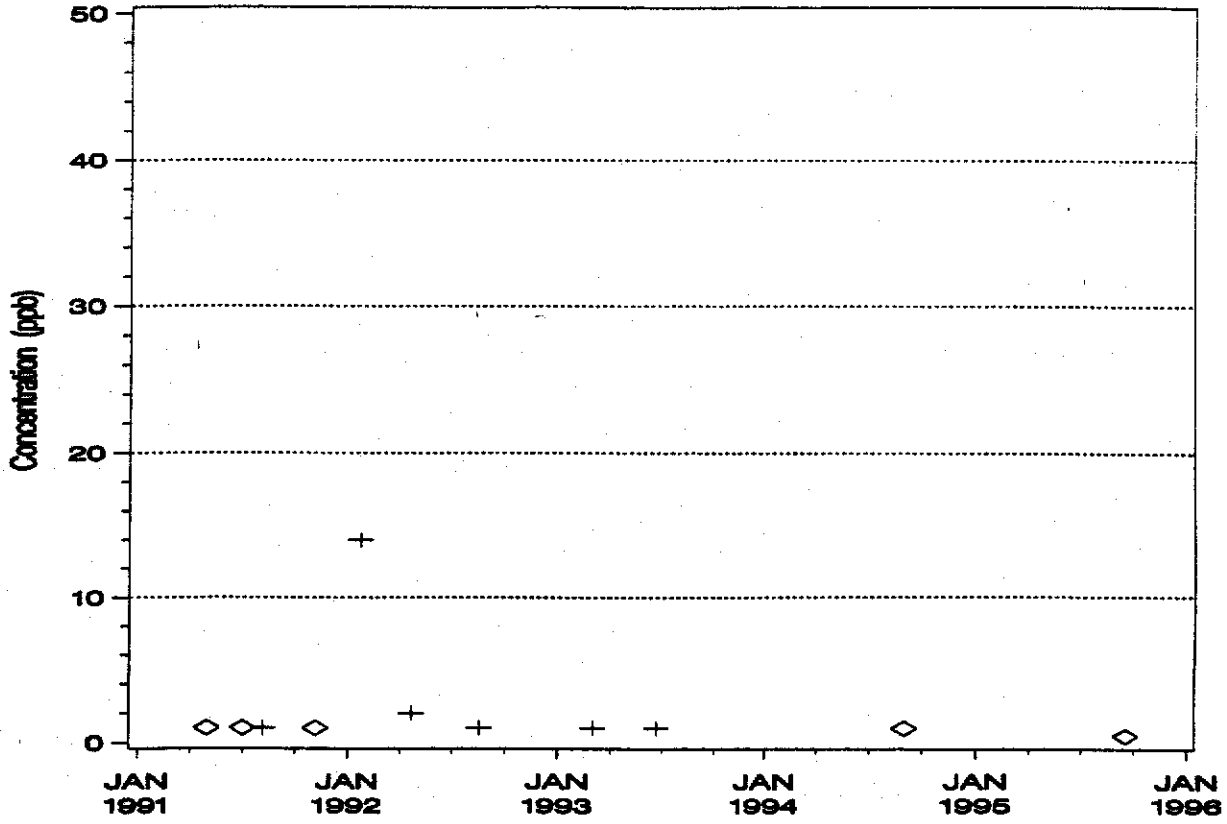
WELL 1481
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



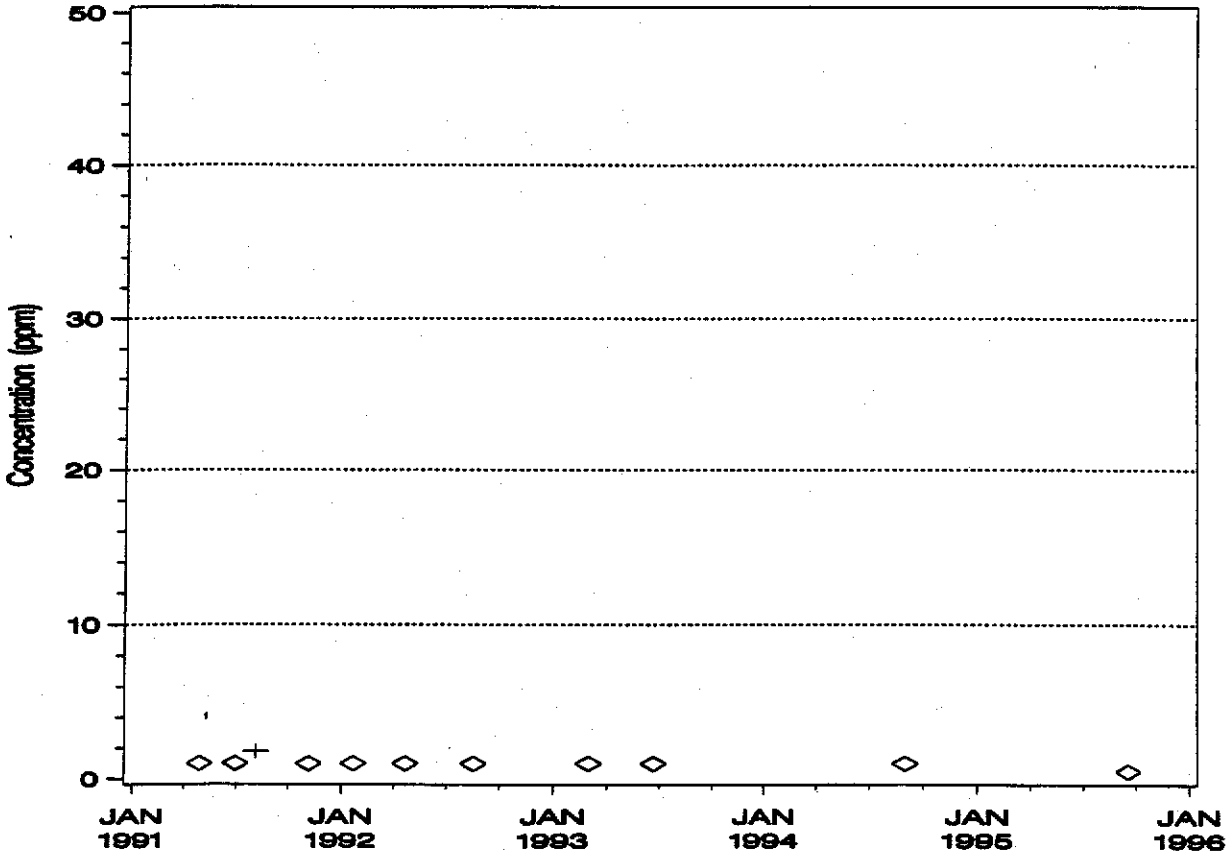
1,1 – DICHLOROETHYLENE Trend



WELL 1482
TRICHLOROETHYLENE Trend

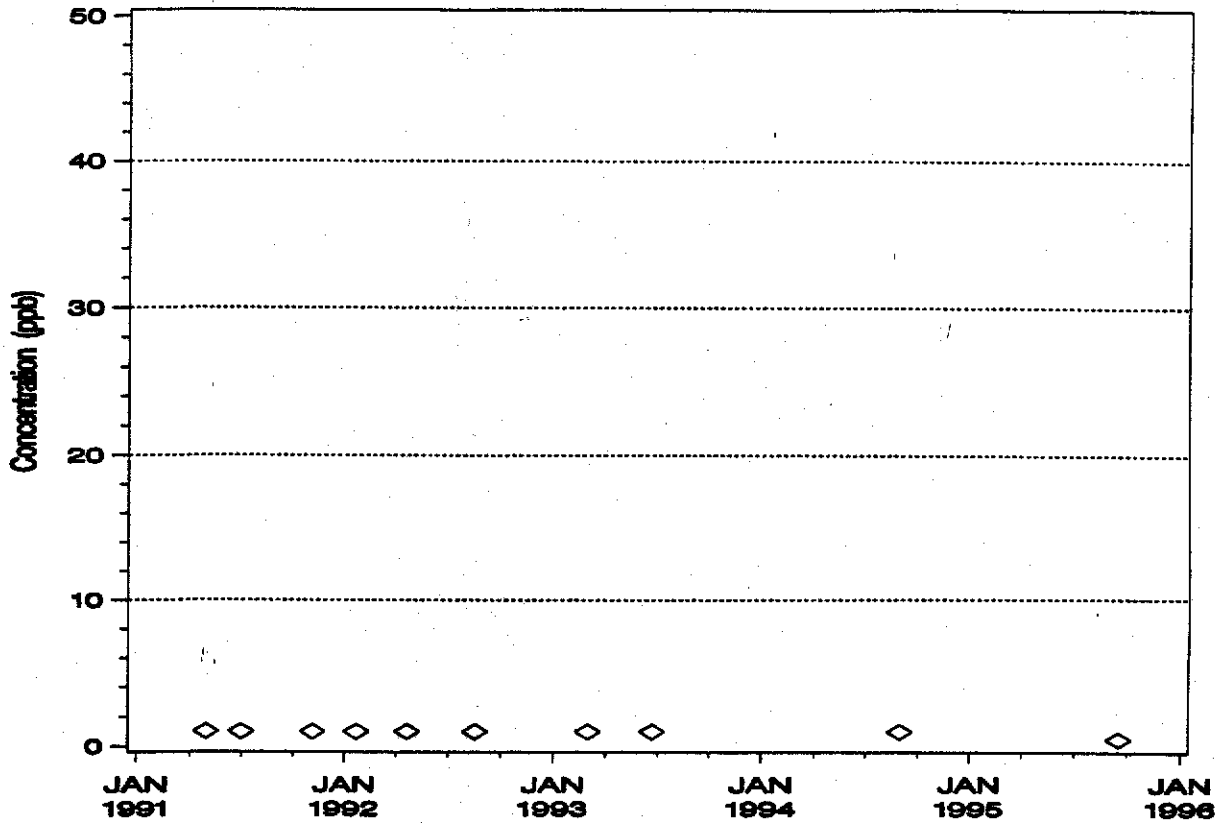


FREON 113 Trend

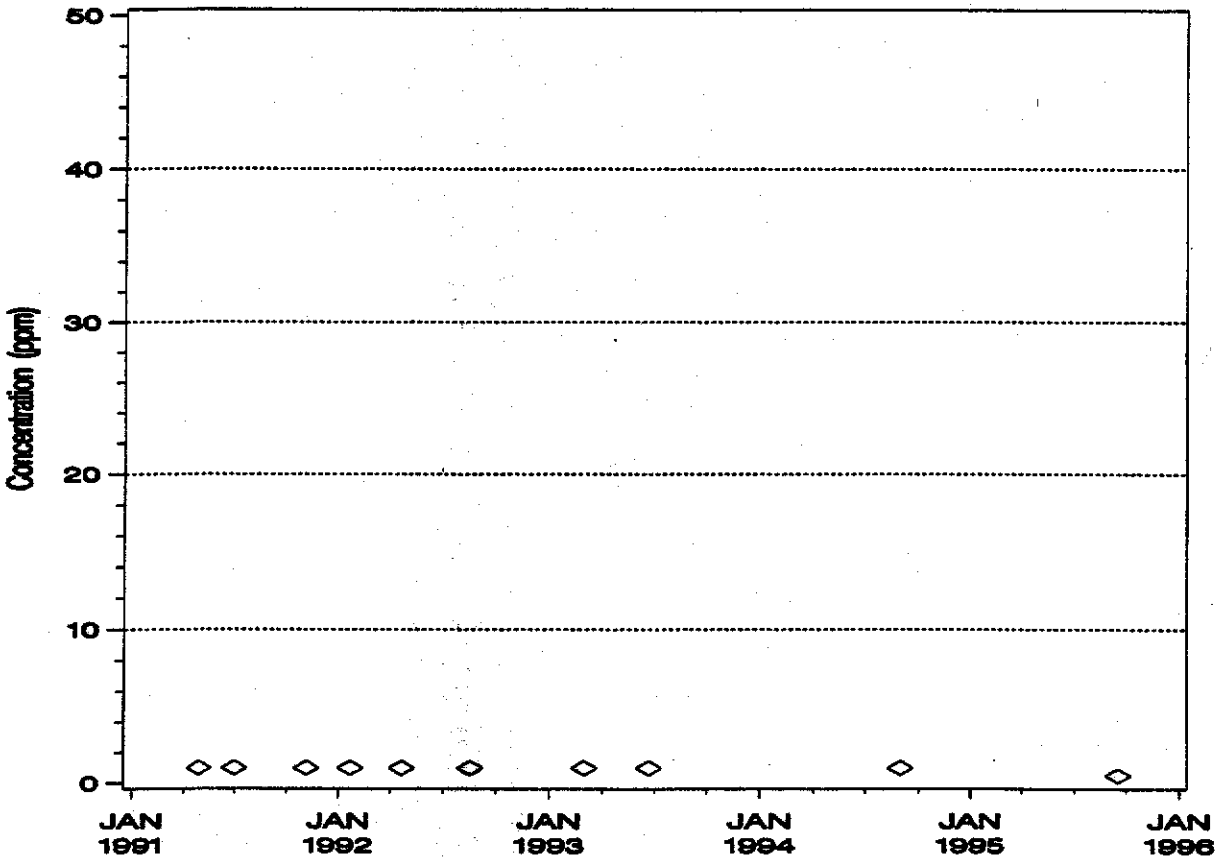


WELL 1482

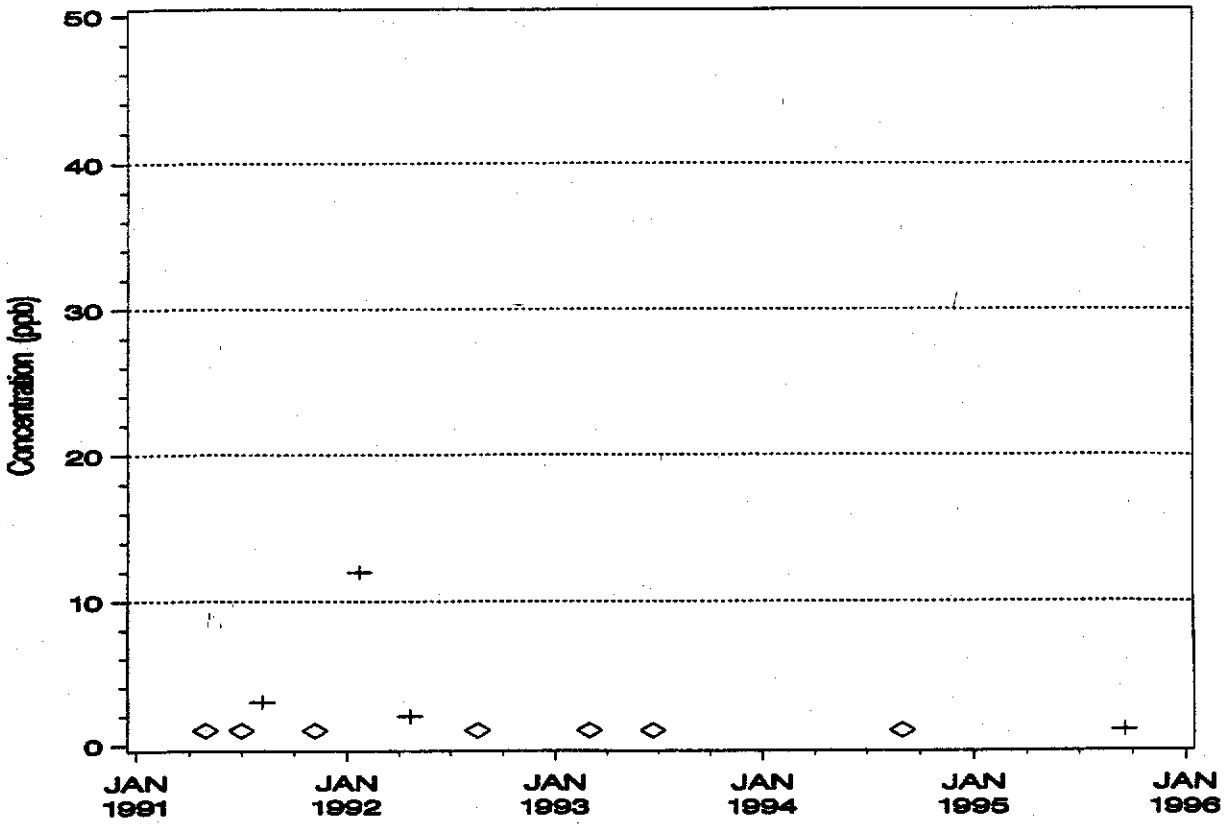
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



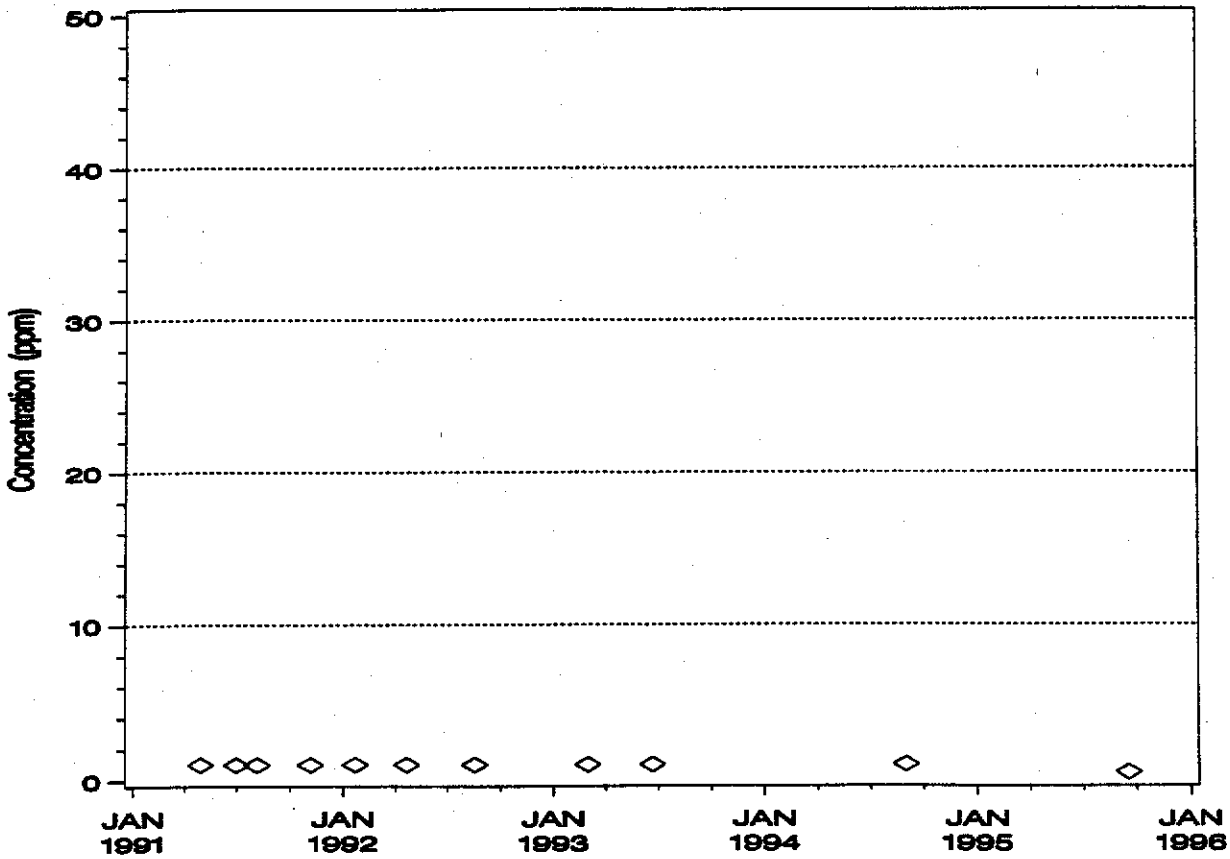
1,1 – DICHLOROETHYLENE Trend



WELL 1483
TRICHLOROETHYLENE Trend

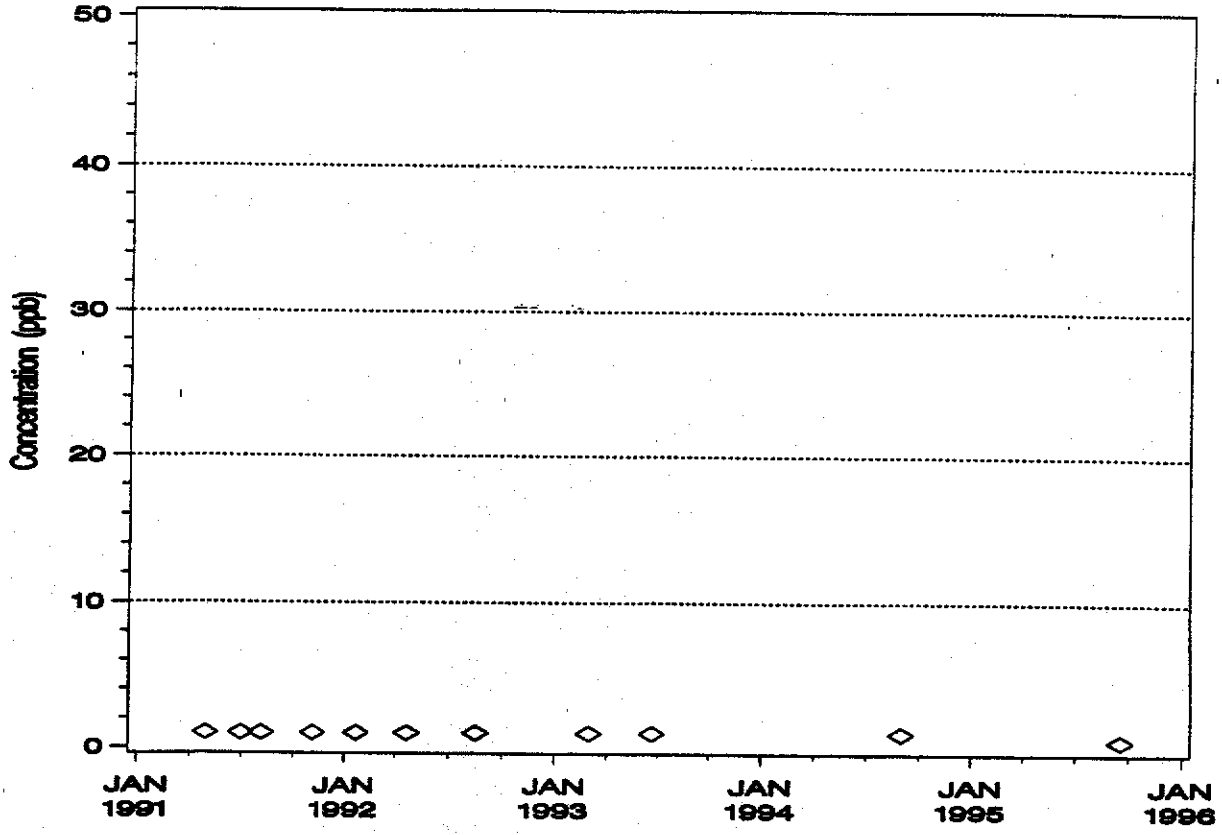


FREON 113 Trend

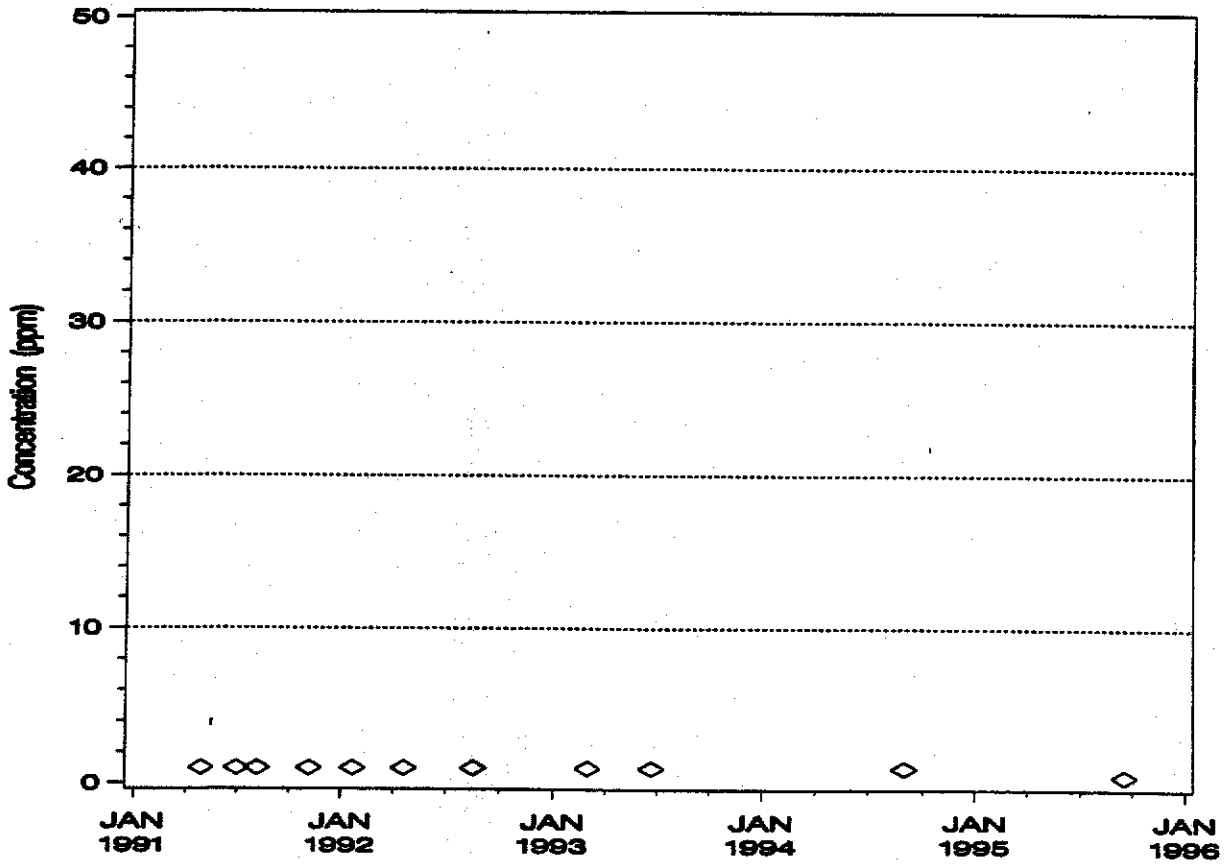


WELL 1483

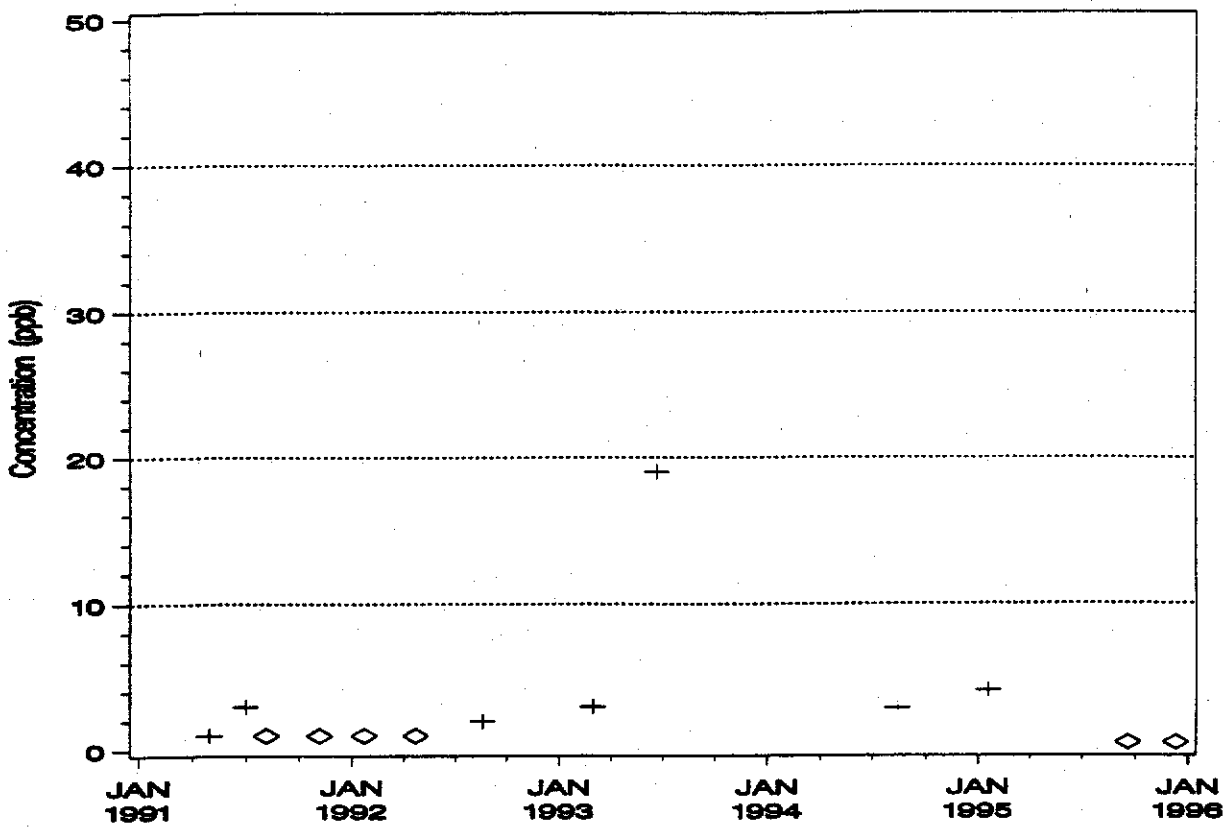
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



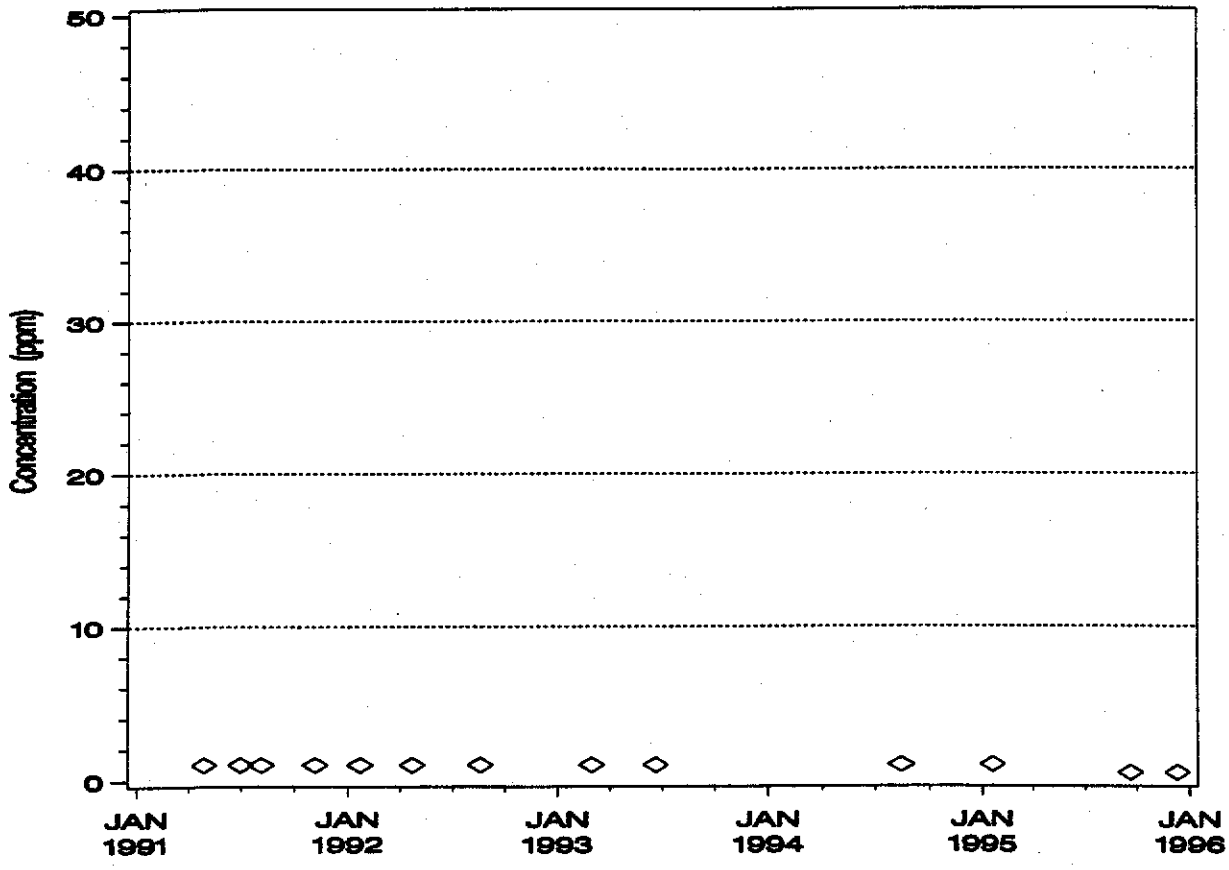
1,1 – DICHLOROETHYLENE Trend



WELL 1487
TRICHLOROETHYLENE Trend

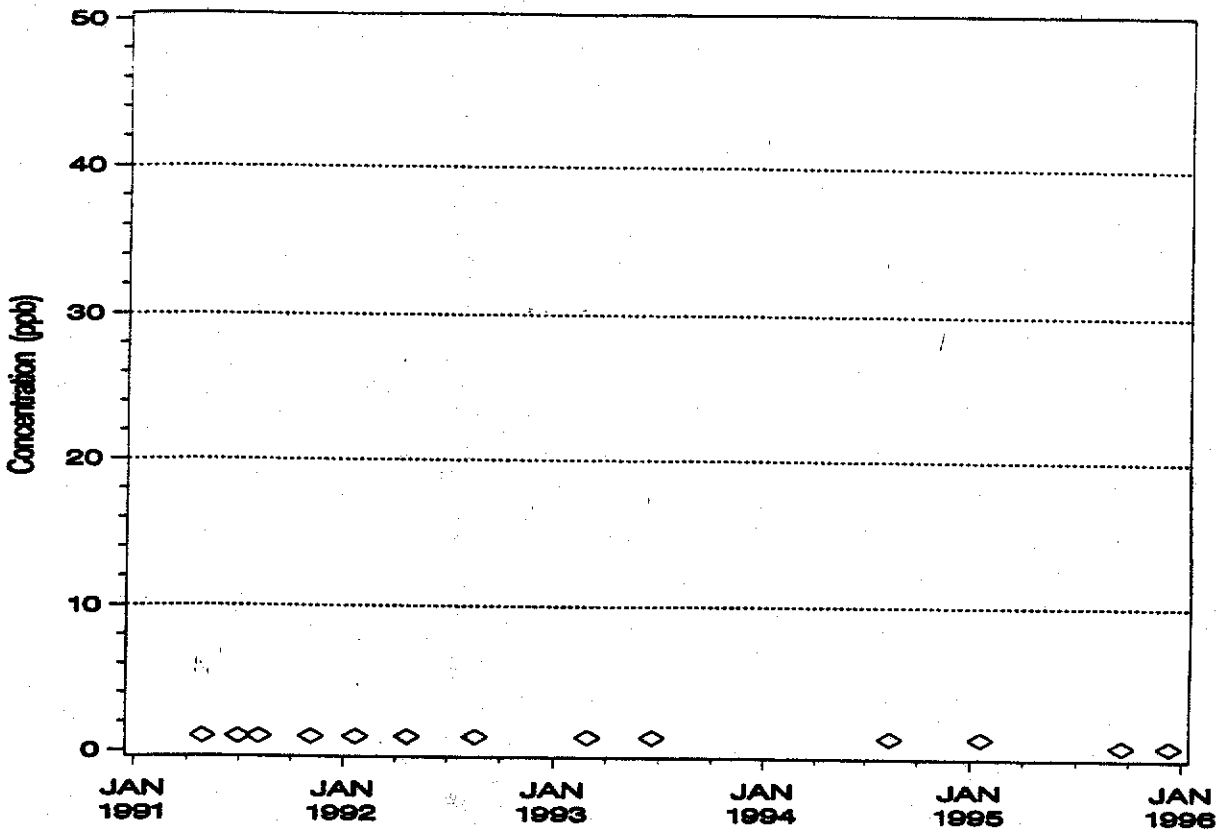


FREON 113 Trend

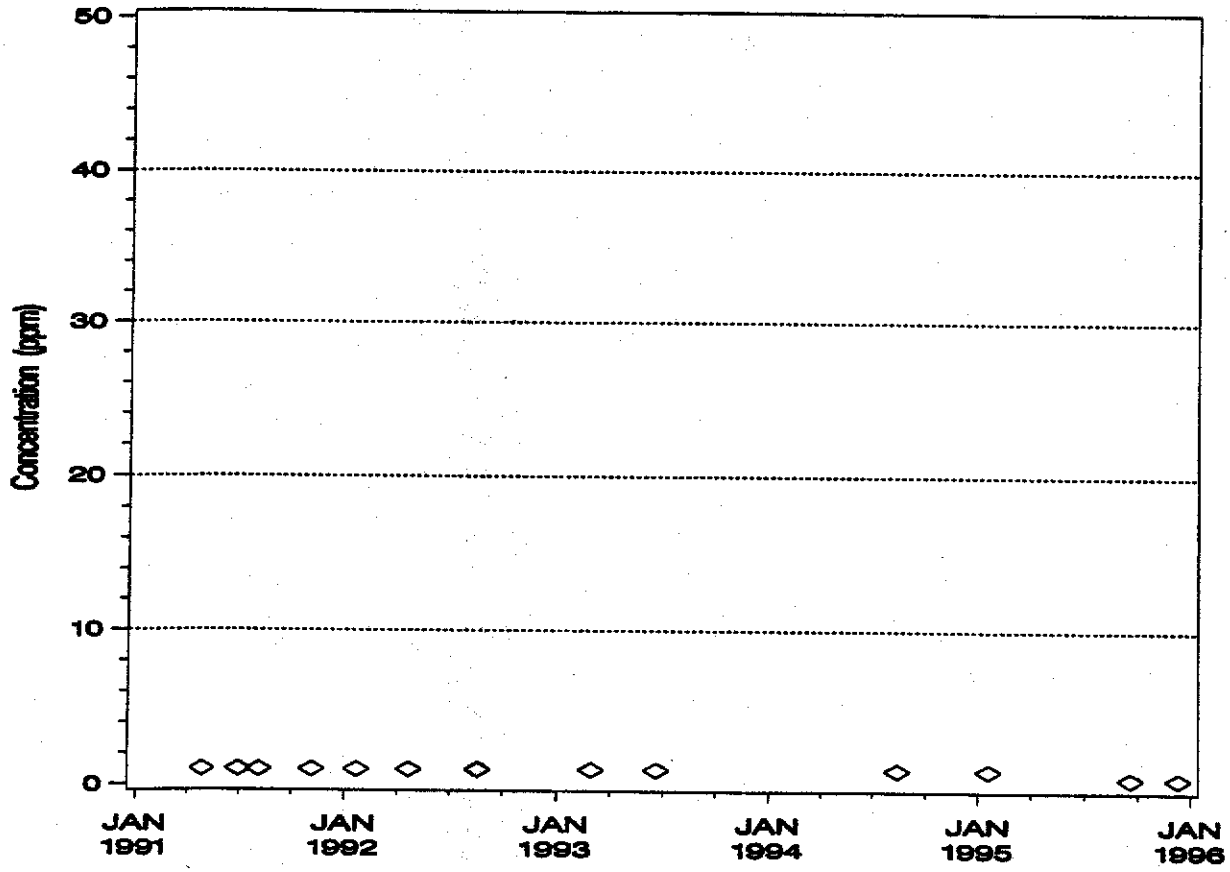


WELL 1487

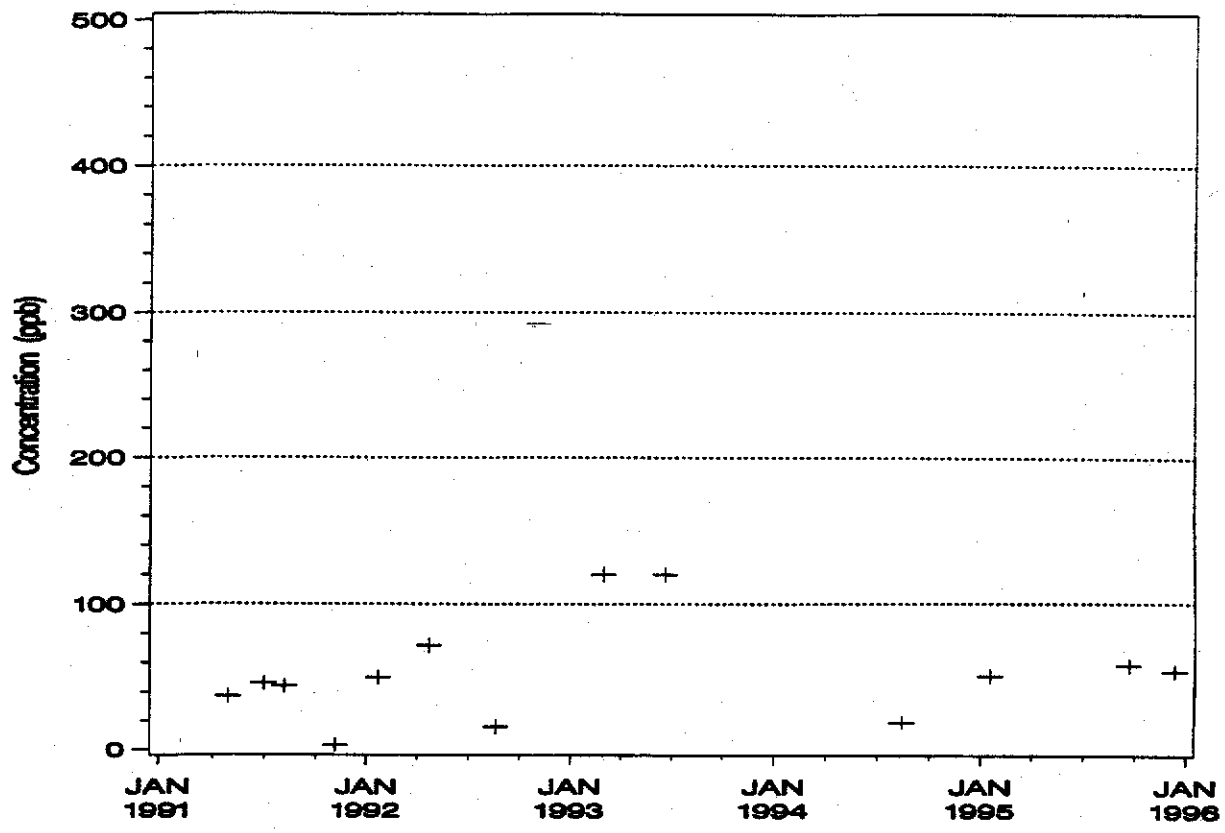
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



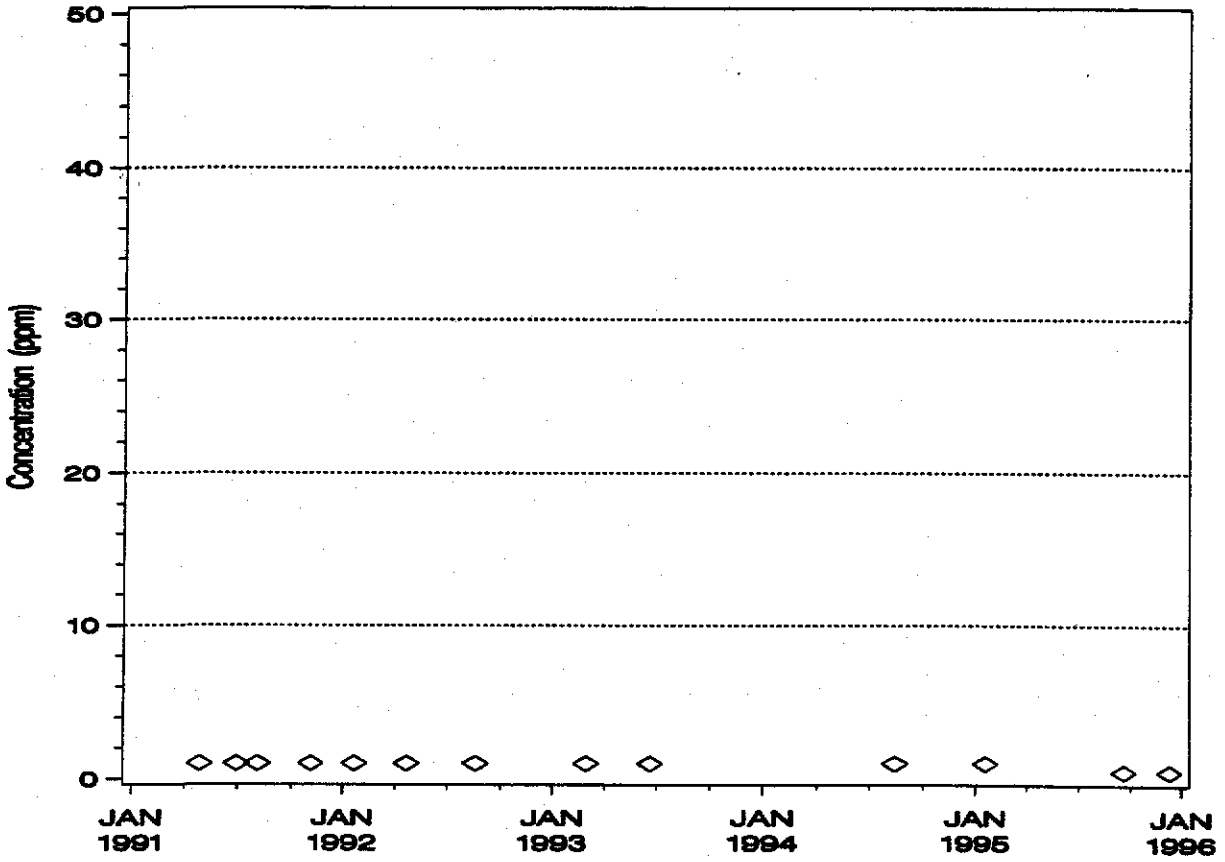
1,1 – DICHLOROETHYLENE Trend



WELL 1488
TRICHLOROETHYLENE Trend

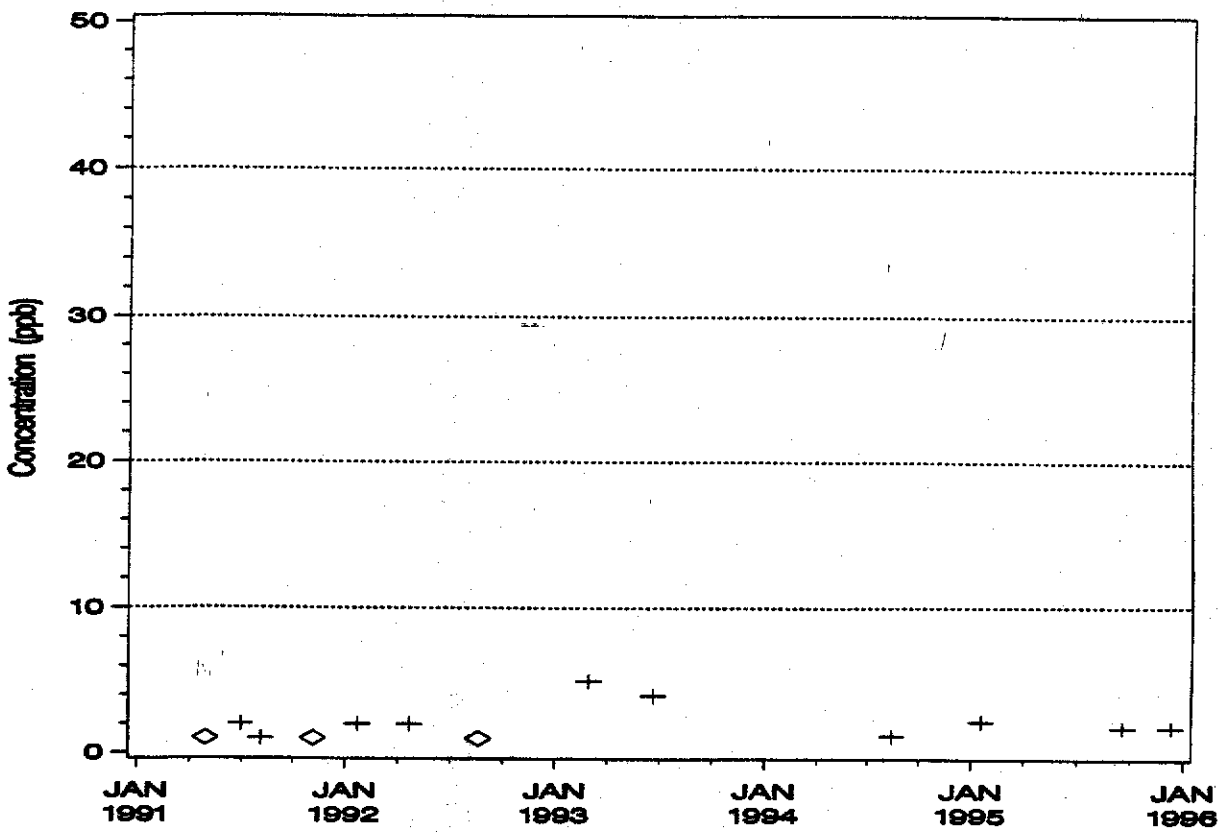


FREON 113 Trend

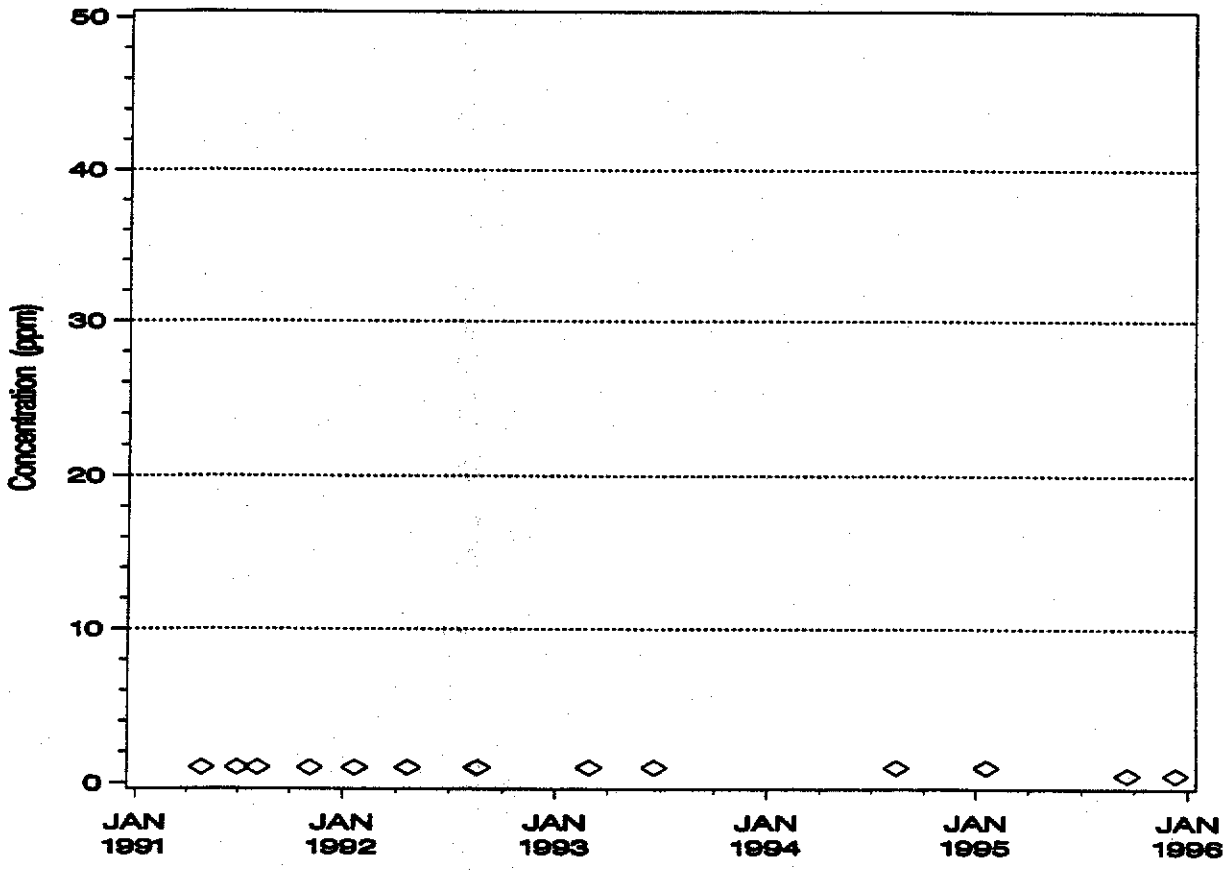


WELL 1488

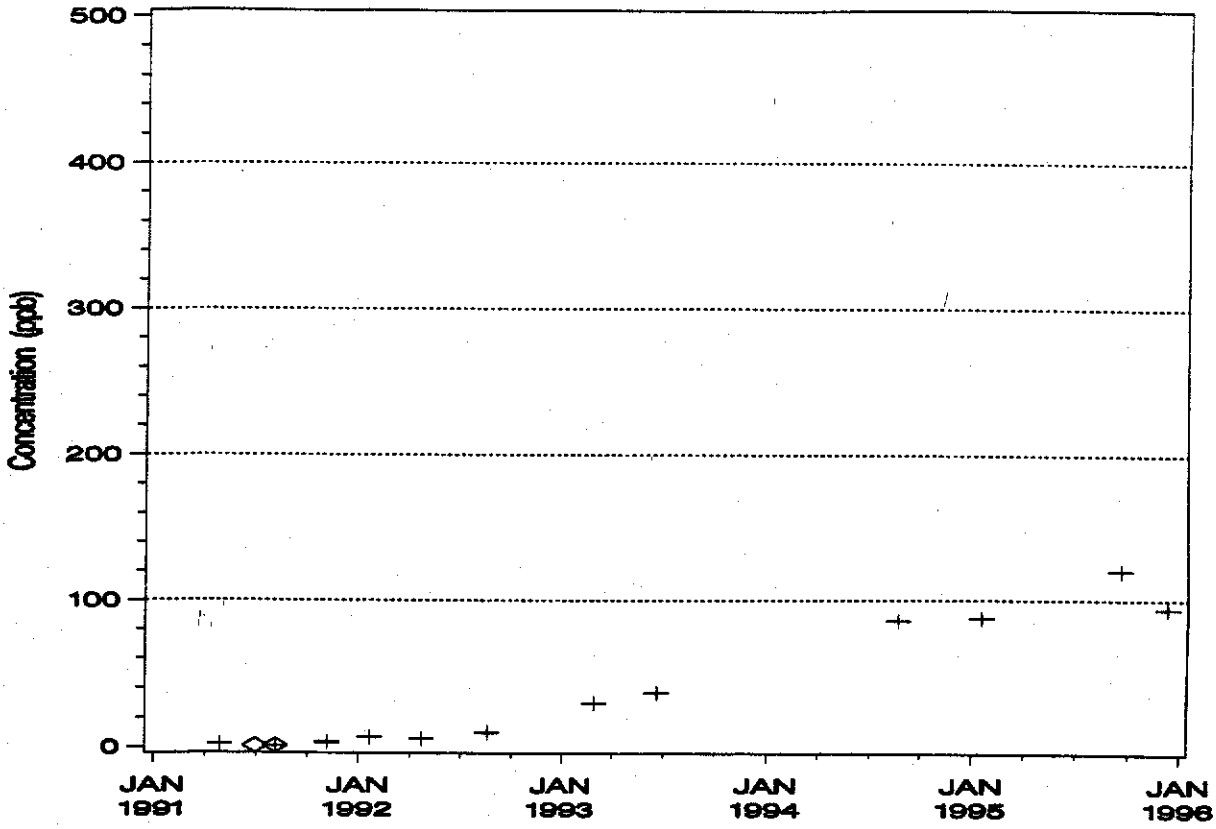
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



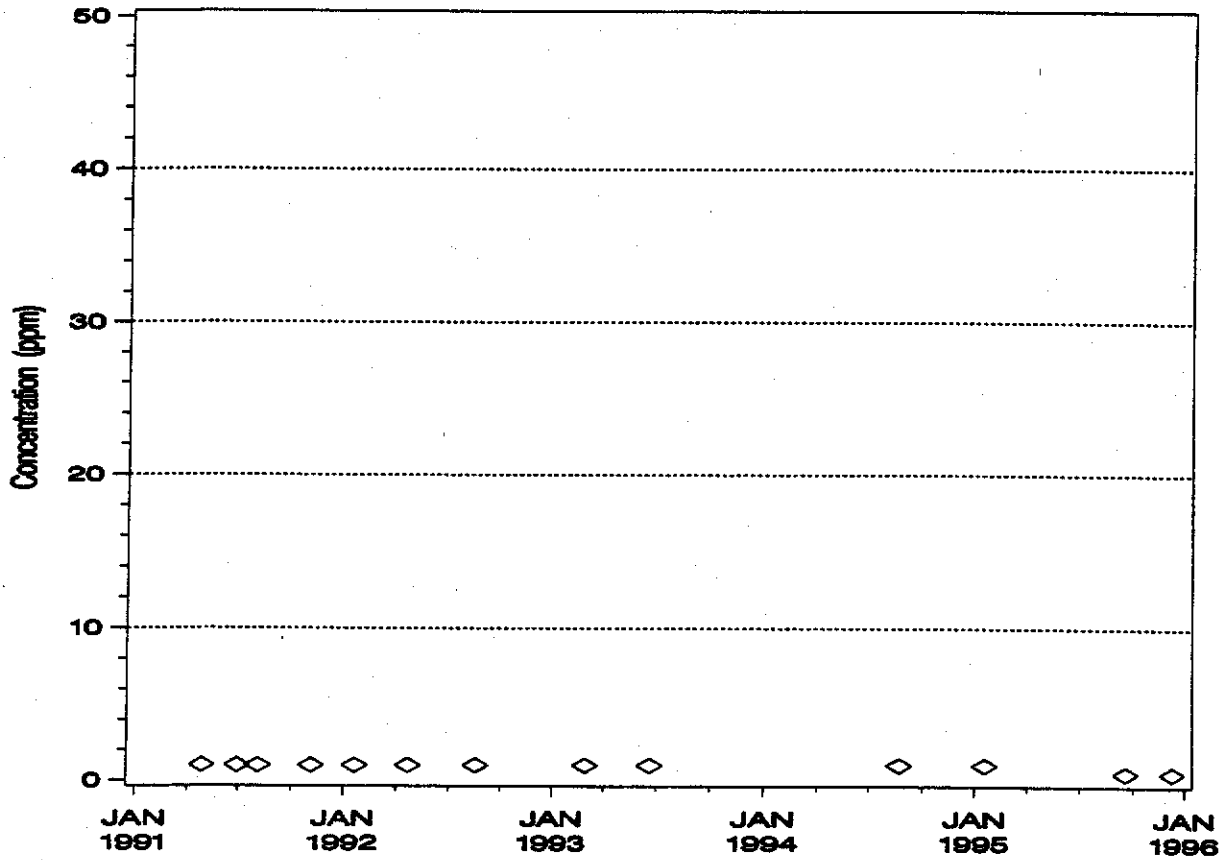
1,1 – DICHLOROETHYLENE Trend



WELL 1489
TRICHLOROETHYLENE Trend

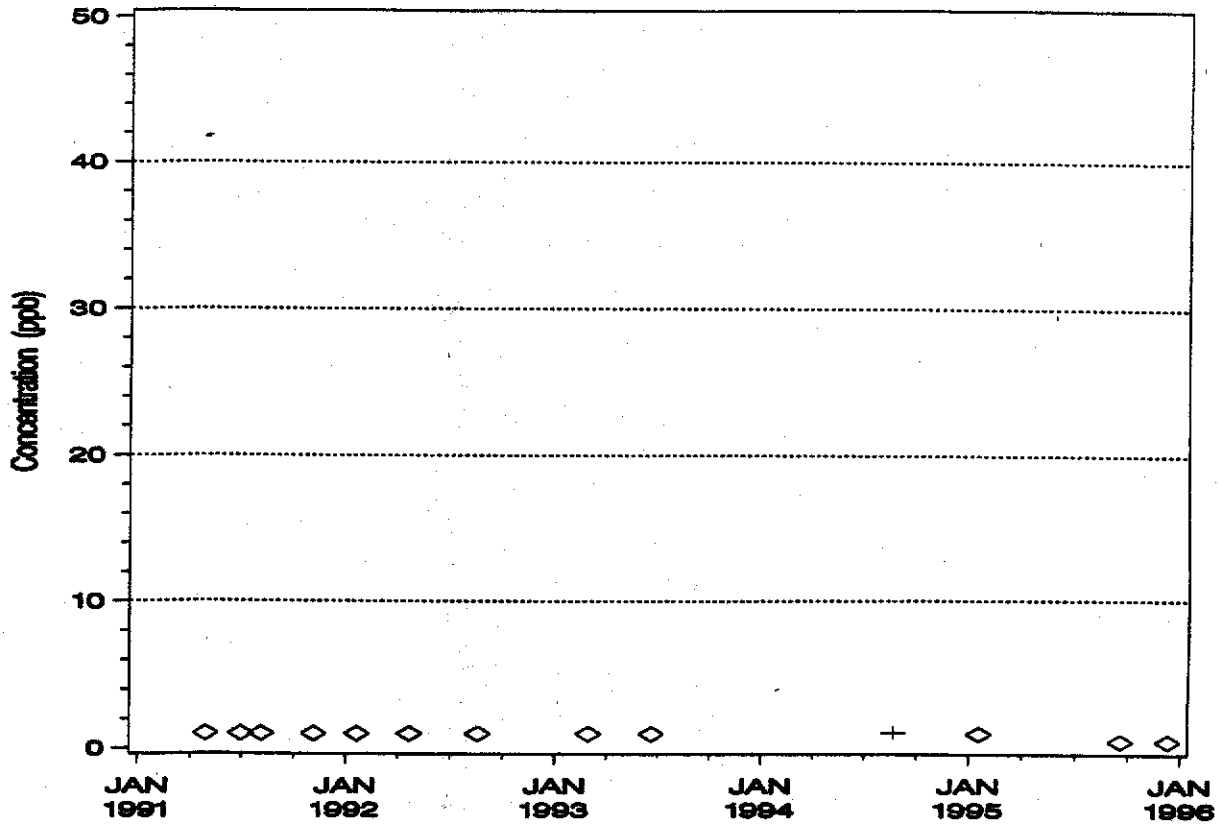


FREON 113 Trend

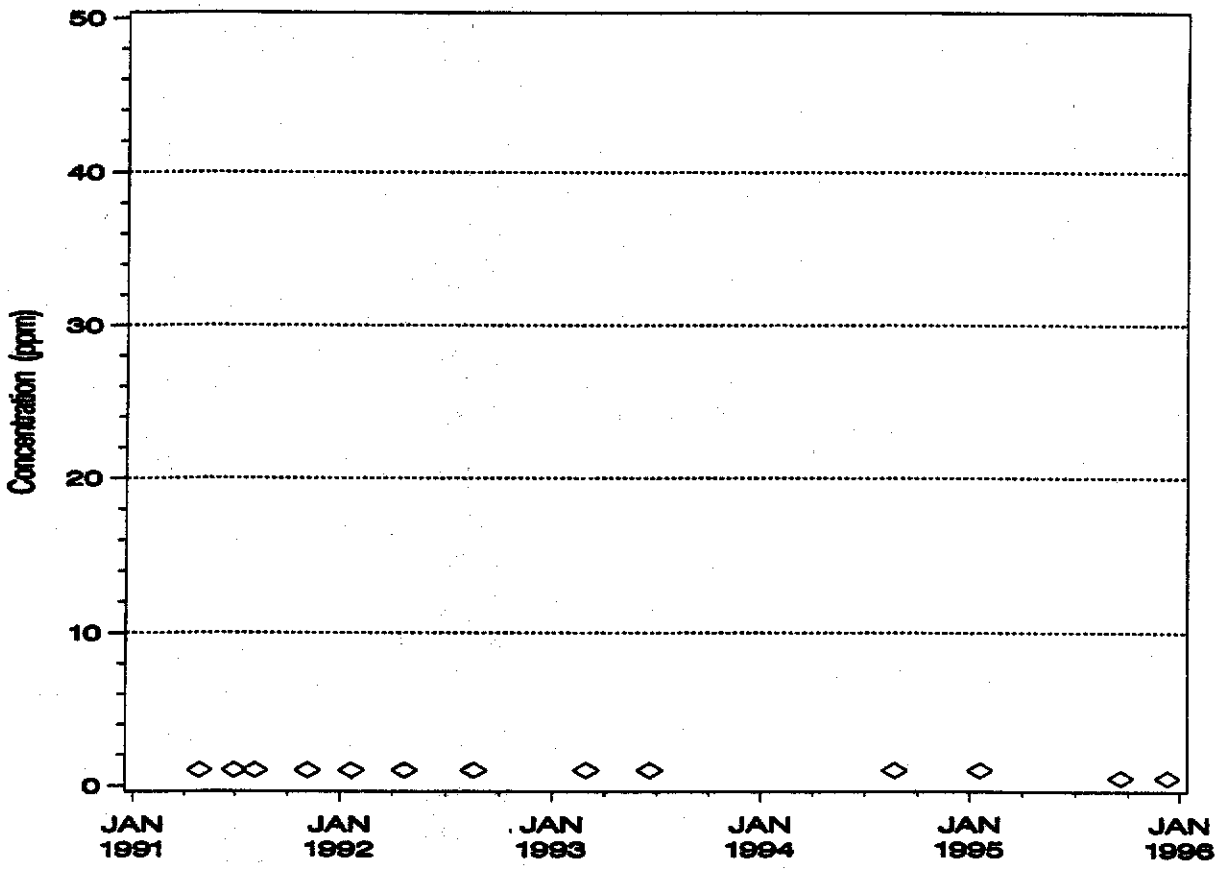


WELL 1489

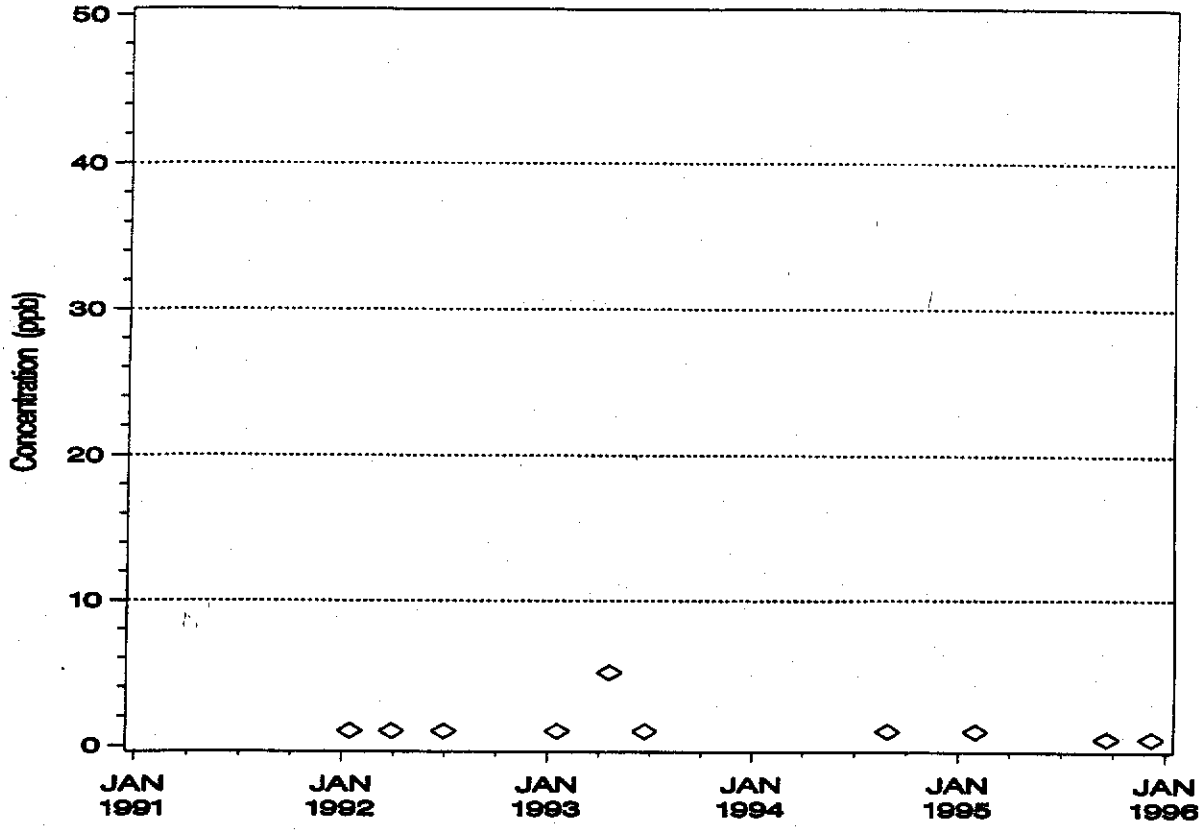
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



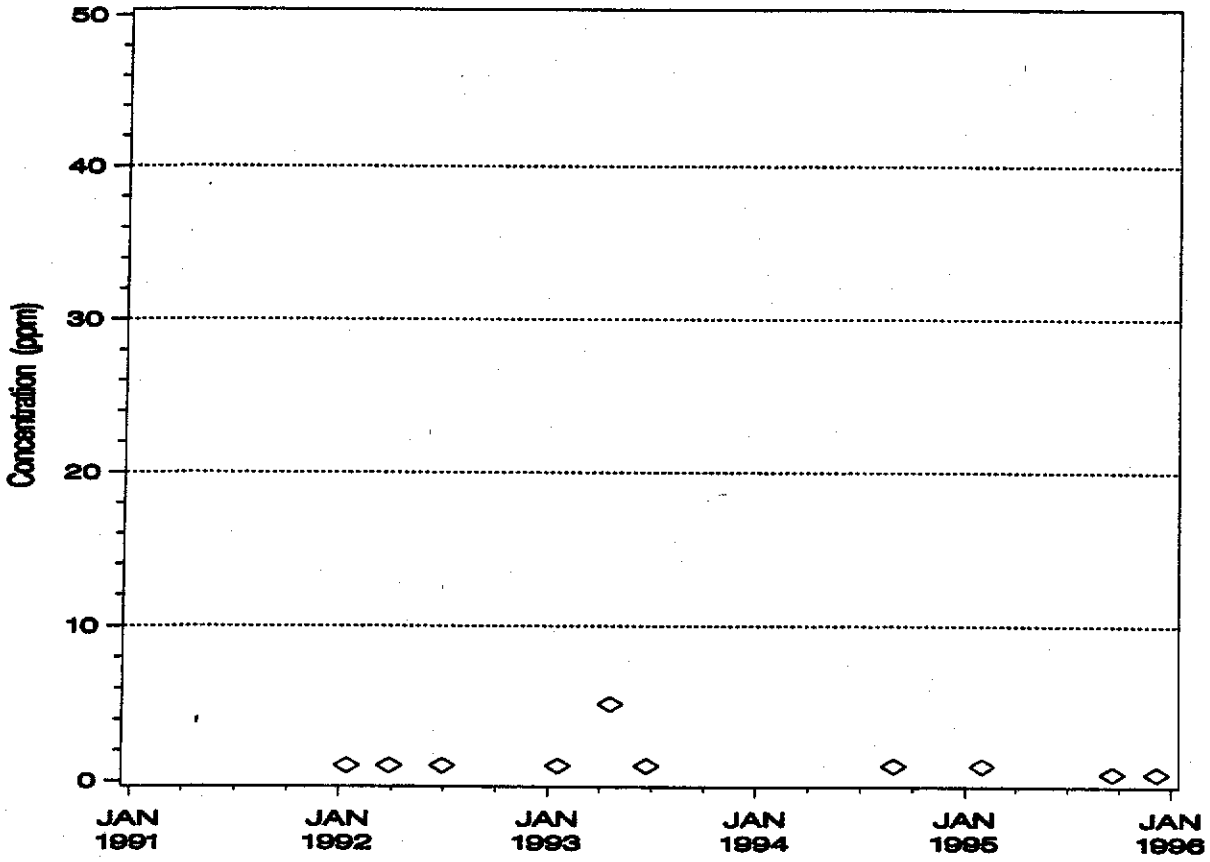
1,1 – DICHLOROETHYLENE Trend



WELL 1506
TRICHLOROETHYLENE Trend

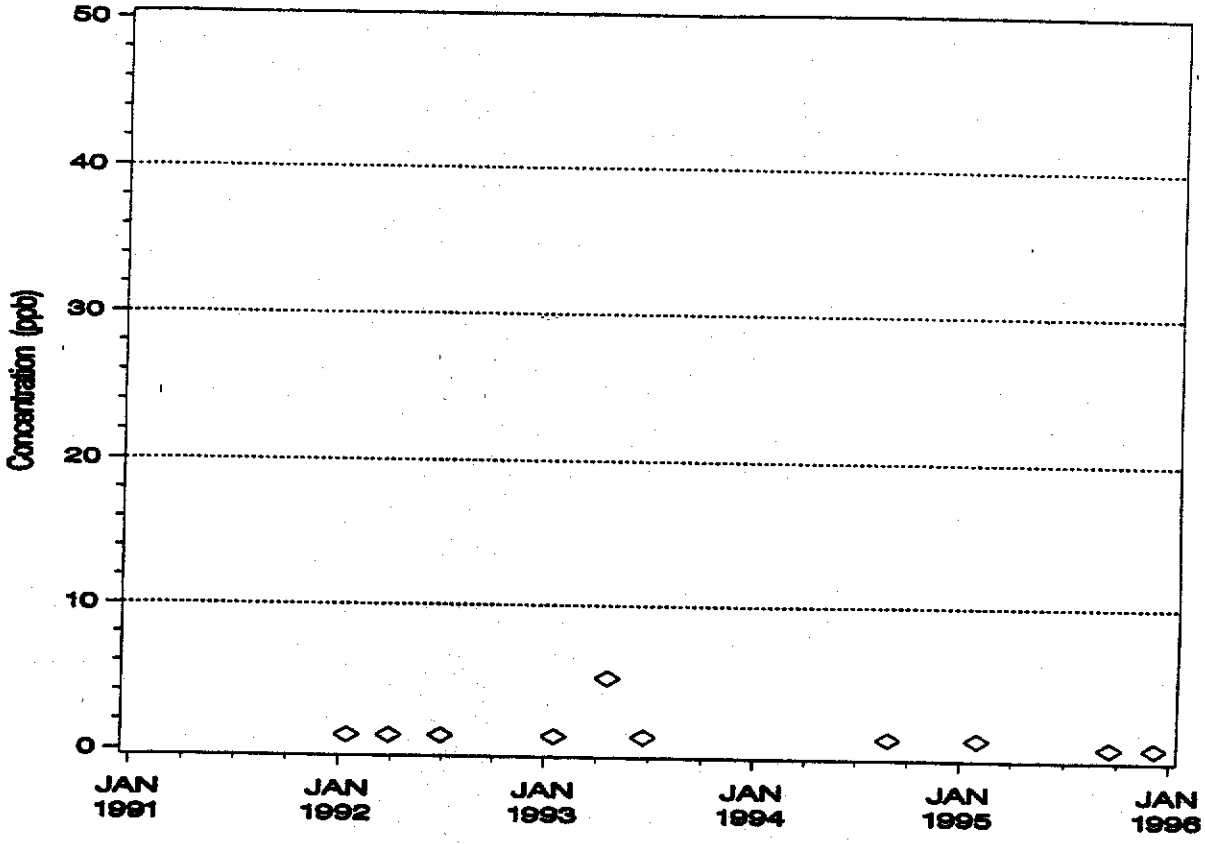


FREON 113 Trend

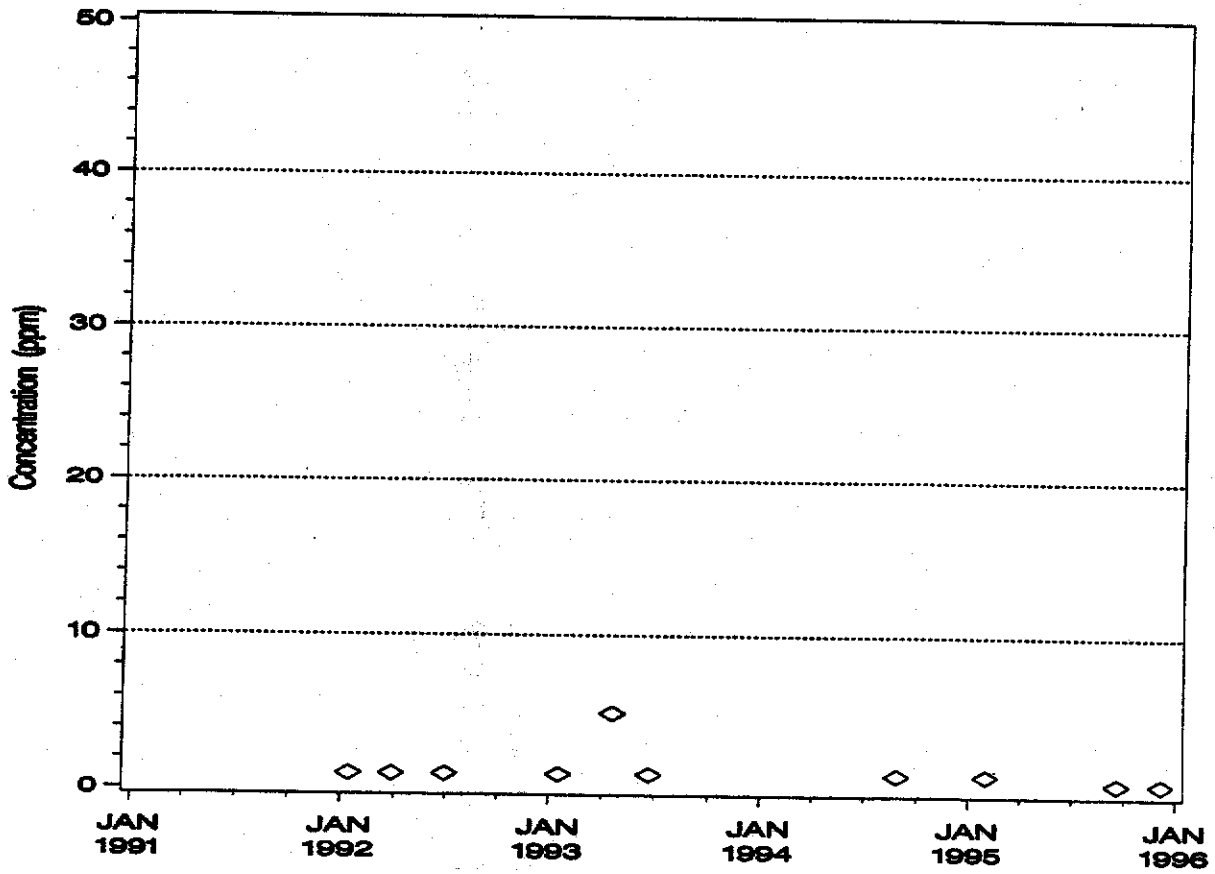


WELL 1506

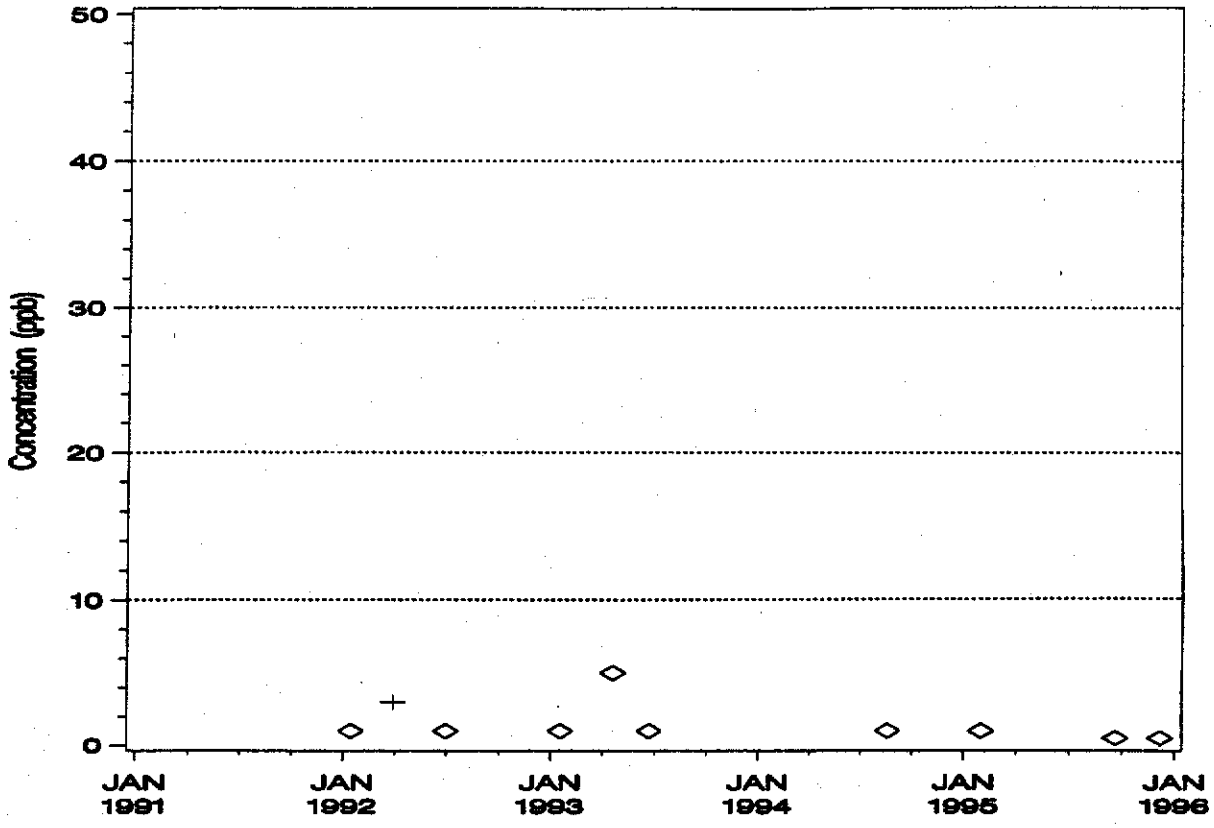
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



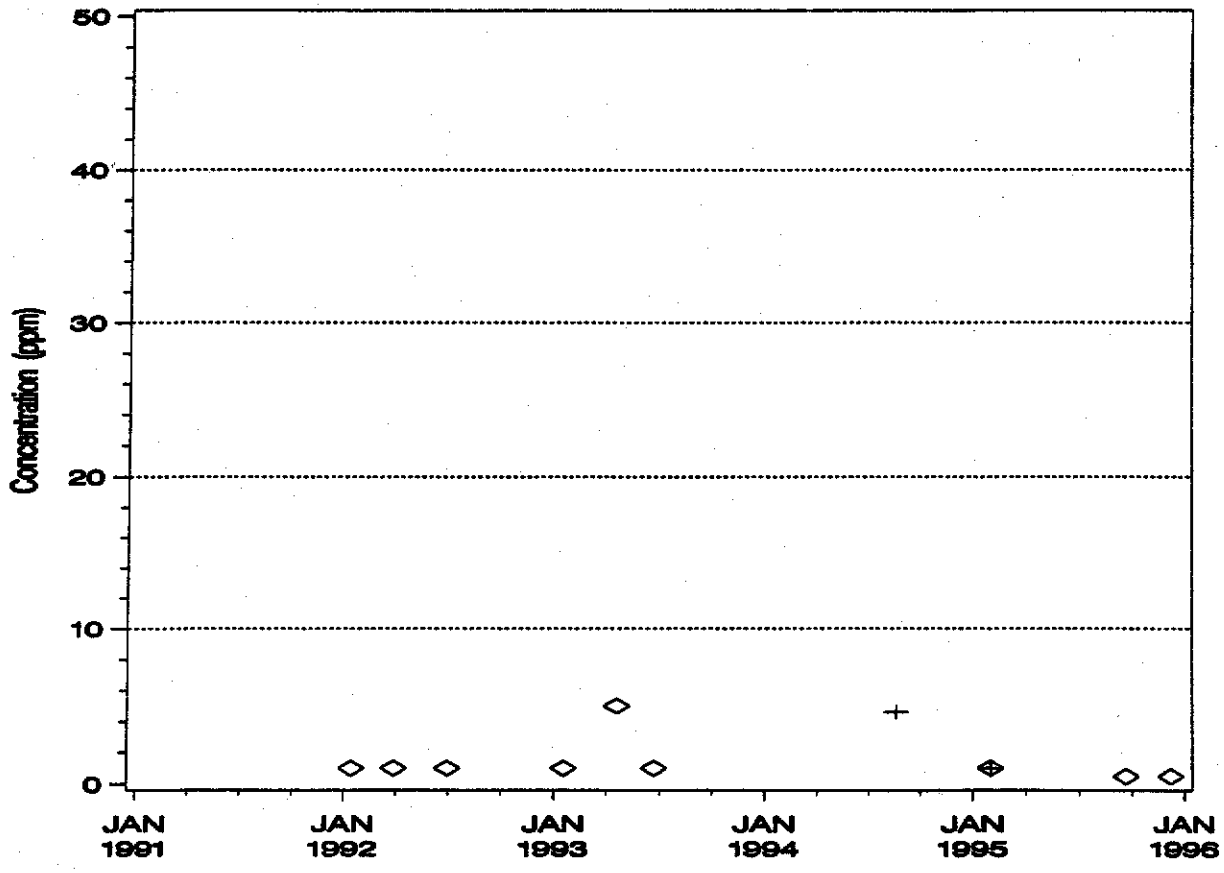
1,1 – DICHLOROETHYLENE Trend



WELL 1507
TRICHLOROETHYLENE Trend

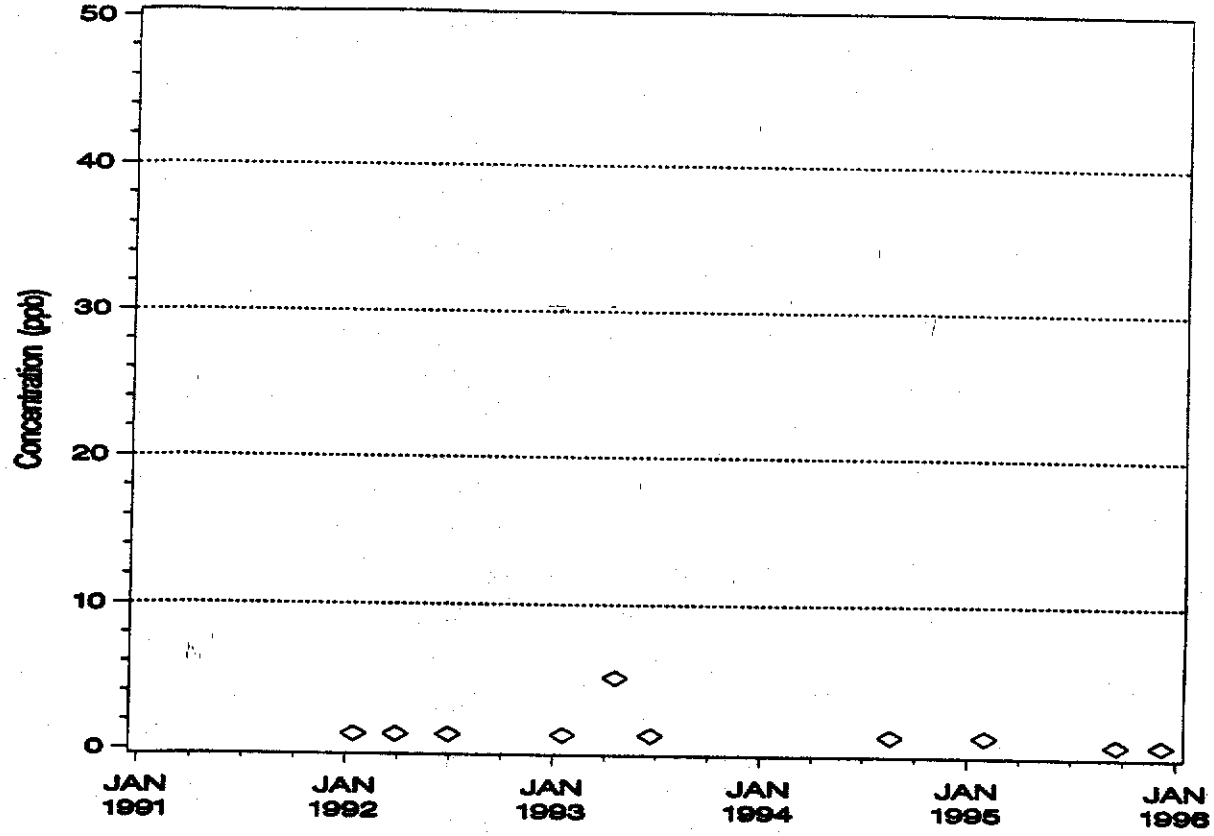


FREON 113 Trend

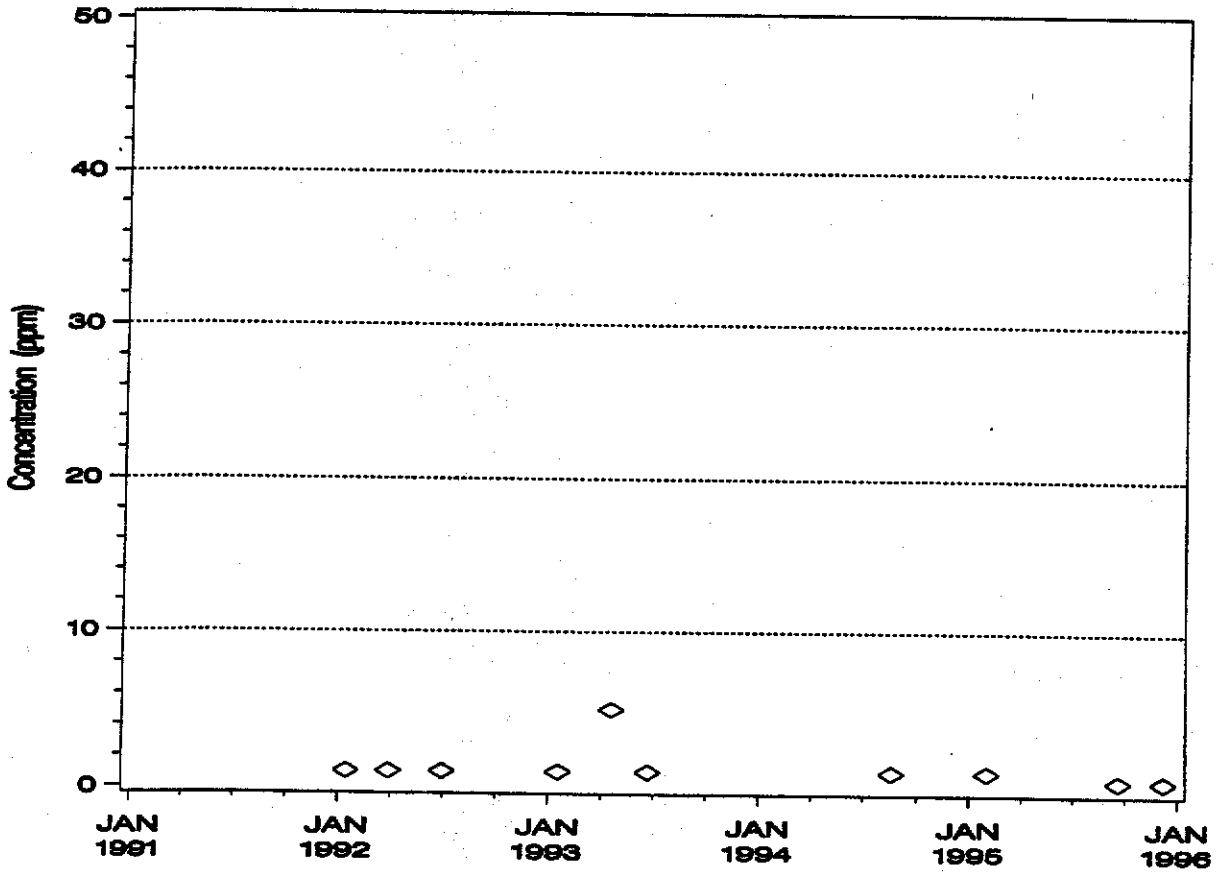


WELL 1507

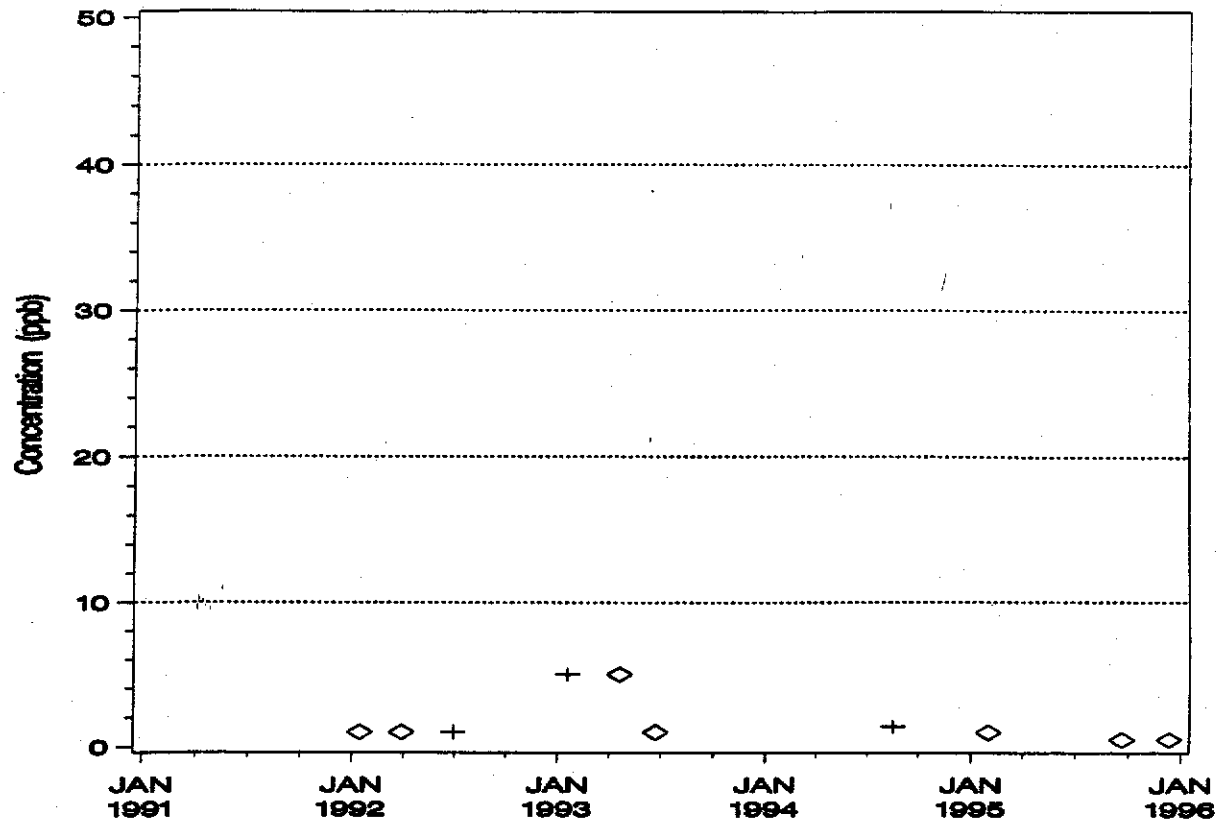
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



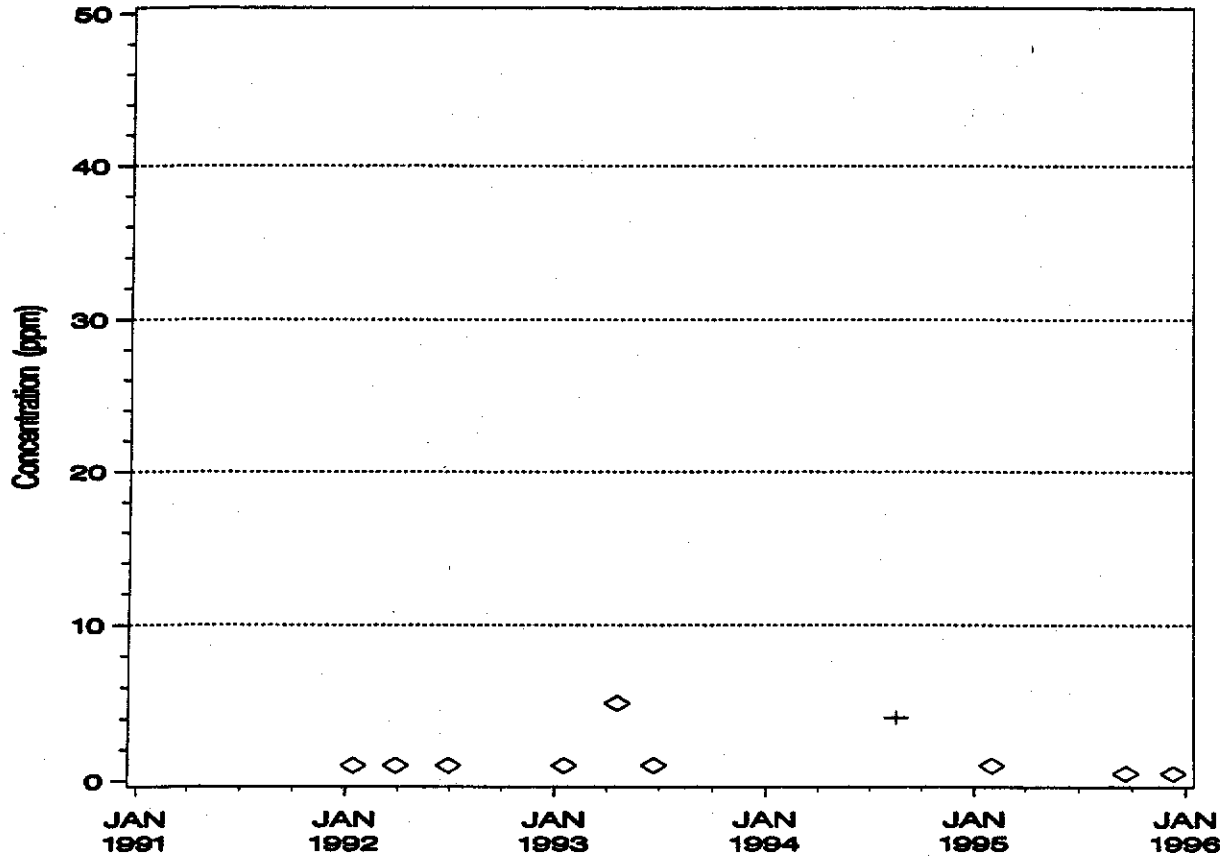
1,1 – DICHLOROETHYLENE Trend



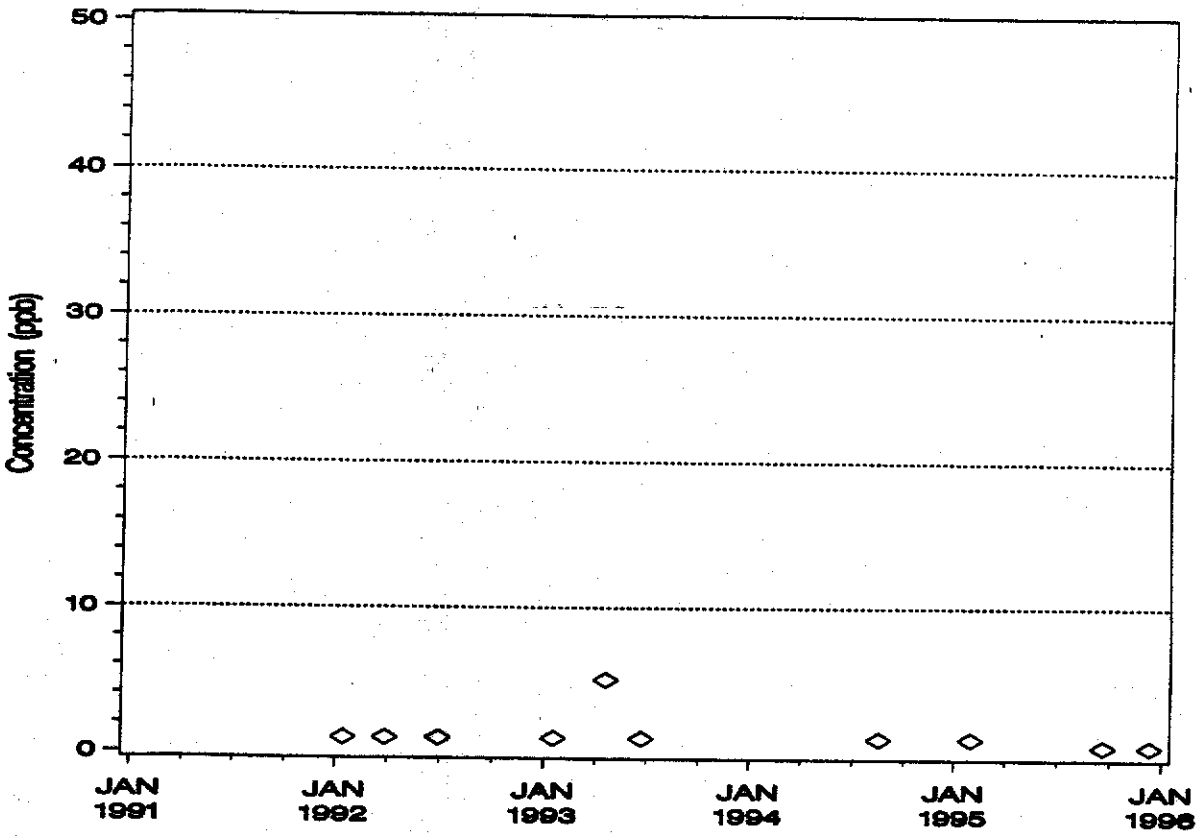
WELL 1508
TRICHLOROETHYLENE Trend



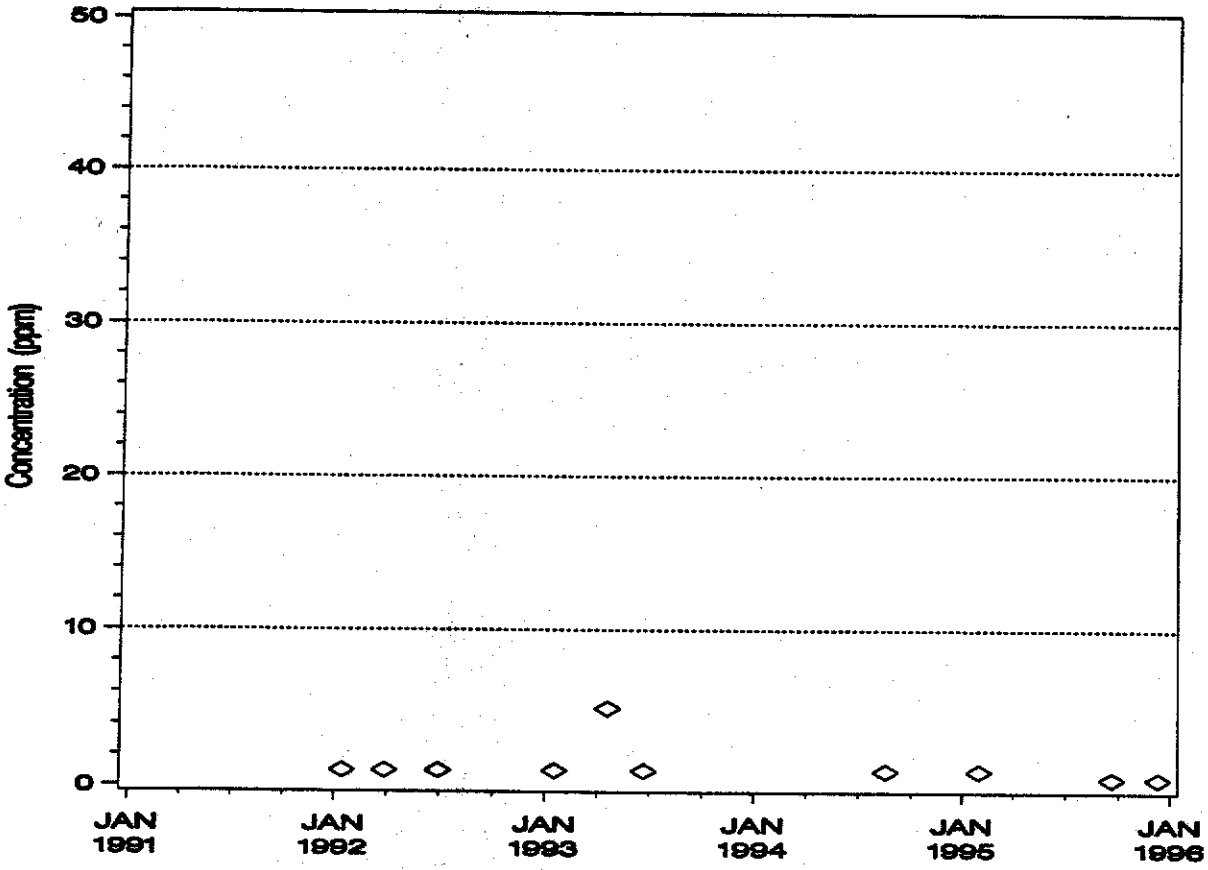
FREON 113 Trend



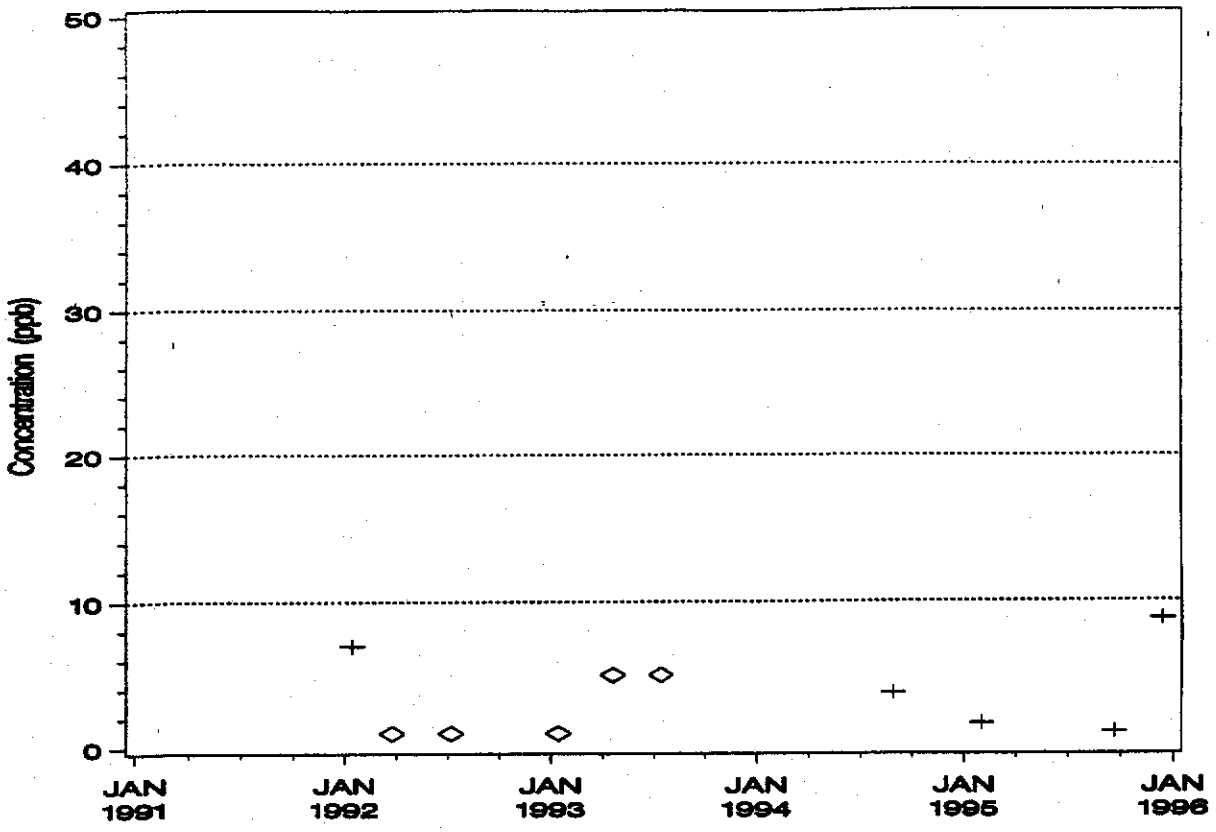
WELL 1508
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



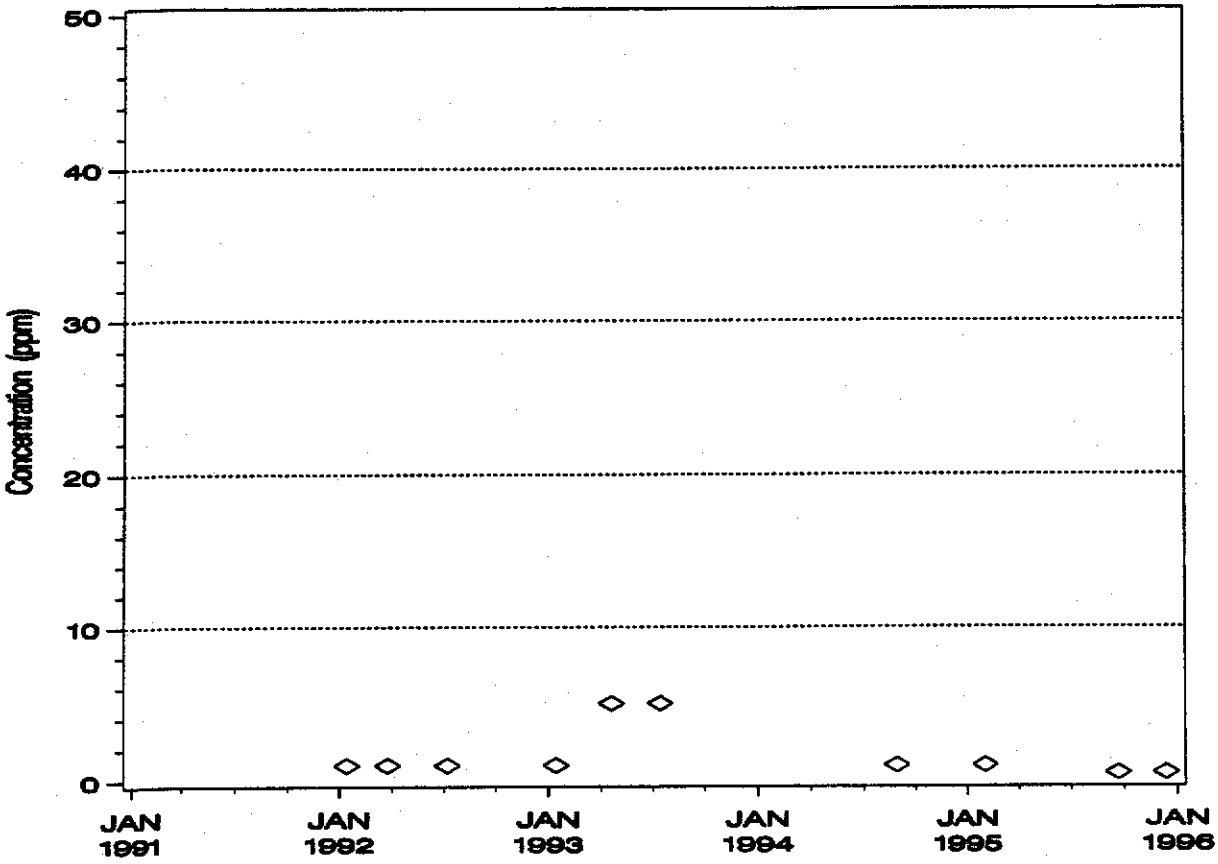
1,1 – DICHLOROETHYLENE Trend



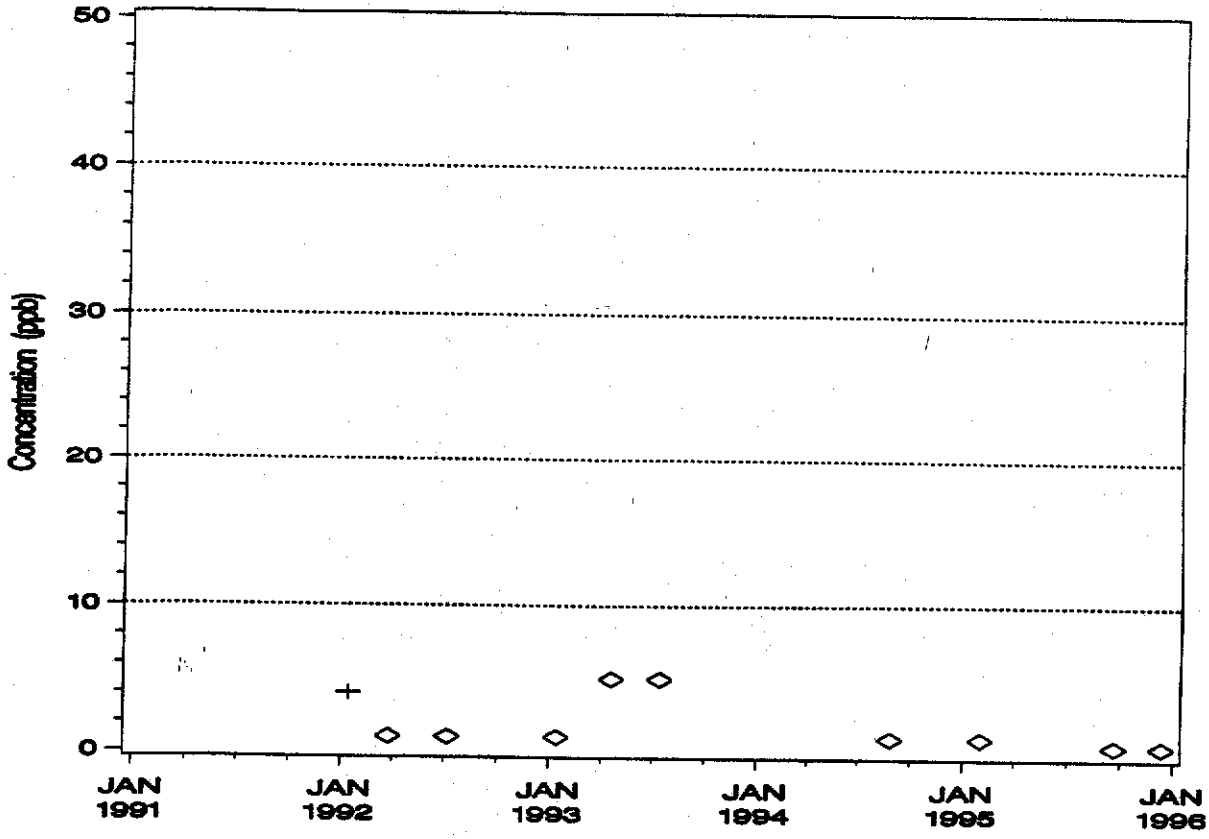
WELL 1509
TRICHLOROETHYLENE Trend



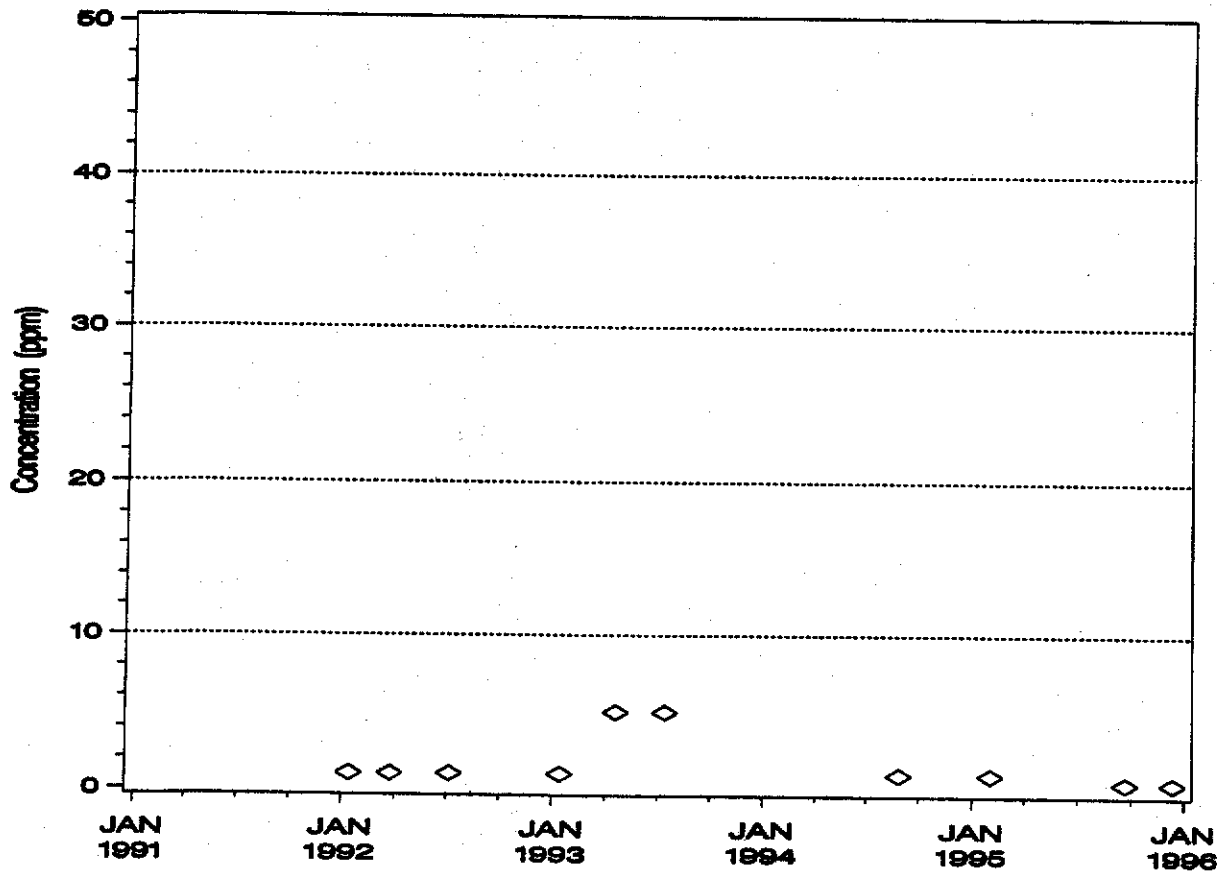
FREON 113 Trend



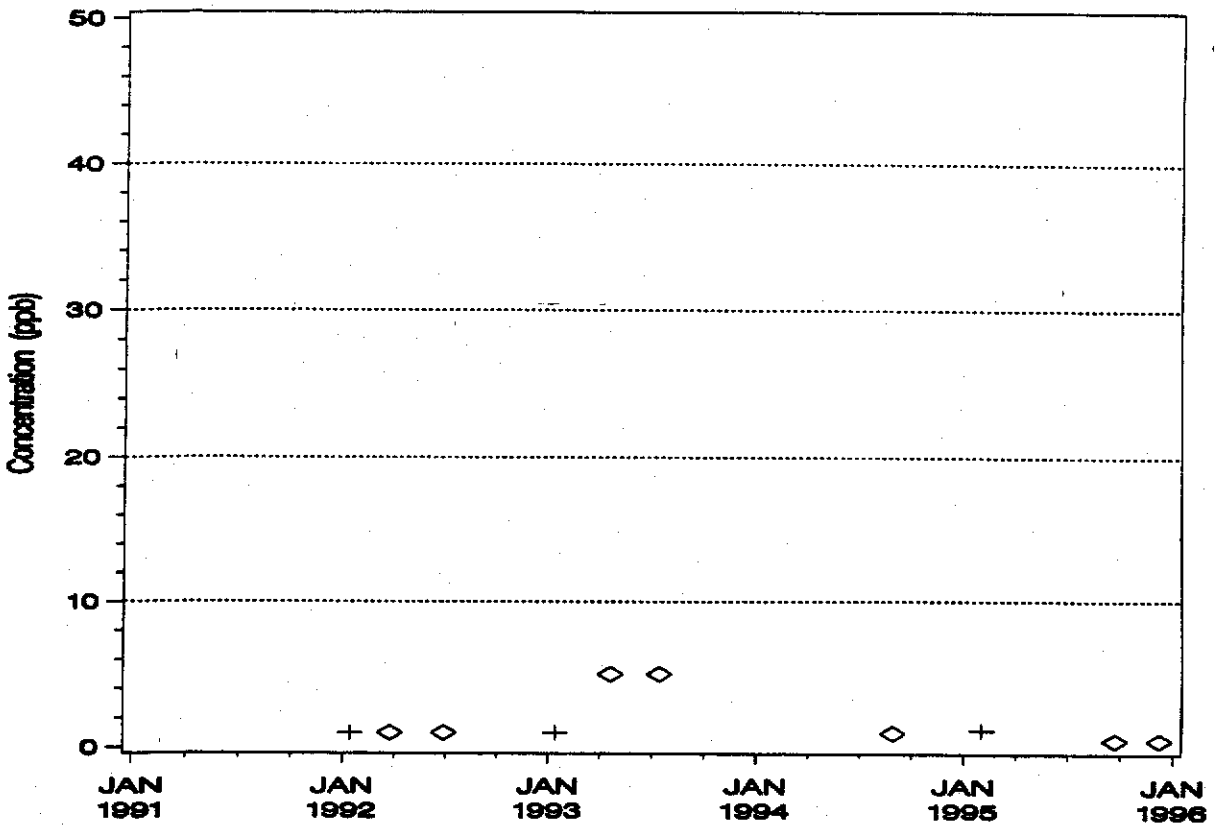
WELL 1509
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



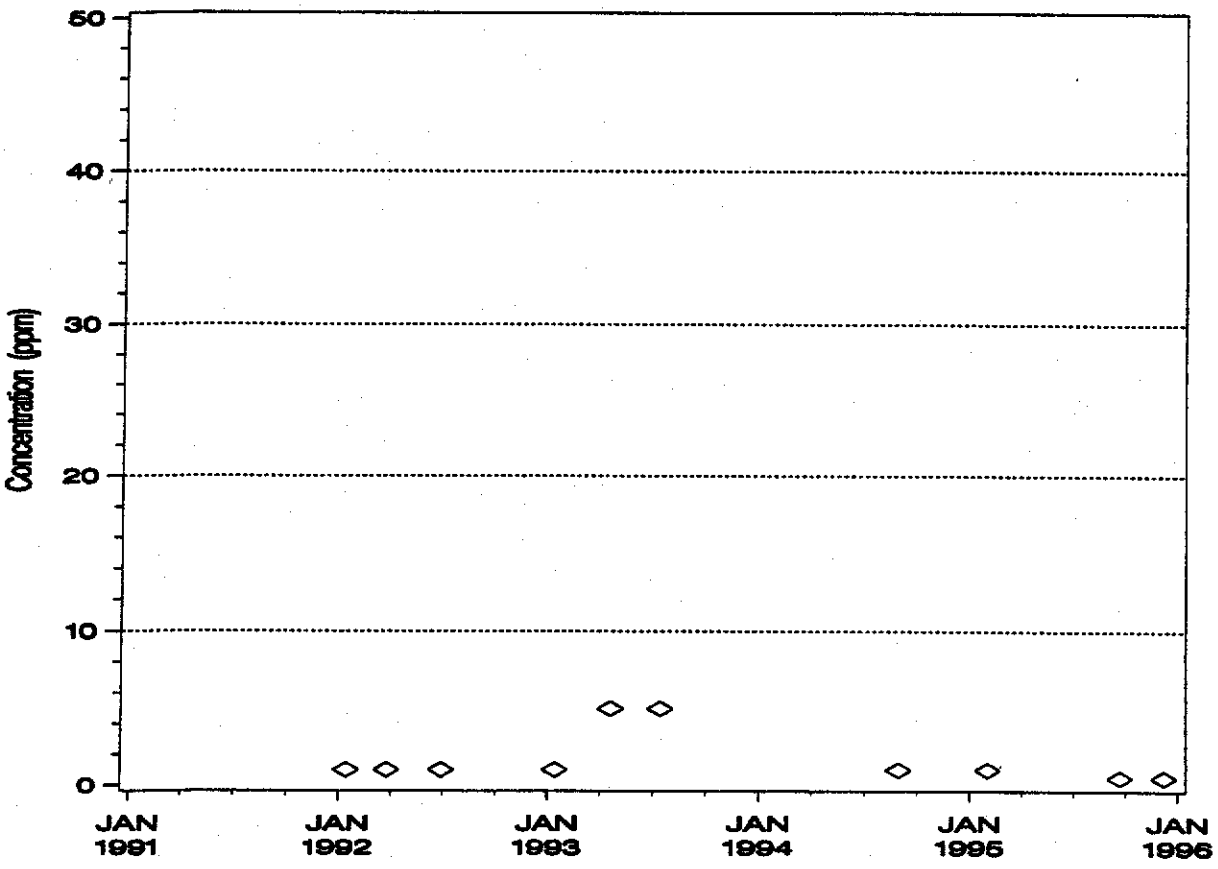
1,1 – DICHLOROETHYLENE Trend



WELL 1510
TRICHLOROETHYLENE Trend

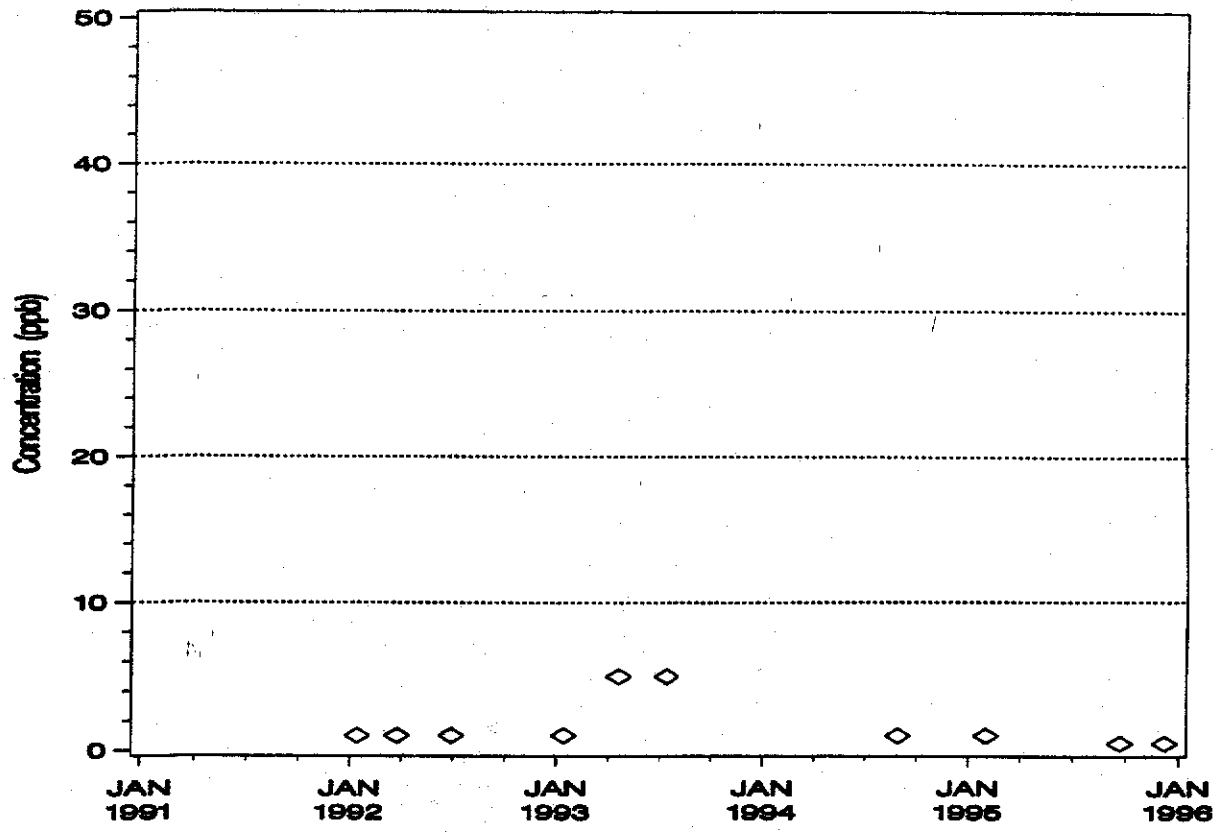


FREON 113 Trend

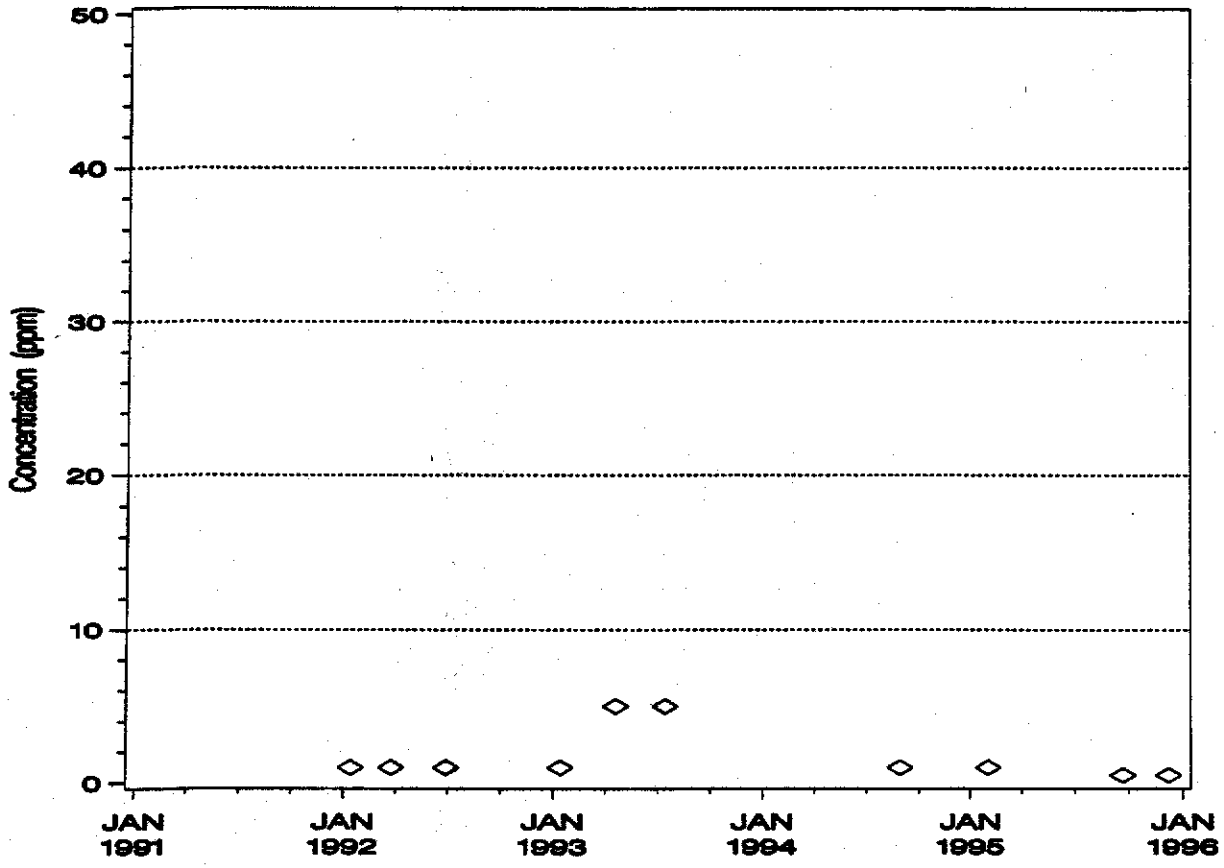


WELL 1510

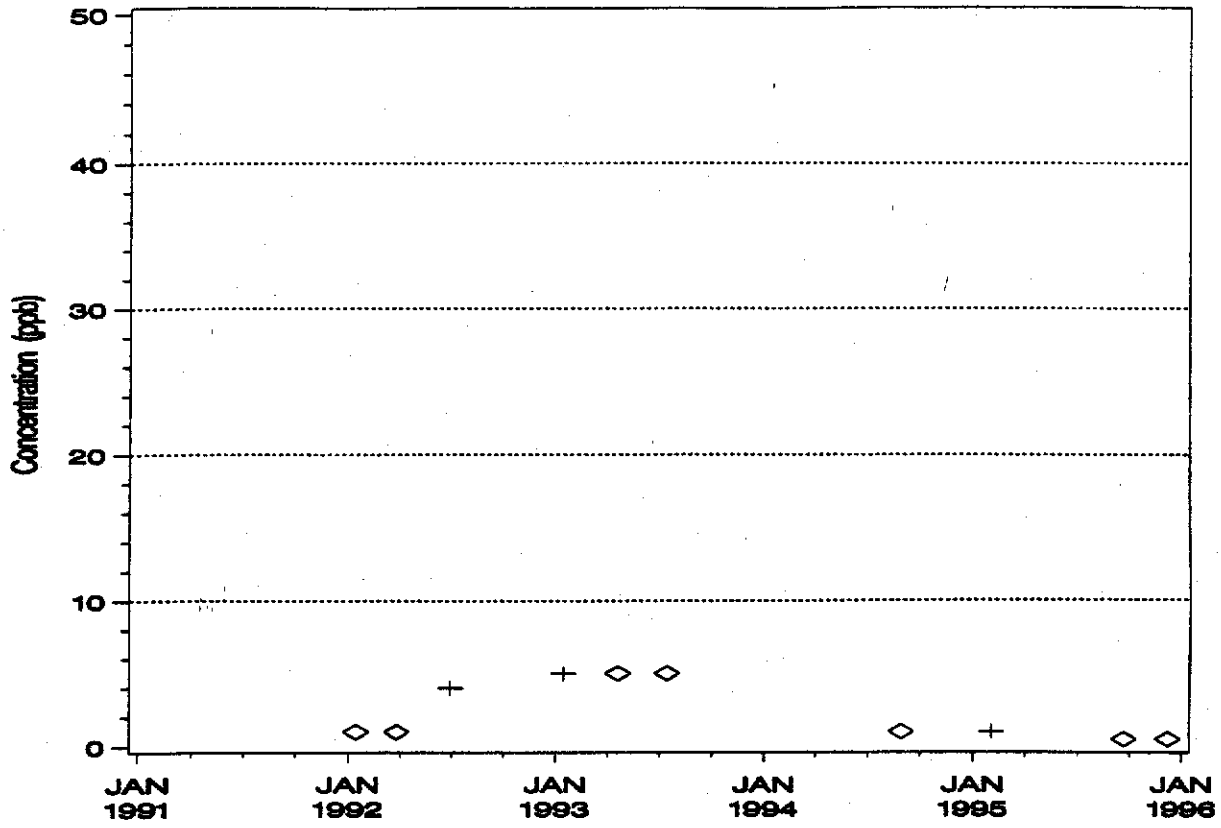
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



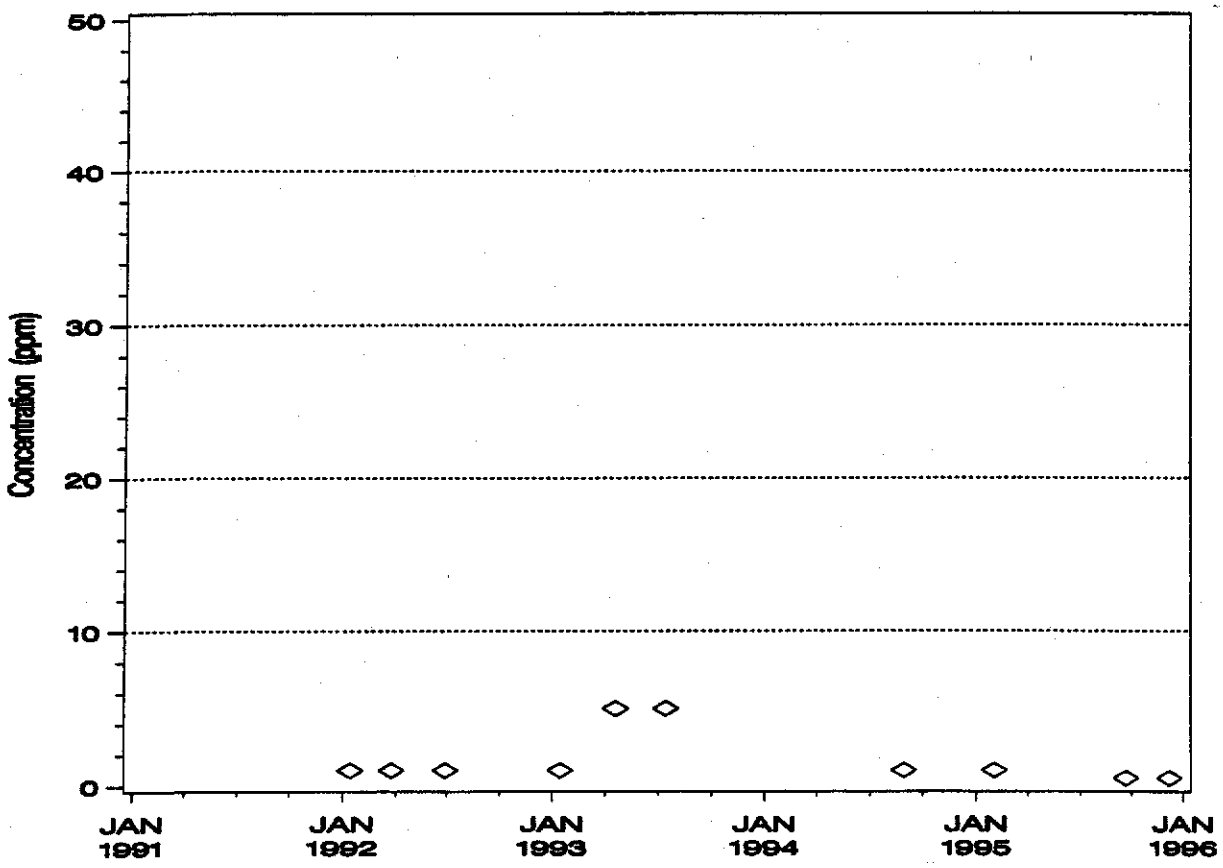
1,1 – DICHLOROETHYLENE Trend



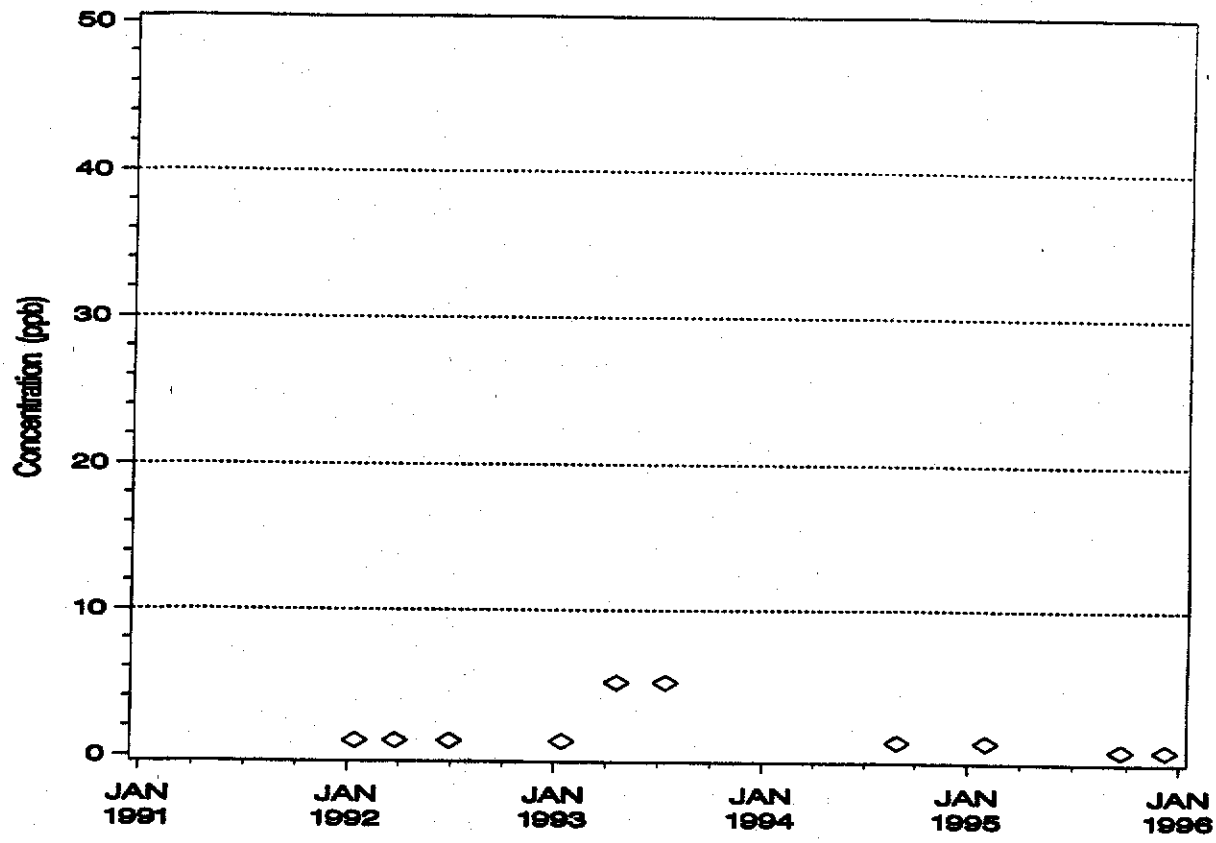
WELL 1511
TRICHLOROETHYLENE Trend



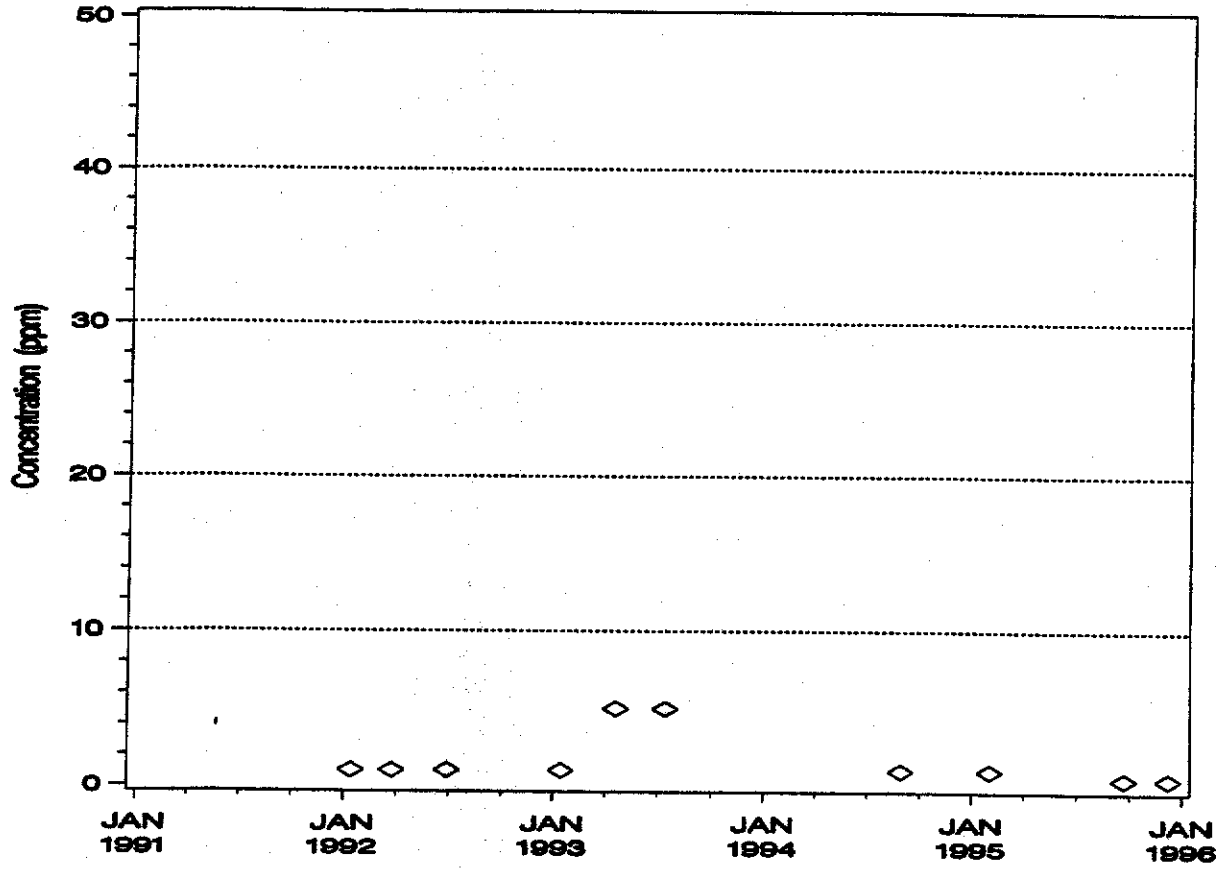
FREON 113 Trend



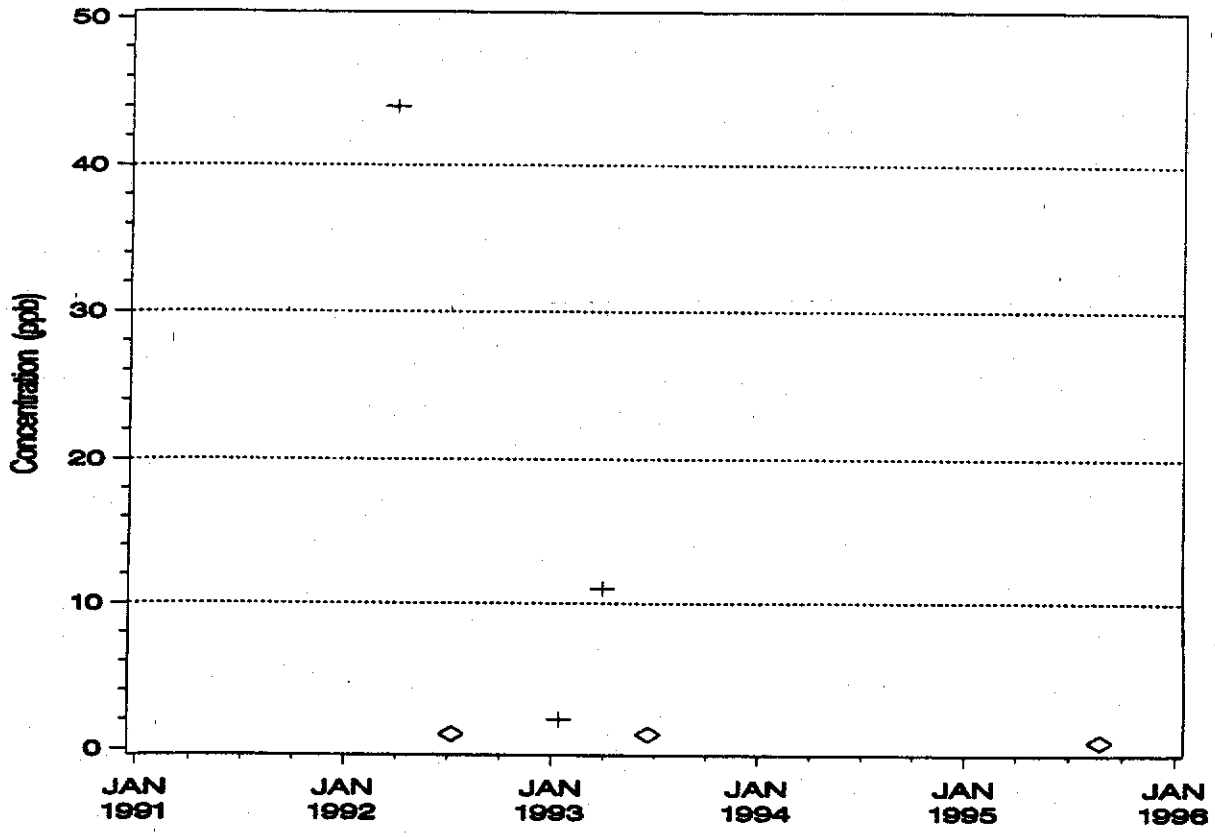
WELL 1511
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



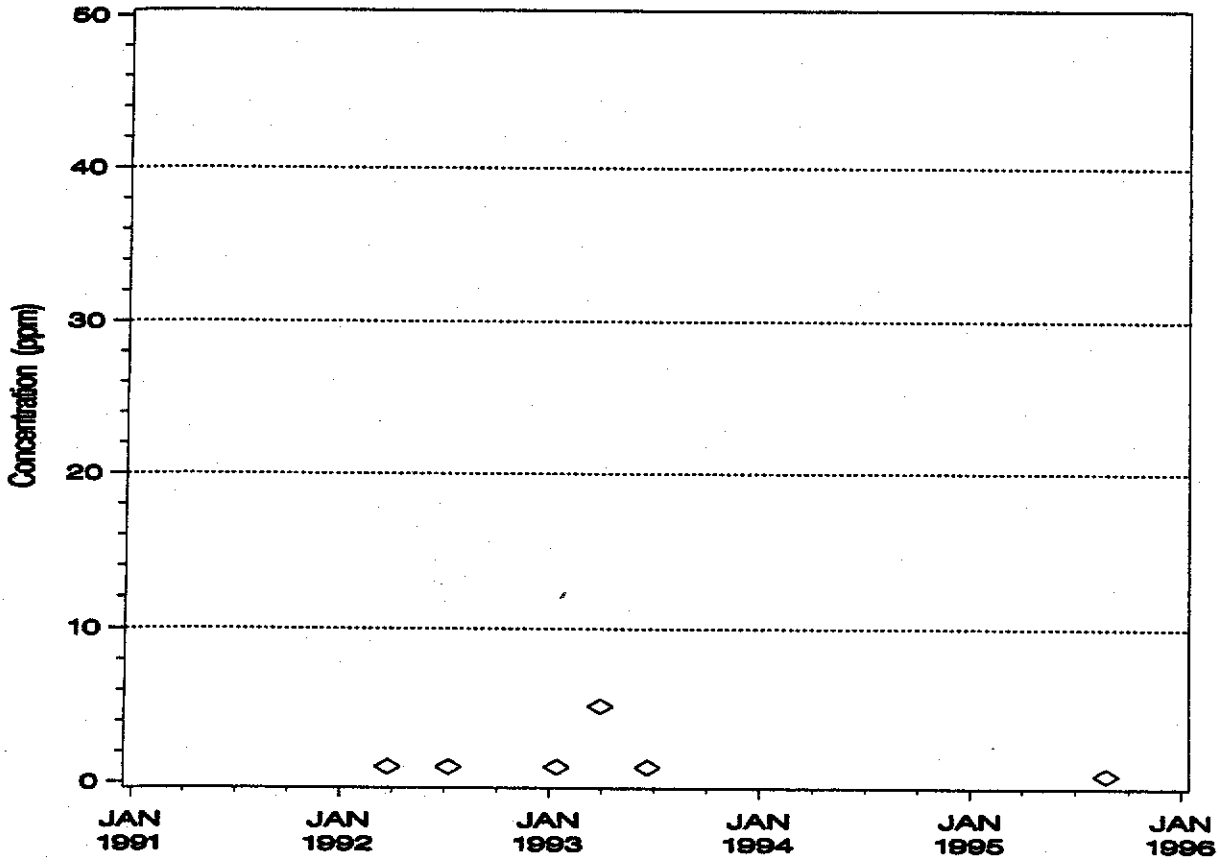
1,1 – DICHLOROETHYLENE Trend



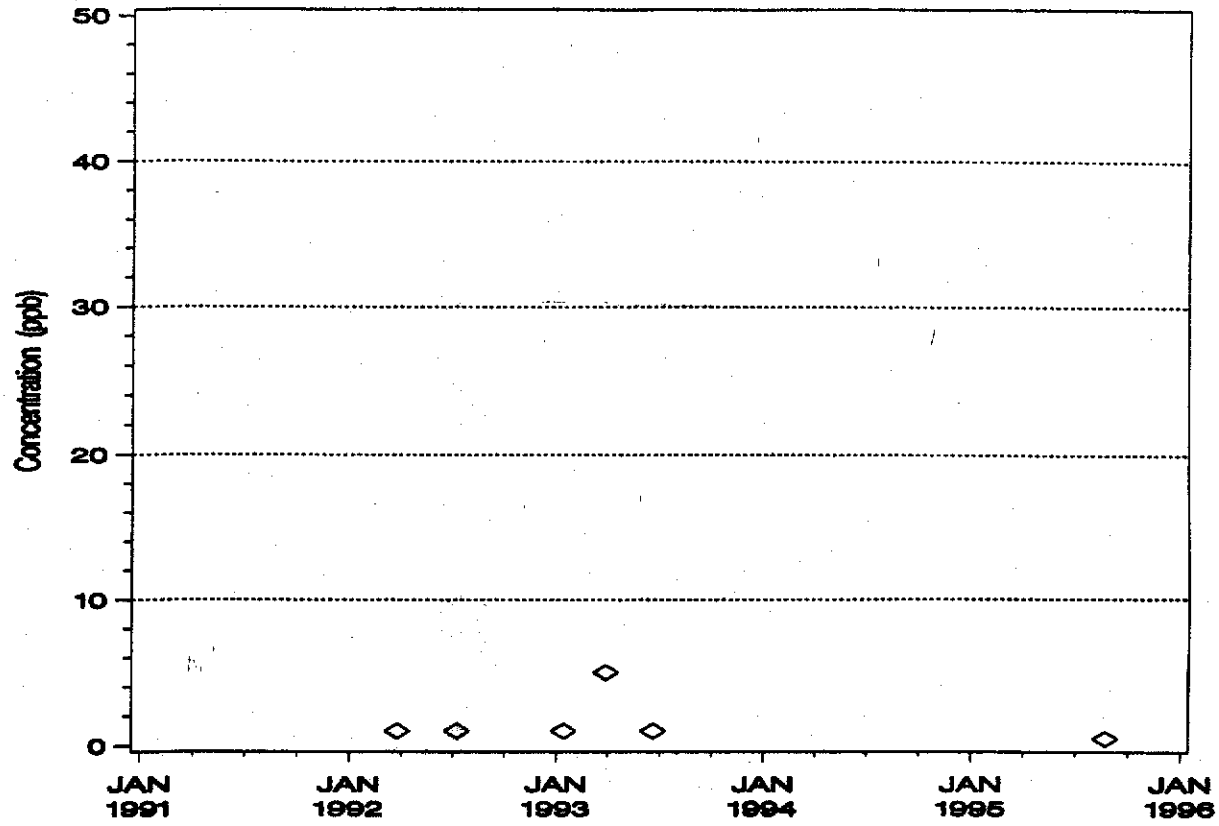
WELL 1516
TRICHLOROETHYLENE Trend



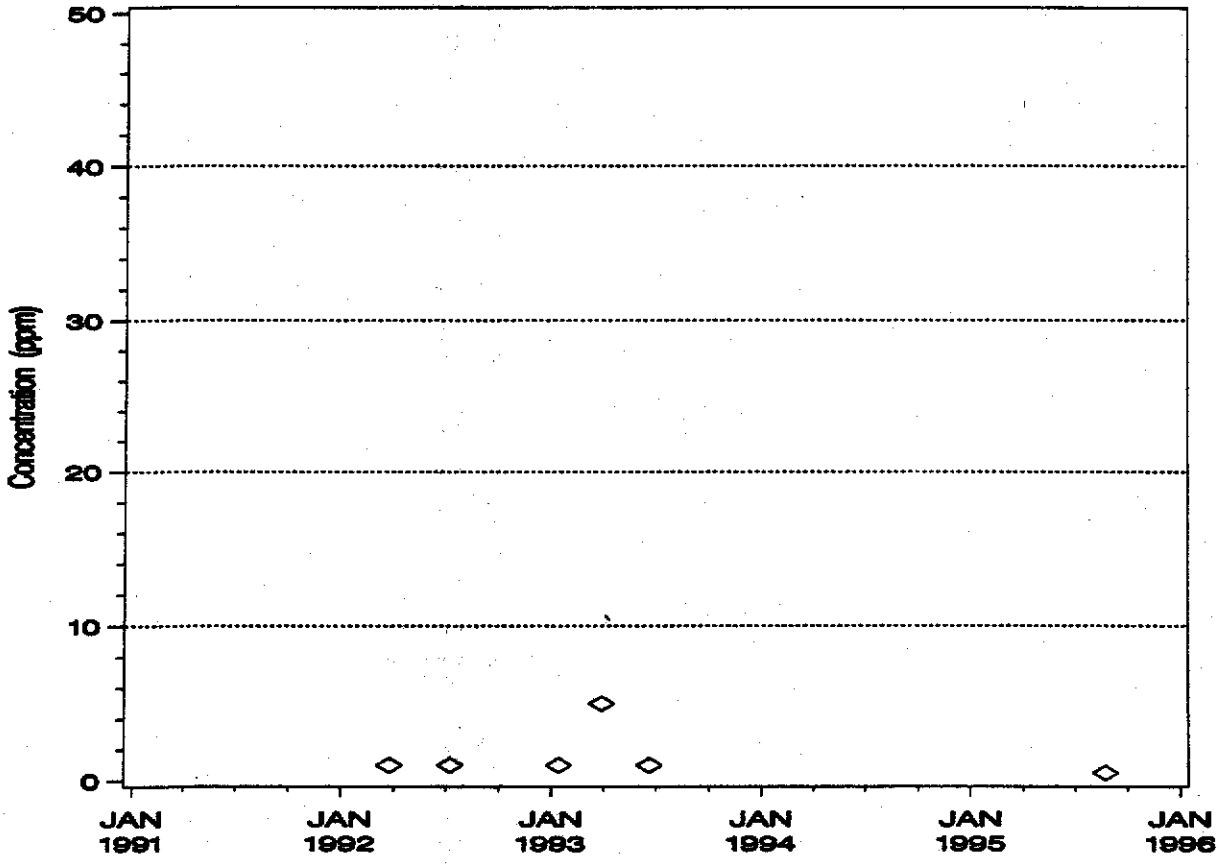
FREON 113 Trend



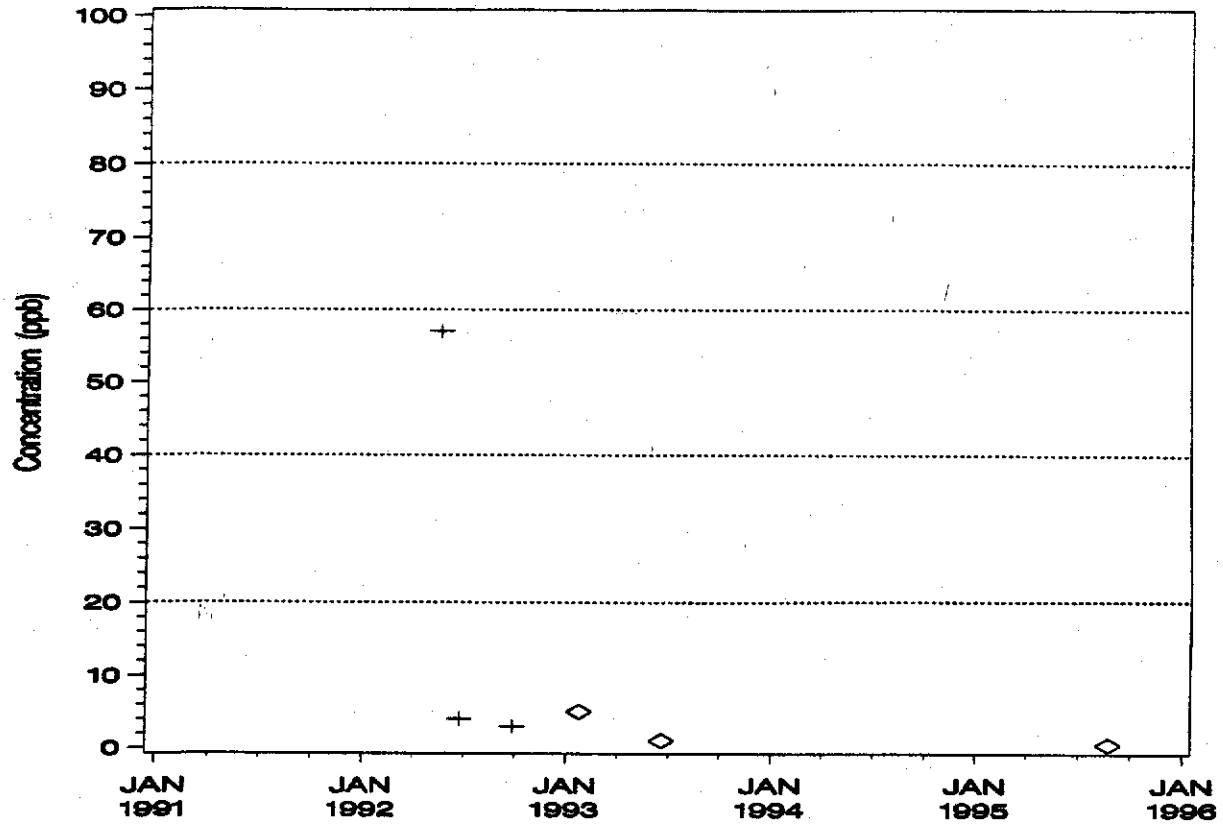
WELL 1516
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



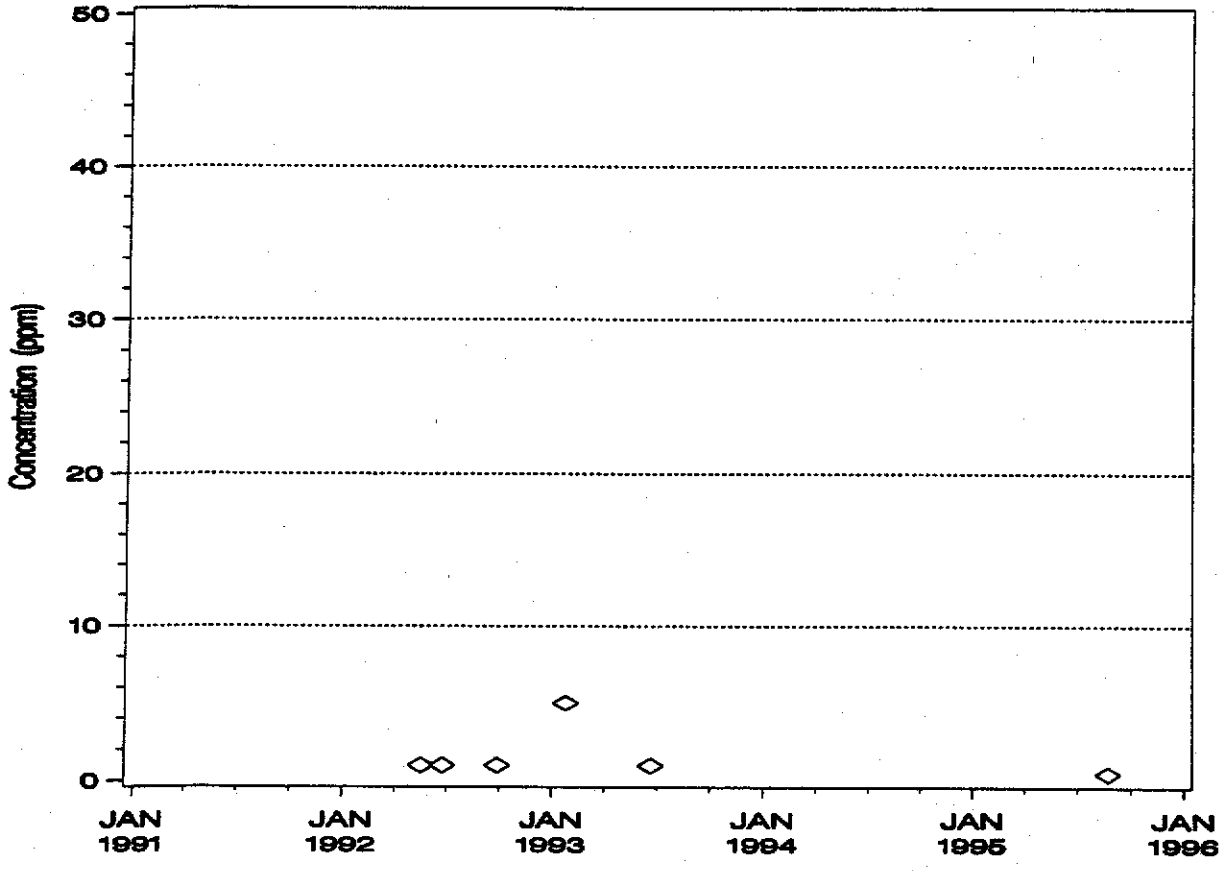
1,1 – DICHLOROETHYLENE Trend



WELL 1517
TRICHLOROETHYLENE Trend

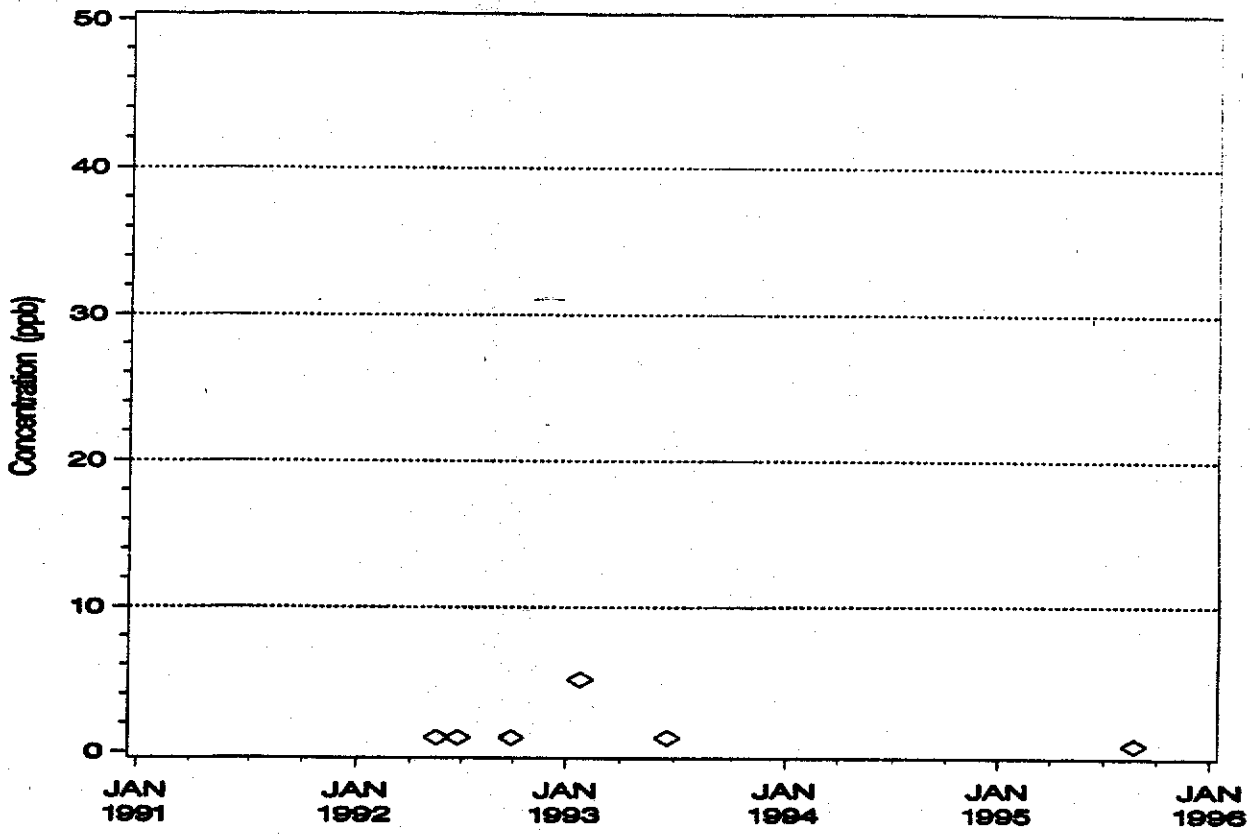


FREON 113 Trend

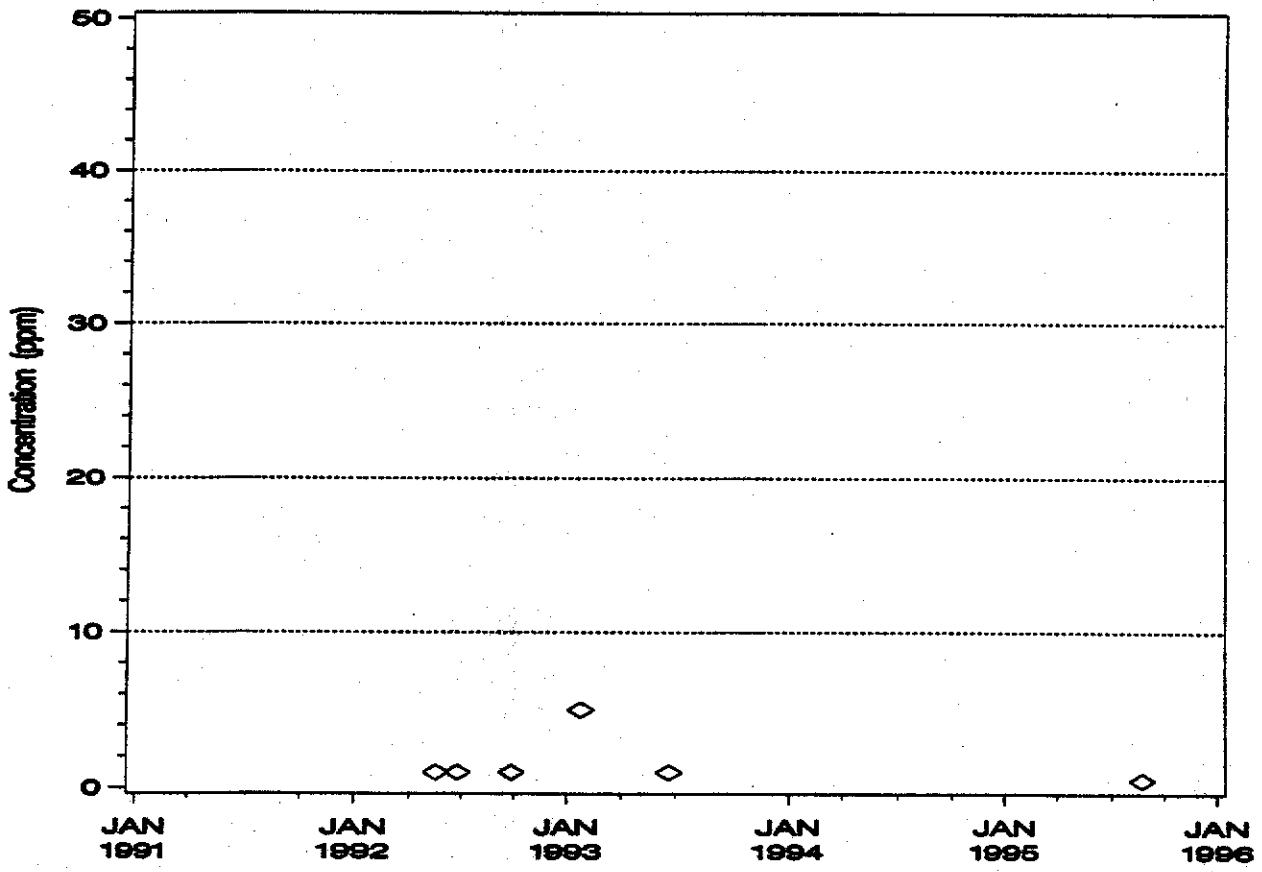


WELL 1517

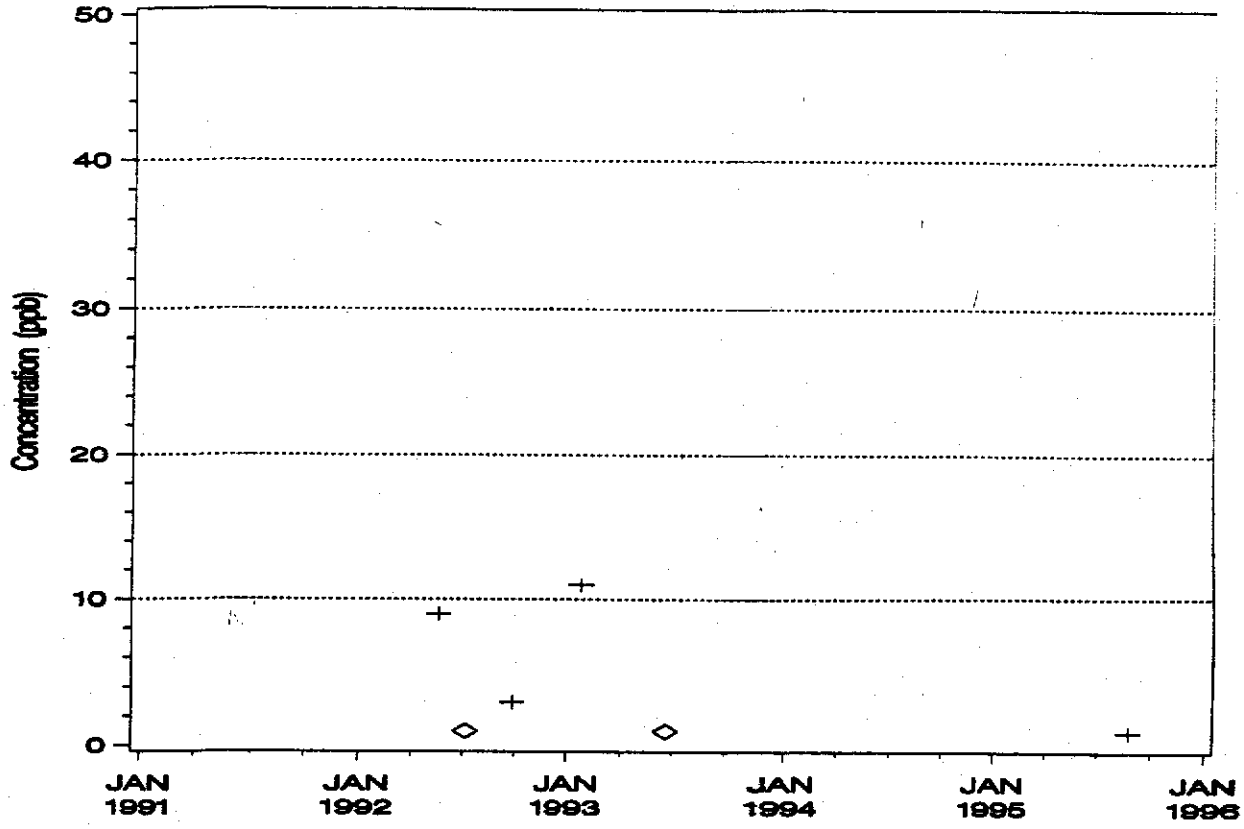
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



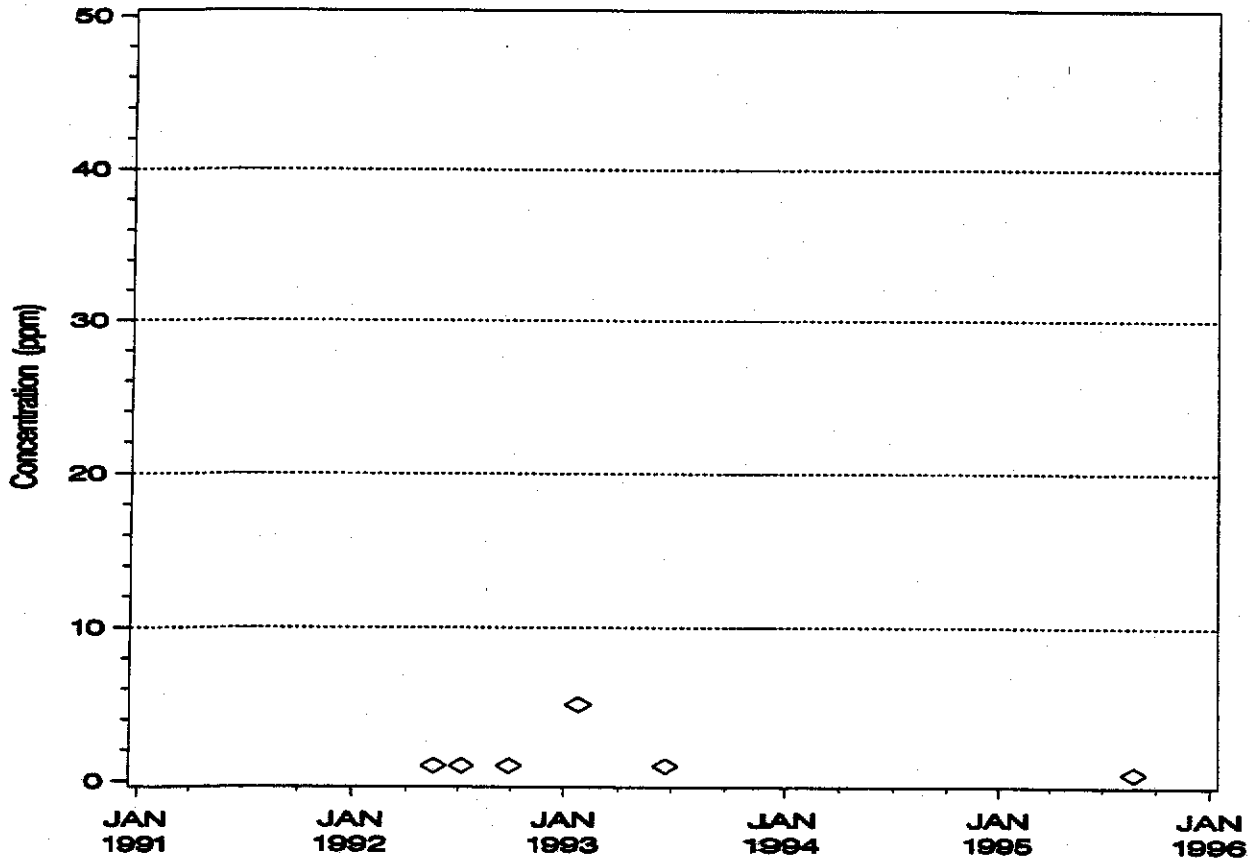
1,1 – DICHLOROETHYLENE Trend



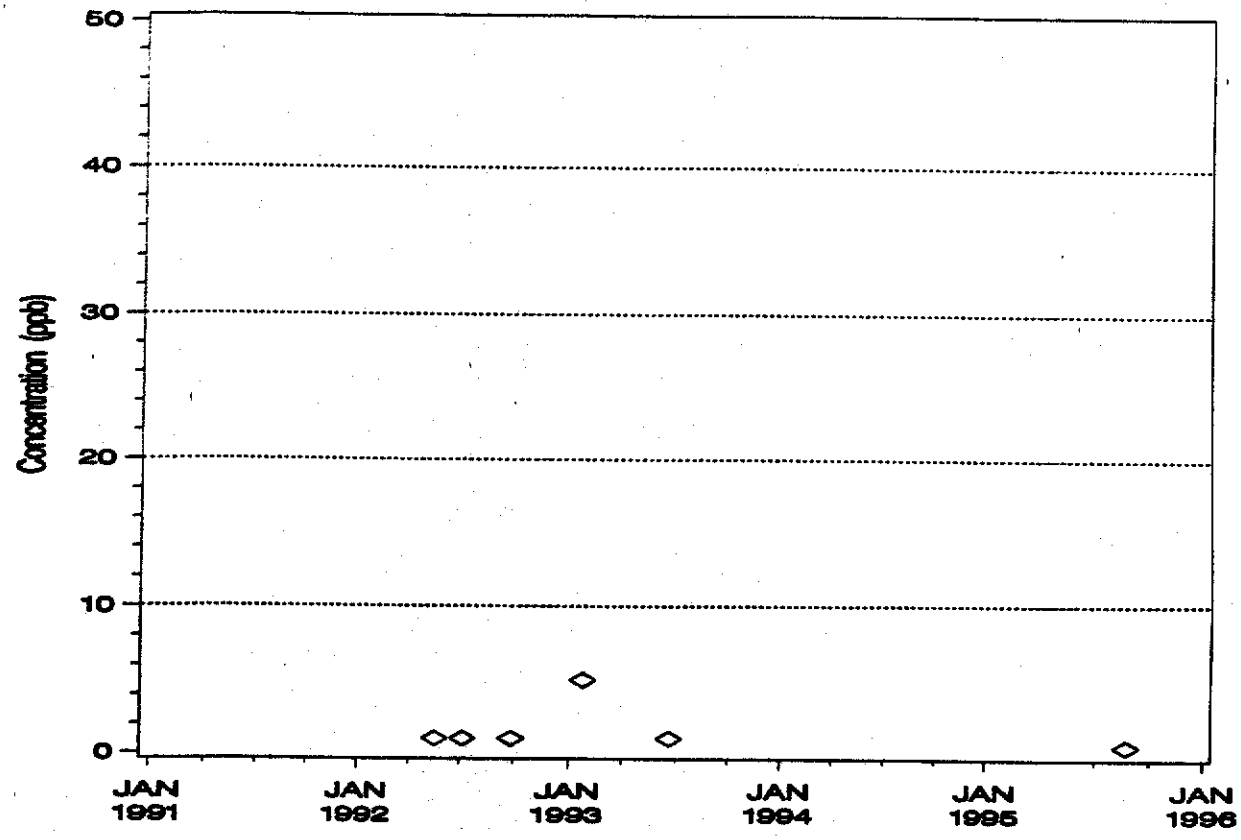
WELL 1518
TRICHLOROETHYLENE Trend



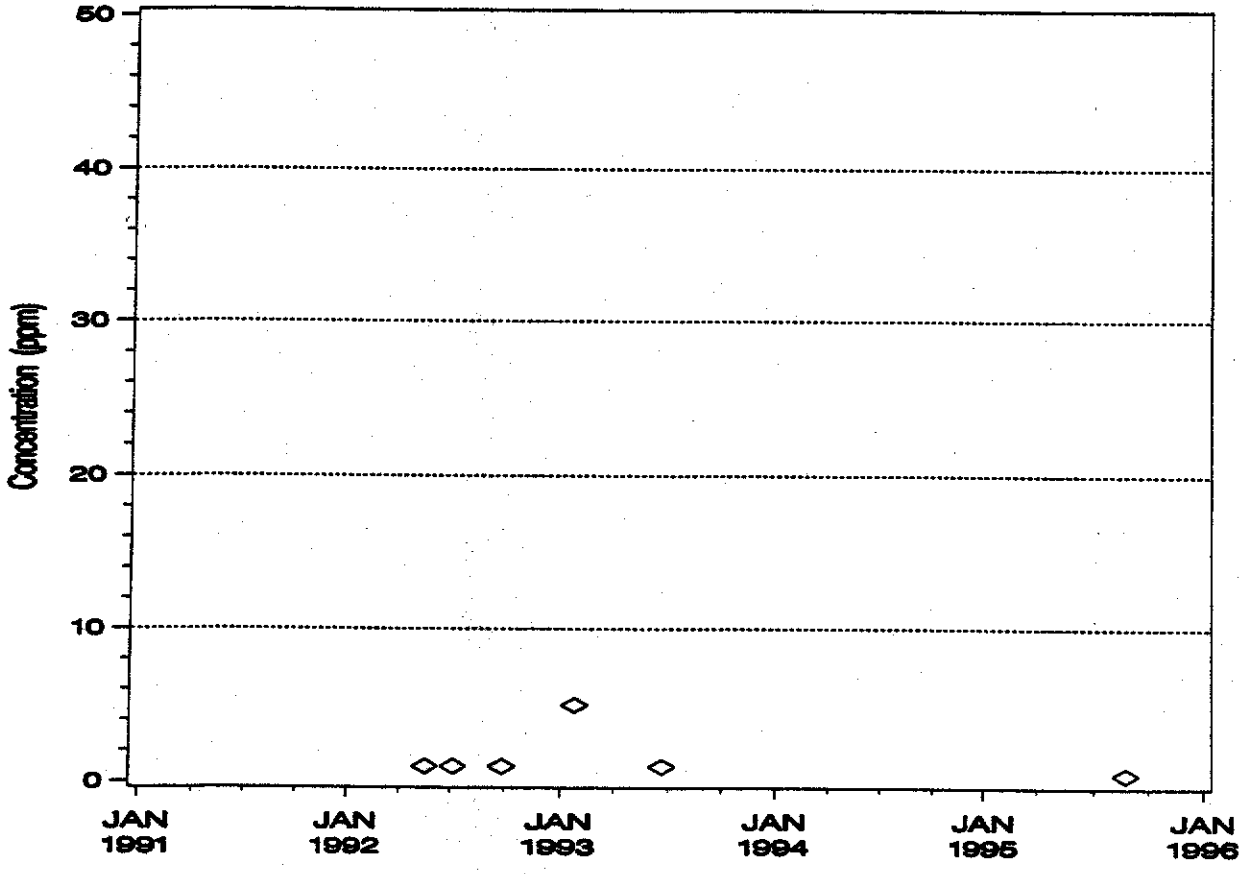
FREON 113 Trend



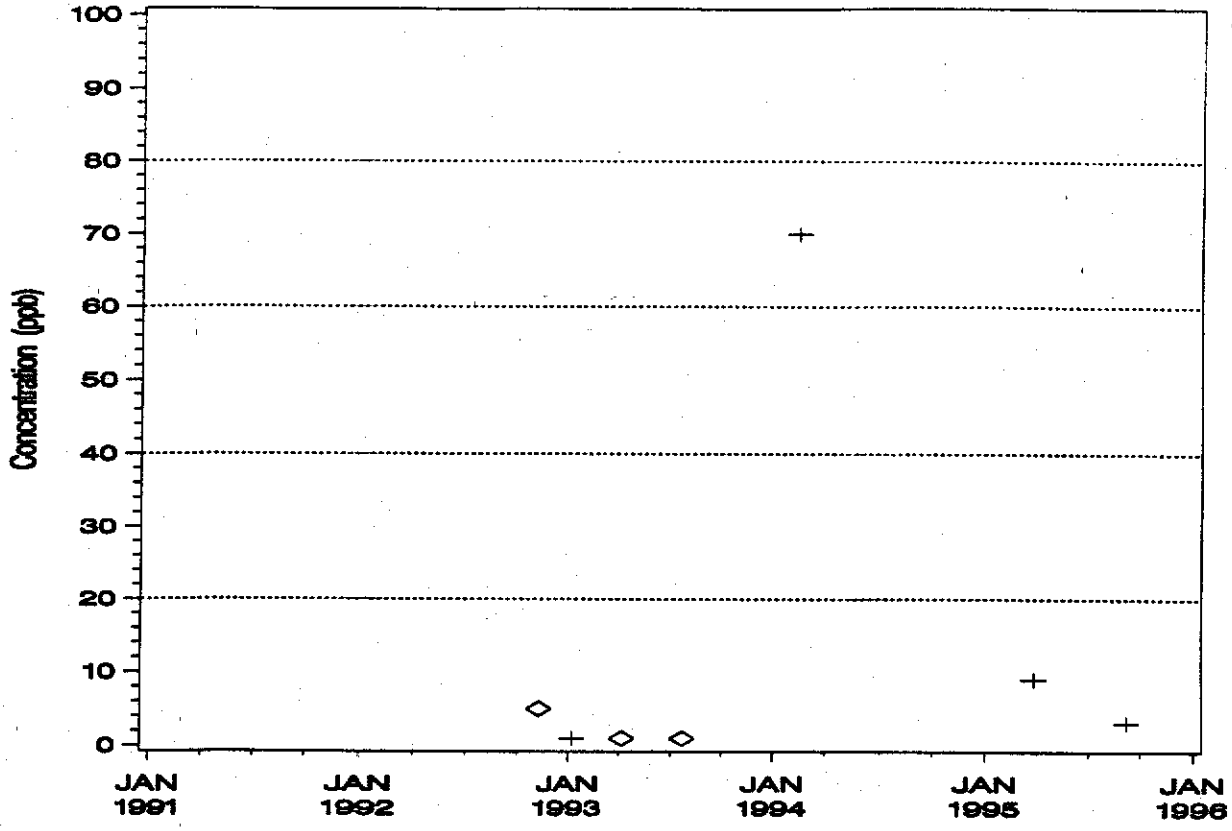
WELL 1518
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



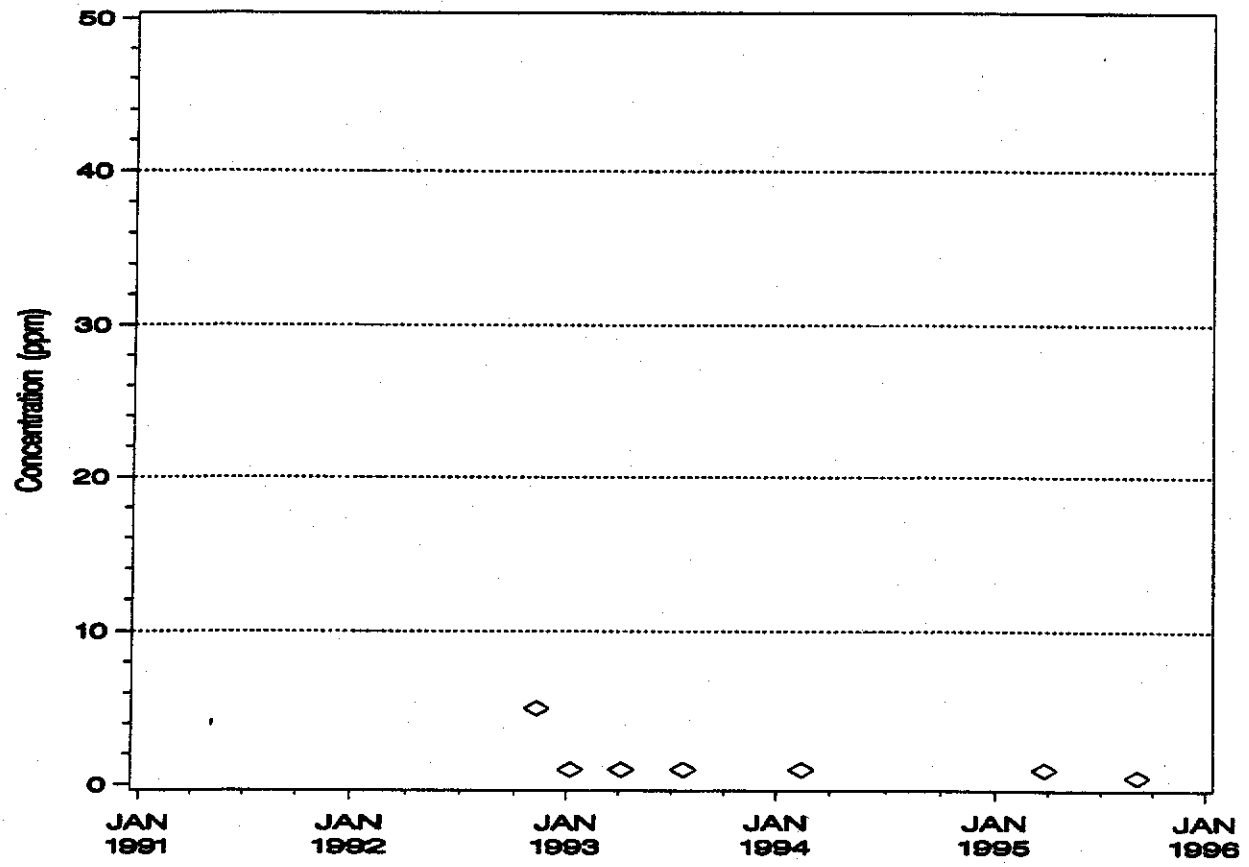
1,1 – DICHLOROETHYLENE Trend



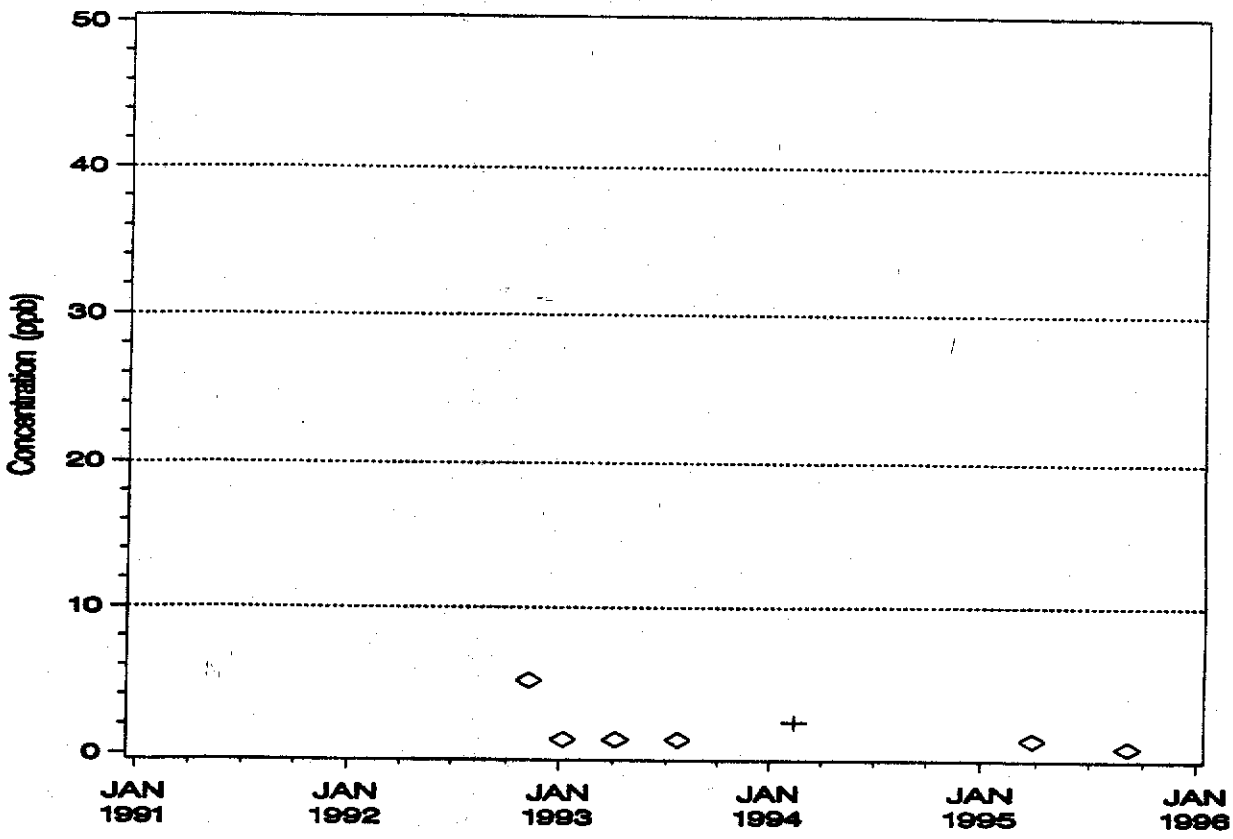
WELL 1519
TRICHLOROETHYLENE Trend



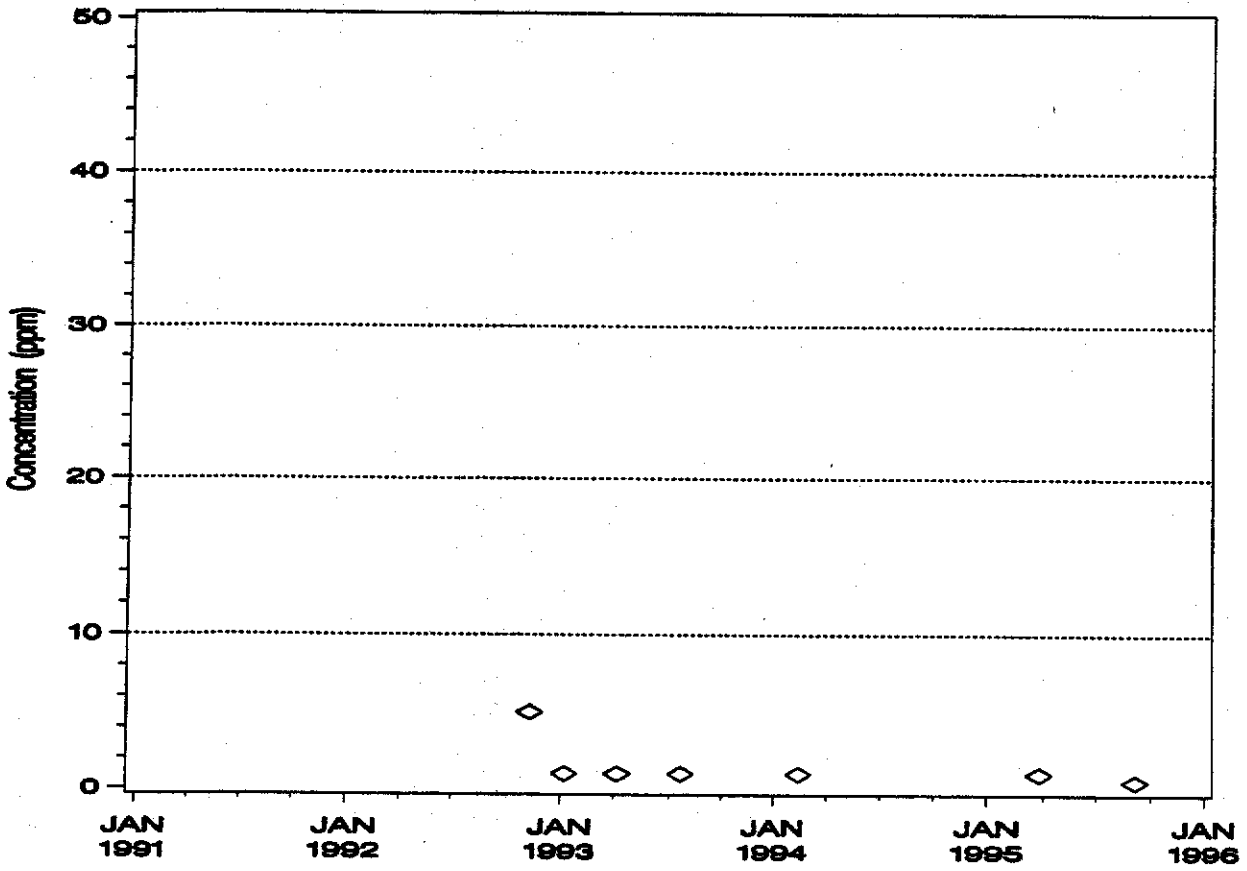
FREON 113 Trend



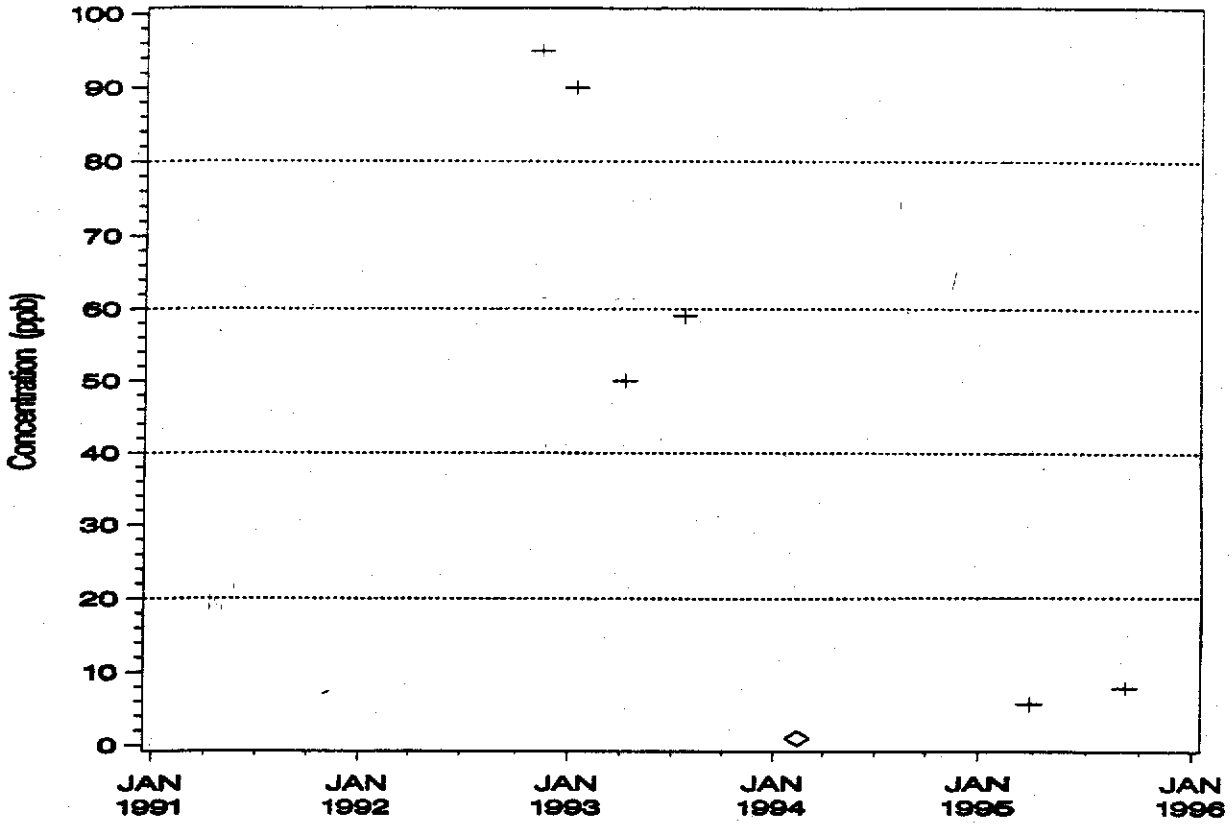
WELL 1519
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



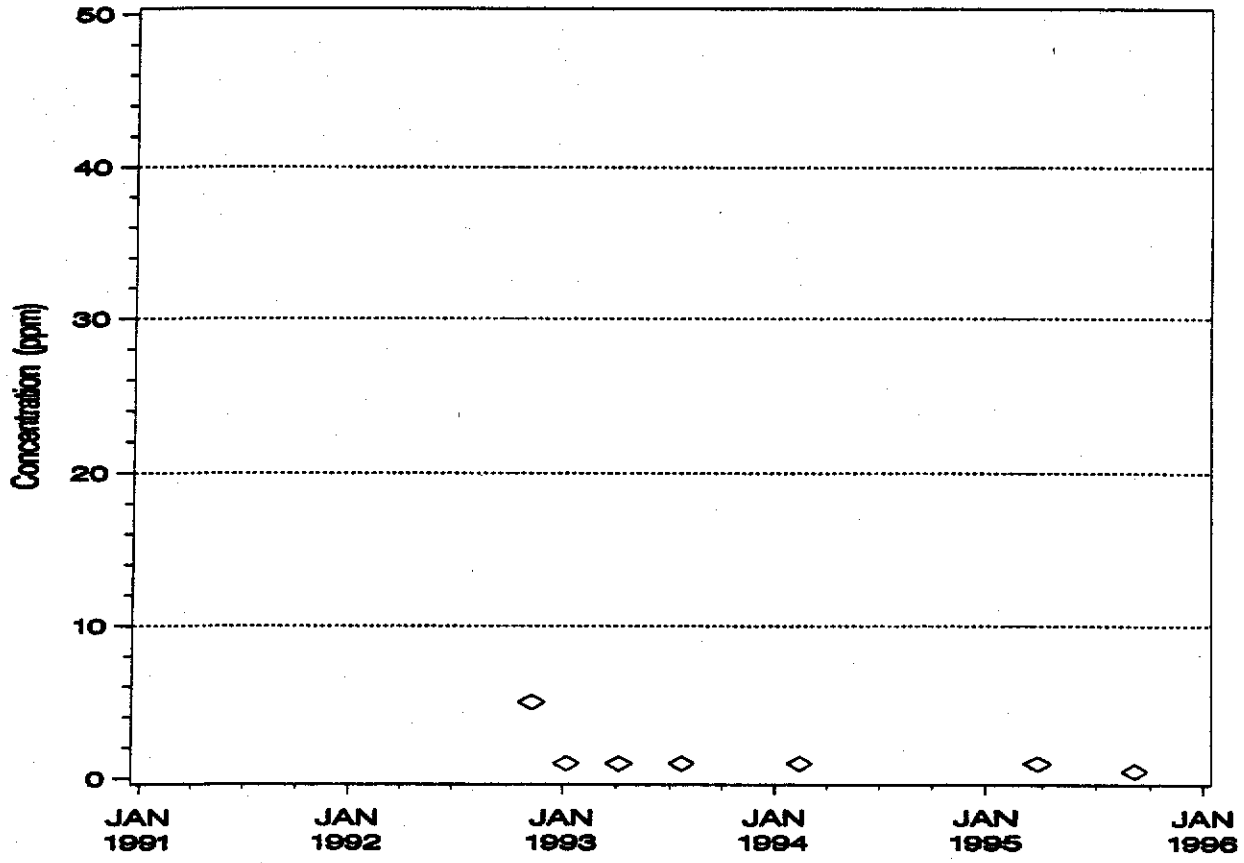
1,1 – DICHLOROETHYLENE Trend



WELL 1520
TRICHLOROETHYLENE Trend

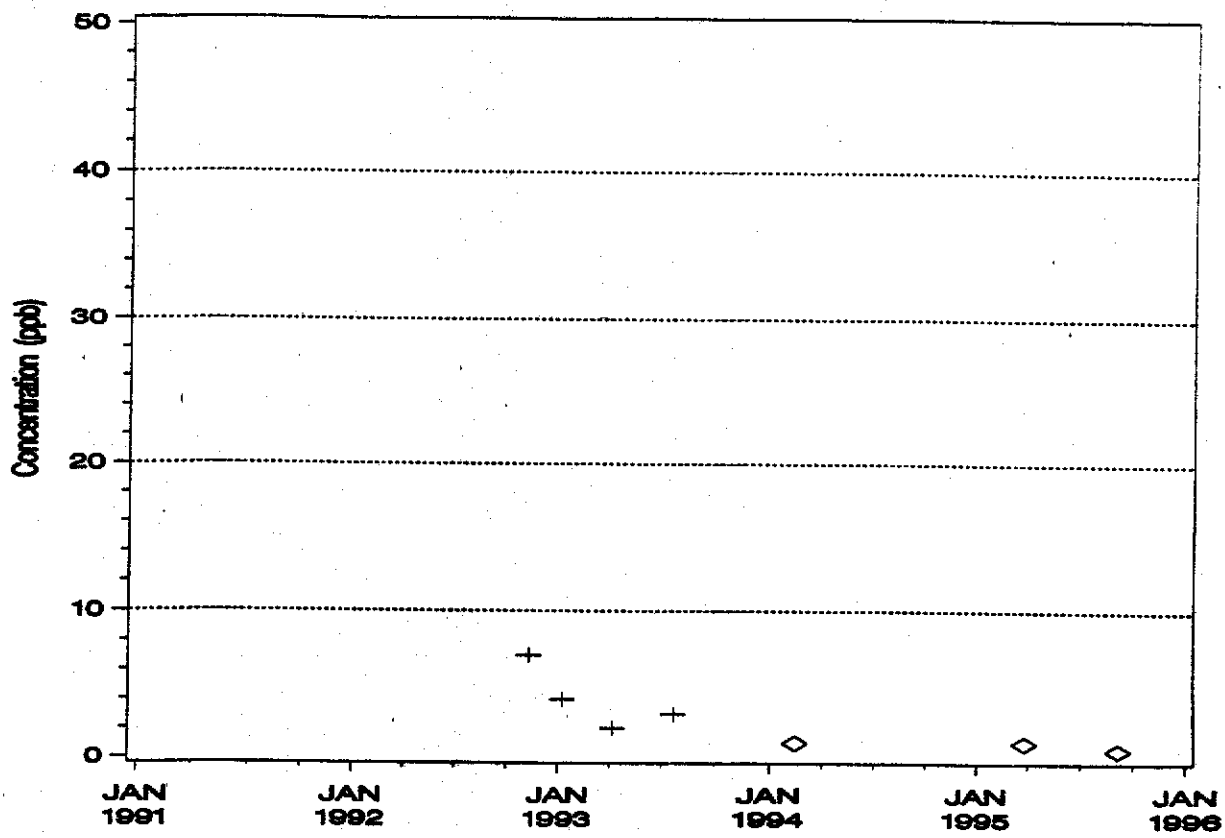


FREON 113 Trend

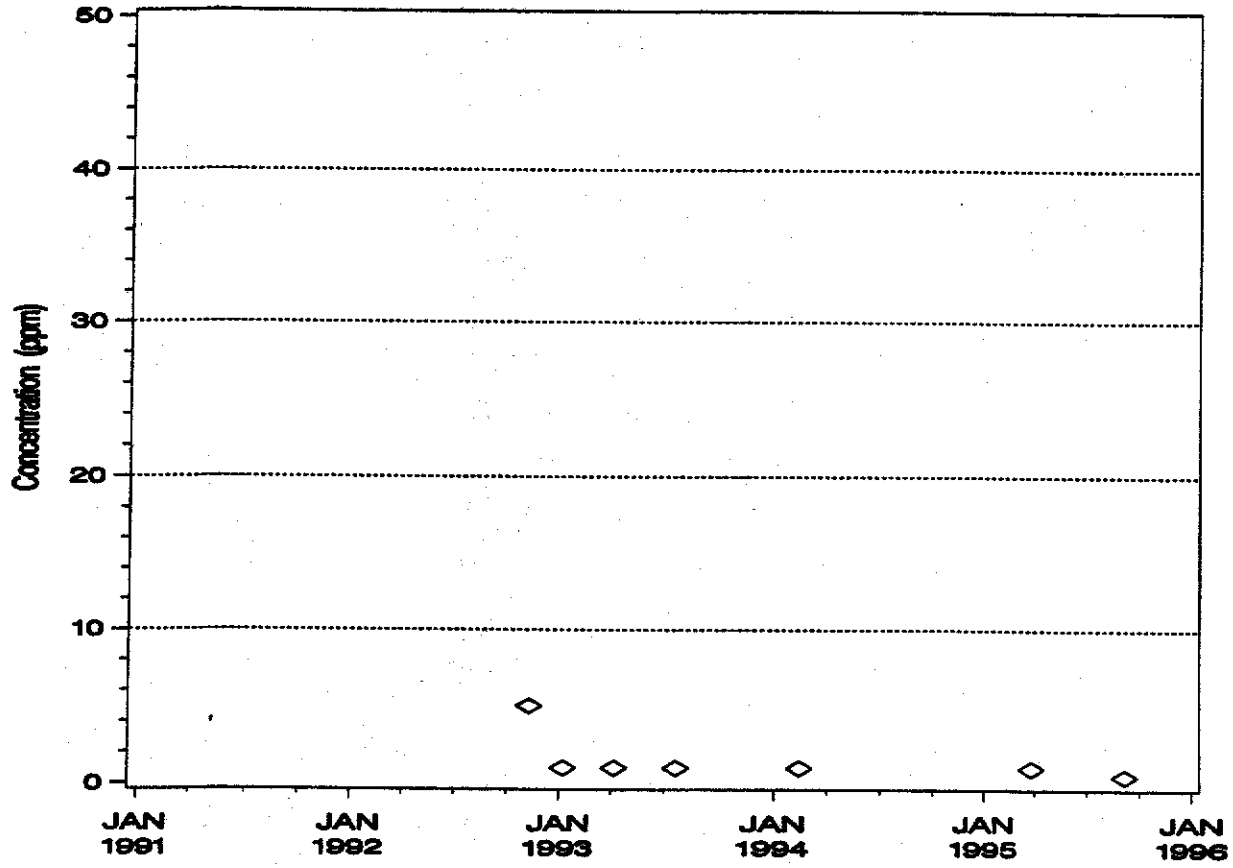


WELL 1520

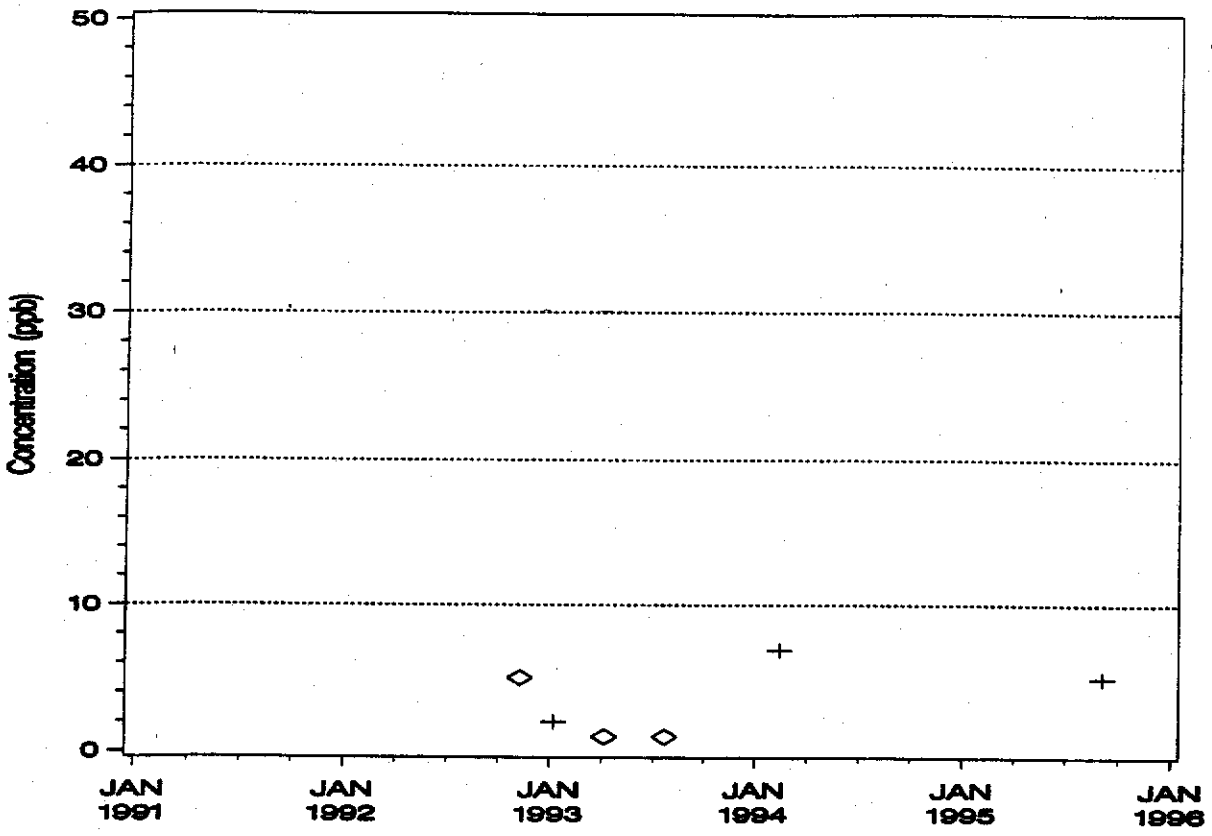
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



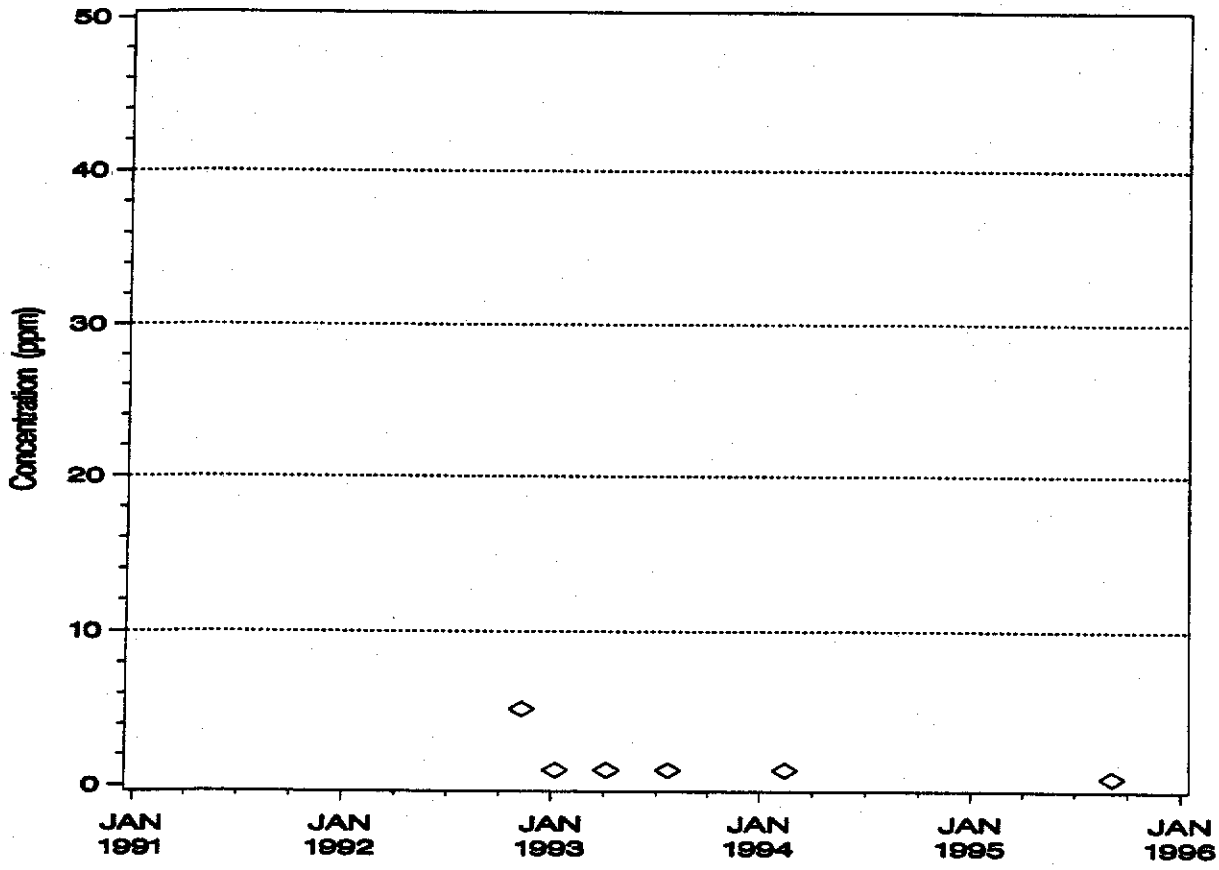
1,1 – DICHLOROETHYLENE Trend



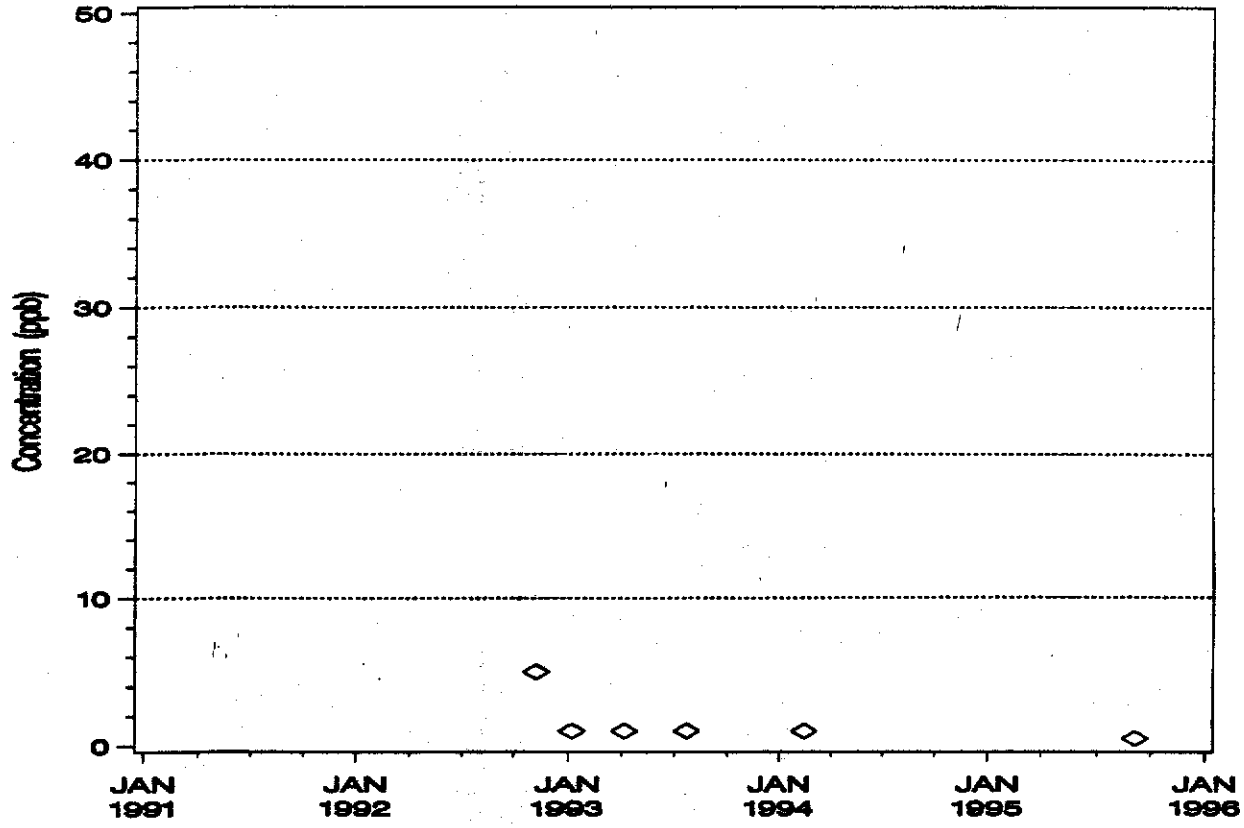
WELL 1521
TRICHLOROETHYLENE Trend



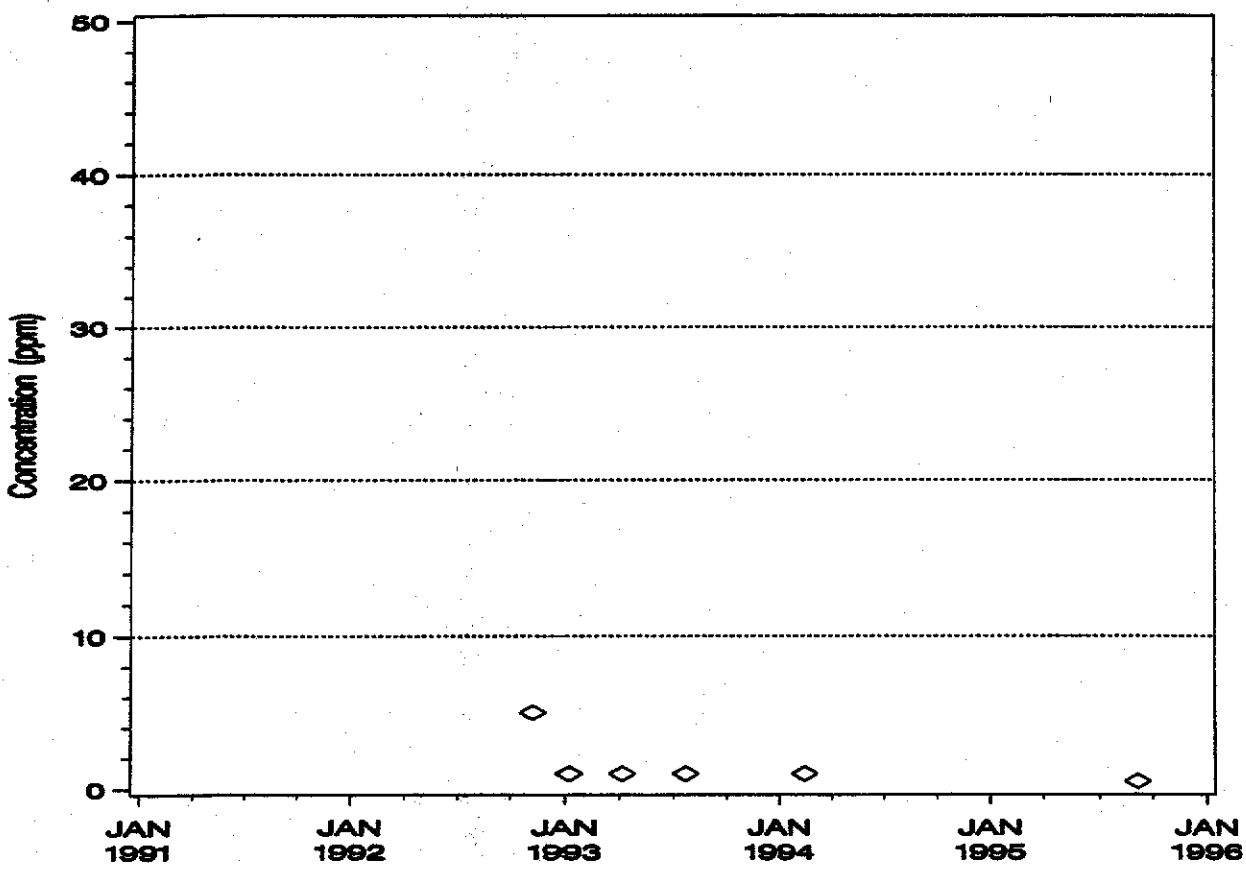
FREON 113 Trend



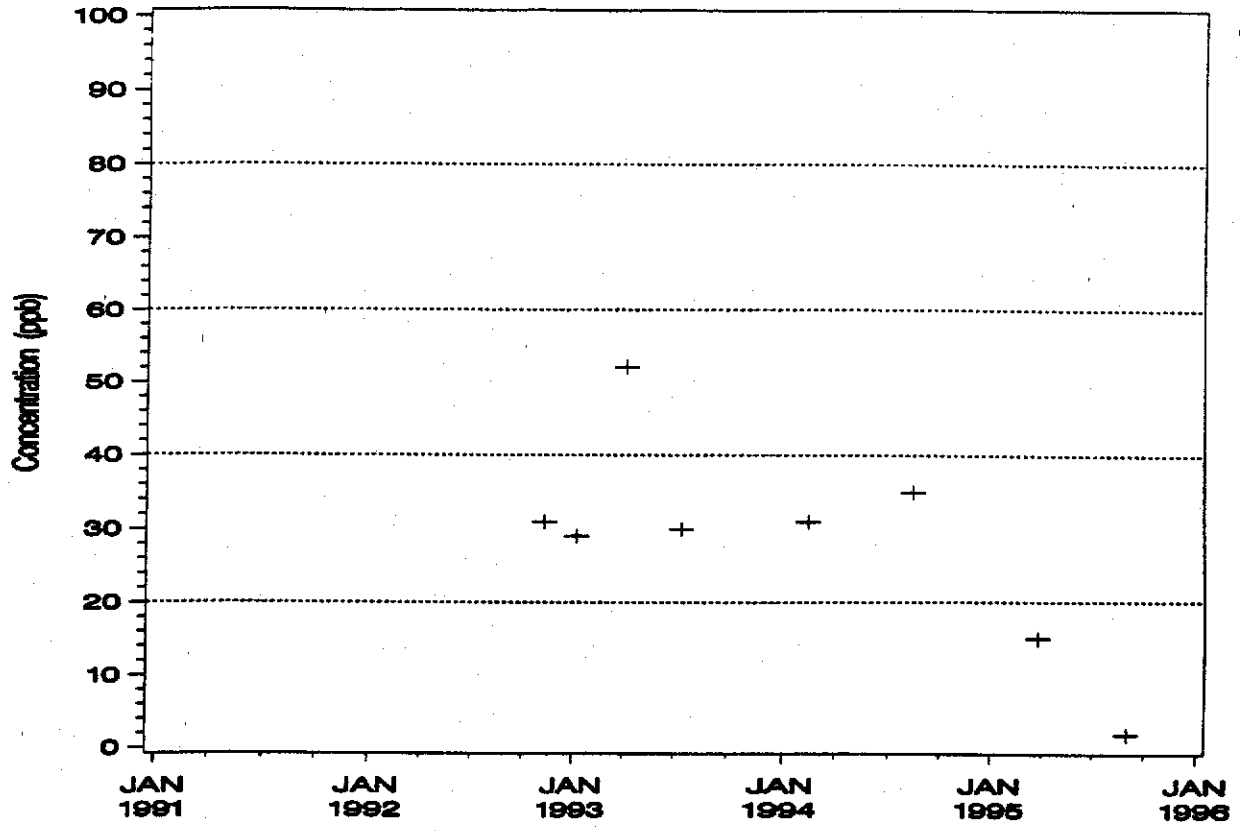
WELL 1521
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



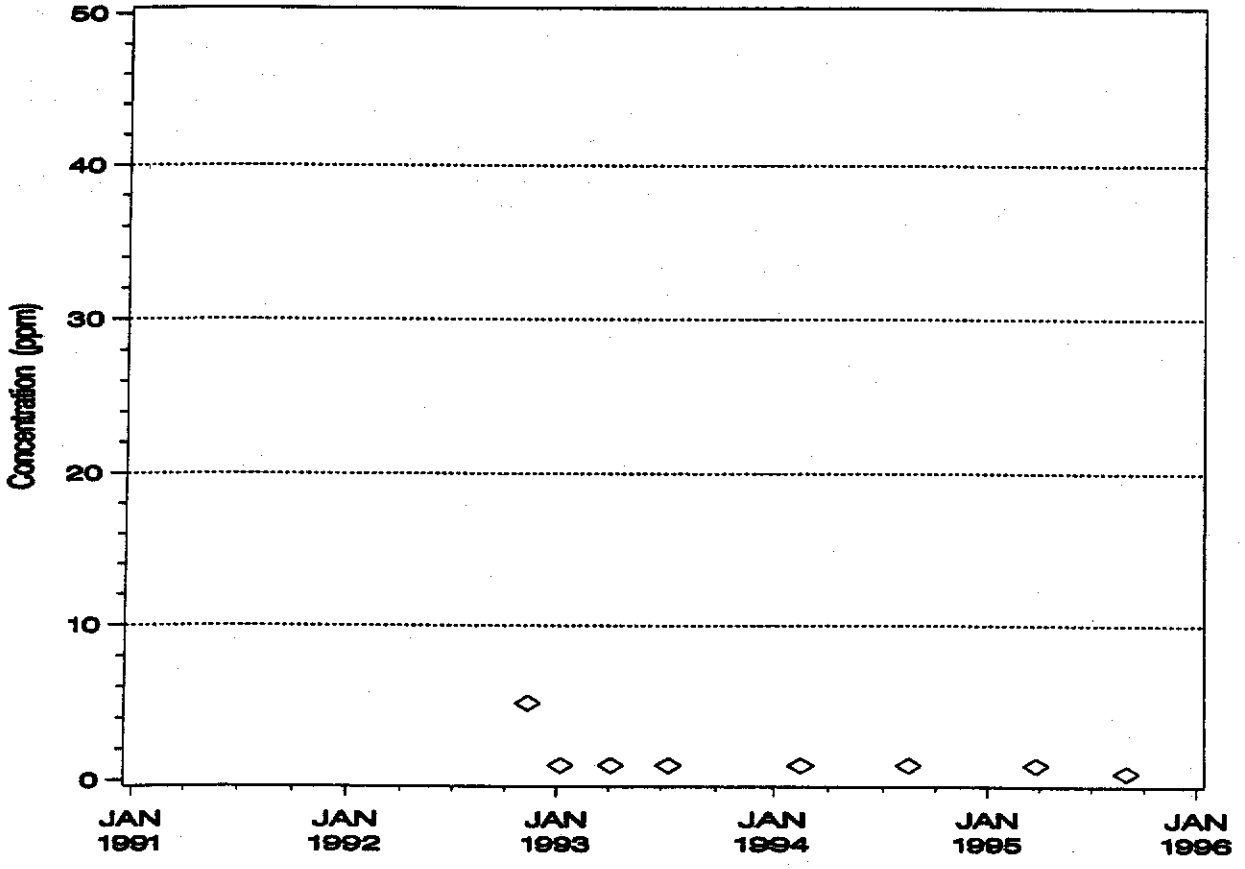
1,1 – DICHLOROETHYLENE Trend



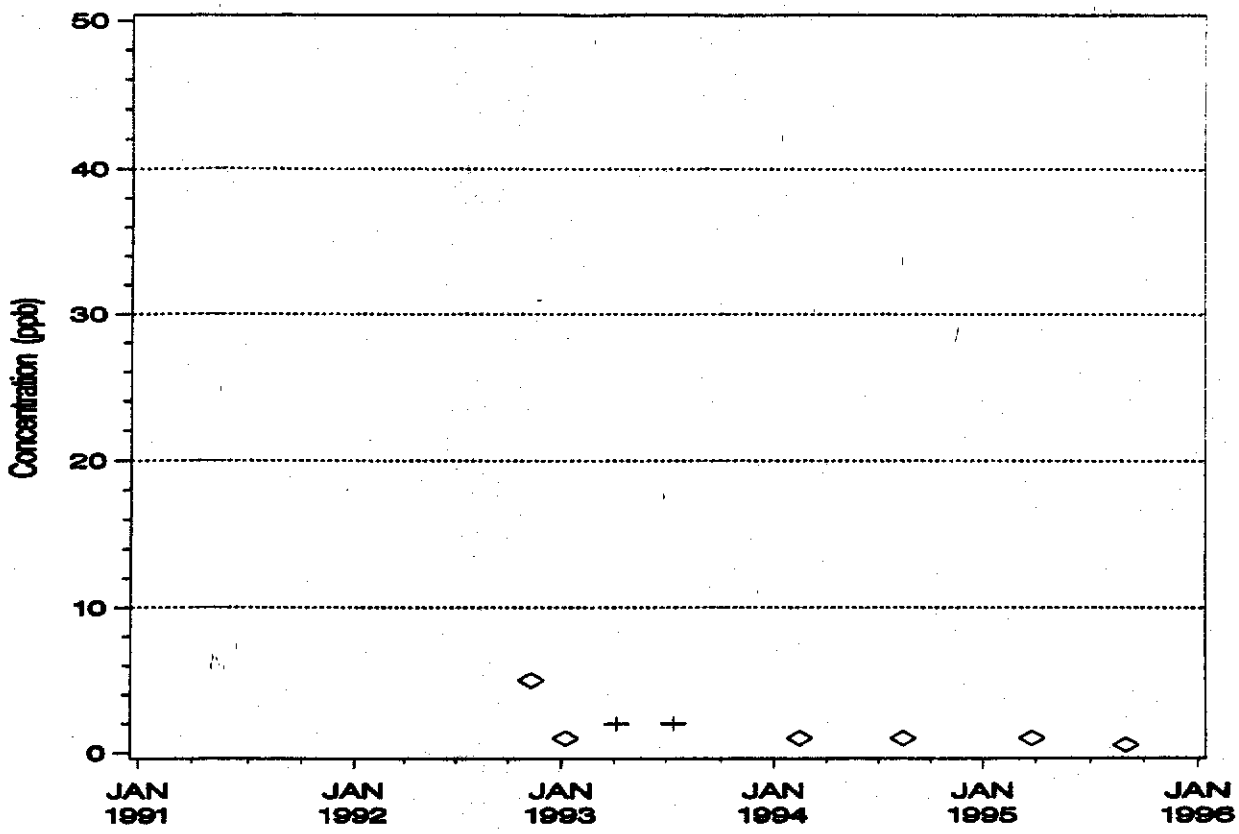
WELL 1522
TRICHLOROETHYLENE Trend



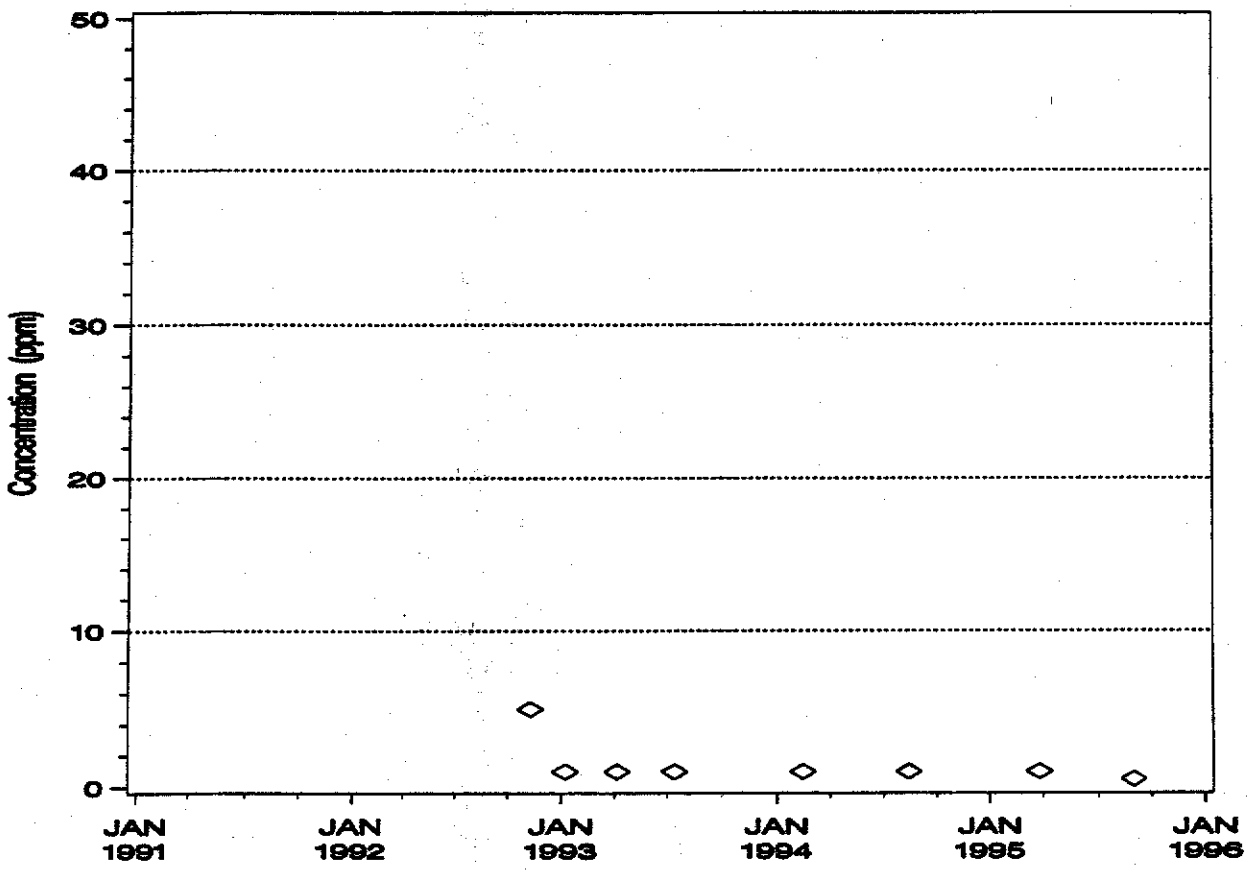
FREON 113 Trend



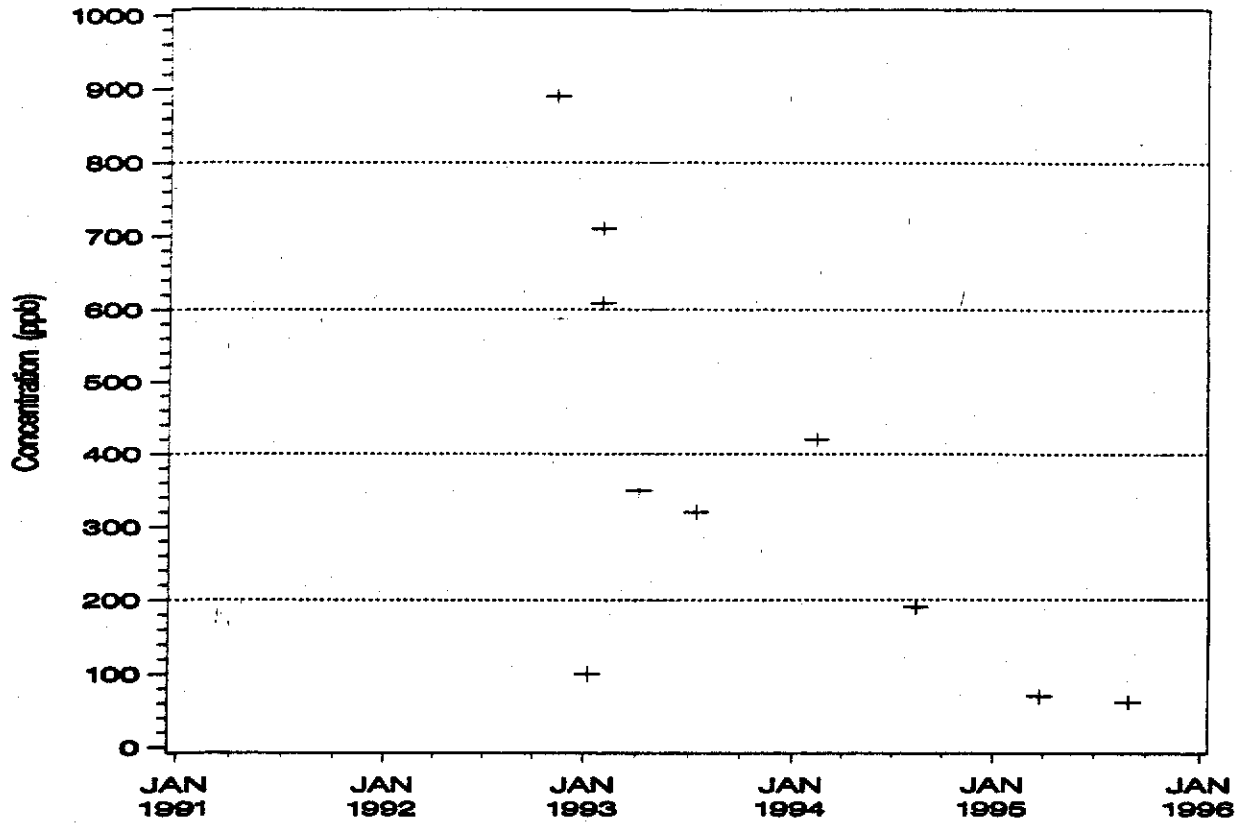
WELL 1522
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



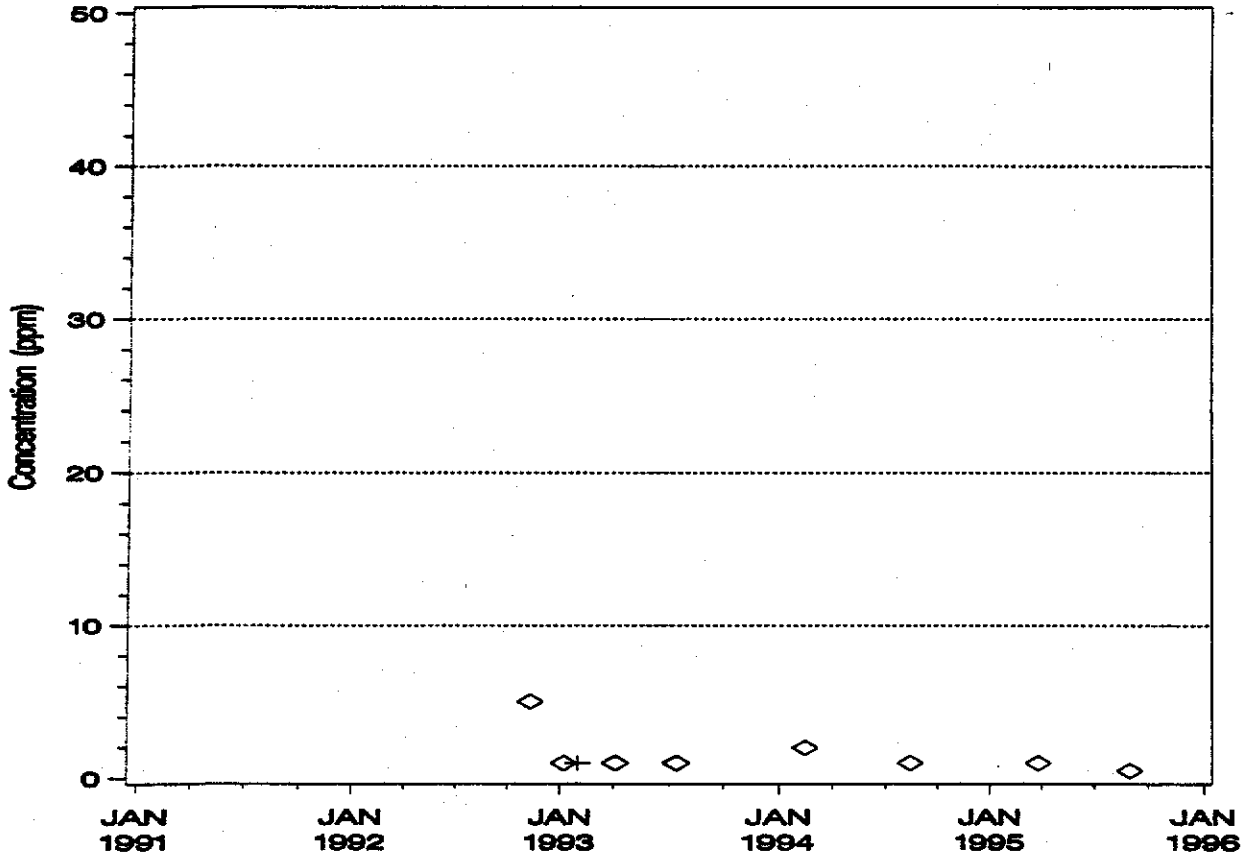
1,1 – DICHLOROETHYLENE Trend



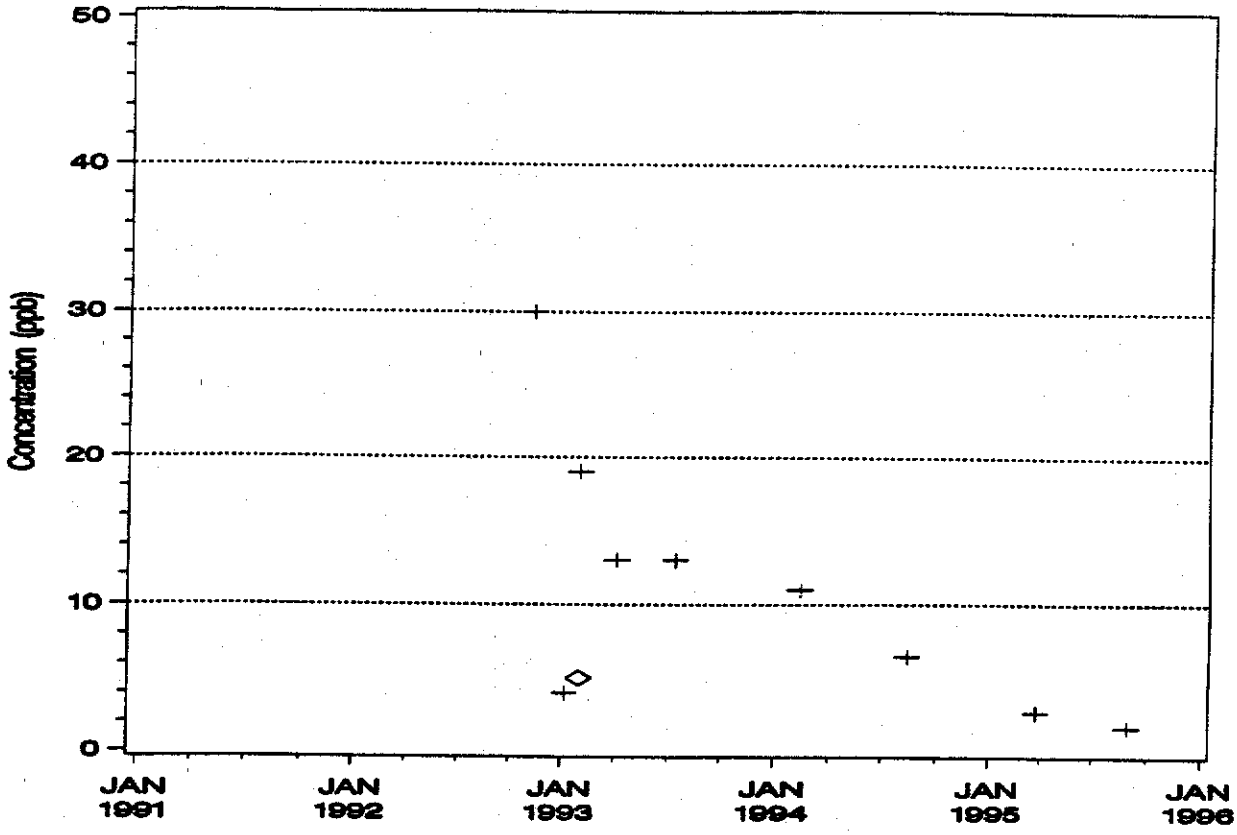
WELL 1523
TRICHLOROETHYLENE Trend



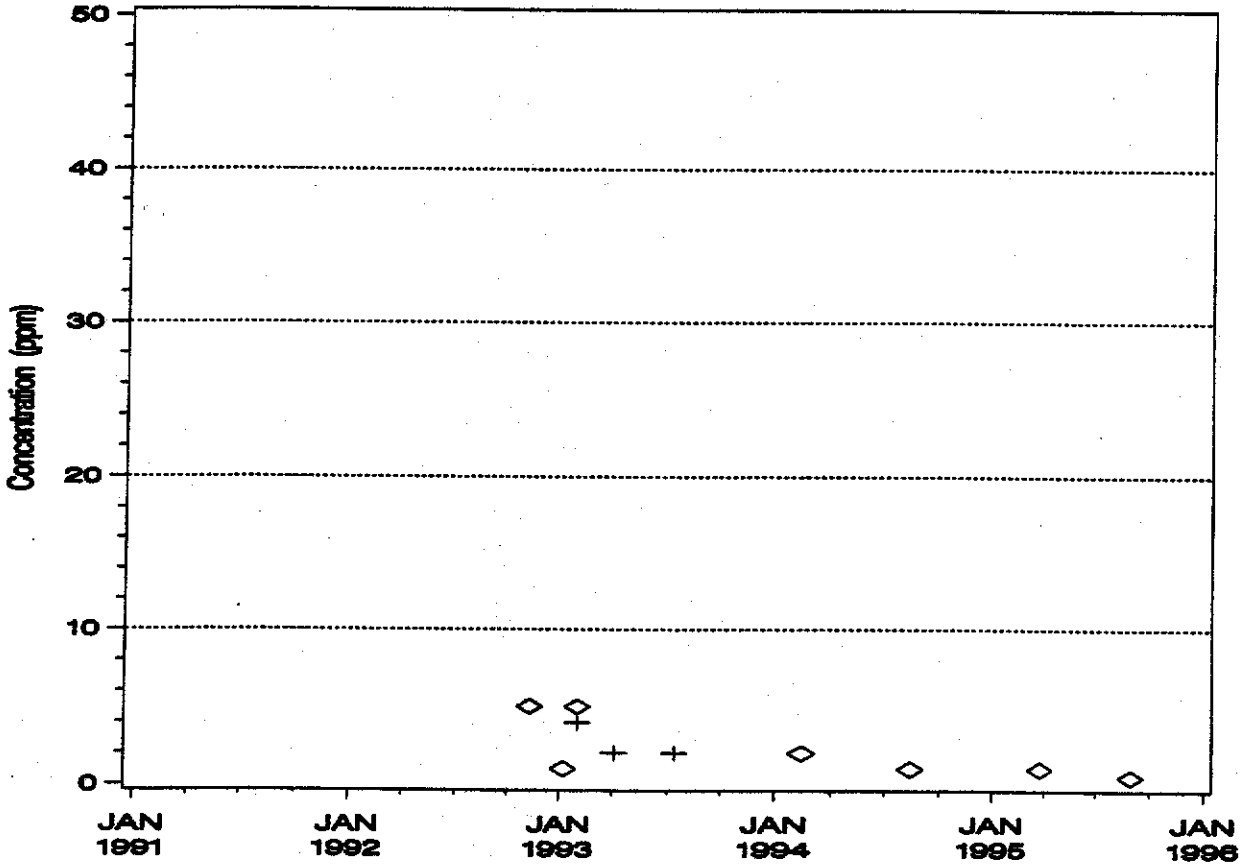
FREON 113 Trend



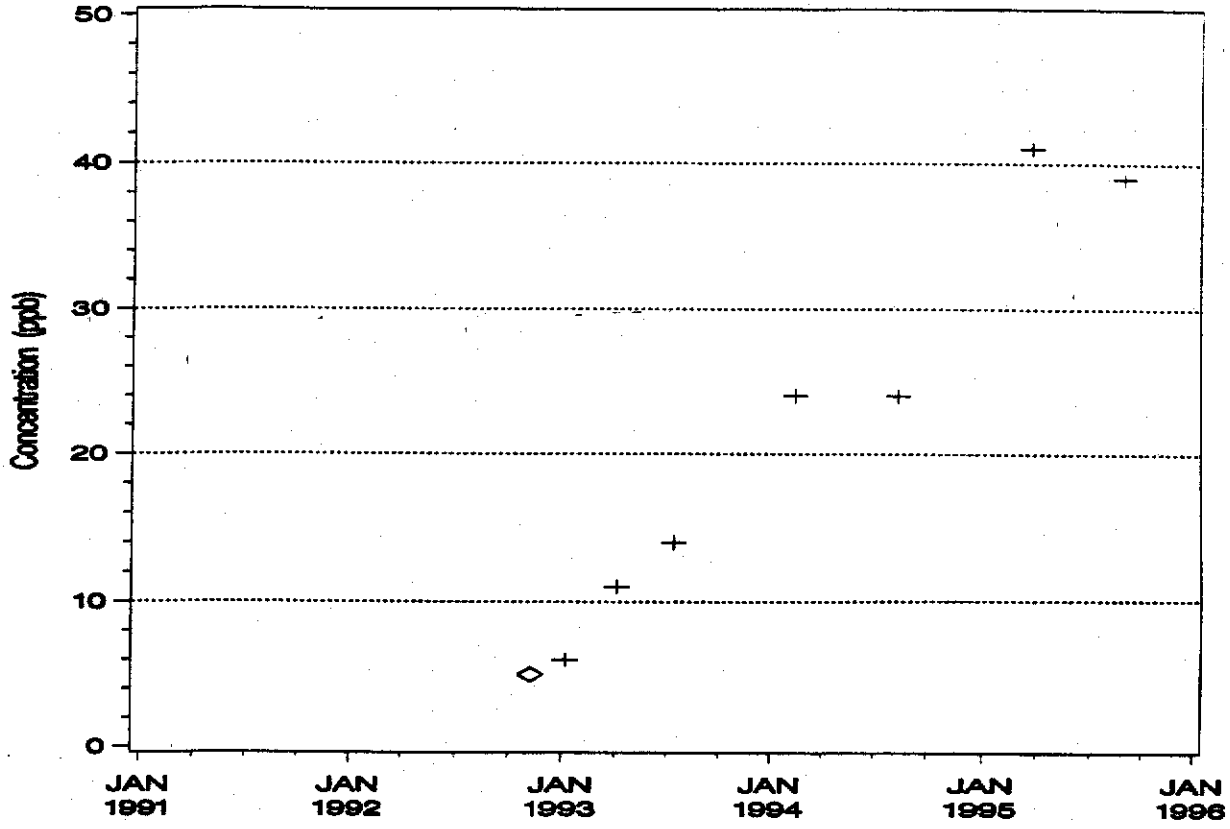
WELL 1523
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



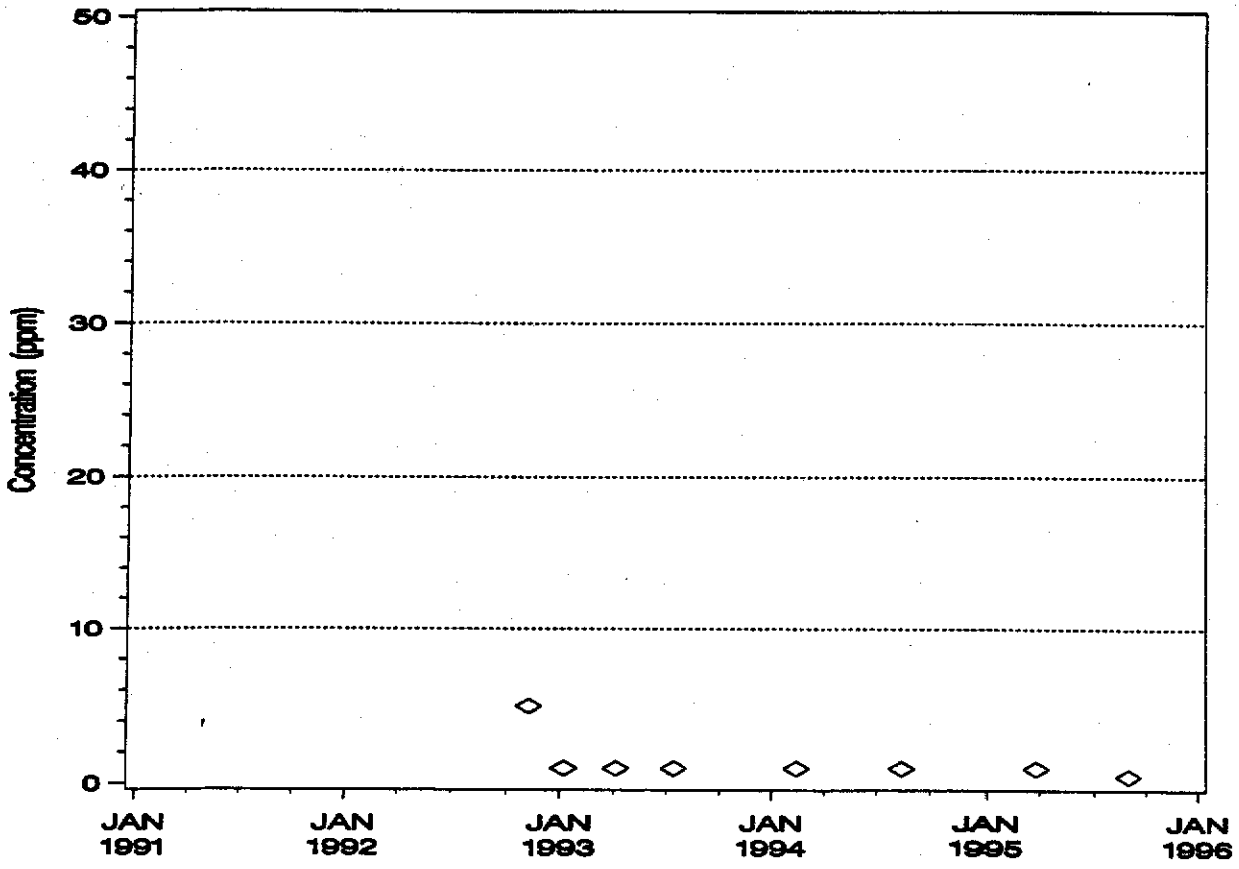
1,1 – DICHLOROETHYLENE Trend



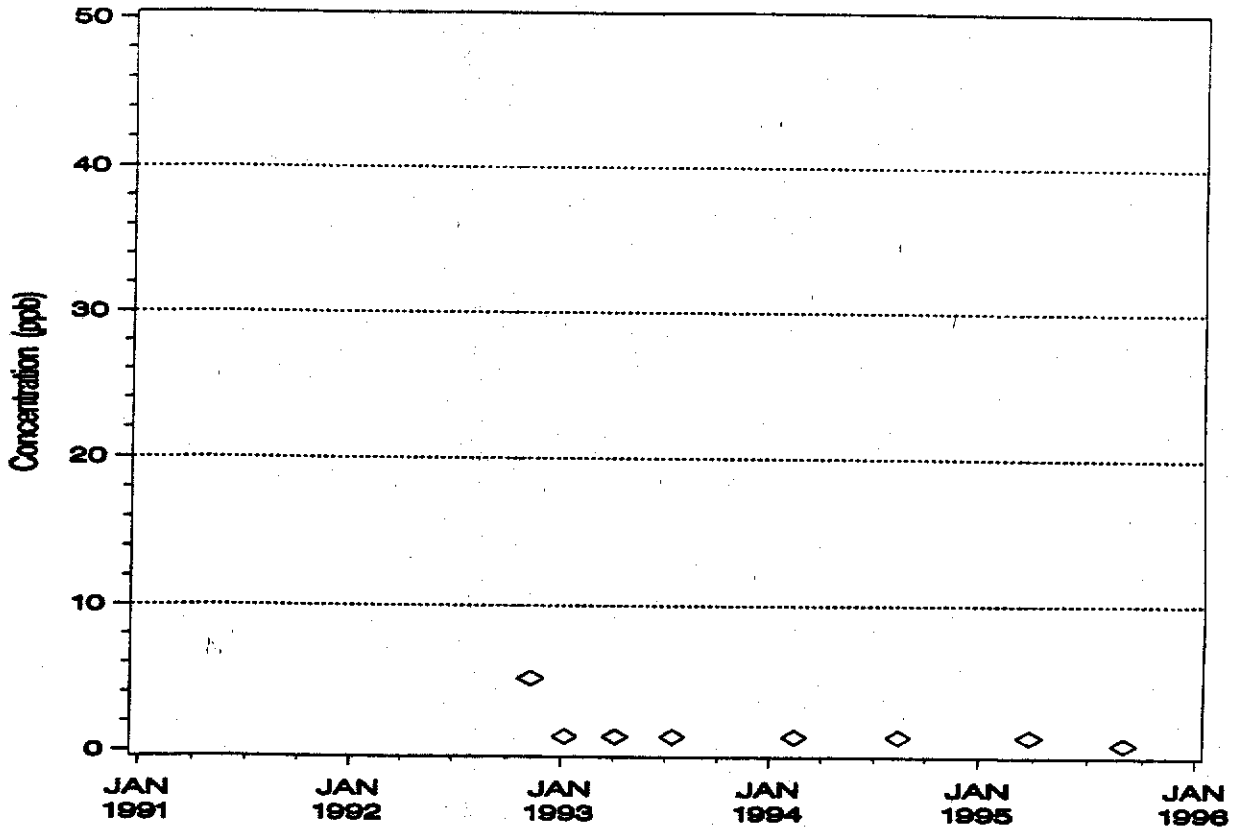
WELL 1524
TRICHLOROETHYLENE Trend



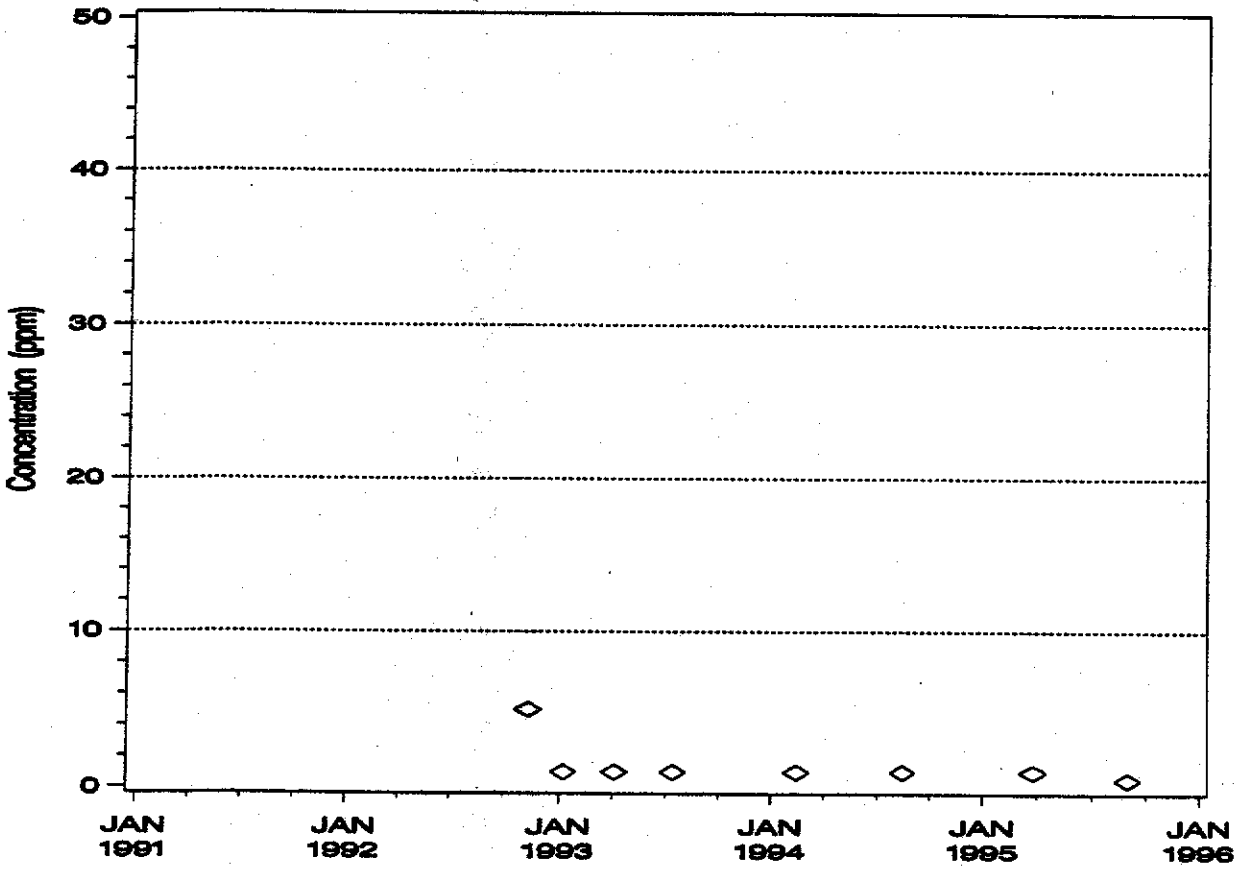
FREON 113 Trend



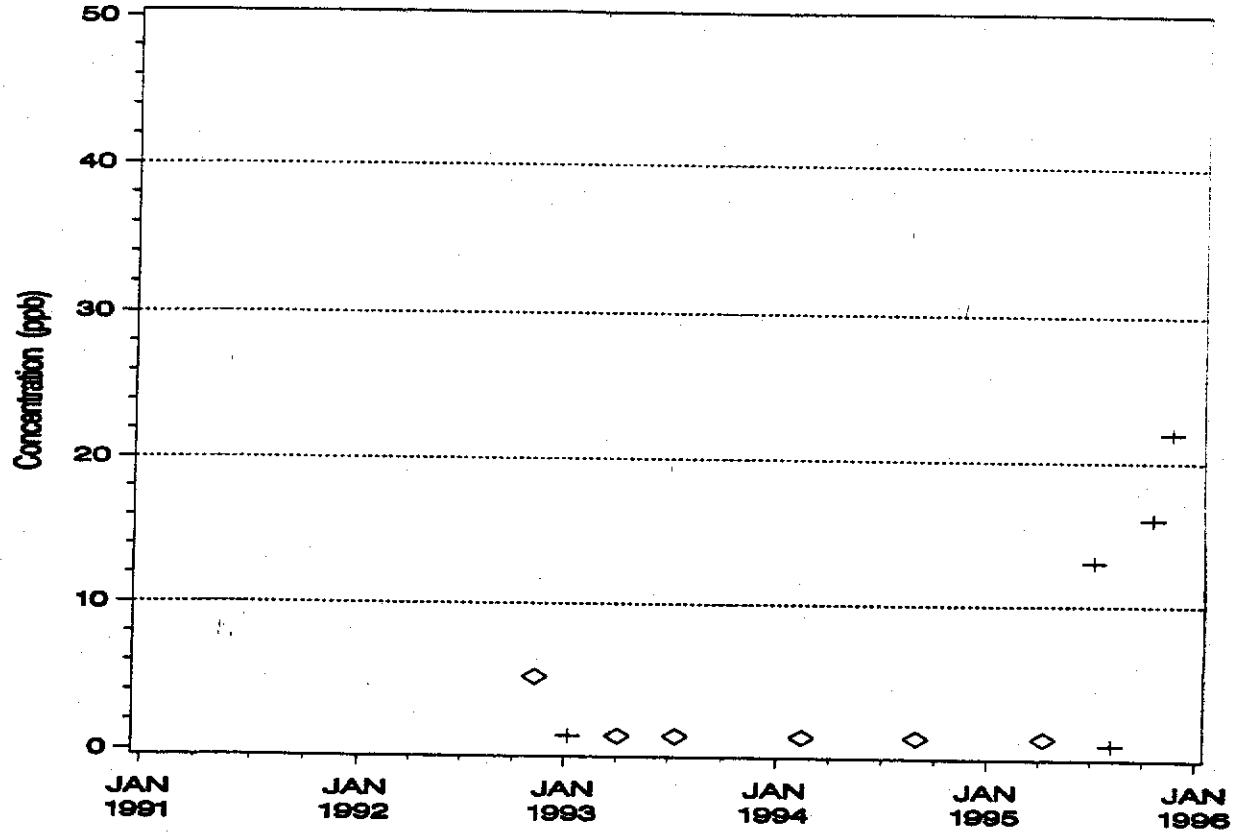
WELL 1524
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



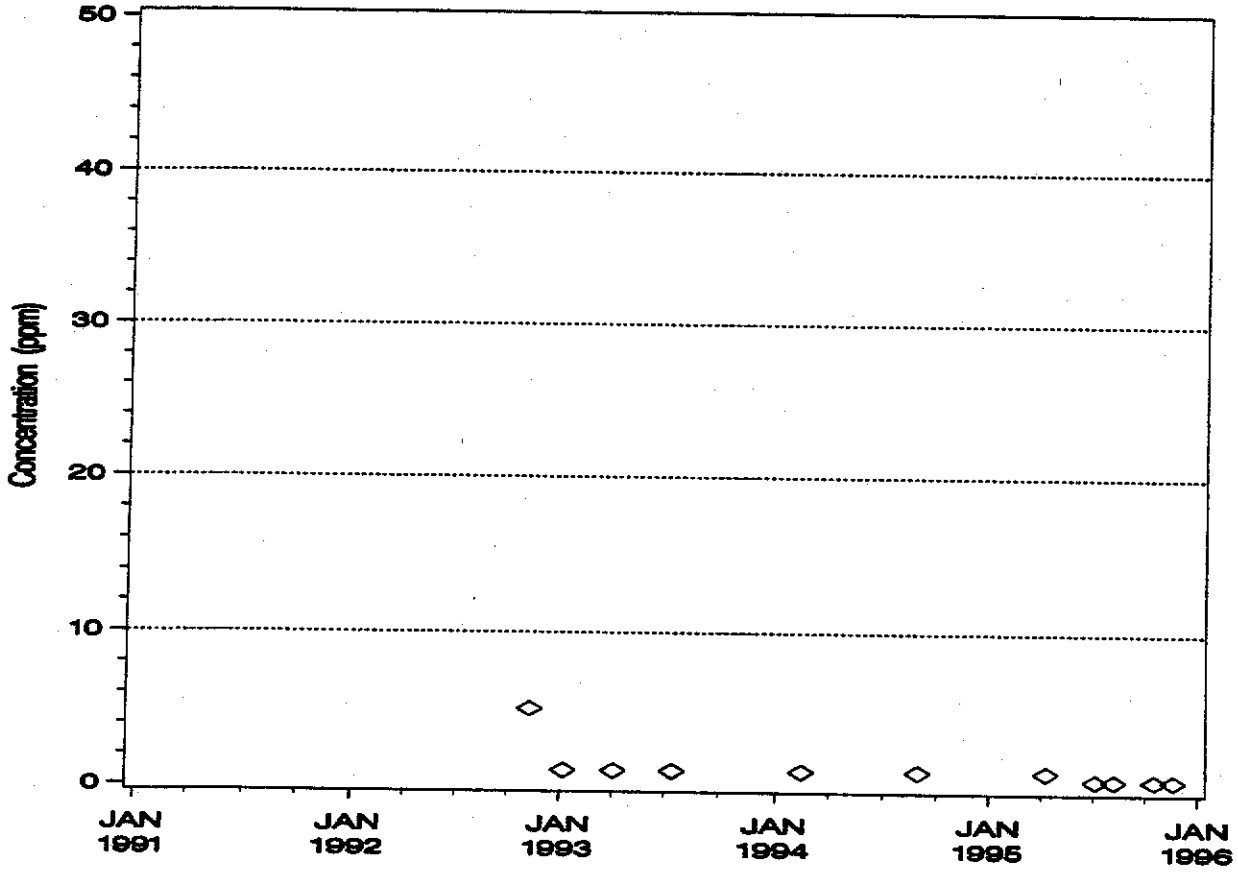
1,1 – DICHLOROETHYLENE Trend



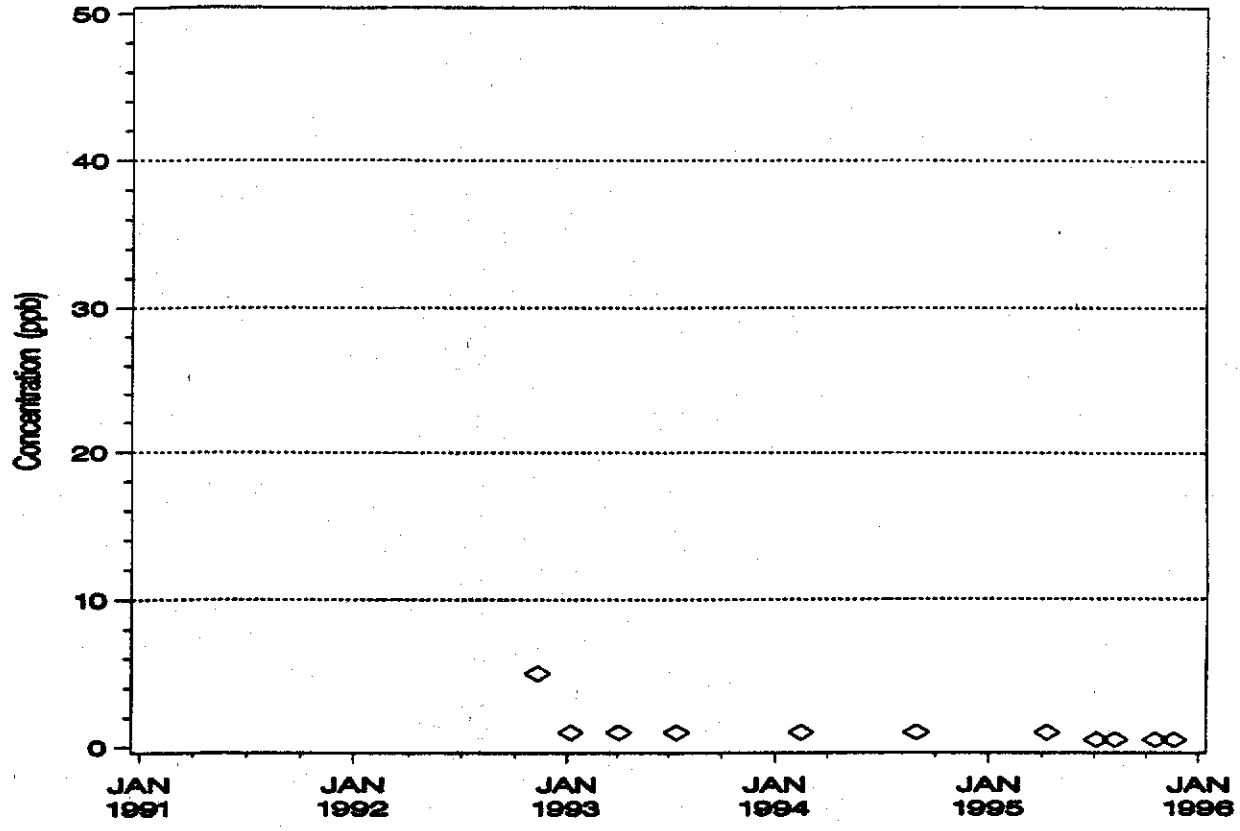
WELL 1525
TRICHLOROETHYLENE Trend



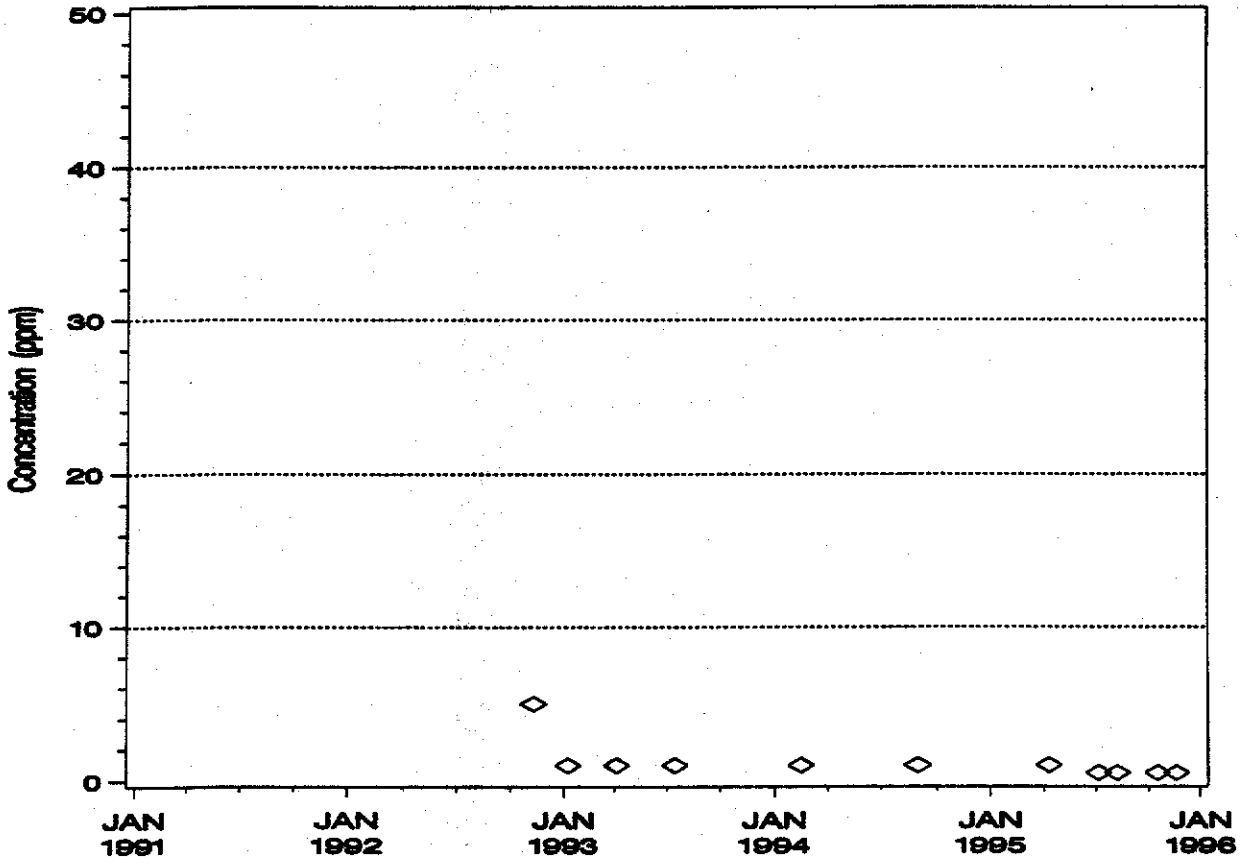
FREON 113 Trend



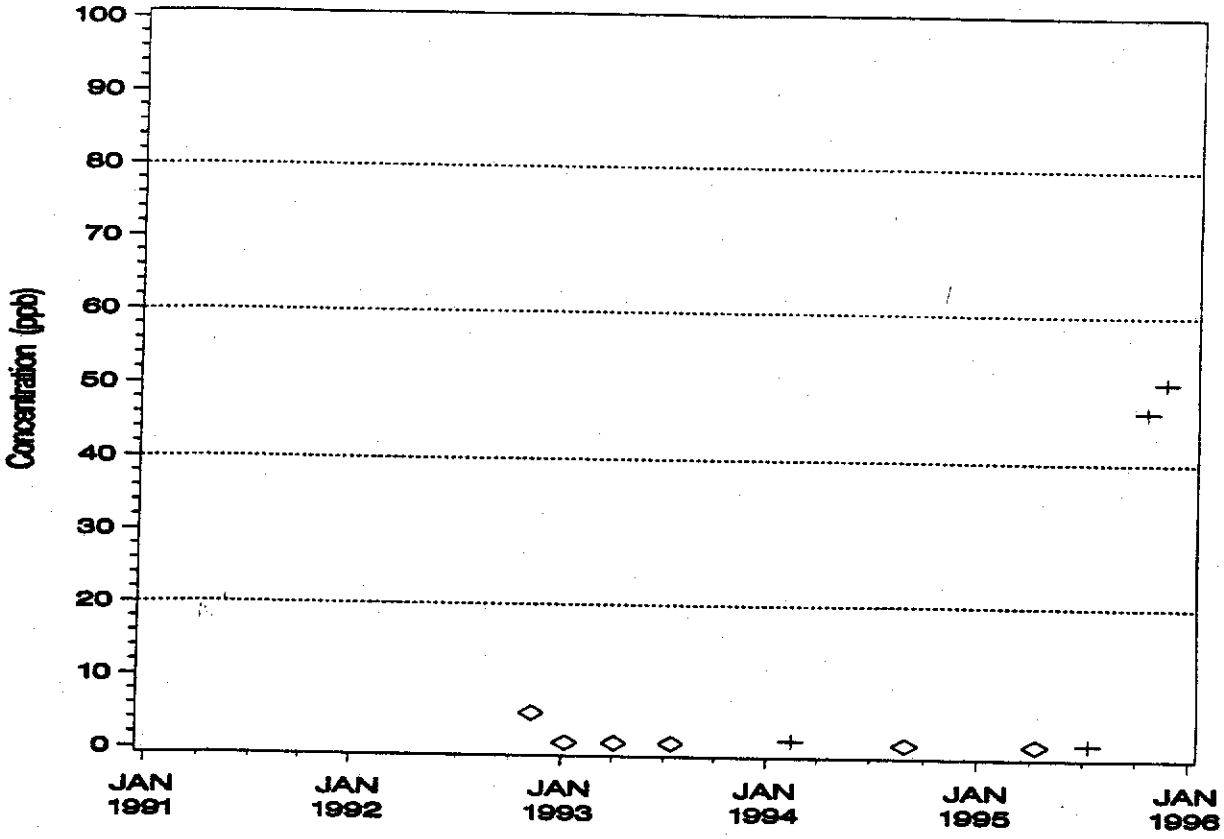
WELL 1525
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



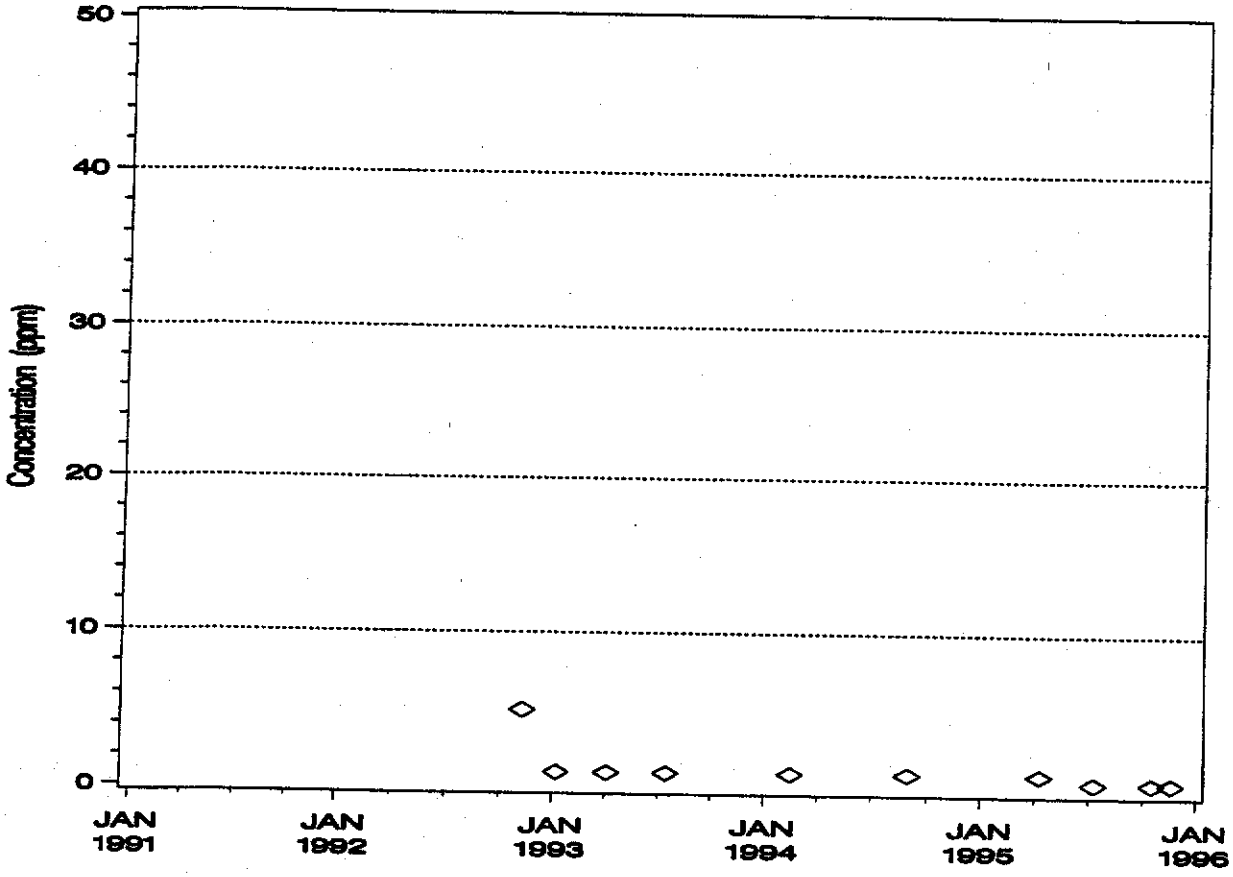
1,1 – DICHLOROETHYLENE Trend



WELL 1526
TRICHLOROETHYLENE Trend

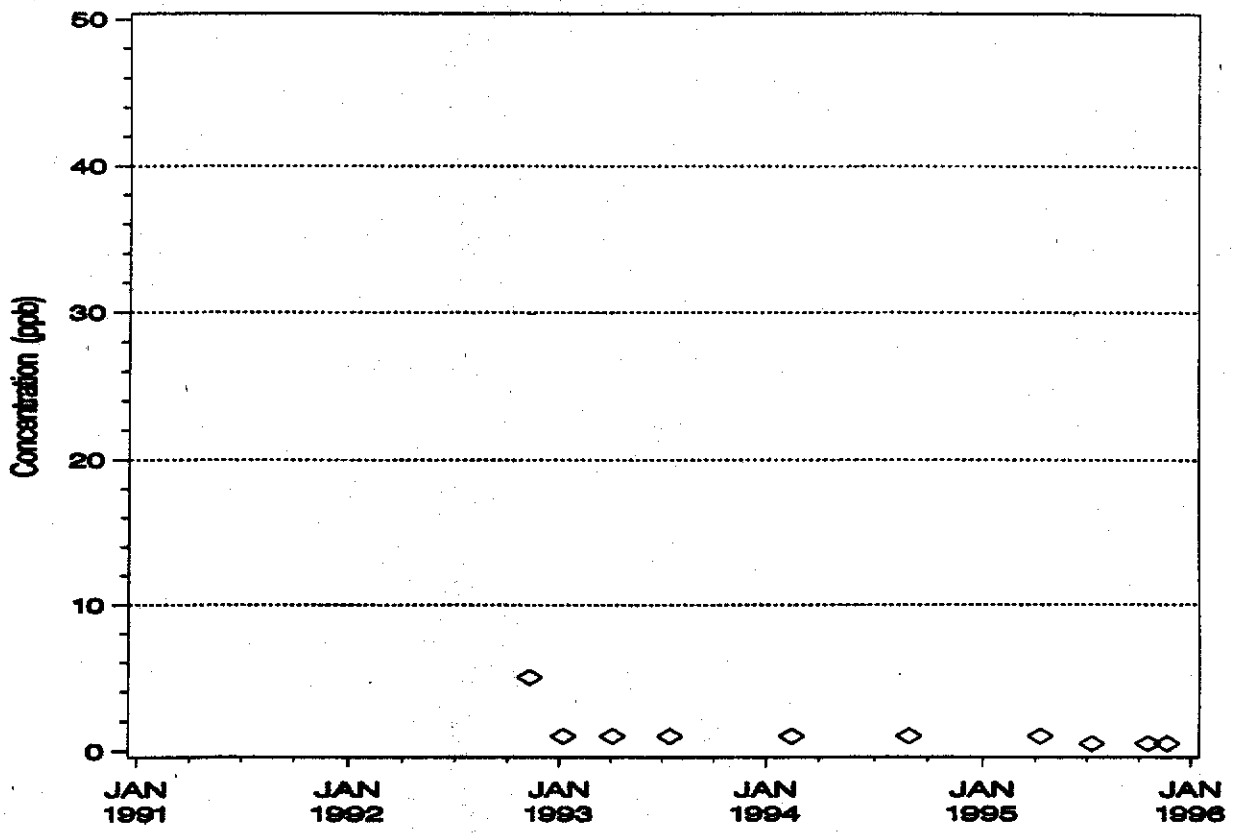


FREON 113 Trend

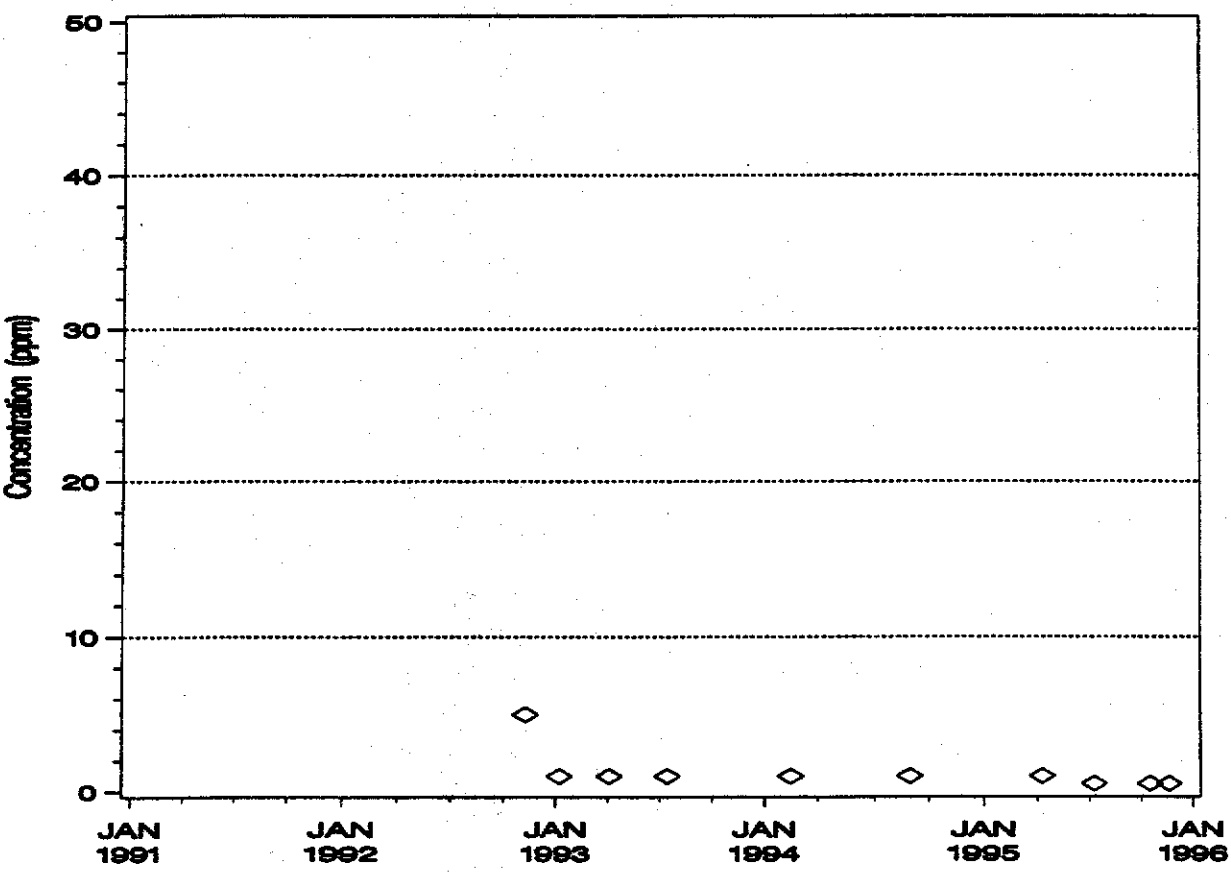


WELL 1526

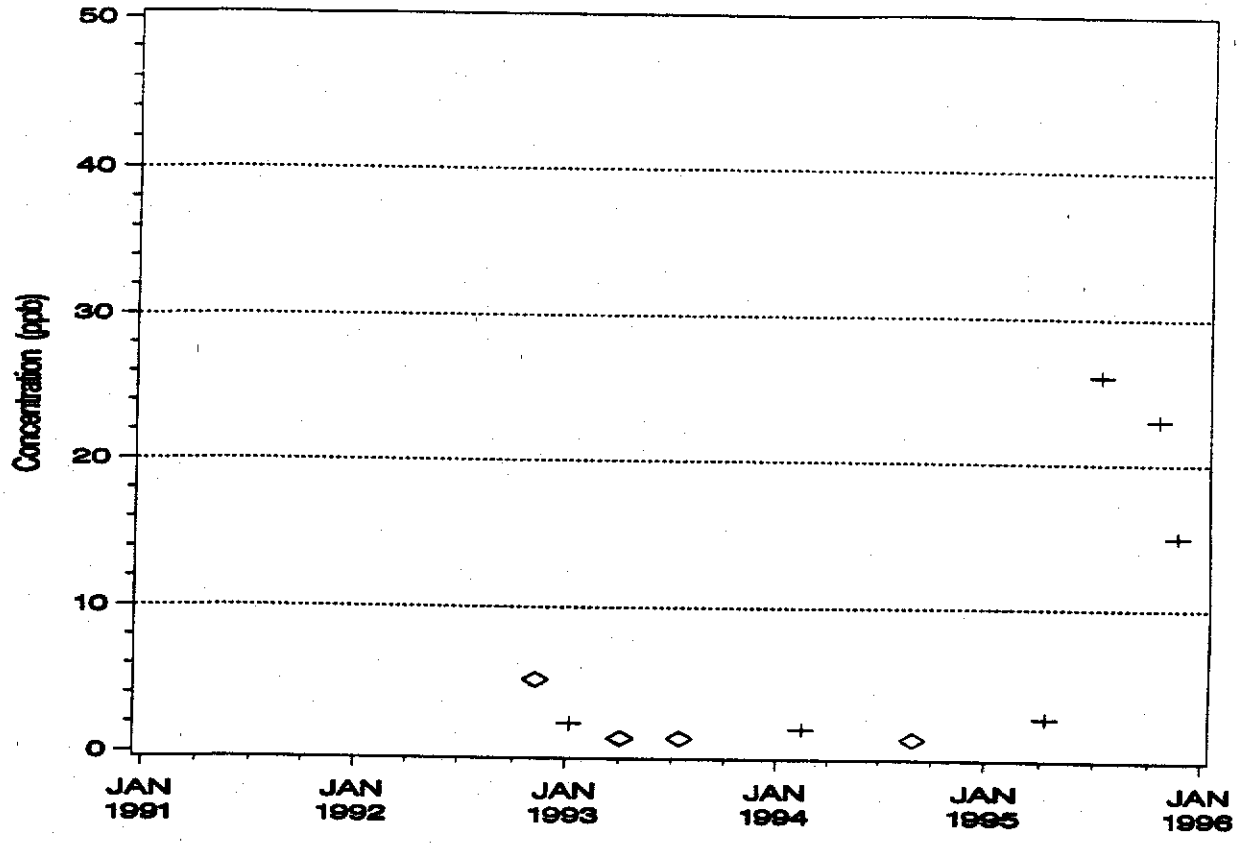
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



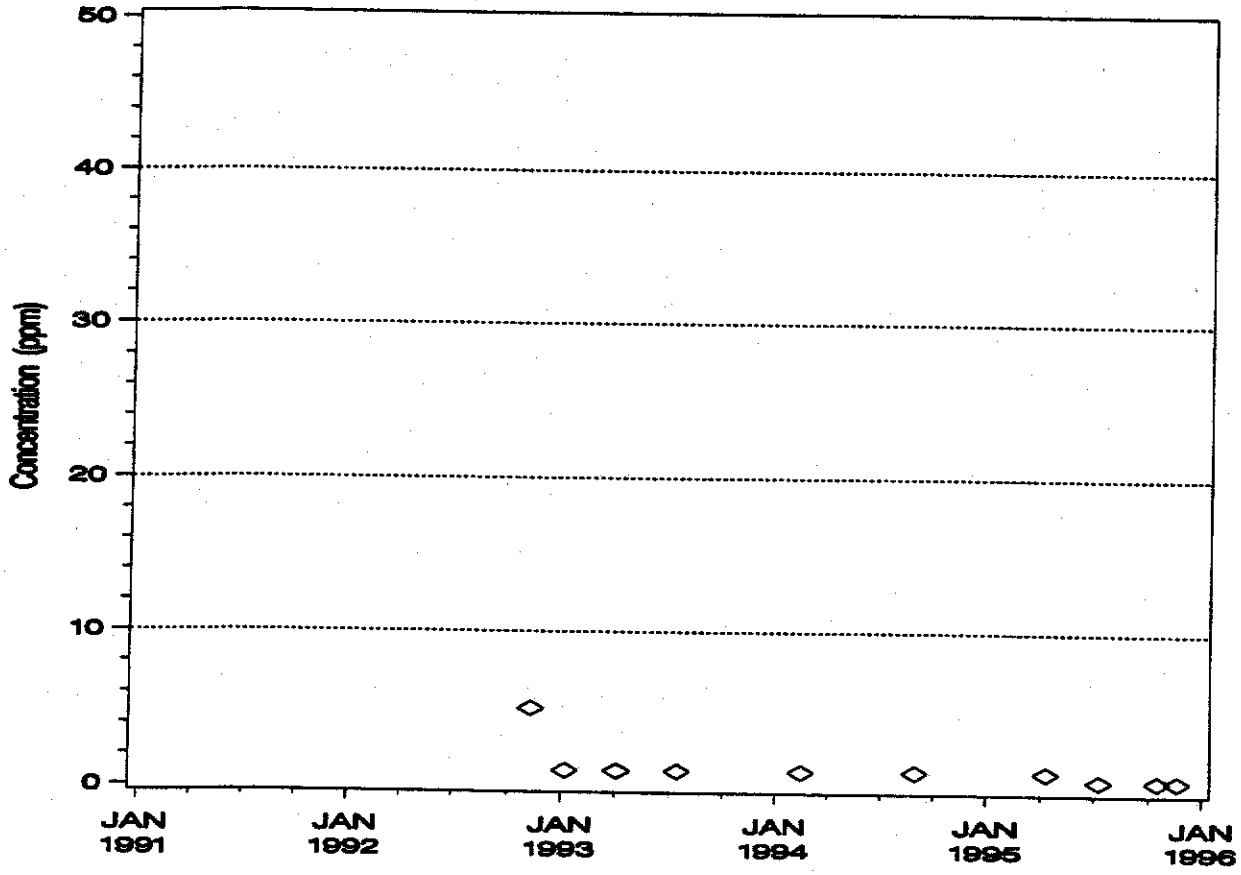
1,1 — DICHLOROETHYLENE Trend



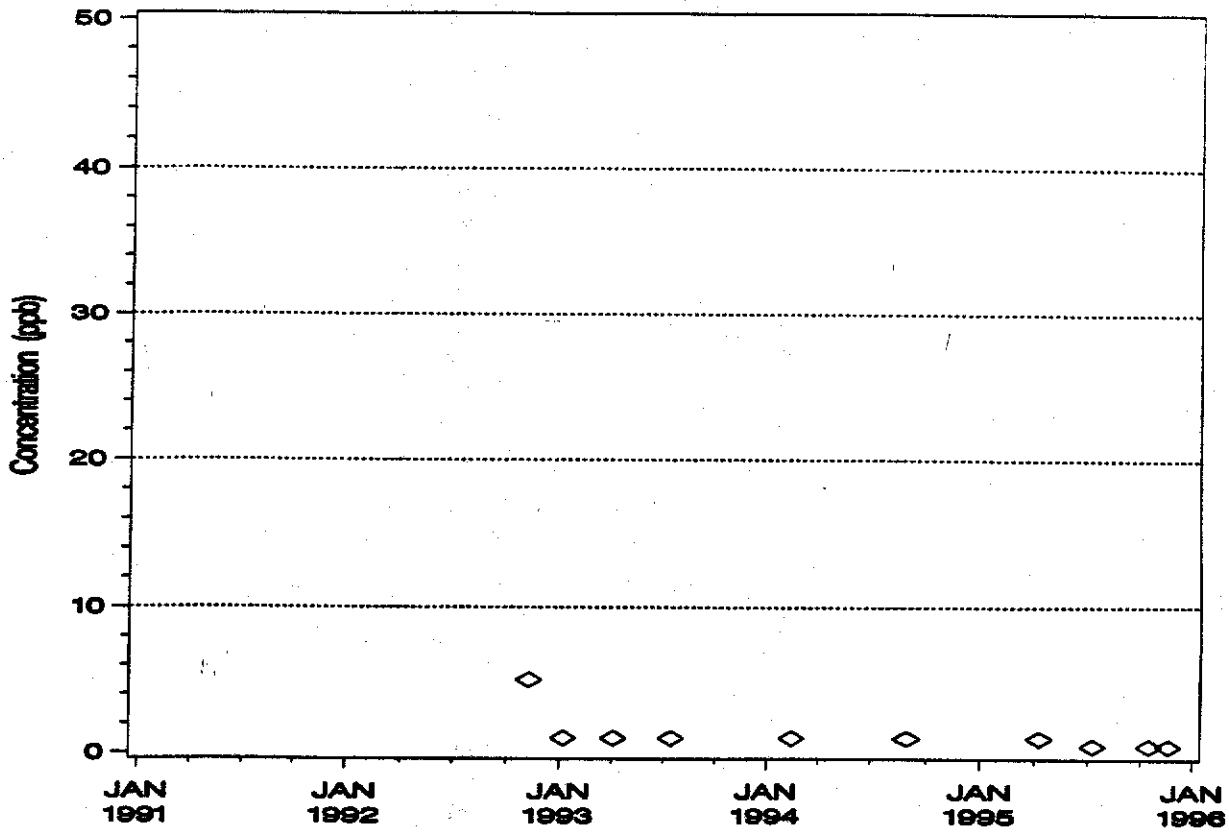
WELL 1527
TRICHLOROETHYLENE Trend



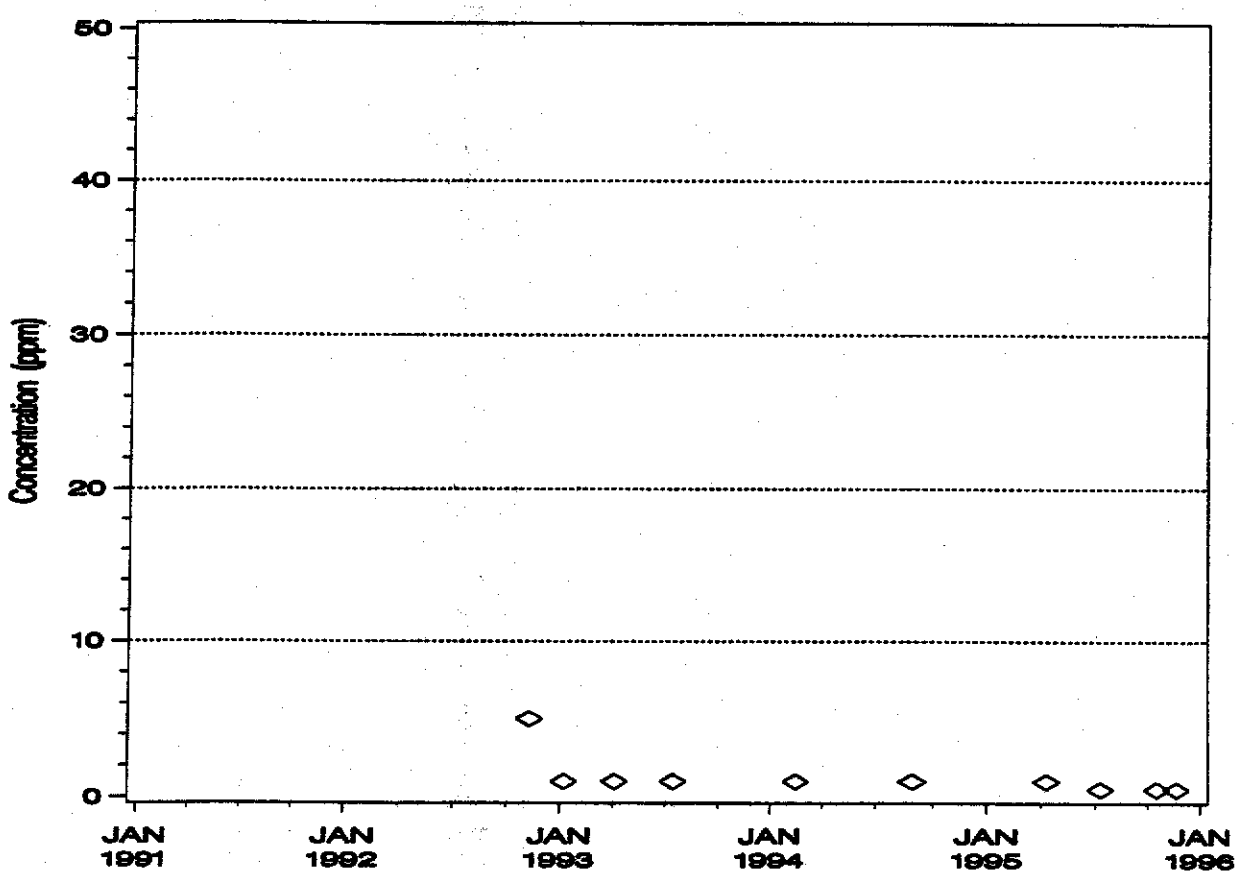
FREON 113 Trend



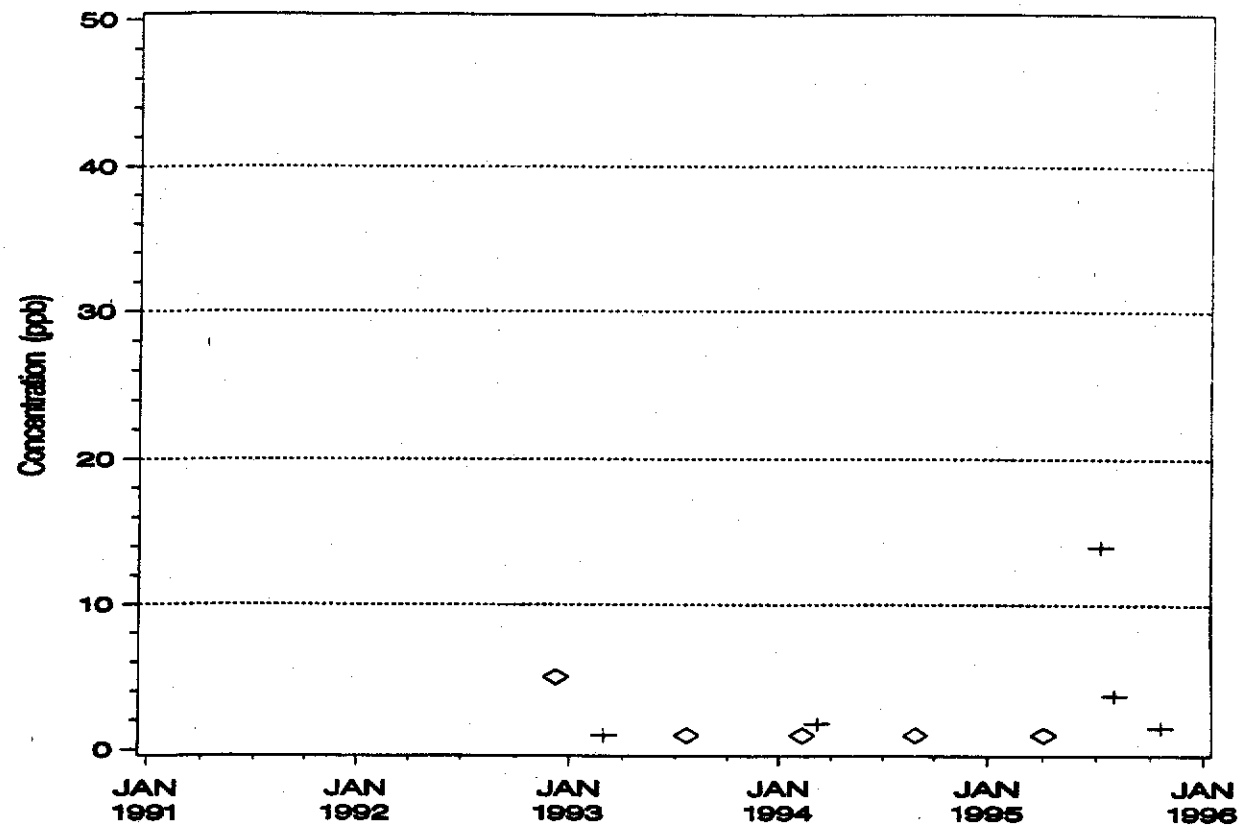
WELL 1527
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



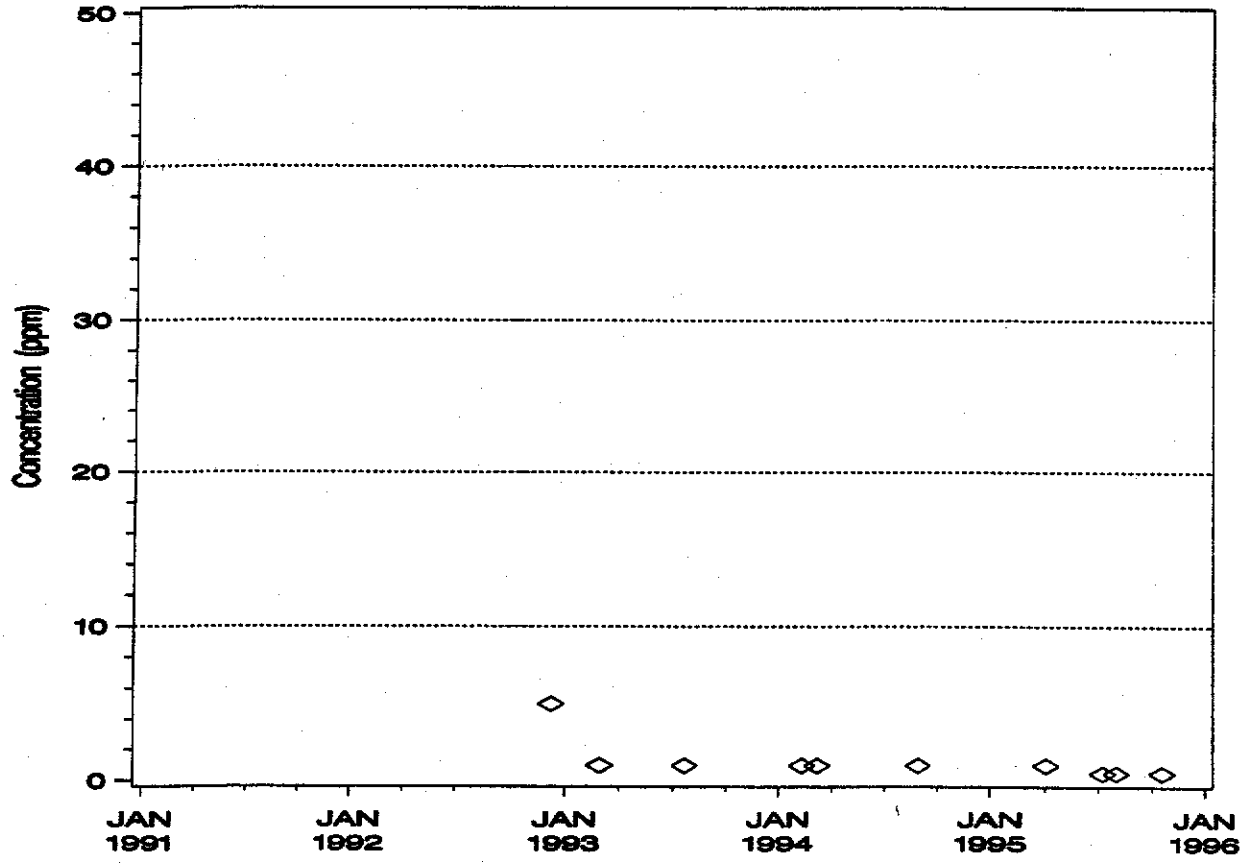
1,1 – DICHLOROETHYLENE Trend



WELL 1528
TRICHLOROETHYLENE Trend

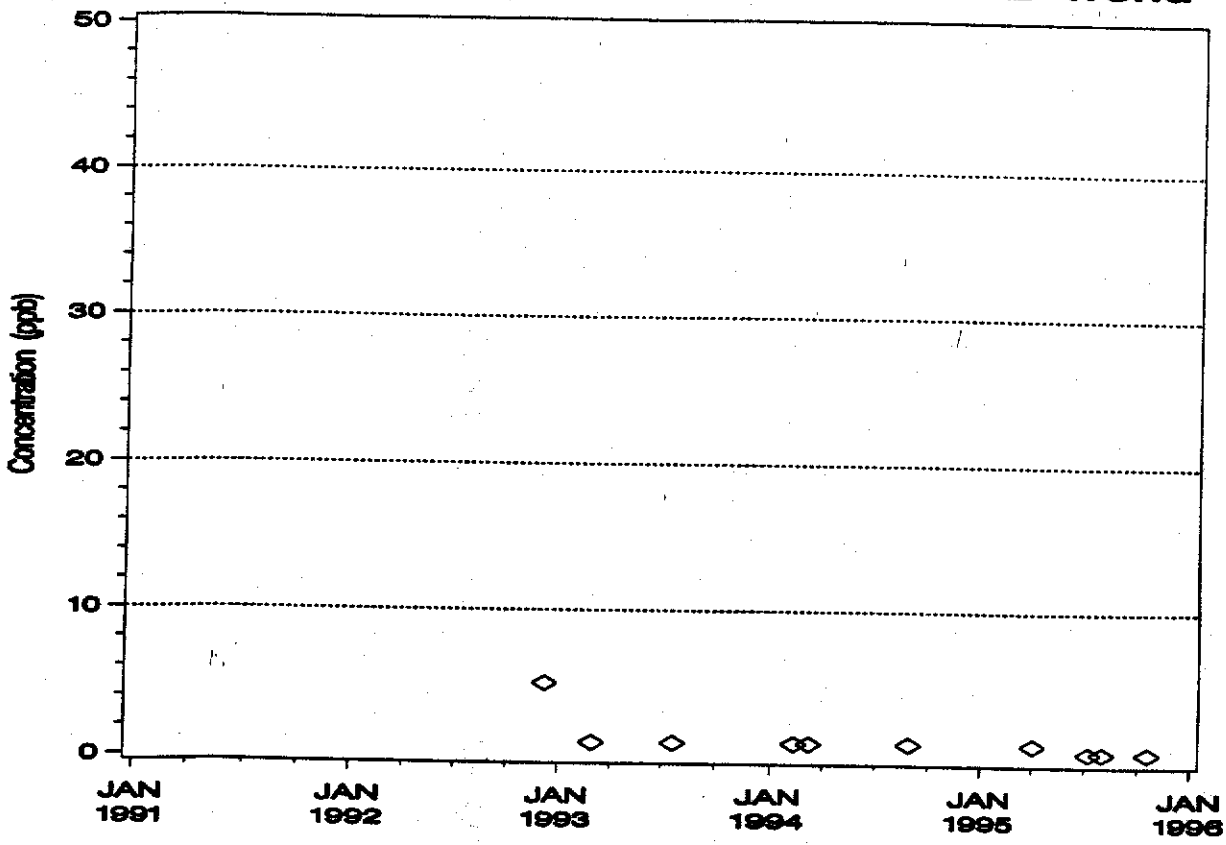


FREON 113 Trend

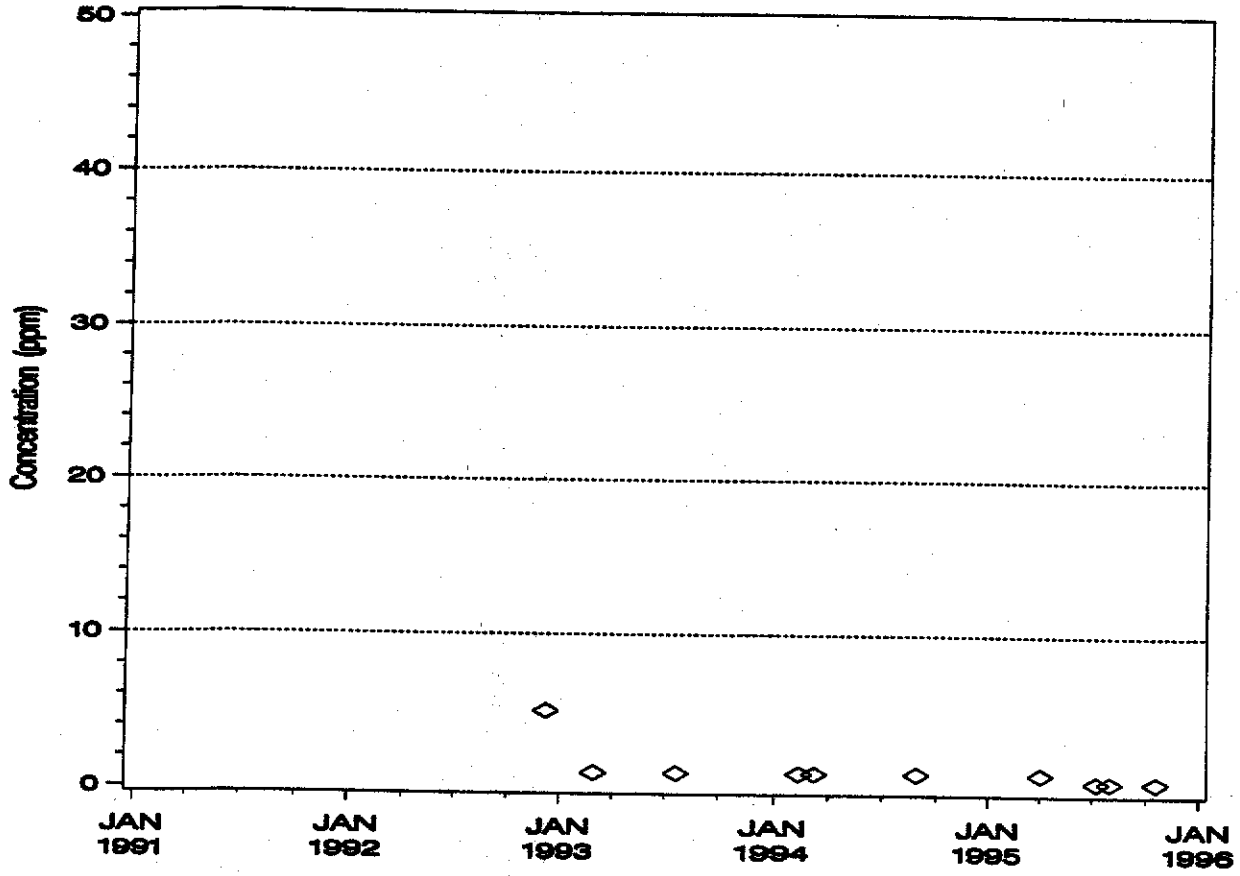


WELL 1528

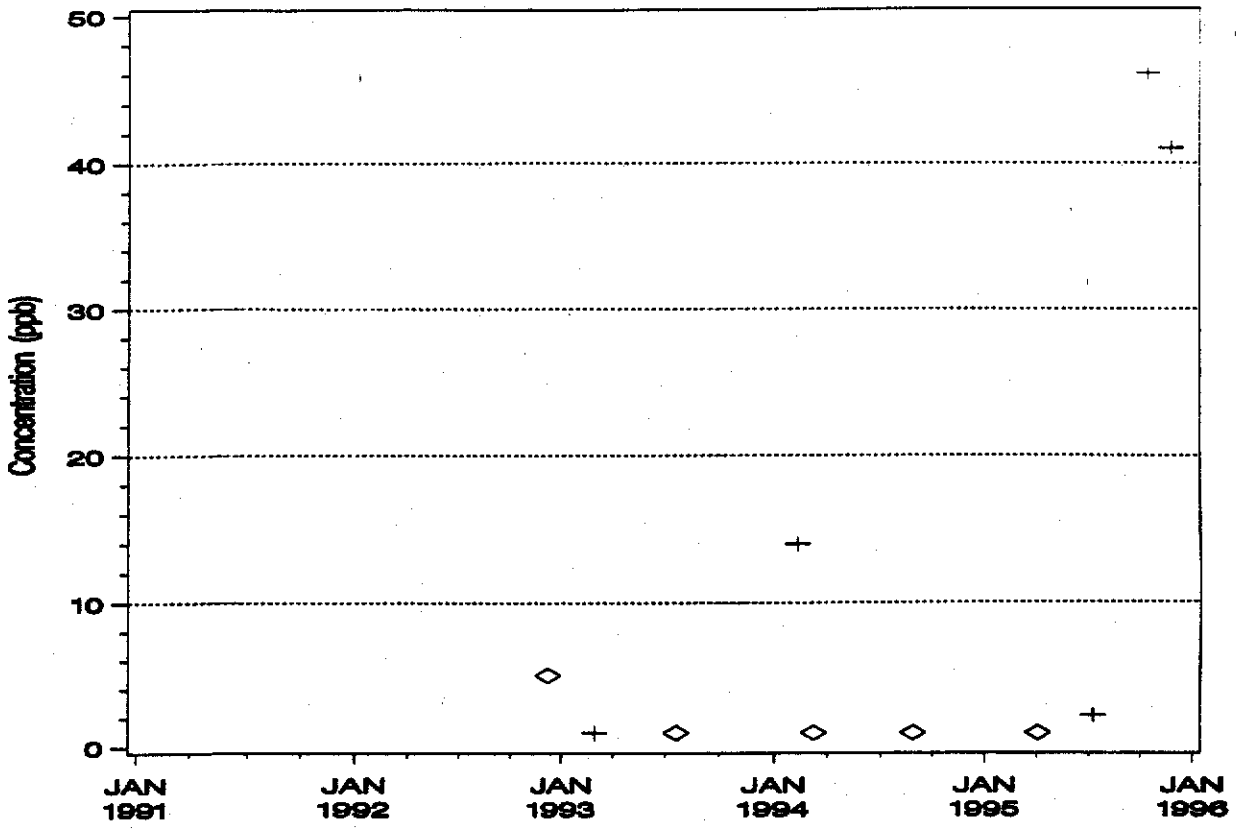
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



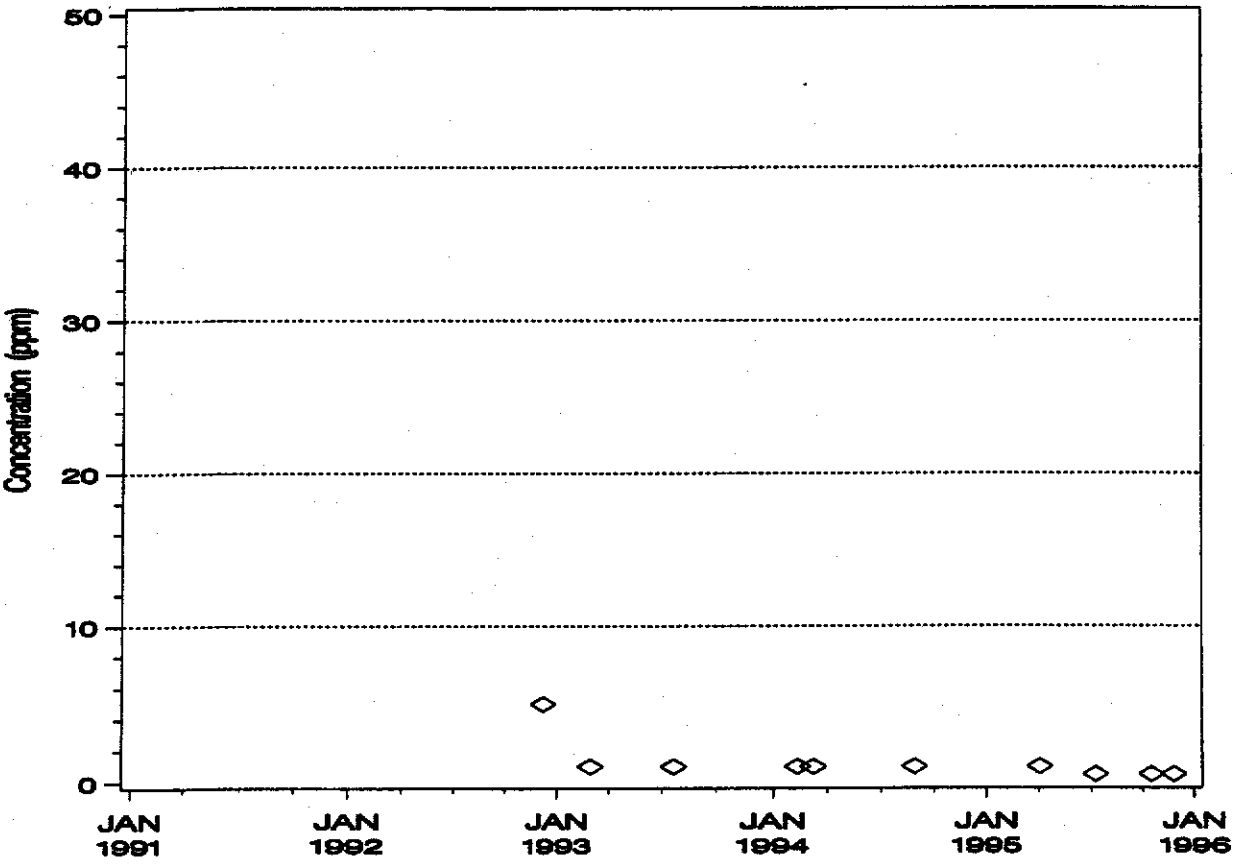
1,1 – DICHLOROETHYLENE Trend



WELL 1529
TRICHLOROETHYLENE Trend

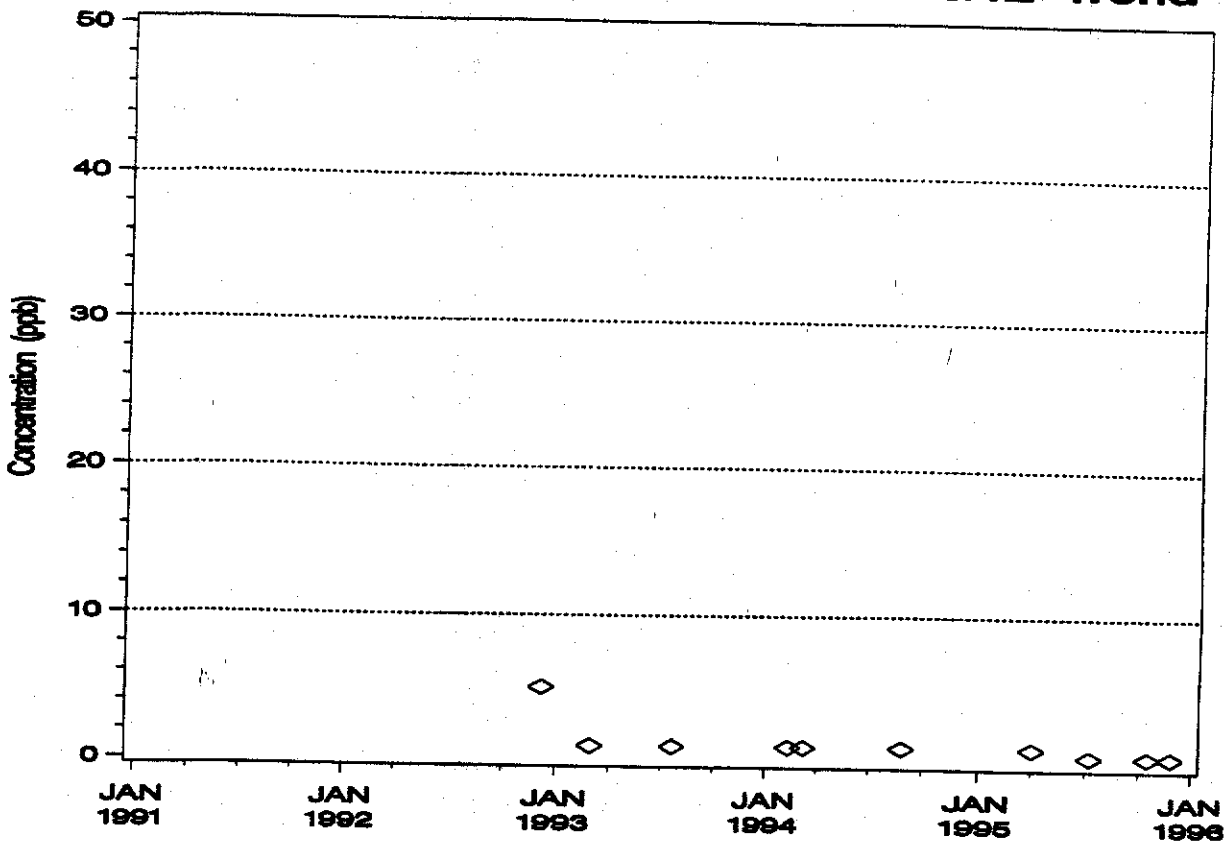


FREON 113 Trend

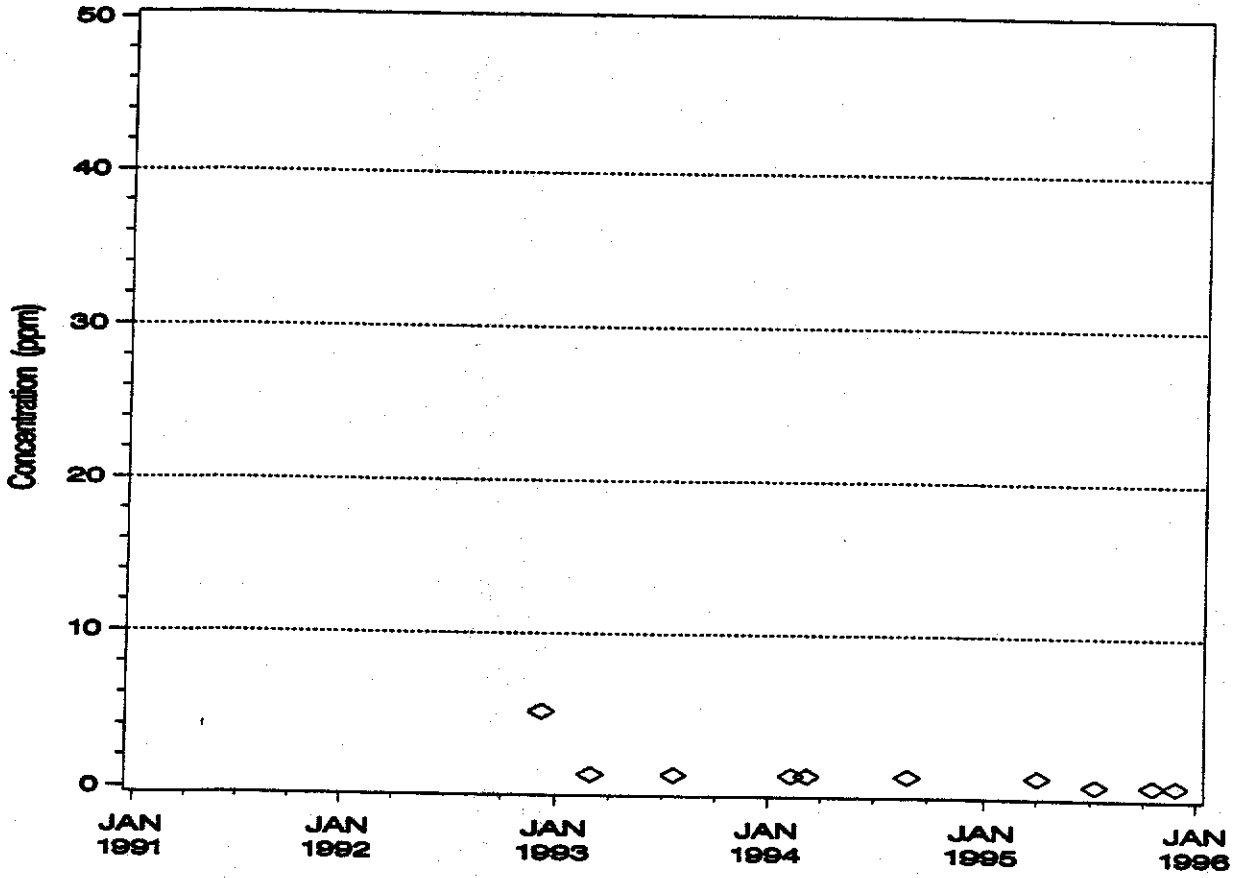


WELL 1529

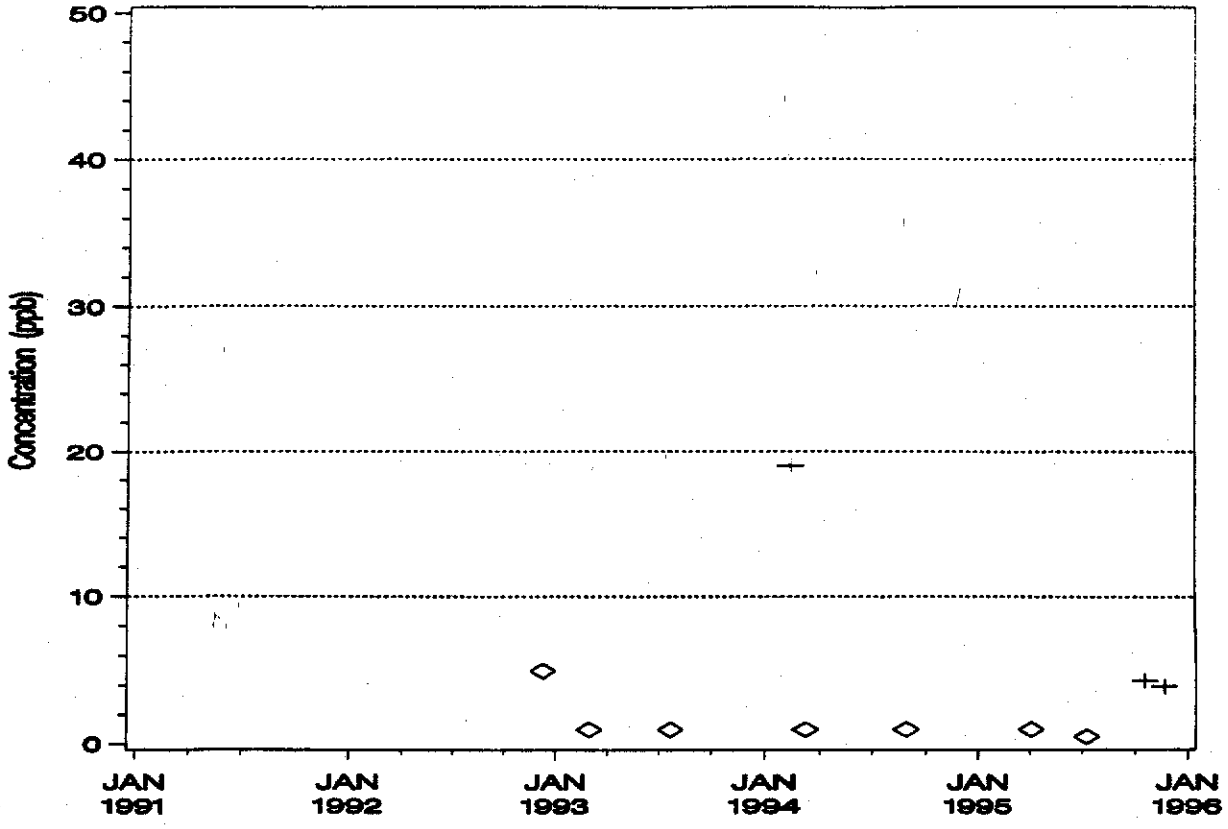
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



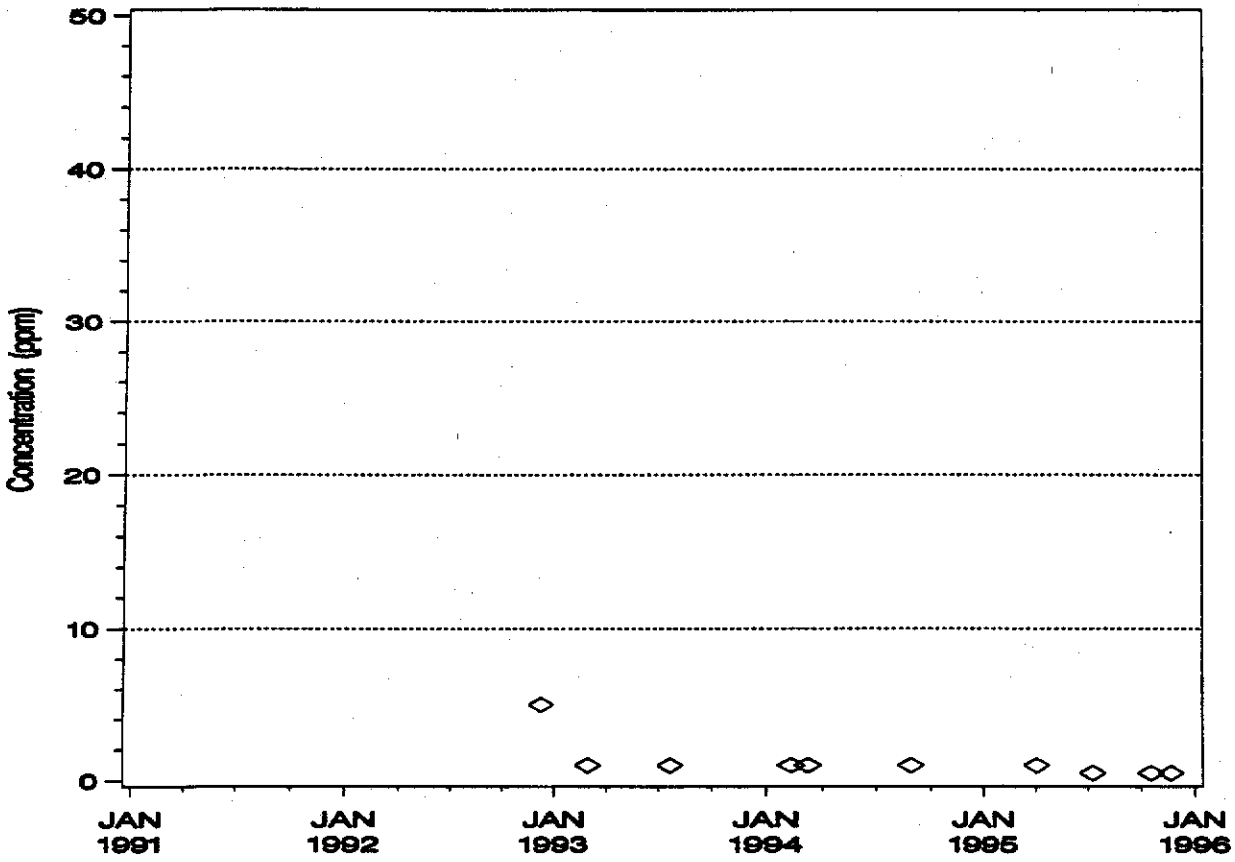
1,1 – DICHLOROETHYLENE Trend



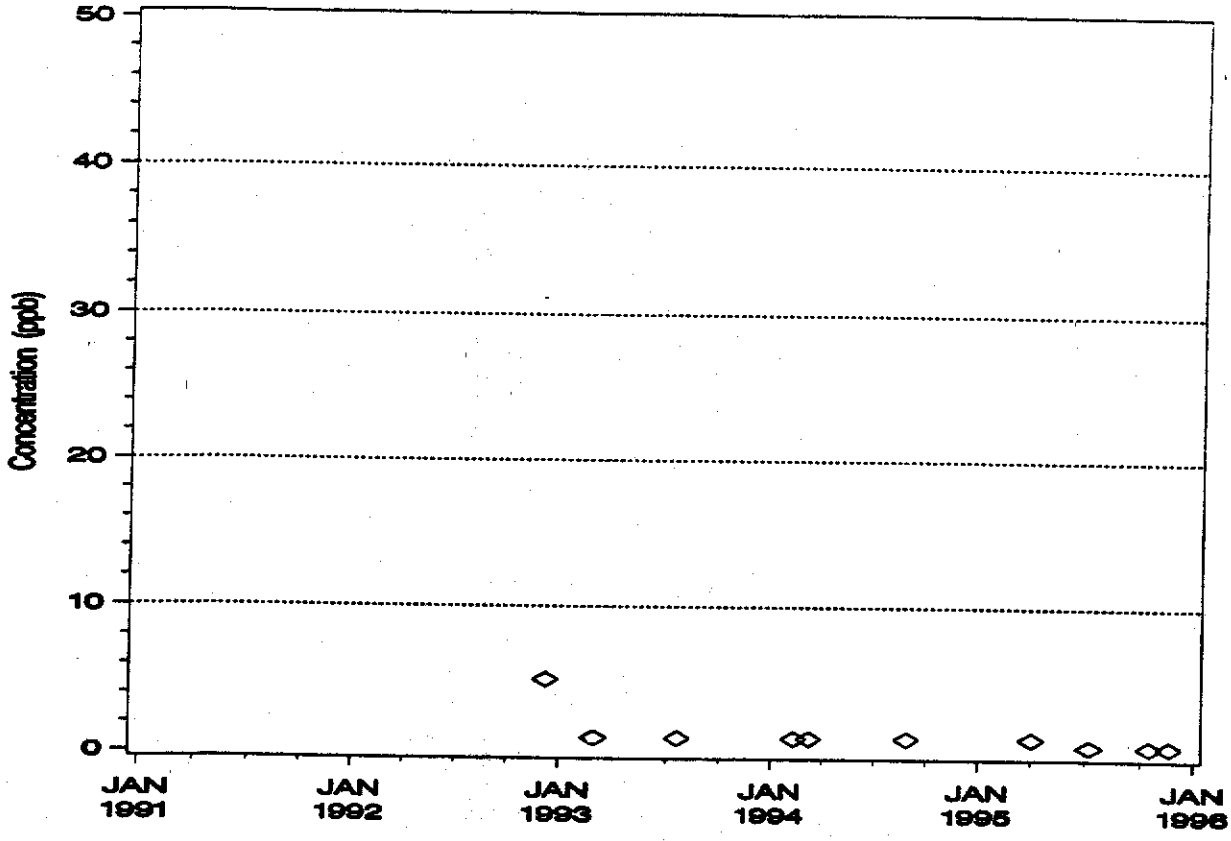
WELL 1530
TRICHLOROETHYLENE Trend



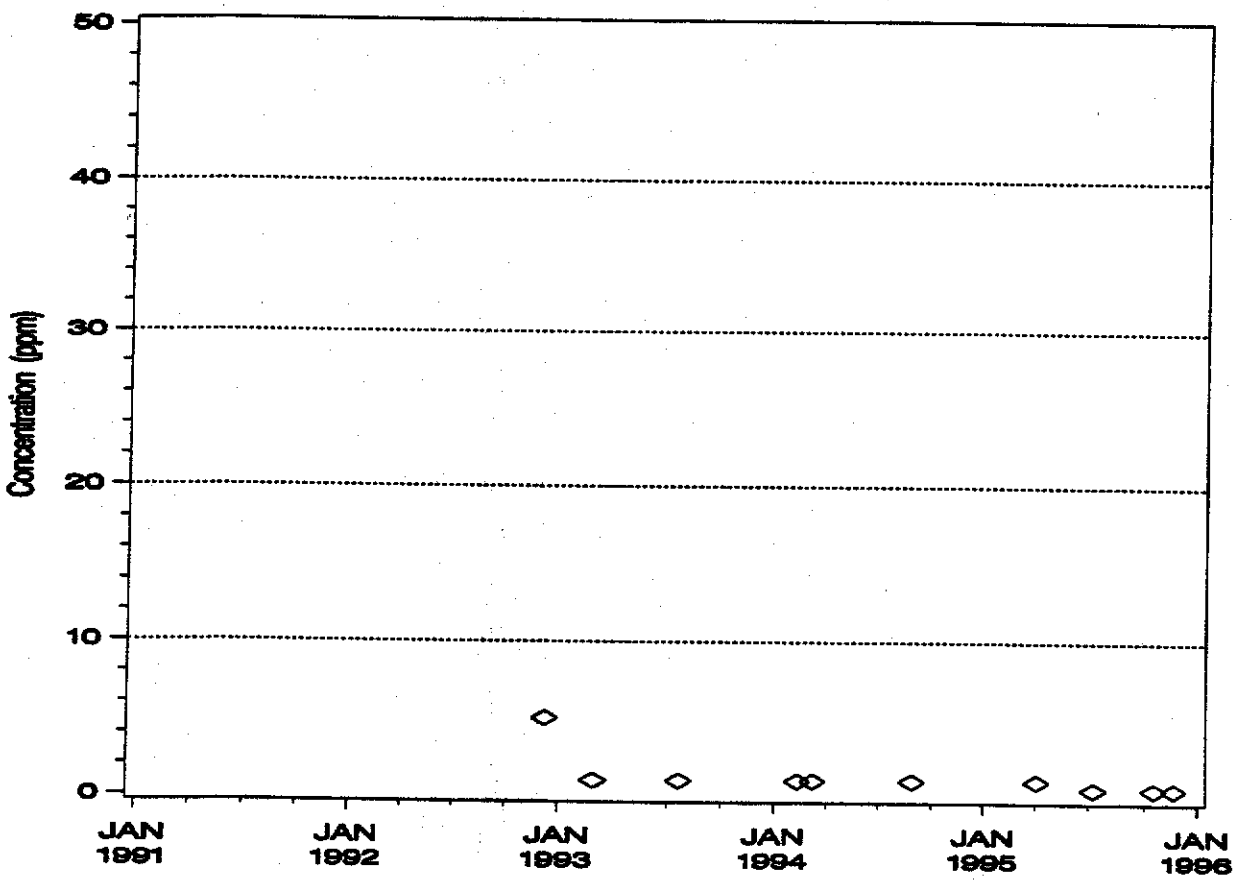
FREON 113 Trend



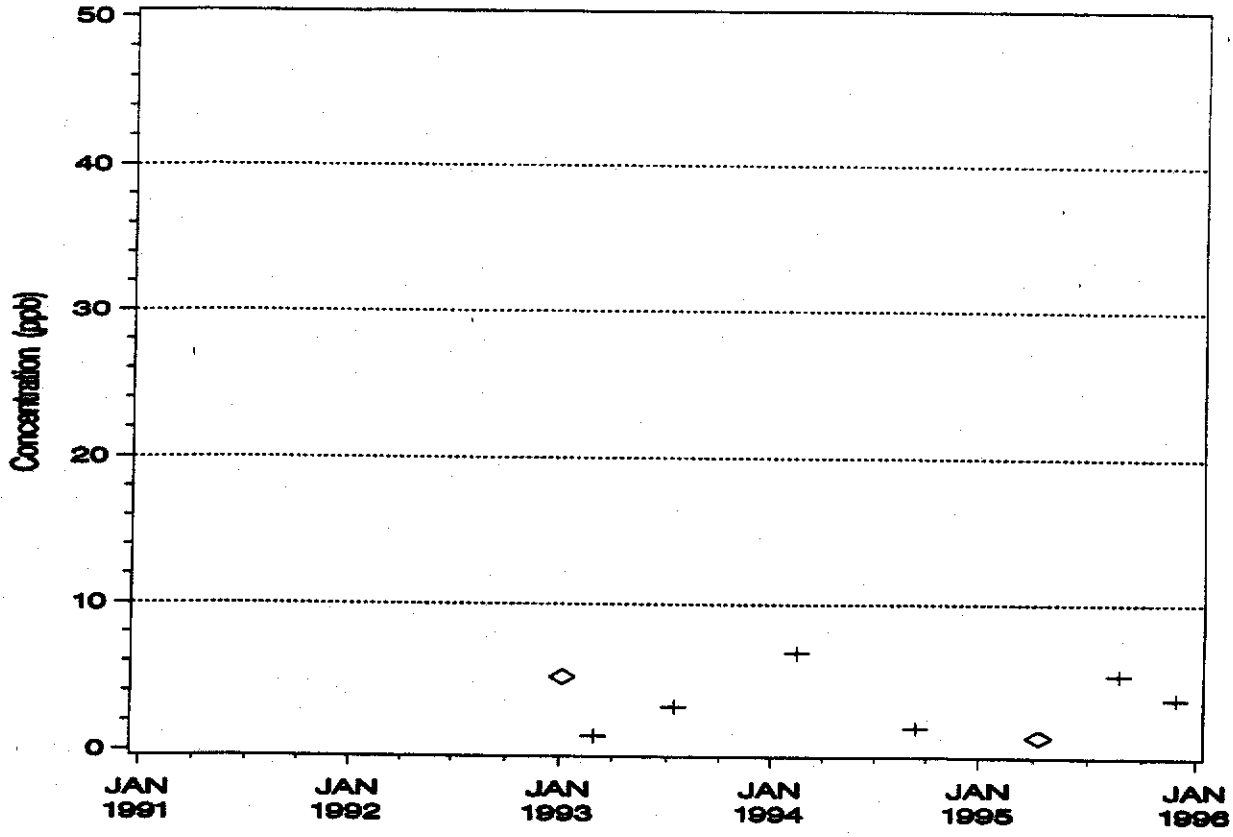
WELL 1530
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



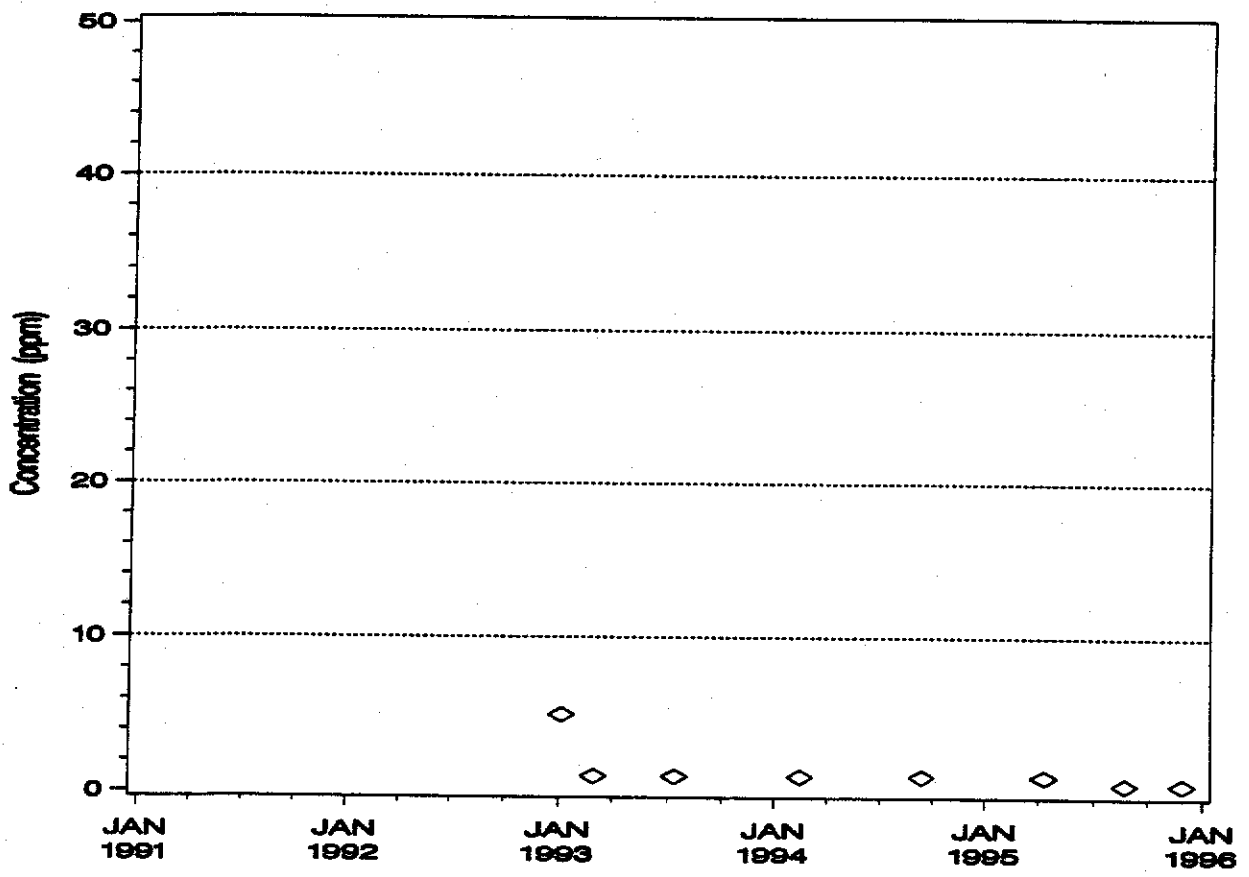
1,1 – DICHLOROETHYLENE Trend



WELL 1531
TRICHLOROETHYLENE Trend

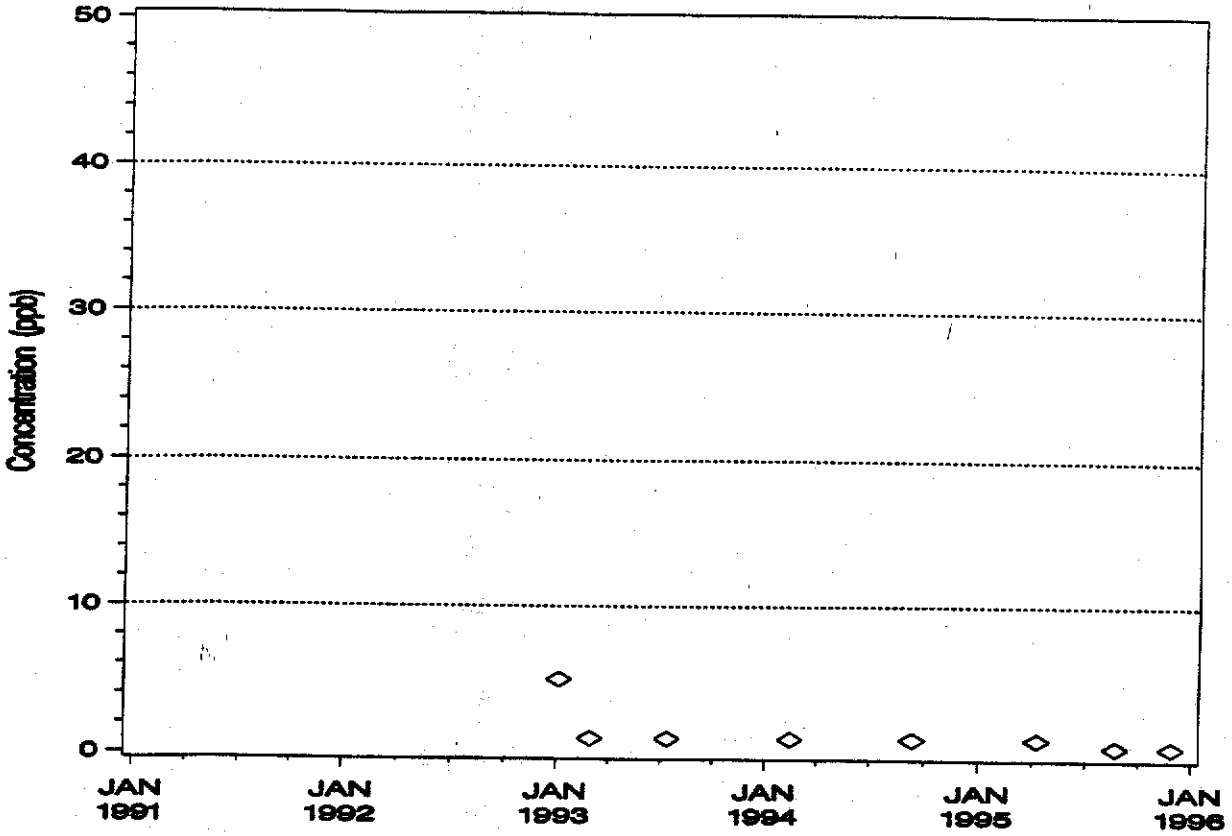


FREON 113 Trend

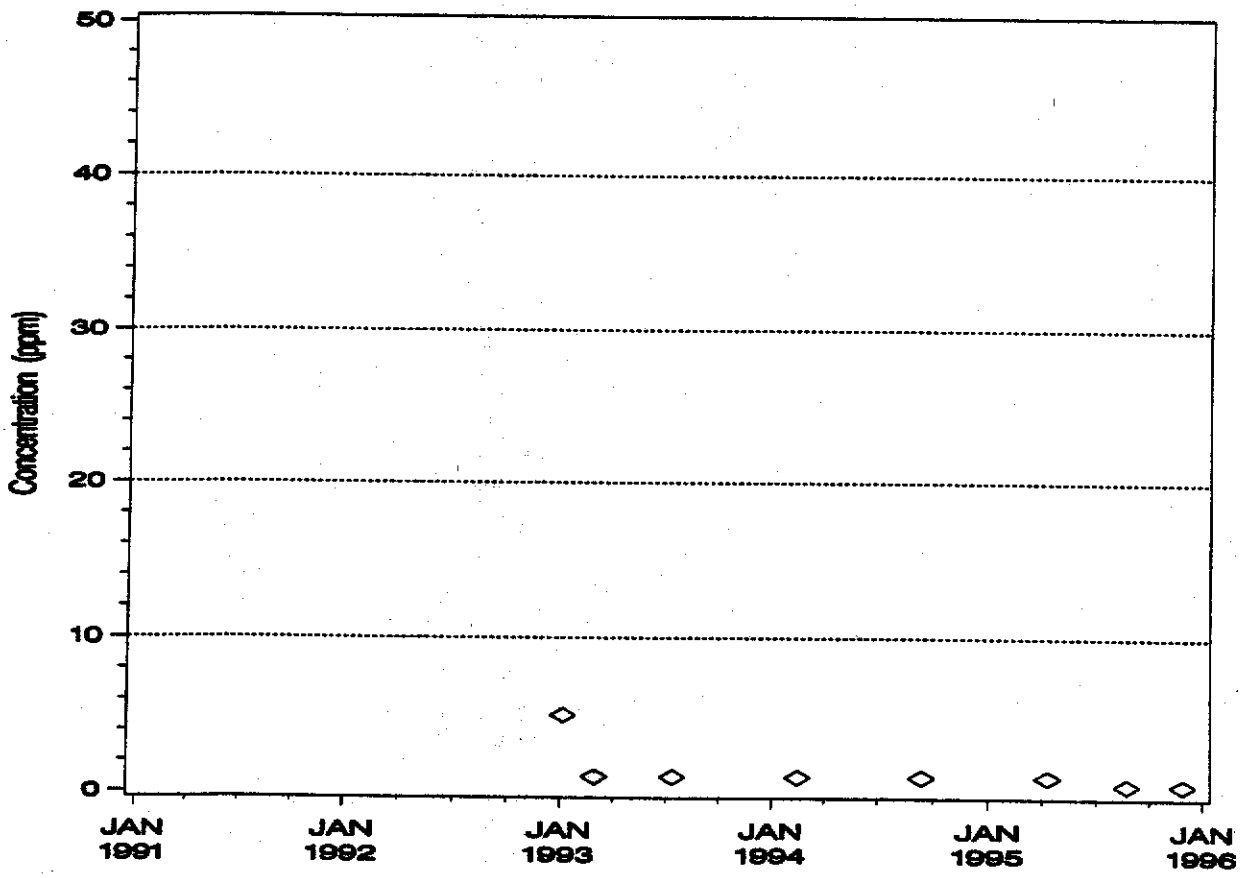


WELL 1531

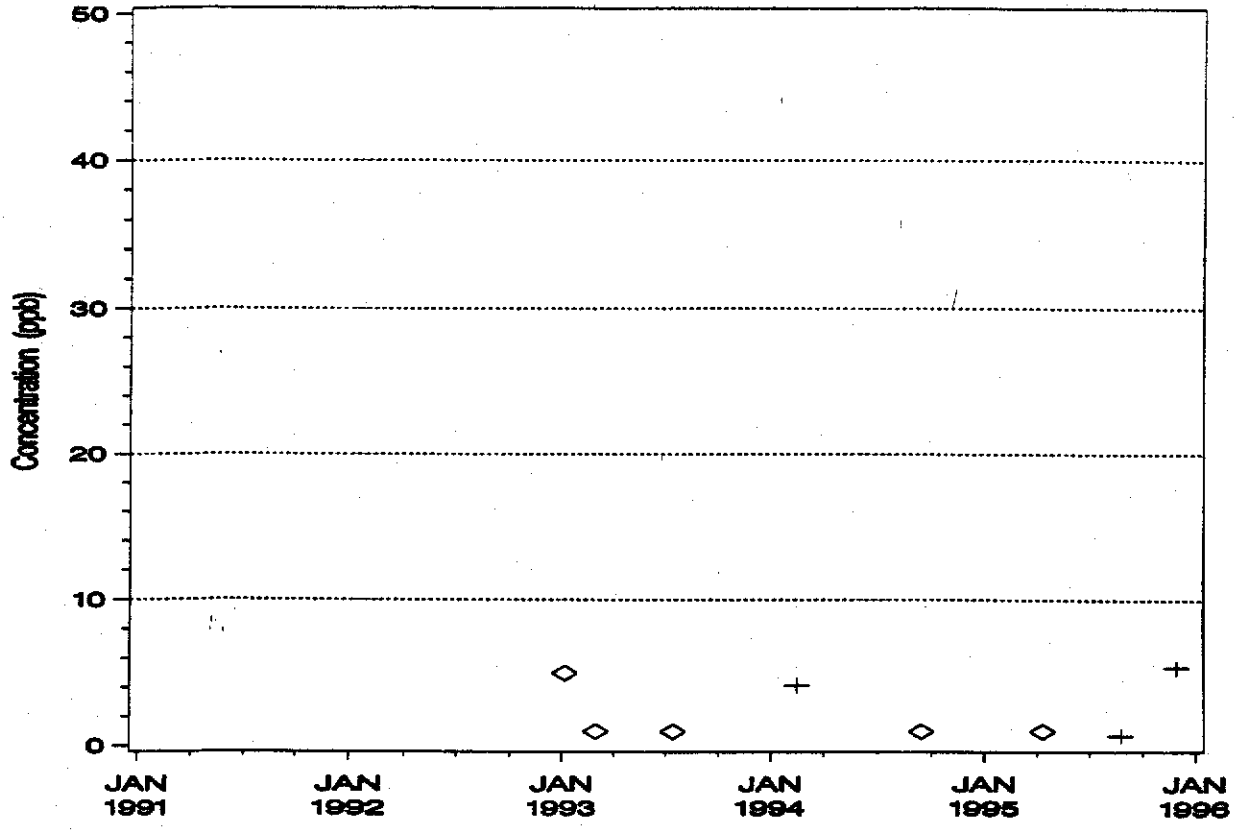
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



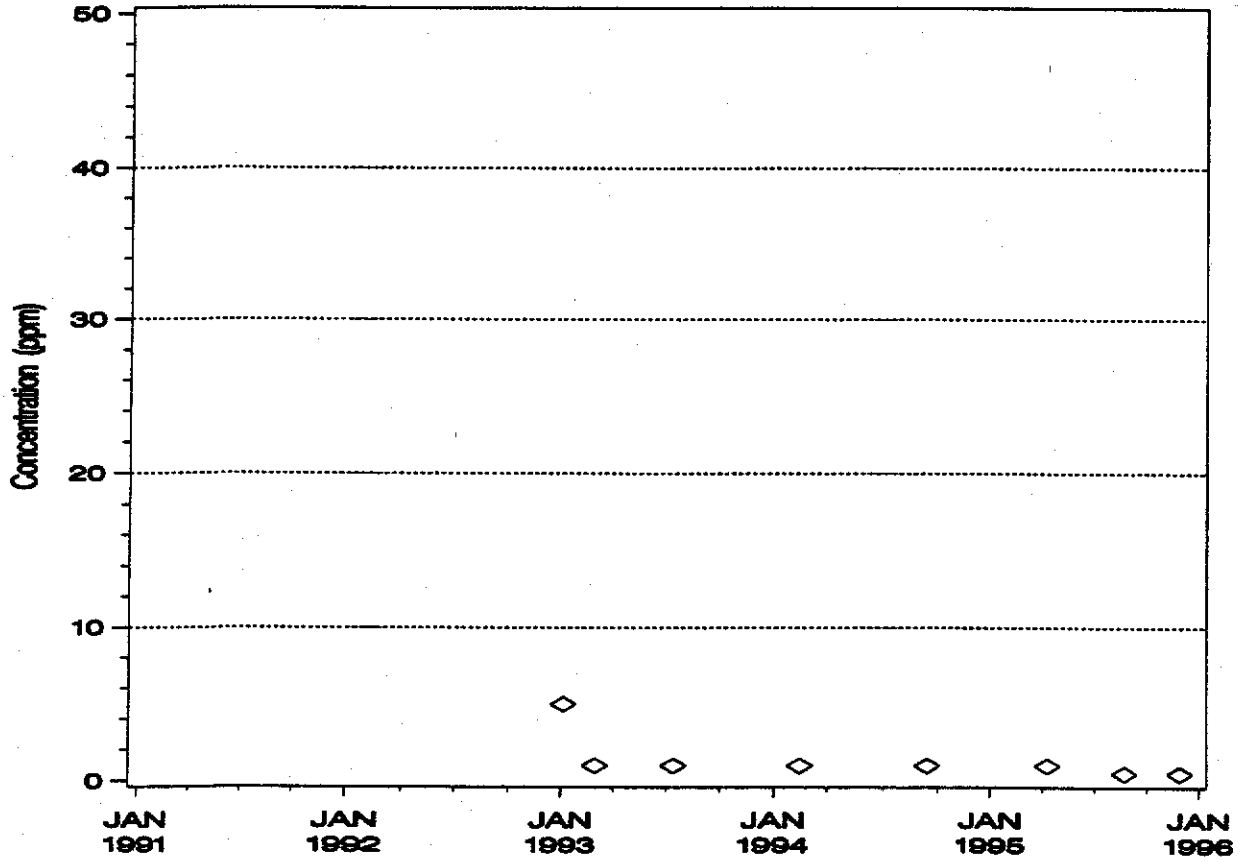
1,1 – DICHLOROETHYLENE Trend



WELL 1532
TRICHLOROETHYLENE Trend

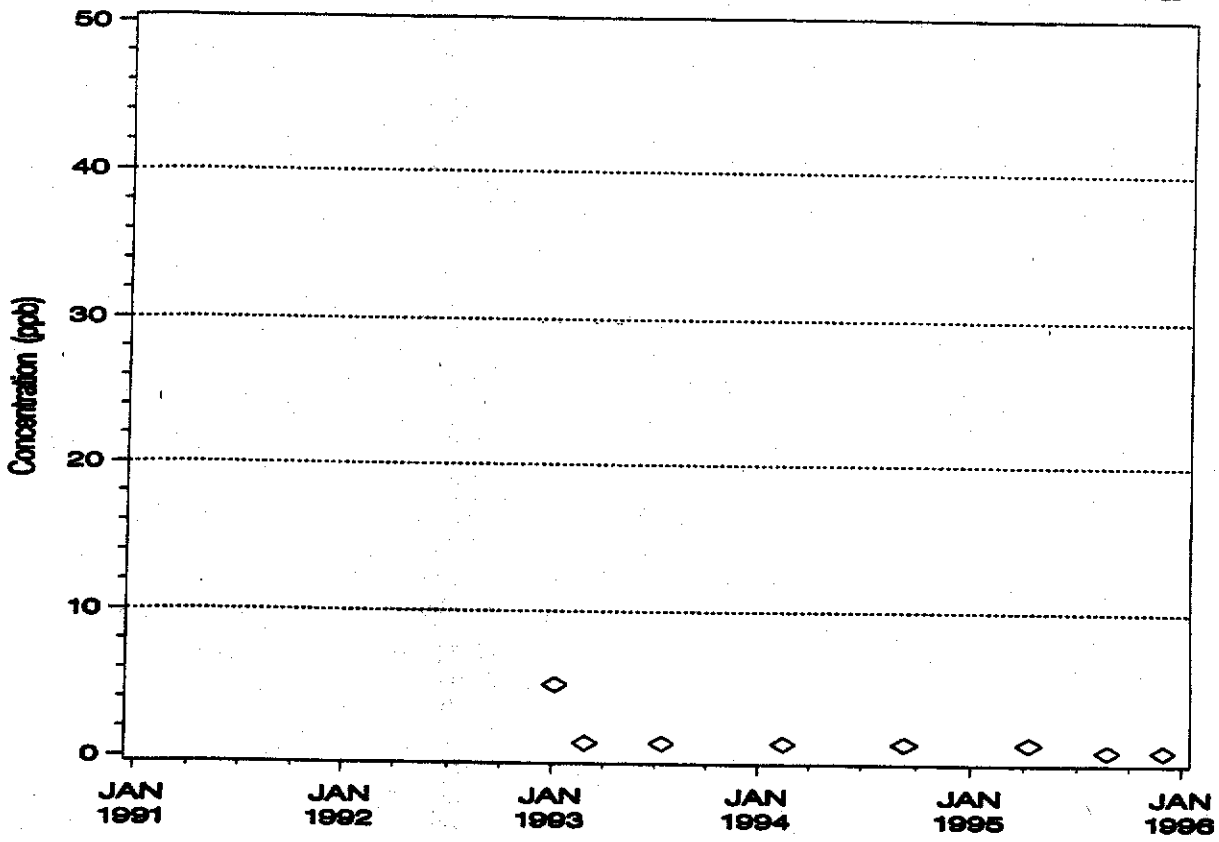


FREON 113 Trend

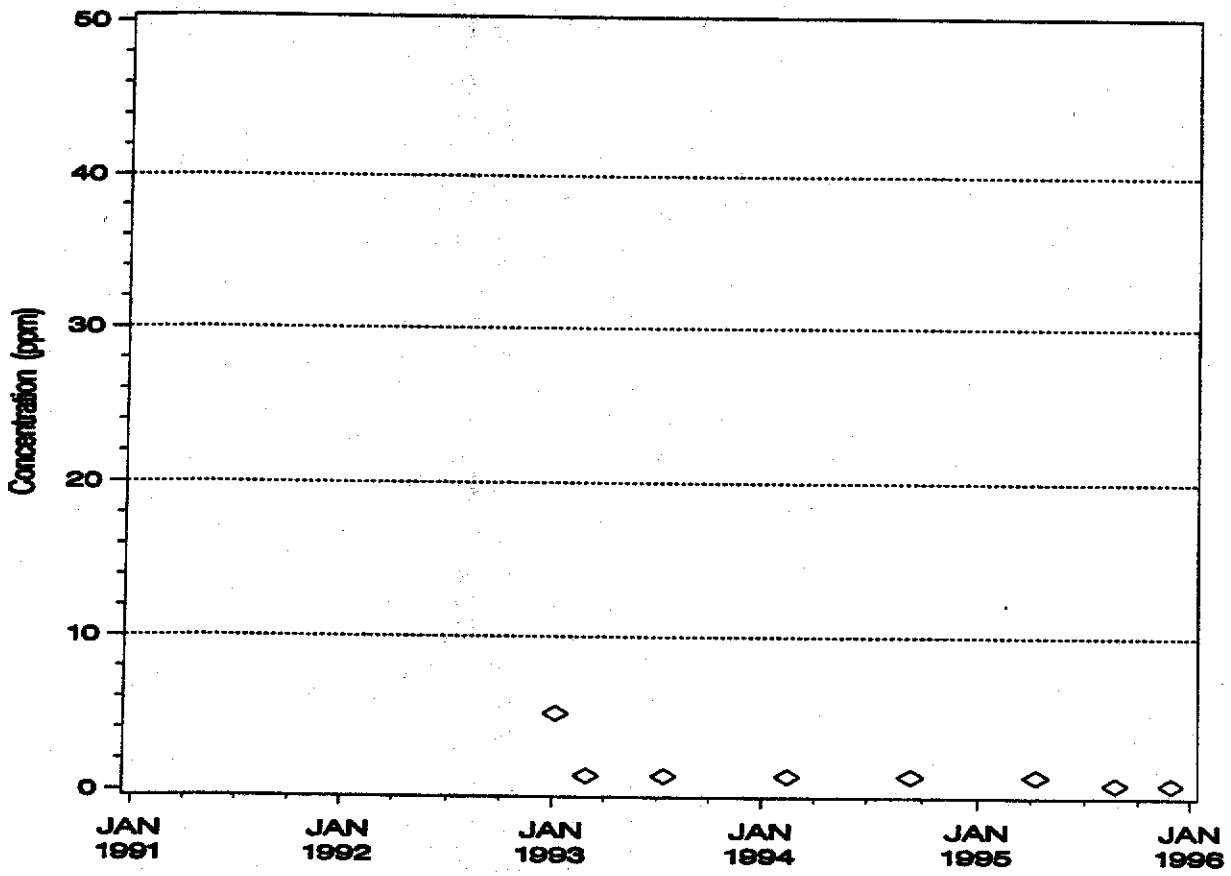


WELL 1532

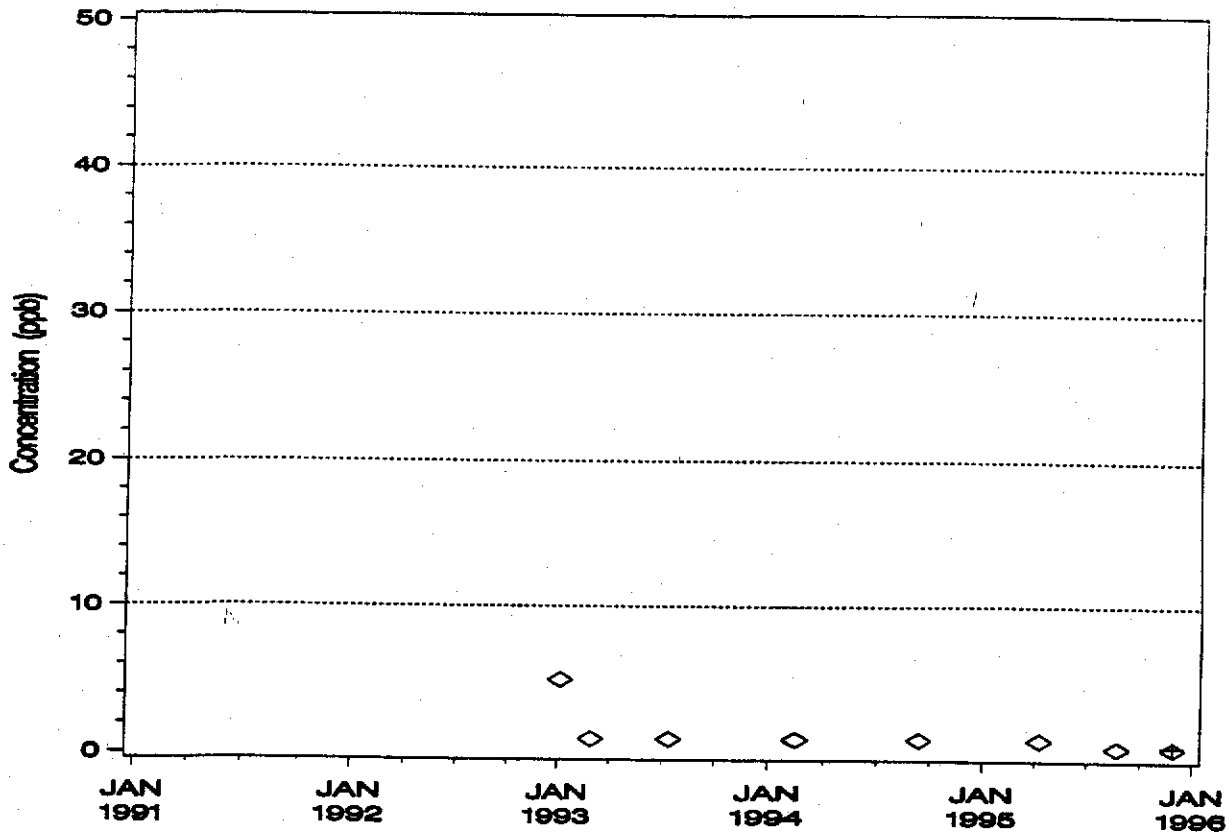
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



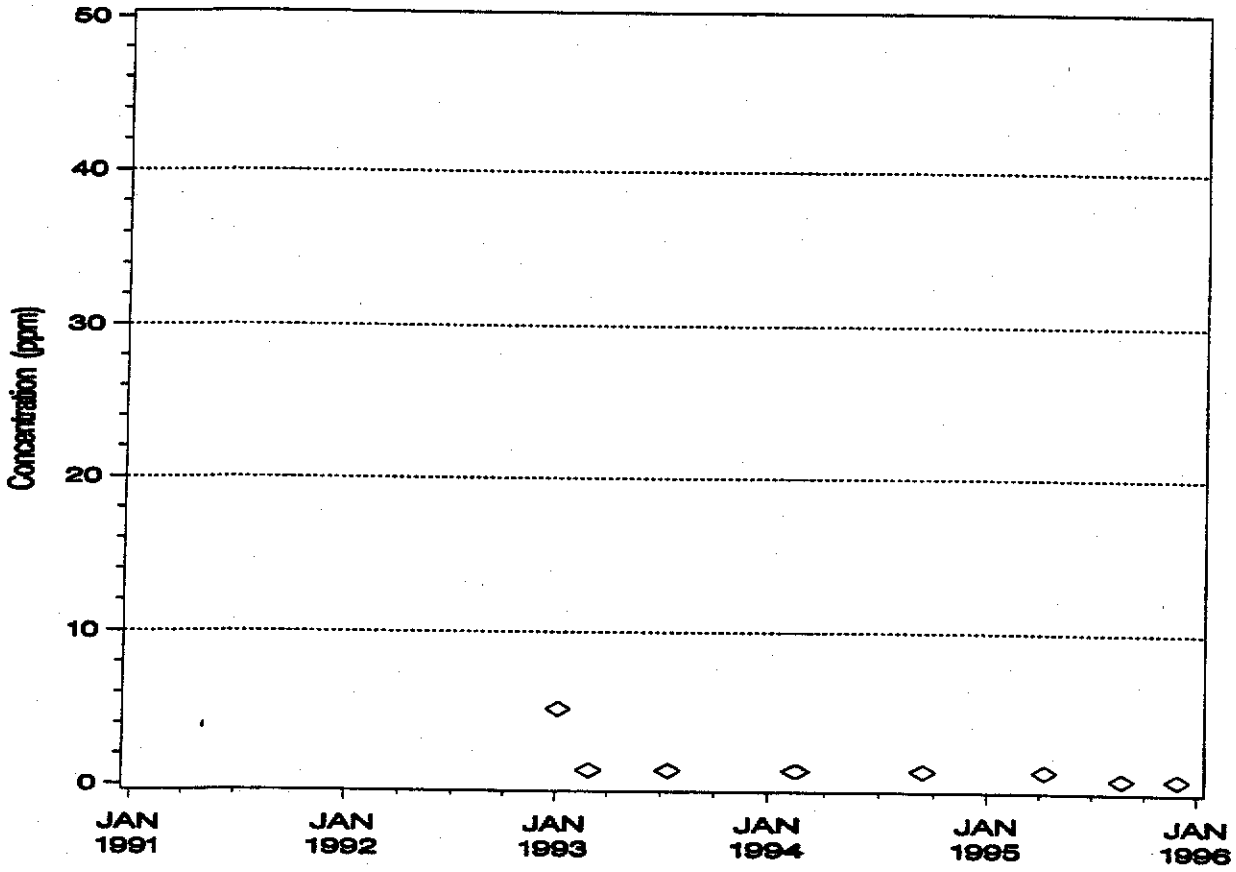
1,1 – DICHLOROETHYLENE Trend



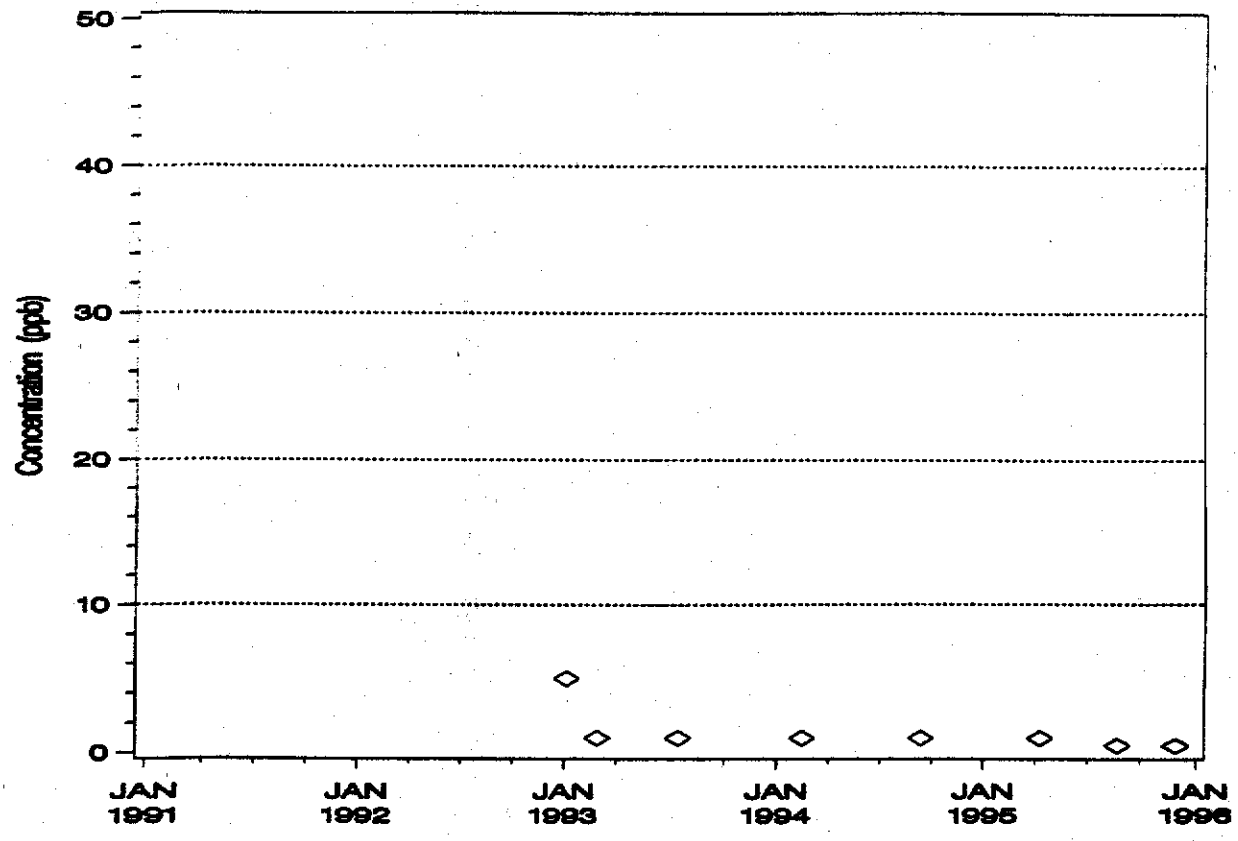
WELL 1533
TRICHLOROETHYLENE Trend



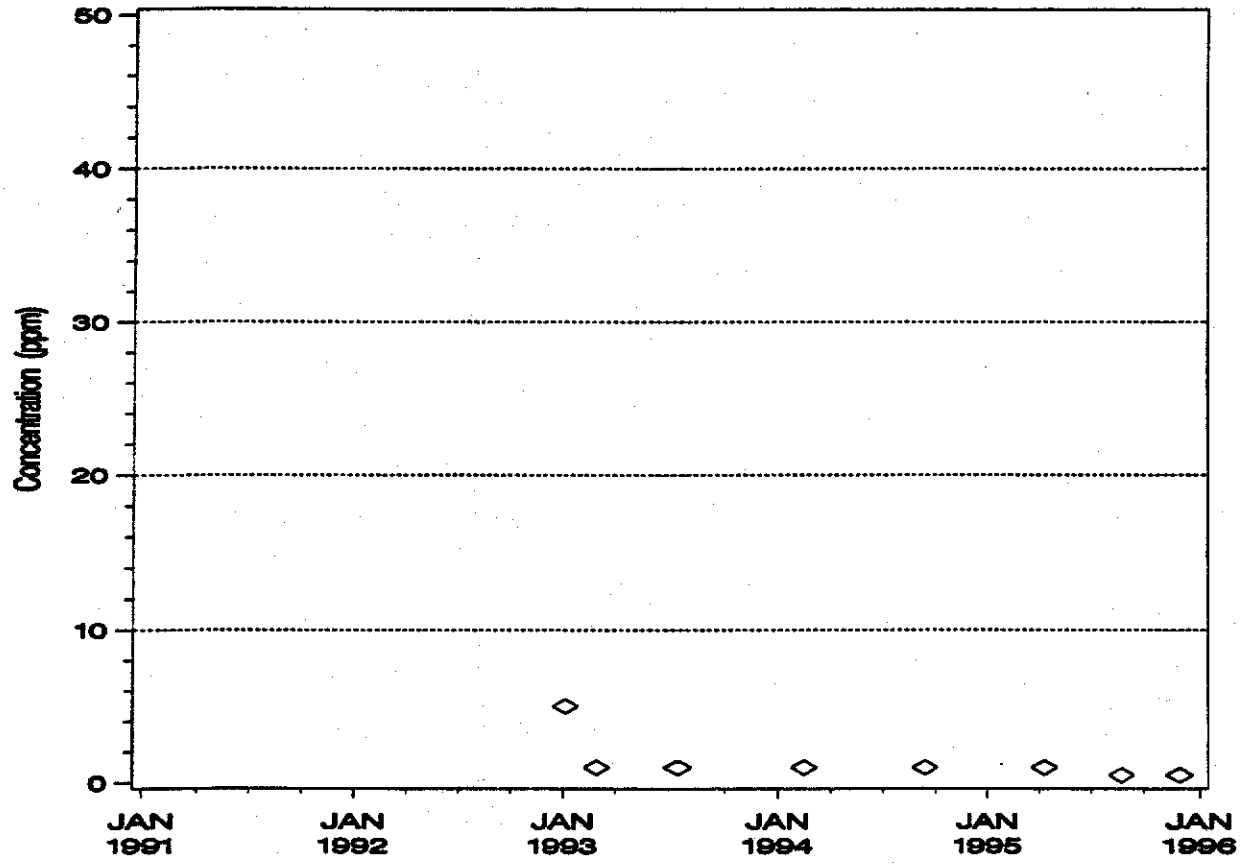
FREON 113 Trend



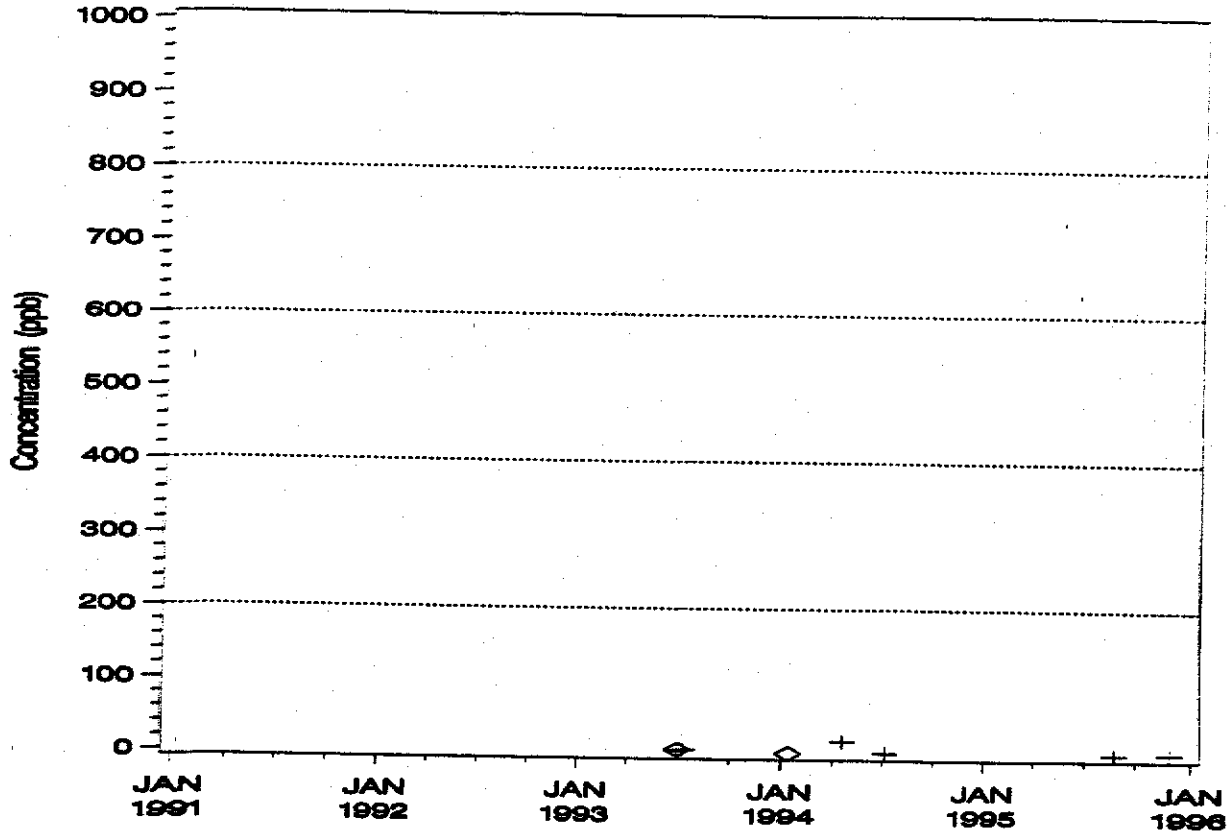
WELL 1533
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



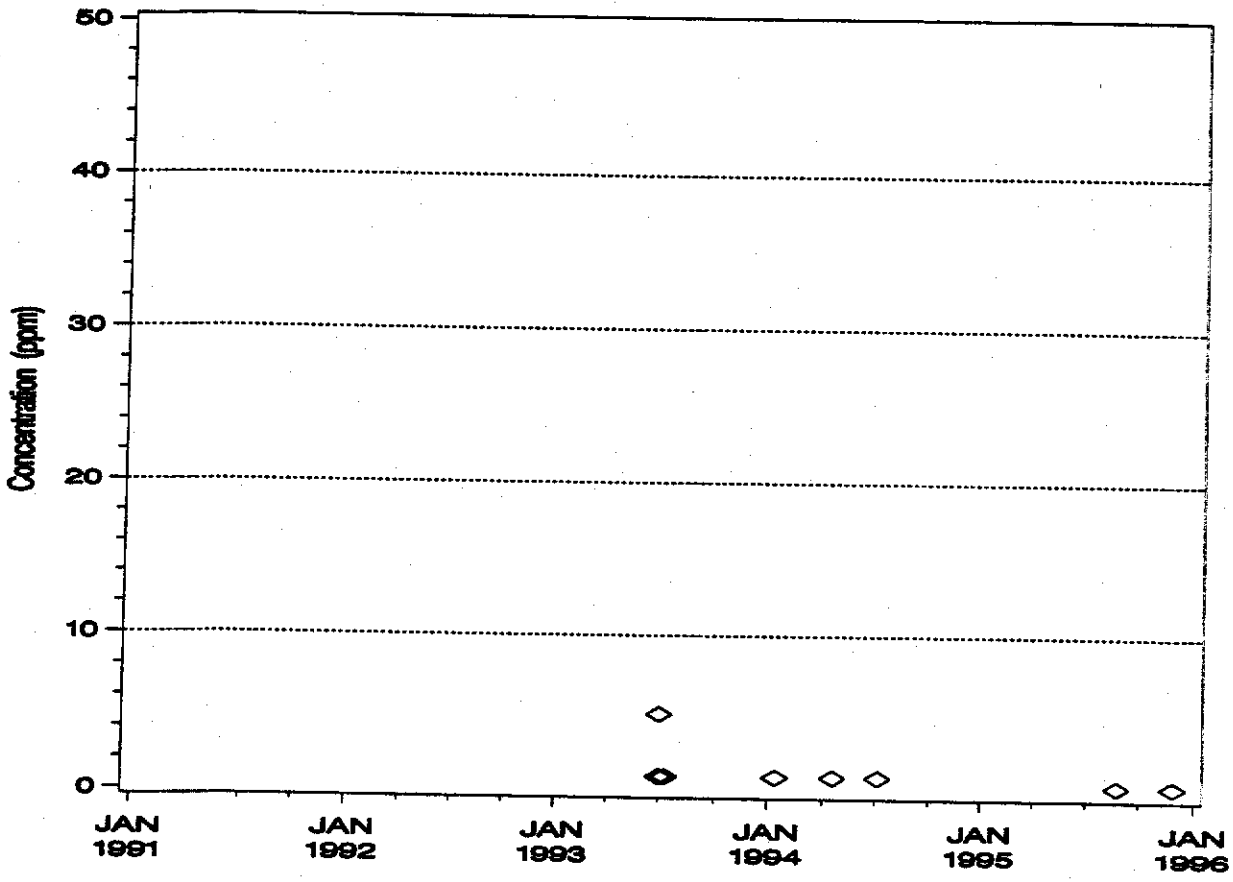
1,1 – DICHLOROETHYLENE Trend



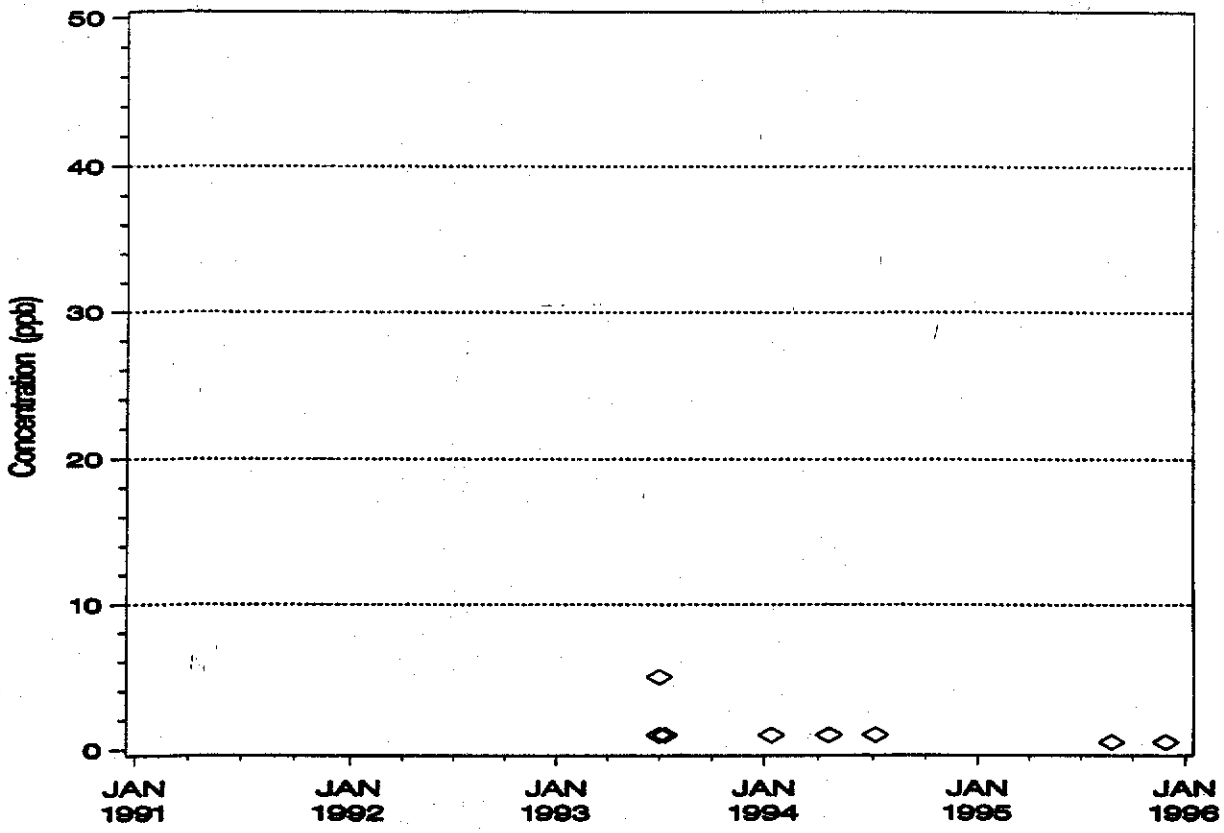
WELL 1538
TRICHLOROETHYLENE Trend



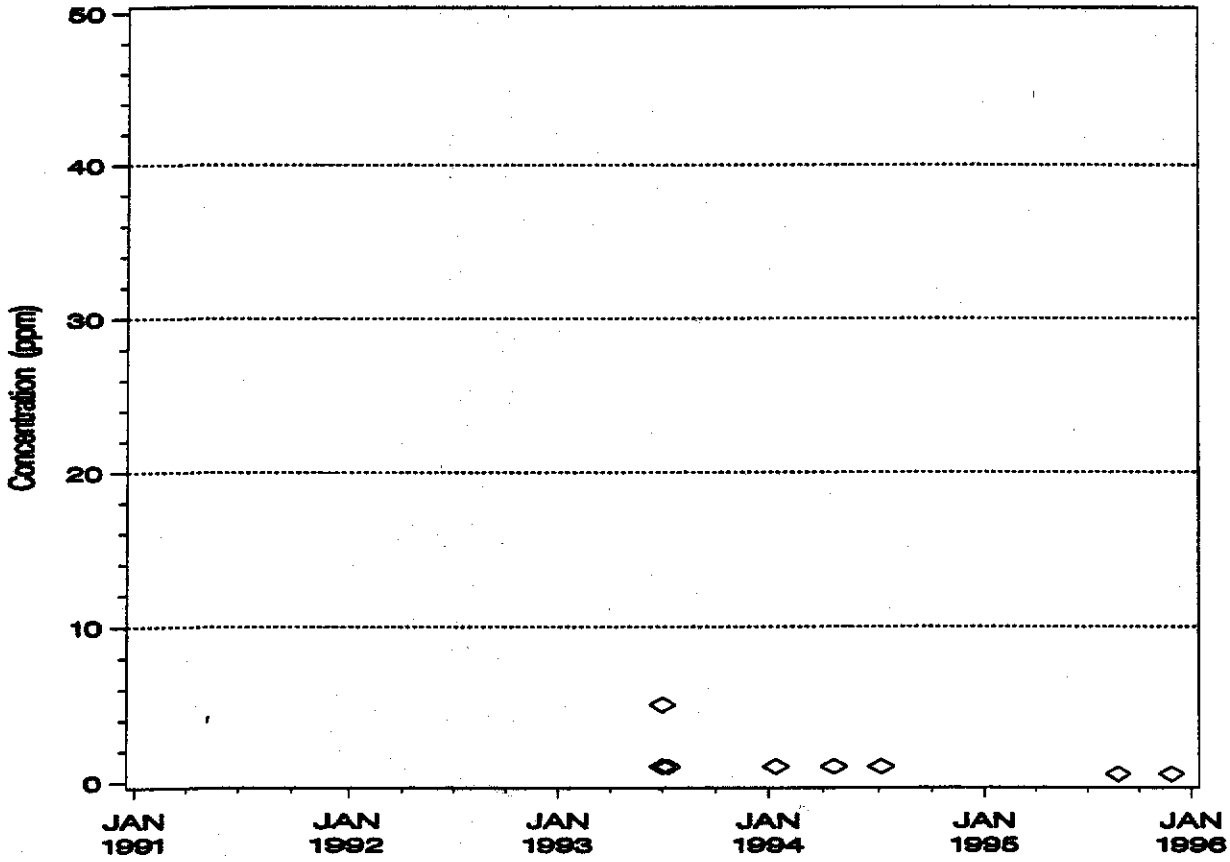
FREON 113 Trend



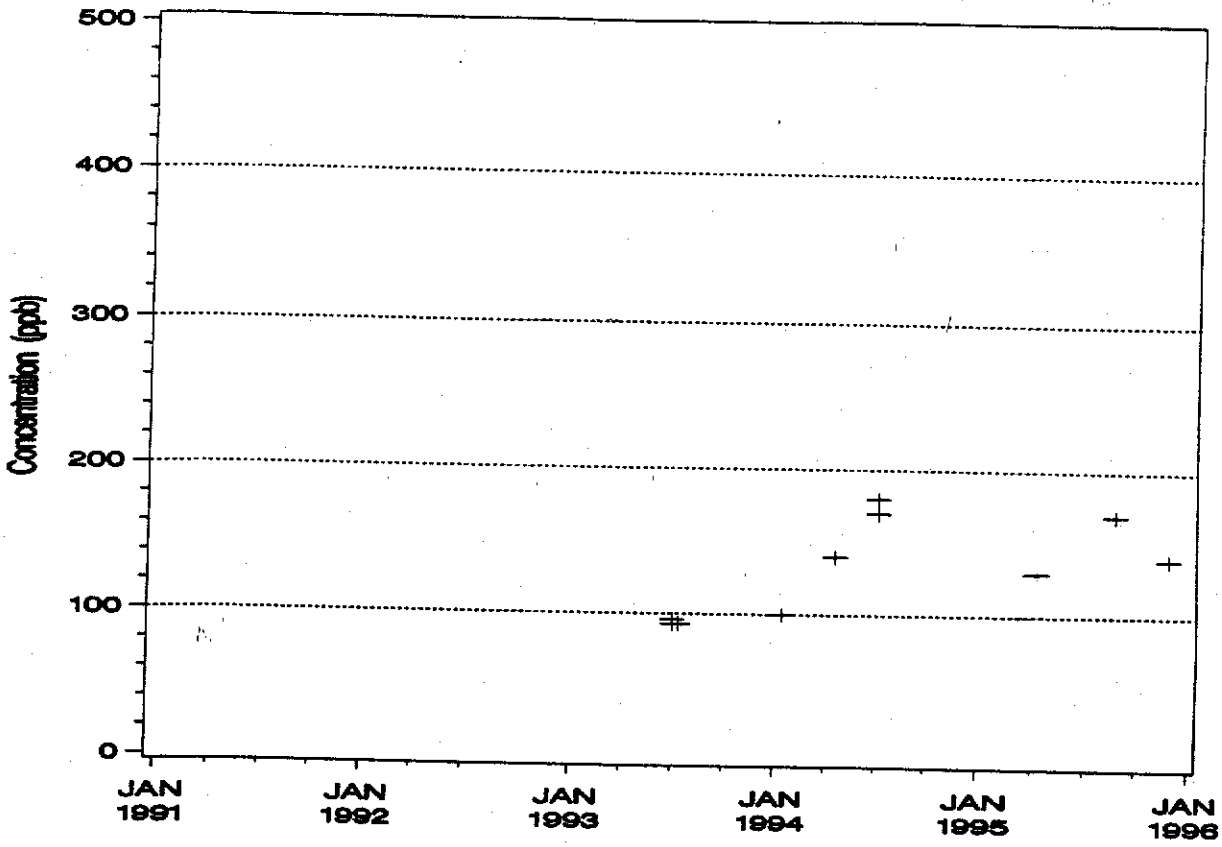
WELL 1538
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



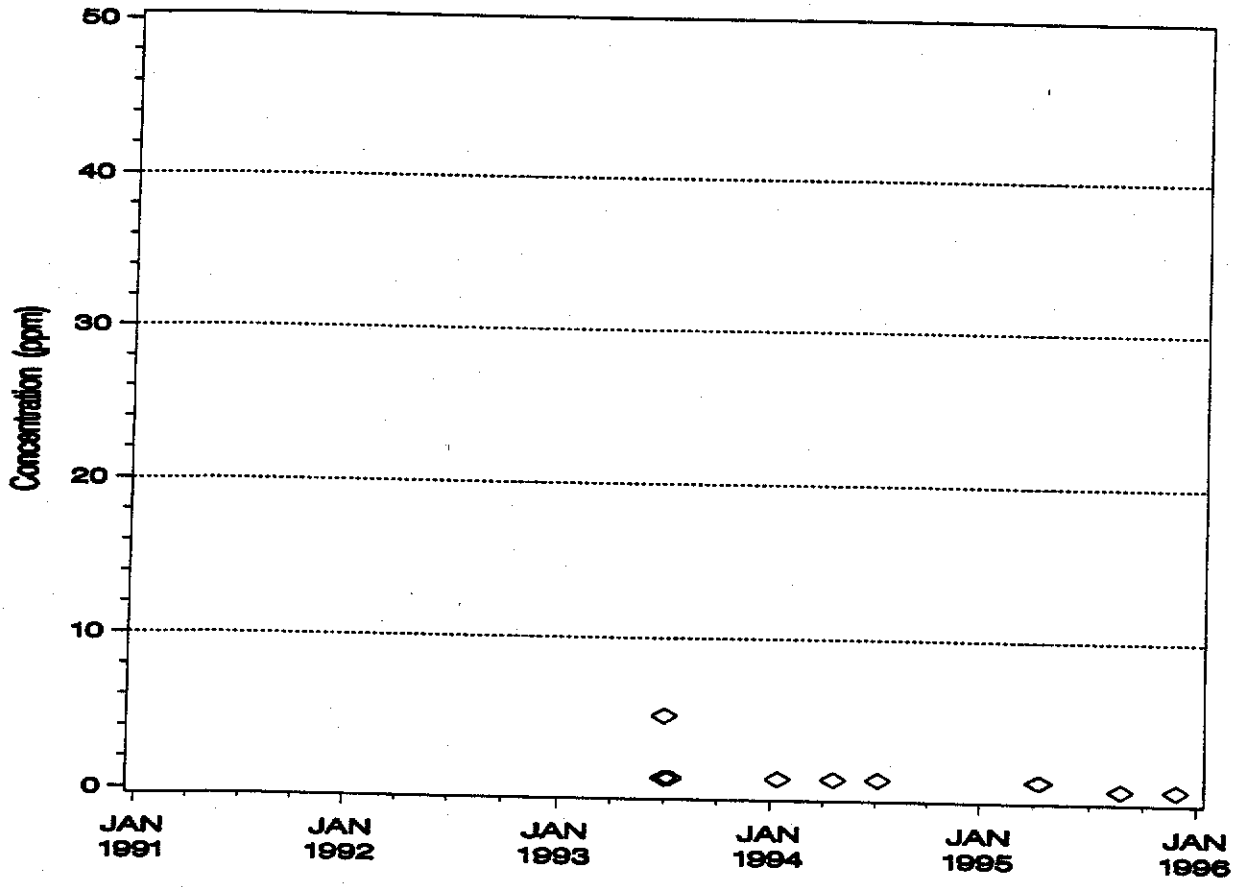
1,1 – DICHLOROETHYLENE Trend



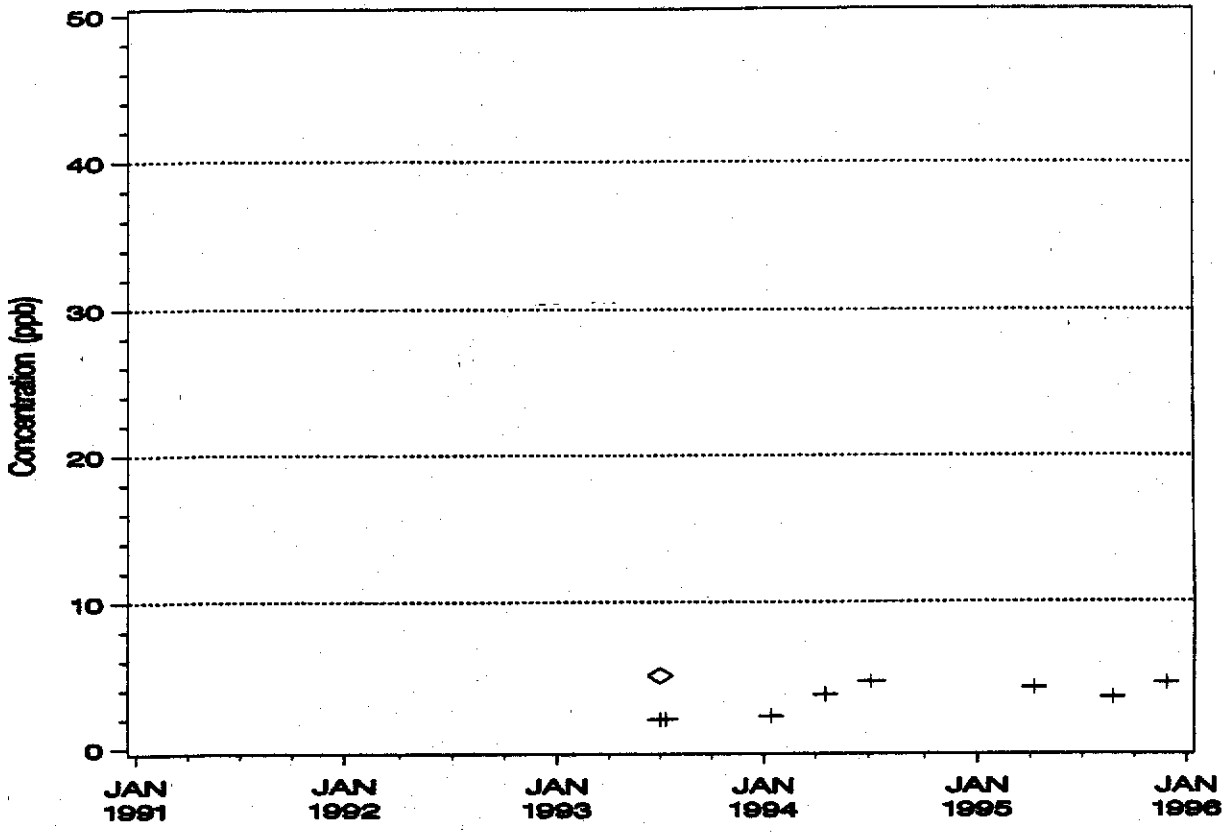
WELL 1539
TRICHLOROETHYLENE Trend



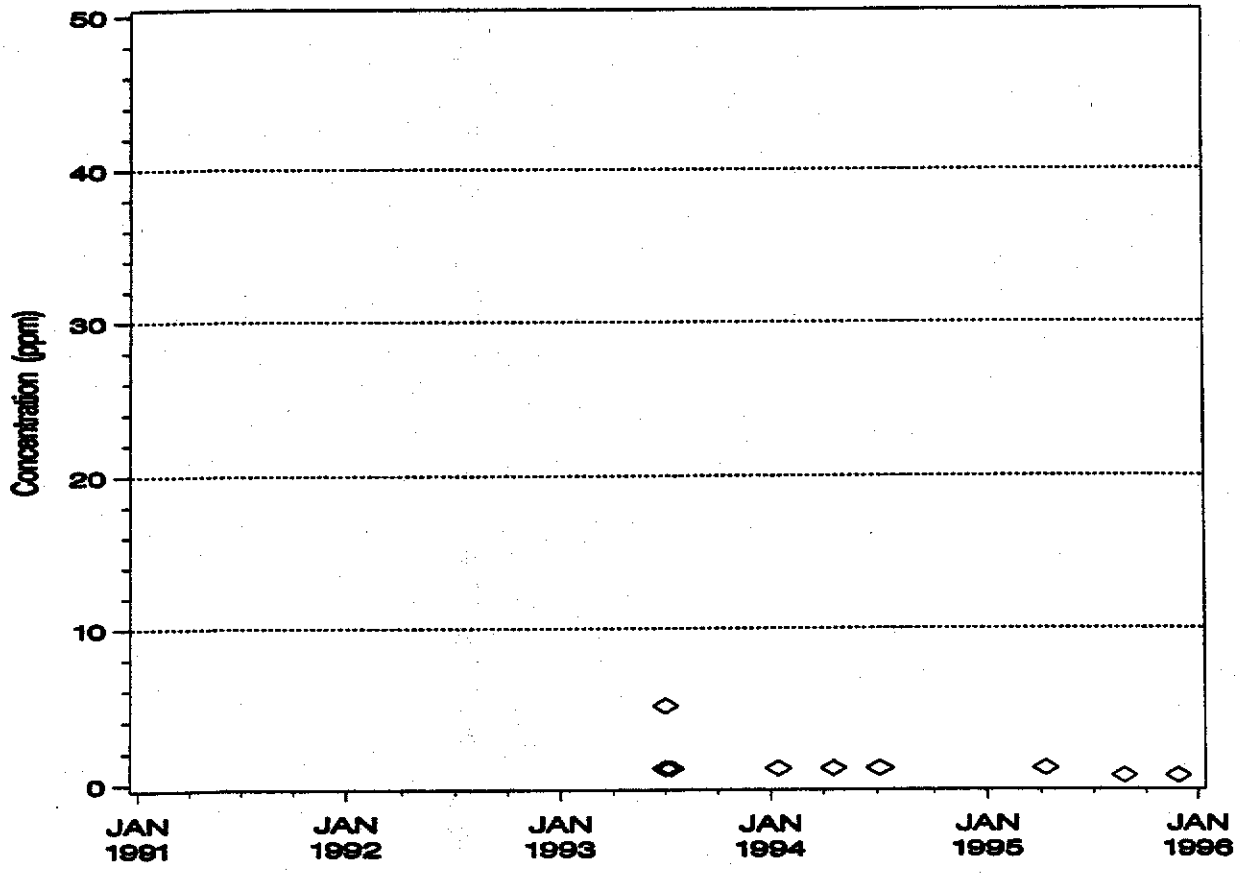
FREON 113 Trend



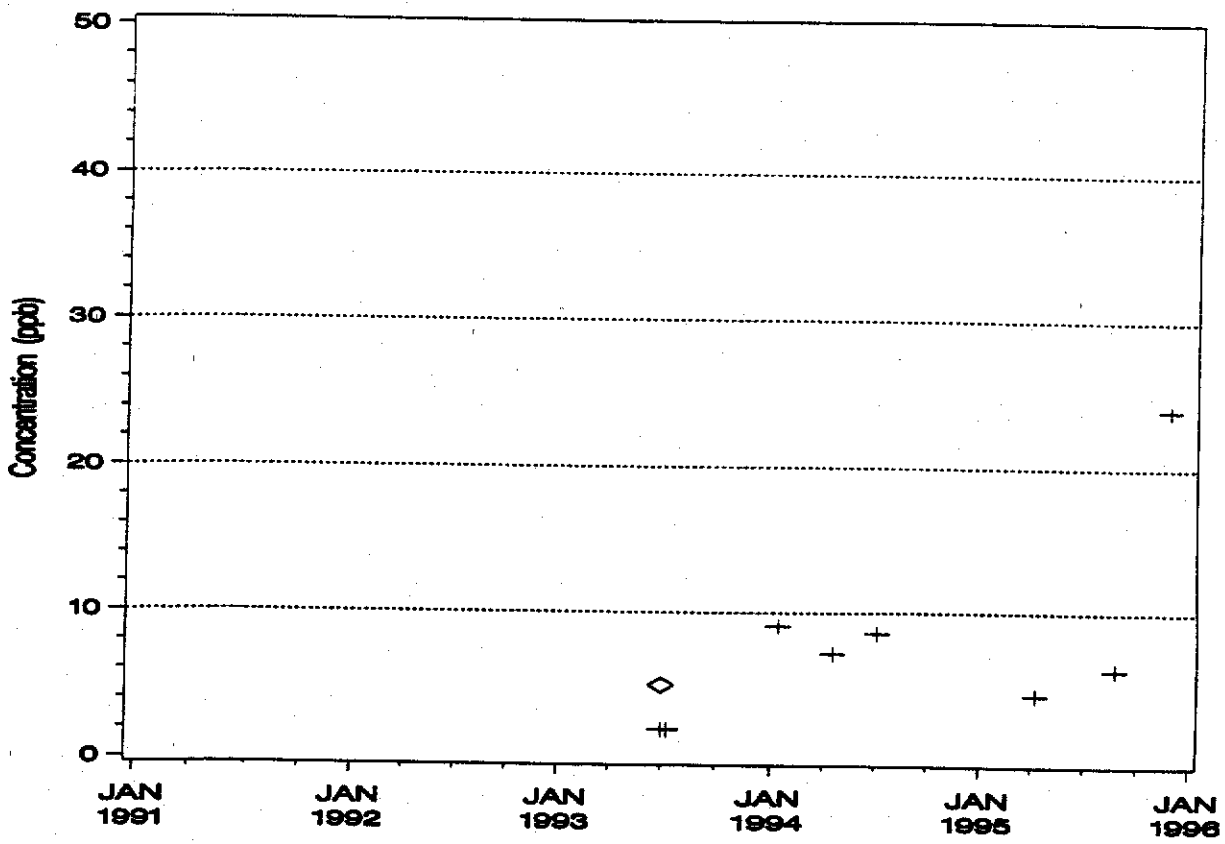
WELL 1539
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



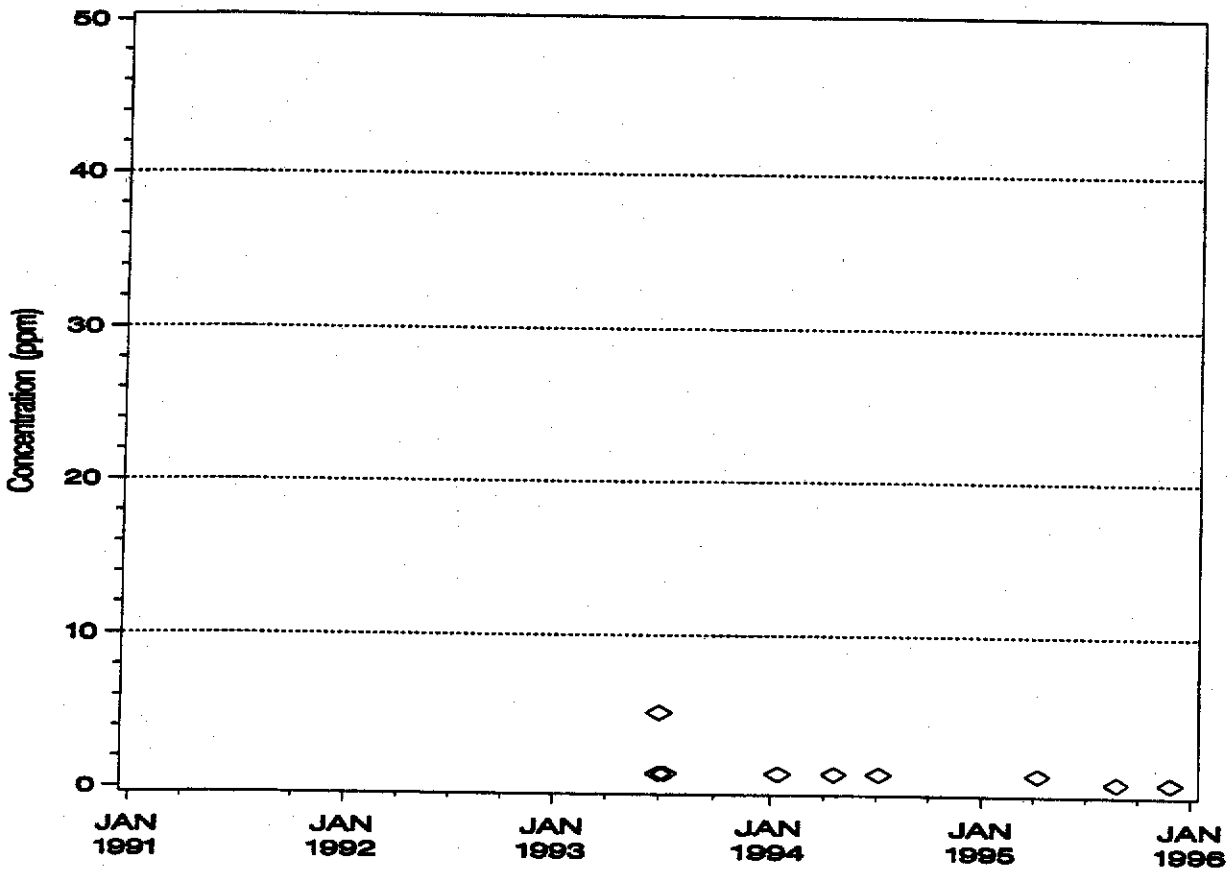
1,1 – DICHLOROETHYLENE Trend



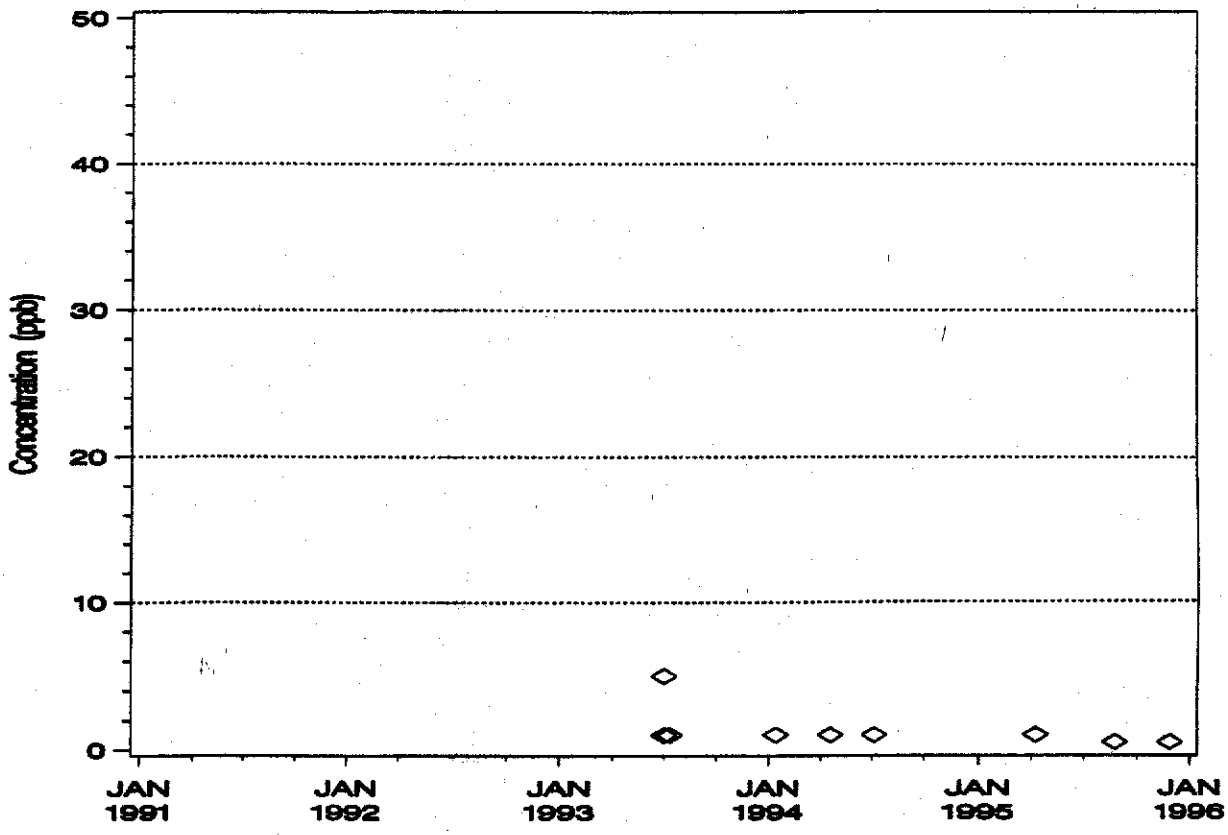
WELL 1540
TRICHLOROETHYLENE Trend



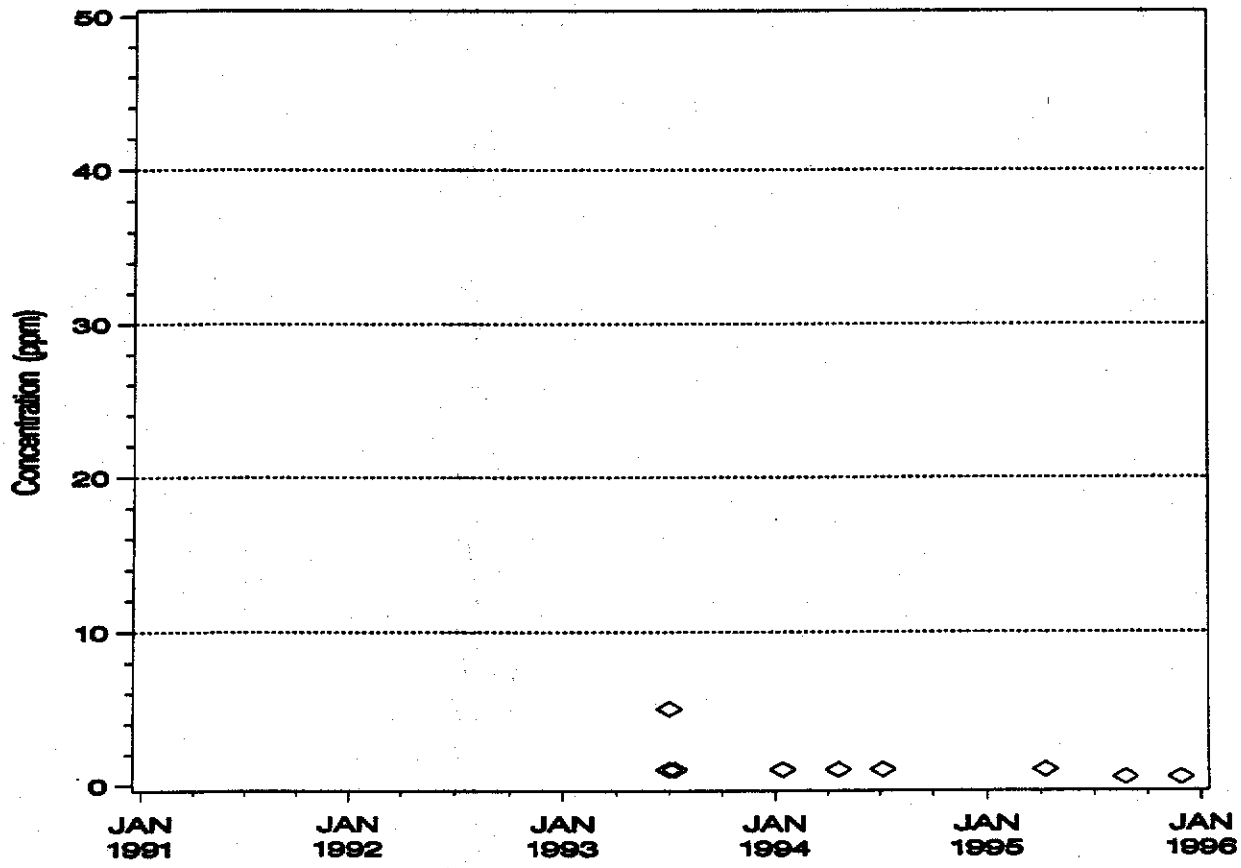
FREON 113 Trend



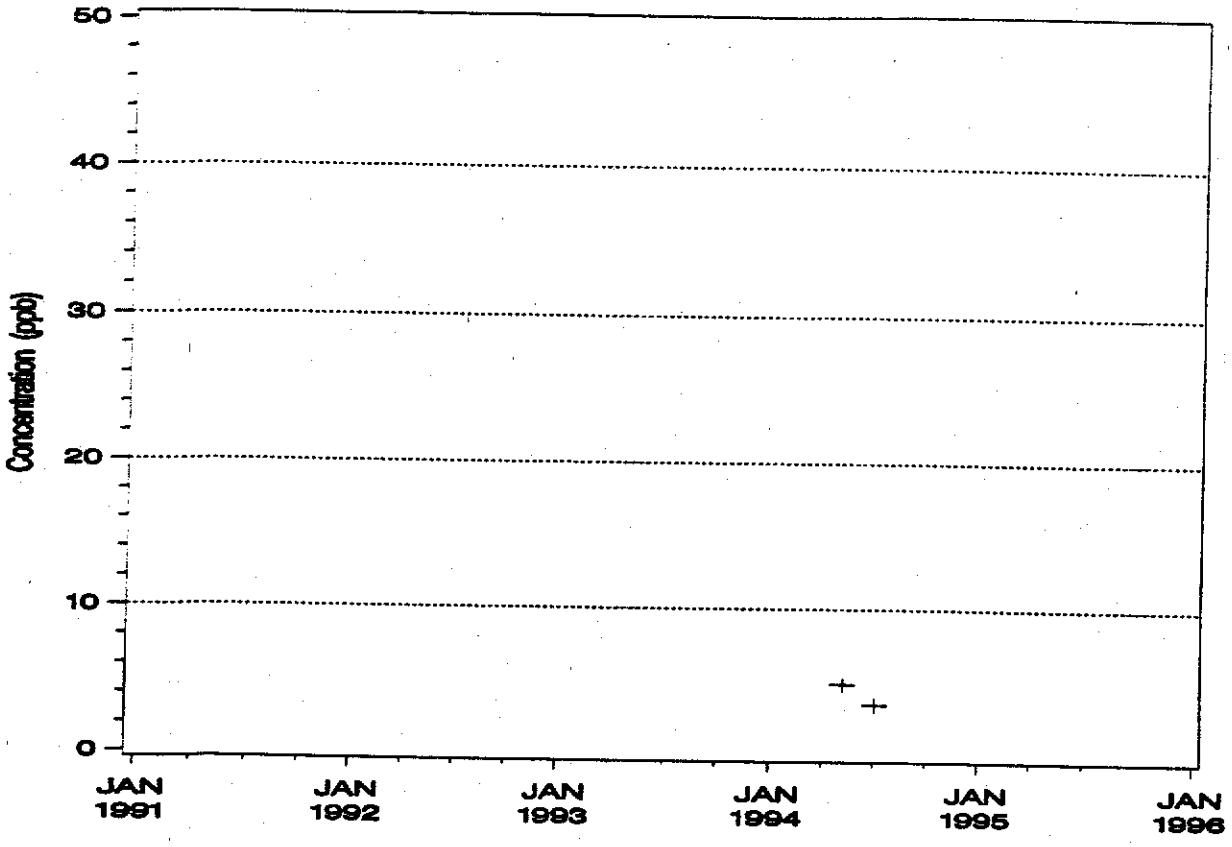
WELL 1540
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



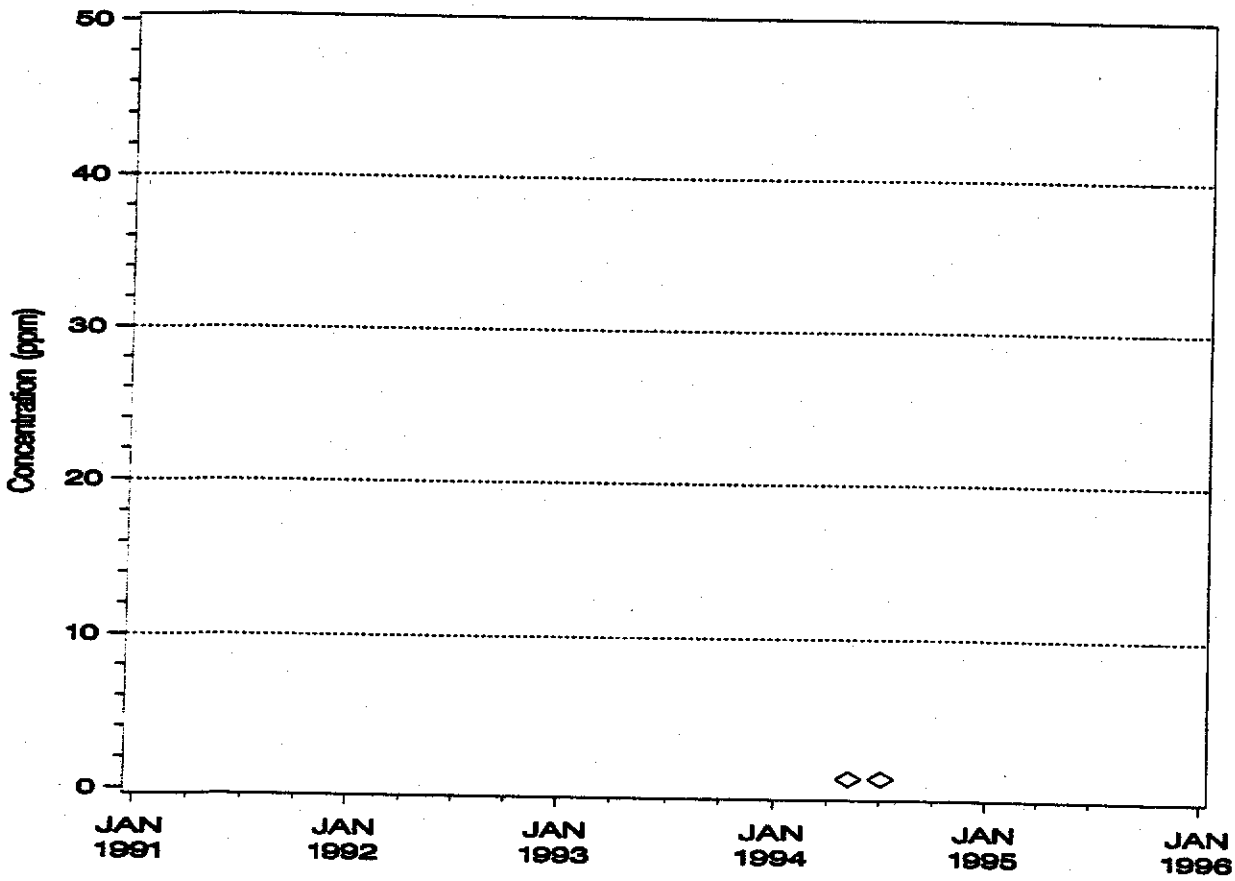
1,1 — DICHLOROETHYLENE Trend



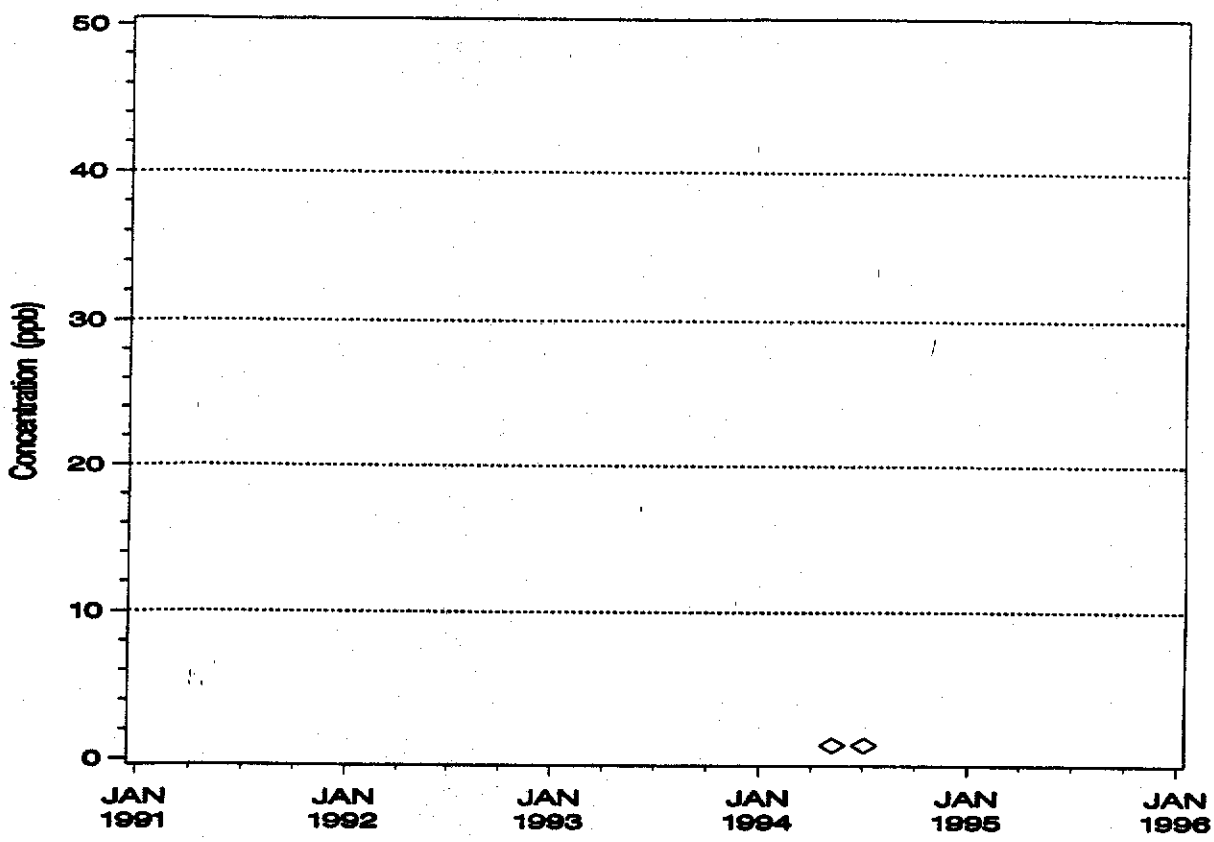
WELL 1556
TRICHLOROETHYLENE Trend



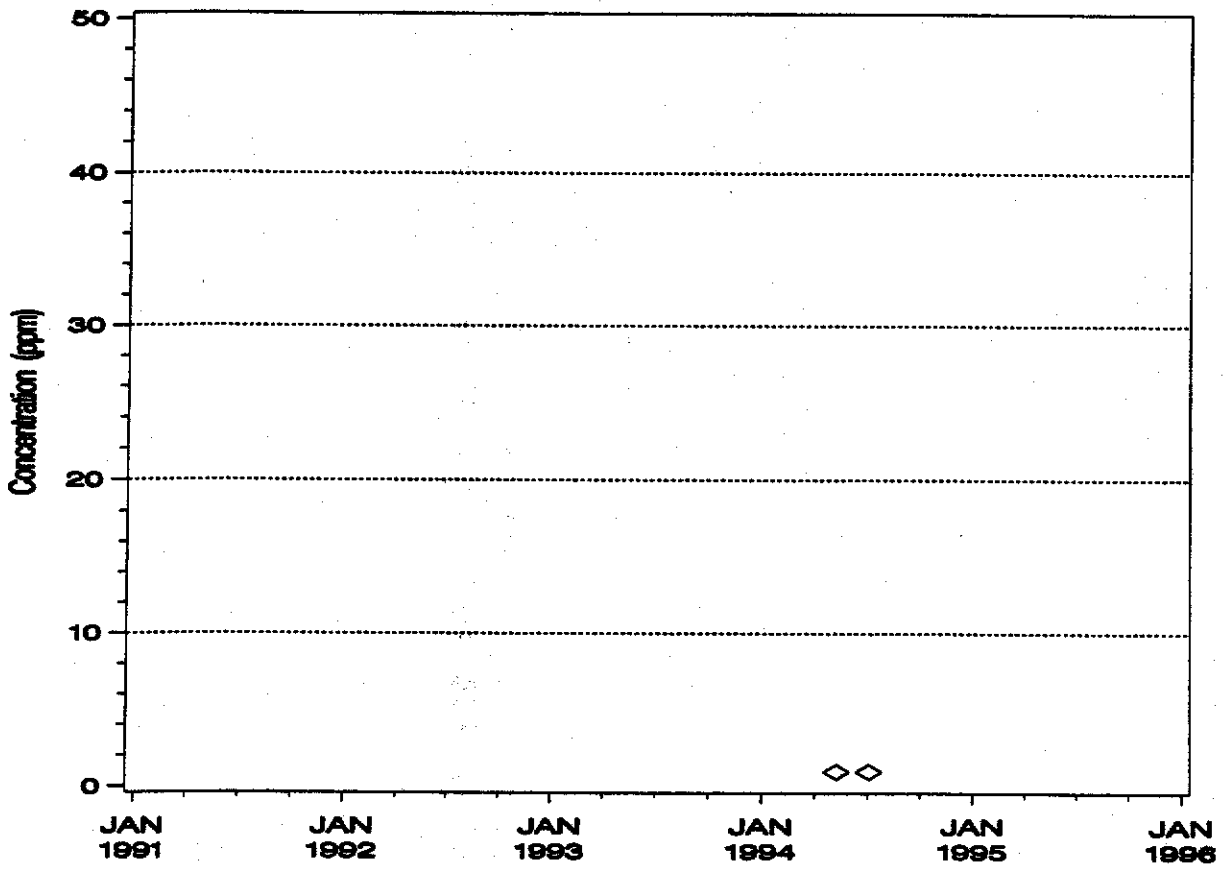
FREON 113 Trend



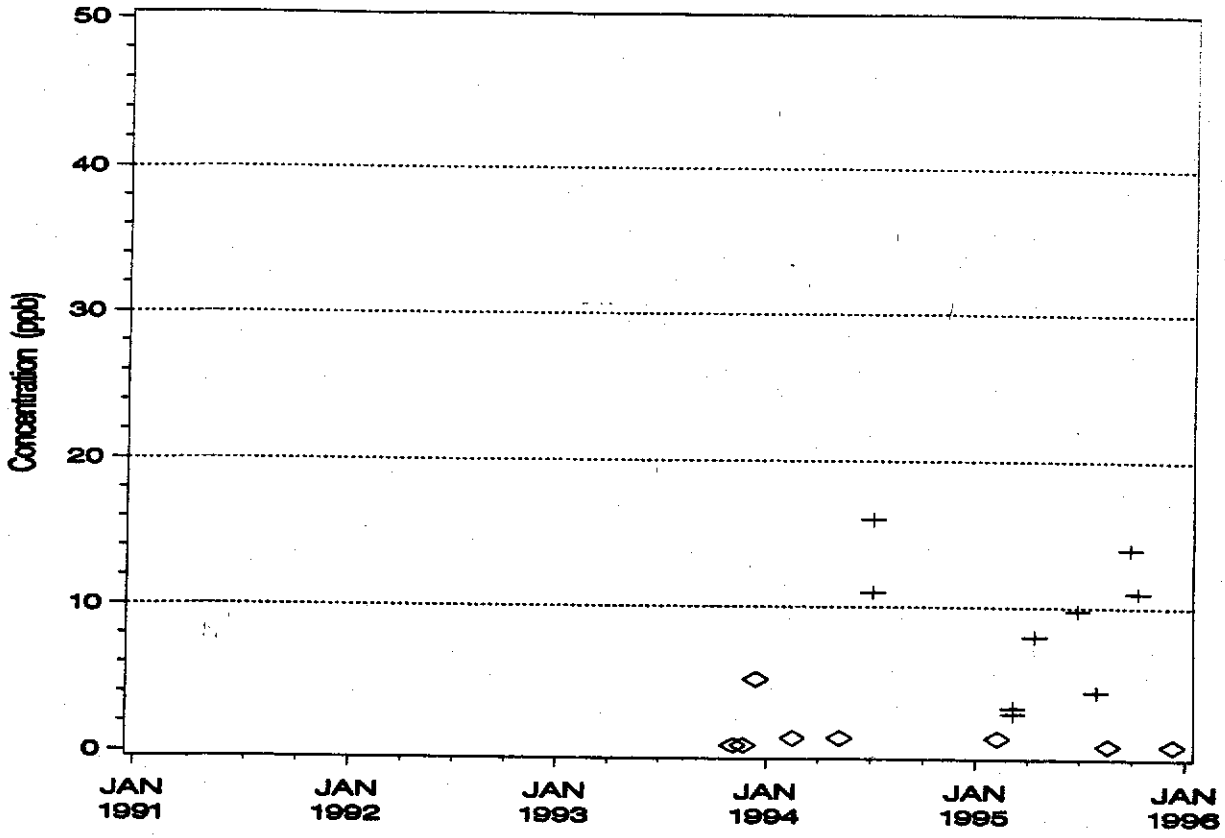
WELL 1556
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



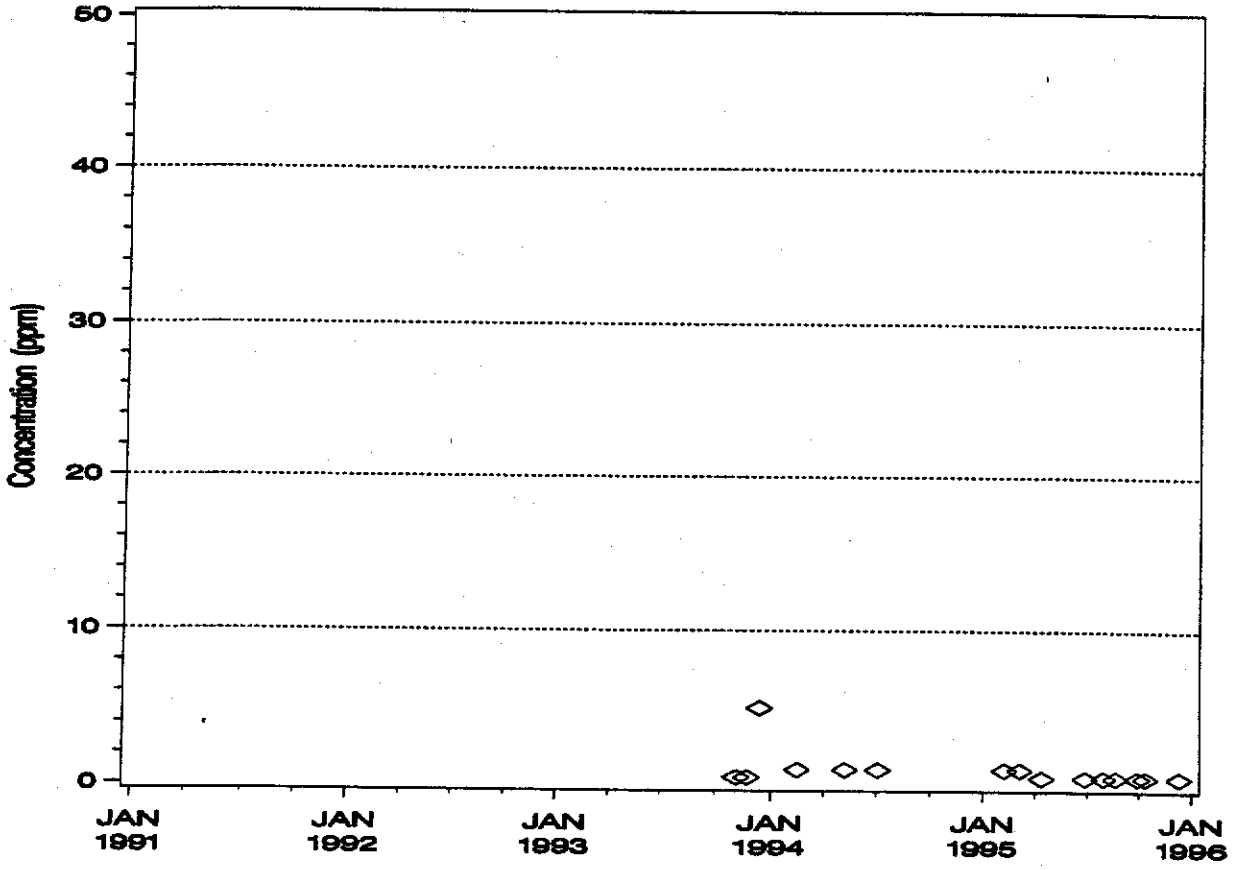
1,1 – DICHLOROETHYLENE Trend



WELL 1557
TRICHLOROETHYLENE Trend

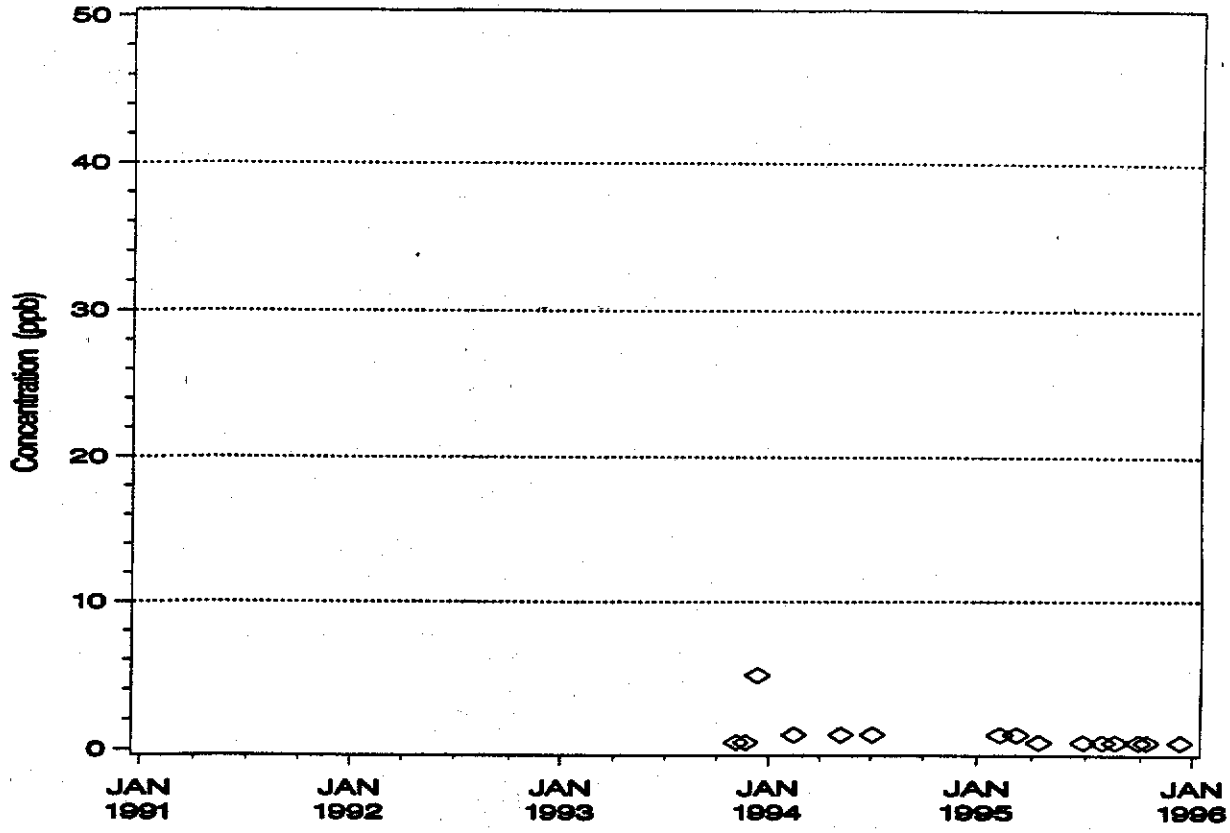


FREON 113 Trend

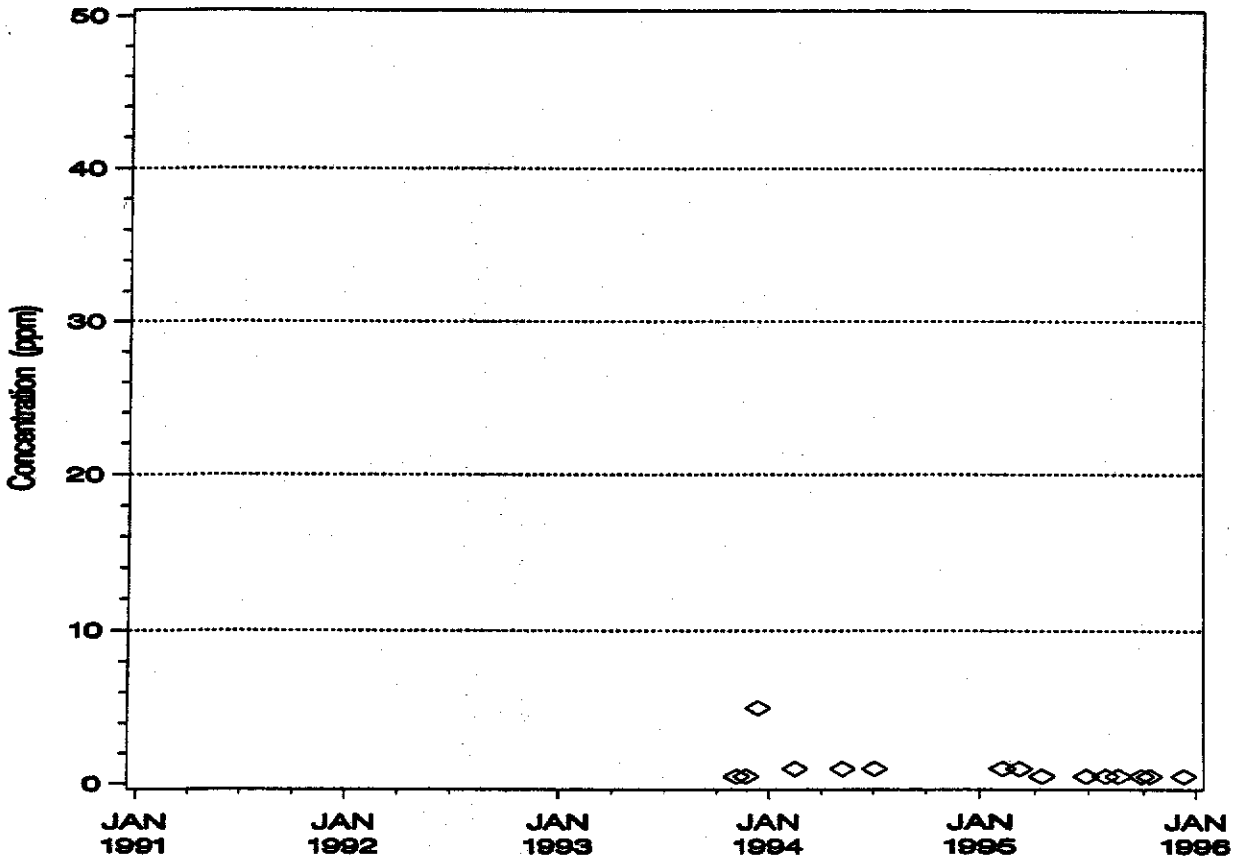


WELL 1557

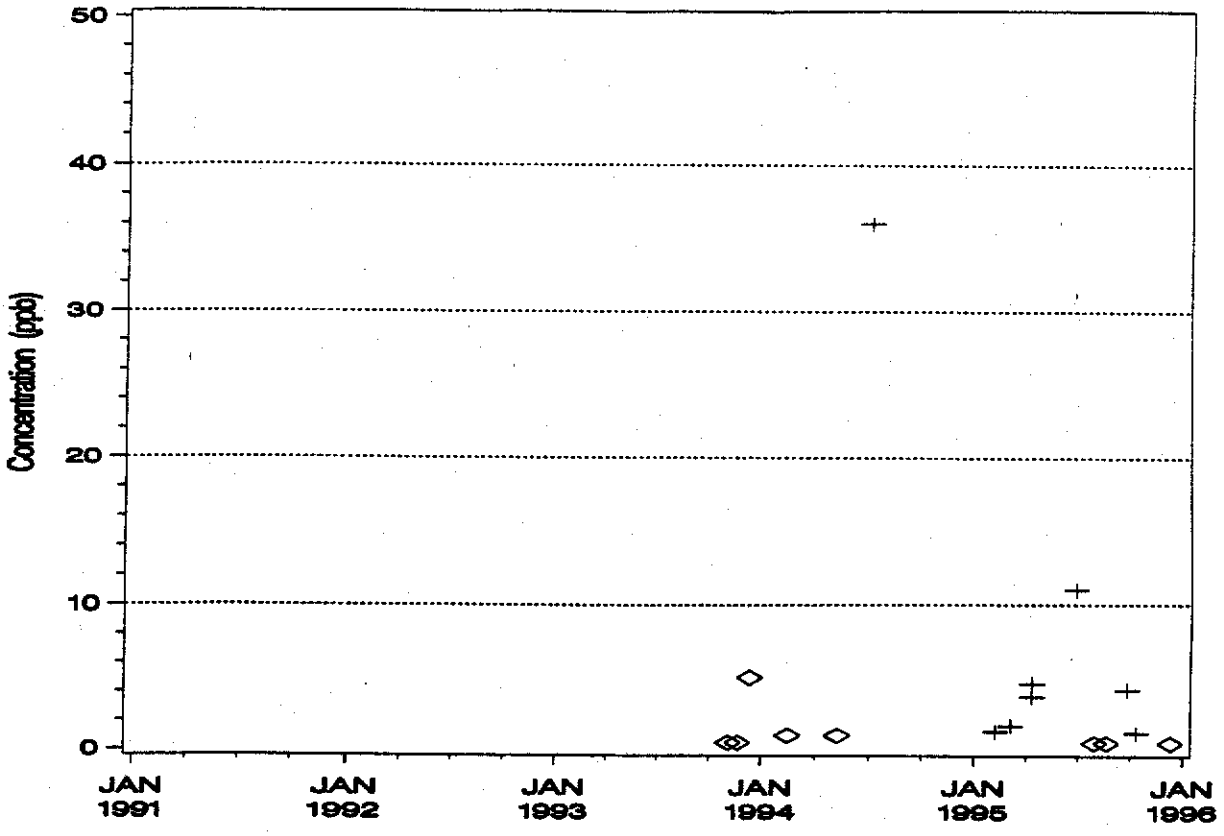
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



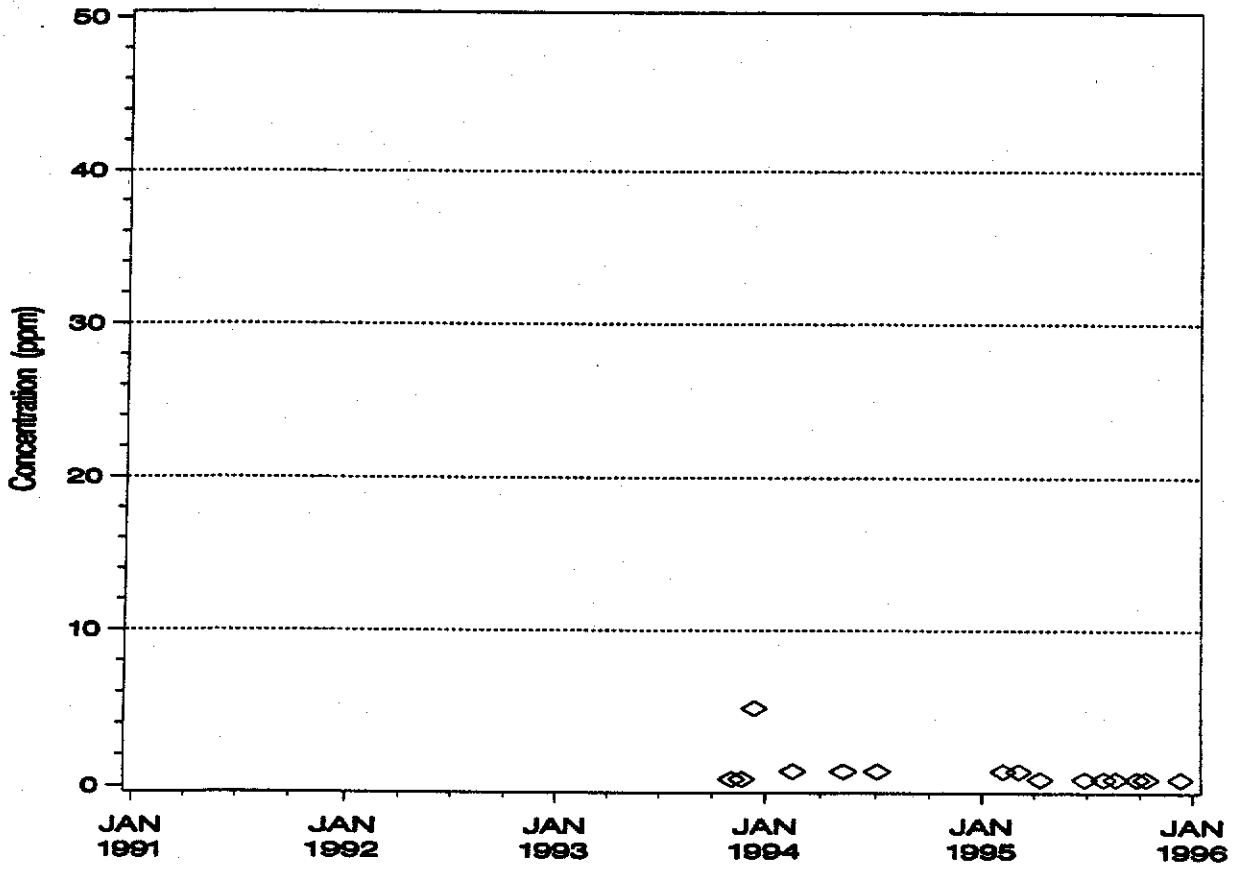
1,1 — DICHLOROETHYLENE Trend



WELL 1558
TRICHLOROETHYLENE Trend

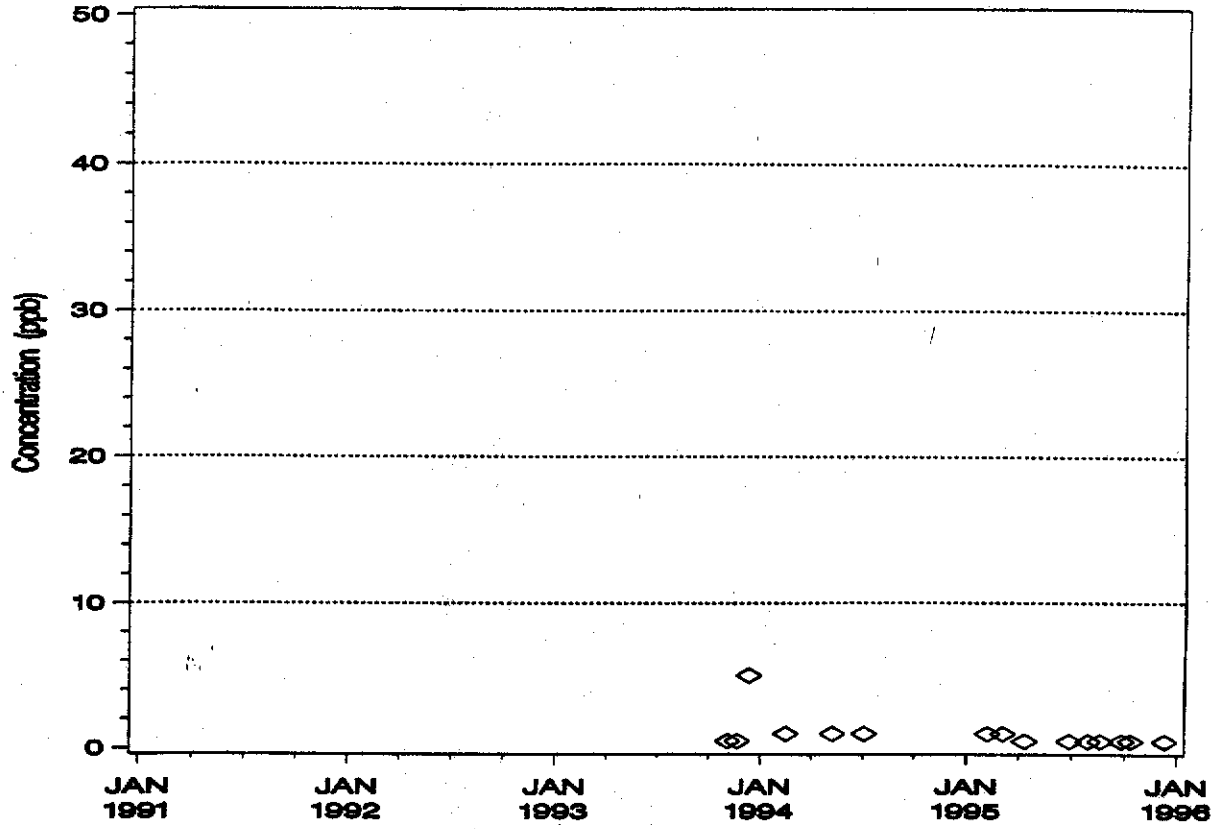


FREON 113 Trend

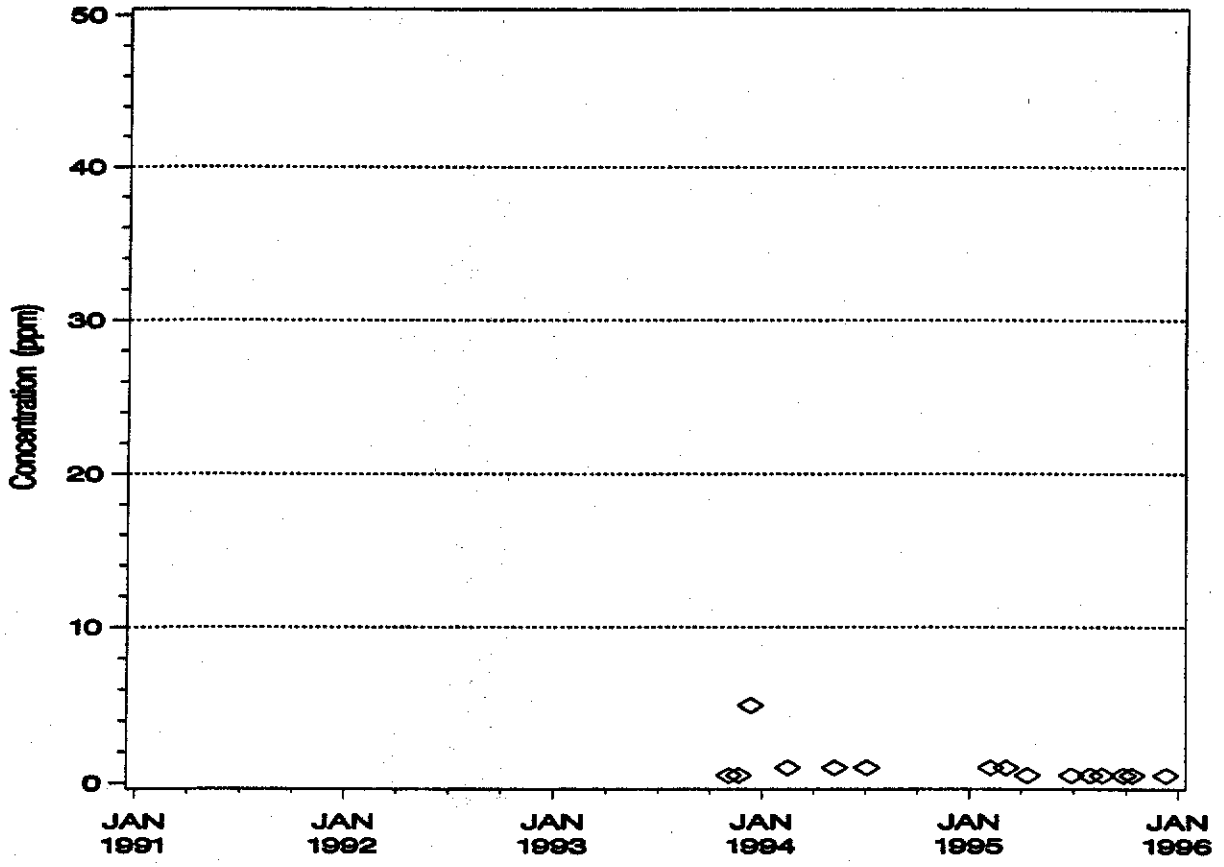


WELL 1558

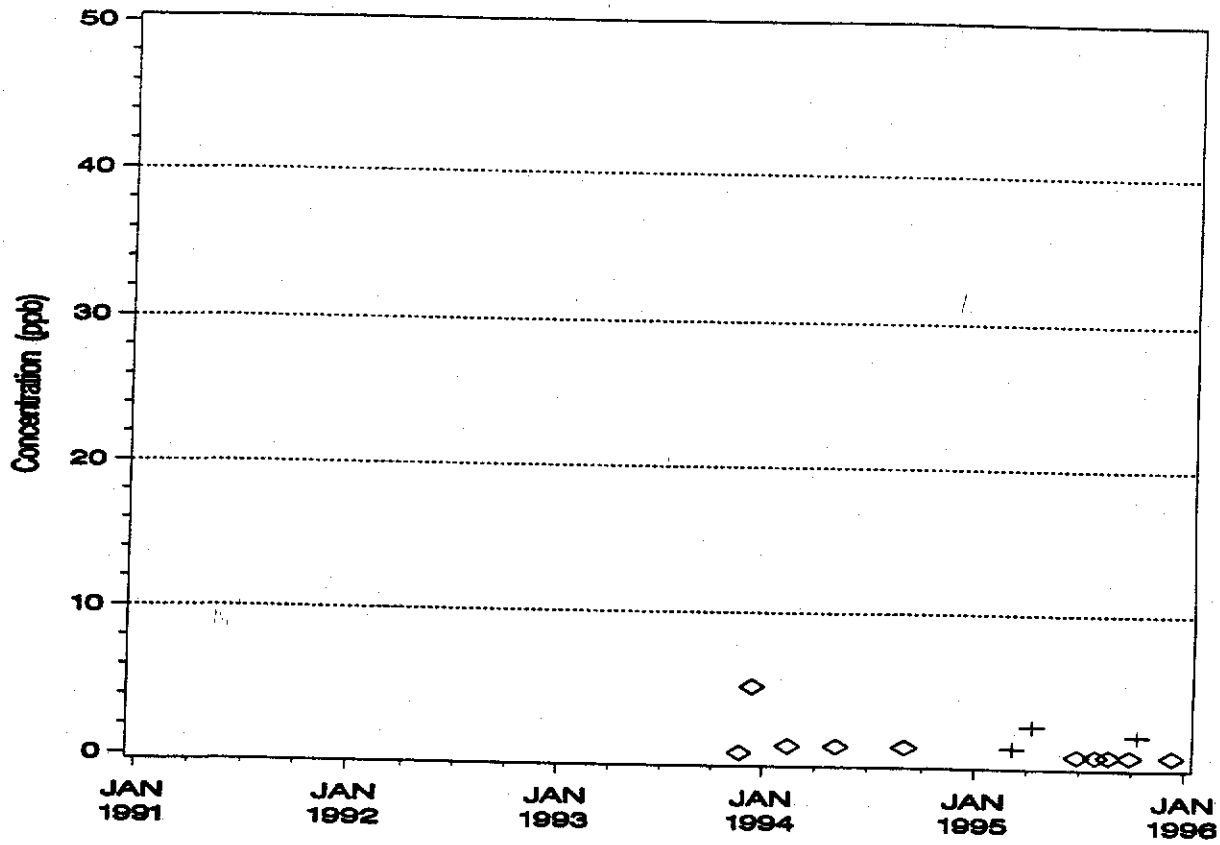
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



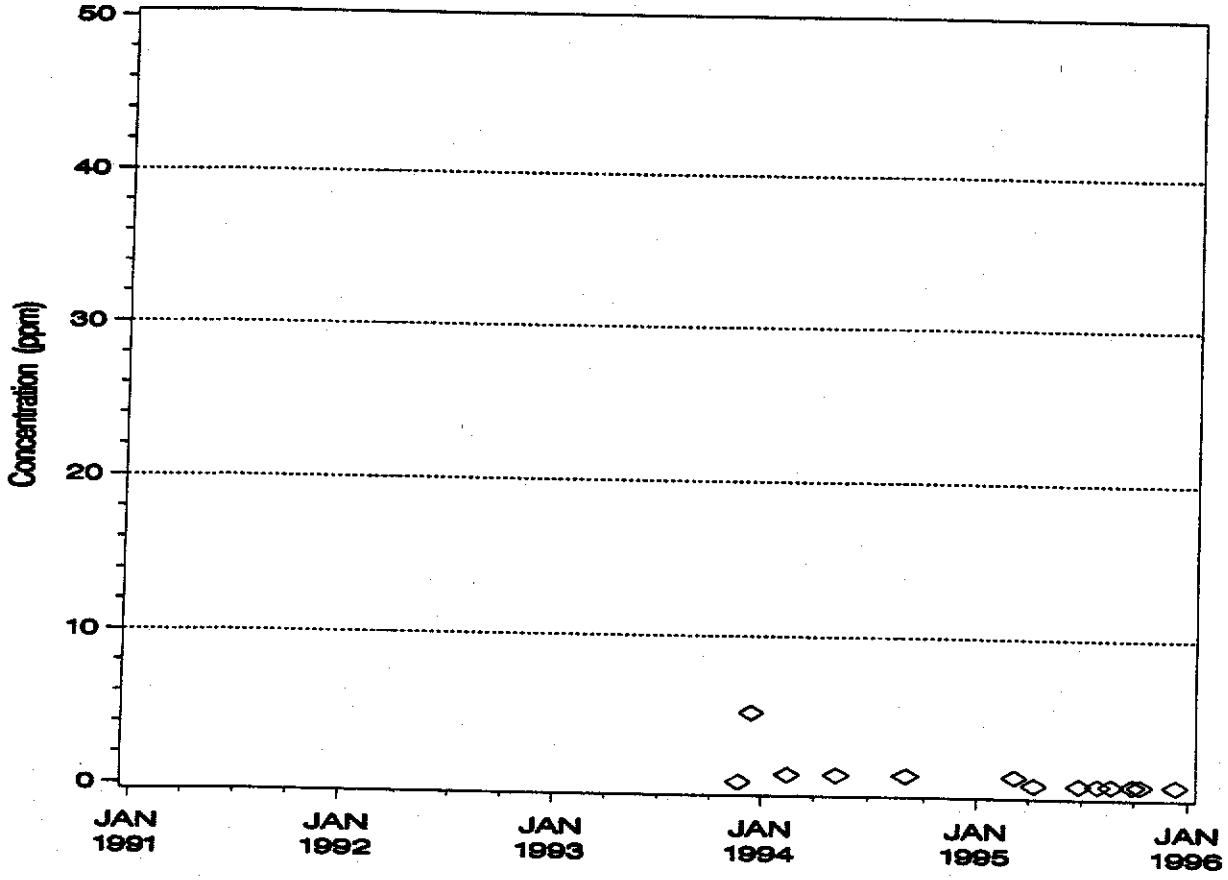
1,1 — DICHLOROETHYLENE Trend



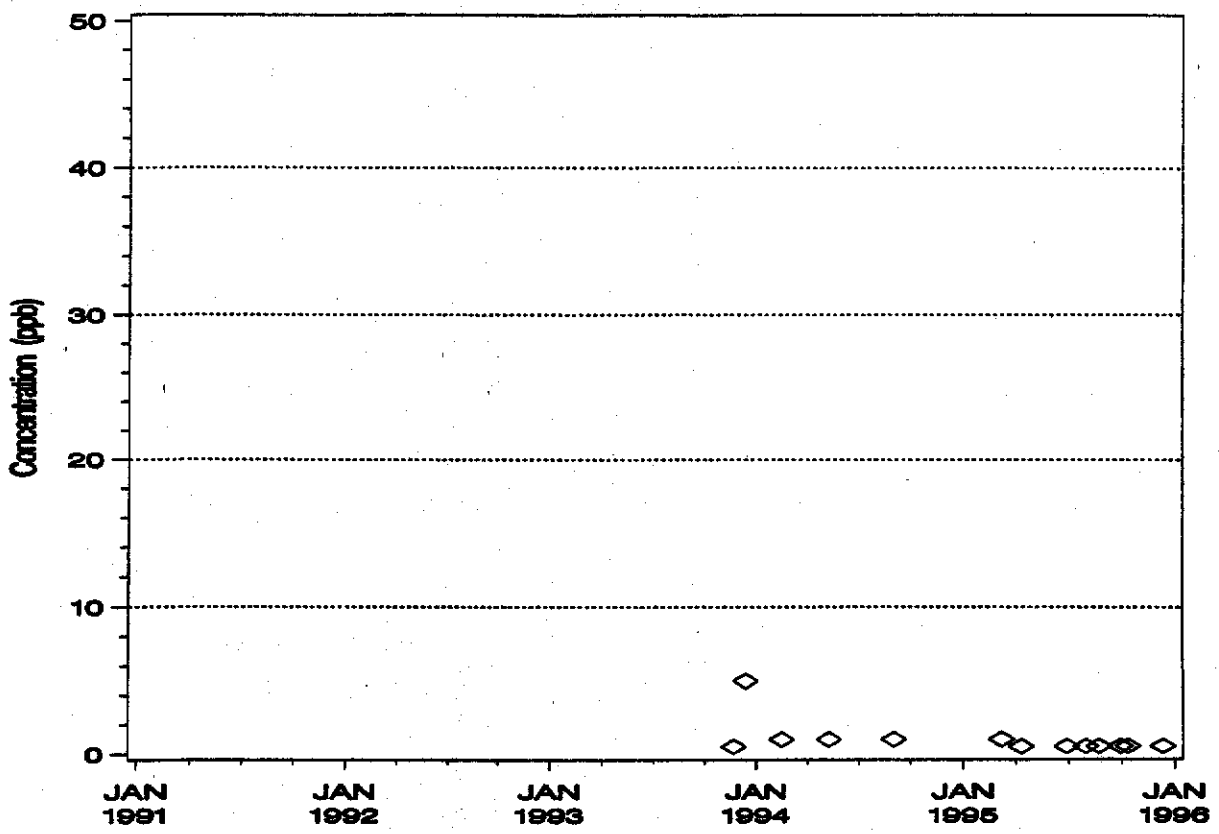
WELL 1559
TRICHLOROETHYLENE Trend



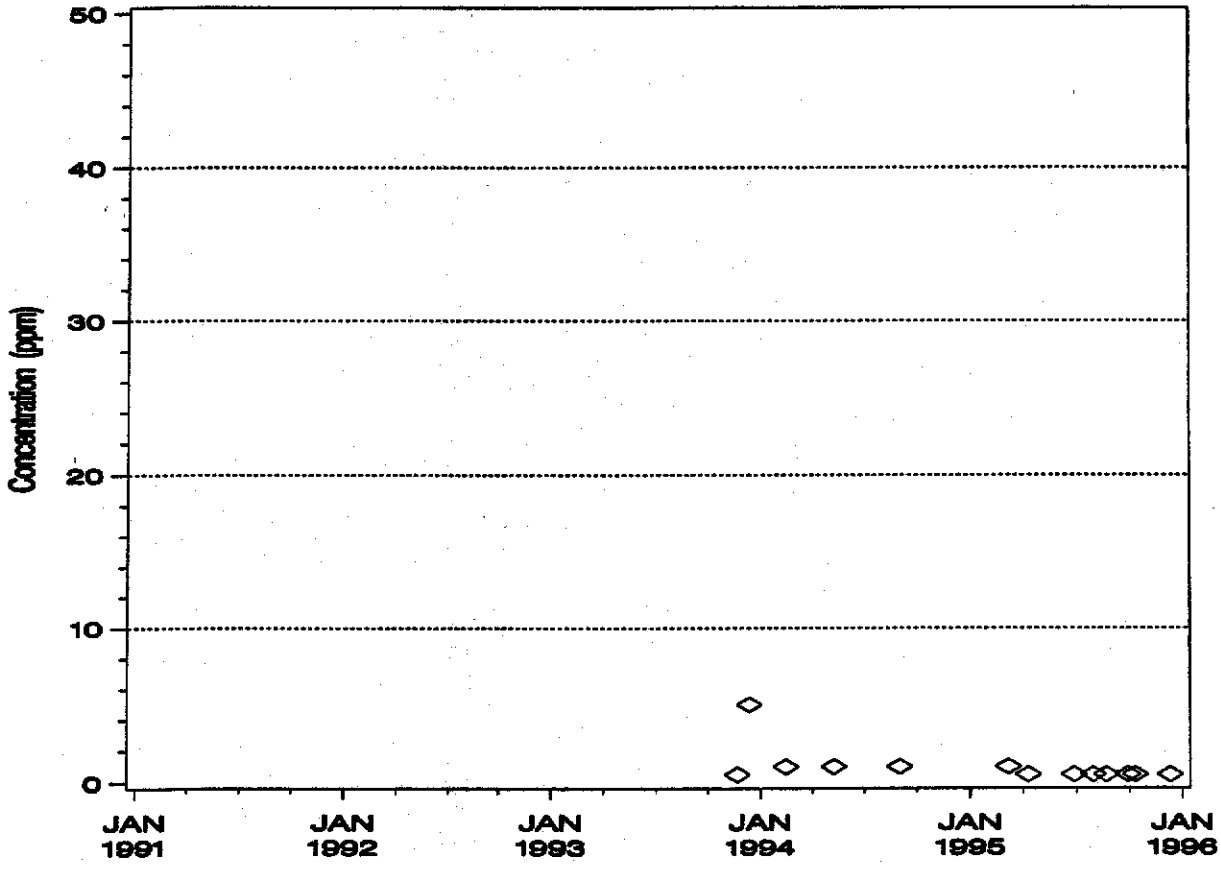
FREON 113 Trend



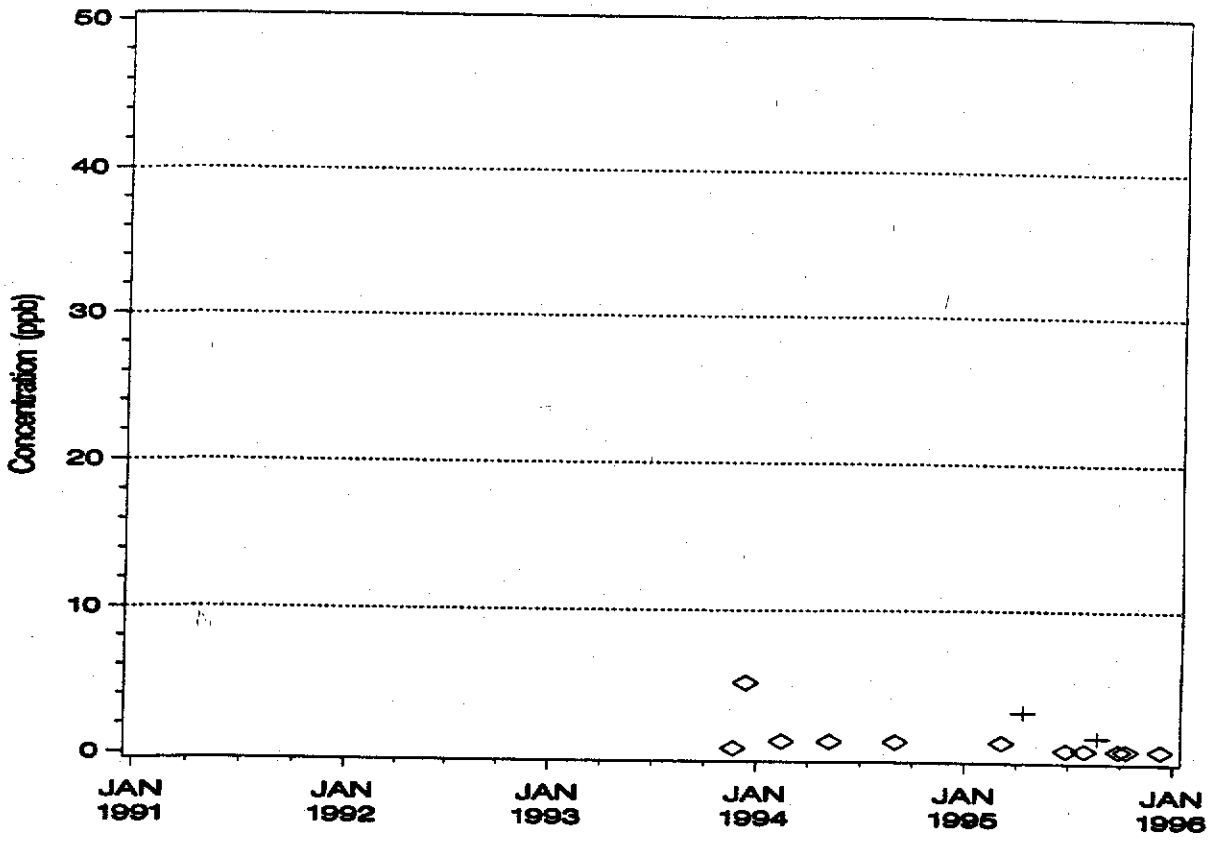
WELL 1559
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



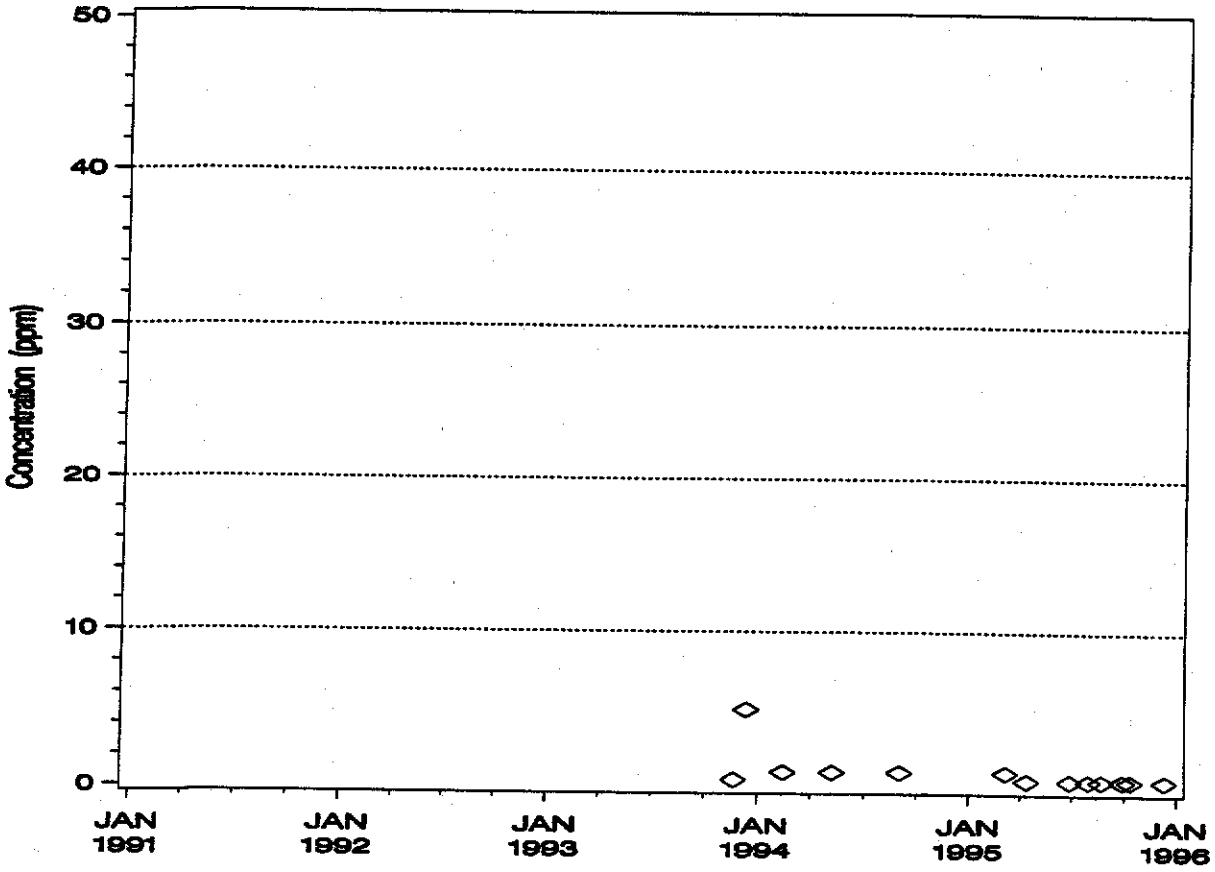
1,1 – DICHLOROETHYLENE Trend



WELL 1560
TRICHLOROETHYLENE Trend

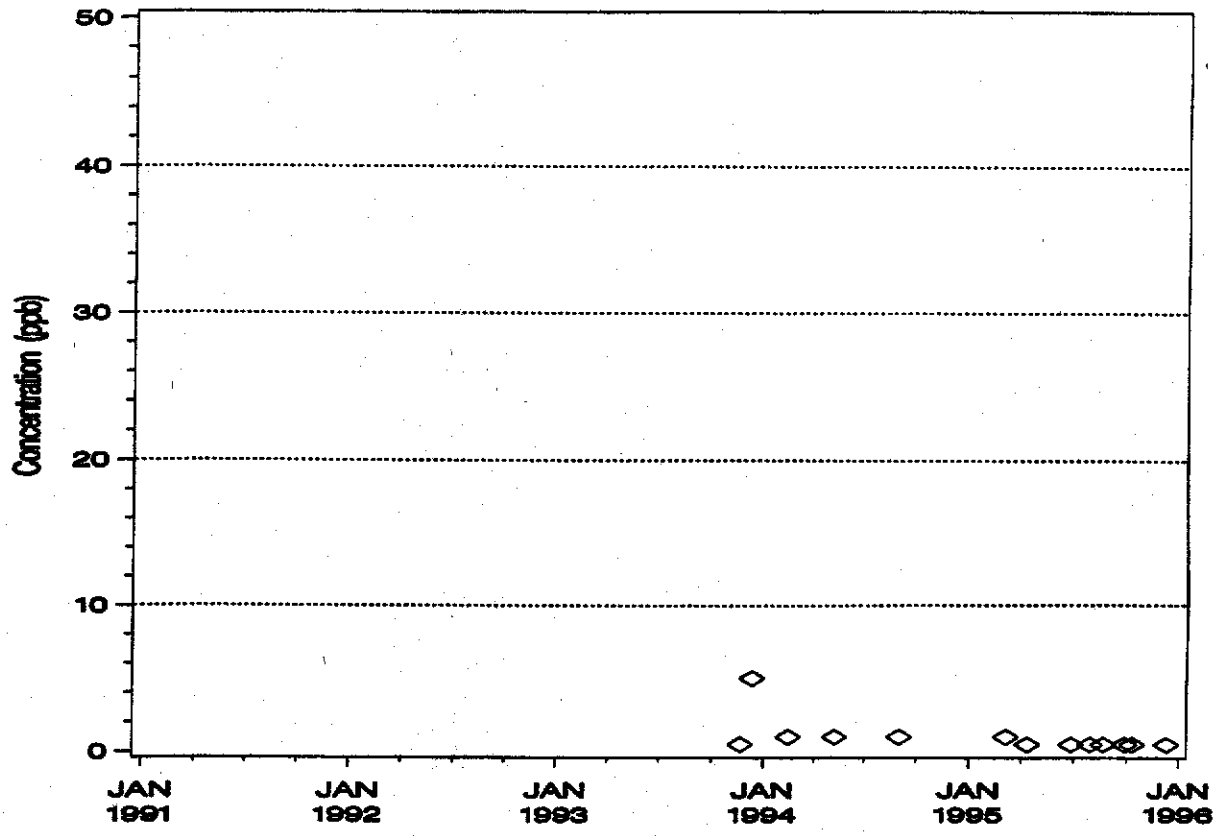


FREON 113 Trend

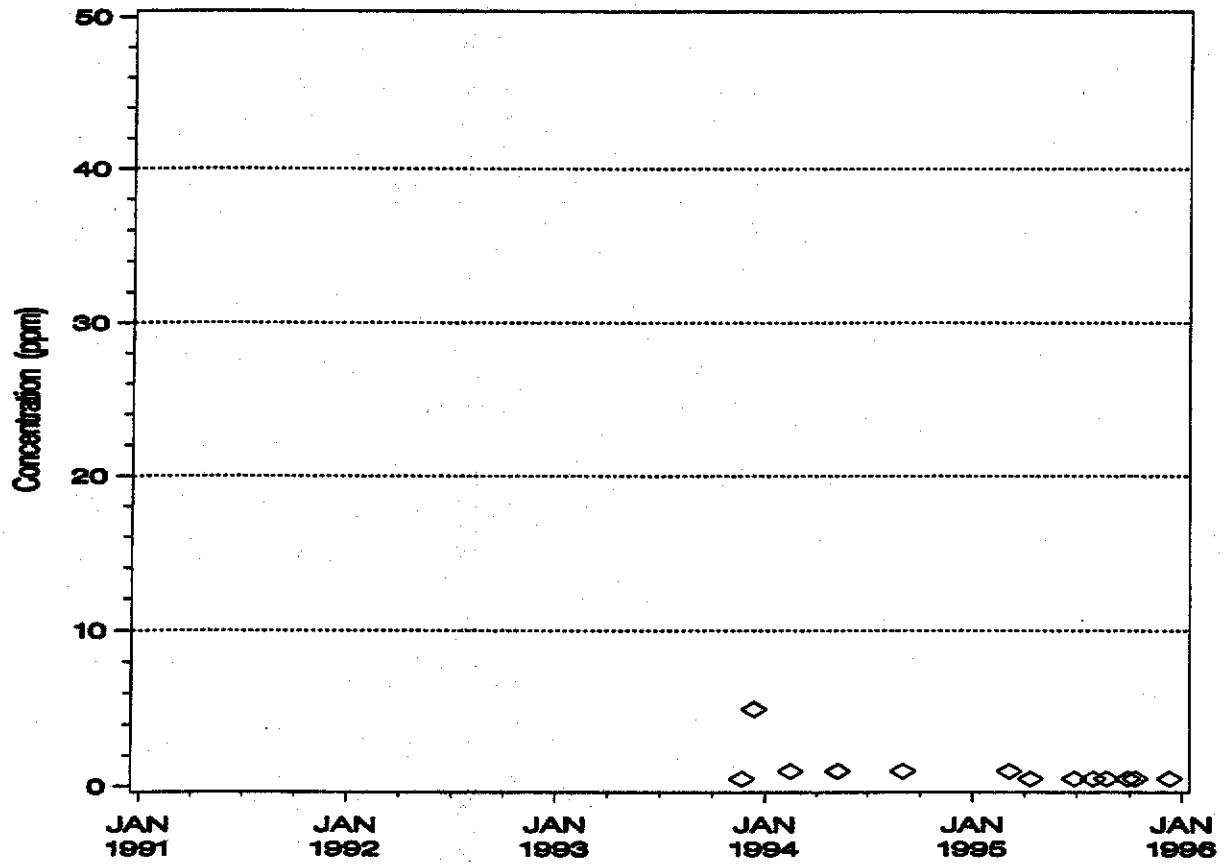


WELL 1560

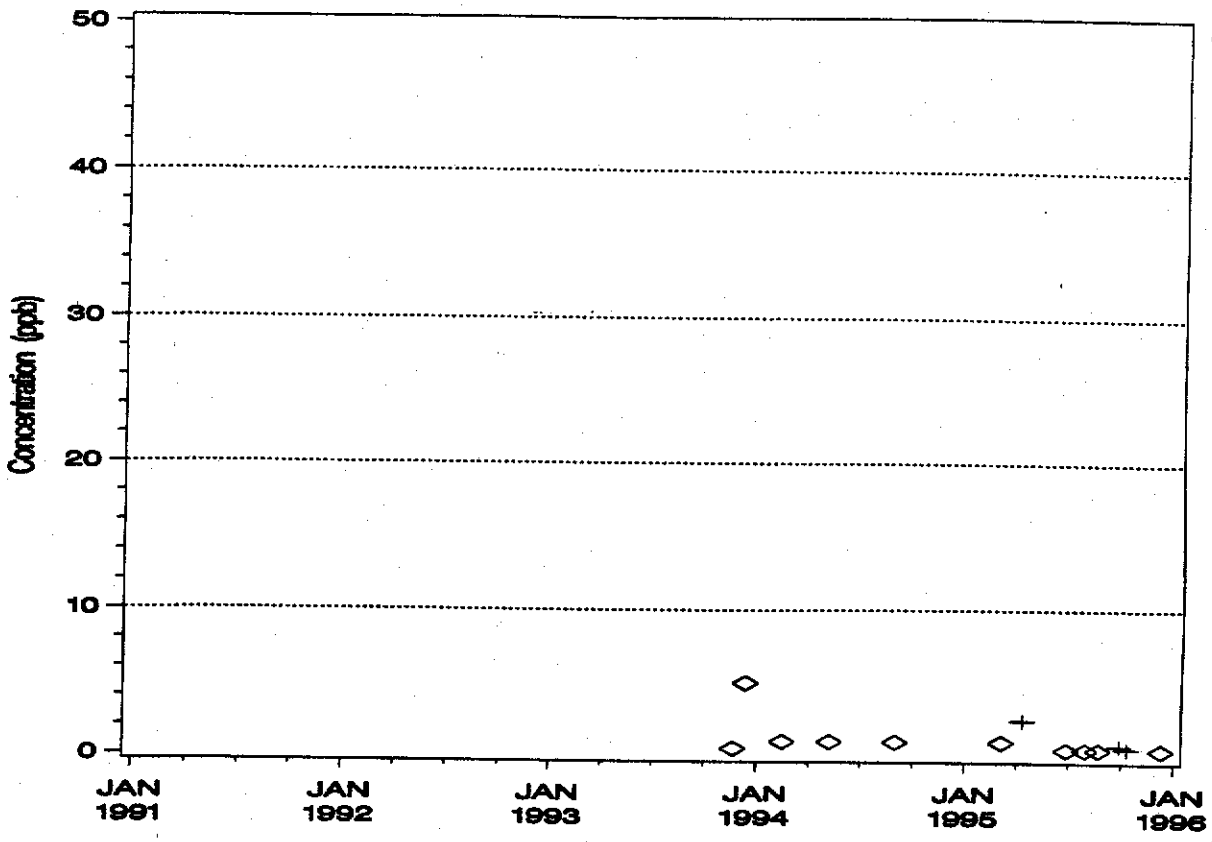
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



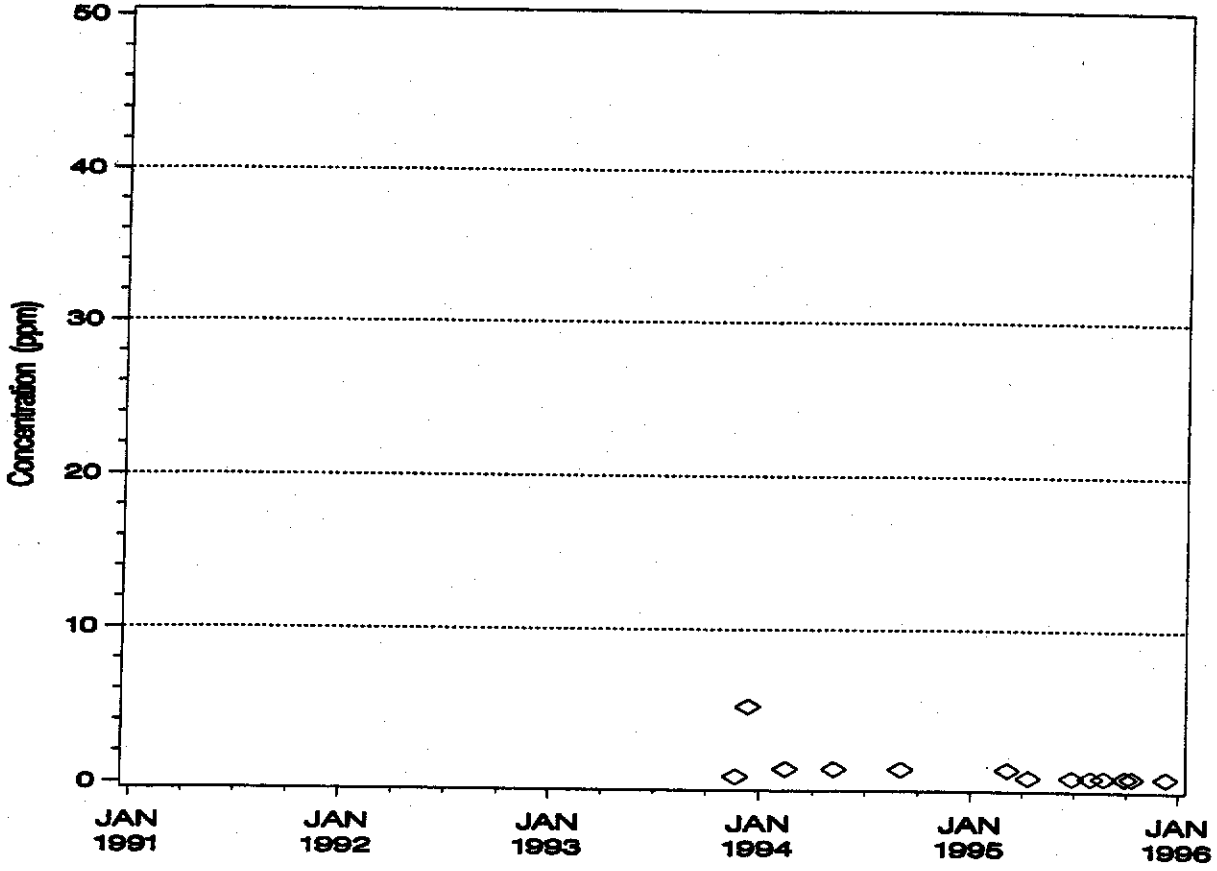
1,1 – DICHLOROETHYLENE Trend



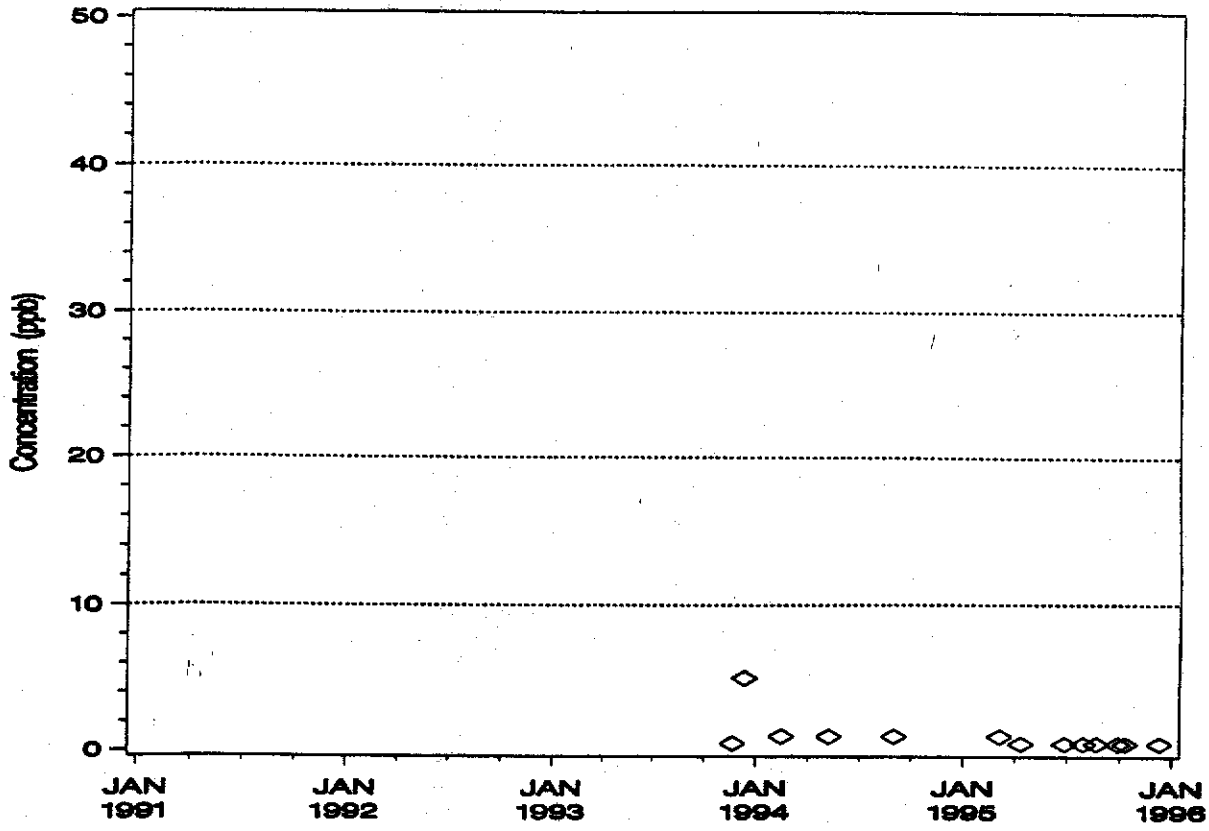
WELL 1561
TRICHLOROETHYLENE Trend



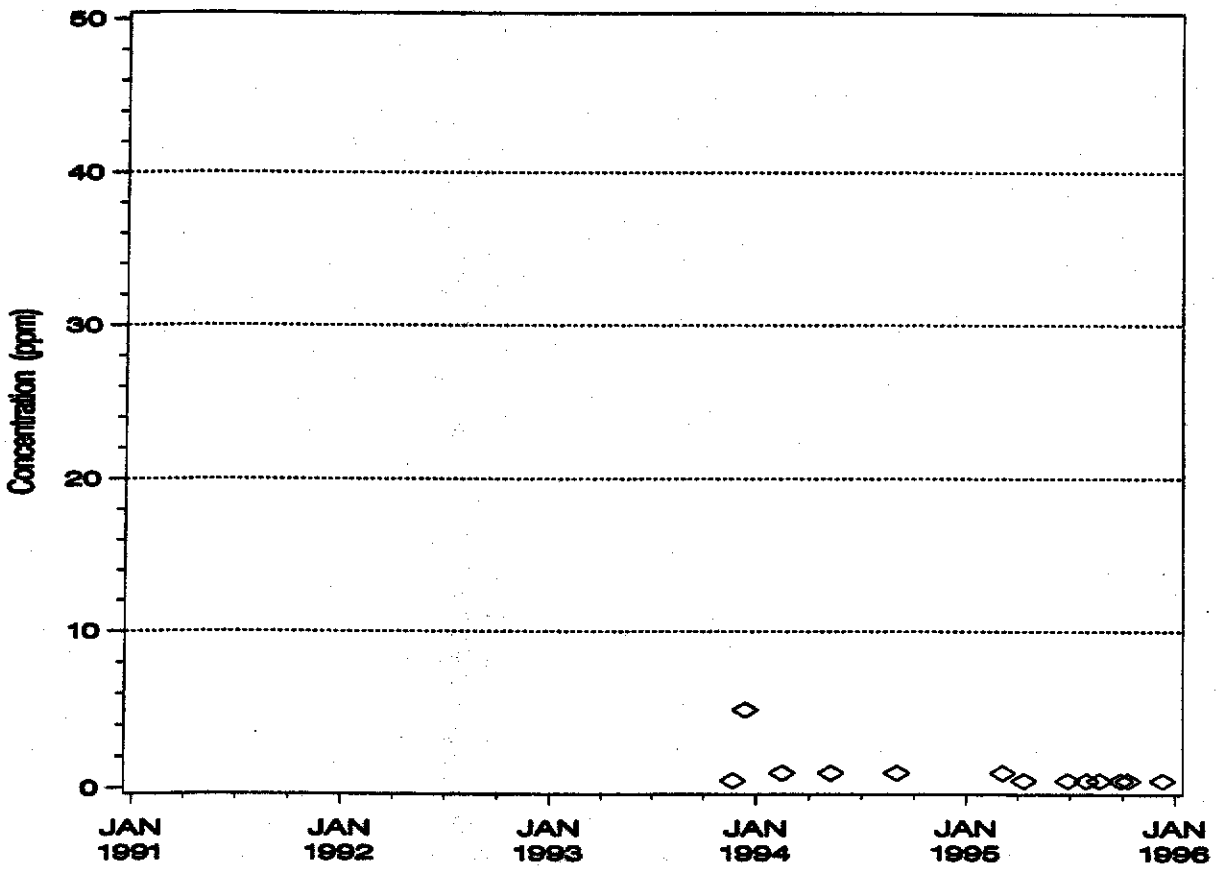
FREON 113 Trend



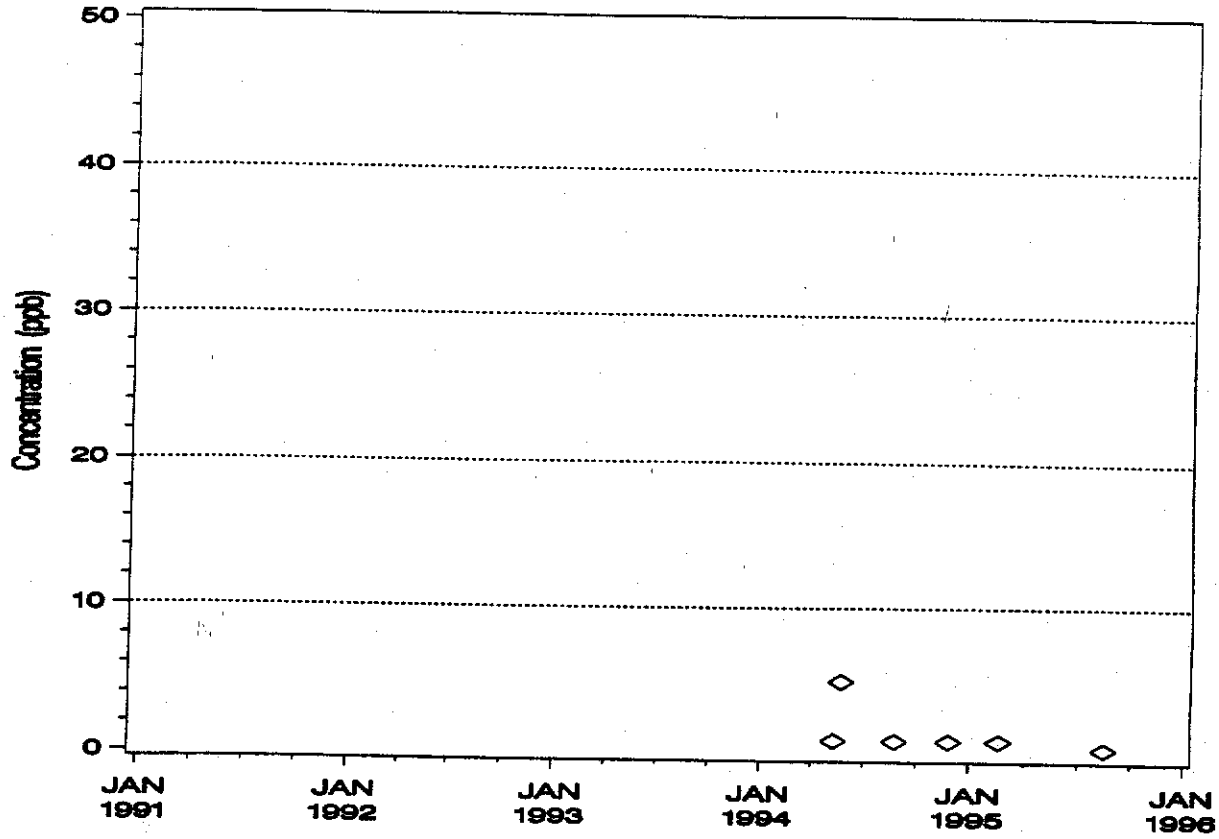
WELL 1561
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



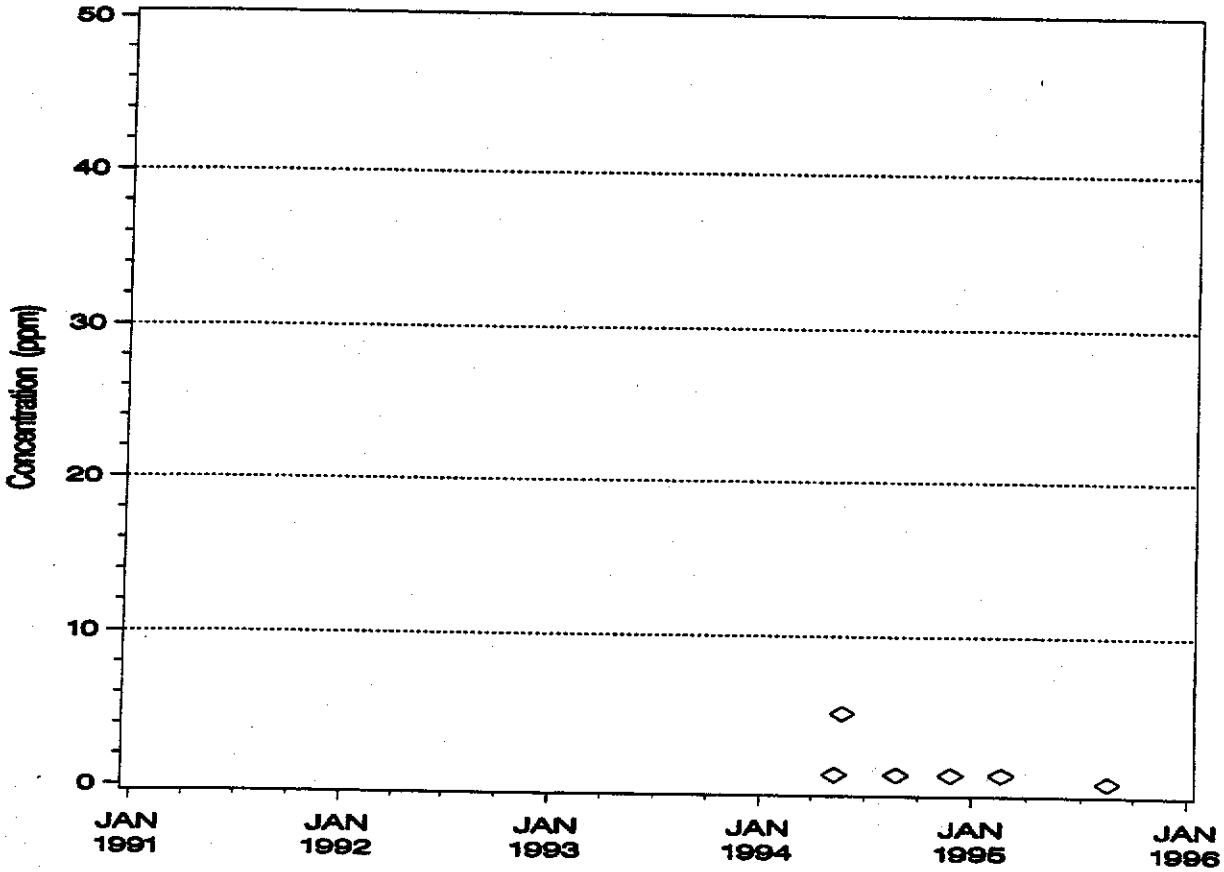
1,1 – DICHLOROETHYLENE Trend



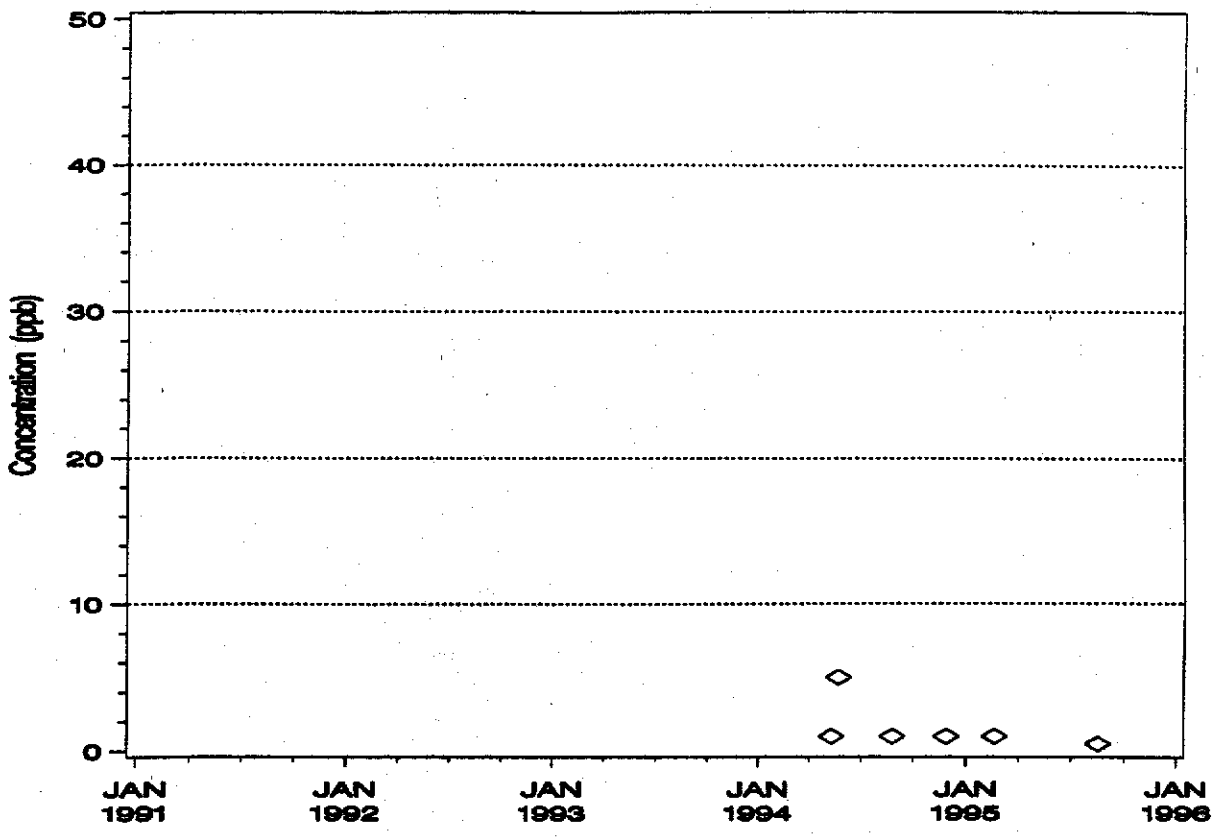
WELL 1562
TRICHLOROETHYLENE Trend



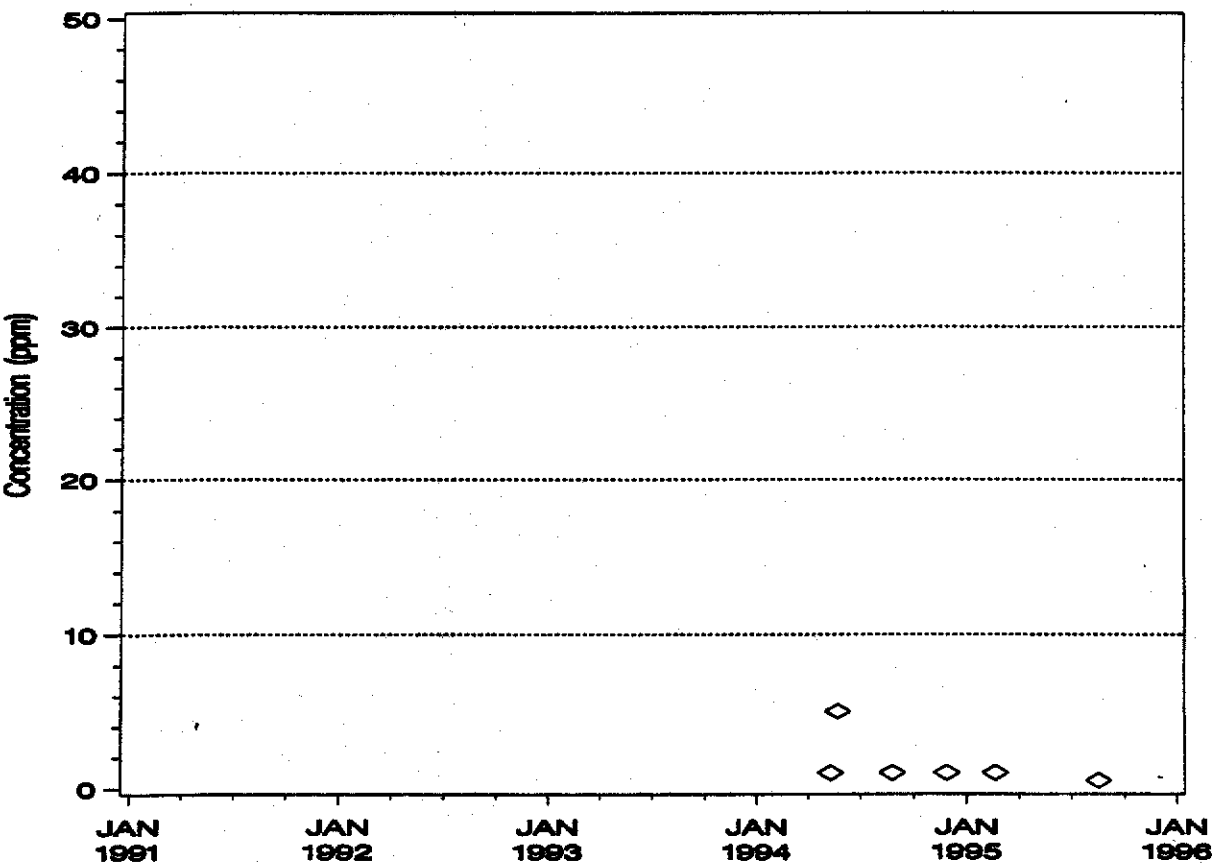
FREON 113 Trend



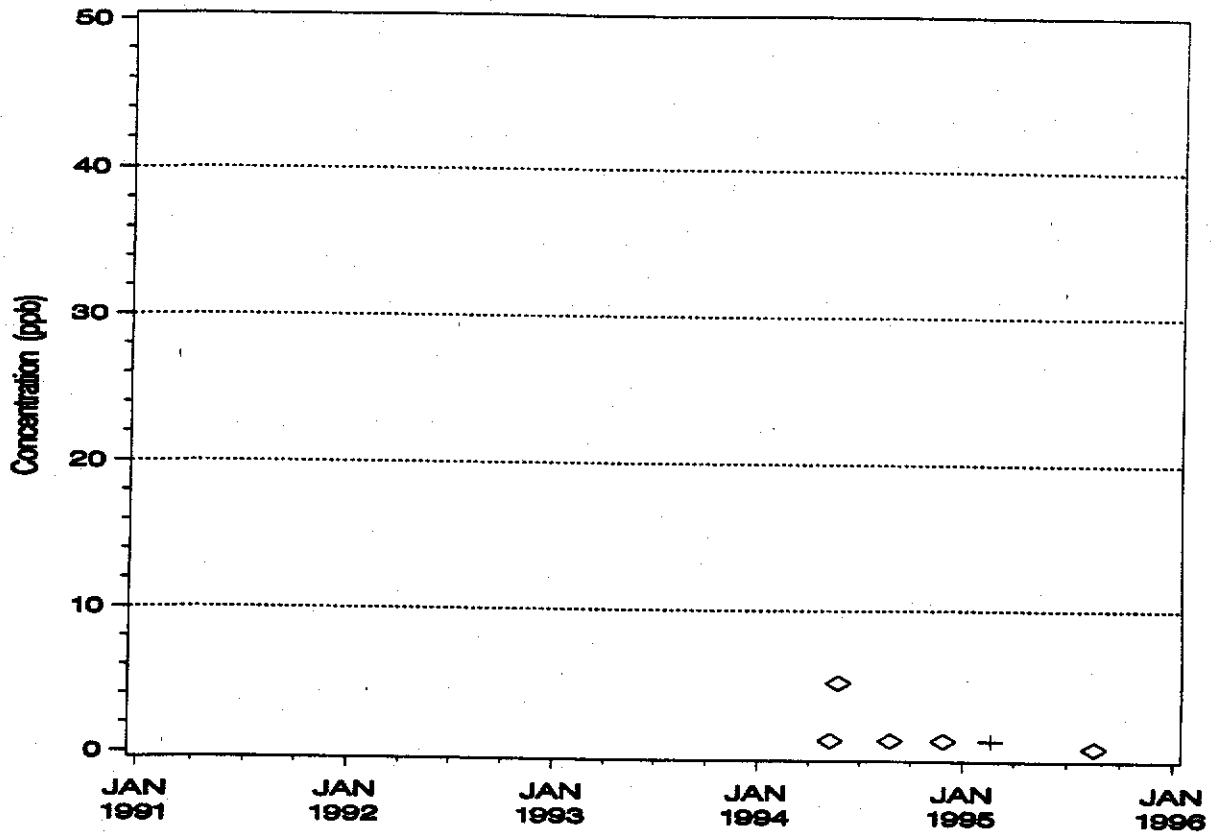
WELL 1562
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



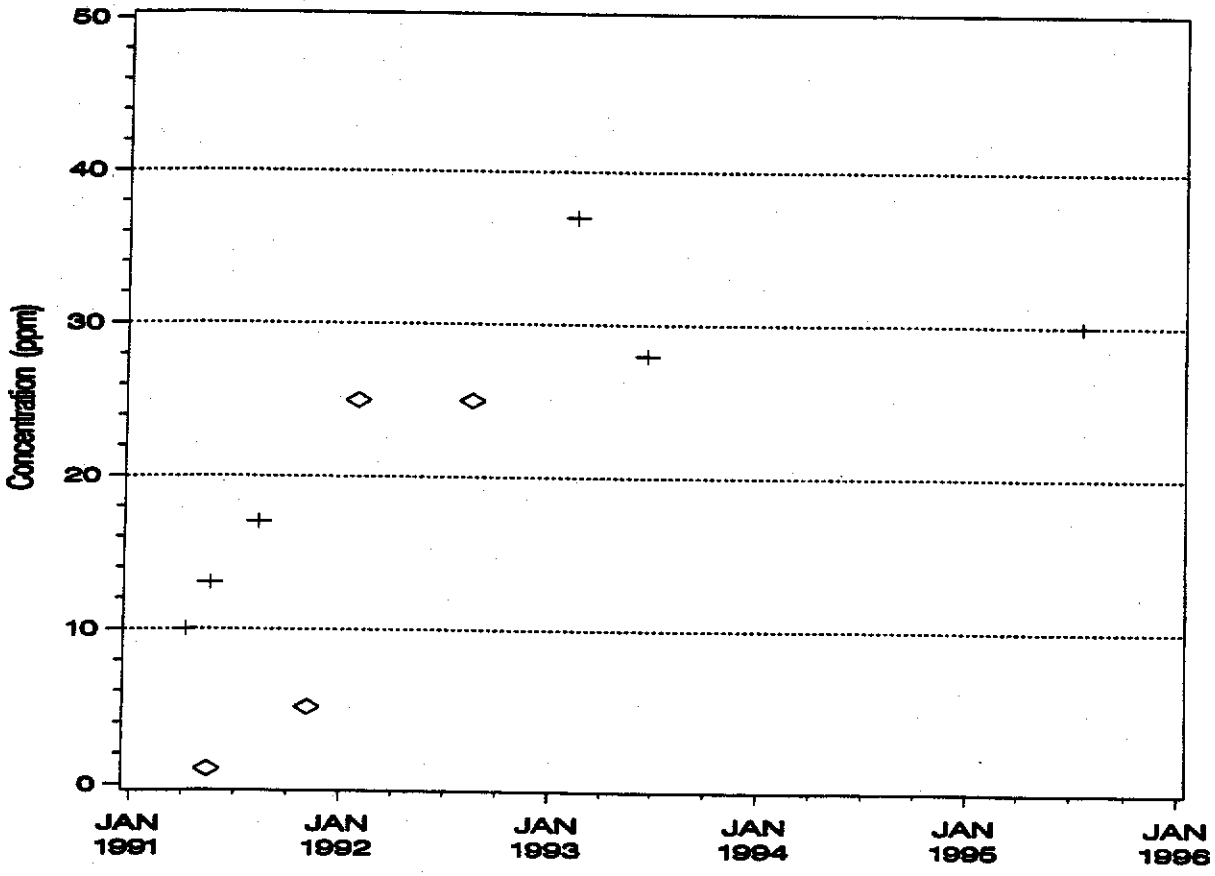
1,1 – DICHLOROETHYLENE Trend



WELL 1563
TRICHLOROETHYLENE Trend

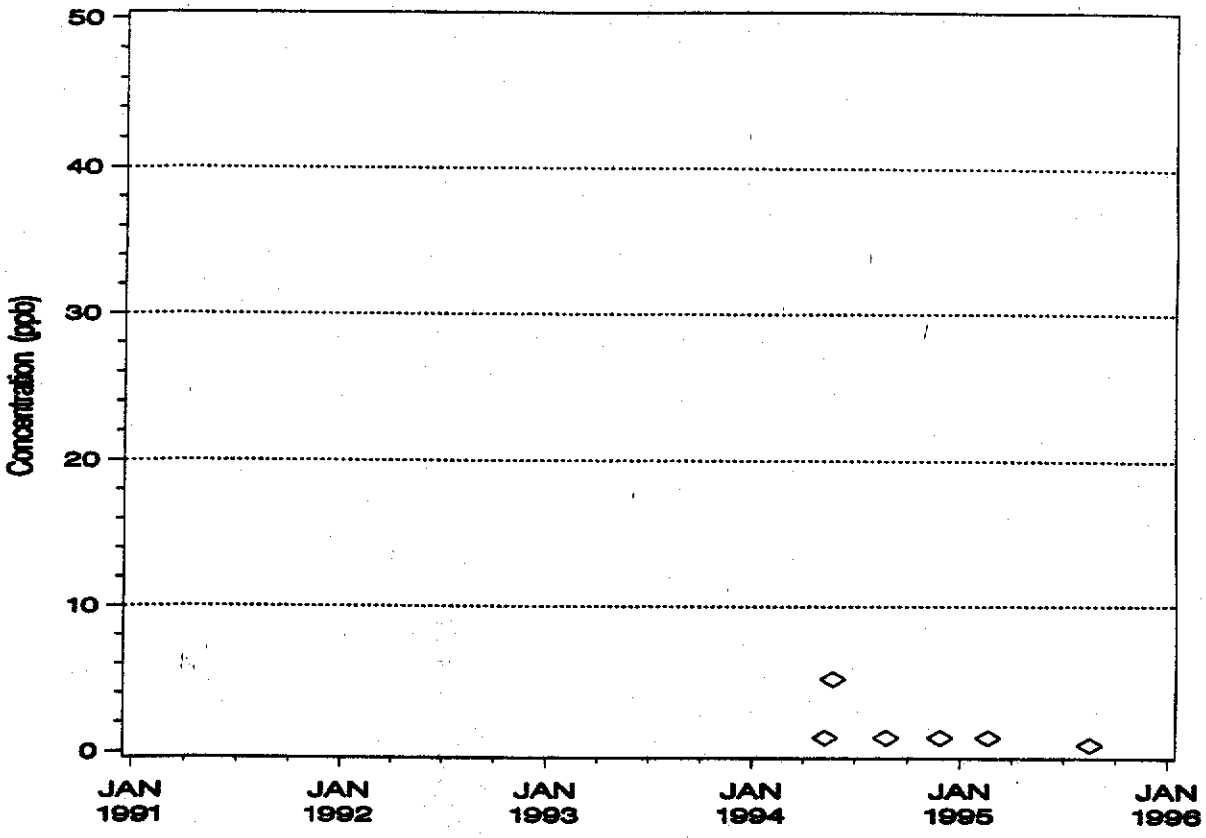


FREON 113 Trend

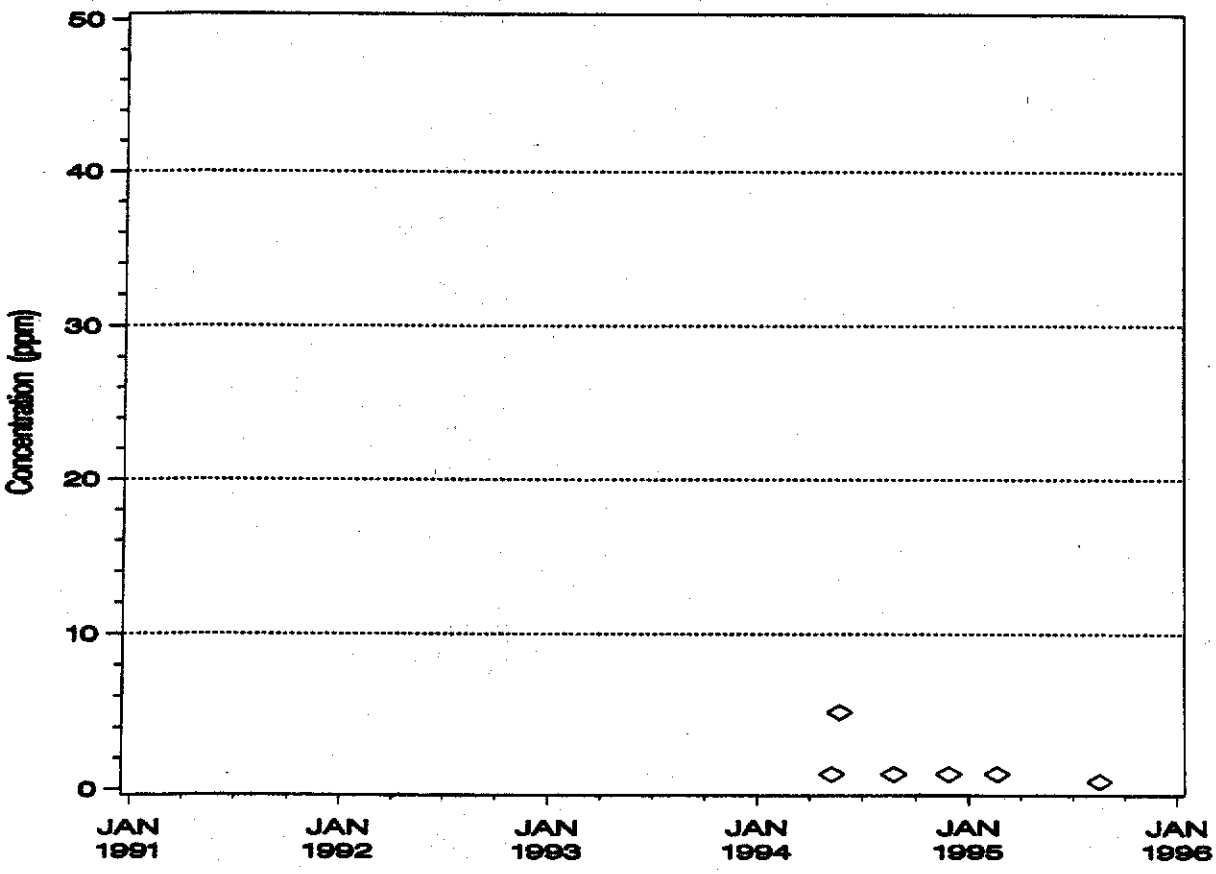


WELL 1563

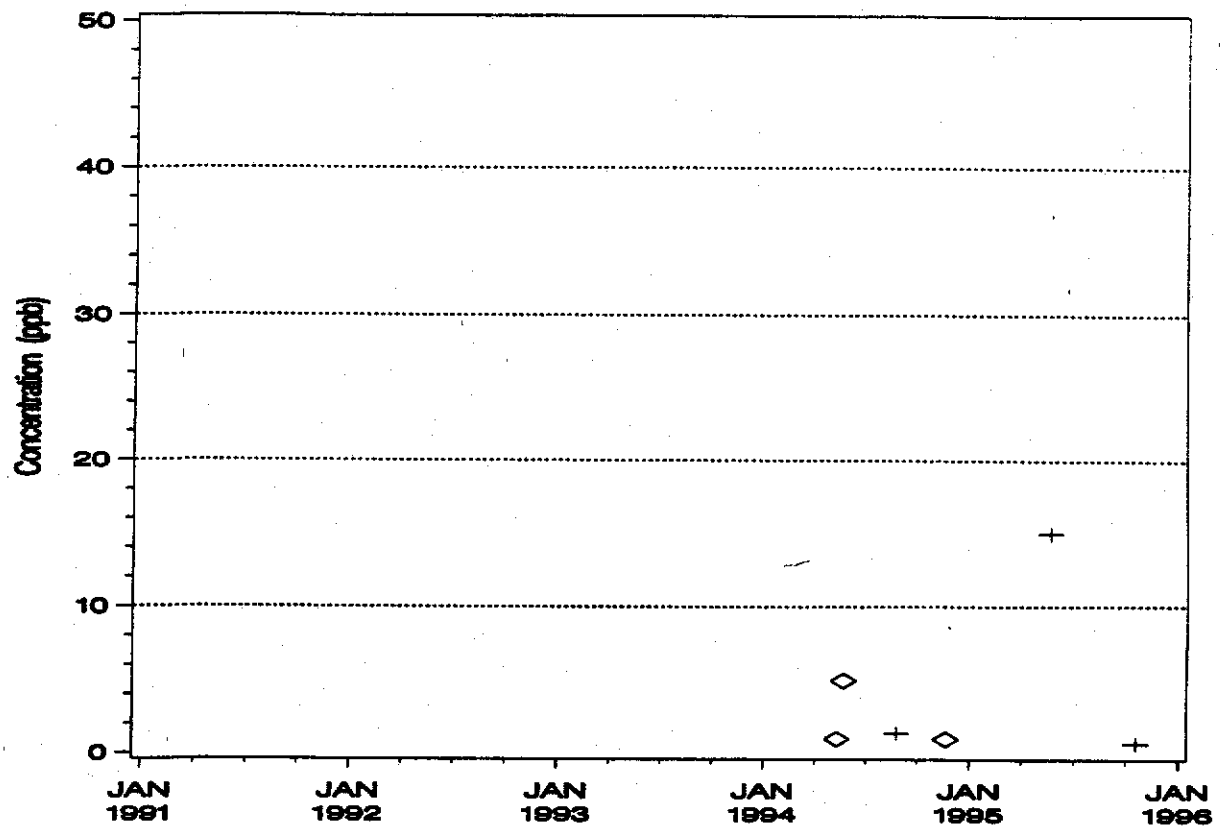
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



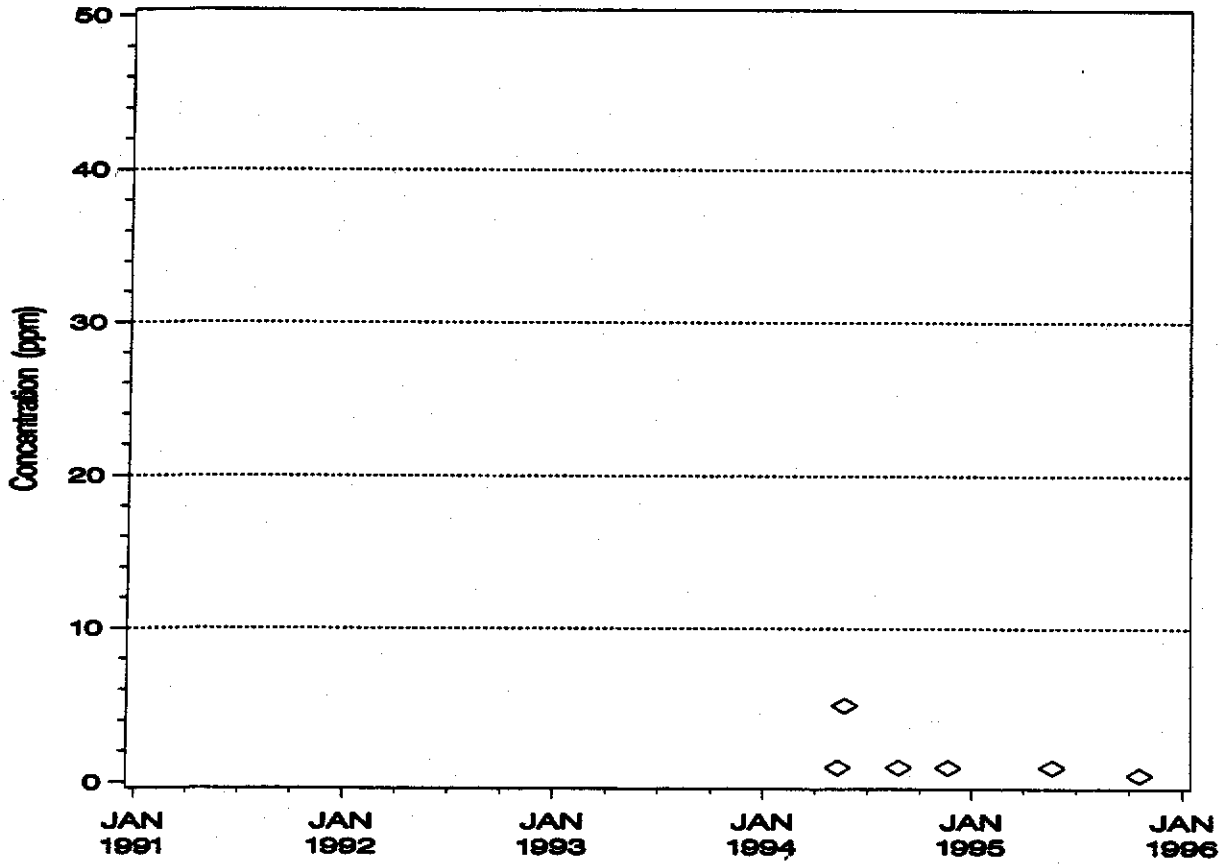
1,1 – DICHLOROETHYLENE Trend



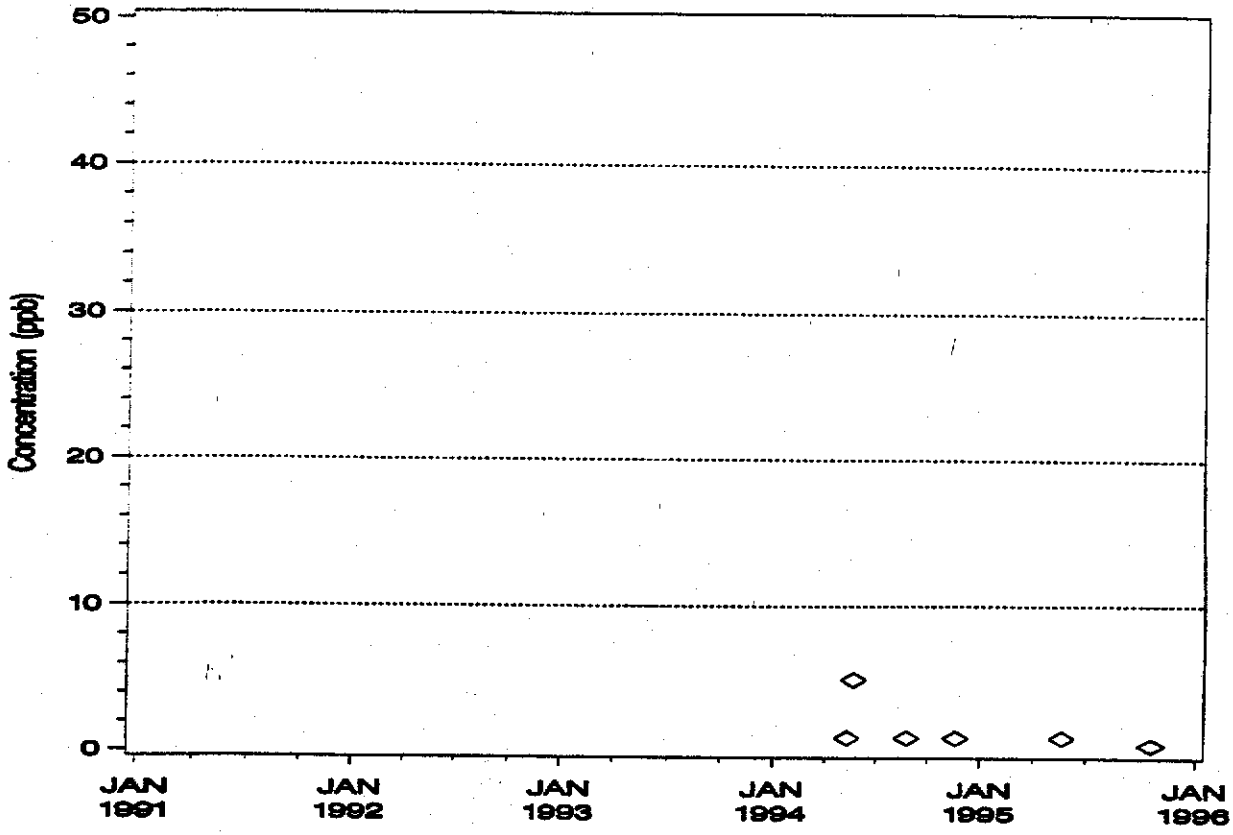
WELL 1564
TRICHLOROETHYLENE Trend



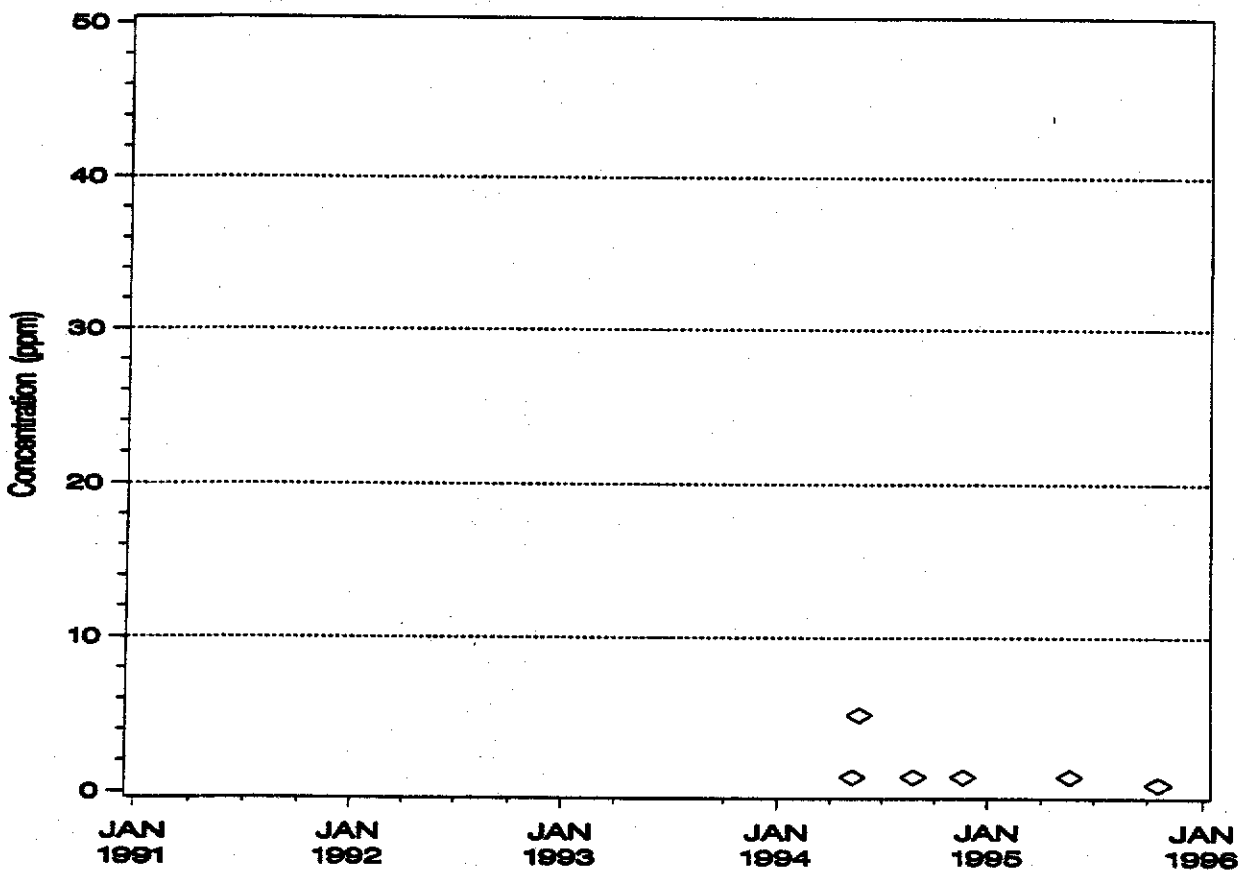
FREON 113 Trend



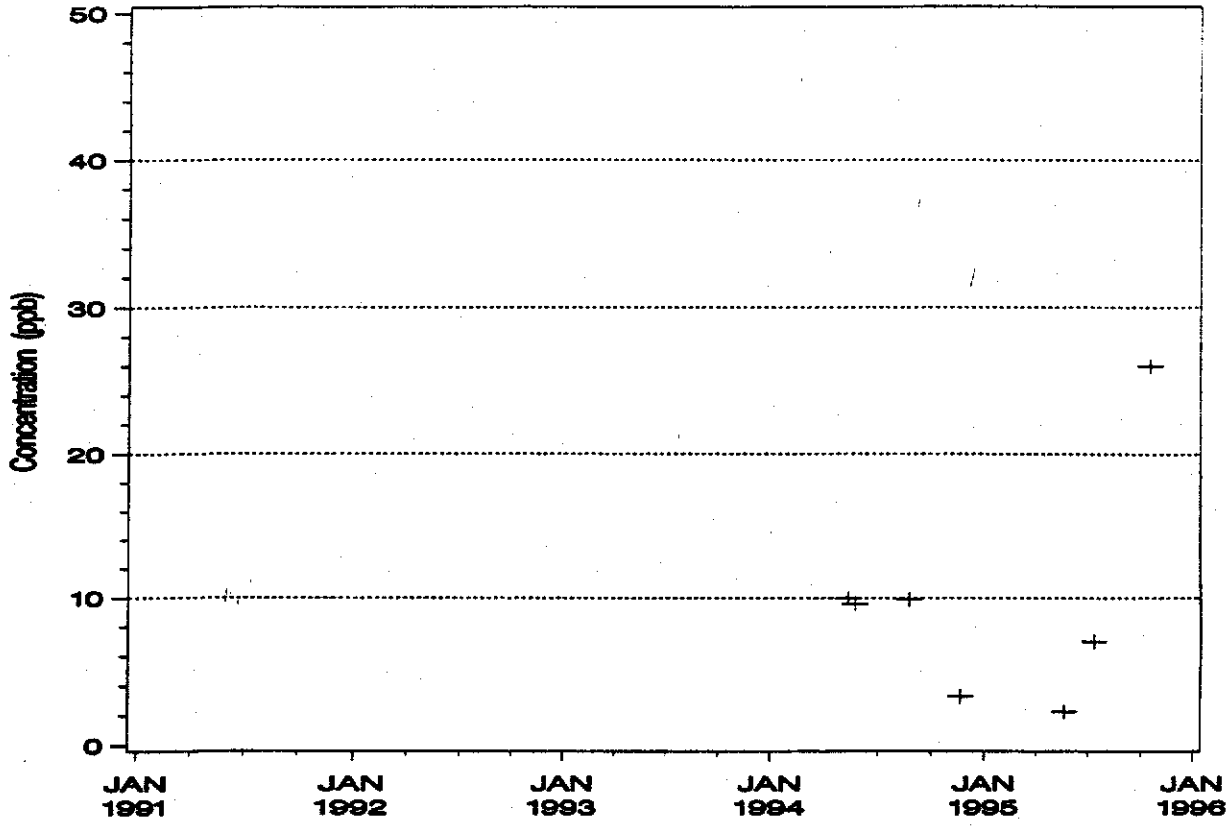
WELL 1564
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



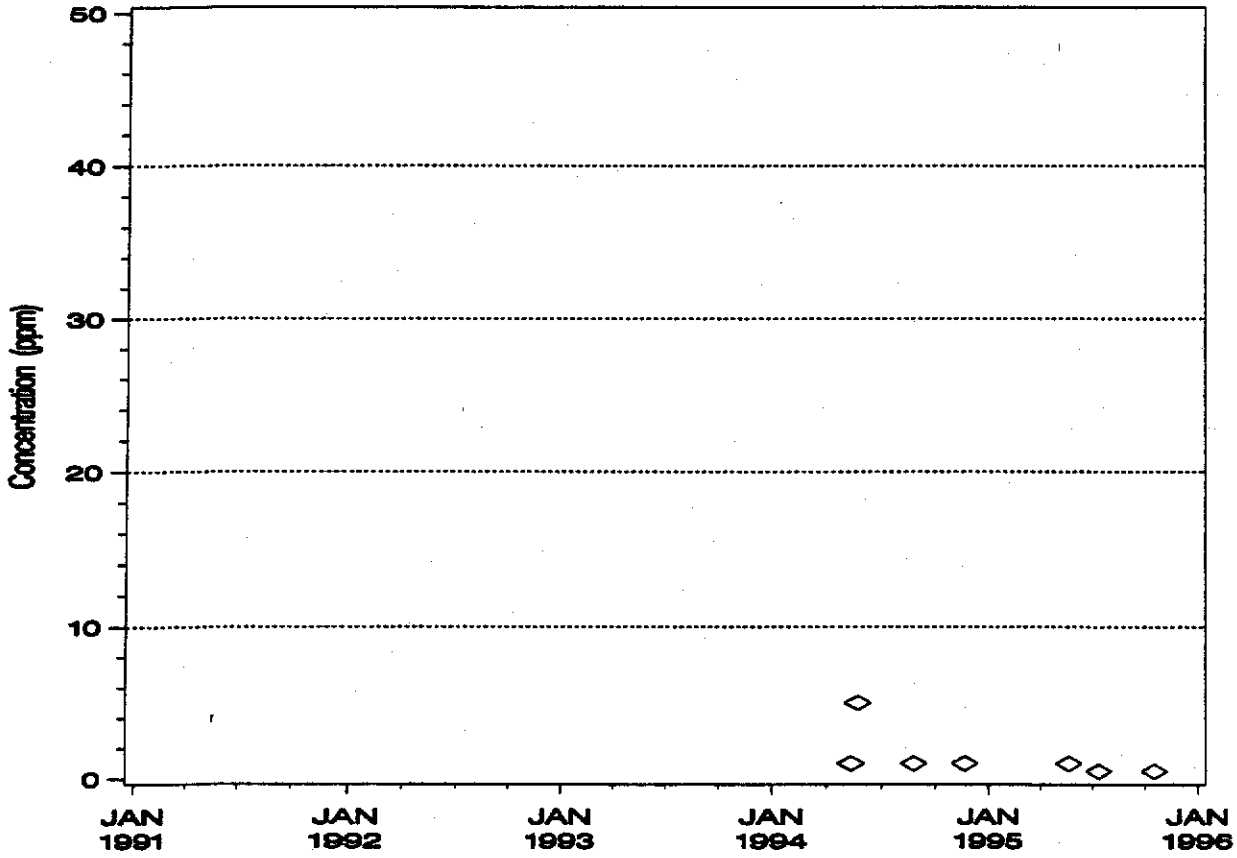
1,1 – DICHLOROETHYLENE Trend



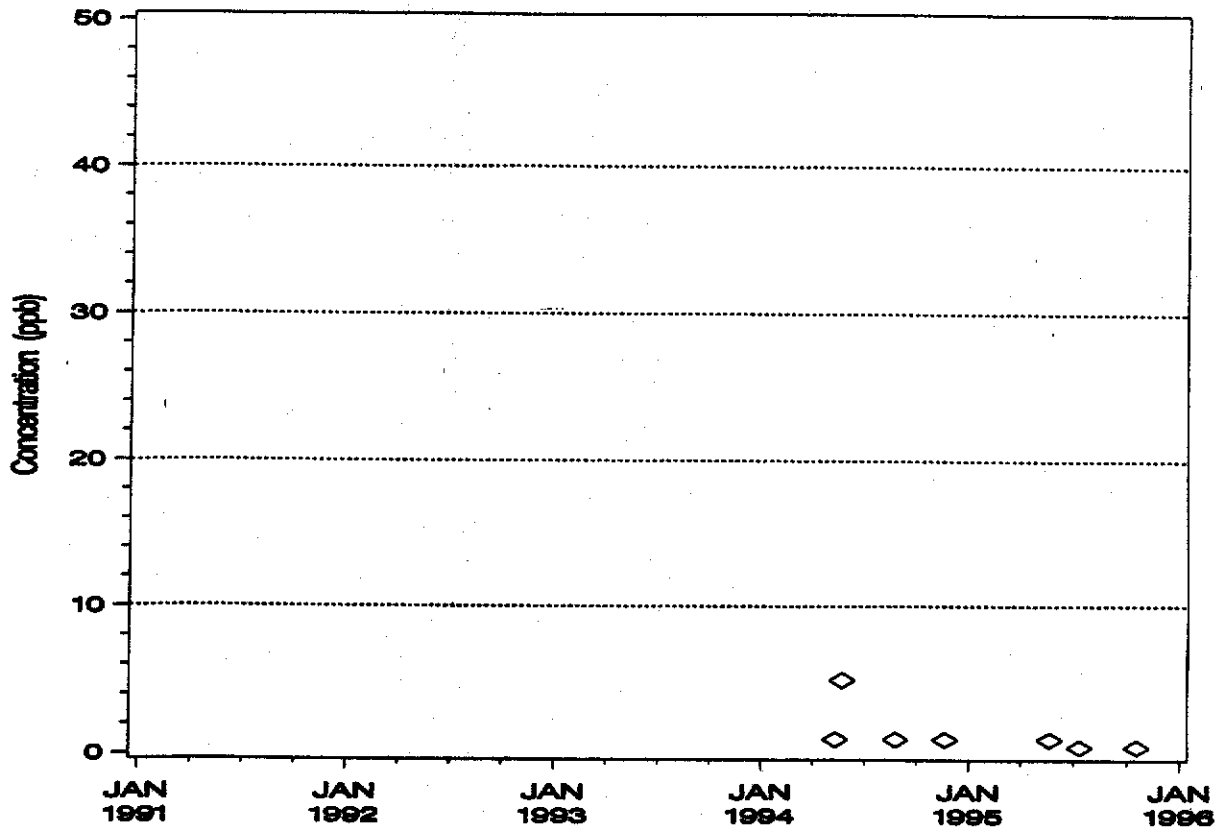
WELL 1565
TRICHLOROETHYLENE Trend



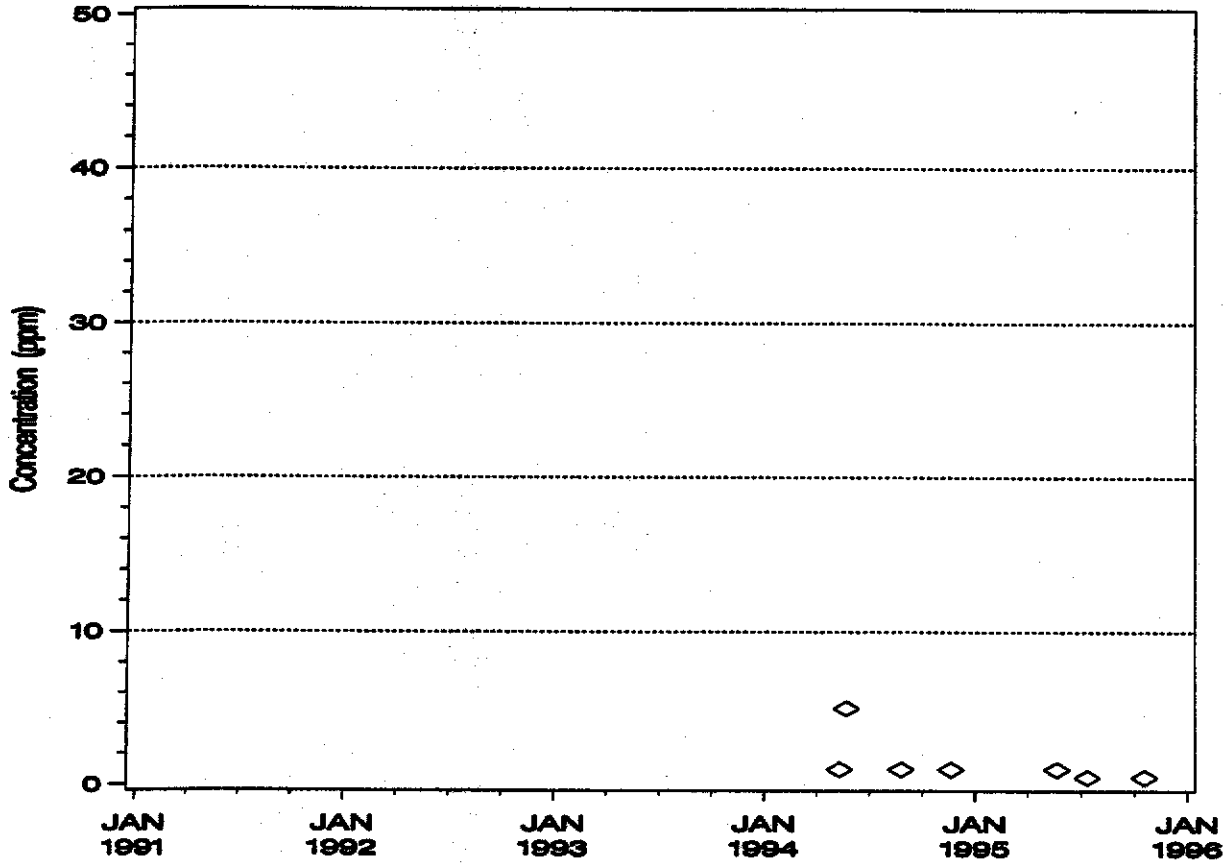
FREON 113 Trend



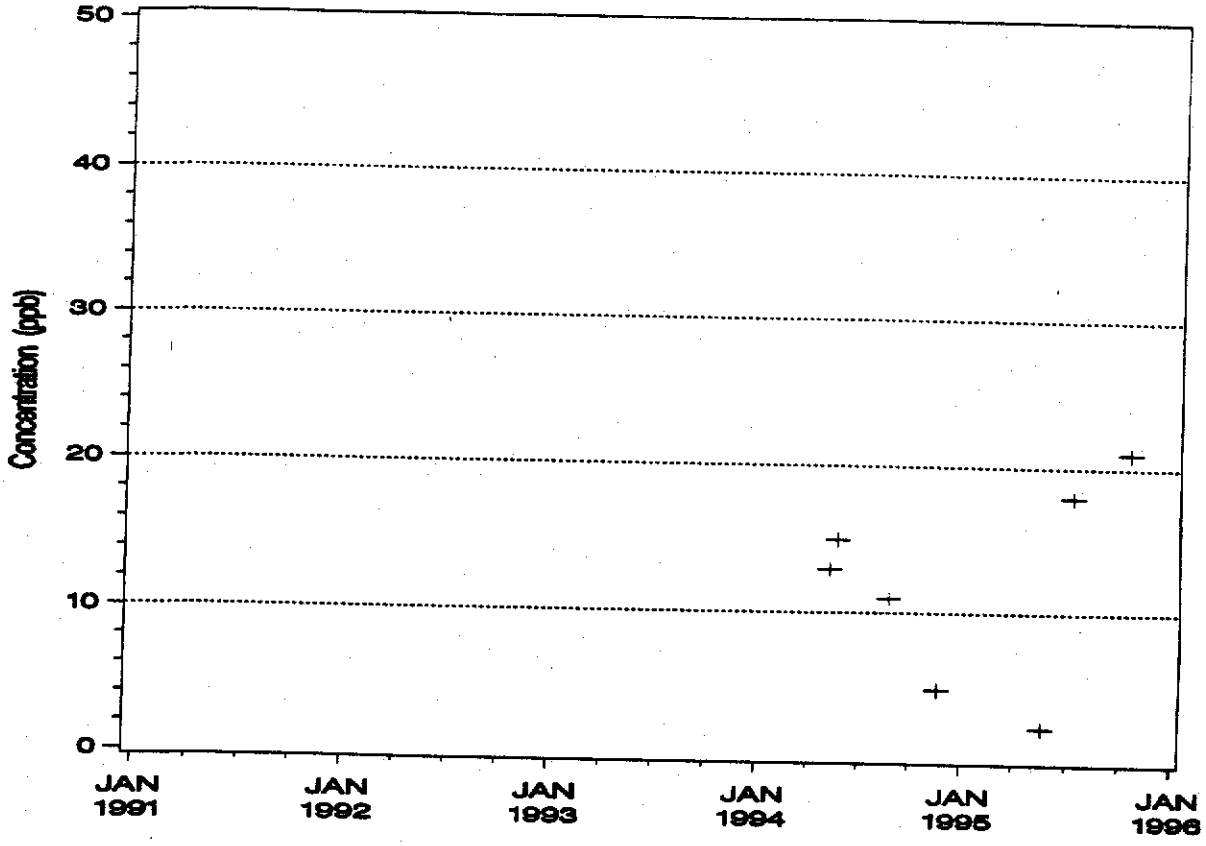
WELL 1565
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



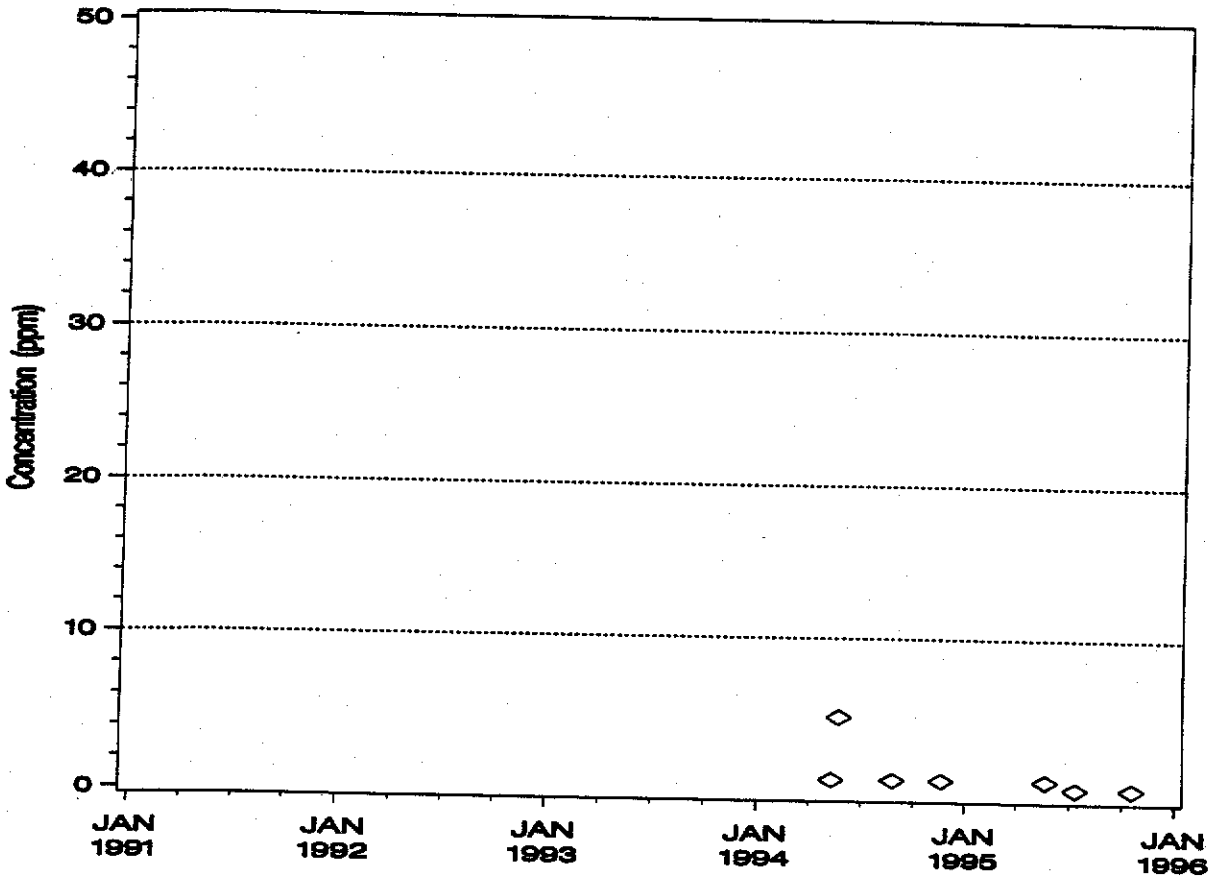
1,1 – DICHLOROETHYLENE Trend



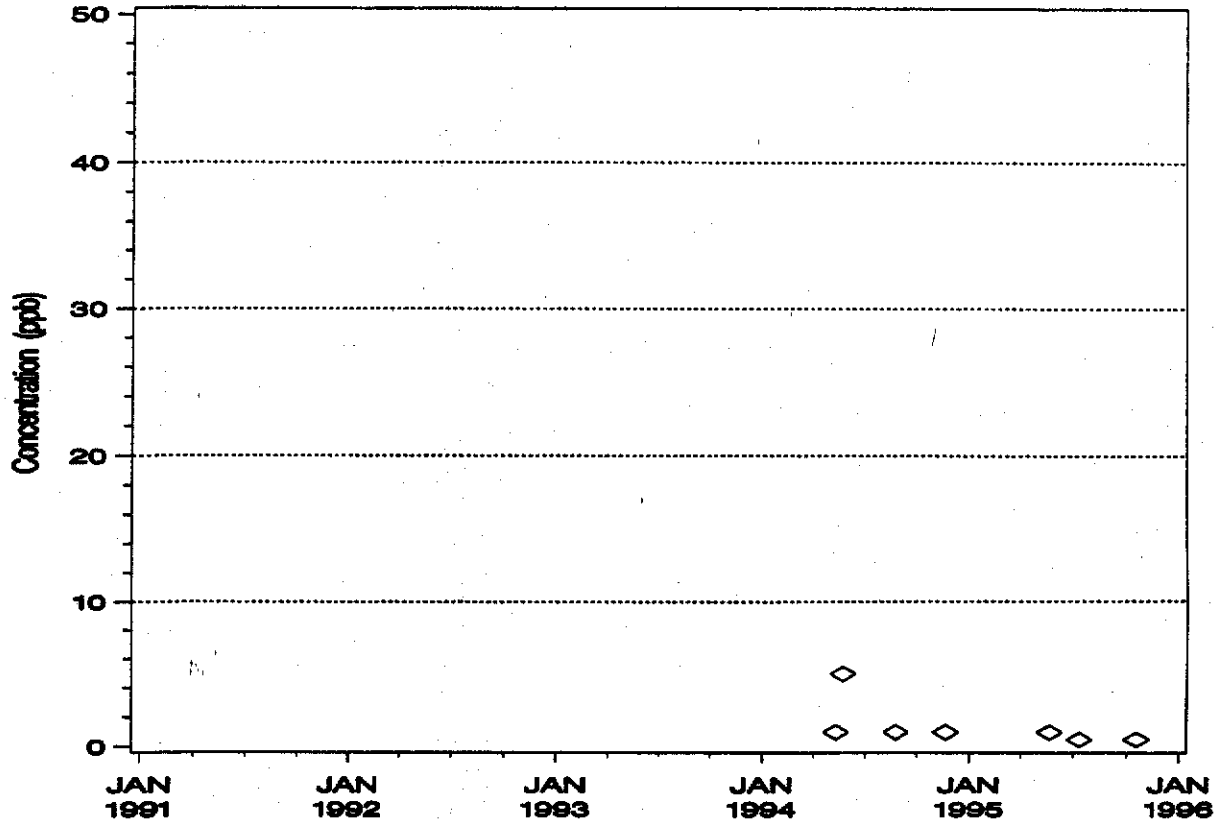
WELL 1566
TRICHLOROETHYLENE Trend



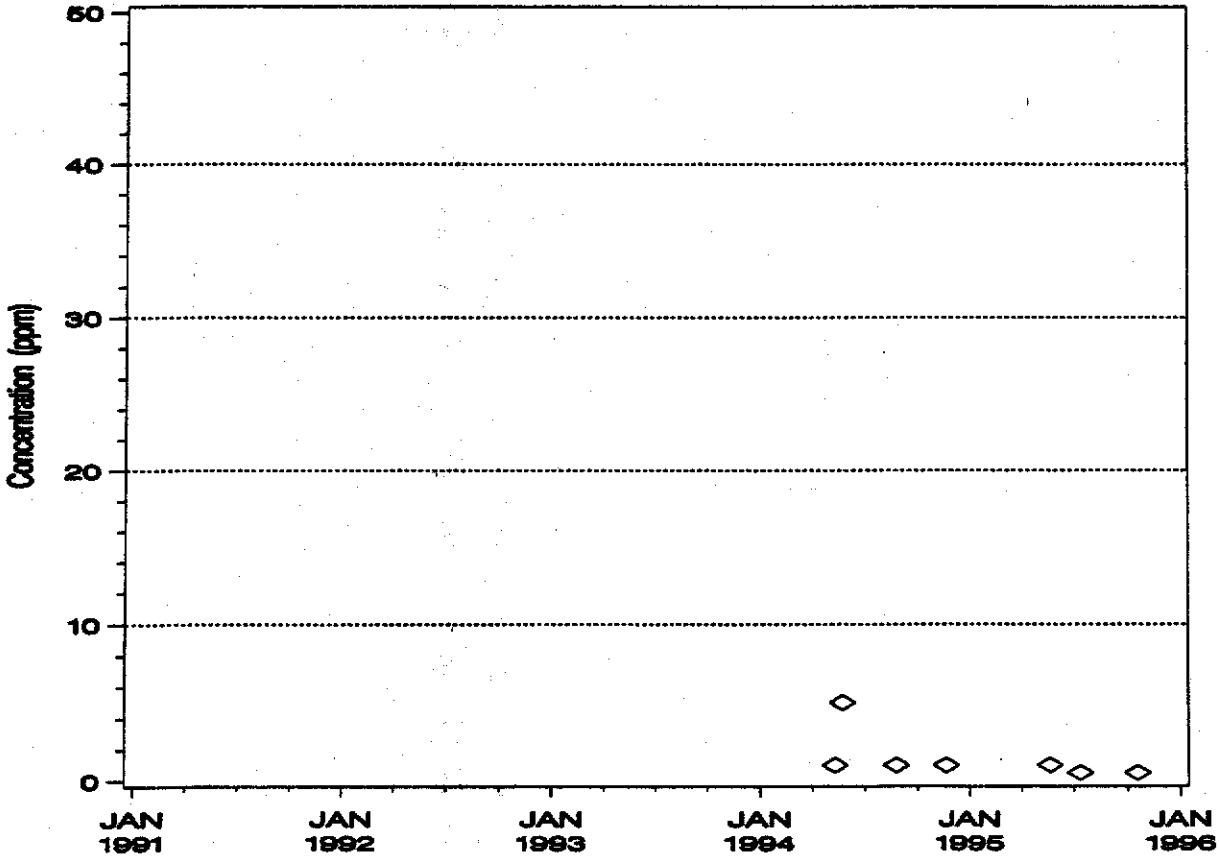
FREON 113 Trend



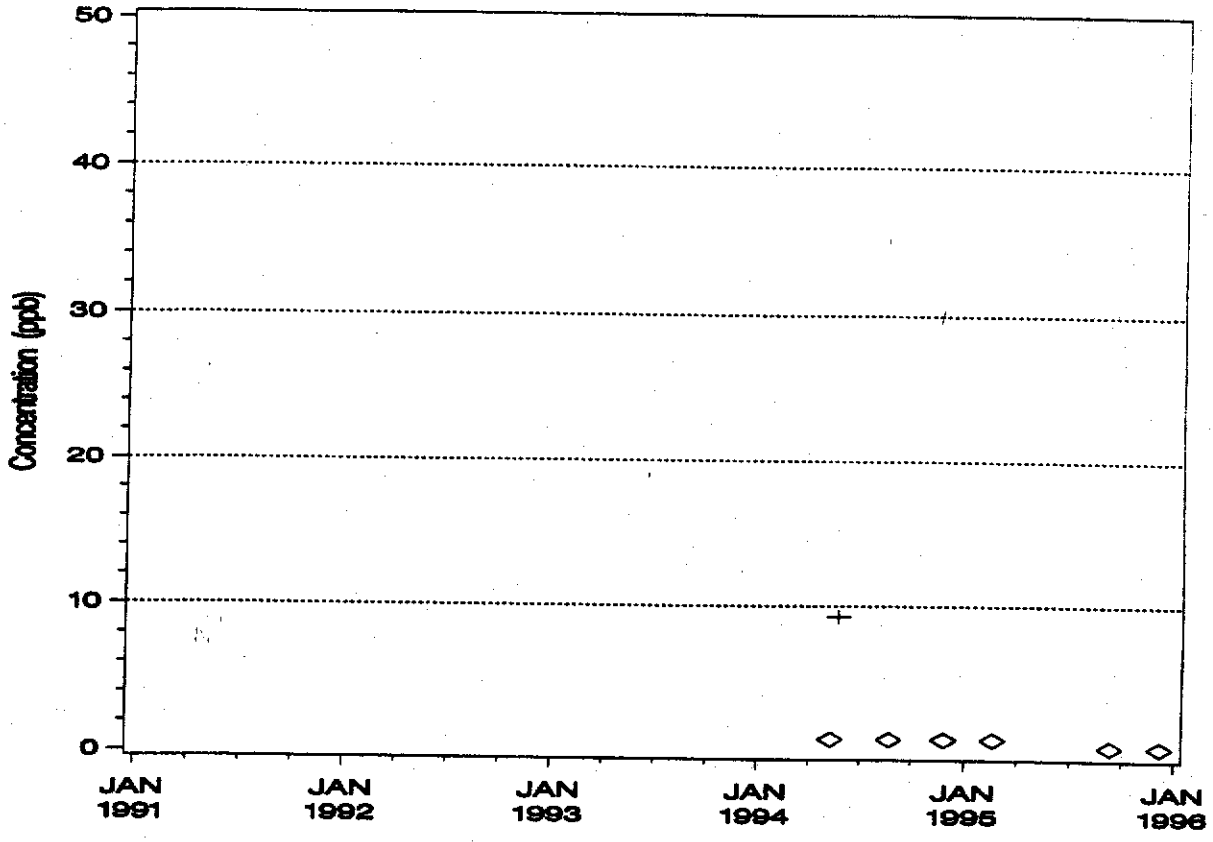
WELL 1566
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



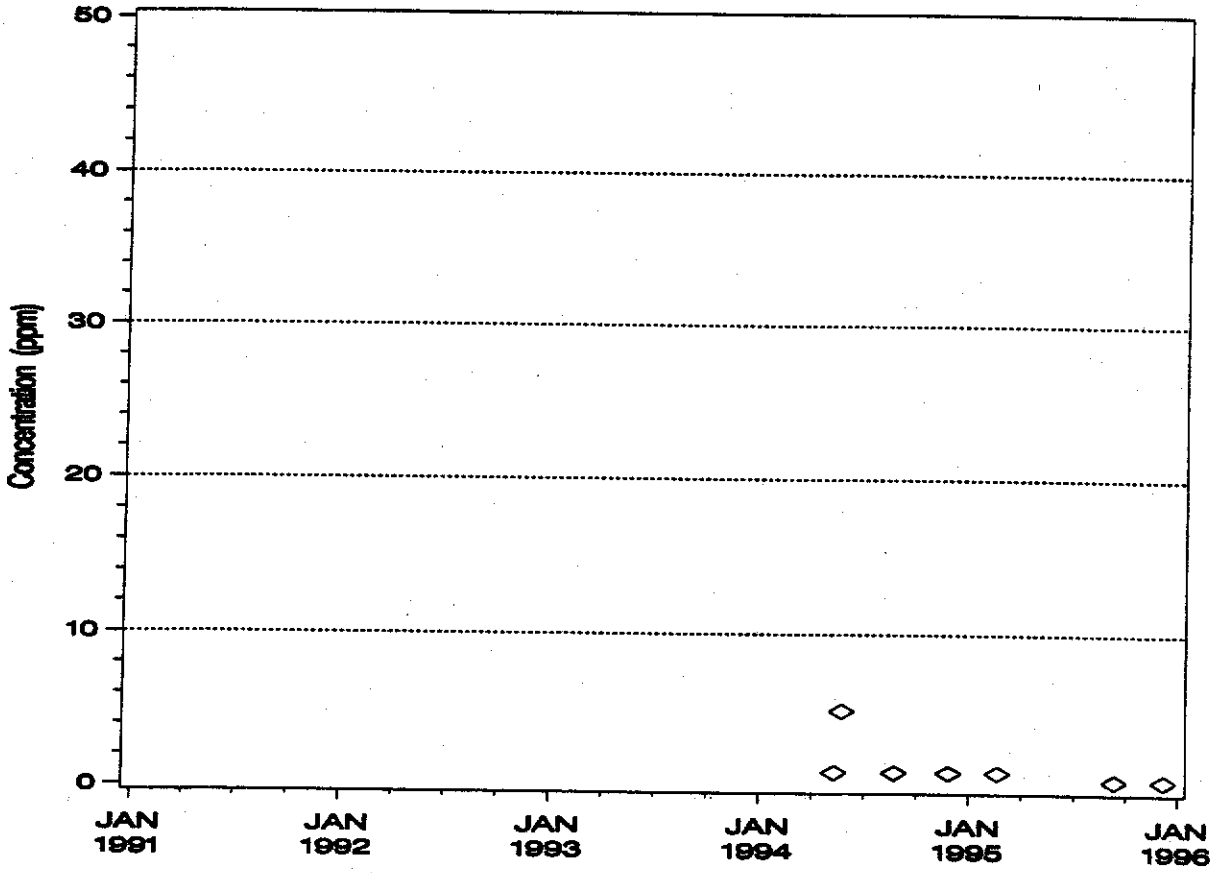
1,1 – DICHLOROETHYLENE Trend



WELL 1567
TRICHLOROETHYLENE Trend

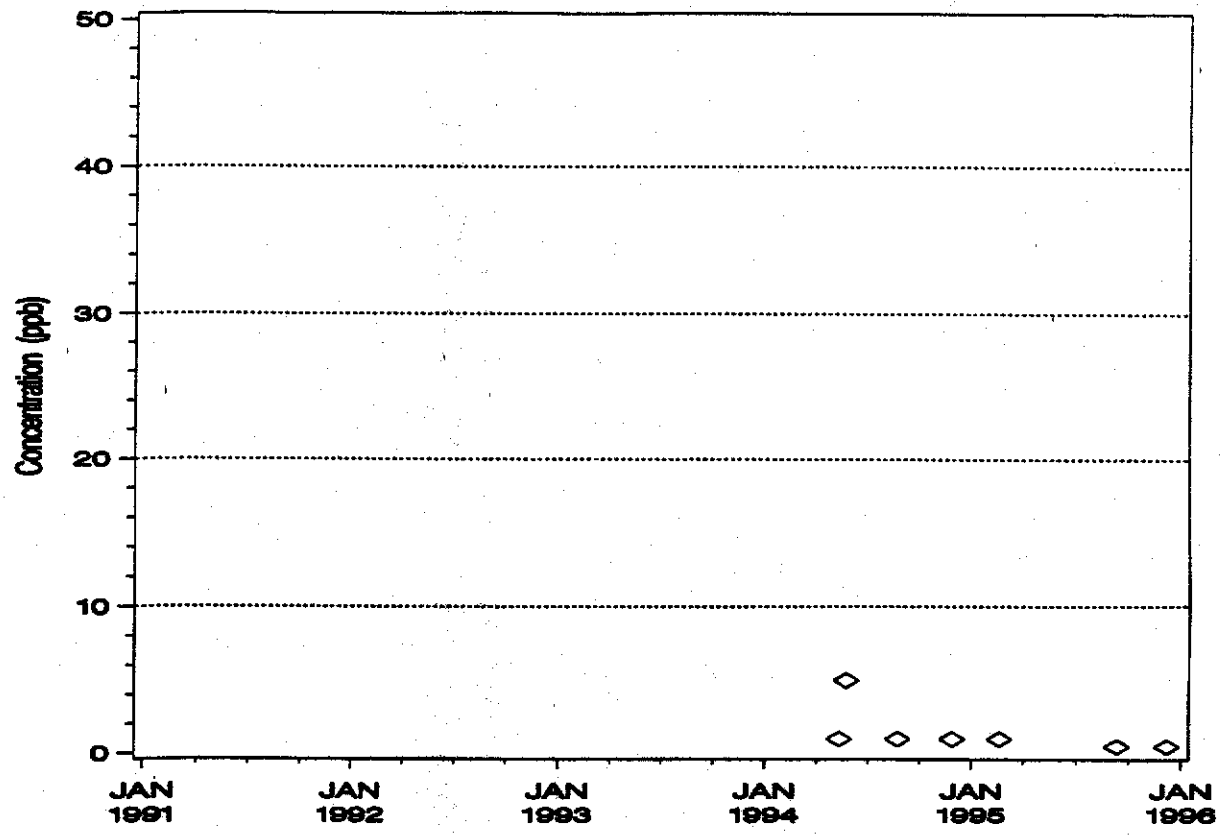


FREON 113 Trend

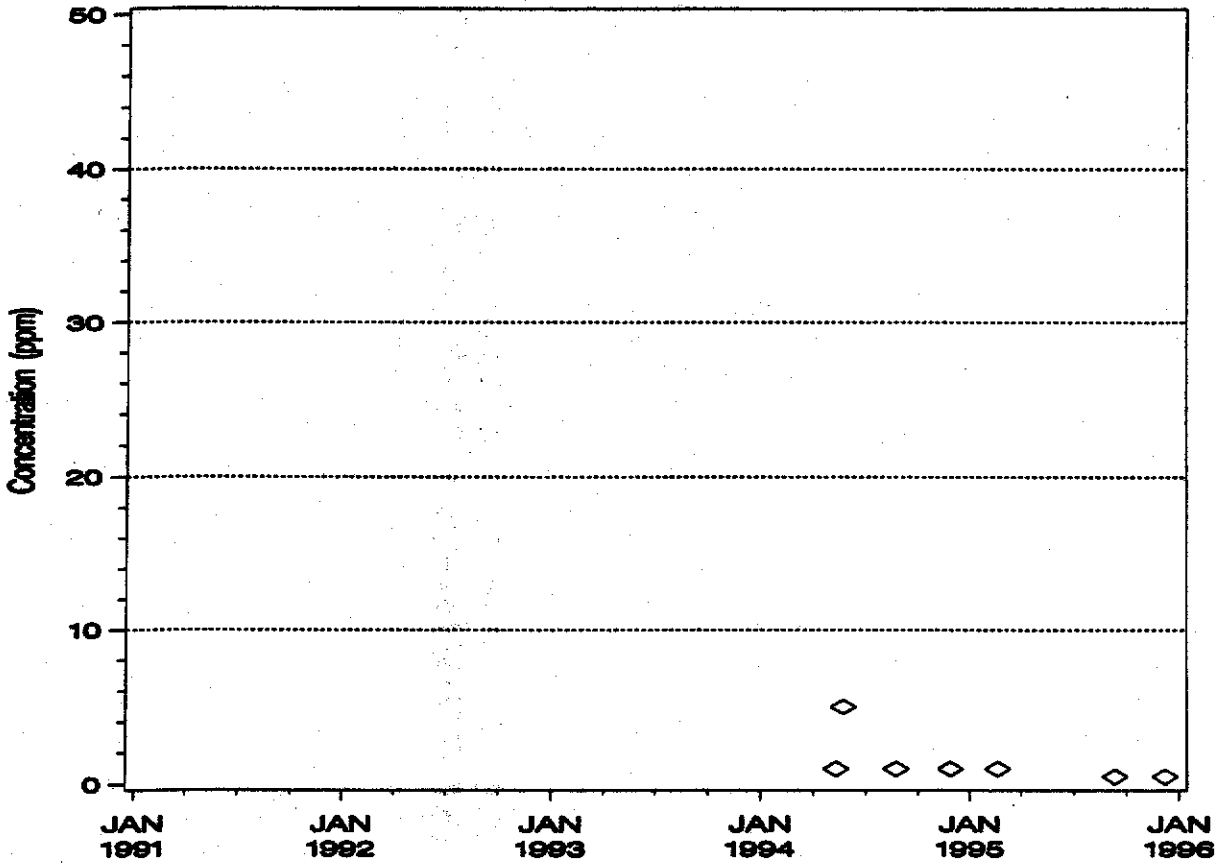


WELL 1567

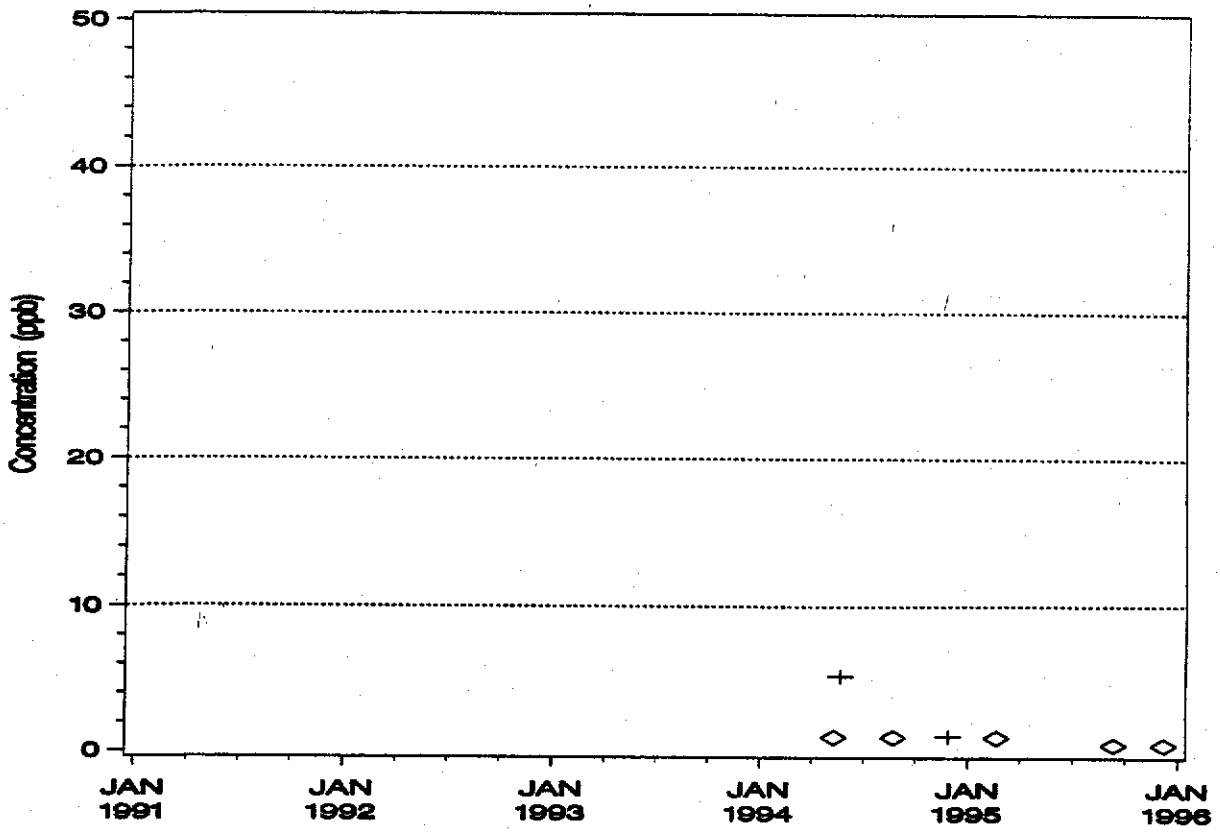
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



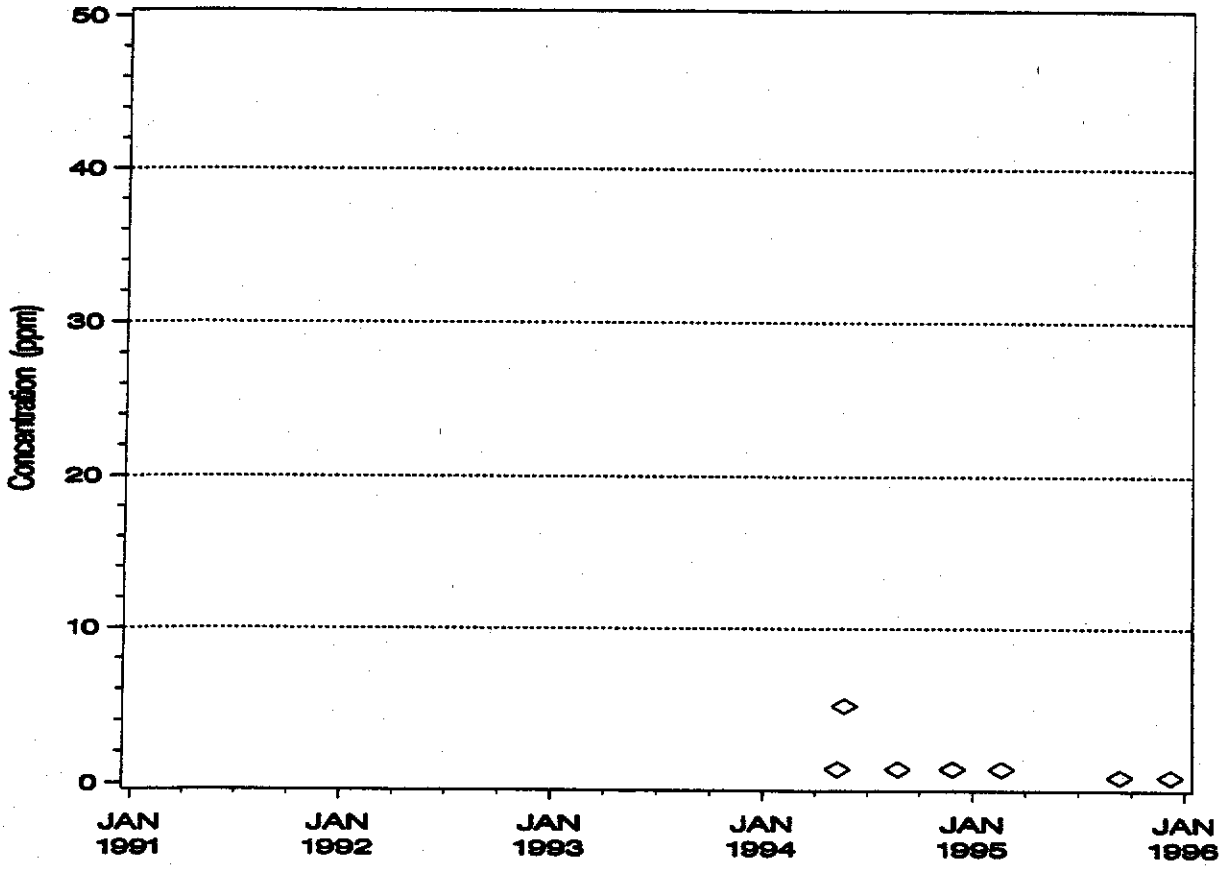
1,1 – DICHLOROETHYLENE Trend



WELL 1568
TRICHLOROETHYLENE Trend

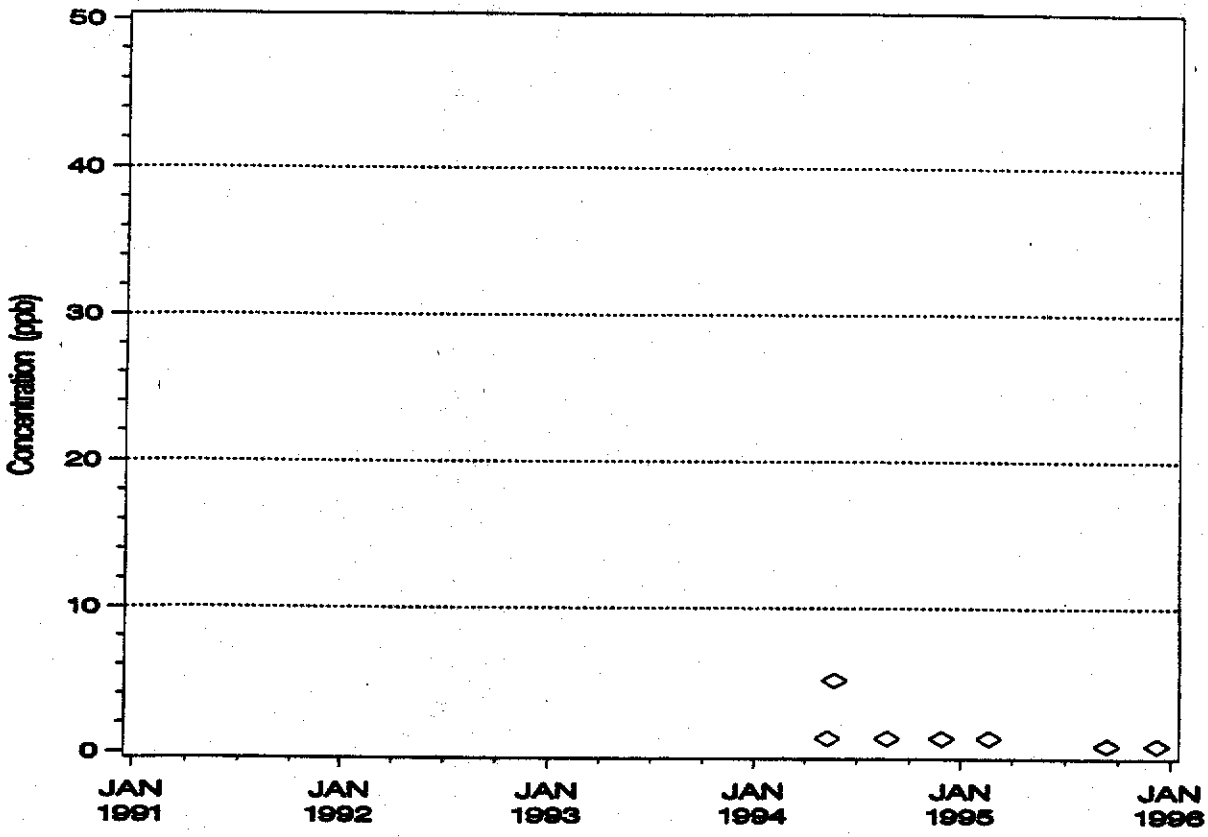


FREON 113 Trend

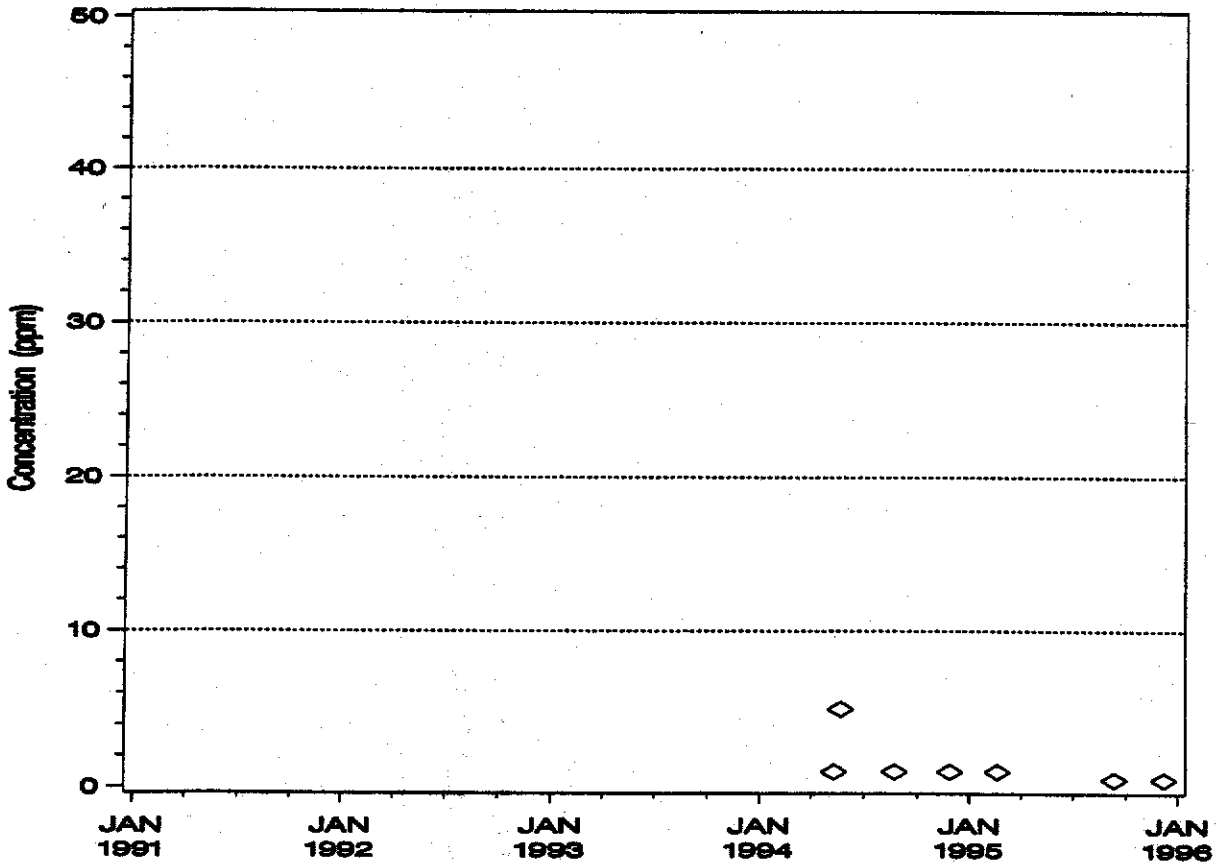


WELL 1568

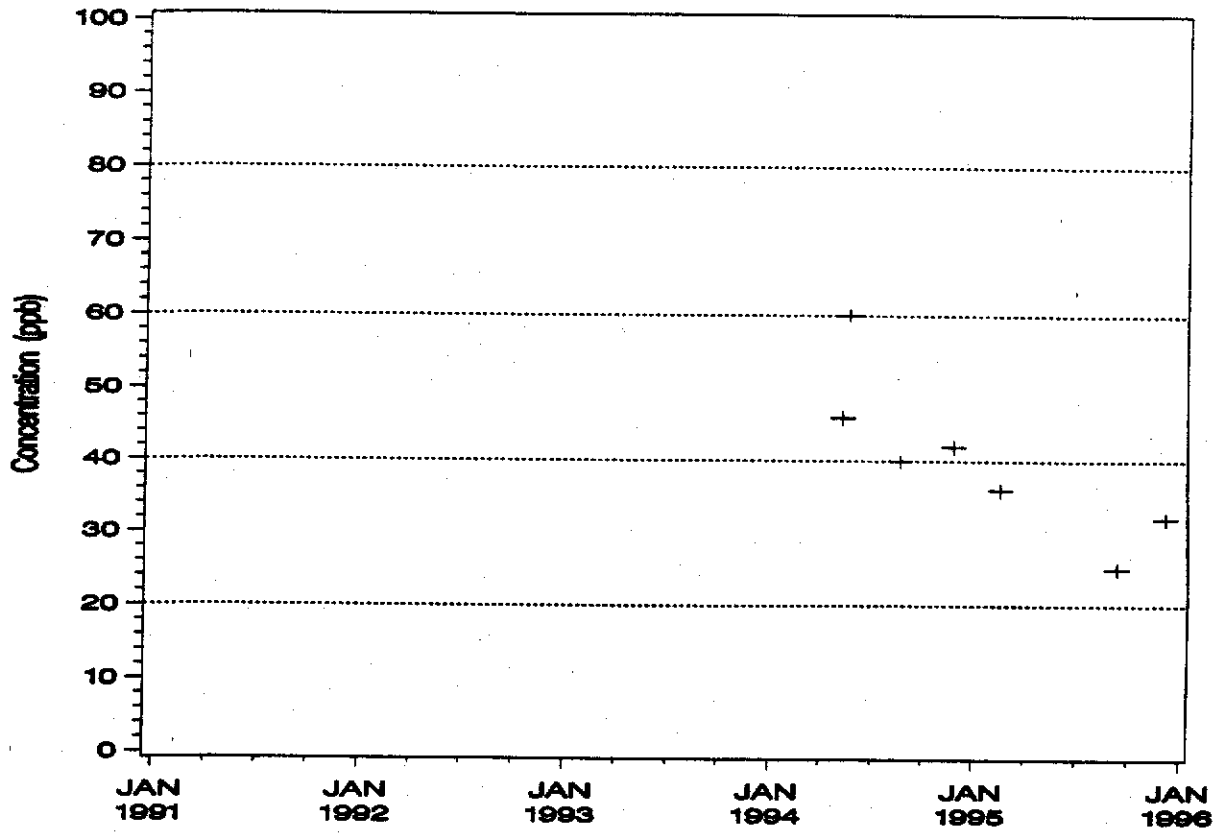
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



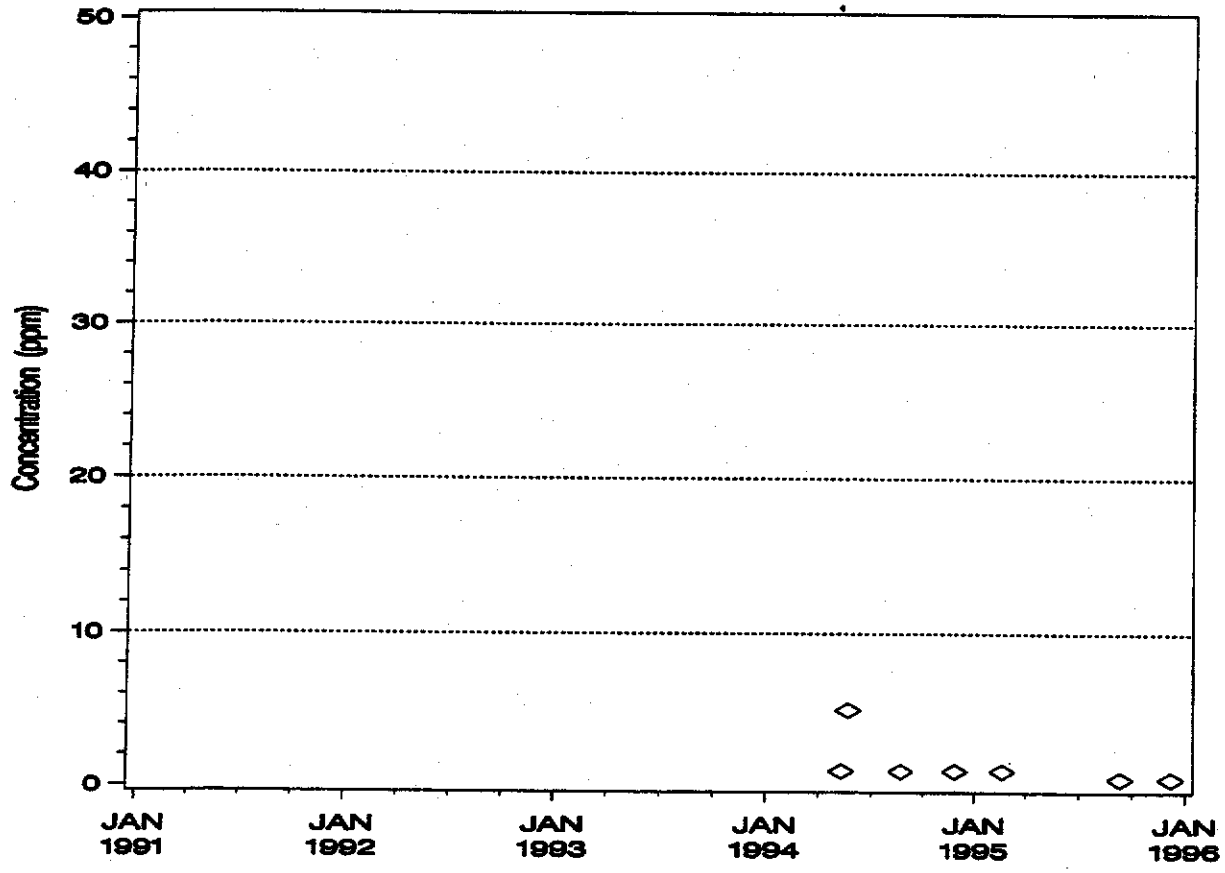
1,1 – DICHLOROETHYLENE Trend



WELL 1569
TRICHLOROETHYLENE Trend

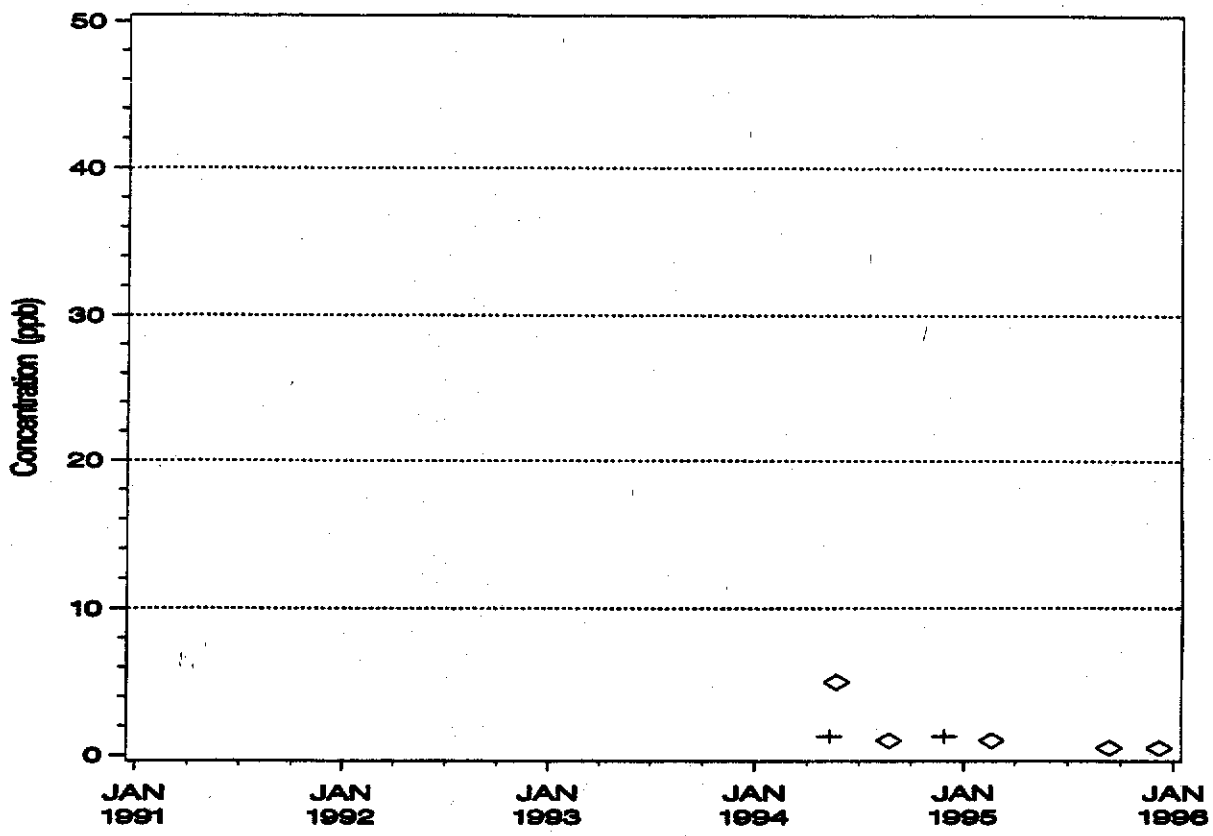


FREON 113 Trend

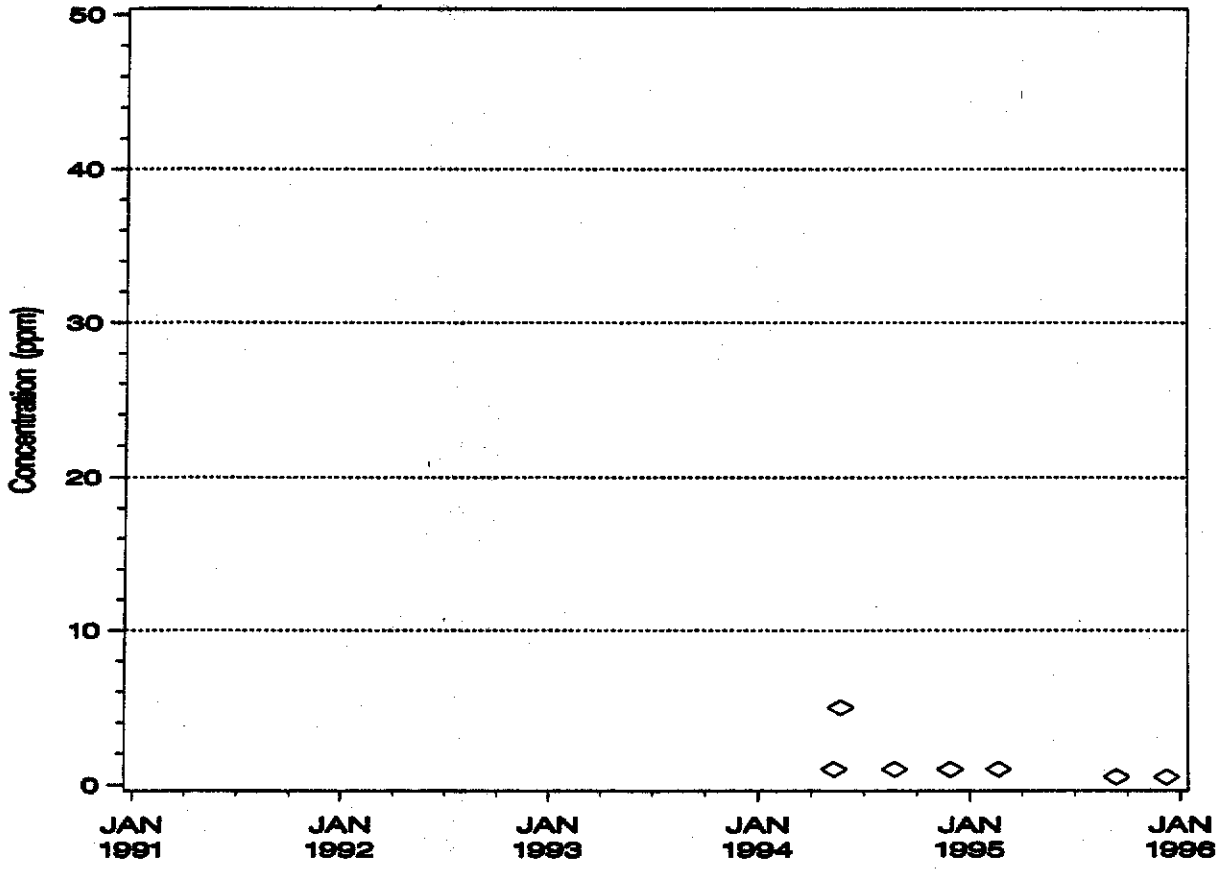


WELL 1569

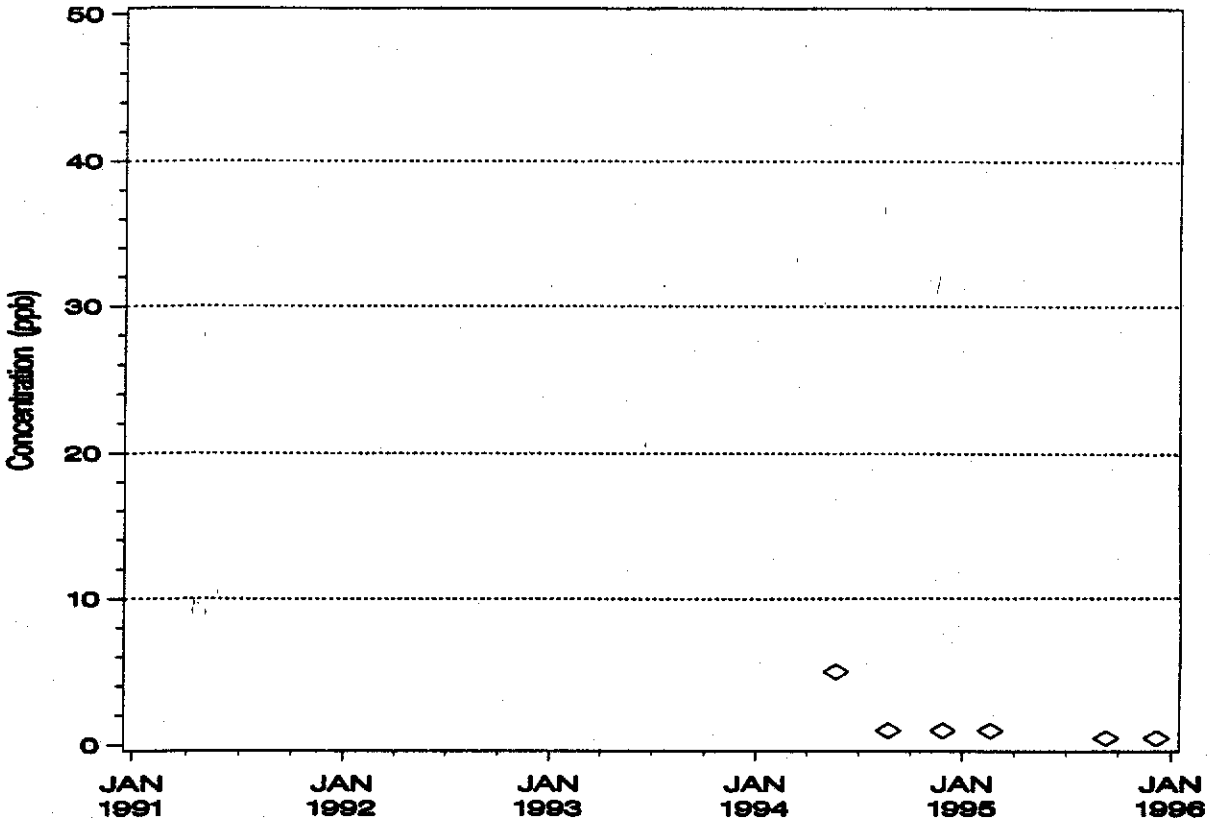
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



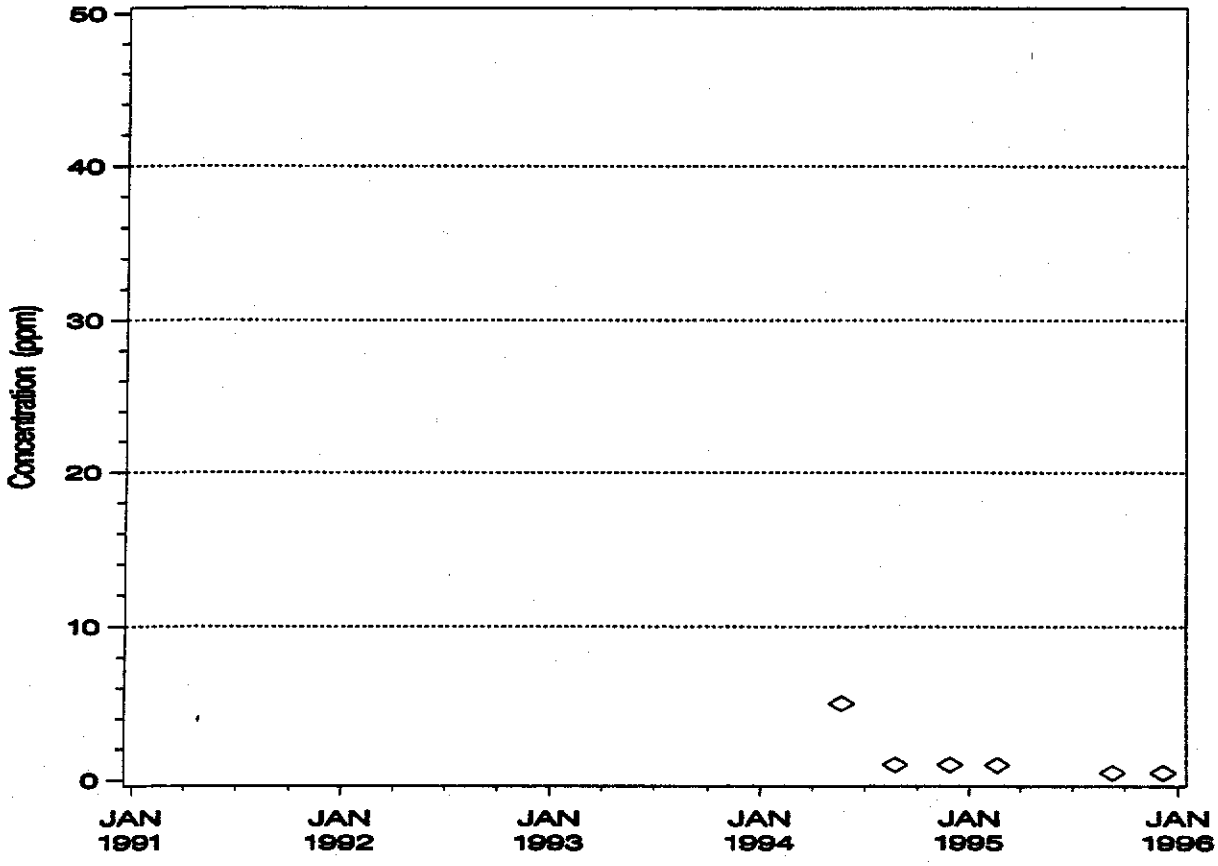
1,1 – DICHLOROETHYLENE Trend



WELL 1570
TRICHLOROETHYLENE Trend

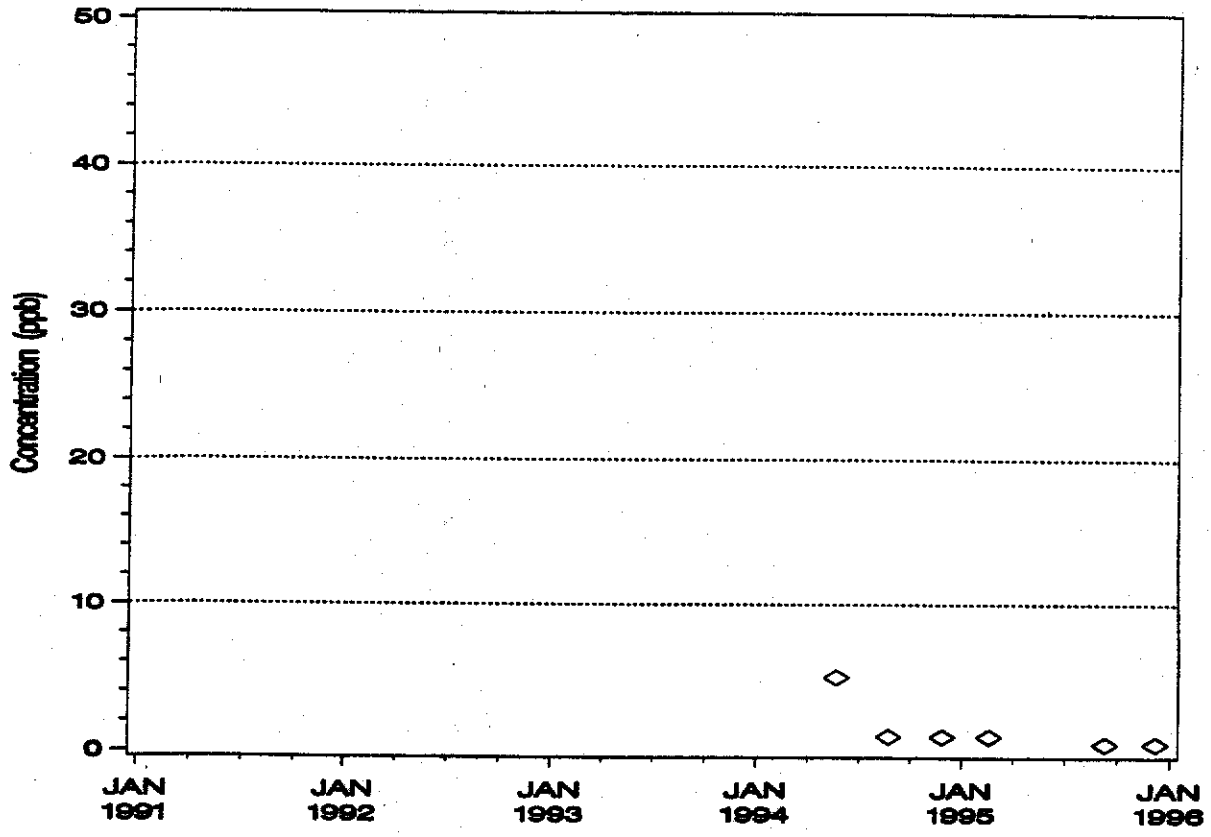


FREON 113 Trend

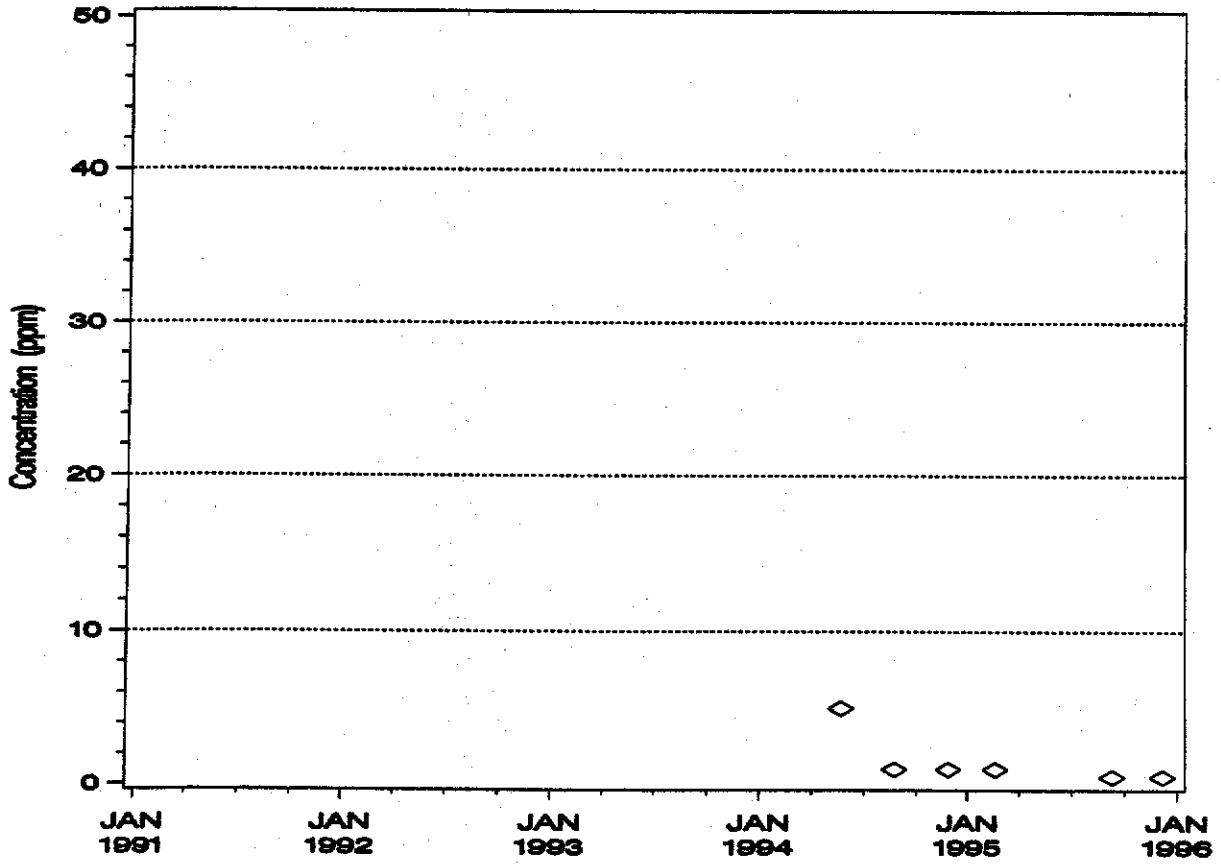


WELL 1570

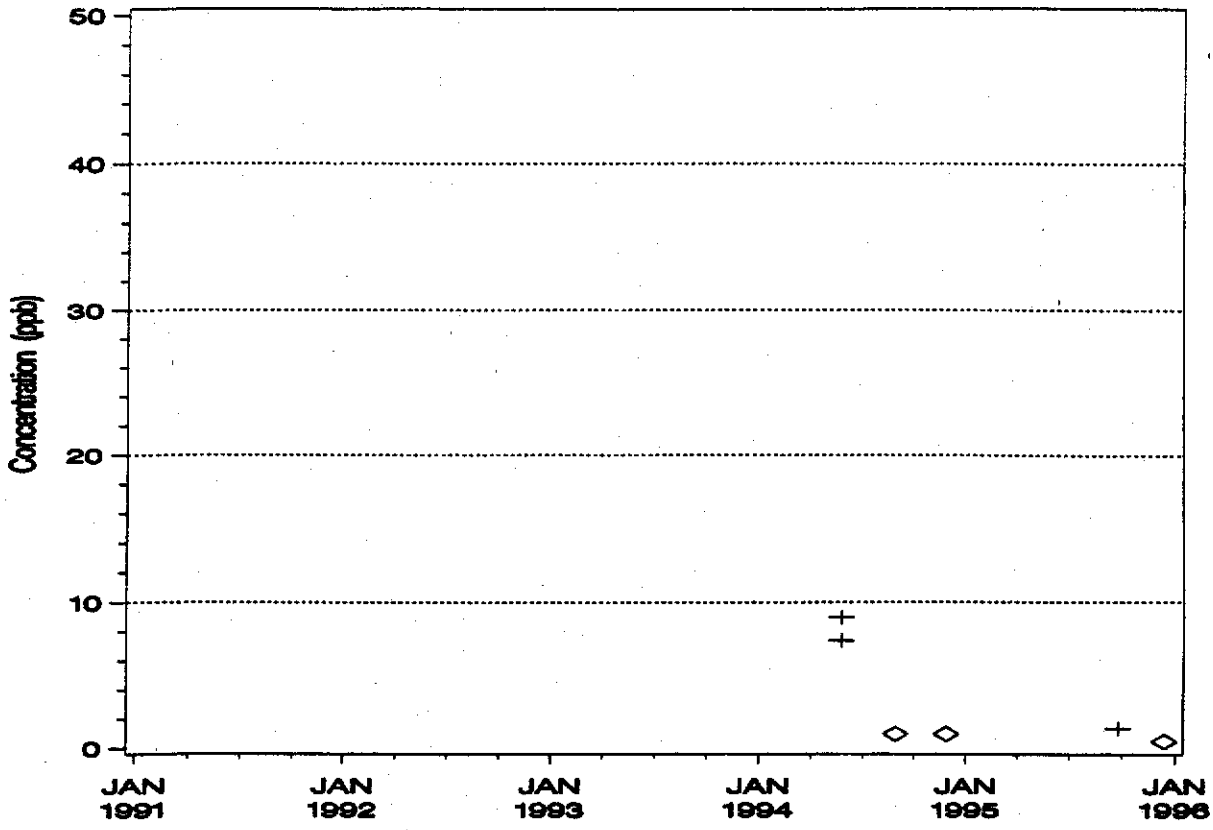
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



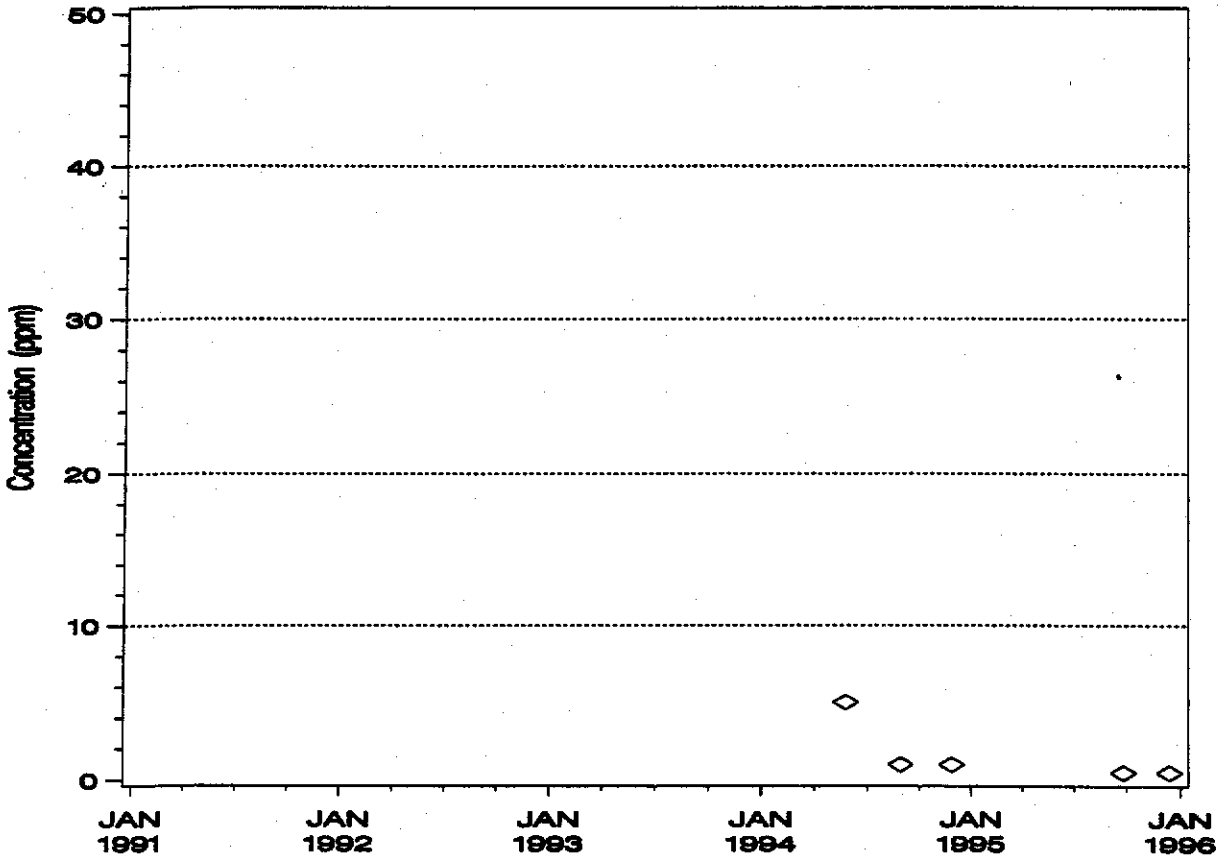
1,1 – DICHLOROETHYLENE Trend



WELL 1571
TRICHLOROETHYLENE Trend

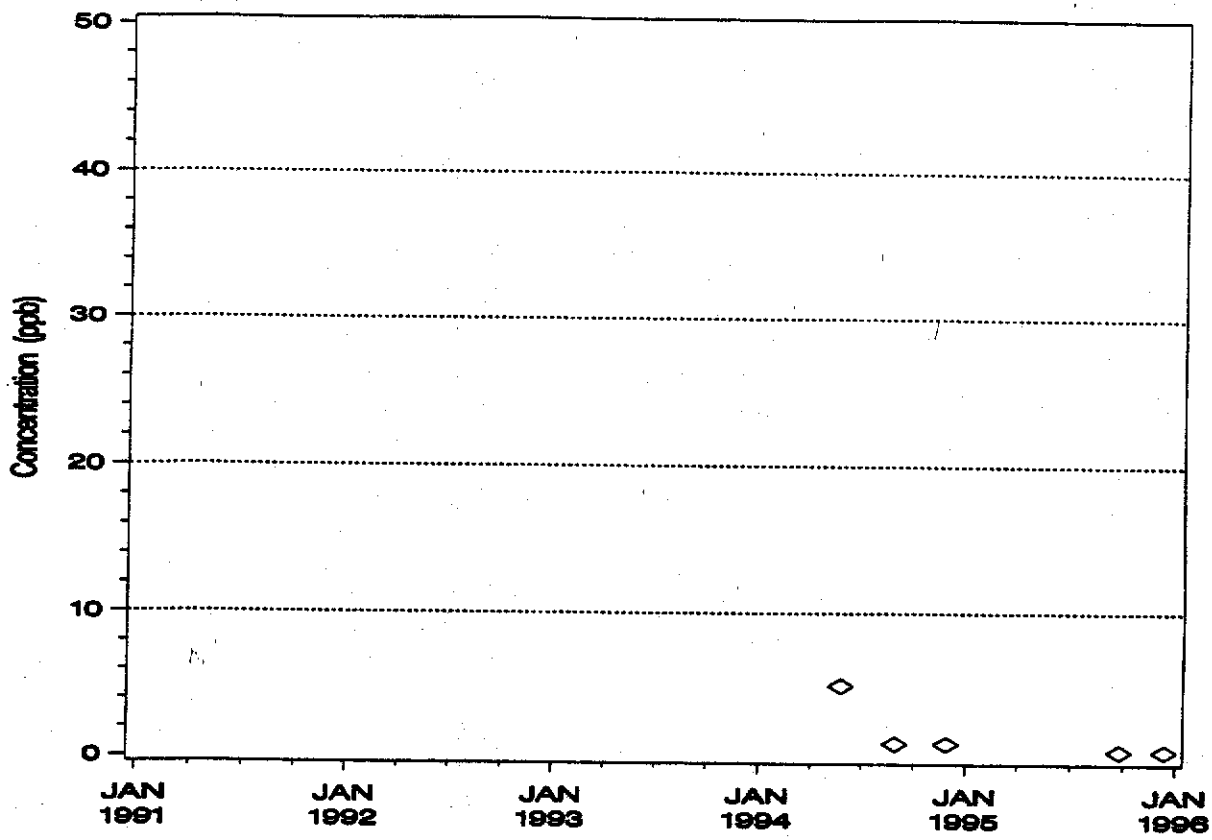


FREON 113 Trend

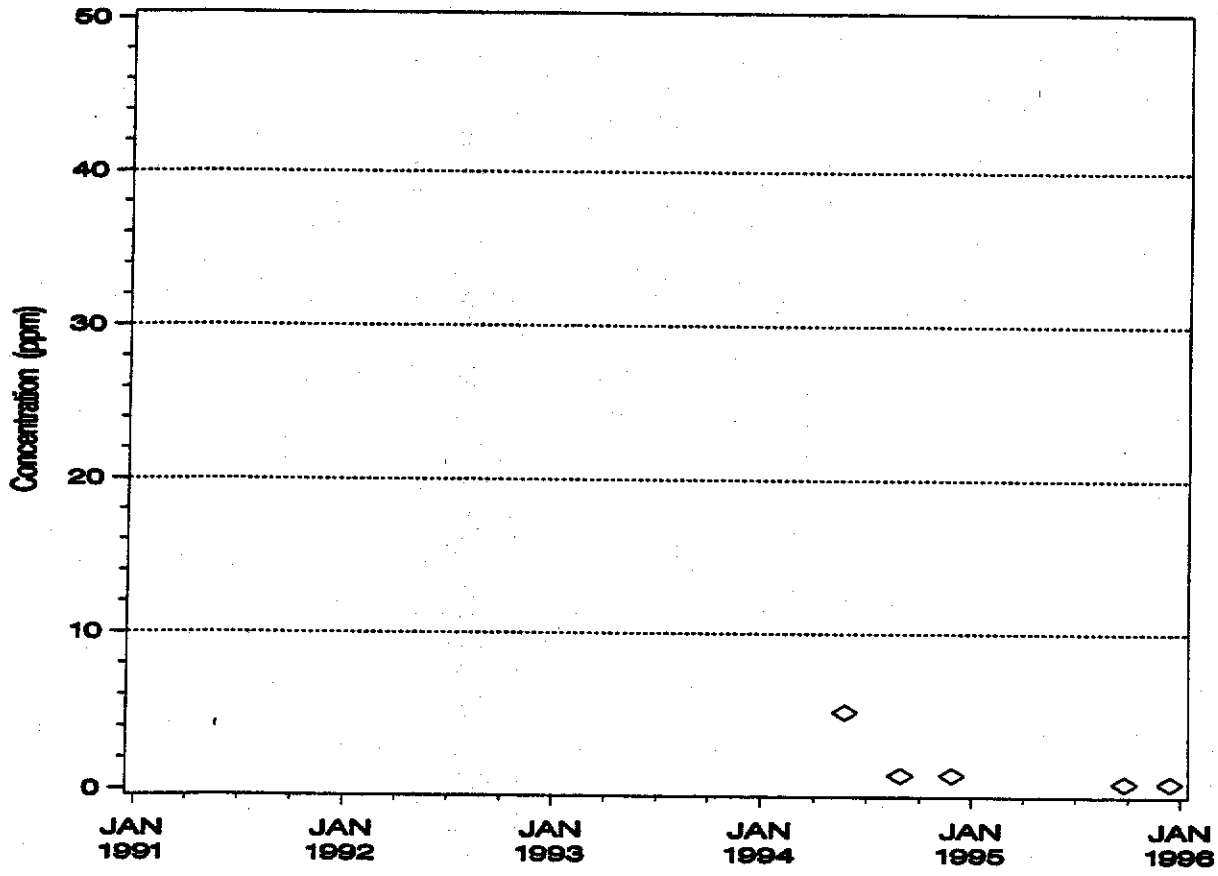


WELL 1571

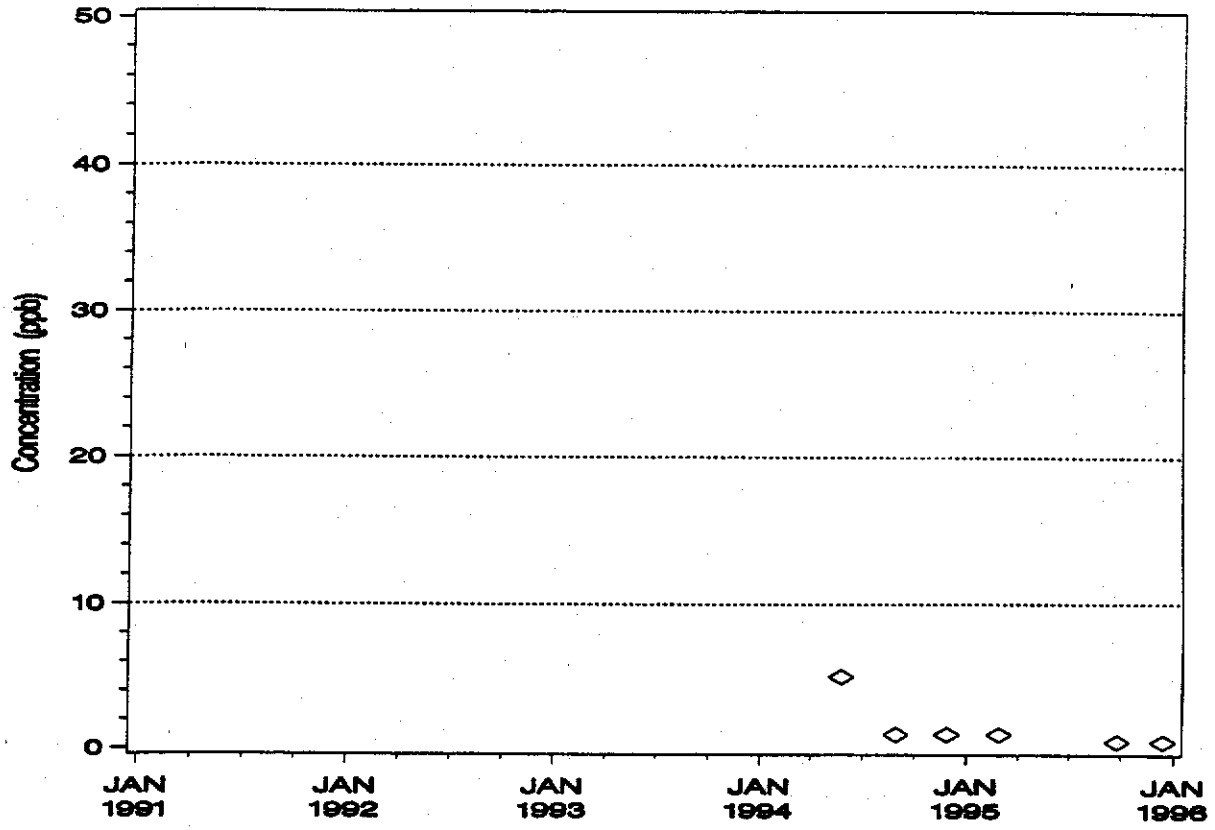
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



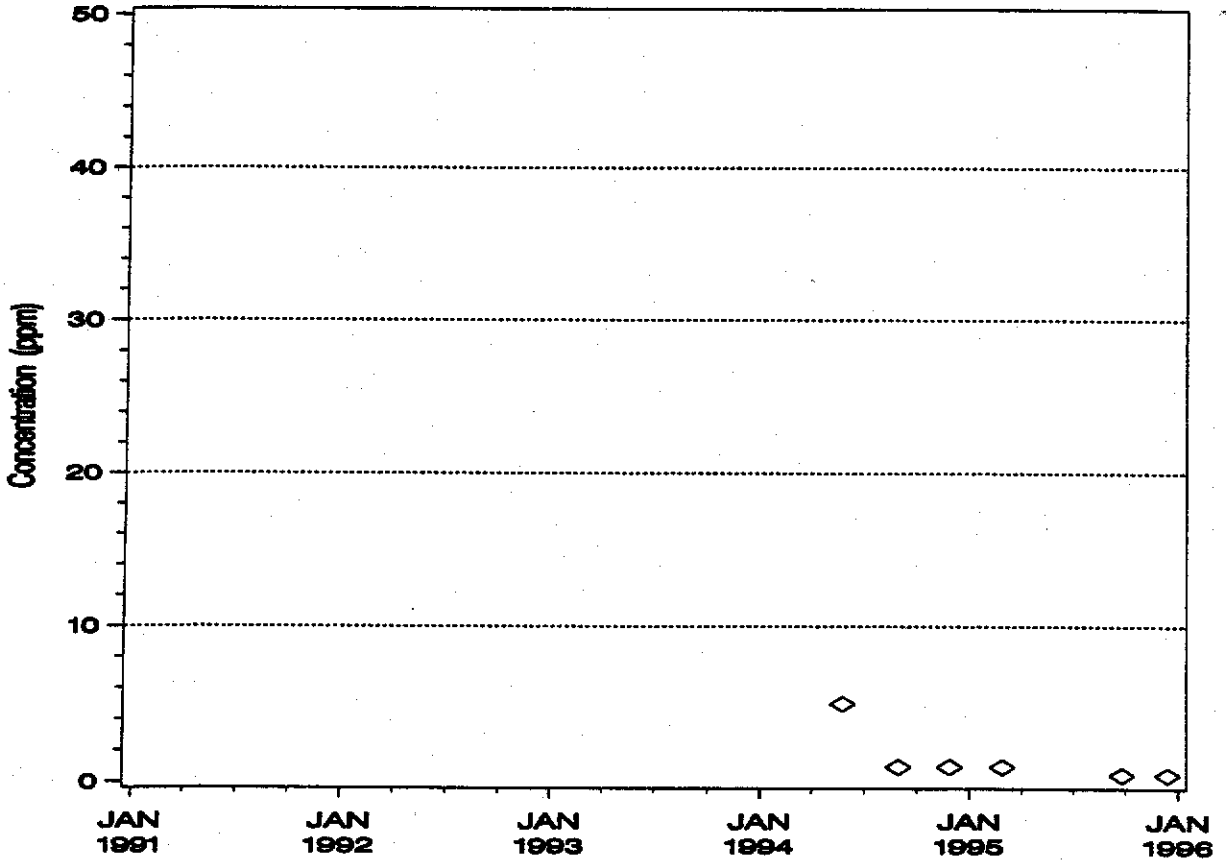
1,1 – DICHLOROETHYLENE Trend



WELL 1572
TRICHLOROETHYLENE Trend

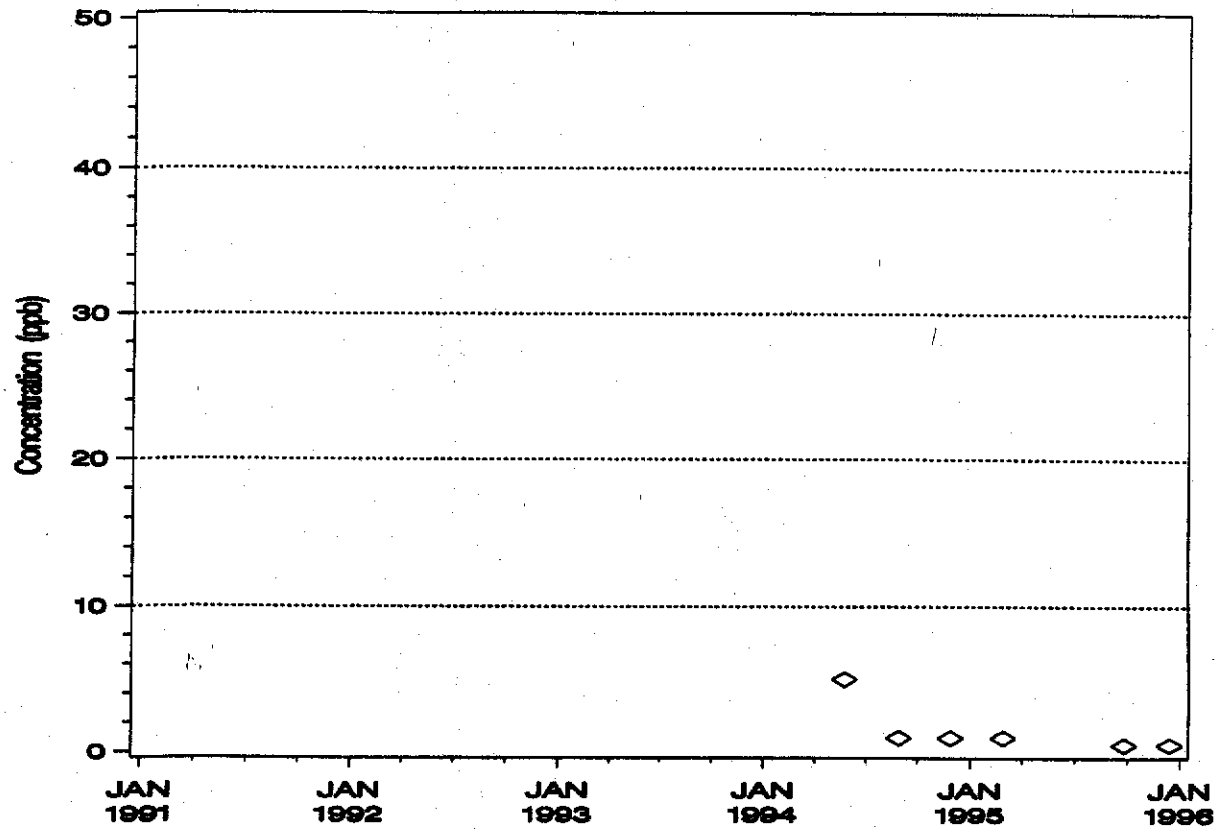


FREON 113 Trend

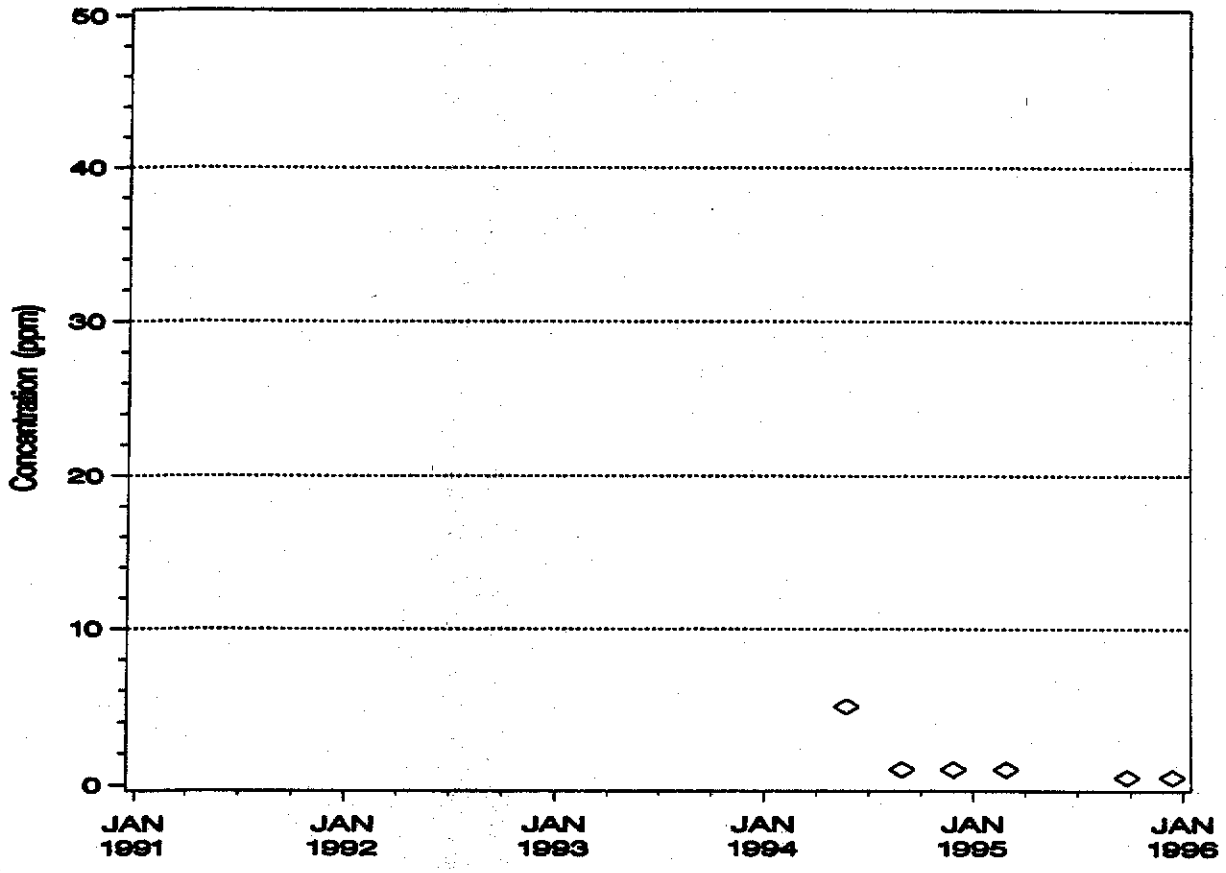


WELL 1572

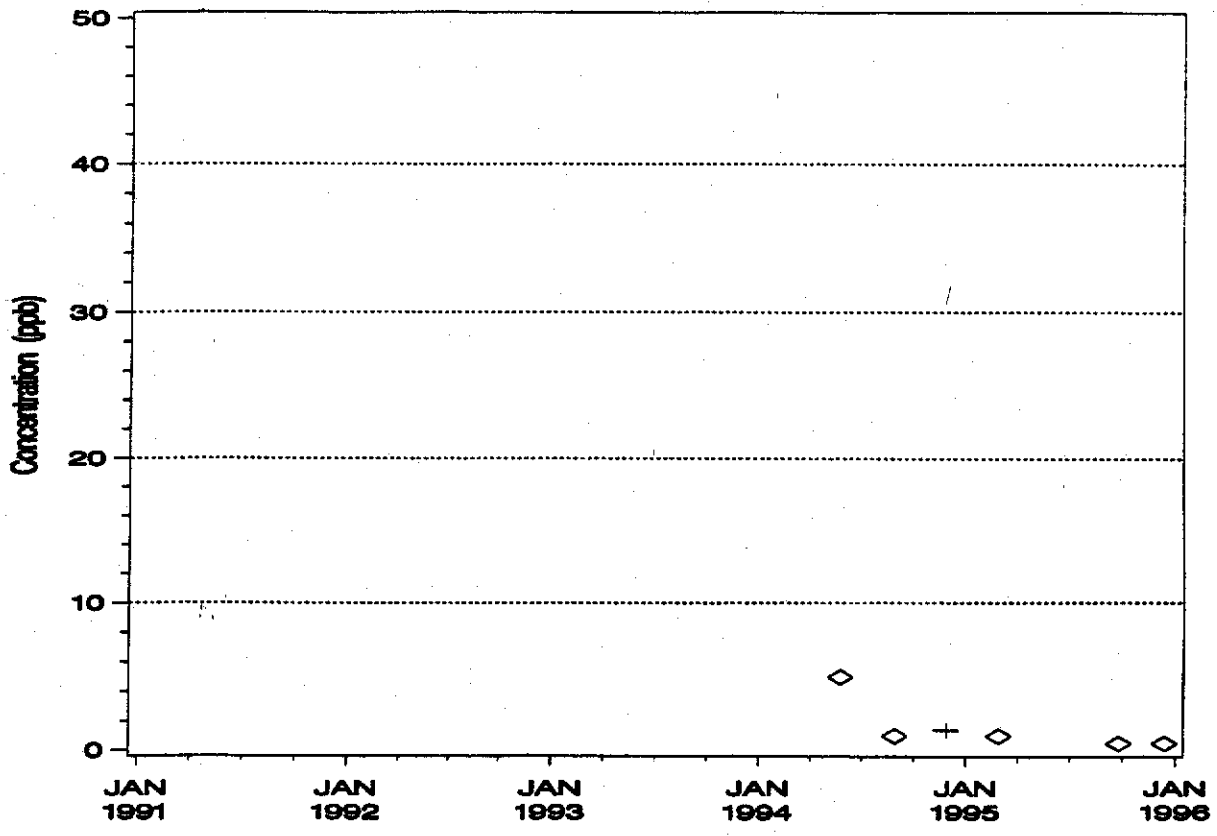
CIS/TRANS — 1,2 — DICHLOROETHYLENE Trend



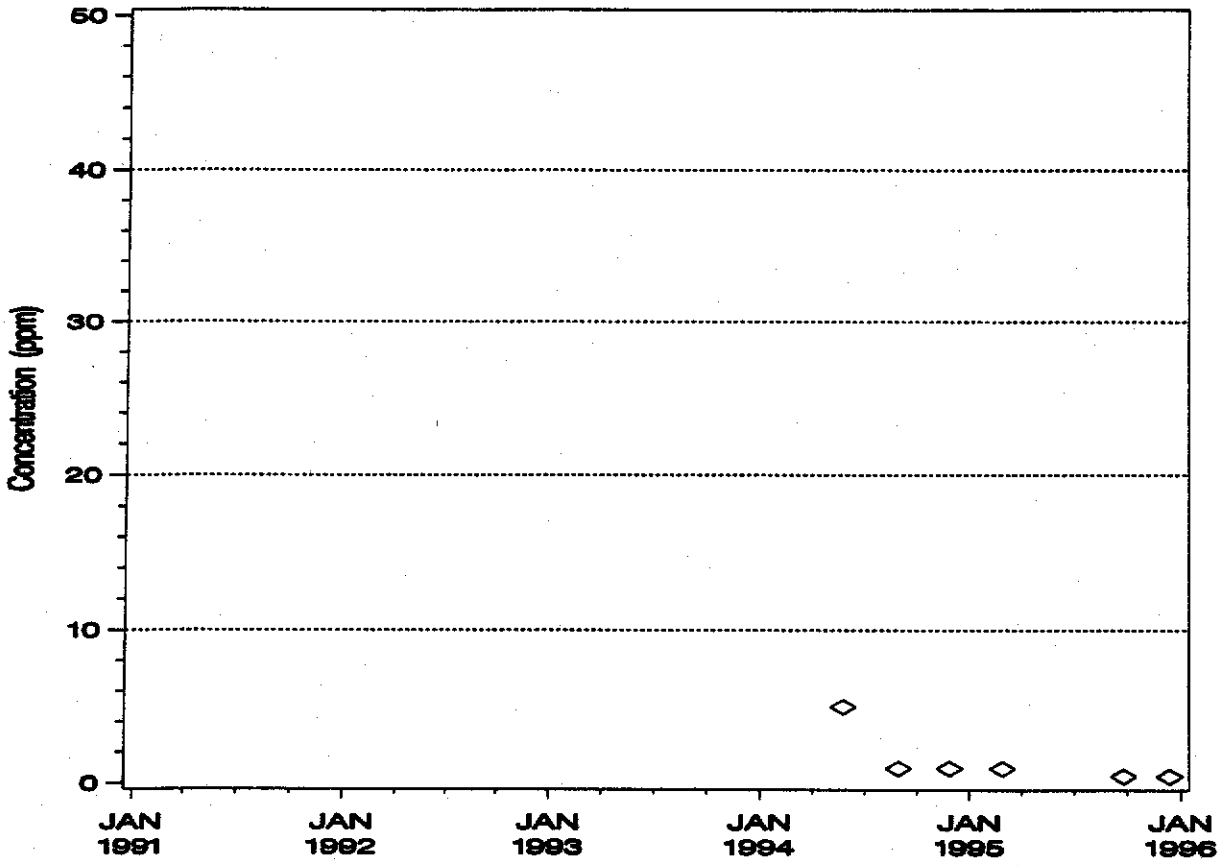
1,1 — DICHLOROETHYLENE Trend



WELL 1573
TRICHLOROETHYLENE Trend

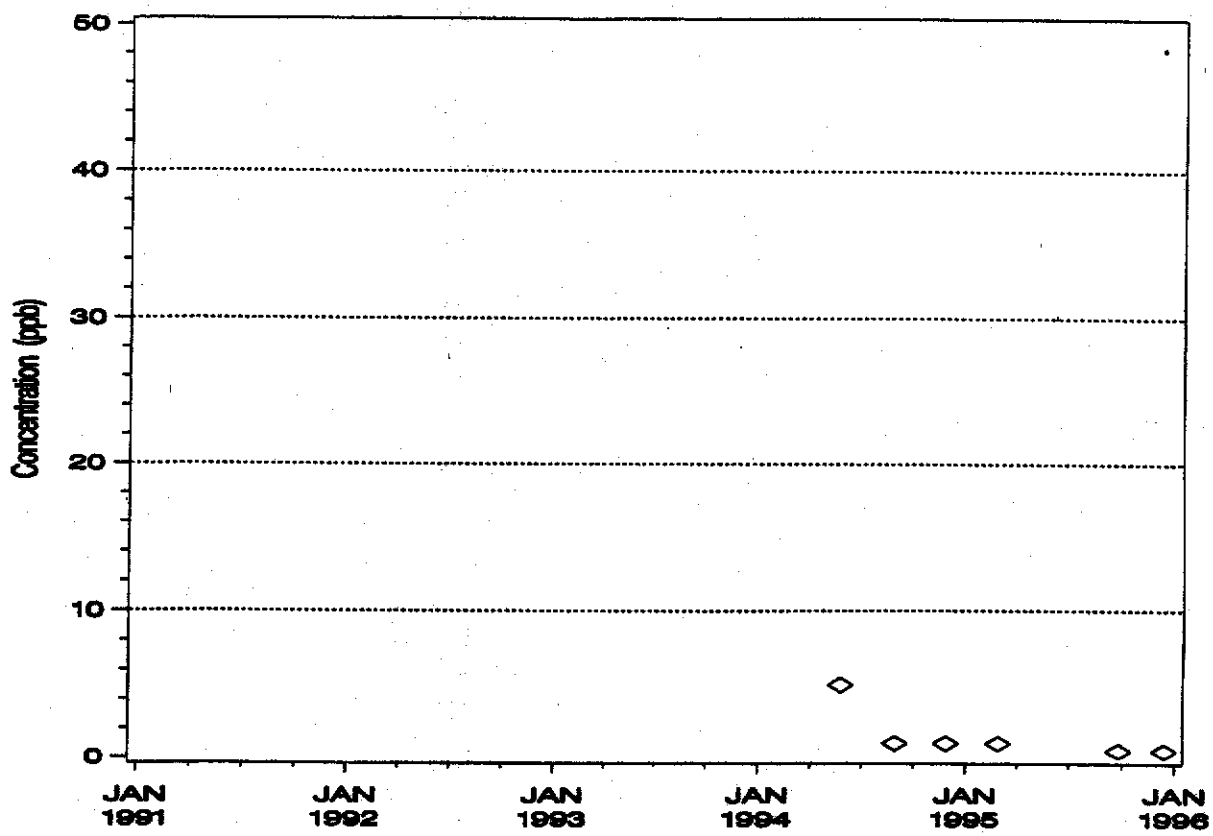


FREON 113 Trend

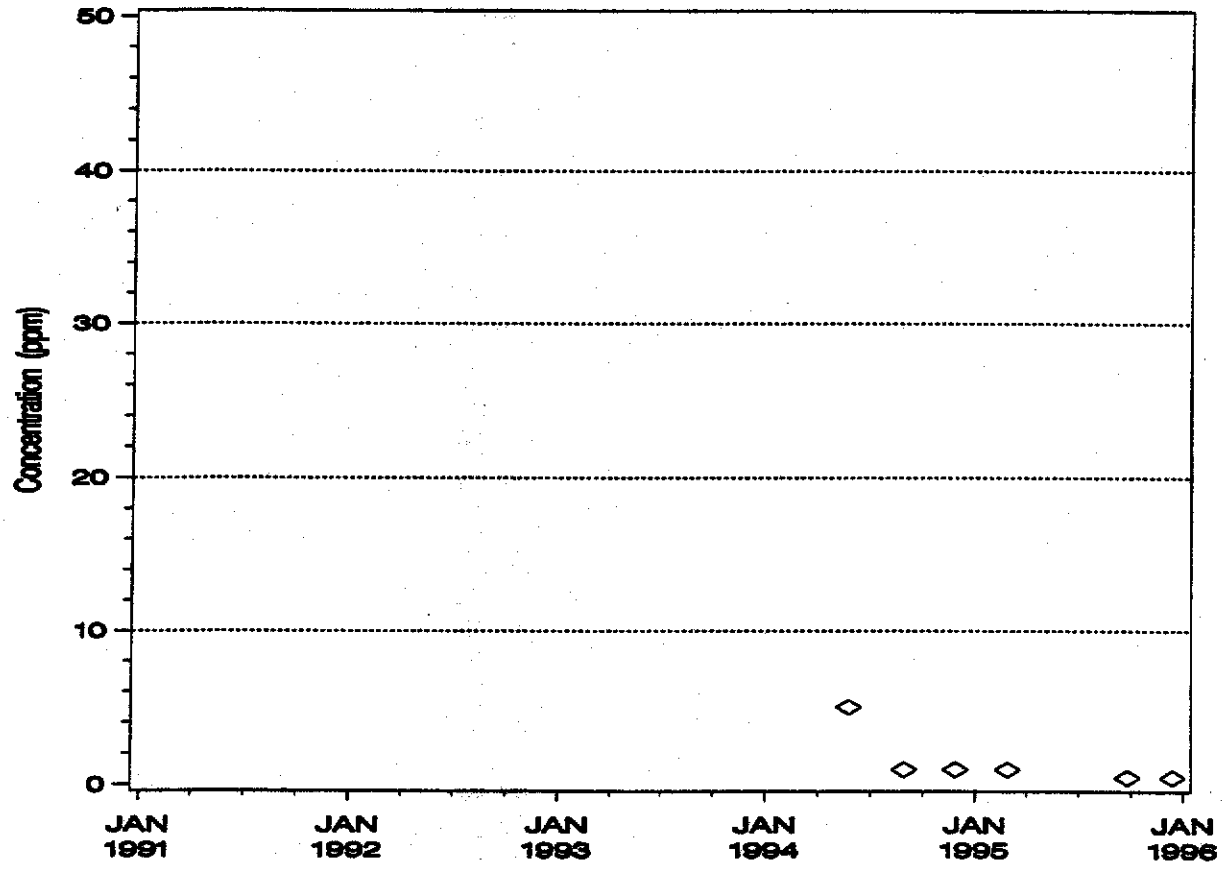


WELL 1573

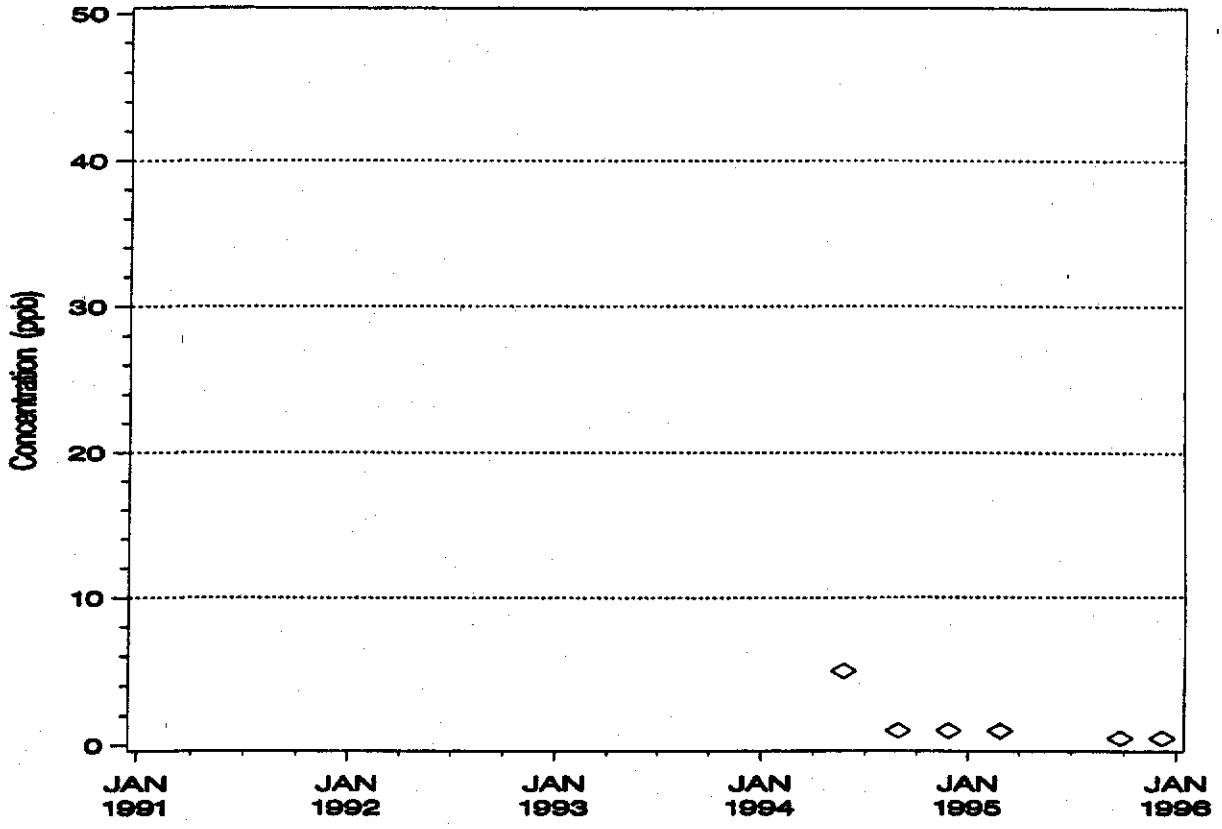
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



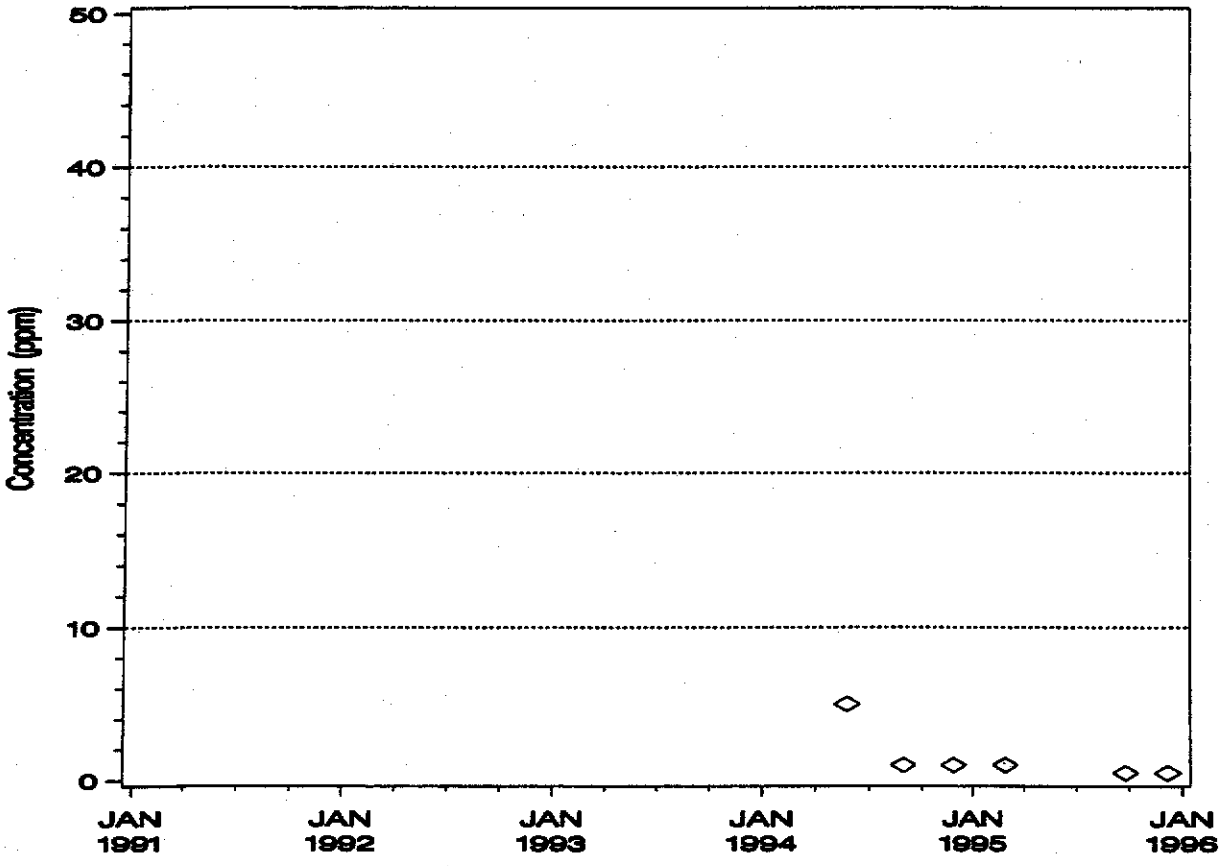
1,1 – DICHLOROETHYLENE Trend



WELL 1574
TRICHLOROETHYLENE Trend

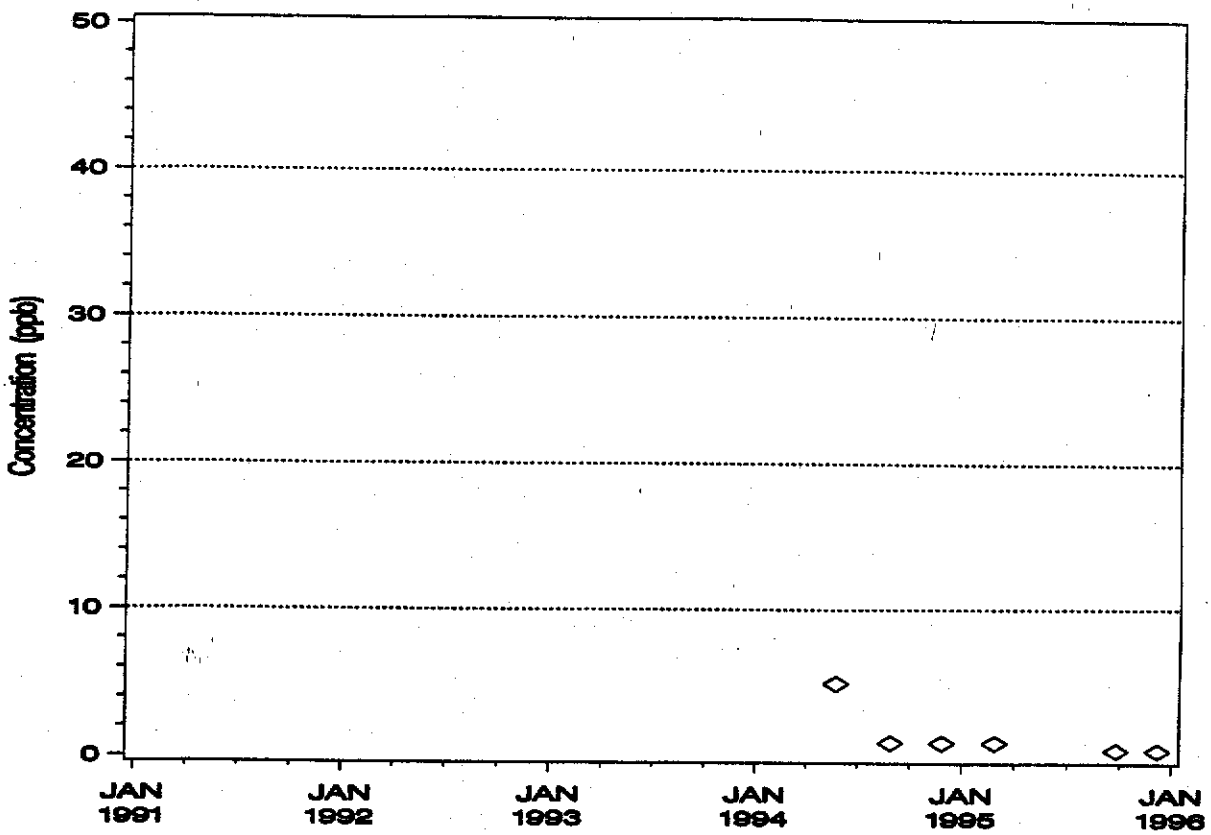


FREON 113 Trend

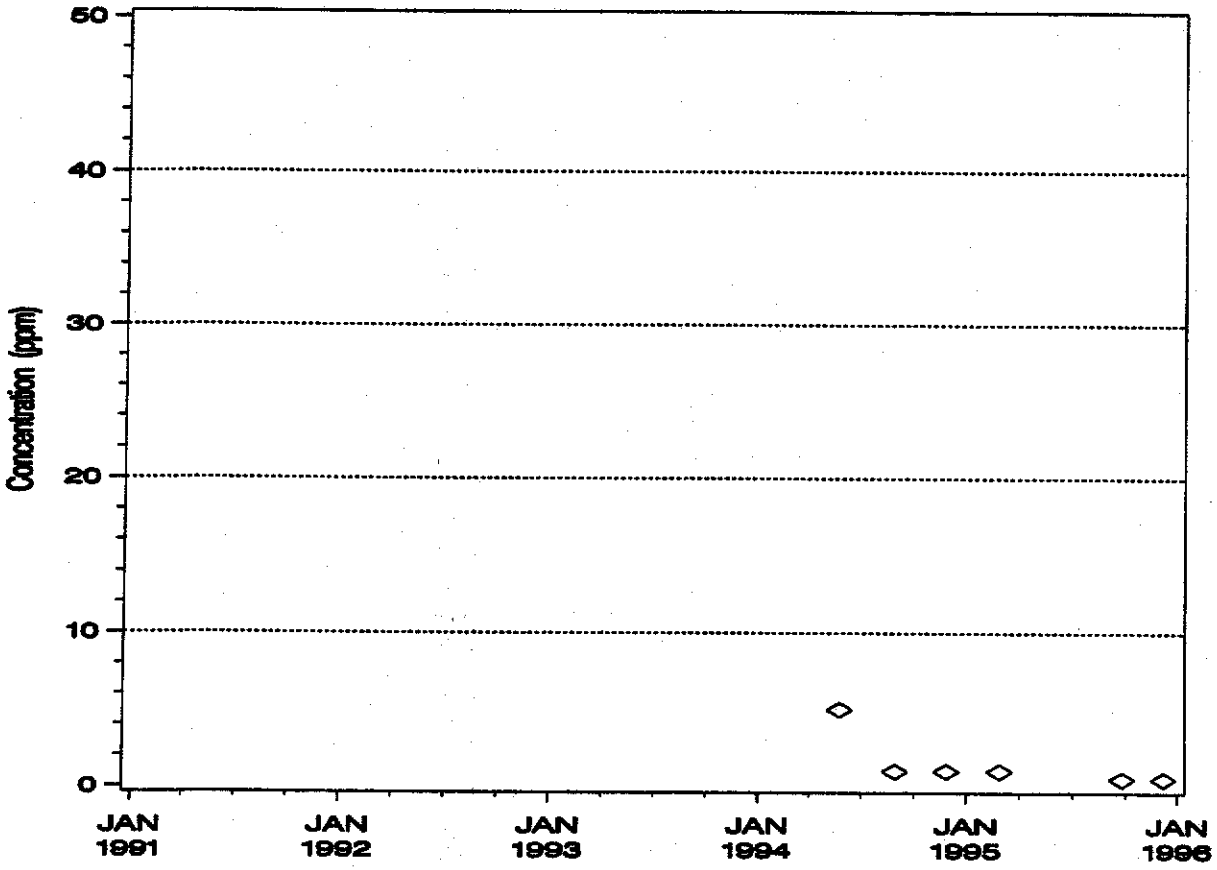


WELL 1574

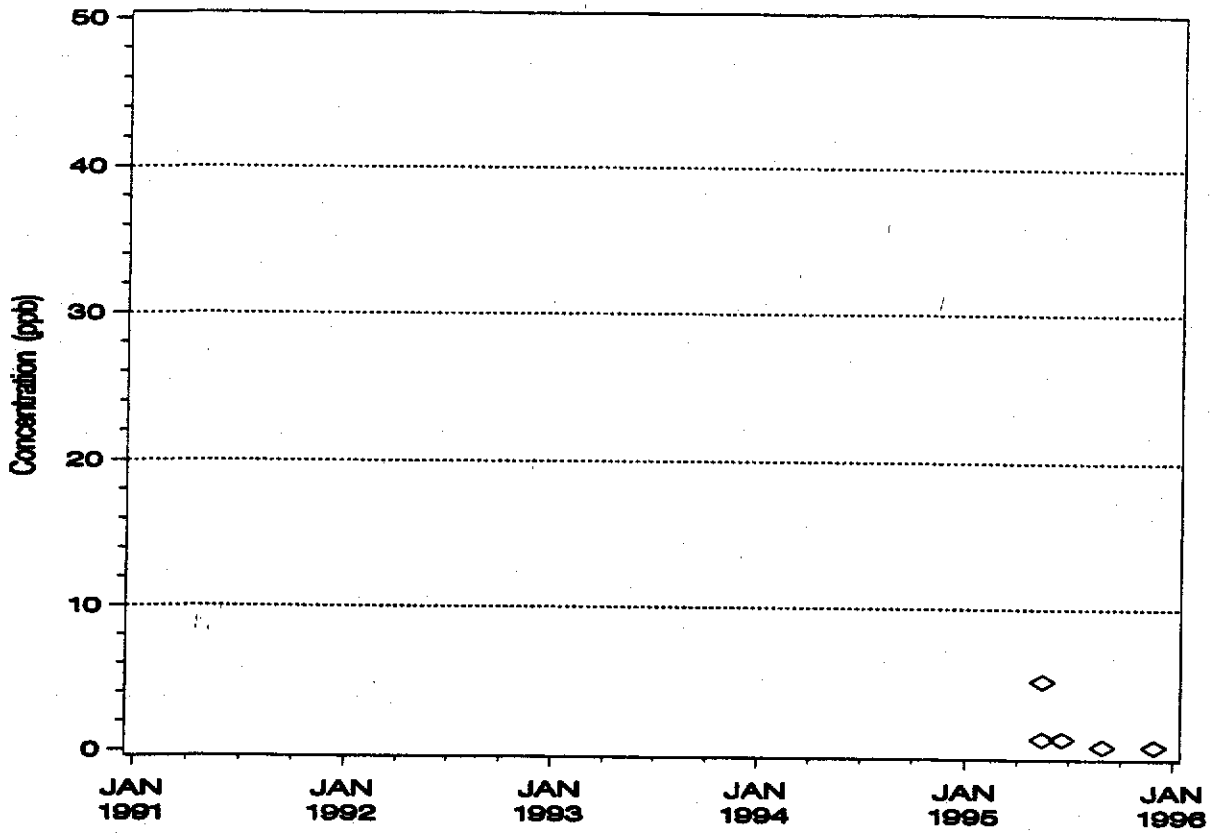
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



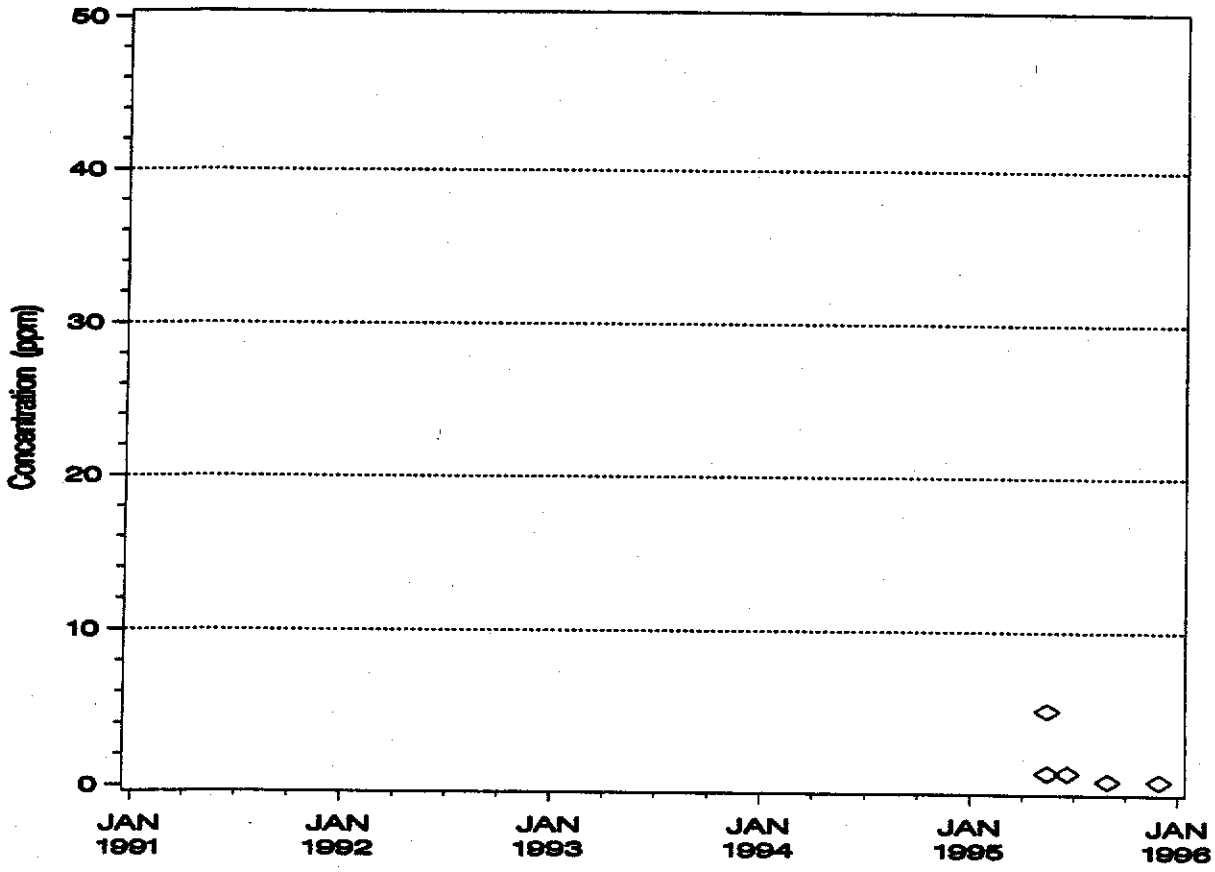
1,1 – DICHLOROETHYLENE Trend



WELL 1585
TRICHLOROETHYLENE Trend

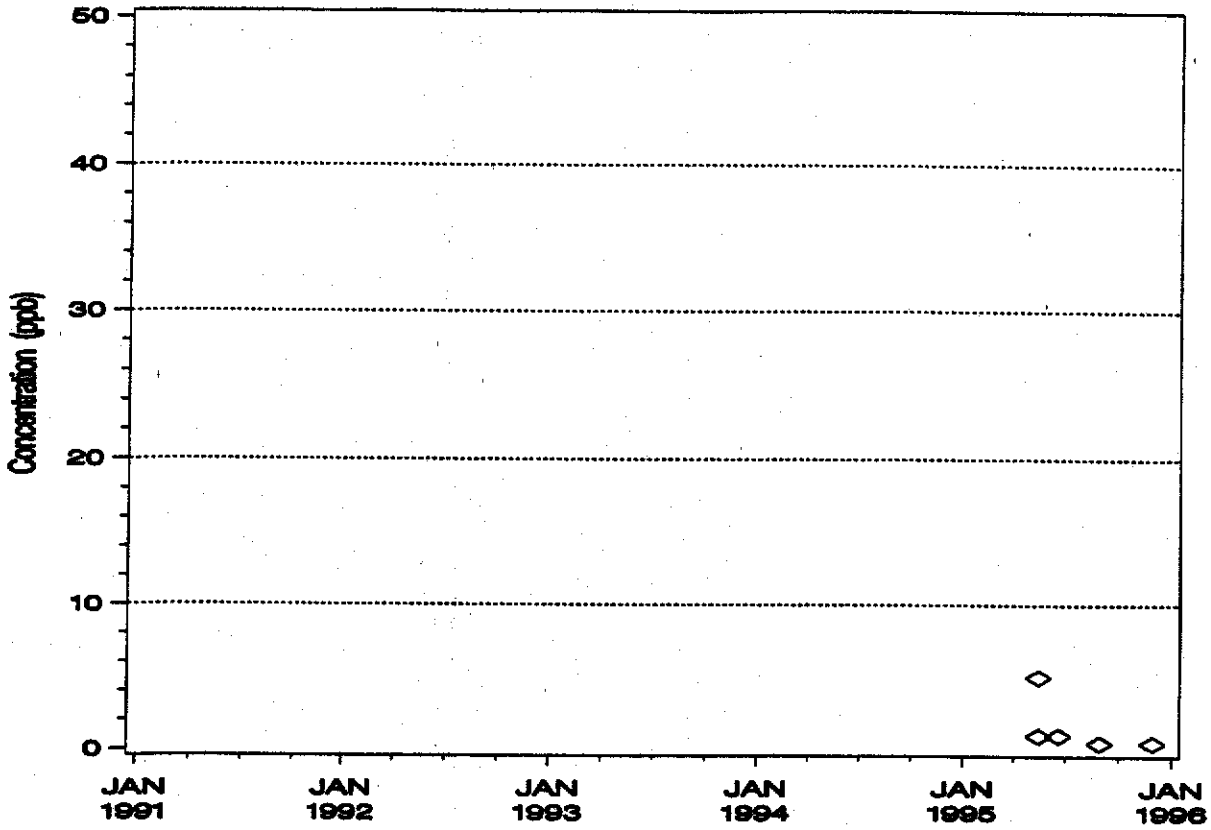


FREON 113 Trend

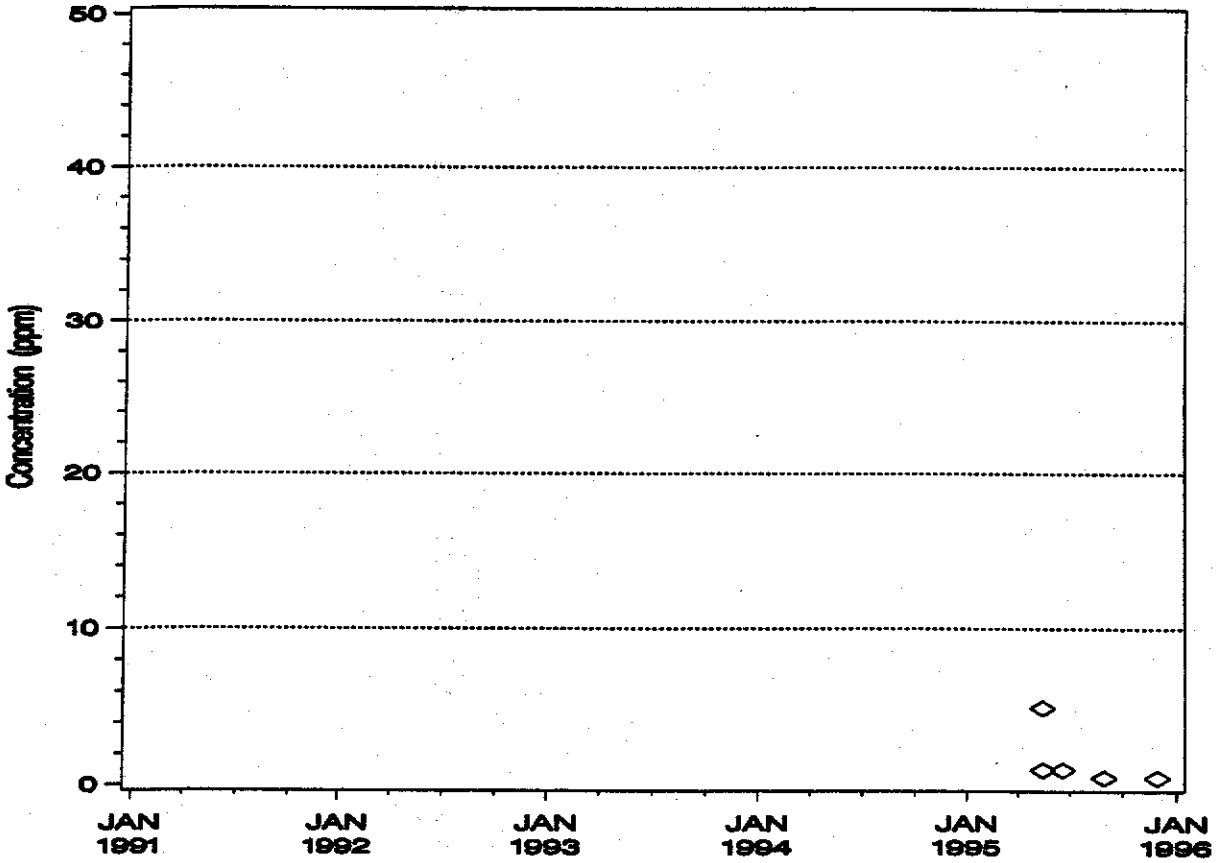


WELL 1585

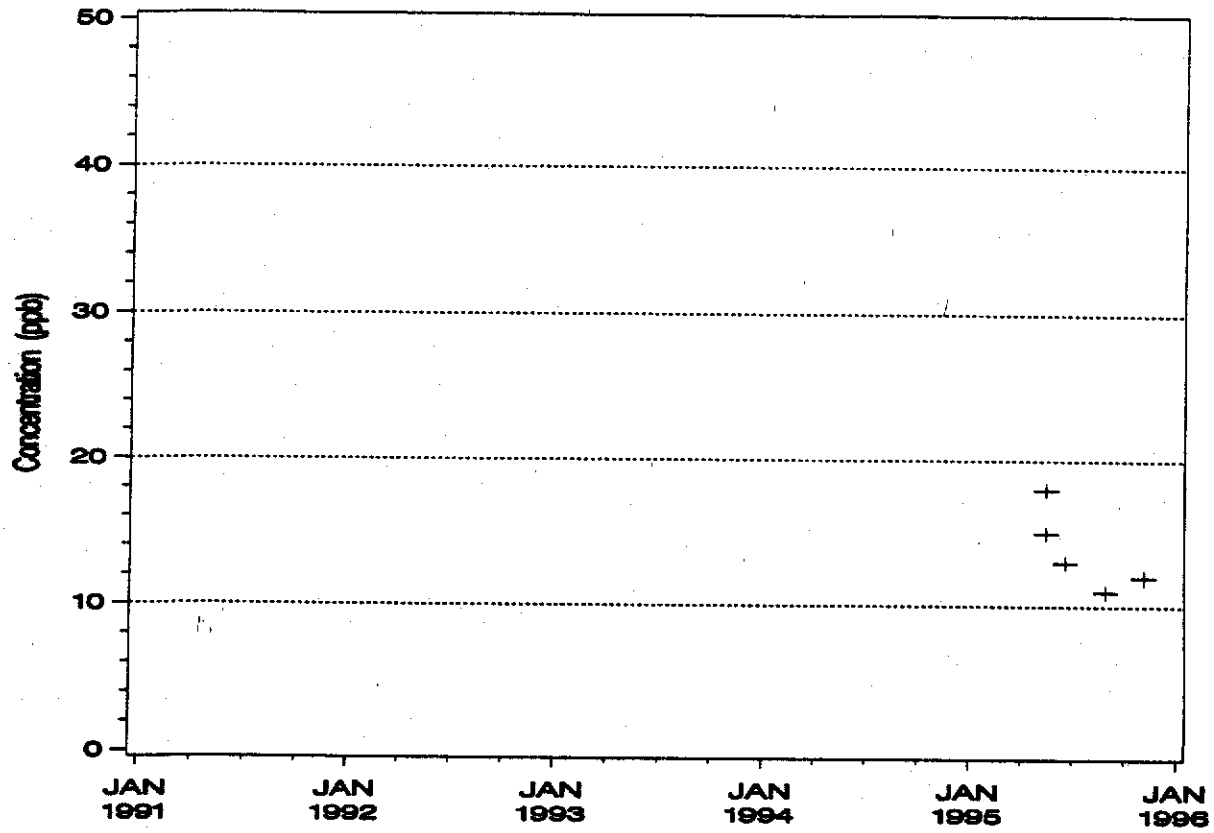
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



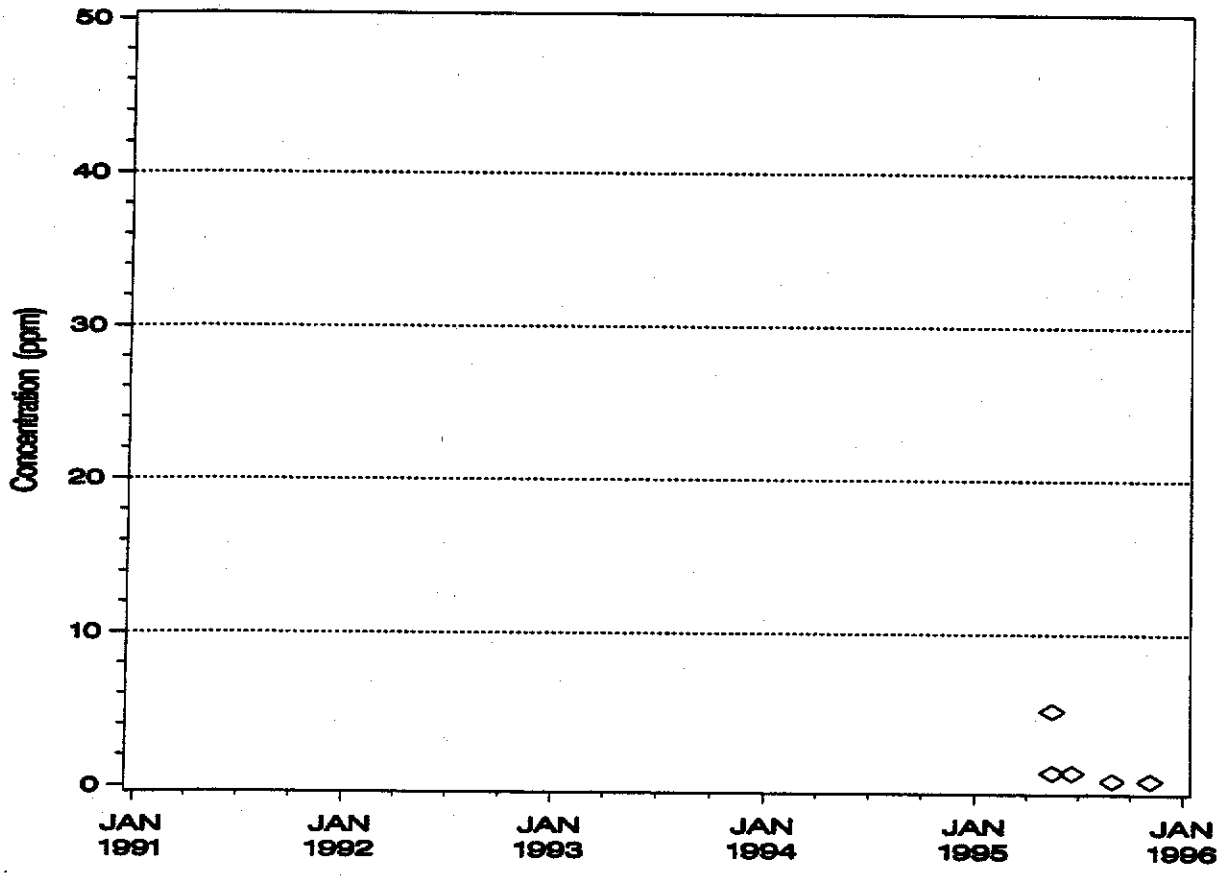
1,1 – DICHLOROETHYLENE Trend



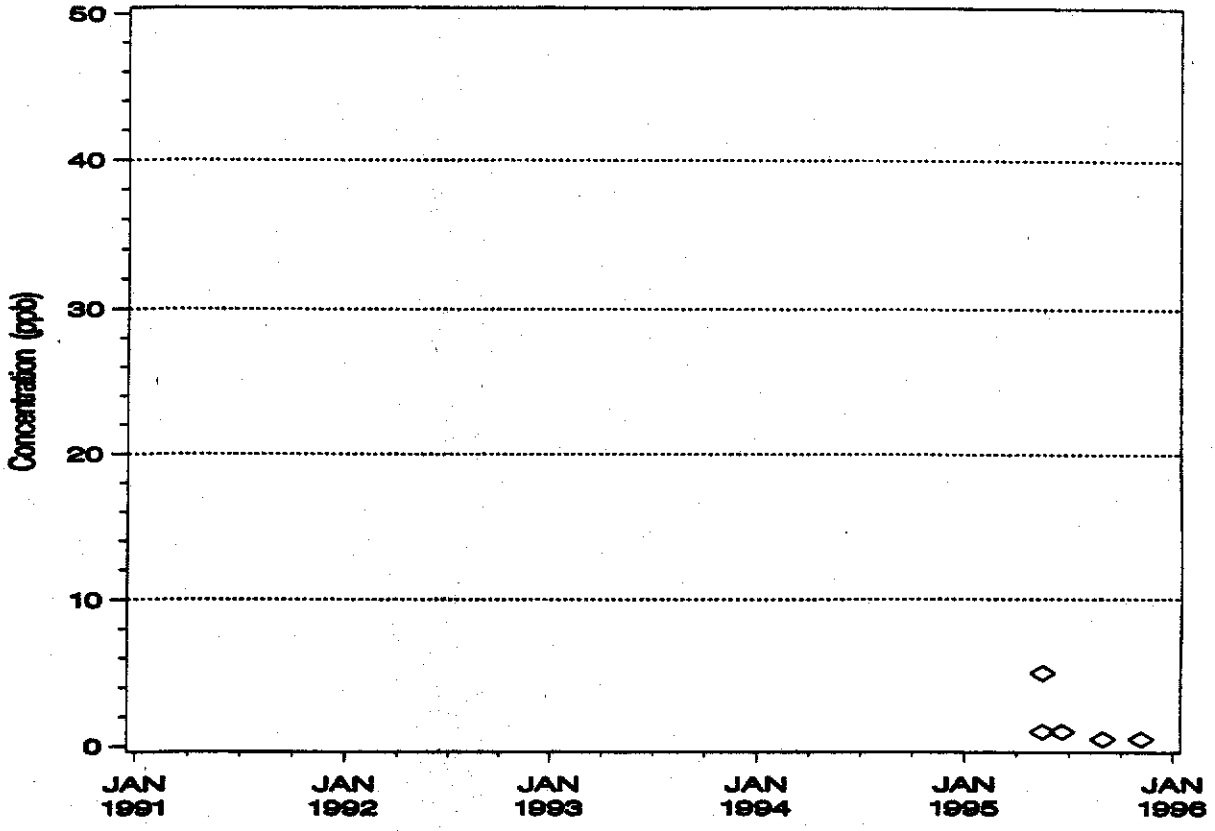
WELL 1586
TRICHLOROETHYLENE Trend



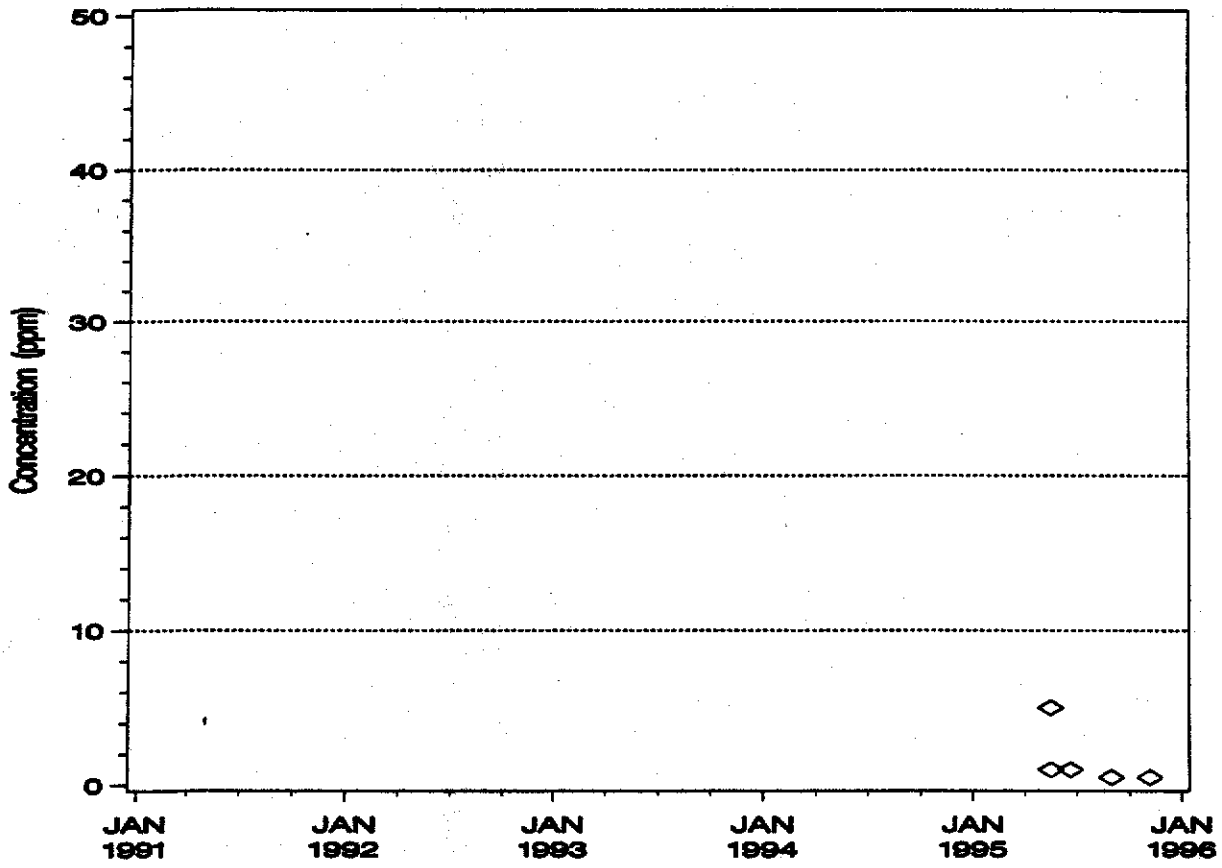
FREON 113 Trend



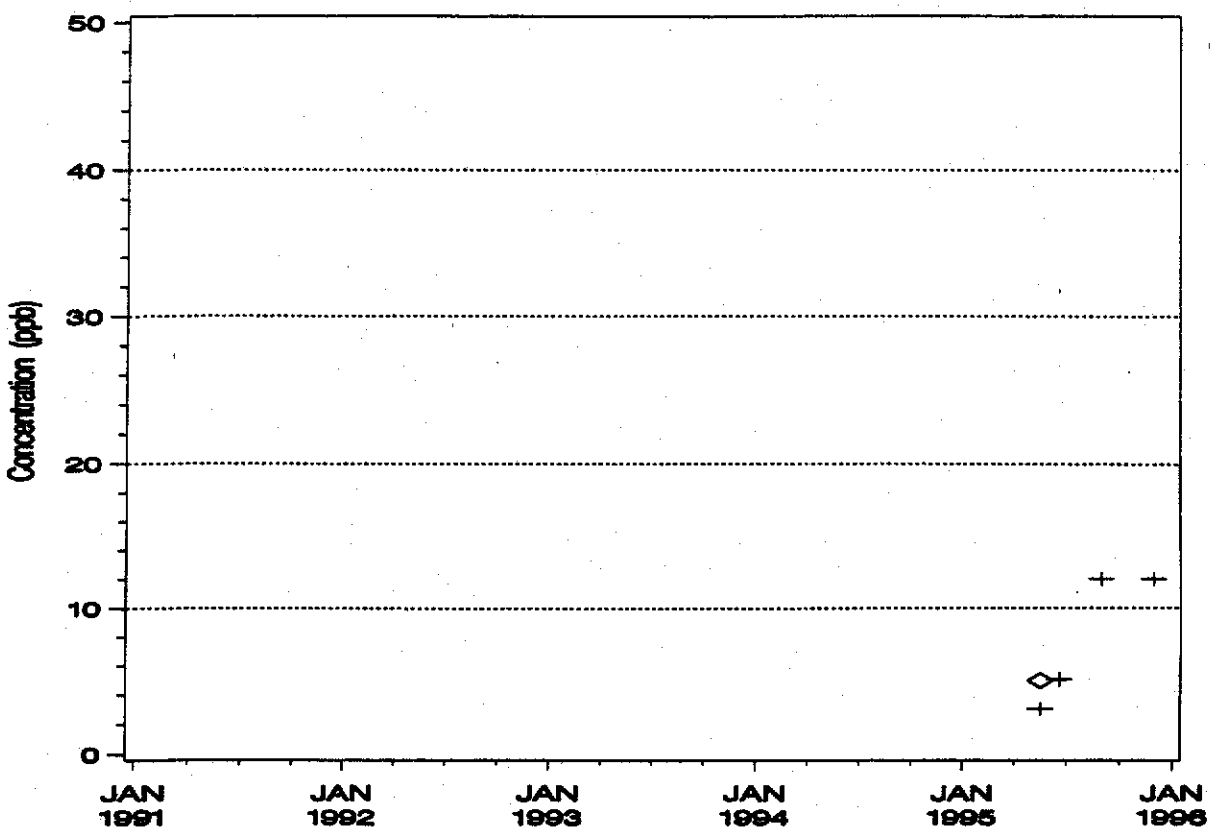
WELL 1586
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



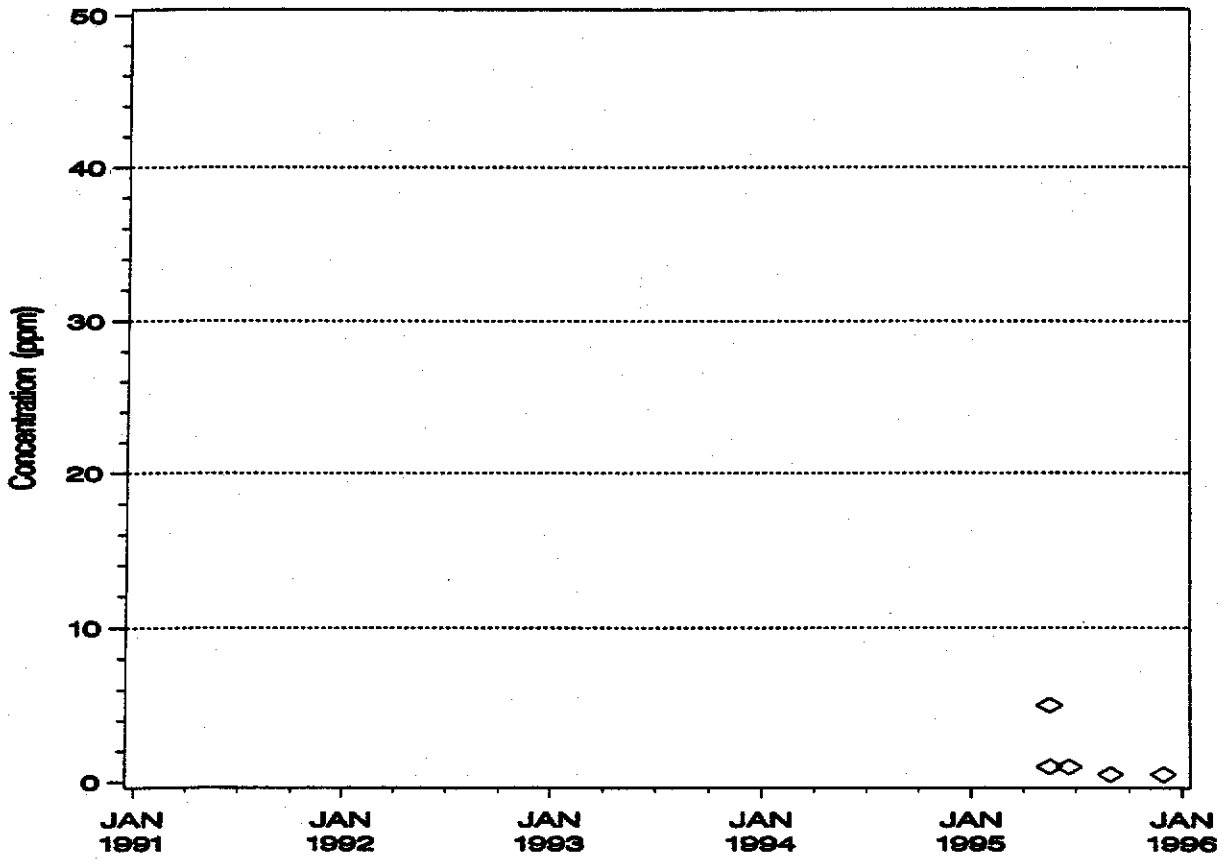
1,1 – DICHLOROETHYLENE Trend



WELL 1587
TRICHLOROETHYLENE Trend

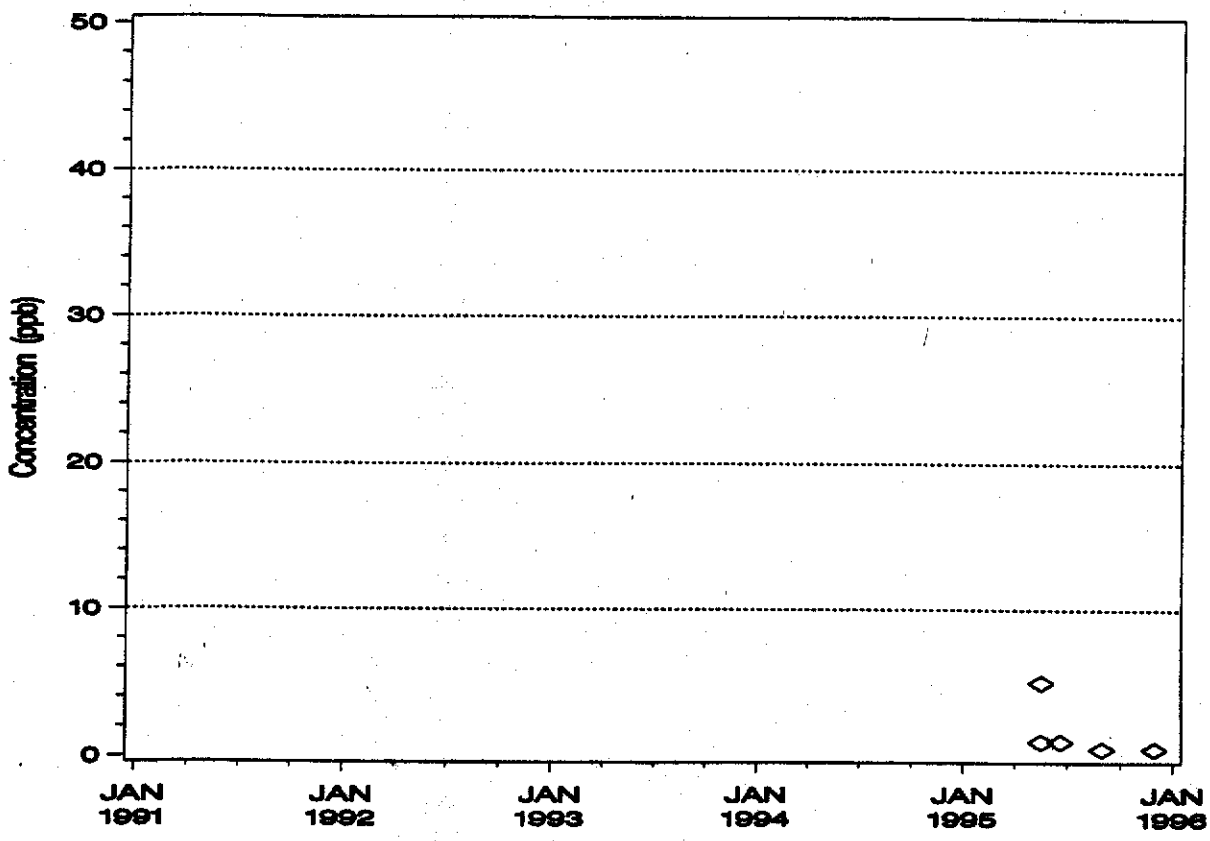


FREON 113 Trend

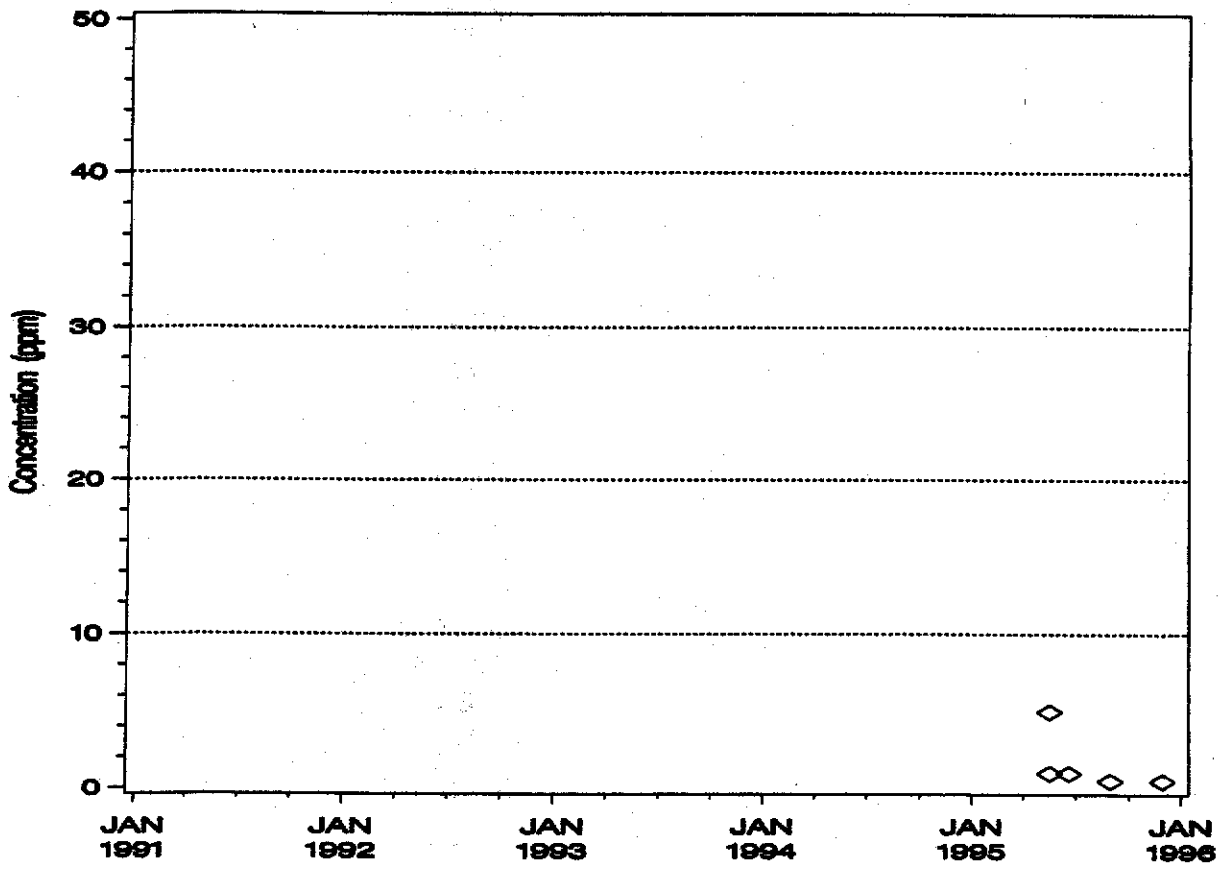


WELL 1587

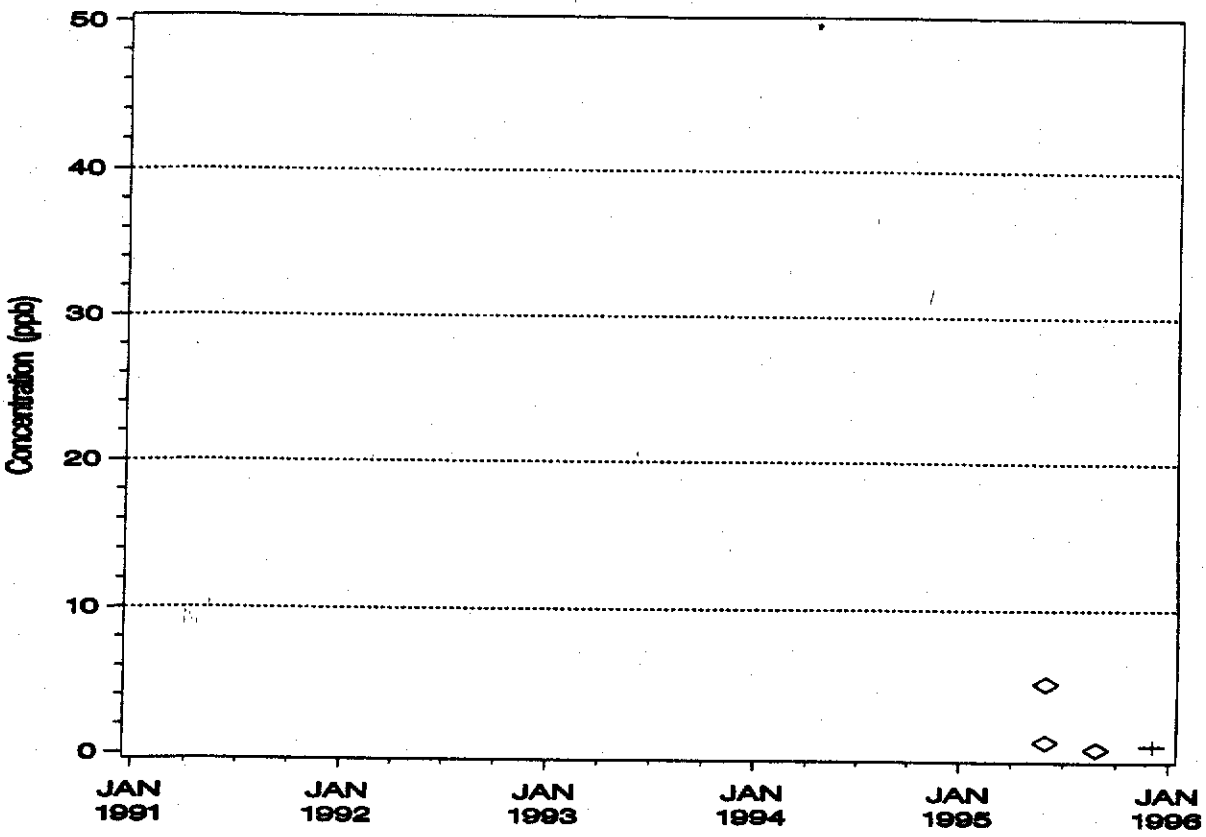
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



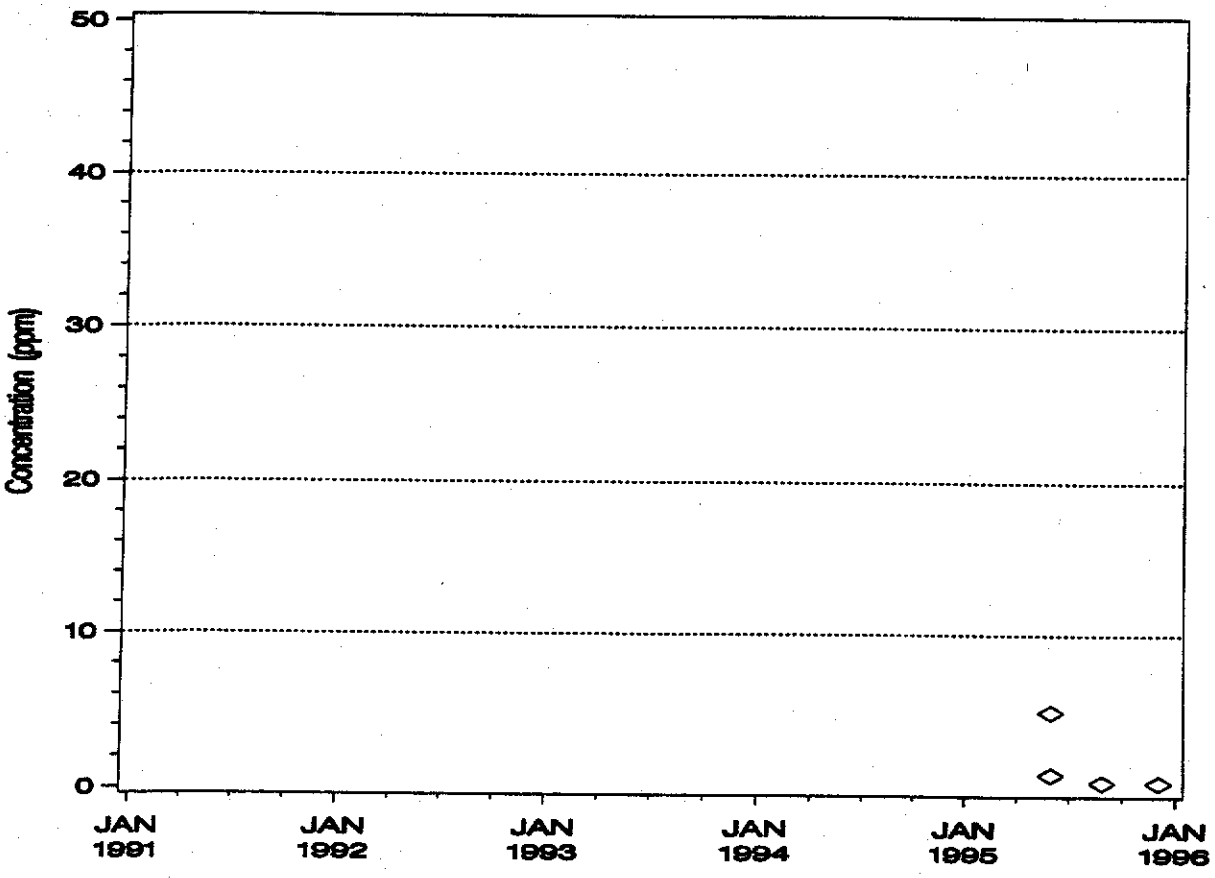
1,1 – DICHLOROETHYLENE Trend



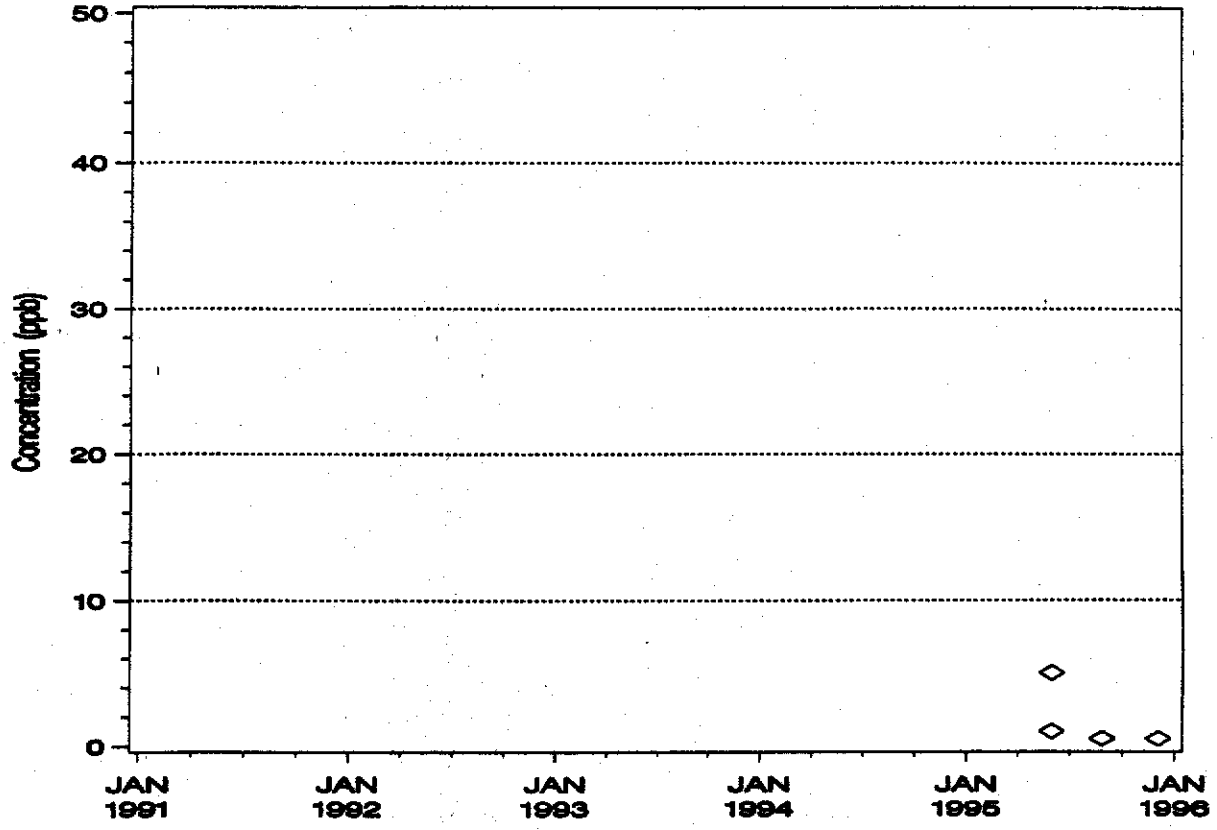
WELL 1588
TRICHLOROETHYLENE Trend



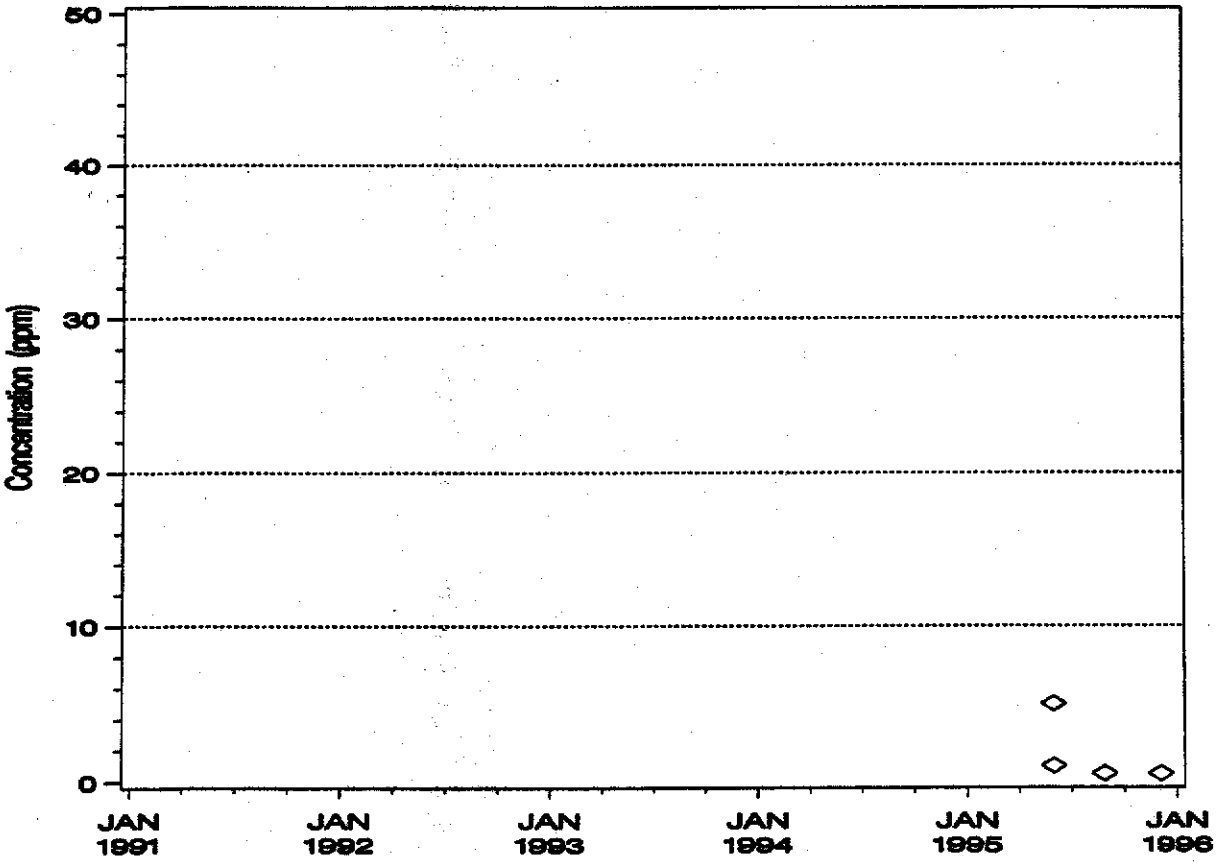
FREON 113 Trend



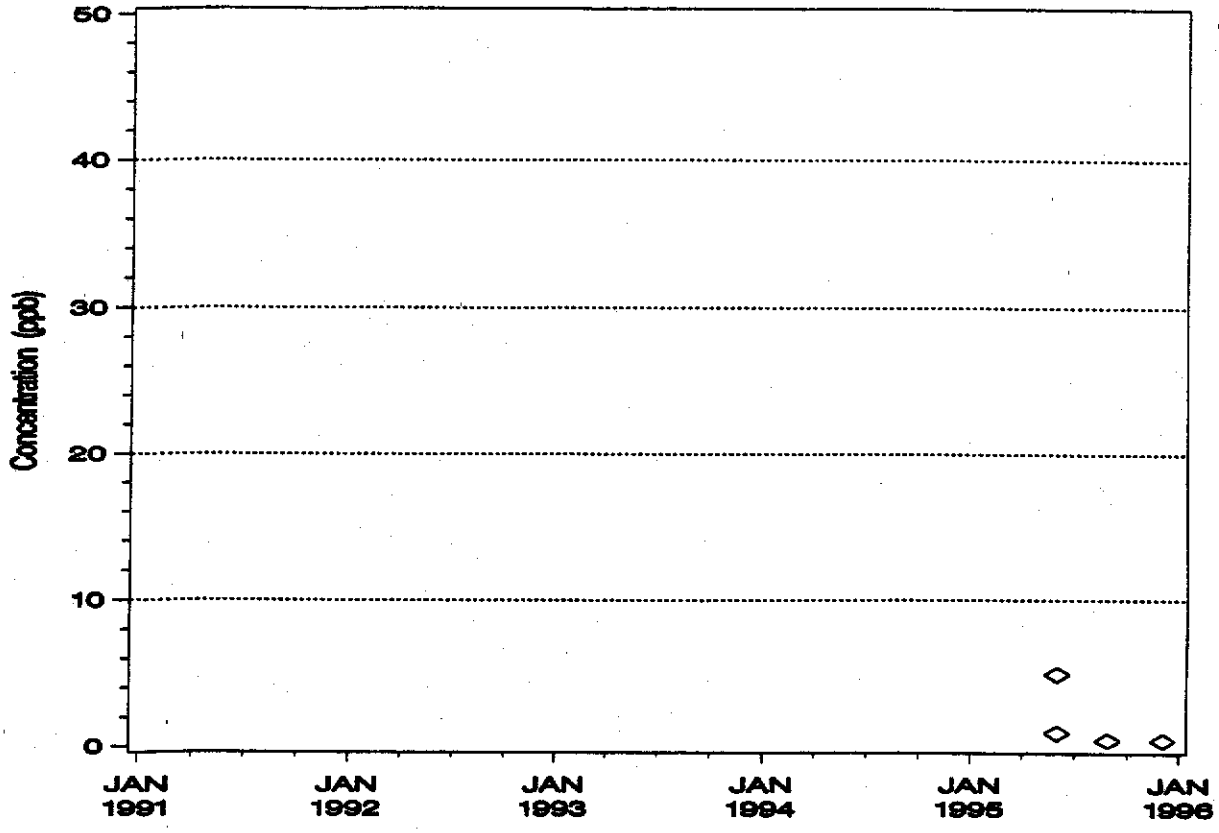
WELL 1588
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



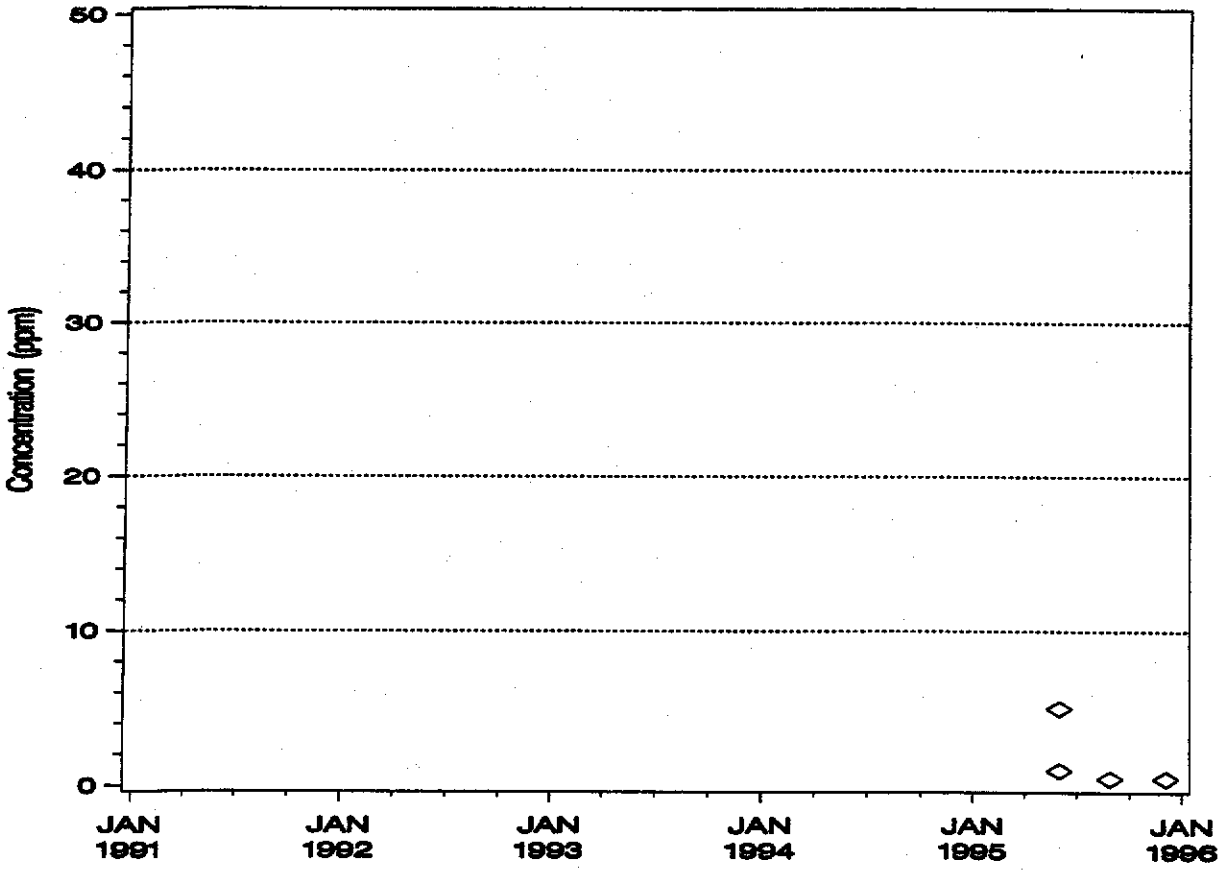
1,1 – DICHLOROETHYLENE Trend



WELL 1589
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend

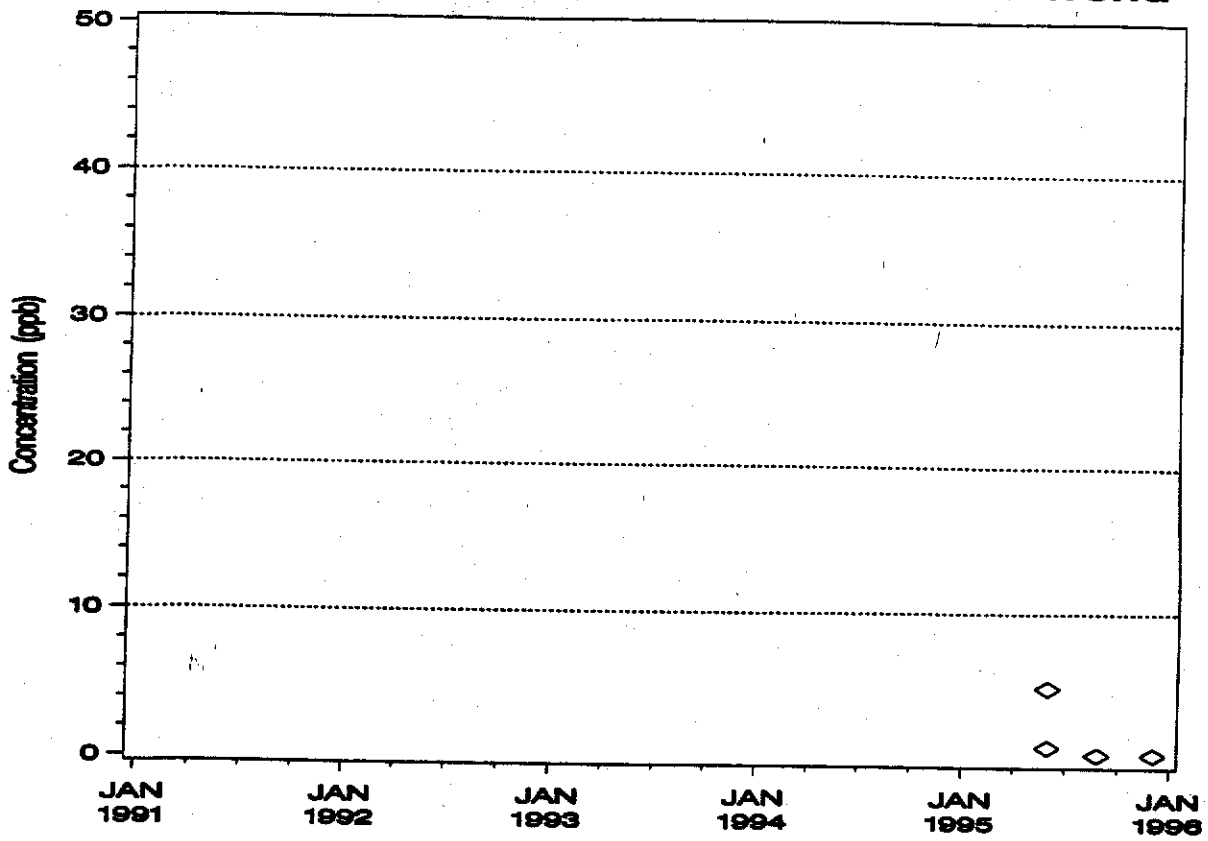


1,1 – DICHLOROETHYLENE Trend

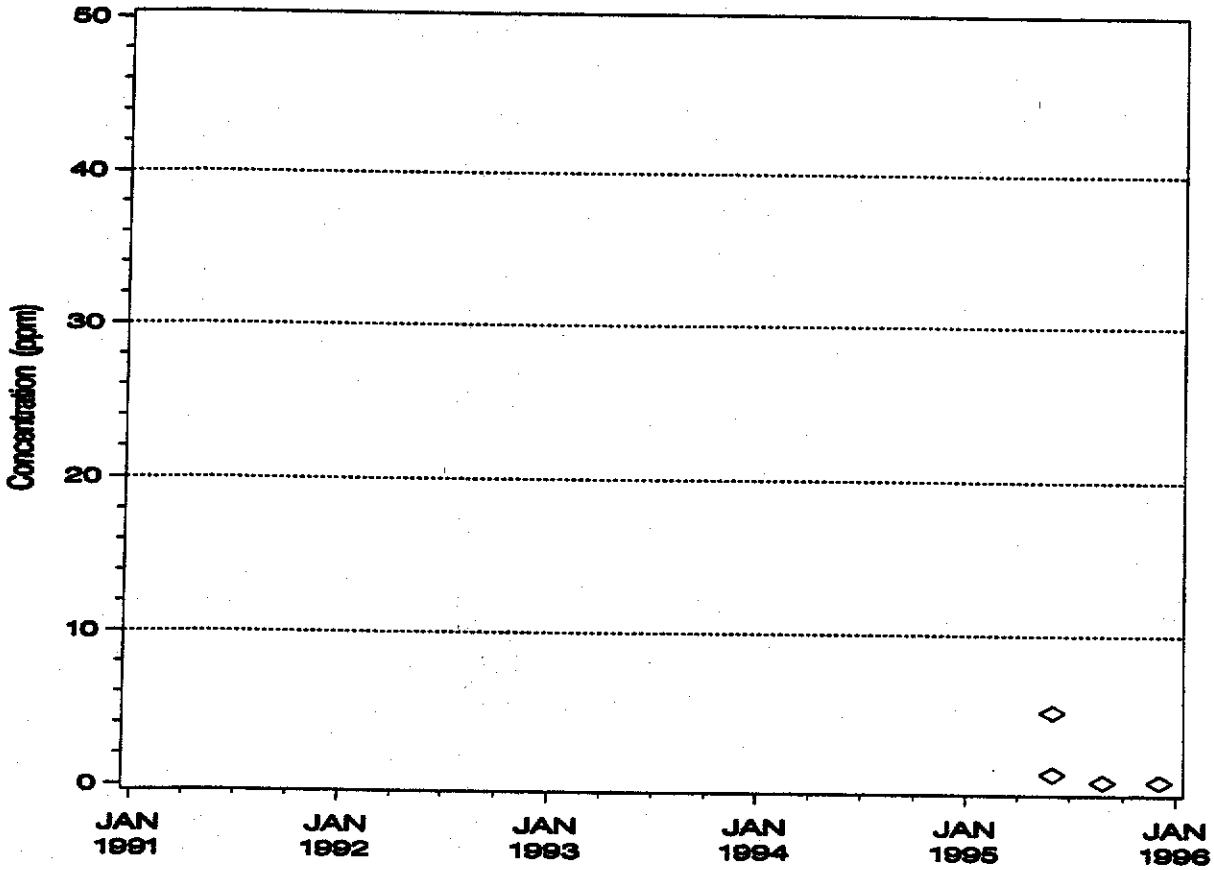


WELL 1590

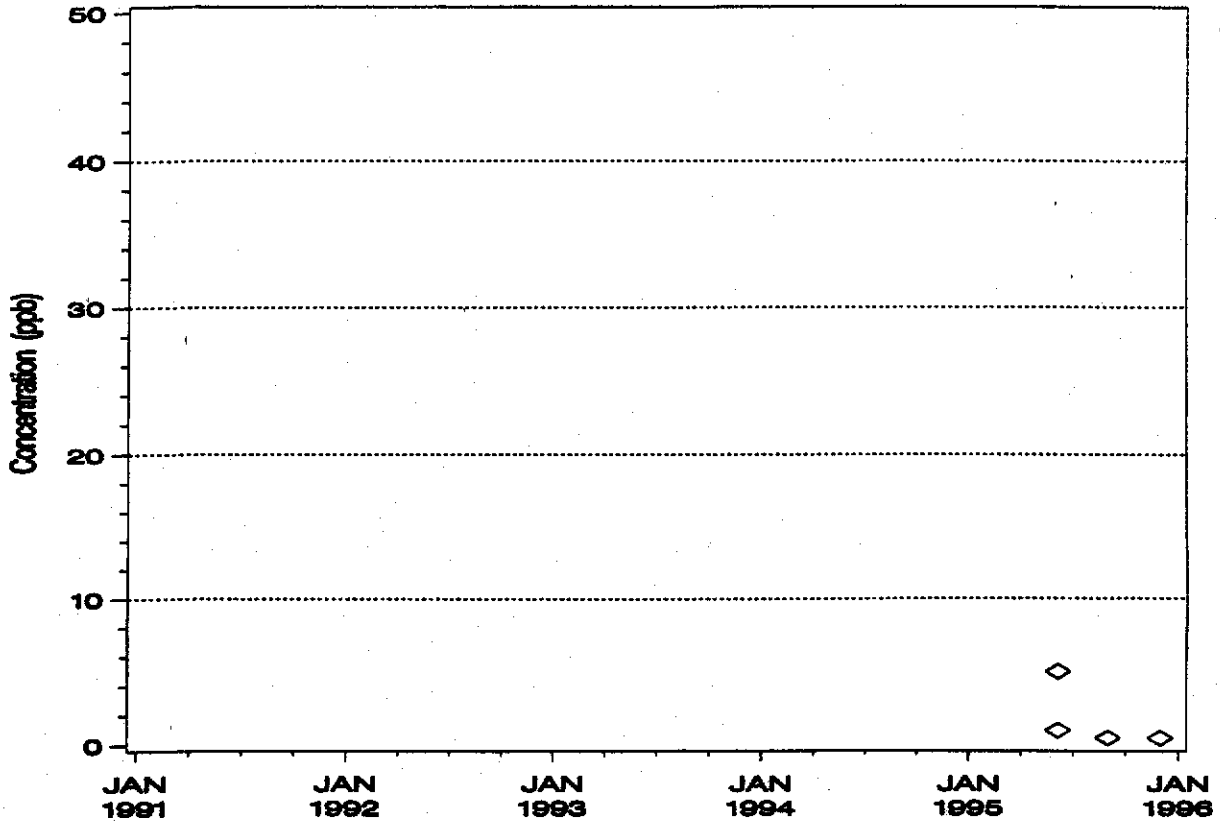
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



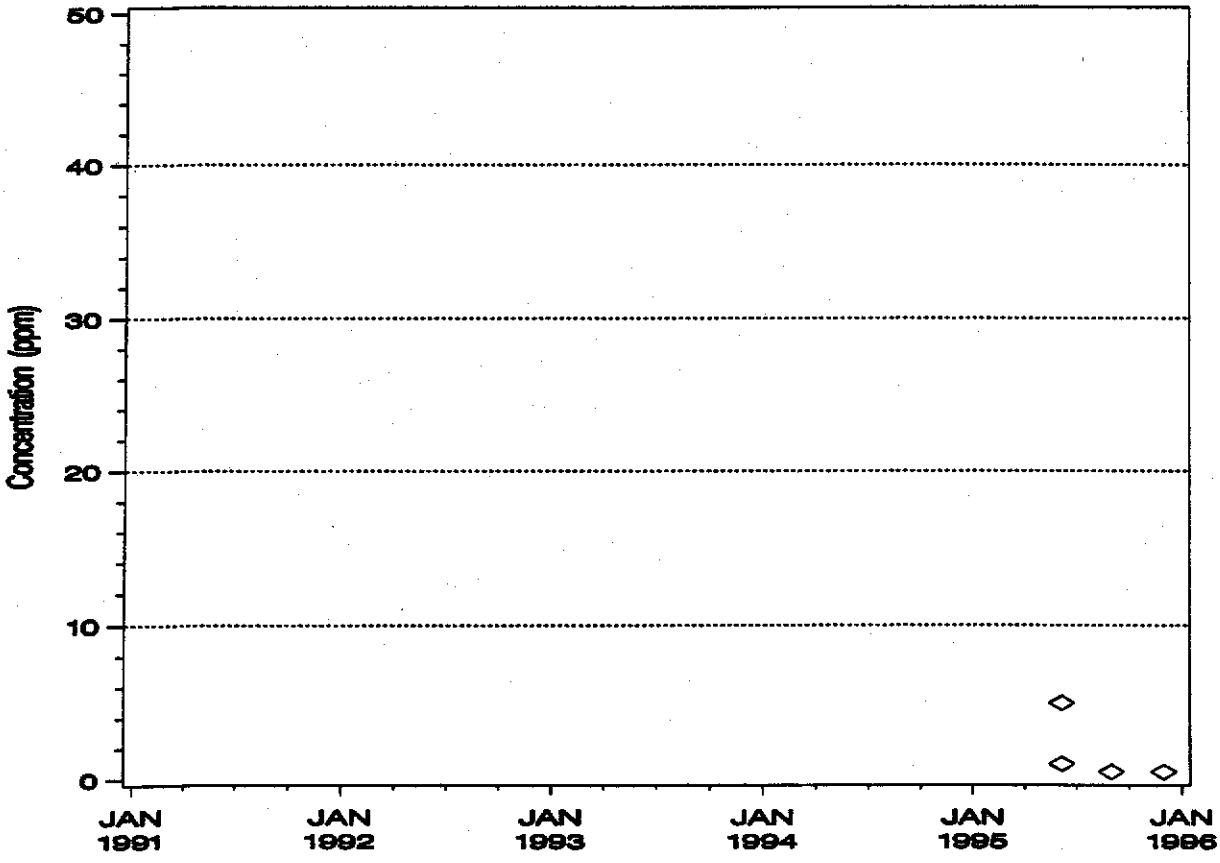
1,1 – DICHLOROETHYLENE Trend



WELL 1591
TRICHLOROETHYLENE Trend

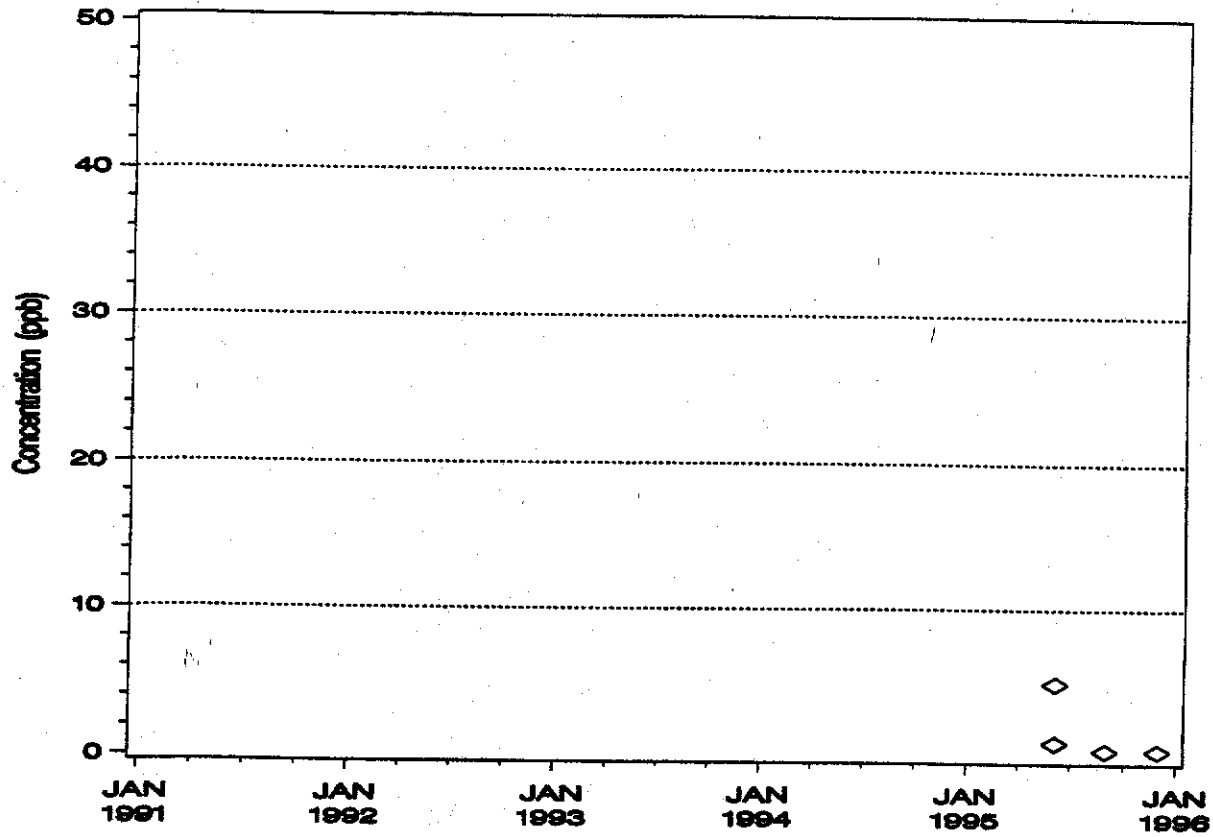


FREON 113 Trend

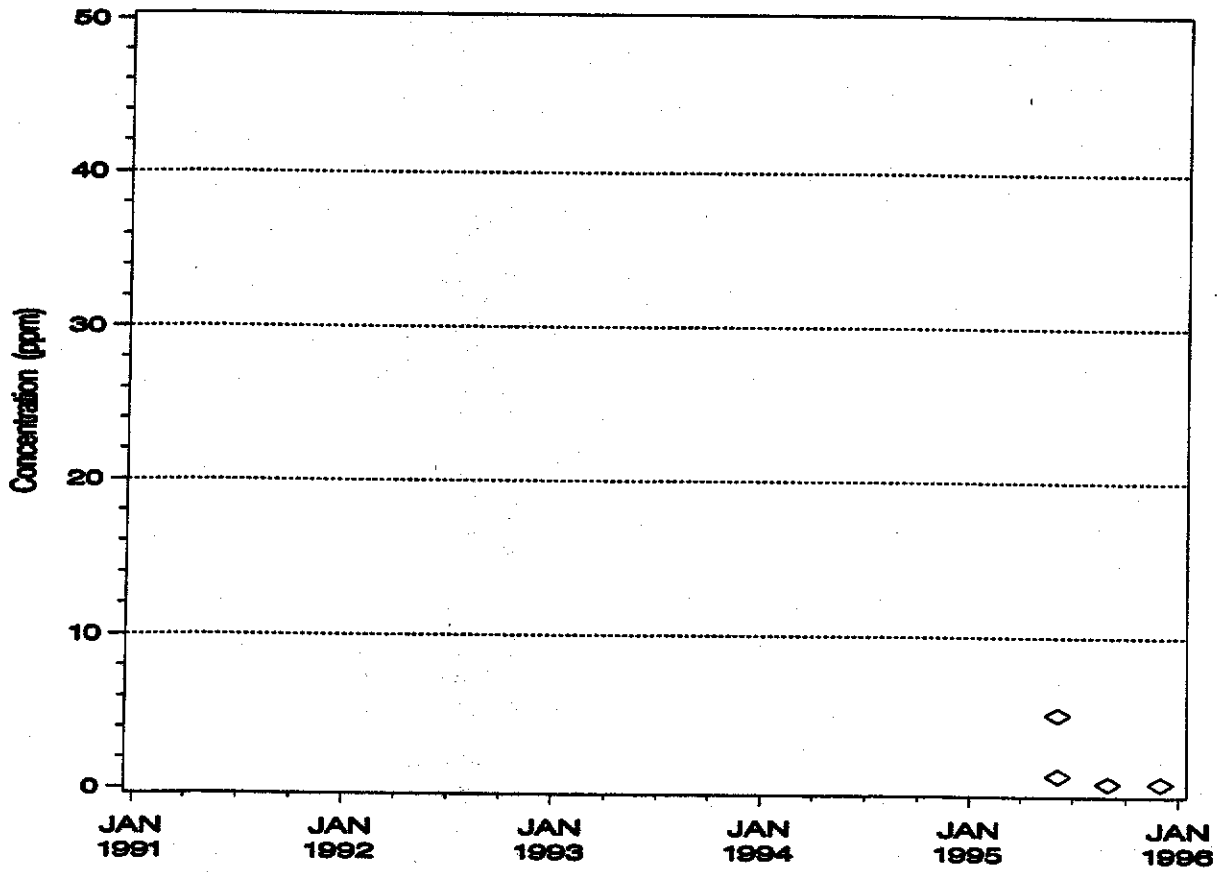


WELL 1591

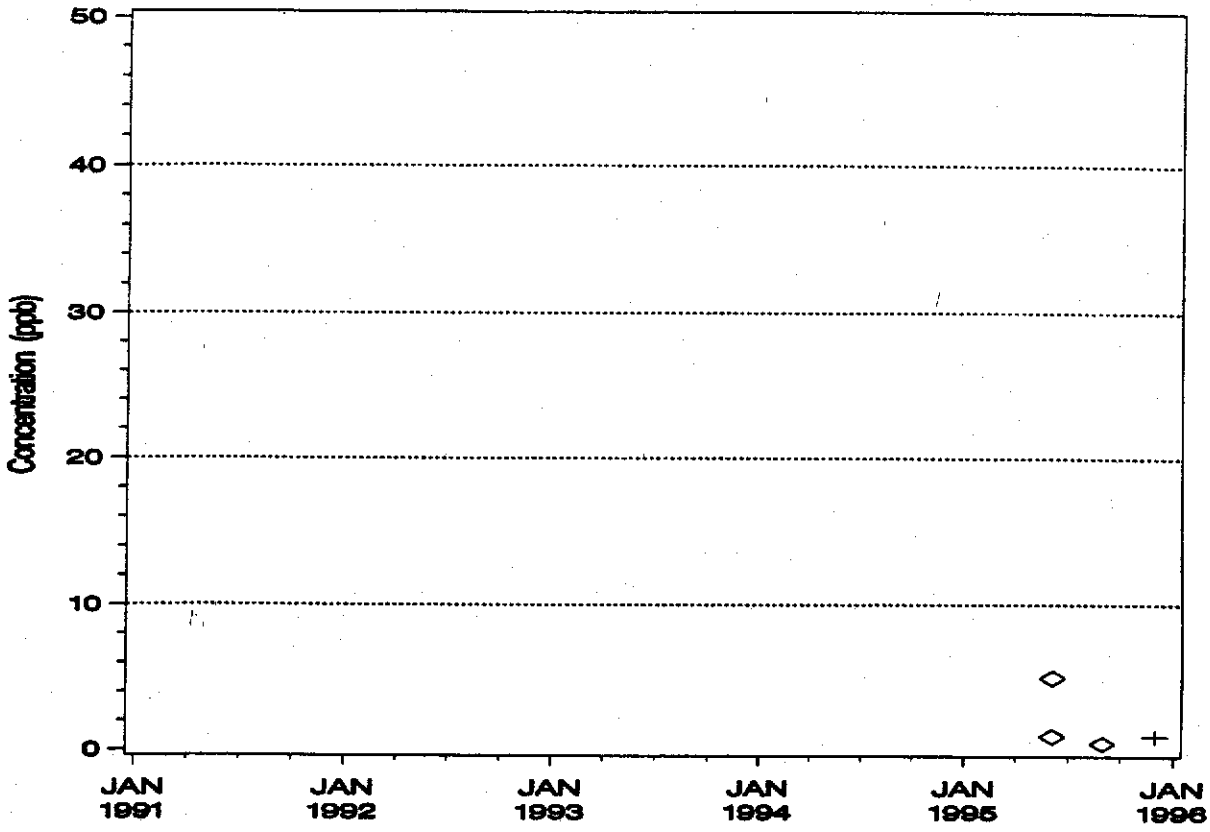
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



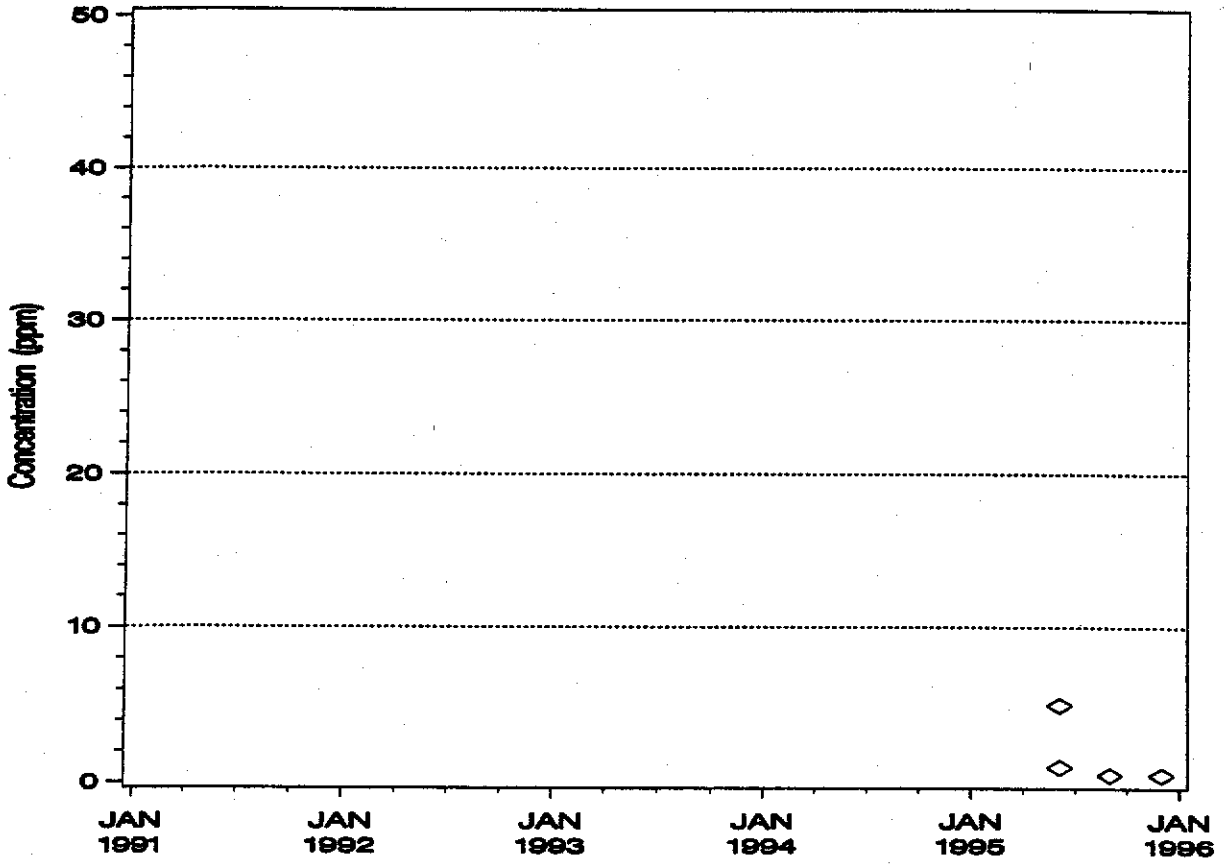
1,1 – DICHLOROETHYLENE Trend



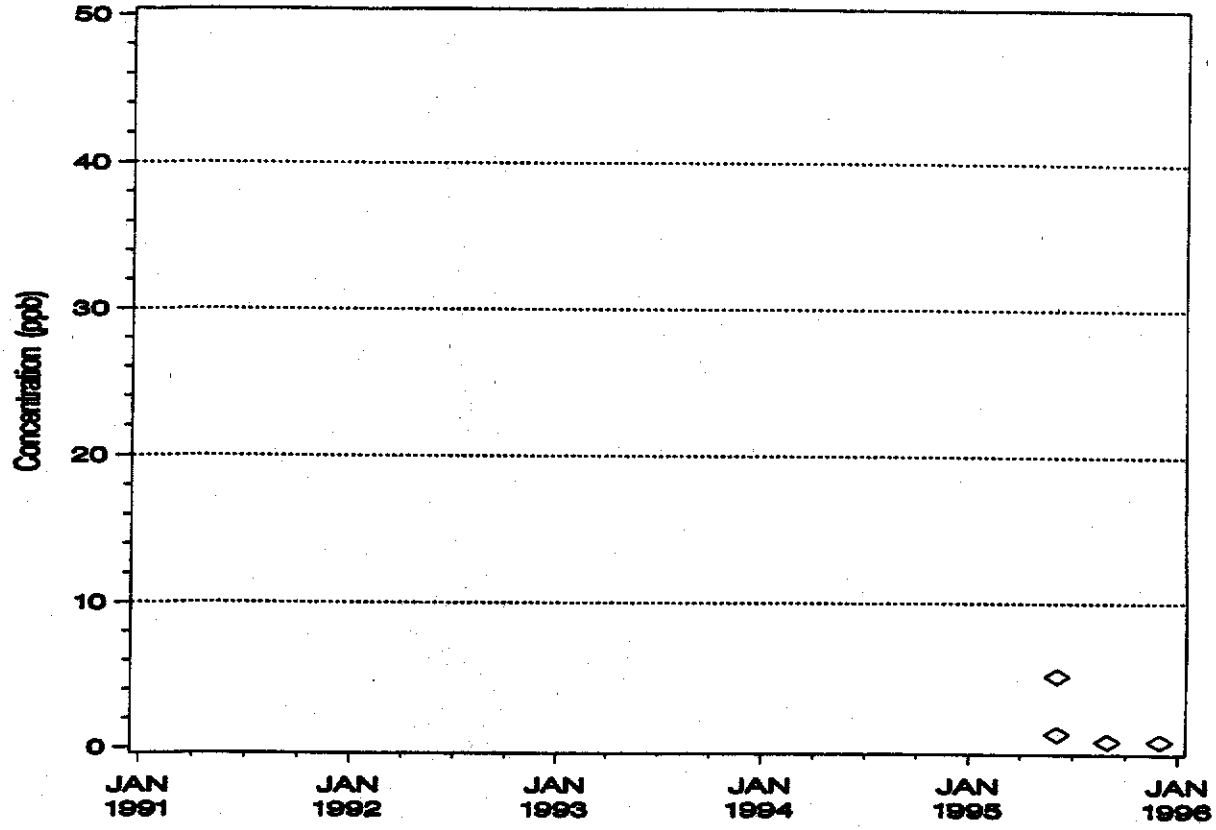
WELL 1592
TRICHLOROETHYLENE Trend



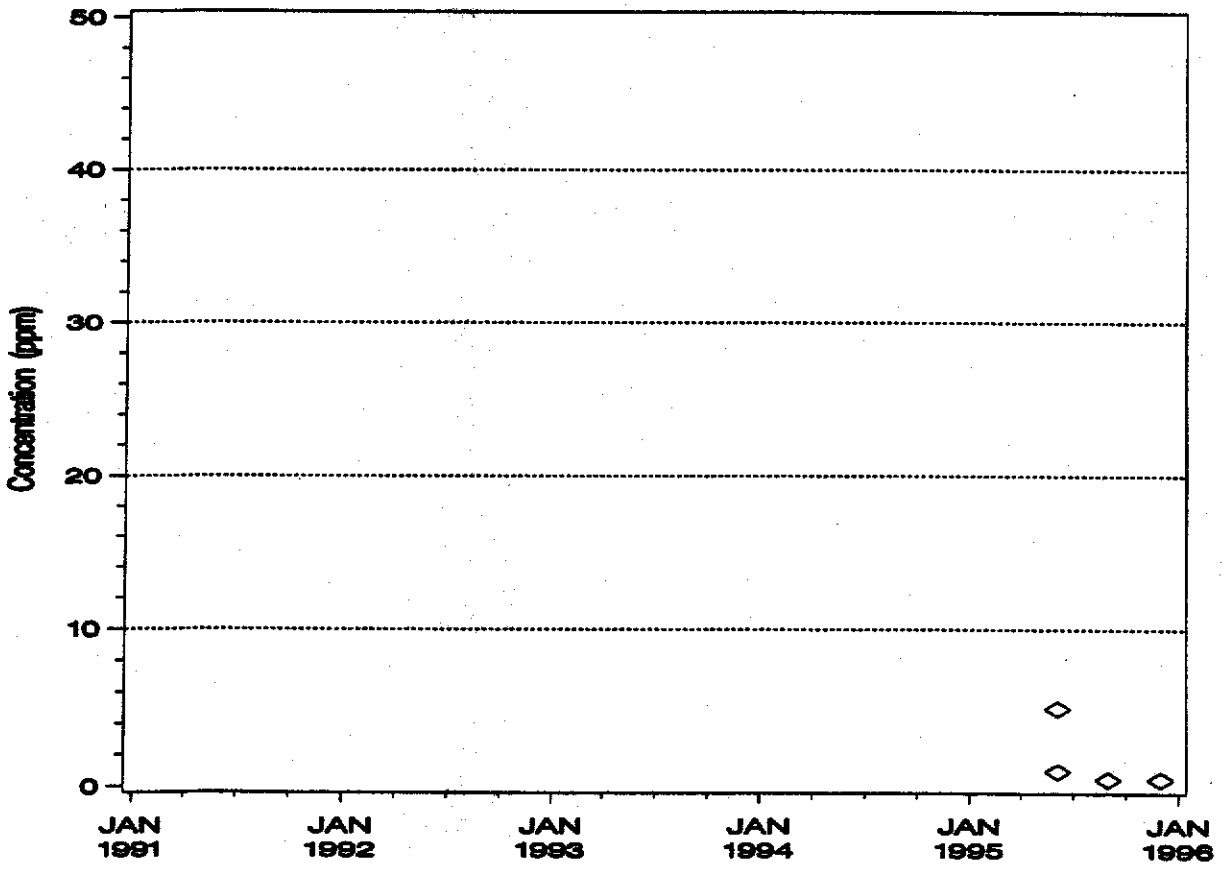
FREON 113 Trend



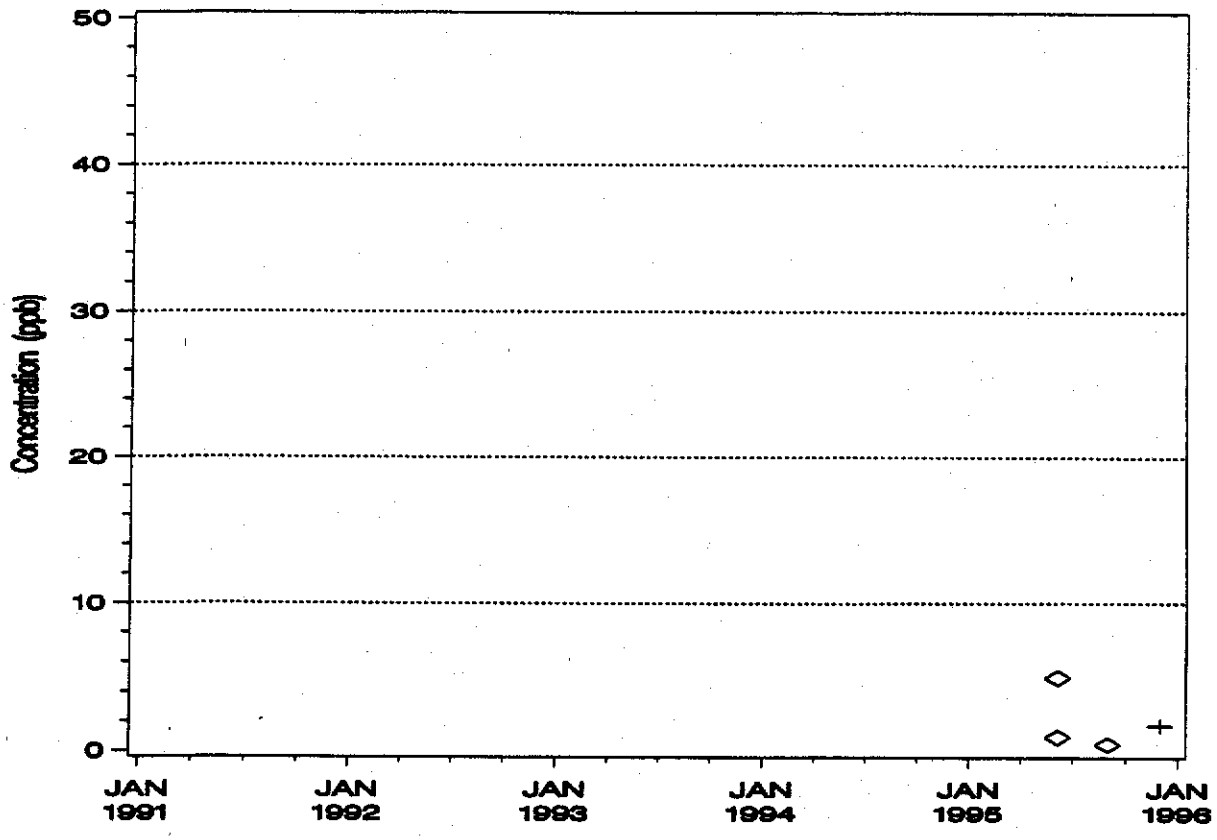
WELL 1592
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



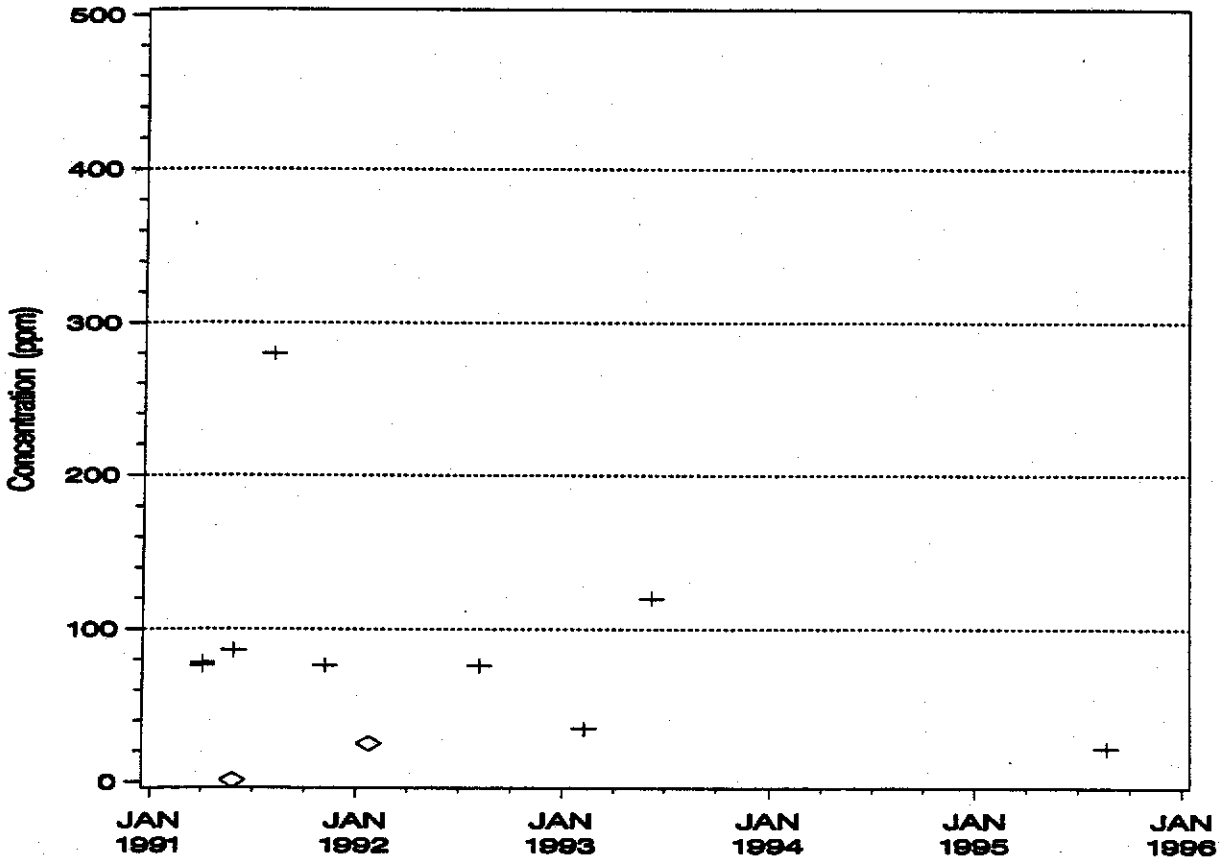
1,1 – DICHLOROETHYLENE Trend



WELL 1593
TRICHLOROETHYLENE Trend

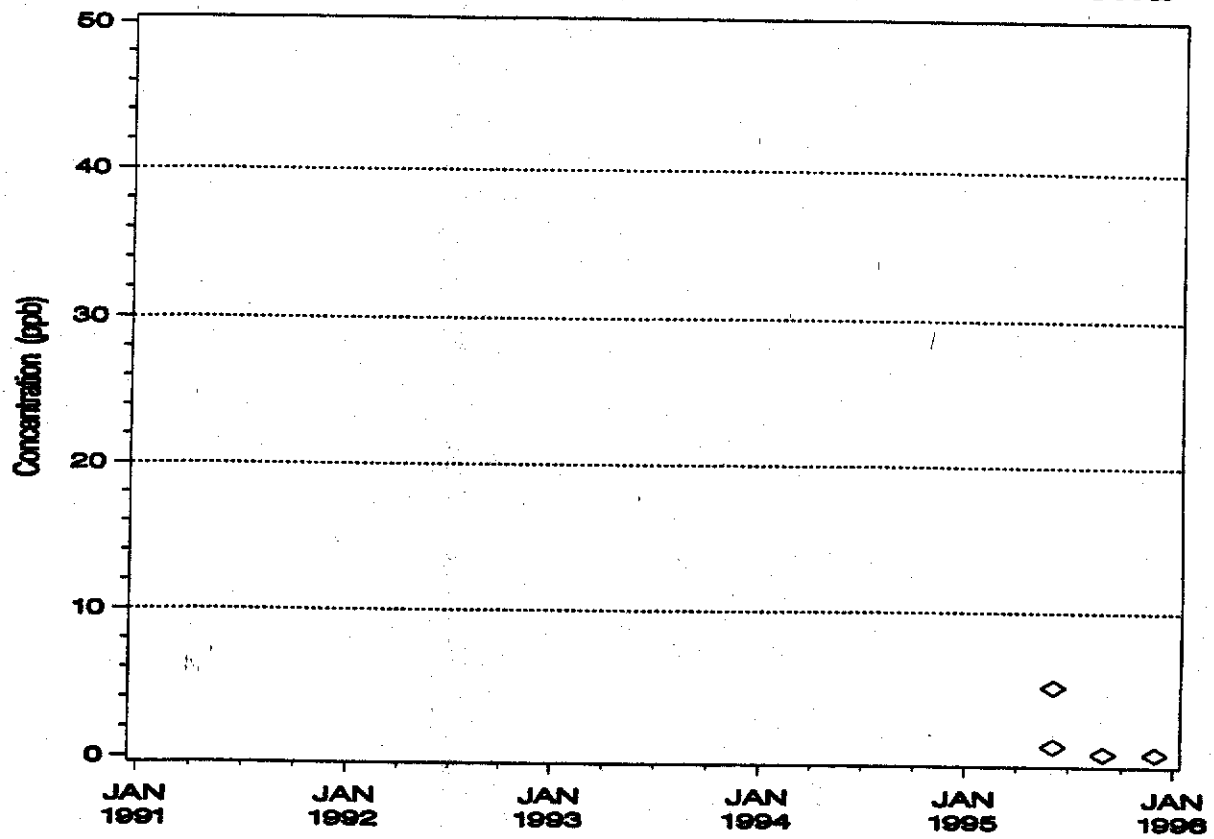


FREON 113 Trend

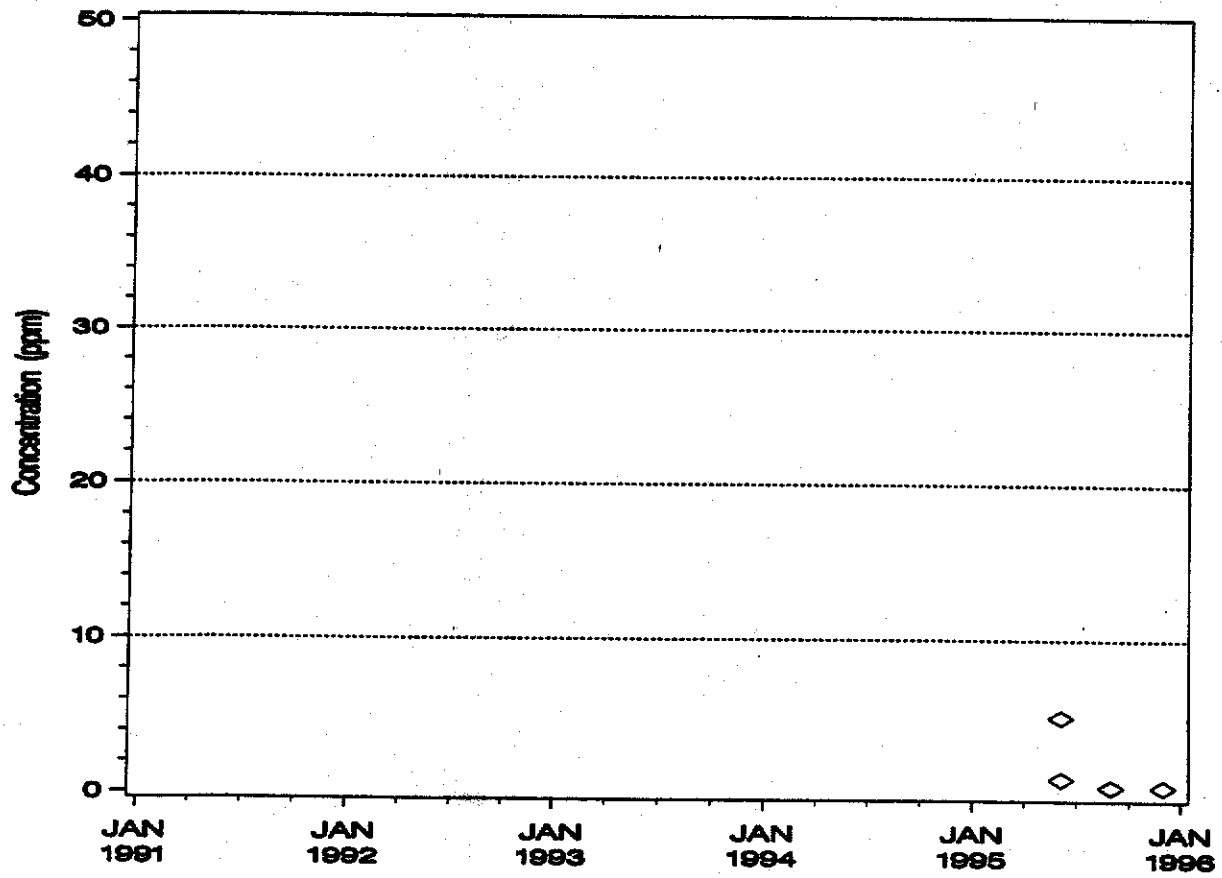


WELL 1593

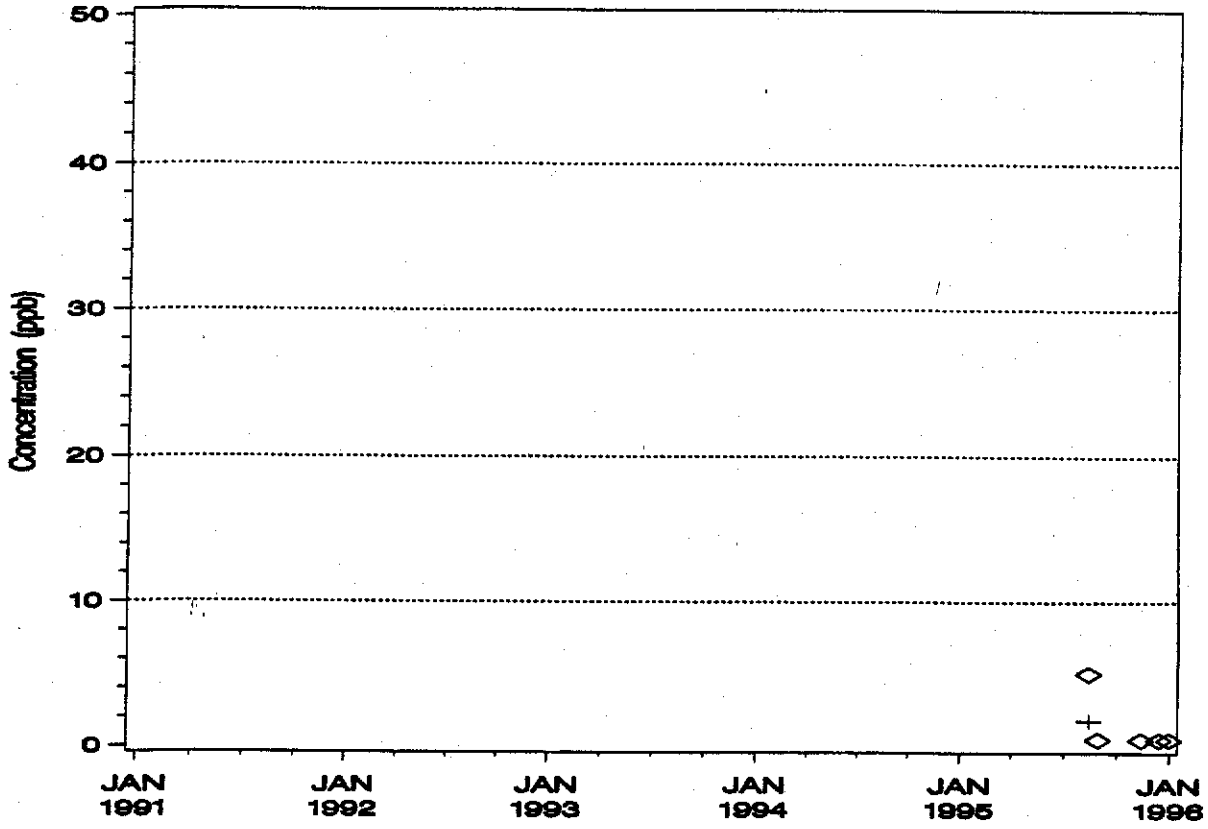
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



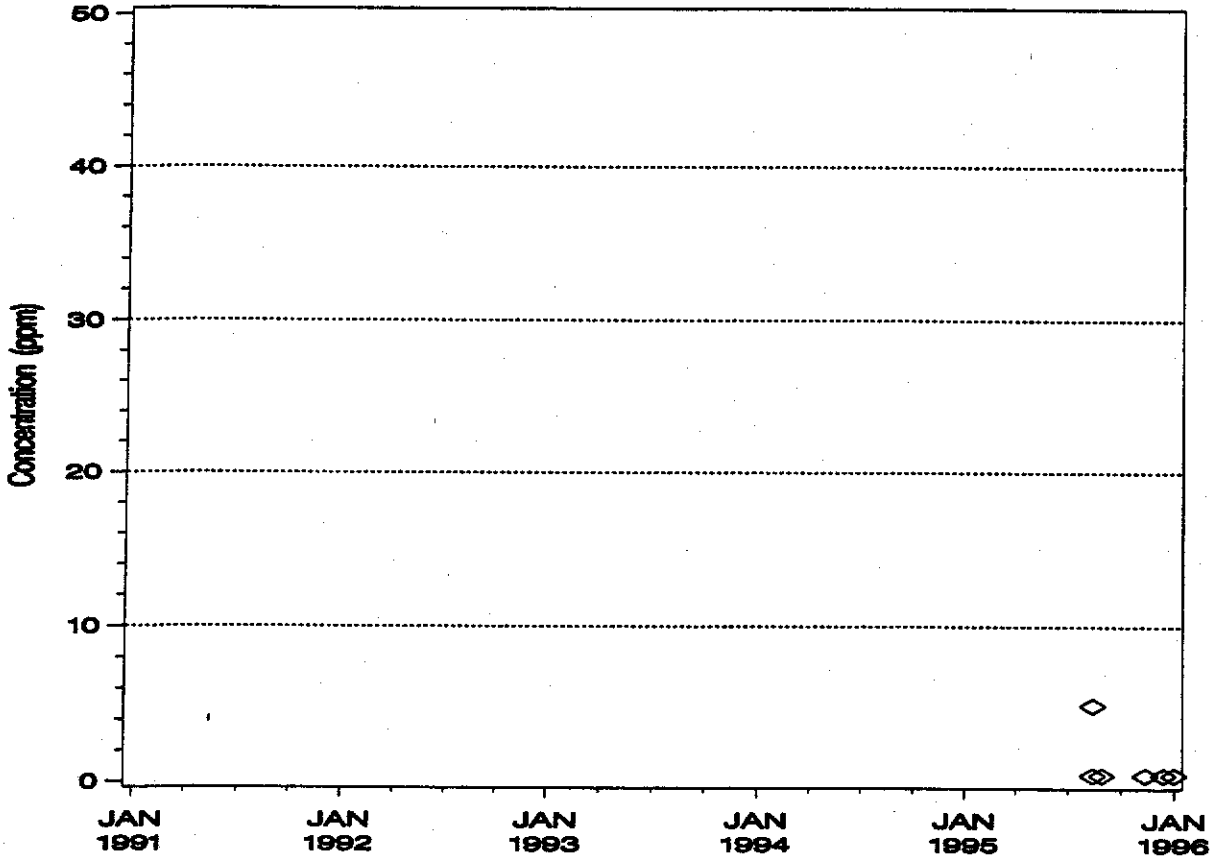
1,1 – DICHLOROETHYLENE Trend



WELL 1594
TRICHLOROETHYLENE Trend

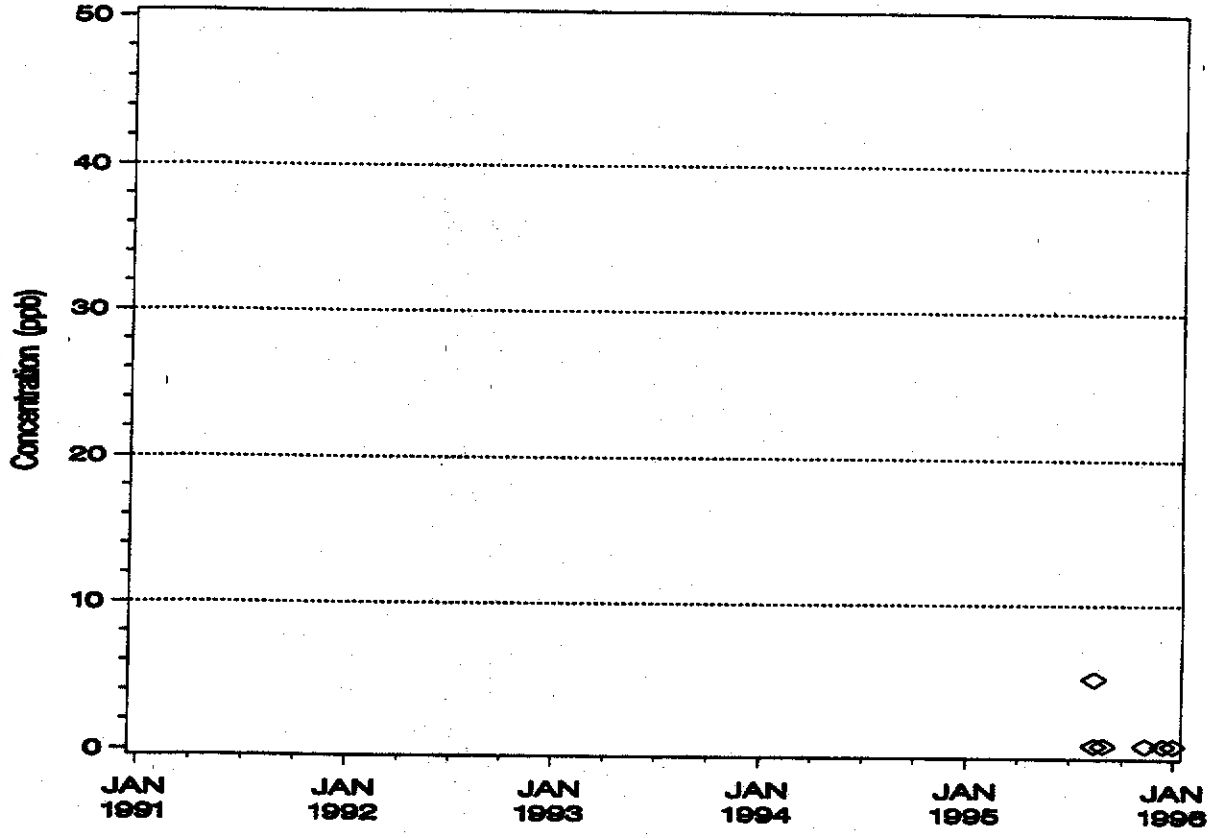


FREON 113 Trend

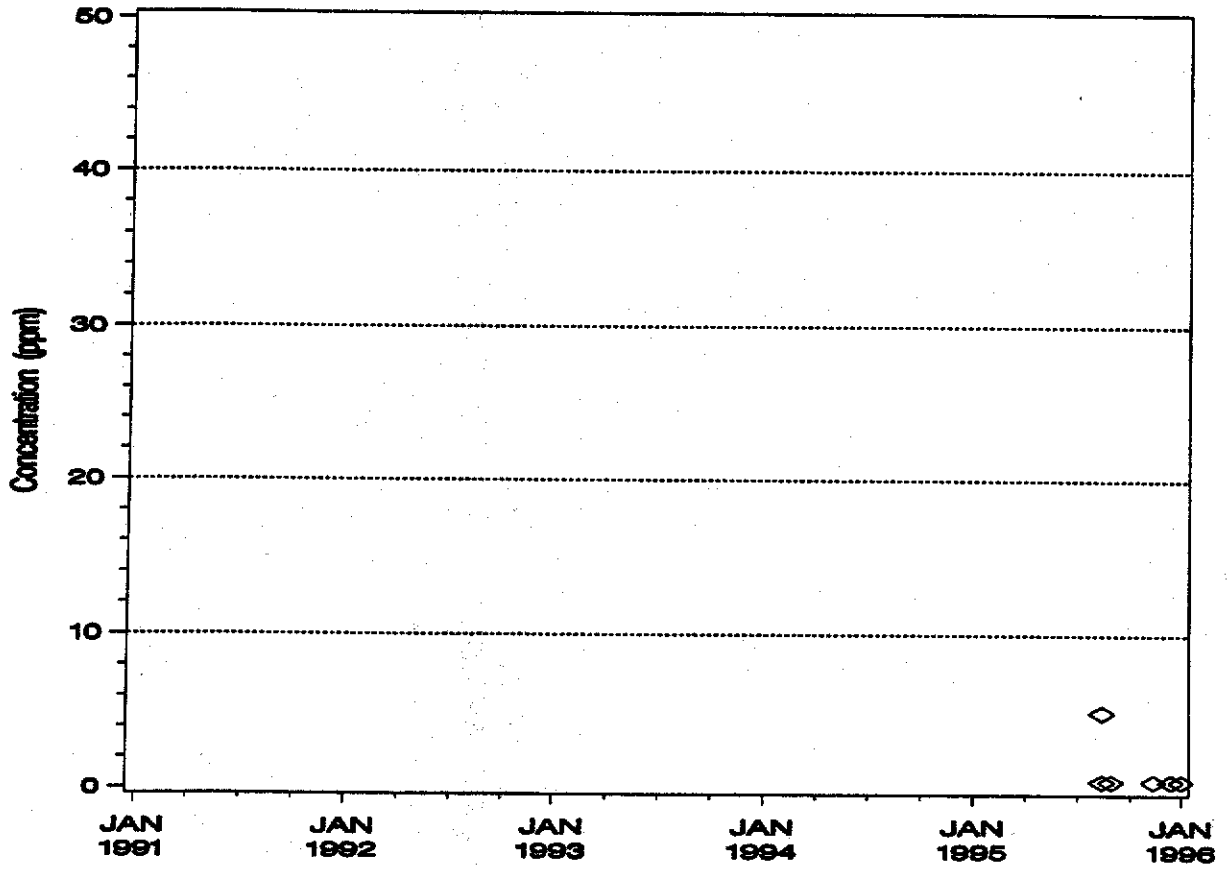


WELL 1594

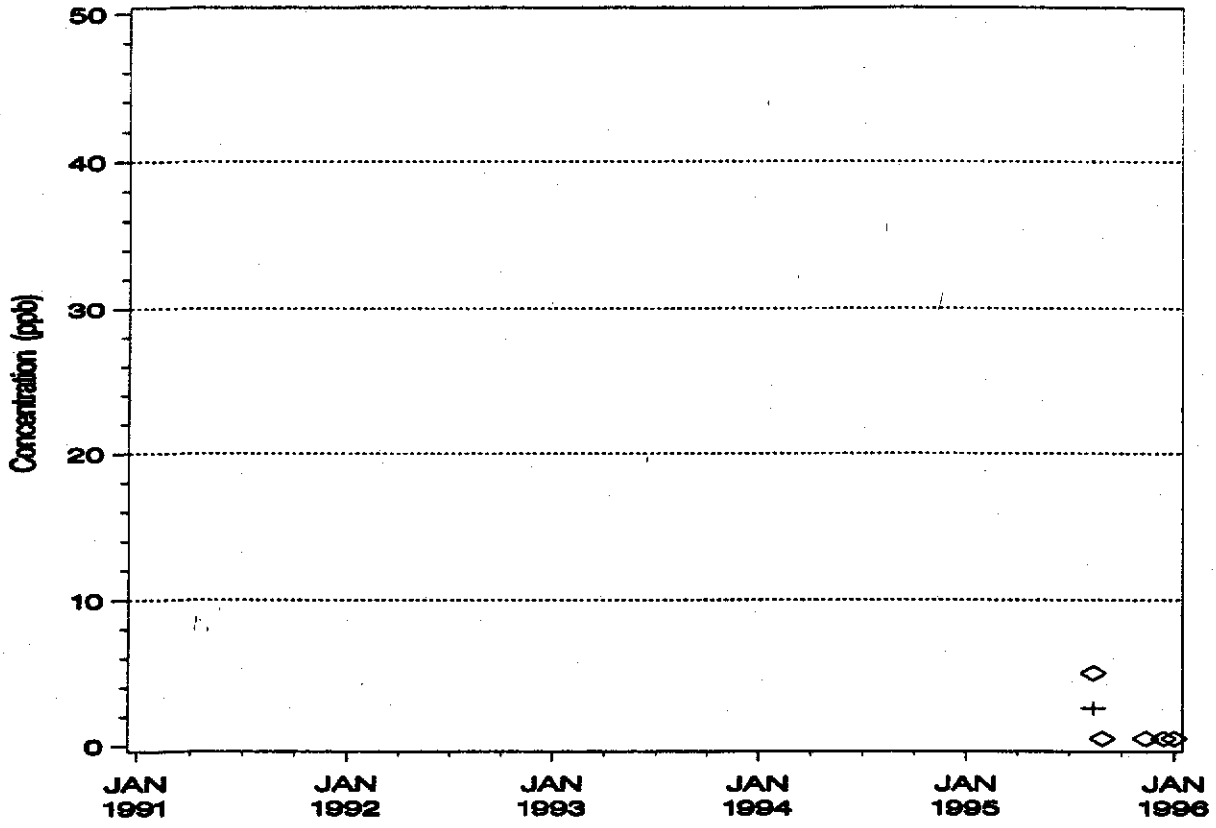
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



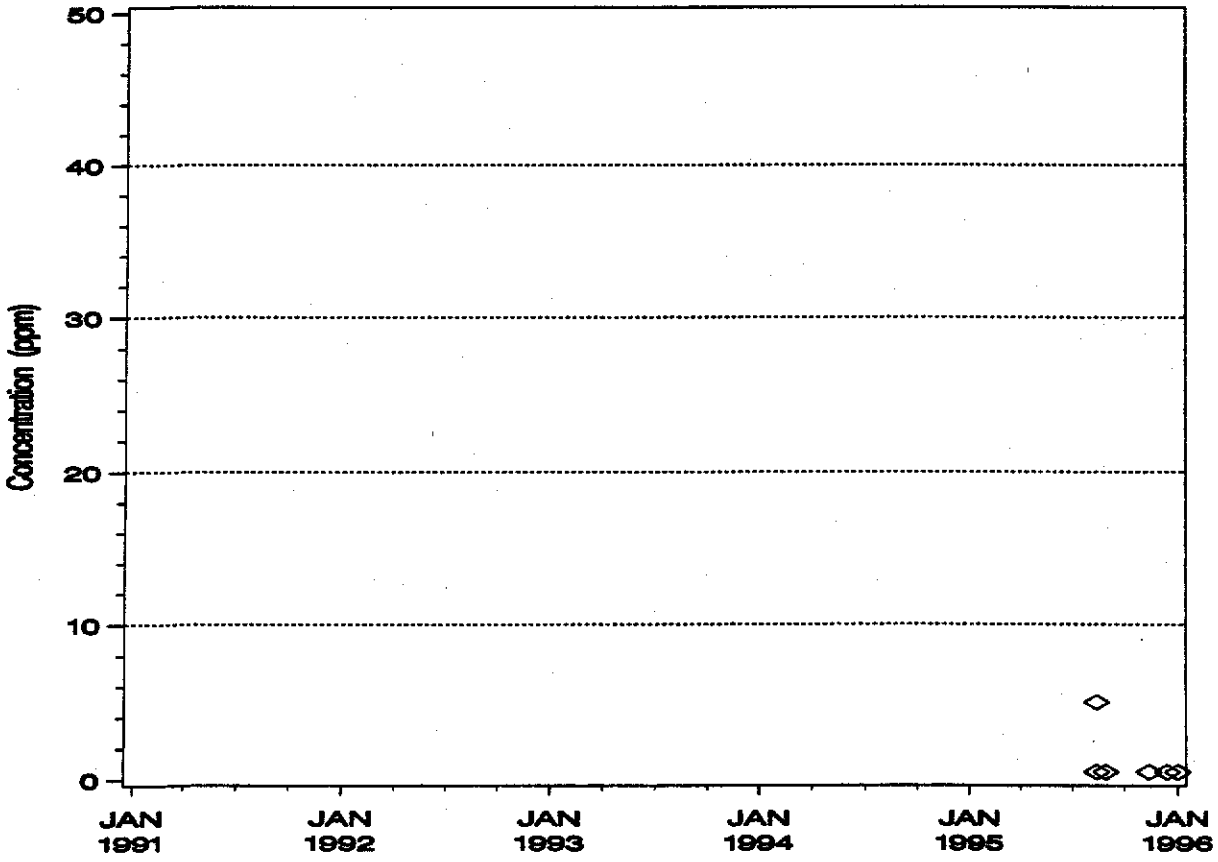
1,1 – DICHLOROETHYLENE Trend



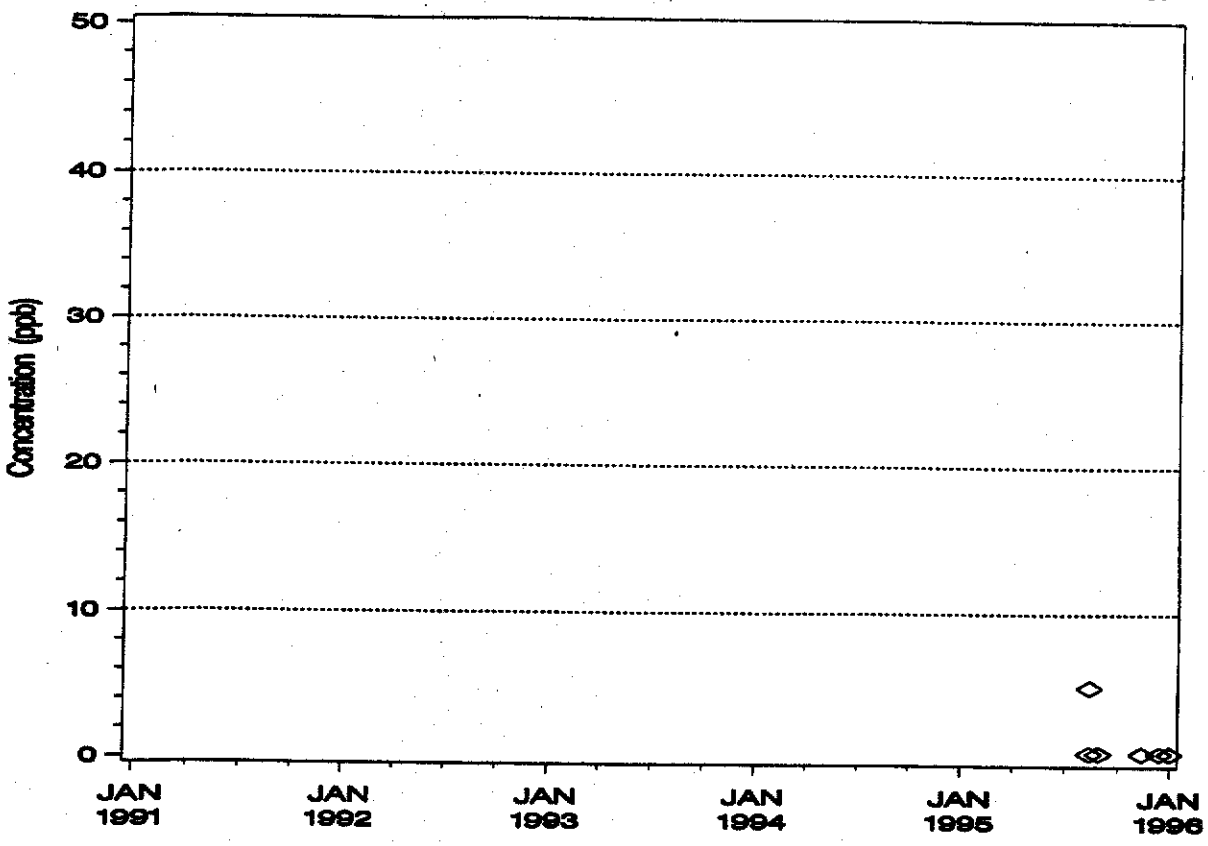
WELL 1595
TRICHLOROETHYLENE Trend



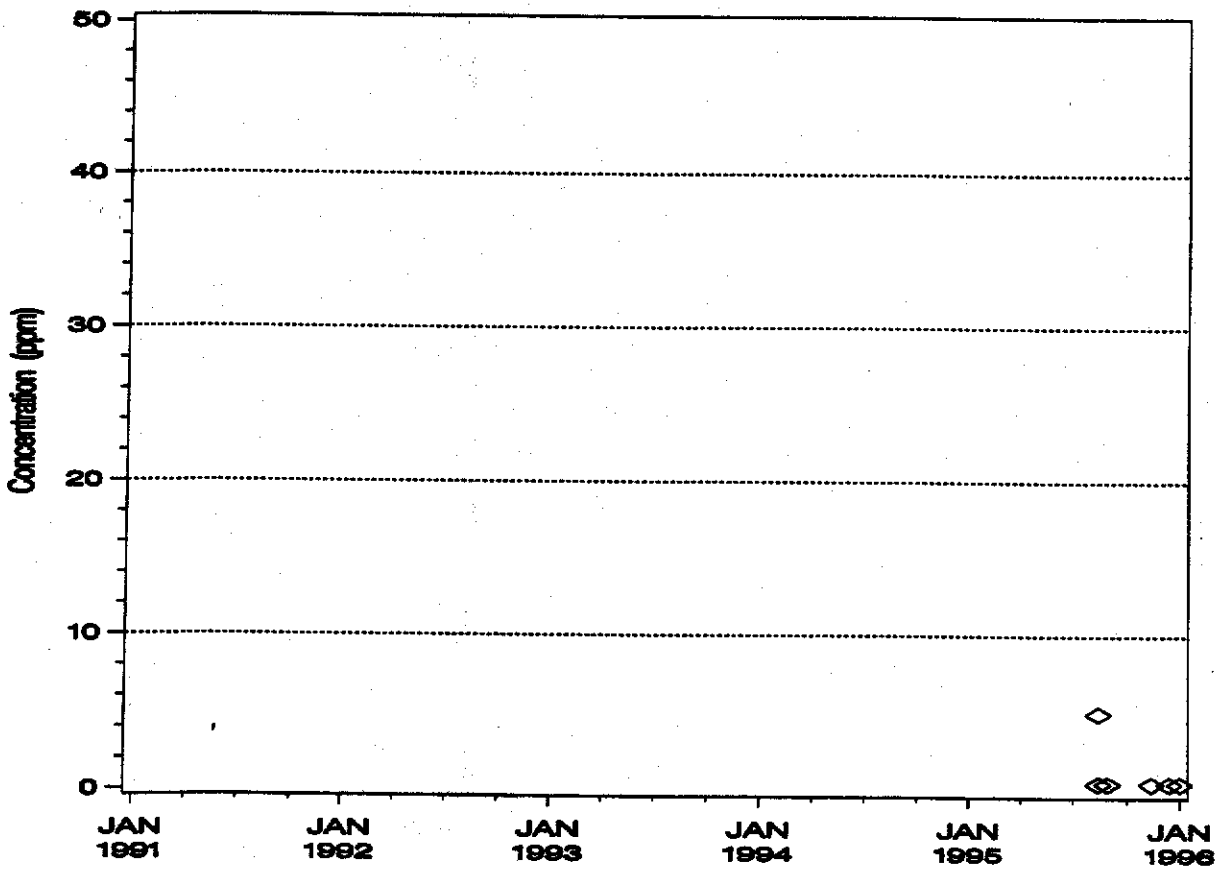
FREON 113 Trend



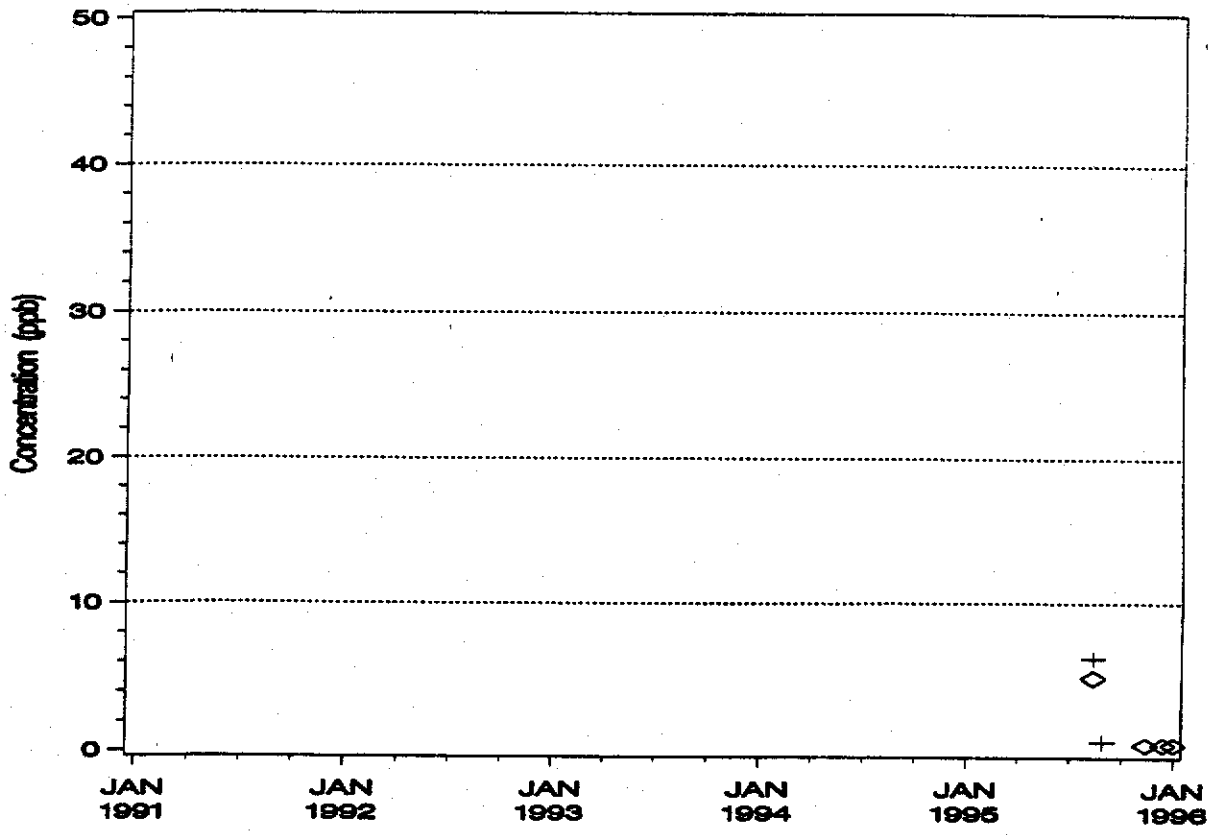
WELL 1595
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



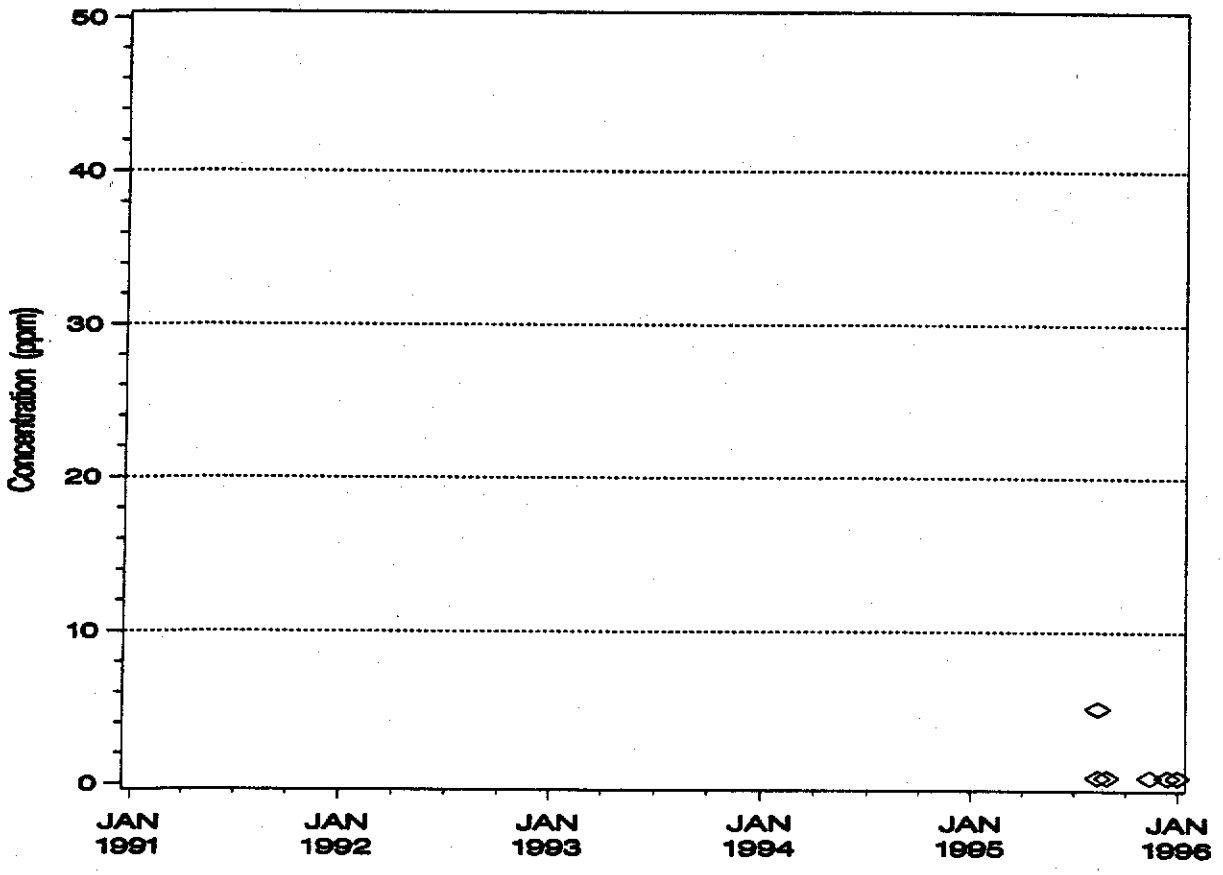
1,1 – DICHLOROETHYLENE Trend



WELL 1596
TRICHLOROETHYLENE Trend

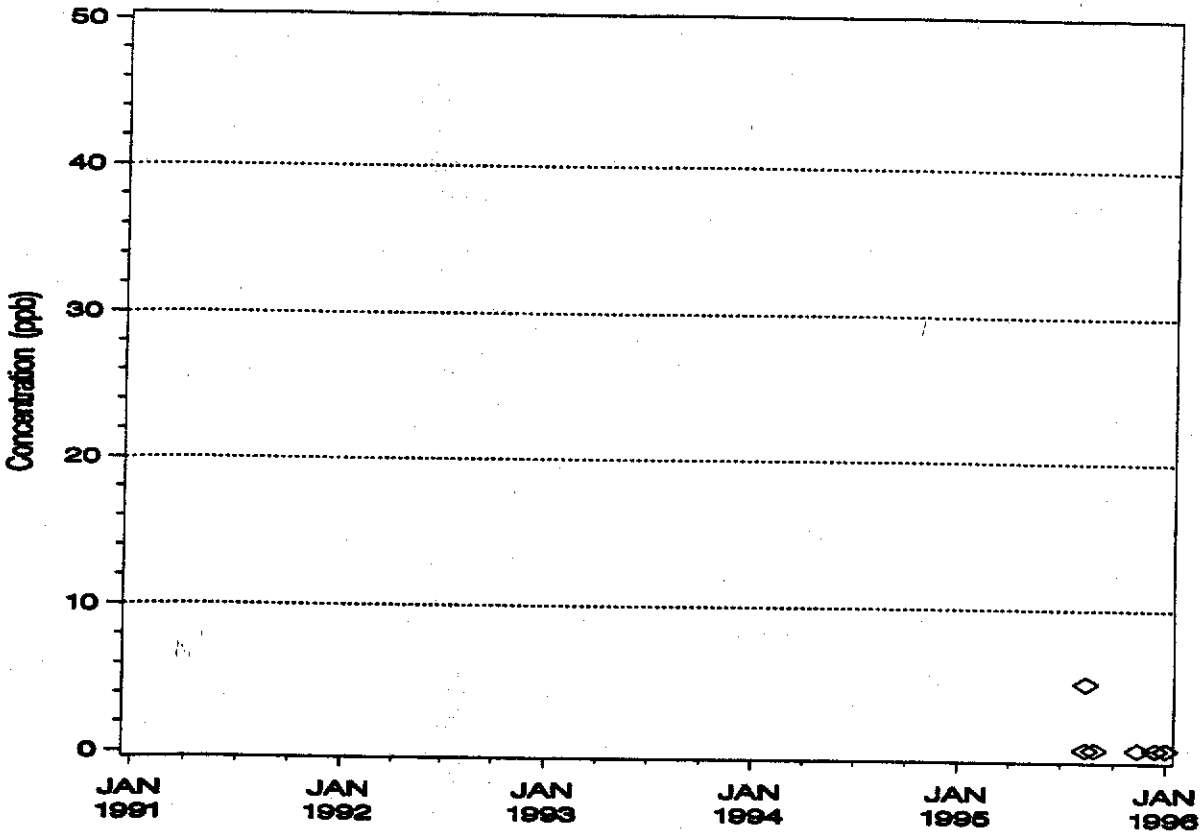


FREON 113 Trend

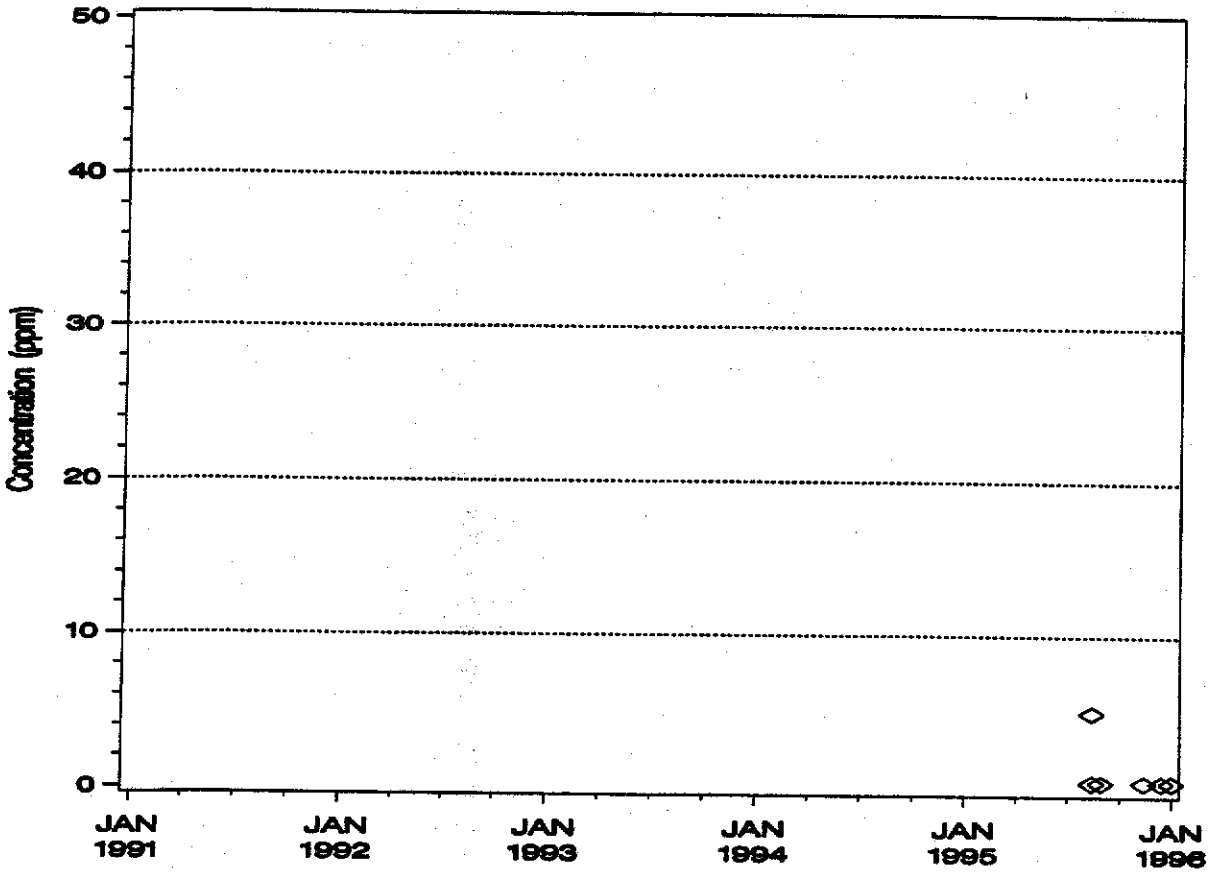


WELL 1596

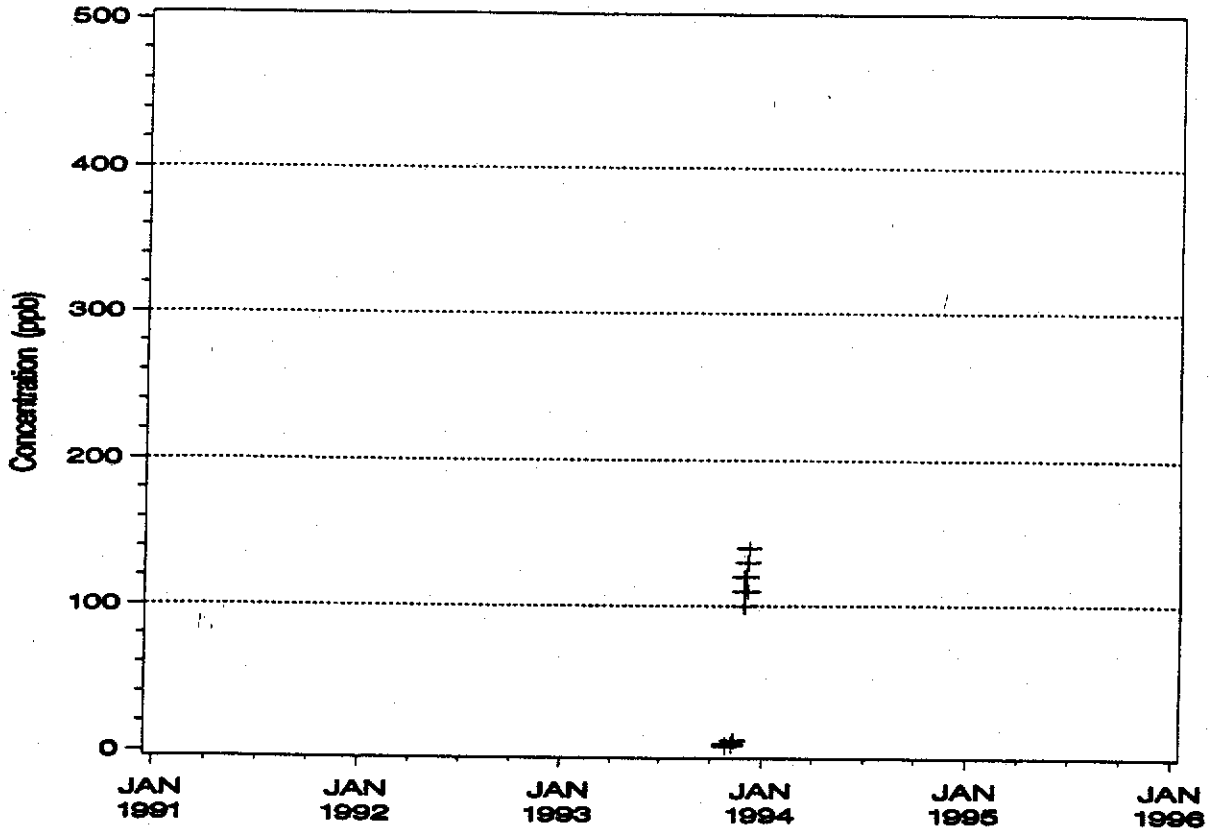
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



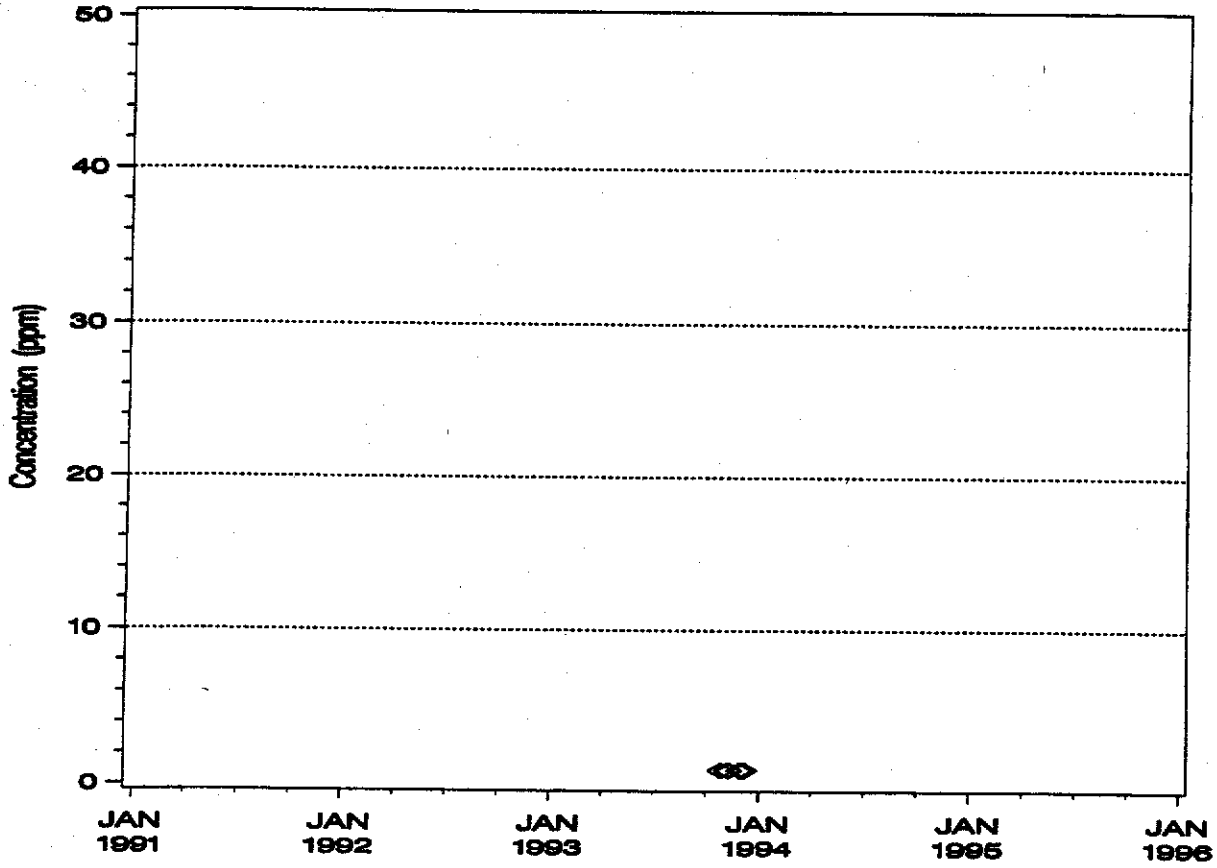
1,1 – DICHLOROETHYLENE Trend



WELL 4300
TRICHLOROETHYLENE Trend

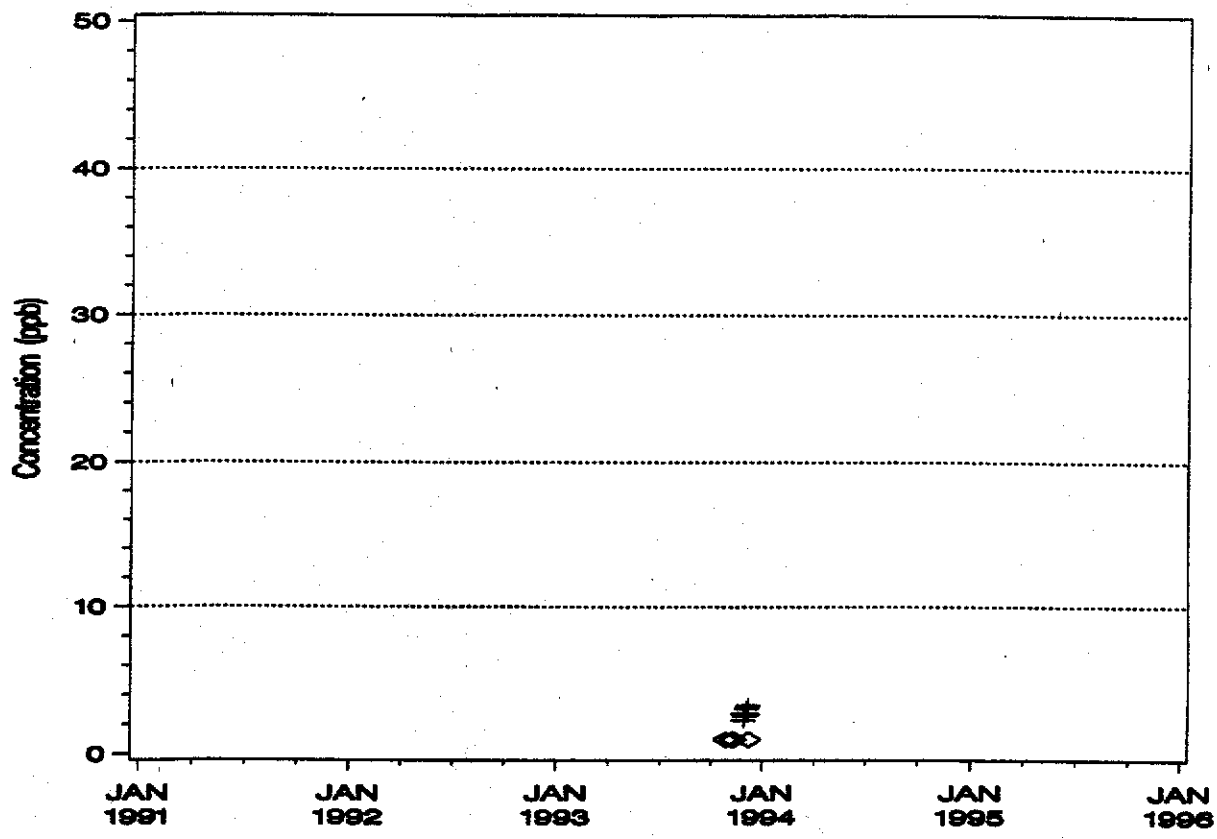


FREON 113 Trend

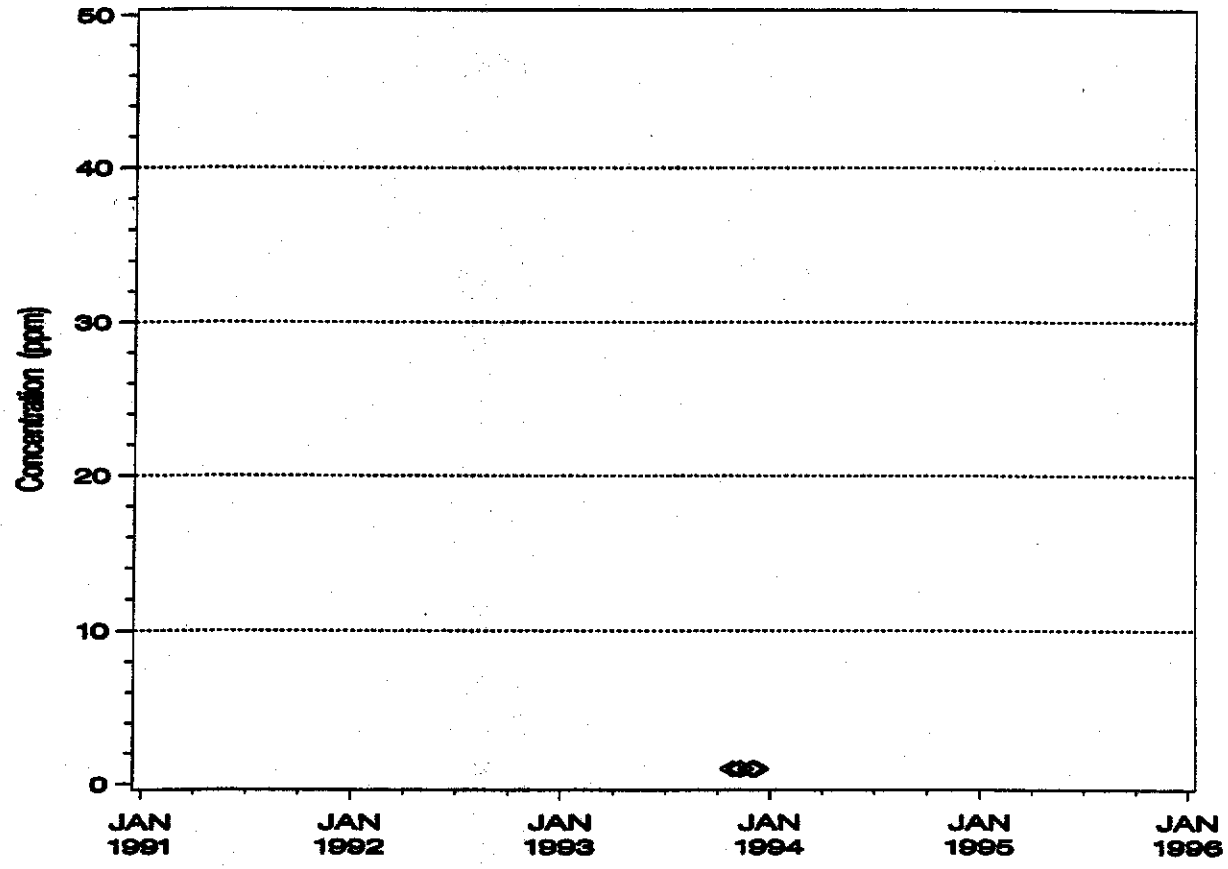


WELL 4300

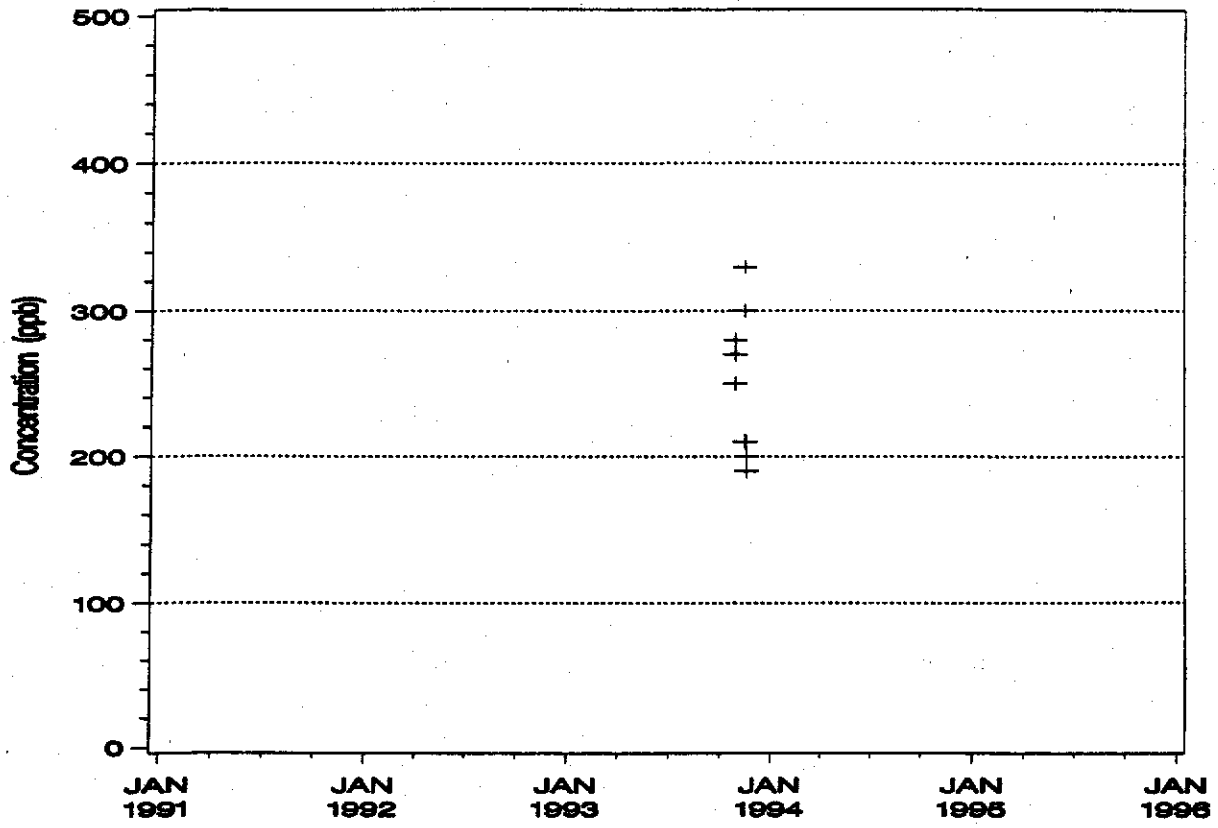
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



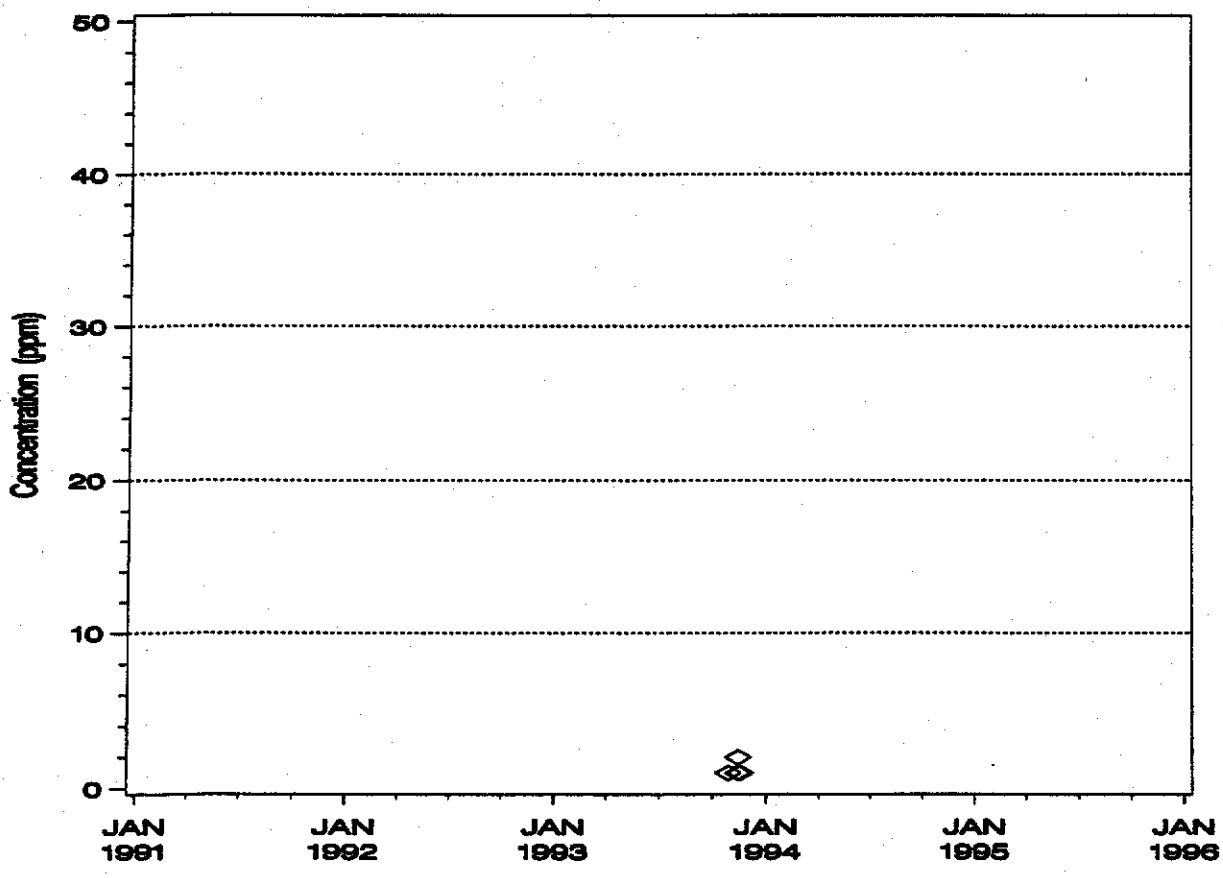
1,1 – DICHLOROETHYLENE Trend



WELL 4301
TRICHLOROETHYLENE Trend

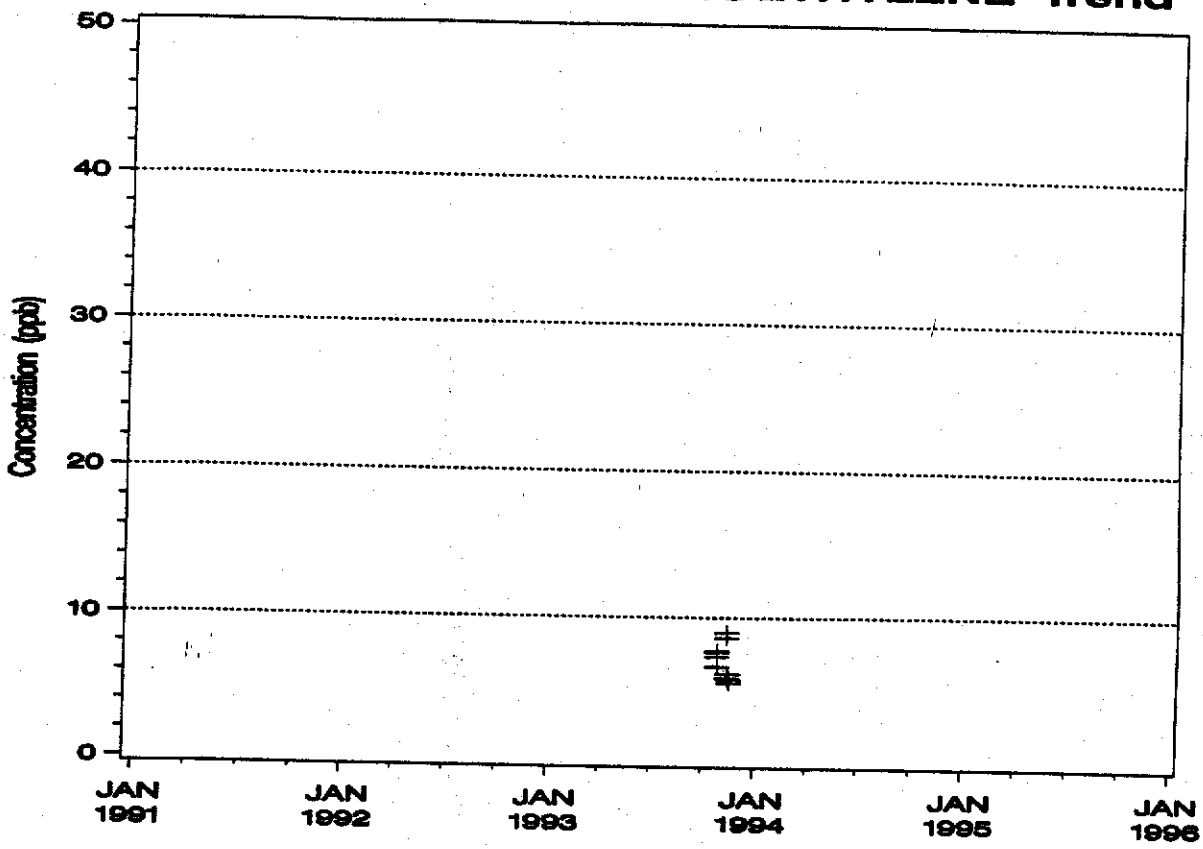


FREON 113 Trend

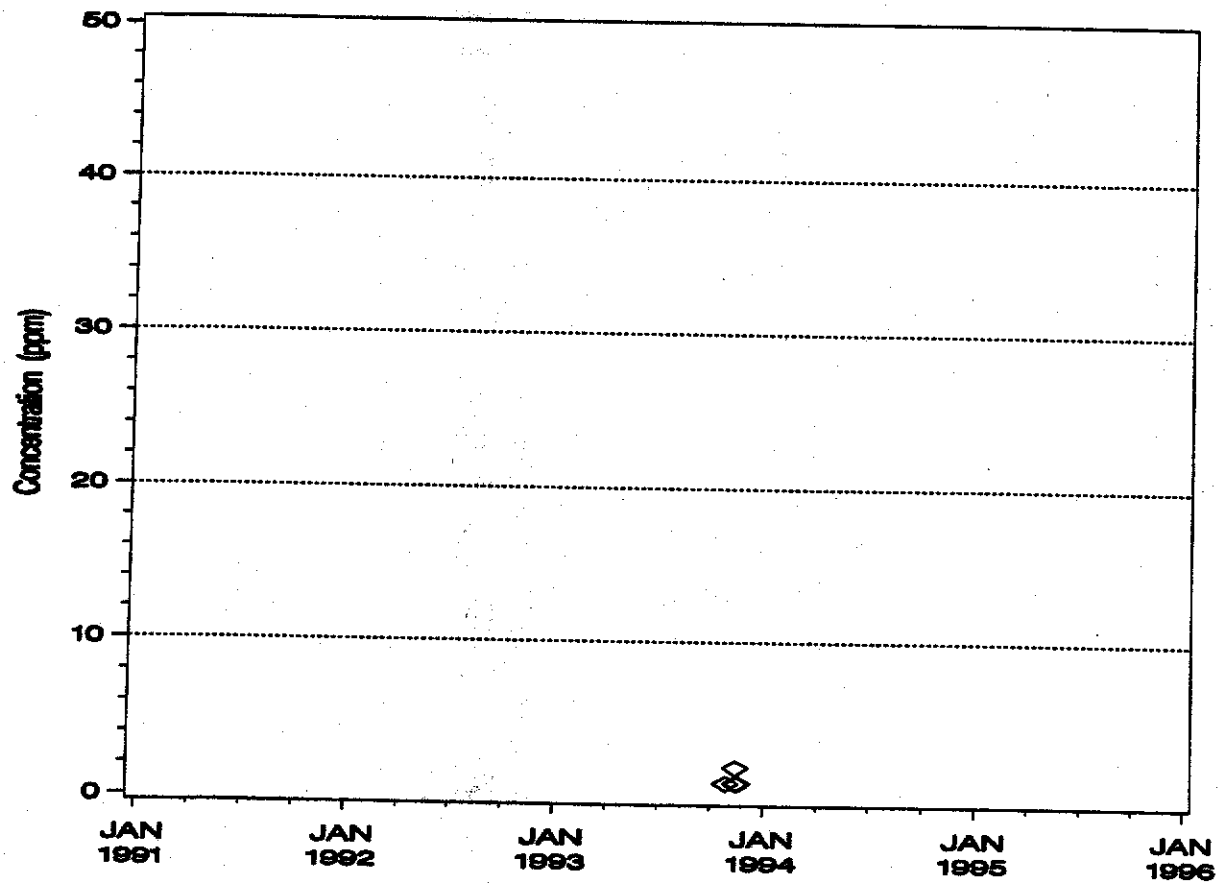


WELL 4301

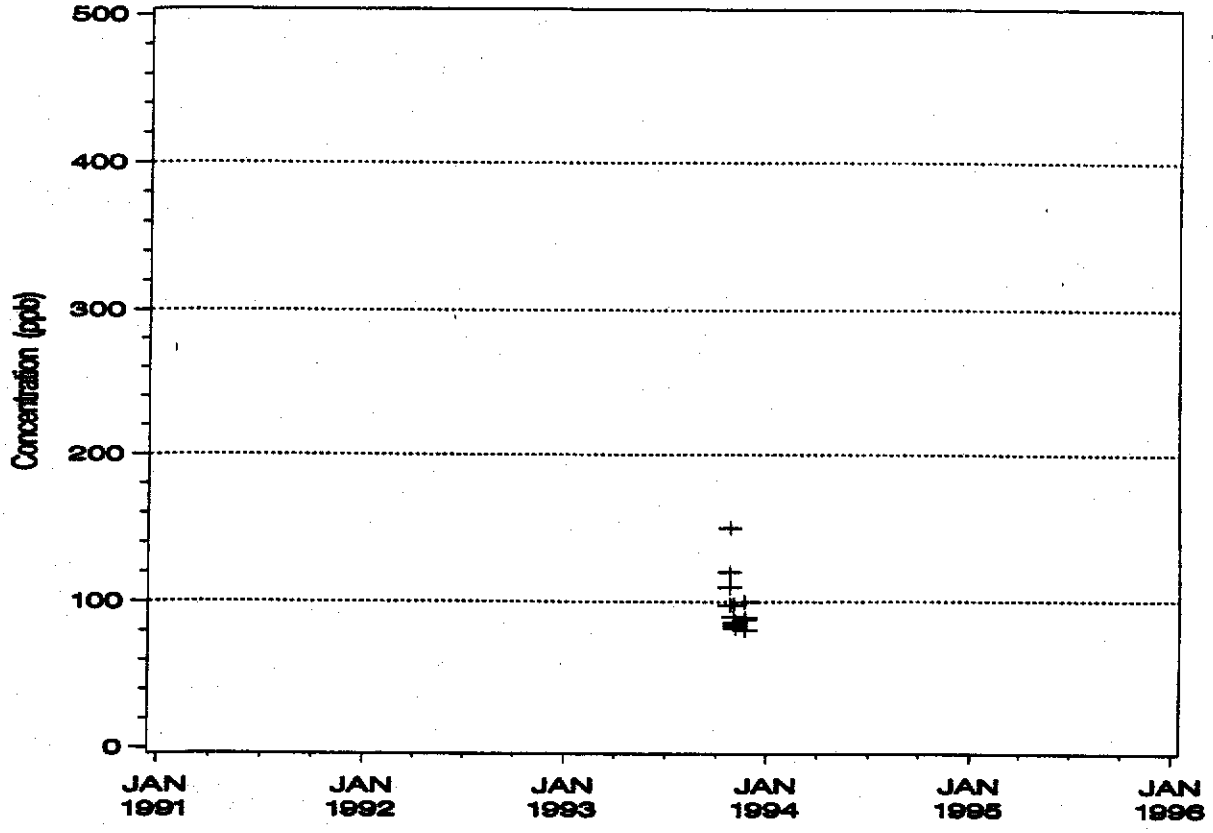
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



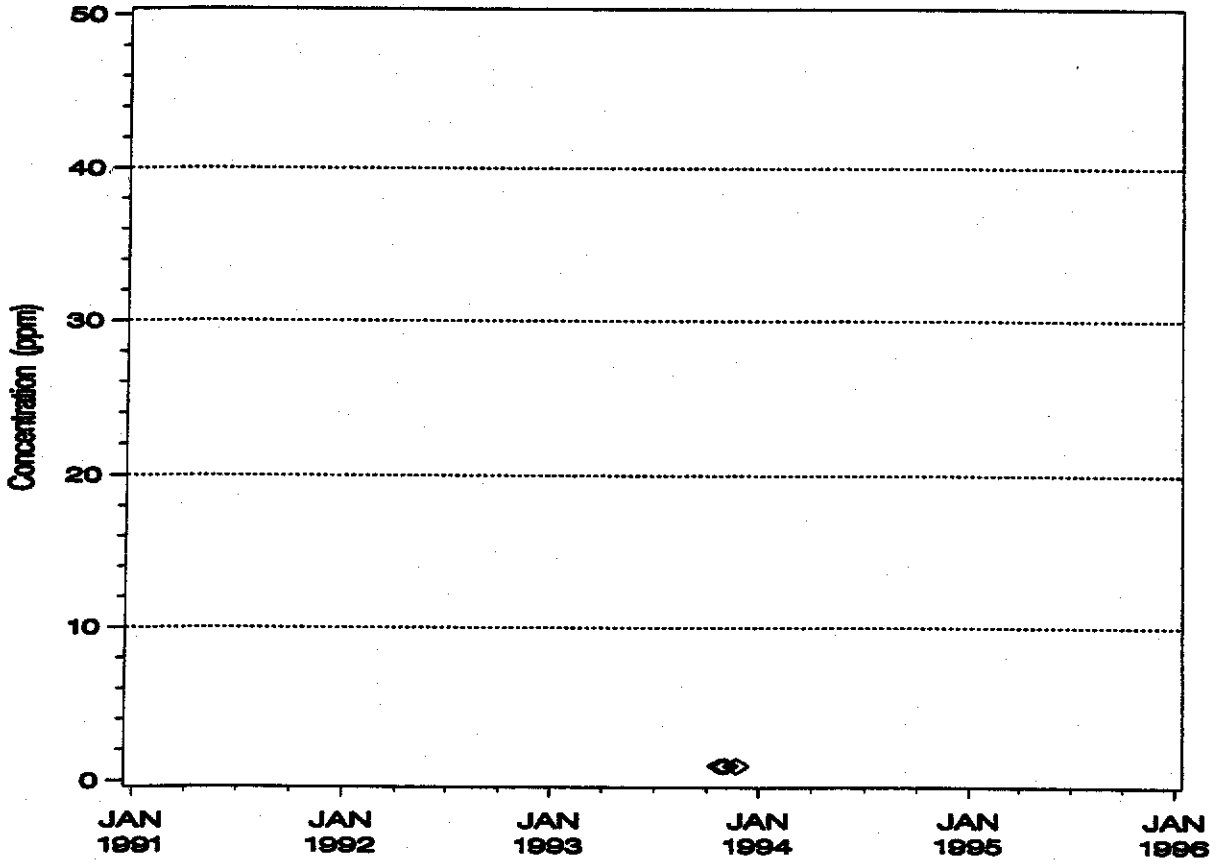
1,1 – DICHLOROETHYLENE Trend



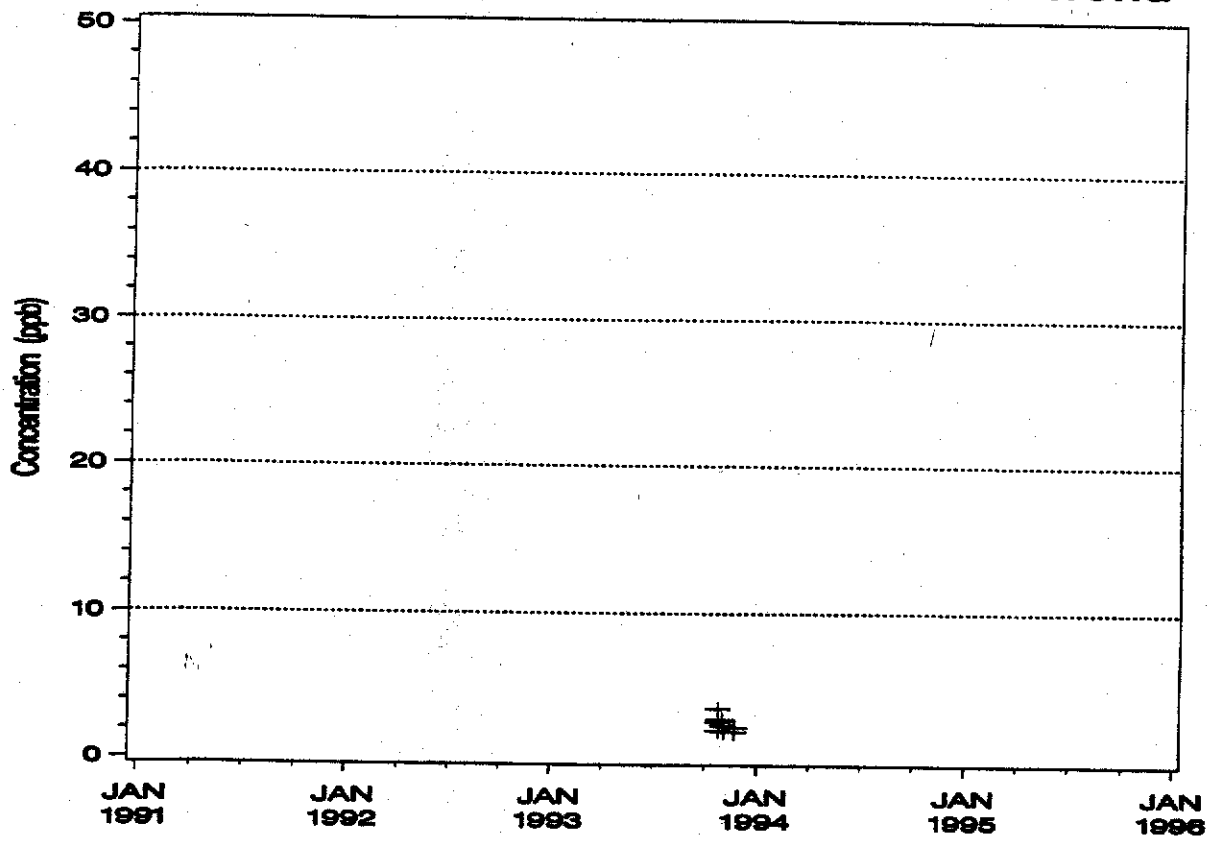
WELL 4302
TRICHLOROETHYLENE Trend



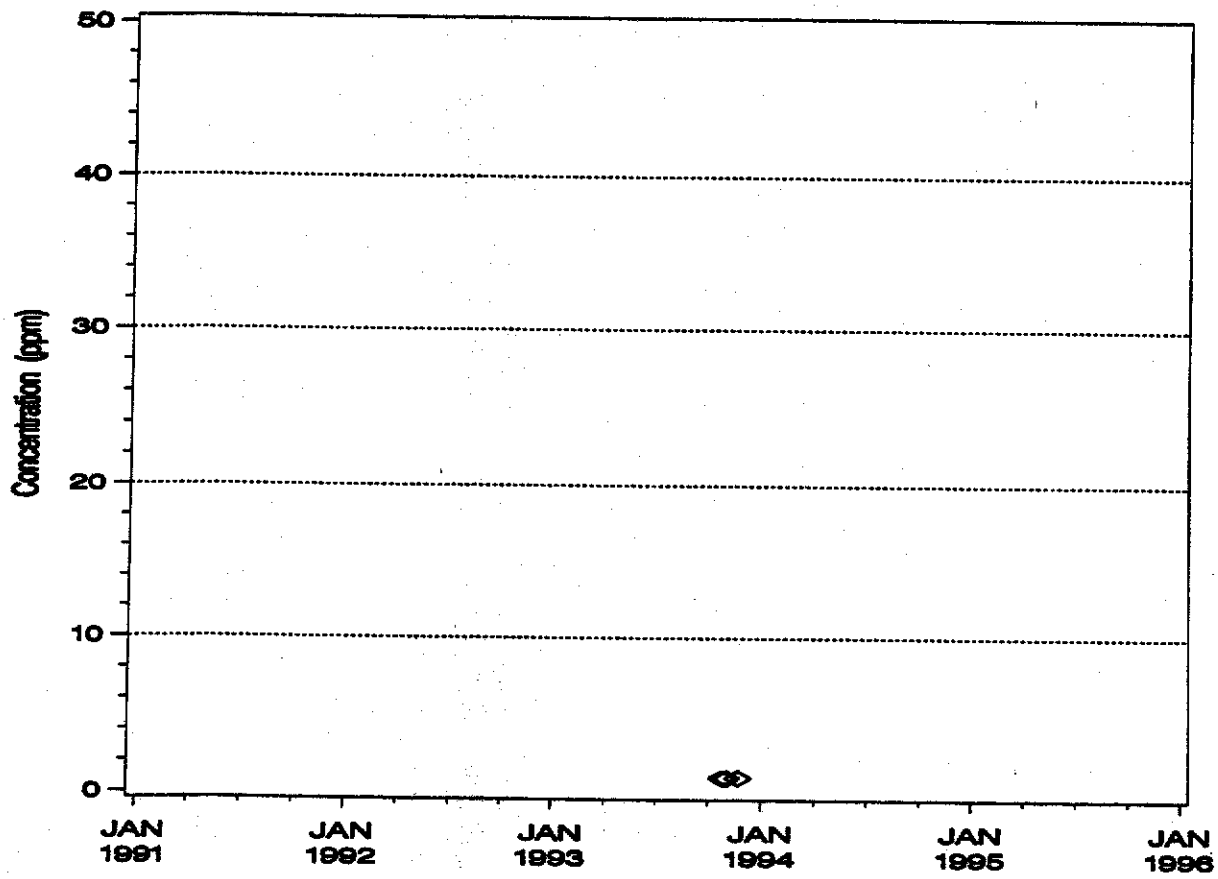
FREON 113 Trend



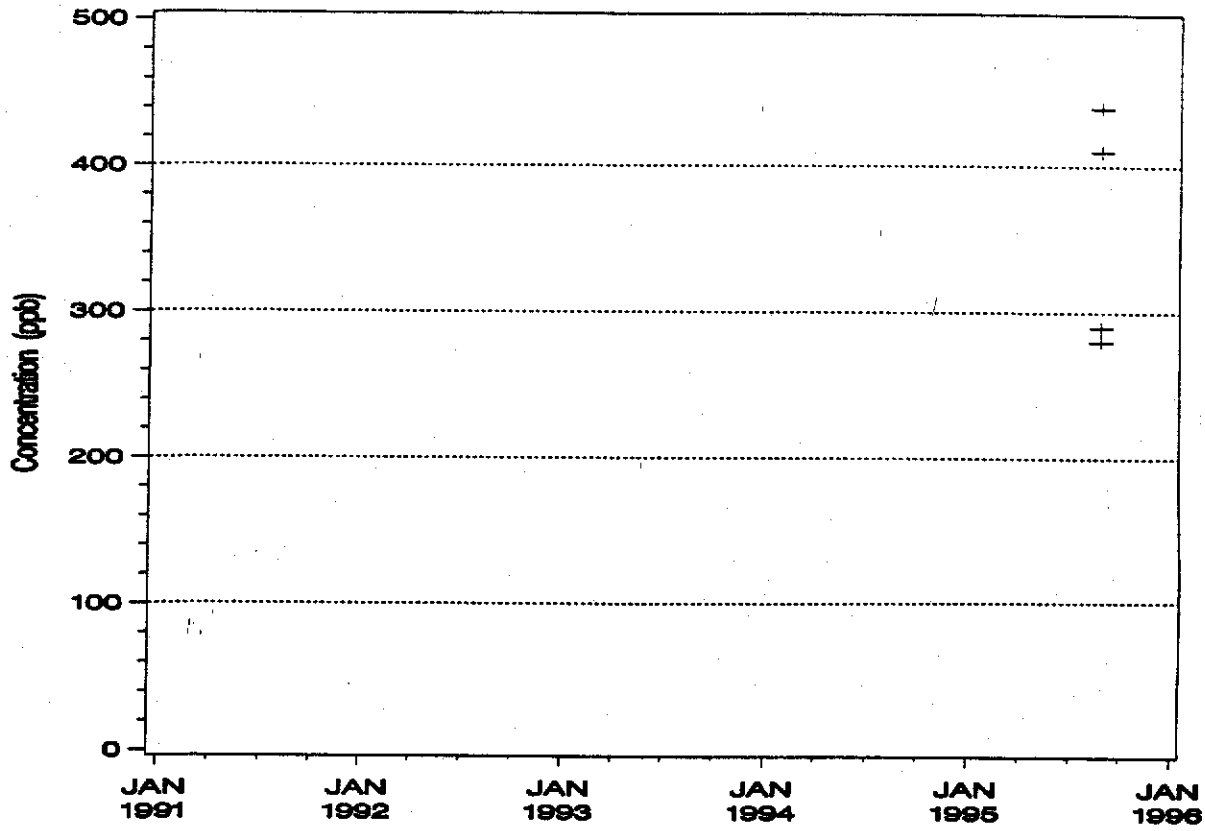
WELL 4302
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



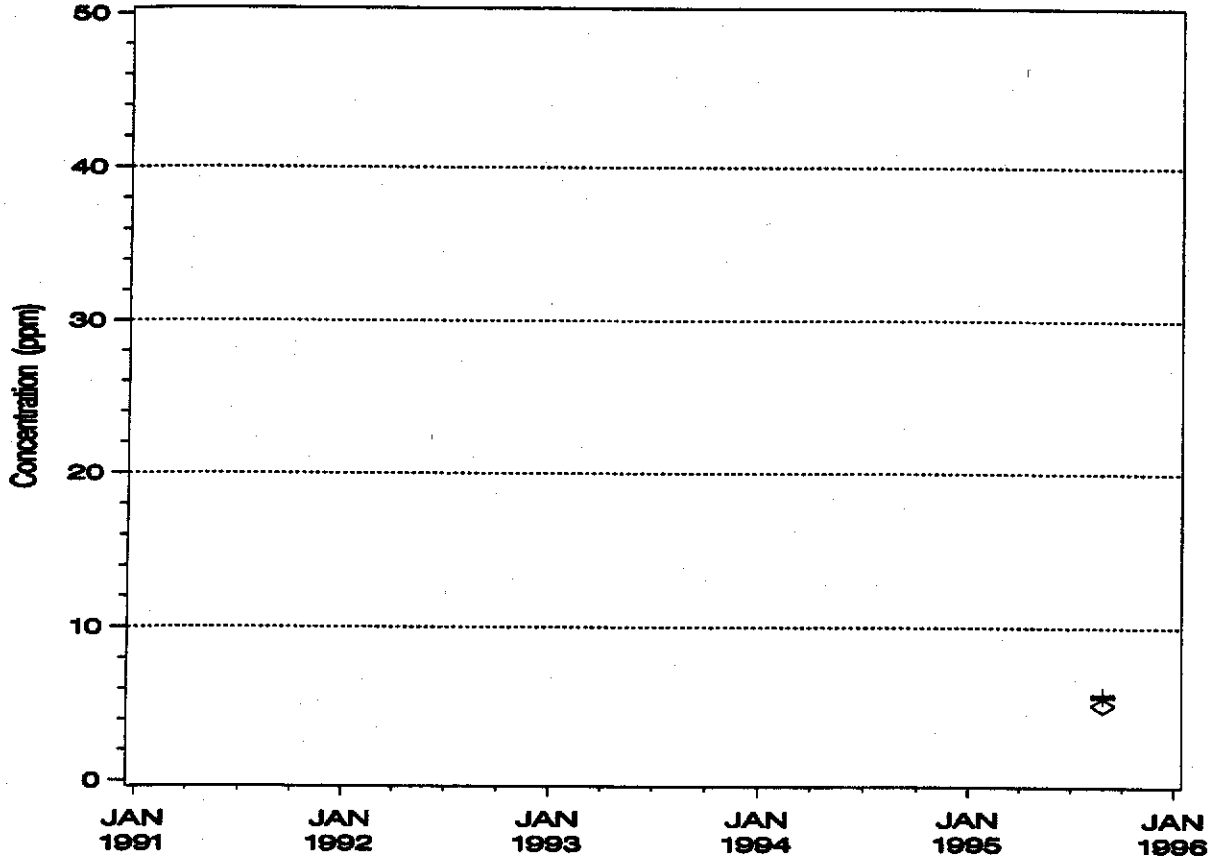
1,1 – DICHLOROETHYLENE Trend



WELL 4325
TRICHLOROETHYLENE Trend

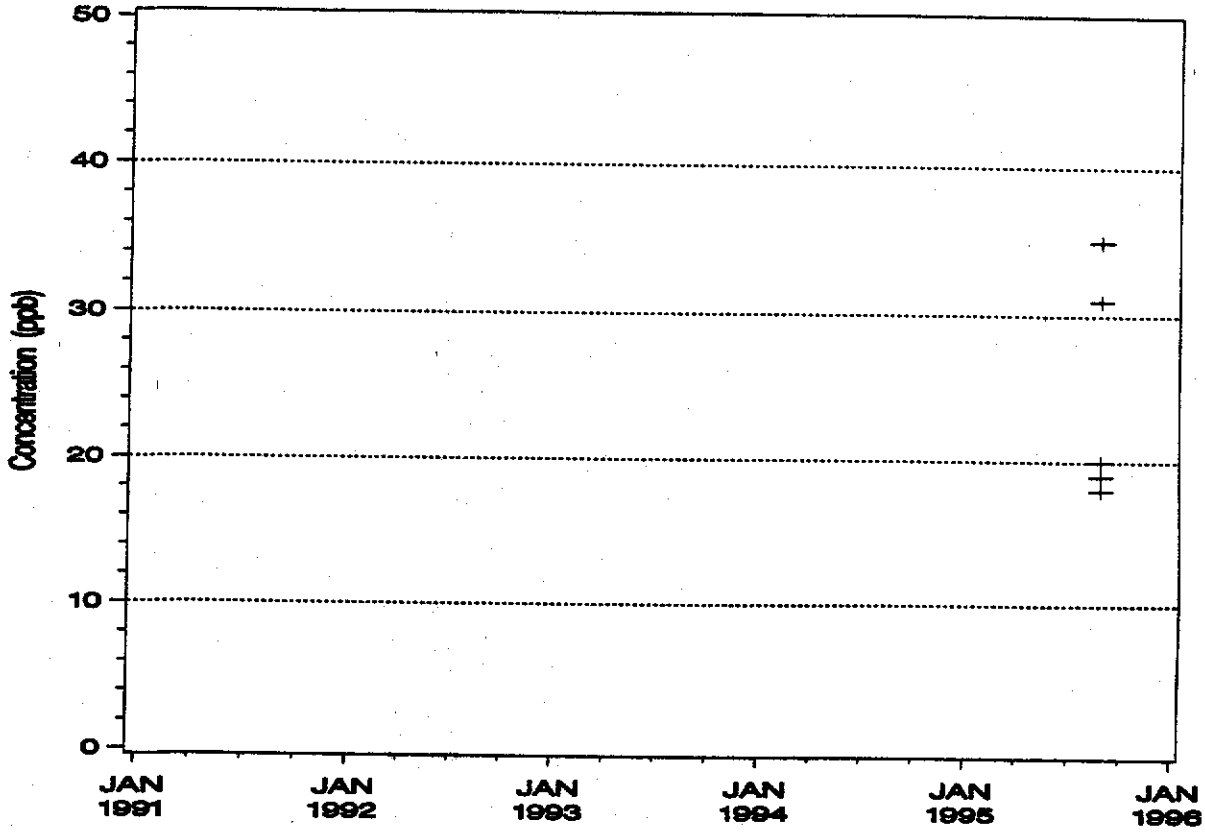


FREON 113 Trend

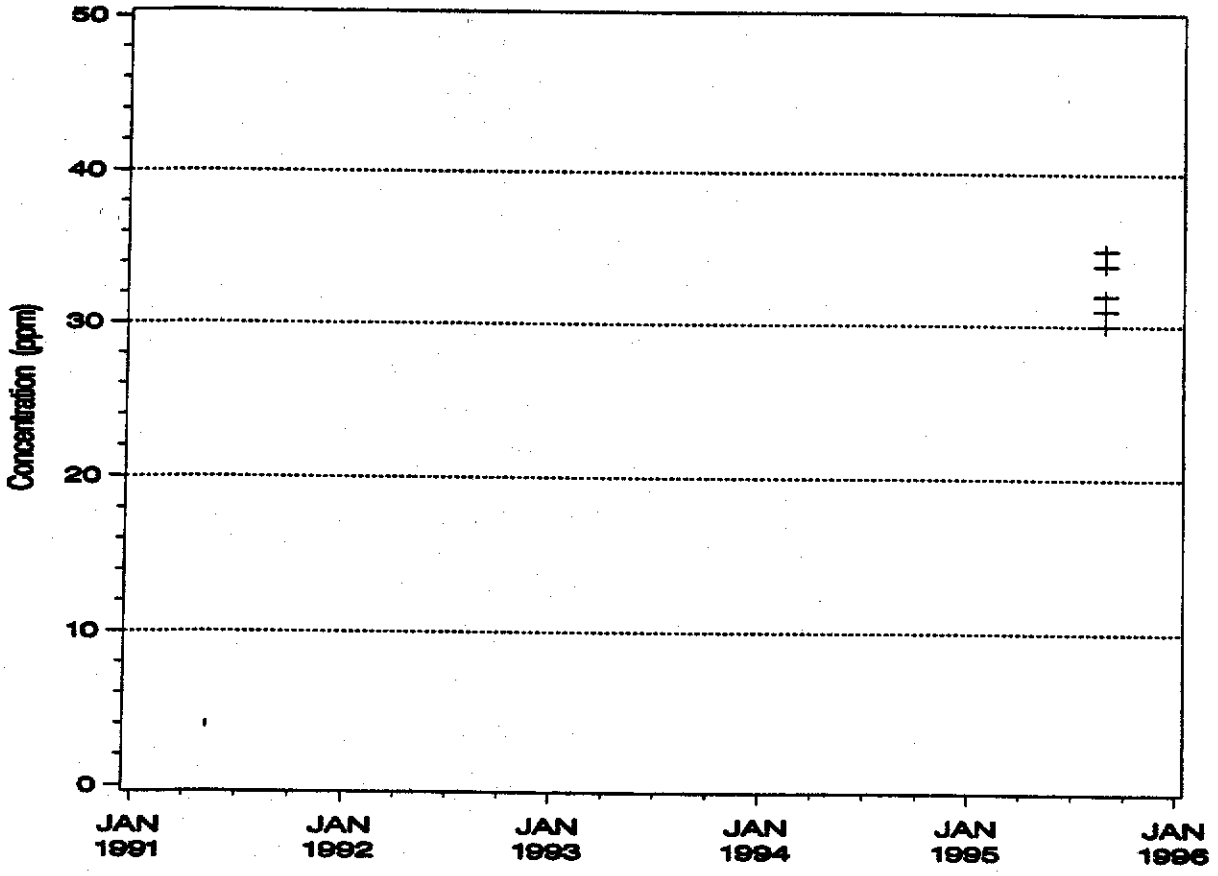


WELL 4325

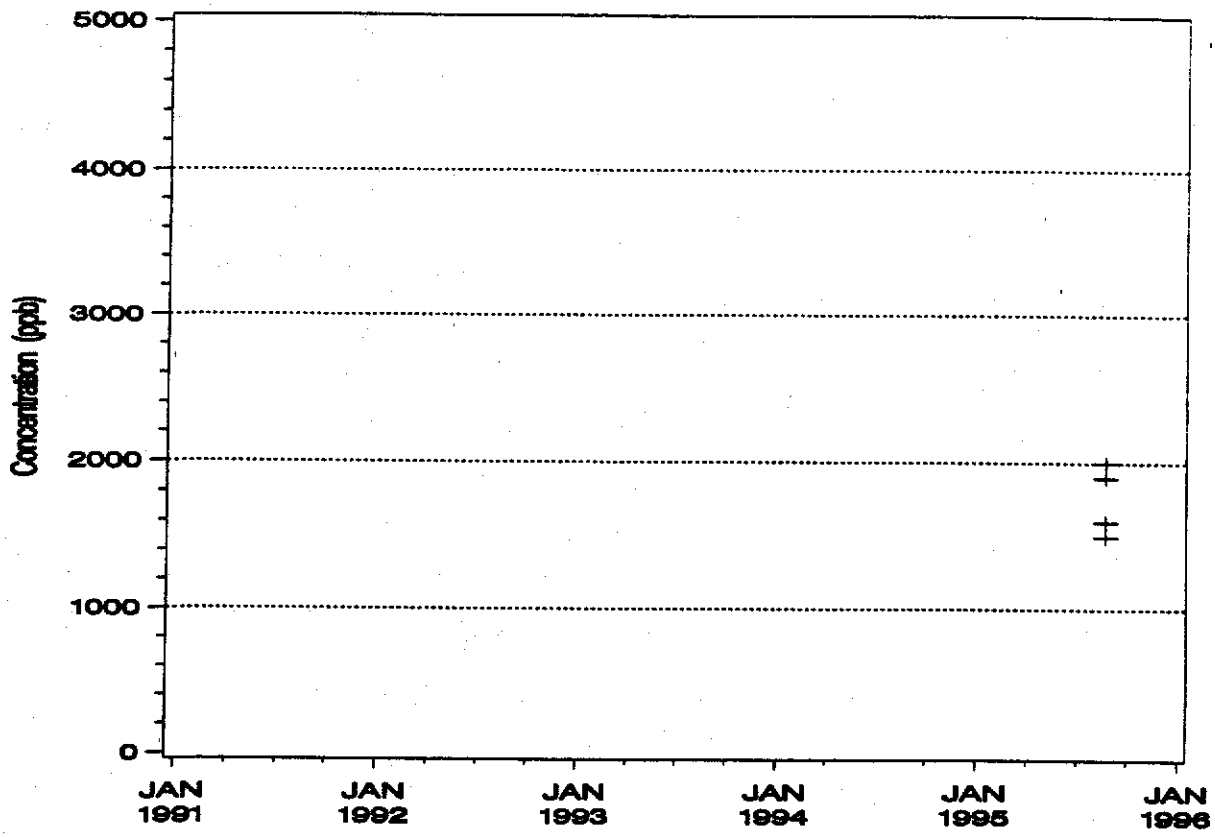
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



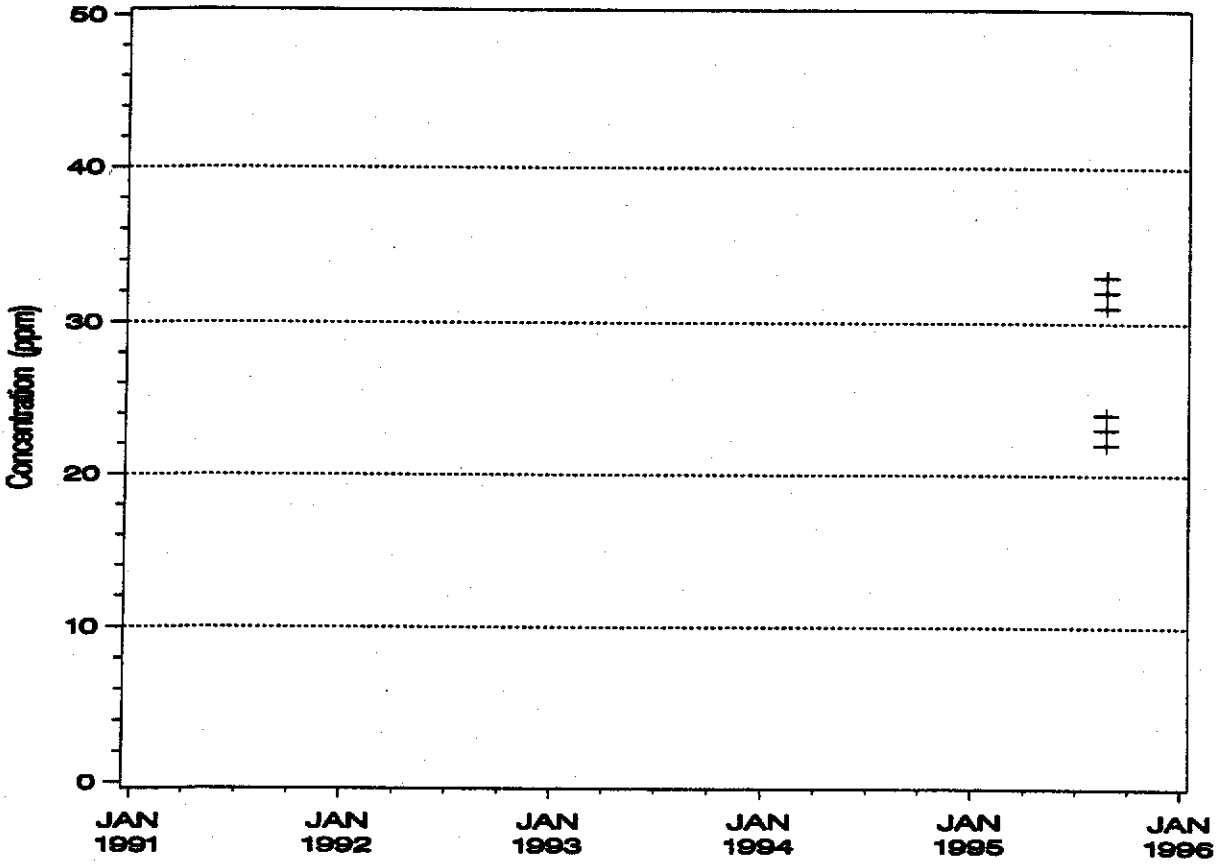
1,1 – DICHLOROETHYLENE Trend



WELL 4330
TRICHLOROETHYLENE Trend

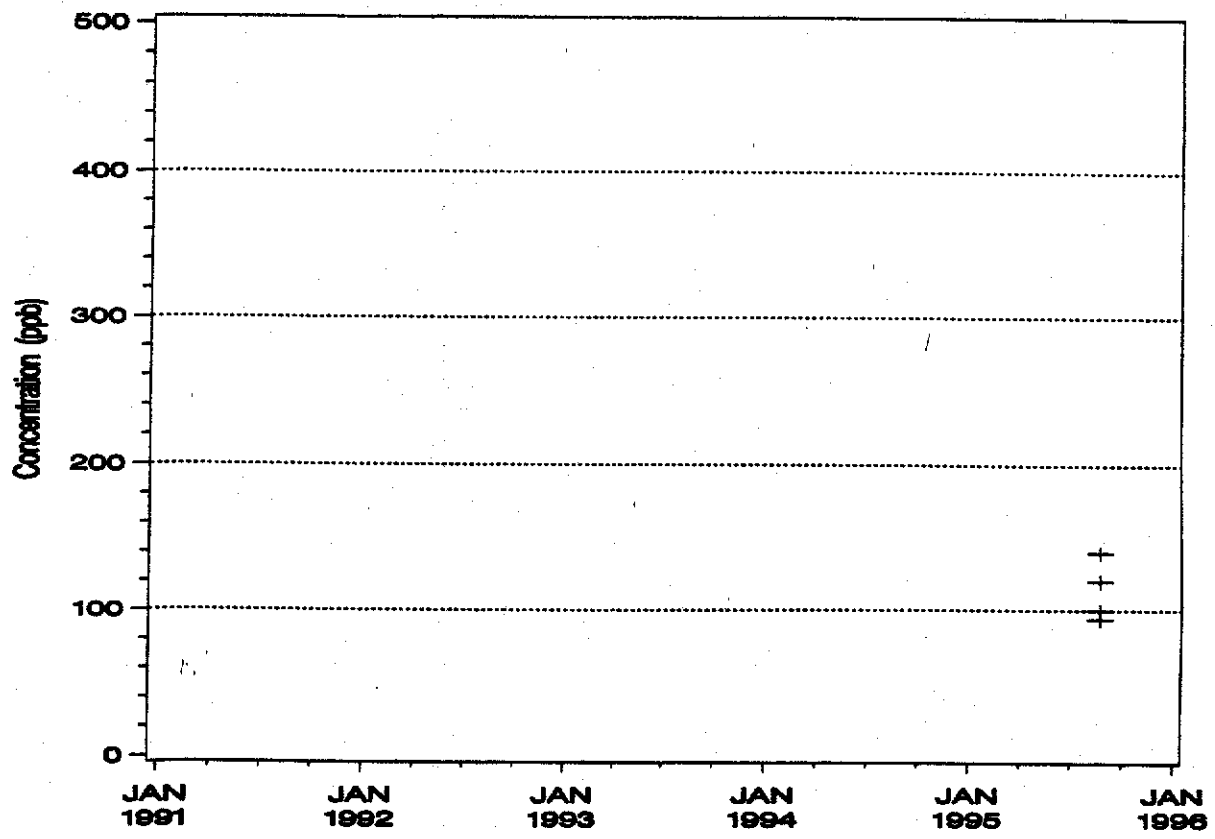


FREON 113 Trend

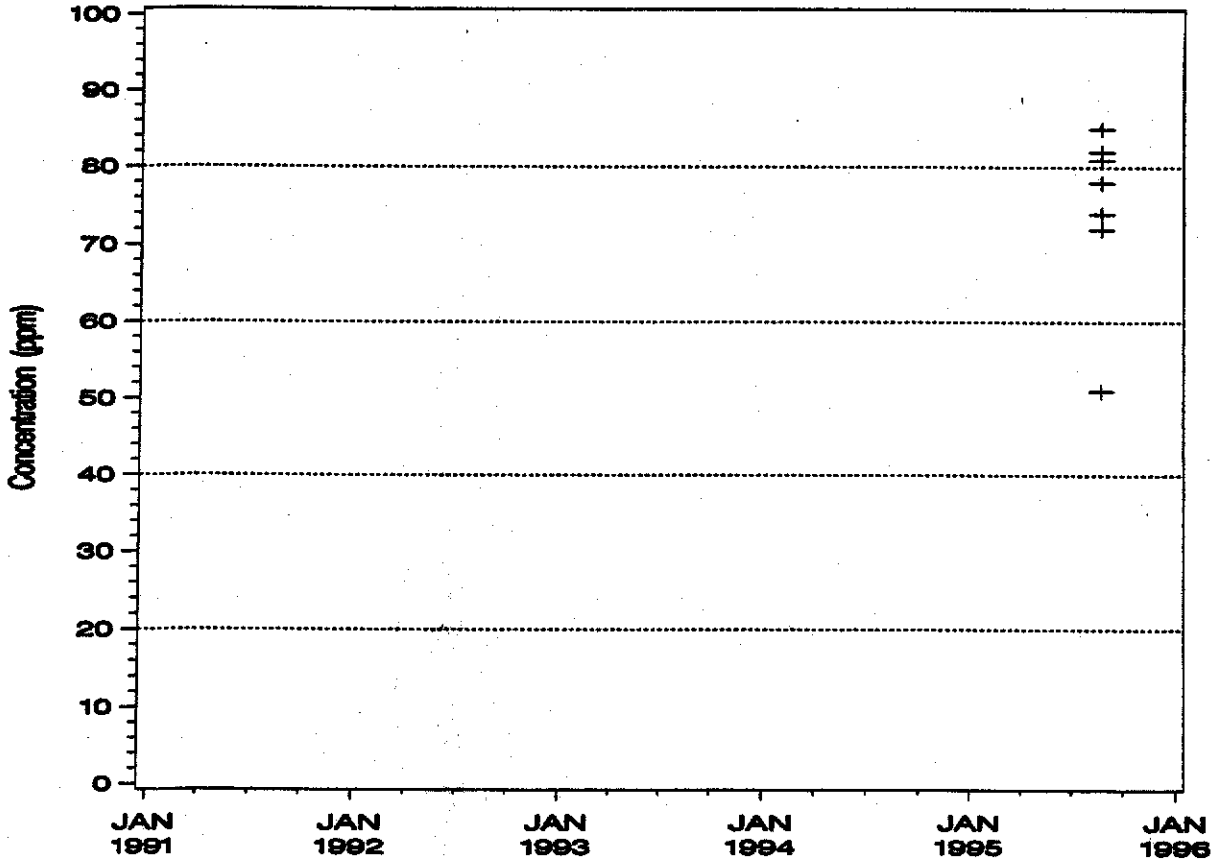


WELL 4330

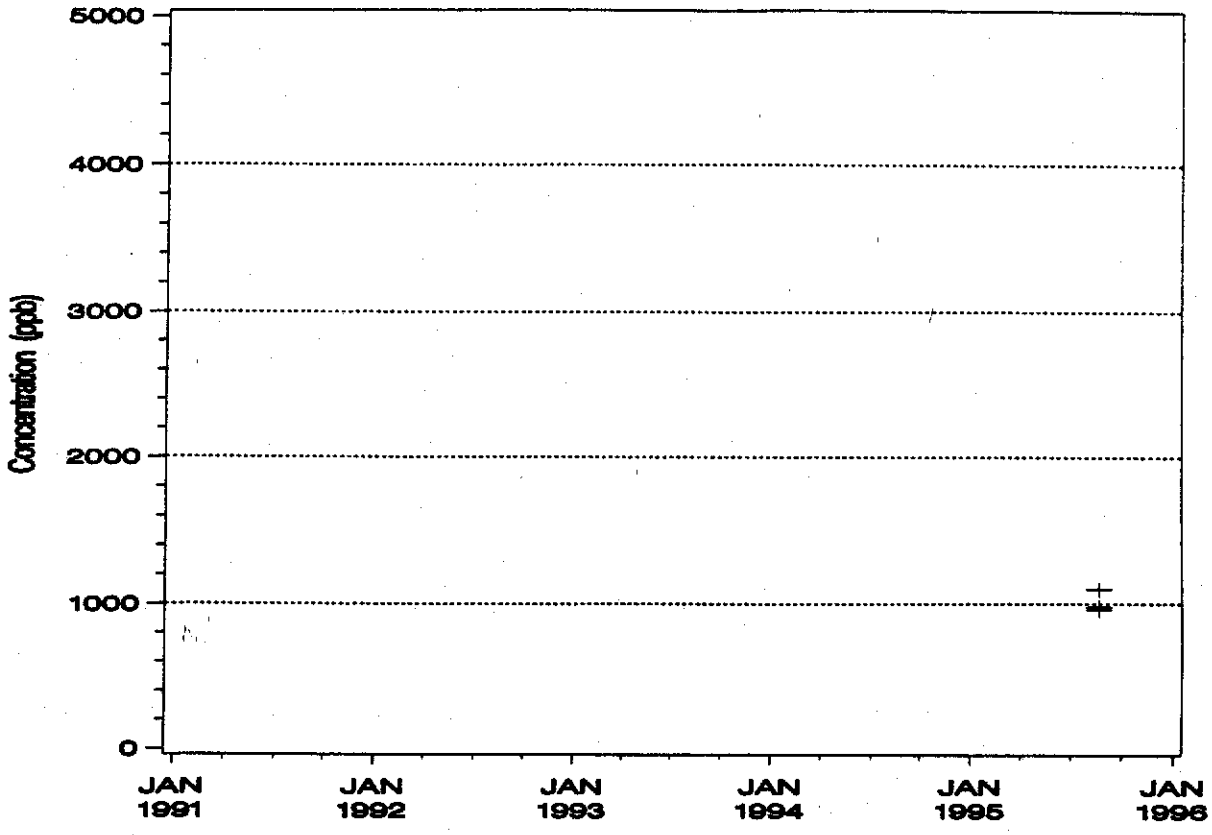
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



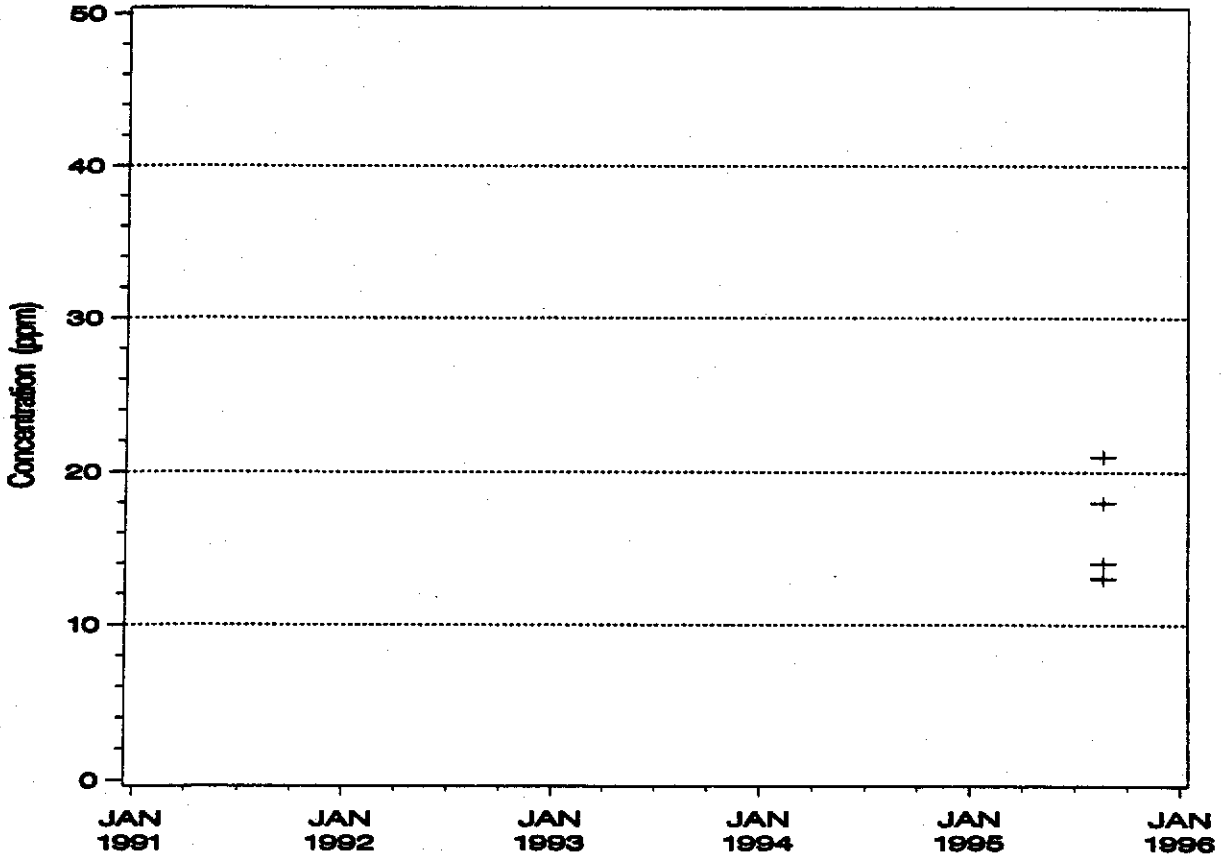
1,1 – DICHLOROETHYLENE Trend



WELL 4335
TRICHLOROETHYLENE Trend

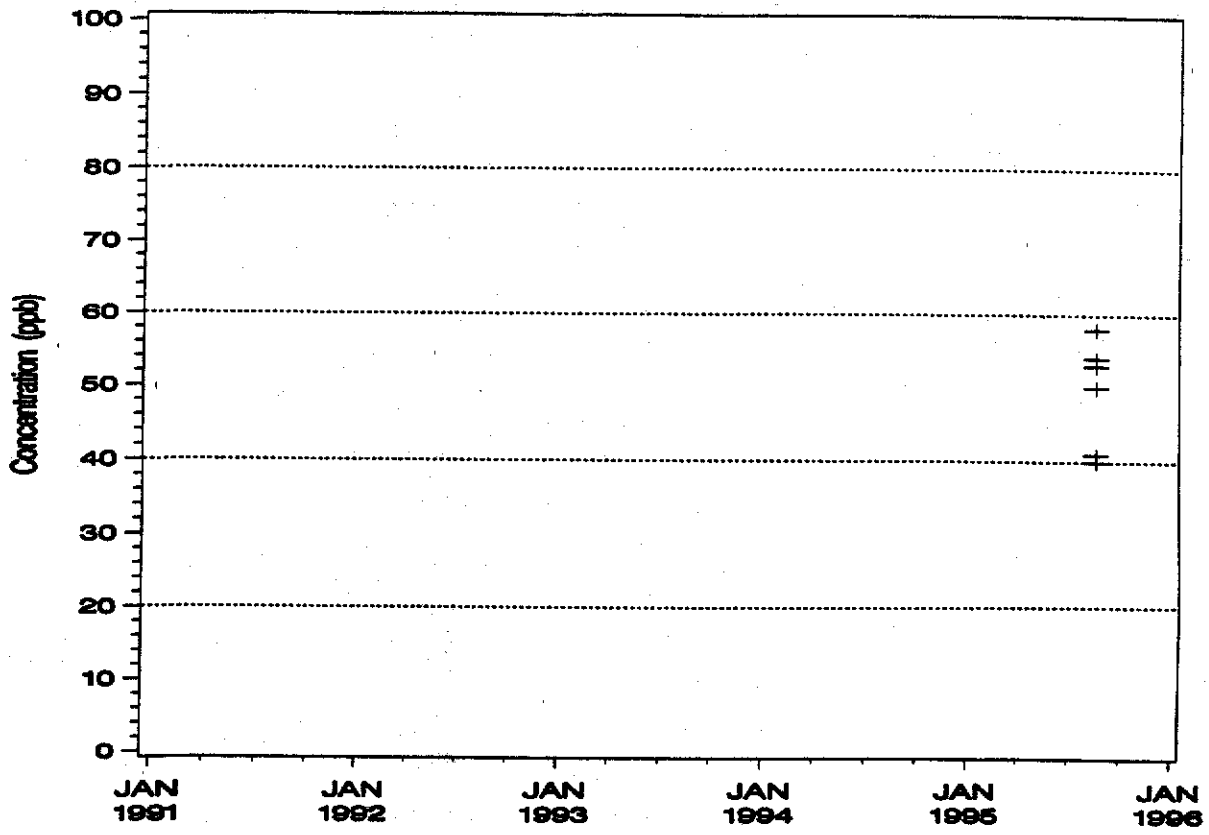


FREON 113 Trend

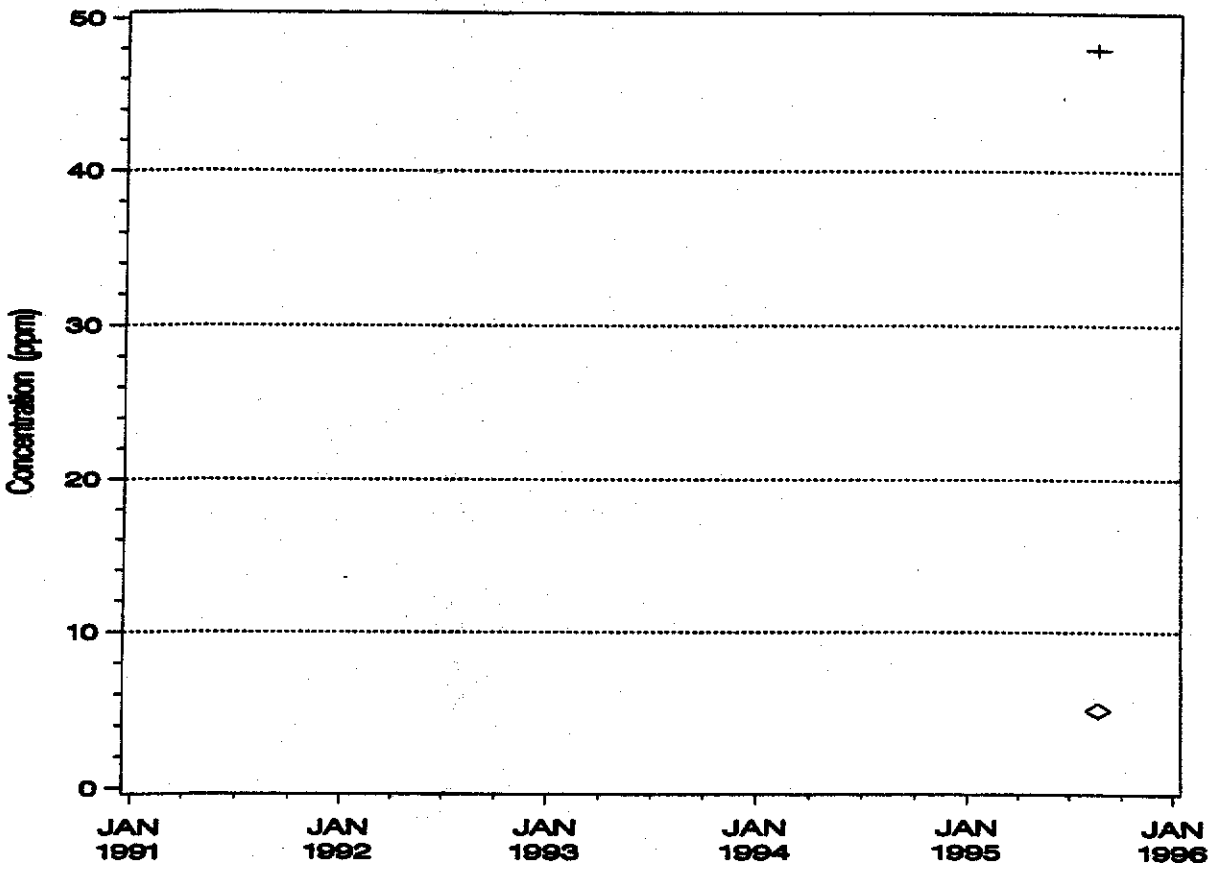


WELL 4335

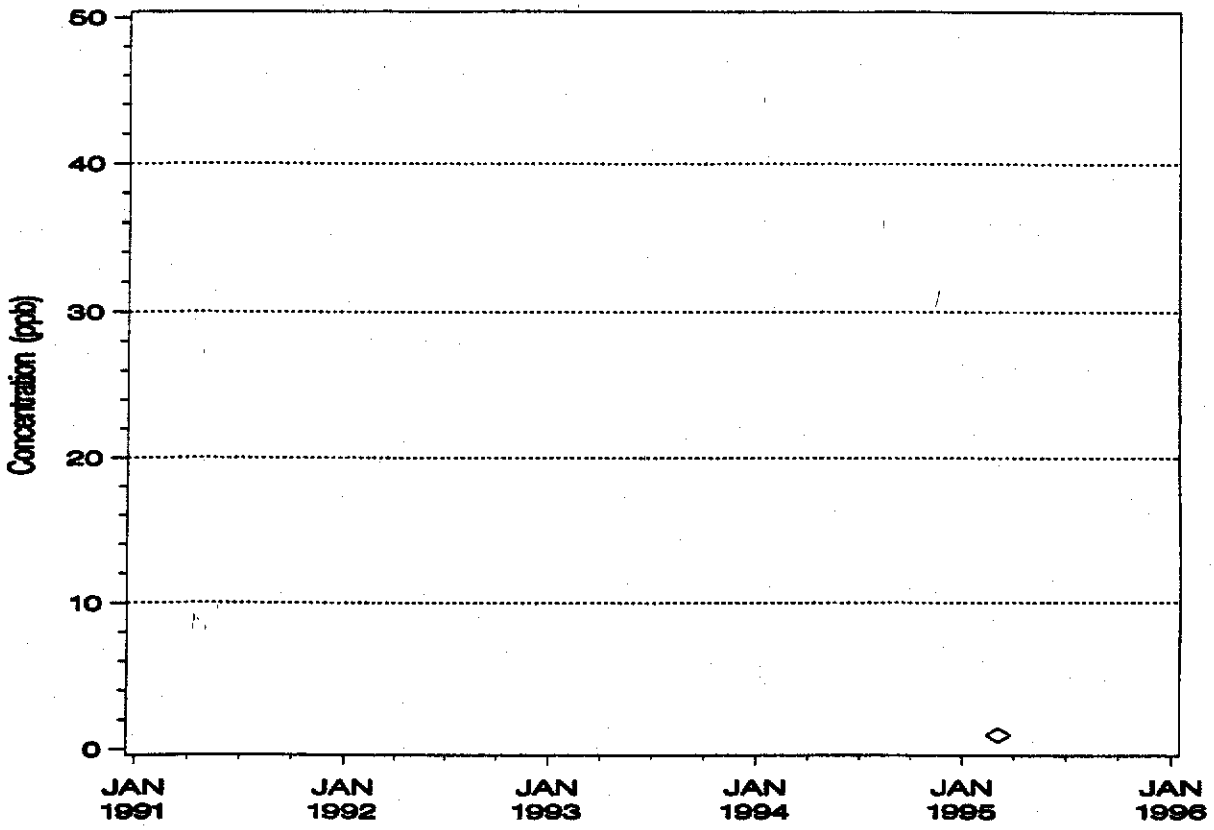
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



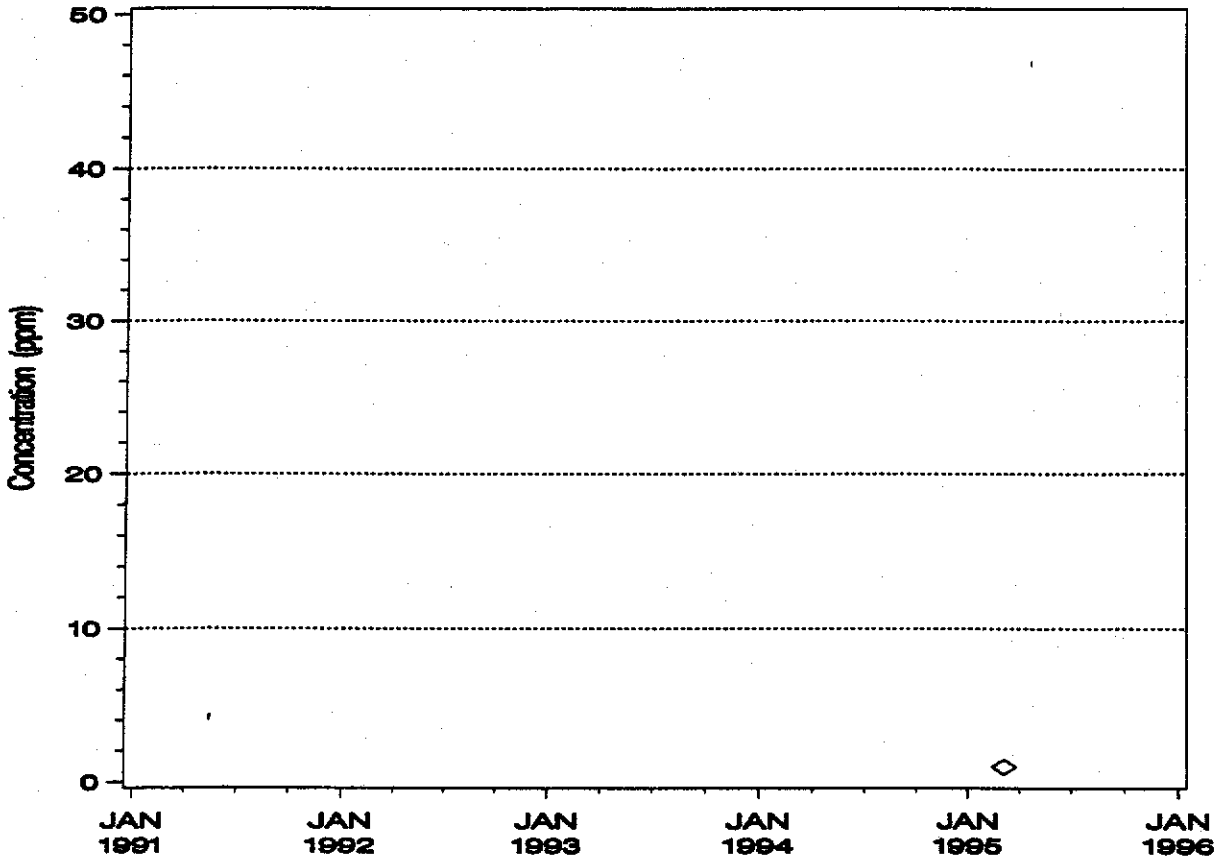
1,1 – DICHLOROETHYLENE Trend



WELL 4340
TRICHLOROETHYLENE Trend

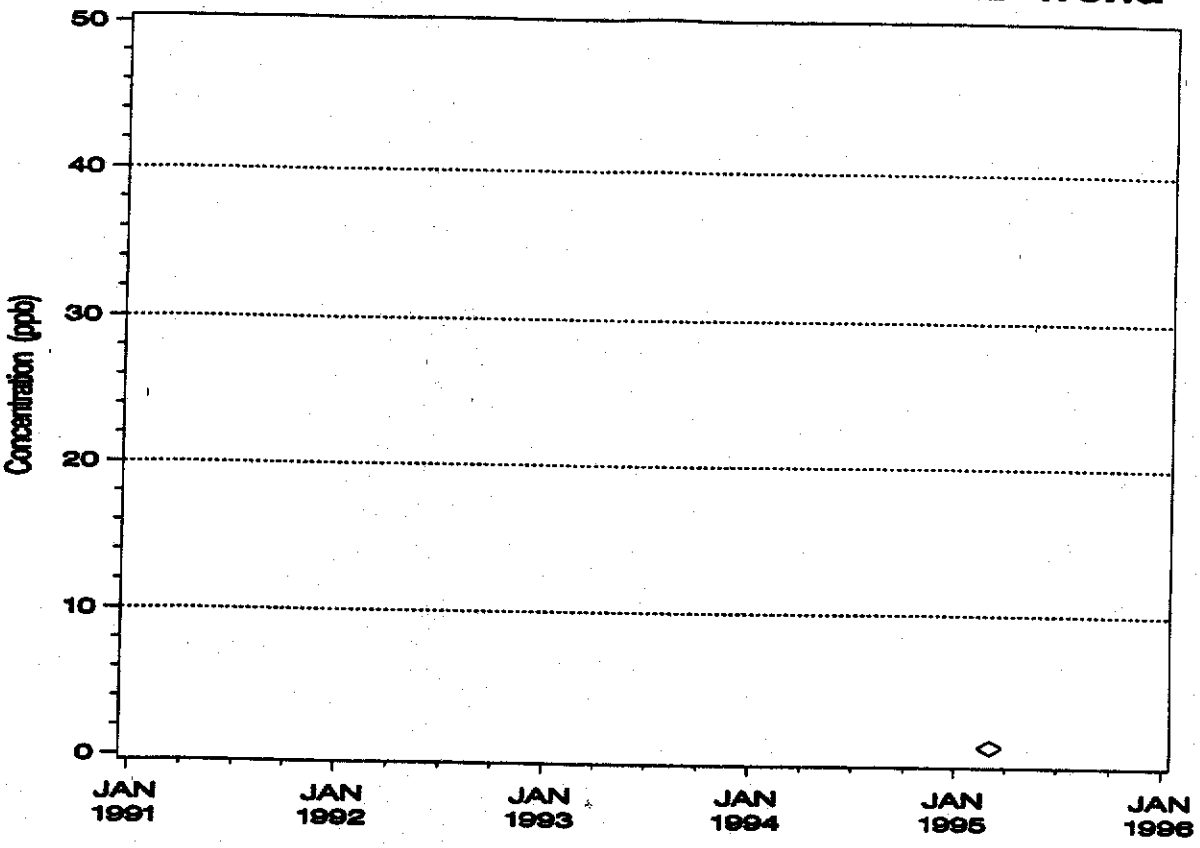


FREON 113 Trend

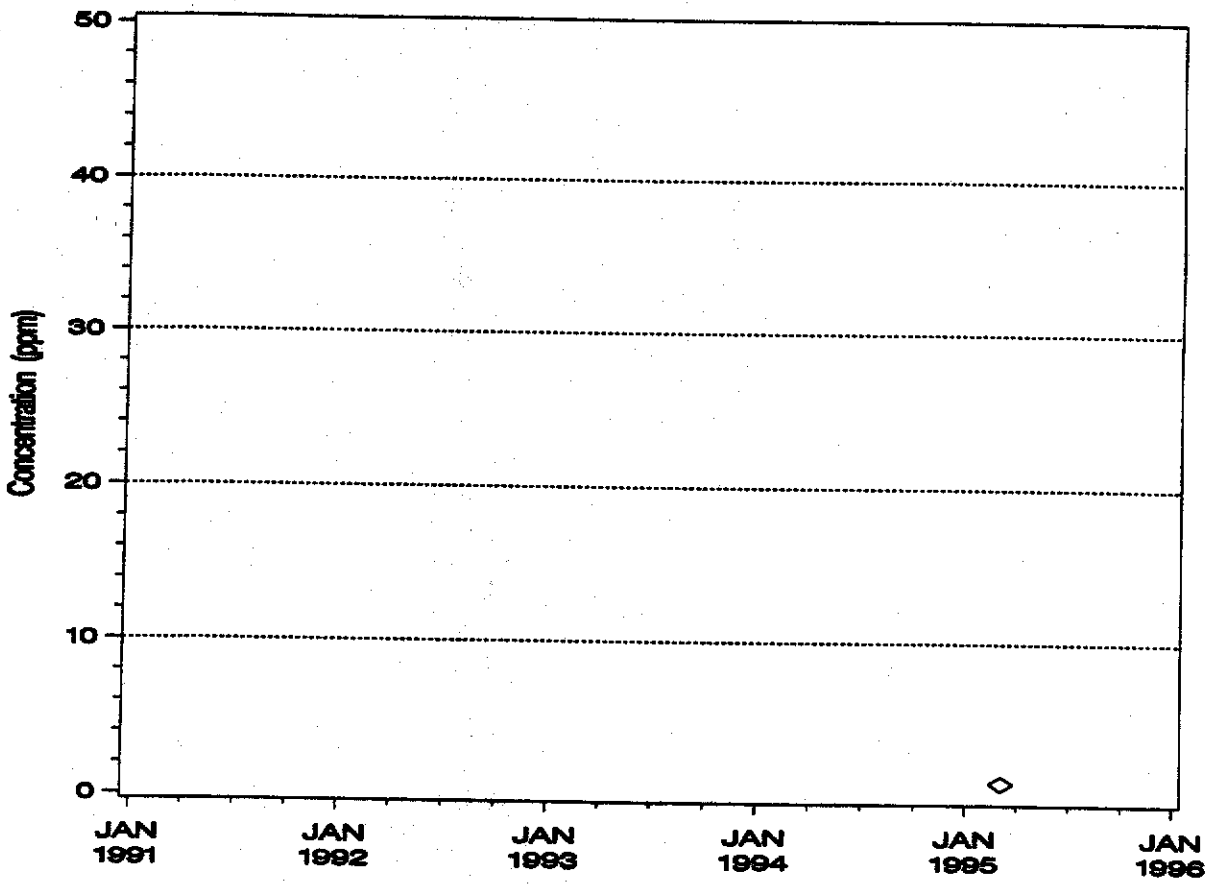


WELL 4340

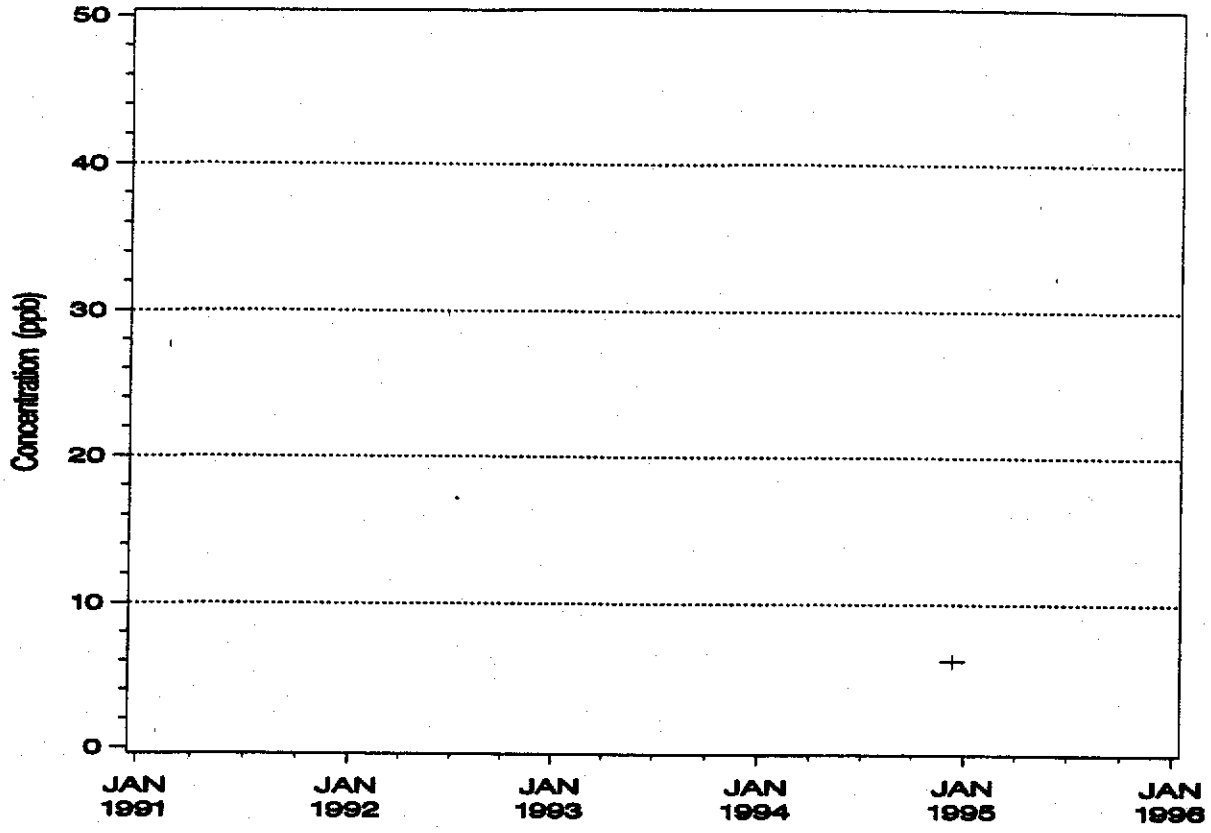
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



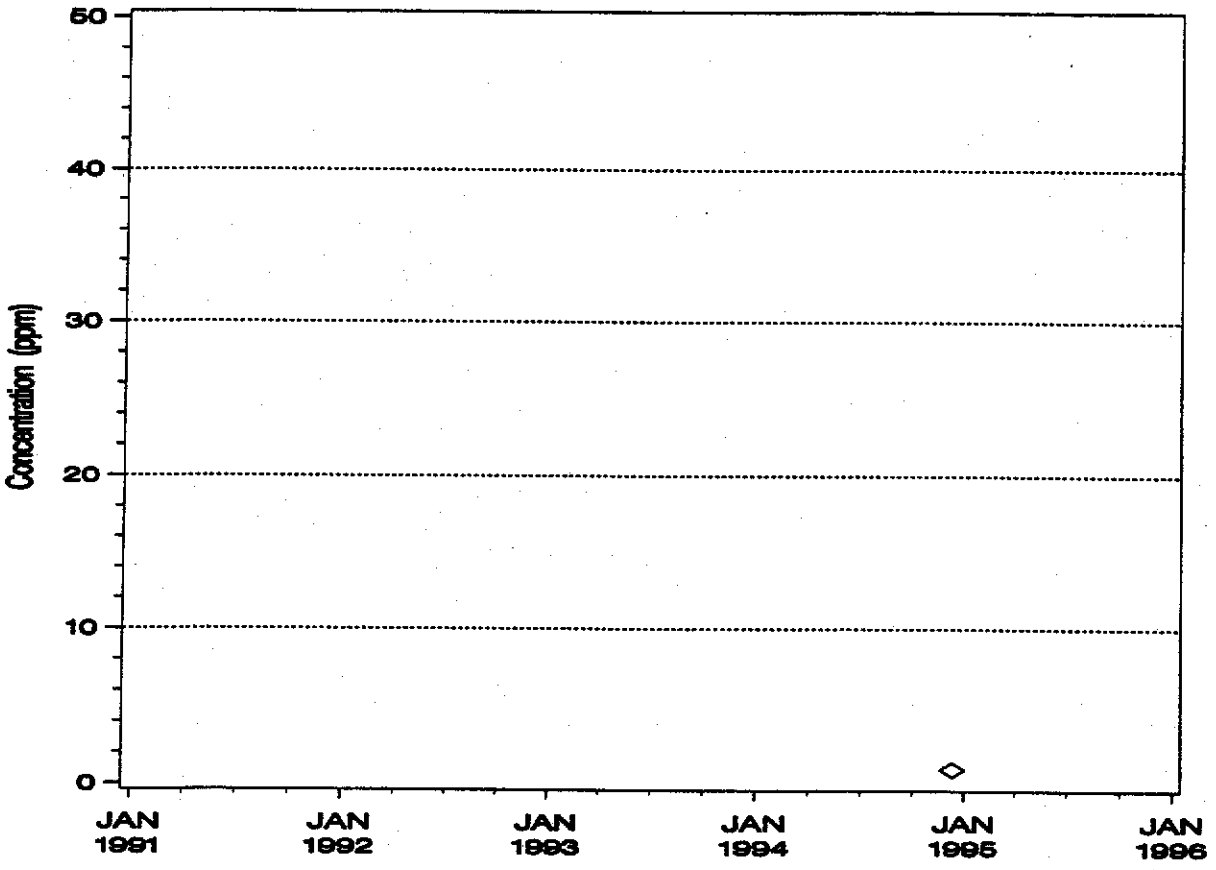
1,1 – DICHLOROETHYLENE Trend



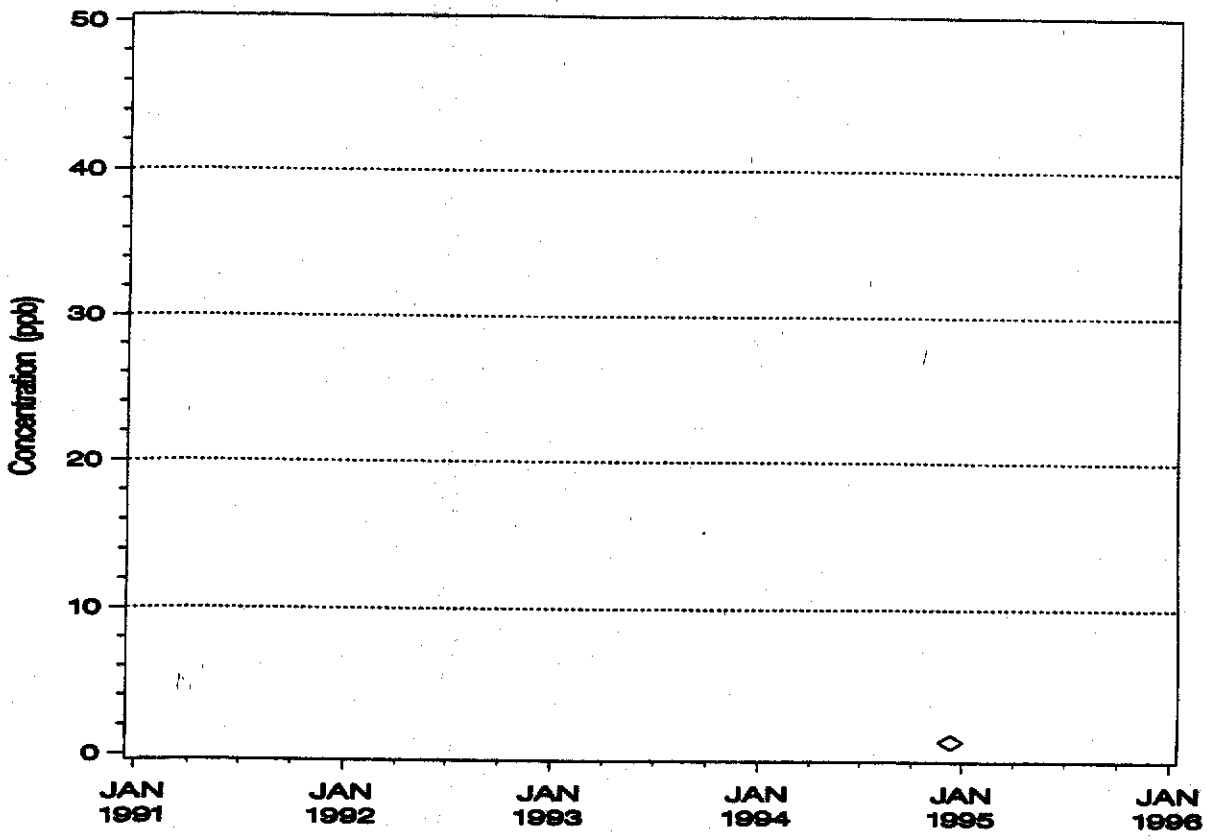
WELL 4345
TRICHLOROETHYLENE Trend



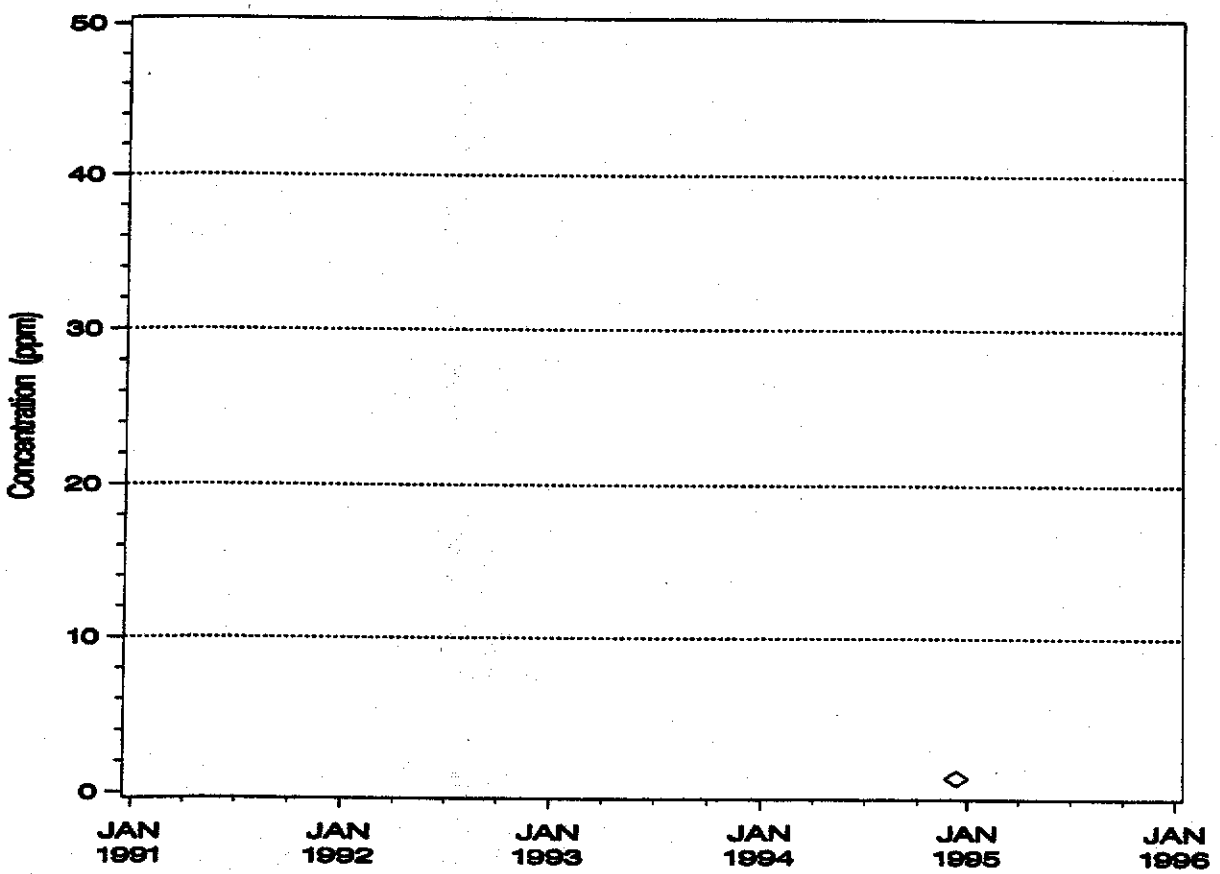
FREON 113 Trend



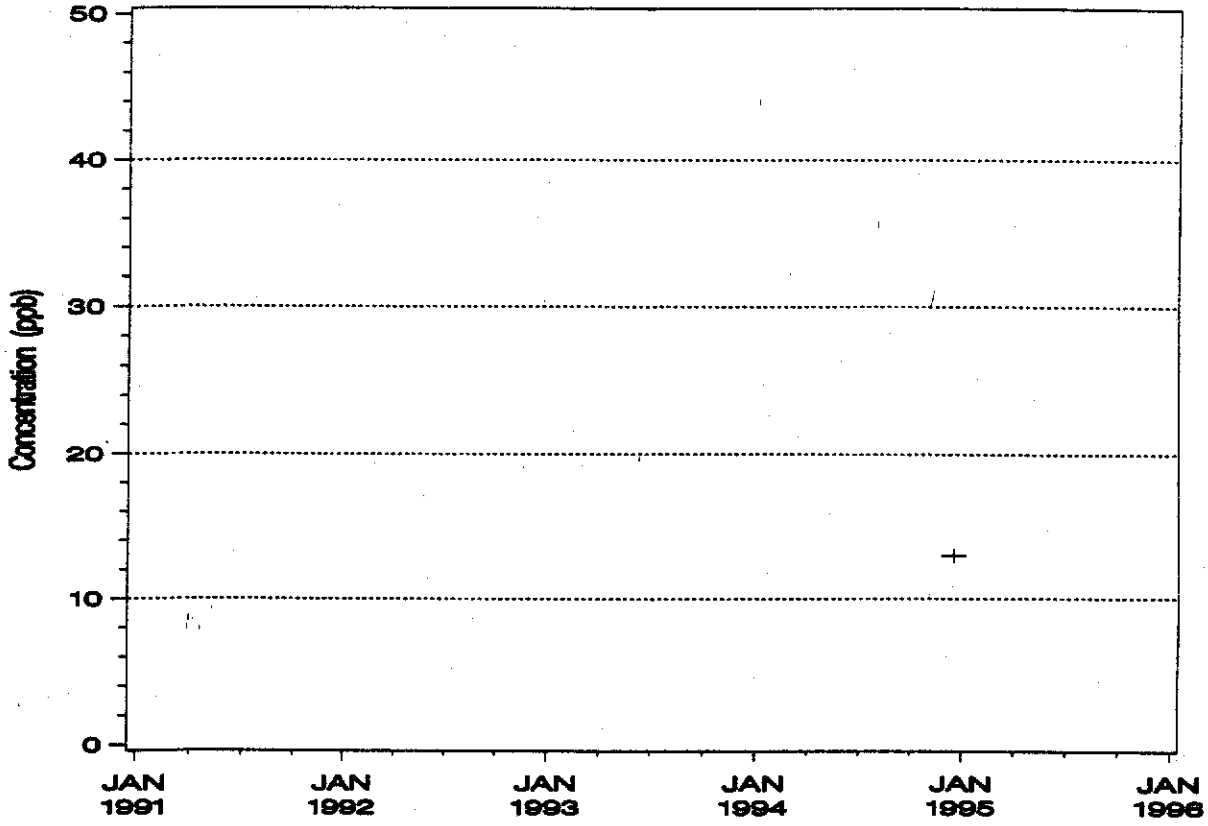
WELL 4345
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



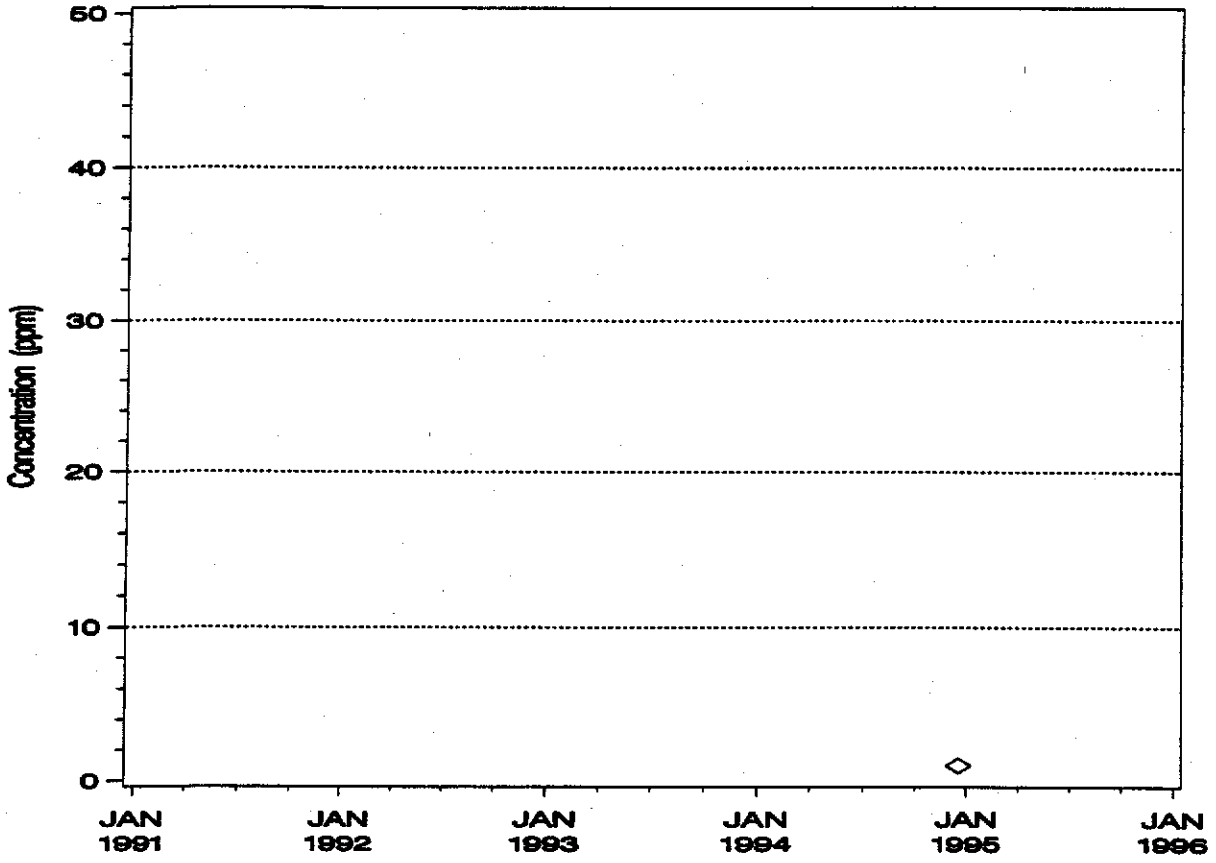
1,1 – DICHLOROETHYLENE Trend



WELL 4350
TRICHLOROETHYLENE Trend

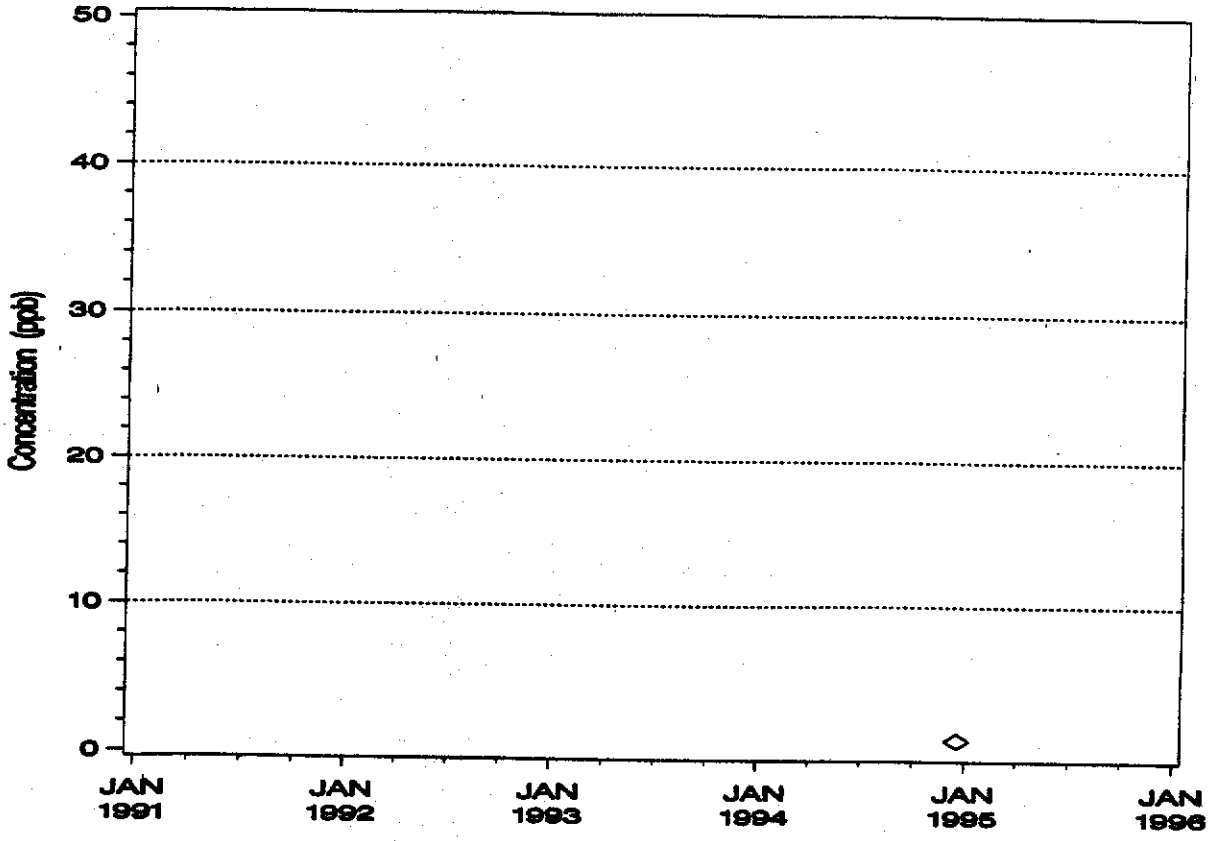


FREON 113 Trend

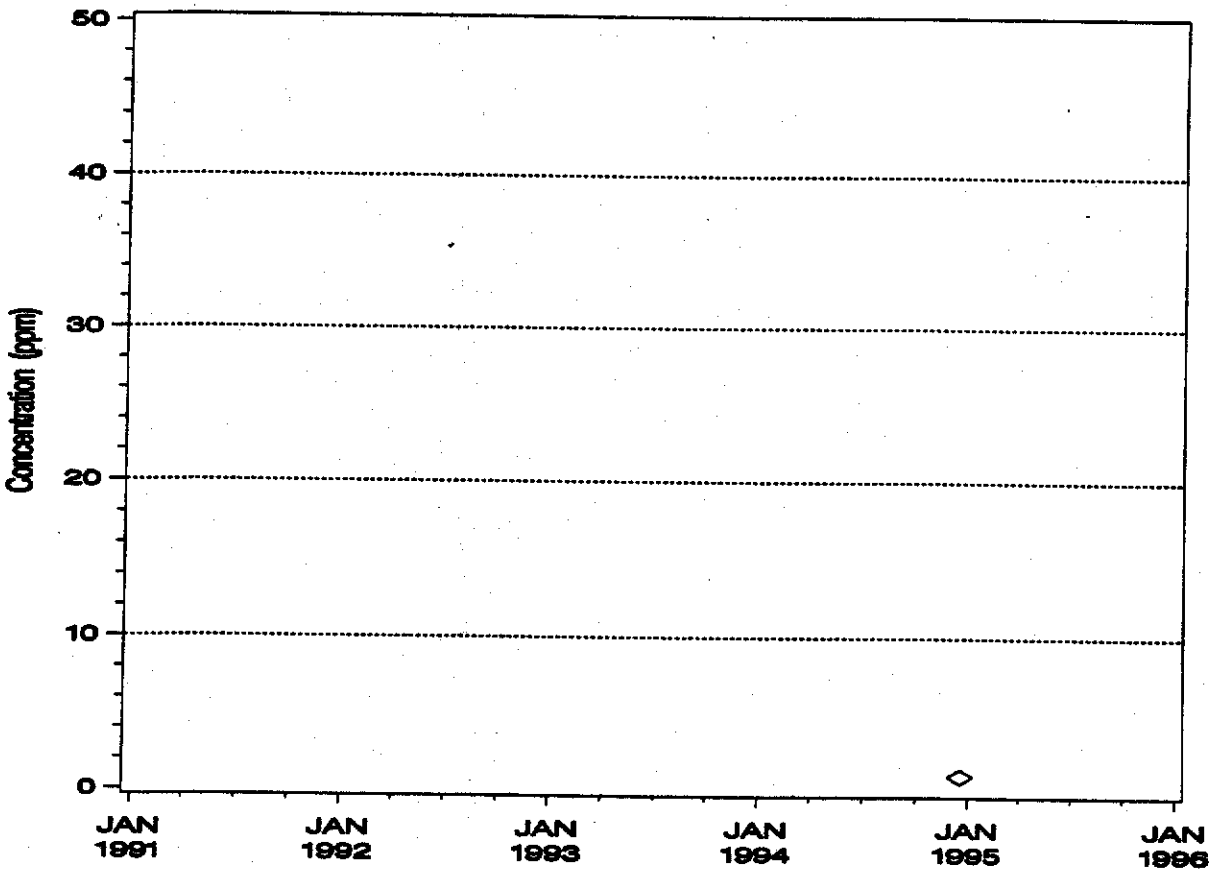


WELL 4350

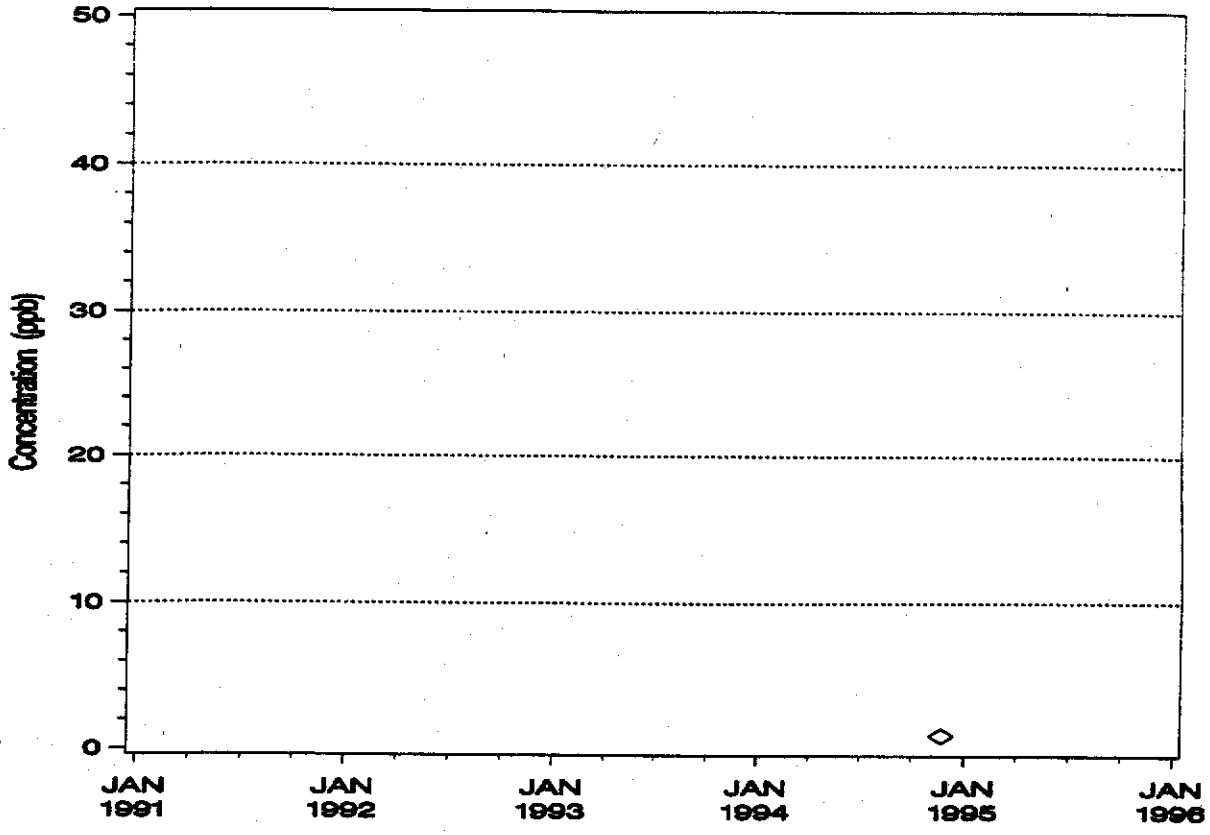
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



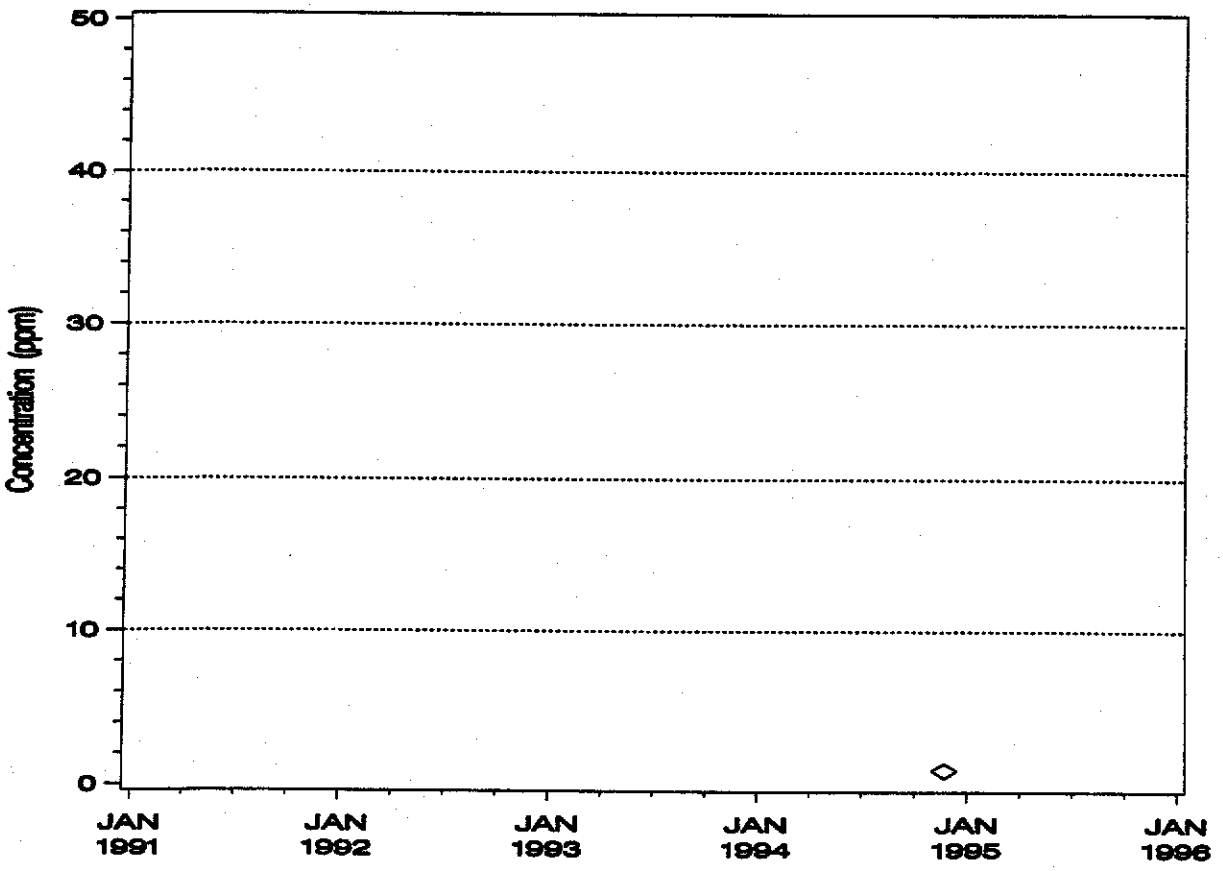
1,1 – DICHLOROETHYLENE Trend



WELL 4355
TRICHLOROETHYLENE Trend

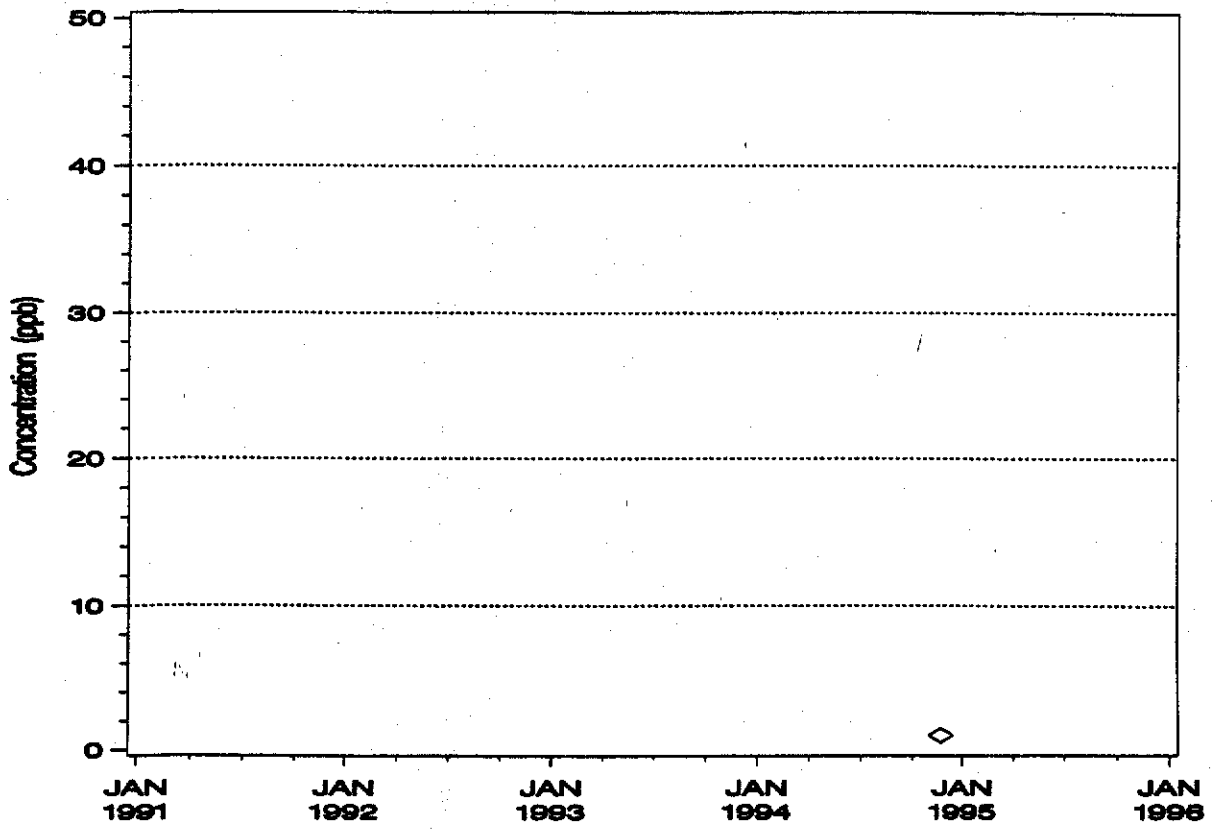


FREON 113 Trend

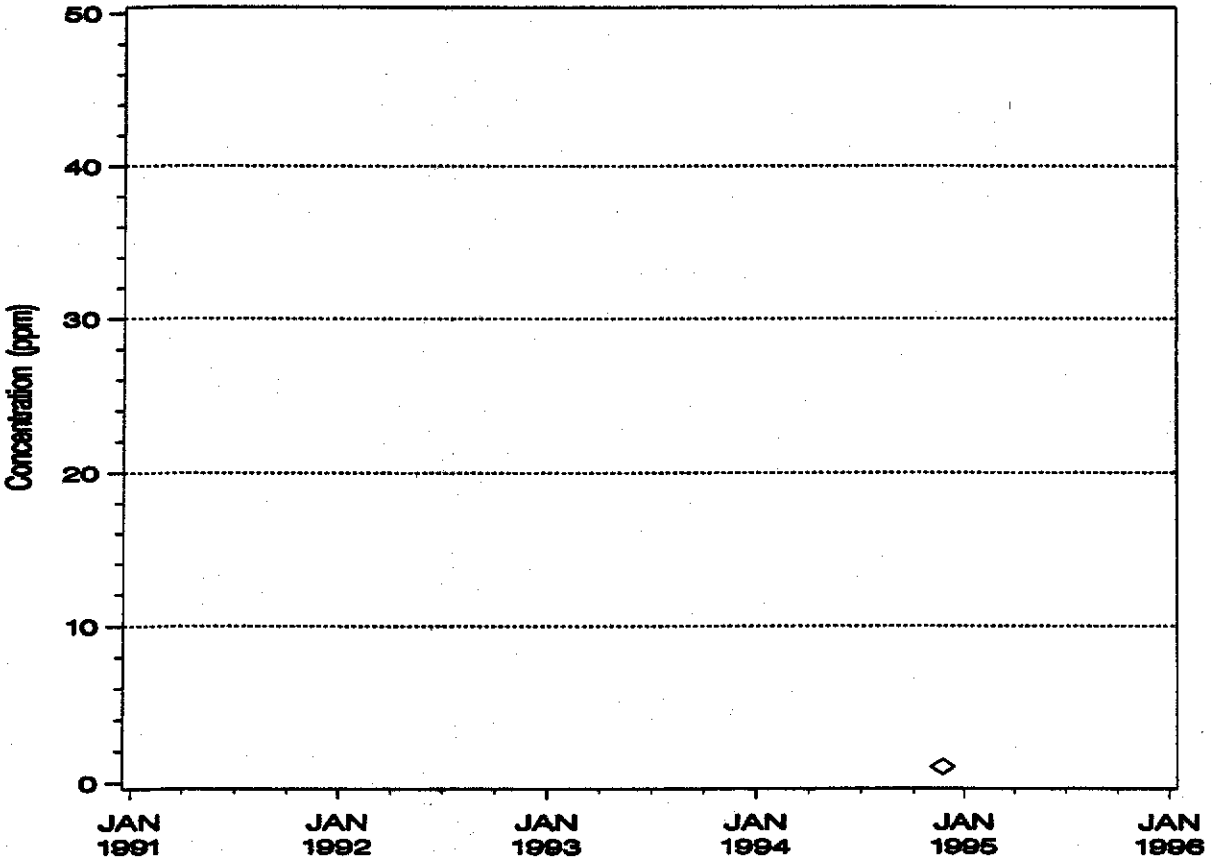


WELL 4355

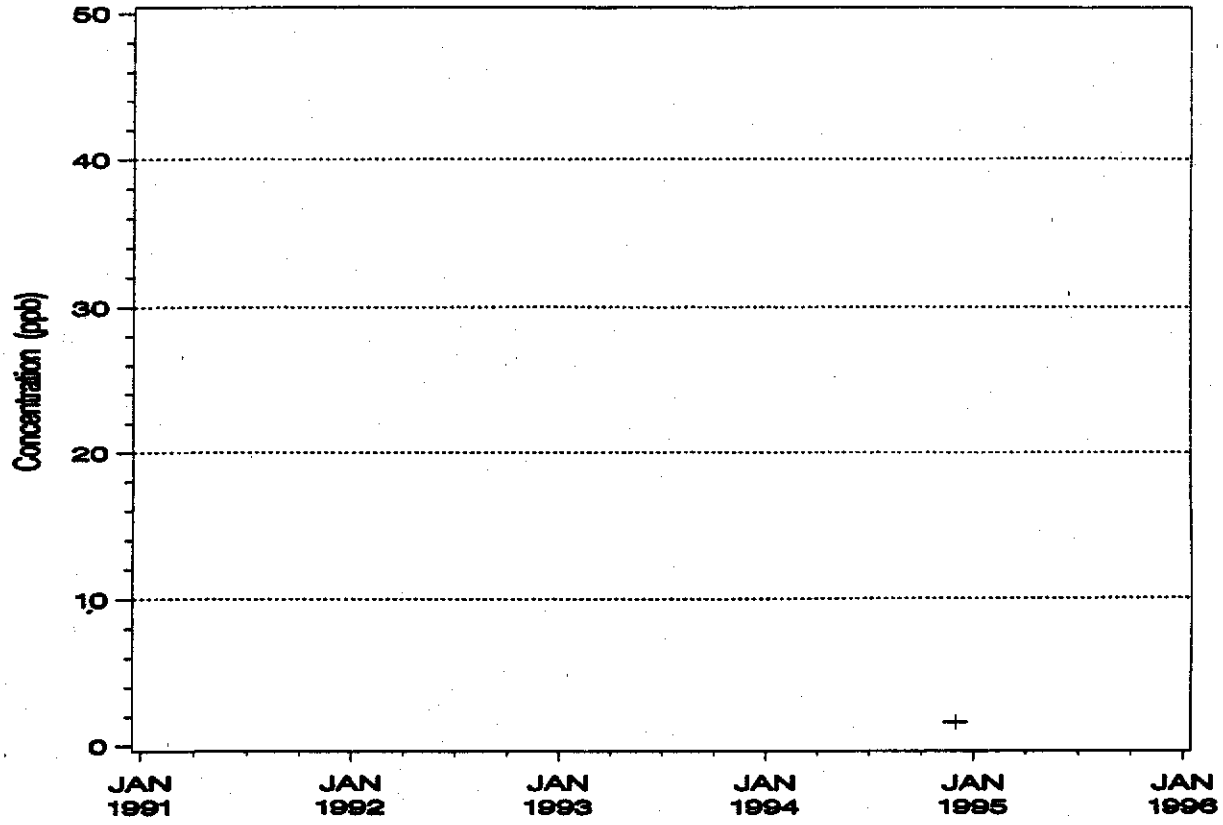
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



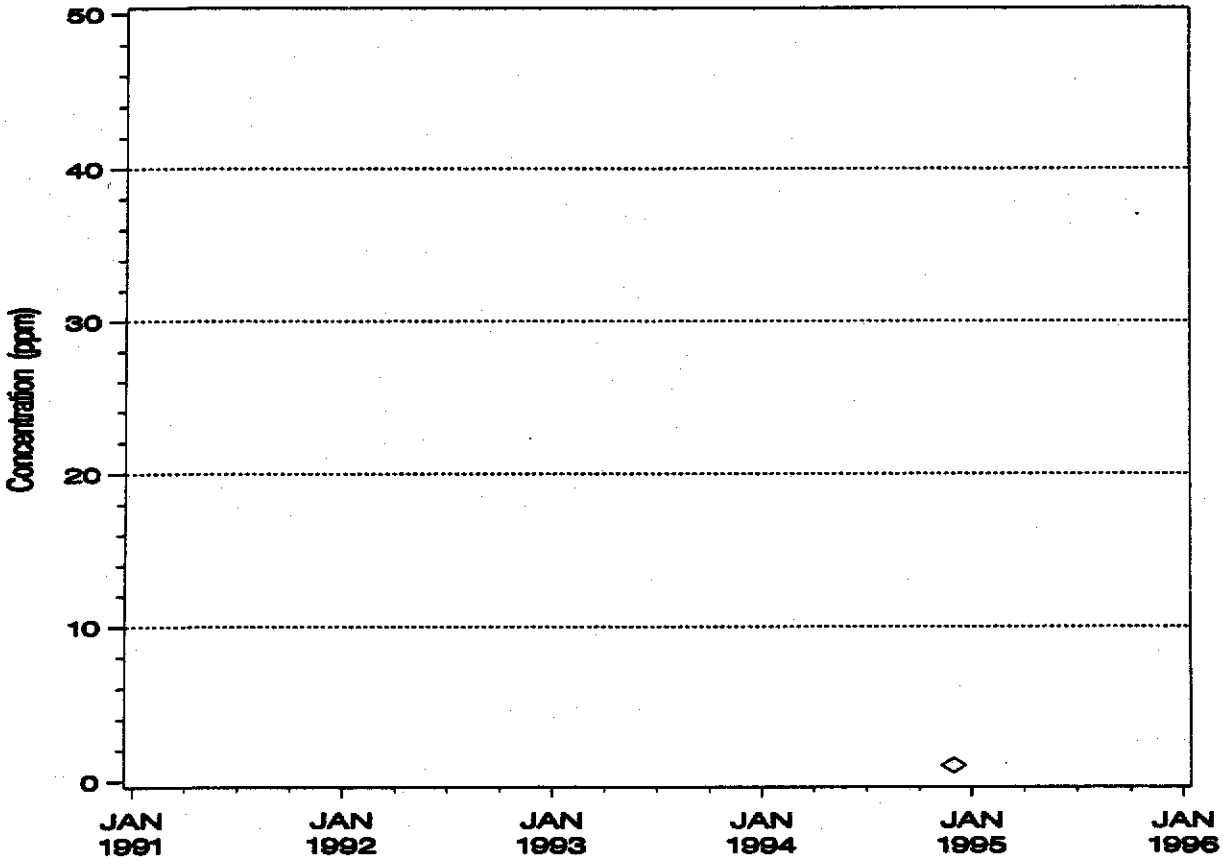
1,1 – DICHLOROETHYLENE Trend



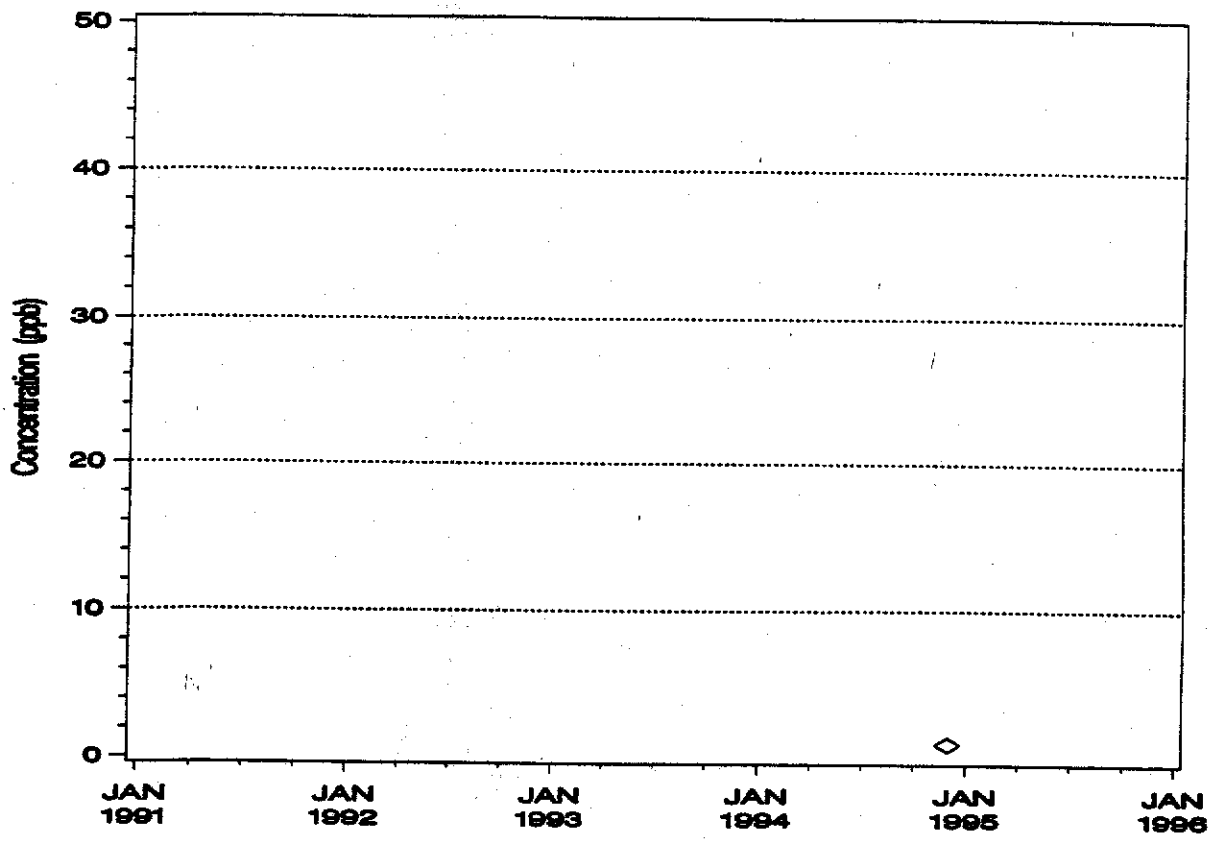
WELL 4360
TRICHLOROETHYLENE Trend



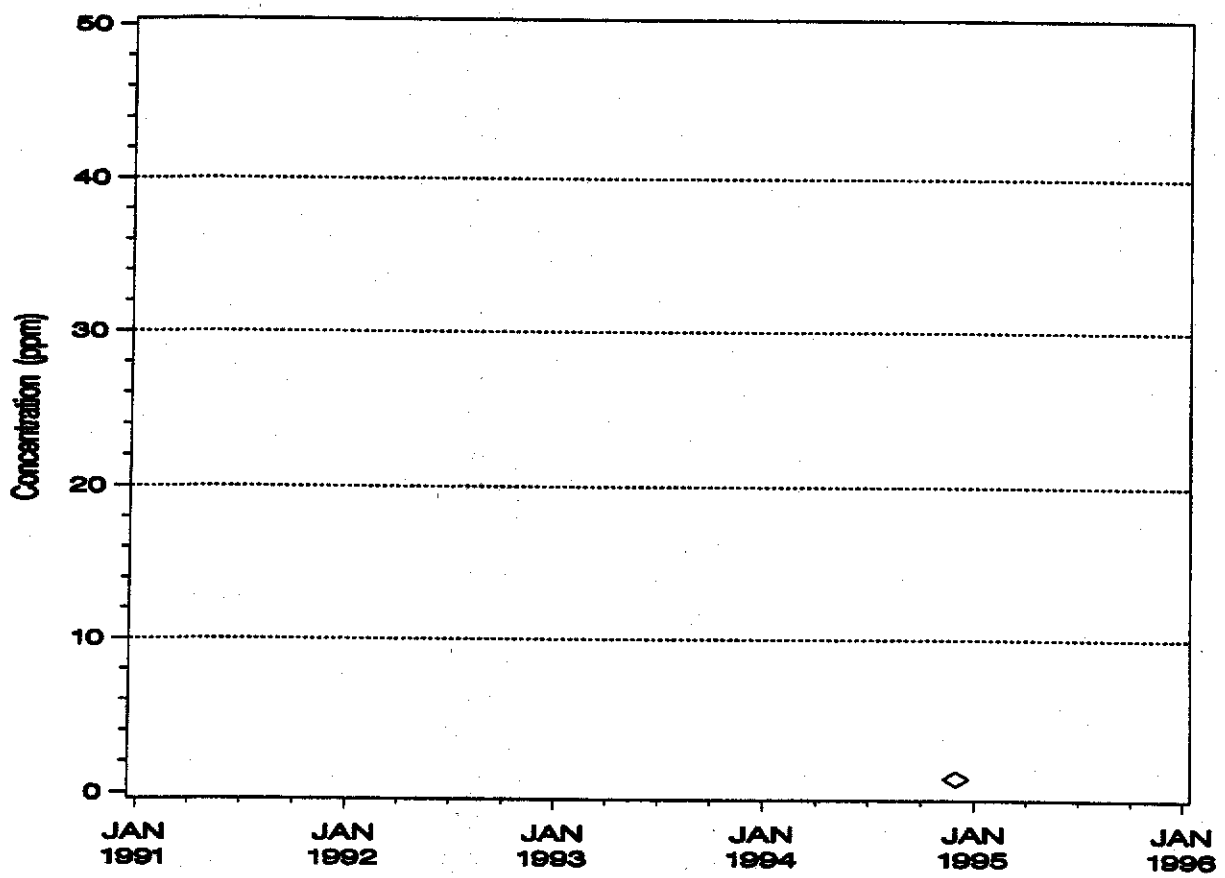
FREON 113 Trend



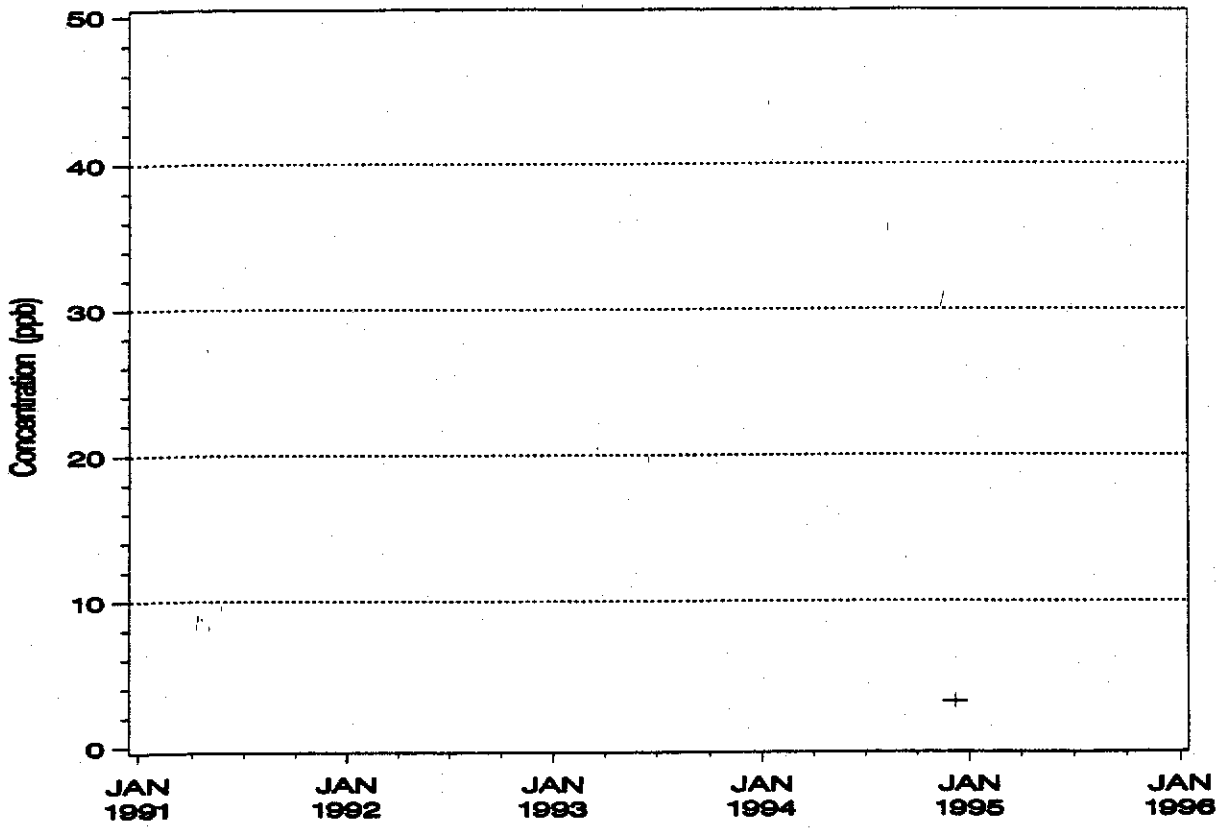
WELL 4360
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



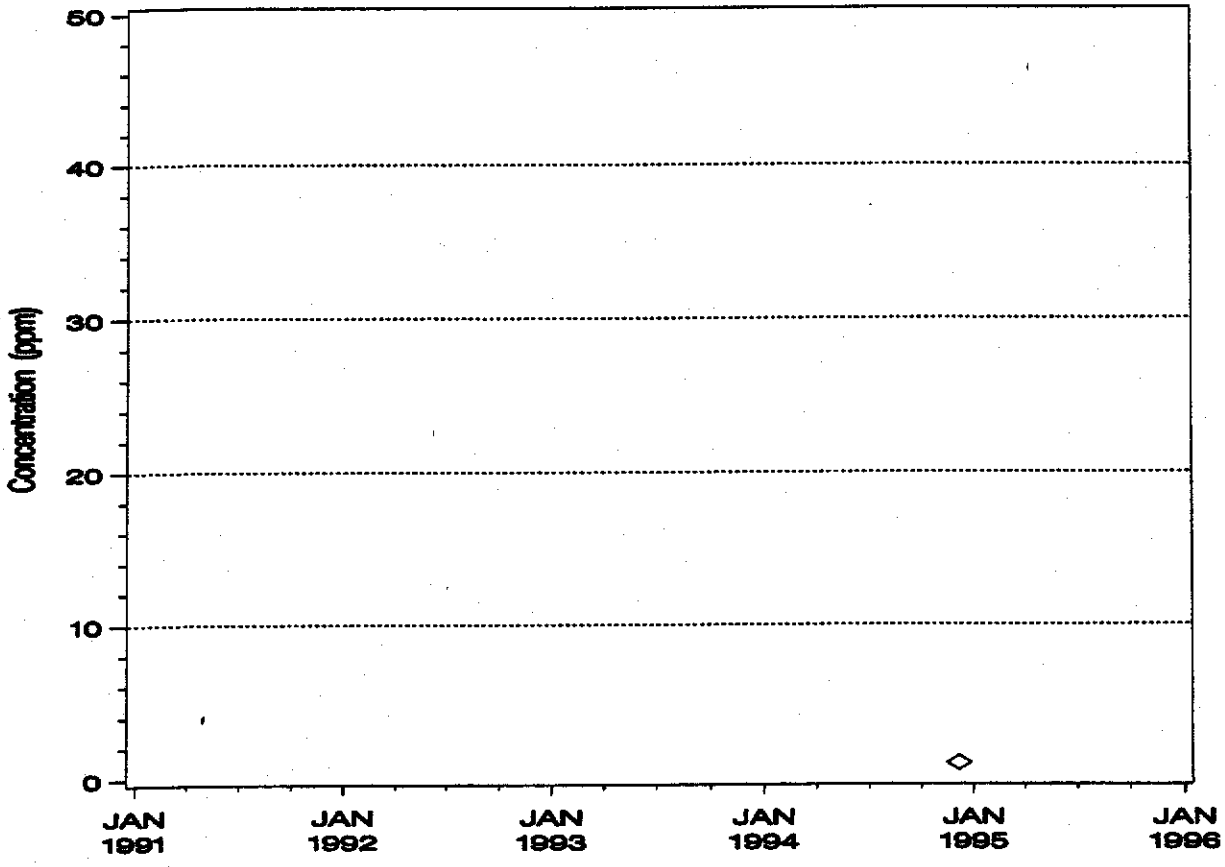
1,1 – DICHLOROETHYLENE Trend



WELL 4365
TRICHLOROETHYLENE Trend

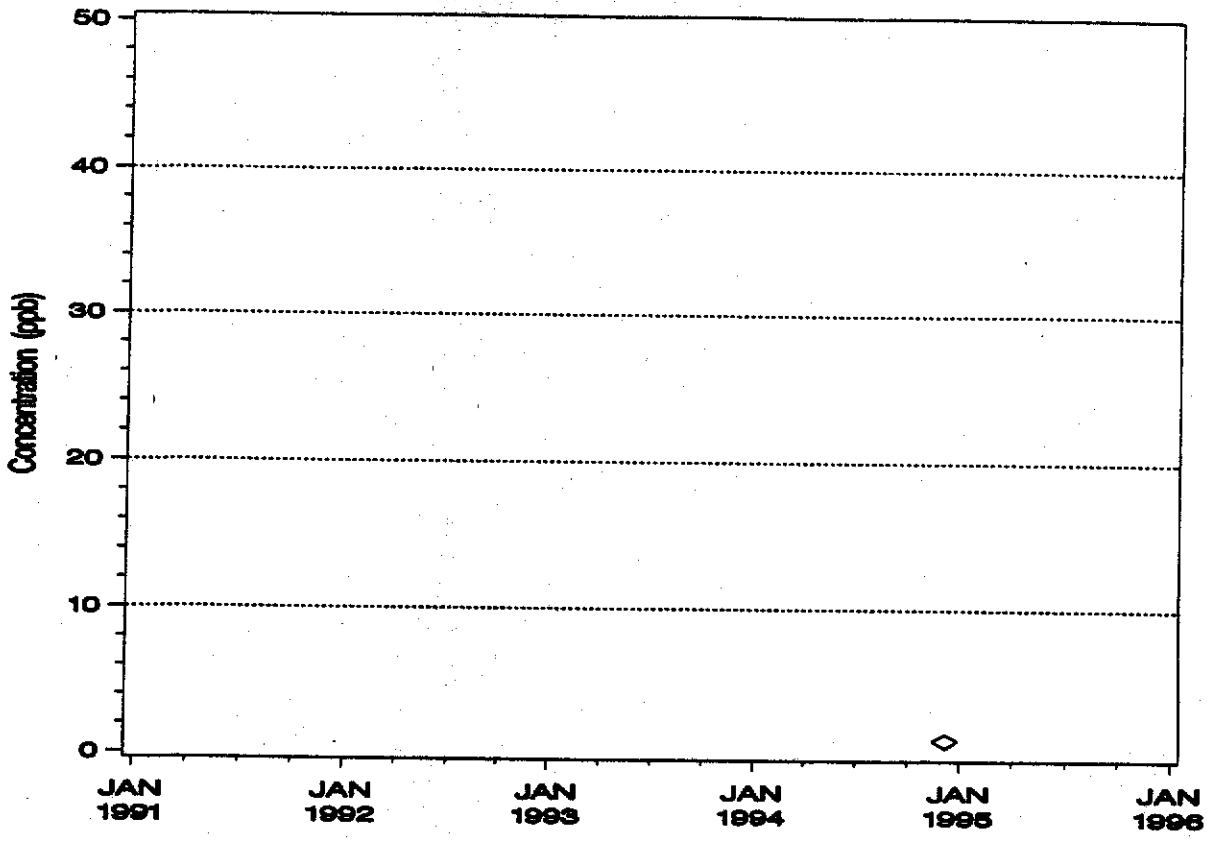


FREON 113 Trend

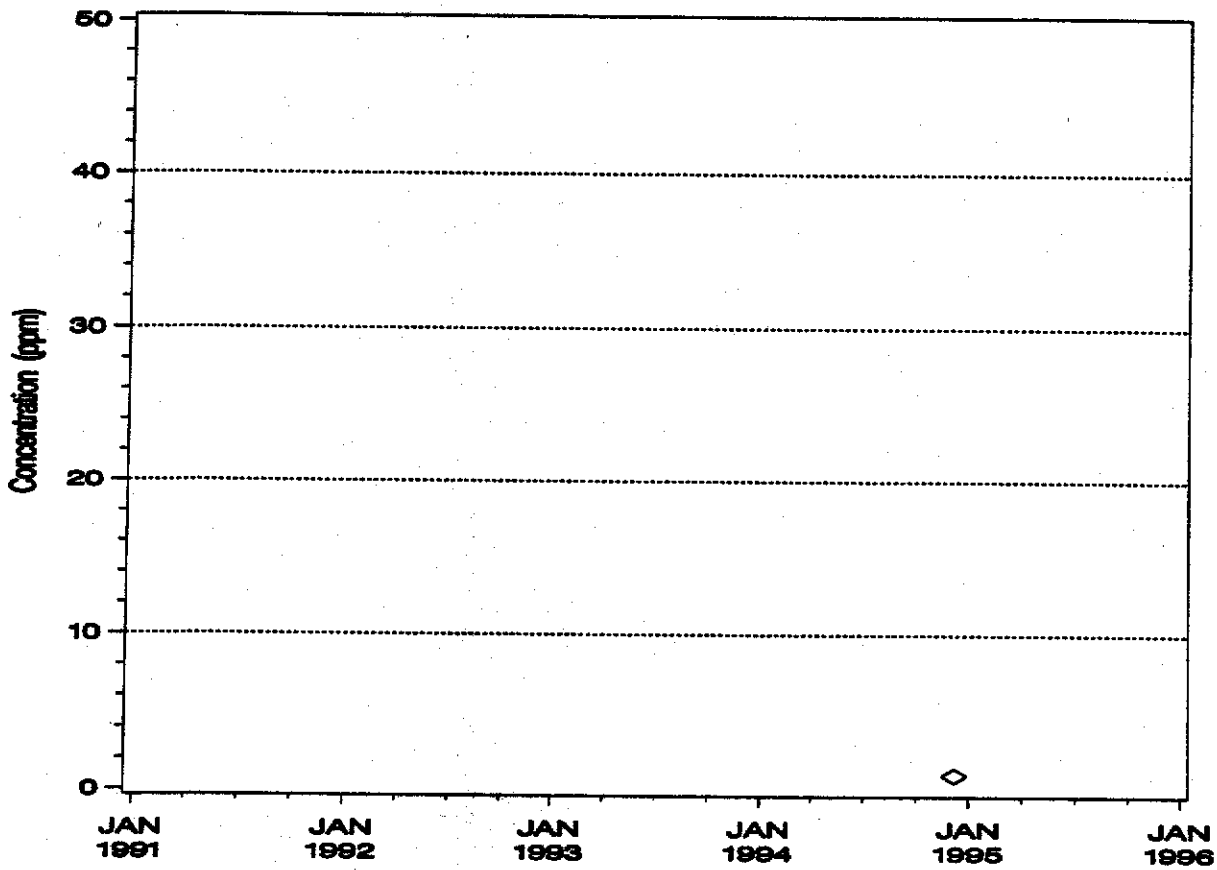


WELL 4365

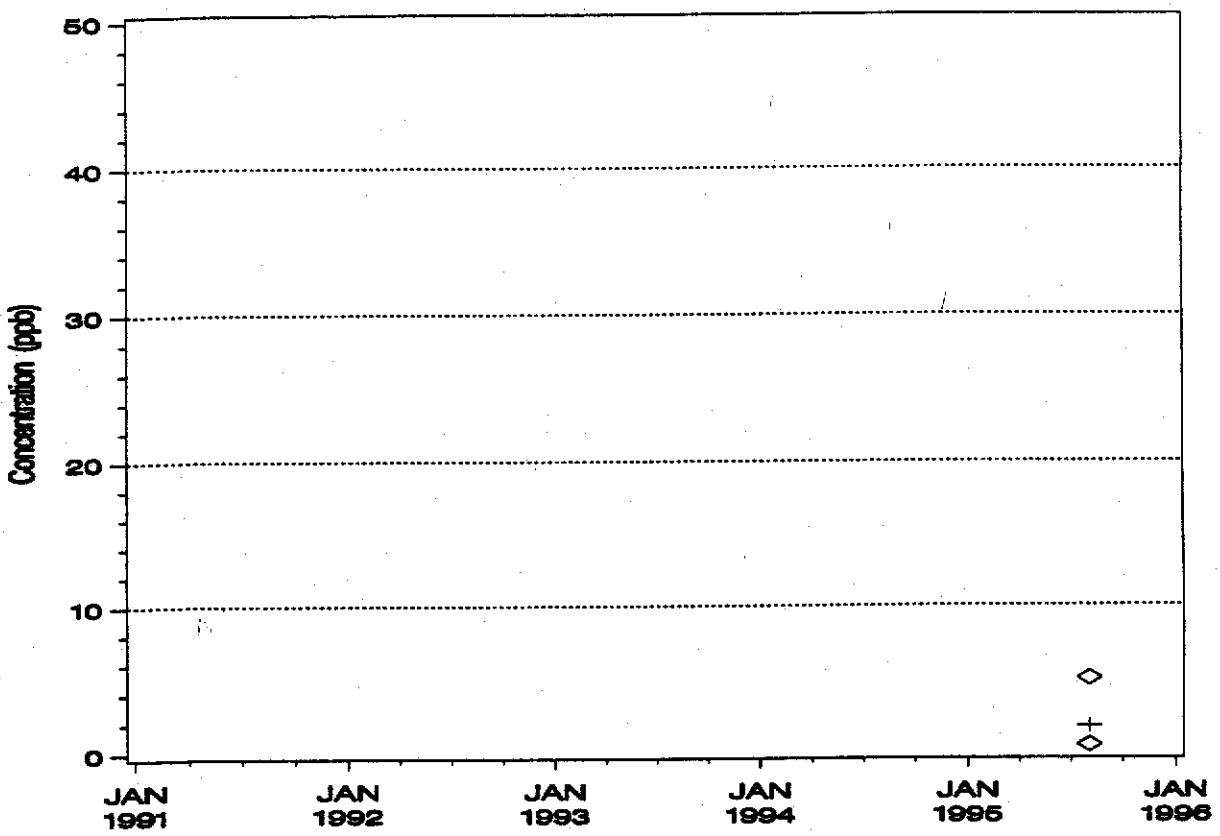
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



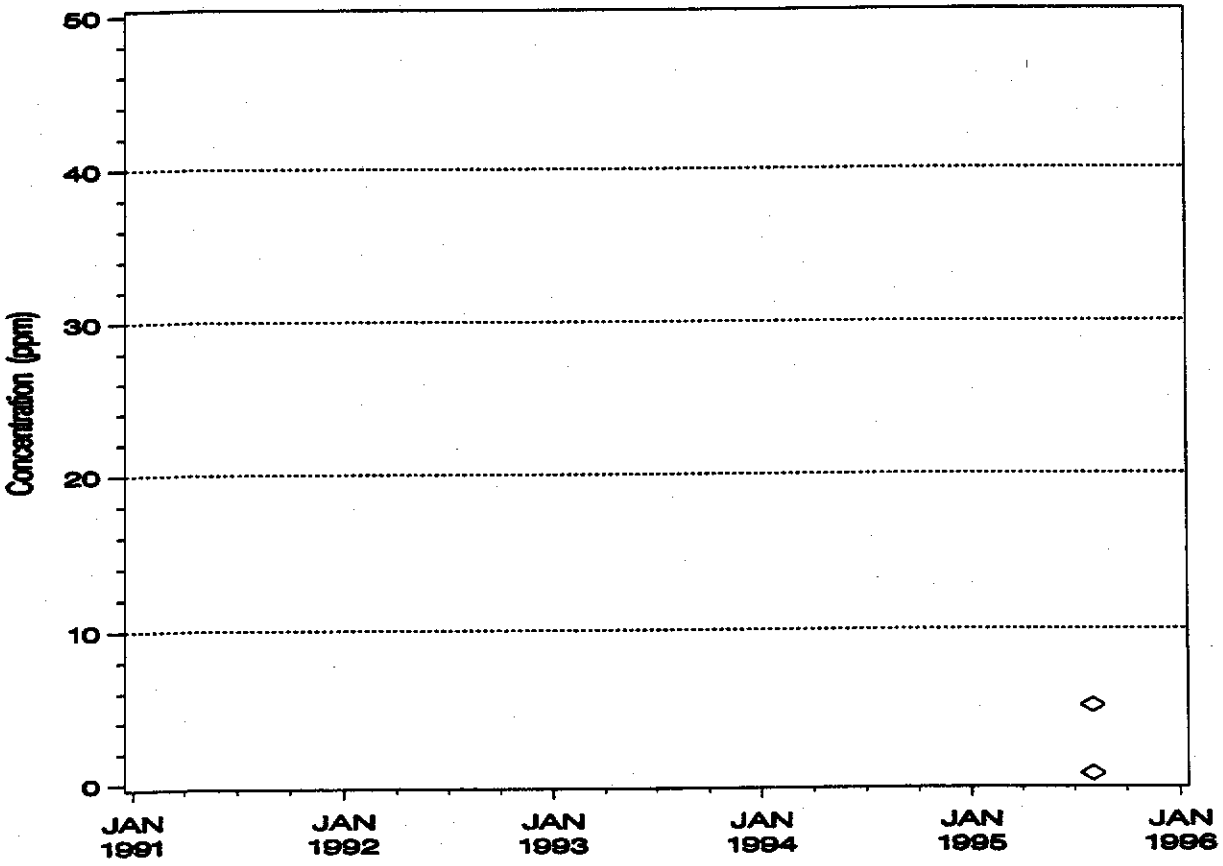
1,1 – DICHLOROETHYLENE Trend



WELL 4370
TRICHLOROETHYLENE Trend

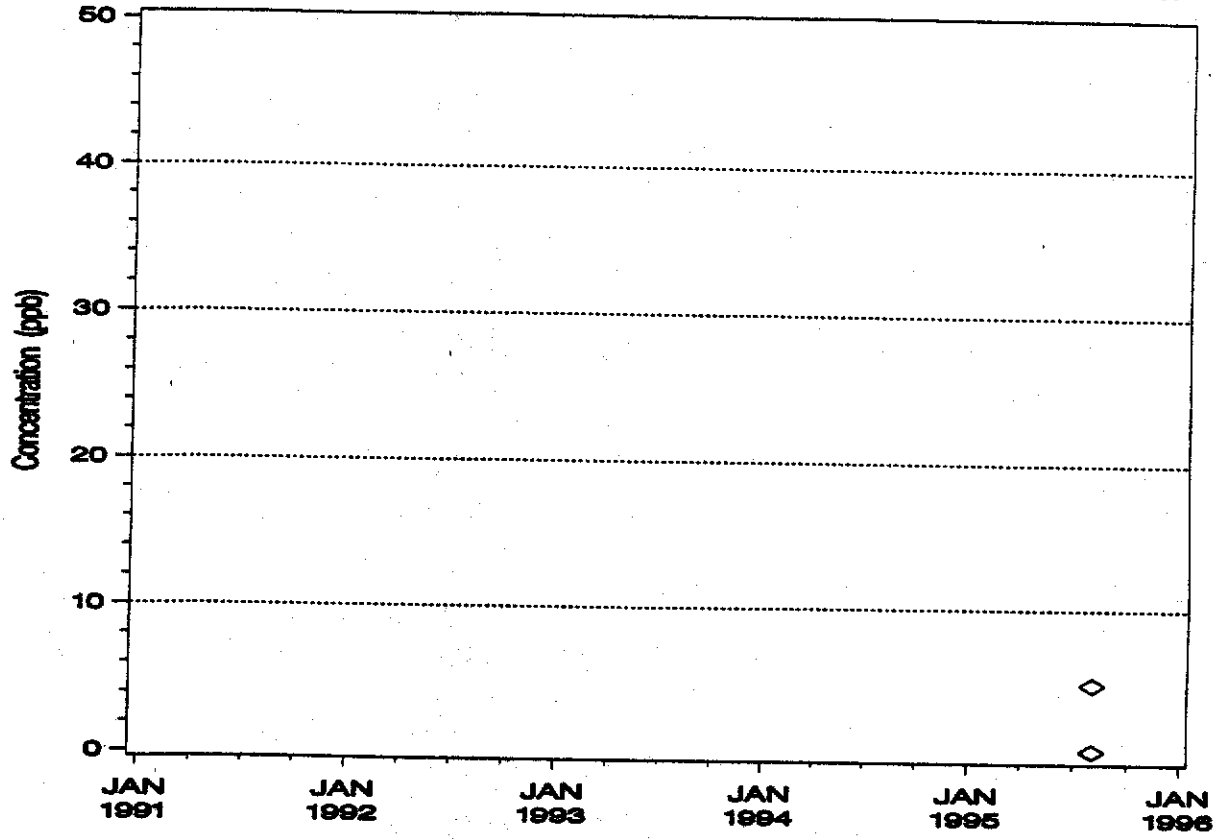


FREON 113 Trend

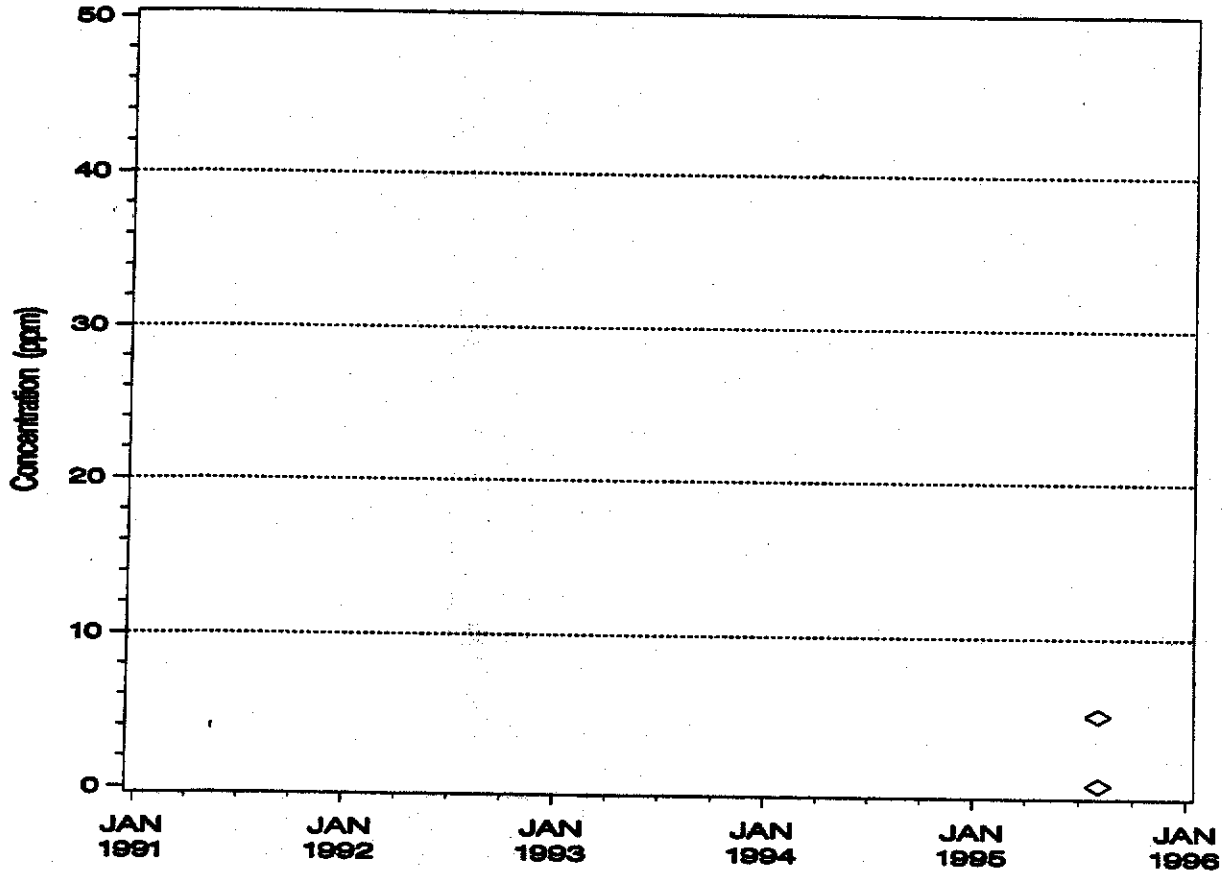


WELL 4370

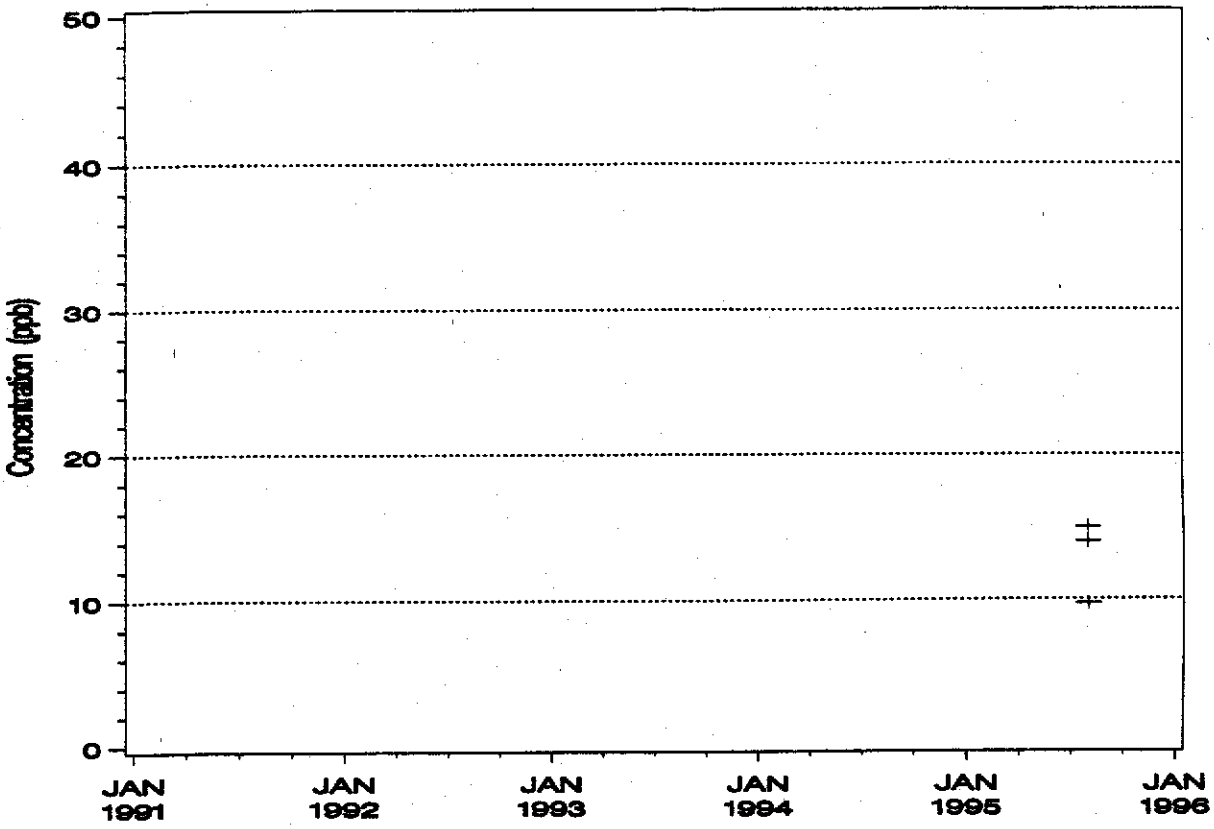
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



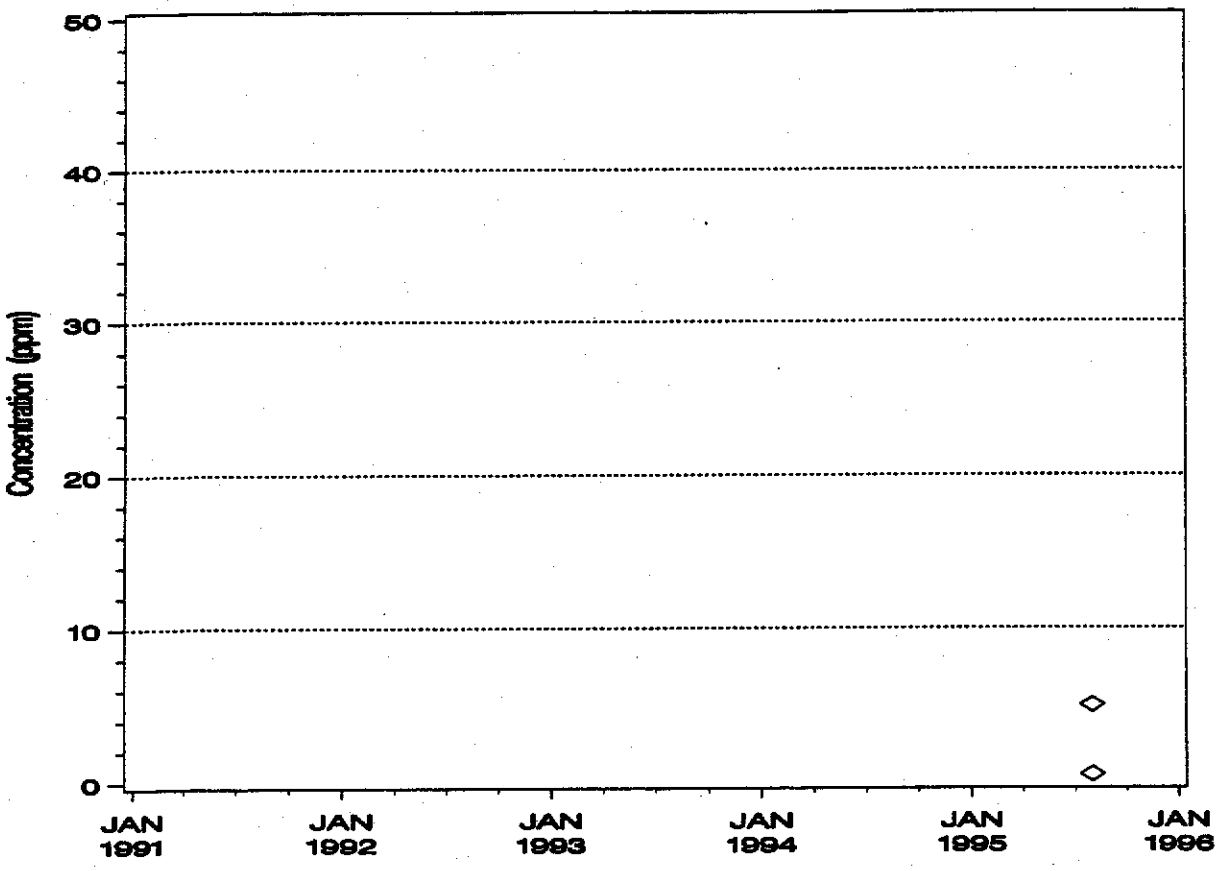
1,1 – DICHLOROETHYLENE Trend



WELL 4375
TRICHLOROETHYLENE Trend

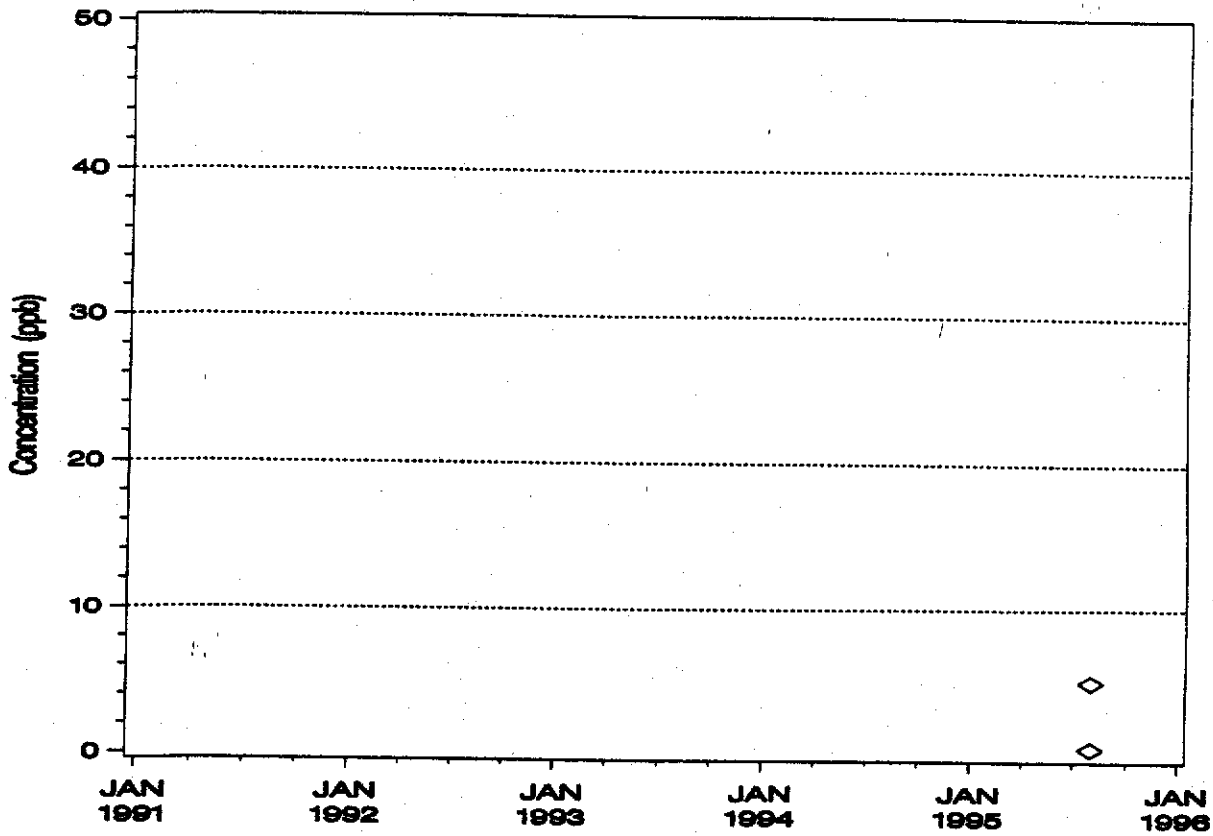


FREON 113 Trend

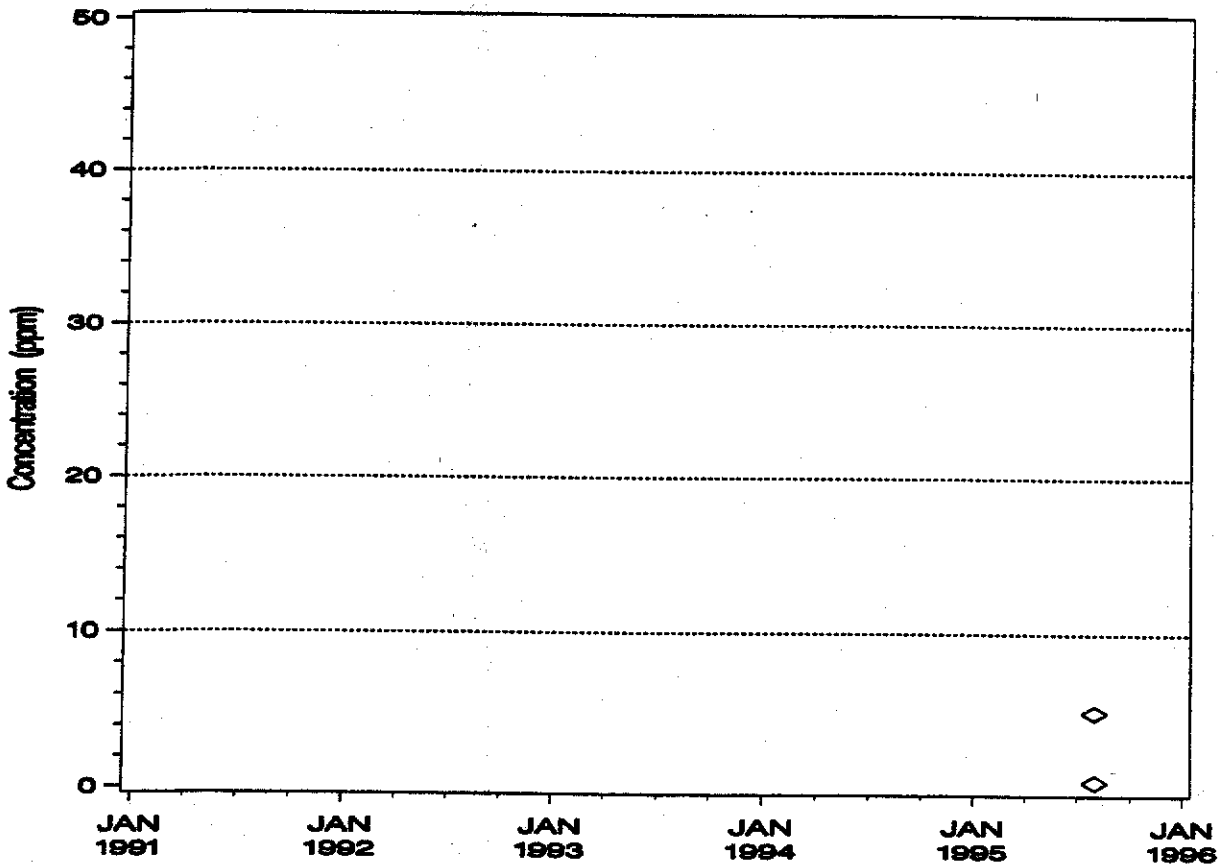


WELL 4375

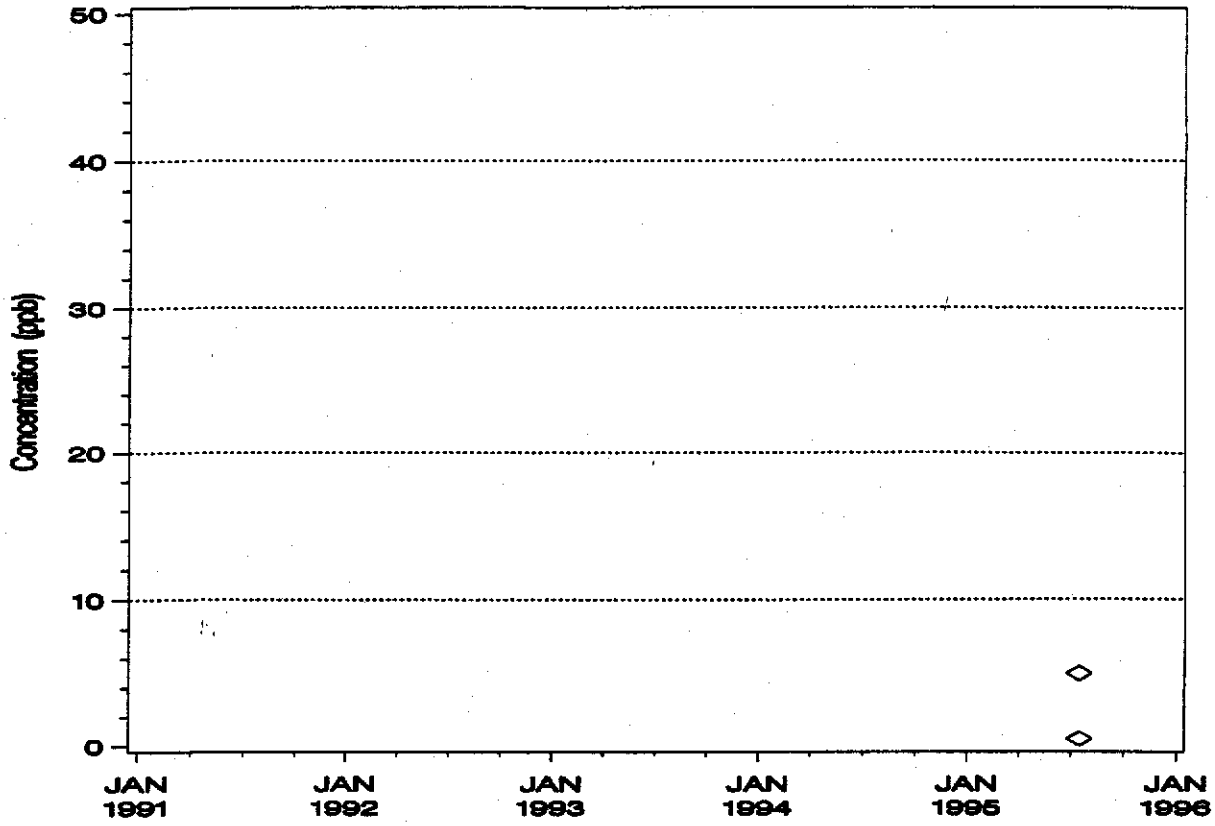
CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



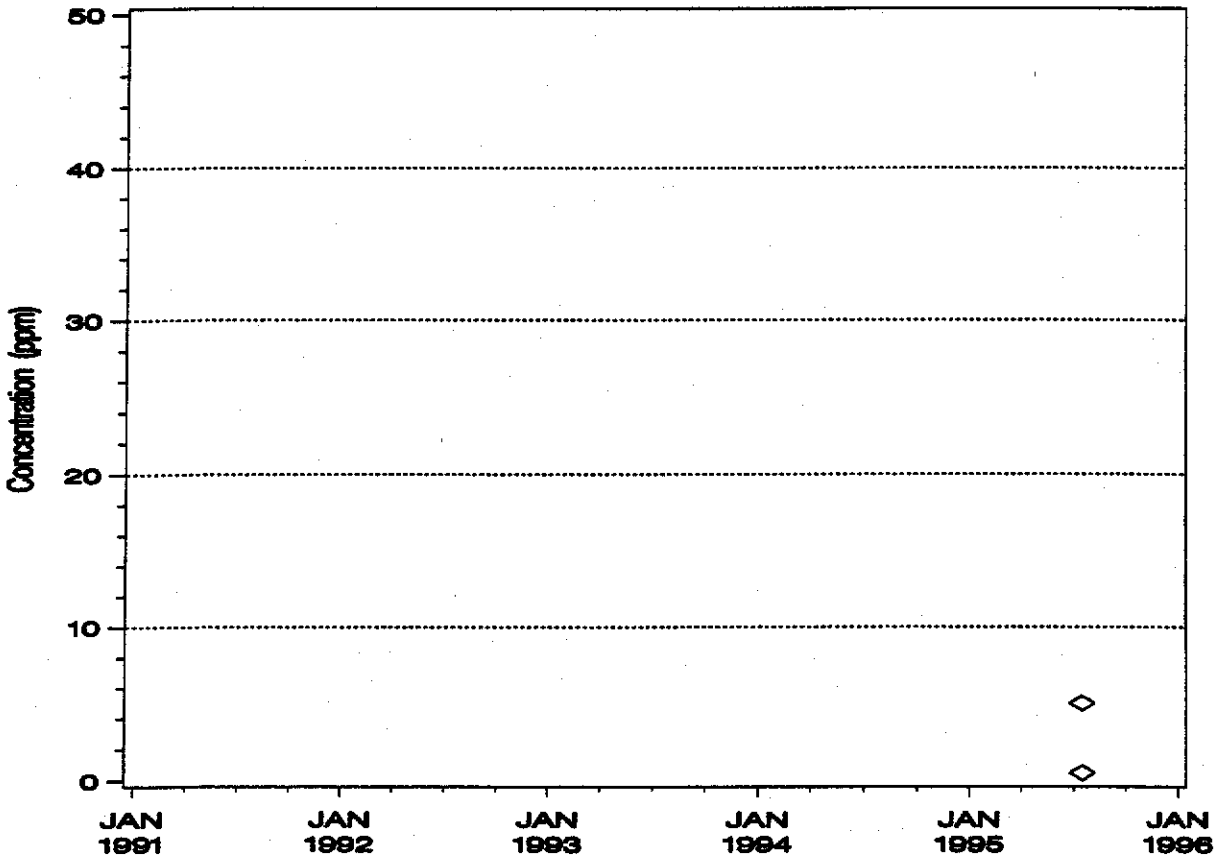
1,1 – DICHLOROETHYLENE Trend



WELL 4380
TRICHLOROETHYLENE Trend

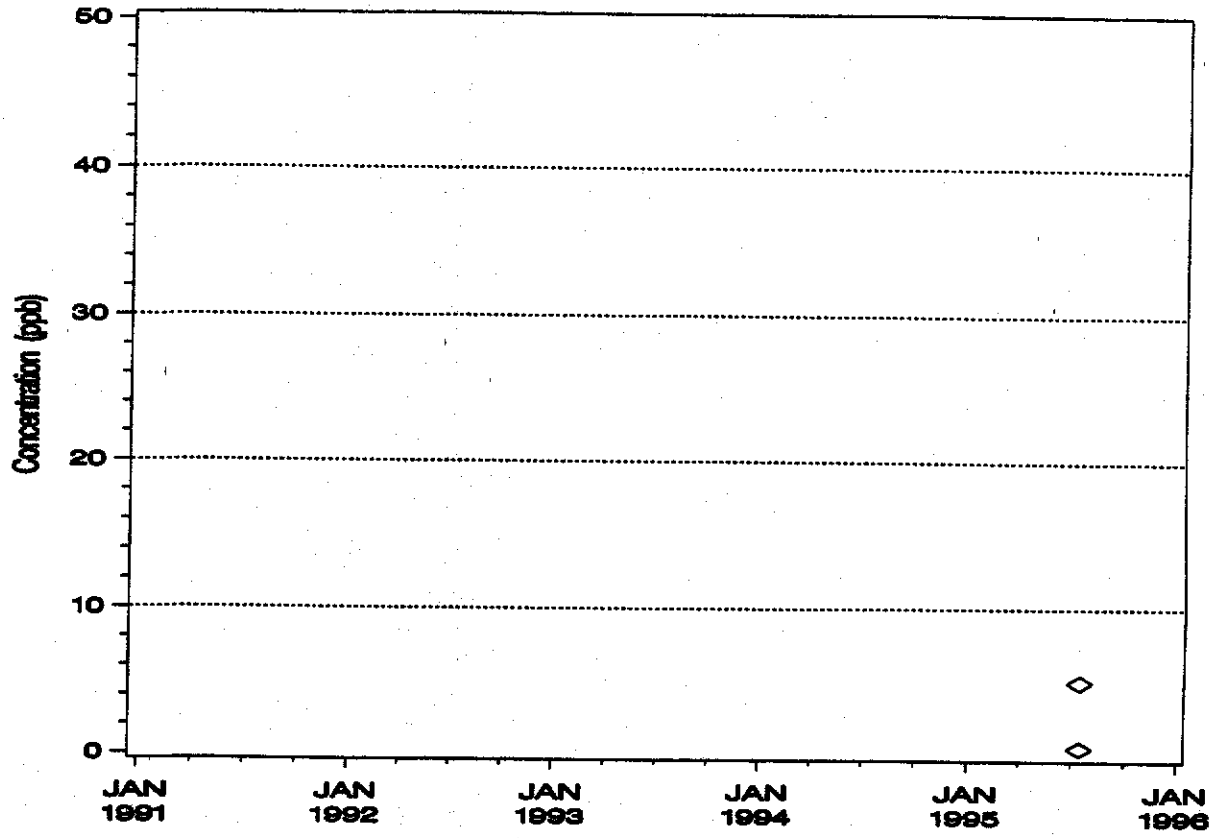


FREON 113 Trend

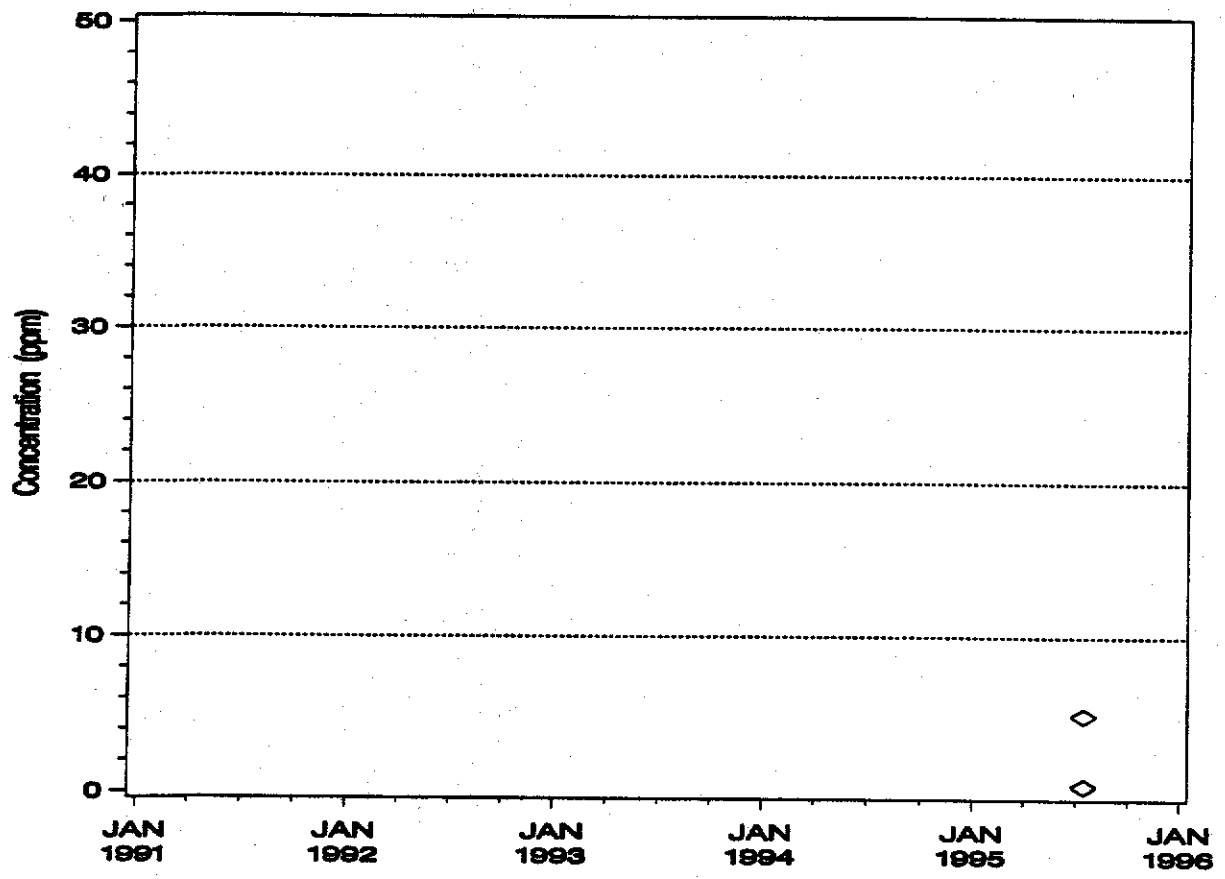


WELL 4380

CIS/TRANS – 1,2 – DICHLOROETHYLENE Trend



1,1 – DICHLOROETHYLENE Trend



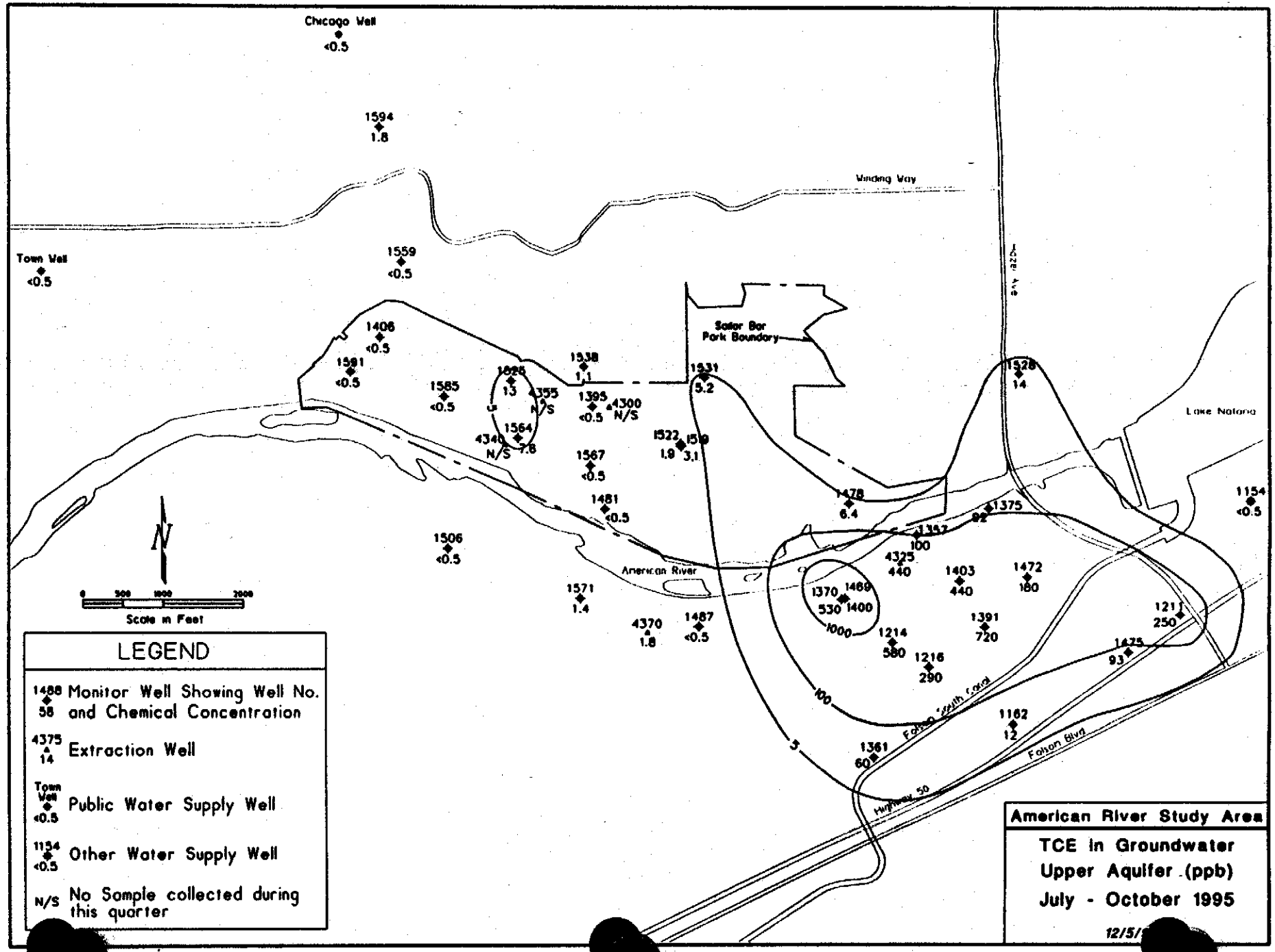
APPENDIX F

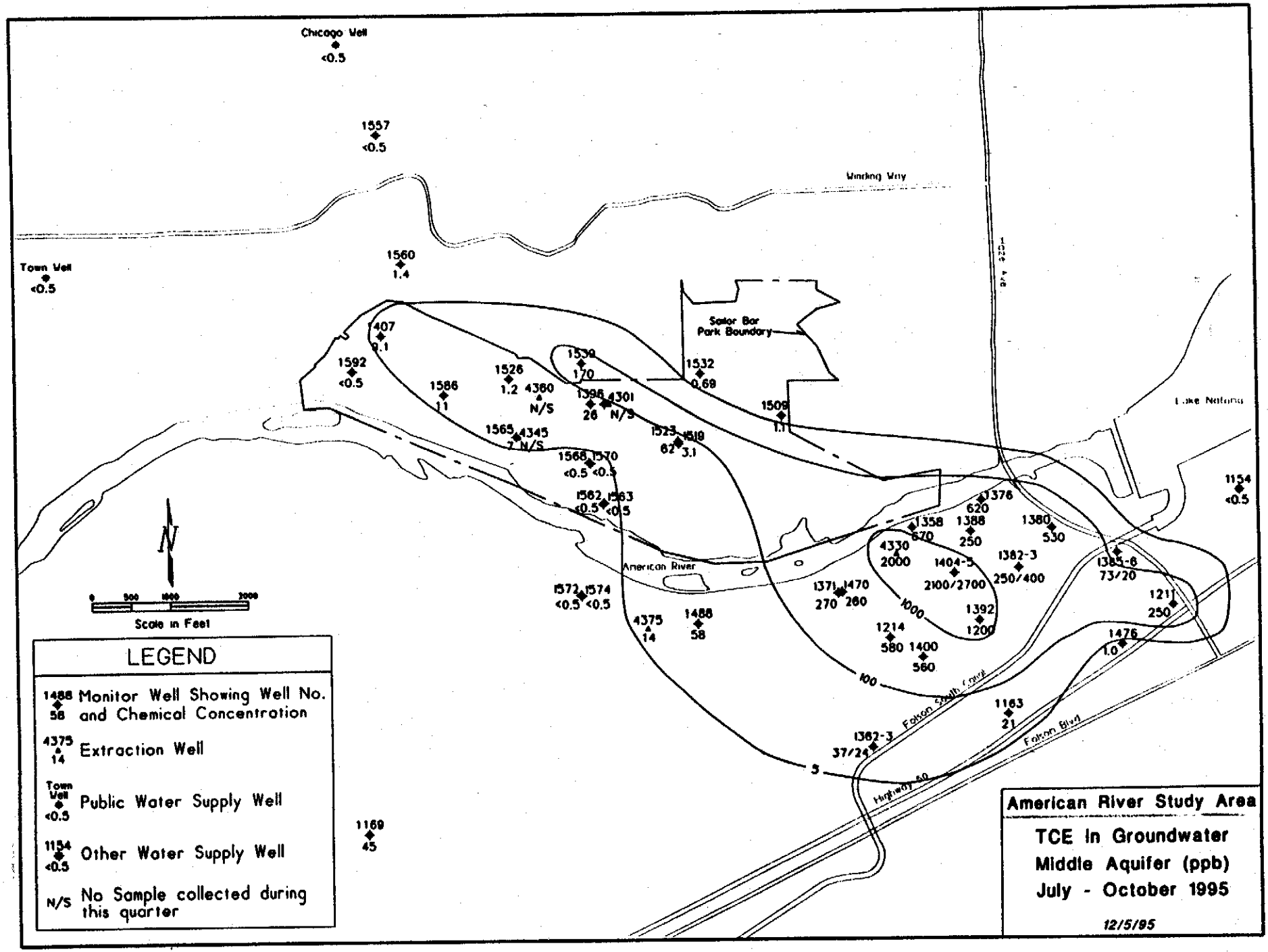
Chemical Distribution Maps

Appendix F

Chemical Distribution Maps

The following maps are sorted by sampling period (July - September 1995 presented first followed by October - December 1995), then by chemical. These maps were previously included in the quarterly sampling reports for these time periods. Maps are presented for the Upper, Middle, Lower and Deeper Aquifers for TCE, 1,4-Dioxane (July - September only since 1,4-Dioxane is only analyzed annually), c/t-1,2-DCE, 1,1-DCE, PCE, and Freon 113.


Chicago Well
<0.5
1594
1.8
Winding Way
Town Well
<0.5
1559
<0.5
Folsom Blvd
Solar Bar Park Boundary
1406
<0.5
1591
<0.5
1585
<0.5
1626
13
4355
N/S
1538
1.1
1395
<0.5
4300
N/S
1564
7.8
4340
N/S
1567
<0.5
1522
1.9
1519
3.1
1481
<0.5
1506
<0.5
1571
1.4
4370
1.8
1487
<0.5
1931
5.2
1528
14
Lake Natoma
1154
<0.5
1478
6.4
1375
82
1352
100
4325
440
1403
440
1472
180
1370
530
1469
1400
1000
1391
720
1214
580
1216
290
1217
250
1475
93
1162
12
1361
60
100
5
American River
Folsom South Canal
Folsom Blvd
Highway 50
N
0 500 1000 2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
TCE in Groundwater
Upper Aquifer (ppb)
July - October 1995
12/5/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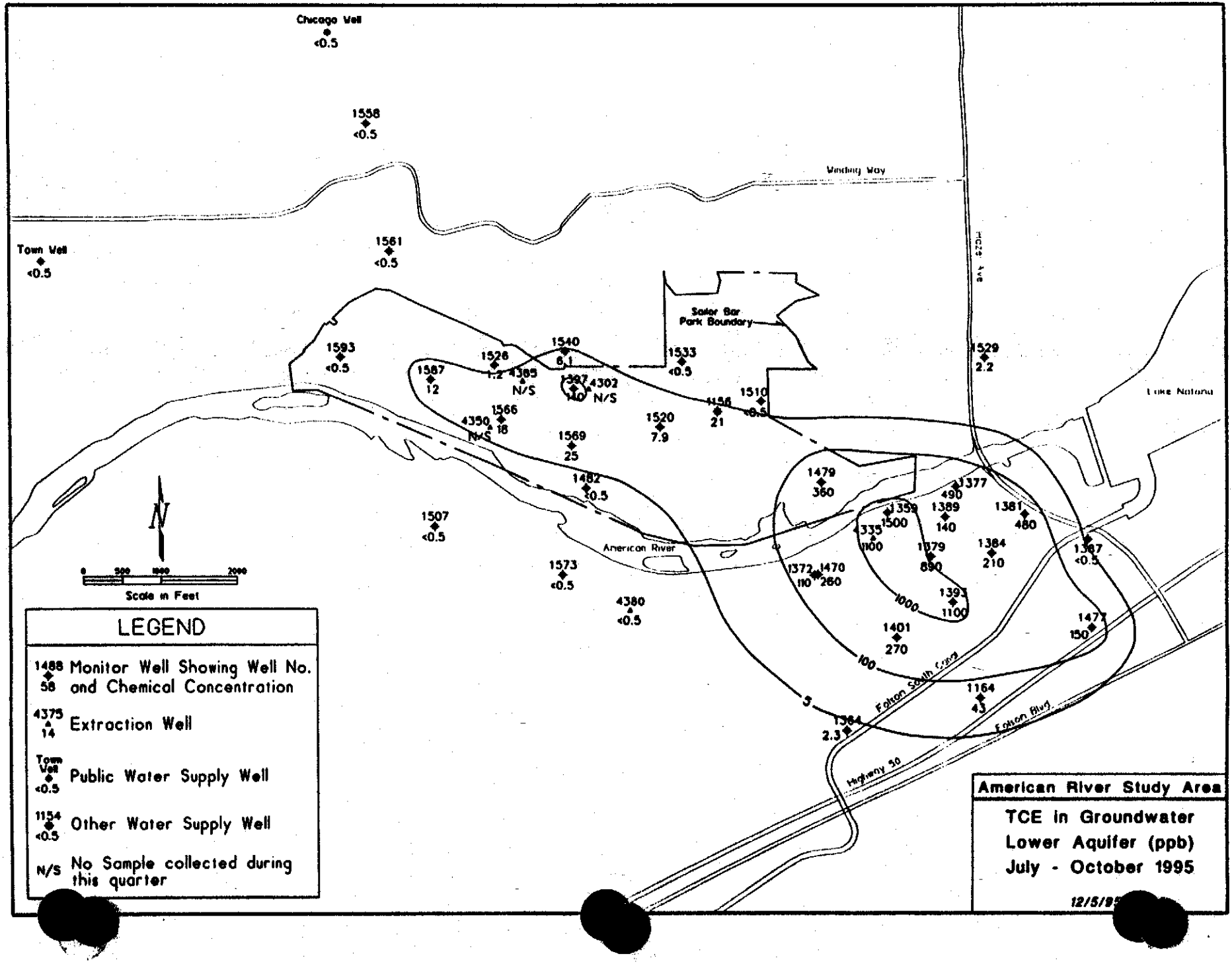
<0.5
Winding Way
Town Well
<0.5
1560
1.4
Sailor Bar
Park Boundary
407
9.1
1592
<0.5
1586
11
1526
1.2
4360
N/S
1539
170
1396
26
4301
N/S
1532
0.69
1508
1.1
1565
2
4345
N/S
1523
62
1519
3.1
1568
<0.5
1570
<0.5
1562
<0.5
1563
<0.5
American River
1572
<0.5
1574
<0.5
4375
14
1488
58
1371
270
1470
280
1376
620
1358
670
1388
250
1380
530
4330
2000
1404-5
2100/2700
1382-3
250/400
1385-6
73/20
1392
1200
1214
580
1400
560
1154
<0.5
121
250
1476
1.0
1163
21
1382-3
37/24
1169
45
Folsom South Canal
Folsom Blvd
Highway 50
Lake Natoma
N
0
500
1000
2000
Scale in Feet
100
1000
5
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
TCE in Groundwater
Middle Aquifer (ppb)
July - October 1995
12/5/95


Chicago Well
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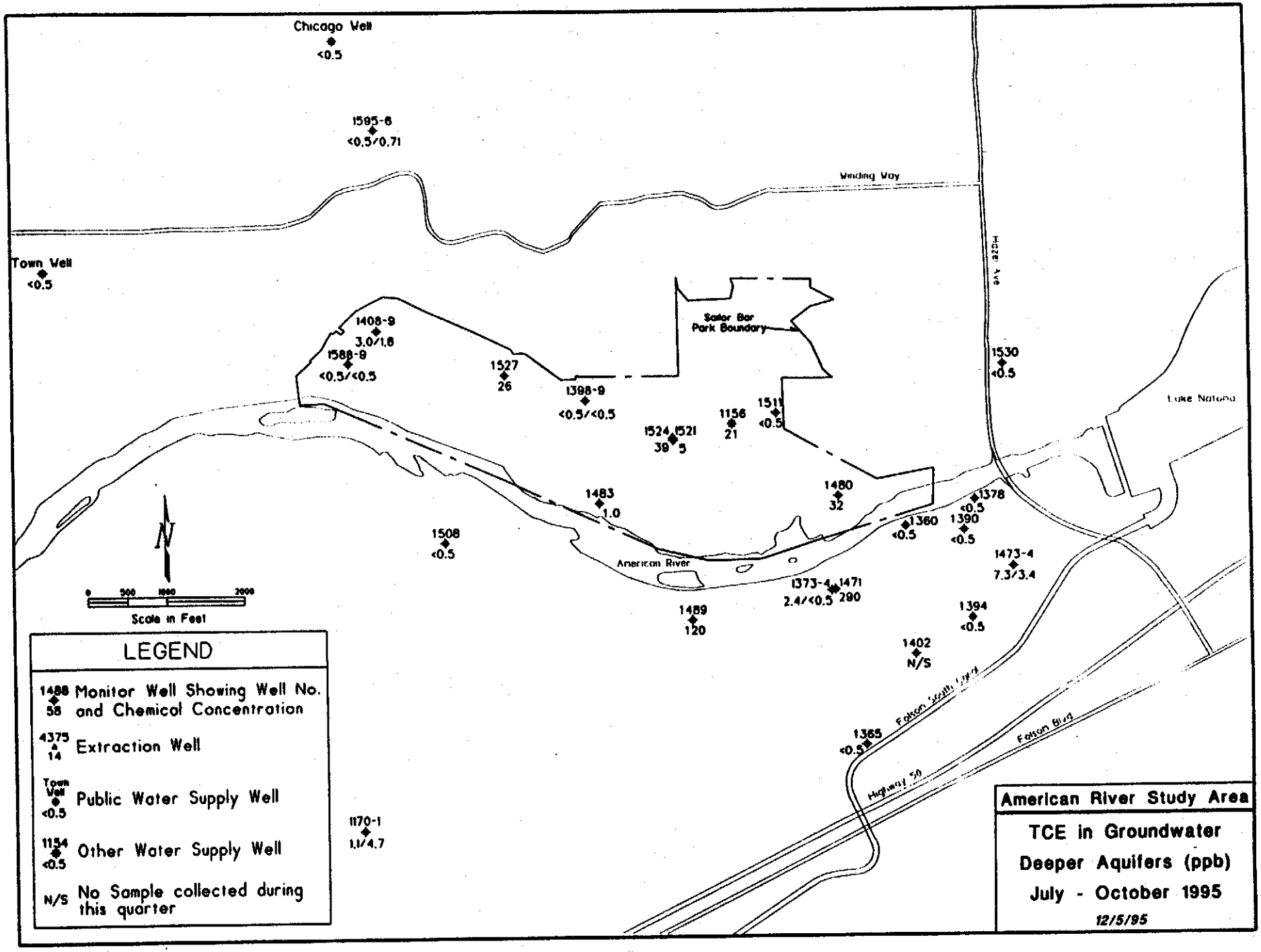
1556
<0.5
Winding Way
Town Well
<0.5
1561
<0.5
Sailor Bar
Park Boundary
1593
<0.5
1526
1.2
1540
6.1
1533
<0.5
1529
2.2
1587
12
4385
N/S
4397
140
4302
N/S
1510
<0.5
1566
18
4350
N/S
1520
7.9
1156
21
1569
25
1482
<0.5
1479
360
1377
490
1359
1500
1389
140
1381
480
1335
1100
1379
690
1384
210
1387
<0.5
1372
110
1470
260
1393
1100
1401
270
1477
150
1507
<0.5
1573
<0.5
4380
<0.5
American River
1000
100
5
1164
43
1364
2.3
Folsom South Canal
Folsom Blvd.
Highway 50
Lake Natoma
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
TCE in Groundwater
Lower Aquifer (ppb)
July - October 1995
12/5/95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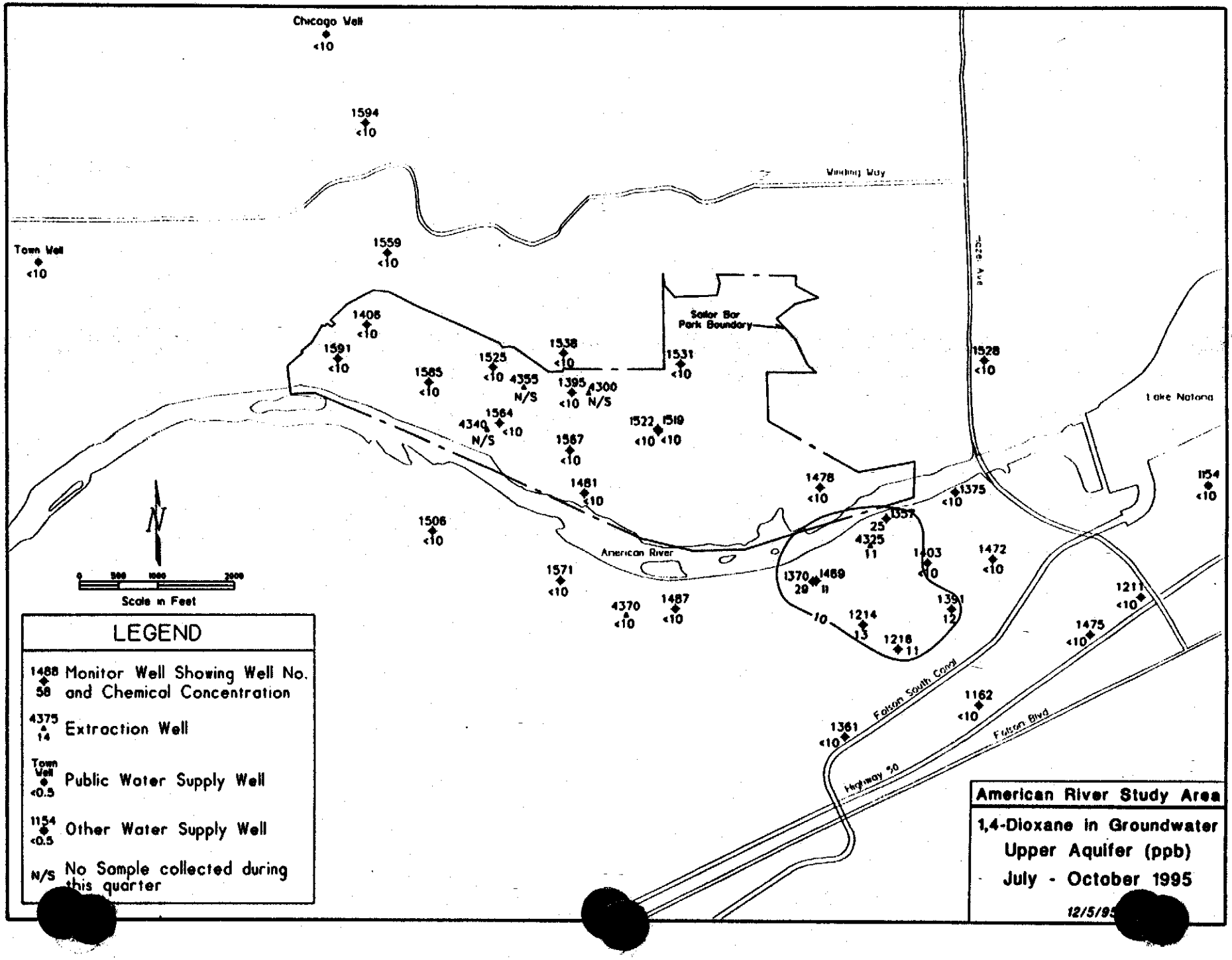
1595-6
<0.5/0.71
Winding Way
Town Well
<0.5
1408-9
3.0/1.6
1588-9
<0.5/<0.5
Sailor Bar
Park Boundary
1527
26
1398-9
<0.5/<0.5
1524
39
1521
5
1156
21
1511
<0.5
1530
<0.5
Lake Natoma
1483
1.0
1480
32
1508
<0.5
American River
1360
<0.5
1378
<0.5
1390
<0.5
1473-4
7.3/3.4
1373-4
2.4/<0.5
1471
290
1489
120
1394
<0.5
1402
N/S
1365
<0.5
Folsom South Line
Folsom Blvd
Highway 50
1170-1
1.1/4.7
N
0 500 1000 2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
TCE in Groundwater
Deeper Aquifers (ppb)
July - October 1995
12/5/95


Chicago Well
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1594
<10
Town Well
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1559
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1406
<10
1591
<10
1585
<10
1525
<10
4355
N/S
1538
<10
1395
<10
4300
N/S
1531
<10
Sailor Bar
Park Boundary
1564
4340
N/S
<10
1522
<10
1519
<10
1567
<10
1481
<10
1506
<10
1571
<10
4370
<10
1487
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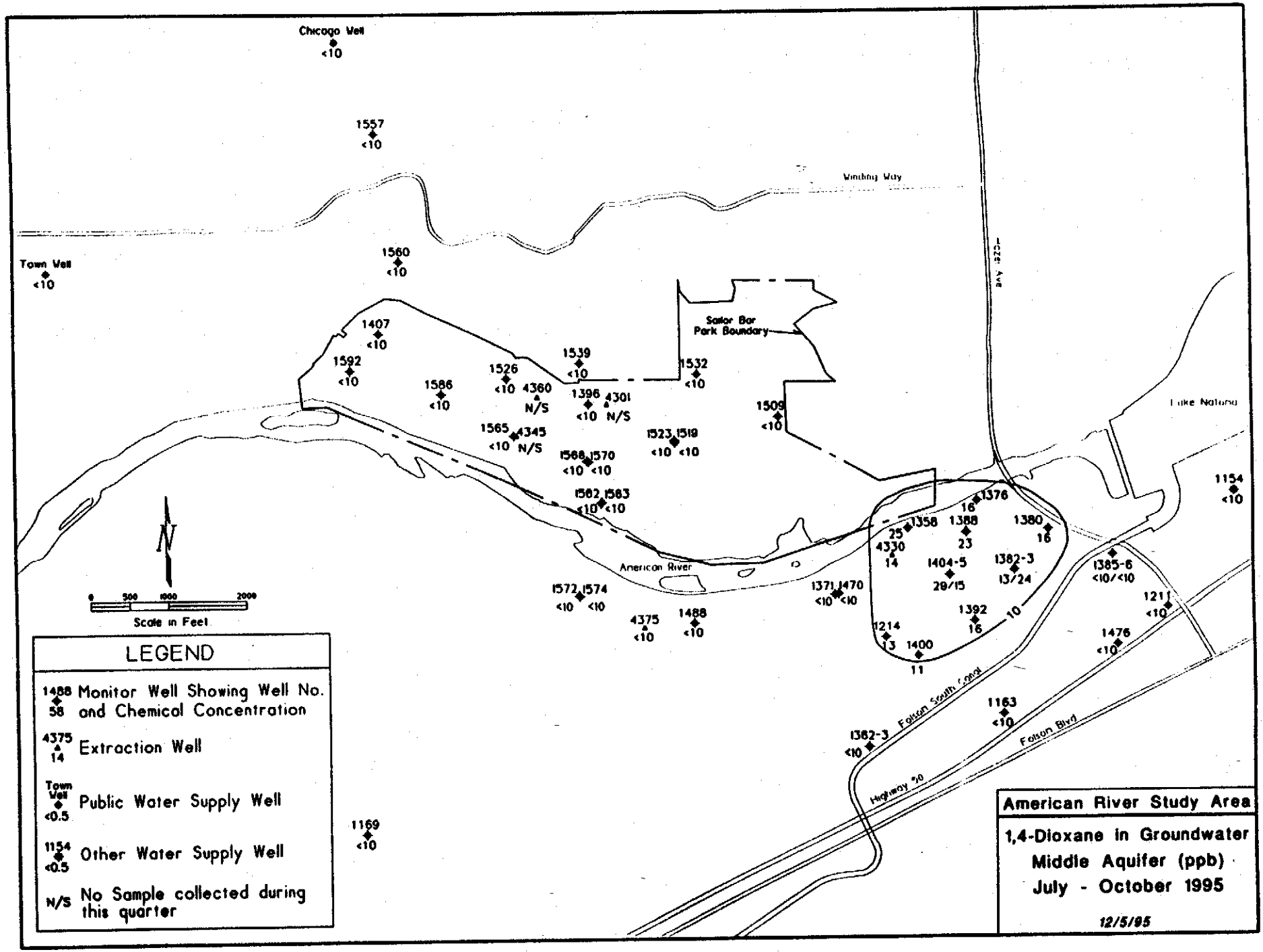
1478
<10
1375
<10
1357
25
4325
11
1403
<10
1472
<10
1370
29
1469
11
1391
12
1214
13
1218
11
1211
<10
1475
<10
1154
<10
1528
<10
1162
<10
1361
<10
Folsom South Canal
Folsom Blvd
Highway 50
American River
Lake Natoma
N
0
500
1000
2000
Scale in Feet
LEGEND
1488
58
Monitor Well Showing Well No. and Chemical Concentration
4375
14
Extraction Well
Town Well
<0.5
Public Water Supply Well
1154
<0.5
Other Water Supply Well
N/S
No Sample collected during this quarter
American River Study Area
1,4-Dioxane in Groundwater
Upper Aquifer (ppb)
July - October 1995
12/5/95


Chicago Well
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Winding Way
Town Well
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1560
<10
Sailor Bar
Park Boundary
1407
<10
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1539
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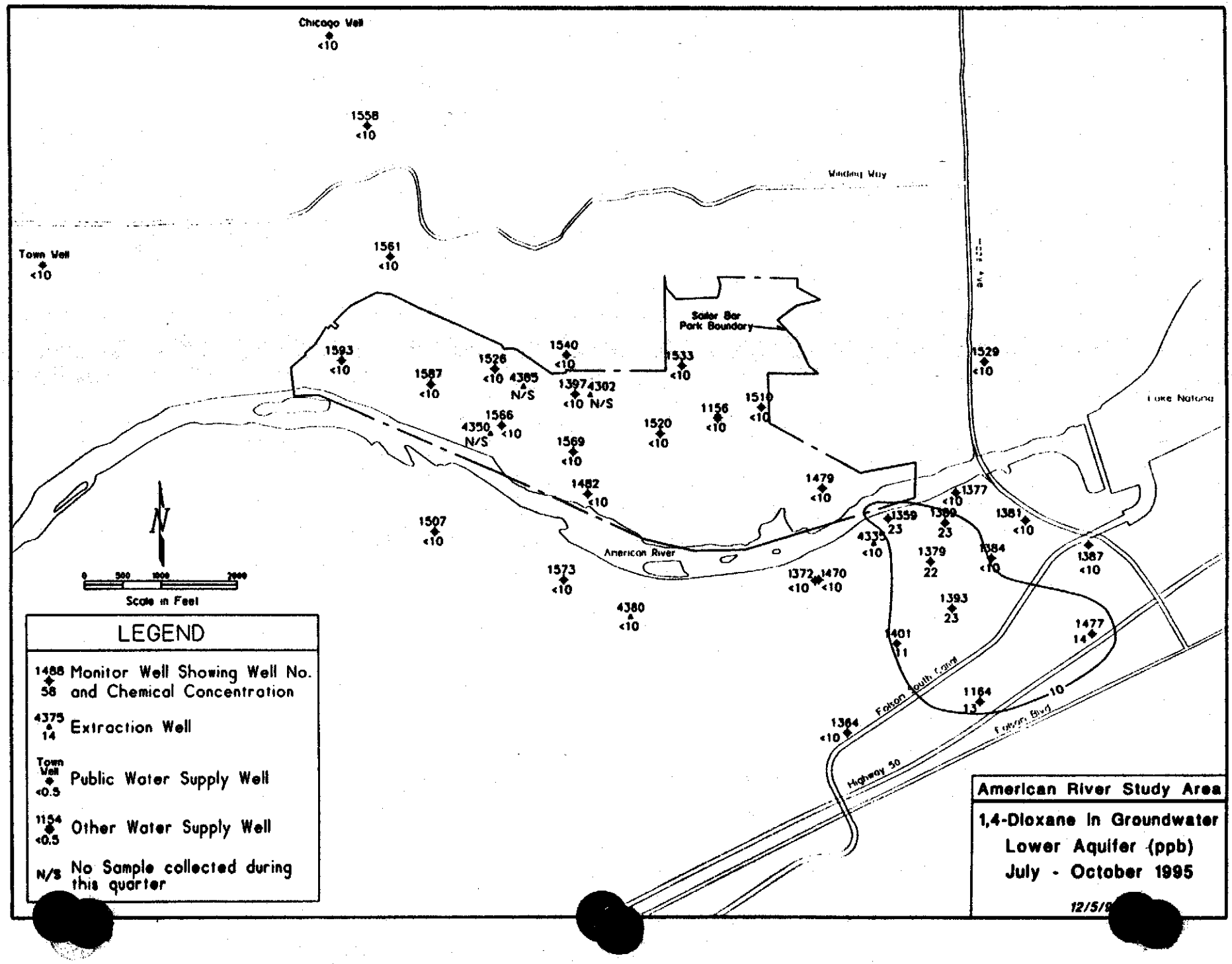
<10
4301
N/S
1532
<10
1509
<10
1565
<10
4345
N/S
1523
<10
1519
<10
1568
<10
1570
<10
1562
<10
1583
<10
Lake Natoma
1154
<10
1376
16
1358
25
1388
23
1380
16
4330
14
1404-5
29/15
1382-3
13/24
1385-6
<10/<10
American River
1572
<10
1574
<10
1371
<10
1470
<10
1392
16
10
1211
<10
1214
13
1400
11
4375
<10
1488
<10
1476
<10
1163
<10
1382-3
<10
Folsom South Canal
Folsom Blvd
Highway 50
1169
<10
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
1,4-Dioxane in Groundwater
Middle Aquifer (ppb)
July - October 1995
12/5/95


Chicago Well
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1558
<10
Winding Way
Town Well
<10
1561
<10
Sailor Bar
Park Boundary
1593
<10
1587
<10
1526
<10
4385
N/S
1540
<10
1397
<10
4302
N/S
1533
<10
1566
4350
N/S
<10
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1156
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Lake Natoma
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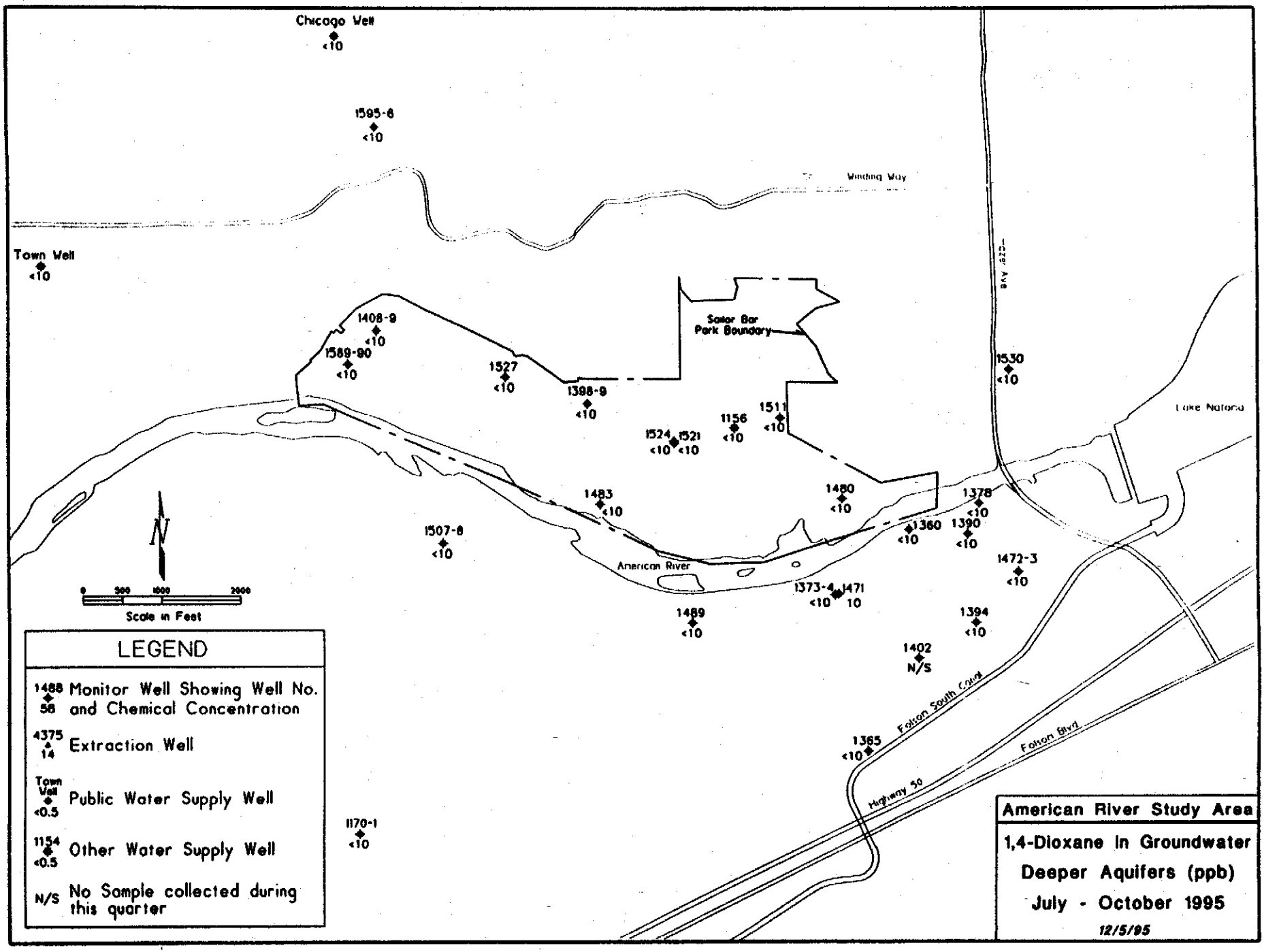
23
1390
23
1381
<10
1507
<10
American River
4335
<10
1379
22
1384
<10
1387
<10
1573
<10
1372
<10
1470
<10
4380
<10
1393
23
1401
11
1477
14
1164
13
10
1364
<10
Folsom South Canal
Folsom Blvd
Highway 50
0 500 1000 2000
Scale in Feet
N
LEGEND
1488 / 58 Monitor Well Showing Well No. and Chemical Concentration
4375 / 14 Extraction Well
Town Well / <0.5 Public Water Supply Well
1154 / <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
1,4-Dioxane In Groundwater
Lower Aquifer (ppb)
July - October 1995
12/5/9


Chicago Well
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1595-6
<10
Winding Way
Town Well
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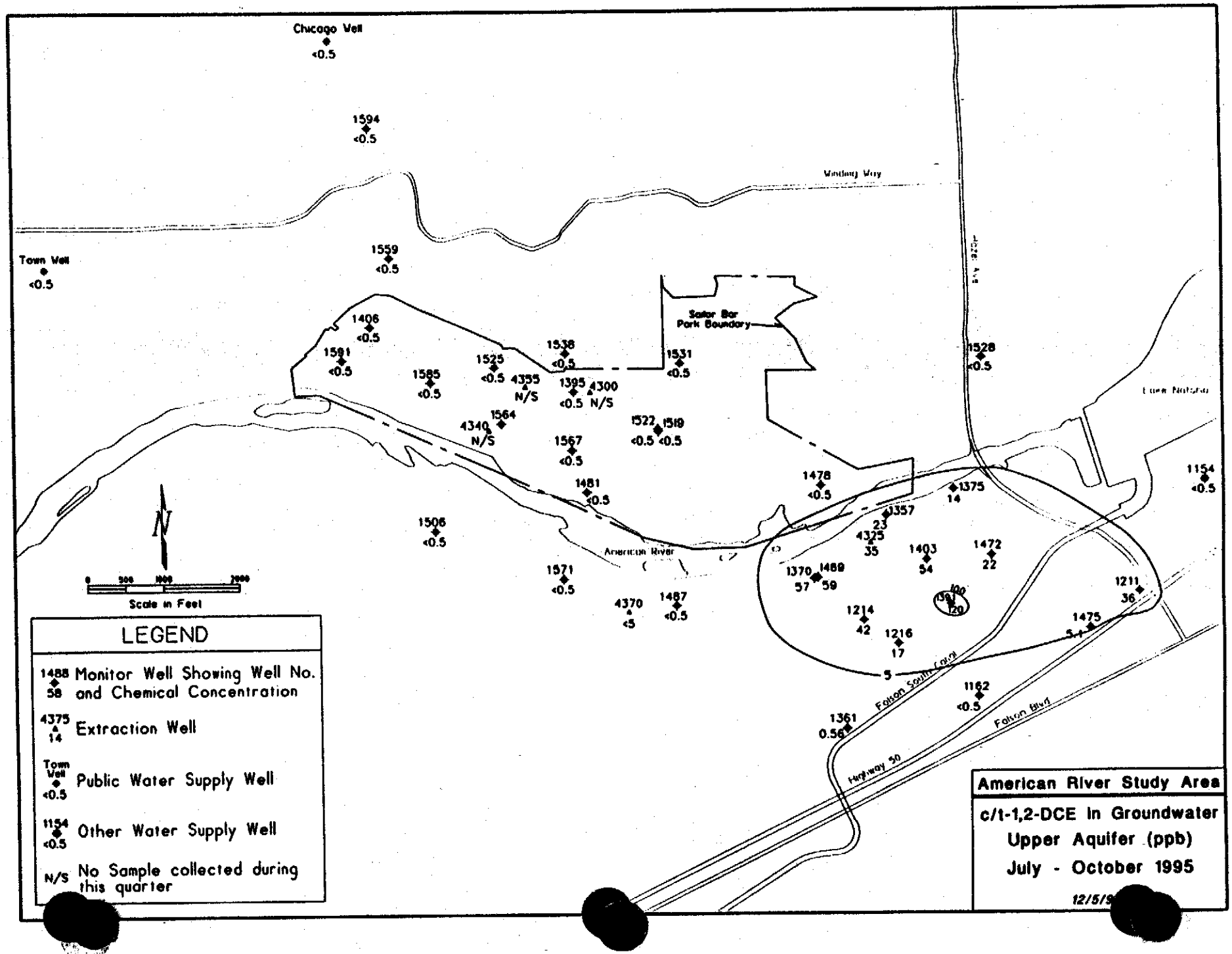
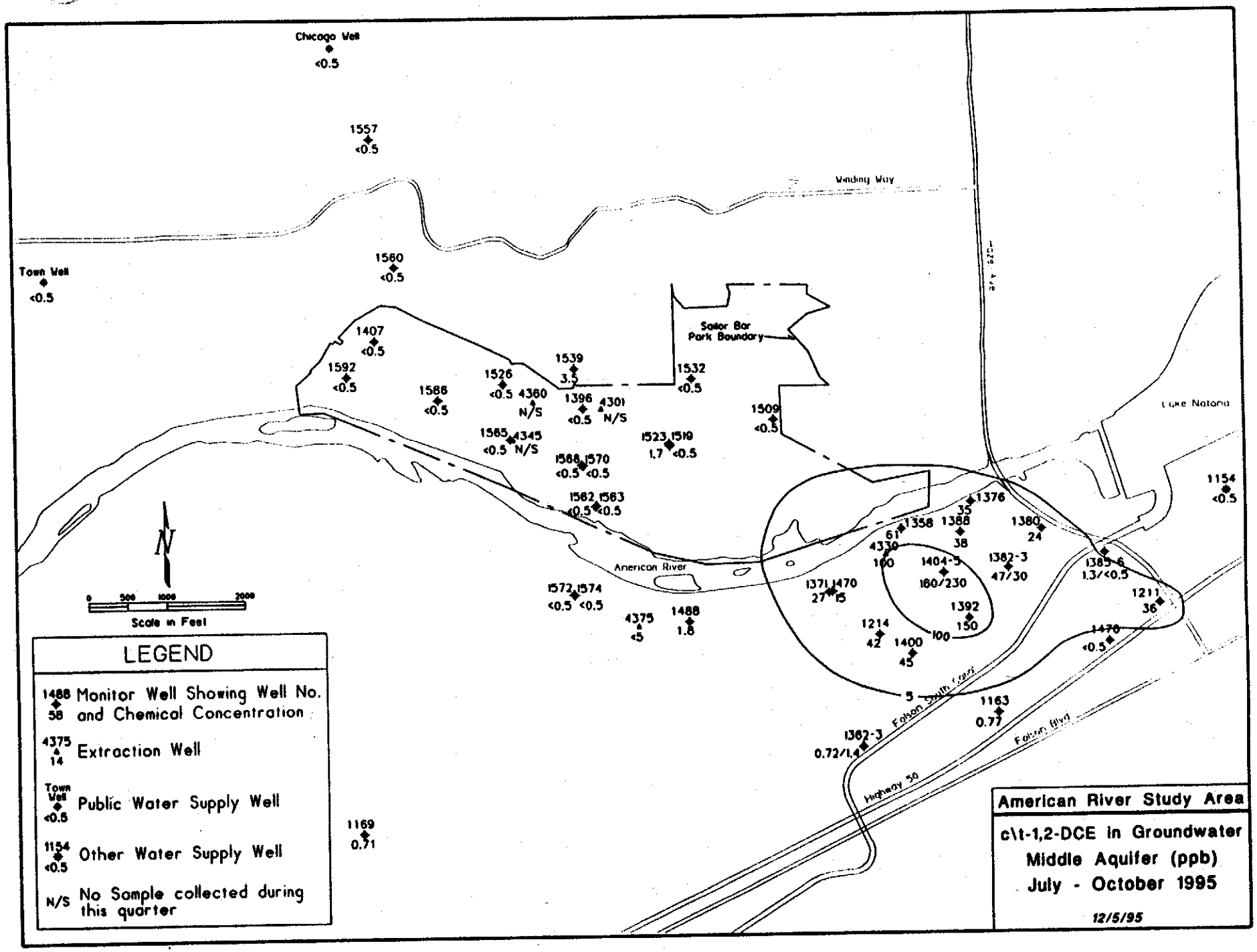
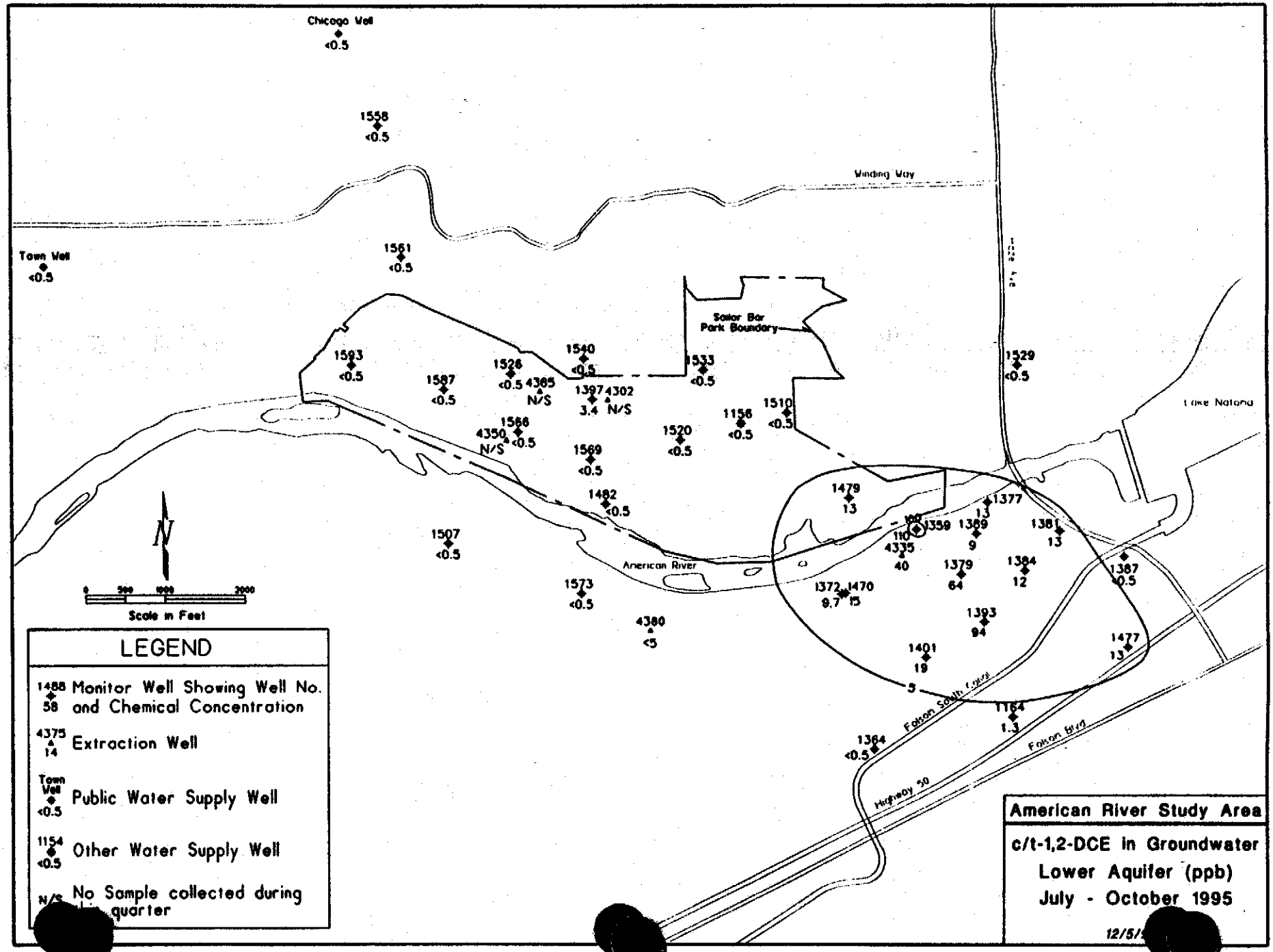
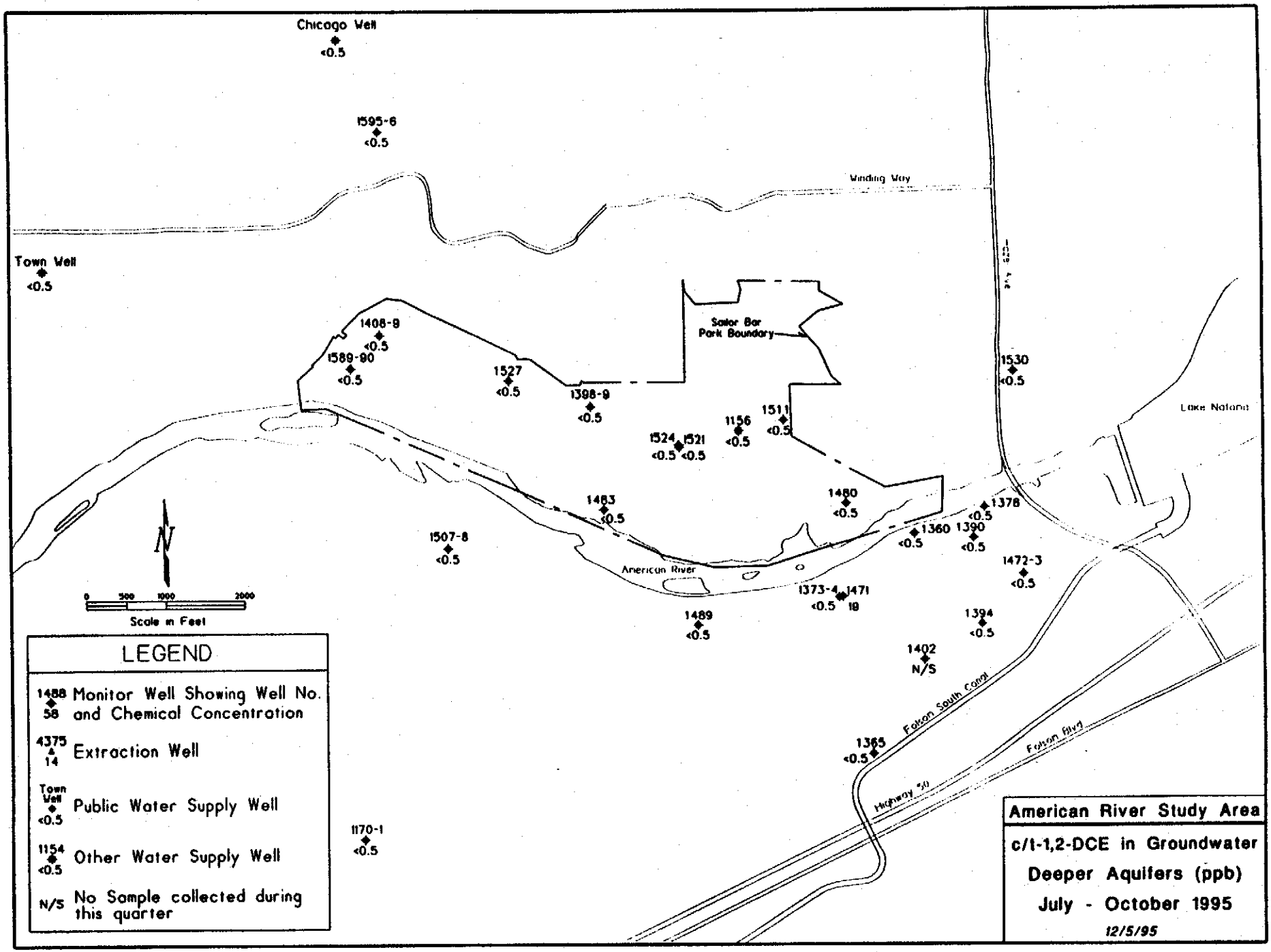
1408-9
<10
1589-90
<10
1527
<10
1388-9
<10
Solar Bar
Park Boundary
1530
<10
Lake Natoma
1511
<10
1156
<10
1524
<10
1521
<10
1483
<10
1480
<10
1378
<10
1360
<10
1390
<10
1507-8
<10
American River
1472-3
<10
1373-4
<10
1471
10
1489
<10
1394
<10
1402
N/S
1365
<10
Folsom South Canal
Folsom Blvd
Highway 50
1170-1
<10
N
0 500 1000 2000
Scale in Feet
LEGEND
1488 56 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
1,4-Dioxane in Groundwater
Deeper Aquifers (ppb)
July - October 1995
12/5/95


Chicago Well
<0.5
1594
<0.5
Town Well
<0.5
1559
<0.5
1406
<0.5
1591
<0.5
1585
<0.5
1525
<0.5
4355
N/S
1538
<0.5
1395
<0.5
4300
N/S
1531
<0.5
Sailor Bar
Park Boundary
1528
<0.5
1564
4340
N/S
1567
<0.5
1522
<0.5
1519
<0.5
1481
<0.5
1506
<0.5
1478
<0.5
1375
14
1357
23
4325
35
1403
54
1472
22
1154
<0.5
1370
57
1489
59
1571
<0.5
4370
<5
1487
<0.5
1214
42
1216
17
1211
36
1475
5.1
5
1162
<0.5
1361
0.56
American River
Folsom South Canal
Folsom Blvd
Highway 50
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
c/t-1,2-DCE In Groundwater
Upper Aquifer (ppb)
July - October 1995
12/5/9


Chicago Well
<0.5
1557
<0.5
Winding Way
Town Well
<0.5
1560
<0.5
1407
<0.5
1592
<0.5
1586
<0.5
1526
<0.5
4360
N/S
1539
3.5
1396
<0.5
4301
N/S
1532
<0.5
Sailor Bar
Park Boundary
1509
<0.5
1565
<0.5
4345
N/S
1523
1.7
1519
<0.5
1568
<0.5
1570
<0.5
1562
<0.5
1563
<0.5
Lake Natoma
1154
<0.5
1376
35
1358
61
1388
38
1380
24
4330
160
1404-5
160/230
1382-3
47/30
1385-6
1.3/<0.5
1371
27
1470
15
1392
150
100
1211
36
1214
42
1400
45
1470
<0.5
5
1163
0.77
1382-3
0.72/1.4
American River
1572
<0.5
1574
<0.5
4375
<5
1488
1.8
1169
0.71
Folsom South Canal
Folsom Blvd
Highway 50
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
c\t-1,2-DCE in Groundwater
Middle Aquifer (ppb)
July - October 1995
12/5/95


Chicago Well
<0.5
1558
<0.5
Winding Way
Town Well
<0.5
1561
<0.5
Solar Bar
Park Boundary
1593
<0.5
1587
<0.5
1528
<0.5
4365
N/S
1540
<0.5
1397
3.4
4302
N/S
1533
<0.5
1529
<0.5
Lake Natoma
1566
4350
N/S
<0.5
1569
<0.5
1520
<0.5
1156
<0.5
1510
<0.5
1479
13
1377
13
1359
1389
9
1381
13
110
4335
40
1379
64
1384
12
1387
<0.5
1372
9.7
1470
15
1393
94
1477
13
1401
19
1482
<0.5
1507
<0.5
American River
1573
<0.5
4380
<5
1164
1.3
1364
<0.5
Folsom South Canal
Folsom Blvd
Highway 50
N
0 500 1000 2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during quarter
American River Study Area
c/t-1,2-DCE in Groundwater
Lower Aquifer (ppb)
July - October 1995
12/5/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Winding Way
Town Well
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1408-9
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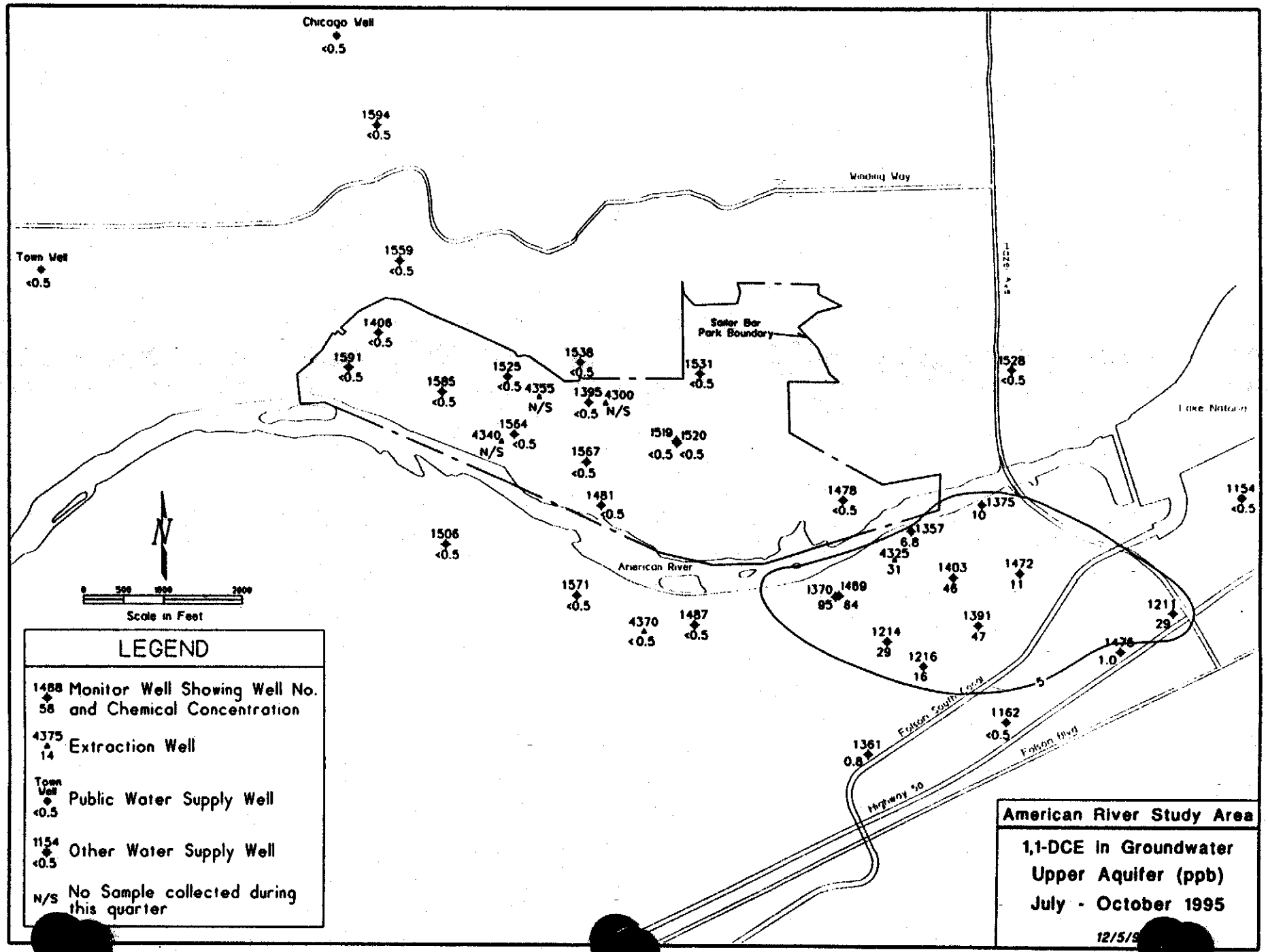
1527
<0.5
1398-9
<0.5
Sailor Bar
Park Boundary
1530
<0.5
Lake Natoma
1511
<0.5
1156
<0.5
1524 1521
<0.5 <0.5
1483
<0.5
1480
<0.5
1378
<0.5
1360
<0.5
1390
<0.5
1507-8
<0.5
American River
1472-3
<0.5
1373-4 1471
<0.5 18
1489
<0.5
1394
<0.5
1402
N/S
1365
<0.5
Folsom South Canal
Folsom Blvd
Highway 50
1170-1
<0.5
N
0 500 1000 2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
c/t-1,2-DCE in Groundwater
Deeper Aquifers (ppb)
July - October 1995
12/5/95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Town Well
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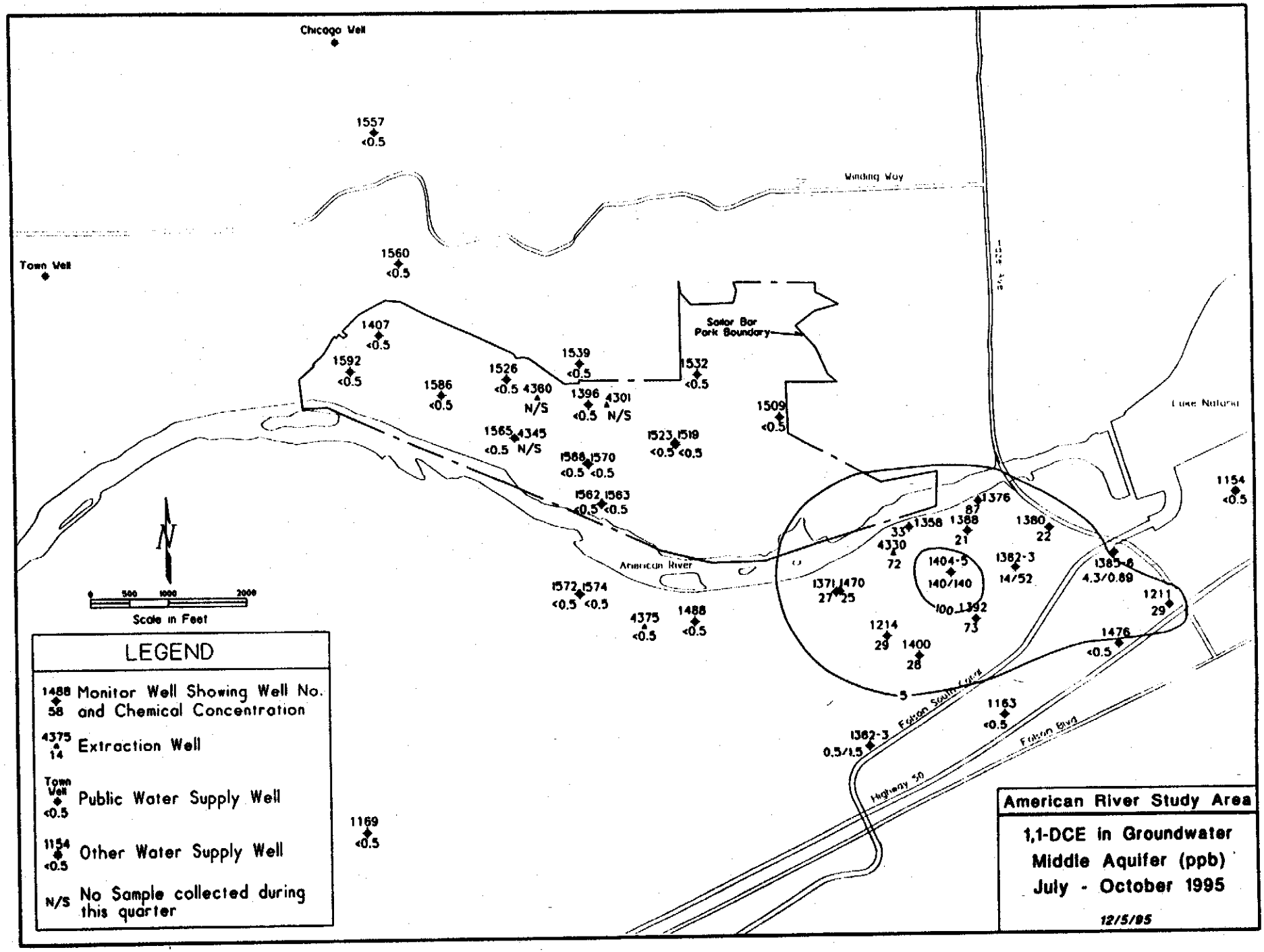
<0.5
1525
<0.5
4355
N/S
1538
<0.5
1395
<0.5
4300
N/S
1531
<0.5
Sater Bar
Park Boundary
1528
<0.5
Lake Natoma
4340
N/S
1564
<0.5
1519
<0.5
1520
<0.5
1567
<0.5
1481
<0.5
1478
<0.5
1375
10
1154
<0.5
1506
<0.5
1357
6.8
4325
31
1403
46
1472
11
American River
1571
<0.5
1370
95
1469
84
1391
47
1211
29
4370
<0.5
1487
<0.5
1214
29
1216
16
1476
1.0
5
1162
<0.5
1361
0.8
Folsom South Canal
Folsom Blvd
Highway 50
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
1,1-DCE in Groundwater
Upper Aquifer (ppb)
July - October 1995
12/5/9


Chicago Well
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Winding Way
Town Well
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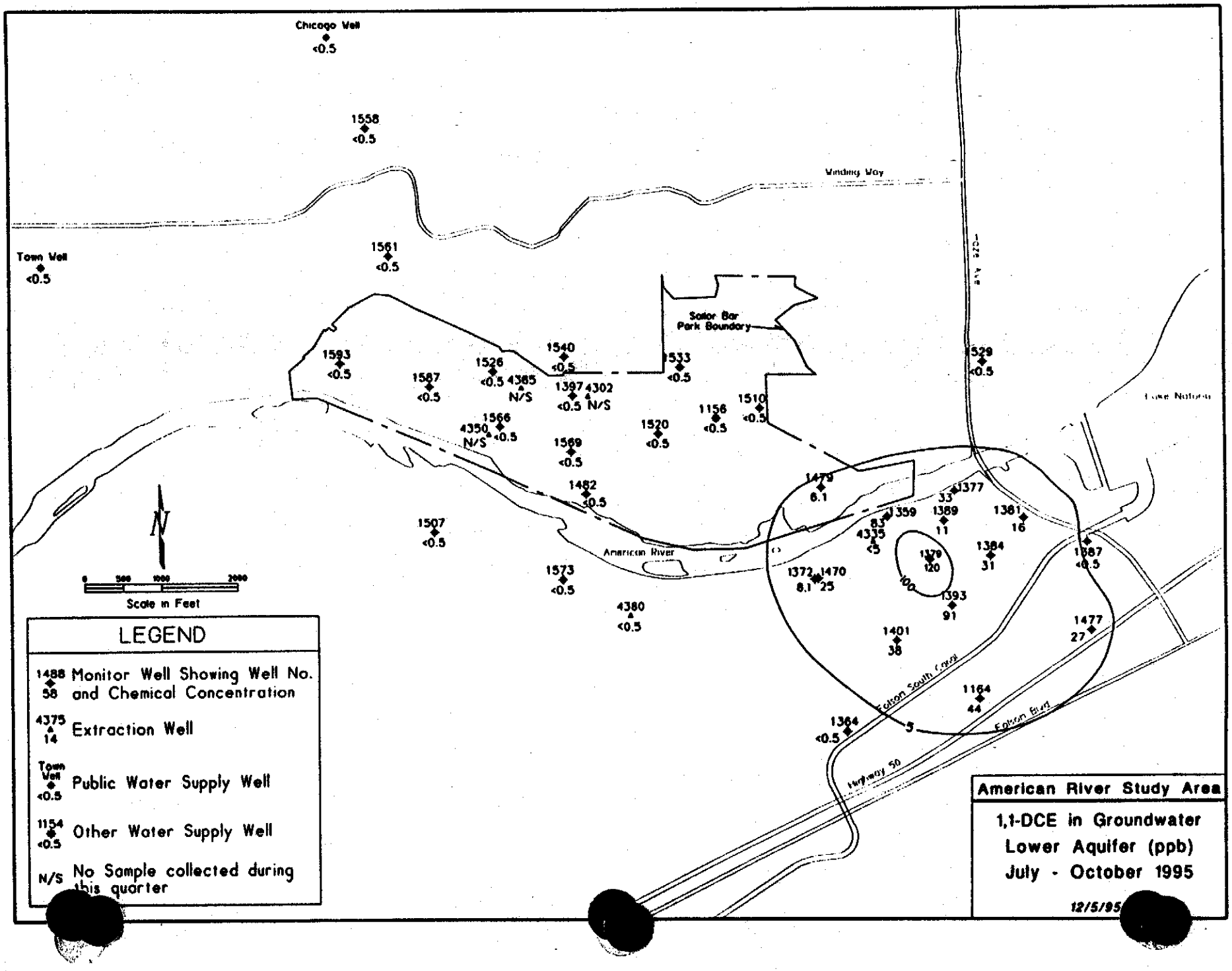
1592 <0.5
1586 <0.5
1526 <0.5
4360 N/S
1539 <0.5
1396 <0.5
4301 N/S
1532 <0.5
Sailor Bar Park Boundary
1509 <0.5
1565 <0.5
4345 N/S
1523 <0.5
1519 <0.5
1568 <0.5
1570 <0.5
1562 <0.5
1563 <0.5
American River
1572 <0.5
1574 <0.5
4375 <0.5
1488 <0.5
1169 <0.5
1154 <0.5
1376 87
1358 33
1388 21
1380 22
4330 72
1404-5 140/140
1382-3 14/52
1385-6 4.3/0.89
1371 27
1470 25
100
1392 73
1214 29
1400 28
1211 29
1476 <0.5
5
1163 <0.5
1382-3 0.5/1.5
Folsom South Canal
Folsom Blvd
Highway 50
N
0 500 1000 2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
1,1-DCE in Groundwater
Middle Aquifer (ppb)
July - October 1995
12/5/95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Winding Way
Town Well
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1561
<0.5
Sailor Bar
Park Boundary
1593
<0.5
1587
<0.5
1526
<0.5
4385
N/S
1540
<0.5
1397
<0.5
4302
N/S
1533
<0.5
1529
<0.5
1156
<0.5
1510
<0.5
1566
4350
N/S
<0.5
1520
<0.5
1569
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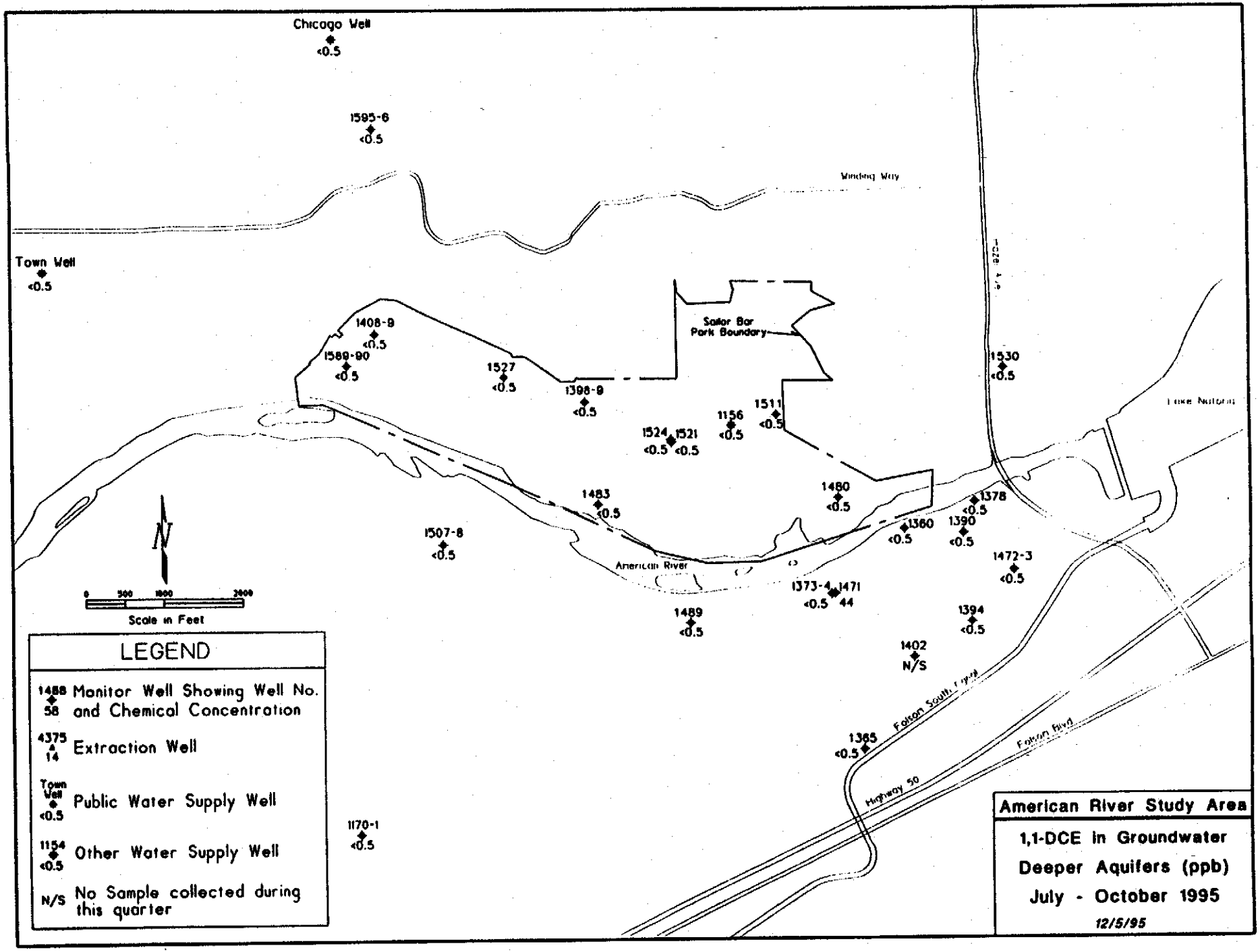
1482
<0.5
1479
6.1
1377
33
1359
1389
11
1381
16
83
4335
<5
1384
31
1379
120
1587
<0.5
1372
8.1
1470
25
100
1393
91
1507
<0.5
American River
1573
<0.5
4380
<0.5
1401
38
1477
27
Folsom South Canal
1164
44
Folsom Blvd
1364
<0.5
5
Highway 50
N
0 500 1000 2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
1,1-DCE in Groundwater
Lower Aquifer (ppb)
July - October 1995
12/5/95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Winding Way
Town Well
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<0.5
1398-9
<0.5
Sailor Bar
Park Boundary
1530
<0.5
Lake Natoma
1524
<0.5
1521
<0.5
1156
<0.5
1511
<0.5
1483
<0.5
1480
<0.5
1378
<0.5
1360
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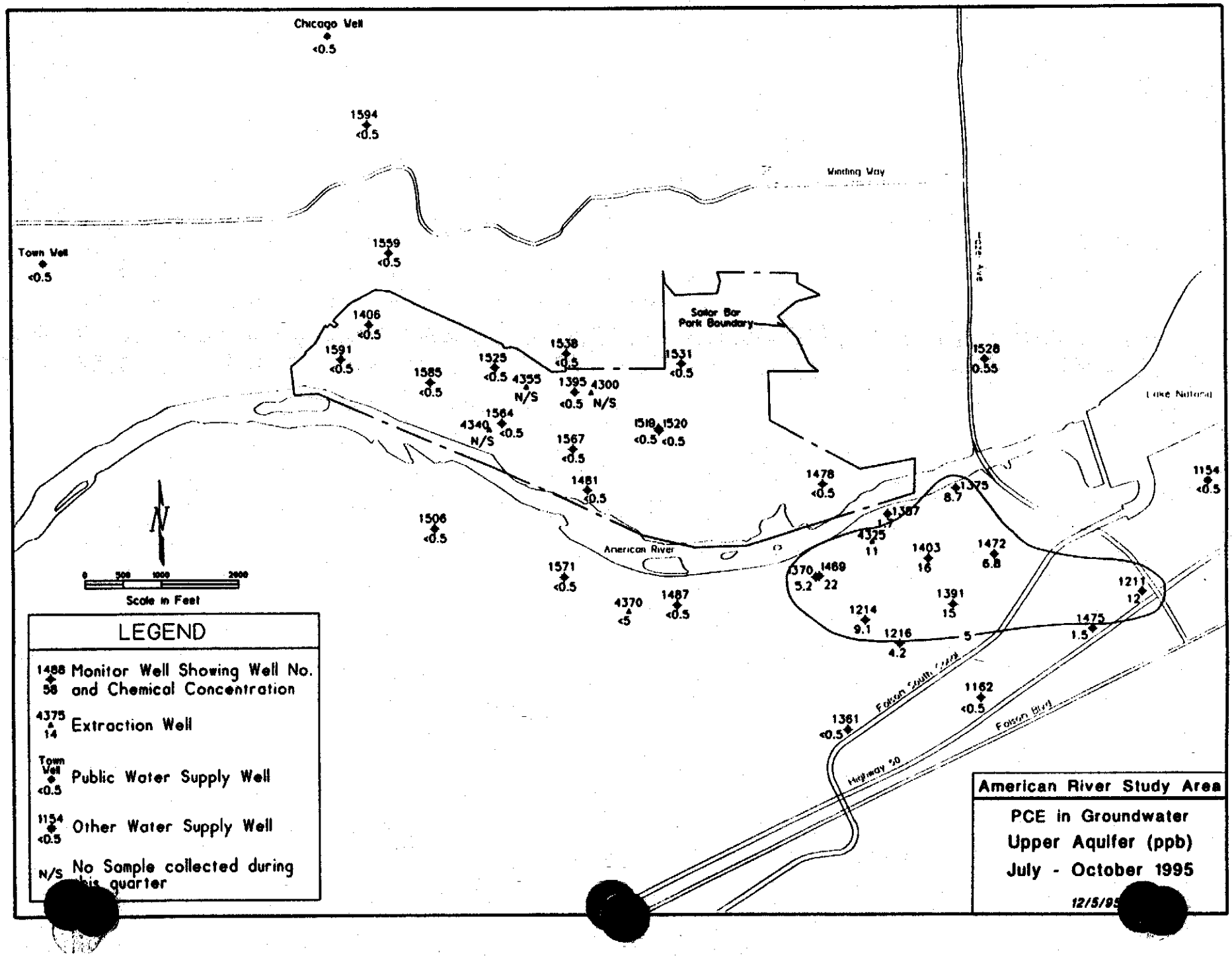
1390
<0.5
1507-8
<0.5
American River
1472-3
<0.5
1373-4
<0.5
1471
44
1489
<0.5
1394
<0.5
1402
N/S
1365
<0.5
Folsom South Canal
Folsom Blvd
Highway 50
1170-1
<0.5
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
1,1-DCE in Groundwater
Deeper Aquifers (ppb)
July - October 1995
12/5/95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Winding Way
Town Well
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1559
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Sailor Bar
Park Boundary
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<0.5
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<0.5
1585
<0.5
1525
<0.5
4355
N/S
1538
<0.5
1395
<0.5
4300
N/S
1531
<0.5
1564
<0.5
4340
N/S
1518
<0.5
1520
<0.5
1567
<0.5
1481
<0.5
1506
<0.5
American River
1571
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4370
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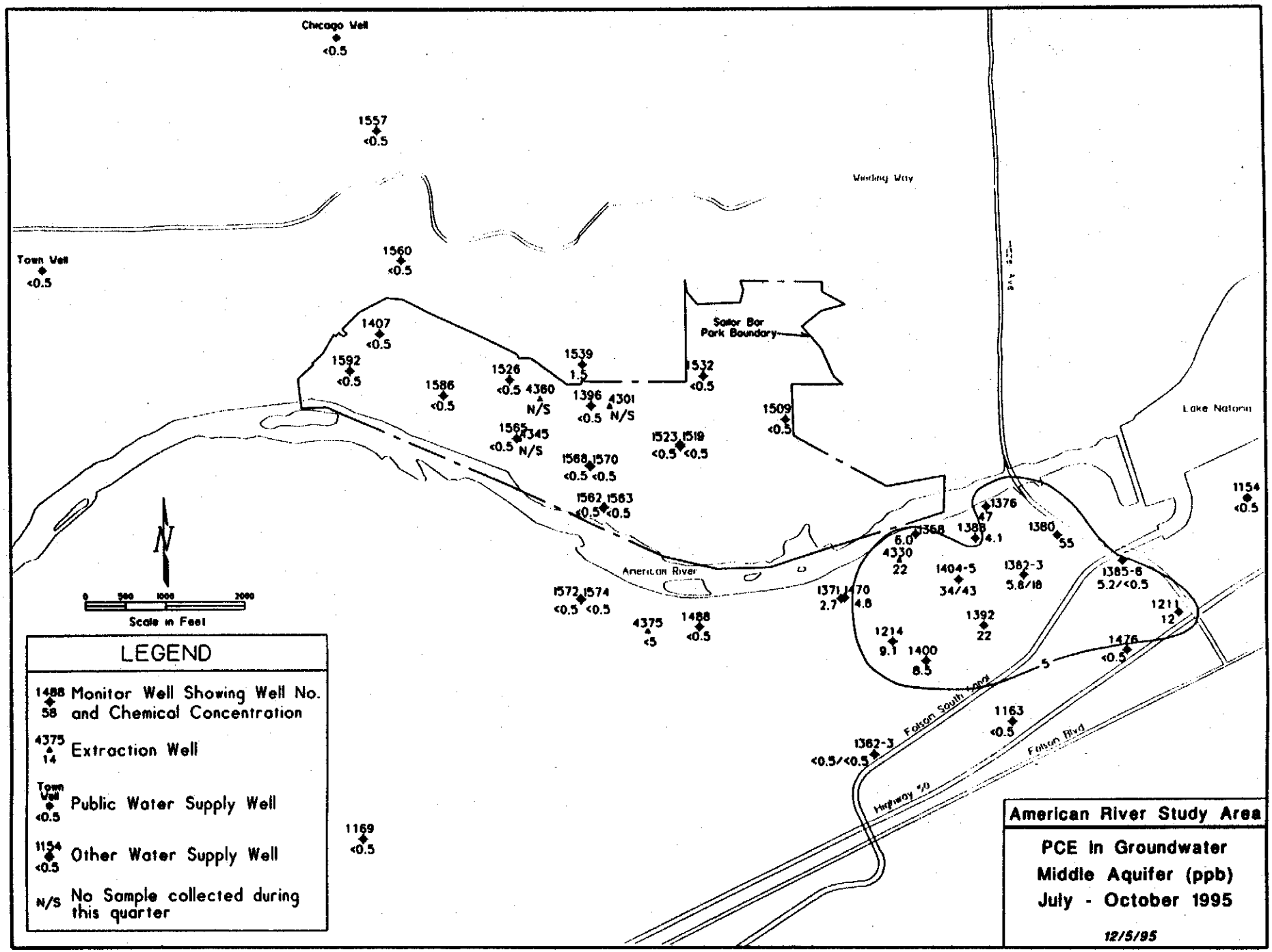
1487
<0.5
1478
<0.5
1375
8.7
1387
1.7
4325
11
1403
16
1472
6.8
1370
5.2
1469
22
1391
15
1214
9.1
1216
4.2
5
1211
12
1475
1.5
1528
0.55
Lake Natoma
1154
<0.5
1162
<0.5
1361
<0.5
Folsom South Canal
Folsom Blvd
Highway 50
N
0 500 1000 2000
Scale in Feet
LEGEND
1488 / 58 Monitor Well Showing Well No. and Chemical Concentration
4375 / 14 Extraction Well
Town Well / <0.5 Public Water Supply Well
1154 / <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
PCE in Groundwater
Upper Aquifer (ppb)
July - October 1995
12/5/95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Winding Way
Town Well
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1560
<0.5
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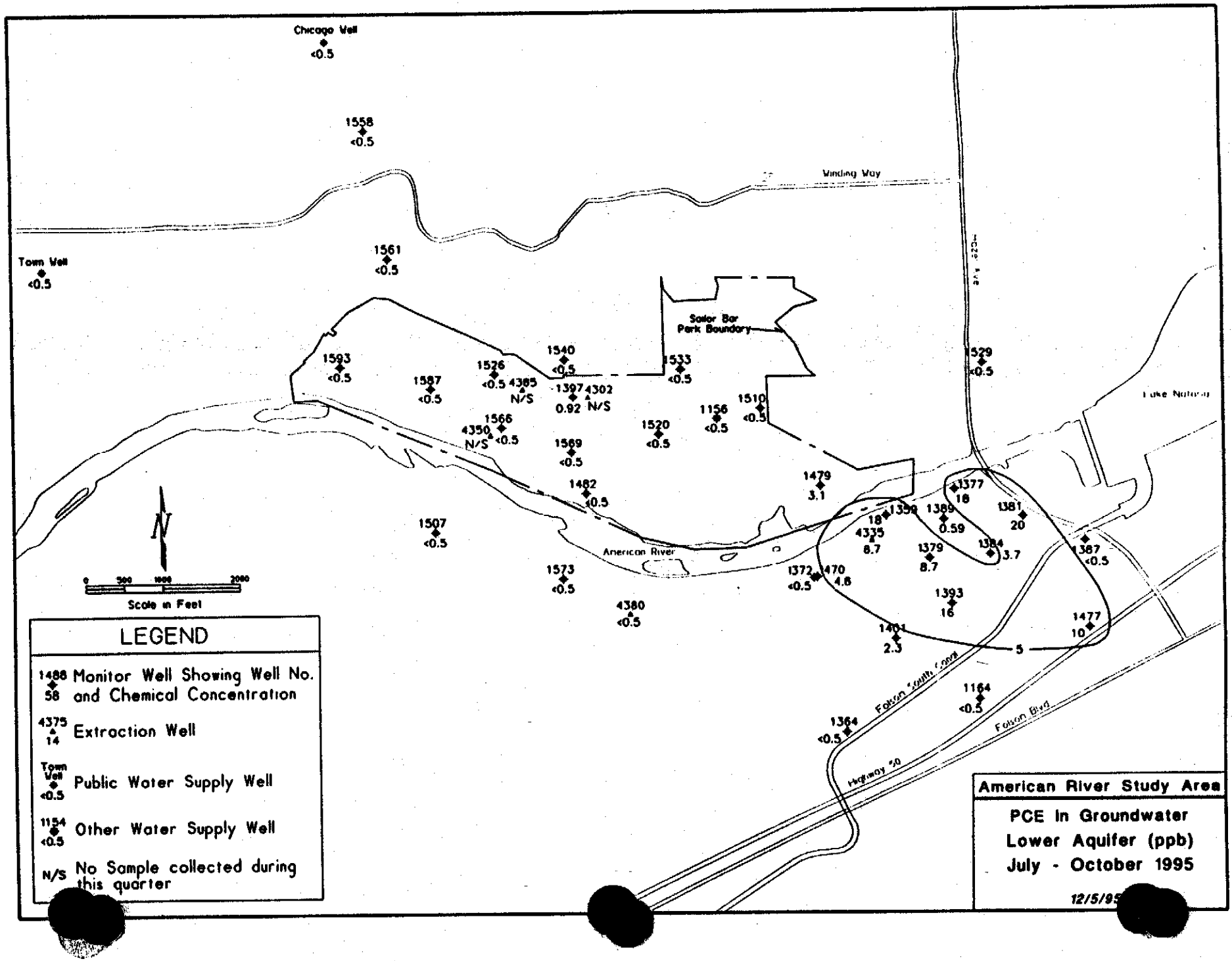
1526
<0.5
4360
N/S
1539
1.5
1396
<0.5
4301
N/S
1532
<0.5
Sailor Bar
Park Boundary
1509
<0.5
1565
<0.5
4345
N/S
1523
<0.5
1519
<0.5
1568
<0.5
1570
<0.5
1562
<0.5
1563
<0.5
Lake Natoma
1154
<0.5
1376
47
1368
6.0
4330
22
1388
4.1
1380
55
1404-5
34/43
1382-3
5.8/18
1385-6
5.2/<0.5
1211
12
1392
22
1214
9.1
1400
8.5
1476
<0.5
5
American River
1572
<0.5
1574
<0.5
4375
<5
1488
<0.5
1371
2.7
1470
4.8
1163
<0.5
1382-3
<0.5/<0.5
Folsom South Canal
Folsom Blvd
Highway 50
1169
<0.5
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 / 58 Monitor Well Showing Well No. and Chemical Concentration
4375 / 14 Extraction Well
Town Well / <0.5 Public Water Supply Well
1154 / <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
PCE in Groundwater
Middle Aquifer (ppb)
July - October 1995
12/5/95


Chicago Well
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<0.5
Winding Way
Town Well
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1561
<0.5
Sailor Bar
Park Boundary
1593
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1587
<0.5
1526
<0.5
4385
N/S
1540
<0.5
1397
0.92
4302
N/S
1533
<0.5
1566
4350
N/S
<0.5
1569
<0.5
1520
<0.5
1156
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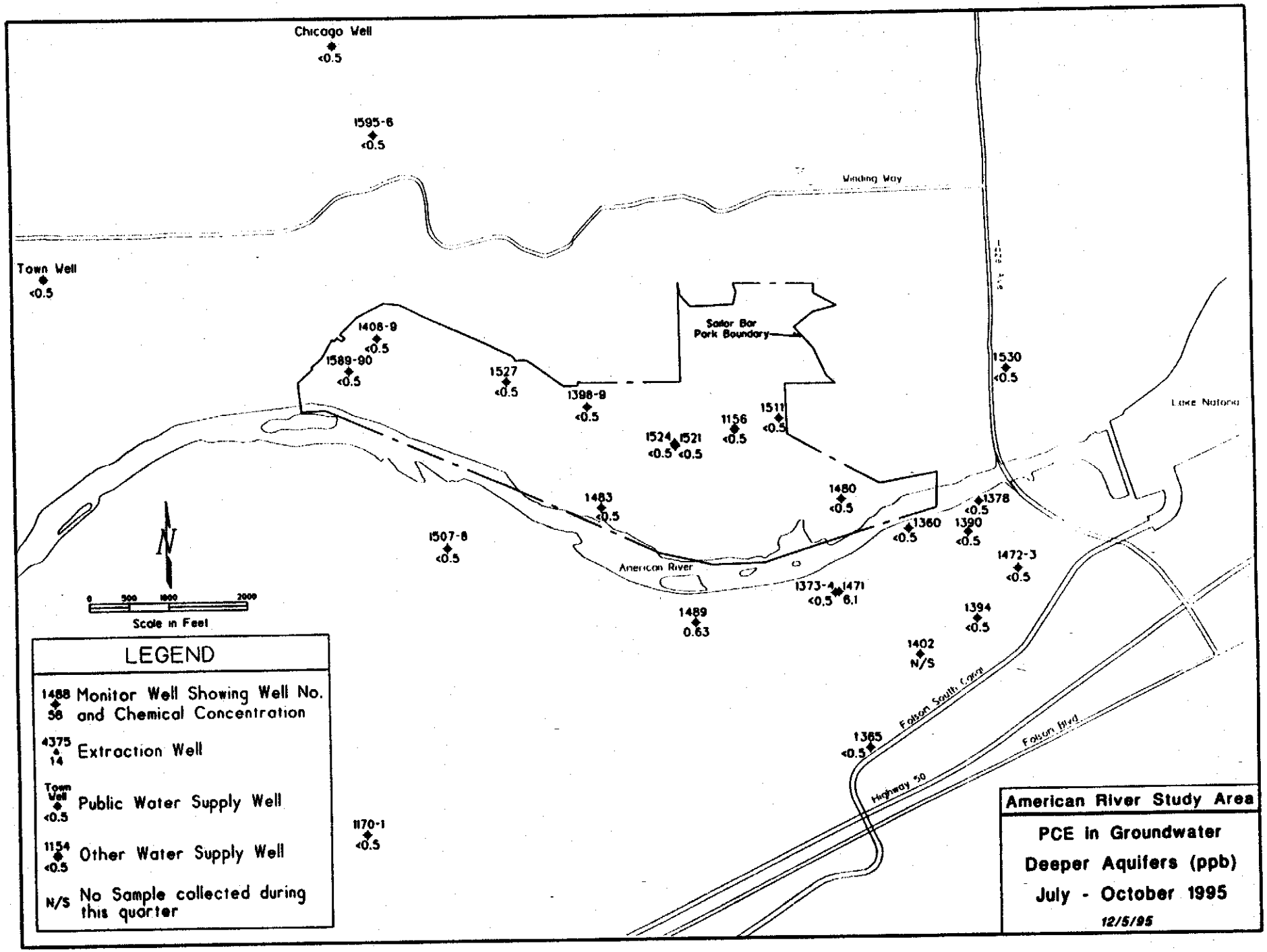
1510
<0.5
1529
<0.5
Lake Natoma
1479
3.1
1482
<0.5
1507
<0.5
American River
1573
<0.5
4380
<0.5
1377
18
1359
18
1389
0.59
1381
20
4335
8.7
1379
8.7
1384
3.7
1387
<0.5
1372
<0.5
1470
4.8
1393
16
1477
10
1401
2.3
5
1164
<0.5
1364
<0.5
Folsom South Canal
Folsom Blvd
Highway 50
N
0
500
1000
2000
Scale in Feet
LEGEND
1486 / 58 Monitor Well Showing Well No. and Chemical Concentration
4375 / 14 Extraction Well
Town Well / <0.5 Public Water Supply Well
1154 / <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
PCE In Groundwater
Lower Aquifer (ppb)
July - October 1995
12/5/95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Winding Way
Town Well
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Sailor Bar
Park Boundary
1408-9
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1589-90
<0.5
1527
<0.5
1398-9
<0.5
1524
<0.5
1521
<0.5
1156
<0.5
1511
<0.5
1530
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Lake Natoma
1483
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1480
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1378
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1390
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1507-8
<0.5
American River
1472-3
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1373-4
<0.5
1471
6.1
1489
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1394
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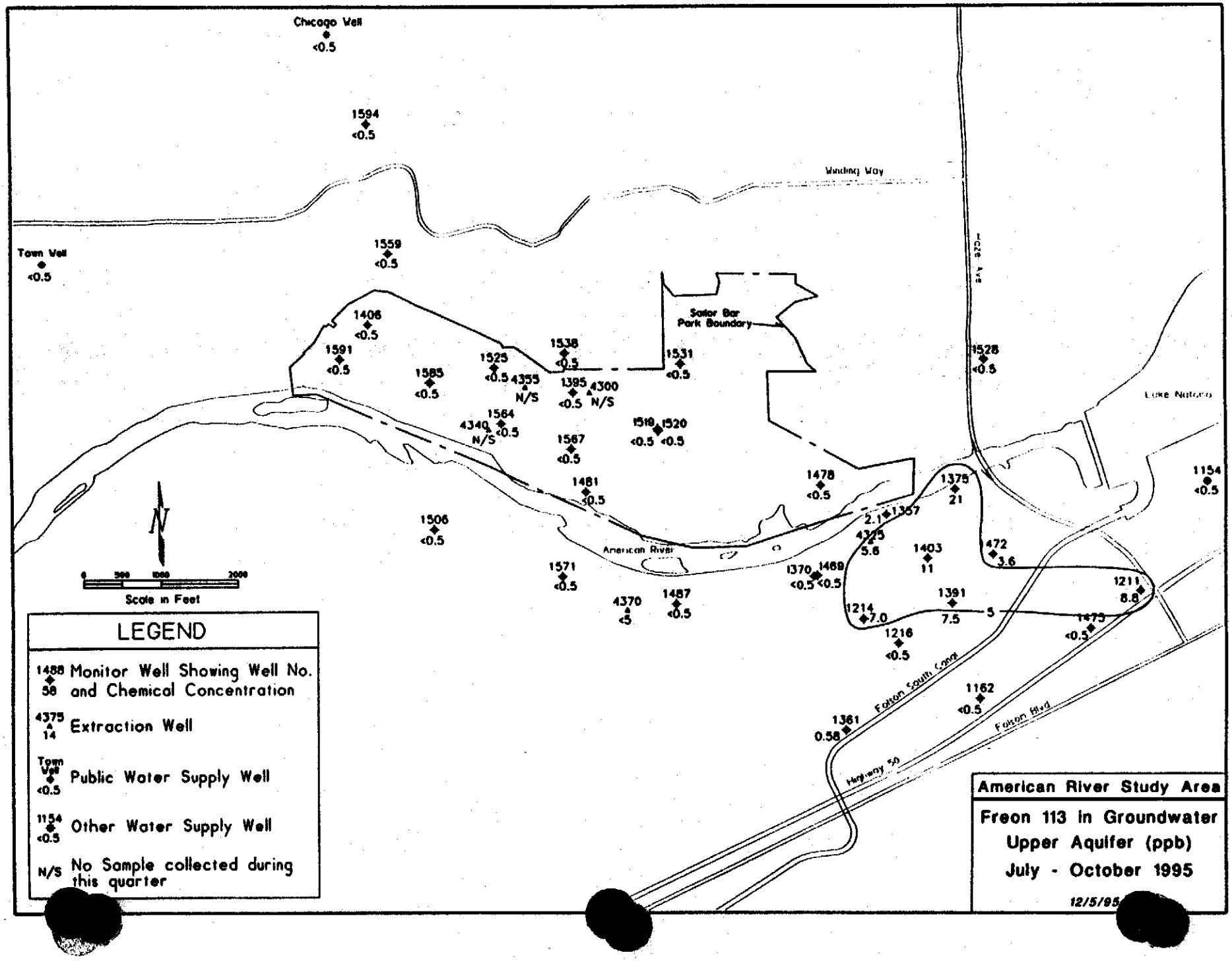
1402
N/S
Folsom South Canal
Folsom Blvd
1365
<0.5
Highway 50
1170-1
<0.5
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
PCE in Groundwater
Deeper Aquifers (ppb)
July - October 1995
12/5/95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Walnut Way
Town Well
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1591
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1585
<0.5
1525
<0.5
4355
N/S
1538
<0.5
1395
<0.5
4300
N/S
Sailor Bar
Park Boundary
1531
<0.5
1528
<0.5
Lake Natoma
1564
4340
N/S
<0.5
1518
1520
<0.5
<0.5
1567
<0.5
1481
<0.5
1478
<0.5
1375
21
1154
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2.1
1357
4375
5.8
1403
11
472
3.6
1506
<0.5
American River
1571
<0.5
1370
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1469
<0.5
1211
8.8
4370
<5
1487
<0.5
1214
7.0
1391
7.5
5
1475
<0.5
1216
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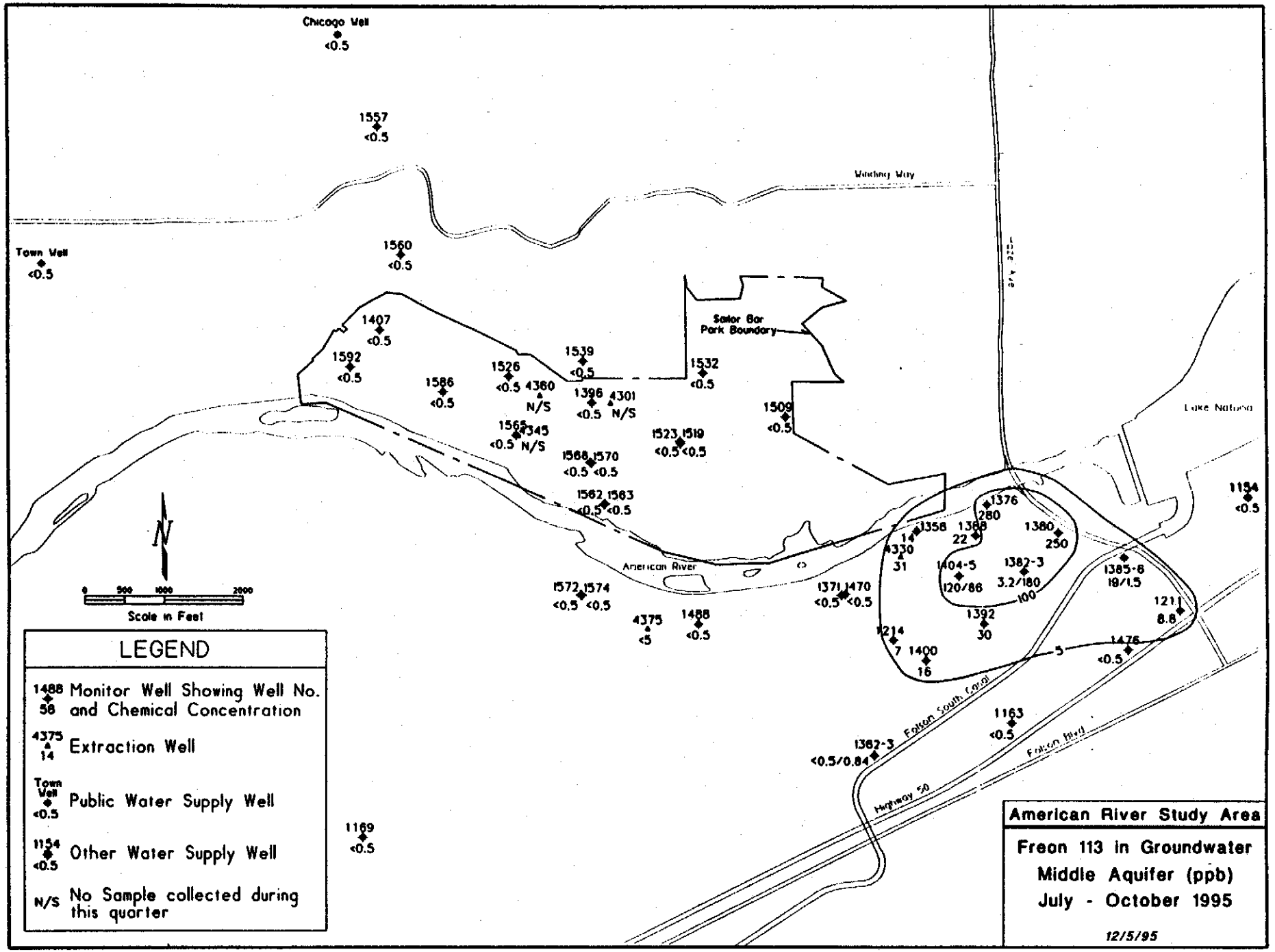
1162
<0.5
1361
0.58
Folsom South Canal
Folsom Blvd
Highway 50
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 / 58 Monitor Well Showing Well No. and Chemical Concentration
4375 / 14 Extraction Well
Town Well / <0.5 Public Water Supply Well
1154 / <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
Freon 113 in Groundwater
Upper Aquifer (ppb)
July - October 1995
12/5/95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Town Well
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Park Boundary
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1592
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1586
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1526
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4360
N/S
1539
<0.5
1396
<0.5
4301
N/S
1532
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1509
<0.5
1565
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4345
N/S
1523
<0.5
1519
<0.5
1568
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1570
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1562
<0.5
1563
<0.5
American River
1572
<0.5
1574
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4375
<5
1488
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1371
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1470
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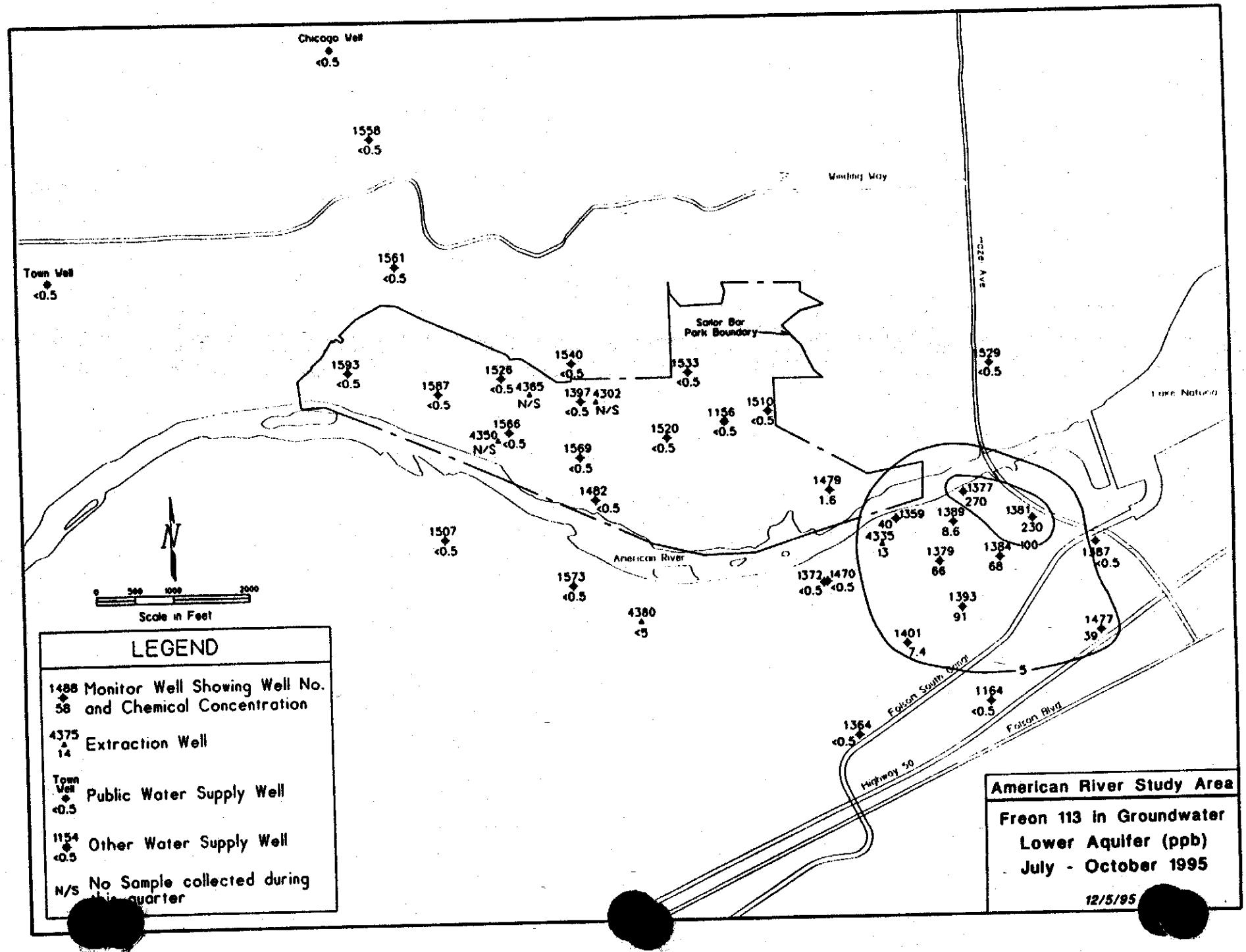
1376
280
1358
14
4330
31
1368
22
1380
250
1404-5
120/86
1382-3
3.2/180
100
1385-6
19/1.5
1392
30
1214
7
1400
16
1476
<0.5
5
1211
8.8
1154
<0.5
1163
<0.5
1382-3
<0.5/0.84
Folsom South Canal
Folsom Blvd
Highway 50
1169
<0.5
Lake Natoma
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 / 58 Monitor Well Showing Well No. and Chemical Concentration
4375 / 14 Extraction Well
Town Well / <0.5 Public Water Supply Well
1154 / <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
Freon 113 in Groundwater
Middle Aquifer (ppb)
July - October 1995
12/5/95


Chicago Well
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Town Well
<0.5
1561
<0.5
Sailor Bar
Park Boundary
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1587
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1526
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4385
N/S
1540
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1397
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4302
N/S
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4350
N/S
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1479
1.6
1377
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1359
40
4335
13
1389
8.6
1381
230
1379
66
1384
100
68
1387
<0.5
1507
<0.5
American River
1573
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1372
<0.5
1470
<0.5
1393
91
4380
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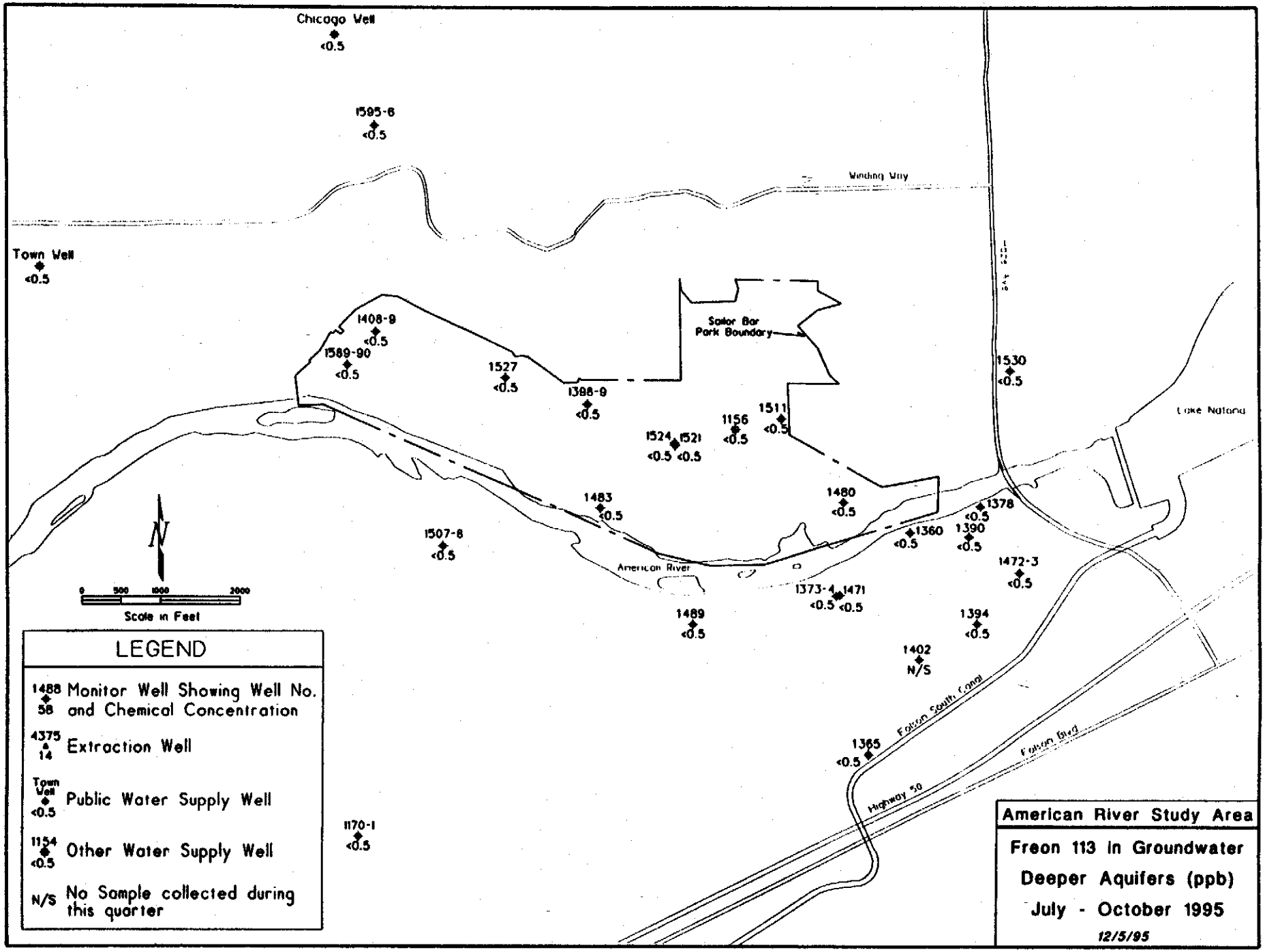
1401
7.4
1477
39
5
1164
<0.5
1364
<0.5
Folsom South Canal
Folsom Blvd
Highway 50
Lake Natoma
N
0
500
1000
2000
Scale in Feet
LEGEND
1488 Monitor Well Showing Well No. and Chemical Concentration
58
4375 Extraction Well
14
Town Well Public Water Supply Well
<0.5
1154 Other Water Supply Well
<0.5
N/S No Sample collected during this quarter
American River Study Area
Freon 113 in Groundwater
Lower Aquifer (ppb)
July - October 1995
12/5/95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Town Well
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1388-9
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Sailor Bar
Park Boundary
1530
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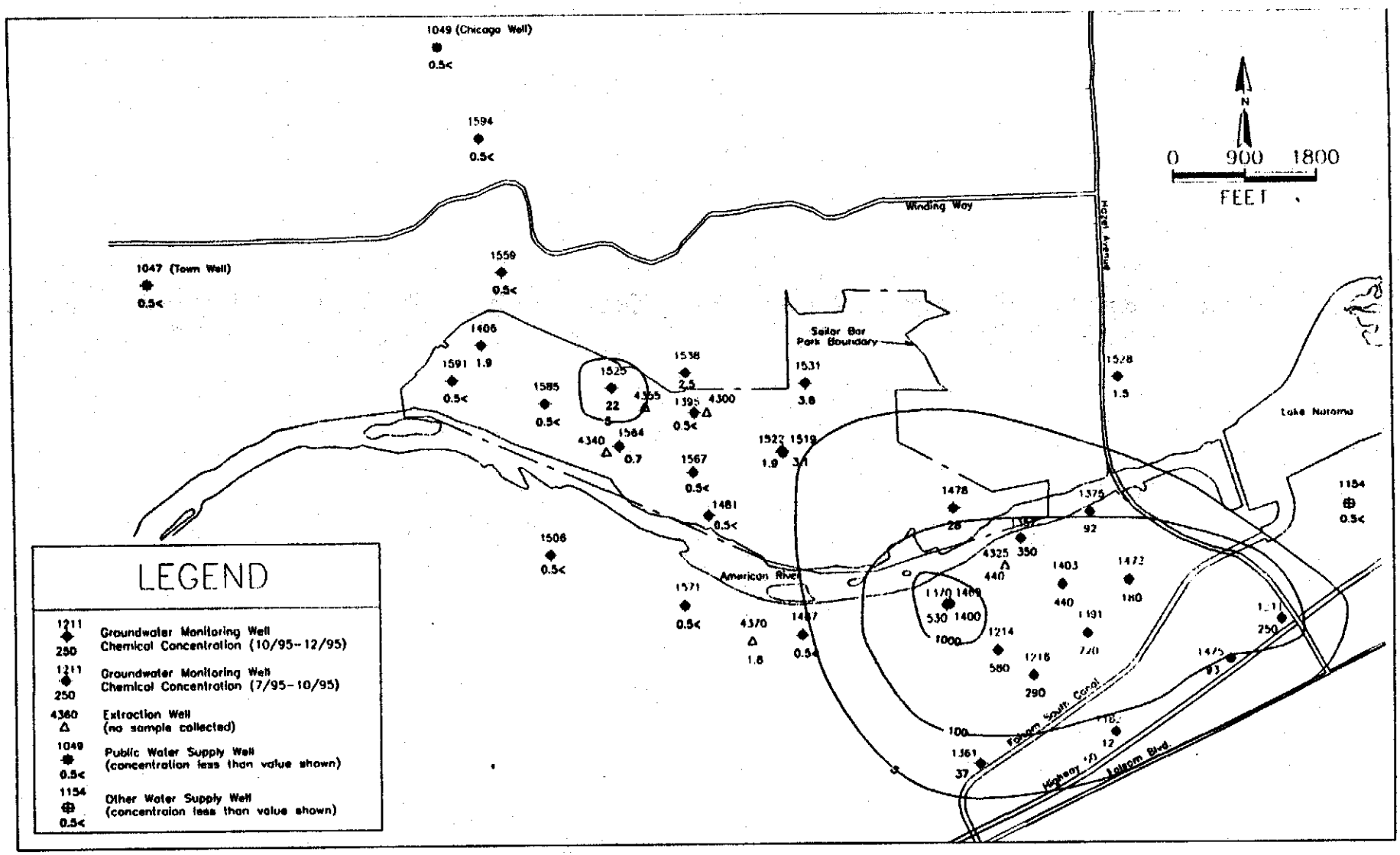
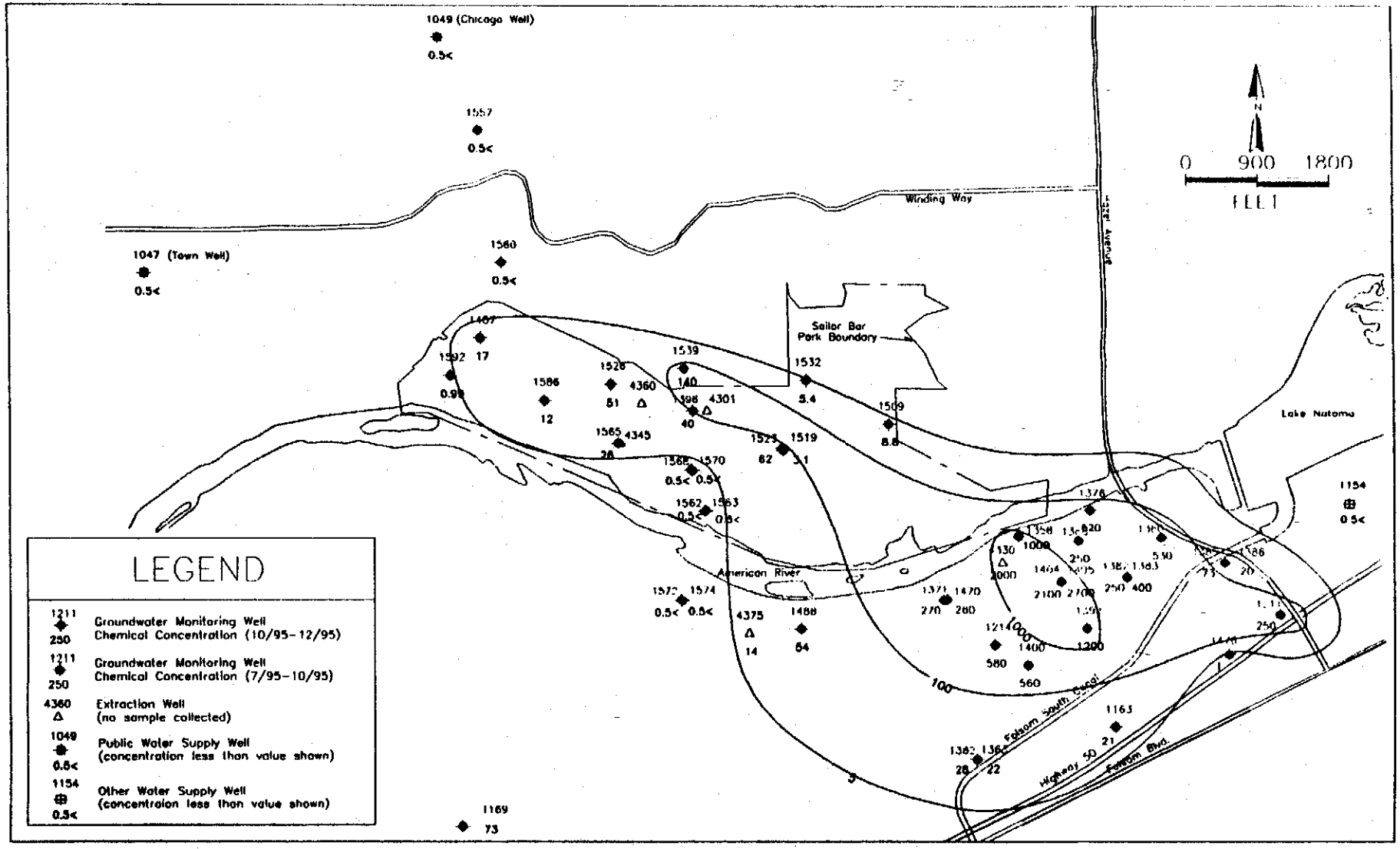
Lake Natoma
1511
<0.5
1156
<0.5
1524
<0.5
1521
<0.5
1483
<0.5
1480
<0.5
1378
<0.5
1360
<0.5
1390
<0.5
1507-8
<0.5
American River
1472-3
<0.5
1373-4
<0.5
1471
<0.5
1489
<0.5
1394
<0.5
1402
N/S
Folsom South Canal
Folsom Blvd
1365
<0.5
Highway 50
1170-1
<0.5
N
0 500 1000 2000
Scale in Feet
LEGEND
1488 58 Monitor Well Showing Well No. and Chemical Concentration
4375 14 Extraction Well
Town Well <0.5 Public Water Supply Well
1154 <0.5 Other Water Supply Well
N/S No Sample collected during this quarter
American River Study Area
Freon 113 in Groundwater
Deeper Aquifers (ppb)
July - October 1995
12/5/95



American River [redacted] Area

TITLE:
TCE Concentrations in PPB
Upper Aquifer Groun[redacted]ter Quality
October to Decembe[redacted]95 Sampling Period

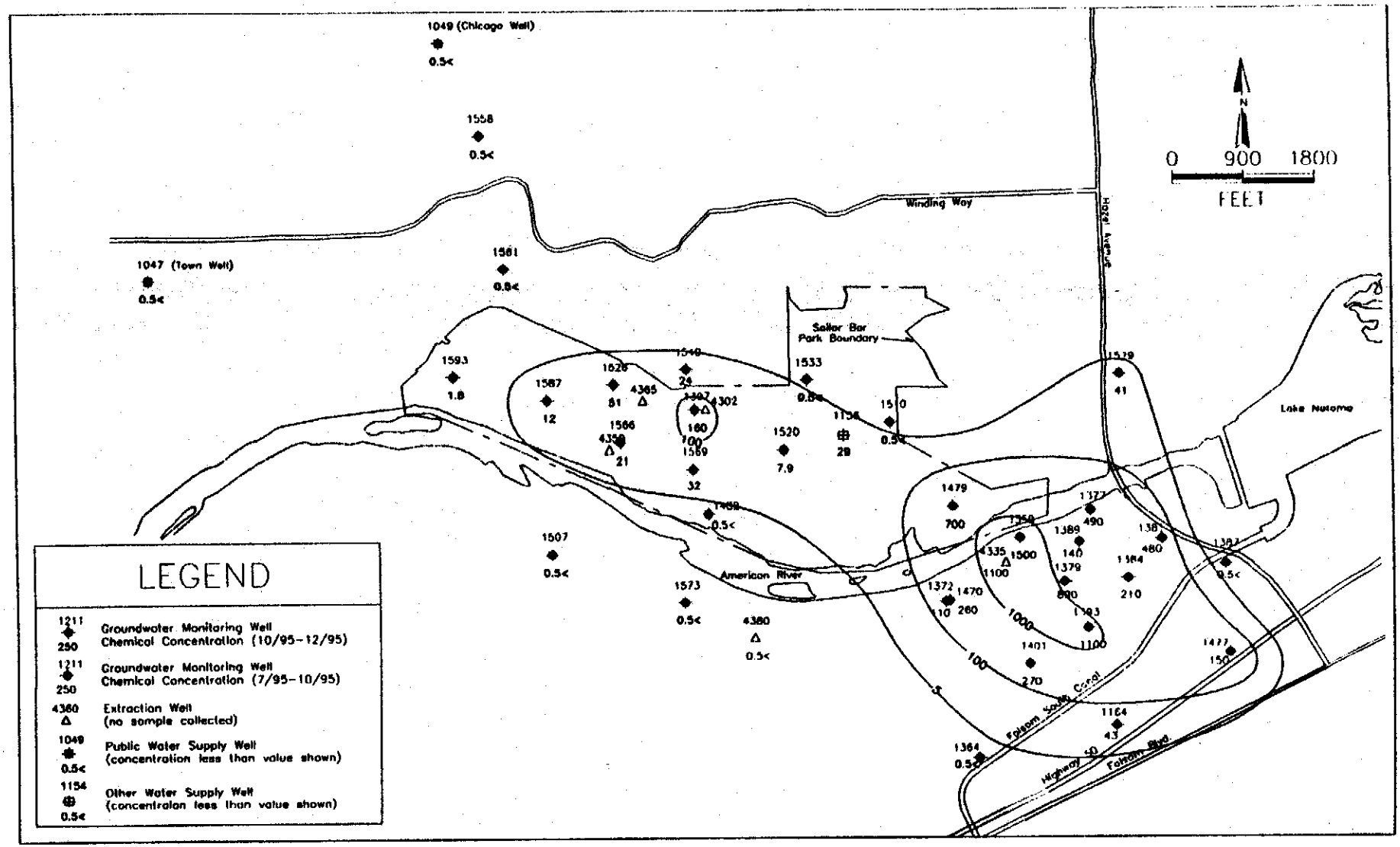
DWN: GWR	DES.: KTK	PROJECT NO.:
CHKD: KTK	APPD: KTK	FIGURE [redacted]
DATE: MAR 96	REV:	



American River Study Area

TITLE:
TCE Concentrations in PPB
Middle Aquifer Groundwater Quality
October to December 1995 Sampling Period

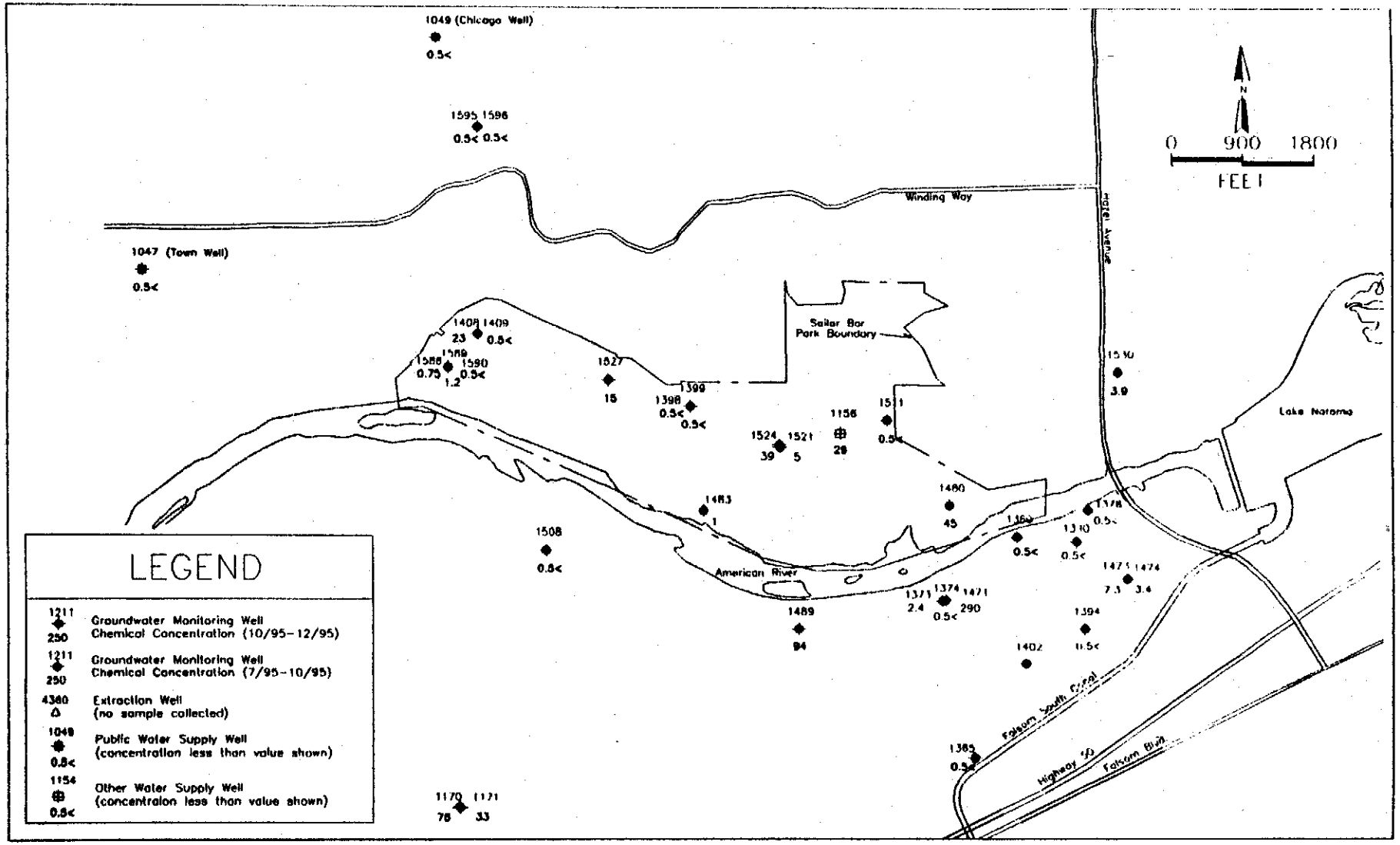
DWN: GWR	DES.: KTK	PROJECT NO.:	
CHKD: KTK	APPD: KTK	FIGURE NO.:	
DATE: MAR 96	REV:		



American River
[redacted] Area

TITLE:
TCE Concentrations in PPB
Lower Aquifer Grou[redacted]er Quality
October to December [redacted]95 Sampling Period

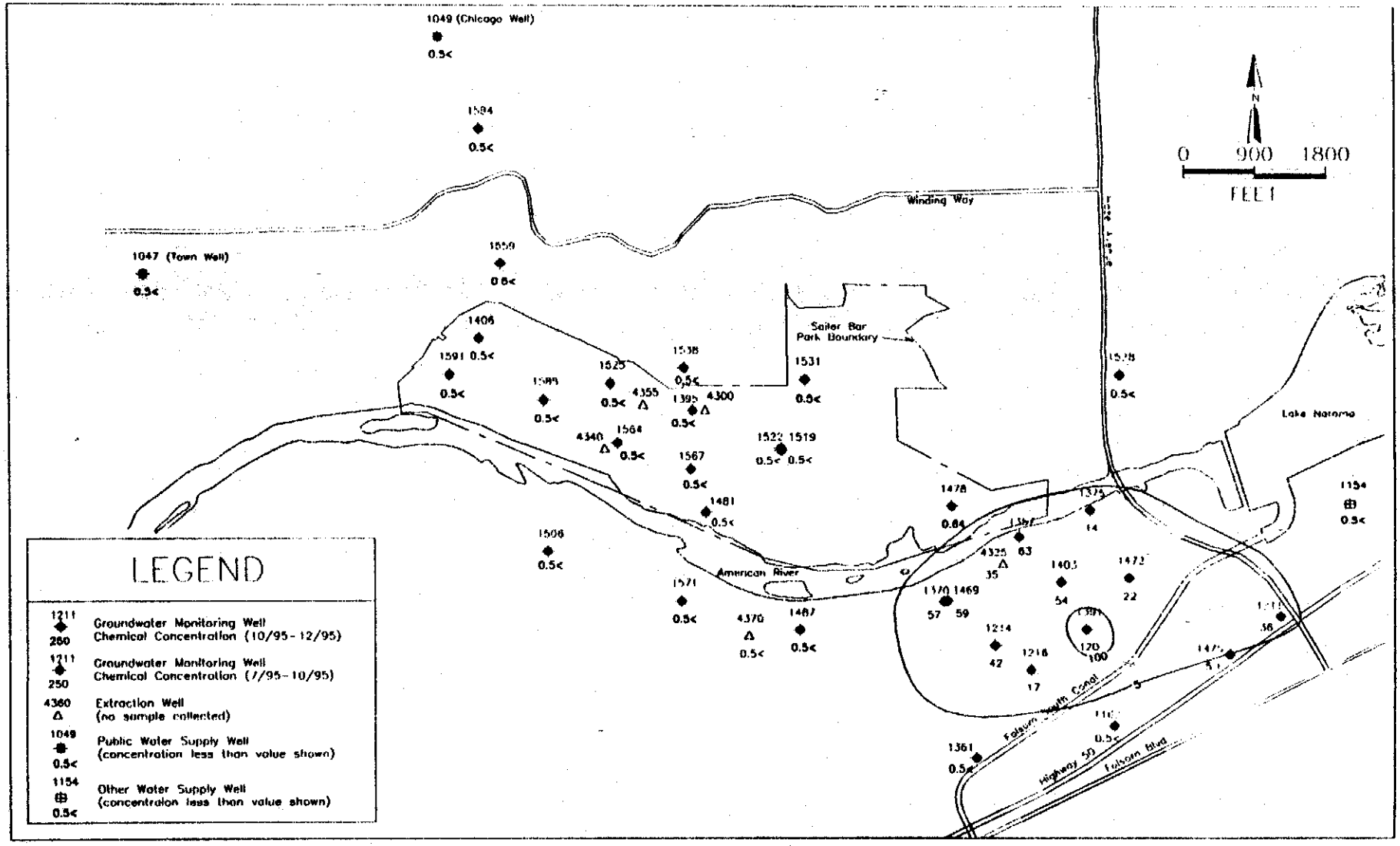
DWN: GWR	DES.: KTK	PROJECT NO.:
CHKD: KTK	APPD: KTK	FIGUR[redacted]
DATE: MAR 96	REV:	



American River Study Area

TITLE:
TCE Concentrations in PPB
Deep Aquifer Groundwater Quality
October to December 1995 Sampling Period

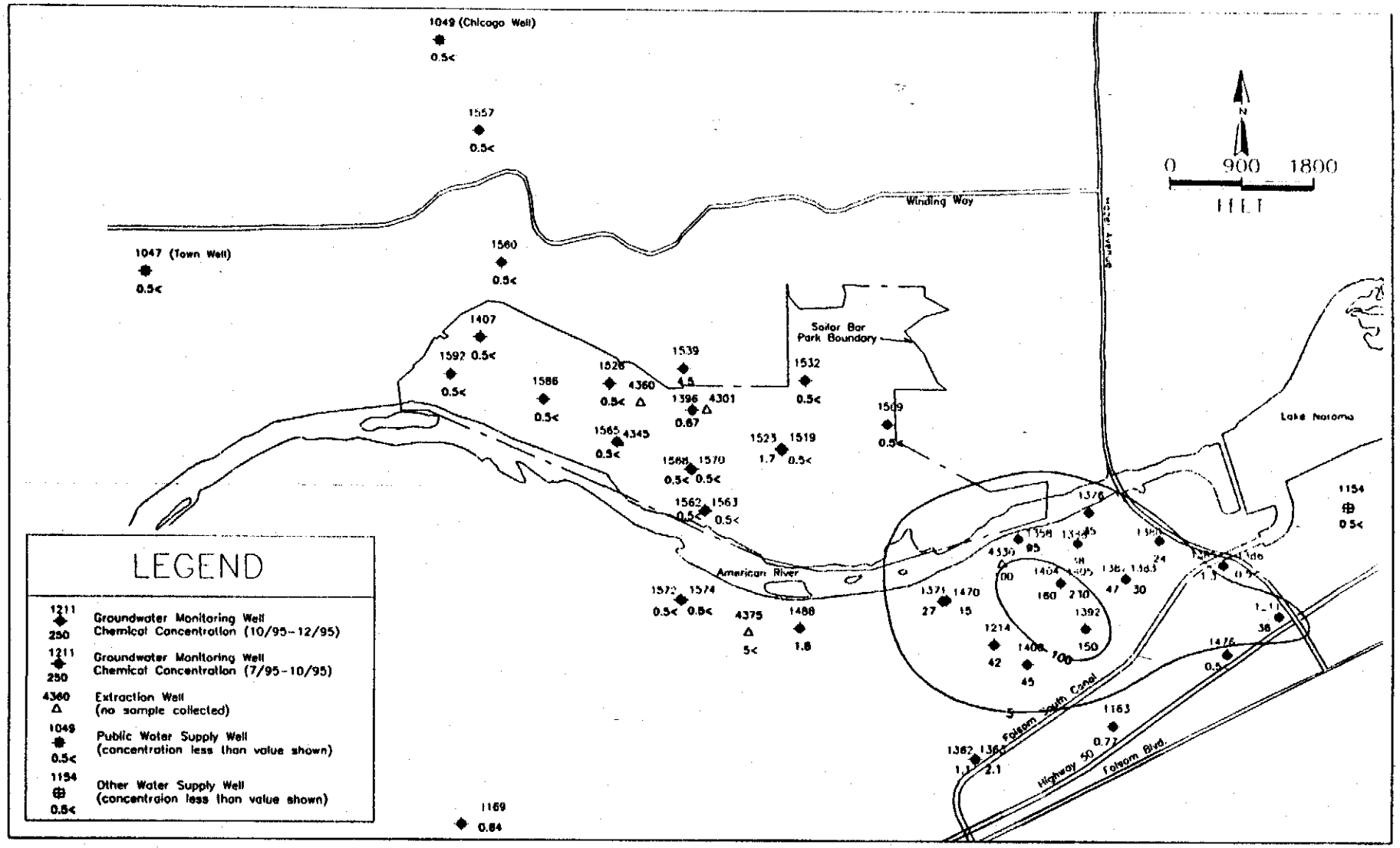
DWN: GWR	DES.: KTK	PROJECT NO.:
CHKD: KTK	APPD: KTK	FIGURE NO.
DATE	REV	



American River
[redacted]y Area

TITLE:
cis/trans 1,2-DCE Concentrations in PPB
Upper Aquifer Grou[redacted]ter Quality
October to December [redacted]95 Sampling Period

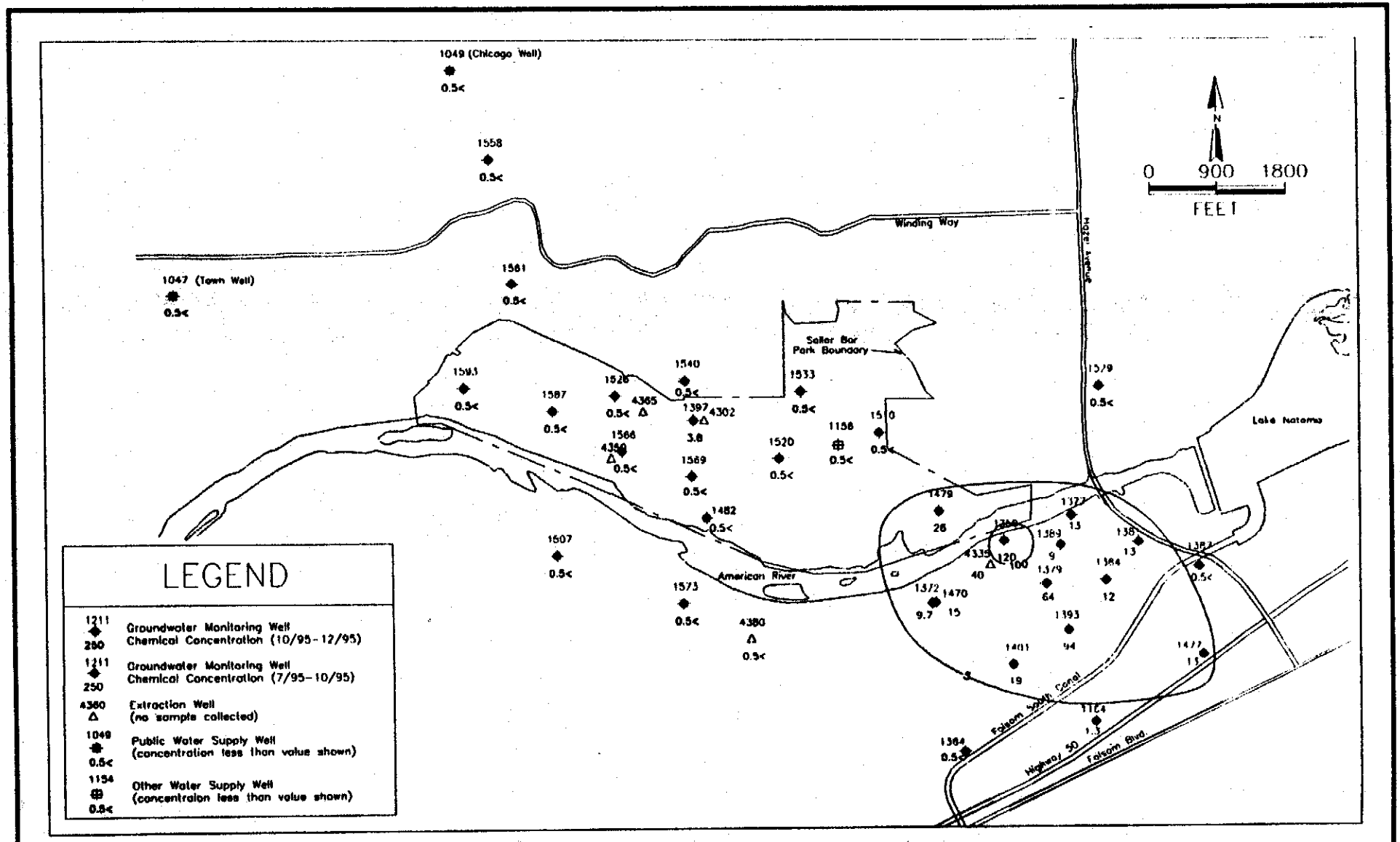
DWN:	DES:	PROJECT NO:
GWR	KTK	
CHKD:	APPD:	FIGURE:
KTK	KTK	[redacted]
DATE:	REV:	
MAR 96		



American River Study Area

TITLE:
cis/trans 1,2-DCE Concentrations in PPB
Middle Aquifer Groundwater Quality
October to December 1995 Sampling Period

DWN: GWR	DES.: KTK	PROJECT NO.:	
CHKD: KTK	APPD: KTK	FIGURE NO.:	
DATE: MAR 96	REV:		



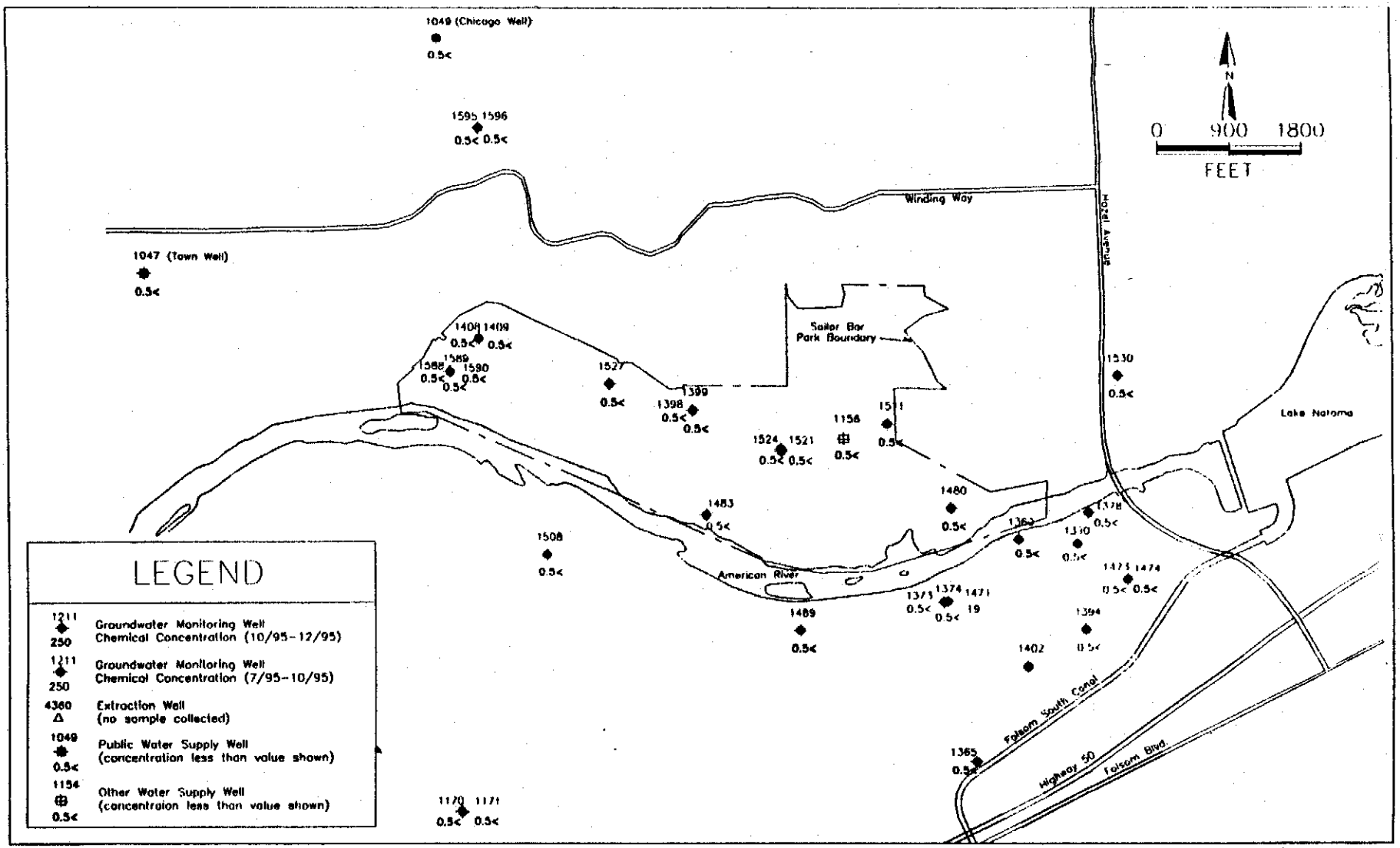
[redacted]rican River
[redacted]y Area

TITLE:
cis/trans 1,2-DCE Concentrations in PPB
Lower Aquifer Grou[redacted]ter Quality
October to Decembe[redacted]95 Sampling Period

DWN: GWR	DES.: KTK
CHKD: KTK	APPD: KTK
DATE: MAR 96	REV:

PROJECT NO.:

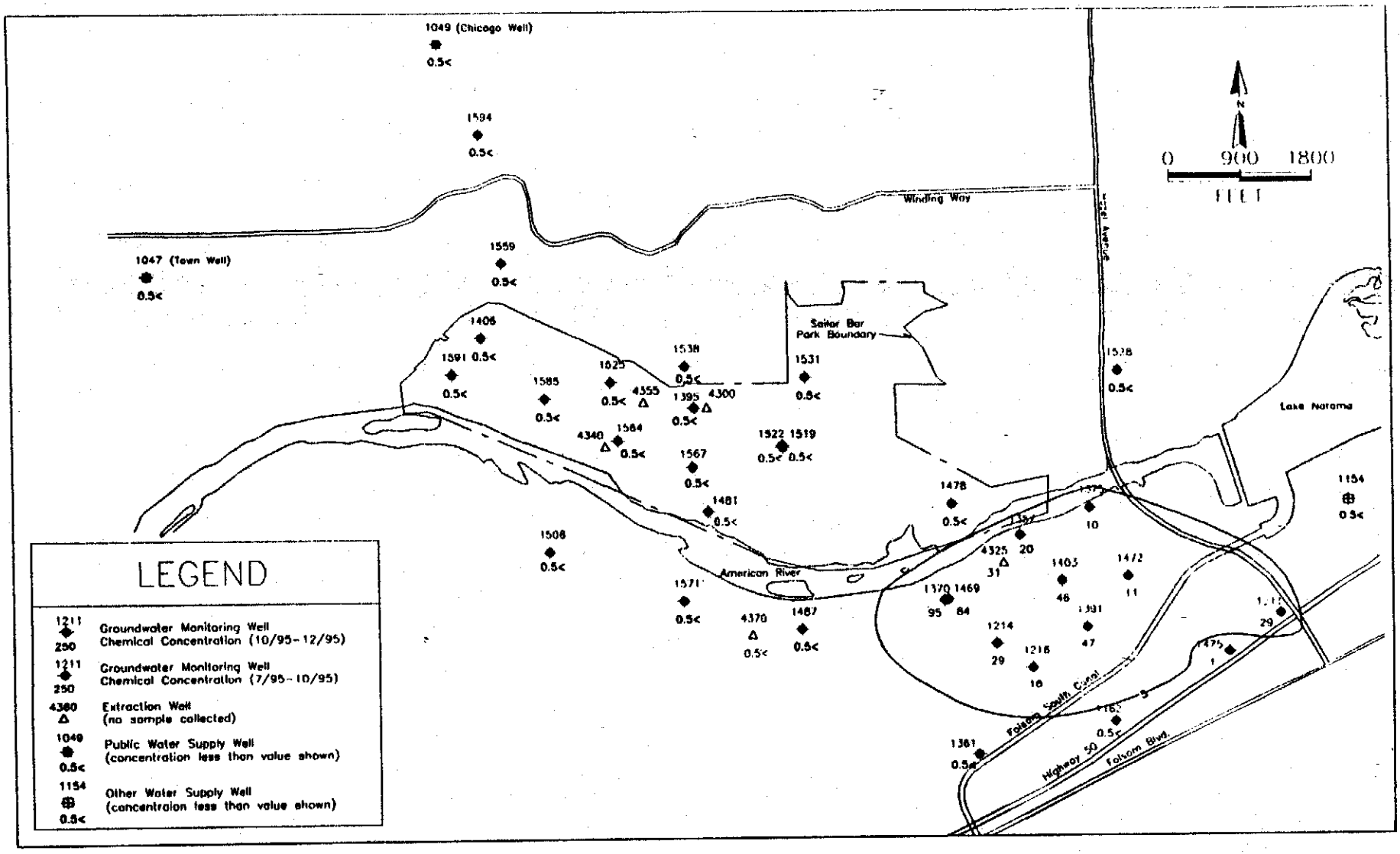
FIGU[redacted]



American River Study Area

TITLE:
cis/trans 1,2-DCE Concentrations in PPB
Deep Aquifer Groundwater Quality
October to December 1995 Sampling Period

DWN:	DES.:	PROJECT NO.:
GWR	KTK	
CHKD.:	APPD.:	FIGURE NO.
KTK	KTK	
DATE:	REV.:	



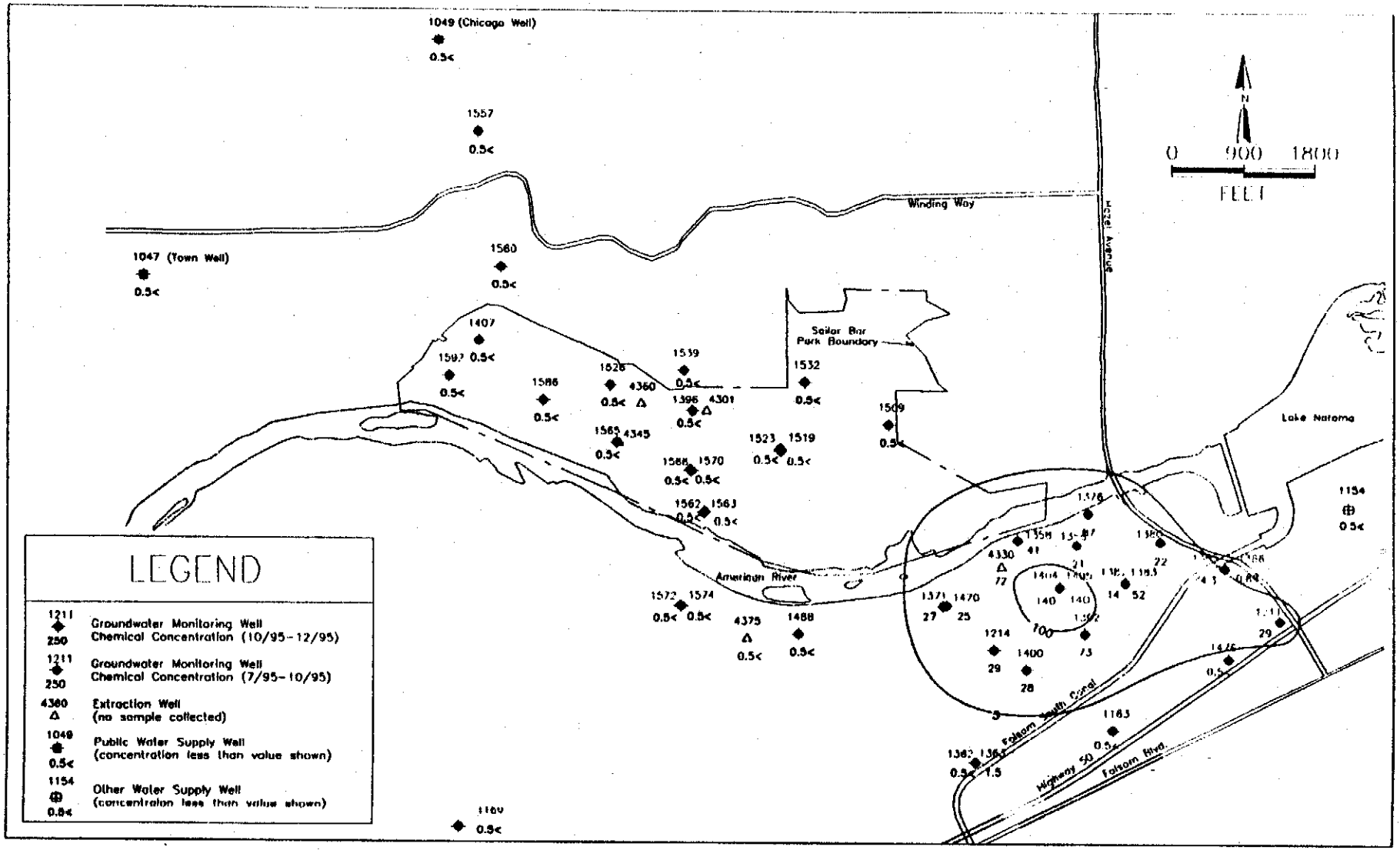
American River Study Area

TITLE:
1,1-DCE Concentrations in PPB
Upper Aquifer Groundwater Quality
October to December 1995 Sampling Period

DWN: GWR	DES: KTK
CHKD: KTK	APPD: KTK
DATE: MAR 96	REV:

PROJECT NO.

FIGURE



American River
Study Area

TITLE:
1,1-DCE Concentrations in PPB
Middle Aquifer Groundwater Quality
October to December 1995 Sampling Period

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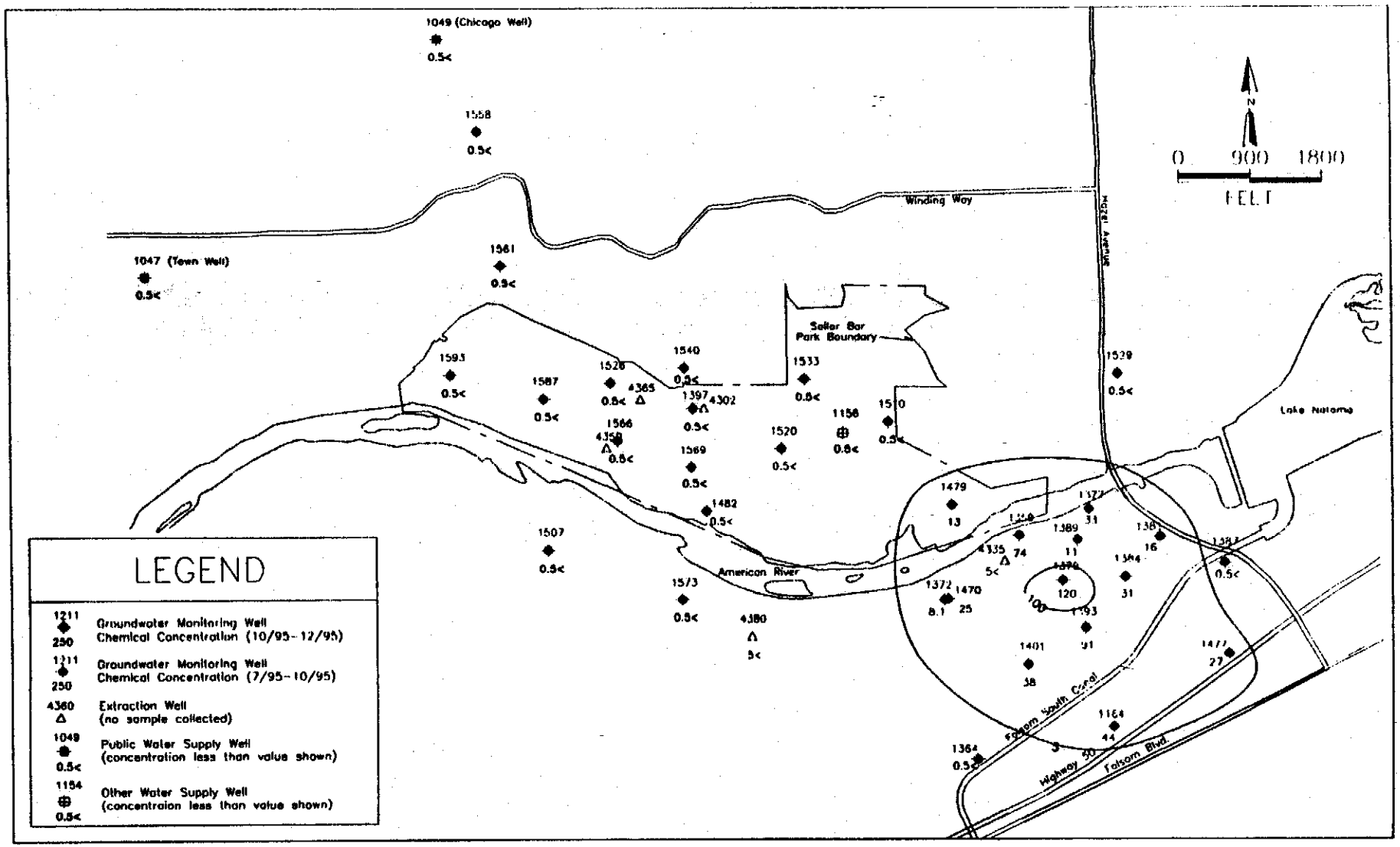
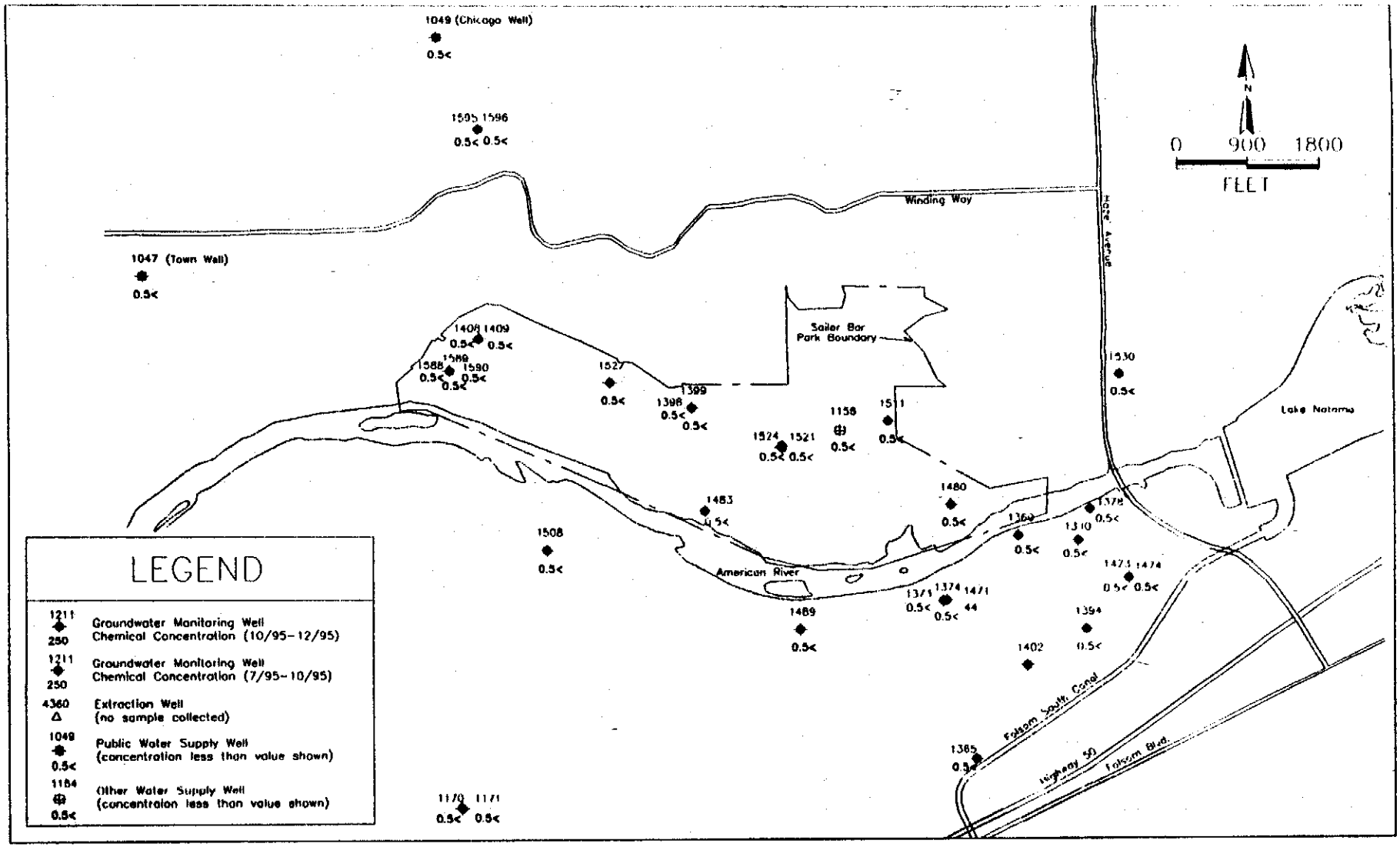
CHKD: KTK	APPD: KTK	FIGURE NO.	
DATE: MAR 96	REV.:		



American River
[redacted] Area

TITLE:
1,1-DCE Concentrations in PPB
Lower Aquifer Grou[redacted]er Quality
October to Decembe[redacted]5 Sampling Period

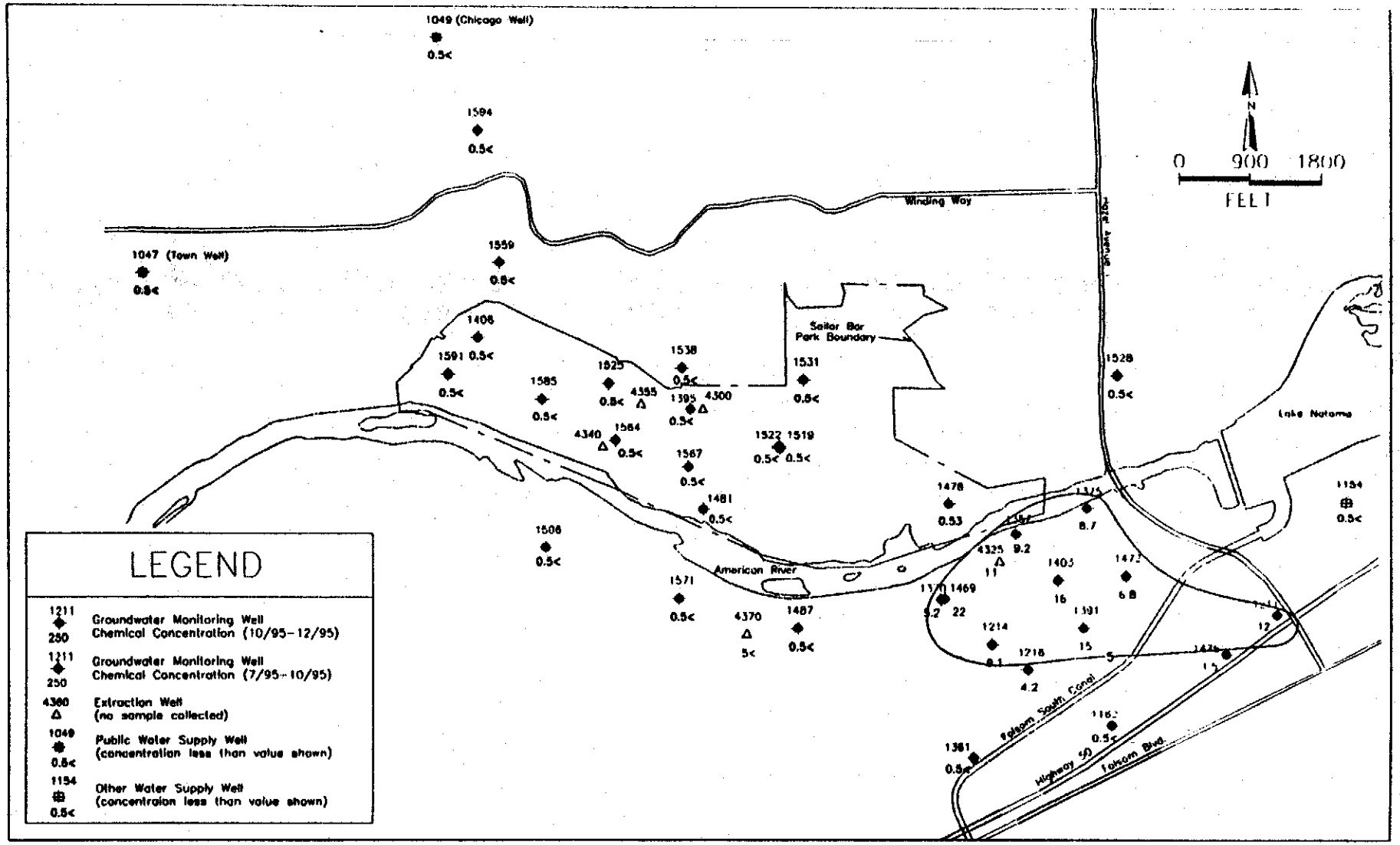
DWN: GWR	DES.: KTK	PROJECT NO.:
CHKD: KTK	APPD: KTK	FIGUR[redacted]
DATE: MAR 96	REV	



American River Study Area

TITLE:
1,1–DCE Concentrations in PPB
Deep Aquifer Groundwater Quality
October to December 1995 Sampling Period

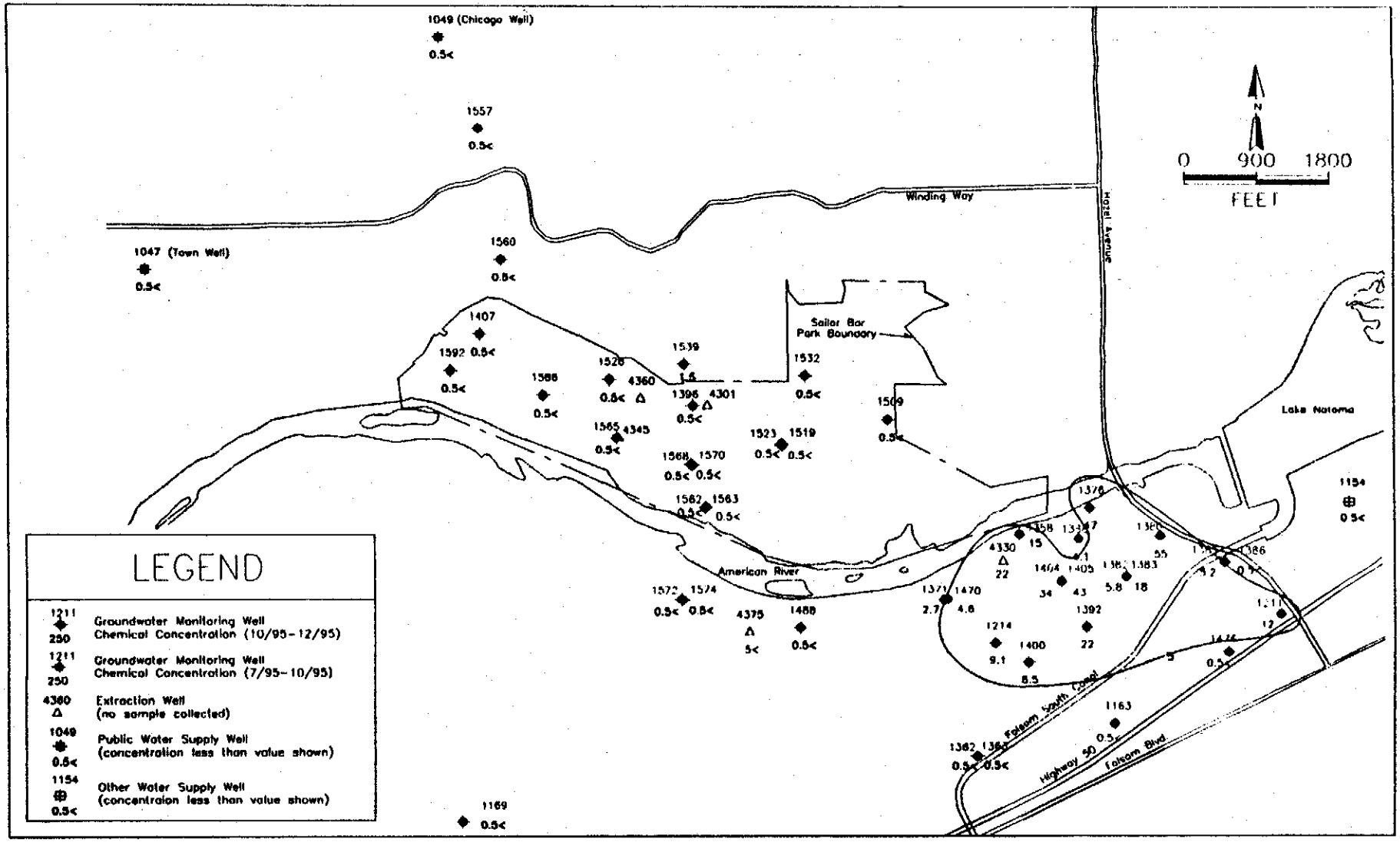
DWN: GWR	DES.: KTK	PROJECT NO.:	
CHKD: KTK	APPD: KTK	FIGURE NO.:	
DATE: MAR 96	REV.:		



American River
[redacted]dy Area

TITLE:
PCE Concentrations in PPB
Upper Aquifer Grou[redacted]er Quality
October to December [redacted]95 Sampling Period

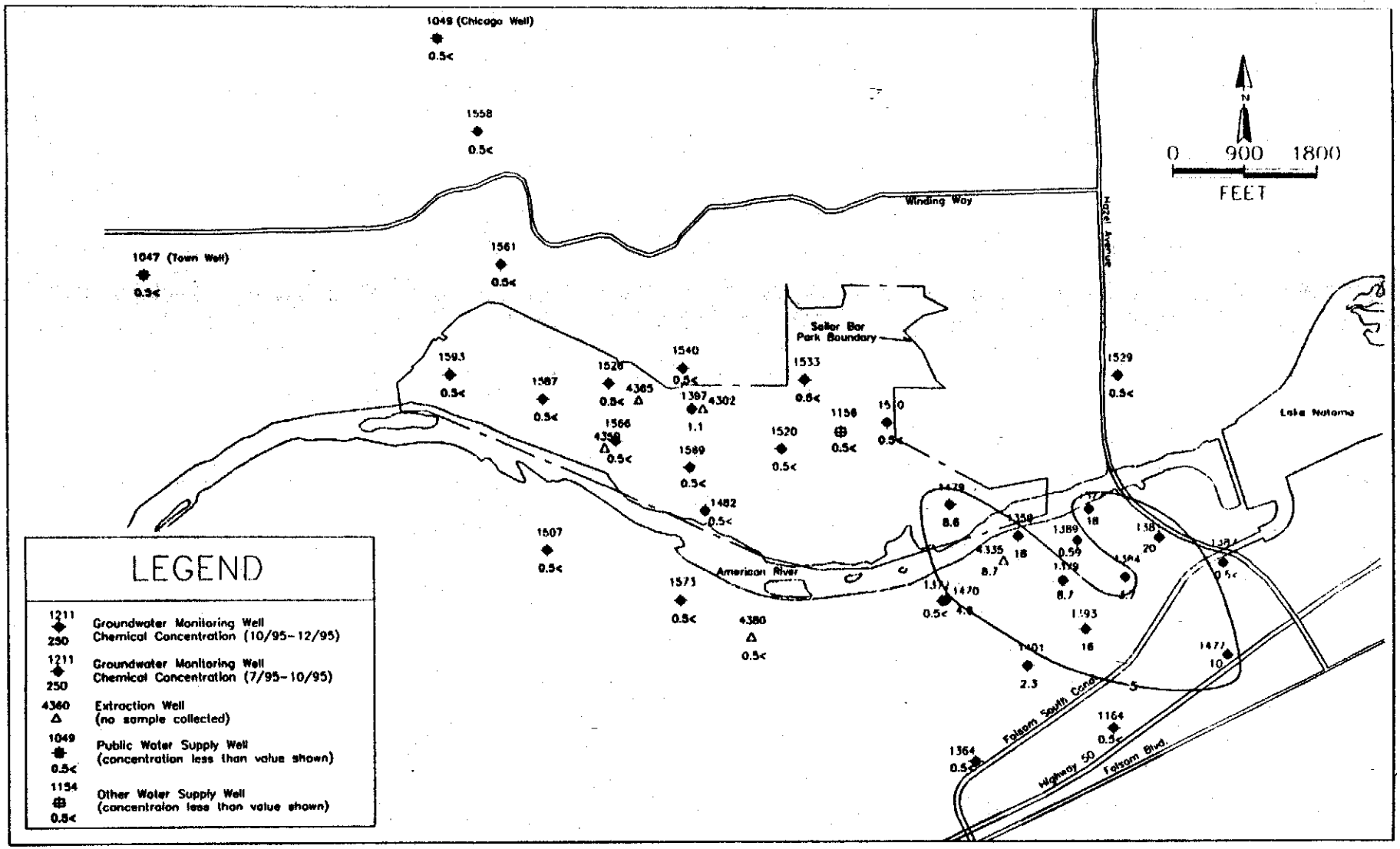
DWN: GWR	DES: KTK	PROJECT NO.:
CHKD: KTK	APPD: KTK	
DATE:	REV	



American River
Study Area

TITLE:
PCE Concentrations in PPB
Middle Aquifer Groundwater Quality
October to December 1995 Sampling Period

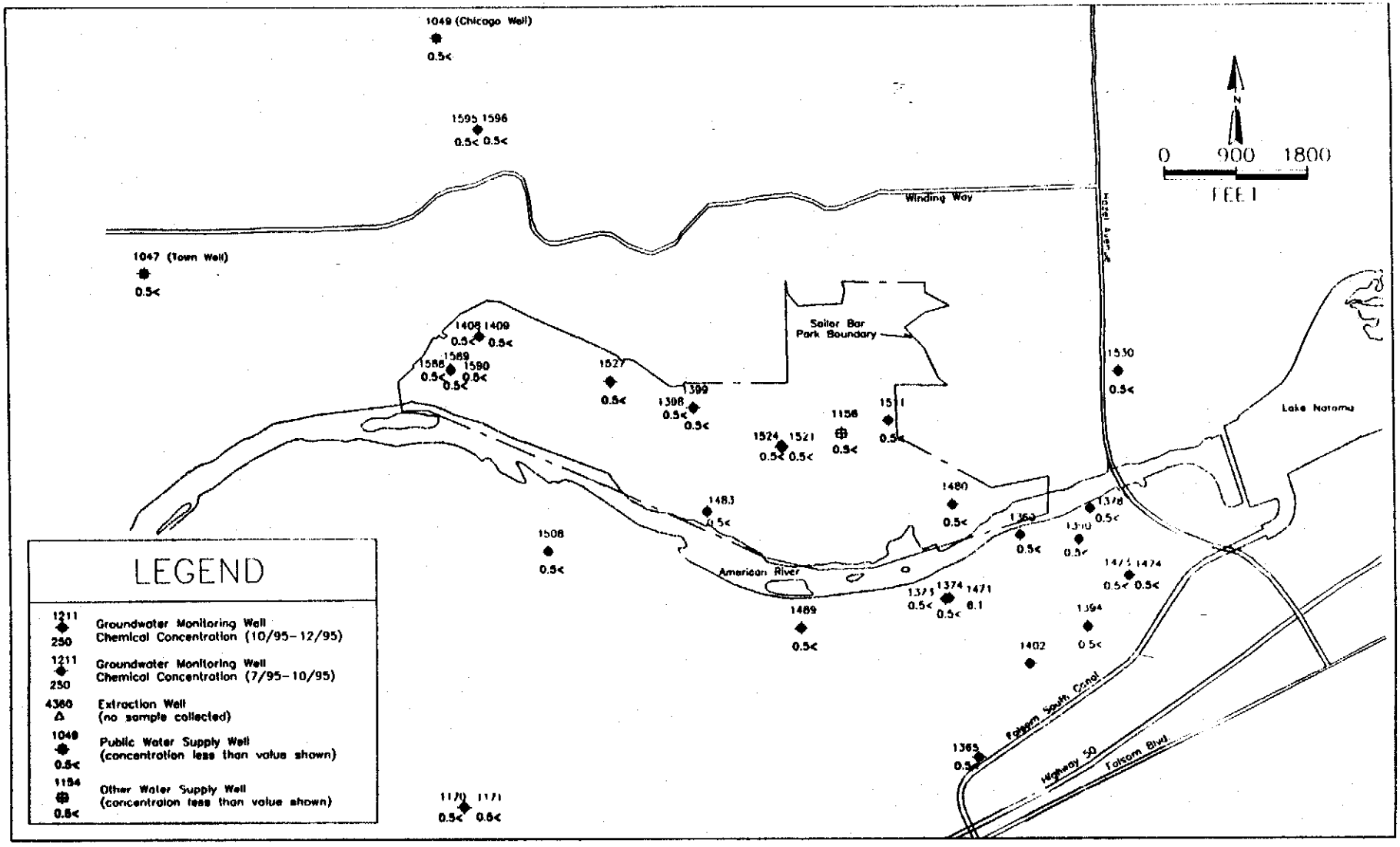
DWN: GWR	DES.: KTK	PROJECT NO.:	
CHKD: KTK	APPD: KTK	FIGURE NO.:	
DATE: MAR 96	REV:		



American River [redacted] Area

TITLE:
PCE Concentrations in PPB
Lower Aquifer Groun[redacted]er Quality
October to December [redacted]95 Sampling Period

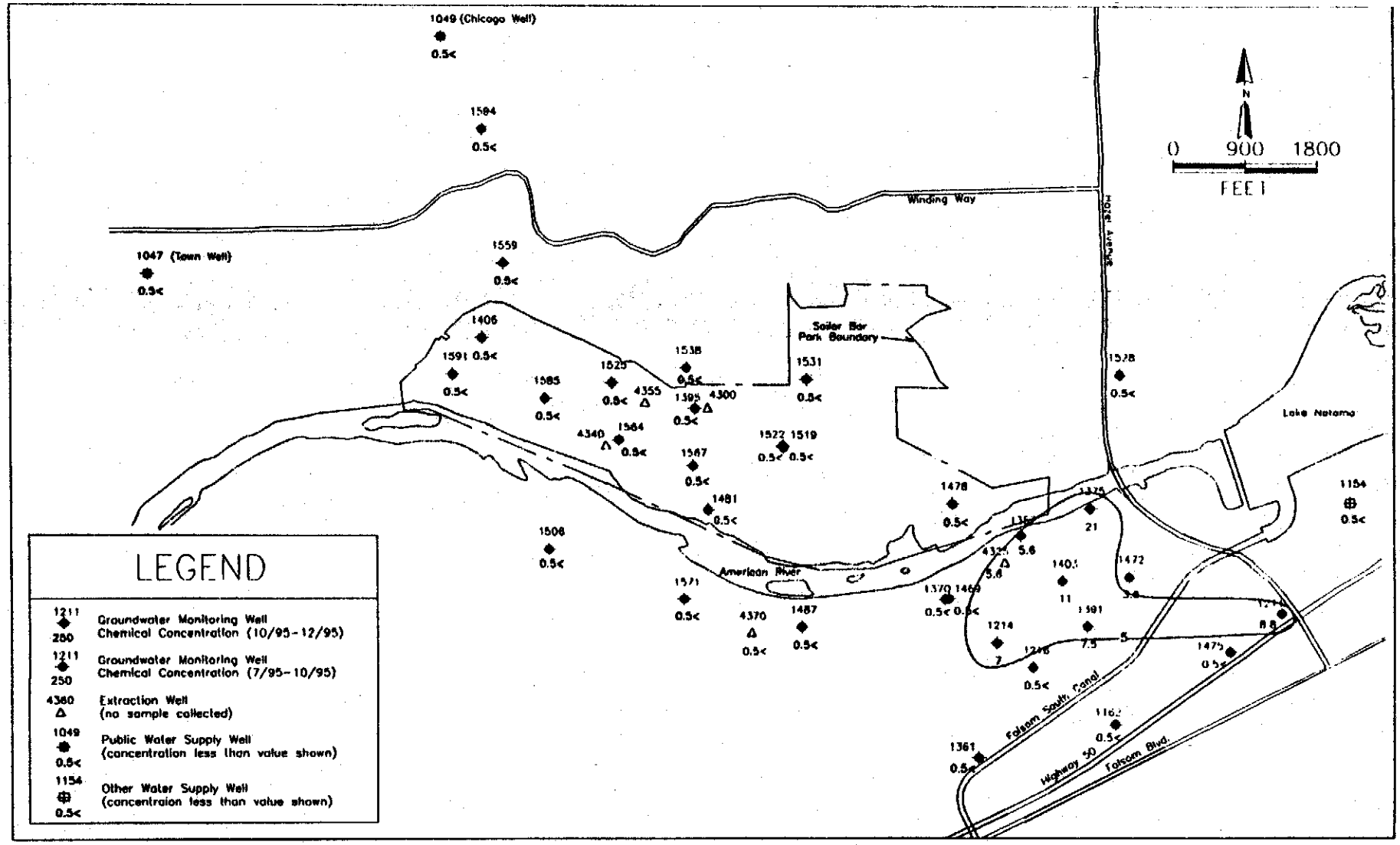
DWN: GWR	DES.: KTK	PROJECT NO.:
CHKD: KTK	APPD: KTK	FIGUR[redacted]
DATE: MAR 96	REV:	



American River Study Area

TITLE:
PCE Concentrations in PPB
Deep Aquifer Groundwater Quality
October to December 1995 Sampling Period

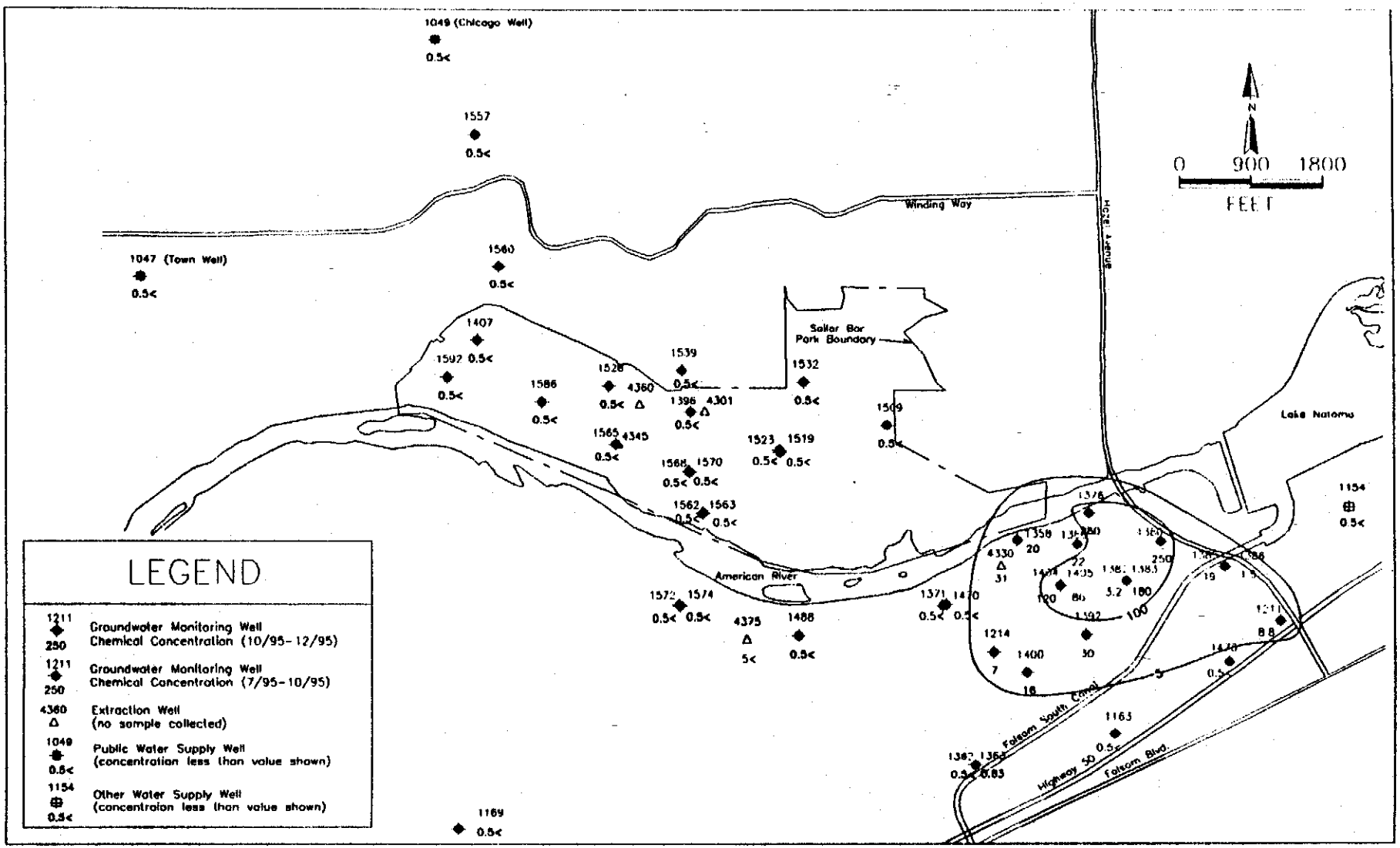
DWN: GWR	DES.: KTK	PROJECT NO.:
CHKD: KTK	APPD: KTK	FIGURE NO.
DATE: MAR 06	REV:	



American River
[redacted]y Area

TITLE:
Freon 113 Concentrations in PPB
Upper Aquifer Grou[redacted]ter Quality
October to Decembe[redacted]95 Sampling Period

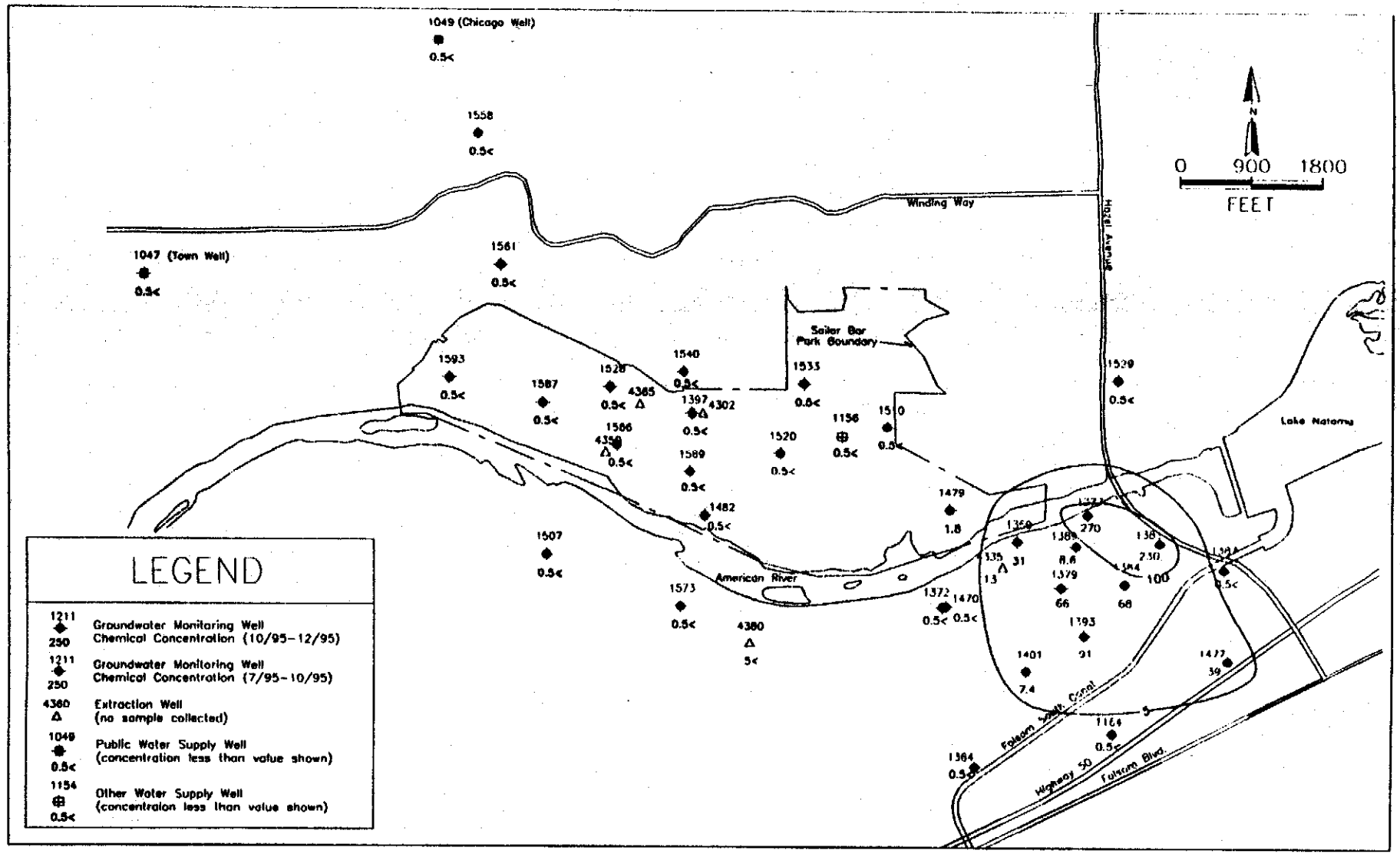
DWN: GWR	DES.: KTK	PROJECT NO.:	
CHKD: KTK	APPD: KTK		
DATE: MAR 96	REV:		



American River
Study Area

TITLE:
Freon 113 Concentrations in PPB
Middle Aquifer Groundwater Quality
October to December 1995 Sampling Period

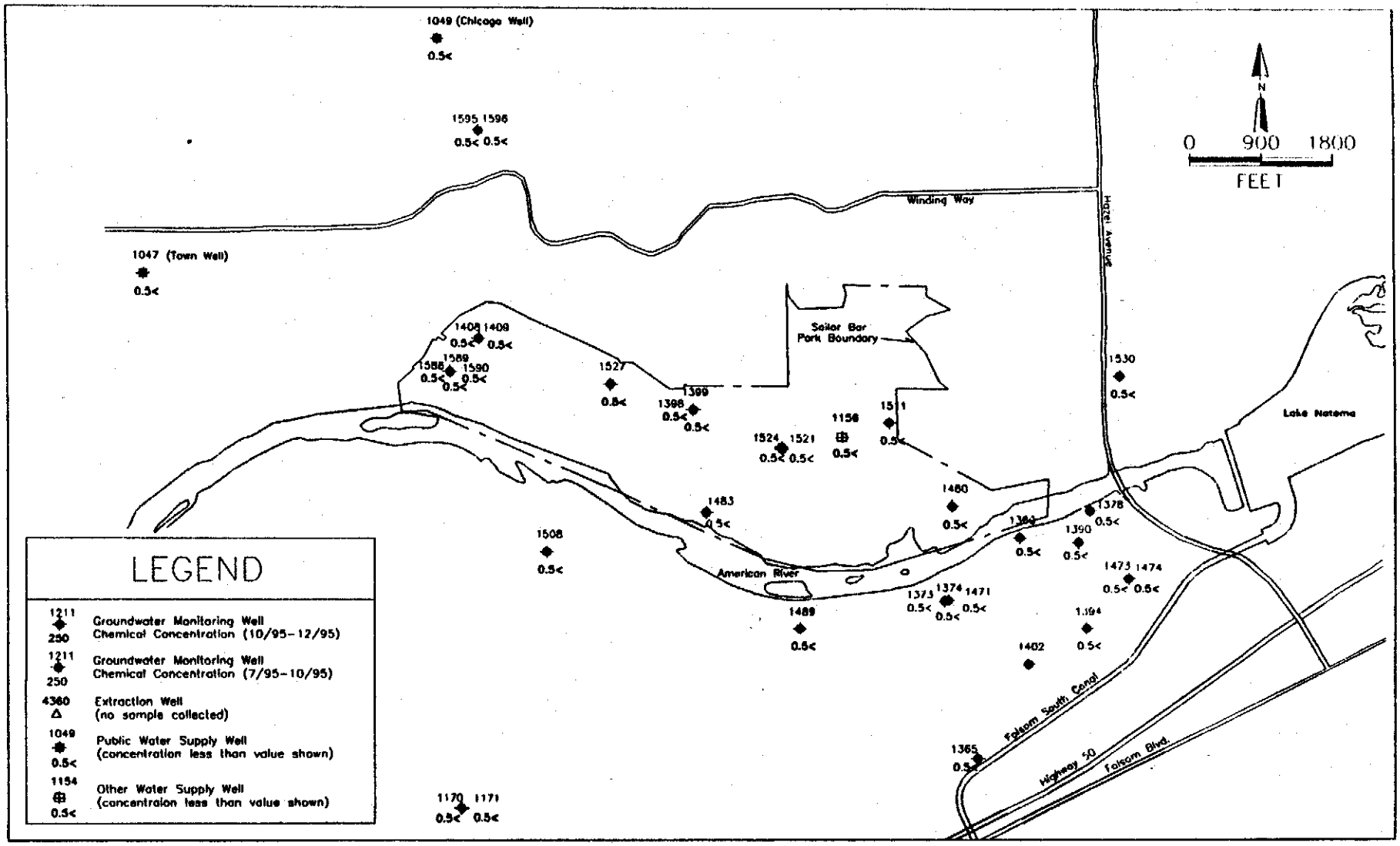
DWN: GWR	DES.: KTK	PROJECT NO.	
CHKD.: KTK	APPD.: KTK	FIGURE NO.	
DATE:	REV.		



American River
[redacted]y Area

TITLE:
Freon 113 Concentrations in PPB
Lower Aquifer Groun[redacted]er Quality
October to Decembe[redacted]95 Sampling Period

DWN: GWR	DES.: KTK	PROJECT NO	
CHKD: KTK	APPD: KTK	FIGURE	[redacted]
DATE: MAR 96	REV:		



American River Study Area

TITLE:
Freon 113 Concentrations in PPB
Deep Aquifer Groundwater Quality
October to December 1995 Sampling Period

DWN: GWR	DES.: KTK	PROJECT NO.:
CHKD: KTK	APPD: KTK	FIGURE NO.:
DATE: MAR 96	REV:	

APPENDIX G

Aquifer Pumping Tests

Appendix G

Aquifer Pumping Tests

Aquifer pumping tests were performed on the 15 extraction wells installed in the ARSA. The purpose of these tests was to determine the approximate quantity of water each well would produce under full-scale operating conditions and to evaluate the hydrologic characteristics of the aquifers being pumped. Table G-1 presents a summary of the aquifer testing and analyses including test dates, duration, pumping rates, drawdown, distance to pumping wells, transmissivity and storage coefficient.

Field Work

The extraction wells were tested using electric submersible pumps powered by diesel generators. The pumped water from the nine wells on the north side of the American River was discharged without treatment and under permit into the County sanitary sewer system which runs through Sailor Bar Park. The pumped water from the six wells south of the river was treated with granular activated carbon prior to discharge under permit to the County sanitary sewer system.

Water levels were monitored in the pumping wells and nearby monitor wells using pressure transducers and data logging equipment. Manual water level measurements were also collected to serve as backup data and to check the consistency of the transducer data.

Groundwater samples were collected from each pumping well during the tests. Samples from the extraction wells north of the river were analyzed for VOCs. Samples from the extraction wells south of the river were analyzed for VOCs, semi-volatile organics, total petroleum hydrocarbons, metals, general minerals, conductivity, corrosivity, perchlorate and total dissolved solids.

Aquifer Test Analyses

The data logger/transducer data was summarized and reduced using spreadsheets to calculate water elevation, drawdown and time since pumping started or stopped.

Drawdown and recovery data was extracted from the spreadsheets for wells that showed response to pumping that could be analyzed with curve-matching techniques using the Hantush-modified Theis method for leaky confined aquifers. The extracted data was formatted for analysis using the computer program GWAP (Graphical Well Analysis Package). GWAP uses on-screen curve matching techniques to analyze aquifer test data using the Hantush method. The following graphs are the output from GWAP and show the data curve, the type curve, the details of the test and the calculated results.

Table G-1
American River Study Area
Aquifer Pumping Test Summary

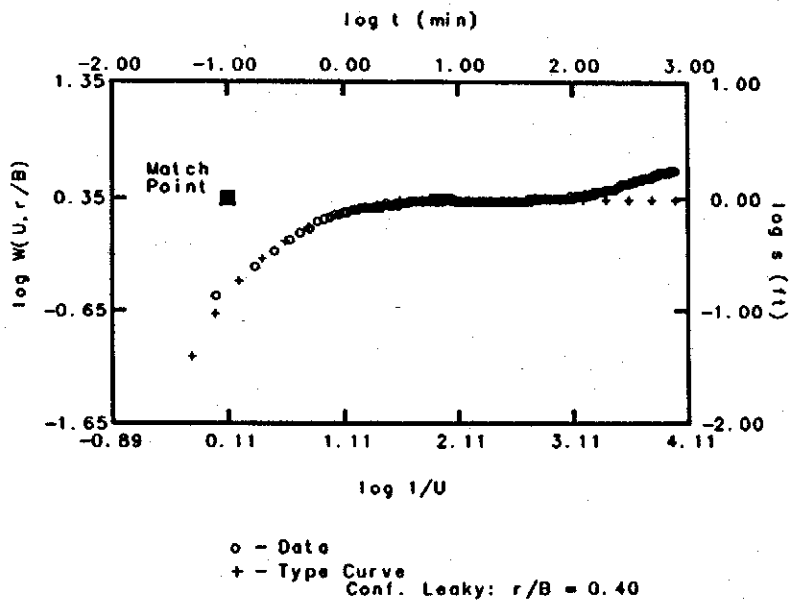
Pumped Well (Aquifer)	Test Date (Duration)	Q (gpm)	Obs. Wells for Analysis	Obs. Well Aquifer	r (feet)	s (feet)	T (gpd/ft)	T (ft^2/day)	S	L (feet)	Type Curve (r/B)
4300	11/8-12/93	308.8	1395 D	Upper	158	2.70	81,050	10,835	9.8E-05	394	0.4
(Upper)	(96 hrs.)		1395 R	Upper	158	--	154,440	20,646	9.0E-05	788	0.2
4301	11/15-19/93	218.3	1396 D	Middle	178	3.30	26,190	3,501	1.3E-04	592	0.3
(Middle)	(96 hrs.)		1396 R	Middle	178	--	24,440	3,267	1.2E-04	592	0.3
			1539 D	Lower	593	0.71	88,740	11,863	2.7E-04	742	0.8
			1539 R	Lower	593	--	62,820	8,398	2.5E-04	593	1.0
4302	11/1-5/93	35.0	1397 D	Lower	139	6.70	697	93	1.9E-04	174	0.8
(Lower)	(96 hrs.)		1397 R	Lower	139	--	621	83	1.8E-04	154	0.9
			1540 D	Lower	581	0.58	4,103	548	3.1E-04	387	1.5
			1540 R	Lower	581	--	4,103	548	2.5E-04	387	1.5
4302	11/22-24/93	35.3	1397 D	Lower	139	6.90	789	105	2.0E-04	199	0.7
(Lower)	(48 hrs.)		1397 R	Lower	139	--	598	80	1.7E-04	154	0.9
			1533 D	Lower	1,343	0.39	9,054	1,210	3.8E-04	1,492	0.9
			1533 R	Lower	1,343	--	10,890	1,456	3.0E-04	1,343	1.0
			1540 D	Lower	581	0.64	4,334	579	2.9E-04	387	1.5
			1540 R	Lower	581	--	3,522	471	2.7E-04	387	1.5
4325	8/29/95	424.8	1357D	Upper	409	1.80	80,770	10,797	2.0E-04	1,364	0.3
(Upper)	(8 hrs.)		1357R	Upper	409	--	80,770	10,797	2.0E-04	1,364	0.3
			1358D	Middle	409	1.86	73,660	9,847	2.1E-04	1,364	0.3
			1358R	Middle	409	--	75,350	10,073	1.9E-04	1,364	0.3
			1370D	Upper	879	0.77	82,650	11,049	1.7E-04	1,255	0.7
			1370R	Upper	879	--	82,650	11,049	1.7E-03	1,255	0.7
			1371D	Middle	879	0.77	53,370	7,135	1.4E-04	879	1.0
			1371R	Middle	879	--	61,270	8,191	1.5E-04	976	0.9
			1388D	Middle	1,003	0.23	627,000	83,818	6.5E-04	3,344	0.3
			1388R	Middle	1,003	--	641,600	85,769	9.0E-04	3,343	0.3
			1404D	Middle	774	0.35	414,200	55,371	5.4E-04	2,581	0.3
			1404R	Middle	774	--	464,800	62,135	6.2E-04	2,581	0.3
			1469D	Upper	834	0.10	475,600	63,578	3.9E-03	927	0.9
			1469R	Upper	834	--	395,600	52,884	3.4E-03	927	0.9
			1478D	Upper	994	0.17	498,000	66,573	1.9E-03	1,987	0.5
			1478R	Upper	994	--	404,800	54,114	2.0E-03	1,987	0.5
4330	8/24/95	452.7	1357D	Upper	389	2.40	58,190	7,779	1.6E-04	1,298	0.3
	(8 hrs.)		1357R	Upper	389	--	60,940	8,146	1.6E-04	1,298	0.3
(Middle)			1358D	Middle	389	2.71	53,070	7,094	1.3E-04	1,298	0.3
			1358R	Middle	389	--	65,300	8,729	1.2E-04	1,947	0.2
			1370D	Upper	891	0.81	55,580	7,430	1.7E-04	891	1.0
			1370R	Upper	891	--	54,310	7,260	1.6E-04	891	1.0
			1371D	Middle	891	0.81	55,580	7,430	1.6E-04	891	1.0
			1371R	Middle	891	--	63,810	8,530	1.6E-04	990	0.9
			1379D	Lower	804	0.17	638,100	85,302	1.3E-02	N/A	Theis
			1379R	Lower	804	--	988,300	132,117	4.0E-03	4,019	0.2
			1388D	Middle	996	0.25	484,000	64,701	6.0E-04	2,489	0.4
			1388R	Middle	996	--	495,300	66,212	7.1E-04	1,991	0.5
			1404D	Middle	780	0.41	367,200	49,088	5.8E-04	2,600	0.3
			1404R	Middle	780	--	358,800	47,965	5.8E-04	1,950	0.4
			1469D	Upper	848	0.13	421,600	56,360	2.9E-03	942	0.9
			1469R	Upper	848	--	412,000	55,076	2.7E-03	942	0.9
			1478D	Upper	978	0.22	312,500	41,775	1.8E-03	1,396	0.7
			1478R	Upper	978	--	393,400	52,590	2.4E-03	1,629	0.6
			1479D	Lower	978	2.25	9,013	1,205	1.0E-03	N/A	Theis
			1479R	Lower	978	--	86,080	11,507	9.3E-04	N/A	Theis
			1480D	Deeper	978	2.08	8,412	1,125	2.0E-03	1,955	0.5
			1480R	Deeper	978	--	80,330	10,739	9.9E-04	N/A	Theis
4335	8/22/95	238.3	1359D	Lower	374	8.10	9,687	1,295	1.8E-04	1,246	0.3
(Lower)	(8 hrs.)		1359R	Lower	374	--	11,650	1,557	1.8E-04	3,738	0.1
			1372D	Lower	912	3.28	12,770	1,707	9.7E-05	1,519	0.6
			1372R	Lower	912	--	20,240	2,706	1.2E-04	N/A	Theis
			1389D	Lower	975	1.04	49,680	6,641	3.9E-04	2,437	0.4
			1389R	Lower	975	--	48,550	6,490	4.1E-04	1,949	0.5
			1479D	Lower	986	2.90	10,360	1,388	8.9E-05	1,233	0.8
			1479R	Lower	986	--	16,830	2,250	1.2E-04	9,862	0.1
			1480D	Deeper	986	2.99	9,687	1,295	9.3E-05	1,233	0.8
			1480R	Deeper	986	--	14,330	1,916	1.3E-04	4,931	0.2
			1510R	Lower	2,303	3.24	17,230	2,303	9.6E-05	N/A	Theis
			1511R	Deeper	2,303	3.15	17,230	2,303	1.0E-05	N/A	Theis

Pumped Well (Aquifer)	Test Date (Duration)	Q (gpm)	Obs. Wells for Analysis	Obs. Well Aquifer	r (feet)	s (feet)	T (gpd/ft)	T (ft^2/day)	S	L (feet)	Type Curve (r/B)
4340	3/7/95	25.3	1564D	Upper	186	0.65	43,870	5,865	8.9E-04	1,864	0.1
(Upper)	(8 hrs.)		1564R	Upper	186	--	60,560	8,096	9.4E-04	1,864	0.1
4345	12/12/94	387.9	1396D	Middle	1,020	0.24	424,400	56,734	3.9E-04	2,039	0.5
(Middle)	(8 hrs.)		1396R	Middle	1,020	--	280,400	37,484	4.6E-04	1,133	0.9
			1397D	Lower	1,020	0.23	337,100	45,064	3.0E-03	1,699	0.6
			1397R	Lower	1,020	--	454,800	60,798	3.2E-03	1,699	0.6
			1525D	Upper	748	0.29	672,700	89,927	2.0E-03	1,869	0.4
			1525R	Upper	748	--	754,700	100,889	3.1E-03	3,738	0.2
			1526D	Middle	748	0.33	546,800	73,097	9.8E-04	2,492	0.3
			1526R	Middle	748	--	405,300	54,181	1.5E-03	1,869	0.4
			1564D	Upper	288	1.18	116,900	15,627	6.0E-02	96	0.3
			1564R	Upper	288	--	189,600	25,346	4.3E-02	288	0.1
			1565D	Middle	288	9.80	6,135	820	1.1E-03	41	0.7
			1565R	Middle	288	--	6,135	820	1.5E-03	41	0.7
			1566D	Lower	288	5.37	8,275	1,106	5.7E-03	32	0.9
			1566R	Lower	288	--	8,087	1,081	7.2E-03	32	0.9
4350	12/19/94	61.5	1565D	Middle	179	0.45	21,770	2,910	5.7E-04	256	0.7
(Lower)	(8 hrs.)		1565R	Middle	179	--	3,614	483	5.7E-04	90	2.0
			1566D	Lower	179	1.00	8,090	1,081	2.5E-04	224	0.8
			1566R	Lower	179	--	3,221	431	3.3E-04	119	1.5
4355	11/23/94	387.7	1395D	Upper	640	0.17	2,126,000	284,205	6.1E-04	12,800	0.05
(Upper)	(8 hrs.)		1395R	Upper	640	--	2,331,000	311,609	1.1E-03	12,800	0.05
			1396D	Middle	640	0.18	866,100	115,781	1.6E-03	6,401	0.1
			1396R	Middle	640	--	487,000	65,102	2.2E-03	914	0.7
			1397D	Lower	640	0.16	119,600	15,988	7.3E-03	427	1.5
			1525D	Upper	487	0.17	627,400	83,871	3.3E-03	1,219	0.4
			1525R	Upper	487	--	971,800	129,911	6.2E-03	1,625	0.3
			1526D	Middle	487	0.19	227,800	30,452	3.1E-03	542	0.9
			1526R	Middle	487	--	286,800	38,340	2.5E-03	542	0.9
			1564D	Upper	573	0.14	510,000	68,177	8.2E-03	955	0.6
			1565D	Middle	573	0.23	928,000	124,056	2.1E-03	N/A	Theis
			1565R	Middle	573	--	1,252,000	167,368	2.8E-03	N/A	Theis
4360	12/1/94	434.2	1395D	Upper	662	0.20	1,435,000	191,832	1.0E-03	13,250	0.05
(Middle)	(8 hrs.)		1395R	Upper	662	--	2,122,000	283,670	1.4E-03	13,250	0.05
			1396D	Middle	662	0.37	464,300	62,068	4.3E-04	3,312	0.2
			1396R	Middle	662	--	249,300	33,327	4.8E-04	946	0.7
			1397D	Lower	662	0.30	38,620	5,163	2.1E-03	331	2.0
			1397R	Lower	662	--	80,680	10,785	3.5E-03	442	1.5
			1525D	Upper	460	0.40	433,300	57,924	2.6E-03	2,298	0.2
			1525R	Upper	460	--	788,400	105,394	1.6E-03	4,595	0.1
			1526D	Middle	460	0.51	377,400	50,451	9.2E-04	2,298	0.2
			1526R	Middle	460	--	612,000	81,813	6.8E-04	7,658	0.06
			1565D	Middle	579	0.33	368,800	49,301	2.8E-03	1,448	0.4
			1565R	Middle	579	--	453,700	60,651	4.0E-03	1,448	0.4
4365	12/7/94	568.0	1397D	Lower	680	0.10	11,570	1,547	6.3E-04	340	2.0
(Lower)	(8 hrs.)		1397R	Lower	680	--	11,310	1,512	6.7E-04	340	2.0
			1566D	Lower	587	0.12	115,700	15,467	9.3E-04	1,173	0.5
			1566R	Lower	587	--	136,000	18,181	3.3E-01	1,173	0.5
4370	8/4/95	391.8	1488D	Middle	648	0.16	391,000	52,269	9.3E-03	926	0.7
(Upper)	(8 hrs.)										
4375	8/2/95	210.9	1488D	Middle	657	0.16	191,900	25,653	3.3E-03	938	0.7
(Middle)	(8 hrs.)		1488R	Middle	657	--	179,100	23,942	2.6E-03	821	0.8
			1572D	Middle	952	0.13	96,190	12,859	1.3E-03	635	1.5
			1572R	Middle	952	--	149,000	19,918	9.2E-04	952	1.0
			1573D	Lower	952	0.17	36,570	4,889	9.0E-04	476	2.0
			1573R	Lower	952	--	34,930	4,669	8.8E-04	476	2.0
4380	8/8/95	98.9	1489D	Deeper	628	1.23	13,620	1,821	7.7E-04	1,569	0.4
(Lower)	(8 hrs.)		1489R	Deeper	628	--	15,290	2,044	1.1E-03	1,569	0.4
			1573D	Lower	1,006	0.13	16,760	2,240	1.3E-03	503	2.0
			1573R	Lower	1,006	--	12,420	1,660	1.2E-03	402	2.5

Notes: D = drawdown analysis
R = recovery analysis
r = distance from pumped well
s = maximum drawdown measured during test
b = aquifer thickness
T = aquifer transmissivity
S = aquifer storage coefficient
L = Leakage Factor (r/(r/B))

Table G-1

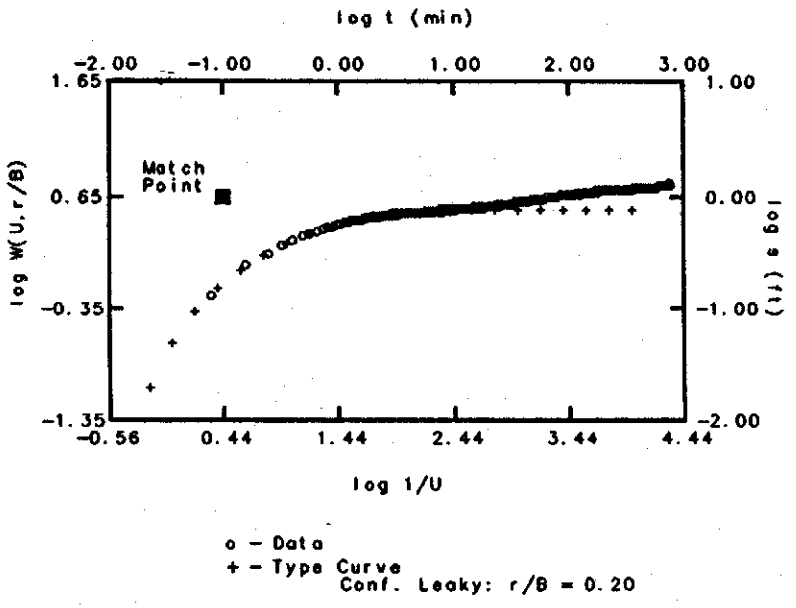
4300 Test – Drawdown Well 1395



MATCH POINT			SOLUTION		
t	=	1.000E-0001	Transmissivity	=	7.920E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.980E+0003 gpd/sq ft
1/U	=	1.288E+0000	Storativity	=	9.182E-0005
W(U,r/B)	=	2.239E-0001	Leakage Factor	=	3.943E+0002 ft

WELL INFORMATION		
WELL IDENTIFICATION	:	1395D
DATE OF AQUIFER TEST	:	11/8/93
AQUIFER THICKNESS (b)	:	4.000E+0001 ft
DISCHARGE RATE (Q)	:	3.088E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.577E+0002 ft

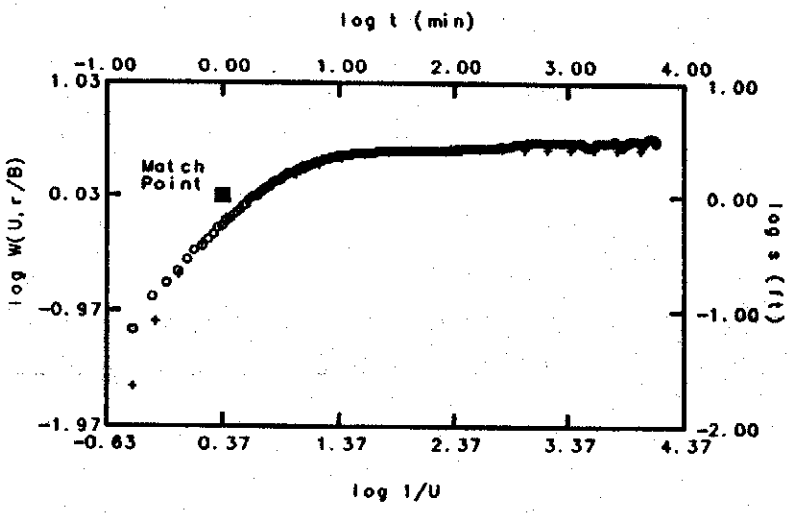
4300 Test – Recovery Well 1395



MATCH POINT			SOLUTION		
t	=	1.000E-0001	Transmissivity	=	1.580E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	3.951E+0003 gpd/sq ft
1/U	=	2.754E+0000	Storativity	=	8.569E-0005
W(U,r/B)	=	4.467E-0001	Leakage Factor	=	7.885E+0002 ft

WELL INFORMATION		
WELL IDENTIFICATION	:	1395R
DATE OF AQUIFER TEST	:	11/8/93
AQUIFER THICKNESS (b)	:	4.000E+0001 ft
DISCHARGE RATE (Q)	:	3.088E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.577E+0002 ft

4301 Test – Drawdown Well 1396



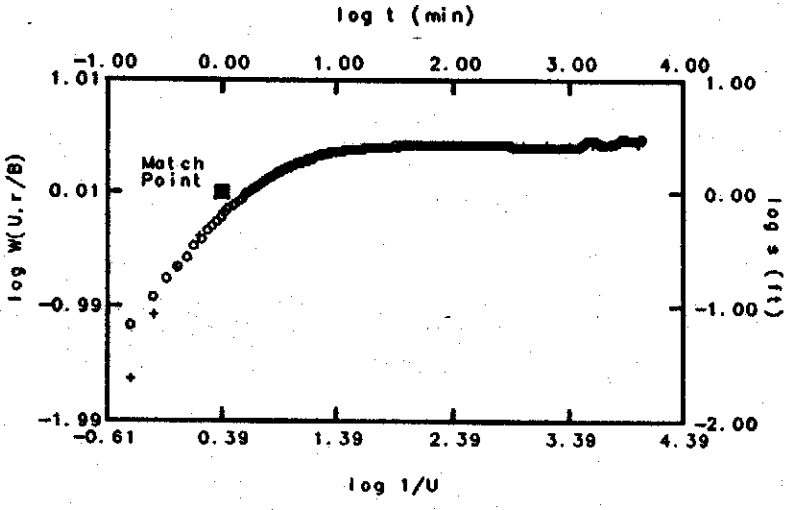
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	2.680E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	2.680E+0003 gpd/sq ft
1/U	=	2.344E+0000	Storativity	=	1.346E-0004
W(U,r/B)	=	1.072E-0001	Leakage Factor	=	5.920E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	1396D
DATE OF AQUIFER TEST	:	11/15/93
AQUIFER THICKNESS (b)	:	1.000E+0001 ft
DISCHARGE RATE (Q)	:	2.183E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.776E+0002 ft

4301 Test – Recovery Well 1396



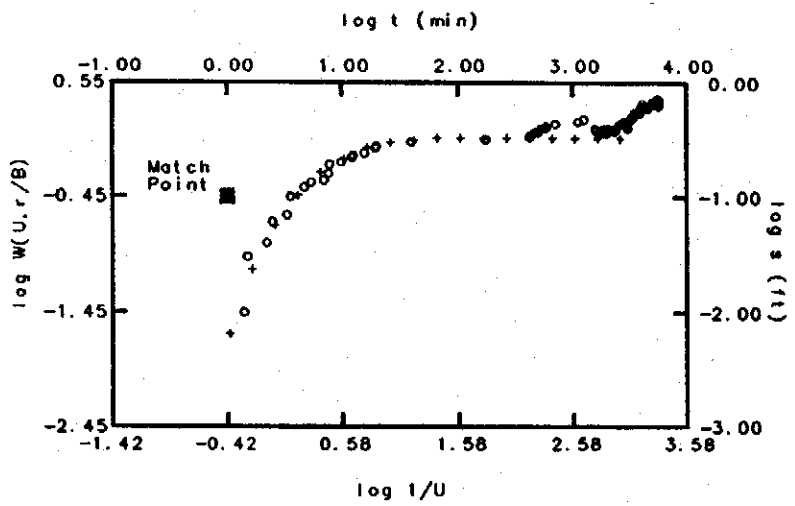
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	2.559E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	2.559E+0003 gpd/sq ft
1/U	=	2.455E+0000	Storativity	=	1.228E-0004
W(U,r/B)	=	1.023E-0001	Leakage Factor	=	5.920E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	1396R
DATE OF AQUIFER TEST	:	11/15/93
AQUIFER THICKNESS (b)	:	1.000E+0001 ft
DISCHARGE RATE (Q)	:	2.183E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.776E+0002 ft

4301 Test – Drawdown Well 1539

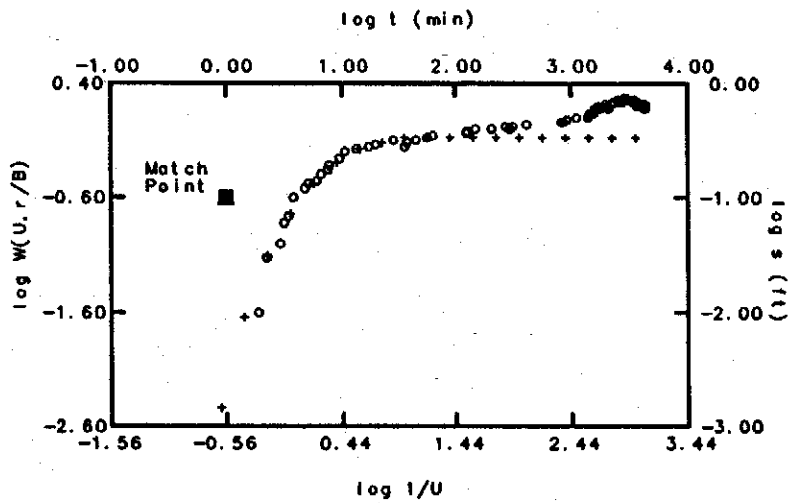


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.80

MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 8.874E+0004 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 8.874E+0003 gpd/sq ft
1/U	= 3.802E-0001	Storativity	= 2.462E-0004
W(U,r/B)	= 3.548E-0002	Leakage Factor	= 7.418E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 1539D
DATE OF AQUIFER TEST	: 11/T5/93
AQUIFER THICKNESS (b)	: 1.000E+0001 ft
DISCHARGE RATE (Q)	: 2.183E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.934E+0002 ft

4301 Test – Recovery Well 1539

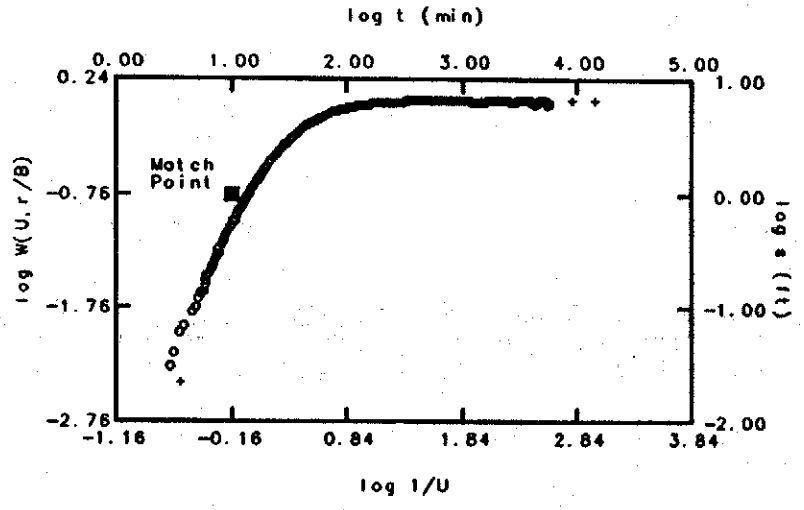


o – Data
+ – Type Curve
Conf. Leaky: r/B = 1.00

MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 6.282E+0004 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 6.282E+0003 gpd/sq ft
1/U	= 2.754E-0001	Storativity	= 2.406E-0004
W(U,r/B)	= 2.512E-0002	Leakage Factor	= 5.934E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 1539R
DATE OF AQUIFER TEST	: 11/15/93
AQUIFER THICKNESS (b)	: 1.000E+0001 ft
DISCHARGE RATE (Q)	: 2.183E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.934E+0002 ft

4302 Test – Drawdown Well 1397

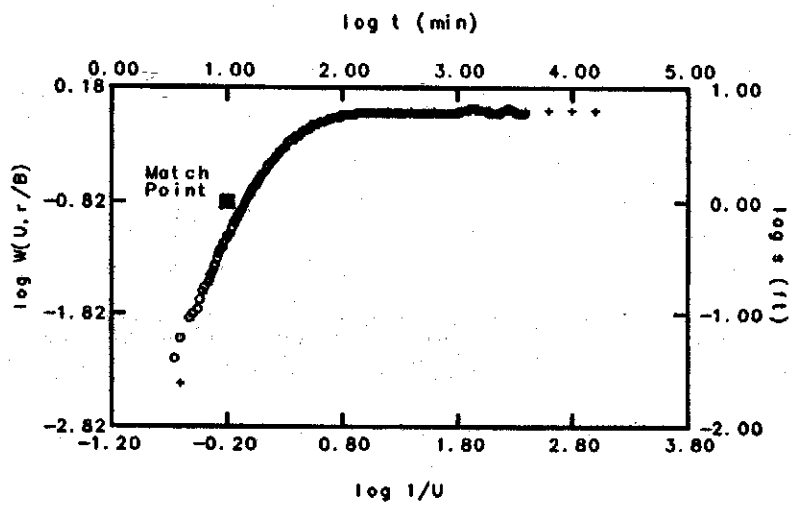


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.80

MATCH POINT		SOLUTION	
t =	1.000E+0001	Transmissivity =	6.969E+0002 gpd/ft
s =	1.000E+0000	Hydraulic. Cond. =	3.484E+0001 gpd/sq ft
1/U =	6.918E-0001	Storativity =	1.936E-0004
W(U,r/B) =	1.738E-0002	Leakage Factor =	1.738E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 1397D
DATE OF AQUIFER TEST	: 11/1/93
AQUIFER THICKNESS (b)	: 2.000E+0001 ft
DISCHARGE RATE (Q)	: 3.500E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.390E+0002 ft

4302 Test – Recovery Well 1397

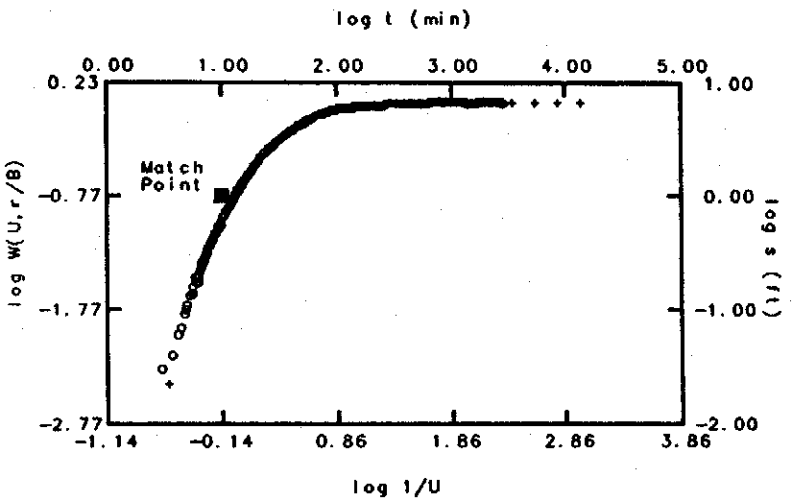


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT		SOLUTION	
t =	1.000E+0001	Transmissivity =	6.069E+0002 gpd/ft
s =	1.000E+0000	Hydraulic. Cond. =	3.035E+0001 gpd/sq ft
1/U =	6.310E-0001	Storativity =	1.849E-0004
W(U,r/B) =	1.514E-0002	Leakage Factor =	1.544E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 1397R
DATE OF AQUIFER TEST	: 11/1/93
AQUIFER THICKNESS (b)	: 2.000E+0001 ft
DISCHARGE RATE (Q)	: 3.500E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.390E+0002 ft

4302 Test – Drawdown Well 1397



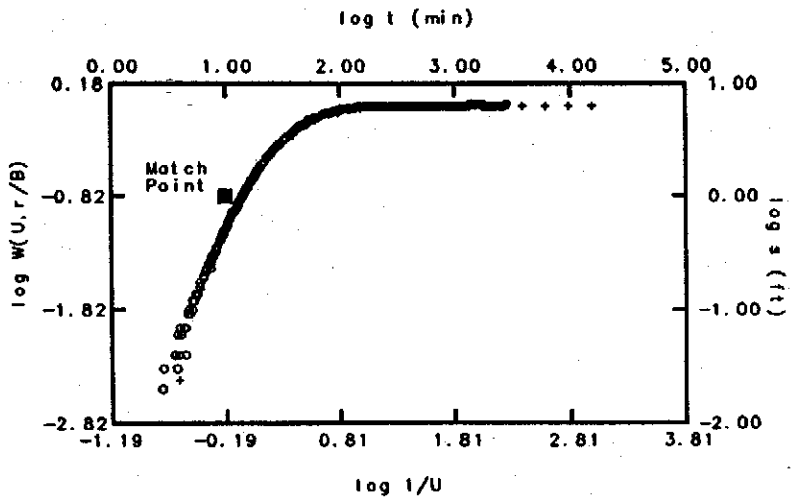
o – Data
+ – Type Curve
Conf Leaky: r/B = 0.80

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	6.868E+0002 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	3.434E+0001 gpd/sq ft
1/U	=	7.244E-0001	Storativity	=	1.822E-0004
W(U,r/B)	=	1.698E-0002	Leakage Factor	=	1.738E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	1397D
DATE OF AQUIFER TEST	:	11/22/93
AQUIFER THICKNESS (b)	:	2.000E+0001 ft
DISCHARGE RATE (Q)	:	3.530E+0001 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.390E+0002 ft

4302 Test – Recovery Well 1397



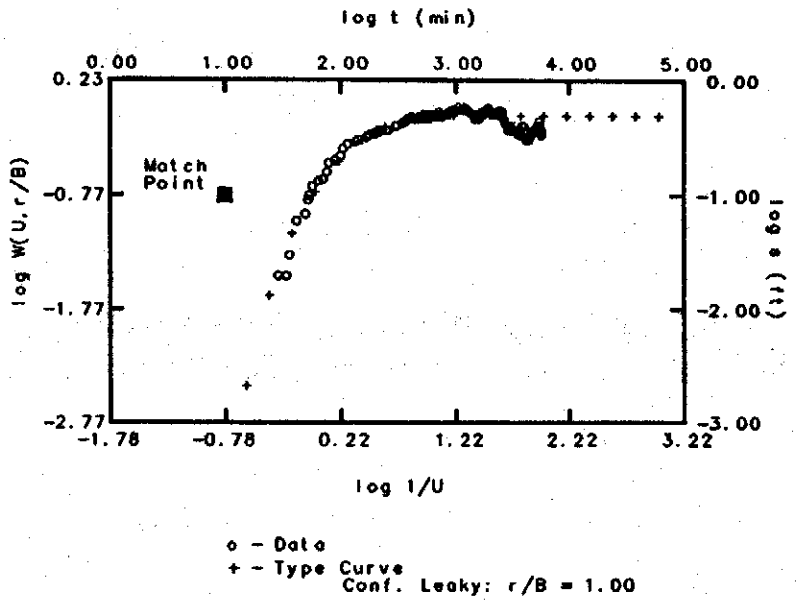
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	6.121E+0002 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	3.061E+0001 gpd/sq ft
1/U	=	6.457E-0001	Storativity	=	1.822E-0004
W(U,r/B)	=	1.514E-0002	Leakage Factor	=	1.544E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	1397R
DATE OF AQUIFER TEST	:	11/22/93
AQUIFER THICKNESS (b)	:	2.000E+0001 ft
DISCHARGE RATE (Q)	:	3.530E+0001 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.390E+0002 ft

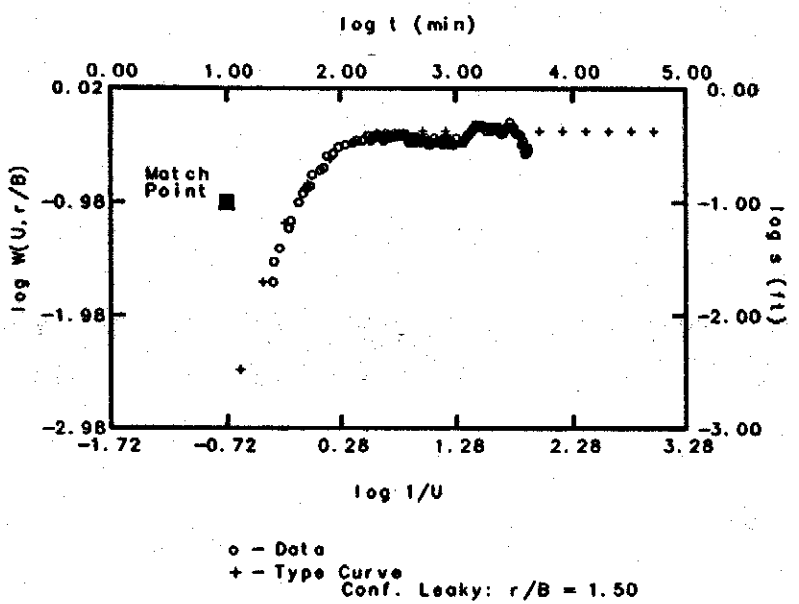
4302 Test – Drawdown Well 1540



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	6.810E+0003 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.405E+0002 gpd/sq ft
1/U	=	1.660E-0001	Storativity	=	4.515E-0004
W(U,r/B)	=	1.698E-0002	Leakage Factor	=	5.810E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 1540D
DATE OF AQUIFER TEST	: 11/1/93
AQUIFER THICKNESS (b)	: 2.000E+0001 ft
DISCHARGE RATE (Q)	: 3.500E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.810E+0002 ft

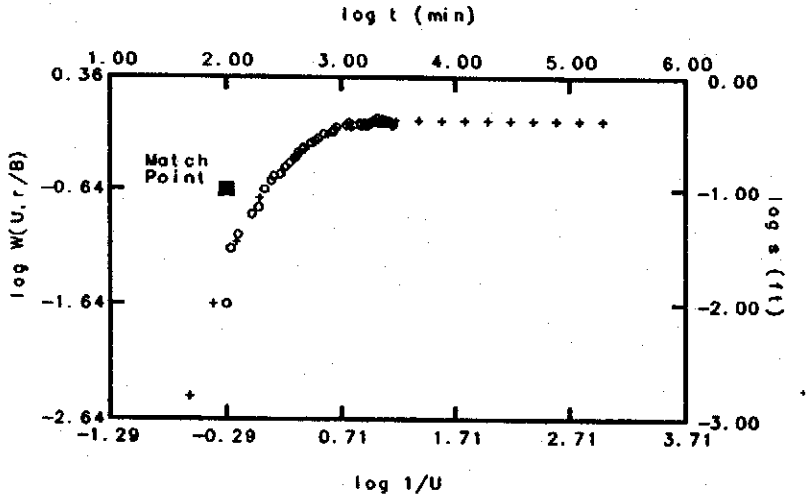
4302 Test – Recovery Well 1540



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	4.199E+0003 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	2.099E+0002 gpd/sq ft
1/U	=	1.905E-0001	Storativity	=	2.425E-0004
W(U,r/B)	=	1.047E-0002	Leakage Factor	=	3.873E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 1540R
DATE OF AQUIFER TEST	: 11/1/93
AQUIFER THICKNESS (b)	: 2.000E+0001 ft
DISCHARGE RATE (Q)	: 3.500E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.810E+0002 ft

4302 Test – Drawdown Well 1533

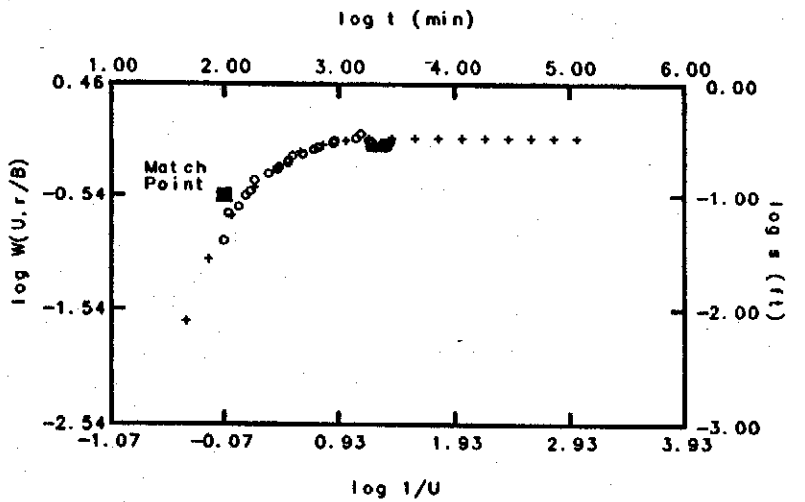


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT		SOLUTION	
t =	1.000E+0002	Transmissivity =	9.186E+0003 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	4.593E+0002 gpd/sq ft
1/U =	5.129E-0001	Storativity =	3.690E-0004
W(U,r/B) =	2.291E-0002	Leakage Factor =	1.492E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 1533D
DATE OF AQUIFER TEST	: 11/22/93
AQUIFER THICKNESS (b)	: 2.000E+0001 ft
DISCHARGE RATE (Q)	: 3.500E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.343E+0003 ft

4302 Test – Recovery Well 1533

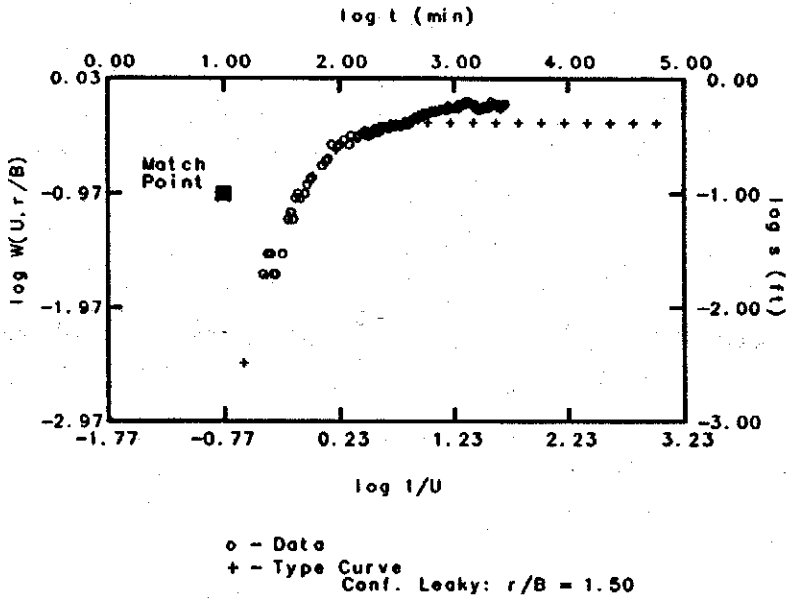


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT		SOLUTION	
t =	1.000E+0002	Transmissivity =	1.156E+0004 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	5.782E+0002 gpd/sq ft
1/U =	8.511E-0001	Storativity =	2.799E-0004
W(U,r/B) =	2.884E-0002	Leakage Factor =	1.492E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 1533R
DATE OF AQUIFER TEST	: 11/22/93
AQUIFER THICKNESS (b)	: 2.000E+0001 ft
DISCHARGE RATE (Q)	: 3.500E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.343E+0003 ft

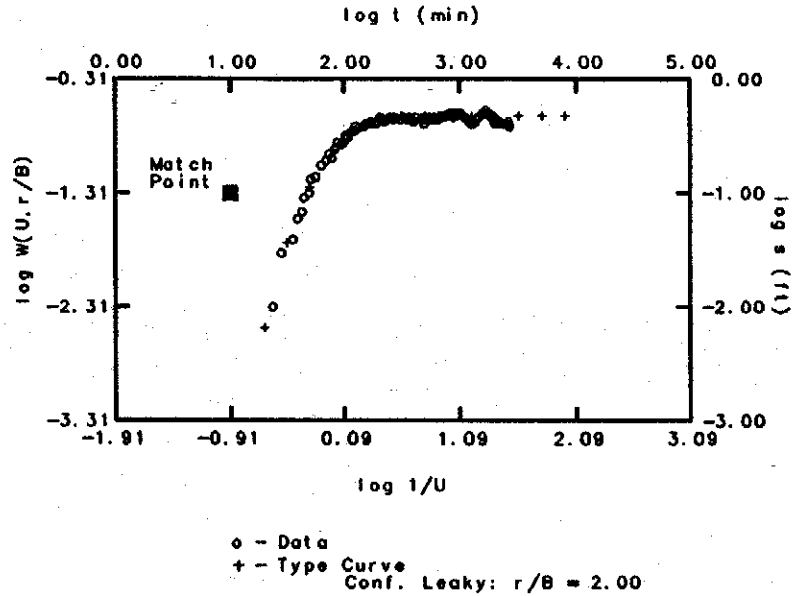
4302 Test – Drawdown Well 1540



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	4.334E+0003 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	2.167E+0002 gpd/sq ft
1/U	=	1.698E-0001	Storativity	=	2.808E-0004
W(U,r/B)	=	1.072E-0002	Leakage Factor	=	3.873E+0002 ft

WELL INFORMATION		
WELL IDENTIFICATION	:	1540D
DATE OF AQUIFER TEST	:	11/22/93
AQUIFER THICKNESS (b)	:	2.000E+0001 ft
DISCHARGE RATE (Q)	:	3.530E+0001 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	5.810E+0002 ft

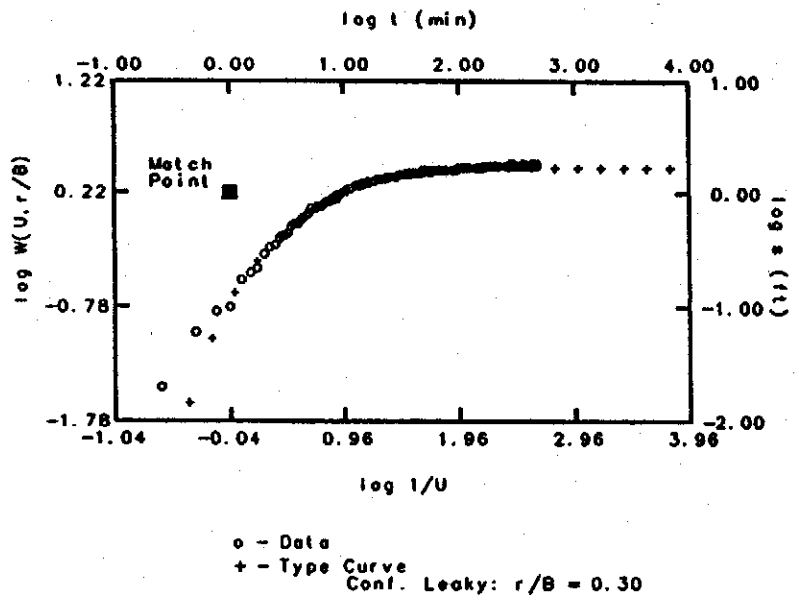
4302 Test – Recovery Well 1540



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.981E+0003 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	9.904E+0001 gpd/sq ft
1/U	=	1.230E-0001	Storativity	=	1.771E-0004
W(U,r/B)	=	4.898E-0003	Leakage Factor	=	2.905E+0002 ft

WELL INFORMATION		
WELL IDENTIFICATION	:	1540R
DATE OF AQUIFER TEST	:	11/22/93
AQUIFER THICKNESS (b)	:	2.000E+0001 ft
DISCHARGE RATE (Q)	:	3.530E+0001 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	5.810E+0002 ft

4325 Test - Drawdown Well 1357

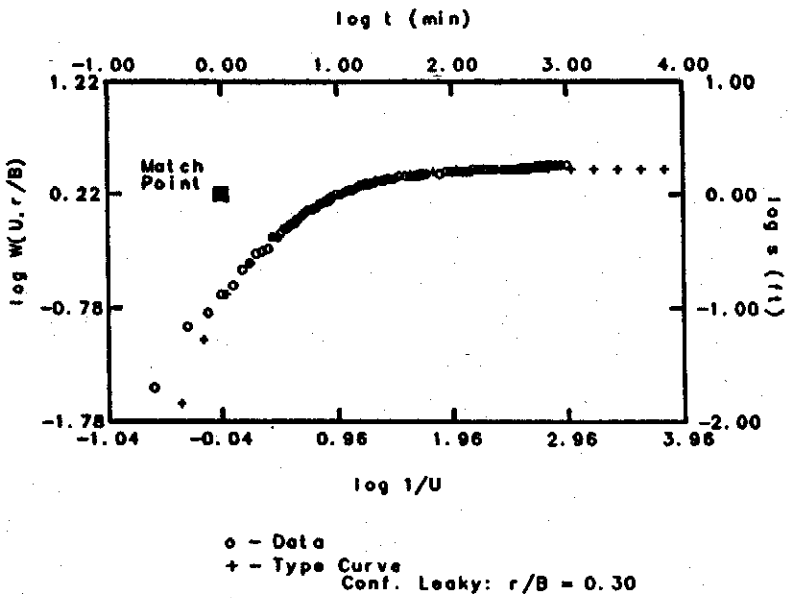


o - Data
+ - Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT		SOLUTION	
t = 1.000E+0000		Transmissivity = 8.077E+0004 gpd/ft	
s = 1.000E+0000		Hydraulic. Cond. = 8.077E+0004 gpd/sq ft	
1/U = 9.120E-0001		Storativity = 1.964E-0004	
W(U,r/B) = 1.660E-0001		Leakage Factor = 1.364E+0003 ft	

WELL INFORMATION	
WELL IDENTIFICATION	: 4325DD
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.092E+0002 ft

4325 Test - Recovery Well 1357

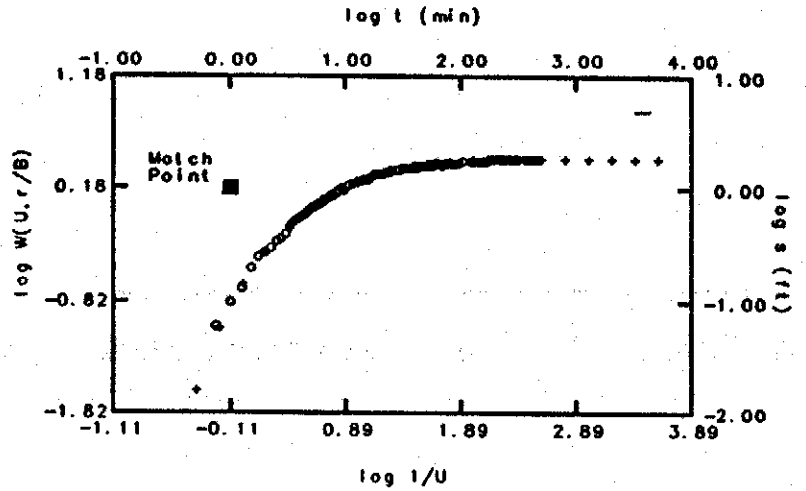


o - Data
+ - Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT		SOLUTION	
t = 1.000E+0000		Transmissivity = 8.077E+0004 gpd/ft	
s = 1.000E+0000		Hydraulic. Cond. = 8.077E+0004 gpd/sq ft	
1/U = 9.120E-0001		Storativity = 1.964E-0004	
W(U,r/B) = 1.660E-0001		Leakage Factor = 1.364E+0003 ft	

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.092E+0002 ft

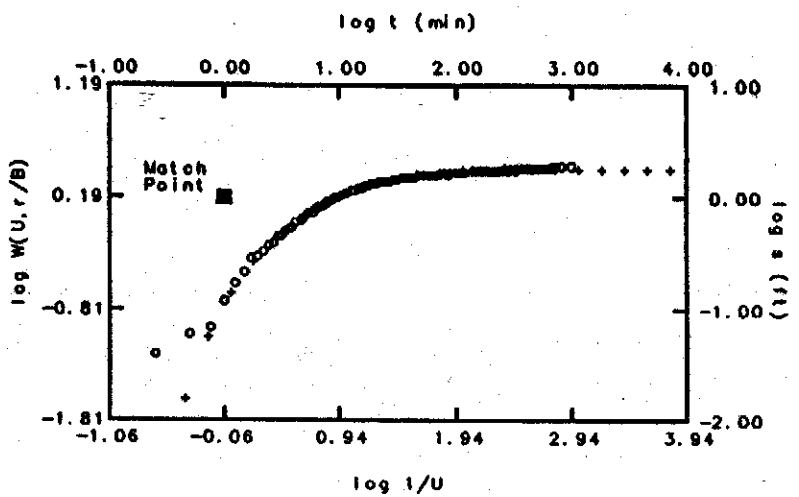
4325 Test – Drawdown Well 1358



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	7.366E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	7.366E+0004 gpd/sq ft
1/U	=	7.762E-0001	Storativity	=	2.105E-0004
W(U,r/B)	=	1.514E-0001	Leakage Factor	=	1.364E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325DD
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.092E+0002 ft

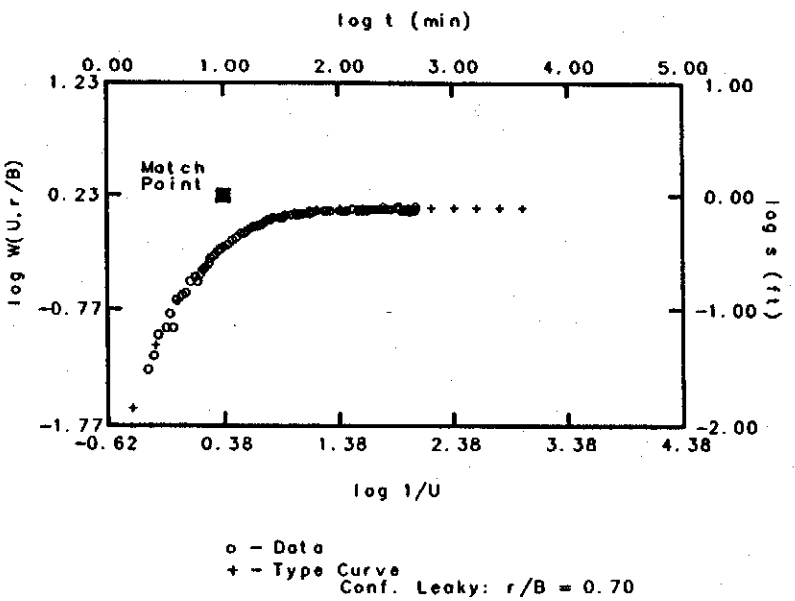
4325 Test – Recovery Well 1358



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	7.538E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	7.538E+0004 gpd/sq ft
1/U	=	8.710E-0001	Storativity	=	1.920E-0004
W(U,r/B)	=	1.549E-0001	Leakage Factor	=	1.364E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.092E+0002 ft

4325 Test – Drawdown Well 1370

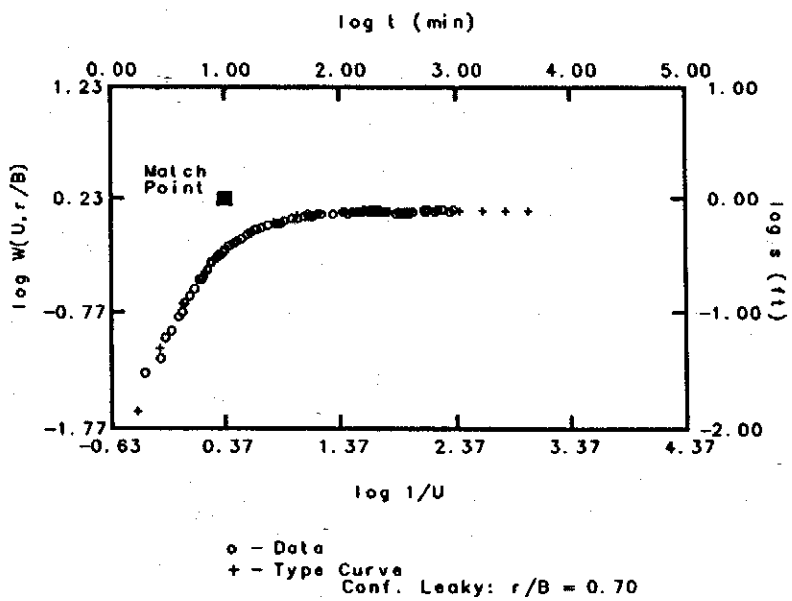


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 8.265E+0004 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 8.265E+0004 gpd/sq ft
1/U	= 2.399E+0000	Storativity	= 1.658E-0004
W(U,r/B)	= 1.698E-0001	Leakage Factor	= 1.255E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.785E+0002 ft

4325 Test – Recovery Well 1370

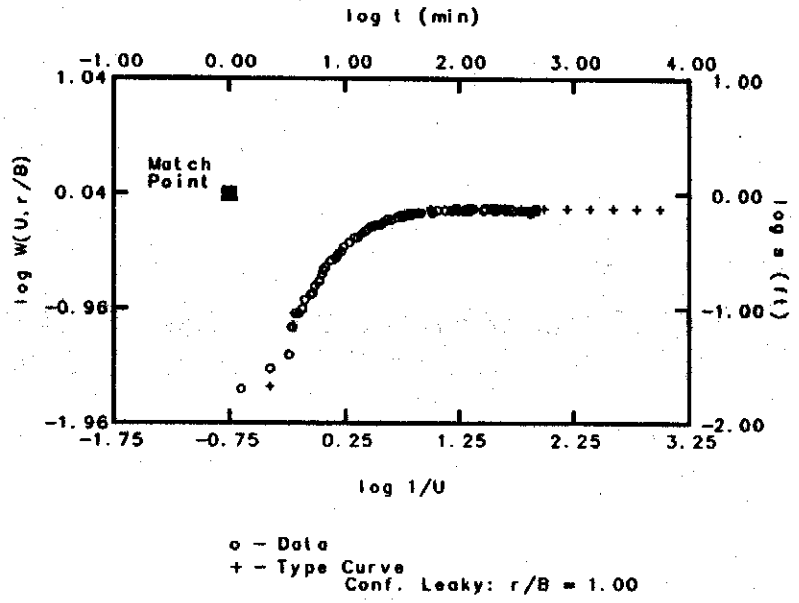


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 8.265E+0004 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 8.265E+0004 gpd/sq ft
1/U	= 2.344E+0000	Storativity	= 1.697E-0004
W(U,r/B)	= 1.698E-0001	Leakage Factor	= 1.255E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.785E+0002 ft

4325 Test – Drawdown Well 1371



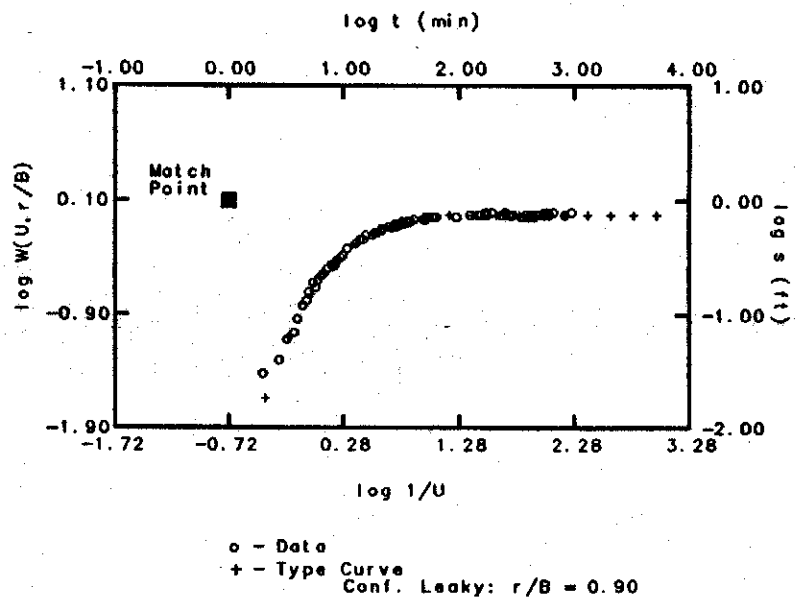
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 1.00

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.337E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	5.337E+0004 gpd/sq ft
1/U	=	1.778E-0001	Storativity	=	1.444E-0004
W(U,r/B)	=	1.096E-0001	Leakage Factor	=	8.785E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4325D
DATE OF AQUIFER TEST	:	8/29/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.248E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	8.785E+0002 ft

4325 Test – Recovery Well 1371



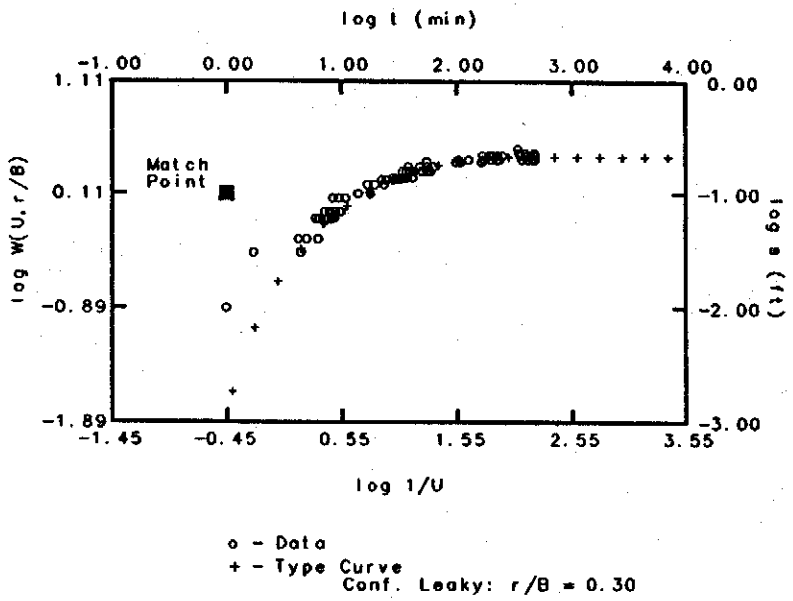
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.127E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	6.127E+0004 gpd/sq ft
1/U	=	1.905E-0001	Storativity	=	1.547E-0004
W(U,r/B)	=	1.259E-0001	Leakage Factor	=	9.761E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4325R
DATE OF AQUIFER TEST	:	8/29/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.248E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	8.785E+0002 ft

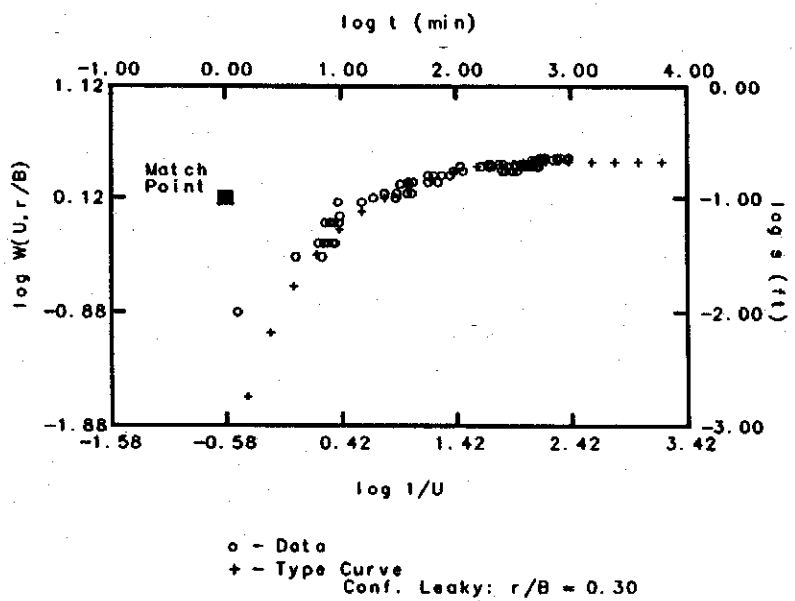
4325 Test – Drawdown Well 1388



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.270E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	6.270E+0005 gpd/sq ft
1/U	=	3.548E-0001	Storativity	=	6.520E-0004
W(U,r/B)	=	1.288E-0001	Leakage Factor	=	3.344E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.003E+0003 ft

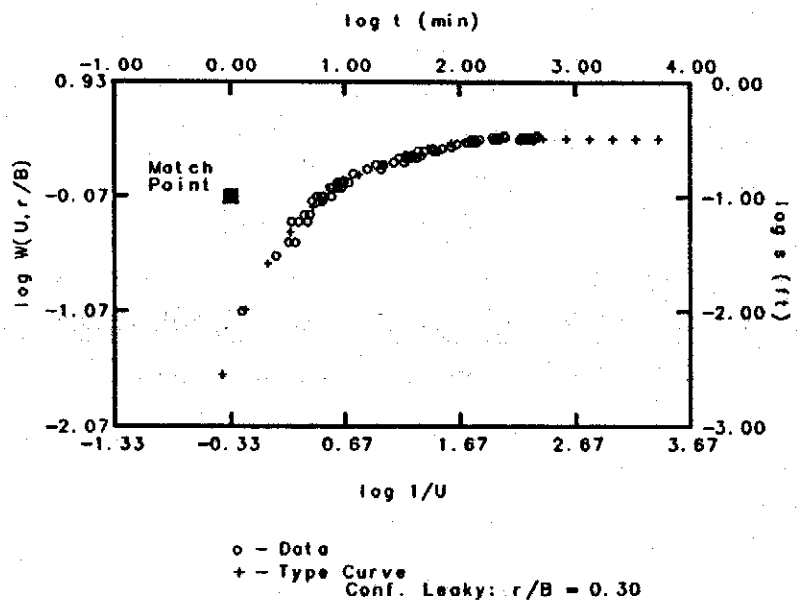
4325 Test – Recovery Well 1388



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.416E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	6.416E+0005 gpd/sq ft
1/U	=	2.630E-0001	Storativity	=	9.005E-0004
W(U,r/B)	=	1.318E-0001	Leakage Factor	=	3.343E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.003E+0003 ft

4325 Test - Drawdown Well 1404

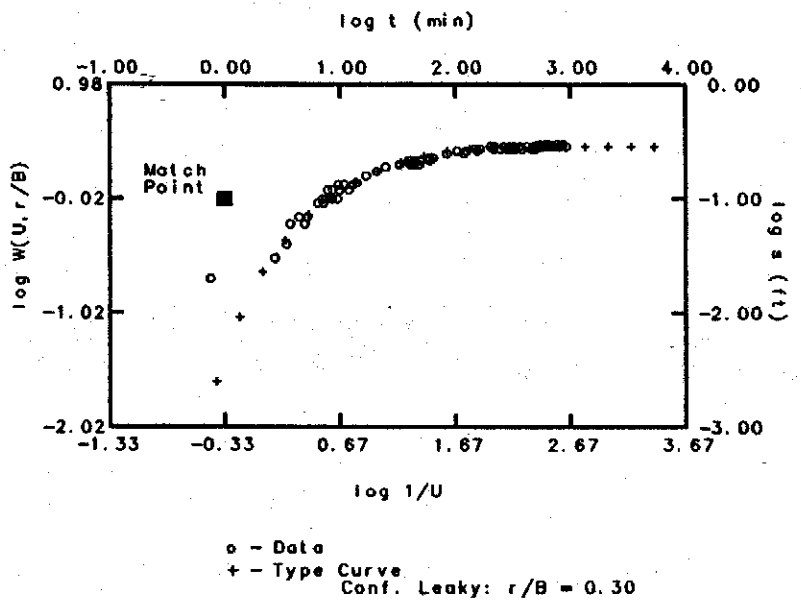


o - Data
+ - Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.142E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.142E+0005 gpd/sq ft
1/U	=	4.677E-0001	Storativity	=	5.488E-0004
W(U,r/B)	=	8.511E-0002	Leakage Factor	=	2.581E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.742E+0002 ft

4325 Test - Recovery Well 1404

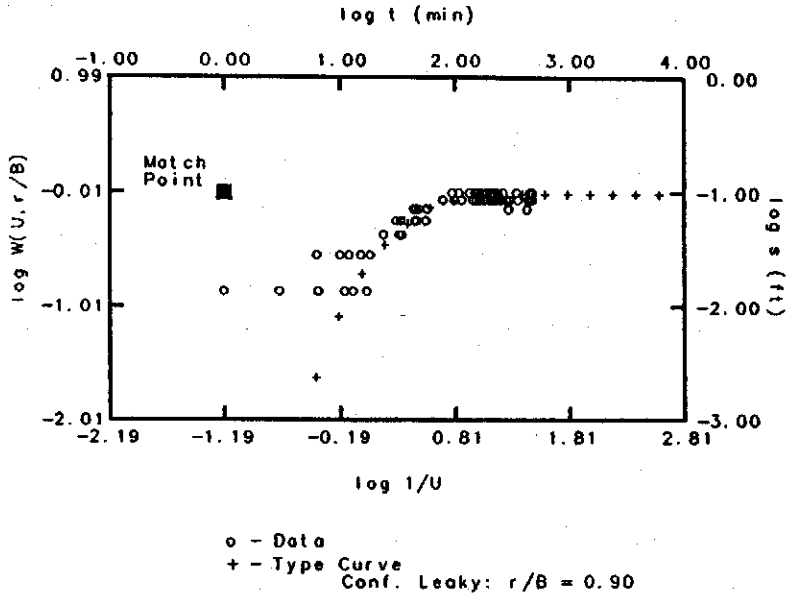


o - Data
+ - Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.648E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.648E+0005 gpd/sq ft
1/U	=	4.677E-0001	Storativity	=	6.157E-0004
W(U,r/B)	=	9.550E-0002	Leakage Factor	=	2.581E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.742E+0002 ft

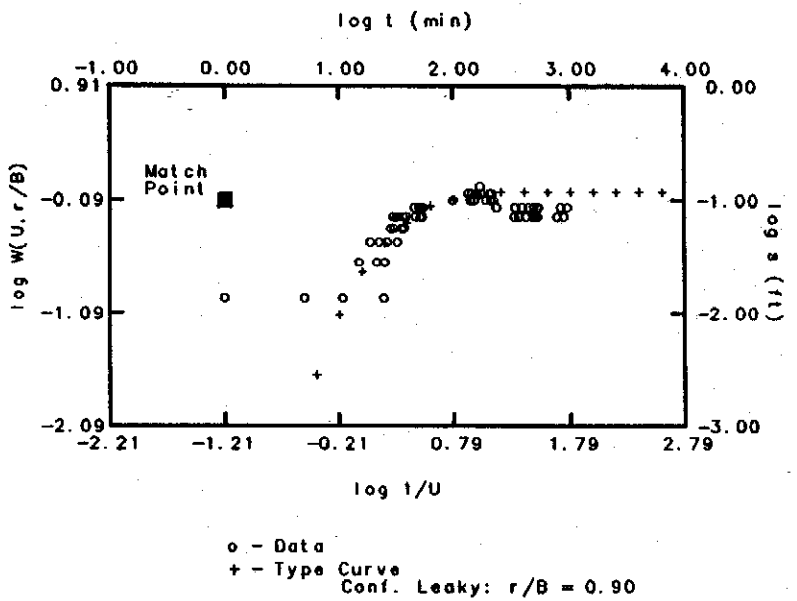
4325 Test – Drawdown Well 1469



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.756E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.756E+0005 gpd/sq ft
1/U	=	6.457E-0002	Storativity	=	3.931E-0003
W(U,r/B)	=	9.772E-0002	Leakage Factor	=	9.270E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.343E+0002 ft

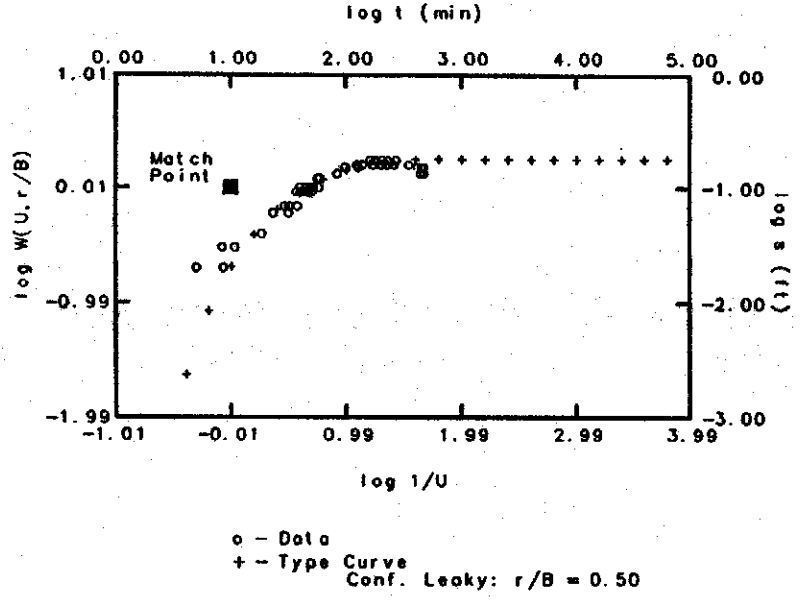
4325 Test – Recovery Well 1469



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	3.956E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.956E+0005 gpd/sq ft
1/U	=	6.166E-0002	Storativity	=	3.423E-0003
W(U,r/B)	=	8.128E-0002	Leakage Factor	=	9.270E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.343E+0002 ft

4325 Test – Drawdown Well 1478



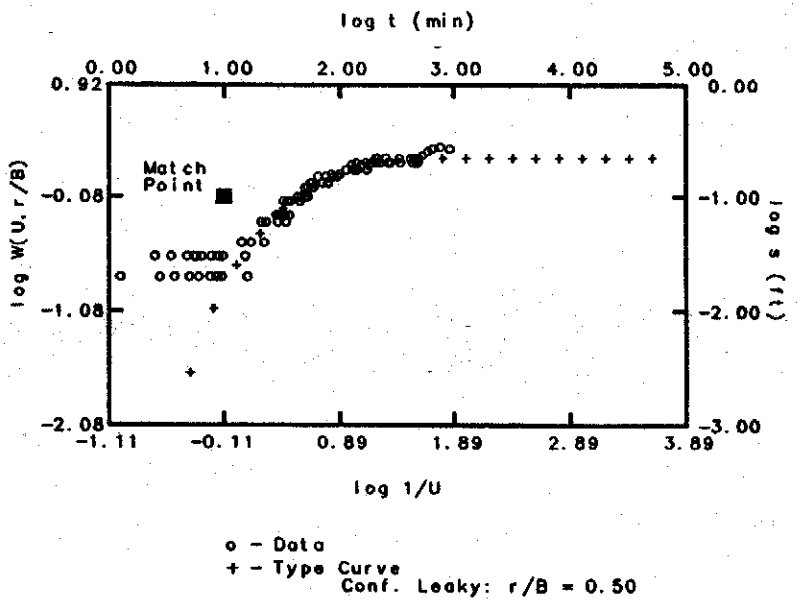
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.50

MATCH POINT		SOLUTION	
t =	1.000E+0001	Transmissivity =	4.980E+0005 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	4.980E+0005 gpd/sq ft
1/U =	9.772E-0001	Storativity =	1.917E-0003
W(U,r/B) =	1.023E-0001	Leakage Factor =	1.987E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4325D
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.936E+0002 ft

4325 Test – Recovery Well 1478



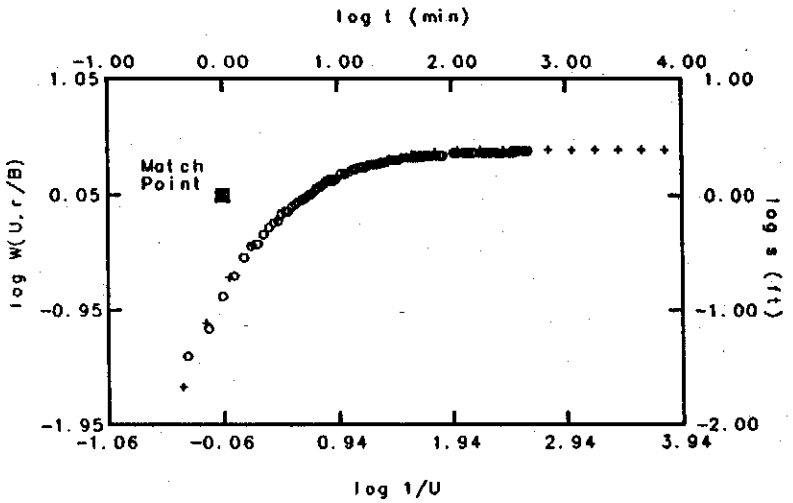
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.50

MATCH POINT		SOLUTION	
t =	1.000E+0001	Transmissivity =	4.048E+0005 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	4.048E+0005 gpd/sq ft
1/U =	7.762E-0001	Storativity =	1.962E-0003
W(U,r/B) =	8.318E-0002	Leakage Factor =	1.987E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4325R
DATE OF AQUIFER TEST	: 8/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.248E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.936E+0002 ft

4330 Test – Drawdown Well 1357

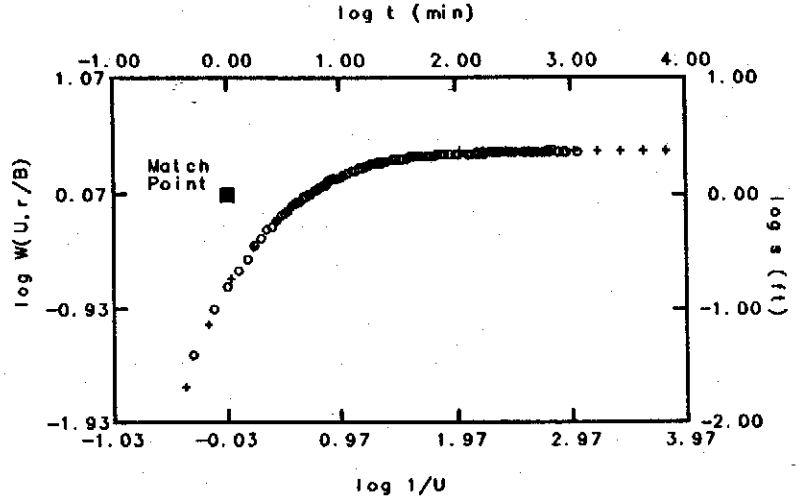


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.819E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	5.819E+0004 gpd/sq ft
1/U	=	8.710E-0001	Storativity	=	1.637E-0004
W(U,r/B)	=	1.122E-0001	Leakage Factor	=	1.298E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330DD
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 3.894E+0002 ft

4330 Test – Recovery Well 1357

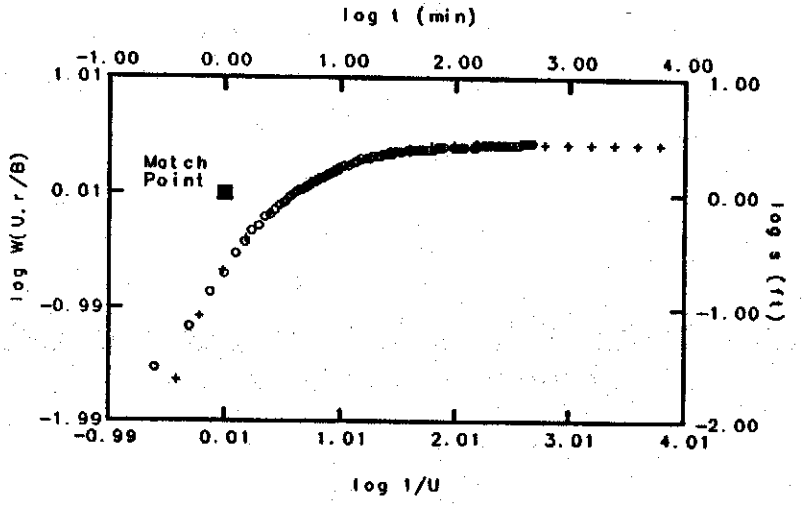


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.094E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	6.094E+0004 gpd/sq ft
1/U	=	9.333E-0001	Storativity	=	1.599E-0004
W(U,r/B)	=	1.175E-0001	Leakage Factor	=	1.298E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 3.894E+0002 ft

4330 Test – Drawdown Well 1358



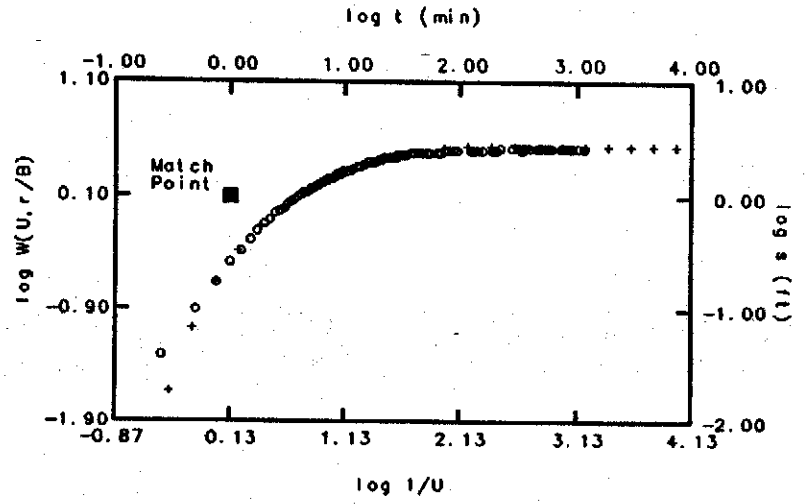
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.307E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	5.307E+0004 gpd/sq ft
1/U	=	1.023E+0000	Storativity	=	1.270E-0004
W(U,r/B)	=	1.023E-0001	Leakage Factor	=	1.298E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4330DD
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	3.894E+0002 ft

4330 Test – Recovery Well 1358



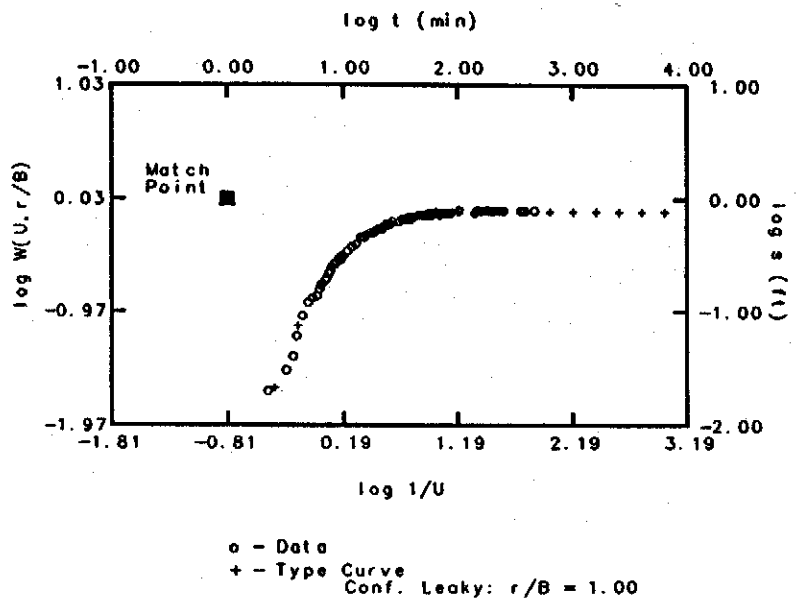
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.530E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	6.530E+0004 gpd/sq ft
1/U	=	1.349E+0000	Storativity	=	1.186E-0004
W(U,r/B)	=	1.259E-0001	Leakage Factor	=	1.947E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4330R
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	3.894E+0002 ft

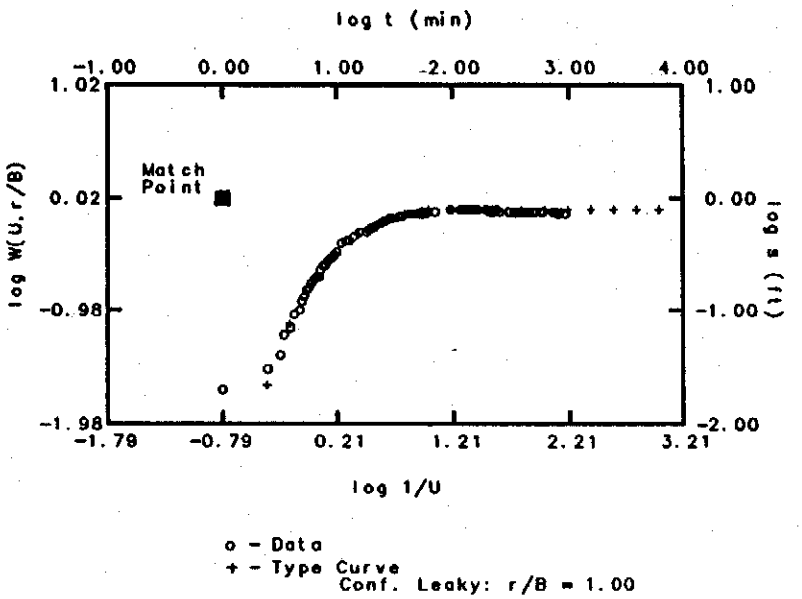
4330 Test – Drawdown Well 1370



MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	5.558E+0004 gpd/ft
s =	1.000E+0000	Hydraulic. Cond. =	5.558E+0004 gpd/sq ft
1/U =	1.549E-0001	Storativity =	1.677E-0004
W(U,r/B) =	1.072E-0001	Leakage Factor =	8.914E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.914E+0002 ft

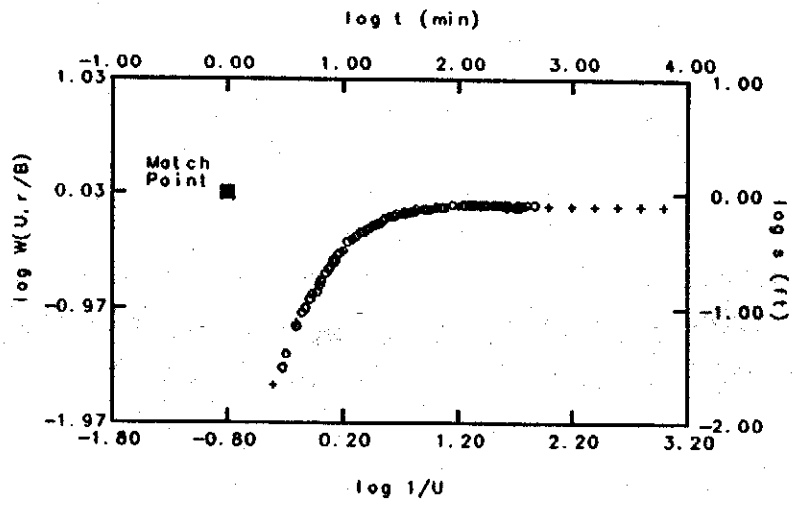
4330 Test – Recovery Well 1370



MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	5.431E+0004 gpd/ft
s =	1.000E+0000	Hydraulic. Cond. =	5.431E+0004 gpd/sq ft
1/U =	1.622E-0001	Storativity =	1.565E-0004
W(U,r/B) =	1.047E-0001	Leakage Factor =	8.914E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.914E+0002 ft

4330 Test – Drawdown Well 1371

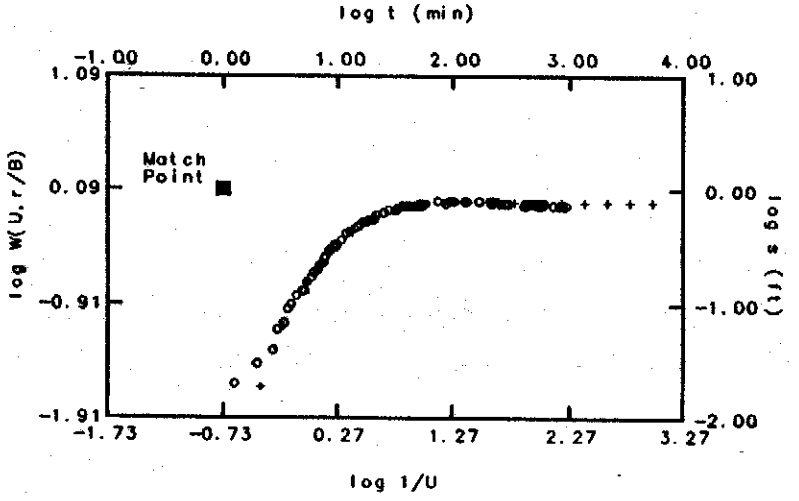


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 1.00

MATCH POINT		SOLUTION	
t = 1.000E+0000		Transmissivity = 5.558E+0004	gpd/ft
s = 1.000E+0000		Hydraulic. Cond. = 5.558E+0004	gpd/sq ft
1/U = 1.585E-0001		Storativity = 1.639E-0004	
W(U, r/B) = 1.072E-0001		Leakage Factor = 8.914E+0002	ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.914E+0002 ft

4330 Test – Recovery Well 1371

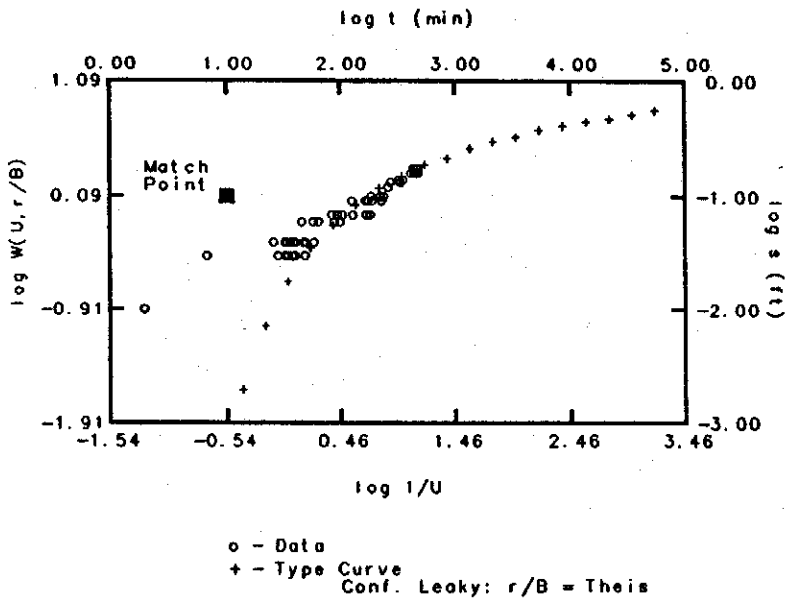


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT		SOLUTION	
t = 1.000E+0000		Transmissivity = 6.381E+0004	gpd/ft
s = 1.000E+0000		Hydraulic. Cond. = 6.381E+0004	gpd/sq ft
1/U = 1.862E-0001		Storativity = 1.602E-0004	
W(U, r/B) = 1.230E-0001		Leakage Factor = 9.904E+0002	ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.914E+0002 ft

4330 Test – Drawdown Well 1379

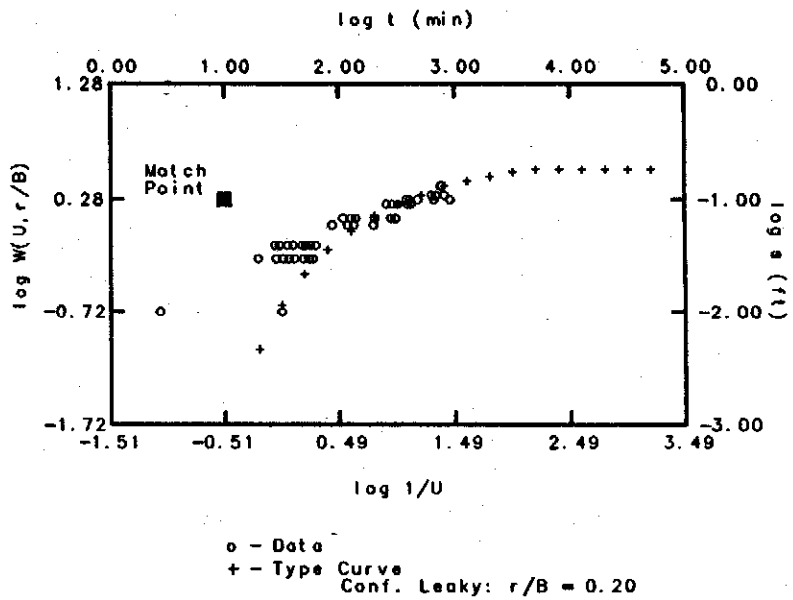


o – Data
\+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	6.381E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	6.381E+0005 gpd/sq ft
1/U	=	2.884E-0001	Storativity	=	1.272E-0002
W(U,r/B)	=	1.230E-0001			

WELL INFORMATION		
WELL IDENTIFICATION	:	4330D
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	8.038E+0002 ft

4330 Test – Recovery Well 1379

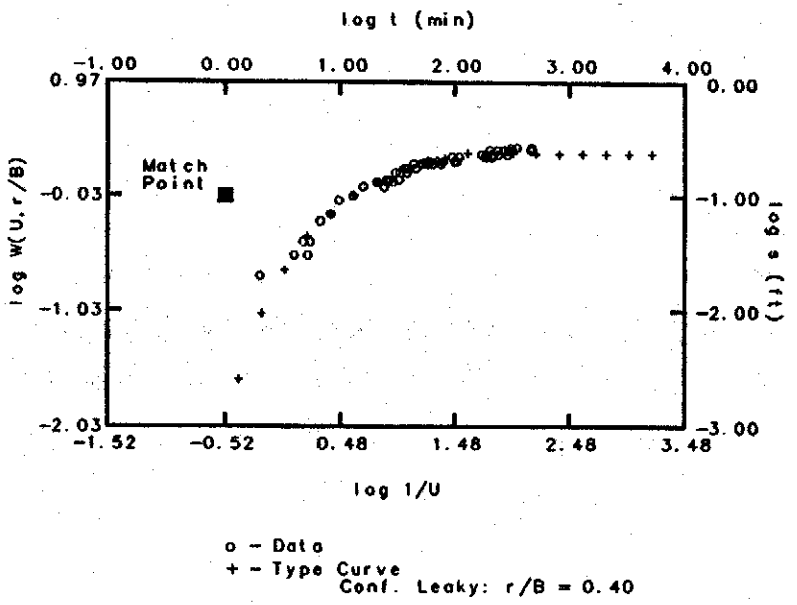


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	9.883E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	9.883E+0005 gpd/sq ft
1/U	=	3.090E-0001	Storativity	=	1.838E-0002
W(U,r/B)	=	1.905E-0001	Leakage Factor	=	4.019E+0003 ft

WELL INFORMATION		
WELL IDENTIFICATION	:	4330R
DATE OF AQUIFER TEST	:	8/24/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.527E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	8.038E+0002 ft

4330 Test – Drawdown Well 1388

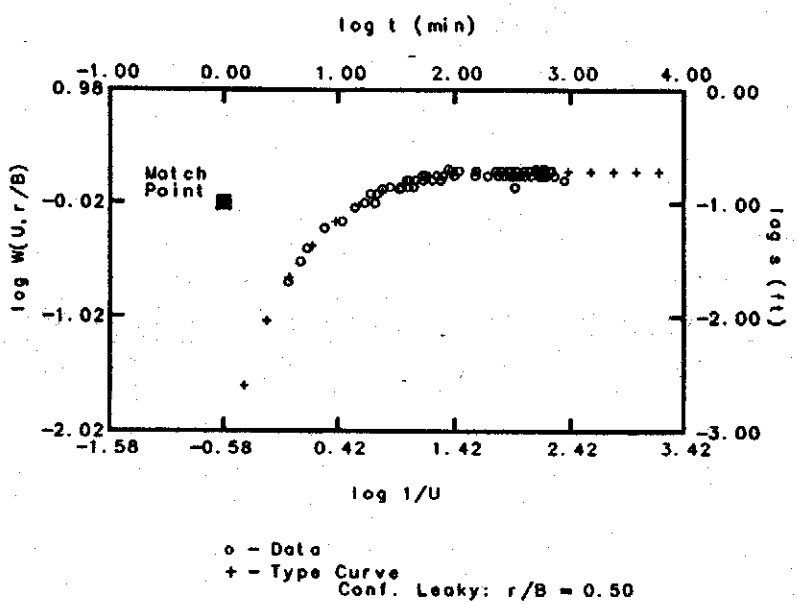


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	4.840E+0005 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	4.840E+0005 gpd/sq ft
1/U =	3.020E-0001	Storativity =	6.007E-0004
W(U,r/B) =	9.333E-0002	Leakage Factor =	2.489E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.955E+0002 ft

4330 Test – Recovery Well 1388

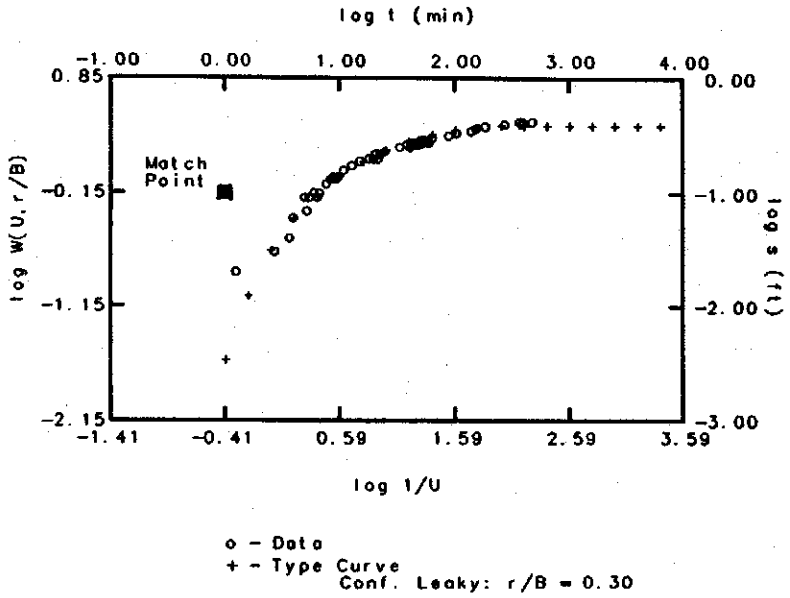


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.50

MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	4.953E+0005 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	4.953E+0005 gpd/sq ft
1/U =	2.630E-0001	Storativity =	7.057E-0004
W(U,r/B) =	9.550E-0002	Leakage Factor =	1.991E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.955E+0002 ft

4330 Test – Drawdown Well 1404

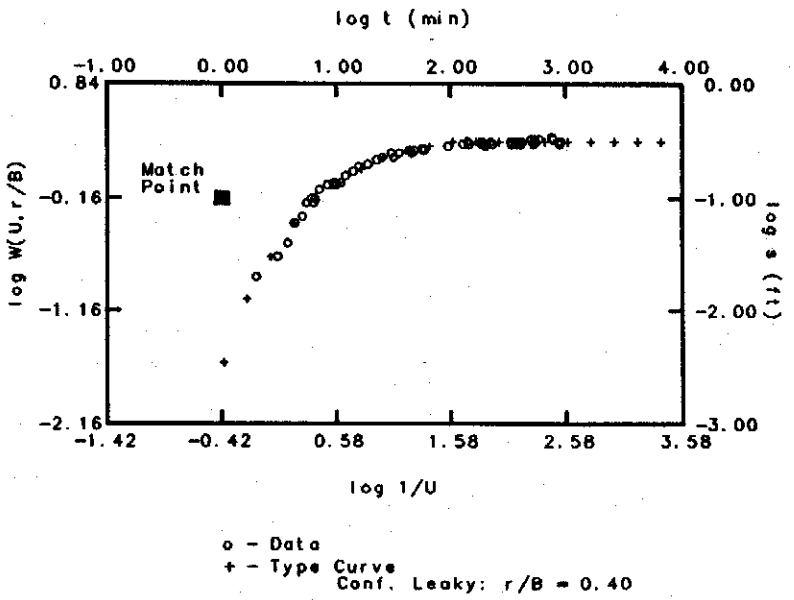


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 3.672E+0005 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 3.672E+0005 gpd/sq ft
1/U	= 3.890E-0001	Storativity	= 5.762E-0004
W(U,r/B)	= 7.079E-0002	Leakage Factor	= 2.600E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.800E+0002 ft

4330 Test – Recovery Well 1404

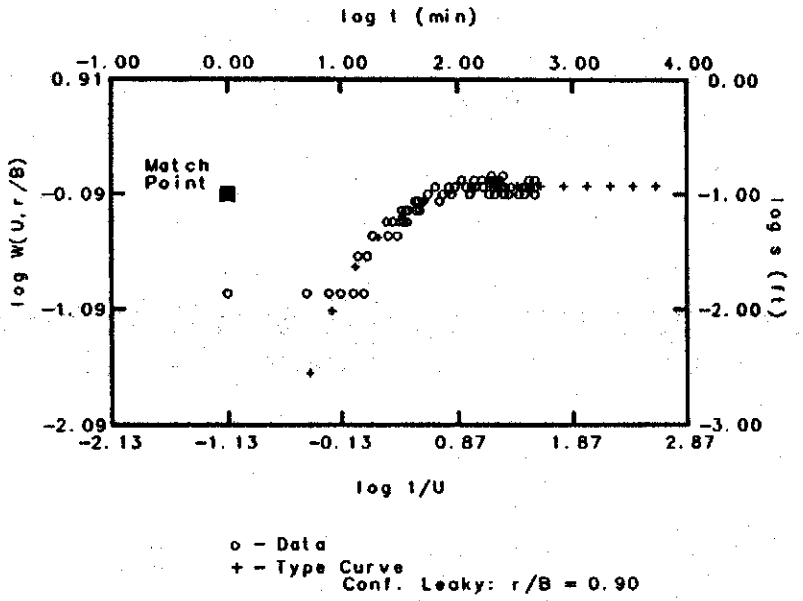


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 3.588E+0005 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 3.588E+0005 gpd/sq ft
1/U	= 3.802E-0001	Storativity	= 5.762E-0004
W(U,r/B)	= 6.918E-0002	Leakage Factor	= 1.950E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.800E+0002 ft

4330 Test – Drawdown Well 1469



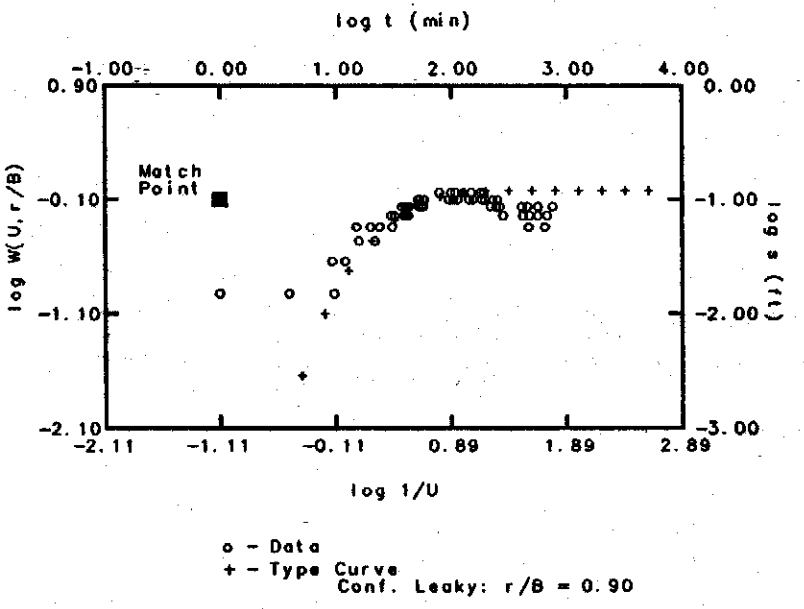
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.216E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.216E+0005 gpd/sq ft
1/U	=	7.413E-0002	Storativity	=	2.940E-0003
W(U,r/B)	=	8.128E-0002	Leakage Factor	=	9.418E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.476E+0002 ft

4330 Test – Recovery Well 1469



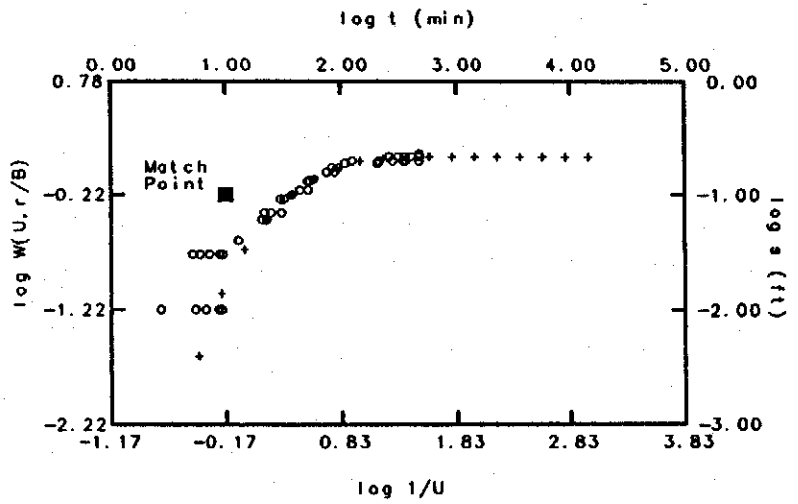
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.120E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.120E+0005 gpd/sq ft
1/U	=	7.762E-0002	Storativity	=	2.744E-0003
W(U,r/B)	=	7.943E-0002	Leakage Factor	=	9.418E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 8.476E+0002 ft

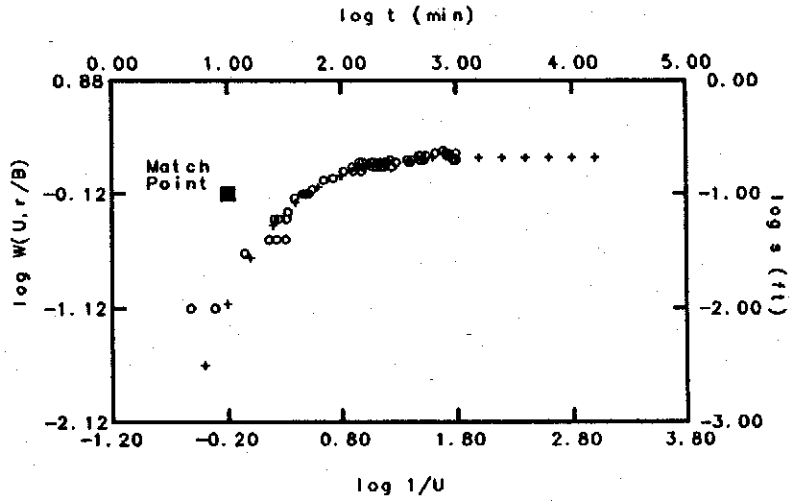
4330 Test – Drawdown Well 1478



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	3.125E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.125E+0005 gpd/sq ft
1/U	=	6.761E-0001	Storativity	=	1.797E-0003
W(U,r/B)	=	6.026E-0002	Leakage Factor	=	1.396E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

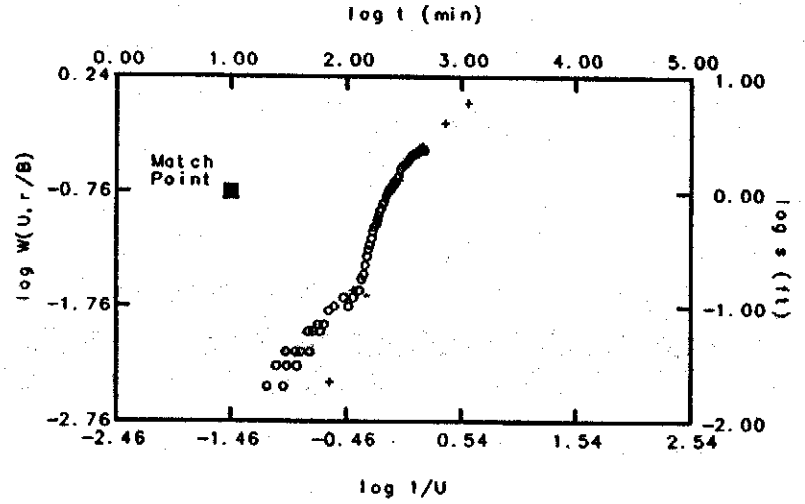
4330 Test – Recovery Well 1478



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	3.934E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.934E+0005 gpd/sq ft
1/U	=	6.310E-0001	Storativity	=	2.424E-0003
W(U,r/B)	=	7.586E-0002	Leakage Factor	=	1.629E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

4330 Test – Drawdown Well 1479

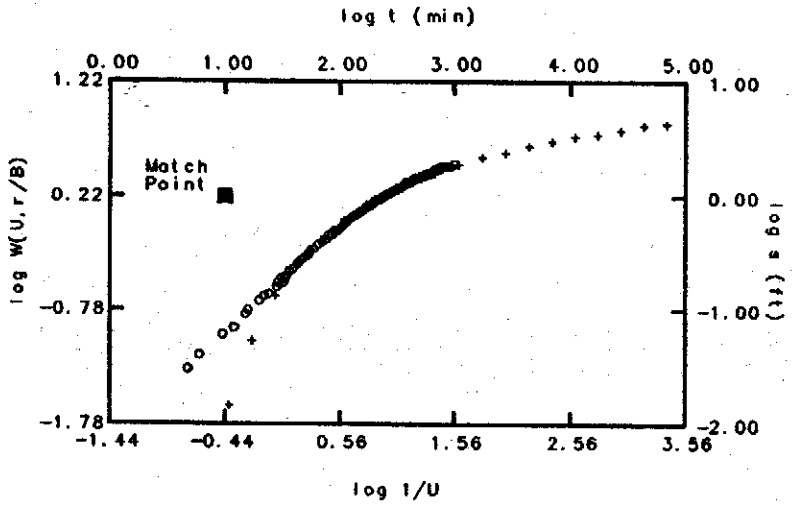


o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	9.013E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	9.013E+0003 gpd/sq ft
1/U	=	3.467E-0002	Storativity	=	1.010E-0003
W(U,r/B)	=	1.738E-0002			

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

4330 Test – Recovery Well 1479

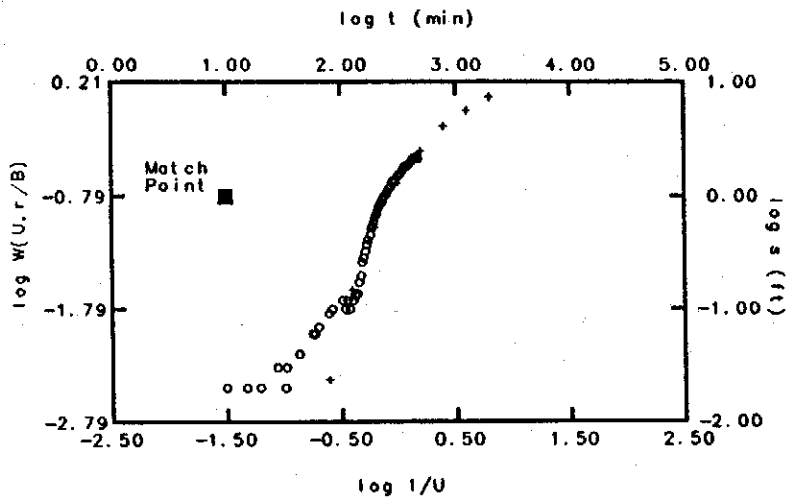


o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	8.608E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	8.608E+0004 gpd/sq ft
1/U	=	3.631E-0001	Storativity	=	9.215E-0004
W(U,r/B)	=	1.660E-0001			

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

4330 Test – Drawdown Well 1480

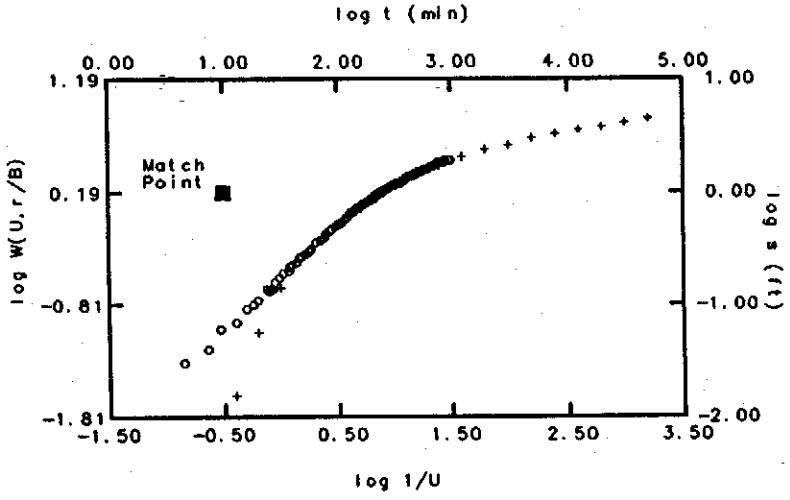


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.50

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	8.412E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	8.412E+0003 gpd/sq ft
1/U	=	3.162E-0002	Storativity	=	1.034E-0003
W(U,r/B)	=	1.622E-0002	Leakage Factor	=	1.955E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4330D
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

4330 Test – Recovery Well 1480

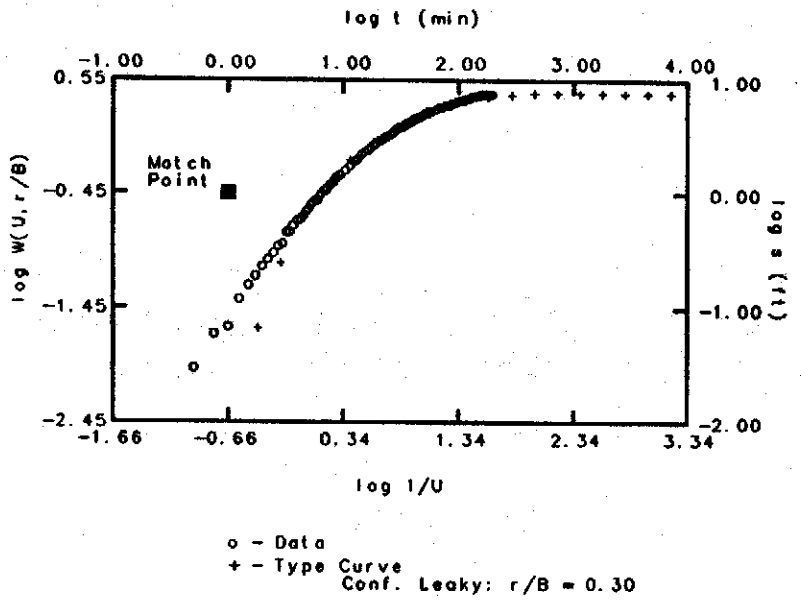


o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	8.033E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	8.033E+0004 gpd/sq ft
1/U	=	3.162E-0001	Storativity	=	9.874E-0004
W(U,r/B)	=	1.549E-0001			

WELL INFORMATION	
WELL IDENTIFICATION	: 4330R
DATE OF AQUIFER TEST	: 8/24/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.527E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.775E+0002 ft

4335 Test – Drawdown Well 1359



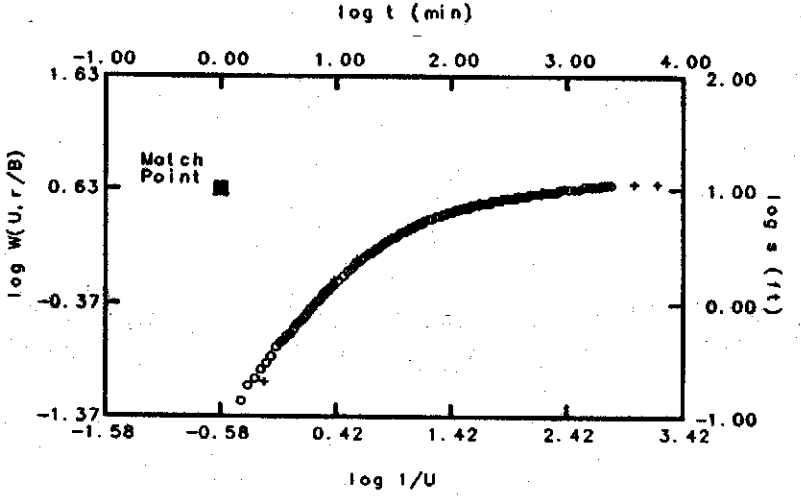
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	9.687E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	9.687E+0003 gpd/sq ft
1/U	=	2.188E-0001	Storativity	=	1.177E-0004
W(U, r/B)	=	3.548E-0002	Leakage Factor	=	1.246E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4335DD
DATE OF AQUIFER TEST	:	8/22/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	2.383E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.167E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	3.738E+0002 ft

4335 Test – Recovery Well 1359



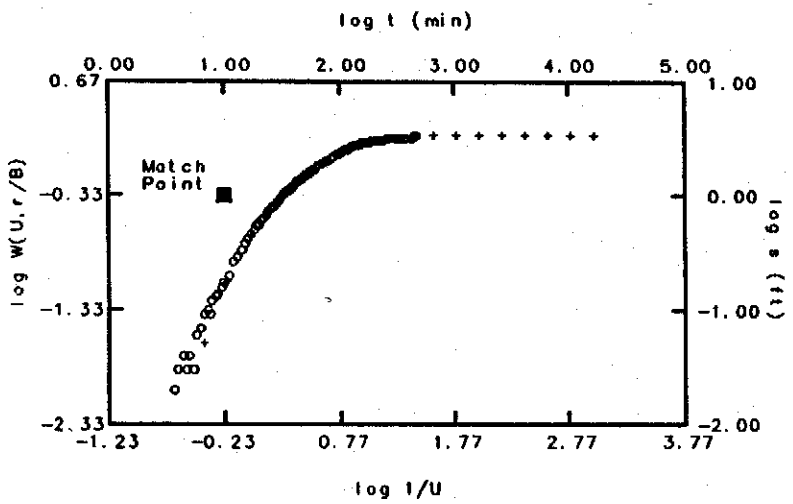
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.165E+0004 gpd/ft
s	=	1.000E+0001	Hydraulic. Cond.	=	1.165E+0004 gpd/sq ft
1/U	=	2.630E-0001	Storativity	=	1.177E-0004
W(U, r/B)	=	4.266E-0001	Leakage Factor	=	3.738E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4335R
DATE OF AQUIFER TEST	:	8/22/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	2.383E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.167E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	3.738E+0002 ft

4335 Test – Drawdown Well 1372

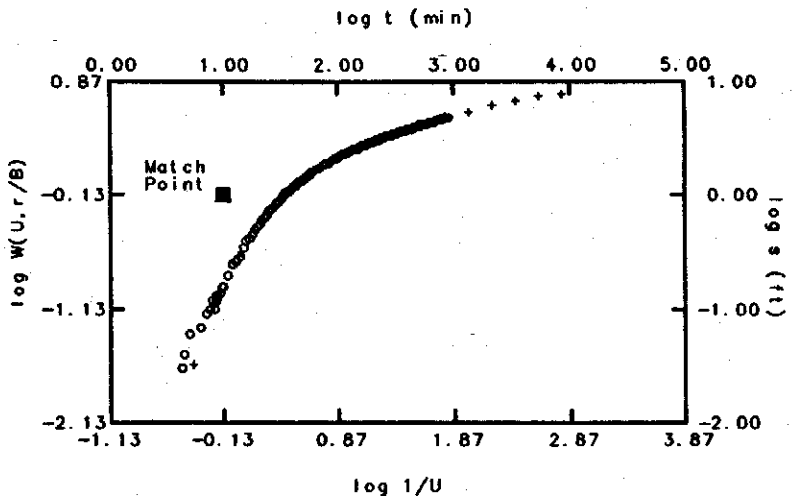


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.60

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.277E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.277E+0004 gpd/sq ft
1/U	=	5.888E-0001	Storativity	=	9.695E-0005
W(U,r/B)	=	4.677E-0002	Leakage Factor	=	1.519E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335D
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.115E+0002 ft

4335 Test – Recovery Well 1372

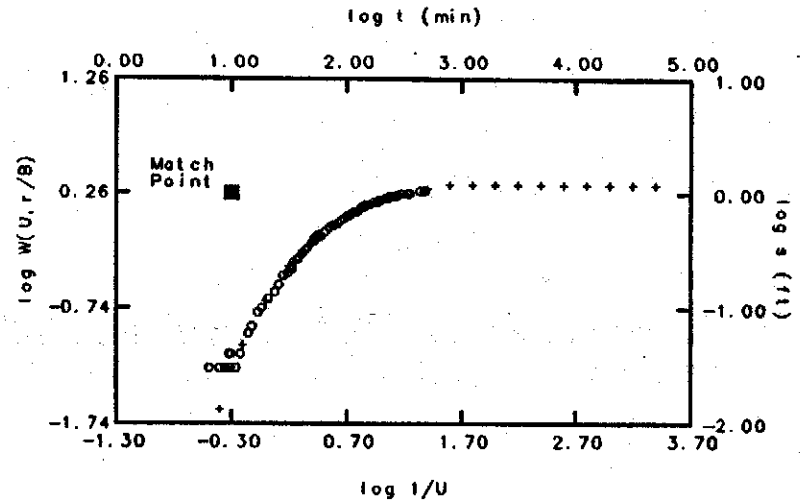


o – Data
\+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	2.024E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	2.024E+0004 gpd/sq ft
1/U	=	7.413E-0001	Storativity	=	1.220E-0004
W(U,r/B)	=	7.413E-0002			

WELL INFORMATION	
WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.115E+0002 ft

4335 Test – Drawdown Well 1389



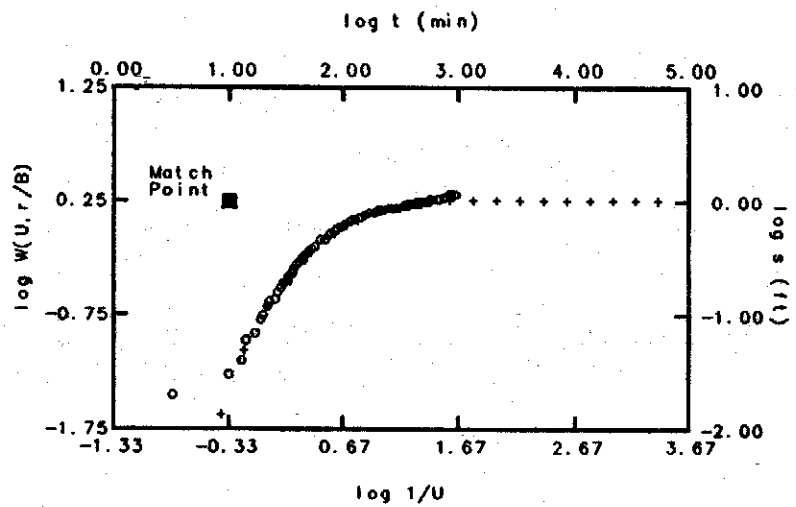
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	4.968E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	4.968E+0004 gpd/sq ft
1/U	=	5.012E-0001	Storativity	=	3.875E-0004
W(U,r/B)	=	1.820E-0001	Leakage Factor	=	2.437E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4335D
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.747E+0002 ft

4335 Test – Recovery Well 1389



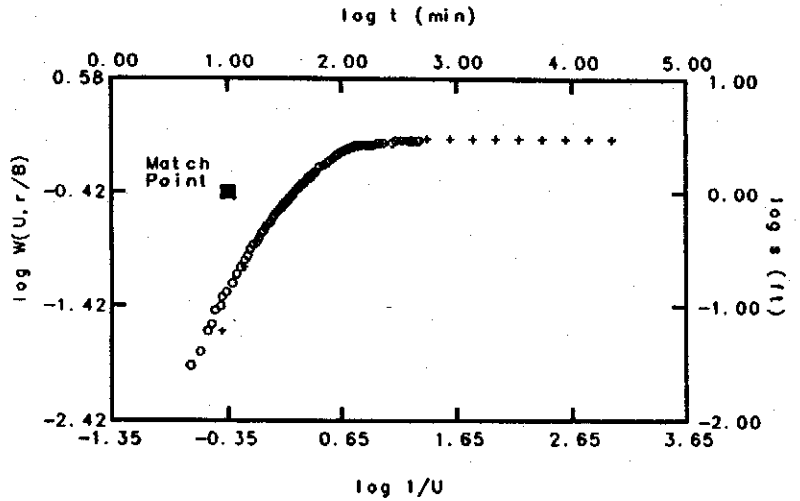
o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.50

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	4.855E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	4.855E+0004 gpd/sq ft
1/U	=	4.677E-0001	Storativity	=	4.058E-0004
W(U,r/B)	=	1.778E-0001	Leakage Factor	=	1.949E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.747E+0002 ft

4335 Test – Drawdown Well 1479

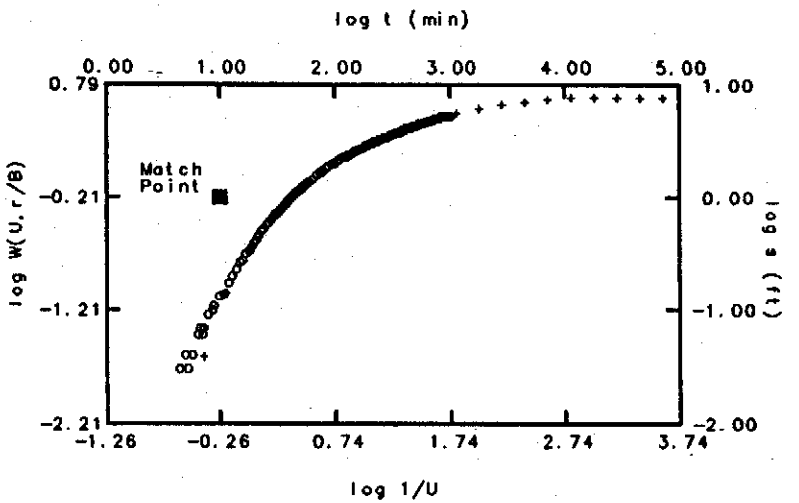


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.80

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.038E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.038E+0004 gpd/sq ft
1/U	=	4.467E-0001	Storativity	=	8.874E-0005
W(U,r/B)	=	3.802E-0002	Leakage Factor	=	1.233E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335D
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.862E+0002 ft

4335 Test – Recovery Well 1479

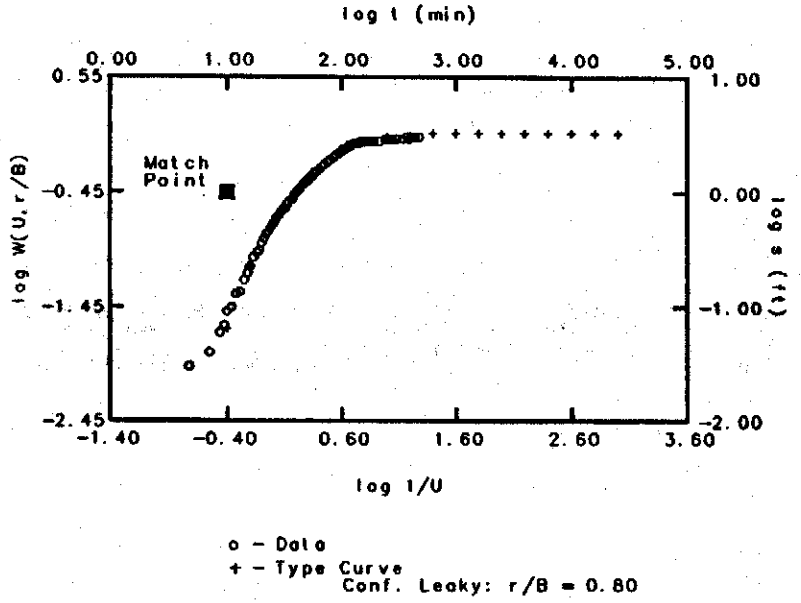


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.683E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.683E+0004 gpd/sq ft
1/U	=	5.495E-0001	Storativity	=	1.170E-0004
W(U,r/B)	=	6.166E-0002	Leakage Factor	=	9.862E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.862E+0002 ft

4335 Test – Drawdown Well 1480

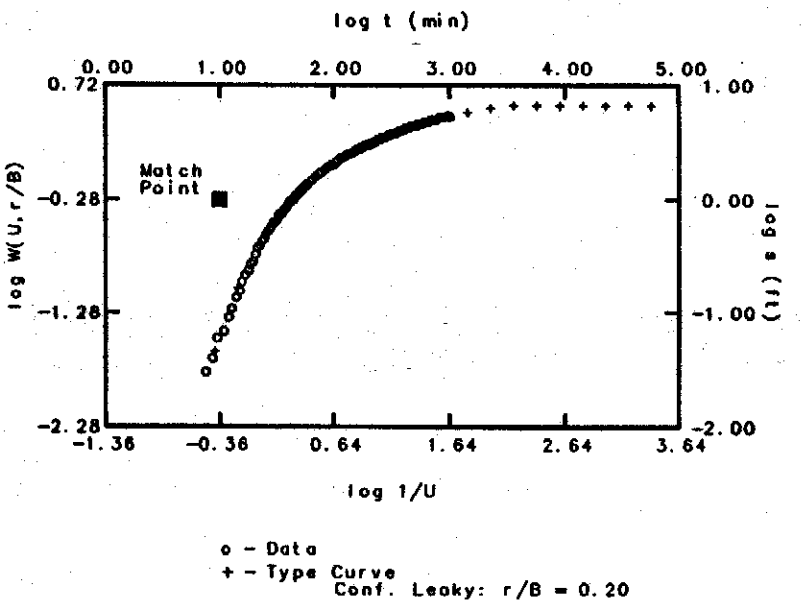


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.80

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	9.687E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	9.687E+0003 gpd/sq ft
1/U	=	3.981E-0001	Storativity	=	9.292E-0005
W(U,r/B)	=	3.548E-0002	Leakage Factor	=	1.233E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335D
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.862E+0002 ft

4335 Test – Recovery Well 1480

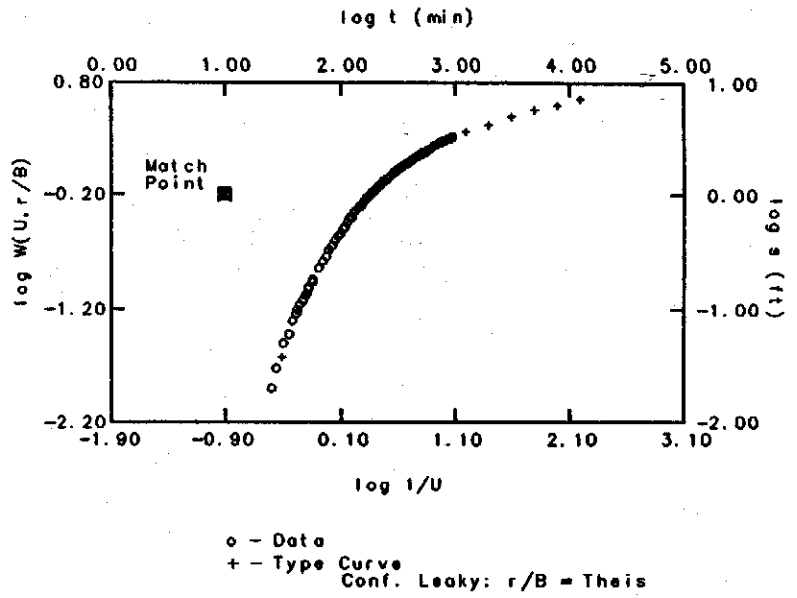


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.433E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.433E+0004 gpd/sq ft
1/U	=	4.365E-0001	Storativity	=	1.253E-0004
W(U,r/B)	=	5.248E-0002	Leakage Factor	=	4.931E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 8/22/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.862E+0002 ft

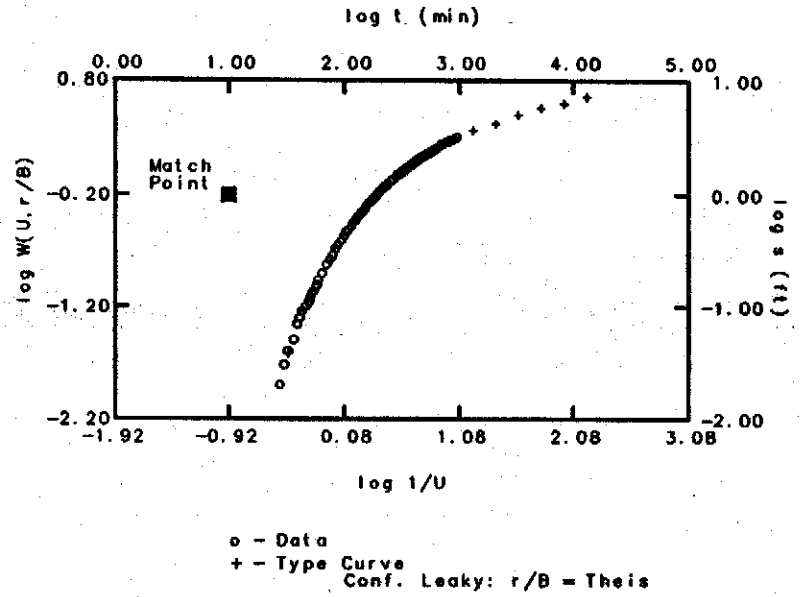
4335 Test – Recovery Well 1510



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.723E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.723E+0004 gpd/sq ft
1/U	=	1.259E-0001	Storativity	=	9.584E-0005
W(U,r/B)	=	6.310E-0002			

WELL INFORMATION		
WELL IDENTIFICATION	:	4335R
DATE OF AQUIFER TEST	:	822/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	2.383E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	2.303E+0003 ft

4335 Test - Recovery Well 1511

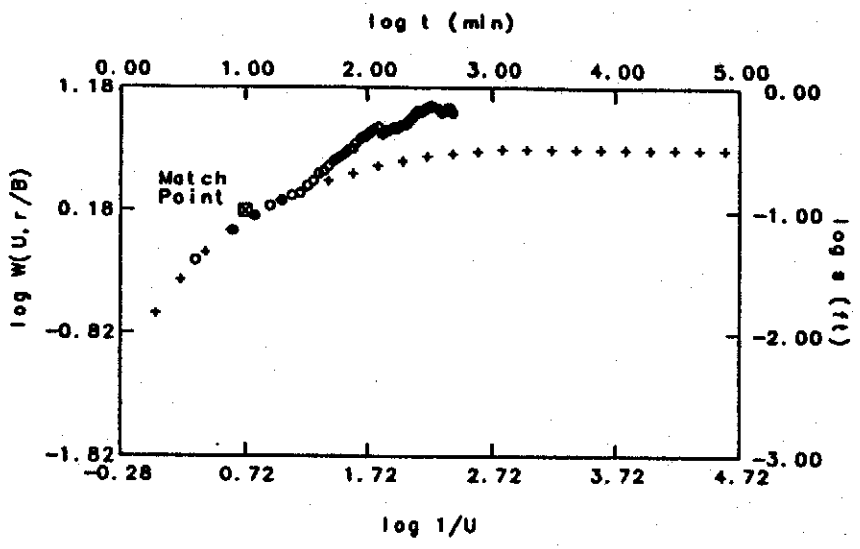


o - Data
+ - Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 1.723E+0004 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 1.723E+0004 gpd/sq ft
1/U	= 1.202E-0001	Storativity	= 1.004E-0004
W(U,r/B)	= 6.310E-0002		

WELL INFORMATION	
WELL IDENTIFICATION	: 4335R
DATE OF AQUIFER TEST	: 822/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.383E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 2.303E+0003 ft

4340 Test – Drawdown Well 1564

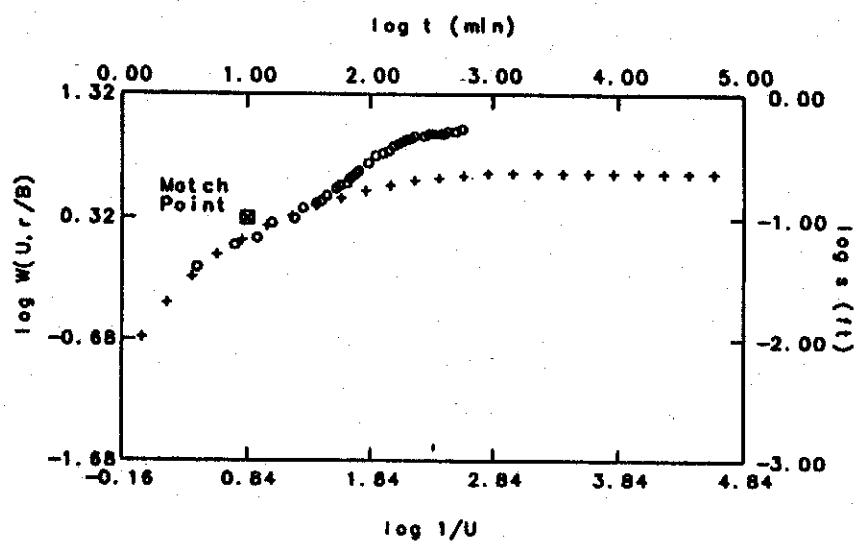


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT		SOLUTION	
t =	1.000E+0001	Transmissivity =	4.387E+0004 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	4.387E+0004 gpd/sq ft
1/U =	5.248E+0000	Storativity =	8.936E-0004
W(U,r/B) =	1.514E-0001	Leakage Factor =	1.864E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4340D
DATE OF AQUIFER TEST	: 3/7/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.530E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.864E+0002 ft

4340 Test – Recovery Well 1564

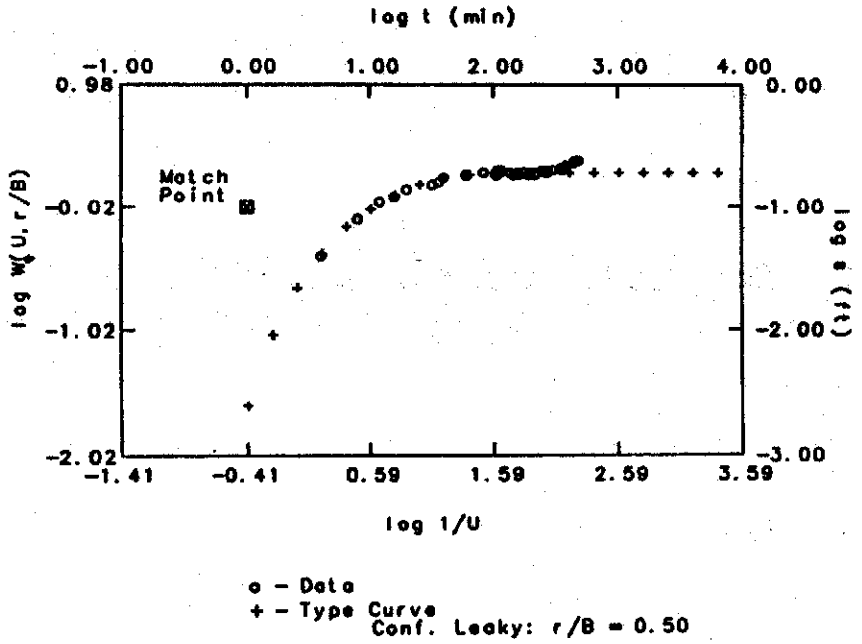


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT		SOLUTION	
t =	1.000E+0001	Transmissivity =	6.056E+0004 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	6.056E+0004 gpd/sq ft
1/U =	6.918E+0000	Storativity =	9.357E-0004
W(U,r/B) =	2.089E-0001	Leakage Factor =	1.864E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4340R
DATE OF AQUIFER TEST	: 3/7/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.530E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.864E+0002 ft

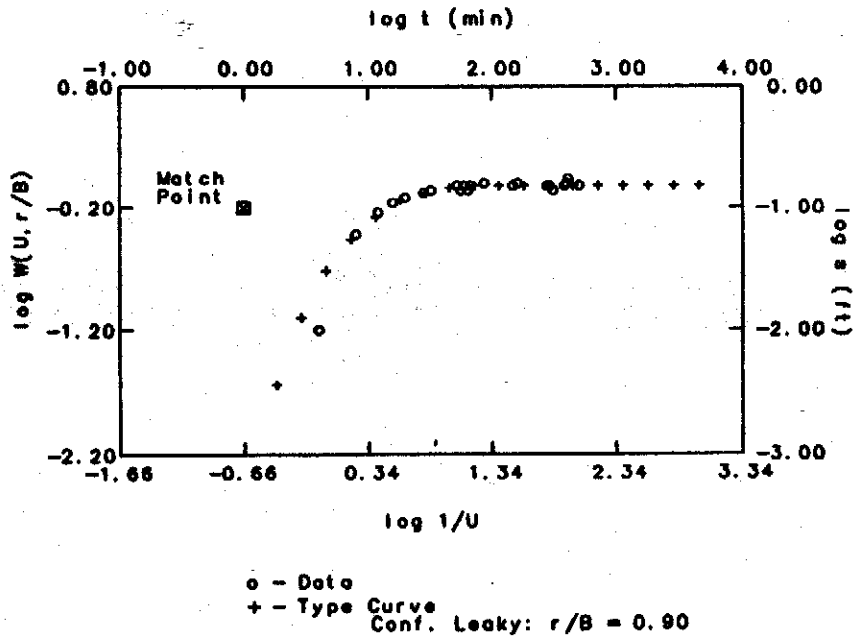
4345 Test – Drawdown Well 1396



MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 4.244E+0005 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 4.244E+0005 gpd/sq ft
1/U	= 3.890E-0001	Storativity	= 3.898E-0004
W(U,r/B)	= 9.550E-0002	Leakage Factor	= 2.039E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4345D
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.020E+0003 ft

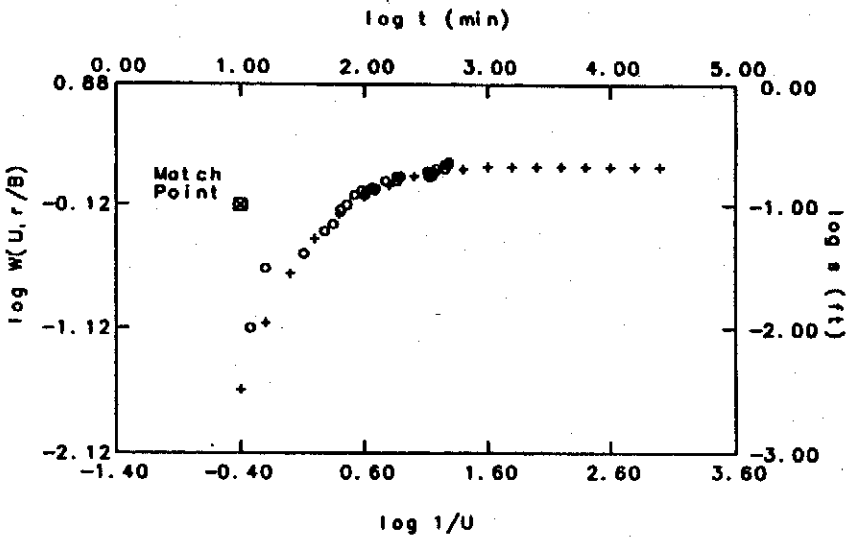
4345 Test – Recovery Well 1396



MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 2.804E+0005 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 2.804E+0005 gpd/sq ft
1/U	= 2.188E-0001	Storativity	= 4.580E-0004
W(U,r/B)	= 6.310E-0002	Leakage Factor	= 1.133E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4345R
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.020E+0003 ft

4345 Test – Drawdown Well 1397



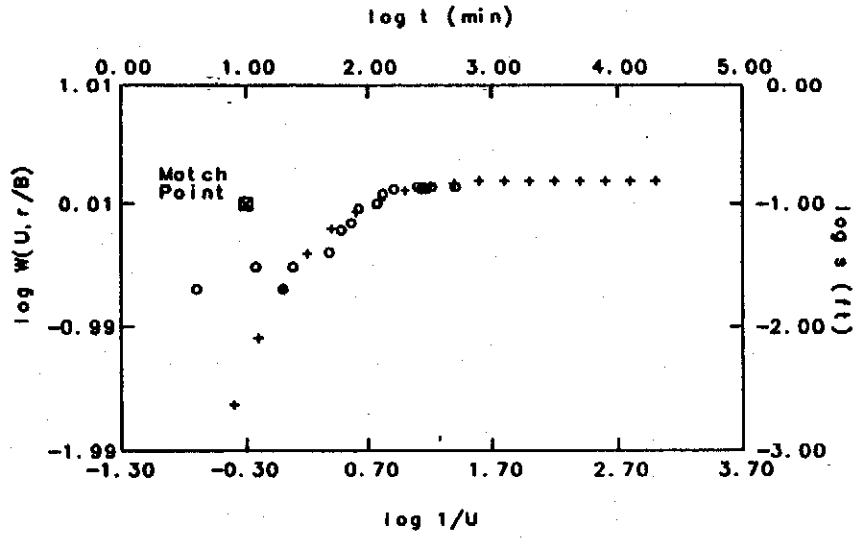
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.60

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 3.371E+0005 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 3.371E+0005 gpd/sq ft
1/U	= 3.981E-0001	Storativity	= 3.026E-0003
W(U,r/B)	= 7.586E-0002	Leakage Factor	= 1.699E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4345D
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.020E+0003 ft

4345 Test – Recovery Well 1397



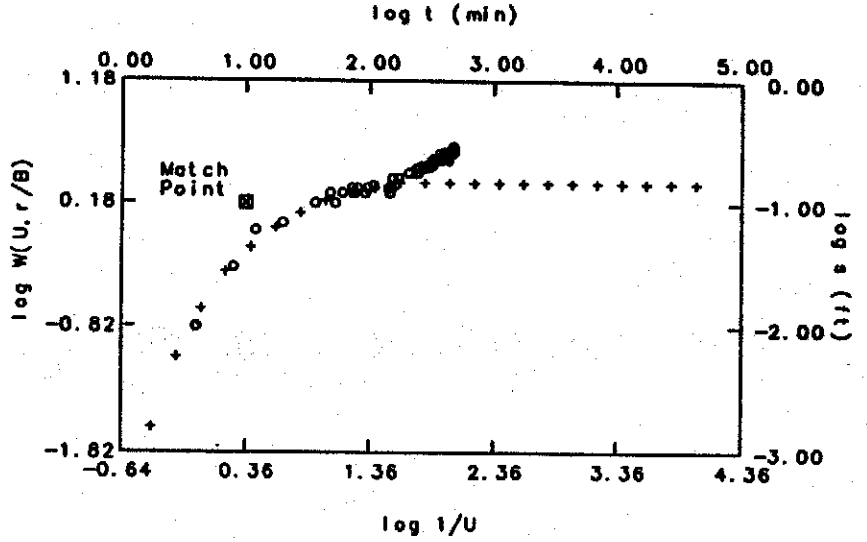
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.60

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 4.548E+0005 gpd/ft
s	= 1.000E-0001	Hydraulic. Cond.	= 4.548E+0005 gpd/sq ft
1/U	= 5.012E-0001	Storativity	= 3.242E-0003
W(U,r/B)	= 1.023E-0001	Leakage Factor	= 1.699E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4345R
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.020E+0003 ft

4345 Test – Drawdown Well 1525

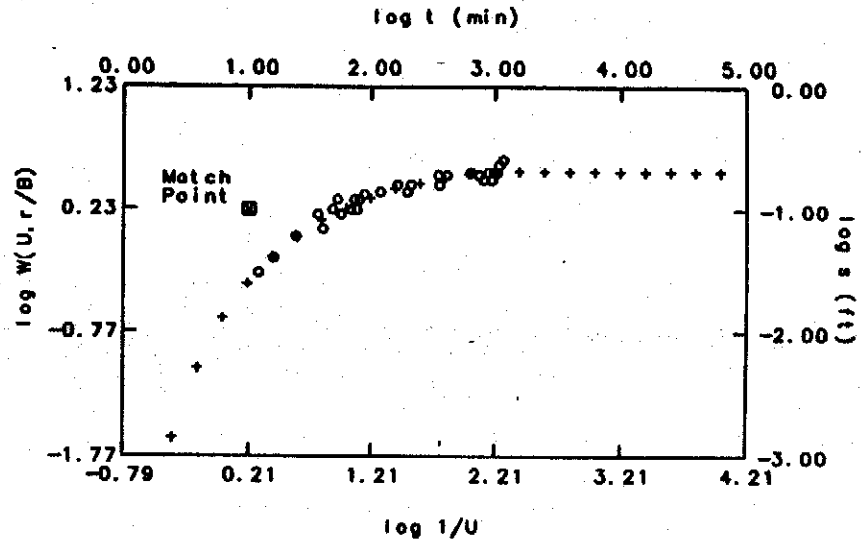


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	6.727E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	6.727E+0005 gpd/sq ft
1/U	=	2.291E+0000	Storativity	=	1.952E-0003
W(U,r/B)	=	1.514E-0001	Leakage Factor	=	1.869E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4345D
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.475E+0002 ft

4345 Test – Recovery Well 1525

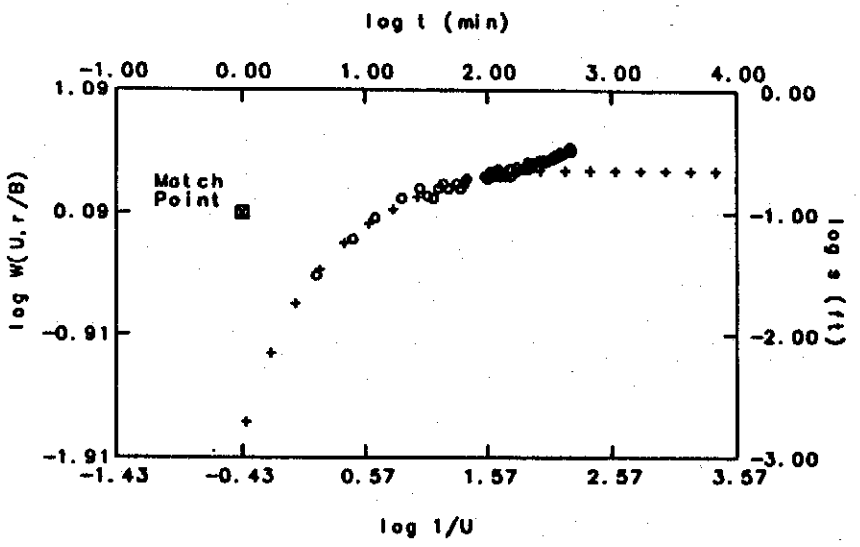


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	7.547E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	7.547E+0005 gpd/sq ft
1/U	=	1.622E+0000	Storativity	=	3.093E-0003
W(U,r/B)	=	1.698E-0001	Leakage Factor	=	3.738E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4345R
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.475E+0002 ft

4345 Test – Drawdown Well 1526

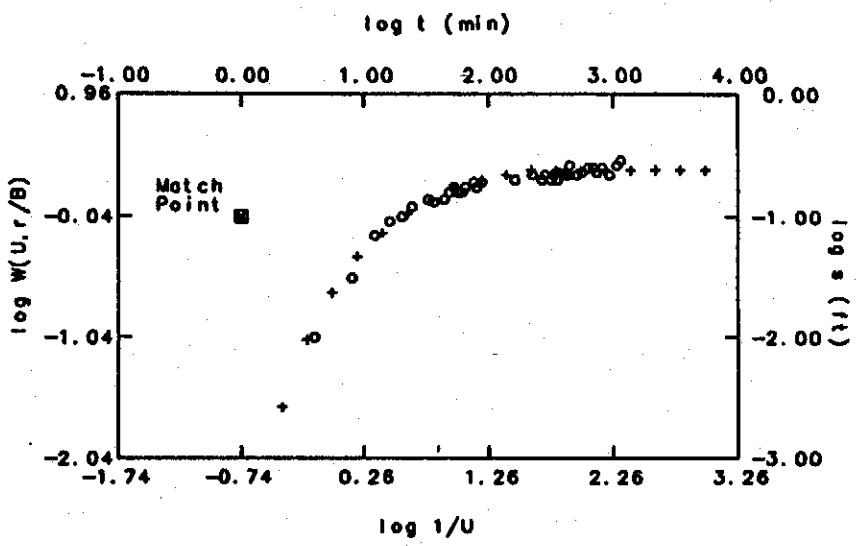


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	5.468E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	5.468E+0005 gpd/sq ft
1/U	=	3.715E-0001	Storativity	=	9.782E-0004
W(U,r/B)	=	1.230E-0001	Leakage Factor	=	2.492E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4345D
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.475E+0002 ft

4345 Test – Recovery Well 1526

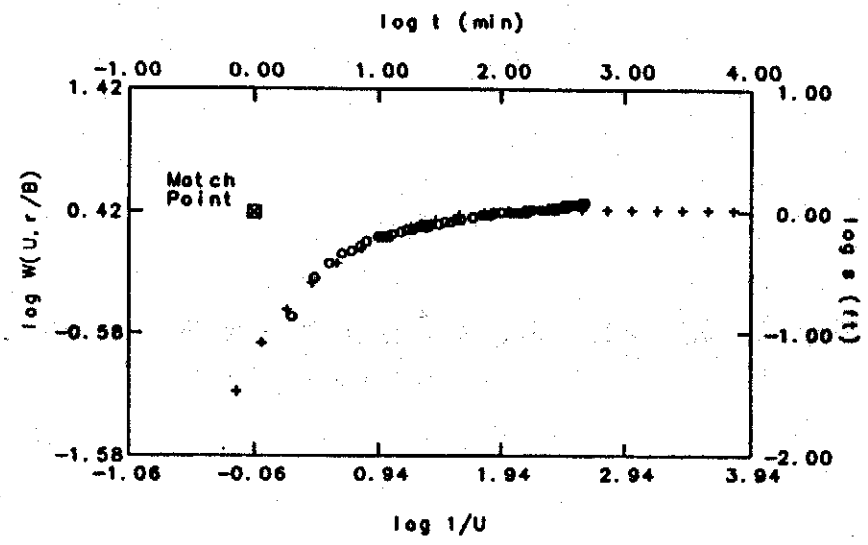


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.053E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.053E+0005 gpd/sq ft
1/U	=	1.820E-0001	Storativity	=	1.481E-0003
W(U,r/B)	=	9.120E-0002	Leakage Factor	=	1.869E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4345R
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.475E+0002 ft

4345 Test – Drawdown Well 1564

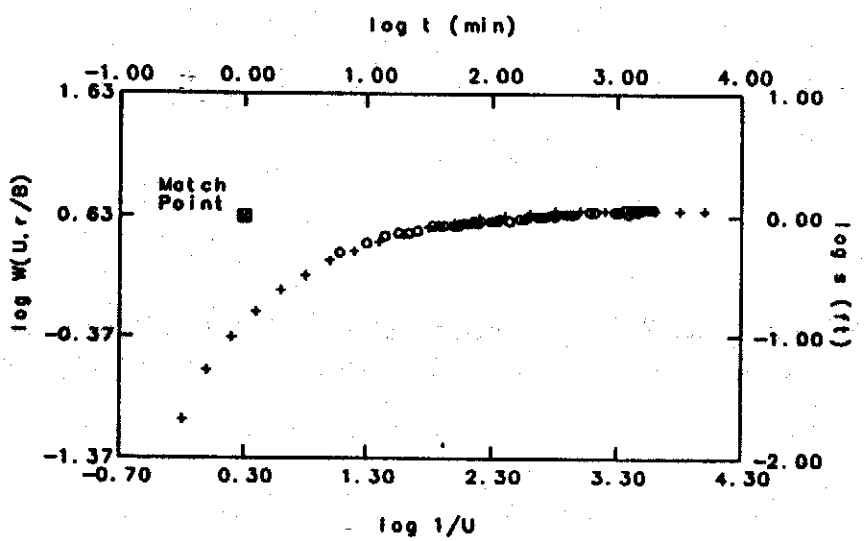


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.169E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.169E+0005 gpd/sq ft
1/U	=	8.710E-0001	Storativity	=	6.010E-0002
W(U,r/B)	=	2.630E-0001	Leakage Factor	=	9.600E+0001 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4345D
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 2.880E+0001 ft

4345 Test – Recovery Well 1564

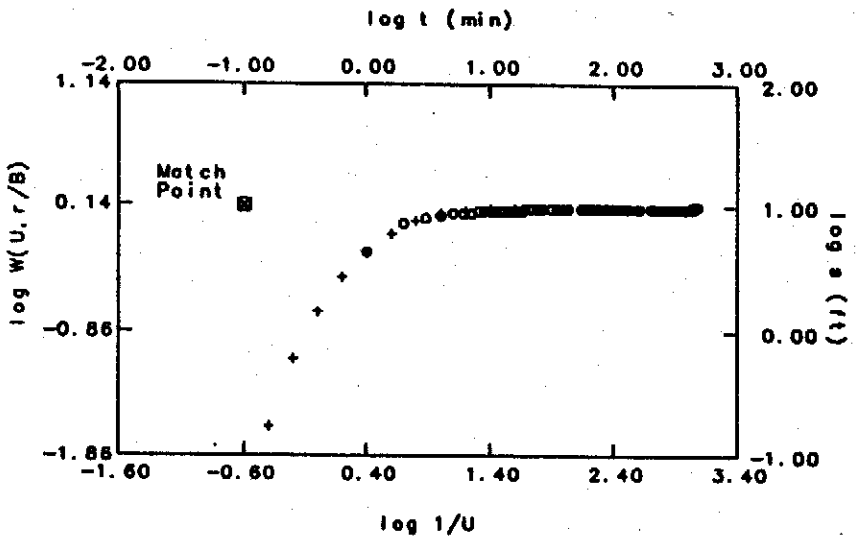


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.896E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.896E+0005 gpd/sq ft
1/U	=	1.995E+0000	Storativity	=	4.255E-0002
W(U,r/B)	=	4.266E-0001	Leakage Factor	=	2.880E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4345R
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 2.880E+0001 ft

4345 Test – Drawdown Well 1565



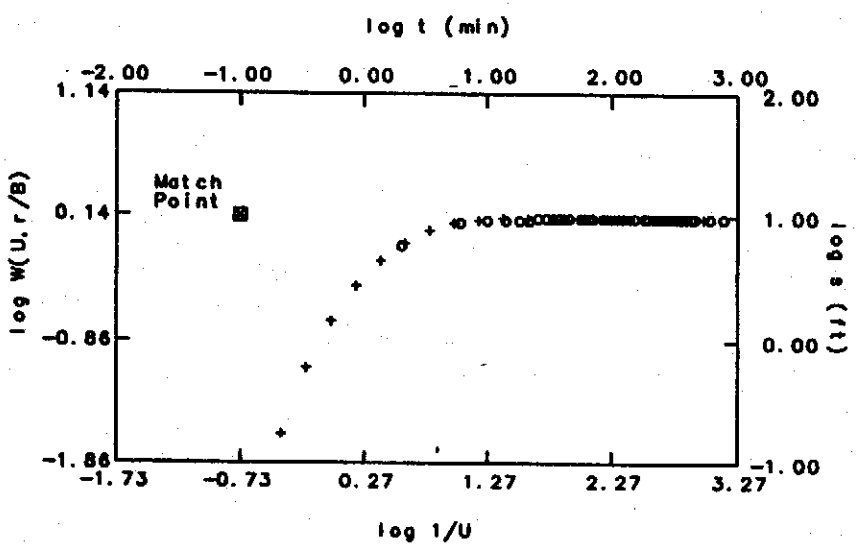
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT			SOLUTION		
t	=	1.000E-0001	Transmissivity	=	6.135E+0003 gpd/ft
s	=	1.000E+0001	Hydraulic. Cond.	=	6.135E+0003 gpd/sq ft
1/U	=	2.512E-0001	Storativity	=	1.094E-0003
W(U,r/B)	=	1.380E-0001	Leakage Factor	=	4.114E+0001 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4345D
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 2.880E+0001 ft

4345 Test – Recovery Well 1565



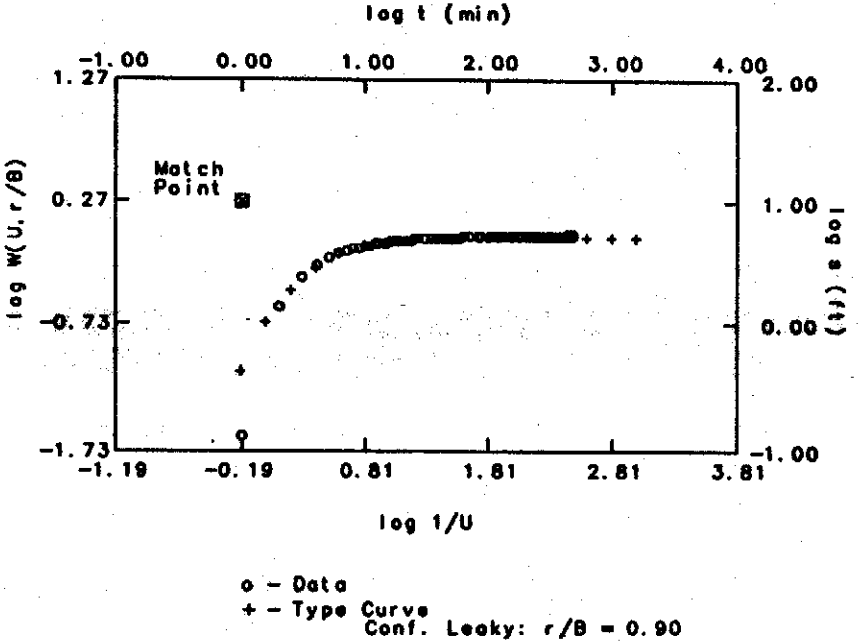
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT			SOLUTION		
t	=	1.000E-0001	Transmissivity	=	6.135E+0003 gpd/ft
s	=	1.000E+0001	Hydraulic. Cond.	=	6.135E+0003 gpd/sq ft
1/U	=	1.862E-0001	Storativity	=	1.475E-0003
W(U,r/B)	=	1.380E-0001	Leakage Factor	=	4.114E+0001 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4345R
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 2.880E+0001 ft

4345 Test – Drawdown Well 1566



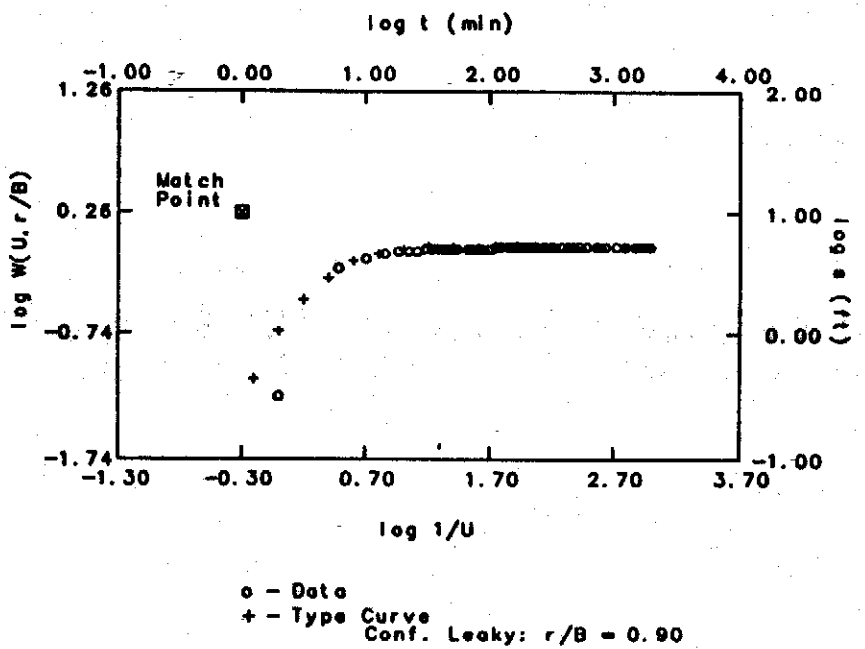
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	8.275E+0003 gpd/ft
s =	1.000E+0001	Hydraulic. Cond. =	8.275E+0003 gpd/sq ft
1/U =	6.457E-0001	Storativity =	5.739E-0003
W(U,r/B) =	1.862E-0001	Leakage Factor =	3.200E+0001 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4345D
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 2.880E+0001 ft

4345 Test – Recovery Well 1566



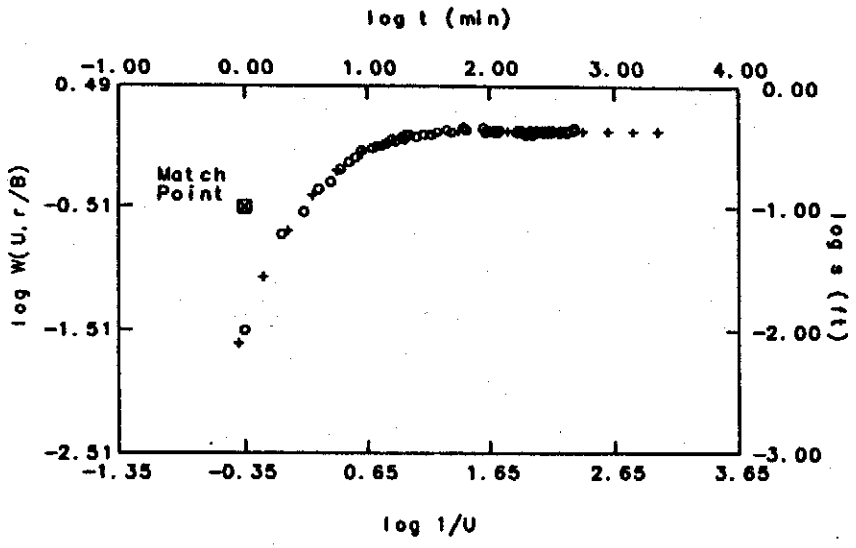
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.90

MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	8.087E+0003 gpd/ft
s =	1.000E+0001	Hydraulic. Cond. =	8.087E+0003 gpd/sq ft
1/U =	5.012E-0001	Storativity =	7.225E-0003
W(U,r/B) =	1.820E-0001	Leakage Factor =	3.200E+0001 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4345R
DATE OF AQUIFER TEST	: 12/12/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.879E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 2.880E+0001 ft

4350 Test – Drawdown Well 1565



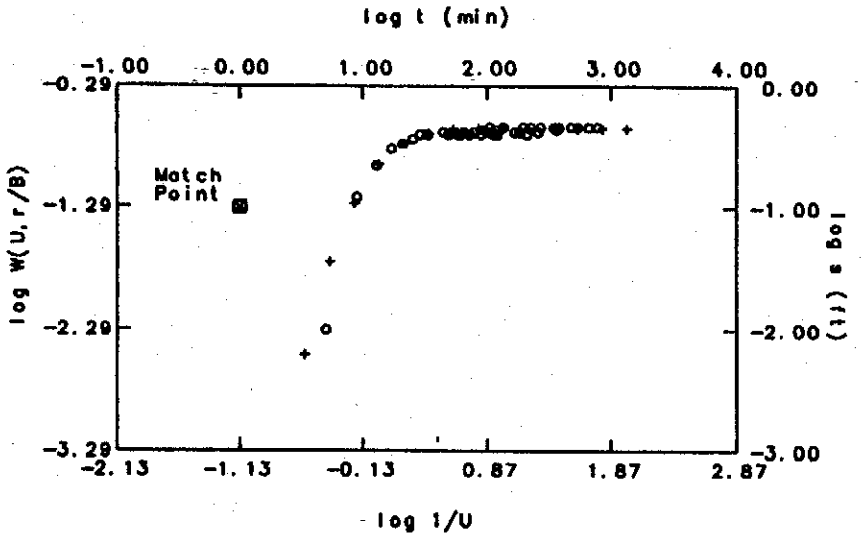
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	2.177E+0004 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	2.177E+0004 gpd/sq ft
1/U	=	4.467E-0001	Storativity	=	5.650E-0004
W(U,r/B)	=	3.090E-0002	Leakage Factor	=	2.557E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4350D
DATE OF AQUIFER TEST	:	12/19/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	6.150E+0001 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.790E+0002 ft

4350 Test – Recovery Well 1565



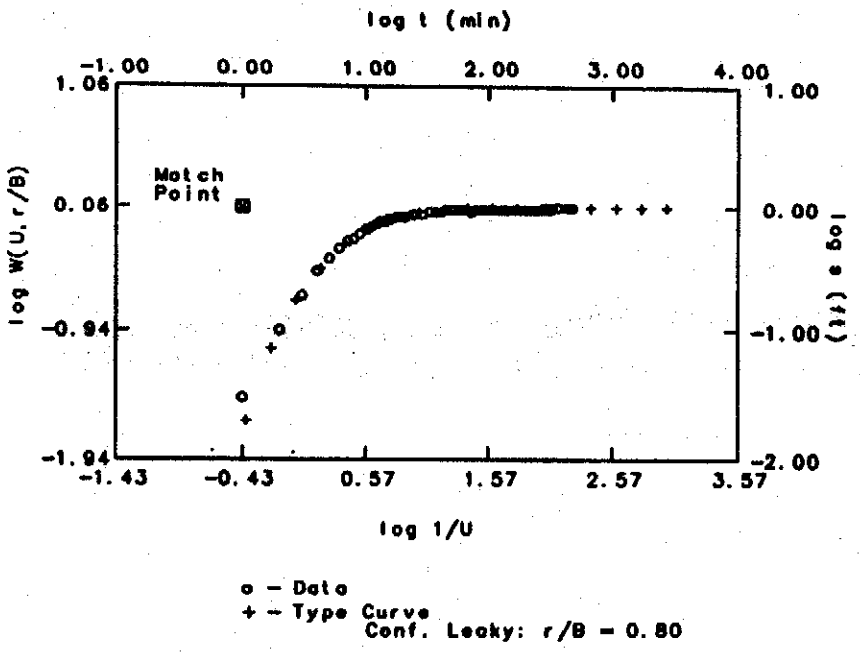
o – Data
+ – Type Curve
Conf. Leaky: r/B = 2.00

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	3.614E+0003 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.614E+0003 gpd/sq ft
1/U	=	7.413E-0002	Storativity	=	5.651E-0004
W(U,r/B)	=	5.129E-0003	Leakage Factor	=	8.950E+0001 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4350R
DATE OF AQUIFER TEST	:	12/19/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	6.150E+0001 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.790E+0002 ft

4350 Test – Drawdown Well 1566



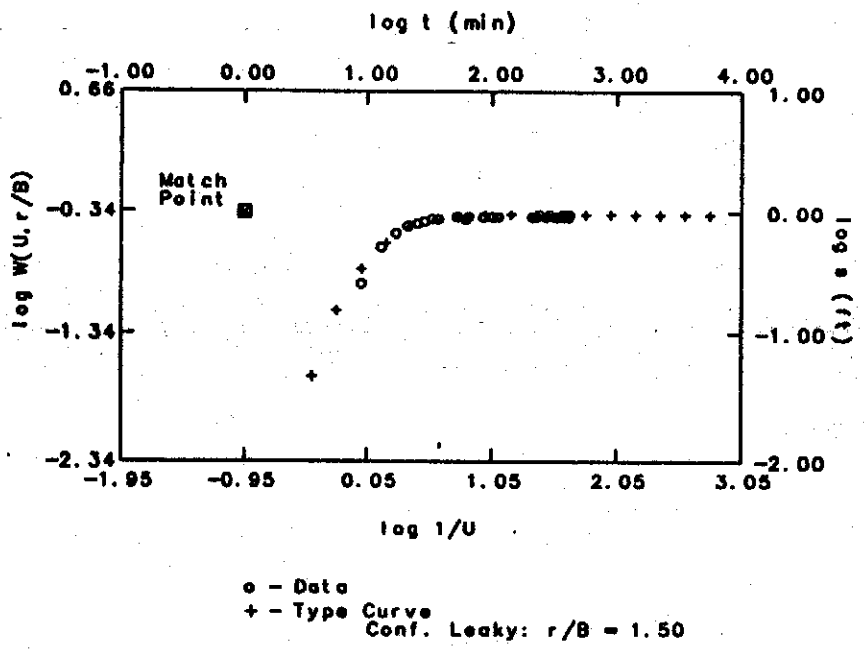
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.80

MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	8.090E+0003 gpd/ft
s =	1.000E+0000	Hydraulic. Cond. =	8.090E+0003 gpd/sq ft
1/U =	3.715E-0001	Storativity =	2.524E-0004
W(U,r/B) =	1.148E-0001	Leakage Factor =	2.238E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4350D
DATE OF AQUIFER TEST	: 12/19/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 6.150E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.790E+0002 ft

4350 Test – Recovery Well 1566



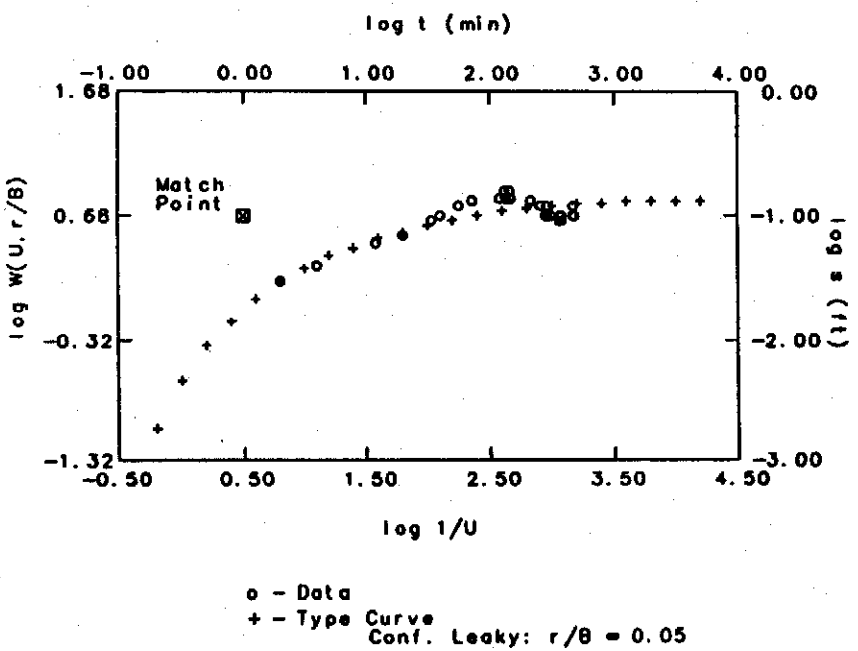
o – Data
+ – Type Curve
Conf. Leaky: r/B = 1.50

MATCH POINT		SOLUTION	
t =	1.000E+0000	Transmissivity =	3.221E+0003 gpd/ft
s =	1.000E+0000	Hydraulic. Cond. =	3.221E+0003 gpd/sq ft
1/U =	1.122E-0001	Storativity =	3.327E-0004
W(U,r/B) =	4.571E-0002	Leakage Factor =	1.193E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4350R
DATE OF AQUIFER TEST	: 12/19/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 6.150E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.790E+0002 ft

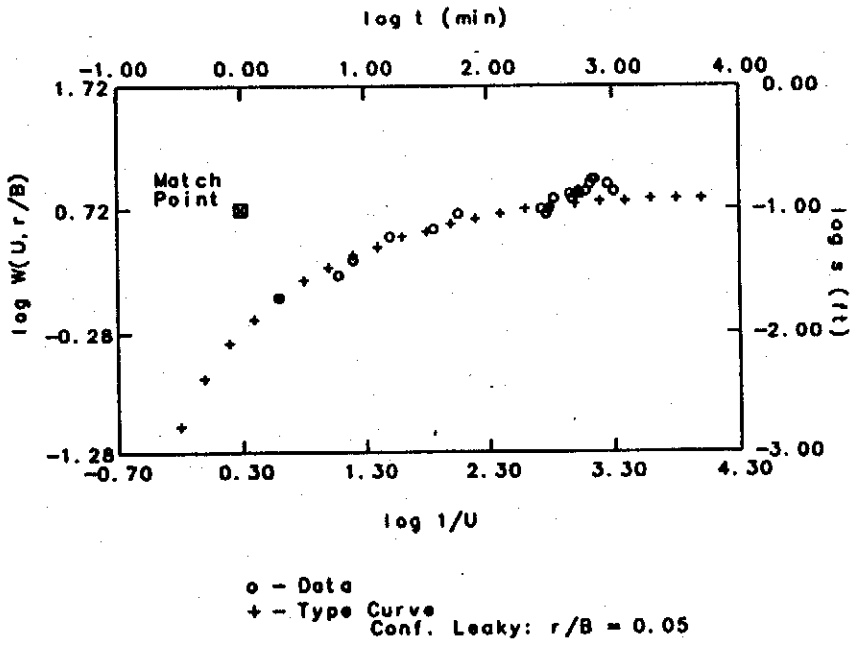
4355 Test – Drawdown Well 1395



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	2.126E+0006 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	2.126E+0006 gpd/sq ft
1/U	=	3.162E+0000	Storativity	=	6.094E-0004
W(U,r/B)	=	4.786E-0001	Leakage Factor	=	1.280E+0004 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4355D
DATE OF AQUIFER TEST	: 11/23/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.877E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.401E+0002 ft

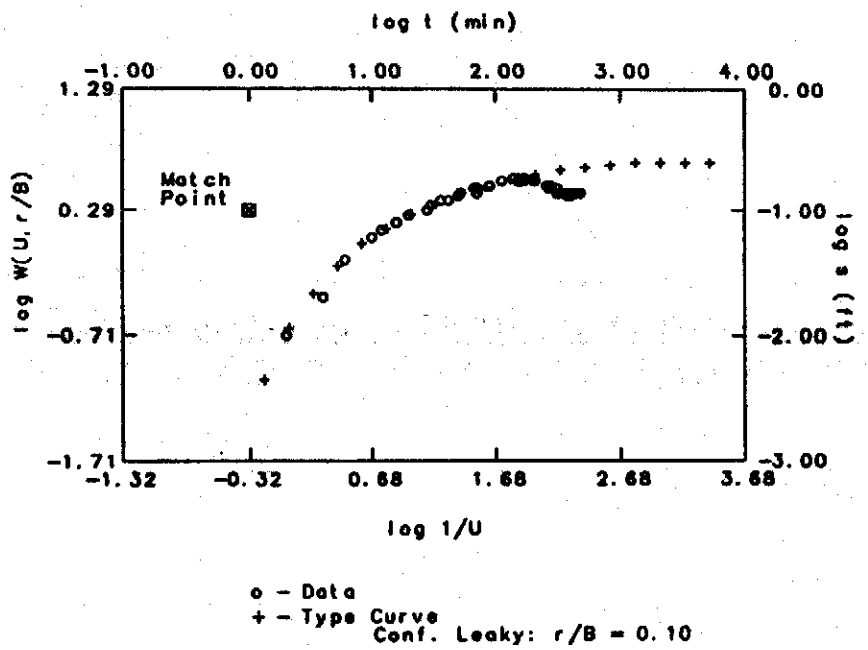
4355 Test – Recovery Well 1395



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	2.331E+0006 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	2.331E+0006 gpd/sq ft
1/U	=	1.995E+0000	Storativity	=	1.059E-0003
W(U,r/B)	=	5.248E-0001	Leakage Factor	=	1.280E+0004 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4355R
DATE OF AQUIFER TEST	: 11/23/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.877E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.401E+0002 ft

4355 Test – Drawdown Well 1396



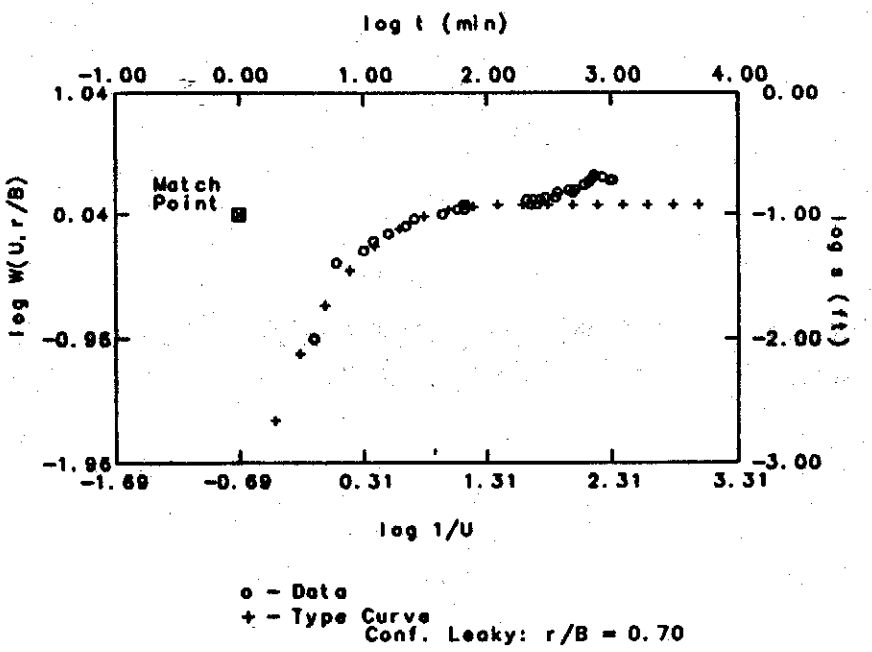
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	8.661E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	8.661E+0005 gpd/sq ft
1/U	=	4.786E-0001	Storativity	=	1.640E-0003
W(U,r/B)	=	1.950E-0001	Leakage Factor	=	6.401E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4355DD
DATE OF AQUIFER TEST	:	11/23/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	3.877E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	6.401E+0002 ft

4355 Test – Recovery Well 1396



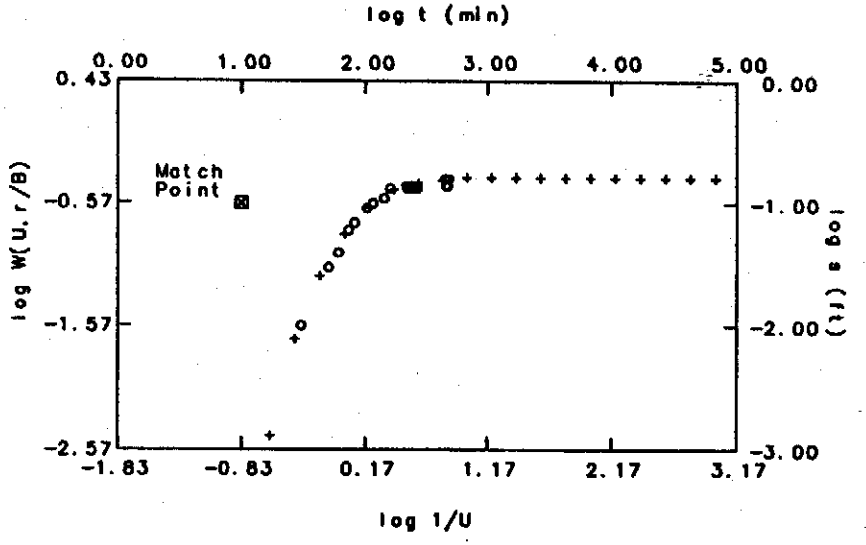
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.870E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.870E+0005 gpd/sq ft
1/U	=	2.042E-0001	Storativity	=	2.162E-0003
W(U,r/B)	=	1.096E-0001	Leakage Factor	=	9.144E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4355R
DATE OF AQUIFER TEST	:	11/23/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	3.877E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	6.401E+0002 ft

4355 Test – Drawdown Well 1397

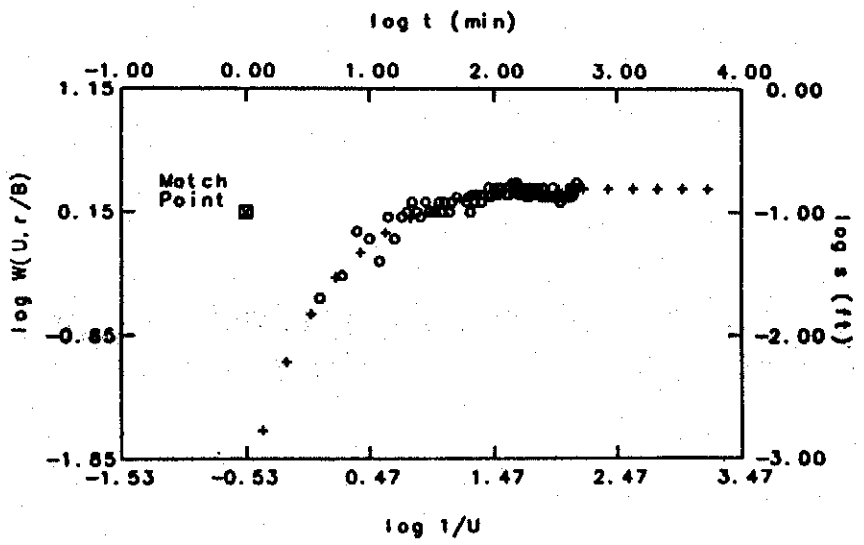


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 1.50

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.196E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.196E+0005 gpd/sq ft
1/U	=	1.479E-0001	Storativity	=	7.327E-0003
W(U, r/B)	=	2.692E-0002	Leakage Factor	=	4.267E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4355D
DATE OF AQUIFER TEST	: 11/23/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.877E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.401E+0002 ft

4355 Test – Drawdown Well 1525



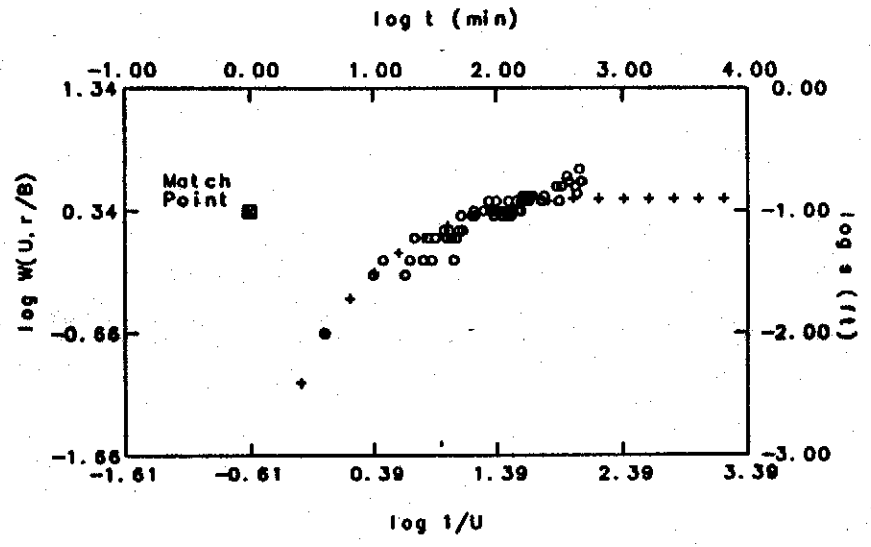
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.274E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	6.274E+0005 gpd/sq ft
1/U	=	2.951E-0001	Storativity	=	3.324E-0003
W(U,r/B)	=	1.413E-0001	Leakage Factor	=	1.219E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4355D
DATE OF AQUIFER TEST	:	11/23/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	3.877E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	4.874E+0002 ft

4355 Test – Recovery Well 1525



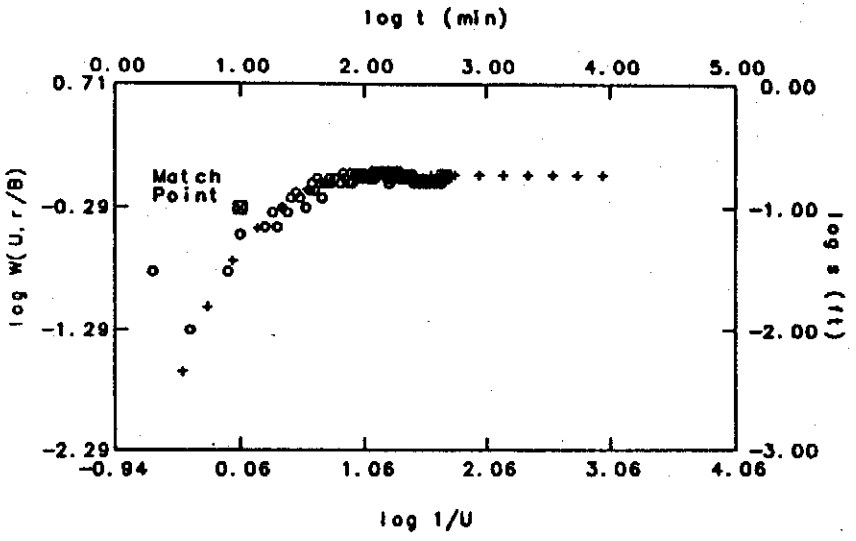
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	9.718E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	9.718E+0005 gpd/sq ft
1/U	=	2.455E-0001	Storativity	=	6.189E-0003
W(U,r/B)	=	2.188E-0001	Leakage Factor	=	1.625E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4355R
DATE OF AQUIFER TEST	:	11/23/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	3.877E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	4.874E+0002 ft

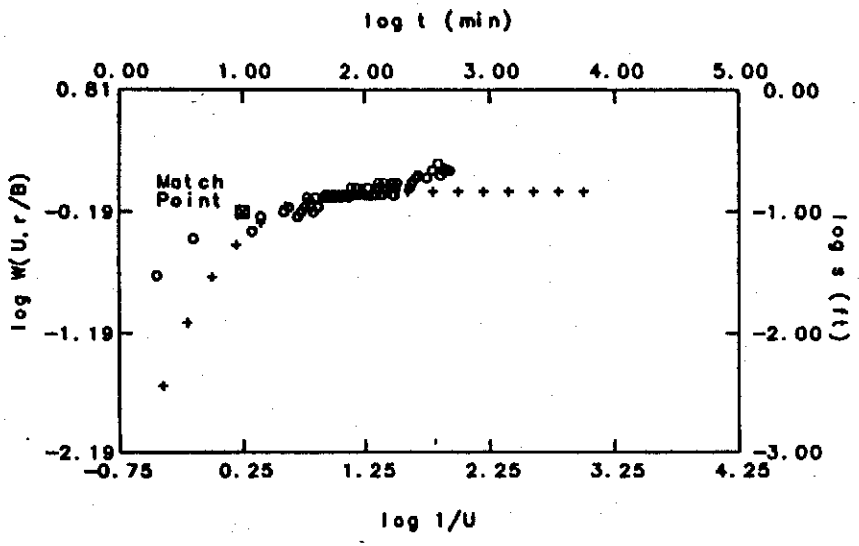
4355 Test – Drawdown Well 1526



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	2.278E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	2.278E+0005 gpd/sq ft
1/U	=	1.148E+0000	Storativity	=	3.102E-0003
W(U,r/B)	=	5.129E-0002	Leakage Factor	=	5.416E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4355D
DATE OF AQUIFER TEST	: 11/23/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.877E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.874E+0002 ft

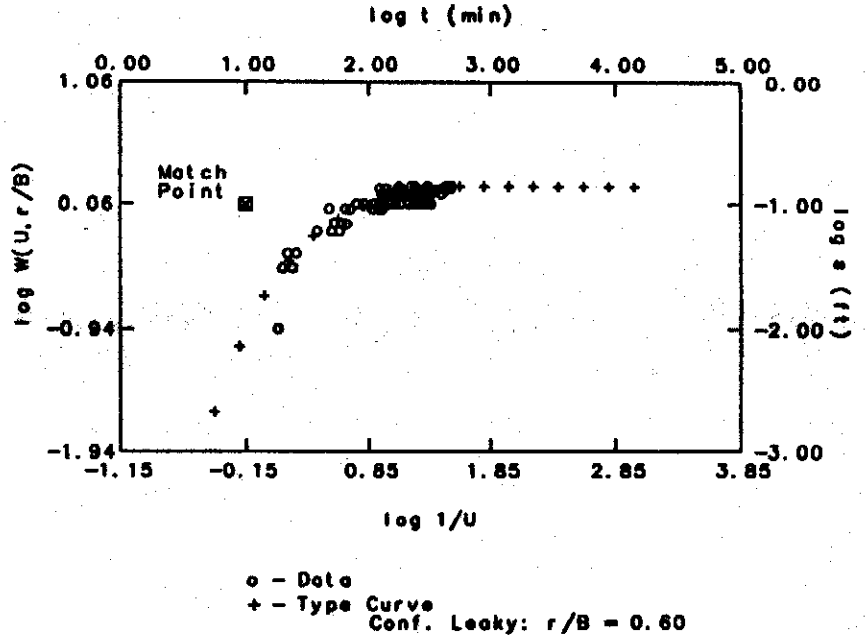
4355 Test – Recovery Well 1526



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	2.868E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	2.868E+0005 gpd/sq ft
1/U	=	1.778E+0000	Storativity	=	2.521E-0003
W(U,r/B)	=	6.457E-0002	Leakage Factor	=	5.416E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4355R
DATE OF AQUIFER TEST	: 11/23/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.877E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.874E+0002 ft

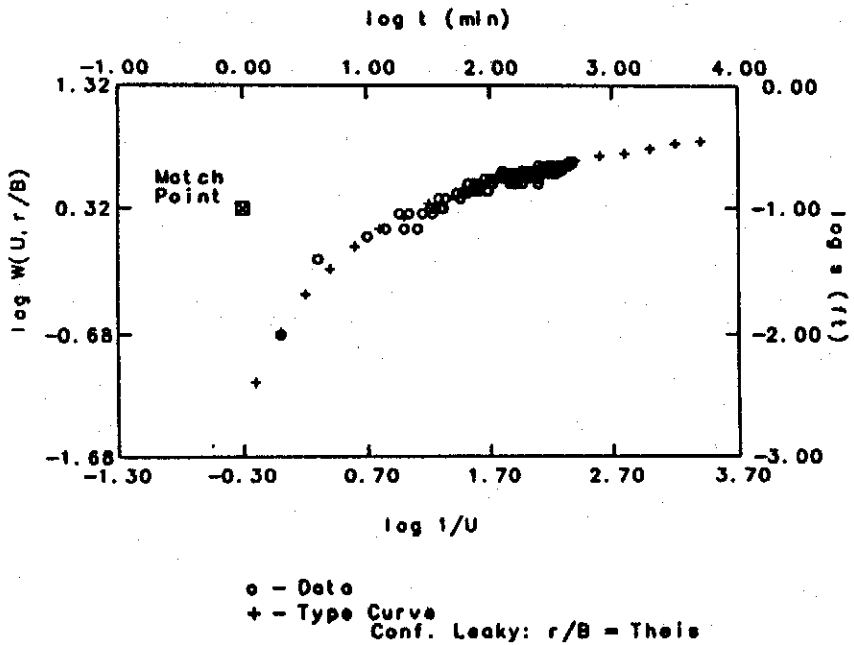
4355 Test – Drawdown Well 1564



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	5.100E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	5.100E+0005 gpd/sq ft
1/U	=	7.079E-0001	Storativity	=	8.152E-0003
W(U,r/B)	=	1.148E-0001	Leakage Factor	=	9.548E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4355D
DATE OF AQUIFER TEST	: 11/23/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.877E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.729E+0002 ft

4355 Test – Drawdown Well 1565



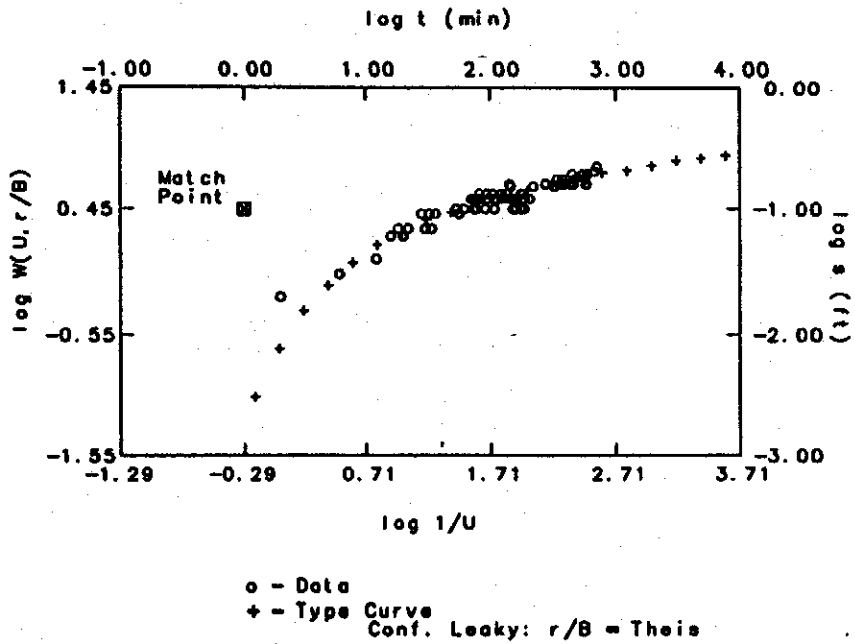
o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	9.280E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	9.280E+0005 gpd/sq ft
1/U	=	5.012E-0001	Storativity	=	2.095E-0003
W(U,r/B)	=	2.089E-0001			

WELL INFORMATION

WELL IDENTIFICATION	:	4355D
DATE OF AQUIFER TEST	:	11/23/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	3.877E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	5.729E+0002 ft

4355 Test – Recovery Well 1565



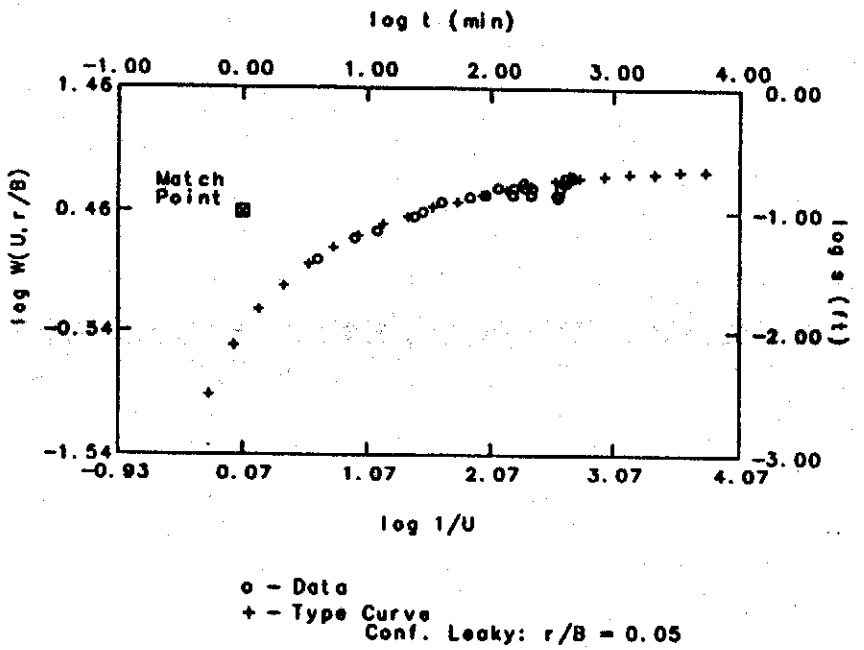
o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.252E+0006 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.252E+0006 gpd/sq ft
1/U	=	5.129E-0001	Storativity	=	2.762E-0003
W(U,r/B)	=	2.818E-0001			

WELL INFORMATION

WELL IDENTIFICATION	:	4355R
DATE OF AQUIFER TEST	:	11/23/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	3.877E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	5.729E+0002 ft

4360 Test – Drawdown Well 1395



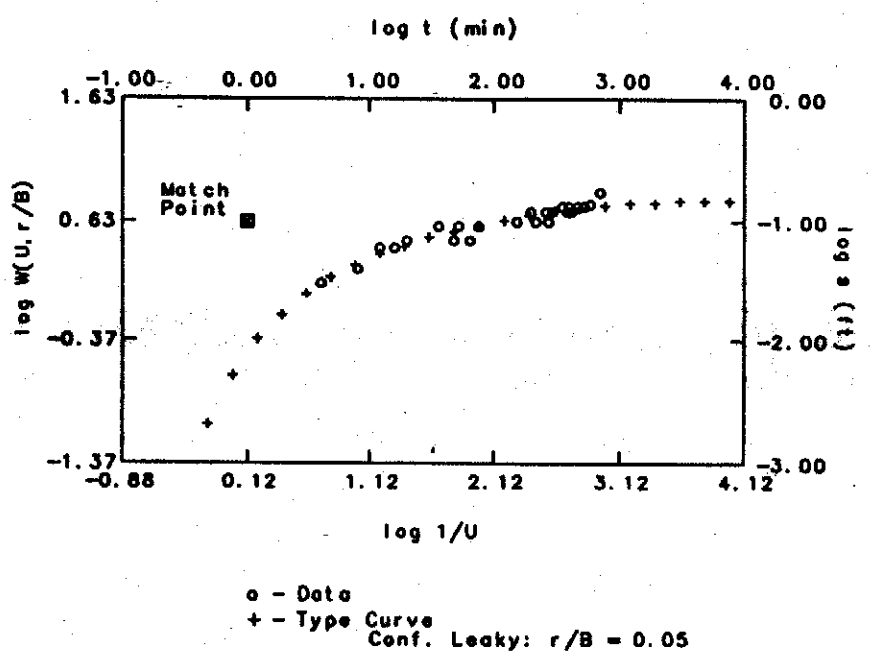
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.05

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.435E+0006 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.435E+0006 gpd/sq ft
1/U	=	1.175E+0000	Storativity	=	1.034E-0003
W(U,r/B)	=	2.884E-0001	Leakage Factor	=	1.325E+0004 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4360D
DATE OF AQUIFER TEST	:	12/1/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.342E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	6.624E+0002 ft

4360 Test – Recovery Well 1395



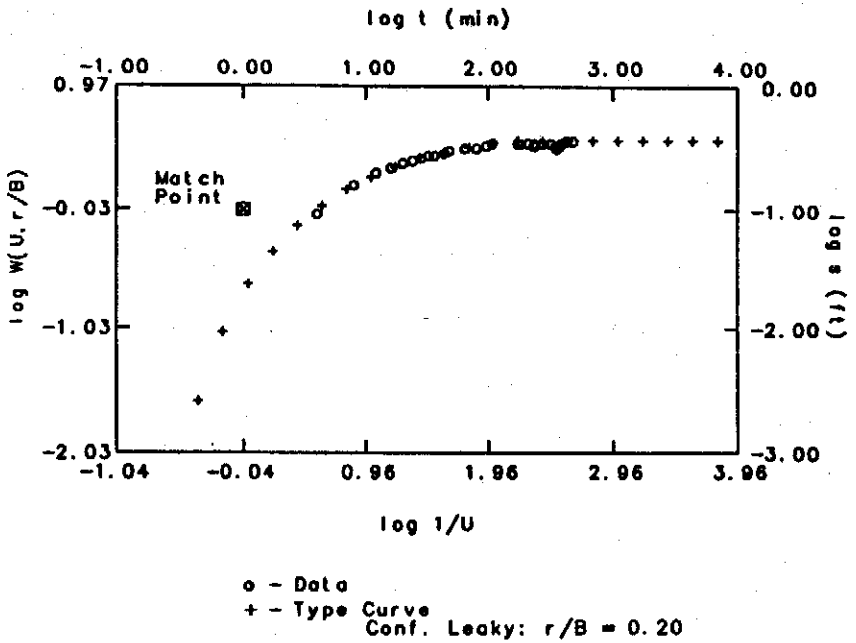
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.05

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	2.122E+0006 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	2.122E+0006 gpd/sq ft
1/U	=	1.318E+0000	Storativity	=	1.363E-0003
W(U,r/B)	=	4.266E-0001	Leakage Factor	=	1.325E+0004 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4360R
DATE OF AQUIFER TEST	:	12/1/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	4.342E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	6.624E+0002 ft

4360 Test – Drawdown Well 1396



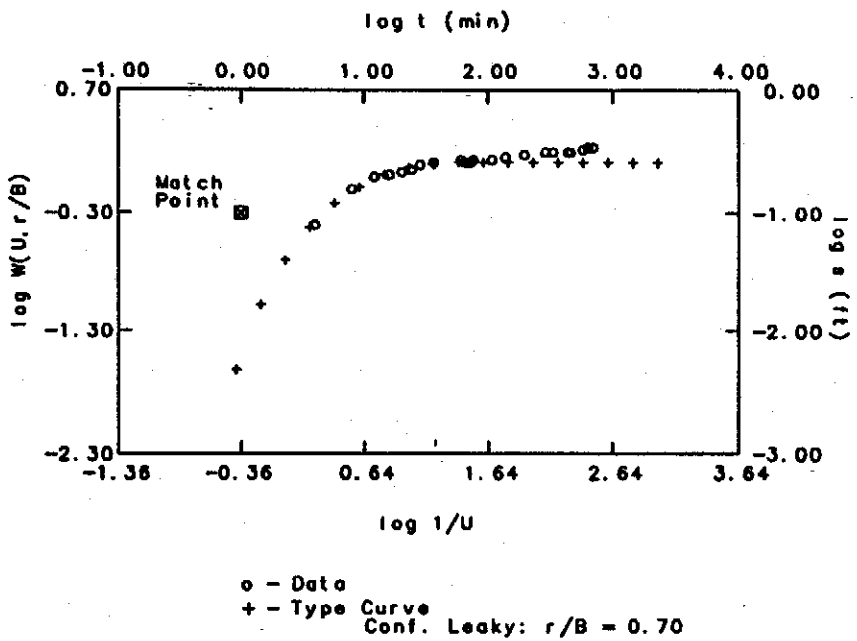
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.643E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.643E+0005 gpd/sq ft
1/U	=	9.120E-0001	Storativity	=	4.309E-0004
W(U,r/B)	=	9.333E-0002	Leakage Factor	=	3.312E+0003 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4360D
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.624E+0002 ft

4360 Test – Recovery Well 1396



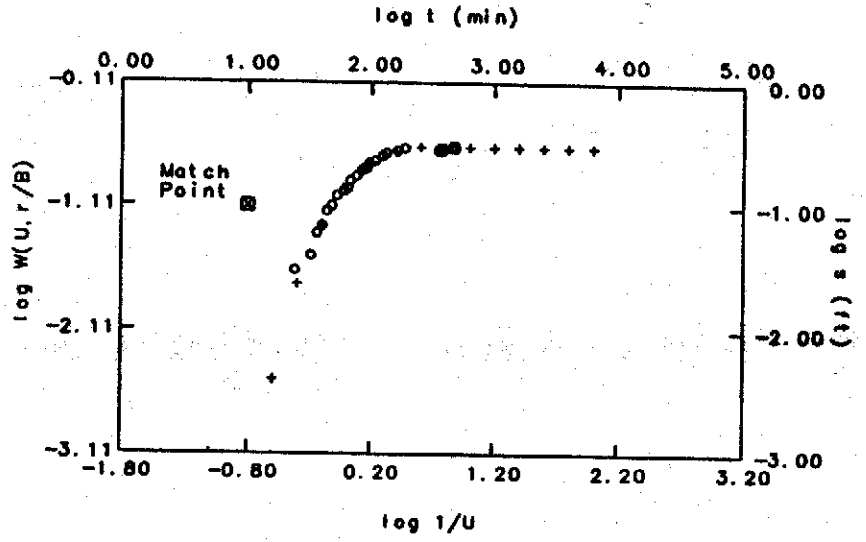
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	2.493E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	2.493E+0005 gpd/sq ft
1/U	=	4.365E-0001	Storativity	=	4.835E-0004
W(U,r/B)	=	5.012E-0002	Leakage Factor	=	9.463E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	: 4360R
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.624E+0002 ft

4360 Test – Drawdown Well 1397

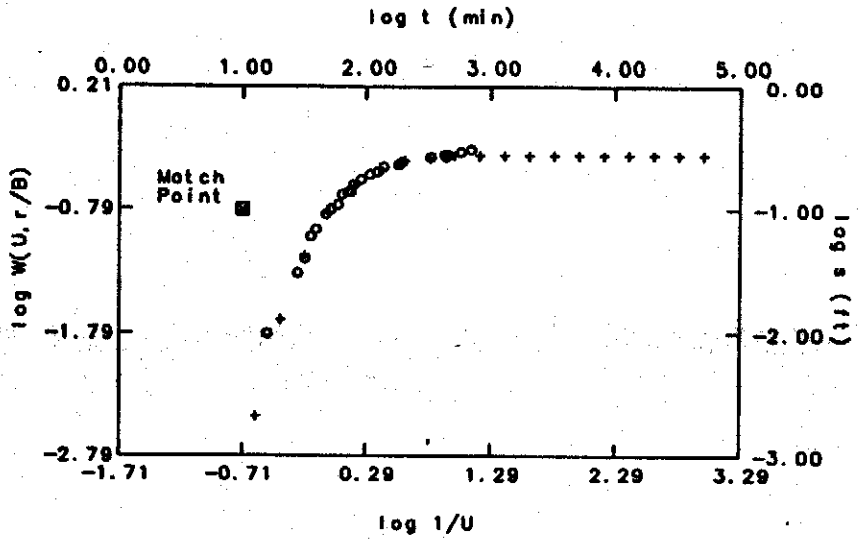


o – Data
+ – Type Curve
Conf. Leaky: r/B = 2.00

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	3.862E+0004 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.862E+0004 gpd/sq ft
1/U	=	1.585E-0001	Storativity	=	2.062E-0003
W(U,r/B)	=	7.762E-0003	Leakage Factor	=	3.312E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4360D
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.624E+0002 ft

4360 Test – Recovery Well 1397

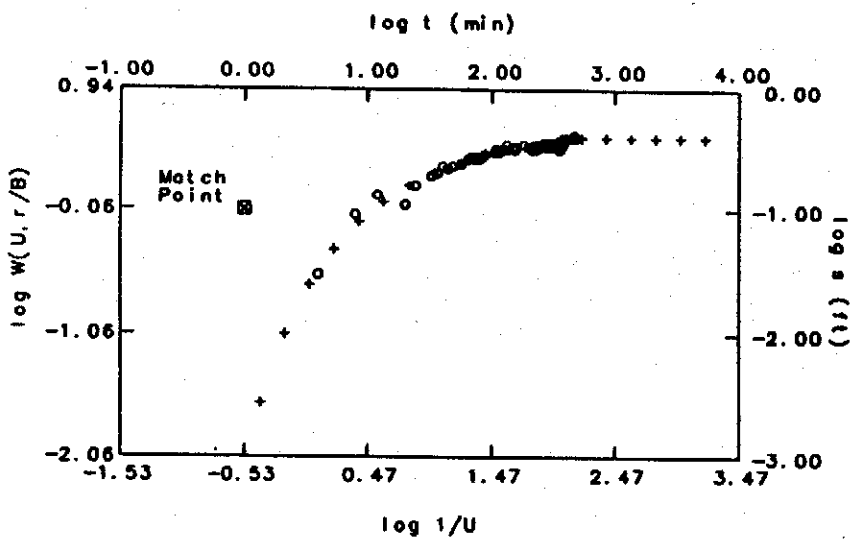


o – Data
+ – Type Curve
Conf. Leaky: r/B = 1.50

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	8.068E+0004 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	8.068E+0004 gpd/sq ft
1/U	=	1.950E-0001	Storativity	=	3.502E-0003
W(U,r/B)	=	1.622E-0002	Leakage Factor	=	4.416E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4360R
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.624E+0002 ft

4360 Test – Drawdown Well 1525

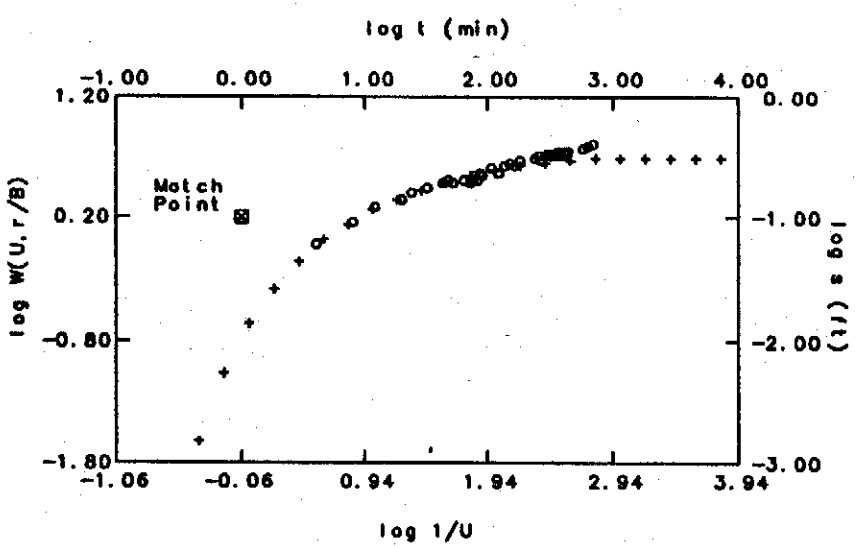


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.333E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.333E+0005 gpd/sq ft
1/U	=	2.951E-0001	Storativity	=	2.582E-0003
W(U,r/B)	=	8.710E-0002	Leakage Factor	=	2.298E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4360D
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.595E+0002 ft

4360 Test – Recovery Well 1525

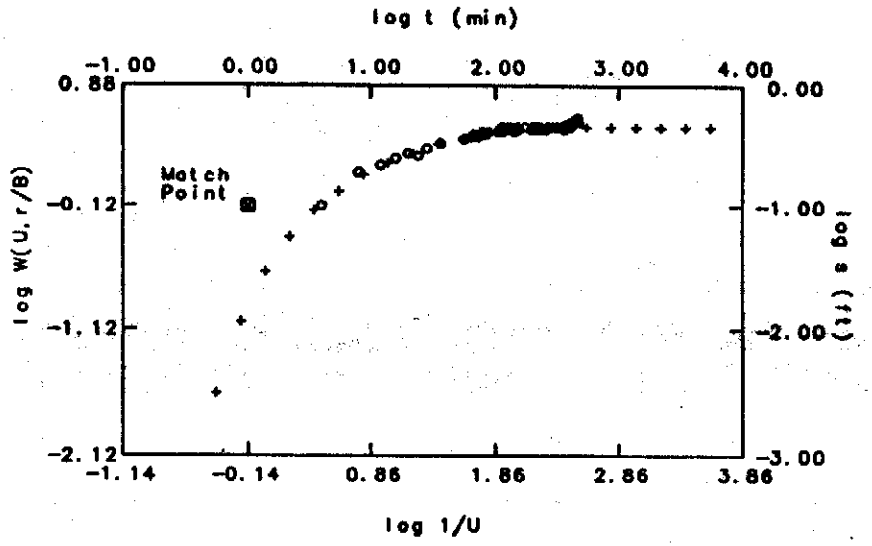


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	7.884E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	7.884E+0005 gpd/sq ft
1/U	=	8.710E-0001	Storativity	=	1.592E-0003
W(U,r/B)	=	1.585E-0001	Leakage Factor	=	4.595E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4360R
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.595E+0002 ft

4360 Test – Drawdown Well 1526

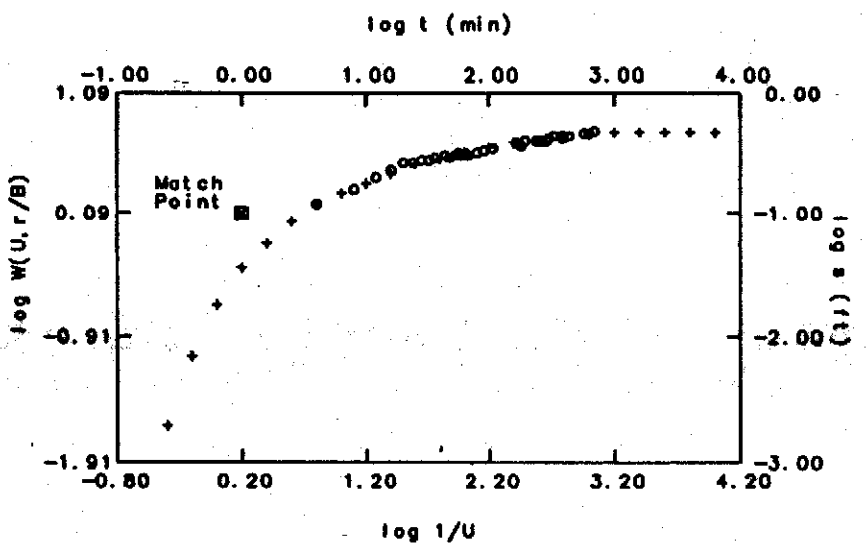


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	3.774E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.774E+0005 gpd/sq ft
1/U	=	7.244E-0001	Storativity	=	9.163E-0004
W(U,r/B)	=	7.586E-0002	Leakage Factor	=	2.298E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4360D
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.595E+0002 ft

4360 Test – Recovery Well 1526

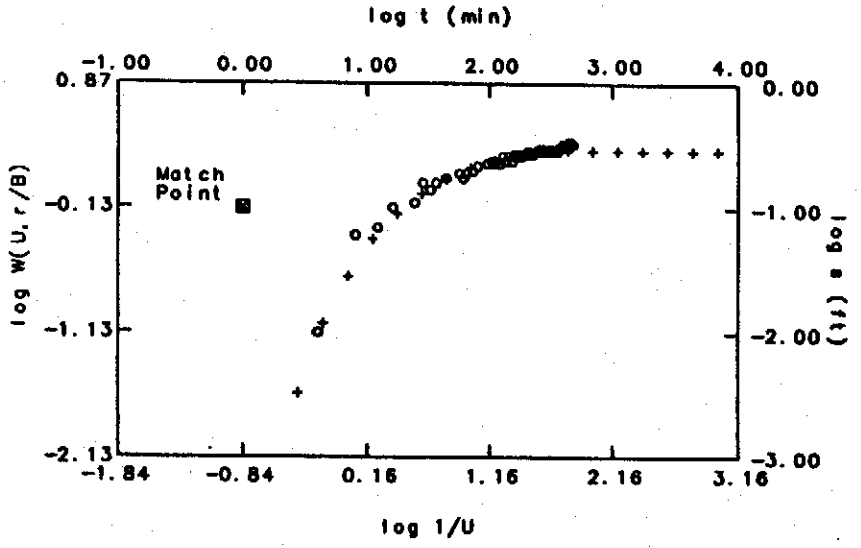


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.06

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	6.120E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	6.120E+0005 gpd/sq ft
1/U	=	1.585E+0000	Storativity	=	6.793E-0004
W(U,r/B)	=	1.230E-0001	Leakage Factor	=	7.658E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4360R
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.595E+0002 ft

4360 Test – Drawdown Well 1565

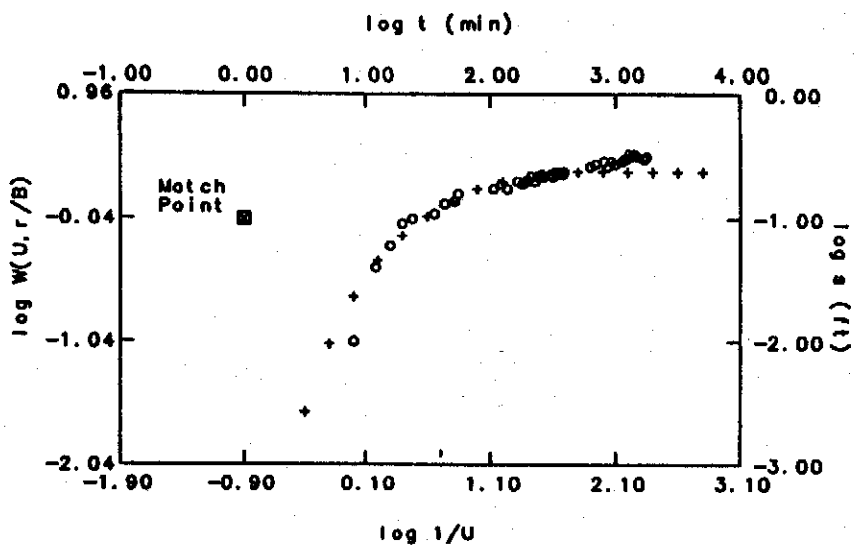


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	3.688E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.688E+0005 gpd/sq ft
1/U	=	1.445E-0001	Storativity	=	2.825E-0003
W(U,r/B)	=	7.413E-0002	Leakage Factor	=	1.448E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4360D
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.792E+0002 ft

4360 Test – Recovery Well 1565

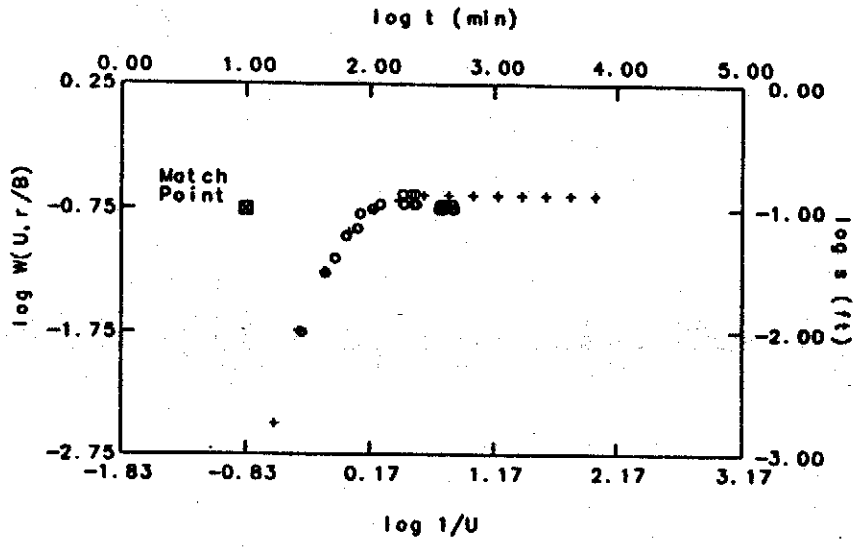


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	4.537E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	4.537E+0005 gpd/sq ft
1/U	=	1.259E-0001	Storativity	=	3.990E-0003
W(U,r/B)	=	9.120E-0002	Leakage Factor	=	1.448E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4360R
DATE OF AQUIFER TEST	: 12/1/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 4.342E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.792E+0002 ft

4365 Test – Drawdown Well 1397



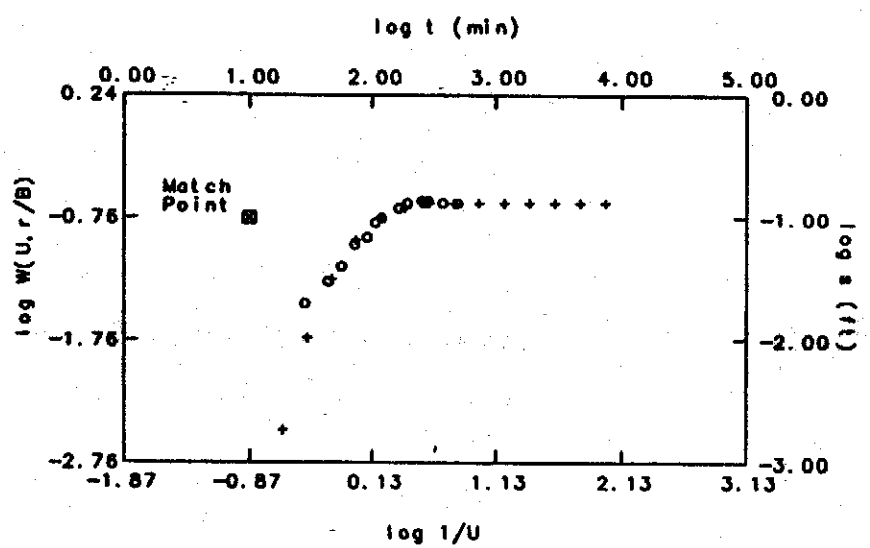
o – Data
+ – Type Curve
Conf. Leaky: r/B = 2.00

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.157E+0004 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.157E+0004 gpd/sq ft
1/U	=	1.479E-0001	Storativity	=	6.282E-0004
W(U,r/B)	=	1.778E-0002	Leakage Factor	=	3.400E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4365D
DATE OF AQUIFER TEST	:	12/7/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	5.680E+0001 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	6.801E+0002 ft

4365 Test – Recovery Well 1397



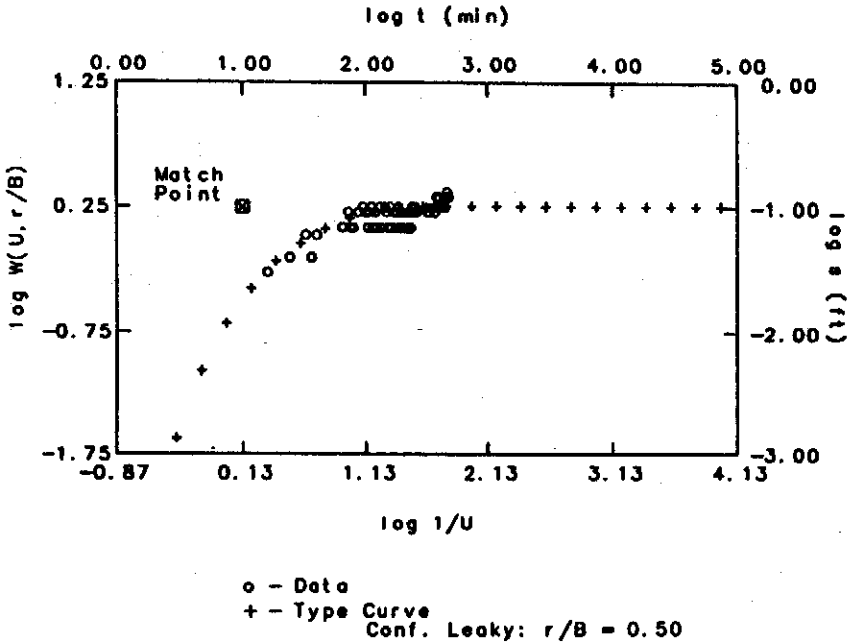
o – Data
+ – Type Curve
Conf. Leaky: r/B = 2.00

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.131E+0004 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.131E+0004 gpd/sq ft
1/U	=	1.349E-0001	Storativity	=	6.732E-0004
W(U,r/B)	=	1.738E-0002	Leakage Factor	=	3.400E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4365R
DATE OF AQUIFER TEST	:	12/7/94
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	5.680E+0001 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	6.801E+0002 ft

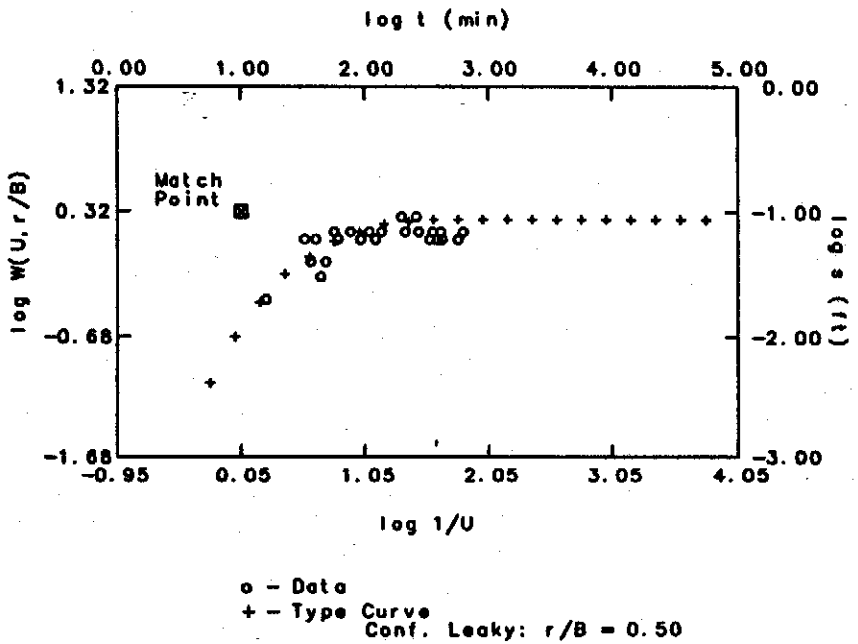
4365 Test – Drawdown Well 1566



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.157E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.157E+0005 gpd/sq ft
1/U	=	1.349E+0000	Storativity	=	9.256E-0004
W(U,r/B)	=	1.778E-0001	Leakage Factor	=	1.173E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4365D
DATE OF AQUIFER TEST	: 12/7/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 5.680E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.867E+0002 ft

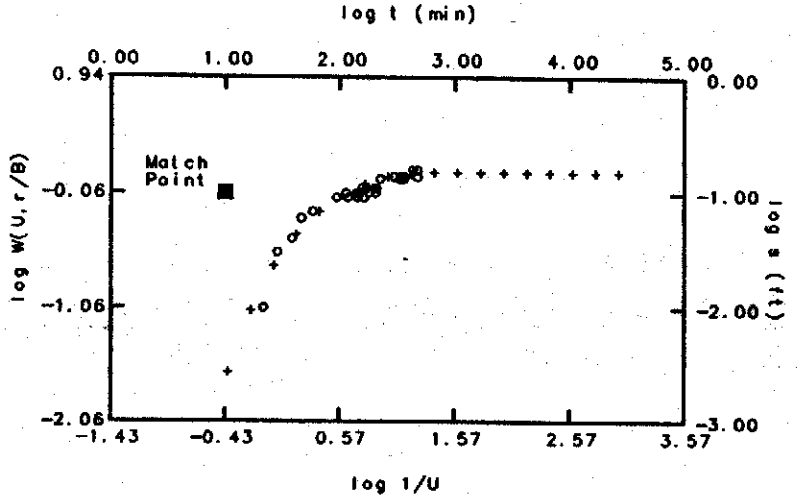
4365 Test – Recovery Well 1566



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.360E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.360E+0005 gpd/sq ft
1/U	=	1.122E+0000	Storativity	=	1.307E-0003
W(U,r/B)	=	2.089E-0001	Leakage Factor	=	1.173E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4365R
DATE OF AQUIFER TEST	: 12/7/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 5.680E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.867E+0002 ft

4370 Test – Drawdown Well 1488

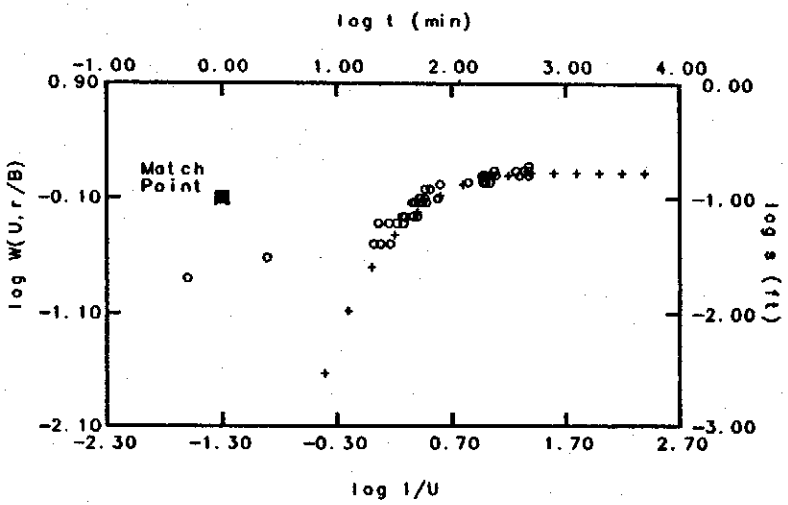


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	3.910E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.910E+0005 gpd/sq ft
1/U	=	3.715E-0001	Storativity	=	9.310E-0003
W(U,r/B)	=	8.710E-0002	Leakage Factor	=	9.256E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4370D
DATE OF AQUIFER TEST	: 8/4/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 3.918E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.479E+0002 ft

4375 Test – Drawdown Well 1488



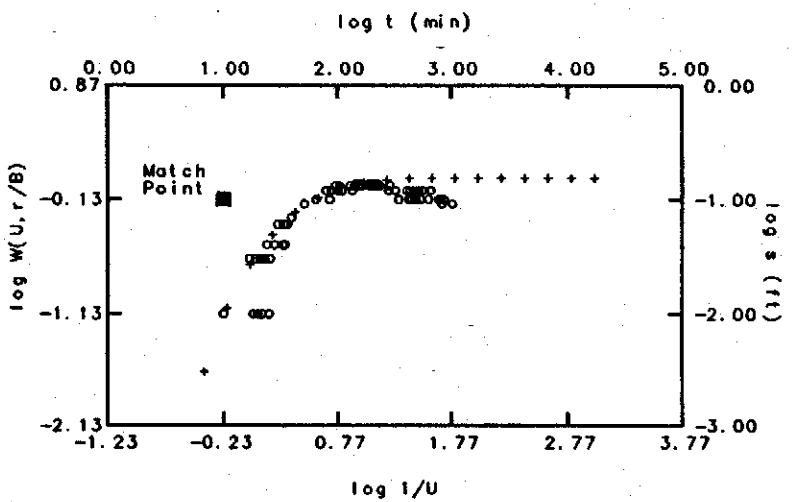
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.70

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.919E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.919E+0005 gpd/sq ft
1/U	=	5.012E-0002	Storativity	=	3.298E-0003
W(U,r/B)	=	7.943E-0002	Leakage Factor	=	9.381E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4375D
DATE OF AQUIFER TEST	:	8/2/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	2.109E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	6.567E+0002 ft

4375 Test – Recovery Well 1488



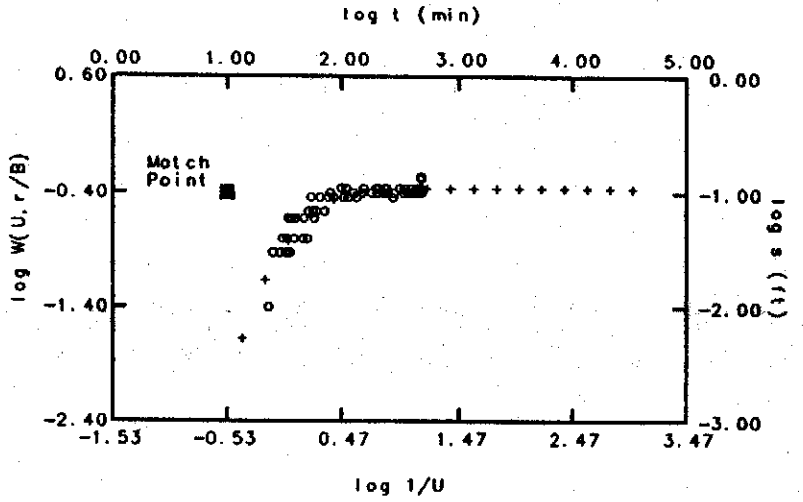
o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.80

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.791E+0005 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.791E+0005 gpd/sq ft
1/U	=	5.888E-0001	Storativity	=	2.620E-0003
W(U,r/B)	=	7.413E-0002	Leakage Factor	=	8.209E+0002 ft

WELL INFORMATION

WELL IDENTIFICATION	:	4375R
DATE OF AQUIFER TEST	:	8/2/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	2.109E+0002 gpm
PUMPING WELL RADIUS (r)	:	9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	6.567E+0002 ft

4375 Test – Drawdown Well 1572

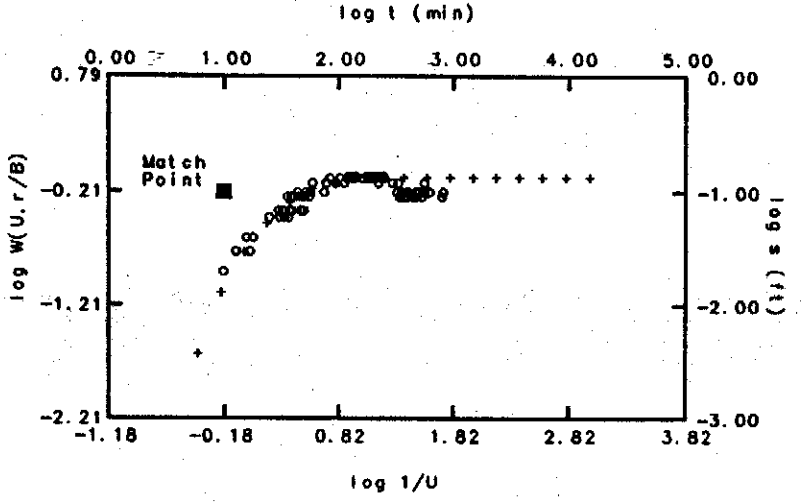


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 1.50

MATCH POINT		SOLUTION	
t =	1.000E+0001	Transmissivity =	9.619E+0004 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	9.619E+0004 gpd/sq ft
1/U =	2.951E-0001	Storativity =	1.337E-0003
W(U,r/B) =	3.981E-0002	Leakage Factor =	6.345E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4375D
DATE OF AQUIFER TEST	: 8/2/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.109E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.517E+0002 ft

4375 Test – Recovery Well 1572

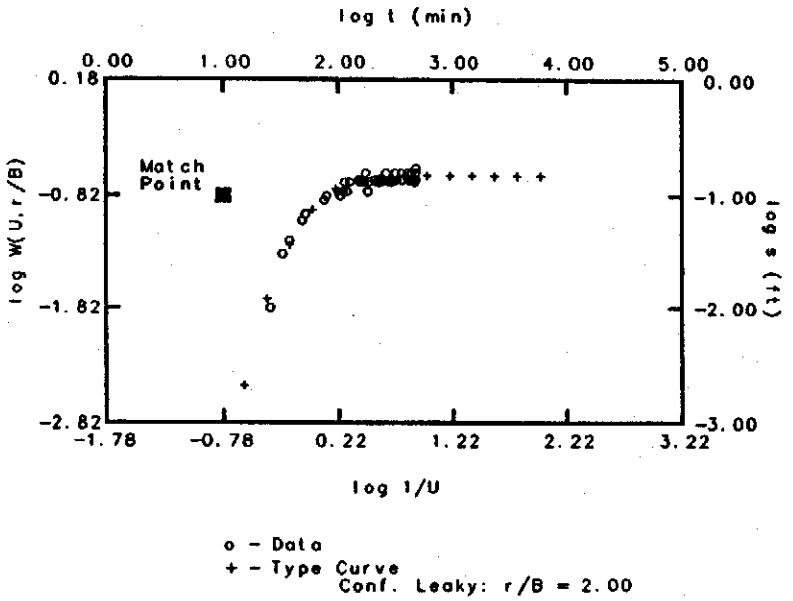


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 1.00

MATCH POINT		SOLUTION	
t =	1.000E+0001	Transmissivity =	1.490E+0005 gpd/ft
s =	1.000E-0001	Hydraulic. Cond. =	1.490E+0005 gpd/sq ft
1/U =	6.607E-0001	Storativity =	9.247E-0004
W(U,r/B) =	6.166E-0002	Leakage Factor =	9.517E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4375R
DATE OF AQUIFER TEST	: 8/2/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.109E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.517E+0002 ft

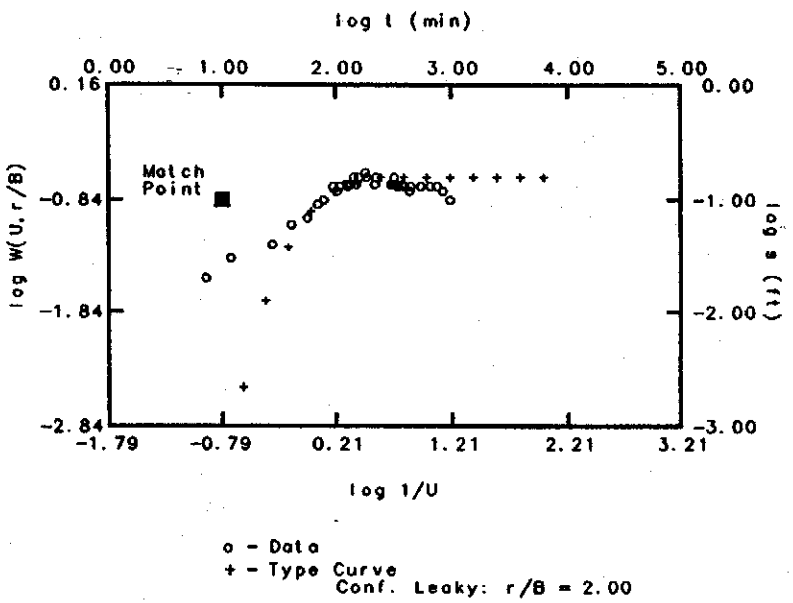
4375 Test – Drawdown Well 1573



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	3.657E+0004 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.657E+0004 gpd/sq ft
1/U	=	1.660E-0001	Storativity	=	9.036E-0004
W(U,r/B)	=	1.514E-0002	Leakage Factor	=	4.759E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4375D
DATE OF AQUIFER TEST	: 8/2/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.109E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.517E+0002 ft

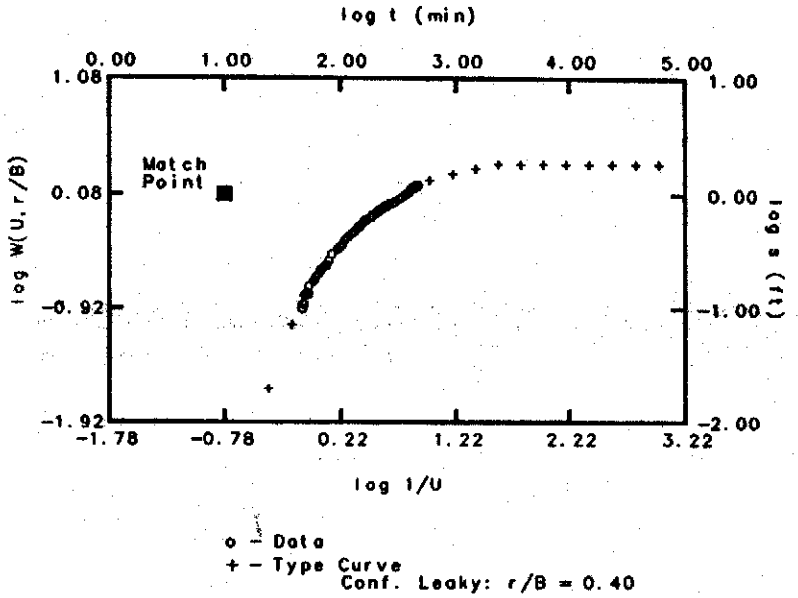
4375 Test – Recovery Well 1573



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	3.493E+0004 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	3.493E+0004 gpd/sq ft
1/U	=	1.622E-0001	Storativity	=	8.831E-0004
W(U,r/B)	=	1.445E-0002	Leakage Factor	=	4.759E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4375R
DATE OF AQUIFER TEST	: 8/2/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 2.109E+0002 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.517E+0002 ft

4380 Test – Drawdown Well 1489

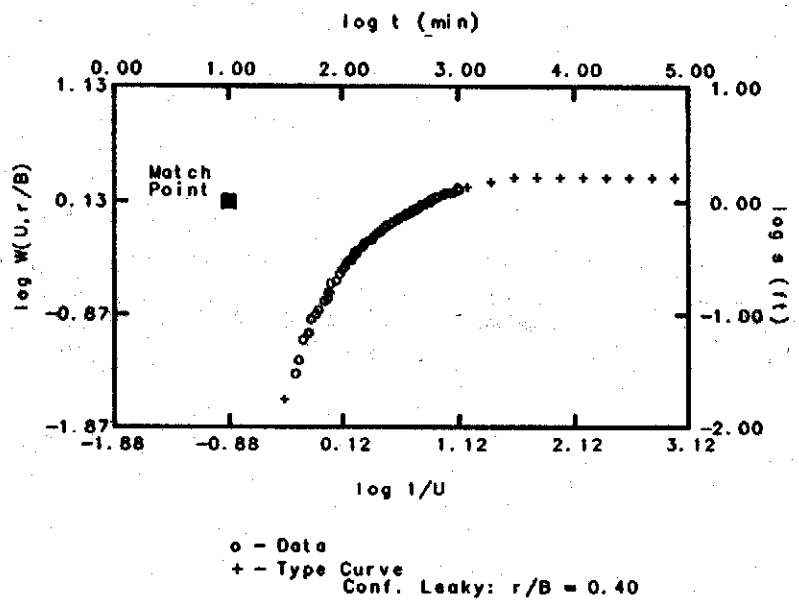


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.362E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.362E+0004 gpd/sq ft
1/U	=	1.660E-0001	Storativity	=	7.738E-0004
W(U,r/B)	=	1.202E-0001	Leakage Factor	=	1.569E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4380D
DATE OF AQUIFER TEST	: 8/8/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 9.890E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.277E+0002 ft

4380 Test – Recovery Well 1489

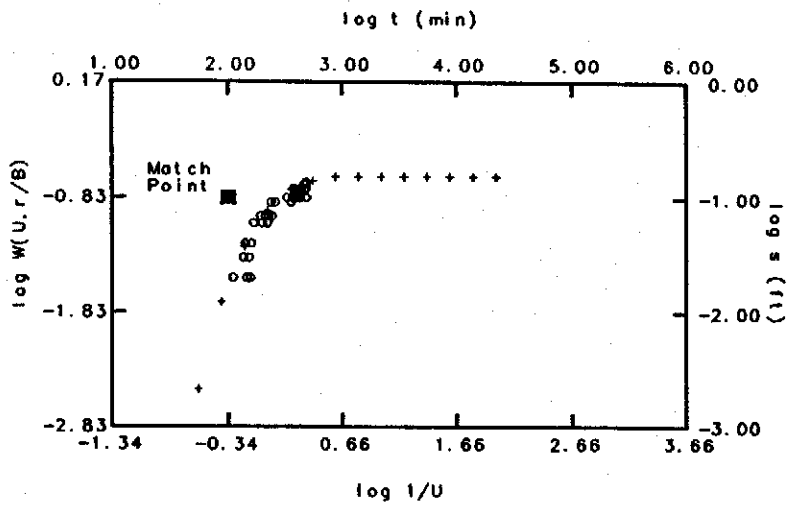


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.529E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.529E+0004 gpd/sq ft
1/U	=	1.318E-0001	Storativity	=	1.093E-0003
W(U,r/B)	=	1.349E-0001	Leakage Factor	=	1.569E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4380R
DATE OF AQUIFER TEST	: 8/8/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 9.890E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.200E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.277E+0002 ft

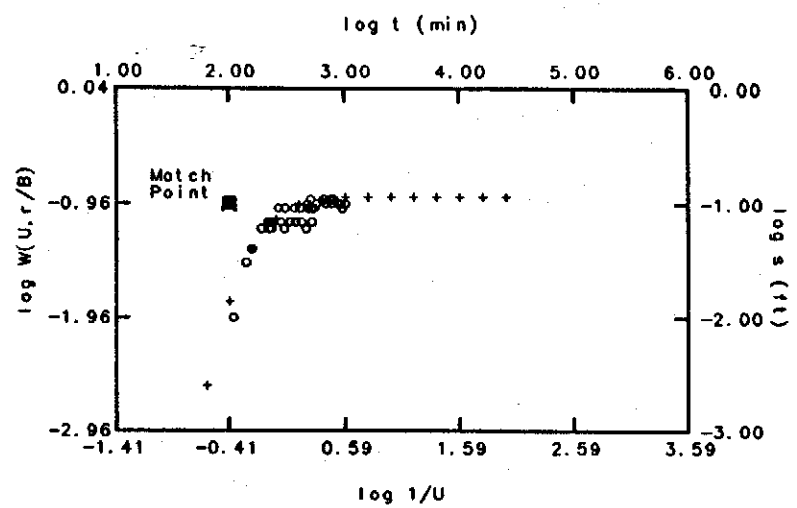
4380 Test – Drawdown Well 1573



MATCH POINT			SOLUTION		
t	=	1.000E+0002	Transmissivity	=	1.676E+0004 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.676E+0004 gpd/sq ft
1/U	=	4.571E-0001	Storativity	=	1.347E-0003
W(U,r/B)	=	1.479E-0002	Leakage Factor	=	5.028E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4380D
DATE OF AQUIFER TEST	: 8/8/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 9.890E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.006E+0003 ft

4380 Test – Recovery Well 1573



MATCH POINT			SOLUTION		
t	=	1.000E+0002	Transmissivity	=	1.242E+0004 gpd/ft
s	=	1.000E-0001	Hydraulic. Cond.	=	1.242E+0004 gpd/sq ft
1/U	=	3.890E-0001	Storativity	=	1.173E-0003
W(U,r/B)	=	1.096E-0002	Leakage Factor	=	4.022E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4380R
DATE OF AQUIFER TEST	: 8/8/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 9.890E+0001 gpm
PUMPING WELL RADIUS (r)	: 9.170E-0001 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.006E+0003 ft

Table G-2
American River Aquifer Tests
Drawdown Summary

Observ. Well No.	Pumped Well No. 4300	4301	4302	4325	4330	4335	4340	4345	4350	4355	4360	4365	4370	4375	4380	Total Drawdown	Obs. Well Aquifer
4300*	**12.38**	1.30	0.20	--	--	--	--	--	--	--	--	--	--	--	--	13.88	Upper
4301*	1.46	**31.43**	0.32	--	--	--	--	--	--	--	--	--	--	--	--	33.21	Middle
4302*	0.44	1.03	**70.65**	--	--	--	--	--	--	--	--	--	--	--	--	72.12	Lower
4325*	--	--	--	**26.70**	0.00	0.00	--	--	--	--	--	--	0.00	0.00	0.00	26.70	Upper
4330*	--	--	--	4.90	**41.33**	0.00	--	--	--	--	--	--	0.00	0.00	0.00	46.23	Middle
4335*	--	--	--	0.00	1.30	**73.73**	--	--	--	--	--	--	0.00	0.00	0.00	75.03	Lower
4340*	--	--	--	--	--	--	**9.77**	--	0.13	--	--	--	--	--	--	9.90	Upper
4345*	--	--	--	--	--	--	--	**28.88**	0.39	0.41	0.67	0.15	--	--	--	30.50	Middle
4350*	--	--	--	--	--	--	--	--	**60.23**	--	--	--	--	--	--	60.23	Lower
4355*	--	--	--	--	--	--	--	--	-0.03	**6.68**	3.03	0.18	--	--	--	9.89	Upper
4360*	--	--	--	--	--	--	--	--	-0.04	2.43	**23.49**	0.43	--	--	--	26.35	Middle
4365*	--	--	--	--	--	--	--	0.55	-0.01	1.14	5.36	**49.35**	--	--	--	56.40	Lower
4370*	--	--	--	0.00	0.00	0.00	--	--	--	--	--	--	**24.83**	1.47	0.00	26.30	Upper
4375*	--	--	--	0.00	0.00	0.00	--	--	--	--	--	--	2.90	**41.70**	0.00	44.60	Middle
4380*	--	--	--	0.00	0.00	0.00	--	--	--	--	--	--	0.00	0.17	**93.38**	93.55	Lower
1357	0.10	0.02	0.03	1.80	2.40	0.00	--	--	--	--	--	--	0.13	-0.02	0.05	4.53	Upper
1358	0.10	0.01	0.01	1.86	2.71	0.05	--	--	--	--	--	--	0.15	-0.05	0.08	4.97	Middle
1359	-0.06	0.09	0.14	-0.87	1.22	8.10	--	--	--	--	--	--	0.34	-0.04	-0.17	9.89	Lower
1361	0.08	0.06	-0.14	--	--	--	--	--	--	--	--	--	--	-0.07	--	0.14	Upper
1362	0.06	0.10	0.31	--	--	--	--	--	--	--	--	--	--	--	--	0.47	Middle
1363	0.02	0.11	0.10	--	--	--	--	--	--	--	--	--	--	--	--	0.23	Lower
1370	0.06	0.16	0.03	0.77	0.81	0.22	--	--	--	--	--	--	0.12	-0.06	--	2.17	Upper
1371	0.05	0.02	0.06	0.77	0.81	0.05	--	--	--	--	--	--	0.15	-0.07	--	1.91	Middle
1372	-0.08	0.10	0.13	-0.77	1.08	3.28	--	--	--	--	--	--	0.12	-0.4	--	4.71	Lower
1375	0.08	0.02	0.03	--	--	--	--	--	--	--	--	--	--	--	--	0.13	Upper
1376	0.09	0.01	-0.02	--	--	--	--	--	--	--	--	--	--	--	--	0.10	Middle
1377	0.01	0.06	-0.12	--	--	--	--	--	--	--	--	--	--	--	--	0.07	Lower
1379	0.04	-0.05	-0.22	-0.06	0.17	0.90	--	--	--	--	--	--	0.10	-0.04	--	1.21	Lower
1380	0.02	0.30	-0.01	--	--	--	--	--	--	--	--	--	--	--	--	0.32	Middle
1381	0.03	0.32	0.00	--	--	--	--	--	--	--	--	--	--	--	--	0.35	Lower
1382	0.04	0.04	-0.1	--	--	--	--	--	--	--	--	--	--	--	--	0.08	Middle
1383	0.03	0.03	-0.2	--	--	--	--	--	--	--	--	--	--	--	--	0.06	Middle
1384	0.00	0.04	-0.13	--	--	--	--	--	--	--	--	--	--	--	--	0.04	Lower
1385	0.03	0.03	0.05	--	--	--	--	--	--	--	--	--	--	--	--	0.11	Upper
1386	0.05	0.06	0.05	--	--	--	--	--	--	--	--	--	--	--	--	0.16	Middle
1387	0.04	0.13	0.15	--	--	--	--	--	--	--	--	--	--	--	--	0.32	Lower
1388	0.21	0.01	0.02	0.23	0.25	0.03	--	--	--	--	--	--	--	--	--	0.75	Middle
1389	0.03	0.55	-0.06	-0.13	0.17	1.04	--	--	--	--	--	--	--	--	--	1.79	Lower
1390	-0.08	0.18	-0.03	0.00	0.06	0.01	--	--	--	--	--	--	--	--	--	0.25	Deeper
1391	0.06	0.05	-0.4	-0.02	0.04	0.03	--	--	--	--	--	--	--	--	--	0.18	Upper
1392	0.04	0.03	-0.02	-0.02	0.08	0.13	--	--	--	--	--	--	--	--	--	0.28	Middle
1393	0.02	0.08	-0.07	-0.08	0.09	0.51	--	--	--	--	--	--	--	--	--	0.70	Lower
1395	2.70	1.04	0.35	-0.05	0.01	-0.02	-0.12	0.07	0.09	0.12	0.20	-0.03	0.05	-0.02	0.02	4.65	Upper
1396	1.20	3.30	0.56	-0.04	0.03	0.00	-0.1	0.24	0.07	0.14	0.37	0.01	0.07	-0.03	0.03	6.02	Middle
1397	0.40	1.18	6.90	-0.06	0.06	0.11	-0.06	0.23	0.06	0.14	0.30	0.10	0.06	-0.05	0.02	9.56	Lower
1400	0.14	0.15	-0.02	--	--	--	--	--	--	--	--	--	--	--	--	0.29	Middle
1401	0.01	0.09	-0.05	--	--	--	--	--	--	--	--	--	--	--	--	0.10	Lower
1402	1.2?	0.26	-0.1	--	--	--	--	--	--	--	--	--	--	--	--	0.26	Deeper
1403	-0.06	-0.06	-0.16	0.07	0.06	-0.08	--	--	--	--	--	--	0.11	-0.01	--	0.24	Upper
1404	0.05	0.05	-0.09	0.35	0.41	0.03	--	--	--	--	--	--	0.11	-0.03	--	1.00	Middle
1405	0.07	0.04	-0.14	0.32	0.39	0.13	--	--	--	--	--	--	0.09	-0.04	--	1.04	Lower
1406	-0.01	0.05	-0.04	--	--	--	--	--	--	--	--	--	--	--	--	0.05	Upper
1407	-0.09	0.09	-0.04	--	--	--	--	--	--	--	--	--	--	--	--	0.09	Middle
1408	-0.33	0.19	-0.01	--	--	--	--	--	--	--	--	--	--	--	--	0.19	Deeper
1409	-0.22	0.15	-0.04	--	--	--	--	--	--	--	--	--	--	--	--	0.15	Deeper
1469	0.08	0.12	0.09	0.10	0.13	-0.02	--	--	--	--	--	--	0.15	-0.02	0.07	0.74	Upper
1470	0.10	0.21	0.10	-0.02	0.59	0.94	--	--	--	--	--	--	0.21	-0.02	0.05	2.20	Deeper
1471	-0.11	0.13	0.06	0.07	-0.01	0.03	--	--	--	--	--	--	0.11	0.00	0.14	0.54	Deeper
1472	0.04	0.06	-0.09	--	--	--	--	--	--	--	--	--	--	--	--	0.10	Upper
1475	0.02	0.06	0.05	--	--	--	--	--	--	--	--	--	--	--	--	0.13	Upper
1476	0.02	0.04	-0.01	--	--	--	--	--	--	--	--	--	--	--	--	0.06	Middle
1477	0.01	0.07	0.05	--	--	--	--	--	--	--	--	--	--	--	--	0.13	Lower
1478	0.06	0.05	0.05	0.17	0.22	0.02	--	--	--	--	--	--	0.12	-0.07	0.01	0.70	Upper

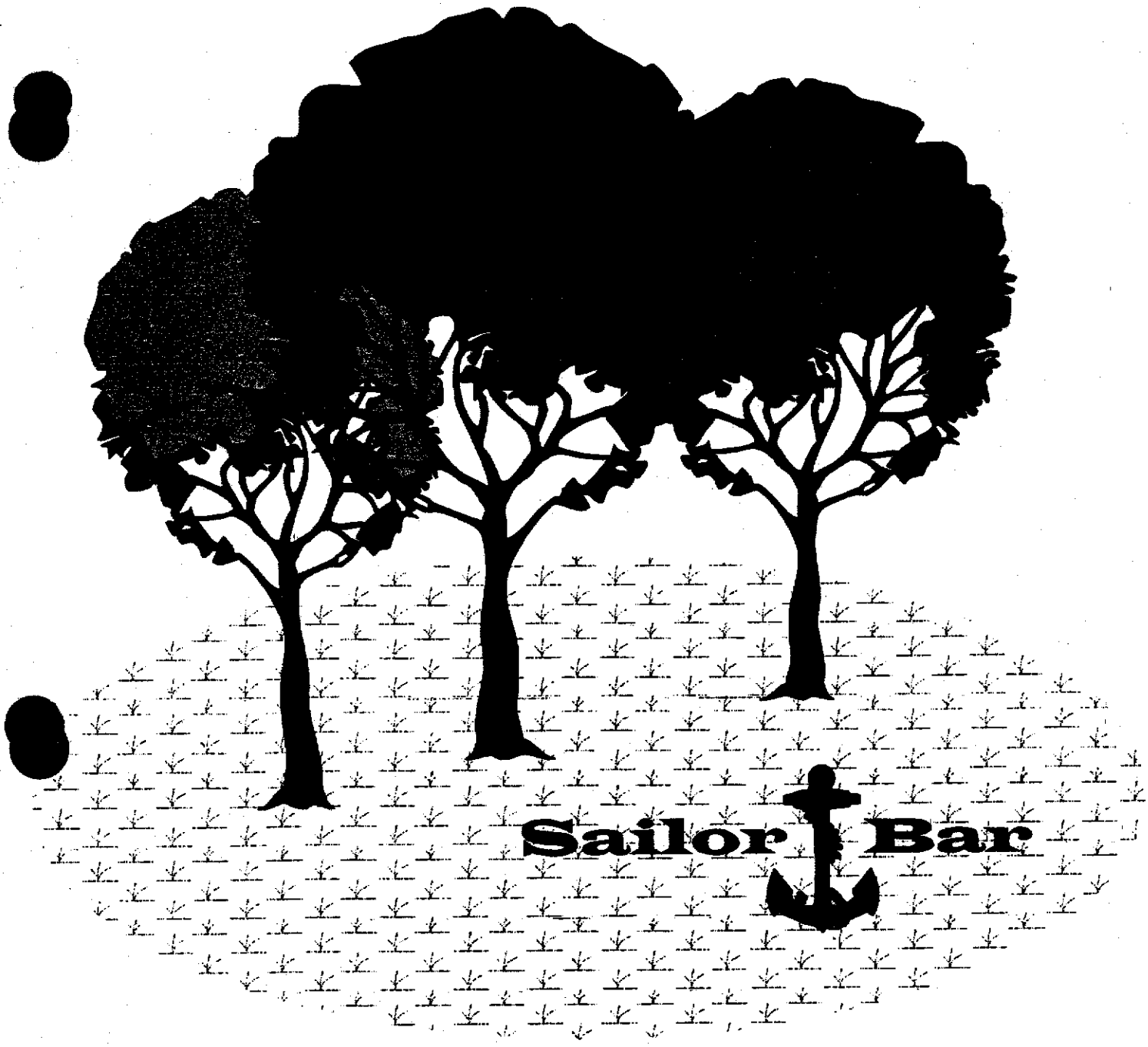
Table G-2
American River Aquifer Tests
Drawdown Summary

Observ. Well No.	Pumped Well No.															Total Drawdown	Obs. Well Aquifer
	4300	4301	4302	4325	4330	4335	4340	4345	4350	4355	4360	4365	4370	4375	4380		
1479	0.03	0.14	0.14	-1.08	2.25	2.90	--	--	--	--	--	--	-0.06	-0.07	0.34	5.80	Lower
1480	0.02	0.01	0.12	-1.09	2.08	2.99	--	--	--	--	--	--	-0.09	-0.07	0.37	5.59	Deeper
1481	0.17	0.02	0.03	--	--	--	--	--	--	--	--	--	0.16	-0.05	1.07	1.45	Upper
1482	0.21	0.19	0.01	--	--	--	--	--	--	--	--	--	0.12	-0.03	0.11	0.64	Lower
1487	0.03	0.05	0.03	--	--	-0.14	--	--	--	--	--	--	--	-0.06	1.07	1.18	Upper
1488	0.06	0.07	0.04	--	--	-0.01	--	--	--	--	--	--	0.24	0.16	--	0.57	Middle
1489	-0.1	0.13	0.15	--	--	1.00	--	--	--	--	--	--	0.15	-0.01	1.23	2.66	Deeper
1506	0.06	0.15	0.05	--	--	--	--	--	--	--	--	--	--	--	--	0.26	Upper
1507	0.05	0.09	0.05	--	--	--	--	--	--	--	--	--	--	--	--	0.19	Middle
1508	-0.15	0.16	0.11	--	--	--	--	--	--	--	--	--	--	--	--	0.27	Deeper
1509	0.24	0.05	0.34	-0.07	0.08	-0.03	--	--	--	--	--	--	--	--	--	0.71	Middle
1510	0.25	0.09	0.38	-1.18	2.82	3.24	--	--	--	--	--	--	--	--	--	6.78	Lower
1511	0.26	0.11	0.40	-1.16	3.03	3.15	--	--	--	--	--	--	--	--	--	6.95	Deeper
1519	0.18	0.29	0.19	--	--	--	--	--	--	--	--	--	0.12	-0.06	0.01	0.79	U/M
1520	0.22	0.22	0.05	--	--	--	--	--	--	--	--	--	0.12	-0.01	-0.08	0.61	Lower
1521	0.16	0.12	0.11	--	--	--	--	--	--	--	--	--	0.19	-0.05	-0.04	0.58	Deeper
1522	0.20	0.11	0.06	--	--	--	--	--	--	--	--	--	0.08	-0.02	0.02	0.47	Upper
1523	0.27	0.35	0.10	--	--	--	--	--	--	--	--	--	0.10	-0.04	0.00	0.82	Middle
1524	0.15	0.06	0.12	--	--	--	--	--	--	--	--	--	0.19	-0.06	-0.09	0.52	Deeper
1525	0.05	0.12	0.03	--	--	--	0.09	0.29	-0.03	0.17	0.40	0.10	--	--	--	1.25	Upper
1526	0.08	0.10	0.00	--	--	--	0.10	0.33	-0.06	0.19	0.51	0.12	--	--	--	1.43	Middle
1527	0.10	0.13	0.04	--	--	--	0.06	0.14	-0.06	0.00	-0.02	0.07	--	--	--	0.54	Deeper
1528	0.22	0.04*	0.50	--	--	--	--	--	--	--	--	--	--	--	--	0.76	Upper
1529	0.31	0.03	0.35	--	--	--	--	--	--	--	--	--	--	--	--	0.69	Lower
1530	0.20	-0.02	0.28	--	--	--	--	--	--	--	--	--	--	--	--	0.48	Deeper
1531	0.13	0.30	0.03	--	--	--	--	--	--	--	--	--	--	--	--	0.46	Upper
1532	0.39	0.32	0.04	--	--	--	--	--	--	--	--	--	--	--	--	0.75	Middle
1533	0.09	0.23	0.24	--	--	--	--	--	--	--	--	--	--	--	--	0.56	Lower
1538	0.16	0.45	0.27	--	--	--	--	--	--	--	--	--	--	--	--	0.88	Upper
1539	0.24	0.71	0.32	--	--	--	--	--	--	--	--	--	--	--	--	1.27	Middle
1540	0.19	0.66	0.64	--	--	--	--	--	--	--	--	--	--	--	--	1.49	Lower
1557	--	-0.11	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	Middle
1558	--	-0.36	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	Lower
1559	--	-0.01	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	Upper
1560	--	-0.03	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	Middle
1561	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.00	Lower
1562	--	--	--	--	--	--	--	--	--	--	--	--	-0.11	-0.01	0.08	0.08	Middle
1563	--	--	--	--	--	--	--	--	--	--	--	--	0.11	-0.03	0.06	0.17	Middle
1564	--	--	--	--	--	--	0.68	1.18	0.11	0.14	0.23	0.06	--	--	--	2.40	Upper
1565	--	--	--	--	--	--	0.66	9.80	0.45	0.23	0.33	0.09	--	--	--	11.56	Middle
1566	--	--	--	--	--	--	-0.04	5.37	1.00	0.35	0.38	0.12	--	--	--	7.22	Lower
1571	--	--	--	--	--	--	--	--	--	--	--	--	0.11	0.02	--	0.13	Upper
1572	--	--	--	--	--	--	--	--	--	--	--	--	0.16	0.13	--	0.29	Middle
1573	--	--	--	--	--	--	--	--	--	--	--	--	0.14	0.17	0.13	0.44	Lower
1574	--	--	--	--	--	--	--	--	--	--	--	--	0.15	0.13	--	0.28	Middle

*Drawdown measured at extraction wells during pumping was reduced by a factor of 25% in order to compensate for potential well loss. Well effeciency assumed to be 75%

APPENDIX H

Environmental Studies
Prepared By *biota biological consulting*



Natural Environment Study

Groundwater Extraction and Treatment Facility

Prepared by:

biota

August 95

Prepared for:

GenCorp Aerojet

& The Spink Corporation

Sailor Bar
Groundwater Extraction and Treatment Facility
Natural Environment Study

Prepared for:

GenCorp Aerojet &
The Spink Corporation

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August 1995

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Appendix A. Plant Species Observed at the Sailor Bar GET Site
Appendix B. Wildlife Species Observed at the Sailor Bar GET Site

1.0 SUMMARY OF FINDINGS

GenCorp Aerojet and Spink Corporation propose to build a North American River Groundwater Extraction and Treatment (GET) Facility within Sailor Bar Park. Five alternative sites, proposed pipeline alignments and recharge well sites were surveyed for sensitive biological resources.

1.1 Alternative 1

No sensitive plant or special status wildlife species were encountered at Alternative 1. The proposed GET facility will be built adjacent to riparian habitat and has potential to impact sensitive wildlife species, especially migratory birds which winter along the American River.

1.2 Alternative 2

No special status wildlife species were encountered at Alternative 2. Damage to five interior live oaks (*Quercus wislizenii*) at the site can probably be avoided.

1.3 Alternatives 3a and 3b

No special status wildlife species were encountered at Alternative sites 3a and 3b. Two interior live oaks and six blue oaks (*Quercus douglasii*) will be removed for either alternative and should be replaced.

1.4 Alternative 4

No special status wildlife species were observed at Alternative 4. Three interior live oaks along Illinois Avenue may suffer root damage. One located on the bluff (which will require layback) may need to be removed. Loss or damage to these oaks should be compensated with new plantings.

1.5 Alternative 5

Alternative 5 would necessitate drilling under the American River. This alternative has potential to impact the following:

- several interior live oaks;
- a vernal pool considered to be potential habitat for the federally endangered vernal pool tadpole shrimp (*Lepidurus packardi*), the federally threatened vernal pool fairy shrimp (*Branchinecta lynchi*) and sensitive vernal pool plant species;
- potential habitat for the federally threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*);
- and potential additional impacts to sensitive species and their special habitats between the American River and the Aerojet property.

1.6 Pipeline

The proposed pipeline alignment has potential to impact the following:

- a pump-fed pond where a turtle, assumed to be a northwestern pond turtle (*Clemmys marmorata marmorata*), and a river otter (*Lutra canadensis*) were encountered;
- several oak trees;
- a seasonal wetland;
- potential habitat for the valley elderberry longhorn beetle;
- a wet crossing that is part of a riparian drainage.

1.7 Recharge Wells

Potential habitat for the valley elderberry longhorn beetle exists near the recharge wells at the western end of the proposed pipeline alignment. The wells are adjacent to riparian habitat. No sensitive species were encountered, but the site could support sensitive avian species in the winter.

Several blue oaks surround the recharge wells near the eastern end of the proposed pipeline alignment. No sensitive species were encountered at this site, but erosion control measures to protect the pond must be taken if construction occurs at this site.

2.0 INTRODUCTION

GenCorp Aerojet and Spink Corporation have proposed to build a North American River Groundwater Extraction and Treatment (GET) Facility within Sailor Bar Park. The GET facility will be used to treat water in three different aquifers which have been contaminated with volatile organic compounds (VOC). *biota biological consulting* (*biota*) was contracted to conduct a Natural Environment Study (NES), assessing potential impacts to biological resources of the five GET facility alternatives, the proposed pipeline alignment and the recharge wells.

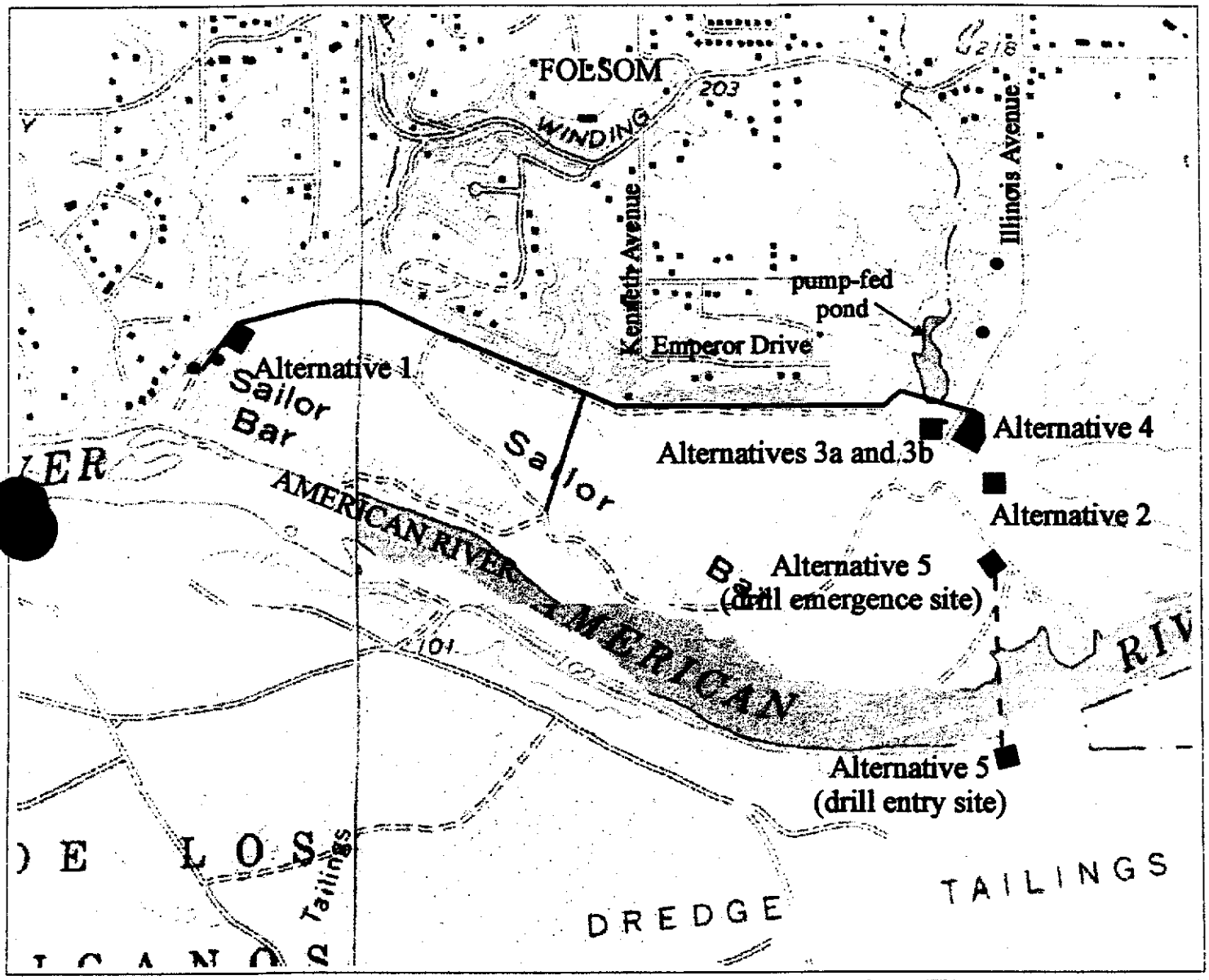
Sailor Bar Park is owned by the County of Sacramento and is under the jurisdiction of the County Department of Parks and Recreation. The approximate 375 acre park is located on the north side of the American River, west of Hazel Avenue in Folsom and east of the old Fair Oaks Bridge. Please refer to Exhibit 1 for a map of the project site and locations of the five alternatives, proposed pipeline alignment(s) and the recharge wells.

Natural communities within Sailor Bar Park have been significantly altered by historic gold dredging and gravel mining, human settlement and other activities (see photo 1). The site is dominated by blue oak woodland in a non-native grassland matrix (see photo 2). Several riparian drainages and seasonal wetlands are scattered throughout the park. Sites of the five alternatives, proposed pipeline alignment and recharge wells were chosen in areas which have already been altered from their natural state. These areas include parking lots, construction laydown areas, abandoned human settlements and existing roads.

Photo 1. Dredge tailing remains from gold mining in Sailor Bar Park.

Photo 2. Sailor Bar Park is dominated by blue oak woodland in a non-native grassland matrix. The proposed pipeline corridor is in the foreground.

Sailor Bar GET
Natural Environment Study Site



Approximate Scale: 1" = 0.4 mile

Exhibit 1

3.0 SURVEY METHODOLOGY

Lists of sensitive plant and wildlife species with potential to occur at the site were developed based on a records search of the California Natural Diversity Data Base (CNDDB 1995) and a literature review of environmental documents prepared for other projects in the vicinity. Summaries of the legal status and habitat requirements of sensitive species are provided in Tables 1 and 2.

Debby Martin, Jessica Martini and Janelle Nolan of *biota* conducted a biological survey for sensitive species at each GET facility alternative, the proposed pipeline corridor and the recharge wells on July 24, 26 and 28, 1995.

3.1 Botany

The floristically appropriate (blooming) time to survey for the target sensitive plant species had already passed when *biota* began the biological survey. An assessment of appropriate habitat was made for these species (see Table 2). All plant species encountered in the surveyed areas were recorded. A list of plant species observed on the project site is included in Appendix A. An assessment of trees to be impacted by the project was made based on engineering drawings provided by Spink Corporation.

3.2 Wildlife

Each treatment plant alternative and recharge well site was surveyed on foot. The proposed pipeline is generally within a ten foot corridor which immediately parallels existing dirt roads and was surveyed from a vehicle with frequent stops at marked well locations and special habitats along the alignment. Elderberry shrubs which are habitat for valley elderberry longhorn beetle were flagged with pink flagging by *biota* where they were within potential impact areas of any project activities. All wildlife species encountered were recorded. A list of wildlife species observed on the project site is included in Appendix B.

Table 1. Sensitive Plant Species Occurring or With Potential to Occur on the Sailor Bar GET Site

Name	Status		Habitat	Blooming Period	Closest Proximity	Potential of Occurrence[3]
	Legal[1]	CNPS[2]				
Atriplex joaquiniana San Joaquin spearscale	/C2	1B	Chenopod scrub, meadows, valley & foothill grassland/alkaline	April-Sept.	Sacramento County (Skinner & Pavlik 1994)	Not encountered in project area
Calystegia stebbinsii Stebbin's morning glory	CE/C2	1B	Chaparral, cismontane woodland, serpentitite or gabbroic	May - June	El Dorado County (Skinner & Pavlik 1994)	Low - little or no habitat exists
Eryngium pinnatisectum Tuolumne button-celery	/C2	4	Cismontane woodland, lower montane coniferous forest, vernal pool/mesic	June	Sacramento County (Skinner & Pavlik 1994)	Low - little or no habitat exists
Fremontodendron decumbens Pine Hill flannelbush	CR/C1	1B	Chaparral, cismontane woodland, serpentitite or gabbroic	April - June	W of Pine Hill, about 9 mi. NE of Aerojet property (Beak 1992)	Low - little or no appropriate soil
Fritillaria agrestis stinkbells	/C3c	4	Chaparral, cismontane woodland, valley & foothill grassland/clay, sometimes serpentine	March - April	Sacramento County (Skinner & Pavlik 1994)	Medium - appropriate habitat exists, pipeline
Gratiola heterosepala Boggs Lake hedge-hyssop	CE/C3c	1B	Marshes & swamps, vernal pools	April - June	On SE corner Aerojet site near Prairie City Rd (Wymer 1988 & 1989)	High - appropriate habitat exists, Alternative 5
Helianthemum suffrutescens Bisbee Peak rush-rose	/C3c	3	Chaparral, often serpentinite, gabbroic or Ione soil	April - May	Near top of Pine Hill, about 9 mi. N of Aerojet property (CNDDB 1995)	Low - no appropriate soil, not encountered (perennial)
Juglans californica var. *hindsii* Northern California black walnut	/C2	1B	Riparian forest & woodland	April - May	Hybrids on Aerojet property (Bowcutt 1981-1982)	Low - no known pure local population, not encountered
Juncus leiospermus var. *ahartii* Ahart's dwarf rush	/C1	1B	Vernal pools	March - May	Sacramento County (Skinner & Pavlik 1994)	Medium - appropriate habitat exists
Legenere limosa Legenere	/C2	1B	Vernal pools	May - June	Approx. 2 mi. S of White Rock Rd. In vernal pool N of Douglas Rd, E of Sunrise Blvd (CNDDB 1995)	High - appropriate habitat exists, Alternative 5
Navarretia eriocephala hoary navarretia	--	4	Cismontane woodland, valley & foothill grassland	May - June	Sacramento & El Dorado Counties (Skinner & Pavlik 1994)	Medium - appropriate habitat exists
Navarretia myersii pincushion navarretia	--	1B	Vernal pools	May	Approx. 2 mi. N at CDFG Phoenix Field Ecological Reserve (CNDDB 1995)	High - appropriate habitat exists

Name	Status		Habitat	Blooming Period	Closest Proximity	Potential of Occurrence[3]
	Legal[1]	CNPS[2]				
Orcuttia tenuis slender Orcutt grass	CE/PT	1B	Vernal pools	May - June	Sacramento County (Skinner & Pavlik 1994)	Medium - appropriate habitat exists, Alternative 5
Orcuttia viscida Sacramento Orcutt grass	CE/PE	1B	Vernal pools	May - June	1.5 mi. N of Aerojet, 0.5 mi. S of Phoenix Field (CNDDB 1995)	Medium - appropriate habitat exists, Alternative 5
Pogogyne douglasii ssp. *parviflora* Douglas' pogogyne	/C3c	3	Chaparral, cismontane woodland, lower montane coniferous forest, meadows, marshes & swamps, valley & foothill grassland, vernal pools/mesic	May - June	Sacramento County (Skinner & Pavlik 1994)	High - appropriate habitat exists, Alternative 5
Psilocarphus brevissimus var. *multiflorus* delta woolly marbles	--	4	Vernal pools	May - June	Yolo County (Skinner & Pavlik 1994)	Low - little or no habitat exists, not encountered
Sagittaria sanfordii Sanford's arrowhead	/C2	1B	Marshes & swamps	May - August	0.5 mi. W of Aerojet on E side of Folsom South Canal at White Rock Rd (CNDDB 1995)	Low - appropriate habitat exists, not encountered
Senecio layneae Layne's ragwort	CR/C2	1B	Chapparal, cismontane woodland, serpentite or gabbroic	April - July	Near Deer Ck, about 8 mi. NE of Aerojet (Beak 1992)	Low - habitat exists, little or no appropriate soil, not encountered
Wyethia reticulata El Dorado County mule ears	/C2	1B	Chapparal, cismontane woodland, serpentite or gabbroic	May - July	Along Martell Ck., about 8.5 mi. NE of Aerojet (Beak 1992)	Low - habitat exists, little or no appropriate soil, not encountered

[1] State/Federal
- C1 = Candidate for Federal listing with sufficient information on hand to support listing
- C2 = Candidate for Federal listing with insufficient information on hand to support listing at this time
- C3c = Federal category 3c; plant too common to warrant listing
- CE = State listed endangered
- CR = State listed rare

[2] CNPS
- 1B = Plants rare and endangered in California and elsewhere
- 3 = Plants which we need more information; a review list
- 4 = Plants of limited distribution; a watch list

[3] Potential of Occurrence (for birds, refers to potential occurrence of nests)
- Low - unlikely to be present
- Medium - likely to be present
- High - very likely to be present

Table 2. Special Status Wildlife Species Occurring or With Potential to Occur at the Sailor Bar GET Site

Name	Status		Habitat	Closest Proximity	Potential of Occurrence[2]
	Federal	State			
Invertebrates					
Branchinecta lynchi vernal pool fairy shrimp	T	--	Vernal pools and other wetland-like habitats	Approximately 1 mile E of Prairie City Road	Medium - appropriate habitat present adjacent to Alternative 5 drill entry pad
Desmocerus californicus dimorphus valley elderberry longhorn beetle	T	--	Valley elderberry shrubs	0.5 mi. N of Aerojet along American River from Nimbus Flat to Lake Natoma	Medium - elderberries shrubs present at several alternatives
Lepidurus packardi vernal pool tadpole shrimp	E	--	Vernal pools and other wetland-like habitats	Phoenix Fields (Goettle 1995)	Medium - appropriate habitat present adjacent to Alternative 5 drill entry pad
Amphibians					
Rana aurora draytonii California red-legged frog	PE	CSC	Moist woods, forest clearings, stream borders, grasslands	"Possible sighting" in pond 0.25 mile W of Prairie City Rd. in Alder Creek	Low - probably extirpated in Sacramento Valley, not encountered
Rana boyleii foothill yellow-legged frog	C2	CSC	Ponds and streams	Probably extirpated in Sacramento Valley	Low - probably extirpated in Sacramento Valley, not encountered
Reptiles					
Clemmys marmorata marmorata northwestern pond turtle	C2	CSC	Slow moving/standing water with overhanging vegetation	Observed in pond N of Alternative 3	High - recorded adjacent to pipeline corridor

Name	Status		Habitat	Closest Proximity	Potential of Occurence
	Federal	State			
Birds					
Accipiter cooperii Cooper's hawk	--	CSC	Woodlands, riparian areas	Observed at Sailor Bar during Audubon Society Christmas Bird Count	High - observed on site, no effect expected
Accipiter striatus sharp-shinned hawk	--	CSC	Mixed woodlands	Observed at Sailor Bar during Audubon Society Christmas Bird Count	High - observed on site, no effect expected
Agelaius tricolor tri-colored blackbird	C2	CSC	Wet meadows, marshes, grassland	Along Scott Rd., within 2 mi. of E end of Alder Ck.	Low - little or no appropriate nesting habitat, no effect expected
Buteo swainsoni Swainson's hawk	--	CT	Riparian, grassland	Several occurrences within 6 mi. of Aerojet property	Medium - appropriate nesting habitat present, no effect expected
Circus cyaneus northern harrier	--	CSC	Wetlands, grassland	Observed at Sailor Bar during Audubon Society Christmas Bird Count	High - observed on site, no effect expected
Dendroica petechia brewsteri yellow warbler	--	CSC	Riparian, cottonwood savanna, dredged areas, foothill oak woodland	Known to nest in Sacramento County (Bell et al. 1993)	Low - unknown whether they breed in the Sacramento Area (Bell et al. 1993), possible impact Alternative 1
Elanus caerulus black-shouldered kite	--	FP	Grassland	Observed on Sailor Bar by *biota*	High - observed on site, no effect expected
Empidonax traillii willow flycatcher	--	CE	Riparian, cottonwood savanna and dredged areas	Observed within 1 mi. of Aerojet property	Low - appropriate nesting habitat along American River, possible impact Alternative 1
Falco mexicanus prairie falcon	--	CSC	Grassland	Approximately 1 mile E of Prairie City Road	Low - no known locations near site, no effect expected
Falco columbarius merlin	--	CSC	Open woods, grassland	Observed on Aerojet property	Medium - appropriate habitat exists, no effect expected
Falco peregrinus peregrine falcon	E	CE	Grassland	Observed at Sailor Bar during Audubon Society Christmas Bird Count	High - observed on site, no effect expected
Gavia immer common loon	--	CSC	Lakes and ponds	Observed at Lake Natoma adjacent to the cliffs S of Negro Bar (Quinn et al. 1991)	Low - potential nesting habitat present, no effect expected
Icteria virens yellow-breasted chat	--	CSC	Dense riparian vegetation	Known nesting locations on Aerojet property riparian areas	Medium - appropriate habitat exists, possible impact Alternative 1
Lanius ludovicianus loggerhead shrike	C2	CSC	Grassland	Observed on Aerojet property	Low - little or no habitat, no effect expected

Name	Status		Habitat	Closest Proximity	Potential of Occurrence[3]
	Federal[1]	State[2]			
Birds (cont')					
Pandion haliaetus osprey	--	CSC	Rivers, lakes and coast	Observed at Sailor Bar during Audubon Society Christmas Bird Count	High - observed on site, no effect expected
Pelecanus erythrorhynchos American white pelican	--	CSC	Islands in lakes and rivers	Flying over S end of Lake Natoma (Quinn et al. 1991)	Low - no nesting habitat on Aerojet, no effect expected
Phalacrocorax auritys double-crested cormorant	--	CSC	Lakes and ponds	Observed at Sailor Bar during Audubon Society Christmas Bird Count	High - observed on site, no effect expected
Riparia riparia bank swallow	FT	--	Nests in steep river banks, cliffs, culverts, under bridges	Nesting evidence previously encountered on Aerojet property	Low - little or no nesting habitat, no effect expected
Speotyto cunicularia burrowing owl	C2	CSC	Open, dry annual or perennial grasslands. Often use Calif. ground squirrel burrows for nesting.	Approximately 2 miles SW of Aerojet, NW of Mather AFB	Low - no little or no nesting habitat, no effect expected

[1] Federal

E = Federally listed endangered
T = Federally listed threatened
PE = Federally proposed endangered
PT = Federally proposed threatened
C1 = Candidate for Federal listing with sufficient information on hand to support listing
C2 = Candidate for Federal listing with insufficient information on hand to support listing at this time
FP = Federally protected under the Bald Eagle Protection Act

[2] State

CE = State listed endangered
CT = State listed threatened
CSC = California Species of Special Concern
FP = Fully protected under California Fish and Game Code

[3] Potential of Occurrence (for birds, refers to potential occurrence of nests)

Low - unlikely to be present
Medium - likely to be present
High - very likely to be present

4.0 RESULTS AND DISCUSSION

4.1 Alternative 1

Please refer to Exhibit 2. This alternative is located near the west entrance to Sailor Bar Park. Alternative 1 was surveyed for biological resources on July 26 and 28, 1995. No sensitive plant or special status wildlife species were encountered. The proposed GET facility will be built on an existing asphalt parking lot and will not require removal of trees in the vicinity. However, it is adjacent to riparian habitat and has potential to impact wildlife species, especially migratory birds which winter along the American River (see Photo 3).

4.2 Alternative 2

Please refer to Exhibit 3. Alternative 2 is located near the east entrance to the park at the base of a bluff, east of a county road gravel and asphalt storage area. This alternative was surveyed on July 26, 1995. No special status wildlife species were encountered. Five interior live oaks (*Quercus wislizenii*) may be impacted by this alternative. The oaks are growing in two clumps at the base of the bluff. They may not require removal but could suffer root damage if construction encroaches within the dripline. Both locations are south of the proposed control panel and can probably to be avoided. Deer (*Odocoileus* sp.) tracks were encountered at this site.

4.3 Alternatives 3a and 3b

Please refer to Exhibits 4 and 5. These alternatives would replace the barn and associated structures west of Illinois Avenue near the west entrance to the park. Alternatives 3a and 3b were surveyed on July 24, 1995. No special status wildlife species were encountered on site. Both design alternatives will impact two interior live oaks and six blue oaks (*Quercus douglasii*). A seventh blue oak on site is dead. For either of the design alternatives, all nine oaks will have to be removed prior to construction of the GET facility.

4.4 Alternative 4

Please refer to Exhibit 6. Alternative 4 is located on an elevated river terrace east of Illinois Avenue against the bluff of a higher terrace. This alternative was surveyed on July 24 and 28, 1995. The bluff face has numerous potential wildlife burrows which were examined for signs of sensitive species, with negative findings. No special status wildlife species were observed. Four interior live oaks were recorded in the immediate vicinity. Three are located along Illinois Avenue. The fourth is located on the bluff which will require layback to a 3:1 slope.

4.5 Alternative 5

Please refer to Exhibit 7. Alternative 5 would necessitate drilling under the American River. This alternative was surveyed on July 26 and 28, 1995. The drill will enter in a parking lot south of the American River in the American River Parkway. This parking lot

Sailor Bar GET
Natural Environment Study
Alternative 1 and Recharge Wells

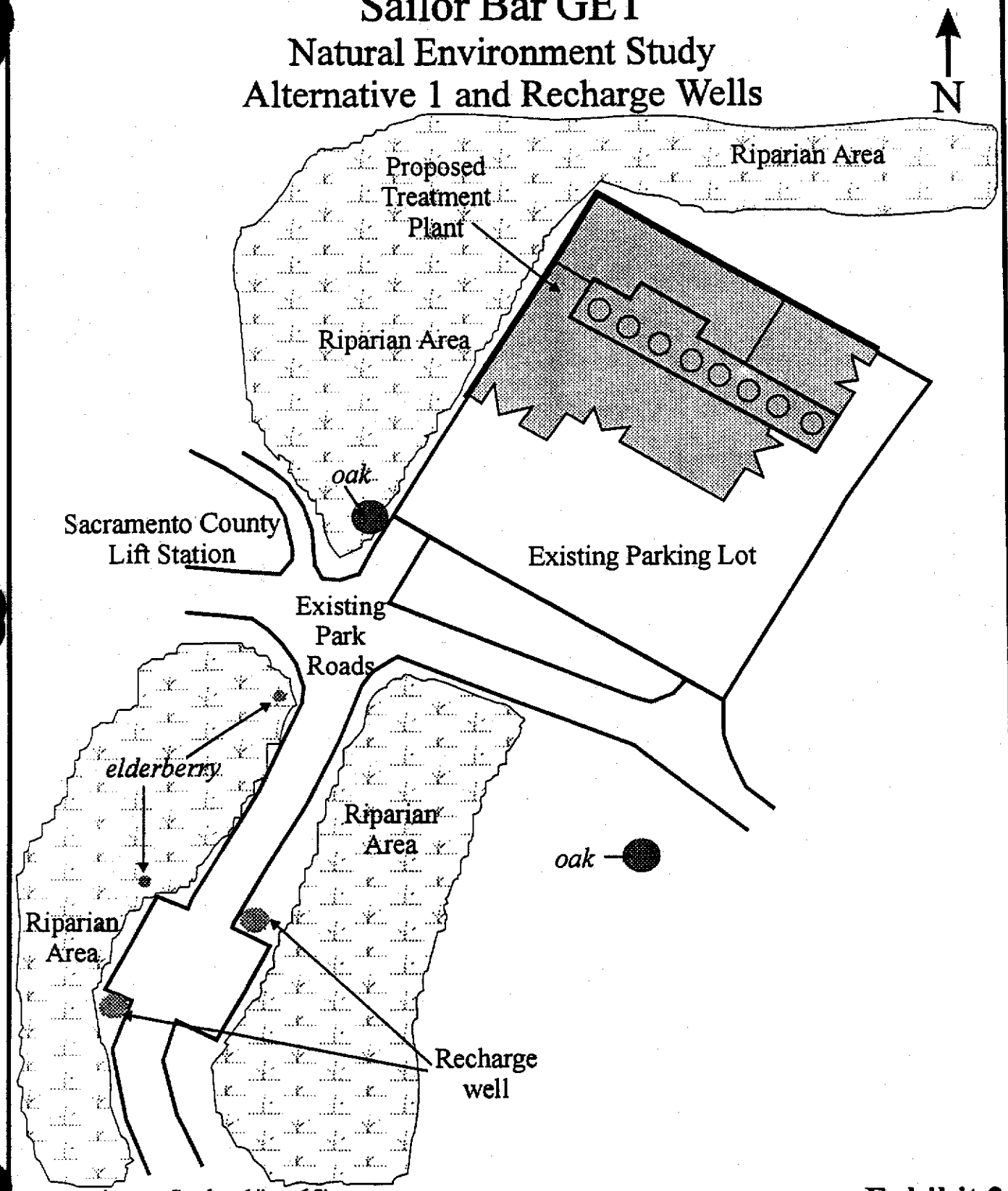
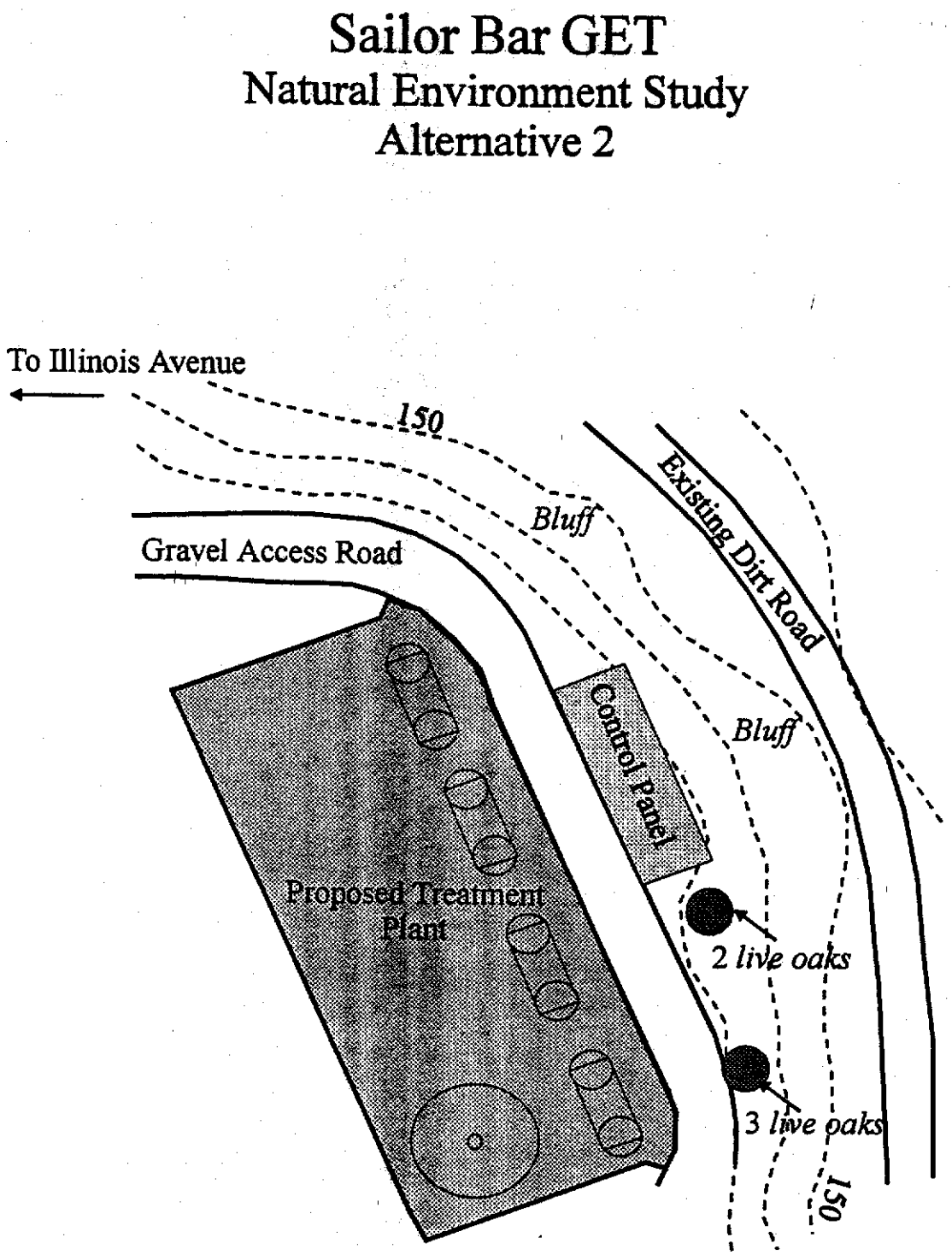


Exhibit 2

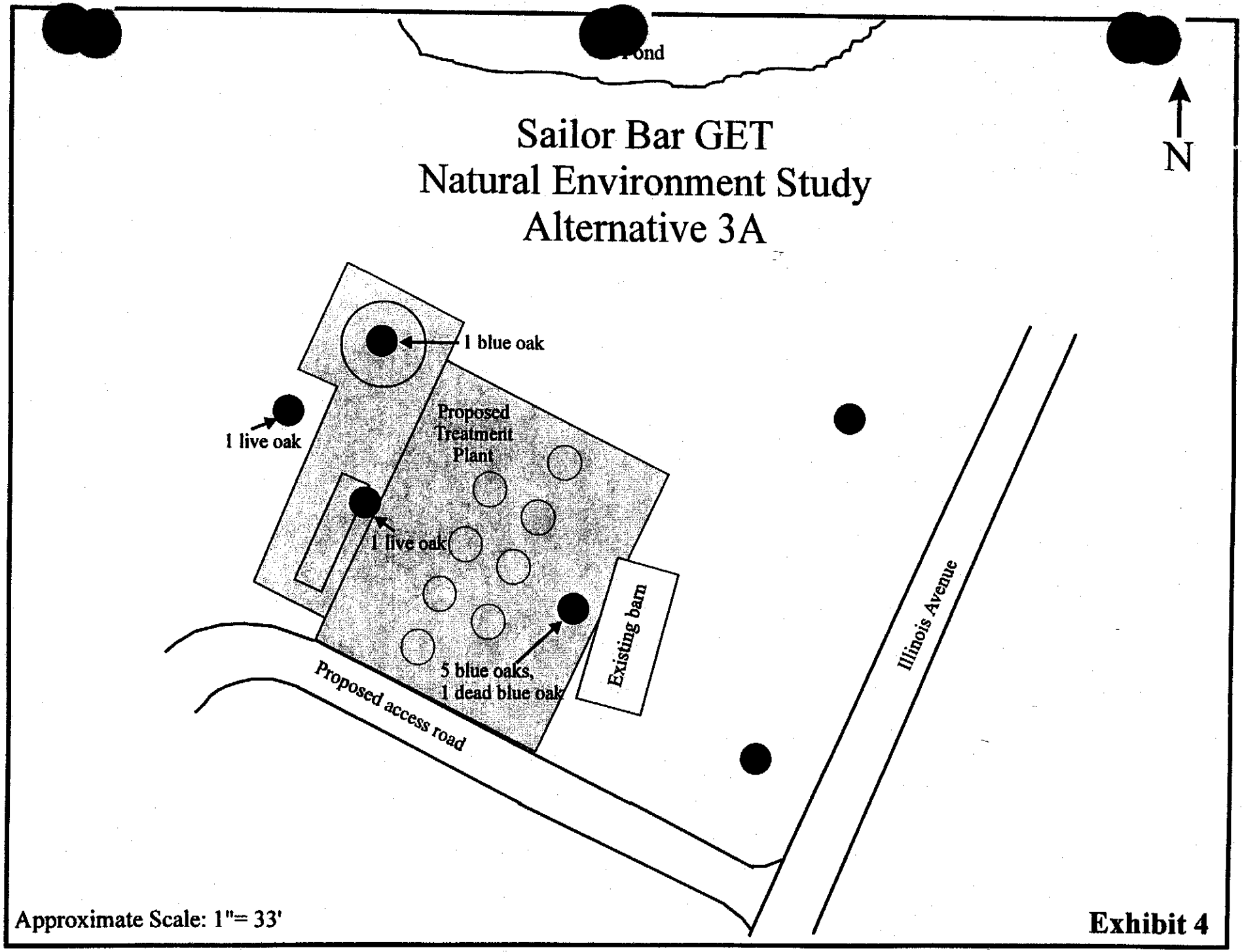
biota biological consulting 95

Sailor Bar GET
Natural Environment Study
Alternative 2



Approximate Scale: 1" = 40'

Exhibit 3



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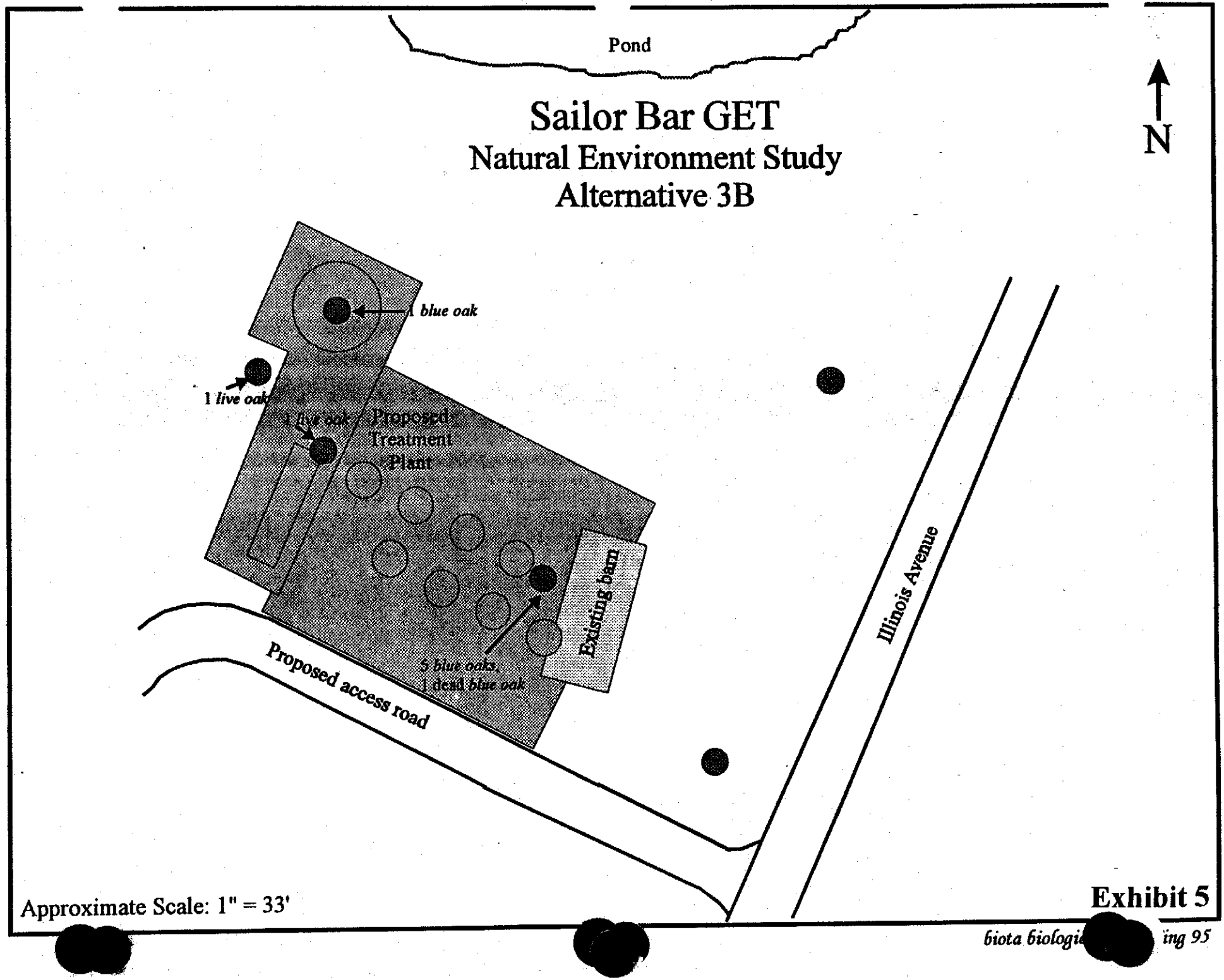
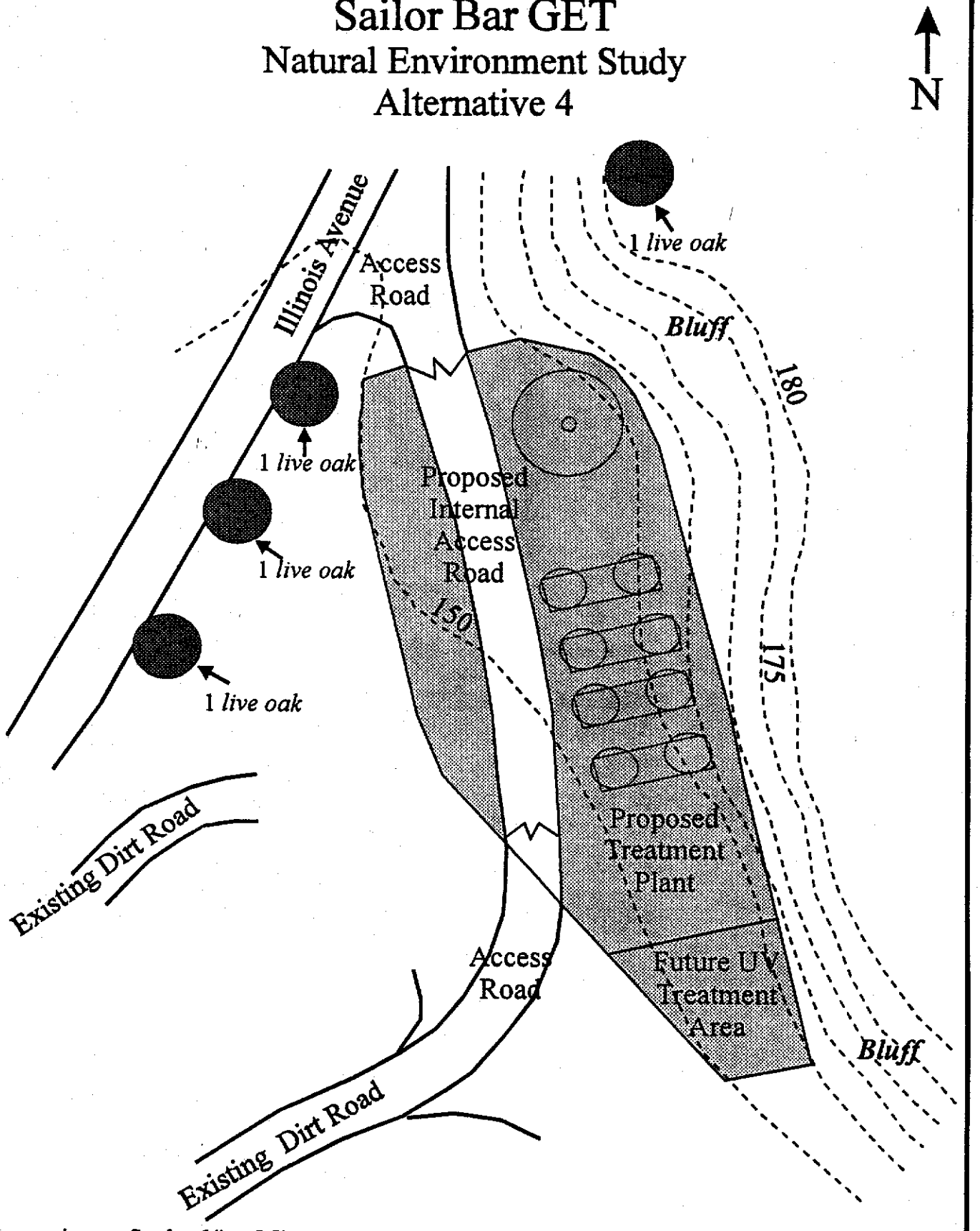

Pond
N
Sailor Bar GET
Natural Environment Study
Alternative 3B
1 blue oak
1 live oak
1 live oak
Proposed Treatment Plant
Existing barn
5 blue oaks,
1 dead blue oak
Proposed access road
Illinois Avenue
Approximate Scale: 1" = 33'
Exhibit 5
biota biologi ing 95

Sailor Bar GET
Natural Environment Study
Alternative 4



Approximate Scale: 1" = 25'

Exhibit 6

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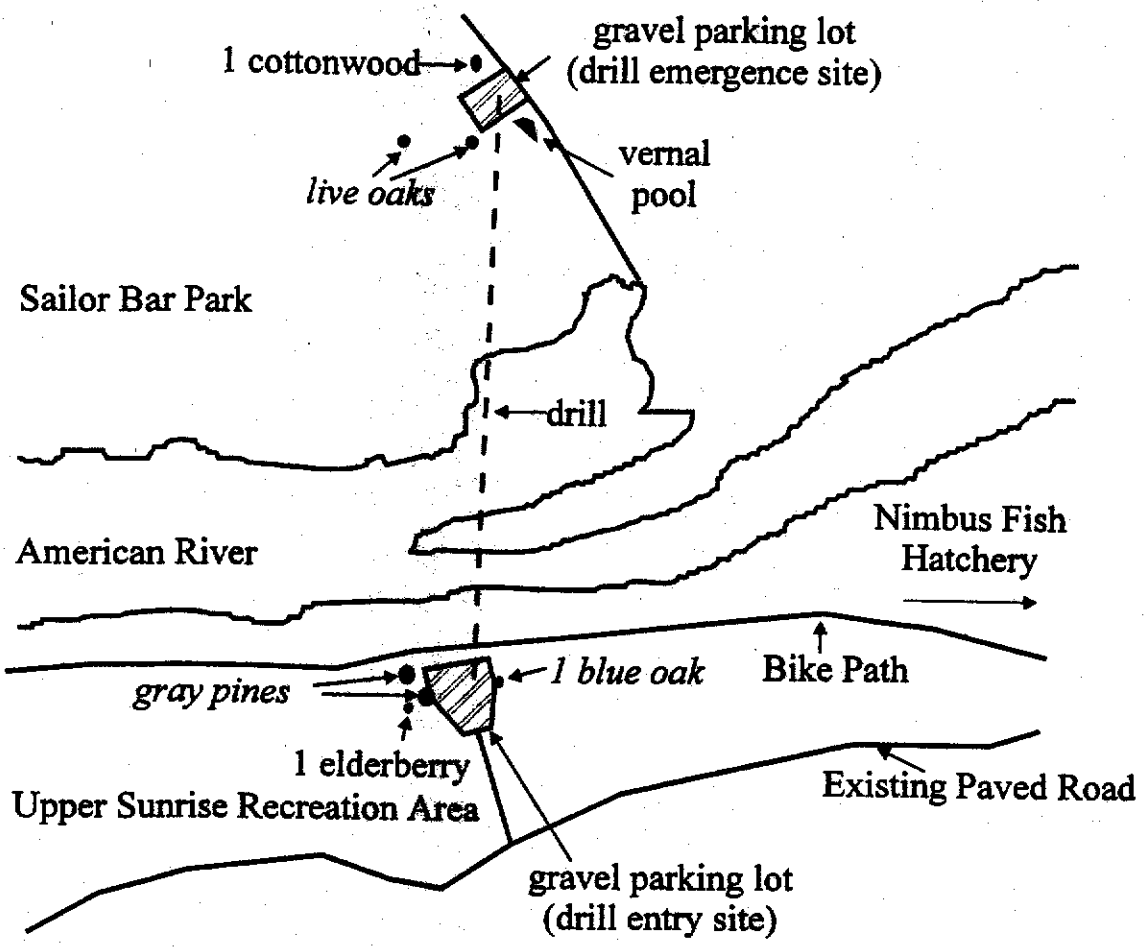
Sailor Bar GET
Natural Environment Study
Alternative 5



Approximate Scale: 1" = 540'

Exhibit 7

has an elderberry shrub (*Sambucus mexicana*) nearby. Elderberry shrubs are habitat for the federally threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*). Although no exit holes were found on the elderberry shrub, it is considered potential habitat and was flagged by *biota*. A 1984 recovery plan for the valley elderberry longhorn beetle identified two areas along the American River in the Sacramento area as critical habitat for the species (USFWS 1991). The same plan designated the American River Parkway below Nimbus Dam as one of two essential habitats. Valley elderberry longhorn beetle larvae feed and mature within elderberry shrubs. Use of the shrub by early stages of the beetle are rarely apparent (USFWS 1993). The only evidence of use of the shrub by the beetle is often an exit hole created by the larvae prior to the pupal stage (USFWS 1993).

From this parking lot, a pipeline would need to be built to carry groundwater to a GET facility on the Aerojet property. The route for this pipeline has not yet been determined and was not surveyed. This pipeline could cause additional impact to sensitive species or special habitats between the American River and the Aerojet property.

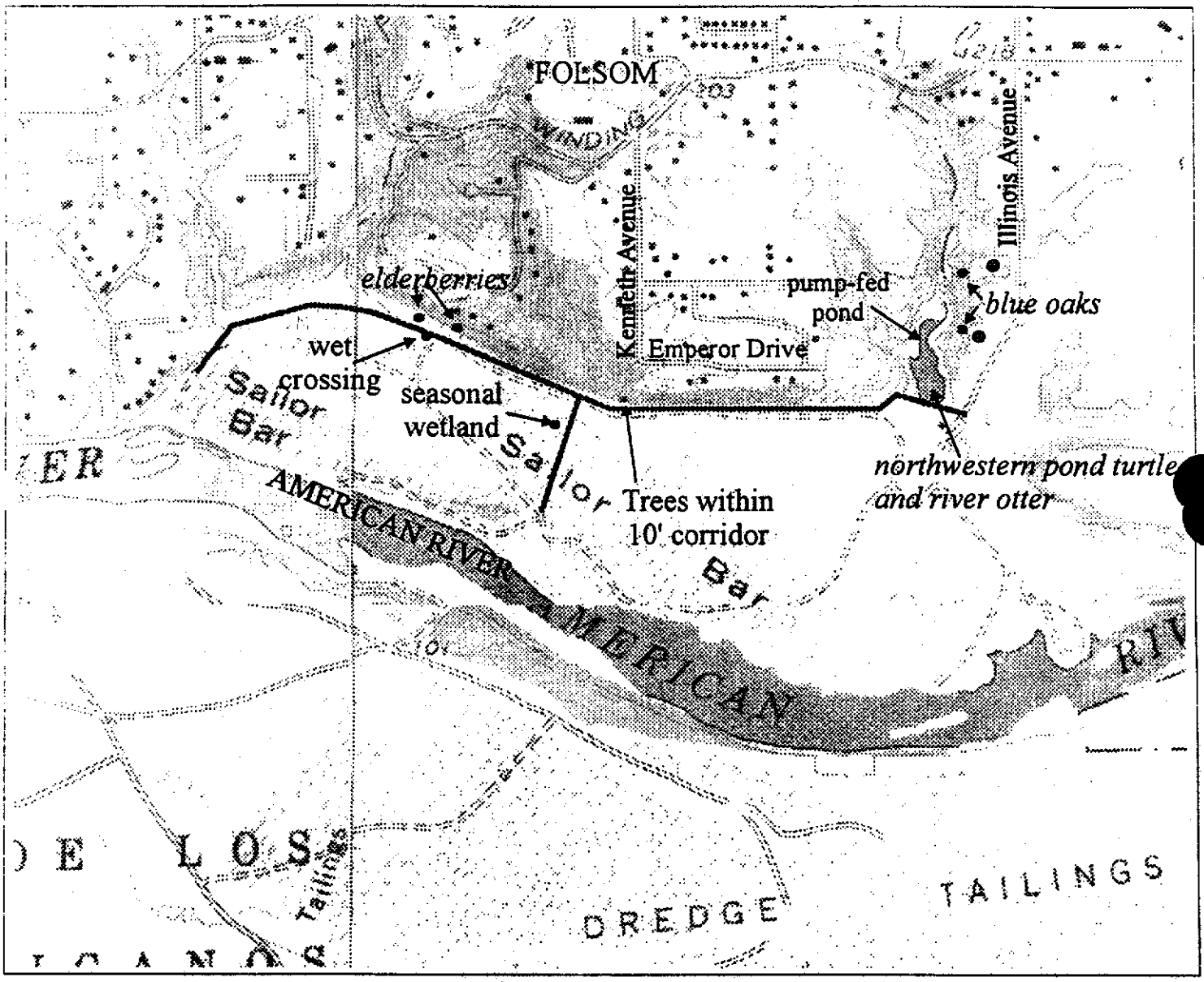
The drill will run under the American River and emerge in a gravel parking lot at Sailor Bar Park. This parking lot has several interior live oaks adjacent and is also immediately north of and adjacent to a vernal pool (see photo 4). The vernal pool is considered to be potential habitat for the federally endangered vernal pool tadpole shrimp (*Lepidurus packardi*) and the federally threatened vernal pool fairy shrimp (*Branchinecta lynchi*). To determine the presence or absence of tadpole shrimp and fairy shrimp, survey protocol requires two years of wet season sampling by a U.S. Fish and Wildlife Service (USFWS) permitted biologist (USFWS 1995). Although two *biota* biologists hold current USFWS permits, the timing of the NES surveys was not appropriate to survey for these species. The pool is also potential habitat for sensitive vernal pool plant species. Due to inappropriate survey timing, *biota* was unable to establish the presence of sensitive species.

4.6 Pipeline

Please refer to Exhibit 8. A pump-fed pond is located at the eastern extent of the proposed pipeline. A turtle, assumed to be a northwestern pond turtle (*Clemmys marmorata marmorata*), was encountered at the pond. The northwestern pond turtle is a Category 2 candidate for federal listing and a California Species of Special Concern. Several species of waterfowl and a river otter (*Lutra canadensis*) were also observed. According to the California Code of Regulations (Title 14, Section 460), it is illegal to take a river otter at any time (Roscoe 1995). The pipeline will be placed along the southern edge of the pond, requiring erosion control measures to be implemented to prevent sedimentation damage to the pond.

The proposed pipeline alignment may impact several trees located at the base of the Kenneth Avenue and Emperor Drive bluff. However, it appears that the 10 foot pipeline

Sailor Bar GET
Natural Environment Study Site
Pipeline and Recharge Wells



Recharge well ●

Proposed Pipeline Corridor ——

Approximate Scale: 1" = 0.4 mile

Exhibit 8

corridor could be moved into the road at the base of the bluff in this area to avoid impacts to trees.

A seasonal wetland just west of the southern extension of the proposed pipeline alignment may be affected by pipeline construction. To determine the boundaries of the wetlnad and its position in relation to the pipeline will require a wetland delineation. If the pipeline cannot avoid the wetland, a permit under Section 404 of the Clean Water Act may be required from the U.S. Army Corps of Engineers (ACOE).

Several elderberry shrubs located along the proposed pipeline alignment, approximately 600 feet east of Alternative 1, were flagged by *biota*. No exit holes were found on the shrubs, but they are considered potential habitat for valley elderberry longhorn beetle and should be avoided.

A small rivulet linking two riparian drainages crosses the pipeline alignment and the parallel dirt road perpendicularly, approximately 450 feet east of Alternative 1. This minor wet crossing may be wet all year, as it had shallow flowing water (flowing north → south) during the July biological survey, which is normally the dry season. Pipeline construction will affect this rivulet and it may require a streambed alteration agreement from the California Department of Fish and Game (CDFG) with specific erosion control measures.

4.7 Recharge Wells

Please refer to Exhibit 8. Recharge wells at the western end of the proposed pipeline alignment have elderberry shrubs in the vicinity. No exits holes were encountered, but the shrubs are considered potential habitat for the valley elderberry longhorn beetle and should be avoided. The shrubs were flagged by *biota*. The wells are also adjacent to a riparian habitat. No sensitive species were encountered, but the site could support sensitive avian species in the winter. The western recharge wells are also adjacent to a riparian habitat.

The recharge wells near the eastern end of the proposed pipeline alignment are located in a non-native annual grassland on a bluff overlooking the pond. Several blue oaks surround the grassland. No sensitive species were encountered at this site, but erosion control measures to protect the pond must be taken if construction occurs at this site.

Photo 3. Riparian habitat within Sailor Bar Park.

Photo 4. Vernal pool adjacent to Alternative 5 drill exit point in Sailor Bar Park.

5.0 MITIGATION RECOMMENDATIONS

5.1 All Alternatives

Oak trees are important habitat for wildlife. Mitigation measures for native oak trees removed by the project may be required according to the Tree Preservation Ordinance of Sacramento County (County of Sacramento 1981). Native oak trees are defined as valley oak (*Quercus lobata*), interior live oak (*Quercus wislizenii*), blue oak (*Quercus douglasii*) and oracle oak (*Quercus morehus*). The County commonly requires an inch for inch replacement (diameter measured at 4.5 feet above grade) with native oak species to compensate for trees removed as an unavoidable consequence of a project (County of Sacramento 1993). A 15 gallon native oak tree or three 5 gallon native oak trees equate to a one inch replacement credit. It is preferred that the replacement planting occur on site or within the vicinity of the project impact. Replacement planting plans should be a part of the project's mitigation monitoring plan (County of Sacramento 1993).

5.2 Alternative 1

To prevent damage to riparian habitats, it will be necessary to implement erosion control measures. A stream alteration agreement with CDFG may be required to connect the proposed pipeline with Alternative 1.

5.3 Alternative 2

If Alternative 2 requires the removal of the five interior live oaks, inch for inch replacement may be required for each oak tree removed (County of Sacramento 1993).

5.4 Alternative 3a and 3b

The two interior live oaks and six blue oaks will have to be removed prior to construction of the GET facility. Inch for inch replacement may be required for each oak tree removed (County of Sacramento 1993).

5.5 Alternative 4

To avoid root damage to three interior live oaks along Illinois Avenue, barrier fencing should be installed one foot outside the driplines of the oak trees prior to beginning construction (County of Sacramento 1993). If the interior live oak on the bluff is removed, inch for inch replacement may be required as compensation (County of Sacramento 1993).

5.6 Alternative 5

Removal of the interior live oaks near the gravel parking lot in Sailor Bar Park may require inch for inch replacement as compensation (County of Sacramento 1993).

The vernal pool adjacent to the drill exit point is potential habitat for the federally endangered vernal pool tadpole shrimp and the federally threatened vernal pool fairy shrimp and sensitive vernal pool plant species. The drill path has potential to punch through the impervious layer beneath the pool and damage or destroy the pool by

changing its hydrological characteristics. If impacts to the pool cannot be avoided, the Spink Corporation and Aerojet should consult with USFWS regarding mitigation measures. The ACOE may also require consultation on the loss of the pool, which is a seasonal wetland.

The elderberry shrub near the parking lot south of the American River is potential habitat for the federally threatened valley elderberry longhorn beetle. If this shrub will be affected, Spink Corporation and Aerojet should consult with USFWS regarding mitigation measures.

The proposed pipeline to carry groundwater to a GET facility on the Aerojet property could cause additional impact to sensitive species or special habitats between the American River and the Aerojet property. Additional biological surveys would be required for that route and mitigation measures will be required for each sensitive species or special habitat impacted.

5.7 Pipeline

The pipeline will be placed along the southern edge of the pump-fed pond, requiring erosion control measures to be implemented to prevent sedimentation damage to the pond. If the pond is fed by contaminated groundwater, CDFG and USFWS should be contacted as further measures may be required to protect the pond turtle and river otter.

A seasonal wetland near the southern extension may be affected by pipeline construction. To determine the boundaries of the wetland and to determine jurisdiction, will require a wetland delineation. If the pipeline cannot avoid the wetland, the ACOE should be contacted regarding a permit (to place fill in a wetland) under Section 404 of the Clean Water Act.

If the 10 foot pipeline corridor cannot be moved into the road at the base of the Kenneth Avenue and Emperor Drive bluff to avoid impacts to trees, inch for inch replacement of native oak trees removed may be required (County of Sacramento 1993).

Several elderberry shrubs along the proposed pipeline alignment are considered potential habitat for valley elderberry longhorn beetle. If any of these shrubs will be affected, Spink Corporation and Aerojet should consult with USFWS regarding mitigation measures.

Pipeline construction will affect a small rivulet crossing east of Alternative 1. California Department of Fish and Game should be contacted concerning the need for a streambed alteration agreement at this location.

5.8 Recharge Wells

Recharge wells at the western end of the proposed pipeline alignment have elderberry shrubs in the vicinity. If the shrubs are to be impacted, the Spink Corporation and Aerojet

may either assume the presence of the species and consult with USFWS regarding mitigation measures or have a survey for the species conducted.

Any impacts to the blue oak trees near the eastern recharge wells may require inch for inch compensation (County of Sacramento 1993). Erosion control measures to protect the pond must be taken if construction occurs at this site.

6.0 REFERENCES

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Wymer, Nancy E. 1989. Vernal Pool Survey of Rare, Endangered, Threatened or Candidate Plant Species. Spring 1989.

Appendix A.

Plant Species Observed at the Sailor Bar Project Site

Family Name	Scientific Name	Common Name
Anacardiaceae	*Toxicodendron diversilobum*	poison oak
Apiaciae	*Anethum graveolens*	dill
	Daucus carota	Queen Anne's lace
	Foeniculum vulgare	wild fennel
Asteraceae	*Baccharis* sp.	baccharis
	Centaurea solstitialis	yellow star thistle
	Lactuca serriola	prickly lettuce
	Madia elegans	common madia
	Psilocarphus tenullus	woolly marbles
	Sonchus sp.	sow thistle
	Xanthium sp.	cocklebur
Brassicaceae	*Brassica nigra*	black mustard
	Raphanus sativus	wild radish
Caprifoliaceae	*Sambucus mexicana*	blue elderberry
Cyperaceae	*Carex* sp.	umbrella sedge
	Cyperus sp.	nutsedge
Euphorbiaceae	*Eremocarpus setigerus*	turkey mullein
Fabaceae	*Lotus purshianus*	vetch
	Vicia sp.	vetch
	Quercus douglasii	blue oak
	Quercus lobata	valley oak
	Quercus wislizenii	interior live oak
Lamiaceae	*Marrubium vulgare*	horehound
	Trichostema lanceolatum	vinegar weed
Lythraceae	*Lythrum* sp.	loosestrife
Pinaceae	*Pinus sabiniana*	gray pine
Poaceae	*Avena fatua*	wild oats
	Bromus diandrus	ripgut grass
	Hordeum sp.	barley
	Juncus buffonius	toad rush
	Lolium multiflorum	annual ryegrass
	Sorghum halepense	johnson grass
Polemoniaceae	*Navarettia* sp.	navarettia
Polygonaceae	*Polygonum* sp.	smartweed
	Rumex sp.	dock
Rhamnaceae	*Ceanothus* sp.	California-lilac
	Rhamnus californica	California coffeeberry
Rosaceae	*Rubus ursinus*	California blackberry
Salicaceae	*Populus fremontii*	Fremont's cottonwood
	Salix laevigata	red willow
	Salix lasiolepis	arroyo willow
	Salix sessilifolia	sandbar willow
Scrophulariaceae	*Mimulus* sp.	bush mimulus
Solanaceae	*Datura* sp.	jimson weed
Verbenaceae	*Verbena* sp.	verbena
Vitaceae	*Vitis californica*	California wild grape

Appendix B.

Wildlife Species Observed at the Sailor Bar Project Site

	Scientific Name	Common Name
Invertebrates		
	Battus philenor	pipevine swallowtail
	Epiloachnini borealis	squash beetle
	Order Odonata	dragonfly
	Order Orthoptera	grasshopper
Reptiles		
	Cnemidophorus tigris	western whiptail
	Scelopouus occidentalis	western fence lizard
Birds		
	* *Accipiter cooperii*	Cooper's hawk
	* *Accipiter striatus*	sharp-shinned hawk
	* *Actitis macularia*	spotted sandpiper
	* *Aechmophorus occidentalis*	western grebe
	* *Aeronautes saxatalis*	white-throated swift
	* *Agelaius phoeniceus*	red-winged blackbird
	* *Aimophila ruficeps*	rufous-crowned sparrow
	* *Aix sponsa*	wood duck
	* *Anas clypeata*	northern shoveler
	Anas platyrhynchos	mallard
	* *Anser albifrons*	greater white-fronted goose
	* *Anthus spinoletta*	water pipit
	Aphelocoma coerulescens	scrub jay
	* *Aquila chrysaetos*	golden eagle
	Ardea herodias	great blue heron
	* *Bombycilla cedrorum*	cedar waxwing
	* *Botaurus lentiginosus*	American bittern
	Branta canadensis	Canada goose
	* *Bubo virginianus*	great-horned owl
	* *Bucephala clangula*	common goldeneye
	* *Bucephala islandica*	Barrow's goldeneye
	Buteo jamaicensis	red-tailed hawk
	Buteo lineatus	red-shouldered hawk
	Butorides striatus	green-backed heron
	* *Calidris minutilla*	least sandpiper
	Callipepla californica	California quail
	Calypte anne	Anna's hummingbird
	* *Carduelis pinus*	pine siskin
	Carduelis psaltria	lesser goldfinch

	Scientific Name	Common Name
Birds (cont')		
*	*Carduelis tristis*	American goldfinch
	Carpodacus mexicanus	house finch
*	*Carpodacus purpureus*	purple finch
	Casmerodius albus	great egret
	Cathartes aura	turkey vulture
*	*Catharus guttatus*	hermit thrush
*	*Certhia americana*	brown creeper
	Ceryle alcyon	belted kingfisher
*	*Chamaea fasciata*	wrentit
*	*Charadrius vociferus*	killdeer
*	*Chondestes grammacus*	lark sparrow
*	*Circus cyaneus*	northern harrier
*	*Cistothorus palustris*	marsh wren
*	*Clangula hyemalis*	oldsquaw
	Colaptes auratus	northern flicker
	Columba livia	rock dove
	Corvus brachyrhynchos	American crow
*	*Cyanocitta stelleri*	Steller's jay
*	*Cygnus columbianus*	tundra swan
*	*Dendroica coronata*	yellow-rumped warbler
	Egretta thula	snowy egret
	Elanus caeruleus	black-shouldered kite
	Euphagus cyanocephalus	Brewer's blackbird
*	*Falco peregrinus*	peregrine falcon
*	*Falco sparverius*	American kestrel
	Fulica caribaea	American coot
	Hirundo rustica	barn swallow
*	*Ixoreus naevius*	varied thrush
*	*Junco hyemalis*	dark-eyed junco
*	*Larus argentatus*	herring gull
*	*Larus californicus*	California gull
*	*Larus canus*	mew gull
*	*Larus delawarensis*	ring-billed gull
*	*Larus glaucescens*	glaucous-winged gull
*	*Larus hyperboreus*	glaucous gull
*	*Larus thayeri*	Thayer's gull
*	*Lophodytes cucullatus*	hooded merganser
	Melanerpes formicivorus	acorn woodpecker
*	*Melospiza lincolnii*	Lincoln's sparrow
*	*Melospiza melodia*	song sparrow

	Scientific Name	Common Name
Birds (cont')		
	Mergus merganser	common merganser
*	*Mimus polyglottos*	northern mockingbird
	Myiarchus cinerascens	ash-throated flycatcher
*	*Otus kennicotti*	western screech owl
*	*Oxyura jamaicensis*	ruddy duck
*	*Pandion haliaetus*	osprey
*	*Parus inornatus*	plain titmouse
	Passer domesticus	house sparrow
*	*Passerculus sandwichensis*	savannah sparrow
*	*Passerella iliaca*	fox sparrow
*	*Phainopepla nitens*	phainopepla
*	*Phalacrocorax auritus*	double-crested cormorant
*	*Phasianus colchicus*	ring-necked pheasant
	Pica nuttalli	yellow-billed magpie
	Picoides nuttallii	Nuttall's woodpecker
	Picoides pubescens	downy woodpecker
	Pipilo erythrophthalmus	rufous-sided towhee
	Pipilo fuscus	California towhee
*	*Podilymbus podiceps*	pied-billed grebe
	Psalitriparus minimus	bushtit
*	*Regulus calendula*	ruby-crowned kinglet
*	*Regulus satrapa*	golden-crowned kinglet
*	*Salpinctes obsoletus*	rock wren
	Sayornis nigricans	black phoebe
*	*Sialia currucoides*	mountain bluebird
	Sialia mexicana	western bluebird
	Sitta carolinensis	white-breasted nuthatch
*	*Sphyrapicus ruber*	red-breasted sapsucker
	Spizella passerina	chipping sparrow
*	*Sturnella neglecta*	western meadowlark
*	*Sturnus vulgaris*	European starling
	Tachycineta bicolor	tree swallow
	Tachycineta thalassina	violet-green swallow
	Thryomanes bewickii	Bewick's wren
*	*Tringa melanoleuca*	greater yellowlegs
*	*Troglodytes aedon*	house wren
	Troglodytes troglodytes	winter wren
*	*Turdus migratorius*	American robin
	Tyrannus vociferans	western kingbird
*	*Tyto alba*	common barn-owl

	Scientific Name	Common Name
Birds (cont')		
	* *Vermivora celata*	orange-crowned warbler
	* *Vireo huttoni*	Hutton's vireo
	Zenaida macroura	mourning dove
	* *Zonotrichia albicollis*	white-throated sparrow
	* *Zonotrichia atricapilla*	golden-crowned sparrow
	* *Zonotrichia leucophrys*	white-crowned sparrow
Mammals		
	Lepus californicus	black-tailed jackrabbit
	Sciurus griseus	western gray squirrel

*Species recorded in at least one of the following years of the Sacramento Audubon Society Folsom Area 6 Christmas Bird Count: 1990, 1992, 1993 and/or 1994.
All unstarred species were recorded by *biota* in July 1995.

AMERICAN RIVER GET SYSTEM
(ARGET)

Valley Elderberry Longhorn Beetle Habitat Mitigation & Monitoring Plan

Prepared for:

GenCorp Aerojet
and The Spink Corporation

Prepared by:

2953 24th Street
Sacramento, California 95818
(916) 456-5819

February 1996

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1. 0 Executive Summary

As a result of past Aerojet activities, water in three aquifers of eastern Sacramento County became contaminated with volatile organic compounds (VOC). To remedy the situation, GenCorp Aerojet (Aerojet) will build a groundwater extraction and treatment (GET) facility, the American River GET System (ARGET). This system will consist of groundwater extraction wells, water pipelines, a water treatment plant and treated water discharge. This project is being developed under CERCLA, as part of a Superfund cleanup ordered by EPA.

The project location is southeast of Fair Oaks, California. Groundwater extraction wells are located on the north side of the American River in Sailor Bar Park, and south of the river near the Nimbus Fish Hatchery. Most of the project activities will take place on County of Sacramento property that is under the jurisdiction of the County Department of Parks and Recreation. A pipeline will cross beneath the American River, conveying water from nine wells north of the American River to a pipeline combining with water from six wells on the south side, and from there to a treatment plant located south of US Highway 50 and east of the Folsom South Canal. The treatment plant, on Aerojet property, will treat the contaminated water and discharge it as directed by EPA.

Construction of the project will require the removal of one elderberry shrub located on County of Sacramento property just west of the under-river drill entrance point. The shrub has a total of 13 stems measuring 1.0 inch or greater in diameter. Numerous emergence (exit) holes were recorded in the shrub branches. Aerojet proposes the following measures to mitigate and compensate for anticipated project impacts on the Valley elderberry longhorn beetle (VELB) and its habitat, in accordance with the General Compensation Guidelines for the Valley Elderberry Longhorn Beetle (USFWS 1994) :

1. Two elderberry shrubs near the project impact area can be avoided and will be fenced off prior to construction.

2. The elderberry shrub which will be affected by the project will be transplanted to the southwest about 100 feet, as detailed in Section 5.0, Mitigation Measures. The transplant area has a healthy un-VELB-occupied elderberry clump, and is sparsely vegetated with native companion shrubs and subshrubs including wild buckwheat, Eriogonum sp.; hoary coffeeberry, Rhamnus tomentella; buckbrush, Ceanothus cuneatus; and bush monkeyflower, mimulus auronticus.

3. Additional compensation will consist of planting 39 rooted cuttings or seedlings (a ratio of 3:1 of the affected shrub's stems greater than 1.0 inch diameter), to ensure survival of 26 plants, or 2:1 ratio. Up to ten of the cuttings may be from the transplanted shrub, if viable.

These replacement plantings will be installed in eight groups of 4 or 5 in the County of Sacramento elderberry mitigation site at Lower Sunrise Recreation Area, approximately 3 miles downstream from the impact site. Companion plantings of redbud, baccharis, blue oak, live oak, valley oak, box elder, and Oregon ash are already in place. Negotiations with the County for the mitigation plantings are underway.

A detailed plan of the replacement plantings and monitoring strategy will be submitted to the Service for approval by May of 1997. The plan will meet or exceed the requirements outlined in the guidelines.

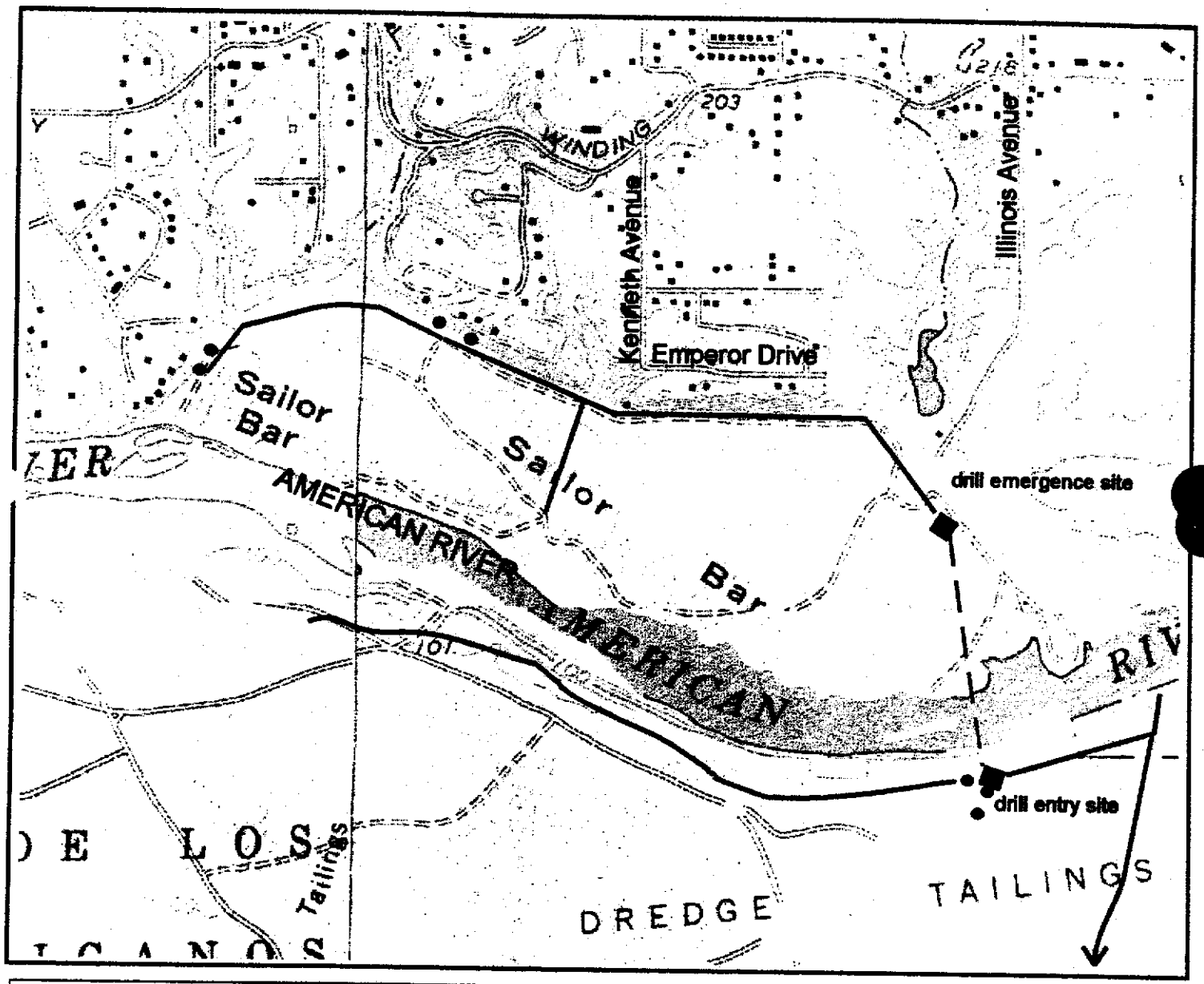
2.0 Background and Introduction

GenCorp Aerojet (Aerojet) has proposed to build a groundwater extraction and treatment (GET) facility in eastern Sacramento County, the American River GET System (Figure 1). The facility will be used to treat water in three aquifers which have been contaminated with volatile organic compounds (VOC). In July 1995, *biota biological consulting* (*biota*) conducted a Natural Environment Study (NES) assessing potential impacts to biological resources of five GET facility alternatives in Sailor Bar Park, a proposed pipeline alignment and several recharge wells (*biota biological consulting 1995*). Aerojet and Spink are now planning to construct the GET facility on Aerojet property south of Highway 50 in east Sacramento County. A pipeline will be constructed to join extraction wells in Sailor Bar Park and carry water to the GET facility. The pipeline will cross beneath the American River. This document discusses mitigation of biological impacts of that segment of the pipeline from Sailor Bar Park to the Upper Sunrise Recreation Area.

Sailor Bar Park is owned by the County of Sacramento and is under the jurisdiction of the County Department of Parks and Recreation. The approximate 375 acre park is located on the north side of the American River, west of Hazel Avenue in Rancho Cordova and east of the old Fair Oaks Bridge. Natural communities within Sailor Bar Park and its vicinity have been significantly altered by historic gold dredging and gravel mining, human settlement and other activities. The area is dominated by oak woodland in a non-native grassland matrix. Several riparian drainages and seasonal wetlands are scattered throughout the park.

During the biological surveys, *biota* identified several elderberry (*Sambucus mexicana*) shrubs in Sailor Bar Park and in the Upper Sunrise Recreation Area in the American River Parkway near the proposed under-river directional drill entrance point. Please refer to Figure 2 for a map of the project site. The drill entrance point is located in a gravel parking lot downstream from Nimbus Dam, in an area designated as one of two essential habitats for the federally threatened valley elderberry longhorn beetle (VELB), *Desmocerus californicus dimorphus*, in the U.S. Fish and Wildlife Service (USFWS) 1984 Recovery Plan for this species (USFWS 1991). Elderberry shrubs are habitat for VELB. Presence of the beetle is indicated by characteristic "exit holes" in branches of elderberry shrubs.

American River GET System
(ARGET)
Project Site



Elderberry Shrub •

Proposed Pipeline Corridor _____

Drill - - -

Approximate Scale: 1" = 0.4 mile

USGS Folsom Quad
T9, R7E
Sacramento County, CA

Figure 1

American River GET System
Valley Elderberry Longhorn Beetle Habitat

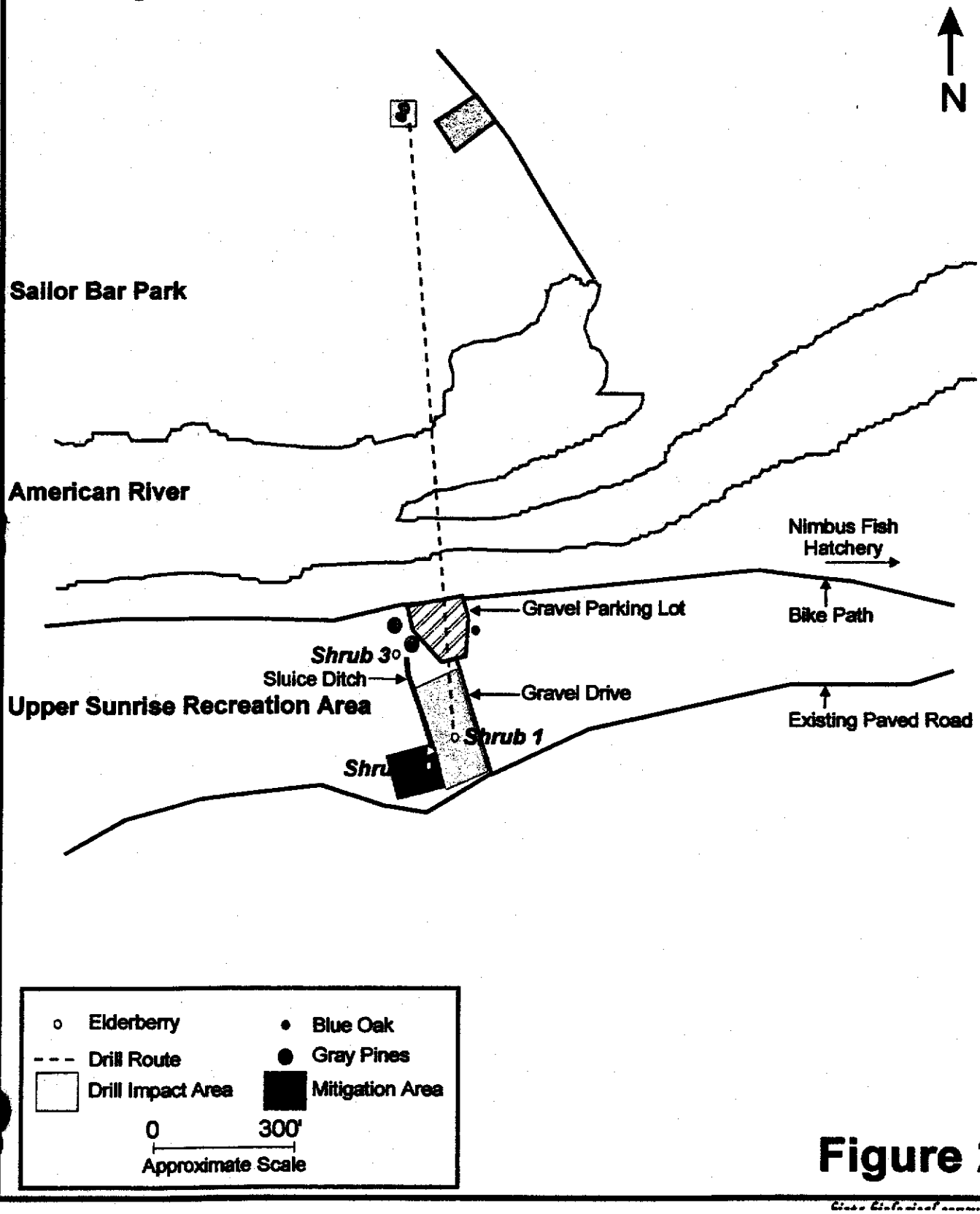


Figure 2

3.0 Survey Methodology

Sailor Bar Park

Surveys for sensitive species and their habitats were conducted by *biota* biologists at five GET facility alternatives, the proposed pipeline corridor and the recharge wells on July 24, 26, and 28, 1995. Each treatment plant alternative and recharge well site was surveyed on foot. The proposed pipeline route in Sailor Bar Park is generally within a ten foot corridor which immediately parallels existing dirt roads and was surveyed from a vehicle with frequent stops at marked well locations and special habitats along the alignment. Elderberry shrubs encountered in or adjacent to the survey area were flagged with pink flagging. Locations of the elderberry shrubs were mapped on aerial photographs at a scale of 1 inch equals 300 feet.

Upper Sunrise Recreation Area

After preliminary biological surveys were conducted for the NES, the location of the under-river drill for the pipeline corridor was altered, to avoid a vernal pool on the norht side. Additional surveys were conducted at a revised directional drill entrance point south of the American River on September 22, 1995 to identify sensitive biological resources in the revised study corridor. The site was surveyed on foot and elderberry shrubs encountered in or adjacent to the survey area were flagged with pink flagging. The shrubs were examined for general condition and for VELB exit holes. Locations of the elderberry shrubs were mapped on aerial photographs at a scale of 1 inch equals 300 feet.

4.0 Results

Sailor Bar Park

Four elderberry shrubs were marked in Sailor Bar Park near the project impact study area. Two were located in a riparian drainage between Alternative 1 and two recharge wells. Two other elderberry shrubs were flagged along the western section of the pipeline route near a pump house.

All four elderberry shrubs identified in Sailor Bar Park will be avoided by project construction and no impact to them is expected.

Upper Sunrise Recreation Area

Three elderberry shrubs were mapped in the Upper Sunrise Recreation Area on the west side of the directional drill entrance point (Figure 2).

One elderberry shrub (Shrub 1) is located within the potential impact area between a gravel drive and a ridge east of a sluice ditch. This shrub is suffering with poor heath and measures about 11' x 6' x 8' h. It has numerous appropriately-sized exit holes and is considered to be occupied by VELB. There are 13 stems greater than one inch in diameter.

A second elderberry clump of about five plants **(Shrub 2)** was recorded in the sluice ditch west of the potential impact area. The clump is in vigorous health, measuring approximately 22' x 22' x 11'h. One potential exit hole was recorded.

The third elderberry shrub **(Shrub 3)** is also outside of the project impact area west of the gravel parking lot and south of the American River bike path. The health of this shrub is also suffering and it is nearly covered with pipevine and grapevines. It has appropriately sized exit holes in old wood.

Shrub 1 on the south side of the American River will be impacted by the directional drill entrance point. Mitigation is required for loss or damage to VELB habitat of Shrub 1. Shrub 2 will be indirectly impacted. Mitigation is required for potential damage to VELB habitat of shrub 2. Shrub 3 will be avoided by project construction and no impact is expected.

5.0 Mitigation Measures

Setback and Temporary Fencing for Shrub 2 and Shrub 3
Shrub 2 and Shrub 3 are close to the potential impact area and will have a temporary fence setback 20 feet from its dripline so construction crews will avoid it.

Transplanting of Shrub 1

- In accordance with the "General Compensation Guidelines for the Valley Elderberry Longhorn Beetle" (USFWS 1993), the following measures will be taken to transplant shrub 1 outside the directional drill entrance impact zone:

- Before project construction begins, Shrub 1 will be transplanted about 100 feet to the southwest, within 20 feet of Shrub 2, on property belonging to the County of Sacramento.

- A hole three to four feet deep will be excavated to receive the planting in the designated mitigation area.

- If possible, ten viable cuttings will be taken from the shrub and rooted for replanting.

- The shrub will be cut back to three to six feet from the ground or 50% of its height (whichever is greater). The trunk and all live stems greater than one inch in diameter will be replanted.

- The shrub will be dug up using suitable equipment, taking as much of the root ball as possible, and will be replanted immediately in the designated area. The shrub will be moved only by the root ball after the ball has been wrapped in burlap and secured in wire. The burlap will be dampened to keep the root ball wet.

- After removing the burlap, the root ball will be planted so it is level with the existing ground. The soil will be compacted so settlement will not occur.

- The soil will be saturated with water. A drip irrigation system will be installed to water the shrub every two weeks at a rate of 50 gallons per application from March 1 to October 1, 1996, except when greater than 0.5 inch of rain has been received during that period.

- Mechanical weed control maintenance will occur every two weeks from March 1 to October 1, 1996. Control will then occur at least once in 1997. Weed control will be by mechanical means only, herbicides are prohibited.

- Throughout the mitigation period, access will be given to California Department of Fish and Game (CDFG) and USFWS biologists and law enforcement personnel.

Replacement Plantings

In addition to transplanting shrub 1, USFWS compensation guidelines (1991) require additional sapling elderberry shrubs to be planted in a mitigation area. The mitigation area chosen by the County of Sacramento is the elderberry mitigation site at Lower Sunrise Recreation area (See Figure 3). In accordance with the guidelines, the following mitigation measures will be taken:

- A minimum of 39 rooted elderberry cuttings will be planted as replacement shrubs in the mitigation area, in groups of 4 or 5. In addition, ten rooted cuttings from the transplanted Shrub 1 will be planted in the mitigation area.

- A drip irrigation system will be installed to water the plants every two weeks at a rate of 10 gallons per application from March 1 to October 1, 1996, except when greater than 0.5 inch of rain has been received during that period.

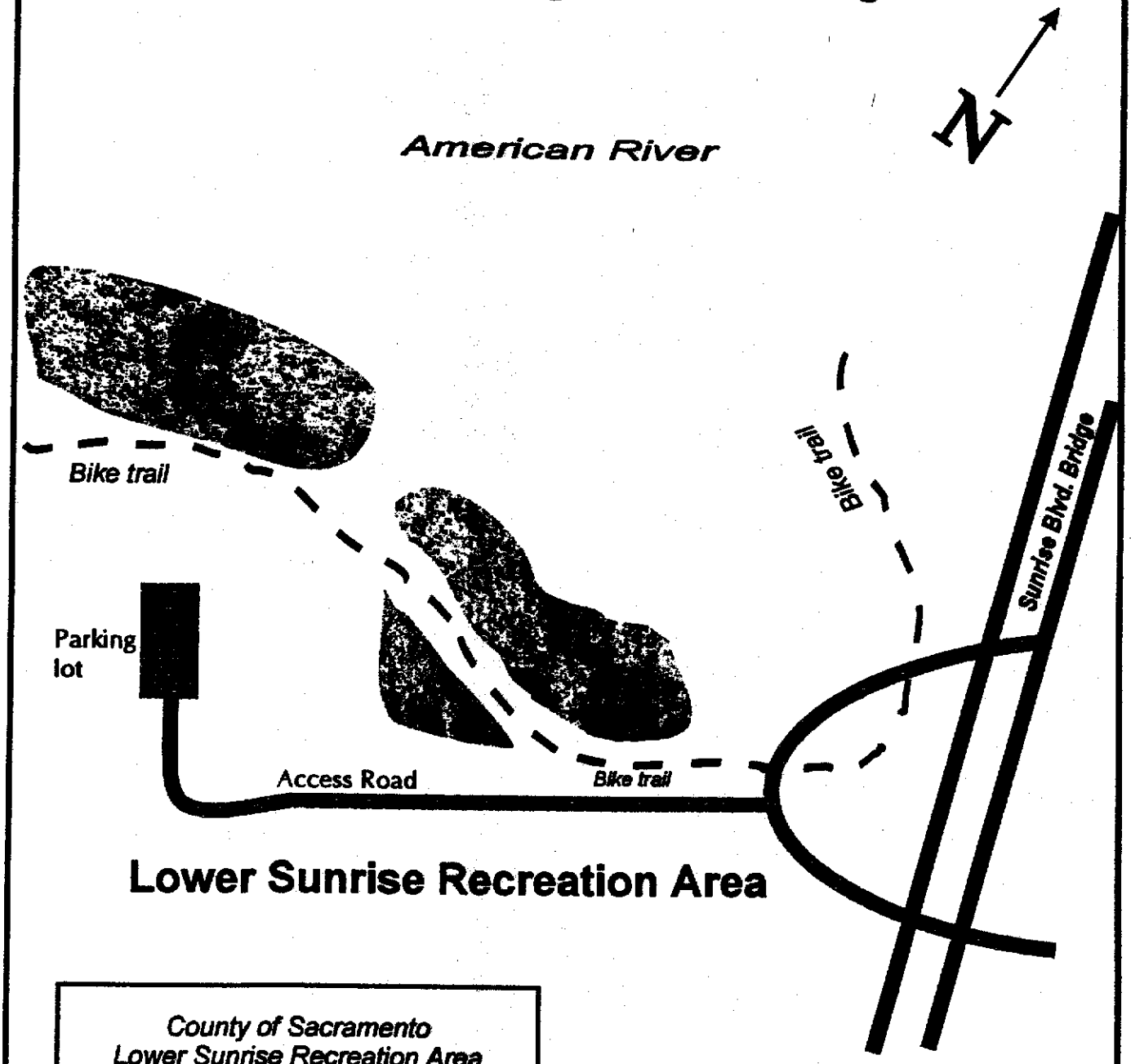
- Mechanical weed control maintenance will occur every two weeks from March 1 to October 1, 1996. Control will then occur at least once in 1997. After 1997, the County of Sacramento will take responsibility for the mitigation area in perpetuity. Weed control will be by mechanical means only, herbicides are prohibited.

- Planting of native associate plants will not be required in the mitigation area as they are already present (Mead, pers. comm.).

- Throughout the mitigation period, access will be given to California Department of Fish and Game (CDFG) and USFWS biologists and law enforcement personnel.

American River GET System

Valley Elderberry Longhorn Beetle Mitigation



Lower Sunrise Recreation Area

County of Sacramento
Lower Sunrise Recreation Area

Elderberry Mitigation Areas
location to be used for
Replacement Plantings

Approximate Scale 1" = 1000'

Figure 3

biota biological consulting

6.0 Monitoring Program

USFWS compensation guidelines (1991) require the mitigation area to be monitored by a qualified biologist annually for ten years beginning with the date the mitigation program is initiated. Two visits between February 14 and June 30 of each year will be made to the transplant site and to the revegetation site, beginning the year the mitigation is begun. The monitoring effort will include the following:

- A population census of the adult VELB, including the actual number of animals observed, their condition, behavior, and precise location at the site.
- A census of the elderberry shrubs including the number of plants observed, their size and condition.
- A general assessment of the habitat, including any real or potential threats to the beetle or its food plants, such as erosion, excessive browsing by hares, or off-road vehicle use.
- Random walk counts will be used, mark and recapture or other methods that involve handling or harassment will not be used.
- A written report will be submitted to the USFWS, CDFG Supervisor of Environmental Services and CDFG California Natural Diversity Data Base Staff Zoologist by December 31 of each year for a ten year period beginning with the date the mitigation program is initiated. The report will include raw data collected during the field surveys and a basic analysis of the population dynamics of VELB at the mitigation site. Maps showing the locations of individual adult beetles and exit holes will be included.
- The report will also include an analysis of the survival rate, condition and size of the elderberry shrubs. Real and potential future threats will be addressed and will include suggested measures to correct the threats.
- Original field notes, photographs, correspondence, and all other pertinent material, as well as a copy of the report, will be deposited and accessioned into the Natural History Museum of Los Angeles County by December 31 of each year for ten years beginning with the date the mitigation was initiated. The USFWS Sacramento Field Office will be provided with the accession numbers given to this material by the Natural History Museum of Los Angeles County.
- The County of Sacramento will assume responsibility for the mitigation area in perpetuity after 2006. This includes weeding, monitoring and providing access to the area to CDFG and USFWS biologists and law enforcement personnel.

7.0 References

biota biological consulting. 1995. Sailor Bar Groundwater Extraction and Treatment Facility Natural Environment Study. Prepared for GenCorp Aerojet and The Spink Corporation. August 1995.

Mead, Deborah. 1996. U.S. Fish and Wildlife Service Entomologist. Telephone conversation with J. Martini of *biota* regarding planting of native associates with elderberry shrubs. January 11, 1996.

U.S. Fish and Wildlife Service. 1991. The Distribution, Habitat, and Status of the Valley Elderberry Longhorn Beetle *Desmocerus californicus dimorphus*. November 1991.

. 1993. General Compensation Guidelines for the Valley Elderberry Longhorn Beetle. February 26, 1993.

biota

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May 22, 1996

Mr. Mike Girard
Aerojet General Corp.
Building 20019
Department 0330
P.O. Box 13222
Sacramento, CA 95818-6000

Re: ARGET biological resources

Dear Mike,

This letter supplements our biological status report, *Biological status, Summary of Work to Date,* submitted to you on May 16, 1996.

In August of 1995, we submitted the *Sailor Bar Natural Environment Study* report to Aerojet (and The Spink Corporation), with associated documentation, including a comparison of alternatives and preliminary findings. These documents informed Aerojet of several biologically sensitive resources that could be affected by various project alternatives.

Alternative #5 involved drilling under the American River. The Natural Environment Study listed four potential impacts to sensitive biological resources that could occur under Alternative #5:

1. removal or damage to interior live oak trees
2. removal or damage to a vernal pool (refer to Map 1, attached)
3. removal or damage to valley elderberry longhorn beetle habitat
4. impacts to potential unknown sensitive resources on the as-yet unchosen pipeline route from the American River to Aerojet.

Alternative #5 is now the preferred project alternative. The purpose of this letter is to clarify some details of plan changes on the ARGET project, as they relate to avoiding or mitigating for impacts to the sensitive biological resources.

Late in August and in September we worked with Spink to work out project changes to avoid the vernal pool, and try to avoid the elderberry plants or mitigate for them. Several phone calls, map exchanges, and field meetings took place. *biota* informed Spink that the drill emergence site should not be moved eastward across the access road, nor southwest, due to the presence of other seasonal wetlands in those locations (*biota* telecon records on file of 8/21/95, 9/20/95, 9/27/95, 10/2/95, 10/4/95, and field meeting records of 10/6/95, 11/8/95, 12/15/95, 1/31/96).

On December 19, 1995, we received revised project limits and Plan and Profile, ARGET River Crossing Sheets 2 and 3, of 3, PRELIMINARY, showing the revised crossing. This revision avoids the vernal pool and the wetland west of the gravel parking lot (refer to Map 2 and Map 3, attached).

The biological impacts of the current underwater drill plan to the before-mentioned resources are as follows.

1. *interior live oak trees*

   The project change to move the drill entrance to the west of the seasonal wetland will avoid impacts to the live oak trees.

2. *vernal pool*

   The project change to move the drill entrance to the west of the seasonal wetland will avoid impacts to the vernal pool. The vernal pool supports a federally listed species, the vernal pool fairy shrimp, *Branchinecta lynchi*. The project change will also avoid two other seasonal wetlands near the vernal pool.

3. *Valley elderberry longhorn beetle habitat*

   The project will avoid impacts to all elderberry shrubs except for one, adjacent to the drill entrance site on the south side of the American River. A mitigation plan was prepared and has received preliminary USFWS approval but is still under Section 7 consultation review. The plan involves transplanting the shrub, and offsite mitigation.

3. *potential unknown sensitive resources on the as-yet unchosen pipeline route from the American River to Aerojet.*

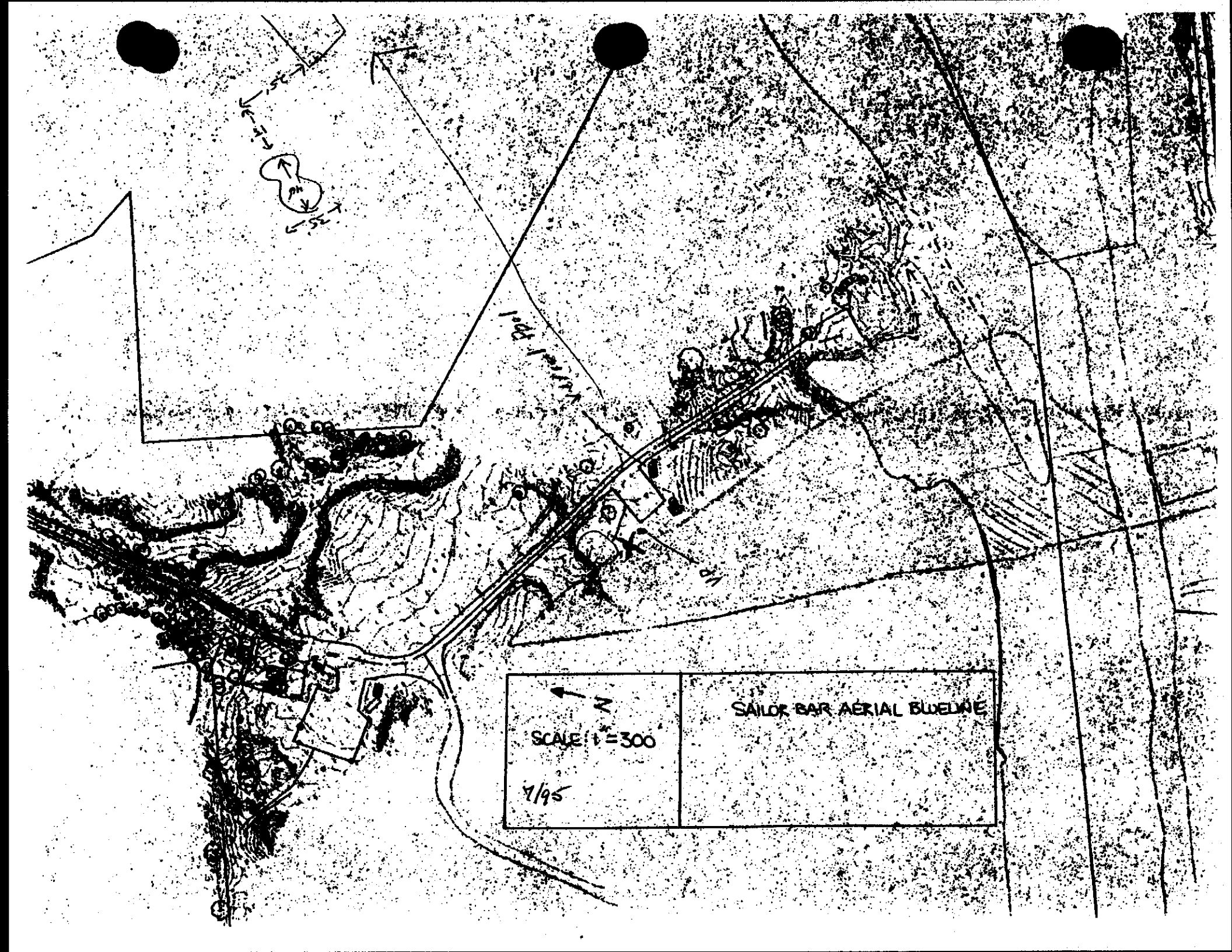
   Elderberry shrubs and oak trees are among biological resources along the pipeline corridor that could potentially be affected. The alignment of the pipeline has not yet been determined. When a corridor is chosen, a biological survey will be conducted and efforts will be made to avoid all sensitive biological resources.

I hope this letter clears up the question of the status of known biological resources on the ARGET project. Feel free to call me if you have any further questions.

Sincerely,

Debby Martin
Senior Biologist

Attachments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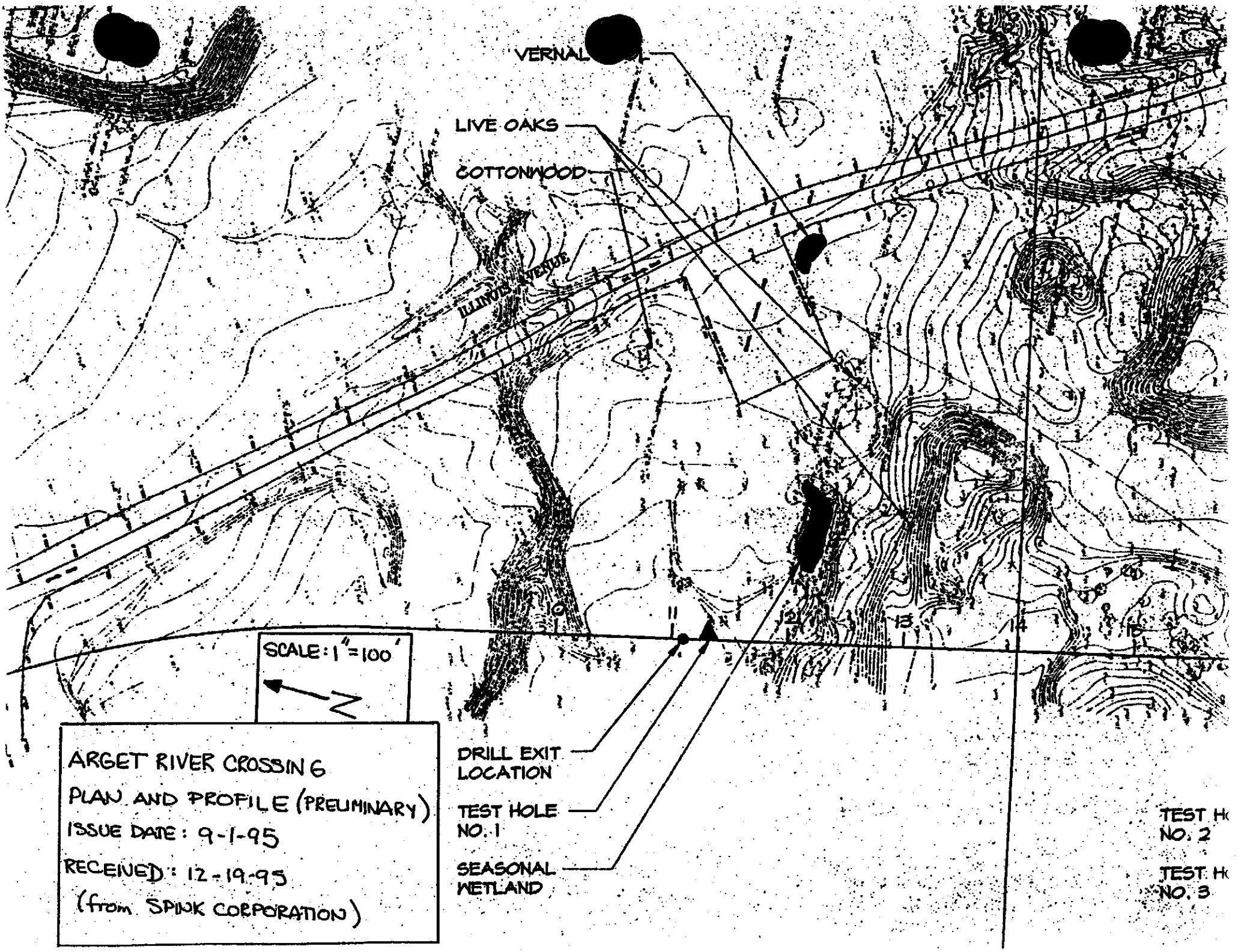
SAILOR BAR AERIAL BLUELINE



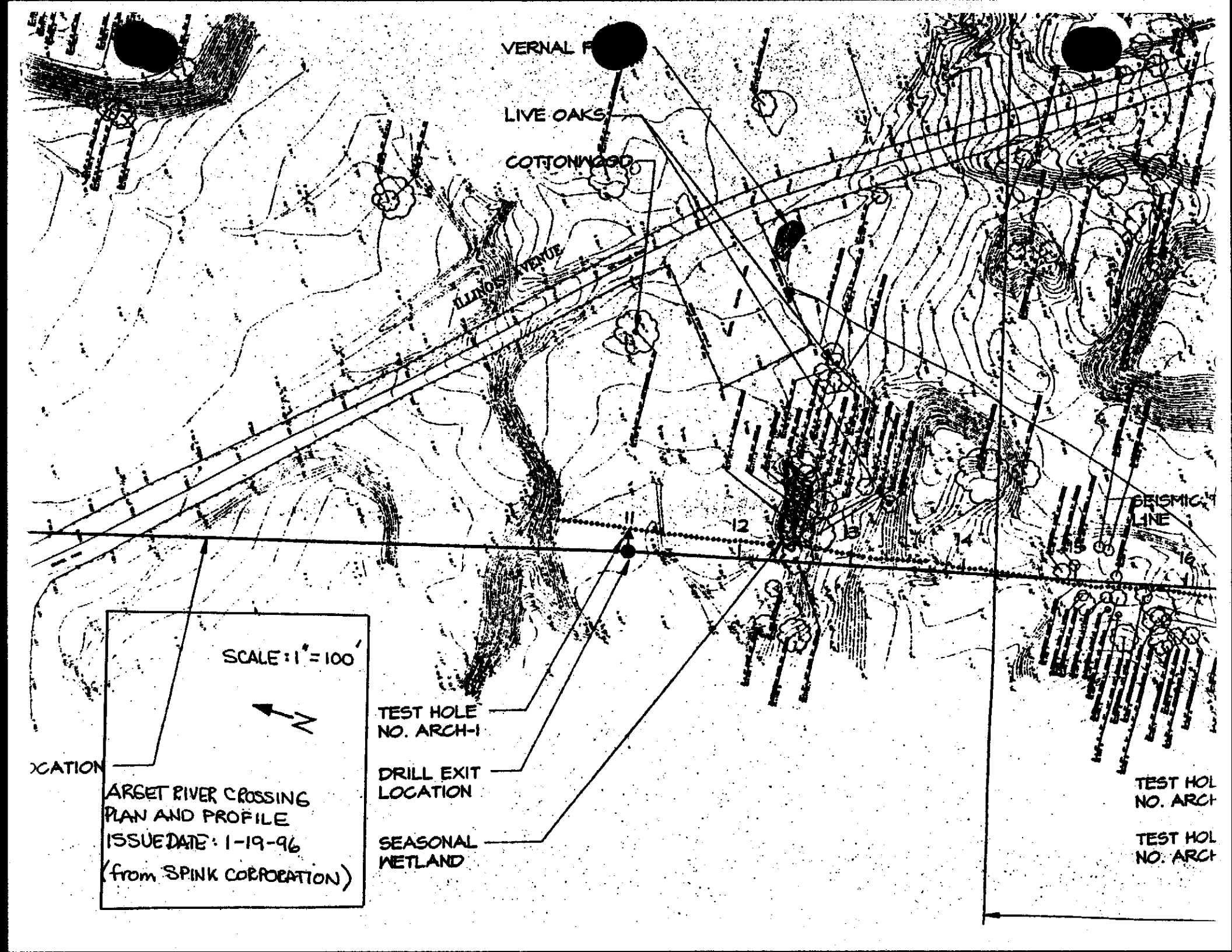
ARGET RIVER CROSSING

PLAN AND PROFILE (PRELIMINARY)

ISSUE DATE: 9-1-95

RECEIVED: 12-19-95

(from SPINK CORPORATION)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ARGET RIVER CROSSING
PLAN AND PROFILE
ISSUE DATE: 1-19-96
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APPENDIX I

SARGET Facility
Pipeline Alternatives
Nimbus Fish Hatchery to Aerojet

AEROJET GENERAL

SARGET FACILITY

PIPELINE ALTERNATIVES
NIMBUS FISH HATCHERY TO AEROJET

September 19, 1995

Prepared By:

The Spink Corporation

Engineering, Architecture, Planning
Surveying, Mapping, Photogrammetry
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1 INTRODUCTION

Aerojet is currently proceeding with plans to extract and treat groundwater in the vicinity of the American River at Hazel Avenue with authorization under a consent decree from the Environmental Protection Agency. One of the proposed facilities, described below, is the South American River Groundwater Extraction and Treatment Facility (SARGET). This report examines alternatives for delivering water from the Nimbus Fish Hatchery area to Aerojet property south of Folsom Boulevard. The purpose of this report is to provide information to aide in evaluating and selecting a route for the water line. The development of detailed alignments and in-depth analysis of engineering and right-of-way issues are beyond the scope of this report.

2 PROJECT DESCRIPTION

Three system alternatives for piping extracted groundwater from the Nimbus Fish Hatchery to Aerojet are studied:

A. Treated Groundwater. A water treatment plant located near the fish hatchery will remove volatile organic compounds (VOC) from groundwater from SARGET extraction wells south of the American River. Treated water will be piped back to Aerojet. This alternative represents the original design concept of a separate system on the south side of the river.

B. Untreated Groundwater. Untreated groundwater from SARGET extraction wells will be piped to Aerojet property for treatment.

C. Combined Untreated Groundwater. Groundwater from extraction wells within the County of Sacramento Sailor Bar Park north of the American River will be piped under the American River and combined with water produced by SARGET extraction wells. The combined flow will be piped from the fish hatchery to Aerojet for treatment.

The SARGET facility is designed to produce 2000 gpm initially. The SARGET treatment plant is designed for expansion to 3200 gpm ultimately, if necessary.

The NARGET treatment plant is designed to treat up to 2600 gpm, with capability for expansion to 3200 gpm. Nine existing extraction wells are expected to produce 2015 gpm initially.

Table 1 provides design criteria for the three system alternatives:

TABLE 1

SYSTEM ALTERNATIVE	FLOW RATE		PROJECTED TCE CONCENTRATION PPB
	DESIGN	WITH EXPANSION	
A	2000 gpm	3200 gpm	5
B	2000 gpm	3200 gpm	3000 - 5000
C	4000 gpm	6400 gpm	1500 - 3100

Polyethylene pipe rated for 150 psi pressure will be used for the carrier pipe. Secondary containment and leak detection is required for all pipeline alternatives. A 16-inch carrier pipe would be used for systems A and B. System C will require a 24-inch carrier pipe. Table 2 identifies characteristics of the polyethylene pipe. Friction losses are calculated using the Hazen-Williams equation and a C factor of 150.

TABLE 2
PIPELINE CHARACTERISTICS

SYSTEM ALTERNATIVE	A OR B	C
Carrier Pipe Size Wall Thickness Inside Diameter	16" 1.455" 13.090"	24" 2.182" 19.636"
Design Flow Velocity Friction Loss/1000'	2,000 gpm 4.77 fps 4.6'	4,000 gpm 4.24 fps 2.3'
Ultimate Flow Velocity Friction Loss/1000'	3,200 gpm 7.63 fps 11.0'	6,400 gpm 6.78 fps 5.5'

For System A, the treatment plant will be located to the south of an existing parking lot on the southwest side of the fish hatchery. The treatment plant site is owned by the County of Sacramento. The plant site will be graded to utilize cobble ridges to partially screen the plant from view. Ridges will border the north, east and south perimeter of the plant while access will be through the west side. A paved driveway off of the existing asphalt paved road will be provided. A building will house process and control equipment.

The seven potential pipeline routes from the Fish Hatchery area to Aerojet shown on Exhibit 1 are examined in this report. For each route, the pipeline will have to cross the Folsom South Canal, Highway 50, Folsom Boulevard, and Southern Pacific Railroad.

3 UNIT COSTS

Table 3 provides unit costs used to develop comparative cost estimates in this report.

TABLE 3
UNIT COSTS

	UNIT	UNIT PRICE
16" in 20" Pipe	LF	$107
24" in 32" Pipe	LF	$170
Control Conduit	LF	$6.30
Pipeline Sump	EA	$4,000
Air Release Valve	EA	$3,000
Pavement Repair	SF	$6.00
Bore and Jack (30" Casing)	LF	$1,500
Bore And Jack (36" Casing)	LF	$1,700
Tunneling	LF	$3,000

PAGES OF OVERSIZED MAPS

(SEE BINDER)

3.1 PIPE

The proposed pipe is high density polyethylene (HDPE), a relatively flexible material used in dual containment systems. The pipe is typically butt fused outside of the trench and then lowered into place. The joining process allows a smaller containment pipe to be used (as opposed to a bell and spigot or mechanical coupling method) and aids in installation of the carrier pipe into the containment pipe. The unit costs for the pipeline includes both the inner and outer pipe materials, trenching, installation, and backfilling.

3.2 CONTROL CONDUIT

A control conduit with telephone and electrical service will be placed in the same trench as the pipeline. Costs include materials and installation. Costs of electrical transmission lines are not included in this study.

3.3 VALVES AND SUMPS

Leak detection will be through sumps placed at low points along the pipe system. An alarm with telemetry connecting to Aerojet will activate when water fills the sump. Air release valves will be placed to allow for release of trapped air at high points.

3.4 PAVEMENT REPAIR

Pavement repair in streets will meet County of Sacramento Standards, which requires 18" aggregate base for the width of the trench and 6" of asphalt concrete for the trench width plus 16".

3.5 BORE AND JACK

Boring and jacking consists of excavating a pit for equipment on one side of the operation and jacking the casing to the other side. A steel casing will likely be used with the dual containment pipe being placed inside. Much of the material in the area is dredge trailings. The high percentage of cobbles may not allow boring and jacking to succeed. If this occurs, tunneling will be required, at a substantial cost increase.

4 LUMP SUM COSTS

4.1 BRIDGE CROSSINGS

Costs for bridge crossings include all fittings, materials, and equipment needed to install the pipe across or through the bridge.

4.2 TRAFFIC CONTROL

Costs for traffic control include construction signs, construction detours, flaggers, and other incidentals associated with performing the work safely and in accordance with the County of Sacramento Standards in traffic areas.

4.3 UTILITY CROSSINGS

Costs include additional labor and materials associated with crossing existing utilities (sewer services, drain, electrical, gas, water, telephone, etc.). Cost is estimated based on the number and type of crossings for each alternative.

5 ALTERNATIVE PIPELINE ROUTES

Seven alternative pipeline routes are examined as detailed in the following pages. The pipeline is expected to operate for the next 20 to 30 years. Construction of the line is planned for Spring 1996.

Table 4 "Pipeline Alternatives" provides a summary of the various alternatives.

Table 5 summarizes the estimated cost for each option. A detailed breakdown for each option is provided in Appendix A.

TABLE 4
AEROJET SARGET FACILITY
PIPELINE ALTERNATIVES

	PIPELINE ROUTE ALTERNATIVE						
	ALT I	ALT II	ALT III	ALT IV	ALT V	ALT VI	ALT VII
Length of Pipe	4800'	4200'	6000'	8300'	8500'	3400'	5400'
Cross Private Property	Yes	Yes	No	No	No	Yes	Yes
Runs along Folsom South Canal	Yes	No	No	No	Yes	No	No
Open Cut at Hazel Avenue	No	No	Yes (1)	Yes (1)	No	No	No
Open Cut at Folsom Boulevard/SPRR	No	Yes	Yes (1)	Yes	No	No	No
Extensive Traffic Impacts	No	No	Yes	No	No	No	No
Bore and Jack/Tunnel Required	No	Yes	No	No	No	No	No
Horizontal Directional Bore	No	No	No	No	No	Yes	No

(1) The County of Sacramento has stated it will not allow open cutting of pavement in these areas prior to Summer 1997.

TABLE 5
PIPELINE COST ESTIMATES

	PIPELINE ROUTE ALTERNATIVE						
	I ($1,000)	II ($1,000)	III ($1,000)	IV ($1,000)	V ($1,000)	VI ($1,000)	VII ($1,000)
System A/B 16" Pipeline	$713	$1,069	$1,049	$1,233	$1,313	$1,371	$920
System C 24" Pipeline	$1,073	$1,438	$1,590	$1,853	$1,945	$1,702	$1,333

6 ROUTE I: CROSSING US 50 AT FOLSOM SOUTH CANAL

Description: Approximately 4800 LF of pipeline from treatment plant to Aerojet property. This alternative runs south along Gold River Unit 14 subdivision boundary to the Folsom South Canal, then west within Folsom South Canal right-of-way to US 50. The Folsom South Canal crosses under US 50, Folsom Boulevard, and a Southern Pacific Railroad (SPRR) line here through 2 - 18' x 19' reinforced box culverts. A 12'-2" x 11'-0" multi-plate underpass also crosses at this location. Under this alternative, the pipeline would be buried in the underpass. After crossing in the underpass, the line would cross over the top of the box culverts and connect to Aerojet property. Refer to Exhibit 1 for the proposed alignment and Exhibit 2 for a detail of the proposed underpass crossing.

Estimated Cost: See Table 5 for a summary of estimated construction costs. See Appendix A, Figures 1 and 2, for breakdown of costs.

Strengths: In this alternative, the water line stays within public property except on either side of Gold Country Boulevard. Only one street is crossed, minimizing traffic impacts. This alternative is also the least expensive, as well as the least intrusive in crossing US 50, Folsom Boulevard, and the SPRR.

Weaknesses: The Bureau of Reclamation, which operates the Folsom South Canal, has a policy of not allowing private utilities to utilize their right-of-way, except at crossings. This alternative would place the water line on Bureau of Reclamation property for approximately 2,000 feet.

7 ROUTE II: CROSSING FOLSOM SOUTH CANAL AT TRIBUTARY CROSSING DRIVE

Description: Approximately 4200 LF of pipeline from treatment plant to Aerojet property. This alternative runs south/east to Tributary Crossing Drive at Gold Country Boulevard. The line would cross the Folsom South Canal by being hung off the existing Tributary Crossing Drive bridge. At Tributary Point Drive the line would run east within the right-of-way for approximately 800 LF, then south in an easement across private property to US 50. Depending on subsurface soils, the pipeline would either be bored and jacked or tunneled under US 50. From US 50 south to Folsom Boulevard the line would be in an easement across private property. At Folsom Boulevard/SPRR the pipeline would be open cut to connect to Aerojet's property. Refer to Exhibit 1 for the proposed alignment.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Estimated Cost: See Table 5 for a summary of construction costs. See Appendix A, Figures 3 and 4, for a breakdown of costs.

Strengths: This is the shortest surface route from the treatment plant to Aerojet. The water main can be hung over the Folsom South Canal with relative ease.

Weaknesses: It may be difficult and expensive to obtain easements across private properties. Tunneling under US 50 will be an expensive proposition, if necessary.

8 ROUTE III: CROSSING US 50 AT HAZEL AVENUE

Description: Approximately 6,000 LF of pipeline from treatment plant to Aerojet property. This alternative runs east along the fish hatchery to Gold Country Boulevard, then within Gold Country Boulevard right-of-way to Hazel Avenue. The pipeline would then run along Hazel Avenue, being hung across the Folsom South Canal bridge and going through an existing conduit within the US 50 bridge on the west side. See Exhibit 3 for Hazel Overcrossing details. The pipeline would be open cut where it crosses the US 50 access ramps. At Folsom Boulevard/SPRR the pipeline would be open cut to connect to Aerojet's property. The County of Sacramento has a policy barring open cutting of pavement within three years of placement. If the work is done prior to summer 1997, and permission to open cut is not obtained from the County of Sacramento, the line will have to be bored and jacked or tunneled under the US 50 access ramps and at Folsom Boulevard.

Estimated Cost: See Table 3 for a summary of construction costs. See Appendix A, Figures 5 and 6, for a breakdown of costs.

Strengths: All work would be done on public property. Pipeline at this location is closest to existing Aerojet water treatment plant.

Weaknesses: Traffic would be impacted at the Hazel/US 50 interchange. If open cutting is not allowed, costs would increase considerably. Use of existing utility opening on Hazel Bridge at US 50 is first come first serve.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

9 ROUTE IV: CROSSING US 50 AT AEROJET ROAD

Description: Approximately 8,300 LF of pipeline from treatment plant to Aerojet property. Same as Route III to Hazel Avenue, from this point the main would be open cut across Hazel Avenue, then attached to the west side of the bridge crossing the Folsom South Canal. From here the line would either run parallel to, and outside, the Caltrans right-of-way to a proposed bicycle bridge at US 50, or along a proposed bicycle path through State property to the bicycle bridge. From the bridge, the line would run south along Aerojet Road. At Folsom Boulevard/SPRR the water main would be open cut to connect to Aerojet's property. Plans for the bicycle bridge are being prepared by the County of Sacramento, and construction is tentatively scheduled to start in May 1996. Utilizing the bridge may require minor redesign. The County may require the crossing at Hazel to be bored if the work is done prior to summer 1997.

Estimated Cost: See Table 3 for a summary of construction costs. See Appendix A, Figures 7 and 8, for a breakdown of costs.

Strengths: Will have less impact on Hazel/US 50 than Route III. Utilizes public property.

Weaknesses: Longest amount of water main. Timing with bicycle bridge may be a problem.

10 ROUTE V: CROSSING US 50 AT FOLSOM SOUTH CANAL (AVOIDANCE OF PRIVATE PROPERTY)

Description: Similar to Route I except a circuitous route is taken to avoid private property along Gold Country Boulevard. Approximately 8,500 LF of pipeline from treatment plant to Aerojet property. This alternative runs east along the fish hatchery to Gold Country Boulevard, then west on Gold Country Boulevard to Tributary Crossing Drive, south to the Folsom South Canal, then west within the Folsom South Canal right-of-way to US 50. The Folsom South Canal crosses under US 50, Folsom Boulevard, and a Southern Pacific Railroad (SPRR) line here through 2 - 18' x 19' reinforced box culverts. A 12'-2 x 11'-0" multi-plate underpass also crosses at this location. Under this alternative, the water line would be buried in the underpass. After crossing in the underpass, the line would cross over the top of the box culverts and connect to Aerojet property. Refer to Exhibit 1 for the proposed alignment and Exhibit 2 for a detail of the proposed underpass crossing.

Estimated Cost: See Table 3 for a summary of estimated construction costs. See Appendix A, Figures 9 and 10, for breakdown of costs.

Strengths: In this alternative, the water line stays within public property. This alternative is also the least intrusive in crossing US 50, Folsom Boulevard, and the SPRR.

Weaknesses: Much more expensive than Route I. The Bureau of Reclamation, which operates the Folsom South Canal, has a policy of not allowing private utilities to utilize their right-of-way, except at crossings. This alternative would place the water line on Bureau of Reclamation property for approximately 3,500 feet.

11 ROUTE VI: HORIZONTAL DIRECTIONAL DRILL UNDER US 50

Description: Approximately 3400 LF of pipeline from treatment plant to Aerojet property. This alternative runs south/east to Tributary Crossing Drive at Gold Country Boulevard. The line would then be bored at a depth of approximately 60 feet for 2,000 feet to Aerojet property. Refer to Exhibit 1 for the proposed alignment.

Estimated Cost: See Table 3 for a summary of construction costs. See Appendix A, Figures 11 and 12, for a breakdown of costs.

Strengths: This is the shortest route from the treatment plant to Aerojet. Existing improvements and roads will not be impacted.

Weaknesses: It may be difficult and expensive to obtain easements across private properties. Boring under US 50 will be expensive.

12 ROUTE VII: CROSSING US 50 AT FOLSOM SOUTH CANAL (AVOIDANCE OF BUREAU OF RECLAMATION RIGHT-OF-WAY)

Description: Similar to Route I, except the pipeline would utilize streets rather than Bureau of Reclamation property (except at the crossing at US 50). Approximately 5400 LF of water main from treatment plant to Aerojet property. This alternative runs south along Gold River Unit 14 subdivision boundary to Gold Country Boulevard then west to Eureka Canal Drive, and through residential streets to the Folsom South Canal at US 50. The Folsom South Canal crosses under US 50, Folsom Boulevard, and a Southern Pacific Railroad (SPRR) line here through 2 - 18' x 19' reinforced box culverts. A 12'-2" x 11'-0"

multi-plate underpass also crosses at this location. Under this alternative, the water line would be buried in the underpass. After crossing in the underpass, the line would cross over the top of the box culverts and connect to Aerojet property. Refer to Exhibit 1 for the proposed alignment and Exhibit 2 for a detail of the proposed underpass crossing.

Estimated Cost: See Table 3 for a summary of estimated construction costs. See Appendix A, Figures 13 and 14, for breakdown of costs.

Strengths: In this alternative, the water line stays within public property, except on either side of Gold Country Boulevard. This alternative is also the least intrusive in crossing US 50, Folsom Boulevard, and the SPRR.

Weaknesses: Major construction on residential streets. More expensive than Route I. Numerous Utility Crossings.

APPENDIX A

PRELIMINARY CONSTRUCTION COST ESTIMATES

FIGURE 1 - ROUTE I
AEROJET
SARGET FACILITY
SYSTEM A/B

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE **DATE: 9/19/95**

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	16" Carrier in 20" Containment Pipe	4,800	LF	107.00	513,600.00
2.	US 50 Undercrossing at Folsom South Canal	1	LS	35,000.00	35,000.00
3.	Control Conduit	4,800	LF	6.30	30,240.00
4.	Pipeline Sump	5	EA	4,000.00	20,000.00
5.	Air Release Valve	5	EA	3,000.00	15,000.00
6.	Pavement Repair	320	SF	6.00	1,920.00
7.	Traffic Control	1	LS	3,000.00	3,000.00
8.	Utility Crossings	1	LS	2,000.00	2,000.00
	CONSTRUCTION SUBTOTAL				**$620,760.00**
	CONTINGENCIES @ 15%				**$93,114.00**
	TOTAL				**$713,874.00**

FIGURE 2 - ROUTE I
AEROJET
SARGET FACILITY
SYSTEM C

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE **DATE: 9/19/95**

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	24" Carrier in 32" Containment Pipe	4,800	LF	170.00	816,000.00
2.	US 50 Undercrossing at Folsom South Canal	1	LS	45,000.00	45,000.00
3.	Control Conduit	4,800	LF	6.30	30,240.00
4.	Pipeline Sump	5	EA	4,000.00	20,000.00
5.	Air Release Valve	5	EA	3,000.00	15,000.00
6.	Pavement Repair	400	SF	6.00	2,400.00
7.	Traffic Control	1	LS	3,000.00	3,000.00
8.	Utility Crossings	1	LS	2,000.00	2,000.00
	CONSTRUCTION SUBTOTAL				**$933,640.00**
	CONTINGENCIES @ 15%				**$140,046.00**
	TOTAL				**$1,073,686.00**

FIGURE 3 - ROUTE II
AEROJET
SARGET FACILITY
SYSTEM A/B

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE **DATE: 9/19/95**

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	16" Carrier in 20" Containment Pipe	4,200	LF	107.00	449,400.00
2.	Bridge Crossing. Tributary Crossing Drive at Folsom South Canal	1	LS	60,000.00	60,000.00
3.	Control Conduit	4,200	LF	6.30	26,460.00
4.	Pipeline Sump	4	EA	4,000.00	16,000.00
5.	Air Release Valve	4	EA	3,000.00	12,000.00
6.	Bore and Jack 24" Casing Under US 50[1]	220	LF	1,500.00	330,000.00
7.	Pavement Repair	2,700	SF	6.00	16,200.00
8.	Traffic Control	1	LS	10,000.00	10,000.00
9.	Utility Crossings	1	LS	10,000.00	10,000.00
	CONSTRUCTION SUBTOTAL				**$930,060.00**
	CONTINGENCIES @ 15%				**$139,509.00**
	CONSTRUCTION TOTAL				**$1,069,569.00**

(1) tunneling may be required at an additional cost of $300,000.

FIGURE 4 - ROUTE II
AEROJET
SARGET FACILITY
SYSTEM C

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 9/19/95

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	24" Carrier in 32" Containment Pipe	4,200	LF	170.00	714,000.00
2.	Bridge Crossing, Tributary Crossing Drive at Folsom South Canal	1	LS	70,000.00	70,000.00
3.	Control Conduit	4,200	LF	6.30	26,460.00
4.	Pipeline Sump	4	EA	4,000.00	16,000.00
5.	Air Release Valve	4	EA	3,000.00	12,000.00
6.	Bore and Jack 36" Casing Under US 50[1]	220	LF	1,700.00	374,000.00
7.	Pavement Repair	3,000	SF	6.00	18,000.00
8.	Traffic Control	1	LS	10,000.00	10,000.00
9.	Utility Crossings	1	LS	10,000.00	10,000.00
	CONSTRUCTION SUBTOTAL				**$1,250,460.00**
	CONTINGENCIES @ 15%				**$187,569.00**
	CONSTRUCTION TOTAL				**$1,438,029.00**

(1) tunneling may be required at an additional cost of $300,000.

FIGURE 5 - ROUTE III
AEROJET
SARGET FACILITY
SYSTEM A/B

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE **DATE: 9/19/95**

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	16" Carrier in 20" Containment Pipe	6,000	LF	107.00	642,000.00
2.	Bridge Crossing, Hazel Avenue at Folsom South Canal	1	LS	70,000.00	70,000.00
3.	Bridge Crossing, Hazel Avenue at US 50	1	LS	20,000.00	20,000.00
4.	Control Conduit	6,000	LF	6.30	37,800.00
5.	Pipeline Sump	6	EA	4,000.00	24,000.00
6.	Air Release Valve	6	EA	3,000.00	18,000.00
7.	Pavement Repair	2,700	SF	6.00	16,200.00
8.	Traffic Control	1	LS	25,000.00	25,000.00
9.	Utility Crossings	1	LS	60,000.00	60,000.00
	CONSTRUCTION SUBTOTAL				**$913,000.00**
	CONTINGENCIES @ 15%				**$136,950.00**
	TOTAL				**$1,049,950.00**

NOTE: Assumes County allows open cutting at Hazel Avenue and Folsom Boulevard.

FIGURE 6 - ROUTE III
AEROJET
SARGET FACILITY
SYSTEM C

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE **DATE: 9/19/95**

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	24" Carrier in 32" Containment Pipe	6,000	LF	170.00	1,020,000.00
2.	Bridge Crossing, Hazel Avenue at Folsom South Canal	1	LS	100,000.00	100,000.00
3.	Bridge Crossing, Hazel Avenue at US 50	1	LS	80,000.00	80,000.00
4.	Control Conduit	6,000	LF	6.30	37,800.00
5.	Pipeline Sump	6	EA	4,000.00	24,000.00
6.	Air Release Valve	6	EA	3,000.00	18,000.00
7.	Pavement Repair	3,000	SF	6.00	18,000.00
8.	Traffic Control	1	LS	25,000.00	25,000.00
9.	Utility Crossings	1	LS	60,000.00	60,000.00
	CONSTRUCTION SUBTOTAL				**$1,382,800.00**
	CONTINGENCIES @ 15%				**$207,420.00**
	TOTAL				**$1,590,220.00**

NOTE: Assumes County allows open cutting at Hazel Avenue and Folsom Boulevard.

FIGURE 7 - ROUTE IV
AEROJET
SARGET FACILITY
SYSTEM A/B

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE **DATE: 9/19/95**

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	16" Carrier in 20" Containment Pipe	8,300	LF	107.00	888,100.00
2.	Bridge Crossing, Hazel Avenue at Folsom South Canal	1	LS	60,000.00	60,000.00
3.	Bike Bridge Crossing at Aerojet Road	1	LS	40,000.00	40,000.00
4.	Control Conduit	8,300	LF	6.30	52,290.00
5.	Pipeline Sump	8	EA	4,000.00	32,000.00
6.	Air Release Valve	8	EA	3,000.00	24,000.00
7.	Pavement Repair	800	SF	6.00	4,800.00
8.	Traffic Control	1	LS	10,000.00	10,000.00
9.	Utility Crossings	1	LS	10,000.00	10,000.00
	CONSTRUCTION SUBTOTAL				**$1,121,190.00**
	CONTINGENCIES @ 10%				**$112,119.00**
	TOTAL				**$1,233,309.00**

NOTE: Assumes County allows open cutting at Hazel Avenue.

FIGURE 8 - ROUTE IV
AEROJET
SARGET FACILITY
SYSTEM C

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 9/19/95

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	24" Carrier in 32" Containment Pipe	8,300	LF	170.00	1,411,000.00
2.	Bridge Crossing, Hazel Avenue at Folsom South Canal	1	LS	90,000.00	90,000.00
3.	Bike Bridge Crossing at Aerojet Road	1	LS	50,000.00	50,000.00
4.	Control Conduit	8,300	LF	6.30	52,290.00
5.	Pipeline Sump	8	EA	4,000.00	32,000.00
6.	Air Release Valve	8	EA	3,000.00	24,000.00
7.	Pavement Repair	900	SF	6.00	5,400.00
8.	Traffic Control	1	LS	10,000.00	10,000.00
9.	Utility Crossings	1	LS	10,000.00	10,000.00
	CONSTRUCTION SUBTOTAL				**$1,684,690.00**
	CONTINGENCIES @ 10%				**$168,469.00**
	TOTAL				**$1,853,159.00**

)TE: Assumes County allows open cutting at Hazel Avenue.

FIGURE 9 - ROUTE V
AEROJET
SARGET FACILITY
SYSTEM A/B

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE **DATE: 9/19/95**

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	16" Carrier in 20" Containment Pipe	8,500	LF	107.00	909,500.00
2.	US 50 Undercrossing at Folsom South Canal	1	LS	35,000.00	35,000.00
3.	Control Conduit	8,500	LF	6.30	53,550.00
4.	Pipeline Sump	9	EA	4,000.00	36,000.00
5.	Air Release Valve	9	EA	3,000.00	27,000.00
6.	Pavement Repair	6,800	SF	6.00	40,800.00
7.	Traffic Control	1	LS	10,000.00	10,000.00
8.	Utility Crossings	1	LS	30,000.00	30,000.00
	CONSTRUCTION SUBTOTAL				**$1,141,850.00**
	CONTINGENCIES @ 15%				**$171,277.50**
	TOTAL				**$1,313,127.50**

FIGURE 10 - ROUTE V
AEROJET
SARGET FACILITY
SYSTEM C

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 9/19/95

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	24" Carrier in 32" Containment Pipe	8,500	LF	170.00	1,445,000.00
2.	US 50 Undercrossing at Folsom South Canal	1	LS	45,000.00	45,000.00
3.	Control Conduit	8,500	LF	6.30	53,550.00
4.	Pipeline Sump	9	EA	4,000.00	36,000.00
5.	Air Release Valve	9	EA	3,000.00	27,000.00
6.	Pavement Repair	7,500	LF	6.00	45,000.00
7.	Traffic Control	1	LS	10,000.00	10,000.00
8.	Utility Crossings	1	LS	30,000.00	30,000.00
	CONSTRUCTION SUBTOTAL				**$1,691,550.00**
	CONTINGENCIES @ 15%				**$253,732.50**
	TOTAL				**$1,945,282.50**

FIGURE 11 - ROUTE VI
AEROJET
SARGET FACILITY
SYSTEM A/B

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 9/19/95

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	16" Carrier in 20" Containment Pipe	1,400	LF	107.00	149,800.00
2.	Horizontal Directional Drill Water Line	2,000	LF	500.00	1,000,000.00
3.	Control Conduit	3,400	LF	6.30	21,420.00
4.	Pipeline Sump	3	EA	4,000.00	12,000.00
5.	Air Release Valve	3	EA	3,000.00	9,000.00
	CONSTRUCTION SUBTOTAL				**$1,192,220.00**
	CONTINGENCIES @ 15%				**$178,833.00**
	TOTAL				**$1,371,053.00**

FIGURE 12 - ROUTE VI
AEROJET
SARGET FACILITY
SYSTEM C

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 9/19/95

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	24" Carrier in 32" Containment Pipe	1,400	LF	170.00	238,000.00
2.	Horizontal Directional Drill	2,000	LF	600.00	1,200,000.00
3.	Control Conduit	3,400	LF	6.30	21,420.00
4.	Pipeline Sump	3	EA	4,000.00	12,000.00
5.	Air Release Valve	3	EA	3,000.00	9,000.00
	CONSTRUCTION SUBTOTAL				**$1,480,420.00**
	CONTINGENCIES @ 15%				**$222,063.00**
	TOTAL				**$1,702,483.00**

FIGURE 13 - ROUTE VII
AEROJET
SARGET FACILITY
SYSTEM A/B

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE **DATE: 9/19/95**

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	16" Carrier in 24" Containment Pipe	5,400	LF	107.00	577,800.00
2.	US 50 Undercrossing at Folsom South Canal	1	LS	35,000.00	35,000.00
3.	Control Conduit	5,400	LF	6.30	34,020.00
4.	Pipeline Sump	6	EA	4,000.00	24,000.00
5.	Air Release Valve	6	EA	3,000.00	18,000.00
6.	Pavement Repair	12,000	SF	6.00	72,000.00
7.	Traffic Control	1	LS	10,000.00	10,000.00
8.	Utility Crossings	1	LS	30,000.00	30,000.00
	CONSTRUCTION SUBTOTAL				**$800,820.00**
	CONTINGENCIES @ 15%				**$120,123.00**
	TOTAL				**$920,943.00**

FIGURE 14 - ROUTE VII
AEROJET
SARGET FACILITY
SYSTEM C

PIPELINE
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 9/19/95

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	24" Carrier in 32" Containment Pipe	5,400	LF	170.00	918,000.00
2.	US 50 Undercrossing at Folsom South Canal	1	LS	45,000.00	45,000.00
3.	Control Conduit	5,400	LF	6.30	34,020.00
4.	Pipeline Sump	6	EA	4,000.00	24,000.00
5.	Air Release Valve	6	EA	3,000.00	18,000.00
6.	Pavement Repair	13,400	SF	6.00	80,400.00
7.	Traffic Control	1	LS	10,000.00	10,000.00
8.	Utility Crossings	1	LS	30,000.00	30,000.00
	CONSTRUCTION SUBTOTAL				**$1,159,420.00**
	CONTINGENCIES @ 15%				**$173,913.00**
	TOTAL				**$1,333,333.00**

APPENDIX J

Calculations Groundwater Treatment Alternatives

CALCULATIONS

GROUNDWATER TREATMENT

ALTERNATIVE 1

(section 4.4.1)

WORST CASE CHEMICAL

CONCENTRATIONS

	A	B	C	D	E	F	G	H	I	J	K
1	American River Study Area										
2	EE/CA II										
3	Flow Weighted Influent VOC Concentration										
4	Flow Weighted Inluent Conc.- Wells 4325,4330 and 4335 only										
5	11-Apr-96										
6											
7											
8											Flow Weighted
9	Well Number	4325	4330	4335	4370	4375	4380	North Wells		Total Flow	Influent Conc.
10											
11	Flow Rate(gpm)	260	310	215	0	0	0	0		785	
12											
13											
14											
15											
16											
17	Chemical Constituent										
18	1,4-Dioxane	11	15	10	0	0	0	0			12.3
19	1,1-Dichloroethylene	30.3	74.8	12.0	0.0	0.0	0.0	0.0			42.9
20	1,1-Dichloroethane	1.5	5.9	1.8	0.0	0.0	0.0	0.0			3.3
21	cis/tran 1,2-Dichloroethylene	19.0	98.5	42.8	0.0	0.0	0.0	0.0			56.9
22	Chloroform	2.5	9.9	8.0	0.0	0.0	0.0	0.0			6.9
23	Freon 113	5.6	31.8	18.8	0.0	0.0	0.0	0.0			19.6
24	1,2-Dichloroethane	0.0	1.0	6.4	0.0	0.0	0.0	0.0			2.1
25	1,1,1-Trichloroethane	1.4	1.9	0.0	0.0	0.0	0.0	0.0			1.2
26	Carbon Tetrachloride	0.0	0.7	0.0	0.0	0.0	0.0	0.0			0.3
27	Trichloroethylene	287.5	1575.0	1005.0	0.0	0.0	0.0	0.0			992.5
28	Tetrachloroethylene	10.3	25.0	9.3	0.0	0.0	0.0	0.0			15.8
29											
30	Total VOC Conc.	358.1	1824.5	1104.1	0.0	0.0	0.0	0.0			1141.5

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,4-DIOXANE INFLUENT CONCENTRATION (PPB)	12.3
1,4-DIOXANE EFFLUENT CONCENTRATION (PPB) (assumes 2.5 ppb discharge limitation and a design standard of 1.25 ppb)	1.25
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	3.85
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,004
LAMP REPLACEMENT COST	$36,013
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,811

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,1-DCE INFLUENT CONCENTRATION (PPB)	42.9
1,1-DCE EFFLUENT CONCENTRATION (PPB)	3.45
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	3.5
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,263
LAMP REPLACEMENT COST	$36,090
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$210,148

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,1-DCA INFLUENT CONCENTRATION (PPB)	3.3
1,1-DCA EFFLUENT CONCENTRATION (PPB)	1.835
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	15
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,008
LAMP REPLACEMENT COST	$36,014
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,816

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,2-DCE INFLUENT CONCENTRATION (PPB)	56.9
1,2-DCE EFFLUENT CONCENTRATION (PPB)	4.6
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	3.5
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,010
LAMP REPLACEMENT COST	$36,015
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,819

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

CHLOROFORM INFLUENT CONCENTRATION (PPB)	6.9
CHLOROFORM EFFLUENT CONCENTRATION (PPB)	5.15
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	30
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,631
LAMP REPLACEMENT COST	$35,902
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,327

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

FREON 113 INFLUENT CONCENTRATION (PPB)	19.6
FREON 113 EFFLUENT CONCENTRATION (PPB)	14.62
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	30
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,884
LAMP REPLACEMENT COST	$35,977
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,656

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,2-DCA INFLUENT CONCENTRATION (PPB)	2.1
1,2-DCA EFFLUENT CONCENTRATION (PPB)	1.167
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	15
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,136
LAMP REPLACEMENT COST	$36,052
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,983

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,1,1-TCA INFLUENT CONCENTRATION (PPB)	1.2
1,1,1-TCA EFFLUENT CONCENTRATION (PPB)	0.895
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	30
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,931
LAMP REPLACEMENT COST	$35,991
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,717

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

CARBON TETRACHLORIDE INFLUENT CONCENTRATION (PPB)	0.3
CARBON TETRACHLORIDE EFFLUENT CONCENTRATION (PPB)	0.2236
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	30
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,208
LAMP REPLACEMENT COST	$36,074
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$210,076

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

TCE INFLUENT CONCENTRATION (PPB)	992.5
TCE EFFLUENT CONCENTRATION (PPB)	53
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	3
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,824
LAMP REPLACEMENT COST	$35,960
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,578

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

PCE INFLUENT CONCENTRATION (PPB)	15.8
PCE EFFLUENT CONCENTRATION (PPB)	3.2
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	5.5
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,727
LAMP REPLACEMENT COST	$35,931
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,452

	A	B	C	D	E	F	G	H	I	J	K
1	American River Study Area										
2	EE/CA II										
3	Flow Weighted Influent VOC Concentration										
4	North and South Side Extraction Wells										
5	Uv/Ox Pretreatment of Wells 4325, 4330 and 4335 for 1,4-Dioxane resulting in partial treatment for other compounds										
6	13-Apr-96										
7											Flow Weighted
8								North		Total	Influent
9	Well Number	4325	4330	4335	4370	4375	4380	Wells		Flow	Conc.
10											
11	Flow Rate(gpm)	260	310	215	325	200	105	2030		3445	
12											
13											
14											
15											
16	Chemical Constituent:										
17											
18	1,4-Dioxane	1.25	1.25	1.25	1.1	1.5	1	5			3.5
19	1,1-Dichloroethylene	3.5	3.5	3.5	3.0	7.5	1.2	15.5			10.7
20	1,1-Dichloroethane	1.8	1.8	1.8	0.2	0.6	0.2	0.0			0.5
21	cis/tran 1,2-Dichloroethylene	4.6	4.6	4.6	1.9	9.9	4.3	49.2			30.9
22	Chloroform	5.2	5.2	5.2	0.3	1.0	0.8	0.0			1.3
23	Freon 113	14.6	14.6	14.6	0.6	3.2	1.9	31.5			22.2
24	1,2-Dichloroethane	1.2	1.2	1.2	0.0	0.1	0.6	0.0			0.3
25	1,1,1-Trichloroethane	0.9	0.9	0.9	0.1	0.2	0.0	0.0			0.2
26	Carbon Tetrachloride	0.2	0.2	0.2	0.0	0.1	0.0	0.0			0.1
27	Trichloroethylene	53.0	53.0	53.0	28.8	157.5	100.5	463.3			300.0
28	Tetrachloroethylene	3.2	3.2	3.2	1.0	2.5	0.9	12.6			1.0
29											
30	Total VOC Conc.	88.1	88.1	88.1	35.8	182.5	110.4	572.1			367.1

GENCORP AEROJET
ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
BUILDING 20-019
13-Apr-96
ARGET EE/CA AIR EMISSIONS RATE INFORMATION

SCENARIO (BASELINE=UNCONTROLLED):	VARIABLES	NOTES:
• INFLUENT FLOW RATE = (gallons per minute)	3445	
VOLUMETRIC FLOW RATE (CUBIC FEET AIR/CUBIC FEET WATER)	60	
• STRIPPING TOWER AIR FLOW RATE =(cubic feet per minute)	27634	
• AIR TEMPERATURE	65°F	
• AIR RELATIVE HUMIDITY	95%	
• REQUIRED AIR EMISSION CONTROL EFFICIENCY	0%	

CONTAMINANT	MOLECULAR WEIGHT	INFLUENT CONC (LIQUID) (ppb)	AIR CONC (lbs. / hour)	AIR CONC (mg / cubic meter)	AIR CONC (ppm (volume))	
1,1-DICHLOROETHYLENE	96.94	10.7	0.018	0.178	0.045	
1,1-DICHLOROETHANE	98.96	0.5	0.001	0.008	0.002	
C/T 1,2-DICHLOROETHYLENE	96.94	30.9	0.053	0.515	0.130	
CHLOROPORM	119.40	1.3	0.002	0.022	0.004	
FREON 113	187.40	22.2	0.038	0.370	0.048	
1,2-DICHLOROETHANE	98.98	0.3	0.001	0.005	0.001	
1,1,1-TRICHLOROETHANE	133.40	0.2	0.000	0.003	0.001	
CARBON TETRACHLORIDE	153.80	0.1	0.000	0.002	0.000	
TRICHLOROETHYLENE	131.40	300.0	0.517	4.999	0.931	
TETRACHLOROETHYLENE	165.80	1.0	0.002	0.017	0.002	
TOTALS:		367.2	0.633	6.119	1.165	

CALCULATIONS

GROUNDWATER TREATMENT

ALTERNATIVE 1

(section 4.4.1)

START-UP CHEMICAL

CONCENTRATIONS

	A	B	C	D	E	F	G	H	I	J	K
1	American River Study Area										
2	EE/CA II										
3	Flow Weighted Influent VOC Concentration										
4	Flow Weighted Inluent Conc.- Wells 4325,4330 and 4335 only										
5	11-Apr-96										
6											Flow Weighted
7								North		Total	Influent
8								Wells		Flow	Conc.
9	Well Number	4325	4330	4335	4370	4375	4380				
10											
11	Flow Rate(gpm)	260	310	215	0	0	0	0		785	
12											
13											
14											
15											
16											
17	Chemical Constituent										
18	1,4-Dioxane	11	15	*10*	0	0	0	0			12.3
19	1,1-Dichloroethylene	30.3	74.8	12.0	0.0	0.0	0.0	0.0			42.9
20	1,1-Dichloroethane	1.5	5.9	1.8	0.0	0.0	0.0	0.0			3.3
21	cis/tran 1,2-Dichloroethylene	19.0	98.5	42.8	0.0	0.0	0.0	0.0			56.9
22	Chloroform	2.5	9.9	8.0	0.0	0.0	0.0	0.0			6.9
23	Freon 113	5.6	31.8	18.8	0.0	0.0	0.0	0.0			19.6
24	1,2-Dichloroethane	0.0	1.0	6.4	0.0	0.0	0.0	0.0			2.1
25	1,1,1-Trichloroethane	1.4	1.9	0.0	0.0	0.0	0.0	0.0			1.2
26	Carbon Tetrachloride	0.0	0.7	0.0	0.0	0.0	0.0	0.0			0.3
27	Trichloroethylene	287.5	1575.0	1005.0	0.0	0.0	0.0	0.0			992.5
28	Tetrachloroethylene	10.3	25.0	9.3	0.0	0.0	0.0	0.0			15.8
29											
30	Total VOC Conc.	368.1	1824.5	1104.1	0.0	0.0	0.0	0.0			1141.5

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,4-DIOXANE INFLUENT CONCENTRATION (PPB)	12.3
1,4-DIOXANE EFFLUENT CONCENTRATION (PPB) (assumes 2.5 ppb discharge limitation and a design standard of 1.25 ppb)	1.25
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	3.85
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,004
LAMP REPLACEMENT COST	$36,013
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,811

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,1-DCE INFLUENT CONCENTRATION (PPB)	42.9
1,1-DCE EFFLUENT CONCENTRATION (PPB)	3.45
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	3.5
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,263
LAMP REPLACEMENT COST	$36,090
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$210,148

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,1-DCA INFLUENT CONCENTRATION (PPB)	3.3
1,1-DCA EFFLUENT CONCENTRATION (PPB)	1.835
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	15
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,008
LAMP REPLACEMENT COST	$36,014
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,816

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,2-DCE INFLUENT CONCENTRATION (PPB)	56.9
1,2-DCE EFFLUENT CONCENTRATION (PPB)	4.6
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	3.5
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,010
LAMP REPLACEMENT COST	$36,015
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,819

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

CHLOROFORM INFLUENT CONCENTRATION (PPB)	6.9
CHLOROFORM EFFLUENT CONCENTRATION (PPB)	5.15
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	30
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,631
LAMP REPLACEMENT COST	$35,902
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,327

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

FREON 113 INFLUENT CONCENTRATION (PPB)	19.6
FREON 113 EFFLUENT CONCENTRATION (PPB)	14.62
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	30
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,884
LAMP REPLACEMENT COST	$35,977
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,656

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,2-DCA INFLUENT CONCENTRATION (PPB)	2.1
1,2-DCA EFFLUENT CONCENTRATION (PPB)	1.167
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	15
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,136
LAMP REPLACEMENT COST	$36,052
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,983

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

1,1,1-TCA INFLUENT CONCENTRATION (PPB)	1.2
1,1,1-TCA EFFLUENT CONCENTRATION (PPB)	0.895
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	30
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,931
LAMP REPLACEMENT COST	$35,991
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,717

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

CARBON TETRACHLORIDE INFLUENT CONCENTRATION (PPB)	0.3
CARBON TETRACHLORIDE EFFLUENT CONCENTRATION (PPB)	0.2236
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	30
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$121,208
LAMP REPLACEMENT COST	$36,074
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$210,076

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

TCE INFLUENT CONCENTRATION (PPB)	992.5
TCE EFFLUENT CONCENTRATION (PPB)	53
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	3
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,824
LAMP REPLACEMENT COST	$35,960
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,578

1,4-DIOXANE COST TREATMENT COST EVALUATION
AEROJET ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
ARGET(WELL 4325,4330, and 4335 ONLY)

GIVEN:

PCE INFLUENT CONCENTRATION (PPB)	15.8
PCE EFFLUENT CONCENTRATION (PPB)	3.2
GROUNDWATER FLOW RATE (GPM)	785
ELECTRICAL POWER COST PER KWH ($/KWH)	0.08
HYDROGEN PEROXIDE DOSE (PPM)	25
ELECTRICAL ENERGY PER ORDER FACTOR (EE/O)	5.5
OPERATING HOURS PER YEAR	8400
HYDROGEN PEROXIDE COST ($/POUND)	0.32
HYDROGEN PEROXIDE STRENGTH (%/100)	0.5

ASSUMPTIONS:

UV LAMP REPLACEMENT COST ASSUME AVERAGE BULB LIFE OF 3000 HOURS

FIND:

KILOWATTS REQUIRED FOR TREATMENT	180
ELECTRICAL COST PER YEAR	$120,727
LAMP REPLACEMENT COST	$35,931
HYDROGEN PEROXIDE COST PER YEAR	$52,794
TOTAL ANNUAL OPERATING COST	$209,452

	A	B	C	D	E	F	G	H	I	J	K
1	American River Study Area										
2	EE/CA II										
3	Flow Weighted Influent VOC Concentration-Start-up										
4	North and South Side Extraction Wells										
5	Uv/Ox Pretreatment of Wells 4325, 4330 and 4335 for 1,4-Dioxane resulting in partial treatment for other compounds										
6	7-May-96										
7											Flow Weighted
8								North		Total	Influent
9	Well Number	4325	4330	4335	4370	4375	4380	Wells		Flow	Conc.
10											
11	Flow Rate(gpm)	260	310	215	325	200	105	2030		3445	
12											
13											
14											
15											
16	Chemical Constituent:										
17											
18	1,4-Dioxane	1.25	1.25	1.25	0.00	0.00	0.00	*0.00*			0.28
19	1,1-Dichloroethylene	3.45	3.45	3.45	0.25	0.25	0.25	0.25			0.98
20	1,1-Dichloroethane	1.84	1.84	1.84	0.00	0.00	0.00	0.00			0.42
21	cis/tran 1,2-Dichloroethylene	4.60	4.60	4.60	0.25	0.25	0.25	0.64			1.47
22	Chloroform	5.15	5.15	5.15	0.00	0.00	0.00	0.00			1.17
23	Freon 113	14.62	14.62	14.62	0.25	0.25	0.25	0.25			3.52
24	1,2-Dichloroethane	1.17	1.17	1.17	0.00	0.00	0.00	0.00			0.27
25	1,1,1-Trichloroethane	0.90	0.90	0.90	0.00	0.00	0.00	0.00			0.20
26	Carbon Tetrachloride	0.22	0.22	0.22	0.00	0.00	0.00	0.00			0.05
27	Trichloroethylene	53.00	53.00	53.00	1.80	14.00	0.25	38.38			35.68
28	Tetrachloroethylene	3.20	3.20	3.20	0.25	0.25	0.25	0.34			0.77
29											
30	Total VOC Conc.	88.14	88.14	88.14	2.80	15.00	1.25	39.86			44.54

GENCORP AEROJET
ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
BUILDING 20-019
7-May-96
AEROJET EECA AIR EMISSIONS RATE INFORMATION

SCENARIO (BASELINE=UNCONTROLLED):	VARIABLES	NOTES:
• INFLUENT FLOW RATE = (gallons per minute)	3445	
VOLUMETRIC FLOW RATE (CUBIC FEET AIR/CUBIC FEET WATER)	60	
• STRIPPING TOWER AIR FLOW RATE =(cubic feet per minute)	27634	
• AIR TEMPERATURE	65°F	
• AIR RELATIVE HUMIDITY	95%	
• REQUIRED AIR EMISSION CONTROL EFFICIENCY	0%	

CONTAMINANT	MOLECULAR WEIGHT	INFLUENT CONC.(LIQUID) (ppb)	AIR CONC. (lbs. / hour)	AIR CONC. (mg / cubic meter)	AIR CONC. (ppbv (volume))	
1,1-DICHLOROETHYLENE	96.94	0.98	0.002	0.016	0.004	
1,1-DICHLOROETHANE	98.96	0.42	0.001	0.007	0.002	
C/T 1,2-DICHLOROETHYLENE	96.94	1.47	0.003	0.024	0.006	
CHLOROFORM	119.40	1.17	0.002	0.019	0.004	
FREON 113	187.40	3.52	0.006	0.059	0.008	
1,2-DICHLOROETHANE	98.98	0.27	0.000	0.004	0.001	
1,1,1-TRICHLOROETHANE	133.40	0.20	0.000	0.003	0.001	
CARBON TETRACHLORIDE	153.80	0.05	0.000	0.001	0.000	
TRICHLOROETHYLENE	131.40	35.68	0.062	0.595	0.111	
TETRACHLOROETHYLENE	165.80	0.77	0.001	0.013	0.002	
TOTALS:		44.53	0.077	0.742	0.138	

CALCULATIONS

GROUNDWATER TREATMENT

ALTERNATIVE 2

(section 4.4.2)

WORST CASE CHEMICAL

CONCENTRATIONS

	A	B	C	D	E	F	G	H	I	J	K
1	American River Study Area										
2	EE/CA II										
3	Flow Weighted Influent VOC Concentration										
4	North and South Side Extraction Wells										
5	11-Apr-96										
6											
7											Flow Weighted
8								North		Total	Influent
9	Well Number	4325	4330	4335	4370*	4375*	4380*	Wells		Flow	Conc.
10											
11	Flow Rate(gpm)	260	310	215	325	200	105	2030		3445	
12											
13											
14											
15	Chemical Constituent										
16	1,4-Dioxane	11	15	*10*	1.1	1.5	1.0	*5*			6.0
17	1,1-Dichloroethylene	30.3	74.8	12.0	3.0	7.5	1.2	15.5			19.7
18	1,1-Dichloroethane	1.5	5.9	1.8	0.2	0.6	0.2	0.0			0.8
19	cis/tran 1,2-Dichloroethylene	19.0	98.5	42.8	1.9	9.9	4.3	49.2			42.8
20	Chloroform	2.5	9.9	8.0	0.3	1.0	0.8	0.0			1.7
21	Freon 113	5.6	31.8	18.8	0.6	3.2	1.9	31.5			23.3
22	1,2-Dichloroethane	0.0	1.0	6.4	0.0	0.1	0.6	0.0			0.5
23	1,1,1-Trichloroethane	1.4	1.9	0.0	0.1	0.2	0.0	0.0			0.3
24	Carbon Tetrachloride	0.0	0.7	0.0	0.0	0.1	0.0	0.0			0.1
25	Trichloroethylene	287.5	1575.0	1005.0	28.8	157.5	100.5	463.3			514.1
26	Tetrachloroethylene	10.3	25.0	9.3	1.0	2.5	0.9	12.6			3.9
27											
28	Total VOC Conc.	368.1	1824.5	1104.1	35.8	182.5	110.4	572.1			607.1
29											
30	* VOC concentrations in wells 4370, 4375 and 4380 assumed to be 10% of the concentrations present										
31	in wells 4325, 4330 and 4335. Italized values are estimated.										

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
ARGET
13-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT:TOWER SPECIFICATIONS

Given:

Liquid Rate (lb / hr) =	1,723,878	3445
Liquid Density (lb / cuft) =	62.4	
Gas Density (lb / cuft) =	0.073	
Liquid Viscosity (cp) =	1	
Henry Constant 15°C (1,1-DCE) =	1148	
Cuft per Gallon (liquid) =	0.1337	
Molar Flowrate Conv. =	177.5	
Influent Conc. (ppb) =	19.7	
Effluent Conc. (ppb) =	0.25	
Packing Factor (F) =	30	

Assumptions:

Volumetric Flowrate Ratio (L/G) =	60
Stripping Factor (R) =	0

Find:

Air Flow Requirements (volumetric)

(liquid flowrate) (cuft / gal.) (volumetric ratio)

Air Flow = 27635.79 cfm 121045 lbs/hr

Air Flow Requirements (stripping factor))

((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant

Air Flow = 0 cfm 0 lbs/hr

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]ARGET
3-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS (cont.)

Find:

Number of Transfer Units Required for Removal (volumetric)

R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))

R = 51.88

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 4.43

Number of Transfer Units Required for Removal (stripping factor)

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = #DIV/0!

Input Information to Flooding Correlation Graphs

x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5

x-axis (vol.) = 0.49

x-axis (R) = #DIV/0!

y-axis =

Tower Dia.(ft)	G'(vol)	G'(R)	Cap. Fact.(vol.)	Cap. Fact.(R.)
8	0.67	0.00	2.48	0.00
9	0.53	0.00	1.96	0.00
10	0.43	0.00	1.58	0.00
11	0.35	0.00	1.31	0.00
12	0.30	0.00	1.10	0.00

Tower Dia.(ft)	y-axis(vol)	y-axis(R)
8	2.95	0.00
9	1.84	0.00
10	1.21	0.00
11	0.83	0.00
12	0.58	0.00

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]RGET
[redacted]-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS

Given:

Liquid Rate (lb / hr) =	1,723,878	3445
Liquid Density (lb / cuft) =	62.4	
Gas Density (lb / cuft) =	0.073	
Liquid Viscosity (cp) =	1	
Henry Constant 15°C (1,1-DCA) =	257	
Cuft per Gallon (liquid) =	0.1337	
Molar Flowrate Conv. =	177.5	
Influent Conc. (ppb) =	0.8	
Effluent Conc. (ppb) =	0.25	
Packing Factor (F) =	30	

Assumptions:

Volumetric Flowrate Ratio (L/G) =	60
Stripping Factor (R) =	4

Find:

Air Flow Requirements (volumetric)

(liquid flowrate) (cuft / gal.) (volumetric ratio)

Air Flow = 27635.79 cfm 121045 lbs/hr

Air Flow Requirements (stripping factor))

((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant

Air Flow = 9517 cfm 41686 lbs/hr

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]ARGET
[redacted]-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT:TOWER SPECIFICATIONS (cont.)

Find:

Number of Transfer Units Required for Removal (volumetric)

R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))

R = 11.61

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 1.21

Number of Transfer Units Required for Removal (stripping factor)

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 1.30

Input Information to Flooding Correlation Graphs

x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5

x-axis (vol.) = 0.49

x-axis (R) = 1.41

y-axis =

Tower Dia.(ft)	G'(vol)	G'(R)	Cap. Fact.(vol.)	Cap. Fact.(R.)
8	0.67	0.23	2.48	0.85
9	0.53	0.18	1.96	0.67
10	0.43	0.15	1.58	0.55
11	0.35	0.12	1.31	0.45
12	0.30	0.10	1.10	0.38

Tower Dia.(ft)	y-axis(vol)	y-axis(R)
8	2.95	0.35
9	1.84	0.22
10	1.21	0.14
11	0.83	0.10
12	0.58	0.07

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]RGET
[redacted]-Apr-96

[redacted]PTION: TREATMENT BY AIR STRIPPING

SUBJECT:TOWER SPECIFICATIONS

Given:

Liquid Rate (lb / hr) =	1,723,878	3445
Liquid Density (lb / cuft) =	62.4	
Gas Density (lb / cuft) =	0.073	
Liquid Viscosity (cp) =	1	
Henry Constant 15°C (cis1,2-DCE) :	184	
Cuft per Gallon (liquid) =	0.1337	
Molar Flowrate Conv. =	177.5	
Influent Conc. (ppb) =	42.8	
Effluent Conc. (ppb) =	0.25	
Packing Factor (F) =	30	

Assumptions:

Volumetric Flowrate Ratio (L/G) =	60
Stripping Factor (R) =	4

Find:

Air Flow Requirements (volumetric)

(liquid flowrate) (cuft / gal.) (volumetric ratio)

Air Flow = 27635.79 cfm 121045 lbs/hr

Air Flow Requirements (stripping factor))

((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant

Air Flow = 13293 cfm 58224 lbs/hr

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
ARGET
13-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT:TOWER SPECIFICATIONS (cont.)

Find:

Number of Transfer Units Required for Removal (volumetric)

R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))

R = 8.32

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 5.70

Number of Transfer Units Required for Removal (stripping factor)

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 6.48

Input Information to Flooding Correlation Graphs

x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5

x-axis (vol.) = 0.49

x-axis (R) = 1.01

y-axis =

Tower Dia.(ft)	G'(vol)	G'(R)	Cap. Fact.(vol.)	Cap. Fact.(R.)
8	0.67	0.32	2.48	1.19
9	0.53	0.25	1.96	0.94
10	0.43	0.21	1.58	0.76
11	0.35	0.17	1.31	0.63
12	0.30	0.14	1.10	0.53

Tower Dia.(ft)	y-axis(vol)	y-axis(R)
8	2.95	0.68
9	1.84	0.43
10	1.21	0.28
11	0.83	0.19
12	0.58	0.13

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
ARGET
13-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS

Given:

Liquid Rate (lb / hr) =	1,723,878	3445
Liquid Density (lb / cuft) =	62.4	
Gas Density (lb / cuft) =	0.073	
Liquid Viscosity (cp) =	1	
Henry Constant 15°C (chloroform) =	132	
Cuft per Gallon (liquid) =	0.1337	
Molar Flowrate Conv. =	177.5	
Influent Conc. (ppb) =	1.7	
Effluent Conc. (ppb) =	0.25	
Packing Factor (F) =	30	

Assumptions:

Volumetric Flowrate Ratio (L/G) =	60
Stripping Factor (R) =	4

Find:

Air Flow Requirements (volumetric)

(liquid flowrate) (cuft / gal.) (volumetric ratio)

Air Flow = 27635.79 cfm 121045 lbs/hr

Air Flow Requirements (stripping factor))

((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant

Air Flow = 18530 cfm 81161 lbs/hr

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
ARGET
13-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT:TOWER SPECIFICATIONS (cont.)

Find:

Number of Transfer Units Required for Removal (volumetric)

R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))

R = 5.97

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 2.12

Number of Transfer Units Required for Removal (stripping factor)

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 2.24

Input Information to Flooding Correlation Graphs

x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5

x-axis (vol.) = 0.49

x-axis (R) = 0.73

y-axis =

Tower Dia.(ft)	G'(vol)	G'(R)	Cap. Fact.(vol.)	Cap. Fact.(R.)
8	0.67	0.45	2.48	1.66
9	0.53	0.35	1.96	1.31
10	0.43	0.29	1.58	1.06
11	0.35	0.24	1.31	0.88
12	0.30	0.20	1.10	0.74

Tower Dia.(ft)	y-axis(vol)	y-axis(R)
8	2.95	1.33
9	1.84	0.83
10	1.21	0.54
11	0.83	0.37
12	0.58	0.26

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]ARGET
3-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS

Given:

Liquid Rate (lb / hr) =	1,723,878	3445
Liquid Density (lb / cuft) =	62.4	
Gas Density (lb / cuft) =	0.073	
Liquid Viscosity (cp) =	1	
Henry Constant 15°C (Freon 113) =	12156	
Cuft per Gallon (liquid) =	0.1337	
Molar Flowrate Conv. =	177.5	
Influent Conc. (ppb) =	23.3	
Effluent Conc. (ppb) =	0.25	
Packing Factor (F) =	30	

Assumptions:

Volumetric Flowrate Ratio (L/G) =	60
Stripping Factor (R) =	4

Find:

Air Flow Requirements (volumetric)

(liquid flowrate) (cuft / gal.) (volumetric ratio)

Air Flow = 27635.79 cfm 121045 lbs/hr

Air Flow Requirements (stripping factor))

((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant

Air Flow = 201 cfm 881 lbs/hr

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]ARGET
[redacted]3-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT:TOWER SPECIFICATIONS (cont.)

Find:

Number of Transfer Units Required for Removal (volumetric)

R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))

R = 549.38

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 4.54

Number of Transfer Units Required for Removal (stripping factor)

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 5.67

Input Information to Flooding Correlation Graphs

x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5

x-axis (vol.) = 0.49

x-axis (R) = 66.90

y-axis =

Tower Dia.(ft)	G'(vol)	G'(R)	Cap. Fact.(vol.)	Cap. Fact.(R.)
8	0.67	0.00	2.48	0.02
9	0.53	0.00	1.96	0.01
10	0.43	0.00	1.58	0.01
11	0.35	0.00	1.31	0.01
12	0.30	0.00	1.10	0.01

Tower Dia.(ft)	y-axis(vol)	y-axis(R)
8	2.95	0.00
9	1.84	0.00
10	1.21	0.00
11	0.83	0.00
12	0.58	0.00

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]ARGET
[redacted]3-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS

Given:

Liquid Rate (lb / hr) =	1,723,878	3445
Liquid Density (lb / cuft) =	62.4	
Gas Density (lb / cuft) =	0.073	
Liquid Viscosity (cp) =	1	
Henry Constant 15°C (1,2-DCA) =	74	
Cuft per Gallon (liquid) =	0.1337	
Molar Flowrate Conv. =	177.5	
Influent Conc. (ppb) =	0.5	
Effluent Conc. (ppb) =	0.25	
Packing Factor (F) =	30	

Assumptions:

Volumetric Flowrate Ratio (L/G) =	60
Stripping Factor (R) =	4

Find:

Air Flow Requirements (volumetric)

(liquid flowrate) (cuft / gal.) (volumetric ratio)

Air Flow = 27635.79 cfm 121045 lbs/hr

Air Flow Requirements (stripping factor))

((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant

Air Flow = 33053 cfm 144774 lbs/hr

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]ARGET
[redacted]-Apr-96

[redacted]PTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS (cont.)

Find:

Number of Transfer Units Required for Removal (volumetric)

R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))

R = 3.34

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 0.76

Number of Transfer Units Required for Removal (stripping factor)

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 0.75

Input Information to Flooding Correlation Graphs

x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5

x-axis (vol.) = 0.49

x-axis (R) = 0.41

y-axis =

Tower Dia.(ft)	G'(vol)	G'(R)	Cap. Fact.(vol.)	Cap. Fact.(R.)
8	0.67	0.80	2.48	2.96
9	0.53	0.63	1.96	2.34
10	0.43	0.51	1.58	1.90
11	0.35	0.42	1.31	1.57
12	0.30	0.36	1.10	1.32

Tower Dia.(ft)	y-axis(vol)	y-axis(R)
8	2.95	4.22
9	1.84	2.63
10	1.21	1.73
11	0.83	1.18
12	0.58	0.83

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]ARGET
[redacted]3-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS

Given:

Liquid Rate (lb / hr) =	1,723,878	3445
Liquid Density (lb / cuft) =	62.4	
Gas Density (lb / cuft) =	0.073	
Liquid Viscosity (cp) =	1	
Henry Constant 15°C (1,1,1-TCA) =	650	
Cuft per Gallon (liquid) =	0.1337	
Molar Flowrate Conv. =	177.5	
Influent Conc. (ppb) =	0.3	
Effluent Conc. (ppb) =	0.25	
Packing Factor (F) =	30	

Assumptions:

Volumetric Flowrate Ratio (L/G) =	60
Stripping Factor (R) =	4

Find:

Air Flow Requirements (volumetric)

(liquid flowrate) (cuft / gal.) (volumetric ratio)

Air Flow = 27635.79 cfm 121045 lbs/hr

Air Flow Requirements (stripping factor))

((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant

Air Flow = 3763 cfm 16482 lbs/hr

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]ARGET
[redacted]3-Apr-96

[redacted]PTION: TREATMENT BY AIR STRIPPING

SUBJECT:TOWER SPECIFICATIONS (cont.)

Find:

Number of Transfer Units Required for Removal (volumetric)

R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))

R = 29.38

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 0.18

Number of Transfer Units Required for Removal (stripping factor)

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 0.19

Input Information to Flooding Correlation Graphs

x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5

x-axis (vol.) = 0.49

x-axis (R) = 3.58

y-axis =

Tower Dia.(ft)	G'(vol)	G'(R)	Cap. Fact.(vol.)	Cap. Fact.(R.)
8	0.67	0.09	2.48	0.34
9	0.53	0.07	1.96	0.27
10	0.43	0.06	1.58	0.22
11	0.35	0.05	1.31	0.18
12	0.30	0.04	1.10	0.15

Tower Dia.(ft)	y-axis(vol)	y-axis(R)
8	2.95	0.05
9	1.84	0.03
10	1.21	0.02
11	0.83	0.02
12	0.58	0.01

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]RGET
[redacted]-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS

Given:

Liquid Rate (lb / hr) =	1,723,878	3445
Liquid Density (lb / cuft) =	62.4	
Gas Density (lb / cuft) =	0.073	
Liquid Viscosity (cp) =	1	
Henry Constant 15°C (TCE) =	377	
Cuft per Gallon (liquid) =	0.1337	
Molar Flowrate Conv. =	177.5	
Influent Conc. (ppb) =	514.1	
Effluent Conc. (ppb) =	0.25	
Packing Factor (F) =	30	

Assumptions:

Volumetric Flowrate Ratio (L/G) =	60
Stripping Factor (R) =	4

Find:

Air Flow Requirements (volumetric)

(liquid flowrate) (cuft / gal.) (volumetric ratio)

Air Flow = 27635.79 cfm 121045 lbs/hr

Air Flow Requirements (stripping factor))

((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant

Air Flow = 6488 cfm 28417 lbs/hr

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]RGET
3-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS (cont.)

Find:

Number of Transfer Units Required for Removal (volumetric)

R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))

R = 17.04

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 8.04

Number of Transfer Units Required for Removal (stripping factor)

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 9.79

Input Information to Flooding Correlation Graphs

x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5

x-axis (vol.) = 0.49

x-axis (R) = 2.07

y-axis =

Tower Dia.(ft)	G'(vol)	G'(R)	Cap. Fact.(vol.)	Cap. Fact.(R.)
8	0.67	0.16	2.48	0.58
9	0.53	0.12	1.96	0.46
10	0.43	0.10	1.58	0.37
11	0.35	0.08	1.31	0.31
12	0.30	0.07	1.10	0.26

Tower Dia.(ft)	y-axis(vol)	y-axis(R)
8	2.95	0.16
9	1.84	0.10
10	1.21	0.07
11	0.83	0.05
12	0.58	0.03

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]RGET
[redacted]-Apr-96

[redacted]OPTION: TREATMENT BY AIR STRIPPING

SUBJECT: TOWER SPECIFICATIONS

Given:

Liquid Rate (lb / hr) =	1,723,878	3445
Liquid Density (lb / cuft) =	62.4	
Gas Density (lb / cuft) =	0.073	
Liquid Viscosity (cp) =	1	
Henry Constant 15°C (PCE) =	628	
Cuft per Gallon (liquid) =	0.1337	
Molar Flowrate Conv. =	177.5	
Influent Conc. (ppb) =	3.9	
Effluent Conc. (ppb) =	0.25	
Packing Factor (F) =	30	

Assumptions:

Volumetric Flowrate Ratio (L/G) =	60
Stripping Factor (R) =	4

Find:

Air Flow Requirements (volumetric)

(liquid flowrate) (cuft / gal.) (volumetric ratio)

Air Flow = 27635.79 cfm 121045 lbs/hr

Air Flow Requirements (stripping factor))

((molar flow rate conversion) (stripping factor) (liquid flow rate (gpm))) / henry's constant

Air Flow = 3895 cfm 17059 lbs/hr

ENVIRONMENTAL OPERATIONS, DEPT 0330
DESIGN AND CONSTRUCTION
[redacted]RGET
[redacted]3-Apr-96

OPTION: TREATMENT BY AIR STRIPPING

SUBJECT:TOWER SPECIFICATIONS (cont.)

Find:

Number of Transfer Units Required for Removal (volumetric)

R=((Henry's constant) (volumetric air flow rate)) / ((molar conversion) (liquid flow rate (gpm))

R = 28.38

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 2.81

Number of Transfer Units Required for Removal (stripping factor)

NTU = (R /(R-1)) ln(((infl. conc./ effl. conc.) (R-1)+1)/R)

NTU = 3.31

Input Information to Flooding Correlation Graphs

x-axis = (Liquid rate (lb/hr))/(Gas rate (lb/hr))*(Gas density/Liquid density (lb/cuft))^0.5

x-axis (vol.) = 0.49

x-axis (R) = 3.46

y-axis =

Tower Dia.(ft)	G'(vol)	G'(R)	Cap. Fact.(vol.)	Cap. Fact.(R.)
8	0.67	0.09	2.48	0.35
9	0.53	0.07	1.96	0.28
10	0.43	0.06	1.58	0.22
11	0.35	0.05	1.31	0.18
12	0.30	0.04	1.10	0.16

Tower Dia.(ft)	y-axis(vol)	y-axis(R)
8	2.95	0.06
9	1.84	0.04
10	1.21	0.02
11	0.83	0.02
12	0.58	0.01

GENCORP AEROJET
ENVIRONMENTAL OPERATIONS
DEPARTMENT 0930
BUILDING 20-019
13-Apr-96
ARGET EE/CA AIR EMISSIONS RATE INFORMATION

SCENARIO (BASELINE=UNCONTROLLED):	VARIABLES	NOTES:
• INFLUENT FLOW RATE = (gallons per minute)	3445	
VOLUMETRIC FLOW RATE (CUBIC FEET AIR/CUBIC FEET WATER)	60	
• STRIPPING TOWER AIR FLOW RATE =(cubic feet per minute)	27634	
• AIR TEMPERATURE	65°F	
• AIR RELATIVE HUMIDITY	95%	
• REQUIRED AIR EMISSION CONTROL EFFICIENCY	0%	

CONTAMINANT	MOLECULAR WEIGHT	INFLUENT CONC (LIQUID) (ppb)	AIR CONC (lb/hr)	AIR CONC (mg / cubic meter)	AIR CONC (ppbv (Volume))	
1,1-DICHLOROETHYLENE	96.94	19.7	0.034	0.328	0.083	
1,1-DICHLOROETHANE	98.96	0.8	0.001	0.013	0.003	
C/T 1,2-DICHLOROETHYLENE	96.94	42.8	0.074	0.713	0.180	
CHLOROFORM	119.40	1.7	0.003	0.028	0.006	
FREON 113	187.40	23.3	0.040	0.388	0.051	
1,2-DICHLOROETHANE	98.98	0.5	0.001	0.008	0.002	
1,1,1-TRICHLOROETHANE	133.40	0.3	0.001	0.005	0.001	
CARBON TETRACHLORIDE	153.80	0.1	0.000	0.002	0.000	
TRICHLOROETHYLENE	131.40	514.1	0.887	8.566	1.595	
TETRACHLOROETHYLENE	165.80	3.9	0.007	0.065	0.010	
TOTALS:		607.2	1.047	10.118	1.931	

CALCULATIONS

GROUNDWATER TREATMENT

ALTERNATIVE 2

(section 4.4.2)

START-UP CHEMICAL

CONCENTRATIONS

	A	B	C	D	E	F	G	H	I	J	K
1	American River Study Area										
2	EE/CA II										
3	Flow Weighted Influent VOC Concentration-Start-up										
4	North and South Side Extraction Wells										
5	6-May-96										
6											Flow Weighted
7								North		Total	Influent
8								Wells		Flow	Conc.
9	Well Number	4325	4330	4335	4370*	4375*	4380*				
10											
11	Flow Rate(gpm)	260	310	215	325	200	105	2030		3445	
12											
13											
14											
15	Chemical Constituent										
16	1,4-Dioxane	11.00	15.00	*10.00*	0.00	0.00	0.00	*0.00*			2.80
17	1,1-Dichloroethylene	30.30	74.80	12.00	0.25	0.25	0.25	0.25			9.96
18	1,1-Dichloroethane	1.50	5.90	1.80	0.00	0.00	0.00	0.00			0.76
19	cis/tran 1,2-Dichloroethylene	19.00	98.50	42.80	0.25	0.25	0.25	0.64			13.39
20	Chloroform	2.50	9.90	8.00	0.00	0.00	0.00	0.00			1.58
21	Freon 113	5.60	31.80	18.80	0.25	0.25	0.25	0.25			4.65
22	1,2-Dichloroethane	0.00	1.00	6.40	0.00	0.00	0.00	0.00			0.49
23	1,1,1-Trichloroethane	1.40	1.90	0.00	0.00	0.00	0.00	0.00			0.28
24	Carbon Tetrachloride	0.00	0.70	0.00	0.00	0.00	0.00	0.00			0.06
25	Trichloroethylene	287.50	1575.00	1005.00	1.80	14.00	0.25	38.38			249.75
26	Tetrachloroethylene	10.30	25.00	9.30	0.25	0.25	0.25	0.34			3.65
27											
28	Total VOC Conc.	358.10	1824.50	1104.10	2.80	15.00	1.25	39.86			284.57
29											
30	* VOC concentrations in wells 4370, 4375 and 4380 based on October-December 1995										
31	monitoring report										

GENCORP AEROJET
ENVIRONMENTAL OPERATIONS
DEPARTMENT 0330
BUILDING 20-019
7-May-96
ARGET EE/CA AIR EMISSIONS RATE INFORMATION

SCENARIO (BASELINE=UNCONTROLLED):	VARIABLES	NOTES:
• INFLUENT FLOW RATE = (gallons per minute)	3445	
VOLUMETRIC FLOW RATE (CUBIC FEET AIR/CUBIC FEET WATER)	60	
• STRIPPING TOWER AIR FLOW RATE =(cubic feet per minute)	27634	
• AIR TEMPERATURE	65°F	
• AIR RELATIVE HUMIDITY	95%	
• REQUIRED AIR EMISSION CONTROL EFFICIENCY	0%	

CONTAMINANT	MOLECULAR WEIGHT	INFLUENT CONC.(LIQUID) (ppb)	AIR CONC. (lbs. / hour)	AIR CONC. (mg / cubic meter)	AIR CONC. (ppm (volume))	
1,1-DICHLOROETHYLENE	96.94	9.96	0.017	0.166	0.042	
1,1-DICHLOROETHANE	98.96	0.76	0.001	0.013	0.003	
C/T 1,2-DICHLOROETHYLENE	96.94	13.39	0.023	0.223	0.056	
CHLOROFORM	119.40	1.58	0.003	0.026	0.005	
FREON 113	187.40	4.65	0.008	0.077	0.010	
1,2-DICHLOROETHANE	98.98	0.49	0.001	0.008	0.002	
1,1,1-TRICHLOROETHANE	133.40	0.28	0.000	0.005	0.001	
CARBON TETRACHLORIDE	153.80	0.06	0.000	0.001	0.000	
TRICHLOROETHYLENE	131.40	249.75	0.431	4.162	0.775	
TETRACHLOROETHYLENE	165.80	3.65	0.006	0.061	0.009	
TOTALS:		284.57	0.491	4.742	0.904	

CALCULATIONS

OPERATION AND MAINTENANCE ESTIMATE

GROUNDWATER PUMPING AND CONVEYANCE COSTS

	A	B	C	D	E	F	G	H
1	ARGET							
2	ESTIMATED PUMPING COST							
3	EE/CA III							
4	5/24/96							
5					DISCHARGE			
6		TOP	PUMPING	FLOW RATE	PRESSURE	TOTAL	PUMP INPUT	ELECTRICAL
7	WELLS	(DEPTH)	LIFT(FT)	(GPM)	(FT)	LIFT(FT)	HP	AMPERAGE
8								
9	4300	44	39	300	115	154	15.6	19.1
10	4301	108	103	220	115	218	16.2	19.8
11	4302	160	155	35	115	270	3.2	3.9
12	4325	68	63	260	115	178	15.6	19.1
13	4330	95	90	310	115	205	21.4	26.2
14	4335	163	158	215	115	273	19.8	24.2
15	4340	60	55	65	115	170	3.7	4.6
16	4345	98	93	400	115	208	28.0	34.3
17	4350	143	138	100	115	253	8.5	10.4
18	4355	42	37	400	115	152	20.5	25.1
19	4360	92	87	450	115	202	30.6	37.5
20	4365	126	121	60	115	236	4.8	5.8
21	4370	67	62	325	115	177	19.4	23.7
22	4375	102	97	200	115	212	14.3	17.5
23	4380	164	159	105	115	274	9.7	11.9
24								
25	TOTAL			3445			231.2	283.0

	I	J	K	L	M
1					
2					
3					
4					
5					
6		OPERATING			OPERATING
7	KW	HRS/YR	KWHR/YR	COST/KWHR	COST($)/YR
8					
9	12.9	8500	109559	0.08	8765
10	13.4	8500	113732	0.08	9099
11	2.6	8500	22410	0.08	1793
12	12.9	8500	109748	0.08	8780
13	17.7	8500	150702	0.08	12056
14	16.4	8500	139189	0.08	11135
15	3.1	8500	26204	0.08	2096
16	23.2	8500	197300	0.08	15784
17	7.1	8500	59996	0.08	4800
18	17.0	8500	144181	0.08	11534
19	25.4	8500	215560	0.08	17245
20	4.0	8500	33579	0.08	2686
21	16.0	8500	136415	0.08	10913
22	11.8	8500	100547	0.08	8044
23	8.0	8500	68225	0.08	5458
24					
25	191.5		1627348		130188

GROUNDWATER TREATMENT ALTERNATIVES

BASIS FOR PRELIMINARY DESIGN ASSUMPTIONS

WORST CASE CHEMICAL CONCENTRATIONS

	A	B	C	D	E	F	G	H	I	J	K
1	American River Study Area										
2	EE/CA II										
3	Flow Weighted Influent VOC Concentration										
4	North and South Side Extraction Wells										
5	11-Apr-96										
6											
7											
8											Flow Weighted
9	Well Number	4325	4330	4335	4370*	4375*	4380*	North Wells		Total Flow	Influent Conc.
10											
11	Flow Rate(gpm)	260	310	215	325	200	105	2030		3445	
12											
13											
14											
15	Chemical Constituent										
16	1,4-Dioxane	11	15	*10*	1.1	1.5	1.0	*6*			6.0
17	1,1-Dichloroethylene	30.3	74.8	12.0	3.0	7.5	1.2	15.5			19.7
18	1,1-Dichloroethane	1.5	5.9	1.8	0.2	0.6	0.2	0.0			0.8
19	cis/tran 1,2-Dichloroethylene	19.0	98.5	42.8	1.9	9.9	4.3	49.2			42.8
20	Chloroform	2.5	9.9	8.0	0.3	1.0	0.8	0.0			1.7
21	Freon 113	5.6	31.8	18.8	0.6	3.2	1.9	31.5			23.3
22	1,2-Dichloroethane	0.0	1.0	6.4	0.0	0.1	0.6	0.0			0.5
23	1,1,1-Trichloroethane	1.4	1.9	0.0	0.1	0.2	0.0	0.0			0.3
24	Carbon Tetrachloride	0.0	0.7	0.0	0.0	0.1	0.0	0.0			0.1
25	Trichloroethylene	287.5	1575.0	1005.0	28.8	157.5	100.5	463.3			514.1
26	Tetrachloroethylene	10.3	25.0	9.3	1.0	2.5	0.9	12.6			3.9
27											
28	Total VOC Conc.	358.1	1824.5	1104.1	35.8	182.5	110.4	572.1			607.1
29											
30	* VOC concentrations in wells 4370, 4375 and 4380 assumed to be 10% of the concentrations present										
31	in wells 4325, 4330 and 4335. Italized values are estimated.										

	A	B	C	D	E	F	G	H	I	J	K	L
1	American River Study Area											
2	EE/CA II											
3	Flow Weighted Influent VOC Concentration											
4	North Side Extraction Wells											
5	Worst Case Assumptions*											
6	11-Apr-96											
7												
8												
9	Well Number	4300	4301	4302	4340	4345	4350	4355	4360	4365	Total	Flow Weighted
10		upper	middle	lower	upper	middle	lower	upper	middle	lower	Flow	Influent
11	Flow Rate(gpm)	300	220	35	65	400	100	400	450	60	2030	Conc.
12												
13	Chemical Constituent											
14												
15	1,4 Dioxane	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0
16	1,1-Dichloroethylene(2.7%)	1.8	25.0	16.7	1.8	25.0	16.7	1.8	25.0	16.7		15.5
17	1,1-Dichloroethane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
18	1,2-Dichloroethylene(8.6%)	5.6	79.6	53.1	5.6	79.6	53.1	5.6	79.6	53.1		49.2
19	Chloroform	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
20	Freon 113(5.5%)	3.6	50.9	34.0	3.6	50.9	34.0	3.6	50.9	34.0		31.5
21	1,2-Dichloroethane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
22	1,1,1-Trichloroethane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
23	Carbon Tetrachloride	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
24	Trichloroethylene(81%)	53.0	750.0	500.0	53.0	750.0	500.0	53.0	750.0	500.0		463.3
25	Tetrachloroethylene(2.2%)	1.4	20.4	13.6	1.4	20.4	13.6	1.4	20.4	13.6		12.6
26												
27	Total VOC Conc.	65.4	925.9	617.4	65.4	925.9	617.4	65.4	925.9	617.4		572.0
28												
29	* based on an average of each VOC percentage to total VOCs presented in Table 1-NARGET preliminary facilities plan and											
30	maximum flow rates presented in table 2 combined with maximum TCE values presented in table1(predicted concs. - NARGET)											
31	1,4-Dioxane values based on 1/2 the method PQL.											

Table 1

Predicted Concentrations for North American River GET

01/29/96

Well Number	Flow Rate (gpm)	TCE (ug/l)	Comments	Concentration at Startup		Predicted Highest Concentration		
				Percent of Total Flow	Weighted TCE (ug/l)	TCE (estim.) (ug/l)*	Percent of Total Flow	Weighted TCE (ug/l)
4300, -1, -2	455	120	Combined flow	N/A	N/A	N/A	N/A	N/A
4300	309	6.4	Avg of 9 samples	16.1%	1.0	53	16.1%	8.6
4301	218	251	Avg of 10 samples	11.4%	28.6	750	11.4%	85.4
4302	35	98.1	Avg of 15 samples	1.8%	1.8	500	1.8%	9.1
4340	25	1	1 sample (<1)	1.3%	0.0	53	1.3%	0.7
4345	388	6.1	1 sample	20.3%	1.2	750	20.3%	151.9
4350	62	13	1 sample	3.2%	0.4	500	3.2%	16.1
4355	388	1	1 sample (<1)	20.2%	0.2	53	20.2%	10.7
4360	434	1.6	1 sample	22.7%	0.4	750	22.7%	170.0
4365	57	3.1	1 sample	3.0%	0.1	500	3.0%	14.8
Total:	***1,915***			***Total:***	***33.7***		***Total:***	***467.3***

*Based on avg concentrations from 1/93 to 5/95 for wells 1478, estimate, and 1479 respectively. No middle aquifer completion at 1478-60; 750 ug/l estimated

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
7-Jan-96

Well Number:	4325	4325	4325	4325		4325	4325	4325
Flow Rate (gpm):	260	260	260	260		260	260	260
Date:	8/29/95	8/29/95	8/29/95	8/29/95		Average	VOC	VOC
Time:	15:02:00	15:02:00	15:02:00	8:20:00		Conc.	Mass	Mass
Sample Identification	317703	317704	317705	317706			Flow Rate	Flow Rate
Analytical Method	601	601	601	601			(Lbs./Day)	(Grams/Sec.)
Chemical Constituent:								
1,1-Dichloroethylene	30	31	30	30		30.3	0.094	0.000496
1,1-Dichloroethane	1.5	1.5	1.4	1.4		1.5	0.005	0.000024
cis/trans 1,2-Dichloroethylene	19	20	19	18		19.0	0.059	0.000312
Chloroform	2.5	2.6	2.5	2.5		2.5	0.008	0.000041
Freon 113	5.6	5.6	5.7	5.5		5.6	0.017	0.000092
1,1,1-Trichloroethane	1.4	1.4	1.4	1.5		1.4	0.004	0.000023
Trichloroethylene	290	290	290	280		287.5	0.897	0.004715
Tetrachloroethylene	10	11	10	10		10.3	0.032	0.000168
TOTAL:						358.0	1.117	0.005872

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
7-Jan-96

Well Number:	4330	4330	4330	4330		4330	4330	4330
Flow Rate (gpm):	310	310	310	310		310	310	310
Date:	8/29/95	8/29/95	8/29/95	8/29/95		Average	VOC	VOC
Time:	15:05:00	15:05:00	8:10:00	15:05:00		Conc.	Mass	Mass
Sample Identification	317671	317672	317673	317674			Flow Rate	Flow Rate
Analytical Method	601	601	601	601			(Lbs./Day)	(Grams/Sec.)
Chemical Constituent:								
1,1-Dichloroethylene	82	85	51	81		74.8	0.278	0.001462
1,1-Dichloroethane	5.9	6.2	5.4	5.9		5.9	0.022	0.000114
cis/trans 1,2-Dichloroethylene	100	100	94	100		98.5	0.367	0.001926
Chloroform	10	9.9	9.6	10		9.9	0.037	0.000193
Freon 113	31	32	33	31		31.8	0.118	0.000621
1,2-Dichloroethane	1.3	1.4	0	1.4		1.0	0.004	0.000020
1,1,1-Trichloroethane	2.5	2.5	0	2.6		1.9	0.007	0.000037
Carbon Tetrachloride	0.91	0.95	0	0.94		0.7	0.003	0.000014
Trichloroethylene	1600	1600	1500	1600		1575.0	5.862	0.030800
Tetrachloroethylene	25	27	22	26		25.0	0.093	0.000489
TOTAL:						1824.4	6.790	0.035677

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
7-Jan-96

Well Number:	4335	4335	4335	4335		4335	4335	4335
Flow Rate (gpm):	215	215	215	215		215	215	215
Date:	8/22/95	8/22/95	8/22/95	8/22/95		Average	VOC	VOC
Time:	15:00:00	15:02:00	15:02:00	8:25:00		Conc.	Mass	Mass
Sample Identification	317679	317680	317681	317682			Flow Rate	Flow Rate
Analytical Method	601	601	601	601			(Lbs./Day)	(Grams/Sec.)
Chemical Constituent:								
1,1-Dichloroethylene	0	0	0	48		12.0	0.031	0.000163
1,1-Dichloroethane	0	0	0	7.2		1.8	0.005	0.000024
cis/trans 1,2-Dichloroethylene	40	41	40	50		42.8	0.110	0.000580
Chloroform	7.6	7.6	7.3	9.5		8.0	0.021	0.000109
Freon 113	21	18	18	18		18.8	0.048	0.000254
1,2-Dichloroethane	6.3	6.3	6.1	6.9		6.4	0.017	0.000087
1,1,1-Trichloroethane	0	0	0	0		0.0	0.000	0.000000
Trichloroethylene	980	980	960	1100		1005.0	2.594	0.013631
Tetrachloroethylene	9.6	9.1	9.3	9.1		9.3	0.024	0.000126
TOTAL:						1104.0	2.850	0.014973

GROUNDWATER TREATMENT

ALTERNATIVES

BASIS FOR PRELIMINARY DESIGN

ASSUMPTIONS

START-UP

CHEMICAL CONCENTRATIONS

	A	B	C	D	E	F	G	H	I	J	K
1	American River Study Area										
2	EE/CA II										
3	Flow Weighted Influent VOC Concentration-Start-up										
4	North and South Side Extraction Wells										
5	6-May-96										
6											
7											Flow Weighted
8								North		Total	Influent
9	Well Number	4325	4330	4335	4370*	4375*	4380*	Wells		Flow	Conc.
10											
11	Flow Rate(gpm)	260	310	215	325	200	105	2030		3445	
12											
13											
14											
15	Chemical Constituent										
16	1,4-Dioxane	11.00	15.00	*10.00*	0.00	0.00	0.00	*0.00*			2.80
17	1,1-Dichloroethylene	30.30	74.80	12.00	0.25	0.25	0.25	0.25			9.96
18	1,1-Dichloroethane	1.50	5.90	1.80	0.00	0.00	0.00	0.00			0.76
19	cis/tran 1,2-Dichloroethylene	19.00	98.50	42.80	0.25	0.25	0.25	0.64			13.39
20	Chloroform	2.50	9.90	8.00	0.00	0.00	0.00	0.00			1.58
21	Freon 113	5.60	31.80	18.80	0.25	0.25	0.25	0.25			4.65
22	1,2-Dichloroethane	0.00	1.00	6.40	0.00	0.00	0.00	0.00			0.49
23	1,1,1-Trichloroethane	1.40	1.90	0.00	0.00	0.00	0.00	0.00			0.28
24	Carbon Tetrachloride	0.00	0.70	0.00	0.00	0.00	0.00	0.00			0.06
25	Trichloroethylene	287.50	1575.00	1005.00	1.80	14.00	0.25	38.38			249.75
26	Tetrachloroethylene	10.30	25.00	9.30	0.25	0.25	0.25	0.34			3.65
27											
28	Total VOC Conc.	358.10	1824.50	1104.10	2.80	15.00	1.25	39.86			284.57
29											
30	* VOC concentrations in wells 4370, 4375 and 4380 based on October-December 1995										
31	monitoring report										

	A	B	C	D	E	F	G	H	I	J	K	L
1	American River Study Area											
2	EE/CA II											
3	Flow Weighted Influent VOC Concentration											
4	North Side Extraction Wells											
5	Start-up Concentrations											
6	6-May-96											
7												
8												
9	Well Number	4300	4301	4302	4340	4345	4350	4355	4360	4365	Total	Flow Weighted
10		upper	middle	lower	upper	middle	lower	upper	middle	lower	Flow	Influent
11	Flow Rate(gpm)	300	220	35	65	400	100	400	450	60	2030	Conc.
12												
13	Chemical Constituent											
14												
15	1,4 Dioxane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
16	1,1-Dichloroethylene(2.7%)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25		0.25
17	1,1-Dichloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
18	1,2-Dichloroethylene(8.6%)	0.25	3.80	0.67	0.25	0.25	0.25	0.25	0.25	0.25		0.64
19	Chloroform	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
20	Freon 113(5.5%)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25		0.25
21	1,2-Dichloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
22	1,1,1-Trichloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
23	Carbon Tetrachloride	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
24	Trichloroethylene(81%)	2.50	160.00	40.00	0.70	26.00	21.00	5.00	51.00	51.00		38.38
25	Tetrachloroethylene(2.2%)	0.25	1.10	0.25	0.25	0.25	0.25	0.25	0.25	0.25		0.34
26												
27	Total VOC Conc.	3.50	165.40	41.42	1.70	27.00	22.00	6.00	52.00	52.00		39.86
28												
29	* based on an monitoring wells information for the period October - December 1995											
30	maximum flow rates presented in table 2											
31	1,4-Dioxane assumed to be absent											

Water Quality Information

Metals, Minerals,

COD, TDS, pH & Conductivity

Summary of Data

from

Extraction Wells

4225, 4230,4235, 4370, 4375 & 4380

American River Study Area
EE/CA II
Ground Water Quality Summary
South Side Extraction Wells
25-Aug-96

Well Number:	4225	4330	4335	4370	4375	4380			
Flow Rate (gpm):	260	310	215	325	200	105		1415	
Chemical Constituent:								Avg. Conc. (ppm)	Avg. Conc. (ppb)
Perchlorate	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Mercury	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Aluminum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Arsenic	0.0000	0.0031	0.0000	0.0000	0.0000	0.0000		0.0007	0.671849
Barium	0.1700	0.1400	0.1000	0.0210	0.0403	0.0520		0.0915	91.48528
Beryllium	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Cadium	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Chromium	0.0060	0.0060	0.0000	0.0000	0.0000	0.0000		0.0024	2.430389
Copper	0.0000	0.0072	0.0000	0.0000	0.0000	0.0000		0.0016	1.577385
Iron	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Lead	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Nickel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Selenium	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Silver	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Thallium	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Zinc	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Antimony	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Boron	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Cobalt	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Molybdenum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Vanadium	0.0081	0.0089	0.0113	0.0080	0.0074	0.0091		0.0087	8.724735
Manganese	0.0038	0.0000	0.0000	0.0000	0.0000	0.0042		0.0010	1.003769
Calcium	69.3333	62.6667	48.6667	9.4000	18.0000	26.6667		40.5453	40545.35
Magnesium	28.3333	25.0000	17.0000	3.3333	6.3333	9.4000		15.6245	15624.5
Sodium	64.0000	18.0000	16.0000	6.2000	10.0000	13.0000		21.9364	21936.4
Potassium	3.9333	4.7000	5.6667	2.1667	3.0000	3.9000		3.8245	3824.499
Chloride	130.0000	51.6667	16.6667	3.6333	8.9000	7.5667		40.3925	40392.46
Sulfate	20.3333	20.0000	15.0000	3.6667	5.7000	8.2000		12.6532	12653.24

American River Study Area
EE/CA II
Ground Water Quality Summary
South Side Extraction Wells
25-Aug-96

Well Number:	4225	4330	4335	4370	4375	4380			
Flow Rate (gpm):	260	310	215	325	200	105		1415	
Chemical Constituent:								Avg. Conc. (ppm)	Avg. Conc. (ppb)
Phosphate	0.4233	0.3367	1.7333	0.5067	0.4000	0.2767		0.6084	608.351
Nitrite	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
Nitrate	21.0000	13.0000	9.5333	1.2000	2.5000	6.0333		9.2319	9231.92
Sulfite	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
COD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0
TDS	490.0000	356.6667	270.0000	83.3333	120.0000	190.0000		259.3993	259399.3
pH	7.0667	7.4667	7.6667	7.7000	7.9333	8.1000		7.5901	
Hardness	200.0000	240.0000	173.3333	41.6667	74.3333	110.0000		143.9046	
Conductance	773.3333	536.6667	386.6667	101.6667	186.6667	240.0000		385.9658	

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
25-Aug-96

Well Number:	4225	4225	4225		4225
Flow Rate (gpm):	260	260	260		260
Date:	8/29/95	8/29/95	8/29/95		Average
Time:	15:02:00	15:02:00	15:02:00		Conc.
Sample Identification	317708	317709	317710		
Chemical Constituent:					
Perchlorate	<0.40	<0.40	<0.40		0.0000
Mercury	<0.0002	<0.0002	<0.0002		0.0000
Aluminum	<0.16	<0.16	<0.16		0.0000
Arsenic	<0.088	<0.088	<0.088		0.0000
Barium	0.17	0.17	0.17		0.1700
Beryllium	<0.0011	<0.0011	<0.0011		0.0000
Cadium	<0.0044	<0.0044	<0.0044		0.0000
Chromium	<0.0088	0.0093	<0.0088		0.0060
Copper	<0.0066	<0.0066	<0.0066		0.0000
Iron	<0.33	<0.33	<0.33		0.0000
Lead	<0.066	<0.066	<0.066		0.0000
Nickel	<0.022	<0.022	<0.022		0.0000
Selenium	<0.11	<0.11	<0.11		0.0000
Silver	<0.022	<0.022	<0.022		0.0000
Thallium	<0.055	<0.055	<0.055		0.0000
Zinc	<0.11	<0.11	<0.11		0.0000
Antimony	<0.44	<0.44	<0.44		0.0000
Boron	<0.044	<0.044	<0.044		0.0000
Cobalt	<0.0088	<0.0088	<0.0088		0.0000
Molybdenum	<0.044	<0.044	<0.044		0.0000
Vanadium	0.0074	0.0092	0.0076		0.0081
Manganese	<0.0055	0.0058	<0.0055		0.0038
Calcium	70	69	69		69.3333
Magnesium	28	28	29		28.3333
Sodium	63	64	65		64.0000
Potasium	3.7	4	4.1		3.9333
Chloride	140	140	110		130.0000
Sulfate	20	20	21		20.3333

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
7-Jan-96

Well Number:	4225	4225	4225		4225
Flow Rate (gpm):	260	260	260		260
Date:	8/29/95	8/29/95	8/29/95		Average
Time:	15:02:00	15:02:00	15:02:00		Conc.
Sample Identification	317708	317709	317710		
Chemical Constituent:					
Phosphate	0.4	0.46	0.41		0.4233
Nitrite	<0.25	<0.25	<0.25		0.0000
Nitrate	21	21	21		21.0000
Sulfite	<10	<10	<10		0.0000
COD	<0.3	<0.3	<0.3		0.0000
TDS	490	490	490		490.0000
pH	7	7.1	7.1		7.0667
Hardness	240	240	240		240.0000
Conductance	780	770	770		773.3333

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
25-Aug-96

Well Number:	4330	4330	4330		4330
Flow Rate (gpm):	310	310	310		310
Date:	8/24/95	8/24/95	8/24/95		Average
Time:	15:05:00	15:05:00	15:05:00		Conc.
Sample Identification	317675	317676	317677		
Chemical Constituent:					
Perchlorate	<0.40	<0.40	<0.40		0.0000
Mercury	<0.0002	<0.0002	<0.0002		0.0000
Aluminum	<0.16	<0.16	<0.16		0.0000
Arsenic	0.0092	<0.088	<0.088		0.0031
Barium	0.14	0.14	0.14		0.1400
Beryllium	<0.0011	<0.0011	<0.0011		0.0000
Cadium	<0.0044	<0.0044	<0.0044		0.0000
Chromium	<0.0088	0.0093	<0.0088		0.0060
Copper	<0.0066	<0.0066	0.015		0.0072
Iron	<0.33	<0.33	<0.33		0.0000
Lead	<0.066	<0.066	<0.066		0.0000
Nickel	<0.022	<0.022	<0.022		0.0000
Selenium	<0.11	<0.11	<0.11		0.0000
Silver	<0.022	<0.022	<0.022		0.0000
Thallium	<0.055	<0.055	<0.055		0.0000
Zinc	<0.11	<0.11	<0.11		0.0000
Antimony	<0.44	<0.44	<0.44		0.0000
Boron	<0.044	<0.044	<0.044		0.0000
Cobalt	<0.0088	<0.0088	<0.0088		0.0000
Molybdenum	<0.044	<0.044	<0.044		0.0089
Vanadium	0.0092	0.009	0.0086		0.0000
Manganese	<0.0055	<0.0055	<0.0055		62.6667
Calcium	63	62	63		25.0000
Magnesium	25	25	25		18.0000
Sodium	18	18	18		4.7000
Potasium	4.9	4.5	4.7		51.6667
Chloride	51	52	52		20.0000
Sulfate	20	20	20		

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
7-Jan-96

Well Number:	4330	4330	4330		4330
Flow Rate (gpm):	310	310	310		310
Date:	8/29/95	8/29/95	8/29/95		Average
Time:	15:02:00	15:02:00	15:02:00		Conc.
Sample Identification	317708	317709	317710		
Chemical Constituent:					
Phosphate	0.36	0.33	0.32		0.3367
Nitrite	<0.15	<0.15	<0.15		0.0000
Nitrate	13	13	13		13.0000
Sulfite	<10	<10	<10		0.0000
COD	<0.3	<0.3	<0.3		0.0000
TDS	350	360	360		356.6667
pH	7.4	7.5	7.5		7.4667
Hardness	200	200	200		200.0000
Conductance	550	530	530		536.6667

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
25-Aug-96

Well Number:	4335	4335	4335		4335
Flow Rate (gpm):	215	215	215		215
Date:	8/22/95	8/22/95	8/22/95		Average
Time:	15:00:00	15:00:00	15:00:00		Conc.
Sample Identification	317683	317684	317685		
Chemical Constituent:					
Perchlorate	<0.40	<0.40	<0.40		0.0000
Mercury	<0.0002	<0.0002	<0.0002		0.0000
Aluminum	<0.16	<0.16	<0.16		0.0000
Arsenic	<0.088	<0.088	<0.088		0.0000
Barium	0.1	0.1	0.1		0.1000
Beryllium	<0.0011	<0.0011	<0.0011		0.0000
Cadium	<0.0044	<0.0044	<0.0044		0.0000
Chromium	<0.0088	<0.0088	<0.0088		0.0000
Copper	<0.0066	<0.0066	<0.0066		0.0000
Iron	<0.33	<0.33	<0.33		0.0000
Lead	<0.066	<0.066	<0.066		0.0000
Nickel	<0.022	<0.022	<0.022		0.0000
Selenium	<0.11	<0.11	<0.11		0.0000
Silver	<0.022	<0.022	<0.022		0.0000
Thallium	<0.055	<0.055	<0.055		0.0000
Zinc	<0.11	<0.11	<0.11		0.0000
Antimony	<0.44	<0.44	<0.44		0.0000
Boron	<0.044	<0.044	<0.044		0.0000
Cobalt	<0.0088	<0.0088	<0.0088		0.0000
Molybdenum	<0.044	<0.044	<0.044		0.0000
Vanadium	0.011	0.011	0.012		0.0113
Manganese	<0.0055	<0.0055	<0.0055		0.0000
Calcium	48	49	49		48.6667
Magnesium	17	17	17		17.0000
Sodium	16	16	16		16.0000
Potasium	6	5.4	5.6		5.6667
Chloride	17	16	17		16.6667
Sulfate	15	15	15		15.0000

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
7-Jan-96

Well Number:	4335	4335	4335		4335
Flow Rate (gpm):	215	215	215		215
Date:	8/22/95	8/22/95	8/22/95		Average
Time:	15:00:00	15:00:00	15:00:00		Conc.
Sample Identification	317683	317684	317685		
Chemical Constituent:					
Phosphate	1.7	1.7	1.8		1.7333
Nitrite	<0.05	<0.05	<0.05		0.0000
Nitrate	9.6	9.5	9.5		9.5333
Sulfite	<10	<10	<10		0.0000
COD	<0.3	<0.3	<0.3		0.0000
TDS	270	270	270		270.0000
pH	8	7.5	7.5		7.6667
Hardness	180	170	170		173.3333
Conductance	400	380	380		386.6667

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
25-Aug-96

Well Number:	4370	4370	4370		4370
Flow Rate (gpm):	325	325	325		325
Date:	8/4/95	8/4/95	8/4/95		Average
Time:	14:17:00	14:17:00	14:17:00		Conc.
Sample Identification	317691	317692	317694		
Chemical Constituent:					
Perchlorate	<0.40	<0.40	<0.40		0.0000
Mercury	<0.0002	<0.0002	<0.0002		0.0000
Aluminum	<0.22	<0.22	<0.22		0.0000
Arsenic	<0.089	<0.089	<0.089		0.0000
Barium	0.021	0.021	0.021		0.0210
Beryllium	<0.0011	<0.0011	<0.0011		0.0000
Cadium	<0.0044	<0.0044	<0.0044		0.0000
Chromium	<0.0089	<0.0089	<0.0089		0.0000
Copper	<0.0067	<0.0067	<0.0067		0.0000
Iron	<0.33	<0.33	<0.33		0.0000
Lead	<0.067	<0.067	<0.067		0.0000
Nickel	<0.022	<0.022	<0.022		0.0000
Selenium	<0.11	<0.11	<0.11		0.0000
Silver	<0.022	<0.022	<0.022		0.0000
Thallium	<0.056	<0.056	<0.056		0.0000
Zinc	<0.11	<0.11	<0.11		0.0000
Antimony	<0.44	<0.44	<0.44		0.0000
Boron	<0.044	<0.044	<0.044		0.0000
Cobalt	<0.0089	<0.0089	<0.0089		0.0000
Molybdenum	<0.044	<0.044	<0.044		0.0000
Vanadium	0.0083	0.008	0.0077		0.0080
Manganese	<0.0056	<0.0056	<0.0056		0.0000
Calcium	9.5	9.4	9.3		9.4000
Magnesium	3.3	3.4	3.3		3.3333
Sodium	6.1	6.3	6.2		6.2000
Potassium	2.1	2.3	2.1		2.1667
Chloride	3.4	3.8	3.7		3.6333
Sulfate	3.6	3.7	3.7		3.6667

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
25-Aug-96

Well Number:	4370	4370	4370		4370
Flow Rate (gpm):	325	325	325		325
Date:	8/4/95	8/4/95	8/4/95		Average
Time:	14:17:00	14:17:00	14:17:00		Conc.
Sample Identification	317691	317692	317694		
Chemical Constituent:					
Phosphate	0.51	0.51	0.5		0.5067
Nitrite	<0.05	<0.05	<0.05		0.0000
Nitrate	1.2	1.2	1.2		1.2000
Sulfite	<10	<10	<10		0.0000
COD	<0.3	<0.3	<0.3		0.0000
TDS	83	83	84		83.3333
pH	7.7	7.7	7.7		7.7000
Hardness	42	41	42		41.6667
Conductance	97	110	98		101.6667

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
25-Aug-96

Well Number:	4375	4375	4375		4375
Flow Rate (gpm):	200	200	200		200
Date:	8/2/95	8/2/95	8/2/95		Average
Time:	15:26:00	15:26:00	15:26:00		Conc.
Sample Identification	317699	3177700	317702		
Chemical Constituent:					
Perchlorate	<0.40	<0.40	<0.40		0.0000
Mercury	<0.0002	<0.0002	<0.0002		0.0000
Aluminum	<0.22	<0.22	<0.22		0.0000
Arsenic	<0.089	<0.089	<0.089		0.0000
Barium	0.04	0.04	0.041		0.0403
Beryllium	<0.0011	<0.0011	<0.0011		0.0000
Cadium	<0.0044	<0.0044	<0.0044		0.0000
Chromium	<0.0089	<0.0089	<0.0089		0.0000
Copper	<0.0067	<0.0067	<0.0067		0.0000
Iron	<0.33	<0.33	<0.33		0.0000
Lead	<0.067	<0.067	<0.067		0.0000
Nickel	<0.022	<0.022	<0.022		0.0000
Selenium	<0.11	<0.11	<0.11		0.0000
Silver	<0.022	<0.022	<0.022		0.0000
Thallium	<0.056	<0.056	<0.056		0.0000
Zinc	<0.11	<0.11	<0.11		0.0000
Antimony	<0.44	<0.44	<0.44		0.0000
Boron	<0.044	<0.044	<0.044		0.0000
Cobalt	<0.0089	<0.0089	<0.0089		0.0000
Molybdenum	<0.044	<0.044	<0.044		0.0000
Vanadium	0.0078	0.0071	0.0074		0.0074
Manganese	<0.0056	<0.0056	<0.0056		0.0000
Calcium	18	18	18		18.0000
Magnesium	6.3	6.4	6.3		6.3333
Sodium	10	10	10		10.0000
Potassium	3.2	3	2.8		3.0000
Chloride	8.8	9.1	8.8		8.9000
Sulfate	5.7	5.7	5.7		5.7000

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
25-Aug-96

Well Number:	4375	4375	4375		4375
Flow Rate (gpm):	200	200	200		200
Date:	8/2/95	8/2/95	8/2/95		Average
Time:	15:26:00	15:26:00	15:26:00		Conc.
Sample Identification	317699	3177700	317702		
Chemical Constituent:					
Phosphate	0.4	0.39	0.41		0.4000
Nitrite	<0.05	<0.05	<0.05		0.0000
Nitrate	2.5	2.5	2.5		2.5000
Sulfite	<10	<10	<10		0.0000
COD	<0.3	<0.3	<0.3		0.0000
TDS	120	120	120		120.0000
pH	8	7.9	7.9		7.9333
Hardness	76	73	74		74.3333
Conductance	180	180	200		186.6667

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
25-Aug-96

Well Number:	4380	4380	4380		4380
Flow Rate (gpm):	105	105	105		105
Date:	7/17/95	7/17/95	7/17/95		Average
Time:	15:20:00	15:20:00	15:20:00		Conc.
Sample Identification	317715	317716	317718		
Chemical Constituent:					
Perchlorate	<0.40	<0.40	<0.40		0.0000
Mercury	<0.0002	<0.0002	<0.0002		0.0000
Aluminum	<0.22	<0.22	<0.22		0.0000
Arsenic	<0.089	<0.089	<0.089		0.0000
Barium	0.052	0.052	0.052		0.0520
Beryllium	<0.0011	<0.0011	<0.0011		0.0000
Cadium	<0.0044	<0.0044	<0.0044		0.0000
Chromium	<0.0089	<0.0089	<0.0089		0.0000
Copper	<0.0067	<0.0067	<0.0067		0.0000
Iron	<0.33	<0.33	<0.33		0.0000
Lead	<0.067	<0.067	<0.067		0.0000
Nickel	<0.022	<0.022	<0.022		0.0000
Selenium	<0.11	<0.11	<0.11		0.0000
Silver	<0.022	<0.022	<0.022		0.0000
Thallium	<0.056	<0.056	<0.056		0.0000
Zinc	<0.11	<0.11	<0.11		0.0000
Antimony	<0.44	<0.44	<0.44		0.0000
Boron	<0.044	<0.044	<0.044		0.0000
Cobalt	<0.0089	<0.0089	<0.0089		0.0000
Molybdenum	<0.044	<0.044	<0.044		0.0000
Vanadium	0.0094	0.0091	0.0088		0.0091
Manganese	<0.0056	<0.0056	0.007		0.0042
Calcium	27	26	27		26.6667
Magnesium	9.4	9.4	9.4		9.4000
Sodium	13	13	13		13.0000
Potassium	4.1	3.8	3.8		3.9000
Chloride	7.7	7.5	7.5		7.5667
Sulfate	8.2	8.2	8.2		8.2000

American River Study Area
EE/CA II
Ground Water Quality Summary
North and South Side Extraction Wells
25-Aug-96

Well Number:	4380	4380	4380		4380
Flow Rate (gpm):	105	105	105		105
Date:	7/17/95	7/17/95	7/17/95		Average
Time:	15:20:00	15:20:00	15:20:00		Conc.
Sample Identification	317715	317716	317718		
Chemical Constituent:					
Phosphate	0.29	0.28	0.26		0.2767
Nitrite	<0.05	<0.05	<0.05		0.0000
Nitrate	6.1	6	6		6.0333
Sulfite	<10	<10	<10		0.0000
COD	<0.3	<0.3	<0.3		0.0000
TDS	190	190	190		190.0000
pH	8.3	8	8		8.1000
Hardness	110	110	110		110.0000
Conductance	260	230	230		240.0000

APPENDIX K

Air Stripper Risk Assessment

RADIAN INTERNATIONAL

MEMORANDUM

To: Craig Fegan, Aerojet

From: Barbara Morrison, Radian

Date: May 8, 1996

Subject: Air Stripper Risk Assessment

INTRODUCTION

This document contains results of a health risk assessment (HRA) prepared for the proposed groundwater treatment device (air stripper). Although this source falls under CERCLA, Aerojet will comply with all applicable SMAQMD air regulations. This technical memorandum describes methodology used to determine ambient concentrations of emitted volatile organic compounds (VOCs) and presents the results of the analysis. One modeled source of VOC was considered. Modeled concentrations were estimated at offsite locations. Three operating scenarios were considered, each with a different set of VOC emission rates.

CONCLUSIONS

The residential 70-year maximum exposed individual (MEI) cancer risk is less than one in one million ($<1 \times 10^{-6}$) for all emissions scenarios. The MEI risks for each scenario are presented Table 1 below. The MEI was at Universal Transverse Mercator (UTM) coordinates of 654,300 m Easting and 4,276,800 m Northing. This point is just north of Highway 50, as shown in Figure 1. Figure 2 shows the 0.1×10^{-6} risk isopleth for all three scenarios.

Table 1. MEI Cancer Risk Results

Scenario	MEI Risk
1 (mid-range emission rates)	0.30×10^{-6}
2 (highest emission rates)	0.54×10^{-6}
3 (lowest emission rates)	0.09×10^{-6}

The MEI risk is below 0.1 in one million ($< 0.1 \times 10^{-6}$) for scenario 3 (low emissions). The chronic and acute hazard indices are well below 1.0 for all scenarios, as shown in Table 2. Therefore, per the SMAQMD *Procedure for Permit Processing* (9/9/91), the deminimus values of 0.1×10^{-6} (0.1 in one million) cancer risk or 1.0 hazard index are

not exceeded. For scenario 3, the toxics review and risk assessment portion of the process is complete.

Table 2. MEI Hazard Index Results

Scenario	Chronic Hazard Index	Acute Hazard Index
1 (mid-range emission rates)	3.21×10^{-3}	5.33×10^{-5}
2 (highest emission rates)	5.48×10^{-3}	9.11×10^{-5}
3 (lowest emission rates)	7.70×10^{-4}	2.66×10^{-5}

METHODOLOGY

The dispersion modeling methodology used to estimate ambient concentrations follows the applicable detailed guidance in the *Guideline on Air Quality Models* (Revised) (U.S. EPA, 1986). The dispersion model and model input are described below.

Dispersion Model

Terrain in the immediate vicinity of the Aerojet facility is relatively flat with gently rolling hills to the east. Approximately 3 or more kilometers to the north of the facility, the terrain rises about 30 to 60 meters above the main elevation of the facility. A majority of the surrounding population is within the flat terrain areas. Elevations of sources and receptors were determined from USGS topographic maps. The Industrial Source Complex Short-Term 2 Model (ISCST2) was used to perform the dispersion modeling. ISCST2 is a U.S. EPA-approved model for both flat and complex terrain. This model accepts actual hourly meteorological data, calculates averaging times from one hour to one year, and simulates direction-dependent aerodynamic downwash.

Recommended regulatory default options were used in the dispersion modeling as listed in the *Guideline on Air Quality Models* (U.S. EPA, 1986). The following model options were used:

- Final plume rise at all receptors;
- Stack-tip downwash;
- Buoyancy-induced dispersion;

- No calms processing;
- Default wind profile exponents;
- Default vertical potential temperature gradient; and
- Rural dispersion coefficients.

Annual average and maximum one-hour ground-level concentrations were calculated at each receptor. Concentrations were estimated at points outside of the facility boundary. Dispersion model output files for the 1987 cancer risk model run are included in Attachment A.

Emission Sources

Figure 1 shows the proposed air stripper location along with the facility property line. UTM coordinates are also shown. Table 3 presents the stack parameters for the modeled point source. Stack parameters were obtained from Aerojet. Emission rates of VOCs for the three scenarios are shown in Table 4. Since the reactive organic compound (ROC) emissions for scenario 3 (low emissions) are less than the level specified in Rule 202, Section 301.1 (10 lb/day), BACT is not necessary. However, ROC emissions for both scenarios 1 and 2 exceed 10 lb/day and would require BACT.

Table 3. Modeled Stack Parameters

UTM E (m)	UTM N (m)	Elevation (m)	Height (m)	Velocity (m/s)	Diameter (m)	Temperature (F)
654,291	4,275,412	47.4	13.4	12.7	1.14	292

Receptor Grids

Concentrations at offsite locations were determined with a coarse grid of receptors. This grid, as shown in Figure 3, has receptors spaced 500 to 1000 meters apart extending at least four kilometers from the facility. This grid was used to identify the initial points of maximum short-term (i.e., 1-hour) and long-term (i.e., annual average) concentrations. A fine grid having a 100-meter spacing and surrounding the initial points of maximum impact was then used to define the point of highest exposure. Figure 3 shows the location of the coarse and fine receptor grids. Receptors located on the property boundary, Folsom Blvd., or U.S. Highway 50 were considered to be occupational, rather than residential, receptors.

Table 4. VOC Emission Rates

Contaminant	Maximum Estimated Emissions (lb/day)		
	Scenario 1	Scenario 2	Scenario 3
Carbon Tetrachloride	4.14×10^{-3}	4.14×10^{-3}	4.14×10^{-3}
Chloroform	5.38×10^{-2}	7.03×10^{-2}	5.79×10^{-2}
1,1-Dichloroethane	2.07×10^{-2}	3.31×10^{-2}	2.07×10^{-2}
1,1-Dichloroethylene	4.43×10^{-1}	8.15×10^{-1}	1.45×10^{-1}
1,2-Dichloroethane	1.24×10^{-2}	2.07×10^{-2}	1.24×10^{-2}
1,2-Dichloroethylene	1.28×10^{0}	1.77×10^{0}	3.18×10^{-1}
Freon 113*	9.18×10^{-1}	9.64×10^{-1}	7.90×10^{-1}
Tetrachloroethylene	4.14×10^{-2}	1.61×10^{-1}	5.38×10^{-2}
1,1,1-Trichloroethane*	8.27×10^{-3}	1.24×10^{-2}	8.27×10^{-3}
Trichloroethylene	1.24×10^{1}	2.13×10^{1}	2.86×10^{0}
Total	14.3	24.1	3.5

* Freon 113 and 1,1,1-Trichloroethane are not considered ROCs under SMAQMD Rule 202, Section 222.

Meteorological Data

Five years of hourly meteorological surface data (1987 through 1991) were used to model dispersion of emissions from the air stripper. These data were collected at the Sacramento Executive Airport, which is a designated National Weather Service Station for Sacramento (Station 23232). The surface data measurements from Executive Airport were augmented with upper air sounding data from the Oakland Airport (Station 23230), which is the closest upper air sounding station to Sacramento. The meteorological data sets were obtained from the National Climatic Data Center and preprocessed for use with the models by Trinity Consultants Inc., Dallas, Texas.

Risk Characterization

The compounds emitted from the air stripper are all volatile and do not deposit on skin, soil, water, or plants. Therefore, the human inhalation exposure pathway was the only pathway considered in this analysis. The CAPCOA guidelines were followed in estimating the MEI risk, chronic hazard index, and acute hazard index (CAPCOA, 1994).

The potential human risk was determined by multiplying the annual average concentration by the unit risk factor (URF) for each VOC. These and other toxicological data (see below) came from one of the following sources:

- U.S. EPA's Integrated Risk Information System (U.S. EPA, 1995);
- U.S. EPA's Health Effects Assessment Summary Tables (U.S. EPA, 1992);
- U.S. EPA Environmental Criteria and Assessment Office; and
- Cal/EPA guidelines (Cal/EPA, 1994);

The chronic hazard index was estimated by dividing the annual average concentration by the chronic reference exposure level (REL). Similarly, the acute hazard index was estimated by dividing the one-hour concentration by the acute REL.

The ISCST2 input files contain either the emission rate multiplied by the URF or the emission rate divided by the REL. Therefore, the model output gives either the risk or hazard index directly. The toxicology data is given in Attachment A, along with results of health effects for each year modeled. Any adjustments for occupational versus residential exposure was performed outside of the model on spreadsheets.

REFERENCES

Cal/EPA, 1994. Memo from Standards and Criteria Work Group(Cal/EPA) to Cal/EPA Departments, Boards, and Offices. November 1.

CAPCOA, 1993. *Revised 1992 CAPCOA Air Toxics "Hot Spots" Program, Risk Assessment Guidelines*. October.

SMAQMD, 1994. *Procedure for Permit Processing*, Sacramento Metropolitan Air Quality Management District, January 3.

U.S. EPA, 1985. *Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Documentation for the Stack Height Regulations)*. Revised. Research Triangle Park, NC: U.S. Environmental Protection Agency, EPA-450/4-80-023R. June.

U.S. EPA, 1986. *Guideline on Air Quality Models (Revised)*. EPA-450/2-78-027R, July.

U.S. EPA, 1992. *Health Effects Assessment Summary Tables (HEAST)*. OHEA, ECAO-CIN-821. March.

U.S. EPA, 1995. Integrated Risk Information System (IRIS). Online. Office of Health and Environmental Assessment, Cincinnati, OH.

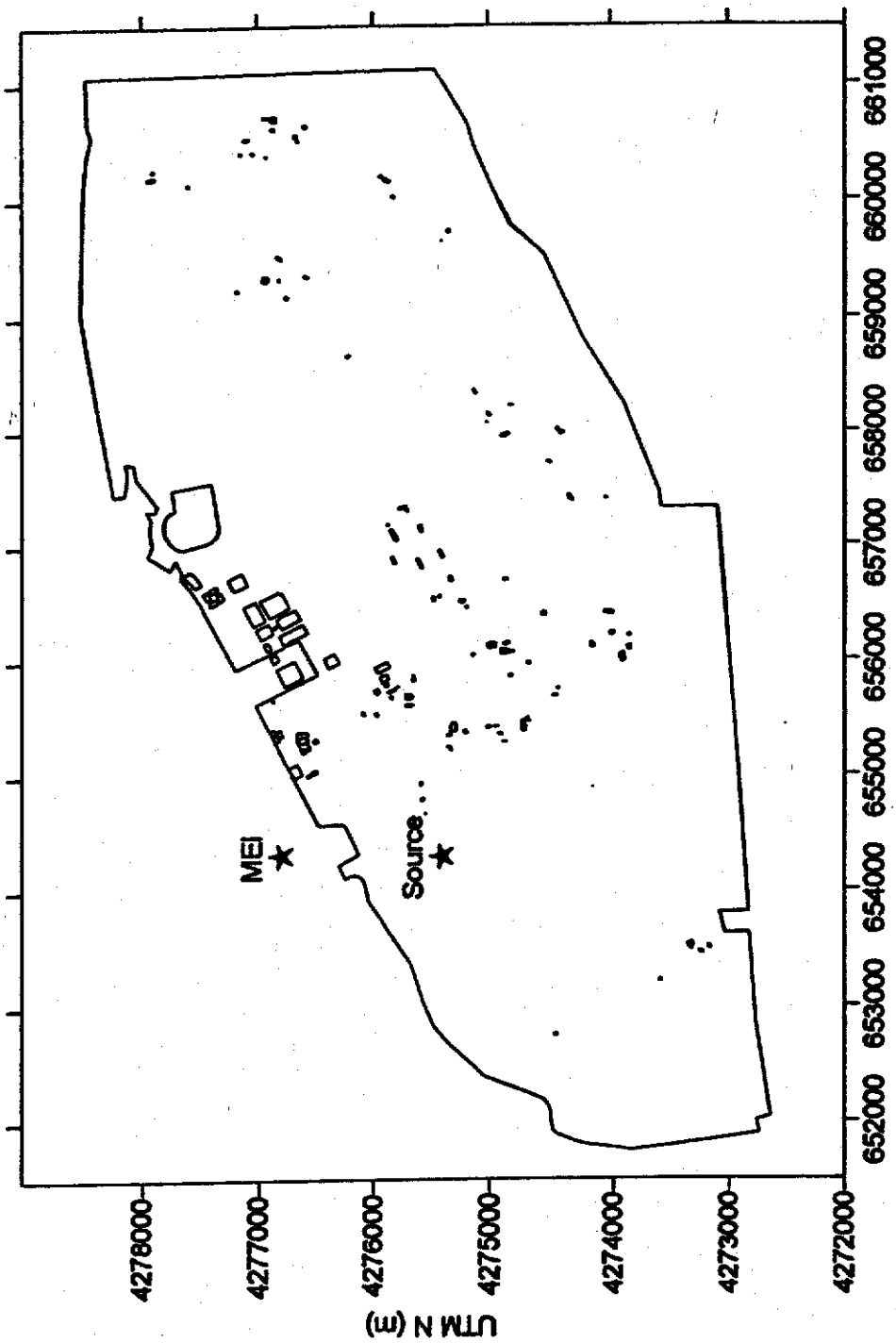

Figure 1. Groundwater Treatment Source and MEI Location

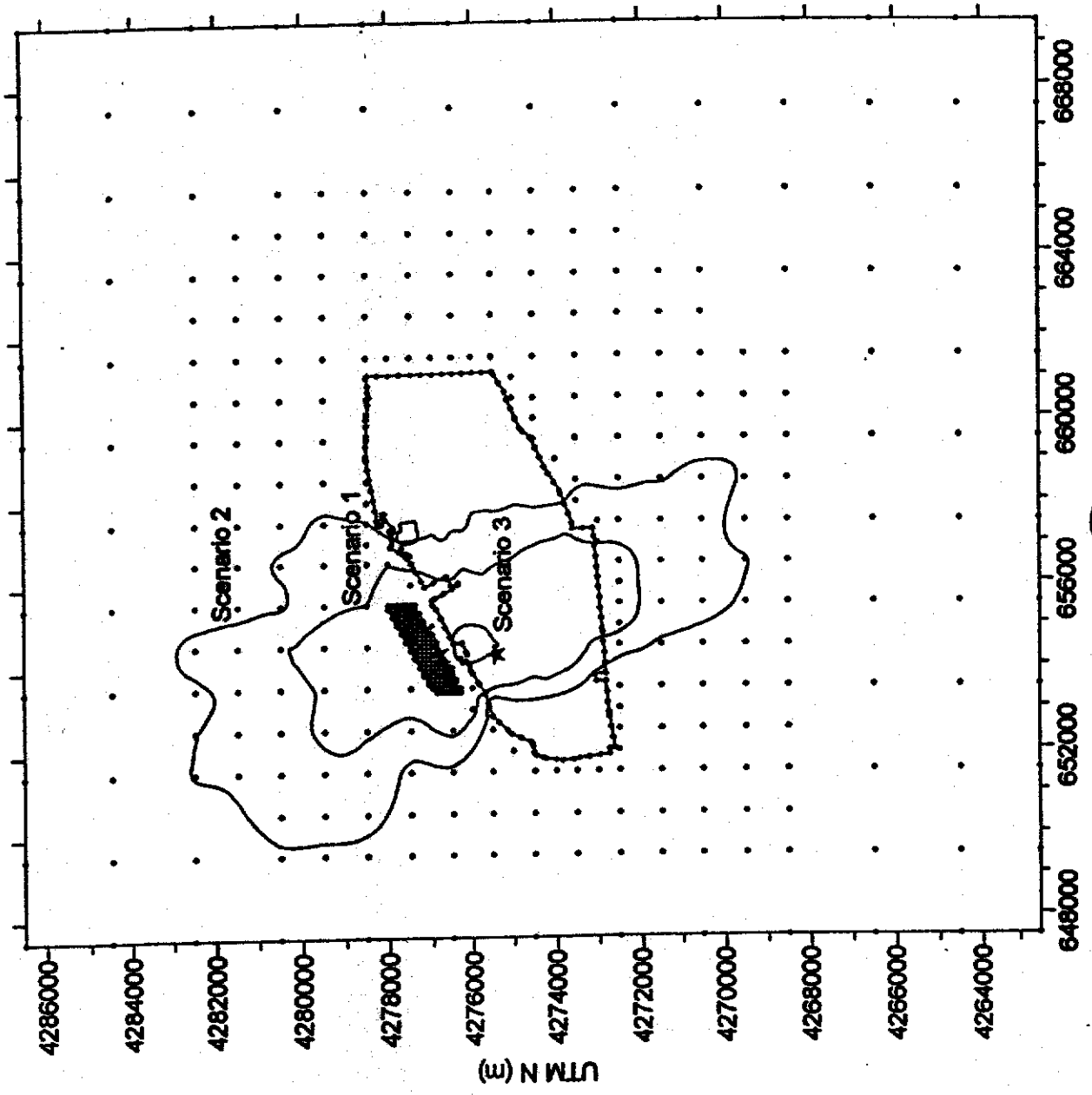

Figure 2. 1 In 10 M[redacted] Cancer Risk Isopleths

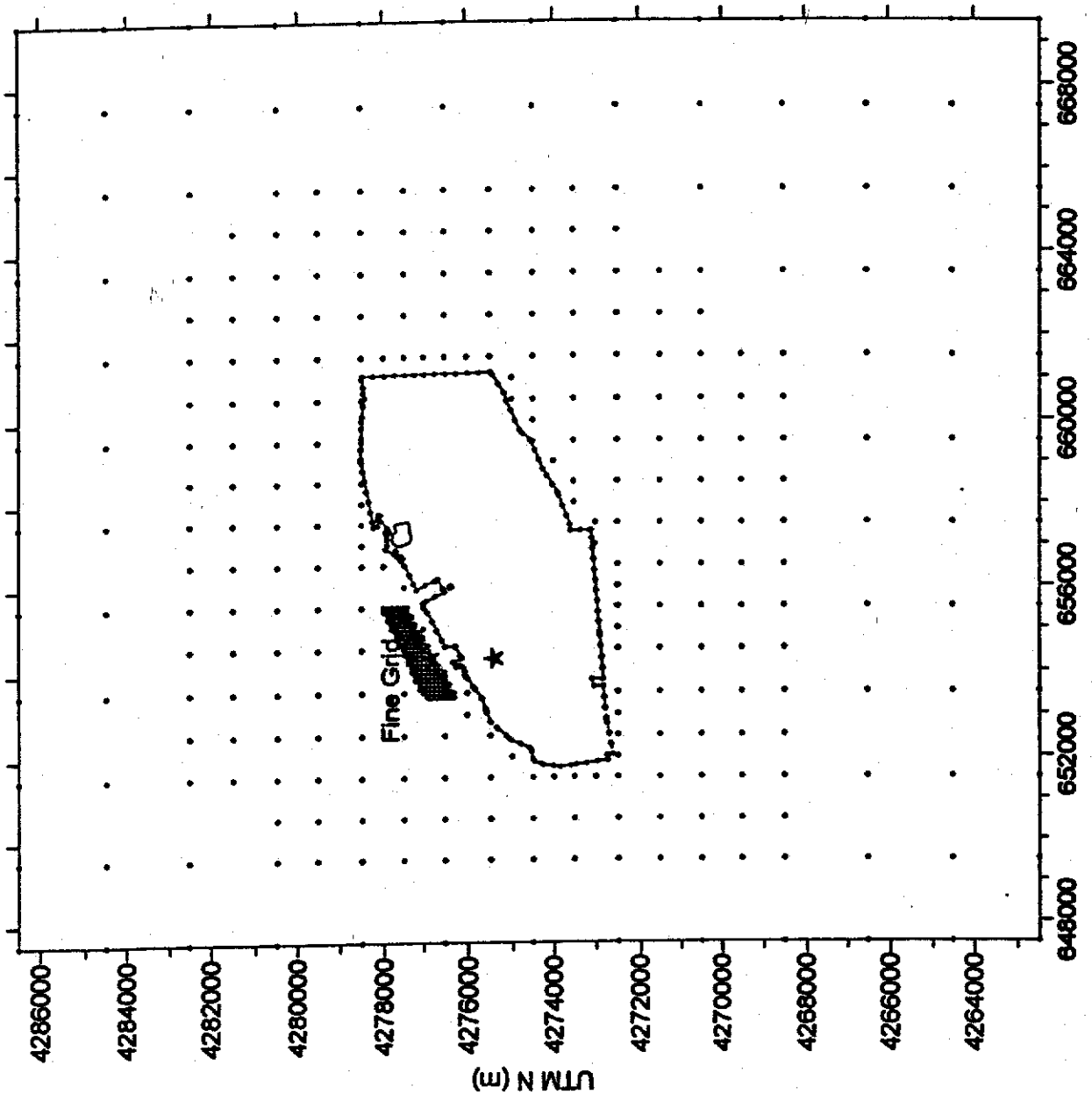

Figure 3. Coarse and Fine Receptor Grids

RADIAN INTERNATIONAL LLC

ATTACHMENT A

CAS Nos

Name	Alternate Name	CAS No.	Order
1,1-Dichloroethylene	Vinylidene Chloride	75-35-4	1
1,1-Dichloroethane	1,1-Dichloroethane	75-34-3	2
1,2-Dichloroethylene	Dichloroethylene,1,2-,Cis-Trans-	540-59-0	3
Chloroform	Chloroform	67-66-3	4
Freon 113	Freon 113	76-13-1	5
1,2-Dichloroethane	1,2-Dichloroethane	107-06-2	6
1,1,1-Trichloroethane	Methyl Chloroform	71-55-6	7
Carbon Tetrachloride	Carbon Tetrachloride	56-23-5	8
Trichloroethylene	Trichloroethylene	79-01-6	9
Tetrachloroethylene	Tetrachloroethylene	127-18-4	10

Acute Tox Data

CONCENTRATION (ug/m3)	CAS No.	Synonym	Order	Aerojet AEL	OB/OD AEL	CAPCOA AEL ug/m3
1,1-Dichloroethylene	75-35-4	Vinylidiene Chloride	1	2.00E+04	2.00E+04	
1,1-Dichloroethane	75-34-3	1,1-Dichloroethane	2	4.05E+05	4.05E+05	TLV
Trans-1,2-Dichloroethylene	540-59-0	Trans-1,2-DCE	3	7.93E+05	7.93E+05	
Chloroform	67-66-3	Chloroform	4	4.90E+04	4.90E+04	
Freon-113	76-13-1	Freon-113	5	7.67E+06	7.67E+06	
1,2-dichloroethane	107-06-2	1,2-dichloroethane	6	4.00E+04	4.00E+04	
1,1,1-trichloroethane	71-55-6	1,1,1-trichloroethane	7	1.90E+05	1.90E+05	
Carbon tetrachloride	56-23-5	Carbon tetrachloride	8	1.90E+02	1.90E+02	1.90E+02
Trichloroethylene	79-01-6	Trichloroethylene	9	2.69E+05	2.69E+05	
Tetrachloroethylene	127-18-4	Tetrachloroethylene	10	6.80E+03	6.80E+03	6.80E+03

								CAPCOA	CAPCOA	Cal EPA	IRIS	IRIS	HEAST	HEAST	Rfc Extp	Rfc Extp	ECAO	Widmore(PBS)	ECAO
				Aerojet	Aerojet	OB/OD	OB/OD	ISF	IRfD	ISF	ISF	IRfD	ISF	IRfD	ISF	IRfD	IRfD	IRfD	ISF
Chemical	CAS No.	Synonym	Order			SFI	RfDi	1/(mg/kg-d)	mg/kg-d	1/(mg/kg-d)	1/(mg/kg-d)	mg/kg-d	1/(mg/kg-d)	mg/kg-d	1/(mg/kg-d)	mg/kg-d	mg/kg-d	mg/kg-d	1/(mg/kg-d)
1,1-Dichloroethylene	75-35-4	Vinylidene Chloride	1			1.6E-01	9.0E-03				1.60E-01					9.00E-03			
1,1-Dichloroethane	75-34-3	1,1-Dichloroethane	2			0.0E+00	1.4E-01	not in OB/OD (from PROs)											
Trans-1,2-Dichloroethylene	540-59-0	Trans-1,2-DCE	3			0.0E+00	2.0E-02									2.00E-02			
Chloroform	67-66-3	Chloroform	4			1.9E-02	1.0E-02			1.90E-02	8.10E-02					1.00E-02			
Freon-113	76-13-1	Freon-113	5			0.0E+00	6.6E+00							6.60E+00					
1,2-dichloroethene	107-06-2	1,2-dichloroethene	6			7.0E-02	2.7E-02			7.00E-02	9.10E-02								
1,1,1-trichloroethane	71-55-6	1,1,1-trichloroethane	7			0.0E+00	2.9E-01											2.90E-01	
Carbon tetrachloride	56-23-5	Carbon tetrachloride	8			1.6E-01	6.7E-04			1.50E-01	8.20E-02						6.70E-04		
Trichloroethylene	79-01-6	Trichloroethylene	9			1.0E-02	6.0E-03			1.00E-02						6.00E-03			6.00E-03
Tetrachloroethylene	127-18-4	Tetrachloroethylene	10			6.1E-02	1.0E-02			6.10E-02						1.00E-02			2.00E-03
Chemical				URF	REL														
1,1-Dichloroethylene	75-35-4	Vinylidene Chloride	1	5.1E-06	3.2E+01	5.1E-06	3.2E+01												
1,1-Dichloroethane	75-34-3	1,1-Dichloroethane	2	0.0E+00	4.9E+02	0.0E+00	4.9E+02												
Trans-1,2-Dichloroethylene	540-59-0	Trans-1,2-DCE	3	0.0E+00	7.0E+01	0.0E+00	7.0E+01												
Chloroform	67-66-3	Chloroform	4	8.1E-06	3.9E+01	8.1E-06	3.9E+01	8.30E-06	3.80E+01										
Freon-113	76-13-1	Freon-113	5	0.0E+00	3.0E+04	0.0E+00	3.0E+04												
1,2-dichloroethane	107-06-2	1,2-dichloroethane	6	2.0E-05	8.5E+01	2.0E-05	8.5E+01	2.00E-05	8.50E+01										
1,1,1-trichloroethane	71-55-6	1,1,1-trichloroethane	7	0.0E+00	3.2E+02	0.0E+00	1.0E+03		3.20E+02										
Carbon tetrachloride	56-23-5	Carbon tetrachloride	8	4.3E-06	2.0E+00	4.3E-06	2.0E+00	4.20E-06	2.40E+00										
Trichloroethylene	79-01-6	Trichloroethylene	9	2.9E-06	2.1E+01	2.9E-06	2.1E+01	2.00E-06	6.40E+02										
Tetrachloroethylene	127-18-4	Tetrachloroethylene	10	1.6E-06	3.6E+01	1.6E-06	3.6E+01	5.80E-06	3.80E+01										

Scenario 1

Order	Contaminant	MW	Influent Conc (ppb)	Flow Rate (lb/hr)	Emission Rate (g/s)	Cancer Multiplier	Chronic Multiplier	Acute Multiplier
1	1,1-Dichloroethylene	96.94	10.7	1.84E-02	2.33E-03	1.20E-07	7.36E-05	1.16E-07
2	1,1-Dichloroethane	98.96	0.5	8.62E-04	1.09E-04	0.00E+00	2.22E-07	2.68E-10
3	1,2-Dichloroethylene	96.94	30.9	5.32E-02	6.72E-03	0.00E+00	9.59E-05	8.47E-09
4	Chloroform	119.4	1.3	2.24E-03	2.83E-04	1.53E-09	8.07E-06	5.77E-09
5	Freon 113	187.4	22.2	3.83E-02	4.82E-03	0.00E+00	1.60E-07	6.29E-10
6	1,2-Dichloroethane	98.96	0.3	5.17E-04	6.52E-05	1.30E-09	6.86E-07	1.63E-09
7	1,1,1-Trichloroethane	133.4	0.2	3.45E-04	4.35E-05	0.00E+00	1.36E-07	2.29E-10
8	Carbon Tetrachloride	153.8	0.1	1.72E-04	2.17E-05	9.31E-10	1.00E-06	1.14E-07
9	Trichloroethylene	131.4	300.0	5.17E-01	6.52E-02	1.86E-07	3.10E-03	2.42E-07
10	Tetrachloroethylene	165.8	1.0	1.72E-03	2.17E-04	3.17E-09	6.21E-06	3.20E-08
						3.13E-07	3.30E-03	6.22E-07
Influent Flow (gpm)	3445							
Air Flow (cfm)	27634							
Diameter (ft)	3.75							
Diameter (m)	1.14							
Velocity (ft/min)	2600							
Velocity (ft/s)	41.67							
Velocity (m/s)	12.70							
Height (ft)	44							
Height (m)	13.41							
Temp (F)	65							
Temp (K)	291.3333333							
Total Emissions (tpy)	2.77							

EMI[redacted]S

[redacted]

[redacted]5/9/96

Order	Contaminant	MW	Influent Conc (ppb)	Flow Rate (lb/hr)	Emission Rate (g/s)	Cancer Multiplier	Chronic Multiplier	Acute Multiplier
1	1,1-Dichloroethylene	96.94	16.7	3.39E-02	4.28E-03	2.20E-07	1.36E-04	2.14E-07
2	1,1-Dichloroethane	98.96	0.8	1.38E-03	1.74E-04	0.00E+00	3.85E-07	4.29E-10
3	1,2-Dichloroethylene	96.94	42.8	7.38E-02	9.30E-03	0.00E+00	1.33E-04	1.17E-06
4	Chloroform	119.4	1.7	2.93E-03	3.69E-04	2.01E-09	1.06E-05	7.54E-09
5	Freon 113	187.4	23.3	4.02E-02	5.06E-03	0.00E+00	1.68E-07	6.60E-10
6	1,2-Dichloroethane	98.96	0.5	8.62E-04	1.09E-04	2.17E-09	1.14E-06	2.72E-09
7	1,1,1-Trichloroethane	133.4	0.3	5.17E-04	6.52E-05	0.00E+00	2.04E-07	3.43E-10
8	Carbon Tetrachloride	153.8	0.1	1.72E-04	2.17E-05	9.31E-10	1.09E-05	1.14E-07
9	Trichloroethylene	131.4	514.1	8.86E-01	1.12E-01	3.19E-07	5.32E-03	4.15E-07
10	Tetrachloroethylene	165.8	3.9	6.72E-03	8.48E-04	1.24E-08	2.42E-05	1.25E-07
						5.67E-07	5.84E-03	8.92E-07
Influent Flow (gpm)	3445							
Air Flow (cfm)	27634							
Diameter (ft)	3.75							
Diameter (m)	1.14							
Velocity (ft/min)	2500							
Velocity (ft/s)	41.67							
Velocity (m/s)	12.70							

Scenario 3

Order	Contaminant	MW	Influent Conc (ppb)	Flow Rate (lb/hr)	Emission Rate (g/s)	Cancer Multiplier	Chronic Multiplier	Acute Multiplier
1	1,1-Dichloroethylene	96.94	3.5	6.03E-03	7.61E-04	3.91E-08	2.41E-05	3.80E-08
2	1,1-Dichloroethane	98.96	0.5	8.62E-04	1.09E-04	0.00E+00	2.22E-07	2.66E-10
3	1,2-Dichloroethylene	96.94	7.7	1.33E-02	1.67E-03	0.00E+00	2.39E-05	2.11E-09
4	Chloroform	119.4	1.4	2.41E-03	3.04E-04	1.65E-09	8.69E-06	6.21E-09
5	Freon 113	187.4	19.1	3.29E-02	4.15E-03	0.00E+00	1.38E-07	5.41E-10
6	1,2-Dichloroethane	98.96	0.3	5.17E-04	6.52E-05	1.30E-09	6.86E-07	1.63E-09
7	1,1,1-Trichloroethane	133.4	0.2	3.45E-04	4.35E-05	0.00E+00	1.36E-07	2.29E-10
8	Carbon Tetrachloride	153.8	0.1	1.72E-04	2.17E-05	9.31E-10	1.09E-05	1.14E-07
9	Trichloroethylene	131.4	69.1	1.19E-01	1.50E-02	4.29E-08	7.15E-04	5.56E-08
10	Tetrachloroethylene	165.8	1.3	2.24E-03	2.83E-04	4.12E-09	6.07E-06	4.15E-08
						9.00E-08	7.92E-04	2.61E-07

Influent Flow (gpm)	3445
Air Flow (cfm)	27634
Diameter (ft)	3.75
Diameter (m)	1.14
Velocity (ft/min)	2500
Velocity (ft/s)	41.67
Velocity (m/s)	12.70

Results of Air Stripper HRA

Fine Grid Maximum Cancer Risk (Residential Risk in One Million)				
Year	Scenario 1	Scenario 2	Scenario 3	
87	0.28	0.50	0.08	
88	0.29	0.51	0.08	
89	0.30	0.54	0.09	
90	0.27	0.49	0.08	
91	0.28	0.50	0.08	
Fine Grid Maximum Chronic Hazard Index				
Year	Scenario 1	Scenario 2	Scenario 3	
87	3.0E-03	5.0E-03	7.1E-04	
88	3.0E-03	5.2E-03	7.3E-04	
89	3.2E-03	5.5E-03	7.7E-04	
90	2.9E-03	4.9E-03	6.9E-04	
91	2.9E-03	5.0E-03	7.1E-04	
Maximum Acute Hazard Index				
Year	Scenario 1	Scenario 2	Scenario 3	
87	5.1E-05	8.8E-05	2.6E-05	
88	5.3E-05	9.1E-05	2.7E-05	
89	5.3E-05	9.1E-05	2.7E-05	
90	5.3E-05	9.1E-05	2.7E-05	
91	5.3E-05	9.1E-05	2.7E-05	

NO ECHO

```
**********
*** SETUP Finishes Successfully ***
**********

1 *** ISCST2 - VERSION 92062 ***     *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96          ***
                                     ***                                                                     ***
                                                                                                        PAGE   1

 *** MODELING OPTIONS USED:  CONC   RURAL  ELEV                                        NOCALM

                                     ***     MODEL SETUP OPTIONS SUMMARY           ***
------------------------------------------------------------------------------------------------------------

**Model Is Setup For Calculation of Average CONCentration Values.

**Model Uses RURAL Dispersion.

**Model Uses User-Specified Options:
          1. Final Plume Rise.
          2. Stack-tip Downwash.
          3. Buoyancy-induced Dispersion.
          4. Not Use Calms Processing Routine.
          5. Not Use Missing Data Processing Routine.
          6. Default Wind Profile Exponents.
          7. Default Vertical Potential Temperature Gradients.

**Model Accepts Receptors on ELEV Terrain.

**Model Assumes No FLAGPOLE Receptor Heights.

**Model Calculates PERIOD Averages Only

**This Run Includes:     1 Source(s);      1 Source Group(s); and    473 Receptor(s)

**The Model Assumes A Pollutant Type of:  CANCER

**Model Set To Continue RUNning After the Setup Testing.

**Output Options Selected:
         Model Outputs Tables of PERIOD Averages by Receptor
         Model Outputs External File(s) of High Values for Plotting (PLOTFILE Keyword)

**Misc. Inputs:  Anem. Hgt. (m) =    10.00 ;   Decay Coef. =       0.     ;   Rot. Angle =     0.0
                 Emission Units = (GRAMS/SEC)                               ;  Emission Rate Unit Factor =  0.10000E+07
                 Output Units   = (MICROGRAMS/CUBIC-METER)

**Detailed Error/Message File:  ERRORS.OUT
1 *** ISCST2 - VERSION 92062 ***     *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96          ***
                                     ***                                                                     ***
                                                                                                        PAGE   2

 *** MODELING OPTIONS USED:  CONC   RURAL  ELEV                                        NOCALM

                                     *** POINT SOURCE DATA ***

                                                                                                  BUILDING EMISSION RATE
   SOURCE      NUMBER EMISSION RATE          X          Y      BASE     STACK   STACK   STACK     STACK    EXISTS  SCALAR VARY
    ID          PART.  (USER UNITS)     (METERS)   (METERS)  ELEV.   HEIGHT  TEMP.  EXIT VEL. DIAMETER             BY
                CATS.                                        (METERS) (METERS) (DEG.K) (M/SEC) (METERS)
------------------------------------------------------------------------------------------------------------

   10001         0   0.31300E+00  654291.5  4275412.8    47.4    13.41   292.00    12.70     1.14      NO
1 *** ISCST2 - VERSION 92062 ***     *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96          ***
                                     ***                                                                     ***
                                                                                                        PAGE   3

 *** MODELING OPTIONS USED:  CONC   RURAL  ELEV                                        NOCALM

                                     *** SOURCE IDs DEFINING SOURCE GROUPS ***

 GROUP ID                                                SOURCE IDs


   1          10001     ,
1 *** ISCST2 - VERSION 92062 ***     *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96          ***
                                     ***                                                                     ***
                                                                                                        PAGE   4

 *** MODELING OPTIONS USED:  CONC   RURAL  ELEV                                        NOCALM

                                     *** DISCRETE CARTESIAN RECEPTORS ***
                                      (X-COORD, Y-COORD, ZELEV, ZFLAG)
                                                (METERS)

     ( 647500.0, 4262500.0,      24.0,      0.0);     ( 649500.0, 4262500.0,      35.0,      0.0);
     ( 651500.0, 4262500.0,      33.0,      0.0);     ( 653500.0, 4262500.0,      42.0,      0.0);
```

(655500.0, 4262500.0,	53.0,	0.0);	(657500.0, 4262500.0,	30.0,	0.0);
(659500.0, 4262500.0,	37.0,	0.0);	(661500.0, 4262500.0,	45.0,	0.0);
(663500.0, 4262500.0,	59.0,	0.0);	(665500.0, 4262500.0,	60.0,	0.0);
(667500.0, 4262500.0,	59.0,	0.0);	(669500.0, 4262500.0,	90.0,	0.0);
(647500.0, 4264500.0,	24.0,	0.0);	(649500.0, 4264500.0,	35.0,	0.0);
(651500.0, 4264500.0,	42.0,	0.0);	(653500.0, 4264500.0,	45.0,	0.0);
(655500.0, 4264500.0,	44.0,	0.0);	(657500.0, 4264500.0,	60.0,	0.0);
(659500.0, 4264500.0,	38.0,	0.0);	(661500.0, 4264500.0,	41.0,	0.0);
(663500.0, 4264500.0,	59.0,	0.0);	(665500.0, 4264500.0,	92.0,	0.0);
(667500.0, 4264500.0,	84.0,	0.0);	(669500.0, 4264500.0,	90.0,	0.0);
(647500.0, 4266500.0,	21.0,	0.0);	(649500.0, 4266500.0,	32.0,	0.0);
(651500.0, 4266500.0,	42.0,	0.0);	(653500.0, 4266500.0,	49.0,	0.0);
(655500.0, 4266500.0,	56.0,	0.0);	(657500.0, 4266500.0,	60.0,	0.0);
(659500.0, 4266500.0,	56.0,	0.0);	(661500.0, 4266500.0,	54.0,	0.0);
(663500.0, 4266500.0,	60.0,	0.0);	(665500.0, 4266500.0,	65.0,	0.0);
(667500.0, 4266500.0,	91.0,	0.0);	(669500.0, 4266500.0,	131.0,	0.0);
(647500.0, 4268500.0,	23.0,	0.0);	(649500.0, 4268500.0,	30.0,	0.0);
(650500.0, 4268500.0,	33.0,	0.0);	(651508.0, 4268500.0,	37.0,	0.0);
(652500.0, 4268500.0,	42.0,	0.0);	(653500.0, 4268500.0,	45.0,	0.0);
(654500.0, 4268500.0,	53.0,	0.0);	(655500.0, 4268500.0,	56.0,	0.0);
(656500.0, 4268500.0,	58.0,	0.0);	(657500.0, 4268500.0,	66.0,	0.0);
(658500.0, 4268500.0,	66.0,	0.0);	(659500.0, 4268500.0,	62.0,	0.0);
(660500.0, 4268500.0,	64.0,	0.0);	(661500.0, 4268500.0,	61.0,	0.0);
(663500.0, 4268500.0,	60.0,	0.0);	(665500.0, 4268500.0,	61.0,	0.0);
(667500.0, 4268500.0,	94.0,	0.0);	(669500.0, 4268500.0,	139.0,	0.0);
(649500.0, 4269500.0,	29.0,	0.0);	(650500.0, 4269500.0,	36.0,	0.0);
(651500.0, 4269500.0,	39.0,	0.0);	(652500.0, 4269500.0,	42.0,	0.0);
(653500.0, 4269500.0,	44.0,	0.0);	(654500.0, 4269500.0,	49.0,	0.0);
(655500.0, 4269500.0,	59.0,	0.0);	(656500.0, 4269500.0,	61.0,	0.0);
(657500.0, 4269500.0,	68.0,	0.0);	(658500.0, 4269500.0,	70.0,	0.0);
(659500.0, 4269500.0,	63.0,	0.0);	(660500.0, 4269500.0,	73.0,	0.0);
(661500.0, 4269500.0,	60.0,	0.0);	(647500.0, 4270500.0,	25.0,	0.0);
(649500.0, 4270500.0,	29.0,	0.0);	(650500.0, 4270500.0,	30.0,	0.0);
(651500.0, 4270500.0,	39.0,	0.0);	(652500.0, 4270500.0,	45.0,	0.0);
(653500.0, 4270500.0,	48.0,	0.0);	(654500.0, 4270500.0,	52.0,	0.0);
(655500.0, 4270500.0,	60.0,	0.0);	(656500.0, 4270500.0,	61.0,	0.0);
(657500.0, 4270500.0,	68.0,	0.0);	(658500.0, 4270500.0,	74.0,	0.0);
(659500.0, 4270500.0,	74.0,	0.0);	(660500.0, 4270500.0,	67.0,	0.0);
(661500.0, 4270500.0,	70.0,	0.0);	(662500.0, 4270500.0,	60.0,	0.0);
(663500.0, 4270500.0,	60.0,	0.0);	(665500.0, 4270500.0,	107.0,	0.0);
(667500.0, 4270500.0,	128.0,	0.0);	(669500.0, 4270500.0,	127.0,	0.0);
(649500.0, 4271500.0,	31.0,	0.0);	(650500.0, 4271500.0,	36.0,	0.0);
(651500.0, 4271500.0,	36.0,	0.0);	(652500.0, 4271500.0,	45.0,	0.0);

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96 *** PAGE 5

*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** DISCRETE CARTESIAN RECEPTORS ***
(X-COORD, Y-COORD, ZELEV, ZFLAG)
(METERS)

(653500.0, 4271500.0,	48.0,	0.0);	(654500.0, 4271500.0,	52.0,	0.0);
(655500.0, 4271500.0,	58.0,	0.0);	(656500.0, 4271500.0,	64.0,	0.0);
(657500.0, 4271500.0,	69.0,	0.0);	(658500.0, 4271500.0,	77.0,	0.0);
(659500.0, 4271500.0,	79.0,	0.0);	(660500.0, 4271500.0,	76.0,	0.0);
(661500.0, 4271500.0,	67.0,	0.0);	(662500.0, 4271500.0,	60.0,	0.0);
(663500.0, 4271500.0,	71.0,	0.0);	(647500.0, 4272500.0,	24.0,	0.0);
(649500.0, 4272500.0,	32.0,	0.0);	(650500.0, 4272500.0,	36.0,	0.0);
(651500.0, 4272500.0,	41.0,	0.0);	(652000.0, 4272500.0,	43.0,	0.0);
(652500.0, 4272500.0,	44.0,	0.0);	(653000.0, 4272500.0,	46.0,	0.0);
(653500.0, 4272500.0,	48.0,	0.0);	(654500.0, 4272500.0,	53.0,	0.0);
(655000.0, 4272500.0,	53.0,	0.0);	(655500.0, 4272500.0,	56.0,	0.0);
(656000.0, 4272500.0,	59.0,	0.0);	(656500.0, 4272500.0,	62.0,	0.0);
(657500.0, 4272500.0,	71.0,	0.0);	(658500.0, 4272500.0,	76.0,	0.0);
(659500.0, 4272500.0,	83.0,	0.0);	(660500.0, 4272500.0,	80.0,	0.0);
(661500.0, 4272500.0,	90.0,	0.0);	(662500.0, 4272500.0,	65.0,	0.0);
(663500.0, 4272500.0,	90.0,	0.0);	(664500.0, 4272500.0,	96.0,	0.0);
(665500.0, 4272500.0,	116.0,	0.0);	(667500.0, 4272500.0,	148.0,	0.0);
(669500.0, 4272500.0,	153.0,	0.0);	(651500.0, 4273000.0,	46.0,	0.0);
(657000.0, 4273000.0,	65.0,	0.0);	(657500.0, 4273000.0,	68.0,	0.0);
(649500.0, 4273500.0,	30.0,	0.0);	(650500.0, 4273500.0,	37.0,	0.0);
(651500.0, 4273500.0,	46.0,	0.0);	(658000.0, 4273500.0,	72.0,	0.0);
(658500.0, 4273500.0,	75.0,	0.0);	(659500.0, 4273500.0,	82.0,	0.0);
(660500.0, 4273500.0,	89.0,	0.0);	(661500.0, 4273500.0,	92.0,	0.0);
(662500.0, 4273500.0,	89.0,	0.0);	(663500.0, 4273500.0,	93.0,	0.0);
(664500.0, 4273500.0,	104.0,	0.0);	(665500.0, 4273500.0,	112.0,	0.0);
(651500.0, 4274000.0,	45.0,	0.0);	(659000.0, 4274000.0,	79.0,	0.0);
(647500.0, 4274500.0,	18.0,	0.0);	(649500.0, 4274500.0,	29.0,	0.0);
(650500.0, 4274500.0,	34.0,	0.0);	(651500.0, 4274500.0,	40.0,	0.0);
(659500.0, 4274500.0,	84.0,	0.0);	(660000.0, 4274500.0,	88.0,	0.0);
(660500.0, 4274500.0,	92.0,	0.0);	(661500.0, 4274500.0,	100.0,	0.0);
(662500.0, 4274500.0,	89.0,	0.0);	(663500.0, 4274500.0,	101.0,	0.0);
(664500.0, 4274500.0,	117.0,	0.0);	(665500.0, 4274500.0,	124.0,	0.0);
(667500.0, 4274500.0,	133.0,	0.0);	(669500.0, 4274500.0,	179.0,	0.0);
(652000.0, 4275000.0,	44.0,	0.0);	(660500.0, 4275000.0,	92.0,	0.0);
(661000.0, 4275000.0,	101.0,	0.0);	(649500.0, 4275500.0,	30.0,	0.0);
(650500.0, 4275500.0,	36.0,	0.0);	(651500.0, 4275500.0,	33.0,	0.0);
(652500.0, 4275500.0,	38.0,	0.0);	(661500.0, 4275500.0,	105.0,	0.0);

(	662500.0,	4275500.0,	91.0,	0.0);	(663500.0,	4275500.0,	106.0,	0.0);
(	664500.0,	4275500.0,	121.0,	0.0);	(665500.0,	4275500.0,	137.0,	0.0);
(	653000.0,	4276000.0,	42.0,	0.0);	(653500.0,	4276000.0,	43.0,	0.0);
(	661500.0,	4276000.0,	103.0,	0.0);	(647500.0,	4276500.0,	29.0,	0.0);
(	649500.0,	4276500.0,	22.0,	0.0);	(650500.0,	4276500.0,	28.0,	0.0);
(	651500.0,	4276500.0,	35.0,	0.0);	(652500.0,	4276500.0,	42.0,	0.0);
(	653500.0,	4276500.0,	45.0,	0.0);	(654000.0,	4276500.0,	45.0,	0.0);
(	661500.0,	4276500.0,	100.0,	0.0);	(662500.0,	4276500.0,	96.0,	0.0);

*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** DISCRETE CARTESIAN RECEPTORS ***
(X-COORD, Y-COORD, ZELEV, ZFLAG)
(METERS)

(	663500.0,	4276500.0,	109.0,	0.0);	(664500.0,	4276500.0,	121.0,	0.0);
(	665500.0,	4276500.0,	139.0,	0.0);	(667500.0,	4276500.0,	170.0,	0.0);
(	669500.0,	4276500.0,	178.0,	0.0);	(654500.0,	4277000.0,	45.0,	0.0);
(	655000.0,	4277000.0,	46.0,	0.0);	(655500.0,	4277000.0,	50.0,	0.0);
(	661500.0,	4277000.0,	98.0,	0.0);	(649500.0,	4277500.0,	35.0,	0.0);
(	650500.0,	4277500.0,	27.0,	0.0);	(651500.0,	4277500.0,	28.0,	0.0);
(	652500.0,	4277500.0,	31.0,	0.0);	(653500.0,	4277500.0,	36.0,	0.0);
(	654500.0,	4277500.0,	45.0,	0.0);	(655500.0,	4277500.0,	45.0,	0.0);
(	656000.0,	4277500.0,	50.0,	0.0);	(661500.0,	4277500.0,	94.0,	0.0);
(	662500.0,	4277500.0,	91.0,	0.0);	(663500.0,	4277500.0,	118.0,	0.0);
(	664500.0,	4277500.0,	121.0,	0.0);	(665500.0,	4277500.0,	168.0,	0.0);
(	656500.0,	4278000.0,	48.0,	0.0);	(661500.0,	4278000.0,	87.0,	0.0);
(	647500.0,	4278500.0,	42.0,	0.0);	(649500.0,	4278500.0,	42.0,	0.0);
(	650500.0,	4278500.0,	54.0,	0.0);	(651500.0,	4278500.0,	49.0,	0.0);
(	652500.0,	4278500.0,	47.0,	0.0);	(653500.0,	4278500.0,	60.0,	0.0);
(	654500.0,	4278500.0,	62.0,	0.0);	(655500.0,	4278500.0,	46.0,	0.0);
(	656500.0,	4278500.0,	45.0,	0.0);	(657000.0,	4278500.0,	49.0,	0.0);
(	657500.0,	4278500.0,	59.0,	0.0);	(658000.0,	4278500.0,	62.0,	0.0);
(	658500.0,	4278500.0,	63.0,	0.0);	(659000.0,	4278500.0,	66.0,	0.0);
(	659500.0,	4278500.0,	73.0,	0.0);	(660000.0,	4278500.0,	76.0,	0.0);
(	660500.0,	4278500.0,	81.0,	0.0);	(661000.0,	4278500.0,	83.0,	0.0);
(	661500.0,	4278500.0,	85.0,	0.0);	(662500.0,	4278500.0,	95.0,	0.0);
(	663500.0,	4278500.0,	114.0,	0.0);	(664500.0,	4278500.0,	145.0,	0.0);
(	665500.0,	4278500.0,	182.0,	0.0);	(667500.0,	4278500.0,	182.0,	0.0);
(	669500.0,	4278500.0,	217.0,	0.0);	(649500.0,	4279500.0,	54.0,	0.0);
(	650500.0,	4279500.0,	60.0,	0.0);	(651500.0,	4279500.0,	60.0,	0.0);
(	652500.0,	4279500.0,	60.0,	0.0);	(653500.0,	4279500.0,	67.0,	0.0);
(	654500.0,	4279500.0,	76.0,	0.0);	(655500.0,	4279500.0,	63.0,	0.0);
(	656500.0,	4279500.0,	51.0,	0.0);	(657500.0,	4279500.0,	45.0,	0.0);
(	658500.0,	4279500.0,	62.0,	0.0);	(659500.0,	4279500.0,	71.0,	0.0);
(	660500.0,	4279500.0,	87.0,	0.0);	(661500.0,	4279500.0,	98.0,	0.0);
(	662500.0,	4279500.0,	107.0,	0.0);	(663500.0,	4279500.0,	118.0,	0.0);
(	664500.0,	4279500.0,	172.0,	0.0);	(665500.0,	4279500.0,	234.0,	0.0);
(	647500.0,	4280500.0,	48.0,	0.0);	(649500.0,	4280500.0,	60.0,	0.0);
(	650500.0,	4280500.0,	60.0,	0.0);	(651500.0,	4280500.0,	63.0,	0.0);
(	652500.0,	4280500.0,	75.0,	0.0);	(653500.0,	4280500.0,	75.0,	0.0);
(	654500.0,	4280500.0,	76.0,	0.0);	(655500.0,	4280500.0,	70.0,	0.0);
(	656500.0,	4280500.0,	60.0,	0.0);	(657500.0,	4280500.0,	45.0,	0.0);
(	658500.0,	4280500.0,	55.0,	0.0);	(659500.0,	4280500.0,	61.0,	0.0);
(	660500.0,	4280500.0,	69.0,	0.0);	(661500.0,	4280500.0,	94.0,	0.0);
(	662500.0,	4280500.0,	117.0,	0.0);	(663500.0,	4280500.0,	121.0,	0.0);
(	664500.0,	4280500.0,	182.0,	0.0);	(665500.0,	4280500.0,	182.0,	0.0);
(	667500.0,	4280500.0,	225.0,	0.0);	(669500.0,	4280500.0,	242.0,	0.0);
(	651500.0,	4281500.0,	60.0,	0.0);	(652500.0,	4281500.0,	60.0,	0.0);
(	653500.0,	4281500.0,	74.0,	0.0);	(654500.0,	4281500.0,	79.0,	0.0);

*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** DISCRETE CARTESIAN RECEPTORS ***
(X-COORD, Y-COORD, ZELEV, ZFLAG)
(METERS)

(	655500.0,	4281500.0,	70.0,	0.0);	(656500.0,	4281500.0,	77.0,	0.0);
(	657500.0,	4281500.0,	47.0,	0.0);	(658500.0,	4281500.0,	60.0,	0.0);
(	659500.0,	4281500.0,	82.0,	0.0);	(660500.0,	4281500.0,	91.0,	0.0);
(	661500.0,	4281500.0,	88.0,	0.0);	(662500.0,	4281500.0,	105.0,	0.0);
(	663500.0,	4281500.0,	118.0,	0.0);	(664500.0,	4281500.0,	141.0,	0.0);
(	647500.0,	4282500.0,	42.0,	0.0);	(649500.0,	4282500.0,	49.0,	0.0);
(	651500.0,	4282500.0,	57.0,	0.0);	(652500.0,	4282500.0,	65.0,	0.0);
(	653500.0,	4282500.0,	75.0,	0.0);	(654500.0,	4282500.0,	81.0,	0.0);
(	655500.0,	4282500.0,	79.0,	0.0);	(656500.0,	4282500.0,	76.0,	0.0);
(	657500.0,	4282500.0,	49.0,	0.0);	(658500.0,	4282500.0,	53.0,	0.0);
(	659500.0,	4282500.0,	79.0,	0.0);	(660500.0,	4282500.0,	105.0,	0.0);
(	661500.0,	4282500.0,	104.0,	0.0);	(662500.0,	4282500.0,	109.0,	0.0);
(	663500.0,	4282500.0,	113.0,	0.0);	(665500.0,	4282500.0,	182.0,	0.0);
(	667500.0,	4282500.0,	278.0,	0.0);	(669500.0,	4282500.0,	354.0,	0.0);
(	647500.0,	4284500.0,	38.0,	0.0);	(649500.0,	4284500.0,	49.0,	0.0);
(	651500.0,	4284500.0,	60.0,	0.0);	(653500.0,	4284500.0,	71.0,	0.0);
(	655500.0,	4284500.0,	76.0,	0.0);	(657500.0,	4284500.0,	88.0,	0.0);

(659500.0,	4284500.0,	60.0,	0.0);	(661500.0,	4284500.0,	148.0,	0.0);
(663500.0,	4284500.0,	121.0,	0.0);	(665500.0,	4284500.0,	180.0,	0.0);
(667500.0,	4284500.0,	237.0,	0.0);	(669500.0,	4284500.0,	308.0,	0.0);
(647500.0,	4286500.0,	45.0,	0.0);	(649500.0,	4286500.0,	46.0,	0.0);
(651500.0,	4286500.0,	54.0,	0.0);	(653500.0,	4286500.0,	58.0,	0.0);
(655500.0,	4286500.0,	79.0,	0.0);	(657500.0,	4286500.0,	116.0,	0.0);
(659500.0,	4286500.0,	142.0,	0.0);	(661500.0,	4286500.0,	142.0,	0.0);
(663500.0,	4286500.0,	142.0,	0.0);	(665500.0,	4286500.0,	142.0,	0.0);
(667500.0,	4286500.0,	186.0,	0.0);	(669500.0,	4286500.0,	304.0,	0.0);
(652035.0,	4272622.0,	43.7,	0.0);	(652282.0,	4272662.0,	44.4,	0.0);
(652528.0,	4272702.0,	44.8,	0.0);	(652775.0,	4272743.0,	45.9,	0.0);
(652869.0,	4272758.0,	46.0,	0.0);	(653118.0,	4272777.0,	46.7,	0.0);
(653368.0,	4272796.0,	47.6,	0.0);	(653623.0,	4272816.0,	48.6,	0.0);
(653620.0,	4273037.0,	48.5,	0.0);	(653799.0,	4273086.0,	49.1,	0.0);
(653800.0,	4272818.0,	49.4,	0.0);	(654049.0,	4272836.0,	50.3,	0.0);
(654299.0,	4272854.0,	51.3,	0.0);	(654548.0,	4272872.0,	52.1,	0.0);
(654797.0,	4272890.0,	52.6,	0.0);	(654874.0,	4272896.0,	52.8,	0.0);
(655123.0,	4272916.0,	53.9,	0.0);	(655372.0,	4272937.0,	55.0,	0.0);
(655622.0,	4272957.0,	56.3,	0.0);	(655871.0,	4272977.0,	57.7,	0.0);
(656120.0,	4272997.0,	59.2,	0.0);	(656369.0,	4273018.0,	60.7,	0.0);
(656618.0,	4273038.0,	62.3,	0.0);	(656867.0,	4273058.0,	64.0,	0.0);
(657117.0,	4273079.0,	65.6,	0.0);	(657317.0,	4273095.0,	66.8,	0.0);
(657317.0,	4273345.0,	66.7,	0.0);	(657317.0,	4273579.0,	66.6,	0.0);
(657447.0,	4273587.0,	67.5,	0.0);	(657680.0,	4273677.0,	69.3,	0.0);
(657914.0,	4273766.0,	71.0,	0.0);	(658147.0,	4273856.0,	72.5,	0.0);
(658227.0,	4273887.0,	73.1,	0.0);	(658440.0,	4274018.0,	74.7,	0.0);
(658653.0,	4274150.0,	76.2,	0.0);	(658812.0,	4274248.0,	77.5,	0.0);
(659040.0,	4274350.0,	79.5,	0.0);	(659268.0,	4274452.0,	81.7,	0.0);

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJN 4/24/96 *** ***

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*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** DISCRETE CARTESIAN RECEPTORS ***
(X-COORD, Y-COORD, ZELEV, ZFLAG)
(METERS)

(659497.0,	4274554.0,	83.9,	0.0);	(659521.0,	4274565.0,	84.1,	0.0);
(659693.0,	4274747.0,	85.3,	0.0);	(659767.0,	4274825.0,	85.9,	0.0);
(659996.0,	4274924.0,	88.1,	0.0);	(660226.0,	4275024.0,	89.9,	0.0);
(660464.0,	4275127.0,	92.1,	0.0);	(660645.0,	4275182.0,	95.4,	0.0);
(660857.0,	4275314.0,	99.0,	0.0);	(661069.0,	4275447.0,	101.0,	0.0);
(661118.0,	4275477.0,	101.7,	0.0);	(661114.0,	4275727.0,	101.3,	0.0);
(661110.0,	4275977.0,	100.5,	0.0);	(661105.0,	4276227.0,	99.3,	0.0);
(661101.0,	4276477.0,	98.0,	0.0);	(661097.0,	4276727.0,	96.4,	0.0);
(661093.0,	4276977.0,	94.9,	0.0);	(661089.0,	4277227.0,	93.0,	0.0);
(661085.0,	4277477.0,	91.0,	0.0);	(661080.0,	4277727.0,	88.4,	0.0);
(661076.0,	4277977.0,	85.6,	0.0);	(661072.0,	4278227.0,	84.4,	0.0);
(661068.0,	4278467.0,	83.4,	0.0);	(660818.0,	4278461.0,	82.4,	0.0);
(660669.0,	4278458.0,	81.8,	0.0);	(660551.0,	4278420.0,	81.5,	0.0);
(660380.0,	4278464.0,	79.9,	0.0);	(660131.0,	4278487.0,	77.3,	0.0);
(660094.0,	4278490.0,	77.0,	0.0);	(659844.0,	4278496.0,	75.1,	0.0);
(659594.0,	4278502.0,	73.6,	0.0);	(659344.0,	4278508.0,	70.8,	0.0);
(659094.0,	4278514.0,	67.3,	0.0);	(659042.0,	4278515.0,	66.6,	0.0);
(658796.0,	4278472.0,	65.0,	0.0);	(658549.0,	4278429.0,	63.8,	0.0);
(658303.0,	4278386.0,	63.2,	0.0);	(658057.0,	4278343.0,	62.7,	0.0);
(657811.0,	4278300.0,	61.4,	0.0);	(657564.0,	4278257.0,	59.5,	0.0);
(657441.0,	4278236.0,	57.7,	0.0);	(657457.0,	4278143.0,	58.0,	0.0);
(657632.0,	4278118.0,	60.0,	0.0);	(657727.0,	4278133.0,	60.9,	0.0);
(657725.0,	4278068.0,	60.8,	0.0);	(657601.0,	4278054.0,	59.7,	0.0);
(657403.0,	4277901.0,	58.0,	0.0);	(657359.0,	4277867.0,	57.5,	0.0);
(657306.0,	4277884.0,	56.8,	0.0);	(657309.0,	4277963.0,	56.5,	0.0);
(657247.0,	4277919.0,	55.9,	0.0);	(657135.0,	4277931.0,	54.5,	0.0);
(657013.0,	4277911.0,	53.3,	0.0);	(656919.0,	4277947.0,	52.2,	0.0);
(656800.0,	4277753.0,	52.4,	0.0);	(656885.0,	4277700.0,	53.5,	0.0);
(656762.0,	4277635.0,	52.8,	0.0);	(656730.0,	4277656.0,	52.4,	0.0);
(656640.0,	4277574.0,	52.2,	0.0);	(656516.0,	4277487.0,	51.7,	0.0);
(656294.0,	4277372.0,	51.5,	0.0);	(656072.0,	4277258.0,	51.1,	0.0);
(655928.0,	4277184.0,	50.3,	0.0);	(656035.0,	4276958.0,	52.1,	0.0);
(656142.0,	4276732.0,	53.7,	0.0);	(656179.0,	4276654.0,	54.2,	0.0);
(655958.0,	4276537.0,	53.5,	0.0);	(655878.0,	4276495.0,	53.1,	0.0);
(655766.0,	4276718.0,	52.0,	0.0);	(655654.0,	4276942.0,	50.8,	0.0);
(655613.0,	4277023.0,	50.1,	0.0);	(655390.0,	4276910.0,	49.3,	0.0);
(655167.0,	4276796.0,	47.8,	0.0);	(654945.0,	4276683.0,	47.2,	0.0);
(654722.0,	4276569.0,	46.8,	0.0);	(654568.0,	4276491.0,	46.4,	0.0);
(654574.0,	4276261.0,	46.9,	0.0);	(654350.0,	4276151.0,	46.5,	0.0);
(654305.0,	4276129.0,	46.4,	0.0);	(654211.0,	4276313.0,	45.9,	0.0);
(654103.0,	4276251.0,	45.6,	0.0);	(654135.0,	4276174.0,	45.7,	0.0);
(654118.0,	4276114.0,	45.7,	0.0);	(654079.0,	4276078.0,	45.6,	0.0);
(653993.0,	4276057.0,	45.3,	0.0);	(653906.0,	4276040.0,	45.1,	0.0);
(653848.0,	4276002.0,	44.7,	0.0);	(653638.0,	4275866.0,	43.8,	0.0);
(653582.0,	4275830.0,	43.7,	0.0);	(653363.0,	4275686.0,	43.3,	0.0);

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJN 4/24/96 *** ***

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*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** DISCRETE CARTESIAN RECEPTORS ***

(X-COORD, Y-COORD, ELEV, ZFLAG)
(METERS)

(653124.0,	4275612.0,	42.3,	0.0);	(653049.0,	4275589.0,	41.9,	0.0);
(652825.0,	4275494.0,	40.4,	0.0);	(652668.0,	4275350.0,	39.8,	0.0);
(652489.0,	4275143.0,	41.4,	0.0);	(652395.0,	4275048.0,	42.4,	0.0);
(652295.0,	4274819.0,	44.0,	0.0);	(652193.0,	4274585.0,	44.4,	0.0);
(652158.0,	4274554.0,	44.3,	0.0);	(652102.0,	4274534.0,	44.2,	0.0);
(651953.0,	4274516.0,	43.7,	0.0);	(651906.0,	4274502.0,	43.3,	0.0);
(651882.0,	4274463.0,	43.3,	0.0);	(651816.0,	4274316.0,	43.2,	0.0);
(651794.0,	4274236.0,	43.3,	0.0);	(651763.0,	4273988.0,	45.5,	0.0);
(651744.0,	4273834.0,	45.7,	0.0);	(651773.0,	4273586.0,	46.2,	0.0);
(651789.0,	4273454.0,	46.3,	0.0);	(651822.0,	4273286.0,	45.8,	0.0);
(651856.0,	4272958.0,	45.5,	0.0);	(651887.0,	4272726.0,	44.2,	0.0);
(652006.0,	4272746.0,	44.3,	0.0);				

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96 ***
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*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***
(1=YES; 0=NO)

1 1 1

87	1	1	6	312.0	2.06	279.8	4	667.3	667.3
87	1	1	7	315.0	2.06	279.8	4	691.8	691.8
87	1	1	8	323.0	3.60	279.3	4	714.7	714.7
87	1	1	9	327.0	5.14	279.8	4	738.4	738.4
87	1	1	10	331.0	5.14	280.4	4	762.1	762.1
87	1	1	11	344.0	5.66	281.5	4	785.8	785.8
87	1	1	12	346.0	2.57	282.6	4	809.6	809.6
87	1	1	13	333.0	6.17	282.6	4	833.3	833.3
87	1	1	14	349.0	6.69	282.6	4	857.0	857.0
87	1	1	15	342.0	6.17	282.6	4	857.0	857.0
87	1	1	16	344.0	7.20	283.2	4	857.0	857.0
87	1	1	17	331.0	6.69	283.2	4	854.5	854.5
87	1	1	18	337.0	7.20	283.2	4	839.3	839.3
87	1	1	19	354.0	6.69	283.2	4	824.1	824.1
87	1	1	20	347.0	5.14	282.6	4	808.8	808.8
87	1	1	21	340.0	3.09	282.6	4	793.6	793.6
87	1	1	22	302.0	3.09	282.0	5	778.4	624.9
87	1	1	23	300.0	1.00	280.4	6	763.2	579.9
87	1	1	24	300.0	1.00	280.4	5	748.0	535.0

*** NOTES: STABILITY CLASS 1=A, 2=B, 3=C, 4=D, 5=E AND 6=F.
FLOW VECTOR IS DIRECTION TOWARD WHICH WIND IS BLOWING.

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96 *** ***

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*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: 1 ***
INCLUDING SOURCE(S): 10001 ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
647500.00	4262500.00	0.00230	649500.00	4262500.00	0.00148
651500.00	4262500.00	0.00135	653500.00	4262500.00	0.00545
655500.00	4262500.00	0.00791	657500.00	4262500.00	0.00631
659500.00	4262500.00	0.00980	661500.00	4262500.00	0.02228
663500.00	4262500.00	0.01335	665500.00	4262500.00	0.01064
667500.00	4262500.00	0.01000	669500.00	4262500.00	0.00826
647500.00	4264500.00	0.00256	649500.00	4264500.00	0.00324
651500.00	4264500.00	0.00171	653500.00	4264500.00	0.00631
655500.00	4264500.00	0.00931	657500.00	4264500.00	0.01271
659500.00	4264500.00	0.02377	661500.00	4264500.00	0.01958
663500.00	4264500.00	0.01276	665500.00	4264500.00	0.01250
667500.00	4264500.00	0.00946	669500.00	4264500.00	0.00765
647500.00	4266500.00	0.00484	649500.00	4266500.00	0.00372
651500.00	4266500.00	0.00265	653500.00	4266500.00	0.00682
655500.00	4266500.00	0.01340	657500.00	4266500.00	0.01659
659500.00	4266500.00	0.03974	661500.00	4266500.00	0.01683
663500.00	4266500.00	0.01616	665500.00	4266500.00	0.01119
667500.00	4266500.00	0.01015	669500.00	4266500.00	0.00830
647500.00	4268500.00	0.00329	649500.00	4268500.00	0.00566
650500.00	4268500.00	0.00488	651500.00	4268500.00	0.00431
652500.00	4268500.00	0.00313	653500.00	4268500.00	0.00627
654500.00	4268500.00	0.01652	655500.00	4268500.00	0.01568
656500.00	4268500.00	0.02426	657500.00	4268500.00	0.05135
658500.00	4268500.00	0.05536	659500.00	4268500.00	0.02880
660500.00	4268500.00	0.02661	661500.00	4268500.00	0.02256
663500.00	4268500.00	0.01419	665500.00	4268500.00	0.01238
667500.00	4268500.00	0.01175	669500.00	4268500.00	0.00594
649500.00	4269500.00	0.00750	650500.00	4269500.00	0.00596
651500.00	4269500.00	0.00675	652500.00	4269500.00	0.00440
653500.00	4269500.00	0.00634	654500.00	4269500.00	0.01946
655500.00	4269500.00	0.01918	656500.00	4269500.00	0.03029
657500.00	4269500.00	0.07031	658500.00	4269500.00	0.03973
659500.00	4269500.00	0.03189	660500.00	4269500.00	0.02759
661500.00	4269500.00	0.02083	647500.00	4270500.00	0.00302
649500.00	4270500.00	0.00525	650500.00	4270500.00	0.00990
651500.00	4270500.00	0.00755	652500.00	4270500.00	0.00548
653500.00	4270500.00	0.00722	654500.00	4270500.00	0.02638
655500.00	4270500.00	0.02943	656500.00	4270500.00	0.07343
657500.00	4270500.00	0.07100	658500.00	4270500.00	0.03957
659500.00	4270500.00	0.03496	660500.00	4270500.00	0.02469

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96 *** ***

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*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: 1 ***
INCLUDING SOURCE(S): 10001 ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC
661500.00	4270500.00	0.02246
663500.00	4270500.00	0.01864
667500.00	4270500.00	0.00482
649500.00	4271500.00	0.00497
651500.00	4271500.00	0.01227
653500.00	4271500.00	0.00740
655500.00	4271500.00	0.05276
657500.00	4271500.00	0.05433
659500.00	4271500.00	0.03092
661500.00	4271500.00	0.02545
663500.00	4271500.00	0.00858
649500.00	4272500.00	0.00322
651500.00	4272500.00	0.01208
652500.00	4272500.00	0.01413
653500.00	4272500.00	0.01051
655000.00	4272500.00	0.05566
656000.00	4272500.00	0.17663
657500.00	4272500.00	0.06696
659500.00	4272500.00	0.03758
661500.00	4272500.00	0.01101
663500.00	4272500.00	0.00851
665500.00	4272500.00	0.00614
669500.00	4272500.00	0.00389
657000.00	4273000.00	0.08316
649500.00	4273500.00	0.00635
651500.00	4273500.00	0.00928
658500.00	4273500.00	0.03398
660500.00	4273500.00	0.01450
662500.00	4273500.00	0.00949
664500.00	4273500.00	0.00641
651500.00	4274000.00	0.00855
647500.00	4274500.00	0.00297
650500.00	4274500.00	0.00826
659500.00	4274500.00	0.01474
660500.00	4274500.00	0.01105
662500.00	4274500.00	0.00870
664500.00	4274500.00	0.00767
667500.00	4274500.00	0.00576
652000.00	4275000.00	0.01888
661000.00	4275000.00	0.01383
662500.00	4270500.00	0.01862
665500.00	4270500.00	0.00738
669500.00	4270500.00	0.00433
650500.00	4271500.00	0.00778
652500.00	4271500.00	0.01170
654500.00	4271500.00	0.03569
656500.00	4271500.00	0.12518
658500.00	4271500.00	0.04668
660500.00	4271500.00	0.02776
662500.00	4271500.00	0.01735
647500.00	4272500.00	0.00347
650500.00	4272500.00	0.00748
652000.00	4272500.00	0.02187
653000.00	4272500.00	0.01575
654500.00	4272500.00	0.05324
655500.00	4272500.00	0.09886
656500.00	4272500.00	0.09260
658500.00	4272500.00	0.04549
660500.00	4272500.00	0.02350
662500.00	4272500.00	0.00929
664500.00	4272500.00	0.00737
667500.00	4272500.00	0.00518
651500.00	4273000.00	0.00954
657500.00	4273000.00	0.05954
650500.00	4273500.00	0.00517
658000.00	4273500.00	0.06188
659500.00	4273500.00	0.01710
661500.00	4273500.00	0.01120
663500.00	4273500.00	0.00814
665500.00	4273500.00	0.00517
659000.00	4274000.00	0.02095
649500.00	4274500.00	0.00668
651500.00	4274500.00	0.01391
660000.00	4274500.00	0.01245
661500.00	4274500.00	0.00946
663500.00	4274500.00	0.00820
665500.00	4274500.00	0.00706
669500.00	4274500.00	0.00464
660500.00	4275000.00	0.01553
649500.00	4275500.00	0.01345

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJN 4/24/96 *** *** PA

*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: 1 ***
INCLUDING SOURCE(S): 10001 .

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC
650500.00	4275500.00	0.01910
652500.00	4275500.00	0.03027
662500.00	4275500.00	0.01286
664500.00	4275500.00	0.00940
653000.00	4276000.00	0.10288
661500.00	4276000.00	0.01388
649500.00	4276500.00	0.00993
651500.00	4276500.00	0.04636
653500.00	4276500.00	0.22147
661500.00	4276500.00	0.01423
663500.00	4276500.00	0.00892
665500.00	4276500.00	0.00696
669500.00	4276500.00	0.00543
655000.00	4277000.00	0.25191
661500.00	4277000.00	0.01550
650500.00	4277500.00	0.04089
652500.00	4277500.00	0.09465
654500.00	4277500.00	0.16073
656000.00	4277500.00	0.21016
662500.00	4277500.00	0.01255
664500.00	4277500.00	0.00980
656500.00	4278000.00	0.14935
647500.00	4278500.00	0.02825
650500.00	4278500.00	0.09203
652500.00	4278500.00	0.11696
654500.00	4278500.00	0.14594
656500.00	4278500.00	0.11566
657500.00	4278500.00	0.09954
658500.00	4278500.00	0.05664
659500.00	4278500.00	0.03891
660500.00	4278500.00	0.03648
661500.00	4278500.00	0.02138
663500.00	4278500.00	0.01038
665500.00	4278500.00	0.00806
651500.00	4275500.00	0.02046
661500.00	4275500.00	0.01551
663500.00	4275500.00	0.01090
665500.00	4275500.00	0.00823
653500.00	4276000.00	0.17507
647500.00	4276500.00	0.01071
650500.00	4276500.00	0.02699
652500.00	4276500.00	0.10269
654000.00	4276500.00	0.21404
662500.00	4276500.00	0.01099
664500.00	4276500.00	0.00770
667500.00	4276500.00	0.00606
654500.00	4277000.00	0.20311
655500.00	4277000.00	0.29605
649500.00	4277500.00	0.03247
651500.00	4277500.00	0.05493
653500.00	4277500.00	0.09038
655500.00	4277500.00	0.17120
661500.00	4277500.00	0.01420
663500.00	4277500.00	0.01106
665500.00	4277500.00	0.00857
661500.00	4278000.00	0.01585
649500.00	4278500.00	0.03911
651500.00	4278500.00	0.11805
653500.00	4278500.00	0.12221
655500.00	4278500.00	0.12718
657000.00	4278500.00	0.12087
658000.00	4278500.00	0.07172
659000.00	4278500.00	0.05051
660000.00	4278500.00	0.03621
661000.00	4278500.00	0.02869
662500.00	4278500.00	0.01427
664500.00	4278500.00	0.00868
667500.00	4278500.00	0.00673

669500.00	4278500.00	0.00575	649500.00	4279500.00	0.06690
650500.00	4279500.00	0.01629	651500.00	4279500.00	0.09264
652500.00	4279500.00	0.08273	653500.00	4279500.00	0.09431
654500.00	4279500.00	0.10452	655500.00	4279500.00	0.11069
656500.00	4279500.00	0.08826	657500.00	4279500.00	0.09012
658500.00	4279500.00	0.07023	659500.00	4279500.00	0.04131

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96 *** ***

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*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: 1 ***
INCLUDING SOURCE(S): 10001 .

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
660500.00	4279500.00	0.03494	661500.00	4279500.00	0.02460
662500.00	4279500.00	0.02554	663500.00	4279500.00	0.01704
664500.00	4279500.00	0.01177	665500.00	4279500.00	0.00904
647500.00	4280500.00	0.03762	649500.00	4280500.00	0.06901
650500.00	4280500.00	0.05665	651500.00	4280500.00	0.07267
652500.00	4280500.00	0.06288	653500.00	4280500.00	0.07165
654500.00	4280500.00	0.08069	655500.00	4280500.00	0.06701
656500.00	4280500.00	0.08564	657500.00	4280500.00	0.05533
658500.00	4280500.00	0.07434	659500.00	4280500.00	0.05241
660500.00	4280500.00	0.03401	661500.00	4280500.00	0.02769
662500.00	4280500.00	0.02287	663500.00	4280500.00	0.01832
664500.00	4280500.00	0.01933	665500.00	4280500.00	0.01408
667500.00	4280500.00	0.00786	669500.00	4280500.00	0.00529
651500.00	4281500.00	0.04726	652500.00	4281500.00	0.04626
653500.00	4281500.00	0.05648	654500.00	4281500.00	0.06491
655500.00	4281500.00	0.05302	656500.00	4281500.00	0.06452
657500.00	4281500.00	0.05084	658500.00	4281500.00	0.05475
659500.00	4281500.00	0.05964	660500.00	4281500.00	0.04128
661500.00	4281500.00	0.02933	662500.00	4281500.00	0.02245
663500.00	4281500.00	0.02071	664500.00	4281500.00	0.01595
647500.00	4282500.00	0.03468	649500.00	4282500.00	0.04037
651500.00	4282500.00	0.03971	652500.00	4282500.00	0.04025
653500.00	4282500.00	0.04837	654500.00	4282500.00	0.05374
655500.00	4282500.00	0.04465	656500.00	4282500.00	0.05448
657500.00	4282500.00	0.04625	658500.00	4282500.00	0.03965
659500.00	4282500.00	0.05136	660500.00	4282500.00	0.04766
661500.00	4282500.00	0.03368	662500.00	4282500.00	0.02555
663500.00	4282500.00	0.01875	665500.00	4282500.00	0.01566
667500.00	4282500.00	0.01222	669500.00	4282500.00	0.01030
647500.00	4284500.00	0.02086	649500.00	4284500.00	0.02853
651500.00	4284500.00	0.02668	653500.00	4284500.00	0.03777
655500.00	4284500.00	0.03247	657500.00	4284500.00	0.03717
659500.00	4284500.00	0.03040	661500.00	4284500.00	0.03804
663500.00	4284500.00	0.02418	665500.00	4284500.00	0.01482
667500.00	4284500.00	0.01251	669500.00	4284500.00	0.00949
647500.00	4286500.00	0.02532	649500.00	4286500.00	0.01940
651500.00	4286500.00	0.02113	653500.00	4286500.00	0.02959
655500.00	4286500.00	0.02383	657500.00	4286500.00	0.02755
659500.00	4286500.00	0.02622	661500.00	4286500.00	0.02209
663500.00	4286500.00	0.02702	665500.00	4286500.00	0.01857

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96 *** ***

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*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: 1 ***
INCLUDING SOURCE(S): 10001 .

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
667500.00	4286500.00	0.01279	669500.00	4286500.00	0.01000
652035.00	4272622.00	0.02191	652282.00	4272662.00	0.02286
652528.00	4272702.00	0.01667	652775.00	4272743.00	0.01651
652869.00	4272758.00	0.01739	653118.00	4272777.00	0.01773
653368.00	4272796.00	0.01226	653623.00	4272816.00	0.01174
653620.00	4273037.00	0.01393	653799.00	4273086.00	0.01379
653800.00	4272818.00	0.01350	654049.00	4272836.00	0.03004
654299.00	4272854.00	0.04444	654548.00	4272872.00	0.06384
654797.00	4272890.00	0.05948	654874.00	4272896.00	0.06431
655123.00	4272916.00	0.09070	655372.00	4272937.00	0.14522
655622.00	4272957.00	0.20451	655871.00	4272977.00	0.17426
656120.00	4272997.00	0.11590	656369.00	4273018.00	0.10644
656618.00	4273038.00	0.10515	656867.00	4273058.00	0.08900
657117.00	4273079.00	0.07381	657317.00	4273095.00	0.06419
657317.00	4273345.00	0.07178	657317.00	4273579.00	0.07237
657447.00	4273587.00	0.07018	657680.00	4273677.00	0.06900

657914.00	4273766.00	0.04164	658147.00	4273856.00	0.02633
658227.00	4273887.00	0.02503	658440.00	4274018.00	0.02401
658653.00	4274150.00	0.02295	658812.00	4274248.00	0.02078
659040.00	4274350.00	0.01964	659268.00	4274452.00	0.01708
659497.00	4274554.00	0.01424	659521.00	4274565.00	0.01406
659693.00	4274747.00	0.01423	659767.00	4274825.00	0.01550
659996.00	4274924.00	0.01694	660226.00	4275024.00	0.01647
660464.00	4275127.00	0.01459	660645.00	4275182.00	0.01361
660857.00	4275314.00	0.01375	661069.00	4275447.00	0.01581
661118.00	4275477.00	0.01631	661114.00	4275727.00	0.01848
661110.00	4275977.00	0.01685	661105.00	4276227.00	0.01352
661101.00	4276477.00	0.01568	661097.00	4276727.00	0.01686
661093.00	4276977.00	0.01660	661089.00	4277227.00	0.01597
661085.00	4277477.00	0.01502	661080.00	4277727.00	0.01596
661076.00	4277977.00	0.01847	661072.00	4278227.00	0.02160
661068.00	4278467.00	0.02665	660810.00	4278461.00	0.03096
660669.00	4278458.00	0.03359	660551.00	4278420.00	0.03481
660380.00	4278466.00	0.03743	660131.00	4278487.00	0.03725
660094.00	4278490.00	0.03699	659844.00	4278496.00	0.03574
659594.00	4278502.00	0.03731	659344.00	4278508.00	0.04272
659094.00	4278514.00	0.04888	659042.00	4278515.00	0.04986
658796.00	4278472.00	0.05345	658549.00	4278429.00	0.05673
658303.00	4278386.00	0.06019	658057.00	4278343.00	0.06498
657811.00	4278300.00	0.07526	657564.00	4278257.00	0.08984

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96 ***
*** ***

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*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: 1 ***
INCLUDING SOURCE(S): 10001 ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
657441.00	4278236.00	0.09554	657457.00	4278143.00	0.09122
657632.00	4278118.00	0.07869	657727.00	4278133.00	0.07455
657725.00	4278068.00	0.07385	657601.00	4278054.00	0.07806
657403.00	4277901.00	0.08330	657359.00	4277867.00	0.08450
657306.00	4277884.00	0.08838	657309.00	4277963.00	0.09237
657247.00	4277919.00	0.09459	657135.00	4277931.00	0.10302
657013.00	4277911.00	0.11001	656919.00	4277947.00	0.11726
656800.00	4277753.00	0.12149	656885.00	4277700.00	0.11344
656762.00	4277635.00	0.12151	656730.00	4277656.00	0.12471
656640.00	4277574.00	0.13023	656516.00	4277487.00	0.13932
656294.00	4277372.00	0.16496	656072.00	4277258.00	0.20006
655928.00	4277184.00	0.22293	656035.00	4276958.00	0.18112
656142.00	4276732.00	0.14798	656179.00	4276654.00	0.14105
655958.00	4276537.00	0.16185	655878.00	4276495.00	0.17003
655766.00	4276718.00	0.21990	655654.00	4276942.00	0.27863
655613.00	4277023.00	0.28058	655390.00	4276910.00	0.29916
655187.00	4276796.00	0.28061	654945.00	4276683.00	0.31761
654722.00	4276569.00	0.33057	654568.00	4276491.00	0.29638
654574.00	4276261.00	0.41184	654350.00	4276151.00	0.41699
654305.00	4276129.00	0.45615	654211.00	4276313.00	0.34622
654103.00	4276251.00	0.26967	654135.00	4276174.00	0.29253
654118.00	4276114.00	0.28547	654079.00	4276078.00	0.25876
653993.00	4276057.00	0.26866	653906.00	4276040.00	0.31291
653848.00	4276002.00	0.28643	653638.00	4275866.00	0.18587
653582.00	4275830.00	0.17474	653363.00	4275686.00	0.07848
653124.00	4275612.00	0.04453	653049.00	4275589.00	0.04369
652825.00	4275494.00	0.03622	652668.00	4275350.00	0.03062
652489.00	4275143.00	0.01806	652395.00	4275048.00	0.02104
652295.00	4274819.00	0.01967	652193.00	4274585.00	0.01954
652158.00	4274554.00	0.01859	652102.00	4274534.00	0.01823
651953.00	4274516.00	0.01818	651908.00	4274502.00	0.01770
651882.00	4274463.00	0.01679	651816.00	4274316.00	0.01257
651794.00	4274236.00	0.01074	651763.00	4273988.00	0.00900
651744.00	4273834.00	0.00825	651773.00	4273586.00	0.01284
651789.00	4273454.00	0.01434	651822.00	4273206.00	0.01035
651856.00	4272958.00	0.01429	651887.00	4272726.00	0.01666
652006.00	4272746.00	0.01898			

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Coarse/87/Revised/Cancer*1e06 - BJM 4/24/96 ***
*** ***

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*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** THE SUMMARY OF MAXIMUM PERIOD (8760 HRS) RESULTS ***

NOTE: THESE RISKS ARE AT OCCUPATIONAL RECEPTORS AND MUST BE ADJUSTED PER CAPCOA

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

GROUP ID	AVERAGE CONC	RECEPTOR (XR, YR, ZELEV, ZFLAG)	OF TYPE	NETWORK GRID-ID
1	1ST HIGHEST VALUE IS	0.45615 AT (654305.00, 4276129.00, 46.37, 0.00)	DC	

```
          2ND HIGHEST VALUE IS      0.41699 AT (  654350.00,  4276151.00,     46.51,     0.00) DC
          3RD HIGHEST VALUE IS      0.41184 AT (  654574.00,  4276261.00,     46.91,     0.00) DC


 *** RECEPTOR TYPES:  GC = GRIDCART
                      GP = GRIDPOLR
                      DC = DISCCART
                      DP = DISCPOLR
                      BD = BOUNDARY
1 *** ISCST2 - VERSION 92062 ***     *** Aerojet EE/CA - Coarse/87/Revised/Cancer*le06 - BJH 4/24/96          ***
                                     ***                                                                     ***
                                                                                                        PAGE  19
  *** MODELING OPTIONS USED:  CONC   RURAL  ELEV                                    NOCALM


 *** Message Summary For ISC2 Model Execution ***

  --------- Summary of Total Messages --------

 A Total of    0 Fatal Error Message(s)
 A Total of    0 Warning Message(s)
 A Total of    1887 Informational Message(s)

 A Total of    1887 Calm Hours Identified


    ******** FATAL ERROR MESSAGES ********
               *** NONE ***


    *********   WARNING MESSAGES   *********
               *** NONE ***


    ***********************************
    *** ISCST2 Finishes Successfully ***
    ***********************************
```

NO ECHO

```
**********************************
*** SETUP Finishes Successfully ***
**********************************

1 *** ISCST2 - VERSION 92062 ***     *** Aerojet EE/CA - Fine/87/Revised/Cancer*1e06 - BJM 4/24/96          ***
                                     ***                                                                   ***
                                                                                                          PAGE   1

                                                                                                  MODCALM
 *** MODELING OPTIONS USED:  CONC   RURAL  ELEV

                                          ***     MODEL SETUP OPTIONS SUMMARY      ***
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

 **Model Is Setup For Calculation of Average CONCentration Values.

 **Model Uses RURAL Dispersion.

 **Model Uses User-Specified Options:
          1. Final Plume Rise.
          2. Stack-tip Downwash.
          3. Buoyancy-induced Dispersion.
          4. Not Use Calms Processing Routine.
          5. Not Use Missing Data Processing Routine.
          6. Default Wind Profile Exponents.
          7. Default Vertical Potential Temperature Gradients.

 **Model Accepts Receptors on ELEV Terrain.

 **Model Assumes No FLAGPOLE Receptor Heights.

 **Model Calculates PERIOD Averages Only

 **This Run Includes:     1 Source(s);     1 Source Group(s); and    165 Receptor(s)

 **The Model Assumes A Pollutant Type of:  CANCER

 **Model Set To Continue RUNning After the Setup Testing.

 **Output Options Selected:
          Model Outputs Tables of PERIOD Averages by Receptor
          Model Outputs External File(s) of High Values for Plotting (PLOTFILE Keyword)

 **Misc. Inputs:  Anem. Hgt. (m) =    10.00 ;   Decay Coef. =       0.     ;   Rot. Angle =     0.0
                  Emission Units = (GRAMS/SEC)                               ;  Emission Rate Unit Factor =   0.10000E+07
                  Output Units   = (MICROGRAMS/CUBIC-METER)

 **Detailed Error/Message File:  ERRORS.OUT
1 *** ISCST2 - VERSION 92062 ***     *** Aerojet EE/CA - Fine/87/Revised/Cancer*1e06 - BJM 4/24/96          ***
                                     ***                                                                   ***
                                                                                                          PAGE   2

                                                                                                  MODCALM
  *** MODELING OPTIONS USED:  CONC   RURAL  ELEV

                                                *** POINT SOURCE DATA ***

                                                                                                                  BUILDING EMISSION RATE
                  NUMBER  EMISSION RATE                                BASE     STACK   STACK     STACK    STACK    EXISTS   SCALAR VARY
    SOURCE        PART.   (USER UNITS)      X          Y              ELEV.    HEIGHT  TEMP.    EXIT VEL.  DIAMETER           BY
     ID           CATS.                   (METERS)   (METERS)       (METERS) (METERS) (DEG.K)  (M/SEC)   (METERS)
- - - - - - - - - - - - - - - - - - - -
```

(653400.0,	4276700.0,	42.9,	0.0);	(653600.0,	4276900.0,	42.0,	0.0);
(653400.0,	4276900.0,	41.1,	0.0);	(653500.0,	4276300.0,	44.2,	0.0);
(653500.0,	4276400.0,	44.6,	0.0);	(653500.0,	4276500.0,	45.0,	0.0);
(653500.0,	4276600.0,	44.1,	0.0);	(653500.0,	4276700.0,	43.3,	0.0);
(653500.0,	4276800.0,	42.4,	0.0);	(653500.0,	4276900.0,	41.6,	0.0);
(653500.0,	4277000.0,	40.7,	0.0);	(653600.0,	4276400.0,	44.9,	0.0);
(653600.0,	4276500.0,	45.0,	0.0);	(653600.0,	4276600.0,	44.1,	0.0);
(653600.0,	4276700.0,	43.3,	0.0);	(653600.0,	4276800.0,	42.4,	0.0);
(653600.0,	4276900.0,	41.6,	0.0);	(653600.0,	4277000.0,	41.1,	0.0);
(653600.0,	4277100.0,	40.2,	0.0);	(653700.0,	4276400.0,	44.9,	0.0);
(653700.0,	4276500.0,	45.0,	0.0);	(653700.0,	4276600.0,	44.1,	0.0);
(653700.0,	4276700.0,	43.3,	0.0);	(653700.0,	4276800.0,	42.4,	0.0);
(653700.0,	4276900.0,	42.6,	0.0);	(653700.0,	4277000.0,	41.6,	0.0);
(653700.0,	4277100.0,	40.7,	0.0);	(653800.0,	4276500.0,	45.0,	0.0);
(653800.0,	4276600.0,	44.1,	0.0);	(653800.0,	4276700.0,	43.3,	0.0);
(653800.0,	4276800.0,	42.9,	0.0);	(653800.0,	4276900.0,	42.5,	0.0);
(653800.0,	4277000.0,	42.0,	0.0);	(653800.0,	4277100.0,	41.1,	0.0);
(653800.0,	4277200.0,	40.2,	0.0);	(653900.0,	4276500.0,	45.0,	0.0);
(653900.0,	4276600.0,	44.1,	0.0);	(653900.0,	4276700.0,	43.7,	0.0);
(653900.0,	4276800.0,	43.3,	0.0);	(653900.0,	4276900.0,	42.9,	0.0);
(653900.0,	4277000.0,	42.5,	0.0);	(653900.0,	4277100.0,	41.5,	0.0);
(653900.0,	4277200.0,	41.6,	0.0);	(654000.0,	4276600.0,	44.6,	0.0);
(654000.0,	4276700.0,	44.2,	0.0);	(654000.0,	4276800.0,	43.8,	0.0);
(654000.0,	4276900.0,	43.3,	0.0);	(654000.0,	4277000.0,	42.9,	0.0);
(654000.0,	4277100.0,	43.0,	0.0);	(654000.0,	4277200.0,	43.0,	0.0);
(654000.0,	4277300.0,	43.1,	0.0);	(654100.0,	4276600.0,	44.8,	0.0);
(654100.0,	4276700.0,	44.4,	0.0);	(654100.0,	4276800.0,	43.9,	0.0);
(654100.0,	4276900.0,	43.5,	0.0);	(654100.0,	4277000.0,	43.3,	0.0);
(654100.0,	4277100.0,	43.4,	0.0);	(654100.0,	4277200.0,	43.5,	0.0);
(654100.0,	4277300.0,	43.5,	0.0);	(654200.0,	4276700.0,	44.6,	0.0);
(654200.0,	4276800.0,	44.1,	0.0);	(654200.0,	4276900.0,	43.9,	0.0);
(654200.0,	4277000.0,	43.8,	0.0);	(654200.0,	4277100.0,	43.8,	0.0);
(654200.0,	4277200.0,	43.9,	0.0);	(654200.0,	4277300.0,	43.9,	0.0);
(654200.0,	4277400.0,	43.9,	0.0);	(654300.0,	4276800.0,	44.6,	0.0);
(654300.0,	4276900.0,	44.4,	0.0);	(654300.0,	4277000.0,	44.2,	0.0);
(654300.0,	4277100.0,	44.2,	0.0);	(654300.0,	4277200.0,	44.3,	0.0);
(654300.0,	4277300.0,	44.3,	0.0);	(654300.0,	4277400.0,	44.3,	0.0);
(654400.0,	4276800.0,	45.0,	0.0);	(654400.0,	4276900.0,	44.8,	0.0);
(654400.0,	4277000.0,	44.6,	0.0);	(654400.0,	4277100.0,	44.6,	0.0);
(654400.0,	4277200.0,	44.6,	0.0);	(654400.0,	4277300.0,	44.6,	0.0);
(654400.0,	4277400.0,	44.6,	0.0);	(654400.0,	4277500.0,	44.6,	0.0);
(654500.0,	4276900.0,	45.2,	0.0);	(654500.0,	4277000.0,	45.0,	0.0);
(654500.0,	4277100.0,	45.0,	0.0);	(654500.0,	4277200.0,	45.0,	0.0);

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Fine/87/Revised/Cancer*1e06 - BJH 4/24/96 ***
***

*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** DISCRETE CARTESIAN RECEPTORS ***
(X-COORD, Y-COORD, ZELEV, ZFLAG)
(METERS)

(654500.0,	4277300.0,	45.0,	0.0);	(654500.0,	4277400.0,	45.0,	0.0);
(654500.0,	4277500.0,	45.0,	0.0);	(654600.0,	4276900.0,	45.5,	0.0);
(654600.0,	4277000.0,	45.2,	0.0);	(654600.0,	4277100.0,	45.2,	0.0);
(654600.0,	4277200.0,	45.2,	0.0);	(654600.0,	4277300.0,	45.2,	0.0);
(654600.0,	4277400.0,	45.2,	0.0);	(654600.0,	4277500.0,	45.2,	0.0);
(654600.0,	4277600.0,	46.6,	0.0);	(654700.0,	4277000.0,	45.4,	0.0);
(654700.0,	4277100.0,	45.4,	0.0);	(654700.0,	4277200.0,	45.4,	0.0);
(654700.0,	4277300.0,	45.4,	0.0);	(654700.0,	4277400.0,	45.4,	0.0);
(654700.0,	4277500.0,	45.5,	0.0);	(654700.0,	4277600.0,	46.8,	0.0);
(654800.0,	4277000.0,	45.6,	0.0);	(654800.0,	4277100.0,	45.6,	0.0);
(654800.0,	4277200.0,	45.6,	0.0);	(654800.0,	4277300.0,	45.6,	0.0);
(654800.0,	4277400.0,	45.7,	0.0);	(654800.0,	4277500.0,	45.7,	0.0);
(654800.0,	4277600.0,	47.1,	0.0);	(654800.0,	4277700.0,	48.4,	0.0);
(654900.0,	4277100.0,	45.8,	0.0);	(654900.0,	4277200.0,	45.8,	0.0);
(654900.0,	4277300.0,	45.9,	0.0);	(654900.0,	4277400.0,	45.9,	0.0);
(654900.0,	4277500.0,	46.0,	0.0);	(654900.0,	4277600.0,	47.3,	0.0);
(654900.0,	4277700.0,	48.0,	0.0);	(655000.0,	4277200.0,	46.1,	0.0);
(655000.0,	4277300.0,	46.1,	0.0);	(655000.0,	4277400.0,	46.2,	0.0);
(655000.0,	4277500.0,	46.2,	0.0);	(655000.0,	4277600.0,	46.9,	0.0);
(655000.0,	4277700.0,	47.6,	0.0);	(655000.0,	4277800.0,	48.3,	0.0);
(655100.0,	4277200.0,	46.9,	0.0);	(655100.0,	4277300.0,	46.9,	0.0);
(655100.0,	4277400.0,	47.0,	0.0);	(655100.0,	4277500.0,	46.0,	0.0);
(655100.0,	4277600.0,	46.7,	0.0);	(655100.0,	4277700.0,	47.4,	0.0);
(655100.0,	4277800.0,	48.0,	0.0);	(655200.0,	4277300.0,	47.7,	0.0);
(655200.0,	4277400.0,	46.7,	0.0);	(655200.0,	4277500.0,	45.7,	0.0);
(655200.0,	4277600.0,	46.4,	0.0);	(655200.0,	4277700.0,	47.1,	0.0);
(655200.0,	4277800.0,	47.8,	0.0);	(655200.0,	4277900.0,	48.1,	0.0);
(655300.0,	4277300.0,	47.5,	0.0);	(655300.0,	4277400.0,	46.5,	0.0);
(655300.0,	4277500.0,	45.5,	0.0);	(655300.0,	4277600.0,	46.2,	0.0);
(655300.0,	4277700.0,	46.9,	0.0);	(655300.0,	4277800.0,	47.2,	0.0);
(655300.0,	4277900.0,	47.4,	0.0);	(655400.0,	4277400.0,	46.2,	0.0);
(655400.0,	4277500.0,	45.2,	0.0);	(655400.0,	4277600.0,	45.9,	0.0);
(655400.0,	4277700.0,	46.2,	0.0);	(655400.0,	4277800.0,	46.5,	0.0);
(655400.0,	4277900.0,	46.8,	0.0);	(655400.0,	4278000.0,	47.1,	0.0);
(655500.0,	4277400.0,	46.0,	0.0);	(655500.0,	4277500.0,	45.0,	0.0);
(655500.0,	4277600.0,	45.3,	0.0);	(655500.0,	4277700.0,	45.6,	0.0);
(655500.0,	4277800.0,	45.9,	0.0);	(655500.0,	4277900.0,	46.2,	0.0);

(655500.0, 4278000.0, 46.4, 0.0); *** ***
1 *** ISCST2 - VERSION 92062 *** *** Aerojet RE/CA - Fine/87/Revised/Cancer*1e06 - BJN 4/26/96 *** ***
*** ***

NOCALM

*** MODELING OPTIONS USED: CONC RURAL ELEV

*** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***
(1=YES; 0=NO)

1 1 1

87	1	1	20	347.0	5.14	282.6	4	808.8	808.8	
87	1	1	21	340.0	3.09	282.6	4	793.6	793.6	
87	1	1	22	302.0	3.09	282.0	5	778.4	624.9	
87	1	1	23	300.0	1.00	280.4	6	763.2	579.9	
87	1	1	24	300.0	1.00	280.4	5	748.0	535.0	

*** NOTES: STABILITY CLASS 1=A, 2=B, 3=C, 4=D, 5=E AND 6=F.
FLOW VECTOR IS DIRECTION TOWARD WHICH WIND IS BLOWING.

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Fine/87/Revised/Cancer*1e06 - BJN 4/24/96 ***
*** ***

*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: 1 ***
INCLUDING SOURCE(S): 10001 .

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
653400.00	4276300.00	0.19179	653400.00	4276400.00	0.23976
653400.00	4276500.00	0.22961	653400.00	4276600.00	0.19378
653400.00	4276700.00	0.19143	653400.00	4276800.00	0.19254
653400.00	4276900.00	0.18194	653500.00	4276300.00	0.25258
653500.00	4276400.00	0.23538	653500.00	4276500.00	0.22147
653500.00	4276600.00	0.22377	653500.00	4276700.00	0.21907
653500.00	4276800.00	0.19569	653500.00	4276900.00	0.16915
653500.00	4277000.00	0.14552	653600.00	4276400.00	0.24236
653600.00	4276500.00	0.25739	653600.00	4276600.00	0.23514
653600.00	4276700.00	0.20131	653600.00	4276800.00	0.17044
653600.00	4276900.00	0.14901	653600.00	4277000.00	0.13629
653600.00	4277100.00	0.12437	653700.00	4276400.00	0.27086
653700.00	4276500.00	0.24415	653700.00	4276600.00	0.20273
653700.00	4276700.00	0.17492	653700.00	4276800.00	0.15573
653700.00	4276900.00	0.14428	653700.00	4277000.00	0.13462
653700.00	4277100.00	0.12341	653800.00	4276500.00	0.20860
653800.00	4276600.00	0.18348	653800.00	4276700.00	0.16532
653800.00	4276800.00	0.15357	653800.00	4276900.00	0.14402
653800.00	4277000.00	0.13674	653800.00	4277100.00	0.12978
653800.00	4277200.00	0.12398	653900.00	4276500.00	0.19656
653900.00	4276600.00	0.17853	653900.00	4276700.00	0.17040
653900.00	4276800.00	0.16512	653900.00	4276900.00	0.15991
653900.00	4277000.00	0.15386	653900.00	4277100.00	0.14421
653900.00	4277200.00	0.14142	654000.00	4276600.00	0.20523
654000.00	4276700.00	0.19598	654000.00	4276800.00	0.18762
654000.00	4276900.00	0.17912	654000.00	4277000.00	0.17148
654000.00	4277100.00	0.16705	654000.00	4277200.00	0.16151
654000.00	4277300.00	0.15651	654100.00	4276600.00	0.23337
654100.00	4276700.00	0.22077	654100.00	4276800.00	0.20848
654100.00	4276900.00	0.19855	654100.00	4277000.00	0.19130
654100.00	4277100.00	0.18690	654100.00	4277200.00	0.18266
654100.00	4277300.00	0.17783	654200.00	4276700.00	0.27384
654200.00	4276800.00	0.25766	654200.00	4276900.00	0.24581
654200.00	4277000.00	0.23545	654200.00	4277100.00	0.22637
654200.00	4277200.00	0.21840	654200.00	4277300.00	0.20982
654200.00	4277400.00	0.20158	654300.00	4276800.00	0.28004
654300.00	4276900.00	0.26363	654300.00	4277000.00	0.24871
654300.00	4277100.00	0.23694	654300.00	4277200.00	0.22685
654300.00	4277300.00	0.21656	654300.00	4277400.00	0.20695
654400.00	4276800.00	0.24319	654400.00	4276900.00	0.22955

1 *** ISCST2 - VERSION 92062 *** *** Aerojet EE/CA - Fine/87/Revised/Cancer*1e06 - BJN 4/24/96 ***
*** ***

*** MODELING OPTIONS USED: CONC RURAL ELEV NOCALM

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: 1 ***
INCLUDING SOURCE(S): 10001 .

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
654400.00	4277000.00	0.21723	654400.00	4277100.00	0.20754
654400.00	4277200.00	0.19858	654400.00	4277300.00	0.19027
654400.00	4277400.00	0.18253	654400.00	4277500.00	0.17509
654500.00	4276900.00	0.21471	654500.00	4277000.00	0.20311
654500.00	4277100.00	0.19366	654500.00	4277200.00	0.18468
654500.00	4277300.00	0.17622	654500.00	4277400.00	0.16831
654500.00	4277500.00	0.16073	654600.00	4276900.00	0.20642
654600.00	4277000.00	0.19321	654600.00	4277100.00	0.18450
654600.00	4277200.00	0.17703	654600.00	4277300.00	0.17024
654600.00	4277400.00	0.16373	654600.00	4277500.00	0.15715
654600.00	4277600.00	0.15752	654700.00	4277000.00	0.20504
654700.00	4277100.00	0.18839	654700.00	4277200.00	0.17578

654700.00	4277300.00	0.16589	654780.00	4277480.00	0.15775
654700.00	4277500.00	0.15123	654780.00	4277680.00	0.15127
654800.00	4277000.00	0.23827	654880.00	4277180.00	0.22029
654800.00	4277200.00	0.20037	654880.00	4277380.00	0.18189
654800.00	4277400.00	0.16713	654880.00	4277580.00	0.15502
654800.00	4277600.00	0.15201	654880.00	4277780.00	0.14951
654900.00	4277100.00	0.22874	654980.00	4277280.00	0.21755
654900.00	4277300.00	0.20769	654980.00	4277480.00	0.19408
654900.00	4277500.00	0.17904	654980.00	4277680.00	0.17040
654900.00	4277700.00	0.15915	655080.00	4277280.00	0.22660
655000.00	4277300.00	0.21027	655080.00	4277480.00	0.19874
655000.00	4277500.00	0.19018	655080.00	4277680.00	0.18605
655000.00	4277700.00	0.17933	655080.00	4277880.00	0.16995
655100.00	4277200.00	0.23053	655180.00	4277380.00	0.22386
655100.00	4277400.00	0.21311	655180.00	4277580.00	0.19208
655100.00	4277600.00	0.18378	655180.00	4277780.00	0.17858
655100.00	4277800.00	0.17491	655280.00	4277380.00	0.21639
655200.00	4277400.00	0.20384	655280.00	4277580.00	0.19336
655200.00	4277600.00	0.19032	655280.00	4277780.00	0.18325
655200.00	4277800.00	0.17482	655280.00	4277980.00	0.16624
655300.00	4277300.00	0.21296	655380.00	4277480.00	0.19634
655300.00	4277500.00	0.18182	655380.00	4277680.00	0.18021
655300.00	4277700.00	0.18080	655380.00	4277880.00	0.17764
655300.00	4277900.00	0.17045	655480.00	4277480.00	0.19087
655400.00	4277500.00	0.17905	655480.00	4277680.00	0.17373
655400.00	4277700.00	0.16734	655480.00	4277880.00	0.16416
655400.00	4277900.00	0.16322	655480.00	4278000.00	0.16159
655500.00	4277400.00	0.18069	655500.00	4277500.00	0.17120

MOCALM

*** MODELING OPTIONS USED: CONC RURAL ELEV

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: 1 ***
INCLUDING SOURCE(S): 10001 .

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
655500.00	4277600.00	0.16819	655500.00	4277700.00	0.16358
655500.00	4277800.00	0.15746	655500.00	4277900.00	0.15205
655500.00	4278000.00	0.14887			

MOCALM

*** MODELING OPTIONS USED: CONC RURAL ELEV

*** THE SUMMARY OF MAXIMUM PERIOD (8760 HRS) RESULTS ***

** CONC OF CANCER IN (MICROGRAMS/CUBIC-METER) **

GROUP ID		AVERAGE CONC	RECEPTOR (XR, YR, ZELEV, ZFLAG)				OF TYPE	NETWORK GRID-ID
1	1ST HIGHEST VALUE IS	0.28004 AT	(654300.00,	4276800.00,	44.60,	0.00)	DC	
	2ND HIGHEST VALUE IS	0.27384 AT	(654200.00,	4276700.00,	44.60,	0.00)	DC	
	3RD HIGHEST VALUE IS	0.27084 AT	(653700.00,	4276400.00,	44.90,	0.00)	DC	

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR
BD = BOUNDARY

MOCALM

*** MODELING OPTIONS USED: CONC RURAL ELEV

*** Message Summary For ISC2 Model Execution ***

--------- Summary of Total Messages --------

A Total of 0 Fatal Error Message(s)
A Total of 0 Warning Message(s)
A Total of 1887 Informational Message(s)

A Total of 1887 Calm Hours Identified

******** FATAL ERROR MESSAGES ********
*** NONE ***

APPENDIX L

Air Stripper T-BACT - Review of Candidate Technologies

RADIAN INTERNATIONAL LLC

MEMORANDUM

To: Craig Fegan, Aerojet

From: Russ Henning, Radian

Date: May 2, 1996

Subject: **Air Stripper TBACT - Review of Candidate Technologies**

OVERVIEW

The planned technology for volatile organic compound (VOC) removal from the groundwater stream is an air stripper. It is likely that the toxic best available control technology (TBACT) will be no control of air emissions. Removal of VOCs from an air stream at the expected stripper outlet concentrations is anticipated to be cost-prohibitive. Of the technologies evaluated, the few that might be effective at removing chlorinated VOCs from the air stripper exhaust would cost over $100,000 per ton VOC removed.

The following technologies were reviewed for this analysis:

- Carbon adsorption;
- Thermal incineration;
- Catalytic incineration;
- Concentration followed by thermal incineration; and
- Biofiltration.

Of these candidate technologies, concentration followed by thermal incineration was deemed to have the most potential for removal of the chlorinated VOCs. This technology was further studied in the second phase of this analysis, but was found to be extremely expensive; the estimated cost is approximately $110,000 per ton VOC removed (Patkar, 1996).

DEFINITION OF TBACT

TBACT is required for all new sources that result in an incremental maximum exposed individual (MEI) cancer risk of 1×10^{-7} (SMAQMD, 1994). The TBACT selection methodology is not as clearly laid out in U.S. EPA and SMAQMD guidance as is the BACT selection methodology. In the absence of regulatory guidance, TBACT selection is a

discretionary process. However, the technologies considered and adopted as TBACT generally correlate with the technologies considered as BACT for pollutants of similar physical characteristics (e.g. particulate matter, volatile organic, acid gas, etc.).

The cost-effectiveness criteria (dollars per ton VOC removed) used in BACT selection may not be directly applicable to TBACT. However, as a frame of reference, the cost-effectiveness threshold in Sacramento for BACT determinations for reactive organic compound (ROC) control is $17,500/ton (De Guzman, 1995).

PROJECT DESCRIPTION

An air stripper is the planned treatment operation for removal of VOCs from groundwater. The air flow from the air stripper is expected to have the following characteristics:

- Volume Flow Rate 27,800 scfm
- Relative Humidity 95%
- Temperature 65°F
- Maximum VOC inlet concentration 2 ppmv

CRITERIA FOR SELECTION OF ROC AND TOXIC ORGANICS ABATEMENT

Design criteria that must be considered in the evaluation of VOC abatement include:

- Air Flow Rate — The volume of air processed has a direct relationship to the size, capital cost, and energy requirements of the abatement system. It is generally desirable to minimize the volume of air to be treated through minimizing exhaust flows, incorporating air recirculation, or installing a carbon rotor concentrator system.

- VOC Concentration in the Gas Stream — Although abatement system calculations typically assume a constant percent control of the inlet stream, most abatement systems are actually constant-ppm outlet systems. Actual control efficiency is therefore very low for streams with inlet concentrations that are down near the minimum outlet concentrations achievable by the abatement technology under consideration.

- Temperature and Humidity of Gas Stream — These parameters are important for carbon adsorption systems because they limit the adsorption capacity of the carbon.

- VOC Species Present in the Gas Stream — Ketones and organics with very low or very high boiling points pose specific problems for systems incorporating carbon adsorption. Halogenated organics pose problems for incineration abatement systems.

- Cyclic Activity - VOC or Air Flow Rate Fluctuations — The abatement system must be designed for the maximum air flow. Periods of lower air flow represent unused capacity and increased costs per ton VOC abated. Incineration systems must have the capability to quickly respond to changing air flows.

DESCRIPTIONS OF ORGANIC POLLUTANT CONTROL TECHNOLOGIES

Several different control technologies are potentially applicable to the control of VOCs in an air stream. It was not possible, however, to document a comparison of expected control efficiencies for these technologies. Literature references do not tabulate control efficiencies for inlet VOC concentrations as low as those expected. The *EPA Handbook of Control Technologies for Hazardous Air Pollutants* (U.S. EPA, 1991) tabulates expected control efficiencies down to 200 ppmv for carbon adsorption, 50 ppmv for catalytic incineration, and 20 ppmv for thermal incineration.

The following paragraphs briefly describe the most common organic pollutant control systems.

Static-Bed Carbon Adsorber Systems

A typical static-bed carbon adsorber system (CAS) consists of two or more adsorbers filled with granular activated carbon (GAC). Banks of adsorbers may be required for large air flows. VOC-laden air is passed through one adsorber that removes the VOCs and discharges the cleaned air to the atmosphere. As adsorption sites in the carbon fill up, the VOC concentration in the discharged air begins to increase. At this point, the air flow is diverted to a second adsorber while the first adsorber is replaced or regenerated by passing steam or hot air through the carbon in a countercurrent direction, removing the VOCs from the carbon. A vacuum pump may also be used to release the organics from the carbon and thus regenerate the carbon beds if the carbon bed vessels are designed to withstand the stress of the vacuum required.

Regeneration steam condensate may be routed to a condenser or other industrial wastewater treatment. Recovered solvents are typically of low quality and must be disposed of as hazardous waste. If hot air or vacuum is used to regenerate the carbon, the resulting air stream can be routed to a catalytic incinerator or a heat-recuperative thermal incinerator.

High temperature air streams (greater than 120°F) limit the adsorbent capacity of carbon. Also, high relative humidity (greater than 50 percent) limits the adsorptive capacity of the carbon. The outlet from an air stripper would be expected to be at 95% relative humidity. The air stream would therefore need to be heated or dehumidified prior to the carbon adsorber to reduce the relative humidity.

Organic compounds with very high boiling points may be difficult to remove from the carbon during regeneration. This should not be an issue, however, in the current application.

Recuperative and Regenerative Incineration

The primary distinction between a recuperative thermal oxidation system and a regenerative thermal oxidation system is the manner in which heat is recovered. A recuperative unit utilizes a conventional heat exchanger to conduct heat from the hot exhaust to the cool inlet air. A regenerative thermal oxidation unit utilizes mechanical valves to switch air flows among the combustion chambers. Each chamber alternately serves as a combustion chamber, then as an inlet air preheat chamber.

Regenerative oxidation systems offer greater heat recovery efficiency than recuperative systems. However, a regenerative system is significantly more mechanically complex than a recuperative system. Both regenerative and recuperative systems are designed for a wide range of air flows. However, regenerative systems are typically considered for applications with extremely large (100,000 cfm and greater) air flows. At high flow volumes, the greater heat recovery and lower fuel costs of a regenerative system will tend to offset its higher initial equipment cost.

Incineration technologies offer an advantage over carbon adsorption in that no waste solvent or solvent-contaminated wastewater is generated (as is the case with carbon adsorption). However, incinerators emit oxides of nitrogen (NO_x) from thermal fixation and from combustion of nitrogen-containing compounds. Regenerative systems typically claim lower flame temperatures and therefore lower NO_x emissions relative to recuperative systems. Carbon monoxide (CO) and organic products of incomplete combustion (PICs) are also emitted from incineration units.

Catalytic Incineration

Catalysts can be used to lower the activation energy (temperature) required to oxidize VOCs. Typical operating temperatures for catalysts range from 600° to 900°F. Thermal incineration

systems, in contrast, operate at 1200° to 1800°F. The lower temperatures of catalytic units result in lower NO_x emissions, although small concentrations of CO and PIC emissions can still be expected.

The primary difficulty with the use of catalytic incineration for industrial operations is the potential for catalyst damage from substances in the air stream. A high degree of particulate matter removal is required to protect the active sites on the catalyst surface from being ..nded by particulate matter or poisoned by metals.

Rotary Wheel VOC Concentrator With Incineration

A rotary wheel concentrator is a device that concentrates the VOCs from a large dilute air stream into a smaller, more manageable air stream. This lowers the capital and operating costs for the final incineration system. The concentrator uses a carbon or zeolite rotor that turns slowly on its axis. Solvent-laden air from the emission source surrounds most of the perimeter of the rotor and is passed through the carbon that captures the VOCs from the air stream. One small section of the rotor is continuously subjected to a low-volume flow of hot desorption air. The volume of desorption air is approximately 10 percent of the air flow volume from the emission source. The result is a tenfold increase in the concentration of VOCs in the air stream to be incinerated. The optimal final VOC concentration is approximately 25 percent of the lower explosive limit, which is approximately 10,000 ppm for most common organics.

Rotary carbon concentrators are commonly used in applications where the initial air flow volume is very large and initial VOC concentrations are low (e.g less than 200-300 ppmv). The negative aspect of concentrators is that a small amount of organics are released in the "cleaned" high volume air stream. This reduces overall system capture and control efficiency.

A hydrophobic zeolite concentrator followed by thermal incineration was considered the most technically viable of the technologies reviewed. The cost of this technology was therefore reviewed in the second tier of this analysis and is documented in a separate memorandum. This technology was deemed cost-prohibitive, however, with an estimated cost per ton of organic removed of approximately $110,000 per ton (Patkar, 1996).

Biofiltration

In biofiltration, air is treated by passing it through a damp, porous medium which has been "seeded" with microorganisms specifically cultured for the VOCs to be consumed. For example, if soil vapor extraction is to be used to remediate the site of a leaking tank, microorganisms found to be thriving in the contaminated soil might be cultured and placed in the specially prepared medium of a biofilter.

Although in-ground biofiltration (using soil as the medium for the microorganisms) has been successfully employed, the more common approach is to use a fabricated bed of compost that is instrumented to precisely control the temperature and humidity of the medium.

Chlorinated VOCs pose special challenges for biofilters because of the effects of the VOCs and their intermediate decomposition products (such as HCl) on the microorganisms. After consulting with an expert in this field, Radian deemed this technology not technically viable for this application.

COST-EFFECTIVENESS OF ORGANIC POLLUTANT CONTROLS

Key data in the technology and cost-effectiveness evaluation are the characteristics of the air stream to be abated; the expected VOC concentrations and total annual emission rate for the air stream to be abated must be quantified. These data were estimated by GenCorp Aerojet Environmental Operations Staff. Table 1 lists the estimated concentrations of VOCs in the exhaust from the proposed air stripper.

Calculation of cost-effectiveness for an unusual application such as this is complicated by the fact that the air stream concentrations are outside the range of data provided in standard references. For example the carbon bed isotherm data provided in *Control Technologies for Hazardous Air Pollutants* (U.S. EPA, 1991) cannot be extrapolated below 10 ppmv.

As would be expected, the cost of abatement, when expressed in dollars per ton of VOC removed, is increases rapidly as the concentration of pollutant in the air stream declines. As an illustration of this, Table 2 presents a comparison of cost-effectiveness estimates that have been prepared for different ranges of concentrations of VOC found in the exhaust streams from aircraft painting facilities.

A recent U.S. EPA study focused on abatement of low concentrations of VOCs (U.S. EPA, 1995). This document focused on the technical feasibility of abating streams with 10 to 100 ppm VOC concentrations. Cost-effectiveness values cited for the lower end (i.e. 10 ppmv) are generally consistent with the 10-50 ppmv values listed in Table 2.

The cost estimates presented in Table 2 were generated by different individuals using various techniques. In general, these estimates are based on vendor estimates for capital costs, ten percent value of money, and ten year equipment life. Other direct and indirect costs, such as engineering, construction, installation, testing, utilities, and maintenance, are estimated as percentages of equipment capital costs using a standard algorithm, such as that provided in the U.S. EPA's Office of Air Quality and Standards (OAQPS) Control Cost Manual (U.S. EPA, 1990. Estimates based on this methodology are considered to be, at best, accurate to $\pm$20 percent.

Table 1. Estimated VOC Concentrations in the Air Stripper Exhaust

VOC Species	Emission Rate lb/hr[b]	Concentration[a] ppmv
1,1-Dichloroethylene	0.006 - 0.034	0.015 - 0.083
1,1-Dichloroethane	0.001 - 0.001	0.002 - 0.003
C/T 1,2-Dichloroethylene	0.013 - 0.074	0.032 - 0.180
Chloroform	0.002 - 0.003	0.005 - 0.006
Freon 113	0.033 - 0.040	0.042 - 0.051
1,2-Dichloroethane	0.001 - 0.001	0.001 - 0.002
1,1,1-Trichloroethane	0.000 - 0.001	0.001 - 0.001
Carbon Tetrachloride	0.000 - 0.000	0.000 - 0.000
Trichloroethylene	0.119 - 0.887	0.214 - 1.595
Tetrachloroethylene	0.002 - 0.007	0.003 - 0.010
Totals	0.178 - 1.047	0.315 - 1.931

[a] Based on 27,634 scfm air flow.
[b] Reference: GenCorp Aerojet, 1996.

Table 2. Example Cost Data for VOC Abatement[a]

Abatement Technology	1-4 ppmv	5-9 ppmv	10-50 ppmv
Thermal Incineration	$158,000[b]	$114,000[c]	$14,000-54,000[d,e]
Catalytic Incineration	$133,000[b]	$66,000[c]	$11,000-15,000[e]
Carbon Adsorption	$220,000[b]	$50,000[c]	$13,000-30,000[d,e]
Adsorption/Concentrator and Incineration	$145,000[b]	$23,000[c]	$20,000[d]

[a] Cost estimates listed as published, not corrected to 1996 dollars. These estimates assume a flow of 100,000 to 500,000 scfm. Costs per ton for a 10,000-50,000 scfm unit would be slightly higher than those listed because some of the capital costs are fixed and do not scale linearly with air flow.
[b] Source: CH2M Hill, 1991
[c] Source: ENSR, 1991
[d] Source: CH2M Hill, 1988
[e] Source: ENSR, 1989

U.S. EPA Control Technology Center distributes HAP-PRO software that is designed to be used for screening reviews of hazardous air pollutant (HAP) abatement equipment. This software was used to generate rough estimates of the sizing, fuel use, and costs of thermal and catalytic oxidation, condensation, and carbon adsorption for the air stripper exhaust stream. Printouts from the HAP-PRO program are presented in Appendix A.

The results from HAP-PRO are only moderately lower than cost estimates presented in Table 2. Some of the data inputs for this application were apparently outside the acceptable parameters for some of the HAP-PRO algorithms. For the condenser technology, HAP-PRO generated results, but the results are suspect as some output fields are blank.

The carbon adsorber calculation for an inlet concentration this low was not possible using HAP-PRO software. If we consider the physics of adsorption, we note that at inlet concentrations below the published isotherms, we start to approach concentrations equal to the vapor pressure of the compounds over virgin carbon. At this point, the calculated pounds of carbon per pound of pollutant increases exponentially.

HAP-PRO calculated total annualized costs in the range of $600,000 to $700,000 per year for thermal incineration, catalytic incineration, and condensation. These were the 1989 dollar costs of the base equipment and operating utilities. Refined estimates would need to consider the costs of site preparation, buildings, ductwork, waste disposal and the escalation of the control cost index of approximately a factor of 1.25 since 1989.

Maximum total VOCs in this air flow are estimated to be 4.2 tons per year. Assuming 90 percent capture and removal, 3.78 tons of VOCs per year might be abated. The cost-effectiveness estimate is therefore greater than $150,000 per ton for VOCs.

HAP-PRO does not have the facility to estimate costs for concentration followed by thermal incineration. After the preliminary literature review and cost estimates, Radian deemed this technology the most technically promising. Therefore, a more detailed analysis was performed for a zeolite concentrator followed by thermal incineration. This analysis is documented in a separate memorandum. Abatement costs for this method would be approximately $110,000 per ton (Patkar 1996). The costs of a similar configuration using a catalytic incinerator would be comparable to those calculated for a thermal incinerator.

ENVIRONMENTAL IMPACTS OF ABATEMENT

An additional consideration when abating extremely dilute air streams is secondary emissions. Based on the HAP-PRO simulations, the fuel use associated with heating the 27,800 scfm air stream would be on the order of 150 MMcf per year. Using AP-42 emission factors for external combustion of natural gas, approximately two pounds of NO_x would be generated for every pound of pollutant removed from the air stream.

The non-combustion technologies, such as carbon adsorption (if viable) also have associated secondary impacts. For a given temperature, a relationship exists between the mass of adsorbate (VOC) adsorbed per unit weight of adsorbent (carbon) and the partial pressure of the VOC in the gas stream. This relationship is described by curves called isotherms. At very low pollutant concentrations, the "loading" potential of carbon is very low; that is, many pounds of carbon are required to adsorb one pound of pollutant. The emissions associated with transporting this carbon to a regeneration site, or with generating the steam to regenerate it in place and then treating the contaminated wastewater, could be significant compared to the original VOC emissions.

CONCLUSIONS

Several types of organic emission abatement equipment were reviewed with regard to their application as TBACT. In each case, end-of-pipe abatement was determined not to be cost-effective in terms of capital and energy expenditure per ton of pollutant abated. The reason that abatement would not be practical in this application is that the quantities of VOC emitted are very small and the volume of air is comparatively large.

The following specific considerations preclude the use of abatement to reduce VOC emissions from the air stripper:

- No abatement technology was identified that would control emissions of these pollutants in the exhaust from the air stripper in a cost-effective manner; and

- The environmental impacts of all abatement alternatives considered includes irreversible allocation of resources and energy for the design, purchase, installation, and operation over the life of the project.

Due to economic and environmental considerations, no abatement is proposed as TBACT for organic toxics control. Abatement technologies that might provide some degree of reduction would do so at the cost of over $100,000 dollars per ton of VOC controlled as well as create significant secondary emissions.

REFERENCES

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GenCorp Aerojet, 1996. *Design Basis for the Proposed Air Stripping Tower*. Prepared by the Environmental Operations Department 0330, April 13.

Patkar, Avi, 1996. Memorandum to Venus Sadeghi of Radian Corporation Re: "Cost Estimation for Concentration and Thermal Destruction of a Dilute Air Stream Containing Halogenated Compounds". April 23.

SMAQMD, 1994. *Procedure for Permit Processing*, Sacramento Metropolitan Air Quality Management District, January 3.

U.S. EPA, 1990. *OAQPS Control Cost Manual*, 4th Edition. EPA 450/3-90-006, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. January.

U.S. EPA, 1991. *Control Technologies for Hazardous Air Pollutants*. EPA-625/6-91-014, United States Environmental Protection Agency, Office of Research and Development. June.

U.S. EPA, 1995. *Survey of Control Technologies for Low Concentration Organic Vapor Gas Streams*. EPA-456/R-95-003, United States Environmental Protection Agency, Office of Air Quality Planning and Standards. May.

HAP-PRO RESULTS

Assumptions and Data Used in HAP-PRO Calculations

90% control for all technologies

8000 hr/yr operation

Heat of combustion is insignificant to calculations, a typical value of 20,000 Btu/lb was used for all VOCs in the stream to satisfy the model.

TCE was used as the key emittant. Required physical parameters were taken from the CRC handbook of chemistry and Physics for TCE:

Heat of vaporization	= 125
Refractive index	= 1.477
Specific Gravity	= 1.464

Caveats

These estimates are preliminary values based on minimal data. Site preparation, building cost, and waste disposal cost are not included. Cost index correction to adjust costs to 1996 dollars is not done within the model. These estimates should be considered to be order-of-magnitude estimates only.

Results of Attached Model Runs

Technology	Cost ($/yr)
Carbon Adsorption	undefined
Condenser	$313,000*
Thermal Incinerator	$661,000
Catalytic Incinerator	$656,000

* Data suspect. HAP-PRO printed a [blank] for required condensation temperature. This may indicate that the input conditions or the requirement for 90% control were outside the range that could be calculated using HAP-PRO's algorithms for condensers.

RADIAN INTERNATIONAL LLC

ATTACHMENT A

HAP-PRO Version 2.0 Date of Print: 04/29/96

[redacted]e: Parameters marked with a * are not used in calculations; all other other parameters must be input to perform calculations accurately.

PLANT DATA

Plant ID: 00002
Company: Aerojet
Description: Wastewater Treatment
Street:
City: Sacramento
State: CA Zip:

Plant Contact:
Telephone:
Permit Date: / /
Reviewer:
Streams: 002

STREAM TYPE -- ORGANIC VAPOR STREAM RELATED PARAMETERS	Applicant	Default	Verified
Emission Stream No.:	01		
Maximum Flow Rate (scfm):	27634		N
Stream Temperature (F):	65	77	N
Oxygen Content (%):	20.0	20	N
* Moisture Content (%):	1.2		N
* Stream Pressure (mmHg):	760.0		N

DEVICE TYPE -- THERMAL INCINERATOR DESIGN RELATED PARAMETERS	Applicant	Default	Verified
Desired Destruction Efficiency (%)	90.0	98	N
Combustion Temp (deg F)	1300	1400	N
Residence Time (sec)	0.75	0.75	N
Heat Exchanger Efficiency (%)	70	70	N
Reference Temp (deg F)	77	77	N
Heat cap. of Air at Comb Temp (Btu/lb F)	0.254	0.254	N

COST RELATED PARAMETERS			
Site Preparation Cost ($)			N
Building Cost ($)			N
Damper Cost ($)			N
Duct Cost ($/linear ft)			N
Length of Duct (ft)	0	0	N
Total Pressure Drop (in H20)	20.0		N
Average Equipment Life (yr)	10	10	N
Fan/Motor Efficiency (%)	60	60	N
Interest Rate (%)	10	10	N
Price of Natural Gas ($/1000 cu ft)	3.30	3.30	N
Operator Labor Requirements (hrs/shift)	0.5	0.5	N
Maintenance Labor Requirements (hrs/shift)	0.5	0.5	N
Operator Labor Wage ($/hr)	12.96	12.96	N
Maintenance Labor Wage ($/hr)	14.26	14.26	N
Operating Hours (hrs/yr)	8000.00	6000	N

[redacted]-PRO Version 2.0 Date of Print: 04/29/96

HAPS IN STREAM:
DICHLOROETHYLENE,1,1- (0.1)*, DICHLOROETHYLENE,1,2-,CIS-TRANS- (0.1)*,
*See WARNING in Expert Review below.

INTERMEDIATE RESULTS

Calculated Destruction Efficiency (%):	100.00
Dilution Air Requirements (scfm):	0.0
Temp of Stream after Heat Exchange (½F):	930
Natural Gas Flow Rate (scfm):	296.1
Combustion Chamber Volume (ft3):	1201.5
Flue Gas Flow Rate (scfm):	27930.1
Electricity Requirement (kWh/yr):	871418.5
Fuel Usage (ft3/yr):	.142E+9
Heat Content (Btu/scf):	0.00

CAPITAL COSTS

Site Preparation:	0
Building:	0
Purchased Equipment:	325,600
Direct Installation:	97,700
Total Direct Costs:	423,300
Total Indirect Costs:	100,900
Total Capital Costs:	$ 524,200

[redacted]ERATING COSTS

Fuel:	469,000
Electricity:	51,400
Labor:	6,500
Supervisory:	1,000
Maintenance Labor:	7,100
Maintenance Materials:	7,100
Direct Annual Costs:	$ 542,100
Overhead:	13,000
Administrative:	10,500
Property Taxes:	5,200
Insurance:	5,200
Capital Recovery:	85,300
Indirect Annual Costs:	$ 119,200
Total Annual Costs:	$ 661,300

[redacted]P-PRO Version 2.0 Date of Print: 04/29/96

[redacted]ce: Parameters marked with a * are not used in calculations; all other other parameters must be input to perform calculations accurately.

PLANT DATA

Plant ID:	00002	Plant Contact:	
Company:	Aerojet	Telephone:	
Description:	Wastewater Treatment	Permit Date:	/ /
Street:		Reviewer:	
City:	Sacramento	Streams:	002
State:	CA Zip:		

STREAM TYPE -- ORGANIC VAPOR STREAM RELATED PARAMETERS	Applicant	Default	Verified
Emission Stream No.:	01		
Maximum Flow Rate (scfm):	27634		N
Stream Temperature (F):	65	77	N
Oxygen Content (%):	20.0	20	N
* Moisture Content (%):	1.2		N
* Stream Pressure (mmHg):	760.0		N

DEVICE TYPE -- CATALYTIC INCINERATOR DESIGN RELATED PARAMETERS	Applicant	Default	Verified
Bed Type	Fixed	Fixed	N
Desired Destruction Efficiency (%)	90.0	95	N
Heat Exchanger Efficiency (%)	50	50	N
[redacted]Heat Cap. of Air at Comb. Temp (Btu/lb deg F)	.254	.254	N
Space Velocity (per hour)	20000	20000	N
Reference Temp (deg F)	77	77	N
Catalytic Oxidation Temp (½F)	850	600	N

COST RELATED PARAMETERS			
Site Preparation Cost ($)			N
Building Cost ($)			N
Damper Cost ($)			N
Duct Cost ($/linear ft)			N
Length of Duct (ft)			N
Total Pressure Drop (in H20)	14.0		N
Average Equipment Life (yr)	10	10	N
Fan/Motor Efficiency (%)	60	60	N
Interest Rate (%)	10	10	N
Price of Natural Gas ($/1000 cu ft)	3.30	3.30	N
Catalyst Replacement Cost ($)			N
Operator Labor Requirements (hrs/shift)	0.5	0.5	N
Maintenance Labor Requirements (hrs/shift)	0.5	0.5	N
Operator Labor Wage ($/hr)	12.96	12.96	N
Maintenance Labor Wage ($/hr)	14.26	14.26	N
Operating Hours (hrs/yr)	8000	6000	N

HAPS IN STREAM:
DICHLOROETHYLENE,1,1- (0.1)*, DICHLOROETHYLENE,1,2-,CIS-TRANS- (0.1)*,
*See WARNING in Expert Review below.

INTERMEDIATE RESULTS

Calculated Destruction Efficiency (%):	92.0
Heat Content (Btu/scf):	0.00
Dilution Air Requirements (scfm):	0.0
Catalytic Oxidation Temp (½F):	850
Temp of Stream after Heat Exchange (½F):	458
Natural Gas Flow Rate (scfm):	280.6
Flue Gas Flow Rate (scfm):	27914.6
Actual Flow Rate (scfm):	68097.1
Catalyst Bed Requirement (ft3):	83.7
Electricity Requirement (kWh/yr):	609654.7
Fuel Usage (ft3/yr):	.134E+9

CAPITAL COSTS

Site Preparation:	0
Building:	0
Purchased Equipment:	431,500
Direct Installation:	129,500
Total Direct Costs:	561,000
Total Indirect Costs:	133,800
Total Capital Costs: $	694,800

OPERATING COSTS

Catalyst Replace Cost:	0
Fuel:	444,500
Electricity:	36,000
Labor:	6,500
Supervisory:	1,000
Maintenance Labor:	7,100
Maintenance Materials:	7,100
Direct Annual Costs: $	502,200
Overhead:	13,000
Administrative:	13,900
Property Taxes:	6,900
Insurance:	6,900
Capital Recovery:	113,100
Indirect Annual Costs: $	153,800
Total Annual Costs: $	656,000

[redacted]-PRO Version 2.0 Date of Print: 04/29/96

Note: Parameters marked with a * are not used in calculations; all other parameters must be input to perform calculations accurately.

PLANT DATA

Plant ID: 000002
Company: Aerojet
Description: Wastewater Treatment
Street:
City: Sacramento
State: CA Zip

Plant Contact:
Telephone:
Permit Date: / /
Reviewer:
Streams: 002

STREAM TYPE -- ORGANIC VAPOR STREAM PARAMETERS	Applicant	Default	Verified
Maximum Flow Rate (scfm):	27634		N
Stream Temperature (½F):	65	77	N
* Oxygen Content (%):	20.0	20	N
* Moisture Content (%):	1.2		N
Stream Pressure (mmHg):	760.0		N

DEVICE TYPE -- CONDENSER DESIGN RELATED PARAMETERS	Applicant	Default	Verified
Condenser Type	1	1	N
Coolant Used	water	water	N
Removal Efficiency (%)	90	90	N
Condensation Temp (deg F)			N
Overall Heat Transfer Coeff (BTU/hr-ft2 deg F)	20	20	N
Avg Specific Heat for Coolant (BTU/hr-ft2-F)			N
Heat Cap. of HAP (BTU/lb mol deg F)			N
Heat Cap. of Air (BTU/lb mol deg F)	6.95	6.95	N
Length of Tube (in)	8	8	N

COST RELATED PARAMETERS			
Site Preparation Cost			N
Building Cost ($)			N
Stack Cost ($)			N
Damper Cost ($)			N
Duct Cost ($/linear ft)			N
Length of Duct (ft)			N
Cost of Fans and Motors ($)			N
Total Pressure Drop (in H2O)	5	5	N
Average Equipment Life (yr)	10	10	N
Interest Rate (%)	10	10	N
Value of Recovered Product ($/lb)			N
Operator Labor Requirements (hrs/shift)	0.5	0.5	N
Maintenance Labor Requirements (hrs/shift)	0.5	0.5	N

[redacted]-PRO Version 2.0

Date of Print: 04/29/96

Operator Labor Wage ($/hr)	12.96	12.96	N
Maintenance Labor Wage ($/hr)	14.26	14.26	N
Operating Hours (hrs/yr)	8000	6000	N

INTERMEDIATE RESULTS

Partial Pressure (mmHg):	.0000836
Log Mean Temp Difference (°F):	30.79
Condensation Temp (°F):	0.00
Condenser Heat Load (Btu/hr):	1910763
Condenser Size:	1600
Coolant Flow Rate (lb/hr):	********
Refrigeration Capacity (tons):	159.2302
Recovered Product (lb/hr):	.5239576

CAPITAL COSTS

Site Preparation:	0
Building Cost:	0
Purchased Equipment:	29,500
Direct Installation:	12,700
Total Direct Costs:	42,200
Refrigerant Capital Costs:	1,264,200
Total Indirect Costs:	9,100
Total Capital Costs:	$ 1,315,500

OPERATING COSTS

Electricity:	11,800
Labor:	6,500
Supervisory:	1,000
Maintenance Labor:	7,100
Maintenance Materials:	7,100
Direct Annual Costs:	$ 33,500
Overhead:	13,000
Administrative:	26,300
Property Taxes:	13,200
Insurance:	13,200
Capital Recovery:	214,100
Indirect Annual Costs:	$ 279,800
Value of Recovered Product:	(0)
Total Annual Costs:	$ 313,300

HAPS IN STREAM:

DICHLOROETHYLENE,1,1- (0.1), DICHLOROETHYLENE,1,2-,CIS-TRANS- (0.1),

APPENDIX M

Cost Estimation for Concentration and Thermal Destruction of a Dilute Air Stream Containing Halogenated Compounds

RADIAN INTERNATIONAL LLC

MEMORANDUM

To: Venus Sadeghi

From: Avi Patkar
Rob Meyers

Date: 23 April 1995

Subject: **Cost Estimation for Concentration and Thermal Destruction of a Dilute Air Stream Containing Halogenated Compounds**

The intent of this memorandum is to summarize the estimated costs of concentration followed by thermal incineration of an air stream containing very low concentrations of halogenated compounds. The following discussion includes a summary of results, a description of the concentrator/thermal oxidation system, a description of the cost estimation procedure, and brief discussion regarding other treatment options.

Summary of Results

This analysis has been performed on a waste stream with the following characteristics:

Volumetric Flow Rate, scfm	27,800
Waste Stream Temperature, °F	65
Waste Stream Humidity, %	95
VOC Mass Flow Rate[1], lb/hr	1.05
VOC Concentration[1], ppmv	1.93
VOC Heat Content[1], Btu/scf	370

[1]Trichloroethylene comprises 83% (by volume) of the stream and has been used as the surrogate VOC for this analysis

These parameters were utilized as input data for the concentrator/thermal oxidation cost estimation spreadsheet. The detailed calculations are attached, and are summarized as follows:

Total Capital Investment	$1,600,000 ($1995)
Total Annual Costs	$416,000
Tons VOC Removed	3.78 tpy
Cost Effectiveness	$110,000 per ton VOC removed

As discussed below, these costs have been estimated using U.S. EPA guidelines for costing control technologies (EPA OAQPS, 1990). It is apparent that this technology is not a cost effective option. In addition, we expect that other special considerations associated with this waste stream would serve to further decrease the effectiveness of this

technology. The high humidity and low concentrations of the waste stream will pose a problem associated with decreased absorption capacity. This would result in an increase in the amount of sorbent required to achieve the desired removal efficiency. Also, the oxidizer must be designed to handle the acidic products of combustion (i.e. HCl) that will form due to the halogens present in the waste gas. There may also be some concern associated with toxic compounds, such as phosgene, dioxins, and furans, that may form as products of incomplete combustion. For these reasons, we do not recommend this as a viable treatment technology for this waste stream.

Concentrator/Thermal Oxidation of the Waste Stream

Concentration followed by thermal destruction can be a cost effective method for controlling streams with a dilute VOC content (Blocki, S.W. "Hydrophobic Zeolitic Adsorbent: A Proven Advancement in Solvent Separation Technology." *Envirnonmental Progress* V.13(3):226-230, 1993). The process involves concentrating the waste stream into an air volume 6 to 18 times less than the original concentration by adsorbing the VOC's on a hydrophobic zeolite. The captured VOC's are desorbed at a much higher concentration in the smaller desorption gas stream, and can be diverted to a smaller and more cost effective oxidizer than would be required without concentration.

The adsorbent can be housed in a rotating cylindrical compartment, or in dual fluidized bed units. In rotating systems, VOC's are adsorbed on the zeolite media and the rotating compartment is subsequently passed through a desorption zone, where a smaller heated air stream strips the solvents. Consequently, the zeolite absorber is regenerated as it passes through the desorption zone (Durr Industries, Inc., Plymouth, MI). Dual bed systems are characterized by a fluidized bed of adsorbent that is pneumatically transferred between adsorption and desorption sections (Weatherly, Inc., Atlanta, GA). A simple schematic of a rotary concentration/thermal oxidation system is attached.

Cost Estimation Methodology

We have developed in-house estimation spreadsheets to estimate the costs of various air pollution technologies. The in-house models are spreadsheet programs that allow input parameters to be adjusted to a specific application. The cost estimates are "planning level" estimates with an accuracy of ±30%. They are, however, very useful for comparative ranking of techniques.

The preliminary design and cost estimates are based on U.S. EPA guidelines for costing control technologies (EPA OAQPS, 1990). The computer model calculates total purchased equipment cost, total capital cost, and total annualized costs. The model also

calculates the amount of VOC controlled by the system based on overall control efficiency. The total annualized cost is divided by the amount of VOCs controlled to obtain a value expressed in $ per ton.

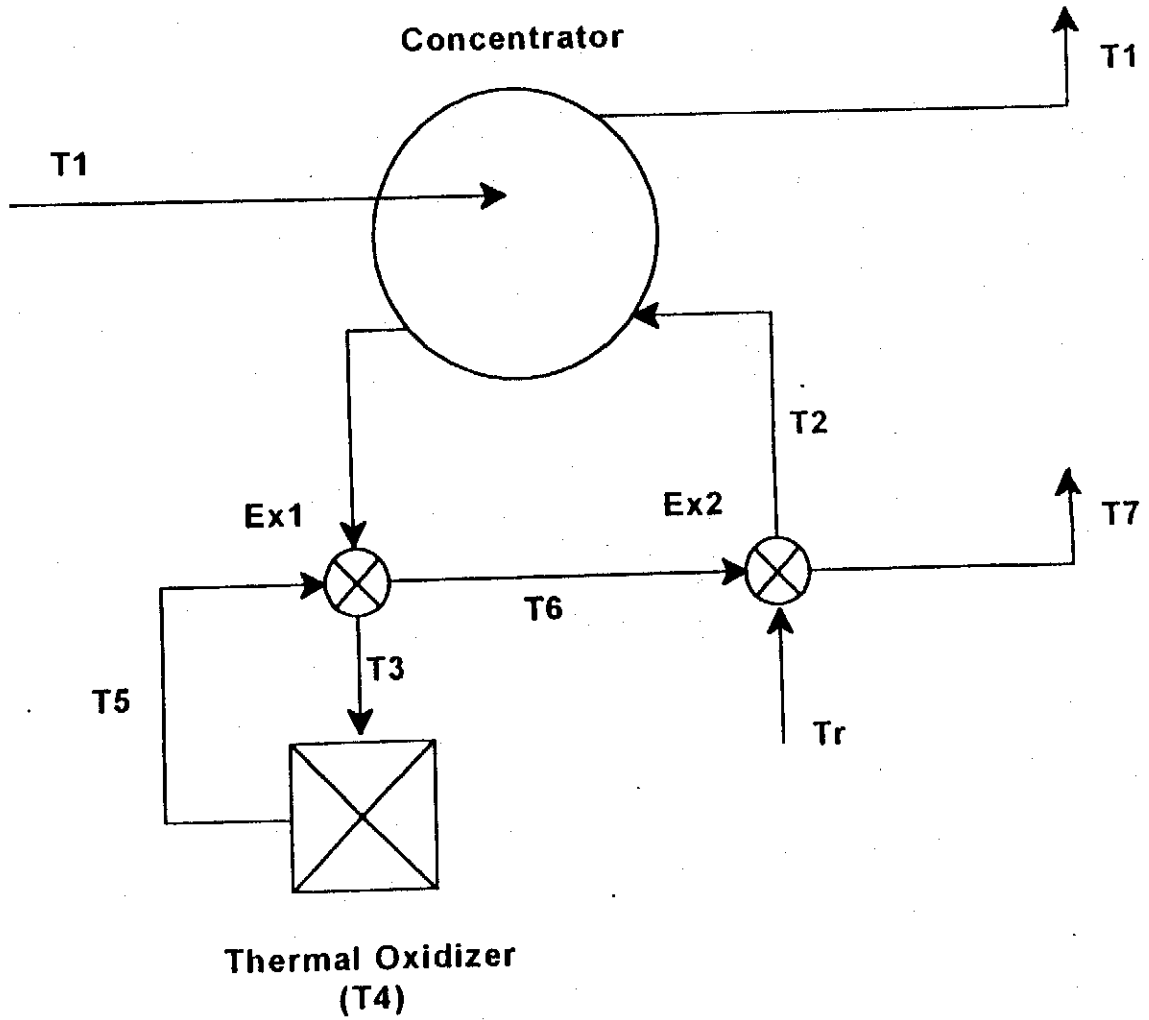
The purchased equipment cost (PEC) has been estimated for the concentrator/thermal oxidation system based on published cost estimating algorithms (EPA OAQPS, 1990) and vendor quotations found in the literature (Blocki, 1993). The computer model was used to estimate other direct and indirect capital equipment costs, and annual operating costs using cost estimating factors. These ancillary costs are itemized in the model spreadsheet, and the cost estimating factors used by the model to predict total capital and annualized costs are included as an attachment.

Other Technologies

We have also considered direct thermal oxidation of the air stream. However, at these low concentrations (less than 2 ppm) none of the vendors we contacted would guarantee 90%+ removal. The concentrations at the stripper outlet are at the low end of the typical oxidizer outlet concentration.

We also evaluated biofiltration, with or without concentration. We consulted Dr. Chang of the University of California at Davis. In his opinion, aerobic degradation of these compounds would not be feasible, especially at these low concentrations. Anaerobic degradation of halogenated compounds in the liquid phase with co-metabolites such as methanol and acetic acid is also being studied by Dr. M. Suidan at the University of Cincinnati, but this technology is not commercially available at this time.

Concentration/Thermal Oxidation System



Client: Aerojet
P.N. 665-133-01-00
Process: Concentrator/Thermal Incineration

Radian International

Run By [redacted]
Checked By ANP

NOTES:
-This program is designed to estimate costs associated with zeolite adsorption followed by an incinerator system that will control VOCs.
See the process note written by JAB on 9/26/93 for a detailed description of the process and assumptions.
- The program was revised by GRM in April 1996 for Aerojet, see supplementary memo (4/23/96) for details.
-Abbreviations include: Ex - heat exchanger; CON - concentrator; CC - combustion chamber
-User input is shaded
* These values are calculated.

MODEL PARAMETERS:

Variable	(Units)	Input	Default
Waste Stream			
Flow	scfm	27800	15000
Mass flow of VOC	lb/hr	1.05	10
VOC Conc	ppm	1.931	100
Mol Wt of VOC	lb/lbmol	131.5	104
Heat Content of VOC	Btu/scf	370	1000
Concentrated Stream			
Concentration Ratio		10	10
Flow (Q2)	scfm	2780	1500 *
Mass flow of VOC	lb/hr	1.05	10.00 *
VOC Conc	ppm	19.31	1000 *
Heat cap air (Cp1)	BTU/scf*oF	0.018	0.018
Heat cap air (Cp4)	BTU/scf*oF	0.02	0.019
Heat cont (h3)	BTU/scf	0.07145	1.000 (to CB)*
Heat cont (hf)	BTU/scf	1000	1000 (natural gas)*
Operating Param.			
Ex1, Ex2 eff (nhe)	fraction	0.7	0.7
CB Residense Time	sec	1.0	0.75 *
Overall press. drop	in wg	36	35 *
Incin eff	fraction	0.95	0.98
Zeolite eff	fraction	0.95	0.98
Capture eff	fraction	1.00	0.95
Overall Efficiency	fraction	0.90	0.91 *

Stream Temp	Input (oF)	Default (oF)
Ref. Temp. (NG)	70	70
1 (waste gas to CON)	65	80
2 (from Ex2 to CON)	1269	990 *
3 (from Ex1 to CC)	1783	1384 *
4 (CC Temp)	2000	1500
5 (from CC to Ex1)	2004	1553 *
6 (from Ex1 to Ex2)	1490	1159 *
7 (from Ex2 to stack)	496	397 *

INCINERATOR DESIGN

Qf =	1.97 scfm	natural gas requirement
Qd =	0.00 scfm	dilution air requirement (max. heat content 10 Btu/scf)
Qtot =	2782 scfm	
CB Volume =	227 ft^3	
Overall Power Req =	25 Hp	
VOC Removed =	3.780 tons/yr	
VOC Emitted =	0.408 tons/yr	

EQUIPMENT COST

The equipment cost of a concentrator/oxidation system = 92% of the cost of a direct regenerative thermal oxidation (RTO) system.
Ref: "Hydrophobic Zeolite Adsorbent: A Proven Advancement in Solvent Separation Technology," Environmental Progress, Aug., 1993.

RTO Cost =	$542,046 (1988, $)	"OAQPS Control Cost Manual, 4th ed.", EPA 450/3-90-006, January, 1990 (EC, RTO = 220,400 + 11.57*Q)
VAPCCI =	100 (1989)	Vatavuk Air Pollution Control Cost Index for Thermal Incinerators, Environmental Engineering World, December 1995
VAPCCI =	125 (1995)	
Incinerator Cost =	$677,558 (1995, $)	
Conc./Ox. Cost =	$623,353 (1995, $)	0.92*RTO Cost

Client: Aerojet
P.N: 665-133-01-00
Process: Concentrator/Thermal Incineration

Radian International

Run By: GRM
Checked By: ANP

CAPITAL COST CALCULATIONS:	('95, $)
DIRECT COSTS	
Purchased Equipment Costs	
Control Equipment	623353
Instrumentation	62335
Sales Tax	31168
Freight	31168
	748033
Direct Installation Costs	
Piping	249341
Electrical	93503
Structural	93503
Paint+Insulation	68569
	504916
Total Capital Direct Costs	1252949
INDIRECT COSTS	
Engineering	74803
Construction	37402
Contractor Fee	74803
Startup	14961
Performance Test	0
Contingencies	149607
Total Indirect Costs	351576
TOTAL CAPITAL COSTS	1604525

ANNUAL COST CALCULATIONS	('95, $)
DIRECT COSTS	
Operating Labor	30000
Supervisor Labor	4500
Maintenance Labor	7500
Maintenance Materials	7500
Electricity	10474
Steam	0
Natural Gas	3777
Process Water	0
Cooling Water	0
Waste Water Treatment	0
Waste Disposal	0
Total Annual Direct Costs:	63751
INDIRECT COSTS	
Overhead	27000
Property Tax	16045
Insurance	16045
Administration	32091
Capital Recovery	261136
Total Annual Indirect Costs:	352317

TOTAL ANNUAL COSTS	(1995 $/yr)	416068
TONS VOC REMOVED	(tons/yr)	3.78
COST EFFECTIVENESS	($/ton)	110081

4/26/96

Direct, Indirect, and Annual Cost Estimation Factors

CAPITAL COSTS	COST FACTOR	REFERENCE
Direct Costs		
Control Equipment	Total Equipment Costs (A)	Vatavuk, W.M. "Estimating Costs of Air Pollution Control", Lewis Publishers, Chelsea, MI (1991)
Instrumentation	0.10 x A	"Organic Chemical Manufacturing Volume 4: Combustion Control Devices", USEPA, EPA-450/3-80-026, December 1980
Sales Tax	0.05 x A	Typical Value
Freight	0.05 x A	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Purchased Equipment Cost (PEC)	1.20 A = B	
Installation Costs		
Piping	0.4 x A	"Organic Chemical Manufacturing Volume 4: Combustion Control Devices", USEPA, EPA-450/3-80-026, December 1980
Electrical	0.15 x A	"Organic Chemical Manufacturing Volume 4: Combustion Control Devices", USEPA, EPA-450/3-80-026, December 1980
Structural	0.15 x A	"Organic Chemical Manufacturing Volume 4: Combustion Control Devices", USEPA, EPA-450/3-80-026, December 1980
Paint/Insulation	0.11 x A	"Organic Chemical Manufacturing Volume 4: Combustion Control Devices", USEPA, EPA-450/3-80-026, December 1980
Total Direct Costs (TDC)	2.01 x A	
Indirect Costs		
Engineering	0.10 x B	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Construction	0.05 x B	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Contractors Fee	0.10 x B	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Start-Up	0.02 x B	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Contingencies	0.20 x B	Engineering Experience
Total Indirect Costs (TIC)	0.47 x B (=0.56 x A)	
TOTAL CAPITAL COST	2.574 X A	
ANNUALIZED COSTS		
Direct Costs		
Operating Labor (OL)	2 h/shift; 8000 h/yr; $15/h	Typical Values
Supervisory Labor	0.15 x OL	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Maintenance Labor (ML)	0.5hr/shift	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Maintenance Materials (MM)	100% Mnt. Labor	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Electricity	$0.07/kWh	Typical Value
Natural Gas	$4/MMBtu	Typical Value
Indirect Costs		
Overhead	0.60 x (DL + ML + MM)	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Property Tax	0.01 x TCI	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Insurance	0.01 x TCI	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Administration	0.02 x TCI	"OAQPS Control Cost Manual, Fourth Edition" USEPA, EPA-450/3-90-006, January 1990
Capital Recovery	0.16275 x TCI	(10%, 10 yr. life)

APPENDIX N

USBR Flow Rate Information

USBR

FLOW RATE INFORMATION

LOWER AMERICAN RIVER

(section 4.6.1)

&

FOLSOM SOUTH CANAL

(section 4.6.2)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

PAGE 4

FOLSOM LAKE OPERATION

FORECAST OF WATER SUPPLY AND REQUIREMENTS

JANUARY 23, 1995

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH)

MONTH	FOLSOM LAKE INFLOW	RELEASE: POWER HOUSE	RELEASE: FOLSOM S.C.	RELEASE: NIMBUS	FOLSOM PUMPS	EVAPORATION	STORAGE: CHANGE	STORAGE: END OF PERIOD	MEAN WATER SURFACE ELEV.	ENERGY AT GENERATION: FOLSOM	ENERGY AT GENERATION: NIMBUS
JAN	406.6	77.9	1.0	76.9	5.6	1.2	321.9	252.3	413.	403.	19.8	2.7
FEB	270.0	265.2	1.2	264.0	3.7	1.2	-.1	574.2	574.	423.	72.5	9.6
MAR	300.0	278.0	1.2	276.8	5.6	1.7	14.7	574.2	582.	424.	76.3	10.1
APR	350.0	120.6	1.6	119.0	9.3	3.7	216.4	588.9	697.	437.	34.5	4.3
MAY	360.0	225.9	1.8	224.1	10.3	5.4	118.3	805.2	864.	453.	68.2	8.2
JUN	190.0	262.7	2.2	260.5	12.1	6.3	-91.1	923.6	878.	454.	79.6	9.5
JUL	120.0	281.6	2.6	279.0	12.1	7.6	-181.3	832.5	742.	441.	81.8	10.1
AUG	90.0	130.6	2.6	128.0	9.3	6.5	-56.4	651.1	623.	429.	36.4	4.7
SEP	90.0	95.2	2.0	93.2	7.5	5.2	-17.9	594.7	586.	424.	26.2	3.4
OCT	50.0	124.6	1.6	123.0	3.7	2.5	-80.8	576.8	536.	419.	33.6	4.5
NOV	50.0	120.2	1.2	119.0	7.5	1.1	-78.8	496.0	457.	409.	31.2	4.3
DEC	70.0	93.3	1.0	92.3	6.5	.6	-30.4	417.1	402.	401.	23.6	3.3
TOTAL	2346.6	2075.7	20.0	2055.7	93.2	43.2	134.4	386.7			583.5	74.7

BASED ON WATER YEAR FORECAST OF 2,177,000 ACRE-FEET.
JAN-DEC INFLOW BASED ON ANNUAL INFLOW WITH 90 PERCENT EXCEEDENCE.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSON LAKE OPERATION

PAGE 4

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH)

FEBRUARY 13, 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE: POWER HOUSE	RELEASE: FOLSOM S.C.	RELEASE: NIMBUS	FOLSOM PUMPS	EVAPORATION	CHANGE	STORAGE: END OF PERIOD	STORAGE: MEAN	MEAN WATER SURFACE ELEV.	ENERGY AT GENERATION: FOLSOM	ENERGY AT GENERATION: NIMBUS
FEB	320.0	322.2	1.2	321.0	3.7	1.1	-7.0	559.1	556.	421.	87.5	11.1
MAR	365.0	253.4	1.2	252.2	5.6	1.8	104.3	552.1	604.	427.	70.1	9.2
APR	405.0	248.2	1.6	246.6	9.3	3.8	143.7	656.3	728.	440.	71.8	9.0
MAY	475.0	293.8	1.8	292.0	10.3	5.5	165.4	800.0	883.	455.	89.1	10.6
JUN	150.0	204.2	2.2	202.0	12.1	6.4	-72.7	965.4	929.	459.	62.7	7.4
JUL	130.0	301.1	2.6	298.5	12.1	7.9	-191.1	892.7	797.	447.	89.0	10.8
AUG	110.0	187.6	2.6	185.0	9.3	6.7	-93.6	701.6	655.	432.	52.9	6.8
SEP	110.0	151.0	2.0	149.0	7.5	5.2	-53.7	608.0	581.	424.	41.4	5.4
OCT	90.0	124.6	1.6	123.0	3.7	2.5	-40.8	554.3	534.	418.	33.5	4.5
NOV	100.0	120.2	1.2	119.0	7.5	1.2	-28.9	513.5	499.	414.	31.9	4.3
DEC	70.0	124.0	1.0	123.0	6.5	.7	-61.2	484.6	454.	408.	32.2	4.5
JAN	120.0	93.0	1.0	92.0	5.6	1.2	20.2	423.4	434.	405.	23.9	3.3
TOTAL	2445.0	2423.2	20.0	2403.2	93.2	44.1	-115.5	443.6			686.0	86.8

BASED ON WATER YEAR FORECAST OF 2,065,000 ACRE-FEET.
FEB-JAN INFLOW BASED ON ANNUAL INFLOW WITH 90 PERCENT EXCEEDENCE.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSOM LAKE OPERATION

REPORT 4

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH)

MARCH 14 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE: POWER HOUSE	RELEASE: FOLSOM S.C.	RELEASE: NIMBUS	RELEASE: FOLSOM PUMPS	EVAPO-RATION	STORAGE: CHANGE	STORAGE: END OF PERIOD	STORAGE: MEAN	EOM WATER SURFACE ELEV.	POWER GENERATION MILLIONS KWH: FOLSOM	POWER GENERATION MILLIONS KWH: NIMBUS
								574.2				
MAR	315.0	219.0	1.2	212.2	5.6	1.8	88.6		621.	436.	62.3	7.5
								668.4				
APR	365.0	227.0	1.6	215.7	9.3	3.8	124.9		736.	458.	66.9	7.6
								802.6				
MAY	365.0	231.0	1.8	218.7	10.3	5.4	118.3		867.	462.	70.5	7.7
								931.2				
JUN	280.0	312.0	2.2	297.5	12.1	6.2	-130.3		872.	451.	95.3	10.1
								813.0				
JUL	60.0	222.0	2.6	207.0	12.1	7.5	-181.6		720.	434.	65.3	7.3
								643.5				
AUG	60.0	145.0	2.6	132.7	9.3	6.3	-100.6		598.	423.	40.9	4.8
								552.2				
SEP	60.0	99.0	2.0	89.3	7.5	4.9	-51.4		530.	418.	27.3	3.3
								500.3				
OCT	50.0	128.0	1.6	123.0	3.7	2.3	-84.0		468.	407.	34.4	4.5
								420.8				
NOV	50.0	120.0	1.2	119.0	7.5	1.0	-86.5		389.	396.	33.0	4.3
								349.0				
DEC	70.0	131.0	1.0	123.0	6.5	0.6	-68.1		310.	385.	32.2	4.5
								287.4				
JAN	120.0	99.0	1.0	92.3	5.6	0.9	14.5		297.	389.	24.0	3.4
								307.5				
FEB	170.0	88.0	1.2	83.3	3.7	0.9	77.4		348.	402.	22.1	3.1
								388.6				
TOTAL	1885.0	2029.0	20.0	1913.7	93.2	61.6	-278.8				574.1	68.0

INFLOW FOR ALL MONTHS BASED ON ANNUAL INFLOW WITH 90 PERCENT EXCEEDANCE
BASED ON WATER YEAR FORECAST OF 2885000 ACRE-FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSOM LAKE OPERATION

REPORT 4

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH)

APRIL 12 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE: POWER HOUSE	RELEASE: FOLSOM S.C.	RELEASE: NIMBUS	RELEASE: FOLSOM PUMPS	EVAPO-RATION	STORAGE: CHANGE	STORAGE: END OF PERIOD	STORAGE: MEAN	EOM WATER SURFACE ELEV.	POWER GENERATION MILLIONS KWH: FOLSOM	POWER GENERATION MILLIONS KWH: NIMBUS
								584.7				
APR	575.0	368.0	1.6	357.0	9.3	3.7	194.0		686.	449.	106.8	11.1
								788.8				
MAY	598.0	396.0	1.8	384.4	10.3	5.4	178.3		882.	466.	121.2	10.4
								976.6				
JUN	500.0	500.6	2.2	490.9	12.1	6.5	-19.2		971.	465.	156.2	11.1
								965.1				
JUL	160.0	199.0	2.6	184.5	12.1	8.4	-59.5		941.	461.	61.8	6.6
								917.7				
AUG	120.0	196.0	2.6	184.5	9.3	7.6	-92.9		876.	453.	59.9	6.6
								834.1				
SEP	120.0	188.0	2.0	178.5	7.5	6.1	-81.6		797.	446.	56.4	6.4
								760.8				
OCT	90.0	190.0	1.6	184.5	3.7	2.9	-106.6		709.	435.	55.5	6.6
								657.1				
NOV	80.0	157.0	1.2	148.8	7.5	1.3	-85.8		618.	426.	44.6	5.4
								578.8				
DEC	70.0	161.0	1.0	153.8	6.5	0.8	-98.3		533.	415.	44.4	5.5
								487.8				
JAN	120.0	130.0	1.0	123.0	5.6	1.3	-16.9		481.	414.	35.1	4.5
								475.7				
FEB	170.0	116.0	1.2	111.0	3.7	1.1	49.2		502.	420.	31.6	4.0
								528.6				
MAR	250.0	130.0	1.2	123.0	5.6	1.7	112.7		588.	434.	36.6	4.5
								646.9				
TOTAL	2845.0	2731.6	20.8	2623.9	93.2	46.8	-26.6				810.1	82.5

INFLOW FOR ALL MONTHS BASED ON ANNUAL INFLOW WITH 90 PERCENT EXCEEDANCE
BASED ON WATER YEAR FORECAST OF 4,661,000 ACRE-FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSOM LAKE OPERATION

REPORT 4

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH)

MAY 24 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE				EVAPO-RATION	STORAGE			EOM WATER SURFACE ELEV.	POWER GENERATION MILLIONS KWH	
		POWER HOUSE	FOLSOM S.C.	NIMBUS	FOLSOM PUMPS		CHANGE	END OF PERIOD	MEAN		FOLSOM	NIMBUS
								756.7				
MAY	875.0	482.6	1.8	814.9	10.3	5.1	377.0		778.	450.	144.1	11.1
								799.6				
JUN	465.0	312.0	2.2	297.5	12.1	6.2	134.7		873.	464.	95.3	10.1
								946.4				
JUL	180.0	261.0	2.6	246.0	12.1	8.3	-101.4		902.	455.	80.3	8.6
								857.1				
AUG	120.0	196.0	2.6	184.5	9.3	7.3	-92.6		815.	447.	59.1	6.6
								773.8				
SEP	120.0	158.0	2.0	148.8	7.5	5.9	-51.4		752.	443.	46.8	5.4
								729.9				
OCT	50.0	159.0	1.6	153.8	3.7	2.8	-115.5		674.	431.	46.0	5.5
								618.1				
NOV	50.0	157.0	1.2	148.8	7.5	1.3	-115.8		564.	418.	43.8	5.4
								509.8				
DEC	60.0	161.0	1.0	153.8	6.5	0.7	-108.2		459.	405.	43.0	5.5
								408.1				
JAN	70.0	130.0	1.0	123.0	5.6	1.1	-66.7		378.	395.	33.3	4.5
								347.0				
FEB	110.0	116.0	1.2	111.0	3.7	0.8	-10.5		344.	394.	29.0	4.0
								340.2				
MAR	180.0	130.0	1.2	123.0	5.6	1.3	43.1		365.	402.	33.0	4.5
								388.9				
APR	220.0	196.0	1.6	184.8	9.3	2.7	12.0		400.	405.	50.8	6.6
								410.2				
TOTAL	2500.0	2458.6	20.0	2689.9	93.2	43.5	-95.3				704.4	77.6

INFLOW FOR ALL MONTHS BASED ON ANNUAL INFLOW WITH 90 PERCENT EXCEEDANCE
BASED ON WATER YEAR FORECAST OF 5001000 ACRE-FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSOM LAKE OPERATION

REPORT 4

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH)

JUNE 12 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE				EVAPO-RATION	STORAGE			EOM WATER SURFACE ELEV.	POWER GENERATION MILLIONS KWH	
		POWER HOUSE	FOLSOM S.C.	NIMBUS	FOLSOM PUMPS		CHANGE	END OF PERIOD	MEAN		FOLSOM	NIMBUS
								743.9				
JUN	790.0	489.9	2.2	541.5	12.1	6.1	281.9		858.	466.	149.1	11.1
								971.8				
JUL	230.0	261.0	2.6	246.0	12.1	8.5	-51.6		952.	462.	81.2	8.6
								932.3				
AUG	140.0	227.0	2.6	215.3	9.3	7.6	-103.9		885.	453.	69.5	7.6
								837.7				
SEP	120.0	218.0	2.0	208.3	7.5	6.0	-111.5		786.	443.	65.2	7.4
								733.7				
OCT	90.0	159.0	1.6	153.8	3.7	2.9	-75.6		698.	436.	46.3	5.5
								661.8				
NOV	80.0	157.0	1.2	148.8	7.5	1.3	-85.8		623.	427.	44.7	5.4
								583.5				
DEC	70.0	161.0	1.0	153.8	6.5	0.8	-98.3		538.	416.	44.5	5.5
								491.7				
JAN	120.0	130.0	1.0	123.0	5.6	1.3	-16.9		486.	414.	35.2	4.5
								480.4				
FEB	170.0	116.0	1.2	111.0	3.7	1.1	49.2		507.	421.	31.7	4.0
								533.3				
MAR	250.0	130.0	1.2	123.0	5.6	1.8	112.6		592.	434.	36.6	4.5
								651.5				
APR	300.0	249.0	1.6	238.0	9.3	3.6	38.1		675.	440.	72.0	8.3
								698.9				
Y	260.0	288.0	1.8	275.8	10.3	4.8	-43.1		683.	436.	83.5	9.5
								666.1				
TOTAL	2620.0	2585.9	20.0	2538.3	93.2	45.8	-104.9				759.5	81.8

INFLOW FOR ALL MONTHS BASED ON ANNUAL INFLOW WITH 50 PERCENT EXCEEDANCE
BASED ON WATER YEAR FORECAST OF 5385000 ACRE-FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSOM LAKE OPERATION REPORT 4

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH) JULY 19 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE				EVAPO-RATION	STORAGE			EOM WATER SURFACE ELEV.	POWER GENERATION MILLIONS KWH	
		POWER HOUSE	FOLSOM S.C.	NIMBUS	FOLSOM PUMPS		CHANGE	END OF PERIOD	MEAN		FOLSOM	NIMBUS
								953.1				
JUL	310.0	310.1	2.6	307.5	12.1	8.4	-20.6		943.	462.	96.3	10.3
								932.7				
AUG	170.0	310.1	2.6	307.5	9.3	7.5	-156.9		854.	447.	94.3	10.3
								776.2				
SEP	140.0	293.5	2.0	291.6	7.5	5.7	-166.7		693.	430.	85.4	9.9
								609.5				
OCT	100.0	155.4	1.6	153.8	3.7	2.6	-61.7		579.	423.	43.6	5.5
								547.9				
NOV	75.0	149.9	1.2	148.8	7.5	1.2	-83.6		506.	412.	40.9	5.4
								464.7				
DEC	70.0	154.8	1.0	153.8	6.5	0.7	-91.9		419.	399.	40.5	5.5
								373.0				
JAN	120.0	93.3	1.0	92.3	5.6	1.1	20.0		383.	402.	23.9	3.4
								392.9				
EB	170.0	84.4	1.2	83.3	3.7	1.0	80.9		433.	414.	22.3	3.1
								473.9				
R	250.0	93.4	1.2	92.3	5.6	1.7	149.3		549.	431.	25.9	3.4
								623.2				
APR	300.0	240.1	1.6	238.5	9.3	3.6	47.0		647.	437.	68.8	8.3
								670.6				
MAY	260.0	209.4	1.8	207.6	10.3	4.8	35.5		688.	440.	60.8	7.3
								705.8				
JUN	120.0	300.3	2.2	298.1	12.1	5.2	-197.6		607.	418.	85.0	10.1
								508.6				
TOTAL	2085.0	2394.7	20.0	2375.1	93.2	43.5	-446.4				687.7	82.7

July through September inflows based on water year forecast of 5387000 acre-feet.

October through June inflows based on annual flows with 70% exceedance probability.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSOM LAKE OPERATION

REPORT 4

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH)

AUGUST 16 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE				EVAPO-RATION	STORAGE			EOM WATER SURFACE ELEV.	POWER GENERATION MILLIONS KWH	
		POWER HOUSE	FOLSOM S.C.	NIMBUS	FOLSOM PUMPS		CHANGE	END OF PERIOD	MEAN		FOLSOM	NIMBUS
								604.6				
AUG	170.0	187.1	2.6	184.5	9.3	6.2	-32.6		589.	426.	52.6	6.6
								572.4				
SEP	140.0	210.3	2.0	208.3	7.5	4.9	-82.7		531.	416.	57.9	7.4
								489.5				
OCT	100.0	124.6	1.6	123.0	3.7	2.3	-30.6		474.	412.	33.6	4.5
								459.2				
NOV	75.0	120.2	1.2	119.0	7.5	1.1	-53.8		432.	404.	31.7	4.3
								405.1				
DEC	70.0	124.0	1.0	123.0	6.5	0.6	-61.1		374.	395.	31.7	4.5
								343.5				
JAN	120.0	93.3	1.0	92.3	5.6	1.1	20.0		353.	398.	23.5	3.4
								363.4				
FEB	170.0	84.5	1.2	83.3	3.7	0.9	80.9		404.	410.	21.9	3.1
								444.5				
MAR	250.0	93.5	1.2	92.3	5.6	1.6	149.3		519.	428.	25.6	3.4
								593.9				
APR	300.0	181.9	1.6	180.3	9.3	3.6	105.2		647.	440.	52.1	6.4
								699.3				
MAY	260.0	151.3	1.8	149.5	10.3	5.0	93.4		746.	449.	44.8	5.4
								792.3				
JUN	120.0	169.3	2.2	167.1	12.1	5.8	-67.2		759.	442.	50.3	6.0
								725.5				
JUL	110.0	202.5	2.6	199.9	12.1	7.2	-111.8		669.	430.	58.5	7.1
								613.3				
TOTAL	1885.0	1742.5	20.0	1722.5	93.2	40.3	9.0				484.2	62.0

AUGUST THROUGH SEPTEMBER INFLOWS BASED ON CURRENT WATER YEAR FORECAST OF 5425000 ACRE-FEET

OCTOBER THROUGH JULY INFLOWS BASED ON ANNUAL FLOW WITH 70 PERCENT PROBABILILY OF EXCEEDANCE

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSOM LAKE OPERATION

REPORT 4

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH) OCTOBER 24 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE				EVAPO-RATION	STORAGE			EOM WATER SURFACE ELEV.	POWER GENERATION MILLIONS KWH	
		POWER HOUSE	FOLSOM S.C.	NIMBUS	FOLSOM PUMPS		CHANGE	END OF PERIOD	MEAN		FOLSOM	NIMBUS
								466.1				
OCT	90.0	186.1	1.6	184.5	3.7	2.1	-101.9	364.0	415.	398.	48.6	6.6
NOV	80.0	150.0	1.2	148.8	7.5	0.9	-78.4	286.1	325.	385.	37.1	5.4
DEC	70.0	154.8	1.0	153.8	6.5	0.9	-91.8	196.6	240.	366.	35.8	5.5
JAN	120.0	124.0	1.0	123.0	5.6	0.7	-10.3	183.9	189.	364.	27.3	4.5
FEB	170.0	112.2	1.2	111.0	5.7	0.6	53.5	237.3	211.	376.	25.2	4.0
MAR	250.0	124.2	1.2	123.0	5.6	1.1	119.1	356.2	297.	397.	30.1	4.5
APR	300.0	120.6	1.6	119.0	9.3	2.9	167.2	523.3	440.	420.	31.9	4.3
MAY	240.0	124.8	1.8	123.0	10.3	4.4	120.5	643.9	584.	434.	35.0	4.5
JUN	120.0	182.2	2.2	180.0	12.1	5.2	-79.5	564.7	604.	425.	51.5	6.4
JUL	110.0	125.6	2.6	123.0	12.1	6.4	-34.1	530.3	548.	421.	36.8	4.5
AUG	100.0	125.6	2.6	123.0	9.3	5.7	-40.6	489.6	510.	416.	34.3	4.5
SEP	100.0	95.0	2.0	91.0	7.5	4.7	-5.2	483.9	487.	415.	25.2	3.4
TOTAL	1770.0	1623.1	20.0	1603.1	95.2	35.2	18.5				416.9	57.9

OCTOBER THROUGH SEPTEMBER INFLOWS BASED ON WATER YEAR FORECAST OF 1770000 ACRE-FEET

WITH 70 PERCENT PROBABILITY OF EXCEEDANCE

NOV-30-1995 11:28

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSOM LAKE OPERATION

REPORT 4

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH)

NOVEMBER 14 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE				EVAPO-RATION	STORAGE			EOM WATER SURFACE ELEV.	POWER GENERATION MILLIONS KWH	
		POWER HOUSE	FOLSOM S.C.	NIMBUS	FOLSOM PUMPS		CHANGE	END OF PERIOD	MEAN		FOLSOM	NIMBUS
								386.0				
NOV	80.0	150.0	1.2	148.8	7.5	0.9	-78.4	308.1	347.	389.	37.6	5.4
DEC	70.0	154.8	1.0	153.8	6.5	0.5	-91.8	216.6	262.	371.	36.5	5.5
JAN	120.0	124.8	1.0	123.0	5.6	0.7	+10.3	205.9	211.	369.	27.9	4.9
FEB	170.0	112.2	1.2	111.0	3.7	0.7	53.4	259.2	233.	380.	25.7	4.0
MAR	250.0	124.2	1.2	123.0	5.6	1.2	119.0	378.0	319.	400.	30.6	4.9
APR	300.0	120.6	1.6	119.0	9.3	2.9	167.2	545.1	462.	422.	32.3	4.3
MAY	260.0	124.8	1.8	123.0	10.3	4.5	120.4	665.6	605.	436.	35.3	4.5
JUN	120.0	180.7	2.2	178.5	12.1	5.3	-78.1	587.3	626.	427.	51.5	6.4
JUL	110.0	125.7	2.6	123.1	12.1	6.6	-34.4	552.7	570.	423.	35.1	4.5
AUG	100.0	125.7	2.6	123.1	9.3	5.9	-40.9	511.8	532.	418.	34.6	4.5
SEP	100.0	91.3	2.0	89.3	7.5	4.8	-3.6	508.0	510.	418.	24.9	3.3
OCT	90.0	109.2	1.6	107.6	3.7	2.4	-25.3	482.6	496.	415.	29.7	3.9
TOTAL	1770.0	1543.2	20.0	1523.2	93.2	56.4	97.2				401.8	55.1

NOVEMBER THROUGH SEPTEMBER INFLOWS BASED ON CURRENT WATER YEAR FORECAST OF 1787400 ACRE-FEET

OCTOBER OF NEXT WATER YEAR INFLOWS BASED ON ANNUAL FLOW OF 70 PERCENT PROBABILITY OF EXCEEDANCE

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT - CALIFORNIA

FOLSOM LAKE OPERATION

TABLE 5

FORECAST OF WATER SUPPLY AND REQUIREMENTS

(UNITS: THOUSANDS OF ACRE FEET - MILLIONS OF KWH)

DECEMBER 18 1995

MONTH	FOLSOM LAKE INFLOW	RELEASE				EVAPO-RATION	STORAGE			EOM WATER SURFACE ELEV.	POWER GENERATION MILLIONS KWH	
		POWER HOUSE	FOLSOM S.C.	NIMBUS	FOLSOM PUMPS		CHANGE	END OF PERIOD	MEAN		FOLSOM	NIMBUS
								307.0				
DEC	80.0	154.8	1.0	153.8	6.5	0.5	-81.8		266.	373.	36.6	5.5
								225.5				
JAN	130.0	124.0	1.0	123.0	5.6	0.8	-0.4		225.	373.	28.3	4.5
								224.7				
FEB	180.0	112.2	1.2	111.0	3.7	0.7	63.4		256.	386.	26.3	4.0
								288.0				
MAR	260.0	124.2	1.2	123.0	5.6	1.3	128.9		352.	406.	31.3	4.5
								416.7				
APR	320.0	204.1	1.6	202.5	9.3	3.0	103.6		469.	419.	54.8	7.2
								520.7				
MAY	290.0	171.2	1.8	169.4	10.3	4.4	104.1		573.	432.	47.9	6.1
								625.3				
JUN	120.0	160.0	2.2	157.8	12.1	5.1	-57.2		597.	425.	45.1	5.7
								568.2				
JUL	110.0	195.9	2.6	193.3	12.1	6.2	-104.2		516.	412.	53.7	6.9
								464.0				
AUG	100.0	125.9	2.6	123.3	9.3	5.3	-40.5		444.	407.	33.4	4.5
								423.7				
SEP	100.0	125.2	2.0	123.2	7.5	4.2	-36.9		405.	401.	32.5	4.5
								386.5				
OCT	50.0	93.9	1.6	92.3	3.7	2.0	-49.6		362.	394.	23.8	3.4
								336.5				
NOV	50.0	90.4	1.2	89.2	7.5	0.9	-48.8		312.	385.	22.2	3.3
								287.6				
TOTAL	1790.0	1681.8	20.0	1661.8	93.2	34.4	-19.4				435.8	59.9

DECEMBER THROUGH SEPTEMBER INFLOWS BASED ON 50% EXCEEDENCE WATER YEAR FORECAST OF 1875000 ACRE-FEET

OCTOBER THROUGH NOVEMBER INFLOWS BASED ON ANNUAL FLOW WITH 70 PERCENT PROBABILILY OF EXCEEDANCE

APPENDIX O

Construction Cost Estimates: Treatment Plant, Extraction Wells and Collection System

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/9/96

TREATMENT PLANT OPTION 1:
DUAL PIPELINES FROM F & G TO TREATMENT PLANT; UV/PEROXIDE TREATMENT SMALL LINE, FOLLOWED BY AIR-STRIPPING OF BOTH LINES COMBINED

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	36,000.00	36,000.00
1.02	Start-up and Testing	1	LS	25,000.00	25,000.00
Subtotal 1.				$61,000.00	
2.	TREATMENT PLANT				
2.01	Site Development, including clear & grub, grading, paving, fencing.	1	LS	65,000.00	65,000.00
2.02	Foundations, Structures, Sumps, Manholes, Containment Wall, Pipe Supports, Railings, Stairs, Ladders, etc.	1	LS	208,000.00	208,000.00
2.03	Duplex Air Stripper Columns, packing, associated piping, ducts and valves (3445 gpm).	1	EA	400,000.00	400,000.00
2.04	Pumps, Transfer and Effluent	2	EA	15,000.00	30,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
2.05	UV/Peroxide Treatment Module, 180 kW, 785 gpm, incl. peroxide tank & associated piping.	1	LS	370,000.00	370,000.00
2.06	Hydropneumatic Tank HT-1, 7500 gallons.	1	EA	26,000.00	26,000.00
2.07	Air Compressor	1	EA	25,000.00	25,000.00
2.08	Process Blowers	2	EA	20,000.00	40,000.00
2.09	Sump Pump and Piping	3	EA	1,000.00	3,000.00
2.10	Flowmeter, 20-inch, Treatment Plant influent	1	EA	8,500.00	8,500.00
2.11	Flowmeter, 10-inch, UV Module effluent	1	EA	5,000.00	5,000.00
2.12	Flowmeter, 4-inch, sump pump dischg.	1	EA	2,700.00	2,700.00
2.13	Station Piping: Raw Water, Treated Water, Reclaim Water, Cooling Water, Steam, Condensate, Sump pump piping, Air	1	LS	100,000.00	100,000.00
2.14	Building w/ a/c	3000	SF	15.00	45,000.00
2.15	Electrical Power Conduits, circuits, and Xfr. Pad	1	LS	10,400.00	10,400.00
2.16	Electrical Contl and Instrumentation, incl. enclosures, grounding, contrlr, transducers, transmitters, gages, security and lighting.	1	LS	150,000.00	150,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
2.17	Telephone Conduit and Pullboxes	1000	LF	8.00	8,000.00
2.18	Telemetry System	1	LS	15,000.00	15,000.00
2.19	Landscaping, Planting, and Irrigation.	1	LS	7,000.00	7,000.00
Subtotal 2.				**$1,518,600.00**	
3.	**POTABLE WATER SYSTEM**				
3.01	Potable Water Pipeline, 8-inch	2000	LF	20.00	40,000.00
3.02	Air Valves	6	EA	1,000.00	6,000.00
3.03	Blow-Offs	6	EA	1,000.00	6,000.00
3.04	8-inch Backflow Preventer and Station Piping	1	EA	3,500.00	3,500.00
3.05	Eyewash & Shower	1	LS	5,000.00	5,000.00
3.06	Restroom	1	LS	16,000.00	16,000.00
Subtotal 3.				**$76,500.00**	
Subtotal Items 1-3.					**$1,656,100.00**
	Contingencies @ 15 %				248,415.00
	TOTAL				1,904,515.00

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/10/96

TREATMENT PLANT OPTION 2:
SINGLE PIPELINE FROM F & G TO TREATMENT PLANT;
AIR-STRIPPING ONLY

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	33,000	33,000.00
1.02	Start-up and Testing	1	LS	25,000	25,000.00
Subtotal 1.			$58,000.00		
2.	TREATMENT PLANT				
2.01	Site Development, including clear & grub, grading, paving, fencing.	1	LS	65,000	65,000.00
2.02	Foundations, Structures, Sumps, Manholes, Containment Wall, Pipe Supports, Railings, Stairs, Ladders, etc.	1	LS	208,000	208,000.00
2.03	Duplex Air Stripper Columns, packing, associated piping, ducts and valves (3445 gpm).	1	EA	400,000	400,000.00
2.04	Pumps, Transfer & Effluent	2	EA	15,000	30,000.00
2.05	Hydropneumatic Tank HT-1, 7500 gallons.	1	EA	26,000	26,000.00
2.06	Air Compressor	1	EA	25,000	25,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
2.07	Process Blowers	2	EA	20,000	40,000.00
2.08	Sump Pump and Piping	3	EA	1,000	3,000.00
2.09	Flowmeter, 24-inch, Treatment Plant influent	1	EA	10,400	10,400.00
2.10	Flowmeter, 4-inch, sump pump dischg.	1	EA	2,700	2,700.00
2.11	Station Piping: Raw Water, Treated Water, Reclaim Water, Cooling Water, Steam, Condensate, Sump pump piping, Air.	1	LS	100,000	100,000.00
2.12	Building w/ a/c	3000	SF	15	45,000.00
2.13	Electrical Power Conduits, circuits, and Xfr. Pad	1	LS	10,400	10,400.00
2.14	Electrical Contl and Instrumentation, incl. enclosures, grounding, contrlr, transducers, transmitters, gages, security and lighting.	1	LS	100,000	100,000.00
2.15	Telephone Conduit and Pullboxes	1000	LF	8	8,000.00
2.16	Telemetry System	1	LS	15,000	15,000.00
2.17	Landscaping, Planting, and Irrigation.	1	LS	7,000	7,000.00
Subtotal 2.				**$1,095,500.00**	
3.	**POTABLE WATER SYSTEM**				
3.01	Potable Water Pipeline, 8-inch	2000	LF	20	40,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
3.02	Air Valves	6	EA	1,000	6,000.00
3.03	Blow-Offs	6	EA	1,000	6,000.00
3.04	8-inch Backflow Preventer and Station Piping	1	EA	3,500	3,500.00
3.05	Eyewash & Shower	1	LS	5,000	5,000.00
3.06	Restroom	1	LS	16,000	16,000.00
Subtotal 3.				$76,500.00	
Subtotal Items 1-3.					$1,230,000
	Contingencies @ 15%				184,500.00
	TOTAL				1,414,500.00

EECA COST ESTIMATES

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Extraction Wells and Collection Pipelines Estimated Cost - $ Thousand				
Alternate	Extraction Wells	Pipelines	River Crossing	TOTAL
Route 1 Single Pipeline	502	2,981	1,388	5,723
Route 1 Dual Pipelines	502	3,405	1,388	6,217
Route 2 Single Pipeline	502	2,524	1,388	5,197
Route 2 Dual Pipelines	502	2,852	1,388	5,574

Effluent Pipeline and Discharge Facilities Estimated Cost - $ Thousand				
Alternate	Effluent Pipelines	Discharge Structure		TOTAL
Buffalo Creek	165	28		233
Folsom South Canal	450	58		601
Recharge Wells	550	1,456		2,371
Percolation Field	1,560	143		1,970

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/8/96

COLLECTION SYSTEM OPTION 1:
ROUTE 1, SINGLE PIPELINE

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	75,000.00	75,000.00
1.02	Start-up and Testing	1	LS	30,000.00	30,000.00
Subtotal 1.			$105,000.00		
2.	EXTRACTION WELLS				
2.01	Pumps, Submersible, 15 total, including discharge piping, Pitless Adapters, cables	1	LS	150,000.00	150,000.00
2.02	Valve Boxes, 2- & 3-inch	5	EA	2,500.00	12,500.00
2.03	Valve Boxes, 4- & 6-inch	10	EA	3,500.00	35,000.00
2.04	Meter Vault Installation, including flow meters, piping, valves, and vaults	5	EA	10,500.00	52,500.00
2.05	Piping, Raw Water and Vent	5	EA	4,000.00	20,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
2.06	Site Development, including grading, and electrical enclosure foundation.	5	EA	6,000.00	30,000.00
2.07	Landscaping, Middle Extraction Well Site	1	LS	900.00	900.00
2.08	Electrical Power Conduits and Pullboxes	5	LS	4,600.00	23,000.00
2.09	Electrical Pedestal	5	EA	35,700.00	178,500.00
	Subtotal 2.			$502,400.00	
3.	**PIPELINES**				
3.01	Raw Water, 16-inch, w/20-inch Containment Pipe	3350	LF	112.00	375,200.00
3.02	Raw Water, 8-inch, w/12-inch Containment Pipe	3000	LF	50.00	150,000.00
3.03	Raw Water, 10-inch w/ 14-in Containment Pipe	450	LF	70.00	31,500.00
3.04	Raw Water, 20-inch, w/ 26-inch Containment Pipe	1800	LF	145.00	261,000.00
3.05	Raw Water, 24-inch, w/30-inch Containment Pipe	9500	LF	170.00	1,615,000.00
3.06	Culvert, Road Improvement @ Sailor Bar Park	1	LS	20,900.00	20,900.00
3.07	USBR Tunnel Crossing	1	LS	244,000.00	244,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
3.08	Raw Water Air Valve	6	EA	3,000.00	18,000.00
3.09	Raw Water Sump	10	EA	4,000.00	40,000.00
3.10	Raw Water Branch Sump	5	EA	5,000.00	25,000.00
3.11	Primary Conduits	9000	LF	12.50	112,500.00
3.12	Control Conduits	14000	LF	6.30	88,200.00
Subtotal 3.				$2,981,300.00	
4.	RIVER CROSSING				
4.01	Horizontal Directional Drilling (incl. mobilization)	1	LS	750,000.00	750,000.00
4.02	Casing Pipe, 30-inch, steel, API 5L (Gr.B), .562 wall	2000	LF	120.00	240,000.00
4.03	Casing Construction	2000	LF	54.00	108,000.00
4.04	Raw Water Pipe, HDPE, 16" Carrier, 24" Containment	2000	LF	125.00	250,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
4.05	HDPE Pipe Construction	2000	LF	10.00	20,000.00
4.06	Misc. Cleanup and Restoration	1	LS	20,000.00	20,000.00
Subtotal 4.				$1,388,000.00	
Subtotal Items 1-4.					4,976,700.00
	Contingencies @ 15%				746,505.00
	TOTAL				5,723,205.00

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/8/96

COLLECTION SYSTEM OPTION 2:
ROUTE 1, DUAL PIPELINES

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	80,000.00	80,000.00
1.02	Start-up and Testing	1	LS	30,000.00	30,000.00
Subtotal 1.			$110,000.00		
2.	EXTRACTION WELLS				
2.01	Pumps, Submersible, 15 total, including discharge piping, Pitless Adapters, cables	1	LS	150,000.00	150,000.00
2.02	Valve Boxes, 2- & 3-inch	5	EA	2,500.00	12,500.00
2.03	Valve Boxes, 4- & 6-inch	10	EA	3,500.00	35,000.00
2.04	Meter Vault Installation, including flow meters, piping, valves, and vaults	5	EA	10,500.00	52,500.00
2.05	Piping, Raw Water and Vent	5	EA	4,000.00	20,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
2.06	Site Development, including grading, and electrical enclosure foundation.	5	EA	6,000.00	30,000.00
2.07	Landscaping, Middle Extraction Well Site	1	LS	900.00	900.00
2.08	Electrical Power Conduits and Pullboxes	5	LS	4,600.00	23,000.00
2.09	Electrical Pedestal	5	EA	35,700.00	178,500.00
Subtotal 2.			$502,400.00		
3.	**PIPELINES**				
3.01	Raw Water, 16-inch, w/20-inch Containment Pipe	3350	LF	112.00	375,200.00
3.02	Raw Water, 8-inch, w/12-inch Containment Pipe	3000	LF	50.00	150,000.00
3.03	Raw Water, 20-inch, w/26-inch Containment Pipe	11300	LF	145.00	1,638,500.00
3.04	Raw Water, 10-inch, w/14-inch Containment Pipe	9900	LF	70.00	693,000.00
3.05	Culvert, Road Improvement @ Sailor Bar Park	1	LS	20,900.00	20,900.00
3.06	USBR Tunnel Crossing	1	LS	244,000.00	244,000.00
3.07	Raw Water Air Valve	6	EA	3,000.00	18,000.00
3.08	Raw Water Sump	10	EA	4,000.00	40,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
3.09	Raw Water Branch Sump	5	EA	5,000.00	25,000.00
3.10	Primary Conduits	9000	LF	12.50	112,500.00
3.11	Control Conduits	14000	LF	6.30	88,200.00
	Subtotal 3.			$3,405,300.00	
4.	**RIVER CROSSING**				
4.01	Horizontal Directional Drilling (incl. mobilization)	1	LS	750,000.00	750,000.00
4.02	Casing Pipe, 30-inch, steel, API 5L (Gr.B), .562 wall	2000	LF	120.00	240,000.00
4.03	Casing Construction	2000	LF	54.00	108,000.00
4.04	Raw Water Pipe, HDPE, 16" Carrier, 24" Containment	2000	LF	125.00	250,000.00
4.05	HDPE Pipe Construction	2000	LF	10.00	20,000.00
4.06	Misc. Cleanup and Restoration	1	LS	20,000.00	20,000.00
	Subtotal 4.			$1,388,000.00	
	Subtotal Items 1-4.				5,405,700.00
	Contingencies @ 15%				810,855.00
	TOTAL				6,216,555.00

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/8/96

COLLECTION SYSTEM OPTION 3:
ROUTE 2, SINGLE PIPELINE

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	75,000.00	75,000.00
1.02	Start-up and Testing	1	LS	30,000.00	30,000.00
Subtotal 1.				$105,000.00	
2.	EXTRACTION WELLS				
2.01	Pumps, Submersible, 15 total, including discharge piping, Pitless Adapters, cables	1	LS	150,000.00	150,000.00
2.02	Valve Boxes, 2- & 3-inch	5	EA	2,500.00	12,500.00
2.03	Valve Boxes, 4- & 6-inch	10	EA	3,500.00	35,000.00
2.04	Meter Vault Installation, including flow meters, piping, valves, and vaults	5	EA	10,500.00	52,500.00
2.05	Piping, Raw Water and Vent	5	EA	4,000.00	20,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
2.06	Site Development, including grading, and electrical enclosure foundation.	5	EA	6,000.00	30,000.00
2.07	Landscaping, Middle Extraction Well Site	1	LS	900.00	900.00
2.08	Electrical Power Conduits and Pullboxes	5	LS	4,600.00	23,000.00
2.09	Electrical Pedestal	5	EA	35,700.00	178,500.00
Subtotal 2.				$502,400.00	
3.	PIPELINES				
3.01	Raw Water, 16-inch, w/20-inch Containment Pipe	3350	LF	112.00	375,200.00
3.02	Raw Water, 8-inch, w/12-inch Containment Pipe	3000	LF	50.00	150,000.00
3.03	Raw Water, 10-inch, w/14-inch Containment Pipe	450	LF	70.00	31,500.00
3.04	Raw Water, 20-inch, w/26-inch Containment Pipe	1800	LF	145.00	261,000.00
3.05	Raw Water, 24-inch, w/30-inch Containment Pipe	6900	LF	170.00	1,173,000.00
3.06	Culvert, Road Improvement @ Sailor Bar Park	1	LS	20,900.00	20,900.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
3.07	USBR Tunnel Crossing	1	LS	244,000.00	244,000.00
3.08	Raw Water Air Valve	6	EA	3,000.00	18,000.00
3.09	Raw Water Sump	10	EA	4,000.00	40,000.00
3.10	Raw Water Branch Sump	5	EA	5,000.00	25,000.00
3.11	Primary Conduits	9000	LF	12.50	112,500.00
3.12	Control Conduits	11500	LF	6.30	72,450.00
Subtotal 3.			$2,523,550.00		
4.	RIVER CROSSING				
4.01	Horizontal Directional Drilling (incl. mobilization)	1	LS	750,000.00	750,000.00
4.02	Casing Pipe, 30-inch, steel, API 5L (Gr.B), .562 wall	2000	LF	120.00	240,000.00
4.03	Casing Construction	2000	LF	54.00	108,000.00
4.04	Raw Water Pipe, HDPE, 16" Carrier, 24" Containment	2000	LF	125.00	250,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
4.05	HDPE Pipe Construction	2000	LF	10.00	20,000.00
4.06	Misc. Cleanup and Restoration	1	LS	20,000.00	20,000.00
Subtotal 4.				$1,388,000.00	
Subtotal Items 1-4.					4,518,950.00
	Contingencies @ 15%				677,842.50
	TOTAL				5,196,792.50

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/8/96

COLLECTION SYSTEM OPTION 4:
ROUTE 2, DUAL PIPELINES

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	75,000.00	75,000.00
1.02	Start-up and Testing	1	LS	30,000.00	30,000.00
Subtotal 1.			$105,000.00		
2.	EXTRACTION WELLS				
2.01	Pumps, Submersible, 15 total, including discharge piping, Pitless Adapters, cables	1	LS	150,000.00	150,000.00
2.02	Valve Boxes, 2- & 3-inch	5	EA	2,500.00	12,500.00
2.03	Valve Boxes, 4- & 6-inch	10	EA	3,500.00	35,000.00
2.04	Meter Vault Installation, including flow meters, piping, valves, and vaults	5	EA	10,500.00	52,500.00
2.05	Piping, Raw Water and Vent	5	EA	4,000.00	20,000.00
2.06	Site Development, including grading, and electrical enclosure foundation.	5	EA	6,000.00	30,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
2.07	Landscaping, Middle Extraction Well Site	1	LS	900.00	900.00
2.08	Electrical Power Conduits and Pullboxes	5	LS	4,600.00	23,000.00
2.09	Electrical Pedestal	5	EA	35,700.00	178,500.00
Subtotal 2.				$502,400.00	
3.	PIPELINES				
3.01	Raw Water, 16-inch, w/20-inch Containment Pipe	3350	LF	112.00	375,200.00
3.02	Raw Water, 8-inch, w/12-inch Containment Pipe	3000	LF	50.00	150,000.00
3.03	Raw Water, 20-inch, w/26-inch Containment Pipe	8700	LF	145.00	1,261,500.00
3.04	Raw Water, 10-inch, w/14-inch Containment Pipe	7350	LF	70.00	514,500.00
3.05	Culvert, Road Improvement @ Sailor Bar Park	1	LS	18,650.00	18,650.00
3.06	USBR Tunnel Crossing	1	LS	264,000.00	264,000.00
3.07	Raw Water Air Valve	6	EA	3,000.00	18,000.00
3.08	Raw Water Sump	10	EA	4,000.00	40,000.00
3.09	Raw Water Branch Sump	5	EA	5,000.00	25,000.00

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
3.10	Primary Conduits	9000	LF	12.50	112,500.00
3.11	Control Conduits	11500	LF	6.30	72,450.00
	Subtotal 3.			$2,851,800.00	
4.	**RIVER CROSSING**				
4.01	Horizontal Directional Drilling (incl. mobilization)	1	LS	750,000.00	750,000.00
4.02	Casing Pipe, 30-inch, steel, API 5L (Gr.B), .562 wall	2000	LF	120.00	240,000.00
4.03	Casing Construction	2000	LF	54.00	108,000.00
4.04	Raw Water Pipe, HDPE, 16" Carrier, 24" Containment	2000	LF	125.00	250,000.00
4.05	HDPE Pipe Construction	2000	LF	10.00	20,000.00
4.06	Misc. Cleanup and Restoration	1	LS	20,000.00	20,000.00
	Subtotal 4.			$1,388,000.00	
	Subtotal Items 1-4.				4,847,200.00
	Contingencies @ 15%				727,080.00
	TOTAL				5,574,280.00

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/8/96

DISPOSAL SYSTEM OPTION 1:
DISCHARGE TO BUFFALO CREEK

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	5,000.00	5,000.00
1.02	Start-up and Testing	1	LS	5,000.00	5,000.00
	Subtotal 1.			$10,000.00	
2.	EFFLUENT PIPELINE				
2.01	Treated Water, 24-inch, pipe, fittings	2000	LF	75.00	150,000.00
2.02	Siphon Breaker, 24-inch	1	EA	5,000.00	5,000.00
2.03	Flow meter, 24-inch, Treatment Plant effluent	1	EA	10,400.00	10,400.00
	Subtotal 2.			$165,400.00	
3.	DISCHARGE STRUCTURE				
3.01	Concrete Outfall	1	LS	20,000.00	20,000.00
3.02	Flap Gate, 24-inch	1	EA	7,500.00	7,500.00
	Subtotal 3.			$27,500.00	
	Subtotal Items 1-3.				202,900.00
	Contingencies @ 15 %				30,435.00
	TOTAL				233,335.00

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/8/96

DISPOSAL SYSTEM OPTION 2:
DISCHARGE TO FOLSOM SOUTH CANAL

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	10,000.00	10,000.00
1.02	Start-up and Testing	1	LS	5,000.00	5,000.00
	Subtotal 1.			$15,000.00	
2.	EFFLUENT PIPELINE				
2.01	Treated Water, 24-inch, pipe, fittings	5800	LF	75.00	435,000.00
2.02	Siphon Breaker, 24-inch	1	EA	5,000.00	5,000.00
2.03	Flow Meter, 24-inch, Treatment Plant effluent	1	EA	10,400.00	10,400.00
	Subtotal 2.			$450,400.00	
3.	DISCHARGE STRUCTURE				
3.01	Concrete Outfall	1	LS	50,000.00	50,000.00
3.02	Flap Gate, 24-inch	1	EA	7,500.00	7,500.00
	Subtotal 3.			$57,500.00	
	Subtotal Items 1-3.				522,900.00
	Contingencies @ 15%				78,435.00
	TOTAL				601,335.00

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/8/96

DISPOSAL SYSTEM OPTION 3:
DISCHARGE TO RECHARGE WELLS

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	42,000.00	42,000.00
1.02	Start-up and Testing	1	LS	15,000.00	15,000.00
Subtotal 1.			$57,000.00		
2.	EFFLUENT PIPELINE				
2.01	Treated Water, 24-inch, pipe, fittings	1500	LF	75.00	112,500.00
2.02	Treated Water, 16-inch, pipe, fittings	3000	LF	50.00	150,000.00
2.03	Treated Water, 12-inch, pipe, fittings	5500	LF	35.00	192,500.00
2.04	Bag Filters (@ Trtmt Plant)	6	EA	14,000.00	84,000.00
2.05	Basket Strainers (@ Trtmt Plant)	3	EA	3,500.00	10,500.00
Subtotal 2.			$549,500.00		

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
3.	RECHARGE WELLS				
3.01	Treated Water, 6-inch, pipe, fittings	200	LF	17.00	3,400.00
3.02	Gate Valves, 6-inch	30	EA	1,000.00	30,000.00
3.03	Flow Control Valves, 6-inch	15	EA	3,200.00	48,000.00
3.04	Flow Meters, Propeller type, 6-inch, w/xmitters	15	EA	3,500.00	52,500.00
3.05	Drill case, and test wells	15	EA	80,000.00	1,200,000.00
3.06	Drop Pipe w/centralizers, 150 feet long	15	EA	1,500.00	22,500.00
3.07	Electrical Control Conduits, wires	10200	LF	6.50	66,300.00
3.08	Well site development-grading, rock	15	EA	1,500.00	22,500.00
3.09	Flow Meter, 24-inch, Treatment Plant effluent	1	EA	10,400.00	10,400.00
	Subtotal 3.			$1,455,600.00	
	Subtotal Items 1-3.				2,062,100.00
	Contingencies @ 15%				309,315.00
	TOTAL				2,371,415.00

AEROJET
ARGET SYSTEM

CONSTRUCTION COST ESTIMATE
5/8/96

DISPOSAL SYSTEM OPTION 4:
ONSITE PERCOLATION DISCHARGE

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
1.	GENERAL				
1.01	Mobilization	1	LS	5,000.00	5,000.00
1.02	Start-up and Testing	1	LS	5,000.00	5,000.00
Subtotal 1.			$10,000.00		
2.	EFFLUENT PIPELINE				
2.01	Treated Water, 24-inch, pipe, fittings	2000	LF	75.00	150,000.00
2.02	Flow Meter, 24-inch, Treatment Plant effluent	1	EA	10,400.00	10,400.00
2.03	Treated Water, 16-inch, pipe & fittings	2000	LF	60.00	120,000.00
2.04	Treated Water, 4-inch, pipe & fittings	90,000	LF	12.00	1,080,000.00
2.05	Sprinkler Stands	800	EA	250.00	200,000.00
Subtotal 2.			$1,560,400.00		

NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	TOTAL
3.	DISCHARGE STRUCTURE				
3.01	Concrete Outfall	1	LS	15,000.00	15,000.00
3.02	Flap Gate, 24-inch	1	EA	7,500.00	7,500.00
3.03	Water Feature	1	EA	120,000.00	120,000.00
Subtotal 3.				$142,500.00	
Subtotal Items 1-3.					1,712,900.00
	Contingencies @ 15%				256,935.00
	TOTAL				1,969,835.00

APPENDIX P

American River Crossing Project Plan

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Aerojet Site

GET E and F Effectiveness

Evaluation Report

April 1996

Prepared for:

Aerojet General Corporation
Sacramento, California

Prepared by:

Hydro-Search, Incorporated
Rancho Cordova, California

and

Aerojet General Corporation
Sacramento, California

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Aerojet Site

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1.0 INTRODUCTION

Pursuant to Exhibit II of the Partial Consent Decree (Decree), Aerojet is evaluating the effectiveness of the existing groundwater extraction and treatment (GET) facilities in controlling plumes of chemicals in groundwater at or near the boundary of the Aerojet Sacramento Operating Plant. This report presents an evaluation of the effectiveness of the GET E and F facilities on intercepting plumes of chemicals in groundwater at or near the Aerojet Operating Plant boundary and presents recommendations, as appropriate, for any modifications to the design or operation of the existing GET facilities.

The distribution of chemicals and effectiveness of groundwater capture in the GET E and GET F areas has previously been evaluated in two reports: the Part 2 GET Effectiveness Report GET E Evaluation (August 1992a) and the Part 2 GET Effectiveness Report GET F Evaluation (October 1992b). An additional report, the Aerojet Site Stage 1 Report-Zone 2, was submitted to the agencies in December 1993.

The purpose of this report is threefold: (1) incorporate new information obtained from work recommended in and performed since the last reports, (2) address the Agency comments on the previous reports, and (3) provide a single report assessing groundwater conditions in the GET E and GET F areas.

Several new wells have been installed in the study area since the previous reports were issued. These wells are listed below and their well construction diagrams are included in Appendix A of this report.

- Three multiple-completion and two single completion monitor wells were installed near the GET E extraction area (Wells 3403-5, 3406-8, 3409-11, 3517, and 3518).
- One single-completion and five multiple-completion monitor wells were installed near the GET F extraction area (Wells 3415-7, 3431-3, 3434-6, 3437-9, 3440-2, and 3476).
- Two new GET F extraction wells were installed (Wells 4310 and 4315).
- Two new GET E extraction wells were installed (Wells 4425 and 4435).

Aquifer tests were performed on both of the new GET E extraction wells and one of the new GET F extraction wells (Well 4315).

This report includes six hydrogeologic cross sections; ten potentiometric contour maps; concentration maps of trichloroethylene (TCE), 1,2-dichloroethane (1,2-DCA), chloroform, and perchlorate in groundwater; and time-series plots for water level elevations and concentrations of chemicals in monitor and extraction wells. The report concludes with Aerojet's recommendations for modifications to the existing extraction well fields.

2.0 GET E AND GET F FACILITY DESCRIPTIONS

2.1 Facility Locations

Aerojet operates five groundwater extraction and treatment (GET) facilities on its property in Rancho Cordova, California. For purposes of the ongoing groundwater investigation and remediation, the Aerojet site has been divided into four zones. Both GET E and GET F are located in Zone 2, which occupies the western portion of the property (Figure 2-1). The GET E extraction area is located in the northwest portion of Zone 2 and the GET F extraction area is located in the southwest portion of Zone 2. Between these two extraction areas is a recharge area that receives the effluent from the GET E and GET F treatment systems.

The study area is primarily open space, with a magazine area located near the center of the study area and Chemical Plant 2 (Plant 2) located near the GET F facility. Aerojet's manufacturing areas are located to the east (upgradient) of the study area. Figure 2-1 shows the locations of chemical Plant 1 and Lines 01, 03, 04, and 05.

Most of the area has been altered by past gold dredging operations. The dredge tailings were deposited in distinct north-south or east-west trending ridges and valleys in north-central and western portions of Sector E and northwestern portions of Sector F.

2.2 System Components

2.2.1 GET E System Components

The GET E system is composed of three extraction wells, a water treatment system, and five recharge wells, three of which are normally used (Figure 2-2). (One of the other recharge wells provides backup capacity during system maintenance and the other has a very low injection capacity.) Two additional extraction wells were installed in late 1995. These wells will be plumbed to the treatment system in fall of 1996.

The active GET E extraction wells (Wells 4070, 4075, and 4200) are oriented in an approximately north-south trending line. The two new extraction wells (Wells 4425 and 4435) are located approximately 250 feet to the east (hydraulically upgradient) of the active extraction wells (see Figure 2-2). The active GET E recharge wells (Wells 4014, 5050, and 5045) are also oriented in a generally north-south trending line approximately 1,200 feet south of the extraction wells.

The treatment system utilizes two parallel pairs of packed, induced-draft stripping towers that have a combined treatment capacity of 2,800 gallons per minute (gpm).

2.2.2 GET F System Components

The GET F system is composed of six extraction wells, a water treatment system with emission control, and five recharge wells (Figure 2-2). Prior to 1995, the groundwater was treated at two separate treatment systems (GET F-South and GET F-North) approximately 2,000 feet apart. The system was since modified so that all of the groundwater is plumbed to and treated by the GET F-North treatment system.

The GET F extraction wells are located in and around the Plant 2 production complex (Figure 2-2). Three extraction wells (Wells 4310, 4315, and 4007) are located within the Plant 2 complex, and three extraction wells (Wells 4140, 4145, and 4060) are oriented in an approximately southeast-northwest trending line west of Plant 2. The northernmost extraction well, Well 4145, is located adjacent to the GET F treatment facility.

Recharge Wells 5095, 5090, 5085, 5080, and 5100 are aligned approximately southeast-northwest from the GET F treatment plant toward the GET E recharge area. The southernmost recharge well (Well 5095) is located approximately 1,500 feet northwest of the treatment plant. The distance between the recharge wells ranges from 600 to 700 feet. An intertie connects the GET F and GET E recharge pipelines. These recharge systems are isolated from each other with a valve that is usually closed.

The treatment system consists of two packed, counter-current air-stripping towers operated in series flow with a maximum capacity of approximately 1,500 gpm. The exhaust from the air-stripping tower passes through a vapor-phase carbon adsorption system to minimize the release of VOCs emitted into the atmosphere. The VOCs are later desorbed from the carbon by steam regeneration, decanted in a gravity separator, and collected in drums for recycling.

2.3 Facility Operation

2.3.1 GET E Operation

GET E went into operation in February 1985. The system currently operates at approximately 2,050 gpm. Well 4070 extracts approximately 400 gpm, Well 4075 extracts approximately 800 gpm and Well 4200 extracts approximately 850 gpm (March 1996 data). The pumping rates are adjusted periodically in response to

changing groundwater levels, interference from adjacent wells as their pumping rates fluctuate, and the efficiency of the well. The extraction wells are periodically rehabilitated; all the wells were rehabilitated in the summer of 1994 and Well 4070 was rehabilitated again in the summer of 1995.

At the current pumping rates, the system extracts, treats and recharges approximately 2.9 million gallons of water per day. Approximately 15 pounds of VOCs are removed from groundwater each day. Since its inception, the system has removed approximately 69,000 pounds of VOCs from approximately 10 billion gallons of water.

2.3.2 GET F Operation

GET F began operation in December 1984 utilizing Well 4060 and the GET F-South air-stripping unit. Extraction Well 4007, a former industrial-water supply well, was added to the system in December 1985, and Extraction Well 4140 was added in May 1987. A separate air-stripping unit with emission control (GET F-North) began operation in April 1988 utilizing Extraction Wells 4140 and 4145. GET F-South was decommissioned and Extraction Wells 4007 and 4060 were plumbed to GET F-North in December 1994. Extraction Wells 4310 and 4315 were plumbed to GET F-North in March 1995.

The system currently operates at its maximum capacity of 1,500 gpm. Well 4007 extracts approximately 3 to 5 gpm, Wells 4060 and 4145 extract approximately 500 gpm each, Well 4140 extracts approximately 350 gpm, Well 4310 extracts approximately 1 to 2 gpm, and Well 4315 extracts approximately 150 gpm (March 1996 data).

The system treats approximately 2.1 million gallons of water per day and removes approximately 48 pounds of VOCs per day. Since start-up, the combined GET F

facilities have removed approximately 155,000 pounds of VOCs from approximately 6.8 billion gallons of water.

3.0 SUBSURFACE CONDITIONS

This section presents an overview of the Aerojet site geology and hydrogeology. The discussion includes a description of the hydrogeologic units, the direction and gradient of groundwater flow, the hydraulic capture zones of the two GET facilities, and the distribution of selected chemicals in groundwater.

3.1 Geology

The Aerojet site is located in eastern Sacramento County at the transition from Sacramento Valley sediments to volcanic and metamorphic basement rocks of the Sierra Nevada Foothills. The sedimentary formations consist of Cretaceous, Tertiary, and Quaternary marine, volcaniclastic, and sedimentary units that were deposited unconformably on the surface of a westward-dipping Jurassic metamorphic basement complex. The sediments form a wedge that thickens from east to west across the Aerojet site and has a one to four degree westerly dip. The thickness of the sedimentary wedge is less than 100 feet at the eastern edge of the Aerojet site and increases across the approximate six-mile width of the site to approximately 2,000 feet near the western edge of the Aerojet site. Approximately 80 percent of the Aerojet site has been disturbed to depths of 40 to 90 feet by gold dredging operations.

More than 120 borings have been drilled both on and off the Aerojet property in the GET E and GET F areas to characterize the geology and groundwater conditions. Lithologic logs were prepared for all borings and all mud rotary borings were also geophysically logged. Table 3-1 lists the wells and borings used in this GET E and GET F evaluation.

3.1.1 Hydrogeologic Cross Sections

Figure 3-1 shows the location of six cross sections (Figures 3-2 through 3-7), which were prepared using lithologic and geophysical logs from the borings. Lithologic data and the screened and gravel-packed intervals of the wells are projected onto the upper cross section. The aquifers and groundwater quality data are shown on the lower cross section of each figure. The cross sections are also presented as full-size drawings in Appendix B.

These cross sections are modified from those presented previously in the 1992 GET E Evaluation and the 1992 GET F Evaluation. The cross sections presented in the GET E Evaluation were labeled alphabetically starting with A-A' and the cross sections from the GET F Evaluation were labeled starting with E-E'. Since the reports were issued, minor modifications have been made to Cross Sections A-A', E-E', and E'-E" to incorporate new information from recently installed wells. Cross Sections B-B' and C-C' presented in this report are not related to Cross Sections B-B' and C-C' presented in the 1992 GET E Evaluation.

Cross section A-A' (Figure 3-2) is oriented south-southwest to north-northeast, parallel to the alignment of the GET E extraction wells. Cross Sections E-E' and E'-E" (Figures 3-6 and 3-7) are oriented approximately northwest-southeast, parallel to the alignment of the GET F extraction and recharge wells. Cross Sections B-B', C-C', and D-D' (Figures 3-3, 3-4, and 3-5) are oriented approximately east-west, roughly parallel to groundwater flow in Zone 2.

These cross sections facilitate the interpretation of the relative permeability of the sediments in the study area. Low-permeability material is divided into either predominantly silt or predominantly clay. Higher permeability material, which is primarily sand, gravel, and sandstone, is not subdivided. This division of aquifer materials emphasizes groundwater movement and its relationship to the extraction

wells, which is the focus of this evaluation. Although the complex sediments are simplified to create these cross sections, every effort was made to retain the major permeability contrasts while minimizing excess detail.

The interpretation of continuity of lenses and layers shown on the cross sections is based on geophysical logs, lithologic descriptions, and, to some extent, relative thicknesses of the units. In some locations, lenses of low-permeability material are included between data points where there is not sufficient data to connect dissimilar, thin silty or clayey units (see Cross Sections C-C' and E'-E", Figures 3-4 and 3-7, respectively). The cross sections also show areas where apparent changes in dip occur due to projection of data to the line of cross section. This level of detail is included in the cross sections where a greater density of lithologic data helped to confirm the location of lithologic contacts. In other areas, the changes in dip are due to refinements made in the continuity of layers and lenses after examination of groundwater levels and pumping-test responses in different completions in the same area.

The cross sections presented in the 1992 GET E Evaluation divided sediments into three units: the pumped aquifer, the aquifer above the pumped aquifer, and the aquifer below the pumped aquifer. The cross sections presented in the 1992 GET F Evaluation portrayed a more detailed picture of the sediments. In that report, five aquifers were recognized: the pumped aquifer from the GET E Evaluation was subdivided into two aquifers, Aquifer C and Aquifer D; the aquifer above the pumped aquifer was also subdivided into two aquifers, Aquifer A and Aquifer B; and the aquifer below the pumped aquifer was labeled Aquifer E. This report continues using the nomenclature used in the GET F Evaluation. The wells in the GET E study area and all associated figures reflect this nomenclature adjustment.

Table 3-2 presents a correlation between the aquifer nomenclature used in the 1992 GET E Evaluation and the aquifer nomenclature used in this report and the

1992 GET F Evaluation. Table 3-2 also presents an approximate correlation between the GET Evaluation nomenclature and the aquifer nomenclature used in the 1993 Stage 2 report for Zone 2.

The change in nomenclature is a refinement, not a redesignation, of aquifers. The pumped aquifer in the GET E area contains a layer of low permeability material that is laterally continuous with the C/D aquitard identified in the GET F Evaluation. However, since the GET E extraction wells are screened across both Aquifer C and Aquifer D, those two aquifers were treated as one (the pumped aquifer) in the GET E Evaluation. The separation of the aquifers is necessary when discussing extraction at GET F since each of the GET F extraction wells is screened across only one aquifer unit. Two of the GET F extraction wells are screened across Aquifer A (4007 and 4310), one GET F extraction well is screened across Aquifer B (4315), and three of the GET F extraction wells are screened across Aquifer C (4060, 4140, and 4145). No GET F extraction wells are screened within Aquifer D.

The approximate upper and lower boundaries of the aquifers are shown on the lower cross sections on Figures 3-2 through 3-7. The aquifer boundaries are interpolated between borings. In some locations, the aquifer boundaries appear to cut across low permeability units which is a result of the projection of wells onto the cross sections and the general geologic complexity of the area.

Some aquifers are not present as discrete units throughout the area. Where no aquitard material was recognized in the lithologic and resistivity data between aquifers, a dashed line shows the approximate location of its boundary based on potentiometric data (see Cross Section A-A'; Figure 3-2).

3.2 Hydrogeology

Potentiometric surface maps for each aquifer, hydrographs, and pumping-test results, are used to describe the hydrogeologic conditions in the GET E and GET F study area. These data are used to assess groundwater flow, the seasonal and long term fluctuations in water levels, and the transmissivity of the aquifer material.

Table 3-3 is a list of GET E and GET F monitor, extraction, and recharge wells and the aquifer in which each well is completed. The assignment of the well completion to the aquifer unit is based on interpretation of the cross sections, response of individual completions to pumping tests performed at GET E and GET F extraction wells, and potentiometric data. Several wells in the study area are completed in lenses within aquitard material or in perched groundwater. These wells are listed in Table 3-3 with no aquifer designation. Instead, a classification of "aquitard" or "perched" is made. The following is a general description of each aquifer.

Aquifer A, the uppermost aquifer, is predominantly composed of unconsolidated sand and gravel. The saturated thickness of the aquifer ranges from 0 to approximately 20 feet. The unsaturated sediments above the water table are not considered to be part of Aquifer A. These materials are unsaturated throughout the northwestern portion of the study area.

Aquifer B is laterally discontinuous throughout the study area. Aquifer B is present in the central and western portion of the area, and is absent in the northern and southwestern portions of the area. Figure 3-8 presents the lateral extent of Aquifer B. Where present, Aquifer B is separated from Aquifer A by a 10- to 50-foot thick aquitard composed predominantly of clay and silt. Aquifer B is predominantly composed of sand and gravel with a few low permeability interbeds of silt and

clay. The thickness of Aquifer B varies over short distances from about 10 feet to 90 feet.

Aquifer C is predominantly composed of sand and gravel with some sandstone. Locally, the aquifer is interbedded with low permeability units which may account for up to one half of its thickness; overall, however, the aquifer has only minor quantities of impermeable lenses. Aquifer C is present throughout Zone 2 and ranges in thickness from approximately 50 feet to 125 feet. Aquifer C is separated from Aquifer B, or from Aquifer A when Aquifer B is not present, by a 25- to 115-foot thick aquitard composed predominantly of silt and clay.

Aquifer D is composed of sands and sandstone with some gravel. It ranges in thickness from 30 feet to 150 feet. Aquifer D is thickest in the area of the recharge wells between the GET E and GET F extraction areas, where it contains numerous low-permeability interbeds. The lower boundary of Aquifer D is not well defined in the southeastern portion of the study area, where fewer boreholes penetrate the aquifer. Aquifer D is separated from Aquifer C by a 10- to 45-foot thick aquitard composed of discontinuous, interbedded clay and silt.

Aquifer E consists of interbedded permeable and low permeability lenses. The permeable material is predominantly sandstone with some sand and local gravel lenses. The total thickness of this aquifer is not defined because few boreholes penetrate it completely. Aquifer E is separated from Aquifer D by a 5- to 85-foot thick aquitard. One well (Monitor Well 86) totally penetrates Aquifer E and partially penetrates a lower unit. This lower unit is continuous with Aquifer F, which was discussed in the Southeast Zone 2 Evaluation (January 1996). Aquifer F is not discussed further in this report.

3.2.1 Water Level Fluctuations

Appendix C contains hydrographs of selected monitor wells in the study area for the period of January 1983 through January 1996. Overall groundwater elevations have decreased as much as 40 to 60 feet since 1983. Water level elevations have not declined as rapidly in the past three to five years and some recovery is evident starting in 1995. The long term decrease in water level elevations is probably due in part to drought conditions, as well as to withdrawal of groundwater by GET E and GET F extraction wells. Record high precipitation in 1993 probably caused the more recent leveling out of the groundwater elevations.

Figure 3-9 shows hydrographs of Monitor Wells 303-6, 399-403, 424-9, and 3113-8. Seasonally, water levels are higher in the spring and lower in the fall of each year. Although the fluctuations in the water level elevations of the aquifers are similar, the head values in each aquifer may differ by as much as twenty-nine feet.

3.2.2 Groundwater Gradient

Figures 3-10 through 3-19 show the potentiometric surfaces of Aquifers A through E. The contour maps were created using the computer program SURFER and are based on water level data collected in October 1994 and April 1995. Appendix D contains a brief description of the input parameters used in SURFER. Water level data for extraction wells were adjusted prior to contouring by assuming a well efficiency of 60 percent. Anomalous water level data, not used in Figures 3-10 through 3-19, are listed in Appendix E.

Lateral hydraulic gradients, as measured from the potentiometric surface maps, are listed in the table below. Groundwater gradients reported in the table were measured across the entire study area for Aquifers A, B, and E. The groundwater

gradient reported for Aquifers C and D were measured both on the eastern side of the study area, as far from the extraction and recharge wells as possible, and on the western side of the study area near the extraction wells.

Aquifer	Groundwater Gradient in October 1994 in foot/foot	Groundwater Gradient in April 1995 in foot/foot
A	0.0071	0.0085
B	0.0040	0.0045
C (East)	0.0062	0.0056
C (Get E-West)	0.0041	0.0059
C (Get F-West)	0.0047	0.0044
D (East)	0.0075	0.0067
D (Get E-West)	0.0024	0.0019
E	0.0047	0.0048

Potentiometric contours shown in Figures 3-10 through 3-19 show a regional flow direction to the west-southwest. All of the aquifers are somewhat influenced by extraction. Aquifer A shows groundwater mounding in the vicinity of Plant 2 (Figures 3-10 and 3-11). Mounding in this area was also evident during the previous GET F Effectiveness report (Aerojet 1992b). A discussion of capture zones is included in section 3.2.5.

3.2.3 Vertical Groundwater Potential

Water level elevations for selected wells are shown on Cross Sections A-A', E-E', and E'-E" for October 1994 and April 1995 (Figures 3-20 through 3-25). These cross sections include the GET E and GET F extraction and recharge areas. The difference in water elevations between consecutive screened zones (the vertical

potential), and sometimes between aquifers, is shown in parentheses on the figures. A negative vertical potential indicates that the potential for groundwater movement is downward, and a positive vertical potential indicates potential for upward groundwater movement. The vertical potentials reflect lower head values in the pumped aquifers in the vicinity of extraction wells and higher head values in the recharged aquifers in the vicinity of recharge wells.

Vertical potentials are primarily downward from Aquifers A and B to Aquifers C and D throughout the extraction well areas. The greatest downward potentials between these aquifers (typically -10 to -20 feet) are observed in fall near the GET F extraction wells (Figure 3-24). The magnitude of the downward potential is smallest between these aquifers near the GET E recharge wells in the spring, with a slight upward potential (1.1 feet) at Well 3351 (Figure 3-23).

The vertical potential between Aquifers C and D and underlying Aquifer E was upward in the vicinity of extraction wells and downward near recharge wells. The magnitude and direction of the potential does not change much from fall to spring (Figures 3-22 through 3-25).

3.2.4 Aquifer Pumping Tests

Three aquifer pumping tests have been conducted since 1992 to evaluate the influence of the extraction wells and to characterize aquifer parameters. Pumping tests were performed on GET E Extraction Wells 4425 and 4435 and on GET F Extraction Well 4315. The analyses of the aquifer pumping tests are presented in Appendix F and are summarized on Table 3-4.

3.2.5 Capture Zones

The capture zone is hand drawn on SURFER-generated contour maps. In GET E, groundwater is extracted from both Aquifers C and D, and recharged into either Aquifer C or Aquifer D. In GET F, most of the groundwater extraction is derived from Aquifer C with minor amounts of groundwater extracted from Aquifers A and B. The GET F Recharge Wells are screened in both Aquifer C and Aquifer D.

The majority of groundwater captured by the extraction systems is from Aquifers C and D, across which most of the extraction wells are screened. Pumping of these wells influences groundwater flow in the other aquifers to varying degrees. Some of the hydraulic capture of chemicals from the other aquifers occurs by vertical movement through aquitards into the pumped aquifers.

Figures 3-26 through 3-30 present the April 1995 capture zones in Aquifers A through E, respectively. Figures 3-31 and 3-32 present the October 1994 capture zones in Aquifers C and D, respectively. These figures were constructed from potentiometric contour maps under typical extraction and recharge conditions. For most of these figures, the capture zones are drawn as the boundary between groundwater flow lines that converge toward or diverge away from the extraction wells. Capture zones for Aquifer D near GET F (Figures 3-29 and 3-32) and for Aquifer E near GET E (Figure 3-30) are drawn around areas where groundwater flow lines converge, although groundwater is not directly extracted from these aquifers at these locations. The flow line convergence is caused by vertical leakage of groundwater into the adjacent pumped aquifer. This interpretation is supported by the distribution of TCE in these aquifers, as discussed in Section 3.3.4 and 3.3.5, and by the upward head potentials as shown in Figures 3-24 and 3-25.

The capture zones for Aquifers C and D are shown for both spring and fall. Although the configuration of the capture zones differ somewhat between the two time periods, the degree of hydraulic capture is similar.

The capture zones for Aquifers C and D in GET E will be enhanced when Extraction Wells 4425 and 4435, recently installed in GET E, become operational. This increased pumping from Aquifers C and D may also increase the capture zones in the adjacent Aquifers B and E.

3.3 Distribution of Contaminants in Groundwater

Concentrations of TCE, 1,2-DCA, perchlorate, and chloroform in groundwater in the GET E and GET F areas are presented in Figures 3-33 through 3-56. Most of the monitor wells were sampled between June and September 1995. In some cases, wells were not sampled during this period, but results from sampling before or after this period were available. These results are shown on the figures with an asterisk (*), and the respective sample dates are listed in Table 3-5. The contours are hand drawn at order-of-magnitude intervals. Contours were not drawn on maps with only a few results greater than the detection limit, although the data is presented as chemical distribution maps in Figures 3-36, 3-52, and 3-56. TCE and perchlorate concentrations in groundwater are also presented in the hydrogeologic cross-sections (Figures 3-2 through 3-7).

The distribution of chemicals in groundwater presented in this report are different than the distributions presented in previous reports for the area. Most of the differences result from the inclusion of additional data from new monitor wells and the assignment of wells to different aquifers rather than significant changes in chemical concentrations.

Time-series graphs (chemical trend over time graphs) of TCE, 1,2-DCA, perchlorate, and chloroform for various wells are discussed throughout this section. These graphs include data from January 1982 through the beginning of 1996. Appendix G contains chemical time-series graphs for the GET E and GET F extraction and recharge wells, and for selected monitor wells.

In general, volatile organic chemicals are present in Aquifers A and B primarily in the southern half of the study area, and in Aquifers C and D in the northern and southern portions of the study area. Volatile organic chemicals in Aquifer E are present only at low concentrations, primarily in the northern portion of the study area.

The source sites from which the plumes emanate are not discussed in this report. However, it is assumed that the volatile organic chemicals were deposited in upper aquifers and these chemicals moved to deeper aquifers as they migrated laterally. This assumption is supported by the distribution of volatile organic chemicals.

Presented below is a discussion of the distribution of chemicals in each aquifer and the hydraulic capture of these chemicals. To illustrate the degree of chemical capture achieved, capture zones have been superimposed onto the TCE isoconcentration contours for each aquifer.

3.3.1 Aquifer A

Figure 3-33 is a contour map of TCE concentrations in groundwater in Aquifer A. TCE appears to be migrating from source areas upgradient of the GET F facility. The highest concentration of TCE in Aquifer A is 240,000 parts-per-billion (ppb), in inactive Extraction Well 4050. The concentrations of TCE diminish west of Extraction Well 4050 to 80 ppb at Extraction Well 4310 in Plant 2 to below the

detection limit west of Plant 2. All monitor wells downgradient of Plant 2 contain less than 3 ppb of TCE.

Also shown on Figure 3-33 is the April 1995 capture zone in Aquifer A. Almost all of the TCE plume is hydraulically captured in this aquifer. There is a thin band of TCE beyond the capture zone, in the vicinity of Wells 3233 and 3264. The concentration of TCE in this area has not varied over the past 10 years, and the 5 ppb TCE contour has not advanced far downgradient beyond the GET F extraction wells, indicating that this area is hydraulically controlled. Figure 3-34 presents the trend of TCE concentrations over time for Wells 3233 and 3264.

Figure 3-35 is a contour map of 1,2-DCA in Aquifer A and shows that 1,2-DCA is localized around Plant 2. The highest concentrations of 1,2-DCA in Aquifer A are in Monitor Well 215 (2,200 ppb), and Extraction Well 4310 (1,400 ppb).

Figure 3-36 shows the distribution of perchlorate in Aquifer A. The figure shows that perchlorate is present in three monitor wells and one inactive extraction well, Extraction Well 4050, which has the highest concentration of perchlorate (100 ppm).

Figure 3-37 is a contour map of chloroform in Aquifer A. This figure shows that a chloroform plume is present in the eastern portion of the study area with low concentrations (8.0 and 8.6 ppb) present in the area of Plant 2. Chloroform was not detected in wells downgradient of Plant 2. The plume is within the Aquifer A capture zone.

The plumes in Aquifer A are generally traveling toward the west-southwest. The higher concentration plumes typically do not travel great lateral distances because there is continuous migration to lower aquifers as they travel downgradient.

3.3.2 Aquifer B

Figure 3-38 is a contour map of TCE in Aquifer B. The figure shows that the TCE plume forms two lobes, one migrating west toward the GET E extraction wells from the central portion of the plant and one migrating southwest toward the GET F extraction wells from the Line 03 and Line 04 areas.

The highest concentration of TCE in Aquifer B is 88,000 ppb in inactive Extraction Well 4045. Active Aquifer B Extraction Well 4315 also has a high concentration of TCE (5,000 ppb). TCE was not detected in wells downgradient of Extraction Well 4315 or in wells south of White Rock Road at concentrations greater than 5 ppb.

Figure 3-38 also shows the capture zone in Aquifer B during April 1995. As shown, the southern lobe of the TCE plume within the 5 ppb contour line is hydraulically captured. Figure 3-8 shows that Aquifer B does not extend beyond the Aerojet property boundary in the northwestern portion of the site. Therefore, the northern lobe of the TCE plume will not migrate beyond Aerojet's western border, but will instead migrate downward into Aquifer C (see Section 3.3.3 for a discussion of capture in Aquifer C).

Figure 3-39 is a contour map of Aquifer B that shows the occurrence of TCE in the GET F study area and upgradient Sector F, utilizing data provided in the Hydrogeologic Evaluation Update of Southeastern Zone 2 (Kleinfelder and Aerojet, 1996). This map shows two plumes upgradient of the GET F study area. (The plume shown in the eastern portion of the maps and its capture are discussed in the 1996 Southeast Zone 2 Report.) One of these plumes is approximately 4,800 feet east-northeast of GET F, near Line 03, and has TCE concentrations greater than 5,000 ppb. Based on current potentiometric surface configurations to the west, this plume is within the GET F capture area for Aquifer B. The second, smaller, plume is southwest of Line 04 and has TCE concentrations greater than

500 ppb. This plume is migrating laterally west-southwest toward the southern Aerojet boundary. As these plumes migrate, they may migrate downward into Aquifer C.

Figure 3-40 is a contour map of 1,2-DCA in Aquifer B. Plumes of 1,2-DCA are located in two areas, near the magazine area and near Plant 2. The highest concentration of 1,2-DCA in Aquifer B is 1,000 ppb in Monitor Well 132, which is adjacent to Extraction Well 4315. Concentrations of 1,2-DCA in all monitor wells downgradient of Monitor Well 132 and in all off-site wells were below the reporting limit. Concentrations of 1,2-DCA near the magazine area are as high as 570 ppb and 480 ppb at Monitor Wells 282 and 484, respectively.

Figure 3-41 is a contour map of perchlorate in Aquifer B. Perchlorate is present primarily in two main areas: near Chemical Plant 2; and in the GET E and GET F recharge area. Low concentrations of perchlorate (near the detection limit of 0.5 ppm) are also present near the magazine area. The highest concentration of perchlorate in Aquifer B is 20 ppm in Monitor Well 213. Perchlorate is present in groundwater in the GET E and GET F recharge area at concentrations ranging from 7.8 ppm (Monitor Well 3160) to 0.52 ppm (Monitor Well 3139).

Figure 3-42 is a contour map of chloroform in Aquifer B. The highest concentrations of chloroform are located in the magazine area (1,200 ppb at Monitor Well 484). Chloroform is also present at Plant 2 at concentrations as high as 640 ppb (Extraction Well 4315). The chloroform near Plant 2 is captured by Extraction Well 4315.

3.3.3 Aquifer C

The TCE isoconcentration contour map for Aquifer C (Figure 3-43) shows that two TCE plumes are present. The northern plume is migrating westward to the GET E

extraction area from sources near Chemical Plant 1, while the southern plume is migrating west-southwest to the GET F extraction area from sources in Line 01, Line 03 and Line 04. The highest concentrations in the northern plume (as high as 2,400 ppb at Monitor Well 165) are found within the GET E extraction area. Concentrations in the southern plume are somewhat higher (Extraction Well 4140 had 5,900 ppb) with the higher concentrations found within and upgradient of the GET F extraction area. Low concentrations of TCE (less than 5 ppb) were detected in samples from four wells within or downgradient of the recharge field. TCE concentrations in most of the wells in that area were below the reporting limit.

A portion of the southern TCE plume in Aquifer C is not captured by the GET F extraction wells. TCE is detected in wells located on Aerojet property south of White Rock Road at concentrations up to 85 ppb. The TCE in this area forms a plume of limited extent, centered around Monitor Well 1354. This plume appears to be a pulse of TCE that is migrating southwest from Monitor Well 1351, where TCE concentration peaked in 1988. See Figure 3-44 for trends in TCE concentrations over time for Monitor Wells 1351 and 1354. The pulse migrated from Monitor Well 1354 to Well 1351 at a rate of 0.69 feet/day, as calculated by dividing the distance between the two wells (1,752 feet) by the time it took for the TCE to travel between the wells (approximately seven years). This migration rate compares very favorably with a groundwater seepage velocity of 0.66 feet/day calculated using Darcy's Law.

TCE was detected at 10 ppb in groundwater downgradient of GET E in Monitor Well 1467, which is located over 3,300 feet west of Aerojet. Monitor wells 1204-5, located between Aerojet and Monitor Well 1467, did not contain detectable concentrations of TCE, suggesting that the TCE in Monitor Well 1467 may be from a source other than Aerojet.

Figure 3-43 also shows the capture zone in Aquifer C during April 1995. The figure shows that GET E and GET F wells appear to capture most of the TCE plume except for two areas: (1) A lobe that extends toward the southwest from the GET F extraction well field, and (2) TCE in the area of Monitor Well 1277-8. It is assumed that the TCE around Monitor Well 1277-8 is a remnant of the main body of TCE plume that was beyond the zone of capture when the extraction system was started, because TCE is not detected in monitor wells between Monitor Wells 1277-8 and Extraction Wells 4060 and 4140.

Figure 3-45 is a contour map showing TCE concentrations in Aquifer C within and upgradient of the GET F study area utilizing information previously presented in the 1996 Southeastern Zone 2 Report (Kleinfelder and Aerojet, 1996). Two areas of TCE concentrations over 500 ppb are evident in the far upgradient area. (A third TCE plume, in the southeastern portion of the map, is discussed in the 1996 Southeastern Zone 2 Report). One plume, which spans approximately 10,000 feet between the GET F extraction area and a 5,000 ppb contour near Line 01, is clearly within the capture area of the GET F extraction wells. A smaller plume, southeast of Line 03, is outside of the GET F capture area. This plume is downgradient of a 500 ppb plume in Aquifer B as discussed in the previous section.

Figure 3-46 is a contour map of 1,2-DCA in Aquifer C. The 1,2-DCA is primarily centered around Plant 2, upgradient of the GET F extraction wells. The Aquifer C plume is similar to the Aquifer B plume in size but the concentrations of 1,2-DCA are much lower. The highest concentration of 1,2-DCA is 320 ppb at Monitor Well 3294. No 1,2-DCA was detected in monitor wells downgradient of the GET F extraction wells or in off-site monitor wells.

Figure 3-47 is a contour map of perchlorate in Aquifer C and shows perchlorate in three main areas. Perchlorate appears to be migrating toward the GET F extraction

wells from sources within the upgradient manufacturing areas. The highest perchlorate concentration in Aquifer C is 23 ppm in Monitor Well 3058, located approximately midway between Extraction Wells 4140 and 4145. A plume is also located in the area of the GET F recharge wells. This plume is likely present because groundwater extracted at GET F is treated to remove VOCs only. The GET E extraction area where the GET E extraction wells capture groundwater from the recharge area is a third area containing perchlorate.

A minor perchlorate plume is present south of the GET F extraction area. Low concentrations of perchlorate in this area (up to 3.4 ppm in Monitor Well 1354) are most likely from an abandoned sprayfield that had been utilized prior to the installation of the GET F air strippers.

Figure 3-48 is a contour map of chloroform in Aquifer C. Two plumes of chloroform are present, one in the Plant 2 area and one near and upgradient of the GET E extraction wells. This distribution is quite different from the distribution of chloroform in Aquifer B, which has a limited extent in the northern portion of the study area. The highest concentration of chloroform is 1,800 ppb at inactive Extraction Well 4018, located approximately 2,500 feet east of the main GET E extraction well area. The highest concentration of chloroform in the Plant 2 area is 1,300 ppb in Extraction Well 4140. Monitor Well 1277 is located south of White Rock Road and contained 9.3 ppb chloroform. The chloroform in Monitor Well 1277 appears anomalous due to the presence of monitor wells with no detectable chloroform between this well and the area of on-site impacted groundwater.

3.3.4 Aquifer D

Figure 3-49 is a contour map of TCE in Aquifer D. Two plumes are present in Aquifer D: a northern plume similar in extent but lower in concentration than the northern Aquifer C TCE plume, and a southern plume, which is smaller in extent

and much lower in concentration than the southern Aquifer C plume. TCE is present in low concentrations off-site to the west of the GET E extraction area. TCE was detected between the GET F extraction and recharge wells at concentrations greater than 5 ppb.

The off-site wells downgradient of GET E include Water Supply Wells 1015 and 1016 that withdraw water from a long interval. The interval is approximately centered at the elevation of Aquifer D. The capture zone shown on Figure 3-49 extends downgradient of the GET E extraction area but does not include these wells. Monitor Wells 1274 and 3336, at the western Aerojet boundary beyond the capture zone of GET E, contain TCE at 2.8 ppb and 10 ppb, respectively. Figure 3-50 presents the trend in TCE concentrations over time in Wells 1274 and 3336. The data show that TCE concentrations have remained below 5 ppb in Monitor Well 1274, and have been declining in Monitor Well 3336. This indicates that the TCE in these wells may be a remnant of TCE that was present prior to operation of the GET E system rather than chemicals bypassing the extraction and recharge area. The capture zone will be enhanced when Extraction Wells 4425 and 4435, recently installed in GET E, become operational.

Although the extraction wells in GET F are not completed in Aquifer D, two wells (Extraction Wells 4060 and 4140) have gravel packs that extend into Aquifer D. The capture in Aquifer D is portrayed on Figure 3-49. The chemical data support the capture zone as depicted.

Figure 3-51 is a contour map showing TCE concentrations in Aquifer D within and upgradient of the GET F study area utilizing information previously reported in the 1996 Southeastern Zone 2 Report (Kleinfelder and Aerojet, 1996). One plume with concentrations greater than 500 ppb is present in the eastern Sector F area northeast of line 03. This plume is upgradient of the GET F extraction area and is similar in size to a TCE plume present in Aquifer B at this location. A similar plume

does not appear at this location in Figure 3-43, which shows TCE concentrations in Aquifer C. There are no wells screened in Aquifer C in this area. It is likely that a TCE plume exists in Aquifer C in this area, given the concentrations in Aquifers B and D.

Figure 3-52 shows the distribution of 1,2-DCA in Aquifer D. Only low concentrations are present in wells that are within or upgradient of the extraction areas. No 1,2-DCA is detected in Aquifer D monitor wells downgradient of the extraction or recharge areas.

Figure 3-53 is a contour map of perchlorate in Aquifer D. The perchlorate plume in Aquifer D is centered around the GET E and GET F recharge wells and the GET E extraction areas with only very low concentrations in the GET F extraction area. The extent and concentrations of the perchlorate plume in the recharge area near the GET E extraction area are reduced compared to the Aquifer C perchlorate plume in these areas.

Figure 3-54 is a contour map of chloroform in Aquifer D. The chloroform plume is within and upgradient of the GET E extraction area. Low concentrations of chloroform are present in several wells in the GET F extraction area.

3.3.5 Aquifer E

Figure 3-55 is a contour map of TCE in Aquifer E. TCE is present within and upgradient of the GET E extraction area. The highest concentration is in Monitor Well 3333 (85 ppb). TCE was detected at a concentration greater than 5 ppb in only one off-site monitor well downgradient of the GET E extraction area, immediately adjacent to the Aerojet Property Boundary. This well is within the capture zone of Aquifer E.

Figure 3-56 shows the distribution of perchlorate in Aquifer E. During the reporting period, perchlorate was detected in eight monitor wells in concentrations ranging from 0.42 ppb in Monitor Well 1286 to 7.0 ppb in on-site Monitor Well 3209.

There was no detectable 1,2-DCA or chloroform in Aquifer E monitor wells sampled for this report.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Results of groundwater sampling in the GET E and GET F study area show that VOCs, predominantly TCE and perchlorate, are present in each of the five aquifers (Aquifers A through E). In general, the plumes in the shallow aquifers are located near the south portion of the study area; the plumes in the middle aquifer are present throughout the study area; and the plumes in the deeper aquifer are more prevalent in the northern portion of the study area. Perchlorate is present in shallow aquifers mainly in the south portion of the study area, and is transported to the deeper aquifers through recharge wells.

The GET E extraction wells are completed within Aquifers C and D. The shallow aquifers are not present near the GET E extraction facilities or have little water. Groundwater flow directions and chemical migration in the deeper aquifer (Aquifer E) are influenced by extraction from the overlying aquifers. Low concentrations of VOCs present downgradient of the GET E extraction wells are likely residual chemicals that were present prior to extraction at GET E rather than the result of ineffective capture.

Extraction wells at GET F are screened in Aquifers A, B, and C, with the greatest volume of extracted water derived from Aquifer C and the least amount from Aquifer A. Chemical migration in Aquifers A through D are influenced by the GET F extraction wells. While few wells downgradient of GET F have chemicals, a portion of the southern plume in Aquifer C is not captured by extraction at GET F. This small plume of TCE is downgradient of the GET F extraction area, on Aerojet-owned property south of White Rock Road. The TCE plume in this area represents a pulse moving through the aquifer. Aerojet proposes to install one groundwater extraction well completed downgradient of and in the same lithologic interval as Well 1354 (Well EW1 on Figure 4-1). This well would operate until TCE content of the water declines to acceptable concentrations.

In Sector F upgradient of the GET F study area, there is a VOC plume with concentrations greater than 500 ppb that may bypass the current GET F extraction wells. To control the migration of these VOCs, two to three extraction wells are recommended in Aquifer C along Old White Rock Road southeast of Line 03 (Wells EW2 and EW3 on Figure 4-1). One well would be installed and tested initially in 1996 and, based on the results of the pumping test, one or two additional wells would be installed in 1997. These wells will capture the upgradient chemicals and control off-site migration toward the southwest.

A high concentration TCE plume exists at Line 03 in Aquifers B and D. These plumes are upgradient of the GET F facility and may be captured by it, however, downward migration will occur as the chemicals travel laterally, making them more difficult and costly to successfully capture. Extraction close to the higher concentration portions of the plume may provide more economic capture of these plumes because of the high concentrations of chemicals that could be extracted. We recommend installation of a multiple completion monitor well and three extraction wells at this location (Wells EW4, EW5, and EW6 on Figure 4-1). The multiple completion monitor well, with two completions in Aquifer C and one completion in Aquifer D, would be installed first. Data from this well will be used to design the target screen depths of the three extraction wells, possibly one each in Aquifers B, C, and D. We do not recommend the use of the existing inactive extraction wells in Aquifer B near Line 03 because they do not produce sufficient quantities of water due to poor drilling methods, inadequate development, and lack of maintenance since construction. The new extraction well will be constructed and developed using methods selected to maximize well yield.

A TCE plume also exists in Aquifers B, C, and D approximately 3,000 feet northeast of Line 03. Given the hydrogeologic regime, this plume may migrate deeper in the water-bearing units prior to reaching the GET F extraction area. Extraction from Aquifers B, C, and D in the Line 03 area, as proposed above, may be sufficient to reduce downward migration. We recommend that the influence of extraction at

Line 03 be monitored during the pumping tests to evaluate the potential effects on chemical migration in this upgradient area. Aerojet will then make recommendations regarding the need for additional groundwater extraction upgradient of Line 03.

Aerojet does not currently have a system capable of treating all of the water that could be generated by the proposed extraction wells. Aerojet is currently evaluating alternatives to provide treatment for this additional water.

5.0 REFERENCES

Aerojet General Corp., August 1992a, Aerojet Site, Part 2 GET Effectiveness Report, GET E Evaluation.

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Aerojet General Corp., August 1993, Aerojet Site, Aerojet Response to Agency Comments, Part 2 GET Effectiveness Reports.

ICF Kaiser, December 1993, Aerojet Site, Stage 1 Report, Zone 2.

ICF Technology, Inc., September 1989, Part 1 GET Effectiveness Report and Part 2 GET Effectiveness Work Plan.

ICF Technology, Inc., November 1992, Part 2 GET Effectiveness Report - Regional Model.

Kleinfelder, Inc. and Aerojet General Corp., January 1996, Aerojet Site, Hydrogeologic Evaluation Update, Southeastern Zone 2.

6.0 ACKNOWLEDGMENTS

This GET Effectiveness Report is the result of the contributions of personnel from Aerojet General Corporation; Hydro-Search, Inc.; and J. H. Kleinfelder & Associates. Specific contributions from each firm are detailed below.

Aerojet General Corporation provided the text and figures for Section 2, geologic and hydrogeologic cross-sections, hydrographs of selected wells, time-series graphs of groundwater chemistry, and log-log plots of water levels for aquifer test analyses, and drew the isoconcentration contours for the figures in Section 3.

Hydro-Search, Inc. conducted the aquifer test on Extraction Well 4315 and analyzed the results of this test and aquifer tests on Extraction Wells 4425 and 4435. Hydro-Search worked with Aerojet in writing the text and Hydro-Search provided the figures for Sections 1, 3, 4 and 5 as well as all tables included in the report.

J. H. Kleinfelder & Associates conducted the groundwater sampling and collected water level measurements used in this report, as well as conducting the aquifer tests on Extraction Wells 4425 and 4435.

Table 3-1. Wells Used in 1996 GET E and GET F Evaluations

GET E ANALYSIS		GET F ANALYSIS		
17	3031 - 36	1	1241 - 5	3348 - 50
22	3048 - 53 *	3	1251 - 5	3351 *
57	3113 - 18	4	1266-70	3352
60	3139 - 44 *	5	1271 - 6 *	3363 - 5
63	3304 - 9	8	1277 - 80	3415 - 7
64	3323 - 5 *	10	1281 - 6	3431 - 3
87	3332 - 4	24	1294-7	3434 - 6
124	3335 - 7 *	25	1329-32	3437 - 9
127 - 8	3338 - 40	75	1333 - 6	3440 - 2
165 - 7	3347	86	1350 - 2	3476
168 - 72 *	3351 *	88	1353 - 6	4007
227 - 30 *	3353	129 - 32	1399	4014 *
242 - 4	3403 - 05	134 - 7	1457 - 9	4016
282	3406 - 08	138 - 42	1463 - 5	4045
283	3409 - 11	168 - 72 *	3043 - 7	4050
284 - 5	3517	180-3	3048 - 53 *	4060
330	3518	187	3057 - 61	4140
368	4014 *	206 - 8	3124 - 8	4145
420 - 2	4018	209 - 11	3139 - 44 *	4310
424 - 9	4070	212 - 4	3145 - 50	4315
437 - 40	4075	215 - 8	3160 - 5	5015
446	4200	219 - 22	3204 - 9	5045 *
447	4425	227 - 30 *	3210 - 5	5050 *
476 - 80	4435	235 - 8	3221 - 6	5055
1015	5045 *	303 - 6	3227 - 32	5080
1016	5050 *	307 - 10	3233 - 8	5085
1203 - 8	5100 *	355 - 8	3244 - 9	5090
1271 - 6 *		374	3264 - 8	5095
1434 - 9		399 - 403	3278 - 83	5100 *
1460 - 2		484 - 7	3292 - 4	
1466 - 8		494 - 5	3295 - 7	
1484 - 6		903	3323 - 5 *	
		1026	3326	
		1229 - 34	3335 - 7 *	
		1236 - 40	3341 - 3	

* = Wells used in both GET E and GET F evaluations.

Table 3-2. Aquifer Units Correlation Table

HYDROGEOLOGIC UNIT DEFINED FOR REGIONAL GROUNDWATER MODEL (1)	AQUIFER NOMENCLATURE DEFINED FOR PART 2 GET EFFECTIVENESS REPORTS	
	GET E REPORT (2)	GET F REPORT (3) (4)
Unconfined Aquifer Unit 1	Upper Aquifer (Aquifers A and B)	Aquifer A & B
Unit 2	Aquitard	Aquitard B-C
Unit 3U	Main Pumped Aquifer (Aquifers C and D)	Aquifer C
Unit 3M		Aquitard C-D
Unit 3L		Aquifer D
Unit 4	Aquitard	Aquitard D-E
Unit 5	Lower Aquifer (Aquifer E)	Aquifer E
Unit 6		
Unit 7		

Relative thicknesses in this table do not correspond with interval thickness. In addition, relationships between the GET nomenclature are not shown.

(1) Part 2 GET Regional Model Report, ICF Kaiser Engineers, December 1992.
(2) Part 2 Effectiveness Report, GET E Evaluation, Aerojet General Corporation, August 1992.
(3) Part 2 Effectiveness Report, GET F Evaluation, Aerojet General Corporation, October 1992.
(4) Nomenclature used in the GET E and F Effectiveness Report, Aerojet General Corporation, April 1996.

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
1	X						65	45	No Chemistry Data
3	X						55	44	No Chemistry Data
4	X						65	25	No Chemistry Data
5		X					82	52	
8	X						85	35	No Chemistry Data
10	X						83	43	
22	X						104	64	
24	X						101	61	
25	X						70	55	
57	X						84	68	Dry
59							103	63	Perched Aquifer
63	X						96	91	No Chemistry Data
64			X				43	33	
75	X						63	27	
86						X	-235	-255	
87					X		-186	-206	
88				X			-212	-232	
124			X				22	-1	
127			X				-36	-68	
128				X			-101	-125	
129							120	100	Perched Aquifer
130	X						80	70	
131	X						51	45	
132		X					15	-5	
134			X				-42	-48	
135			X				-74	-100	
136				X			-127	-137	
137				X			-165	-176	
138			X				-35	-77	
139			X				-96	-108	No Data Used
140				X			-215	-223	
141					X		-285	-305	
142					X		-339	-362	
165			X				-29	-39	
166							-58	-68	Well In Aquitard
167				X			-94	-104	
168		X					65	44	Dry
169							23	9	Well In Aquitard
170			X				-14	-52	
171				X			-79	-87	
172				X			-111	-128	
206			X				-88	-109	

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
207				X			-163	-194	
208					X		-333	-354	
209			X				8	0	
210			X				-23	-26	No Chemistry Data
211				X			-92	-97	
212							91	61	Well In Aquitard
213		X					17	-4	
214				X			-53	-74	
215	X						65	53	
216		X					27	13	
217			X				-7	-17	No Chemistry Data
218				X			-75	-91	
219			X				-5	-20	
220			X				-37	-58	No Chemistry Data
221			X				-77	-85	
222				X			-109	-119	
227			X				6	-15	
228			X	X			-37	-58	
229				X			-108	-129	
230				X			-147	-173	
235		X					30	20	No Chemistry Data
236			X				-34	-44	No Chemistry Data
237				X			-132	-138	No Chemistry Data
238				X			-164	-174	No Chemistry Data
242				X			-30	-45	
243				X			-70	-85	
244				X			-120	-141	
282		X					-123	-140	
283		X					-1	-9	
302							117	89	Perched Aquifer
303	X						92	82	No Chemistry Data
304		X					62	56	
305		X					32	22	
306			X				-32	-42	
307	X						101	80	
308		X					60	39	
309		X					16	6	
310			X				-12	-22	
330	X						94	80	
355	X						88	67	Dry
356							-44	-54	No Data Used
357			X				-78	-88	

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
358				X			-152	-162	
368	X						115	97	
374	X						100	58	Dry
399			X				3	-13	
400			X				-45	-66	No Chemistry Data
401				X			-109	-119	
402				X			-151	-171	
403					X		-217	-227	
420			X				-1	-14	
421				X			-41	-52	
422				X			-73	-94	
424	X						81	71	Dry
425			X				36	26	
426			X				5	-5	
427				X			-41	-51	
428				X			-89	-99	
429				X			-125	-135	
437			X				3	-7	
438			X				-31	-48	
439				X			-77	-98	
440							-119	-129	Well In Aquitard
446				X			-115	-125	
447			X				-28	-49	
476				X			-112	-122	
477					X		-219	-227	No Chemistry Data
478					X		-258	-268	
479					X		-321	-331	
480					X		-373	-383	
484		X					42	21	
485		X					-4	-14	No Chemistry Data
486			X	X			-71	-92	
487				X			-118	-138	
494			X				1	-20	
495			X				-49	-59	
1015				X			-118	-449	ACWS Well
1016				X			-73	-230	ACWS Well
1203							58	42	Well In Lens
1204			X				-55	-66	
1205			X				-97	-134	
1206				X			-164	-185	
1207					X		-242	-263	
1208					X		-378	-399	

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
1229	X						53	33	No Chemistry Data
1230		X					10	-0	No Chemistry Data
1231			X				-55	-75	
1232				X			-137	-157	
1233					X		-191	-199	
1234					X		-246	-266	
1236	X						113	103	Dry
1237	X						75	54	No Chemistry Data
1238		X					32	22	
1239			X				1	-9	
1240			X				-41	-51	
1241	X						89	79	Dry
1242		X					33	12	
1243		X					-13	-28	
1244			X				-54	-60	
1245			X				-93	-103	
1251		X					19	9	
1252		X					-15	-25	
1253			X				-45	-55	
1254				X			-105	-125	
1255					X		-153	-163	
1271							16	-14	
1272			X				-34	-64	
1273			X				-89	-129	
1274				X			-154	-174	
1275					X		-239	-269	
1276							-289	-479	
1277			X				-19	-40	
1278			X				-92	-113	
1279				X			-146	-167	
1280					X		-211	-231	
1281	X						70	49	
1282			X				-4	-25	
1283			X				-63	-73	
1284			X				-100	-110	
1285				X			-210	-225	
1286					X		-310	-380	
1333		X					18	8	
1334			X				-48	-58	
1335			X				-83	-93	
1336				X			-123	-133	
1350			X				-26	-36	

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
1351			X				-62	-72	
1352			X				-104	-114	
1353			X				-29	-39	
1354			X				-64	-74	
1355			X				-101	-111	
1356				X			-142	-162	
1434			X				29	19	
1435			X				-16	-37	
1436				X			-103	-113	
1437				X	X		-176	-183	
1438					X		-254	-264	
1439					X		-356	-366	
1457			X				2	-19	
1458				X			-134	-155	
1459					X		-203	-213	
1460			X				-23	-33	
1461				X			-144	-154	
1462					X		-355	-376	
1463				X			-130	-140	
1464					X		-202	-220	
1465					X		-370	-390	
1466							-3	-8	Well In Aquitard
1467			X				-87	-97	
1468					X		-357	-377	
1484			X				-9	-30	
1485				X			-92	-113	
1486					X		-179	-189	
3031		X					53	32	Gravel Extends Into Aquitard
3032			X				-18	-28	
3033				X			-82	-92	
3034				X			-117	-137	
3035				X			-161	-171	
3036					X		-209	-219	
3043	X						73	63	No Chemistry Data
3044		X					25	15	No Chemistry Data
3045				X			-67	-77	No Chemistry Data
3046				X			-149	-159	No Chemistry Data
3047					X		-241	-251	No Chemistry Data
3048							65	55	Well In Aquitard
3049			X				21	11	
3050			X				-23	-33	
3051				X			-58	-78	

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
3052				X			-126	-146	
3053					X		-197	-207	
3057	X						84	74	
3058			X				7	-3	
3059			X				-49	-59	
3060			X				-85	-95	
3061				X			-165	-180	
3113		X					43	33	
3114			X				-9	-30	
3115				X			-85	-95	
3116				X			-121	-131	
3117					X		-195	-205	
3118					X		-234	-244	
3124			X				-15	-25	
3125			X				-49	-54	
3126			X				-84	-89	
3127				X			-121	-131	
3128				X			-157	-167	
3139		X					41	31	
3140			X				-30	-43	
3141			X				-74	-79	
3142				X			-131	-152	
3143							-193	-203	Well In Aquitard
3144					X		-239	-249	
3145		X					15	5	
3146			X				-17	-27	
3147			X				-57	-67	
3148				X			-102	-112	
3149				X			-180	-205	
3150				X			-232	-242	
3160		X					6	-4	
3161			X				-42	-52	
3162				X			-110	-120	
3163				X			-150	-171	
3164				X			-195	-205	
3165				X			-232	-253	
3204		X					13	3	
3205			X				-18	-28	
3206			X				-57	-67	
3207				X			-135	-145	
3208				X			-209	-219	
3209					X		-332	-342	

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
3210		X					36	26	
3211			X				-44	-54	
3212				X			-114	-124	
3213				X			-174	-194	
3214					X		-254	-274	
3215					X		-324	-334	
3221	X						92	71	Dry
3222	X						51	41	
3223			X				21	11	
3224			X				-9	-13	
3225			X				-69	-74	
3226				X			-155	-165	
3227							31	10	Well In Aquitard
3228			X				-59	-69	
3229				X			-113	-123	
3230					X		-226	-233	
3231					X		-303	-313	
3232					X		-369	-379	
3233	X						74	59	
3234		X					28	23	
3235			X				-1	-11	
3236			X				-50	-55	
3237				X			-77	-87	
3238				X			-145	-165	
3244	X						91	70	Dry
3245			X				-44	-54	
3246				X			-101	-111	
3247				X			-162	-172	
3248					X		-253	-268	
3249					X		-368	-378	
3264	X						68	47	
3265			X				13	-1	
3266			X				-31	-41	
3267				X			-95	-105	
3268					X		-167	-172	
3278	X						28	7	
3279			X				-35	-44	
3280			X				-85	-96	
3281				X			-135	-145	
3282					X		-205	-225	
3283					X		-328	-338	
3292	X						80	59	

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
3293		X					15	10	
3294			X				-32	-48	
3295							54	44	Well In Lens
3296			X				-2	-13	
3297			X				-38	-49	
3304			X				22	12	
3305				X			-46	-56	
3306				X			-94	-104	
3307					X		-184	-194	
3308					X		-238	-258	
3309					X		-284	-294	
3323			X				-3	-24	
3324				X			-127	-148	
3325					X		-226	-236	
3332				X			-97	-107	
3333					X		-207	-217	
3334					X		-280	-311	
3335			X				-35	-69	
3336				X			-159	-169	
3337					X		-312	-333	
3338			X				11	-10	
3339					X		-205	-212	
3340					X		-299	-320	
3341			X				-16	-37	
3342			X				-99	-109	
3343					X		-216	-226	
3348	X						87	53	
3349			X				-58	-88	
3350				X			-186	-207	
3351		X					38	17	
3352							49	29	Well In Aquitard
3353			X				-20	-41	
3364			X				-41	-58	
3365				X			-211	-221	
3403			X				24	10	
3404					X		-192	-207	
3405					X		-279	-305	
3406			X				26	16	
3407				X			-154	-171	
3408					X		-224	-238	
3409		X					64	43	
3410				X			-116	-131	

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
3411					X		-192	-202	
3415				X			-124	-130	
3416				X			-169	-185	
3417					X		-340	-354	
3431	X						63	53	
3432			X				23	13	
3433			X				-38	-59	
3434	X						-6	-12	
3435			X				-30	-44	
3436			X				-78	-90	
3437							61	51	Well In Aquitard
3438			X				-32	-52	
3439				X			-148	-158	
3440							60	55	Well In Aquitard
3441			X				8	-1	
3442			X				-74	-84	
3476	X						69	49	
3517			X	X			10	-108	
3518			X	X			No data	No data	
4007	X						104 & -57	96 & -67	
4014			X				-12	-52	
4016	X	X					81	61	
4018			X				6	-34	
4045		X					70	50	
4050	X						69	49	
4060			X				-45	-105	Gravel In Aquifer D
4070			X	X			-32	-112	
4075			X	X			-18	-118	
4140			X				-6	-66	Gravel In Aquifer D
4145			X				1	-73	
4200			X	X			-29	-119	
4310	X						78	53	
4315		X					12	-2.6	
4425			X	X			-10	-110	
4435			X	X			-8	-108	
5045				X			-103	-143	
5050				X			-116	-156	
5080			X	X			-47	-159	
5085			X	X			-17	-187	
5090			X	X			-25	-205	

Table 3-3. Aquifer Designations and Well Construction Details for Wells Used in the 1996 GET E and GET F Evaluation

Well	Aquifers						Top of Screen * (msl)	Bottom of Screen * (msl)	Remarks
	A	B	C	D	E	F			
5095			X	X			-24	-204	Gravel In Aquifer E
5100			X				-1	-91	Gravel In Aquifers B & D

msl = Mean Sea Level Datum

* Top and bottom of screen elevations were measured from the ground surface elevation.

Table 3-4. Aquifer Test Results for Wells 4315, 4425, and 4435

Pumping Well	Observation Well	Date of Test	Distance from Pumping Well (ft)	Maximum Drawdown (ft)	Aquifer	Theis Transmissivity (gpd/ft)	Storage Coefficient	Cooper/Jacob Transmissivity (gpd/ft)	Storage Coefficient	Recovery Transmissivity (gpd/ft)
4315		05/18/94	0	22.20	B					
GET F	132		62	10.70	B	10,530	0.007541	9,216	0.010	
	357		945	1.30	C	6,798 (1)	0.001665			
	495		909	3.91	C	11,810 (1)	0.002273	16,952	0.00043	
	1244		859	2.80	C			19,495	0.00082	
	1245		859	2.60	C			21,754	0.00101	
	3061		1026	0.70	D					
	3245		682	4.05	C	13,560 (1)	0.0009218	14,692	0.00082	
	3293		549	7.40	B	9,826 (1)	0.0004198	10,451	0.00048	
	3349		436	3.70	C	12,950 (1)	0.002362	17,182	0.00226	
4425		11/07/95		35.09	C/D	(2)		124,608		110,400
GET E	124		56	7.02	C	64,710 (1)	0.01925	75,796	0.151	
	165		180	5.24	C	174,200	0.0024	184,331	0.00249	
	166		180	8.41	Aquitard	83,360 (1)	0.001907	113,693	0.00117	
	167		180	9.27	D	(2)		111,257	0.00050	
	437		391	6.24	C	126,200	0.00114	136,035	0.000930	
	438		391	4.94	C	148,200	0.00168	139,695	0.00228	
	439		391	5.46	D	158,800	0.00072	184,331	0.00064	
	440		391	5.39	D	155,200	0.000926	180,069	0.00071	
	476		940	3.70	D	144,900	0.00136	109,690	0.00163	
	477		940	1.50	E					
	478		940	1.50	E					
	479		940	1.40	E					
	3332		308	6.44	D	135,200 (1)	0.00068	159,754	0.00053	
	3333		308	1.62	E					

(1) Confined Leaky

(2) Log-Log Drawdown Plot does not conform to Type Curves.

Table 3-4. Aquifer Test Results for Wells 4315, 4425, and 4435

Pumping Well	Observation Well	Date of Test	Distance from Pumping Well (ft)	Maximum Drawdown (ft)	Aquifer	Theis Transmissivity (gpd/ft)	Storage Coefficient	Cooper/Jacob Transmissivity (gpd/ft)	Storage Coefficient	Recovery Transmissivity (gpd/ft)
	3334		308	1.61	E					
	3353		309	6.00	C	129,100 (1)	0.0015	138,453	0.00142	
	3403		1059	3.36	C	104,900 (1)	0.0022	110,078	0.00184	
	3404		1059	1.32	E					
	3405		1059	1.36	E					
	3406		1520	<0.05	C					
	3407		1520	3.22	D	126,200 (1)	0.0012	123,619	0.00106	
	3408		1520	1.53	E					
	3517		15	12.86	C/D	95,710	0.0097	114,952		
	3518		569	5.50	C/D	117,700	0.0013	103,152	0.00172	
	4070		456	5.22	C/D	117,700 (1)	0.0018	143,558	0.00142	
	4435		560	0.40	C/D					
4435		11/29/95		49.40	C/D	(2)		135,709		102,900
GET E	87		567	<0.05	E					
	124		506	3.35	C					
	127		603	5.03	C	124,100	0.001359	155,647	0.00107	
	128		603	0.29	D					
	165		382	6.60	C			108,370	0.00152	
	166		382	6.60	Aquitard			106,279	0.00141	
	167		382	5.40	D			123,793	0.00212	
	476		669	4.00	D	139,300	0.001524	115,234	0.0002	
	477		669	1.44	E					
	478		669	1.39	E					
	479		669	1.36	E					
	480		669	0.10	E					
	3332		720	3.98	D	115,800	0.0009979	123,002	0.00208	
	3333		720	1.33	E					

(1) Confined Leaky

(2) Log-Log Drawdown Plot does not conform to Type Curves.

Table 3-4. Aquifer Test Results for Wells 4315, 4425, and 4435

Pumping Well	Observation Well	Date of Test	Distance from Pumping Well (ft)	Maximum Drawdown (ft)	Aquifer	Theis Transmissivity (gpd/ft)	Storage Coefficient	Cooper/Jacob Transmissivity (gpd/ft)	Storage Coefficient	Recovery Transmissivity (gpd/ft)
	3334		720	1.32	E					
	3338		199	7.32	C					
	3339		199	1.42	E					
	3340		199	1.43	E					
	3353		714	4.70	C	139,300	0.000969	109,472	0.00148	
	3517		555	5.82	C/D	130,000	0.001036	134,047	0.0010	
	3518		9.8	25.00	C/D	179,400	0.001483	117,291		
	4070		502	5.51	C/D	136,000	0.001237	140,951	0.00107	
	4075		533	6.00	C/D	127,000	0.000851	124,873	0.00084	
	4200		1006	3.17	C/D	167,500	0.001654	142,171	0.00193	
	4425		560	5.71	C/D	130,000	0.00109	140,951	0.00103	

(1) Confined Leaky

(2) Log-Log Drawdown Plot does not conform to Type Curves.

Table 3-5. Sample Collection Dates for Wells Sampled Prior to June 1995 and After September 1995

Well Number	Aquifer Designation	Date Sampled
5	B	February-95
181	A	January-95
183	C	January-95
187	D	January-95
222	D	September-93
282	B	March-95
283	B	March-95
284	D	March-95
285	D	March-95
304	B	January-95
307	A	January-95
308	B	January-95
309	B	January-95
310	C	January-95
358	D	October-95
477	E	March-94
486	C	March-95
494	C	March-95
903	A	March-94
1204	C	February-96
1205	C	February-96
1206	D	February-96
1207	E	February-96
1231	C	June-94
1232	D	February-95
1233	E	February-95
1234	E	February-95
1267	C	December-95
1268	D	December-95
1277	C	December-95
1280	E	October-95
1282	C	December-95
1286	E	February-95
1294	C	January-96
1295	C	January-96
1296	D	January-96
3053	E	November-92
3225	C	October-92
3226	D	April-93
3326	B	January-95
3364	C	April-95

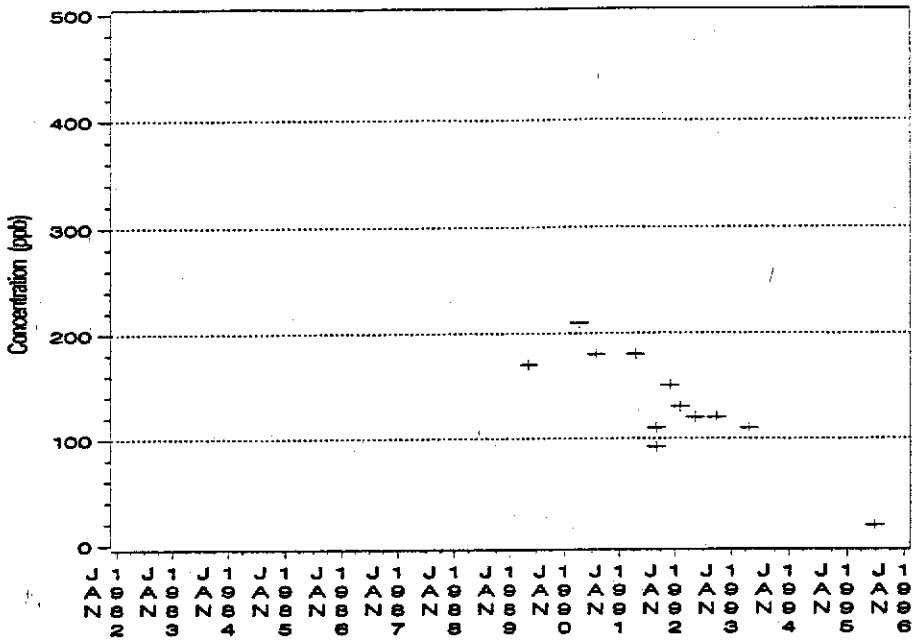
Table 3-5. Sample Collection Dates for Wells Sampled Prior to June 1995 and After September 1995

Well Number	Aquifer Designation	Date Sampled
3365	D	April-95
4016	A/B	January-95
4018	C	November-95
4045	B	February-95
4050	A	March-95
4425	C/D	November-95
4435	C/D	November-95

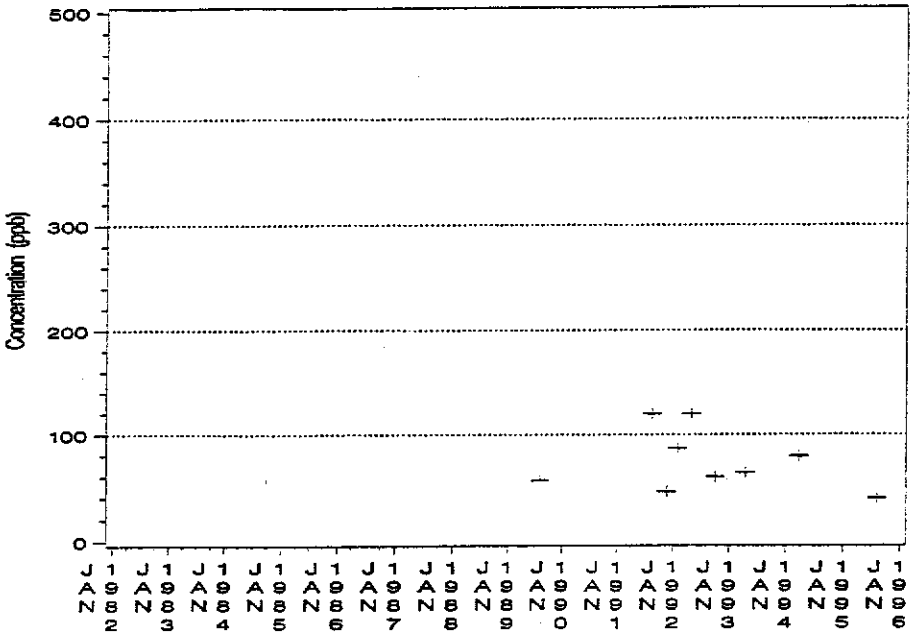
PAGES OF OVERSIZED MAPS

(SEE BINDER)

WELL 3233
TRICHLOROETHYLENE Trend



WELL 3264
TRICHLOROETHYLENE Trend



◇ TCE VALUE LESS THAN DETECTION LIMIT

+ TCE VALUE GREATER THAN OR EQUAL TO DETECTION LIMIT

Aerojet General Corporation
Sacramento, CA

TCE Trend in Wells 3233 & 3264

DATE:	04-19-96
DESIGNED:	MH
CHECKED:	
APPROVED:	
DRAWN:	GHP
PROJ.:	501285049

HYDRO-SEARCH, INC.
A Tetra Tech Company

Figure 3-34

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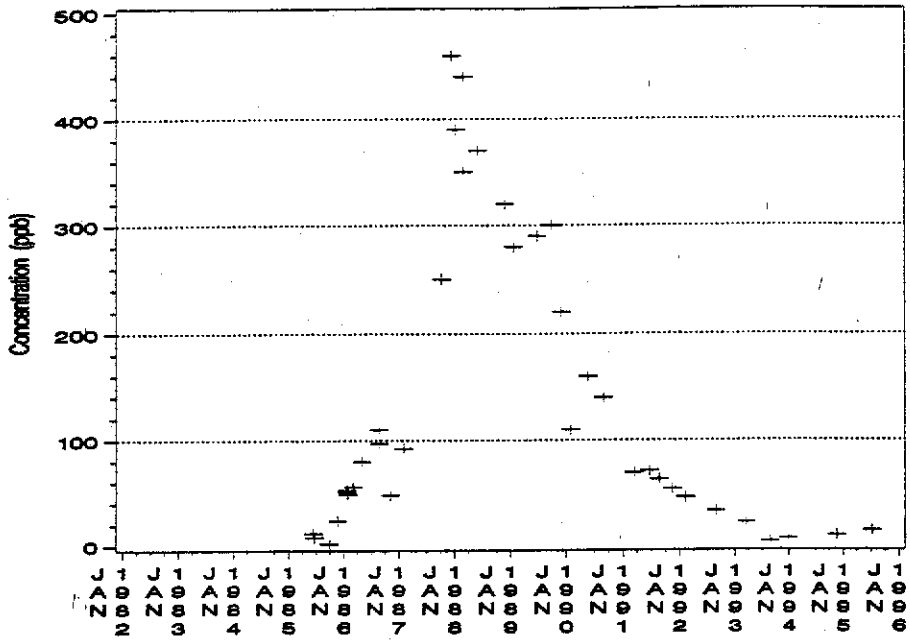
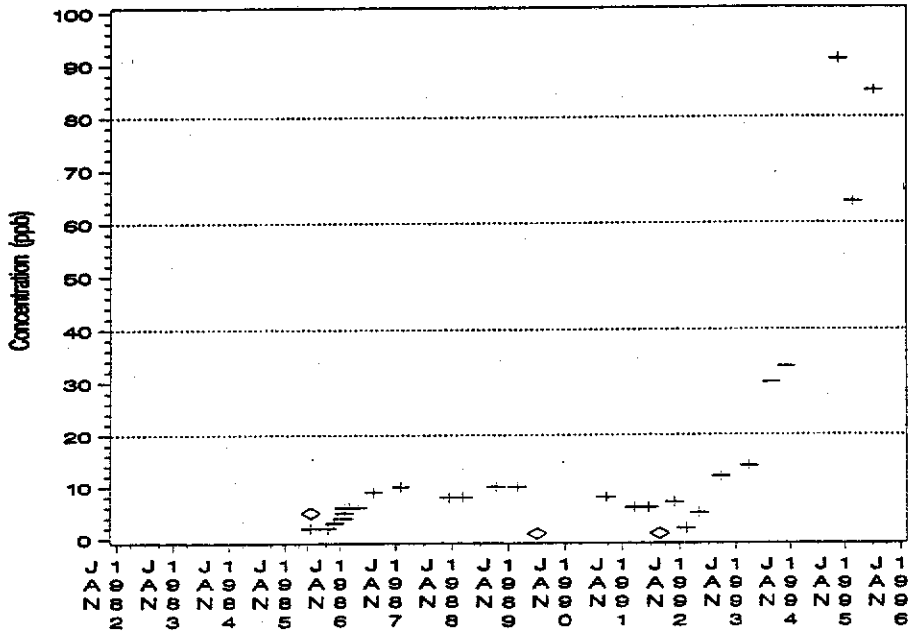
PAGES OF OVERSIZED MAPS

(SEE BINDER)

WELL 1351
TRICHLOROETHYLENE Trend



WELL 1354
TRICHLOROETHYLENE Trend



◇ TCE VALUE LESS THAN DETECTION LIMIT

\+ TCE VALUE GREATER THAN OR EQUAL TO DETECTION LIMIT

Aerojet General Corporation
Sacramento, CA

TCE Trend in Wells 1351 & 1354

DATE:	04-16-96
DESIGNED:	
CHECKED:	
APPROVED:	
DRAWN:	GHP
PROJ.:	501285049

HYDRO-SEARCH, INC.
A Tetra Tech Company

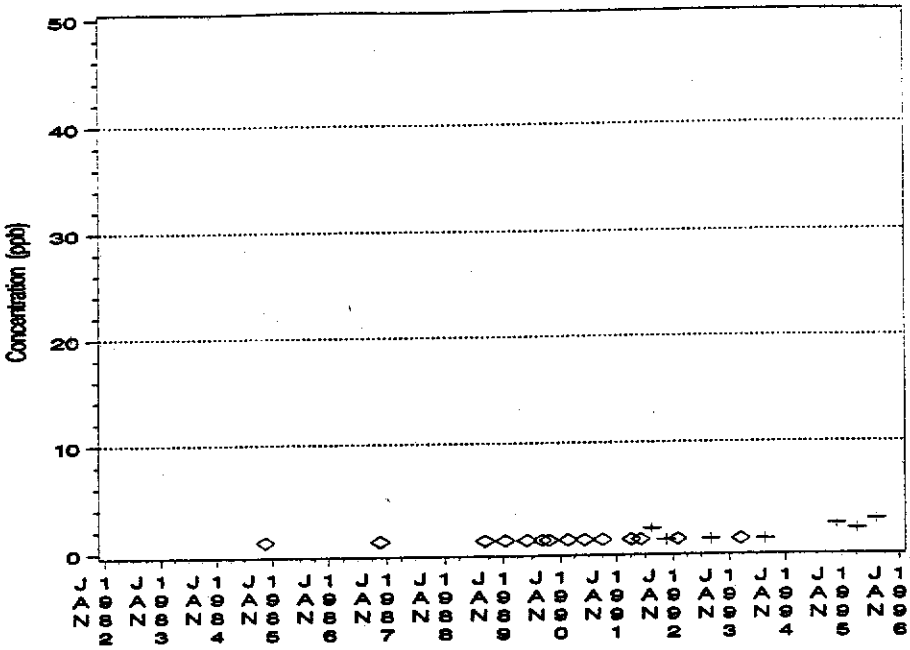
Figure 3-44

e\1285\49tt13

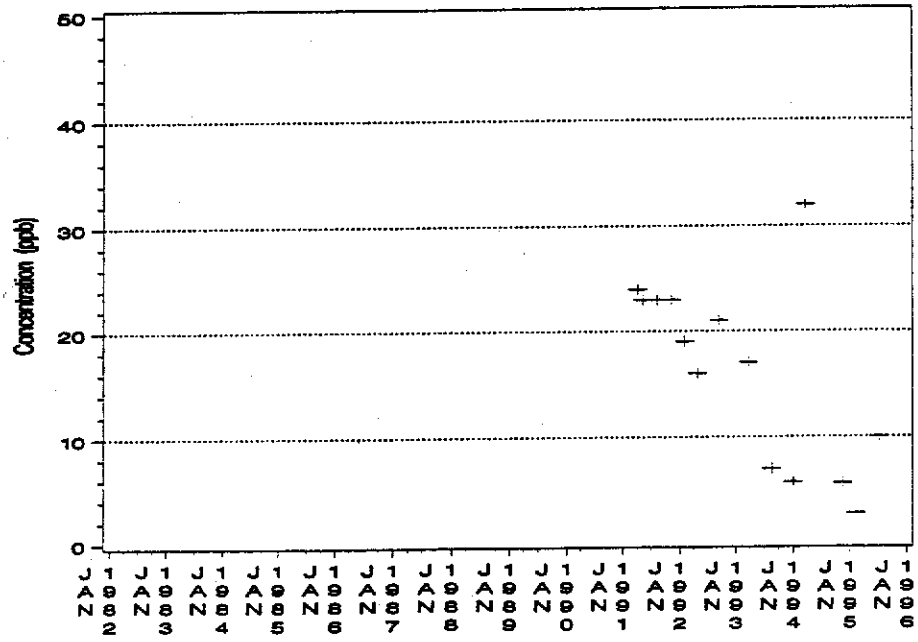
PAGES OF OVERSIZED MAPS

(SEE BINDER)

WELL 1274
TRICHLOROETHYLENE Trend



WELL 3336
TRICHLOROETHYLENE Trend



◇ TCE VALUE LESS THAN DETECTION LIMIT

\+ TCE VALUE GREATER THAN OR EQUAL TO DETECTION LIMIT

Aerojet General Corporation Sacramento, CA	DATE: 04-16-96
TCE Trend in Wells 1274 & 3336	DESIGNED:
	CHECKED:
	APPROVED:
	DRAWN: GHP
	PROJ.: 501285049
HYDRO-SEARCH, INC. A Tetra Tech Company	Figure 3-50

a\1285\49tt12

PAGES OF OVERSIZED MAPS

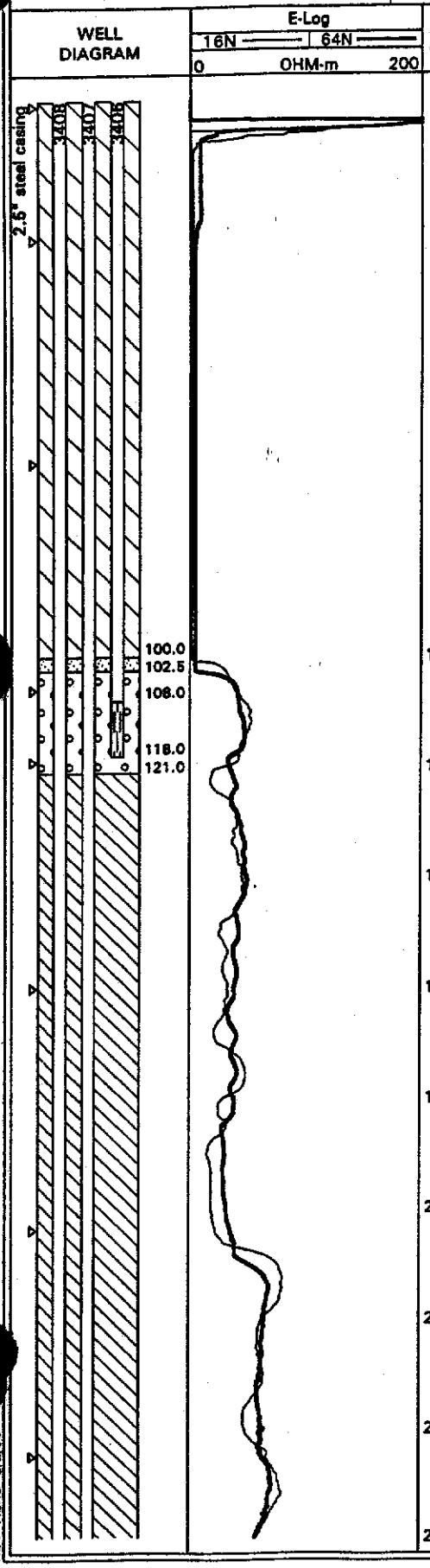
(SEE BINDER)

APPENDIX A

Construction Diagrams for New Wells

AEROJET

TOTAL DEPTH BORING ft: 465.0	WELL ID: 3406-08 Page 1 of 2
TOTAL DEPTH WELL ft: 118, 305, 372	SITE: 93GETE04
SURFACE ELEVATION ft MSL: 133.9	EAST = 2214962.0 NORTH = 343909.0
TOC ELEVATION ft MSL: 136.50	DATE COMPLETED: 5/4/93 LOGGED BY: Booth/Honea
BOREHOLE DIAMETER: 10 1/2"	



DESCRIPTION

0 to 1' [ML]: SILT; yellow-brown (10YR, 5/8), dry.

1' to 24' [GM]: SILTY GRAVEL (Dredge Tailings); poorly sorted, cobbles, rounded to subrounded, loose, predominantly mafic and metavolcanics, silt decreasing with depth.

24' to 42' [ML]: SANDY SILT; yellow-brown (10YR, 5/8) and mottled light brown (7.5YR, 6/4), moist, rare mica.

42' to 80' [GM]: SILTY GRAVEL; variegated, fine sand to coarse gravel, subangular to rounded, moist, common mica.

80' to 87' [ML]: CLAYEY SILT; yellow-brown (10YR, 5/8), 30% clay, moist, common mica.

87' to 110' [ML]: SILTSTONE; brown (7.5YR, 4/4), well indurated, common black organics, rare mica; interbedded with 10% to 20% sandstone, olive-brown (2.5Y, 4/2), moderately indurated, fine to medium, moderately sorted, rare mica.

110' to 123' [GP]: GRAVEL; darkly variegated, medium sand to fine gravels, subangular to subrounded, common mica.

123' to 125' [ML]: CLAYEY SILT; light brown (7.5YR, 6/4), moderately indurated, slightly plastic, common siltstone, .

125' to 151' [SP]: SANDSTONE; black to yellow, moderately to well indurated, angular to subangular, abundant tuff, common fine gravel in one foot interbeds.

151' to 171' [SM]: SILTY SAND; dark brown (7.5YR, 3/2), fine, micaceous; 40% silt and siltstone, yellow-brown (10YR, 5/8), well indurated.

171' to 183' [SP]: SANDSTONE; black, well indurated, very fine to medium.

183' to 190' [ML]: SILT; light brown (7.5YR, 6/4), with 40% moderately well indurated siltstone.

190' to 201' [ML]: SILTSTONE; light olive-brown, well indurated, common silt.

201' to 205' [ML]: CLAYEY SILT; blue-gray, slightly plastic, with 20% clay and 10% sand, common moderately to well indurated siltstone.

205' to 210' [ML]: SILTSTONE; light olive-brown, well indurated.

210' to 223' [SP]: SAND; black to darkly variegated, fine to coarse, subangular to subrounded, rare white tuff nodules.

223' to 235' [SP]: SANDSTONE; dark olive-brown, poorly to moderately indurated, fine to medium, common gray clayey silt.

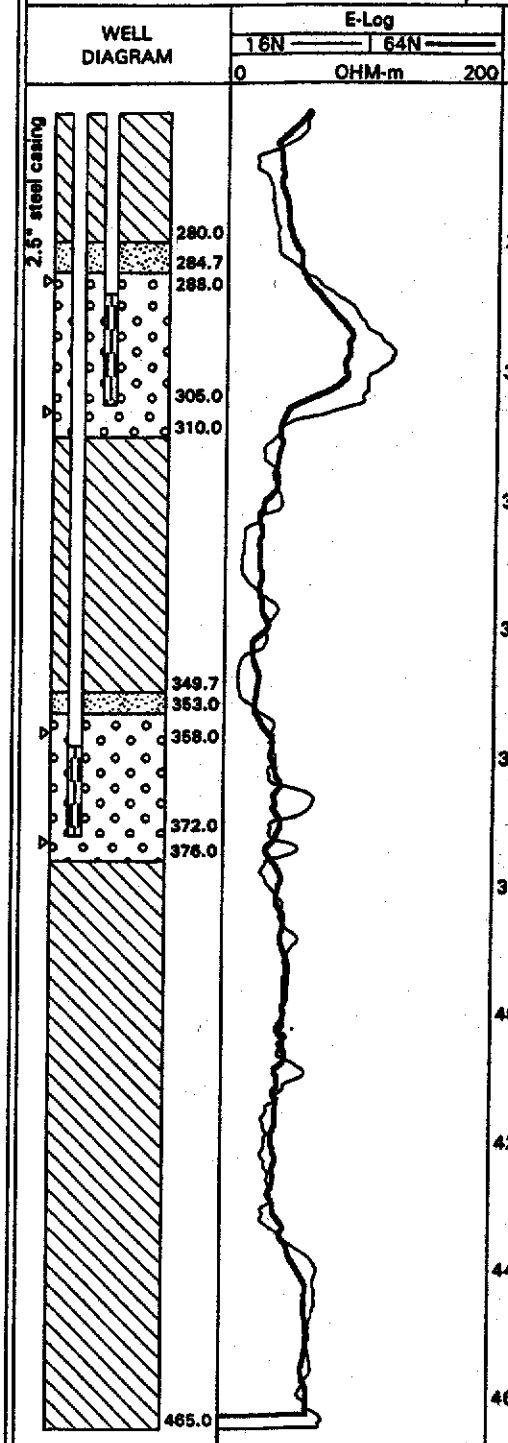
235' to 245' [SM]: SILTY SAND; brown, very fine, with 40% silty sandstone, moderately indurated, very fine.

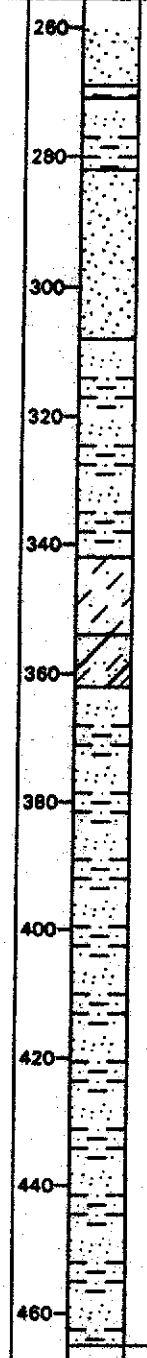
245' to 269' [SP]: SAND; black to darkly variegated, predominantly fine to coarse, subangular to subrounded.

ROT_AERO 2/2/95

AEROJET

TOTAL DEPTH BORING ft: 465.0	WELL ID: 3406-08
TOTAL DEPTH WELL ft: 118, 305, 372	
SURFACE ELEVATION ft MSL: 133.9	SITE: 93GETE04
TOC ELEVATION ft MSL: 136.50	EAST = 2214962.0 NORTH = 343909.0
BOREHOLE DIAMETER: 10 1/2"	DATE COMPLETED: 5/4/93 LOGGED BY: Booth/H





DESCRIPTION

269' to 271' [ML]: SILTSTONE; light yellow-brown, moderately to well indurated, common silt.

271' to 282' [ML]: SANDY SILT; brown, 20% to 30% sand and 30% to 40% silty sandstone, moderately indurated, very fine sand.

282' to 308' [SP]: SAND; black to darkly variegated, moderately indurated, subangular to angular, mafic, common gravel, rare yellow tuff, quartz increasing with depth.

308' to 324' [SM]: SILTY SAND; olive-brown, moderately indurated, fine to medium, subrounded to subangular, with common yellow tuff and sandstone.

324' to 342' [ML]: SANDY SILT; light brown to olive, subangular, mafic, common yellow tuff, 10% to 30% sand, sand decreasing with depth.

342' to 354' [CL]: SILTY CLAY; brown to light olive brown, slight plasticity, with 20% silt.

354' to 362' [CL]: SANDY CLAY; gray, moderate plasticity, subangular, 20% sand.

362' to 375' [SM]: SILTY SAND; dark gray, moderately indurated, poorly sorted, subangular, with common light brown siltstone.

375' to 410' [ML]: SANDY SILTSTONE; light olive-brown, moderately indurated, fine, subangular, with 20% mafic sand. Sand increases to 40% and becomes well indurated with depth.

410' to 420' [SM]: SILTY SAND; olive-brown, moderately indurated, fine, subrounded, rare clay.

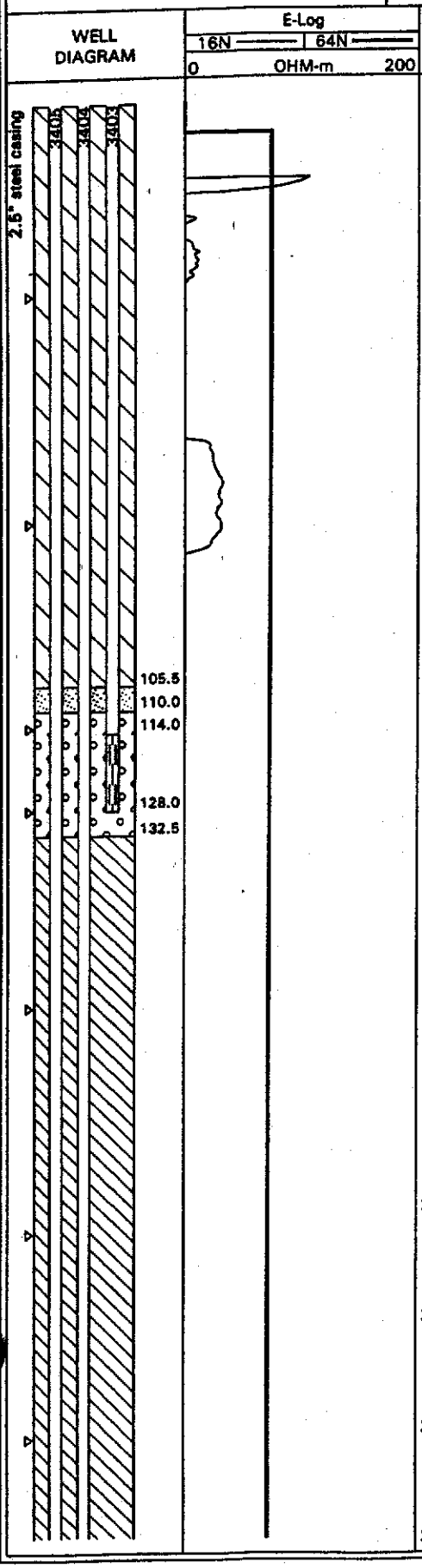
420' to 465' [SP]: SAND; dark gray to black, variegated, medium to coarse, subangular to angular, mafic, common gravel, interbedded with silt.

Total Depth of Borehole: 465 feet

ROT AERO 2/2/95

AEROJET

TOTAL DEPTH BORING ft: 450.0	WELL ID: 3403-05 Page 1 of 2
TOTAL DEPTH WELL ft: 128, 345, 443	
SURFACE ELEVATION ft MSL: 138.1	SITE: 93GETE02
TOC ELEVATION ft MSL: 138.07	EAST = 2215452.0 NORTH = 346395.0
BOREHOLE DIAMETER: 10 5/8"	DATE COMPLETED: 4/22/93 LOGGED BY: C. Clark



DESCRIPTION

0 to 17' [GW]: SANDY GRAVEL; 60% gravel up to 10" diameter, subrounded to well rounded; 35% sand, fine to coarse, metamorphics; 5% red-brown silt.

17' to 53' [CL]: SILTY CLAY; red-brown, 80% clay and 20% silt.

53' to 59' [ML]: SANDY SILT; dark red-brown, fine to medium, 70% silt and 30% sand.

59' to 81' [SM]: SILTY SAND; red-brown, 65% to 70% fine to coarse sand, and 25% to 30% silt.
65' Gravel up to 1" diameter, fine, well rounded.

81' to 101' [CL]: SILTY CLAY; light red-brown, 70% clay, 25% silt, and 5% fine to medium sand.

91.5' to 92.5' Lens of moderately indurated sandstone, grades to red-gray, becoming darker with depth.

101' to 136' [SM]: SAND/SANDSTONE; variegated (mostly black) with a red-brown matrix, poorly to moderately indurated, fine to coarse, angular to subrounded, metavolcanics, 5% to 20% silt.

136' to 142' [SM/ML]: SANDSTONE/SILTSTONE; medium brown to black, poorly indurated, fine to medium sand, metavolcanics, interbedded.

142' to 166' [SM]: SANDSTONE; black to medium gray-brown, poorly to moderately indurated, fine to medium, interbedded with thin beds of siltstone and some claystone, grades to predominantly sandstone with little or no silt/claystone with depth.

166' to 178' [ML/CL]: SILTSTONE/CLAYSTONE; medium brown, poorly to moderately indurated.

178' to 189' [SW]: SANDSTONE; gray-brown, poorly to moderately indurated, medium to coarse.

189' to 202' [SM/ML]: SILTY SANDSTONE/SILTSTONE; medium to dark gray, 60% silty sandstone, fine, and 30% siltstone.

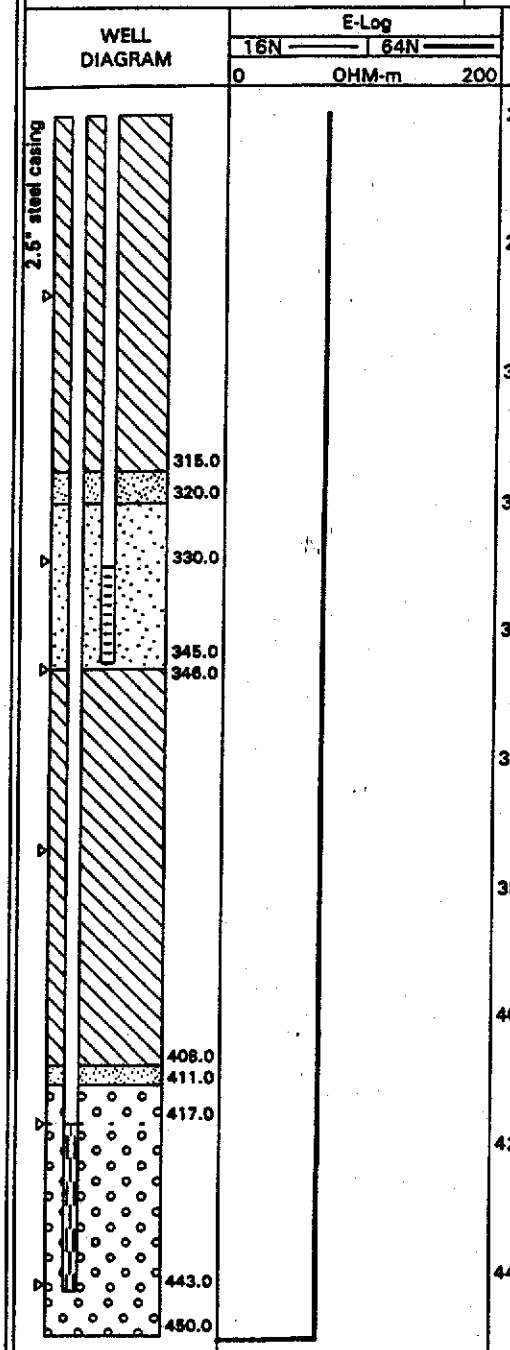
202' to 220' [ML/CL]: SILTSTONE/CLAYSTONE; light to medium brown, poorly to moderately indurated.

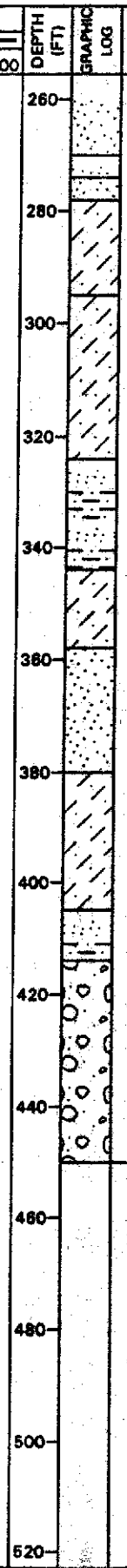
220' to 226' [SW]: SAND/SANDSTONE; medium to coarse.

226' to 260' [ML]: SILTSTONE; light to medium brown, poorly indurated, with very fine silty sandstone, fine sand increasing with depth.

AEROJET

TOTAL DEPTH BORING ft: 450.0	WELL ID: 3403-05 Page 2 of 2
TOTAL DEPTH WELL ft: 128, 345, 443	
SURFACE ELEVATION ft MSL: 138.1	SITE: 93GETE02
TOC ELEVATION ft MSL: 138.07	EAST= 2215452.0 NORTH= 346395.0
BOREHOLE DIAMETER: 10 5/8"	DATE COMPLETED: 4/22/93 LOGGED BY: C. Clark





DESCRIPTION

260' to 270' [SP]: SAND; black to yellow, loose to poorly indurated, fine to medium, subangular, predominantly mafics and tuff.

270' to 274' [SM]: SILTY SANDSTONE; poorly indurated, fine.

274' to 278' [SP]: SAND; black to yellow, fine to medium, predominantly mafics and tuff, loose.

278' to 295' [ML]: CLAYEY SILT; dark brown, trace of very fine sand.

295' to 300' [SP]: SAND; black, medium to coarse, subangular, mafics.

300' to 324' [ML/CL]: SANDY SILTSTONE/CLAYSTONE; red-brown to gray-brown, soft to poorly indurated, silt increasing and fine sand/clay decreasing with depth.

324' to 344' [SM/ML]: SILTSTONE/SANDSTONE; gray-brown, poorly to moderately indurated, fine sand.

344' to 358' [ML/CL]: SILTSTONE/CLAYSTONE; medium to dark brown, soft to poorly indurated, interbedded.

358' to 380' [SM]: SANDSTONE; dark brown, moderately indurated, fine to medium, with thin interbeds of siltstone.

380' to 405' [ML/CL]: CLAYSTONE/SILTSTONE; medium brown, poorly indurated.

405' to 414' [ML]: SANDY SILTSTONE; medium brown, fine sand, sand content and grain size increasing with depth.

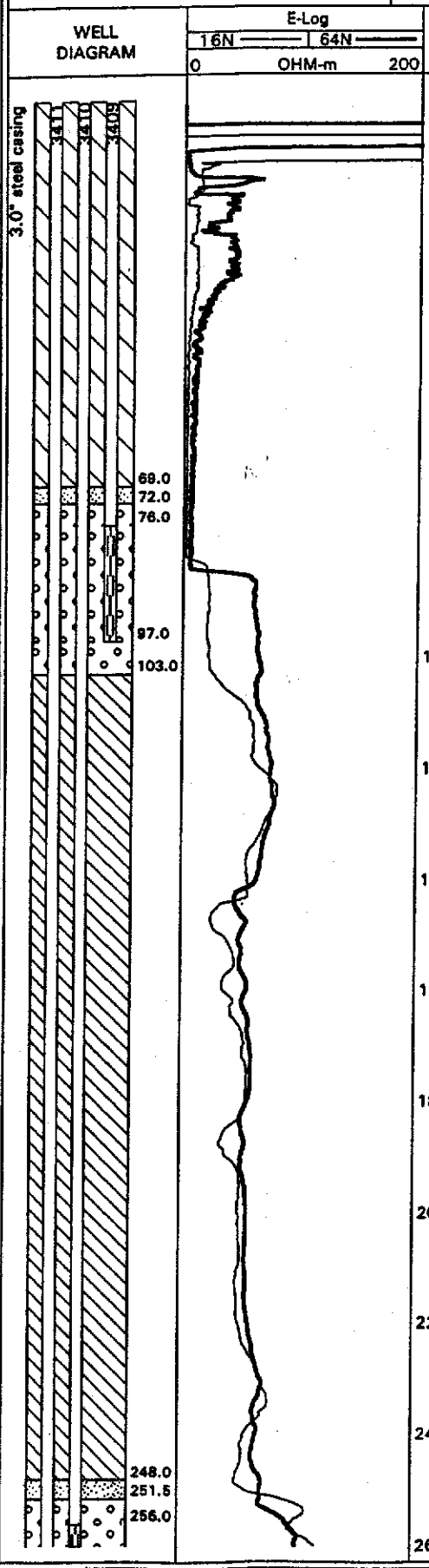
414' to 450' [GW]: SANDY GRAVEL; predominantly black (some dark red, brown, and dark green), sand: medium to coarse, subangular to subrounded; gravel: subrounded to well rounded, up to 0.5" diameter; loose, predominantly metavolcanics.

Total Depth of Borehole: 450 feet

ROT AERO 2/2/95

AEROJET

TOTAL DEPTH BORING ft: 400.0	WELL ID: 3409-11
TOTAL DEPTH WELL ft: 97, 274, 342	
SURFACE ELEVATION ft MSL: 139.8	SITE: GETE 93E-3
TOC ELEVATION ft MSL: 142.14	EAST = 2216071.0 NORTH = 345567.0
BOREHOLE DIAMETER: 10 1/2"	DATE COMPLETED: 5/10/93 LOGGED BY: C. Clark



DESCRIPTION

0 to 19' [GP]: SANDY GRAVEL; dark red-brown, 60% subrounded to well rounded gravel up to 8"diameter; 30% fine to coarse, subangular to subrounded sand; 10% silt and clay.

19' to 33' [SP]: GRAVELLY SAND; medium red-brown, 65% fine to coarse sand; 25% subrounded to well rounded gravel, 3" to 4" diameter, 10% silt and clay.

33' to 60' [GP]: SANDY GRAVEL; medium red-brown, 60% subrounded to well rounded gravel up to 10" diameter, 30% fine to coarse sand, 5% silt and clay.

60' to 82' [SP]: GRAVELLY SAND; 60% to 65% fine to coarse sand, 20% fine gravel up to 1.5" diameter; 20% silt and clay; 5% sandstone fragments, red-brown, moderately indurated, medium sand.

82' to 110' [SC]: CLAYEY SAND; red-gray to red-brown, fine to medium, increasing in size with depth.

101' to 110' Grades to clayey sandstone, poorly indurated, fine.

110' to 122' [SP]: GRAVELLY SAND/SANDSTONE; variegated (mostly black), fine to coarse, subangular to subrounded; sandstone: poorly to moderately indurated; gravel to 1/4" diameter, increasing to 1/2" diameter with depth.

122' to 138' [SP]: GRAVELLY SAND/SANDSTONE; 60% sand; 40% gravel decreasing in size to 1/2" diameter with depth; sandstone: moderately to well indurated.

138' to 143' [SP]: SANDSTONE/SAND; mostly black, fine to medium, metavolcanics.

143' to 148' [ML]: SILTSTONE; medium brown, poorly to moderately indurated.

148' to 158' [SP]: SANDSTONE; dark brown, moderately to well indurated, fine to mostly medium.

158' to 162' [SM]: SILTY SANDSTONE; similar to above.

162' to 187' [SP]: SAND/SANDSTONE; variegated (mostly black), fine to coarse; sandstone: moderately to well indurated; 10% gravel.

187' to 189' [ML/CL]: CLAY/SILT; medium brown.

189' to 211' [SP]: SAND/SANDSTONE; variegated (mostly black), fine to coarse, subangular to subrounded, metavolcanics.

211' to 230' [SP]: GRAVELLY SANDSTONE; medium to mostly coarse, fine gravel to 1/2" diameter, subrounded.

230' to 240' [GW]: SANDY GRAVEL; variegated (mostly black), 70% subrounded gravel to 1.5" diameter, 30% medium to coarse sand.

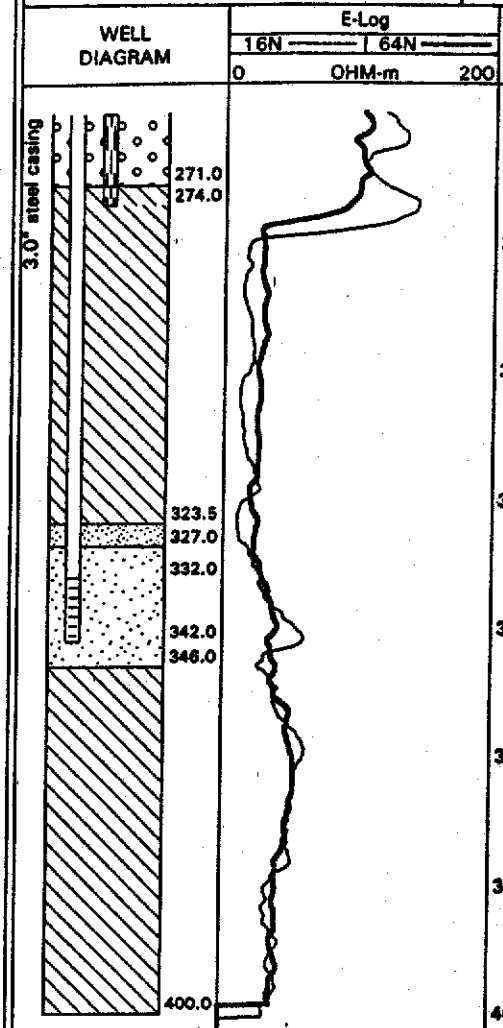
240' to 249' [SM]: SILTY SAND; variegated (mostly black and dark green), loose to poorly indurated, fine to medium, with some interbedded, soft, red-gray sandy clay.

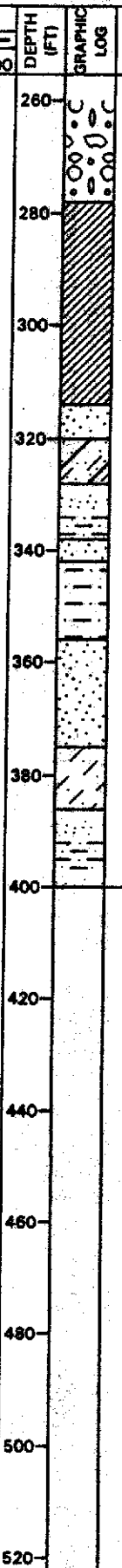
249' to 256' [GW]: SANDY GRAVEL; variegated (mostly dark green), angular to subrounded.

ROT AERO 2/3/95

AEROJET

TOTAL DEPTH BORING ft: 400.0	WELL ID: 3409-11 Page 2 of 2
TOTAL DEPTH WELL ft: 97, 274, 342	
SURFACE ELEVATION ft MSL: 139.8	SITE: GETE 93E-3
TOC ELEVATION ft MSL: 142.14	EAST = 2216071.0 NORTH = 345567.0
BOREHOLE DIAMETER: 10 1/2"	DATE COMPLETED: 5/10/93 LOGGED BY: C. Clark





DESCRIPTION

256' to 278' [GP]: GRAVEL and SAND; variegated (black and dark green), gravel to cobbles, subrounded, medium to mostly coarse sand.

269' to 274' Coarse gravel.

278' to 302' [CL]: CLAY; greenish-yellow, soft..

290' Grades to medium brown.

298' Grades to include fine sand.

302' to 314' Color change to yellow-brown, no sand.

314' to 320' [SP]: SANDSTONE; red-brown, moderately to well indurated, mostly fine to medium.

320' to 328' [CL]: SANDY CLAY; medium gray, fine sand.

328' to 338' [ML/SM]: SILTSTONE/SANDSTONE; yellow-brown, moderately indurated, fine to medium, interbedded.

338' to 342' [SW]: GRAVELLY SAND; 70% fine to coarse sand, 30% black, fine, gravel to 1/2" diameter, mafic.

342' to 356' [ML]: SILTSTONE; medium brown, poorly to moderately indurated.

356' to 375' [SM]: SANDSTONE; medium to dark brown, poorly to moderately indurated, fine to medium, subangular.

364' Interbedded siltstones.

372' to 375' Coarse sandstone.

375' to 386' [ML/CL]: CLAY/SILTSTONE; medium gray, poorly indurated, interbedded.

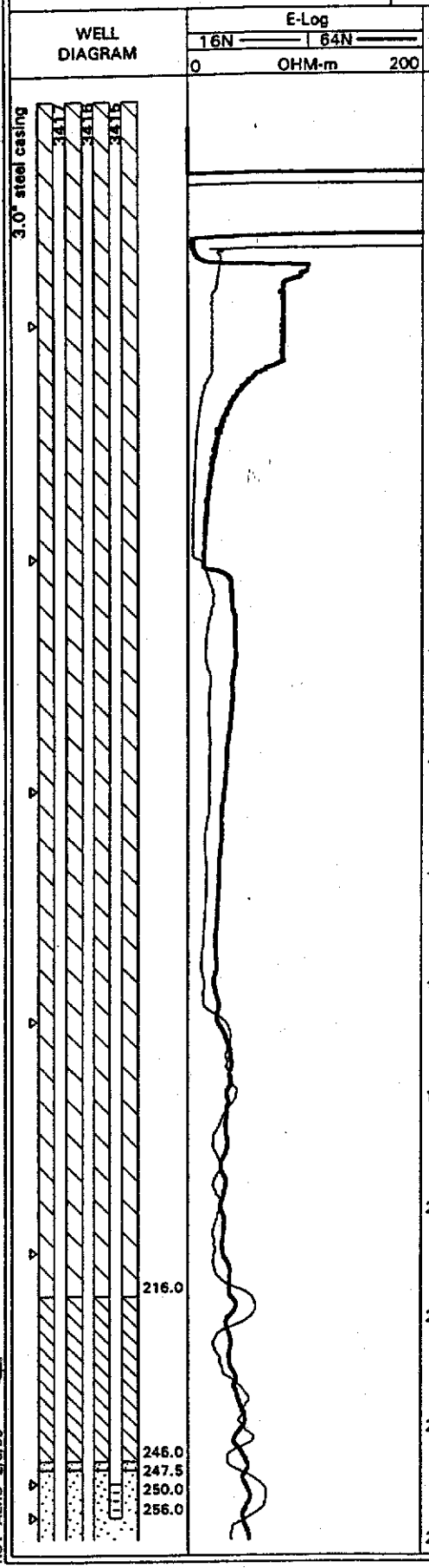
386' to 400' [SM]: SANDSTONE/SILTSTONE; dark gray, poorly indurated, fine, interbedded.

Total Depth of Borehole: 400 feet

ROT AERO 2/3/95

AEROJET

TOTAL DEPTH BORING ft: 500.0	WELL ID: 3415-17 Page 1 of 2
TOTAL DEPTH WELL ft: 256, 311, 480	SITE: 93 F-6
SURFACE ELEVATION ft MSL: 125.9	EAST = 2213236.0 NORTH = 338632.0
TOC ELEVATION ft MSL: 128.43	DATE COMPLETED: 5/20/93 LOGGED BY: C. Clark
BOREHOLE DIAMETER: 10 5/8"	



DESCRIPTION

0 to 10' [GM]: SILTY GRAVEL; red-brown, gravel up to 6" diameter, well rounded, 40% silt, 60% gravel, gravel decreasing with depth.

10' to 24' [SM/GM]: SILTY SAND and GRAVEL; red-brown, sand: fine to medium; gravel: subrounded to well rounded, up to 3" diameter.

24' to 27' [GP]: SANDY GRAVEL; dark brown, subrounded to well rounded, gravel up to 6" diameter.

27' to 30' [SC]: CLAYEY SAND and GRAVEL; red-brown.

30' to 34' [SM]: SILTY SAND; dark red-brown, fine, trace of well rounded gravel up to 3" diameter.

34' to 49' [SC]: CLAYEY SAND; fine, loose.
46' to 49' Grades to include coarse sand and gravel.

49' to 61' [GP]: SANDY GRAVEL; up to 4" diameter, subangular to subrounded.

61' to 81' [CL]: CLAY; red-brown, soft.

81' to 162' [CL]: CLAY; light gray-brown, interbedded with 1' to 2' thick lenses of medium brown, fine, sand.

120' Grades to include 20% to 30% sandstone, poorly indurated, very fine.

131' Grades back to predominantly clay.

162' to 166' [SC]: CLAYEY SAND; poorly indurated, fine.

166' to 182' [SP]: SAND; variegated (mostly black), fine to coarse, subangular to subrounded, metavolcanic, some poorly indurated sandstone.

178' to 182' Becomes medium to coarse, trace gravel up to 1/2" diameter.

182' to 200' [SM/ML]: SANDSTONE/SILTSTONE; interbedded, sandstone: dark brown, poorly to moderately indurated, medium to fine; siltstone: medium brown, poorly indurated.

200' to 212' [ML/CL]: SILTSTONE/CLAY; interbedded, with minor sandstone, fine.

212' to 216' [SM/ML]: SILTSTONE/SANDSTONE; interbedded, poorly indurated, fine to medium.

216' to 222' [SM]: SILTY SAND; variegated (mostly black), fine to coarse, some fine gravel up to 1/2" diameter.

222' to 230' [ML]: SILT/SILTSTONE; medium to dark reddish-brown, interbedded, poorly indurated, with some clay.

230' to 234' [ML]: SILTSTONE; medium to dark reddish-brown, poorly to moderately indurated, with minor sandstone, very fine.

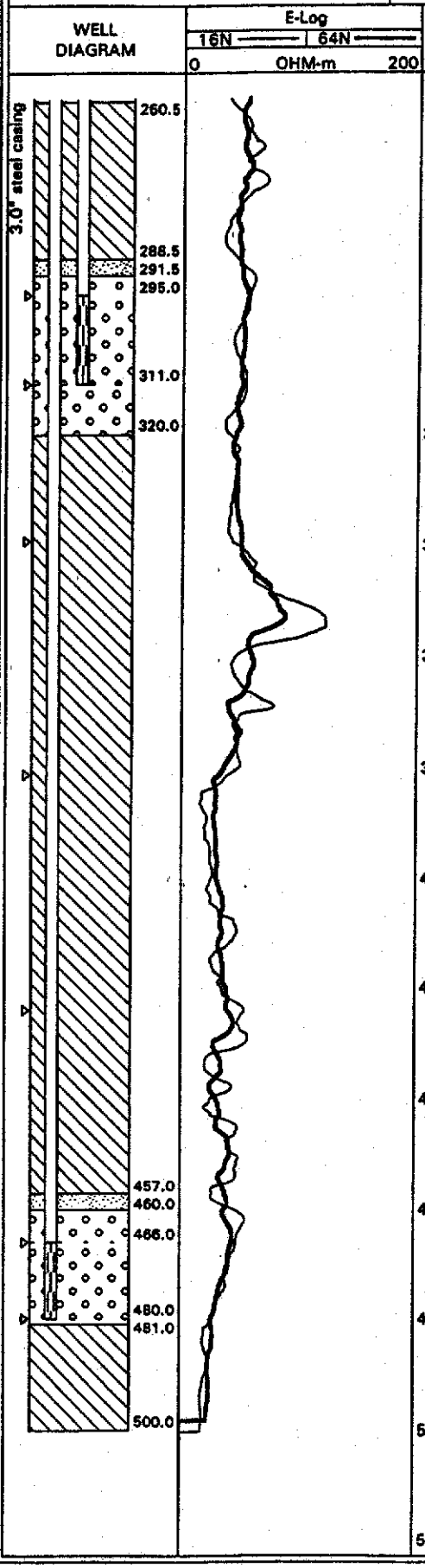
234' to 245' [SM]: SILTY SAND; variegated (mostly black), fine to coarse, metavolcanics, with some interbedded siltstone.

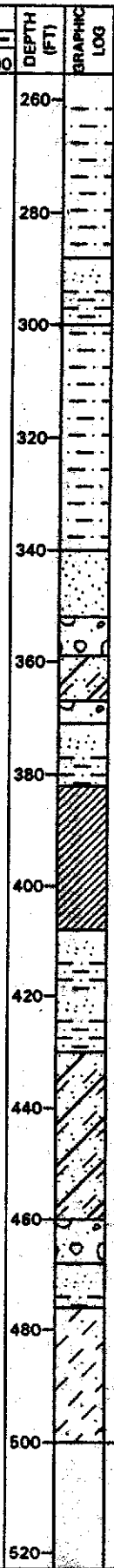
245' to 258' [SP]: SAND/SILTY SANDSTONE; poorly indurated, very fine to coarse, trace gravel up to 1" diameter.

ROT AERO 2/3/95

AEROJET

TOTAL DEPTH BORING ft: 500.0	WELL ID: 3415-17 Page 2 of 2
TOTAL DEPTH WELL ft: 256, 311, 480	
SURFACE ELEVATION ft MSL: 125.9	SITE: 93 F-6
TOC ELEVATION ft MSL: 128.43	EAST = 2213236.0 NORTH = 338632.0
BOREHOLE DIAMETER: 10 5/8"	DATE COMPLETED: 5/20/93 LOGGED BY: C. Clark





DESCRIPTION

258' to 264' [ML]: SILTSTONE; medium gray, poorly indurated.

264' to 278' [ML/SM]: SILTSTONE/SAND/SANDSTONE; interbedded, sand: black, fine to medium.

278' to 288' [ML/SM]: SILTSTONE/SANDSTONE; medium gray, interbedded, moderately indurated, fine sand.

288' to 300' [SM/ML]: SANDSTONE/SILTSTONE; medium gray, fine to medium sand, interbedded.

300' to 340' [ML/CL/SM]: SILTSTONE/CLAY/SANDSTONE; interbedded, fine to medium sandstone; grades to include gray clay and fine black sand.

340' to 352' [SP]: SAND/SANDSTONE; dark gray to black, poorly indurated, fine to medium, subangular, coarsening with depth.

352' to 359' [GP]: SANDY GRAVEL; variegated (mostly dark green to black), subangular to subrounded, metavolcanics.

359' to 367' [SM/CL]: SAND/SILTY CLAY; black to medium gray, metavolcanics.

367' to 371' [GP]: SANDY GRAVEL; black, metavolcanics.

371' to 382' [SM]: SILTY SAND; variegated (mostly black), fine to medium, subangular, metavolcanics.

382' to 408' [CL]: CLAY; blue-gray, soft.

408' to 430' [SM]: SILTY SAND; mostly black, fine to medium, metavolcanics.

412' to 420' Grades to medium blue-gray silt and clay.

420' to 430' Grades back to silty sand.

430' to 460' [SM/CL]: SAND/CLAY; variegated (mostly black), fine to medium, metavolcanics, interbedded with bluish-gray clay.

460' to 468' [SP]: GRAVELLY SAND; variegated (mostly black and dark green), fine to coarse, subangular, metavolcanics, with fine gravel.

468' to 476' [SM]: SAND/SILT; medium, becoming finer and grades to silt with depth.

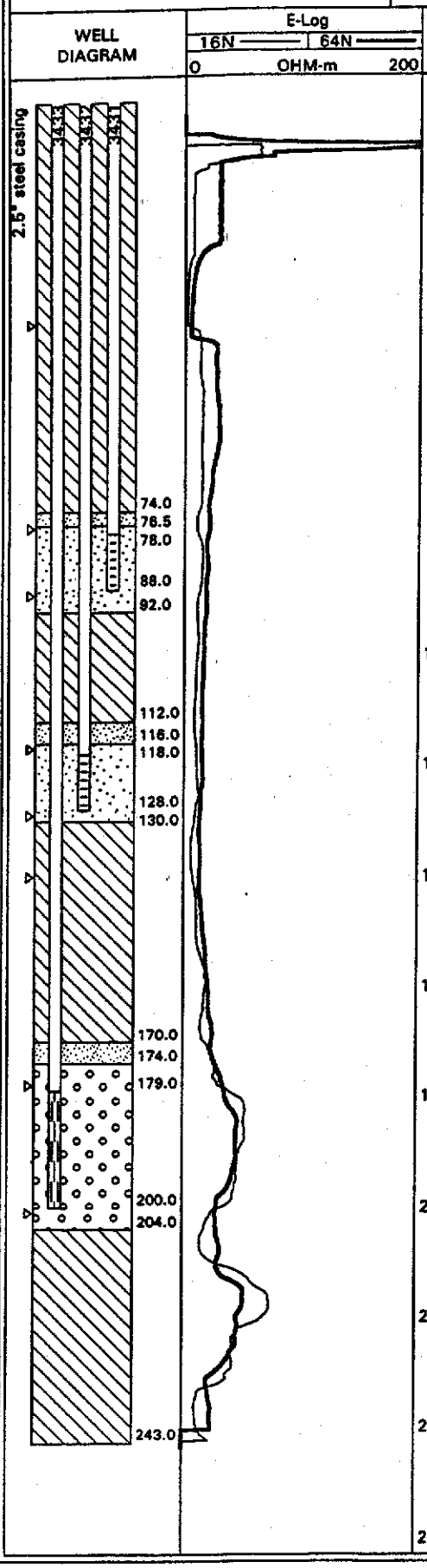
476' to 500' [ML/CL]: SILT/CLAY; medium blue-gray, grades to silt with depth.

Total Depth of Borehole: 500 feet

ROT_AERO 2/3/95

AEROJET

TOTAL DEPTH BORING ft: 243.0	WELL ID: 3431-33 Page 1 of 1
TOTAL DEPTH WELL ft: 88, 128, 200	SITE: F-1
SURFACE ELEVATION ft MSL: 140.9	EAST = 2216156.0 NORTH = 340168.0
TOC ELEVATION ft MSL: 144.05	DATE COMPLETED: 6/28/93 LOGGED BY: B. Honea
BOREHOLE DIAMETER: 10.6"	



DESCRIPTION

0 to 18' [GW]: SANDY GRAVEL; brown, poorly sorted, cobbles up to 10" diameter, loose, 30% sand and silt, dry.

18' to 26' [SP]: SILTY SAND; gray-brown, fine to medium, dense, mafic, mica common, quartz rare, with 10% gravels, moist.

26' to 29' [GP]: SANDY GRAVEL; gray-brown, coarse gravels, medium dense, mafic, 30% to 40% sand, moist.

29' to 38' [SP]: SAND; brown, fine, medium dense, trace clay and gravel, mica common, moist.

38' to 41' [CL]: SILTY CLAY; brown, medium stiff, wet.

41' to 44' [GP]: SANDY GRAVEL; darkly variegated.

44' to 68' [CL]: SILTY CLAY; light brown, medium plasticity.

68' to 78' [SM]: SILTY SAND; dark brown, poorly to moderately indurated, fine.

78' to 94' [CL]: SILTY CLAY; light brown, medium plasticity.

94' to 98' [SM]: SILTY SAND; dark brown, moderately indurated, fine.

98' to 119' [CL]: SILTY CLAY; light brown, medium plasticity, grades to minor sand.

119' to 122' [SM]: SILTY SAND; brown to dark brown, moderately to well indurated.

122' to 146' [CL]: SILTY CLAY; light brown to gray-brown, medium plasticity.

146' to 158' [SC]: CLAYEY SAND: brown to gray, medium, medium dense to poorly indurated.

158' to 171' [GP]: SANDY GRAVEL; darkly variegated, fine gravel and medium to coarse sand, mafic.

171' to 174' [ML]: CLAYEY SILT/SILTSTONE; light brown, moderately to well indurated.

174' to 193' [SM]: SILTY SANDSTONE; brown to dark brown, moderately to well indurated, fine, with siltstone interbeds.

193' to 237' [SP]: SANDSTONE; darkly variegated (black to green), moderately indurated, medium to coarse, with yellow quartz common.

Grades to gravelly.

Color change: dark gray to black.

Color change: green to brown.

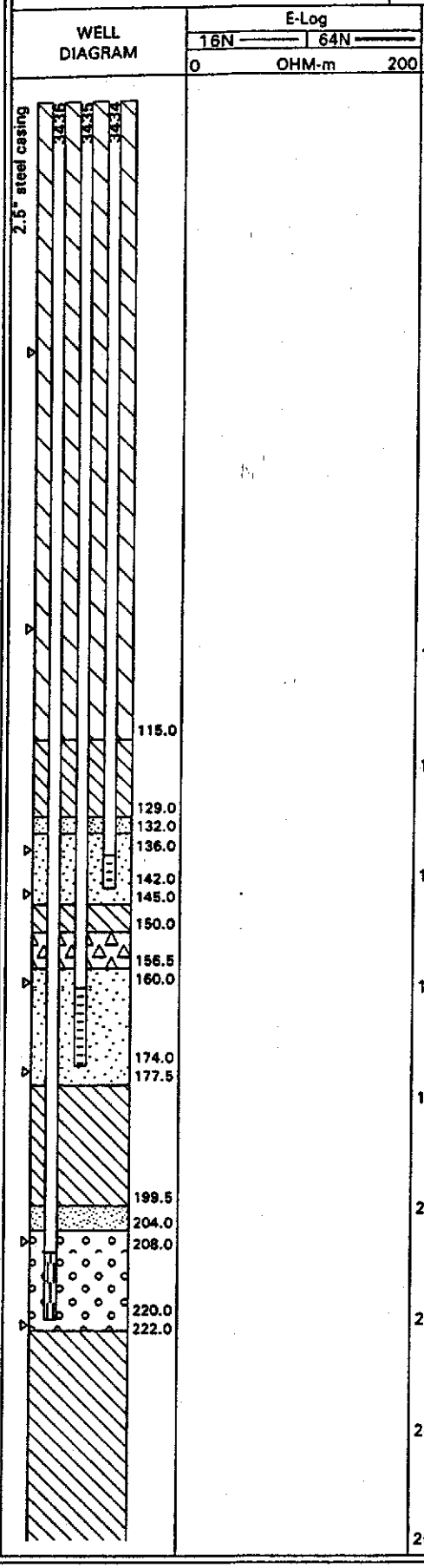
237' to 243' [ML]: SILTSTONE; dark gray, moderately indurated, with common clayey zones.

Total Depth of Borehole: 243 feet

ROT AERO 2/3/95

AEROJET

TOTAL DEPTH BORING ft: 283.0	WELL ID: 3434-36
TOTAL DEPTH WELL ft: 142, 174, 220	SITE: F-4
SURFACE ELEVATION ft MSL: 129.6	EAST = 2213862.0 NORTH = 340484.0
TOC ELEVATION ft MSL: 132.70	DATE COMPLETED: 7/7/93 LOGGED BY: B. Honea
BOREHOLE DIAMETER: 10.6"	



DESCRIPTION

0 to 17' [GM]: SILTY GRAVEL; light red-brown, gravel to 12" diameter, loose, 30% silt and 10% to 15% fine sand, dry to moist.

Grades to gray-brown, loose to dense, with minor clay pockets, moist.

17' to 27' [SP]: GRAVELLY SAND; red-brown to brown, loose to medium dense, 25% gravel, 10% clay pockets, moist.

27' to 36' [ML]: CLAYEY SILT; brown, medium stiff, medium to low plasticity, moist.

36' to 42' [ML]: GRAVELLY SILT; olive-brown to olive, dense, silty clay common in thin lenses, moist.

42' to 92' [ML]: CLAYEY SILT; brown, medium stiff.

92' to 110' [CL]: SILTY CLAY; gray-brown, medium to high plasticity.

110' to 134' [SM/ML]: SILTY SAND/SANDY SILT; brown to light brown, with well indurated siltstone pieces.

134' to 155' [CH]: SILTY CLAY; olive-brown to gray, stiff, high plasticity.

155' to 172' [SM]: SILTY SAND; brown, moderately indurated, fine.

Grades to well indurated, some coarse sand, quartz common.

Grades to coarse sand.

172' to 178' [CL]: SILTY CLAY; light brown, medium plasticity, soft.

178' to 182' [SP]: SANDSTONE; darkly variegated, medium.

182' to 194' [SC]: CLAYEY SAND; olive, medium dense, fine.

194' to 201' [SP]: SANDSTONE; yellow-brown, well indurated, fine to medium.

201' to 208' [SM]: SILTY SANDSTONE; yellow-brown, moderately indurated, fine.

208' to 222' [SP]: SANDSTONE; darkly variegated, moderately indurated, medium to coarse.

222' to 234' [ML]: SILTSTONE/SANDSTONE; light brown, poorly to moderately indurated, fine sand, interbedded.

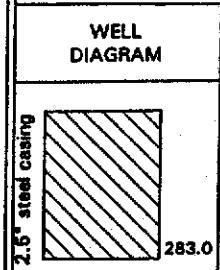
230' Well indurated.

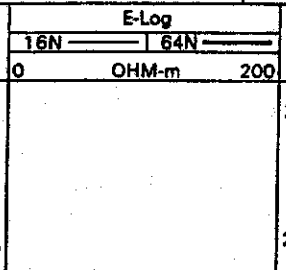
234' to 273' [ML/SM]: SILTSTONE/SANDSTONE; dark gray-green, well indurated, interbedded.

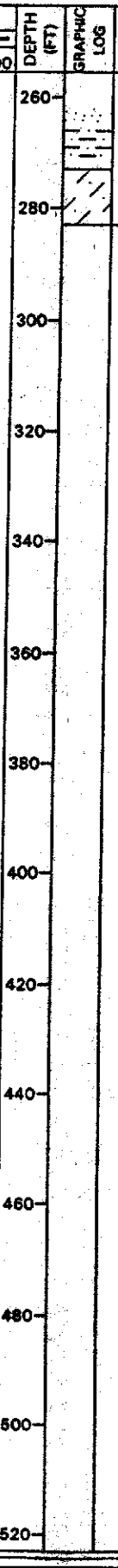
ROT_AERO 2/3/95

AEROJET

TOTAL DEPTH BORING ft: 283.0	WELL ID: 3434-36
TOTAL DEPTH WELL ft: 142, 174, 220	Page 2 of 2
SURFACE ELEVATION ft MSL: 129.6	SITE: F-4
TOC ELEVATION ft MSL: 132.70	EAST = 2213862.0 NORTH = 340484.0
BOREHOLE DIAMETER: 10.6"	DATE COMPLETED: 7/7/93 LOGGED BY: B. Hone







DESCRIPTION

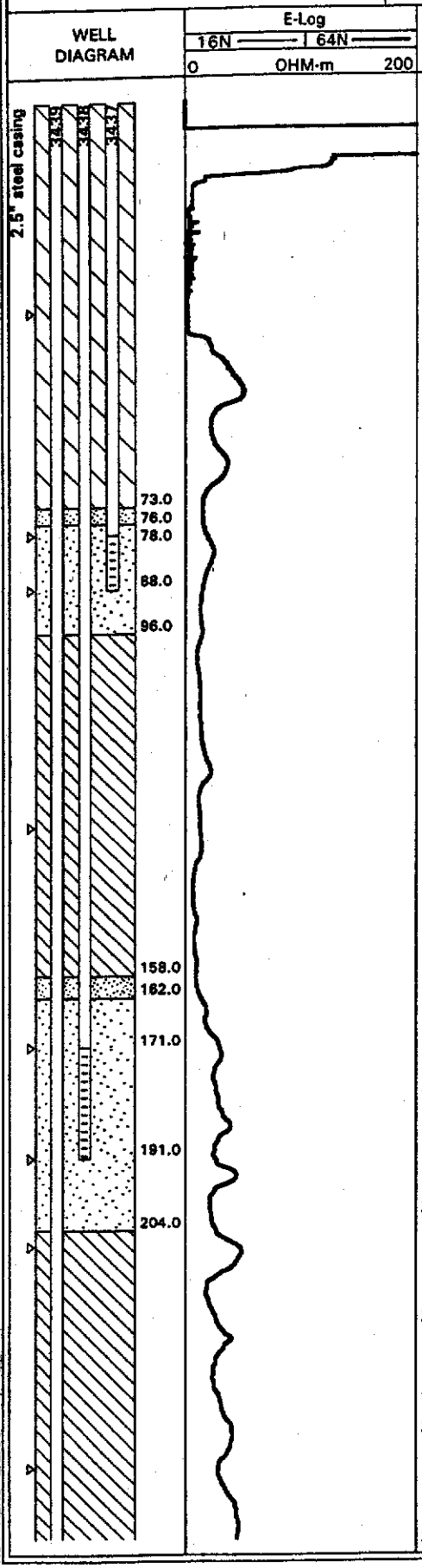
273' to 283' [ML]: CLAYEY SILT; gray, soft to moderately indurated, low plasticity.

Total Depth of Borehole: 283 feet

ROT AERO 2/3/05

AEROJET

TOTAL DEPTH BORING ft: 309.0	WELL ID: 3437-39 Page 1 of 2
TOTAL DEPTH WELL ft: 88, 191, 297	SITE:
SURFACE ELEVATION ft MSL: 139.0	EAST = 2214591.0 NORTH = 338680.0
TOC ELEVATION ft MSL: 141.54	DATE COMPLETED: 7/13/93 LOGGED BY: C. Clark
BOREHOLE DIAMETER: 10 5/8"	



DESCRIPTION

0 to 27' [GM]: SILTY GRAVEL; red-brown, subrounded to well rounded, up to 8" diameter.

23' Grades out of cobbles.

27' to 45' [CL]: SILTY CLAY; red-brown, moist.

40' Grades to include sand.

45' to 57' [GC]: CLAYEY SANDY GRAVEL; variegated (mostly dark green to red-brown), gravel up to 8" diameter, clay matrix.

57' to 63' [CL]: SANDY CLAY; red-brown, fine sand, soft, slightly sticky.

63' to 68' [SC]: CLAYEY SAND; gray-brown, fine to medium.

68' to 78' [CL]: SANDY CLAY; red-brown, fine, similar to clay at 57' to 63'.

78' to 84' [SP]: SANDSTONE; dark red-brown, poorly indurated, fine to medium.

84' to 90' [CL]: SANDY CLAY; red-brown, fine sand, similar to clay at 57' to 63'.

90' to 96' [SP]: SAND/SANDSTONE; dark red-brown, poorly indurated, fine to medium.

96' to 119' [CL/SC]: CLAY/CLAYEY SAND/SANDSTONE; clay: red-brown, soft; clayey sand: green-gray, fine; sandstone: poorly to moderately indurated, fine, interbedded.

119' to 121' [SP]: SANDSTONE; gray-brown, poorly to moderately indurated, fine to medium.

121' to 162' [CL/SP]: SANDY CLAY/SANDSTONE; sandy clay: gray-brown, fine sand; sandstone: poorly to moderately indurated, fine to medium, interbedded.

162' to 168' [SP]: SAND; variegated (mostly red and black), subangular to subrounded, fine to medium, metavolcanics.

168' to 176' [SP]: SANDSTONE; medium olive-brown, poorly to moderately indurated, fine to medium.

176' to 182' [CL]: SANDY CLAY; medium gray, fine.

182' to 185' [SP]: SANDSTONE; medium to dark olive, moderately to well indurated, fine to medium.

185' to 188' [SP]: SAND; variegated (mostly black), fine to medium, metavolcanics.

188' to 192' [ML/SM]: SILTSTONE/SANDSTONE; olive-brown, poorly to moderately indurated, fine, interbedded.

192' to 196' [SP]: SANDSTONE; dark brown, medium.

196' to 206' [ML/SM]: SILTSTONE/SANDSTONE; olive to dark brown, moderately to well indurated, fine, interbedded.

206' to 213' [SP/GP]: SAND/GRAVEL; variegated (black to red), subangular to subrounded, cobbles to 6" diameter, metavolcanics.

213' to 220' [CL]: SANDY CLAY; gray-brown to olive-brown, fine.

220' to 228' [ML/SM]: SILTSTONE/SANDSTONE/SAND; dark brown, siltstone: moderately to well indurated; sandstone: fine to medium; sand: darkly variegated, subangular, medium to coarse, metavolcanics, interbedded.

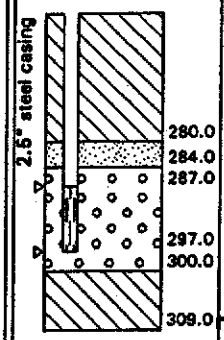
228' to 234' [CL]: SANDY CLAY; gray-brown to olive-brown, fine.

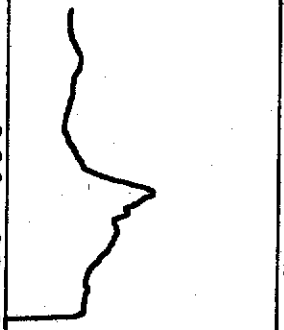
234' to 237' [ML/SM]: SILTSTONE/SANDSTONE; interbedded as above at 220' to 228'.

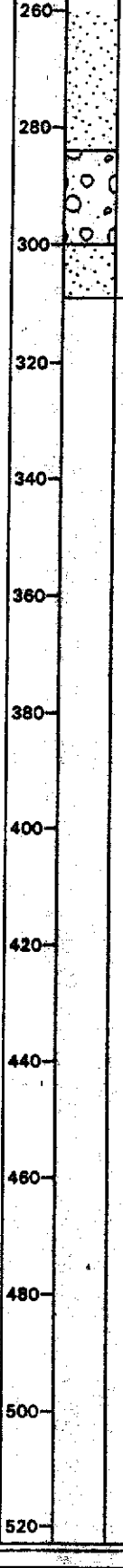
237' to 244' [SP]: SAND; variegated (mostly black), medium to coarse, metavolcanics.

AEROJET

TOTAL DEPTH BORING ft: 309.0	WELL ID: 3437-39 Page 2 of 2
TOTAL DEPTH WELL ft: 88, 191, 297	SITE:
SURFACE ELEVATION ft MSL: 139.0	EAST = 2214591.0 NORTH = 338680.0
TOC ELEVATION ft MSL: 141.54	DATE COMPLETED: 7/13/93 LOGGED BY: C. Clark
BOREHOLE DIAMETER: 10 5/8"	







DESCRIPTION

244' to 250' [ML/SM]: SILTSTONE/SANDSTONE; siltstone: yellow-brown, moderately to well indurated; sandstone: dark brown, moderately to well indurated, interbedded.

250' to 284' [SP]: SAND; variegated (mostly black), fine to coarse, some interbedded sandy clay, metavolcanics.

284' to 300'. [SP/GM]: SAND/GRAVEL; variegated (dark green, yellow, red, black), medium to coarse sand, gravel up to 2" diameter, subangular, metamorphic rock fragments.

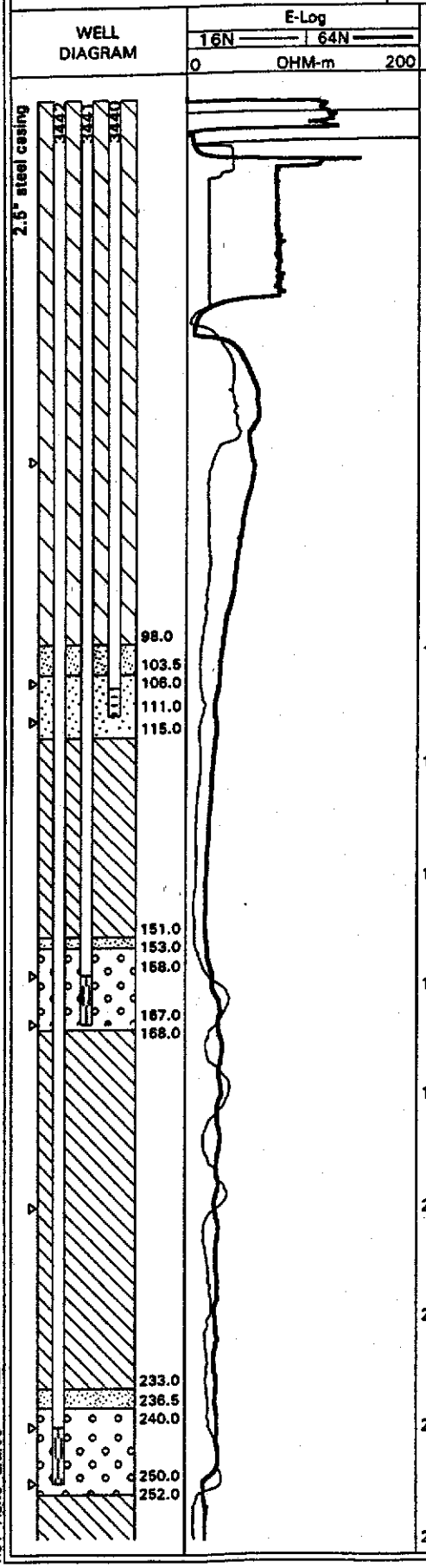
300' to 309' [SP]: SAND; variegated, fine, some gravels, similar to above, decreasing grain size with depth.

Total Depth of Borehole: 309 feet

ROT_AERO 2/2/95

AEROJET

TOTAL DEPTH BORING ft: 273.0	WELL ID: 3440-42 Page 1 of 2
TOTAL DEPTH WELL ft: 111, 167, 250	
SURFACE ELEVATION ft MSL: 166.0	SITE:
TOC ELEVATION ft MSL: 168.25	EAST = 2217043.0 NORTH = 338736.0
BOREHOLE DIAMETER: 10 5/8"	DATE COMPLETED: 7/15/93 LOGGED BY: Honea/Richards



DESCRIPTION

0 to 13' [GM]: SILTY GRAVEL; brown, poorly indurated, well rounded, mafic with some quartzite, gravel to 6" diameter, dry to moist.

13' to 20' [SM]: SILTY SAND; brown, very fine to fine, loose, some clay, wet.

20' to 64' [GM]: SILTY GRAVEL; brown, well rounded, wet.

Becomes coarser.

Interbedded with siltstone/claystone, light brown, moderately to well indurated.

64' to 68' [SP/SM]: SAND/SILTY SAND; brown, subangular to subrounded, quartzose with some feldspar and chert, trace coarse sand and fine gravel, moist.

68' to 106' [ML]: SILTSTONE; light brown, well indurated, some fine sand, interbedded with light brown soft clay.

Occasional trace of fine sand, poorly to moderately indurated.

106' to 112' [SM]: SILTY SANDSTONE; light brown to brown, moderately indurated, sandstone fragments common.

112' to 146' [ML]: SILTSTONE; light brown to brown, moderately to well indurated, rare clay/claystone interbeds.

Soft zone.

146' to 153' [SM]: SILTY SAND; light blue-gray, soft to moderately indurated, fine, rare, clay.

153' to 159' [ML]: SILTSTONE; light blue-gray, soft to moderately indurated, trace of very fine sand.

159' to 168' [SW]: SAND; dark gray to black, fine to coarse, subangular to angular, mafic.

168' to 176' [ML]: SILTSTONE; brown, well indurated, interbedded with some light brown claystone.

176' to 186' [SP]: SAND; green to dark green-brown (some red grains), medium to coarse, angular to subangular.

186' to 194' [ML]: SILTSTONE; gray to dark green, moderately to well indurated.

194' to 204' [ML]: SANDY SILTSTONE; olive-gray (dark gray to forest green sand), well indurated, very fine, angular to subangular.

204' to 235' [ML]: SILTSTONE; gray, moderately to well indurated, with minor sand interbeds.

Grades: brown to light brown.

Grades to minor clay interbeds.

235' to 242' [ML/SM]: SILTSTONE/SANDSTONE; gray to blue-gray, moderately to well indurated, very fine sand.

242' to 253' [SP]: SAND; dark gray to forest green, fine to coarse, subangular, mafic, with siltstone interbeds.

253' to 267' [CL]: SILTY CLAY; blue-gray, soft to poorly indurated, trace of very fine sand.

ROT AERO 2/2/95

AEROJET

TOTAL DEPTH BORING ft: 273.0	WELL ID: 3440-42
TOTAL DEPTH WELL ft: 111, 167, 250	SITE:
SURFACE ELEVATION ft MSL: 166.0	EAST = 2217043.0 NORTH = 338736.0
TOC ELEVATION ft MSL: 168.25	DATE COMPLETED: 7/15/93 LOGGED BY: Honea/R
BOREHOLE DIAMETER: 10 5/8"	

WELL DIAGRAM

2.5" steel casing

273.0

E-Log
16N — 64N
0 OHM-m 200

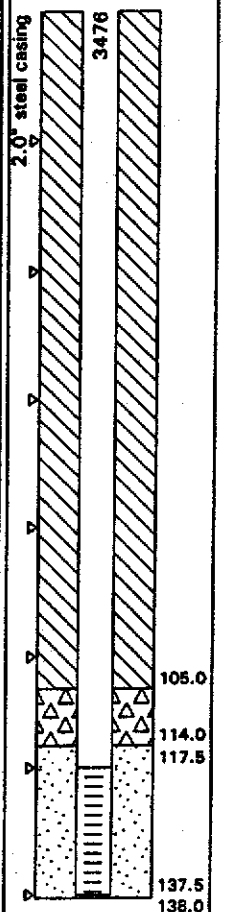
DEPTH (FT)	GRAPHIC LOG	DESCRIPTION
260		
		267' to 273' [SC]: CLAYEY SAND; light brown to gray, fine to medium, subangular.
		Total Depth of Borehole: 273 feet
280		
300		
320		
340		
360		
380		
400		
420		
440		
460		
480		
500		
520		

ROT AERO 2/2/95

AEROJET

TOTAL DEPTH BORING ft: 138.0	WELL ID: 3476 Page 1 of 1
TOTAL DEPTH WELL ft: 137.5	SITE: Southwest of Line 03, L3-5
SURFACE ELEVATION ft MSL: 186.0	EAST= 2221654.0 NORTH= 340006.0
TOC ELEVATION ft MSL: 188.20	
BOREHOLE DIAMETER: 6 7/8"	DATE COMPLETED: 5/16/94 LOGGED BY: M. Silva

WELL DIAGRAM



E-Log
16N — 64N
0 OHM-m

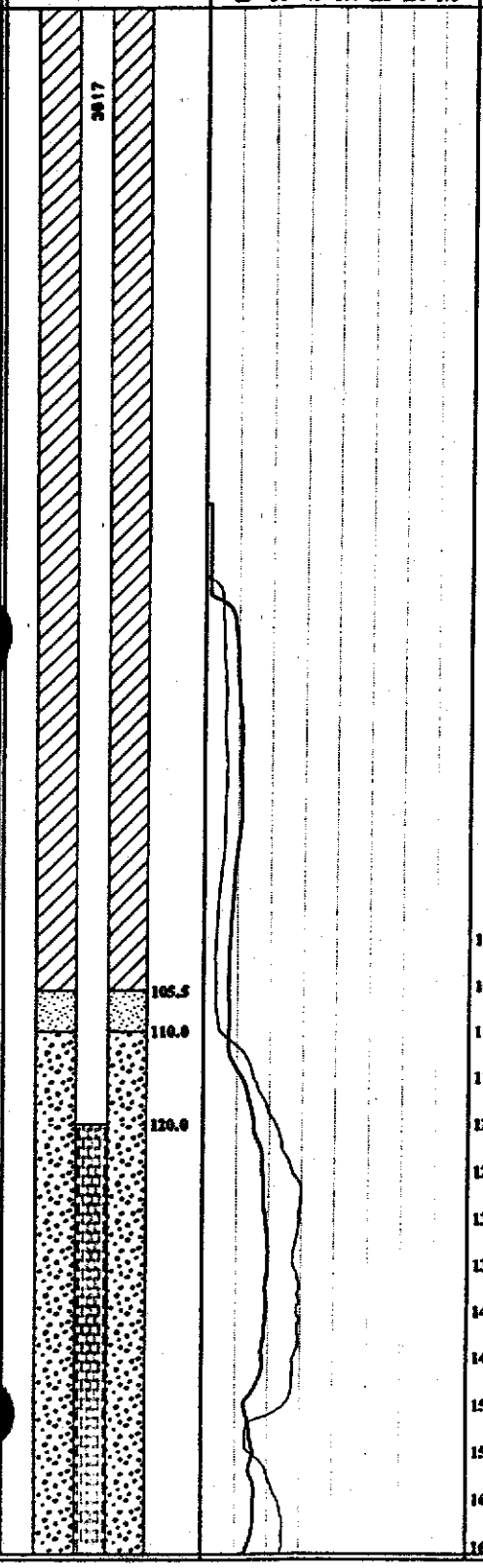
DEPTH (FT)	GRAPHIC LOG	DESCRIPTION
0		0 to 29' [GW]: SILTY SANDY GRAVEL; brown (7.5YR, 5/2), fine sand to boulders, subrounded, loose, mafic and felsic in composition, dry.
20		
40		29' to 32' [SM]: SILTY SAND; strong brown (7.5YR, 5/8), well sorted, fine, loose, dry. 32' to 40' [GM]: SILTY GRAVEL; strong brown (7.5YR 5/8), fine sand to cobbles, subrounded, predominantly mafic, dry. 40' to 48' [GW]: SANDY GRAVEL; light reddish-brown (5YR, 6/3), poorly sorted, subangular, mafic and felsic composition, with abundant quartz, dry. 48' to 53' [SM]: SILTY SAND; dark reddish-brown (5YR, 5/4), moderately sorted, fine to medium, dry, with occasional gravel. 53' to 60' [GM]: SILTY GRAVEL; weak red (10YR, 5/4), poorly sorted, mafic and felsic composition, very minor clay, dry.
60		60' to 64' [SM]: CLAYEY SILTY SAND; reddish-brown (5YR, 5/4), moderately sorted, fine to coarse, loose, dry. 64' to 79' [ML]: CLAYEY SILT; yellowish-red (5YR, 4/6), no plasticity, micaceous, dry.
80		79' to 92' [GW]: SANDY GRAVEL; reddish-brown (5YR, 3/4), poorly sorted, subrounded, dry. 86' Becomes damp.
100		92' to 105' [SP]: SAND; reddish-brown (5YR, 5/4), well sorted, fine to medium, micaceous, less than 5% silt, damp. 105' to 107' Grades to fine to coarse, with occasional gravel. 107' to 113' [SC]: CLAYEY SAND; dark reddish-gray (5YR, 4/2), fine to coarse, subrounded, micaceous, damp.
120		113' to 116' [CL]: SILTY CLAY; light brown (7.5YR, 6/3), no plasticity, very stiff, approximately 20% silt, dry. 116' to 126' [SM]: SILTY SAND; light brown (7.5YR, 6/3), fine to coarse, subrounded, dry. 122' Approximately 10% clay noted in cuttings, becomes moist to wet.
140		126' to 137.5' [SW]: GRAVELLY SAND; variegated, moderately to well indurated, fine to coarse, subrounded, felsic and mafic in composition, 10% fine gravel, wet. 137.5' to 138' [GW]: GRAVEL; variegated, fine to coarse, subrounded, mixed mafic and felsic composition, wet.
160		Total Depth of Borehole: 138 feet
180		
200		
220		
240		
260		

ROT AERO 2/2/95

GenCorp Aerojet

SITE: Area "E".	**BORING ID: 95ECH-1**
NORTH: 345425.075 EAST: 2215005.944	**WELL ID: 3517**
SURFACE ELEVATION (ft, MSL): 129.80	
TOC ELEVATION (ft, MSL): 132.37	
BOREHOLE DIAMETER (in): 8-5/8	TOTAL DEPTH BORING (ft): 318.0
DATE COMPLETED: 9/6/95	TOTAL DEPTH WELL (ft): 238.0
LOGGED BY: R. Wheeler	PAGE 1 of 3 ; 0.0 to 166.8 ft

WELL DIAGRAM



DEPTH (ft)	GRAPHIC LOG	DESCRIPTION
0		0 to 13 feet: GRAVEL (GW): fine grained, angular to subangular
5		
10		at 8 feet: sand present
15		13 to 20 feet: SAND/GRAVEL (GW-SM): red-brown, fine sand, subrounded, angular gravel
20		20 to 30 feet: Silty SAND (SM): red-brown fine grained, with fine angular gravel
25		at 25 feet: grades moist
30		30 to 32 feet: GRAVEL (GM): subrounded, angular, fine to coarse grained, with red-brown silty sand
35		32 to 34 feet: Silty SAND (SM): red-brown, fine grained, with subangular gravel
40		34 to 40 feet: GRAVEL (GM): varigated, fine angular with some coarse subangular at 38 feet: fine subangular gravel with fine multicolored sand
45		40 to 50 feet: Silty SAND (SM): red-brown, loose, fine grained, with trace fine gravel at 45 feet: grades wet
50		50 to 54 feet: SAND/Silty SAND (SM-SP): red-brown, wet, subangular, fine to coarse sand with mica
55		54 to 100 feet: SAND/GRAVEL (SM-GM): red-brown, wet
60		
65		
70		
75		
80		
85		
90		
95		
100		100 to 109 feet: SILT (ML): gray-brown, moist
105		at 104 feet: with trace to little clay at 106 feet: calcite layer
110		at 107 feet: gray-blue, moderately indurated
115		109 to 152 feet: SAND (SP): varigated, fine to medium grained, moderately indurated at 112 feet: trace coarse sand at 115 feet: trace coarse sand
120		at 119 feet: varigated, well indurated, fine to medium with trace coarse grained
125		at 125 feet: trace coarse sand at 127 feet: grades to fine sand
130		at 131 feet: grades to medium to coarse grained at 132 feet: dark brown, loose, fine to medium grained
135		at 135 feet: grades coarse at 136 feet: dark brown, wet, fine grained
140		at 142 feet: dark brown, wet, fine to coarse grained, with trace fine gravel
145		at 148 feet: with fine to coarse gravel
150		at 149 feet: sandstone: varigated, well indurated, fine grained
155		152 to 156 feet: Siltstone: light brown, wet, moderately to well indurated, little clay
160		156 to 162 feet: Sandstone: dark brown, moderately indurated, fine to medium sand, grades to fine
165		162 to 170 feet: Silty SAND (SM): dark brown, wet, minimal induration, fine grained

GCAJ-2

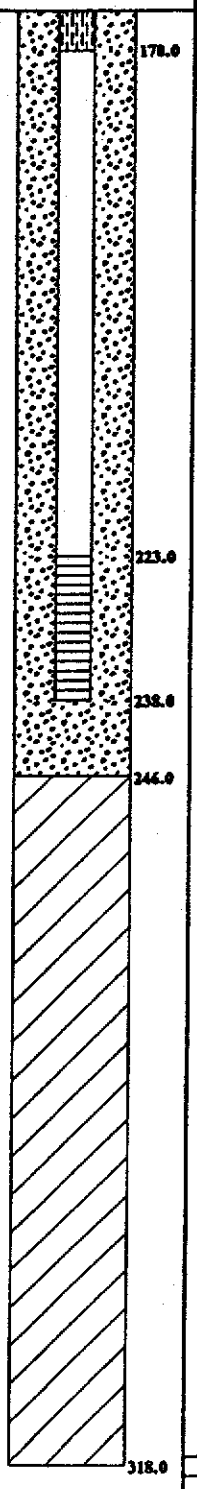
GENCORP AEROJET

SITE: Area "E".
NORTH: 345425.075 EAST: 2215005.944
SURFACE ELEVATION (ft, MSL): 129.90
TOC ELEVATION (ft, MSL): 132.37
BOREHOLE DIAMETER (in): 8-5/8
DATE COMPLETED: 9/8/95
LOGGED BY: R. Wheeler

BORING ID: 95ECH-1
WELL ID: 3517

TOTAL DEPTH BORING (ft): 318.0
TOTAL DEPTH WELL (ft): 238.0
PAGE 2 of 3 ; 165.8 to 318.0 ft

WELL DIAGRAM



E-Log (OHM/m)
16N — 64N —
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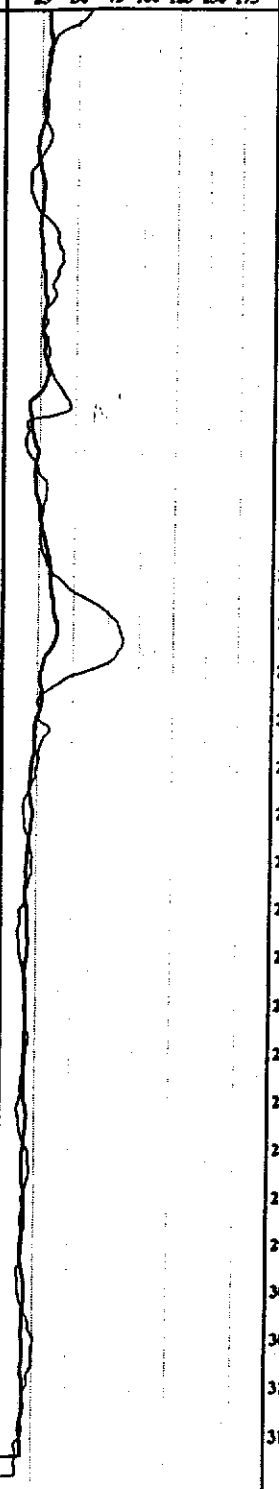


DEPTH (ft)	DESCRIPTION
170	170 to 171 feet: Siltstone: light brown, moist, well indurated, grades to sandy silt
175	171 to 172 feet: Sandy SILT (ML): dark brown, wet, fine grained
	172 to 173 feet: Siltstone: light brown, moist, well indurated, grades to sandy silt
180	173 to 174 feet: Sandy SILT (ML)
	174 to 176 feet: Sandstone: dark brown, wet, fine to moderately indurated
185	176 to 179 feet: SILT (ML): yellow-brown, moist to wet, minimal induration, trace to little clay
190	179 to 184 feet: Silty SAND (SM): dark brown, wet, fine grained, moderately indurated
195	184 to 188 feet: SAND/GRAVEL (SP-GM): mix, light yellow-brown, wet, fine sand, fine to coarse gravel, well indurated
200	188 to 190-1/2 feet: Sandstone: dark brown, wet, fine to coarse sand, moderately to well indurated
205	190-1/2 to 192-1/2 feet: Sandy SILT (ML): gray-brown, dry, fine grained, with trace clay
210	192-1/2 to 196 feet: Sandstone: dark brown, well indurated, medium to coarse sand
215	196 to 198 feet: Clayey SILT (ML): yellow-brown, moist
	198 to 199-1/2 feet: Siltstone
220	199-1/2 to 201-1/2 feet: Sandstone: dark brown, wet, fine, minimal induration
225	201-1/2 to 208 feet: Silty SAND (SM): gray-brown, dry, fine grained, minimal indurated
	208 to 214 feet: Silty SAND (SM): brown, wet, fine grained, with trace to little clay, and trace coarse gravel
230	214 to 222 feet: Sandstone: dark brown to black, fine with trace medium grained, well indurated
235	222 to 223 feet: Siltstone: yellow-brown, moderately indurated
240	223 to 228-1/2 feet: SILT (ML): yellow-brown, moist to wet, little clay grading to less clay at 225 feet: some fine sand at 227 feet: trace to little clay
245	
250	228-1/2 to 230 feet: Silty SAND (SM): wet, fine grained
255	230 to 237 feet: SAND (SP): dark gray, wet, fine grained, trace silt at 232 feet: without silt at 236 feet: wet
260	237 to 239-1/2 feet: SILT (ML): gray-brown, moist, poorly indurated, trace to little clay
	239-1/2 to 241-1/2 feet: SAND/Silty SAND (SP-SM): light gray-brown, fine grained
265	241-1/2 to 252 feet: Sandy SILT (ML): light brown to tan, moist, with calcite, grades stiff
270	at 249 feet: SILT/Siltstone: light brown, stiff, grades with trace fine sand at 251 feet: Sandy Silt: light brown, stiff
275	252 to 253 feet: Silty SAND (SM): dark brown, wet, fine grained
	253 to 255 feet: SAND (SP): grades to medium to coarse grained
280	255 to 256 feet: SILT (ML): brown, dense, moist
285	256 to 257 feet: Silty SAND/SAND (SM-SP)
	257 to 260 feet: SILT (ML): light brown, dry, dense at 259 feet: grades to little clay
290	260 to 265 feet: Silty SAND/Sandy SILT (SM-ML): brown, moist, moderately indurated at 262 feet: grades to silty sand
295	265 to 270 feet: Silty SAND (SM): dark brown, moist, minimal cementation
300	270 to 272 feet: SILT (ML): light brown, moist, minimal to moderately cemented, grades to little to some calcite
305	272 to 276 feet: Silty SAND (SM): light brown, wet, fine grained
310	276 to 286 feet: SILT (ML): light brown, moist, moderately cemented at 284 feet: yellow-brown, trace clay
315	286 to 295 feet: SAND (SP): yellow-brown, wet, fine to coarse grained, subangular, trace silt, trace to little clay at 290 feet: grades fine at 291 feet: light brown, moist, fine, with trace silt, micaceous at 293-1/2 feet: Sandstone: dark brown, fine to coarse grained, with trace fine gravel
	295 to 296 feet: Clayey SAND (SC): light brown, moist, fine grained
	296 to 298 feet: SAND (SP): yellow-brown, wet, fine to coarse grained

GENCORP AEROJET

SITE: Area "E".
NORTH: 345425.075 EAST: 2215005.944
SURFACE ELEVATION (ft, MSL): 129.90
TOC ELEVATION (ft, MSL): 132.37
BOREHOLE DIAMETER (in): 8-5/8
DATE COMPLETED: 9/6/95
LOGGED BY: R. Wheeler

BORING ID: 95ECH-1
WELL ID: 3517

TOTAL DEPTH BORING (ft): 318.0
TOTAL DEPTH WELL (ft): 238.0
PAGE 3 of 3 ; 331.6 to ft

WELL DIAGRAM	E-Log (OHM/m) 16N / 64N 25 50 75 100 125 150 175	DEPTH (ft)	GRAPHIC LOG	DESCRIPTION
				298 to 300 feet: SILT (ML): light brown, moist, moderately cemented, with fine sand
				300 to 301 feet: Silty SAND (SM): brown, moist, moderately cemented, fine grained
				301 to 305 feet: Sandy SILT (ML): brown, moist, minimal cementation, with fine sand
				305 to 306-1/2 feet: SAND (SP): dark brown, wet, fine to medium grained, grades to loose
				306-1/2 to 308 feet: SILT (ML): light brown, dry, well cemented at 307-1/2 feet: grades to Sandy Silt, brown, dry, minimal cementation, fine grained
				308 to 309 feet: SAND (SP): dark brown, moist to wet, fine grained
				309 to 310 feet: SILT (ML): brown, moist, moderately cemented
				310 to 312 feet: Sandstone: dark brown, wet, well indurated, fine grained
				312 to 313-1/2 feet: Silty SAND (SM): dark brown grading to purple, moist, fine grained
				313-1/2 to 315 feet: SILT (ML): brown, dry, moderately cemented
				315 to 316 feet: Clayey SILT (ML): olive-brown, moist, moderate plasticity
				316 to 318 feet: SILT (ML): light brown to yellow, moist, with trace fine sand
				Boring completed at a depth of approximately 318 feet below existing site grade.

GCAJ-2

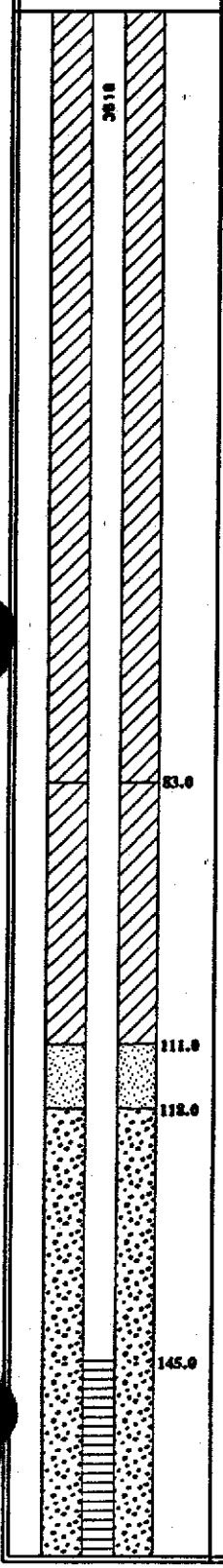
GENCORP AEROJET

SITE: Area "E".
NORTH: 344865.019 EAST: 2214942.526
SURFACE ELEVATION (ft, MSL): 131.50
TOC ELEVATION (ft, MSL): 134.05
BOREHOLE DIAMETER (in): 8-5/8
DATE COMPLETED: 9/7/95
LOGGED BY: C. Clark

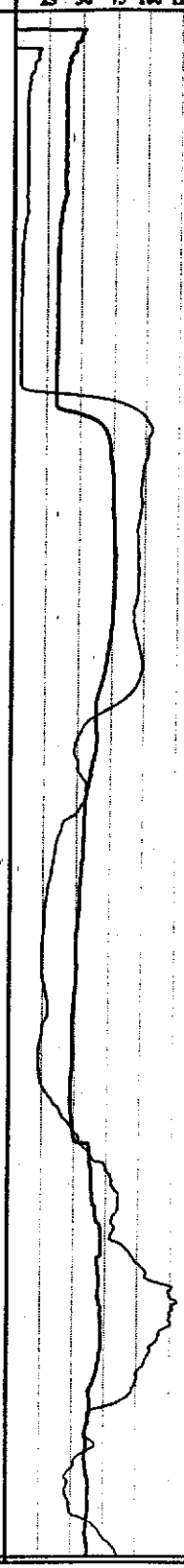
BORING ID: 95ECH-2
WELL ID: 3518

TOTAL DEPTH BORING (ft): 271.0
TOTAL DEPTH WELL (ft): 225.0
PAGE 1 of 2 ; 0.0 to 166.8 ft

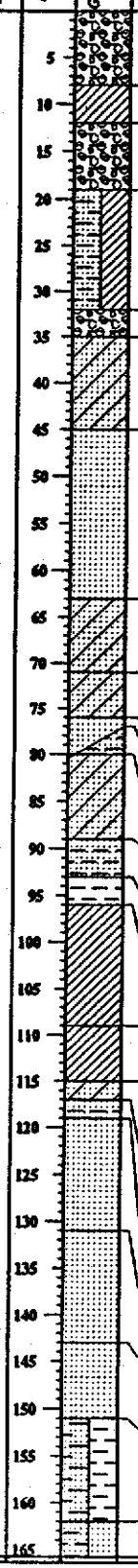
WELL DIAGRAM



E-Log (OHM/m)
16N | 64N
25 50 75 100 125 150 175



DEPTH (ft) | GRAPHIC LOG



DESCRIPTION

0 to 8 feet: Silty GRAVEL (GM): light brown, dry, loose, sub to well rounded, with sand and medium to dark gray mafics

8 to 12 feet: Silty CLAY (CL): Red-brown, medium stiff, trace fine sand

12 to 19 feet: Silty GRAVEL (GM): light brown, dry, loose, sub to well rounded, with sand and medium to dark gray mafics

19 to 32 feet: Silty SAND (SM-ML): interbedded, red-brown, fine to medium grained, with gravel and sandy silt

32 to 35 feet: Sandy GRAVEL (GM): light brown, dry, to about 1/2 inch in diameter, with silt

35 to 45 feet: Clayey SAND (SC): medium brown, loose, fine to trace medium grained, mica abundant

45 to 63 feet: SAND (SP): loose, fine to medium grained, abundant mica, trace to some silt and clay

63 to 71 feet: Clayey SAND (SC): varigated metasediments, loose, fine to medium grained, abundant mica

71 to 76 feet: Clayey SAND (SC): varigated metasediments gray, brown, yellow, dark green, and grey; fine to coarse grained; some weathered pebble gravel

76 to 77 feet: SAND (SP): gray, fine to coarse grained, quartz common

77 to 80 feet: Silty SAND (SM): red-brown, moderately cemented, fine grained, fine roots common

80 to 89 feet: Gravelly SAND (SC): predominantly mottled gray with varigated metasediments, with clay and 3/4 inch pebble gravel

89 to 93 feet: Silty SAND (SM): red-brown, loose to medium dense, fine grained, black roots common

93 to 96 feet: grades to SILT (ML): with trace fine sand, medium brown, medium stiff to very stiff, black nodules and roots common

96 to 109 feet: grades to CLAY (CL): with silt, medium brown, medium stiff to very stiff

at 104 feet: grades to Sandy CLAY, red-brown, stiff

109 to 115 feet: Sandy CLAY (CL): distinctive red-gray volcanic, fine to medium grained sand

115 to 117 feet: Clayey SAND (SC): varigated predominantly dark red, gray, and black; fine to medium grained volcanic sand; some fine to medium grained moderately to well cemented lenses of medium gray sandstone

117 to 119 feet: grades to Silty SAND (SM): mottled red-gray with varigated dark mafics and volcanics, mostly fine to medium grained with some coarse grained, with pebble gravel

119 to 131 feet: SAND (SP): Dark gray, black, and red mafics/volcanics, with some brown metasediments; well cemented; fine to coarse grained; with some pebble gravel and trace silty clay

131 to 143 feet: Gravelly SAND (SP): varigated, weakly to strongly cemented, fine to coarse grained sand, gravel to 2 inches in diameter, sand/gravel subrounded to subangular, with trace gray clayey silt

143 to 151 feet: SAND (SP): mostly dark volcanics, loose to medium dense, not cemented, fine to medium grained with trace coarse grained, with trace gravel, silt and clay

151 to 162 feet: Interbedded Siltstone/Silty SAND (ML-SM): siltstone; medium brown, weakly to moderately indurated; silty sand; mostly black mafics/volcanics in olive-brown to olive-gray silt matrix, fine to trace coarse grained

162 to 190 feet: interbedded Silty SAND/SAND (SM-SP): silty sand; mostly black

GCAJ-2

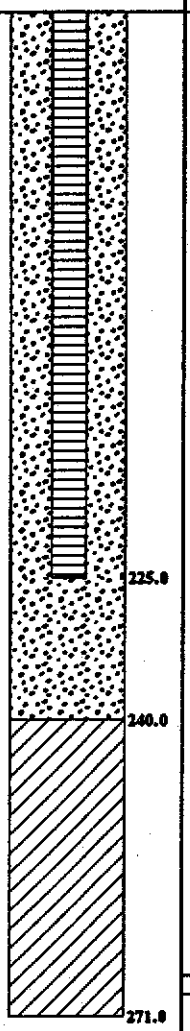
GENCORP AEROJET

SITE: Area "E".
NORTH: 344865.019 EAST: 2214942.526
SURFACE ELEVATION (ft, MSL): 131.50
TOC ELEVATION (ft, MSL): 134.05
BOREHOLE DIAMETER (in): 8-5/8
DATE COMPLETED: 9/7/95
LOGGED BY: C. Clark

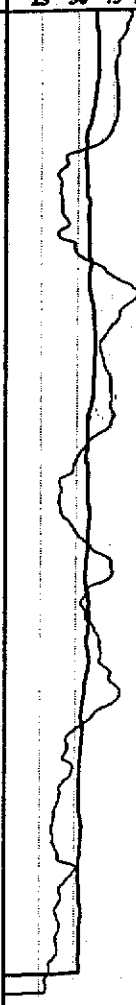
BORING ID: 95ECH-2
WELL ID: 3518

TOTAL DEPTH BORING (ft): 271.0
TOTAL DEPTH WELL (ft): 225.0
PAGE 2 of 2 ; 165.8 to 271.0 ft

WELL DIAGRAM



E-Log (OHM/m)
16N | 64N
25 50 75 100 125 150 175

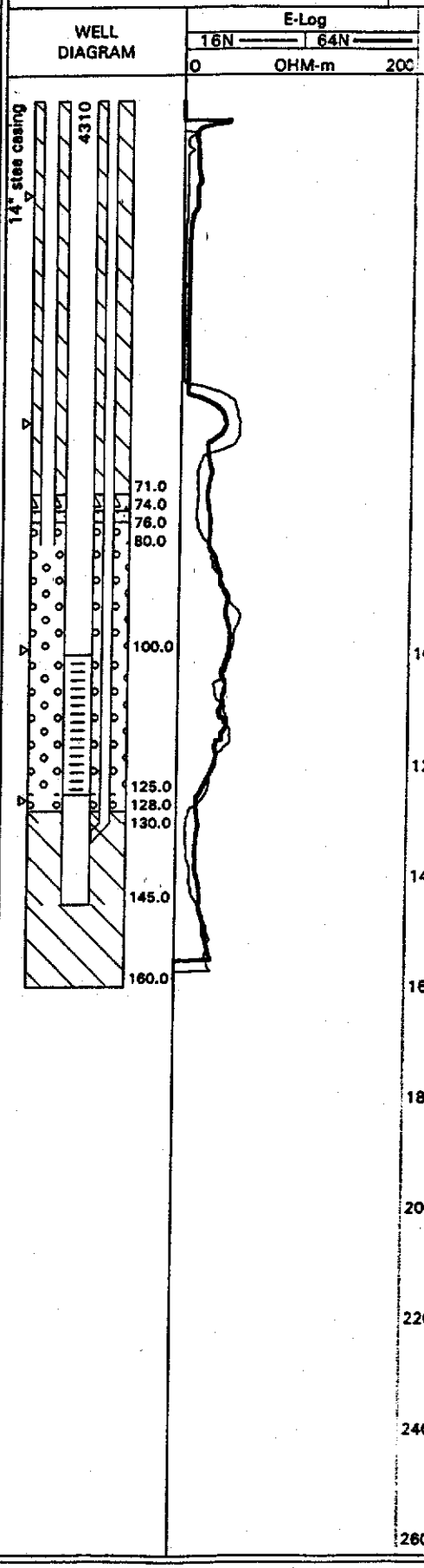


DEPTH (ft)	DESCRIPTION
170	mafics in gray-brown silt matrix, fine to medium grained, some moderately to well cemented sandstone lenses: sand; mostly dark brown to black, loose
175	
180	
185	182 to 190 feet: Silty SAND (SM): mottled medium gray, yellow-olive, olive, and medium brown; fine to coarse sand; with clay and subangular gravel fragments; very poorly sorted; appears to be volcanic mud/debris flow
190	190 to 195 feet: Sandstone (SM): red-brown (rust), moderately to well cemented, fine to medium grained, with silt
195	distinct layer of ash like, white, soft, angular fragments
200	195 to 208 feet: SAND (SP): dark gray mafic, dense to very dense, mostly not cemented with some weakly to moderately cemented, fine to trace medium grained, with trace silt
205	at 200 feet: grades to include lenses of either calcite or ash (white, semi-hard)
210	208 to 214 feet: Silty SAND (SM): yellow-brown, fine grained
215	214 to 216 feet: Silty SAND (SM-CL): olive-brown, fine to medium grained, with sub to well rounded gravel fragments, silty matrix mottled yellow, olive, and gray; with thin interbeds of clay
220	216 to 219 feet: Silty Sandstone/Sandstone (SM): Sandstone; dark red, moderately to well cemented, fine to medium grained; Siltstone; weak to moderately indurated, with yellowish ash/calcite lenses
225	219 to 225 feet: Silty SAND/Silty Sandstone (SM): mottled red-brown to olive-brown grading to medium gray, loose, moderately cemented, fine to medium grained
230	225 to 231 feet: Clayey SILT (ML): interbedded red, gray, and olive-gray; with dark gray fine sand
235	231 to 240 feet: Silty SAND/Siltstone (SM-ML): silty sand; olive-gray to dark gray, dense, not cemented to weakly cemented; thin interbeds of olive-gray, weakly to moderately indurated siltstone
240	240 to 255 feet: interbedded Clayey Siltstone/SAND (ML): siltstone medium brown, weak to moderately indurated, grades to olive-brown silt with trace clay; sand dark gray, dense, not cemented, very fine (flour like)
245	grained
250	255 to 270 feet: Silty SAND (SM-ML): dark gray, dense, noncemented to trace moderately cemented, very fine grained (flour like); interbedded with olive-gray mottled yellowish, fine sand with clay
255	
260	
265	
270	Well completed at a depth of approximately 271 feet below existing site grade.

GCAJ-2

AEROJET

TOTAL DEPTH BORING ft: 160.0	WELL ID: 4310
TOTAL DEPTH WELL ft: 145	Page 1 of 1
SURFACE ELEVATION ft MSL: 178.4	SITE: Chemical Plant 2, F05
TOC ELEVATION ft MSL: 180.99	EAST = 2218333.0 NORTH = 339880.0
BOREHOLE DIAMETER: 28"	DATE COMPLETED: 12/14/93 LOGGED BY: C. Clark



DESCRIPTION

0 to 13' [GM/SM]: GRAVEL/SILTY SAND; medium yellow-brown, cobbles up to 14" diameter, subrounded to well rounded, moist.

13' to 18' [GC]: CLAYEY GRAVEL; red-brown, grades to predominantly cobble gravel in clay matrix with thin interbeds of fine to medium quartz sand.

18' to 29' [SM/CL]: SILTY SAND/CLAY; silty sand: yellow-brown, fine to medium; clay: brick red, interbedded, increasing clay with depth, moist.

29' to 35' [CL]: CLAY; brick red, soft to medium stiff, thin interbeds of yellow-brown, fine sand.

36' to 63' [GC/SC]: GRAVEL/SAND/CLAY; gravel: fine to 12" diameter, subrounded to well rounded; sand: fine to coarse, subrounded to well rounded; clay: mottled to layered red, yellow, brown, and light gray, interbedded.

63' to 78' [CL]: SANDY CLAY; light red-brown to tan, very fine, soft.

78' to 87' [SC]: CLAYEY SAND; medium brown, fine, increasing sand content and grain size with depth.

86' Maroon clay fragments.

87' to 93' [SM]: SAND; medium brown, fine to medium, subangular to subrounded, common, mica.

93' to 102' [GW]: SANDY GRAVEL; medium brown, medium sand to fine cobbles up to 3" diameter, subrounded to well rounded, metamorphics, common mica.

102' to 118' [GC]: SANDY CLAYEY GRAVEL; medium sand to fine gravel, metavolcanics; variegated clay (dark green red-brown, black, yellow and white).
104' Clay bed.
111' Clay bed.

118' to 128' [SC]: CLAYEY SAND; variegated, metavolcanics, grading from coarse to fine with depth.

128' to 136' [CL]: CLAY; olive-gray to red-gray, sticky, stiff, trace fine sand.

136' to 144' [SM]: SANDSTONE/SILT/CLAY; sandstone: red-brown, poorly to moderately indurated; silt: light gray; sandy clay: fine sand.

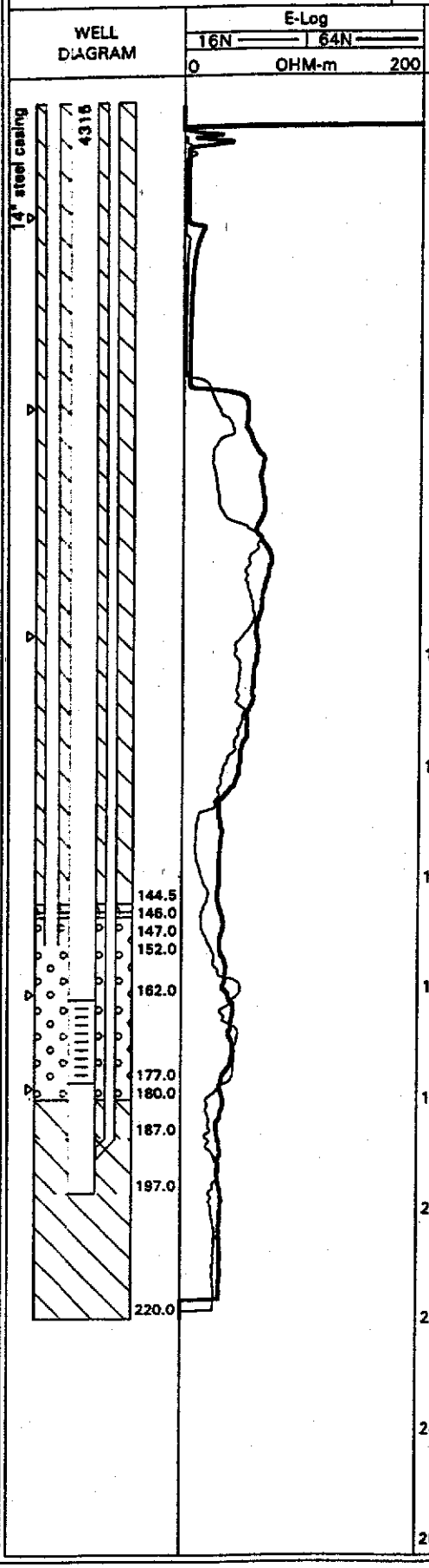
144' to 160' [SP]: SAND/SANDSTONE; black, poorly indurated, fine to coarse, metavolcanics.

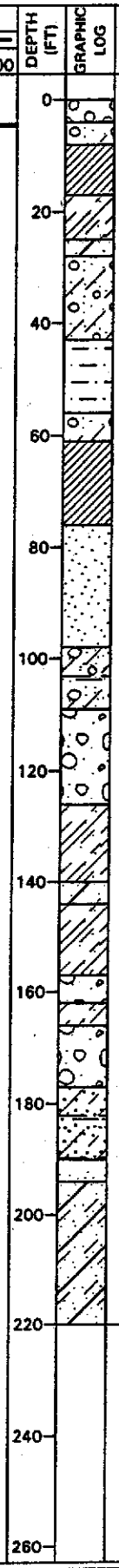
Total Depth of Borehole: 160 feet

ROT AERO 2/3/95

AEROJET

TOTAL DEPTH BORING ft: 220.0	WELL ID: 4315
TOTAL DEPTH WELL ft: 197	
SURFACE ELEVATION ft MSL: 174.4	SITE: Chemical Plant 2, F07
TOC ELEVATION ft MSL: 178.62	EAST = 2218072.0 NORTH = 339072.0
BOREHOLE DIAMETER: 28"	DATE COMPLETED: 2/1/94 LOGGED BY: C. Clark





DESCRIPTION

0 to 4' [GM]: SILTY SANDY GRAVEL; medium yellow-brown, well rounded, cobbles to 8" diameter, damp.

4' to 8' [GC]: CLAYEY SANDY GRAVEL; red-brown, cobbles to 6" diameter, well rounded, moist.

8' to 17' [CL]: CLAY; red-brown, trace of fine sand, gravel to cobbles up to 3" diameter, thin interbeds of fine yellow-brown sand.

17' to 25' [CL]: SANDY CLAY; red-brown, fine, soft, moist to wet.
22' Includes cobbles up to 3" diameter.

25' to 28' [SC]: CLAYEY SAND; fine sand, with cobbles up to 8" diameter.

28' to 43' [SC]: GRAVELLY CLAYEY SAND; mottled red-brown to yellow-brown, cobbles up to 12" diameter, well rounded, very moist, some cobbles decomposed to soft, sandy multi-colored masses.

43' to 56' [ML]: SILT; medium olive-brown, rust mottling, trace clay and fine sand, moist.

56' to 61' [SC]: GRAVELLY CLAYEY SAND; dark green with red-brown clay, medium sand, cobbles up to 6" diameter, well rounded.

61' to 76' [CL]: CLAY; red-gray, with silt and trace fine sand, stiff, grading to soft with depth.

76' to 98' [SP]: SAND; medium to dark brown, fine to coarse, with some fine to medium gravel, subangular to subrounded, trace silt, metasedimentary (mostly quartz).
80' to 92' No fine gravel, some silt and clay, mixture of variegated color grains, metamorphics.
92' to 94' Includes fine to medium gravel.
94' to 98' No gravel, decreasing overall grain size.

98' to 109' [SM]: SILTY SAND; gray-brown, medium, some clay.
104' to 109' Includes fine gravel.

109' to 126' [GP/SP]: GRAVEL/SAND; dark green and black, coarse gravel up to 3" diameter, subrounded to well rounded, grading to medium sand with depth, metasedimentary/metavolcanic origin.

126' to 140' [CL]: SANDY CLAY; light red-gray, fine sand, slightly sticky.

140' to 144' [SC]: CLAYEY SAND; brown to dark brown, some moderately indurated, fine to coarse.

144' to 157' [CL]: SANDY CLAY; light brown, fine sand.
152' to 157' Grades to dark brown, fine to coarse sand.

157' to 162' [GP]: SANDY GRAVEL; variegated black, red, brown, yellow, fine sand to medium gravel, metasedimentary/metavolcanic origin.

162' to 166' [SC]: SANDY CLAY; dark brown, fine sand.

166' to 177' [GP/SP]: SANDY GRAVEL/SANDSTONE; sandy gravel: variegated black, red, brown, yellow, fine sand to medium gravel; sandstone: dark brown to black, poorly to moderately indurated, fine to medium.

177' to 190' [ML/SM]: CLAY/SILTSTONE/SANDSTONE; clay: yellow-brown, soft; siltstone: brown, poorly to moderately indurated; sandstone: black, poorly indurated, fine to medium, interbedded.

190' to 194' [SM]: SILTY SANDSTONE; medium to dark brown, poorly to moderately indurated, fine to medium.

194' to 220' [SC]: CLAYEY SAND; dark brown to black, fine to medium, metavolcanics; interbedded with some poorly to moderately indurated sandstone.

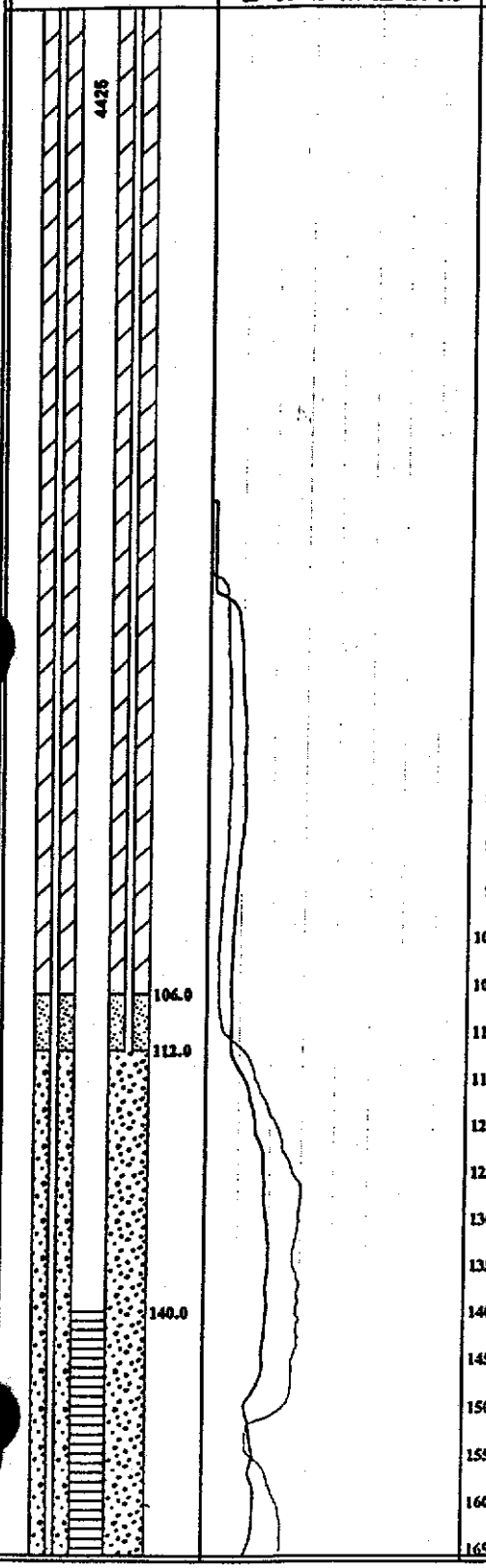
Total Depth of Borehole: 220 feet

GENCORP AEROJET

SITE: Area "E".	**BORING ID: 95EEW-1**
NORTH: 345428.346 EAST: 2215020.504	**WELL ID: 4425**
SURFACE ELEVATION (ft, MSL): 129.90	
TOC ELEVATION (ft, MSL): 131.00	
BOREHOLE DIAMETER (in): 26	TOTAL DEPTH BORING (ft): 318.0
DATE COMPLETED: 10/3/95	TOTAL DEPTH WELL (ft): 260.0
LOGGED BY: R. Wheeler	PAGE 1 of 3 ; 0.0 to 165.8 ft

WELL DIAGRAM

E-Log (OHM/m)
16N —— | 64N ——
25 50 75 100 125 150 175



DEPTH (ft)	DESCRIPTION
0	0 to 13 feet: GRAVEL (GW): fine grained, angular to subangular
10	at 8 feet: sand present
15	13 to 20 feet: SAND/GRAVEL (GW-SM): red-brown, fine sand, subrounded, angular gravel
20	20 to 30 feet: Silty SAND (SM): red-brown fine grained, with fine angular gravel
25	at 25 feet: grades moist
30	30 to 32 feet: GRAVEL (GM): subrounded, angular, fine to coarse grained, with red-brown silty sand
35	32 to 34 feet: Silty SAND (SM): red-brown, fine grained, with subangular gravel
40	34 to 40 feet: GRAVEL (GM): variated, fine angular with some coarse subangular at 38 feet: fine subangular gravel with fine multicolored sand
45	40 to 50 feet: Silty SAND (SM): red-brown, loose, fine grained, with trace fine gravel at 45 feet: grades wet
50	50 to 54 feet: SAND/Silty SAND (SM-SP): red-brown, wet, subangular, fine to coarse sand with mica
55	54 to 100 feet: SAND/GRAVEL (SM-GM): red-brown, wet
60	
65	
70	
75	
80	
85	
90	
95	
100	100 to 109 feet: SILT (ML): gray-brown, moist
105	at 104 feet: with trace to little clay at 106 feet: calcite layer
110	at 107 feet: gray-blue, moderately indurated
115	109 to 152 feet: SAND (SP): variated, fine to medium grained, moderately indurated at 112 feet: trace coarse sand at 115 feet: trace coarse sand
120	at 119 feet: variated, well indurated, fine to medium with trace coarse grained
125	at 125 feet: trace coarse sand at 127 feet: grades to fine sand
130	at 131 feet: grades to medium to coarse grained at 132 feet: dark brown, loose, fine to medium grained
135	at 135 feet: grades coarse at 136 feet: dark brown, wet, fine grained
140	at 142 feet: dark brown, wet, fine to coarse grained, with trace fine gravel
145	at 148 feet: with fine to coarse gravel
150	at 149 feet: sandstone: variated, well indurated, fine grained
155	152 to 156 feet: Siltstone: light brown, wet, moderately to well indurated, little clay
160	156 to 162 feet: Sandstone: dark brown, moderately indurated, fine to medium sand, grades to fine
165	162 to 170 feet: Silty SAND (SM): dark brown, wet, minimal induration, fine grained

GenCorp Aerojet

SITE: Area "E"
NORTH: 345428.346 EAST: 2215020.504
SURFACE ELEVATION (ft, MSL): 129.90
TOC ELEVATION (ft, MSL): 131.00
BOREHOLE DIAMETER (in): 26
DATE COMPLETED: 10/3/95
LOGGED BY: R. Wheeler

BORING ID: 95EEW-1
WELL ID: 4425

TOTAL DEPTH BORING (ft): 318.0
TOTAL DEPTH WELL (ft): 260.0
PAGE 2 of 3 ; 165.8 to 318.0 ft

WELL DIAGRAM

E-Log (OHM/m)
16N | 64N
25 50 75 100 125 150 175

240.0
243.5
245.5
249.0
260.0
265.0

DEPTH (ft) | GRAPHIC LOG

DEPTH (ft)	DESCRIPTION
170	170 to 171 feet: Siltstone: light brown, moist, well indurated, grades to sandy silt
175	171 to 172 feet: Sandy SILT (ML): dark brown, wet, fine grained
	172 to 173 feet: Siltstone: light brown, moist, well indurated, grades to sandy silt
180	173 to 174 feet: Sandy SILT (ML)
	174 to 176 feet: Sandstone: dark brown, wet, fine to moderately indurated
185	176 to 179 feet: SILT (ML): yellow-brown, moist to wet, minimal induration, trace to little clay
190	179 to 184 feet: Silty SAND (SM): dark brown, wet, fine grained, moderately indurated
195	184 to 188 feet: SAND/GRAVEL (SP-GM): mix, light yellow-brown, wet, fine sand, fine to coarse gravel, well indurated
200	188 to 190-1/2 feet: Sandstone: dark brown, wet, fine to coarse sand, moderately to well indurated
205	190-1/2 to 192-1/2 feet: Sandy SILT (ML): gray-brown, dry, fine grained, with trace clay
210	192-1/2 to 196 feet: Sandstone: dark brown, well indurated, medium to coarse sand
	196 to 198 feet: Clayey SILT (ML): yellow-brown, moist
215	198 to 199-1/2 feet: Siltstone
220	199-1/2 to 201-1/2 feet: Sandstone: dark brown, wet, fine, minimal induration
	201-1/2 to 208 feet: Silty SAND (SM): gray-brown, dry, fine grained, minimal indurated
225	208 to 214 feet: Silty SAND (SM): brown, wet, fine grained, with trace to little clay, and trace coarse gravel
230	214 to 222 feet: Sandstone: dark brown to black, fine with trace medium grained, well indurated
235	222 to 223 feet: Siltstone: yellow-brown, moderately indurated
240	223 to 228-1/2 feet: SILT (ML): yellow-brown, moist to wet, little clay grading to less clay at 225 feet: some fine sand at 227 feet: trace to little clay
245	228-1/2 to 230 feet: Silty SAND (SM): wet, fine grained
250	230 to 237 feet: SAND (SP): dark gray, wet, fine grained, trace silt at 232 feet: without silt at 236 feet: wet
255	237 to 239-1/2 feet: SILT (ML): gray-brown, moist, poorly indurated, trace to little clay
260	239-1/2 to 241-1/2 feet: SAND/Silty SAND (SP-SM): light gray-brown, fine grained
265	241-1/2 to 252 feet: Sandy SILT (ML): light brown to tan, moist, with calcite, grades stiff at 249 feet: SILT/Siltstone: light brown, stiff, grades with trace fine sand at 251 feet: Sandy Silt: light brown, stiff
270	252 to 253 feet: Silty SAND (SM): dark brown, wet, fine grained
275	253 to 255 feet: SAND (SP): grades to medium to coarse grained
280	255 to 256 feet: SILT (ML): brown, dense, moist
285	256 to 257 feet: Silty SAND/SAND (SM-SP)
290	257 to 260 feet: SILT (ML): light brown, dry, dense at 259 feet: grades to little clay
295	260 to 265 feet: Silty SAND/Sandy SILT (SM-ML): brown, moist, moderately indurated at 262 feet: grades to silty sand
300	265 to 270 feet: Silty SAND (SM): dark brown, moist, minimal cementation
	270 to 272 feet: SILT (ML): light brown, moist, minimal to moderately cemented, grades to little to some calcite
305	272 to 276 feet: Silty SAND (SM): light brown, wet, fine grained
310	276 to 286 feet: SILT (ML): light brown, moist, moderately cemented at 284 feet: yellow-brown, trace clay
315	286 to 295 feet: SAND (SP): yellow-brown, wet, fine to coarse grained, subangular, trace silt, trace to little clay at 290 feet: grades fine at 291 feet: light brown, moist, fine, with trace silt, micaceous at 293-1/2 feet: Sandstone: dark brown, fine to coarse grained, with trace fine gravel
	295 to 296 feet: Clayey SAND (SC): light brown, moist, fine grained
	296 to 298 feet: SAND (SP): yellow-brown, wet, fine to coarse grained

GCAJ-2

GenCorp Aerojet

SITE: Area "E".
NORTH: 345428.346 EAST: 2215020.504
SURFACE ELEVATION (ft, MSL): 129.90
TOC ELEVATION (ft, MSL): 131.00
BOREHOLE DIAMETER (in): 26
DATE COMPLETED: 10/3/95
LOGGED BY: R. Wheeler

BORING ID: 95EEW-1
WELL ID: 4425

TOTAL DEPTH BORING (ft): 318.0
TOTAL DEPTH WELL (ft): 260.0
PAGE 3 of 3 ; 331.6 to ft

WELL DIAGRAM	E-Log (OHM/m) 16N / 64N 25 50 75 100 125 150 175	DEPTH (ft)	GRAPHIC LOG	DESCRIPTION
				298 to 300 feet: SILT (ML): light brown, moist, moderately cemented, with fine sand
				300 to 301 feet: Silty SAND (SM): brown, moist, moderately cemented, fine grained
				301 to 305 feet: Sandy SILT (ML): brown, moist, minimal cementation, with fine sand
				305 to 306-1/2 feet: SAND (SP): dark brown, wet, fine to medium grained, grades to loose
				306-1/2 to 308 feet: SILT (ML): light brown, dry, well cemented at 307-1/2 feet: grades to Sandy Silt, brown, dry, minimal cementation, fine grained
				308 to 309 feet: SAND (SP): dark brown, moist to wet, fine grained
				309 to 310 feet: SILT (ML): brown, moist, moderately cemented
				310 to 312 feet: Sandstone: dark brown, wet, well indurated, fine grained
				312 to 313-1/2 feet: Silty SAND (SM): dark brown grading to purple, moist, fine grained
				313-1/2 to 315 feet: SILT (ML): brown, dry, moderately cemented
				315 to 316 feet: Clayey SILT (ML): olive-brown, moist, moderate plasticity
				316 to 318 feet: SILT (ML): light brown to yellow, moist, with trace fine sand
				Boring completed at a depth of approximately 318 feet below existing site grade.

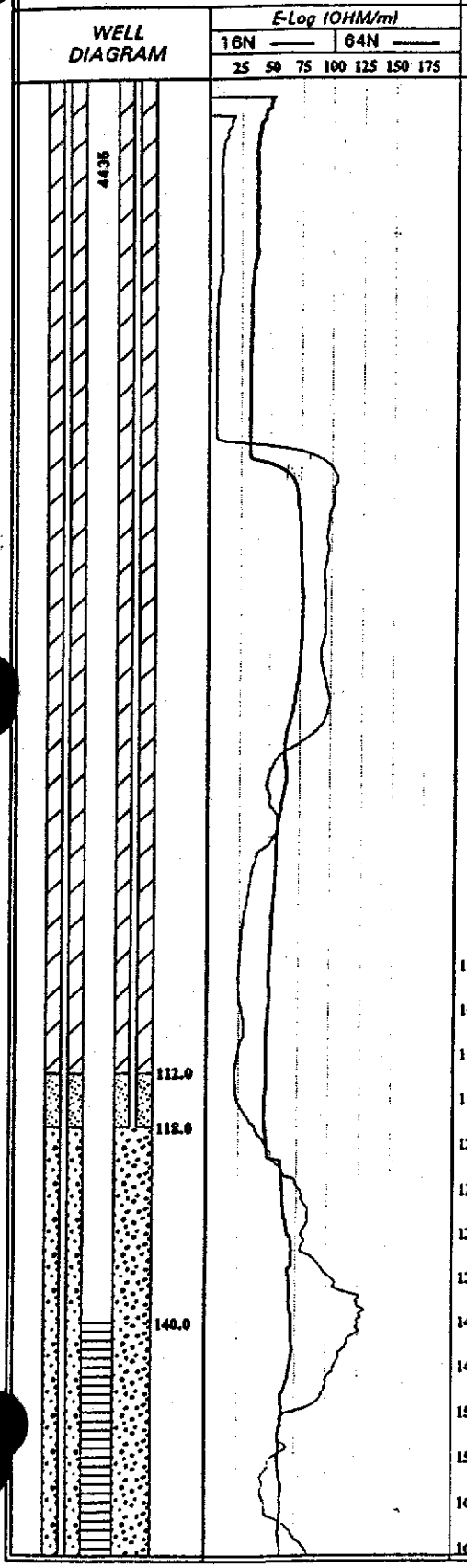
GCAJ-2

GenCorp Aerojet

SITE: Area "E"
NORTH: 344873.177 EAST: 2214947.979
SURFACE ELEVATION (ft, MSL): 131.50
TOC ELEVATION (ft, MSL): 132.38
BOREHOLE DIAMETER (in): 26
DATE COMPLETED: 10/13/95
LOGGED BY: C. Clark

BORING ID: 95EEW-2
WELL ID: 4435

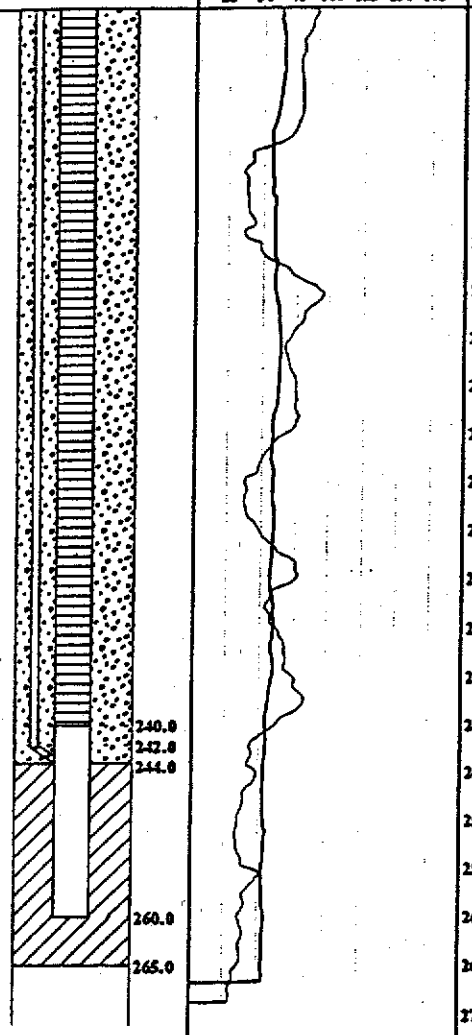
TOTAL DEPTH BORING (ft): 271.0
TOTAL DEPTH WELL (ft): 260.0
PAGE 1 of 2 ; 0.0 to 165.8 ft



DEPTH (ft)	DESCRIPTION
0	0 to 8 feet: Silty GRAVEL (GM): light brown, dry, loose, sub to well rounded, with sand and medium to dark gray mafics
10	8 to 12 feet: Silty CLAY (CL): Red-brown, medium stiff, trace fine sand
15	12 to 19 feet: Silty GRAVEL (GM): light brown, dry, loose, sub to well rounded, with sand and medium to dark gray mafics
20	19 to 32 feet: Silty SAND (SM-ML): interbedded, red-brown, fine to medium grained, with gravel and sandy silt
30	
35	32 to 35 feet: Sandy GRAVEL (GM): light brown, dry, to about 1/2 inch in diameter, with silt
40	35 to 45 feet: Clayey SAND (SC): medium brown, loose, fine to trace medium grained, mica abundant
45	45 to 63 feet: SAND (SP): loose, fine to medium grained, abundant mica, trace to some silt and clay
50	
55	
60	
65	63 to 71 feet: Clayey SAND (SC): varigated metasediments, loose, fine to medium grained, abundant mica
70	71 to 76 feet: Clayey SAND (SC): varigated metasediments gray, brown, yellow, dark green, and gray; fine to coarse grained; some weathered pebble gravel
75	76 to 77 feet: SAND (SP): gray, fine to coarse grained, quartz common
80	77 to 80 feet: Silty SAND (SM): red-brown, moderately cemented, fine grained, fine roots common
85	80 to 89 feet: Gravelly SAND (SC): predominantly mottled gray with varigated metasediments, with clay and 3/4 inch pebble gravel
90	89 to 93 feet: Silty SAND (SM): red-brown, loose to medium dense, fine grained, black roots common
95	93 to 96 feet: grades to SILT (ML): with trace fine sand, medium brown, medium stiff to very stiff, black nodules and roots common
100	96 to 109 feet: grades to CLAY (CL): with silt, medium brown, medium stiff to very stiff at 104 feet: grades to Sandy CLAY, red-brown, stiff
105	
110	109 to 115 feet: Sandy CLAY (CL): distinctive red-gray volcanic, fine to medium grained sand
115	115 to 117 feet: Clayey SAND (SC): varigated predominantly dark red, gray, and black; fine to medium grained volcanic sand; some fine to medium grained moderately to well cemented lenses of medium gray sandstone
120	117 to 119 feet: grades to Silty SAND (SM): mottled red-gray with varigated dark mafics and volcanics, mostly fine to medium grained with some coarse grained, with pebble gravel
125	119 to 131 feet: SAND (SP): Dark gray, black, and red mafics/volcanics, with some brown metasediments; well cemented; fine to coarse grained; with some pebble gravel and trace silty clay
130	131 to 143 feet: Gravelly SAND (SP): varigated, weakly to strongly cemented, fine to coarse grained sand, gravel to 2 inches in diameter, sand/gravel subrounded to subangular, with trace gray clayey silt
135	143 to 151 feet: SAND (SP): mostly dark volcanics, loose to medium dense, not cemented, fine to medium grained with trace coarse grained, with trace gravel, silt and clay
140	151 to 162 feet: Interbedded Siltstone/Silty SAND (ML-SM): siltstone; medium brown, weakly to moderately indurated; silty sand; mostly black mafics/volcanics in olive-brown to olive-gray silt matrix, fine to trace coarse grained
145	162 to 190 feet: interbedded Silty SAND/SAND (SM-SP): silty sand; mostly black
150	
155	
160	
165	

GENCORP AEROJET

SITE: Area "E".	BORING ID: 95EEW-2
NORTH: 344873.177 EAST: 2214947.979	WELL ID: 4435
SURFACE ELEVATION (ft, MSL): 131.50	
TOC ELEVATION (ft, MSL): 132.38	
BOREHOLE DIAMETER (in): 26	TOTAL DEPTH BORING (ft): 271.0
DATE COMPLETED: 10/13/95	TOTAL DEPTH WELL (ft): 260.0
LOGGED BY: C. Clark	PAGE 2 of 2 ; 165.8 to 271.0 ft



DEPTH (ft)	DESCRIPTION
170	mafics in gray-brown silt matrix, fine to medium grained, some moderately to well cemented sandstone lenses: sand; mostly dark brown to black, loose
175	
180	
185	182 to 190 feet: Silty SAND (SM): mottled medium gray, yellow-olive, olive, and medium brown; fine to coarse sand; with clay and subangular gravel fragments; very poorly sorted; appears to be volcanic mud/debris flow
190	190 to 195 feet: Sandstone (SM): red-brown (rust), moderately to well cemented, fine to medium grained, with silt
195	distinct layer of ash like, white, soft, angular fragments
200	195 to 208 feet: SAND (SP): dark gray mafic, dense to very dense, mostly not cemented with some weakly to moderately cemented, fine to trace medium grained, with trace silt
205	at 200 feet: grades to include lenses of either calcite or ash (white, semi-hard)
210	208 to 214 feet: Silty SAND (SM): yellow-brown, fine grained
215	214 to 216 feet: Silty SAND (SM-CL): olive-brown, fine to medium grained, with sub to well rounded gravel fragments, silty matrix mottled yellow, olive, and gray; with thin interbeds of clay
220	216 to 219 feet: Silty Sandstone/Sandstone (SM): Sandstone; dark red, moderately to well cemented, fine to medium grained; Siltstone; weak to moderately indurated, with yellowish ash/calcite lenses
225	219 to 225 feet: Silty SAND/Silty Sandstone (SM): mottled red-brown to olive-brown grading to medium gray, loose, moderately cemented, fine to medium grained
230	225 to 231 feet: Clayey SILT (ML): interbedded red, gray, and olive-gray; with dark gray fine sand
235	231 to 240 feet: Silty SAND/Siltstone (SM-ML): silty sand; olive-gray to dark gray, dense, not cemented to weakly cemented; thin interbeds of olive-gray, weakly to moderately indurated siltstone
240	240 to 255 feet: interbedded Clayey Siltstone/SAND (ML): siltstone medium brown, weak to moderately indurated, grades to olive-brown silt with trace clay; sand dark gray, dense, not cemented, very fine (floue like)
245	grained
250	255 to 270 feet: Silty SAND (SM-ML): dark gray, dense, noncemented to trace moderately cemented, very fine grained (flour like); interbedded with olive-gray mottled yellowish, fine sand with clay
255	
260	
265	
270	

Well completed at a depth of approximately 271 feet below existing site grade.

GCAJ-2

APPENDIX B

Cross Sections

PAGES OF OVERSIZED MAPS

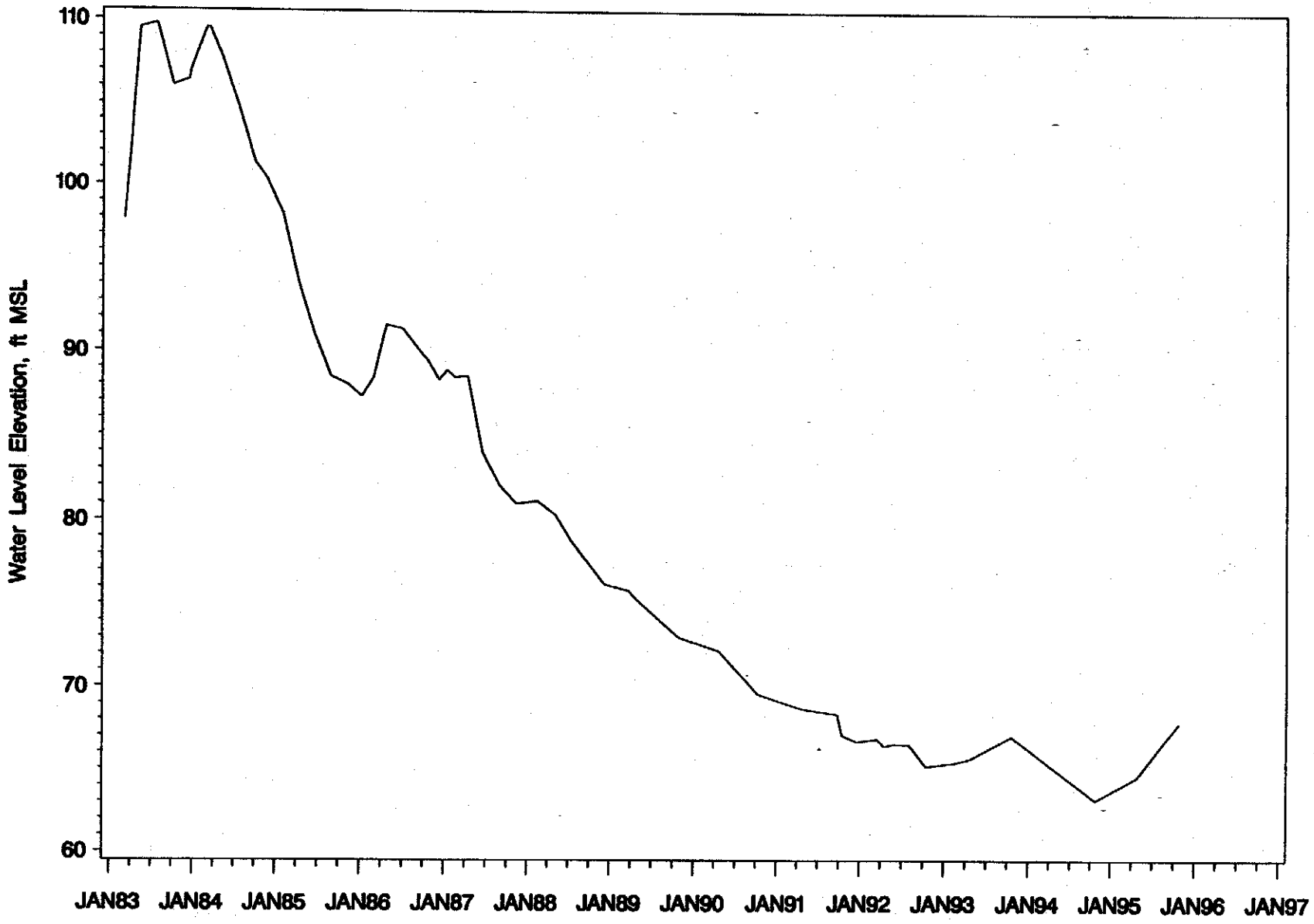
(SEE BINDER)

APPENDIX C

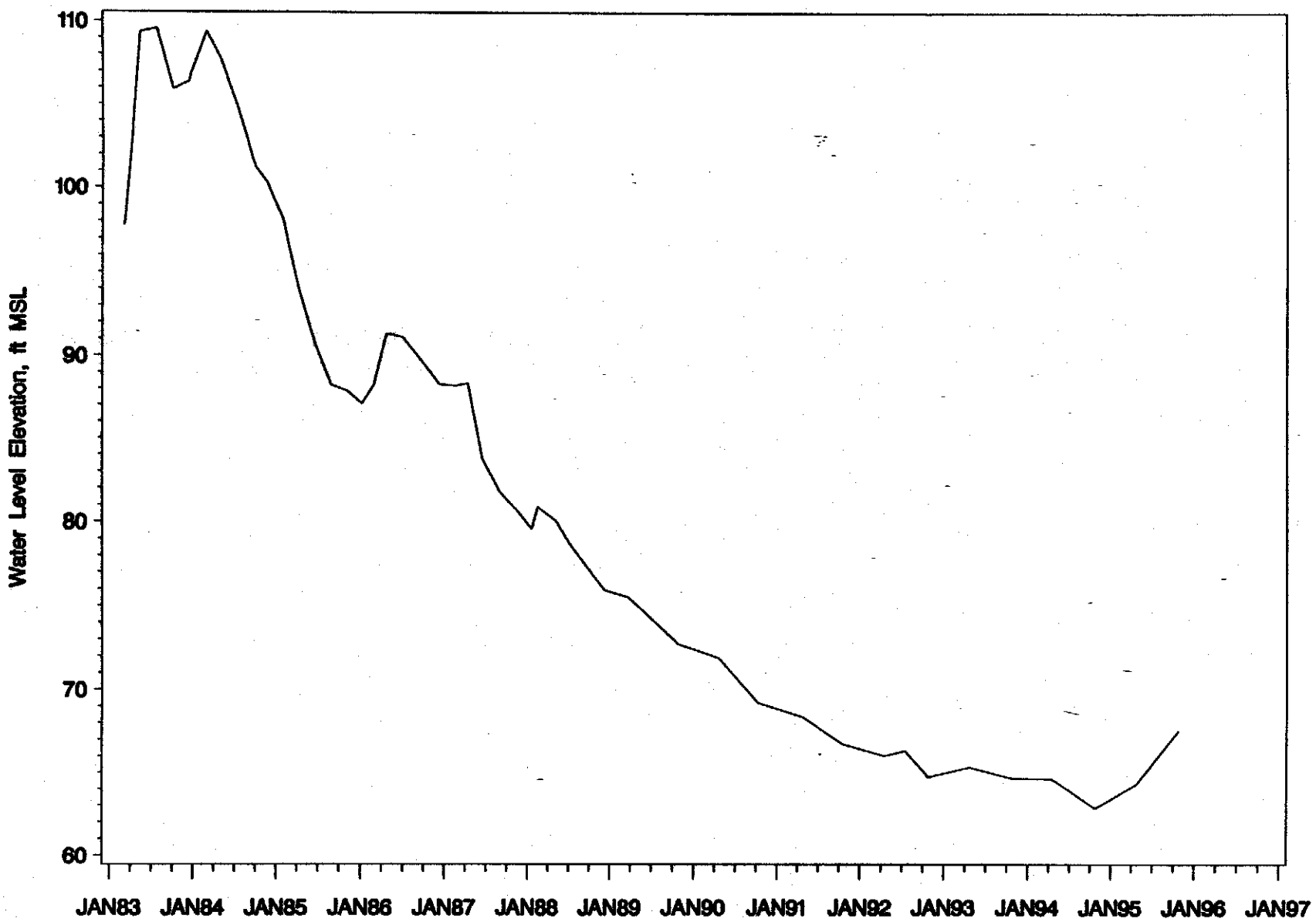
Hydrographs of Selected Wells

HYDROGRAPH

WELL=1

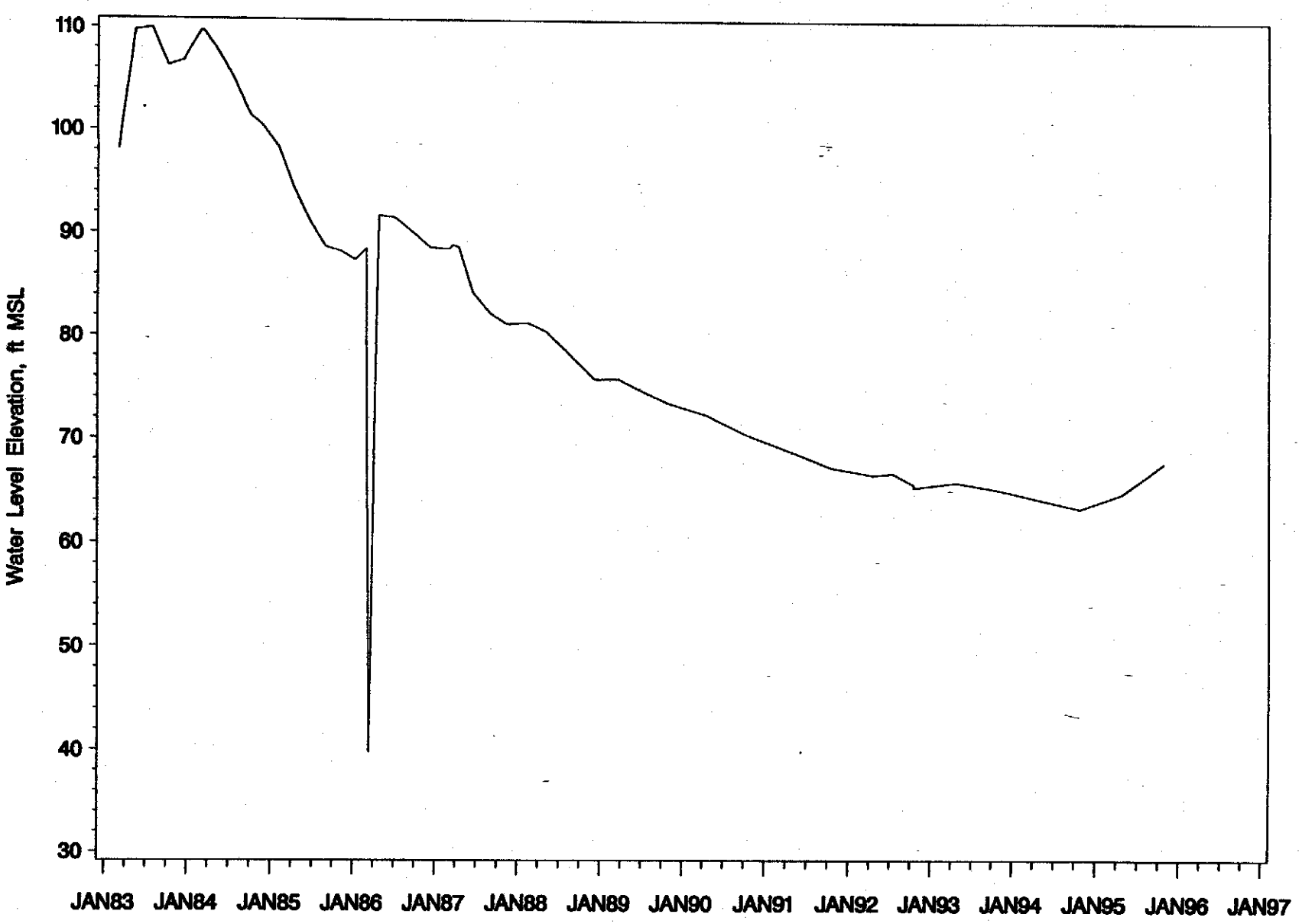


HYDROGRAPH


WELL-3
Water Level Elevation, ft MSL
110
100
90
80
70
60
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97

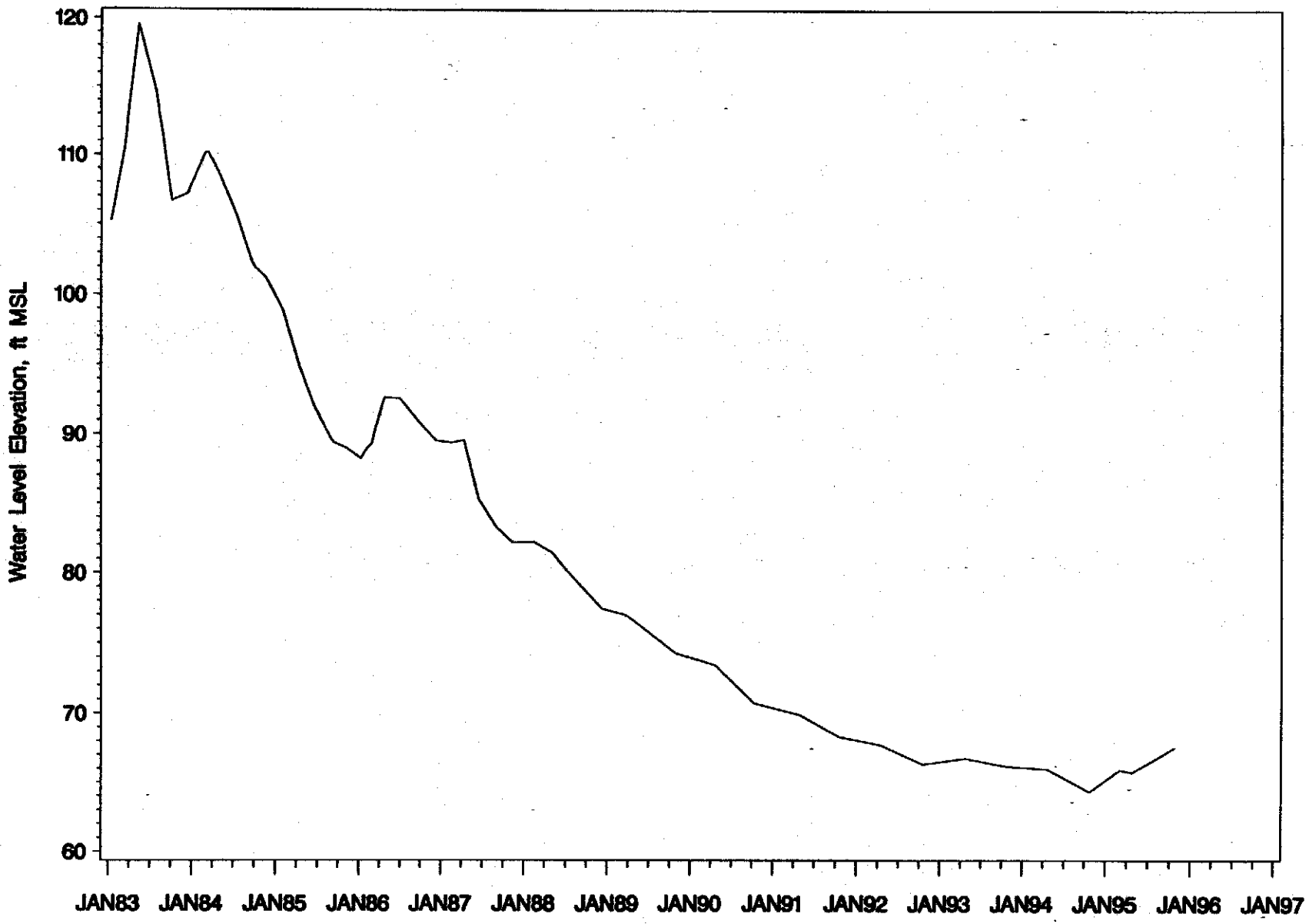
HYDROGRAPH

WELL = 4

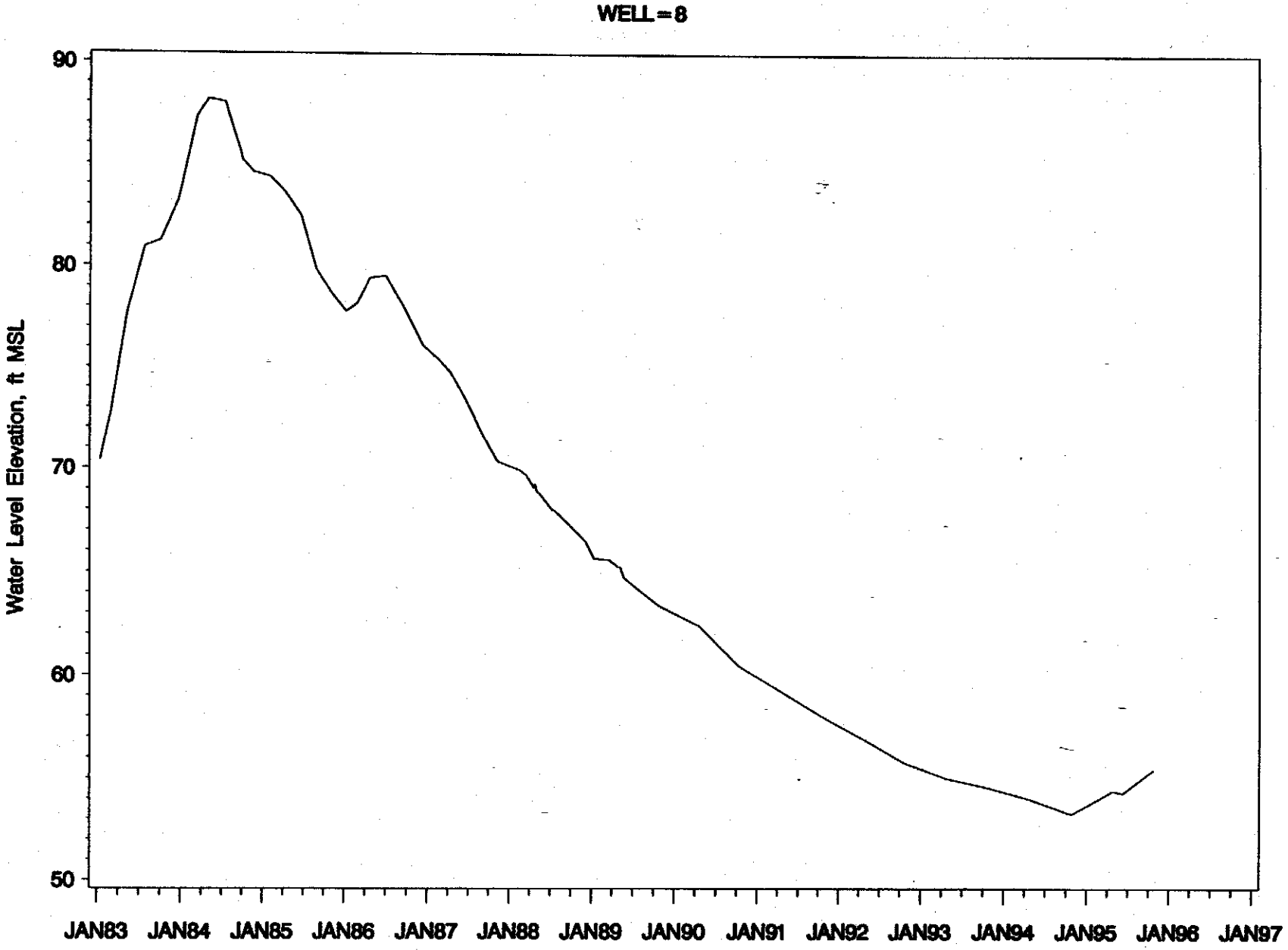


HYDROGRAPH

WELL=5



HYDR[redacted]RAPH



HYDROGRAPH

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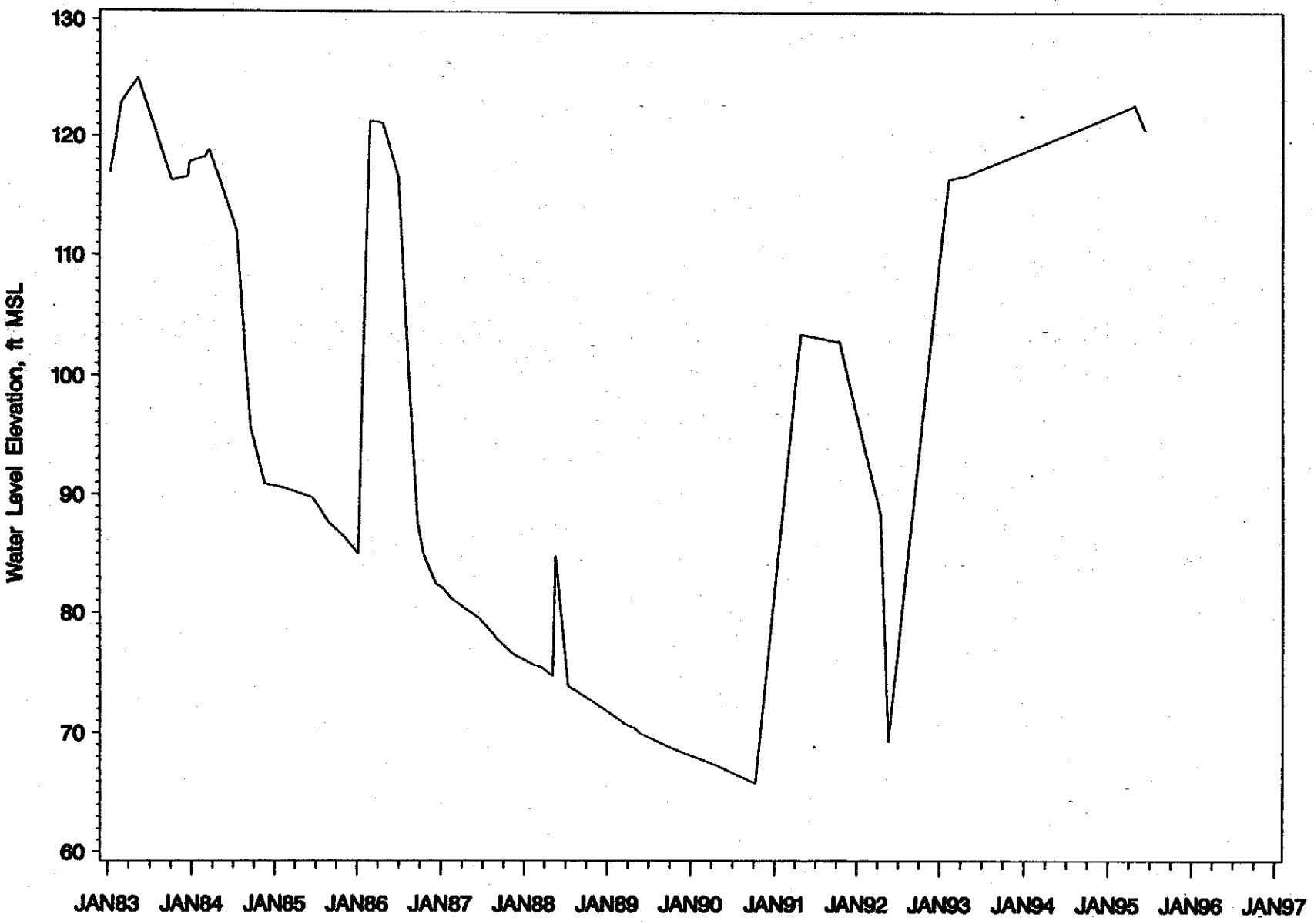

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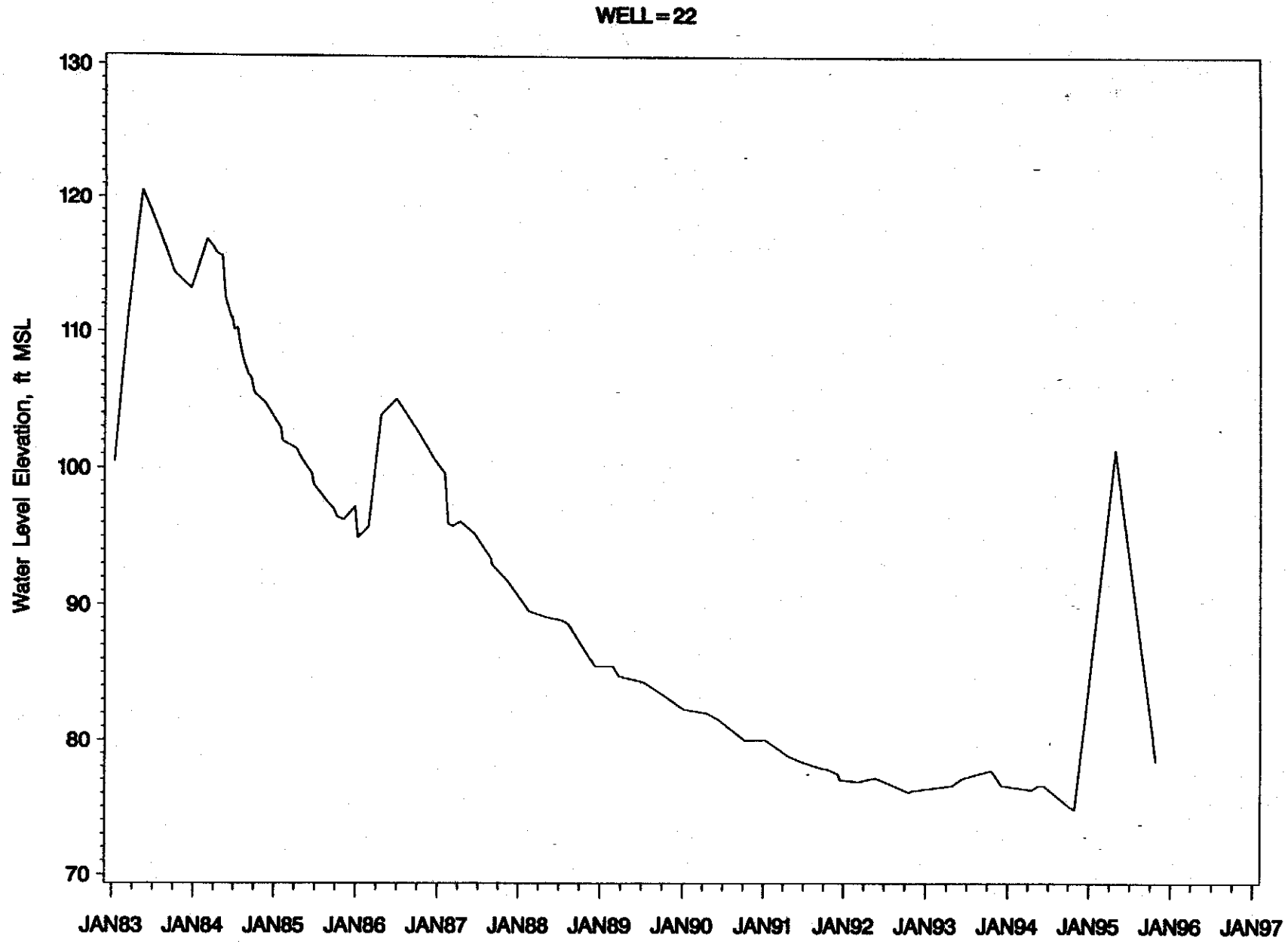
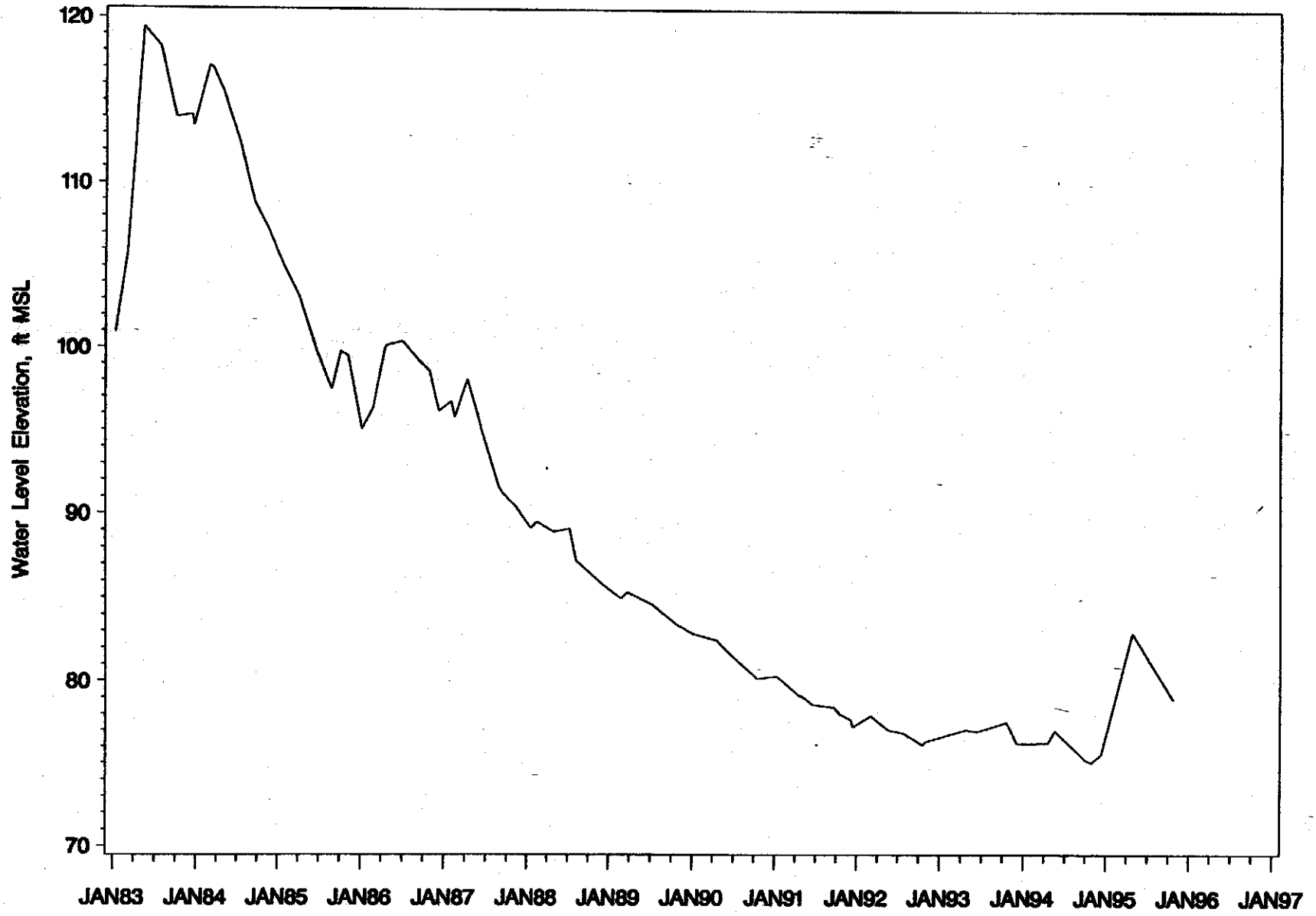

WELL=22
Water Level Elevation, ft MSL
130
120
110
100
90
80
70
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97

HYDROGRAPH

WELL=24



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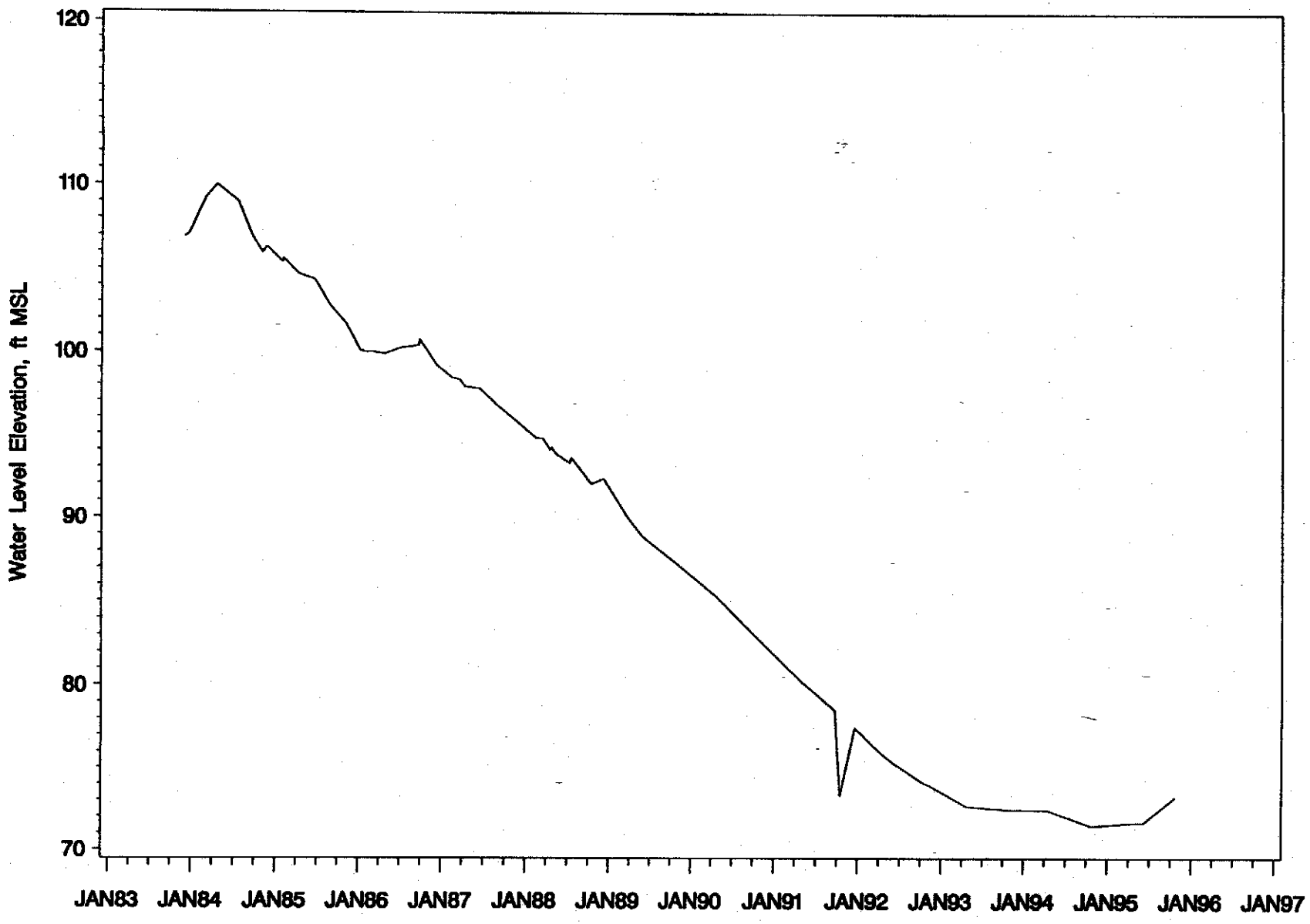
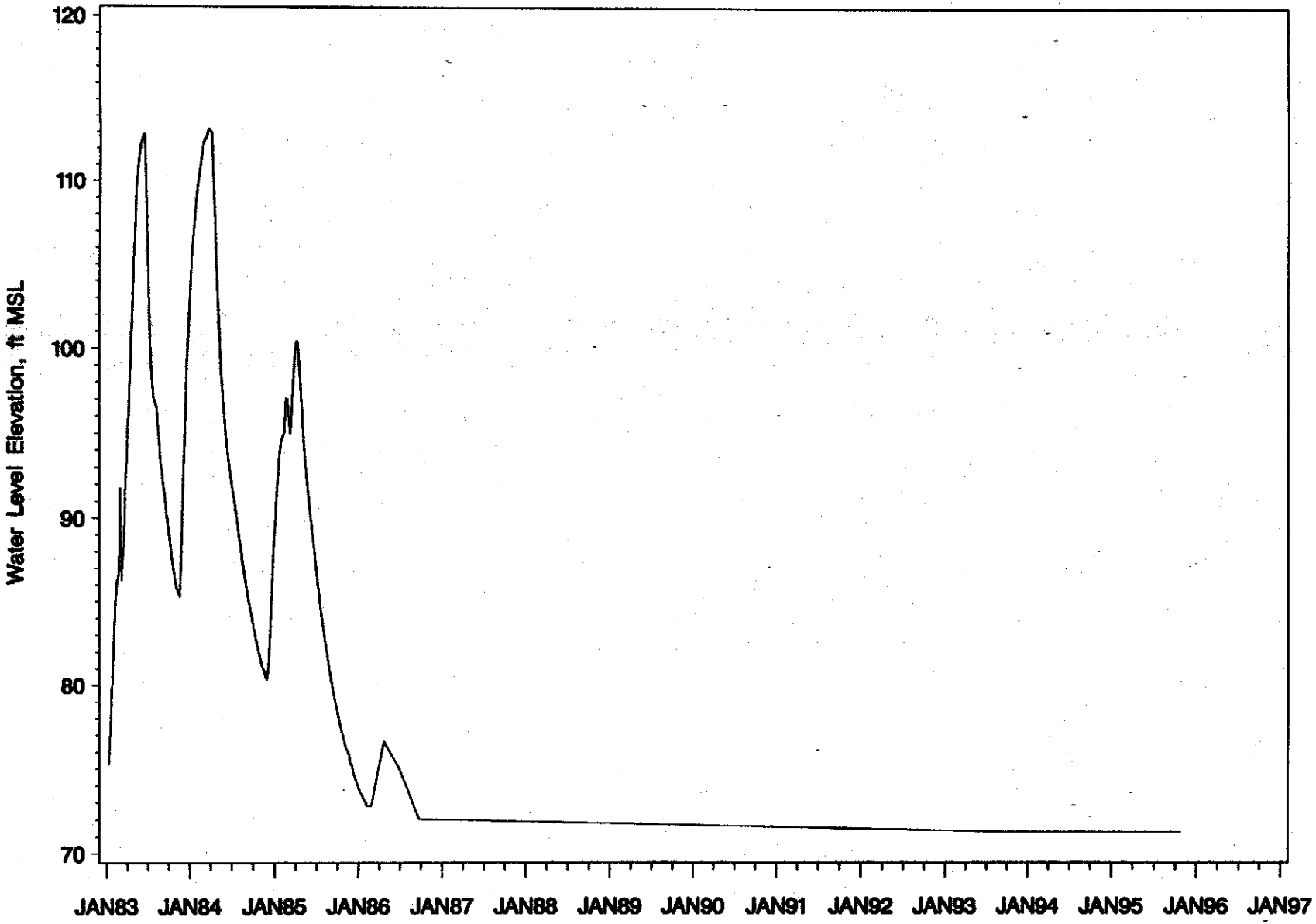


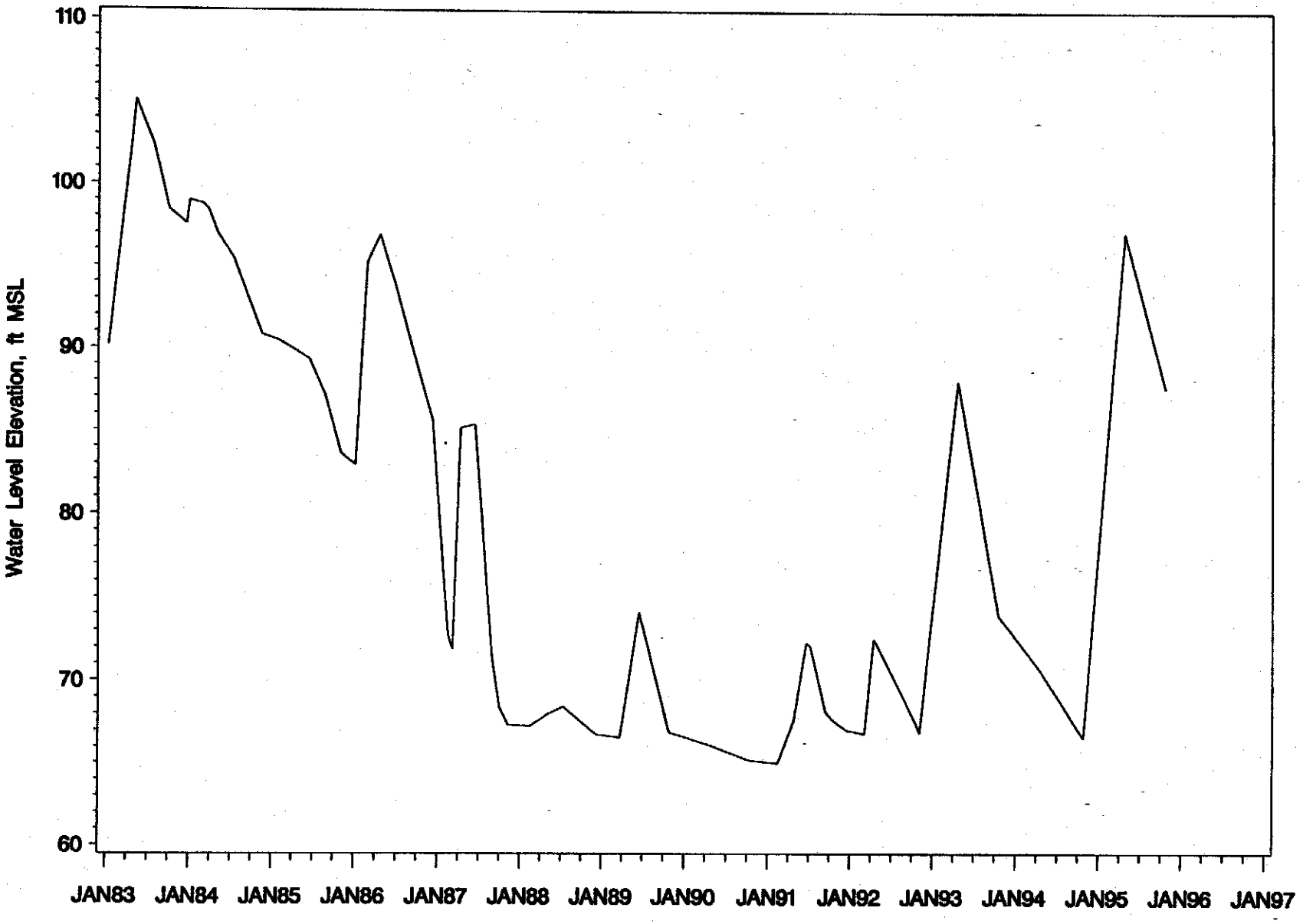
HYDROGRAPH

WELL=57



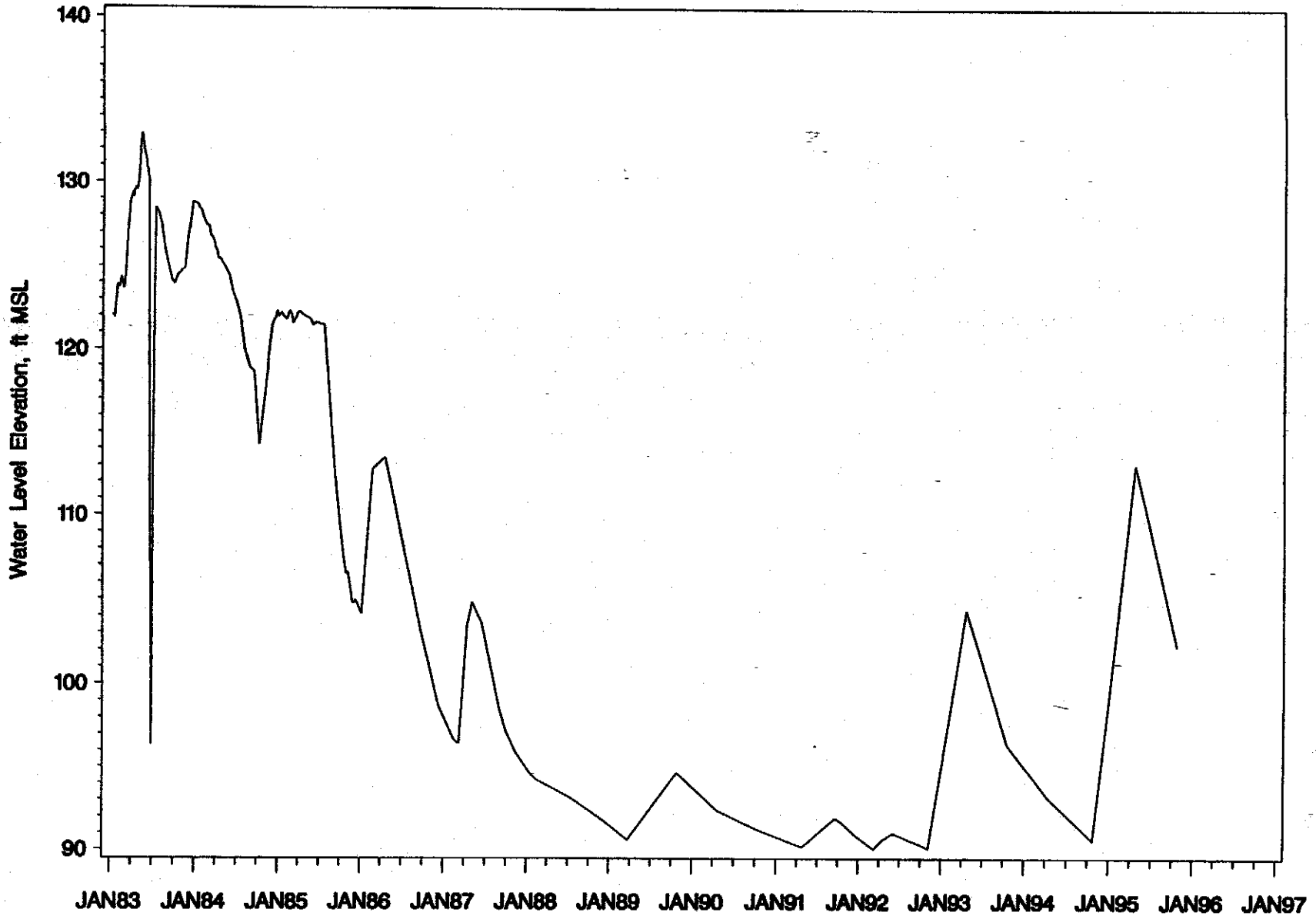
HYDROGRAPH

WELL=59



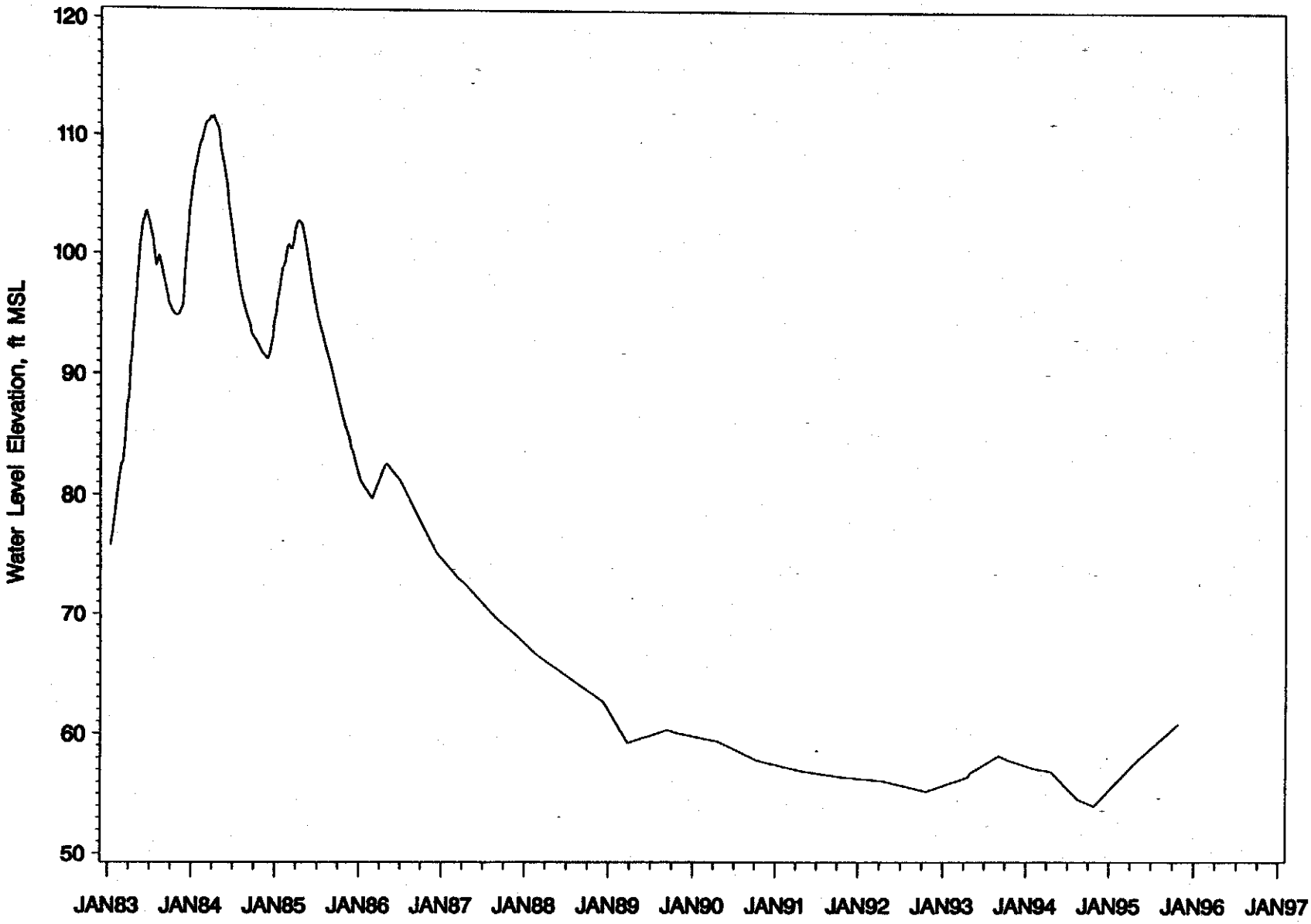
HYDROGRAPH

WELL = 63



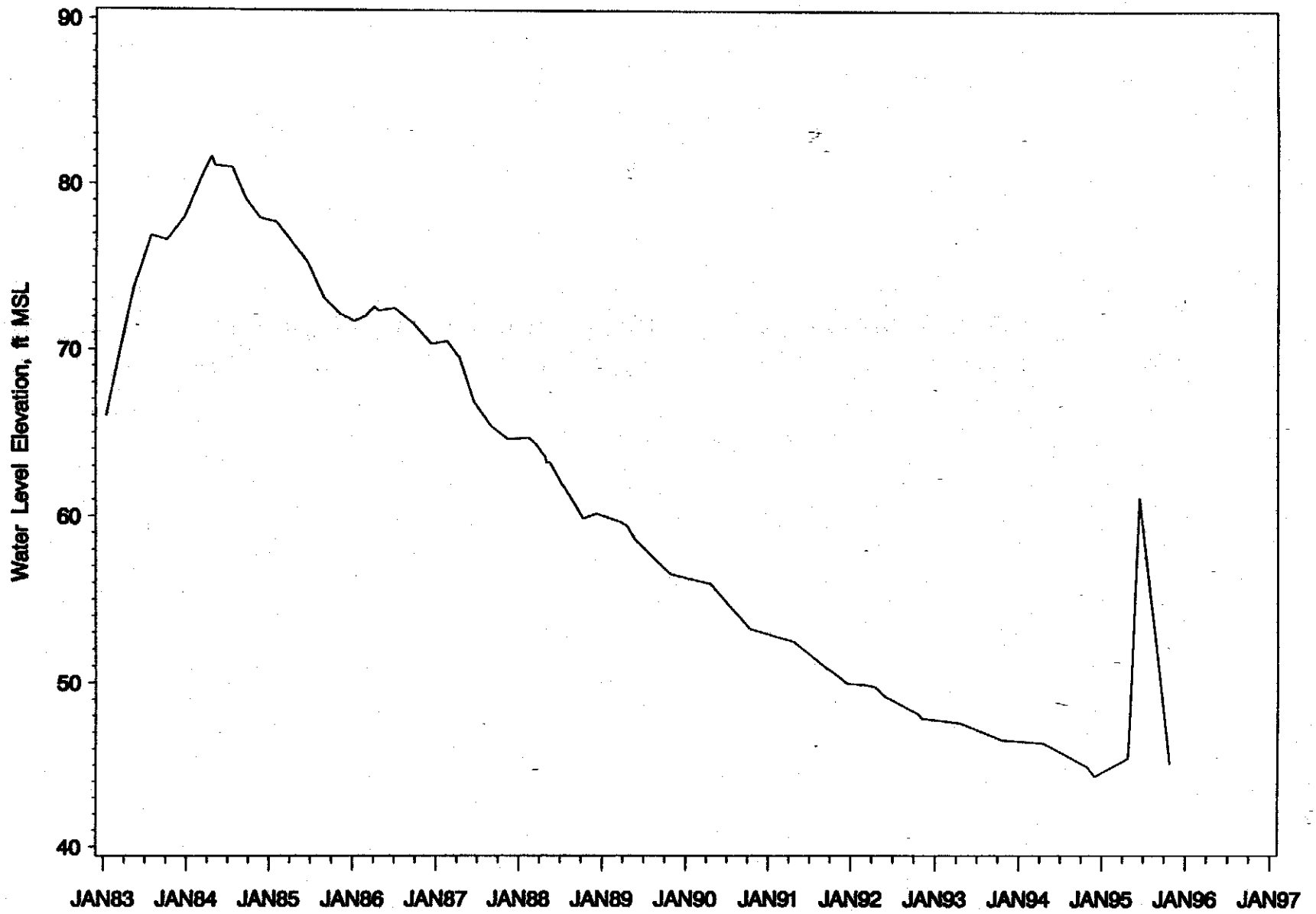
HYDROGRAPH

WELL = 64



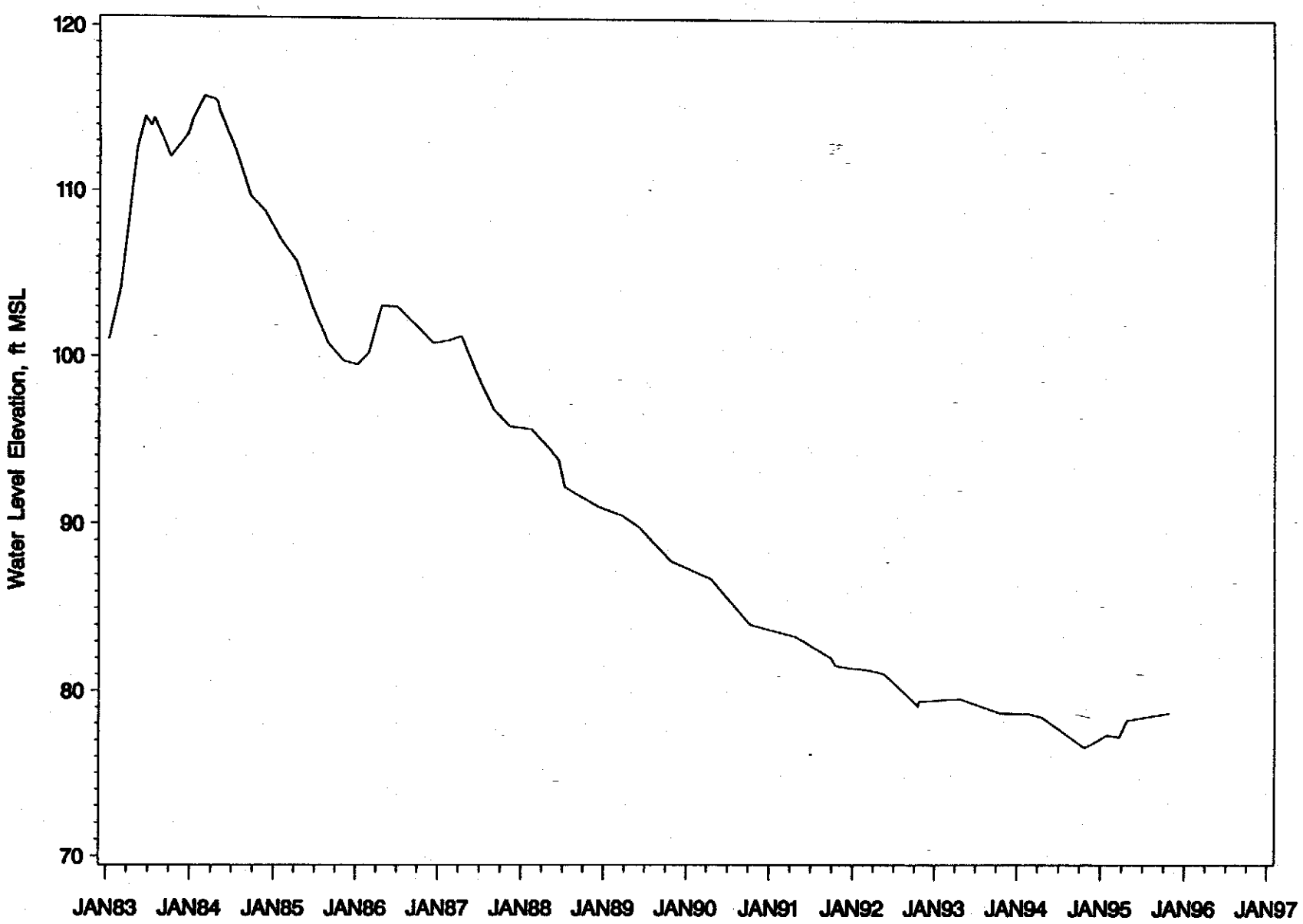
HYDROGRAPH

WELL=75



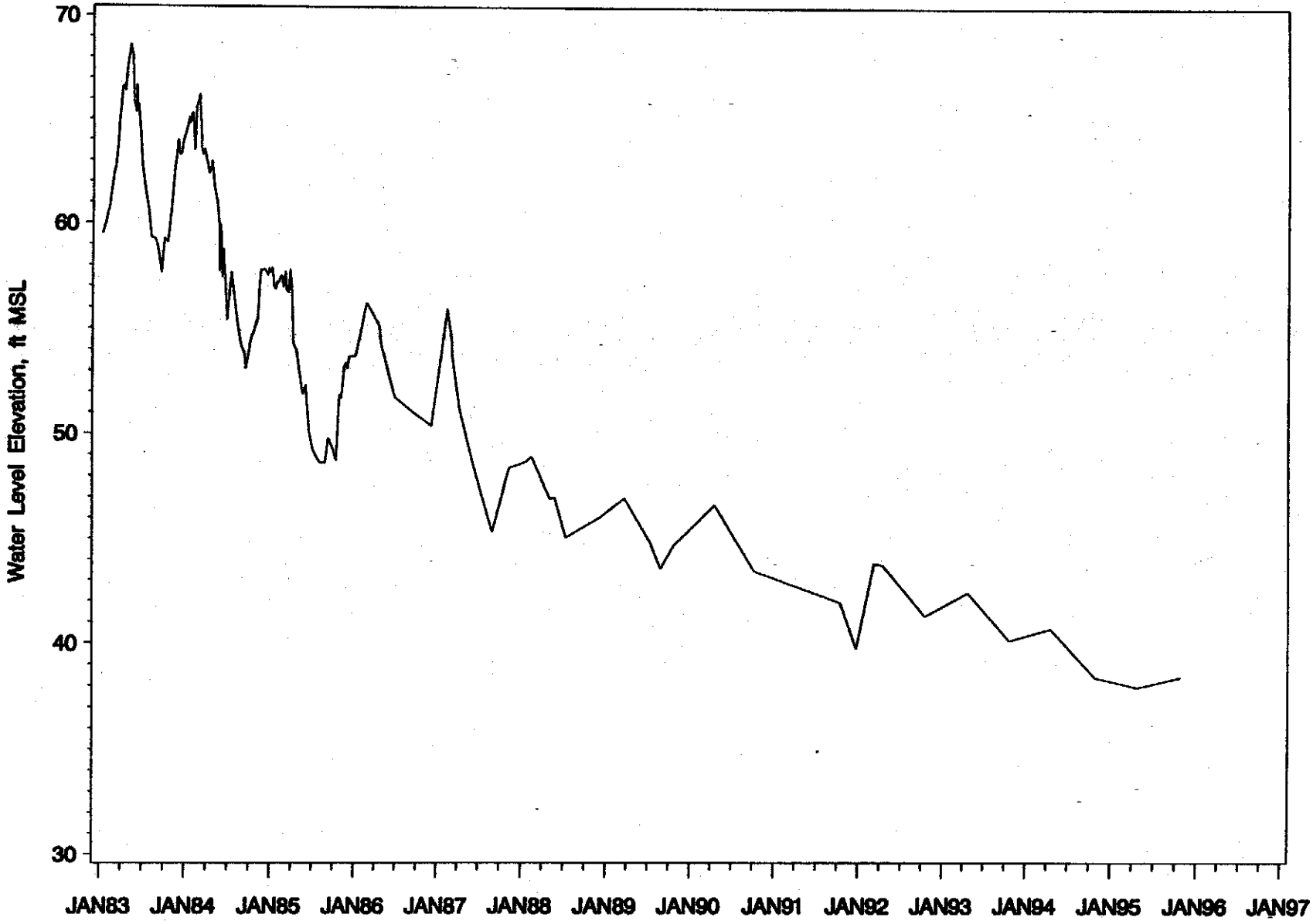
HYDROGRAPH

WELL = 86



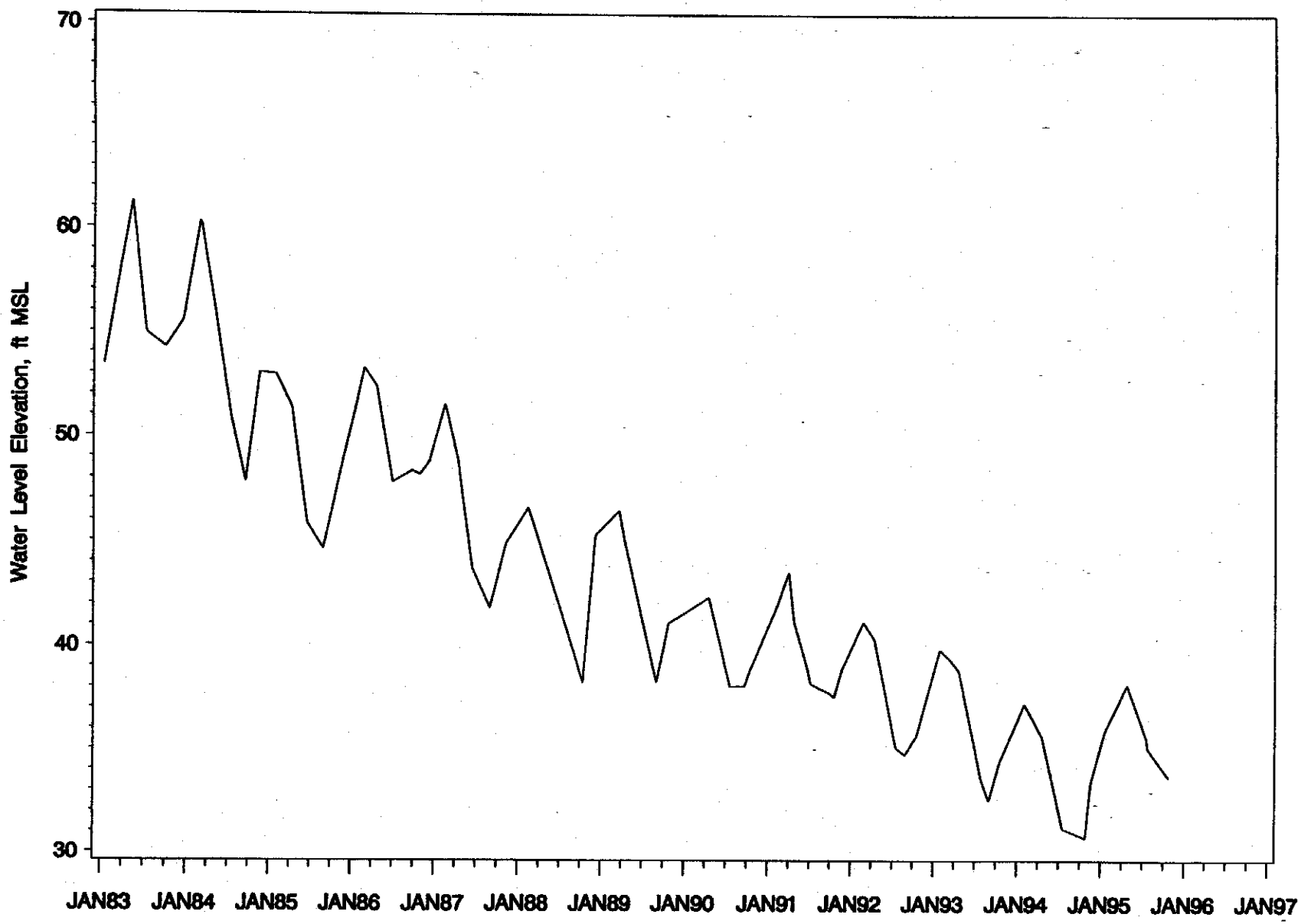
HYDROGRAPH

WELL=87



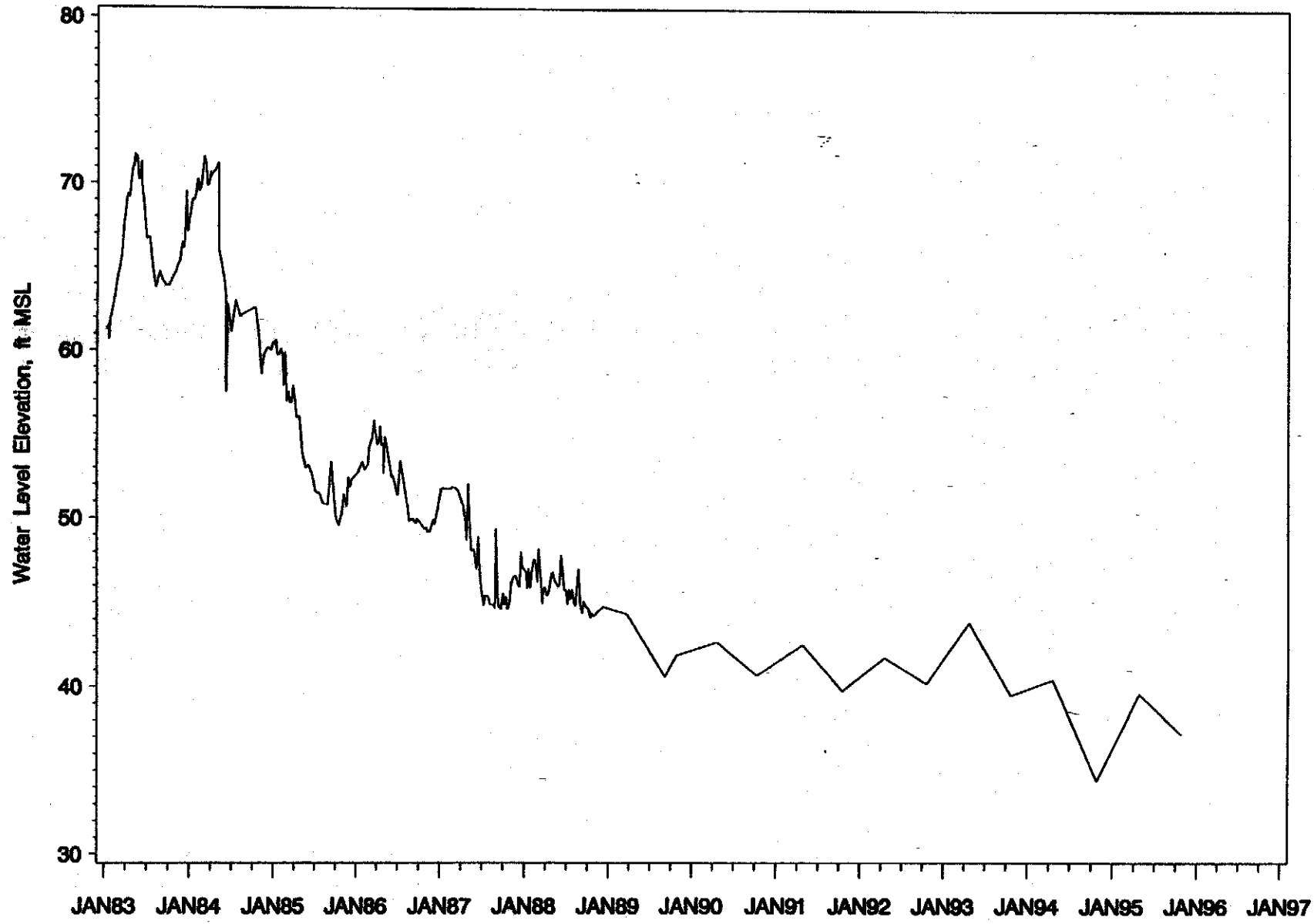
HYDROGRAPH

WELL = 88



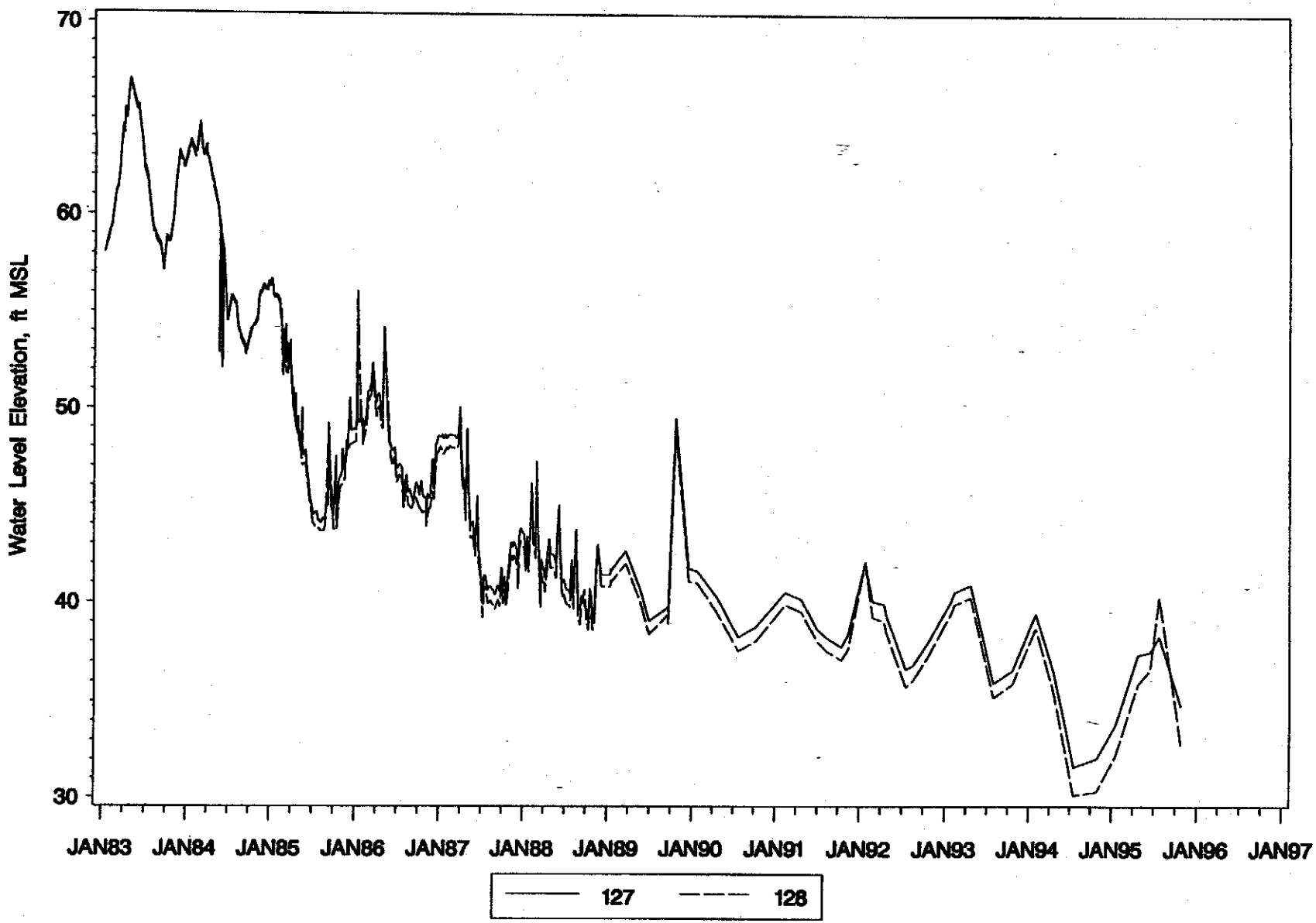
HYDROGRAPH

WELL = 124

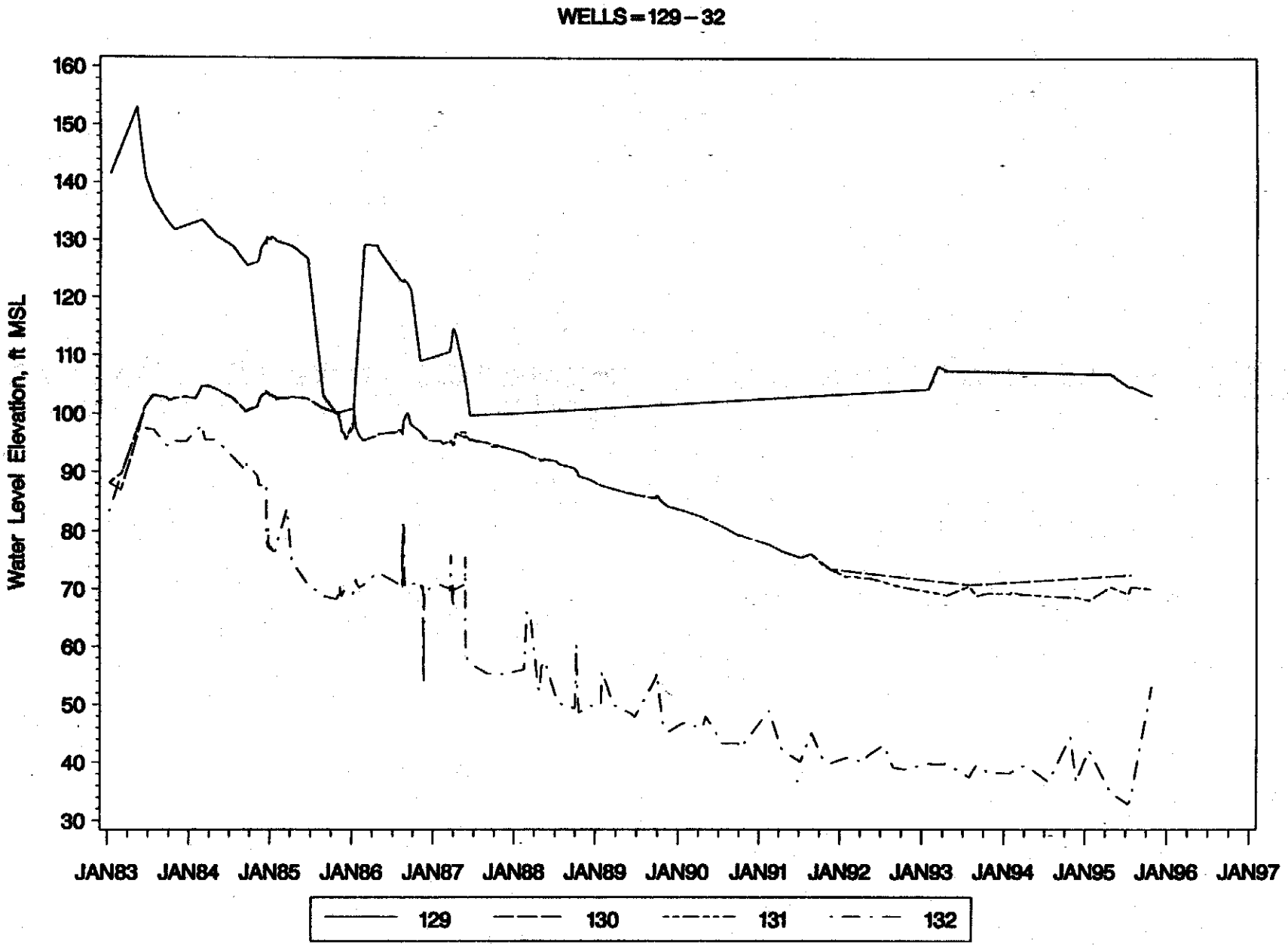


HYDROGRAPH

WELLS = 127 – 8

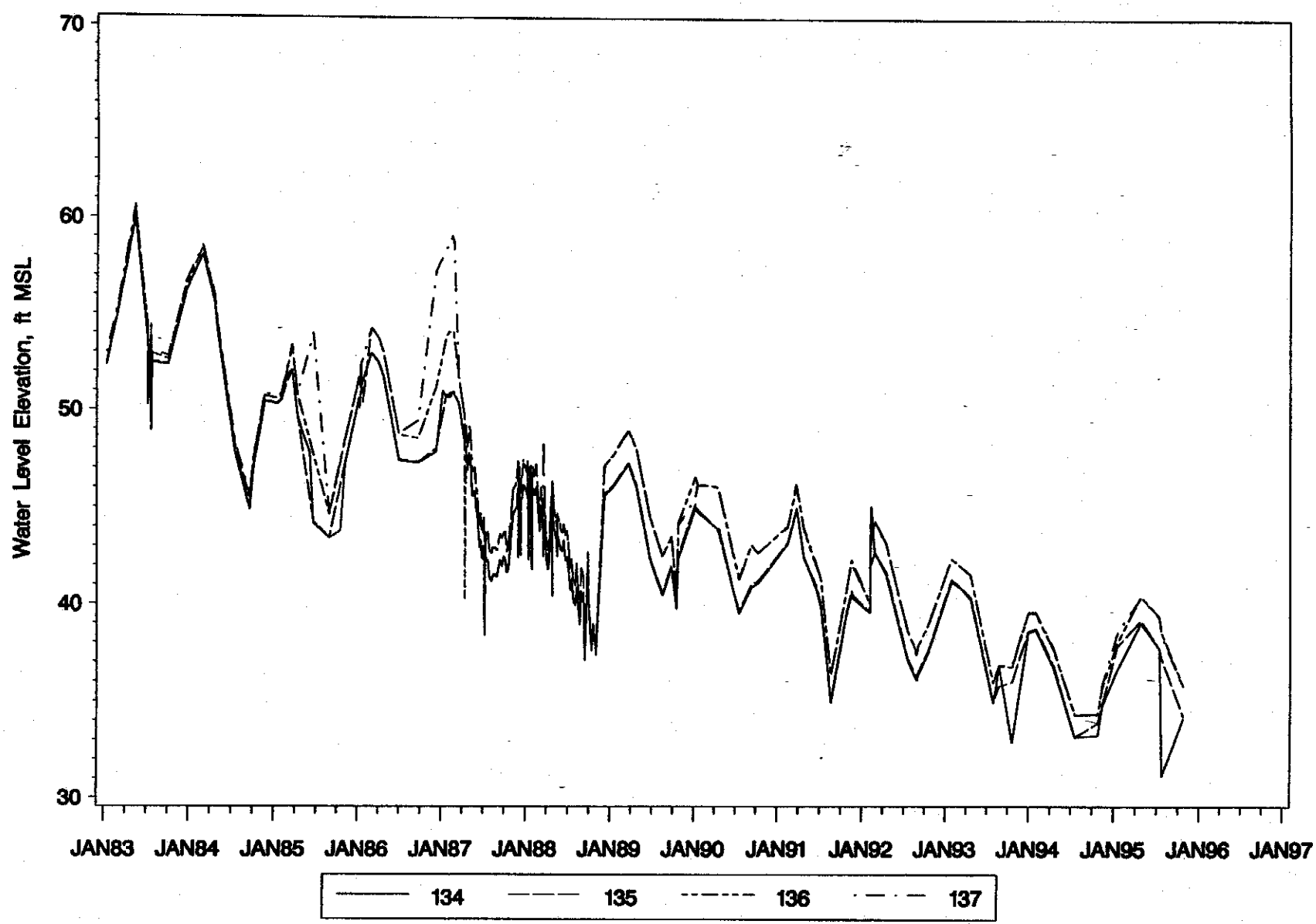


HYDROGRAPH

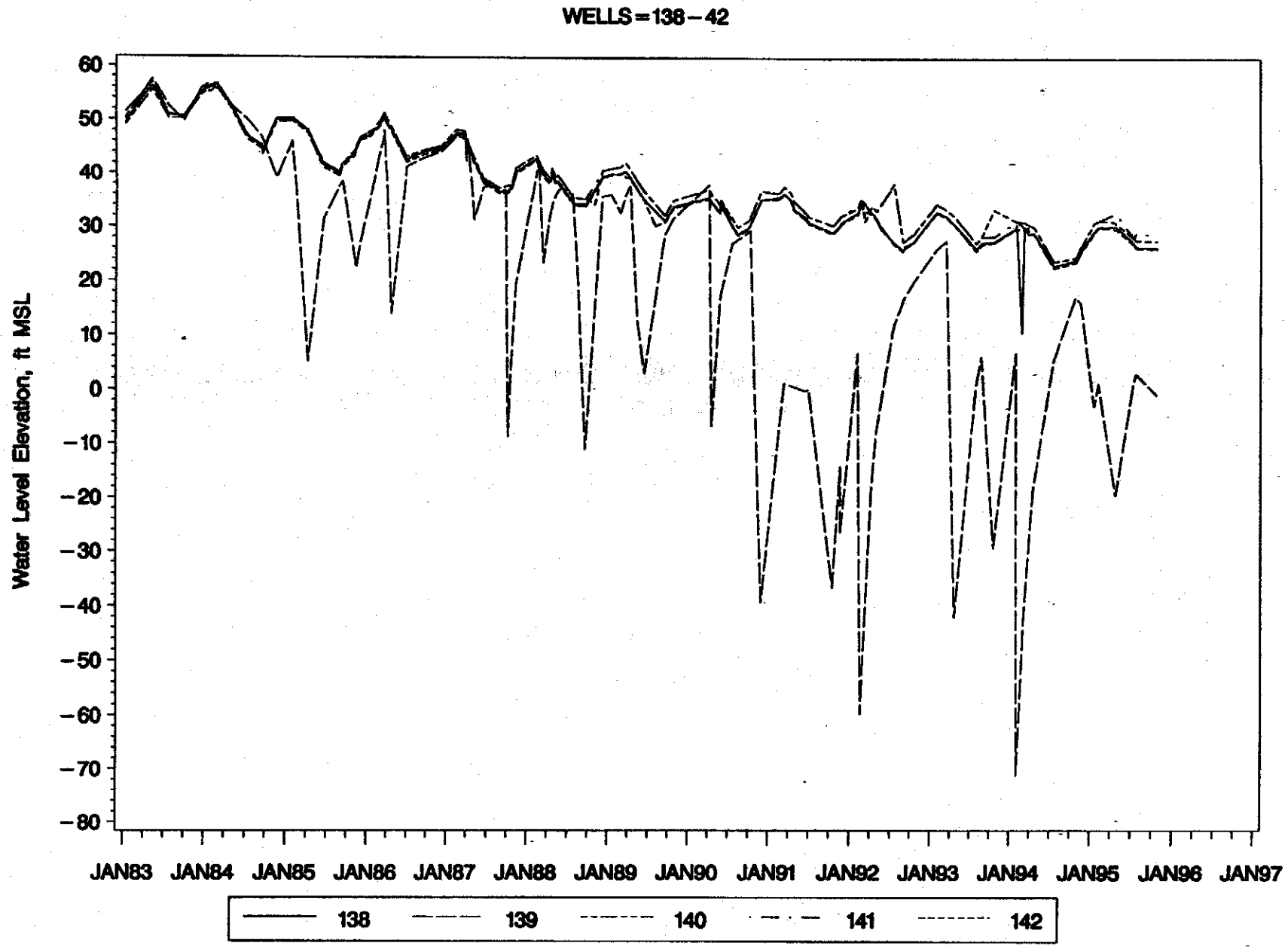

WELLS=129-32
Water Level Elevation, ft MSL
160
150
140
130
120
110
100
90
80
70
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
129
130
131
132

HYDROGRAPH

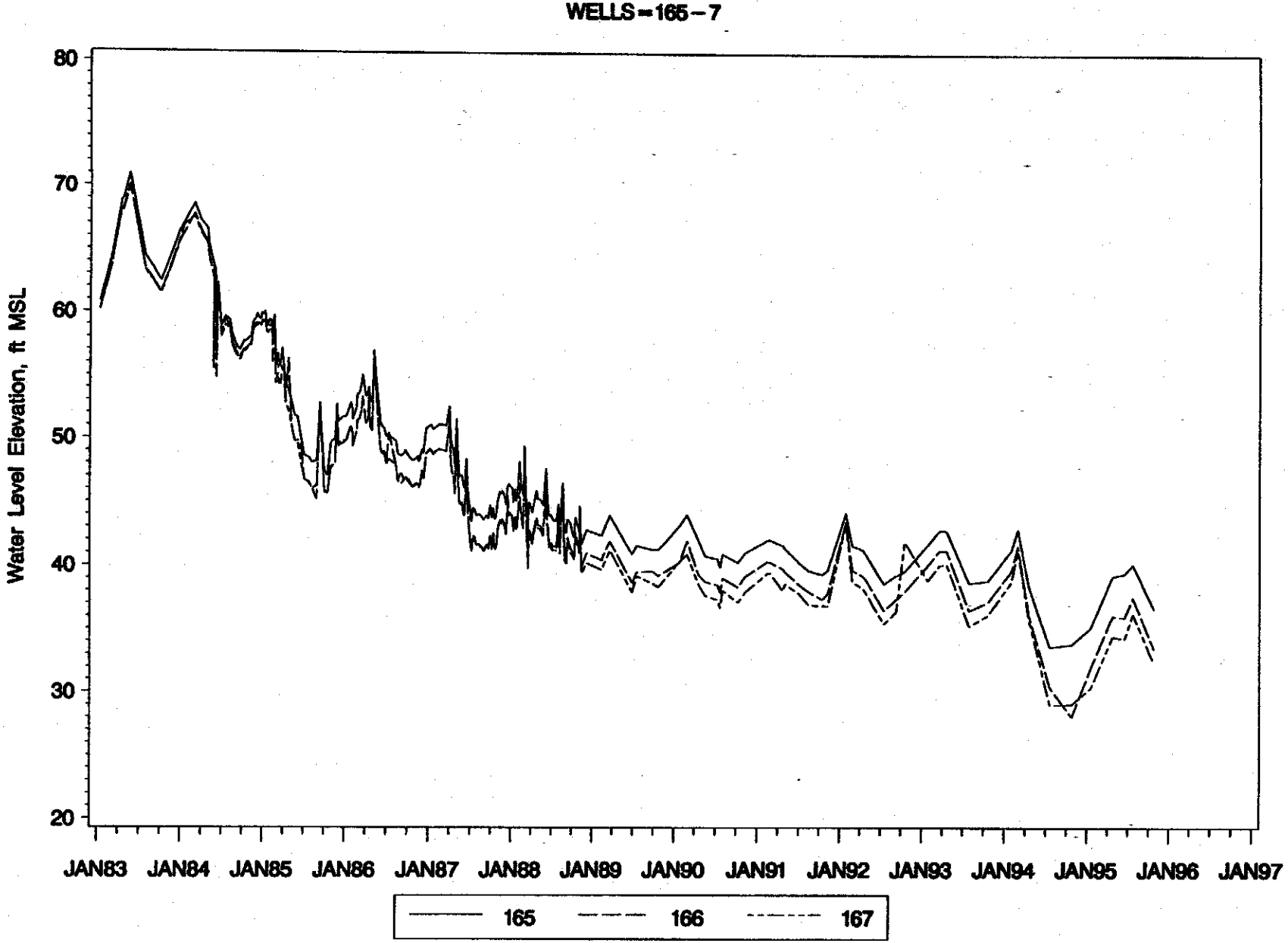
WELLS=134-7



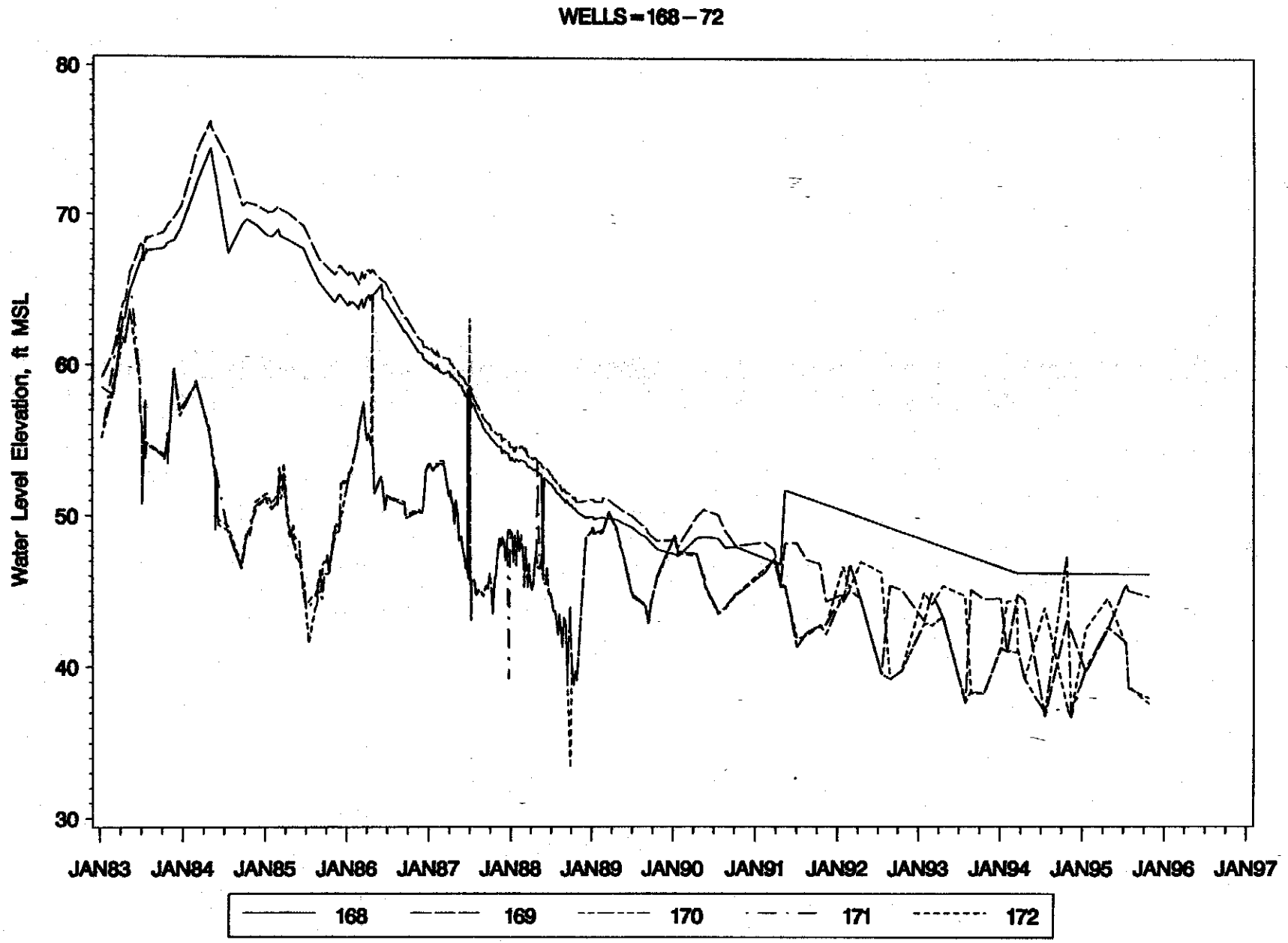
HYDROGRAPH


WELLS=138-42
Water Level Elevation, ft MSL
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
138
139
140
141
142

HYDR[illegible]RAPH

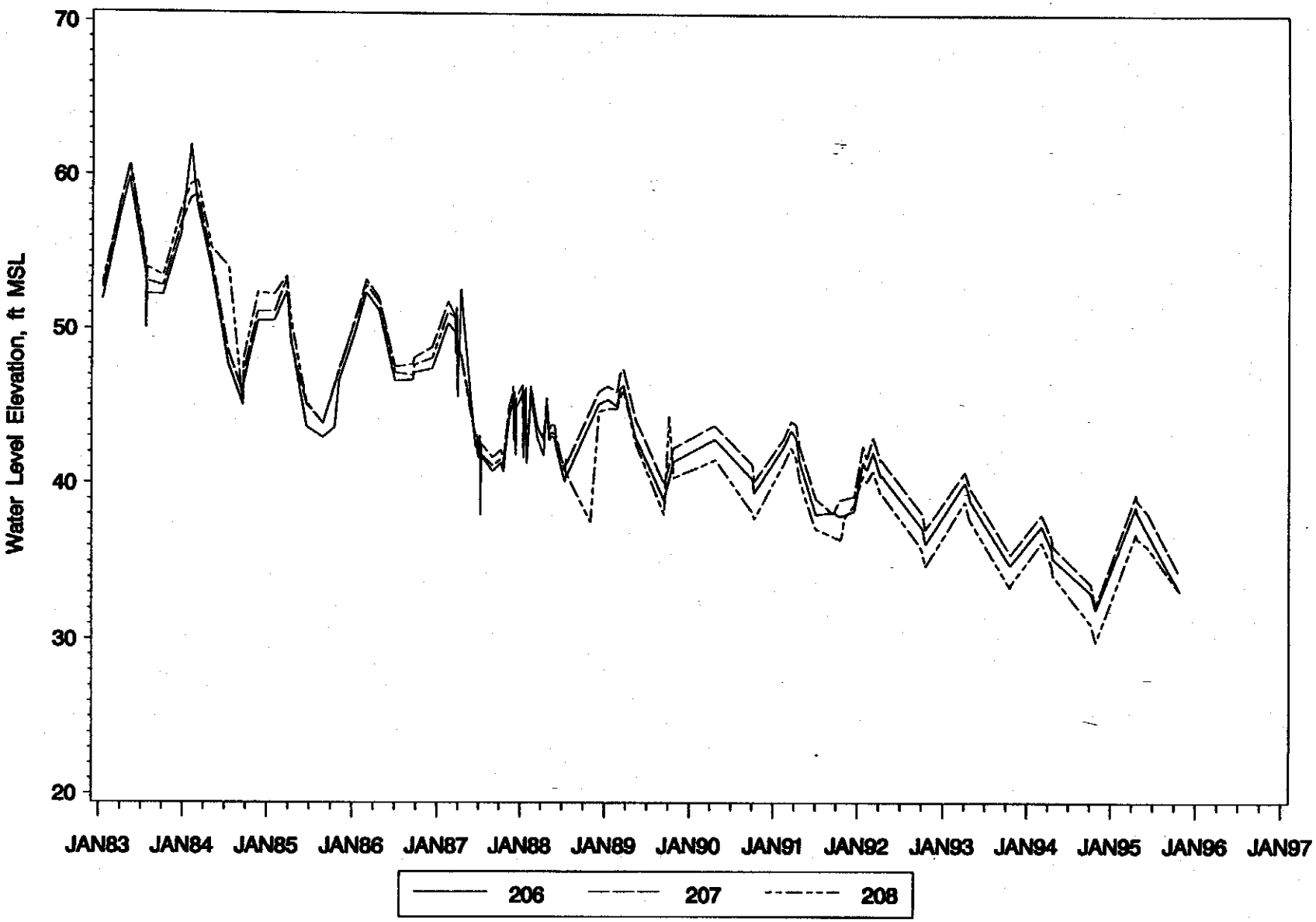

WELLS=165-7
Water Level Elevation, ft MSL
80
70
60
50
40
30
20
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
165
166
167

HYDROGRAPH

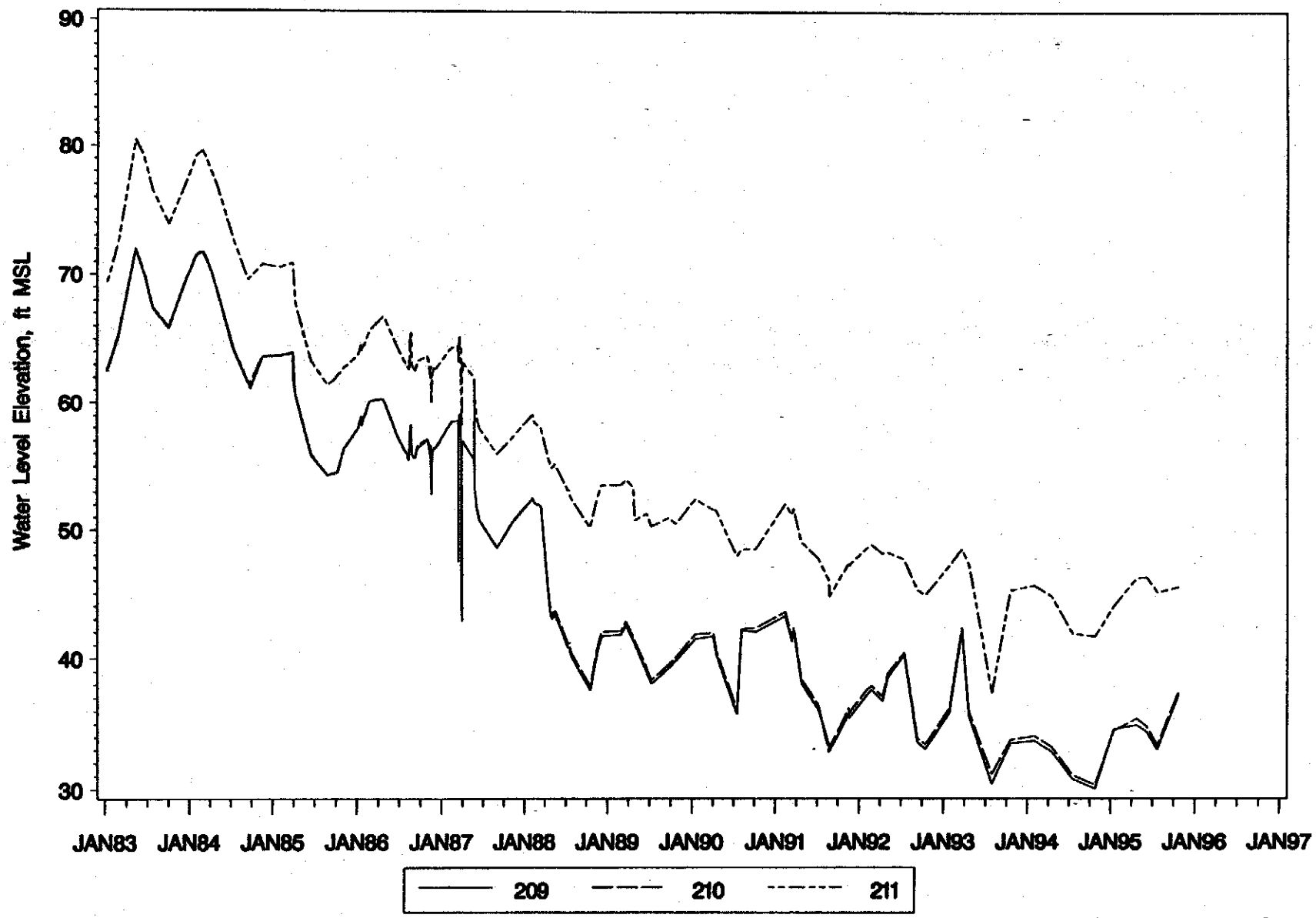

WELLS=168-72
Water Level Elevation, ft MSL
80
70
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
168
169
170
171
172

HYDROGRAPH

WELLS=206-8

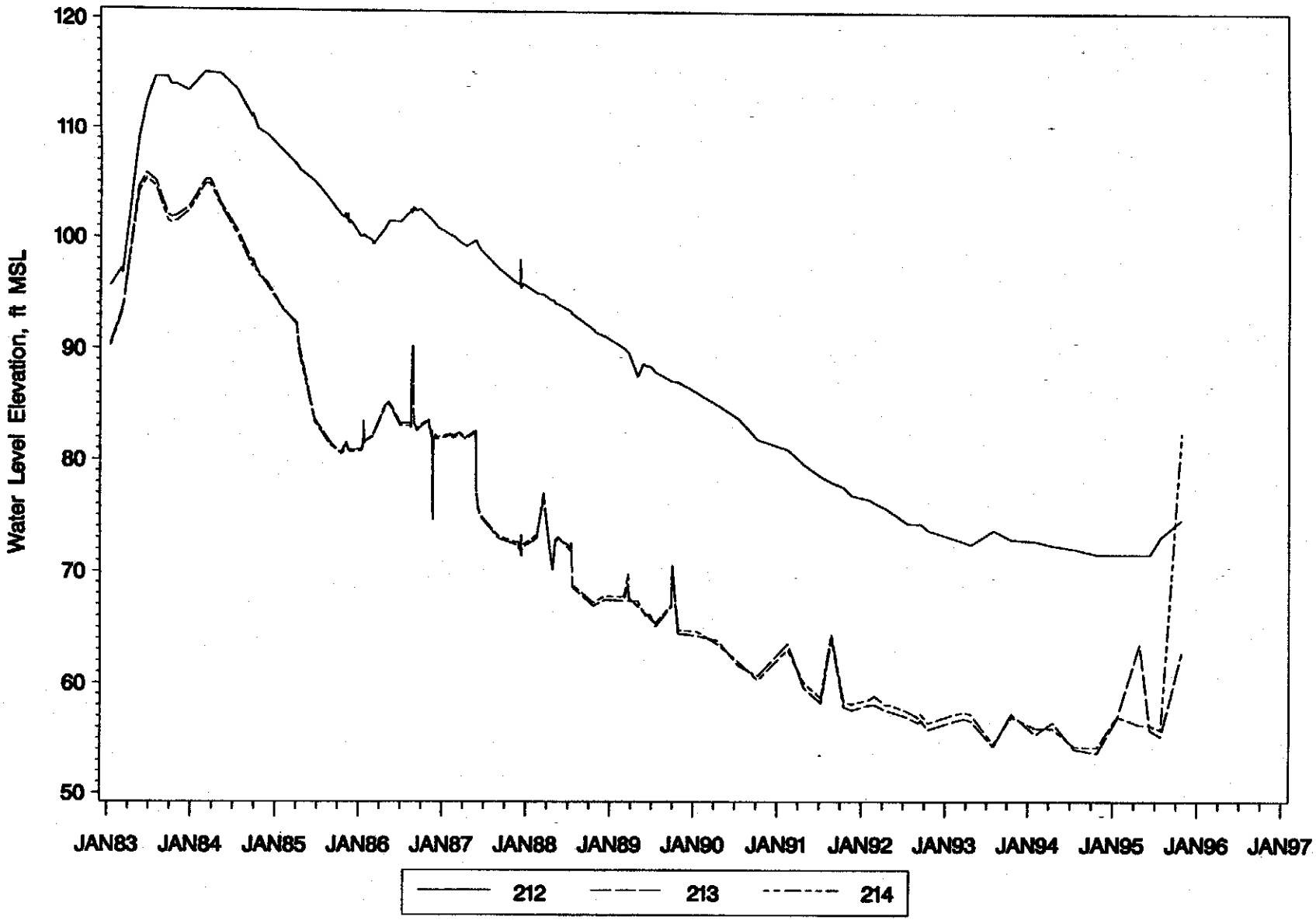


HYDROGRAPH

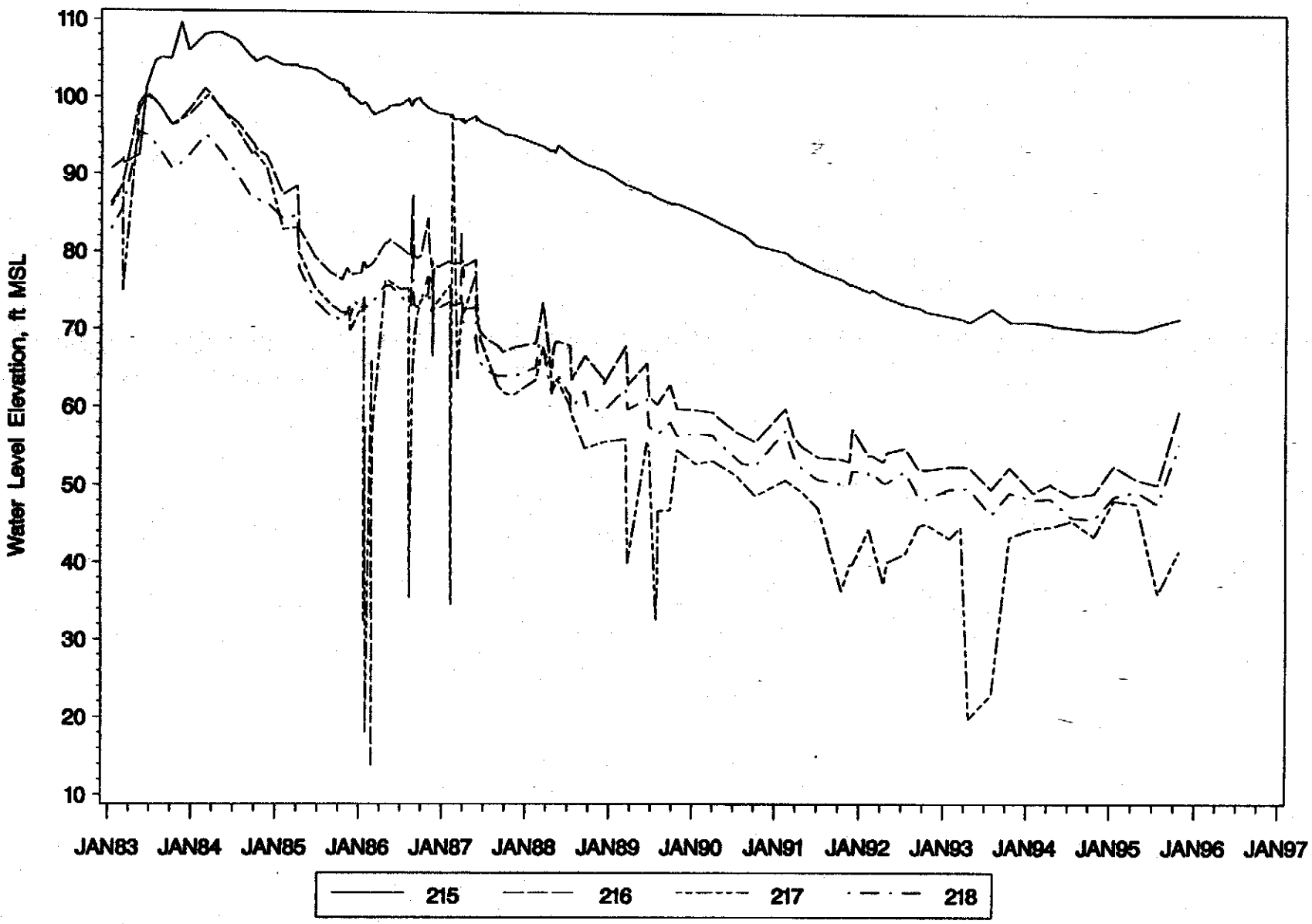

WELLS=209-11
Water Level Elevation, ft MSL
90
80
70
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
209
210
211

HYDR[illegible]RAPH

WELLS=212-4

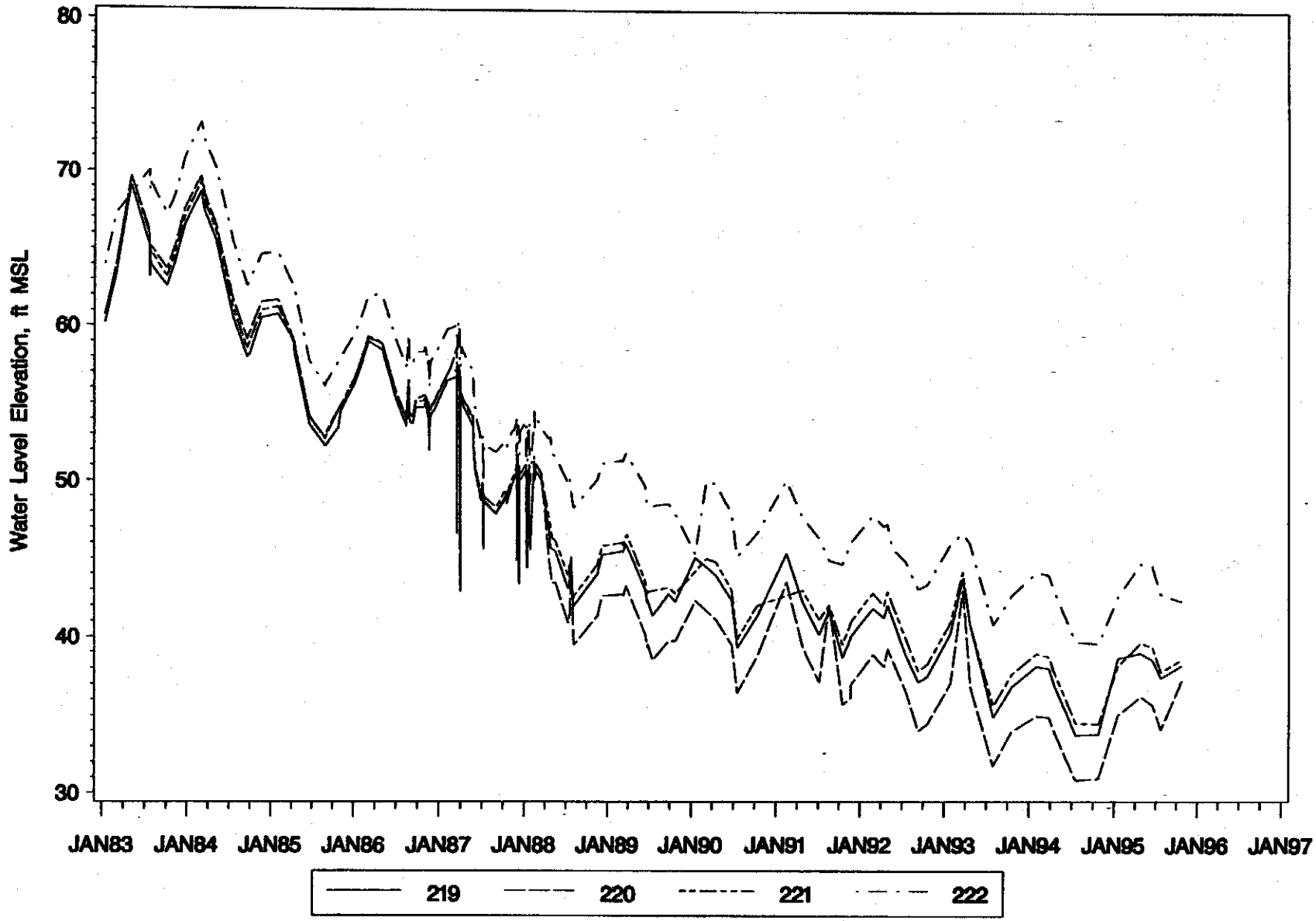


HYDROGRAPH


WELLS=215-8
Water Level Elevation, ft MSL
110
100
90
80
70
60
50
40
30
20
10
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
215
216
217
218

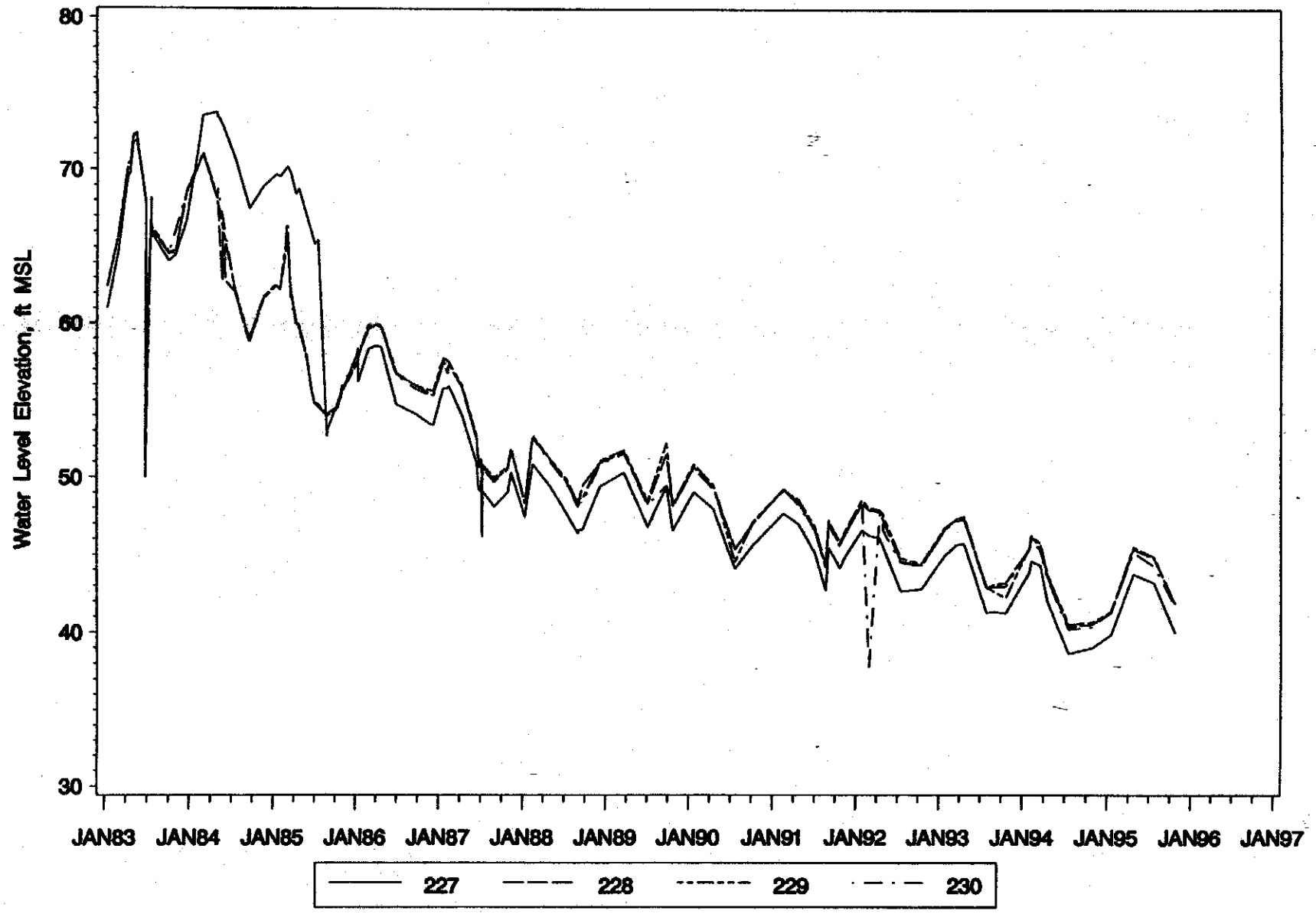
HYDROGRAPH

WELLS=219-22

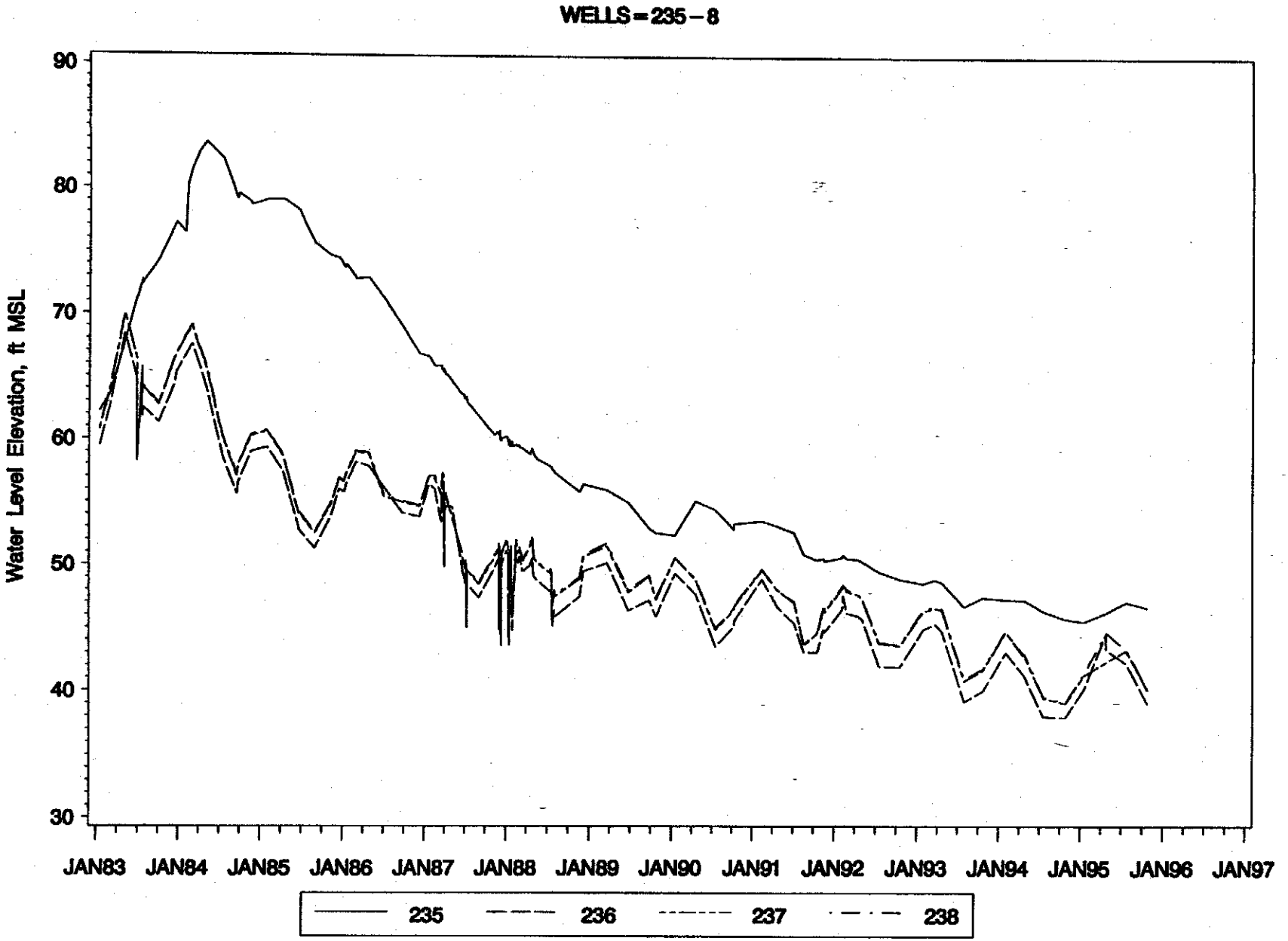


HYDROGRAPH

WELLS = 227 – 30

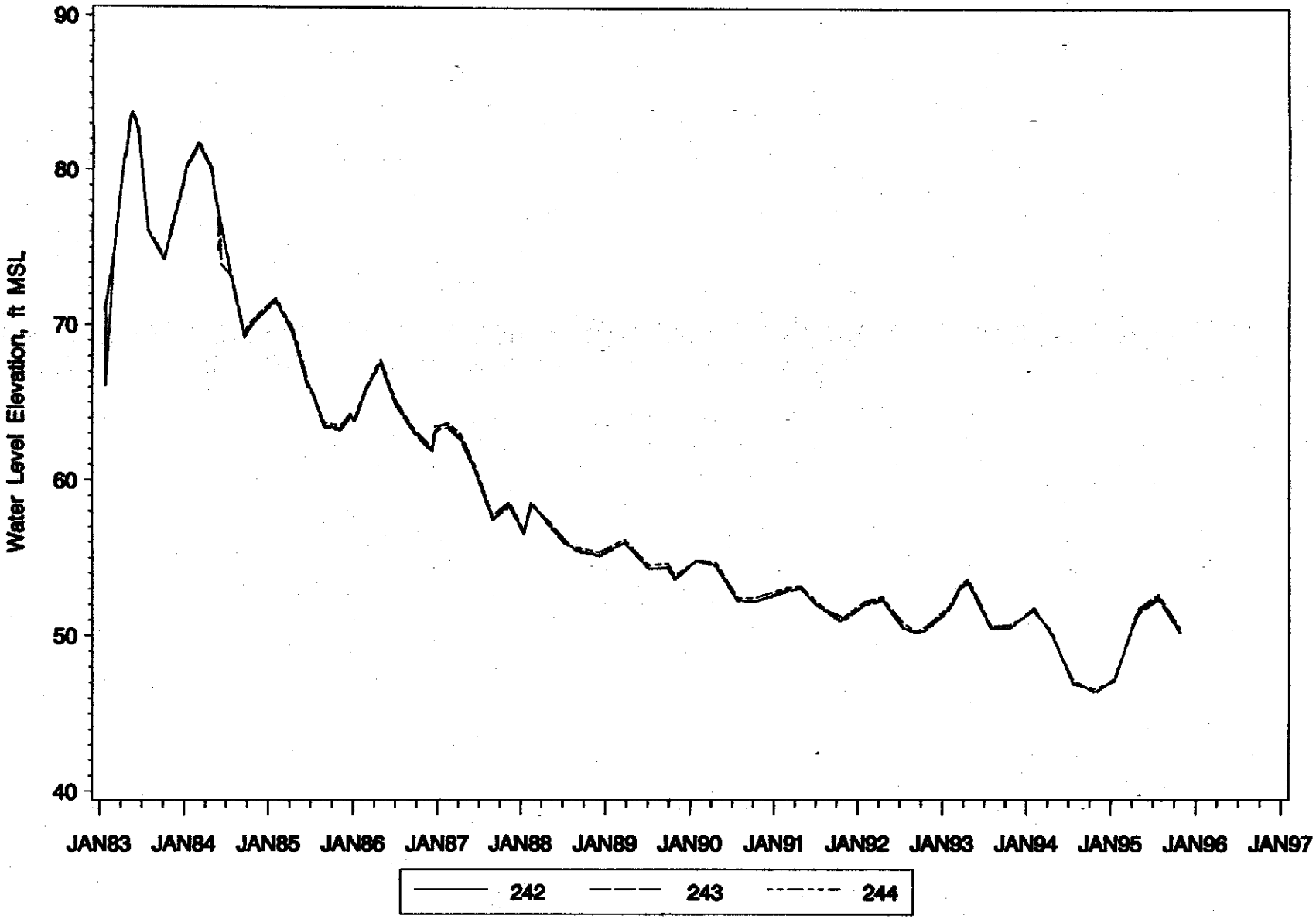


HYDROGRAPH


WELLS=235-8
Water Level Elevation, ft MSL
90
80
70
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
235
236
237
238

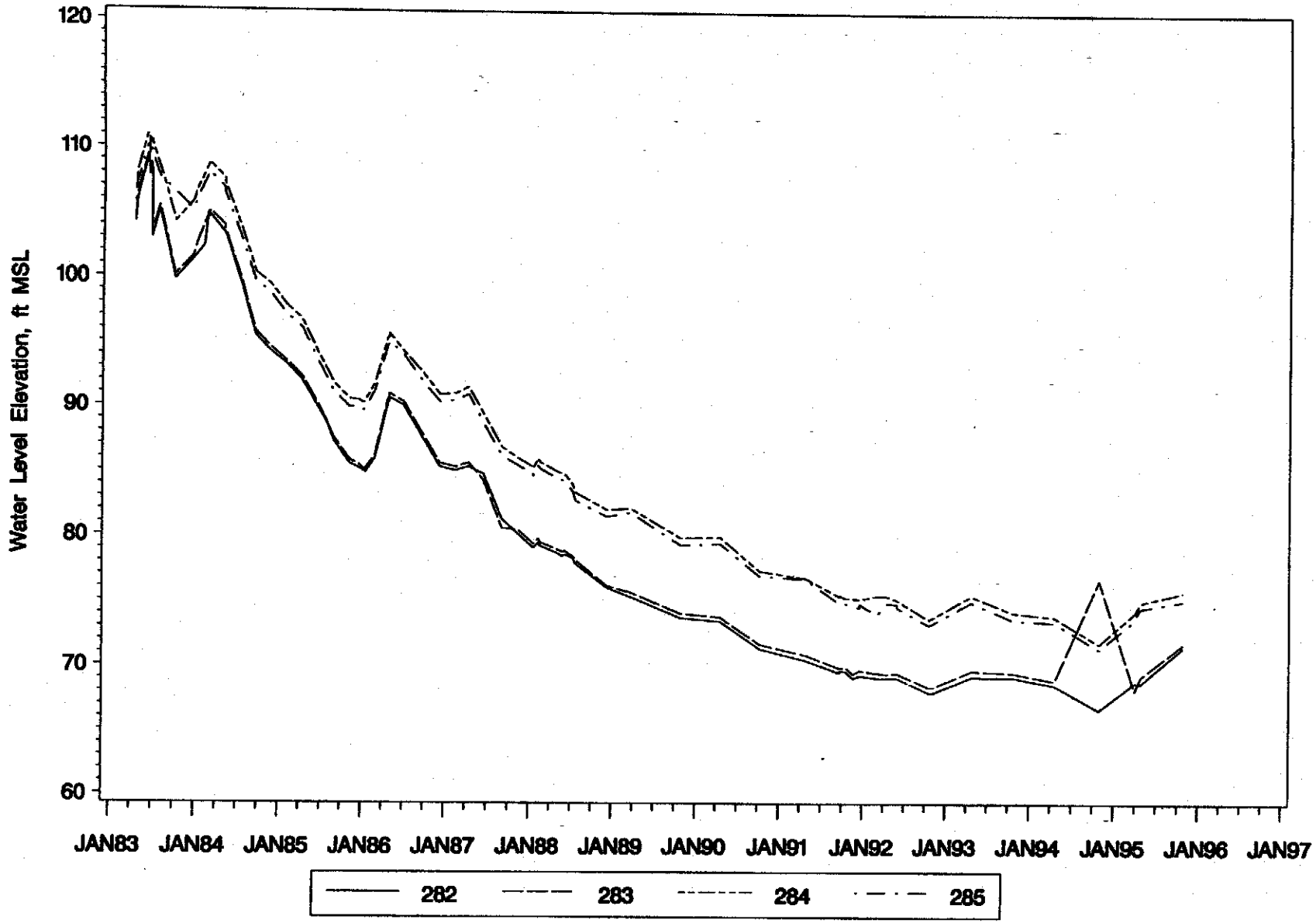
HYDROGRAPH

WELLS=242-4



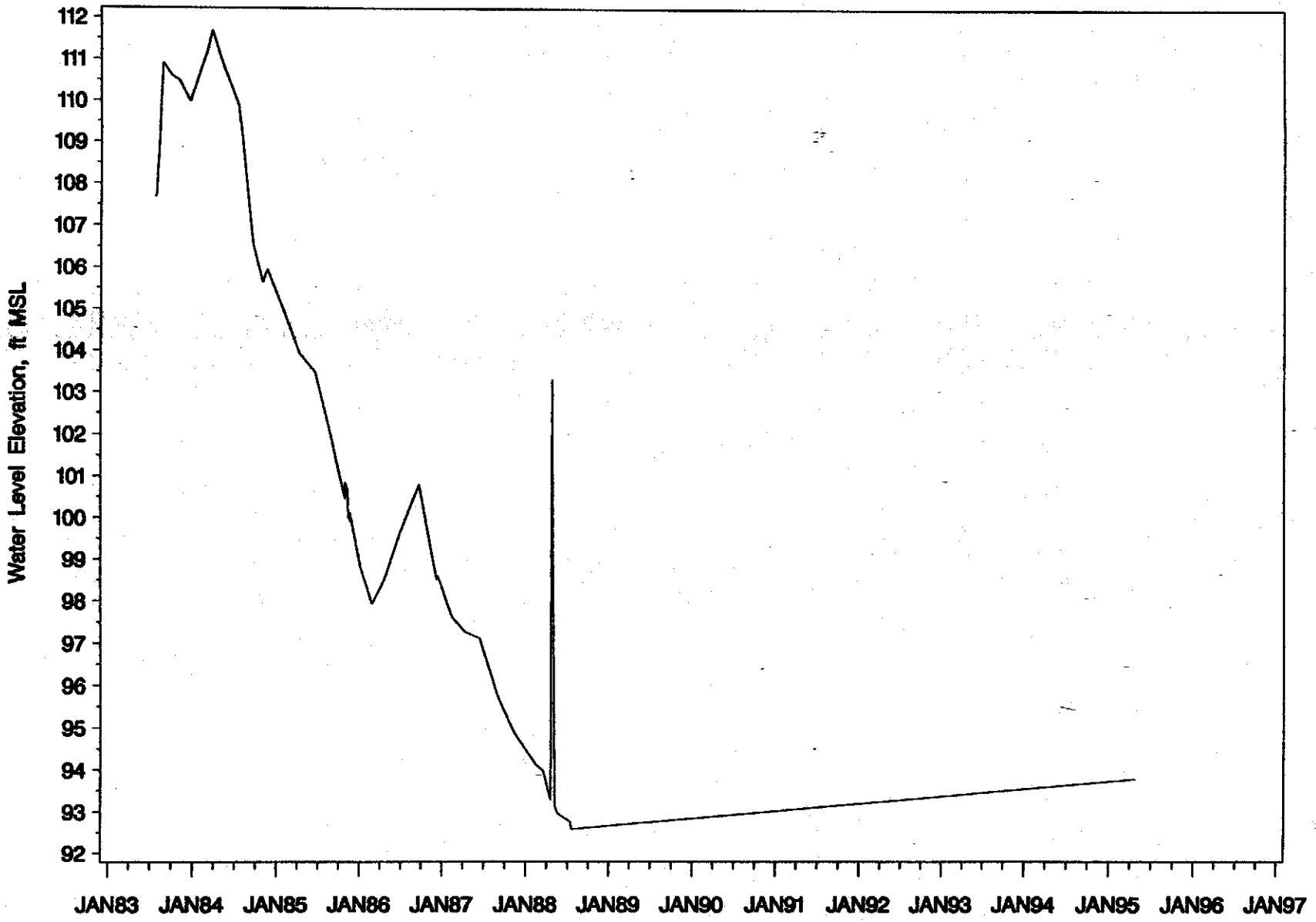
HYDROGRAPH

WELLS=282-5



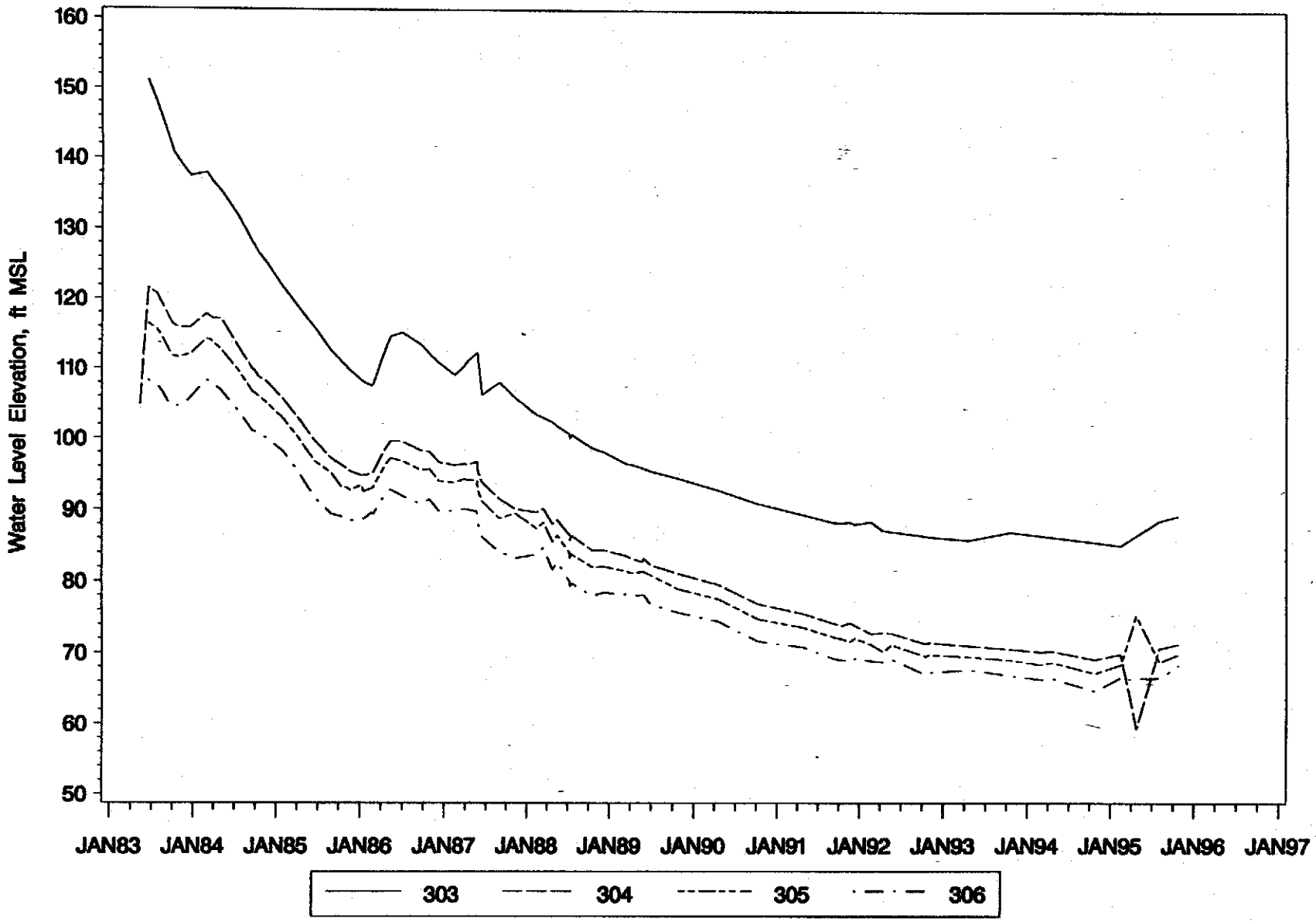
HYDROGRAPH

WELL=302

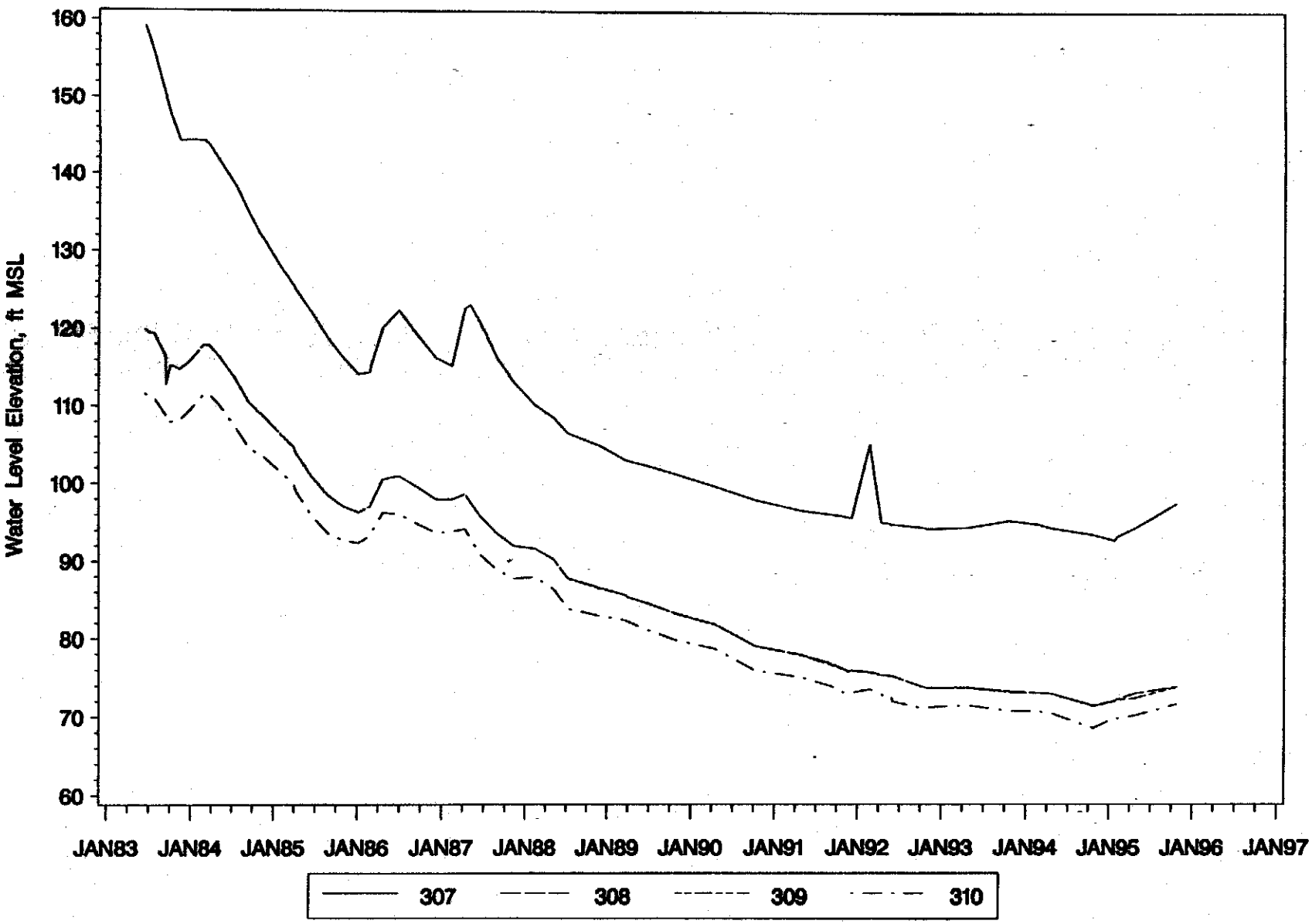


HYDR[redacted]RAPH

WELLS=303-6

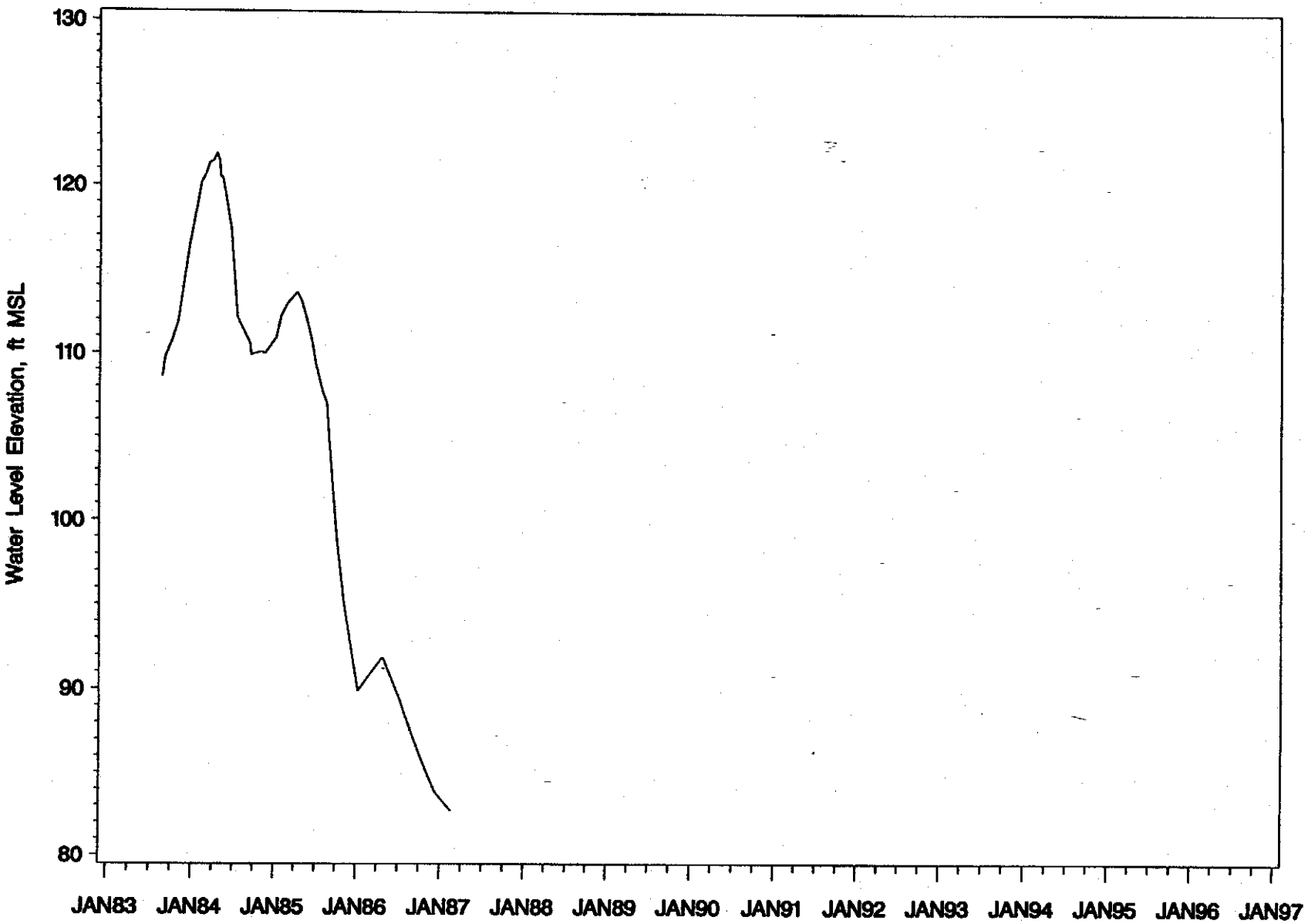


HYDROGRAPH


WELLS=307-10
Water Level Elevation, ft MSL
160
150
140
130
120
110
100
90
80
70
60
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
307
308
309
310

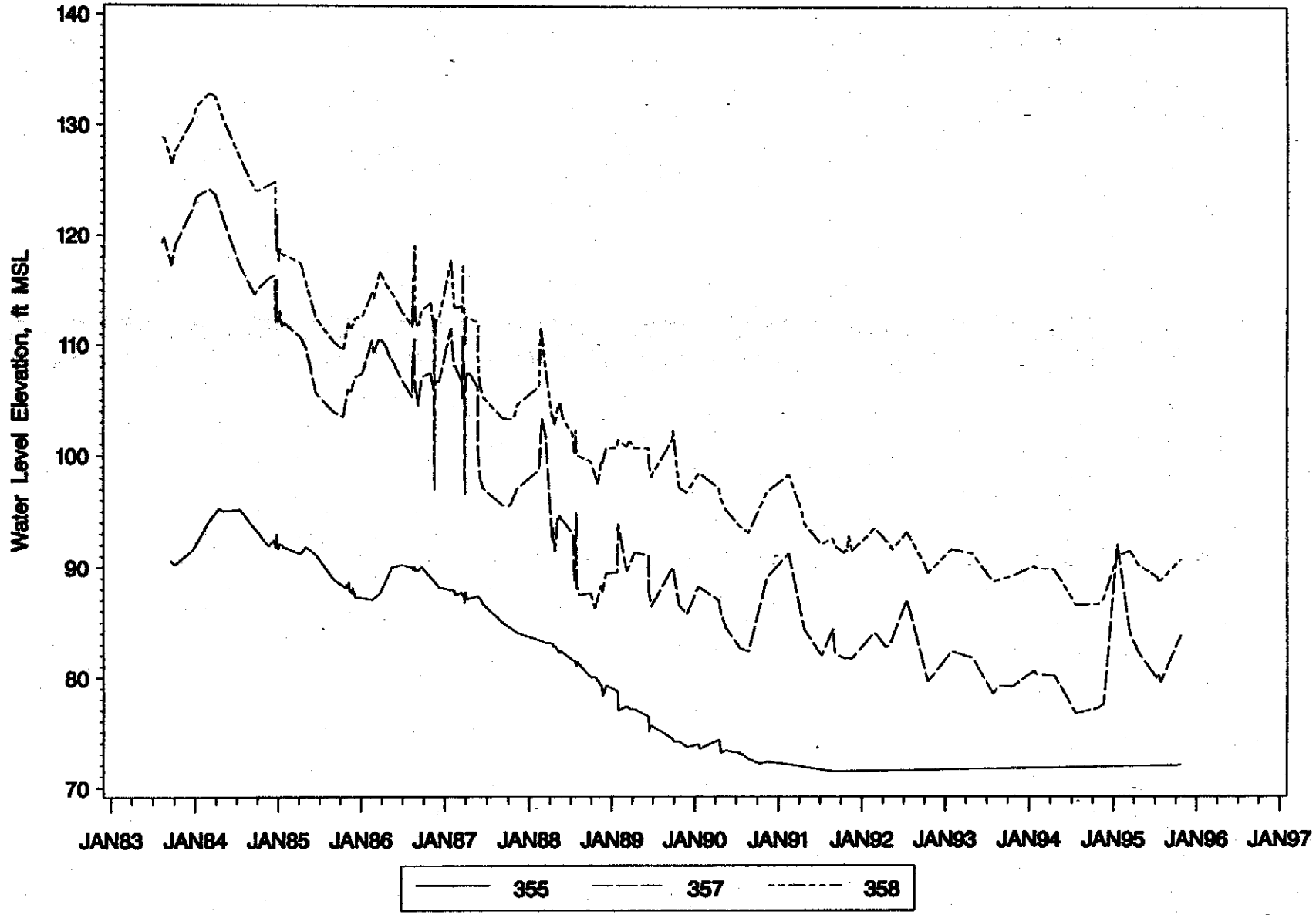
HYDROGRAPH

WELL = 330



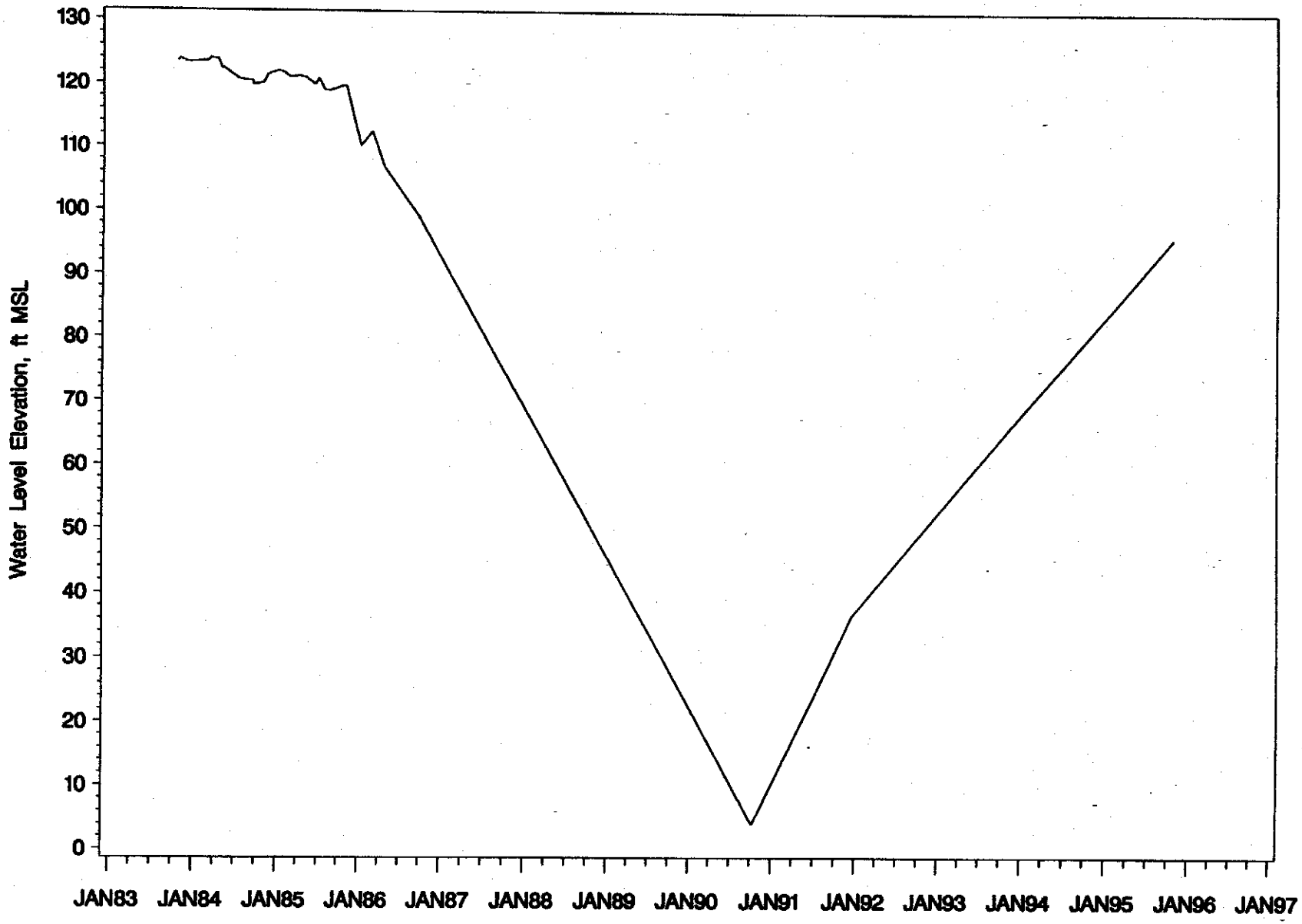
HYDROGRAPH

WELLS=355-8



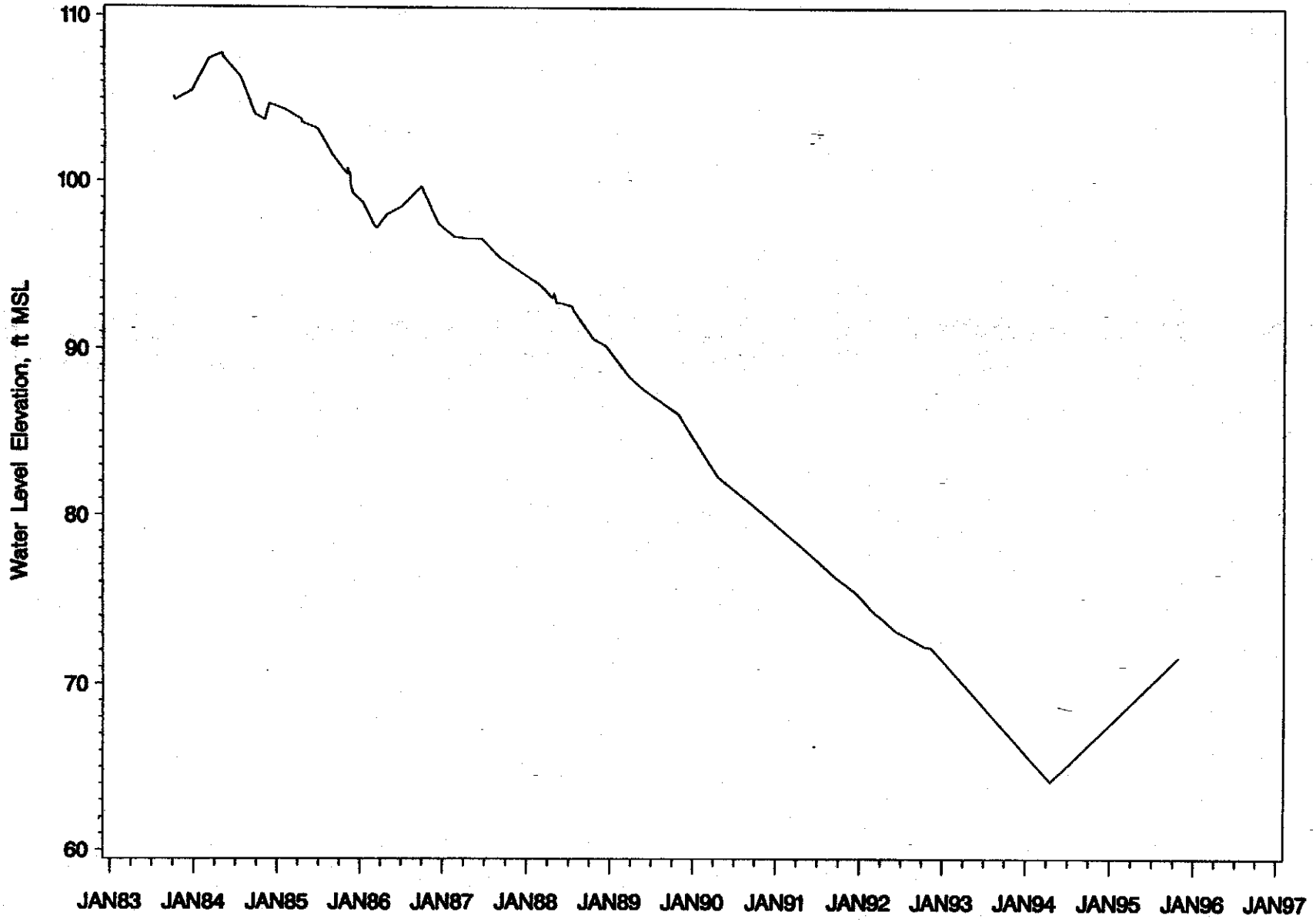
HYDROGRAPH

WELL=368



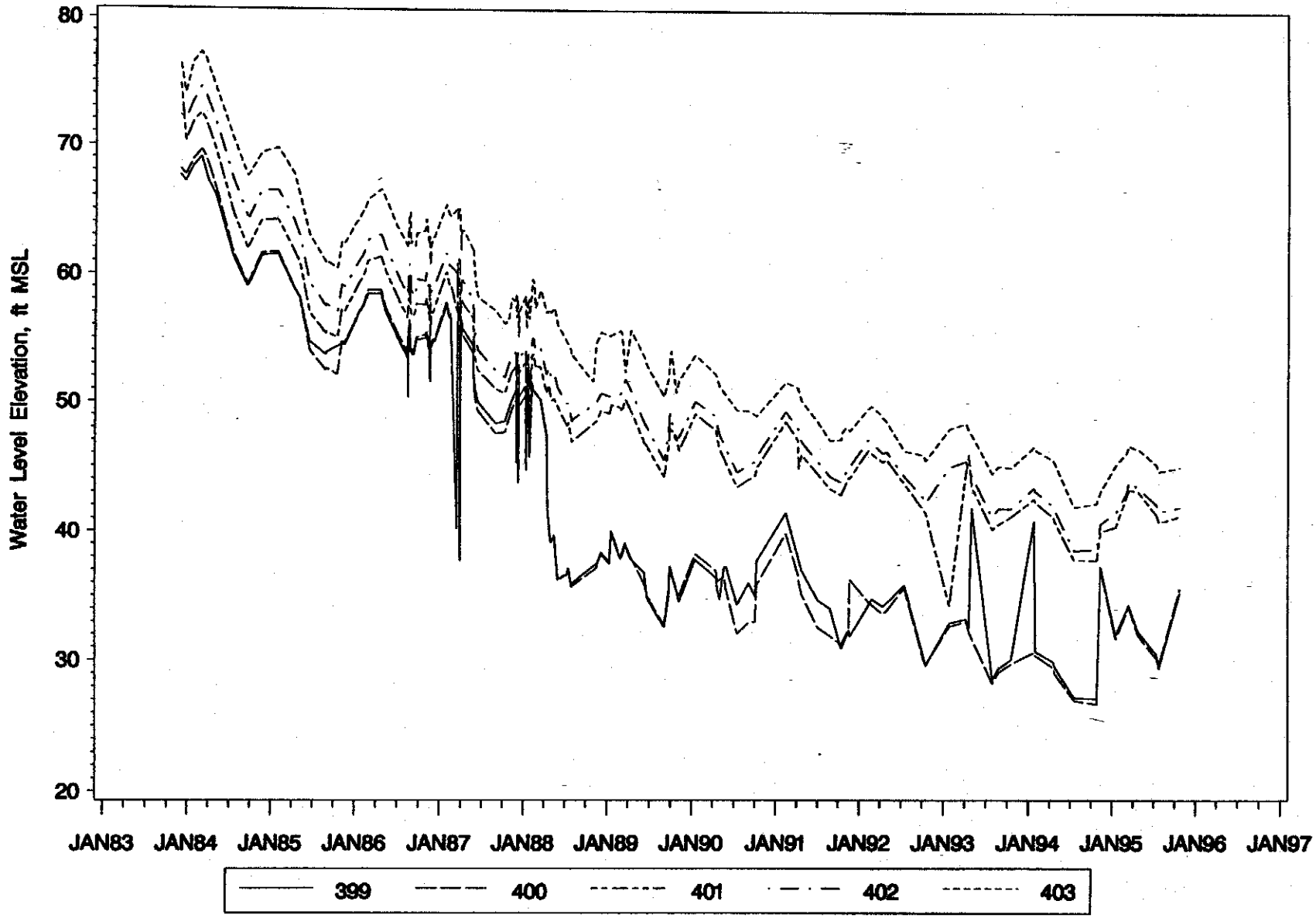
HYDROGRAPH

WELL=374



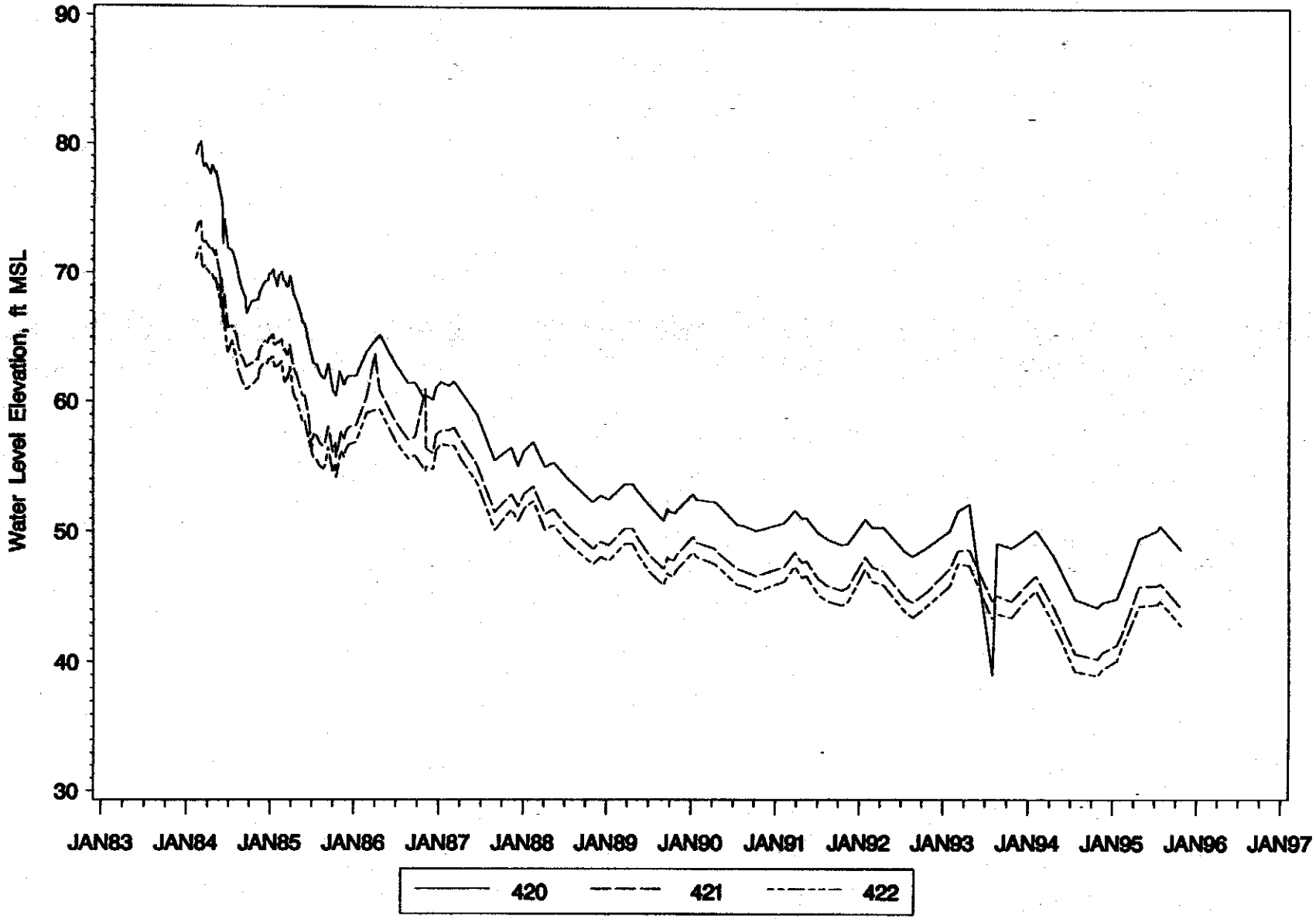
HYDROGRAPH

WELLS = 399 – 403



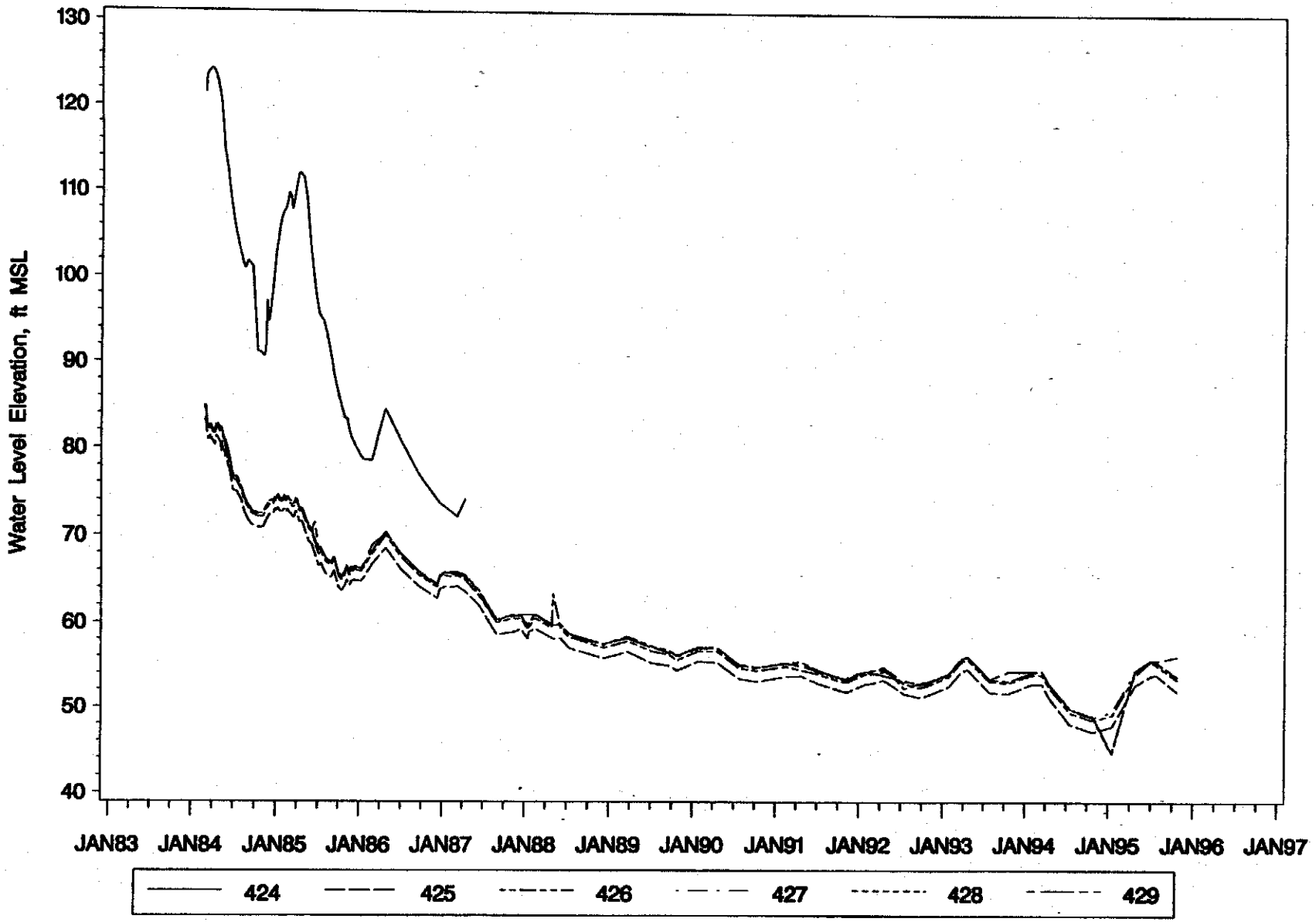
HYDROGRAPH

WELLS = 420 – 2



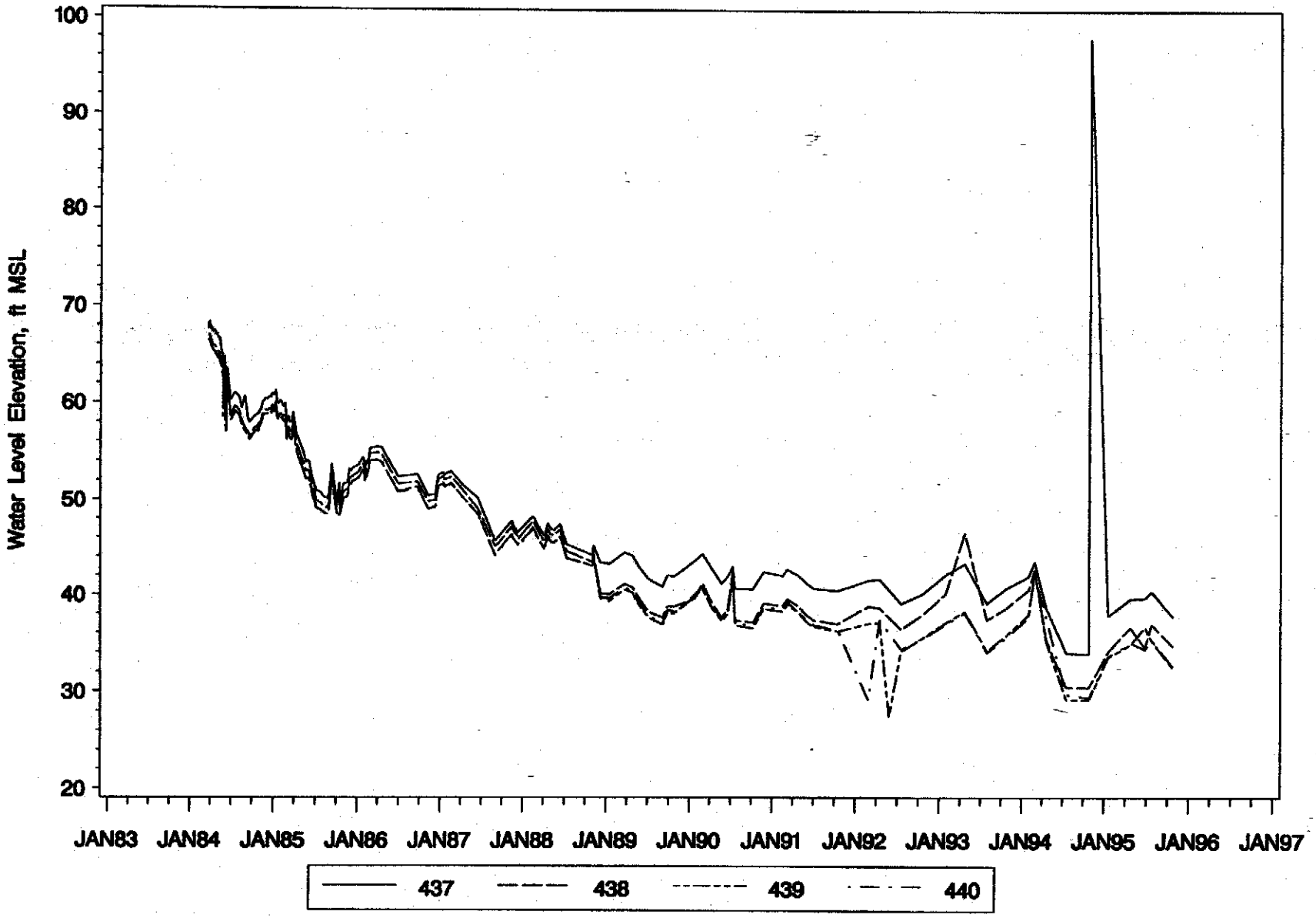
HYDROGRAPH

WELLS=424-9



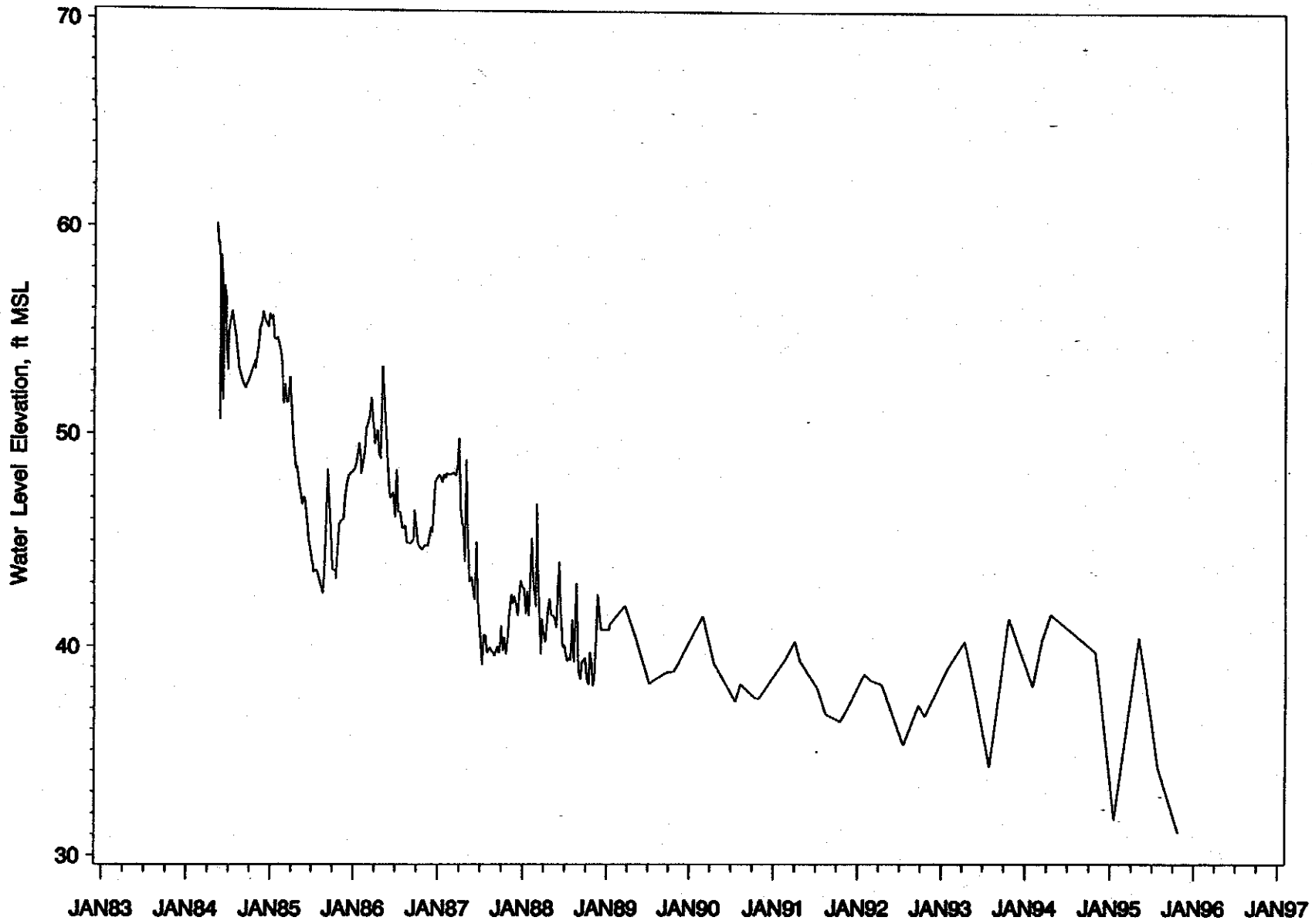
HYDROGRAPH

WELLS = 437 – 40



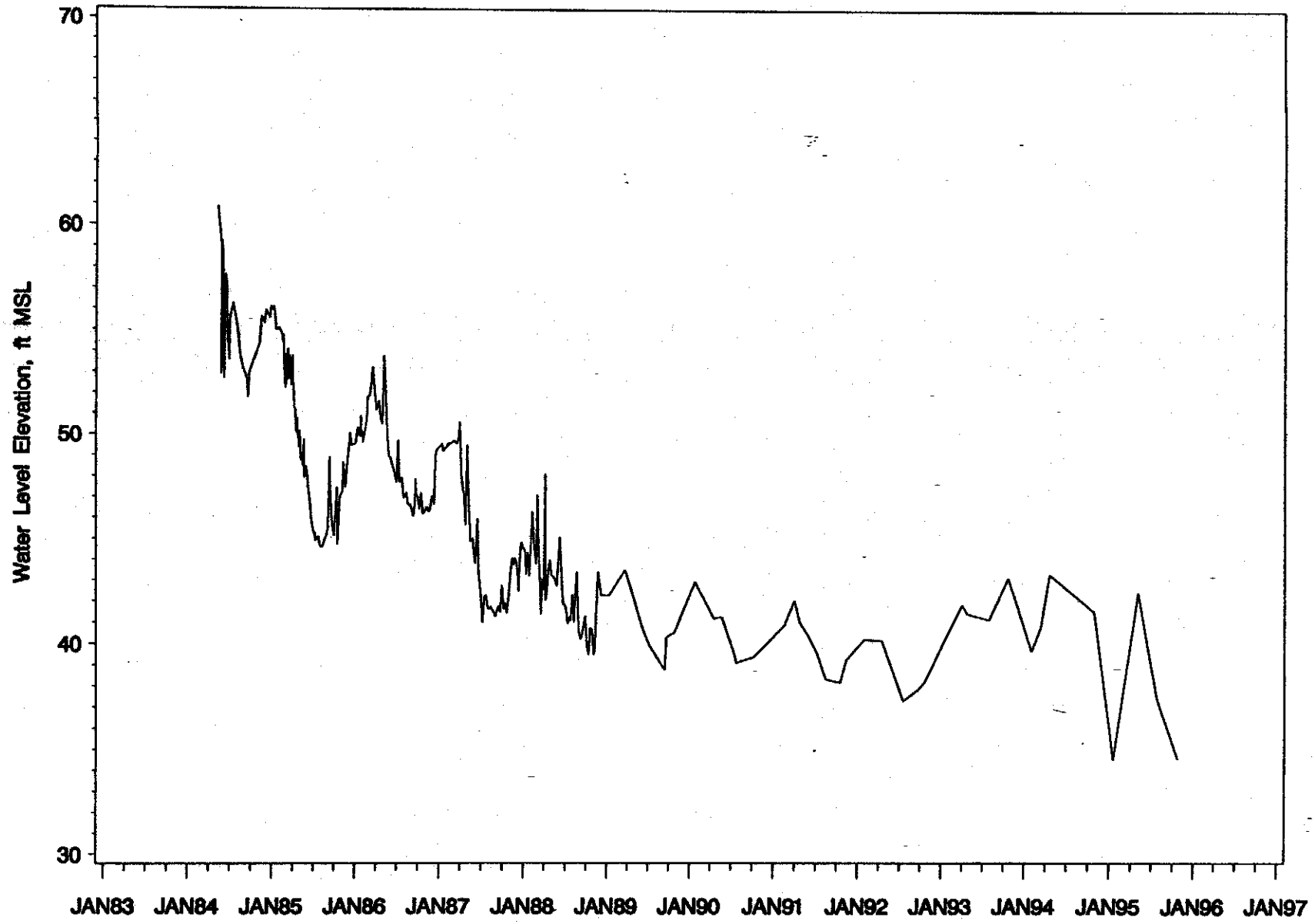
HYDROGRAPH

WELL=446



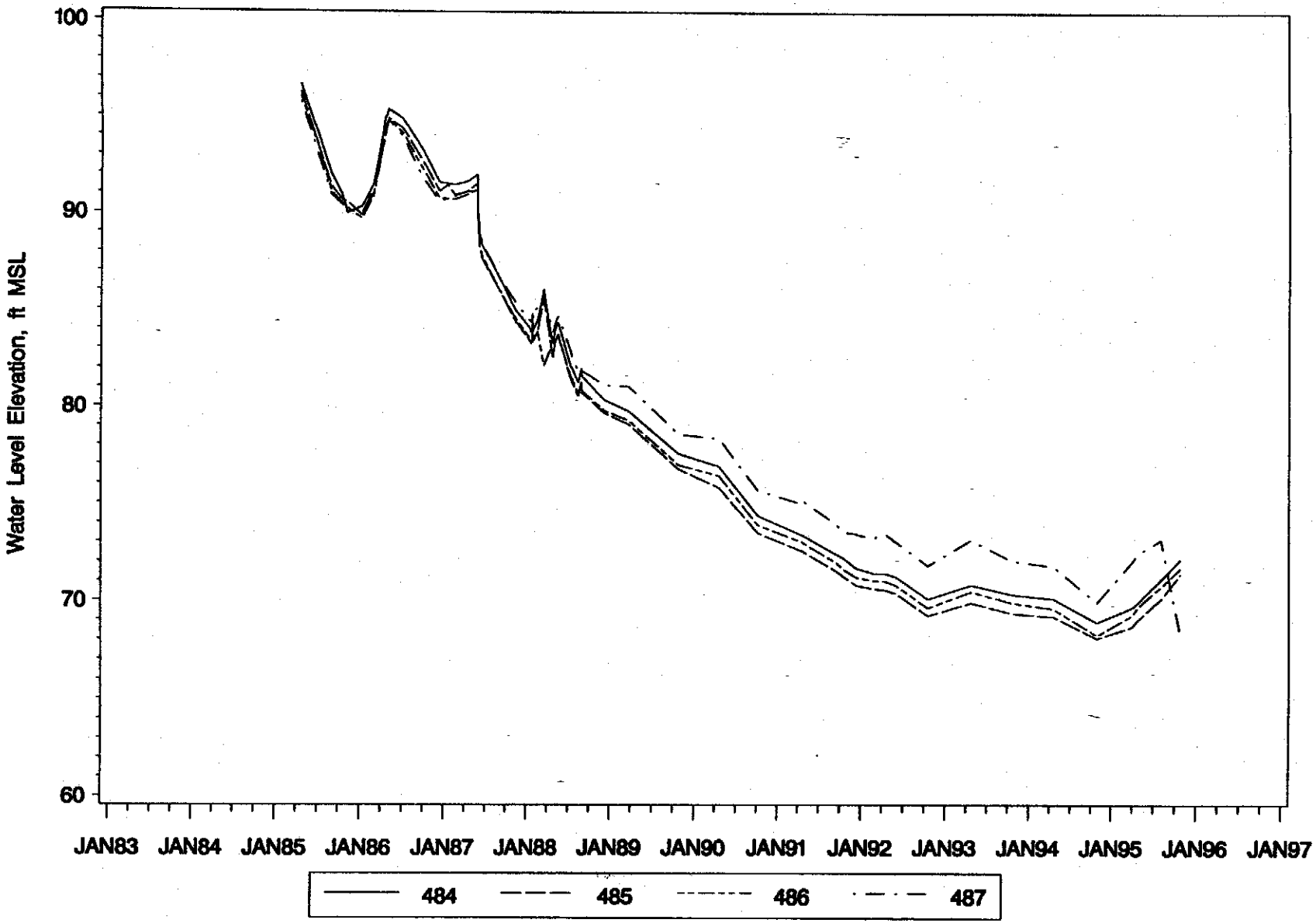
HYDROGRAPH

WELL=447



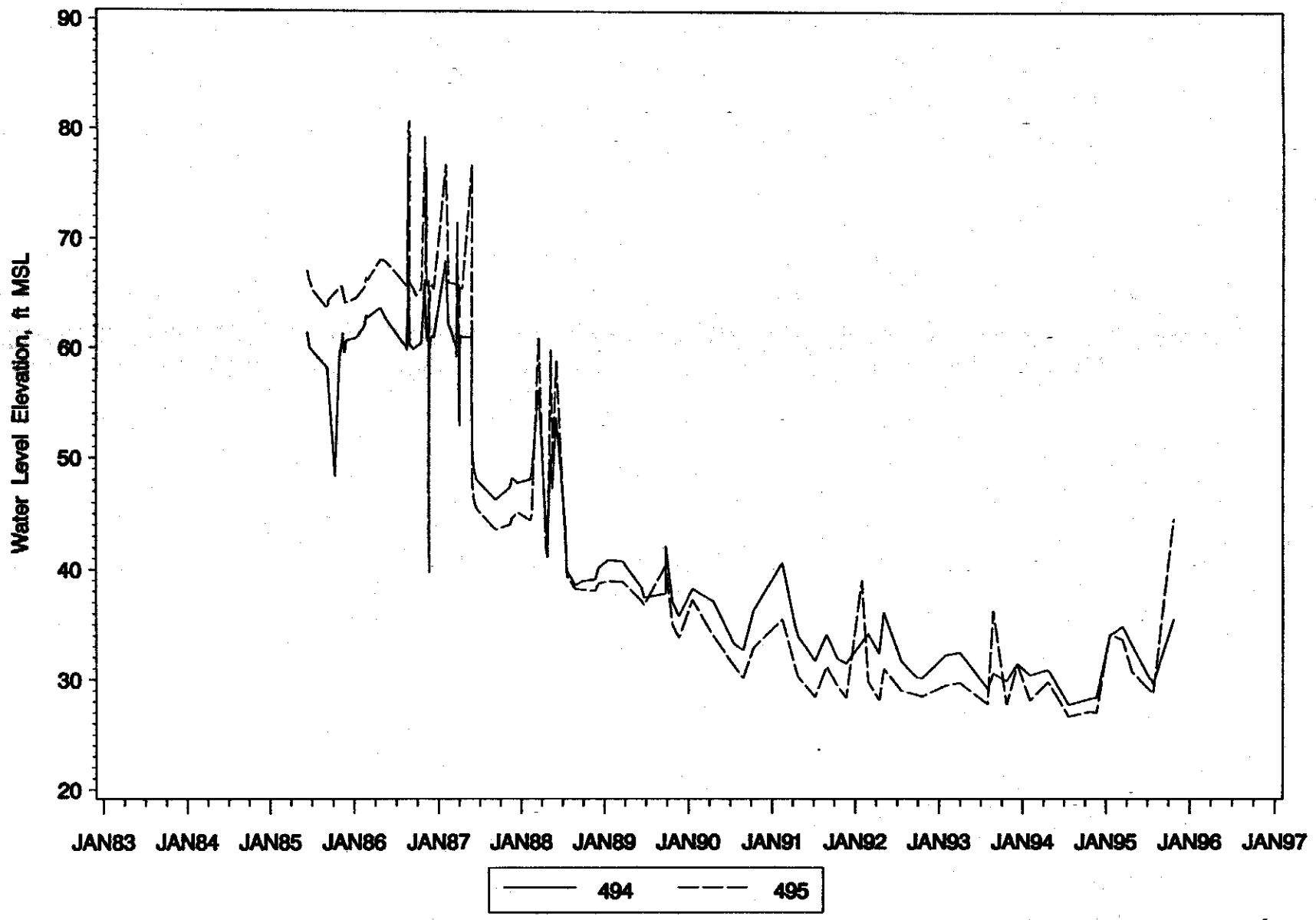
HYDROGRAPH

WELLS=484-7



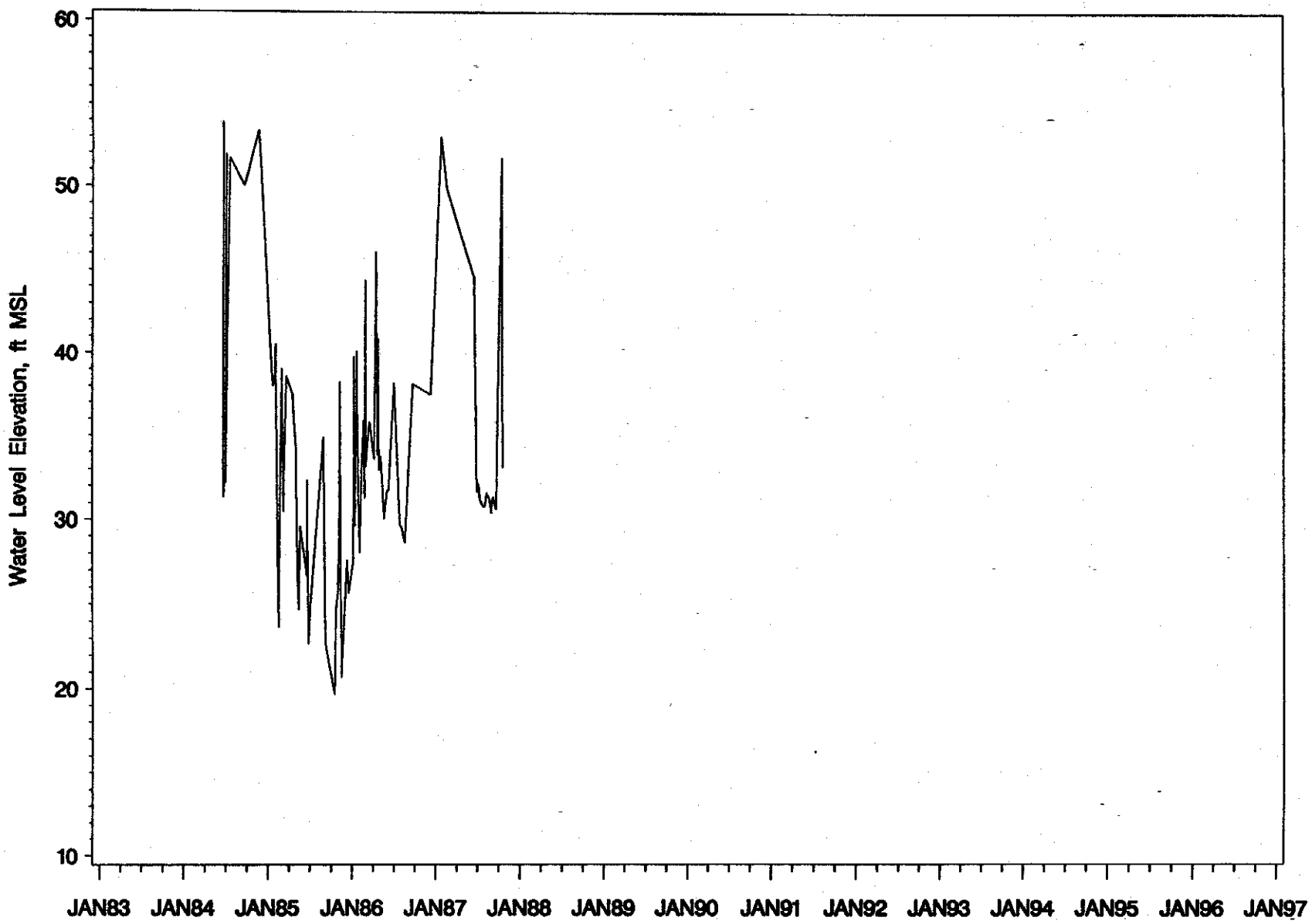
HYDROGRAPH

WELLS=494-5



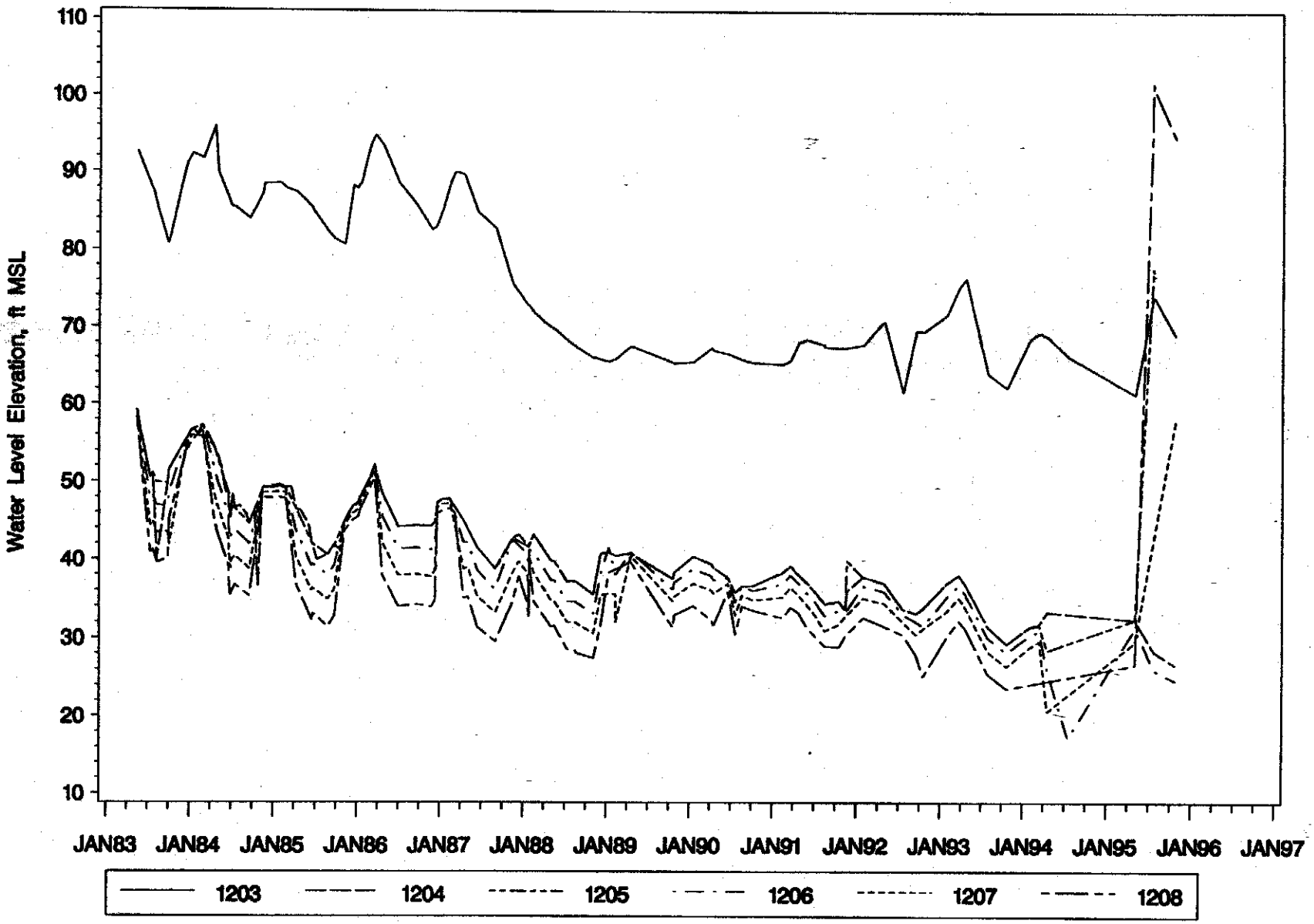
HYDROGRAPH

WELL=1016



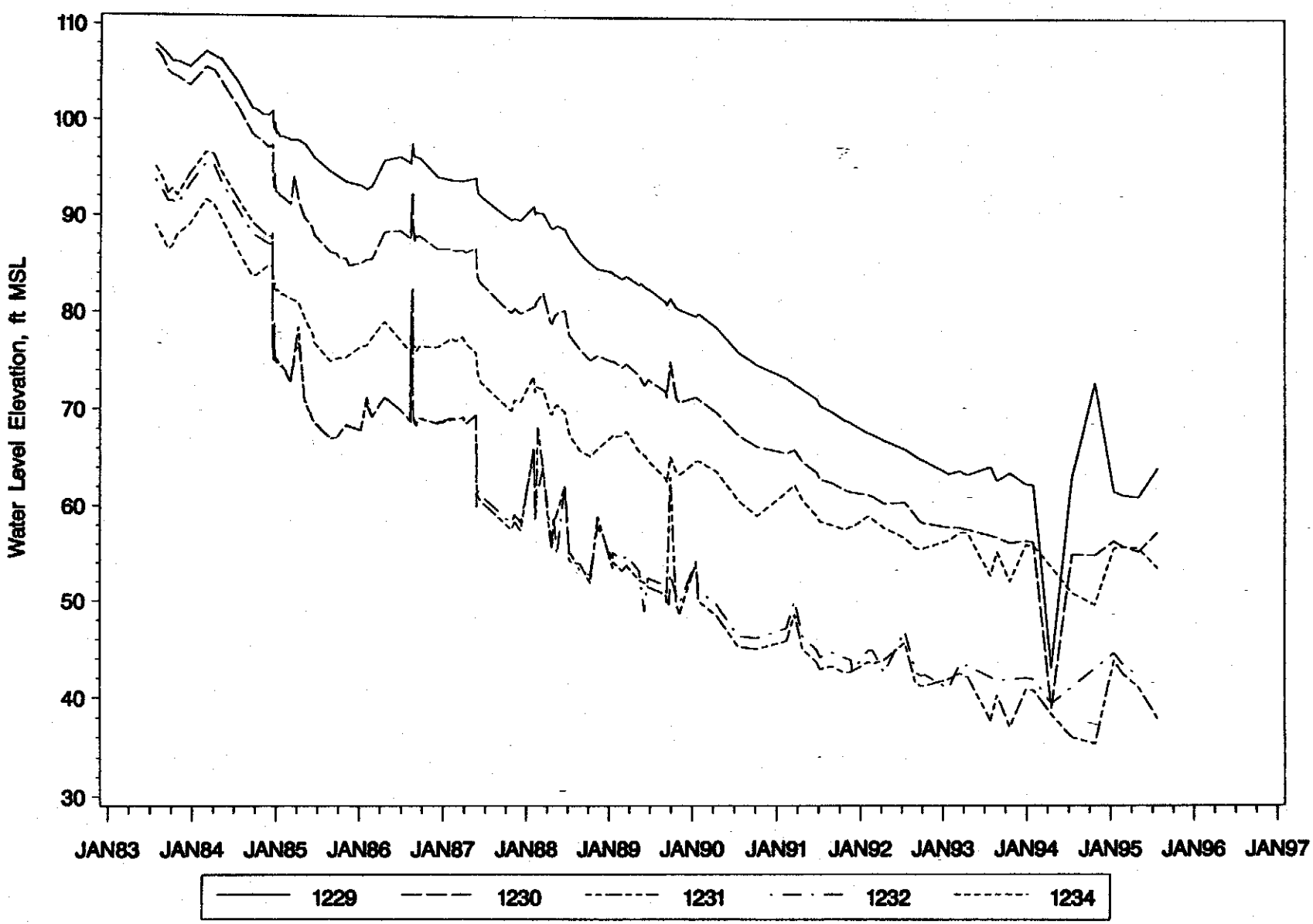
HYDROGRAPH

WELLS = 1203 – 8

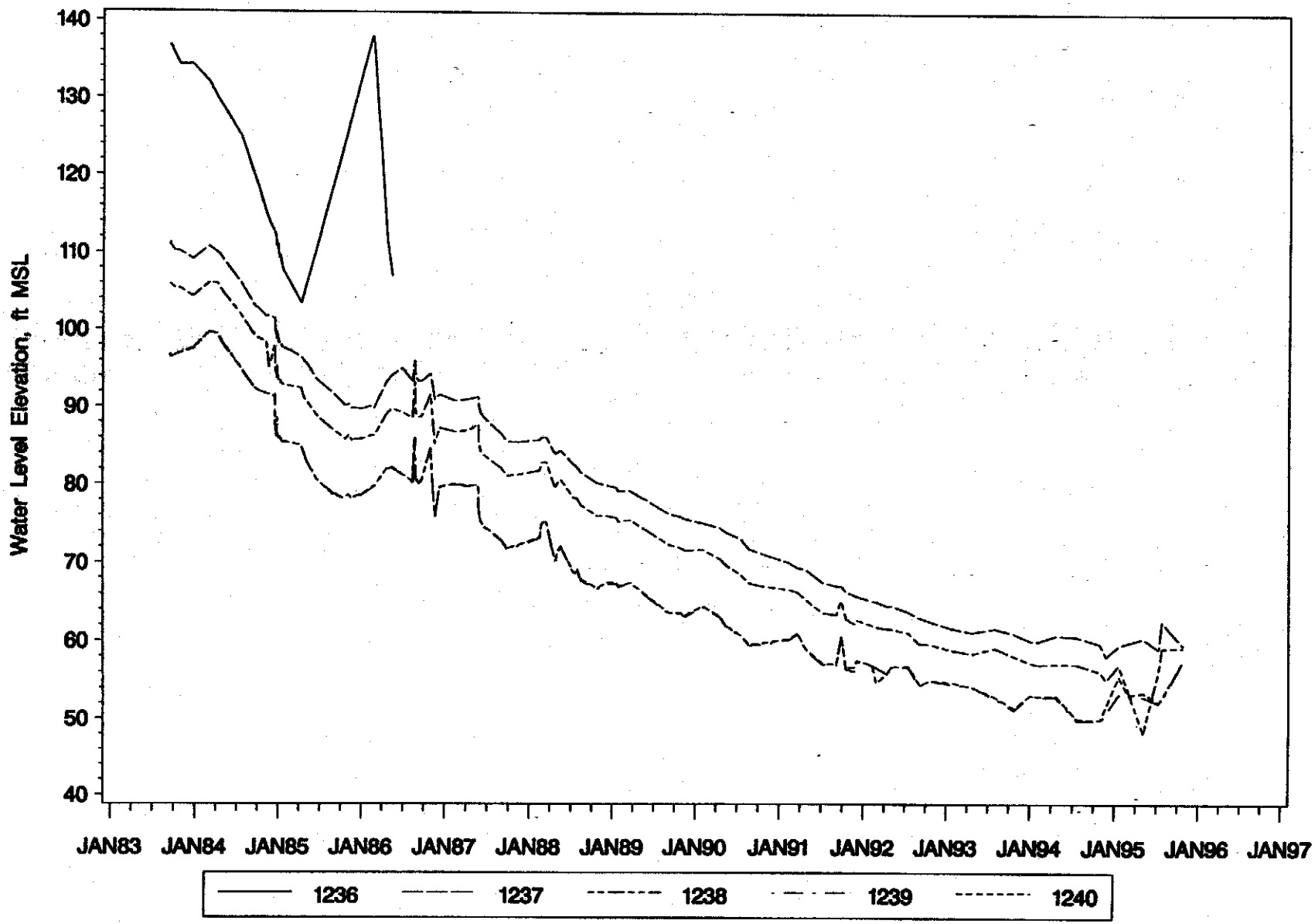


HYDROGRAPH

WELLS = 1229 – 34

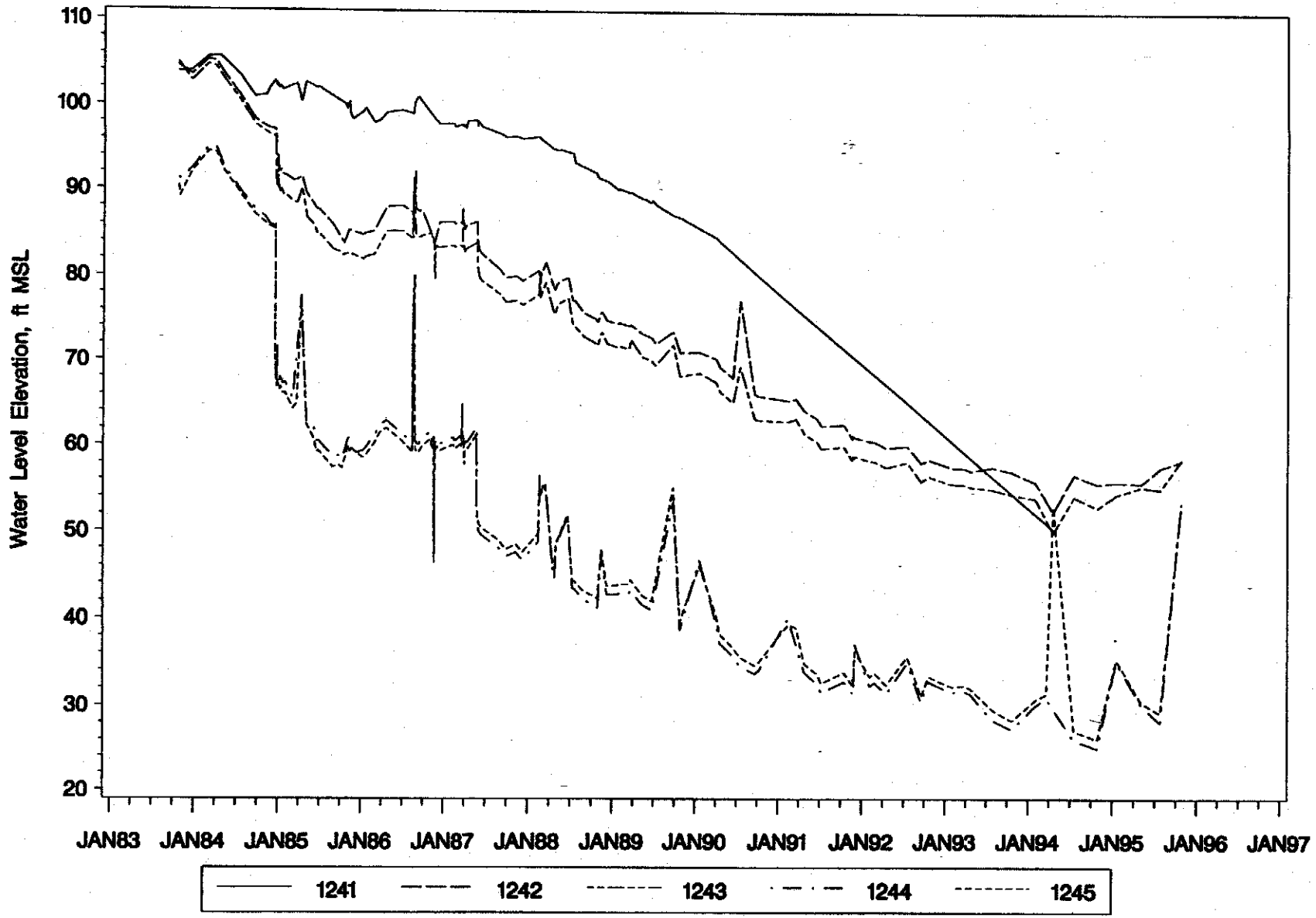


HYDROGRAPH


WELLS = 1236 – 40
Water Level Elevation, ft MSL
140
130
120
110
100
90
80
70
60
50
40
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
1236
1237
1238
1239
1240

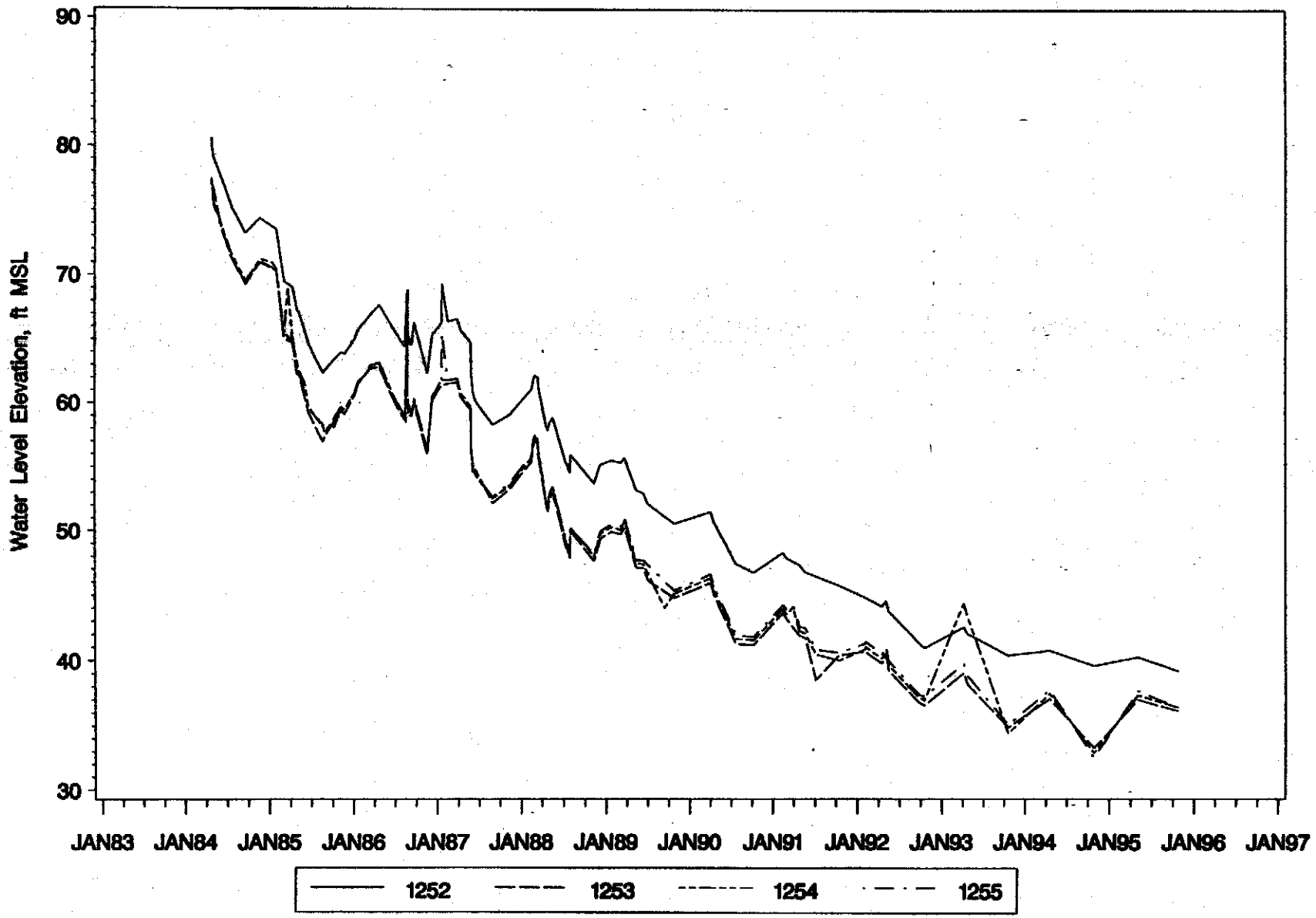
HYDROGRAPH

WELLS = 1241 – 5



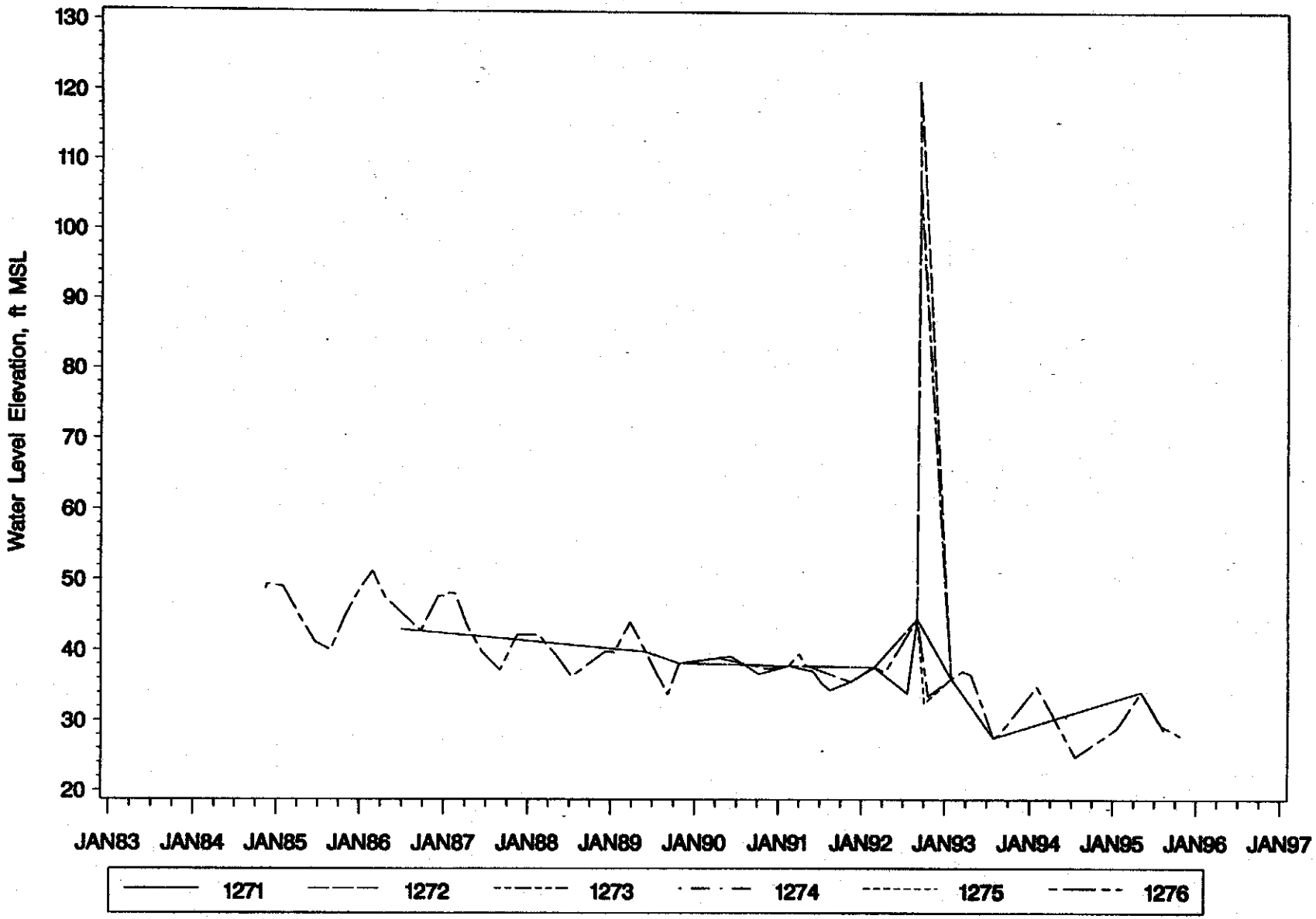
HYDROGRAPH

WELLS = 1251 – 5



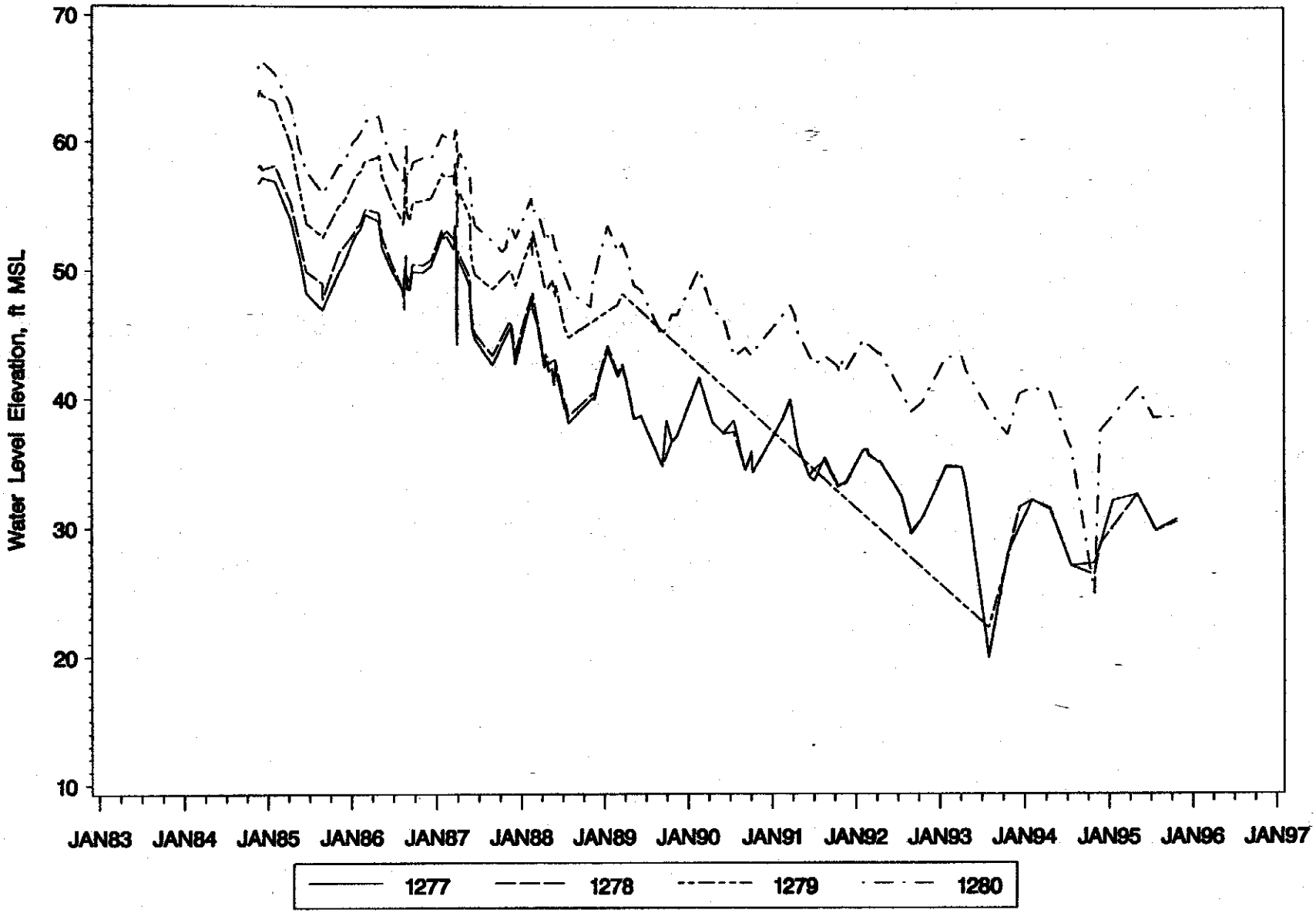
HYDROGRAPH

WELLS=1271-6

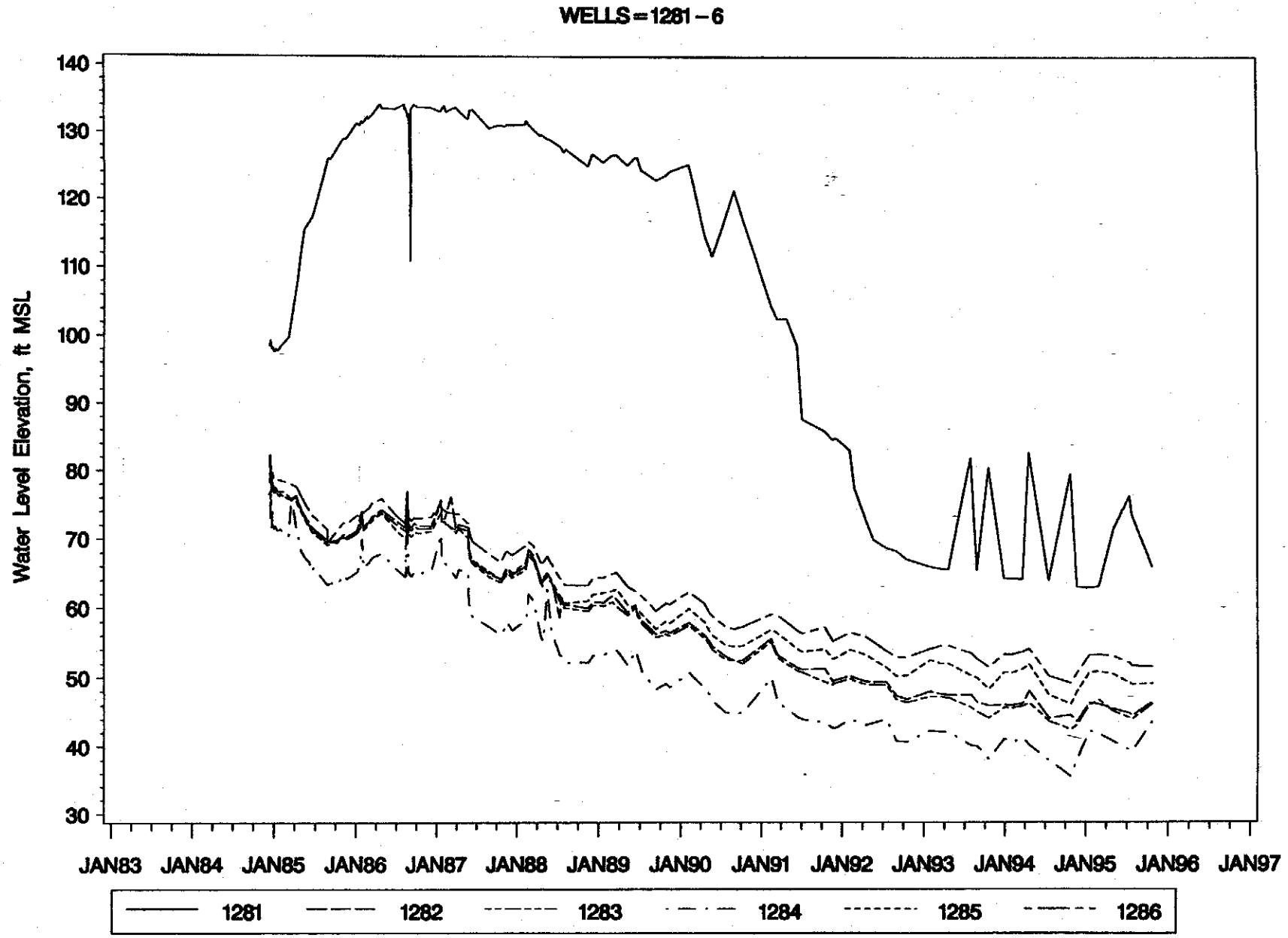


HYDROGRAPH

WELLS = 1277 – 80

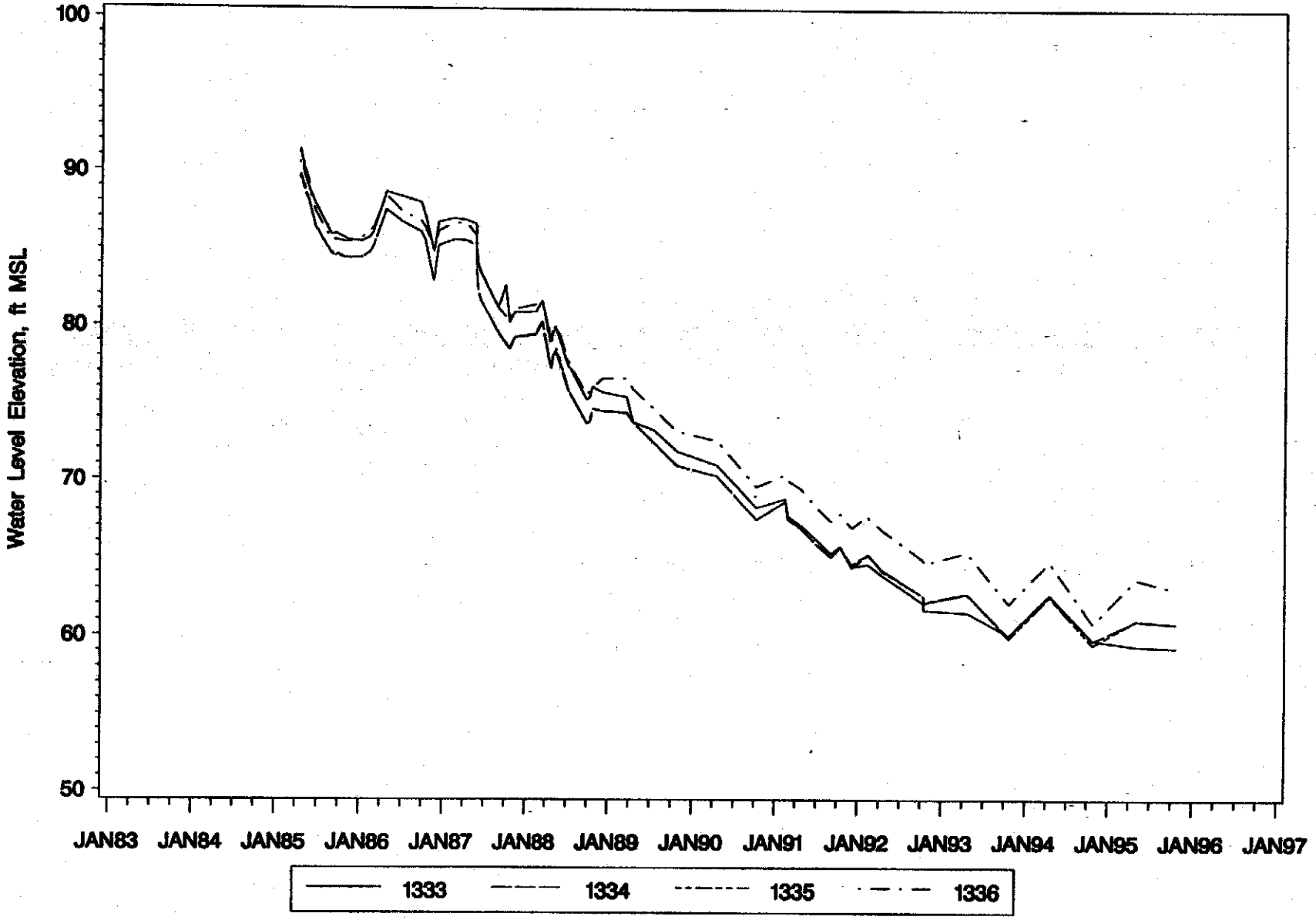


HYDROGRAPH


WELLS=1281-6
Water Level Elevation, ft MSL
140
130
120
110
100
90
80
70
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
1281
1282
1283
1284
1285
1286

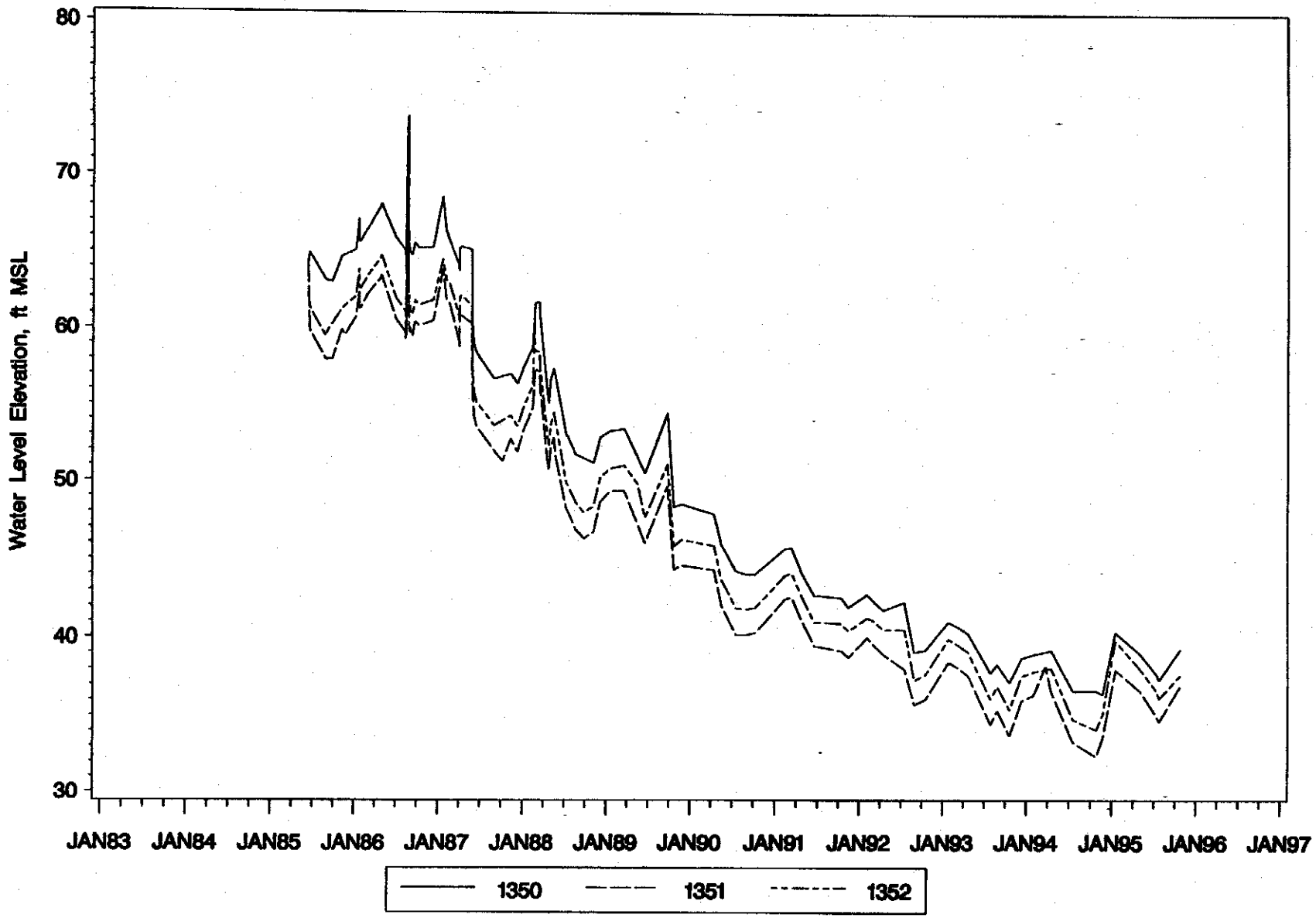
HYDROGRAPH

WELLS = 1333 – 6



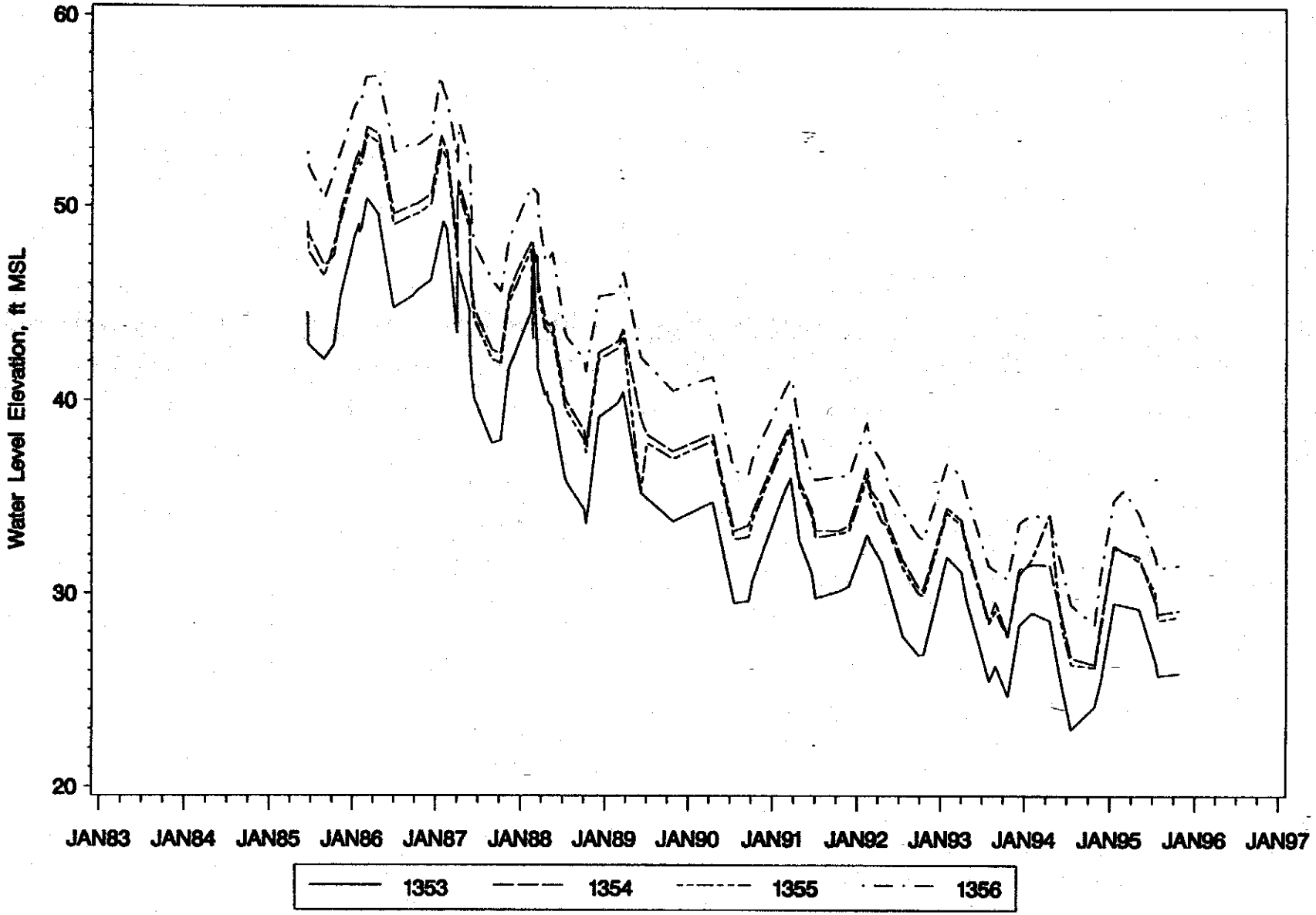
HYDROGRAPH

WELLS=1350-2



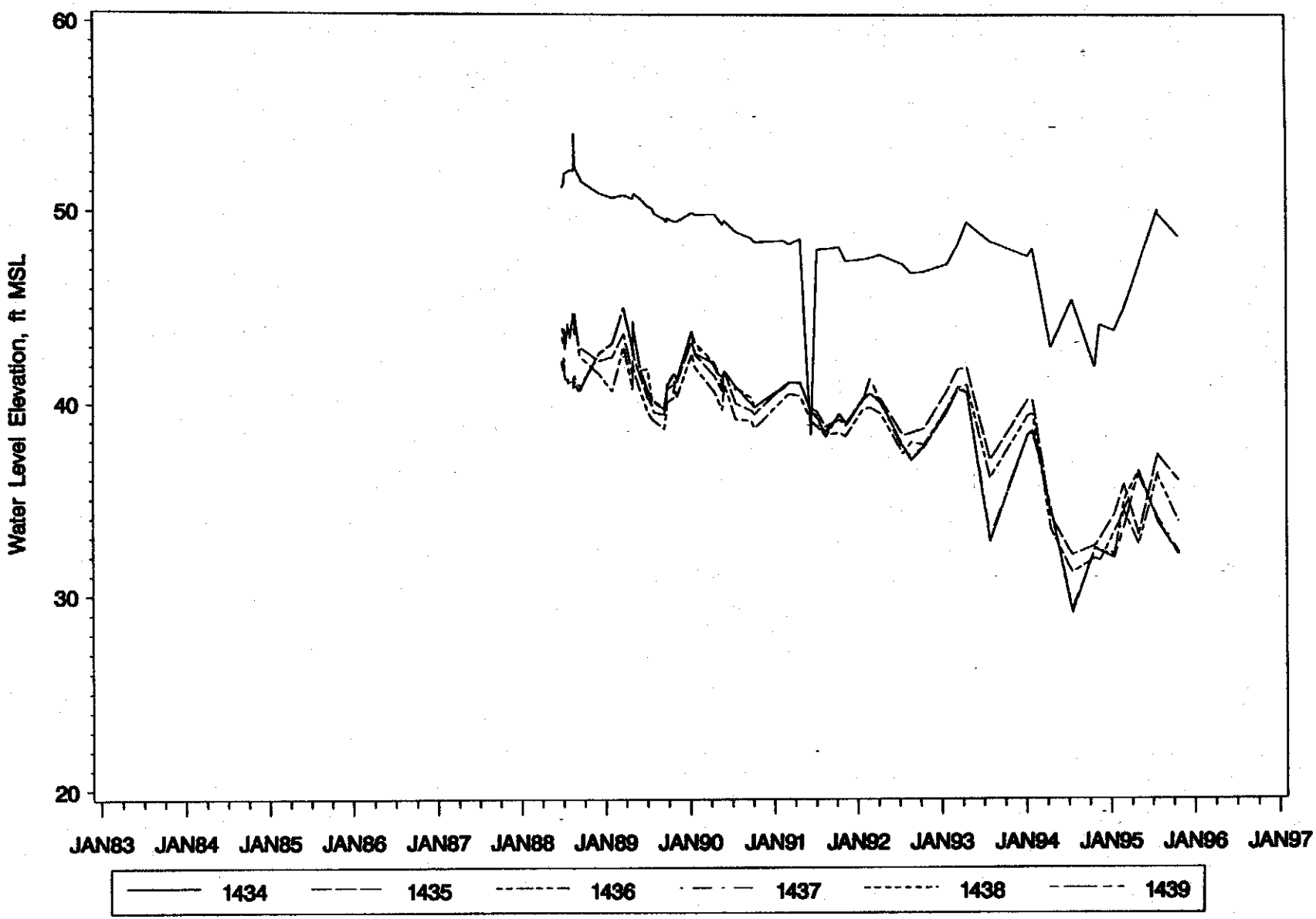
HYDROGRAPH

WELLS = 1353 – 6



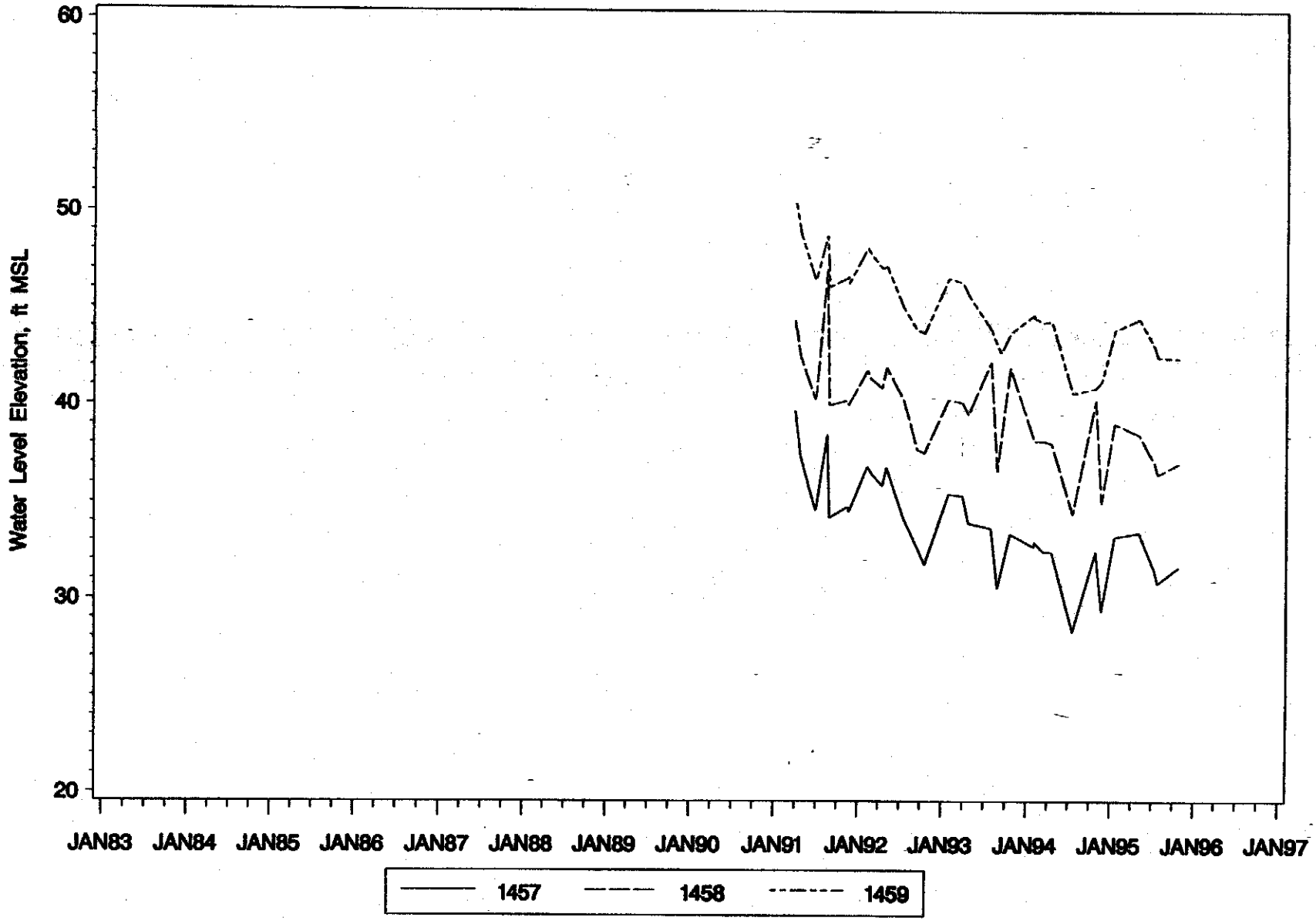
HYDROGRAPH

WELLS = 1434 – 9



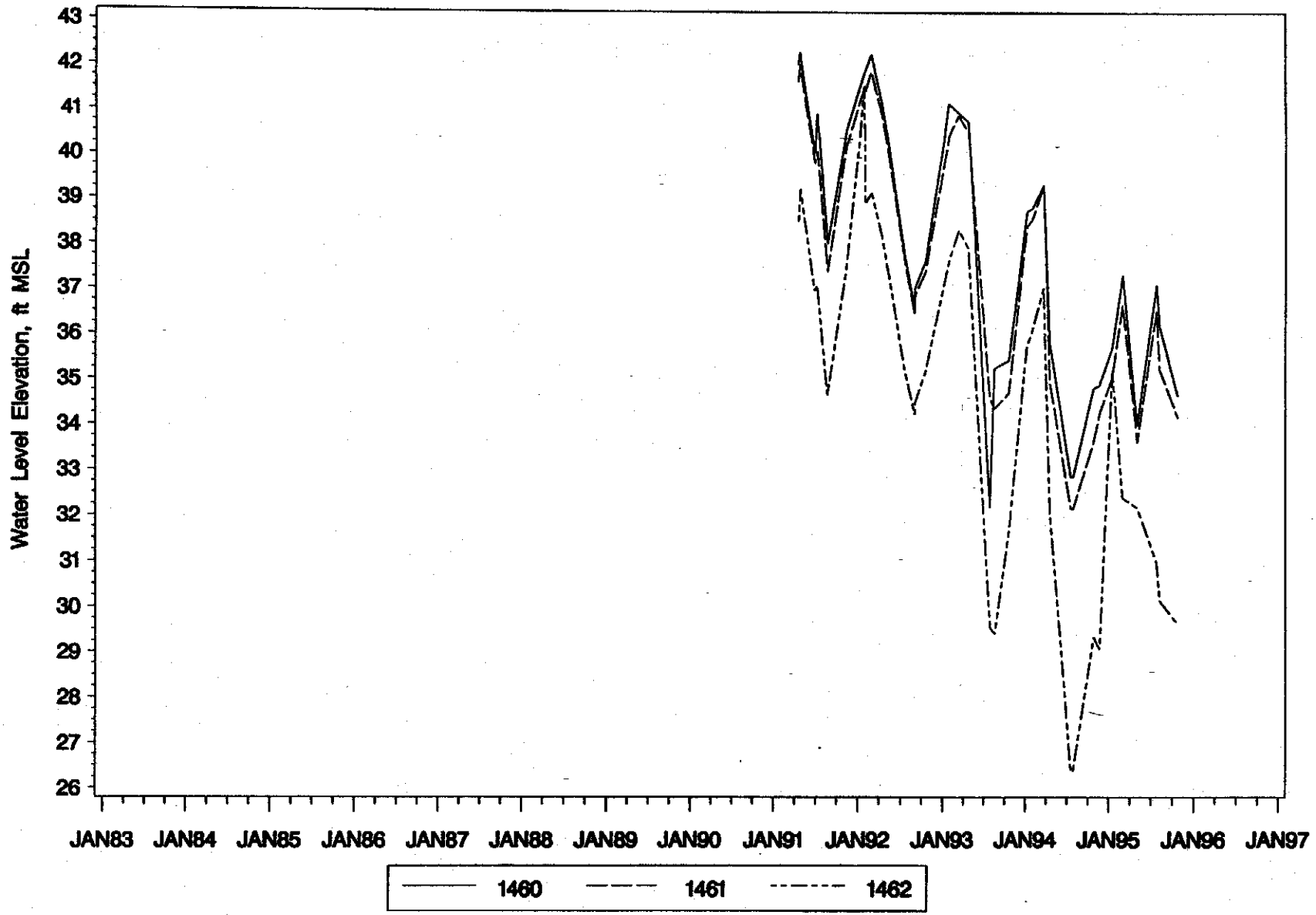
HYDROGRAPH

WELLS=1457-9

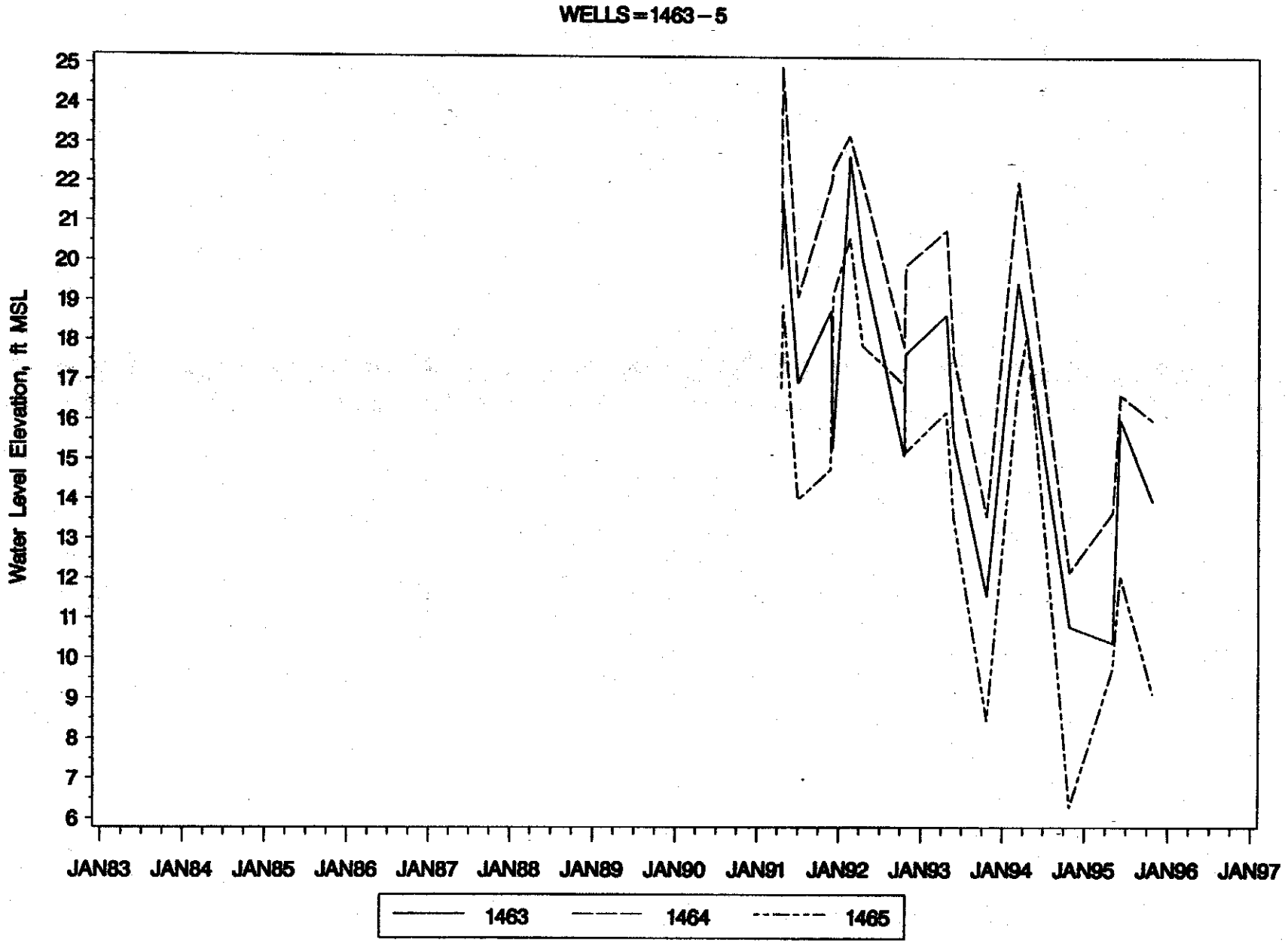


HYDROGRAPH

WELLS=1460-2

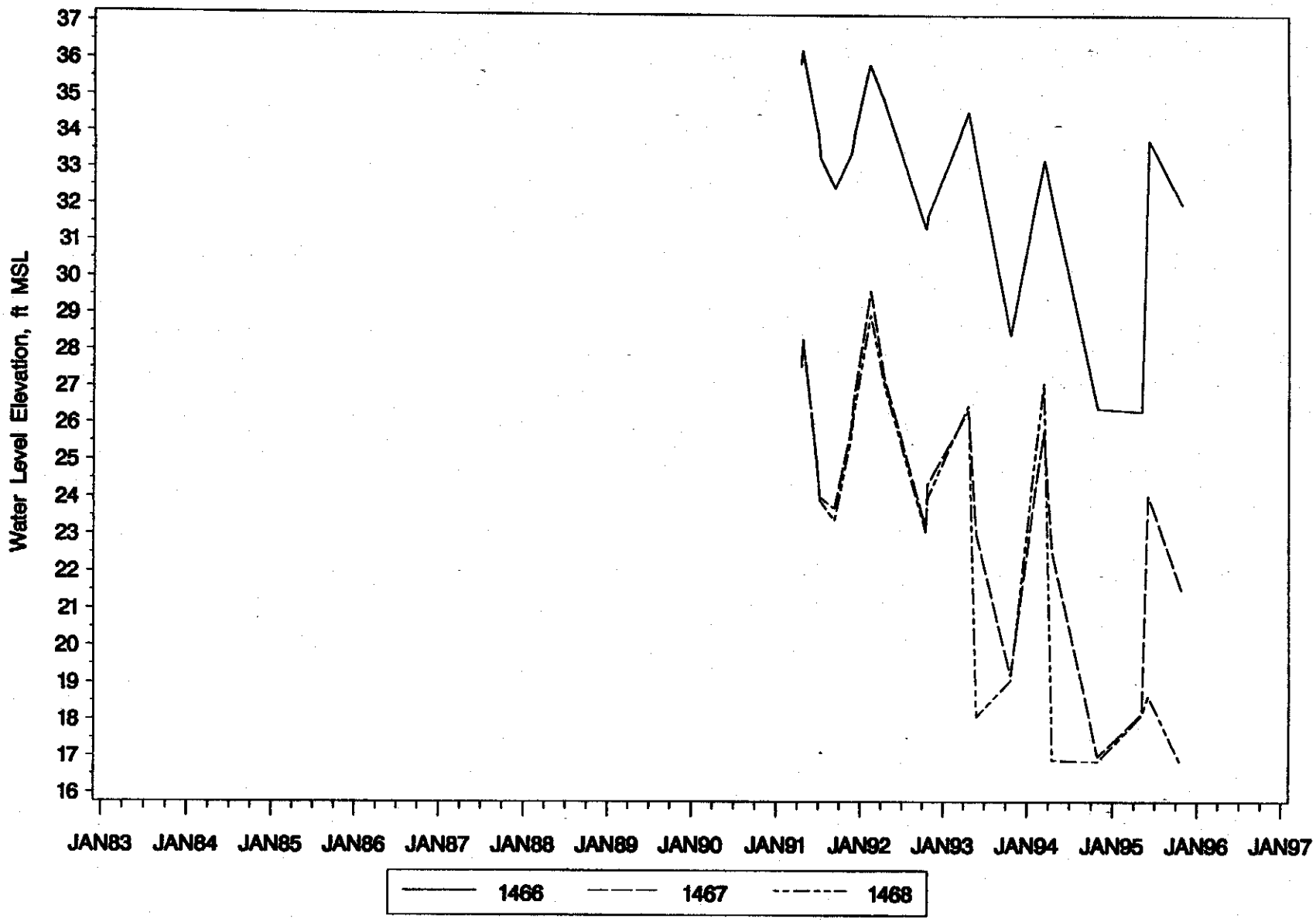


HYDROGRAPH


WELLS=1463-5
Water Level Elevation, ft MSL
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
1463
1464
1465

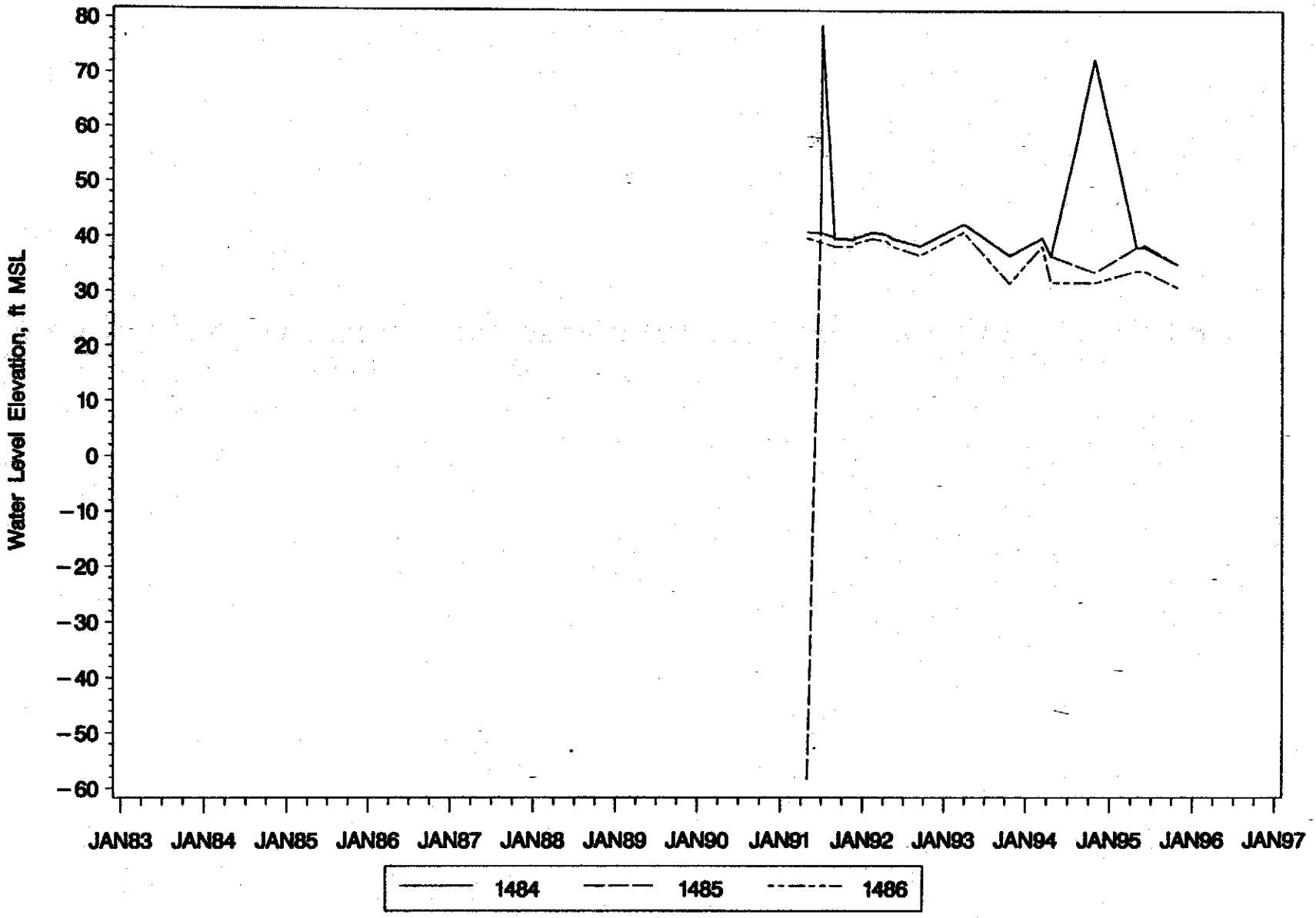
HYDROGRAPH

WELLS=1466-8

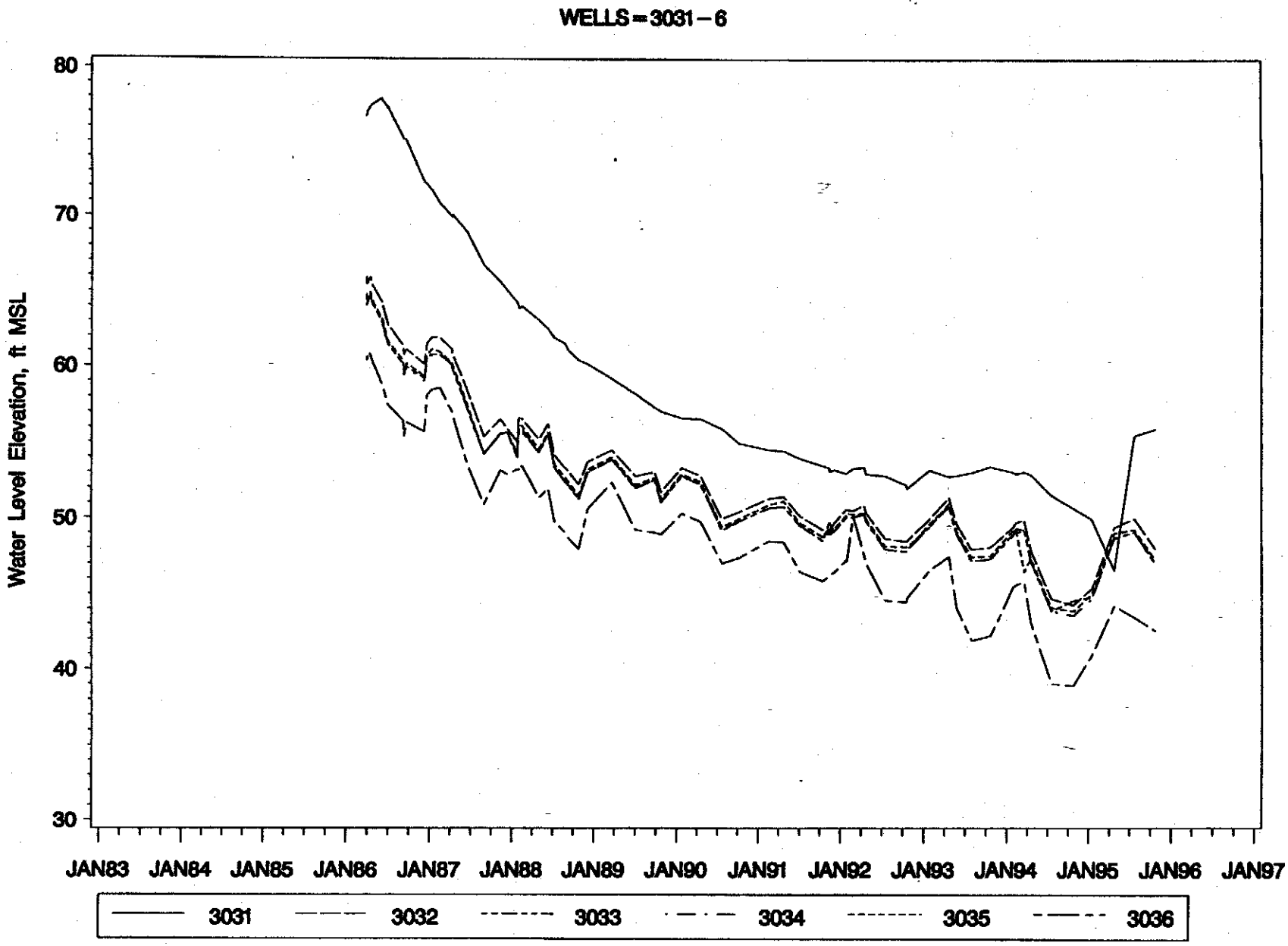


HYDROGRAPH

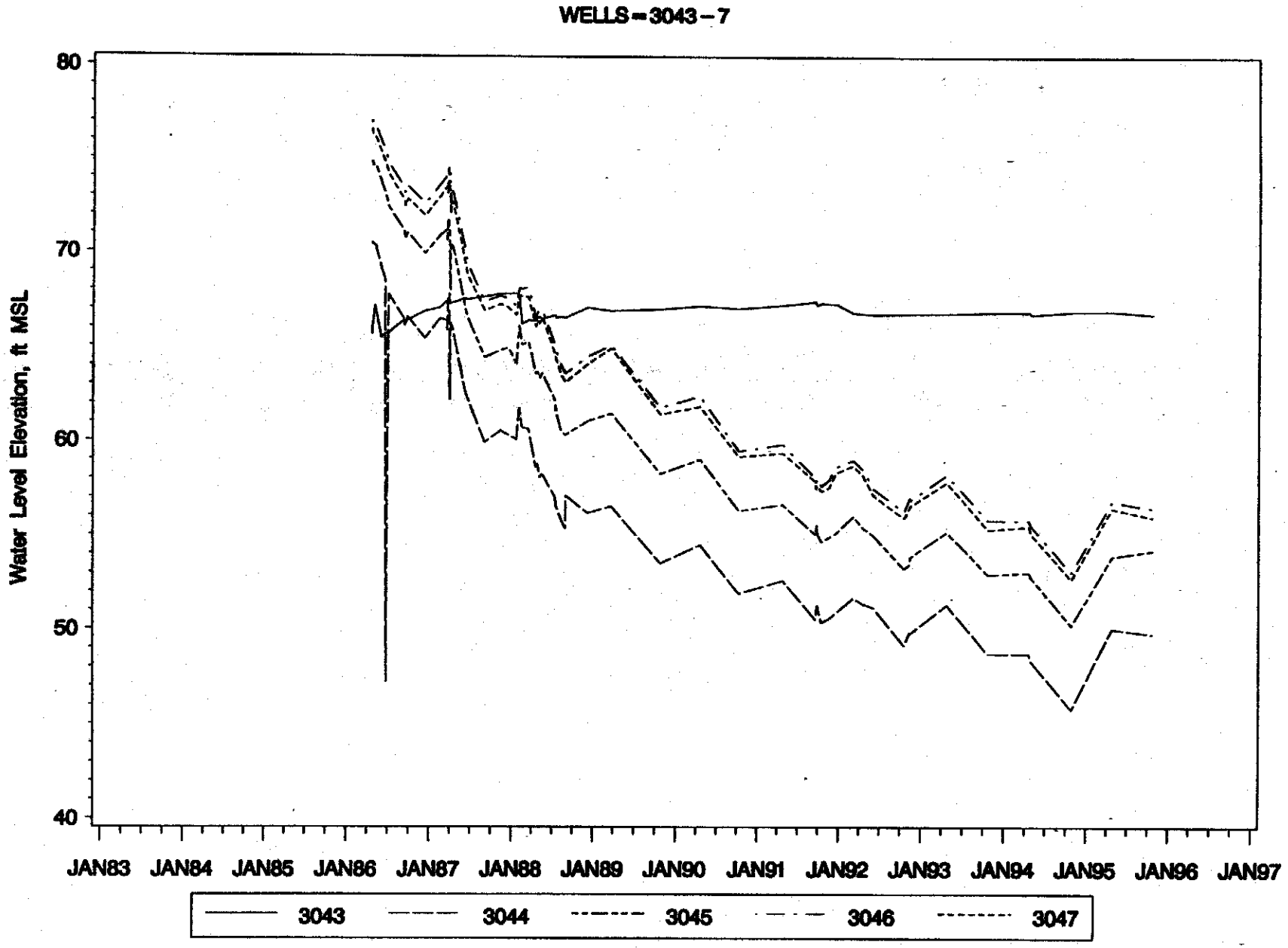
WELLS = 1484 – 6



HYDROGRAPH

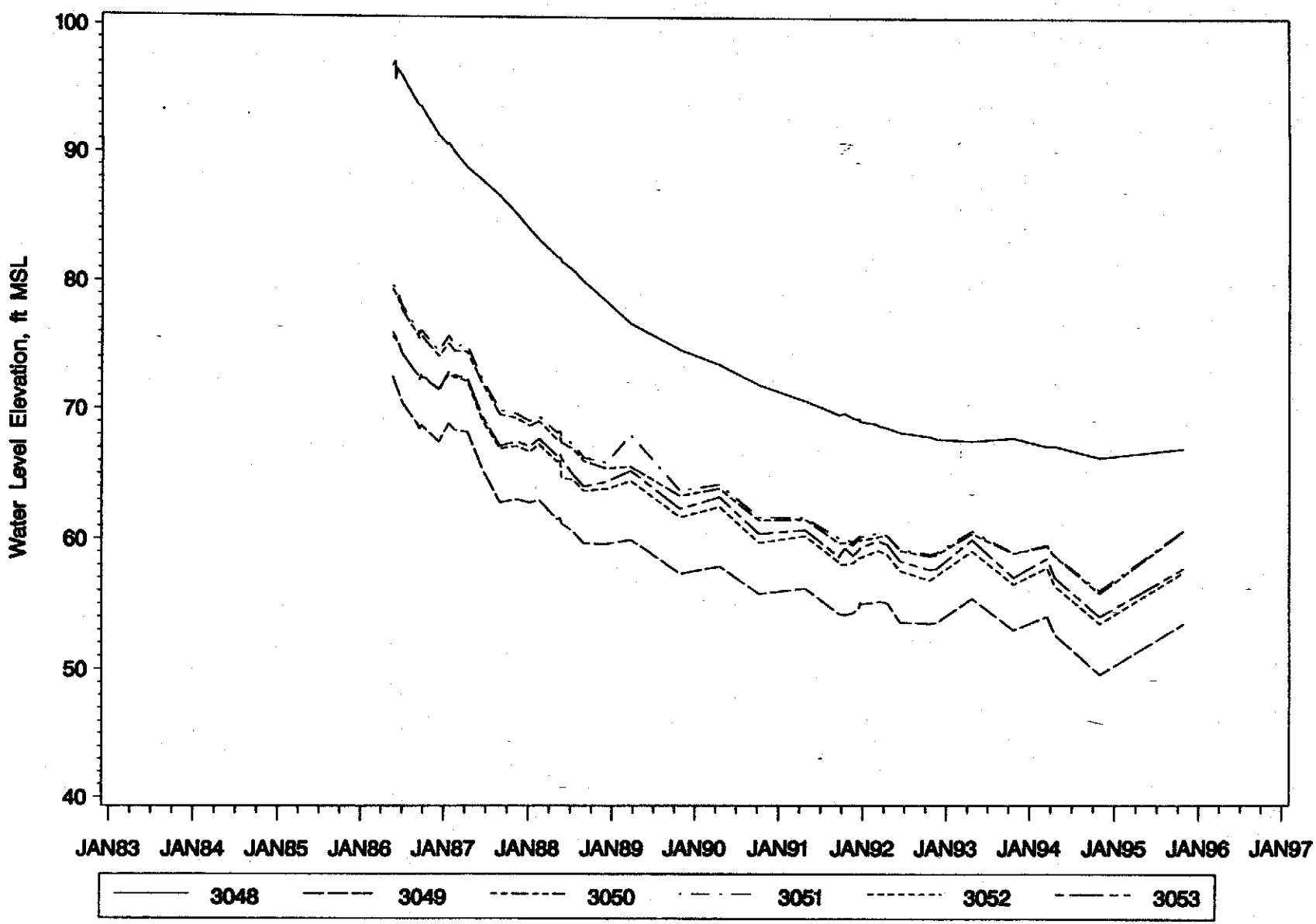

WELLS = 3031 – 6
Water Level Elevation, ft MSL
80
70
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3031
3032
3033
3034
3035
3036

HYDROGRAPH


WELLS=3043-7
Water Level Elevation, ft MSL
80
70
60
50
40
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3043
3044
3045
3046
3047

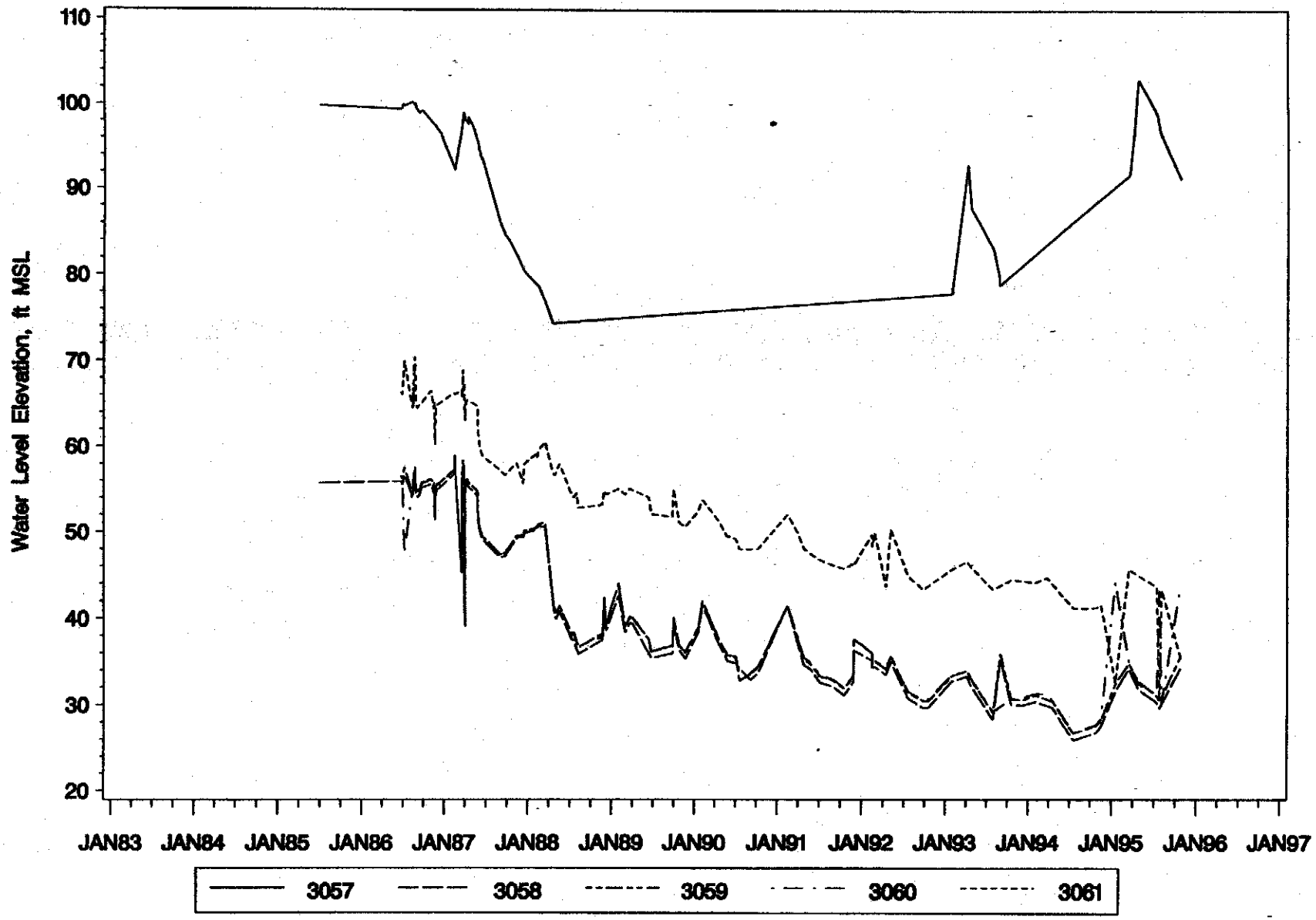
HYDROGRAPH

WELLS=3048-53



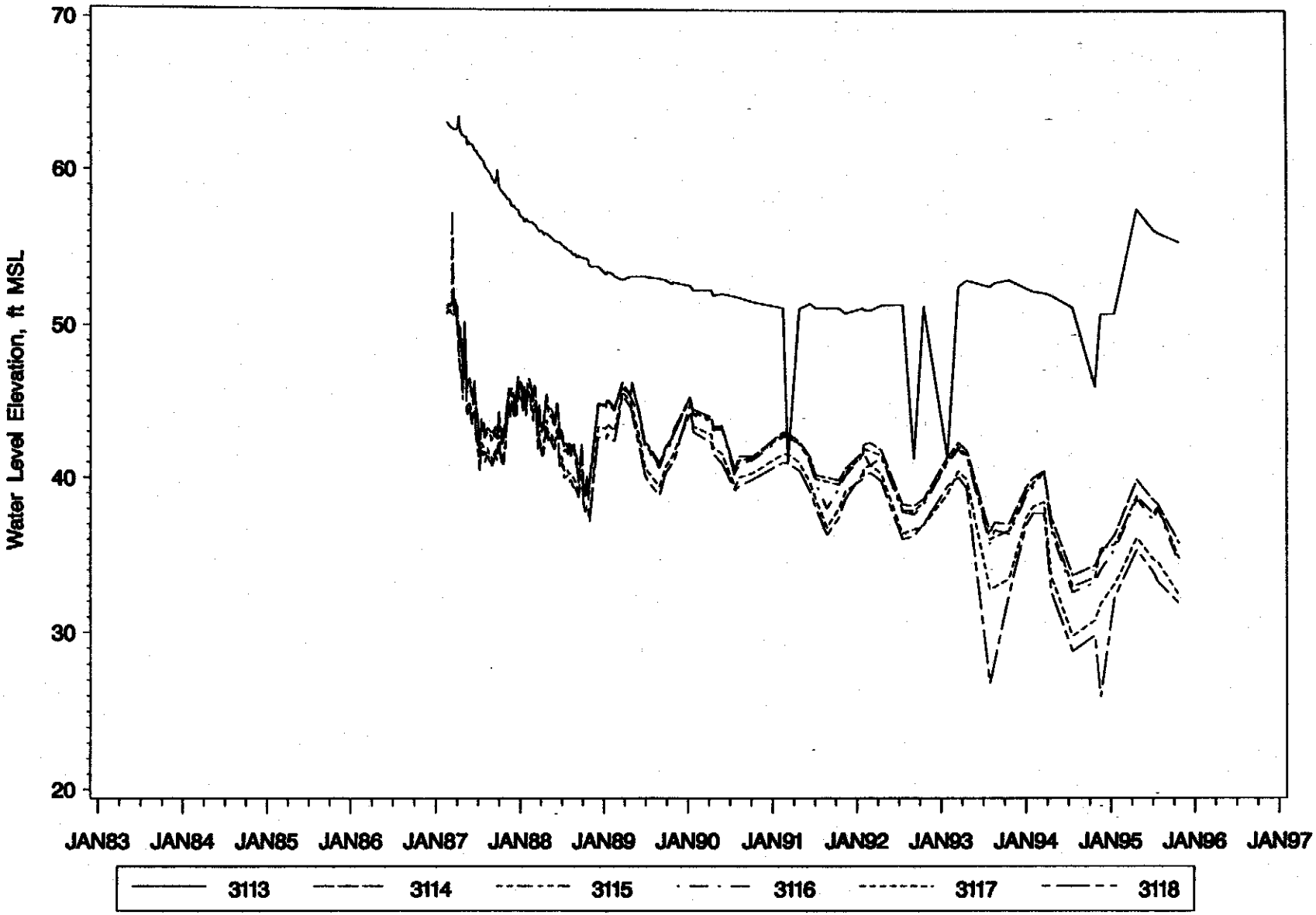
HYDROGRAPH

WELLS = 3057 – 61

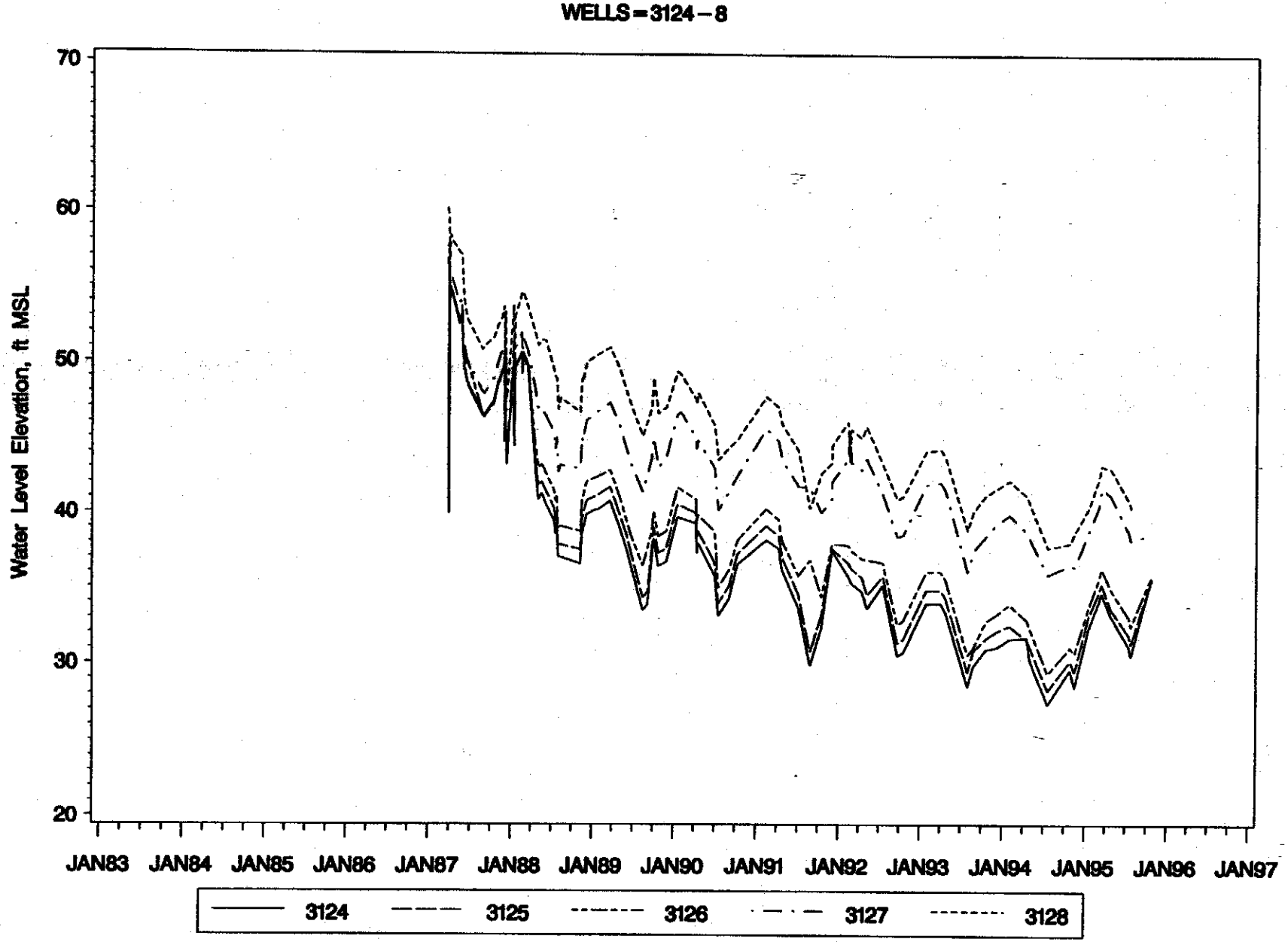


HYDROGRAPH

WELLS = 3113 – 8

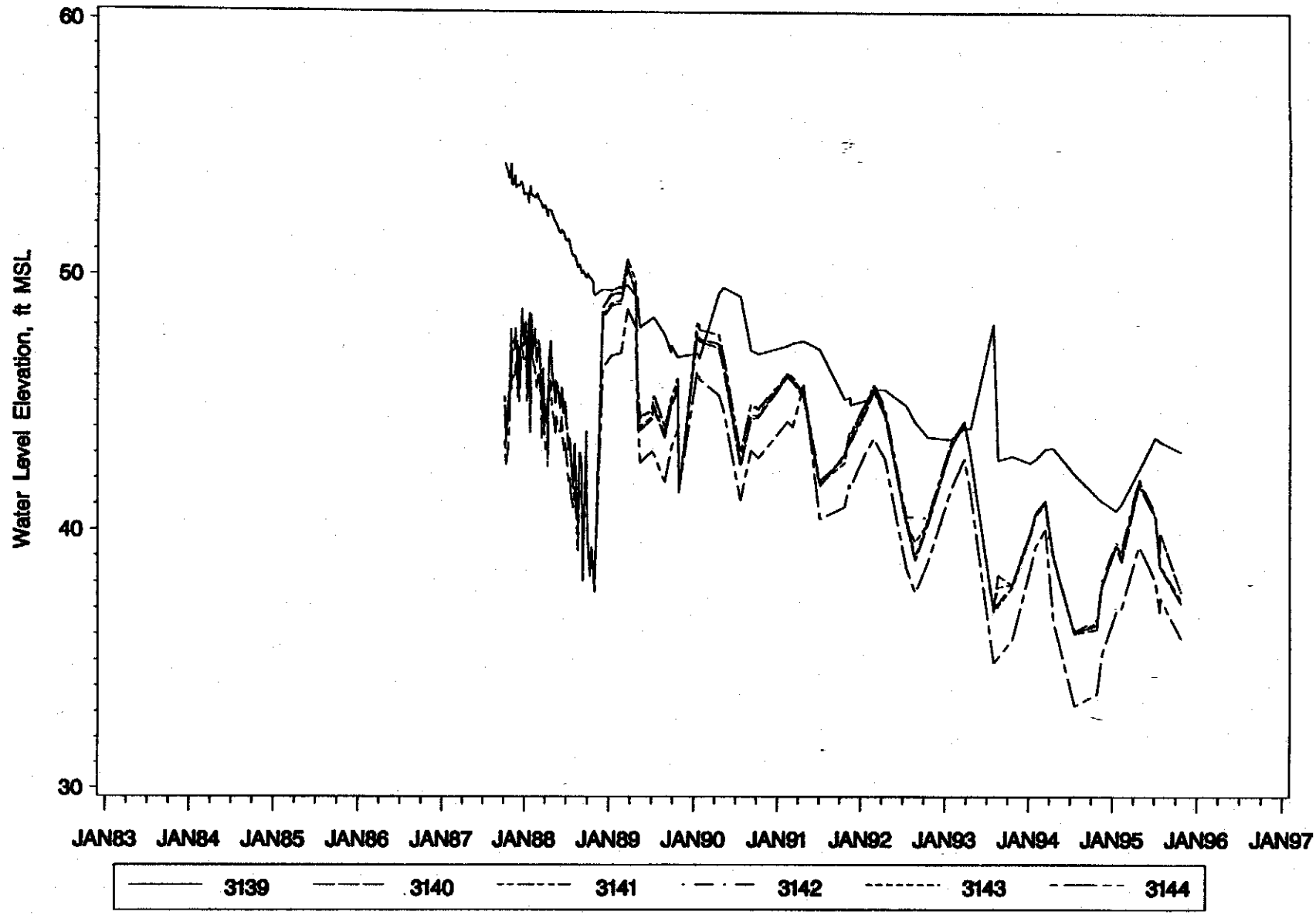


HYDROGRAPH


WELLS=3124-8
Water Level Elevation, ft MSL
70
60
50
40
30
20
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3124
3125
3126
3127
3128

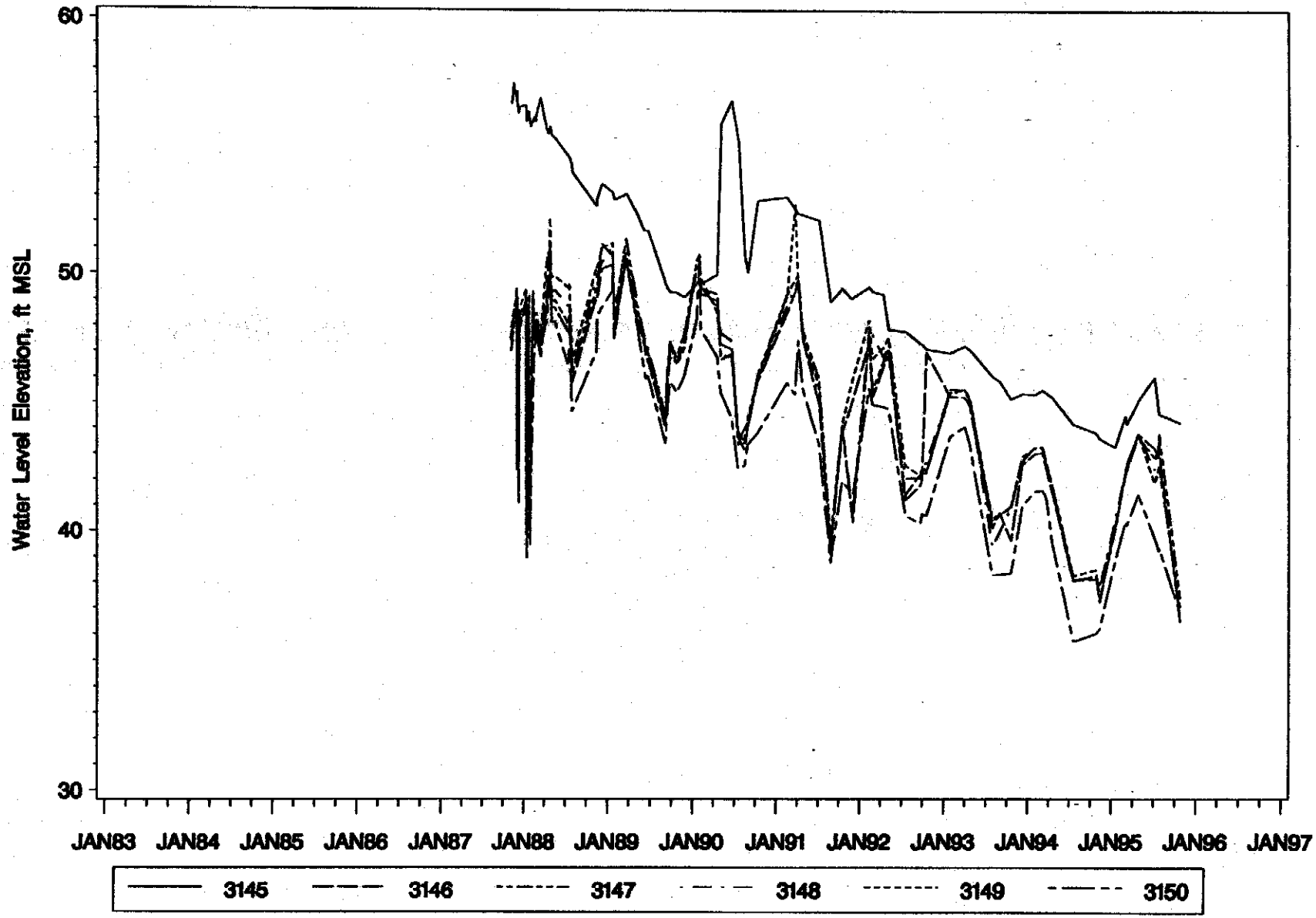
HYDROGRAPH

WELLS=3139-44



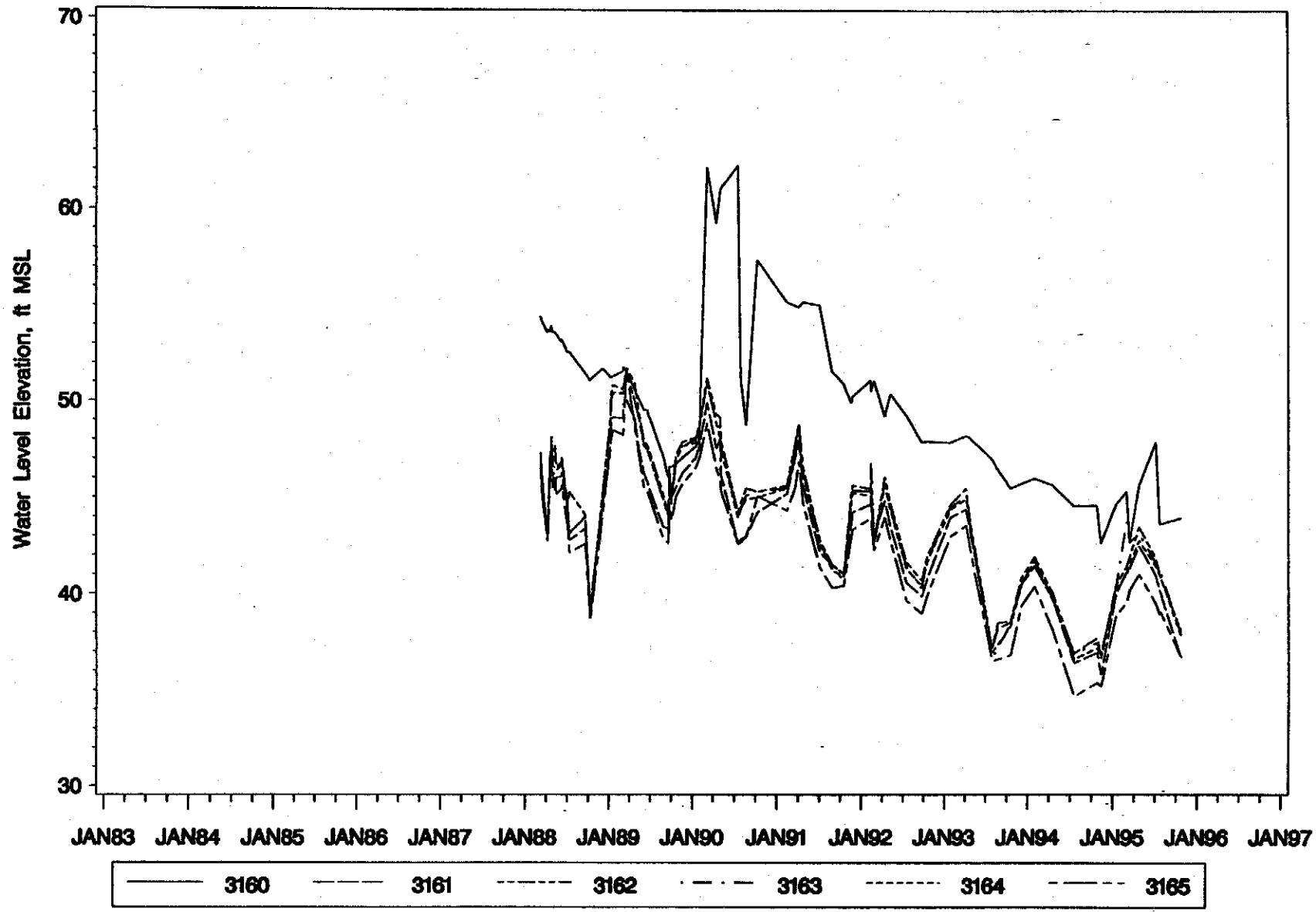
HYDROGRAPH

WELLS=3145-50

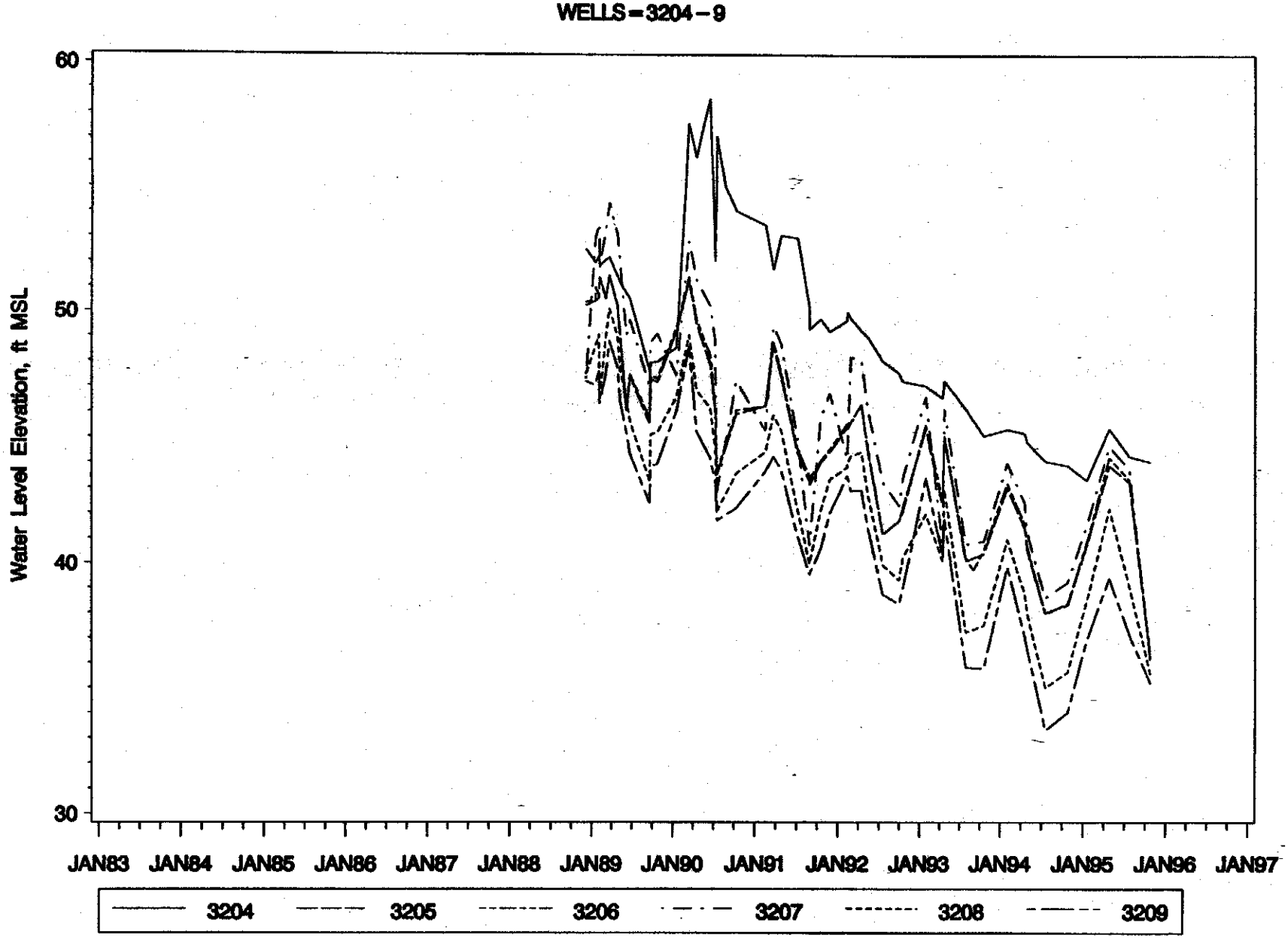


HYDROGRAPH

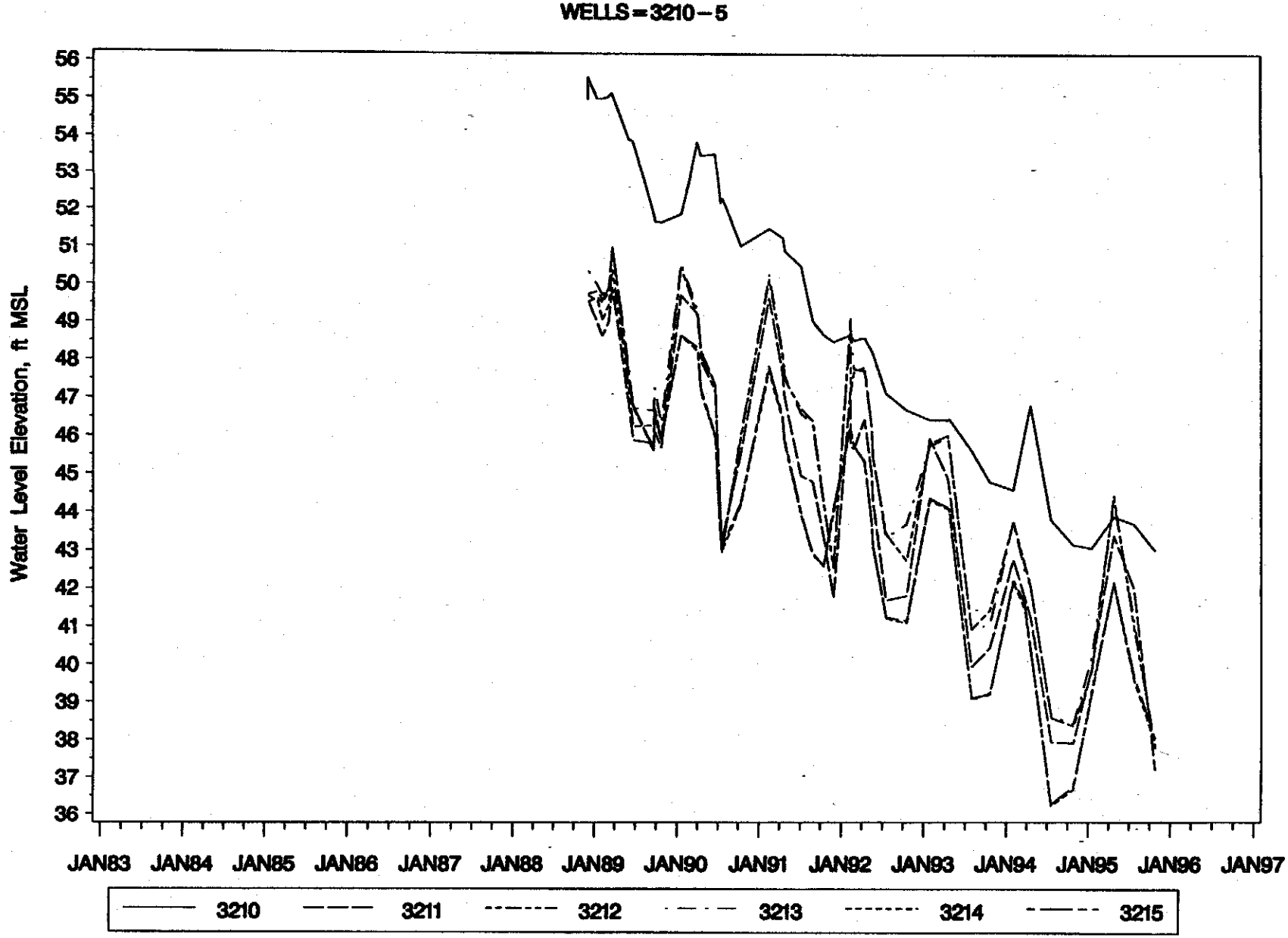
WELLS=3160-5



HYDROGRAPH

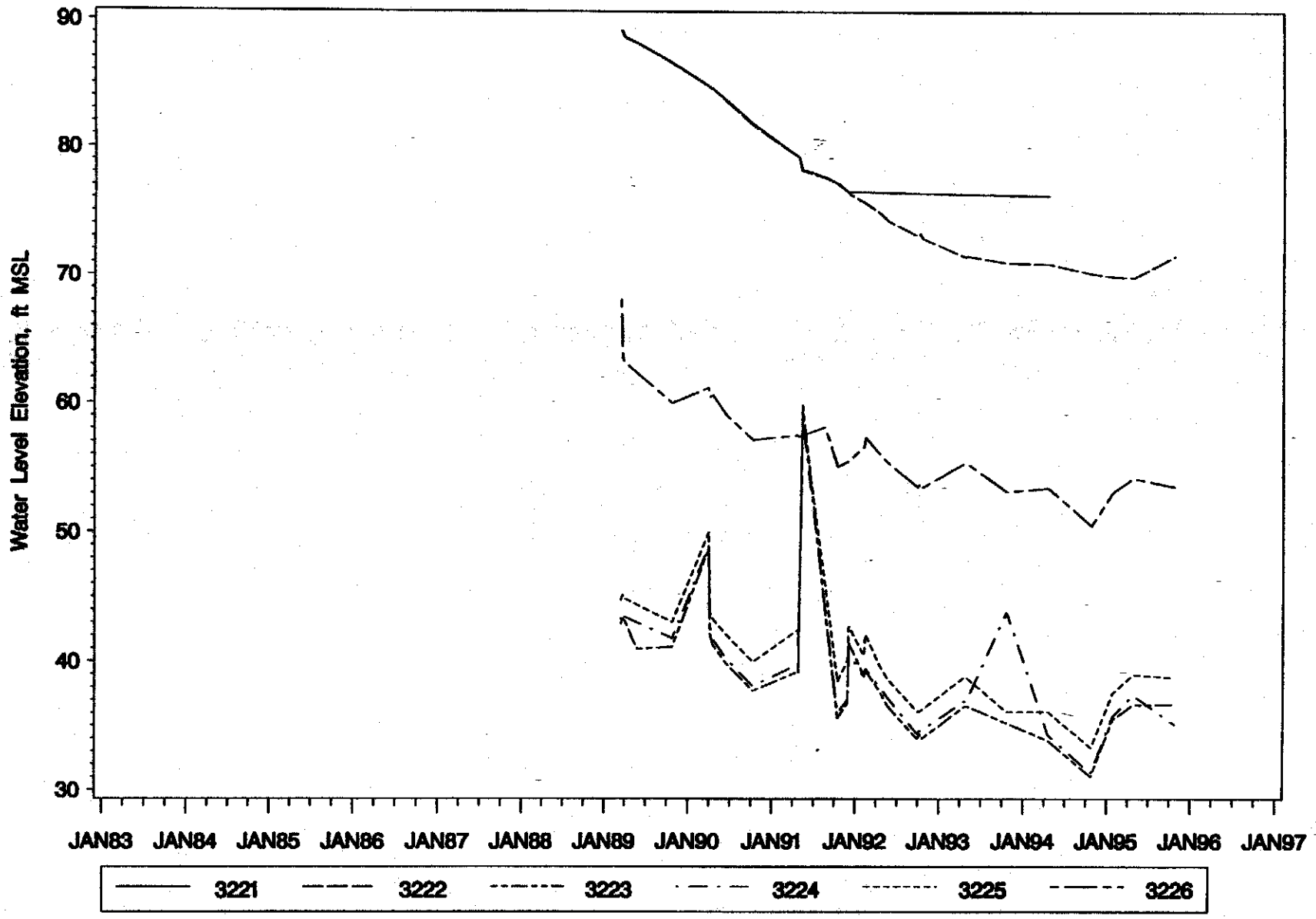

WELLS=3204-9
Water Level Elevation, ft MSL
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3204
3205
3206
3207
3208
3209

HYDR[illegible]RAPH

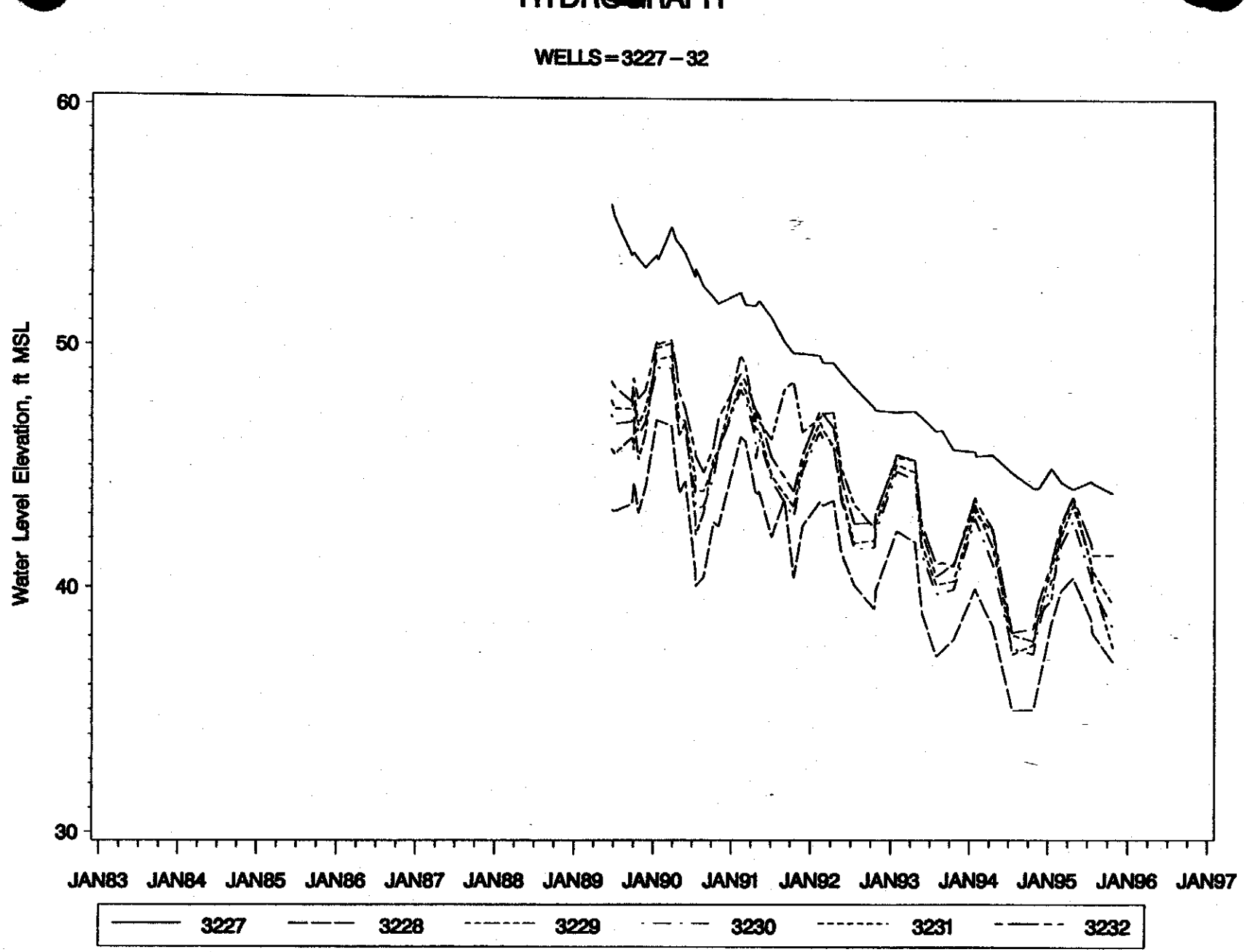

WELLS=3210-5
Water Level Elevation, ft MSL
56
55
54
53
52
51
50
49
48
47
46
45
44
43
42
41
40
39
38
37
36
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3210
3211
3212
3213
3214
3215

HYDROGRAPH

WELLS = 3221 – 6

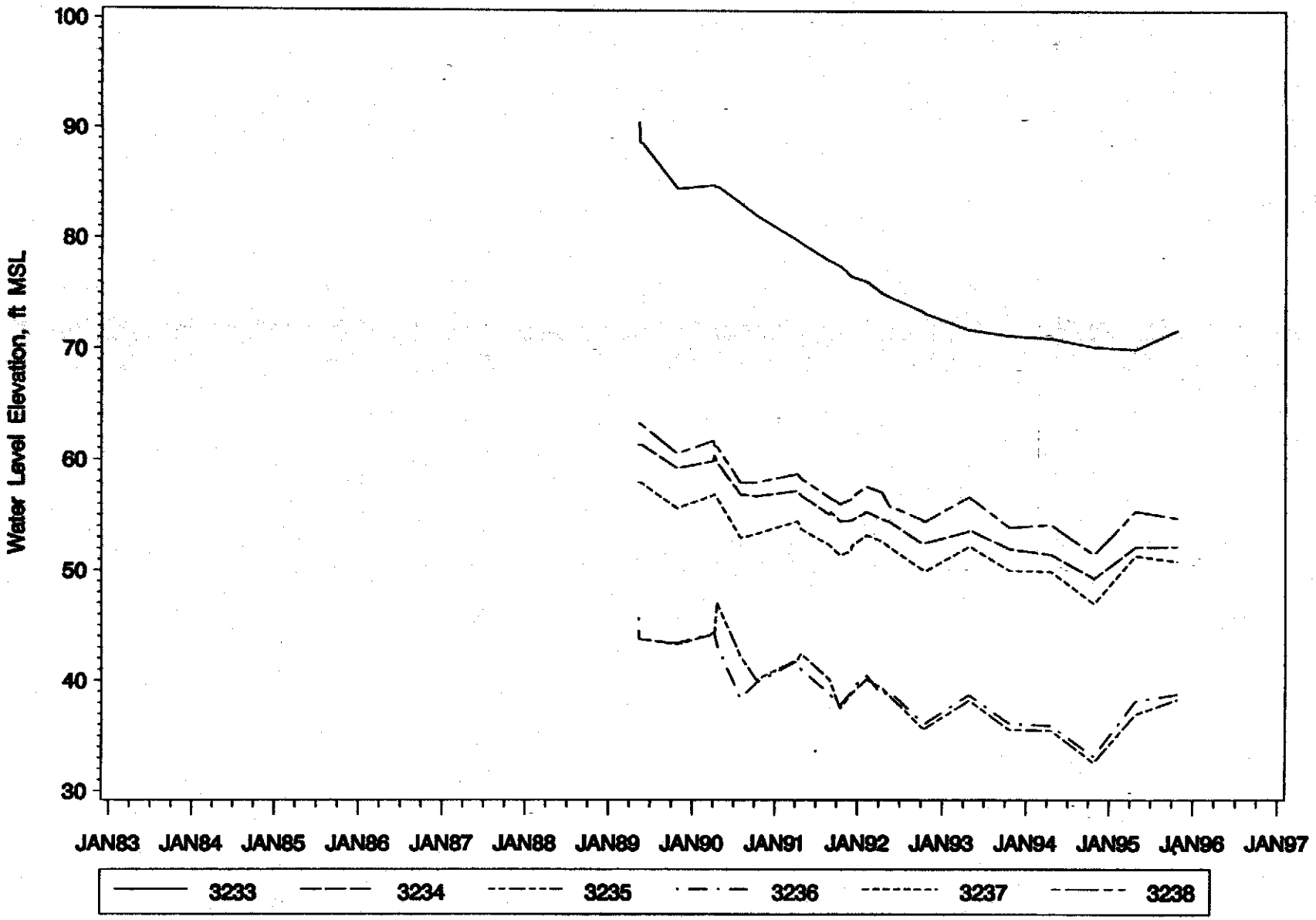


HYDROGRAPH


WELLS=3227-32
Water Level Elevation, ft MSL
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3227
3228
3229
3230
3231
3232

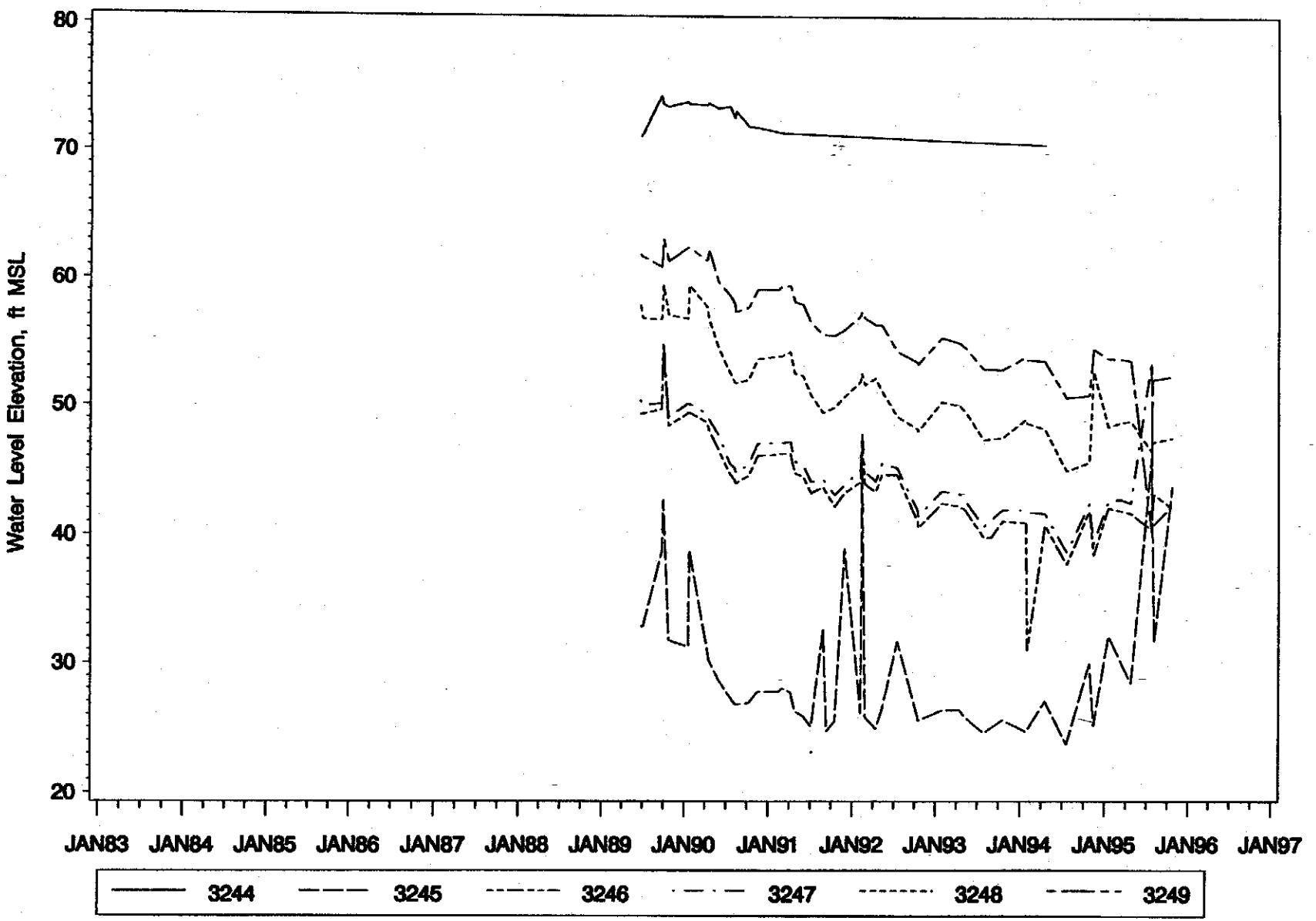
HYDROGRAPH

WELLS = 3233 – 8



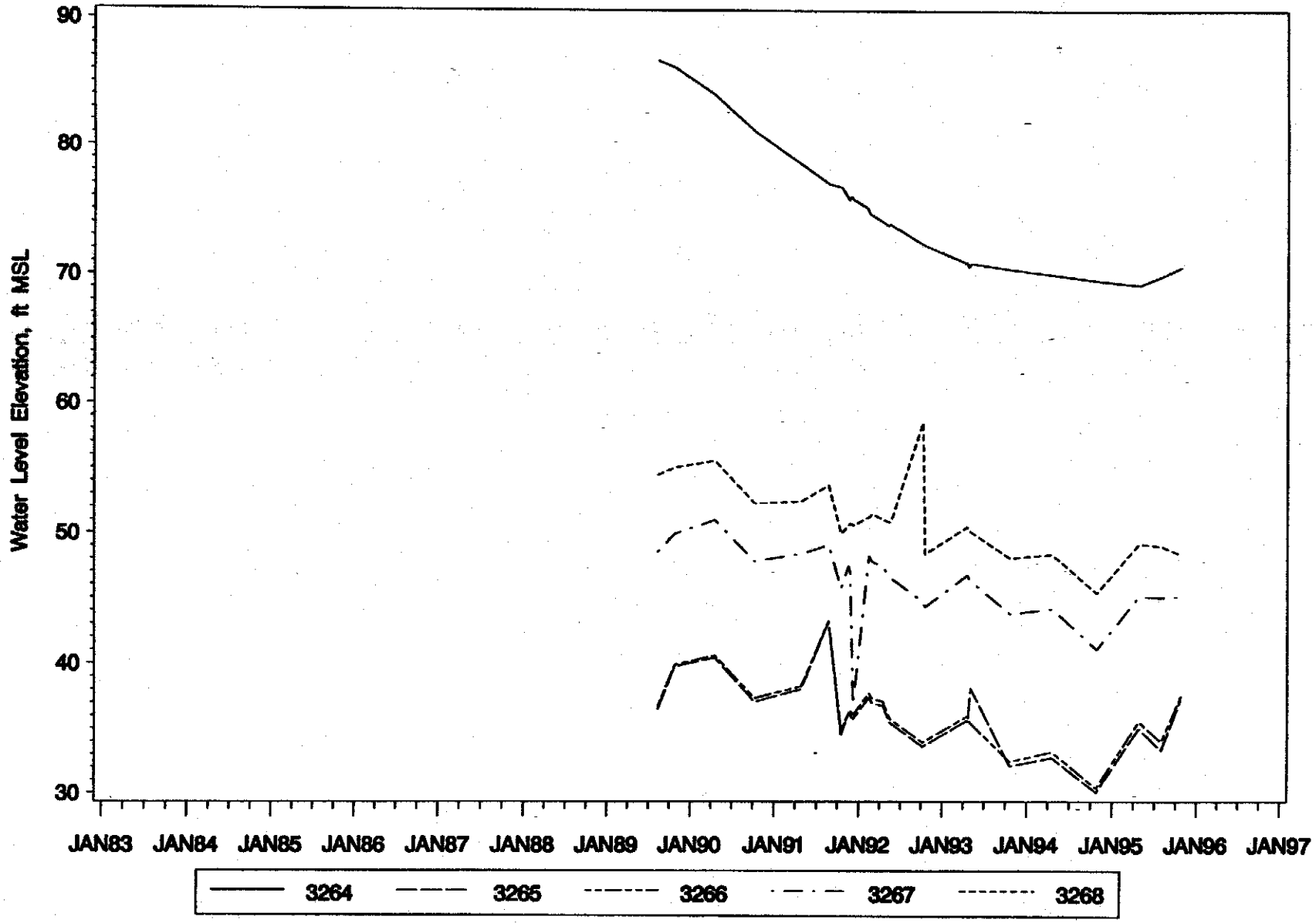
HYDROGRAPH

WELLS = 3244 - 9

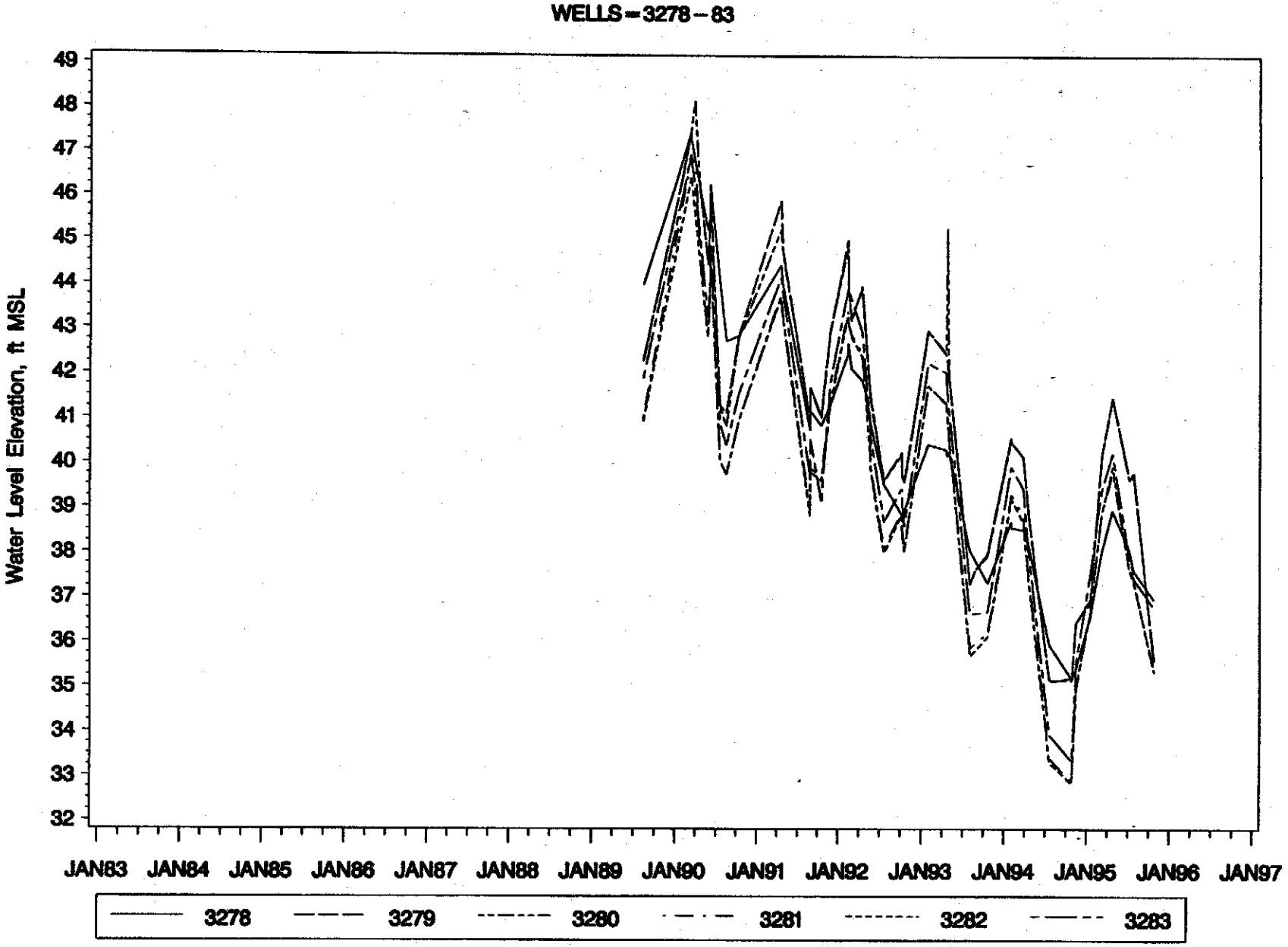


HYDROGRAPH

WELLS = 3264 – 8

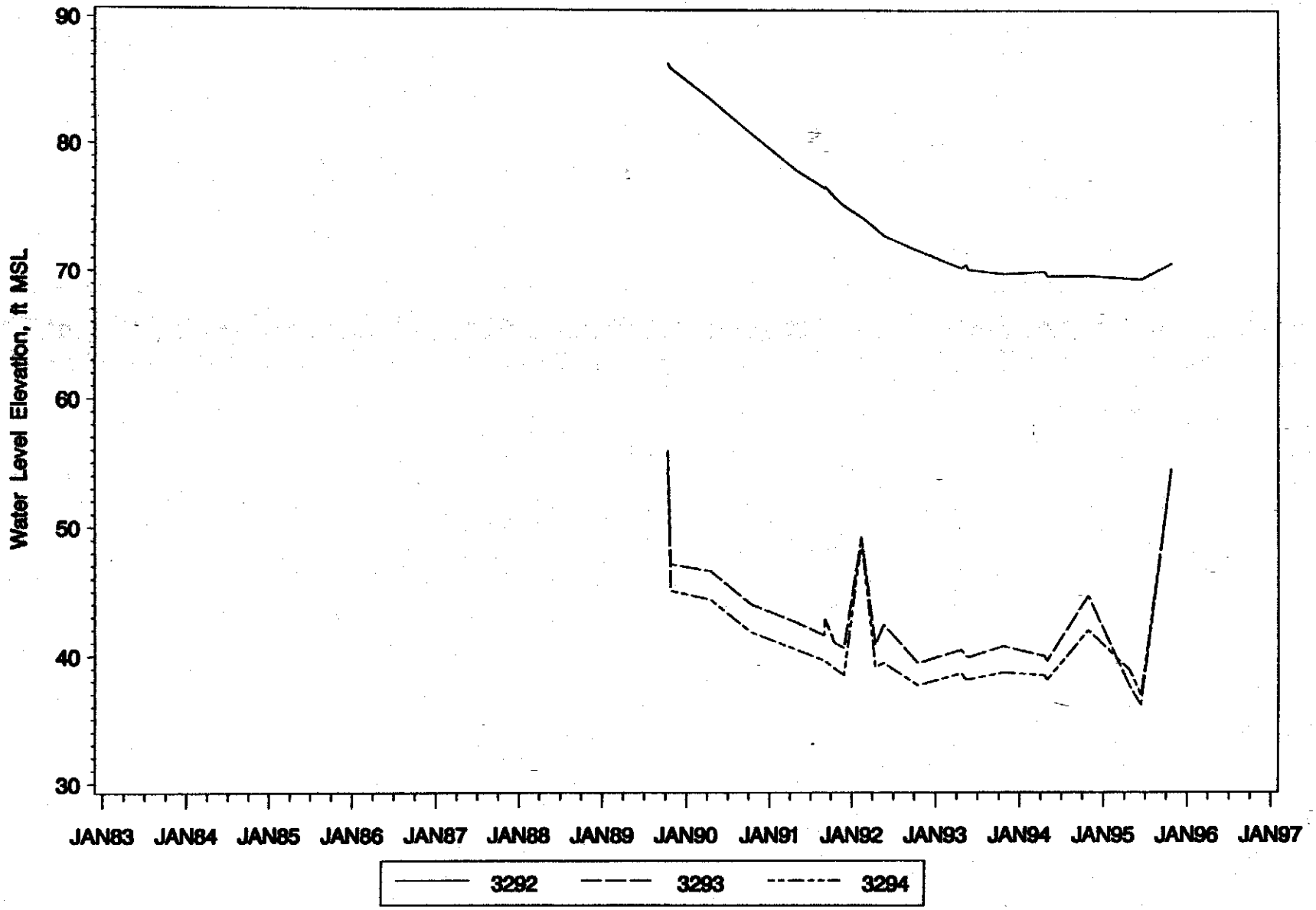


HYDROGRAPH


WELLS=3278-83
Water Level Elevation, ft MSL
49
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3278
3279
3280
3281
3282
3283

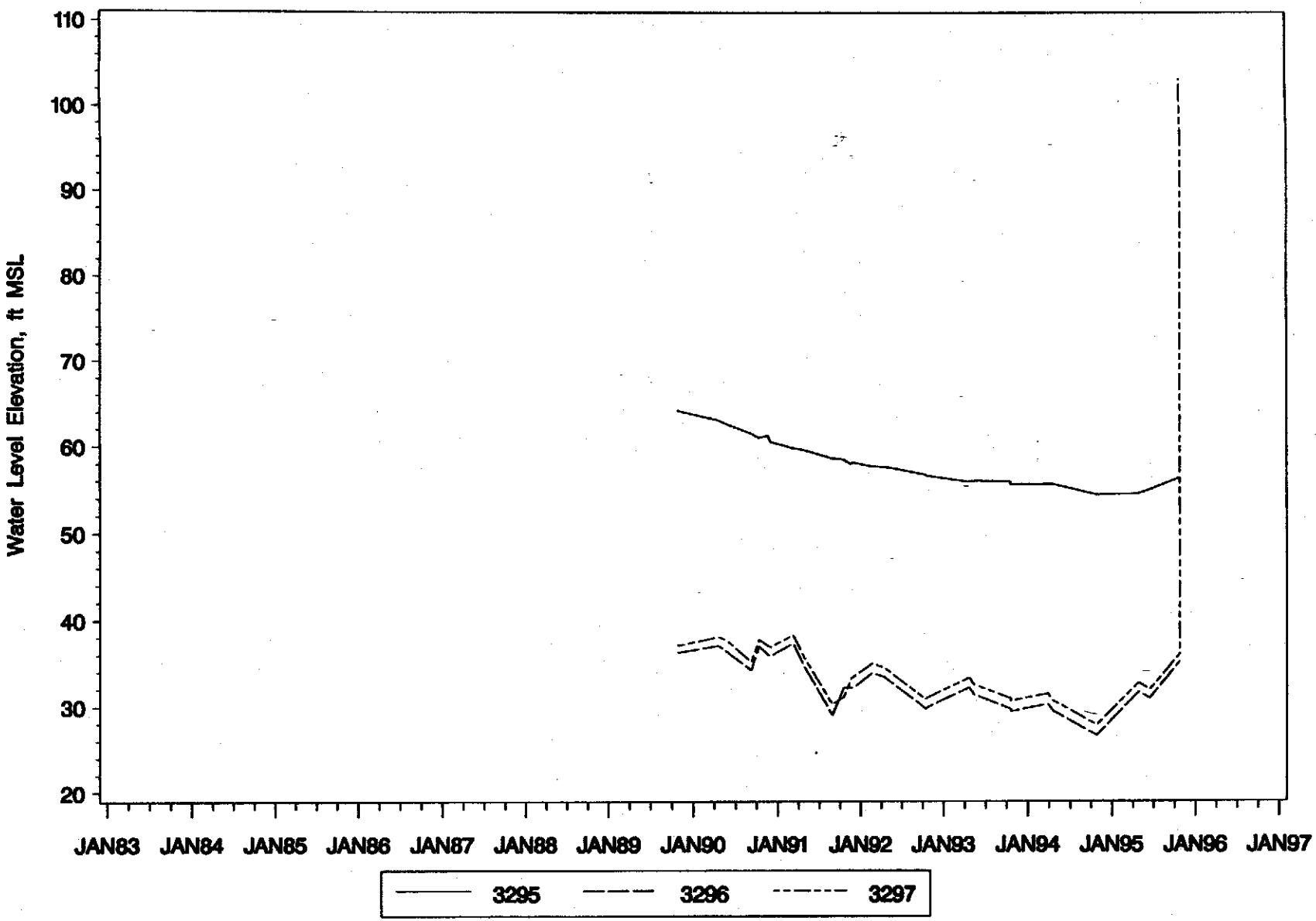
HYDROGRAPH

WELLS=3292-4



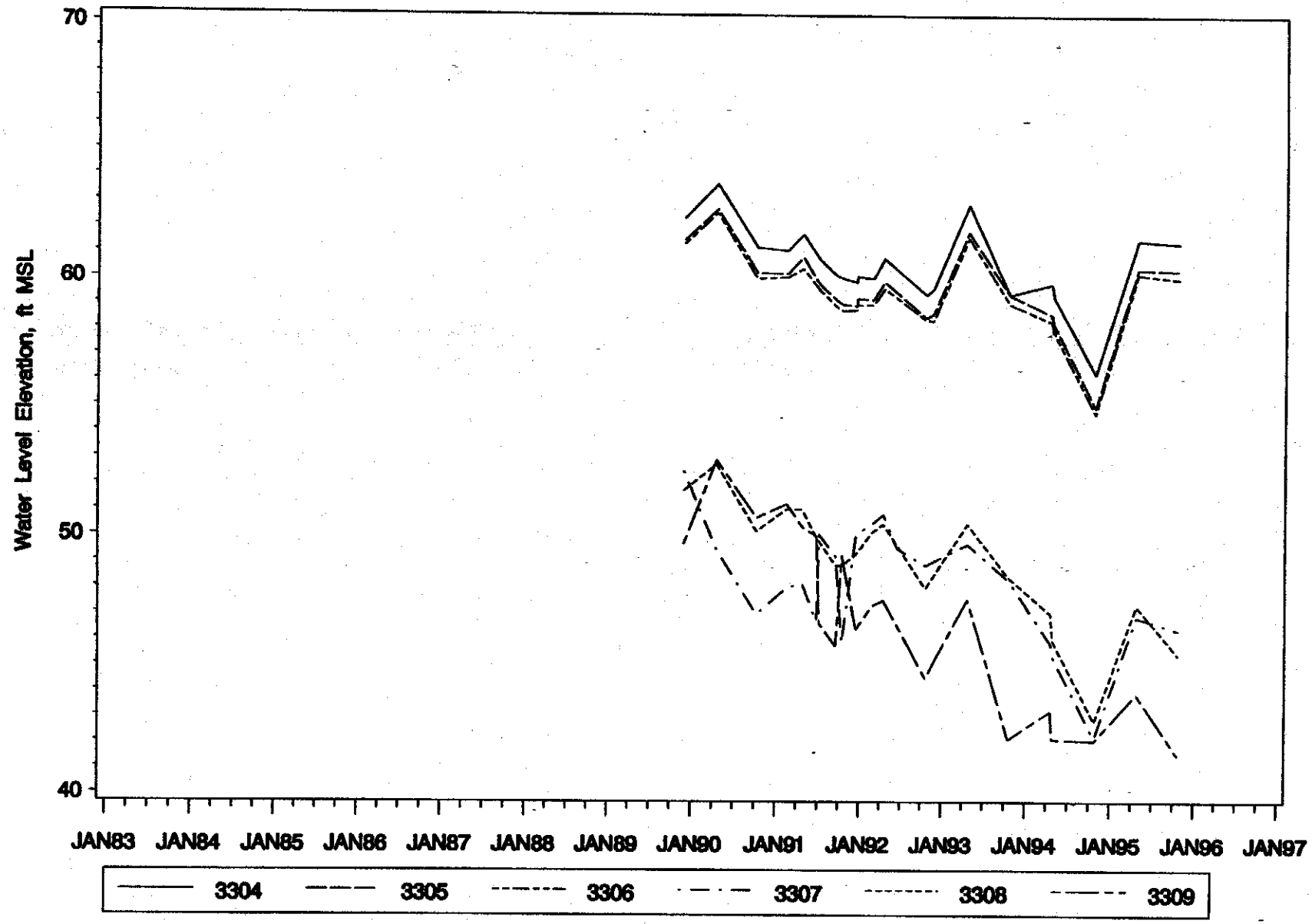
HYDROGRAPH

WELLS=3295-7

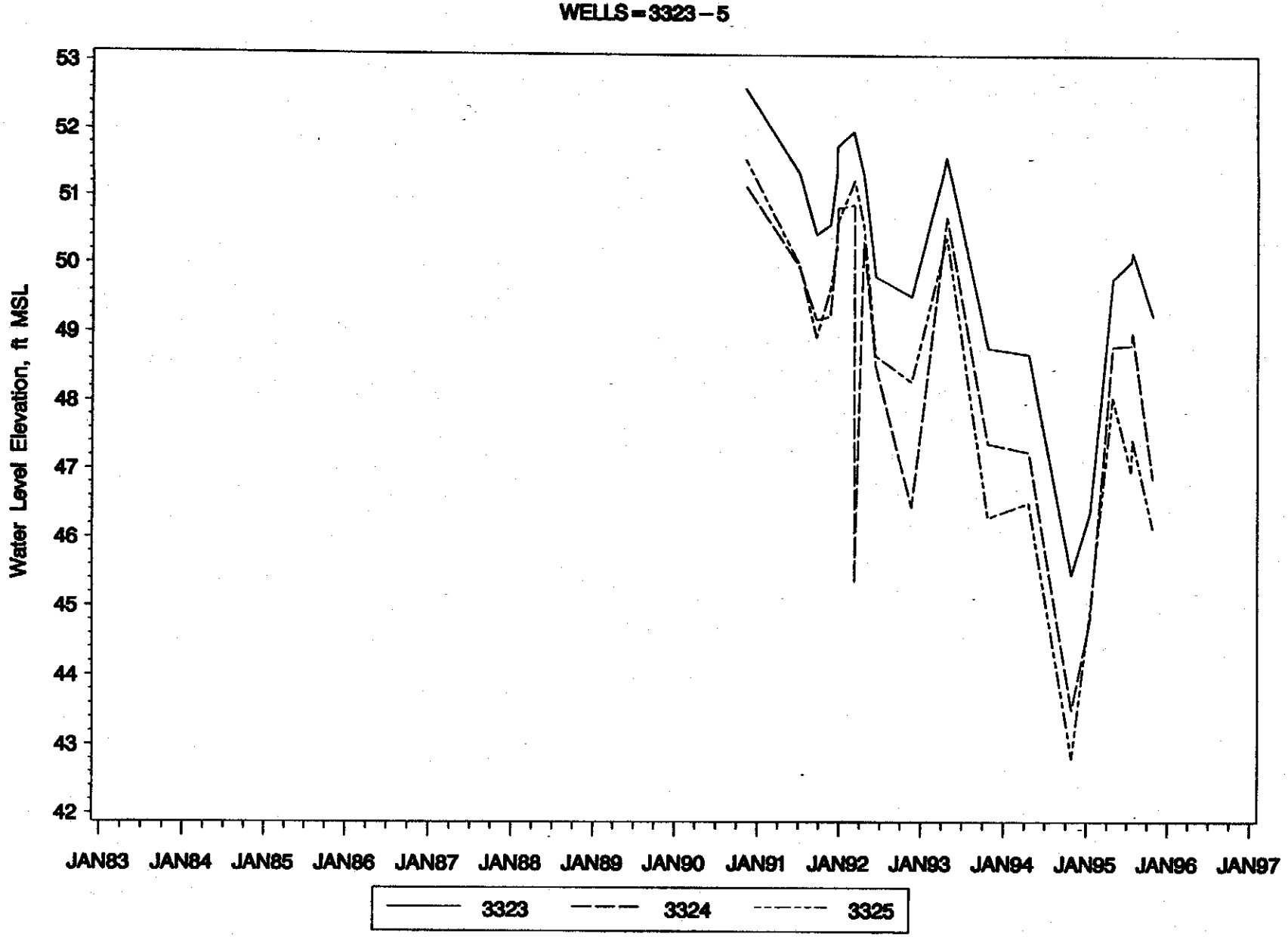


HYDROGRAPH

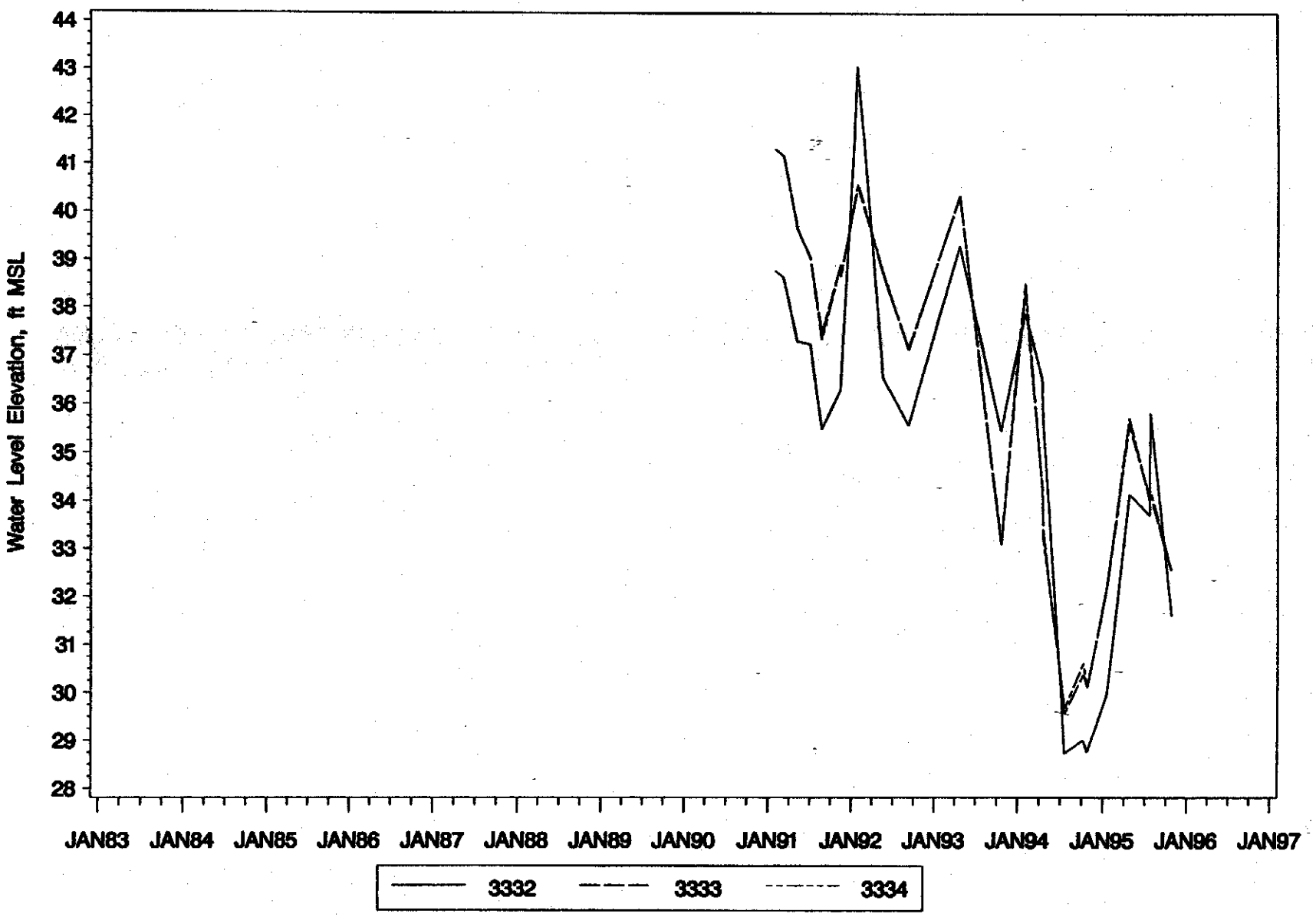
WELLS=3304-9



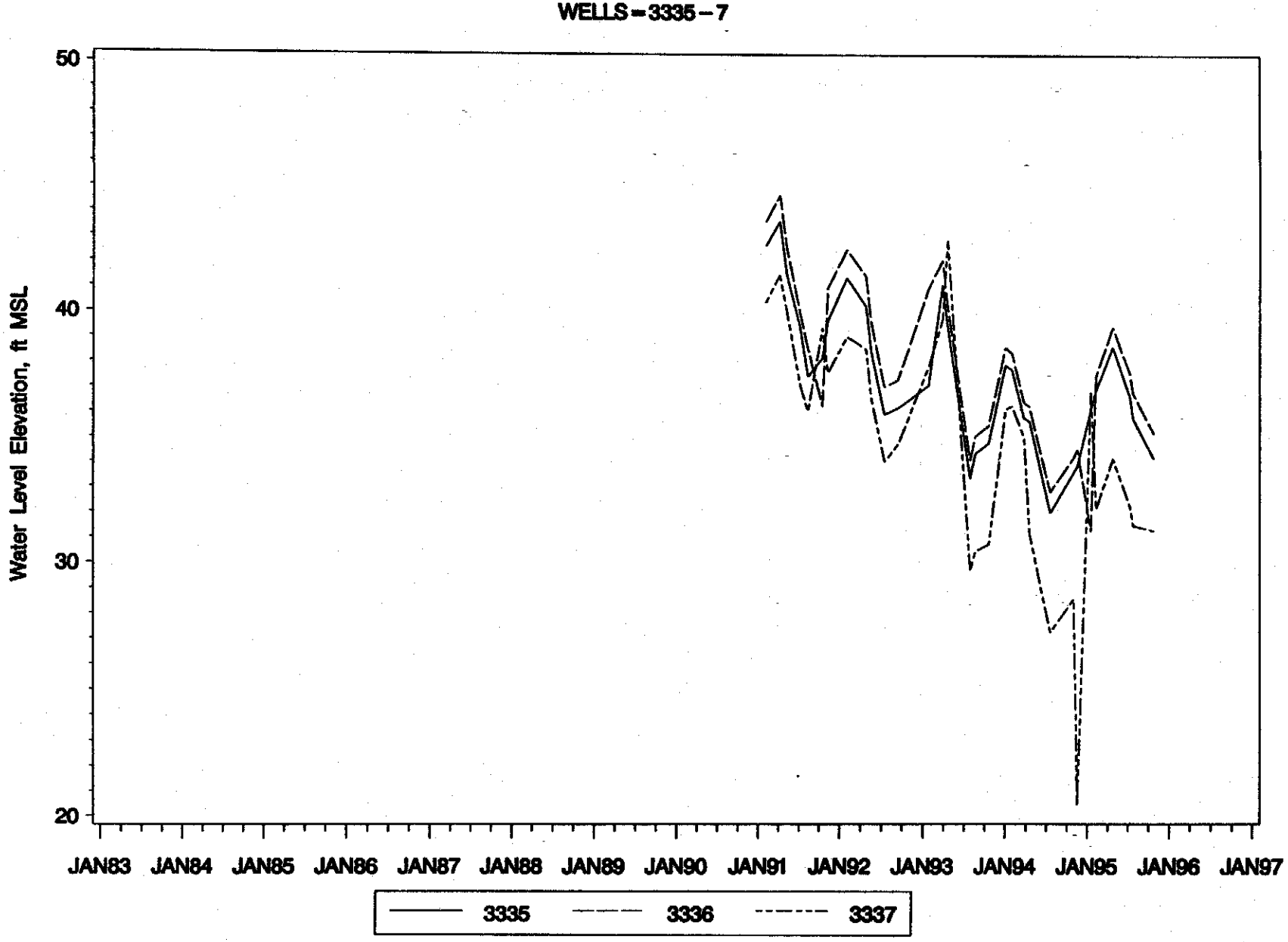
HYDROGRAPH


WELLS=3323-5
Water Level Elevation, ft MSL
53
52
51
50
49
48
47
46
45
44
43
42
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3323
3324
3325

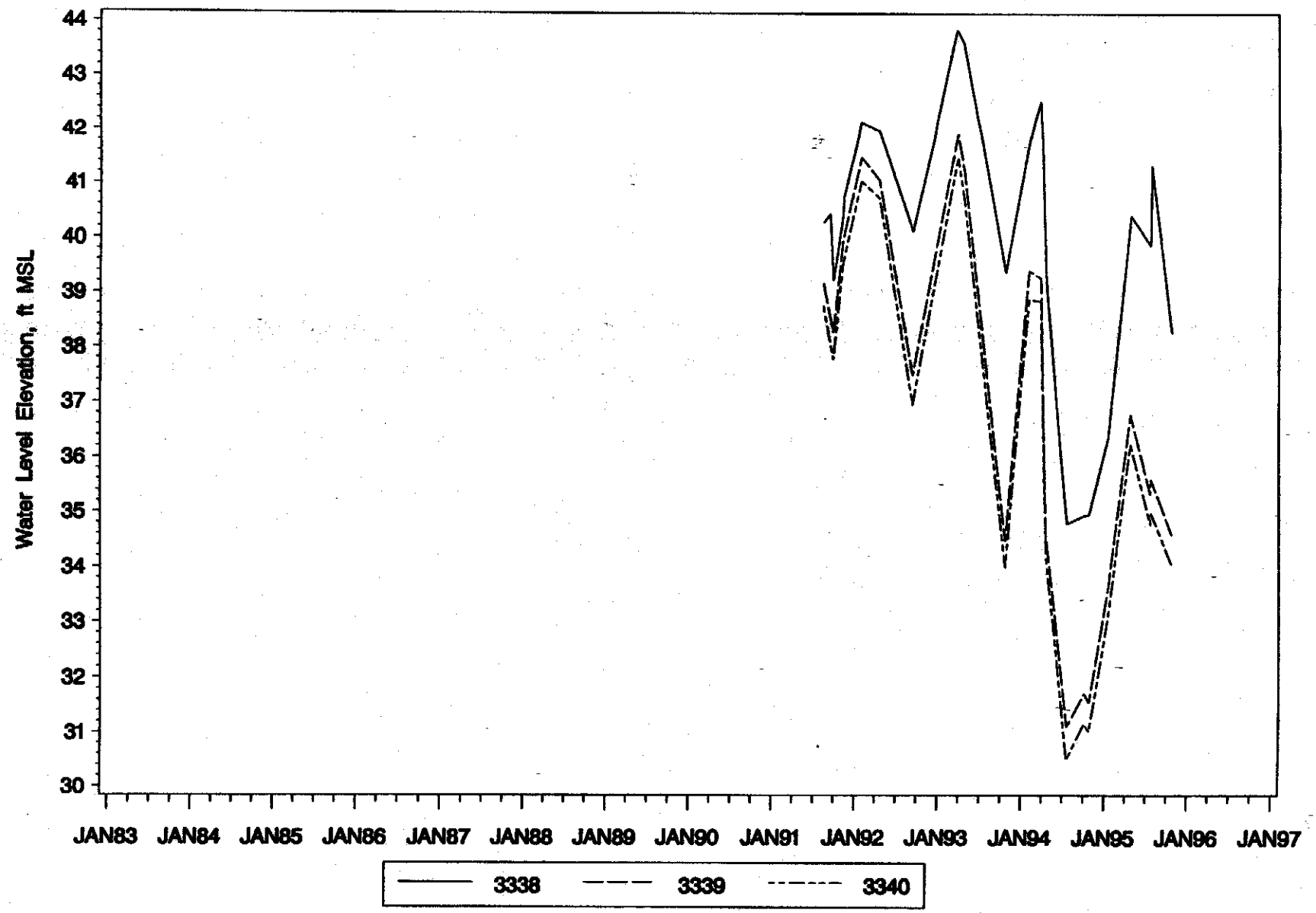
HYDROGRAPH


WELLS=3332-4
Water Level Elevation, ft MSL
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3332
3333
3334

HYDROGRAPH

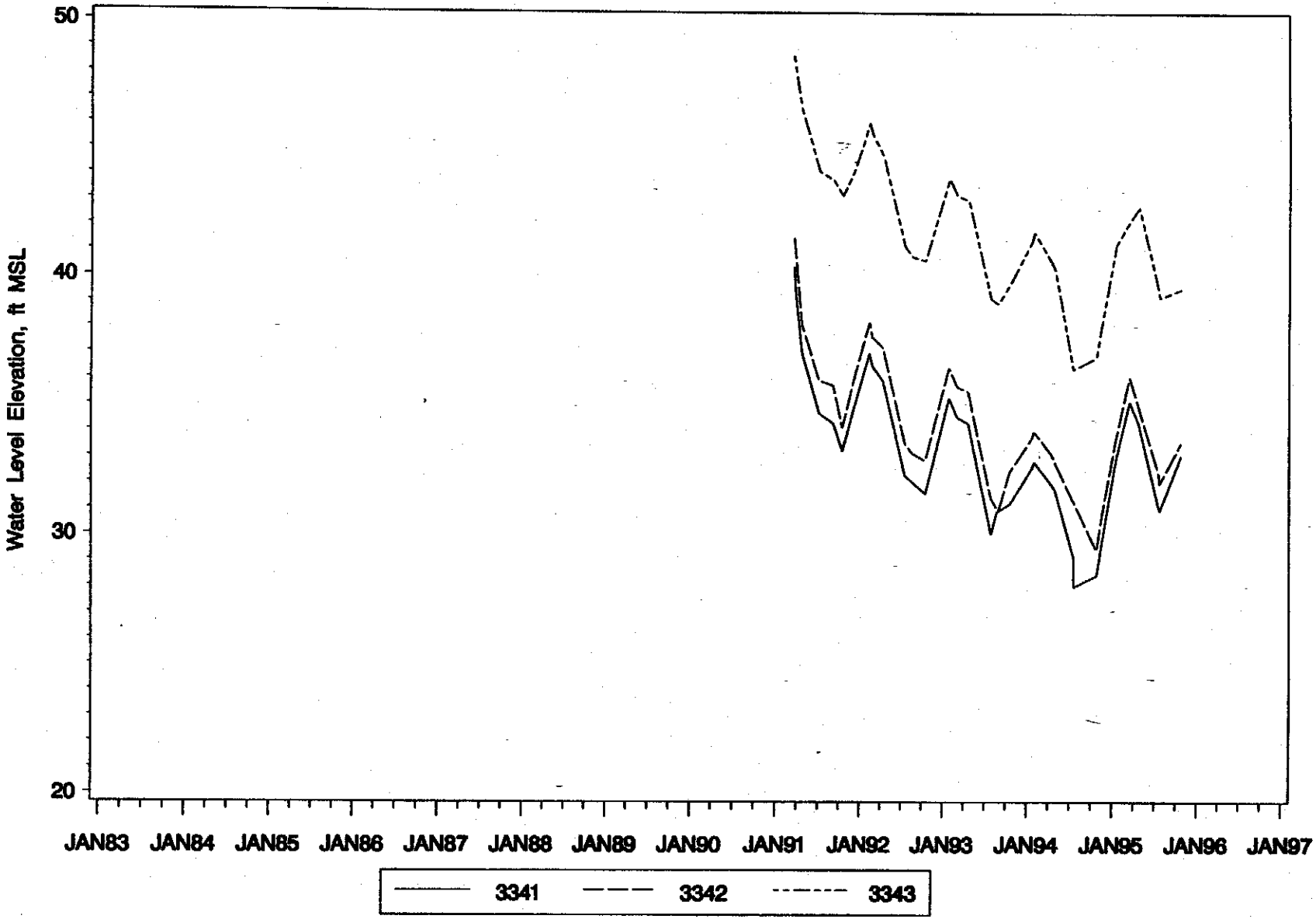

WELLS=3335-7
Water Level Elevation, ft MSL
50
40
30
20
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3335
3336
3337

HYDROGRAPH


WELLS=3338-40
Water Level Elevation, ft MSL
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3338
3339
3340

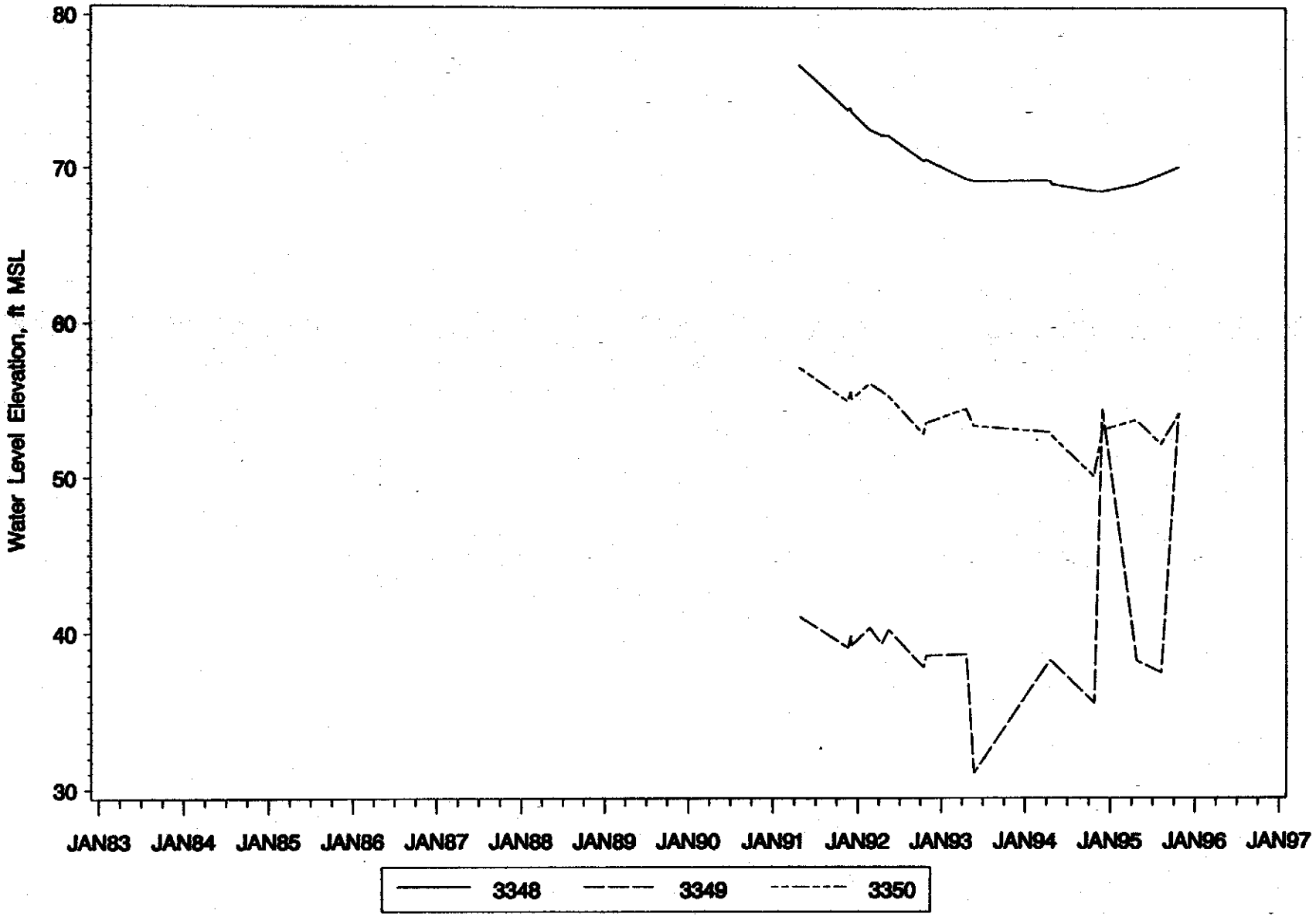
HYDROGRAPH

WELLS=3341-3

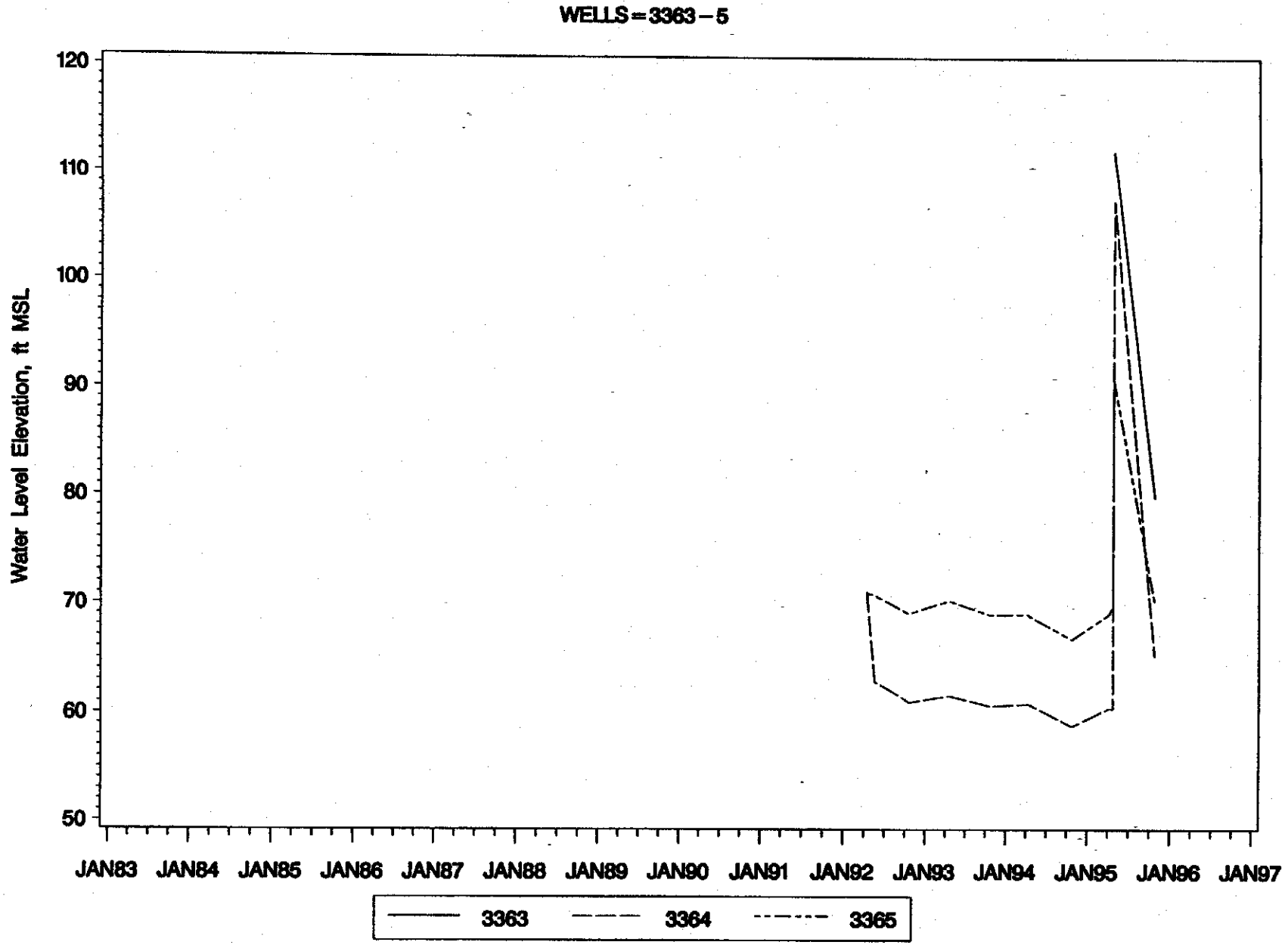


HYDROGRAPH

WELLS=3348-50

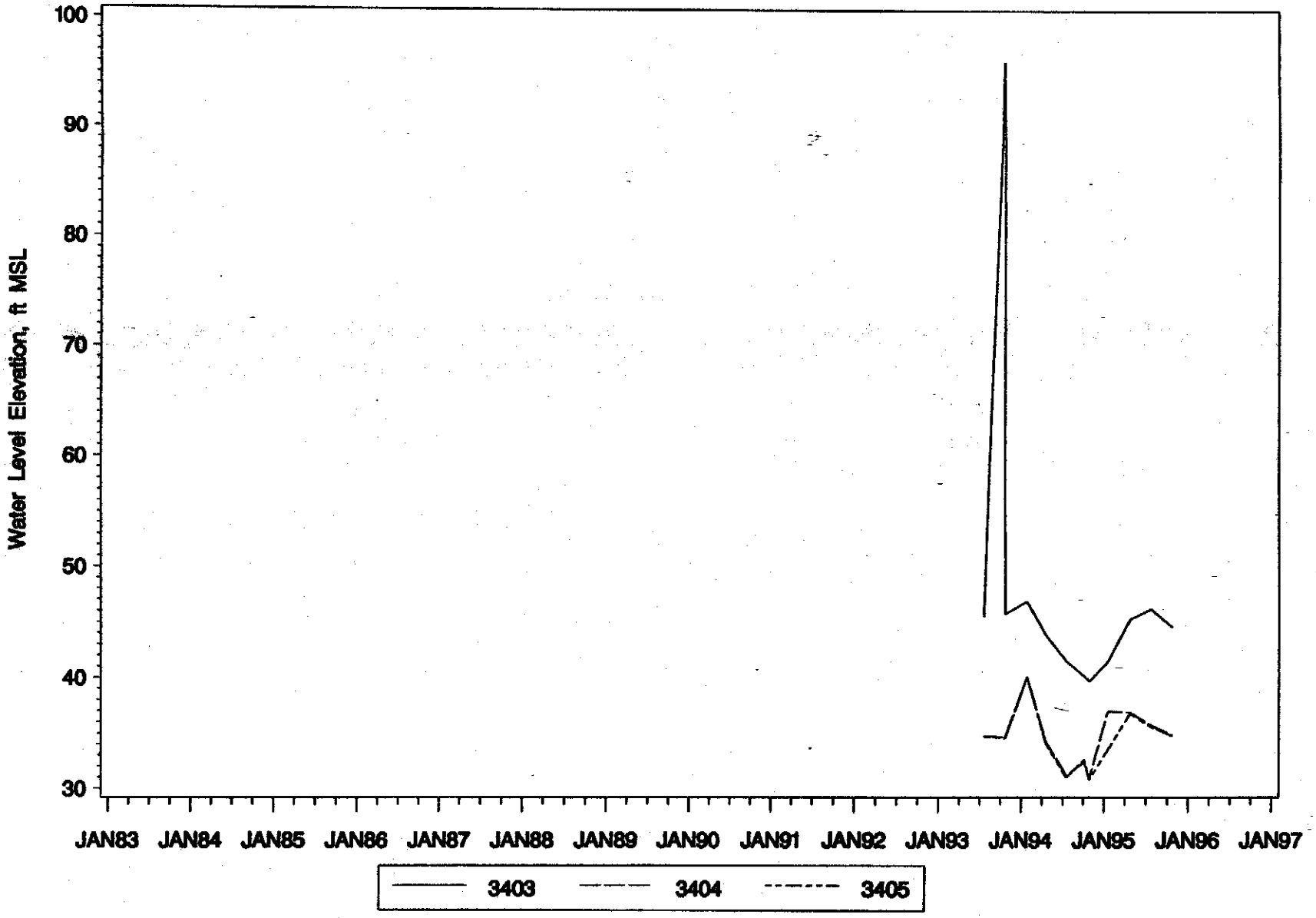


HYDROGRAPH


WELLS=3363-5
Water Level Elevation, ft MSL
120
110
100
90
80
70
60
50
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3363
3364
3365

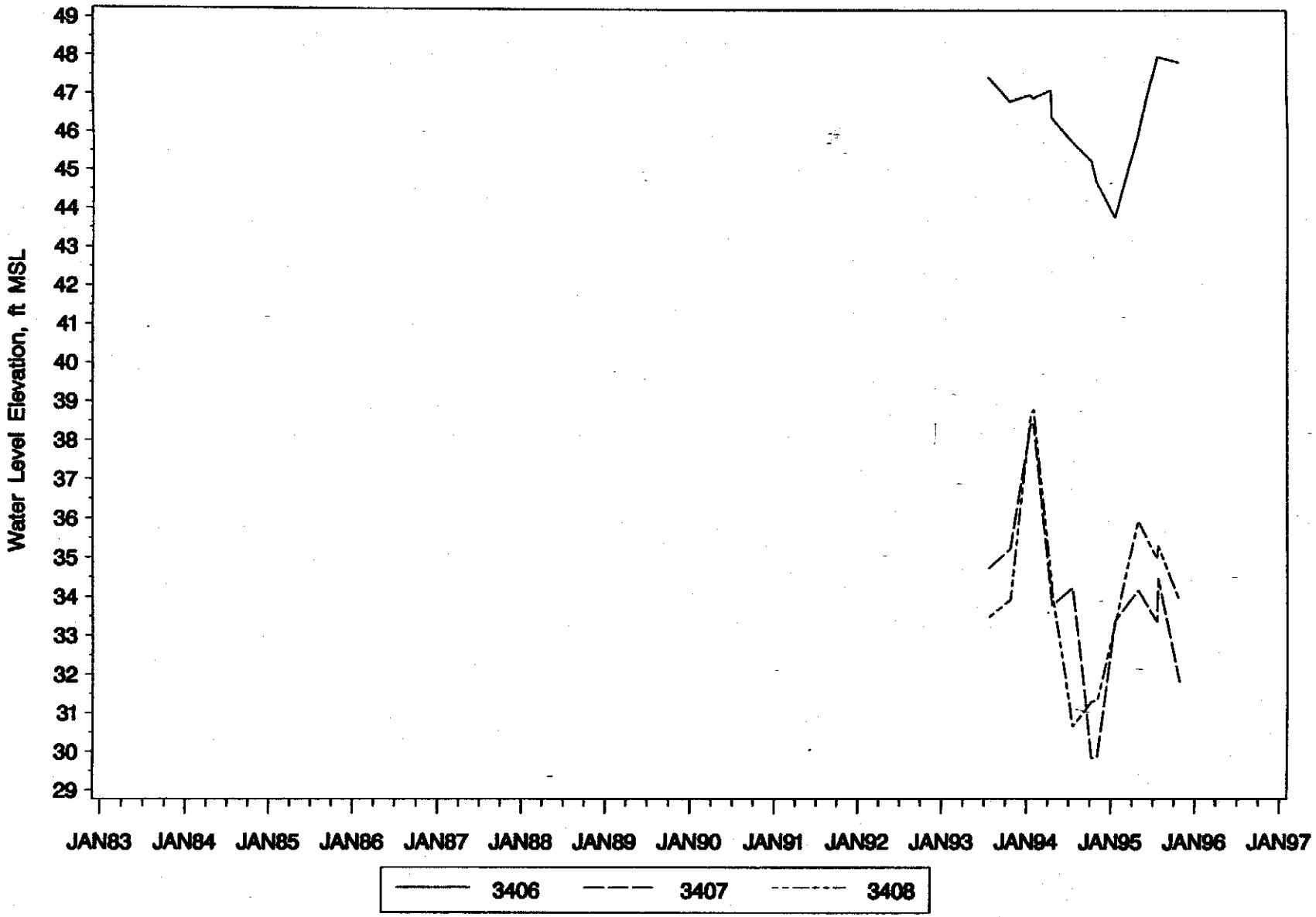
HYDROGRAPH

WELLS=3403-5

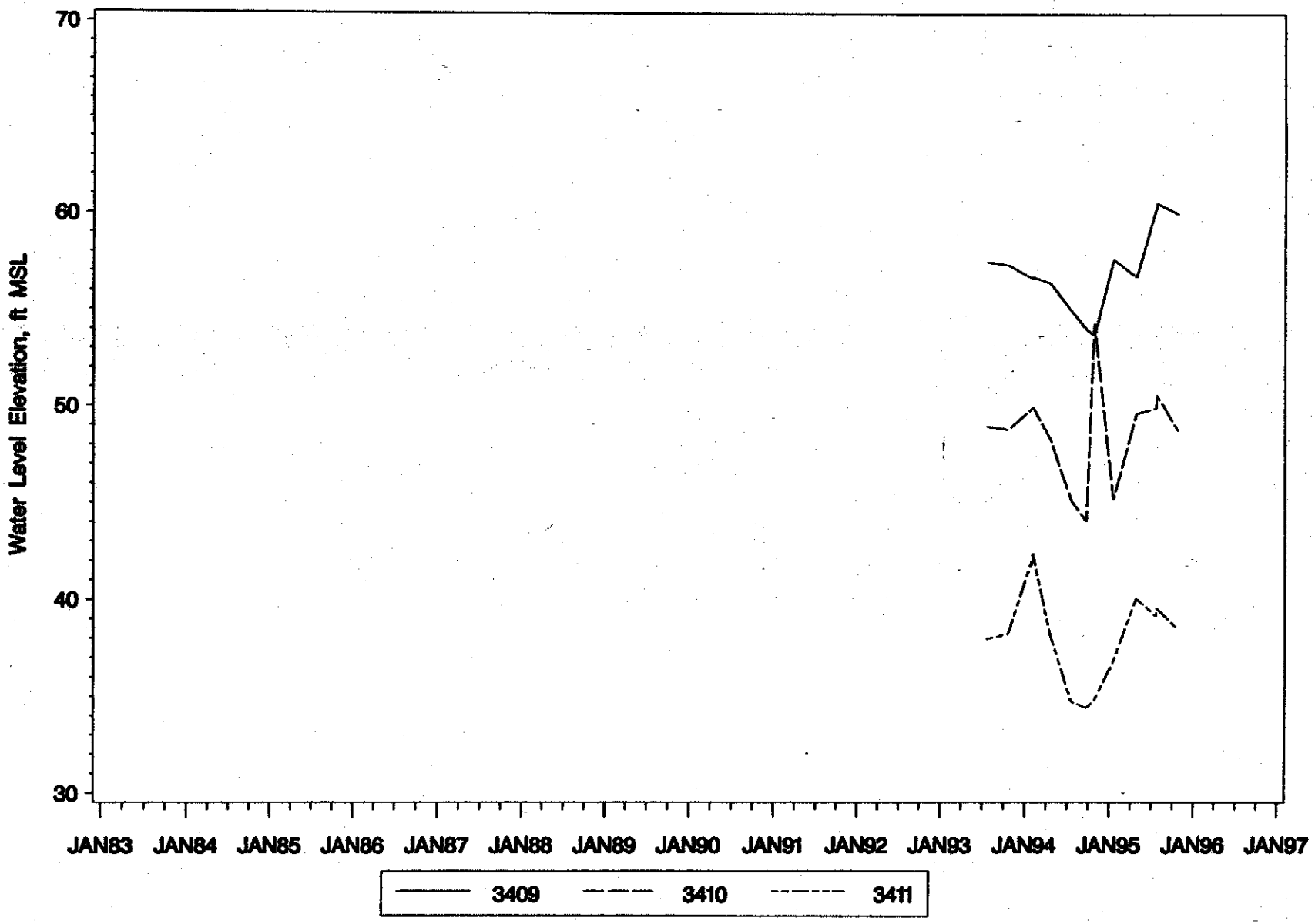


HYDROGRAPH

WELLS=3406-8

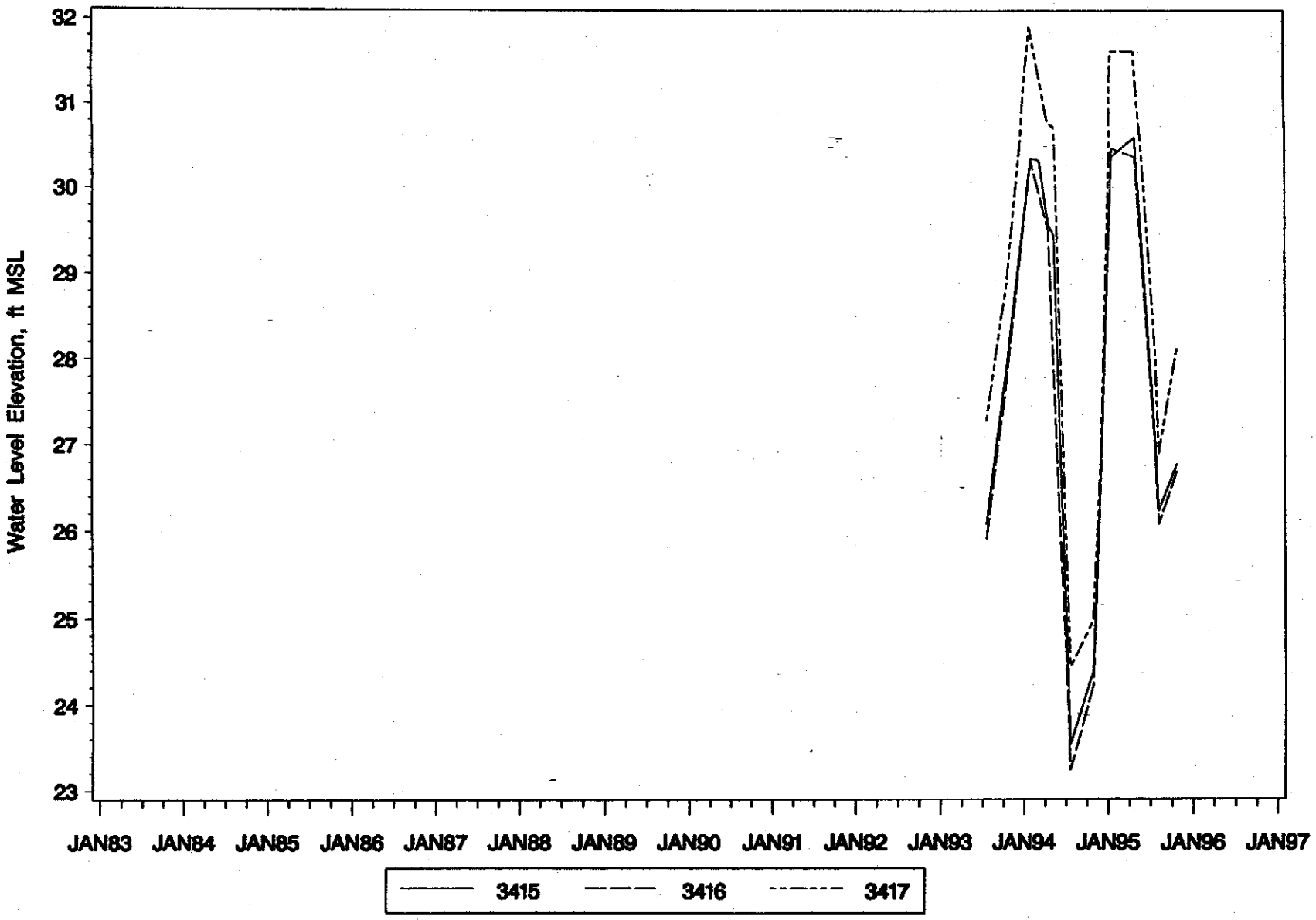


HYDROGRAPH

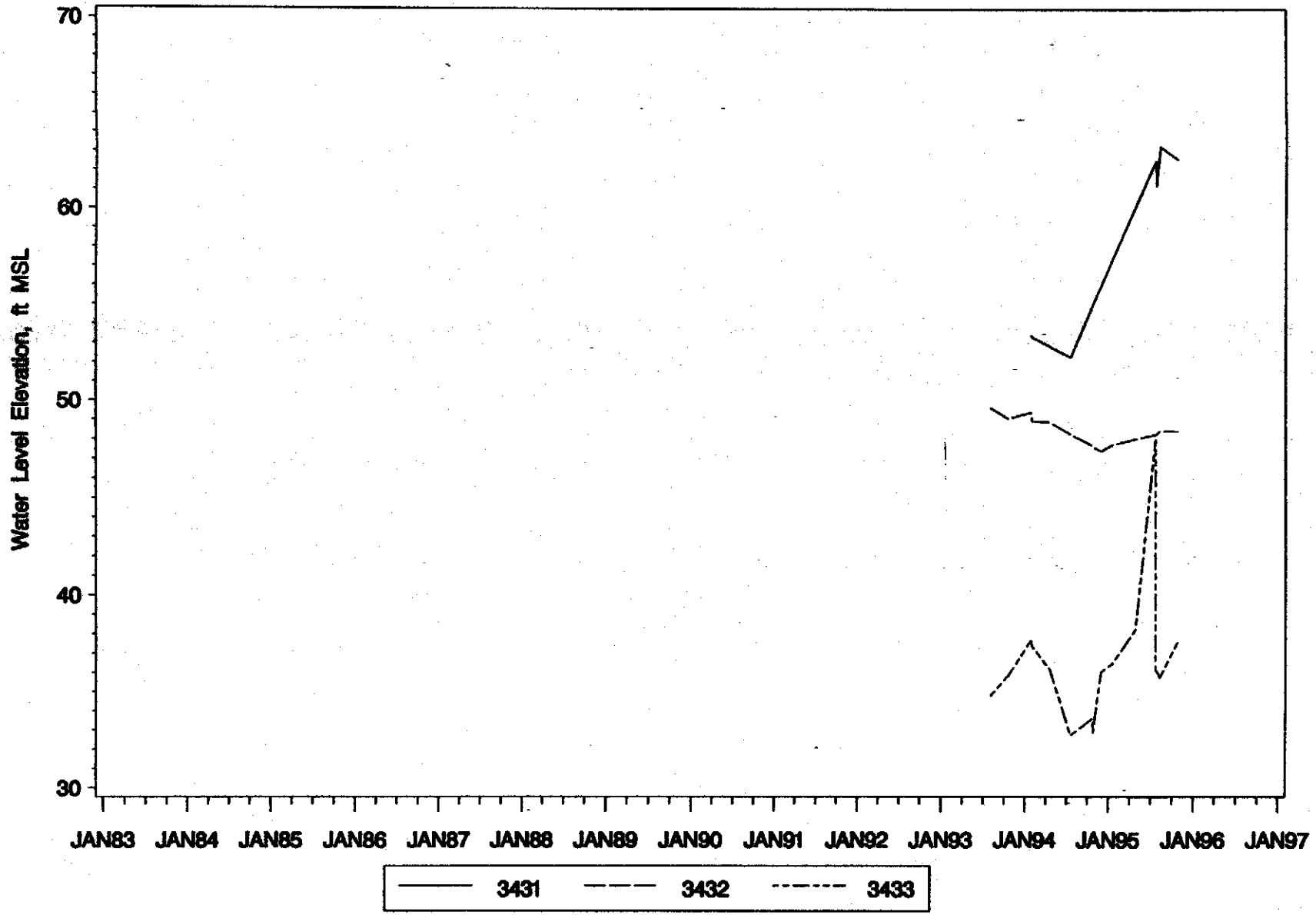

WELLS=3409-11
Water Level Elevation, ft MSL
70
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3409
3410
3411

HYDROGRAPH

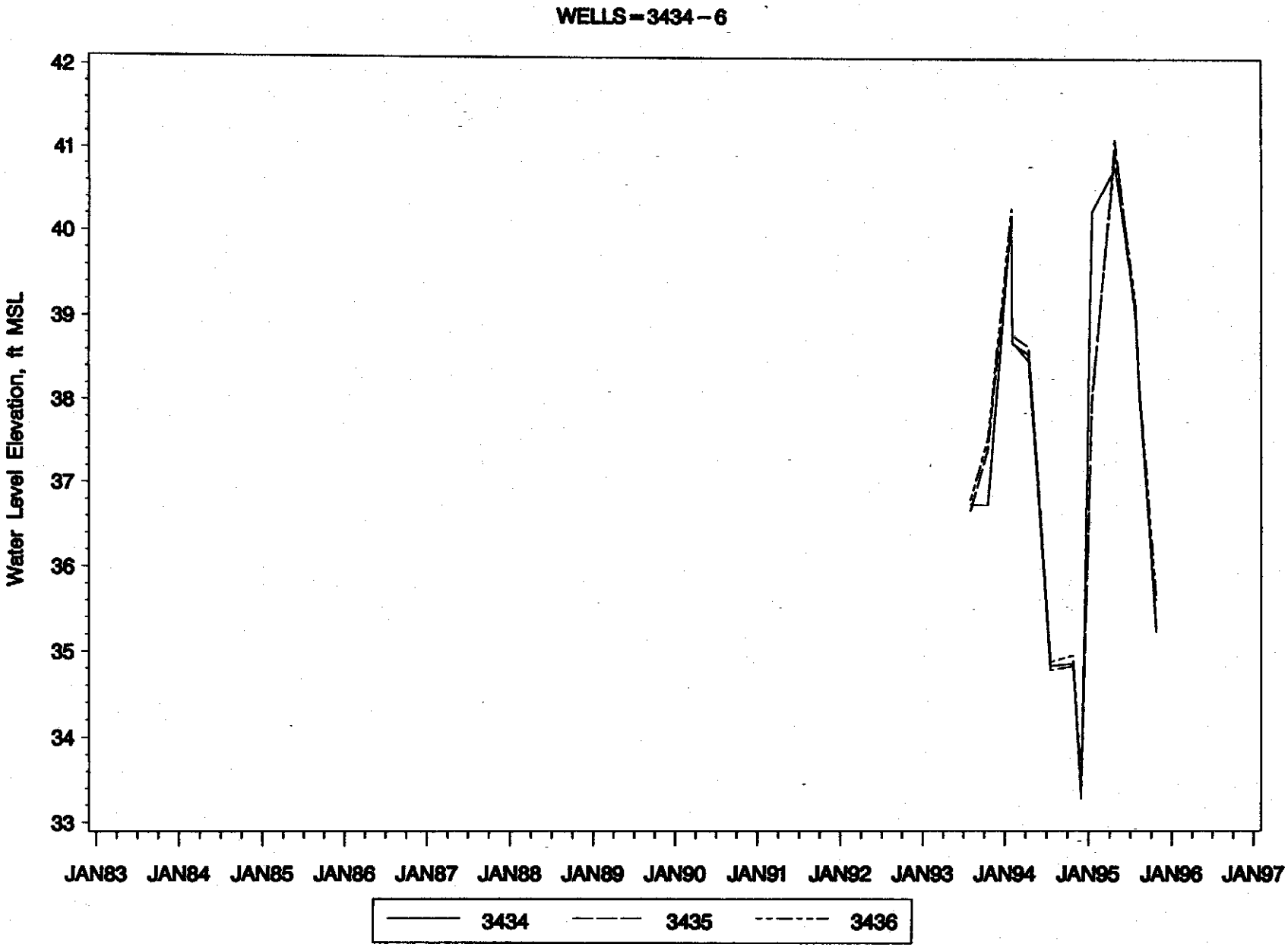
WELLS=3415-7



HYDROGRAPH

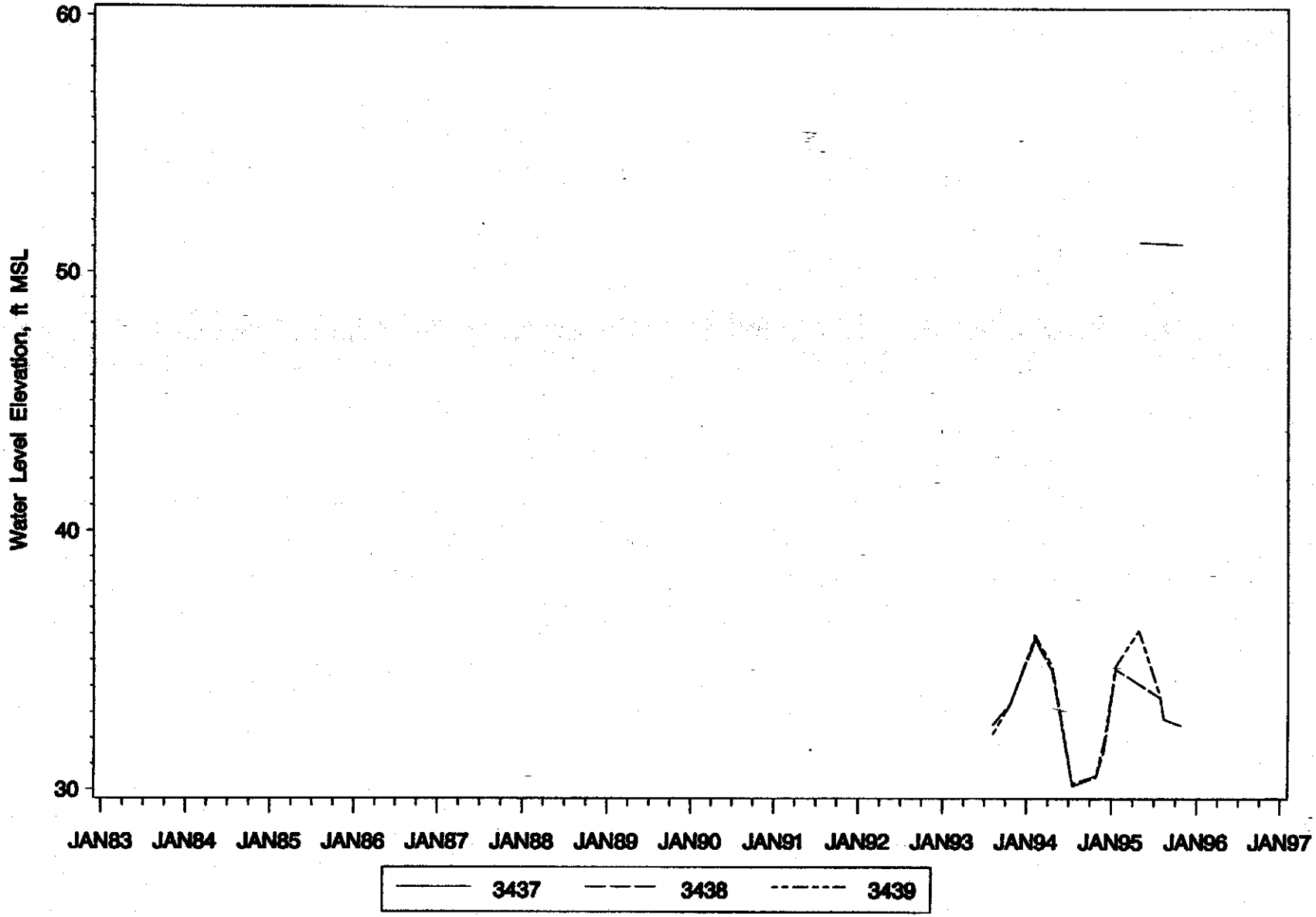

WELLS=3431-3
Water Level Elevation, ft MSL
70
60
50
40
30
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3431
3432
3433

HYDROGRAPH


WELLS=3434-6
Water Level Elevation, ft MSL
42
41
40
39
38
37
36
35
34
33
JAN83
JAN84
JAN85
JAN86
JAN87
JAN88
JAN89
JAN90
JAN91
JAN92
JAN93
JAN94
JAN95
JAN96
JAN97
3434
3435
3436

HYDROGRAPH

WELLS=3437-9



HYDR[redacted]RAPH

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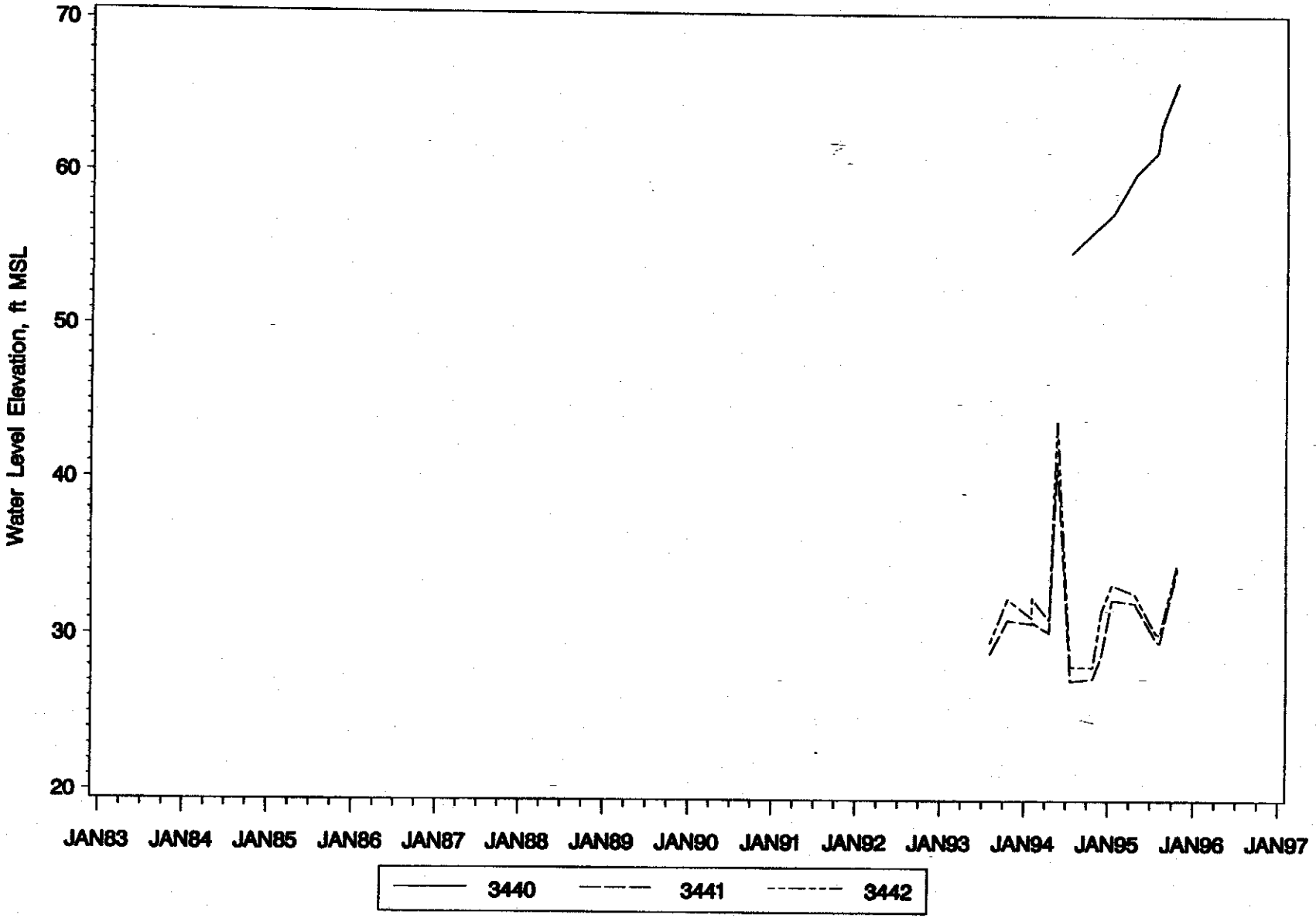


Appendix D

Specifications for SURFER Generated Contour Maps

Specifications for SURFER Generated Contour Maps

The potentiometric contour maps in this report were generated with the program SURFER for Windows (version 5.0), manufactured by Golden Software Incorporated. The parameters used in the program are listed below.

Grids:

1. Grid size: 48 east-west by 40 north-south (grid spacing is 278 by 278).

2. Gridding Method: Ordinary Kriging (no drift), Linear Variogram, All Data Search.

3. Boundary (California Coordinates):
   - minimum x 2209420 feet
   - maximum x 2222520 feet
   - minimum y 336380 feet
   - maximum y 347233 feet

4. Contour Interval: 10 feet

5. Minor refinements to contours were performed manually.

Data:

1. Water level elevation values were averaged at locations with more than one well completion in the same aquifer.

2. Extraction well efficiency was estimated at 60 percent, and the pumping water levels for operating extraction wells were then adjusted and used for contouring.

3. Injection well water levels were not used for contouring because they represent back pressures in the manifold conveyance system rather than actual ground water levels.

APPENDIX E

Anomalous Monitoring Well Data

Anomalous Monitoring Well Data

Well No.	Aquifer	Explanation
10	A	The April 1995 water level is anomalously high and was not used for contouring.
59	n/a	This well was determined to be completed in a perched zone above Aquifer A, and water levels were not used for contouring.
129	n/a	This well was determined to be completed in a perched zone above Aquifer A, and water levels were not used for contouring.
302	n/a	This well was determined to be completed in a perched zone above Aquifer A, and water levels were not used for contouring.
303	A	Water levels in this well were anomalously high in October 1994 and the well was dry in April 1995. The data was not used for contouring.
307	A	Water levels in this well were anomalously high in October 1994 and in April 1995, and the data was not used for contouring.
1229	A	The October 1994 water level was anomalously high, and the data was not used for contouring.
1484	C	The October 1994 water level was anomalously high, and the data was not used for contouring.
3044	B	The October 1994 water level was anomalously low, and the data was not used for contouring.
3057	A	The April 1995 water level was anomalously high, and the data was not used for contouring. The well was dry in October 1994.

Well No.	Aquifer	Explanation
3113	B	The April 1995 water level was anomalously high, and the data was not used for contouring.
3410	D	The October 1994 water level was anomalously high, and the data was not used for contouring.
3437	n/a	This well was determined to be completed in an aquitard comparable to Aquifer B, and water levels were not used for contouring.
3440	n/a	This well was determined to be completed in an aquitard comparable to Aquifer B, and water levels were not used for contouring.
4014	C	This well has been converted to an injection well. Water levels were not used for contouring.
4045	B	This well is no longer used as an extraction well. Water levels from this well are used for contouring in Aquifer B.
4050	A	This well is no longer used as an extraction well. Water levels from this well are used for contouring in Aquifer A.
4145	C	Reported water levels were anomalously high in October 1994 and in April 1995. It was previously reported that pump lubrication oil floating on the water inside the well casing distorts true water level measurements. Water levels from this well were not used for contouring.
Extraction Wells		The water levels used for the potentiometric contour maps were based on an estimated well efficiency of 60%. The pumping water levels were corrected prior to contouring.
Injection Wells		Accurate water level measurements cannot be obtained from the injection wells since the water is pumped into the wells under pressure. Water levels from the injection wells were not used for contouring.

APPENDIX F

Summary of Aquifer Test Analyses

Summary of Aquifer Test Analyses

Introduction

Aquifer tests were conducted on three groundwater extraction wells in Get E and GET F. Well 4315, in Get F was tested on May 18, 1994, Wells 4425 and 4435, in Get E were tested in November 7 and November 29, 1995, respectively. The tests were conducted to further characterize the aquifer material in the vicinity of groundwater extraction in GET E and GET F and to calculate aquifer parameters.

Procedures

Field Activities

Pumping rates were measured during each aquifer test using a totalizing flow meter and stop watch. Water levels in the pumping well and selected monitor wells were measured electronically with Aquistar pressure transducers and data loggers supplied by Aerojet General Corporation. The data loggers were programmed to collect measurements at specified time intervals and record them in electronic memory. Manual water levels were also collected with an electric water level sounder.

Data Analysis

Transmissivity (T) and storage coefficient (S) values were calculated from drawdown data collected during the pumping test using the Theis method or the Hantush leaky method when leaky aquifer conditions were indicated. Aquifer parameters were also calculated using the Cooper-Jacob method. Transmissivity was calculated for the pumping well and selected monitor wells from recovery data using the Jacob recovery method. Curve matching and calculations for Theis and

Hantush methods were performed using Graphical Well Analysis Package (GWAP) software (from Groundwater Graphics). Straight line matching for Cooper-Jacob drawdown and Cooper recovery methods were done by hand. Aquifer test results are summarized on Table F-1. Hydrographs, log-log plots, and semi-log plots of drawdown over time for most wells monitored during the tests are presented in this appendix.

Aquifer Test 4315

A 72 hour constant-rate aquifer test was conducted on Extraction Well 4315 between 10:00 AM May 18 and 10:00 AM May 21, 1994. Hydro-Search personnel monitored the aquifer test, Layne-Western personnel monitored the pump during the test. A step test with pumping rates of 100, 148, 219, and 230 gpm was conducted prior to the constant-rate test to establish the optimum pumping rate. An optimum pumping rate of approximately 192 gpm was used during the constant-rate test. Electronic water level data were not collected in the pumping well during the constant-rate test.

Barometric Pressure Effects

Barometric pressure data, expressed in feet of water, for the period of the Well 4315 aquifer test are included in this appendix. Barometric pressure changes were sufficiently small that barometric corrections to the drawdown data were not necessary. The maximum change in barometric pressure during the 72-hour constant-rate test was approximately 0.2 foot. The maximum change in barometric pressure during the 24-hour recovery period (after the pump was turned off) was approximately 0.1 foot.

Data Analysis

Drawdown plots for eight monitor wells are presented in this appendix.

Pumping Well 4315 has a fifteen foot screen that partially penetrates Aquifer B. At Well 4315, Aquifer B is about 30 feet thick and is composed of sand and gravel. Aquifer B at Well 4315 is separated from the overlying Aquifer A by approximately 28 feet of predominantly clay and from the underlying Aquifer C by approximately 12 feet of predominantly silt. The saturated thickness of Aquifer B at Well 4315 is approximately 30 feet.

Results

Two Aquifer B monitor wells; Wells 132 and 3293 responded to the pumping test and were analyzed using the confined leaky method. The calculated average transmissivity is 10,000 gpd/ft and the average storage coefficient is 4.6×10^{-3}.

Six Aquifer C monitor wells; Wells 357, 495, 1244, 1245, 3245, and 3349 responded to the pumping test with enough drawdown for analysis. The calculated transmissivities and storage coefficients are presented in Table F-1; however, the parameters are not representative of conditions in Aquifer C because the flow contributed by that aquifer cannot be determined.

Conclusions

Average transmissivity of 10,000 gpd/ft and average storage coefficient of 4.6×10^{-3} were calculated for Aquifer B from this aquifer test.

The strong response to pumping in Aquifer B seen in Aquifer C wells indicates a high degree of hydraulic connection between Aquifers B and C.

Aquifer Test 4425

A 24 hour constant-rate pumping test was conducted on Extraction Well 4425 between 12:01 PM November 7 and 12:00 PM November 8, 1995. The Well 4425 aquifer test was supervised by Kleinfelder personnel and the pump was monitored by Water Development personnel. The pumping rate averaged 1,180 gpm during the constant-rate test.

Barometric Pressure Effects

Barometric pressure data, expressed in feet of water, for the period of the Well 4425 aquifer test are presented in this appendix. Barometric pressure changes were sufficiently small that barometric corrections to the drawdown data were not necessary. The maximum change in barometric pressure during the 24-hour period of the constant-rate test was approximately 0.2 foot. The maximum change in barometric pressure during the 24-hour recovery period (after the pump was turned off) was approximately 0.1 foot.

Data Analysis

Drawdown plots for the pumping well and 16 monitor wells are included in this appendix. A recovery plot for the pumping well is also presented.

The pumping well is screened over 100 feet in Aquifers C and D. Aquifers C and D are 60 and 40 feet thick, respectively, at the pumping well. The aquifer material is composed predominantly of sand and gravel separated by 30 feet of silty material. The saturated thickness of Aquifers C and D at Well 4425 is approximately 130 feet. The log-log plot for the pumping well does not match Theis or Hantush type curves and aquifer parameters were not calculated using this method. The Cooper-

Jacob drawdown and recovery transmissivities for the pumping well are 124,600 and 110,400 gpd/ft, respectively.

Three monitor wells; Wells 3517, 3518, and 4070, are also screened in Aquifers C and D. Calculated transmissivities and storage coefficients range from 95,700 to 143,600 gpd/ft and 1.3×10^{-3} and 9.7×10^{-3}, respectively. The average transmissivity and storage coefficient values for combined Aquifers C and D monitor wells are 115,500 gpd/ft and 3.2×10^{-3}, respectively.

Drawdown data collected for new Extraction Well 4435 during the pumping of Well 4425 is not considered representative of aquifer conditions. It is suspected that the measuring port in Well 4435 is not in hydraulic connection with the aquifer.

Six Aquifer C monitor wells; Wells 124, 165, 437, 438, 3353, and 3403 responded to the pumping test. Aquifer parameters calculated at Well 124 are outside the range of other Aquifer C wells and are believed to represent only local conditions. Calculated transmissivities and storage coefficients at the other Aquifer C wells range from 104,900 to 184,300 gpd/ft and 9.3×10^{-4} and 2.5×10^{-3}, respectively.

Six Aquifer D monitor wells; Wells 167, 439, 440, 3332, and 3407 responded to the pumping test. Calculated transmissivities range from 109,700 to 184,300 gpd/ft, and storage coefficients range from 5.0×10^{-4} and 1.6×10^{-3}.

Eight Aquifer E wells responded to the pumping test with only minimal drawdown and were not analyzed.

Conclusions

Average calculated transmissivity and storage coefficient values for Aquifers C and D monitor wells are 115,500 gpd/ft and 3.2×10^{-3}, respectively.

Drawdown measured in wells screened in Aquifer E is useful as an indication of the degree of hydraulic connection with Aquifers C and D. There was very little response of Aquifer E wells to the pumping test, indicating little hydraulic connection between Aquifers C and D and Aquifer E.

Aquifer Test 4435

A 23.25-hour constant-rate test was conducted at Extraction Well 4435 between 10:00 PM November 29 and 9:15 PM November 30, 1995. Pump failure terminated the test early and the data loggers were not programmed to properly record water levels during recovery. To collect recovery data, the well was pumped again between 7:00 AM December 1 and 7:34 AM December 2, 1995.

The Well 4435 aquifer test was supervised by Kleinfelder personnel and the pump was monitored by Water Development personnel. The pumping rate averaged 1,244 gpm during the initial constant-rate test and 1,255 gpm during pumping for recovery test data.

Water levels in Wells 87, 165, 166, and 167 during the initial constant-rate test were not available for analysis. Data collected from these wells during pumping for the recovery test were used for drawdown analysis.

Barometric Pressure Effects

Barometric pressure data, expressed in feet of water, for the period of the 4435 aquifer test are presented in this appendix. Barometric pressure changes were sufficiently small that barometric corrections to drawdown data were not necessary. The maximum change in barometric pressure during the 23.25-hour period of the constant-rate test was approximately 0.1 foot. The maximum change in barometric pressure during the 24.5-hour pumping period for the recovery test data was approximately 0.2 foot and was approximately 0.1 foot during the 24-hour recovery period (after the pump was turned off).

Data Analysis

Drawdown plots for the pumping well and fourteen monitor wells are presented in this appendix.

The pumping well is screened over 100 feet in Aquifers C and D. Aquifers C and D are 60 and 40 feet thick, respectively, at the pumping well. The aquifers are composed of predominantly sand and gravel with silt lenses, separated by 30 feet of predominantly silt. The saturated thickness at Well 4435 is approximately 130 feet.

Pumping Well 4435 and six monitor wells; Wells 3517, 3518, 4070, 4075, 4200, and 4425 are screened in Aquifers C and D. Calculated transmissivity and storage coefficient values from these monitor wells range from 117,300 to 179,400 gpd/ft and 8.4×10^{-4} to 1.9×10^{-3}, respectively. The drawdown data for the pumping well does not match Theis or Hantush Leaky type curves and aquifer parameters were not calculated by these methods. The calculated Cooper-Jacob drawdown and recovery transmissivities for the pumping well are 135,700 and 102,900 gpd/ft, respectively.

Five Aquifer C monitor wells; Wells 124, 127, 165, 3338, and 3353 responded to the pumping test. Drawdown data collected for Wells 124 and 3338 do not match Theis curves or a Cooper-Jacob straight line and were not analyzed. Calculated transmissivity and storage coefficient values for the other three wells range from 108,400 to 155,600 gpd/ft and 9.7×10^{-4} to 1.1×10^{-3}, respectively.

Three Aquifer D monitor wells; Wells 167, 476, and 3332 responded to the pumping test. Calculated transmissivity and storage coefficient values range from 115,200 to 139,300 gpd/ft and 2.0×10^{-4} to 2.1×10^{-3}, respectively.

Aquifer E Wells 477, 478, 479, 3333, 3334, 3339, and 3340 responded to the pumping test with minimal or no drawdown and were not analyzed.

Conclusions

Average calculated transmissivity and storage coefficient values for combined Aquifers C and D are 139,200 gpd/ft and 1.2×10^{-3}, respectively.

Drawdown measured in wells screened in Aquifer E is useful as an indication of the degree of hydraulic connection with Aquifers C and D. There was very little response of Aquifer E wells to the pumping test, indicating little hydraulic connection between Aquifers C and D and Aquifer E.

Table F-1. Aquifer Test Results for Wells 4315, 4425, and 4435

Pumping Well	Observation Well	Date of Test	Distance from Pumping Well (ft)	Maximum Drawdown (ft)	Aquifer	Theis Transmissivity (gpd/ft)	Storage Coefficient	Cooper/Jacob Transmissivity (gpd/ft)	Storage Coefficient	Recovery Transmissivity (gpd/ft)
4315		05/18/94	0	22.20	B					
GET F	132		62	10.70	B	10,530	0.007541	9,216	0.010	
	357		945	1.30	C	6,798 (1)	0.001665			
	495		909	3.91	C	11,810 (1)	0.002273	16,952	0.00043	
	1244		859	2.80	C			19,495	0.00082	
	1245		859	2.60	C			21,754	0.00101	
	3061		1026	0.70	D					
	3245		682	4.05	C	13,560 (1)	0.0009218	14,692	0.00082	
	3293		549	7.40	B	9,826 (1)	0.0004198	10,451	0.00048	
	3349		436	3.70	C	12,950 (1)	0.002362	17,182	0.00226	
4425		11/07/95		35.09	C/D	(2)		124,608		110,400
GET E	124		56	7.02	C	64,710 (1)	0.01925	75,796	0.151	
	165		180	5.24	C	174,200	0.0024	184,331	0.00249	
	166		180	8.41	Aquitard	83,360 (1)	0.001907	113,693	0.00117	
	167		180	9.27	D	(2)		111,257	0.00050	
	437		391	6.24	C	126,200	0.00114	136,035	0.000930	
	438		391	4.94	C	148,200	0.00168	139,695	0.00228	
	439		391	5.46	D	158,800	0.00072	184,331	0.00064	
	440		391	5.39	D	155,200	0.000926	180,069	0.00071	
	476		940	3.70	D	144,900	0.00136	109,690	0.00163	
	477		940	1.50	E					
	478		940	1.50	E					
	479		940	1.40	E					
	3332		308	6.44	D	135,200 (1)	0.00068	159,754	0.00053	
	3333		308	1.62	E					

(1) Confined Leaky

(2) Log-Log Drawdown Plot does not conform to Type Curves.

Table F-1. Aquifer Test Results for Wells 4315, 4425, and 4435

Pumping Well	Observation Well	Date of Test	Distance from Pumping Well (ft)	Maximum Drawdown (ft)	Aquifer	Theis Transmissivity (gpd/ft)	Storage Coefficient	Cooper/Jacob Transmissivity (gpd/ft)	Storage Coefficient	Recovery Transmissivity (gpd/ft)
	3334		308	1.61	E					
	3353		309	6.00	C	129,100 (1)	0.0015	138,453	0.00142	
	3403		1059	3.36	C	104,900 (1)	0.0022	110,078	0.00184	
	3404		1059	1.32	E					
	3405		1059	1.36	E					
	3406		1520	<0.05	C					
	3407		1520	3.22	D	126,200 (1)	0.0012	123,619	0.00106	
	3408		1520	1.53	E					
	3517		15	12.86	C/D	95,710	0.0097	114,952		
	3518		569	5.50	C/D	117,700	0.0013	103,152	0.00172	
	4070		456	5.22	C/D	117,700 (1)	0.0018	143,558	0.00142	
	4435		560	0.40	C/D					
4435		11/29/95		49.40	C/D	(2)		135,709		102,900
GET E	87		567	<0.05	E					
	124		506	3.35	C					
	127		603	5.03	C	124,100	0.001359	155,647	0.00107	
	128		603	0.29	D					
	165		382	6.60	C			108,370	0.00152	
	166		382	6.60	Aquitard			106,279	0.00141	
	167		382	5.40	D			123,793	0.00212	
	476		669	4.00	D	139,300	0.001524	115,234	0.0002	
	477		669	1.44	E					
	478		669	1.39	E					
	479		669	1.36	E					
	480		669	0.10	E					
	3332		720	3.98	D	115,800	0.0009979	123,002	0.00208	
	3333		720	1.33	E					

(1) Confined Leaky

(2) Log-Log Drawdown Plot does not conform to Type Curves.

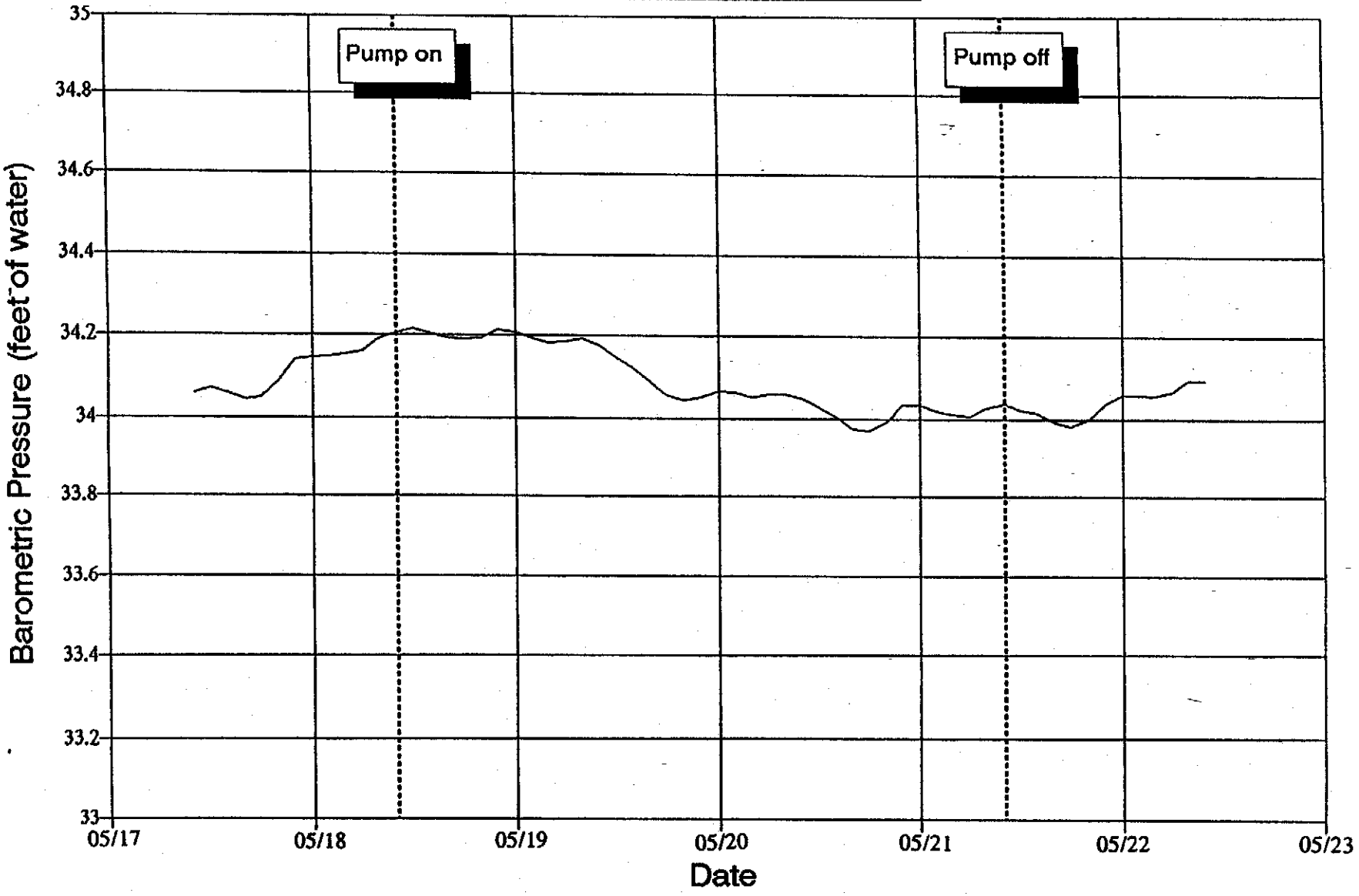
Table F-1. Aquifer Test Results for Wells 4315, 4425, and 4435

Pumping Well	Observation Well	Date of Test	Distance from Pumping Well (ft)	Maximum Drawdown (ft)	Aquifer	Theis Transmissivity (gpd/ft)	Storage Coefficient	Cooper/Jacob Transmissivity (gpd/ft)	Storage Coefficient	Recovery Transmissivity (gpd/ft)
	3334		720	1.32	E					
	3338		199	7.32	C					
	3339		199	1.42	E					
	3340		199	1.43	E					
	3353		714	4.70	C	139,300	0.000969	109,472	0.00148	
	3517		555	5.82	C/D	130,000	0.001036	134,047	0.0010	
	3518		9.8	25.00	C/D	179,400	0.001483	117,291		
	4070		502	5.51	C/D	136,000	0.001237	140,951	0.00107	
	4075		533	6.00	C/D	127,000	0.000851	124,873	0.00084	
	4200		1006	3.17	C/D	167,500	0.001654	142,171	0.00193	
	4425		560	5.71	C/D	130,000	0.00109	140,951	0.00103	

(1) Confined Leaky

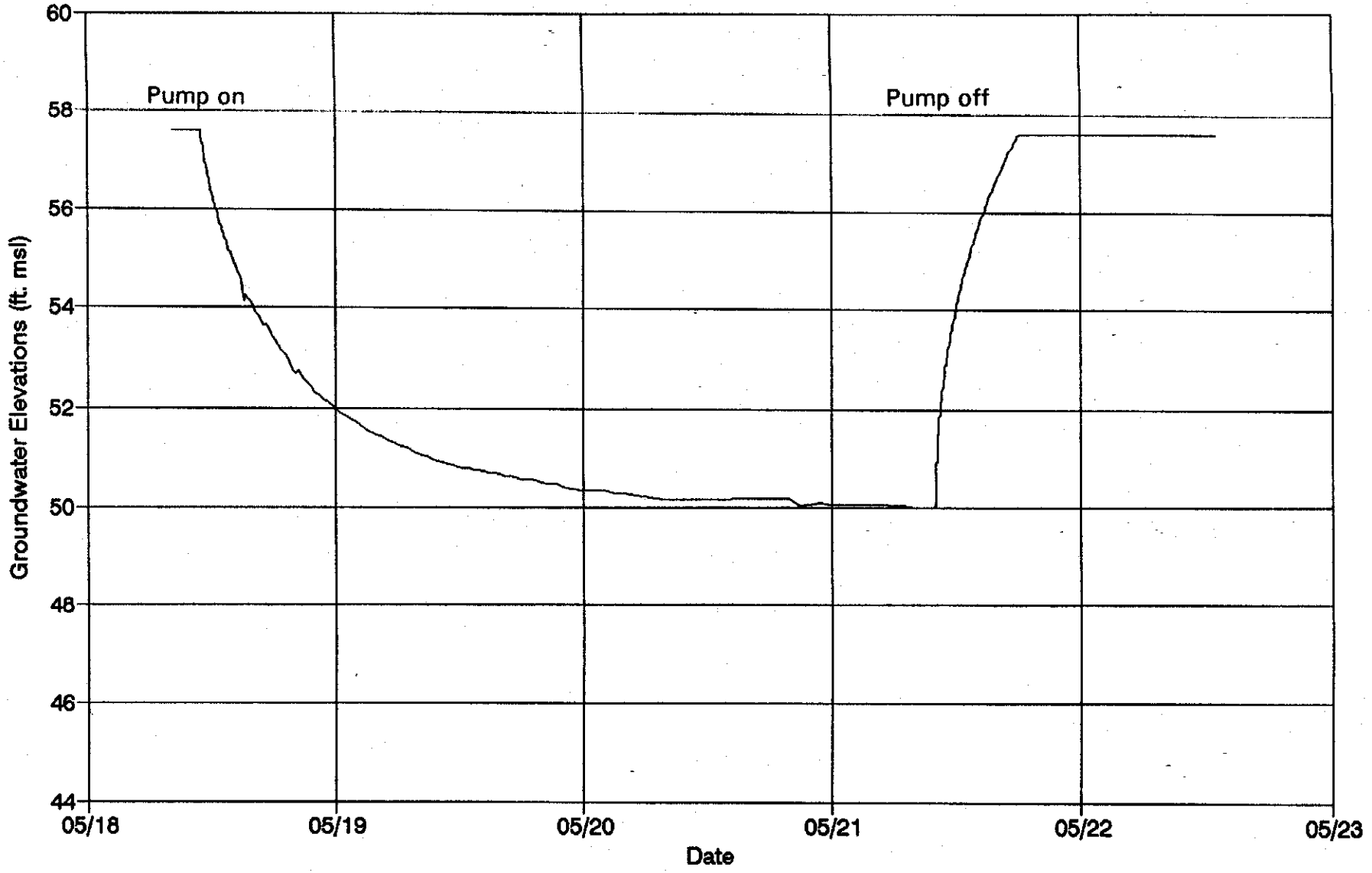
(2) Log-Log Drawdown Plot does not conform to Type Curves.

4315 Aquifer Test
Barometric Pressure Data



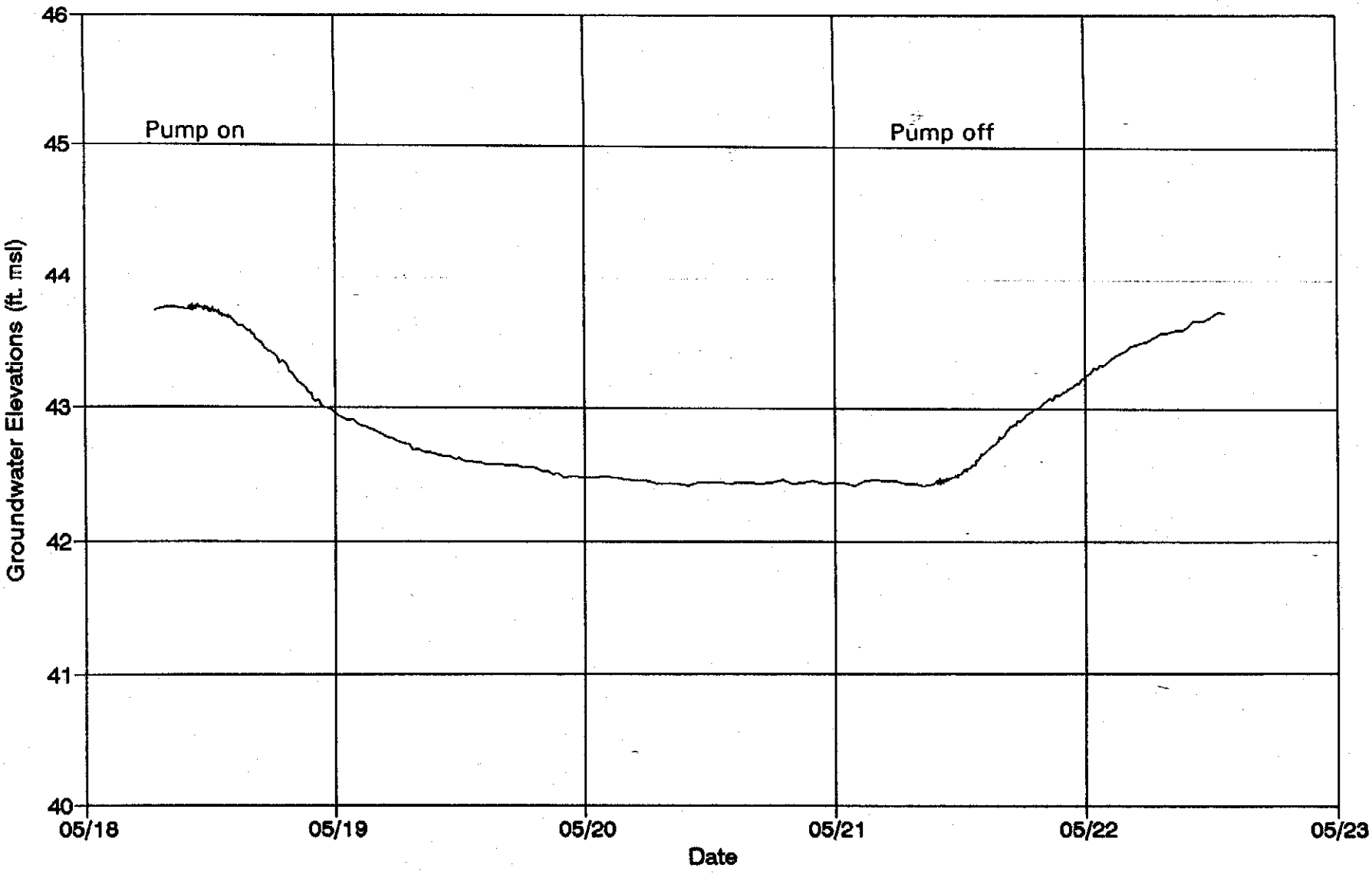
4315 Aquifer Test

Hydrograph for Well 132



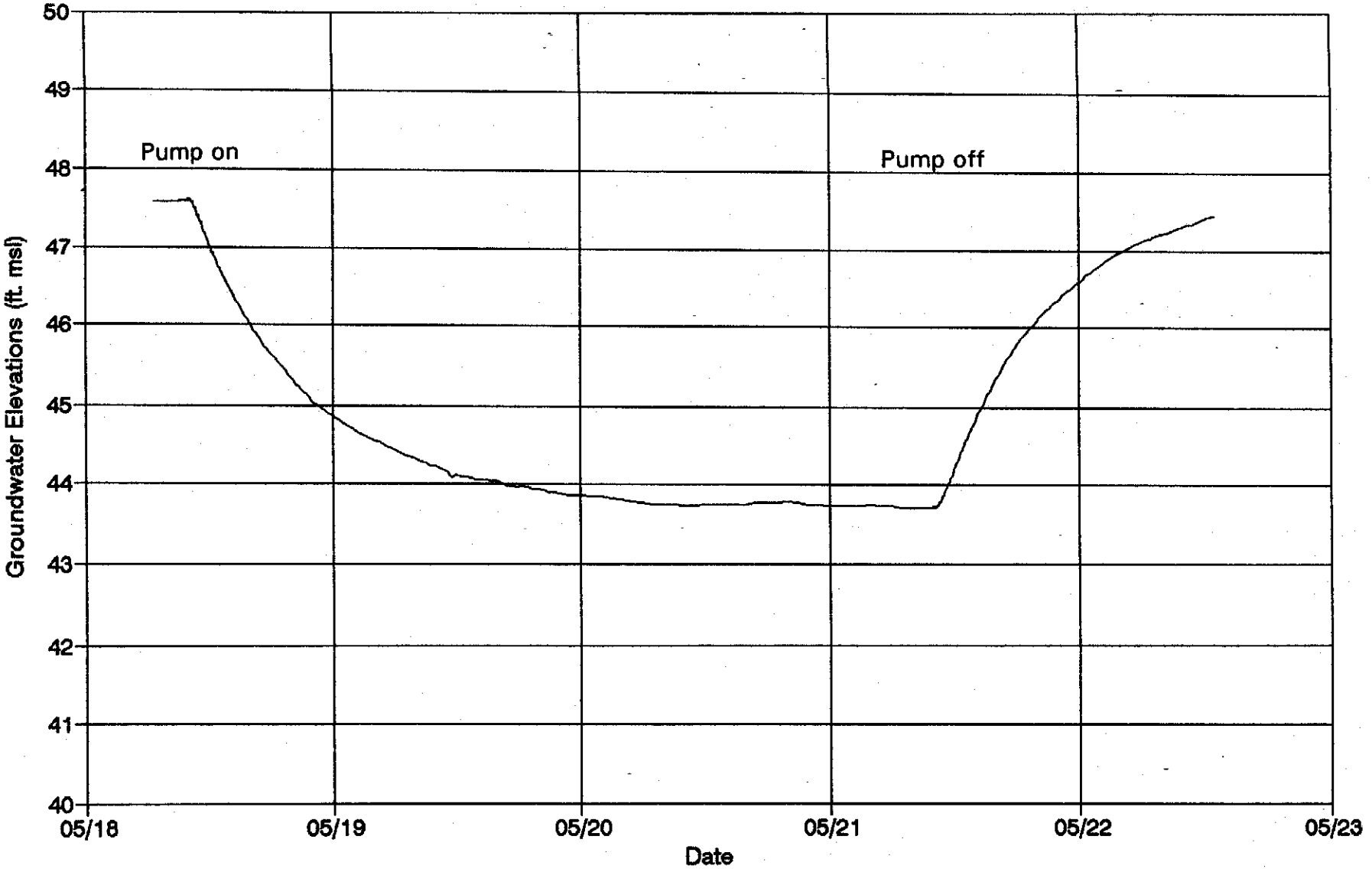
4315 Aquifer Test

Hydrograph for Well 357



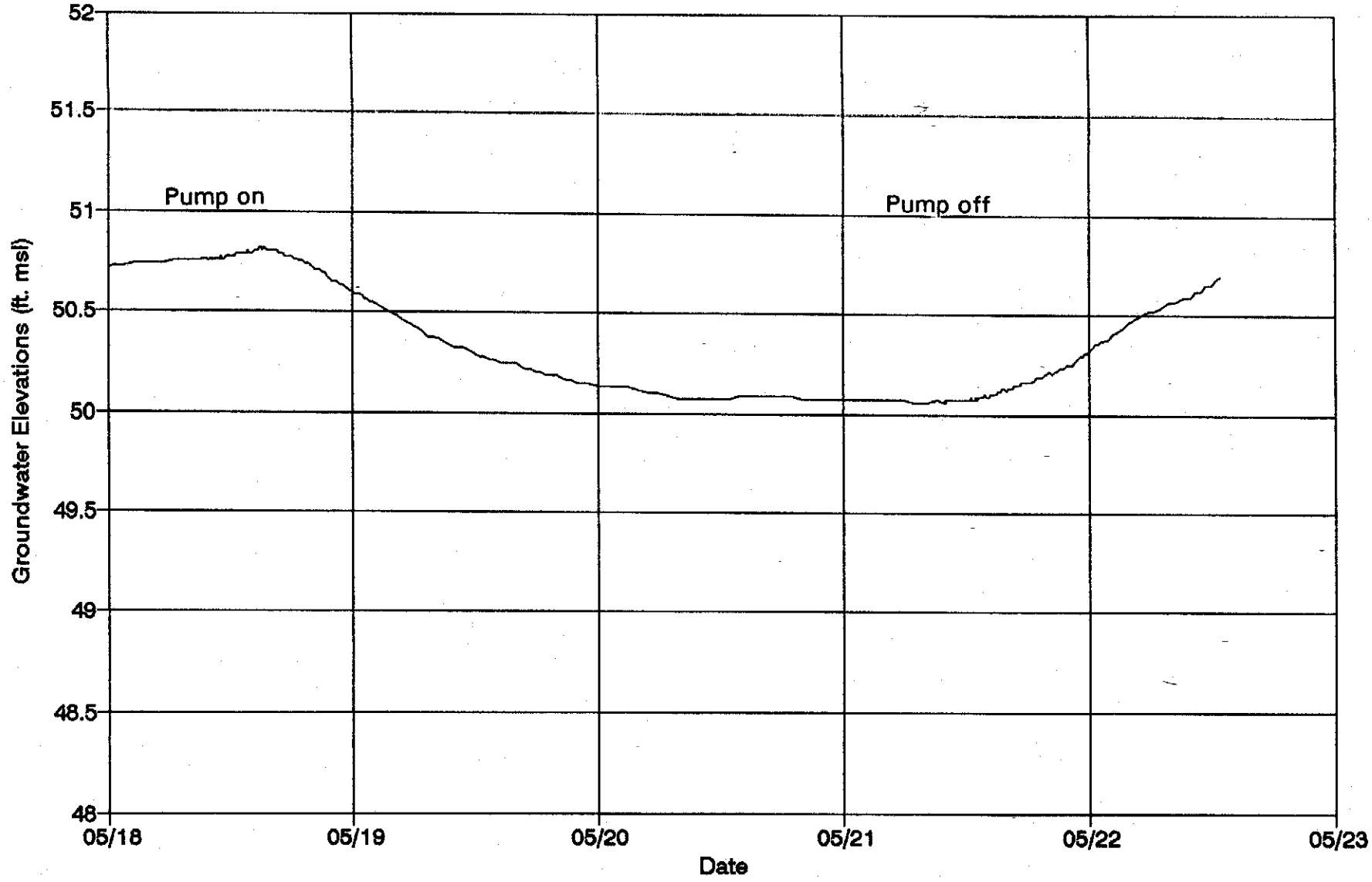
4315 Aquifer Test

Hydrograph for Well 495



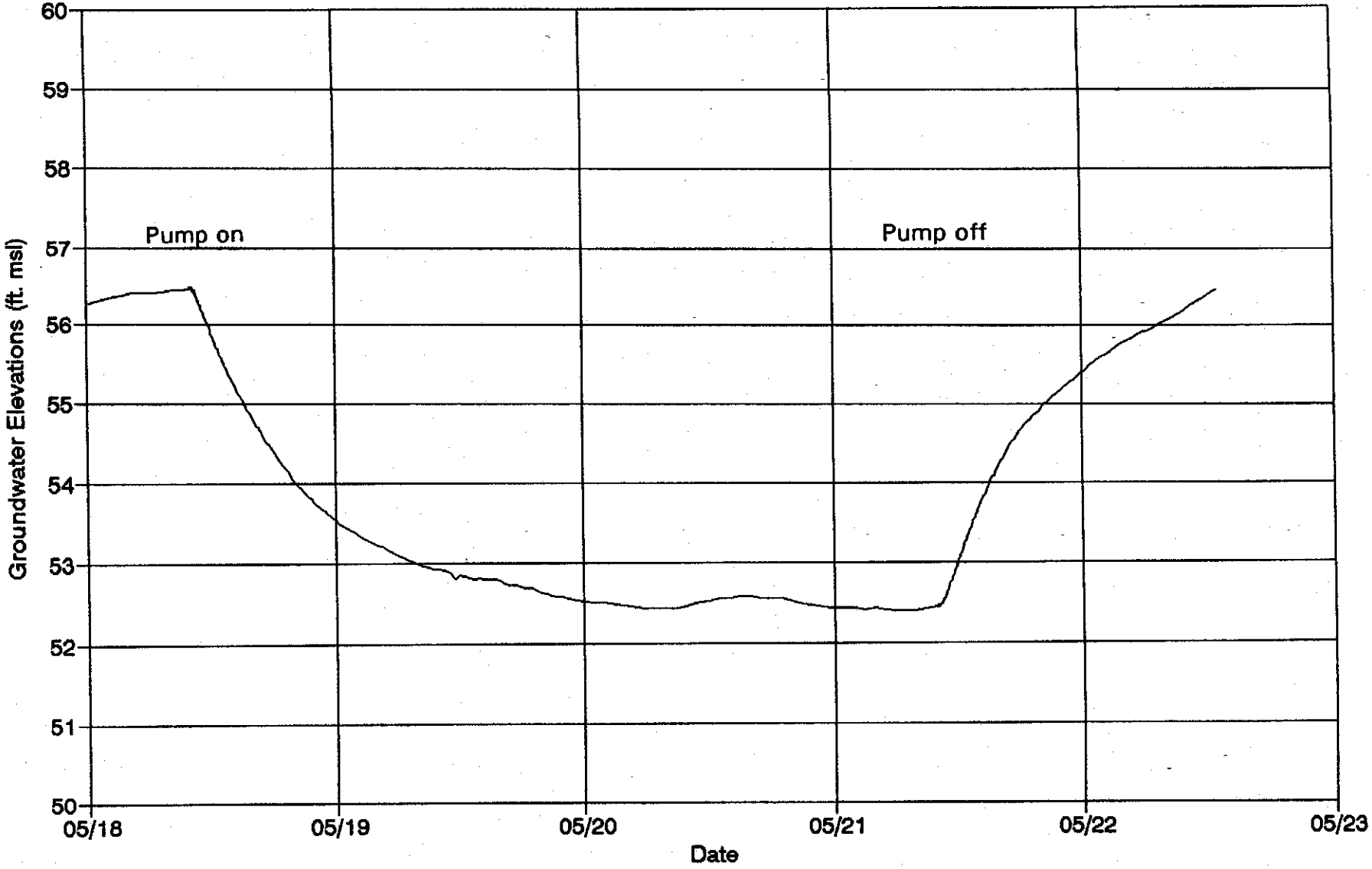
4315 Aquifer Test

Hydrograph for Well 3061



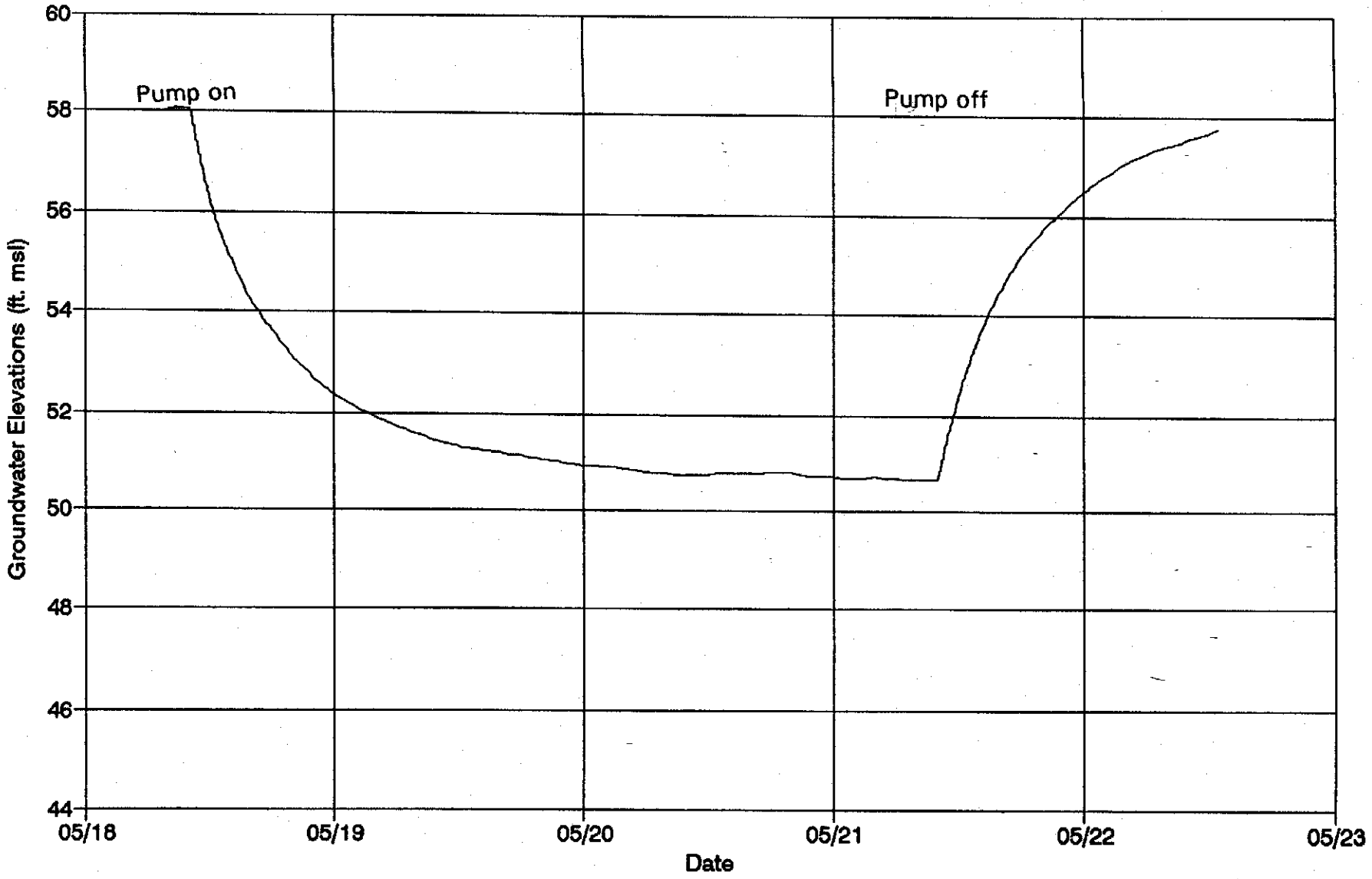
4315 Aquifer Test

Hydrograph for Well 3245



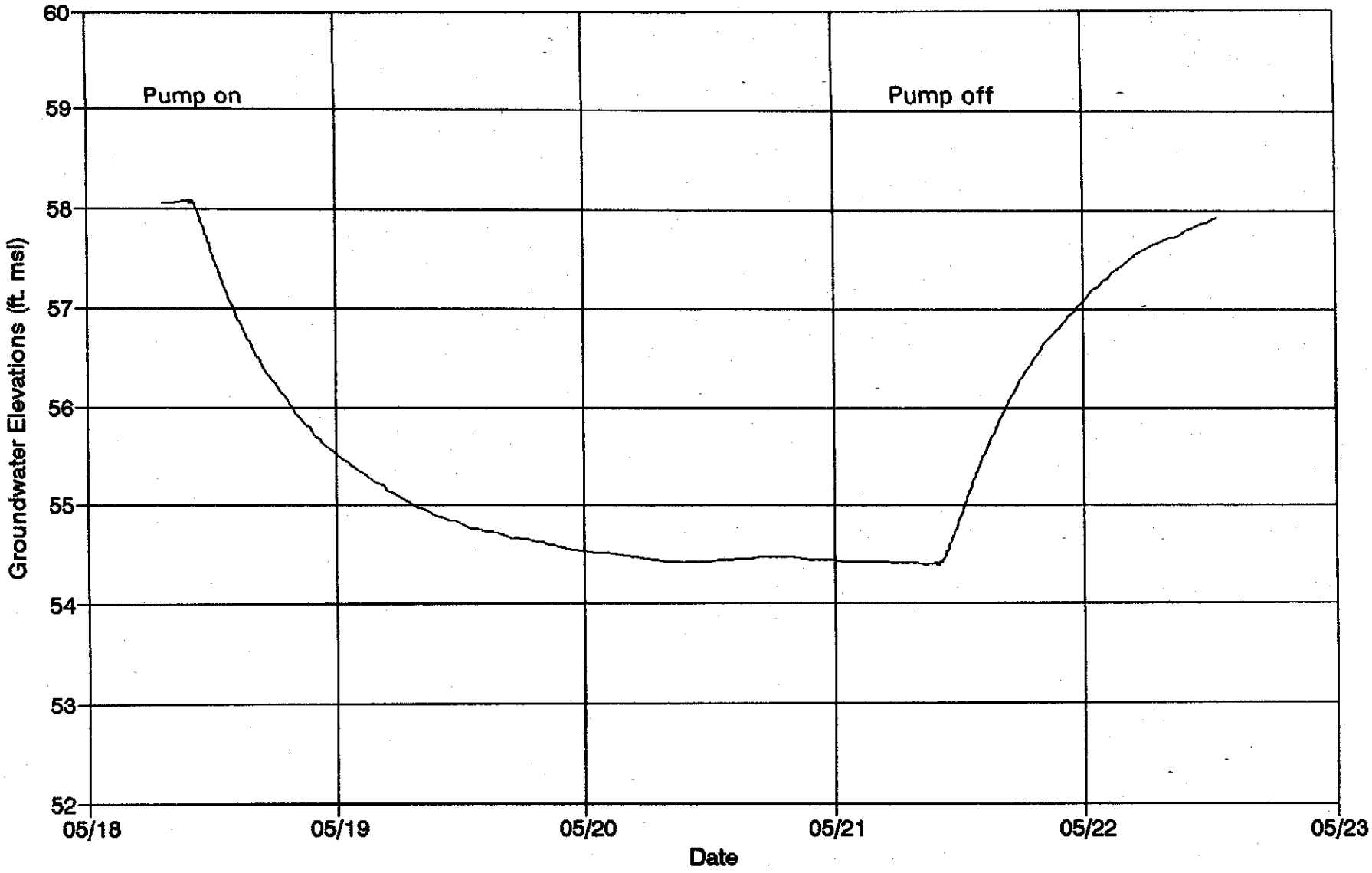
4315 Aquifer Test

Hydrograph for Well 3293

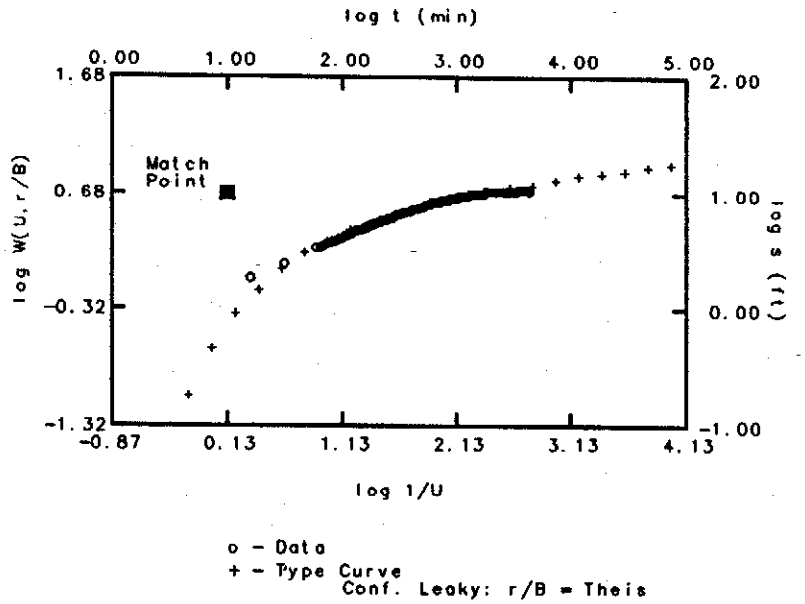


4315 Aquifer Test

Hydrograph for Well 3349



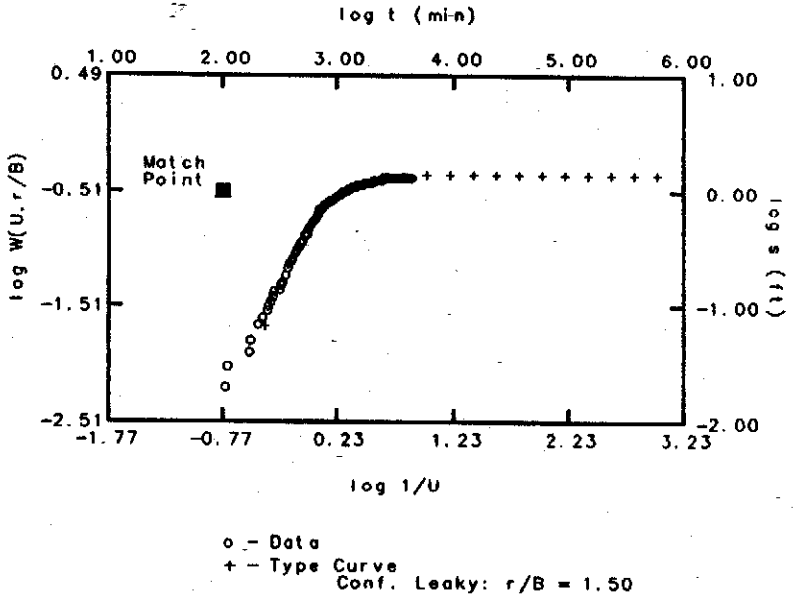
4315 Test – Drawdown Well 132



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.053E+0004 gpd/ft
s	=	1.000E+0001	Hydraulic. Cond.	=	1.053E+0004 gpd/sq ft
1/U	=	1.349E+0000	Storativity	=	7.541E-0003
W(U,r/B)	=	4.786E-0001			

WELL INFORMATION	
WELL IDENTIFICATION	: 132
DATE OF AQUIFER TEST	: 05/18/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.920E+0002 gpm
PUMPING WELL RADIUS (r)	: 1.170E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.200E+0001 ft

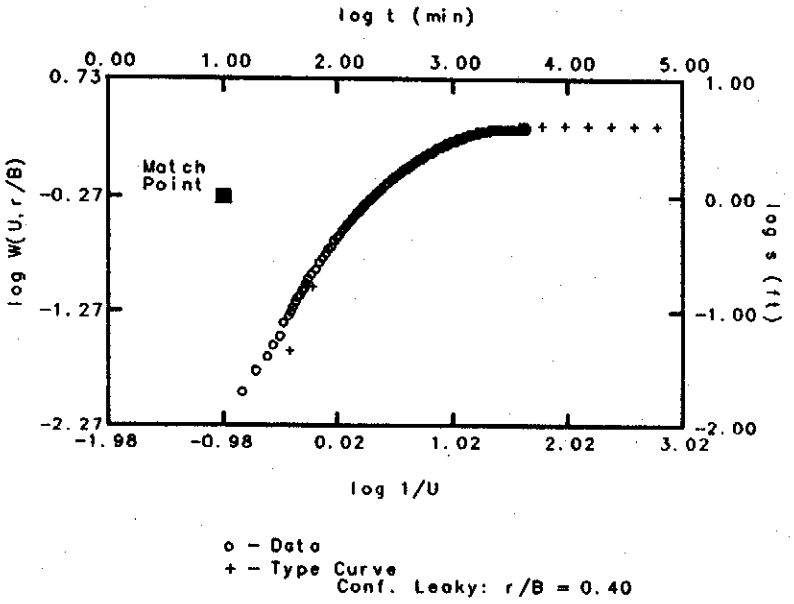
4315 Test – Drawdown Well 357



MATCH POINT			SOLUTION		
t	=	1.000E+0002	Transmissivity	=	6.798E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	6.798E+0003 gpd/sq ft
1/U	=	1.698E-0001	Storativity	=	1.665E-0003
W(U,r/B)	=	3.090E-0002	Leakage Factor	=	6.300E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 357
DATE OF AQUIFER TEST	: 05/18/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.920E+0002 gpm
PUMPING WELL RADIUS (r)	: 1.170E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.450E+0002 ft

4315 Test – Drawdown Well 495

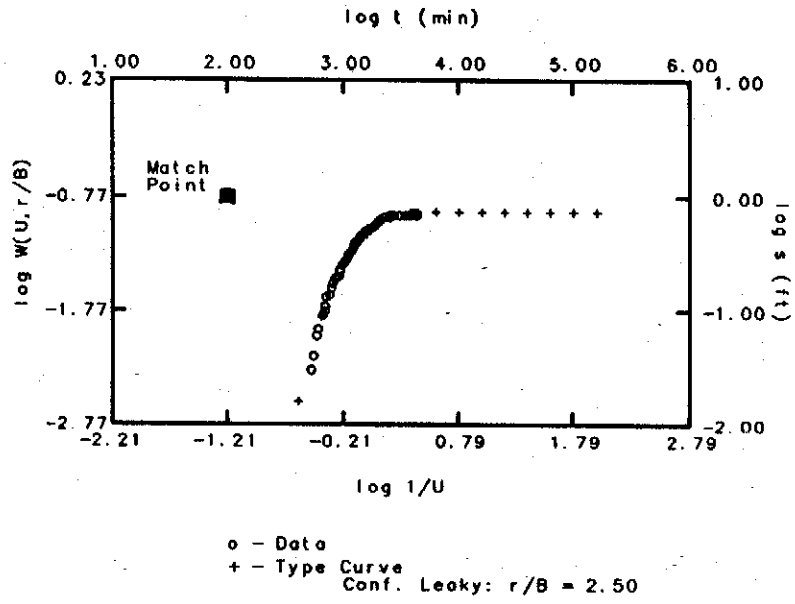


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.181E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.181E+0004 gpd/sq ft
1/U	=	1.047E-0001	Storativity	=	5.071E-0004
W(U,r/B)	=	5.370E-0002	Leakage Factor	=	2.273E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 495
DATE OF AQUIFER TEST	: 05/18/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.920E+0002 gpm
PUMPING WELL RADIUS (r)	: 1.170E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.090E+0002 ft

4315 Test – Drawdown Well 3061

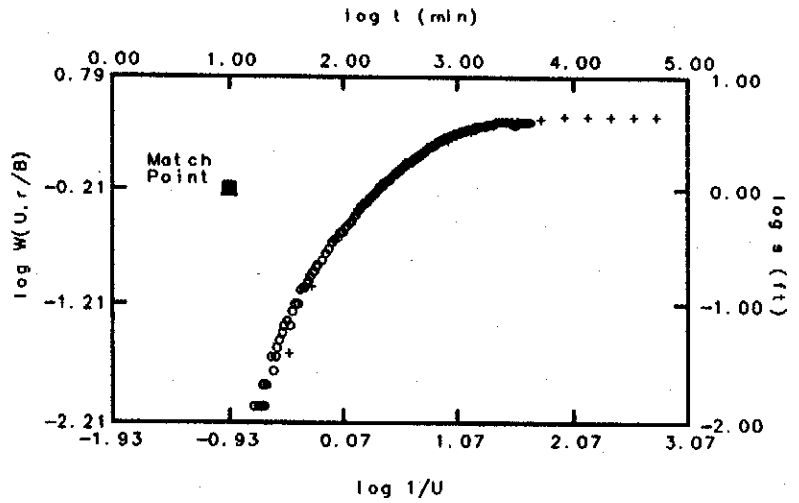


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 2.50

MATCH POINT			SOLUTION		
t	=	1.000E+0002	Transmissivity	=	3.736E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	3.736E+0003 gpd/sq ft
1/U	=	6.166E-0002	Storativity	=	2.138E-0003
W(U,r/B)	=	1.698E-0002	Leakage Factor	=	4.104E+0002 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 3061
DATE OF AQUIFER TEST	: 05/18/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.920E+0002 gpm
PUMPING WELL RADIUS (r)	: 1.170E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.026E+0003 ft

4315 Test - Drawdown Well 3245

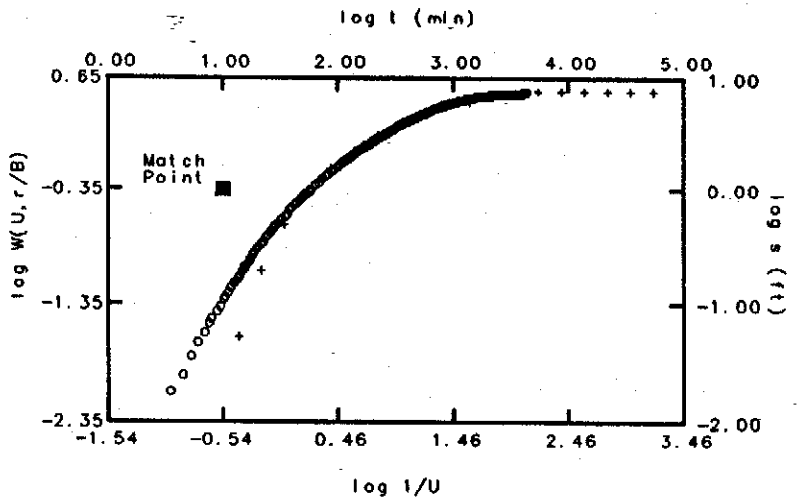


o - Data
+ - Type Curve
Conf. Leaky: r/B = 0.30

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.356E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.356E+0004 gpd/sq ft
1/U	=	1.175E-0001	Storativity	=	9.218E-0004
W(U,r/B)	=	6.166E-0002	Leakage Factor	=	2.273E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 3245
DATE OF AQUIFER TEST	: 05/18/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.920E+0002 gpm
PUMPING WELL RADIUS (r)	: 1.170E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.820E+0002 ft

4315 Test - Drawdown Well 3293

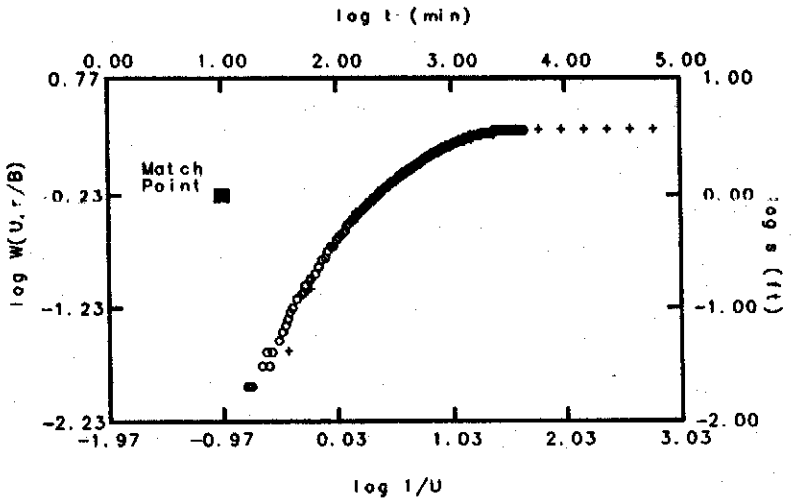


o - Data
+ - Type Curve
Conf. Leaky: r/B = 0.20

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	9.826E+0003 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	9.826E+0003 gpd/sq ft
1/U	=	2.884E-0001	Storativity	=	4.198E-0004
W(U,r/B)	=	4.467E-0002	Leakage Factor	=	2.745E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 3293
DATE OF AQUIFER TEST	: 05/18/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.920E+0002 gpm
PUMPING WELL RADIUS (r)	: 1.170E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.490E+0002 ft

4315 Test - Drawdown Well 3349



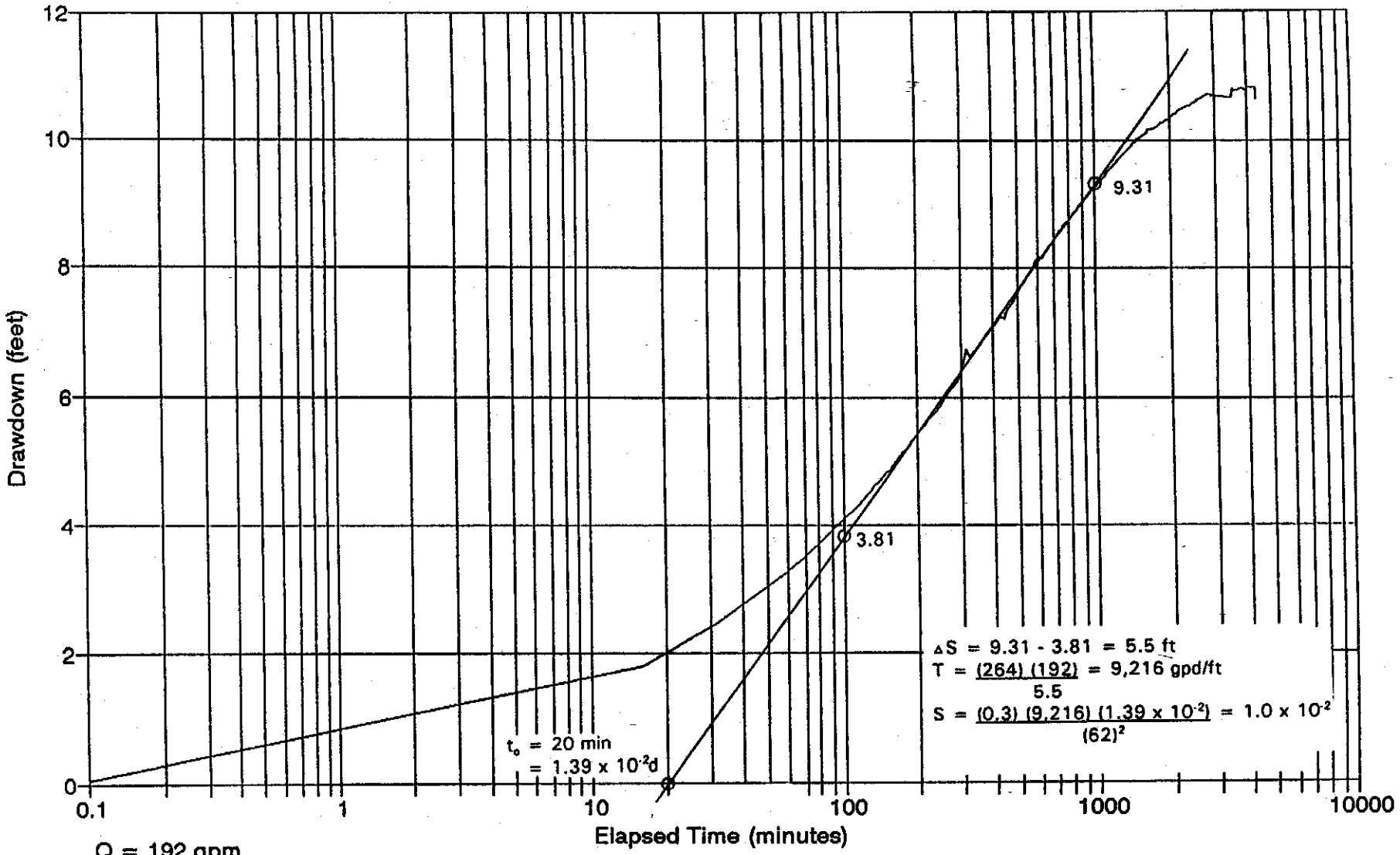
o - Data
\+ - Type Curve
Conf. Leaky: r/B = 0.40

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.295E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.295E+0004 gpd/sq ft
1/U	=	1.072E-0001	Storativity	=	2.362E-0003
W(U,r/B)	=	5.888E-0002	Leakage Factor	=	1.090E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 3349
DATE OF AQUIFER TEST	: 05/18/94
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.920E+0002 gpm
PUMPING WELL RADIUS (r)	: 1.170E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.360E+0002 ft

4315 Aquifer Test

Drawdown for Well 132

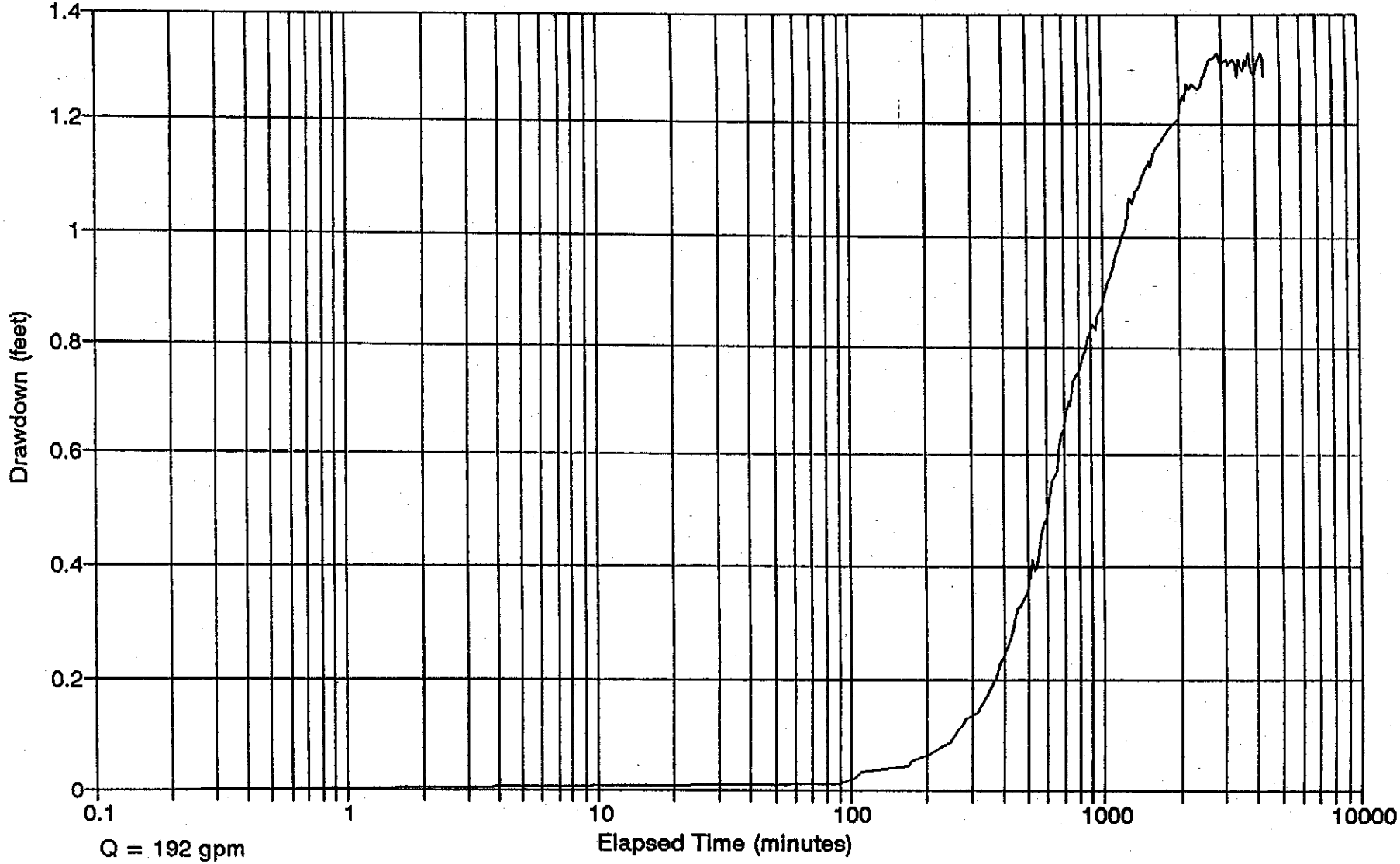


Q = 192 gpm

Distance from Pumping well = 62 feet

4315 Aquifer Test

Drawdown for Well 357

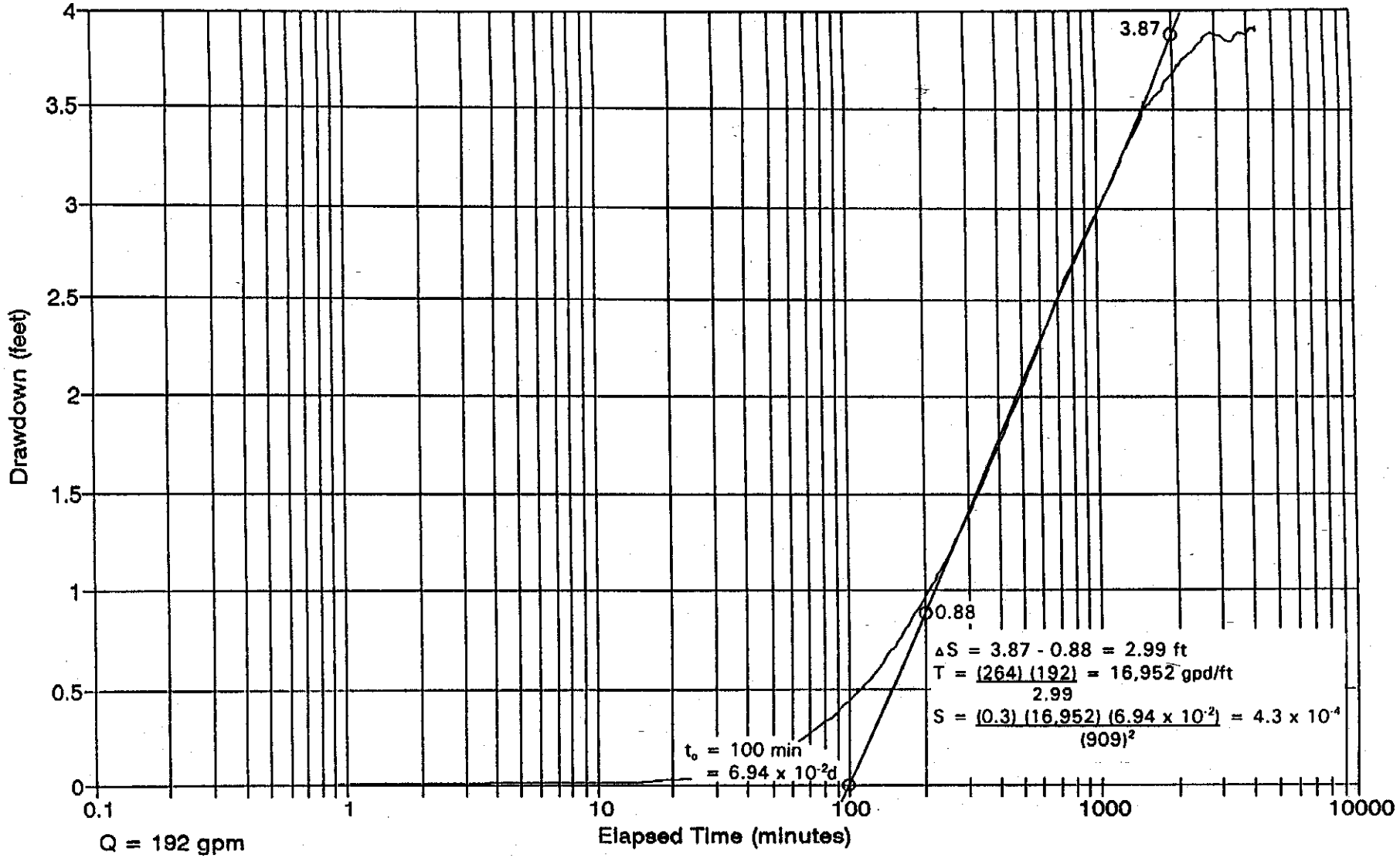


Q = 192 gpm

Distance from Pumping well = 945 feet

4315 Aquifer Test

Drawdown for Well 495

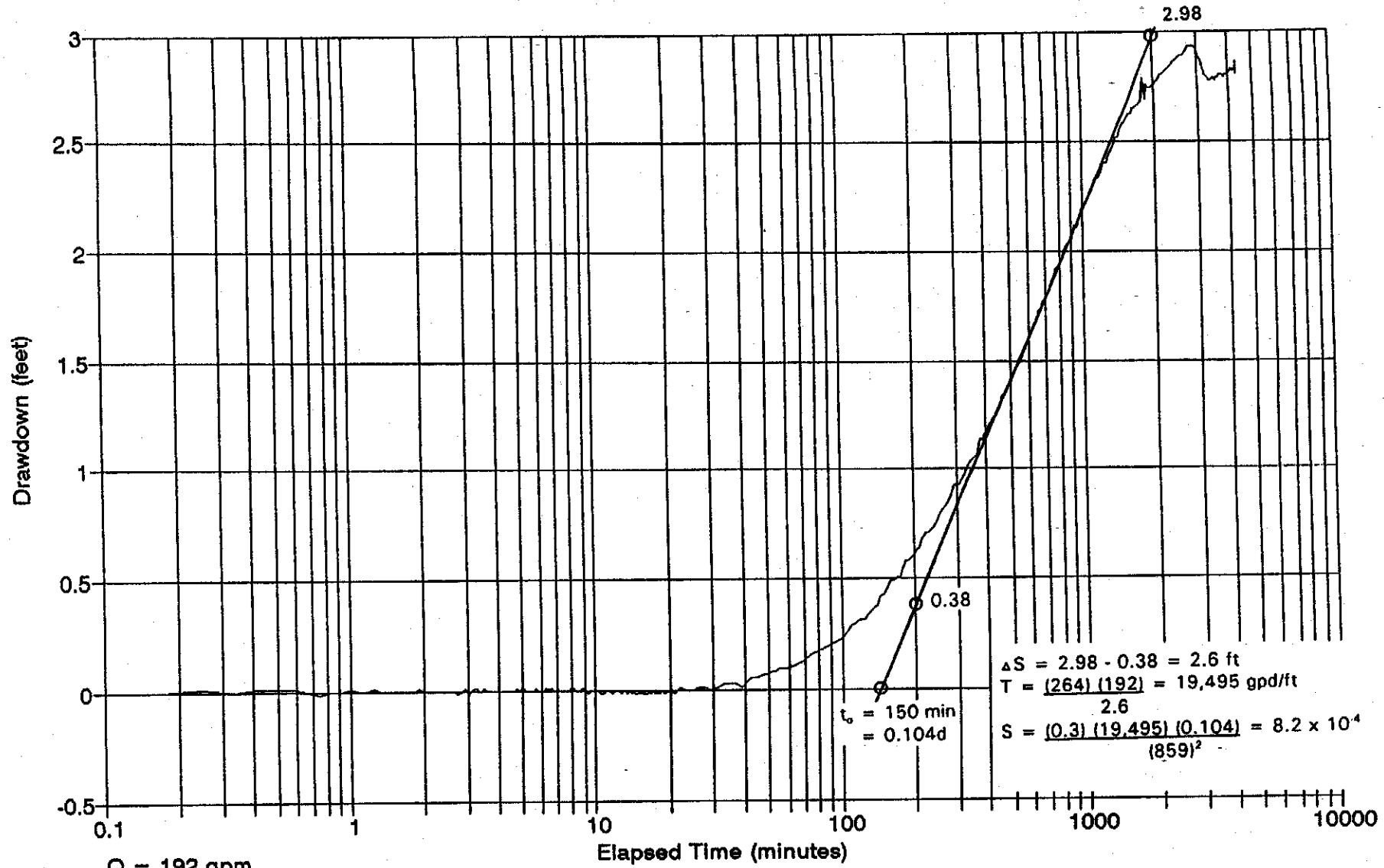


Q = 192 gpm

Distance from Pumping well = 909 feet

4315 Aquifer Test

Drawdown for Well 1244

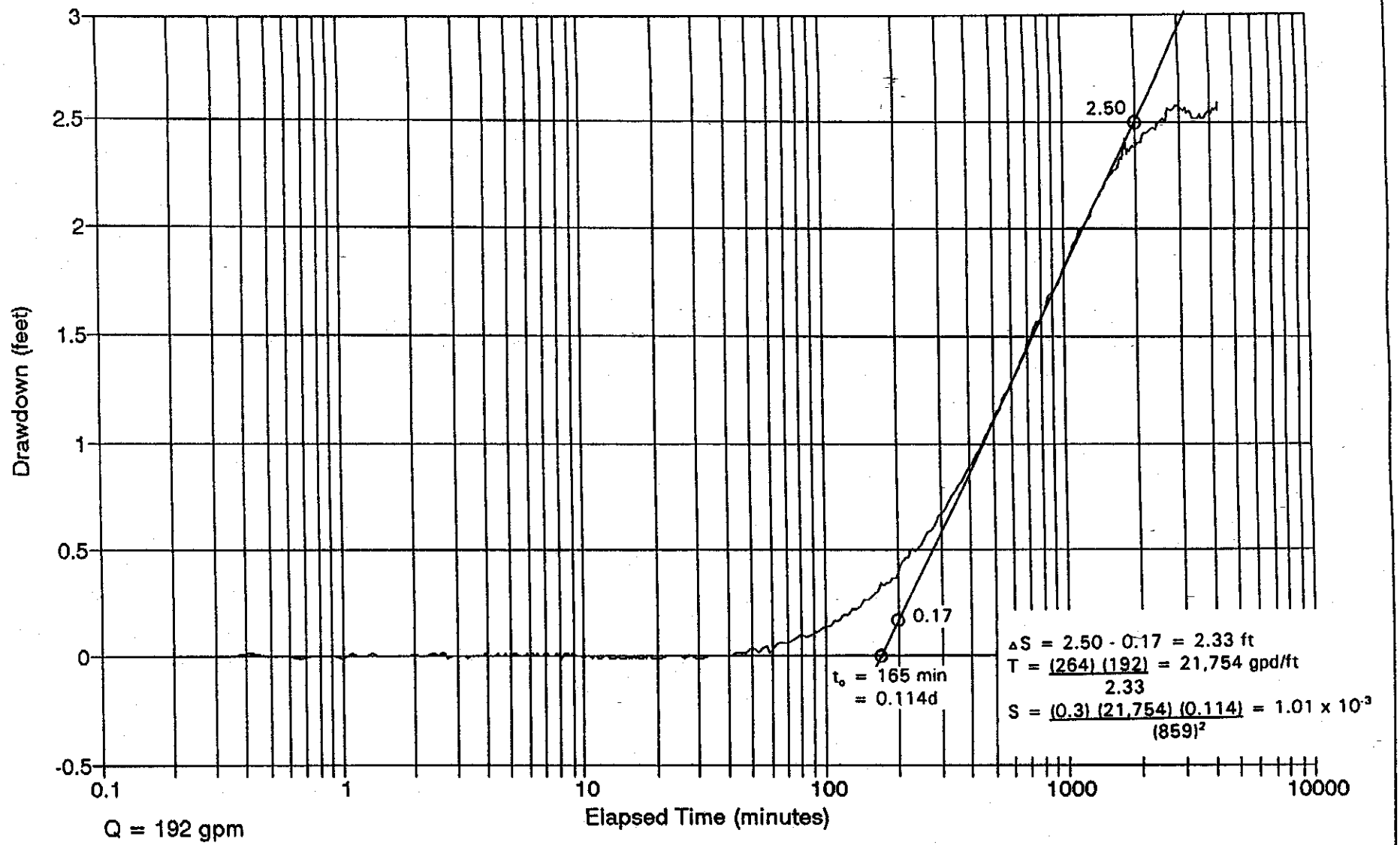


Q = 192 gpm

Distance from Pumping well = 859 feet

4315 Aquifer Test

Drawdown for Well 1245

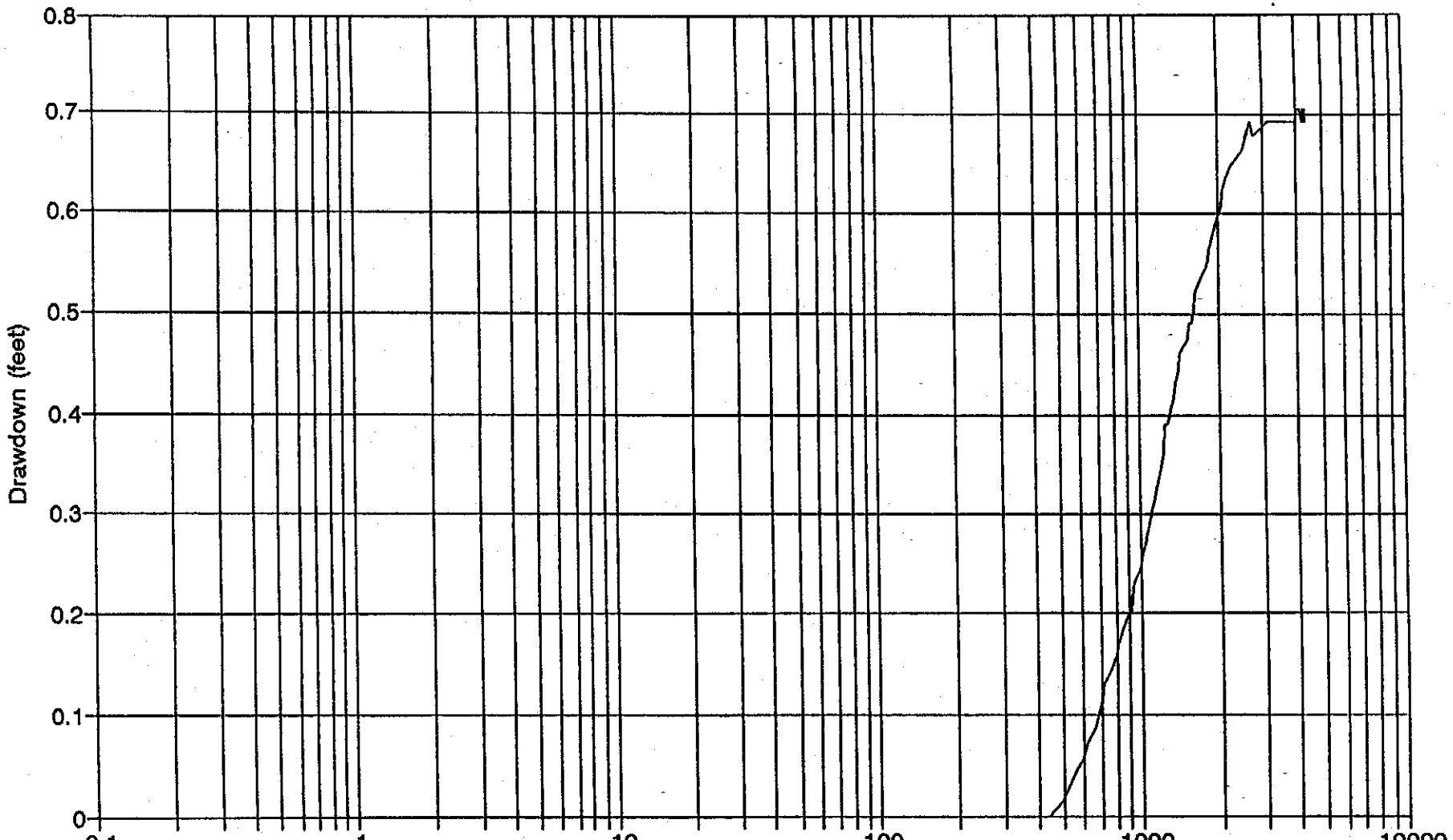


Q = 192 gpm

Distance from Pumping well = 859 feet

4315 Aquifer Test

Drawdown for Well 3061

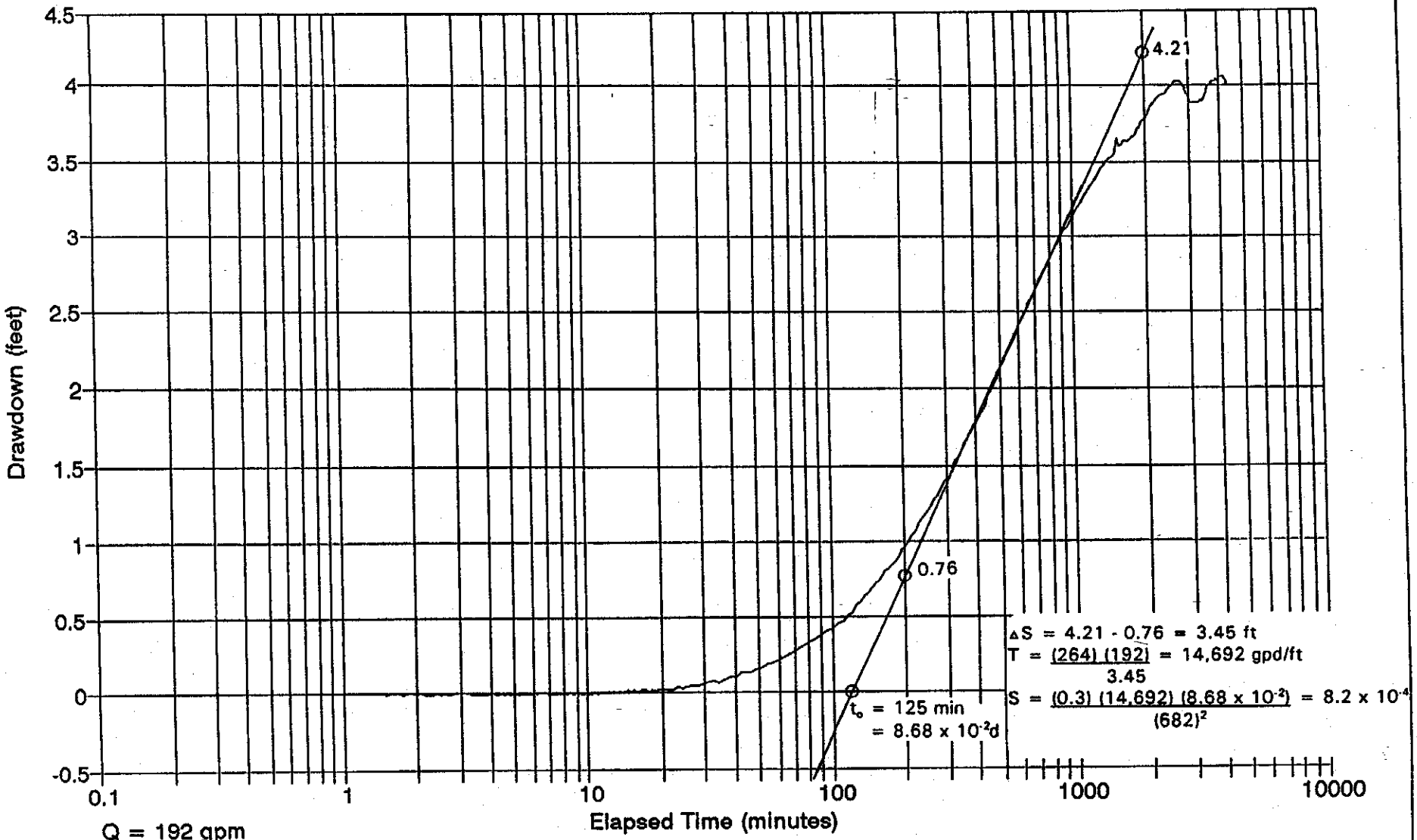


Q = 192 gpm

Distance from Pumping well = 1026 feet

4315 Aquifer Test

Drawdown for Well 3245

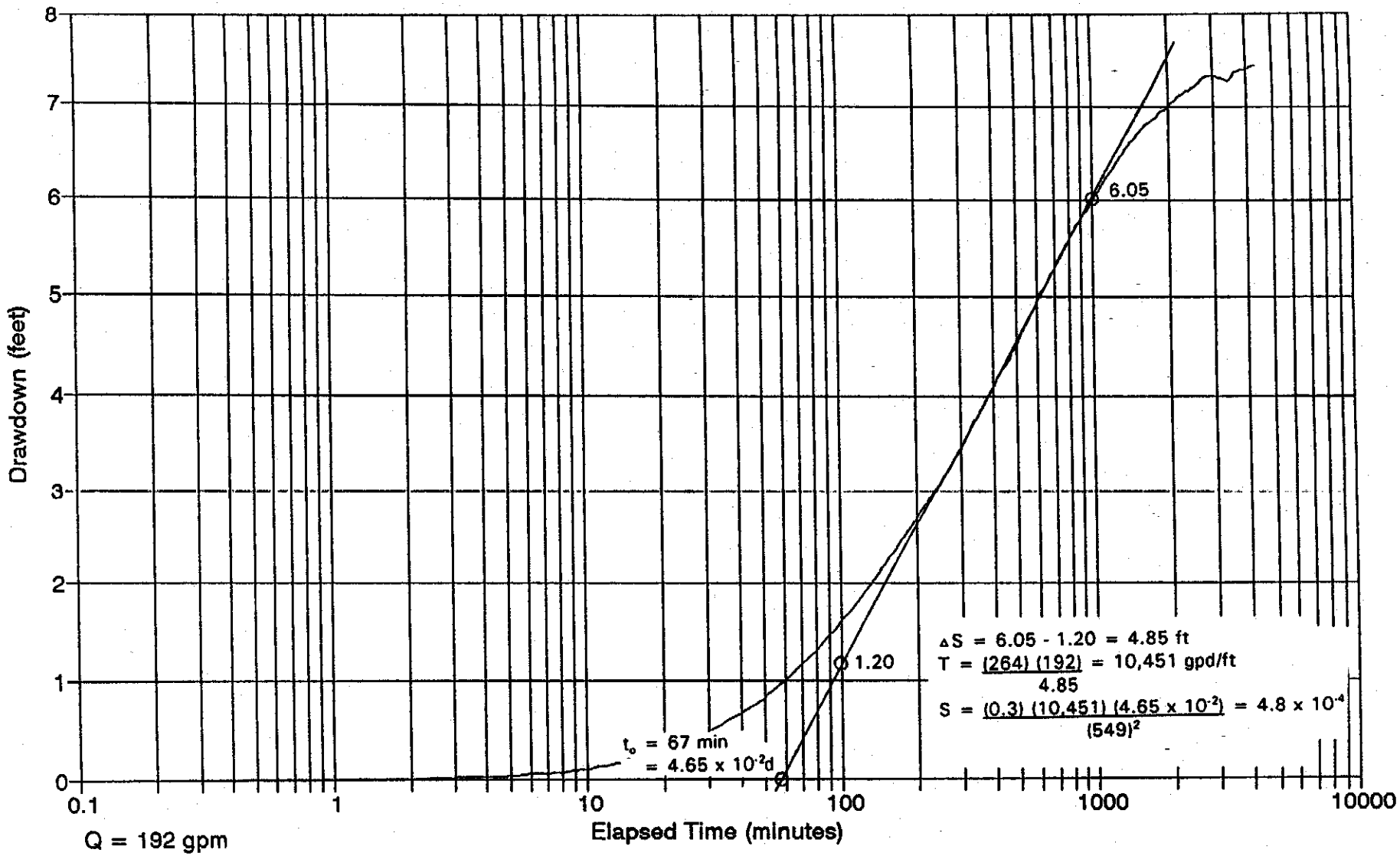


Q = 192 gpm

Distance from Pumping well = 682 feet

4315 Aquifer Test

Drawdown for Well 3293

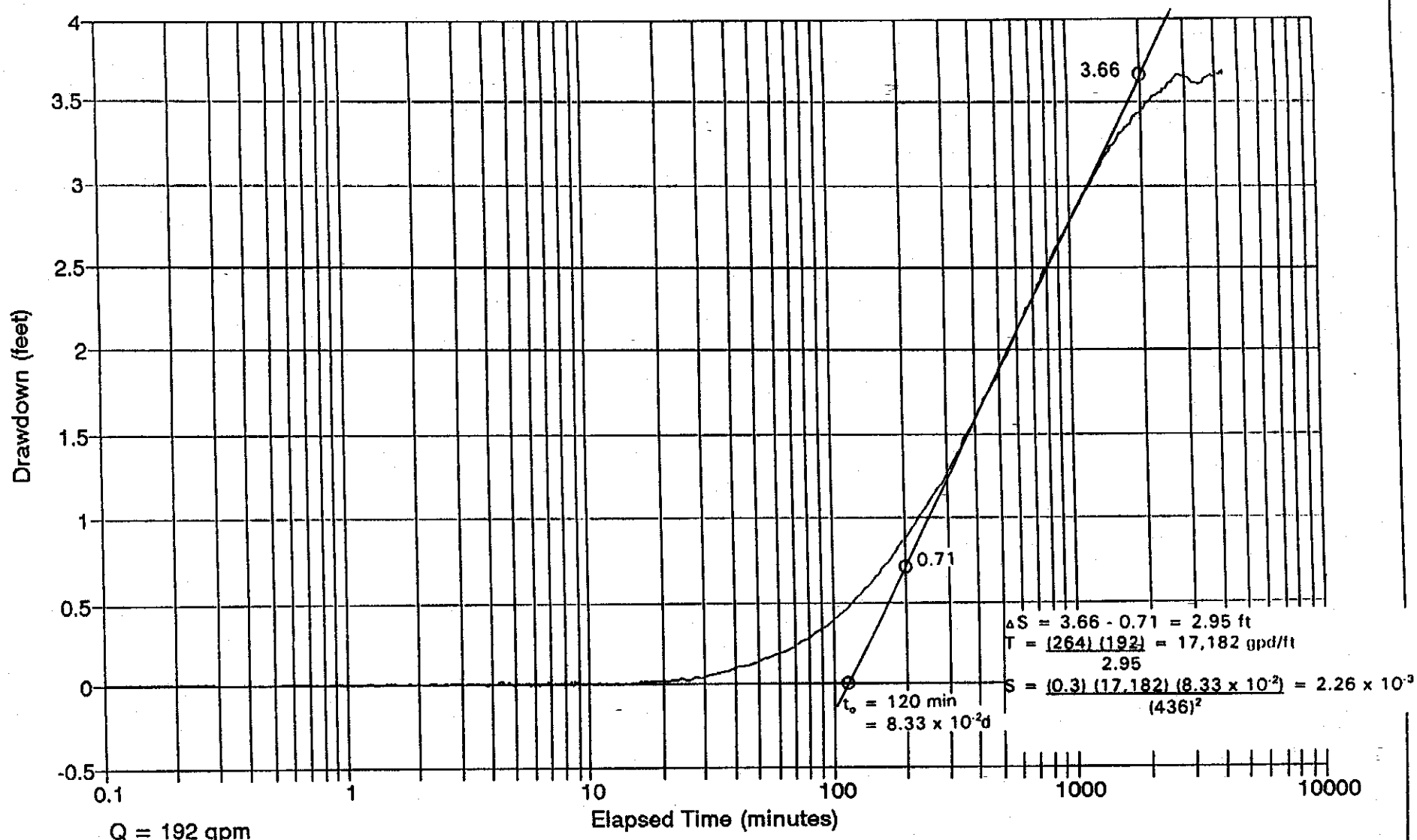


Q = 192 gpm

Distance from Pumping well = 549 feet

4315 Aquifer Test

Drawdown for Well 3349

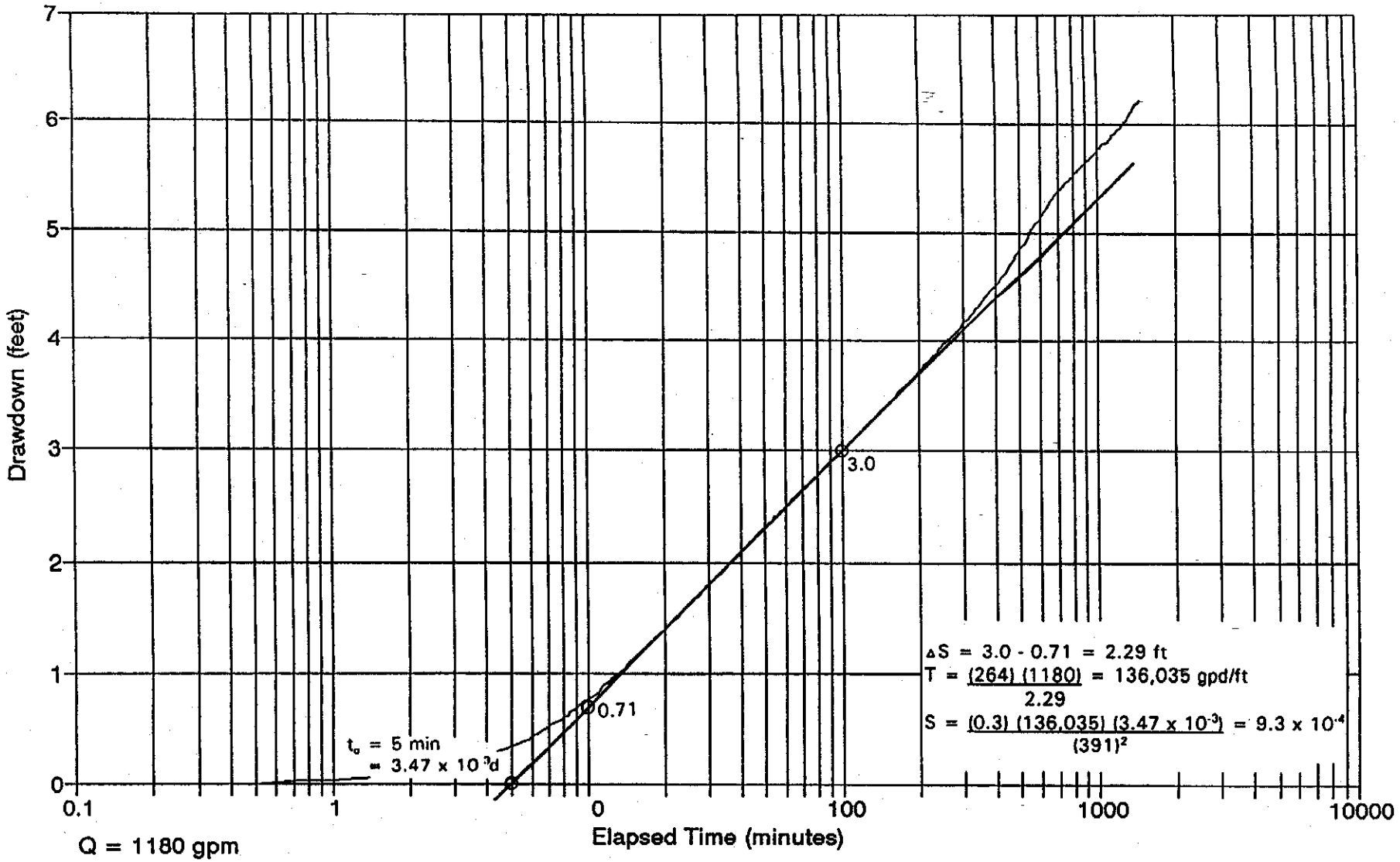


Q = 192 gpm

Distance from Pumping well = 436 feet

4425 Aquifer Test

Drawdown for Well 437

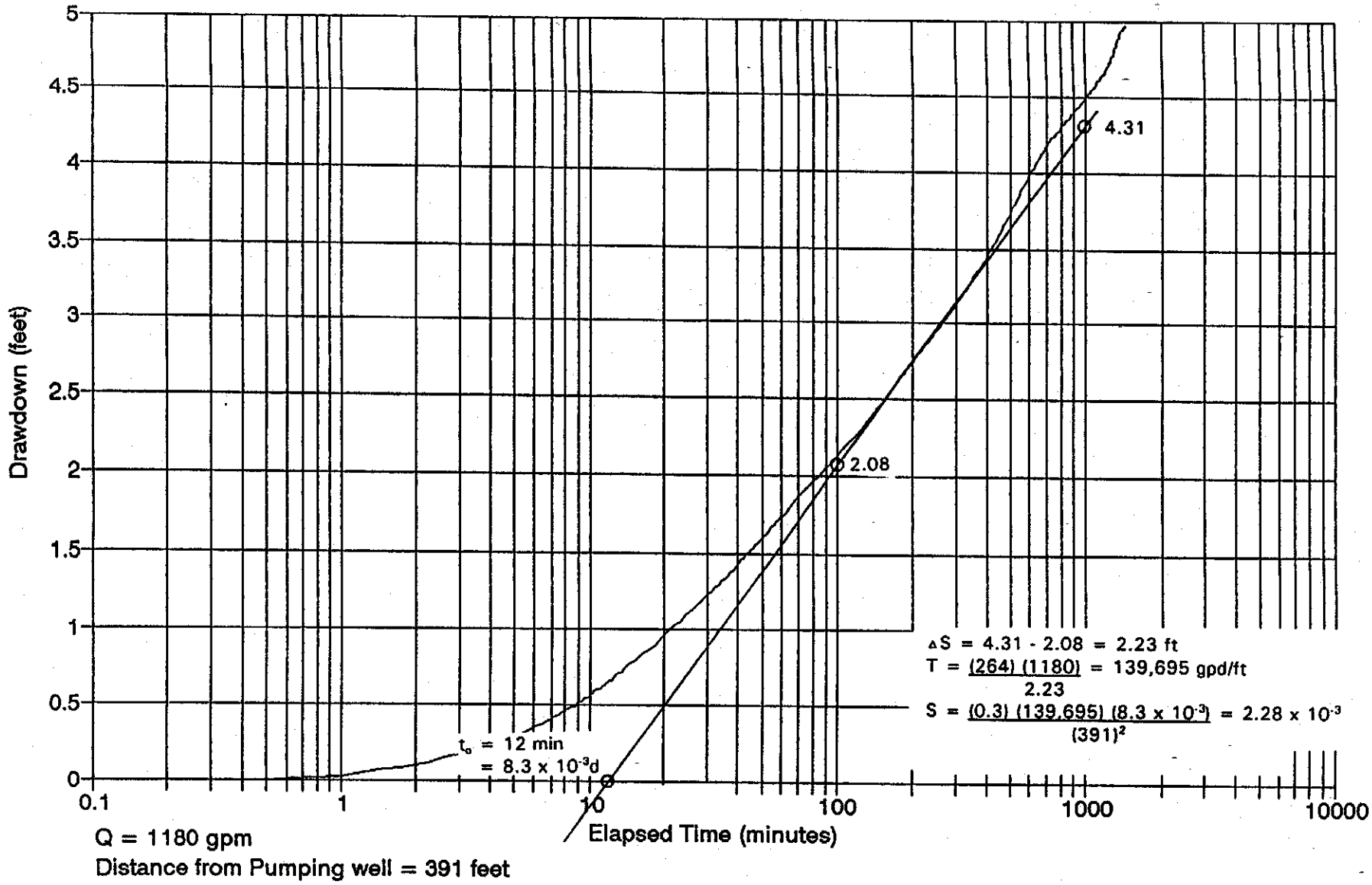


Q = 1180 gpm

Distance from Pumping well = 391 feet

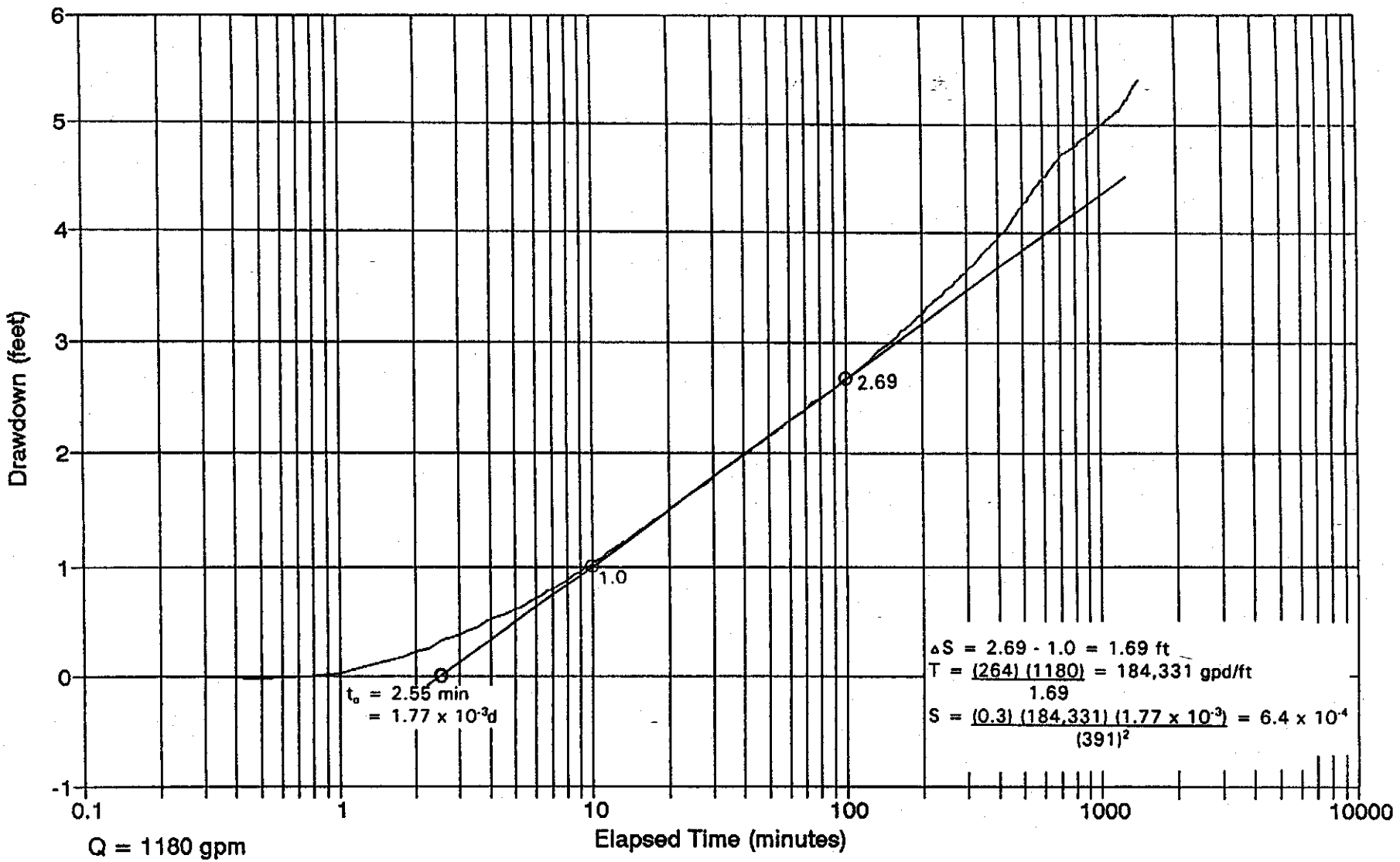
4425 Aquifer Test

Drawdown for Well 438



4425 Aquifer Test

Drawdown for Well 439

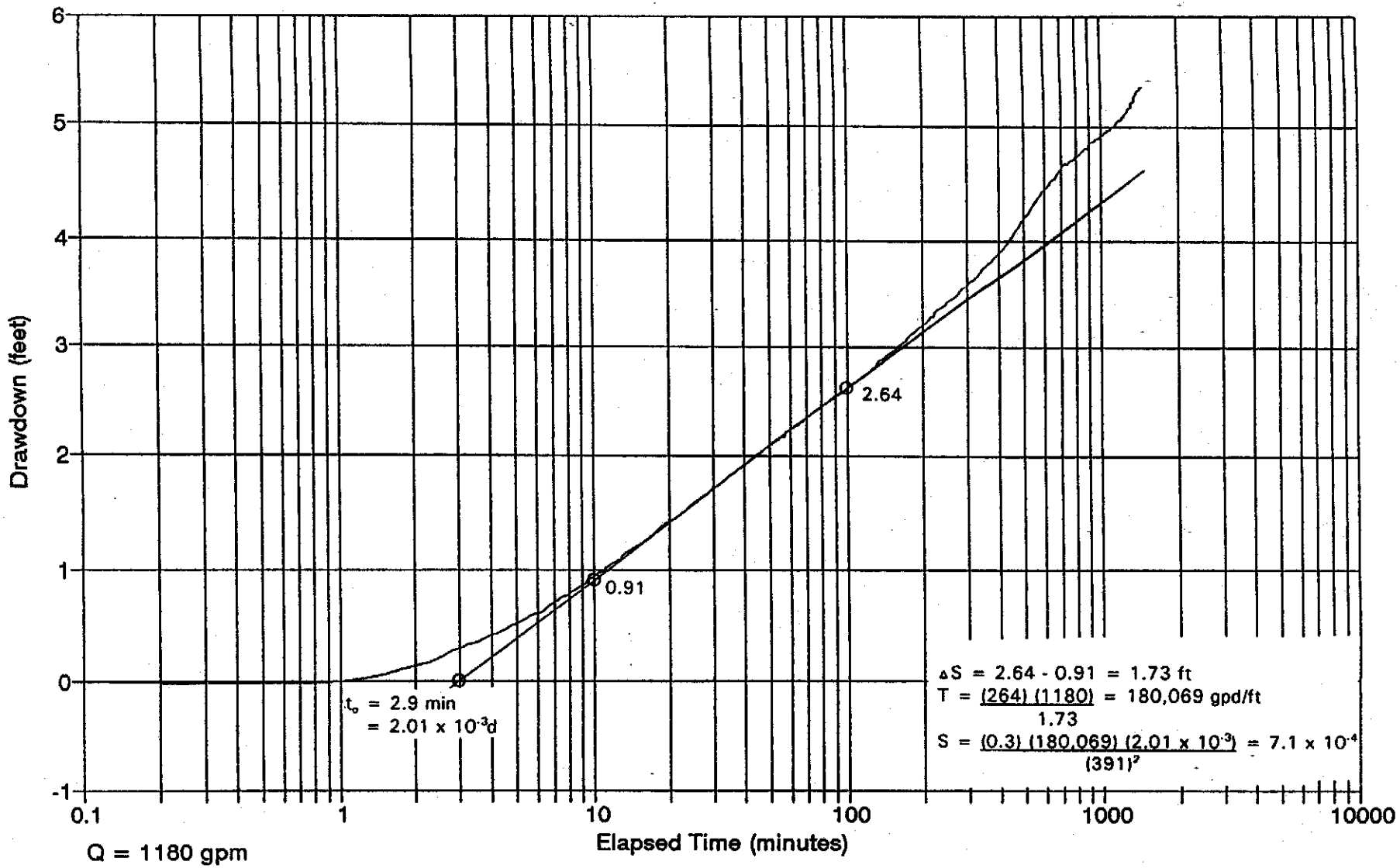


Q = 1180 gpm

Distance from Pumping well = 391 feet

4425 Aquifer Test

Drawdown for Well 440

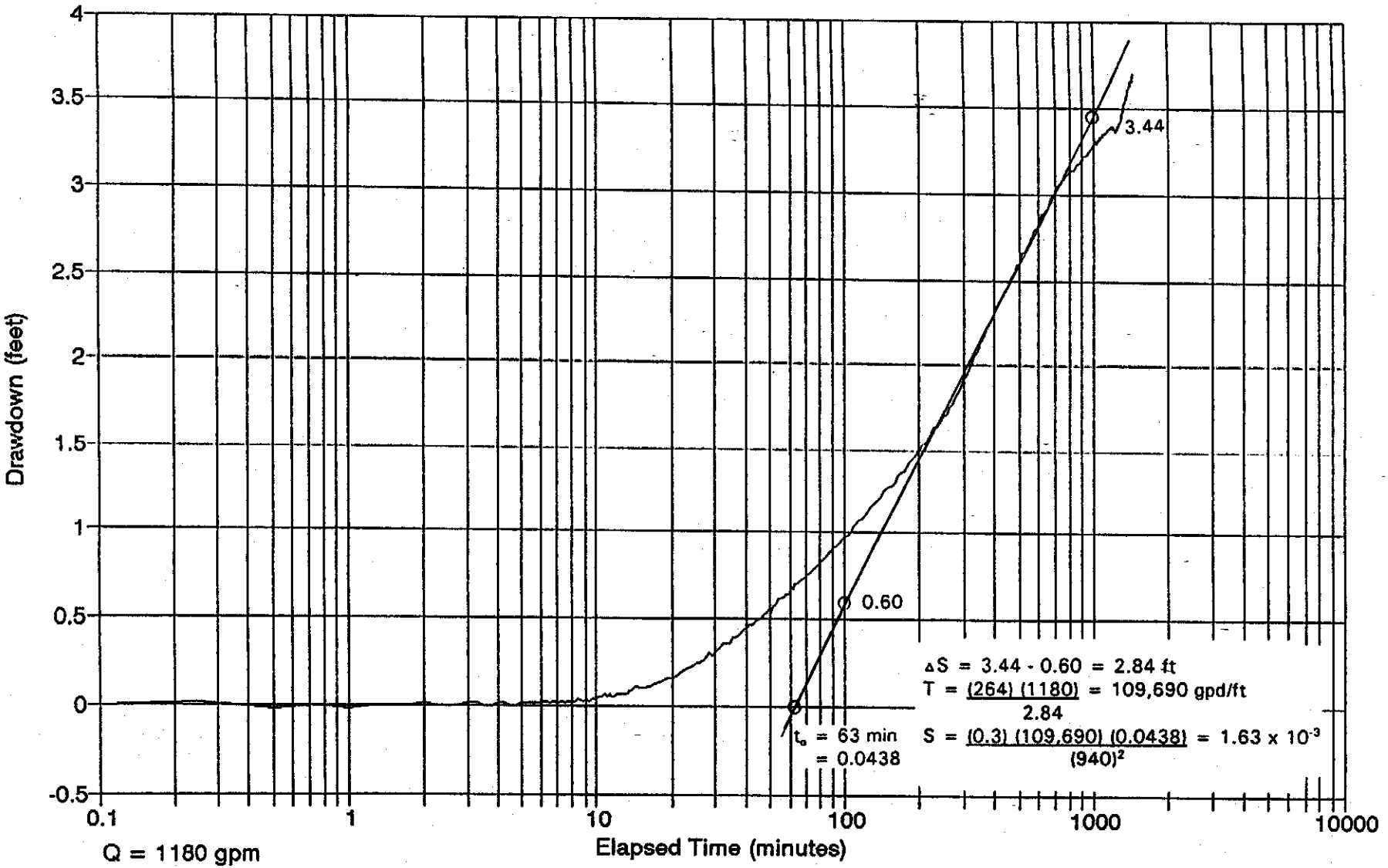


Q = 1180 gpm

Distance from Pumping well = 391 feet

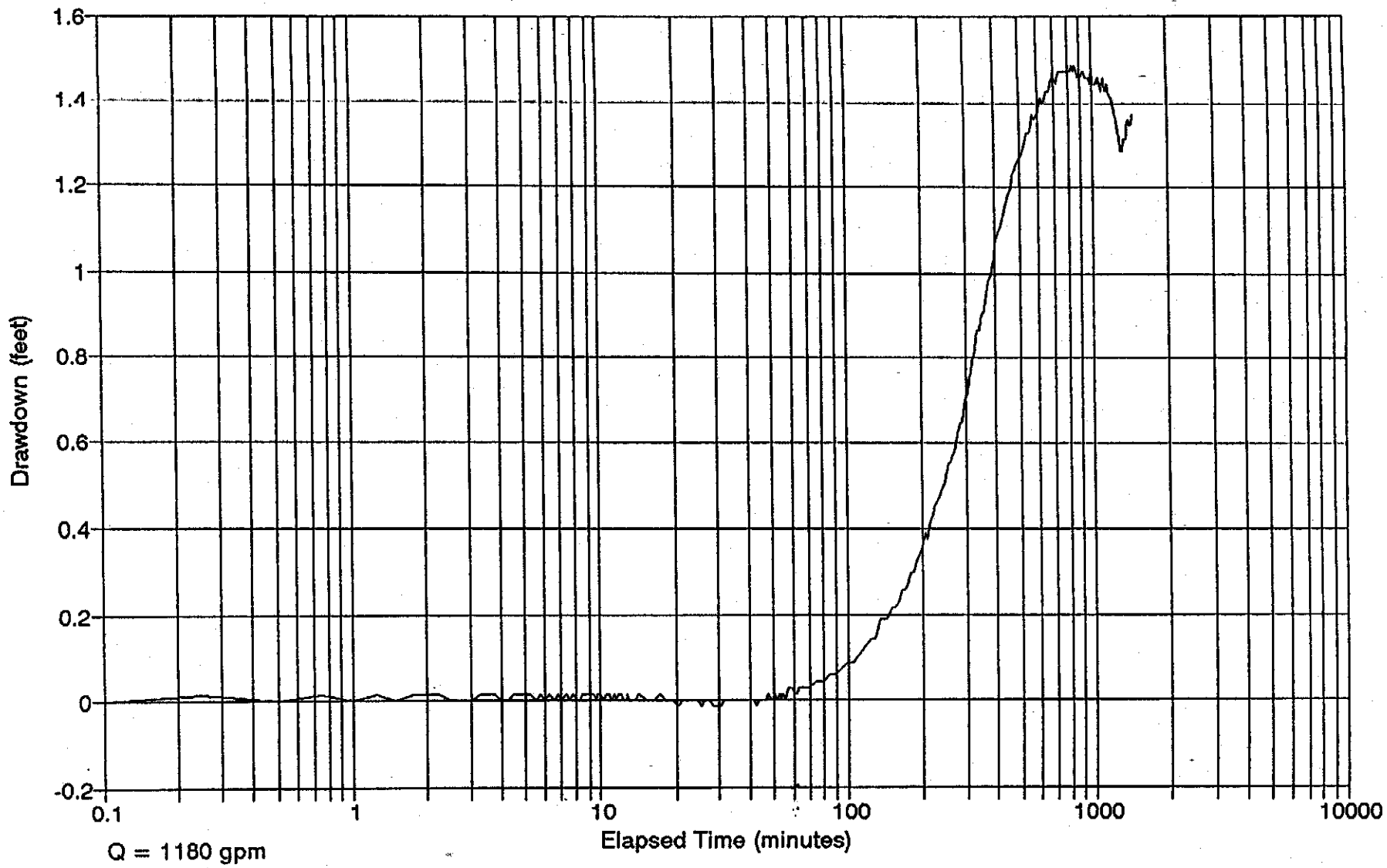
4425 Aquifer Test

Drawdown for Well 476



4425 Aquifer Test

Drawdown for Well 477

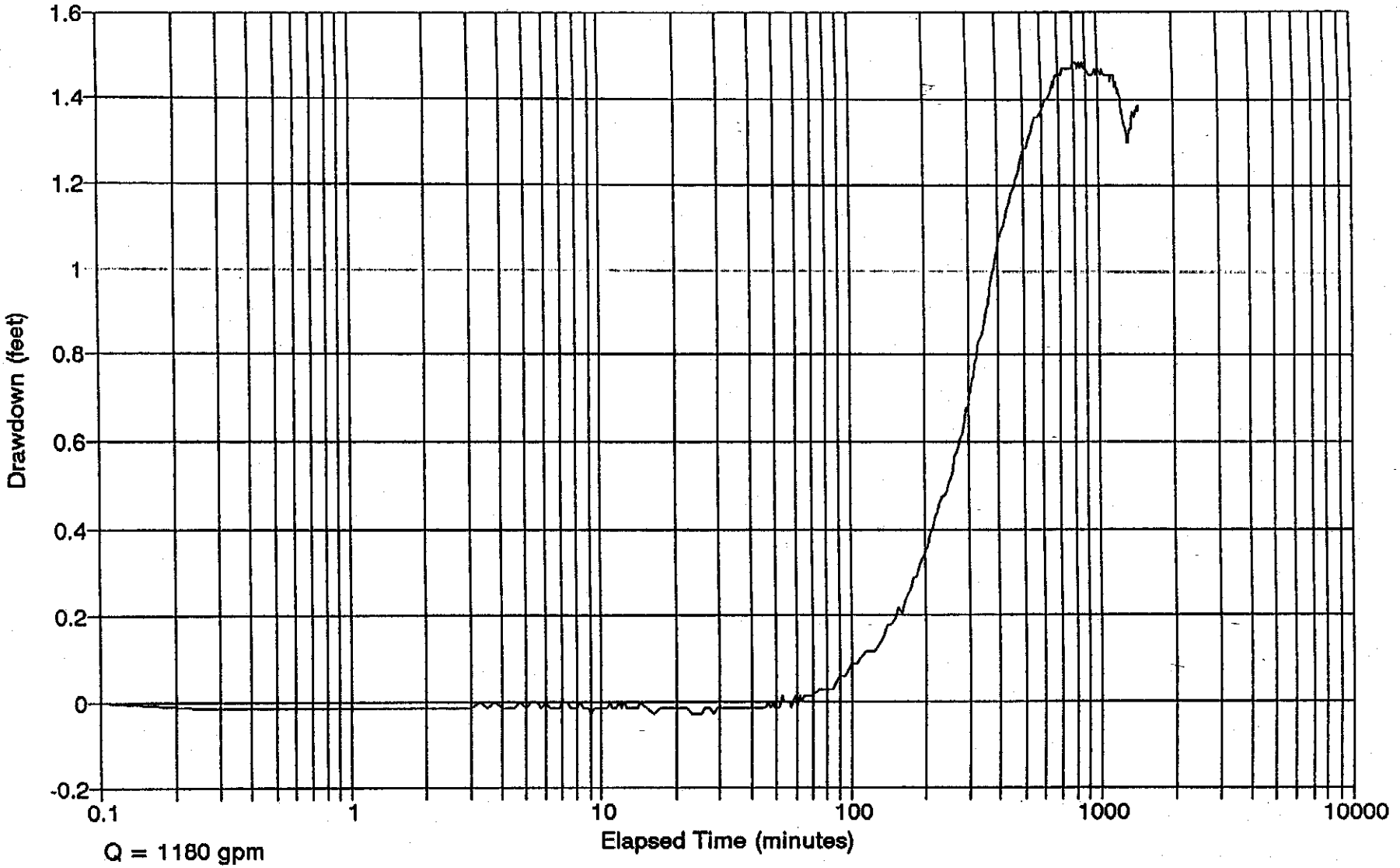


Q = 1180 gpm

Distance from Pumping well = 940 feet

4425 Aquifer Test

Drawdown for Well 478

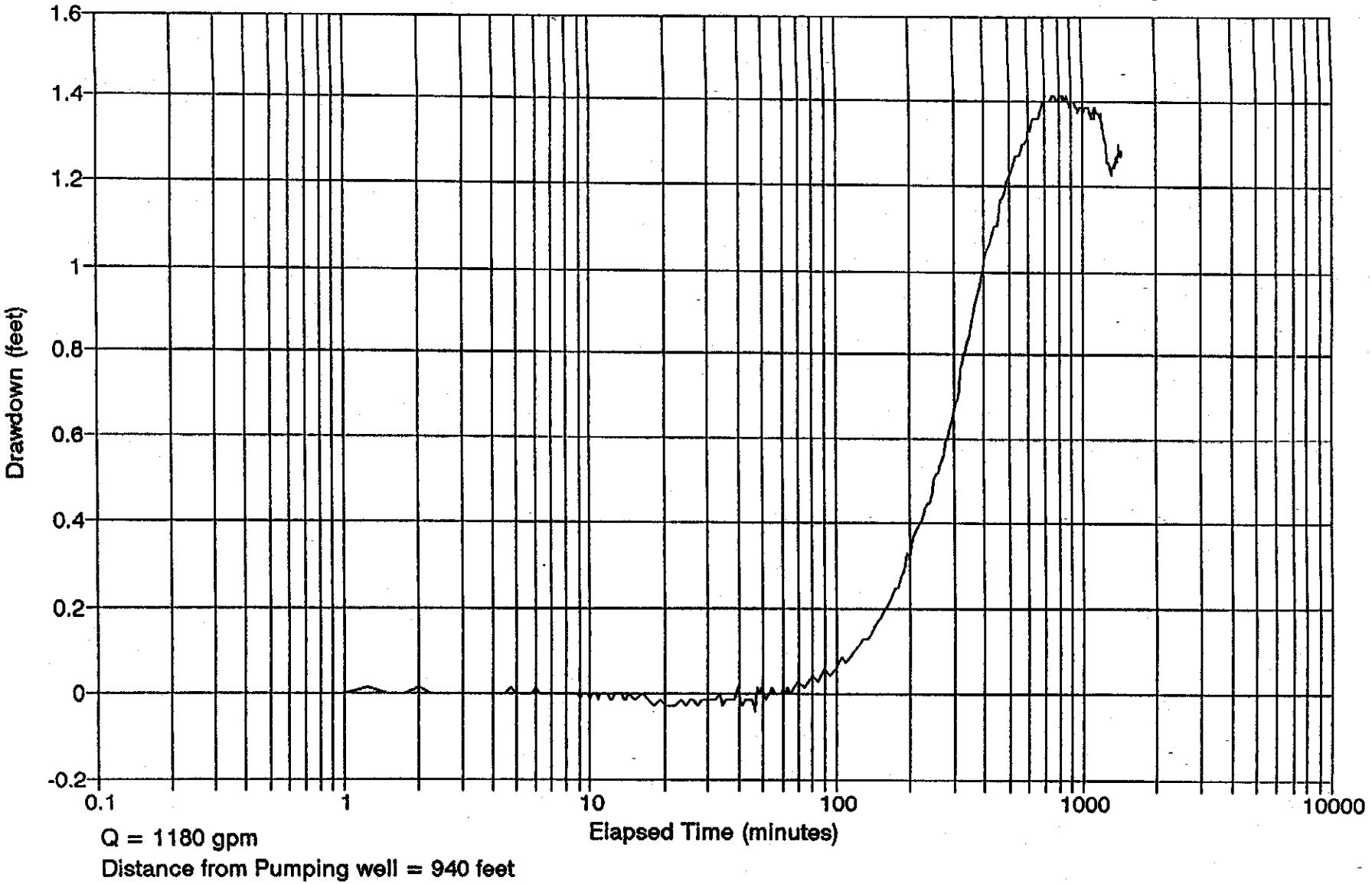


Q = 1180 gpm

Distance from Pumpiing well = 940 feet

4425 Aquifer Test

Drawdown for Well 479

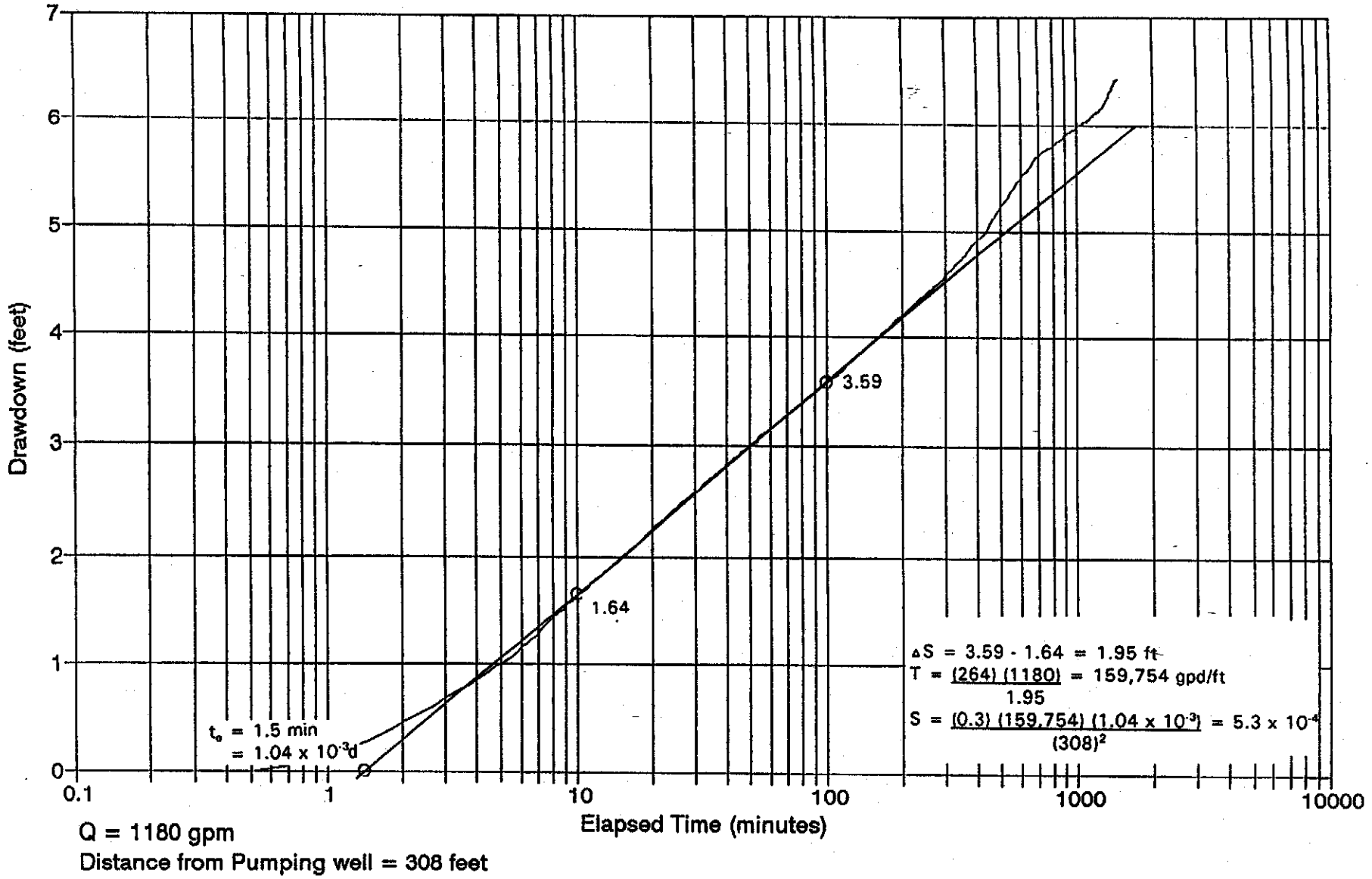


Q = 1180 gpm

Distance from Pumping well = 940 feet

4425 Aquifer Test

Drawdown for Well 3332

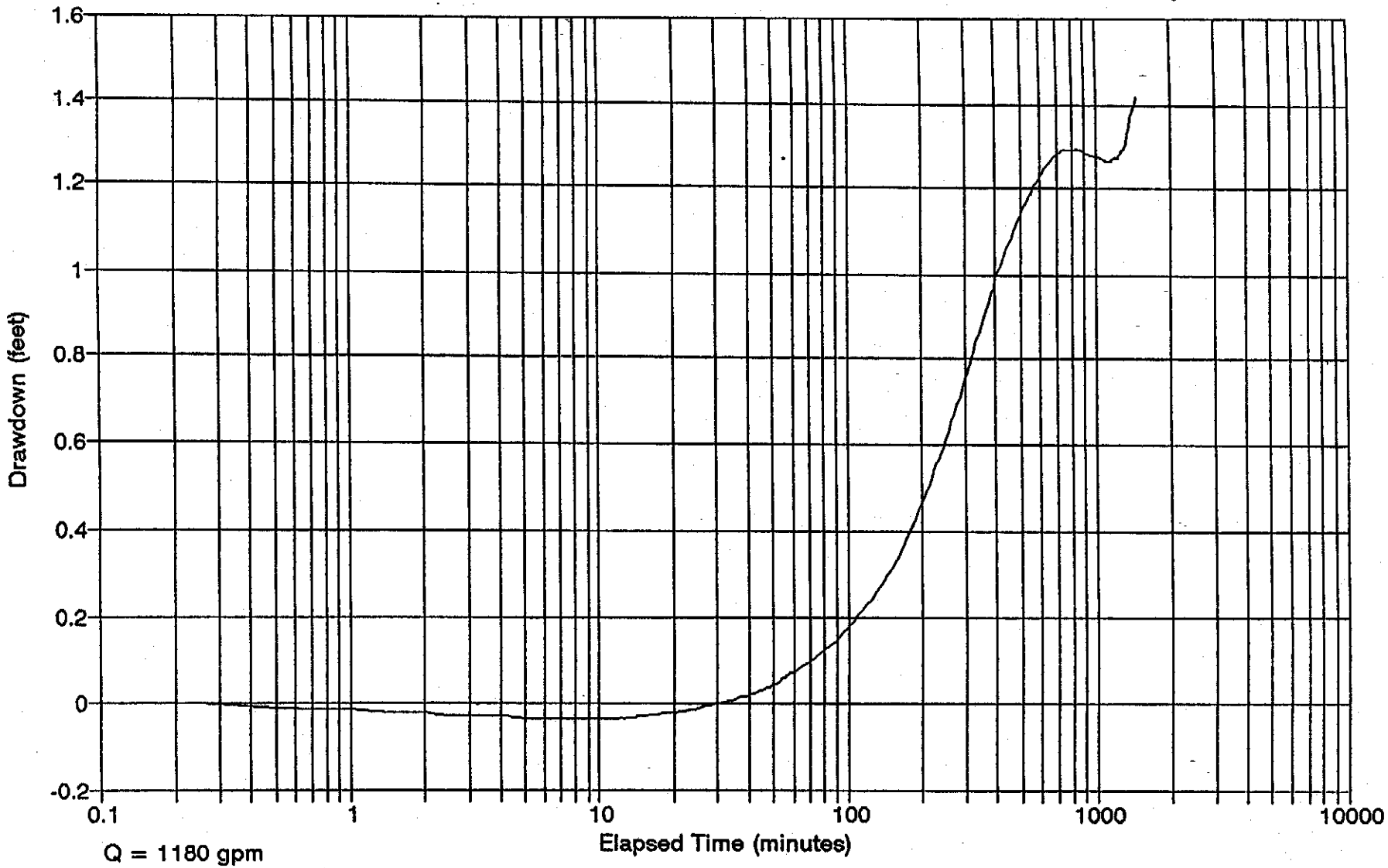


Q = 1180 gpm

Distance from Pumping well = 308 feet

4425 Aquifer Test

Drawdown for Well 3333

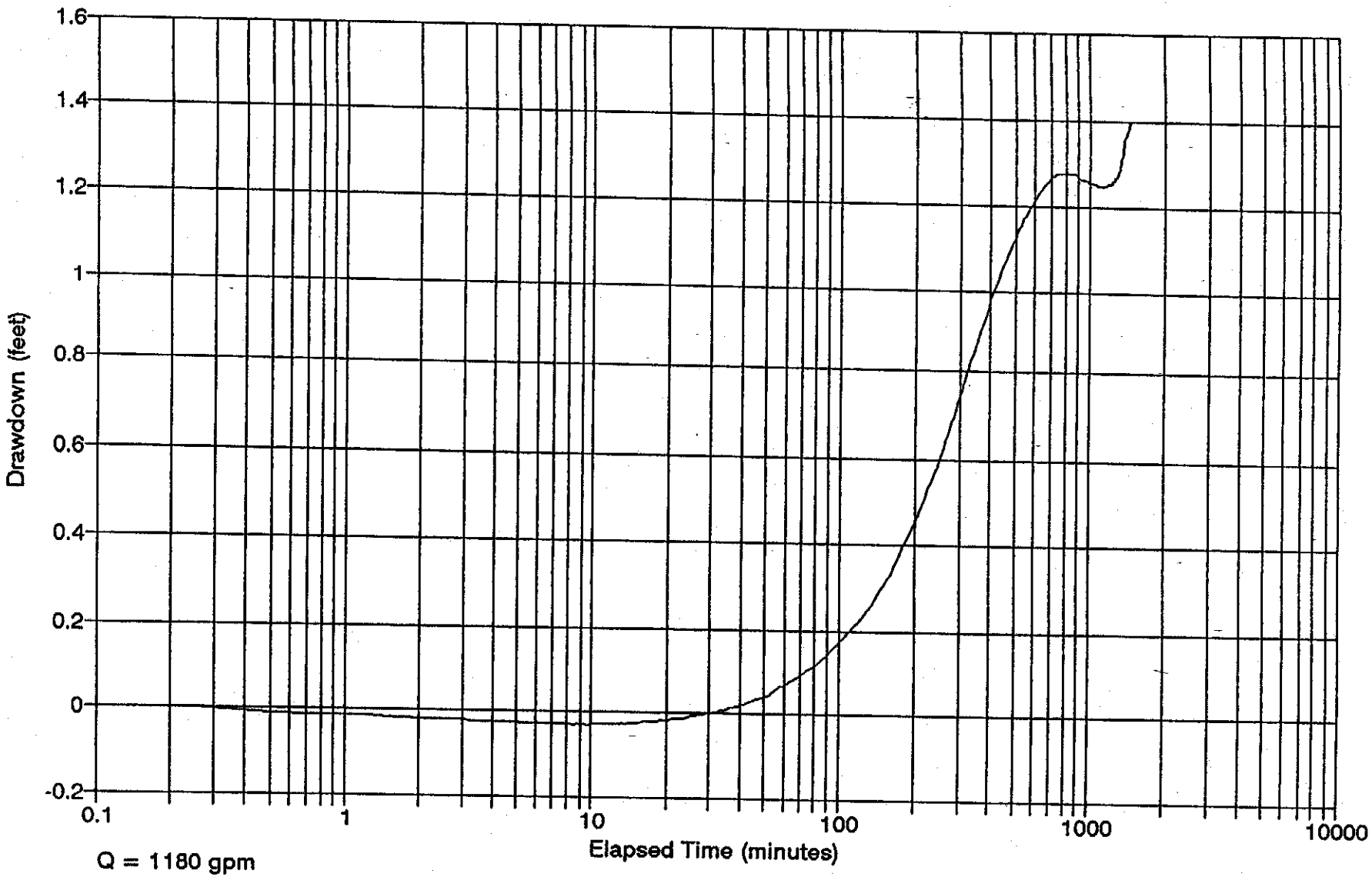


Q = 1180 gpm

Distance from Pumping well = 308 feet

4425 Aquifer Test

Drawdown for Well 3334

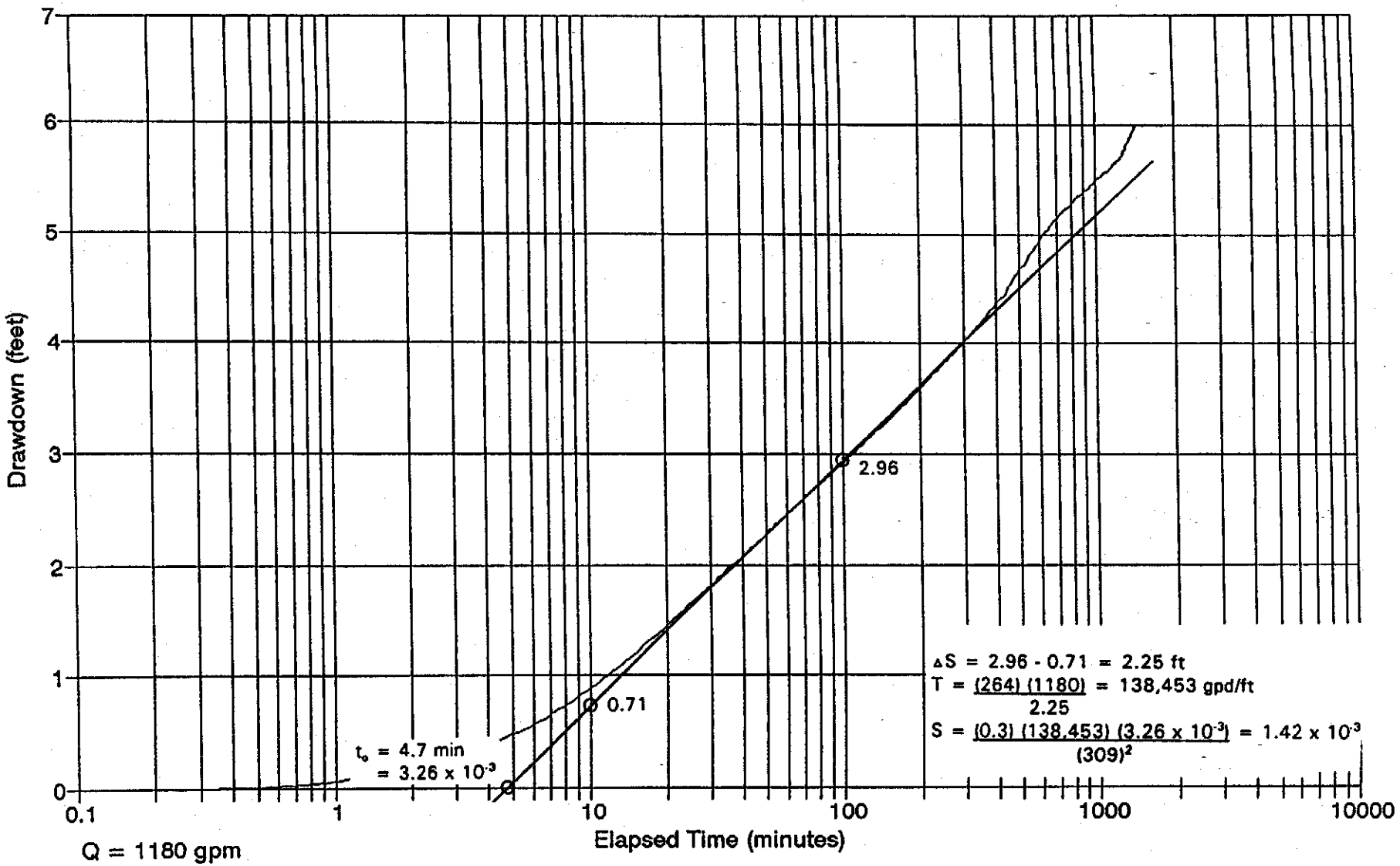


Q = 1180 gpm

Distance from Pumping well = 308 feet

4425 Aquifer Test

Drawdown for Well 3353

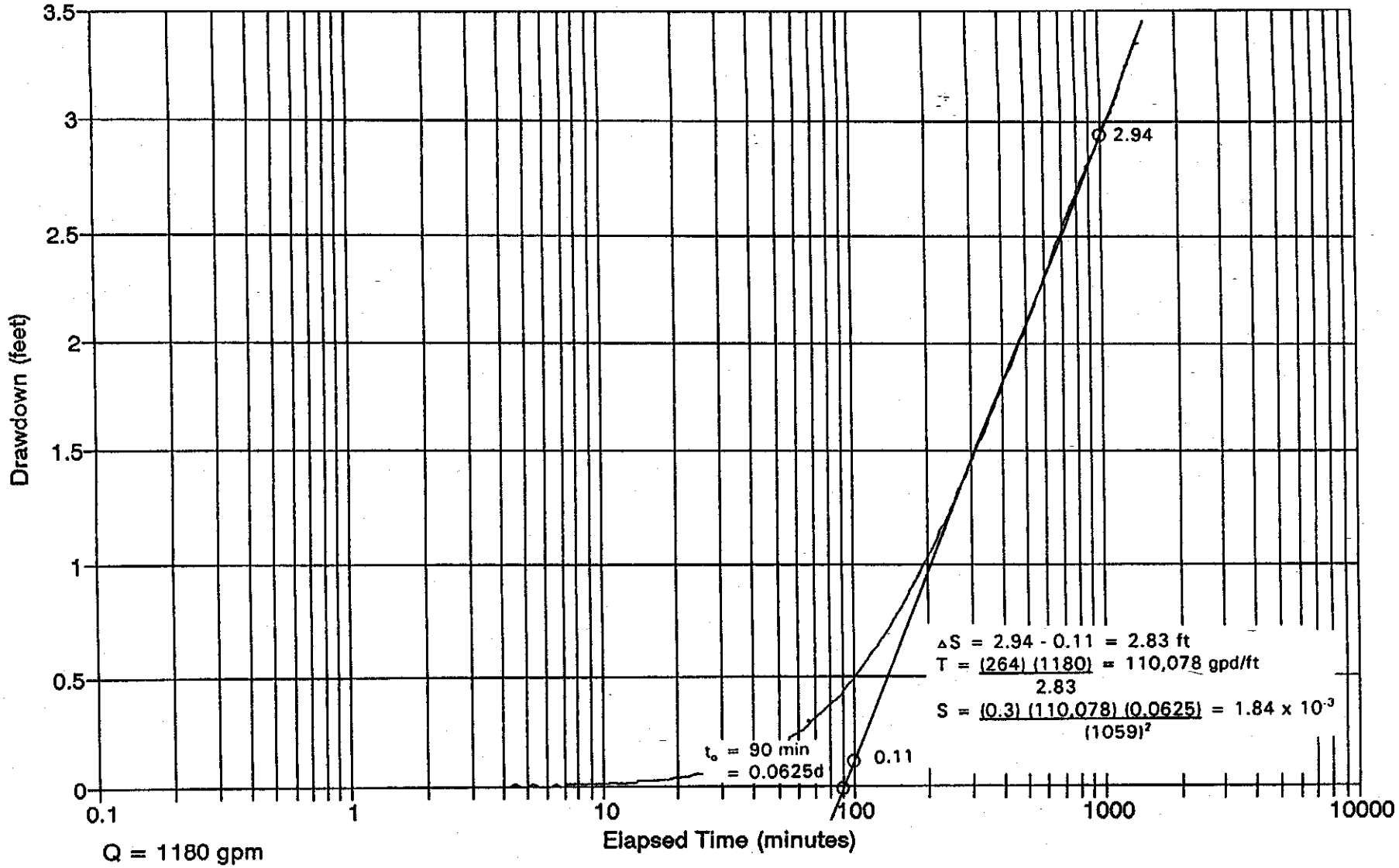


Q = 1180 gpm

Distance from Pumping well = 309 feet

4425 Aquifer Test

Drawdown for Well 3403

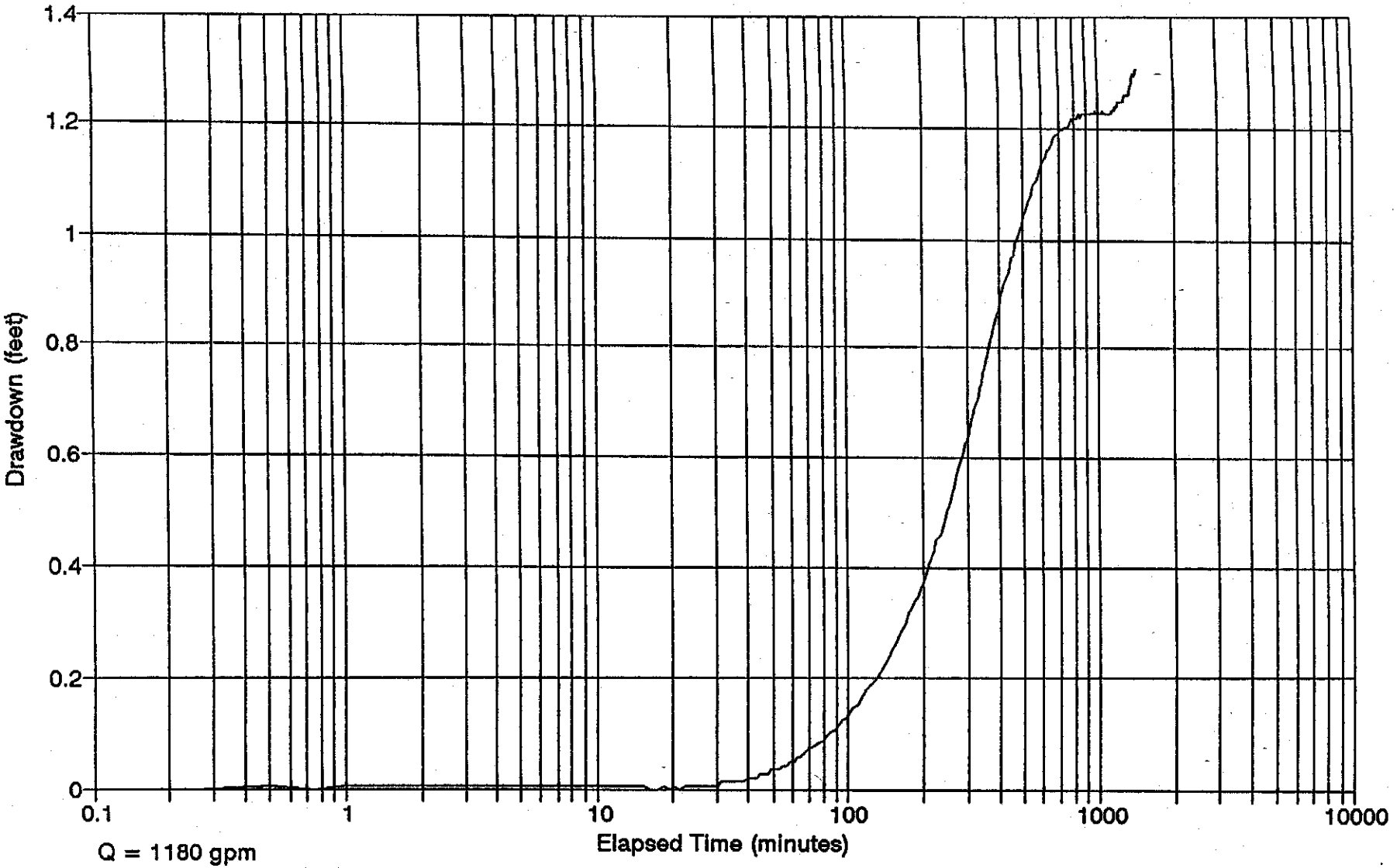


Q = 1180 gpm

Distance from Pumping well = 1059 feet

4425 Aquifer Test

Drawdown for Well 3404

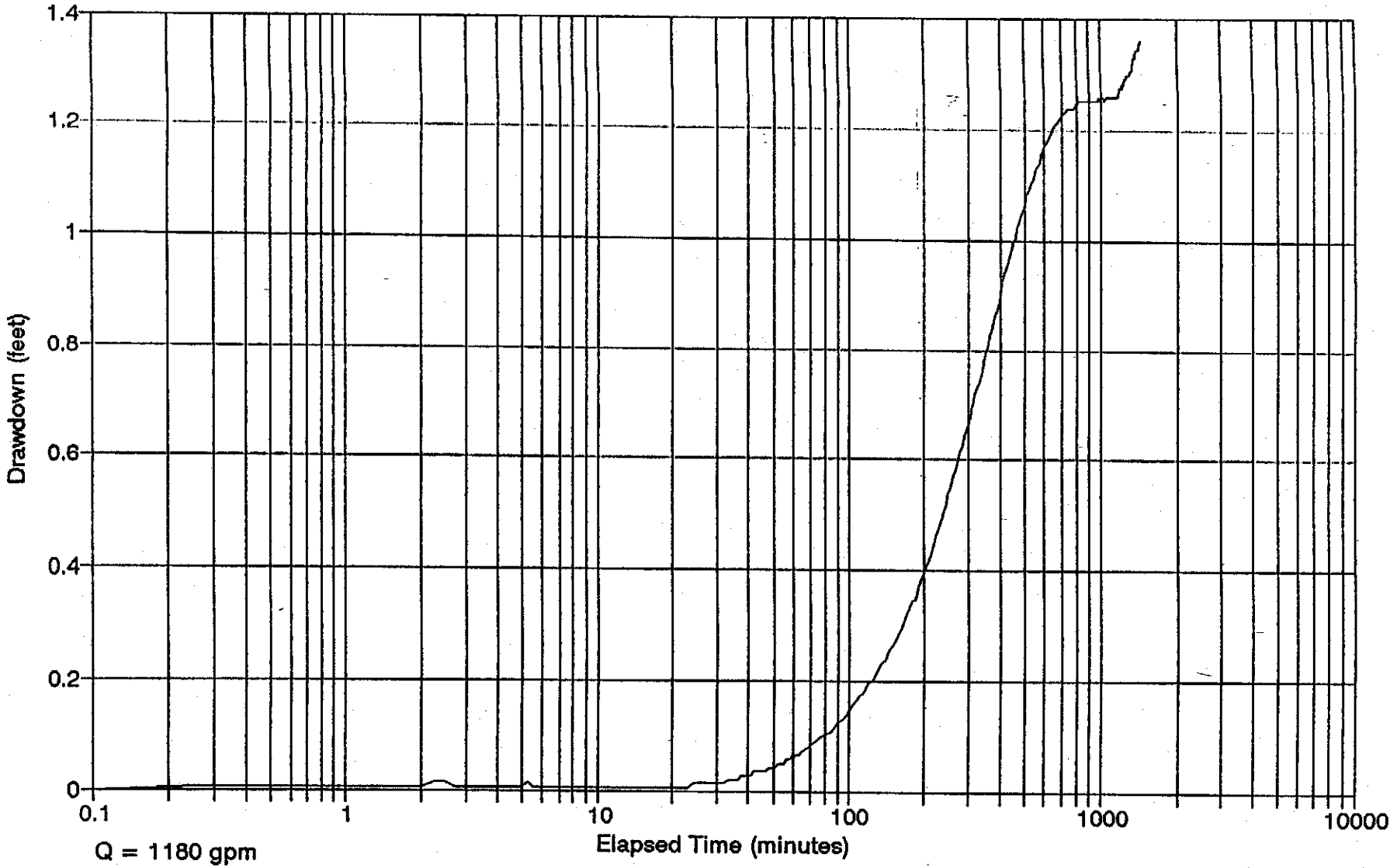


Q = 1180 gpm

Distance from Pumping well 1059 feet

4425 Aquifer Test

Drawdown for Well 3405

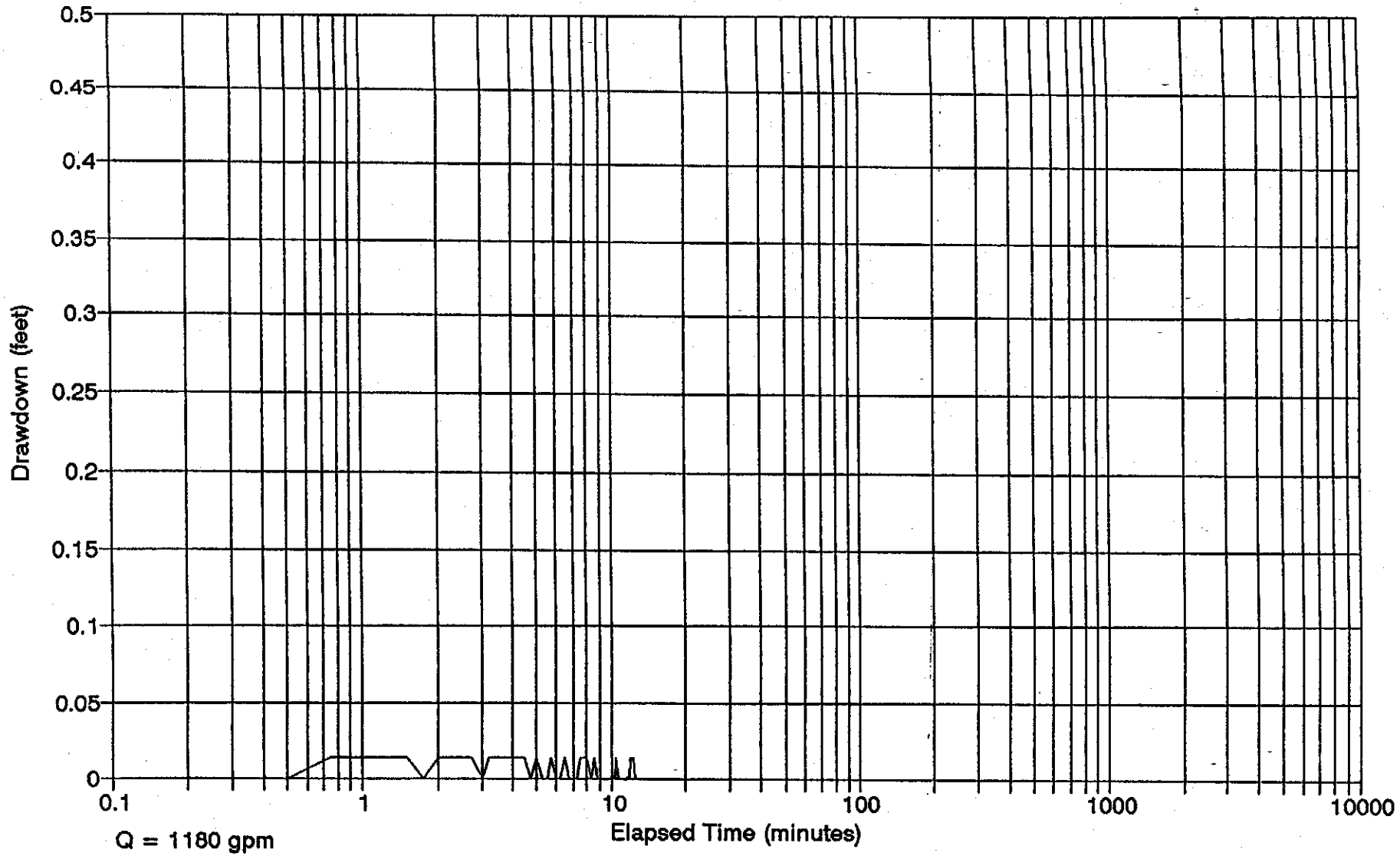


Q = 1180 gpm

Distance from Pumping well = 1059 feet

4425 Aquifer Test

Drawdown for Well 3406

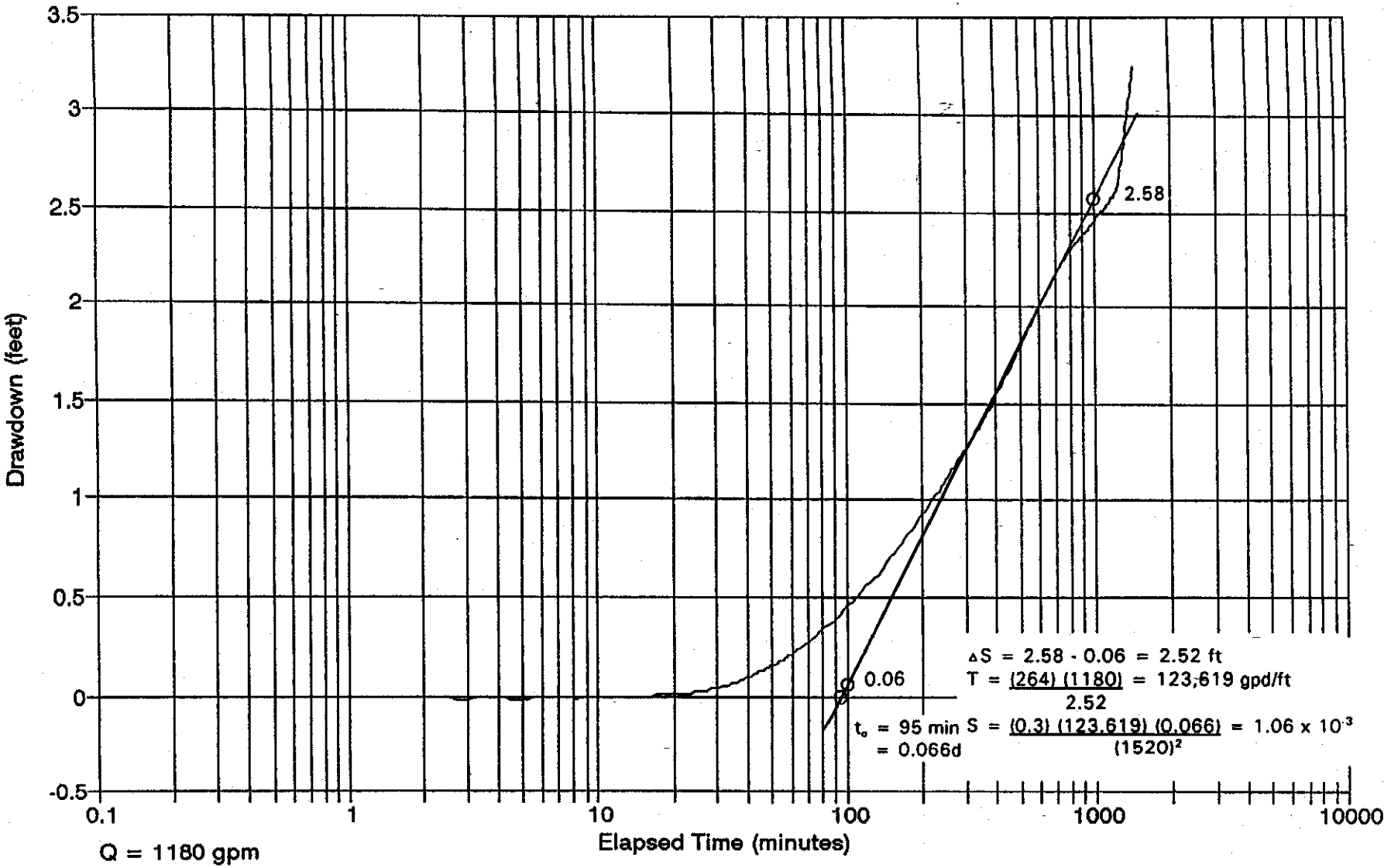


Q = 1180 gpm

Distance from Pumping well = 1520 feet

4425 Aquifer Test

Drawdown for Well 3407

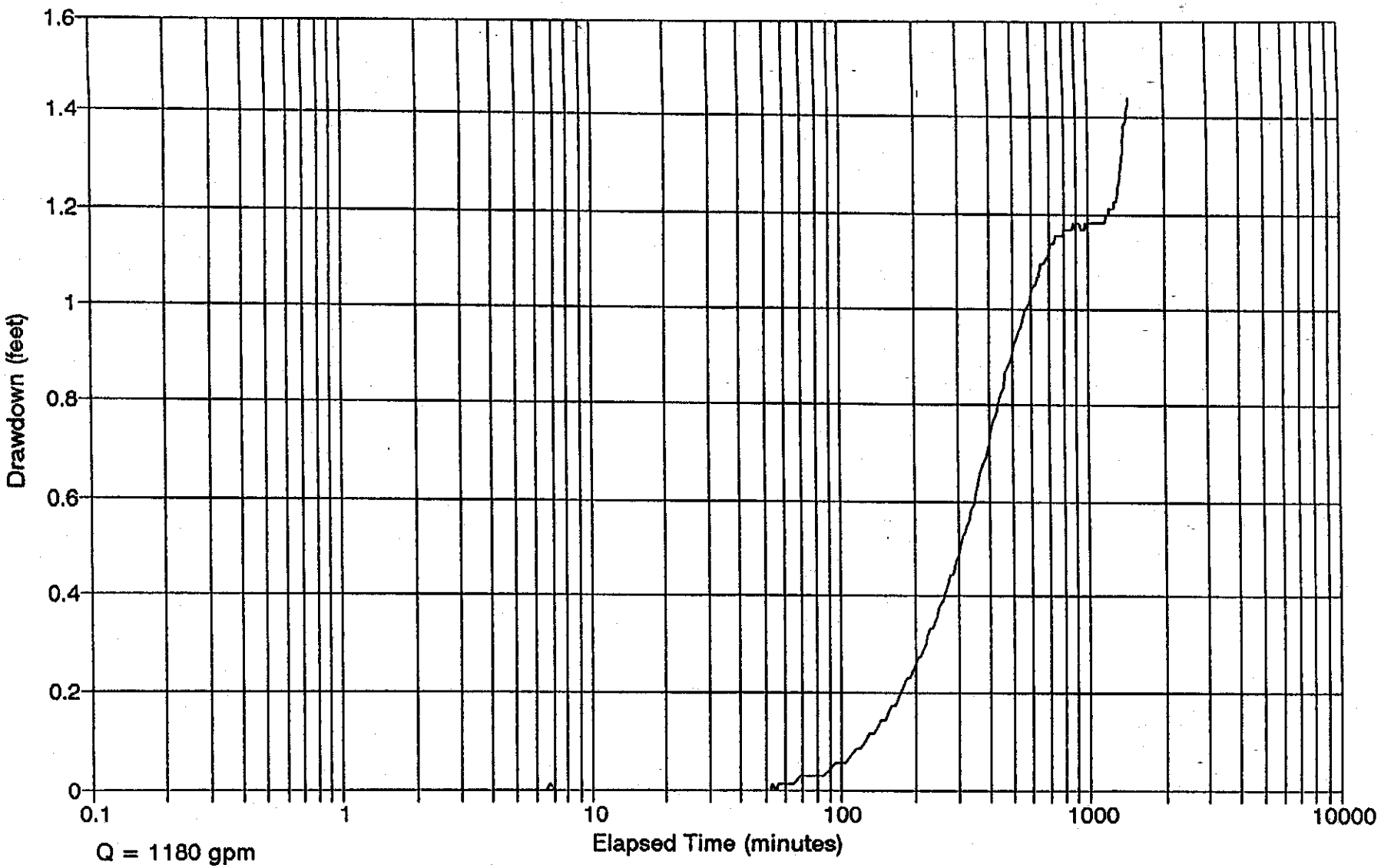


Q = 1180 gpm

Distance from Pumping well = 1520 feet

4425 Aquifer Test

Drawdown for Well 3408

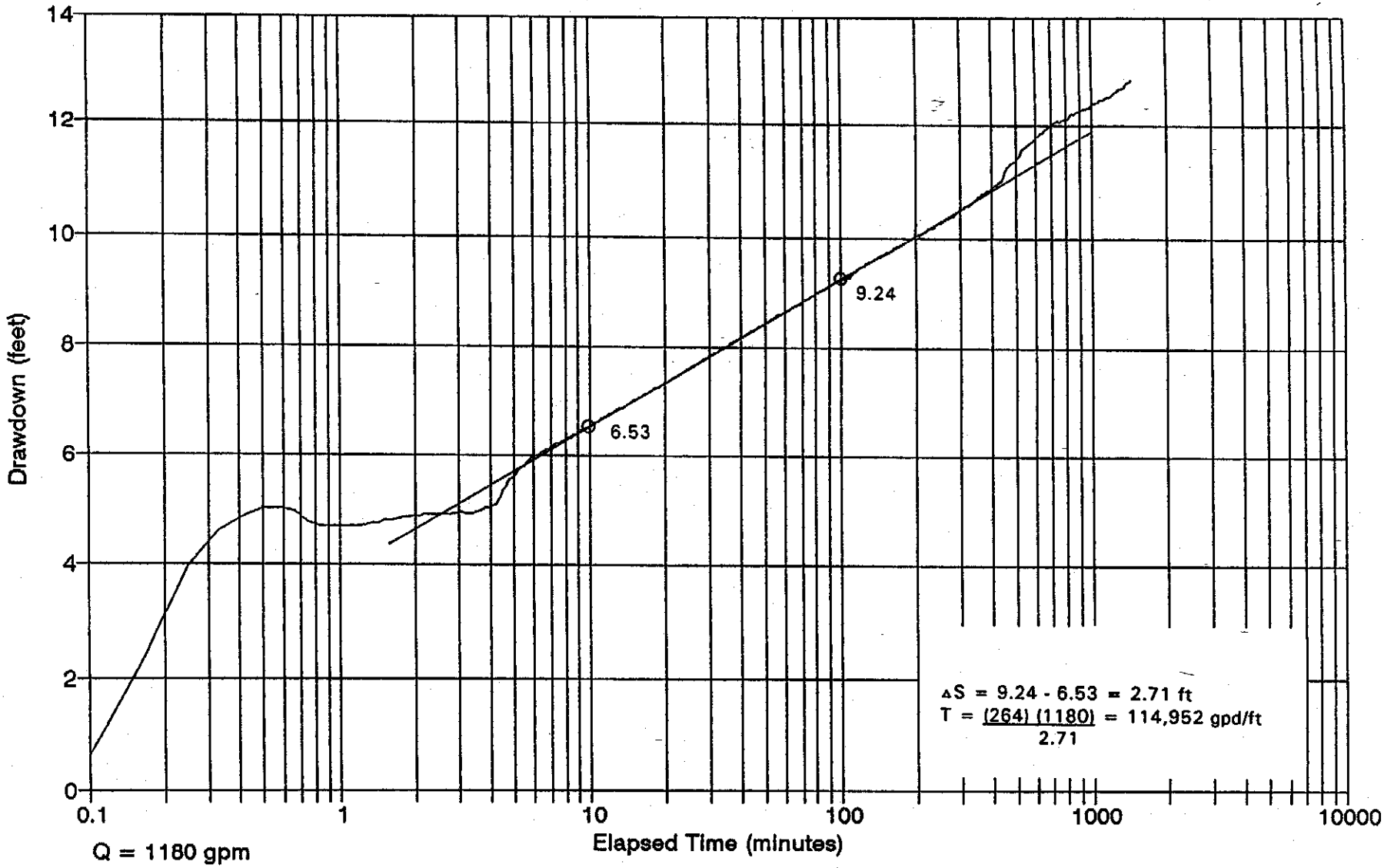


Q = 1180 gpm

Distance from Pumping well = 1520 feet

4425 Aquifer Test

Drawdown for Well 3517

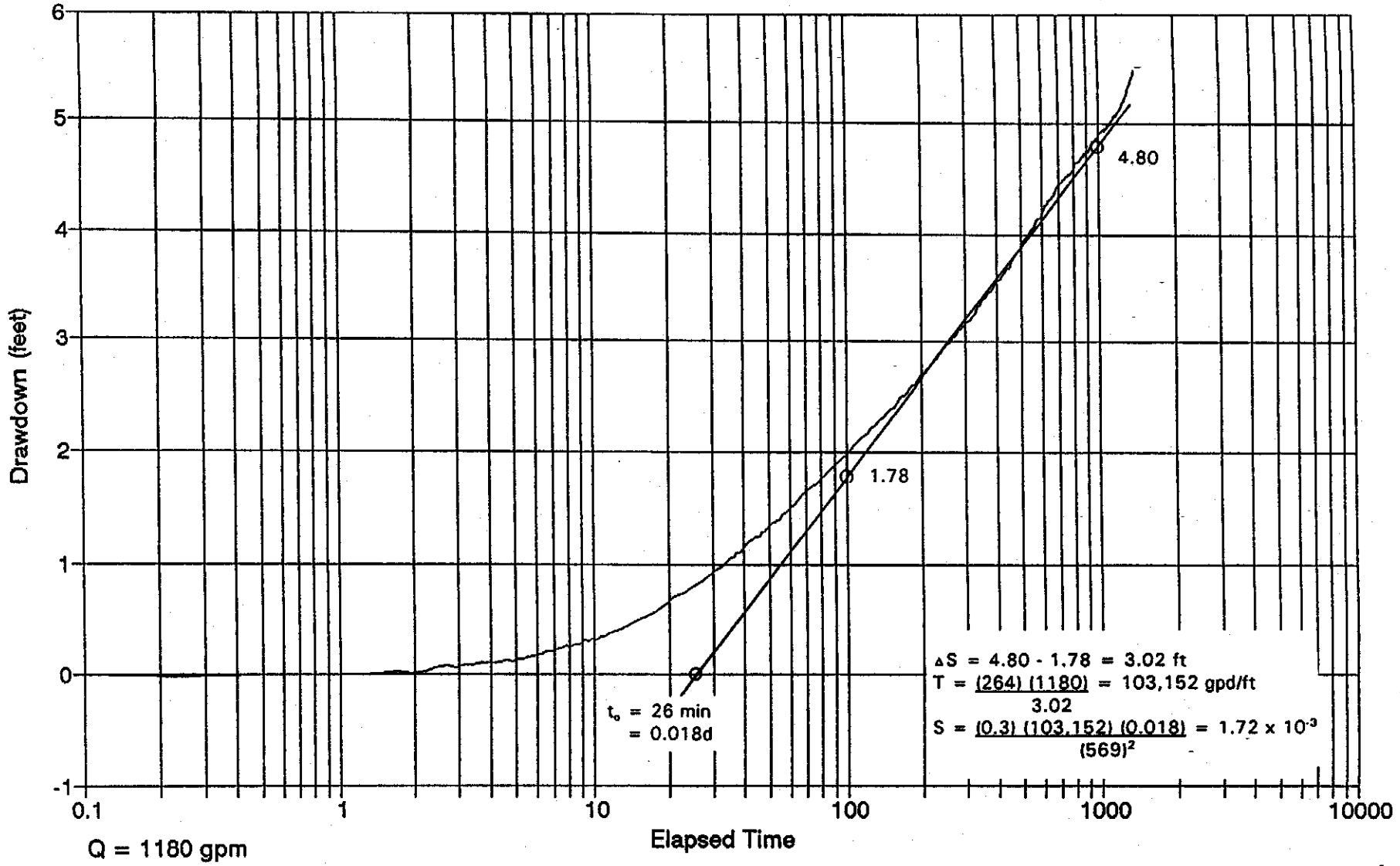


Q = 1180 gpm

Distance from Pumping well = 15 feet

4425 Aquifer Test

Drawdown for Well 3518

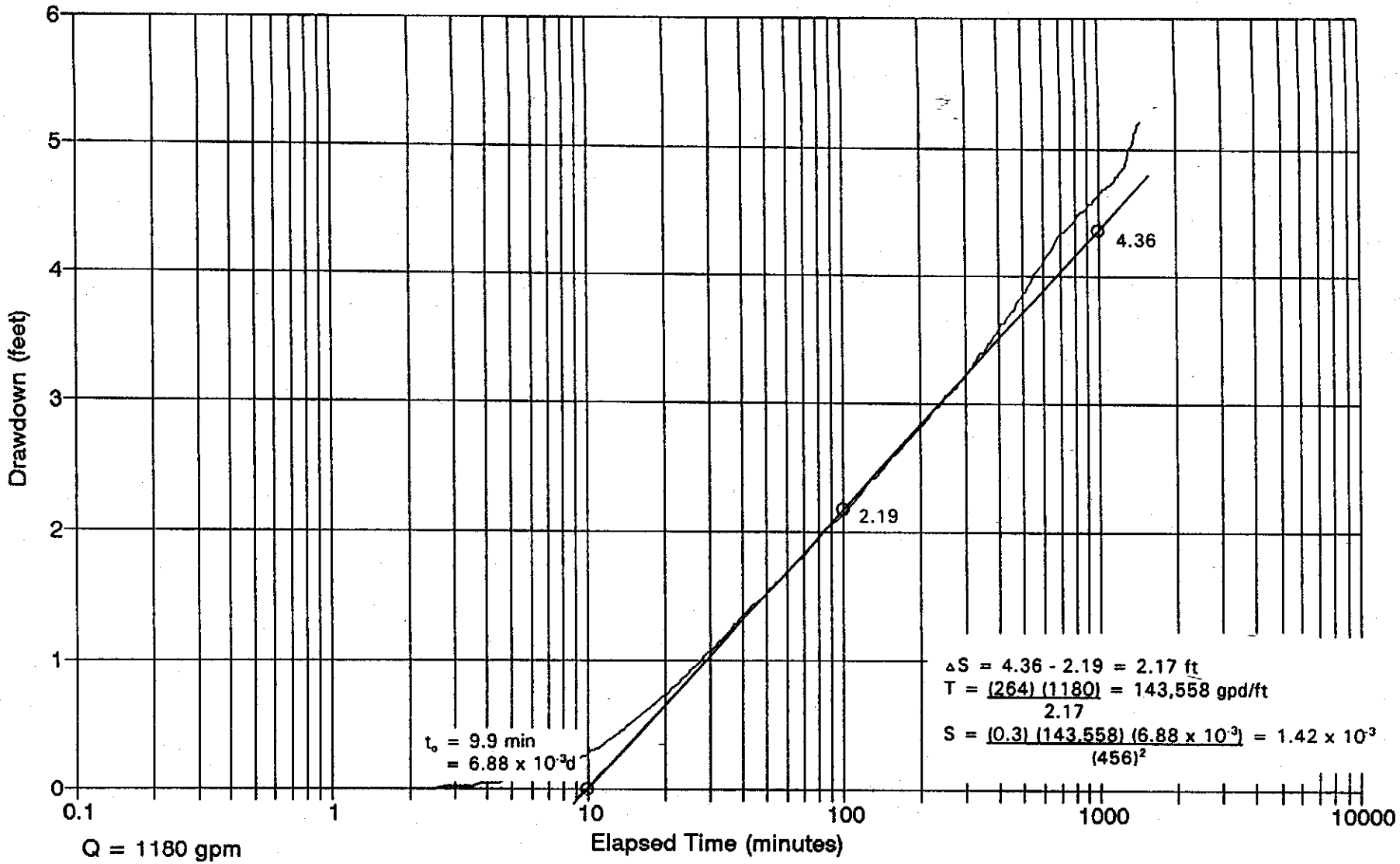


Q = 1180 gpm

Distance from Pumping well = 569 feet

4425 Aquifer Test

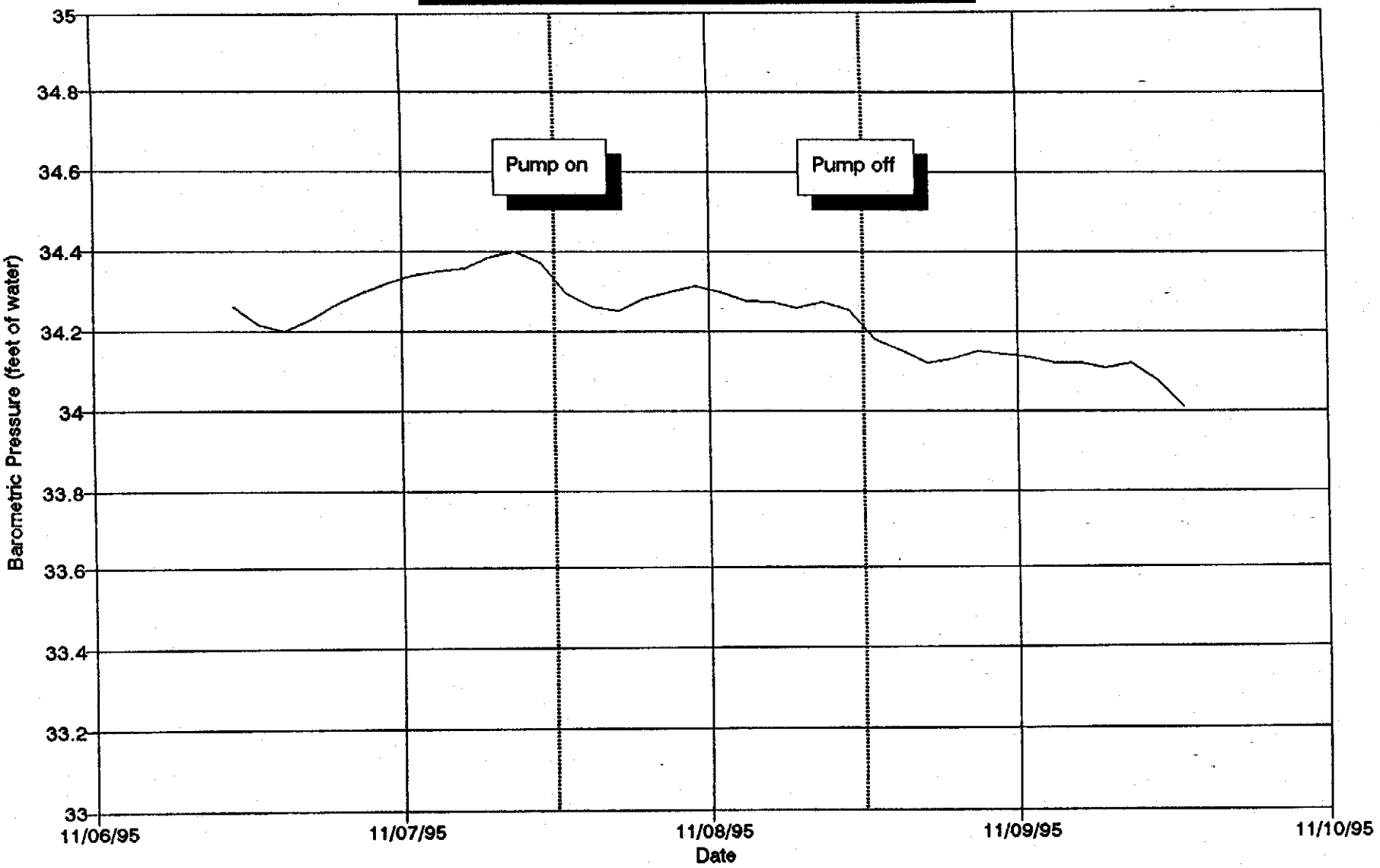
Drawdown for Well 4070



Q = 1180 gpm

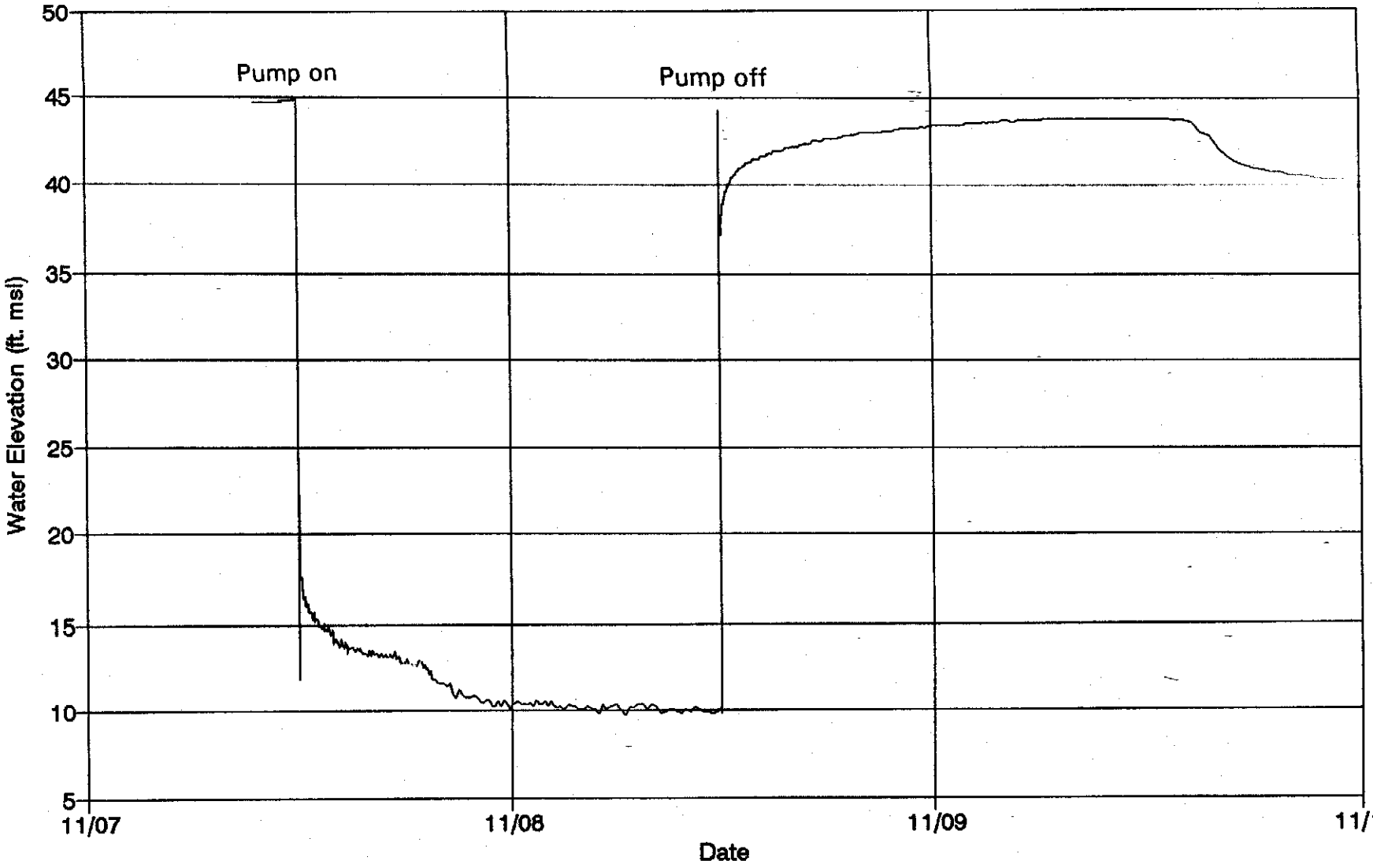
Distance from Pumping well = 456 feet

4425 Aquifer Test
Barometric Pressure Data



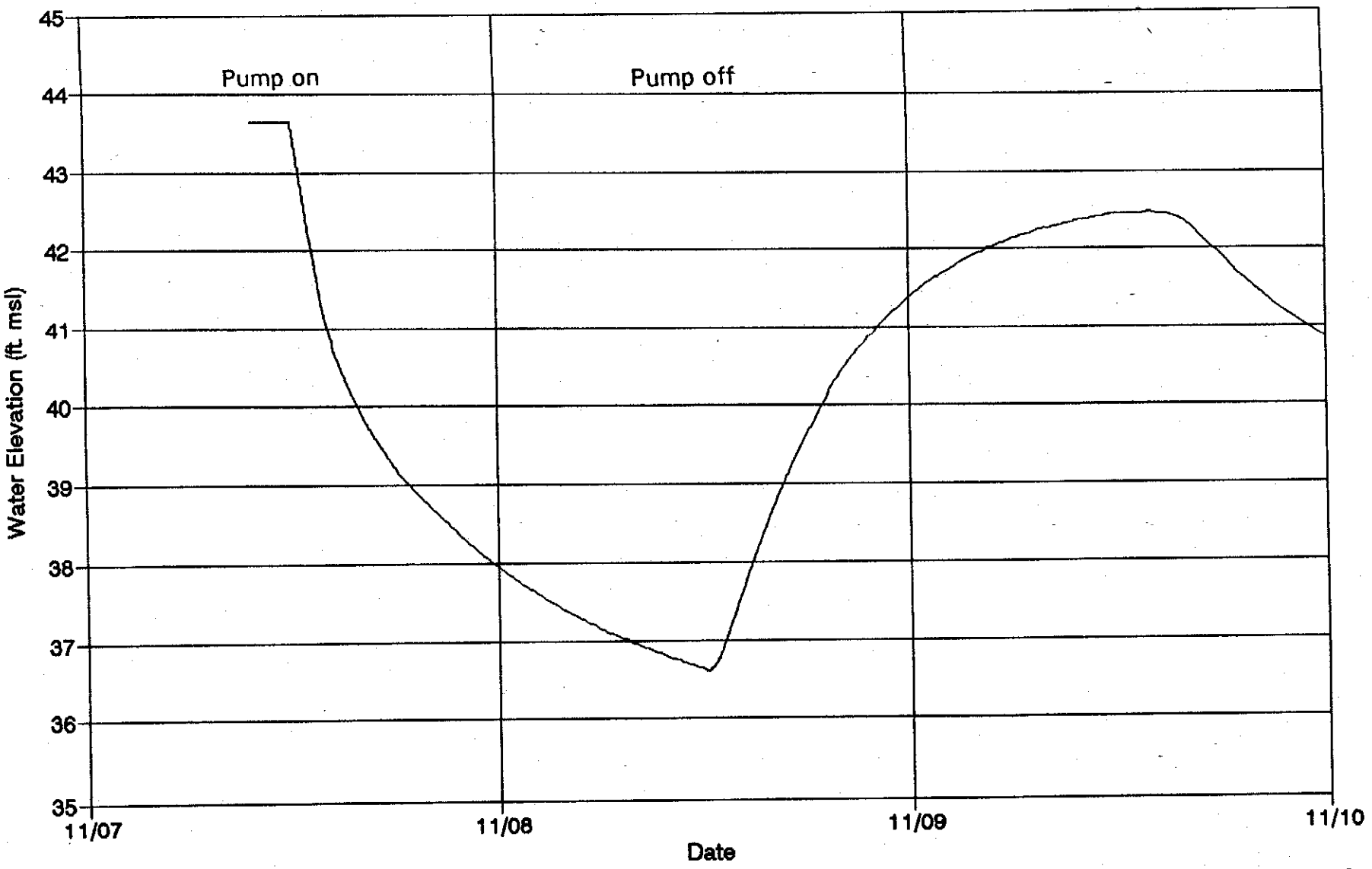
4425 Aquifer Test

Hydrograph for Pumping Well 4425



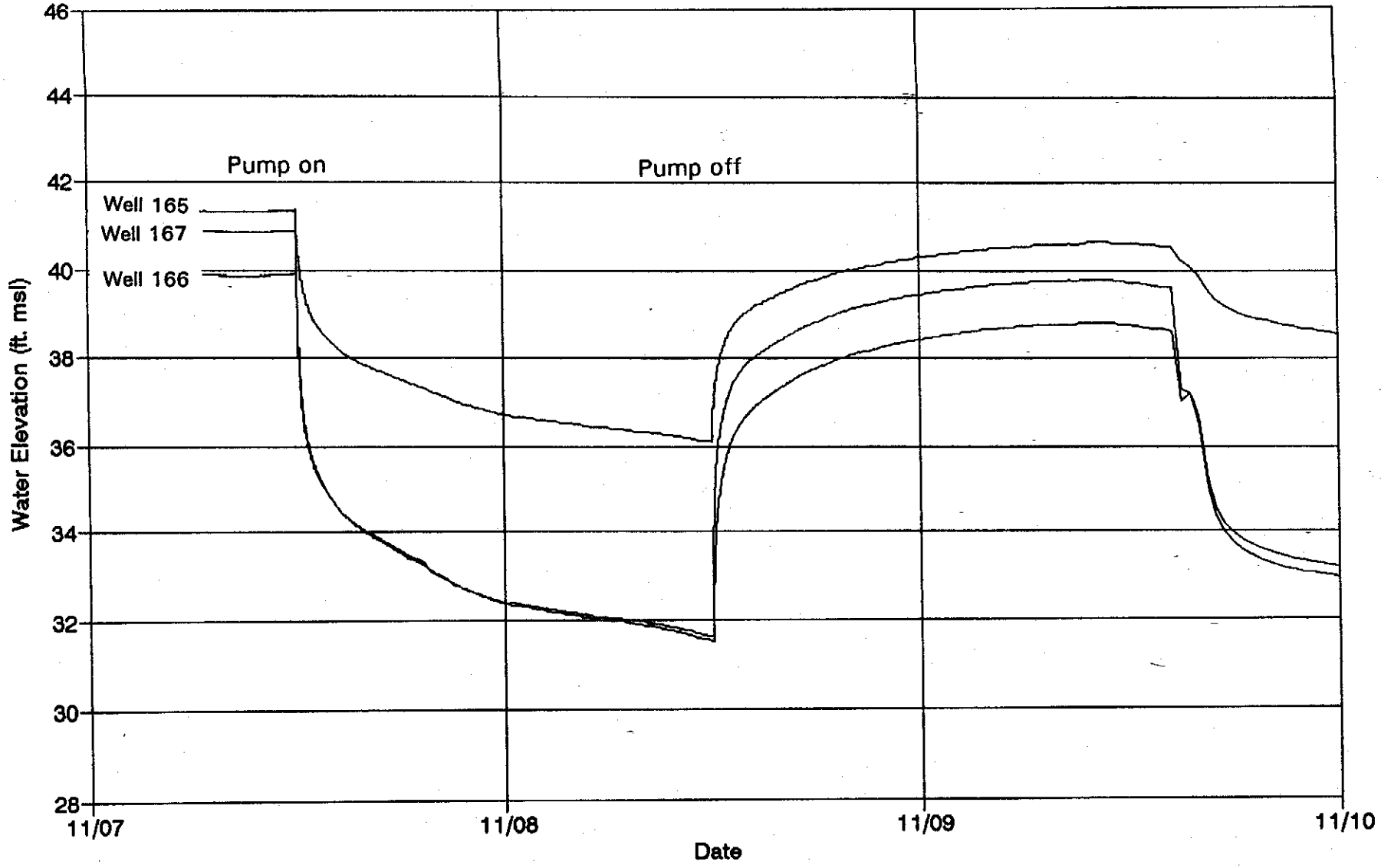
Aquifer Test of 4425

Hydrograph for Well 124



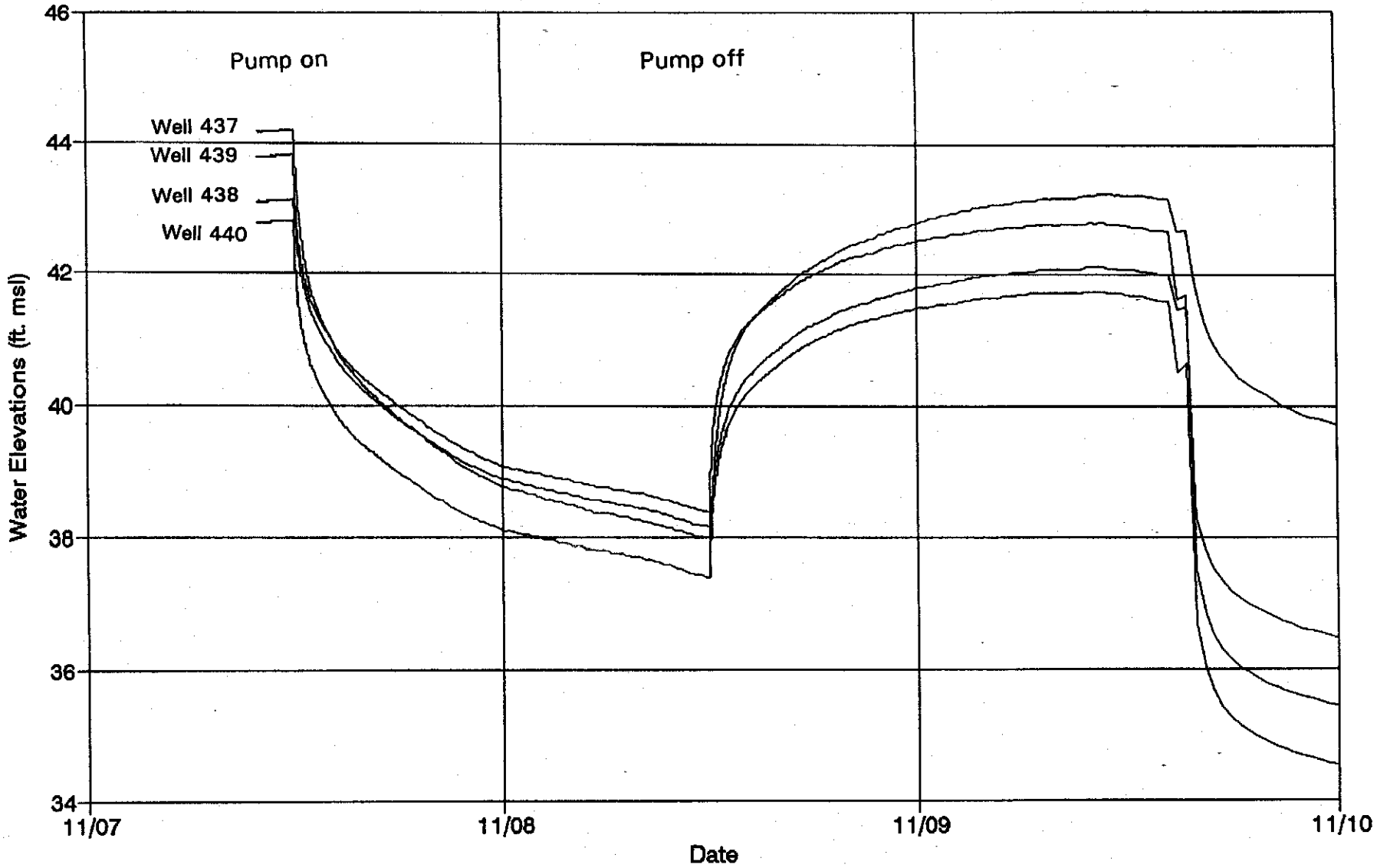
Aquifer Test of 4425

Hydrograph for Wells 165 - 167



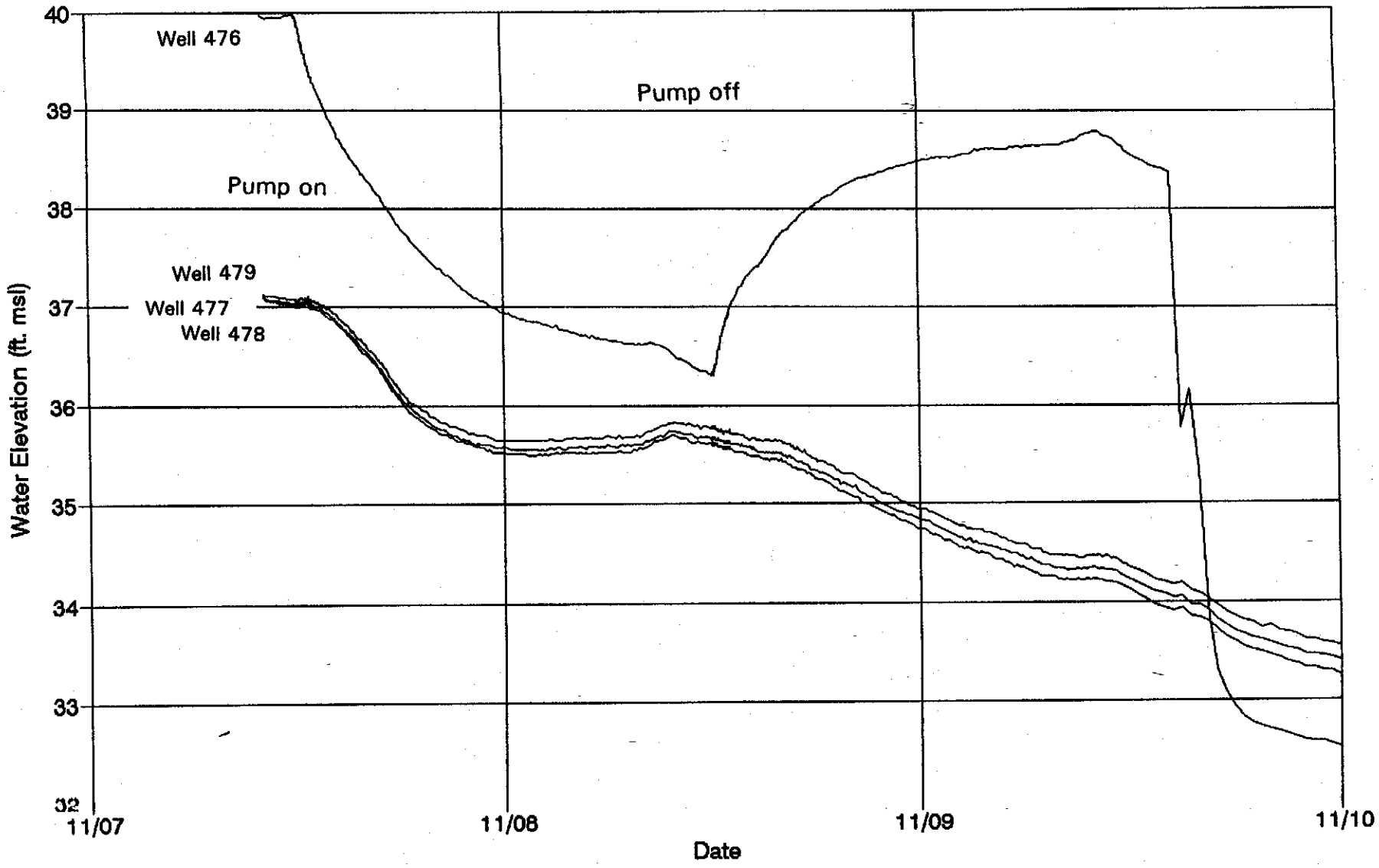
4425 Aquifer Test

Hydrograph for Wells 337 - 340



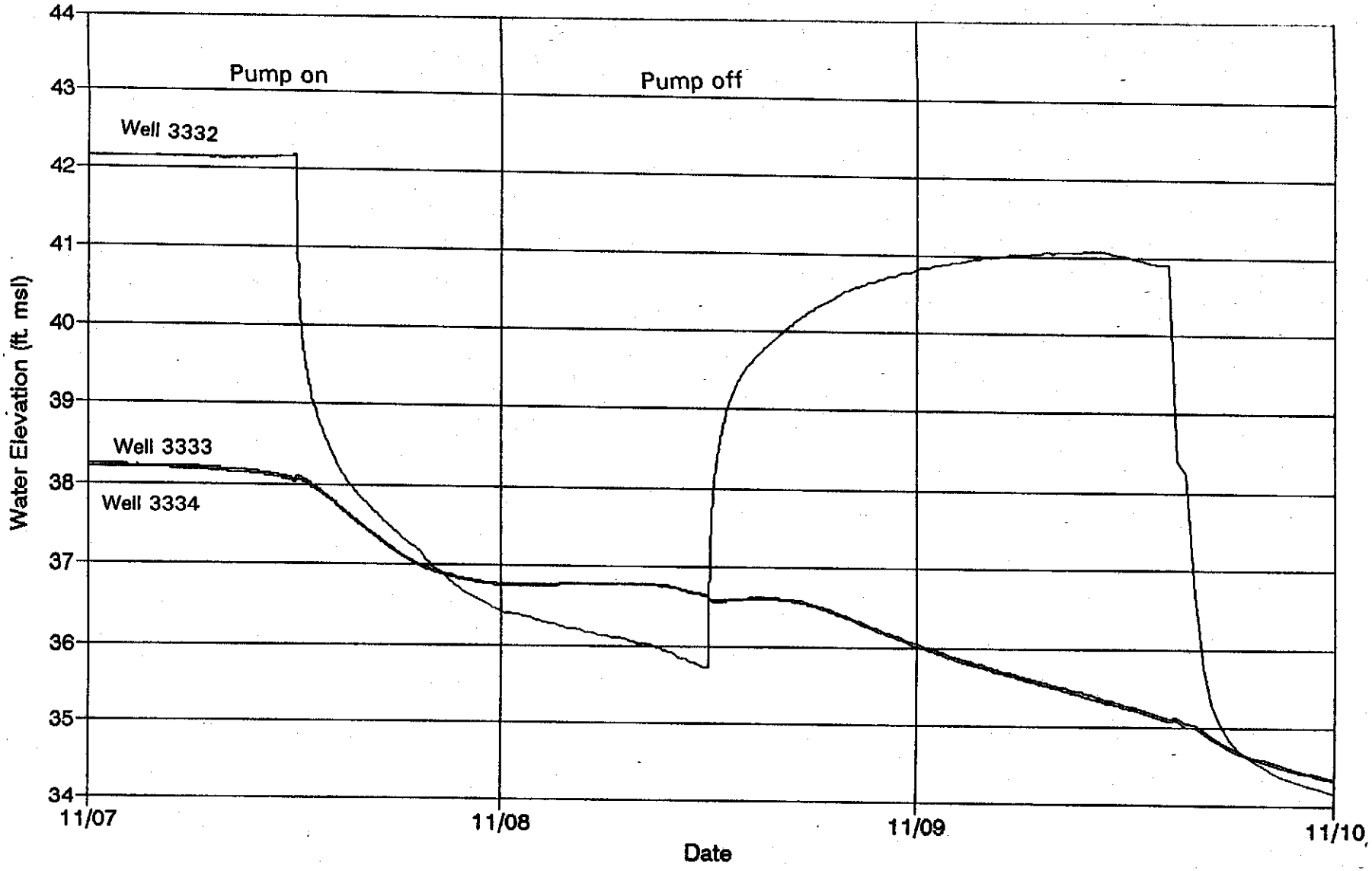
4425 Aquifer Test

Hydrograph for Wells 476 - 479



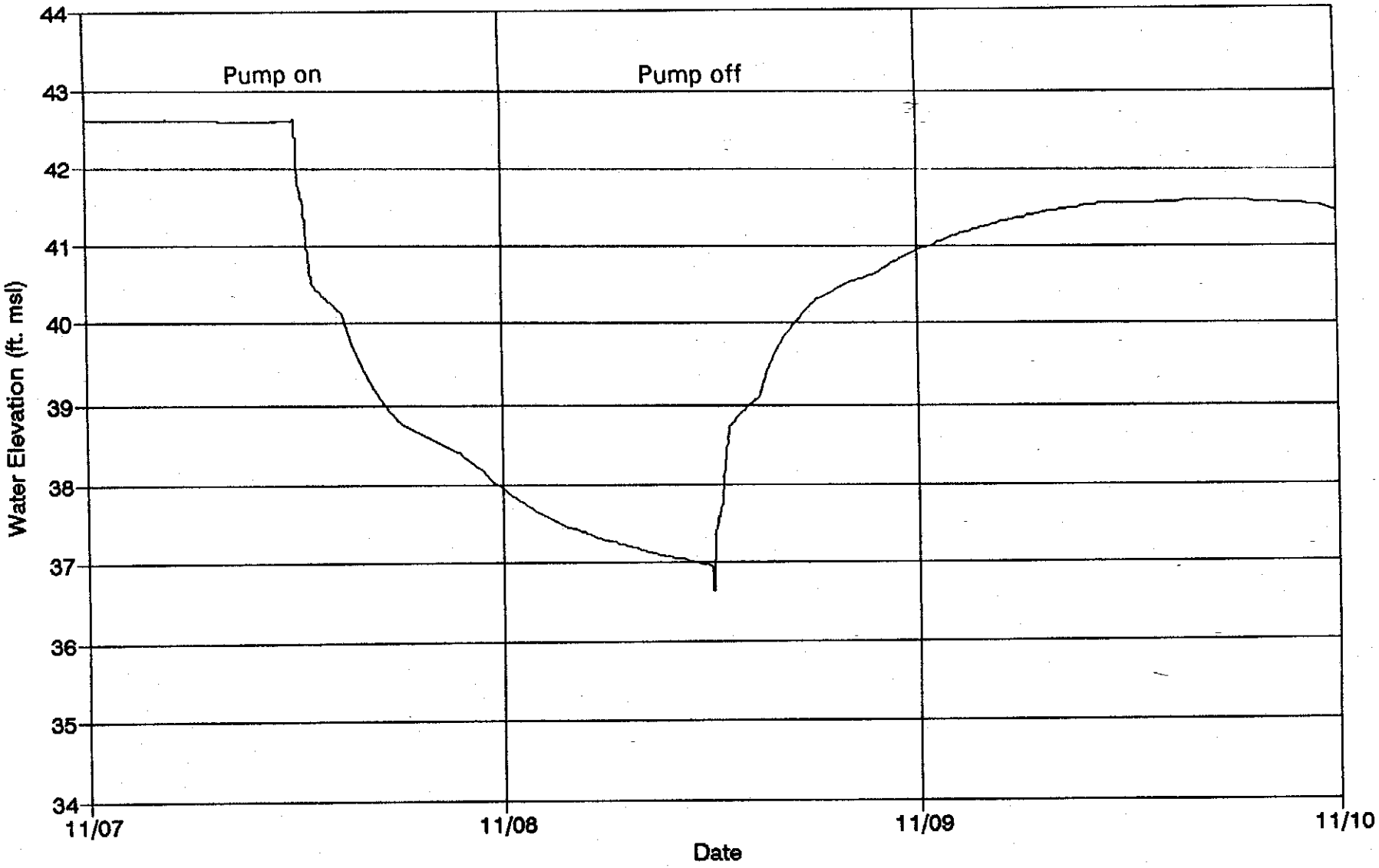
4425 Aquifer Test

Hydrograph for Wells 3332 - 3334



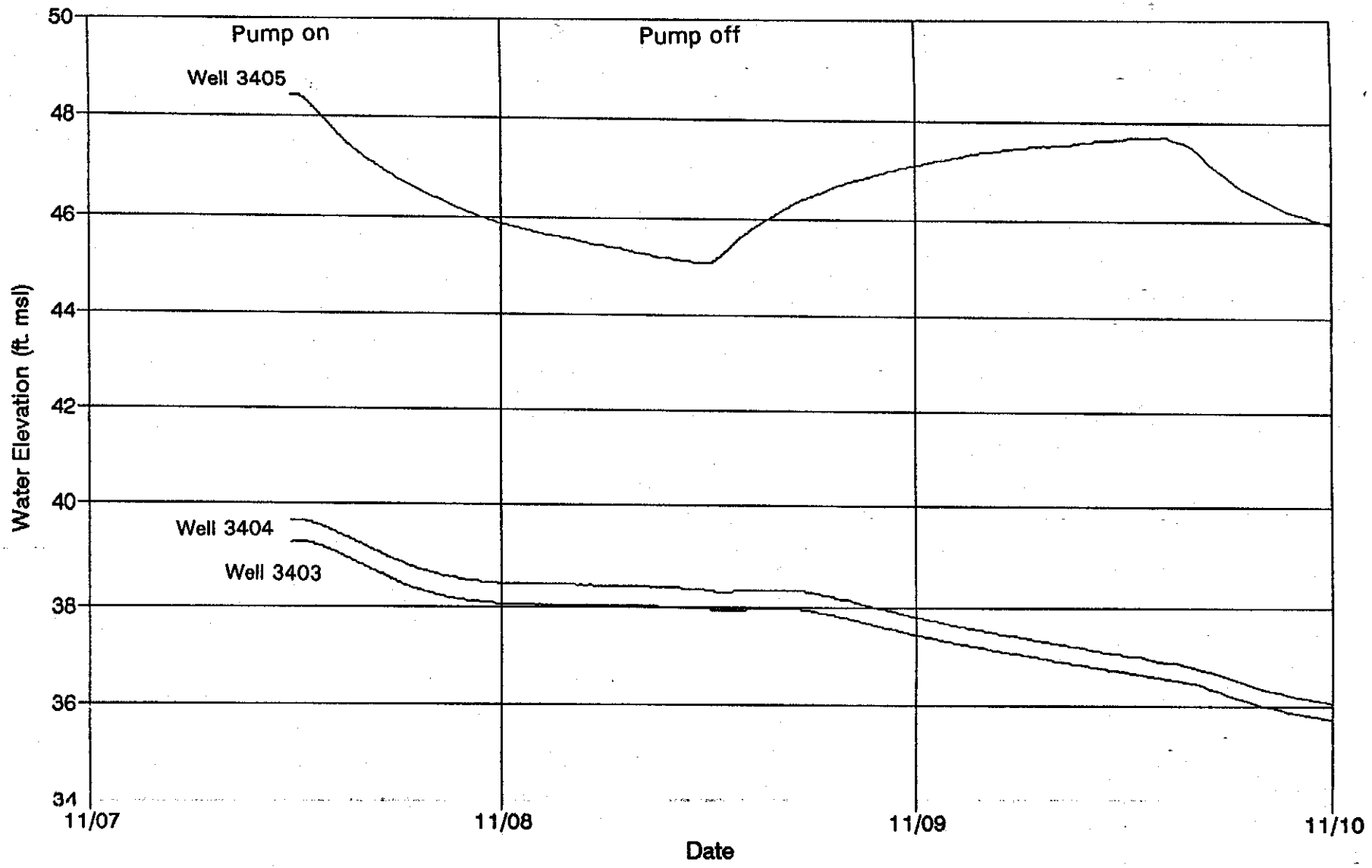
4425 Aquifer Test

Hydrograph for Well 3353



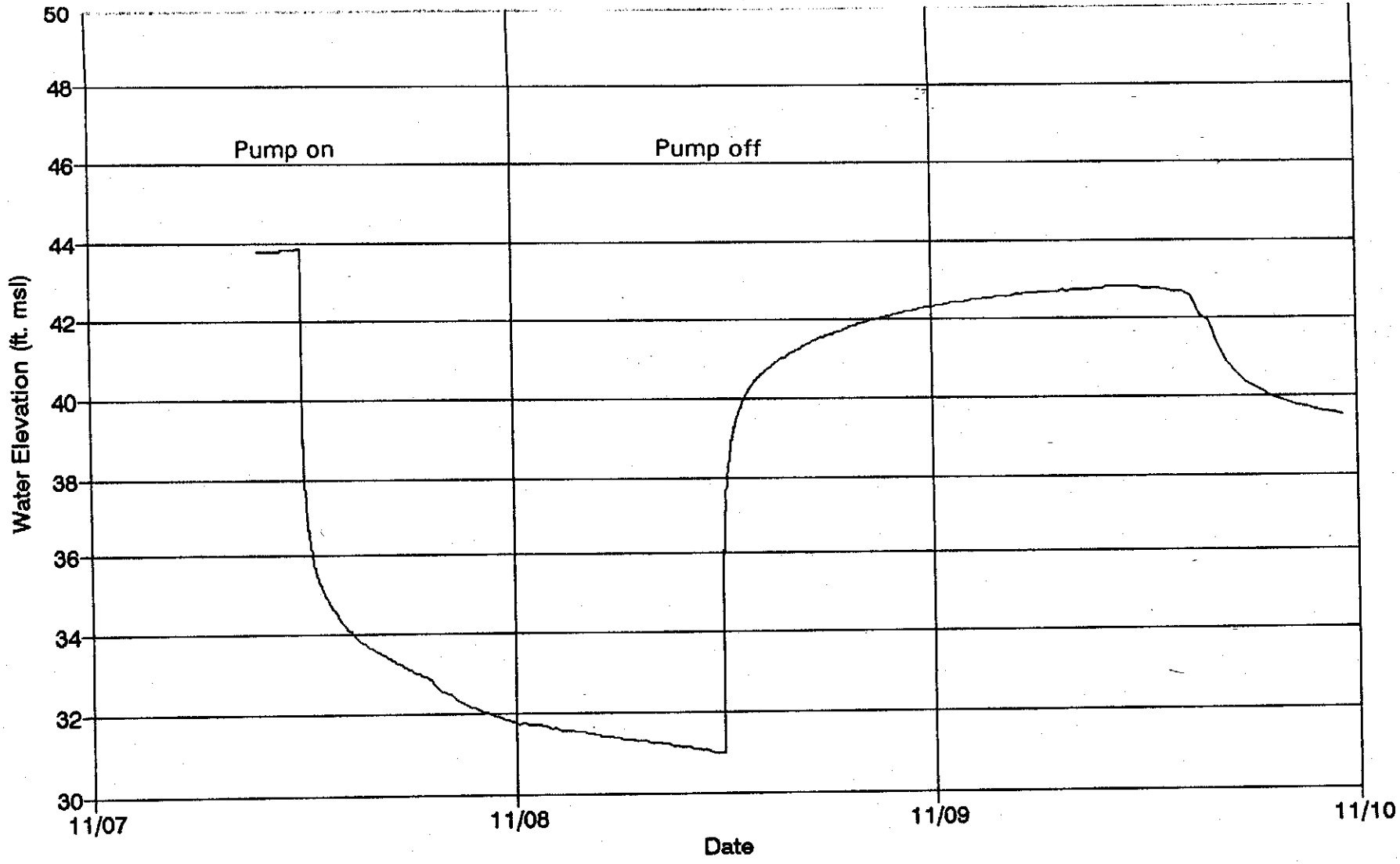
4425 Aquifer Test

Hydrograph for Wells 3403 - 3405



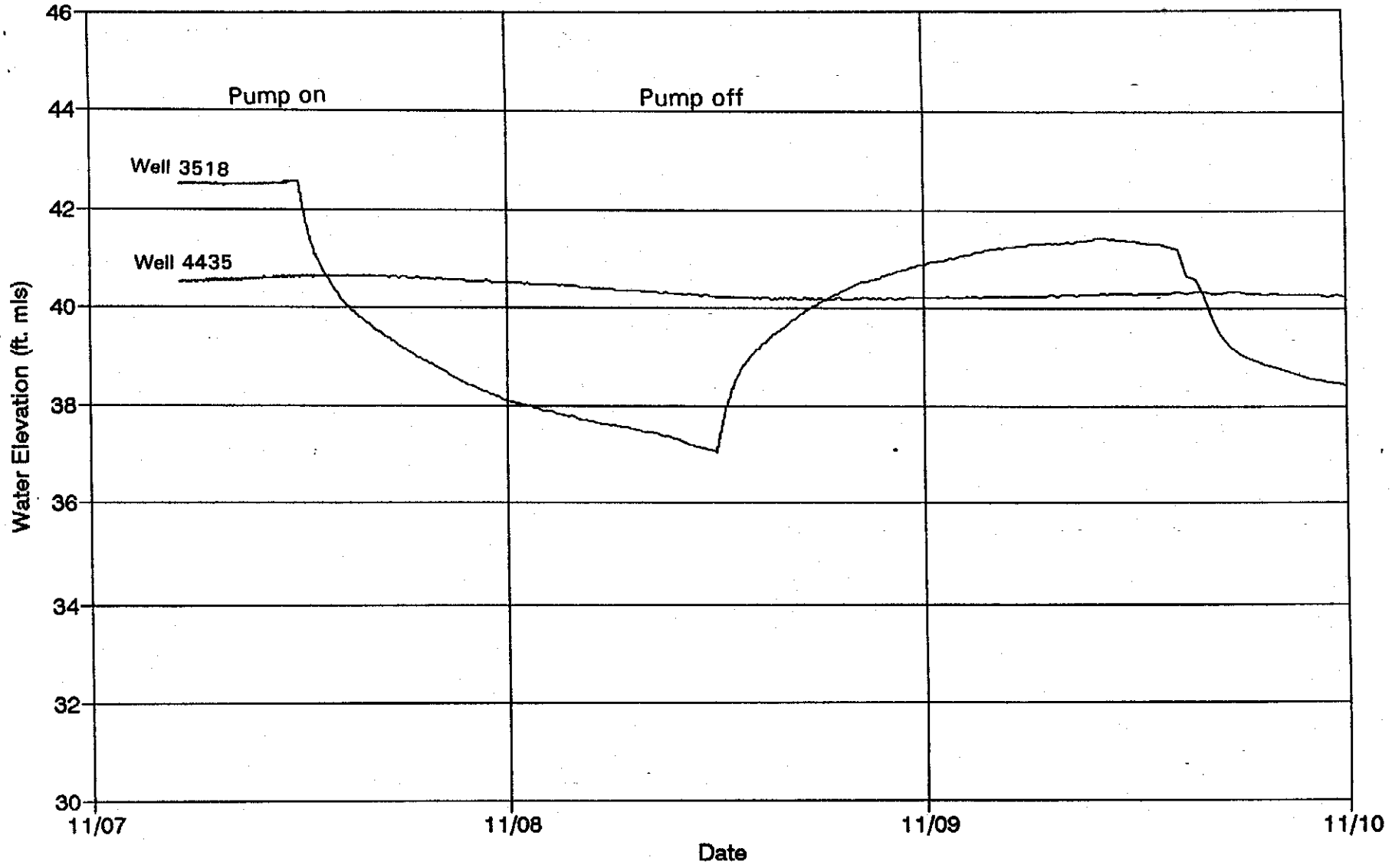
4425 Aquifer Test

Hydrograph for Well 3517

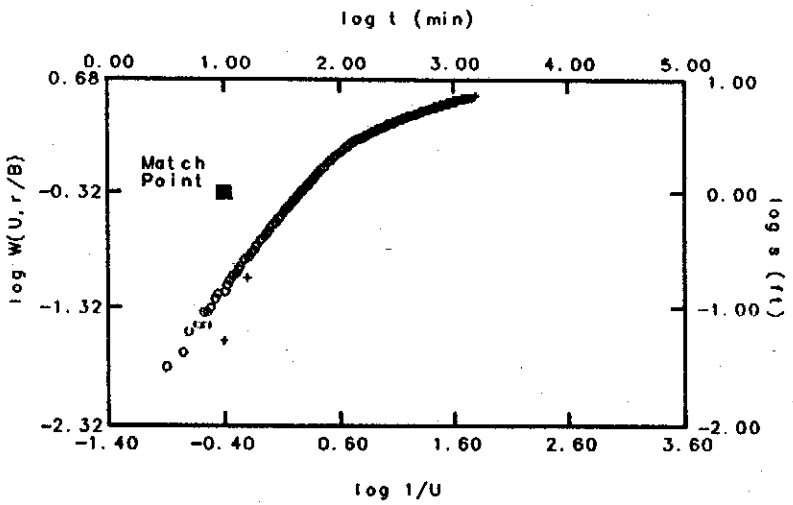


4425 Aquifer Test

Hydrograph for Wells 4435 & 3518



4425 Test – Drawdown Well 124

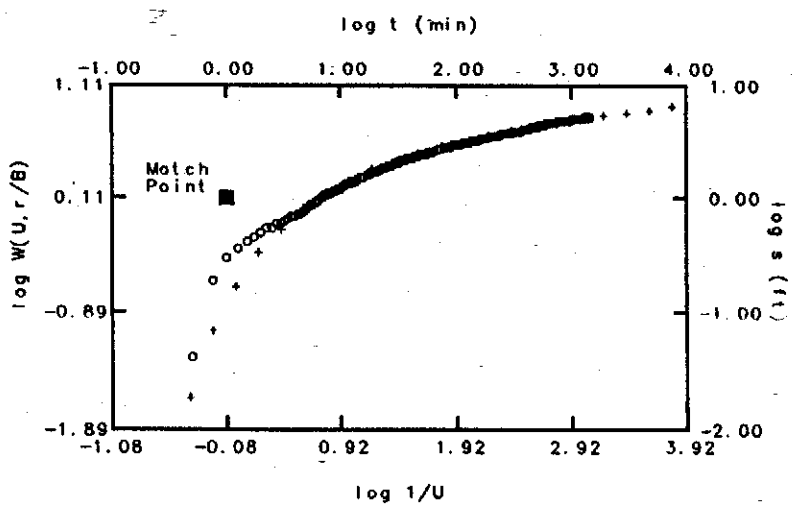


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.05

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 6.471E+0004 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 6.471E+0004 gpd/sq ft
1/U	= 3.981E-0001	Storativity	= 1.925E-0001
W(U,r/B)	= 4.786E-0002	Leakage Factor	= 1.120E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 124
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (h)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.600E+0001 ft

4425 Test – Drawdown Well 165

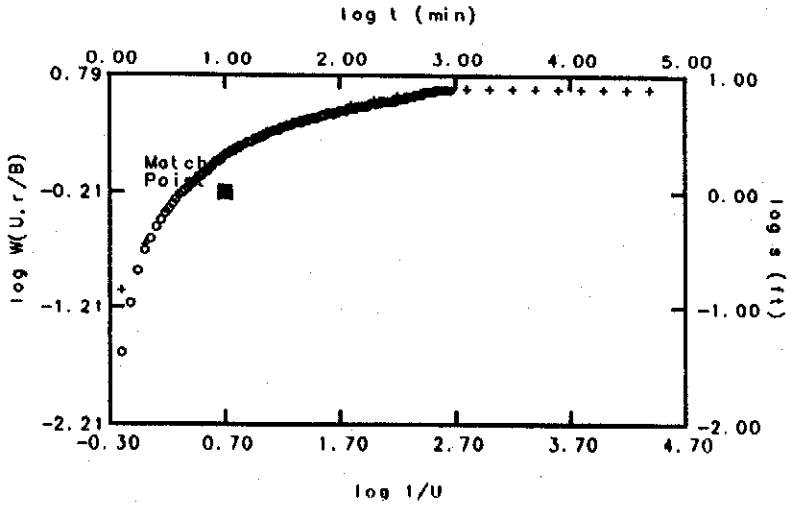


o – Data
+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 1.742E+0005 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 1.742E+0005 gpd/sq ft
1/U	= 8.318E-0001	Storativity	= 2.400E-0003
W(U,r/B)	= 1.288E-0001		

WELL INFORMATION	
WELL IDENTIFICATION	: 165
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (h)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.800E+0002 ft

4425 Test – Drawdown Well 166

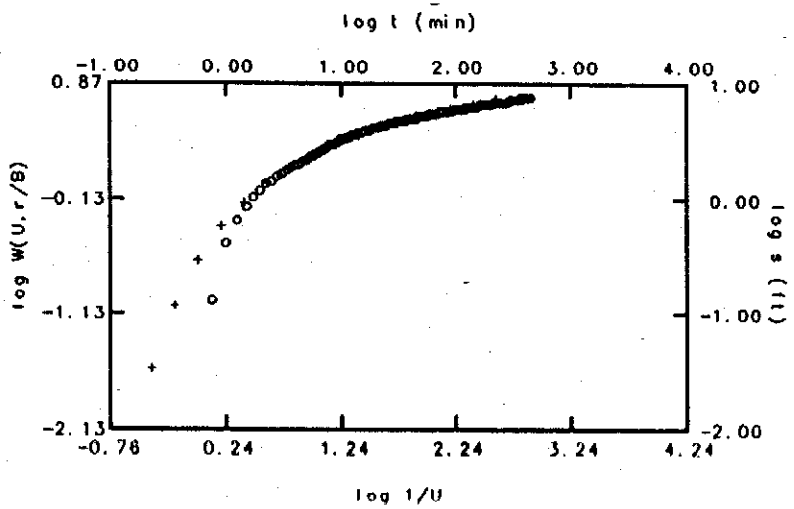


o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.10

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	8.336E+0004 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	8.336E+0004 gpd/sq ft
1/U	=	5.012E+0000	Storativity	=	1.907E-0003
W(U,r/B)	=	6.166E-0002	Leakage Factor	=	1.800E+0003 ft

WELL INFORMATION		
WELL IDENTIFICATION	:	166
DATE OF AQUIFER TEST	:	11/07/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.180E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.800E+0002 ft

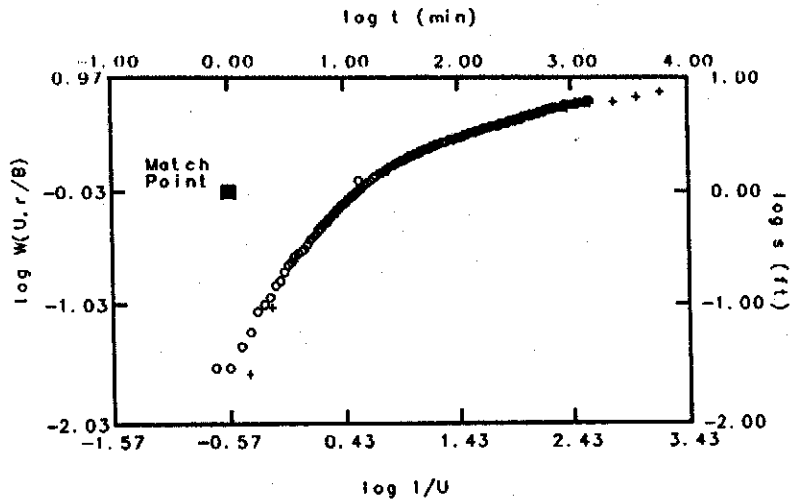
4425 Test – Drawdown Well 167



o – Data
+ – Type Curve
Conf. Leaky: r/B = 0.02

WELL INFORMATION		
WELL IDENTIFICATION	:	167
DATE OF AQUIFER TEST	:	11/07/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.180E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.800E+0002 ft

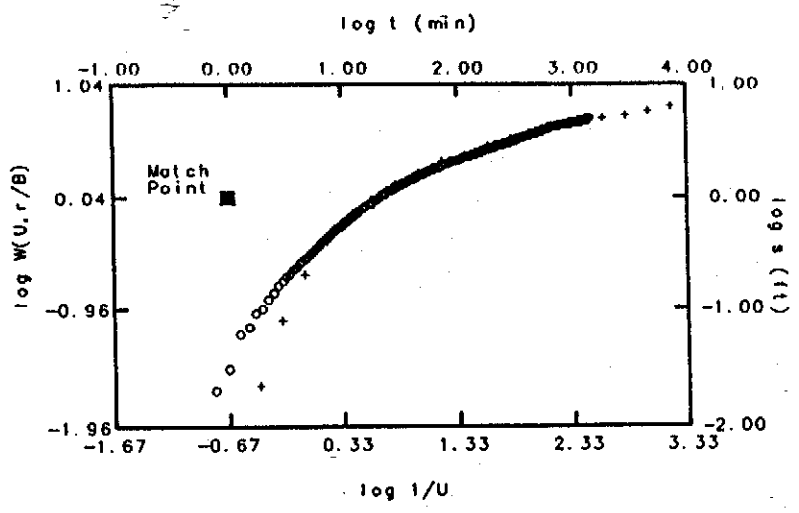
4425 Test – Drawdown Well 437



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.262E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.262E+0005 gpd/sq ft
1/U	=	2.692E-0001	Storativity	=	1.139E-0003
W(U,r/B)	=	9.333E-0002			

WELL INFORMATION		
WELL IDENTIFICATION	:	437
DATE OF AQUIFER TEST	:	11/07/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.180E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	3.910E+0002 ft

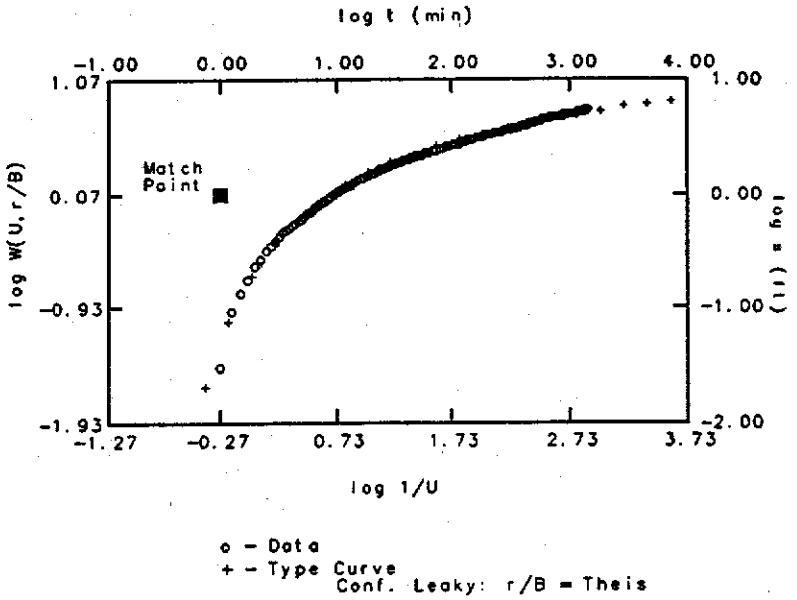
4425 Test – Drawdown Well 438



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.482E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.482E+0005 gpd/sq ft
1/U	=	2.138E-0001	Storativity	=	1.684E-0003
W(U,r/B)	=	1.096E-0001			

WELL INFORMATION		
WELL IDENTIFICATION	:	438
DATE OF AQUIFER TEST	:	11/07/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.180E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	3.910E+0002 ft

4425 Test – Drawdown Well 439



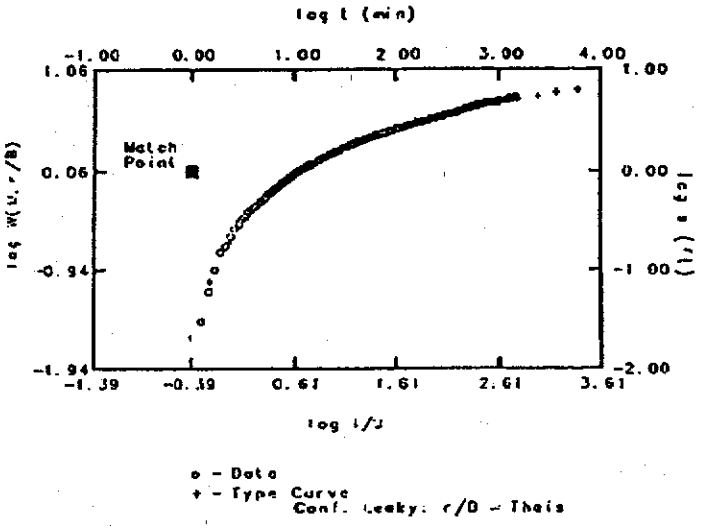
o – Data
\+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.588E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.588E+0005 gpd/sq ft
1/U	=	5.370E-0001	Storativity	=	7.185E-0004
W(U,r/B)	=	1.175E-0001			

WELL INFORMATION

WELL IDENTIFICATION	:	439
DATE OF AQUIFER TEST	:	11/07/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.180E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	3.910E+0002 ft

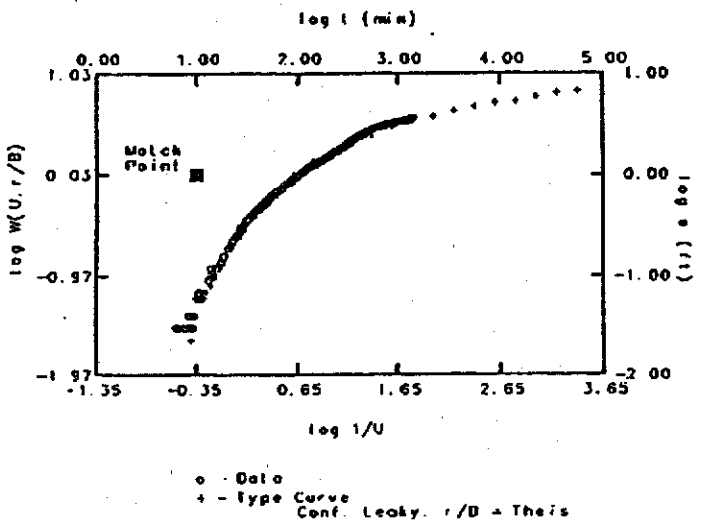
4425 Test – Drawdown Well 440



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.552E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic Cond.	=	1.552E+0005 gpd/sq ft
1/u	=	4.074E-0001	Storativity	=	9.256E-0004
W(u,r/B)	=	1.148E-0001			

WELL INFORMATION	
WELL IDENTIFICATION	: 440
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.000E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 3.910E+0002 ft

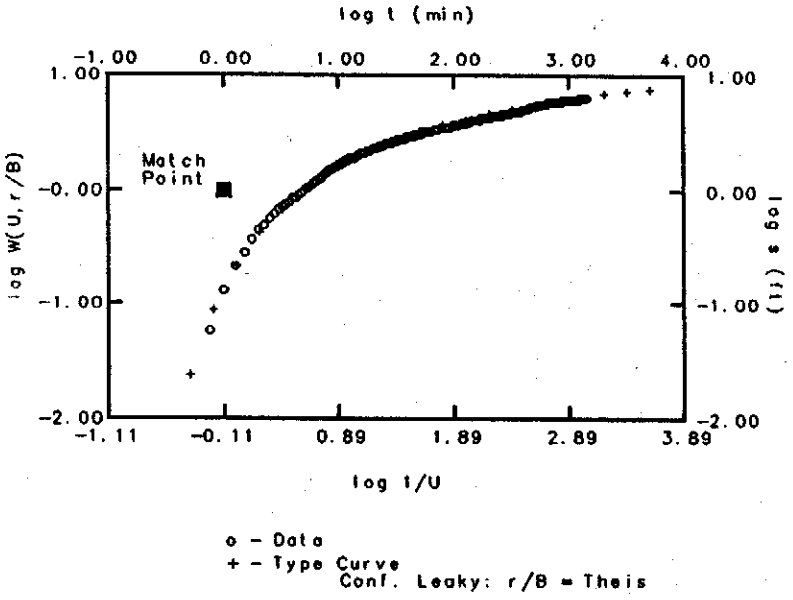
4425 Test - Drawcown Well 476



MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 1.449E+0005 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 1.449E+0005 gpd/sq ft
1/U	= 4.467E-0001	Storativity	= 1.363E-0003
W(U,r/B)	= 1.072E-0001		

WELL INFORMATION	
WELL IDENTIFICATION	: 476
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.400E+0002 ft

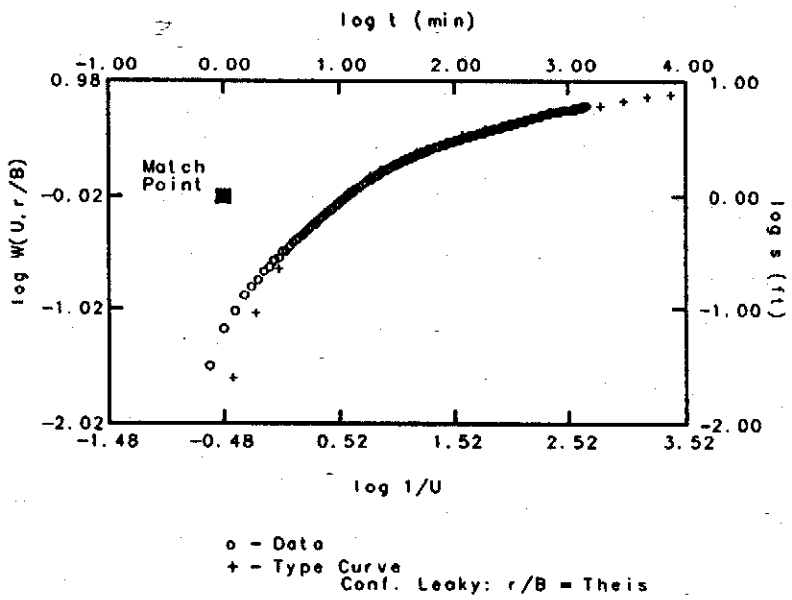
4425 Test – Drawdown Well 3332



MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 1.352E+0005 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 1.352E+0005 gpd/sq ft
1/U	= 7.762E-0001	Storativity	= 6.819E-0004
W(U,r/B)	= 1.000E-0001		

WELL INFORMATION	
WELL IDENTIFICATION	: 3332
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 3.080E+0002 ft

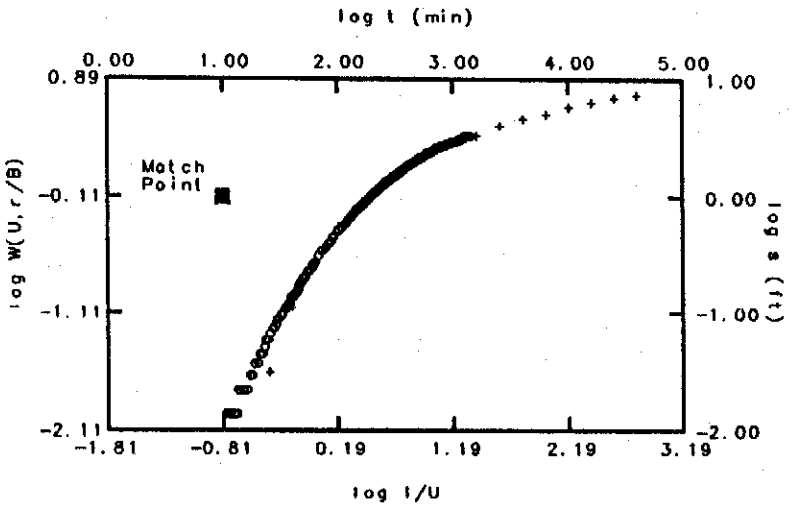
4425 Test – Drawdown Well 3353



MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 1.291E+0005 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 1.291E+0005 gpd/sq ft
1/U	= 3.311E-0001	Storativity	= 1.517E-0003
W(U,r/B)	= 9.550E-0002		

WELL INFORMATION	
WELL IDENTIFICATION	: 3353
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 3.090E+0002 ft

4425 Test – Drawdown Well 3403

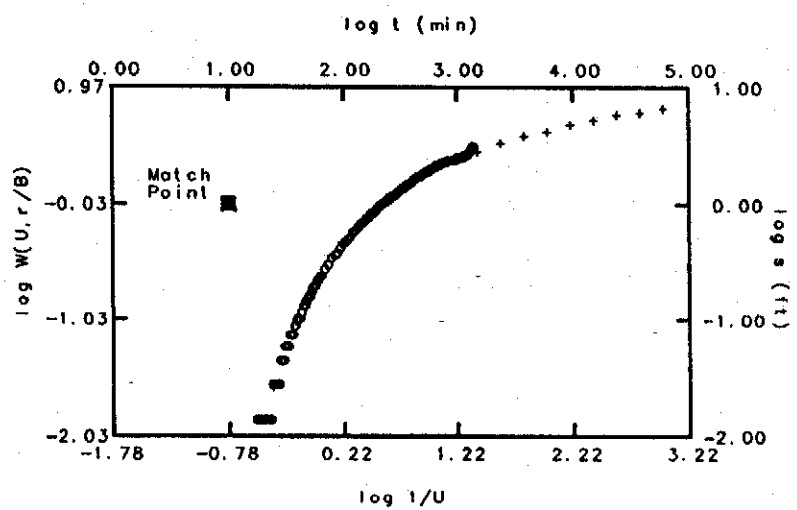


o – Data
\+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.049E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.049E+0005 gpd/sq ft
1/U	=	1.549E-0001	Storativity	=	2.244E-0003
W(U,r/B)	=	7.762E-0002			

WELL INFORMATION		
WELL IDENTIFICATION	:	3403
DATE OF AQUIFER TEST	:	11/07/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.180E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.059E+0003 ft

4425 Test – Drawdown Well 3407

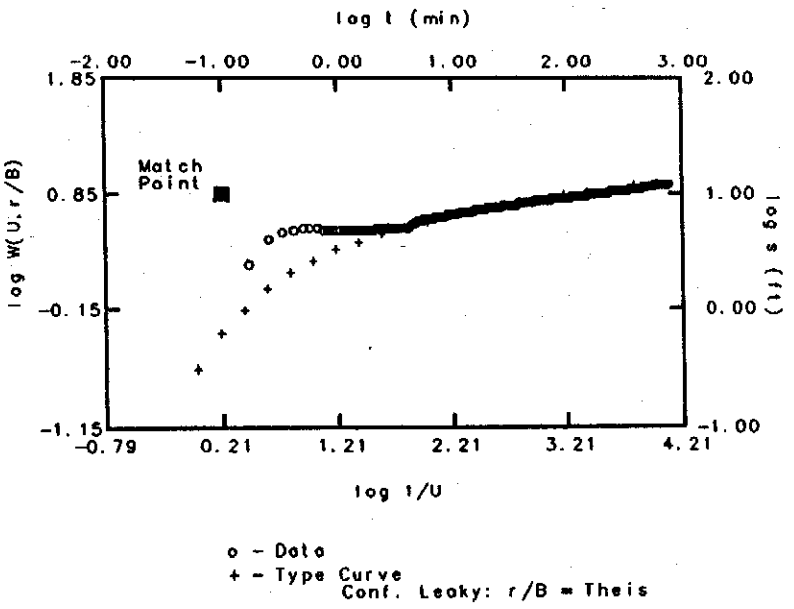


o – Data
\+ – Type Curve
Conf. Leaky: r/B = Theis

MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.262E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.262E+0005 gpd/sq ft
1/U	=	1.660E-0001	Storativity	=	1.222E-0003
W(U,r/B)	=	9.333E-0002			

WELL INFORMATION		
WELL IDENTIFICATION	:	3407
DATE OF AQUIFER TEST	:	11/07/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.180E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.520E+0003 ft

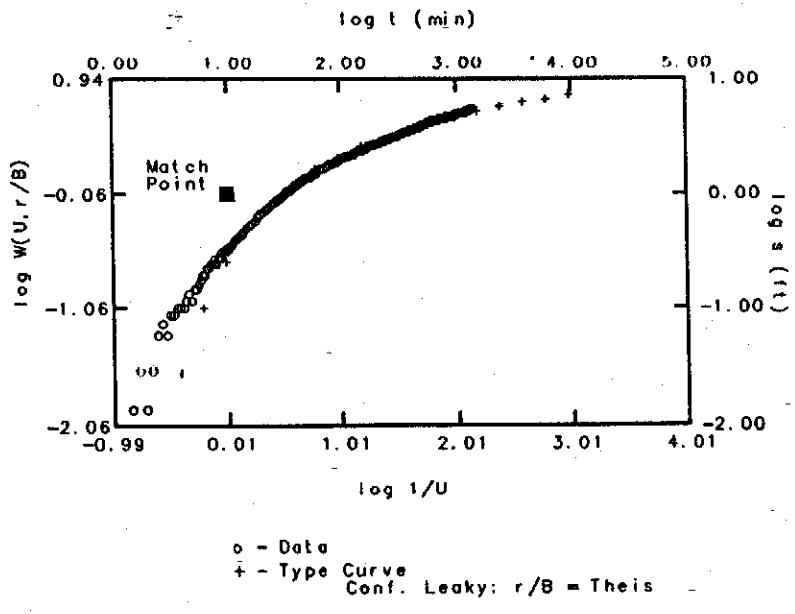
4425 Test – Drawdown Well 3517



MATCH POINT		SOLUTION	
t	= 1.000E-0001	Transmissivity	= 9.571E+0004 gpd/ft
s	= 1.000E+0001	Hydraulic. Cond.	= 9.571E+0004 gpd/sq ft
1/U	= 1.622E+0000	Storativity	= 9.741E-0003
W(U,r/B)	= 7.079E-0001		

WELL INFORMATION	
WELL IDENTIFICATION	: 3517
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.500E+0001 ft

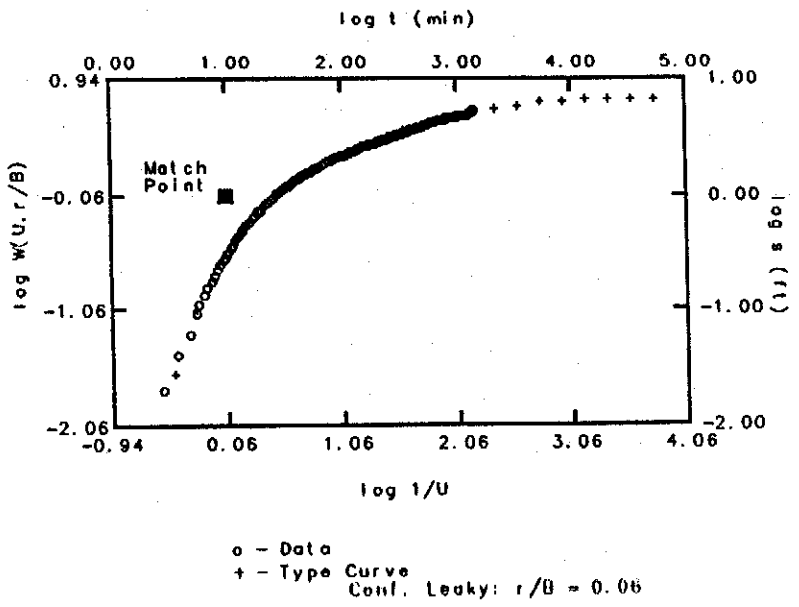
4425 Test – Drawdown Well 3518



MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 1.177E+0005 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 1.177E+0005 gpd/sq ft
1/U	= 1.023E+0000	Storativity	= 1.320E-0003
W(U,r/B)	= 8.710E-0002		

WELL INFORMATION	
WELL IDENTIFICATION	: 3518
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.690E+0002 ft

4425 Test – Drawdown Well 4070

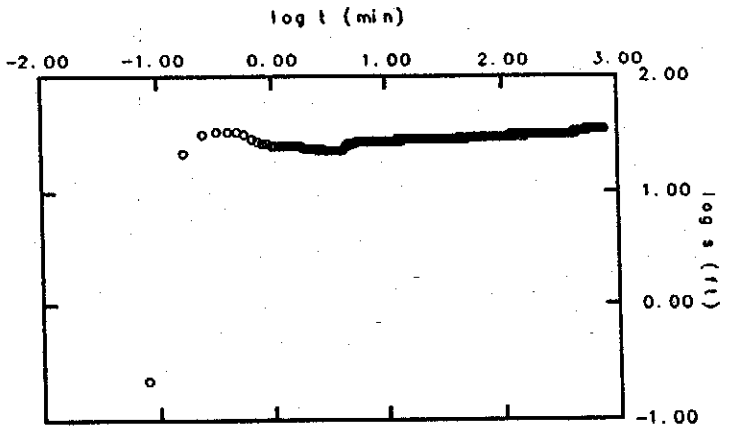


o – Data
\+ – Type Curve
Conf. Leaky: r/B = 0.06

MATCH POINT		SOLUTION	
t	= 1.000E+0001	Transmissivity	= 1.177E+0005 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 1.177E+0005 gpd/sq ft
1/U	= 1.148E+0000	Storativity	= 1.832E-0003
W(U,r/B)	= 8.710E-0002	Leakage Factor	= 7.600E+0003 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 4070
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 4.560E+0002 ft

4425 Test – Drawdown Well 4425

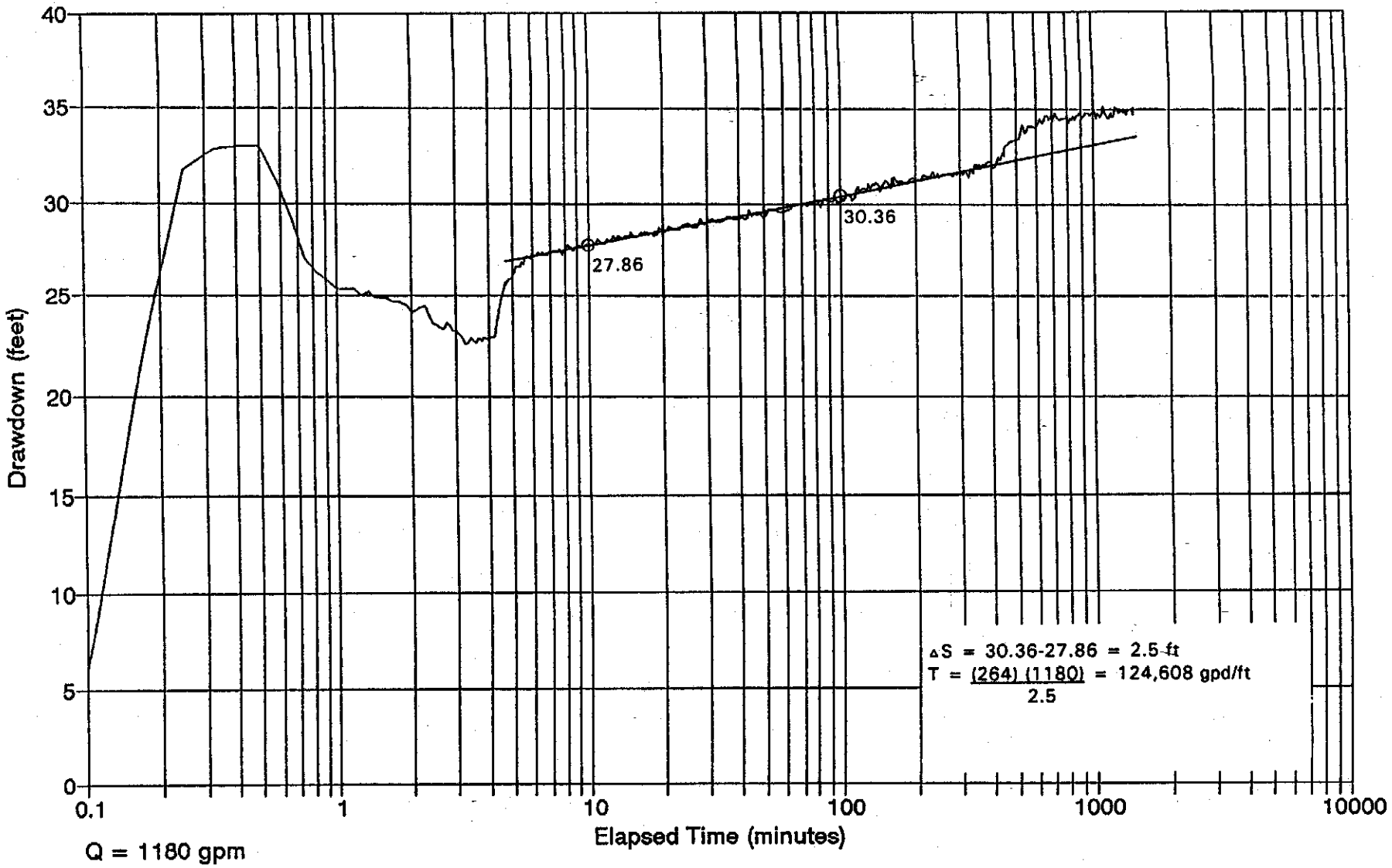


o – Data

WELL INFORMATION	
WELL IDENTIFICATION	: 4425
DATE OF AQUIFER TEST	: 11/07/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.180E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.080E+0000 ft

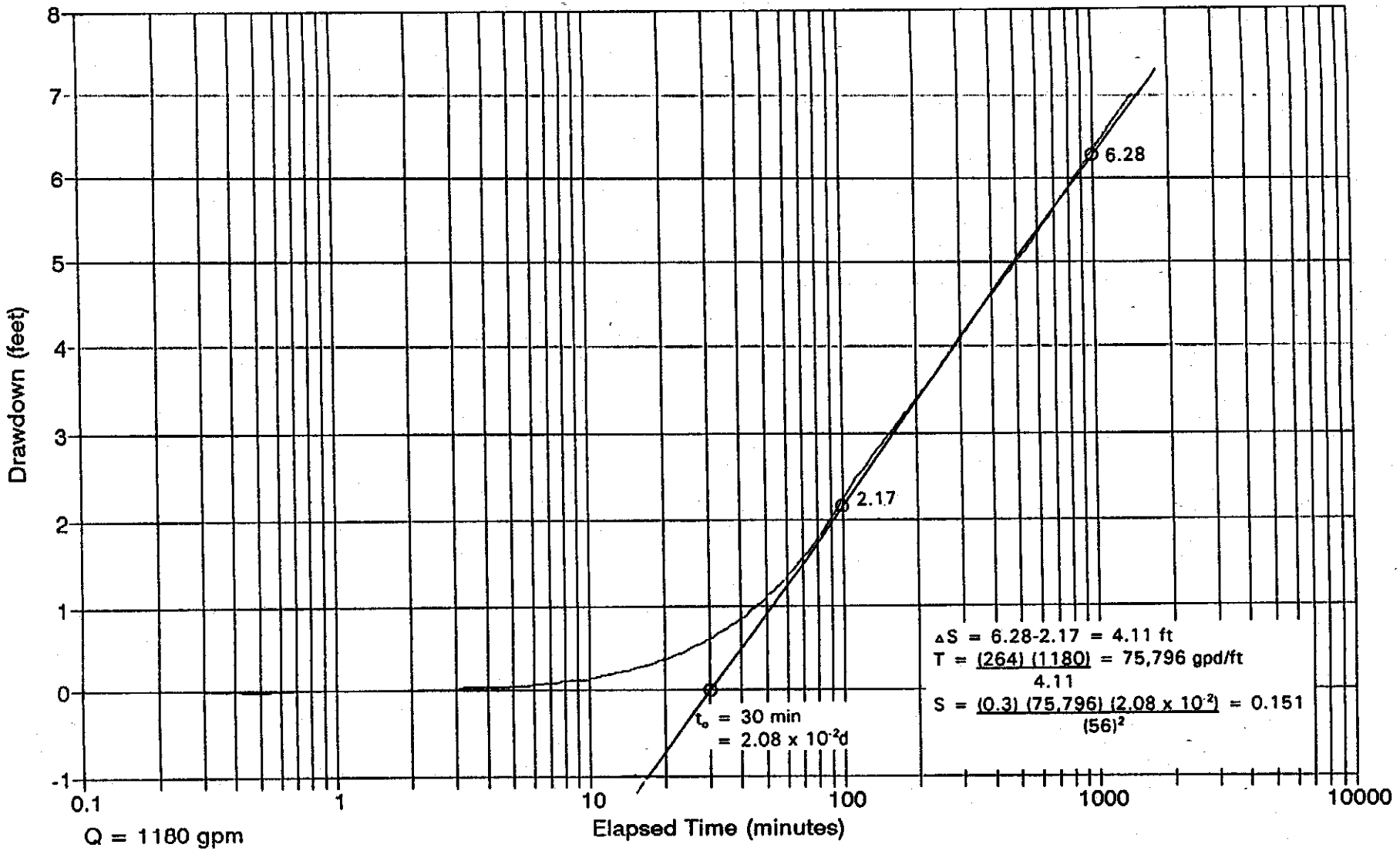
4425 Aquifer Test

Drawdown for Pumping Well 4425



4425 Aquifer Test

Drawdown for Well 124

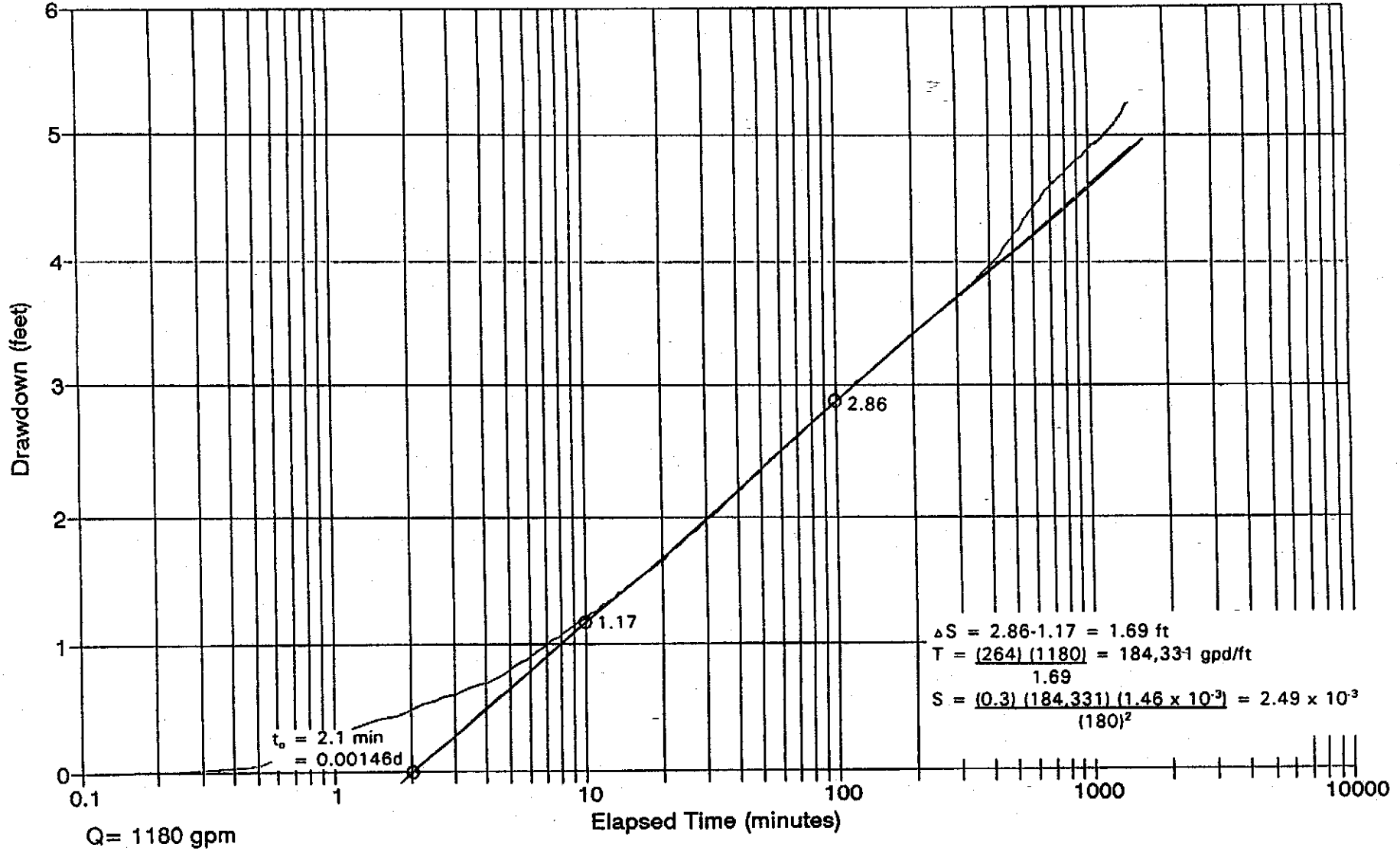


Q = 1180 gpm

Distance from Pumping well = 56 feet

4425 Aquifer Test

Drawdown for Well 165

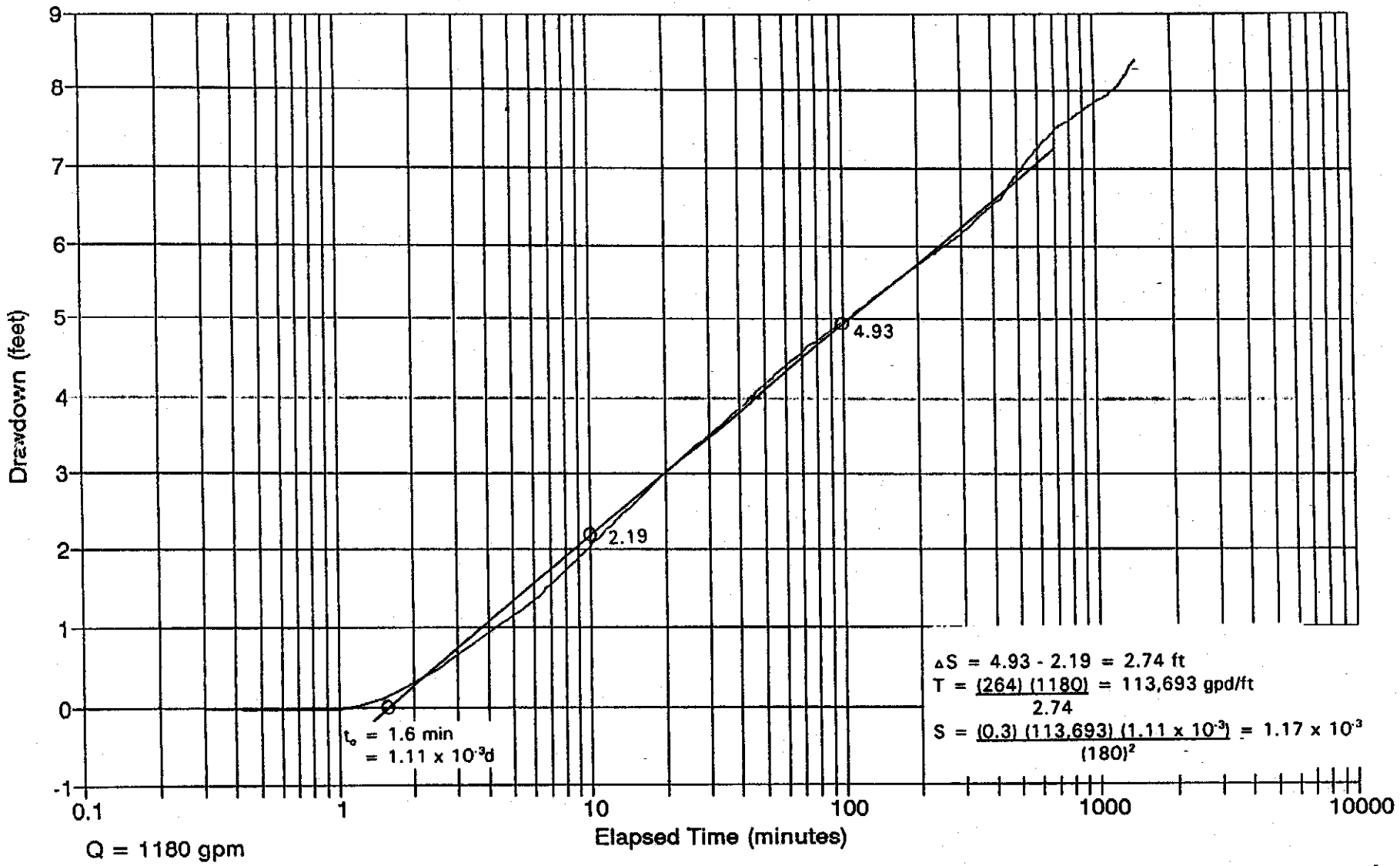


Q= 1180 gpm

Distance from Pumping well = 180 feet

4425 Aquifer Test

Drawdown for Well 166

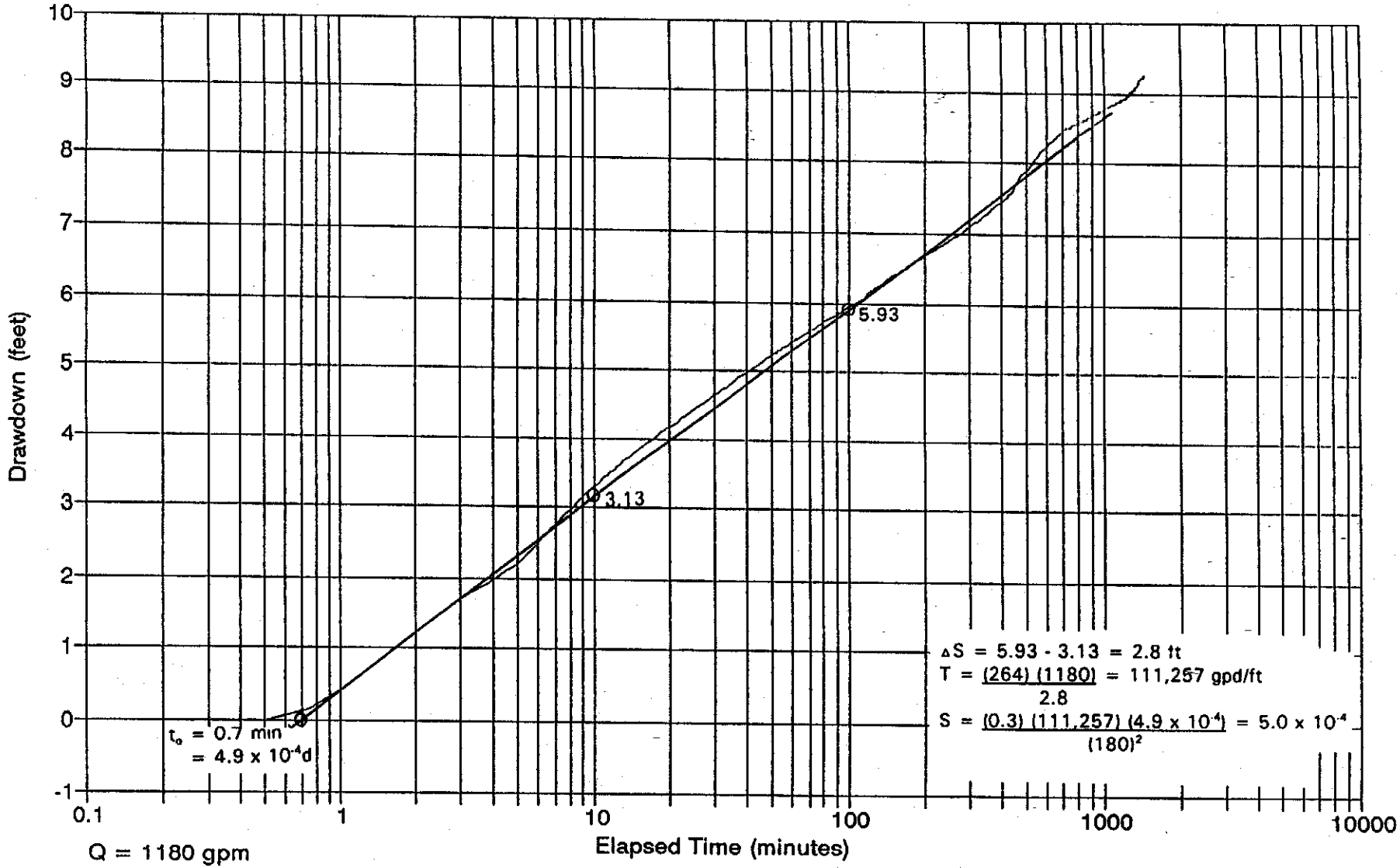


Q = 1180 gpm

Distance from Pumping well = 180 feet

4425 Aquifer Test

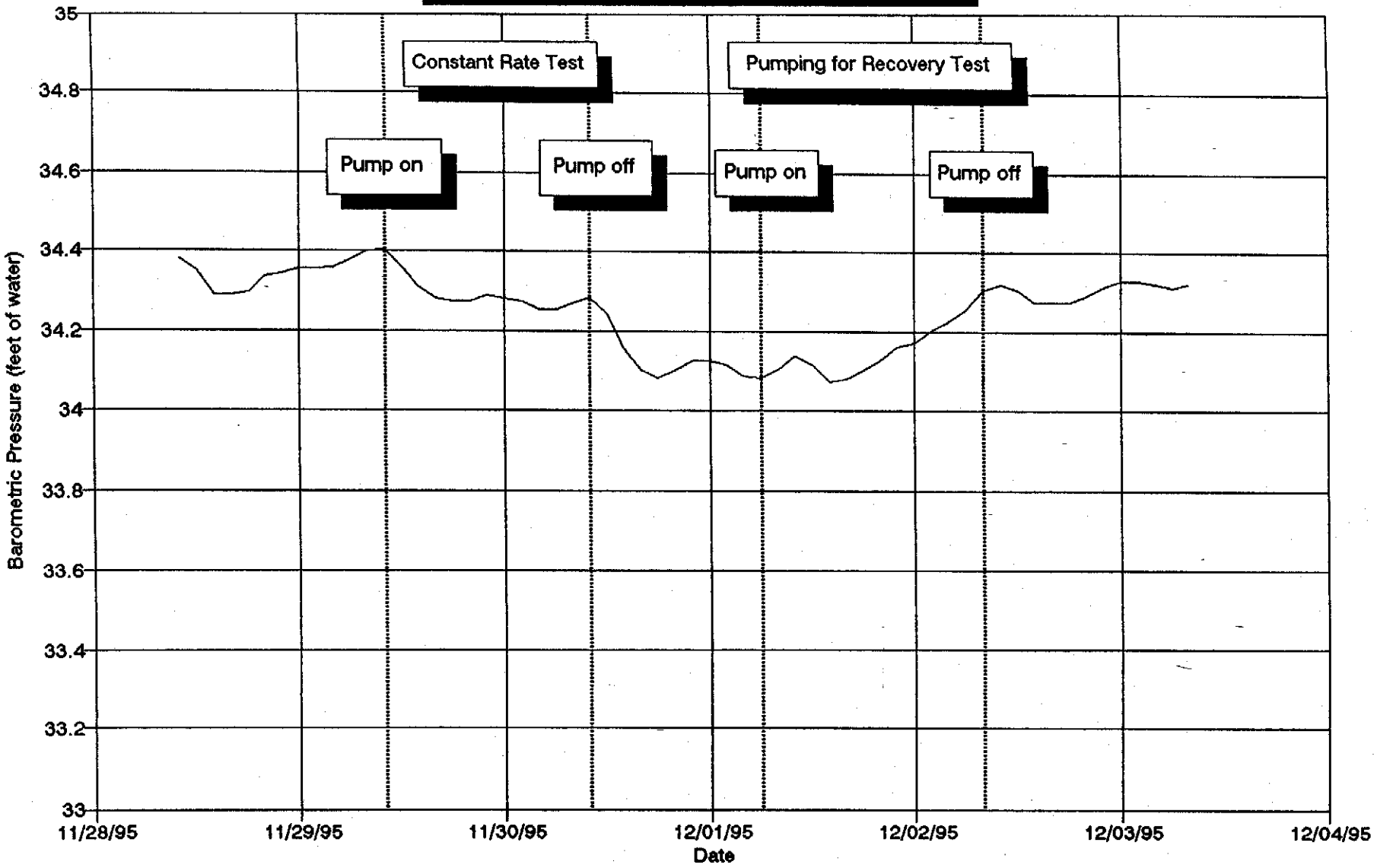
Drawdown for Well 167



Q = 1180 gpm

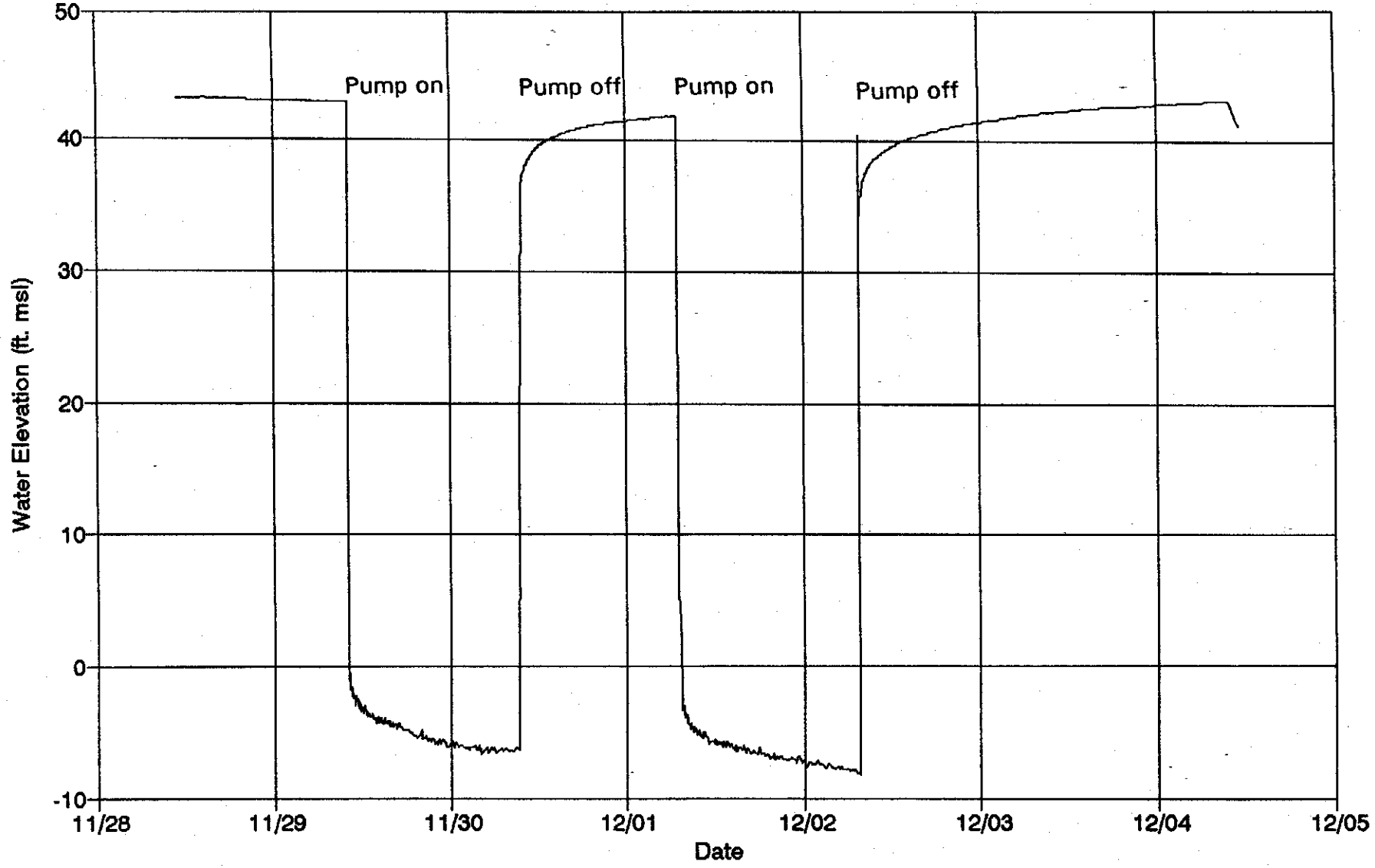
Distance from Pumping well = 180 feet

4435 Aquifer Test
Barometric Pressure Data



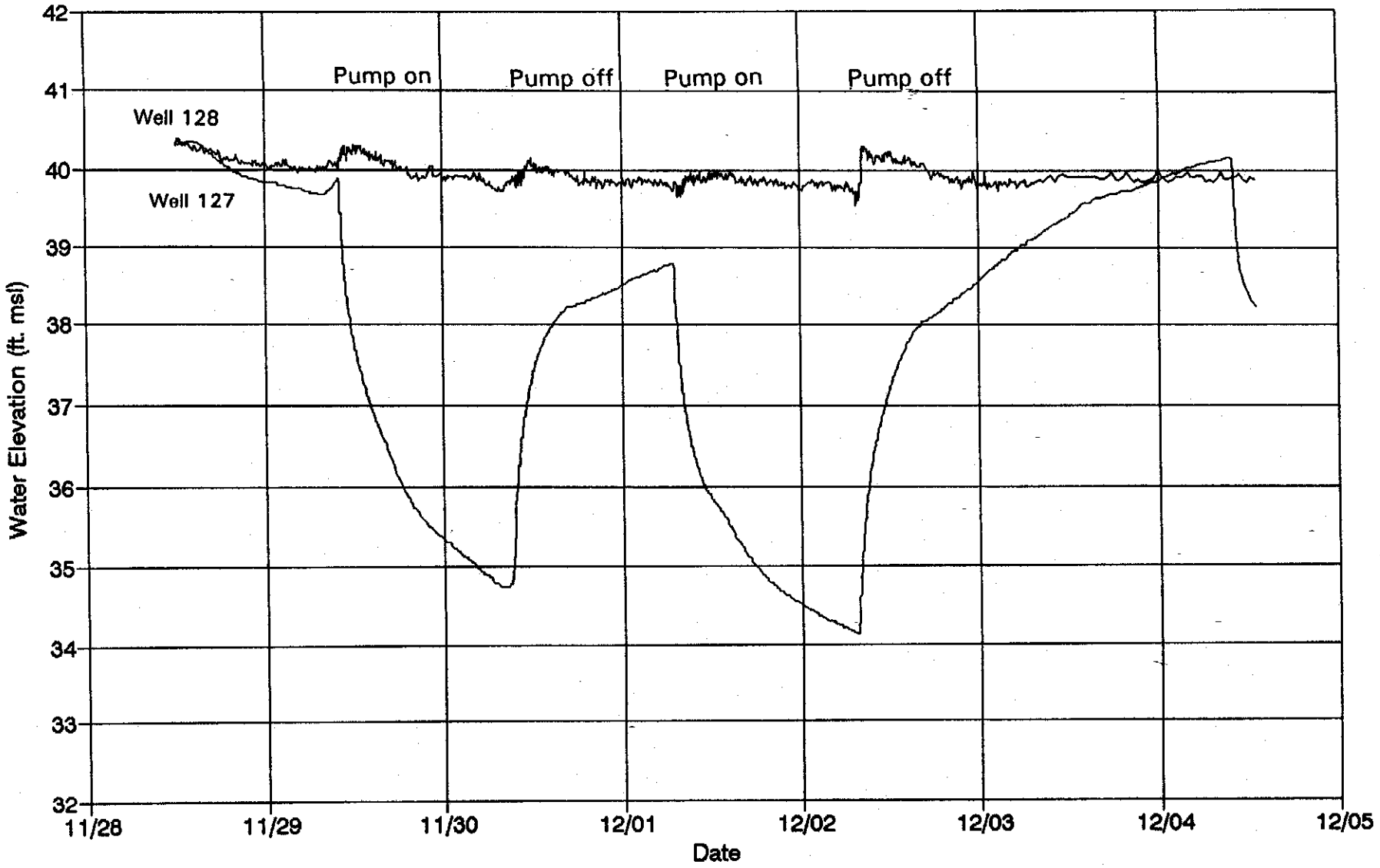
4435 Aquifer Test

Hydrograph for Pumping Well 4435



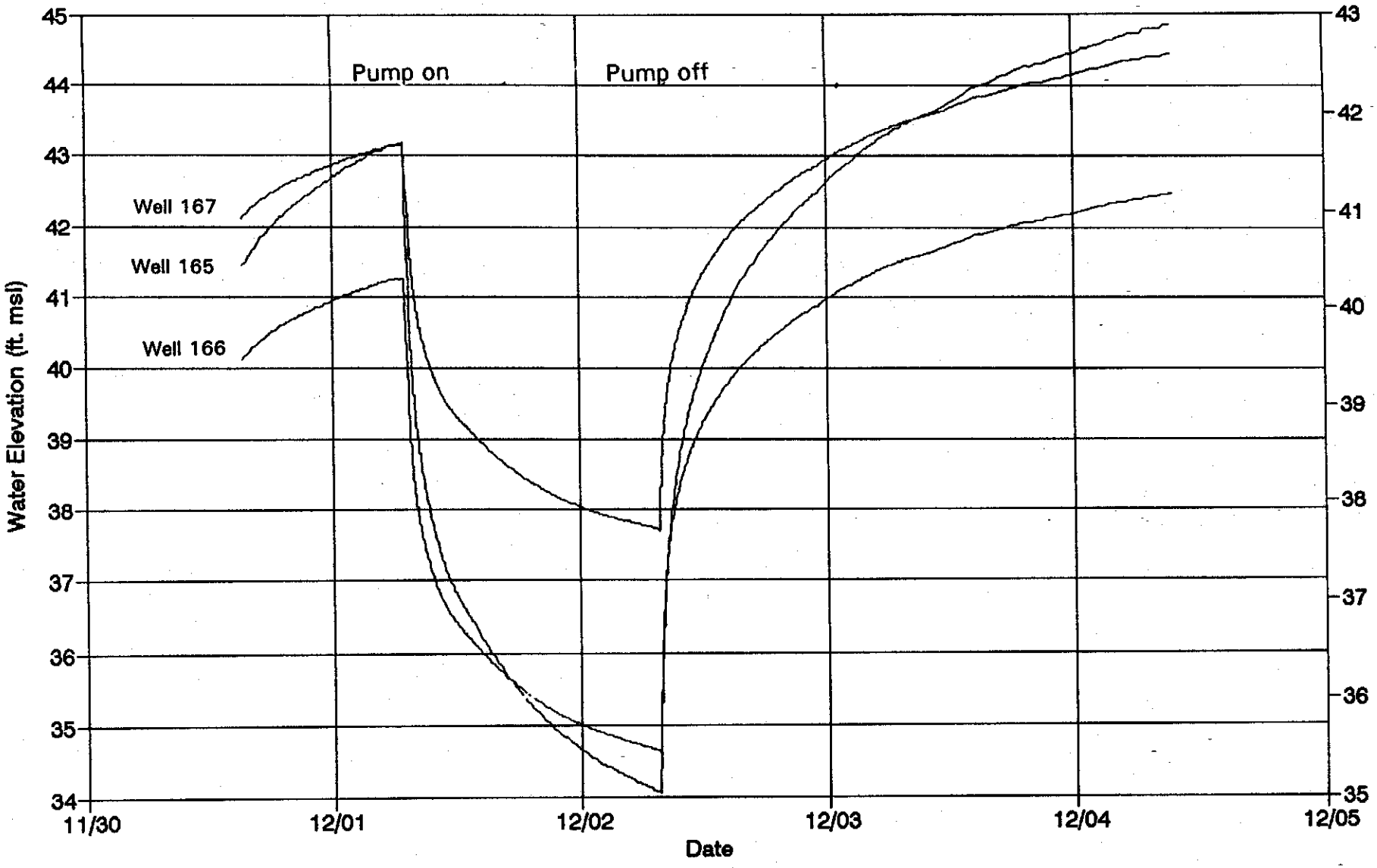
4435 Aquifer Test

Hydrograph for Wells 127 - 128



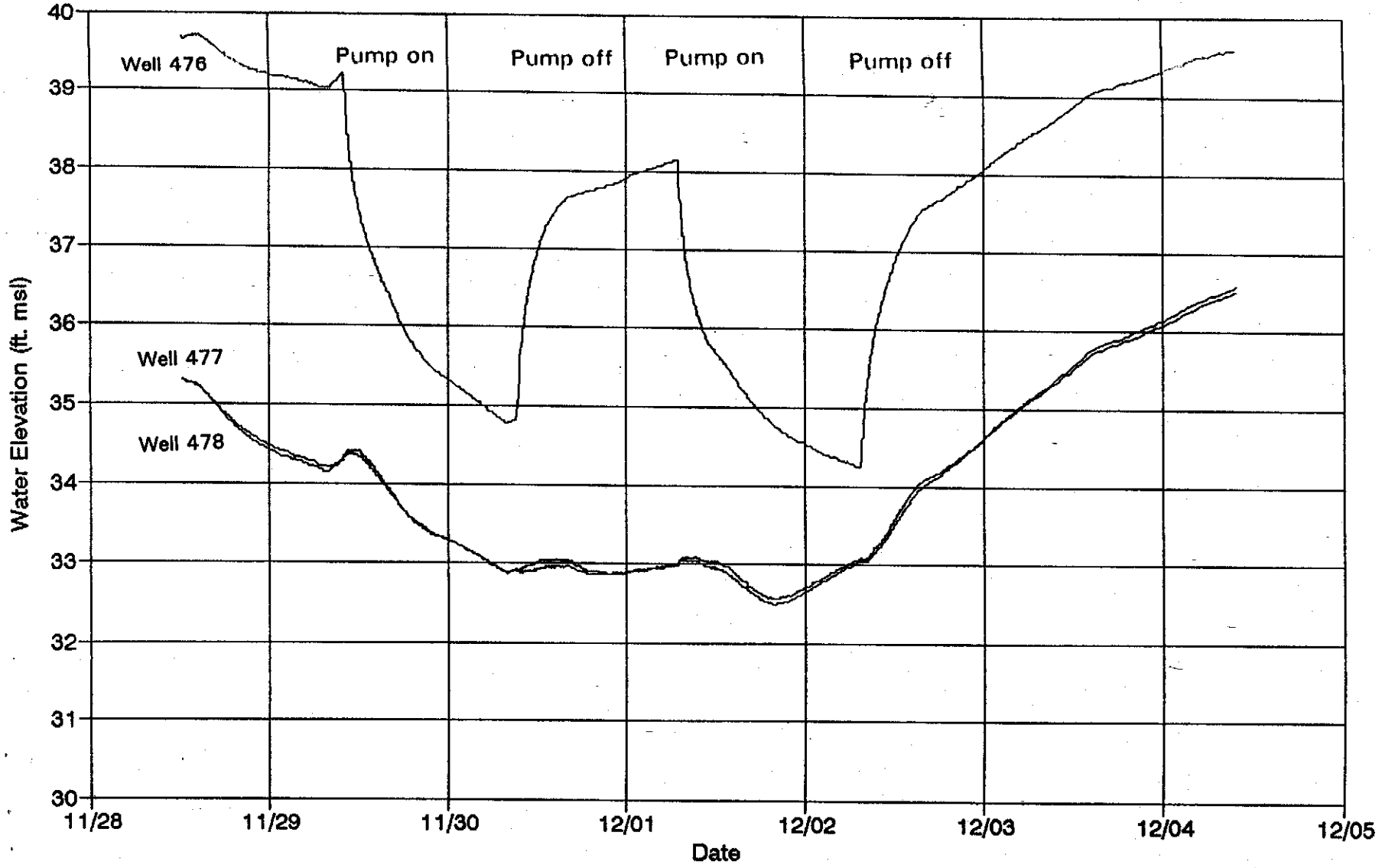
4435 Aquifer Test

Hydrograph for Wells 165 - 167



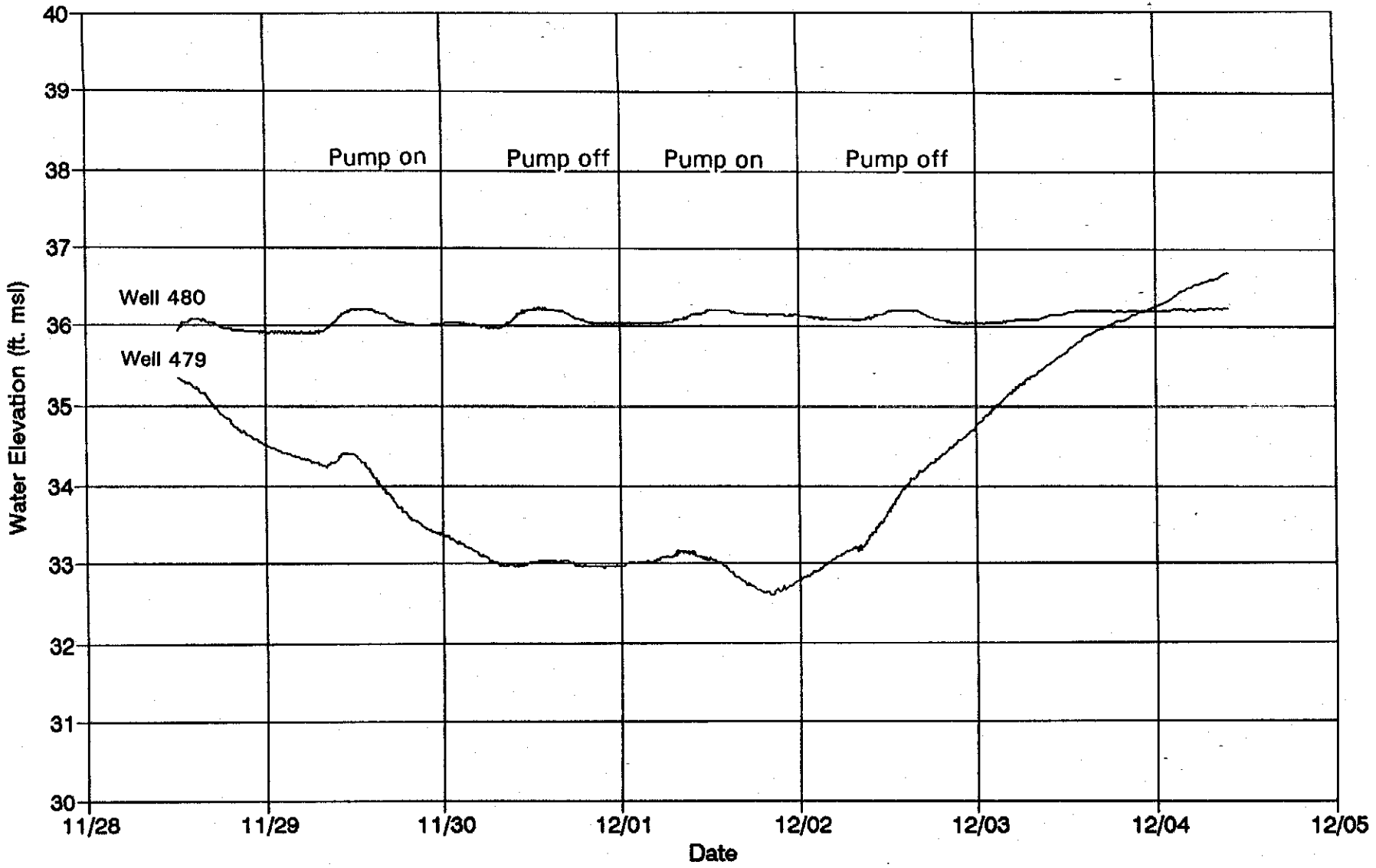
4435 Aquifer Test

Hydrograph for Wells 476 - 478



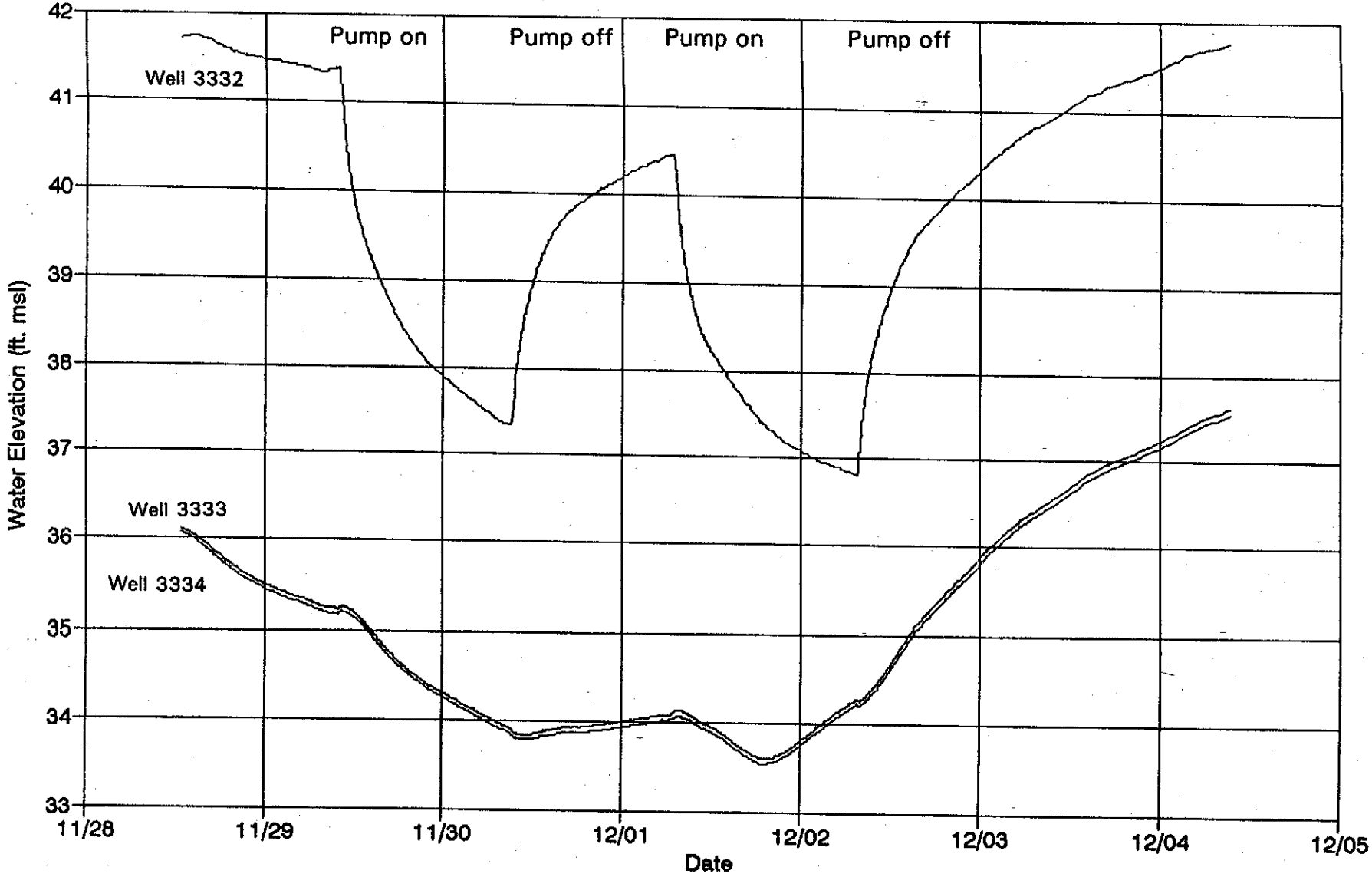
4435 Aquifer Test

Hydrograph for Wells 479 - 480



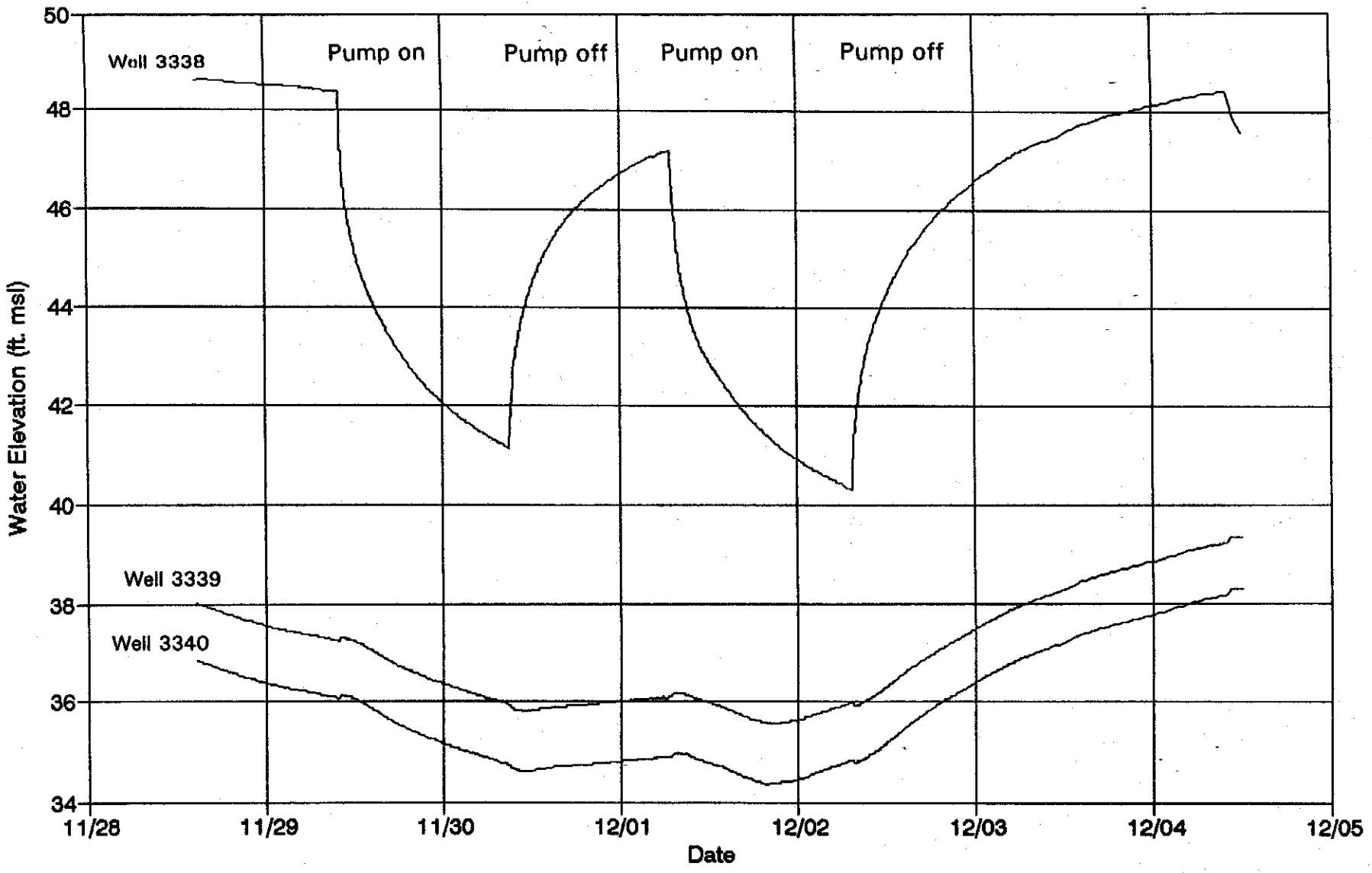
4435 Aquifer Test

Hydrograph for Wells 3332 - 3334



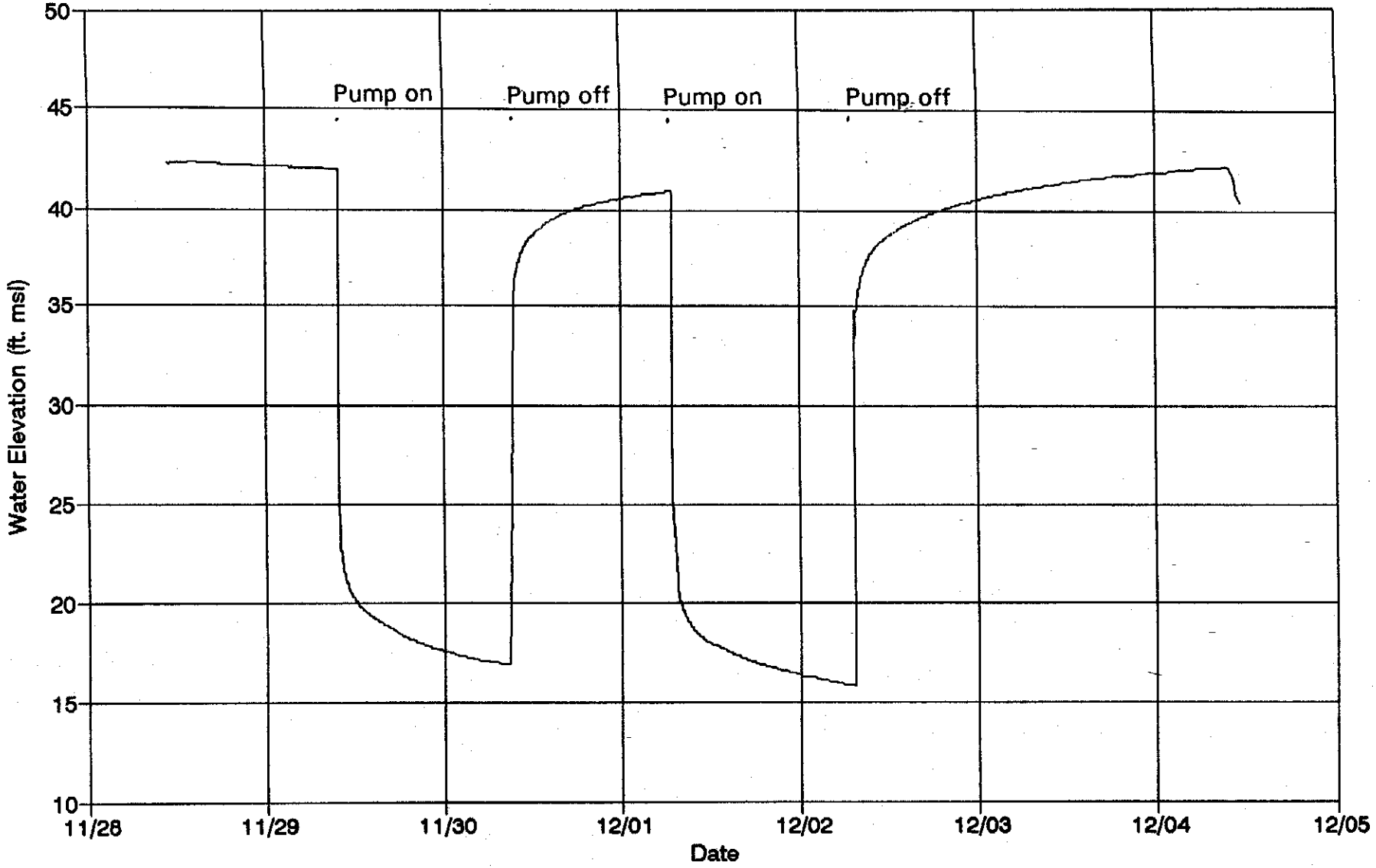
4435 Aquifer Test

Hydrographs for Wells 3338 - 3340



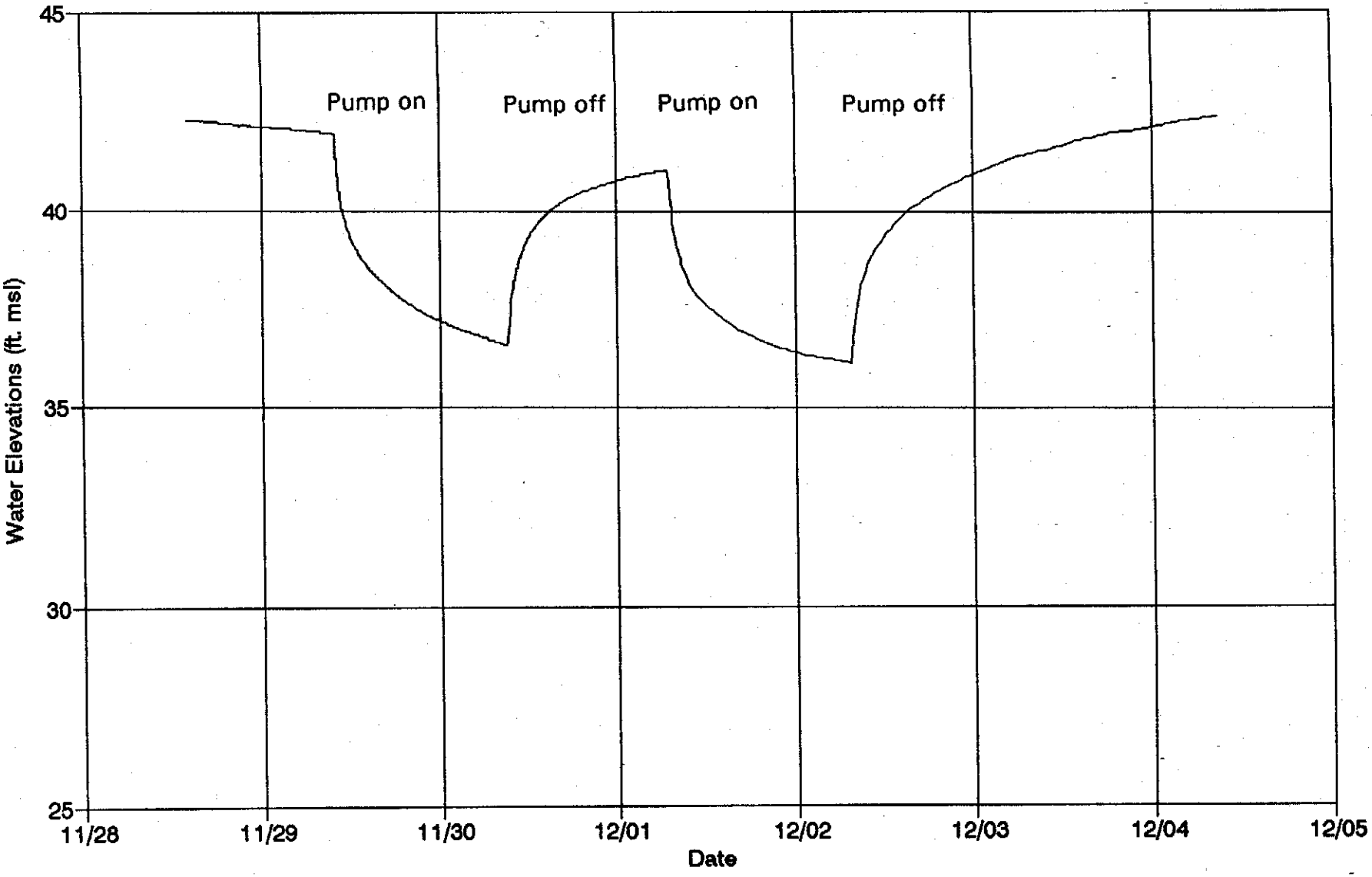
4435 Aquifer Test

Hydrograph for Well 3518



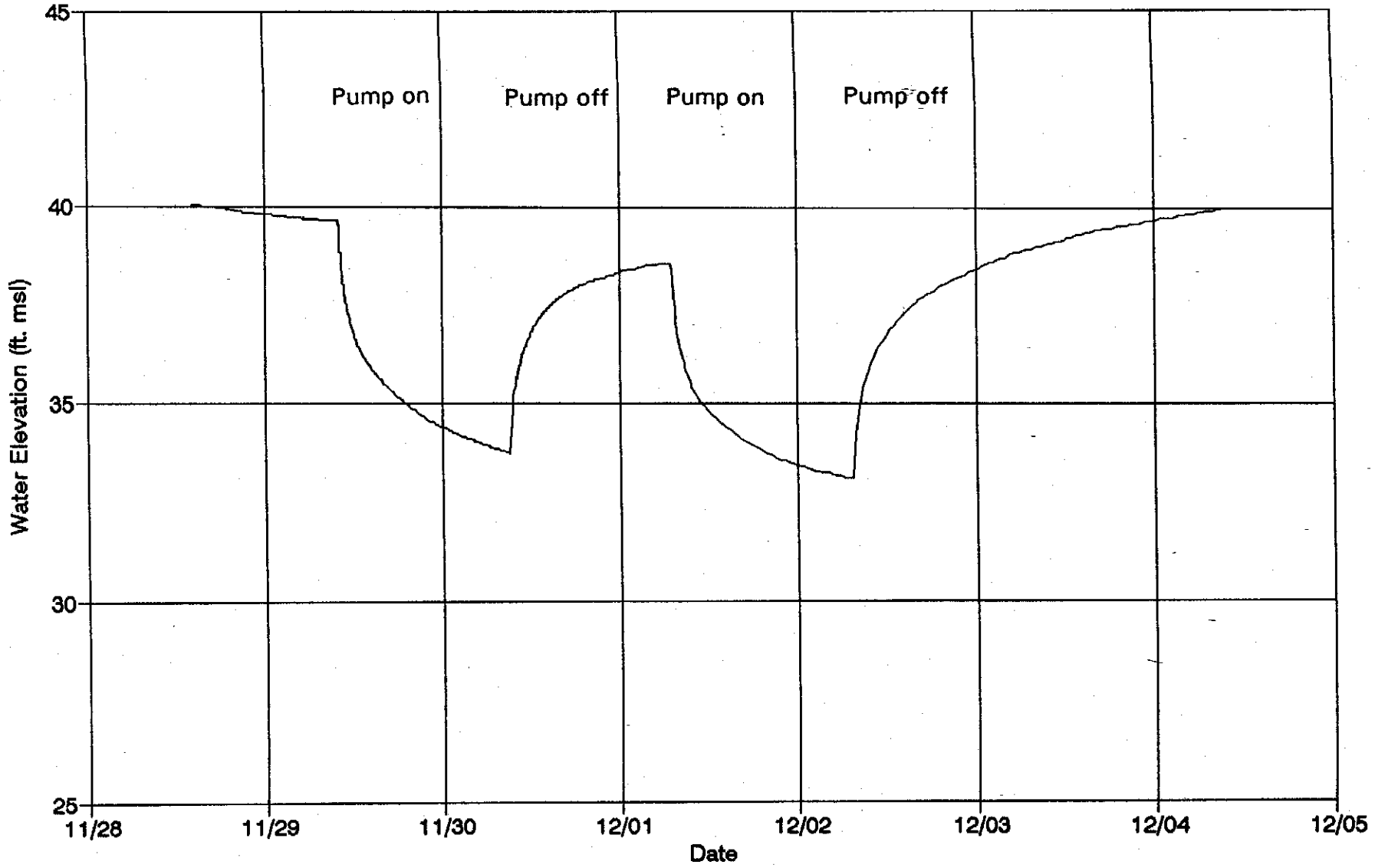
4435 Aquifer Test

Hydrograph for Well 4070



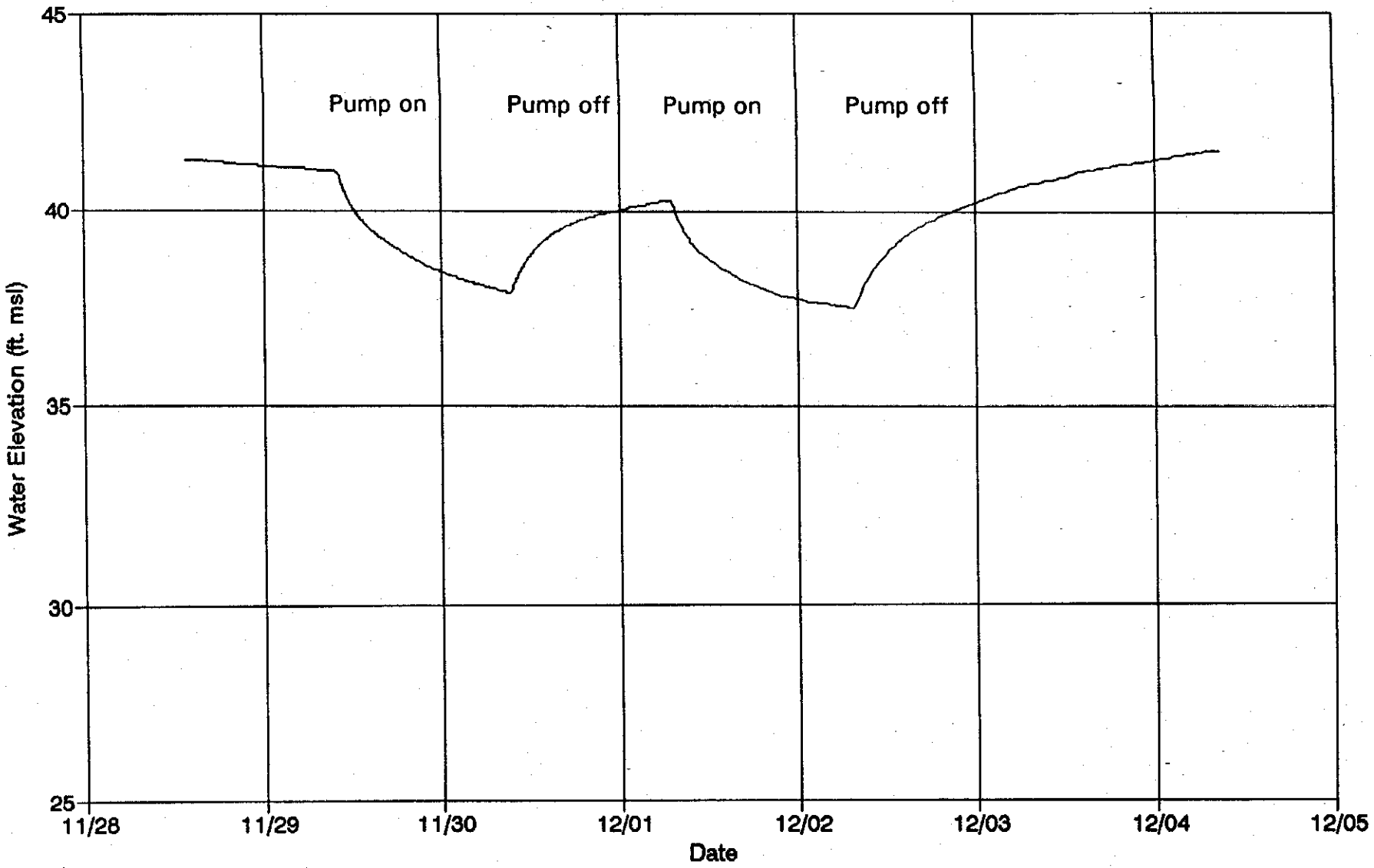
4435 Aquifer Test

Hydrograph for Well 4075



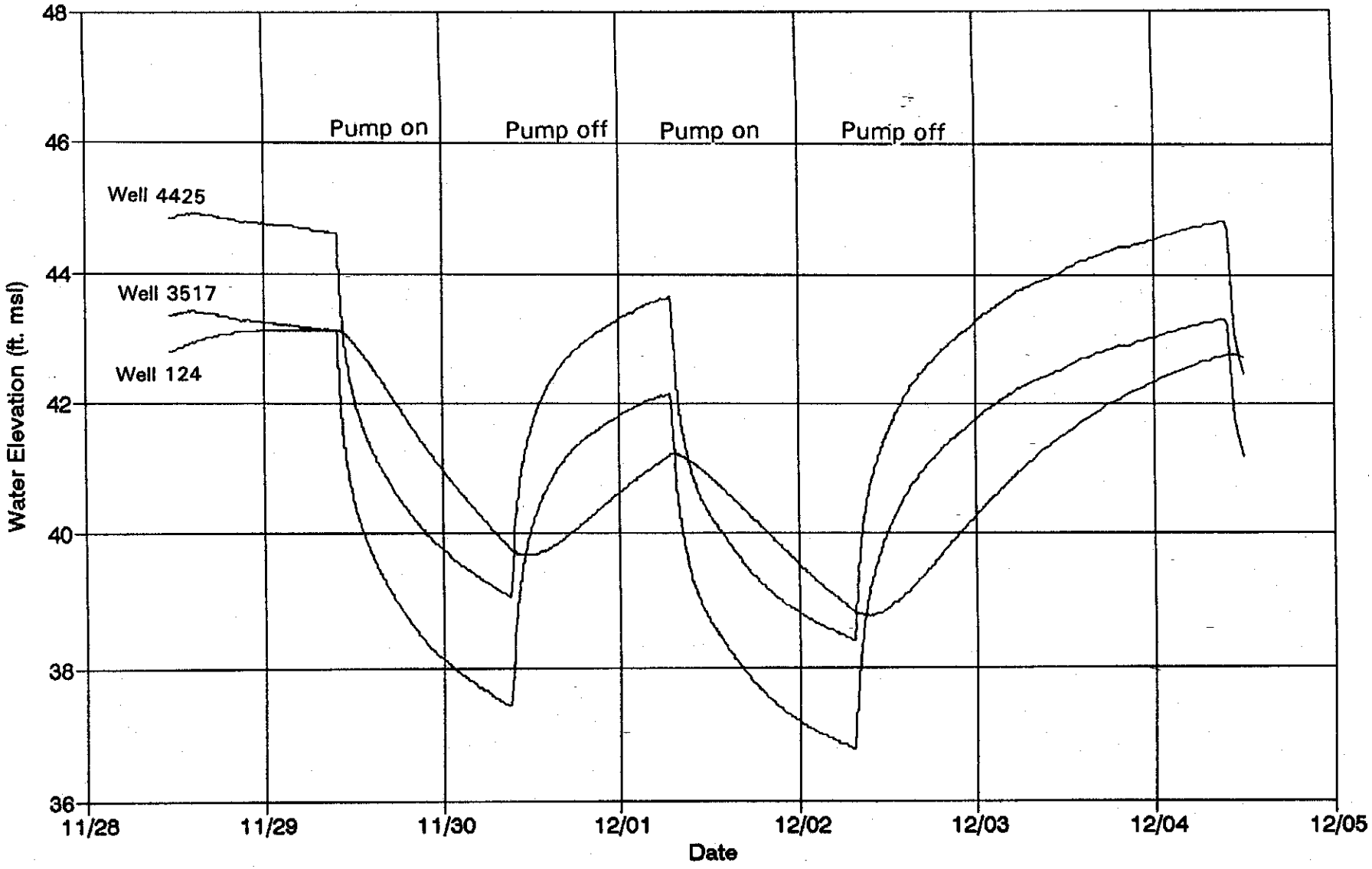
4435 Aquifer Test

Hydrograph for Well 4200

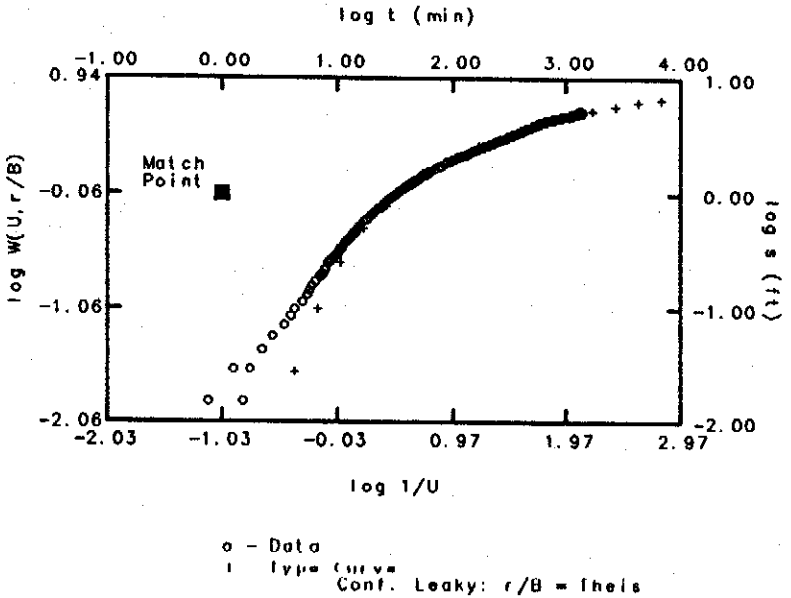


4435 Aquifer Test

Hydrograph for Wells 4425, 3517 & 124



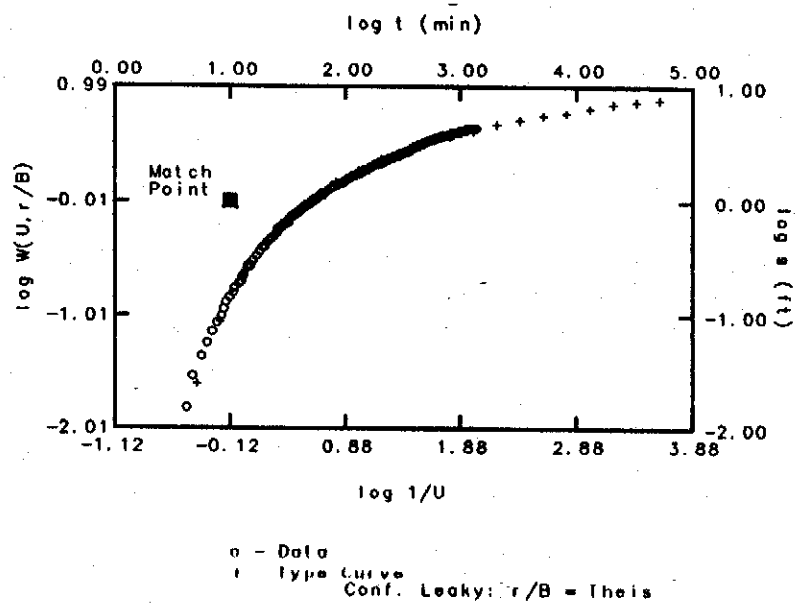
4435 Test – Drawdown Well 127



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.241E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.241E+0005 gpd/sq ft
1/U	=	9.333E-0002	Storativity	=	1.359E-0003
W(U,r/B)	=	8.710E-0002			

WELL INFORMATION	
WELL IDENTIFICATION	: 127
DATE OF AQUIFER TEST	: 11/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.244E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.030E+0002 ft

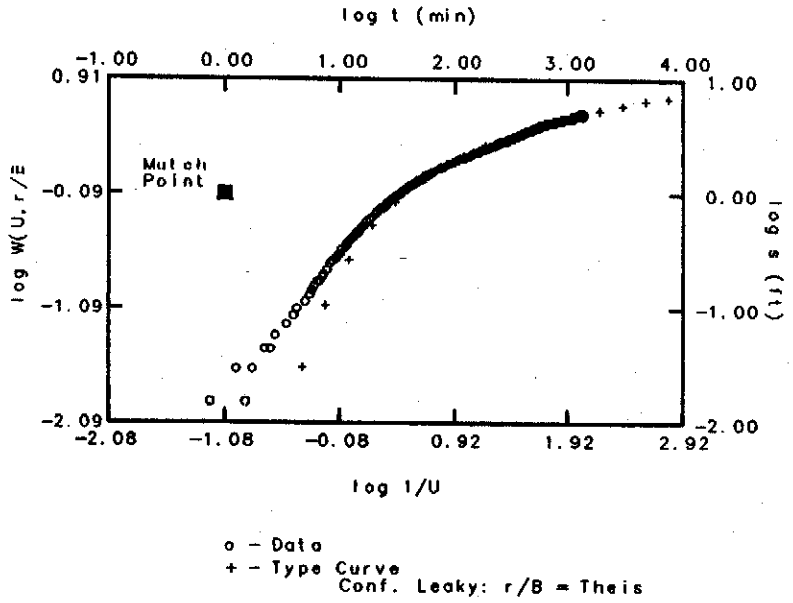
4435 Test – Drawdown Well 476



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.393E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.393E+0005 gpd/sq ft
1/U	=	7.586E-0001	Storativity	=	1.524E-0003
W(U,r/B)	=	9.772E-0002			

WELL INFORMATION	
WELL IDENTIFICATION	: 476
DATE OF AQUIFER TEST	: 11/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.244E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 6.690E+0002 ft

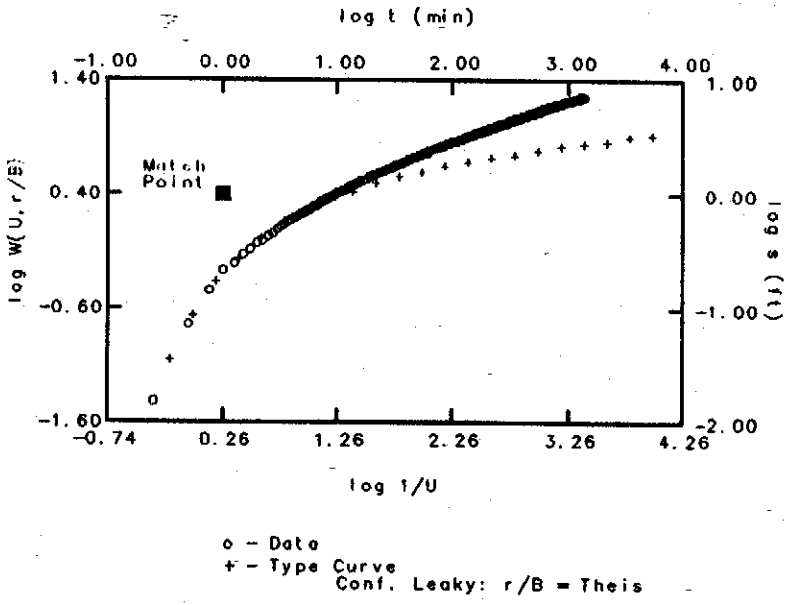
4435 Test – Drawdown Well 3332



MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 1.158E+0005 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 1.158E+0005 gpd/sq ft
1/U	= 8.318E-0002	Storativity	= 9.979E-0004
W(U,r/B)	= 8.128E-0002		

WELL INFORMATION	
WELL IDENTIFICATION	: 3332
DATE OF AQUIFER TEST	: 11/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.244E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 7.200E+0002 ft

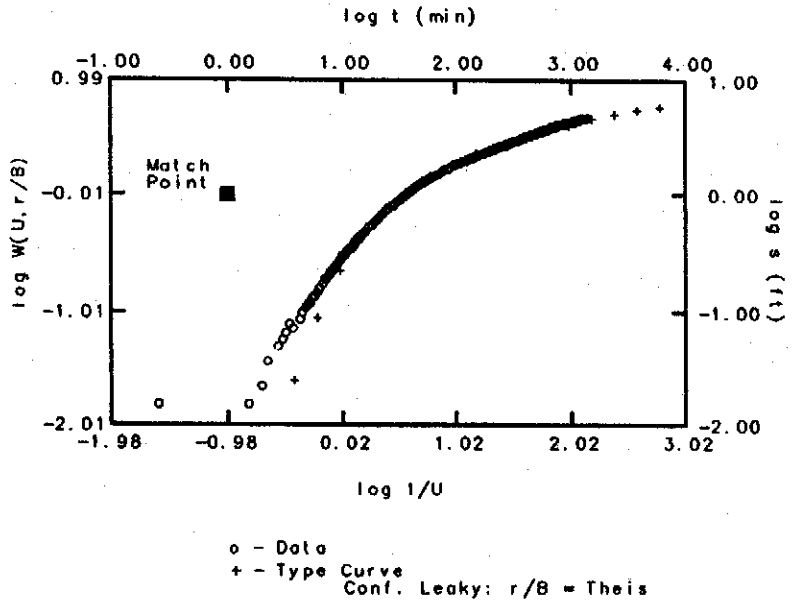
4435 Test – Drawdown Well 3338



MATCH POINT		SOLUTION	
t	= 1.000E+0000	Transmissivity	= 3.580E+0005 gpd/ft
s	= 1.000E+0000	Hydraulic. Cond.	= 3.580E+0005 gpd/sq ft
1/U	= 1.820E+0000	Storativity	= 1.845E-0003
W(U,r/B)	= 2.512E-0001		

WELL INFORMATION	
WELL IDENTIFICATION	: 3338
DATE OF AQUIFER TEST	: 11/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.244E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.990E+0002 ft

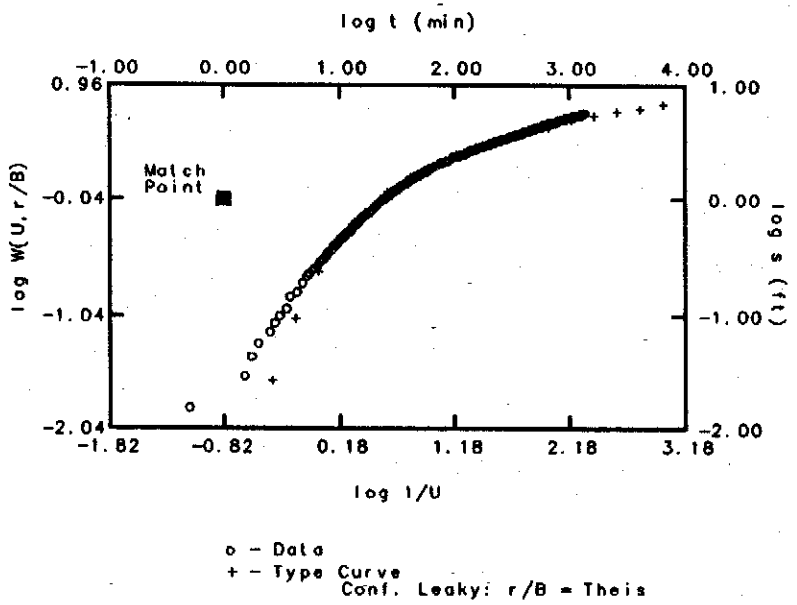
4435 Test – Drawdown Well 3353



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.393E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.393E+0005 gpd/sq ft
1/U	=	1.047E-0001	Storativity	=	9.690E-0004
W(U,r/B)	=	9.772E-0002			

WELL INFORMATION		
WELL IDENTIFICATION	:	3353
DATE OF AQUIFER TEST	:	11/29/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.244E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	7.140E+0002 ft

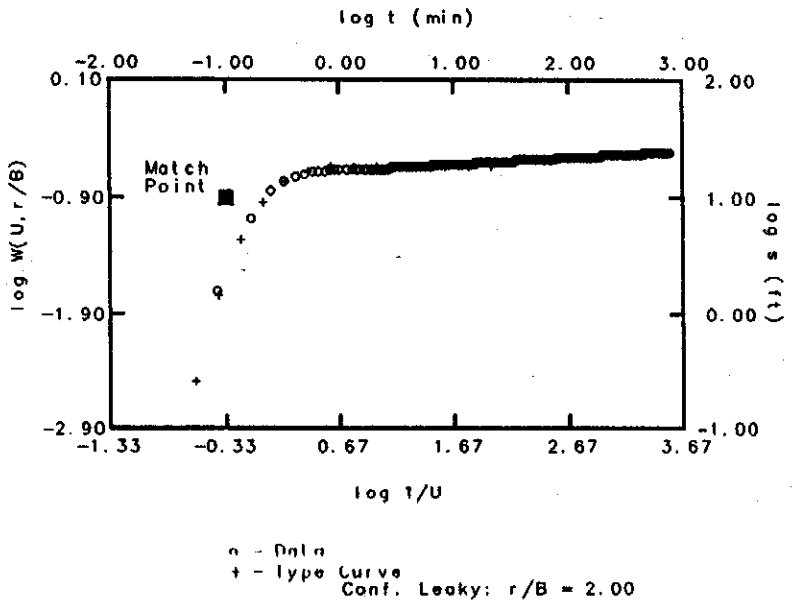
4435 Test – Drawdown Well 3517



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.300E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.300E+0005 gpd/sq ft
1/U	=	1.514E-0001	Storativity	=	1.036E-0003
W(U,r/B)	=	9.120E-0002			

WELL INFORMATION		
WELL IDENTIFICATION	:	3517
DATE OF AQUIFER TEST	:	11/29/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.244E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	5.550E+0002 ft

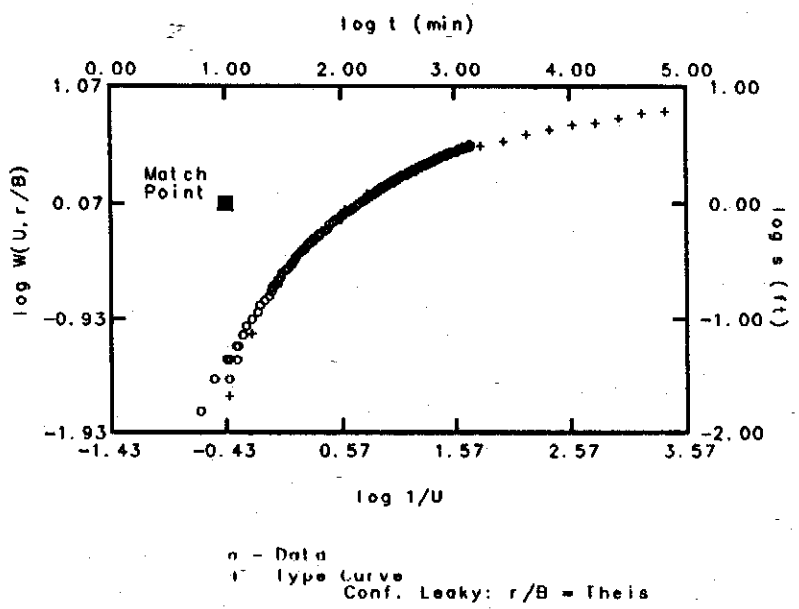
4435 Test – Drawdown Well 3518



MATCH POINT			SOLUTION		
t	=	1.000E-0001	Transmissivity	=	1.794E+0003 gpd/ft
s	=	1.000E+0001	Hydraulic. Cond.	=	1.794E+0003 gpd/sq ft
1/U	=	4.677E-0001	Storativity	=	1.483E-0003
W(U,r/B)	=	1.259E-0002	Leakage Factor	=	4.900E+0000 ft

WELL INFORMATION	
WELL IDENTIFICATION	: 3518
DATE OF AQUIFER TEST	: 11/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.244E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 9.800E+0000 ft

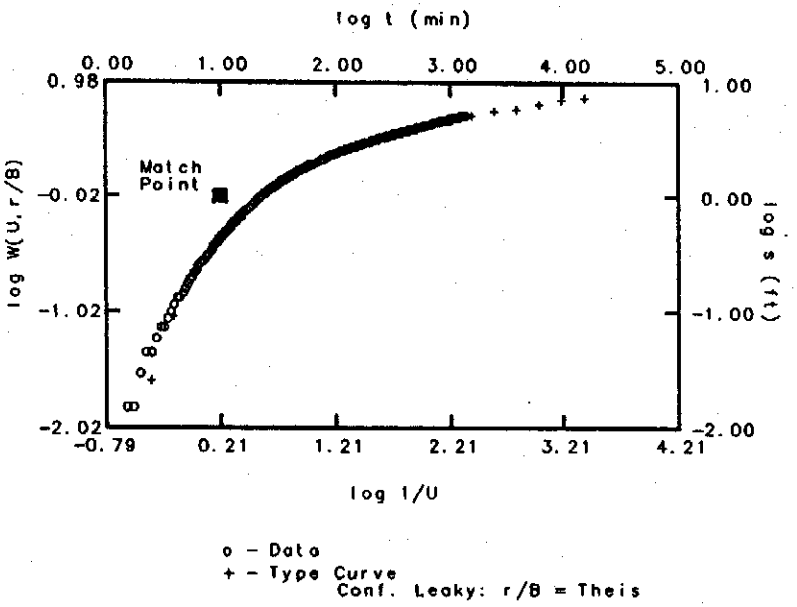
4435 Test – Drawdown Well 4200



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.675E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.675E+0005 gpd/sq ft
1/U	=	3.715E-0001	Storativity	=	1.654E-0003
W(U,r/B)	=	1.175E-0001			

WELL INFORMATION	
WELL IDENTIFICATION	: 4200
DATE OF AQUIFER TEST	: 11/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.244E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 1.006E+0003 ft

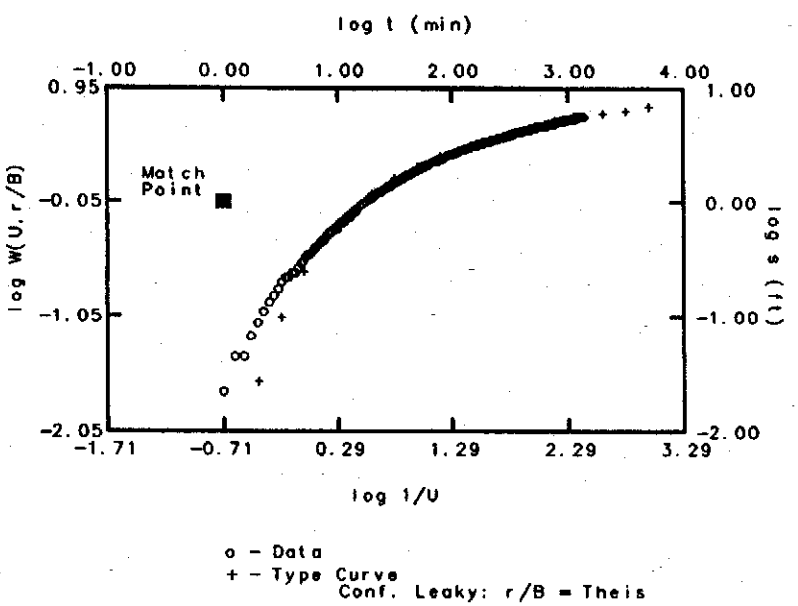
4435 Test – Drawdown Well 4070



MATCH POINT			SOLUTION		
t	=	1.000E+0001	Transmissivity	=	1.361E+0005 gpd/ft
u	=	1.000E-0000	Hydraulic. Cond.	=	1.361E+0005 gpd/sq ft
1/U	=	1.622E+0000	Storativity	=	1.237E-0003
W(U,r/B)	=	9.550E-0002			

WELL INFORMATION	
WELL IDENTIFICATION	: 4070
DATE OF AQUIFER TEST	: 11/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.244E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.020E+0002 ft

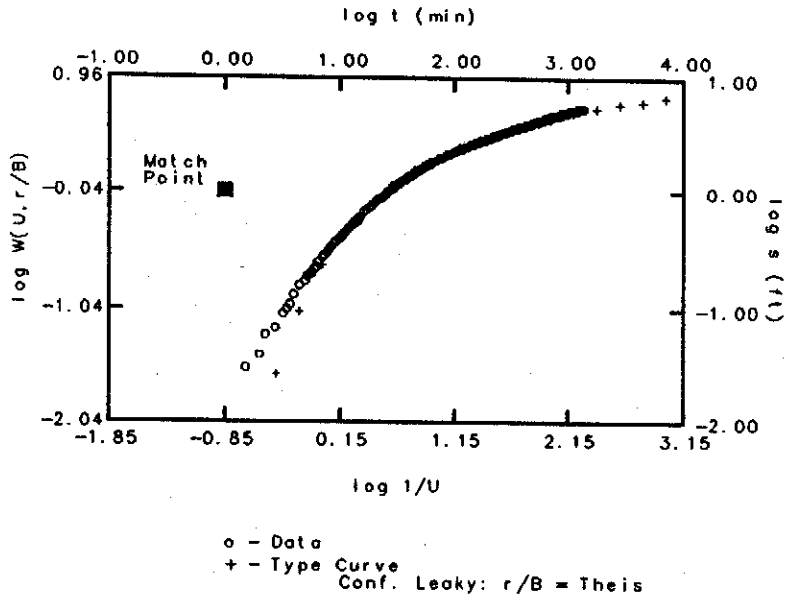
4435 Test – Drawdown Well 4075



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.270E+0005 gpd/ft
u	=	1.000E-0000	Hydraulic. Cond.	=	1.270E+0005 gpd/sq ft
1/U	=	1.950E-0001	Storativity	=	8.517E-0004
W(U,r/B)	=	8.913E-0002			

WELL INFORMATION	
WELL IDENTIFICATION	: 4075
DATE OF AQUIFER TEST	: 11/29/95
AQUIFER THICKNESS (b)	: 1.000E+0000 ft
DISCHARGE RATE (Q)	: 1.244E+0003 gpm
PUMPING WELL RADIUS (r)	: 1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	: 5.330E+0002 ft

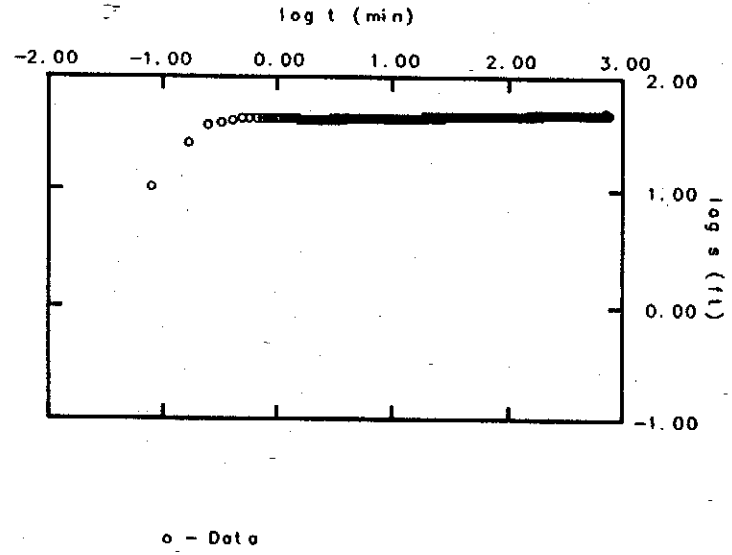
4435 Test – Drawdown Well 4425



MATCH POINT			SOLUTION		
t	=	1.000E+0000	Transmissivity	=	1.300E+0005 gpd/ft
s	=	1.000E+0000	Hydraulic. Cond.	=	1.300E+0005 gpd/sq ft
1/U	=	1.413E-0001	Storativity	=	1.090E-0003
W(U,r/B)	=	9.120E-0002			

WELL INFORMATION		
WELL IDENTIFICATION	:	4425
DATE OF AQUIFER TEST	:	11/29/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.244E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	5.600E+0002 ft

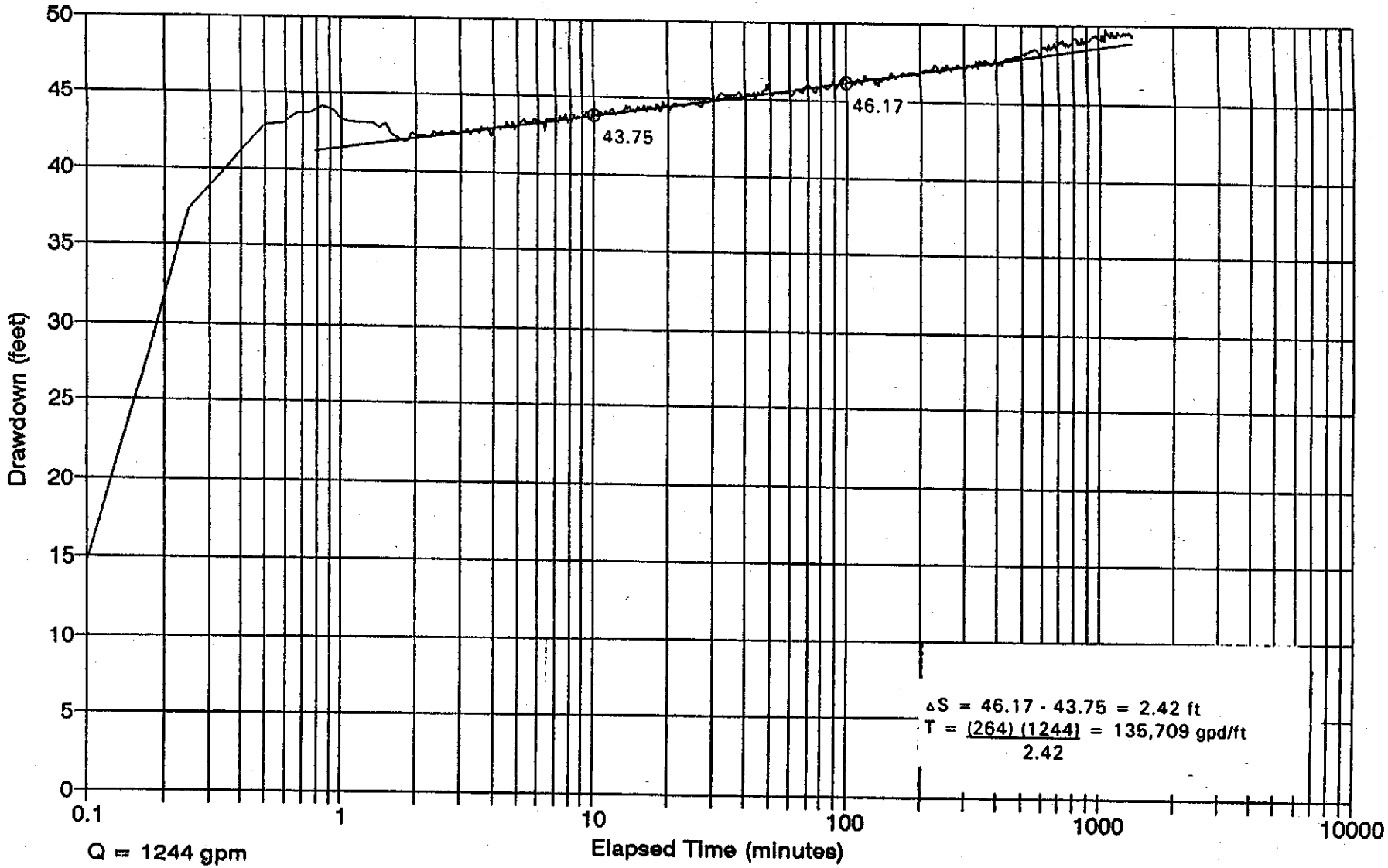
4435 Test – Drawdown Well 4435



WELL INFORMATION		
WELL IDENTIFICATION	:	4435
DATE OF AQUIFER TEST	:	11/29/95
AQUIFER THICKNESS (b)	:	1.000E+0000 ft
DISCHARGE RATE (Q)	:	1.244E+0003 gpm
PUMPING WELL RADIUS (r)	:	1.080E+0000 ft
DISTANCE OF OBS. WELL FROM PUMPING WELL (d)	:	1.080E+0000 ft

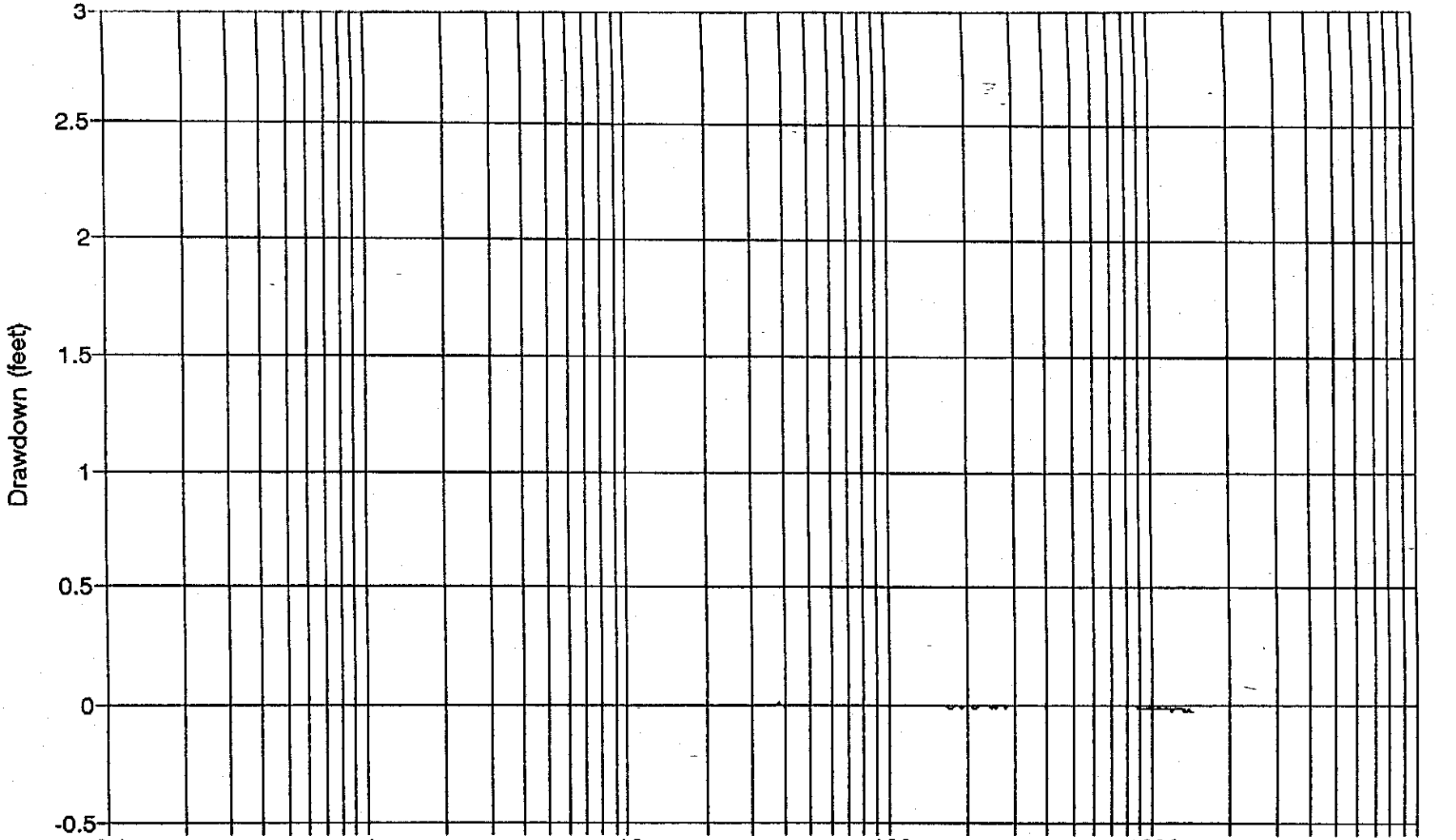
4435 Aquifer Test

Drawdown for Pumping Well 4435



4435 Aquifer Test

Drawdown for Well 87

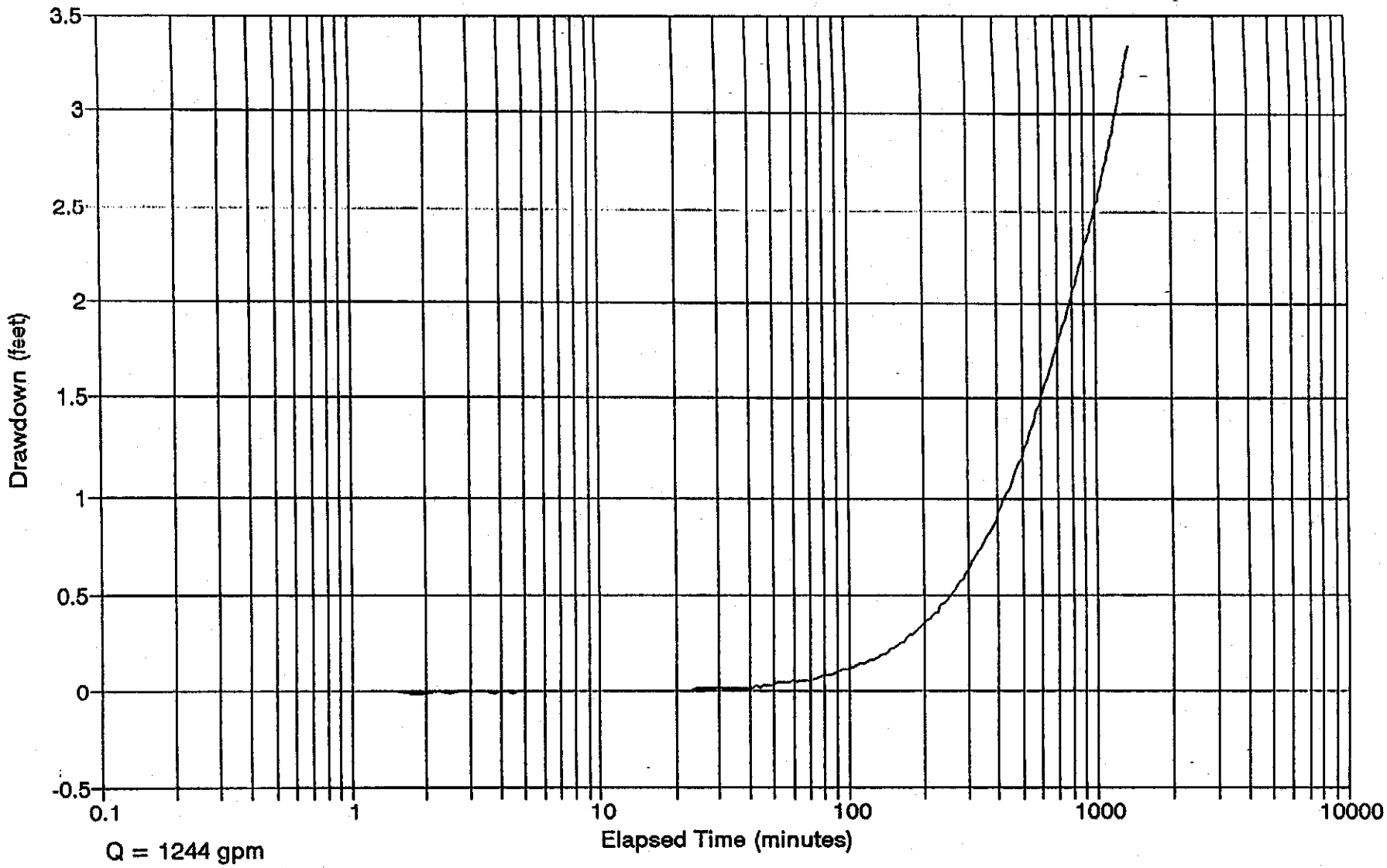


Q = 1255 gpm

Distance from Pumping well = 567 feet

4435 Aquifer Test

Drawdown for Well 124

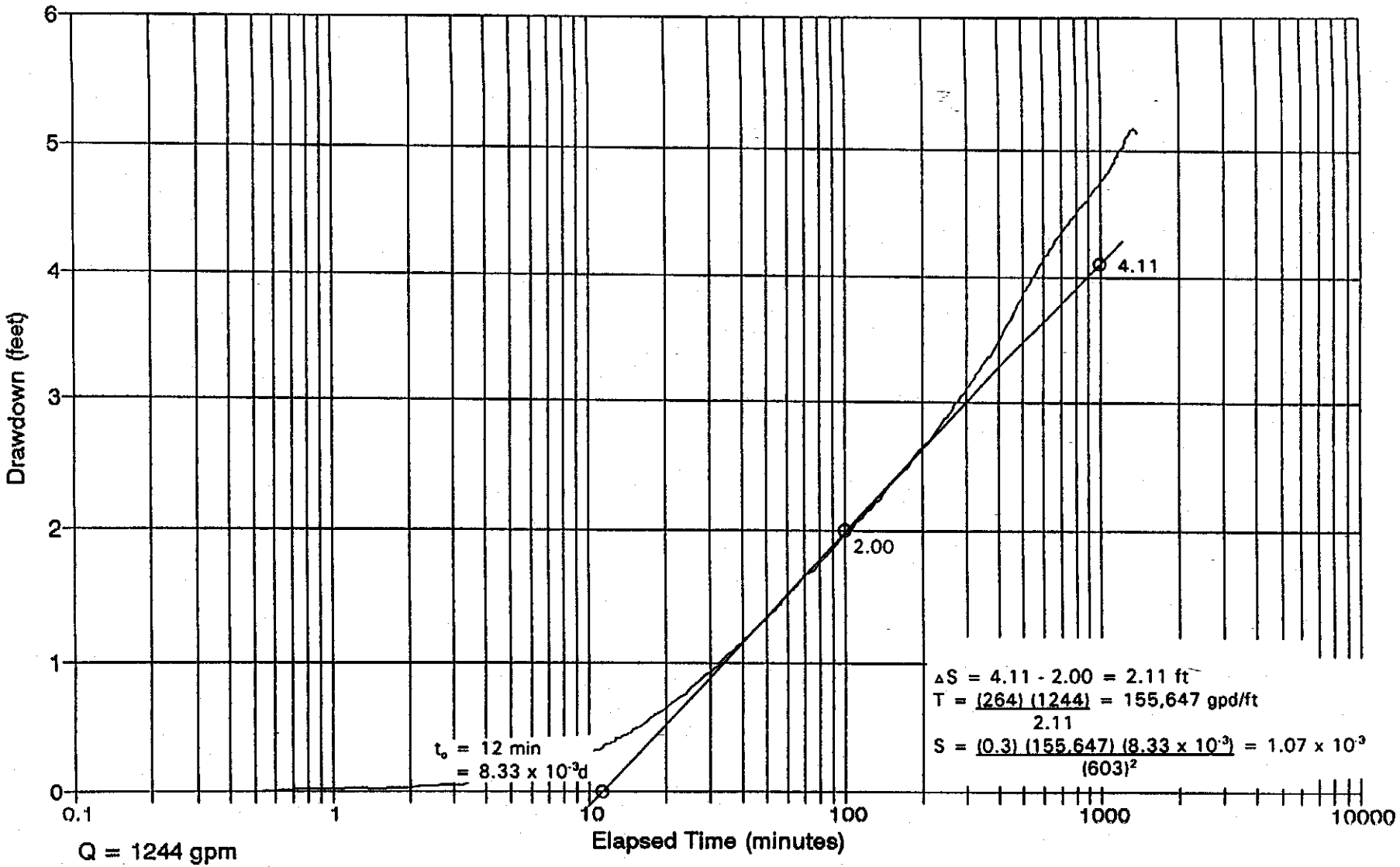


Q = 1244 gpm

Distance from Pumping well = 506 feet

4435 Aquifer Test

Drawdown for Well 127

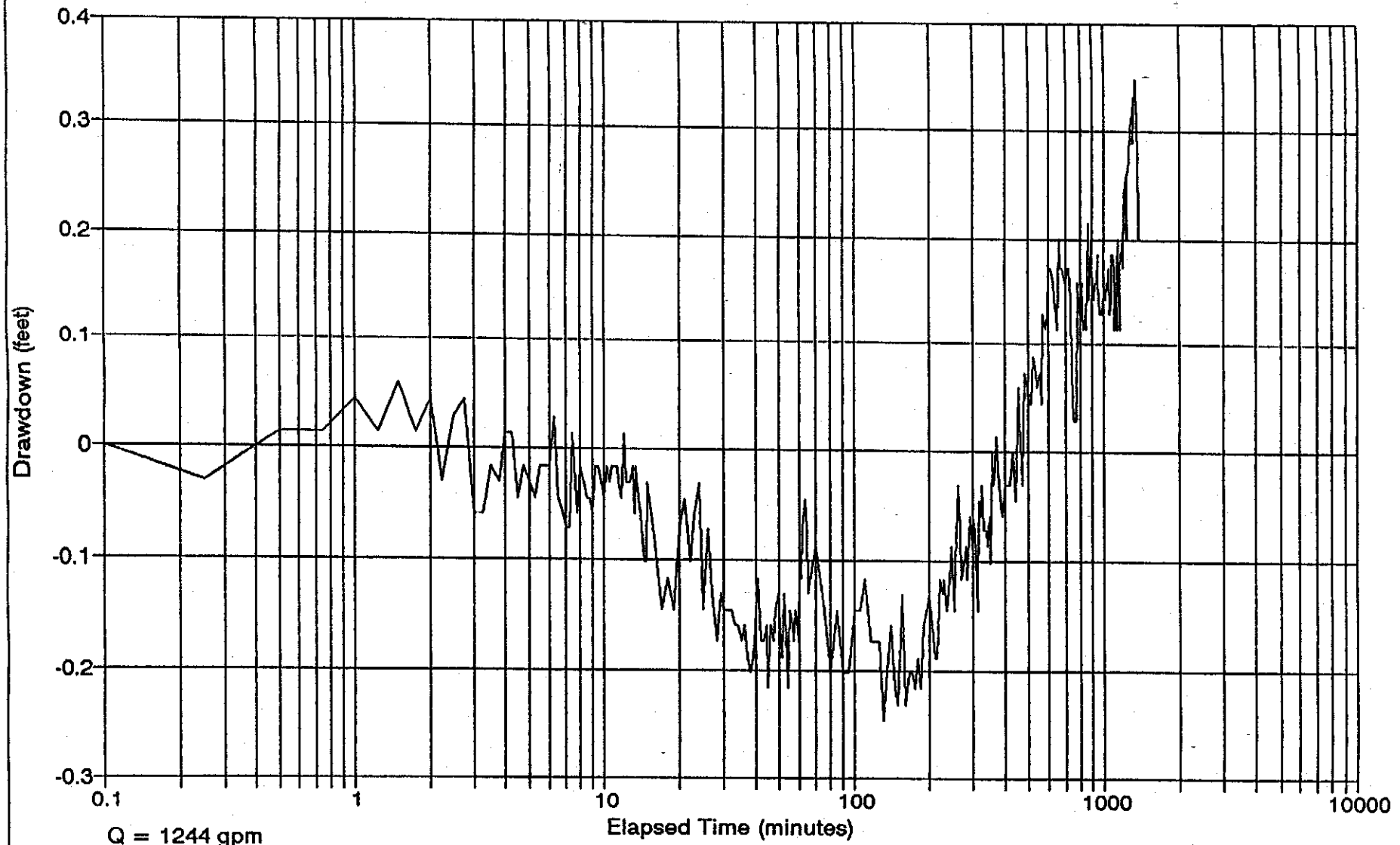


Q = 1244 gpm

Distance from Pumping well = 603 feet

4435 Aquifer Test

Drawdown for Well 128



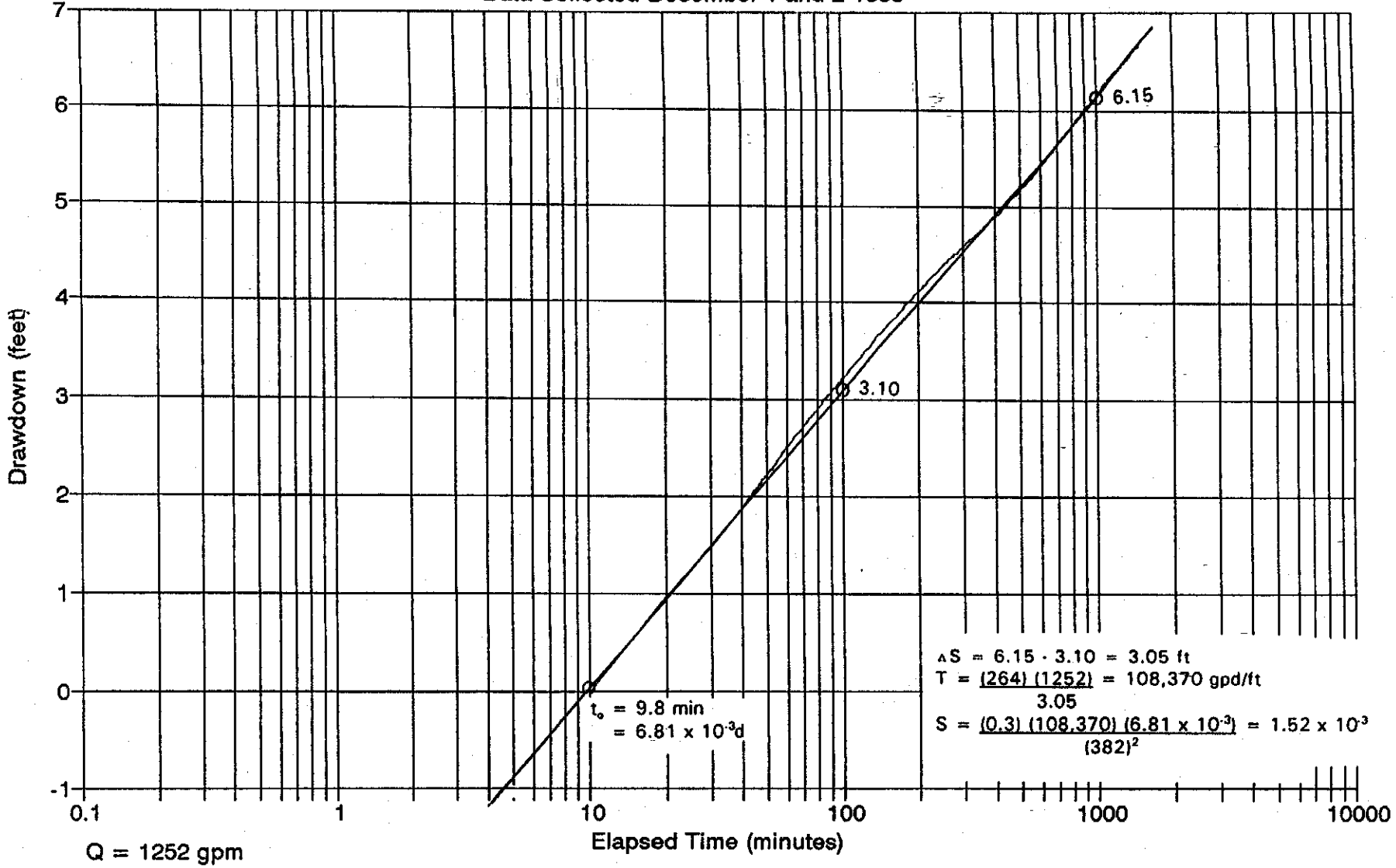
Q = 1244 gpm

Distance from Pumping well = 603 feet

4435 Aquifer Test

Drawdown for Well 165

Data Collected December 1 and 2 1995



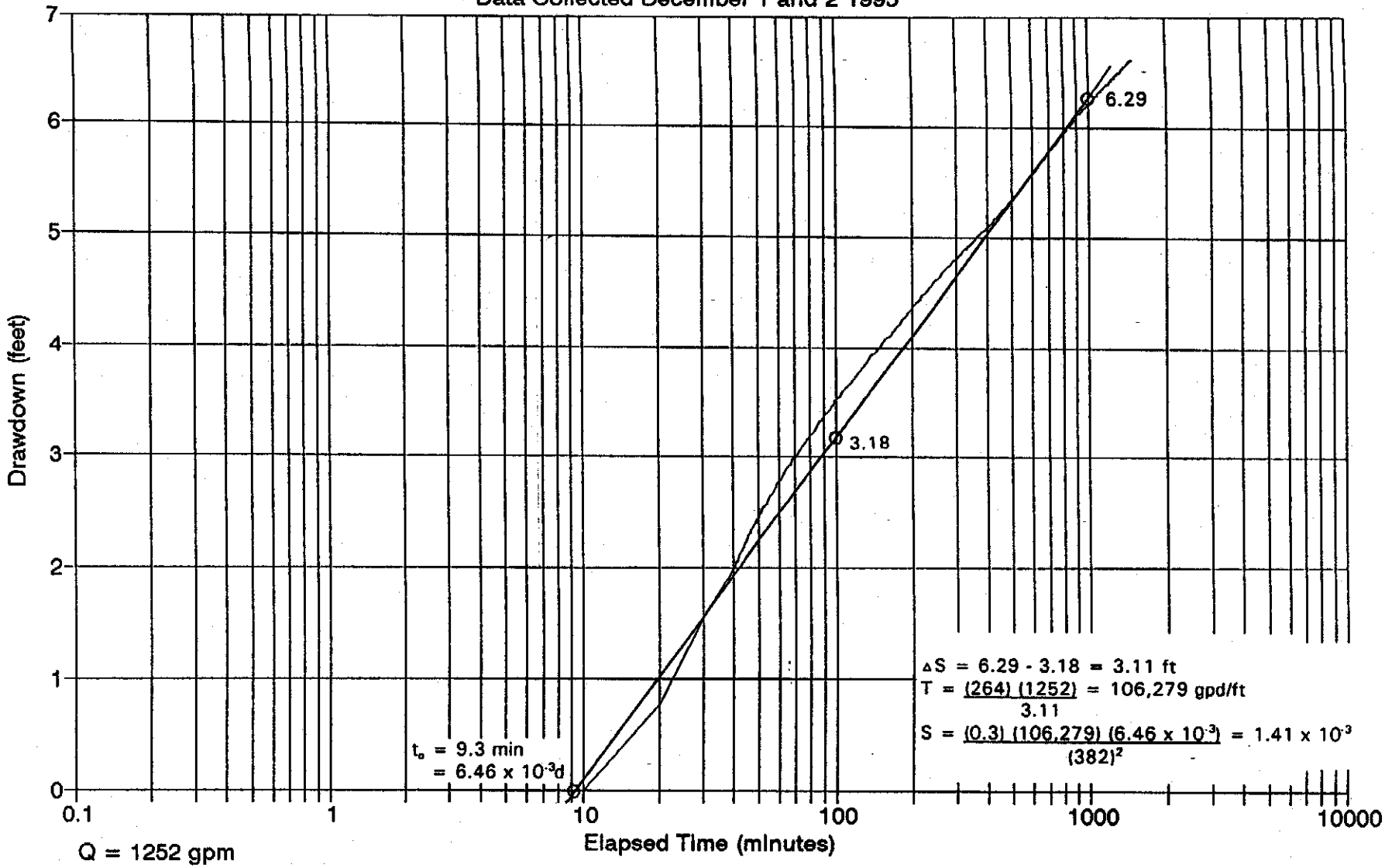
Q = 1252 gpm

Distance from Pumping well = 382 feet

4435 Aquifer Test

Drawdown for Well 166

Data Collected December 1 and 2 1995



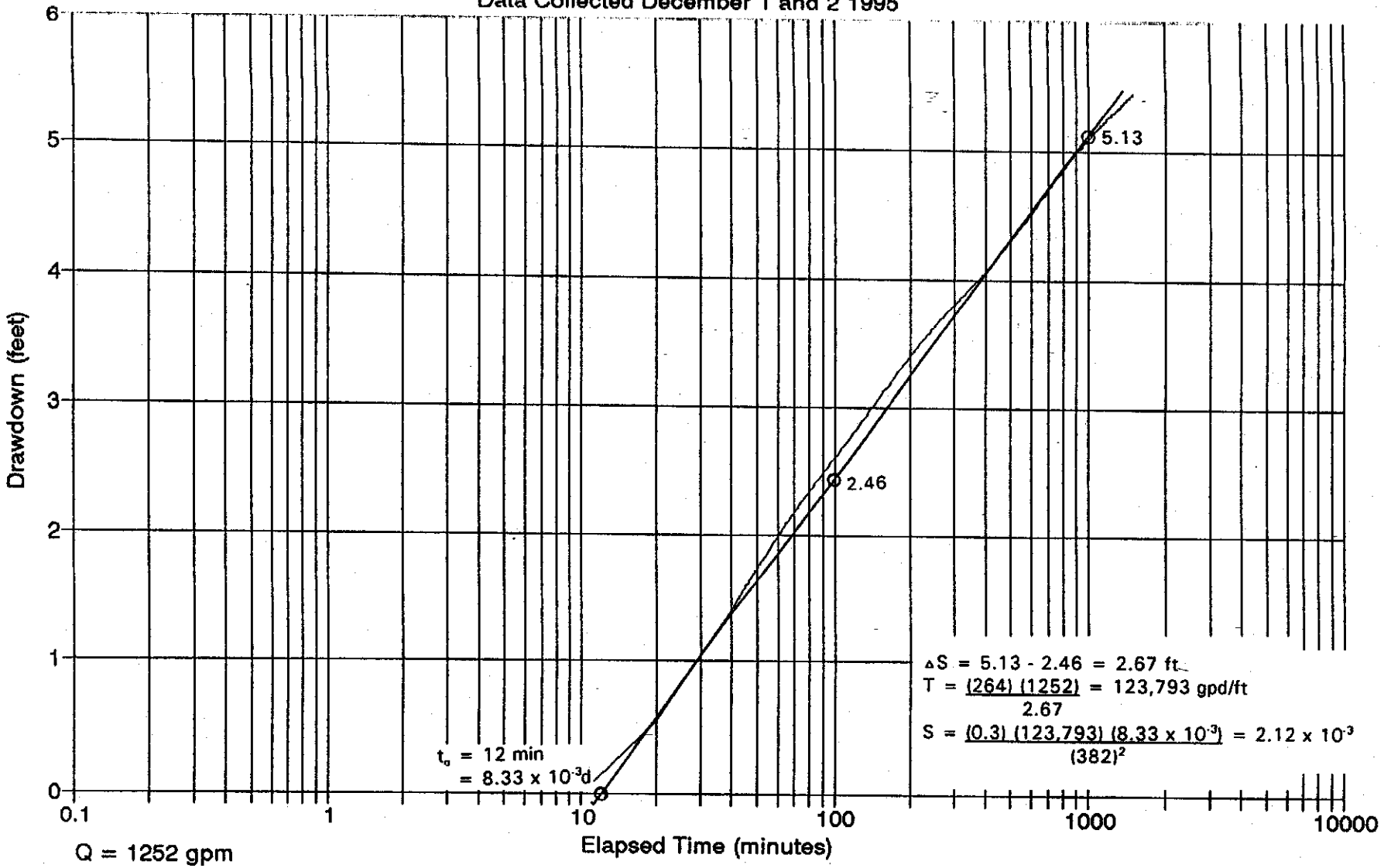
Q = 1252 gpm

Distance from Pumping well = 382 feet

4435 Aquifer Test

Drawdown for Well 167

Data Collected December 1 and 2 1995

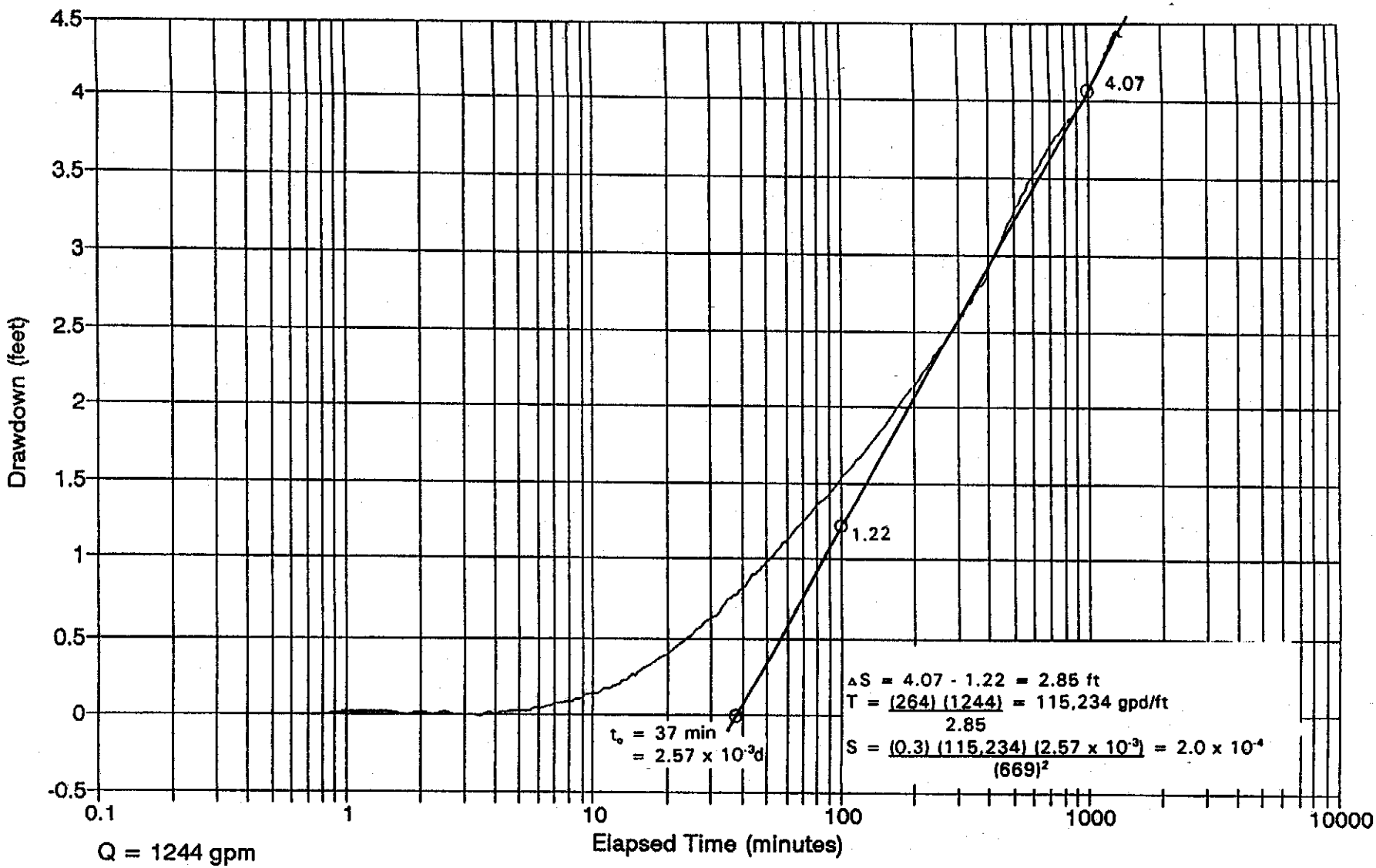


Q = 1252 gpm

Distance from Pumping well = 382 feet

4435 Aquifer Test

Drawdown for Well 476

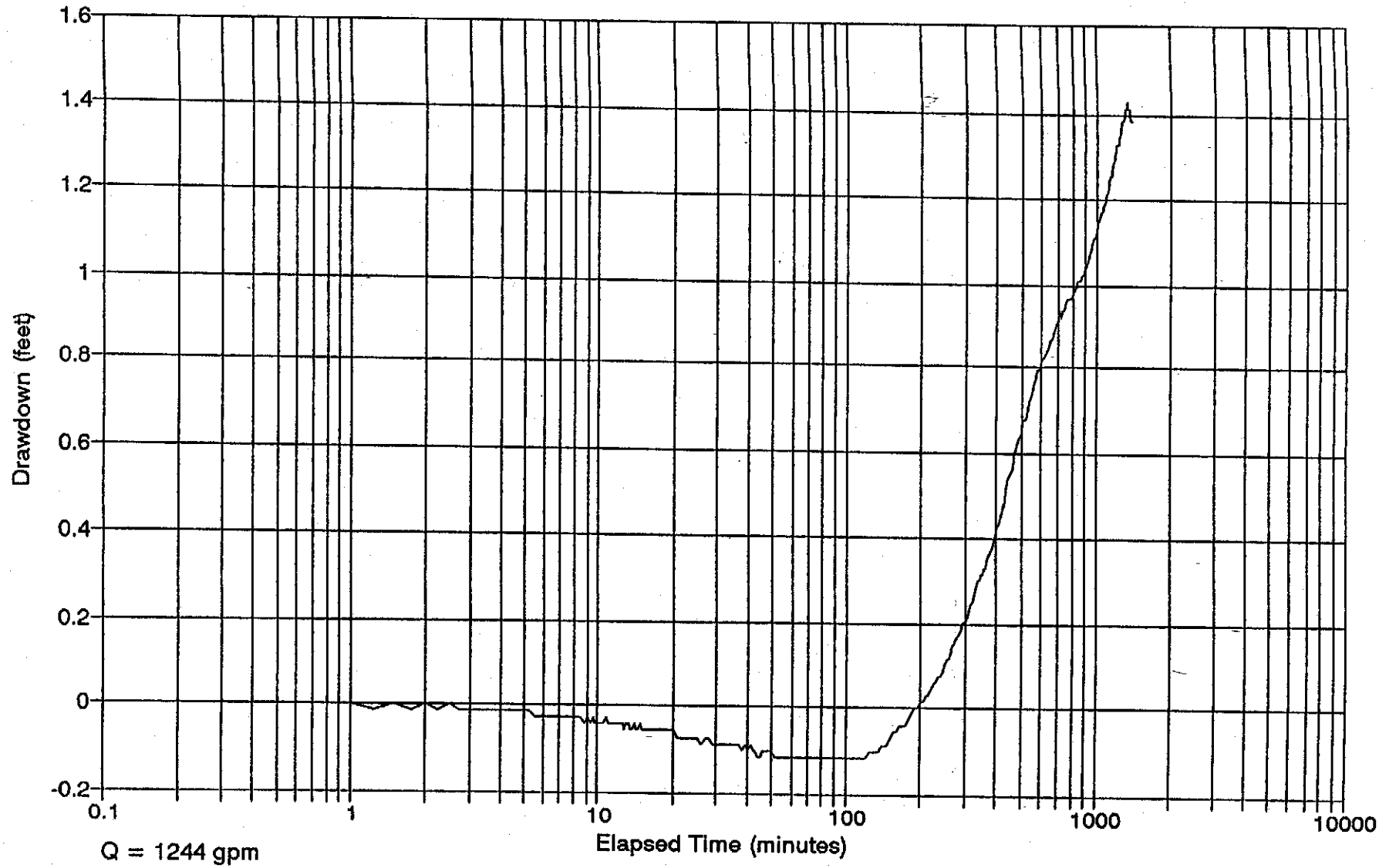


Q = 1244 gpm

Distance from Pumping well = 669 feet

4435 Aquifer Test

Drawdown for Well 477

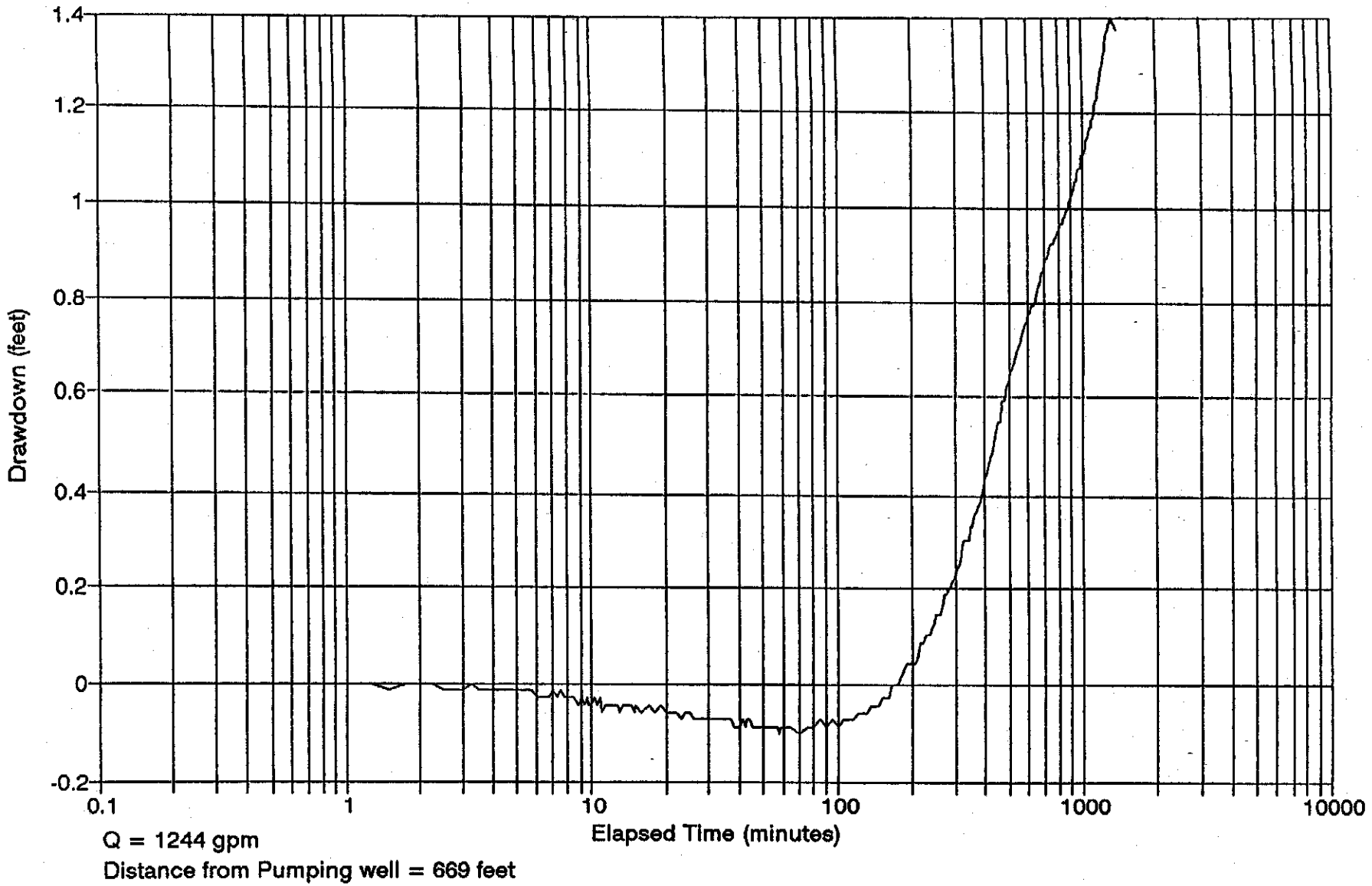


Q = 1244 gpm

Distance from Pumping well = 669 feet

4435 Aquifer Test

Drawdown for Well 478

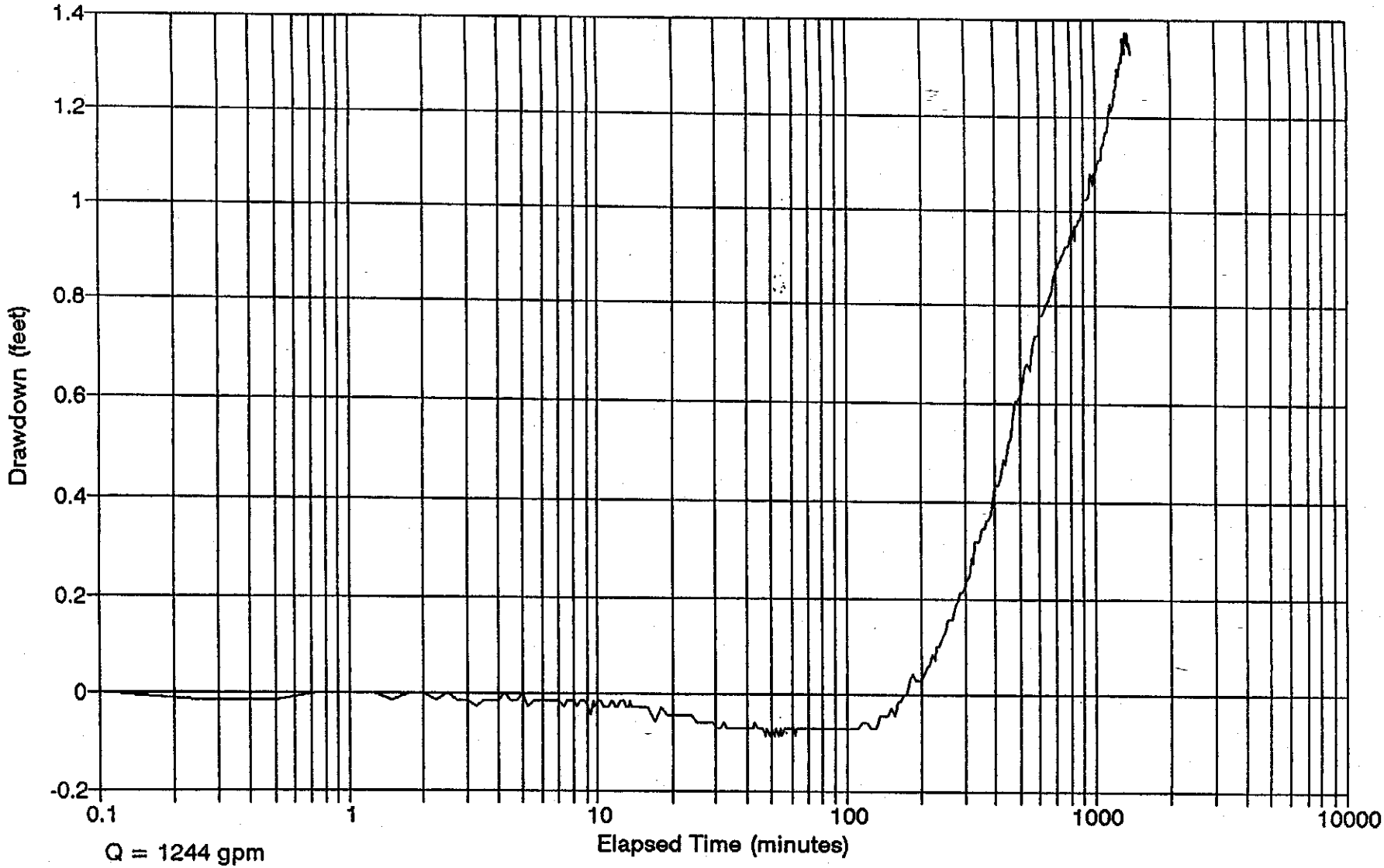


Q = 1244 gpm

Distance from Pumping well = 669 feet

4435 Aquifer Test

Drawdown for Well 479

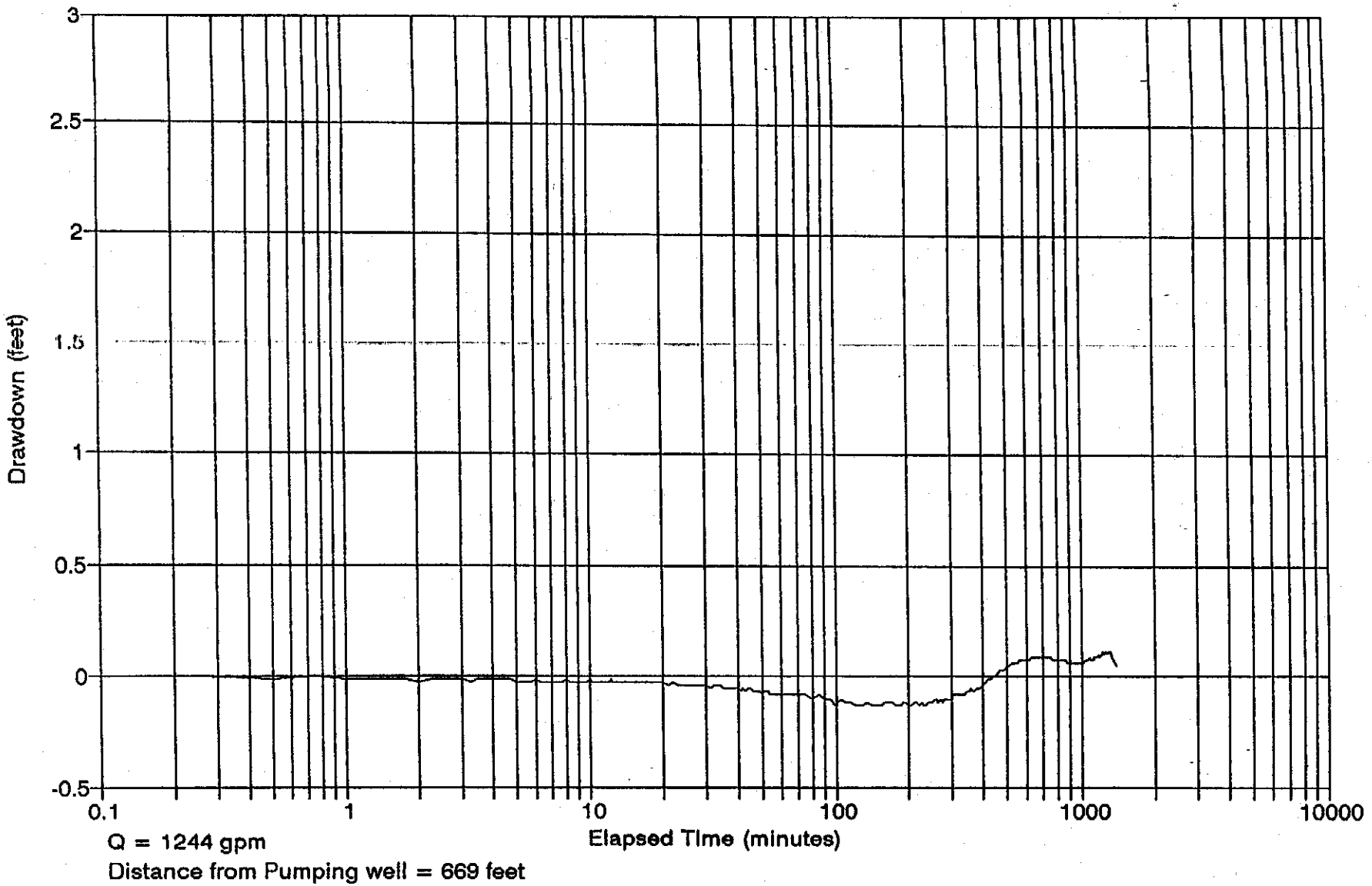


Q = 1244 gpm

Distance from Pumping well = 669 feet

4435 Aquifer Test

Drawdown for Well 480

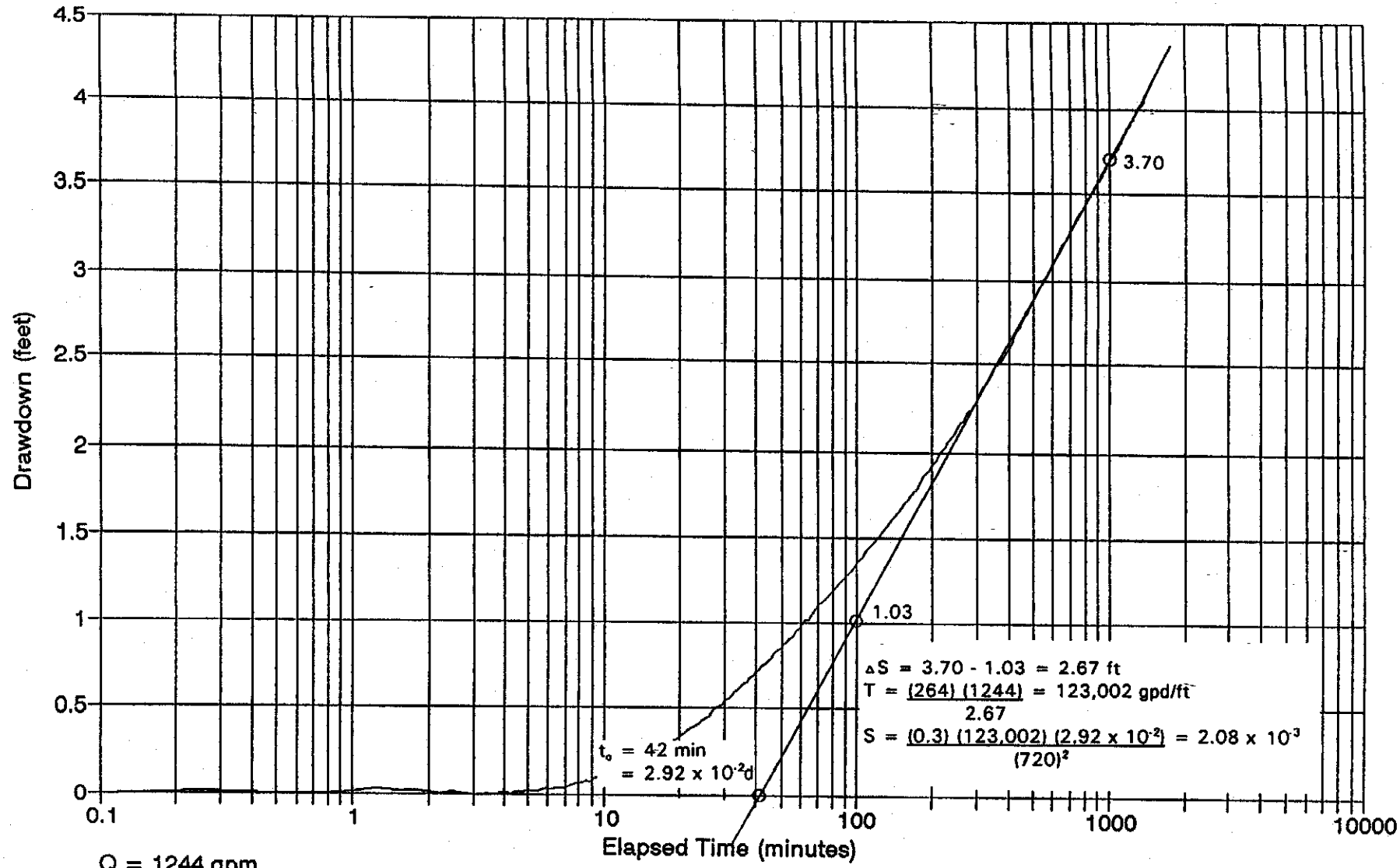


Q = 1244 gpm

Distance from Pumping well = 669 feet

4435 Aquifer Test

Drawdown for Well 3332

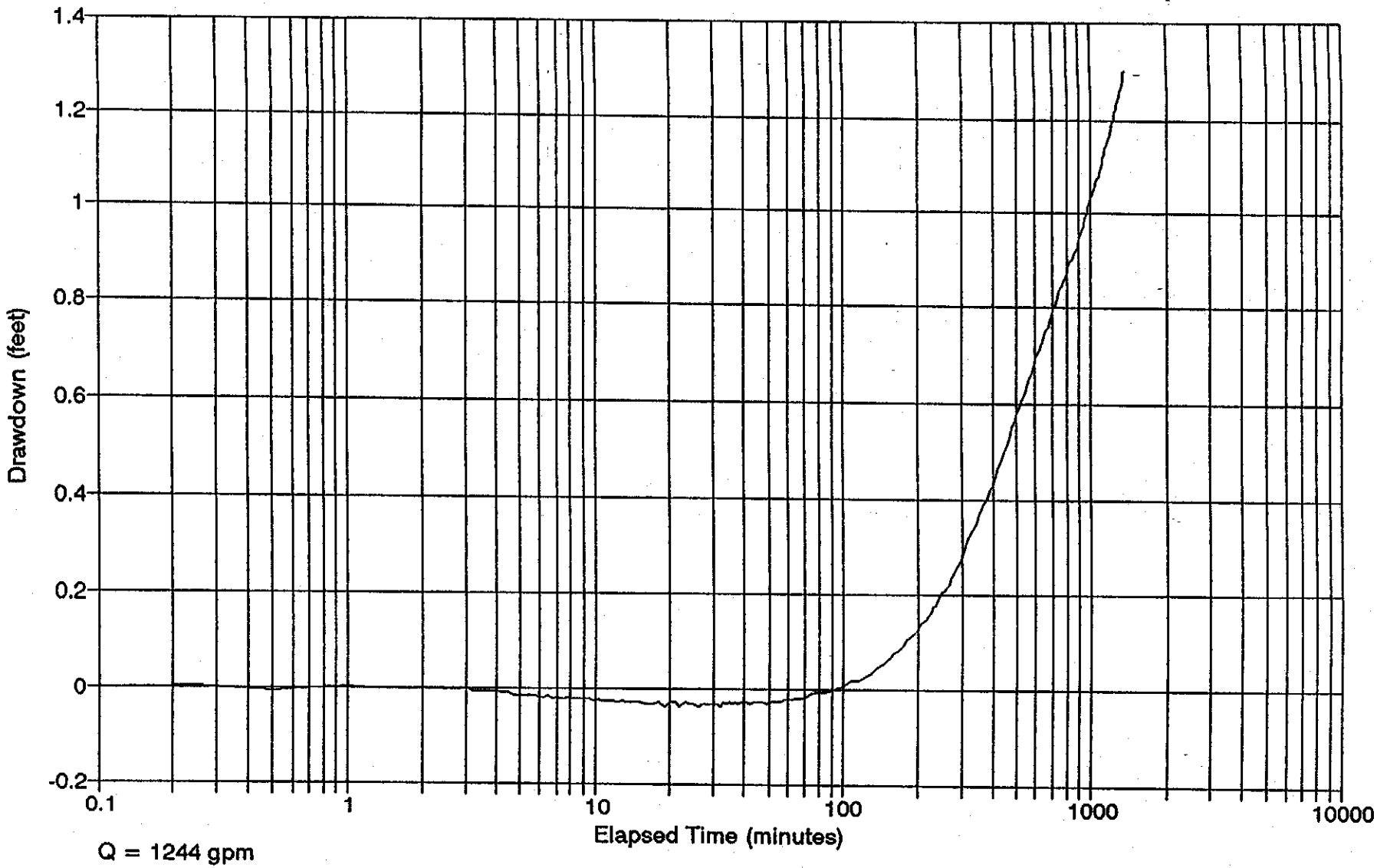


Q = 1244 gpm

Distance from Pumping well = 720 feet

4435 Aquifer Test

Drawdown for Well 3333

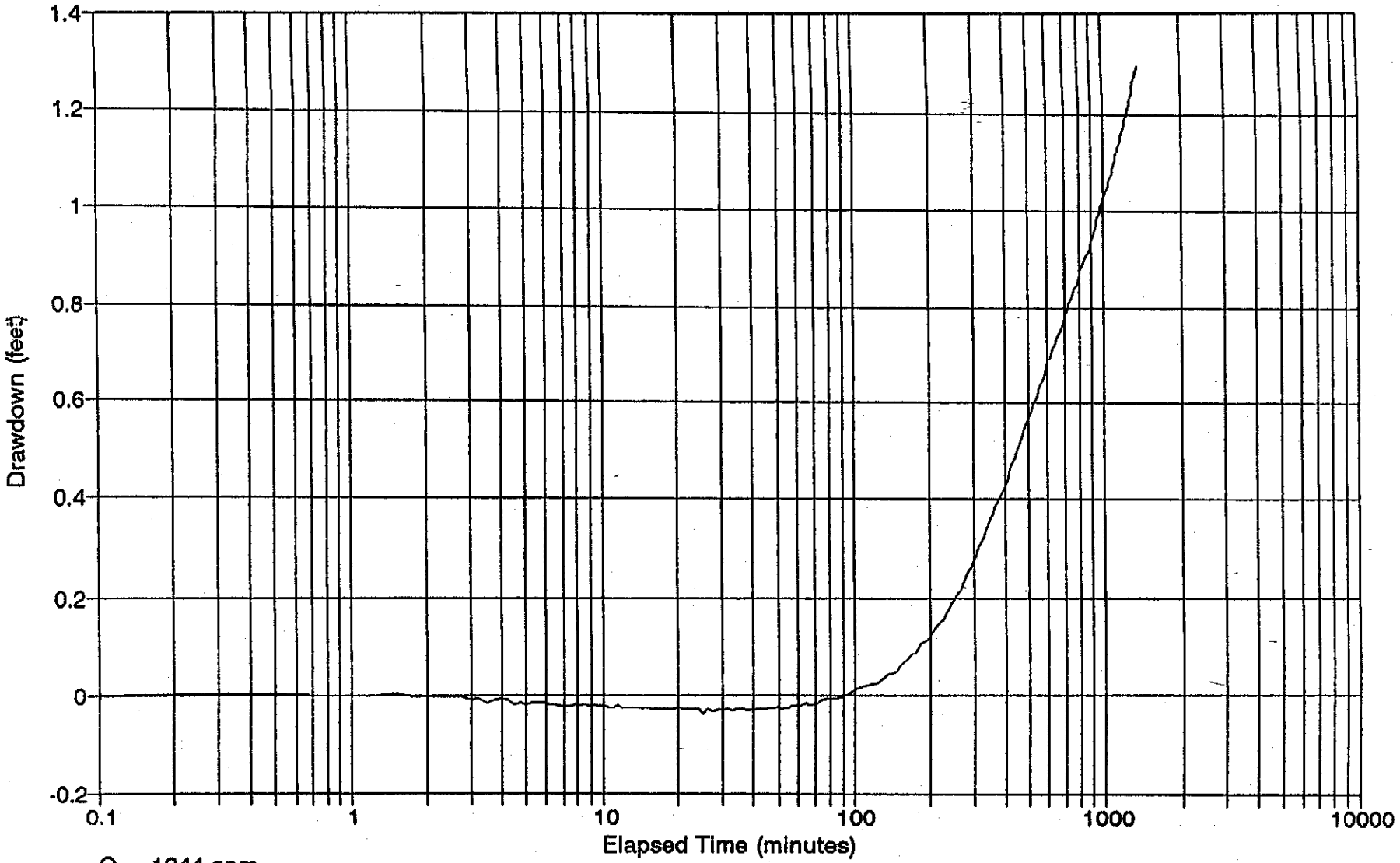


Q = 1244 gpm

Distance from Pumping well = 720 feet

4435 Aquifer Test

Drawdown for Well 3334

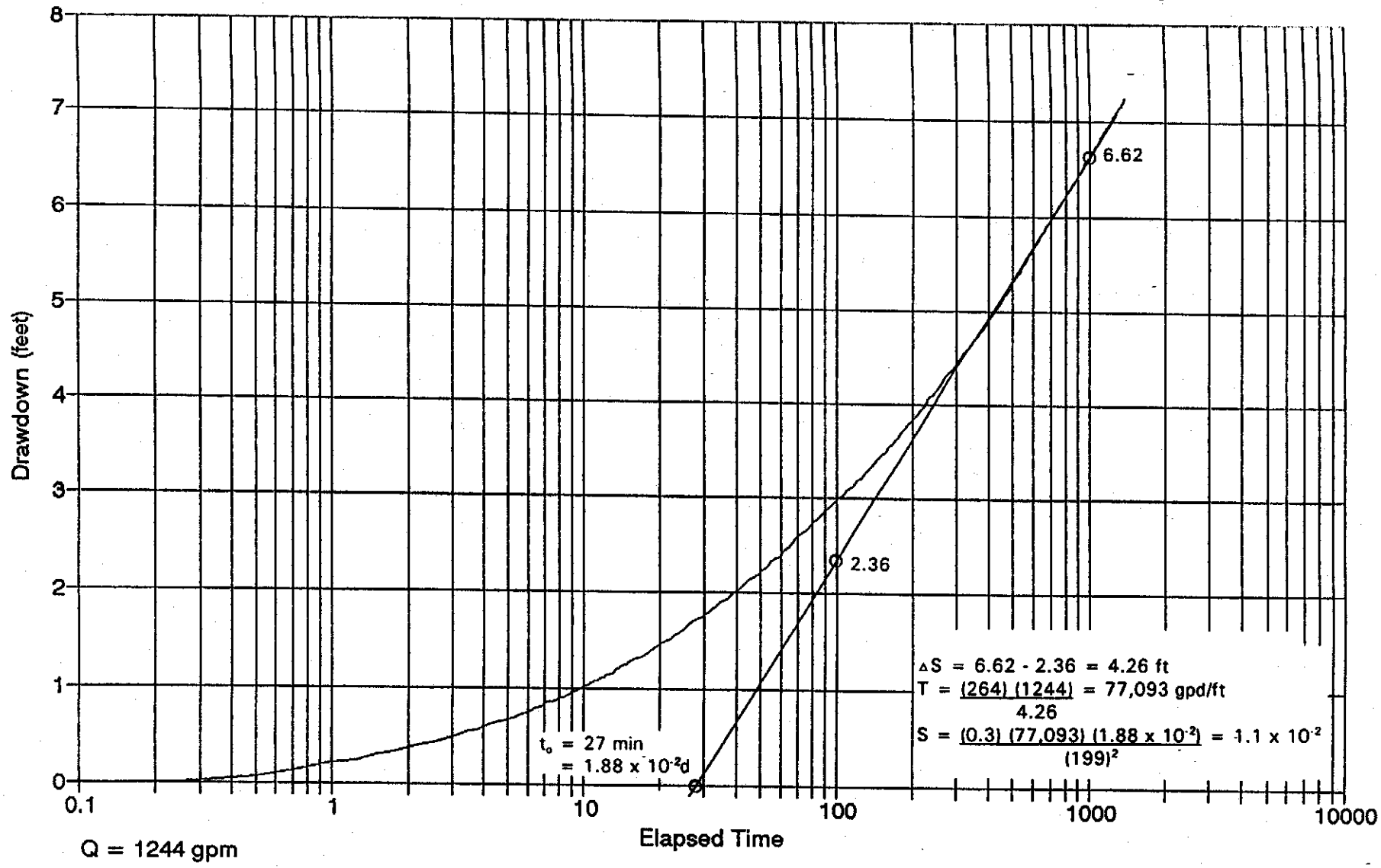


Q = 1244 gpm

Distance from Pumping well = 720 feet

4435 Aquifer Test

Drawdown for Well 3338

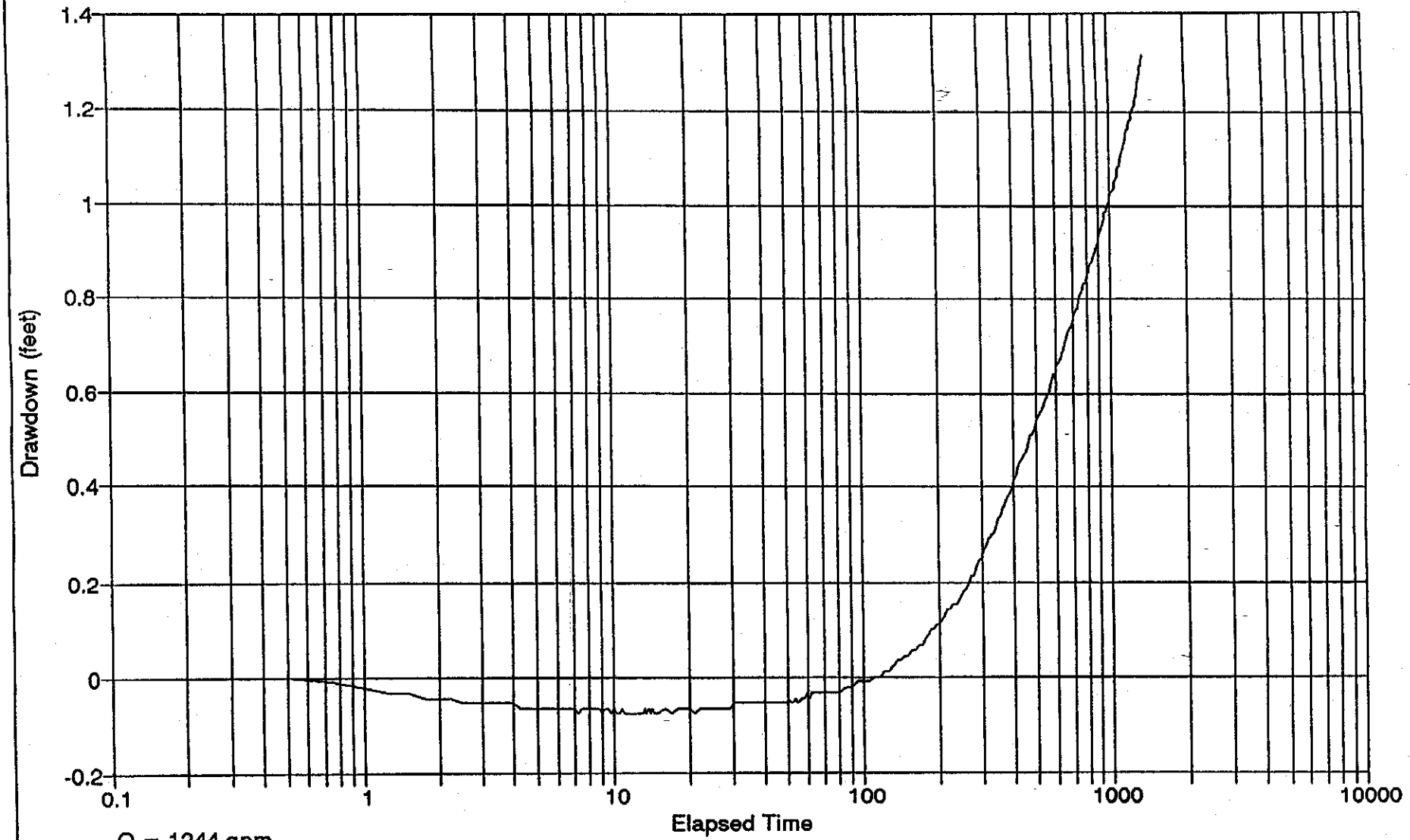


Q = 1244 gpm

Distance from Pumping well = 199 feet

4435 Aquifer Test

Drawdown for Well 3339

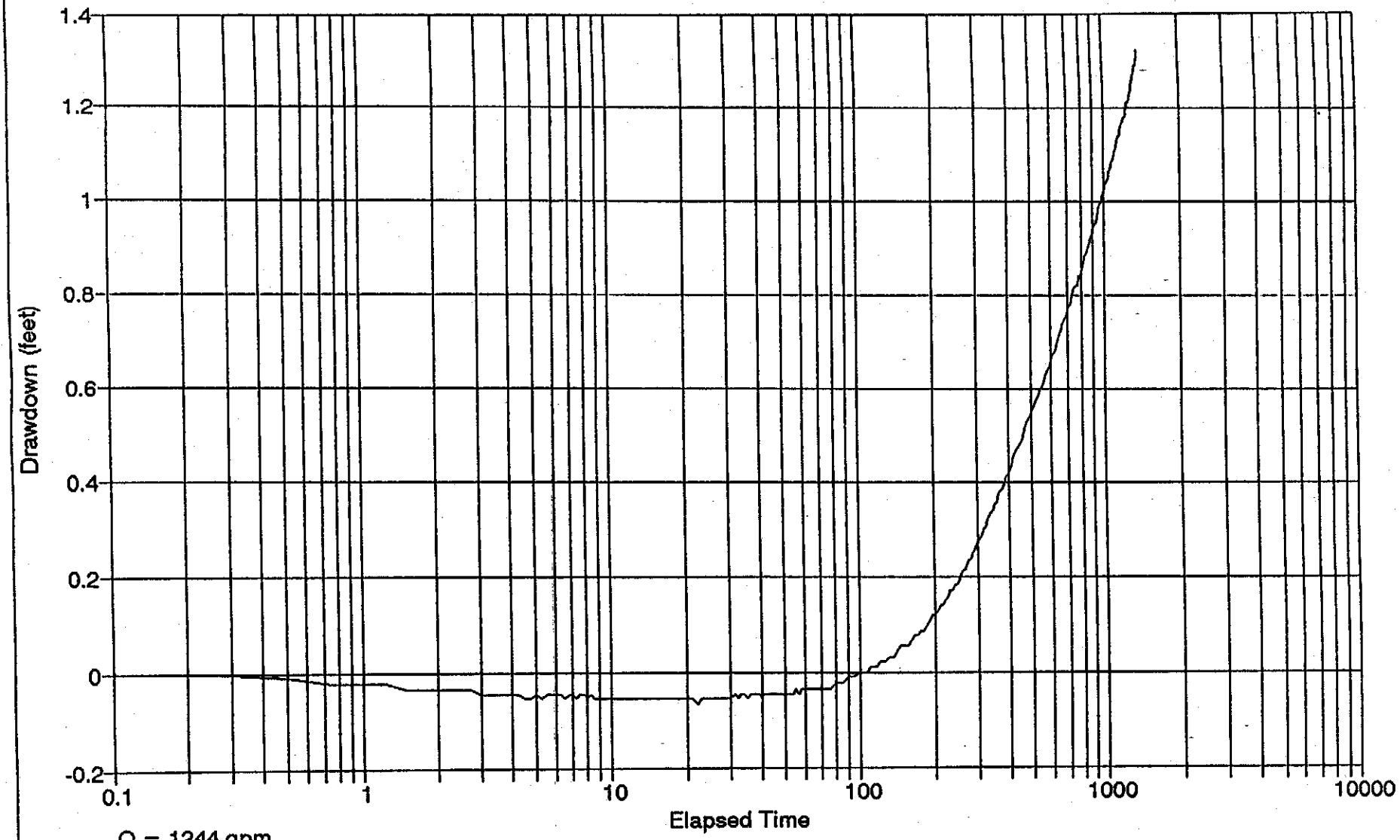


Q = 1244 gpm

Distance from Pumping well = 199 feet

4435 Aquifer Test

Drawdown for Well 3340

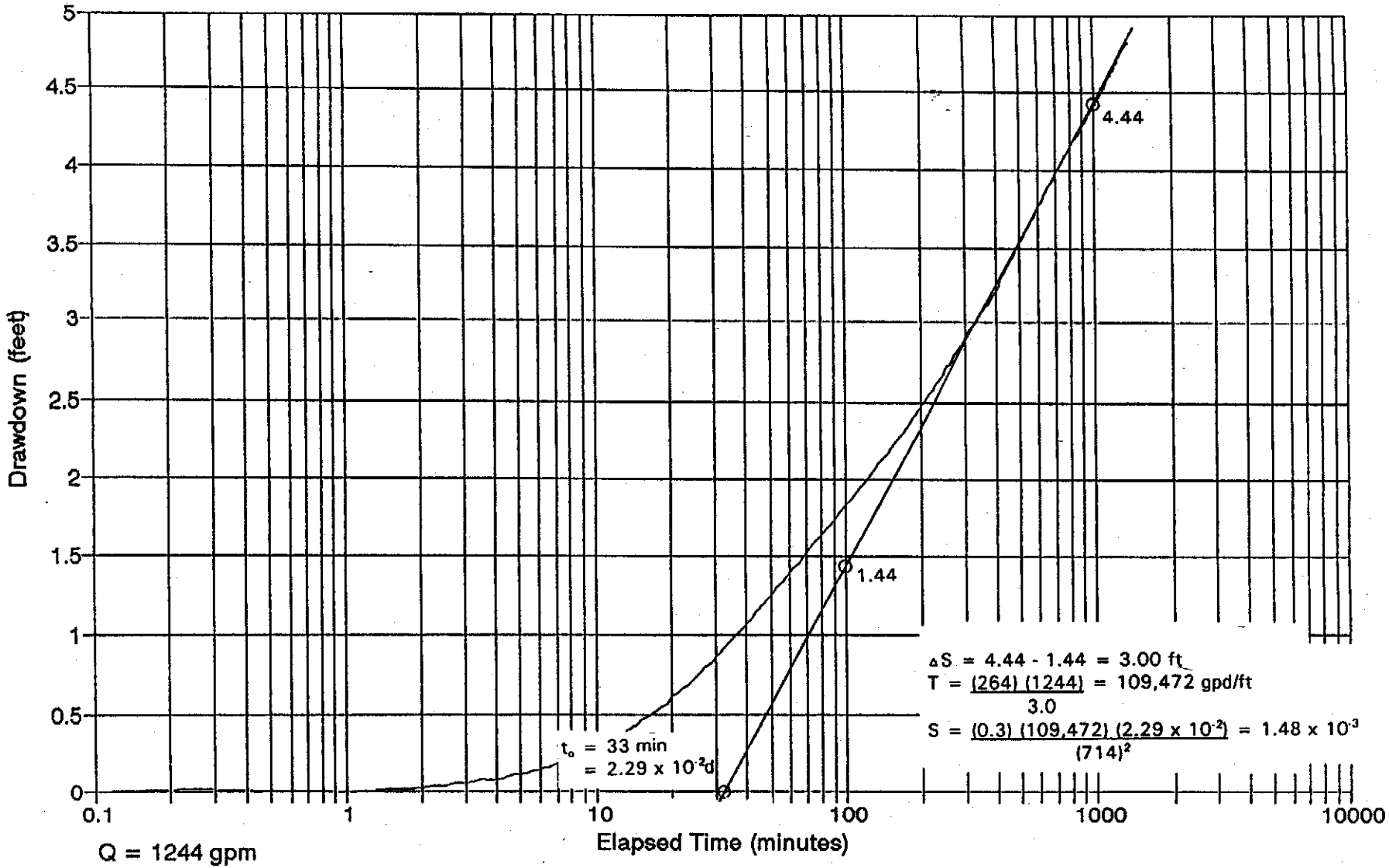


Q = 1244 gpm

Distance from Pumping well = 199 feet

4435 Aquifer Test

Drawdown for Well 3353

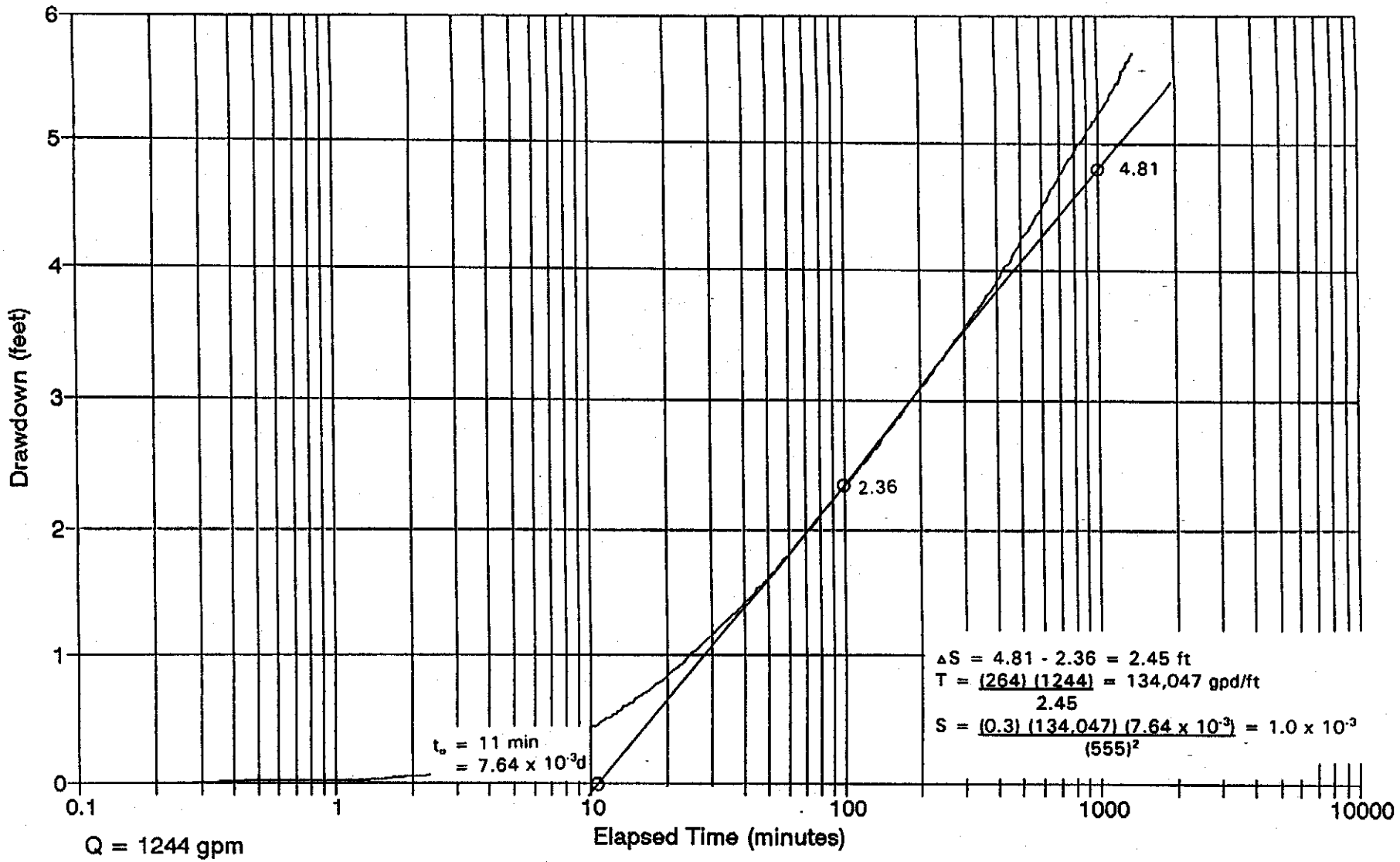


Q = 1244 gpm

Distance from Pumping well = 714 feet

4435 Aquifer Test

Drawdown for Well 3517

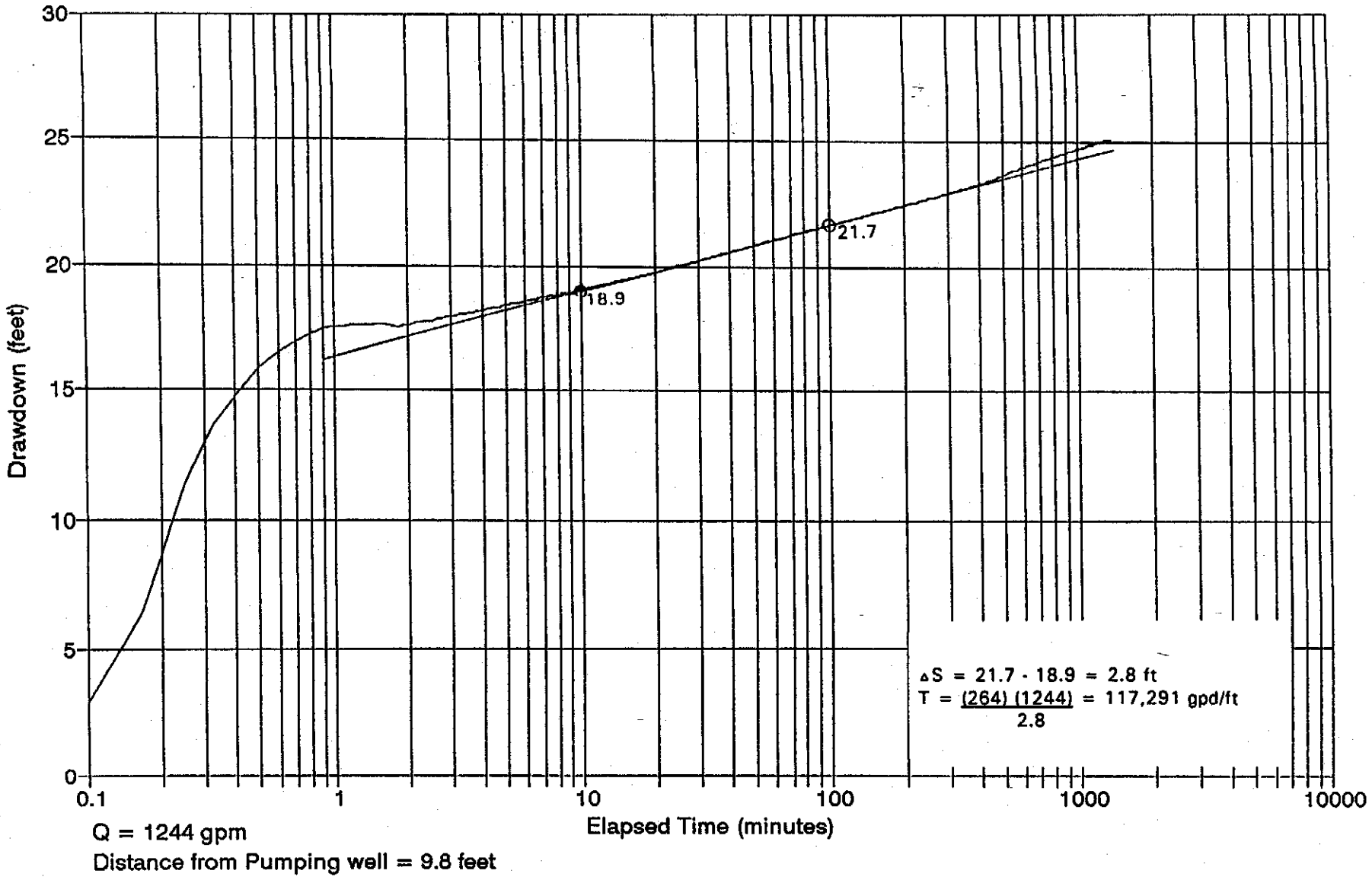


Q = 1244 gpm

Distance from Pumping well = 555 feet

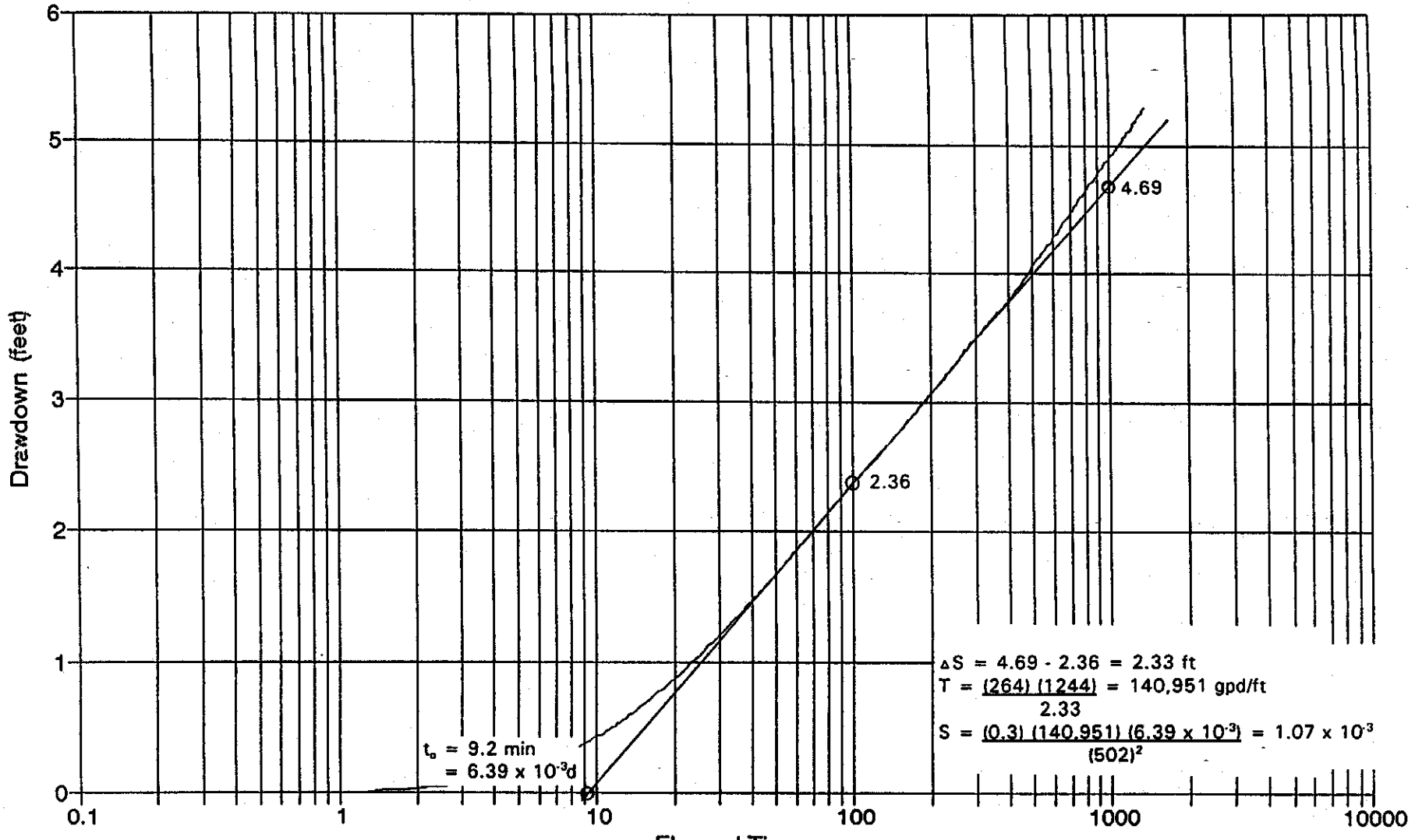
4435 Aquifer Test

Drawdown for Well 3518



4435 Aquifer Test

Drawdown for Well 4070

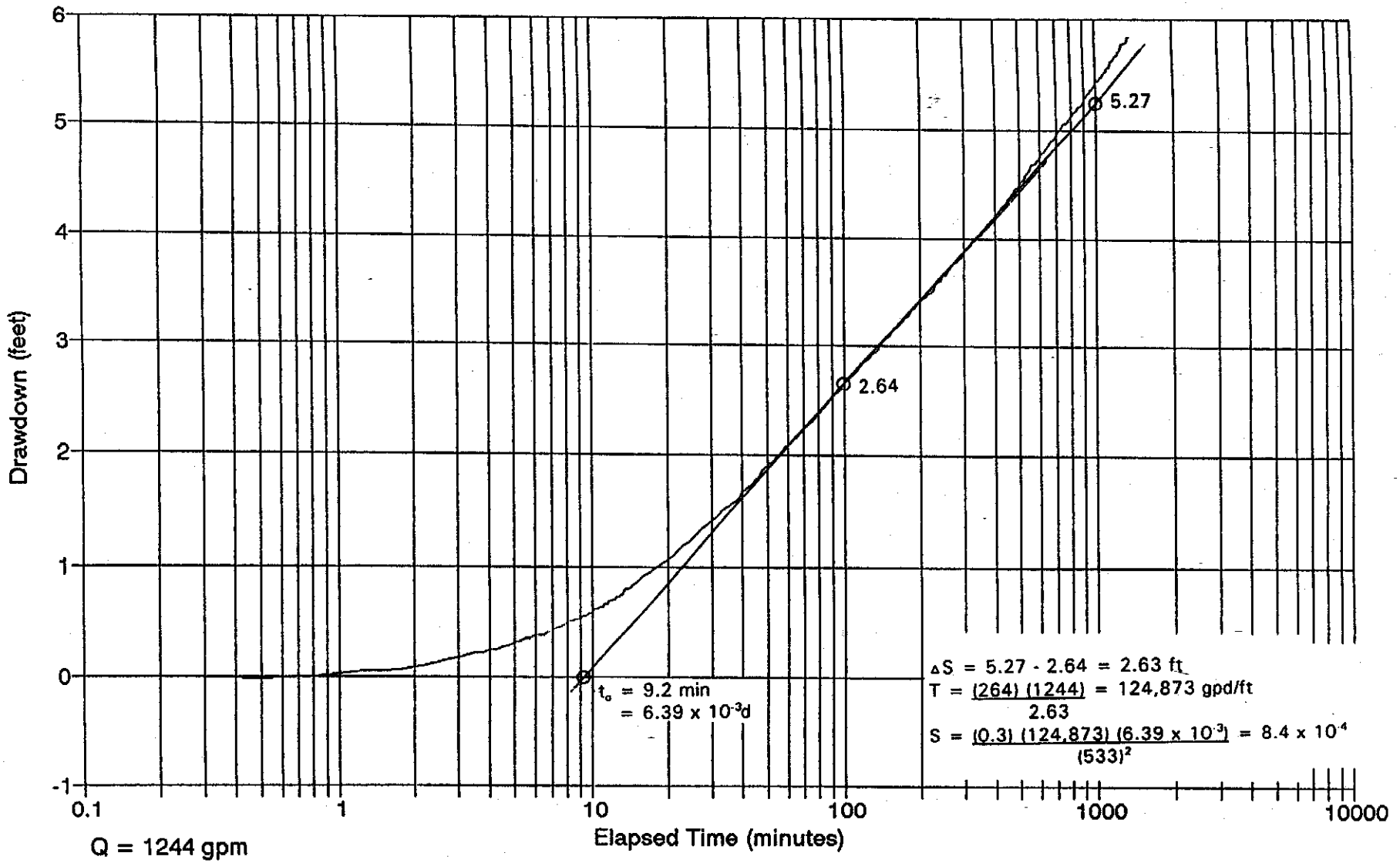


Q = 1244 gpm

Distance from Pumping well = 502 feet

4435 Aquifer Test

Drawdown for Well 4075

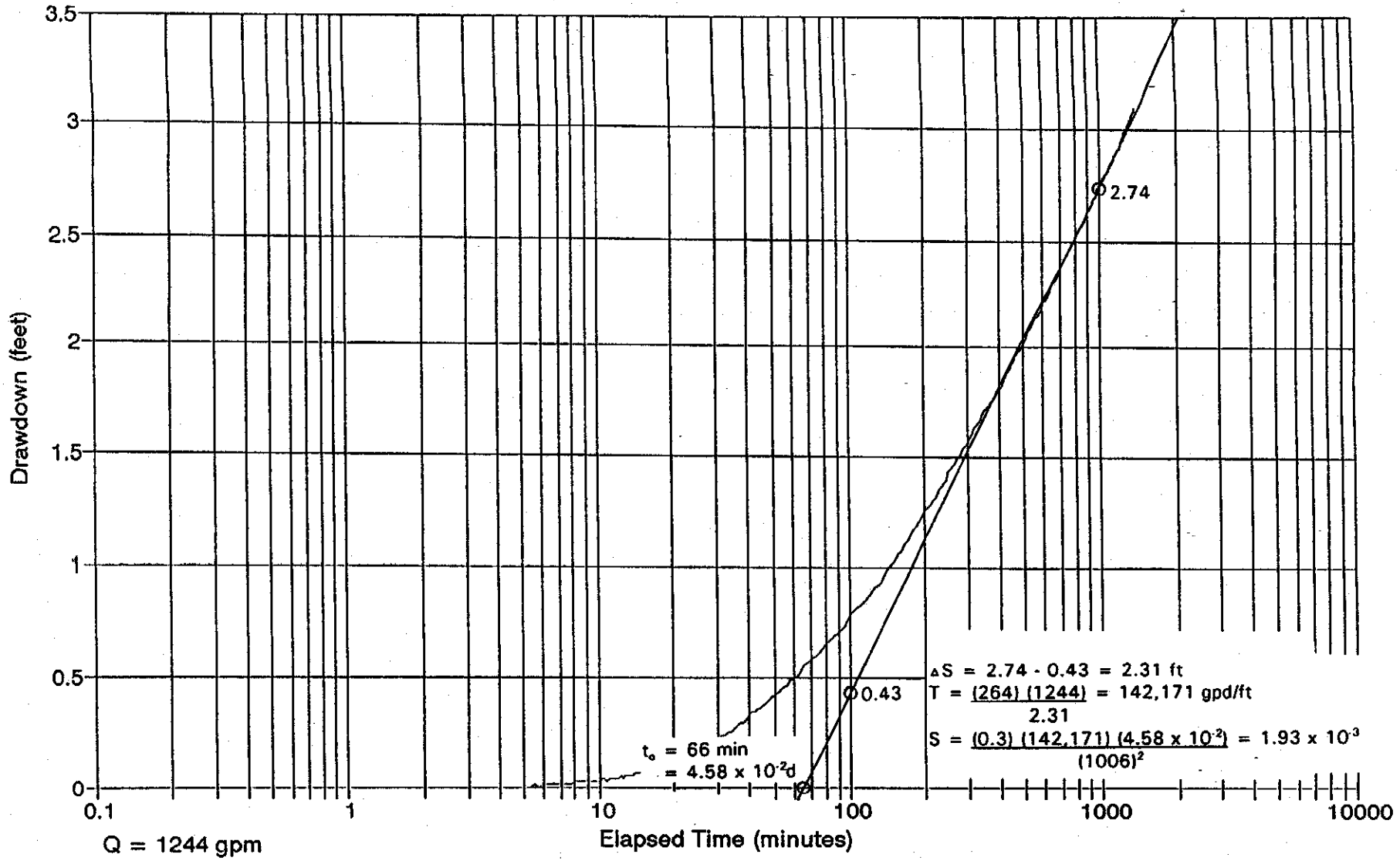


Q = 1244 gpm

Distance from Pumping well = 533 feet

4435 Aquifer Test

Drawdown for Well 4200

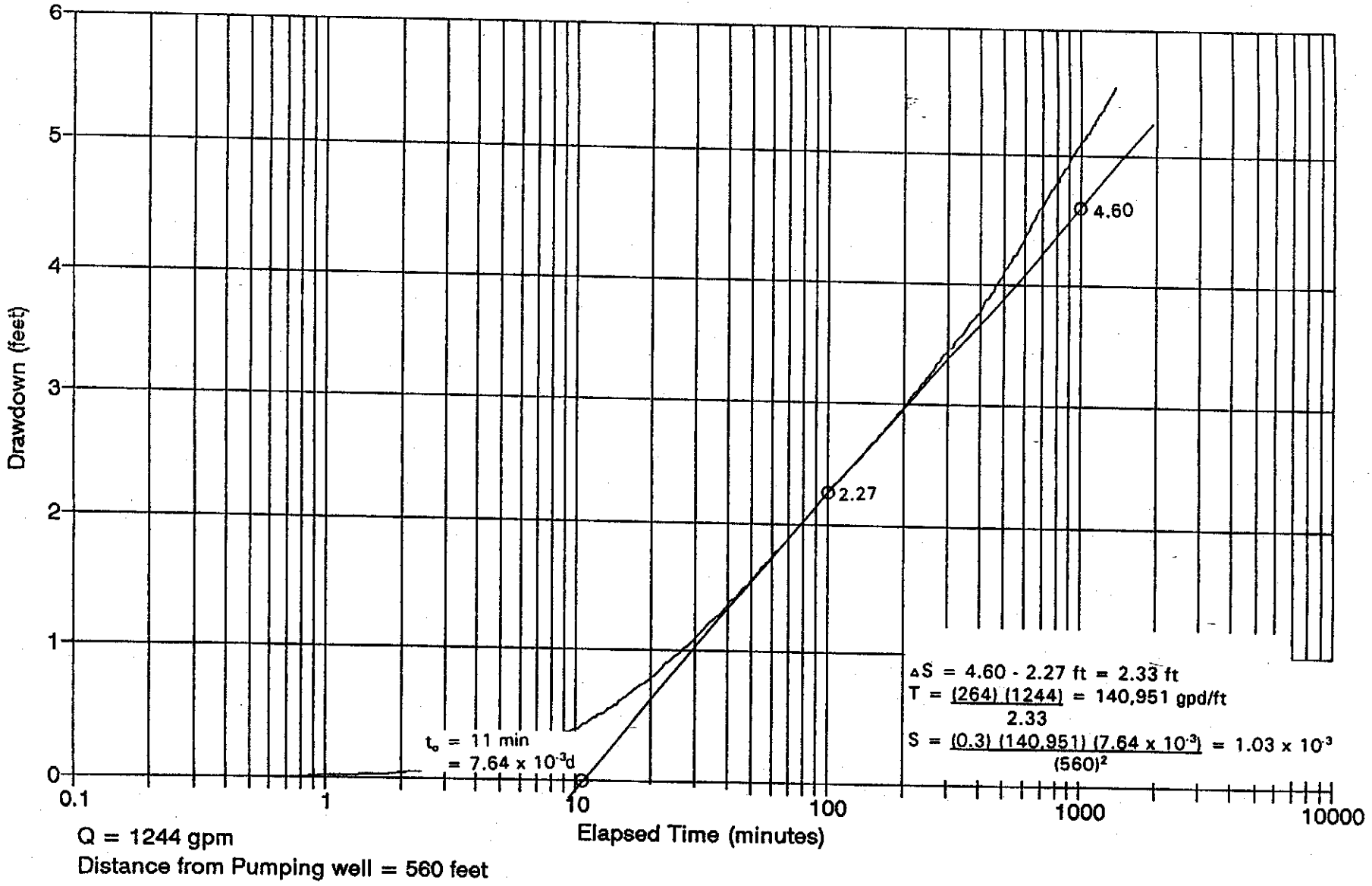


Q = 1244 gpm

Distance from Pumping well = 1006 feet

4435 Aquifer Test

Drawdown for Well 4425



Q = 1244 gpm

Distance from Pumping well = 560 feet

APPENDIX G

Time-Series Graphs of Trichloroethylene, 1,2-Dichloroethane, Perchlorate, and Chloroform for Selected Wells

Time-Series Graphs of Trichloroethylene, 1,2-Dichloroethane, Perchlorate, and Chloroform for Selected Wells

Well No.	Well No.	Well No.
Well 131	Well 1351	Well 3146
Well 172	Well 1352	Well 3204
Well 206	Well 1353	Well 3226
Well 207	Well 1354	Well 3264
Well 222	Well 1435	Well 3279
Well 235	Well 1437	Well 3280
Well 401	Well 1438	Well 3333
Well 446	Well 1459	Well 3334
Well 447	Well 1460	Well 3336
Well 1016	Well 1461	Well 3341
Well 1204	Well 1462	Well 3342
Well 1233	Well 1464	Well 3343
Well 1234	Well 1466	Well 3352
Well 1237	Well 1467	Well 3431
Well 1252	Well 1484	Well 3439
Well 1253	Well 3031	Well 4018
Well 1254	Well 3050	Well 4060
Well 1255	Well 3051	Well 4070
Well 1273	Well 3052	Well 4075
Well 1274	Well 3053	Well 4140
Well 1277	Well 3115	Well 4145
Well 1282	Well 3116	Well 4200
Well 1284	Well 3139	Well 4310
Well 1286	Well 3140	Well 4315
Well 1350	Well 3145	

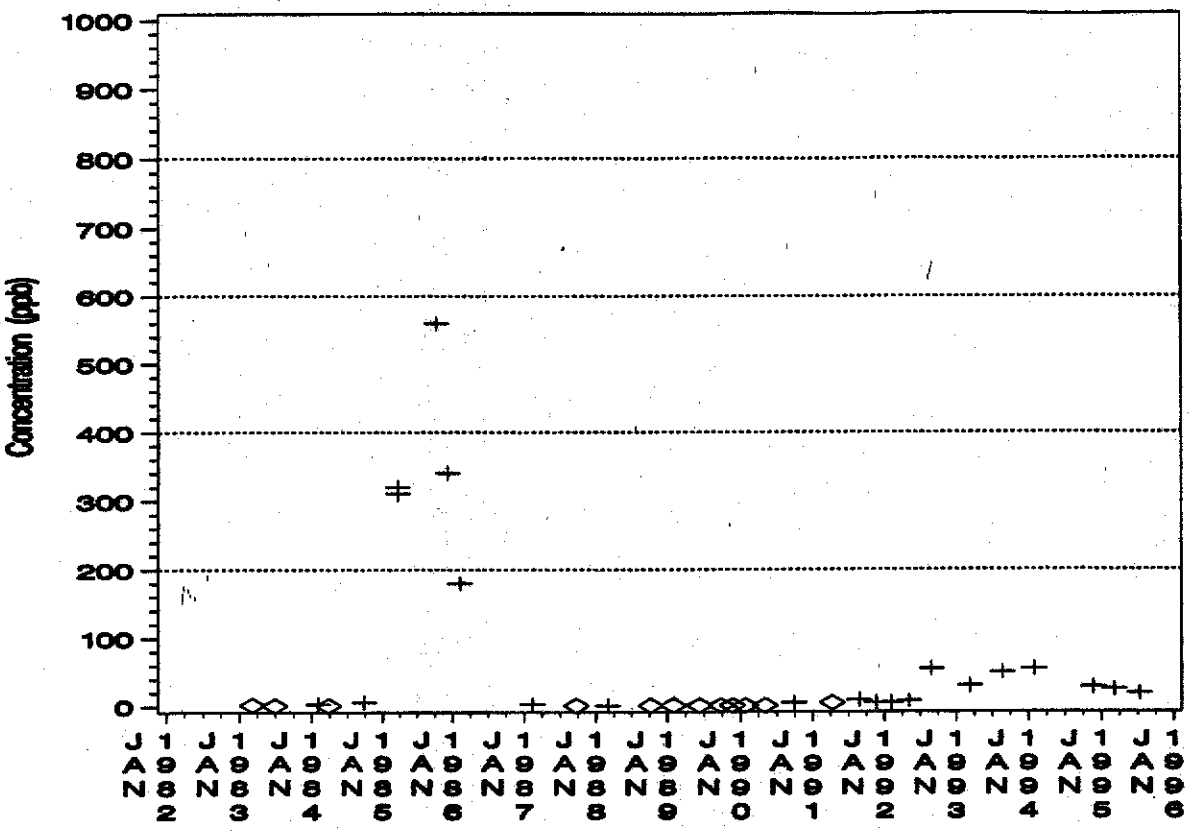
Legend for the following graphs:

◇ TCE value less than detection limit.

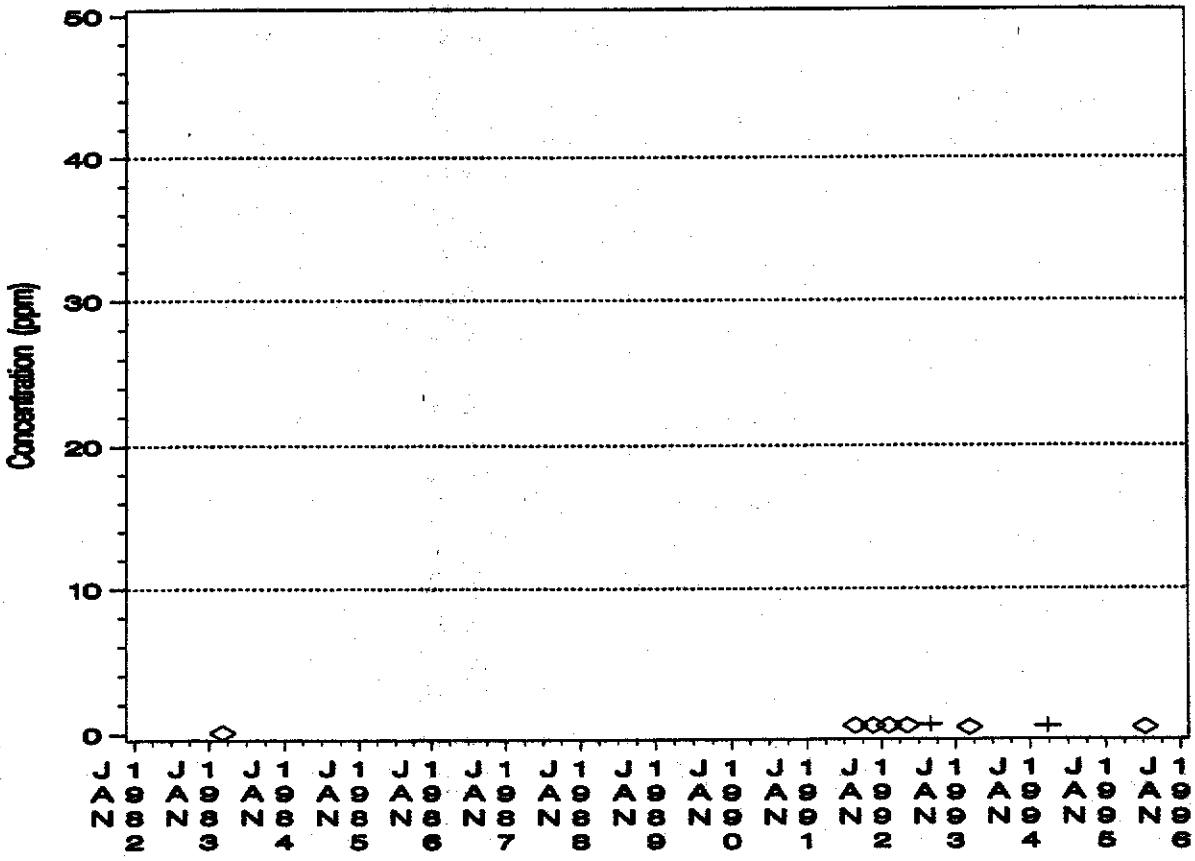
+ TCE value greater than or equal to detection limit.

C:\WP51\AEROJET\5049\TIME-SER.TBL

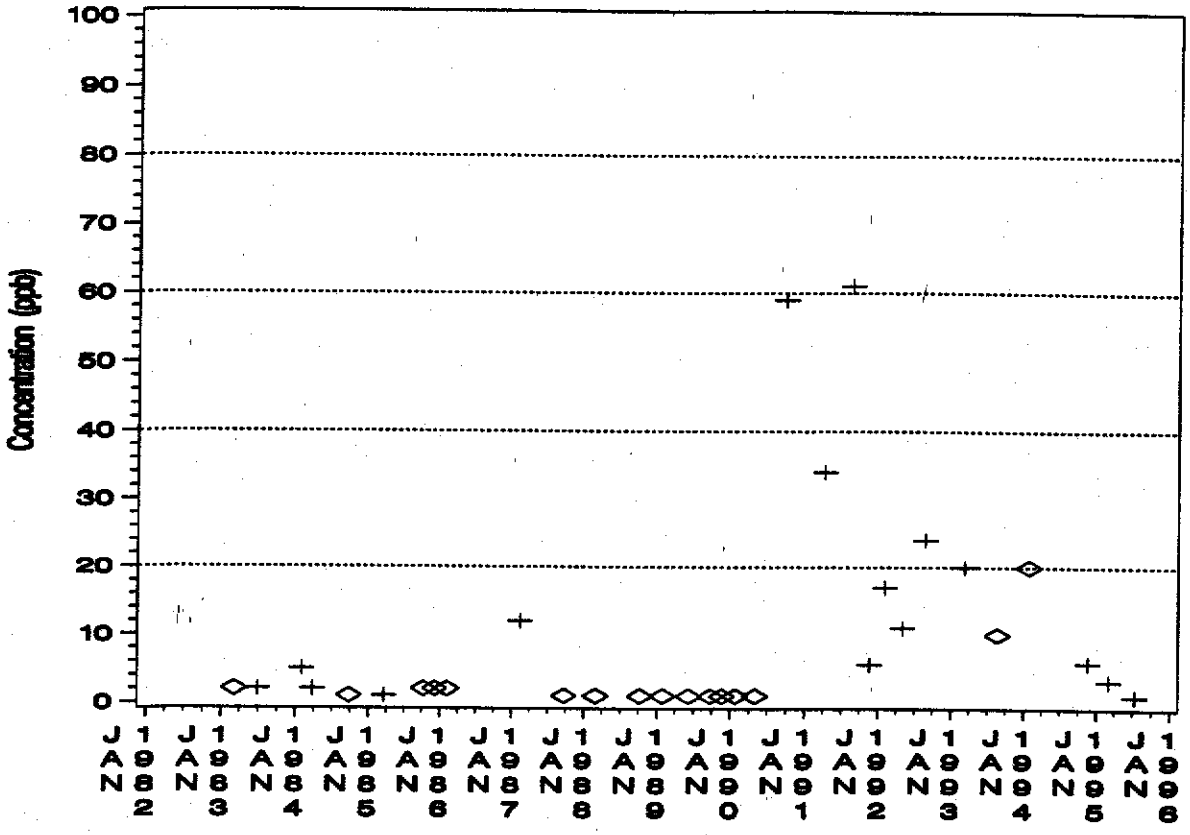
WELL 131
TRICHLOROETHYLENE Trend



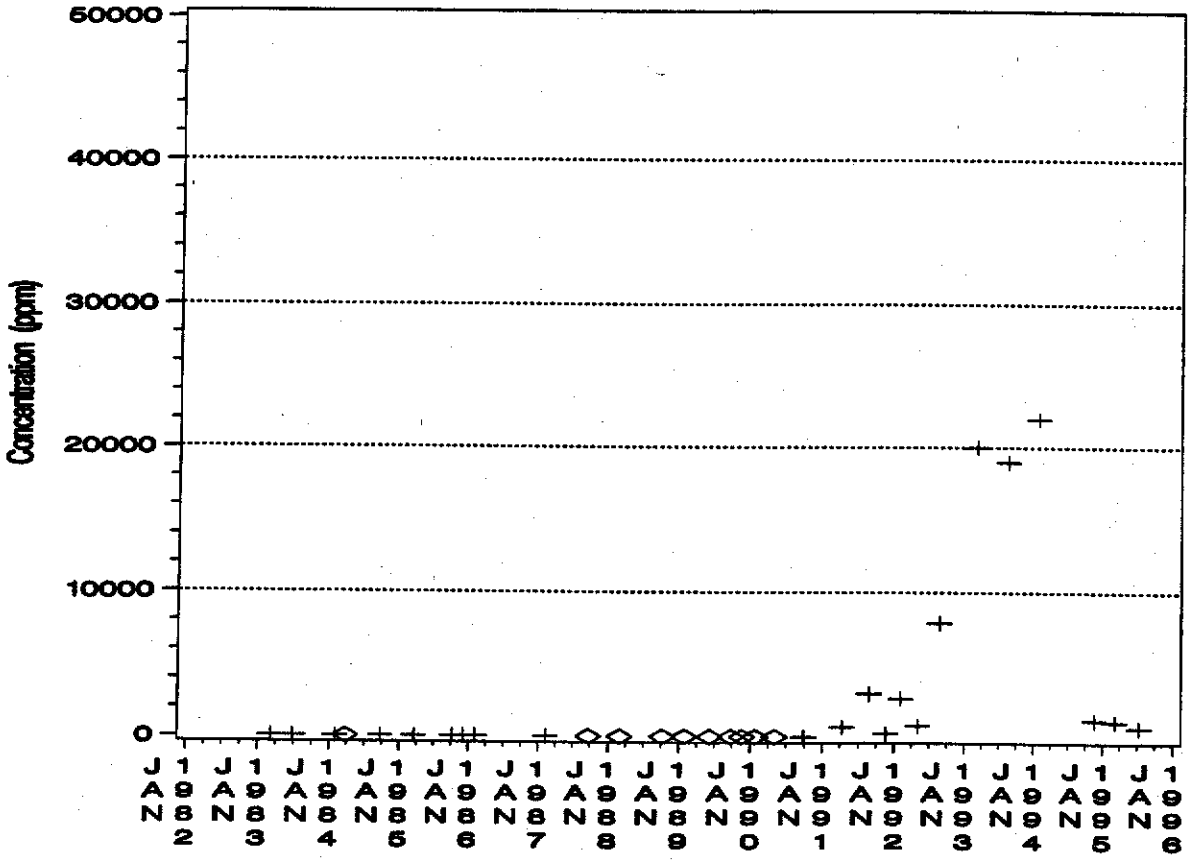
PERCHLORATE Trend



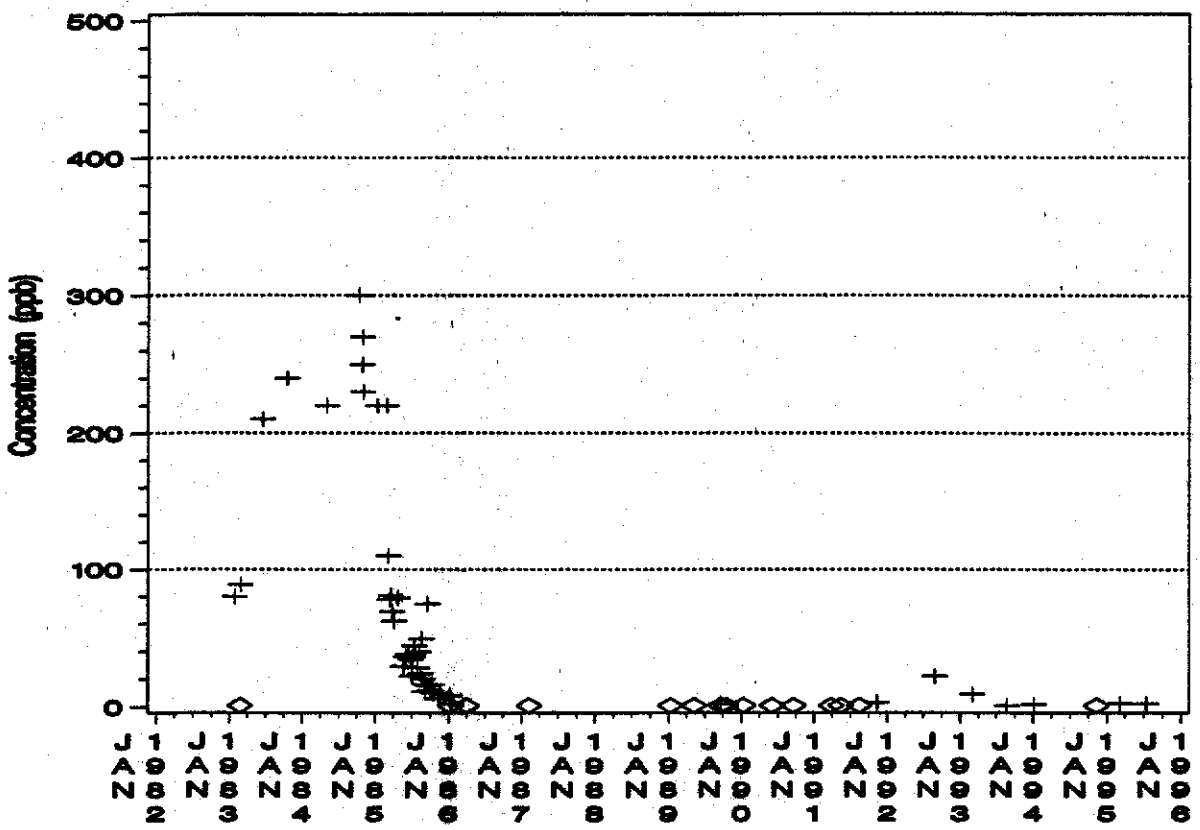
WELL 131
CHLOROFORM Trend



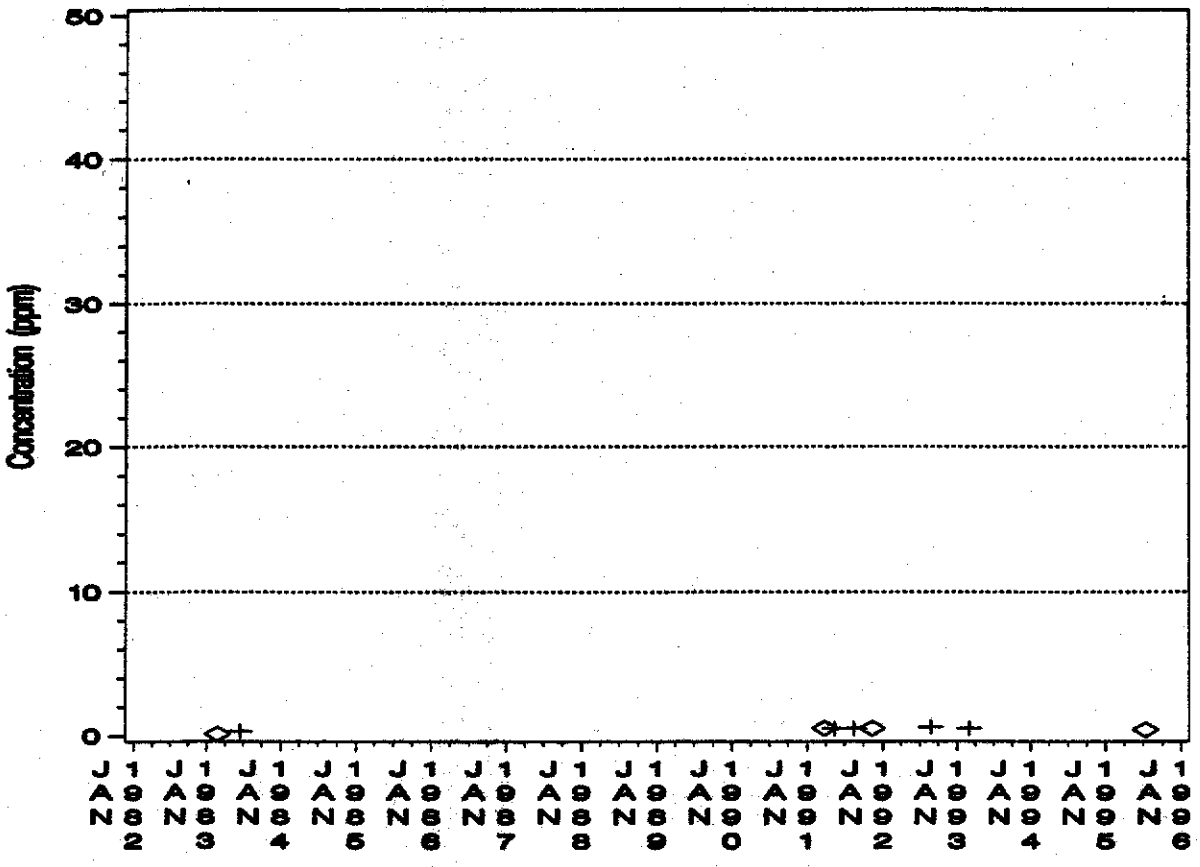
1,2 – DICHLOROETHANE Trend



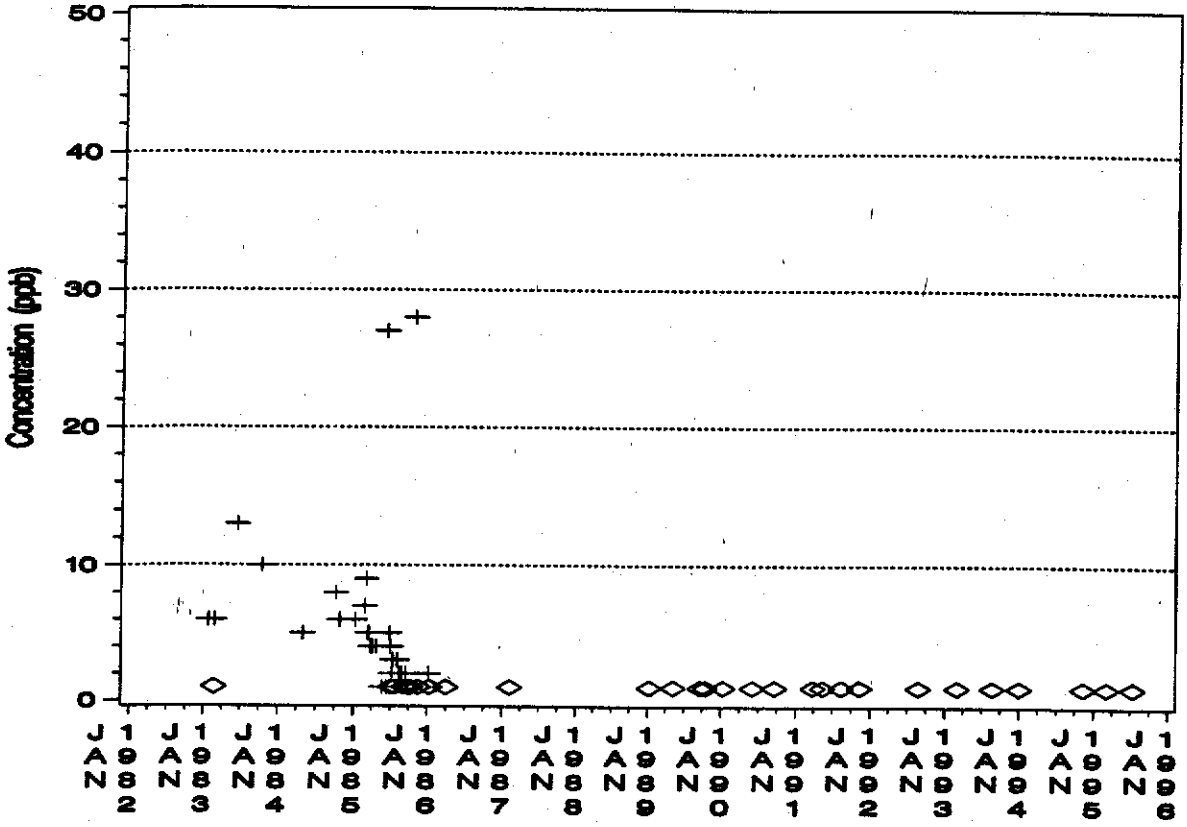
WELL 172
TRICHLOROETHYLENE Trend



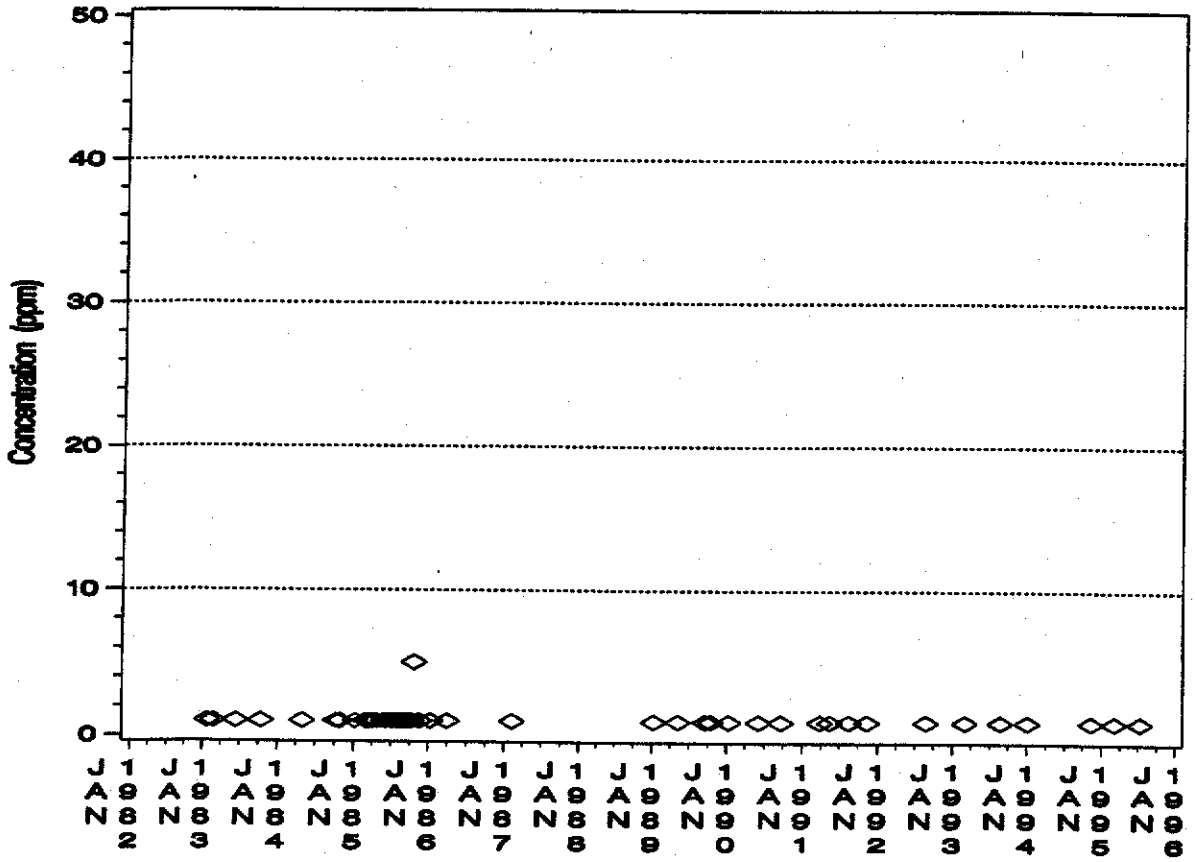
PERCHLORATE Trend



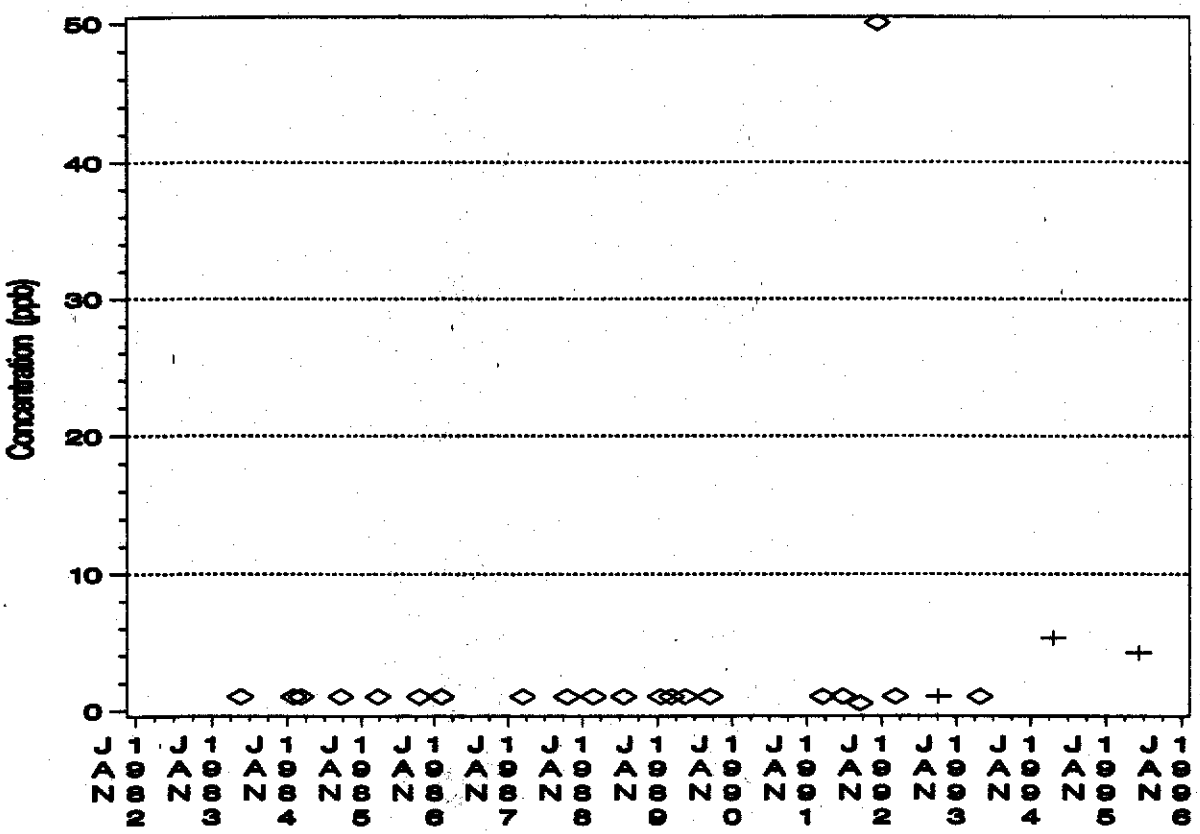
WELL 172
CHLOROFORM Trend



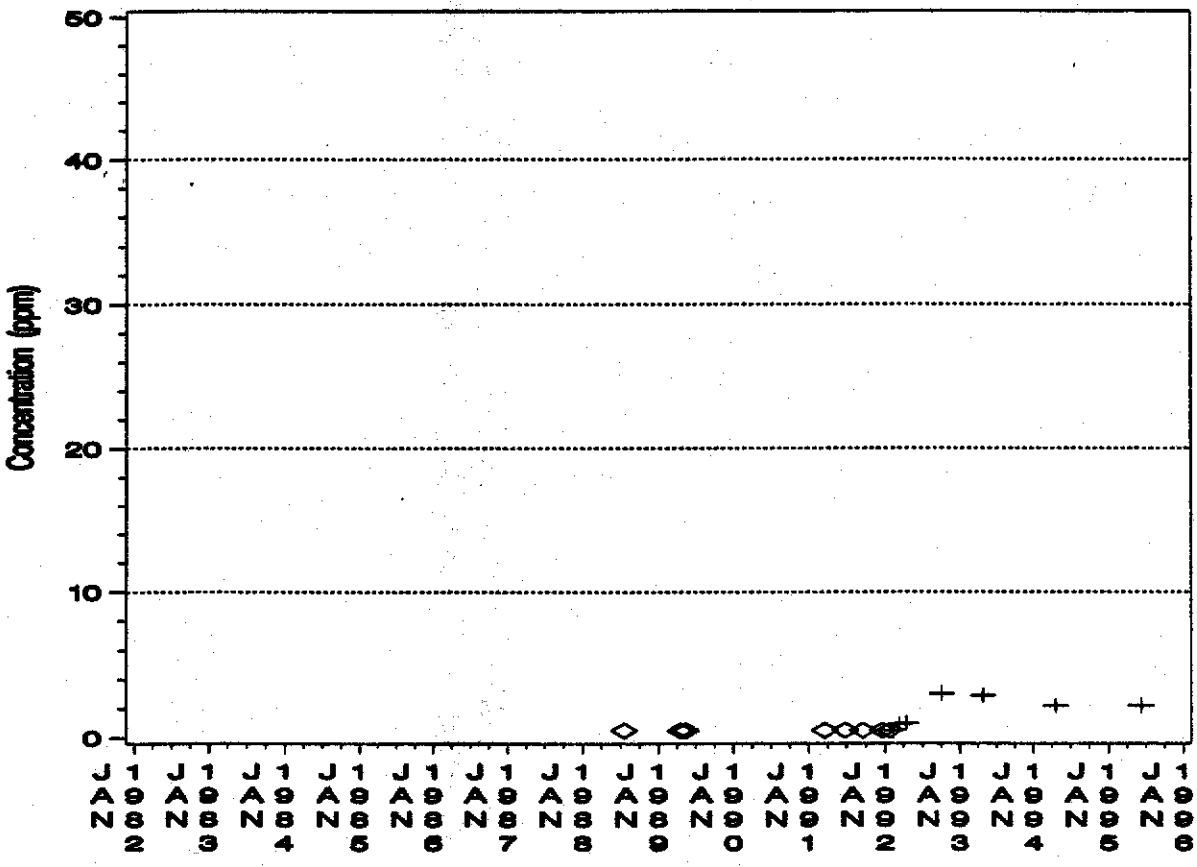
1,2 – DICHLOROETHANE Trend



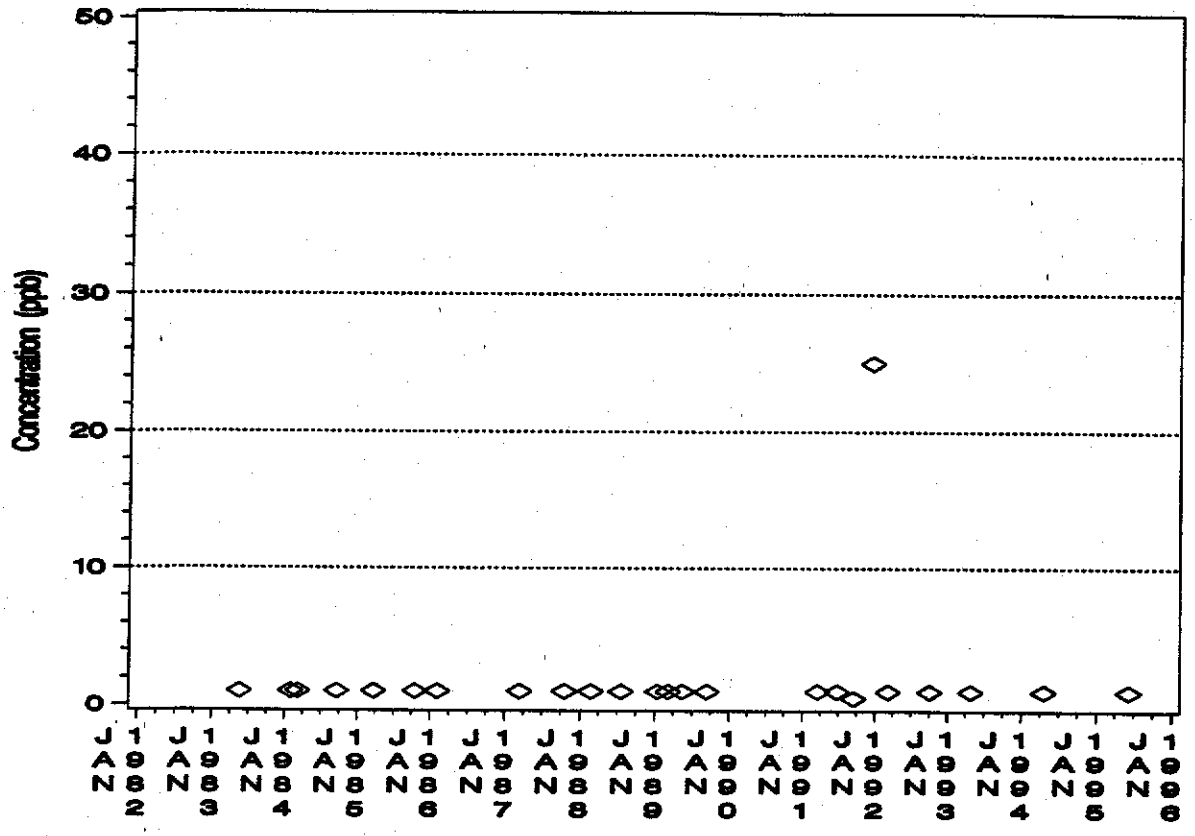
WELL 206
TRICHLOROETHYLENE Trend



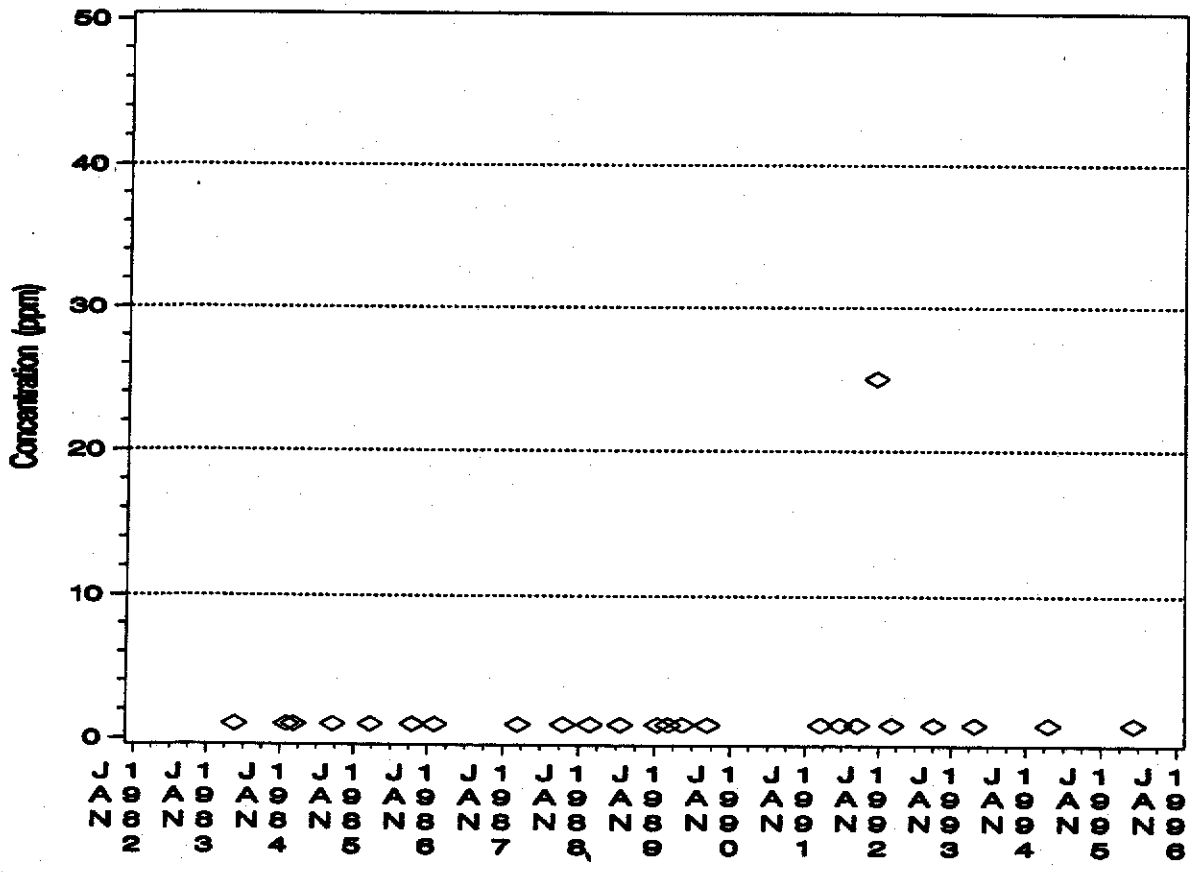
PERCHLORATE Trend



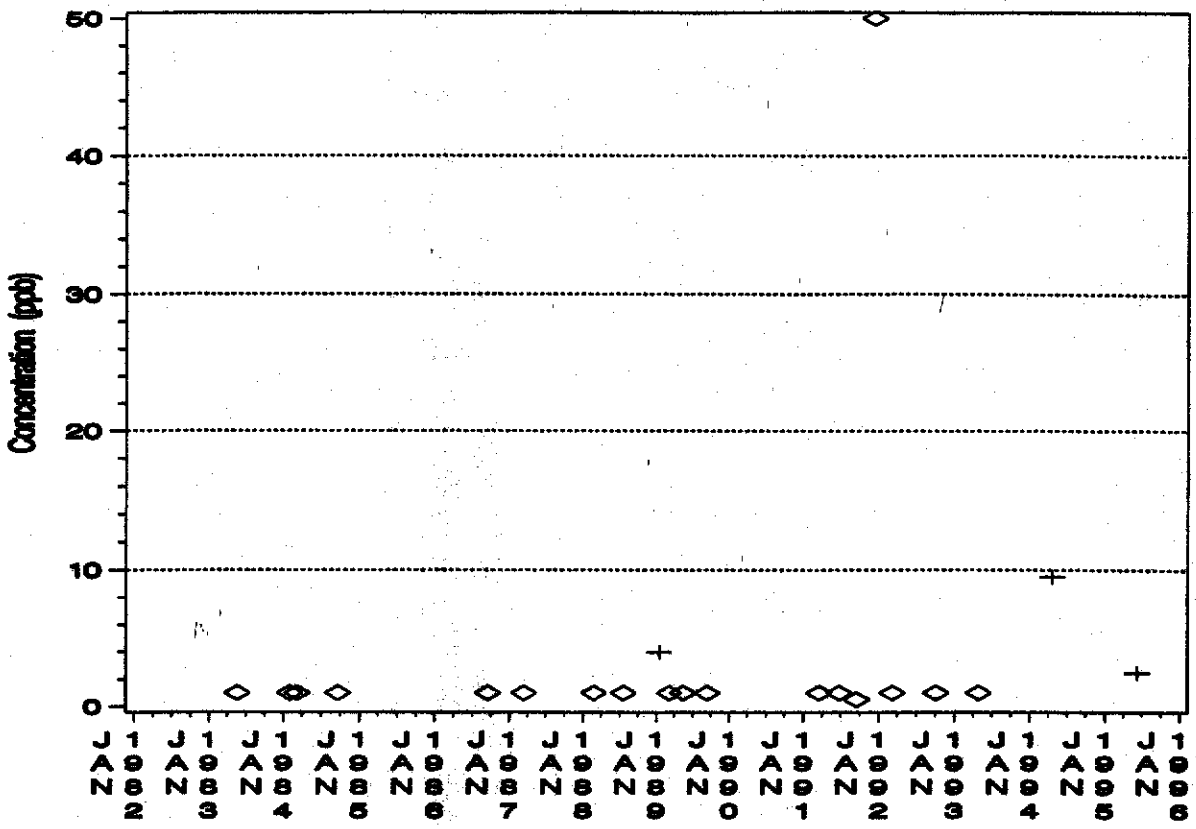
WELL 206
CHLOROFORM Trend



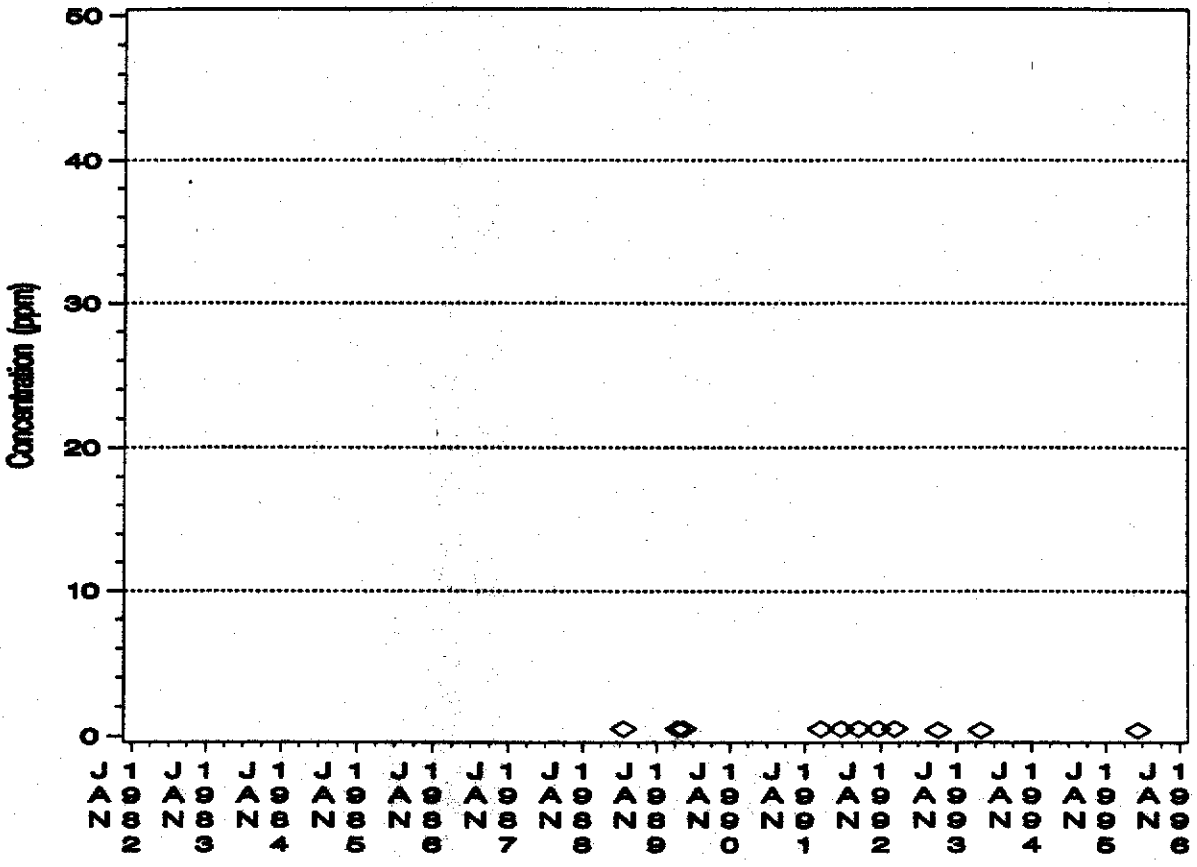
1,2 – DICHLOROETHANE Trend



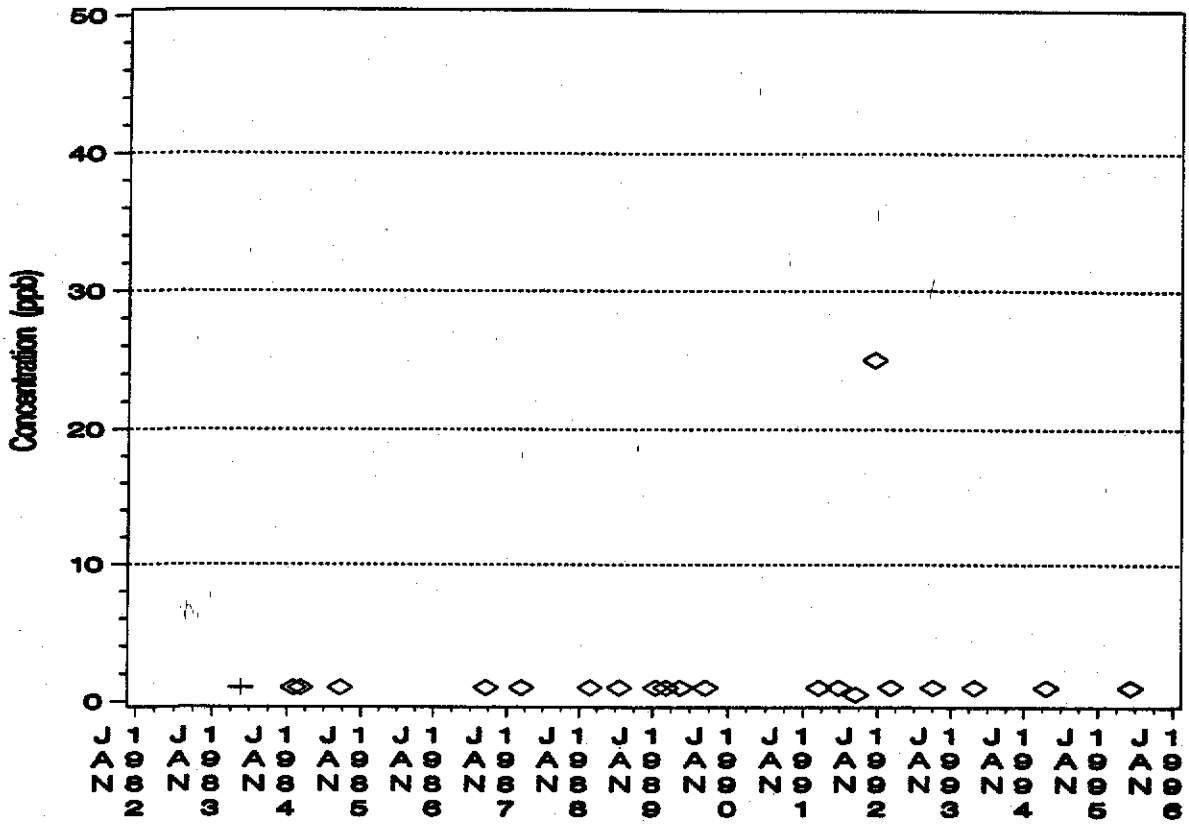
WELL 207
TRICHLOROETHYLENE Trend



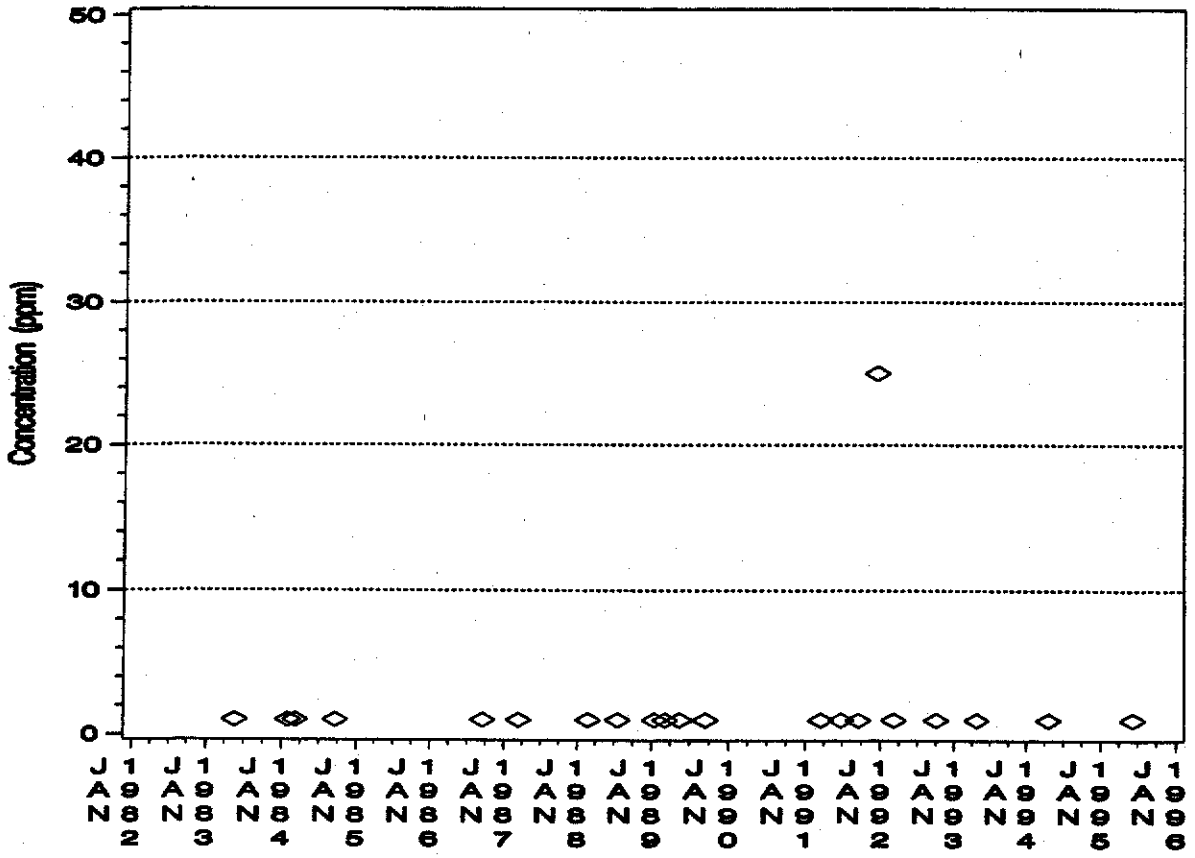
PERCHLORATE Trend



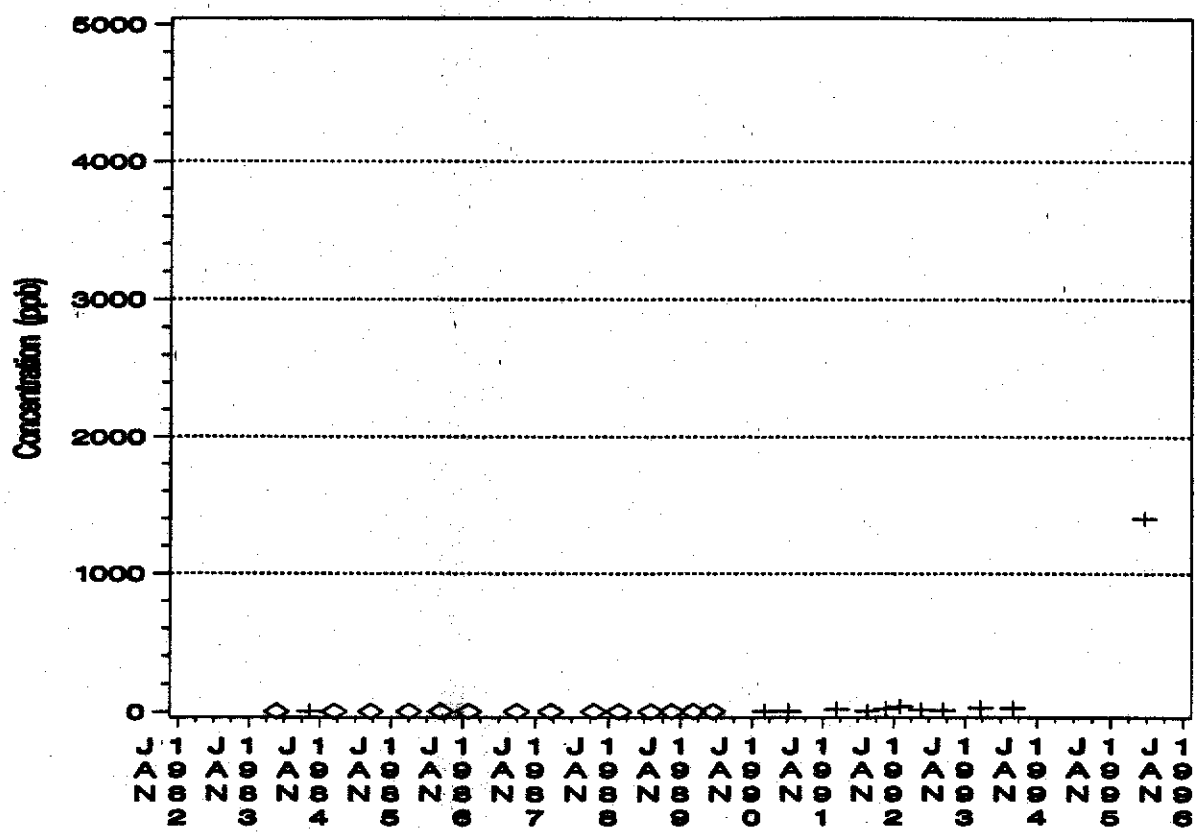
WELL 207
CHLOROFORM Trend



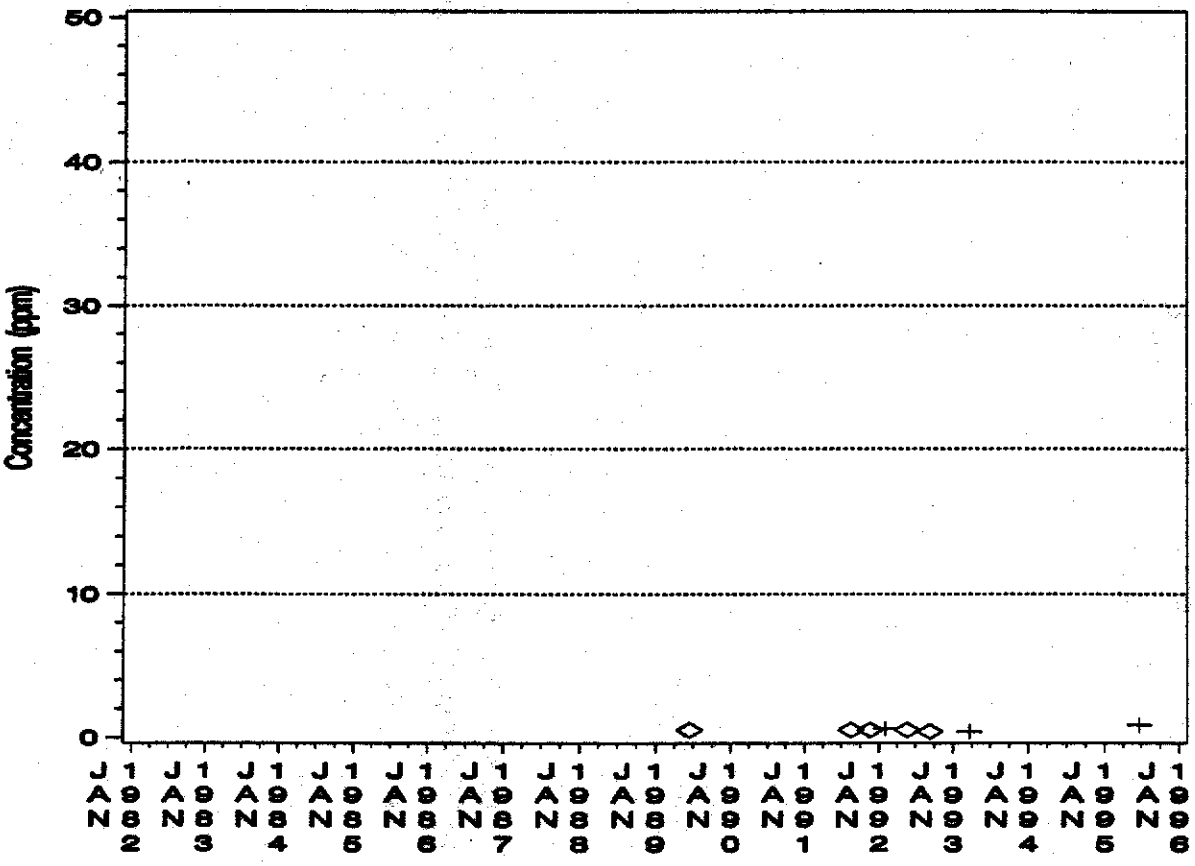
1,2 – DICHLOROETHANE Trend



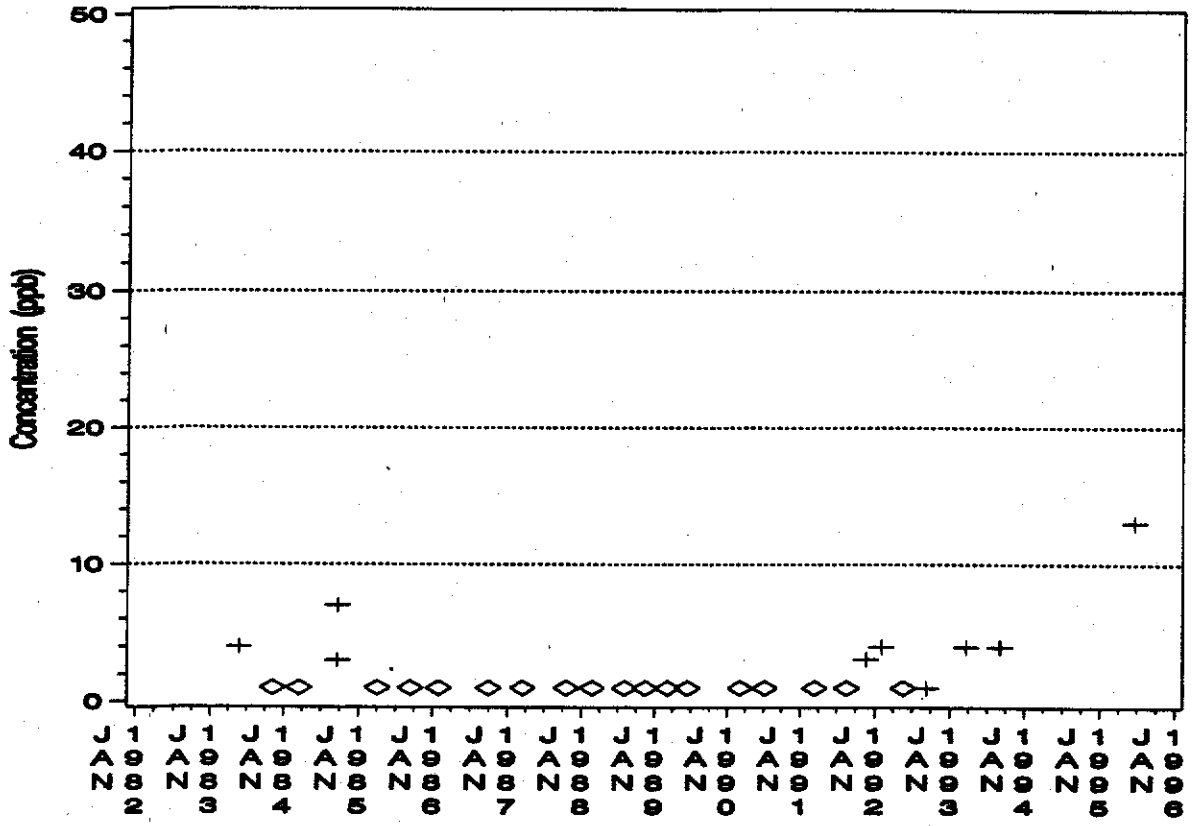
WELL 222
TRICHLOROETHYLENE Trend



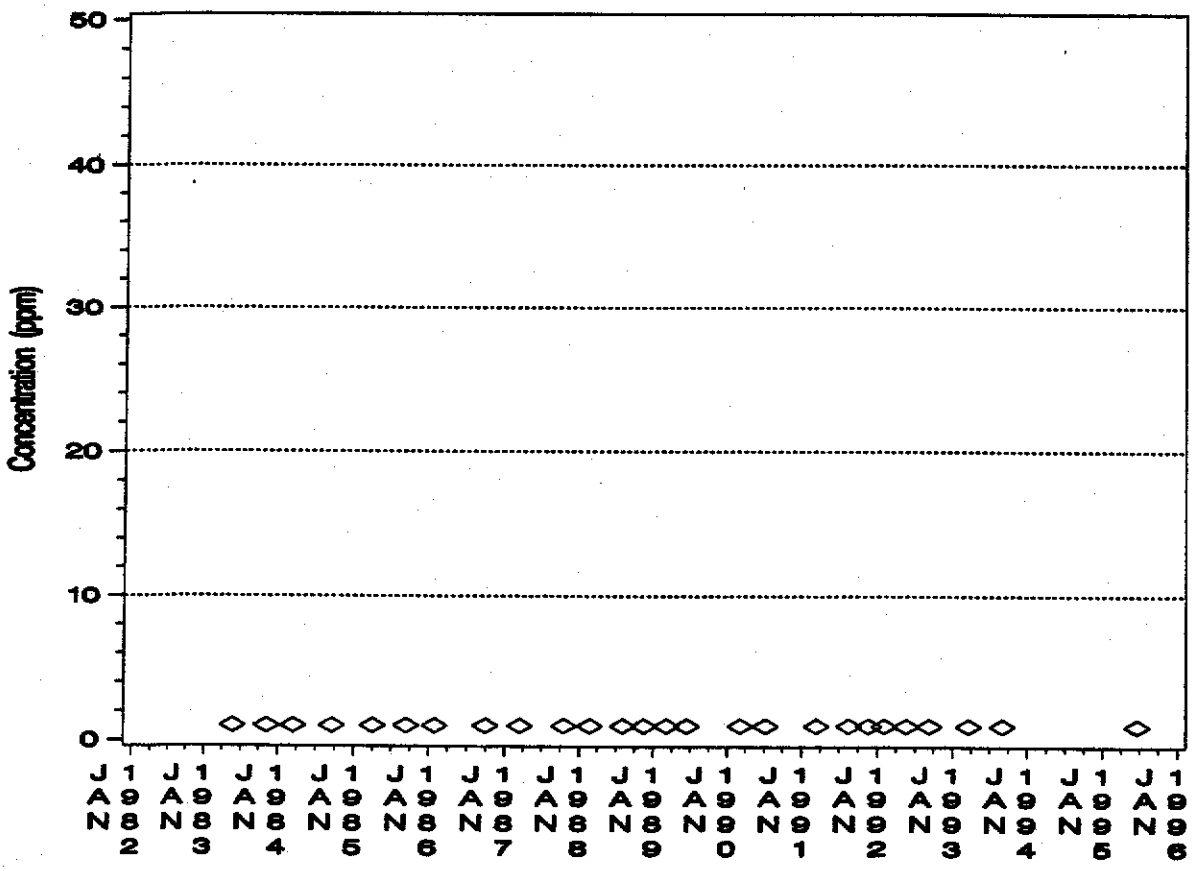
PERCHLORATE Trend



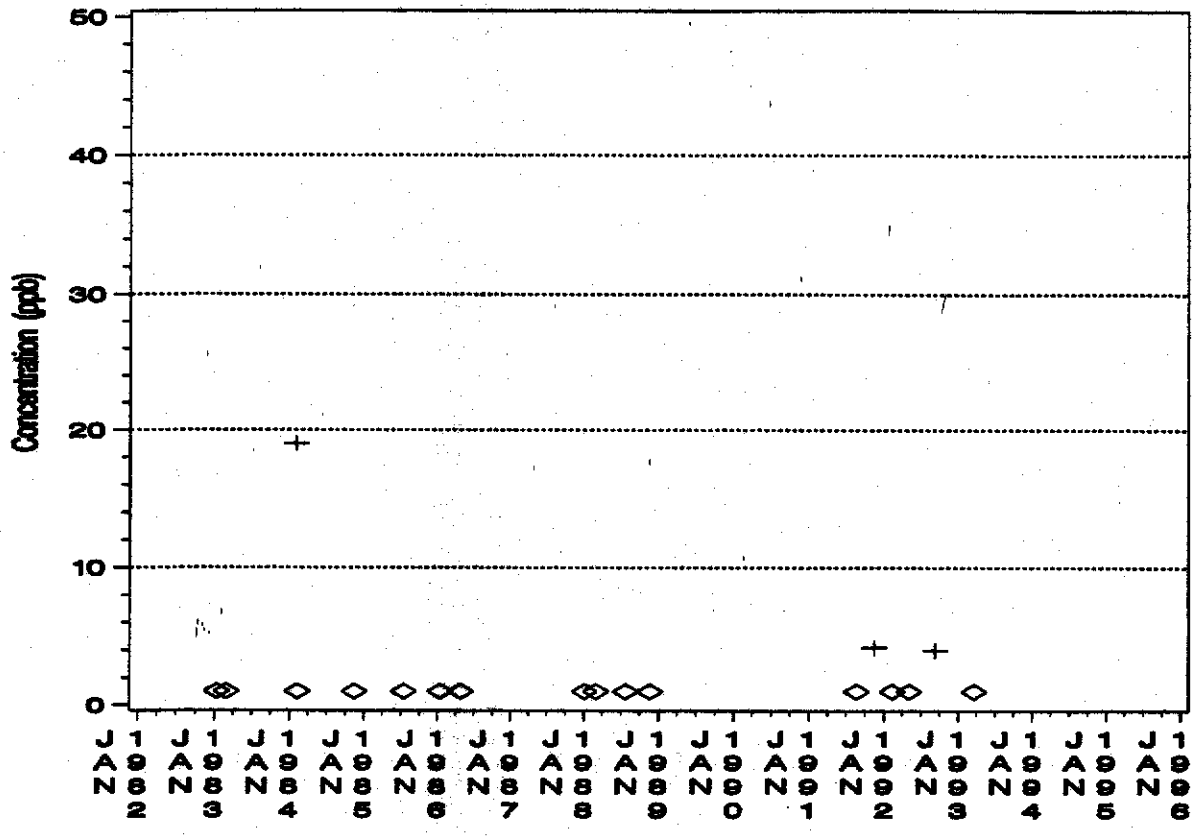
WELL 222
CHLOROFORM Trend



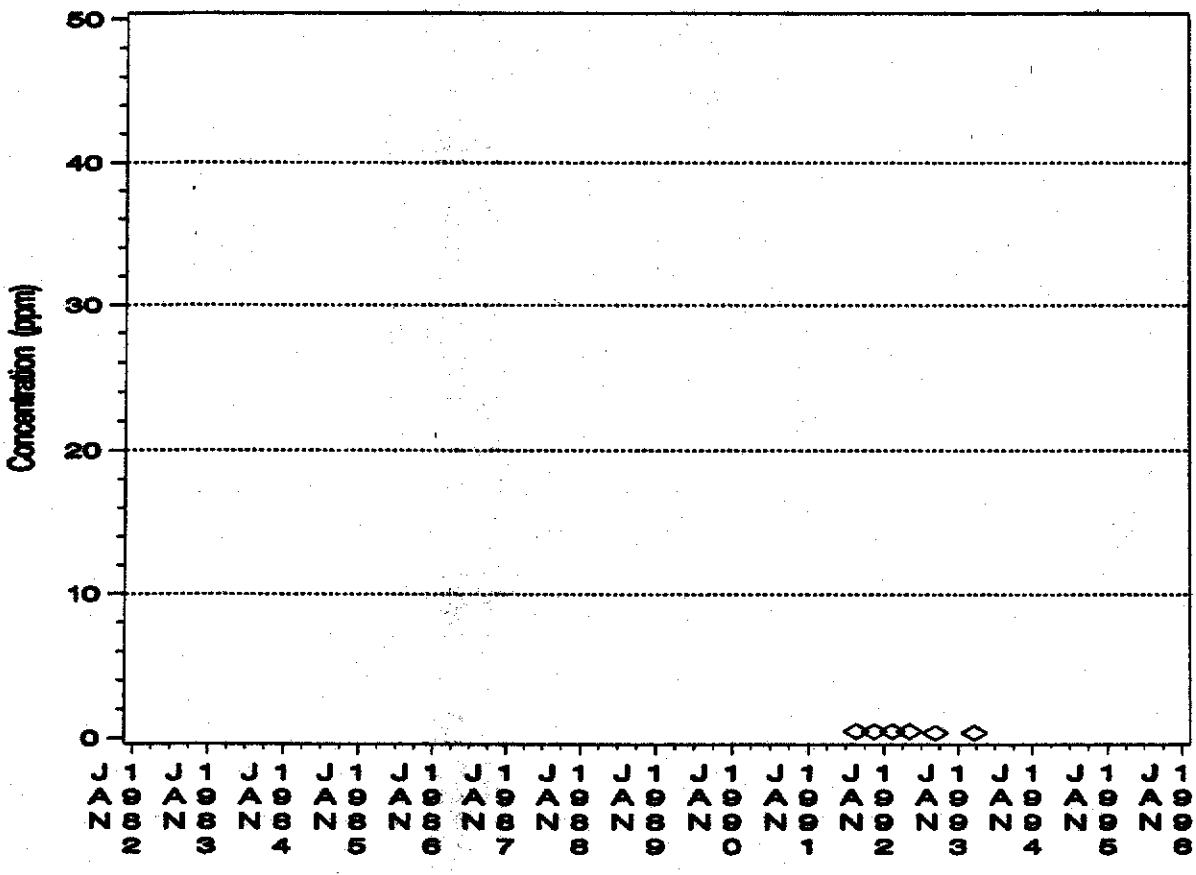
1,2 – DICHLOROETHANE Trend



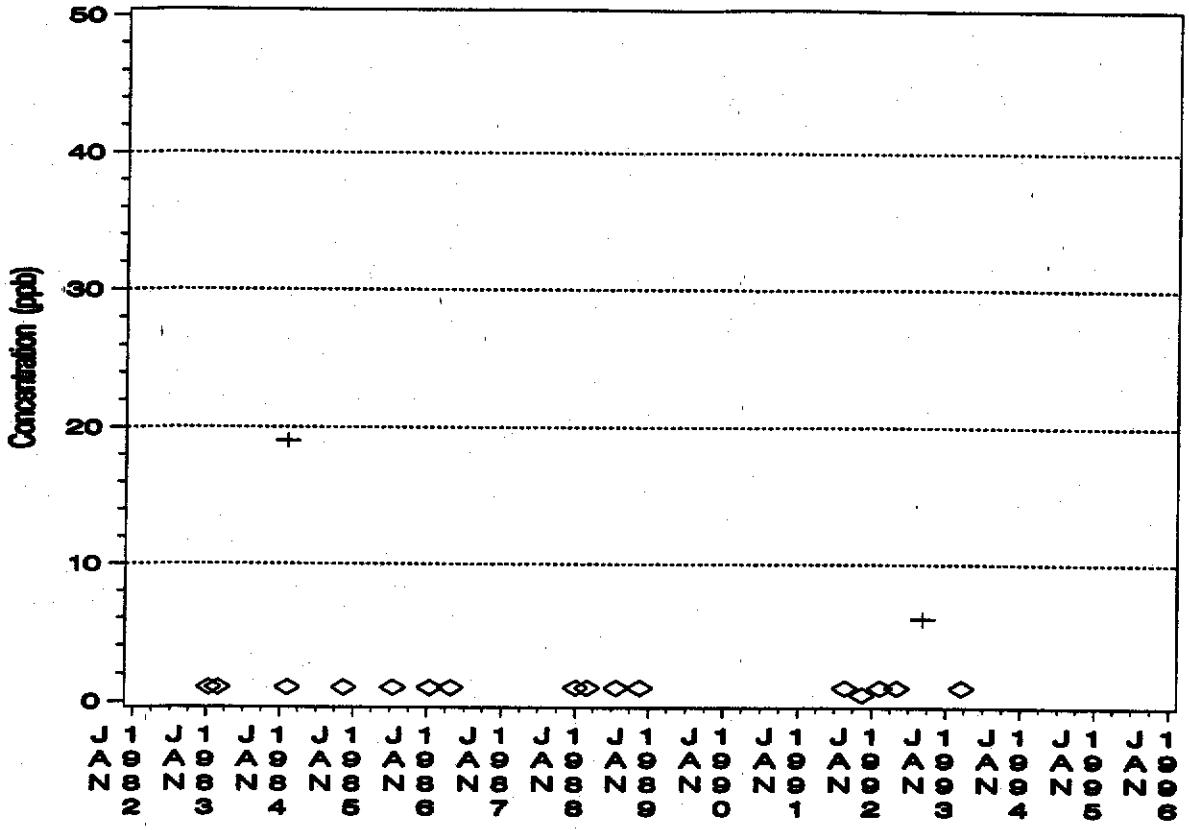
WELL 235
TRICHLOROETHYLENE Trend



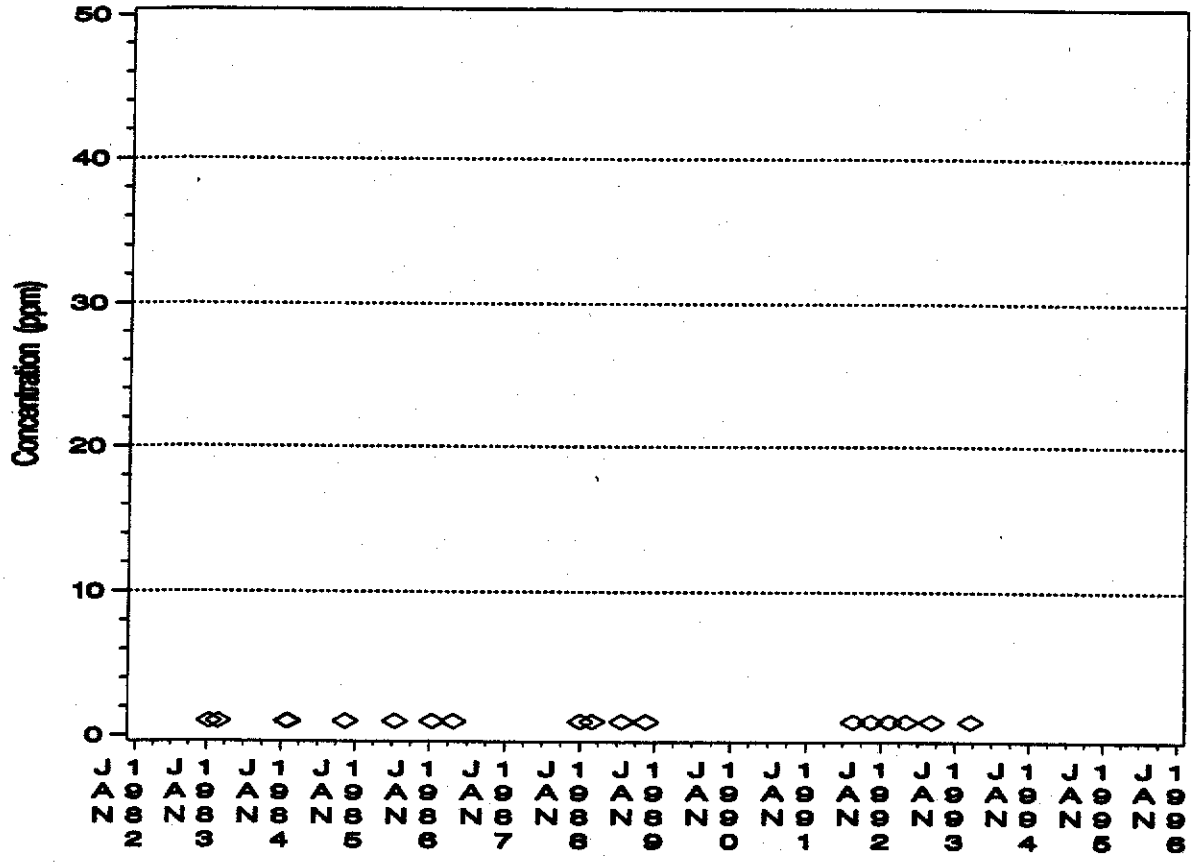
PERCHLORATE Trend



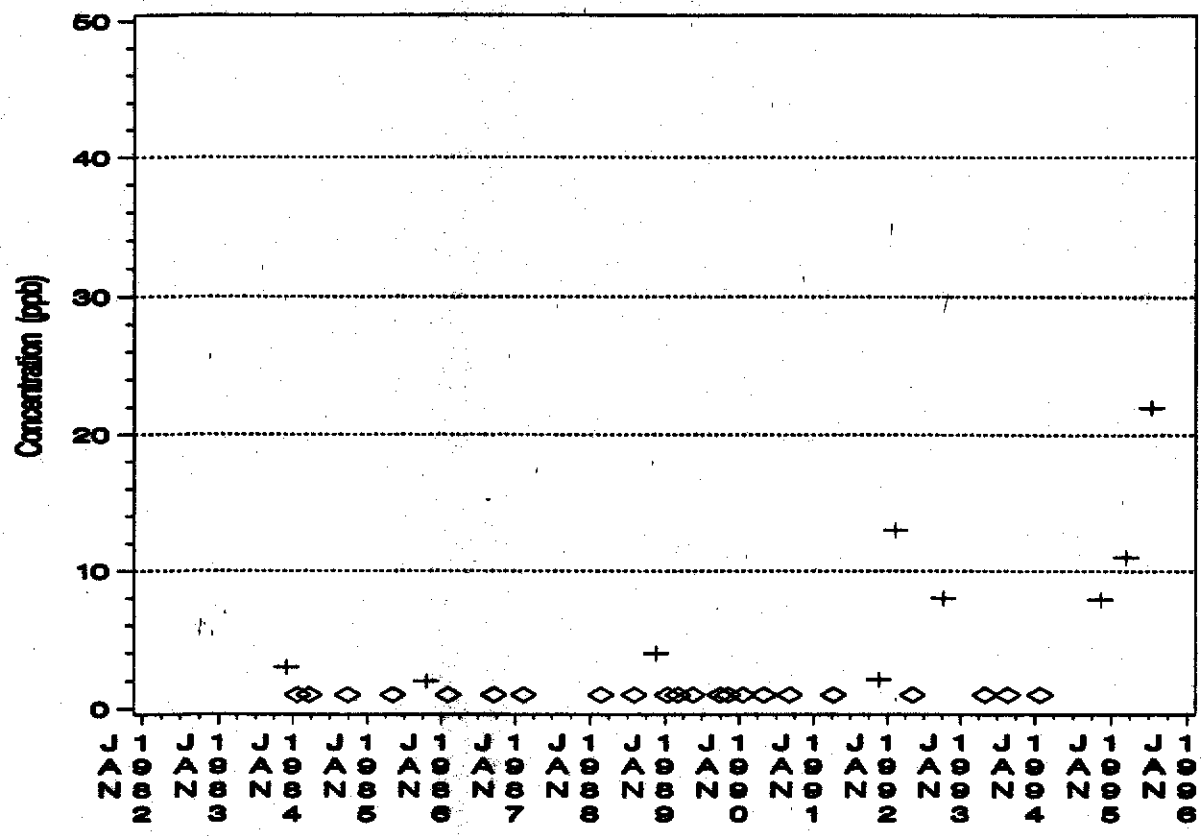
WELL 235
CHLOROFORM Trend



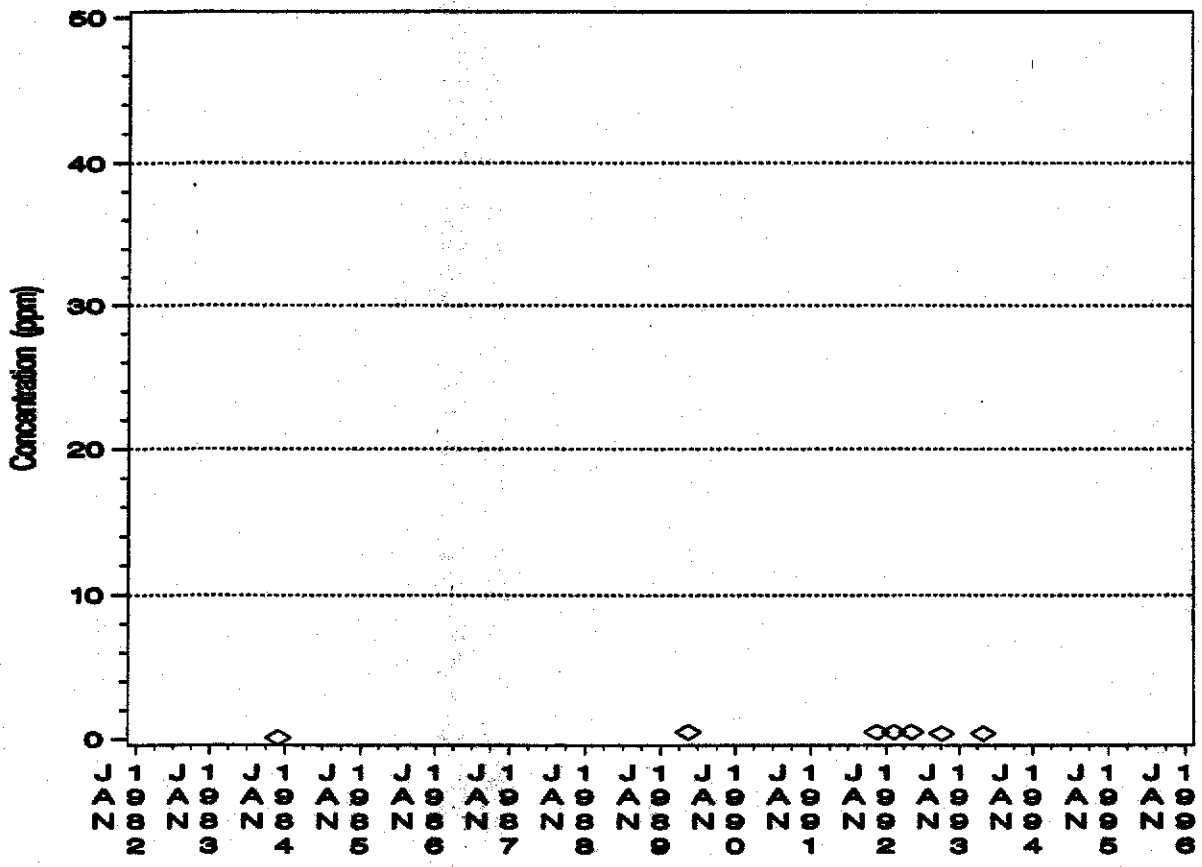
1,2 – DICHLOROETHANE Trend



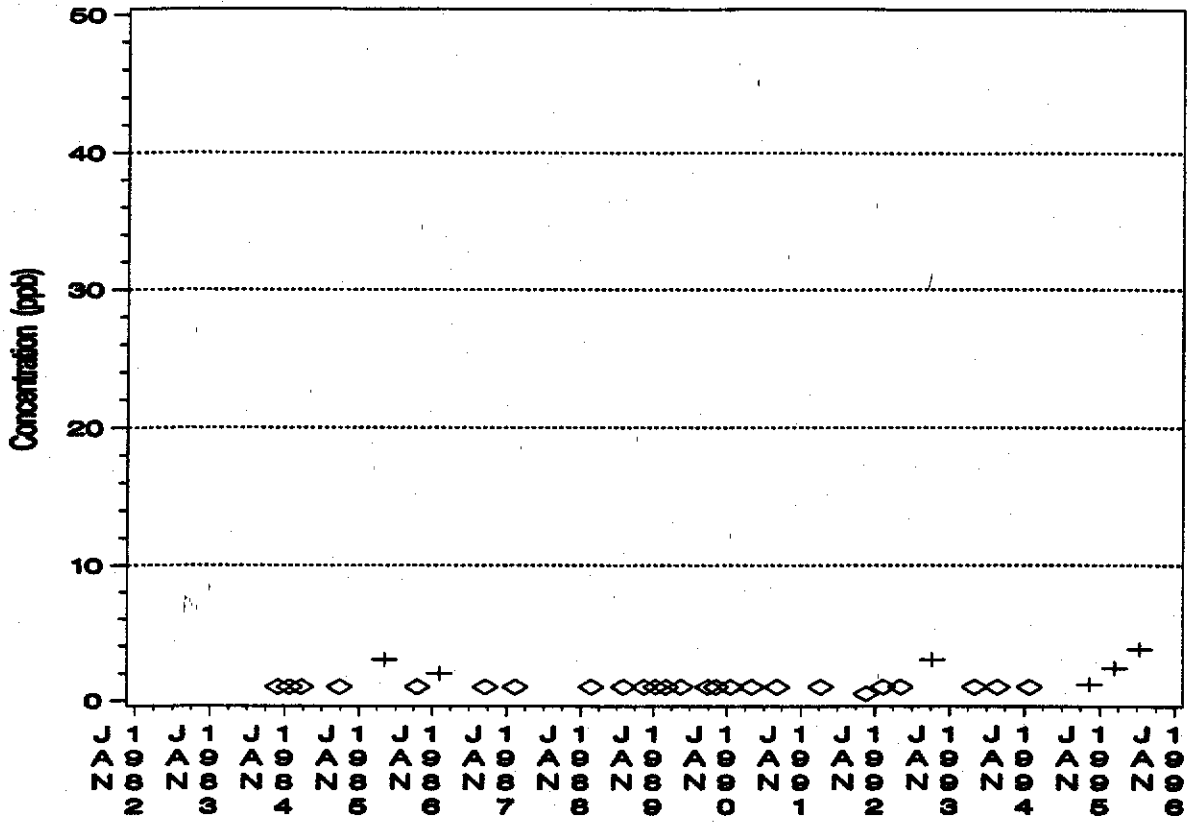
WELL 401
TRICHLOROETHYLENE Trend



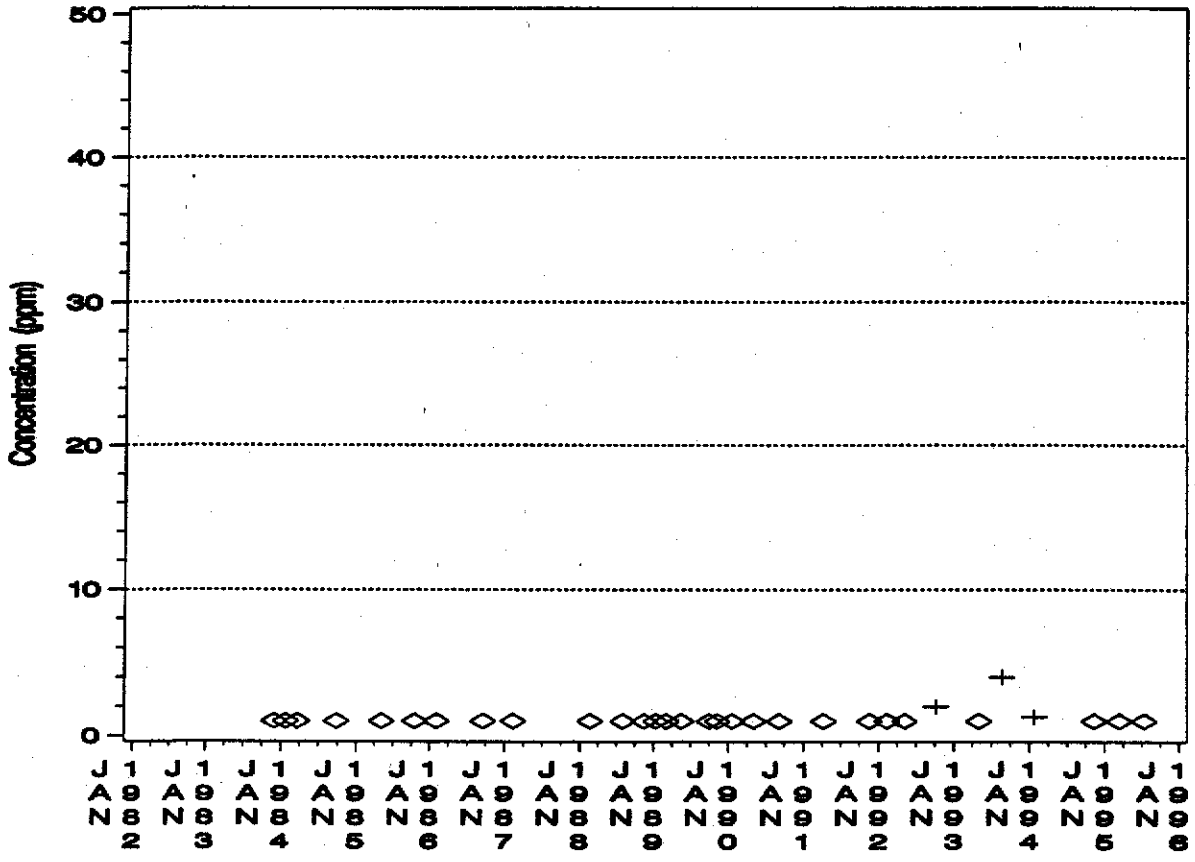
PERCHLORATE Trend



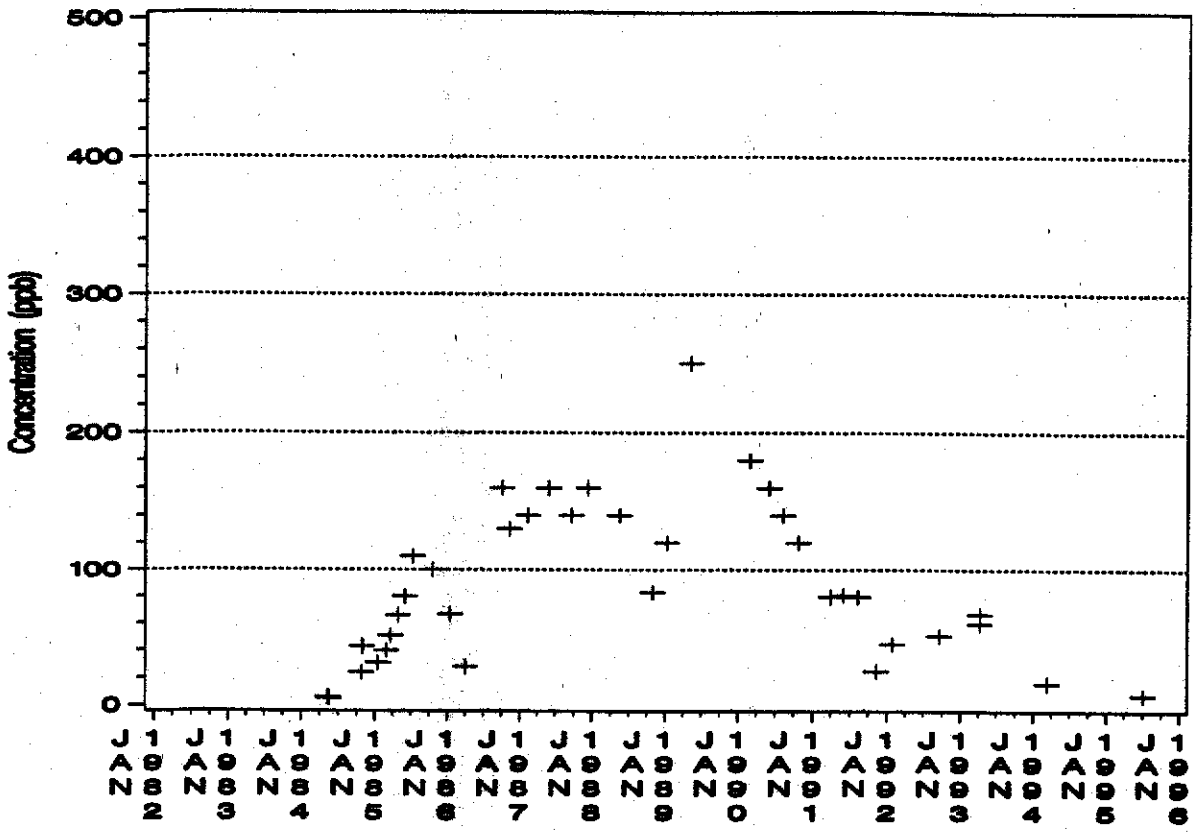
WELL 401
CHLOROFORM Trend



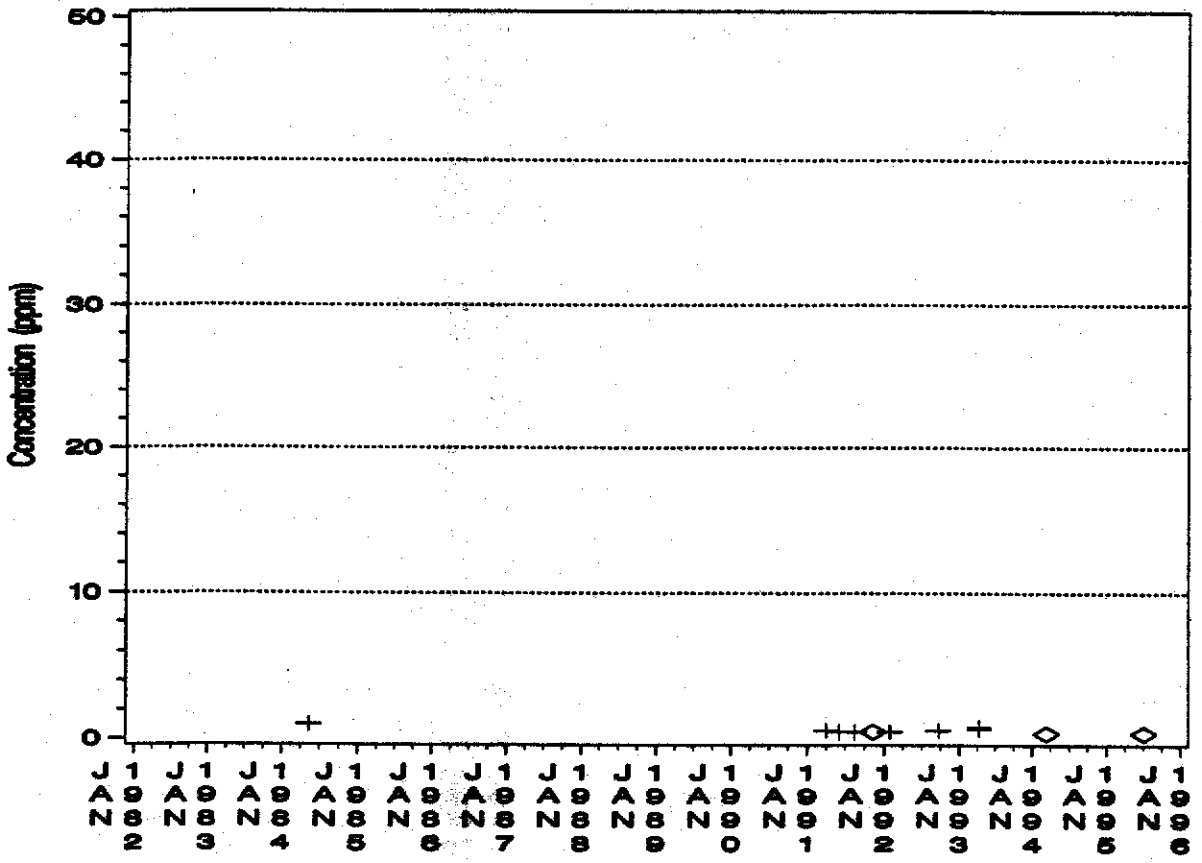
1,2 – DICHLOROETHANE Trend



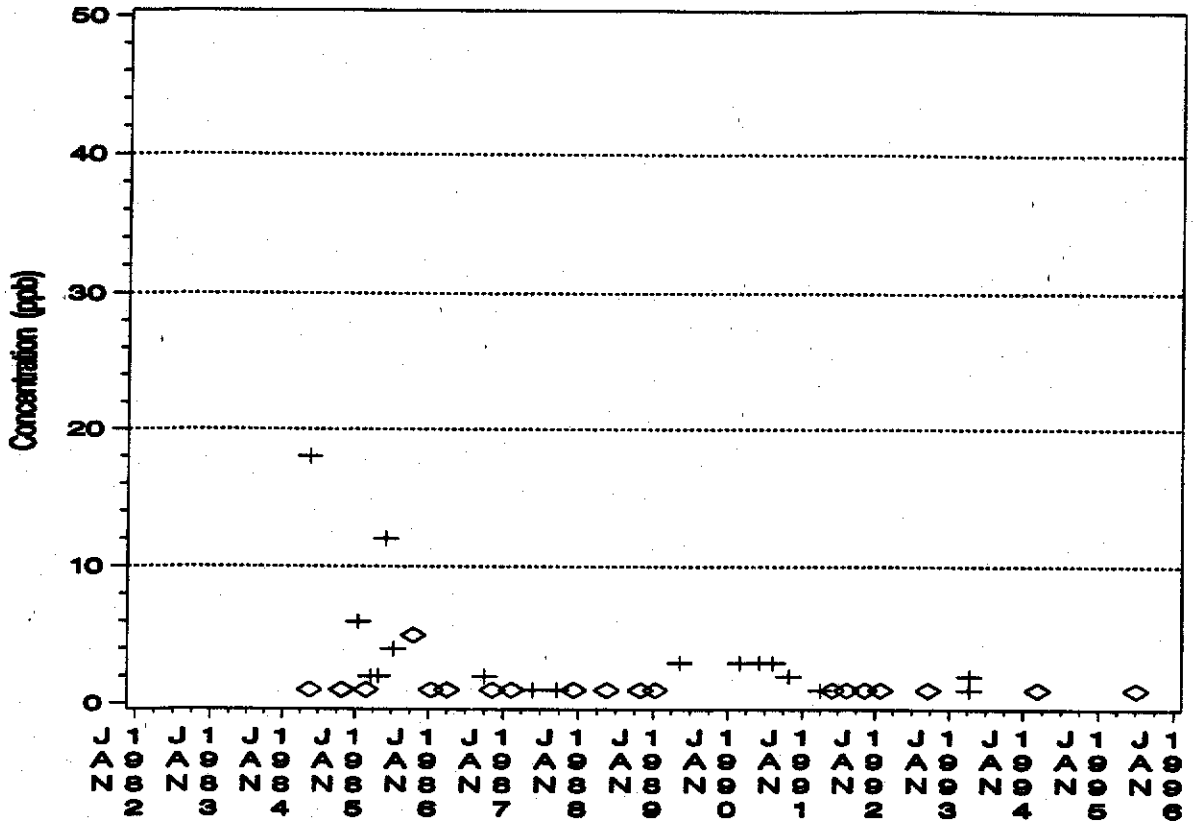
WELL 446
TRICHLOROETHYLENE Trend



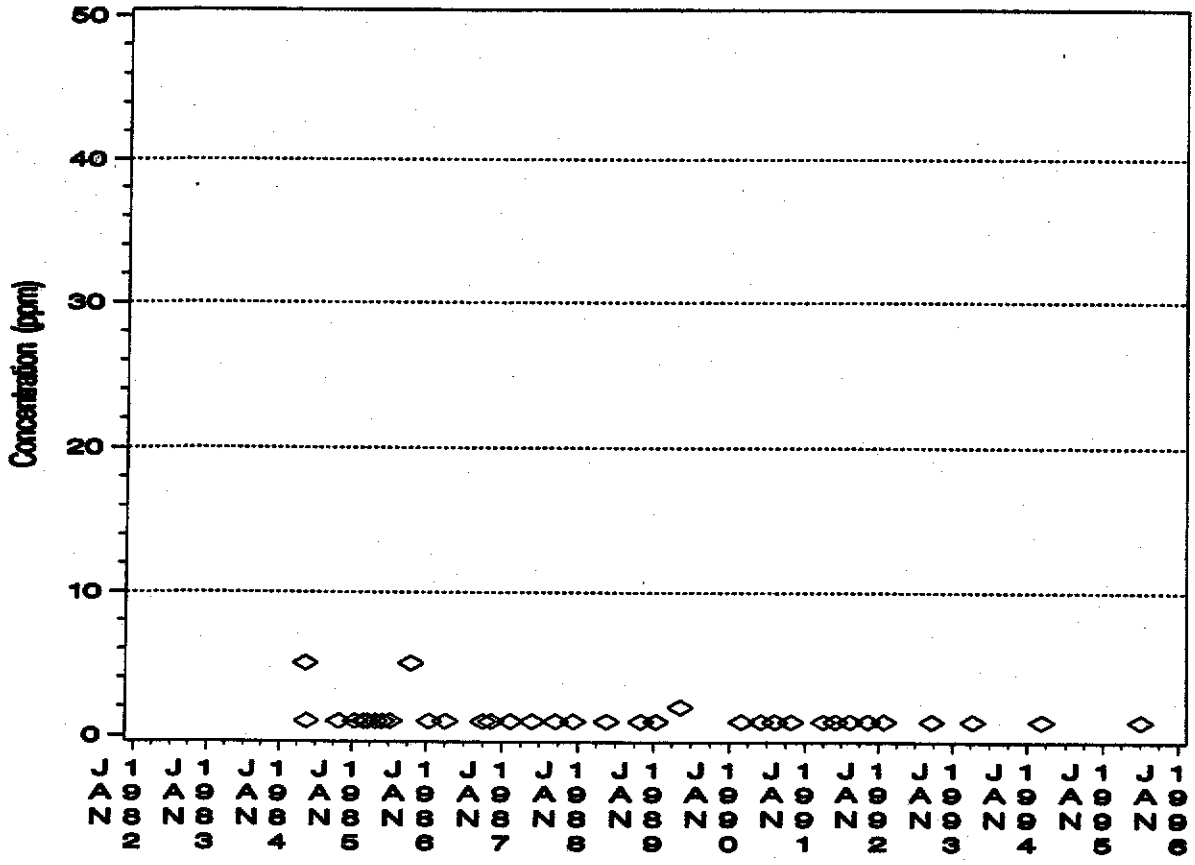
PERCHLORATE Trend



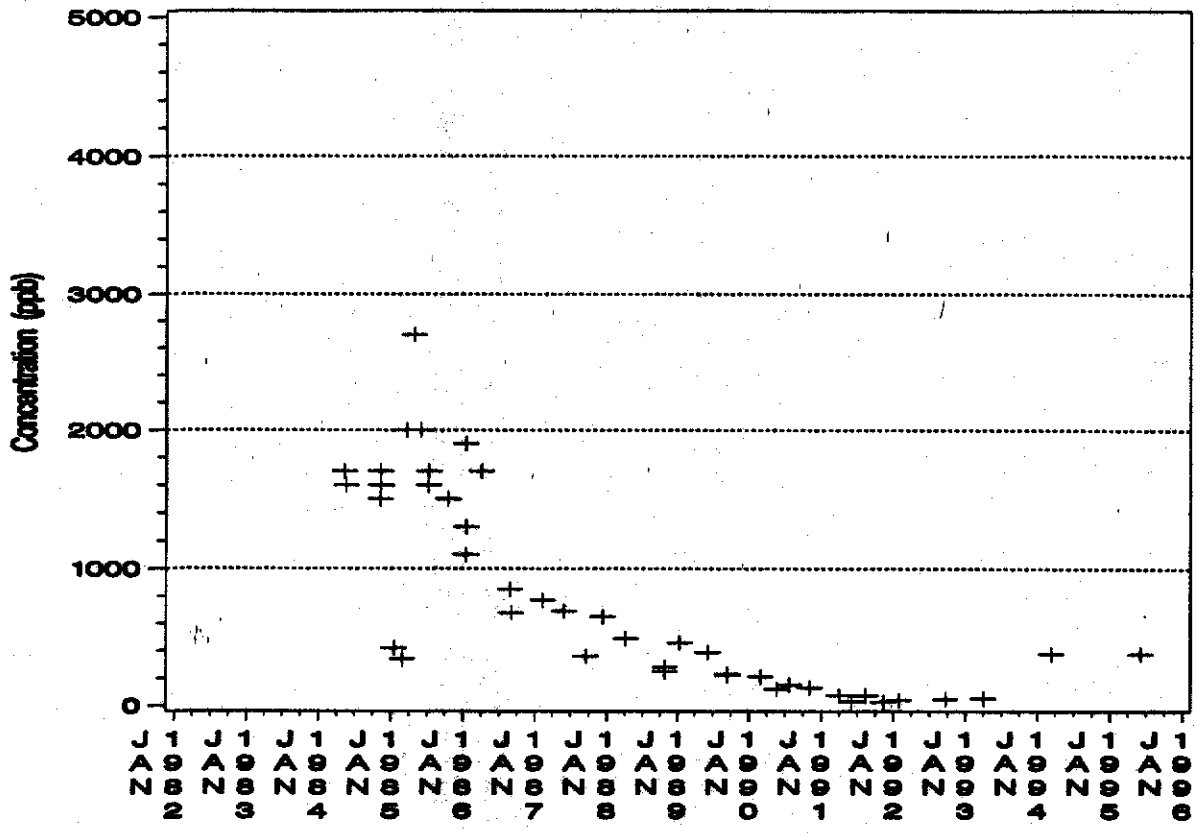
WELL 446
CHLOROFORM Trend



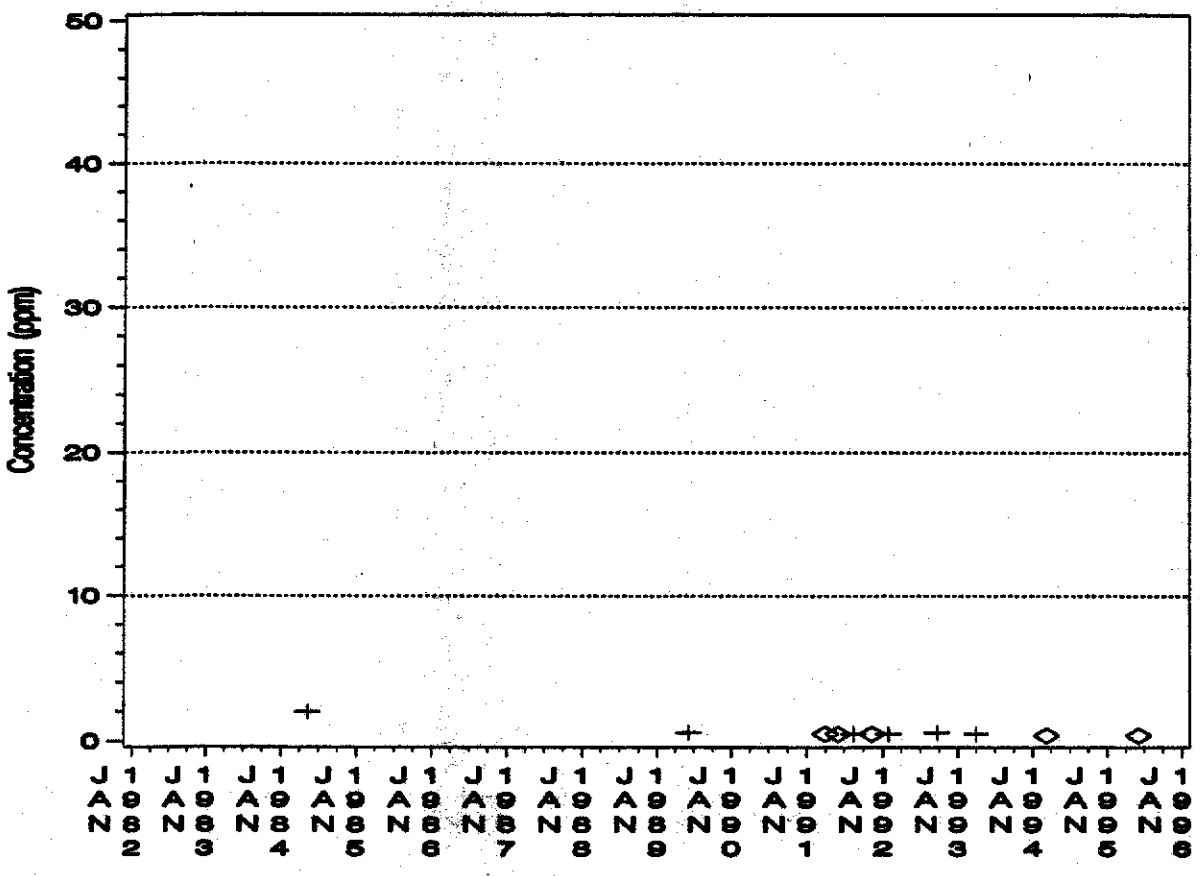
1,2 – DICHLOROETHANE Trend



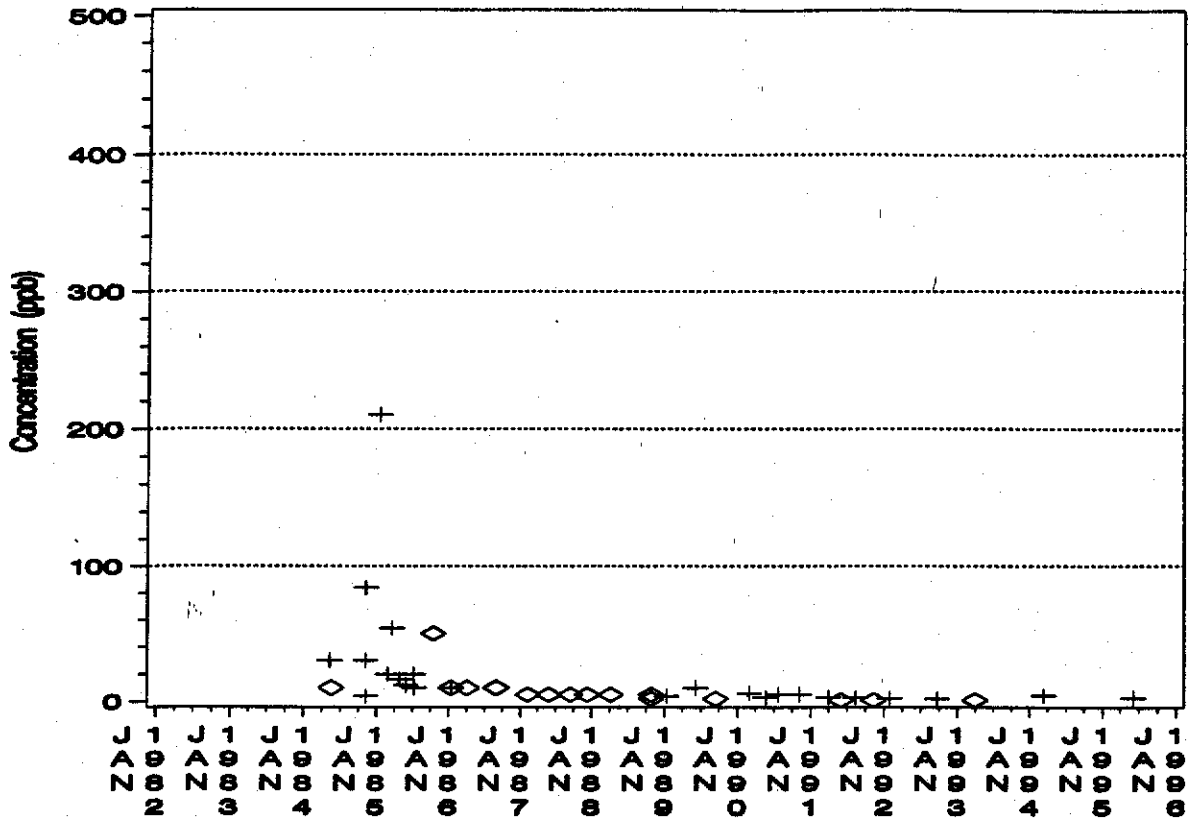
WELL 447
TRICHLOROETHYLENE Trend



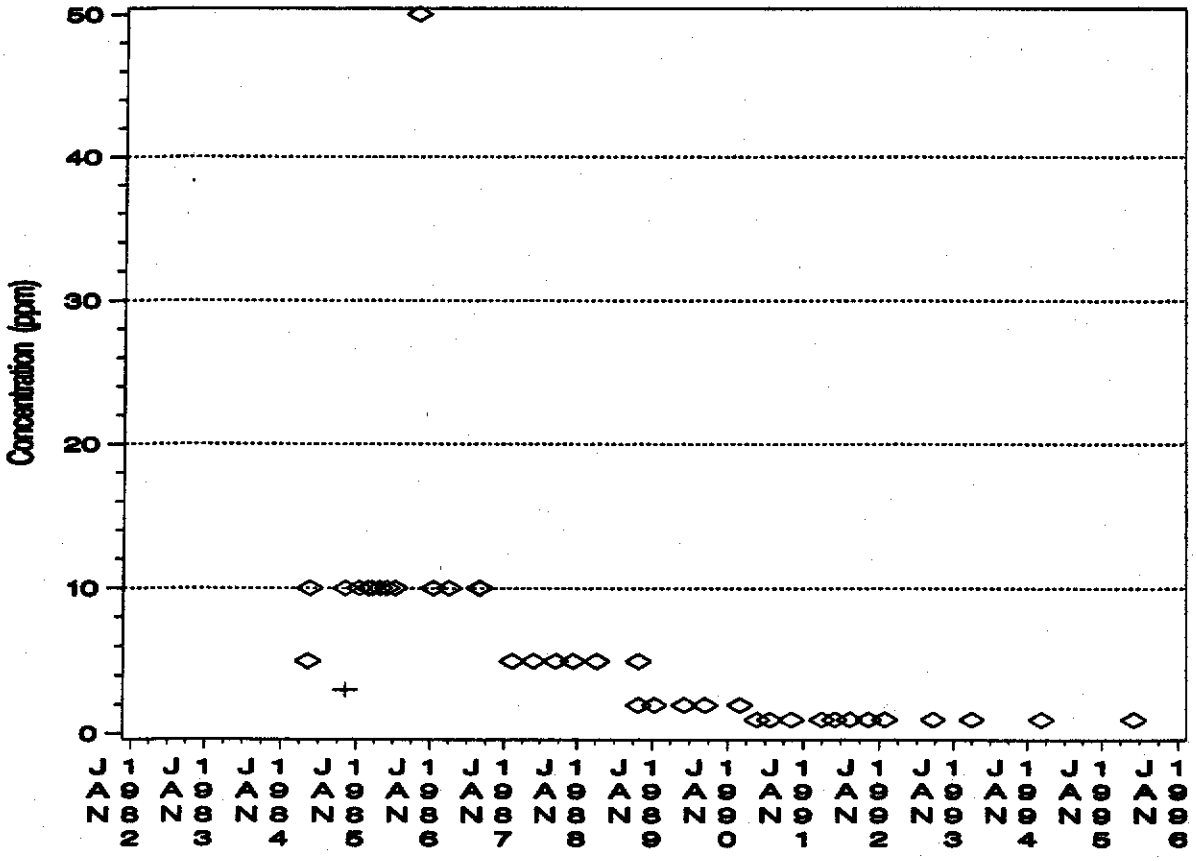
PERCHLORATE Trend



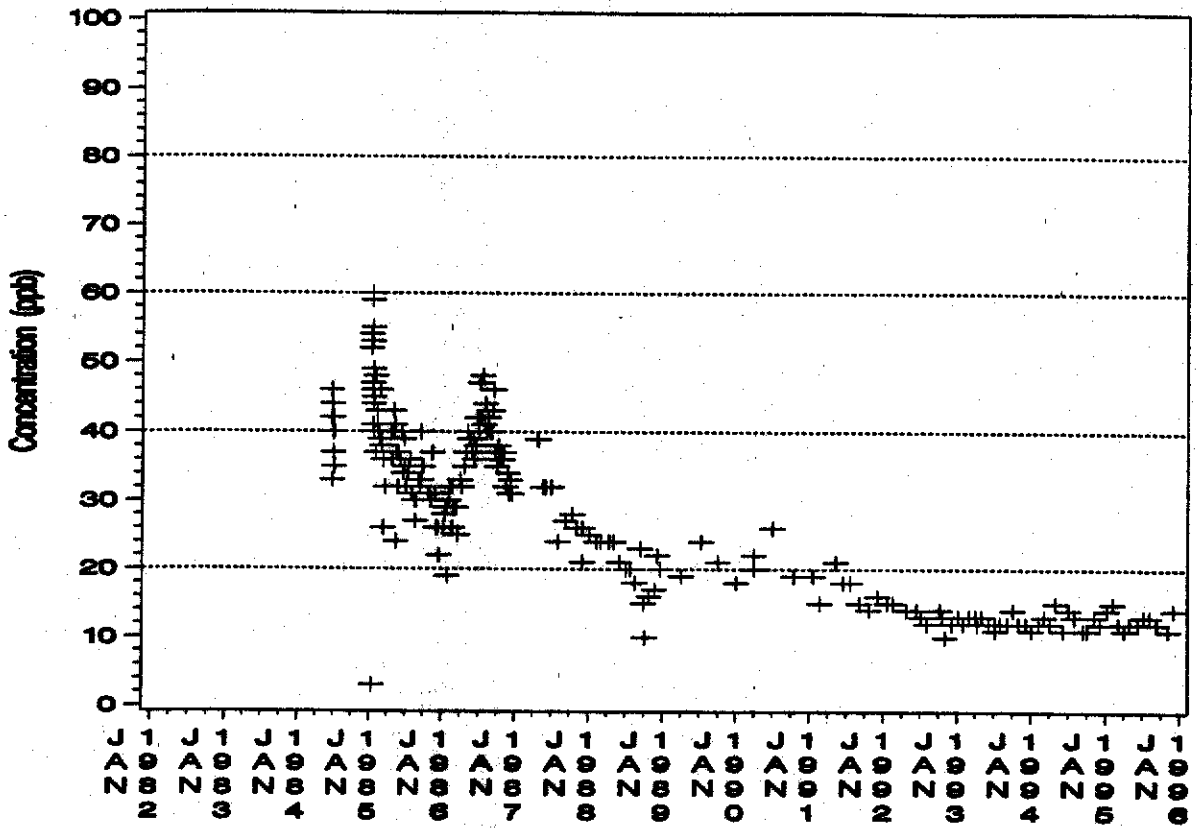
WELL 447
CHLOROFORM Trend



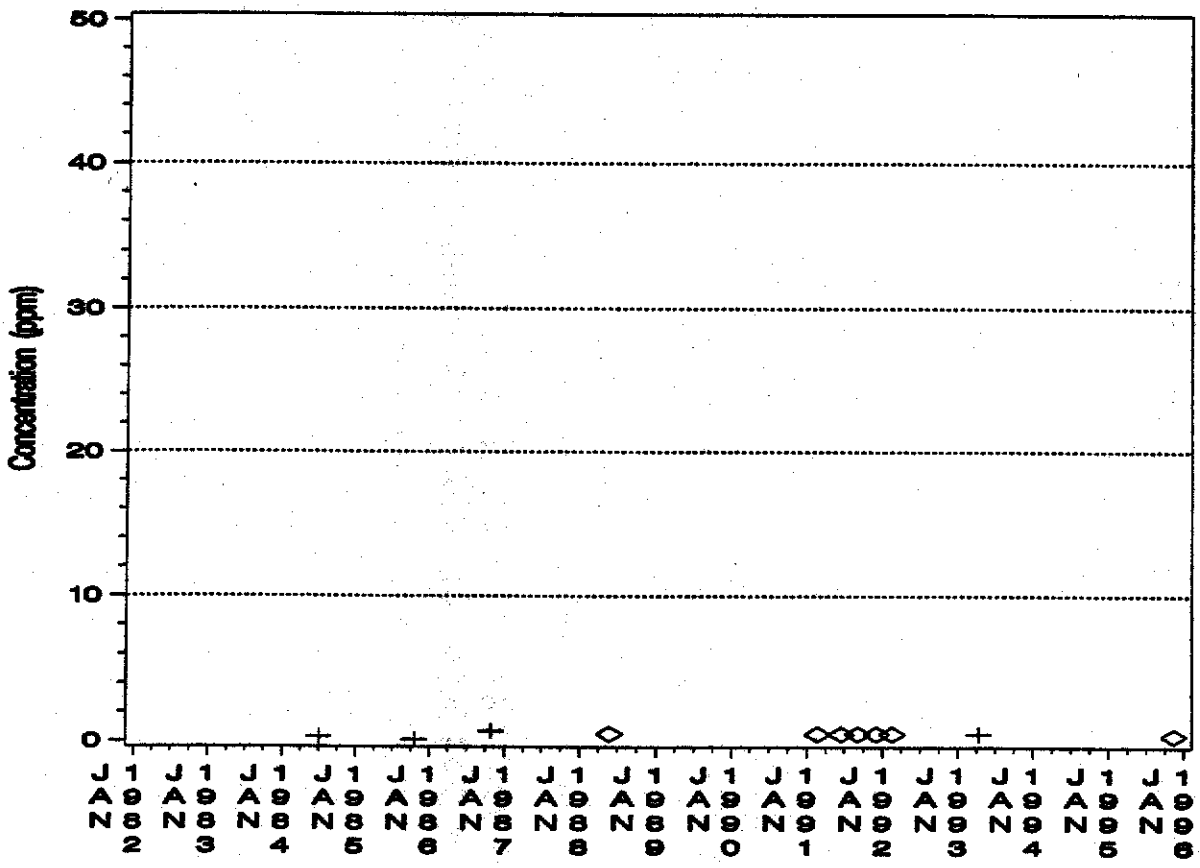
1,2 – DICHLOROETHANE Trend



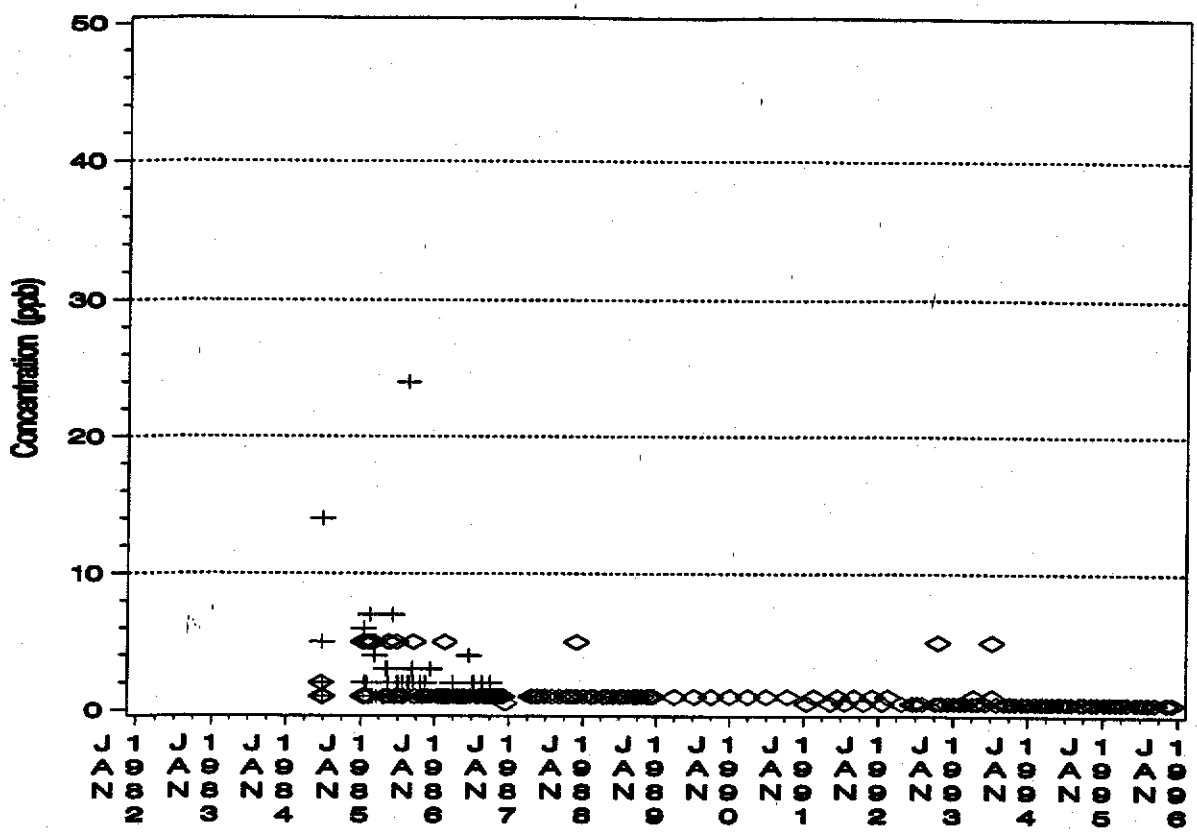
WELL 1016
TRICHLOROETHYLENE Trend



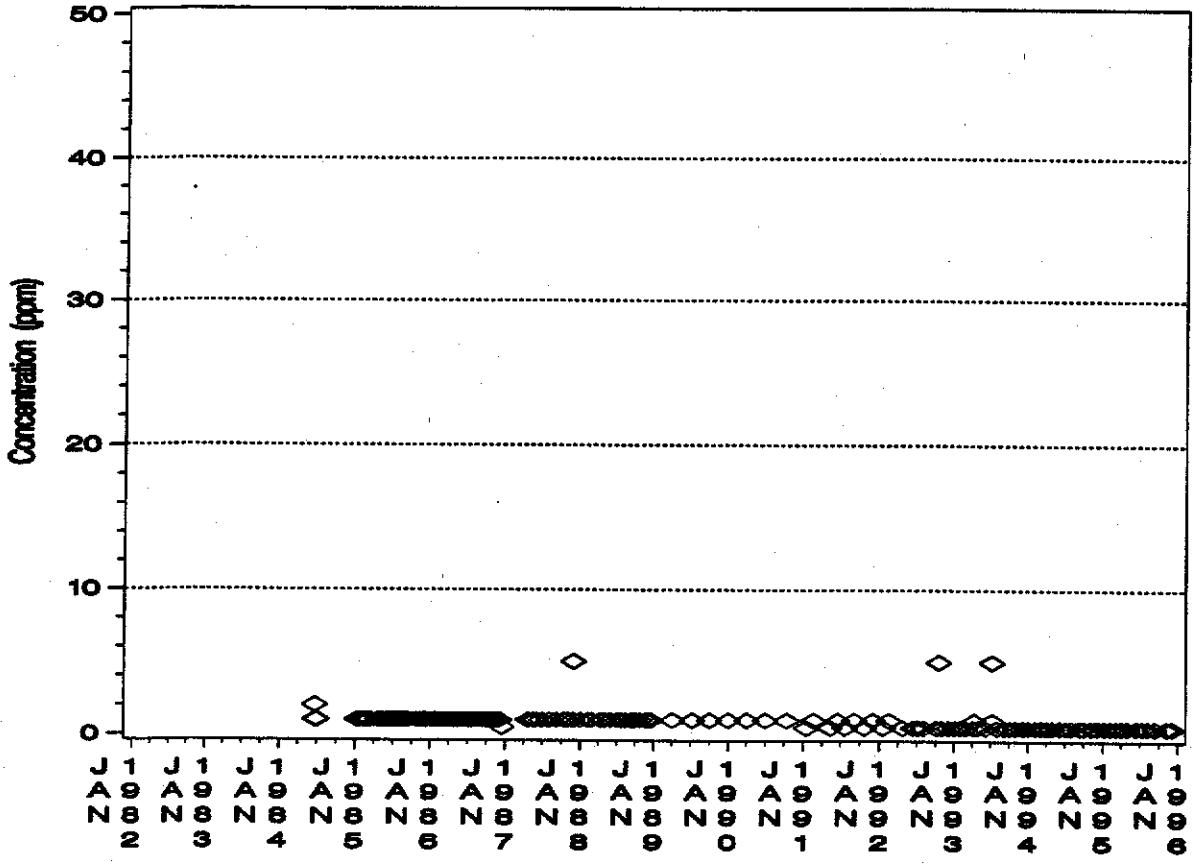
PERCHLORATE Trend



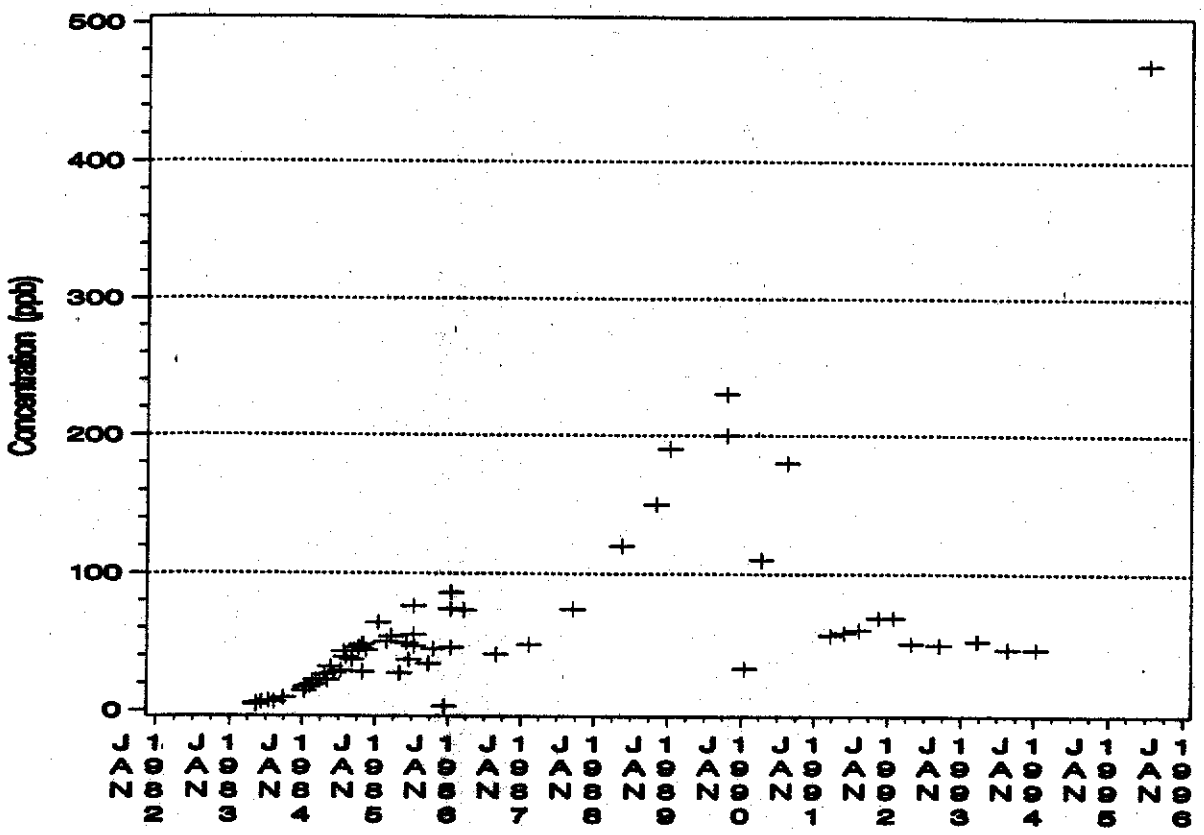
WELL 1016
CHLOROFORM Trend



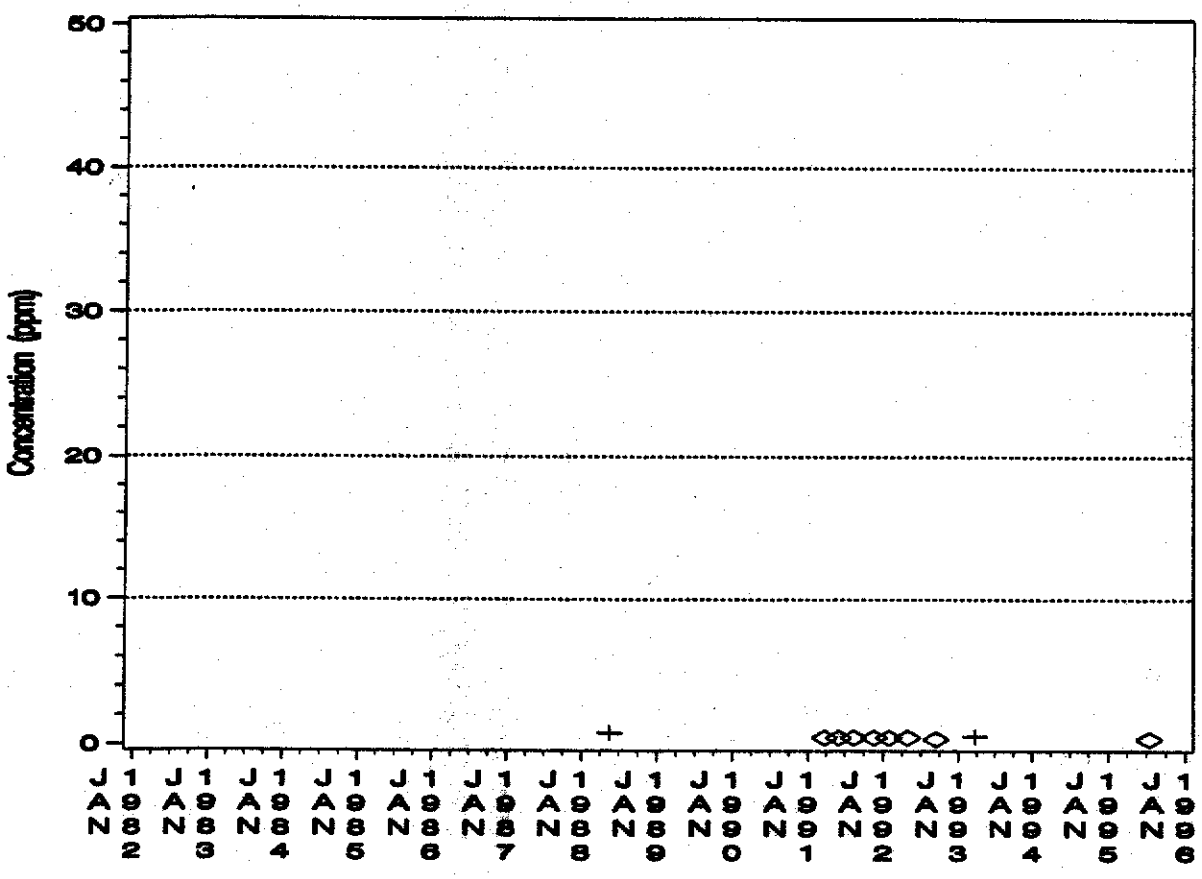
1,2 – DICHLOROETHANE Trend



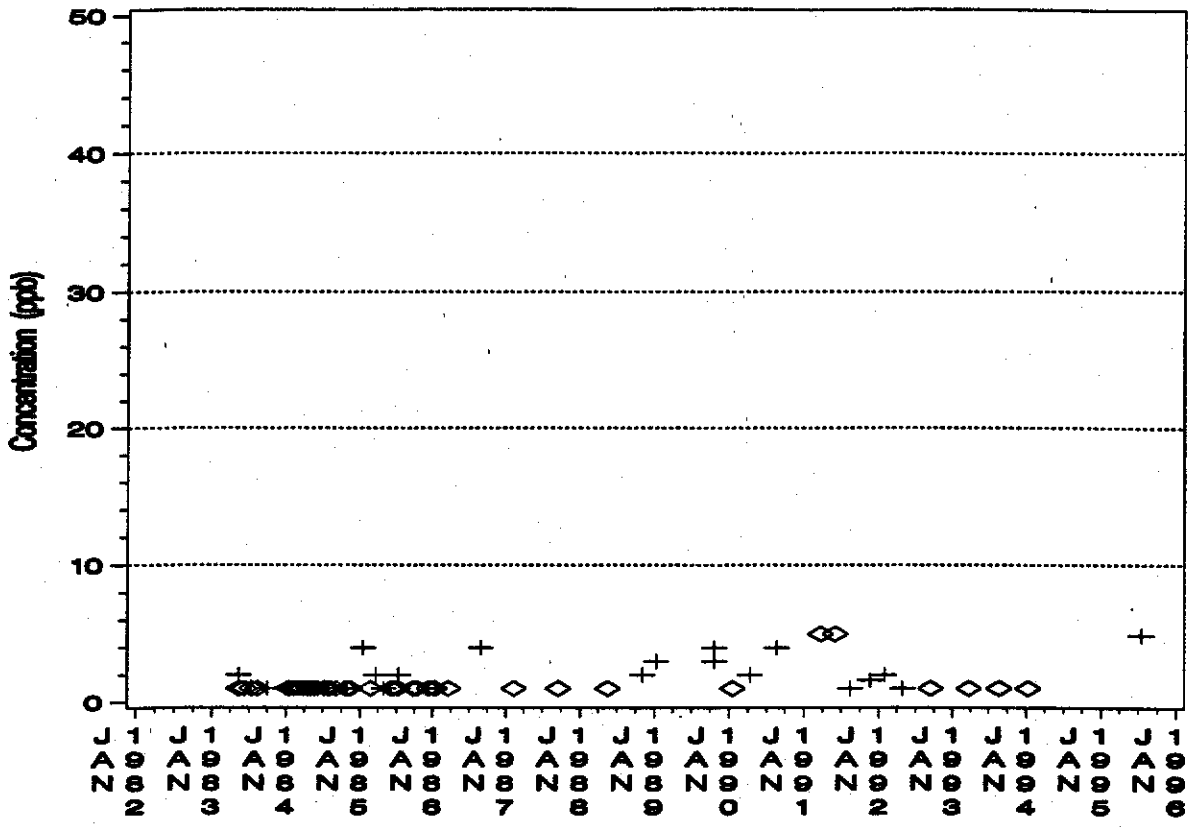
WELL 1204
TRICHLOROETHYLENE Trend



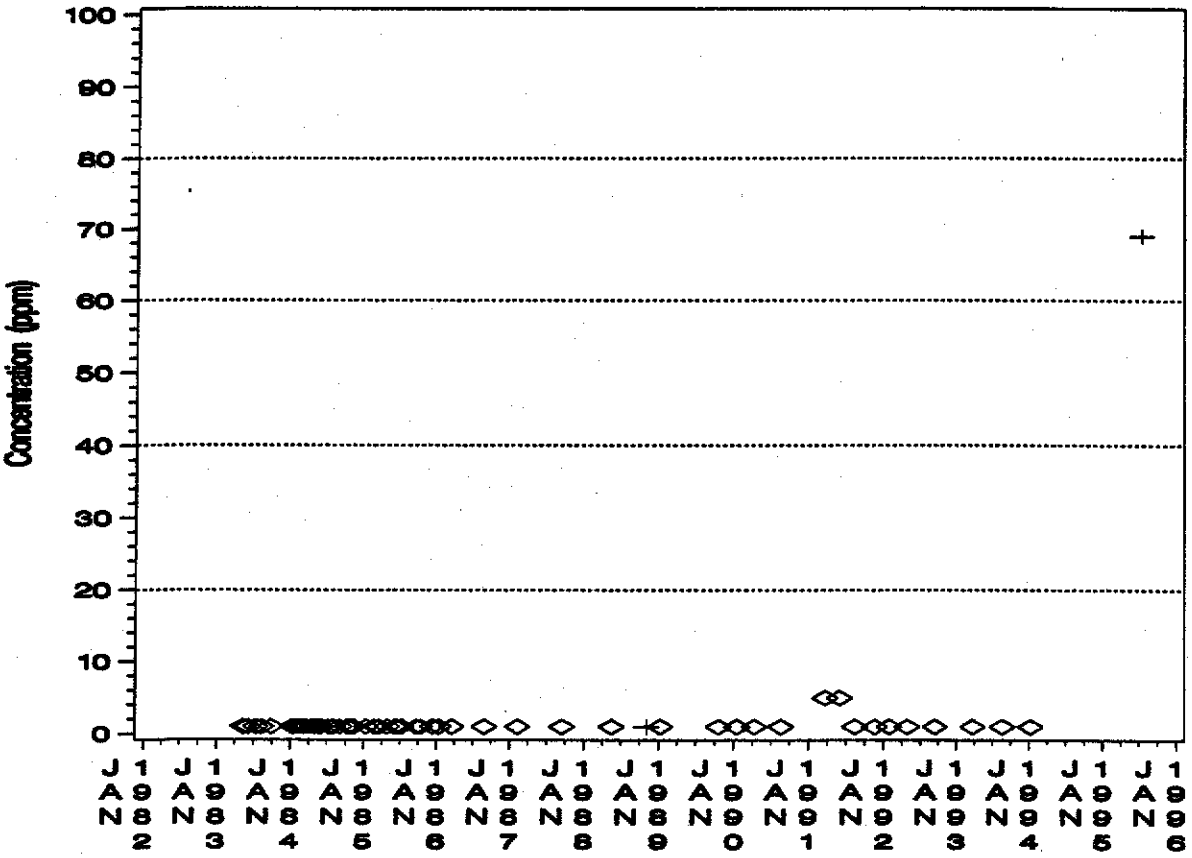
PERCHLORATE Trend



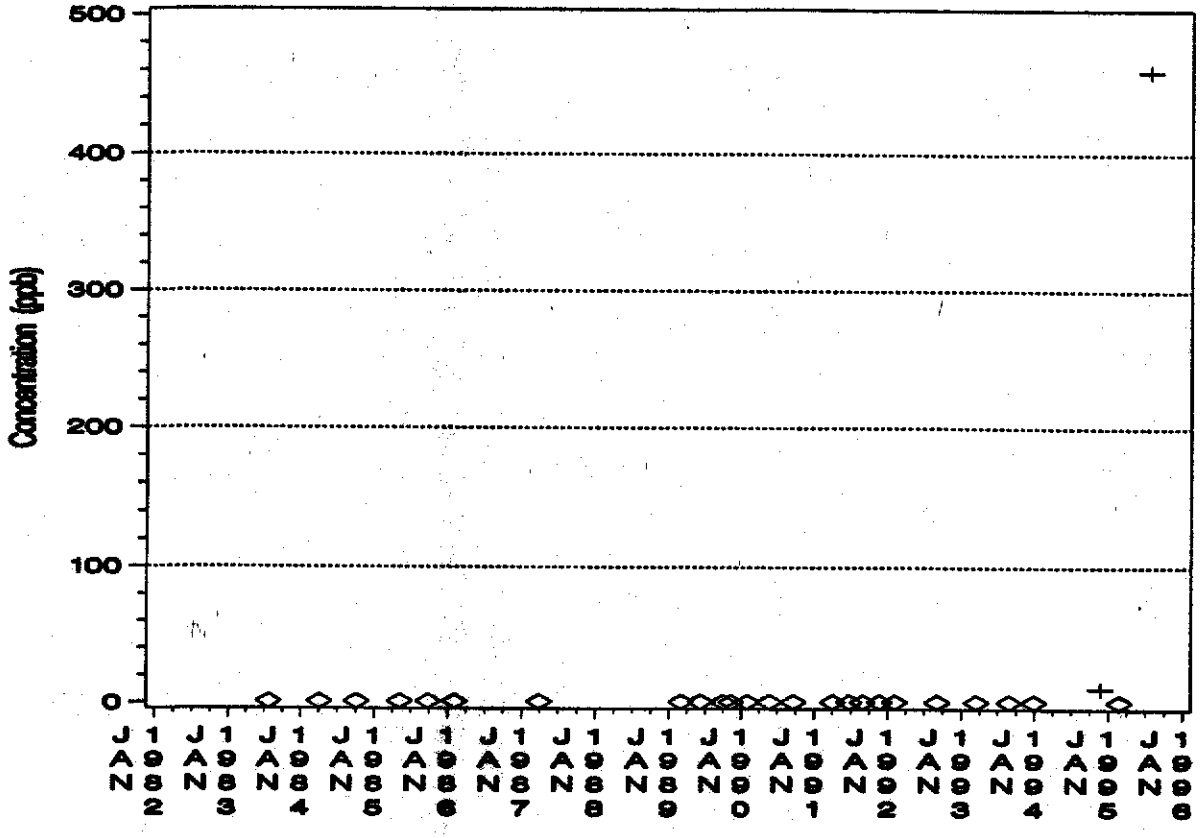
WELL 1204
CHLOROFORM Trend



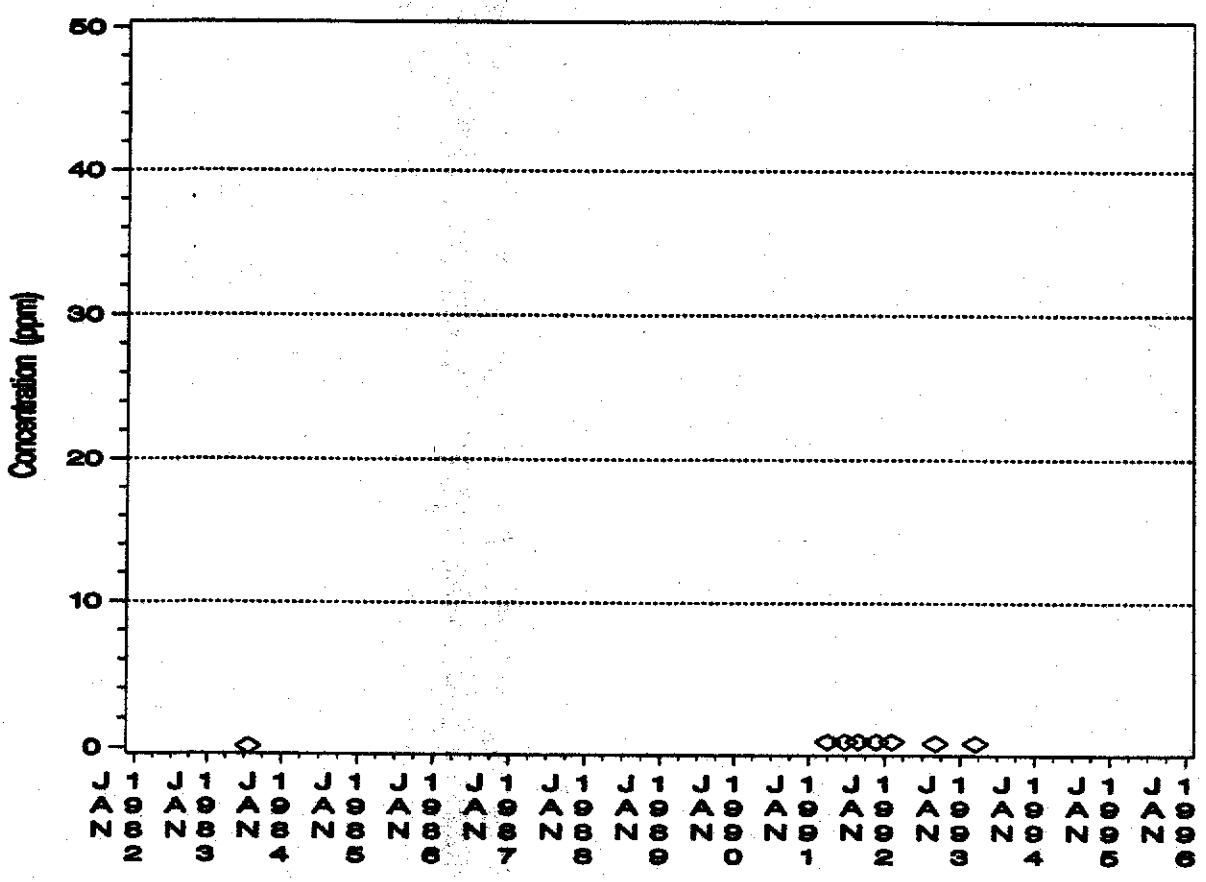
1,2 – DICHLOROETHANE Trend



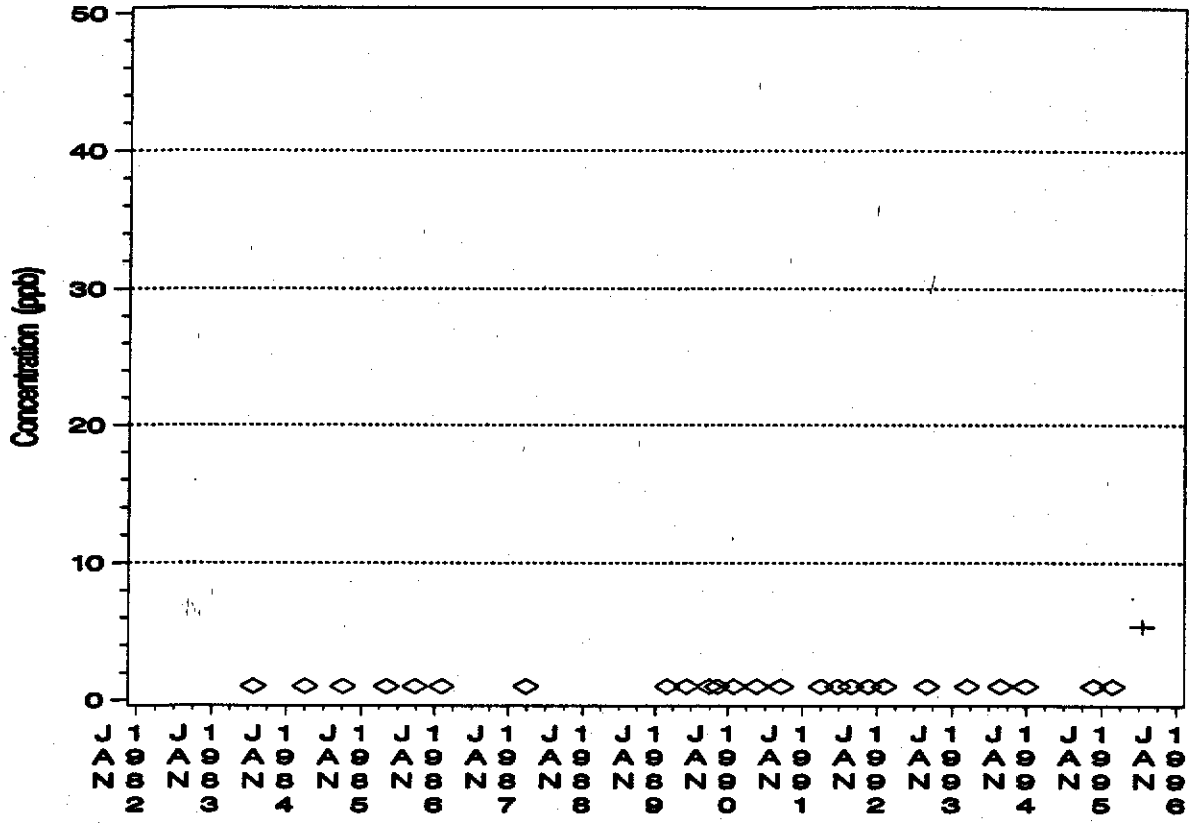
WELL 1233
TRICHLOROETHYLENE Trend



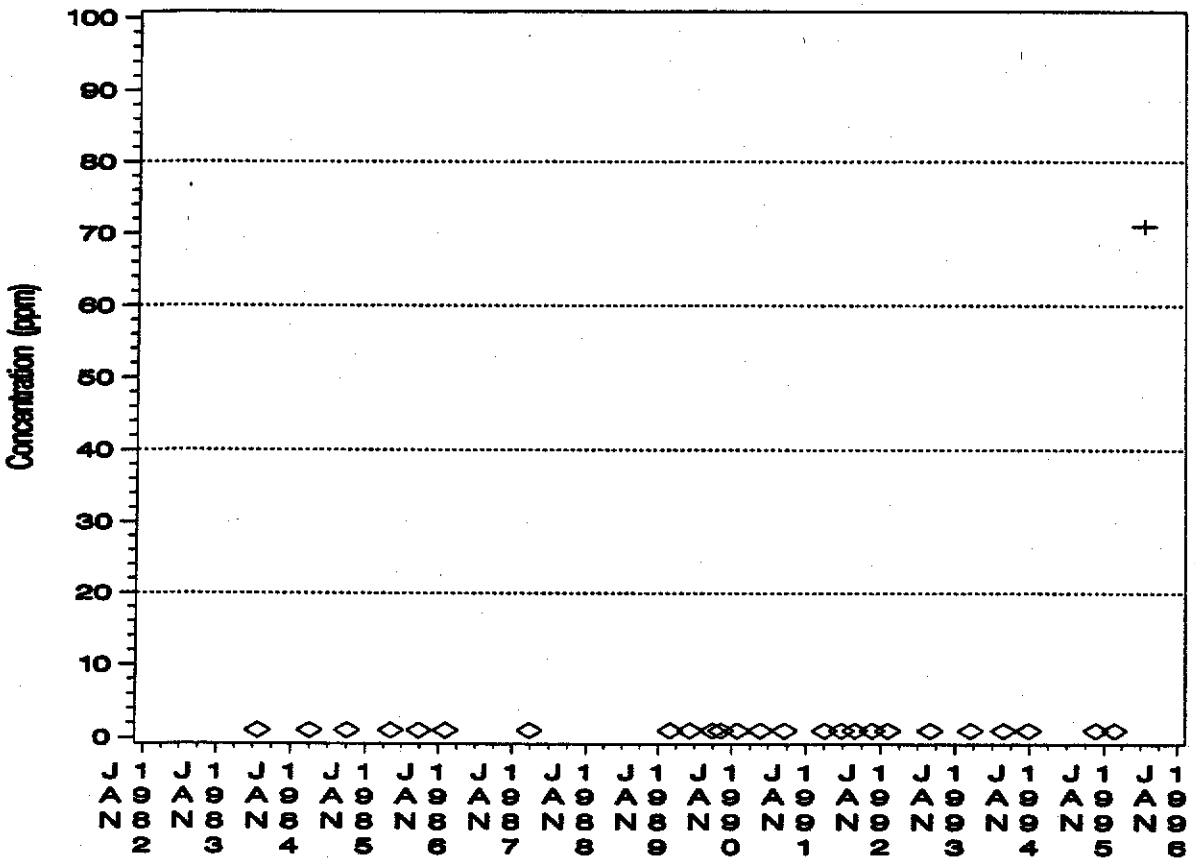
PERCHLORATE Trend



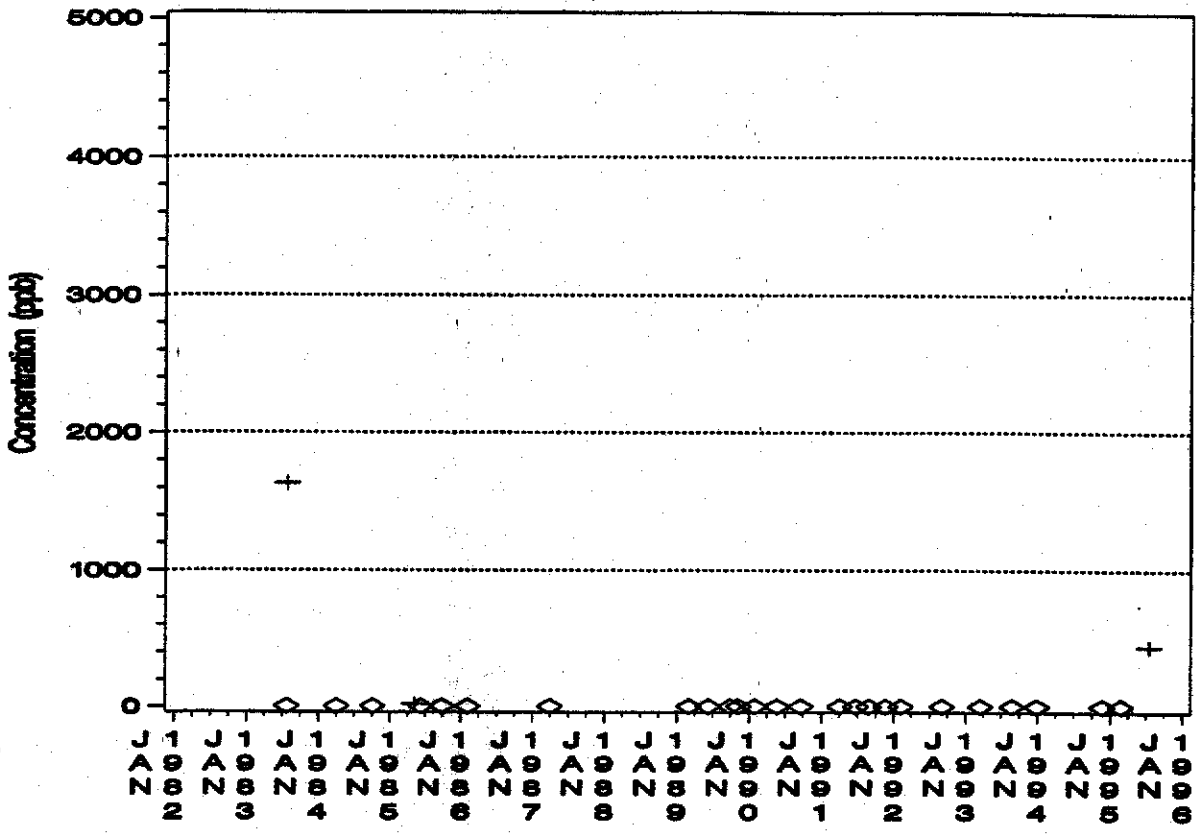
WELL 1233
CHLOROFORM Trend



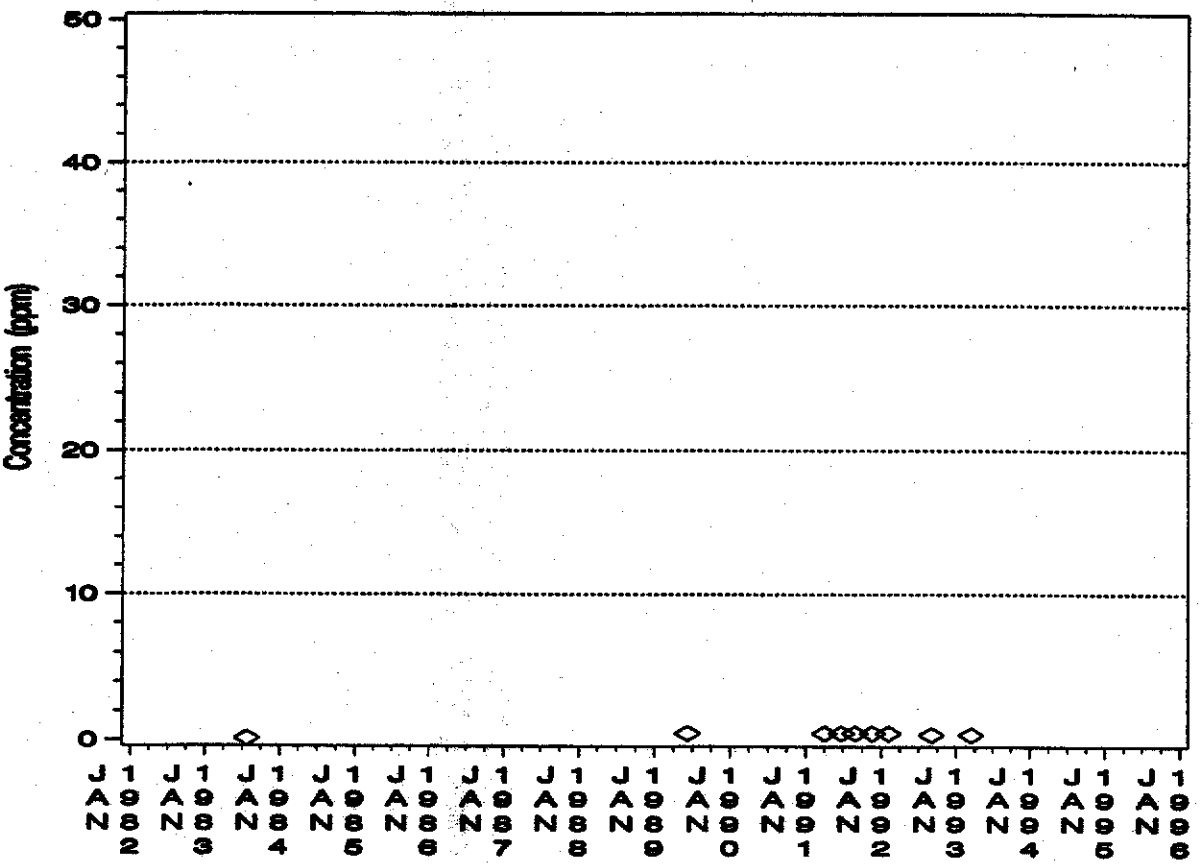
1,2 – DICHLOROETHANE Trend



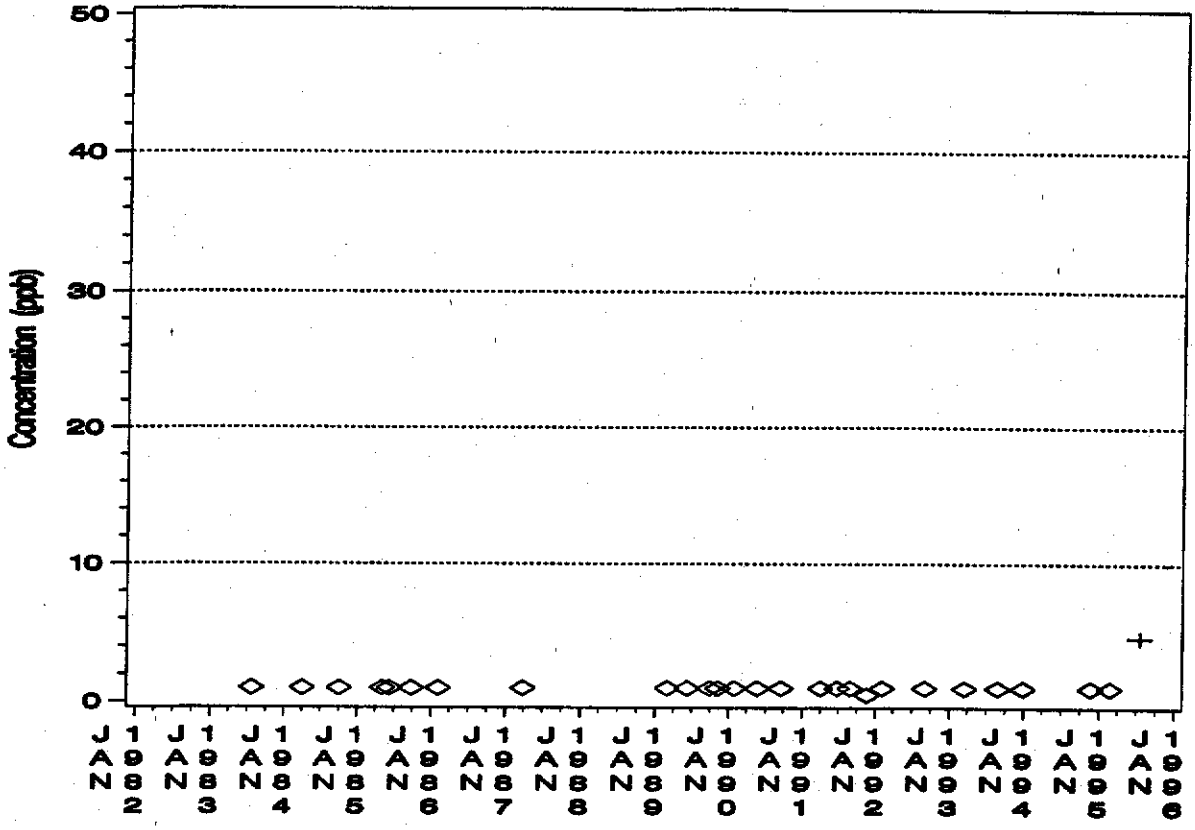
WELL 1234
TRICHLOROETHYLENE Trend



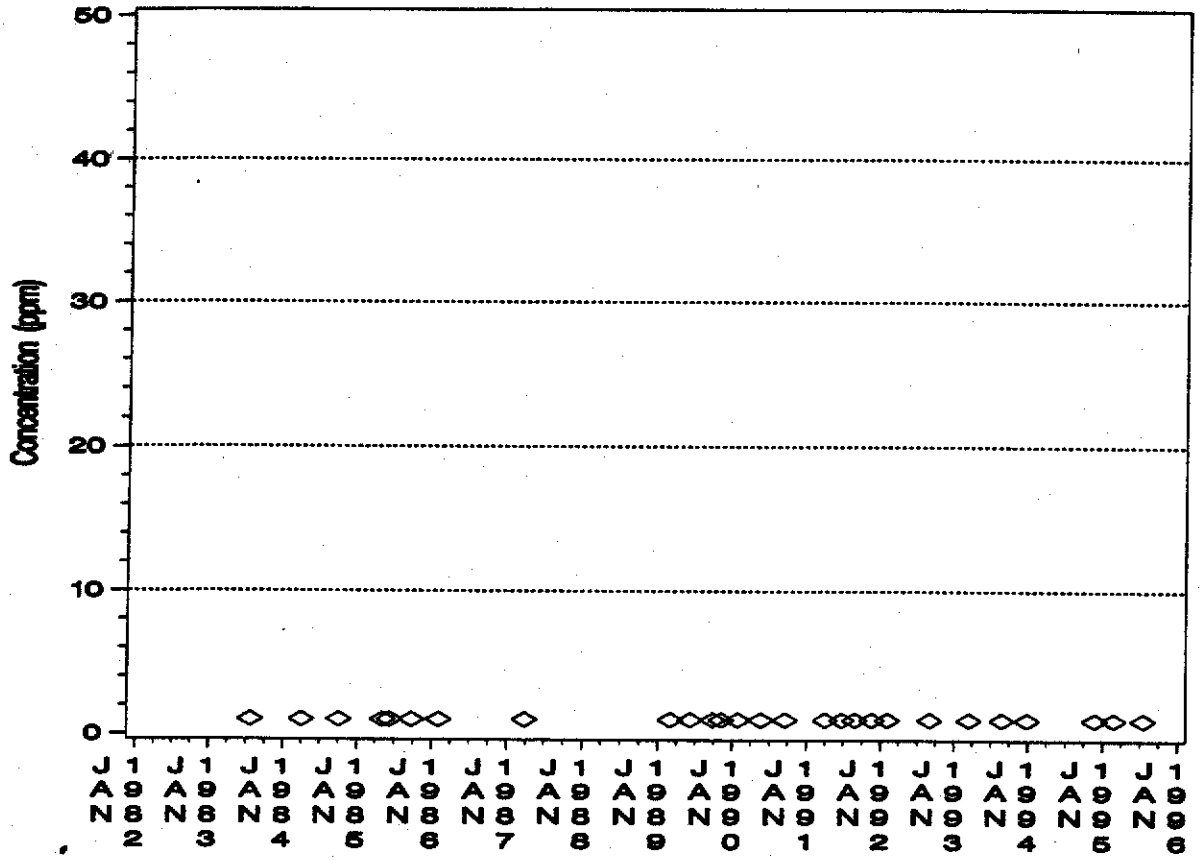
PERCHLORATE Trend



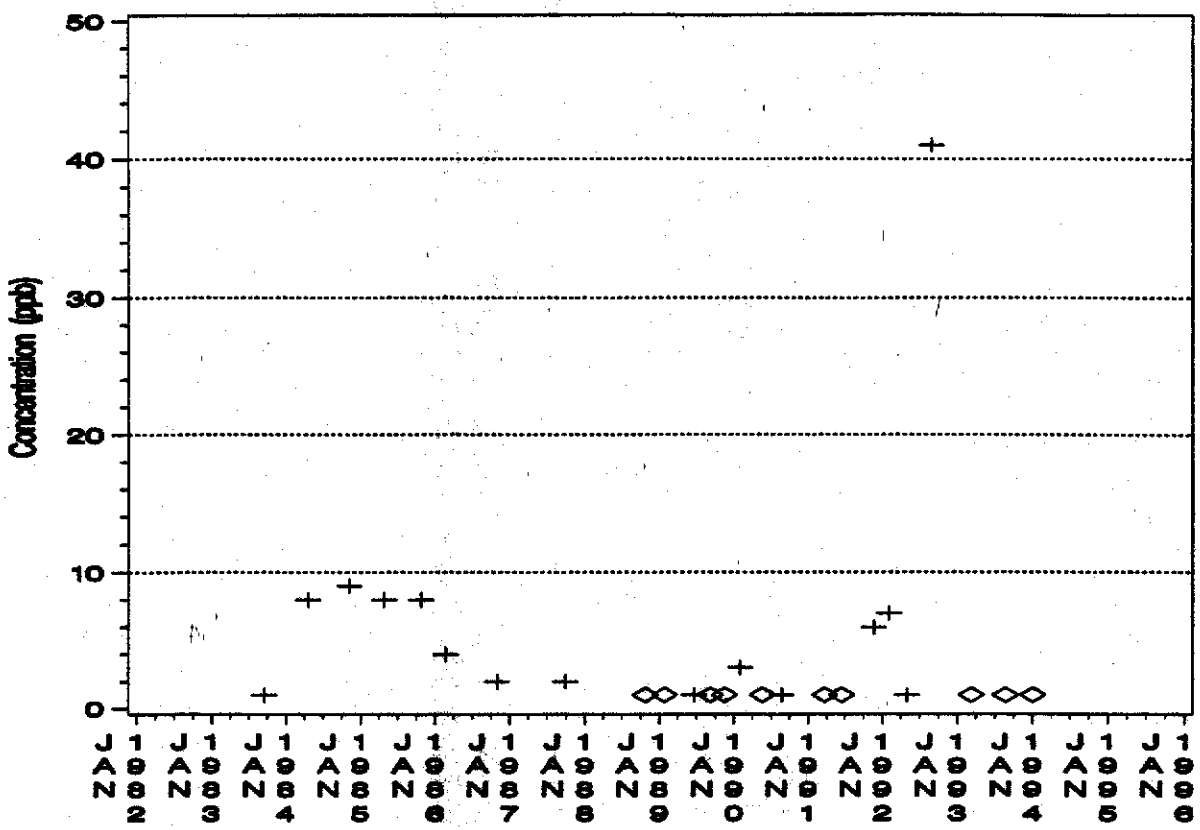
WELL 1234
CHLOROFORM Trend



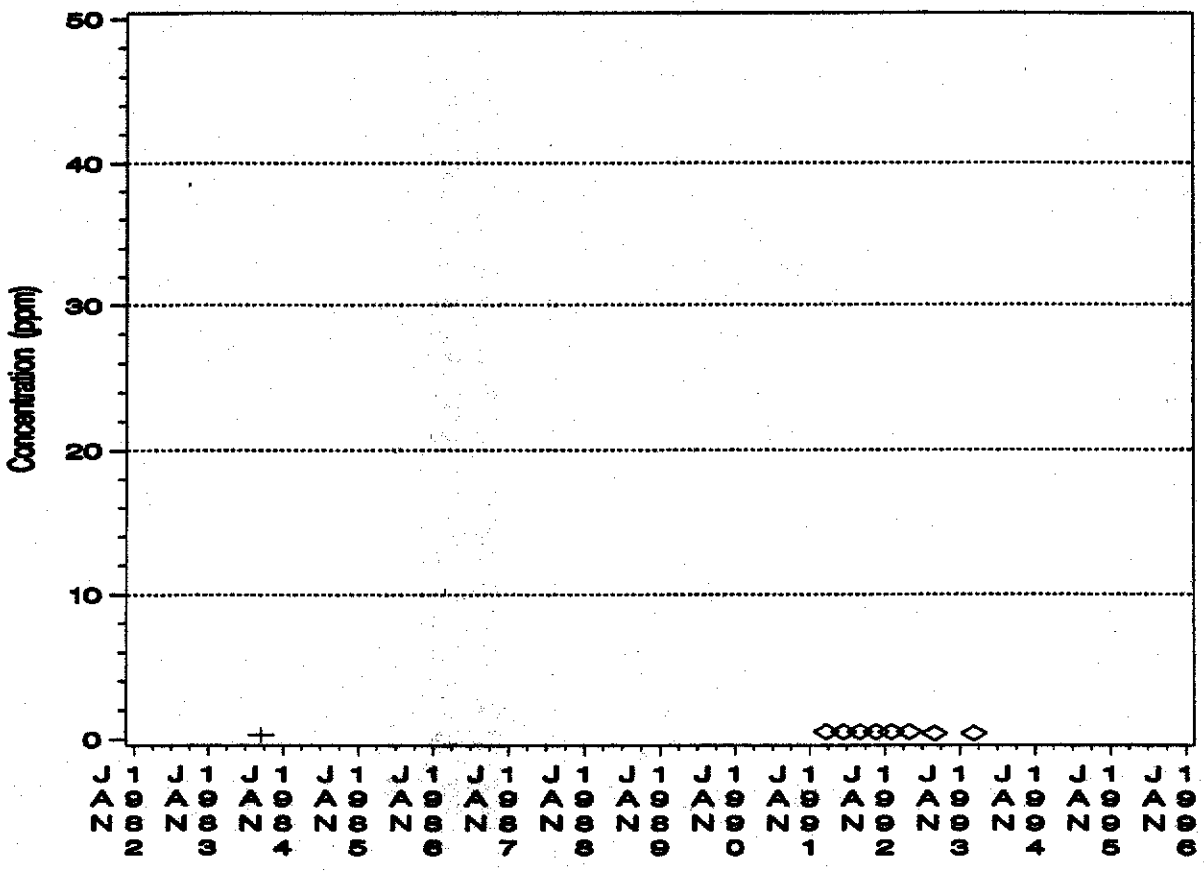
1,2 – DICHLOROETHANE Trend



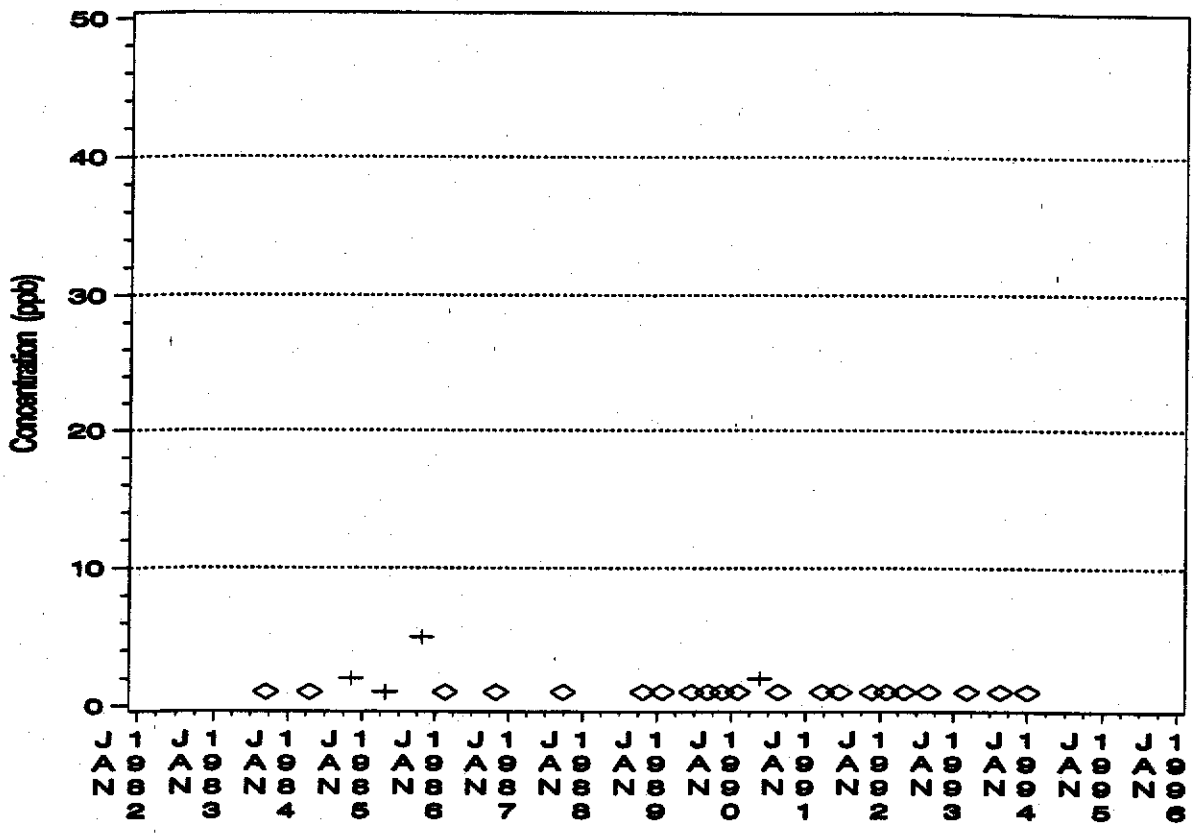
WELL 1237
TRICHLOROETHYLENE Trend



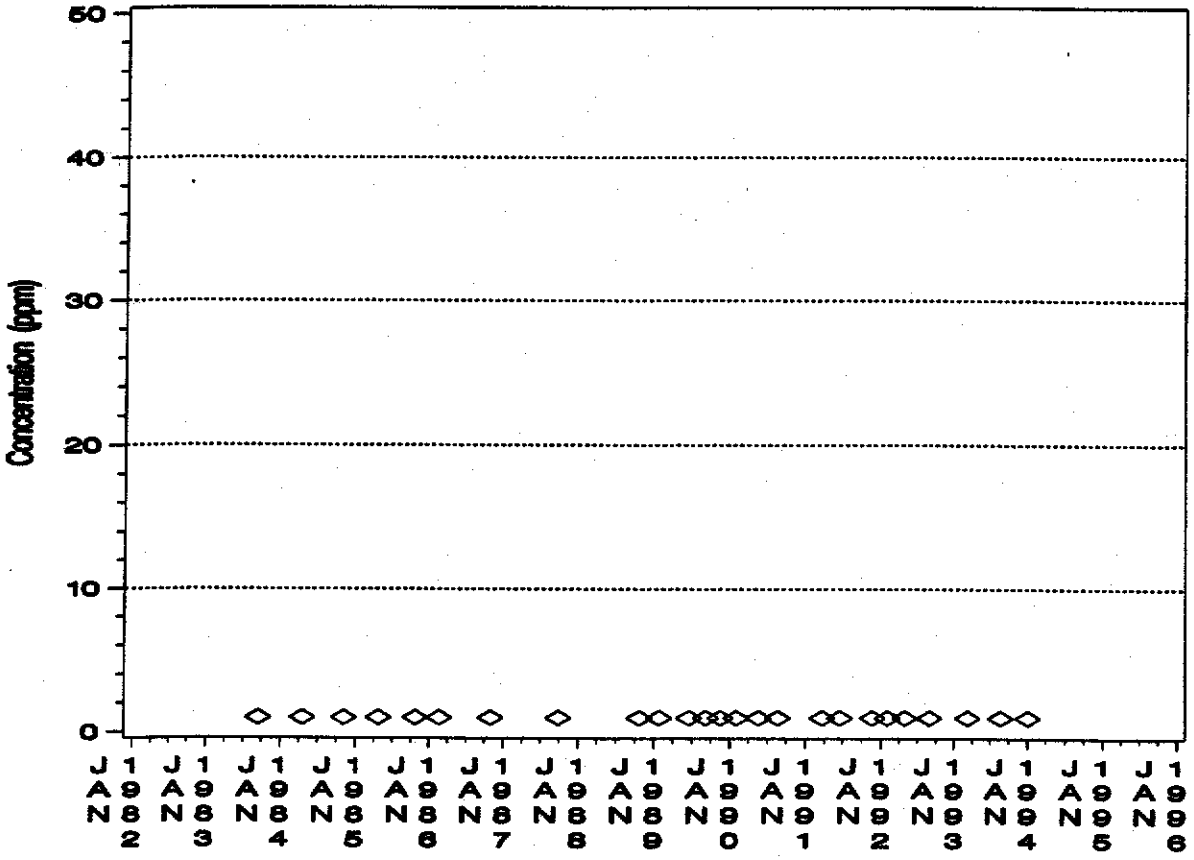
PERCHLORATE Trend



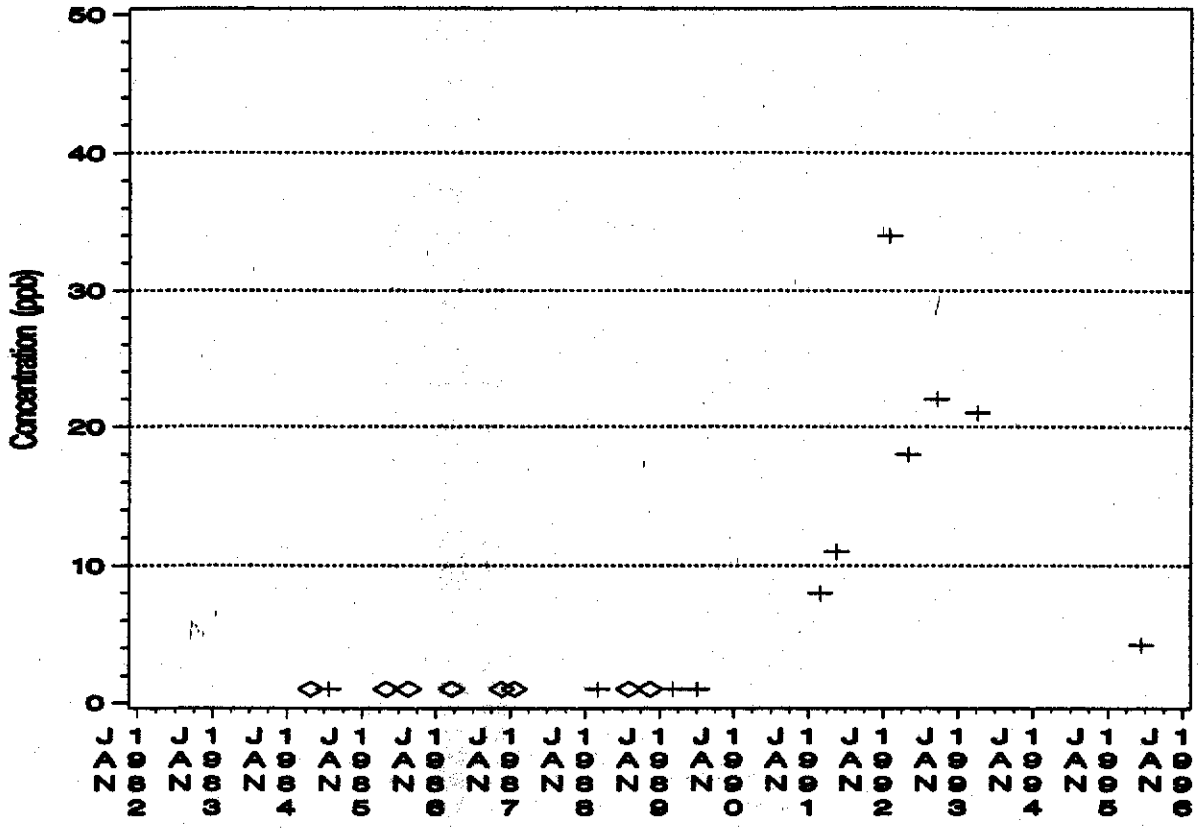
WELL 1237
CHLOROFORM Trend



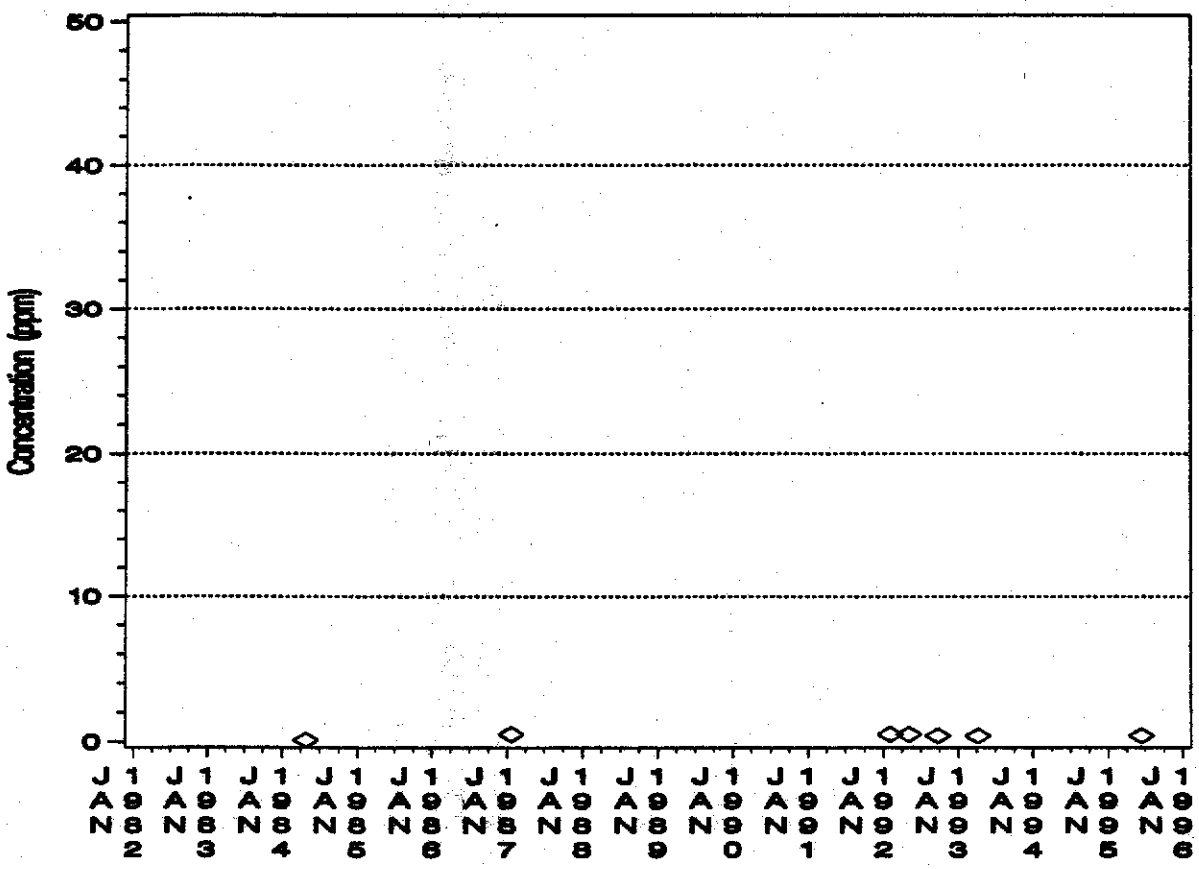
1,2 — DICHLOROETHANE Trend



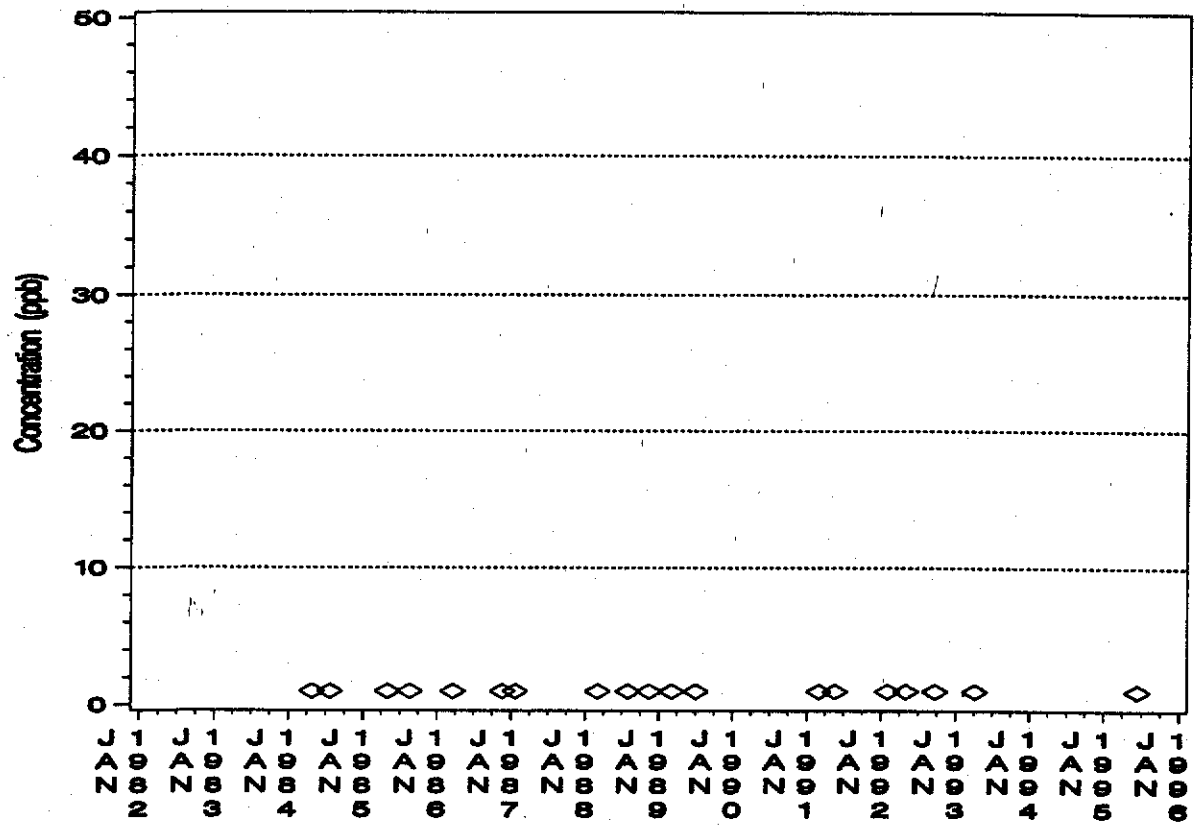
WELL 1252
TRICHLOROETHYLENE Trend



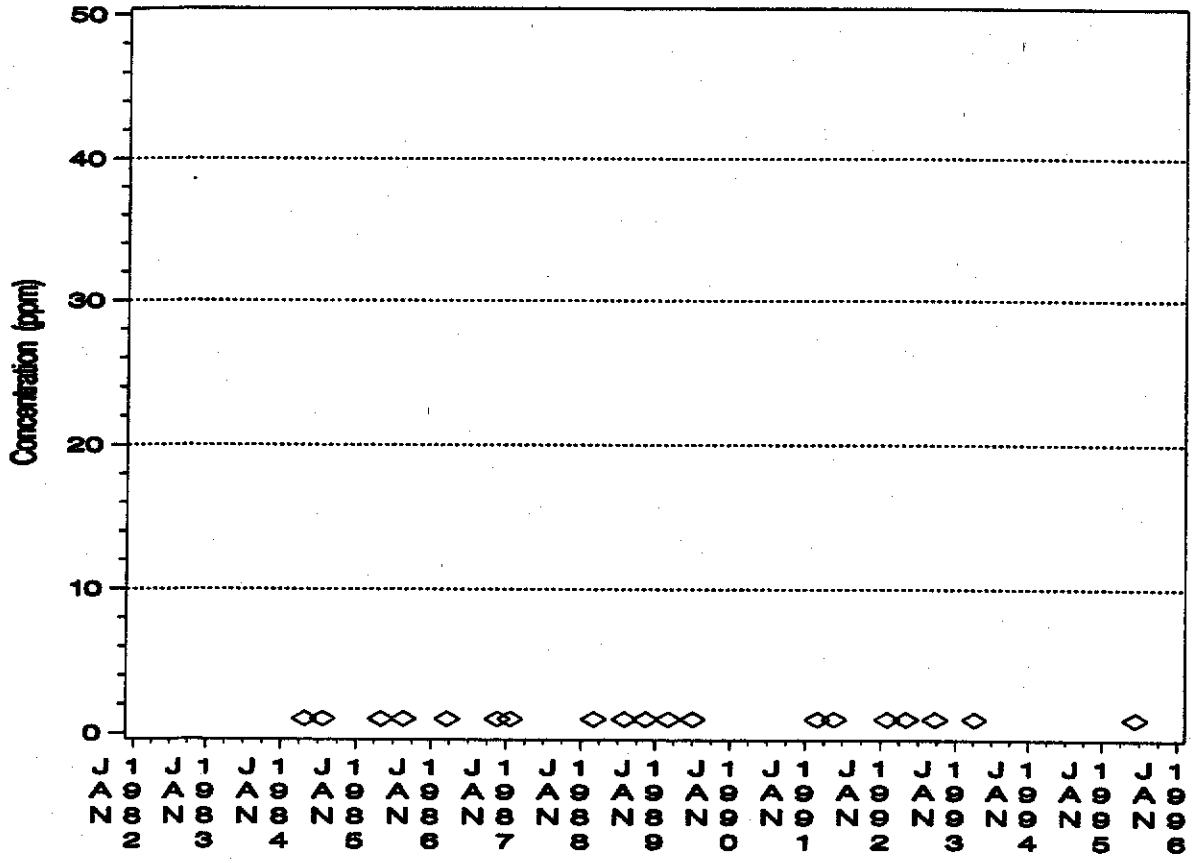
PERCHLORATE Trend



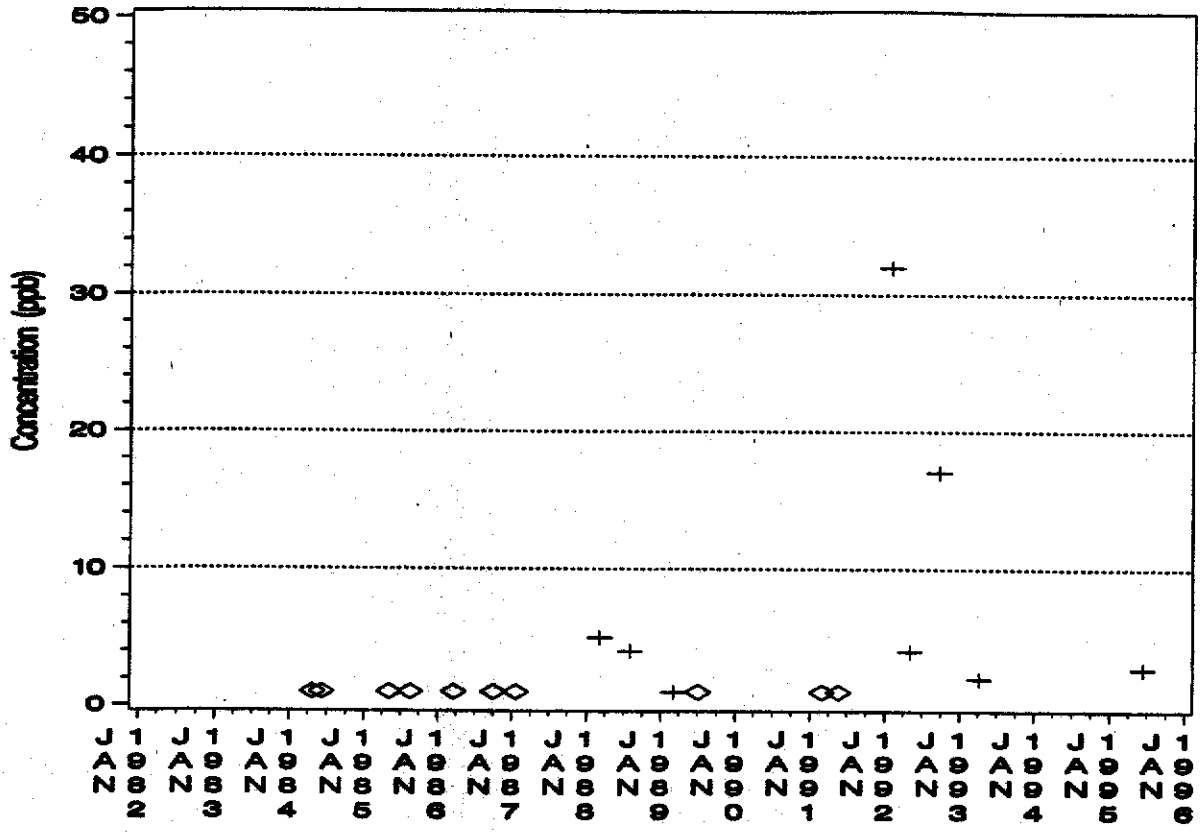
WELL 1252
CHLOROFORM Trend



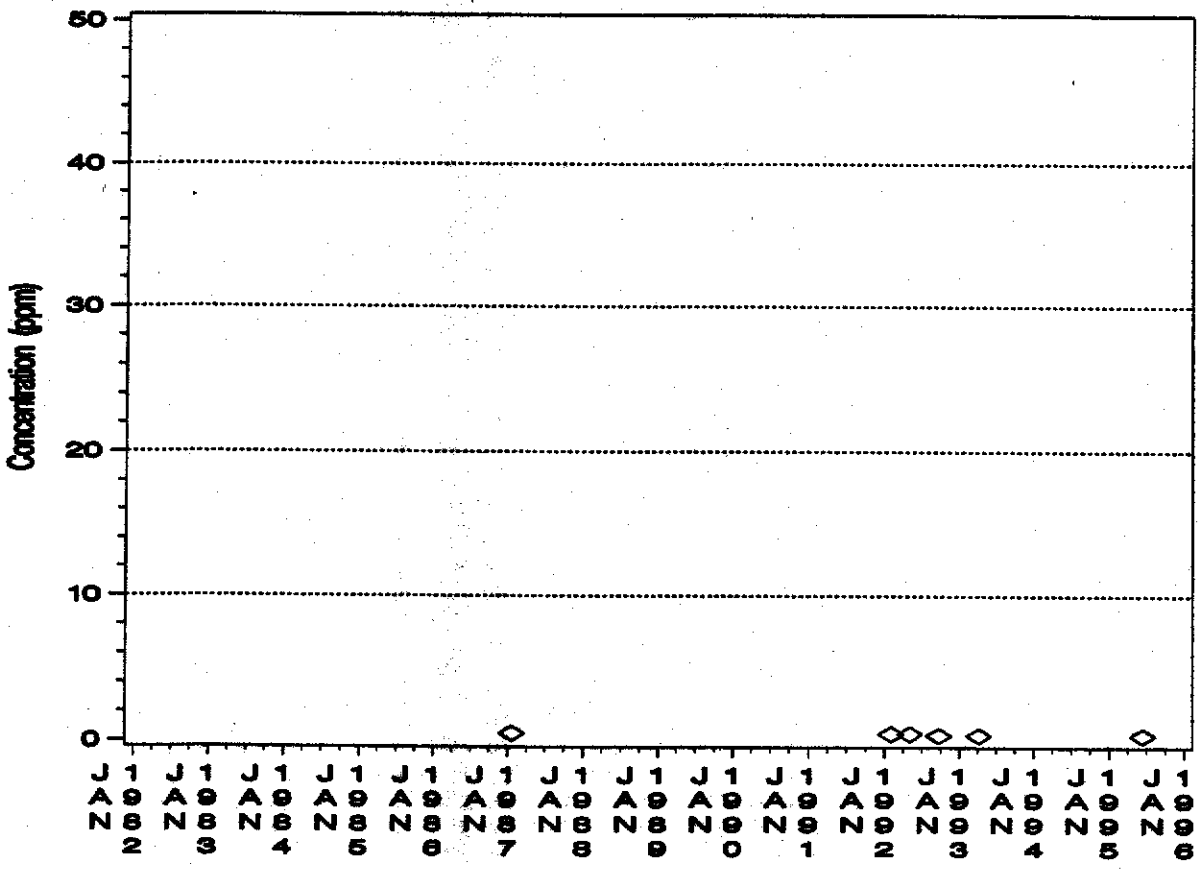
1,2 – DICHLOROETHANE Trend



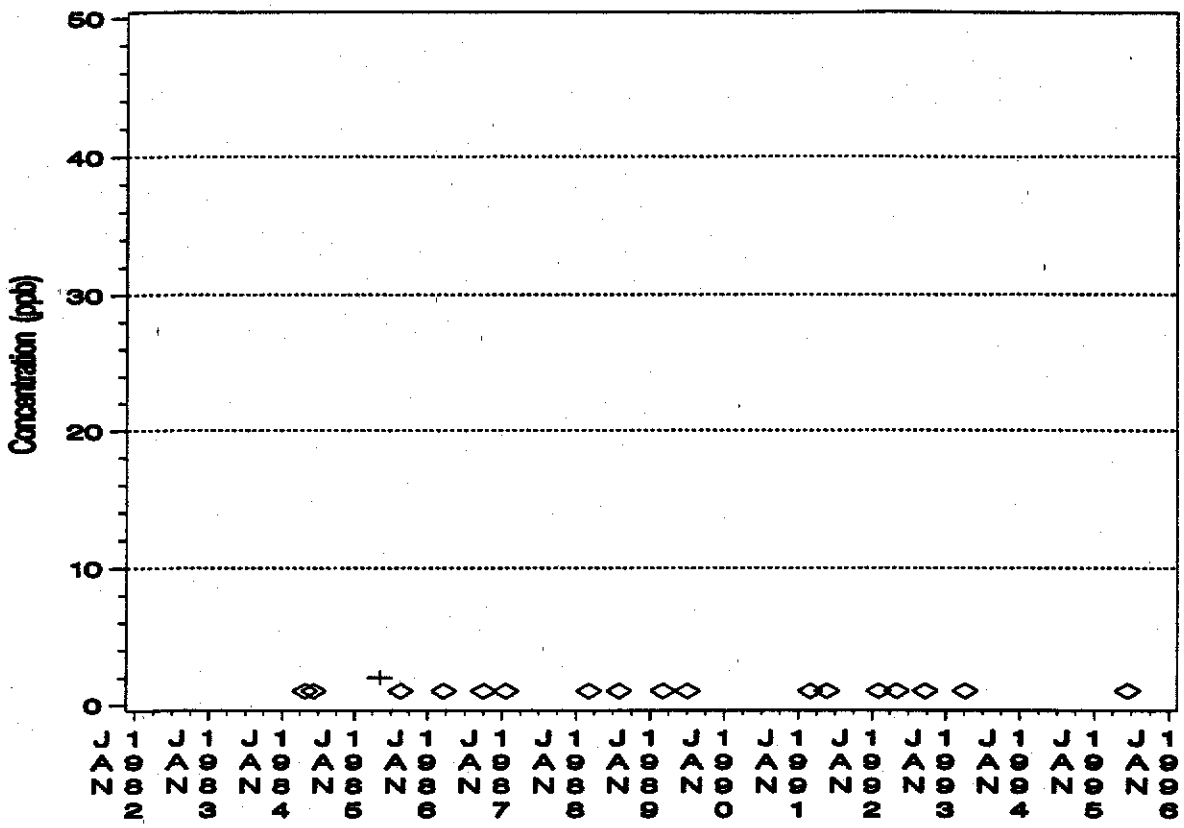
WELL 1253
TRICHLOROETHYLENE Trend



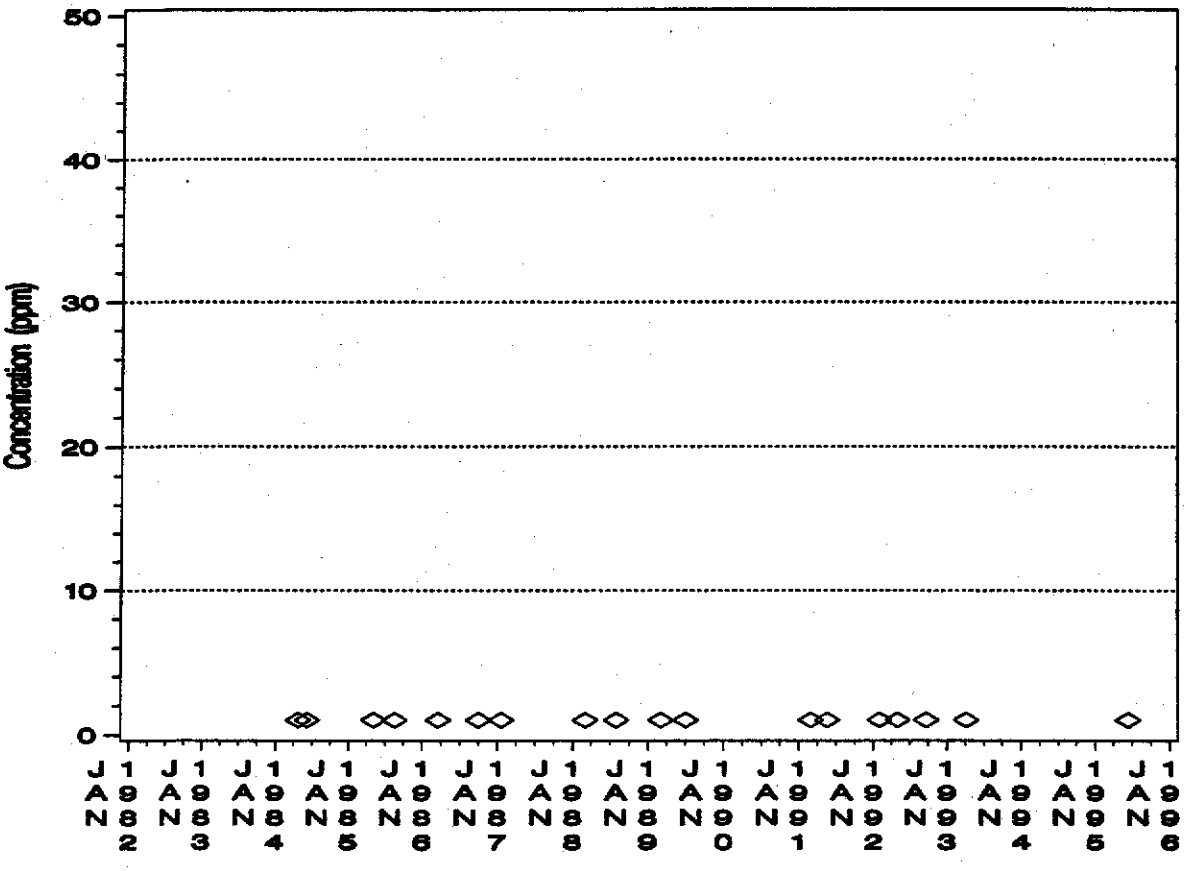
PERCHLORATE Trend



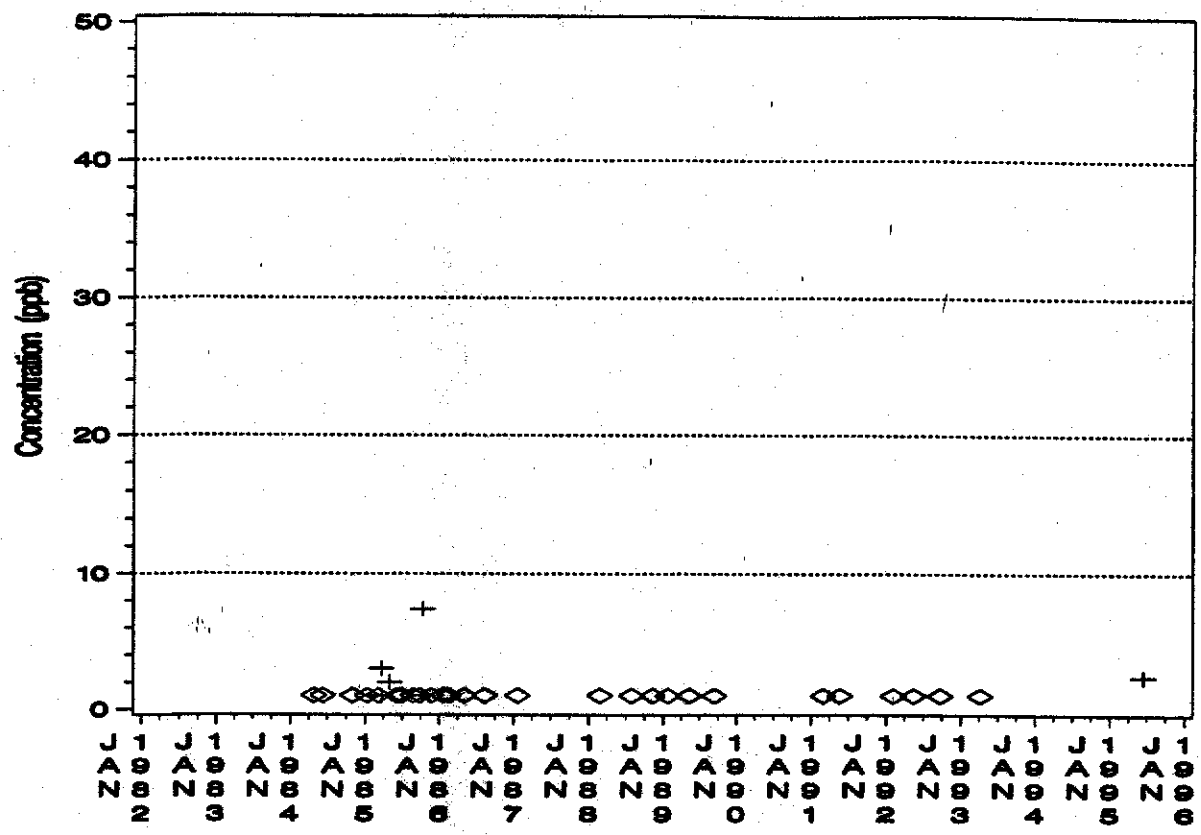
WELL 1253
CHLOROFORM Trend



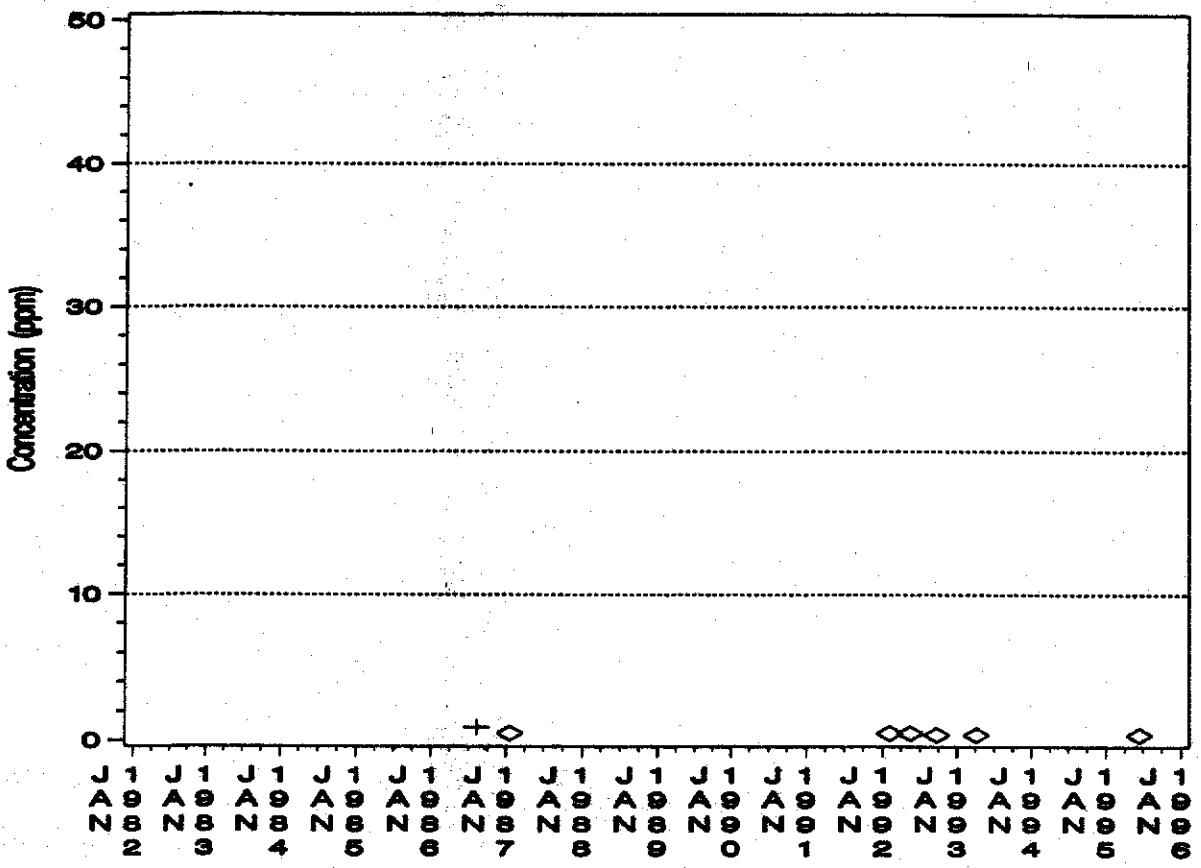
1,2 – DICHLOROETHANE Trend



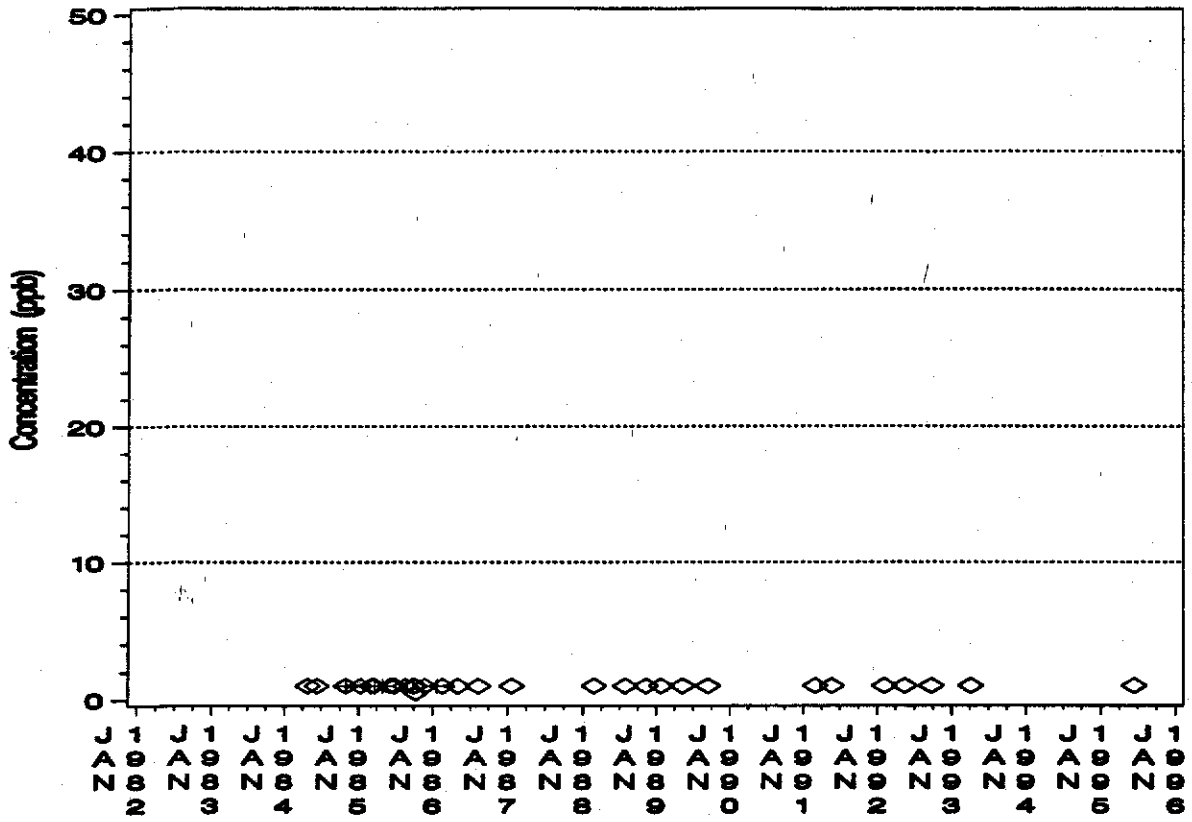
WELL 1254
TRICHLOROETHYLENE Trend



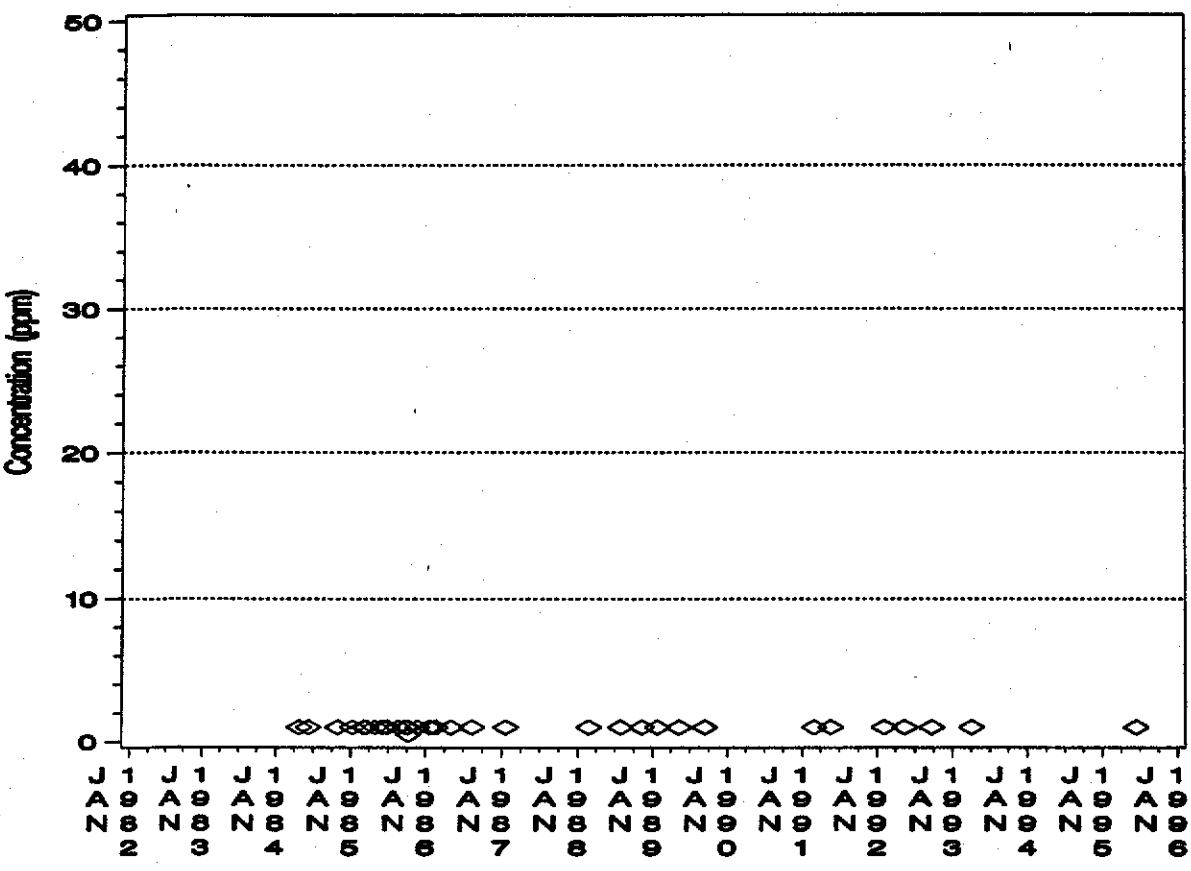
PERCHLORATE Trend



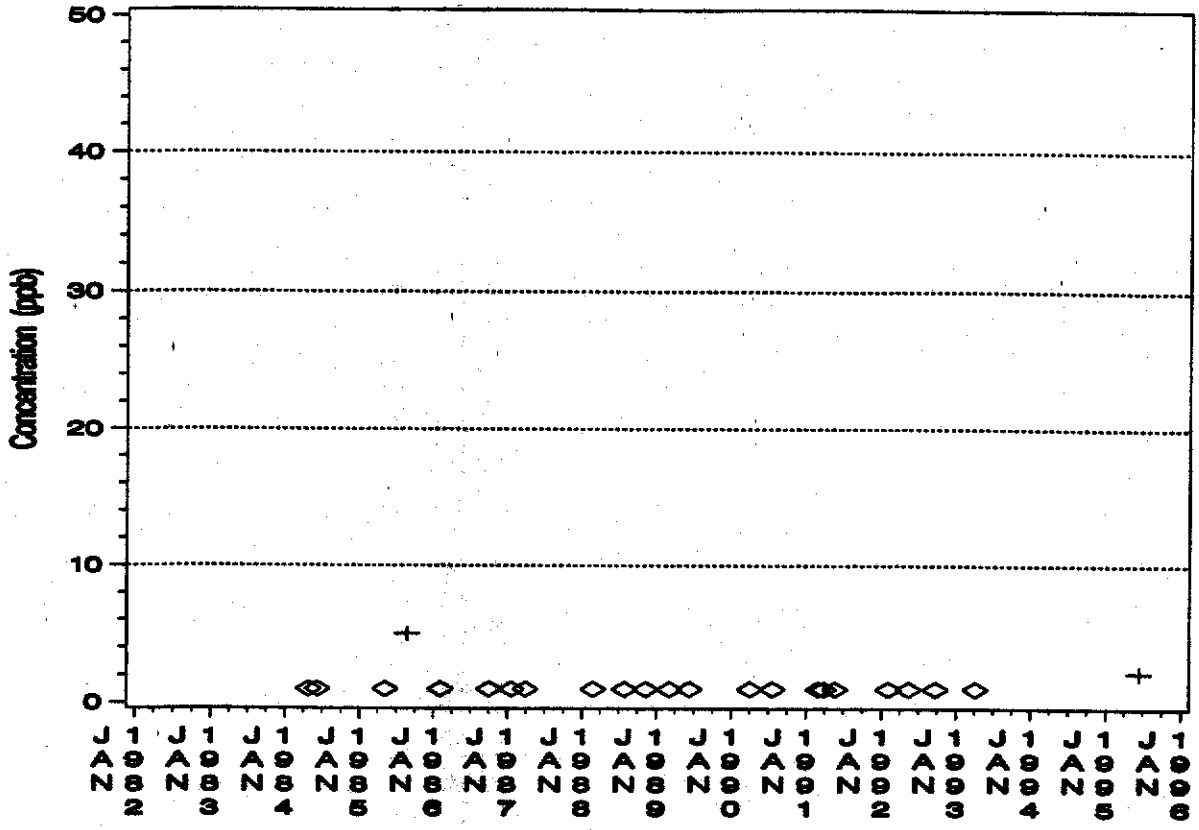
WELL 1254
CHLOROFORM Trend



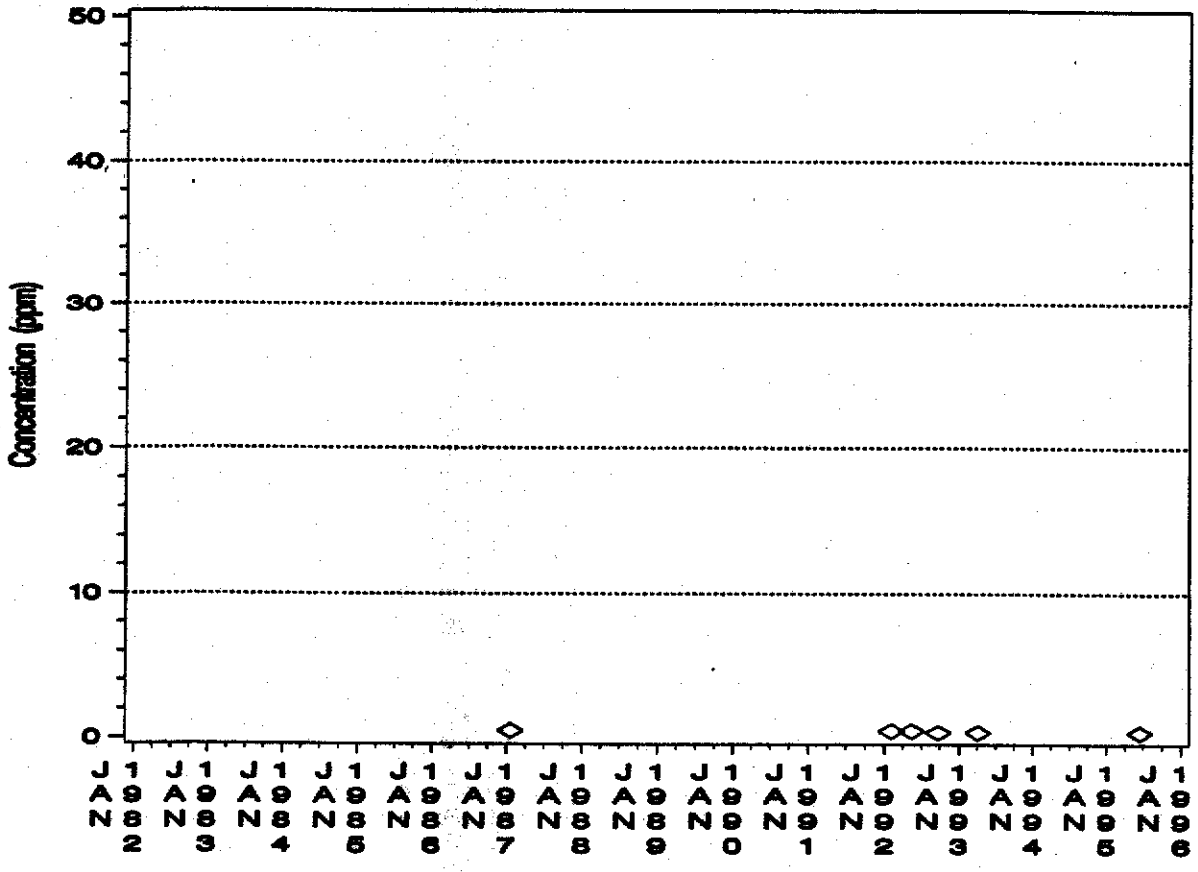
1,2 – DICHLOROETHANE Trend



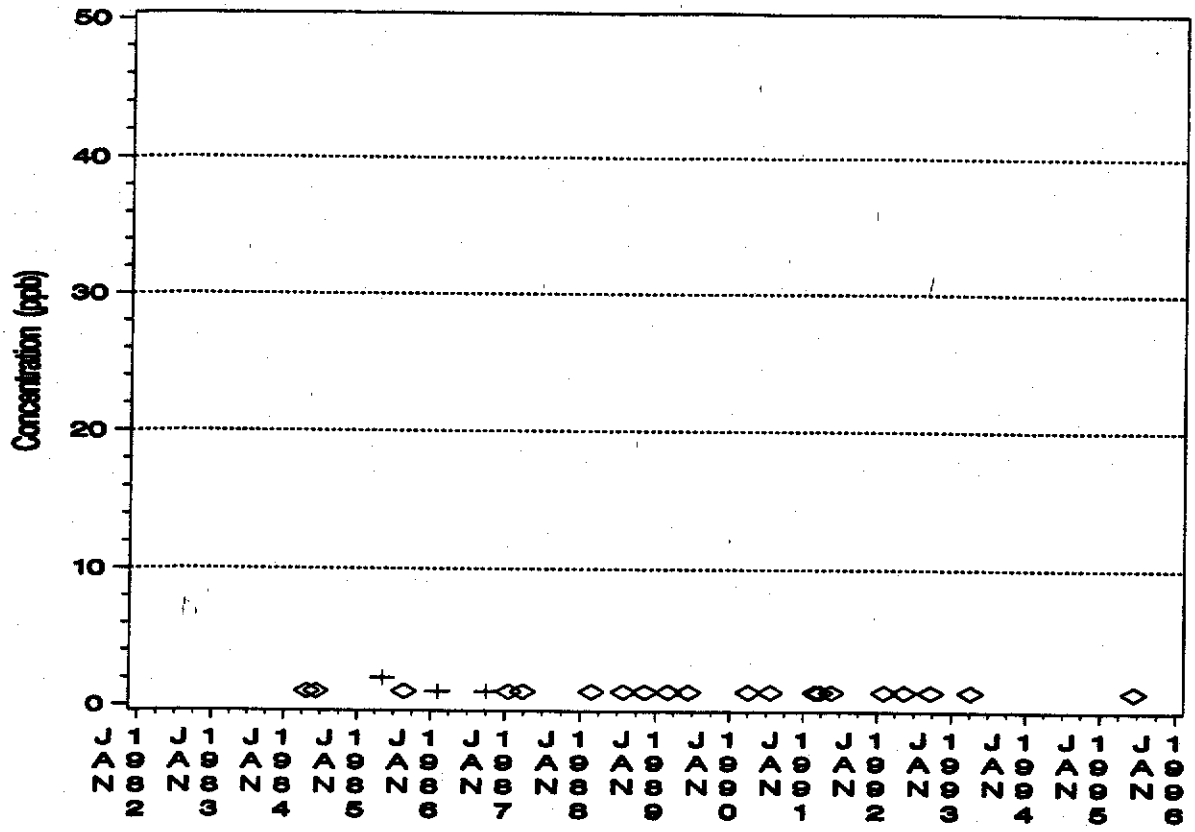
WELL 1255
TRICHLOROETHYLENE Trend



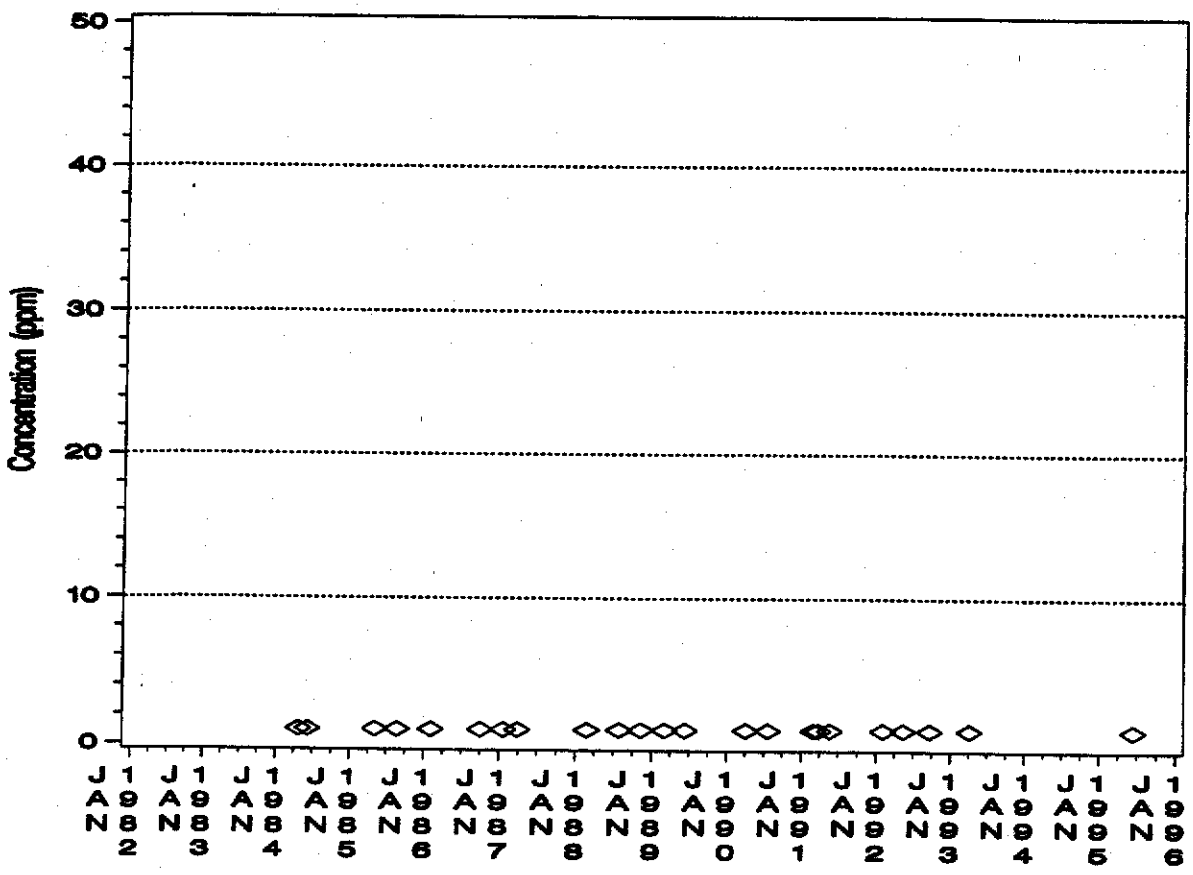
PERCHLORATE Trend



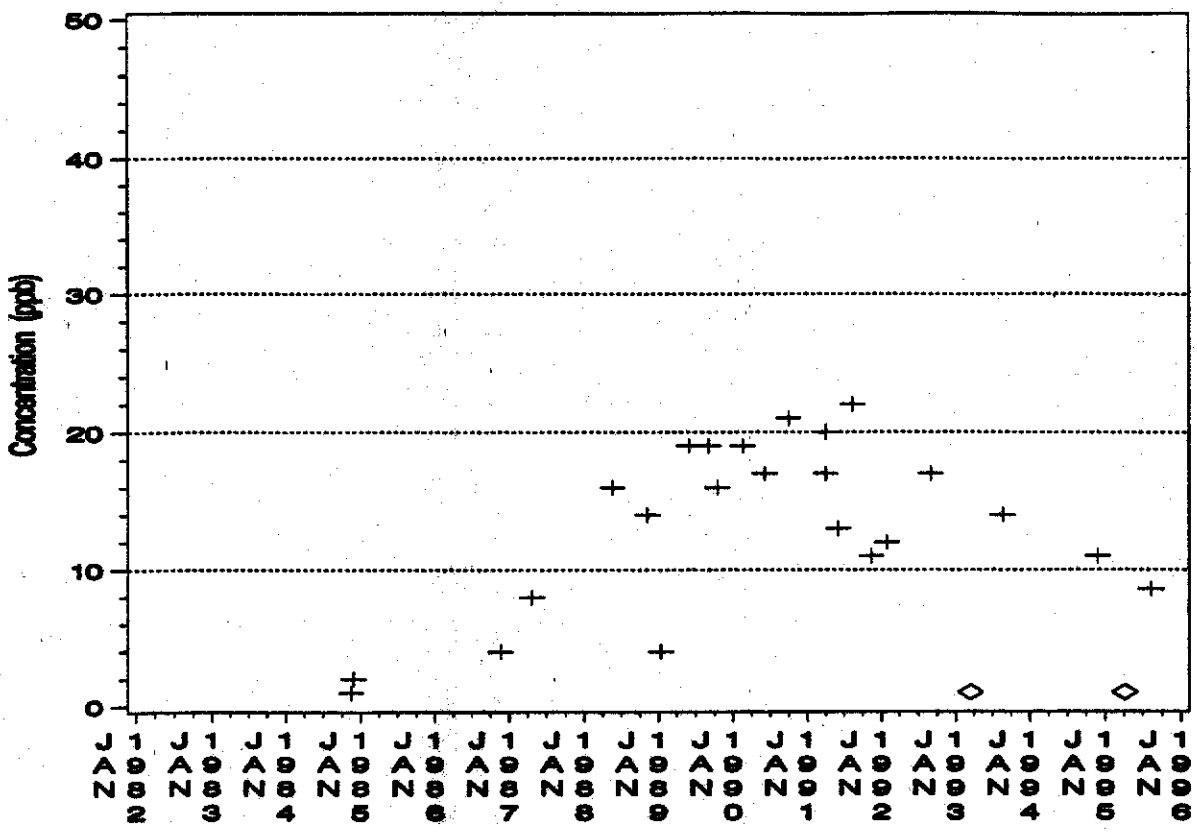
WELL 1255
CHLOROFORM Trend



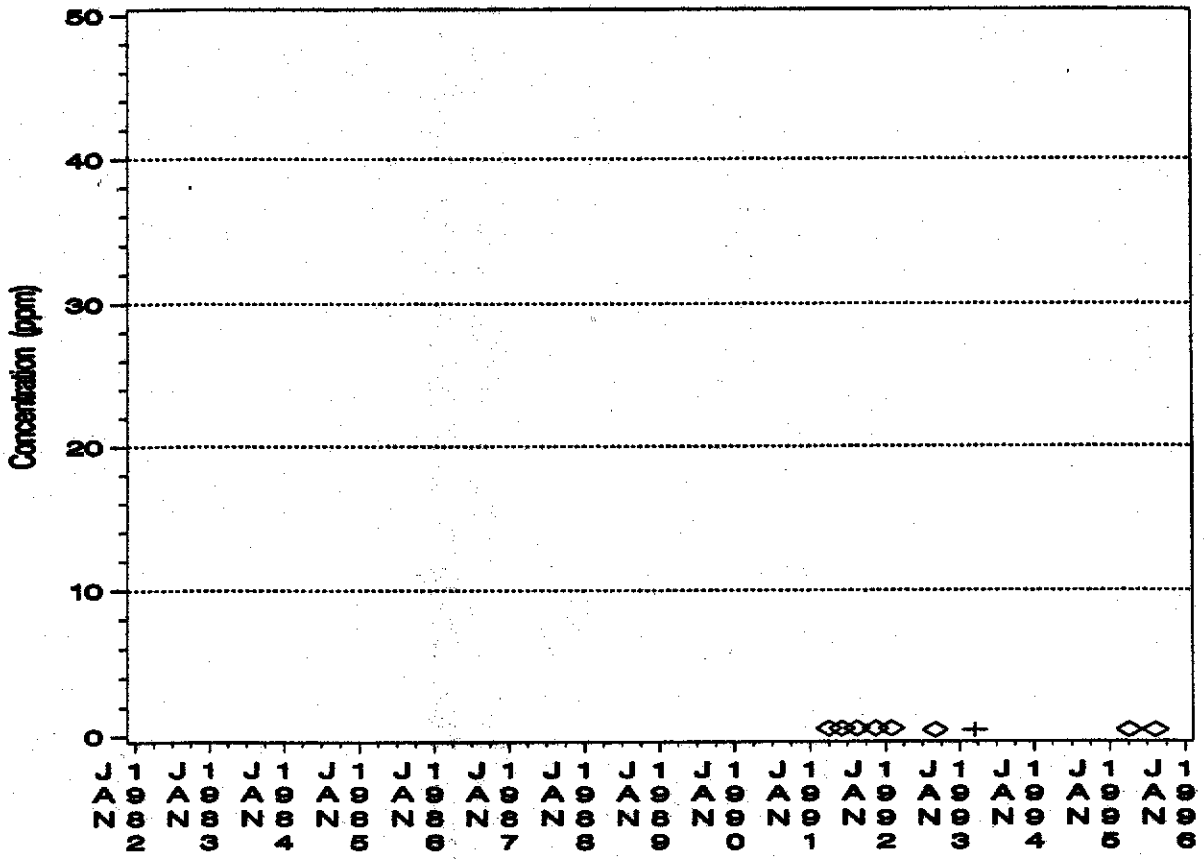
1,2 – DICHLOROETHANE Trend



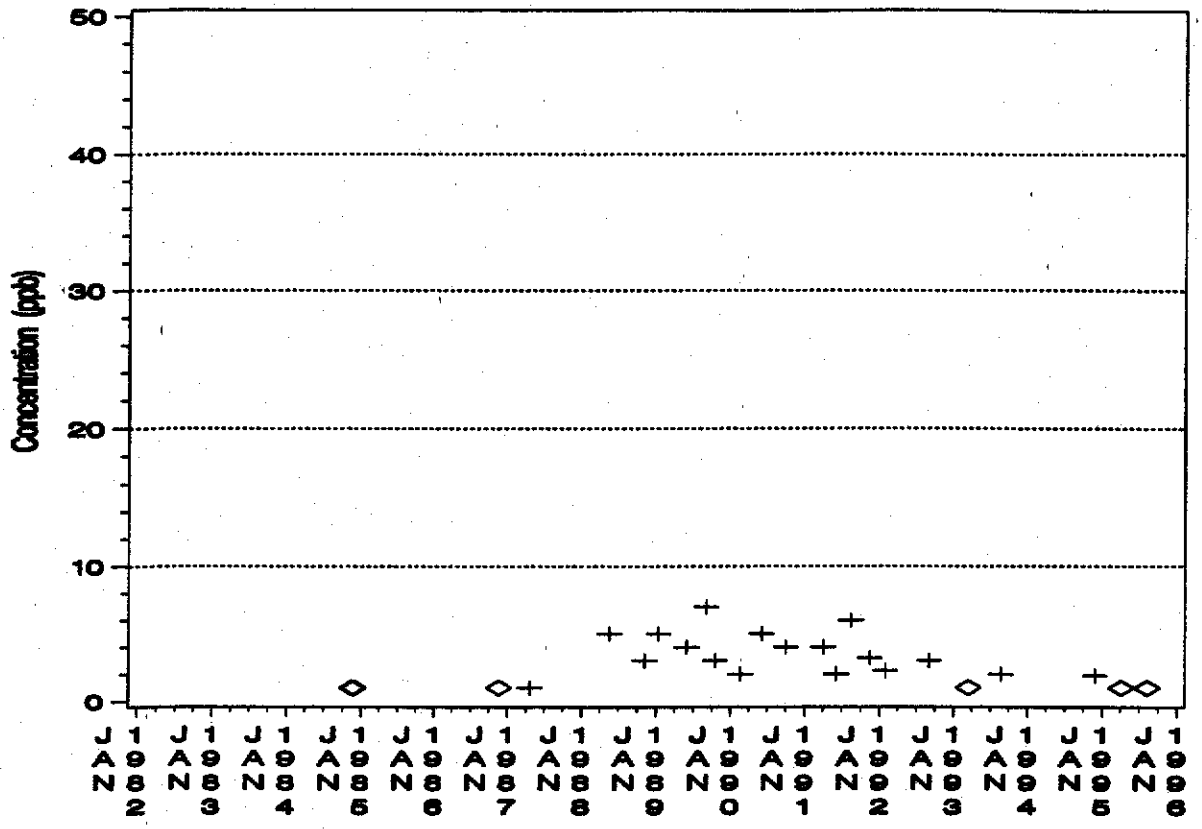
WELL 1273
TRICHLOROETHYLENE Trend



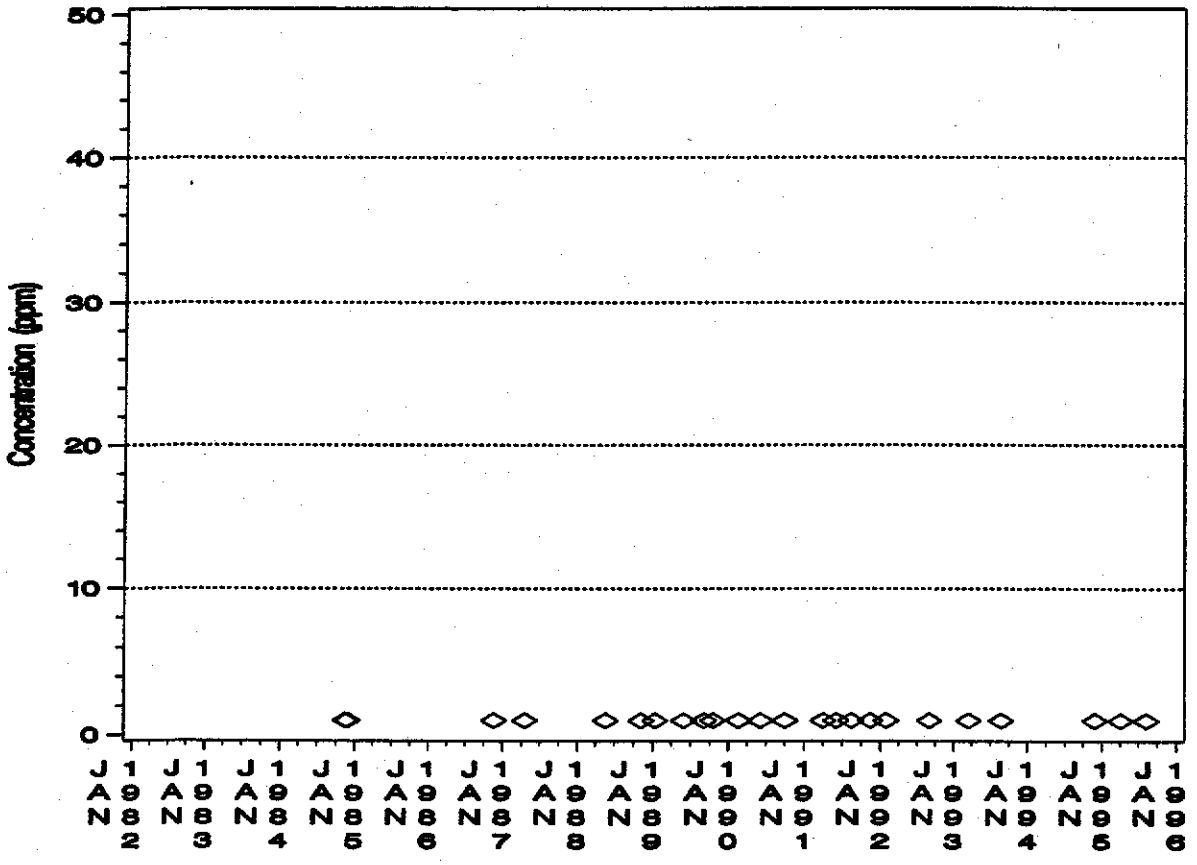
PERCHLORATE Trend



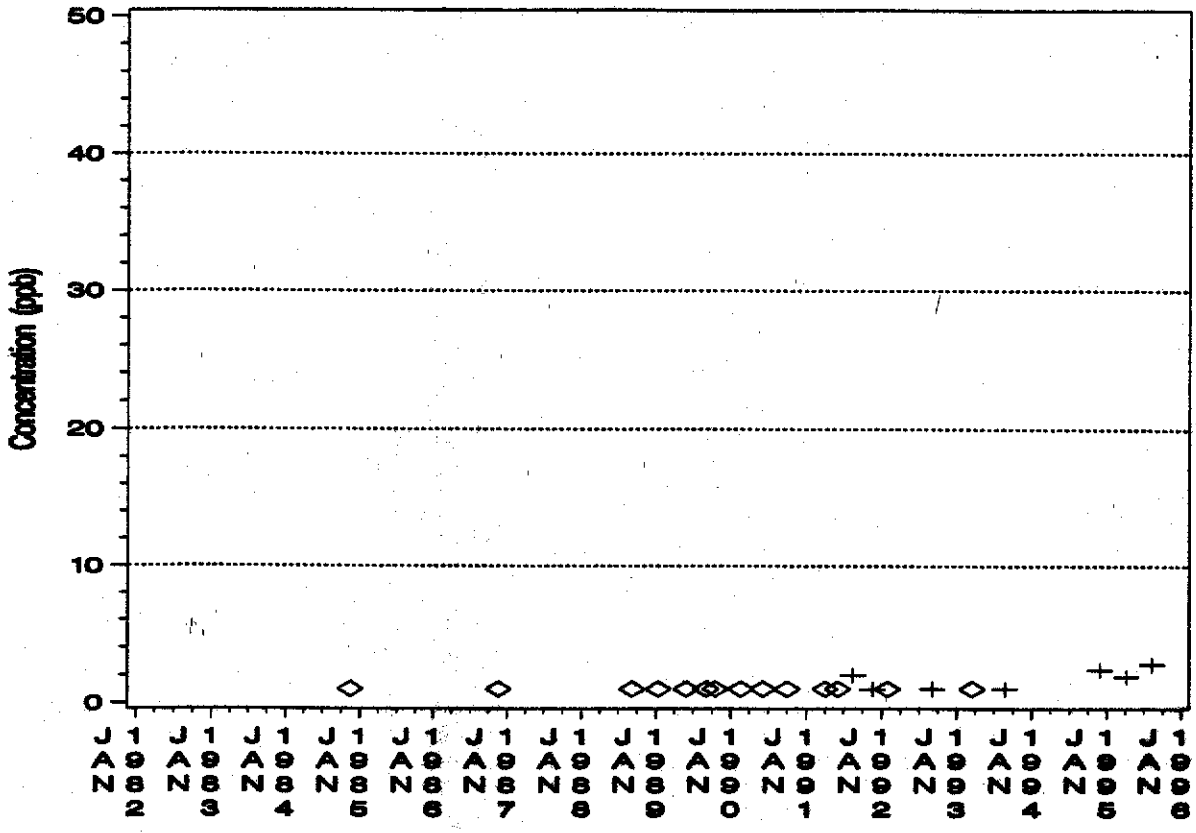
WELL 1273
CHLOROFORM Trend



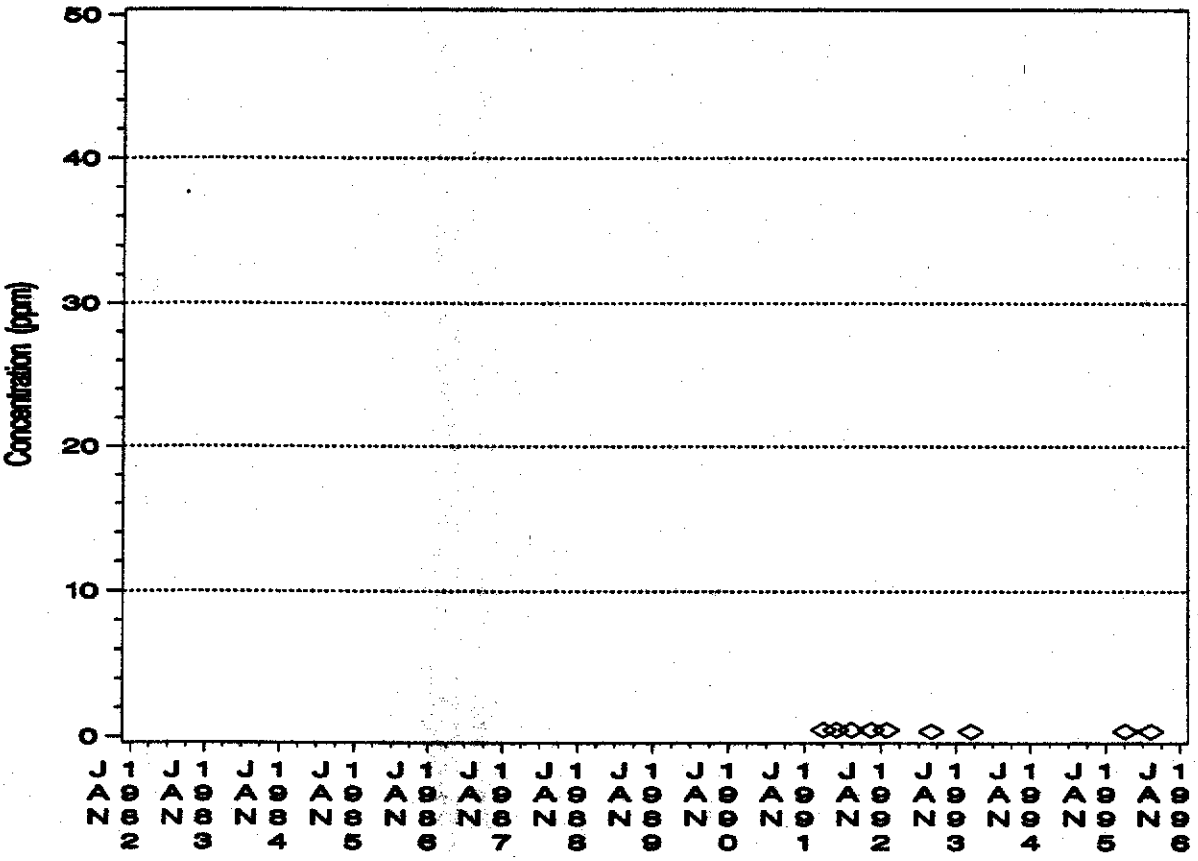
1,2 – DICHLOROETHANE Trend



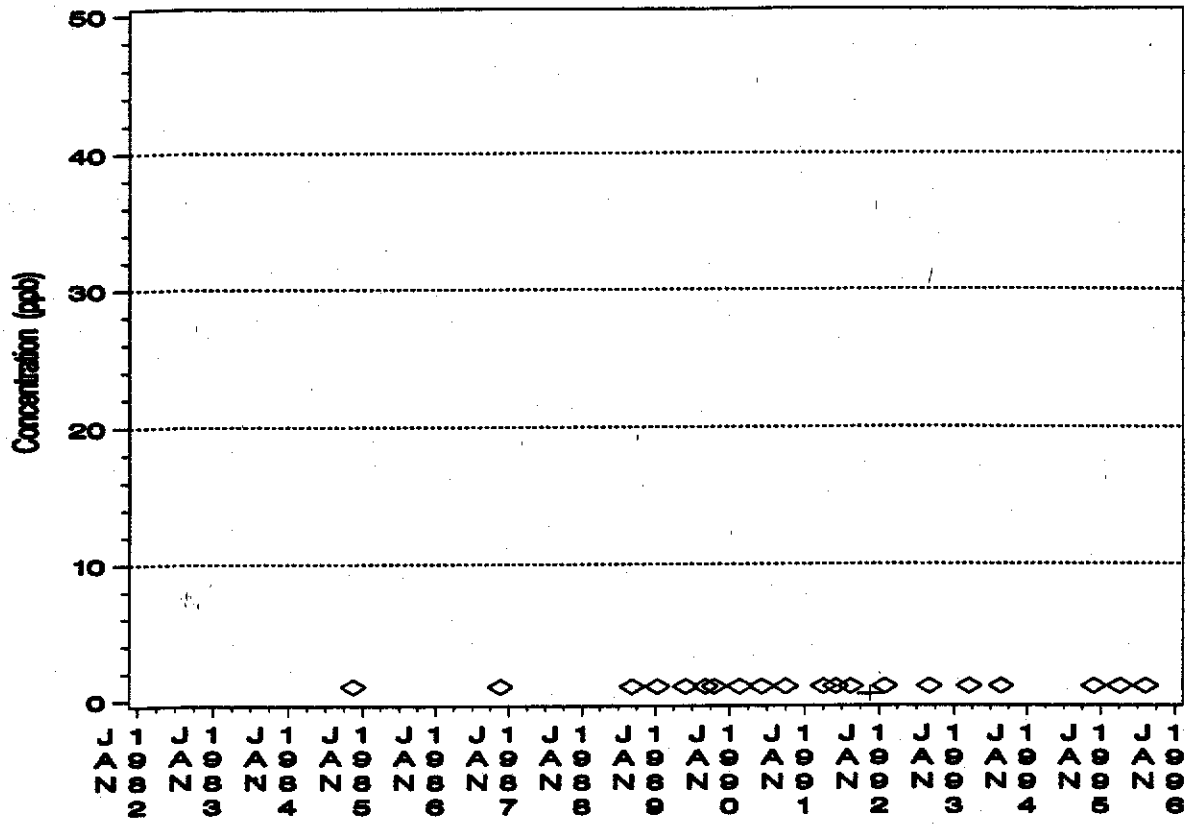
WELL 1274
TRICHLOROETHYLENE Trend



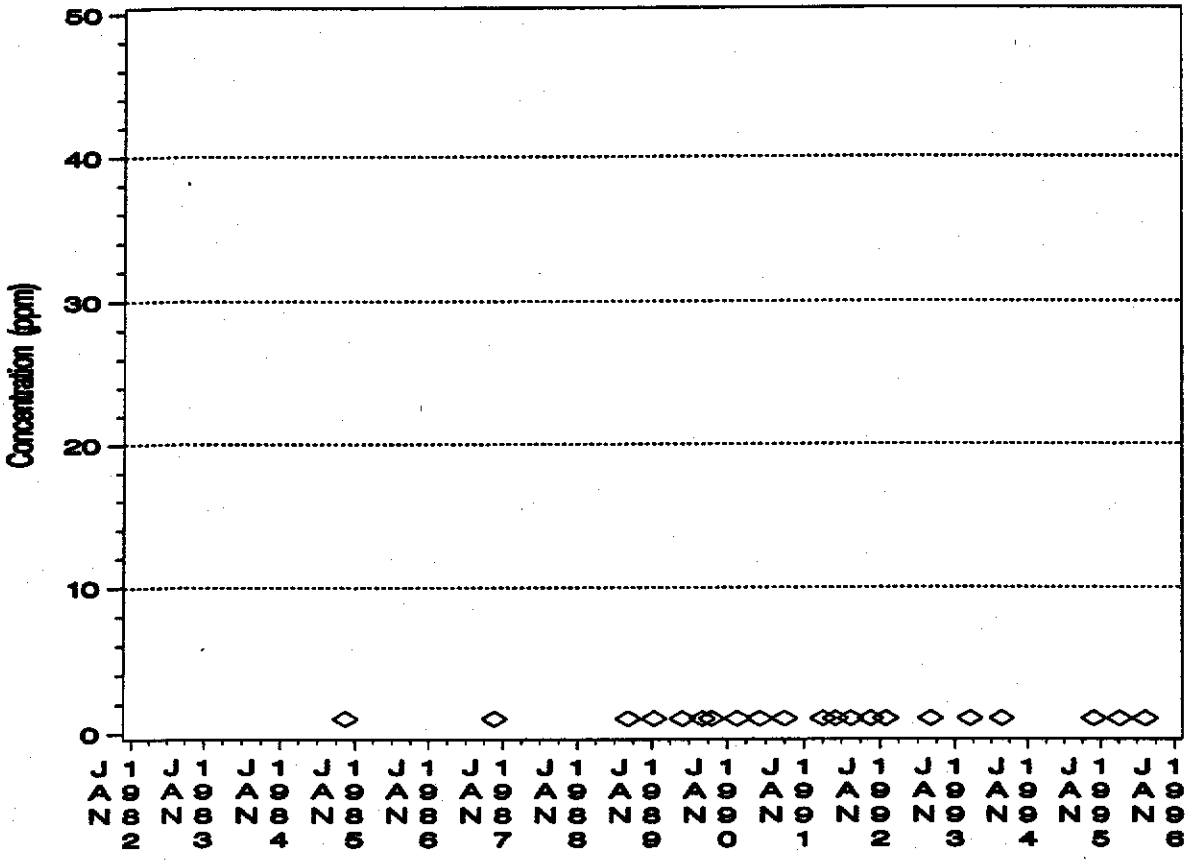
PERCHLORATE Trend



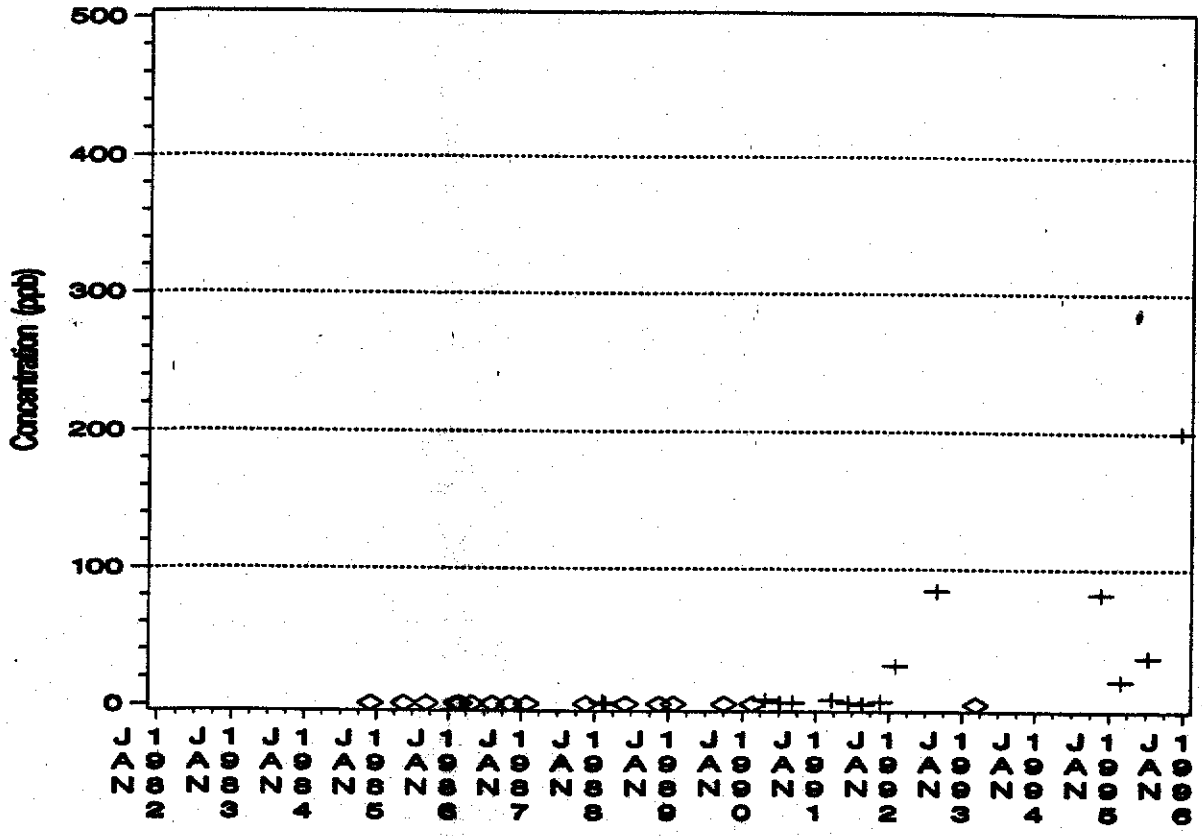
WELL 1274
CHLOROFORM Trend



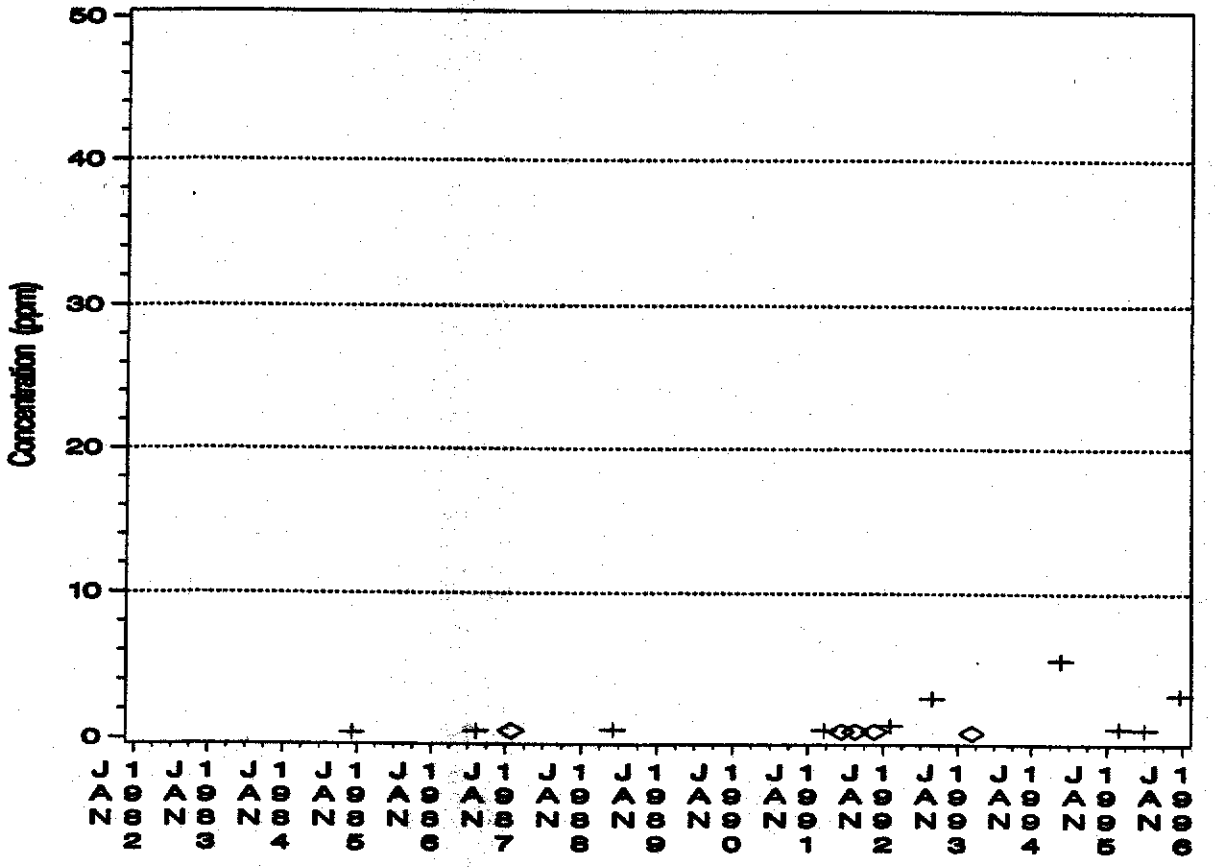
1,2 – DICHLOROETHANE Trend



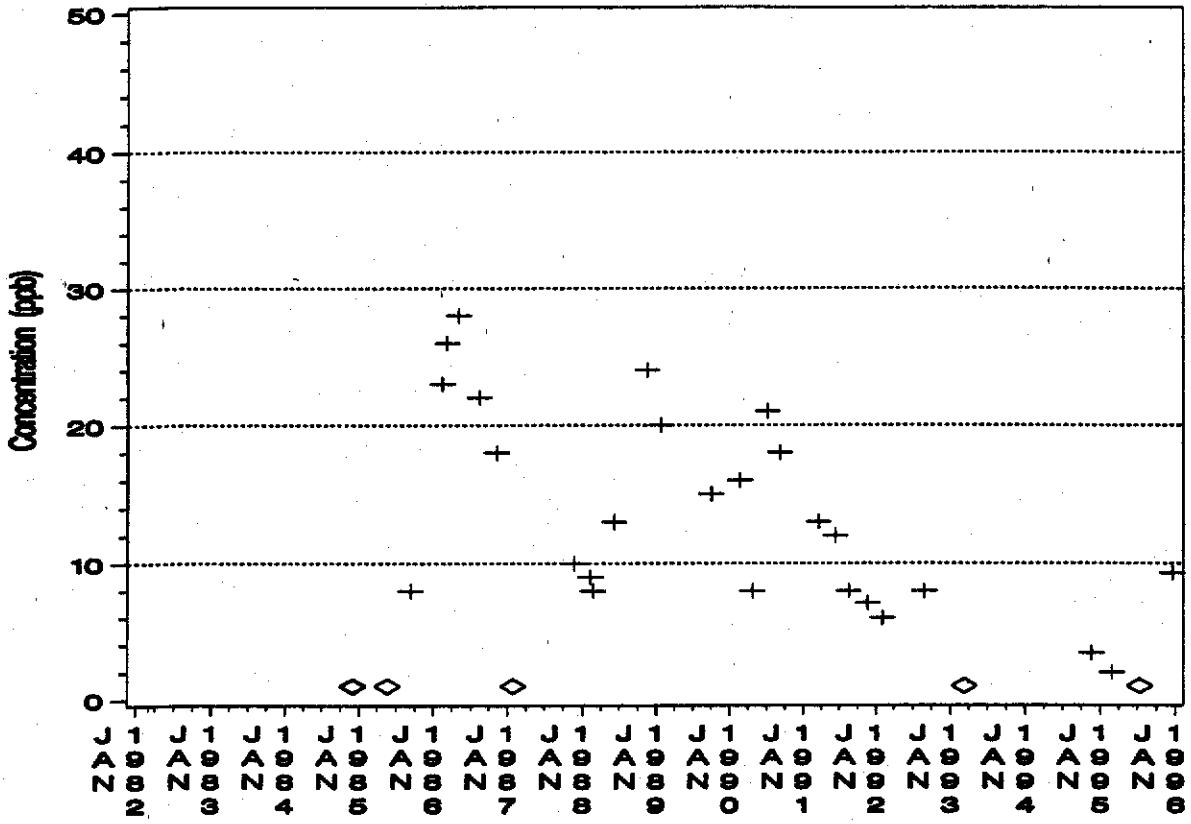
WELL 1277
TRICHLOROETHYLENE Trend



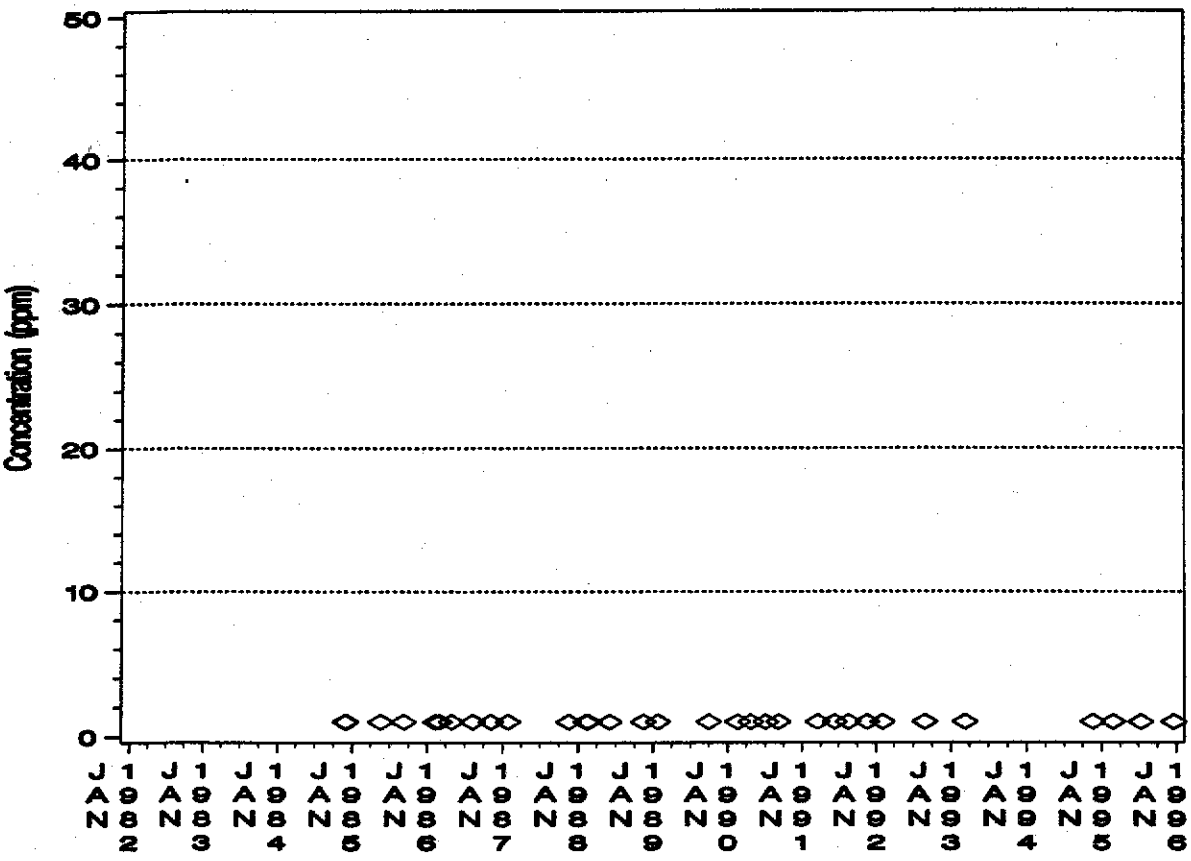
PERCHLORATE Trend



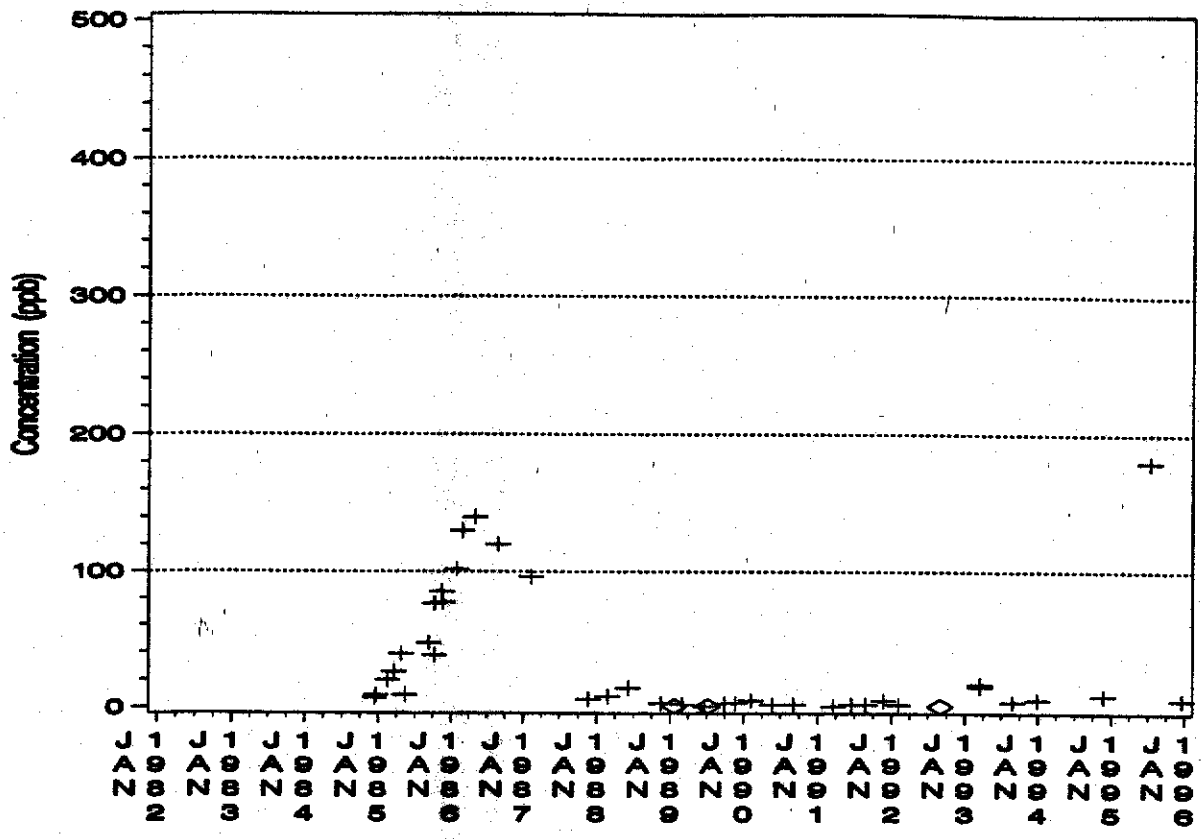
WELL 1277
CHLOROFORM Trend



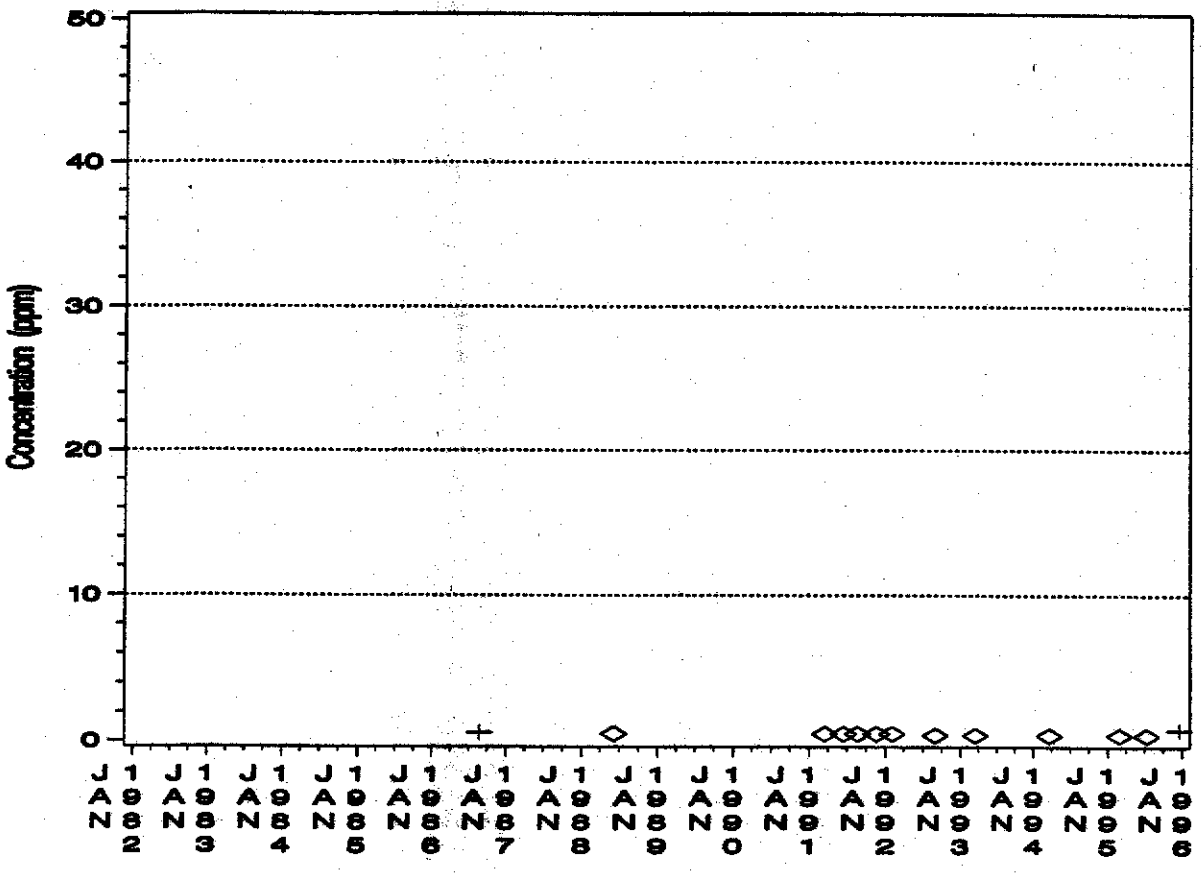
1,2 – DICHLOROETHANE Trend



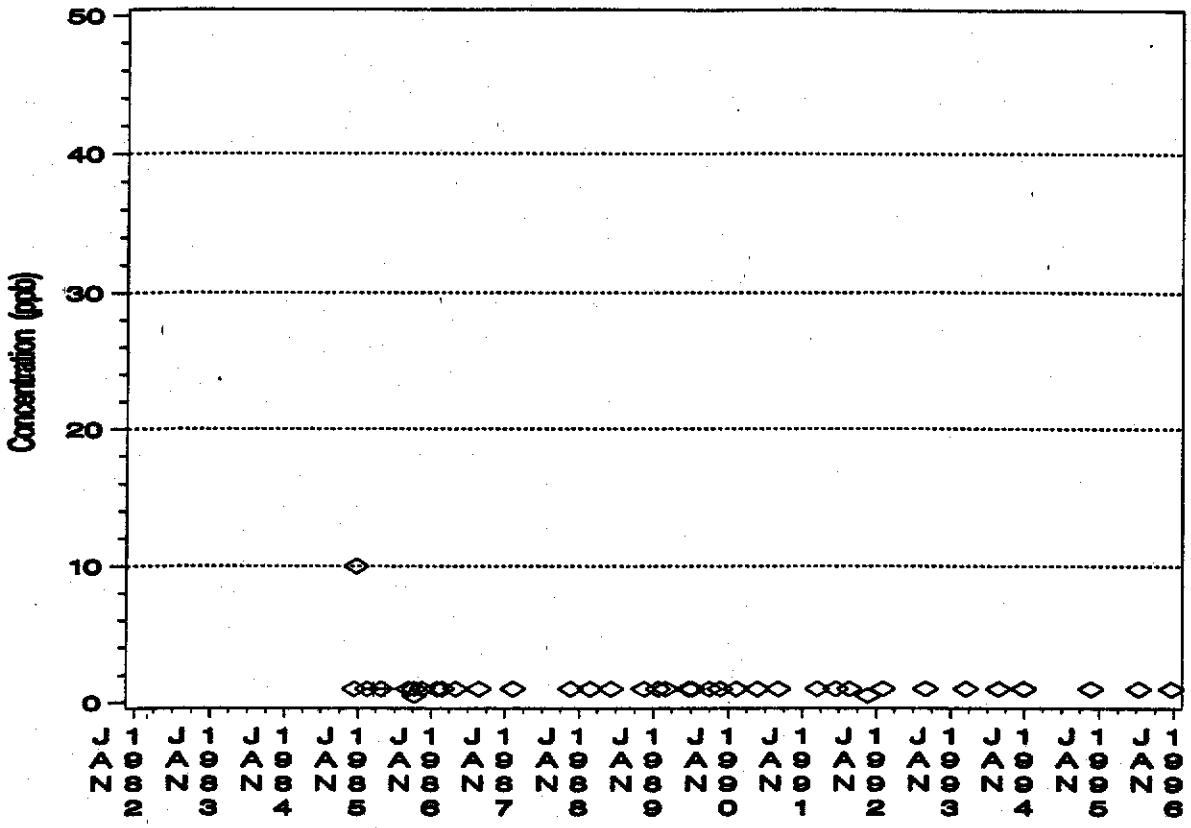
WELL 1282
TRICHLOROETHYLENE Trend



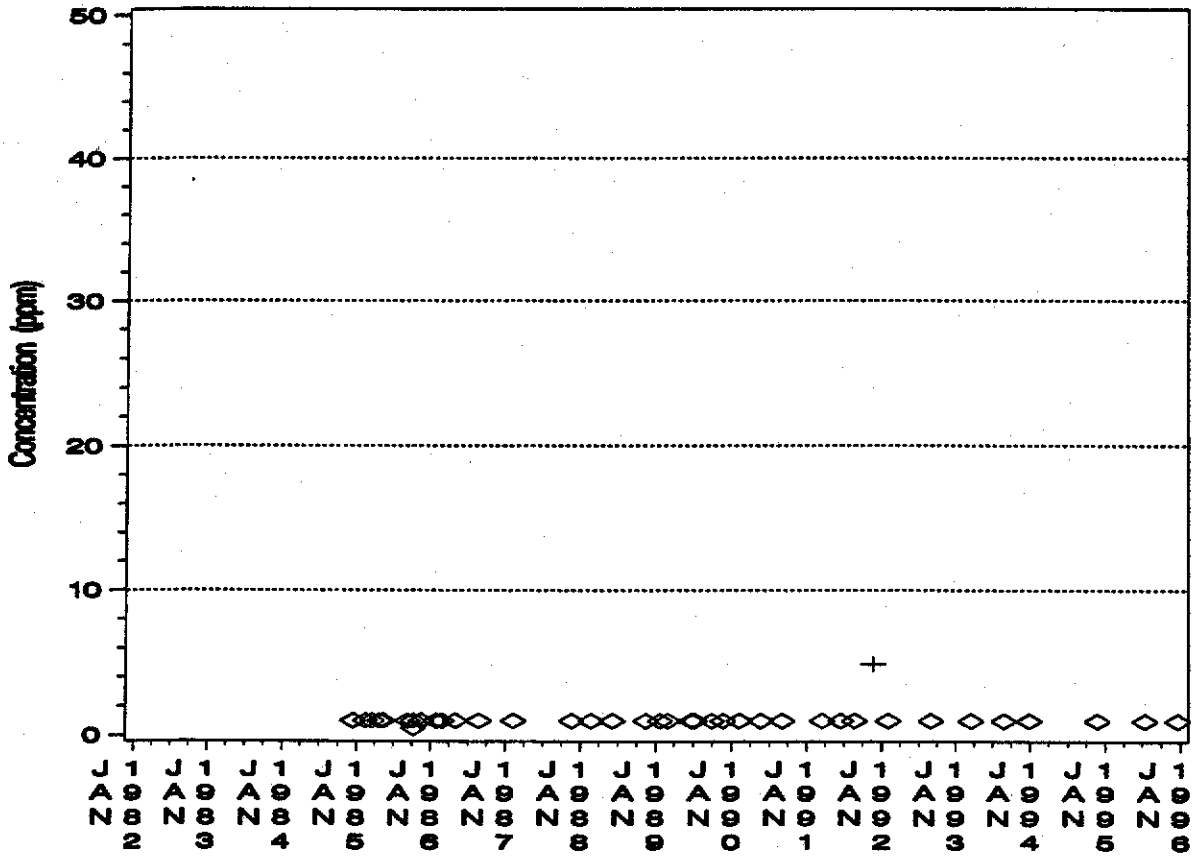
PERCHLORATE Trend



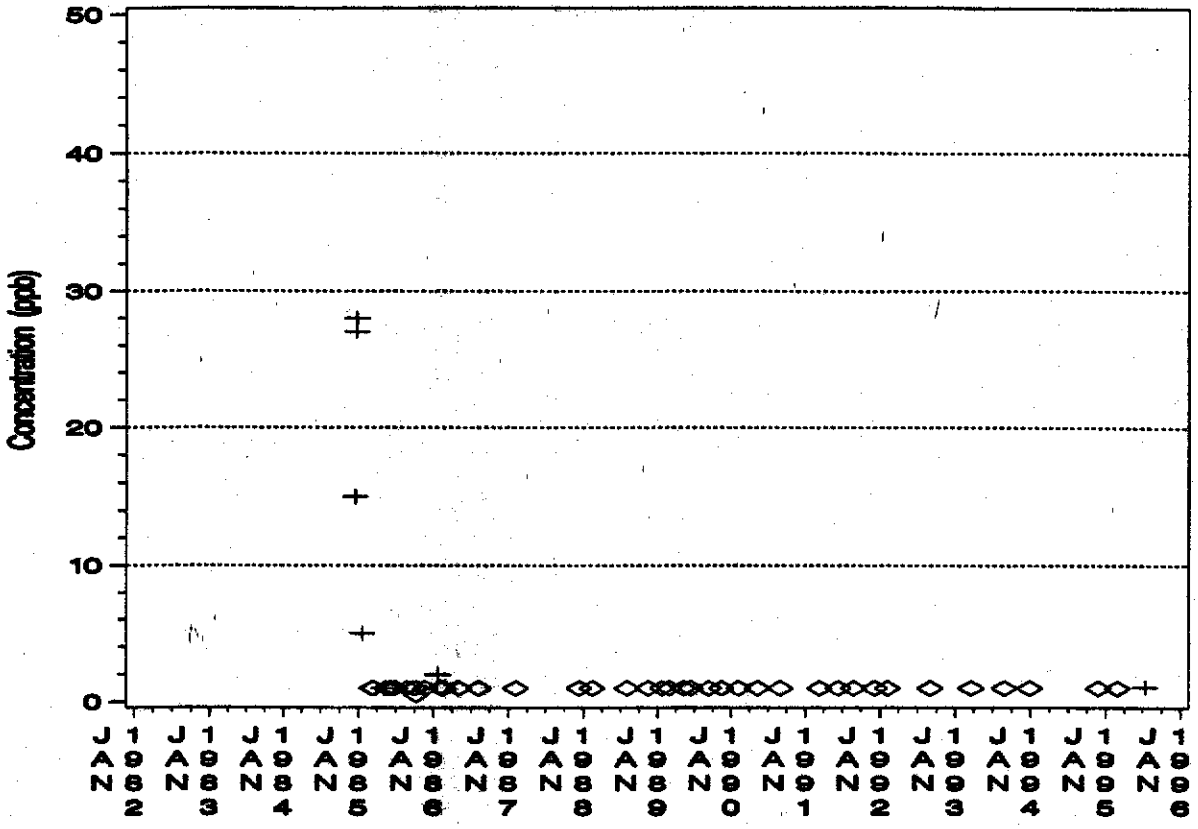
WELL 1282
CHLOROFORM Trend



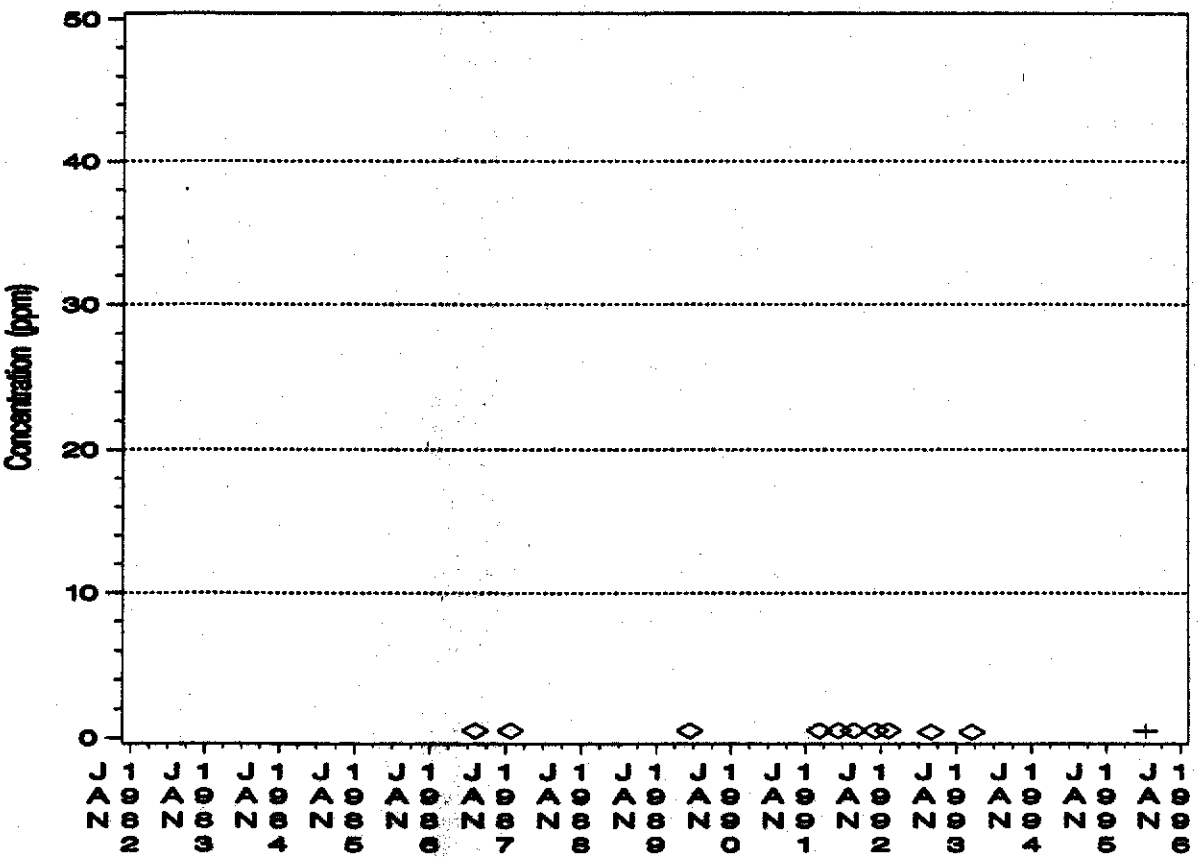
1,2 – DICHLOROETHANE Trend



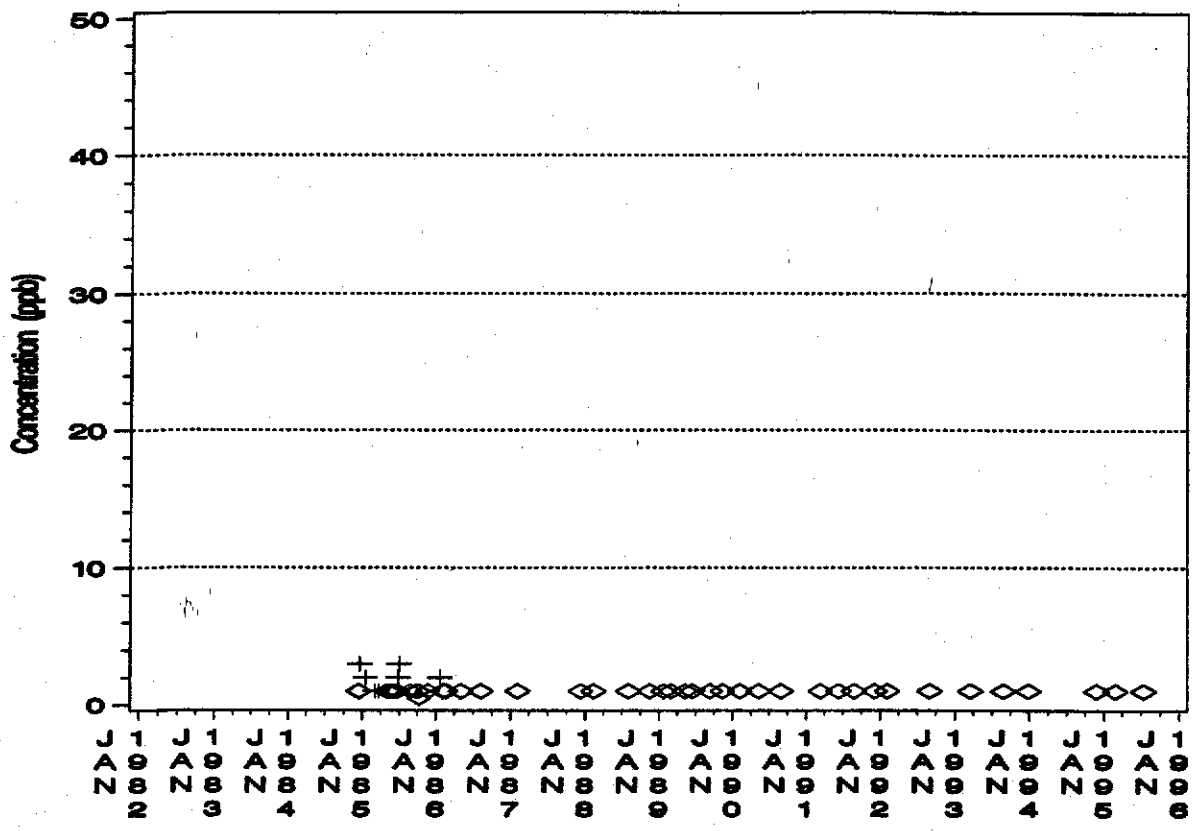
WELL 1284
TRICHLOROETHYLENE Trend



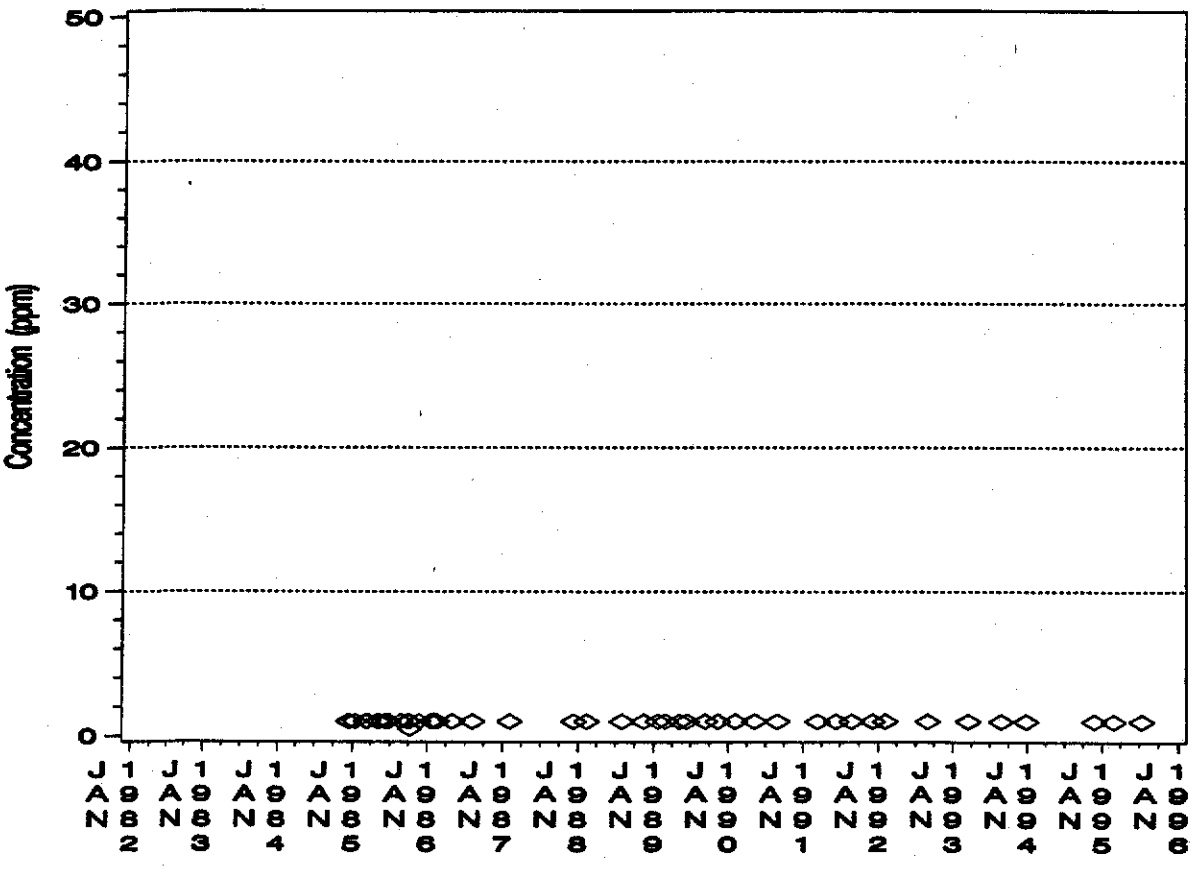
PERCHLORATE Trend



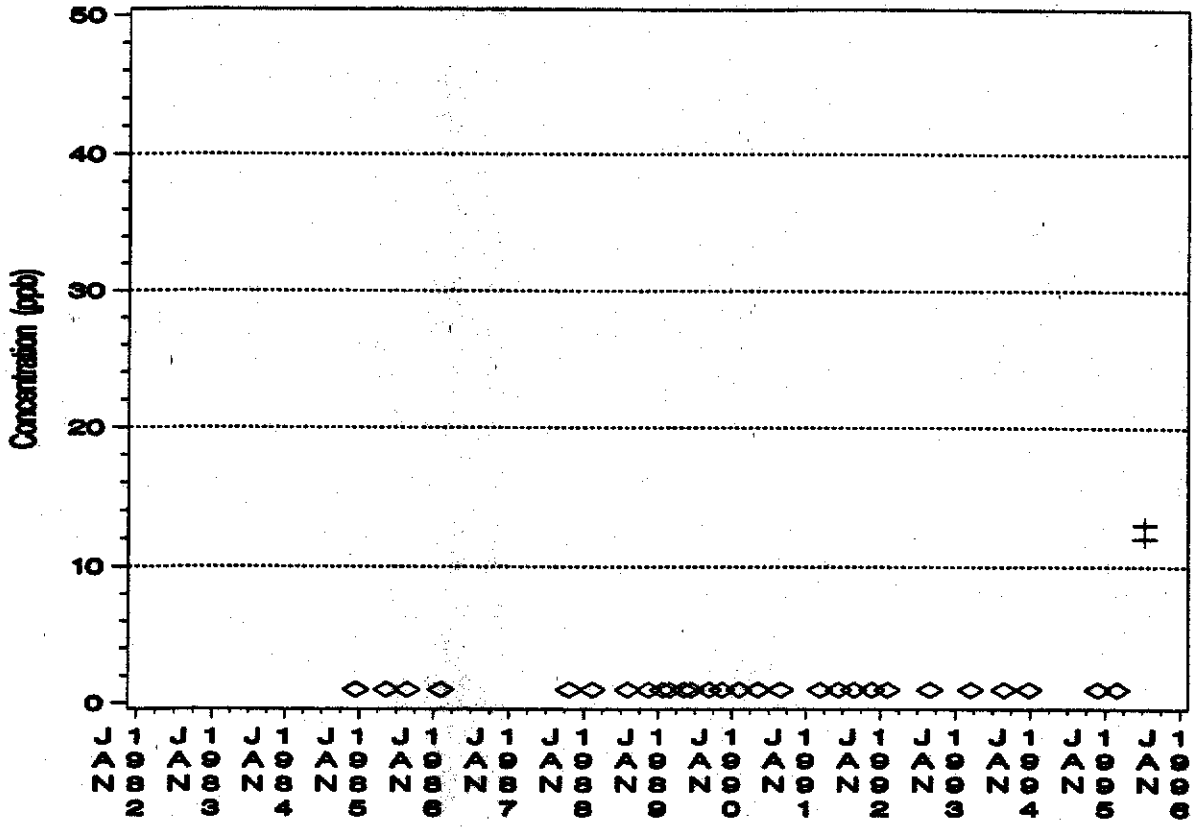
WELL 1284
CHLOROFORM Trend



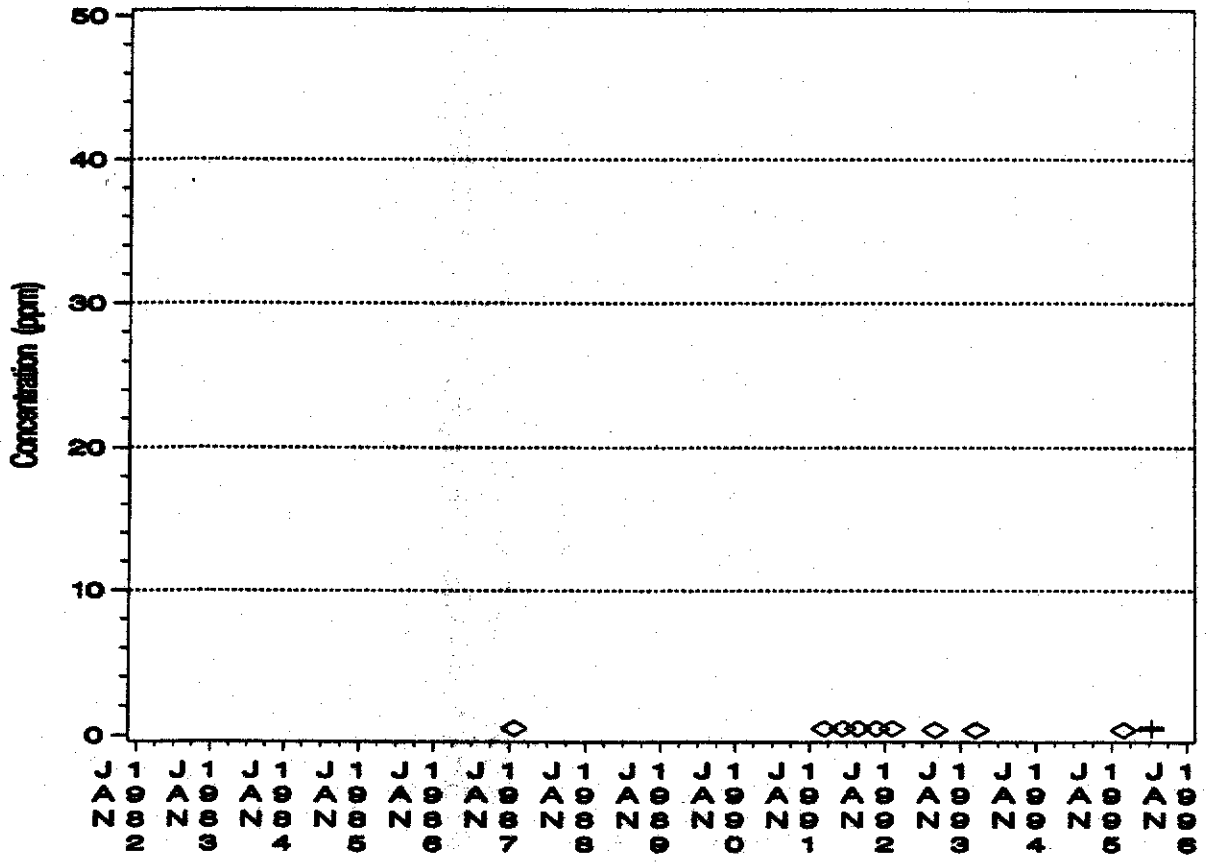
1,2 – DICHLOROETHANE Trend



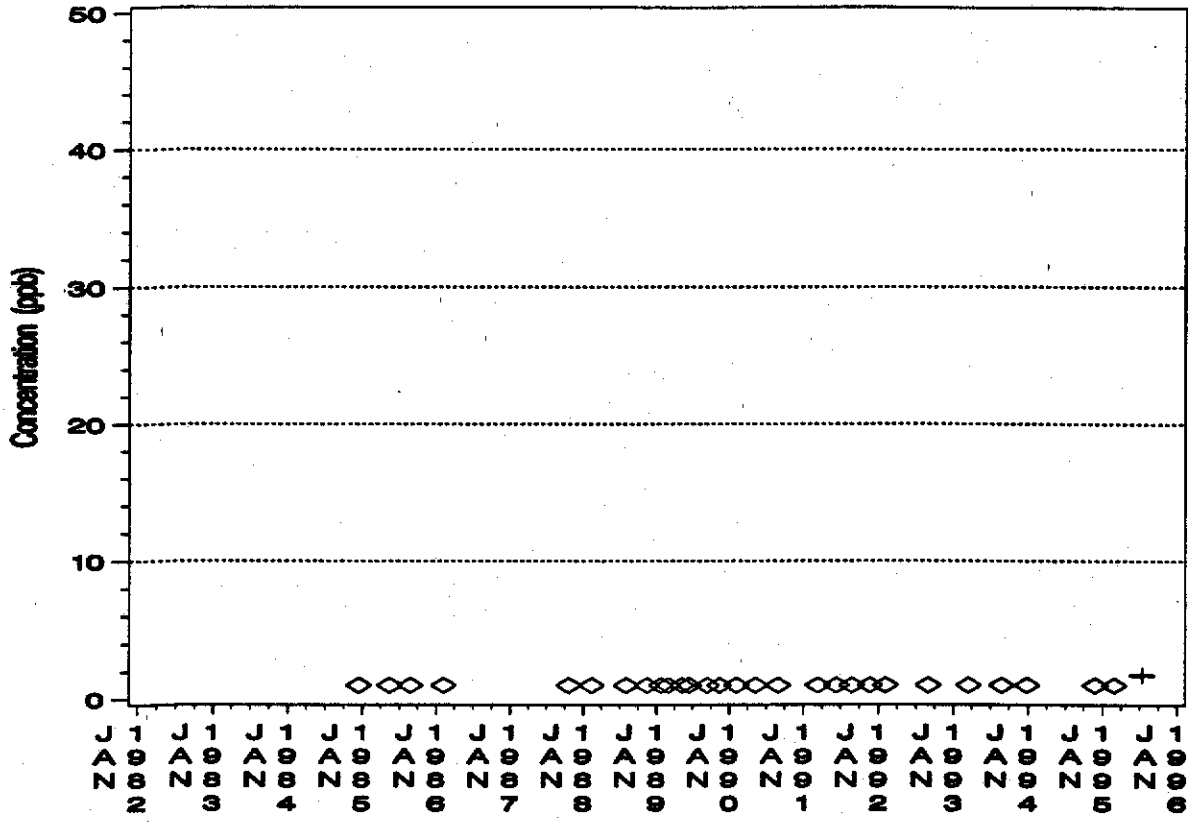
WELL 1286
TRICHLOROETHYLENE Trend



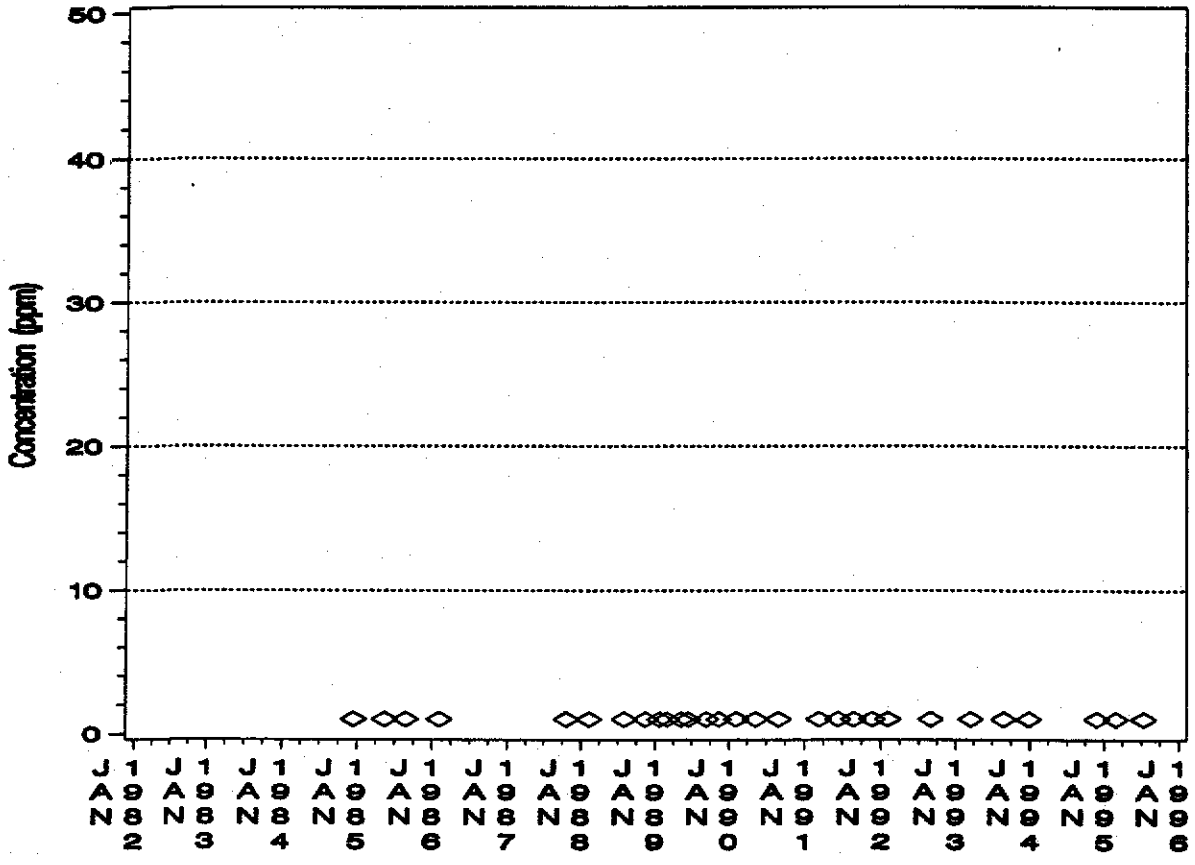
PERCHLORATE Trend



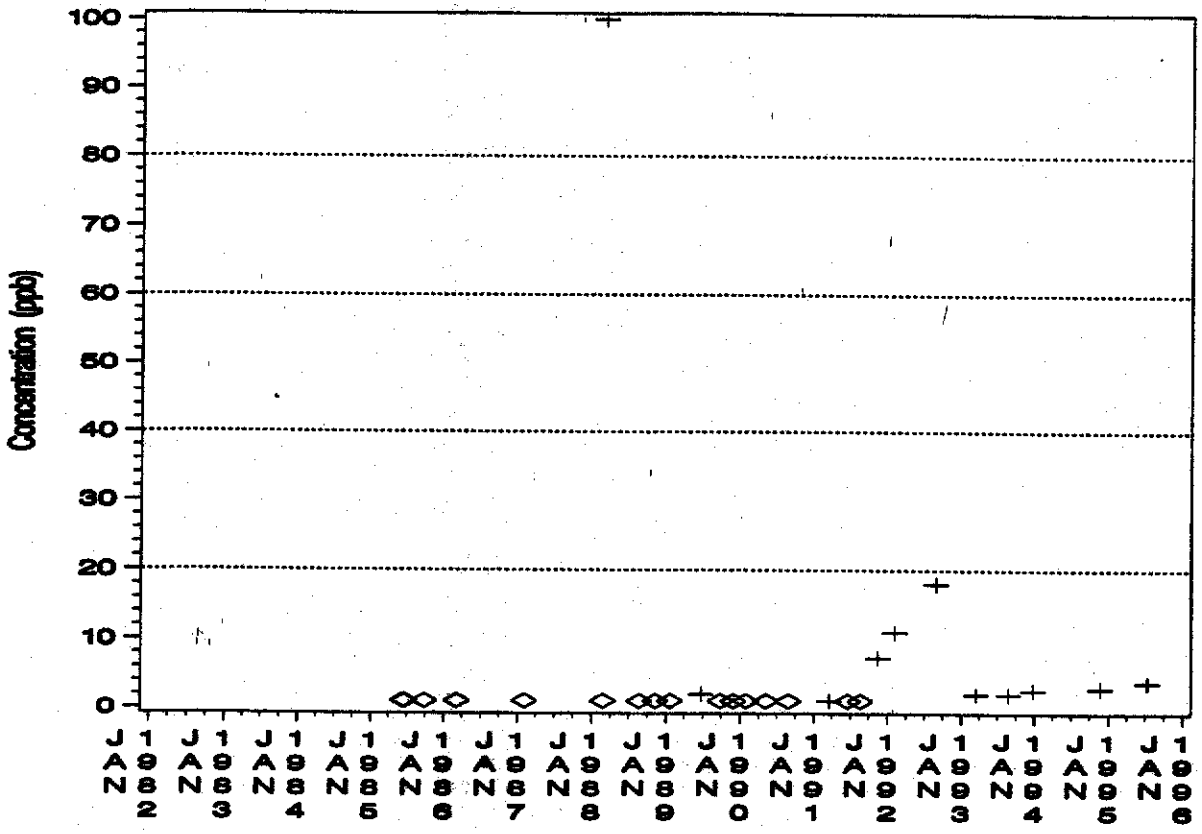
WELL 1286
CHLOROFORM Trend



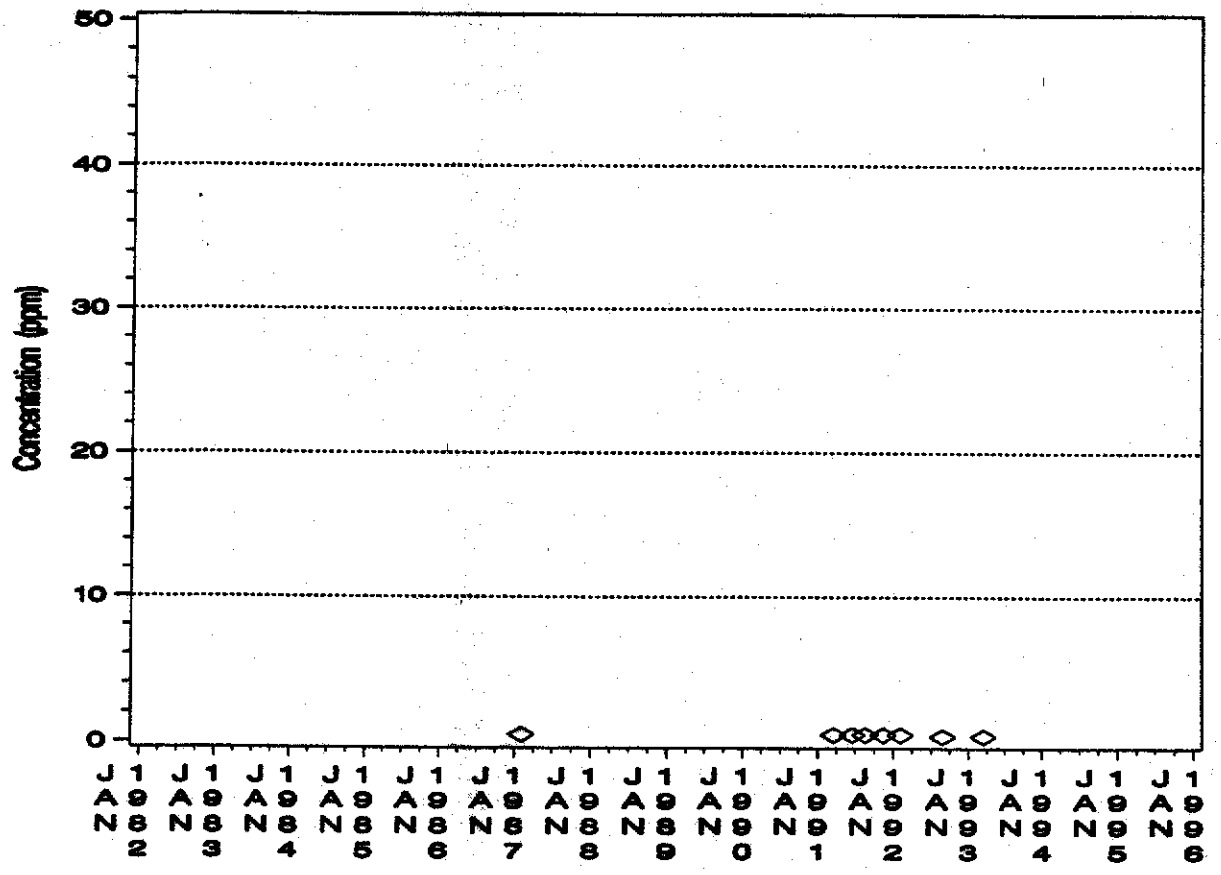
1,2 – DICHLOROETHANE Trend



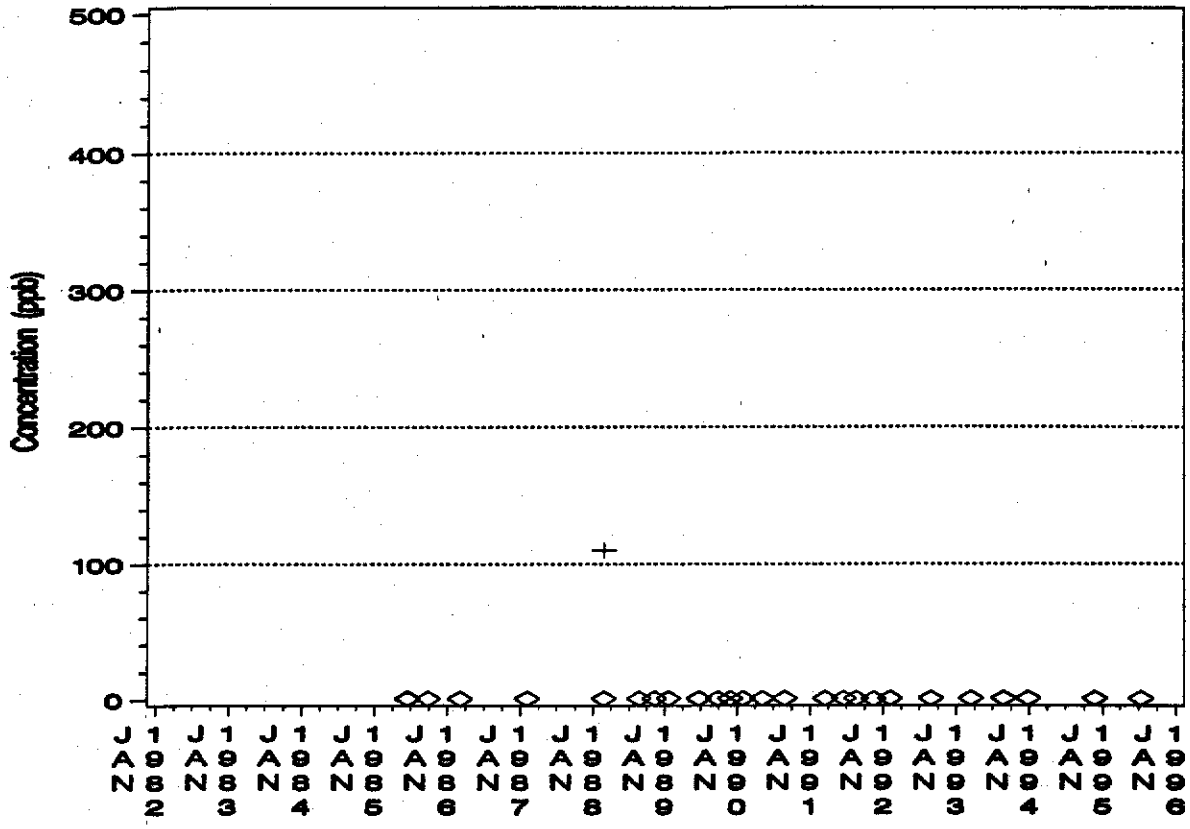
WELL 1350
TRICHLOROETHYLENE Trend



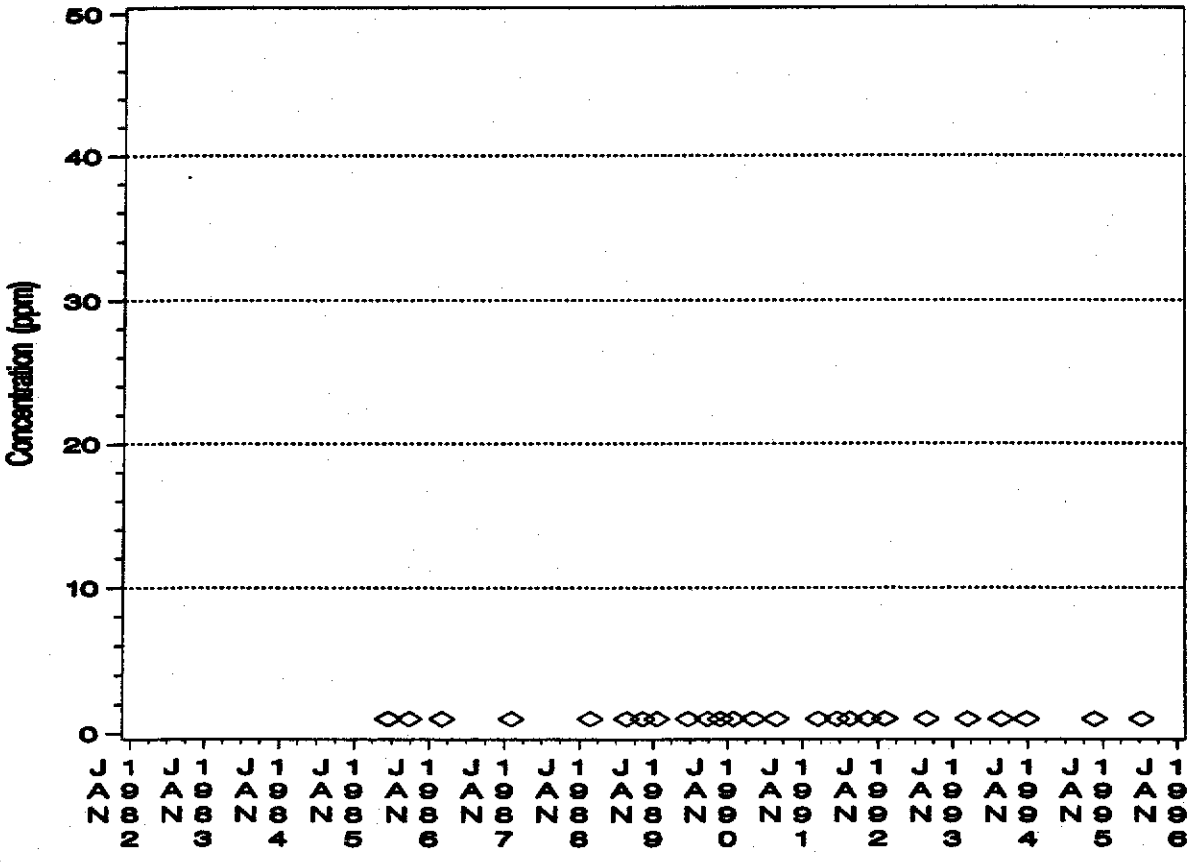
PERCHLORATE Trend



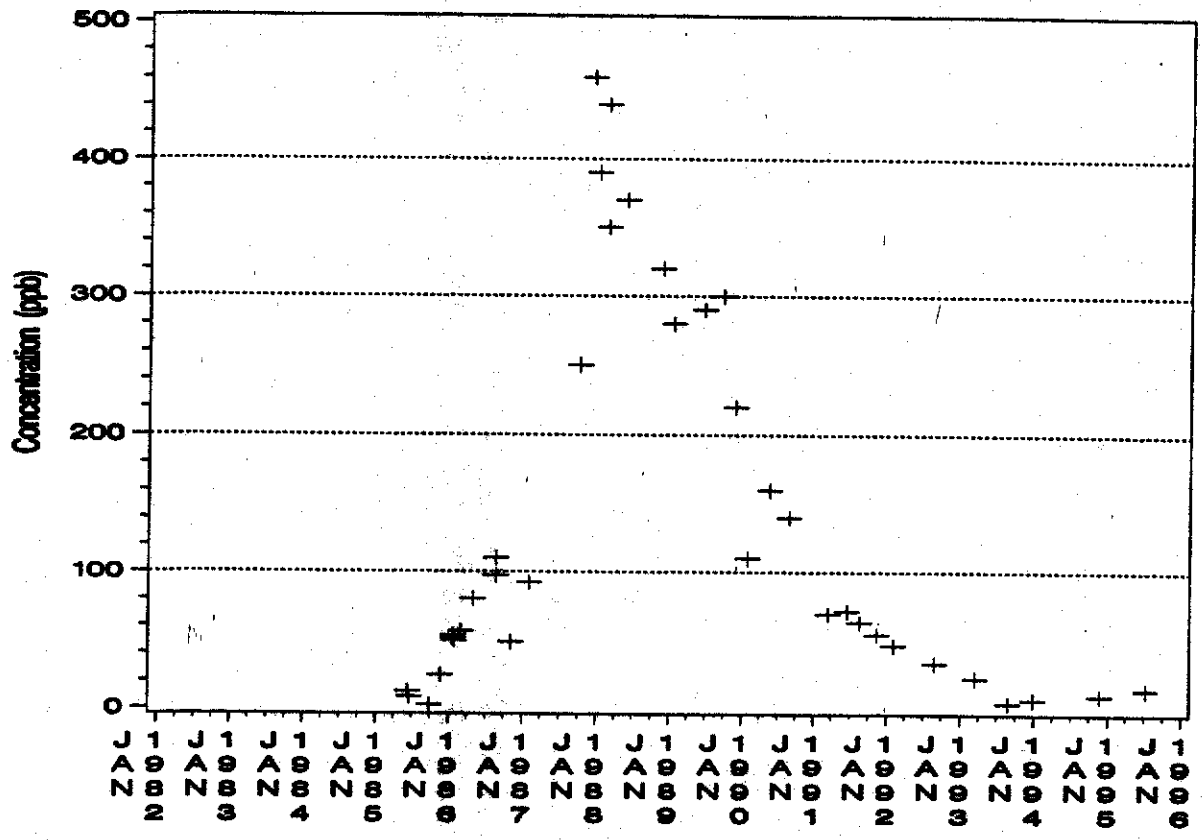
WELL 1350
CHLOROFORM Trend



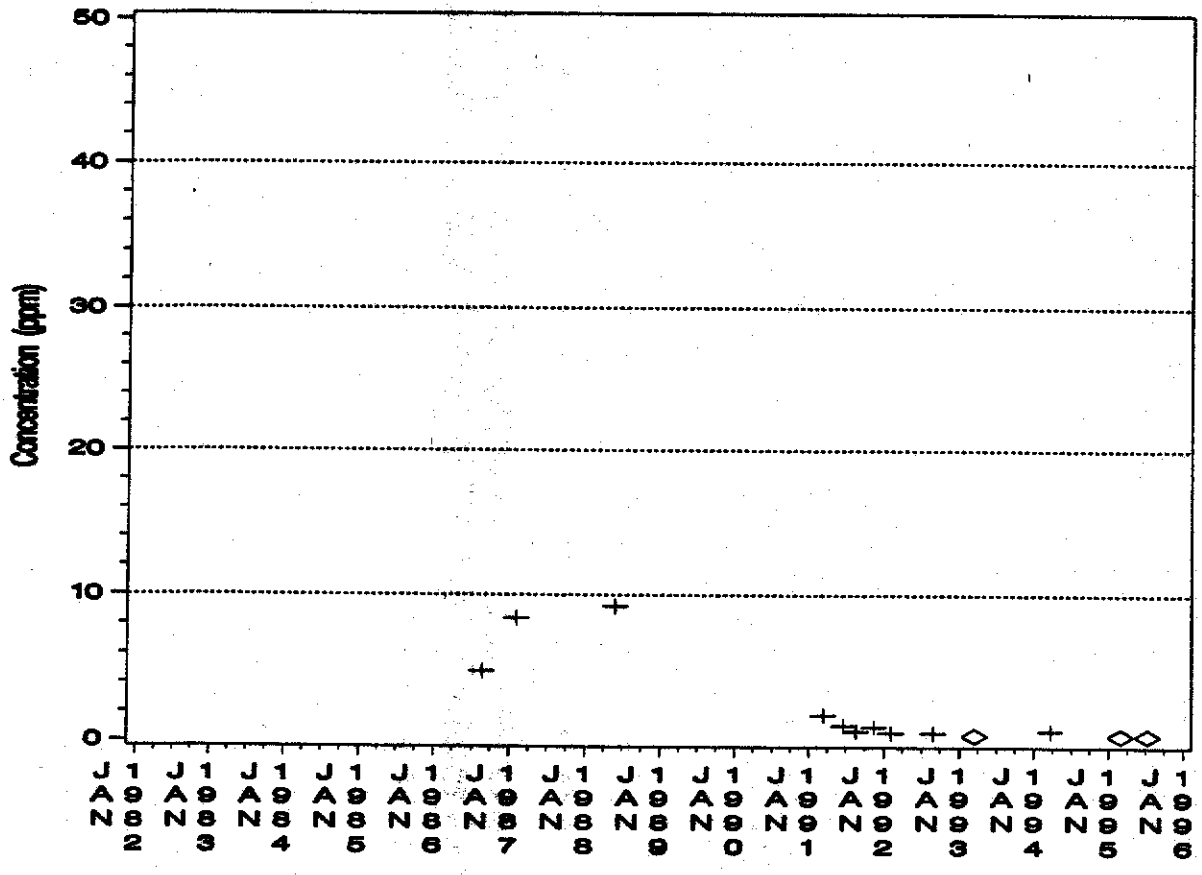
1,2 – DICHLOROETHANE Trend



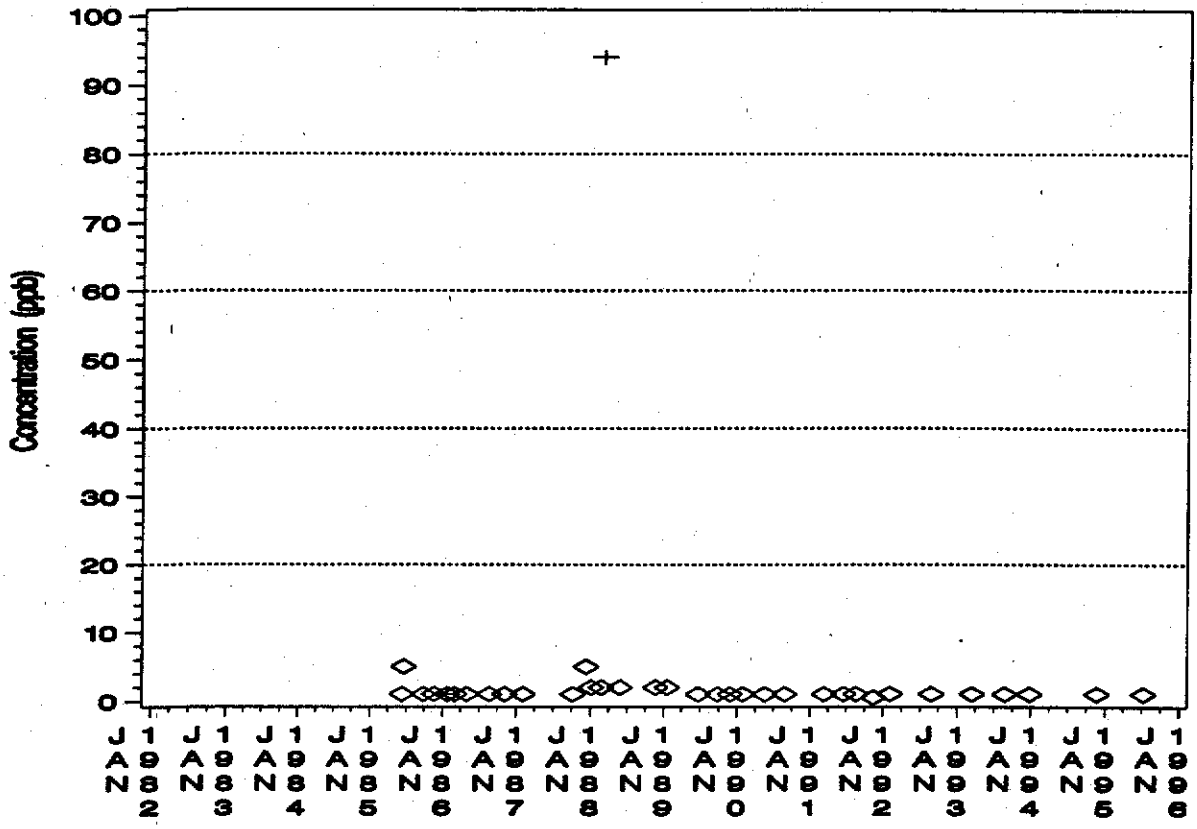
WELL 1351
TRICHLOROETHYLENE Trend



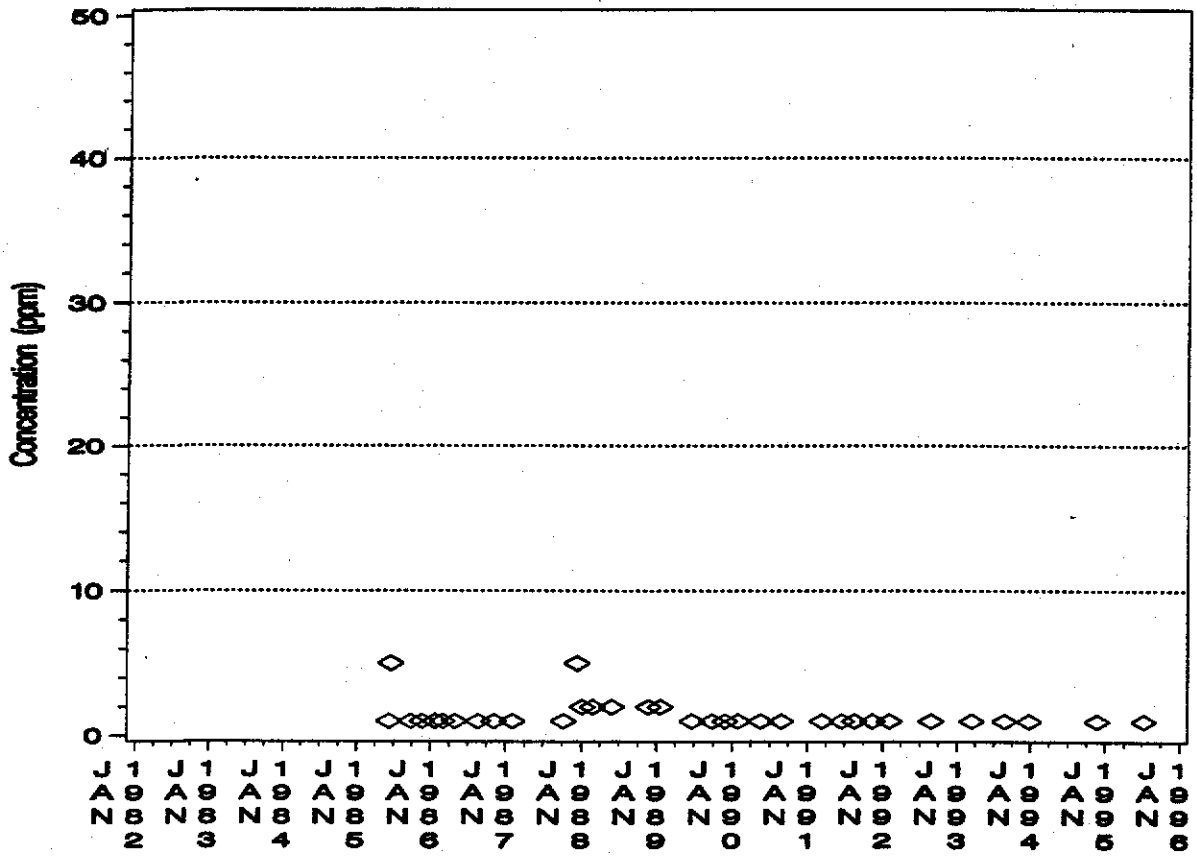
PERCHLORATE Trend



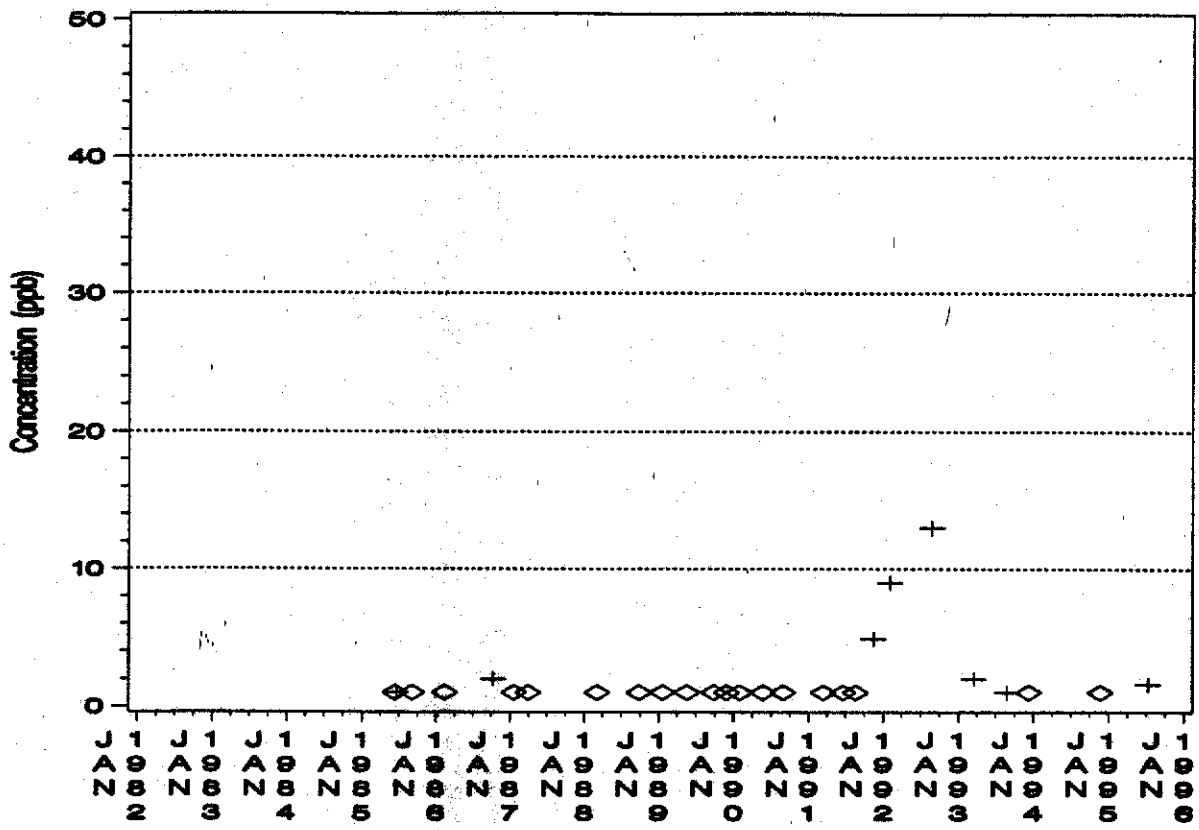
WELL 1351
CHLOROFORM Trend



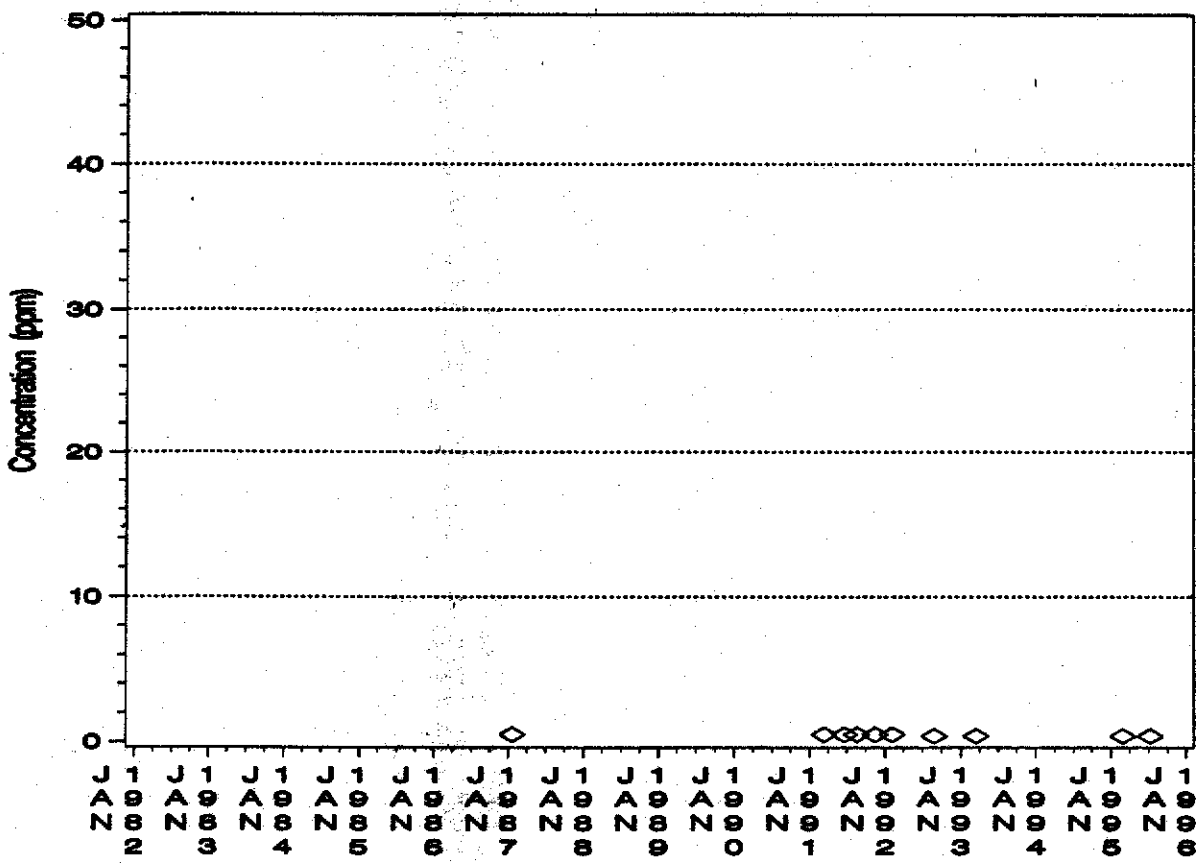
1,2 – DICHLOROETHANE Trend



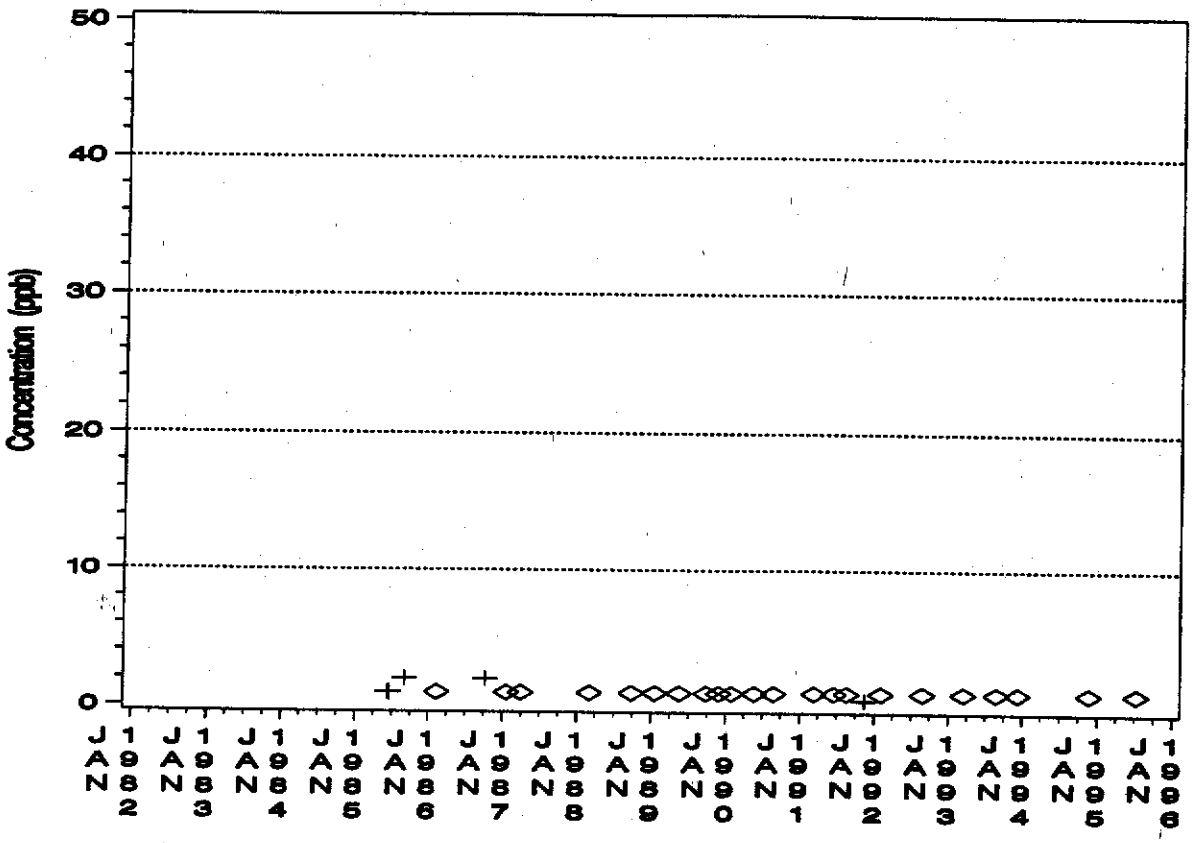
WELL 1352
TRICHLOROETHYLENE Trend



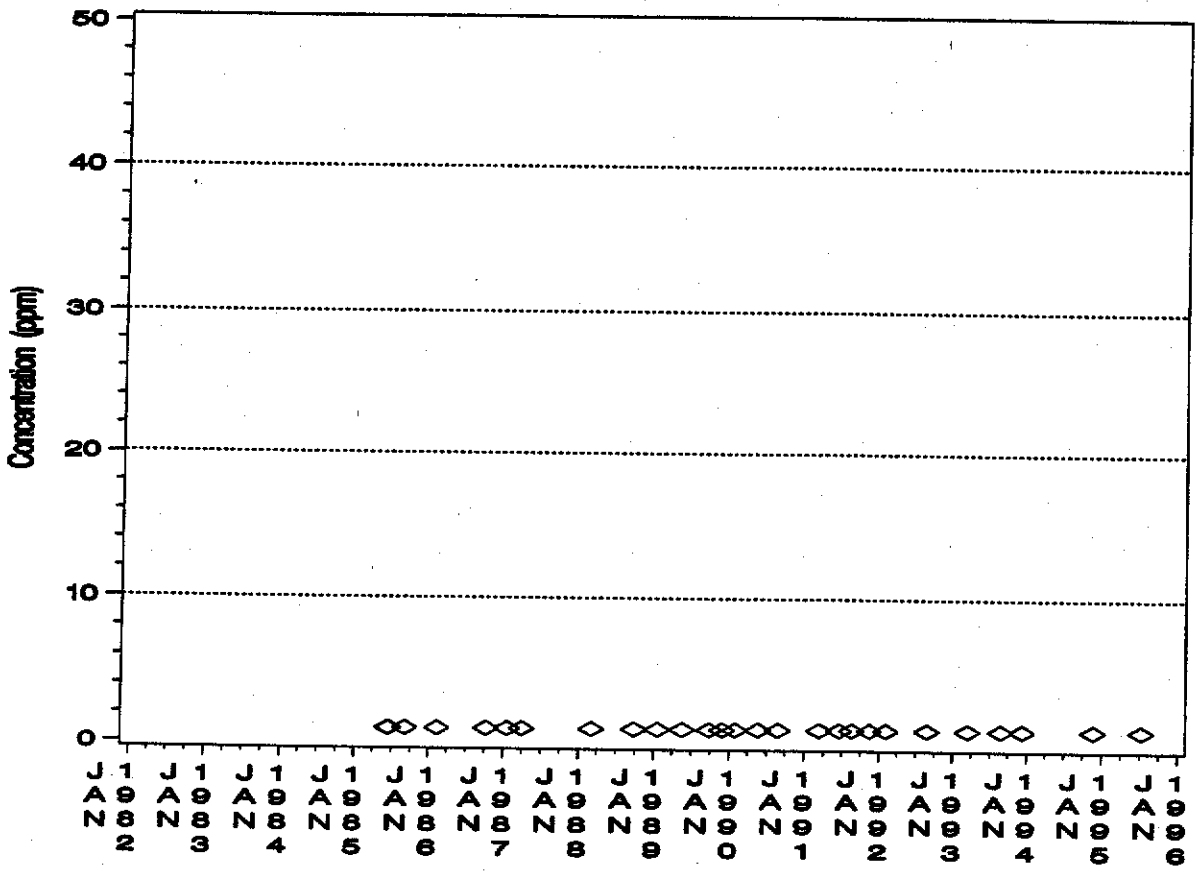
PERCHLORATE Trend



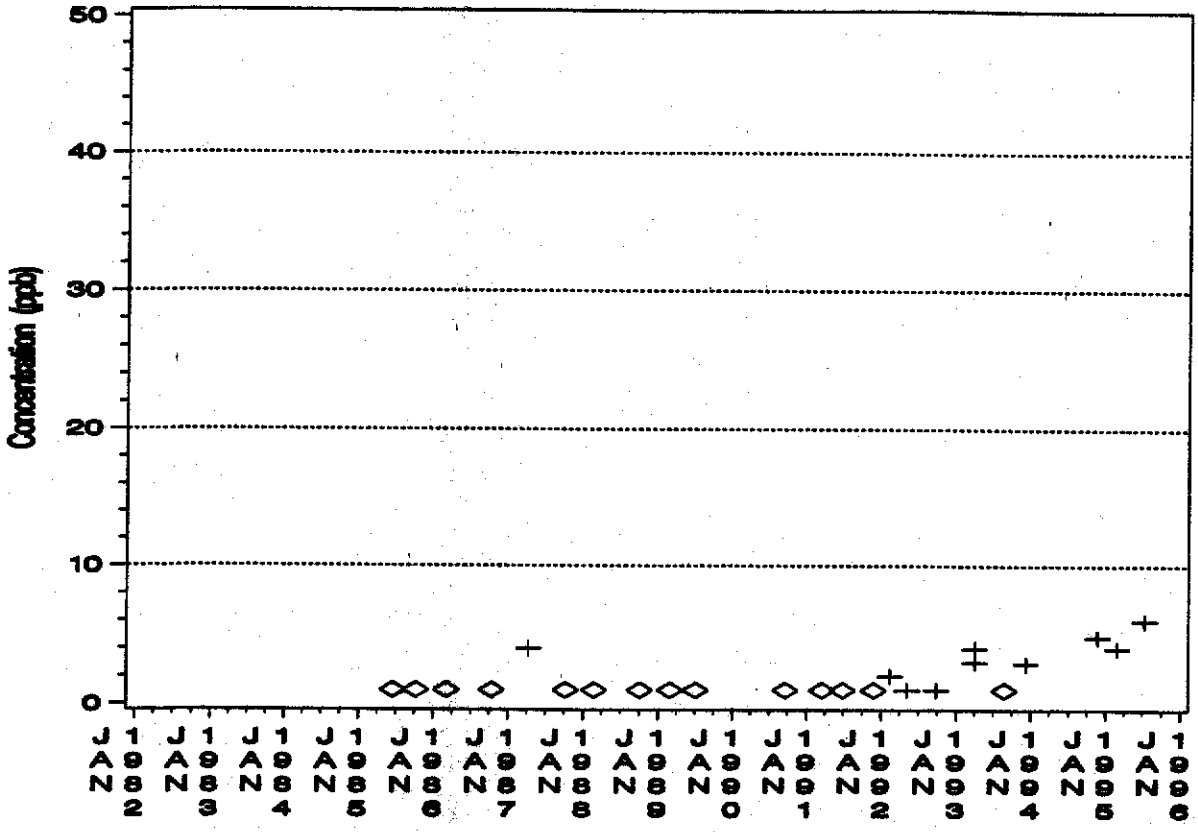
WELL 1352
CHLOROFORM Trend



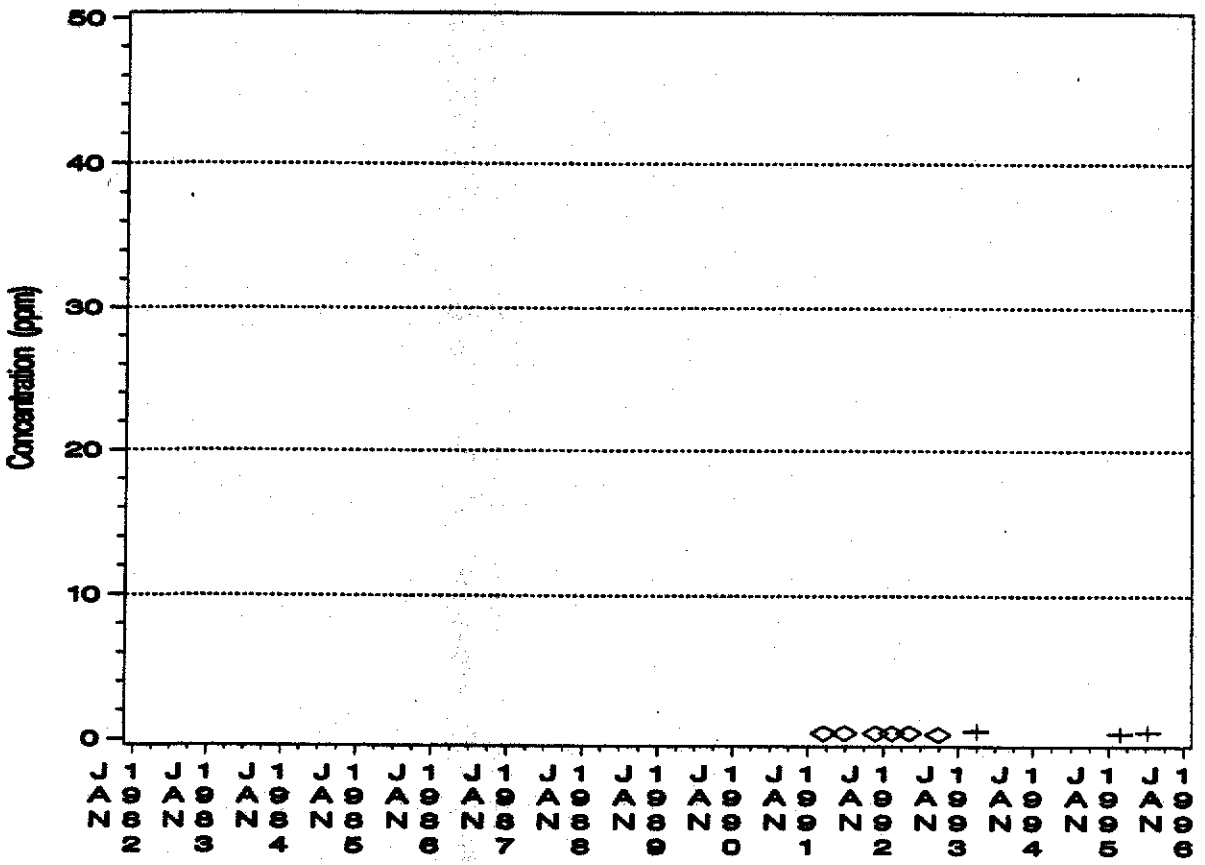
1,2 — DICHLOROETHANE Trend



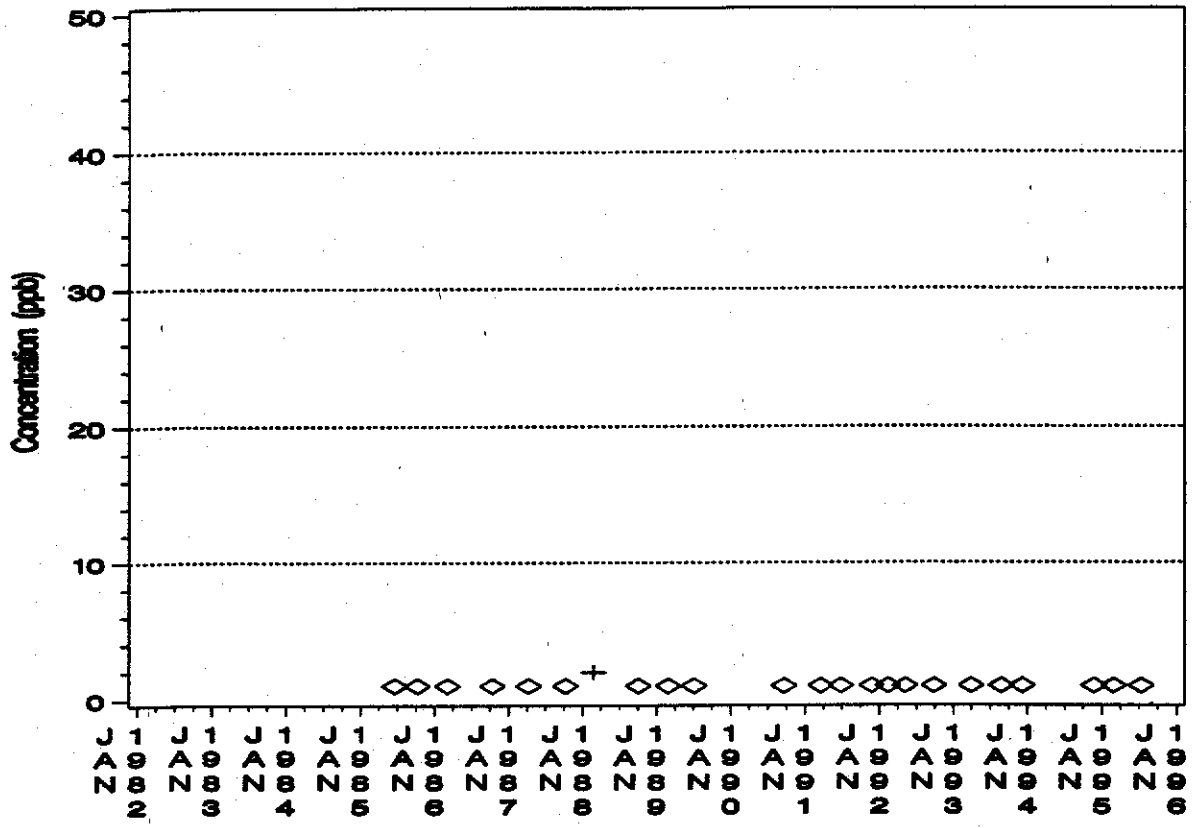
WELL 1353
TRICHLOROETHYLENE Trend



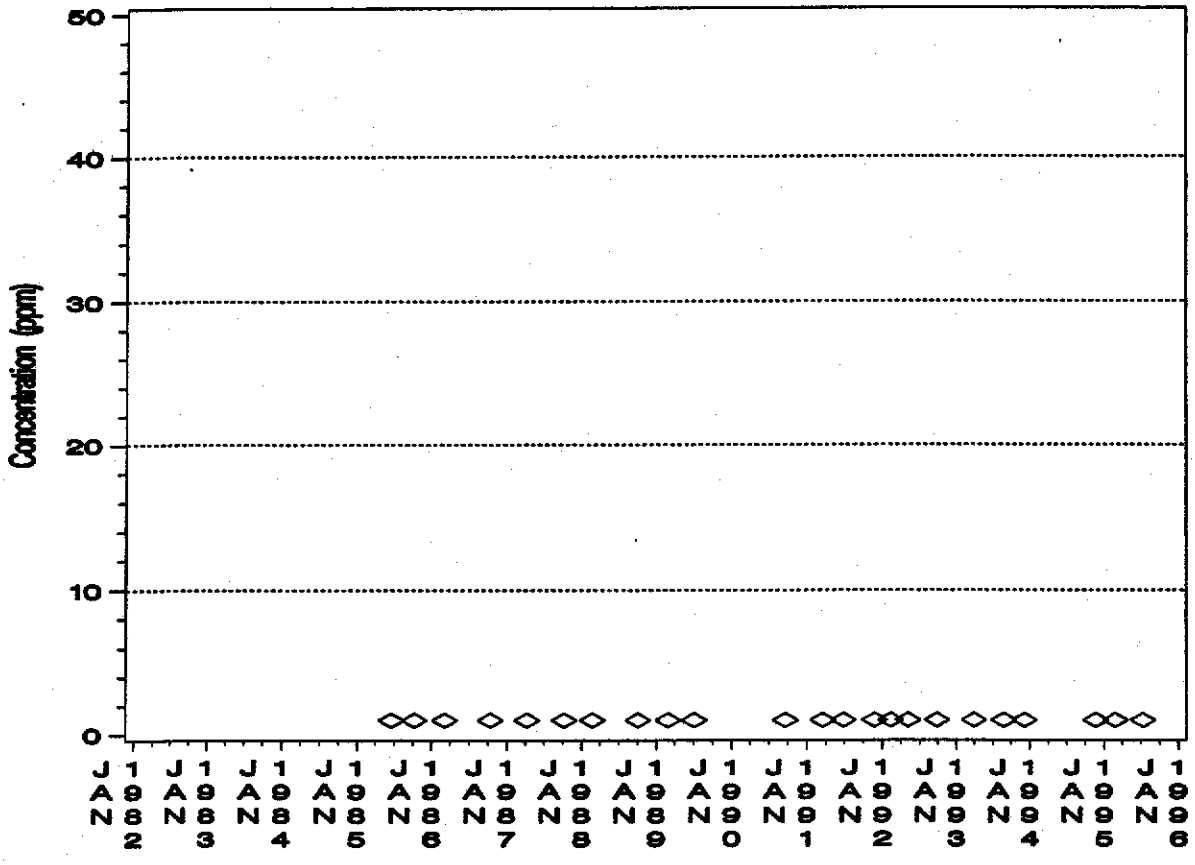
PERCHLORATE Trend



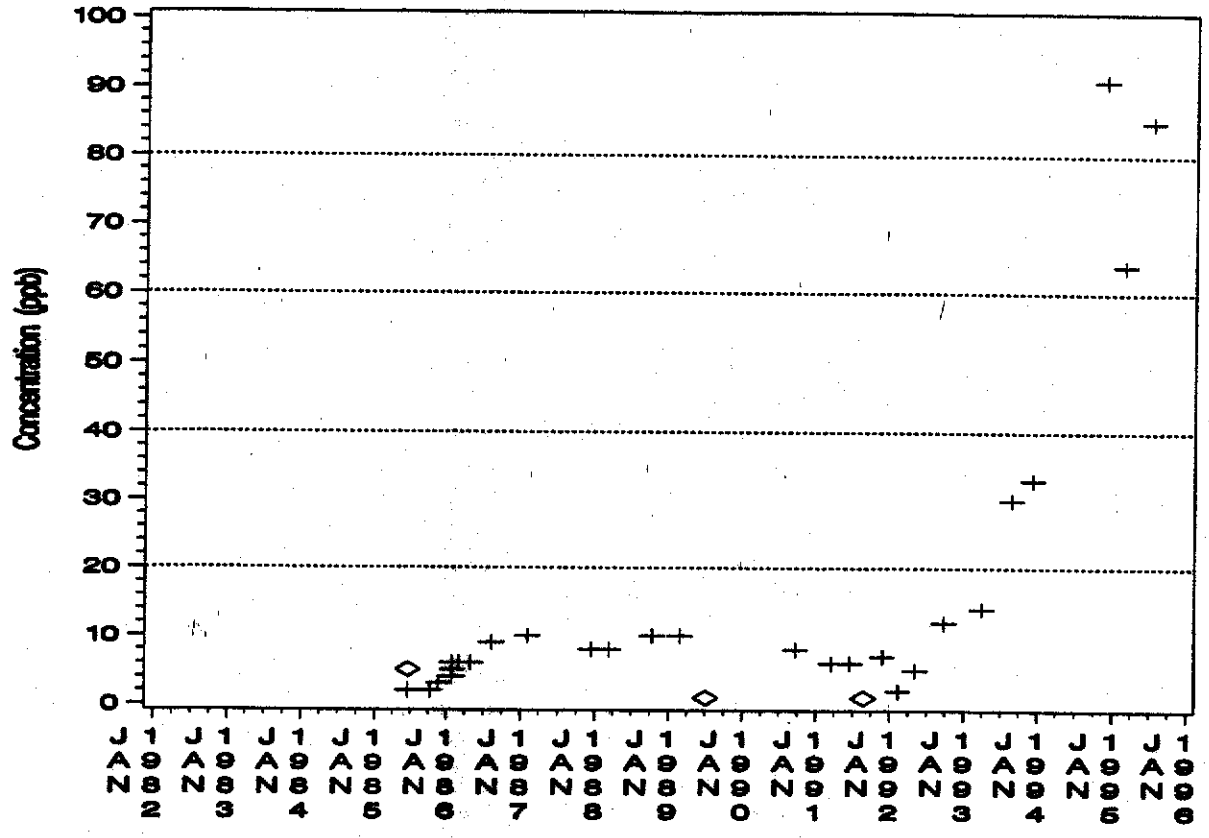
WELL 1353
CHLOROFORM Trend



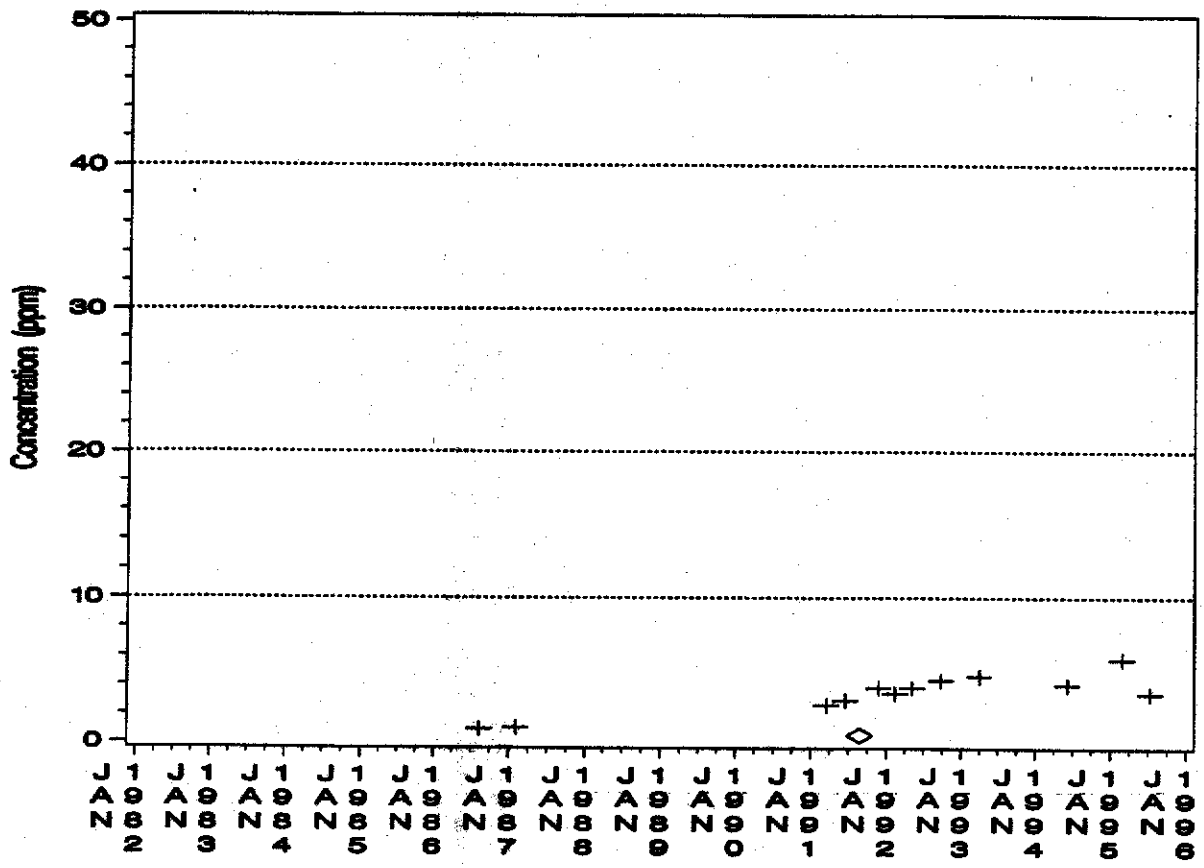
1,2 – DICHLOROETHANE Trend



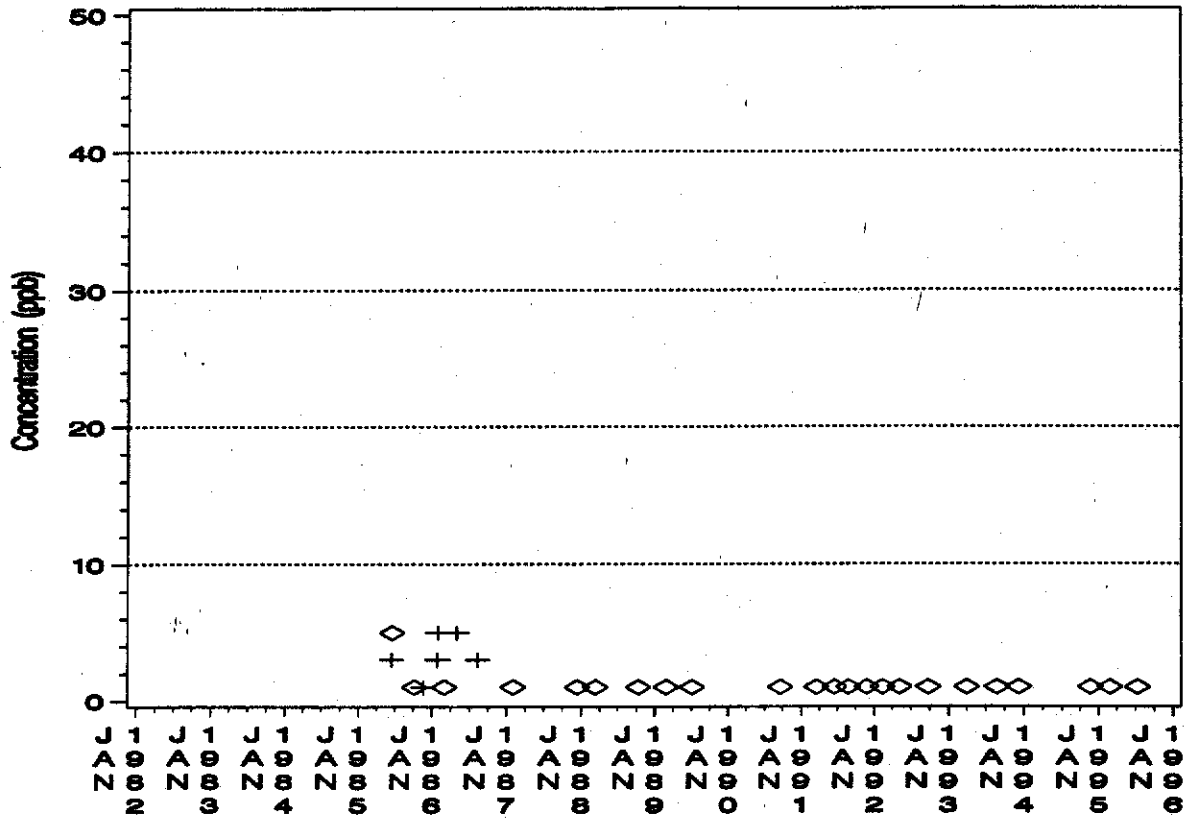
WELL 1354
TRICHLOROETHYLENE Trend



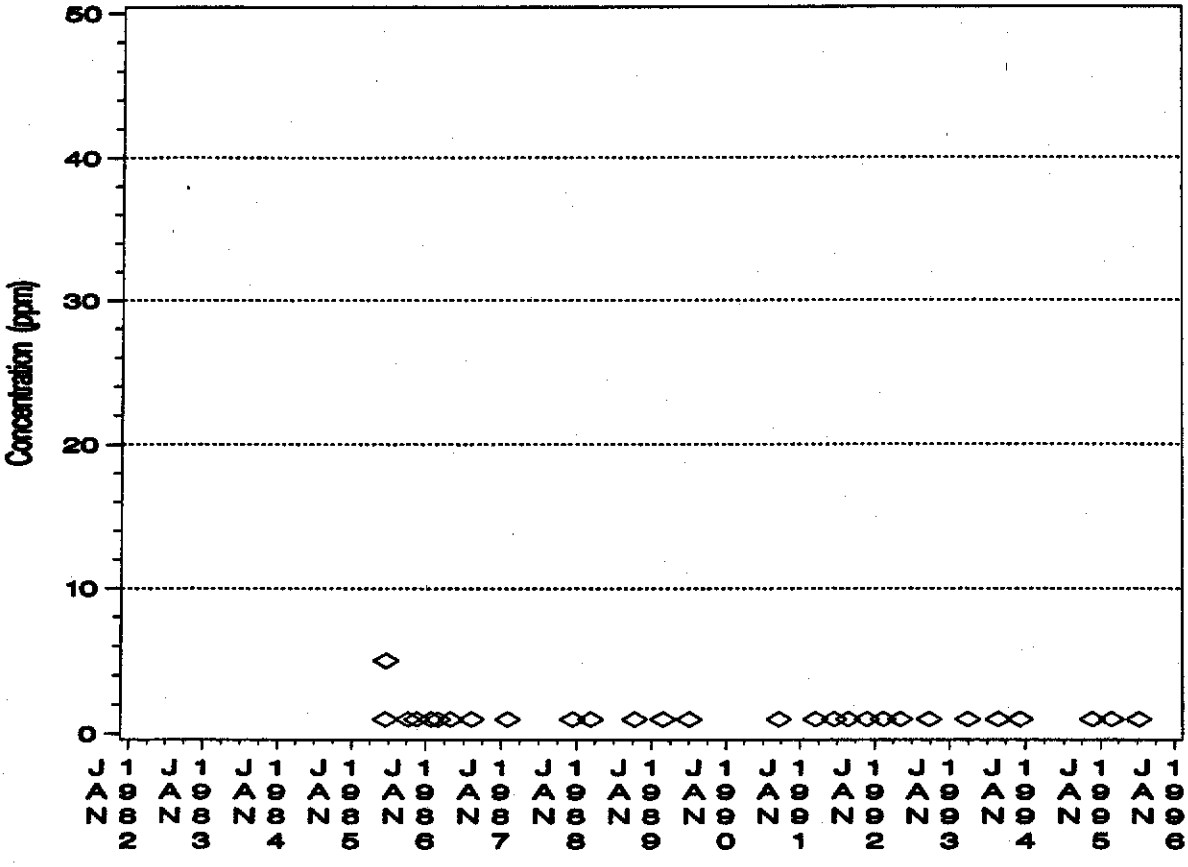
PERCHLORATE Trend



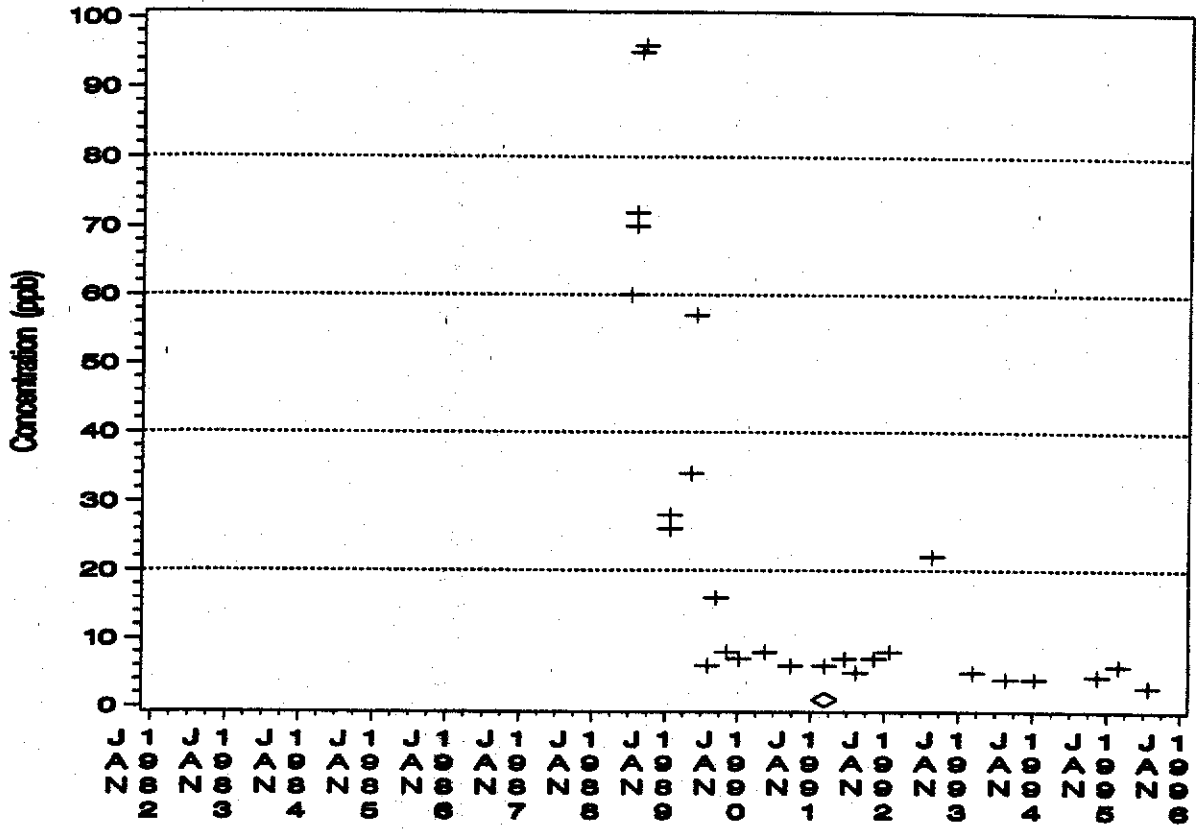
WELL 1354
CHLOROFORM Trend



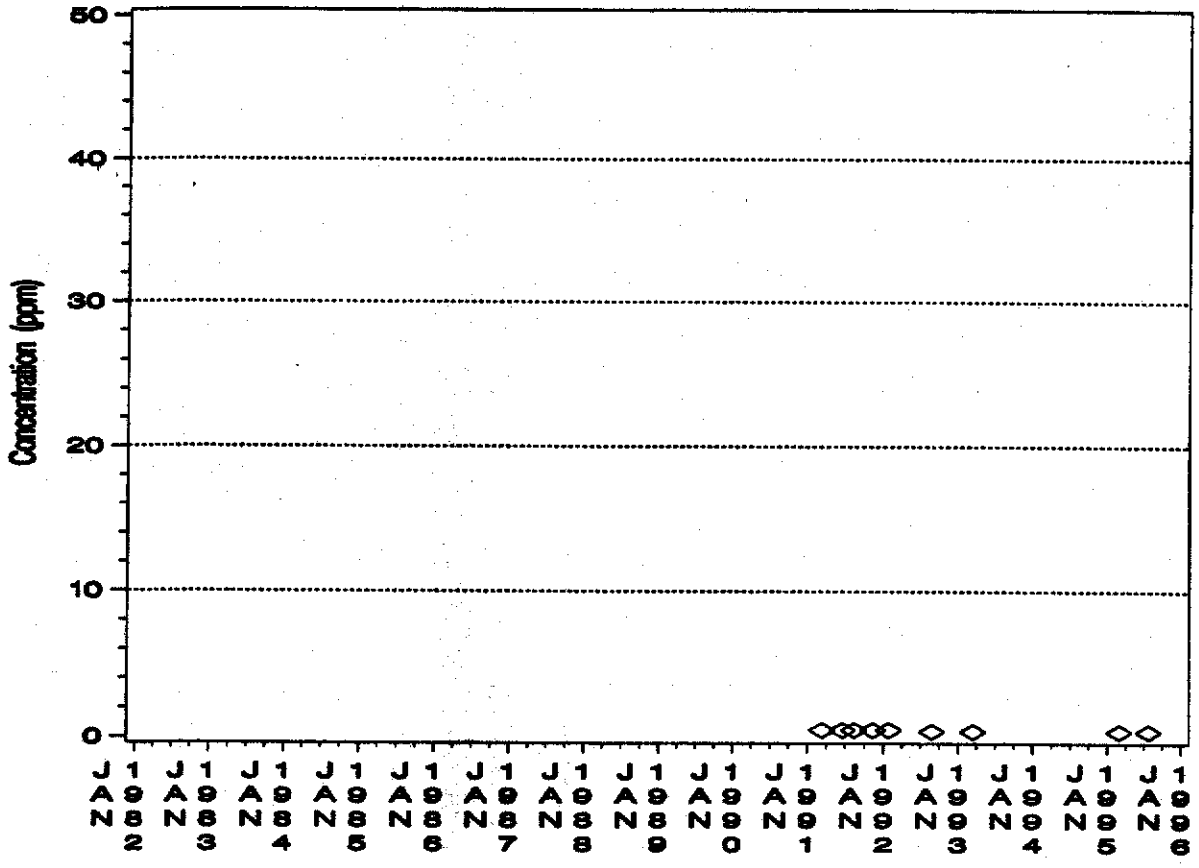
1,2 – DICHLOROETHANE Trend



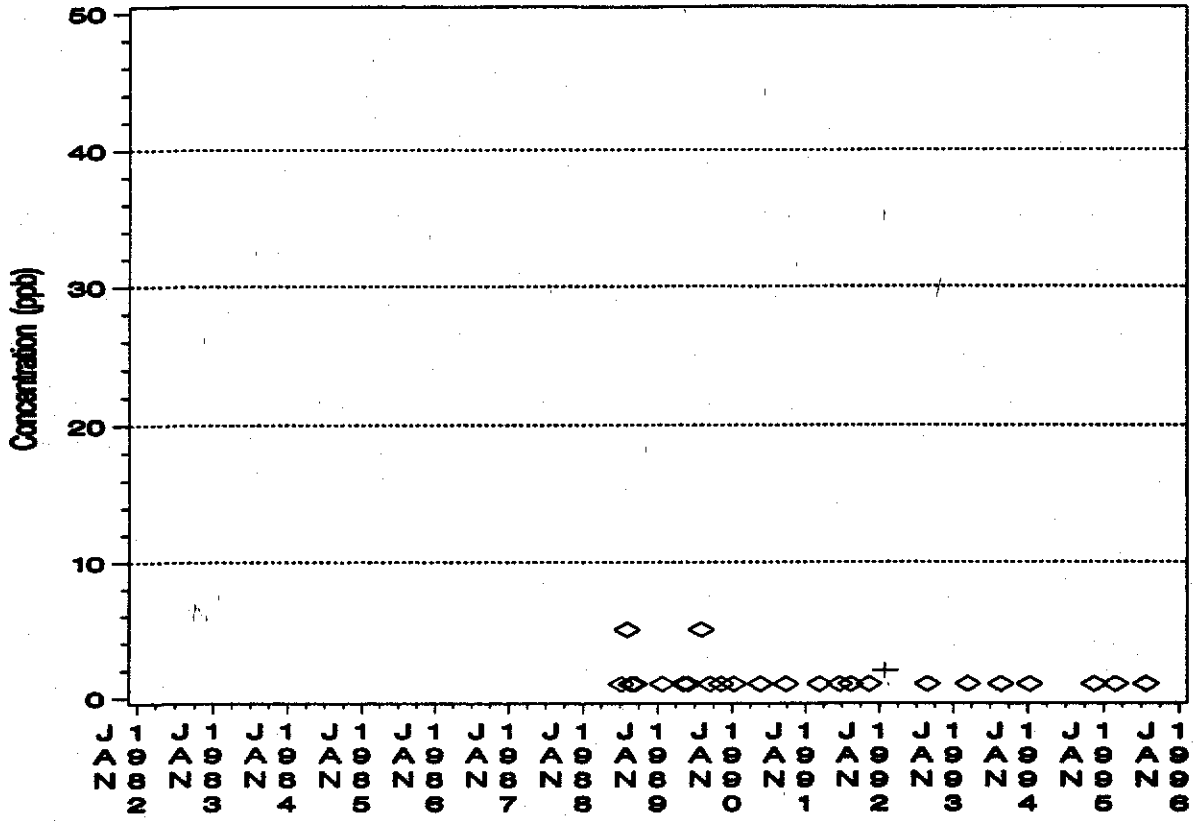
WELL 1435
TRICHLOROETHYLENE Trend



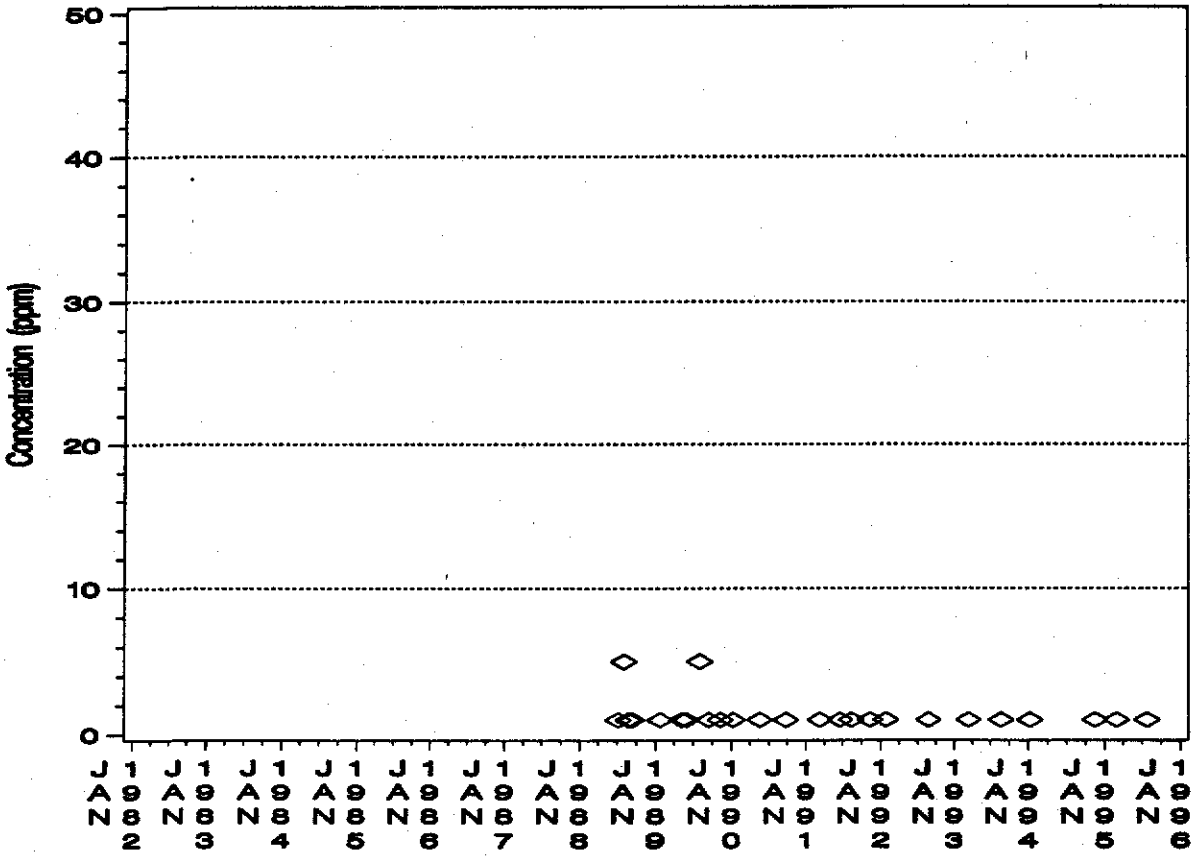
PERCHLORATE Trend



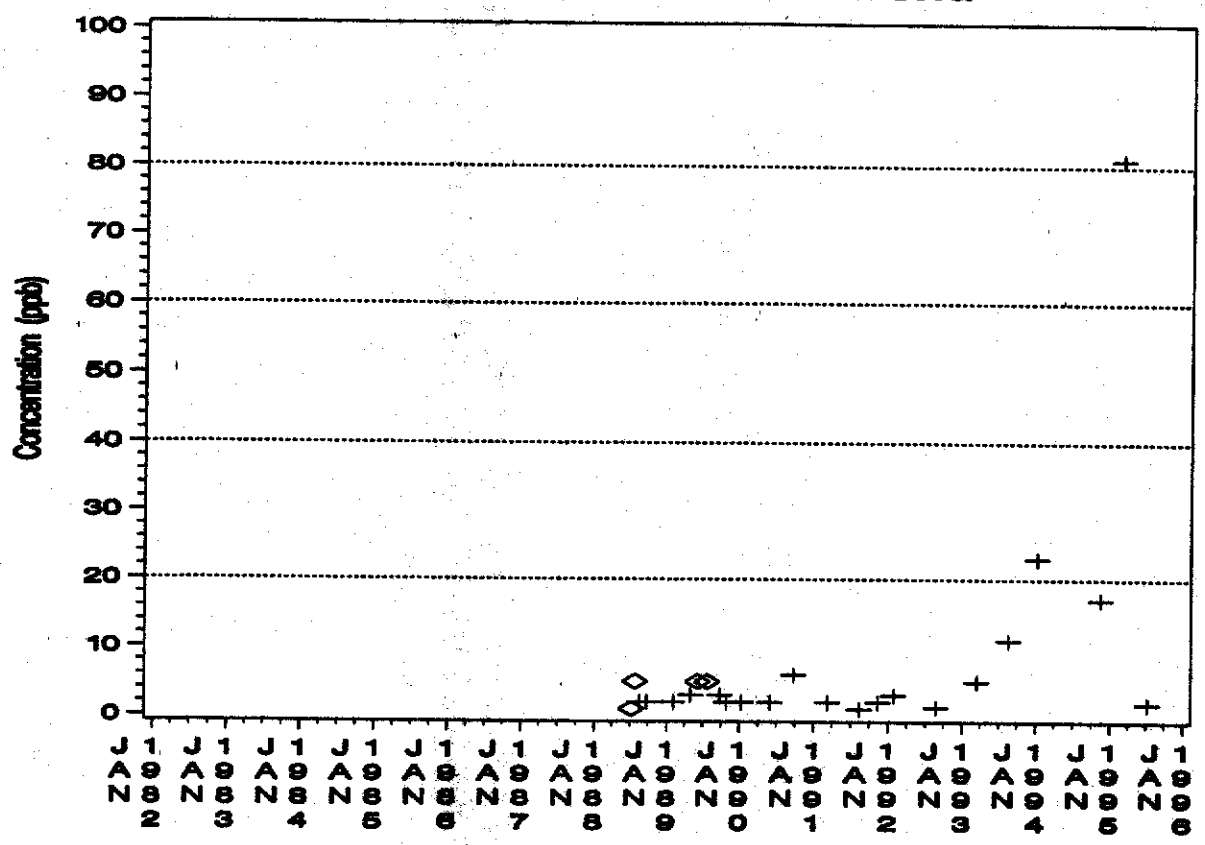
WELL 1435
CHLOROFORM Trend



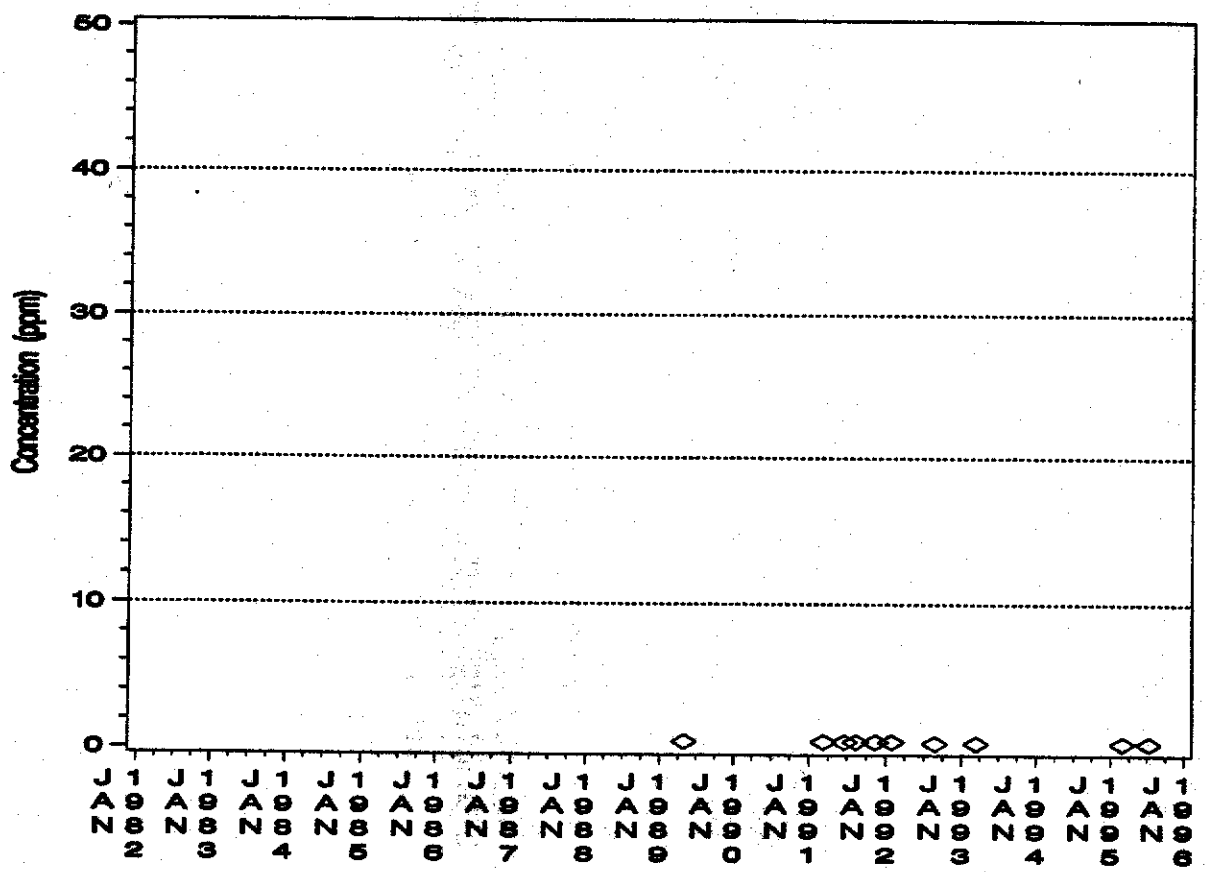
1,2 — DICHLOROETHANE Trend



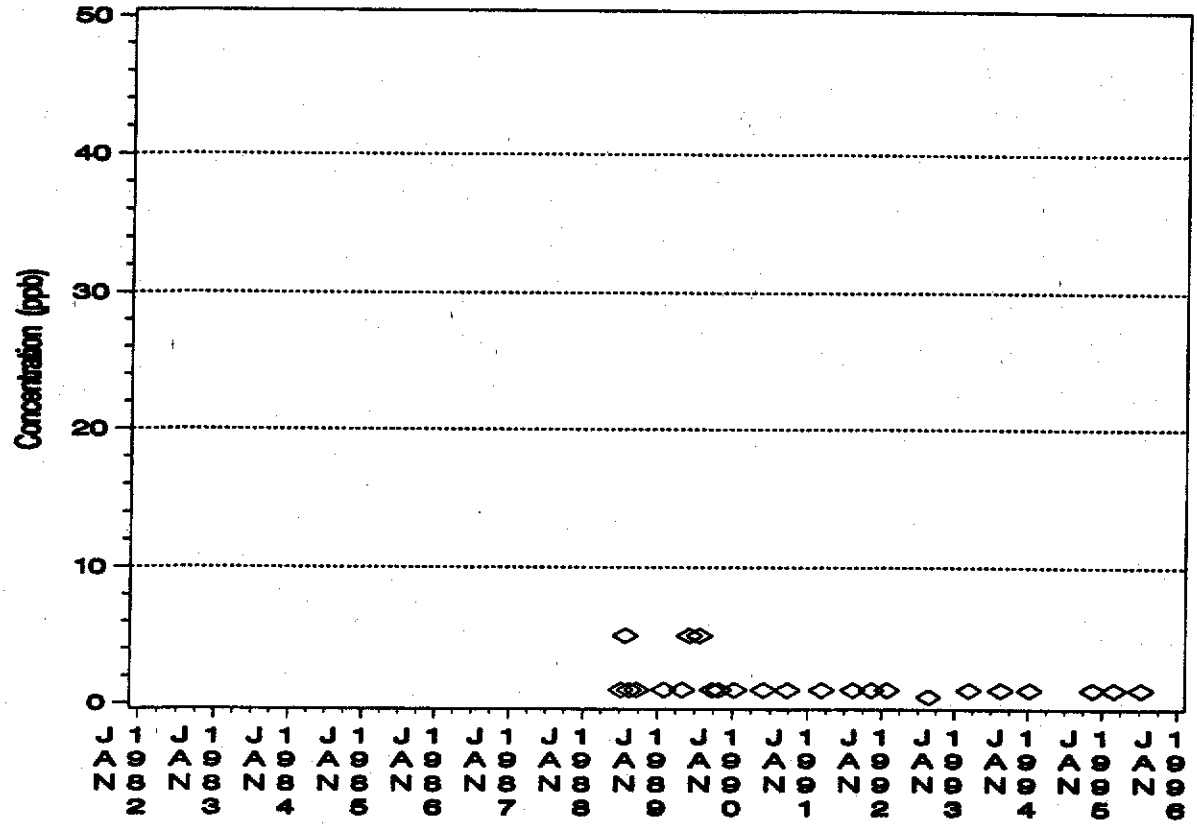
WELL 1437
TRICHLOROETHYLENE Trend



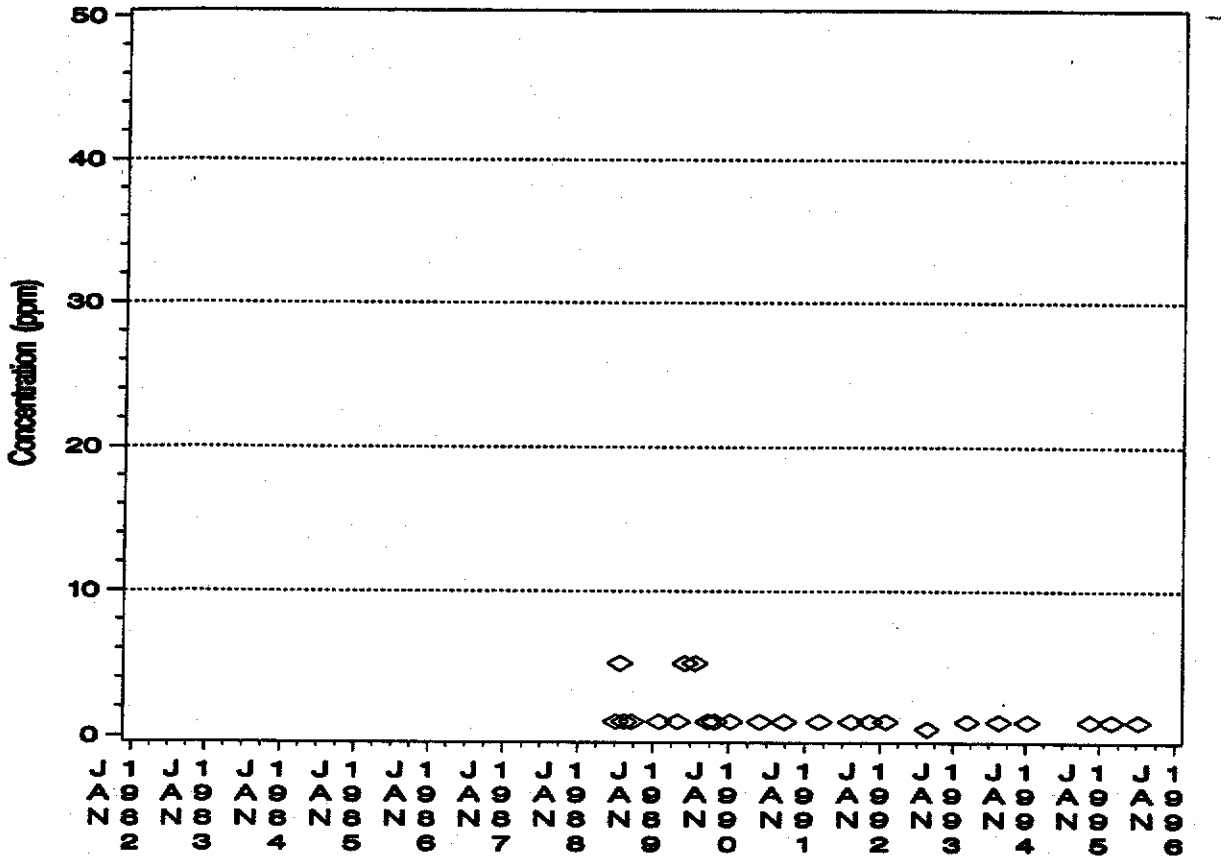
PERCHLORATE Trend



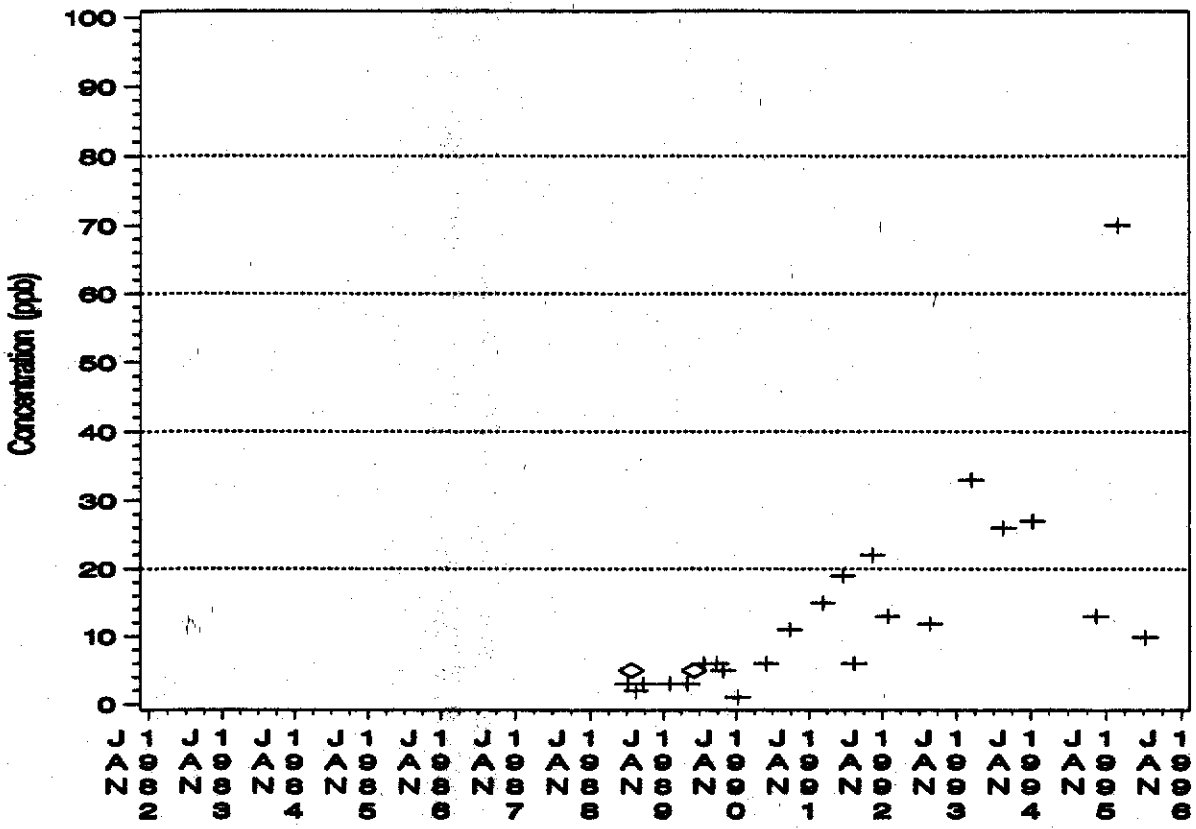
WELL 1437
CHLOROFORM Trend



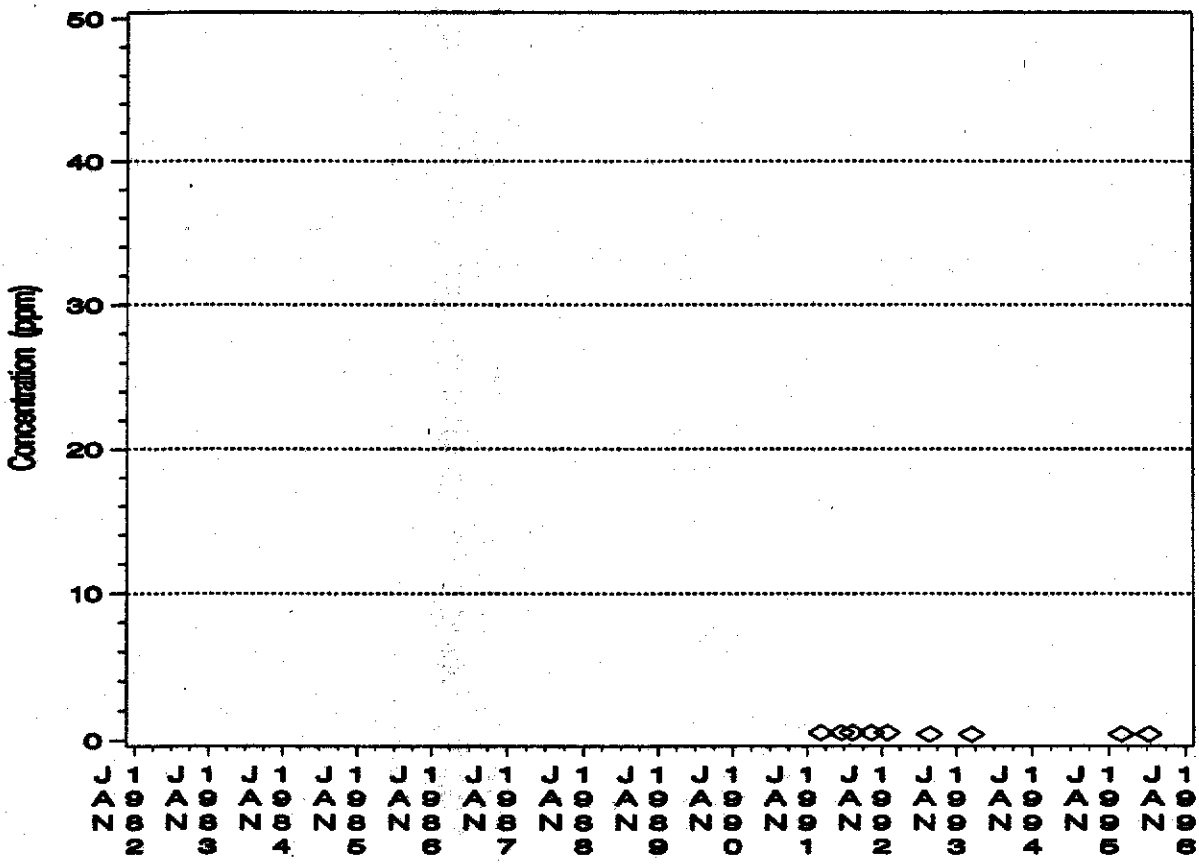
1,2 – DICHLOROETHANE Trend



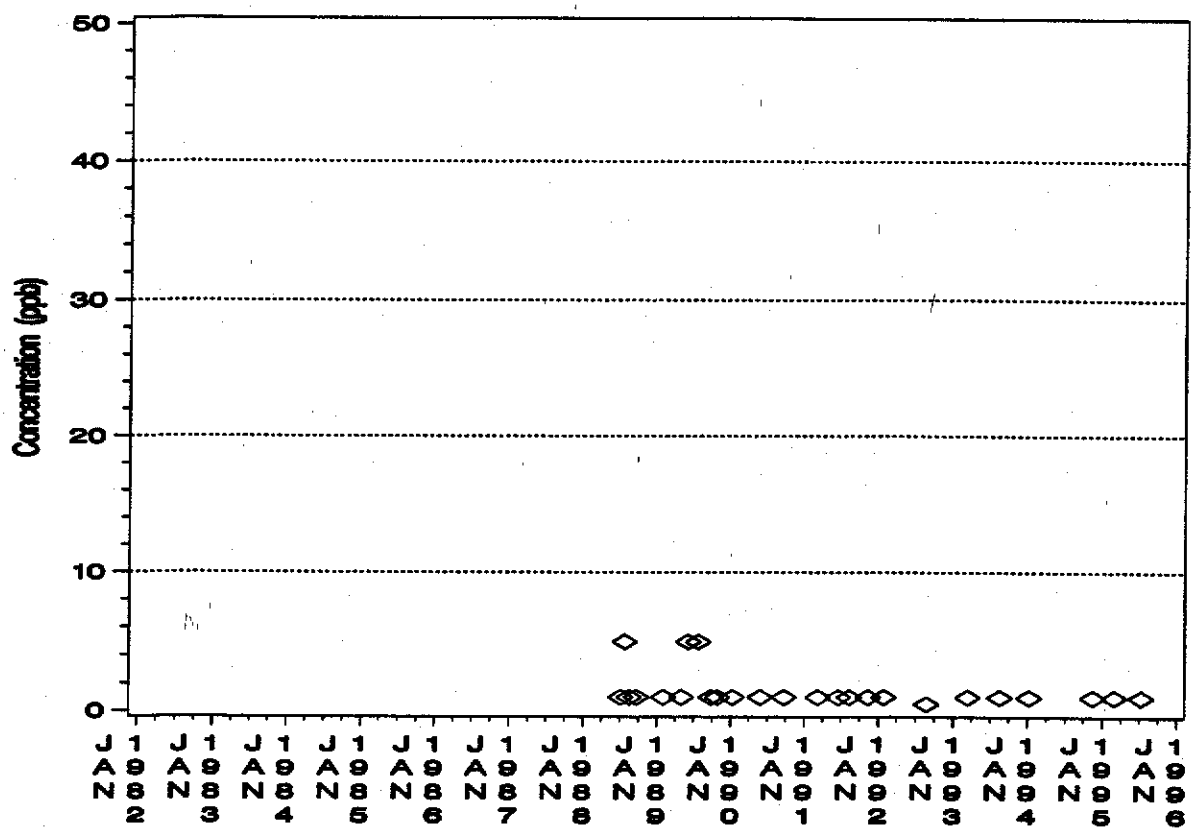
WELL 1438
TRICHLOROETHYLENE Trend



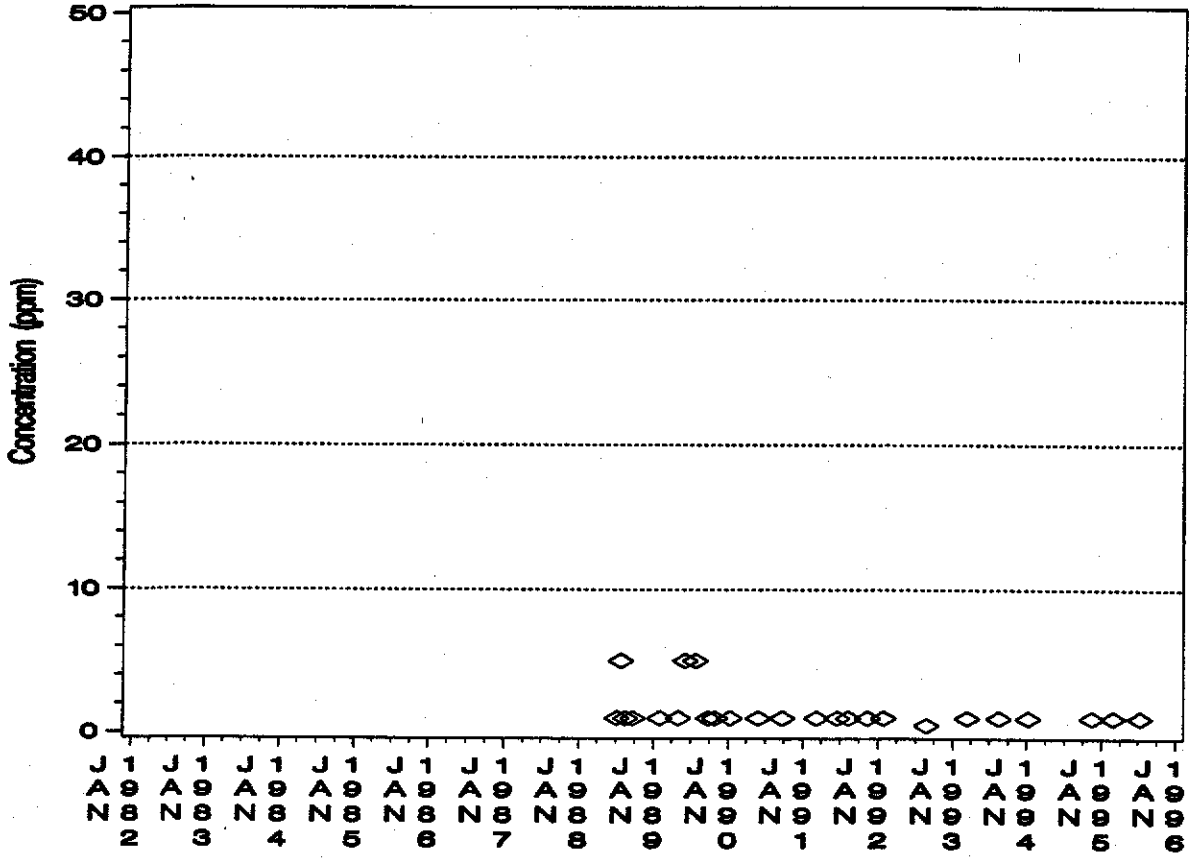
PERCHLORATE Trend



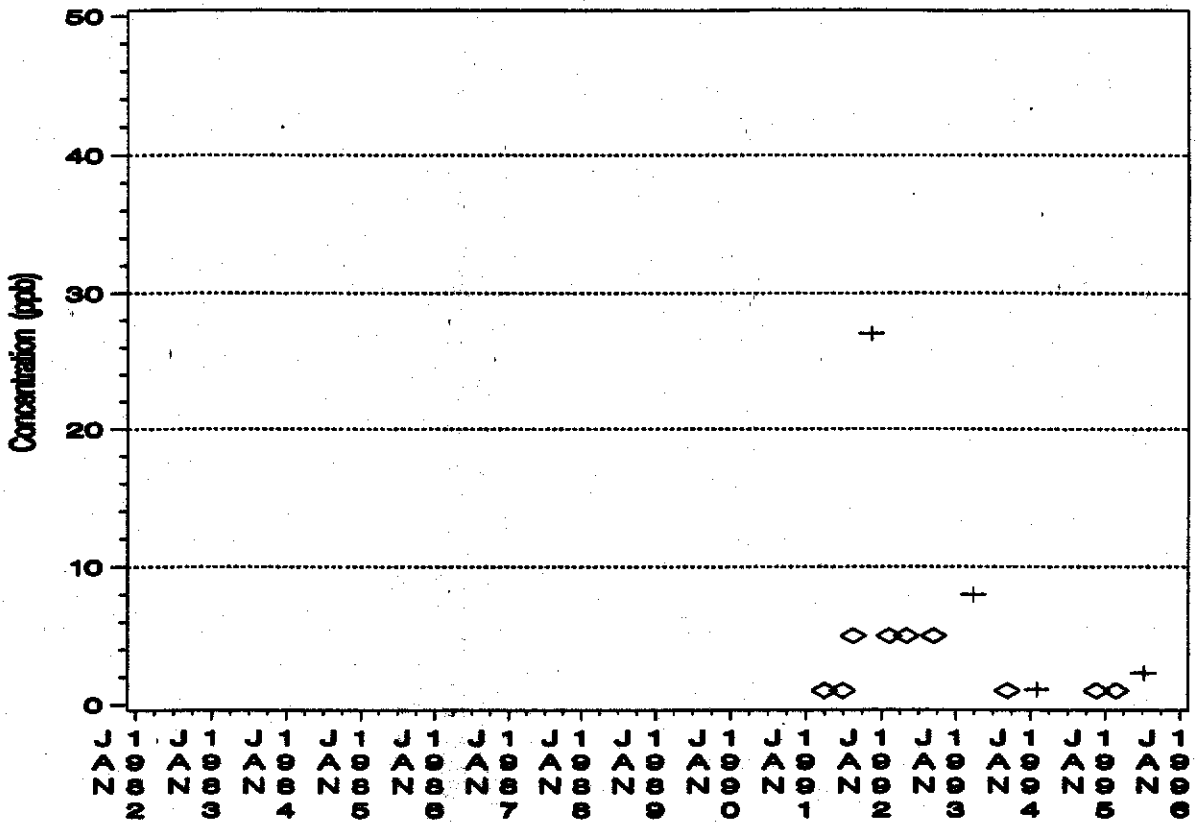
WELL 1438
CHLOROFORM Trend



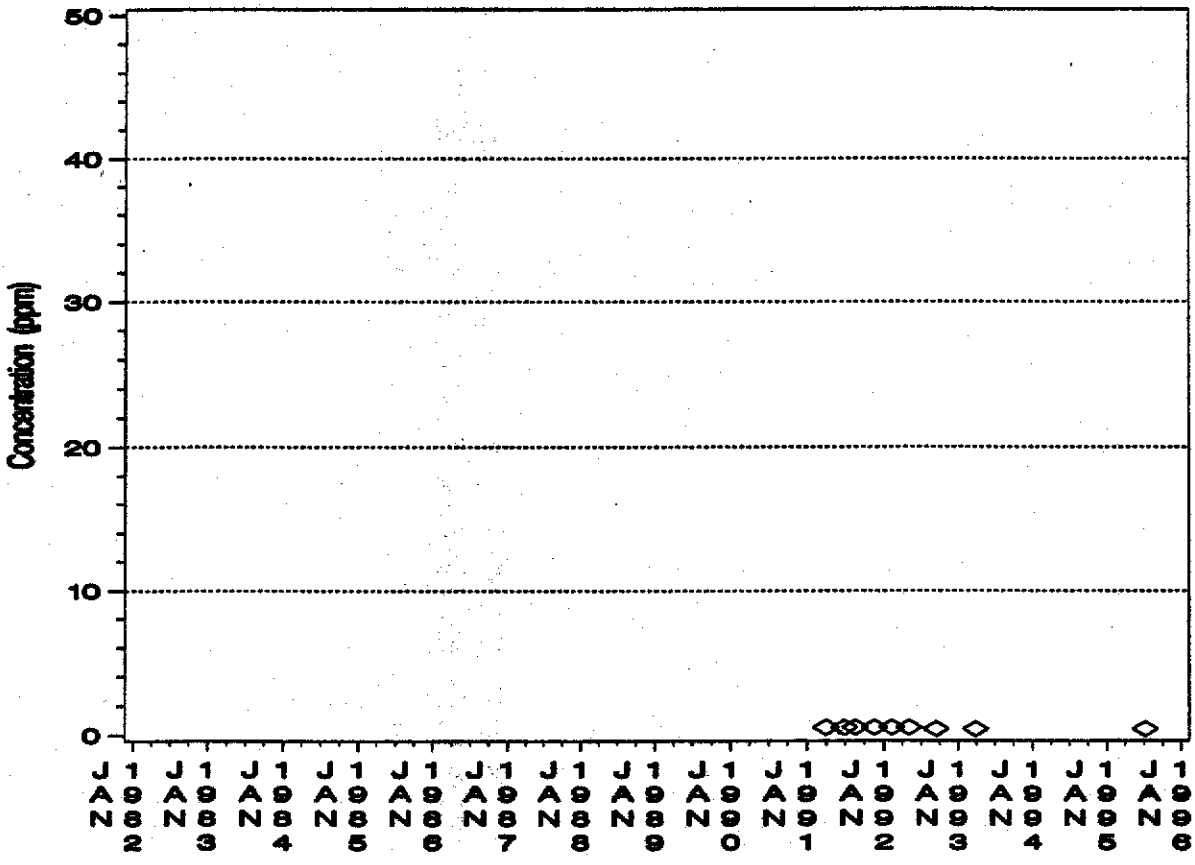
1,2 – DICHLOROETHANE Trend



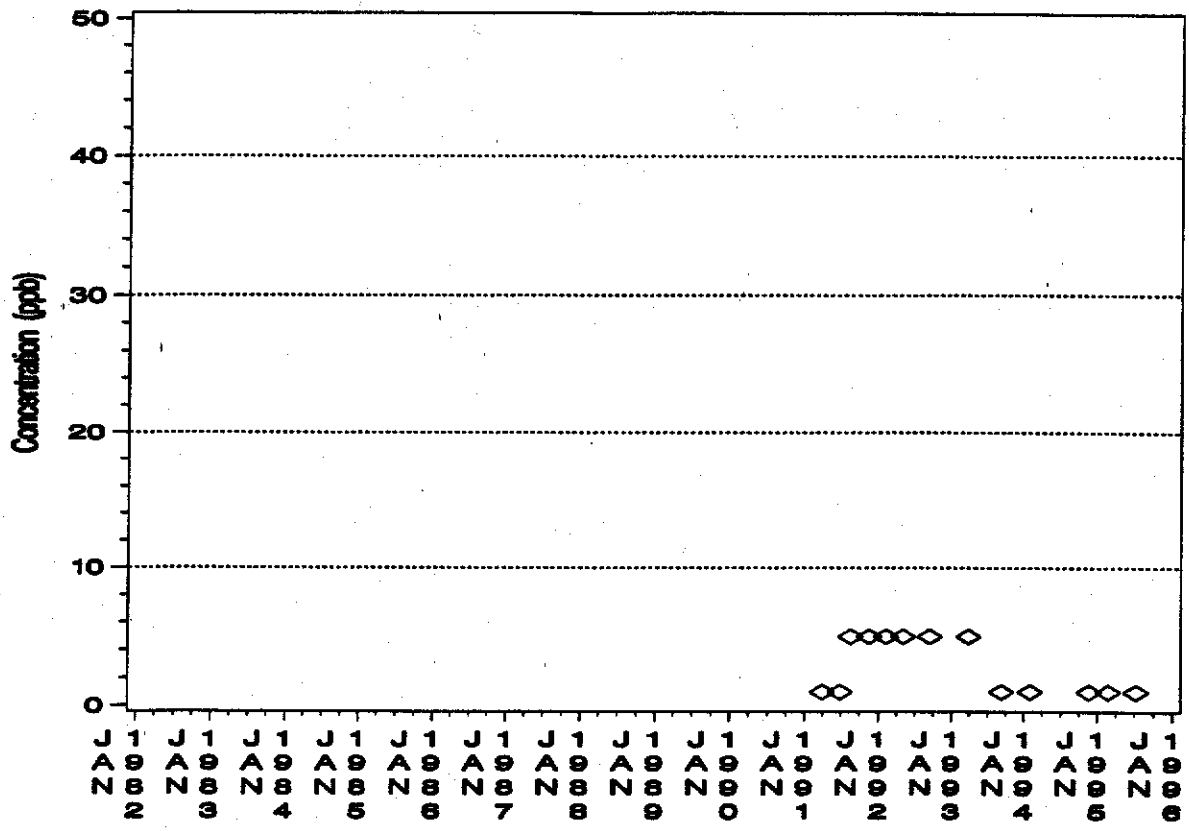
WELL 1459
TRICHLOROETHYLENE Trend



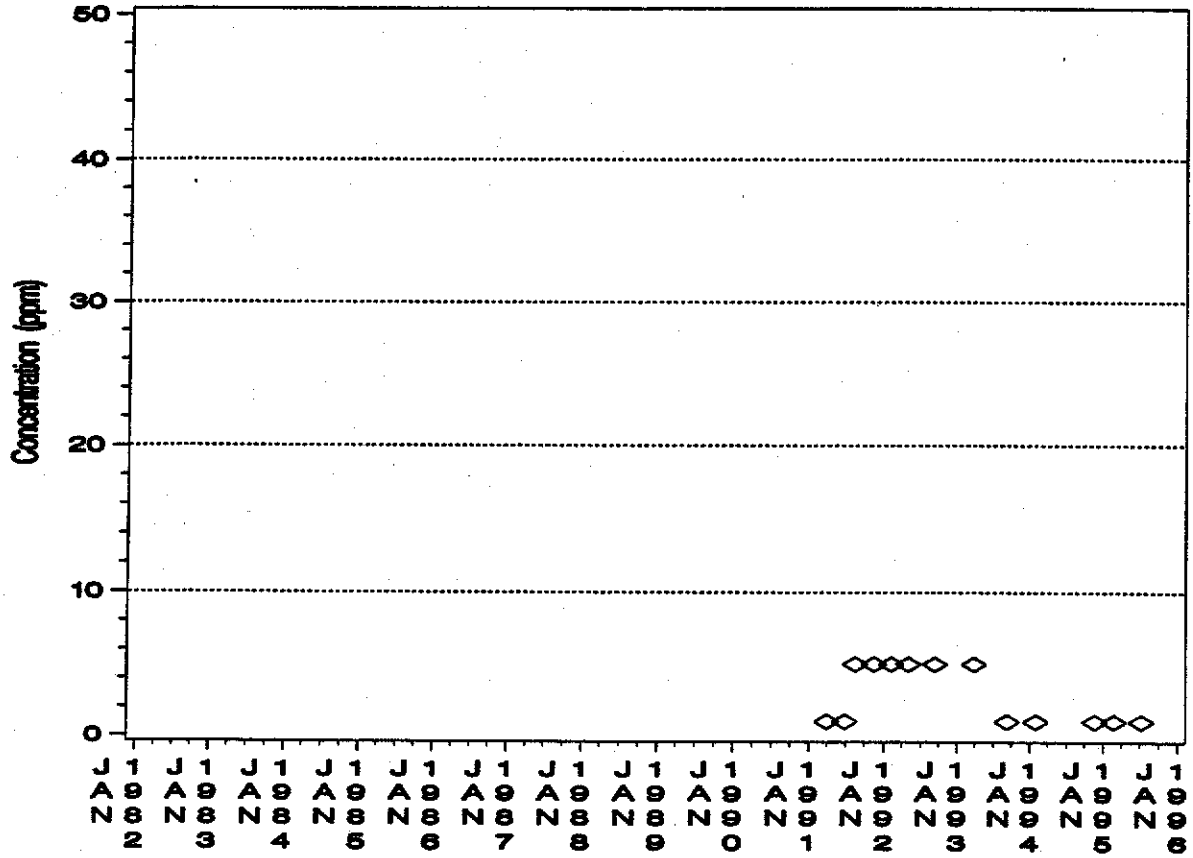
PERCHLORATE Trend



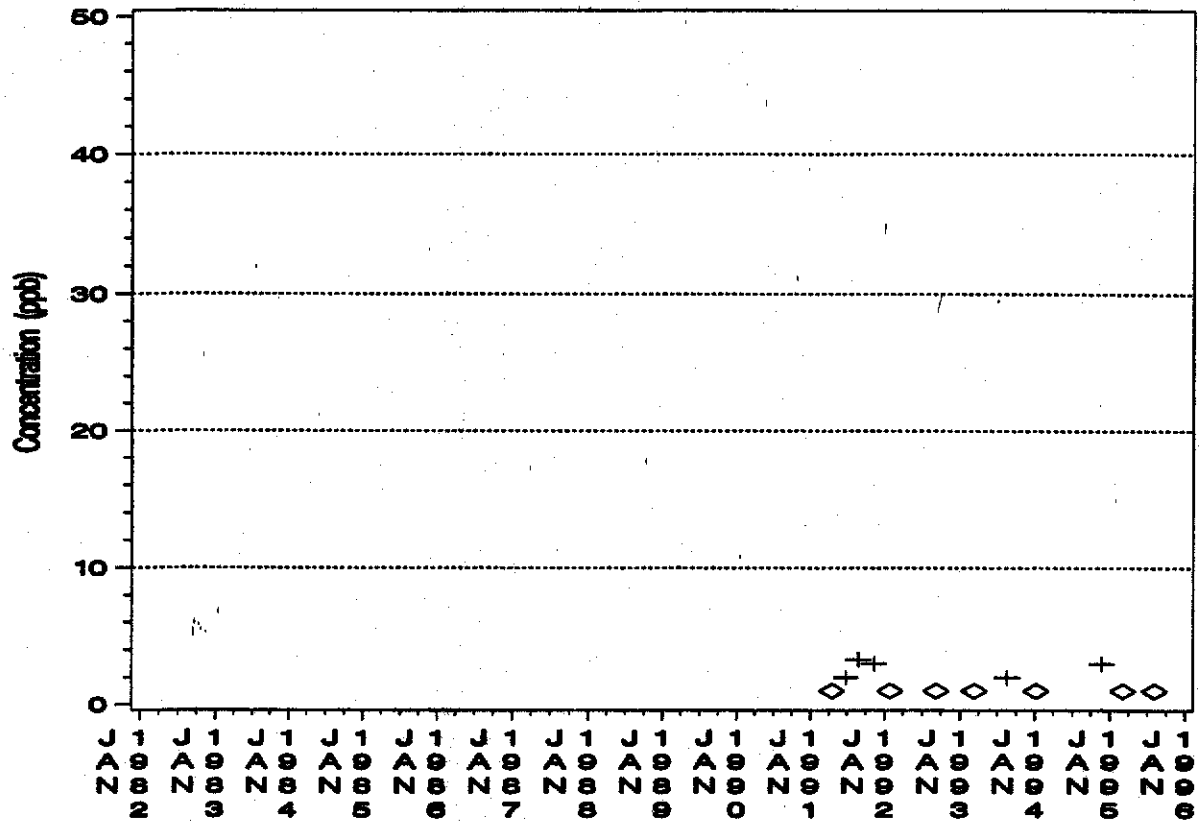
WELL 1459
CHLOROFORM Trend



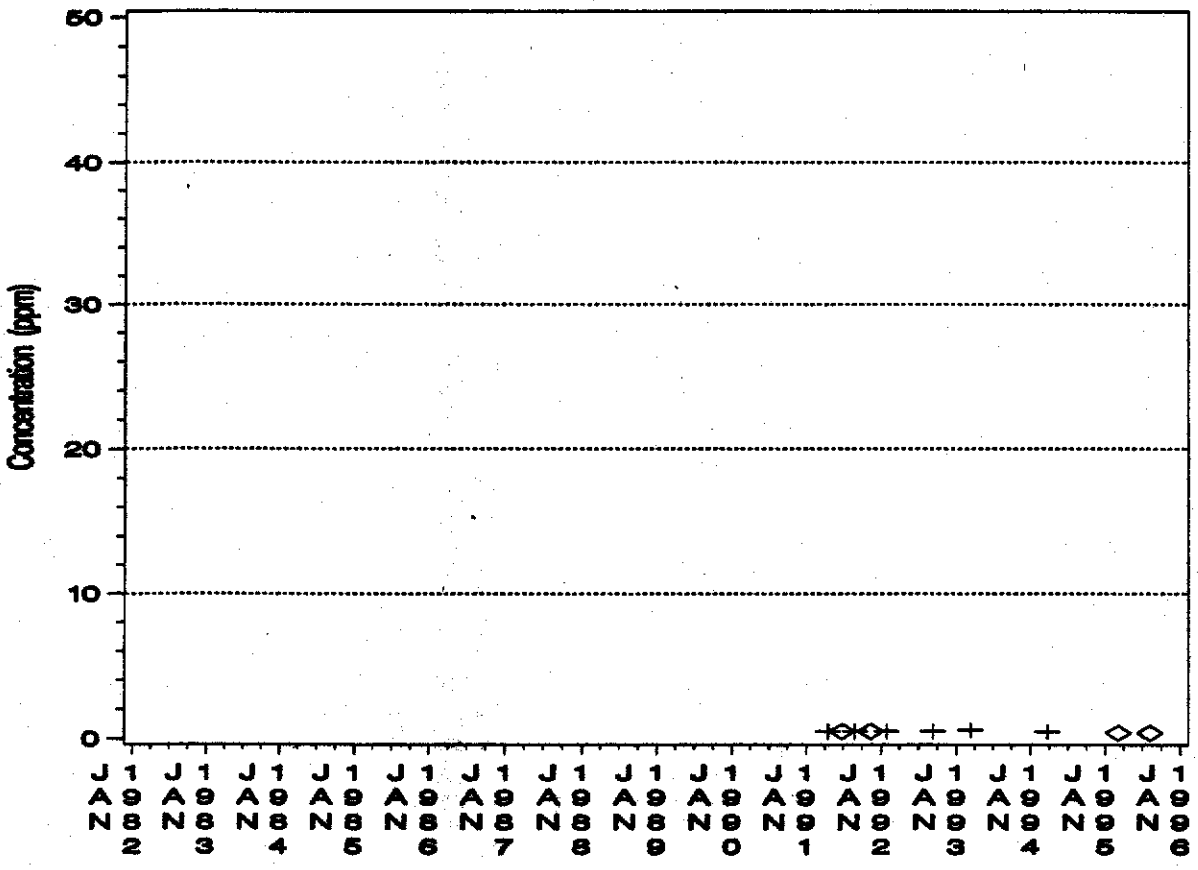
1,2 – DICHLOROETHANE Trend



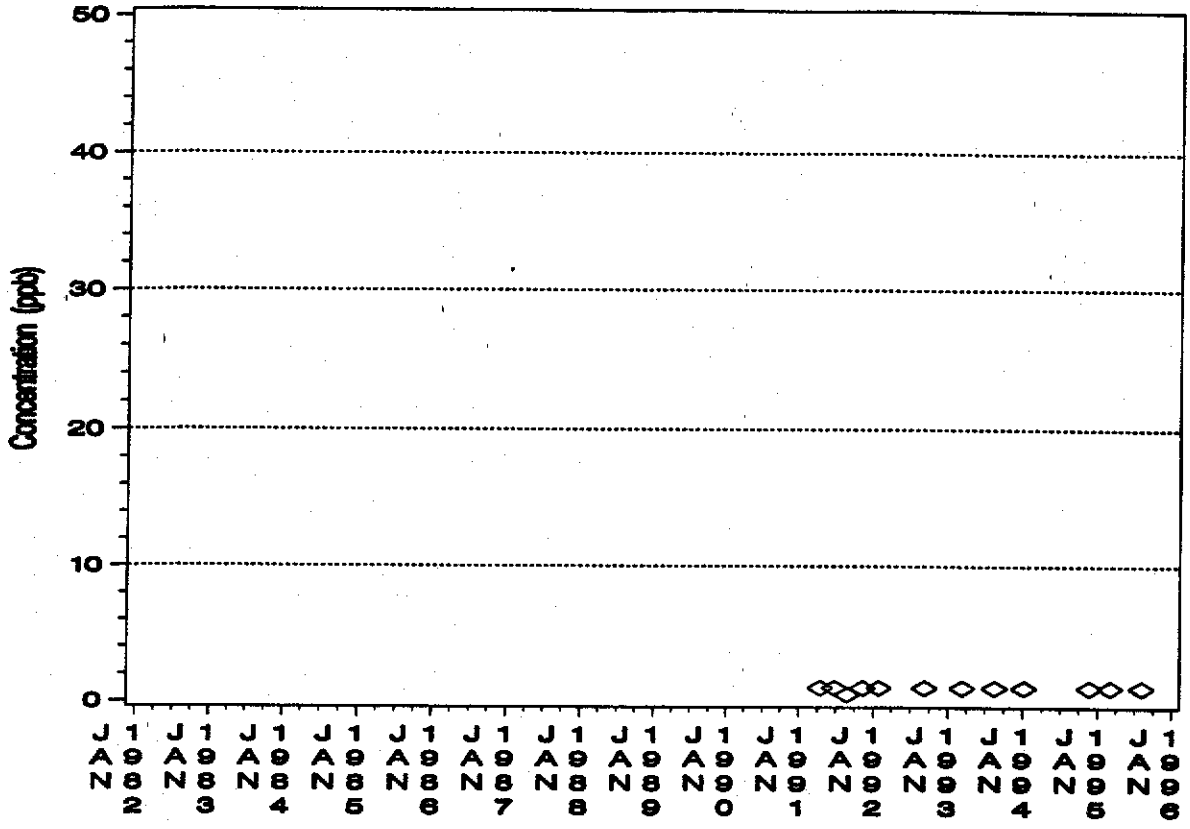
WELL 1460
TRICHLOROETHYLENE Trend



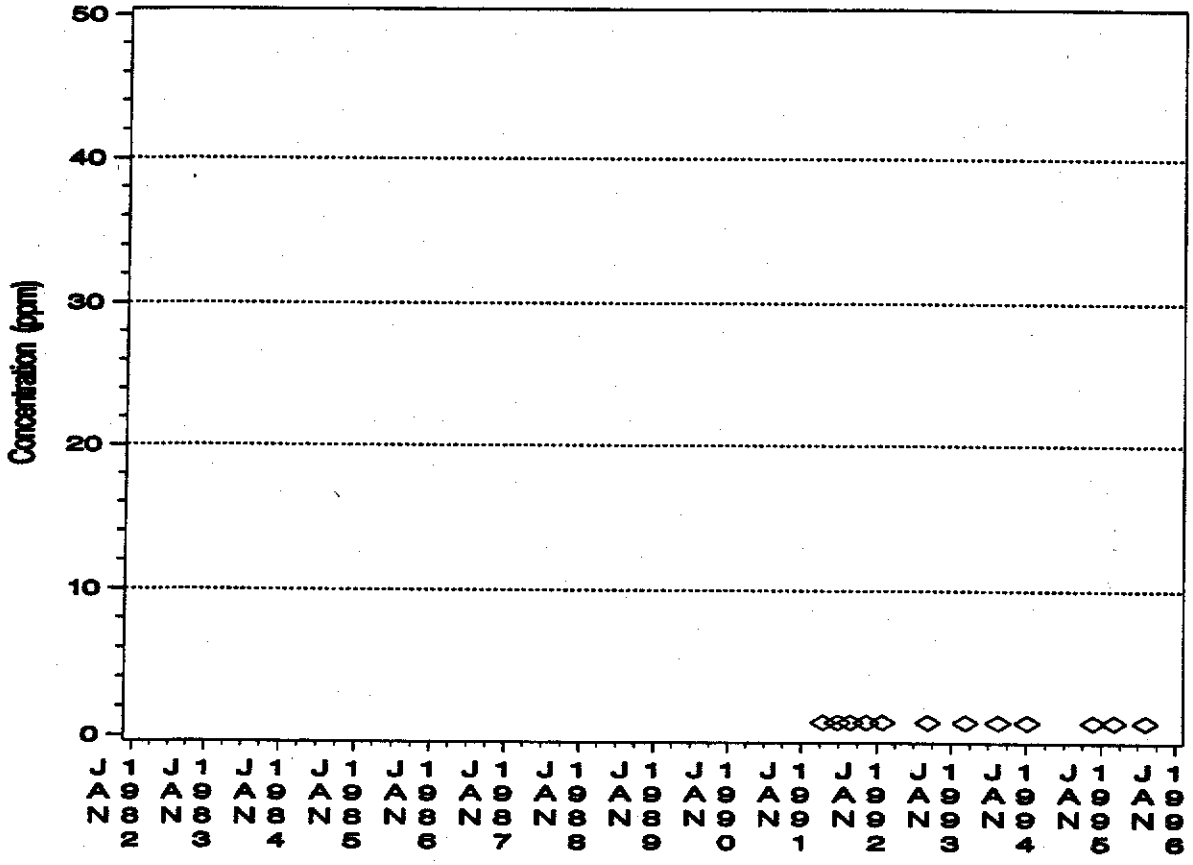
PERCHLORATE Trend



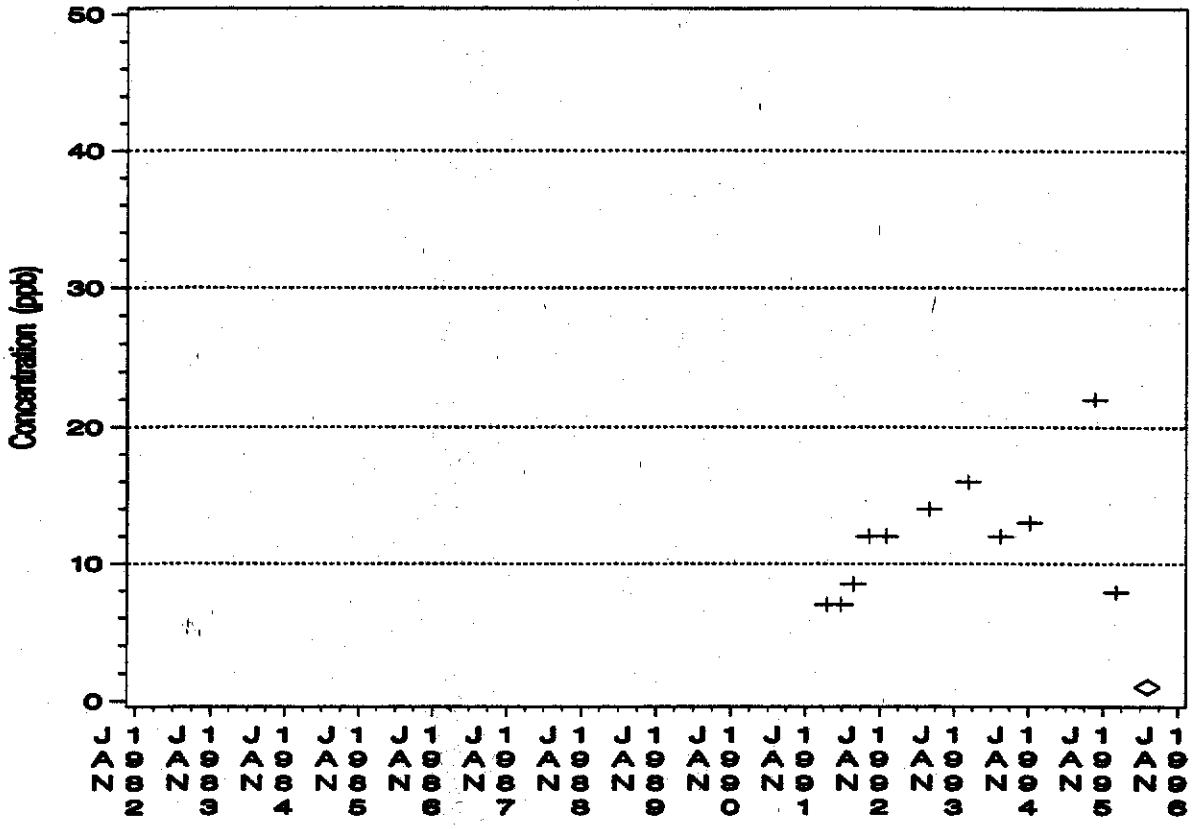
WELL 1460
CHLOROFORM Trend



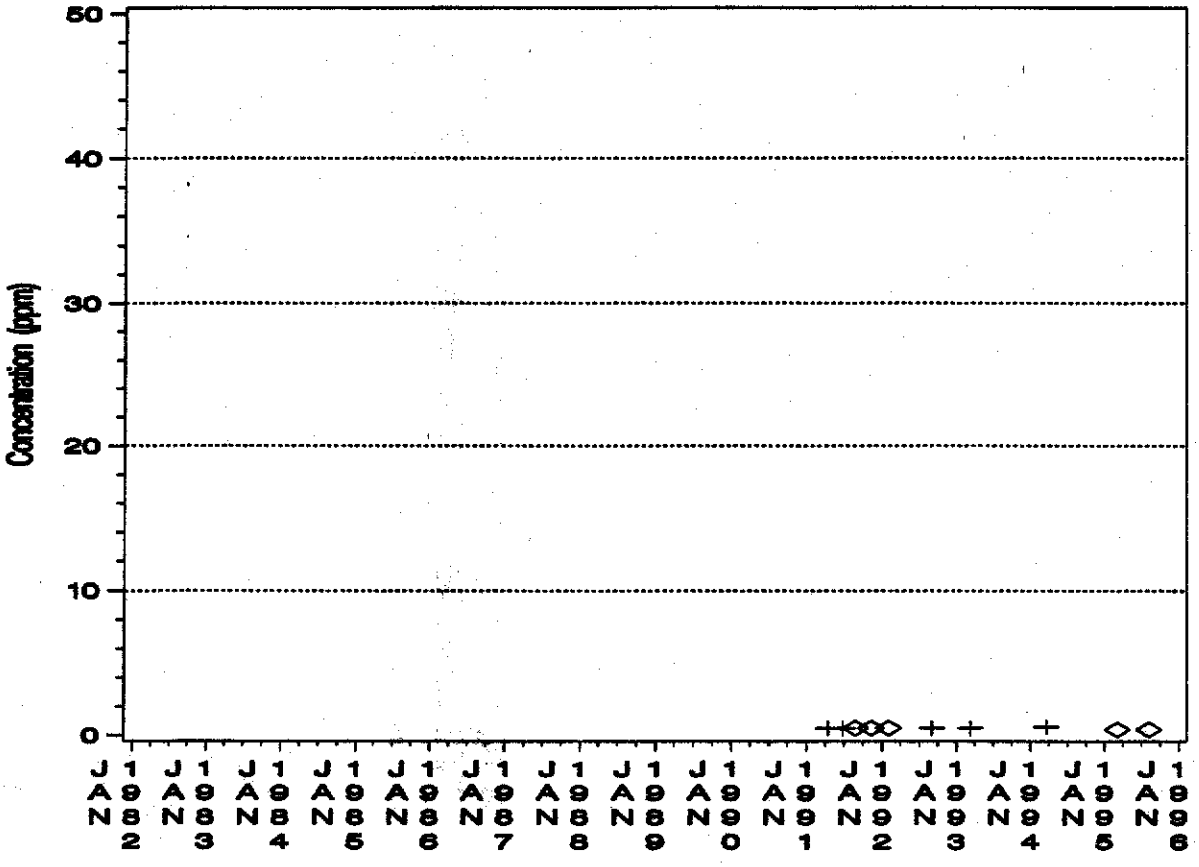
1,2 – DICHLOROETHANE Trend



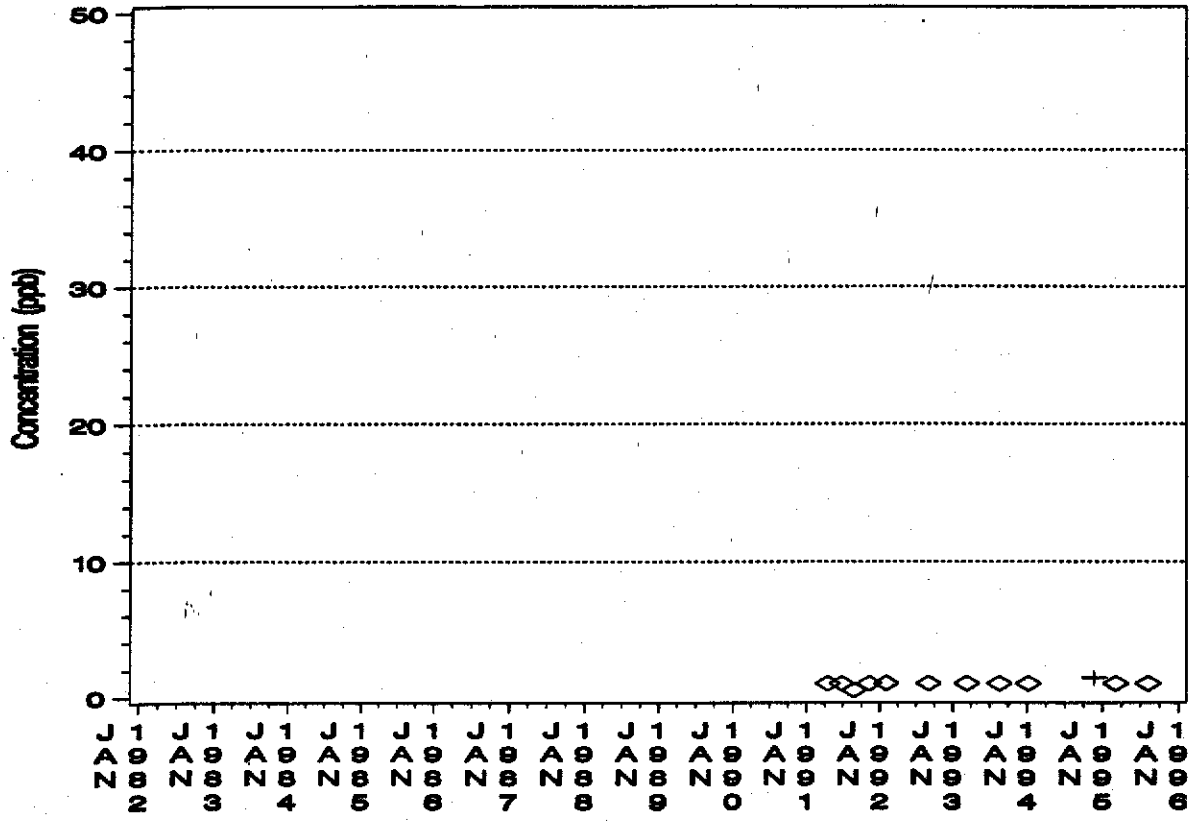
WELL 1461
TRICHLOROETHYLENE Trend



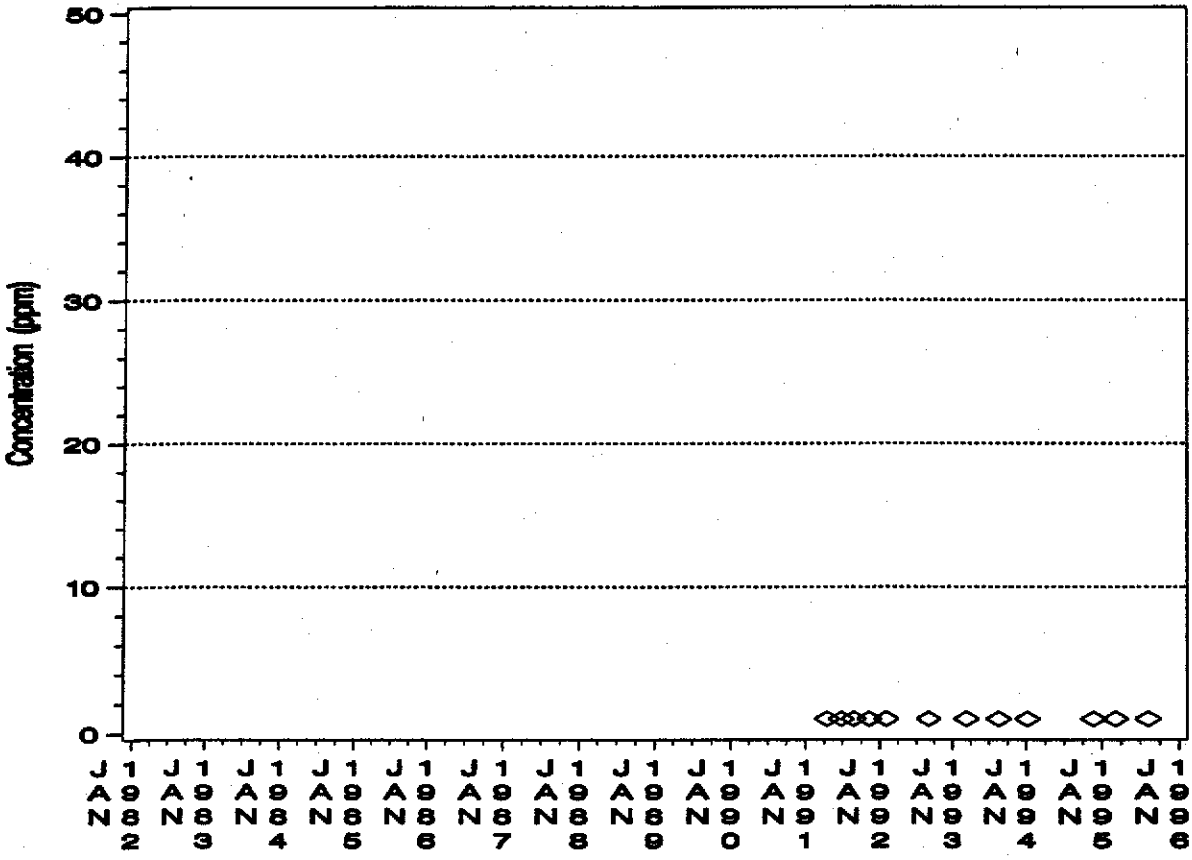
PERCHLORATE Trend



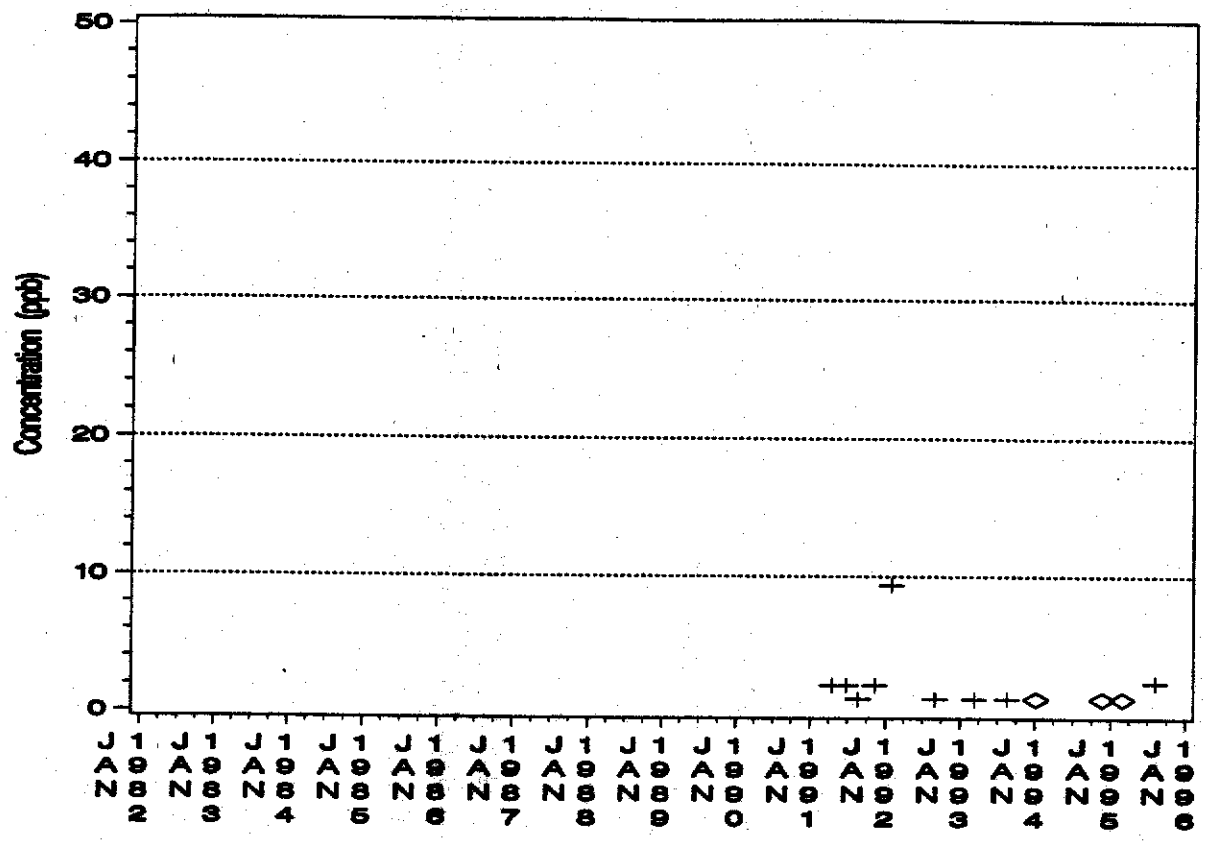
WELL 1461
CHLOROFORM Trend



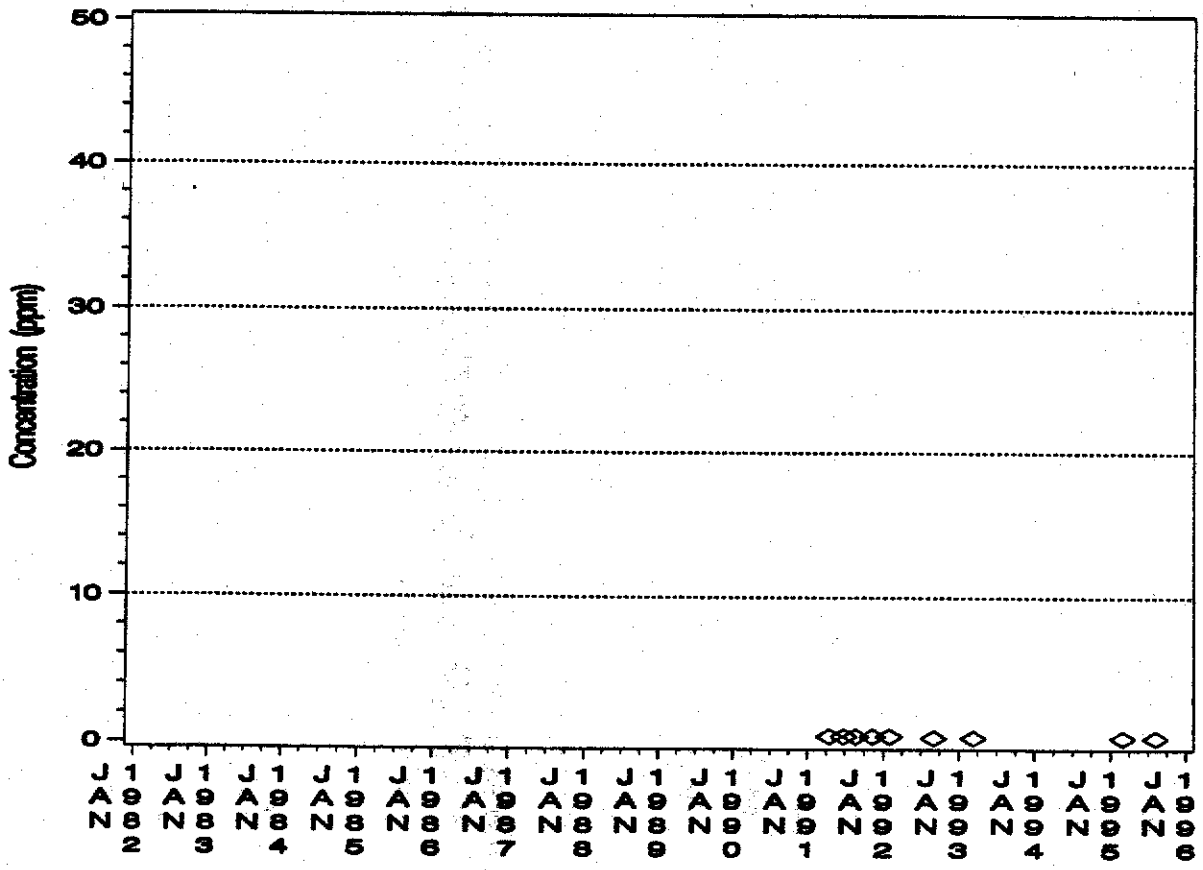
1,2 – DICHLOROETHANE Trend



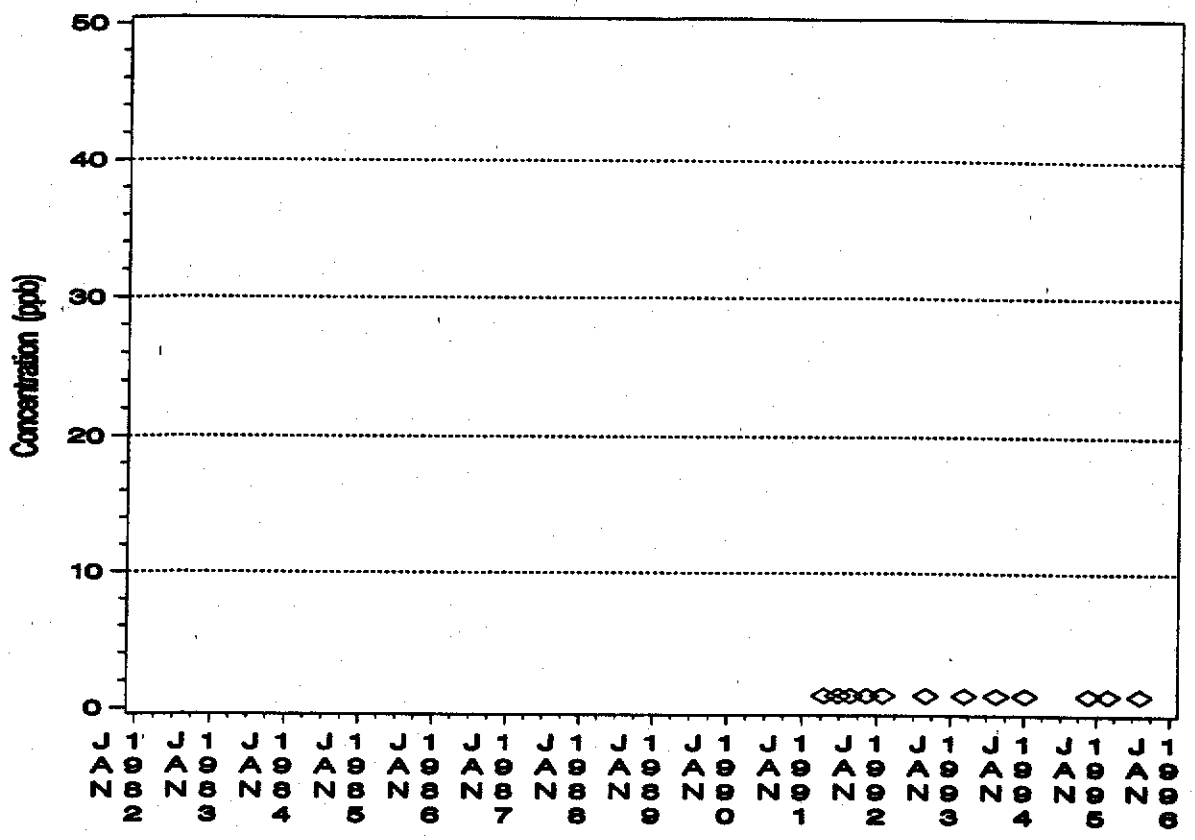
WELL 1462
TRICHLOROETHYLENE Trend



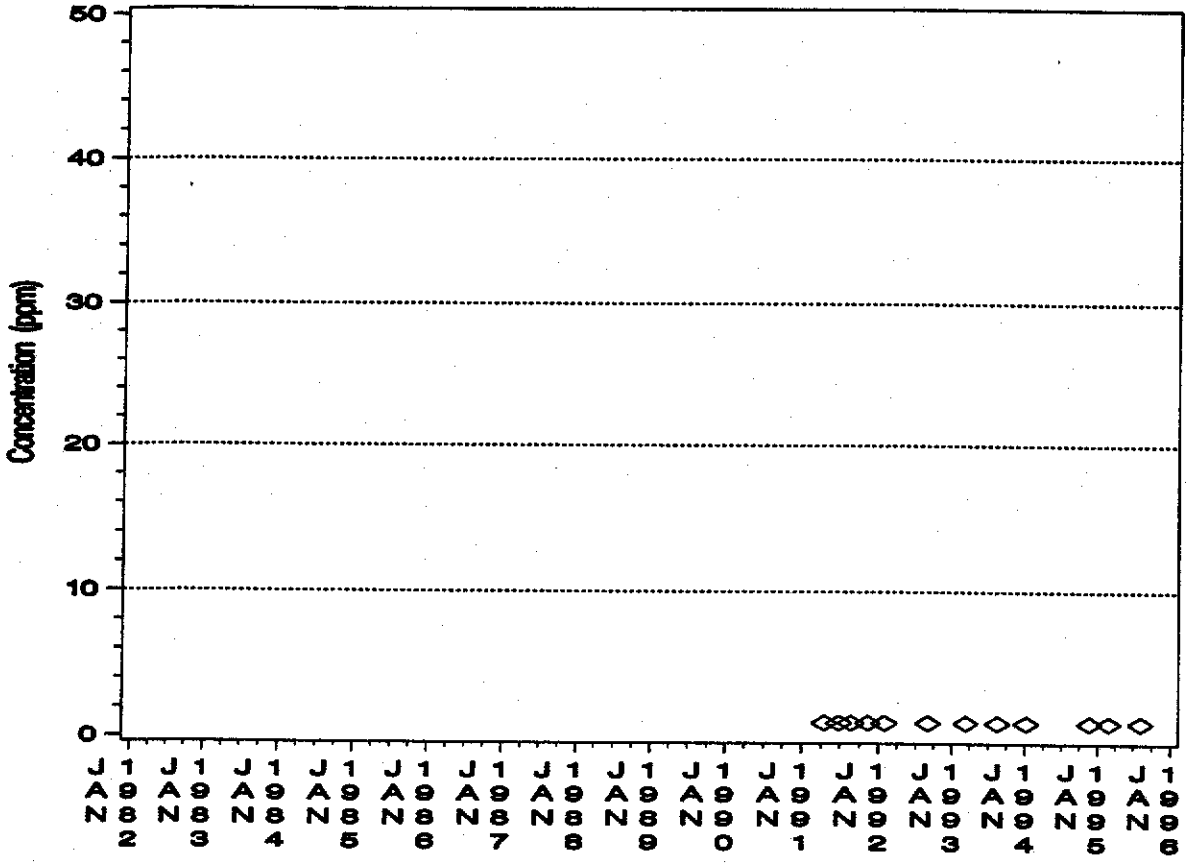
PERCHLORATE Trend



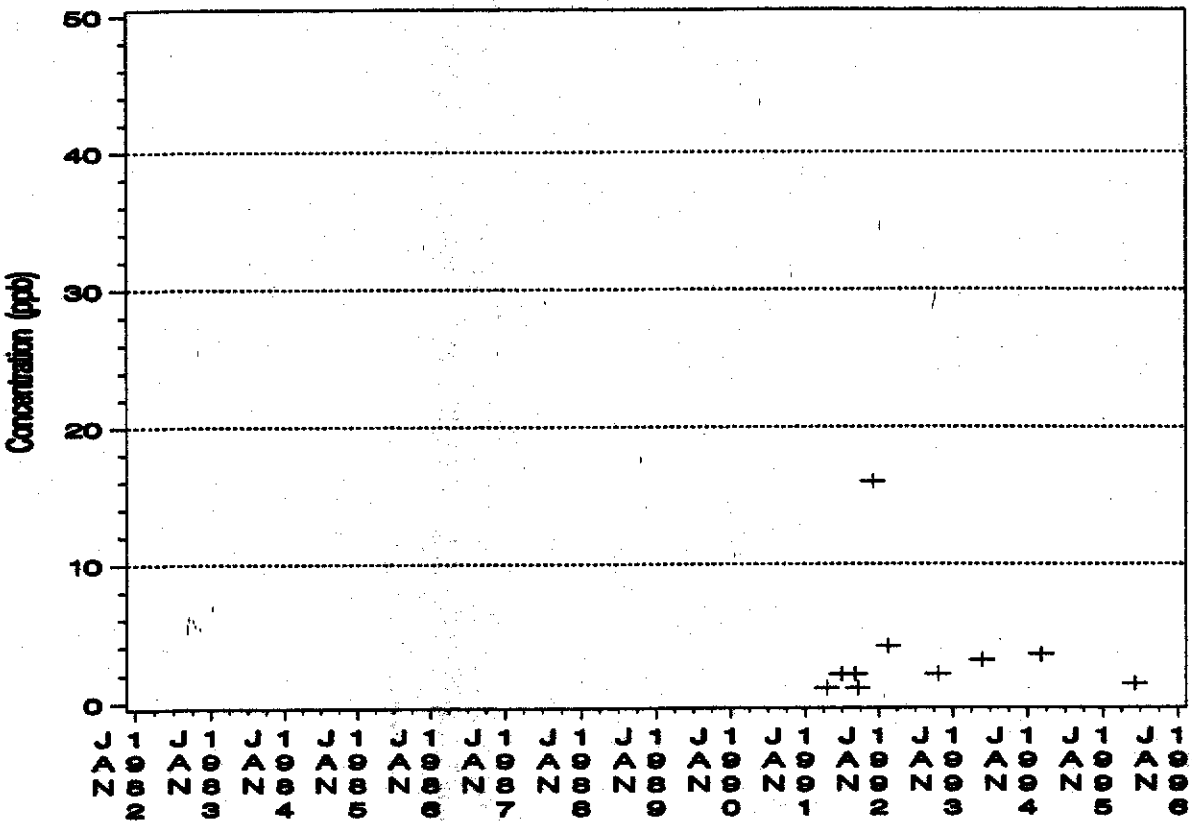
WELL 1462
CHLOROFORM Trend



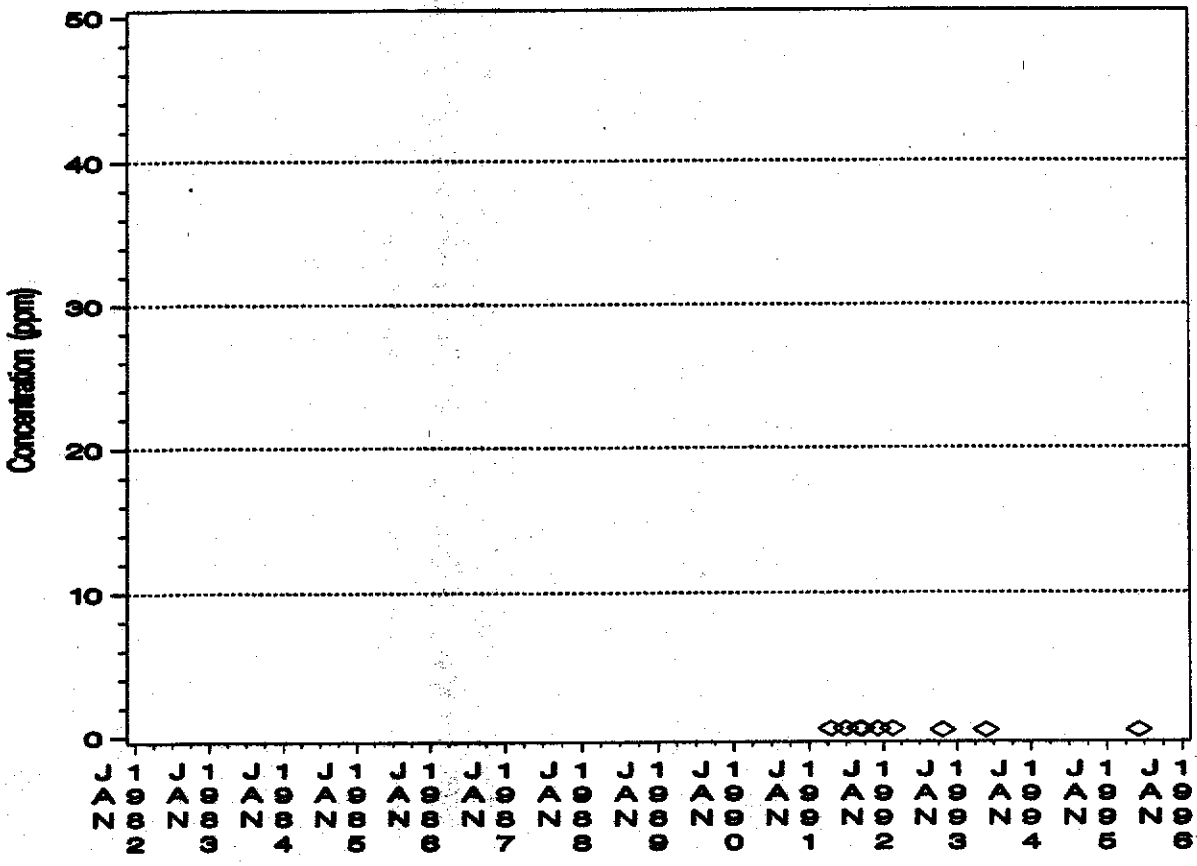
1,2 – DICHLOROETHANE Trend



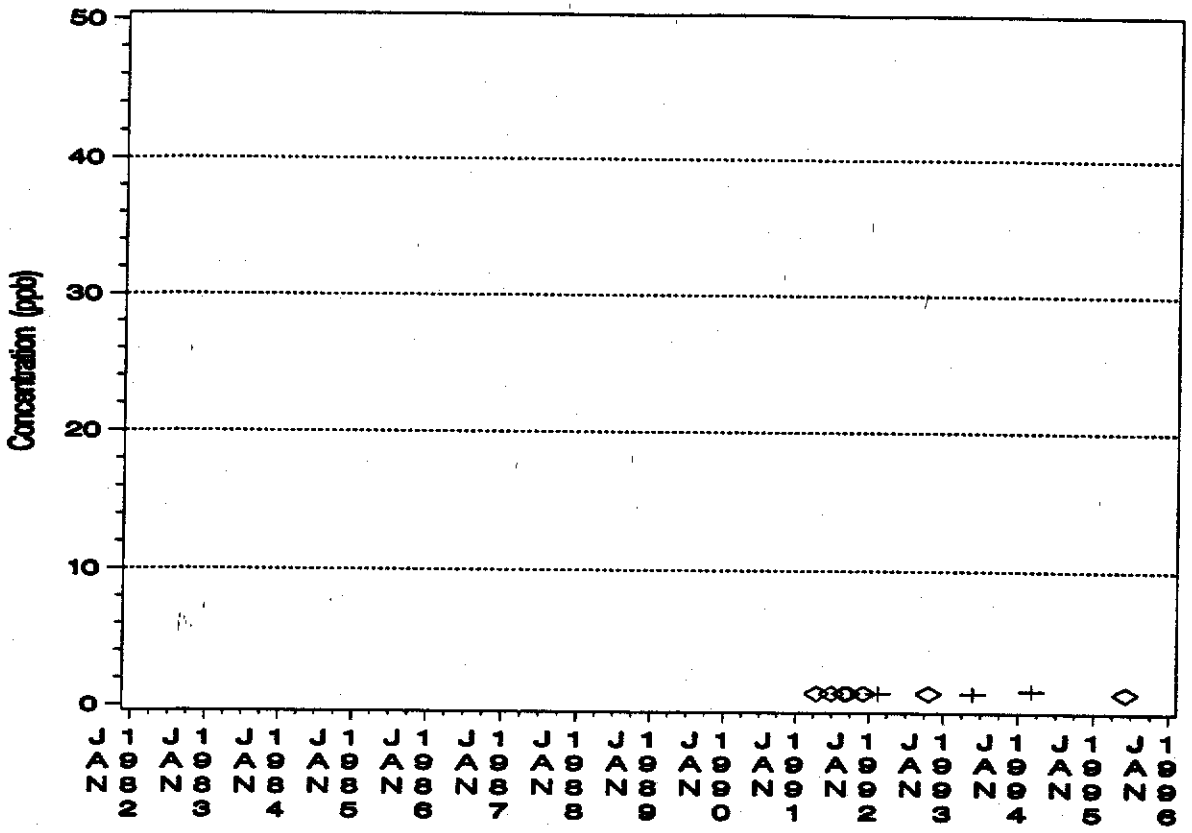
WELL 1464
TRICHLOROETHYLENE Trend



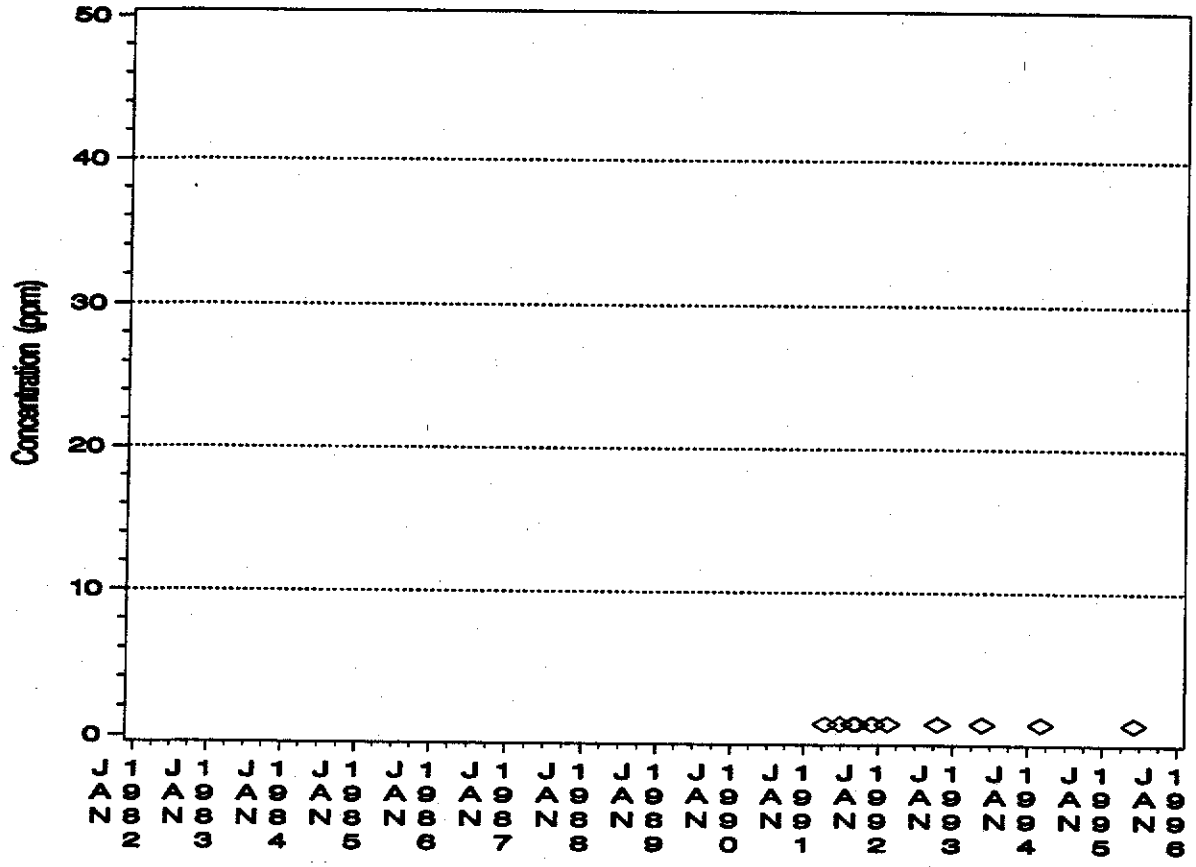
PERCHLORATE Trend



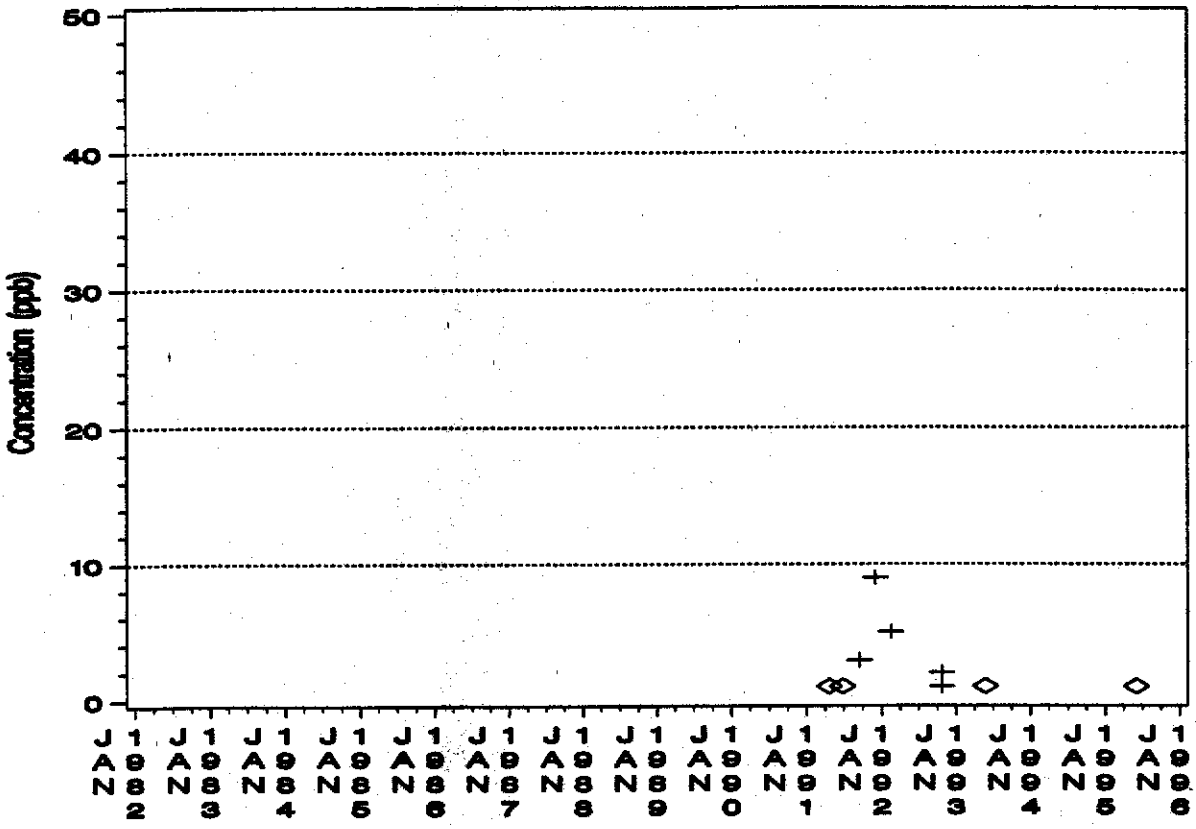
WELL 1464
CHLOROFORM Trend



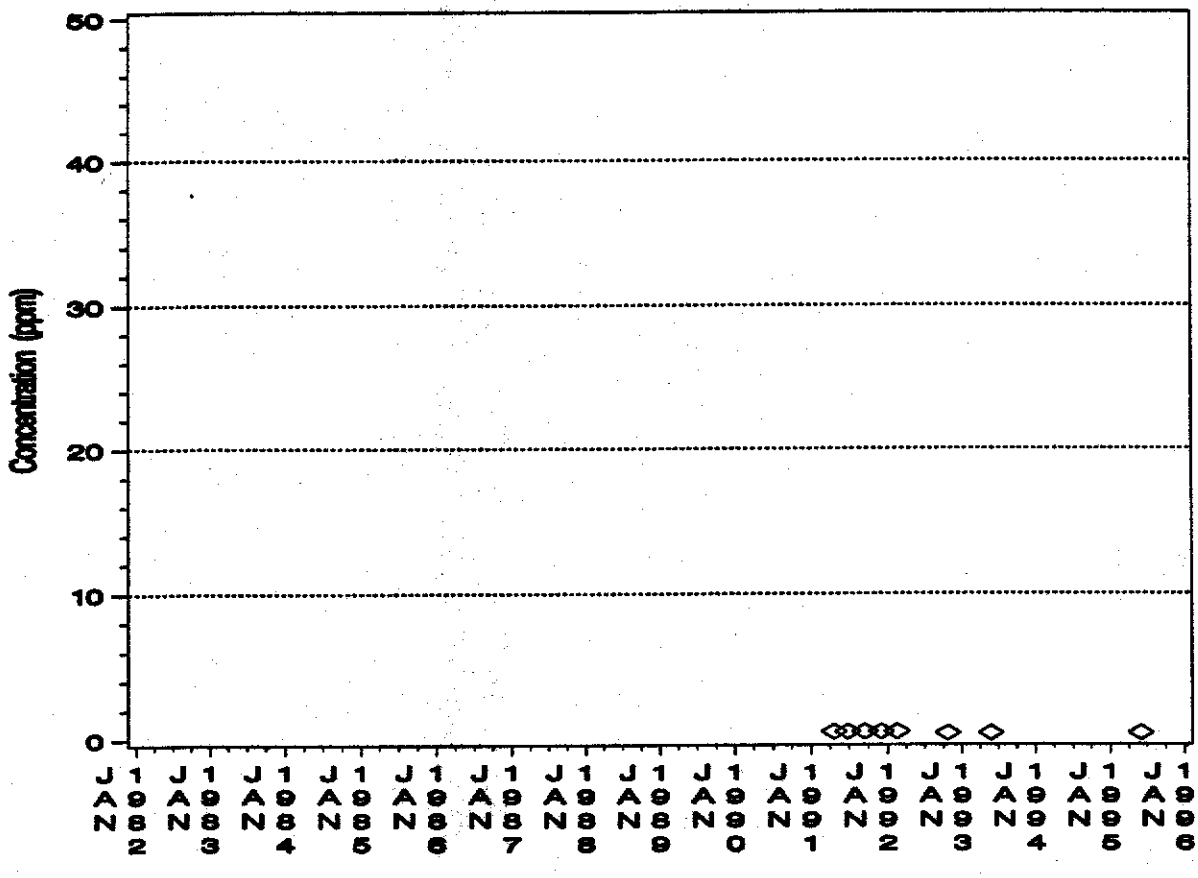
1,2 – DICHLOROETHANE Trend



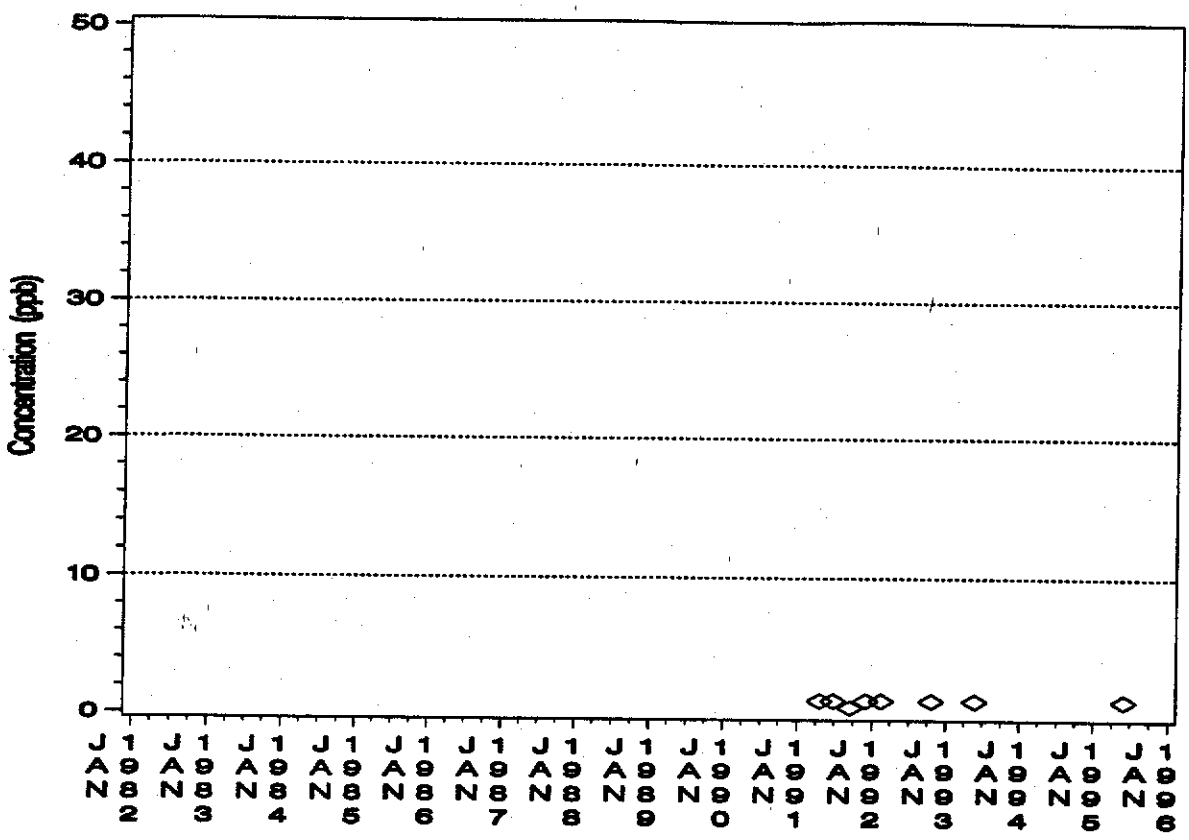
WELL 1466
TRICHLOROETHYLENE Trend



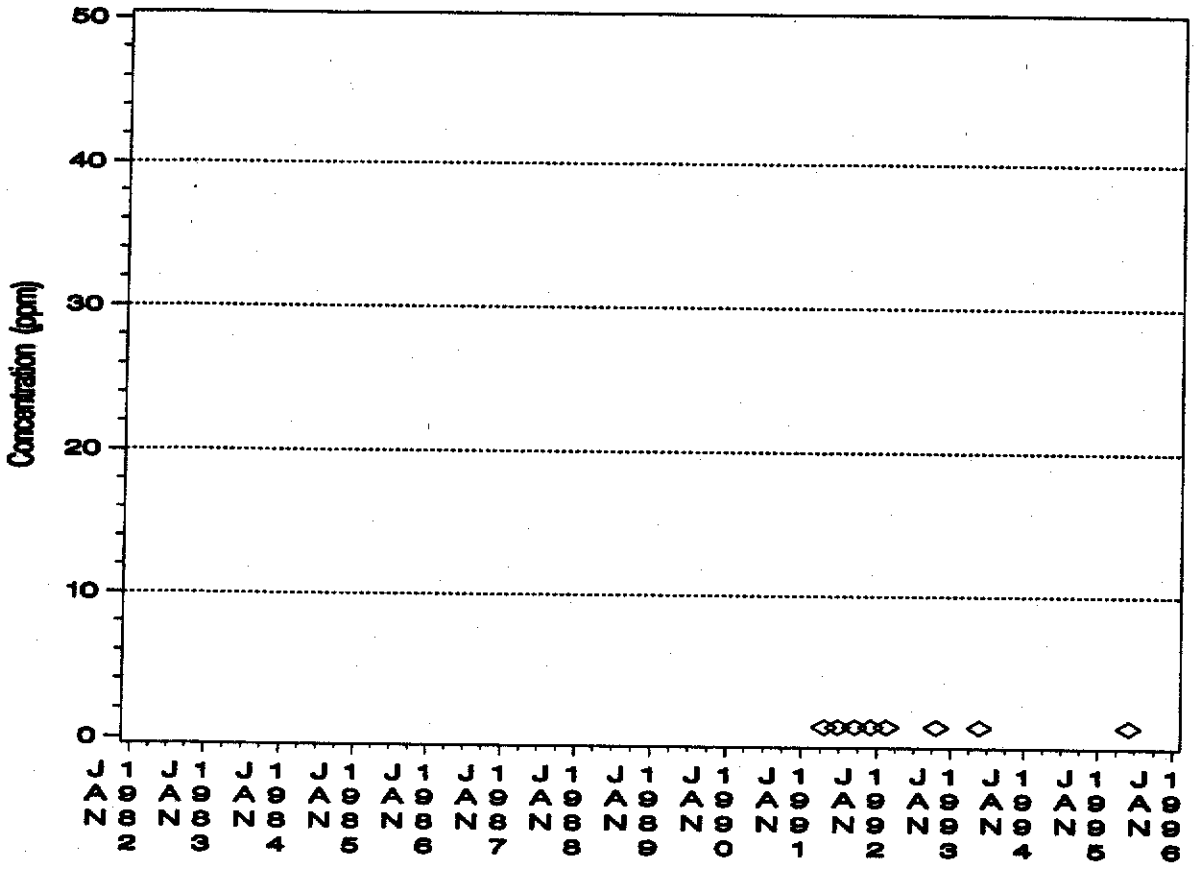
PERCHLORATE Trend



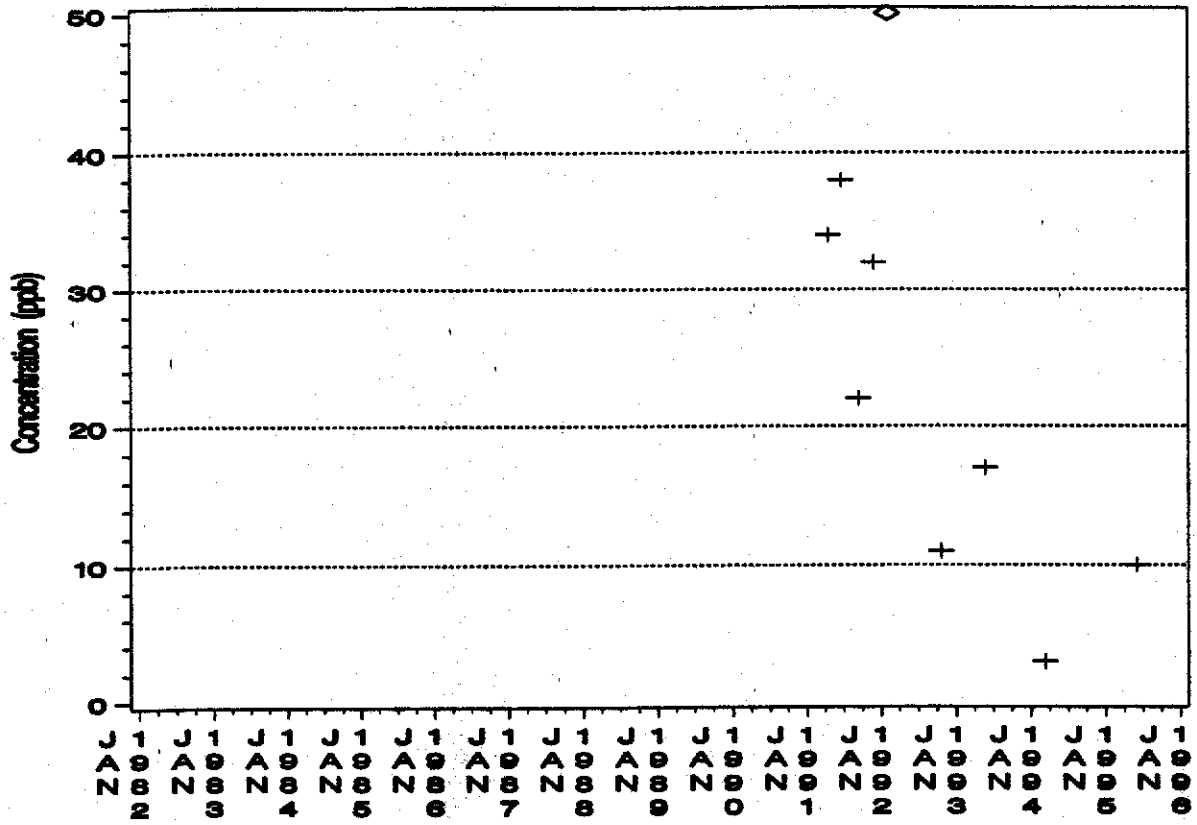
WELL 1466
CHLOROFORM Trend



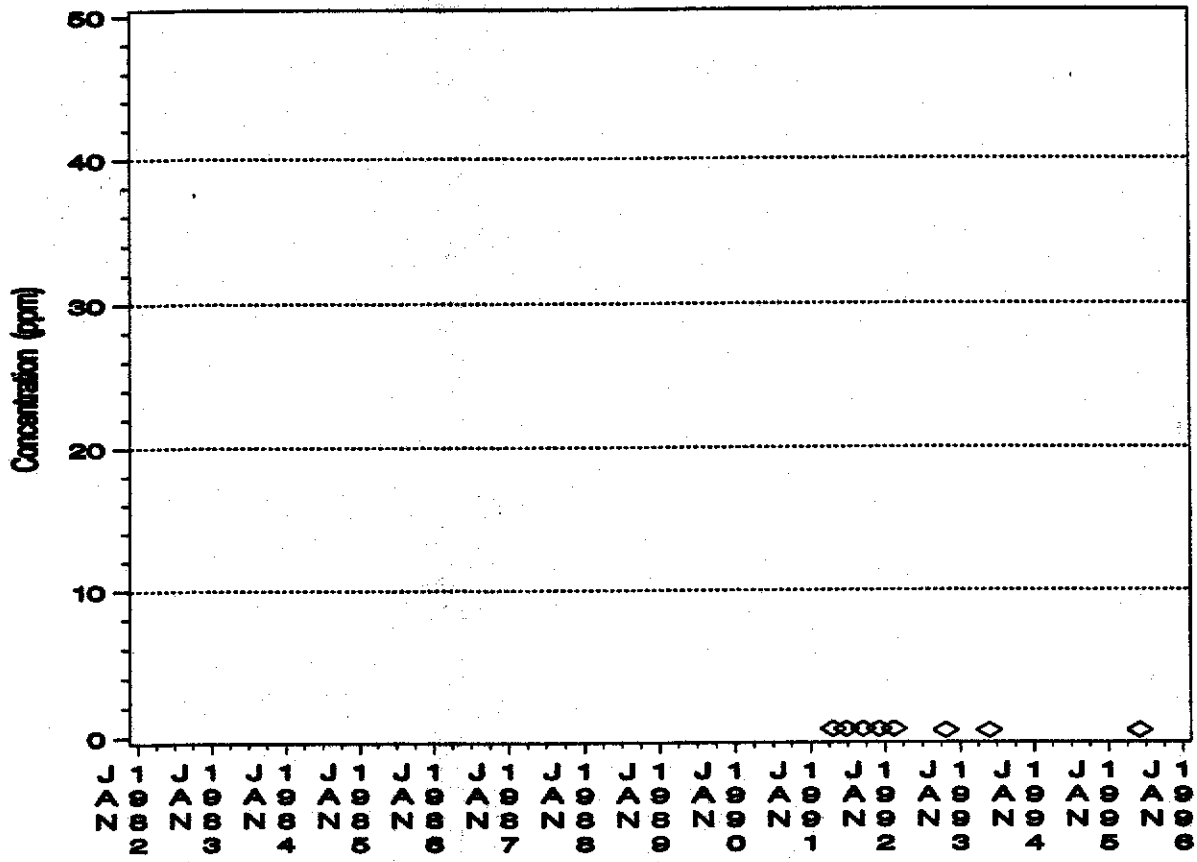
1,2 – DICHLOROETHANE Trend



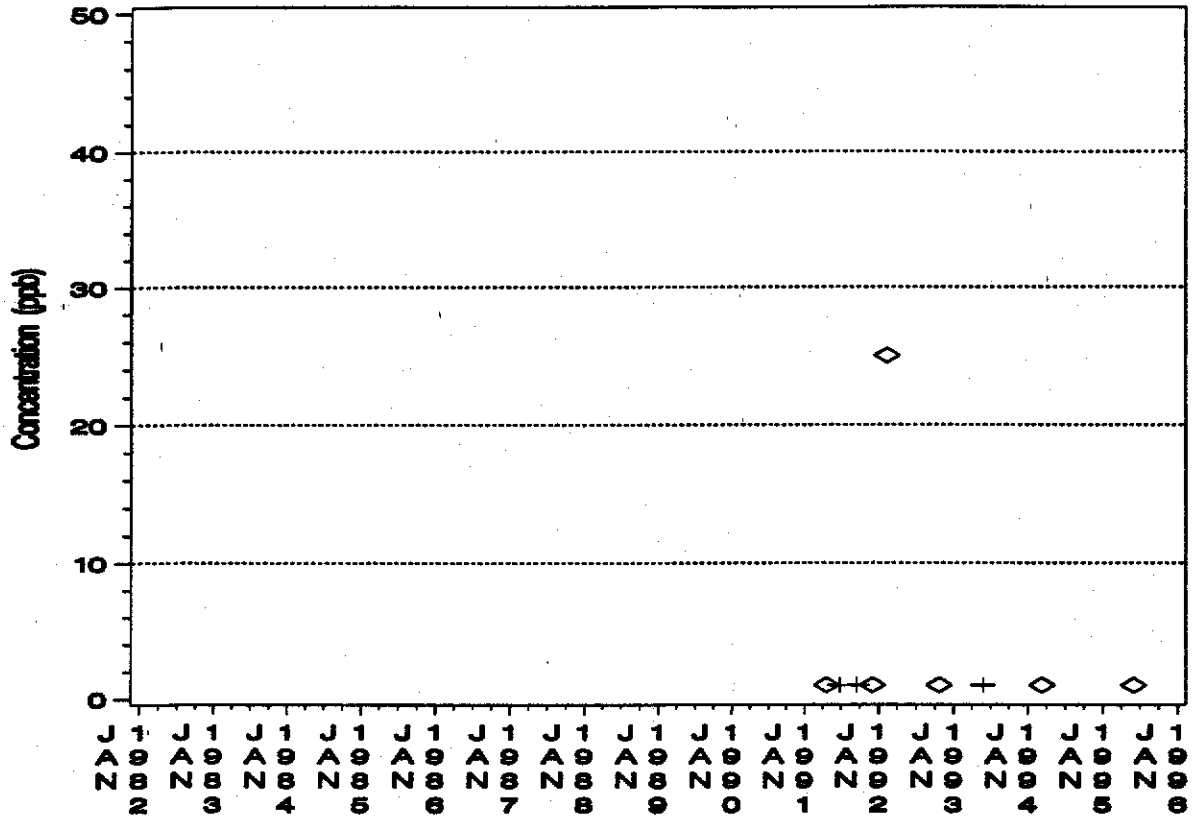
WELL 1467
TRICHLOROETHYLENE Trend



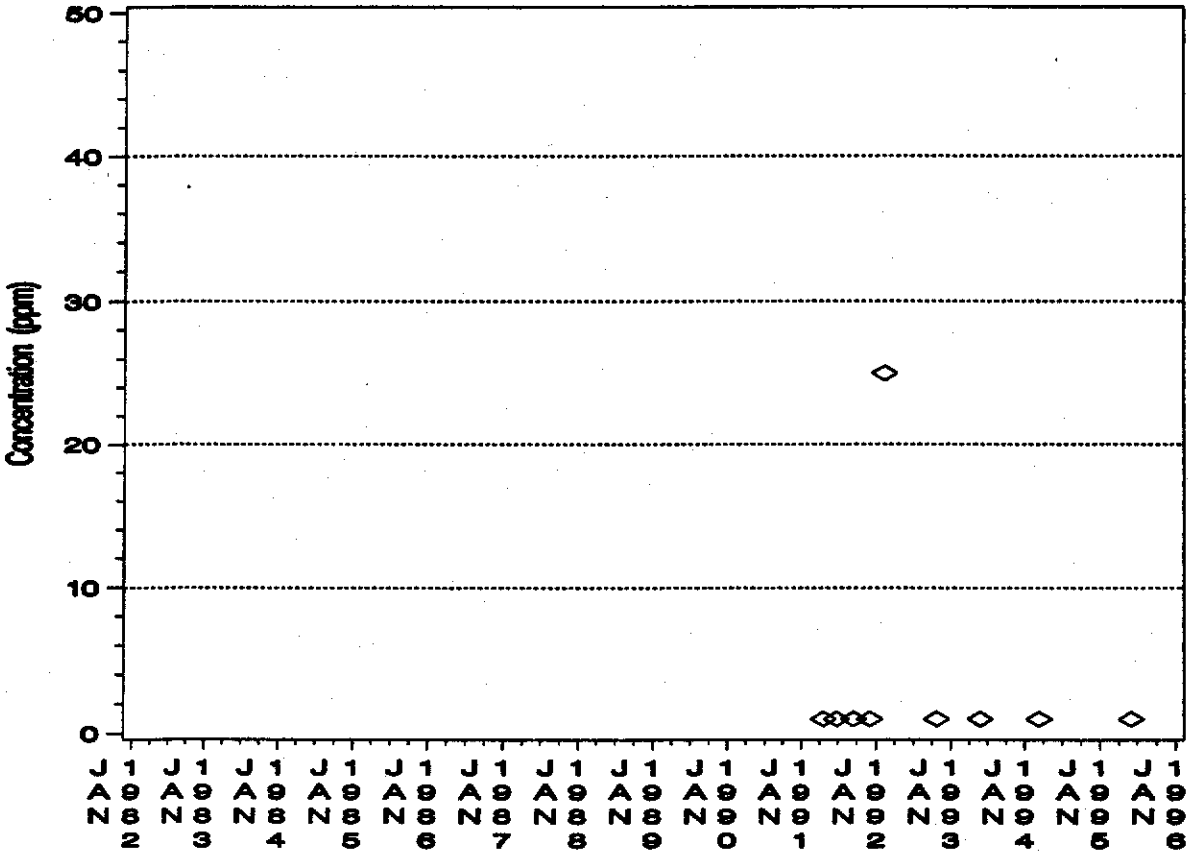
PERCHLORATE Trend



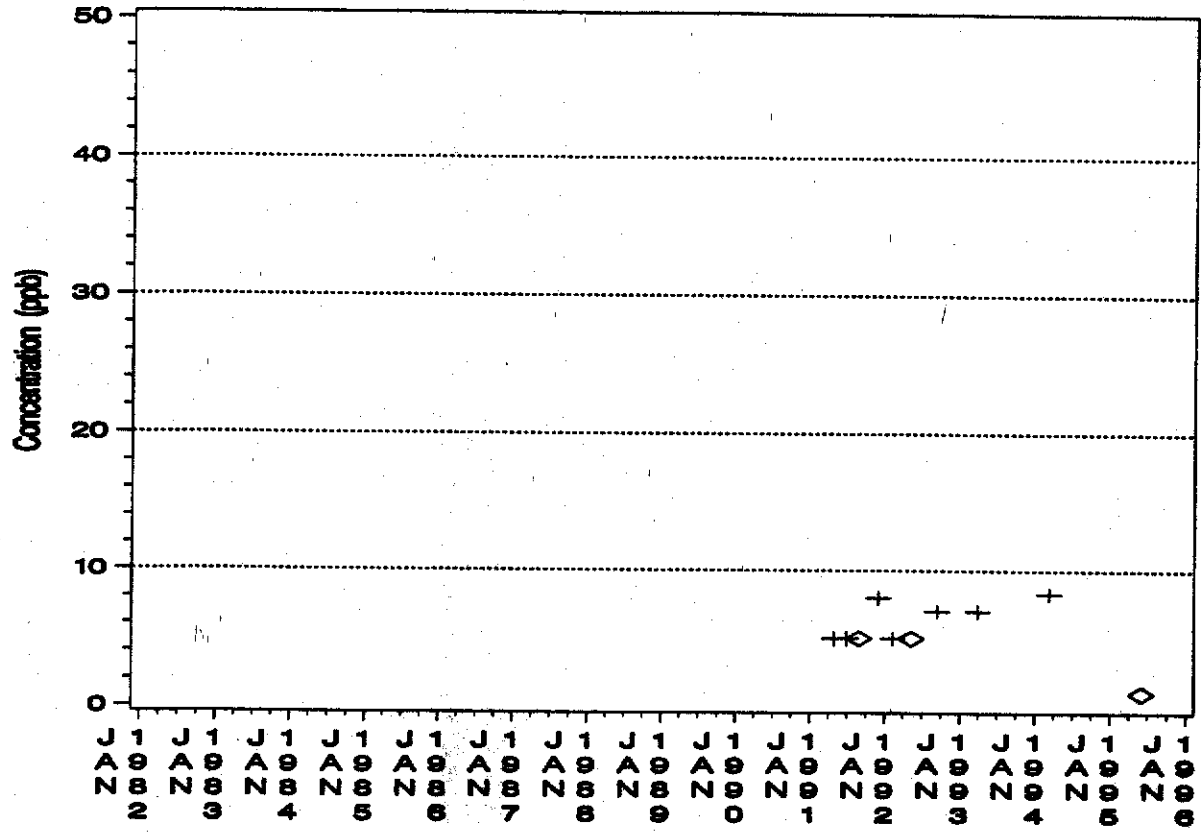
WELL 1467
CHLOROFORM Trend



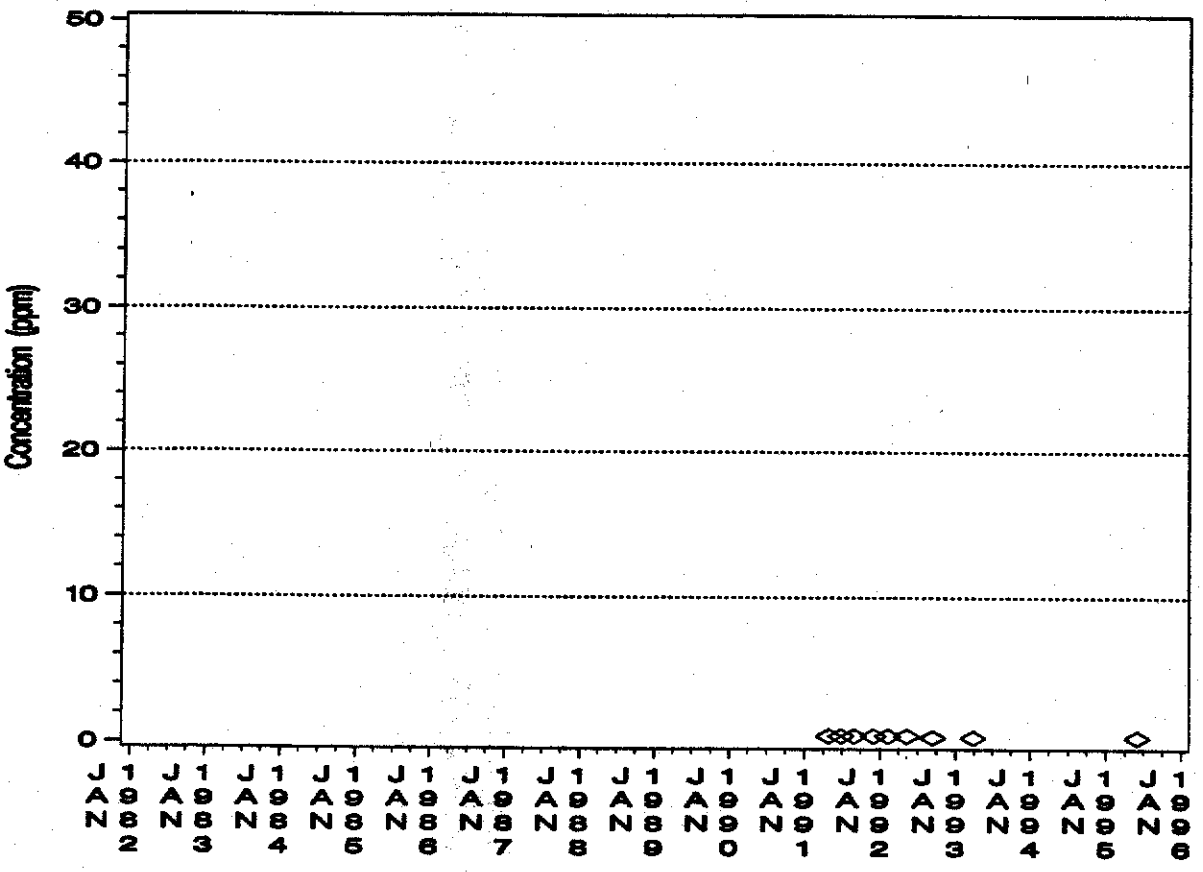
1,2 — DICHLOROETHANE Trend



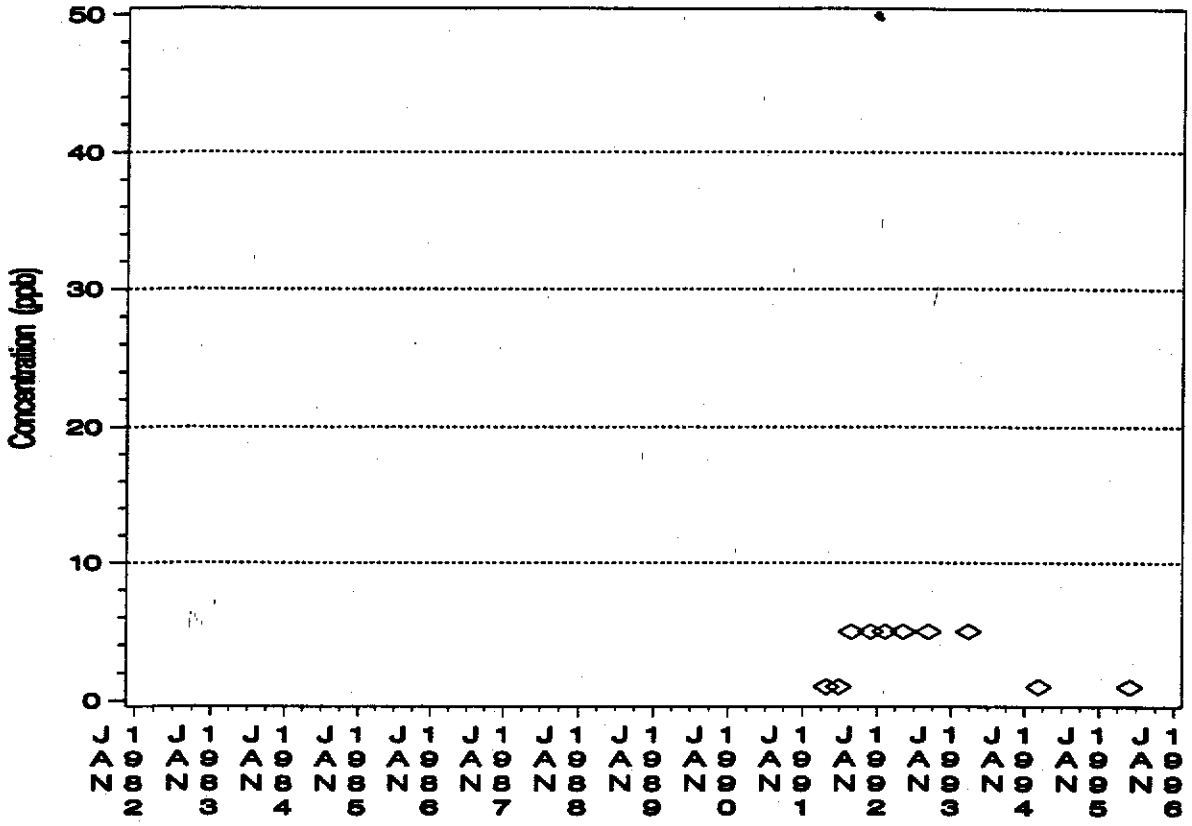
WELL 1484
TRICHLOROETHYLENE Trend



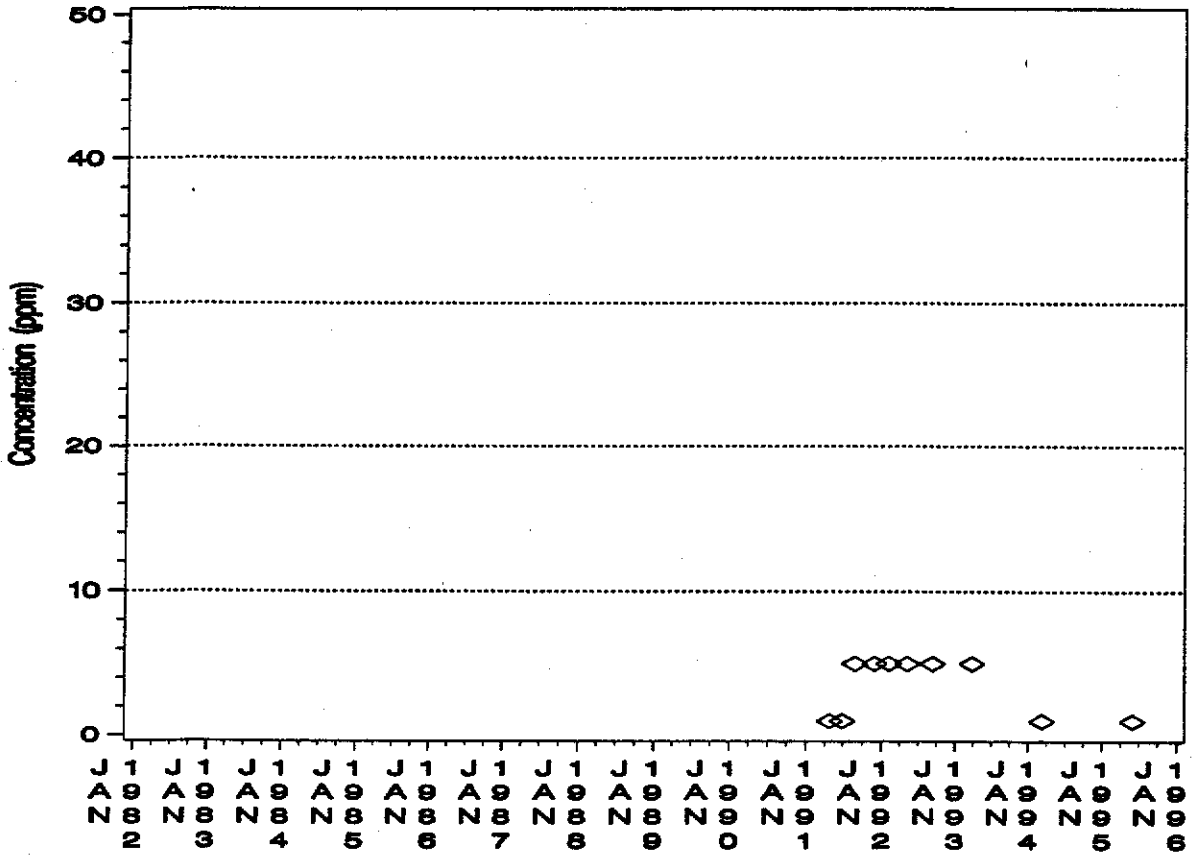
PERCHLORATE Trend



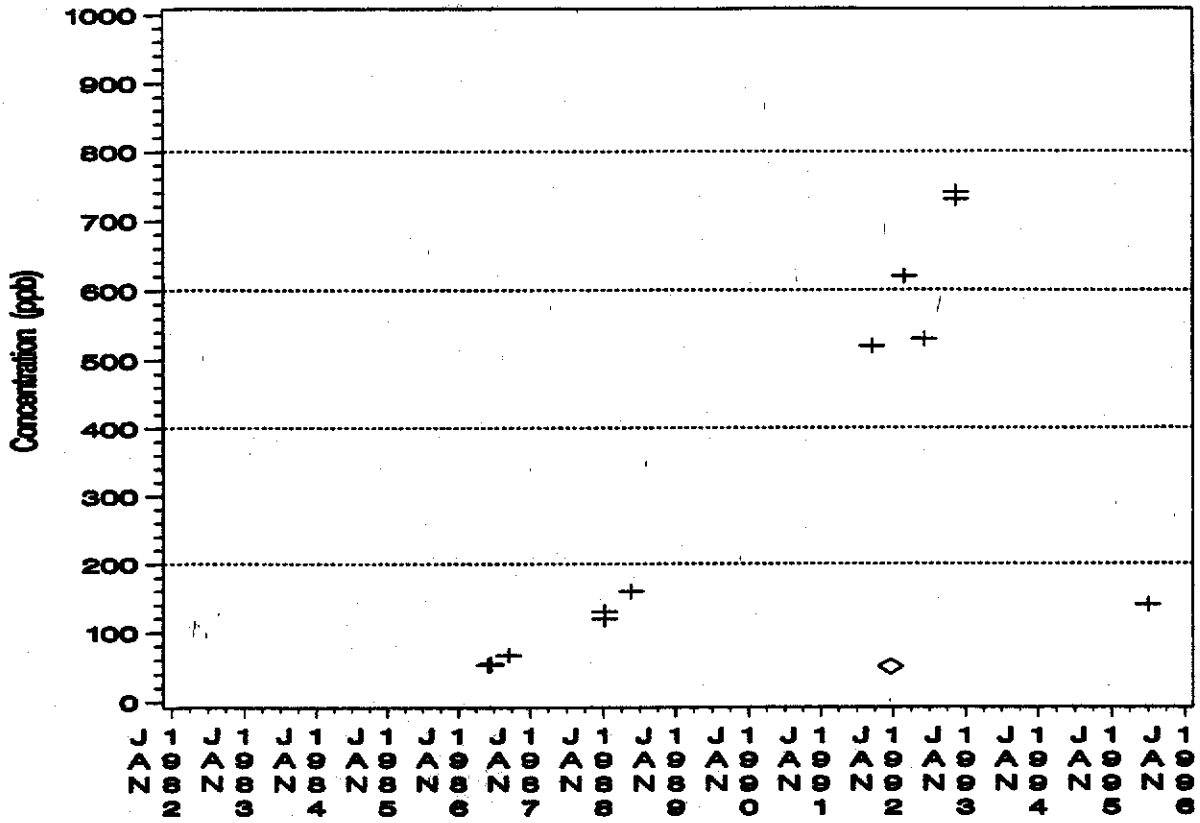
WELL 1484
CHLOROFORM Trend



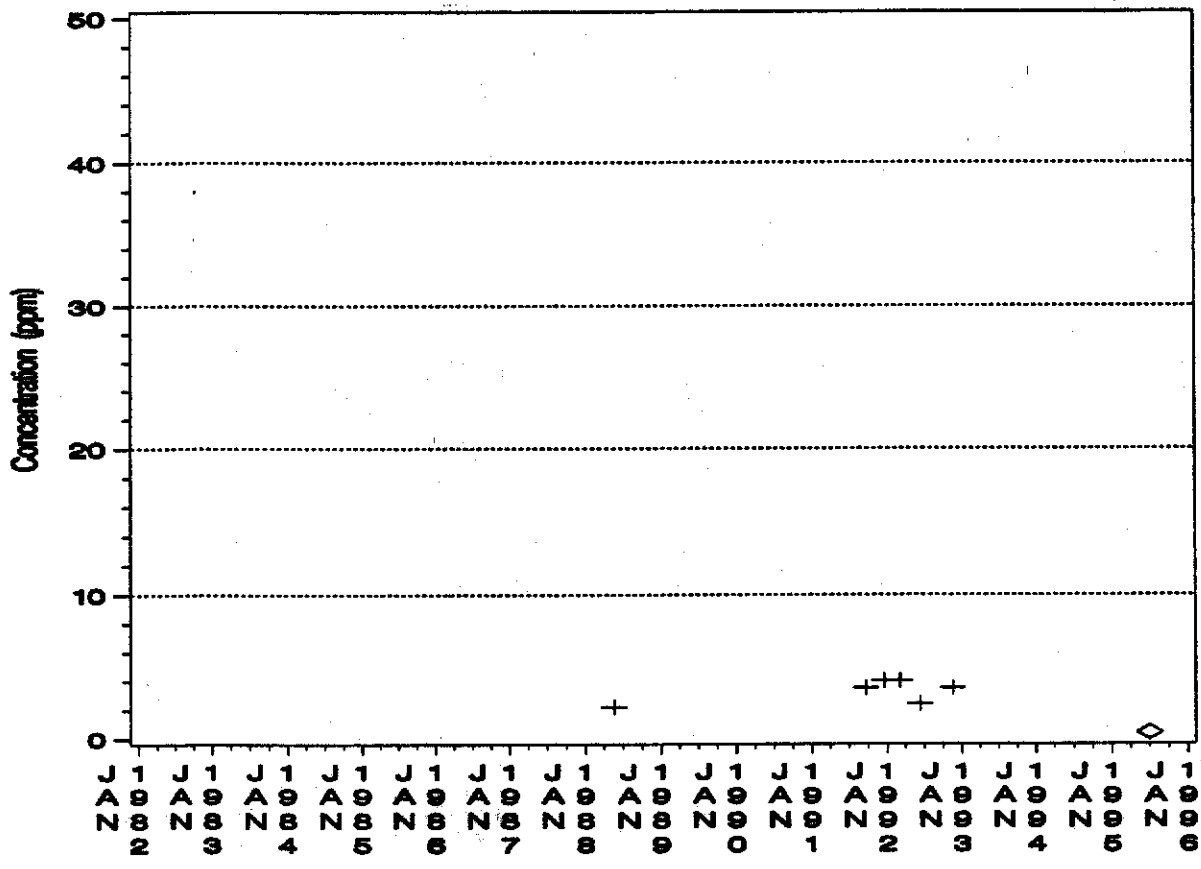
1,2 – DICHLOROETHANE Trend



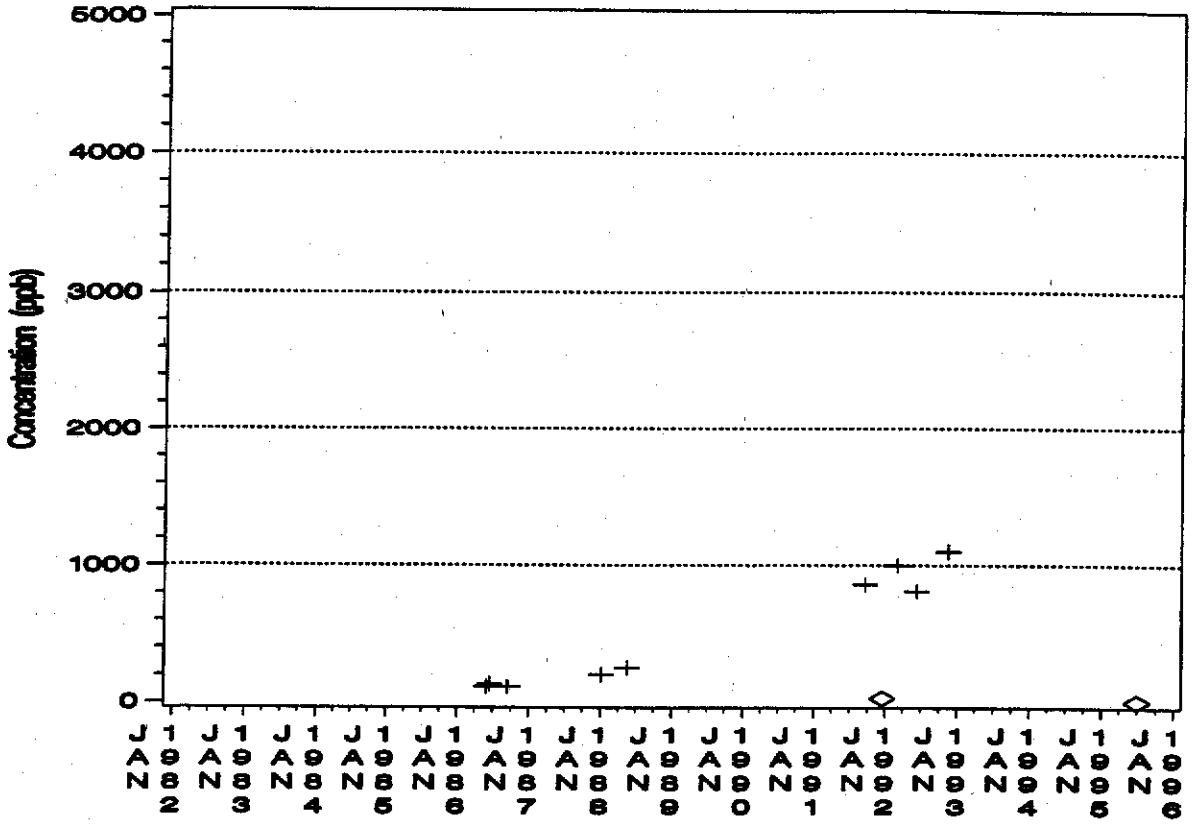
WELL 3050
TRICHLOROETHYLENE Trend



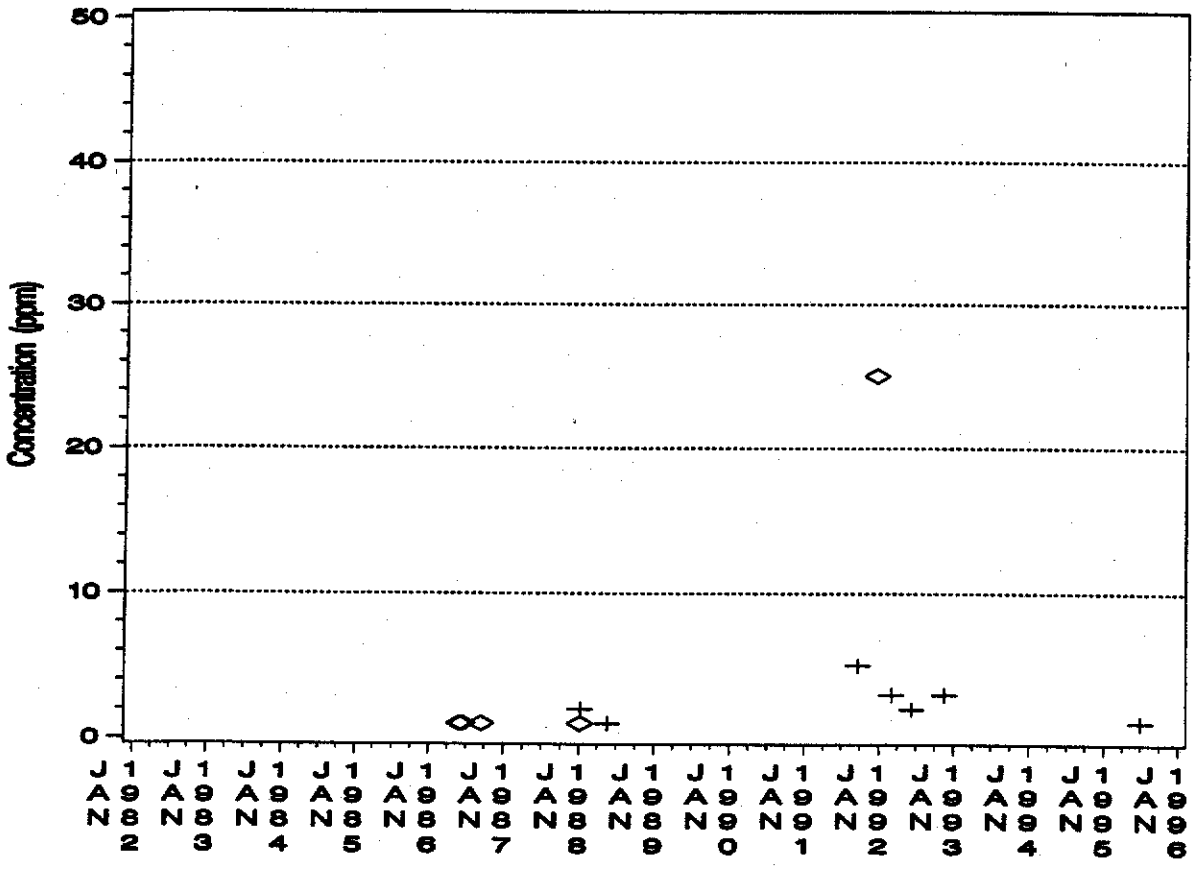
PERCHLORATE Trend



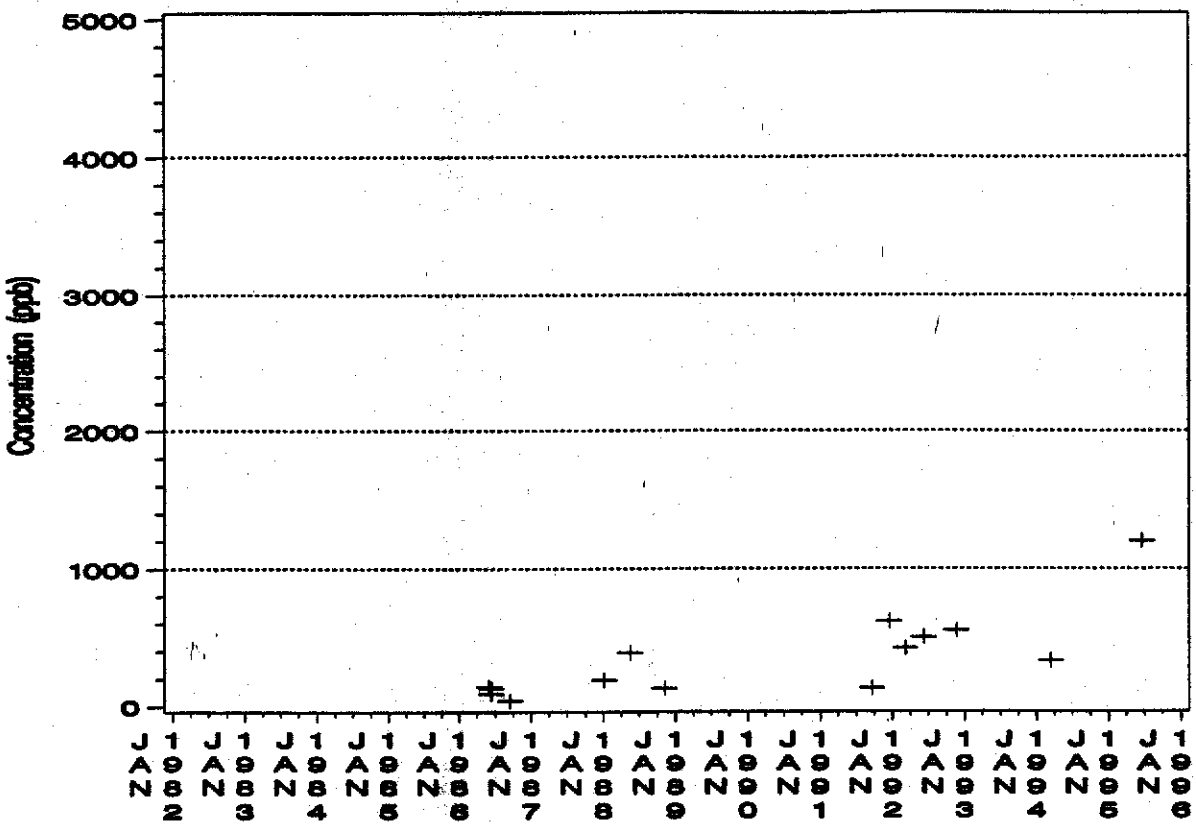
WELL 3050
CHLOROFORM Trend



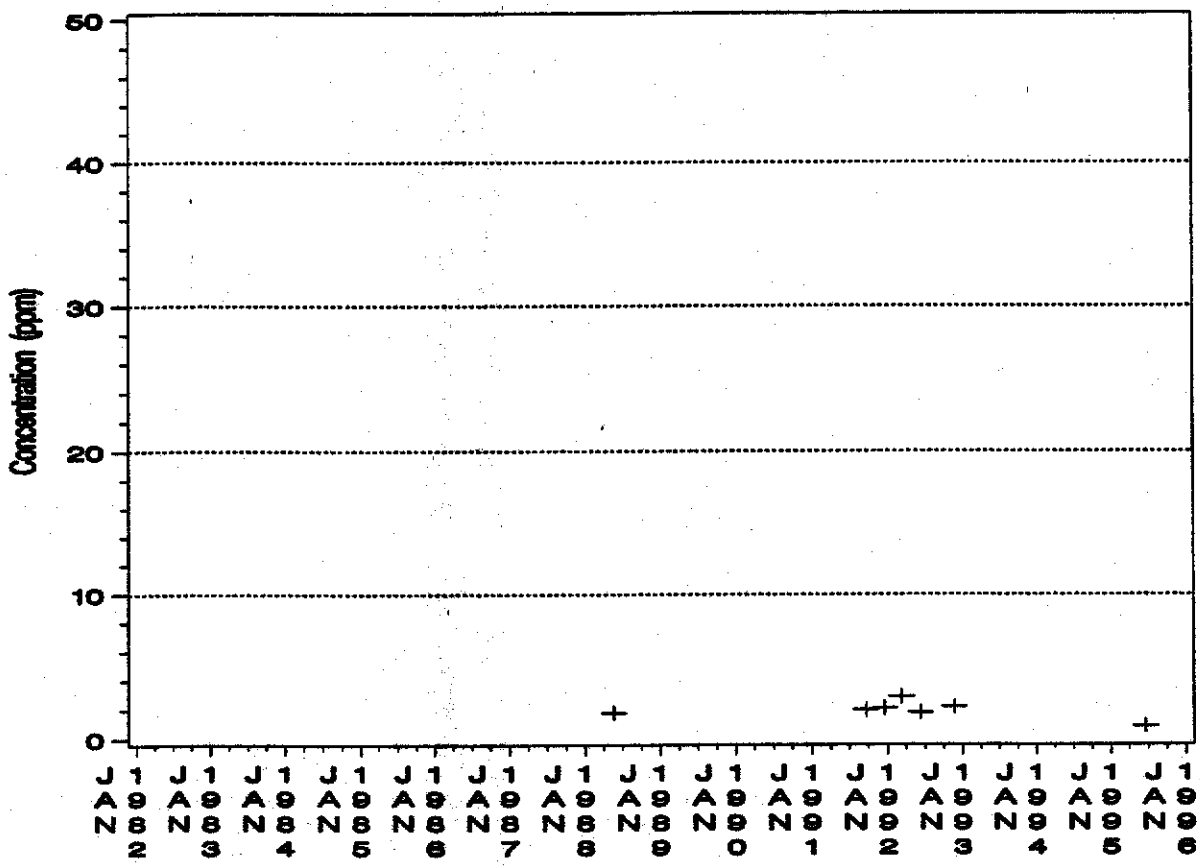
1,2 – DICHLOROETHANE Trend



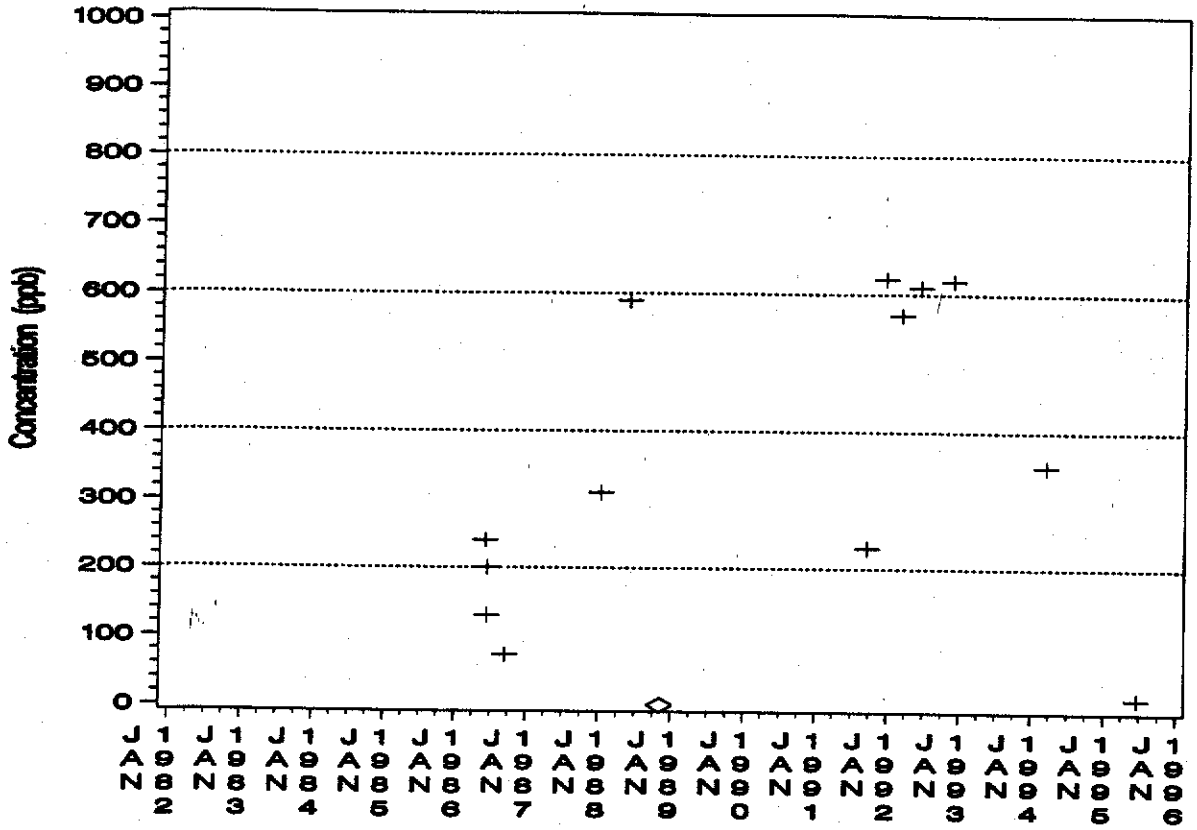
WELL 3051
TRICHLOROETHYLENE Trend



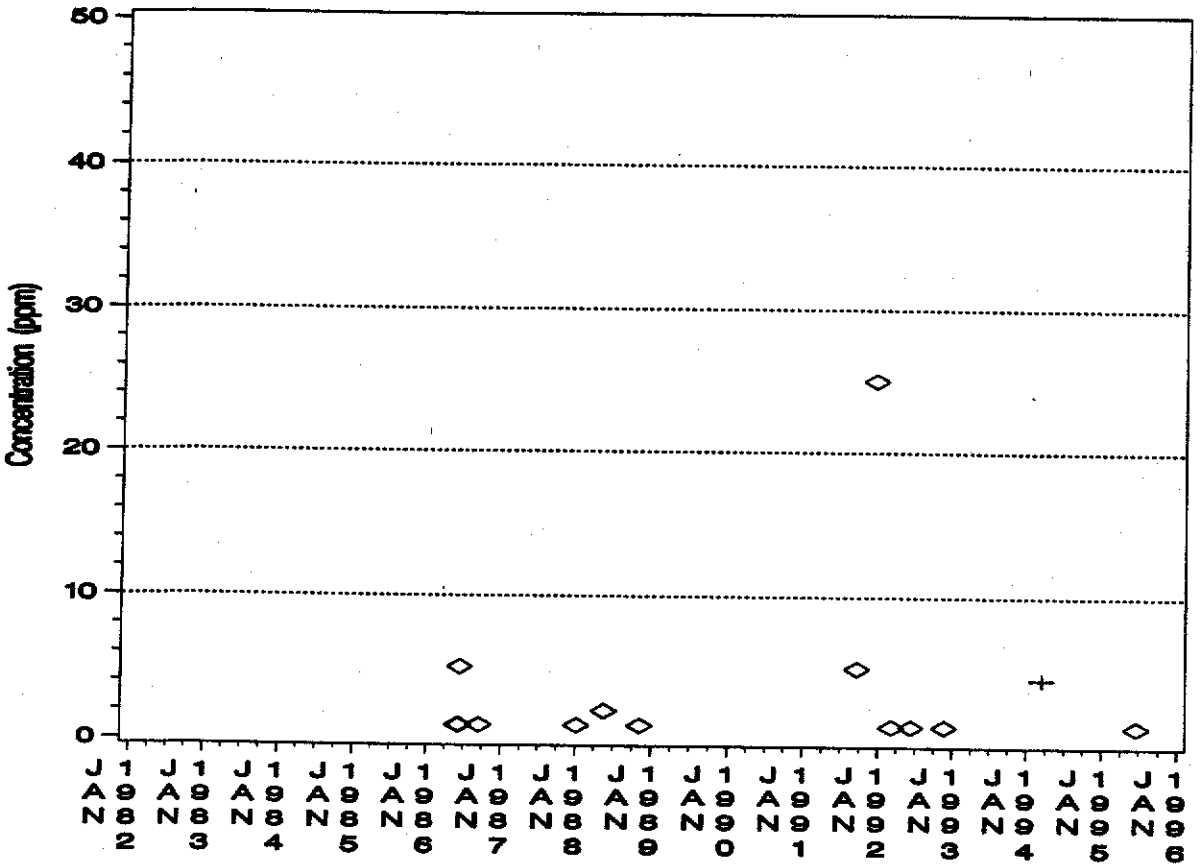
PERCHLORATE Trend



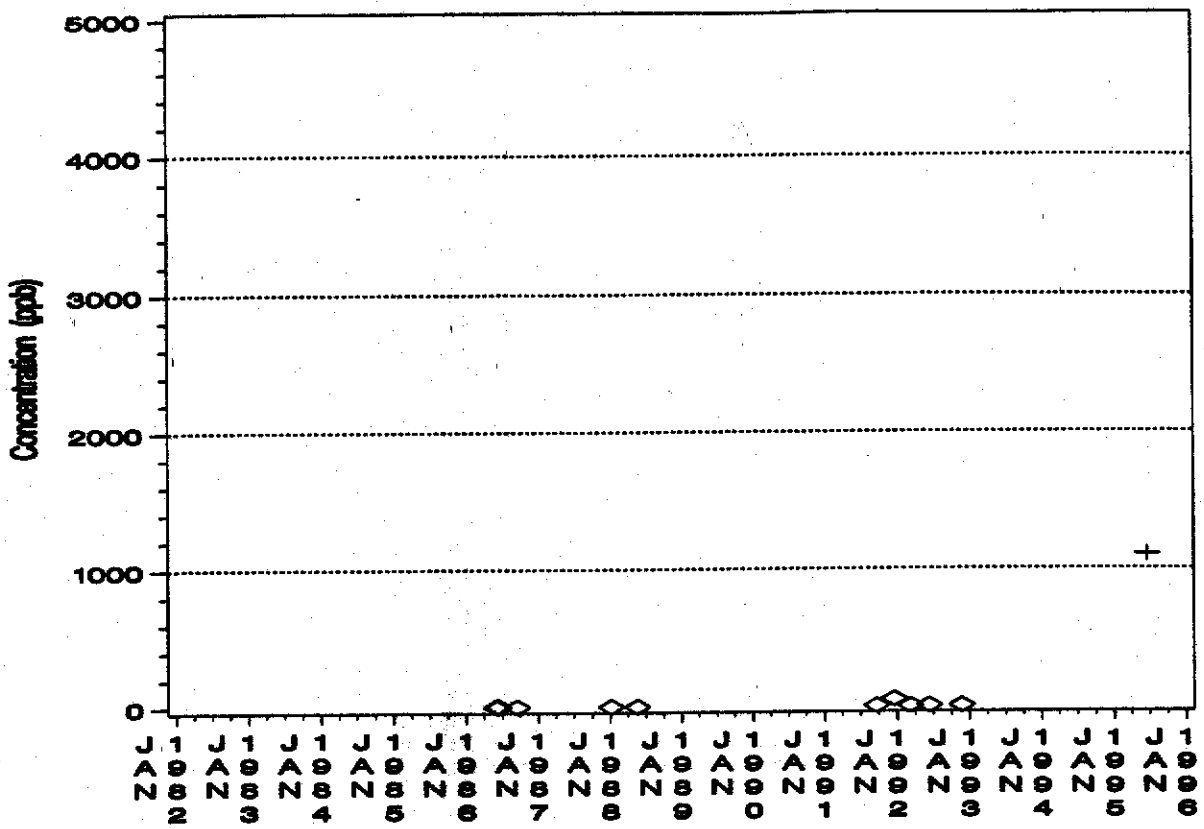
WELL 3051
CHLOROFORM Trend



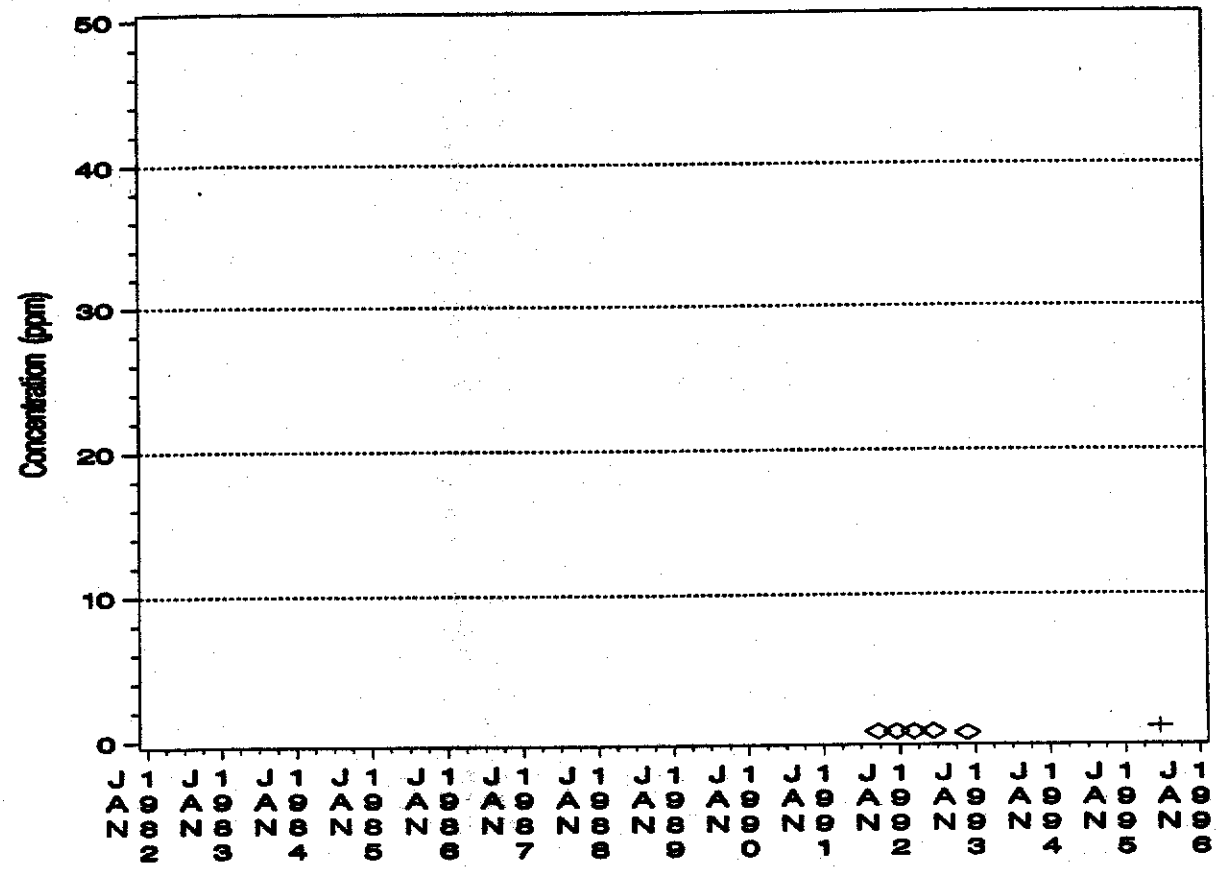
1,2 – DICHLOROETHANE Trend



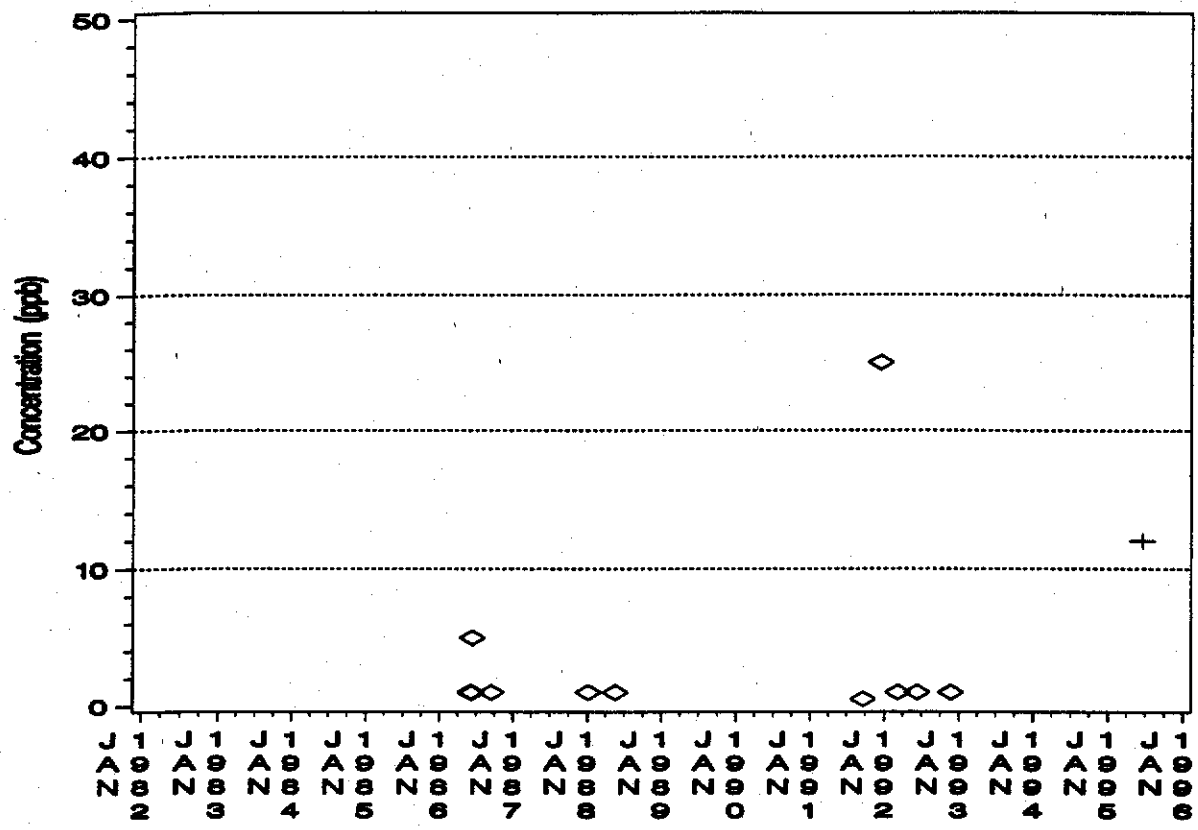
WELL 3052
TRICHLOROETHYLENE Trend



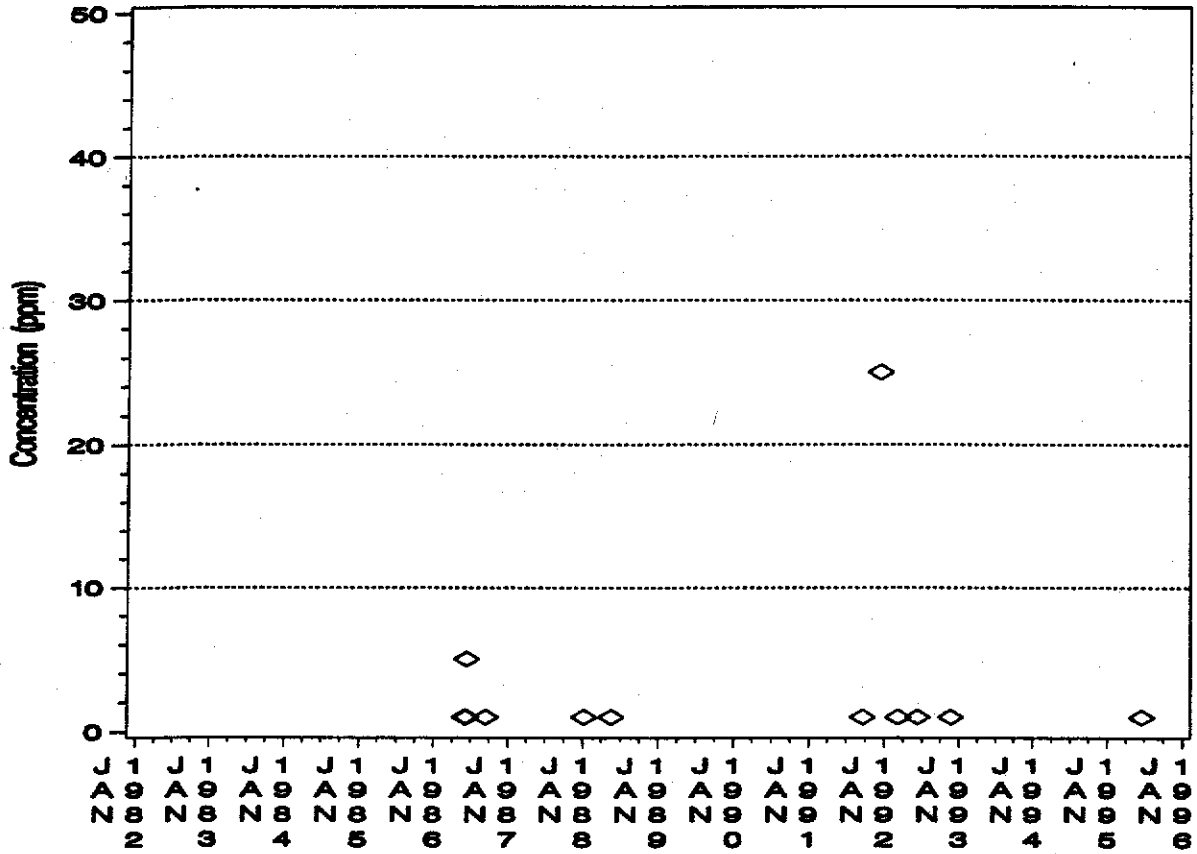
PERCHLORATE Trend



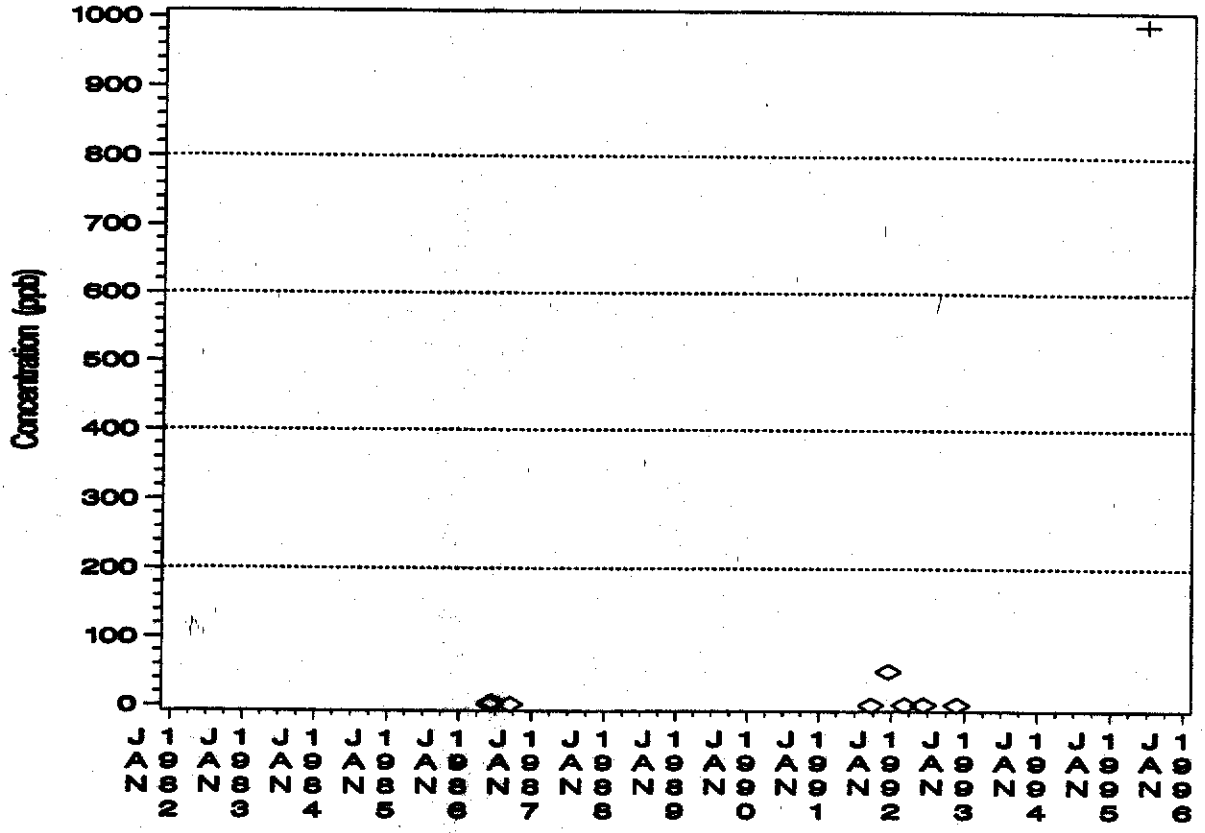
WELL 3052
CHLOROFORM Trend



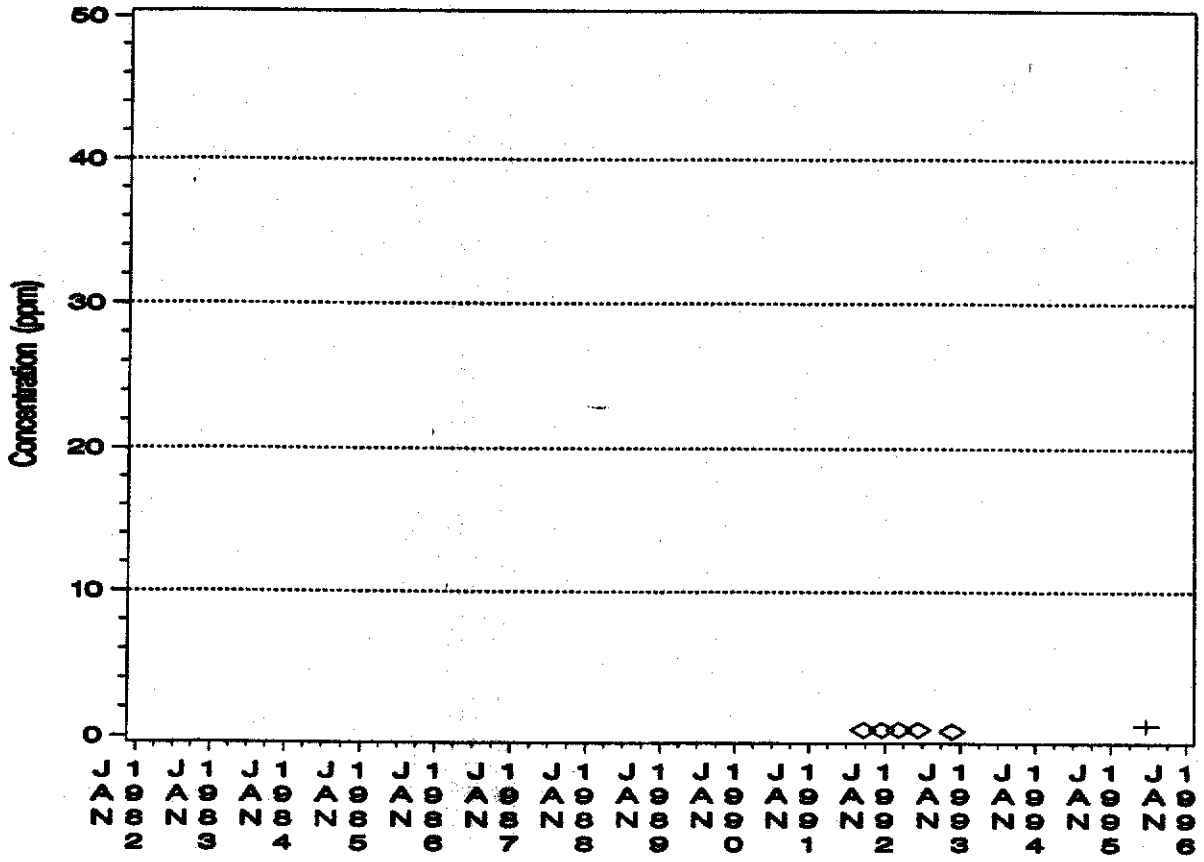
1,2 – DICHLOROETHANE Trend



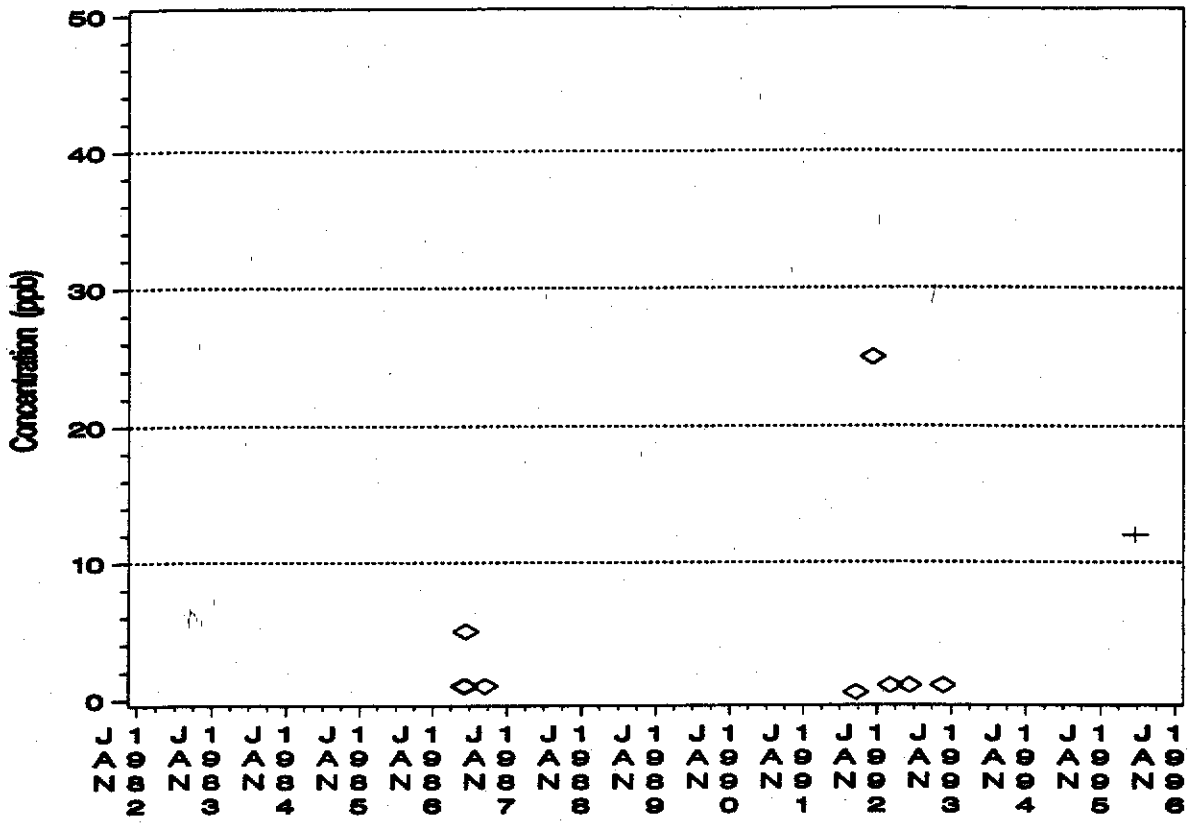
WELL 3053
TRICHLOROETHYLENE Trend



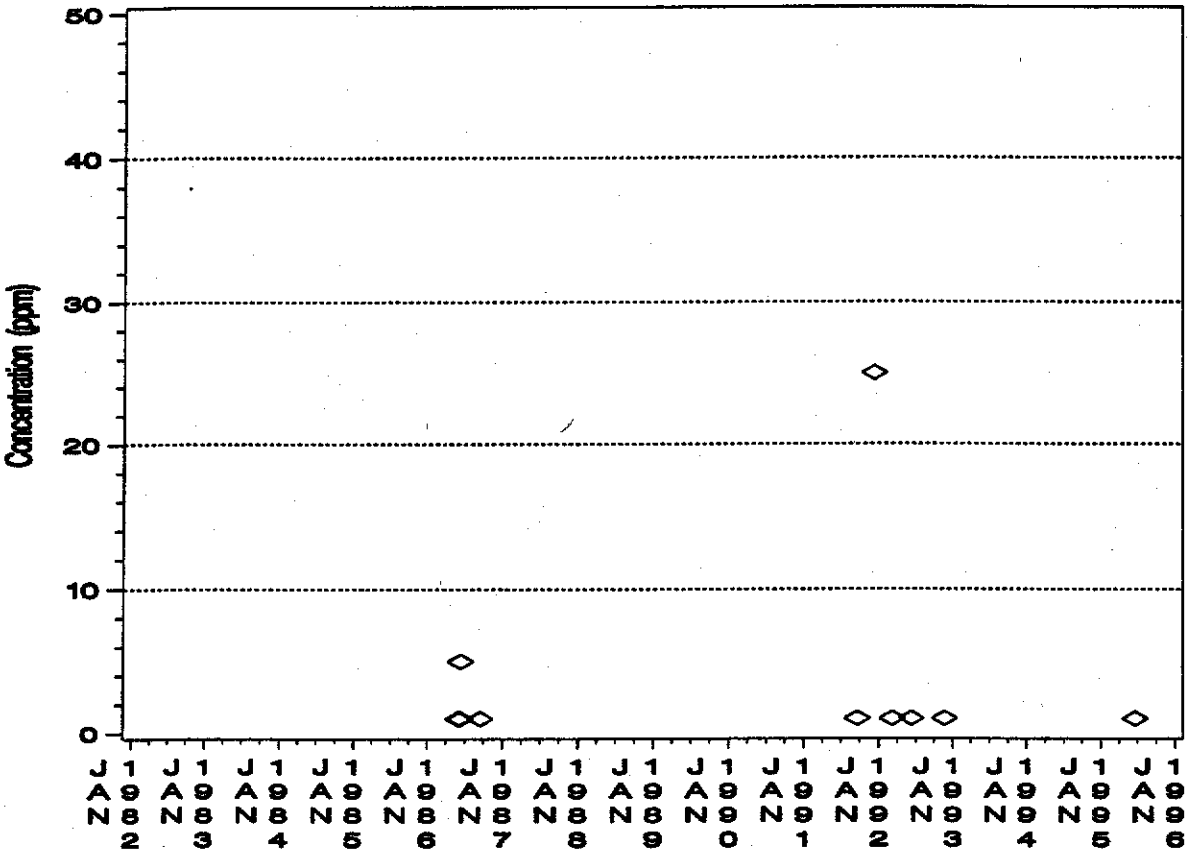
PERCHLORATE Trend



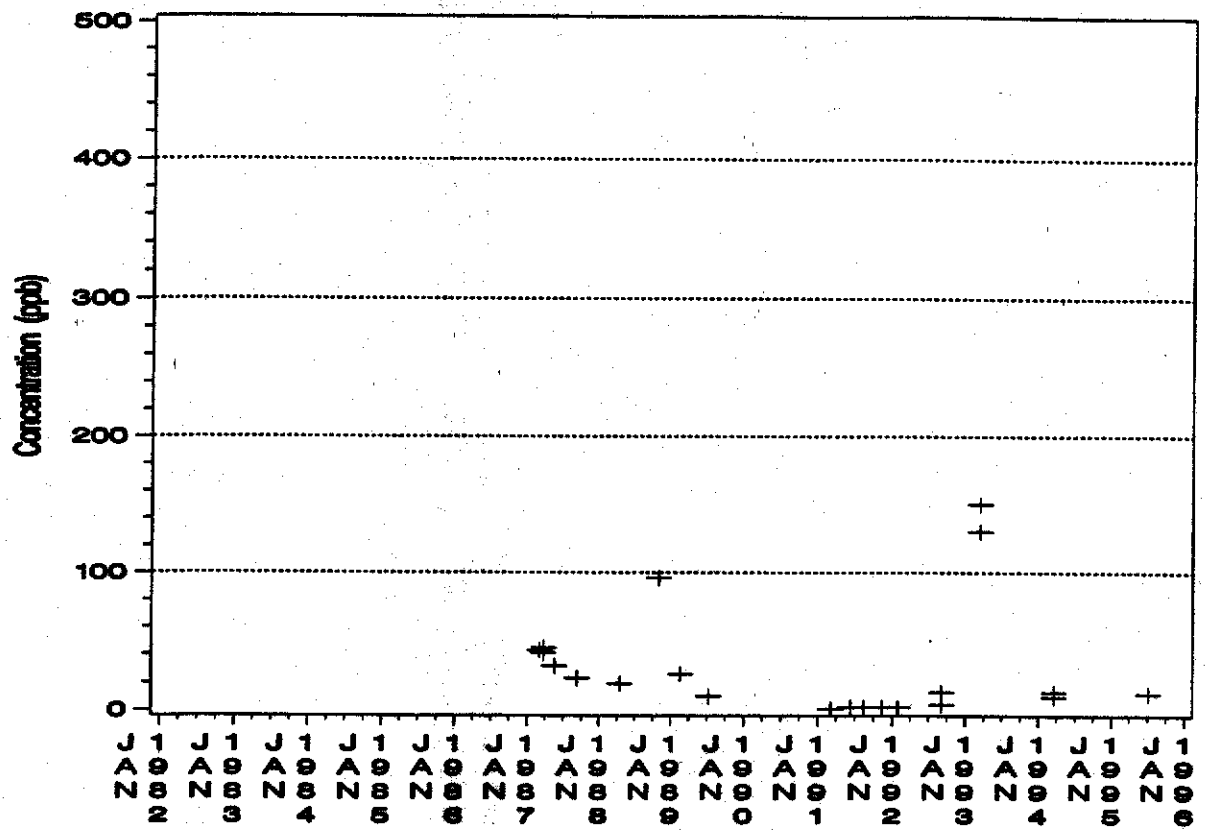
WELL 3053
CHLOROFORM Trend



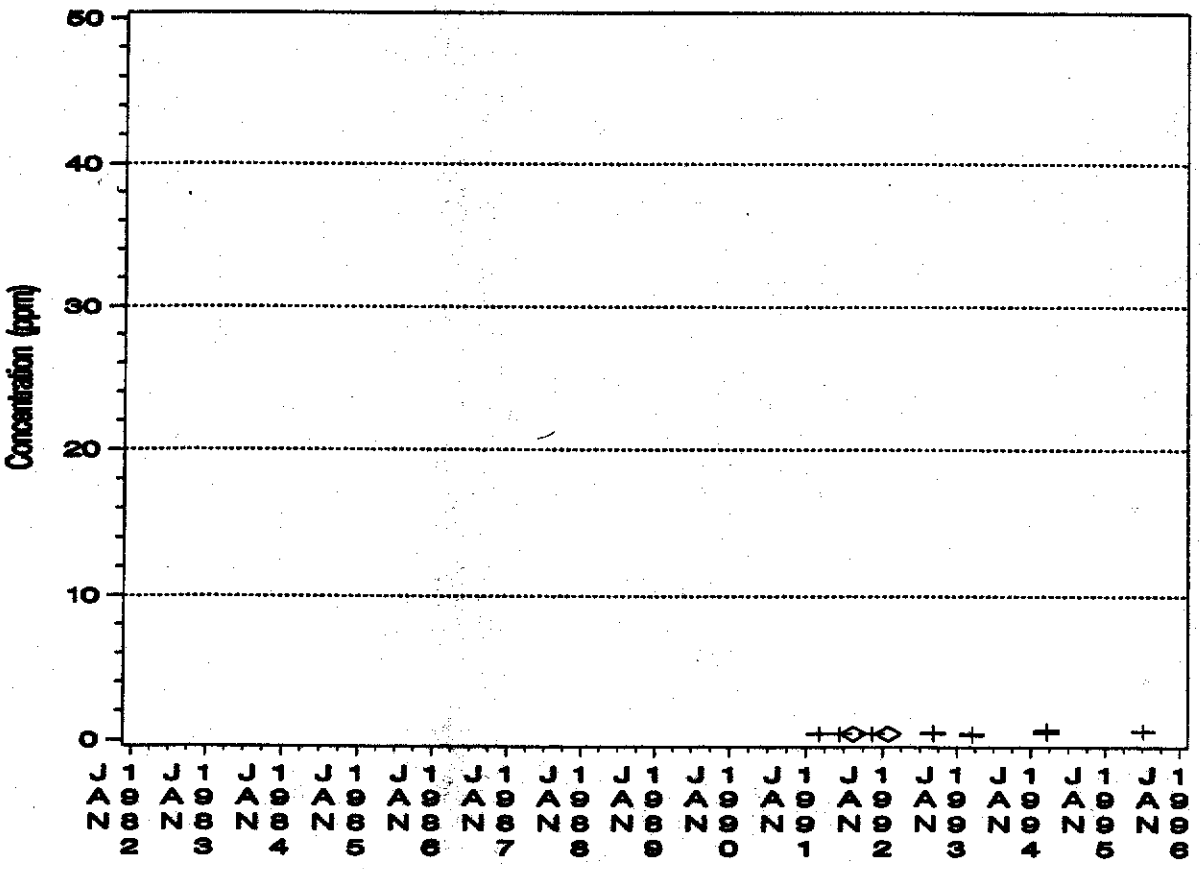
1,2 – DICHLOROETHANE Trend



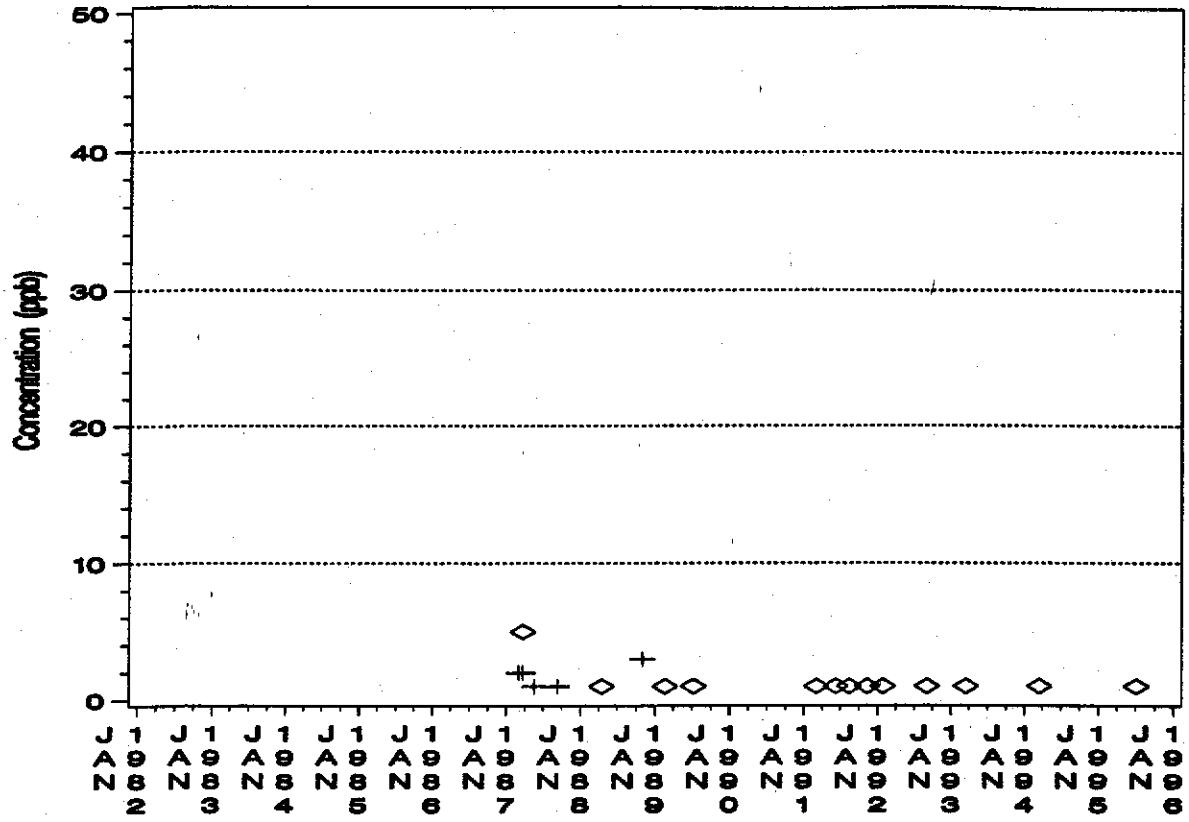
WELL 3115
TRICHLOROETHYLENE Trend



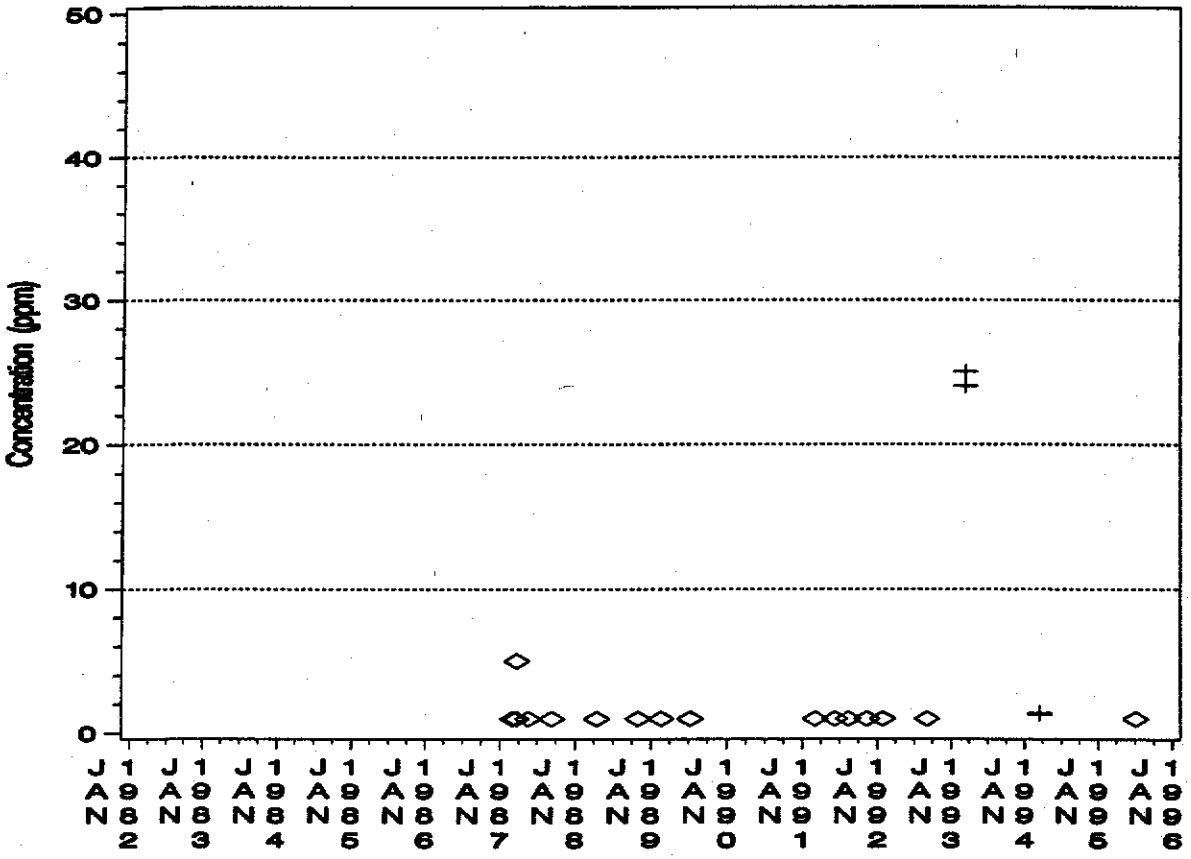
PERCHLORATE Trend



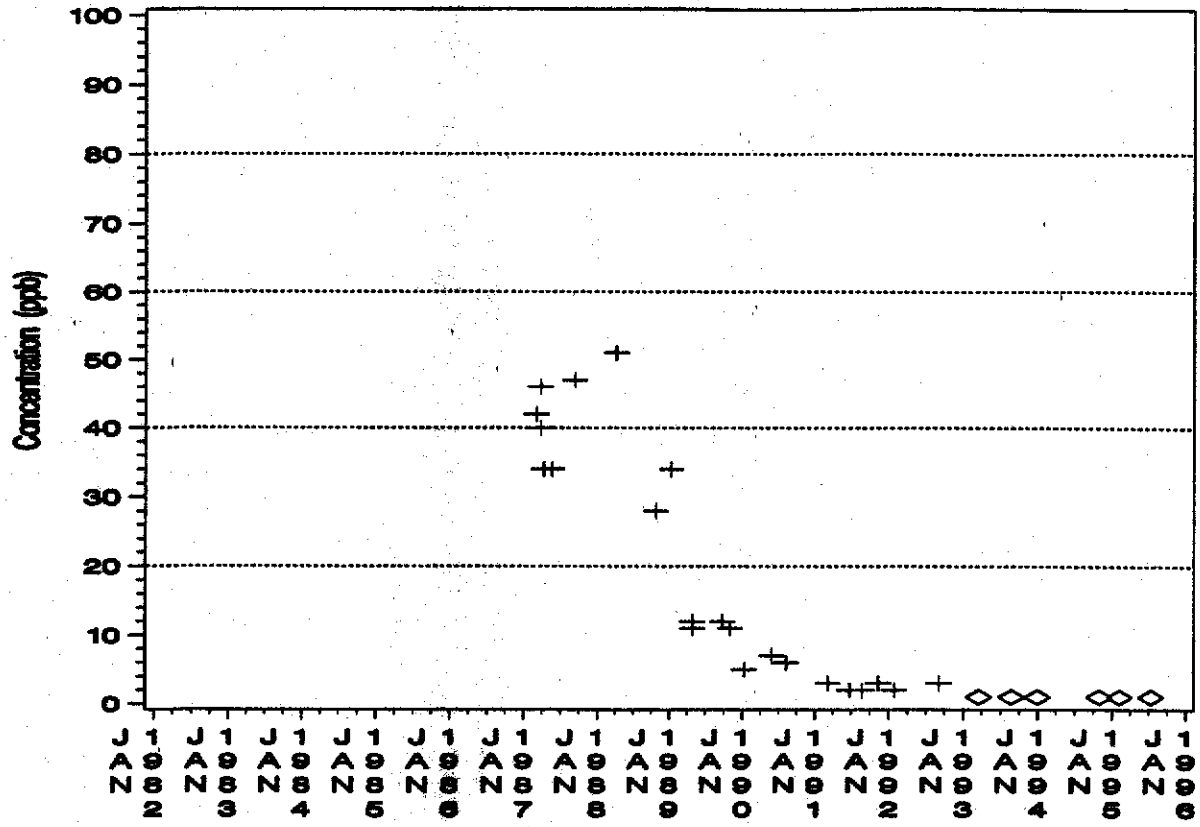
WELL 3115
CHLOROFORM Trend



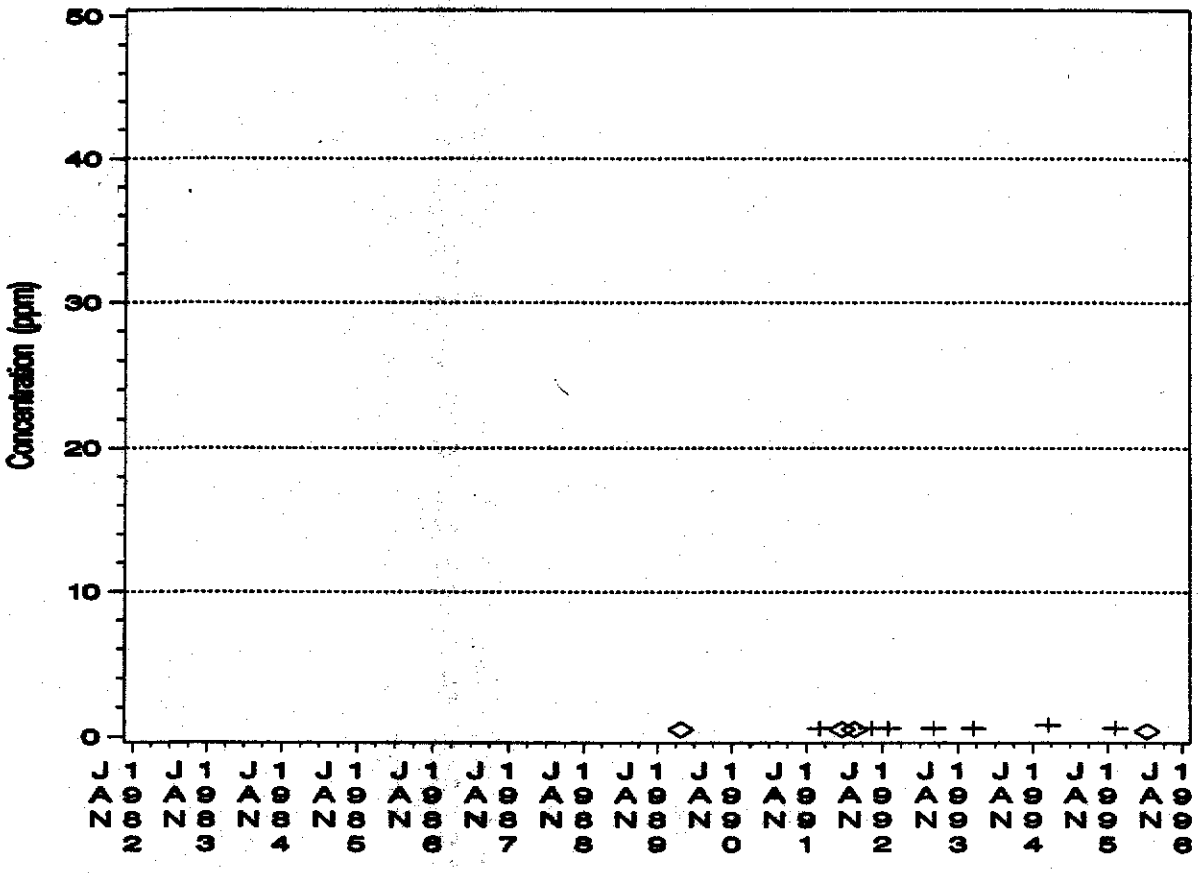
1,2 – DICHLOROETHANE Trend



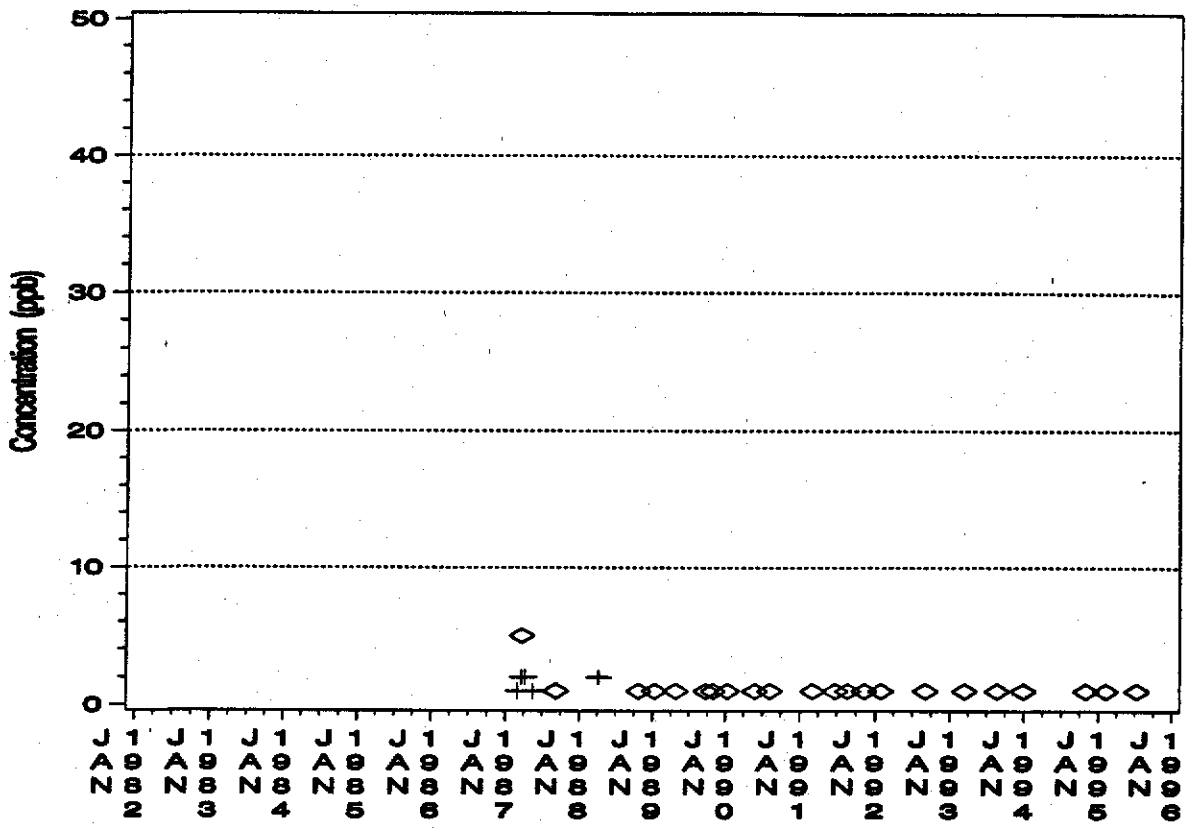
WELL 3116
TRICHLOROETHYLENE Trend



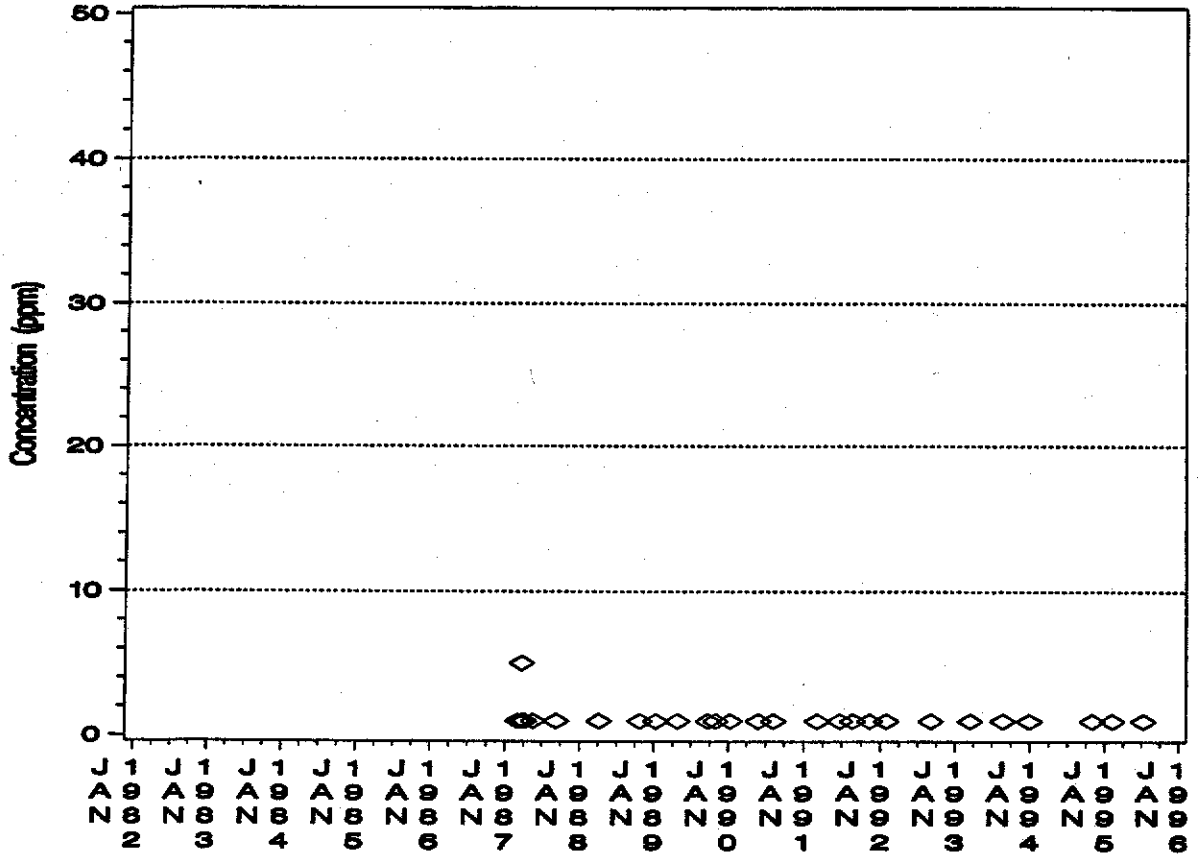
PERCHLORATE Trend



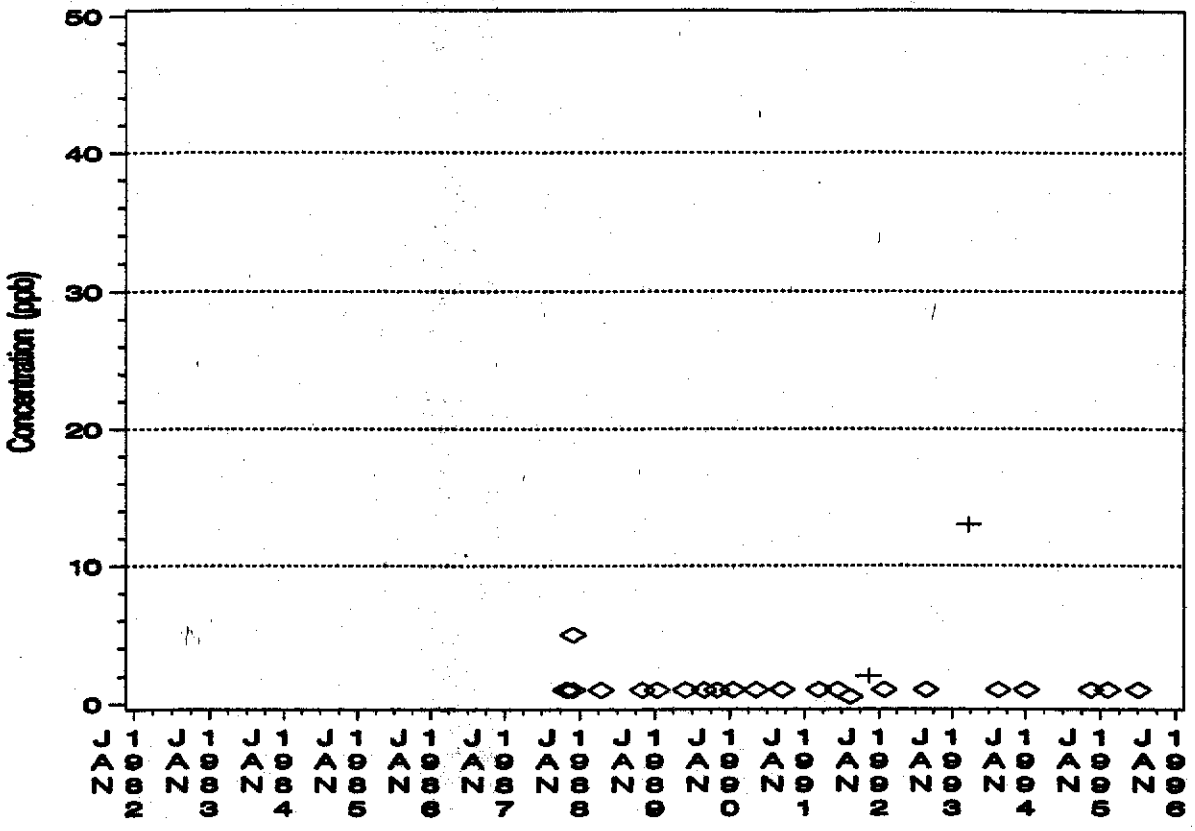
WELL 3116
CHLOROFORM Trend



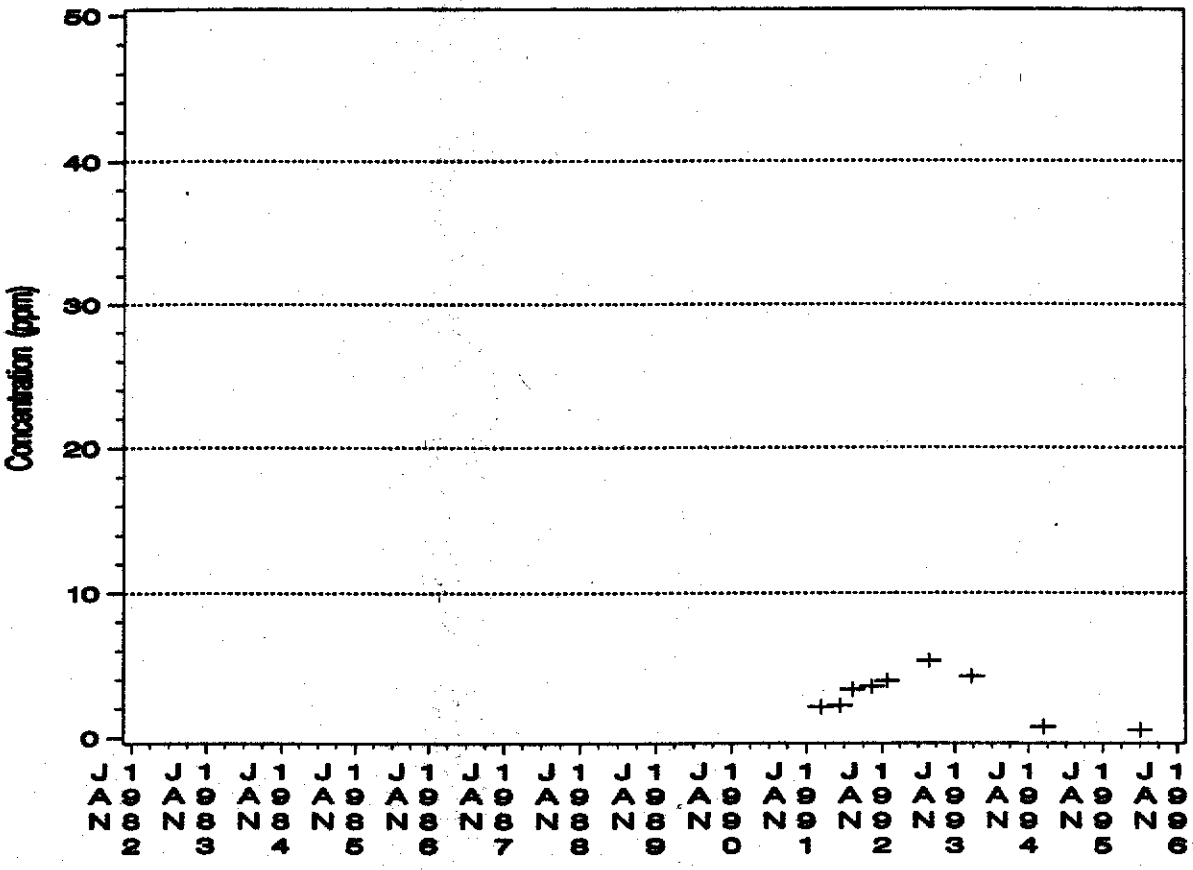
1,2 – DICHLOROETHANE Trend



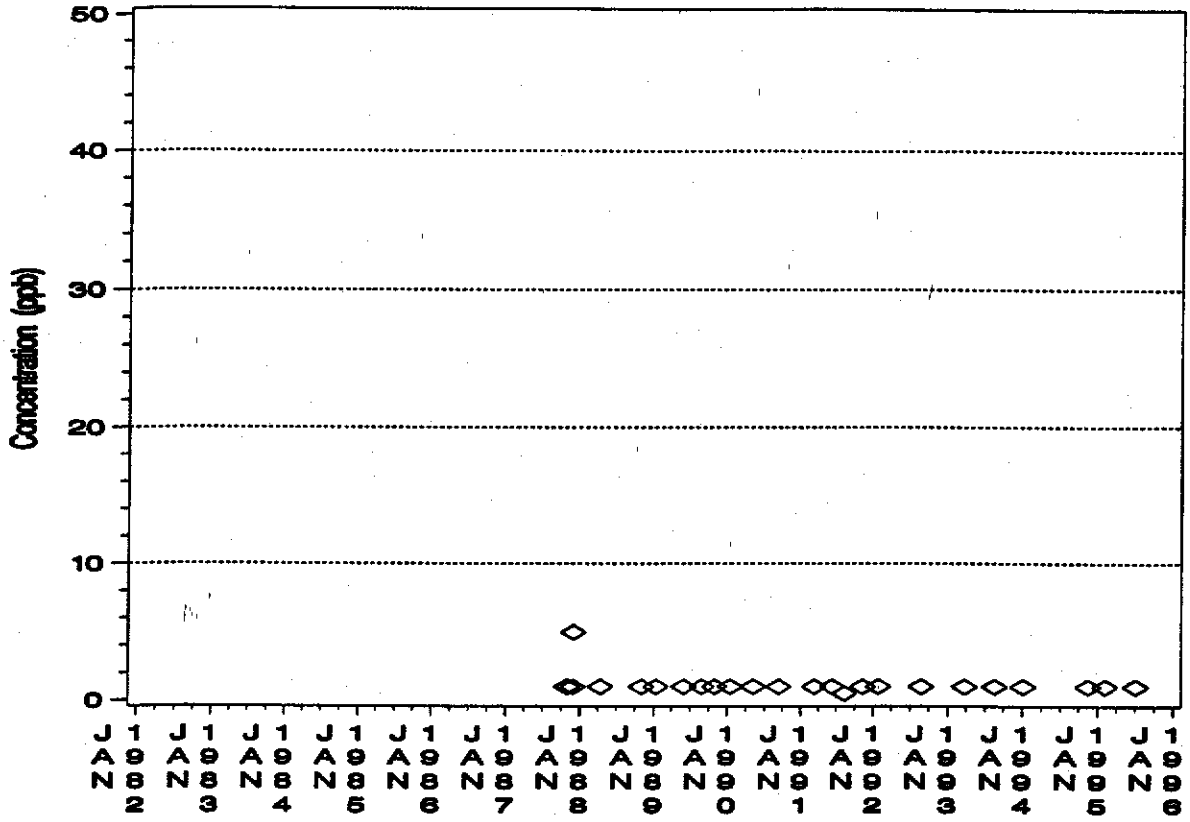
WELL 3139
TRICHLOROETHYLENE Trend



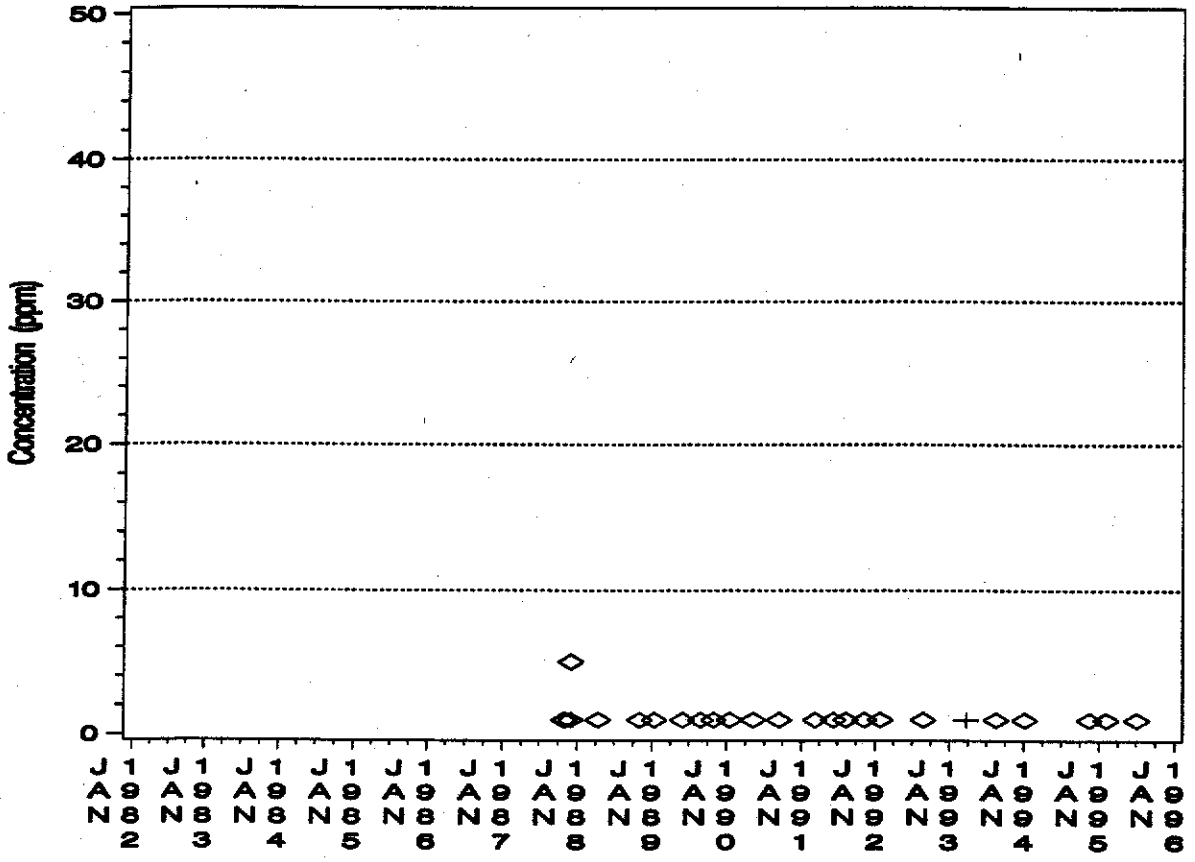
PERCHLORATE Trend



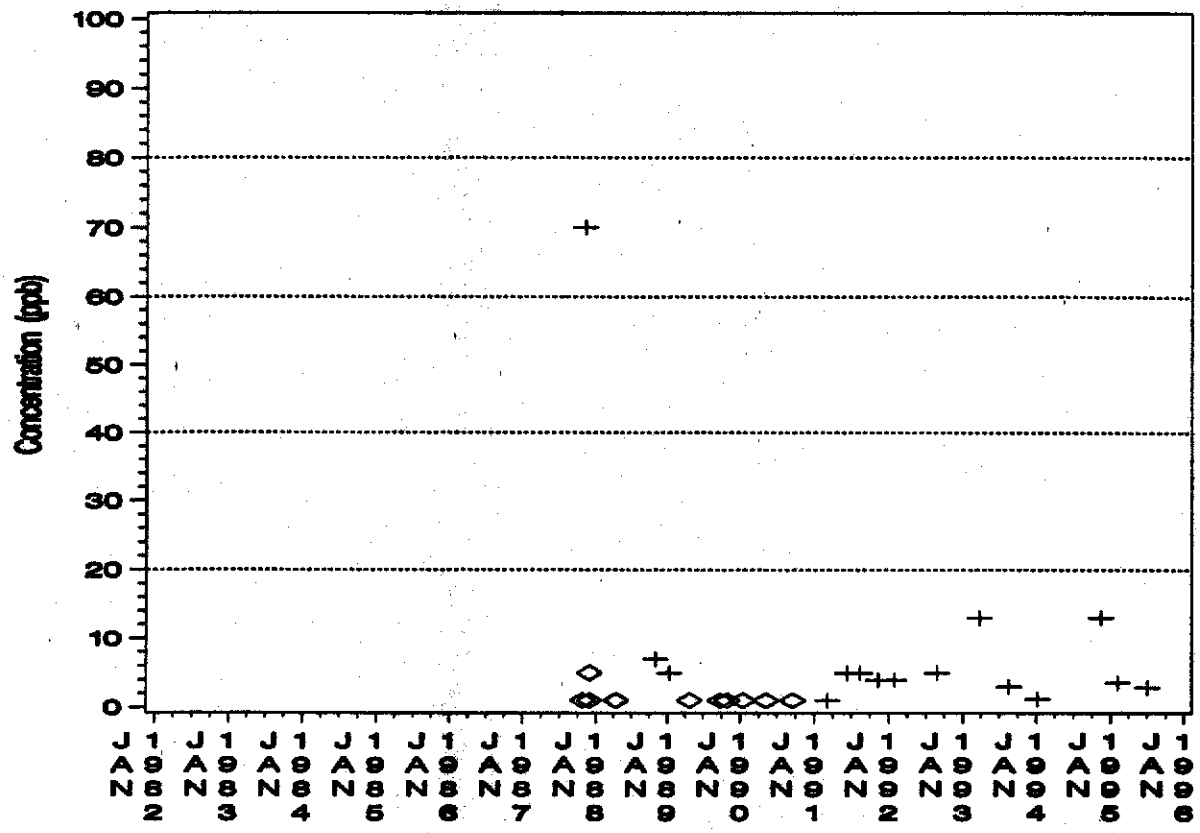
WELL 3139
CHLOROFORM Trend



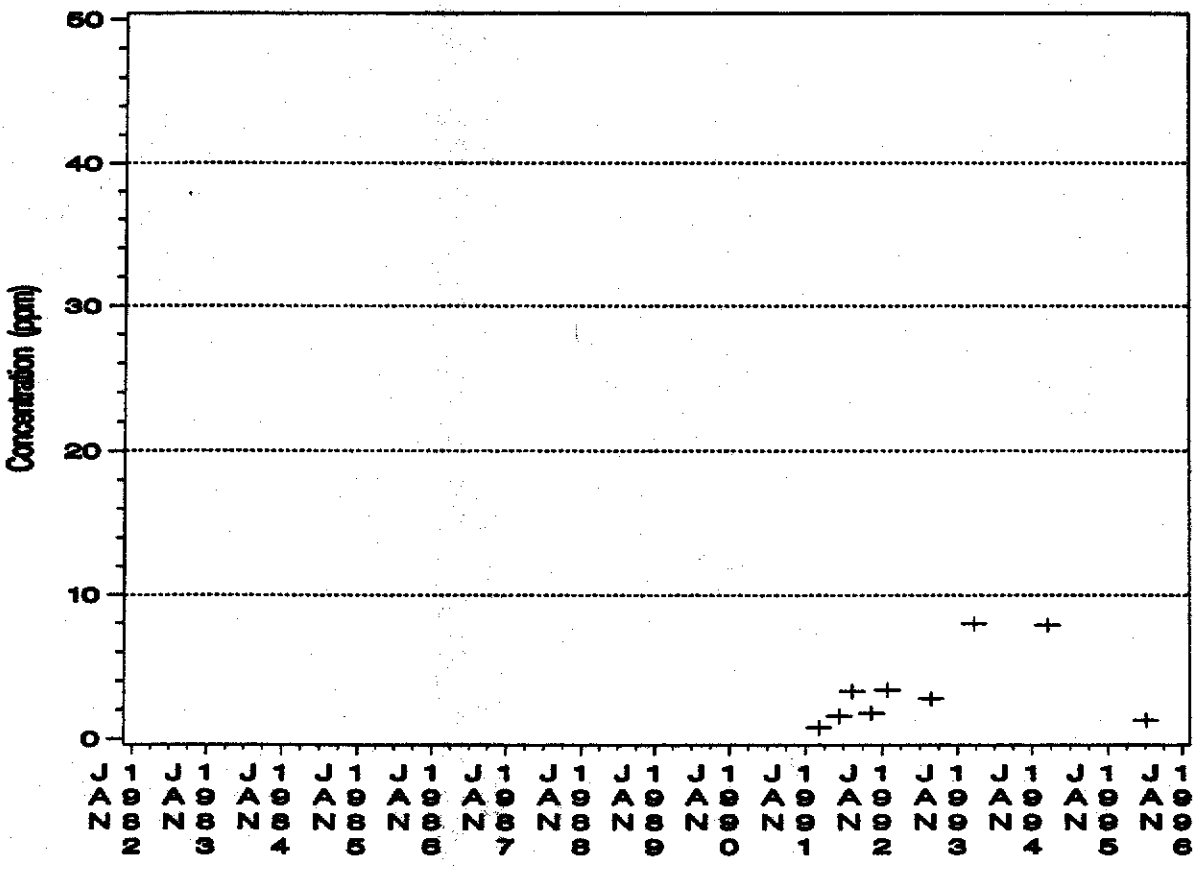
1,2 — DICHLOROETHANE Trend



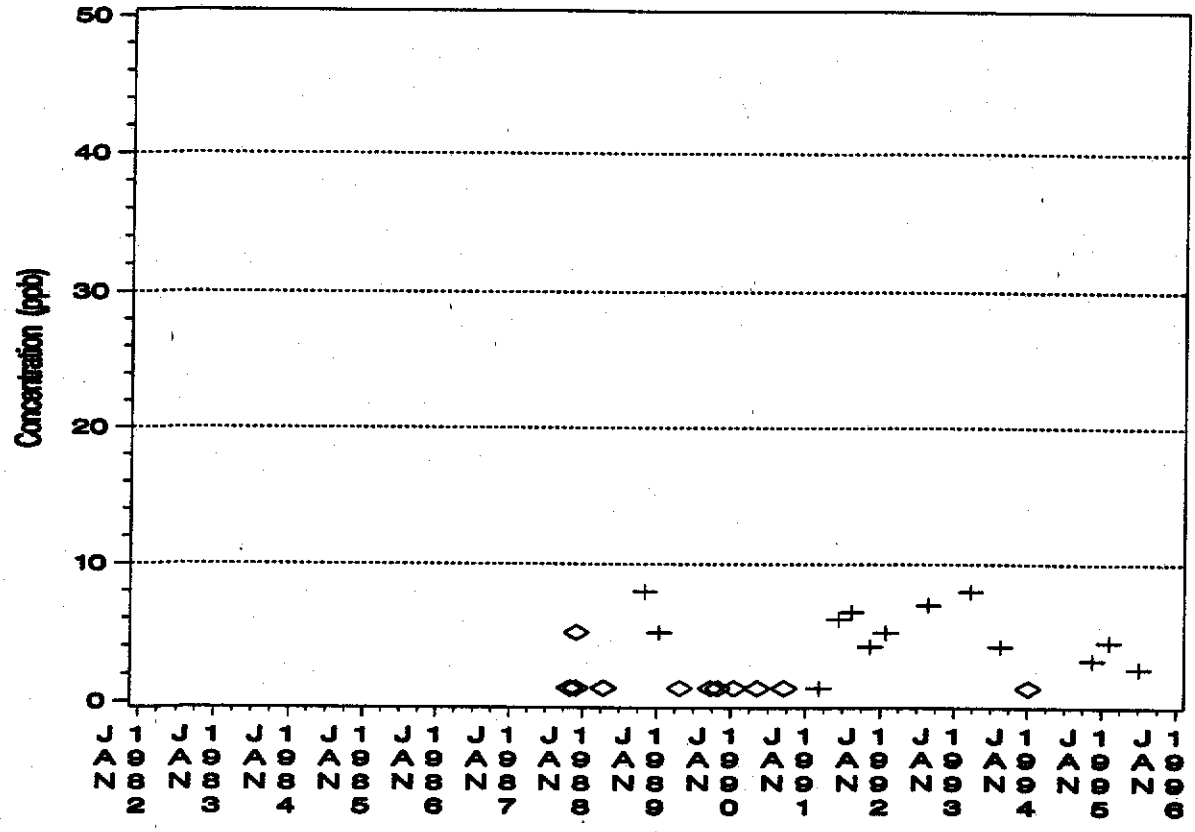
WELL 3140
TRICHLOROETHYLENE Trend



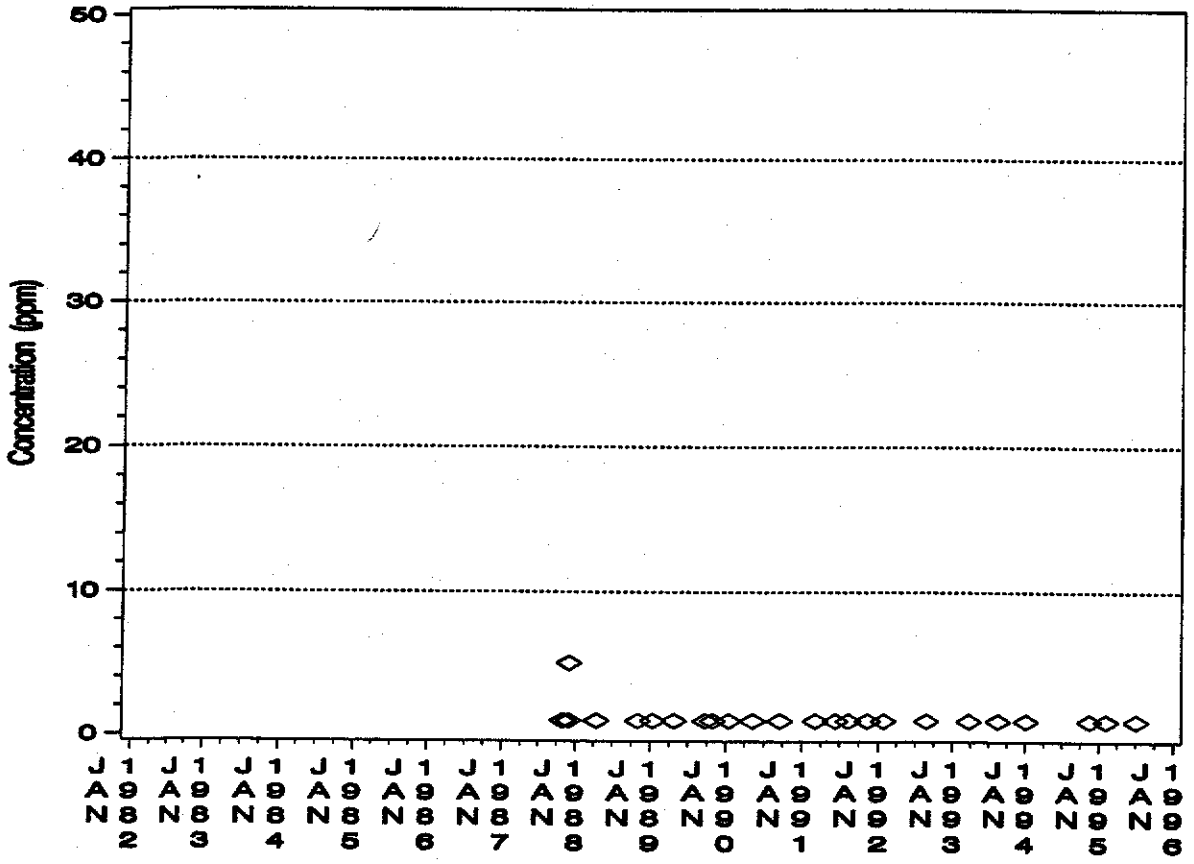
PERCHLORATE Trend



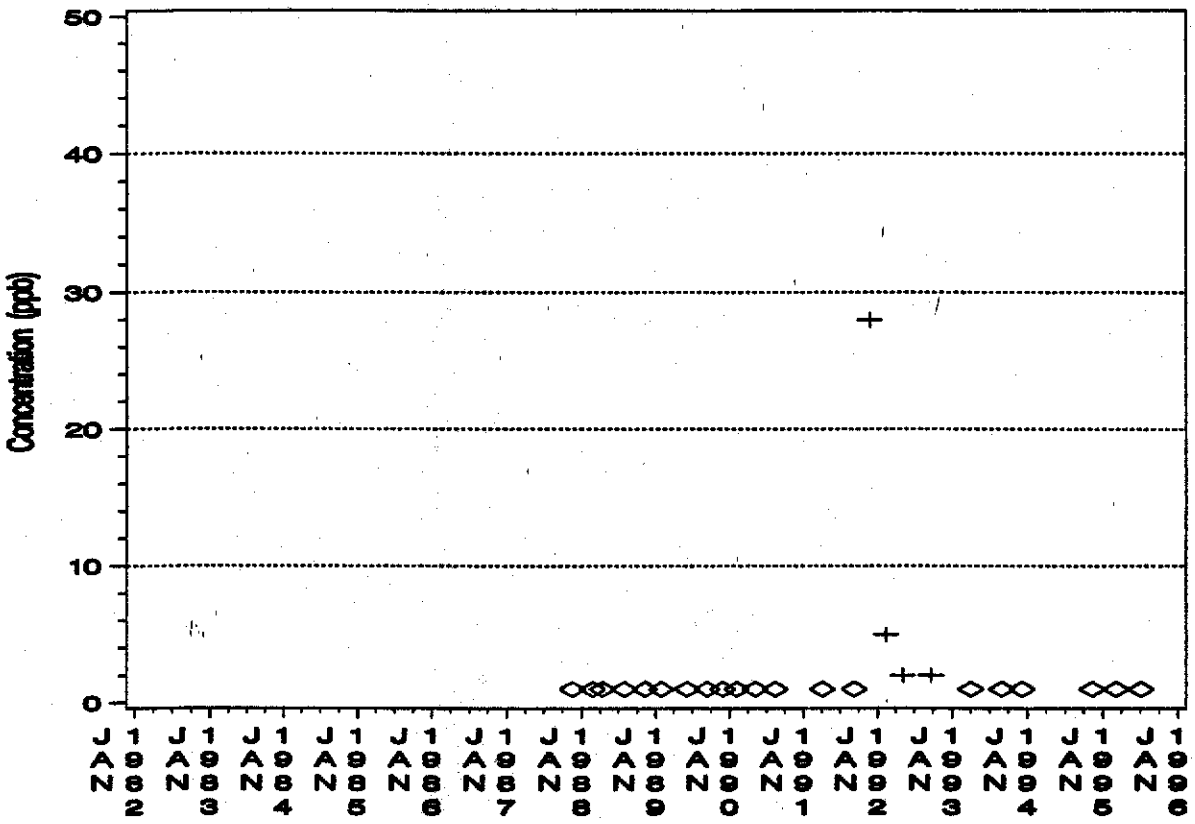
WELL 3140
CHLOROFORM Trend



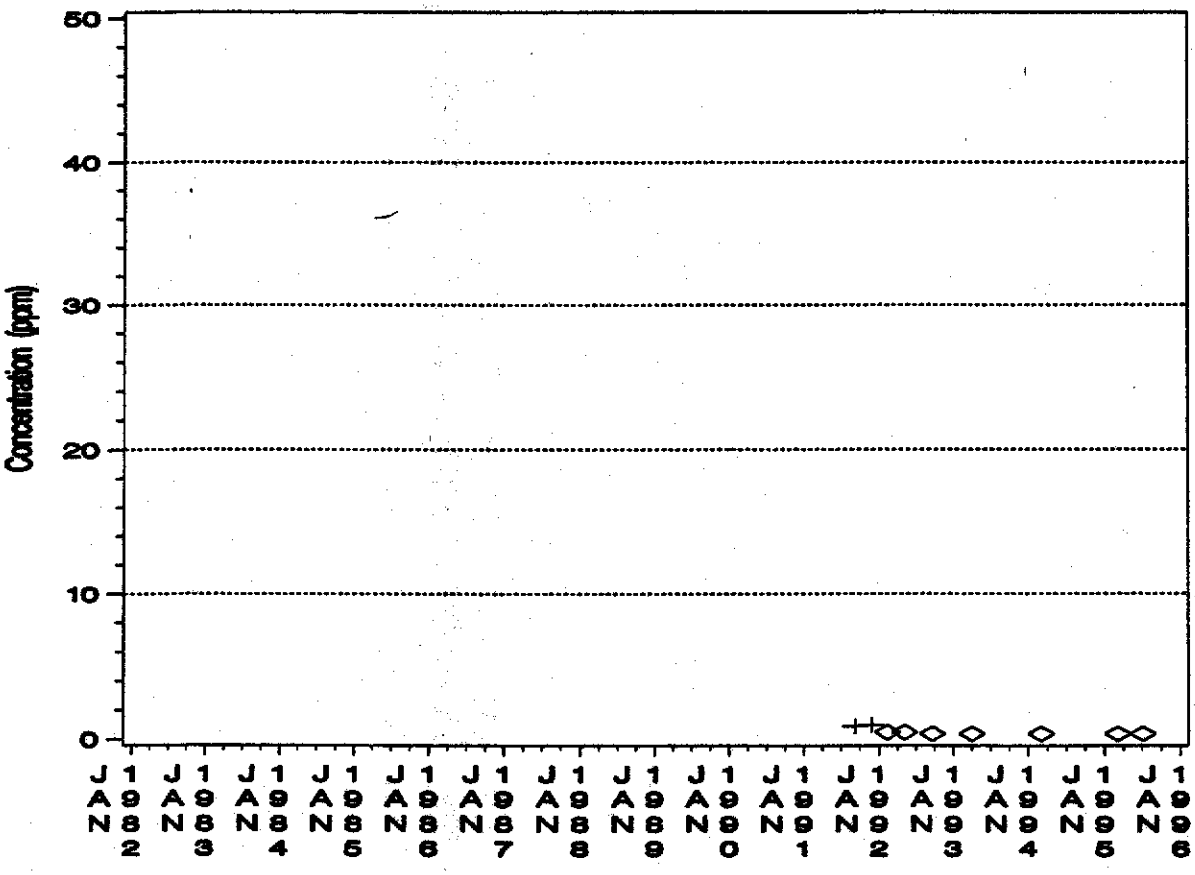
1,2 – DICHLOROETHANE Trend



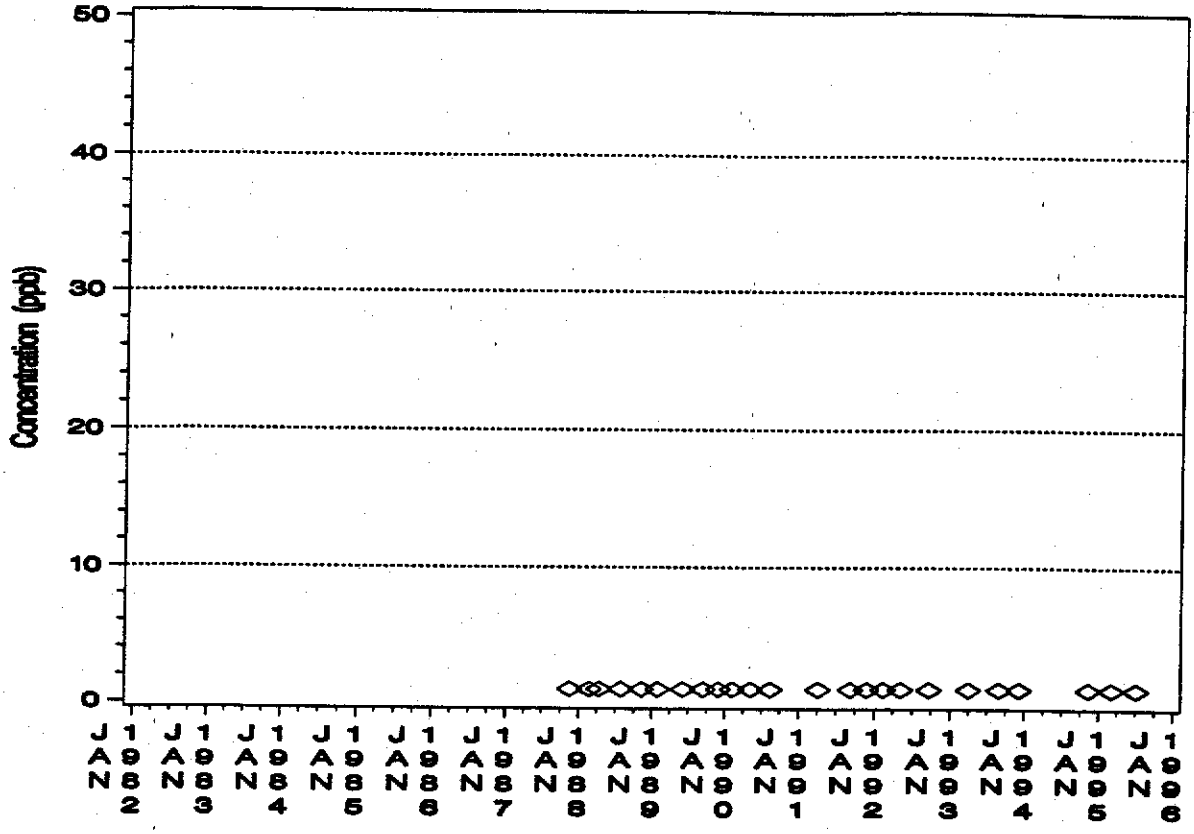
WELL 3145
TRICHLOROETHYLENE Trend



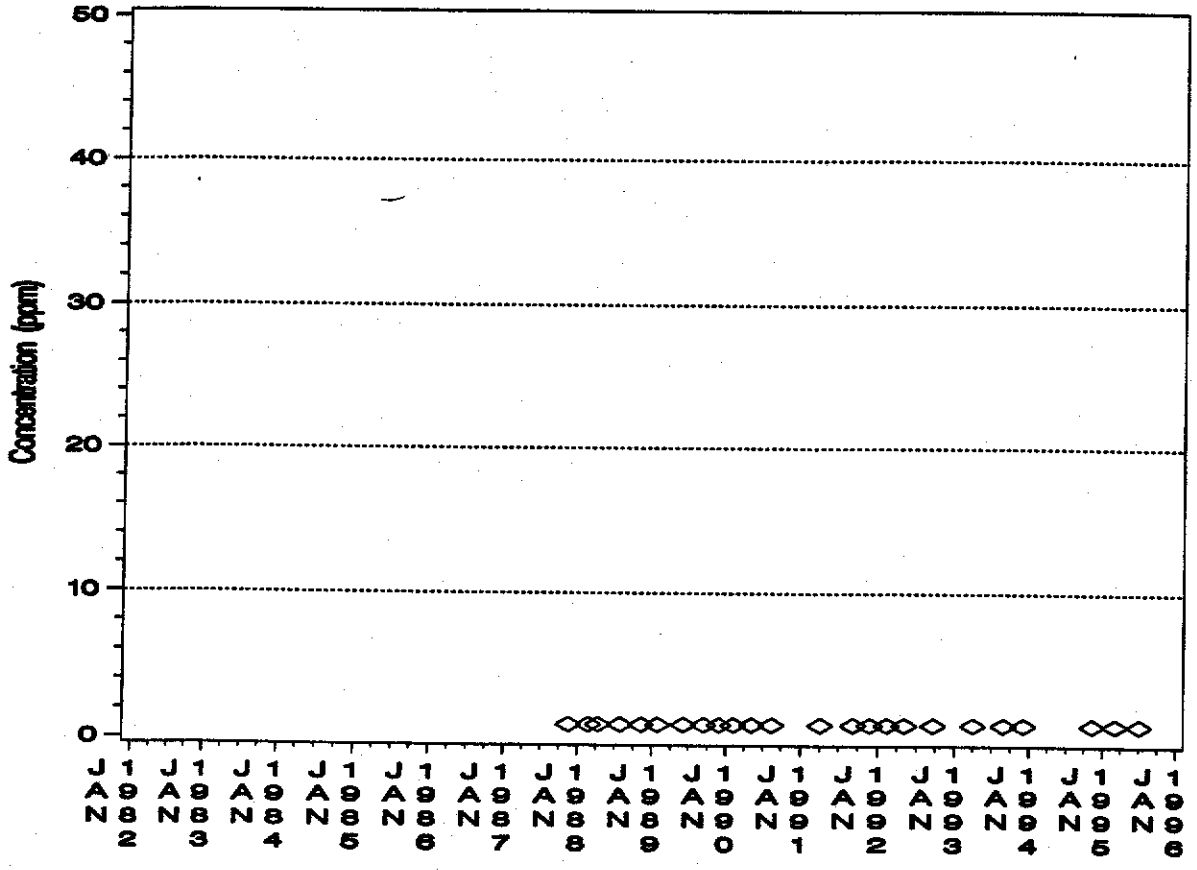
PERCHLORATE Trend



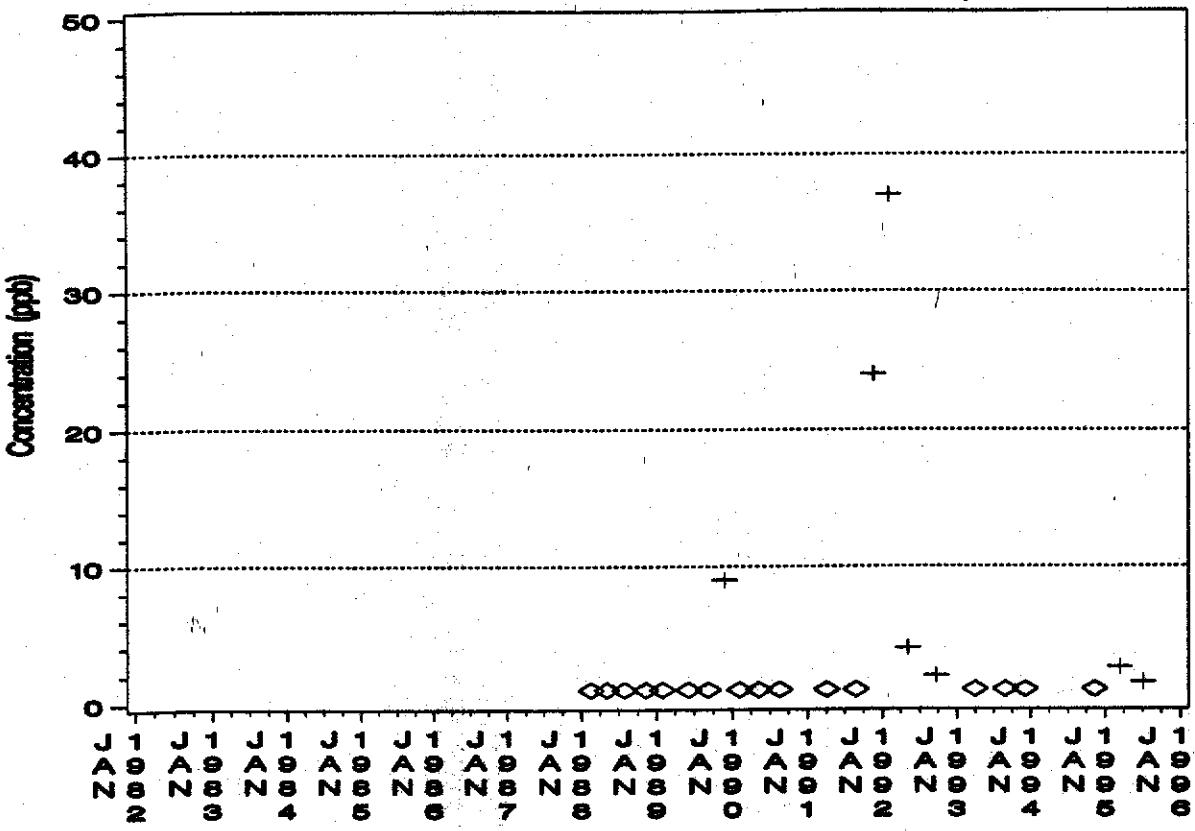
WELL 3145
CHLOROFORM Trend



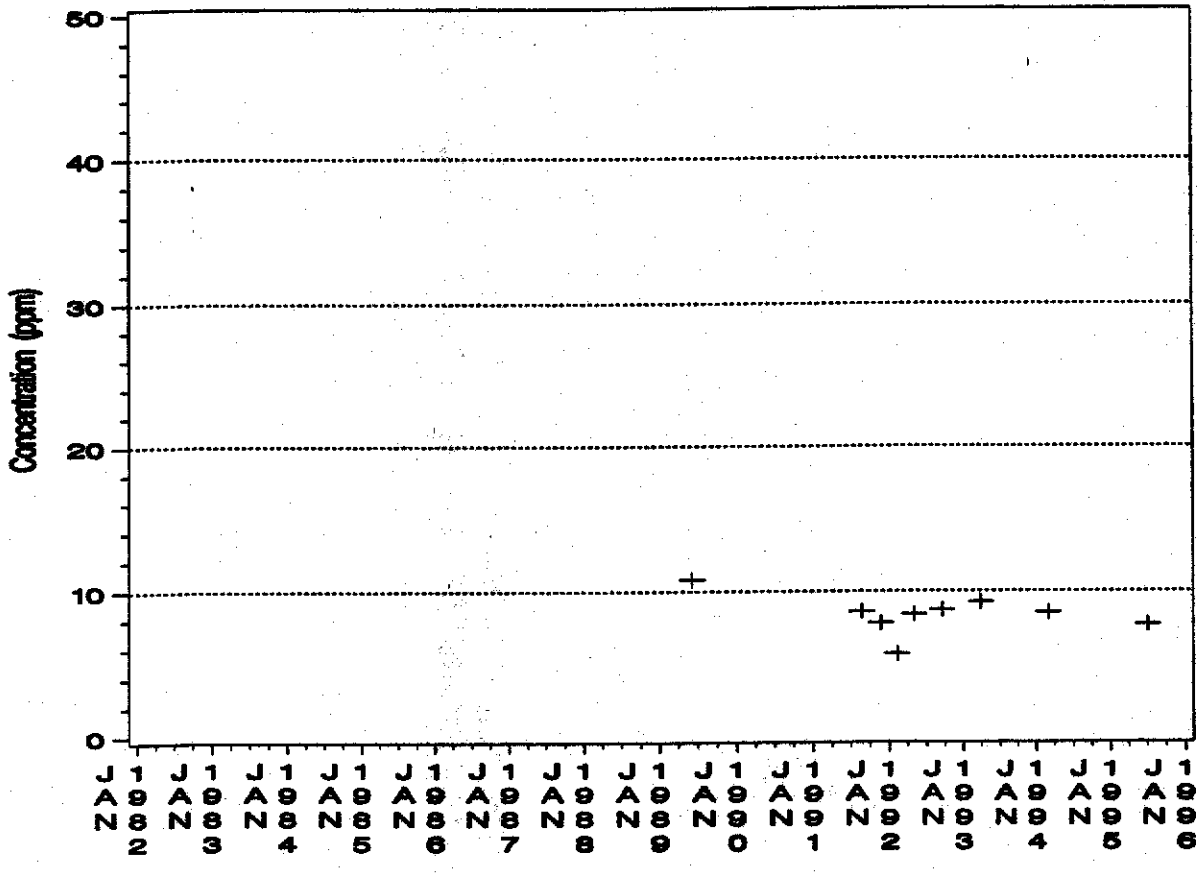
1,2 – DICHLOROETHANE Trend



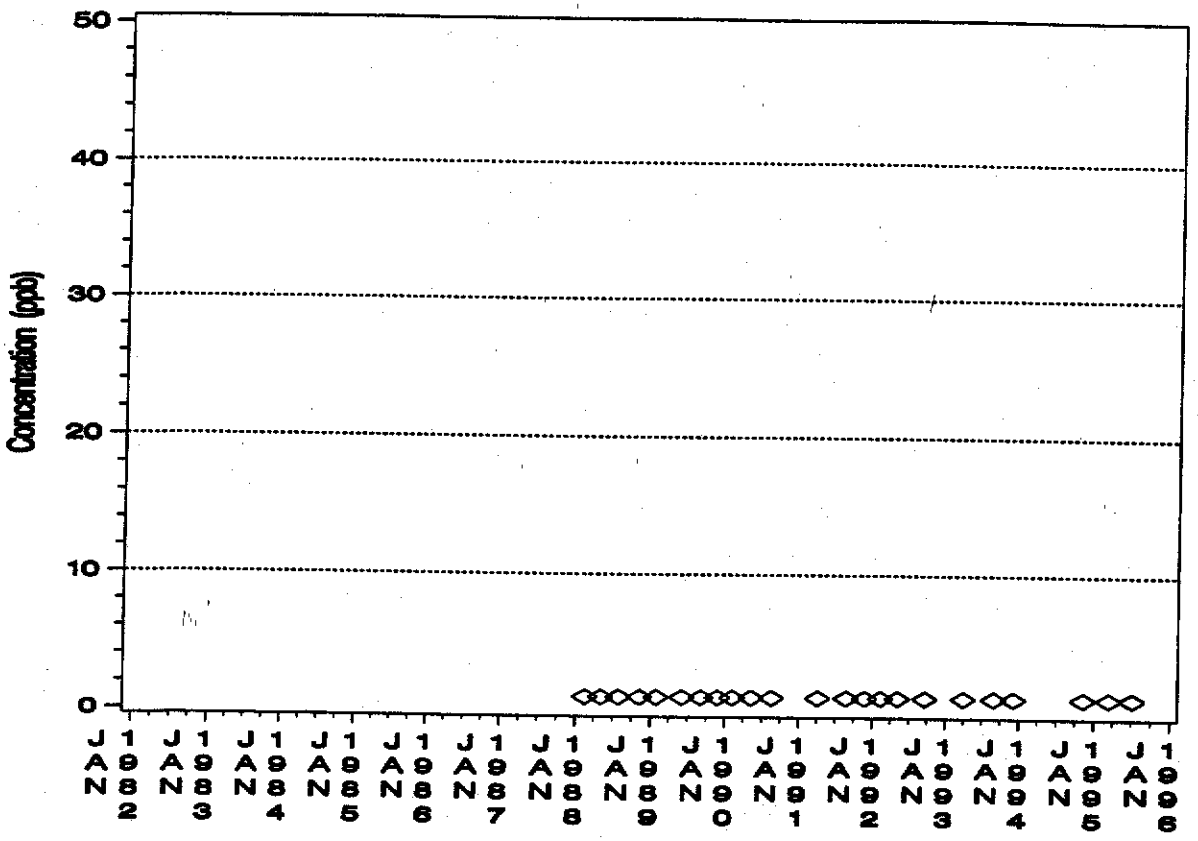
WELL 3146
TRICHLOROETHYLENE Trend



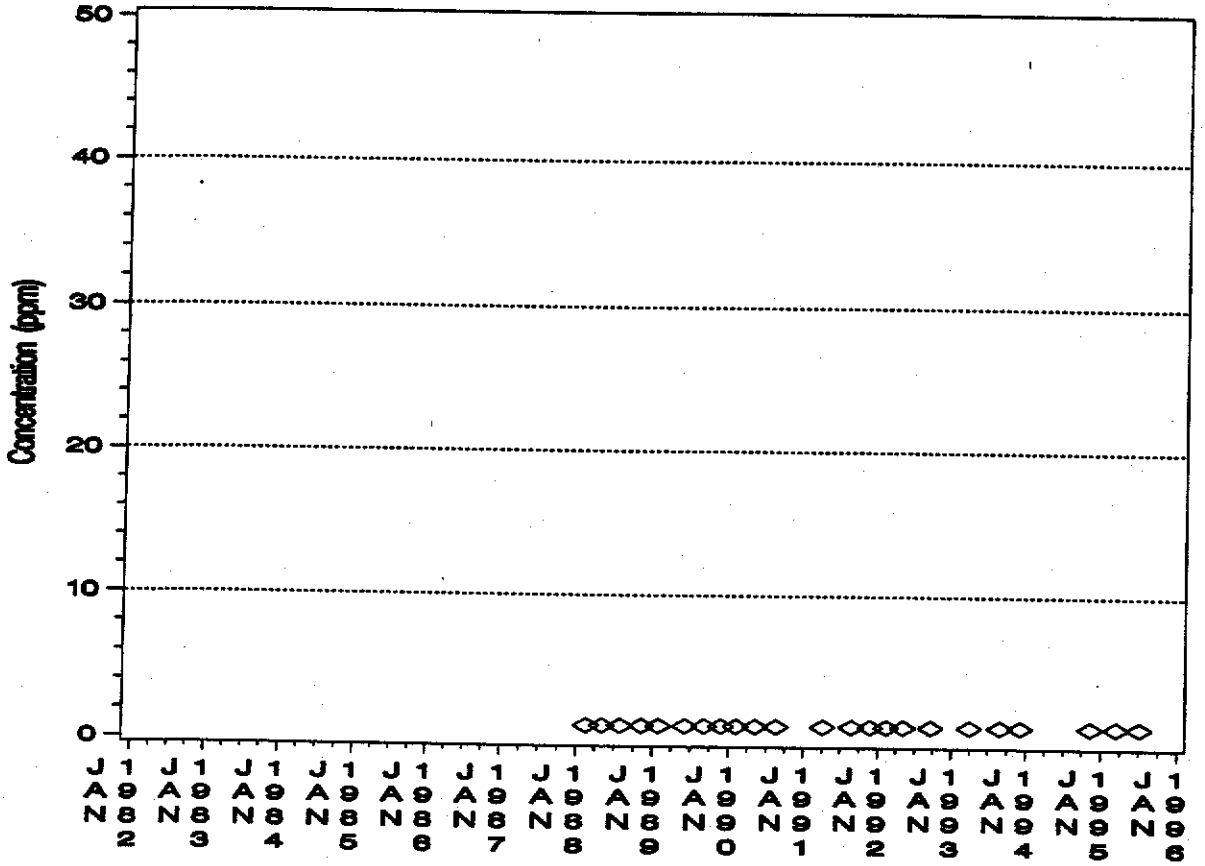
PERCHLORATE Trend



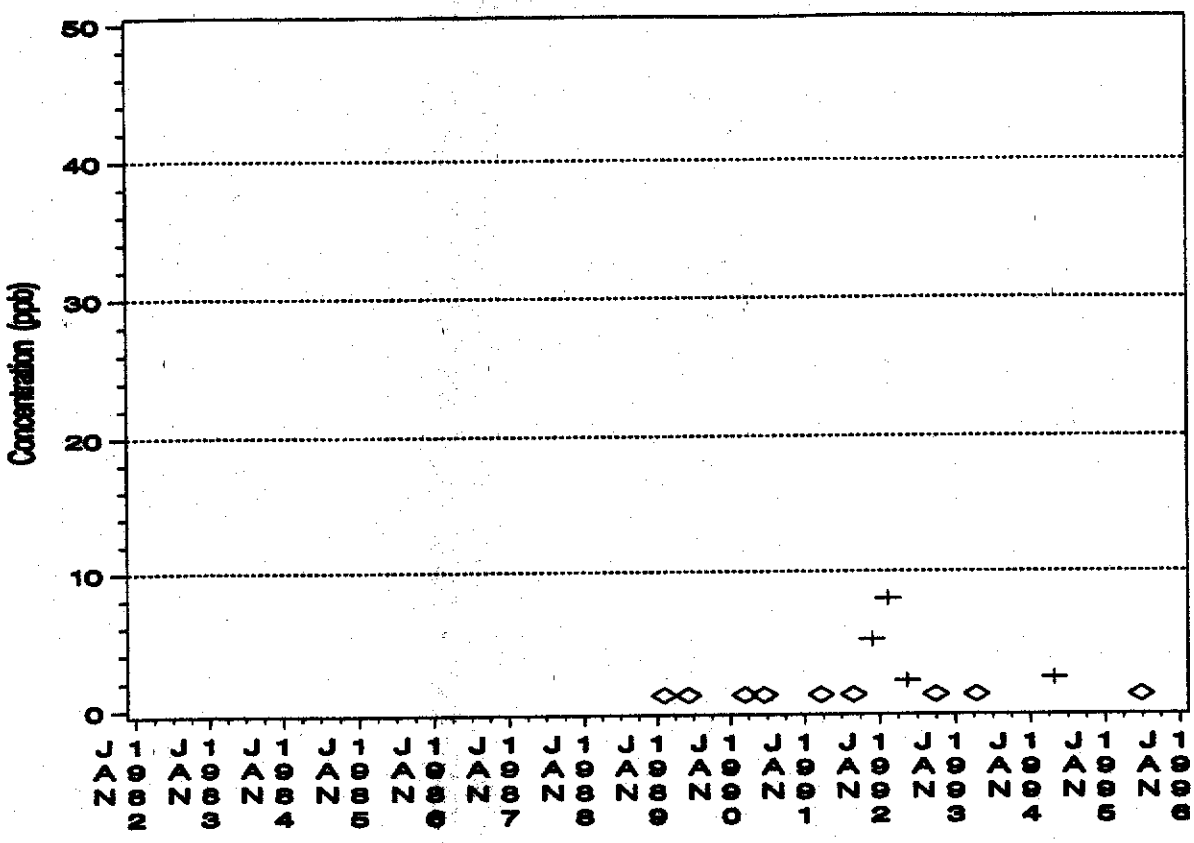
WELL 3146
CHLOROFORM Trend



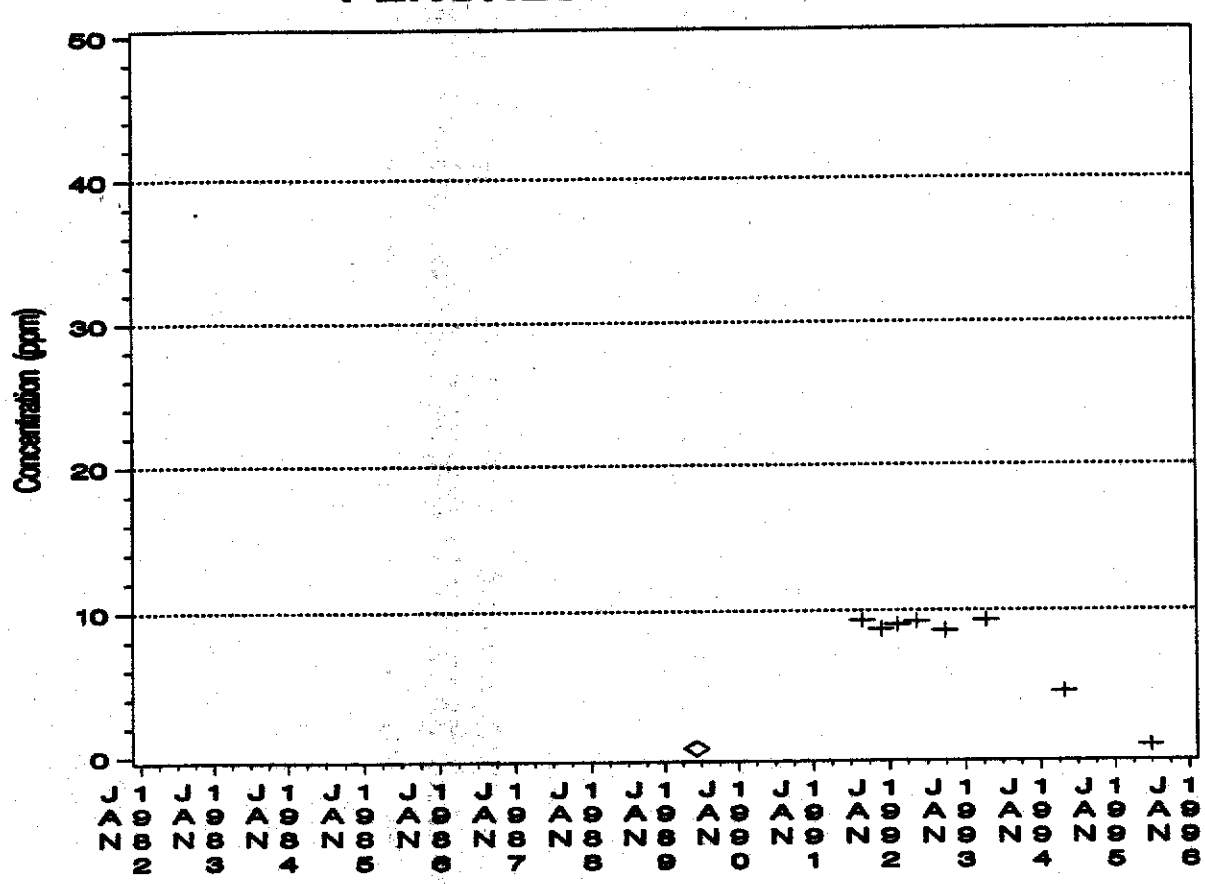
1,2 – DICHLOROETHANE Trend



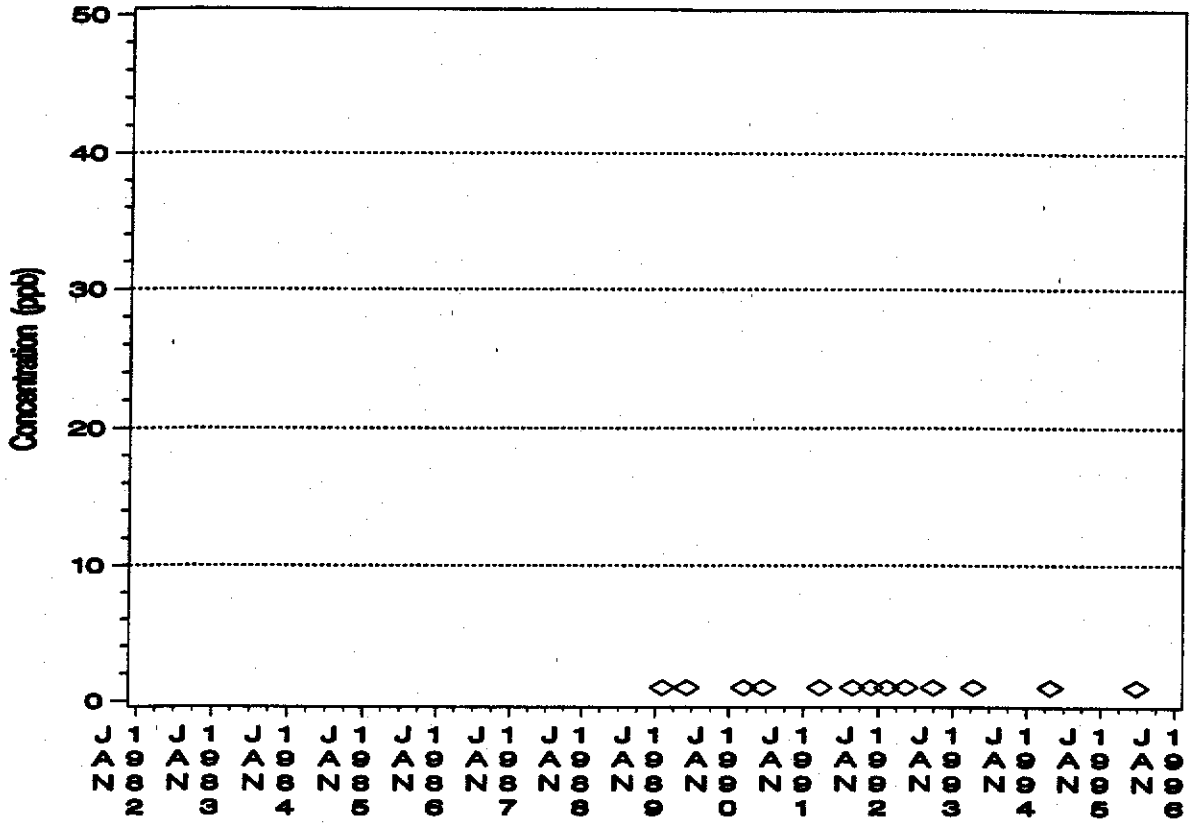
WELL 3204
TRICHLOROETHYLENE Trend



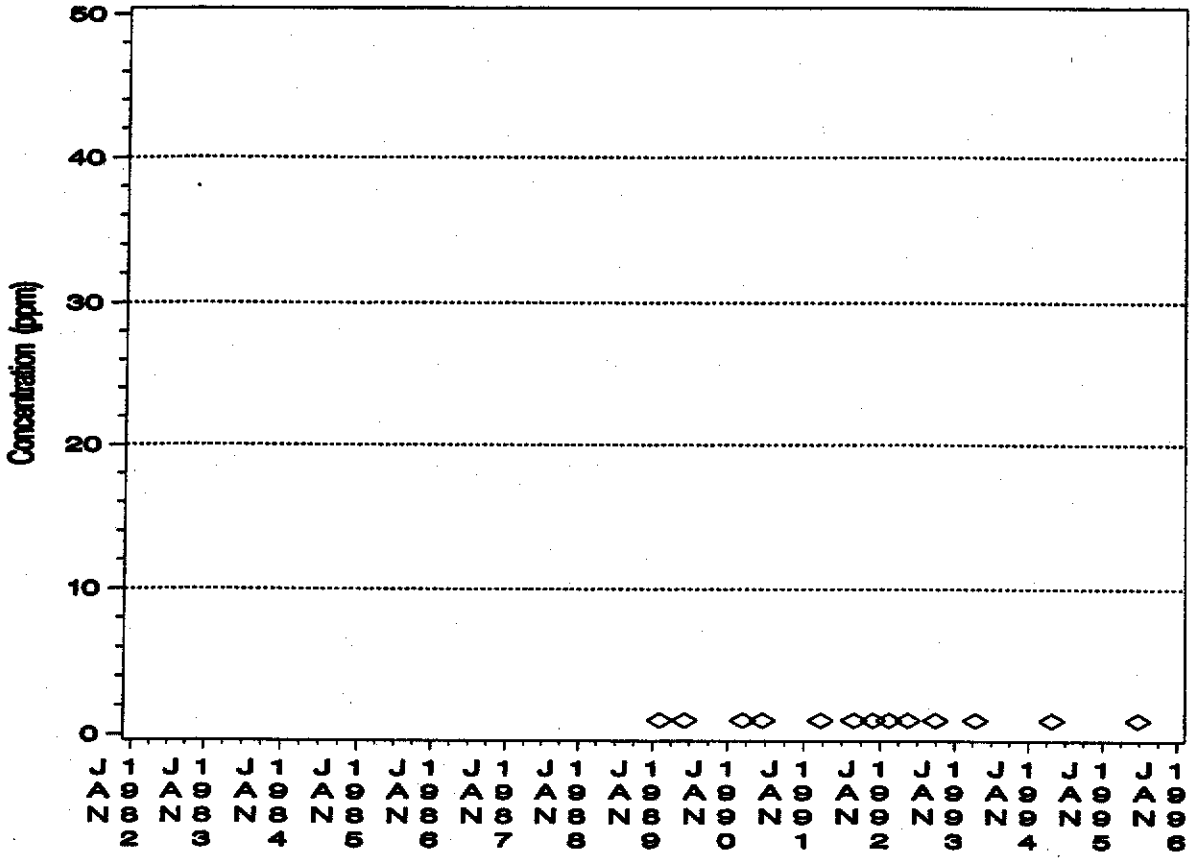
PERCHLORATE Trend



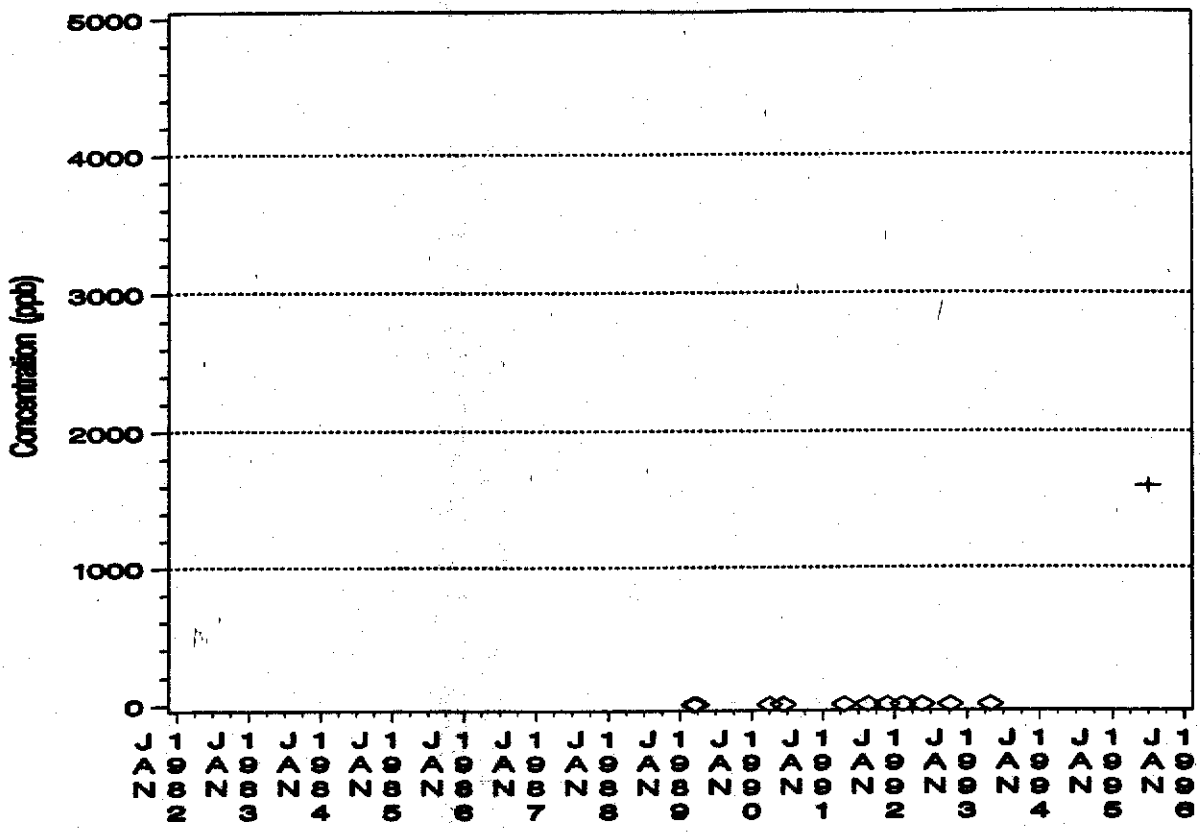
WELL 3204
CHLOROFORM Trend



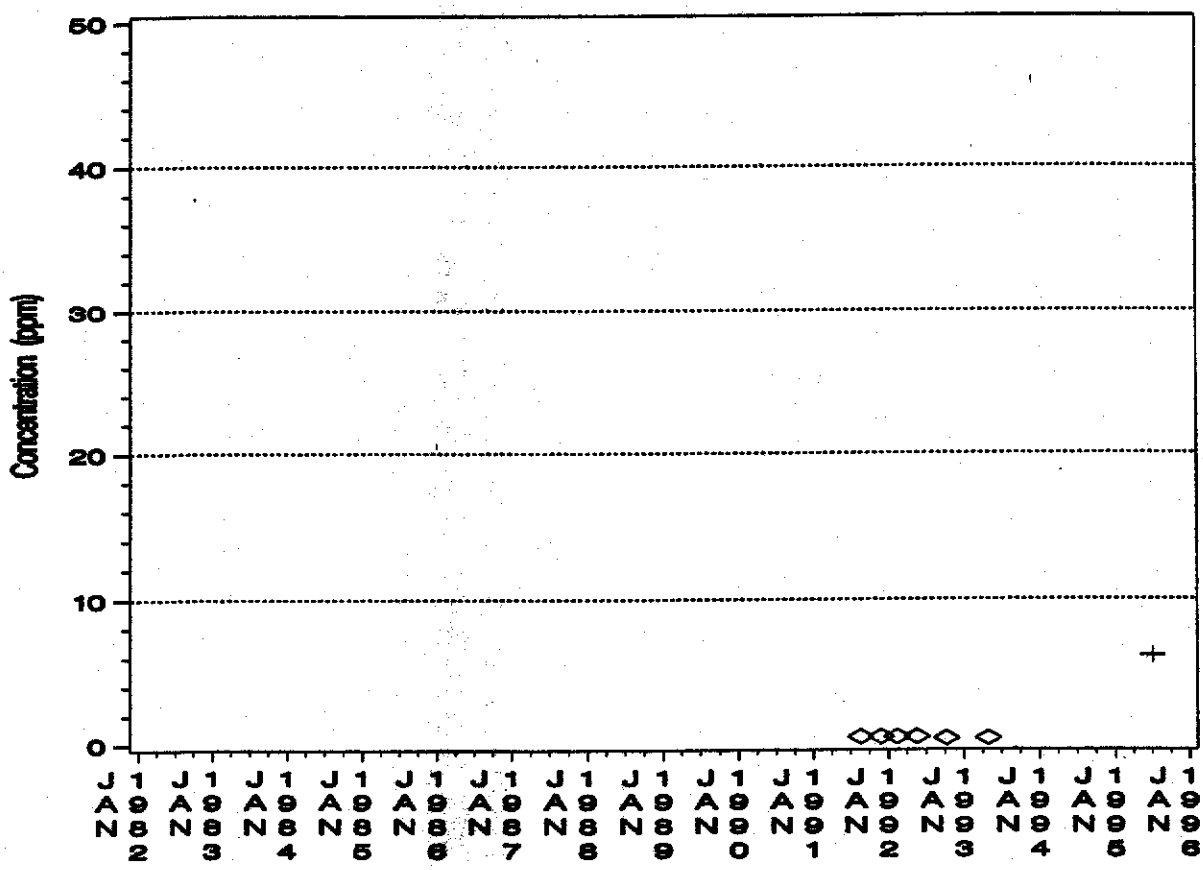
1,2 – DICHLOROETHANE Trend



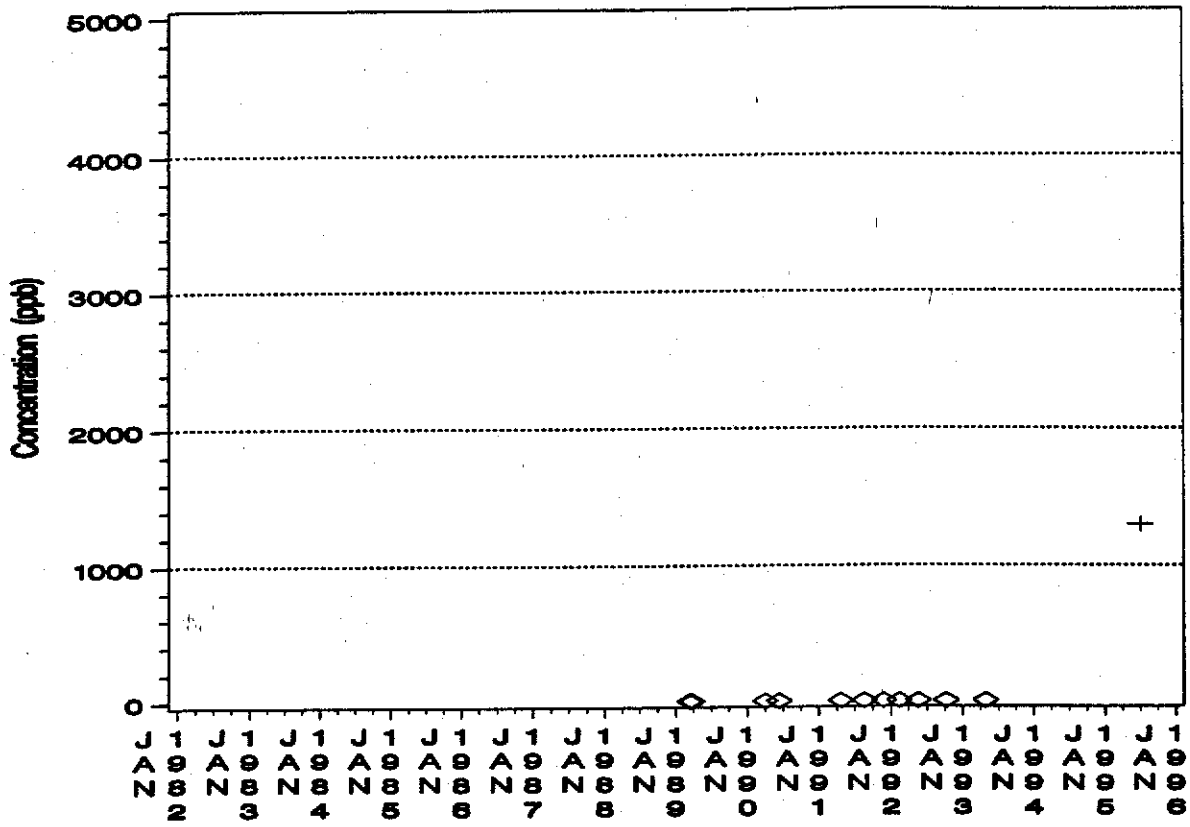
WELL 3226
TRICHLOROETHYLENE Trend



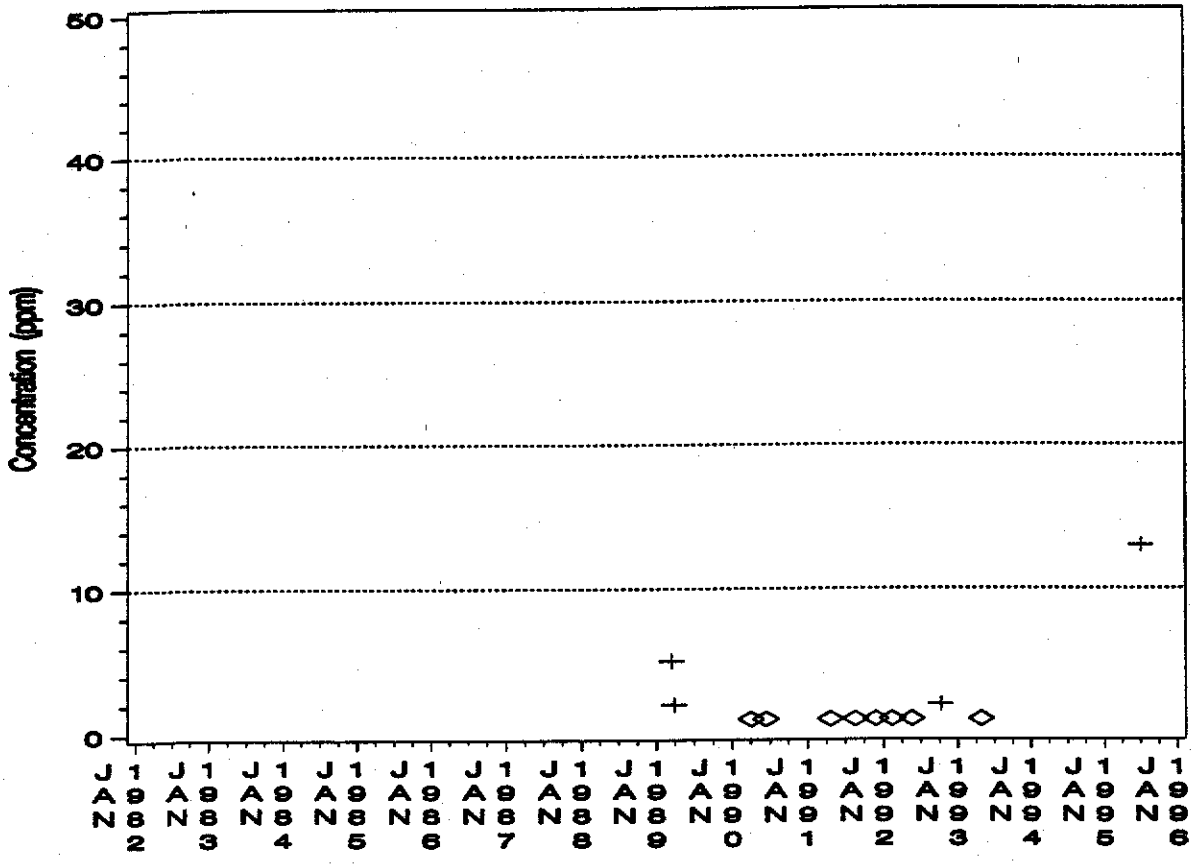
PERCHLORATE Trend



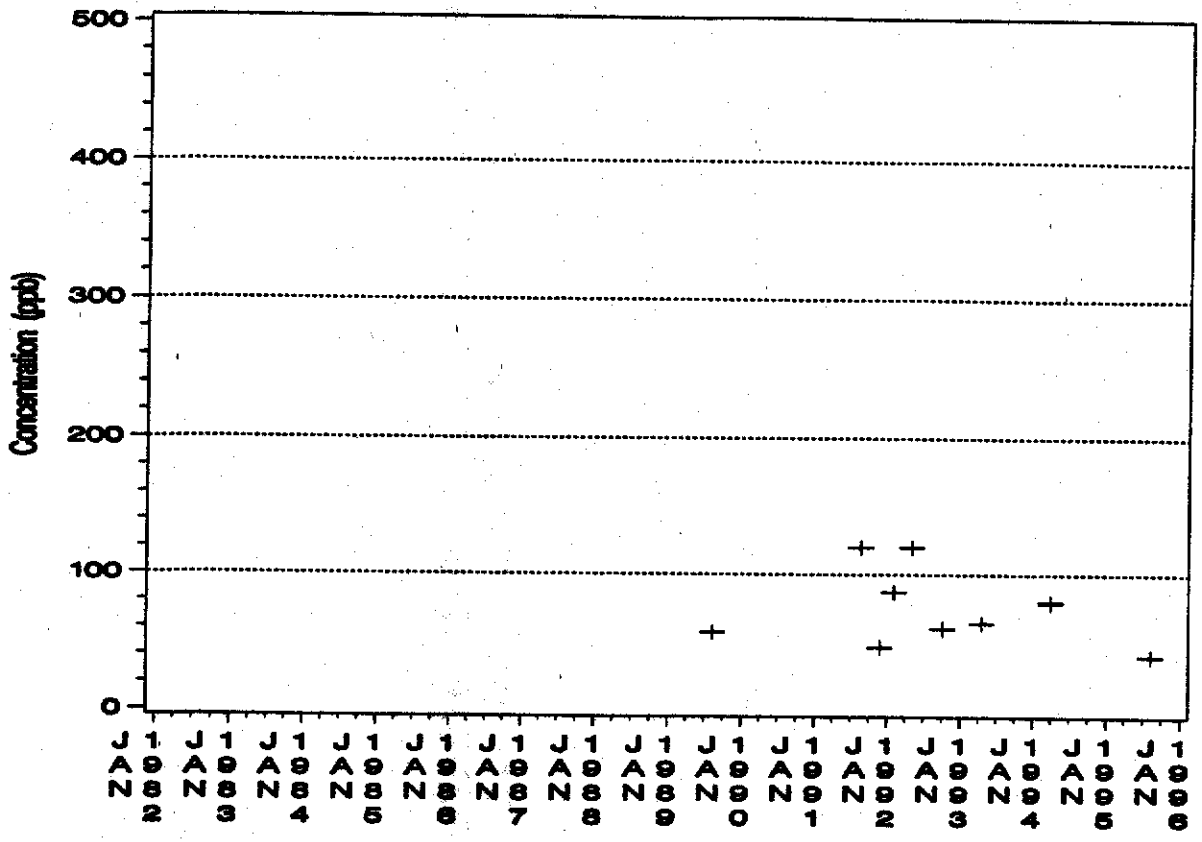
WELL 3226
CHLOROFORM Trend



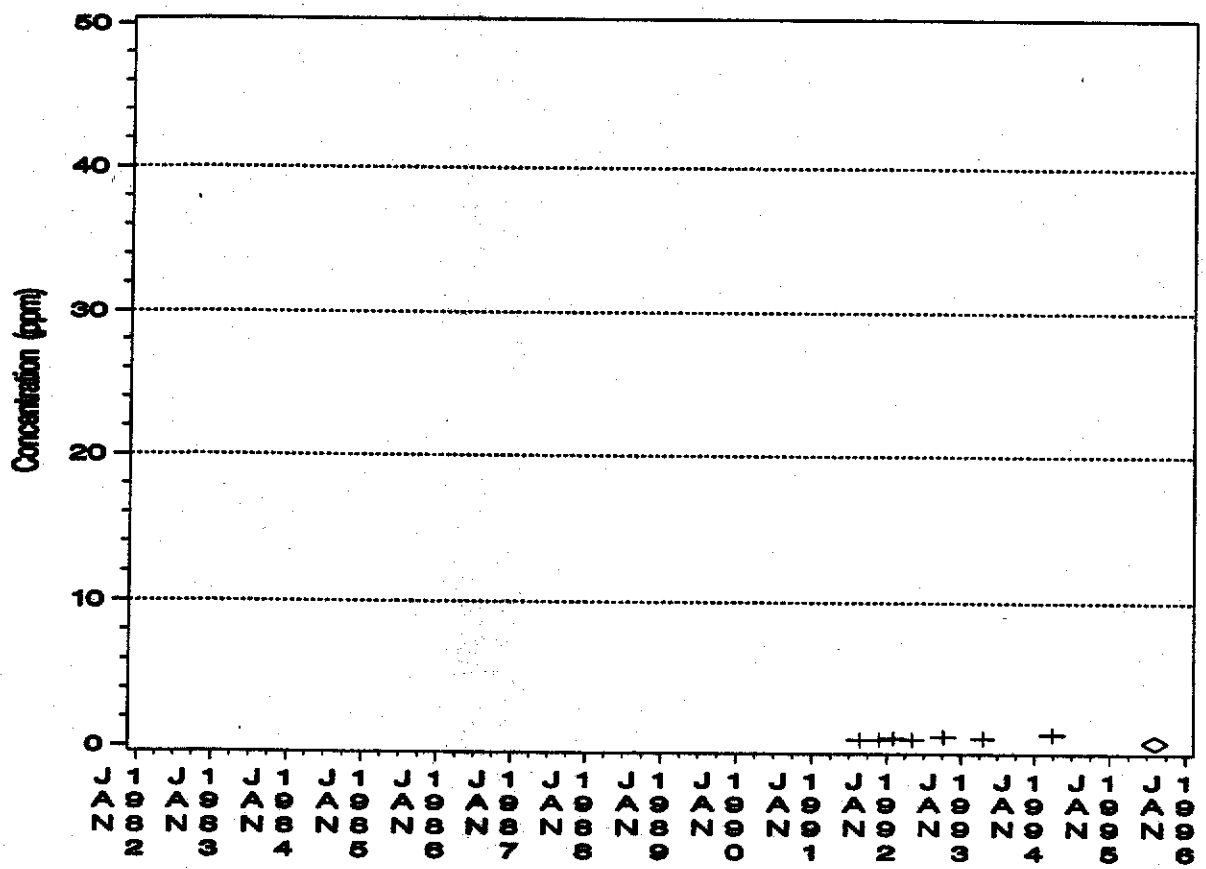
1,2 – DICHLOROETHANE Trend



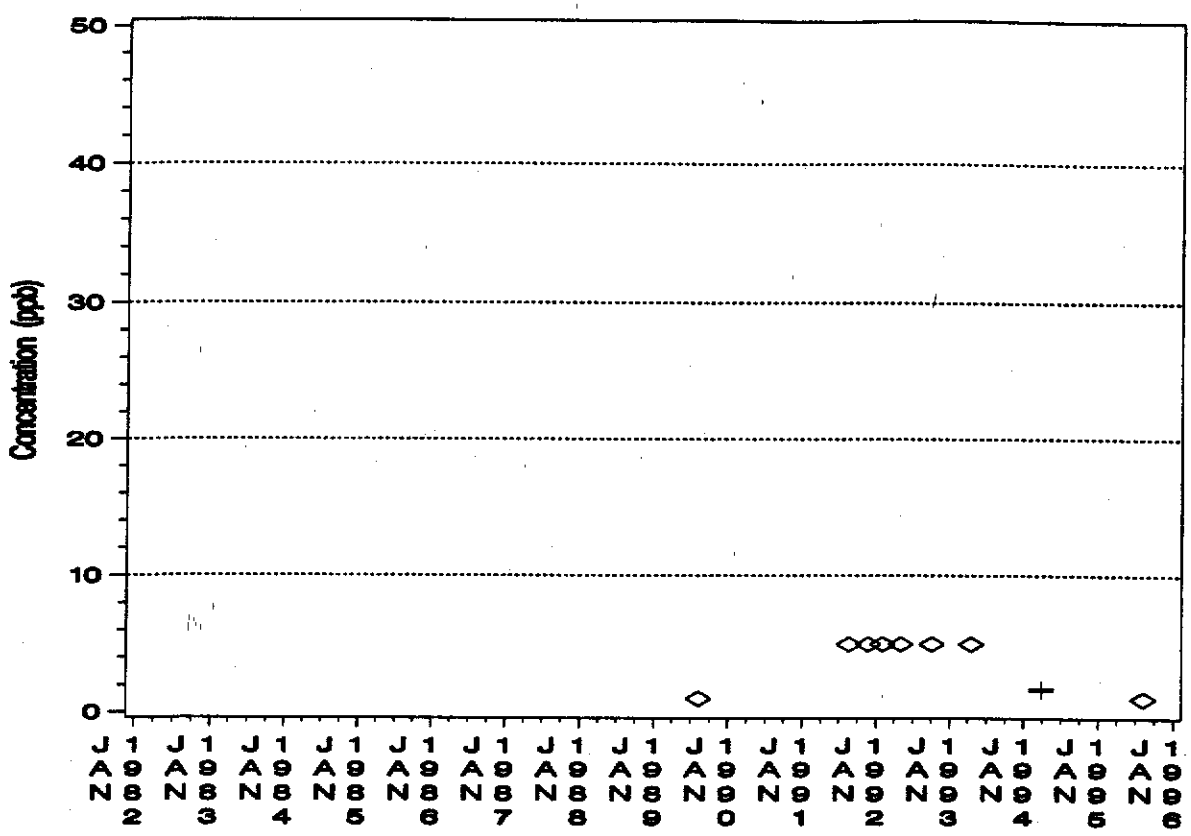
WELL 3264
TRICHLOROETHYLENE Trend



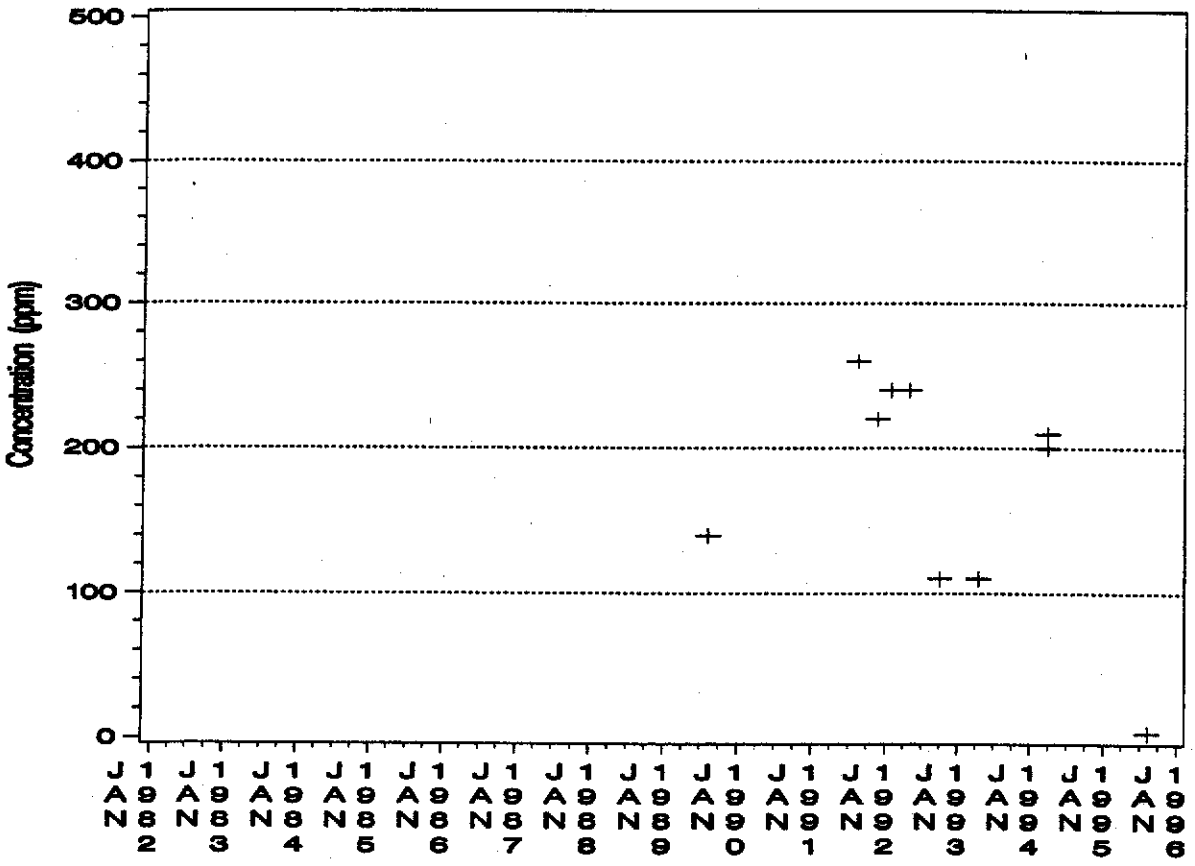
PERCHLORATE Trend



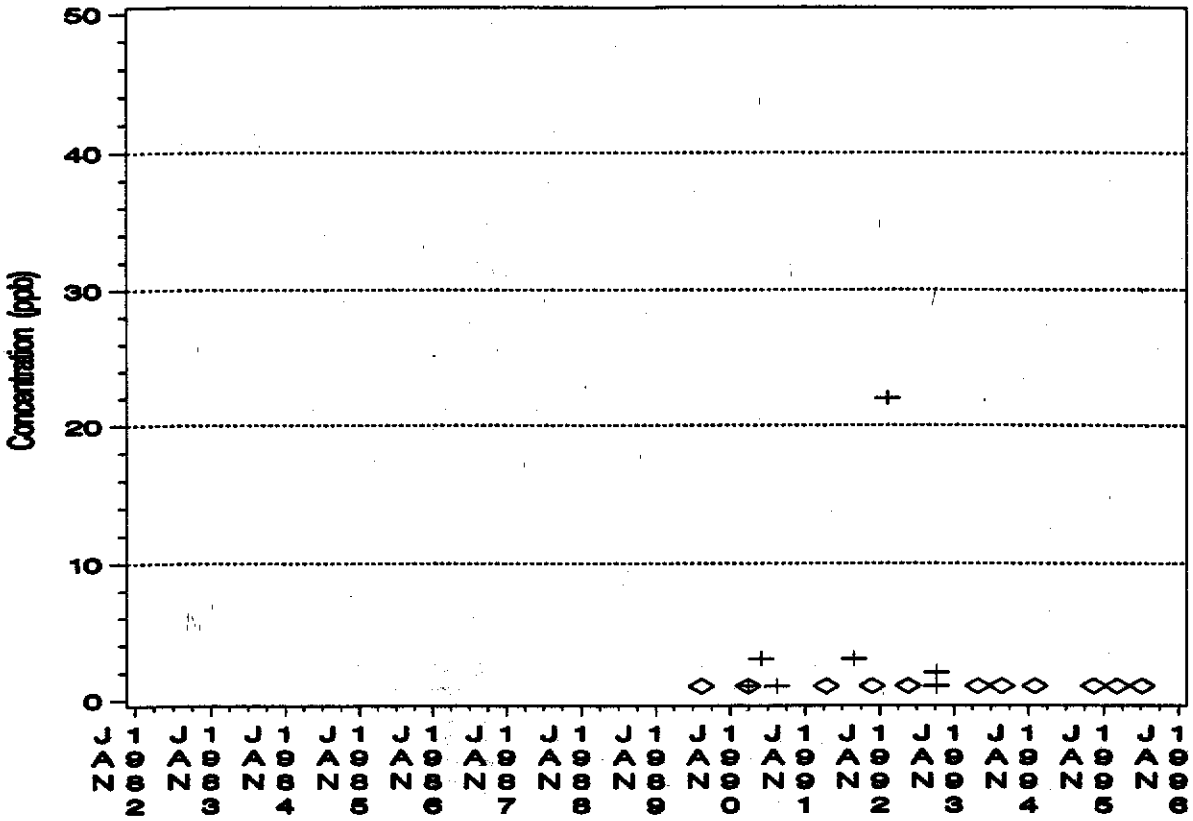
WELL 3264
CHLOROFORM Trend



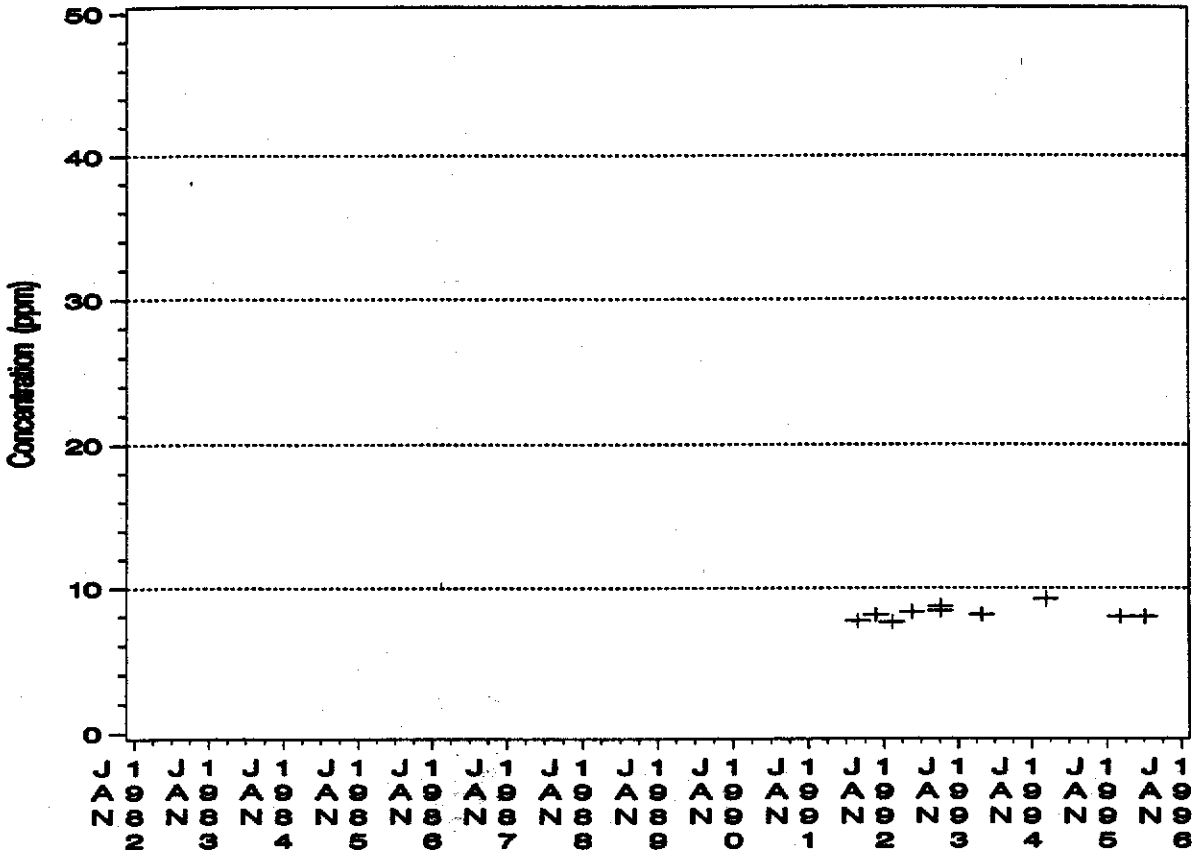
1,2 – DICHLOROETHANE Trend



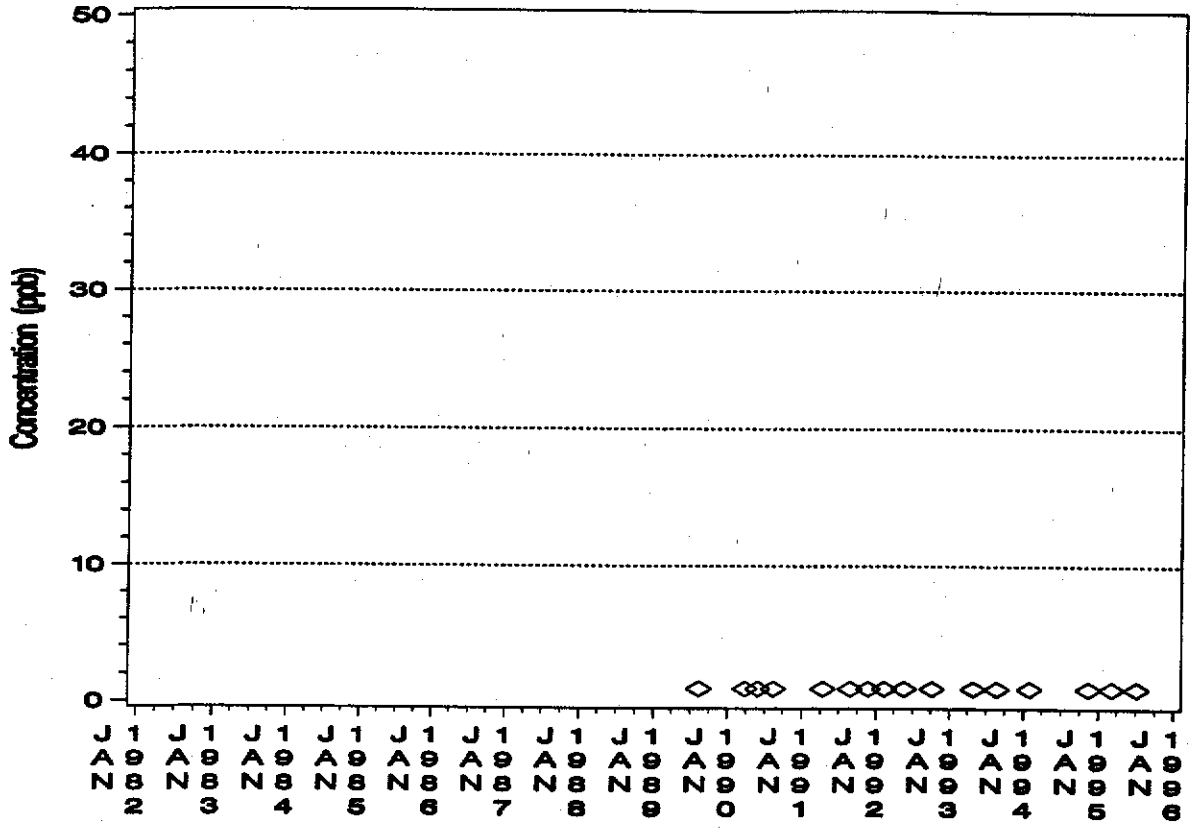
WELL 3280
TRICHLOROETHYLENE Trend



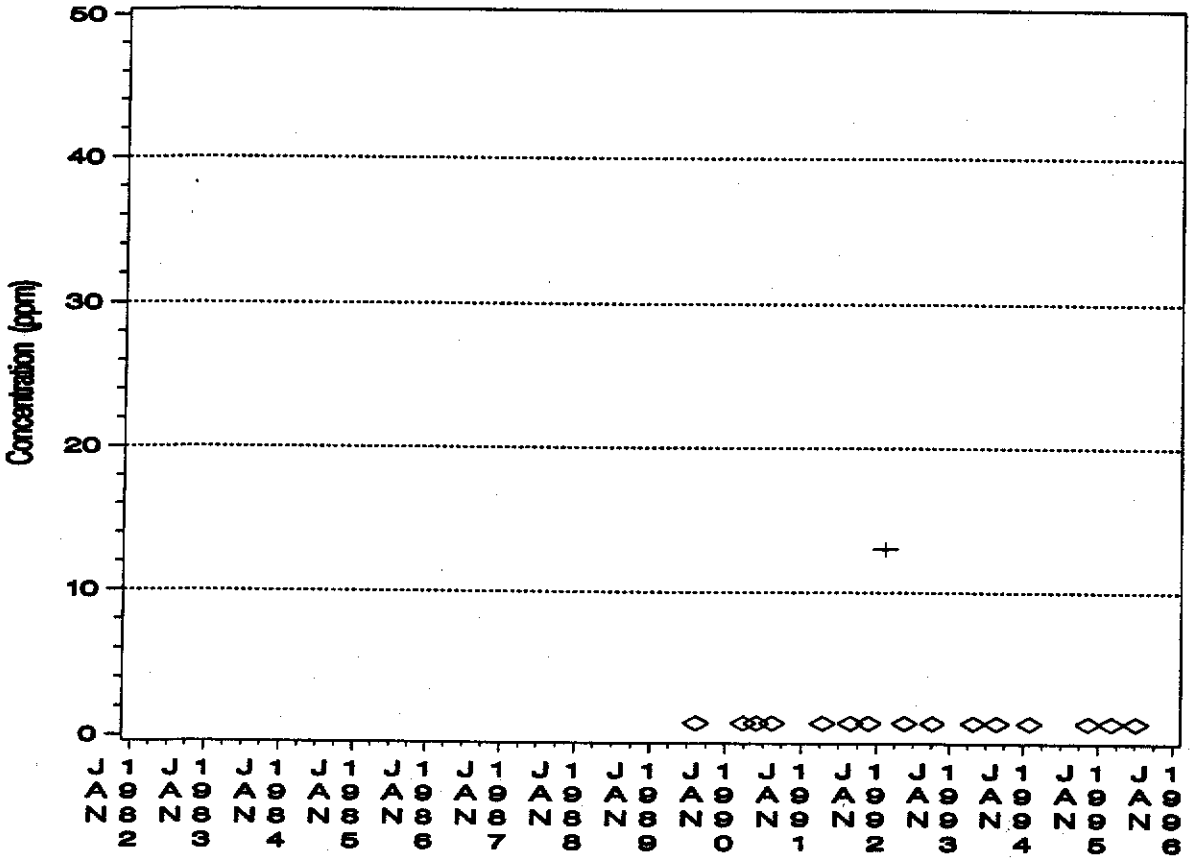
PERCHLORATE Trend



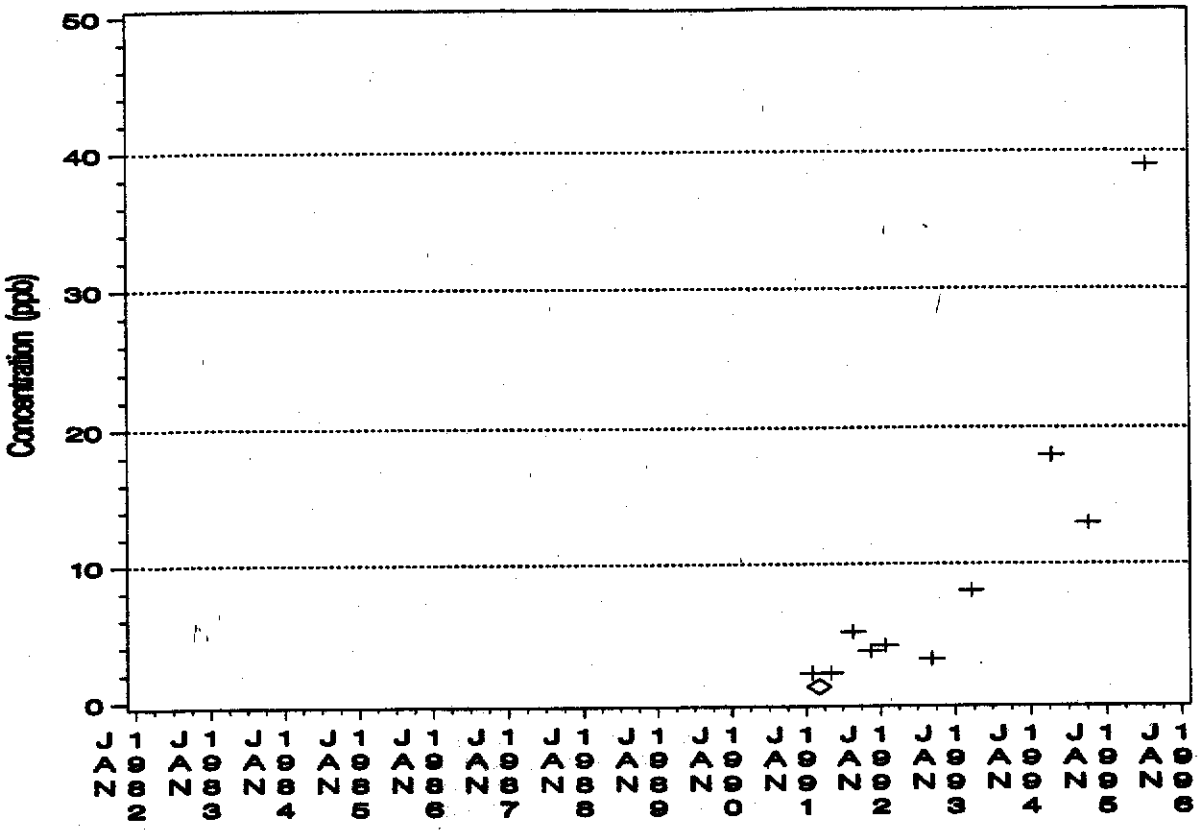
WELL 3280
CHLOROFORM Trend



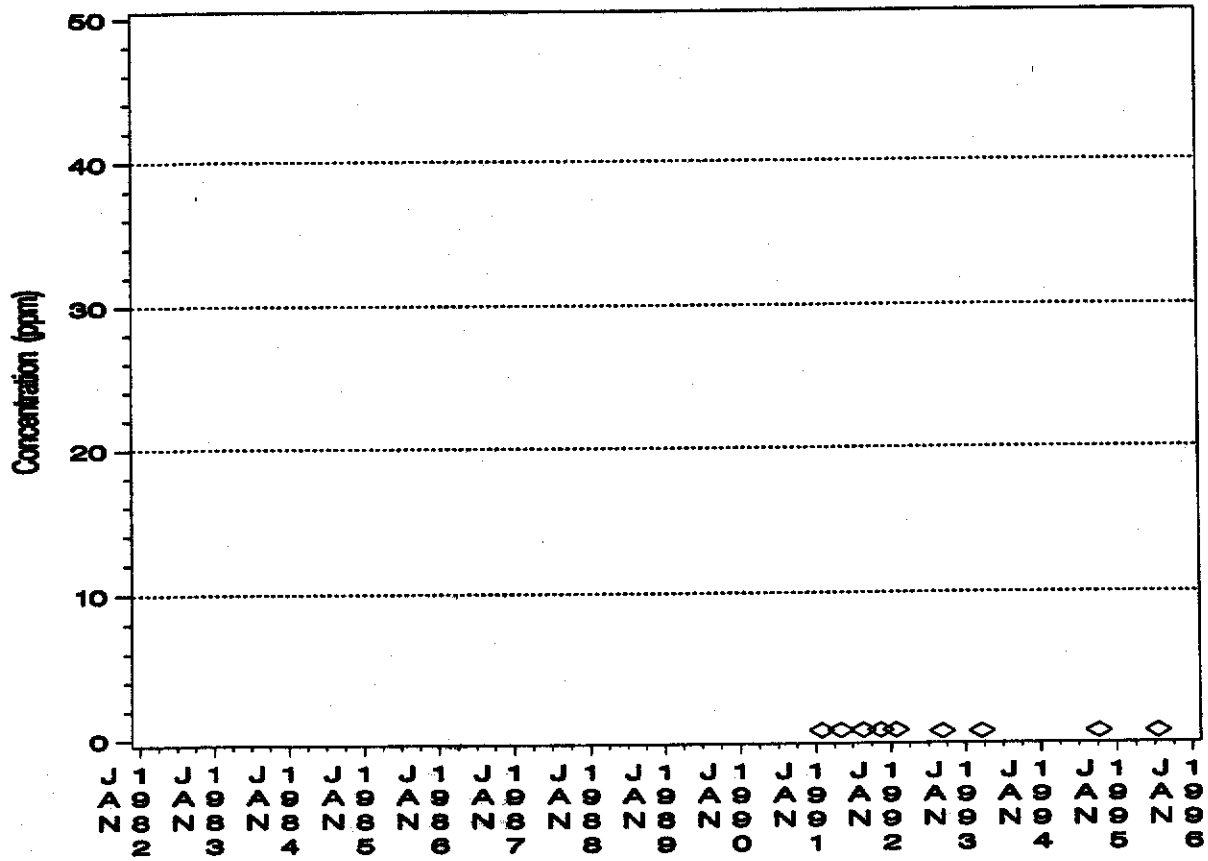
1,2 – DICHLOROETHANE Trend



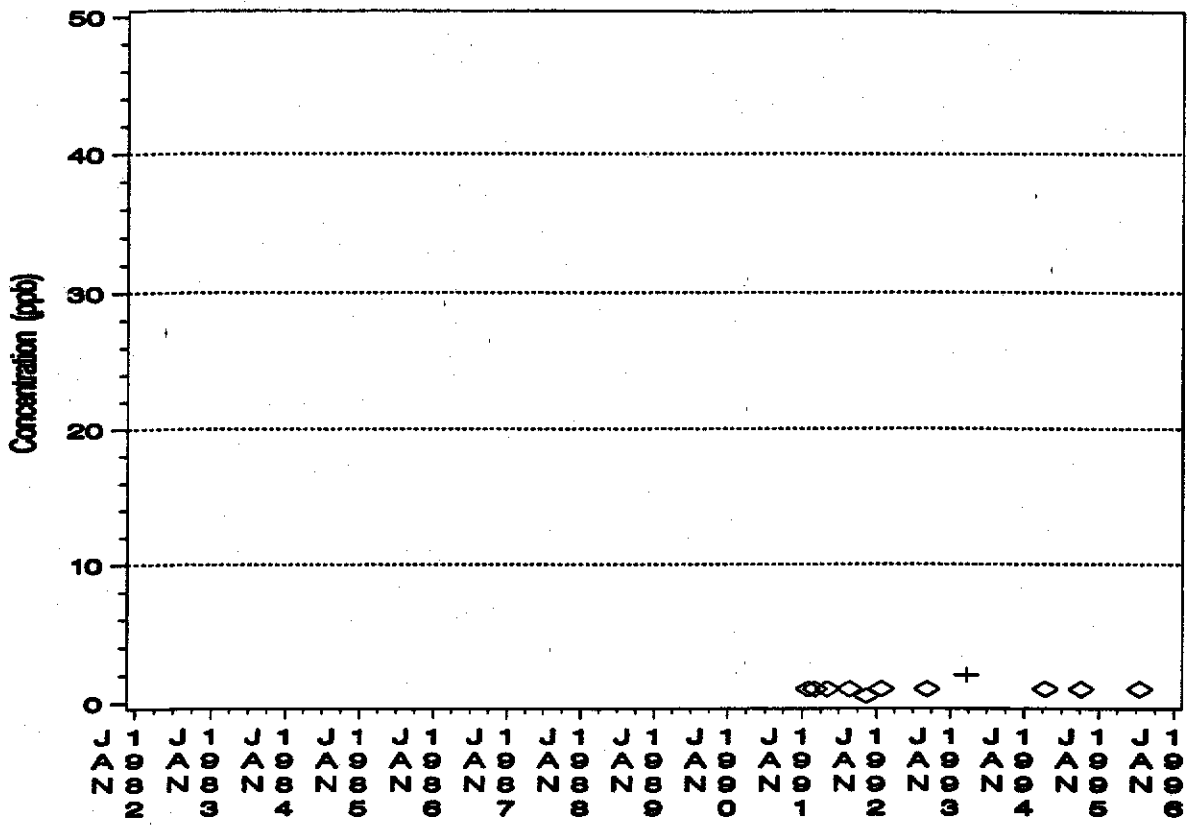
WELL 3334
TRICHLOROETHYLENE Trend



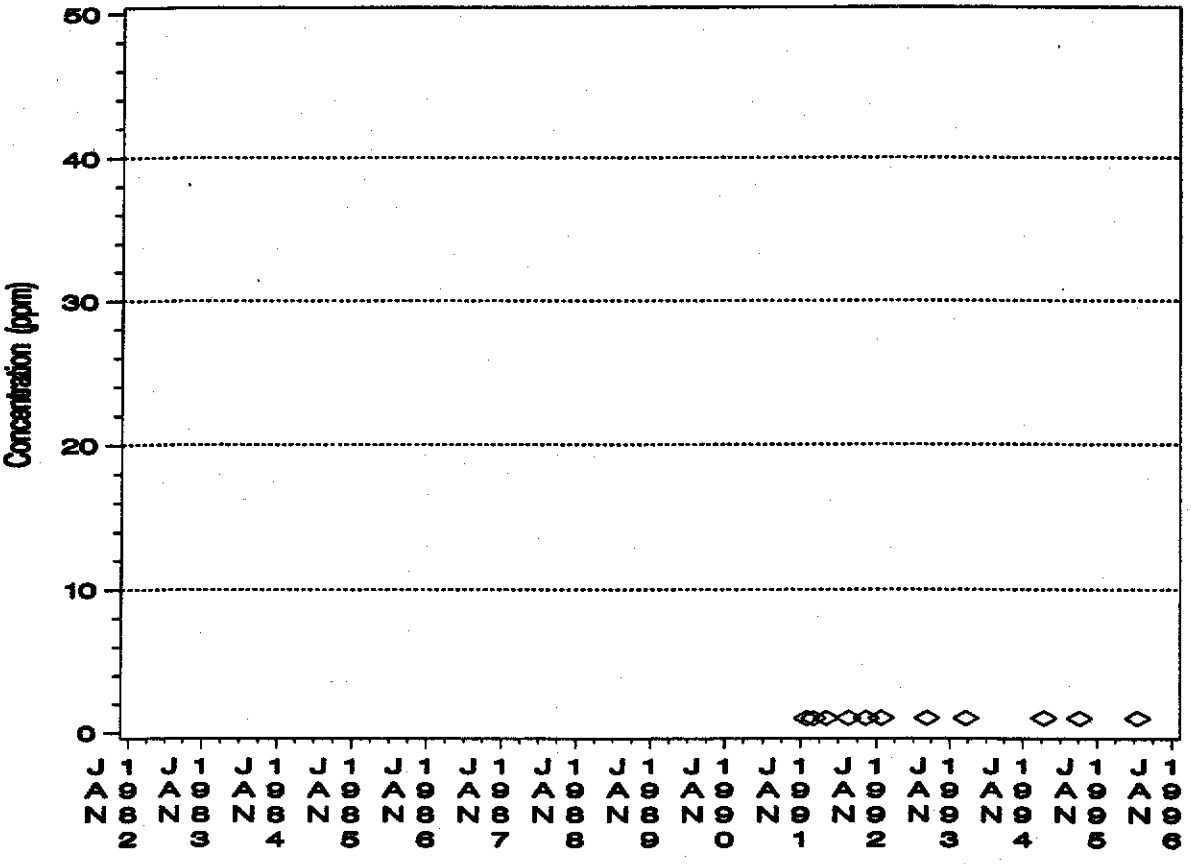
PERCHLORATE Trend



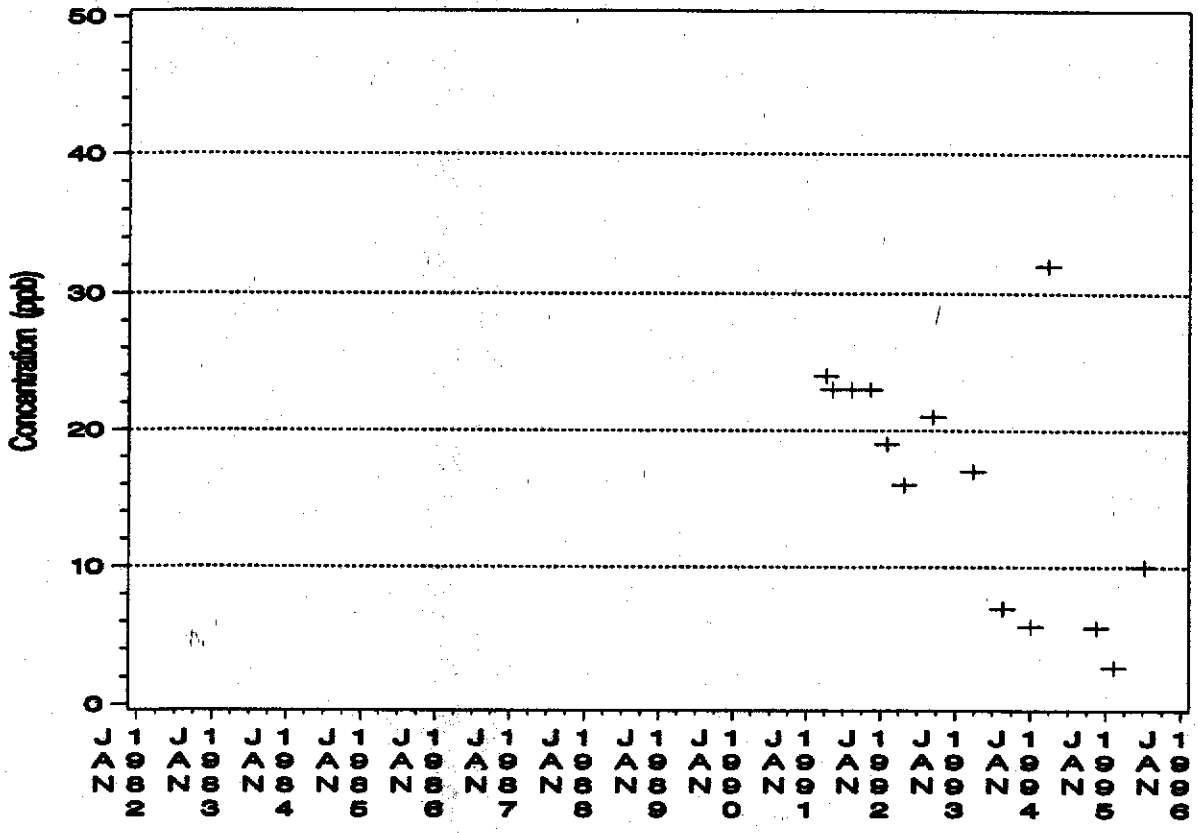
WELL 3334
CHLOROFORM Trend



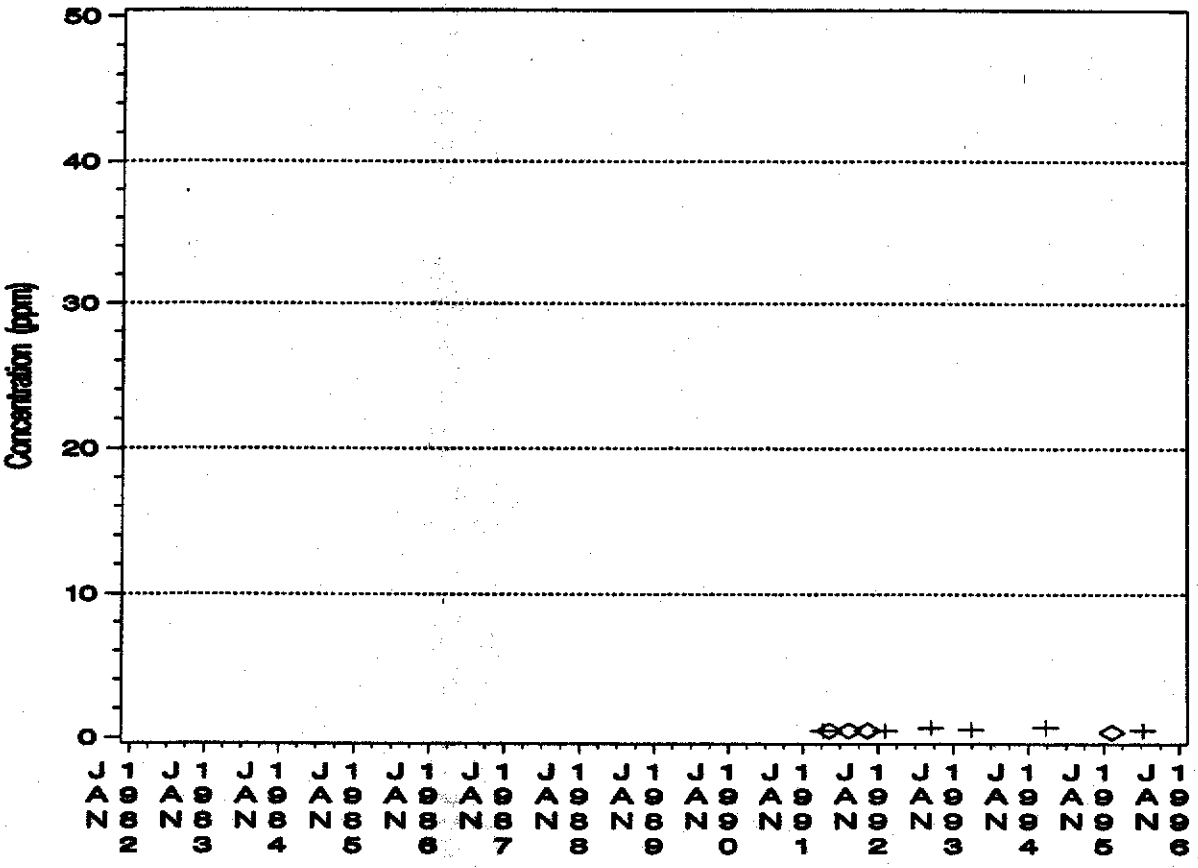
1,2 – DICHLOROETHANE Trend



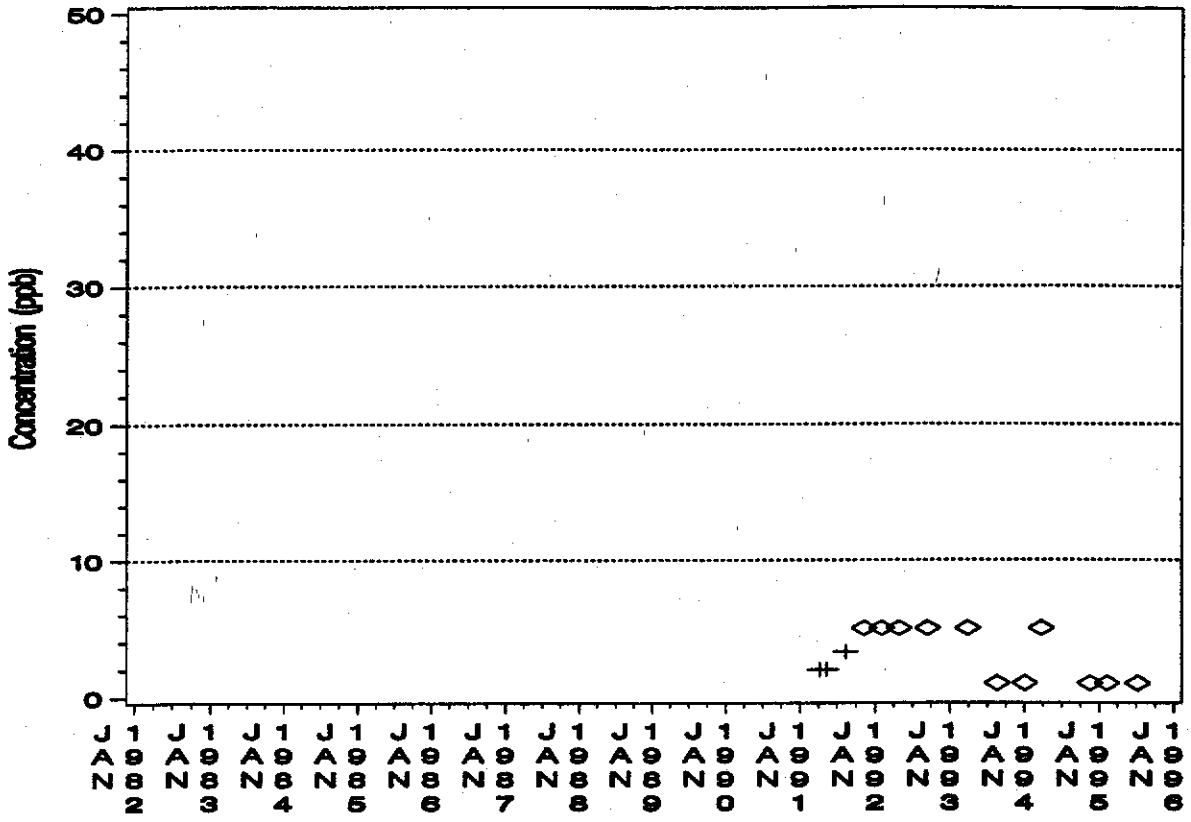
WELL 3336
TRICHLOROETHYLENE Trend



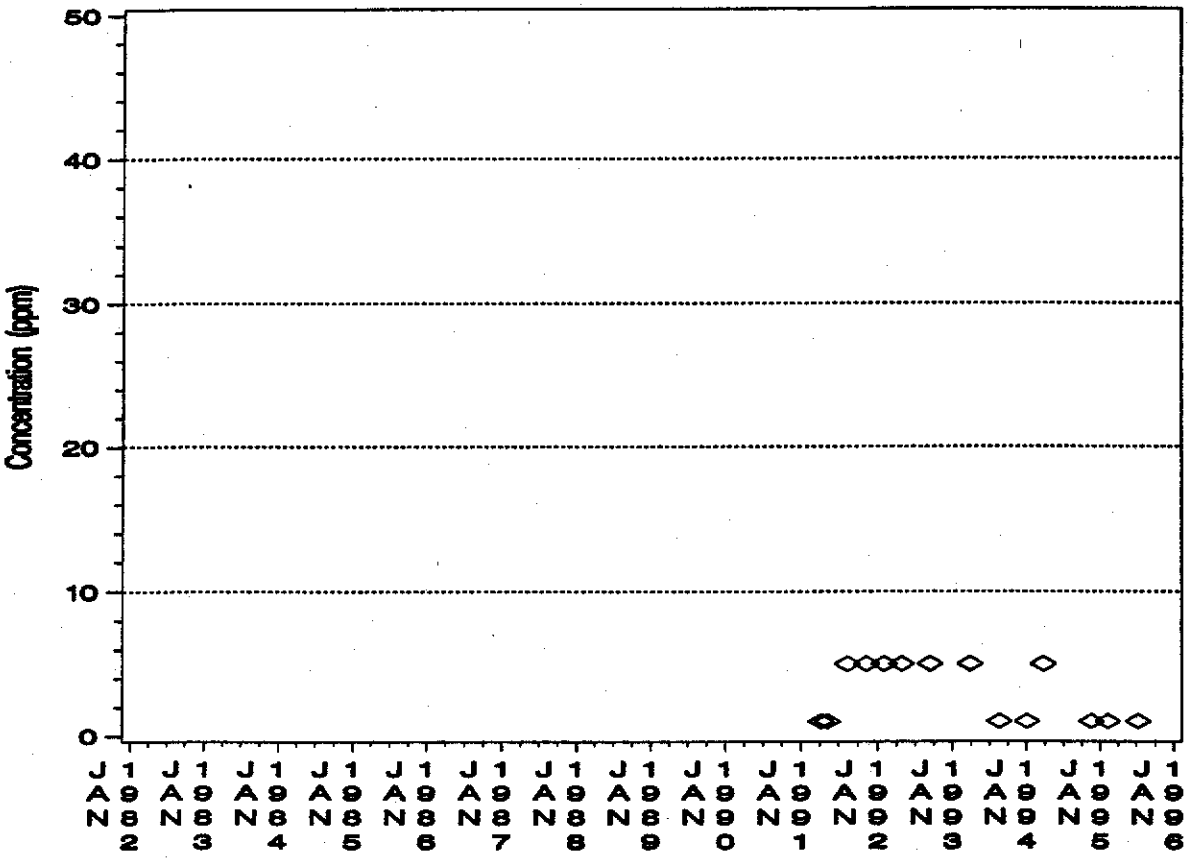
PERCHLORATE Trend



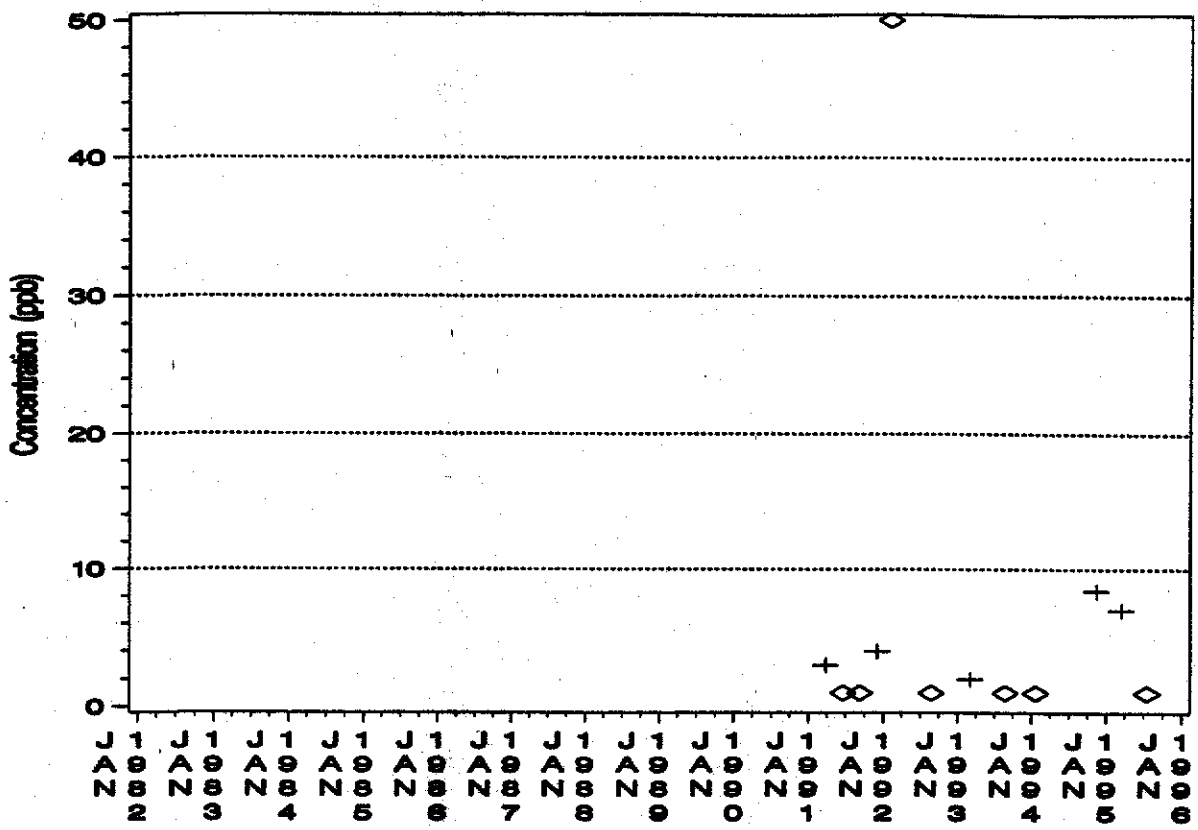
WELL 3336
CHLOROFORM Trend



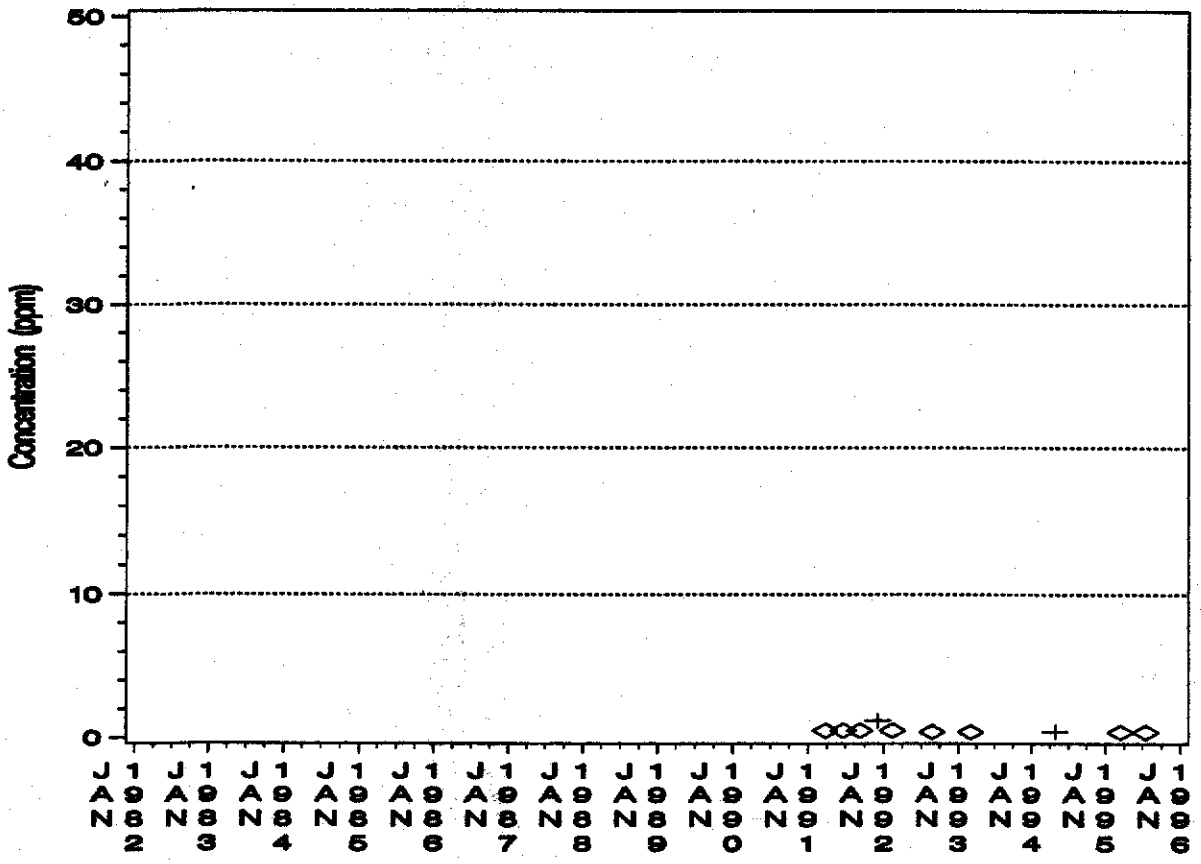
1,2 – DICHLOROETHANE Trend



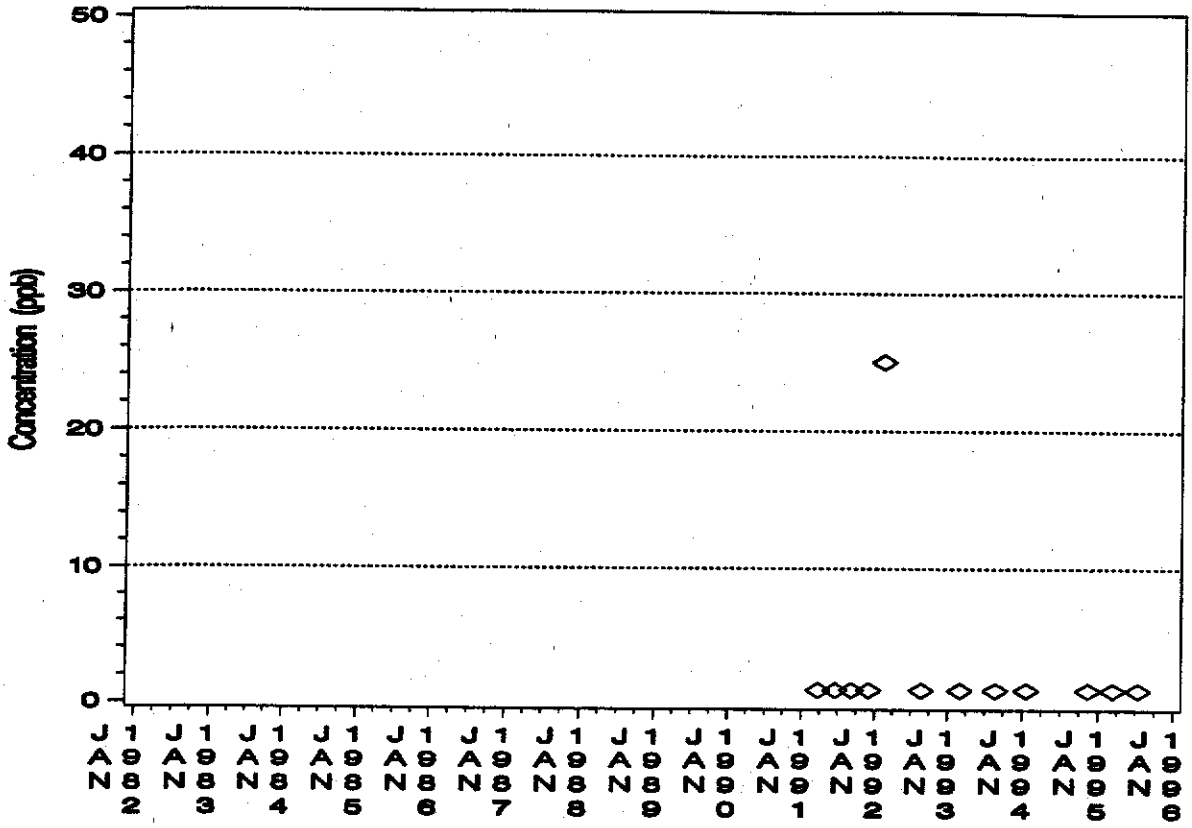
WELL 3341
TRICHLOROETHYLENE Trend



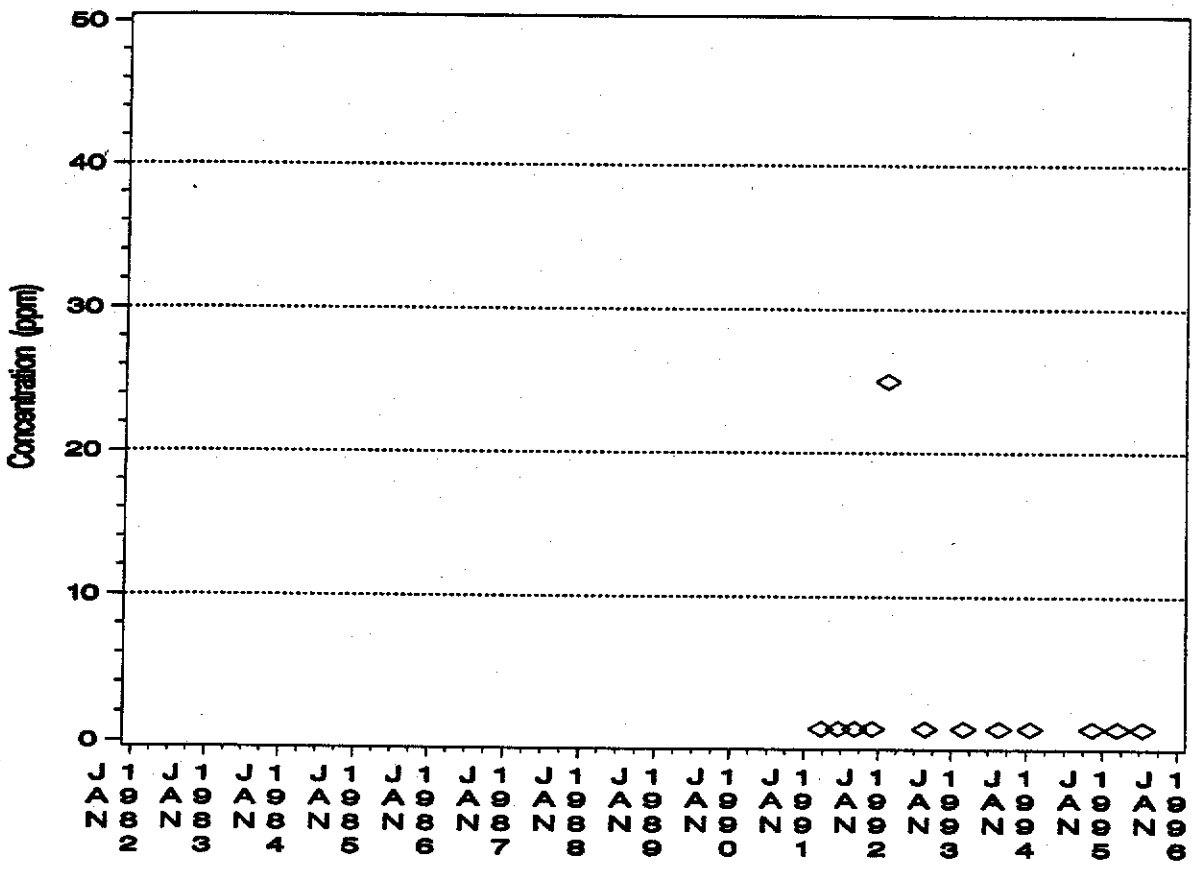
PERCHLORATE Trend



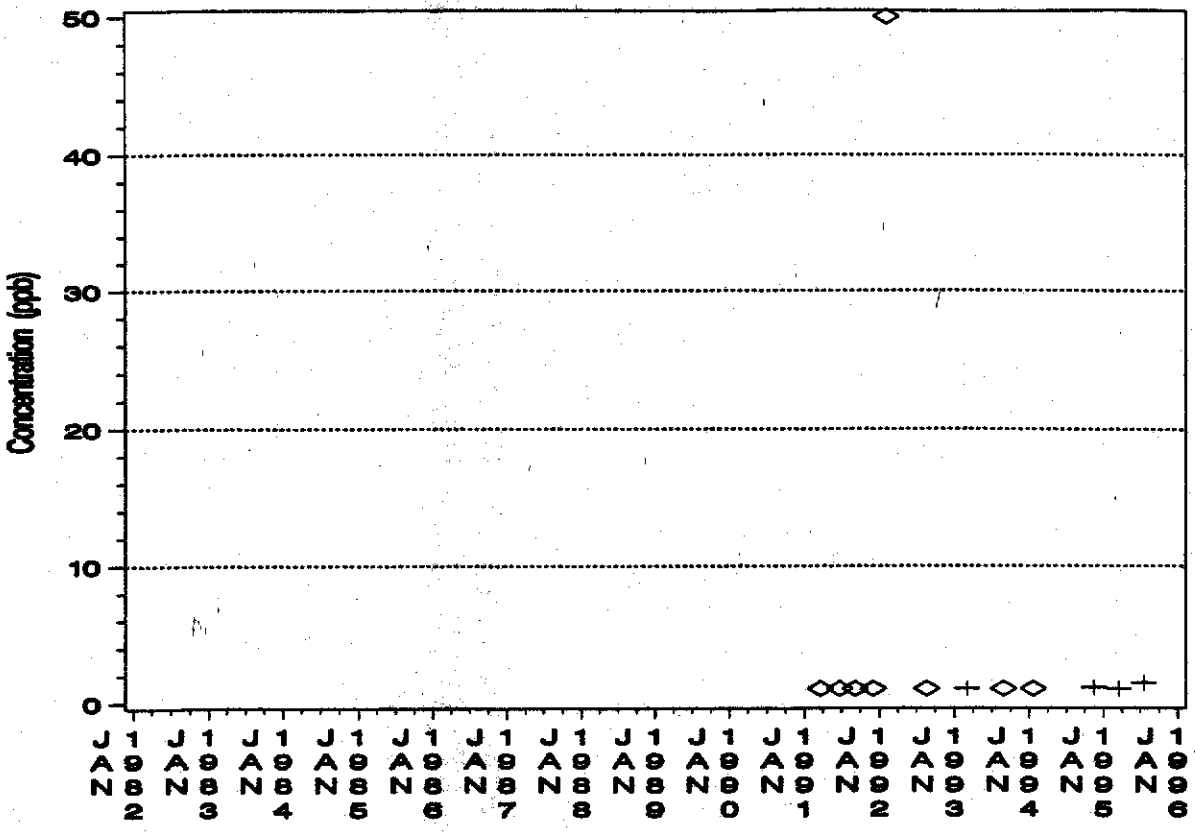
WELL 3341
CHLOROFORM Trend



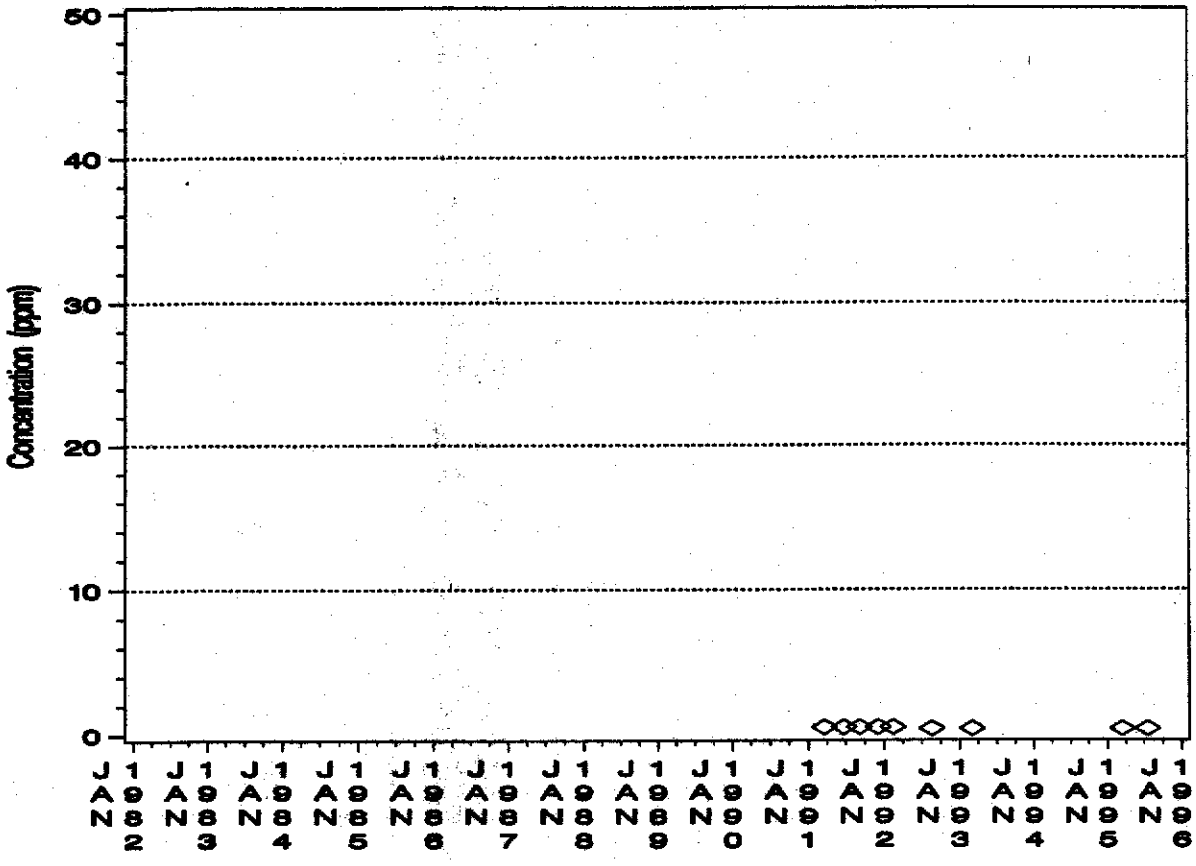
1,2 – DICHLOROETHANE Trend



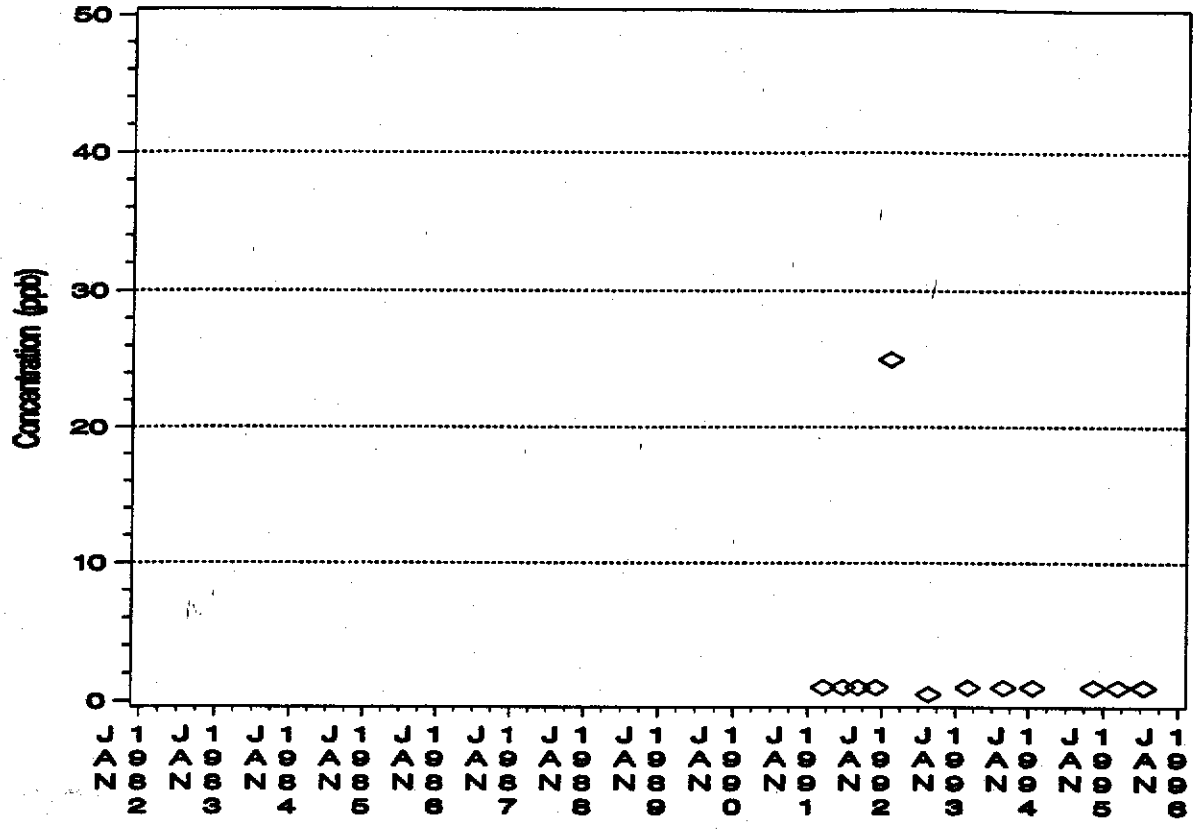
WELL 3342
TRICHLOROETHYLENE Trend



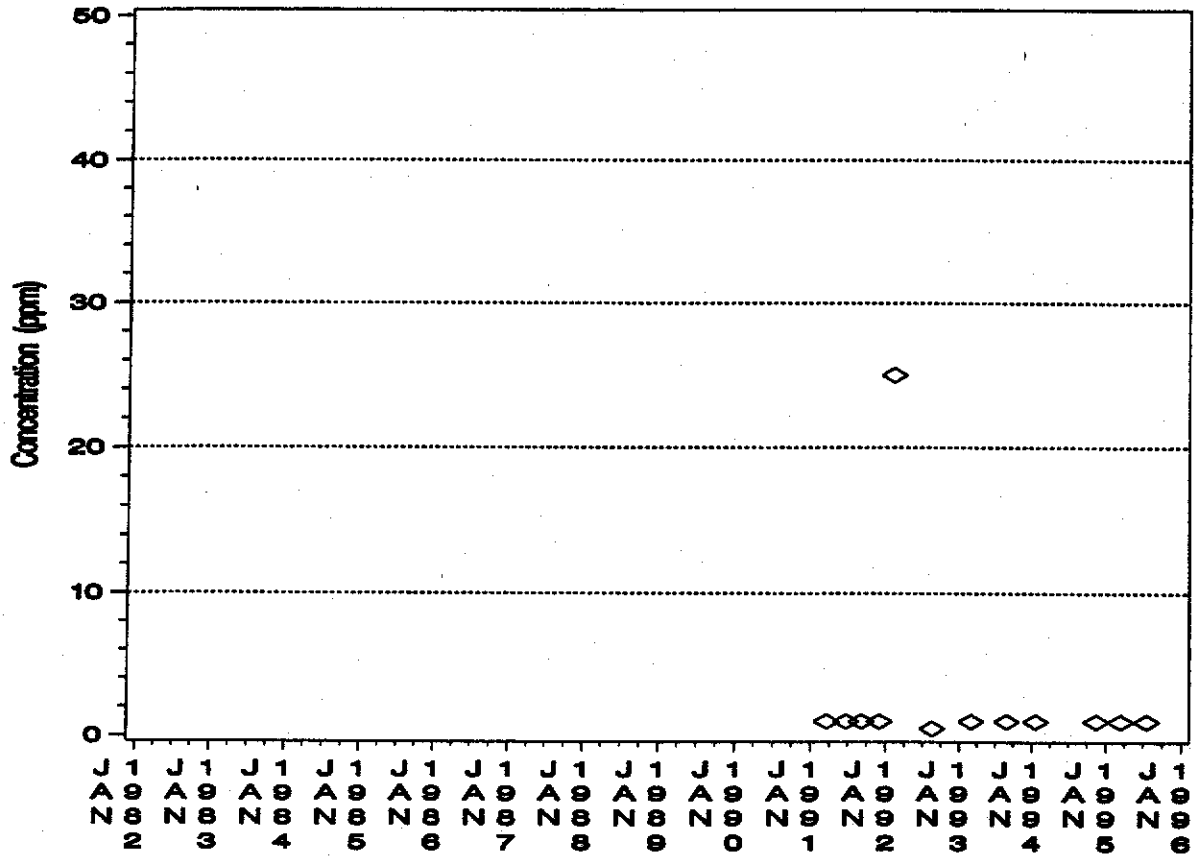
PERCHLORATE Trend



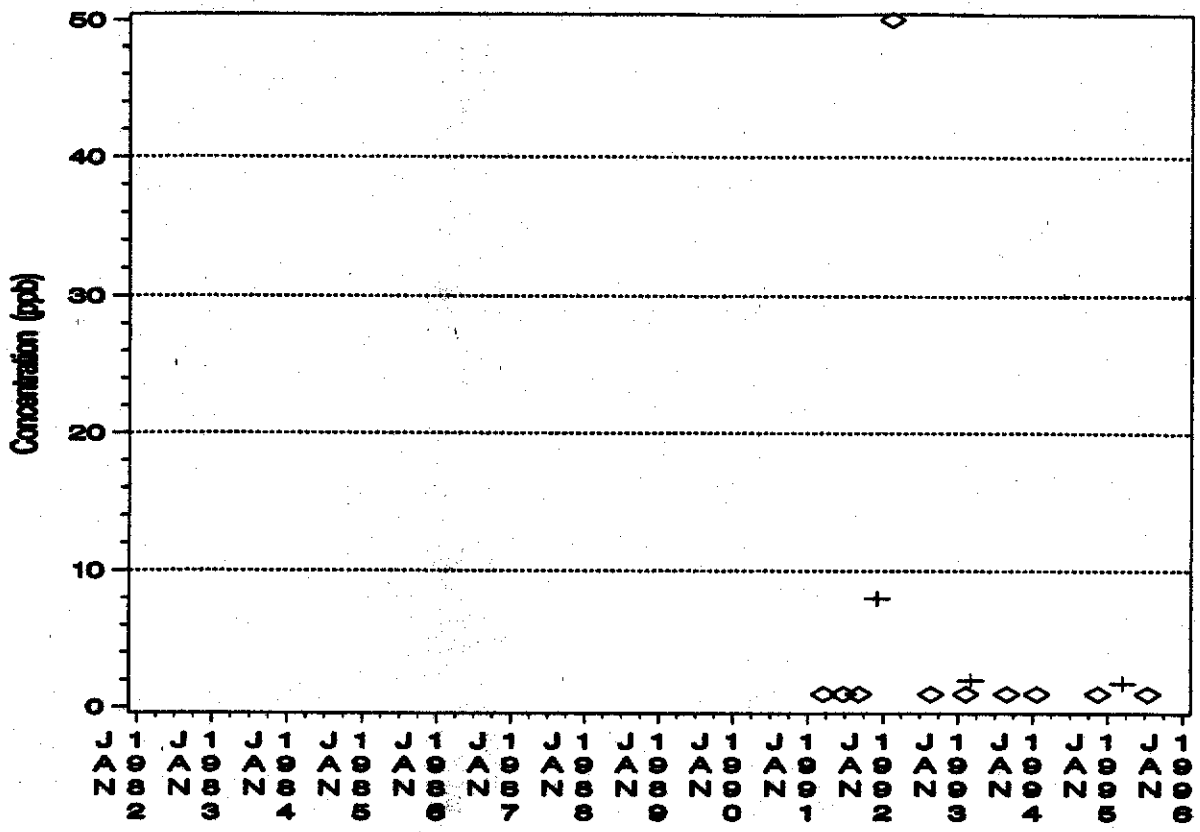
WELL 3342
CHLOROFORM Trend



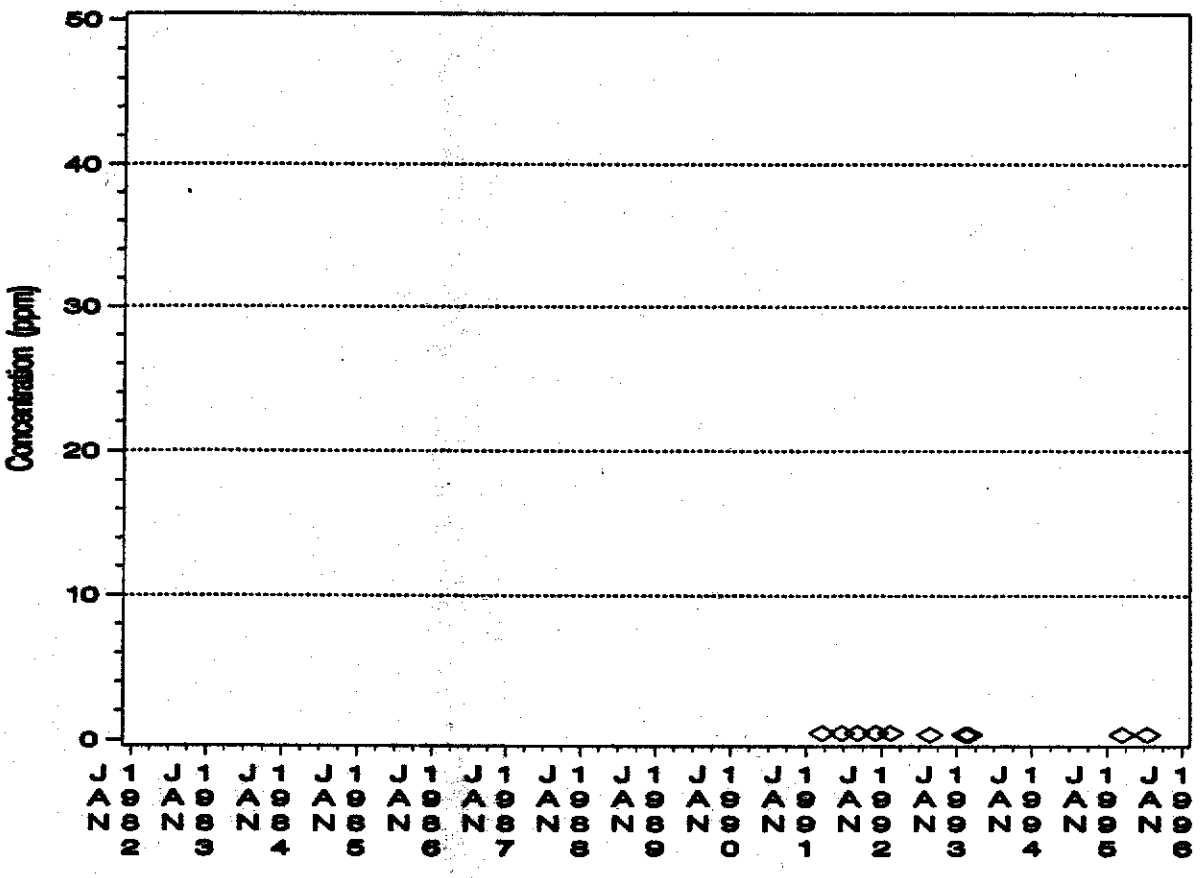
1,2 – DICHLOROETHANE Trend



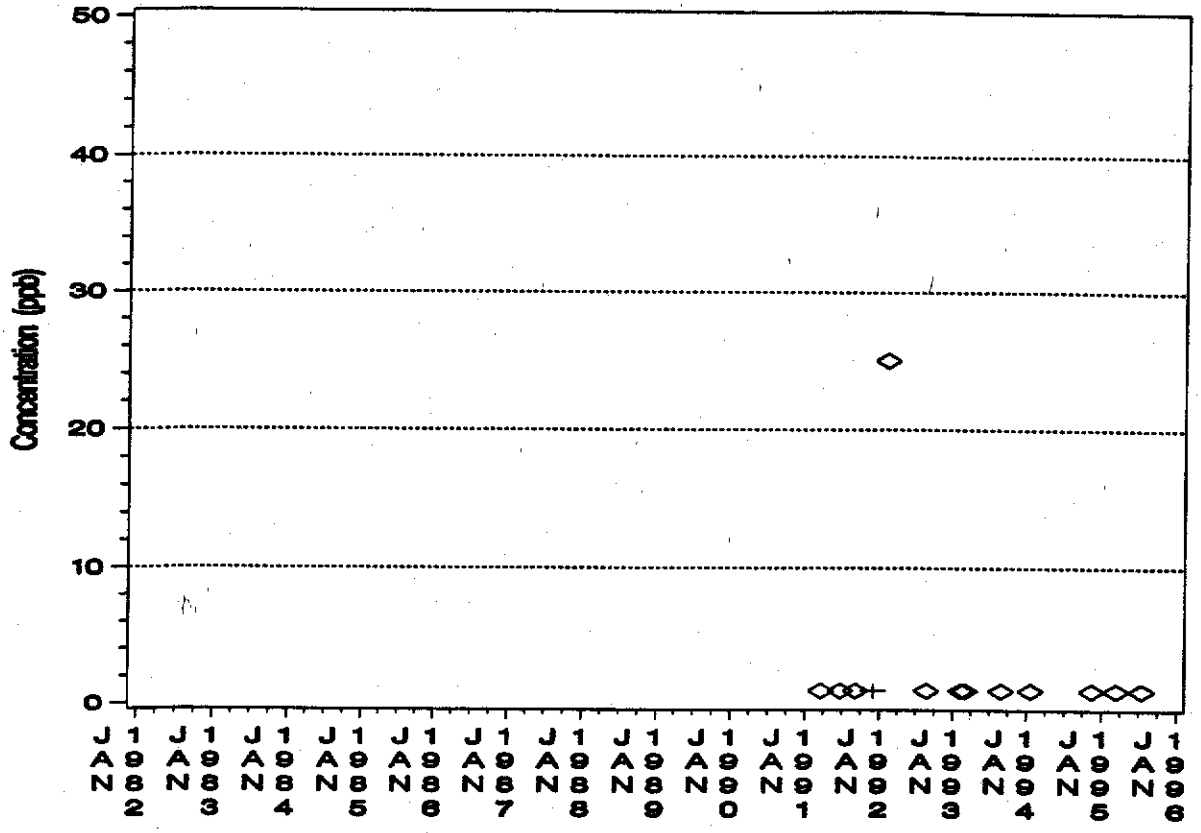
WELL 3343
TRICHLOROETHYLENE Trend



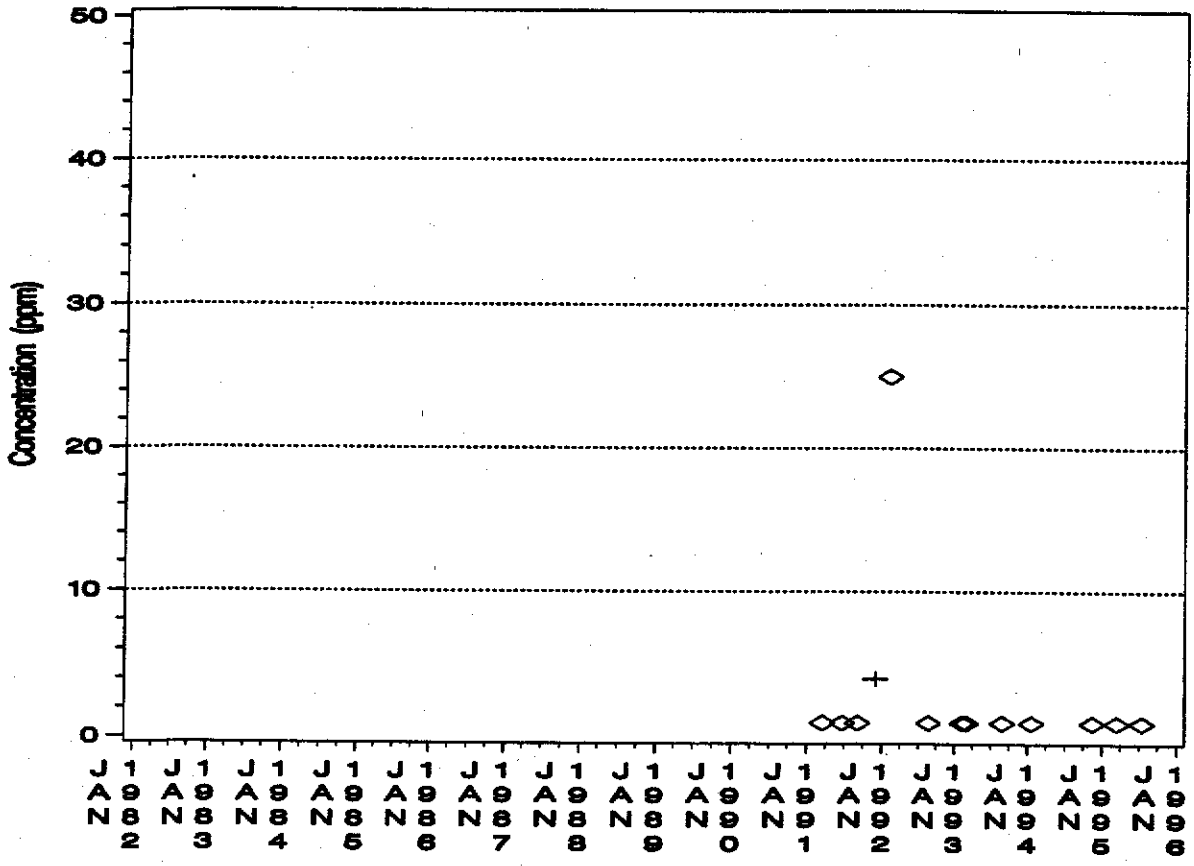
PERCHLORATE Trend



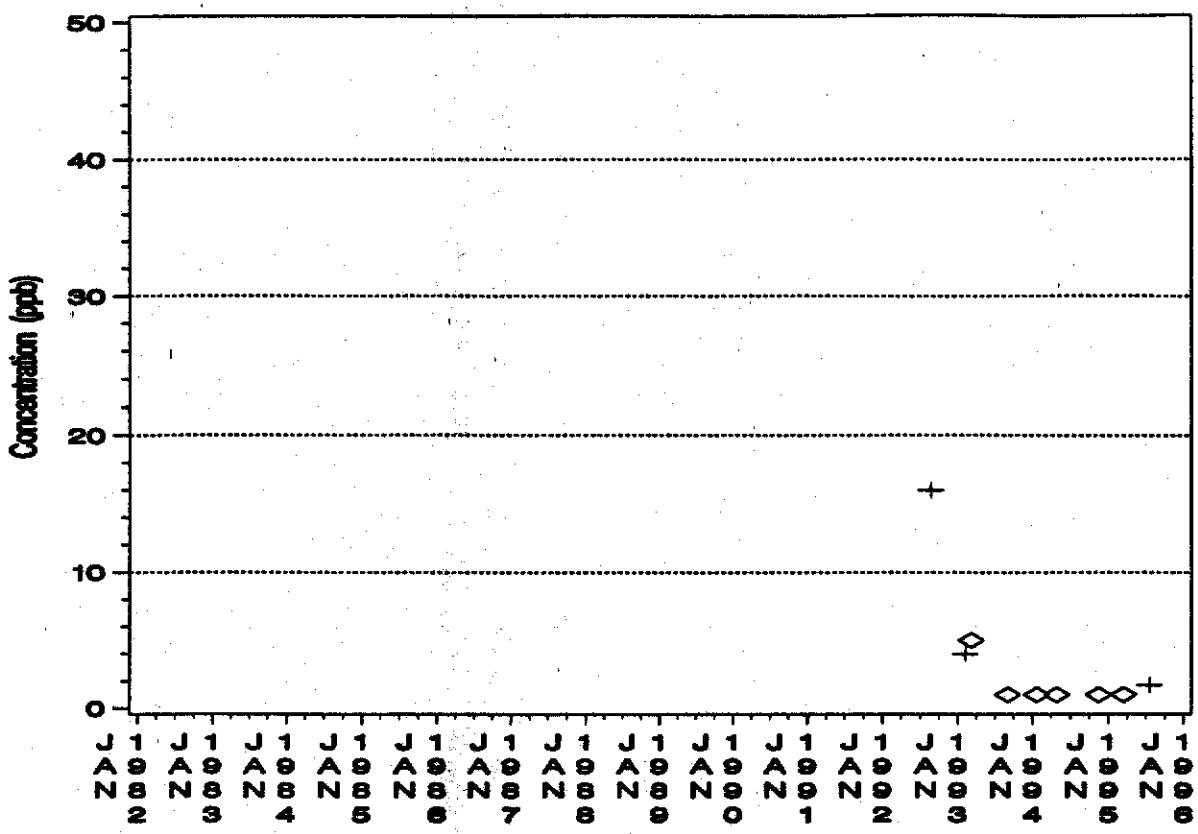
WELL 3343
CHLOROFORM Trend



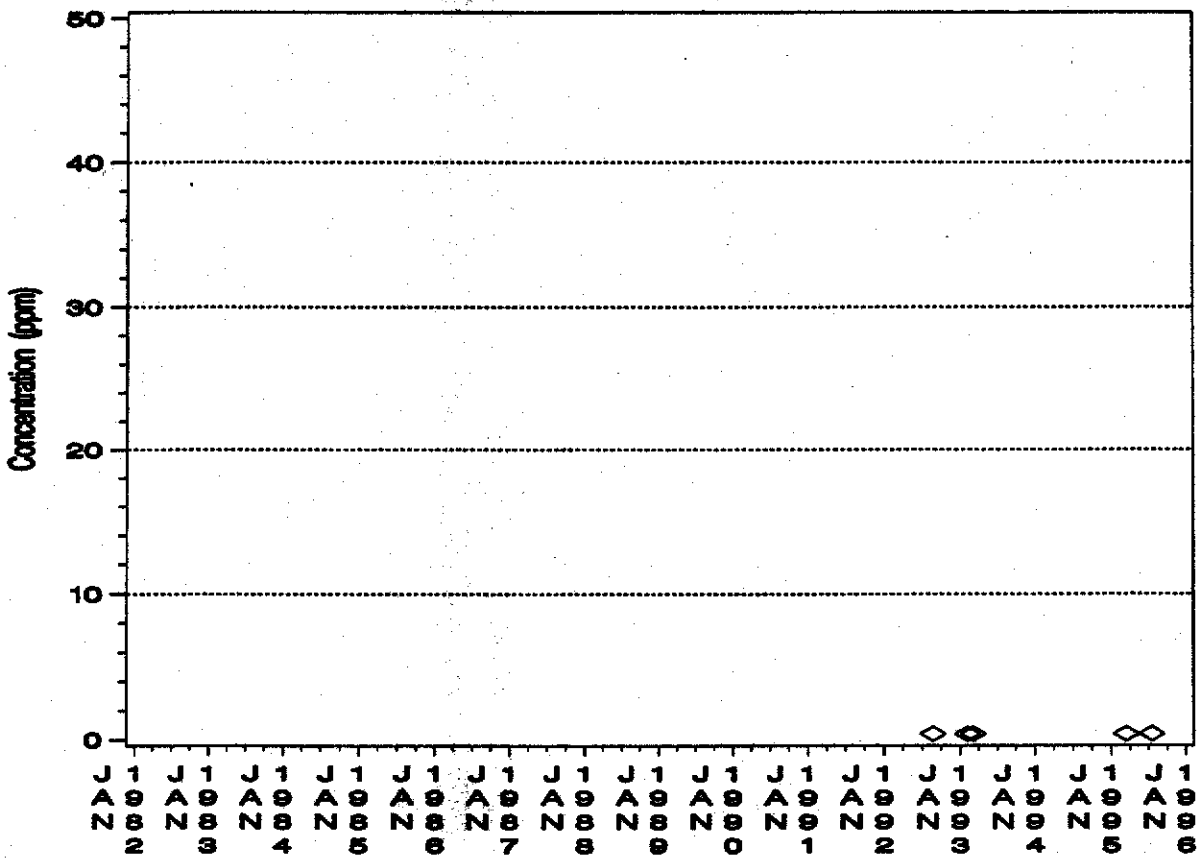
1,2 – DICHLOROETHANE Trend



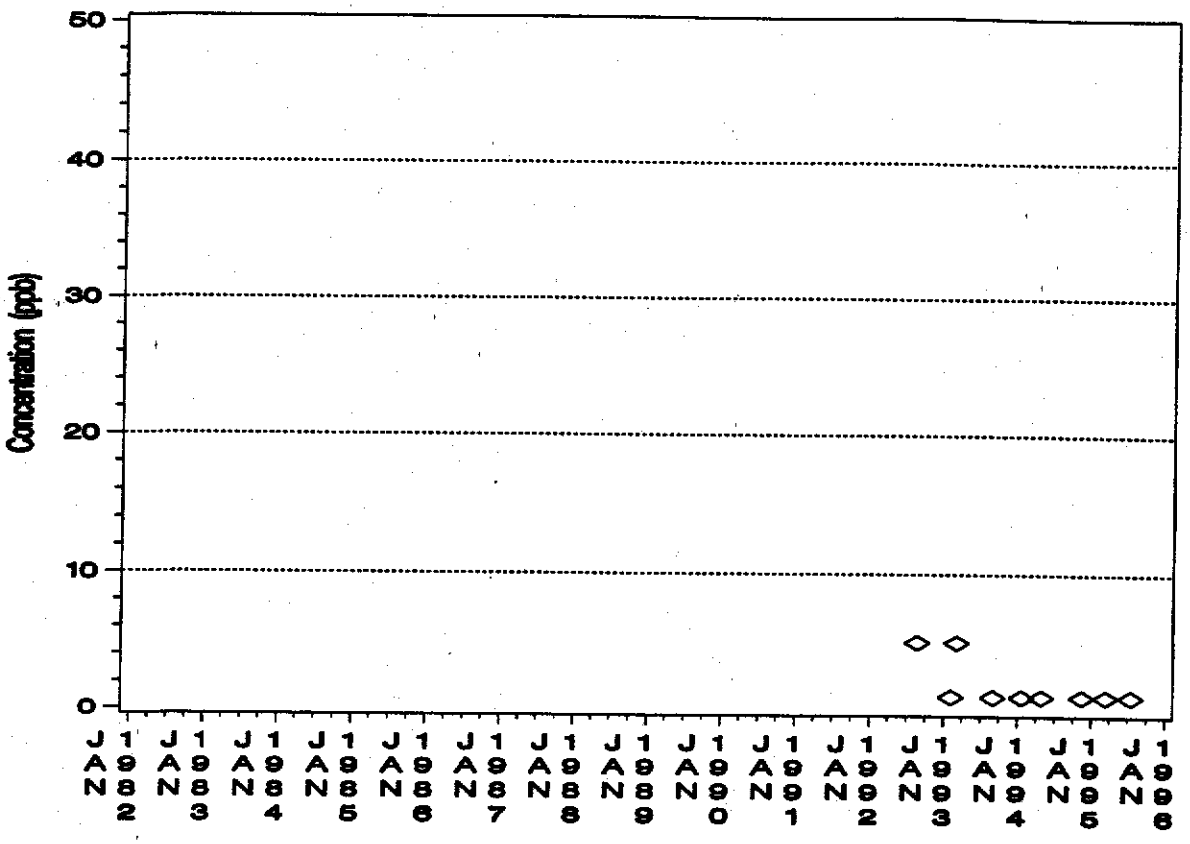
WELL 3352
TRICHLOROETHYLENE Trend



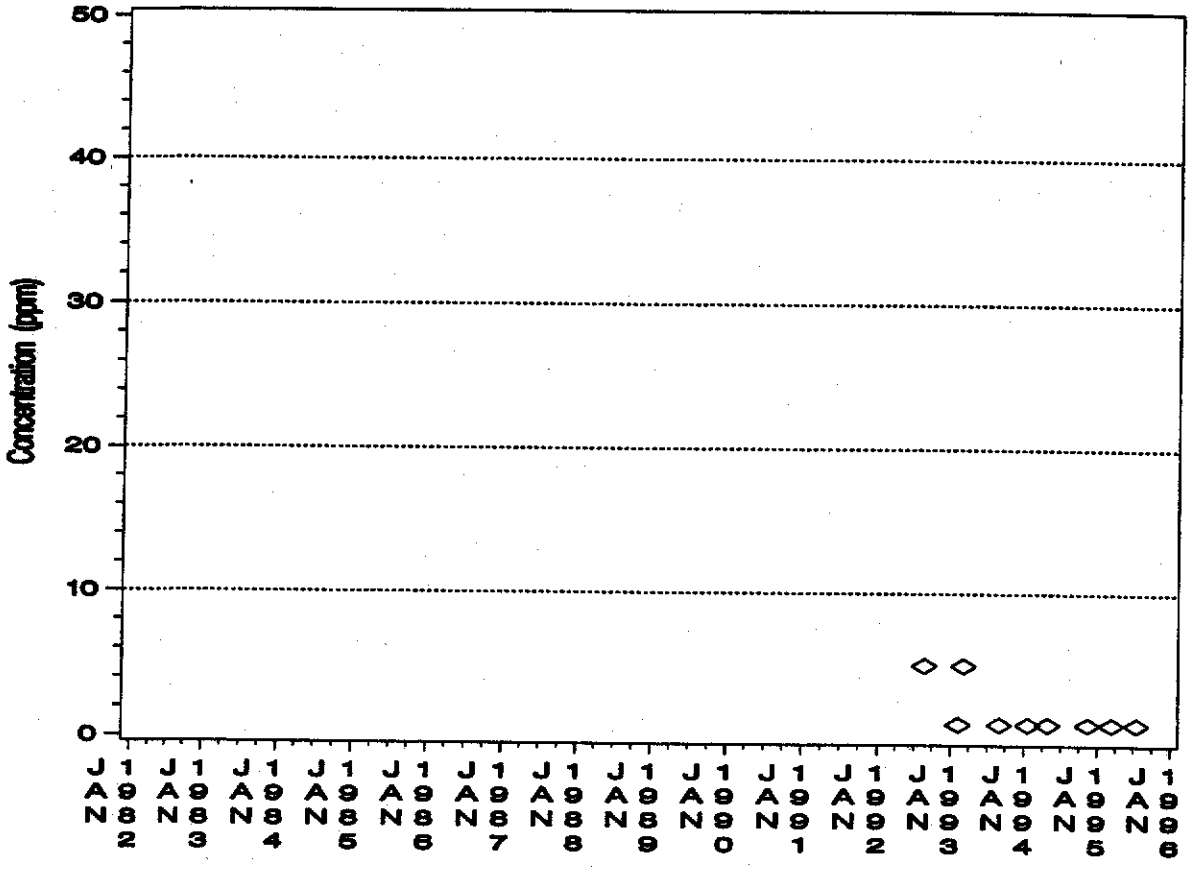
PERCHLORATE Trend



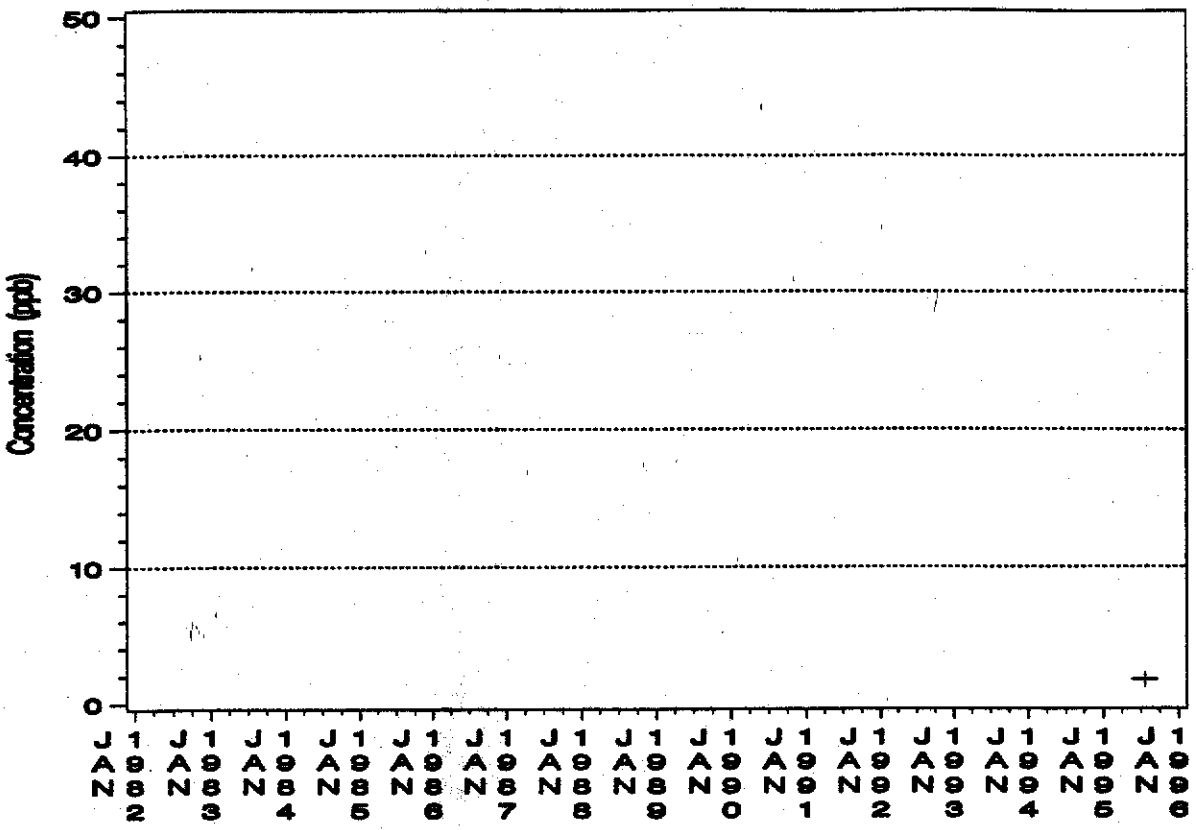
WELL 3352
CHLOROFORM Trend



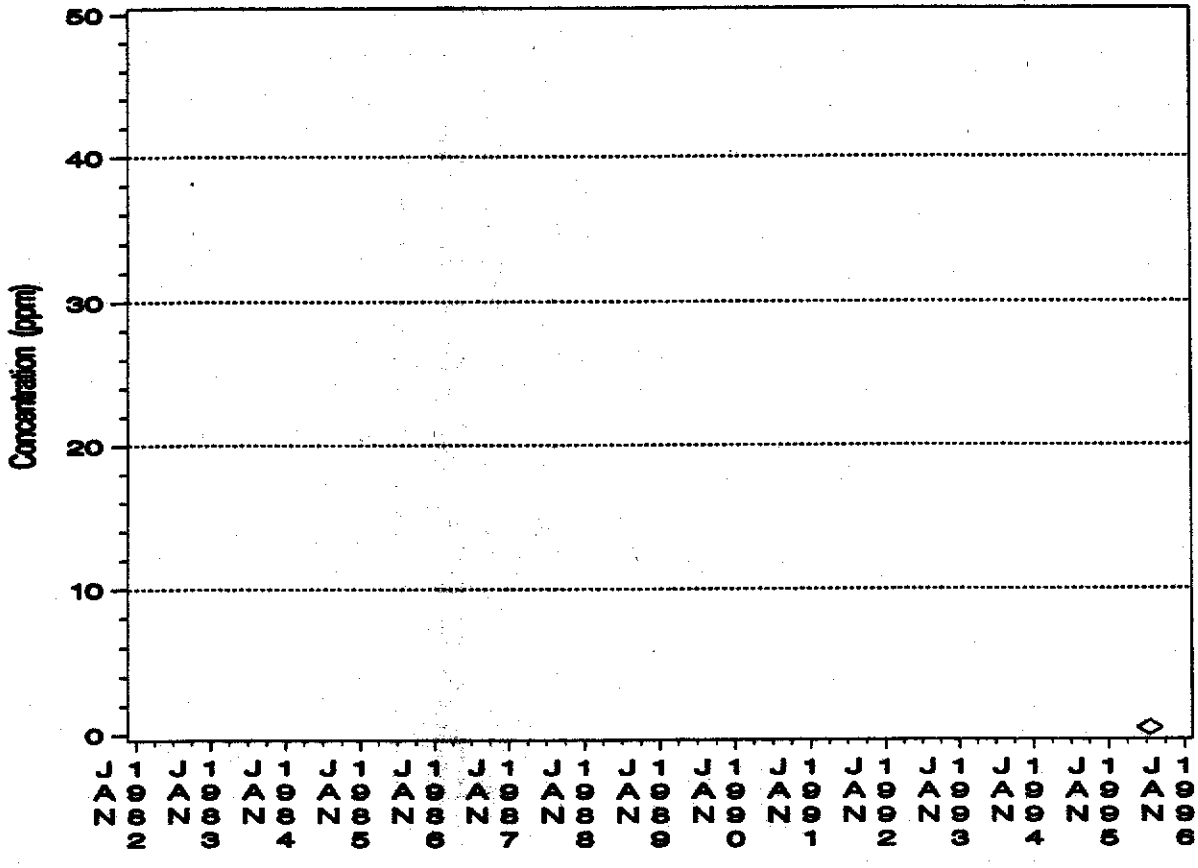
1,2 – DICHLOROETHANE Trend



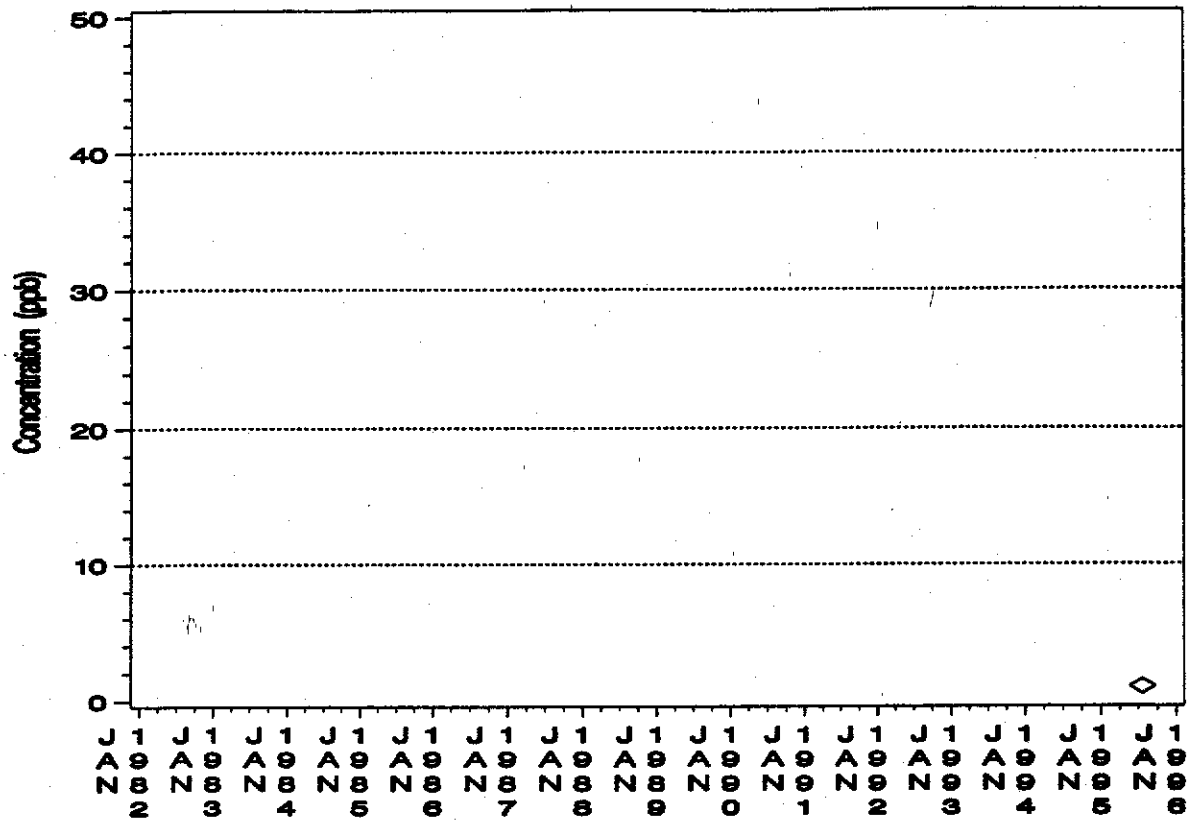
WELL 3431
TRICHLOROETHYLENE Trend



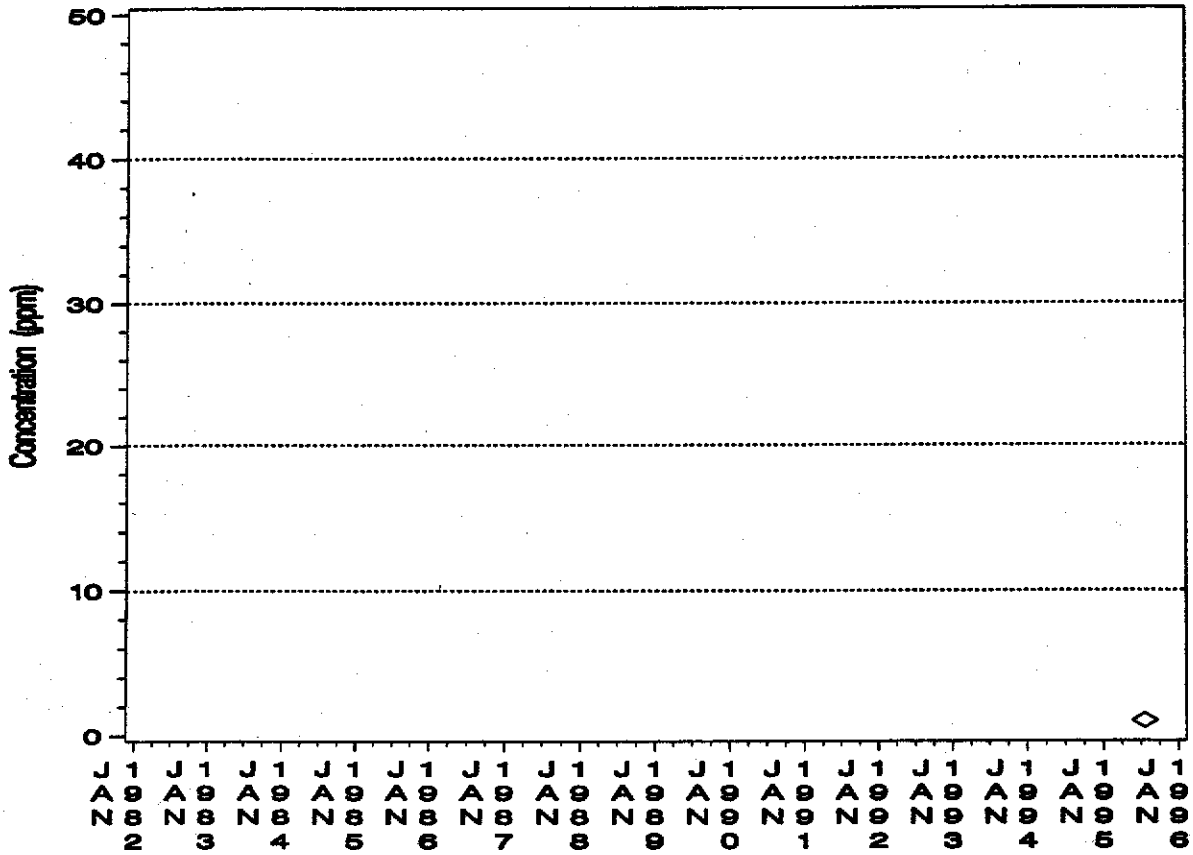
PERCHLORATE Trend



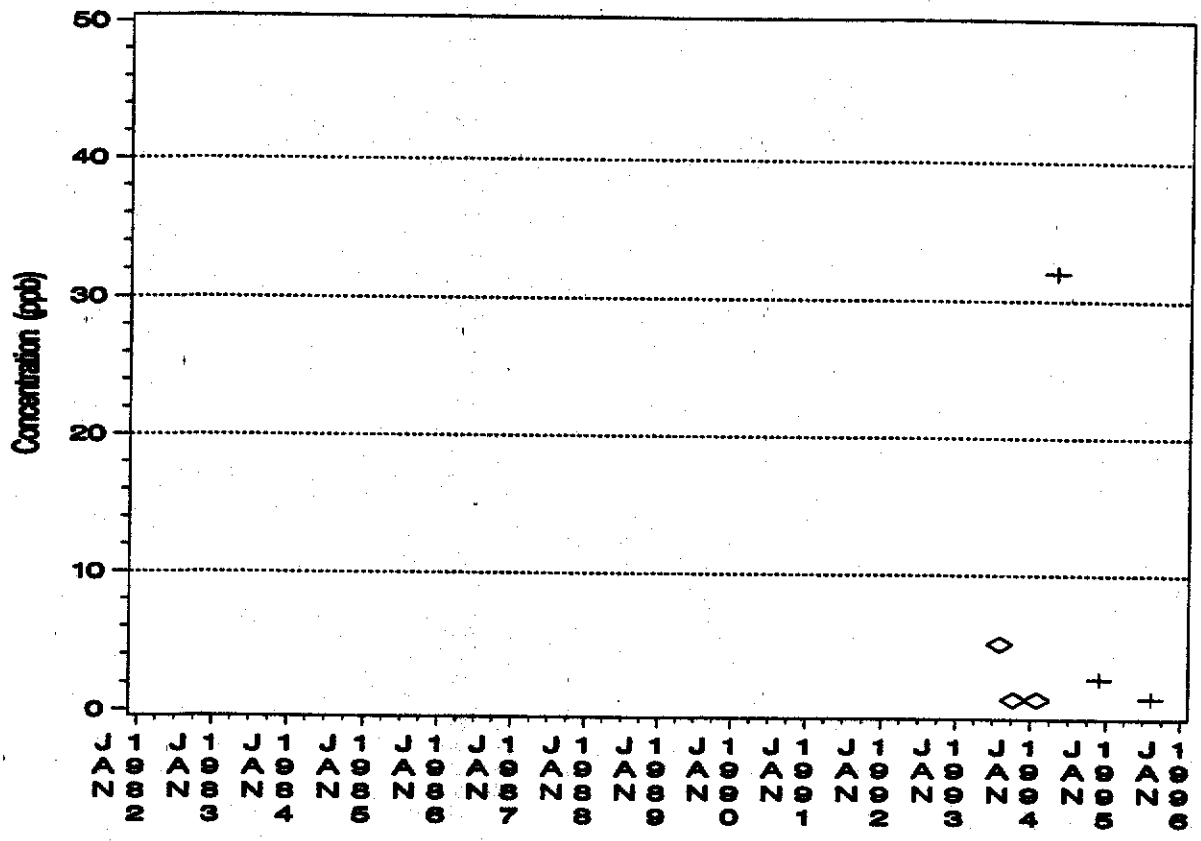
WELL 3431
CHLOROFORM Trend



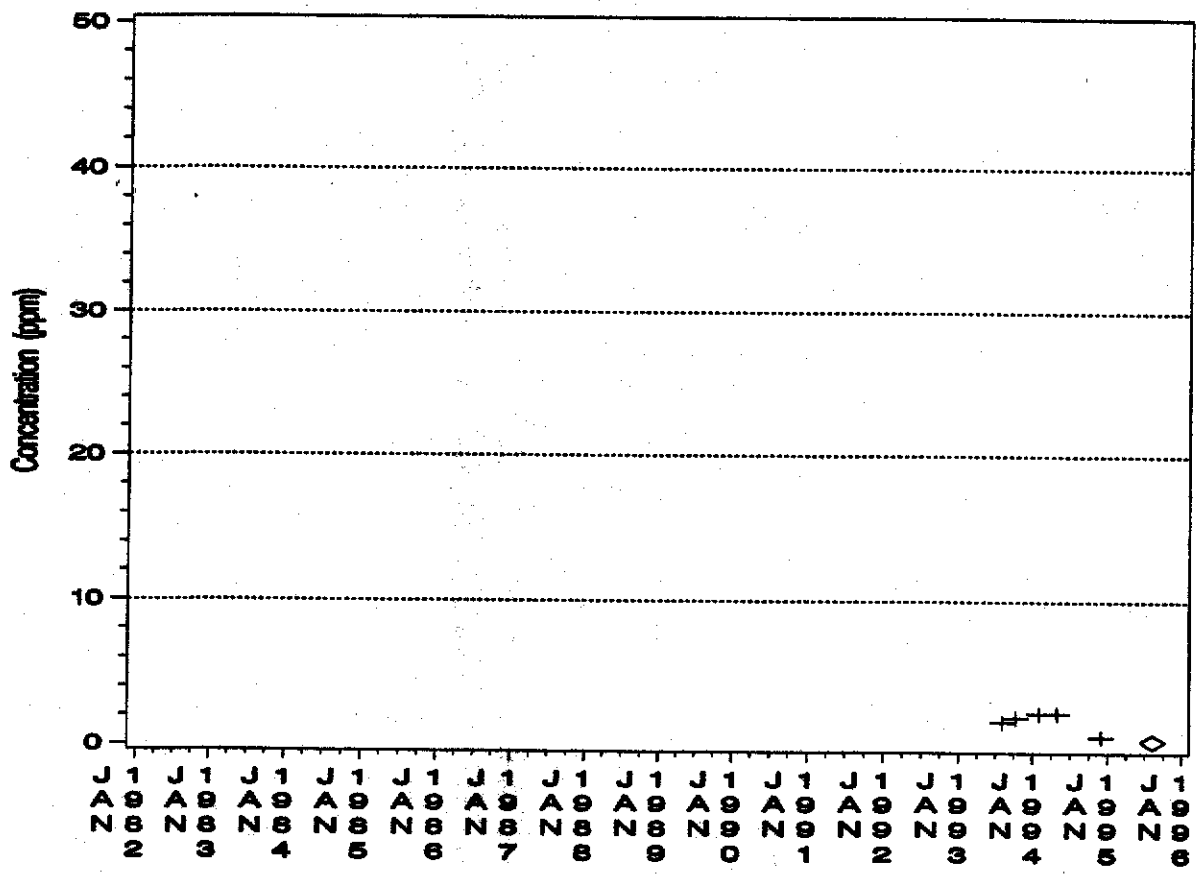
1,2 — DICHLOROETHANE Trend



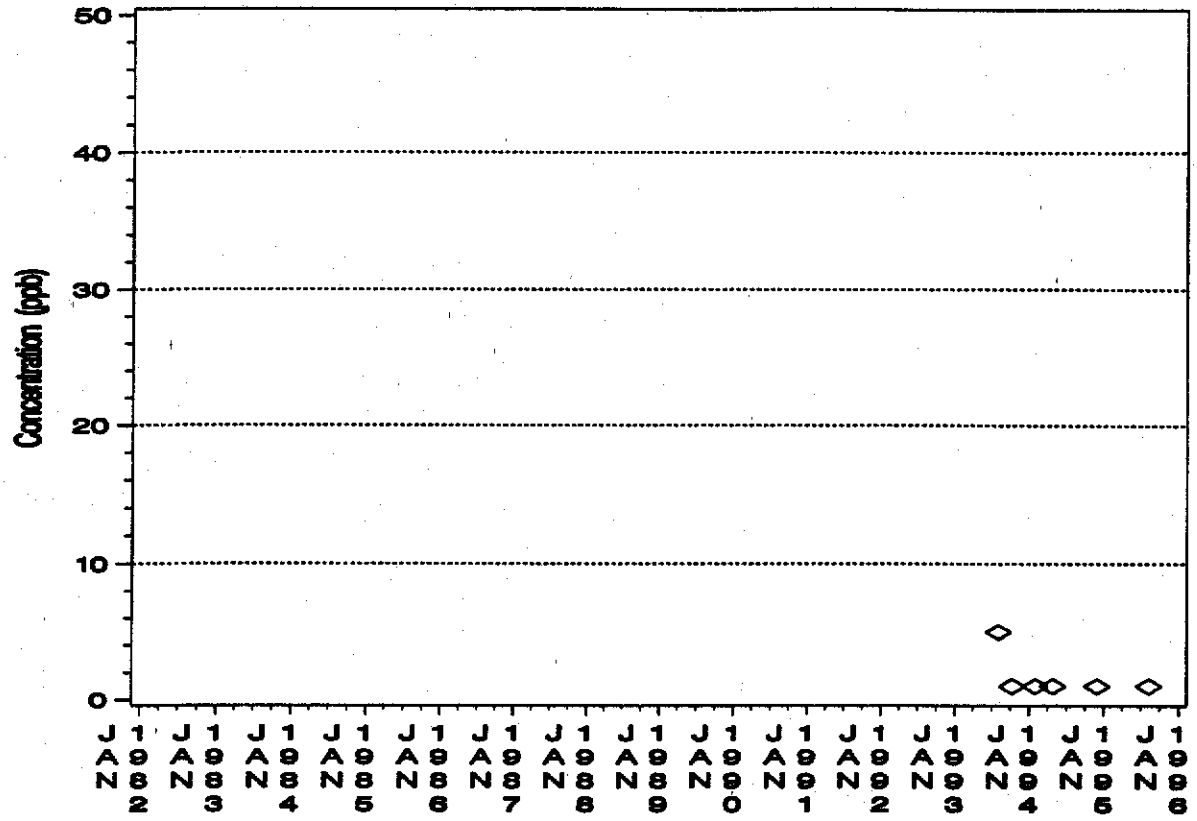
WELL 3439
TRICHLOROETHYLENE Trend



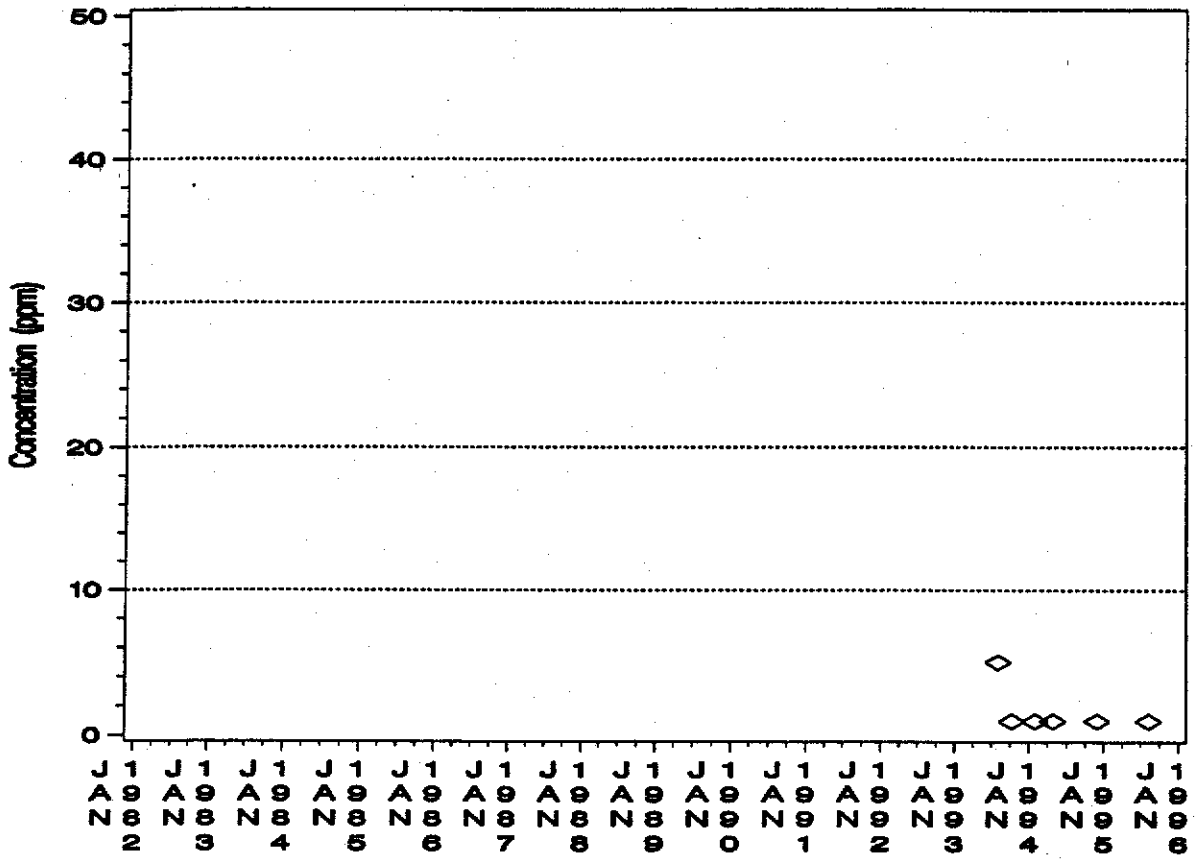
PERCHLORATE Trend



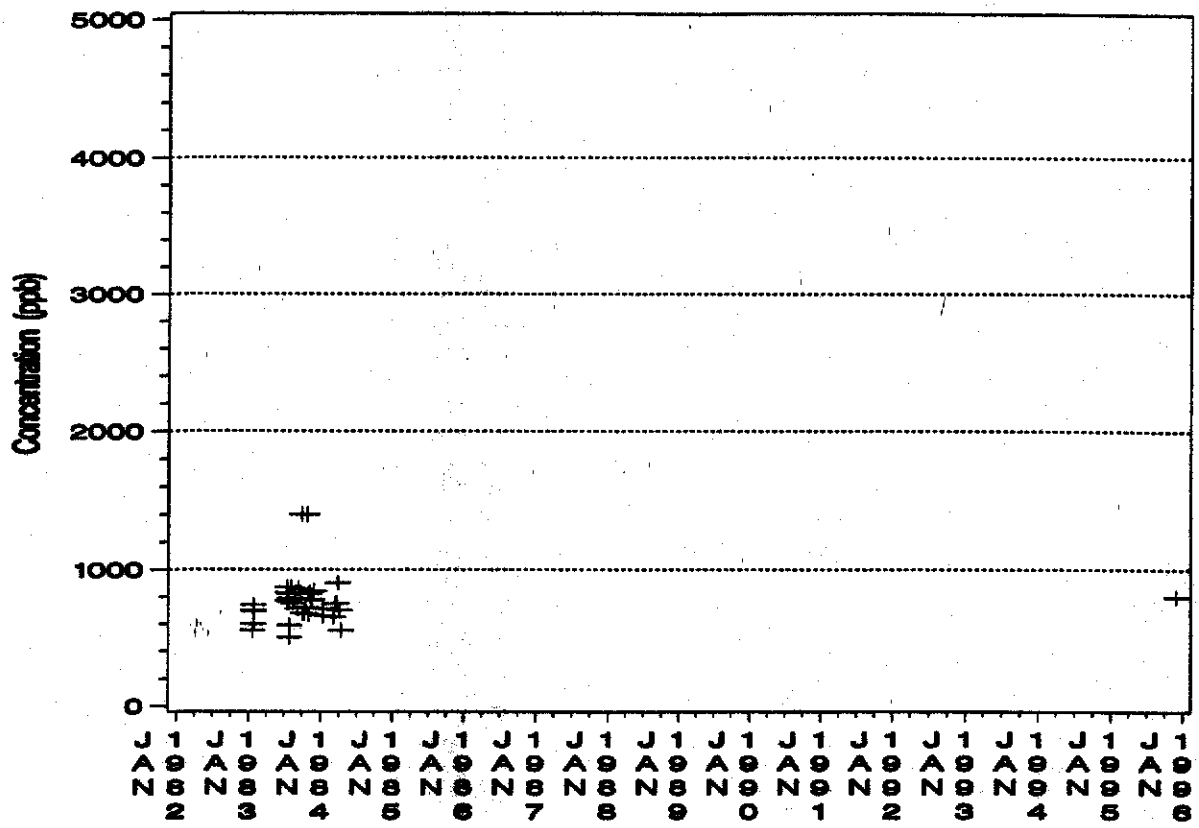
WELL 3439
CHLOROFORM Trend



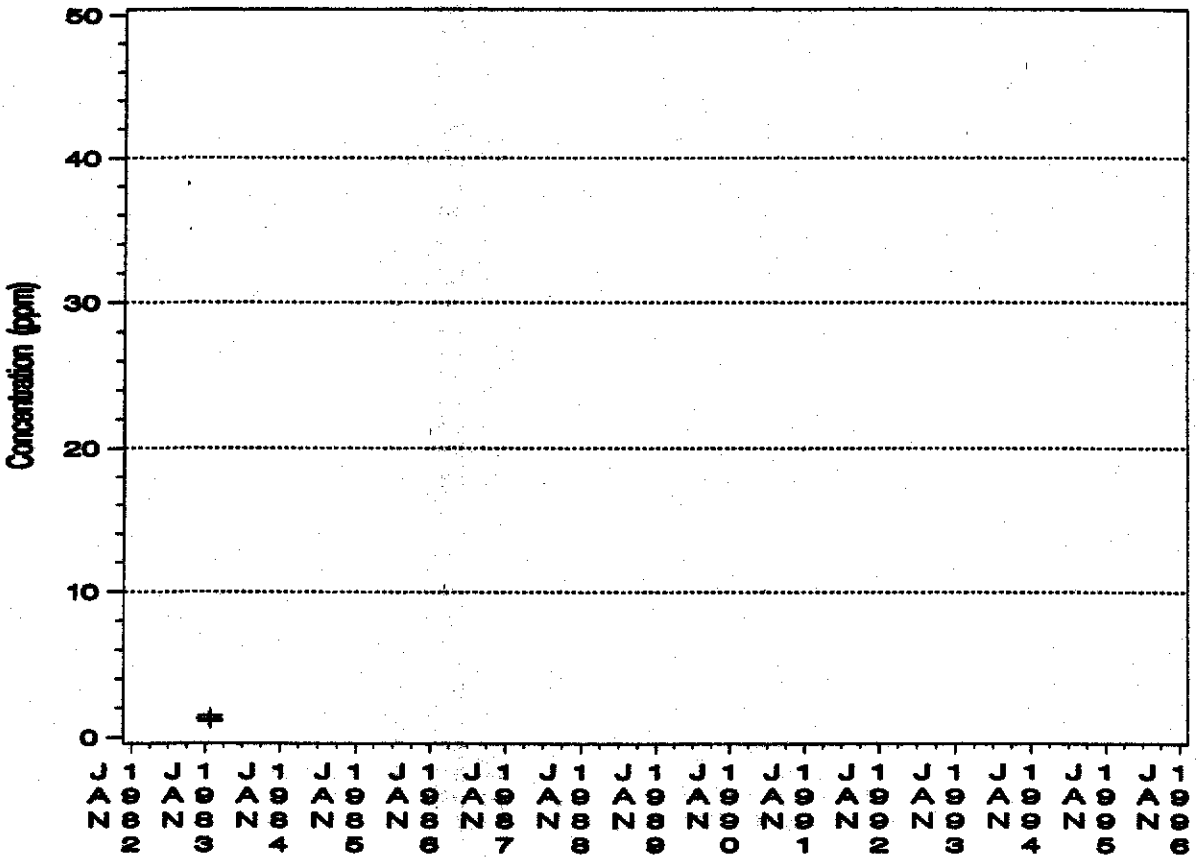
1,2 – DICHLOROETHANE Trend



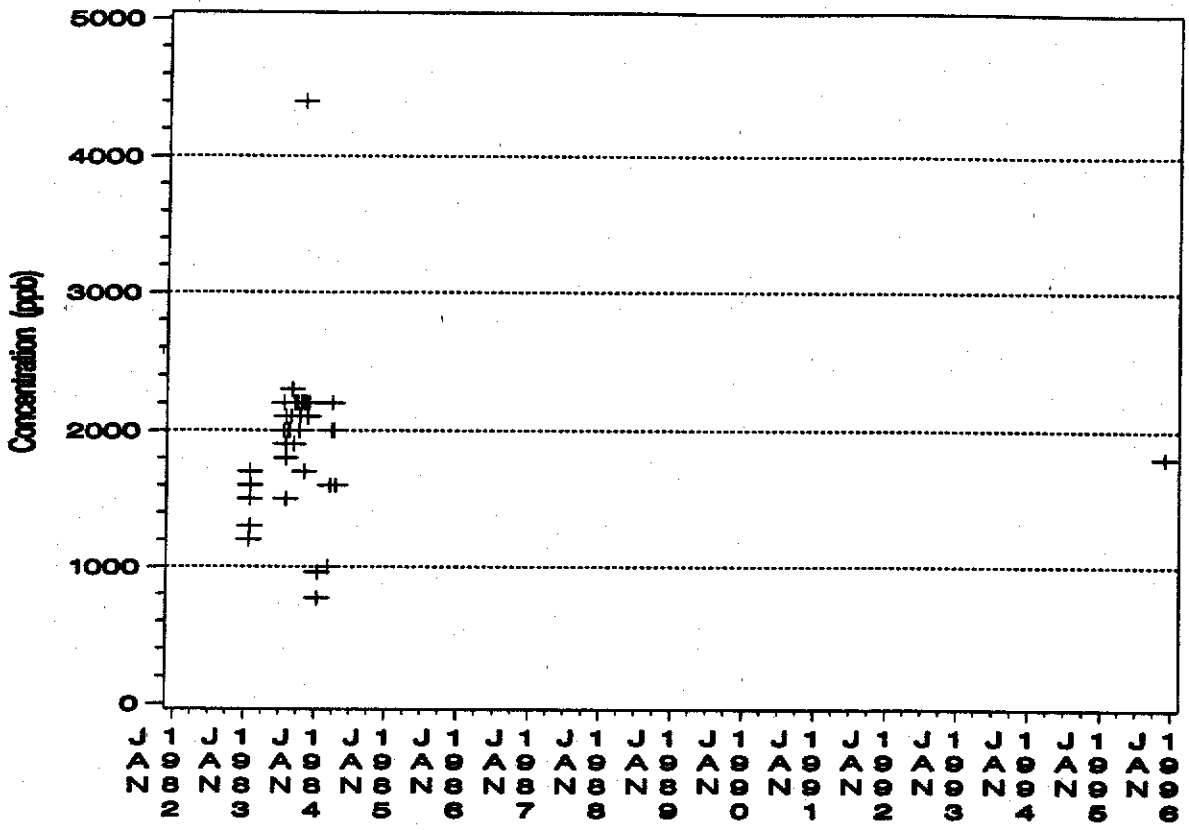
WELL 4018
TRICHLOROETHYLENE Trend



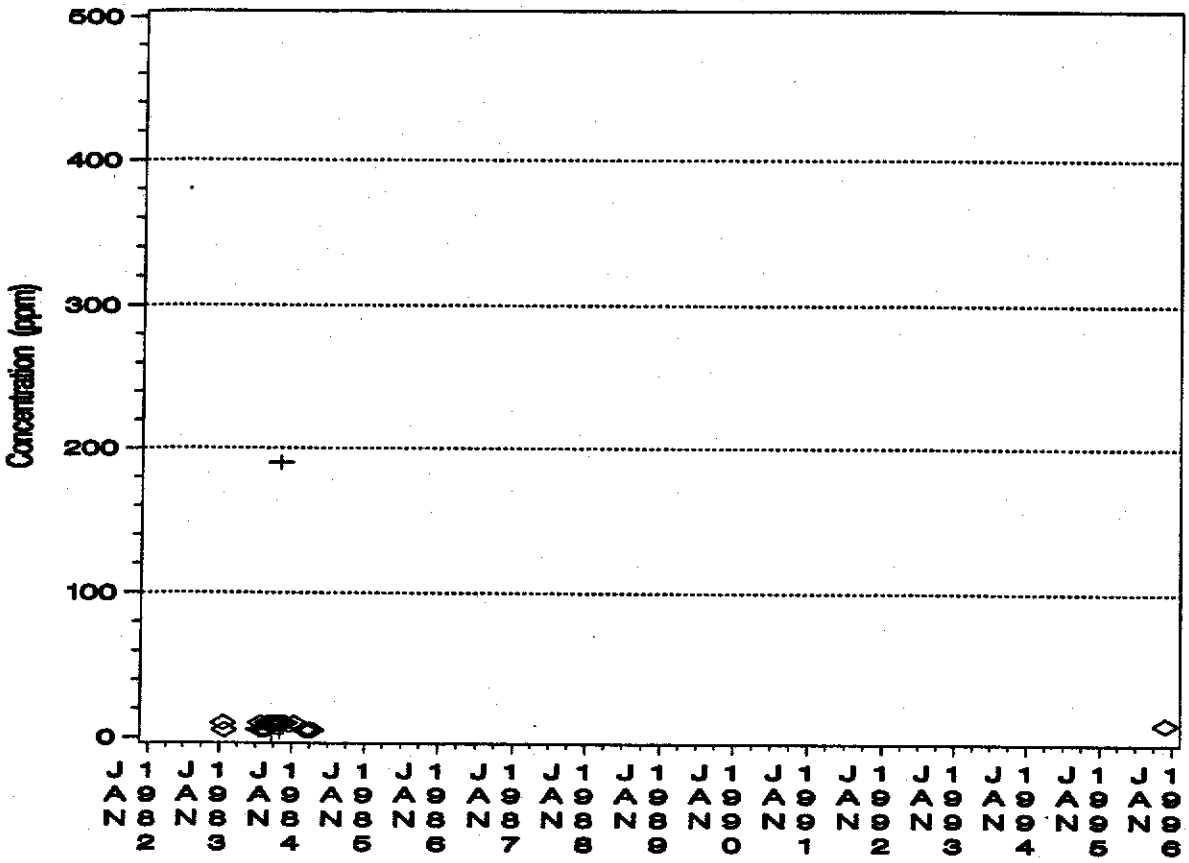
PERCHLORATE Trend



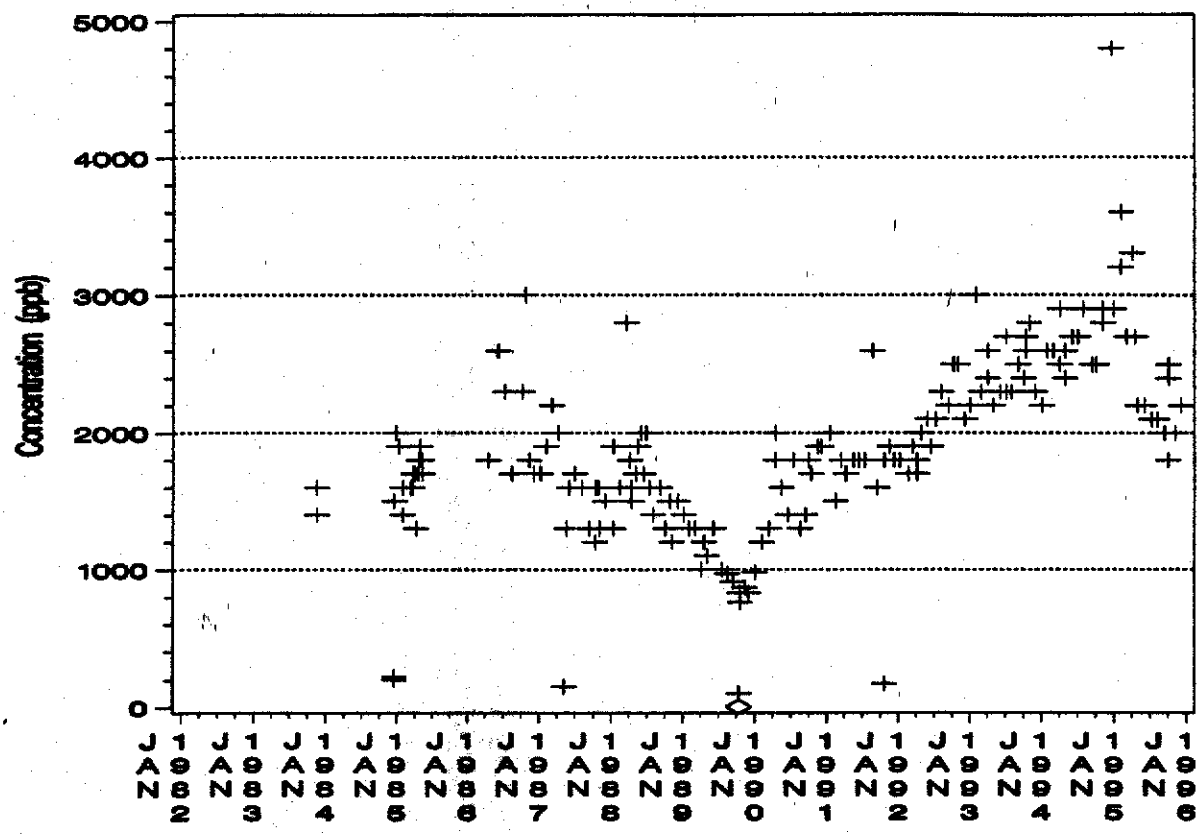
WELL 4018
CHLOROFORM Trend



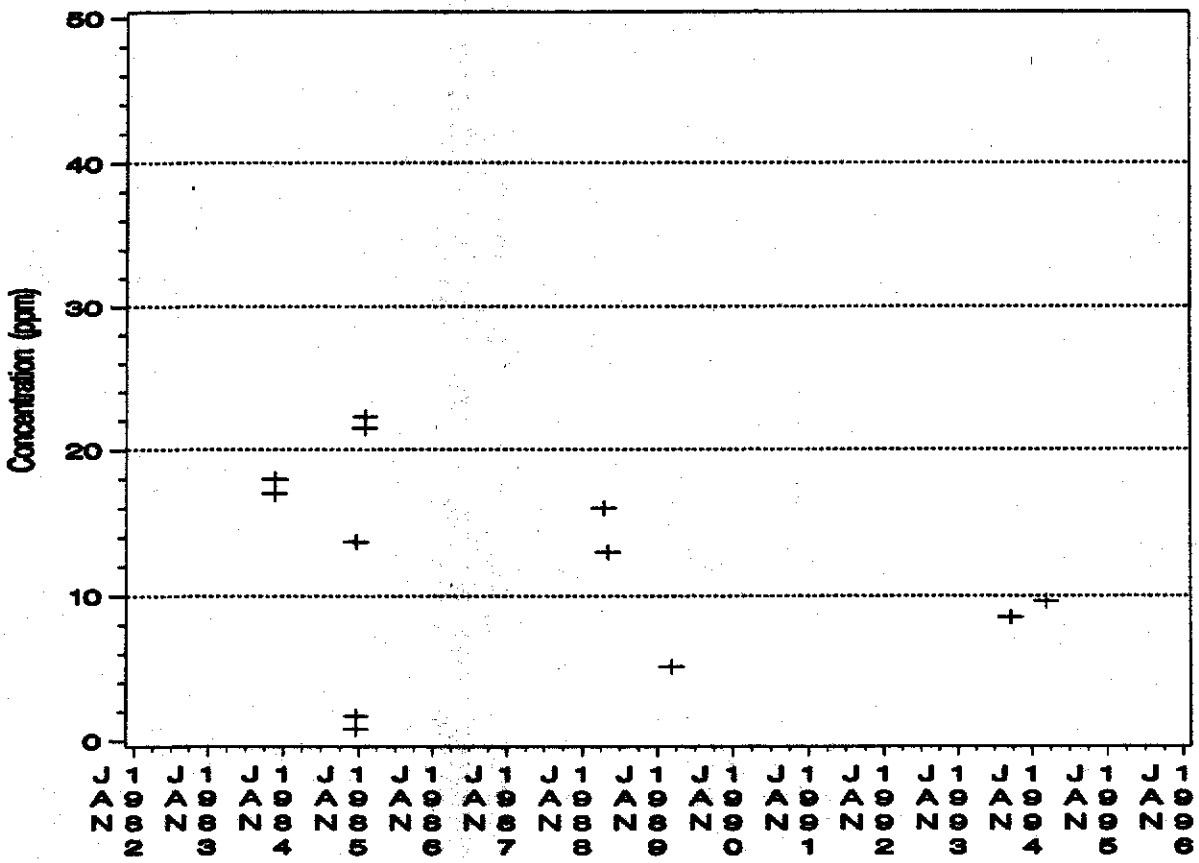
1,2 — DICHLOROETHANE Trend



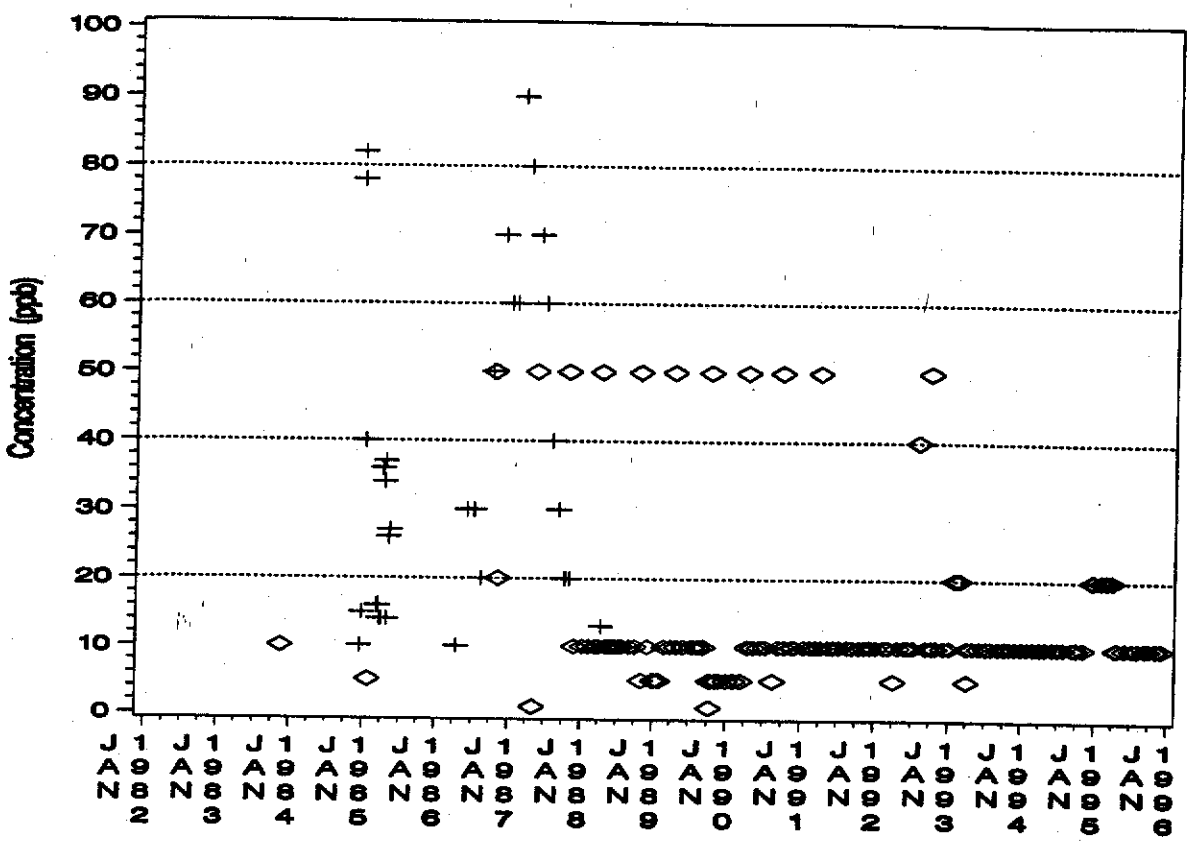
WELL 4060
TRICHLOROETHYLENE Trend



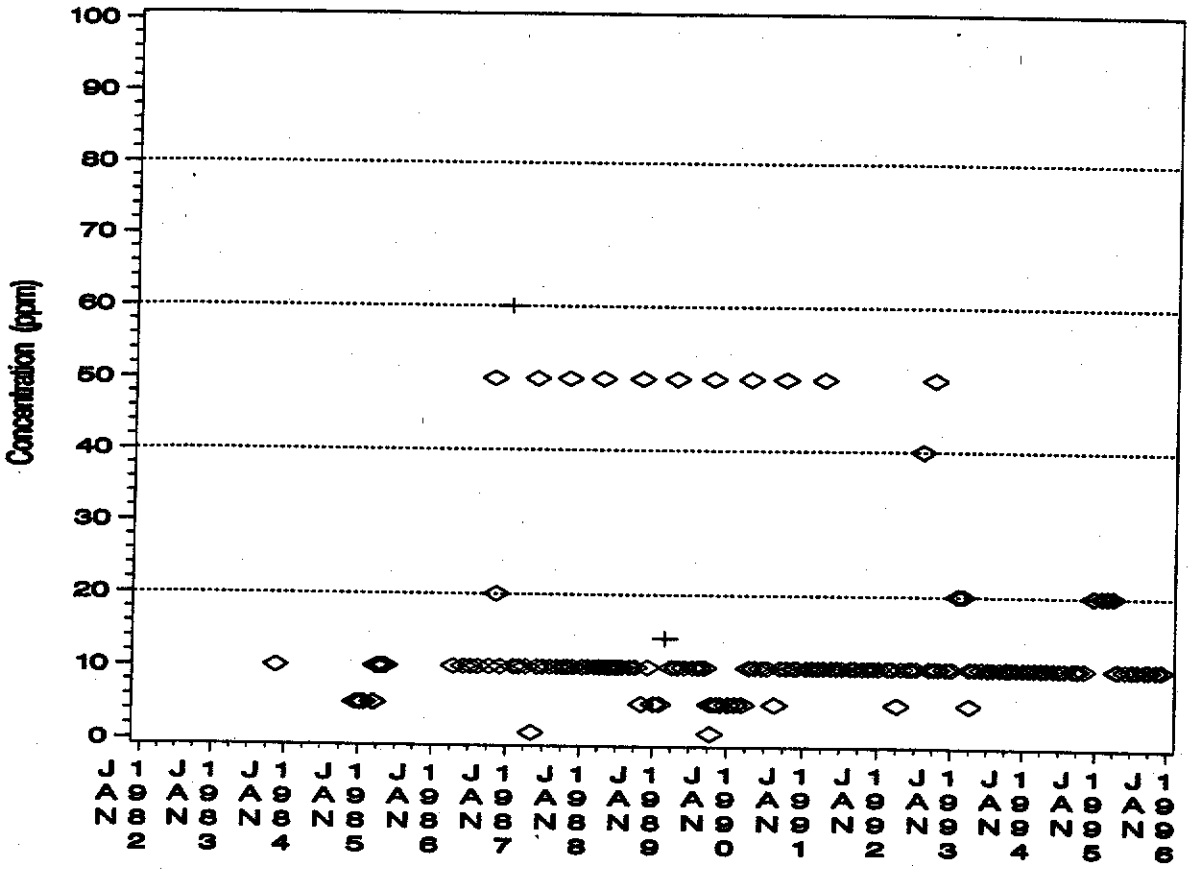
PERCHLORATE Trend



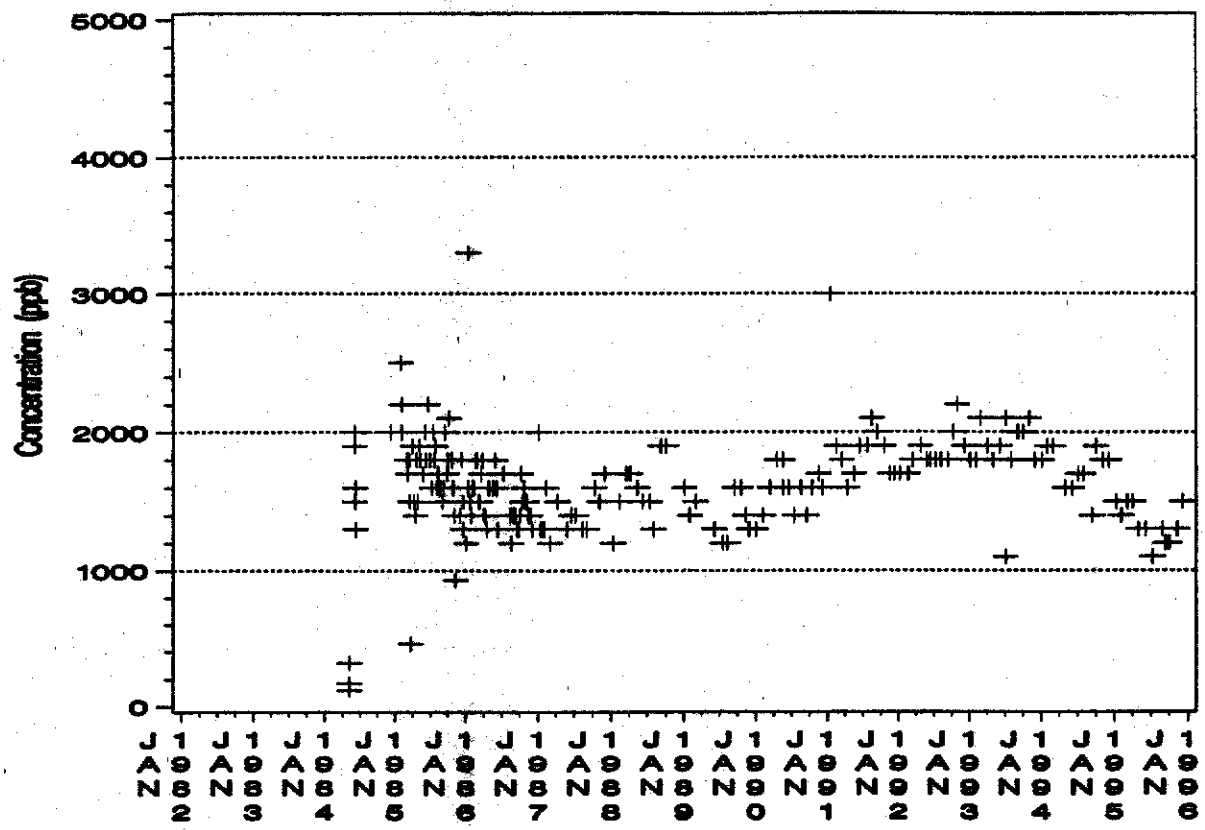
WELL 4060
CHLOROFORM Trend



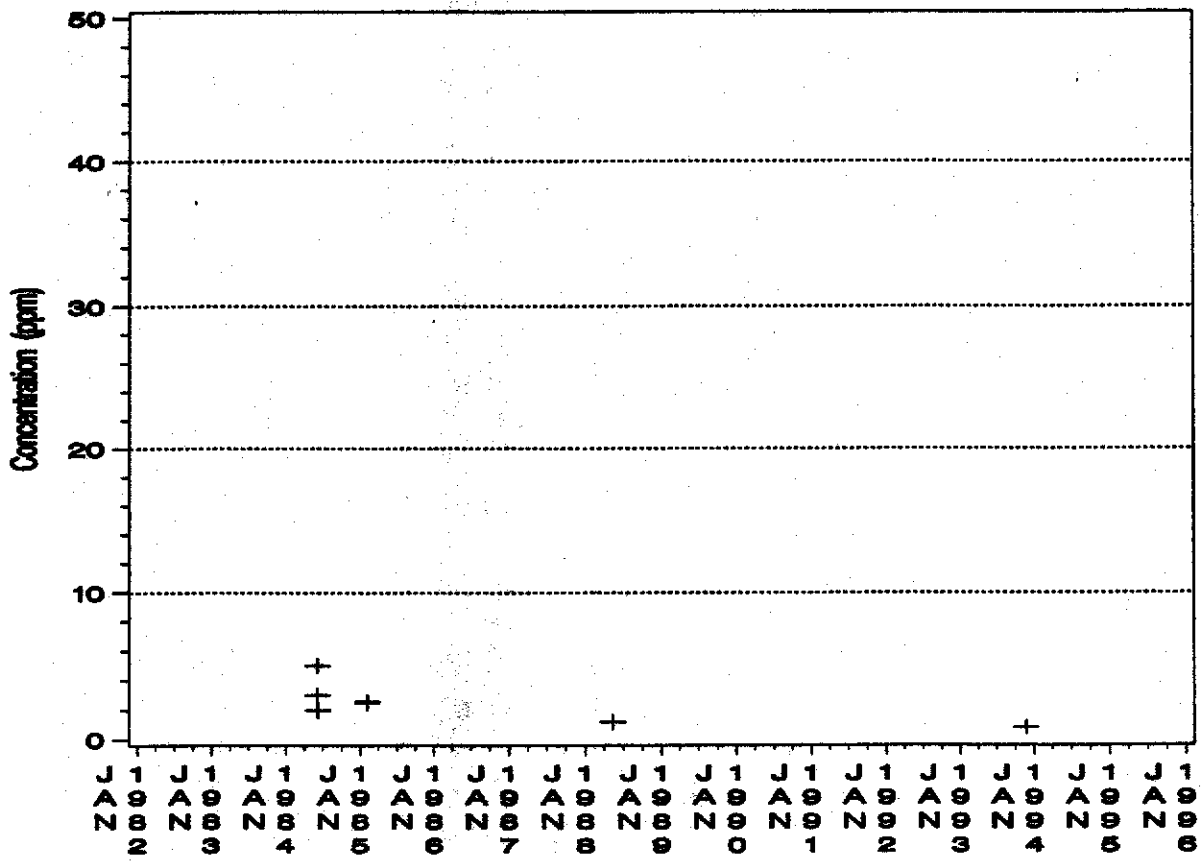
1,2 – DICHLOROETHANE Trend



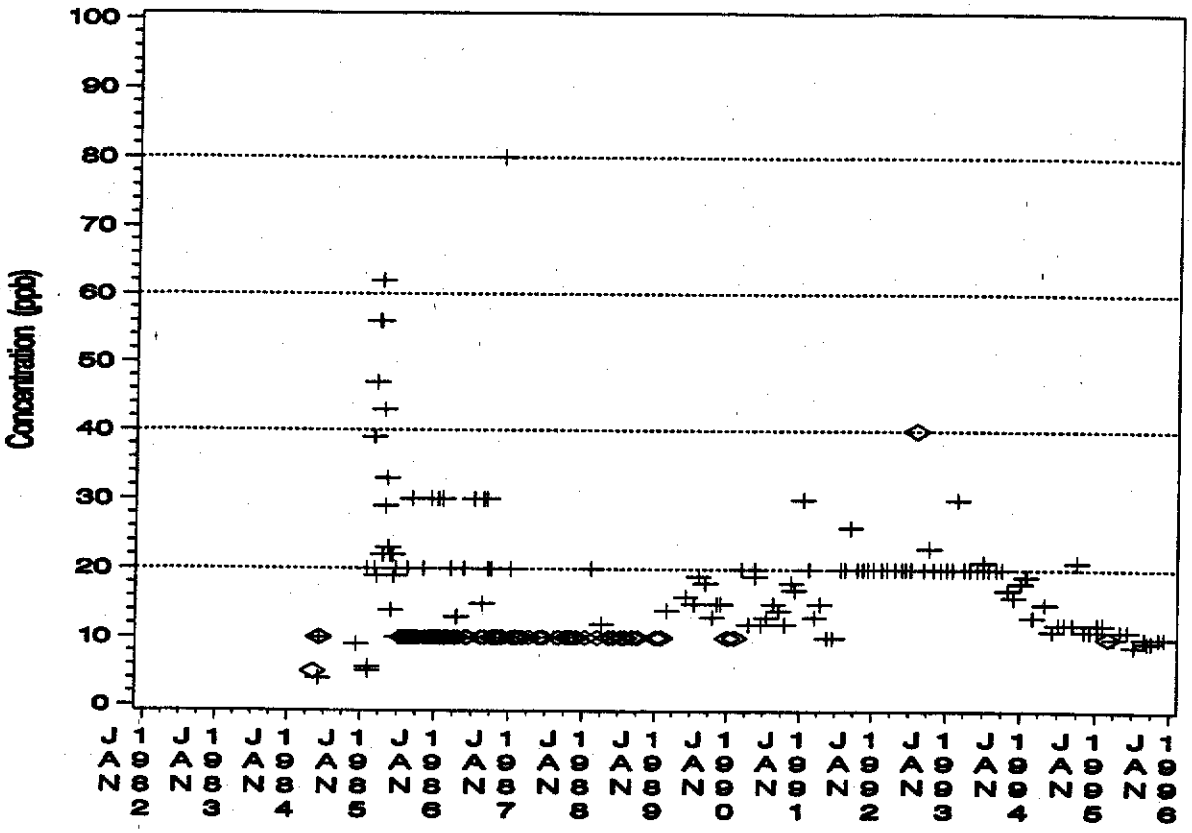
WELL 4070
TRICHLOROETHYLENE Trend



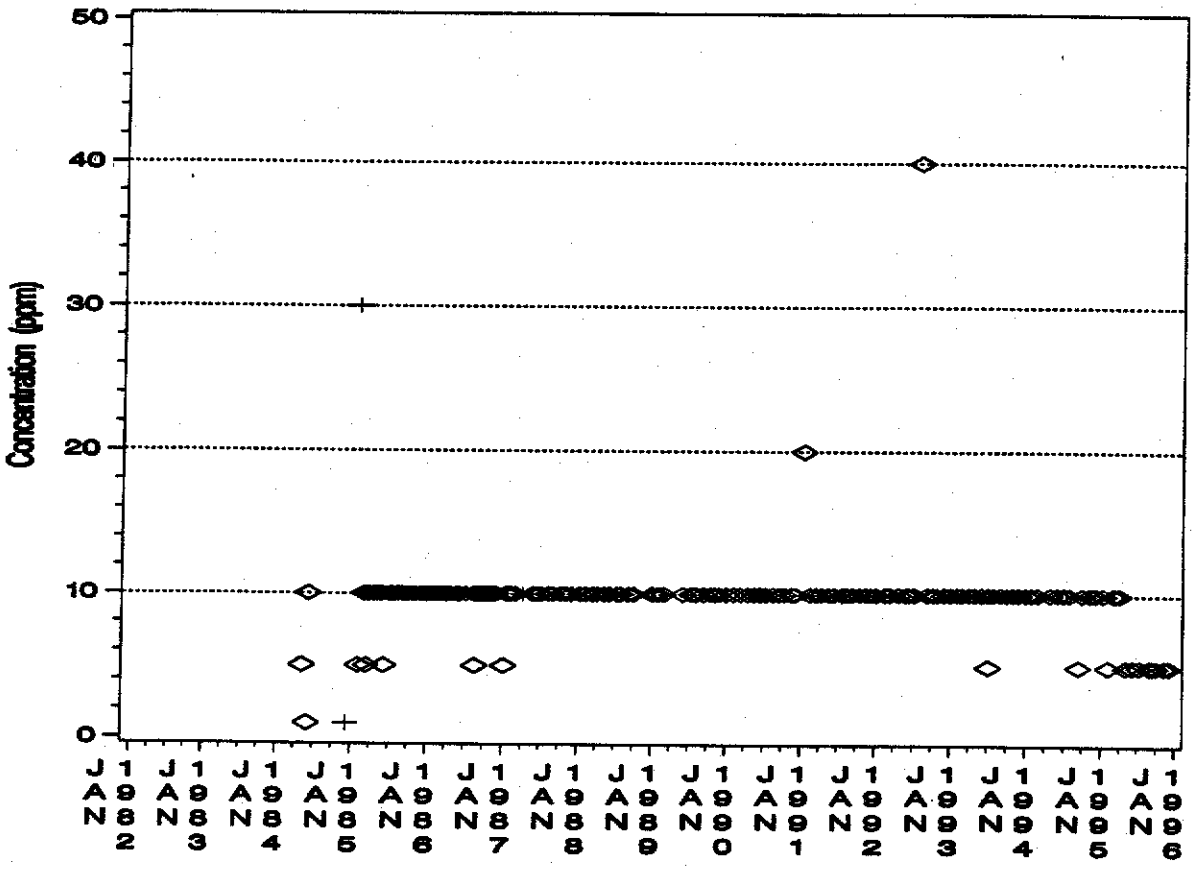
PERCHLORATE Trend



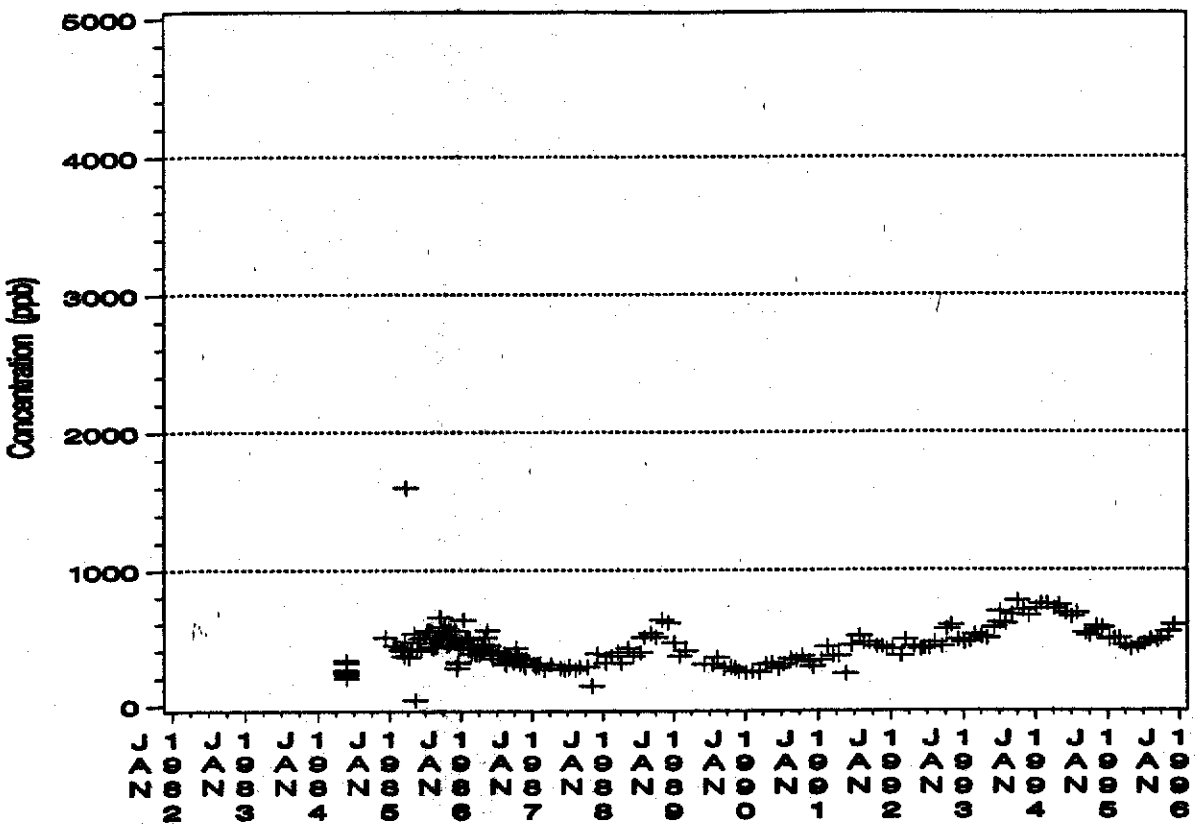
WELL 4070
CHLOROFORM Trend



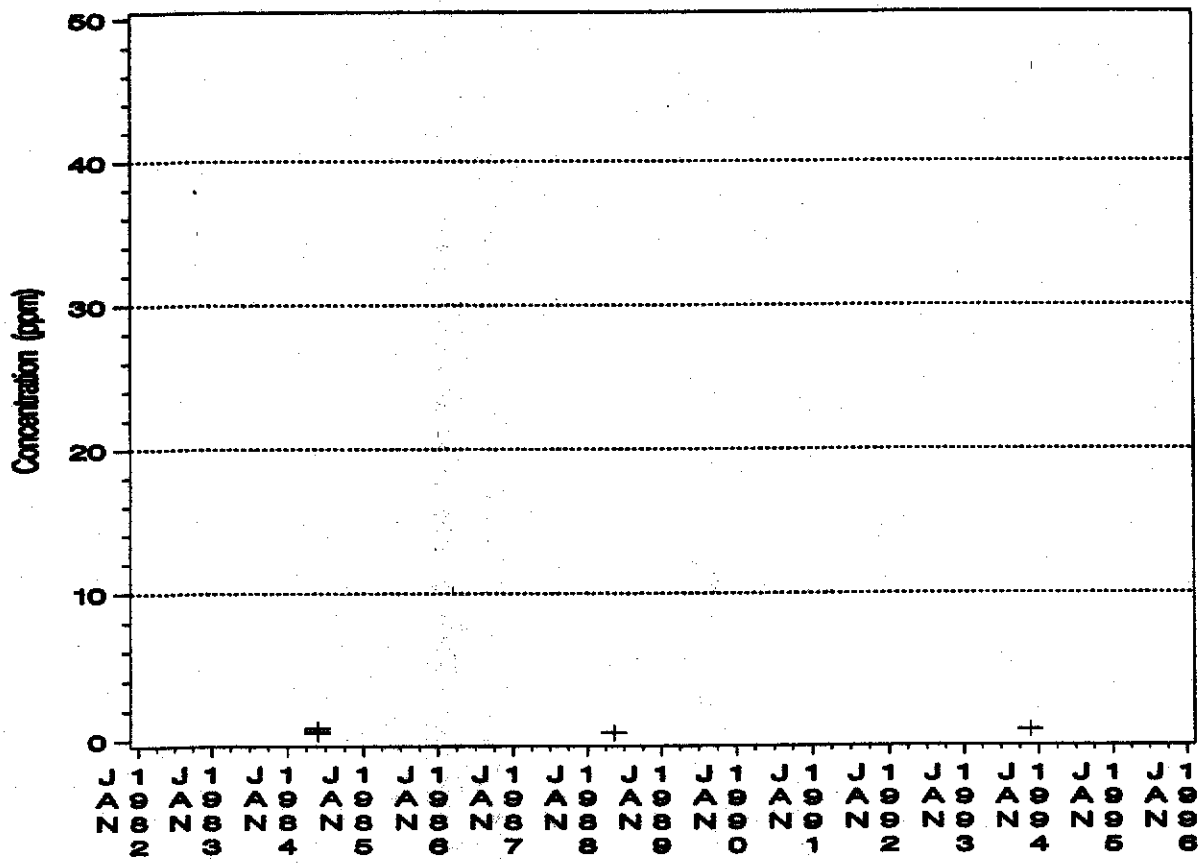
1,2 – DICHLOROETHANE Trend



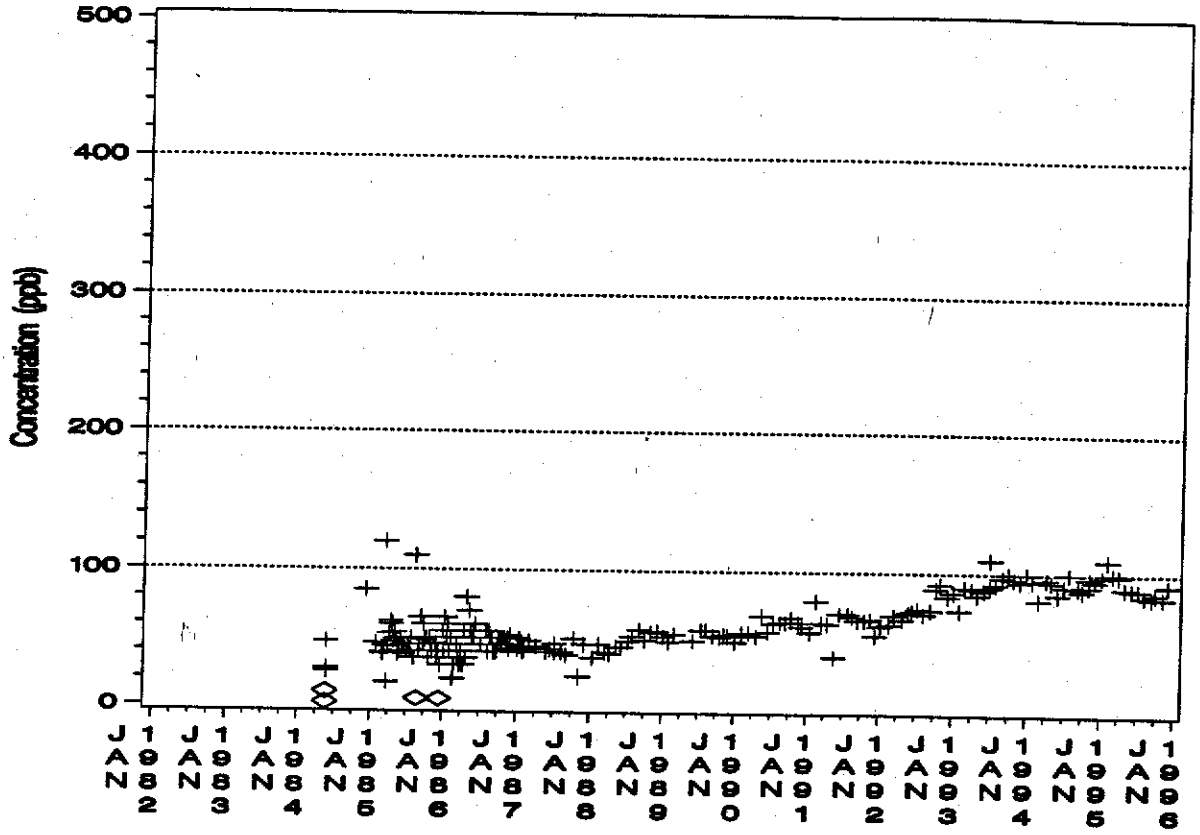
WELL 4075
TRICHLOROETHYLENE Trend



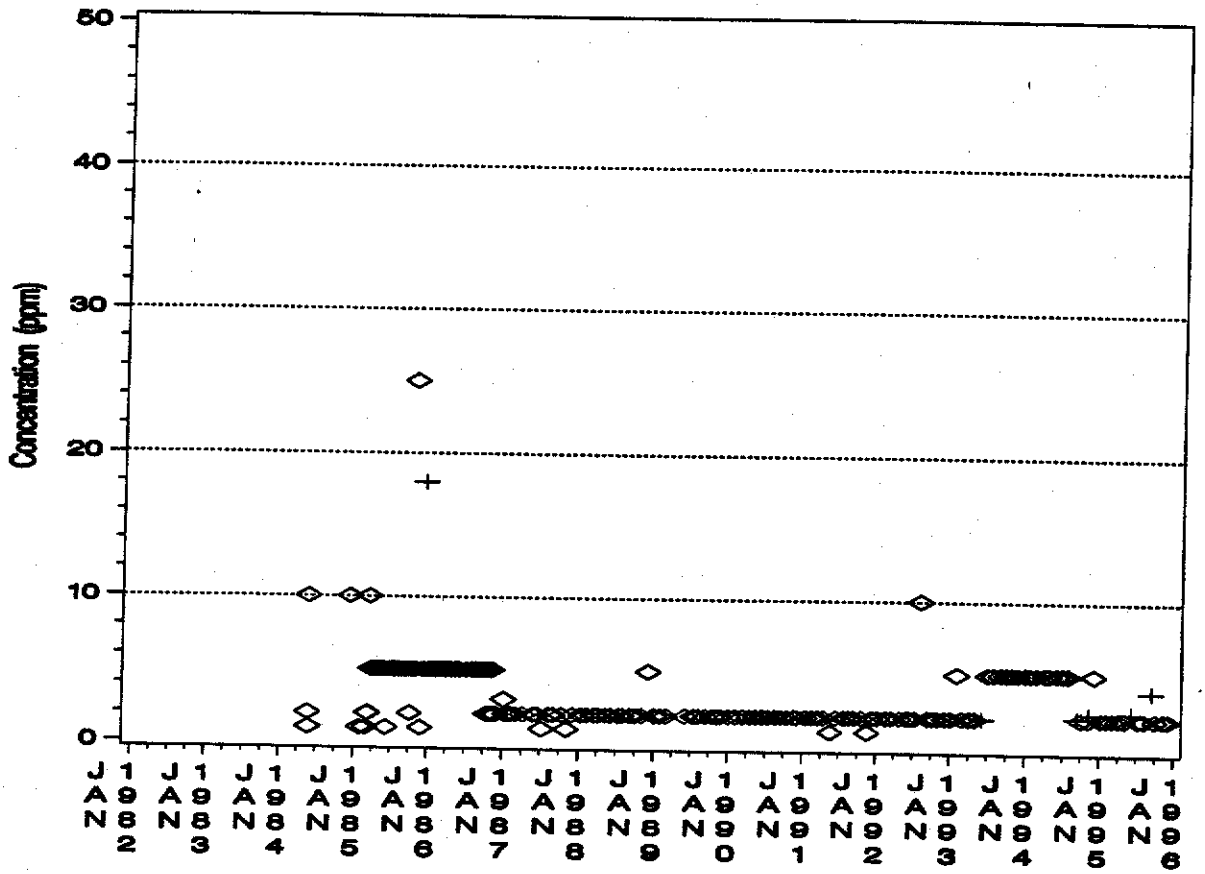
PERCHLORATE Trend



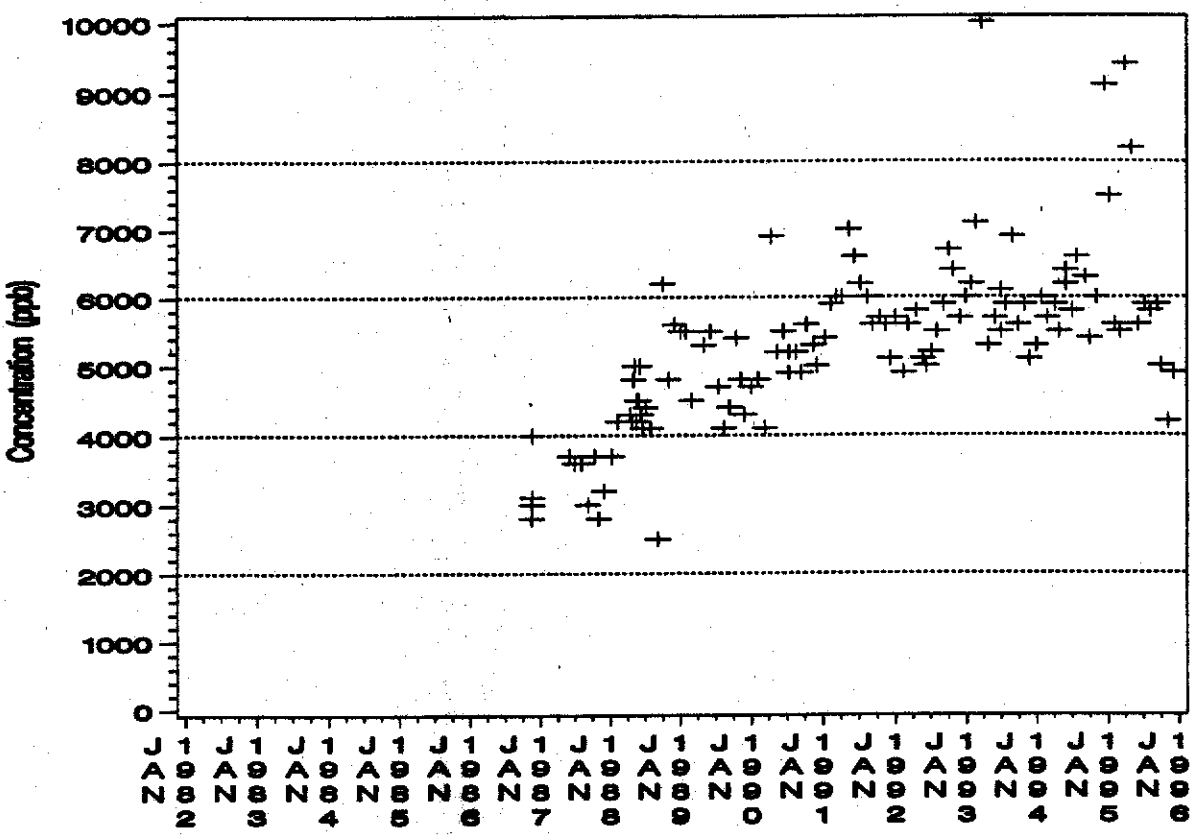
WELL 4075
CHLOROFORM Trend



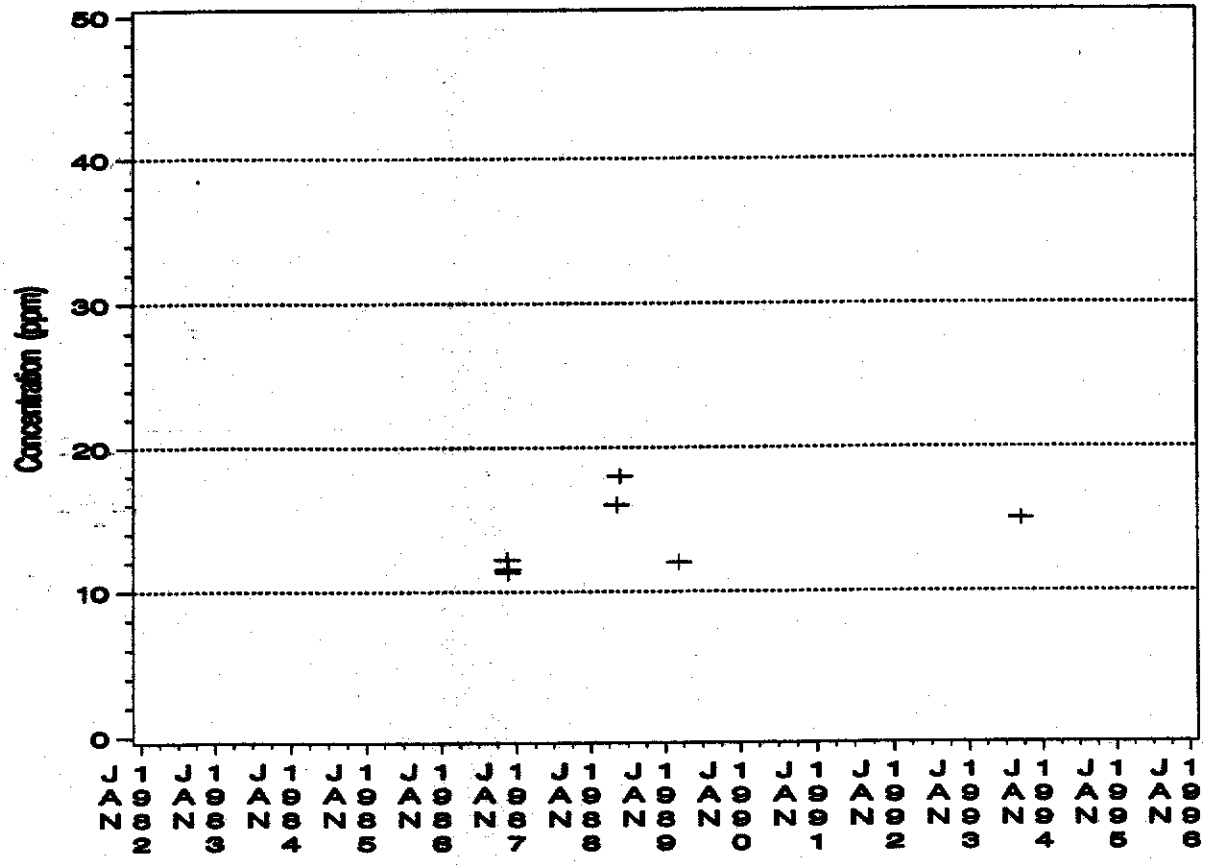
1,2 – DICHLOROETHANE Trend



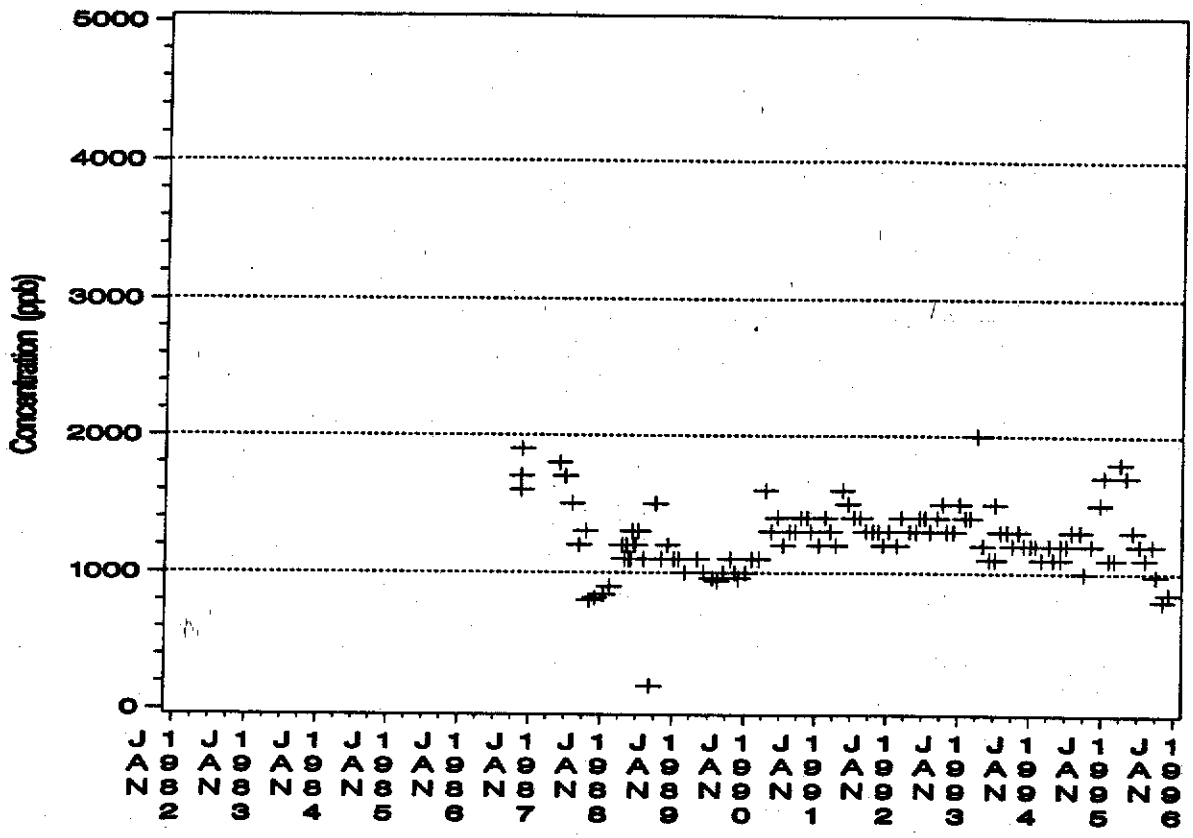
WELL 4140
TRICHLOROETHYLENE Trend



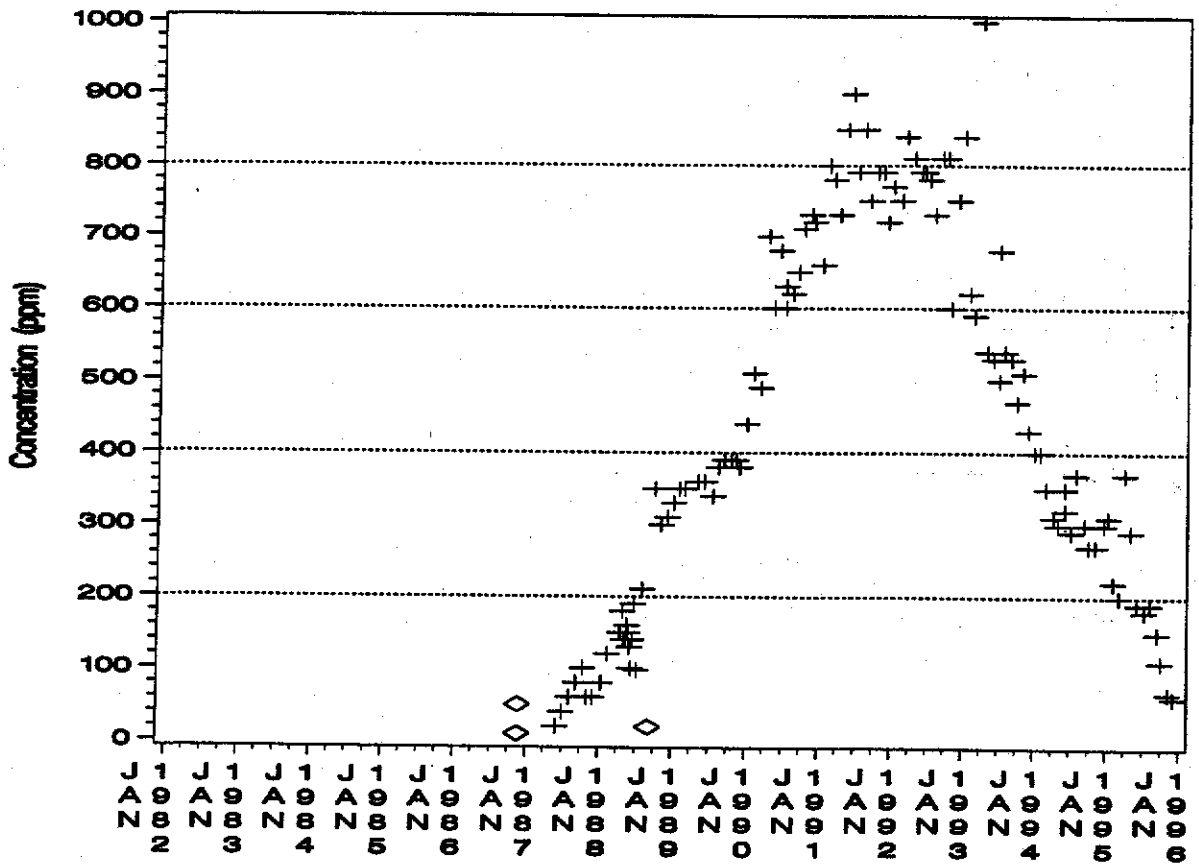
PERCHLORATE Trend



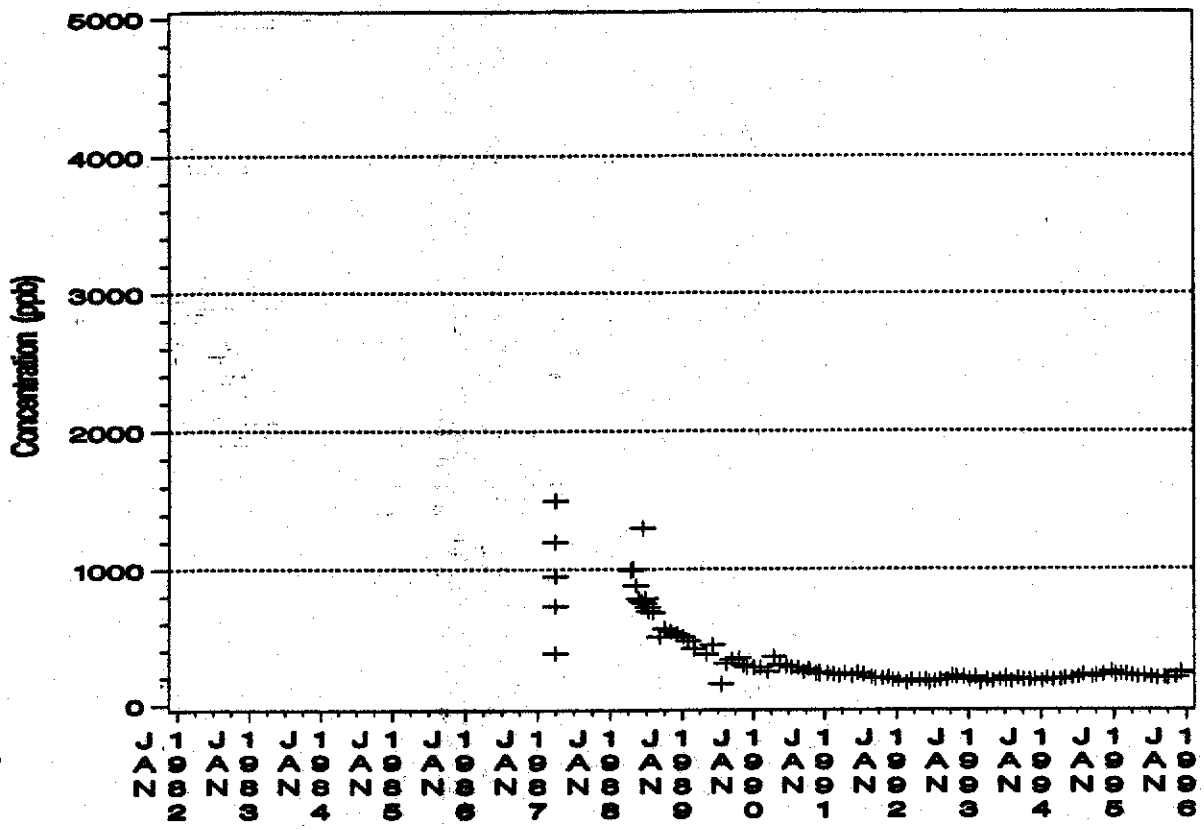
WELL 4140
CHLOROFORM Trend



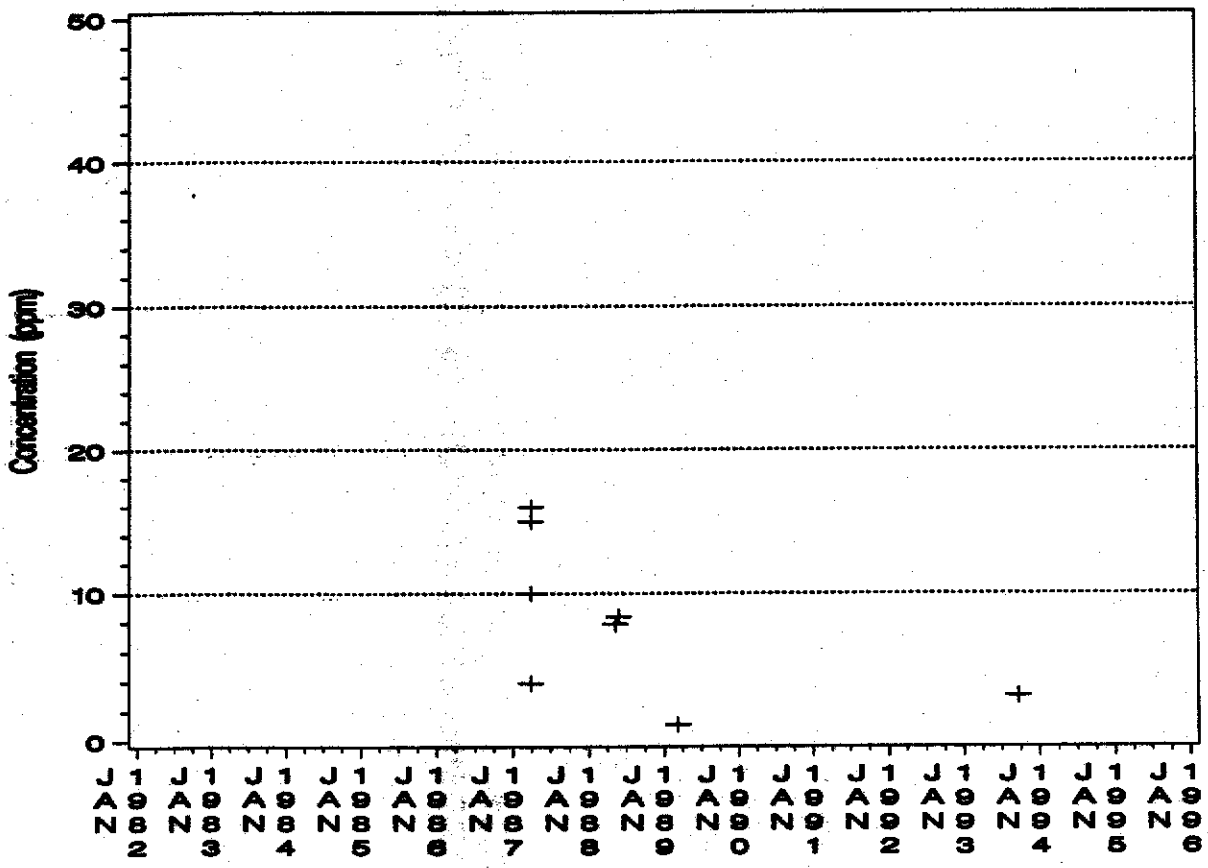
1,2 – DICHLOROETHANE Trend



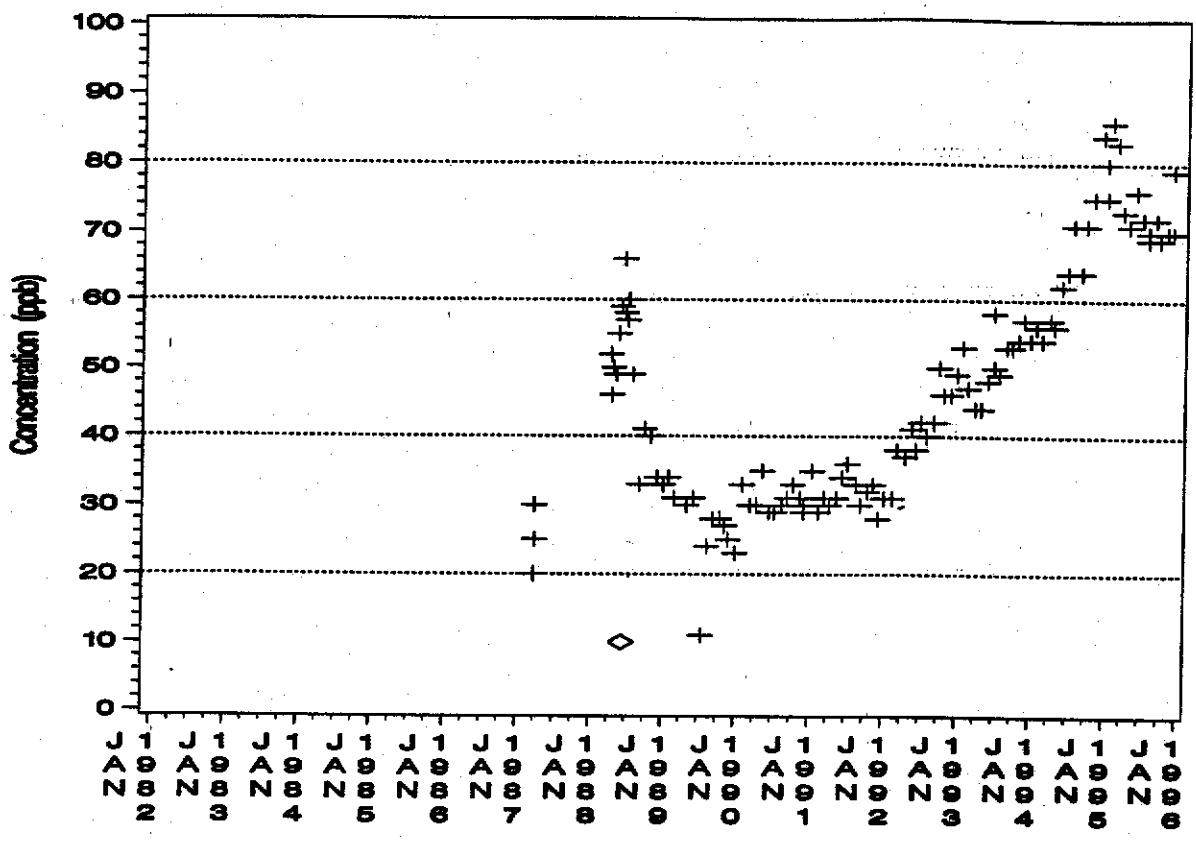
WELL 4145
TRICHLOROETHYLENE Trend



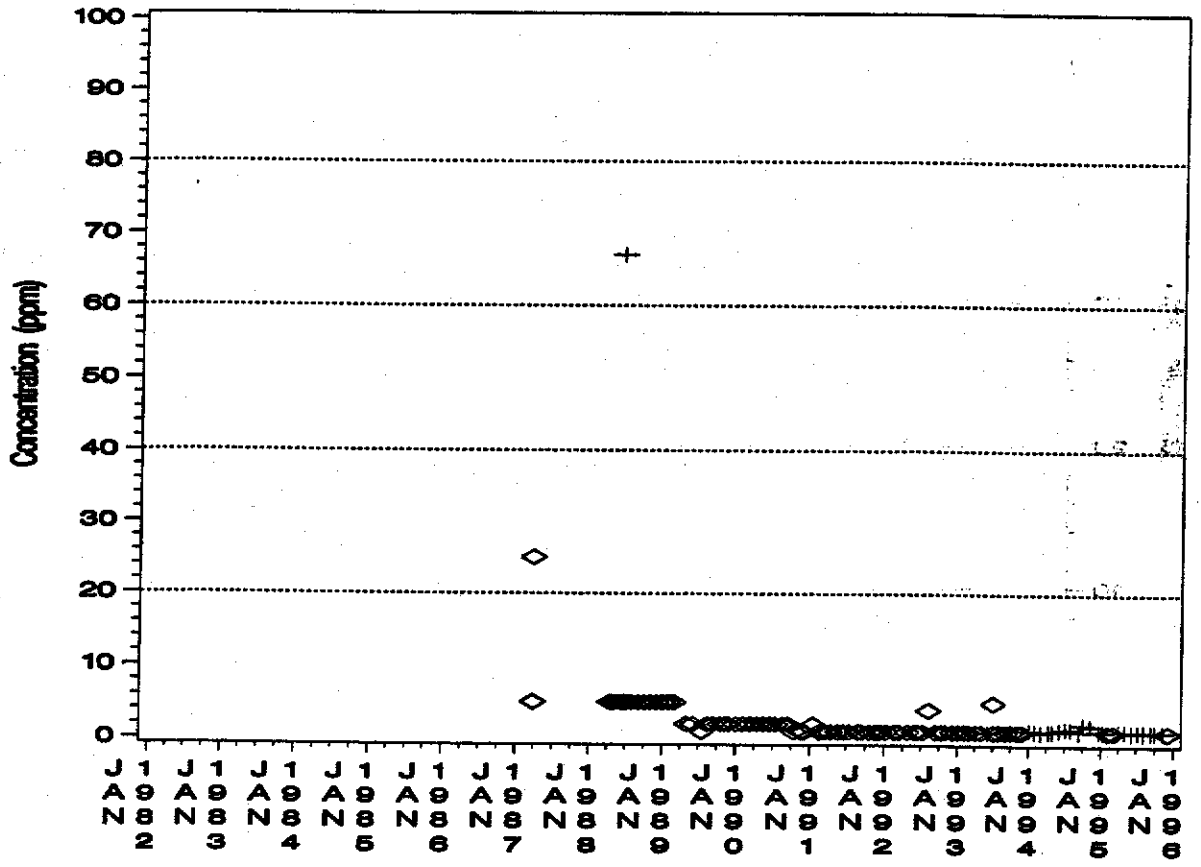
PERCHLORATE Trend



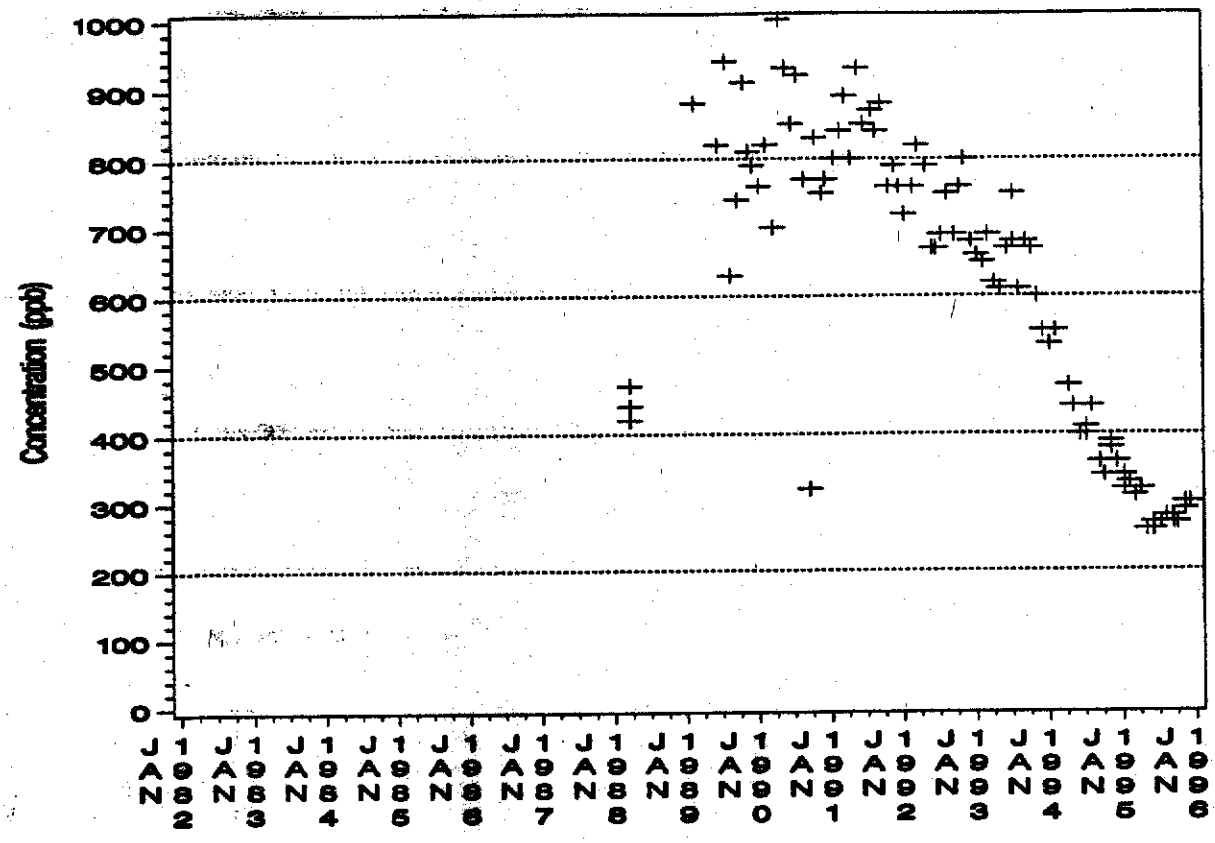
WELL 4145
CHLOROFORM Trend



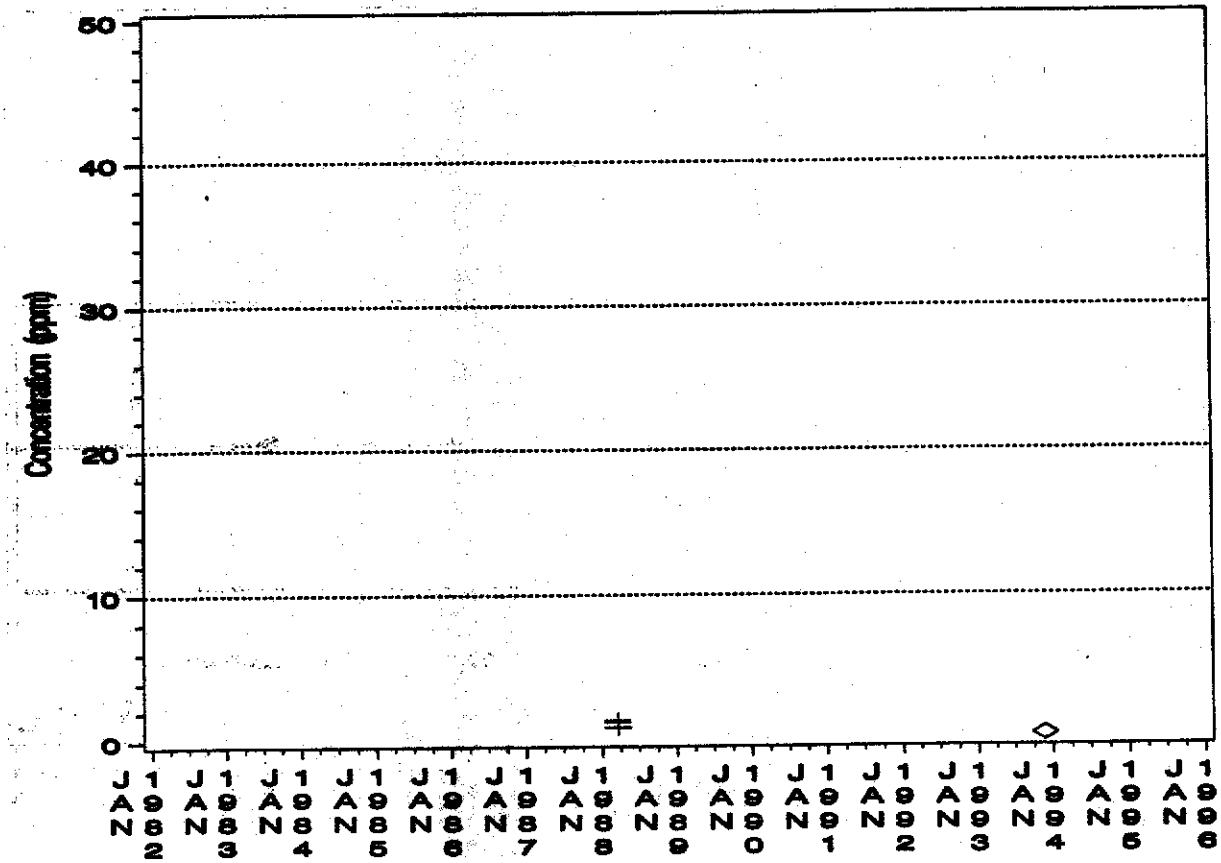
1,2 – DICHLOROETHANE Trend



WELL 4200
TRICHLOROETHYLENE Trend



PERCHLORATE Trend



WELL 4200
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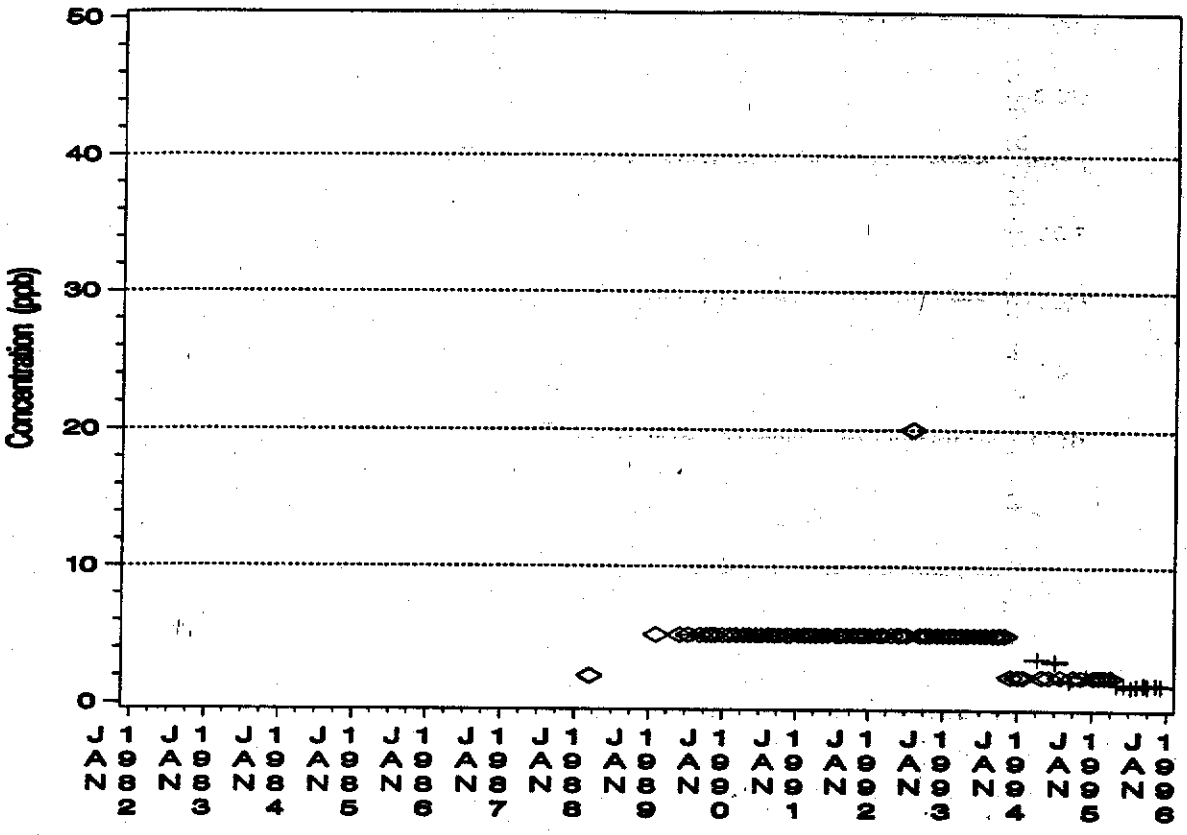
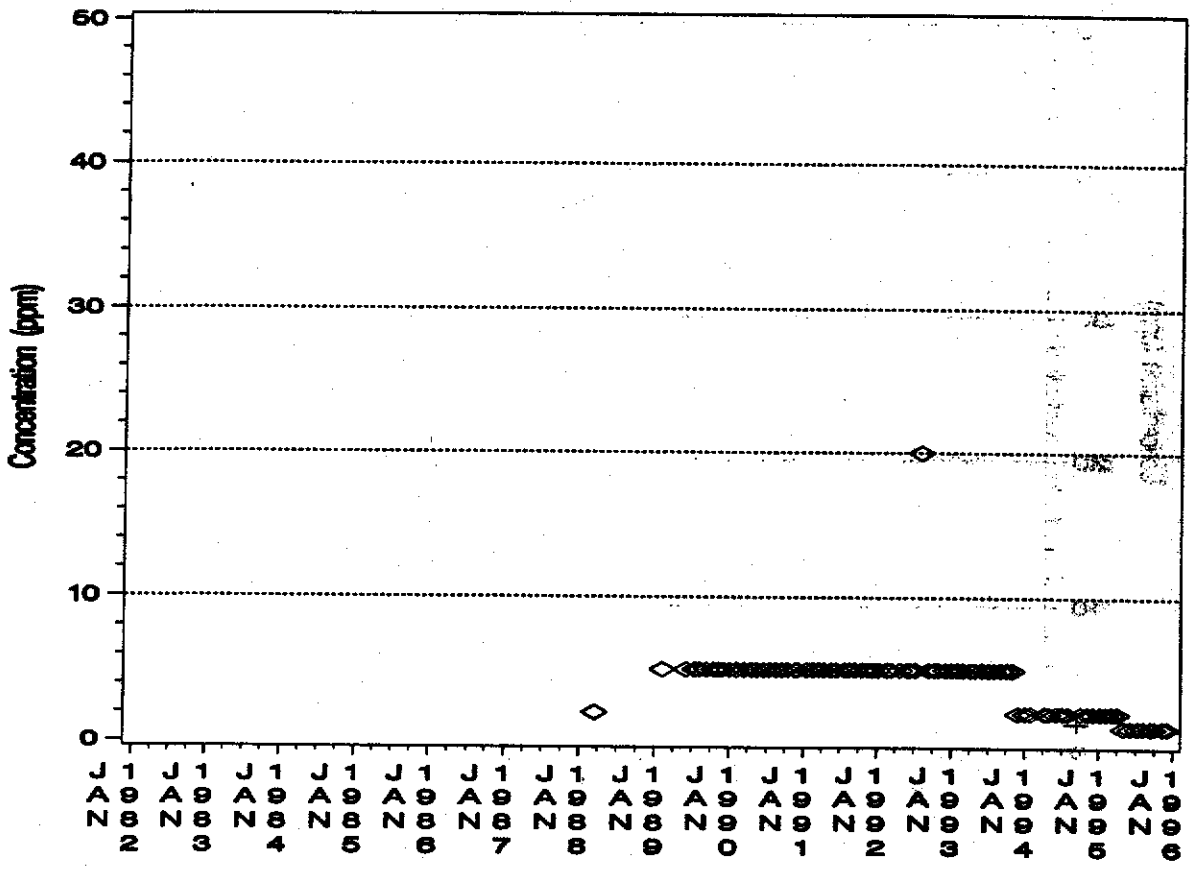
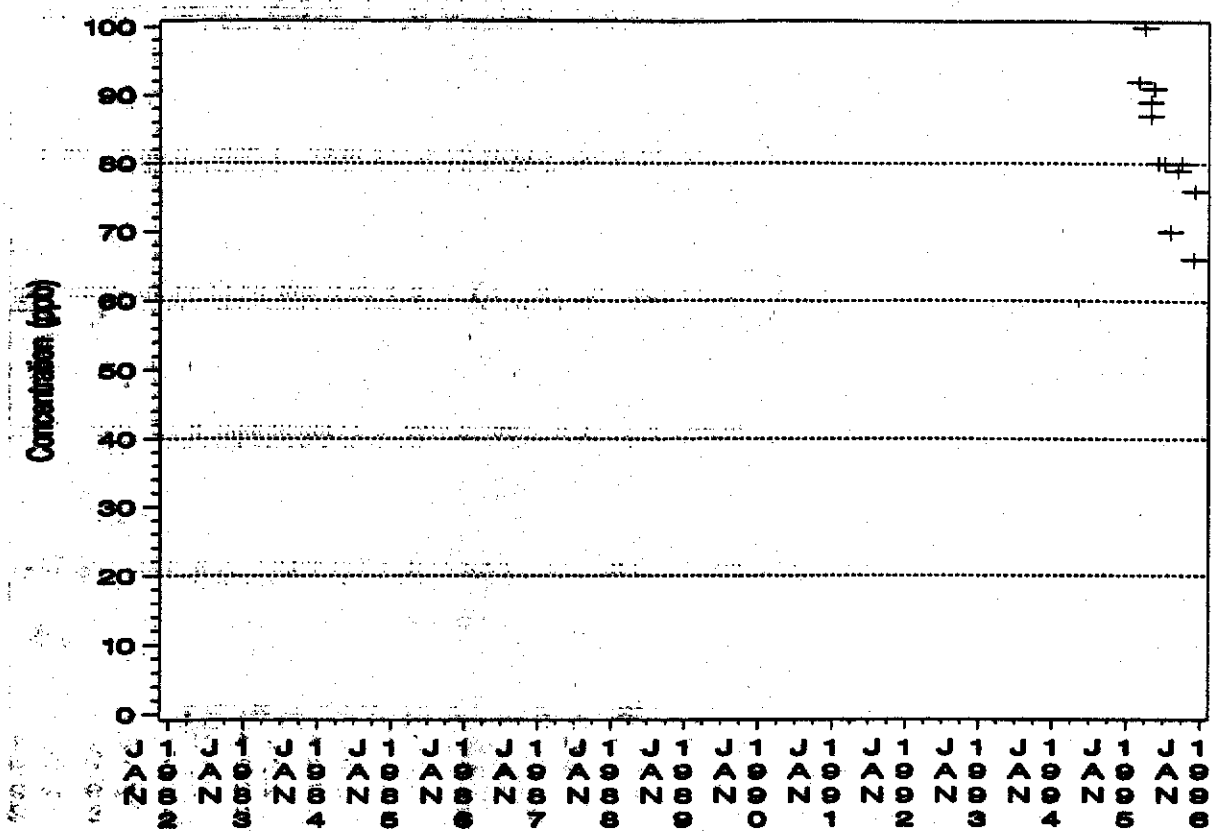


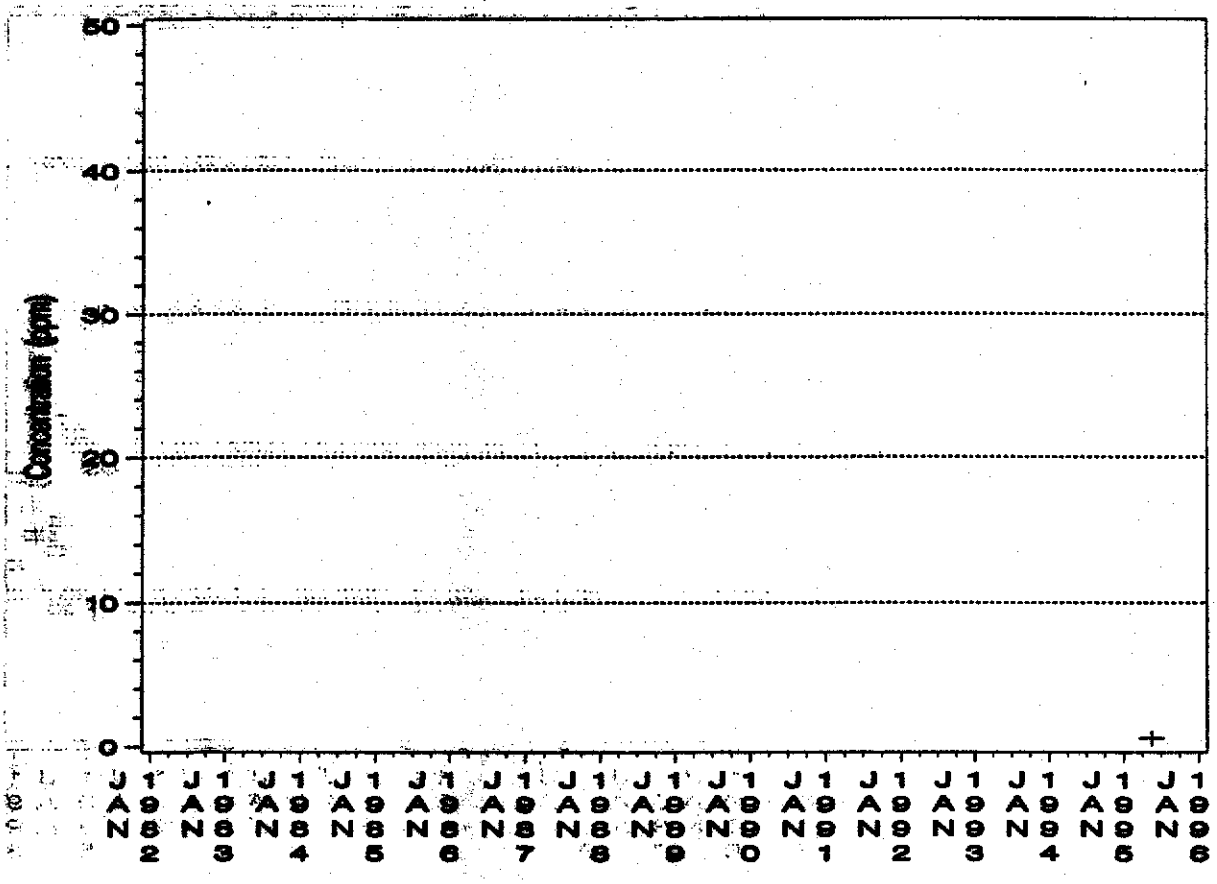
1,2 – DICHLOROETHANE Trend



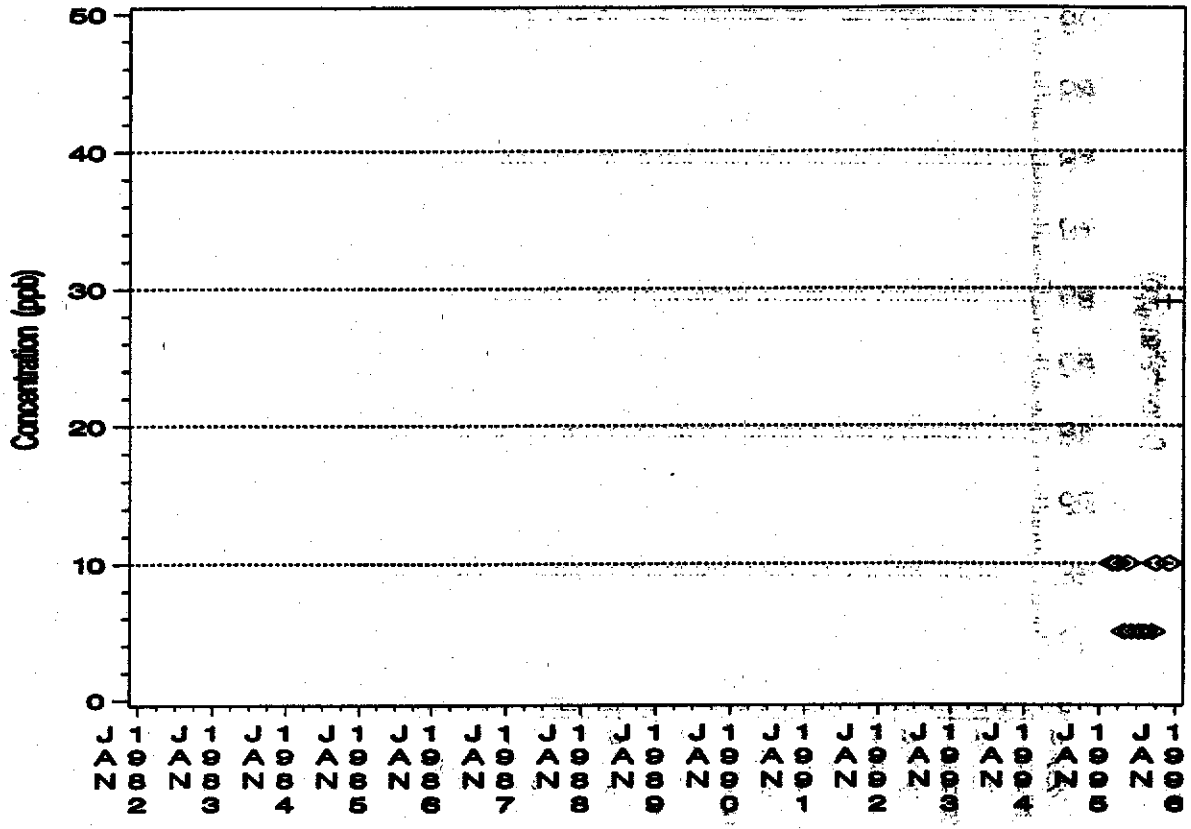
WELL 4310
TRICHLOROETHYLENE Trend



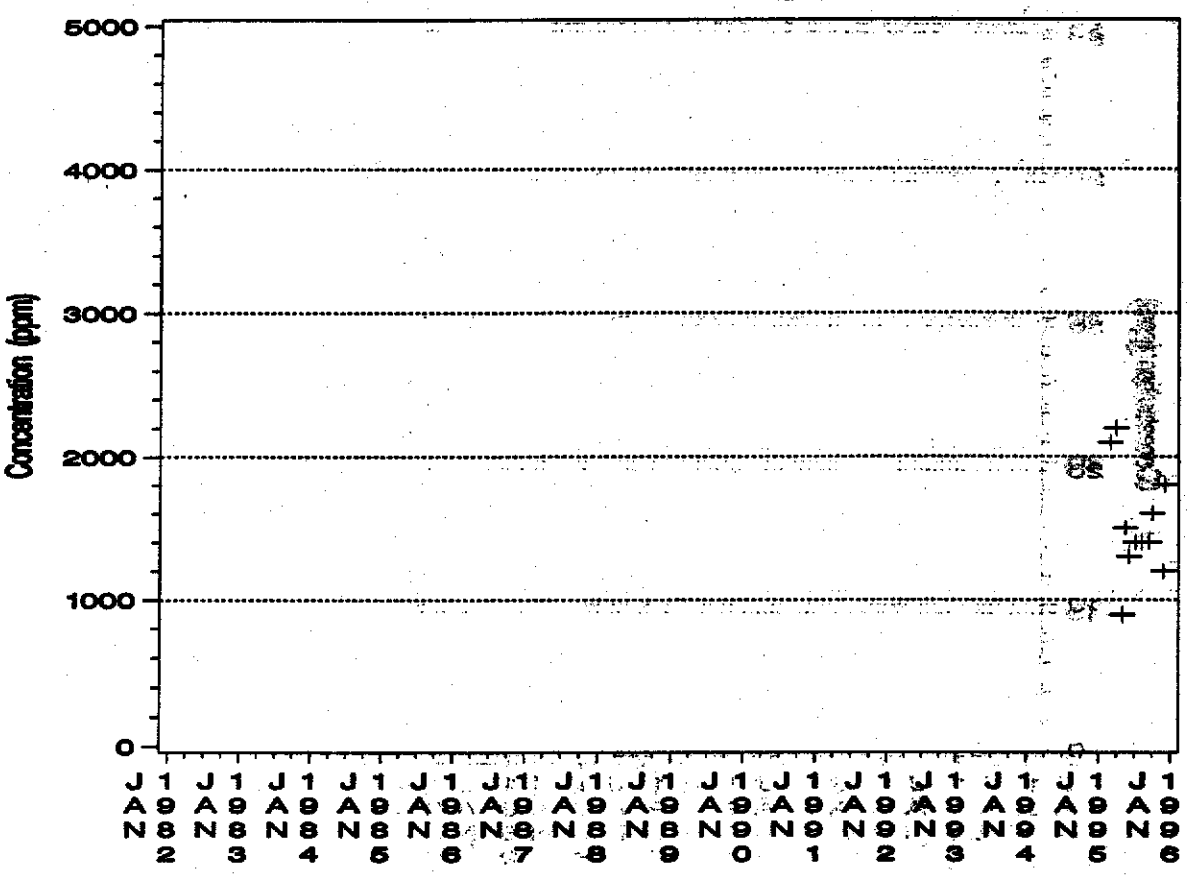
PERCHLORATE Trend



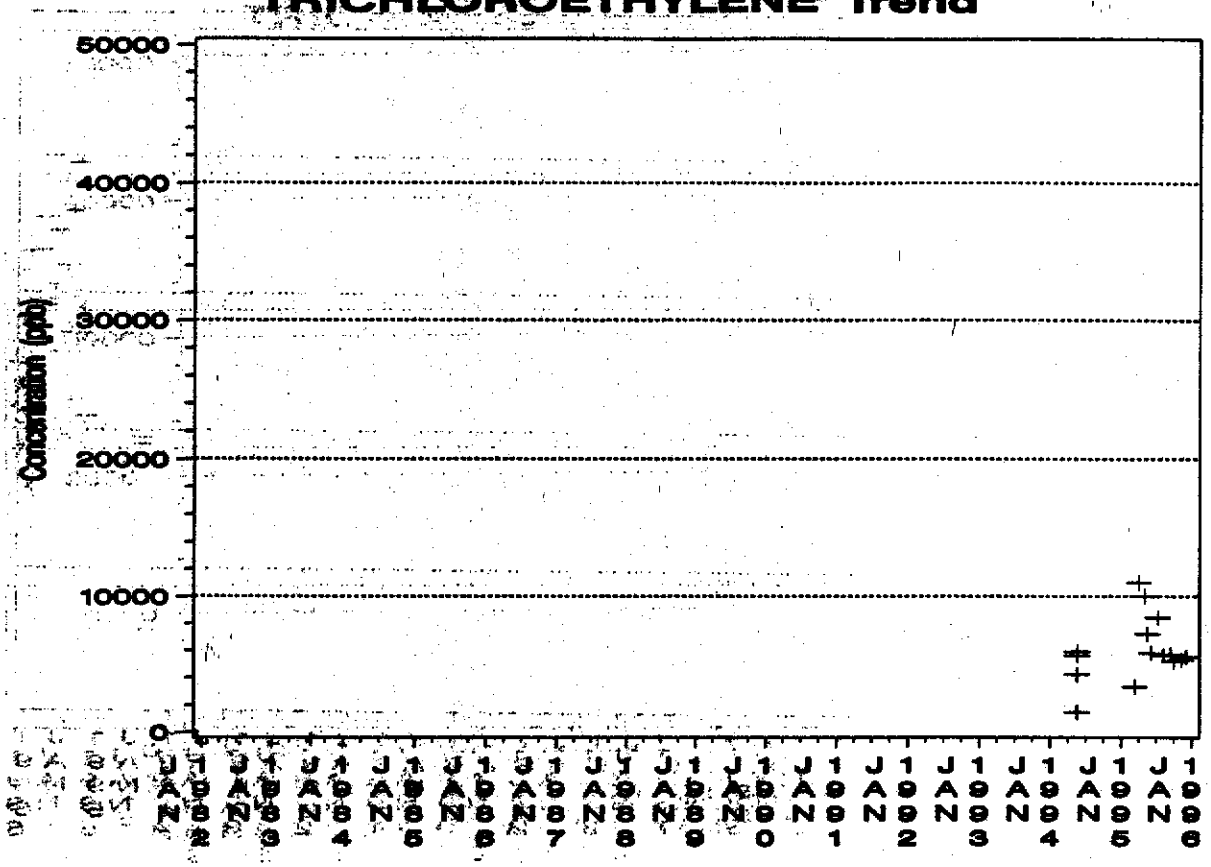
WELL 4310
CHLOROFORM Trend



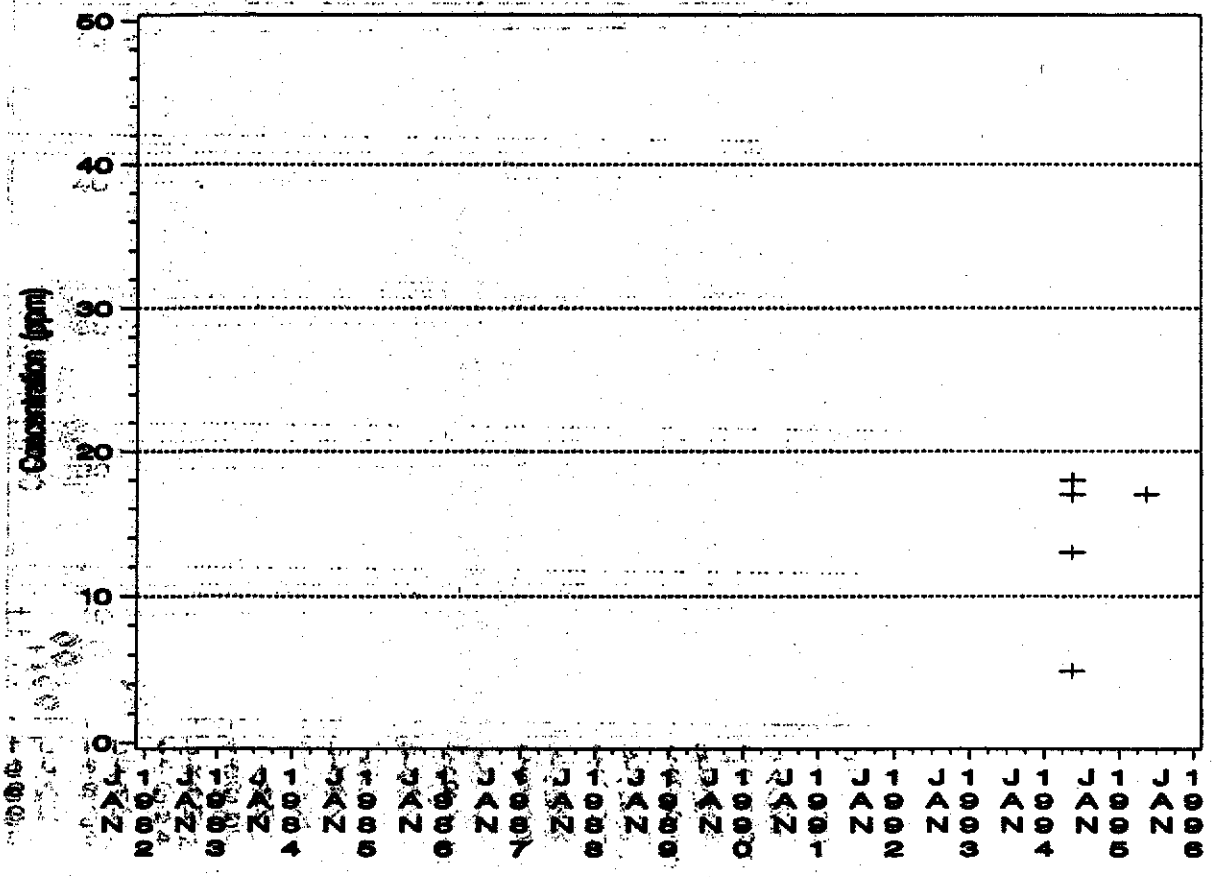
1,2 – DICHLOROETHANE Trend



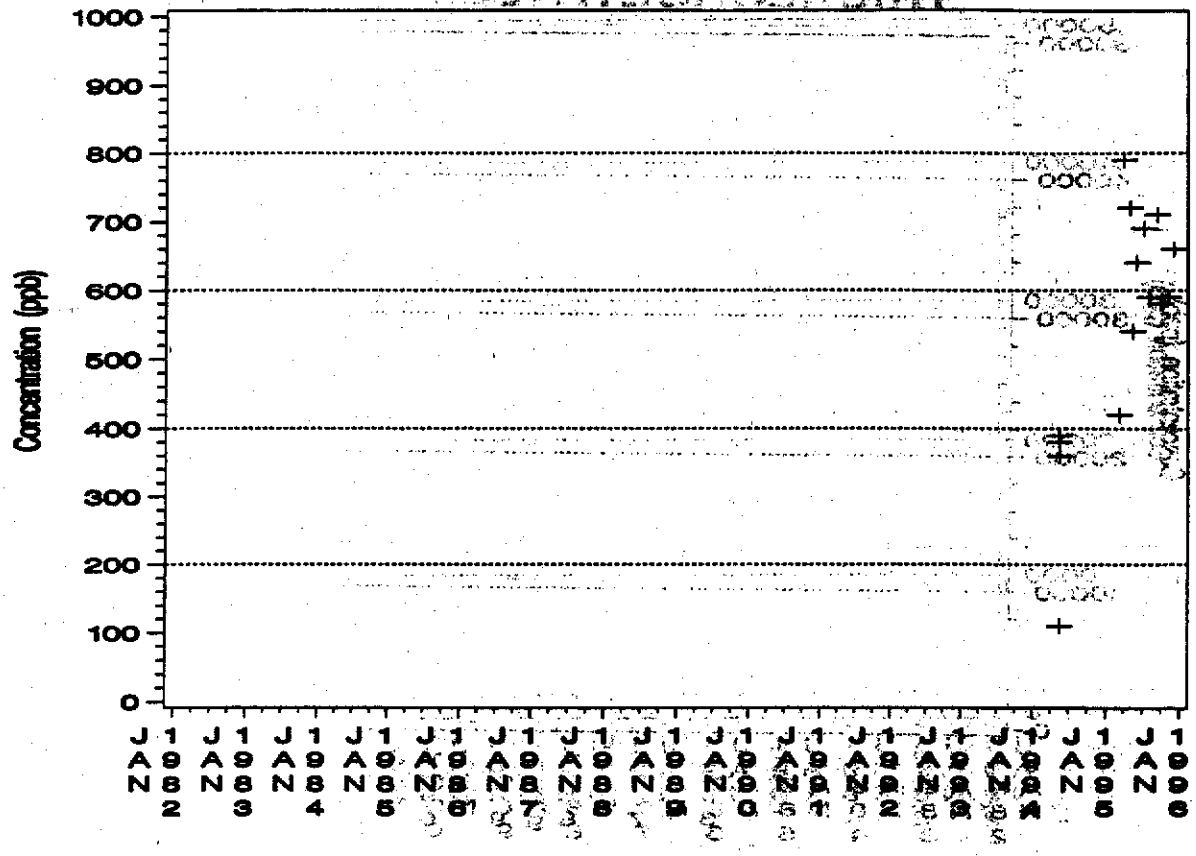
WELL 4315
TRICHLOROETHYLENE Trend



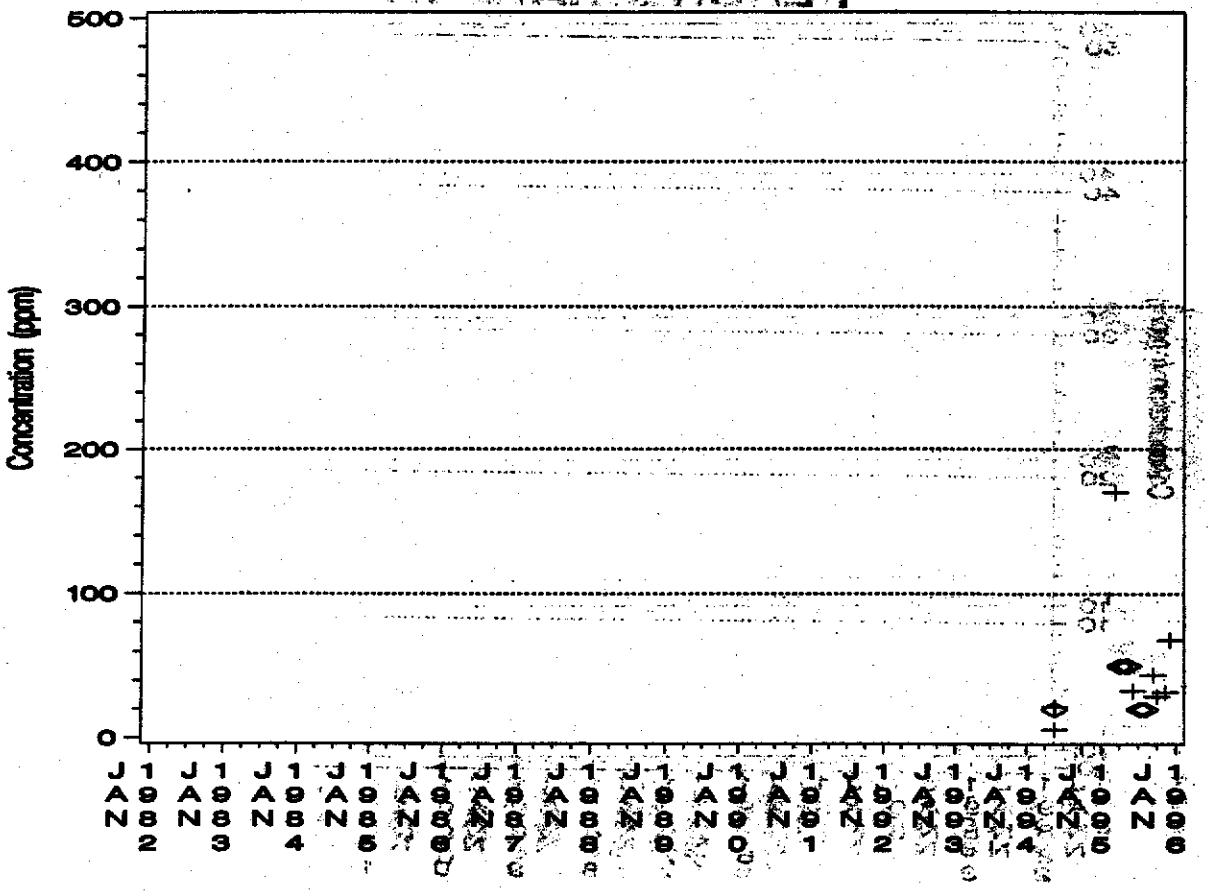
PERCHLORATE Trend



WELL 4315
CHLOROFORM Trend



1,2 – DICHLOROETHANE Trend



AEROJET

P O Box 13222
Sacramento CA 95813-6000

15 April 2002

Mr. Charles Berrey
U.S. EPA (SFD-7-2)
75 Hawthorne Street
San Francisco, CA 94105

Mr. Alexander MacDonald
California Regional Water
Quality Control Board
Central Valley Region
3443 Routier Road
Sacramento, CA 95827-3003

Mr. Ed Cargile
National Priority List Unit
Northern California-Central Cleanup
Operations Branch
Site Mitigation Program
8800 Cal Center Drive, Suite 350
Sacramento, Ca 95826-3200

RE: Perimeter Groundwater Operable Unit Draft RI/FS Workplan

Dear Mr. Berrey, Mr. MacDonald, and Mr. Cargile:

Please find attached the above-referenced document submitted in accordance with Exhibit II of the Modified Partial Consent Decree. Aerojet has prepared an additional copy of this document to send to EPA's consultant, if so required. Aerojet looks forward to receipt of your comments on this workplan within 30 days of submittal as specified in Exhibit II. Please call either Cindy Caulk at (916) 355-2601 or me at (916) 355-5454 with any questions you have regarding this submittal.

Sincerely,

C. Scott Goulart
Program Coordinator

Attachments

cc: M. Silva (CVEI, w/out CD)
B. Jelinek (EMSI, w/out CD)
B. Lewis (ERM, w/out CD)
C. Caulk, (Aerojet, w/out CD)
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DRAFT
Remedial Investigation/Feasibility Study Work Plan

for the

Perimeter Groundwater Operable Unit

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List of Acronyms

AAL	Aerojet's Analytical Laboratory
ACWS	Arden Cordova Water System
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
ARGET	American River groundwater extraction and treatment system
ARSA	American River Study Area
Basin Plan	Water Quality Control Plan for the Sacramento and San Joaquin River Basins
bgs	below the ground surface
BRA	Baseline Risk Assessment
BTEX	Benzene, ethyl benzene, toluene, and xylene
Cal-EPA	California Environmental Protection Agency
CAO	Cleanup and Abatement Order
CCR	California Code of Regulations
CD	Consent Decree
CDA	Central Disposal Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (as amended)
CFR	Code of Federal Regulations
CVEI	Central Valley Environmental, Inc.
CZ	Containment Zone
DAA	detailed analysis of alternatives
DCA	Dichloroethane
DCE	Dichloroethene
DDC	density driven convection
DHS	California Department of Health Services
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DoD	Department of Defense
DQO	Data Quality Objective
DTSC	California Department of Toxic Substances Control
EBMUD	East Bay Municipal Utility District
EE/CA	Engineering Evaluation/Cost Analysis
EMSI	Engineering Management Support, Inc.
EPA	U.S. Environmental Protection Agency
ERM	Environmental Resources Management
ESD	explanation of significant difference
FB	fluidized bed
Freon-11	trichlorofluoromethane
Freon-113	1,1,2-trichloro-1,2,2-trifluoroethane
Freon-12	dichlorodifluoromethane
FS	Feasibility Study
ft	Feet

List of Acronyms (continued)

GAC	granular activated carbon
GET	groundwater extraction and treatment
gpm	gallons per minute
GRA	General Response Action
GWTP	groundwater treatment plant
HMX	cyclotetramethylenetetranitramine
IRCTS	Inactive Rancho Cordova Test Site
IRZ	In-situ Reactive Zone
ISEO	Imminent and Substantial Endangerment Order
ISO	in-situ oxidation
ISRM	in-situ redox manipulation
LPGAC	liquid-phase granular activated carbon
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	method detection limit
ug/L	micrograms per liter
MNA	monitored natural attenuation
msl	mean sea level
MUN	Municipal use
NCP	National Contingency Plan
NDMA	n-nitrosodimethylamine
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
nVOCs	non-VOCs
O&M	operation and maintenance
OBPA	10, 10'-oxybisphenoxarsine
ORNL	Oak Ridge National Laboratory
ORP	Oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAHs	poly-aromatic hydrocarbons
PCBs	poly chlorinated biphenyls
PCD	Partial Consent Decree
PCE	tetrachloroethene
PGOU	Perimeter Groundwater Operable Unit
PNAs	poly-nuclear aromatics
PNH	poly-nucleic hydrocarbons
PNNL	Pacific Northwest National Laboratory
POTW	Publicly-Owned Treatment Works
PQL	Practical quantitation limit
PRG	Preliminary Remedial Goal
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control

List of Acronyms (continued)

RAO	remedial action objectives
RCRA	Resource Conservation and Recovery Act of 1976 (as amended)
RD/RA	remedial design/remedial action
RfD	reference dose
RI	Remedial Investigation
RL	Reporting limit
RO	Reverse osmosis
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
scfm	Standard cubic feet per minute
SCM	Site Conceptual Model
SDWA	Safe Drinking Water Act
SERDP	Strategic Environmental Research and Development Program
SMAQMD	Sacramento Metropolitan Air Quality Management District
SMUD	Sacramento Metropolitan Utility District
SOPs	Standard Operating Procedures
SVOC	semi-volatile organic compound
SVRA	State Vehicle Recreation Area
TBC	To-be-considered criteria
TCA	Trichloroethane
TCE	Trichloroethene
TI	technical impracticability
TOC	total organic carbon
TPH	total petroleum hydrocarbons
USBR	United States Bureau of Reclamation
USGS	U. S. Geological Survey
UTL	upper tolerance limit
UV	ultraviolet
VOC	volatile organic compound
WGOU	Western Groundwater Operable Unit
WQO	Water Quality Objectives

1 INTRODUCTION

This Work Plan presents an overall plan for performance of a remedial investigation (RI) and feasibility study (FS) for the Perimeter Groundwater Operable Unit (PGOU) at the Aerojet Sacramento Site (the Site) located in Sacramento County, California (Figure 1-1). This section includes a discussion of the regulatory framework under which this PGOU RI/FS is being prepared, the purpose and scope of the PGOU RI/FS, and a discussion on the organization of this Work Plan.

1.1 Regulatory Background

The RI/FS is being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (a.k.a. Superfund) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. The Site CERCLIS Identification Number is CAD980358832. Government oversight is shared by the United States Environmental Protection Agency – Region IX (EPA), the State of California Environmental Protection Agency through the Regional Water Quality Control Board – Region 5 (RWQCB), and the State Department of Toxic Substances Control (DTSC).

The Operable Unit Remedial Investigation Feasibility Study Program Plan (Exhibit II) is administered through a Partial Consent Decree (PCD) entered by the Court in June 1989 and modified December 1989, June 1990, June 1998, and April 2002. The PCD contemplated the completion of a site-wide RI/FS prior to beginning remedial action at the Site. Exhibit II to the PCD contains the Program Plan for completing the RI/FS through operable units.

The first RI/FS conducted for an operable unit at the site was completed in April 2000 for OU-3 (Western Groundwater OU, or WGOU) and addressed perimeter groundwater at and beyond the western perimeter of the Aerojet property (Aerojet, 2000a and EMSI et al., 2000). The RI/FS for the PGOU, OU-5, will address chemicals in groundwater at and beyond the remaining portions of the Site perimeter, including the American River Study Area (OU-2) and several off-site properties currently or formerly owned by Aerojet. Specifically, Exhibit II to the modified PCD states that the PGOU *"...shall include all of the remaining plumes of chemicals in the groundwater at and beyond the boundary of the Aerojet Site that are not addressed by the Western Groundwater OU, the Area 41 Soil and Groundwater OU, or the remedial program for the Inactive Rancho Cordova Test Site (IRCTS) under DTSC Order No. I&/SE 93/94/-016 and Regional Board CAO 97-093. This OU shall include, without limitation, the plumes of chemicals in the groundwater at Areas 39 and 40 and the remaining plumes of chemicals in the groundwater migrating from the Aerojet-General Operating Plant beneath the Inactive Rancho Cordova Test Site (IRCTS). The American River Study Area is included in this*

OU." The potential source sites upgradient of the PGOU will be addressed by future RI/FS'.

The PGOU RI/FS will also meet the RI/FS-like substantive requirements of RWQCB Cleanup and Abatement Orders (CAOs) 96-230, 96-259, and 500-718 that address the American River Study Area, perchlorate in groundwater, and perchlorate at one existing groundwater extraction and treatment facility (GET D), respectively.

1.2 Purpose of Work Plan and Scope of RI/FS

The purpose of this RI/FS Work Plan is to identify the activities necessary to complete the RI for the PGOU and to identify the activities necessary to prepare the FS.

The scope of the PGOU RI/FS can be described as follows:

- Complete the RI for the PGOU Study Area to characterize subsurface conditions and the nature and extent of chemicals in groundwater and to provide sufficient data for the evaluation of potential risks to human health and environment and selection of a remedy;

- Prepare a baseline risk assessment to identify any potential risks that may be posed to human health and the environment by chemicals in groundwater in the Study Area;

- Prepare an FS by developing and evaluating a range of remedial alternatives that provide for protection of human health and the environment, and that consider technical, institutional, and cost considerations in accordance with CERCLA and the National Contingency Plan (NCP) so that relevant information regarding the remedial alternatives can be presented to a decision maker and an appropriate remedy can be selected for the PGOU; and

- Integrate the FS with all applicable RI, risk assessment, and treatability study activities to ensure that remedial alternatives are developed, screened, and evaluated in a systematic and objective manner.

This RI/FS Work Plan has been prepared in accordance with the requirements set forth in the Exhibit II Operable Unit Remedial Investigation Feasibility Study Program Plan for OU RI/FS work plans, specifically those requirements in Paragraph 3: *"Each OU RI/FS Workplan shall describe the discrete steps and schedule necessary to complete the OU RI/FS in accordance with the latest pertinent RI/FS guidance, including, but not limited to, scoping, characterization, development of alternatives, screening of alternatives, performance of treatability studies (if applicable), detailed analysis of alternatives, and comparative analysis of alternatives. Each OU RI/FS Workplan shall also specify the schedule for submission of a draft and final OU RI/FS Report consistent with the*

schedule in Paragraph 13 (Deliverables and Schedule) below, and for any other submittals that will be prepared to support the OU RI/FS (e.g., treatability study workplans and reports), including Plaintiffs' comment/approval periods for these submittals." Paragraph 10 of Exhibit II also specifies that *"Each OU RI/FS Report shall contain a human health risk assessment and an ecological risk assessment ..... that is consistent with 40 CFR 300.430 and any amendments thereto and pertinent RI/FS guidance documents and any pertinent updates thereto."* Elements required to be included in the Human Health and Ecological risk assessments are also listed in Paragraph 10.

1.3 Work Plan Organization

This Work Plan is organized according to the suggested RI/FS Work Plan format contained in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988a) and includes the following sections:

- Section 2: Site Background and Setting includes a summary of site history, a description of the Study Area including the various groundwater management areas, and summaries of land use, groundwater use, topography, surface water hydrology, geology, hydrogeology, and previous investigations.

- Section 3: Initial Evaluation presents the initial evaluations of existing data performed during the Work Plan scoping process. These evaluations include a preliminary site conceptual model, known and suspected sources of contamination, potential chemical transport and routes of chemical migration, potential receptors and exposure pathways, a preliminary analysis of potential applicable or relevant and appropriate requirements (ARARs), discussions of existing Interim Actions and current treatability studies, and a preliminary identification of response objectives and technologies/process options.

- Section 4: Work Plan Rationale includes the data requirements necessary to support the development of the RI, risk assessment, and FS.

- Section 5: RI/FS Tasks lists the tasks and describes the specific activities that will be conducted to complete PGOU RI/FS. The tasks include project planning, community relations, field investigation, sample analysis/data validation/data management, data evaluation, risk assessment, treatability studies, RI Report, remedial alternatives development/screening, detailed analysis of alternatives, and FS Report.

- Section 6: Schedule includes a proposed project schedule to complete the PGOU RI/FS and an associated discussion. A target date schedule, for planning purposes only, for selection and implementation of any remedy is also provided in Section 6.

- Section 7: Project Management provides an organization chart for the RI/FS and describes the roles and responsibilities of the individuals and the various organizations that will be involved. Project communications and reporting requirements are also included in this section.

- Section 8 References contains a list of references.

- Appendices A through D contain preliminary data assessments with respect to characterizing chemicals in groundwater and identifying data gaps for each of the four management Zones (i.e., Zones 1 through 4; see description of "Zones" in Section 2.2). Recommendations for field investigation activities to complete the PGOU RI/FS are also included in these Appendices.

2 SITE BACKGROUND AND SETTING

This section includes discussions of site history, a description of the Study Area including the various zones, sectors, land use, groundwater use, topography, surface water hydrology, geology, and hydrogeology. A summary of previous investigations that have been completed that are relevant to completing the RI/FS for the PGOU is included at the end of the section.

2.1 Site History

The Aerojet Site has been utilized to develop rocket propulsion systems in support of national defense, space exploration, and satellite deployment since the 1950's. Industrial activities supporting this work included solid rocket motor manufacturing, testing, and rehabilitation (hogout); liquid rocket engine manufacturing and testing; and chemical manufacturing. A variety of chemicals were used at the Site, including solvents, propellants, fuels, oxidizers, metals, and various other chemicals produced to support industrial operations.

2.2 Physical Description of Study Area

The boundaries for the Study Area are shown on Figure 2-1 and are defined by the PCD as *"all remaining plumes of chemicals in groundwater at and beyond the Aerojet Site that are not addressed by the Western Groundwater OU, the Area 41 soil and groundwater OU, or the remedial program for the IRCTS, ... and shall include, without limitation, the plumes of chemicals in groundwater at Areas 39 and 40 and the remaining plumes of chemicals in groundwater migrating from the Aerojet-General Operating Plant beneath the IRCTS. The American River Study Area is included in this OU..."* (PCD Exhibit II, 2002).

This Work Plan and the pending RI/FS will follow the existing Zone and Sector nomenclature (described in the following paragraphs and used in the many previous RI/FS reports and deliverables) to distinguish among the different geographic areas and groundwater flow directions within the PGOU. The source(s) and types of chemicals, potential exposure pathways, potential receptors, and potential remedial alternatives may vary depending on the direction of groundwater flow in each area.

The Site was divided into four management Zones (Zones 1 through 4) during the Stage 1 RI Report (ICF Kaiser Engineers, 1993a-c), and was historically divided into Sectors A through G based on groundwater flow directions (Figure 2-1). The Stage 1 RI sub-divided the Zones into Management Areas (e.g., Line 01, Area 20), distinguished by

location and the common operations conducted in each area which contain the potential source sites. The letter designations of the potential source sites identify the groundwater Sector where the potential source site is located (e.g., Site 44D is located in Sector D). The existing groundwater extraction and treatment (GET) facilities (Figure 2-2) are lettered according to the Sector where they are located (e.g., GET A is located in Sector A). Table 2-1 shows the relationships among the various Site divisions.

The portions of the PGOU not part of the Aerojet Site are shown on Figure 2-1, the majority of which is located northwest and south of the Aerojet Site boundary. These areas are being evaluated in this RI/FS because chemicals have potentially migrated in groundwater into these areas from the Aerojet Site. Moving clockwise from the northeastern boundary of the WGOU around the Study Area, the formal and informal designations for these areas include:

- The American River Study Area (ARSA), also known as OU-2; and
- Aerojet-owned Enisz Property (a.k.a., GET B South).

The specific descriptions of these areas are included in the Preliminary Data Summaries and Proposed Data Collection analyses prepared for each Zone, which are included as Appendices A through D. Area 40 and Area 39 include locations of potential source areas to groundwater and include locations formerly used to burn chemical wastes. In areas where chemicals are present in groundwater downgradient of the Site, chemical migration will be assessed at the property boundary and at the downgradient PGOU boundary. The PGOU includes approximately 12.5 of the 17.3-mile Aerojet property boundary; the remaining 5 miles were addressed by the WGOU RI/FS.

2.3 Land Use

The Aerojet Site is zoned for industrial use. The facilities that support industrial operations are grouped into manufacturing areas comprised of multiple buildings. Large areas of undeveloped land are located between manufacturing areas and between most manufacturing areas and the Site perimeters. The majority of land around the Site perimeters served as "buffer space" between operations and neighboring properties. Large areas of land located along the northern and northeastern Site boundaries were recently removed from the Superfund Site boundaries and may be subject to future development.

The Aerojet property was designated as a "Special Planning Area" by Sacramento County Ordinance, Title V, Chapter 8, Article 3 of the Zoning Code of Sacramento County. This ordinance identifies existing permitted uses and "provides a regulatory mechanism for making land use decisions that maintain a safe environment in which the subject property can be used given the special requirements of the property owner".

Land use in the areas off-site includes residential, commercial, industrial, agricultural, recreational, and undeveloped areas. The greatest amount of development is north and northwest of the Site in the communities of Rancho Cordova and Gold River. These communities have a combined population of approximately 60,000. The City of Folsom, located approximately 2.5 miles northeast of the Site, is outside of the Study Area.

The southern and eastern areas around the Site boundaries are primarily undeveloped. The State Vehicle Recreation Area (SVRA) [Area 39] is mainly undeveloped and used for off-road recreation. Aggregate mining is conducted northeast of the SVRA, south of the former Ehnisz property, and on privately-owned property and the IRCTS south of White Rock Road. The IRCTS is currently owned by Aerojet, but was formerly leased by the McDonnell-Douglas Corporation (and subsequently purchased by the Boeing Company) for rocket testing operations. Chemicals in soil and groundwater beneath the IRCTS are being jointly investigated by Aerojet and the Boeing Company under a separate State Order. Two unoccupied and undeveloped former municipal landfills, the White Rock North Dump (WRND) and White Rock South Dump (WRSD) are located on the north and south sides of White Rock Road, respectively, and are also being investigated and remediated pursuant to a State Cleanup and Abatement Order. . There are a few ranchettes and houses south of White Rock Road, including the Clark Cattle Company. Portions of this area are used for cattle grazing and small farming operations. The specific land uses identified in each area are also presented in the more detailed analysis of each Zone (Appendices A through D).

2.4 Groundwater Use

Groundwater within the PGOU is designated for municipal use (MUN) as a potential drinking water source in the Central Valley Regional Water Quality Control Board (CVRWQCB) Basin Plan (RWQCB, 1998a). Groundwater on-site is not used for any purposes, and future groundwater use on lands removed from the Superfund Site boundary is limited through environmental restrictions included in the PCD.

Groundwater is primarily used for domestic and industrial purposes off of the Aerojet Site. The location of water supply wells within a one-mile radius of the PGOU boundaries are shown on Figure 2-3. Three water-supply wells (AC-17, -21, and -22) operated by the Arden-Cordova Water Service (ACWS) are in the PGOU. Several wells operated by ACWS and the Fair Oaks Water District are located just west and north of the PGOU boundaries, respectively. The public water supply wells are monitored in accordance with the provisions in the Exhibit IV Groundwater Monitoring Plan (PCD, 1989), which is discussed in Appendices A through D.

Groundwater is also used for industrial and domestic purposes to the south and southwest of the Aerojet Site (Figure 2-3). Water used for industrial purposes includes Wells 1943 (AKT-1) and 1059 that are both used to supply water for gravel mining operations. Well 1058 also provides water to the SVRA and an adjacent trailer park. Domestic wells south

of the Aerojet Site primarily provide water to individual residences and are monitored as discussed in Appendices A through D.

2.5 Topography

The Site is characterized by a relatively flat topographic surface gently sloping (less than 1 degree) to the west. Some areas in the eastern portion of the Site south of GET B dip to the south and east. The elevations in PGOU range from approximately 200 feet above Mean Sea Level (amsl) in the east to approximately 60 feet amsl in the west.

Most of the on-site topography is dominated by rows of dredge tailings left from gold-mining operations that began in the early 1900's. The tailings consist of alternating rows of loose cobble mounds and intervening low areas comprised of silt and clay ("slickens"). Much of the area surrounding the Aerojet Site, including Gold River, portions of the IRCTS, and areas south of GET B (Figure 2-2), were also dredged, although development has obscured most of the tailings. The dredging apparently disturbed the sediments to depths ranging from 20 to 80 feet below ground surface (bgs).

Other topographic features include two ancestral American River terrace scarps that generally trend northeast-southwest across the Site (Figure 2-1). Alder Creek trends east-west through an incised channel cut through the sediments just south of the northern Site perimeter. To the north, a ridge of 30- to 60-foot high bluffs parallels the north side of the American River.

2.6 Surface Water Hydrology

Regional and local surface water hydrology are discussed in this section.

2.6.1 Regional Surface Waters

Regional surface water bodies in the vicinity of the Study Area include Folsom Lake, Lake Natoma, the American River, Coyote Creek, Morrison Creek, and the Folsom South Canal (Figure 2-4). The American River drains a substantial portion of the western Sierra Nevada east of Sacramento County. The American River is used as a municipal and agricultural water supply and provides recreational, fishery, and wildlife uses. The portion of the American River downstream of Lake Natoma serves as spawning ground for salmon, steelhead trout, and shad. The American River is sampled for volatile organic compounds (VOCs) pursuant to Exhibit V of the PCD. TCE has not been detected in the samples collected from the river.

Flows on the American River are controlled by the United States Bureau of Reclamation (USBR) through Folsom Dam, and to a lesser extent, Nimbus Dam. Folsom Dam is

located approximately 3.5 miles northeast (upstream) of Lake Natoma. Lake Natoma is formed by Nimbus Dam, and is located approximately ¼ to ½ mile north of Aerojet's northern property boundary. Contours of the potentiometric surface in the vicinity of Lake Natoma indicate the American River is gaining in the vicinity of Lake Natoma (i.e., groundwater discharges to the river). Lake Natoma is located along the northern perimeter and generally side-gradient of the Aerojet Site.

The Folsom South Canal originates at the southwest end of Lake Natoma, and trends along portions of the northern and western Aerojet boundaries. The Folsom South Canal is a concrete-lined canal and was intended to provide cooling water for the Sacramento Municipal Utility District's (SMUD) Rancho Seco Nuclear Power Plant and municipal water for the East Bay Municipal Utility District (EBMUD). The nuclear power plant is being decommissioned and current use of the canal is limited to relatively small amounts by SMUD, ACWS, and various other water purveyors and agricultural water users.

The eastern area of the PGOU may be in the Cosumnes River Watershed. Coyote Creek is located east of the Prairie City State Vehicle Recreation Area and flows to the Cosumnes River. The headwaters for Morrison Creek, an ephemeral stream, are located near Grant Line Road, approximately 5,000 feet south of White Rock Road (Figure 2-4). Morrison Creek flows into the Sacramento River.

2.6.2 Local Surface Waters

Local surface water features include: Buffalo Creek, the Administration Ditch, West Area Lake, Alder Creek, Rebel Hill Ditch, the headwaters for Morrison Creek, and various man-made ditches and ponds located onsite and off-site (Figure 2-4). Most of these features are used to divert and control seasonal storm-water runoff from the Aerojet Site. Alder Creek is located along the northeastern Aerojet boundary and receives a minor amount of storm water runoff from undeveloped areas on and east of Aerojet. Alder Creek is generally ephemeral, although the western portion of the creek often flows year-round. Alder Creeks flows west and drains into Lake Natoma. Potential groundwater discharge to Alder Creek will be evaluated in the RI (Appendix D).

Most storm-water runoff originating in the northern (Administration Area) and northeastern (Liquid Rocket Test Area) portions of the Aerojet Site flows through the Administration Ditch or Buffalo Creek into the West Area Lake. Storm-water runoff is staged in West Area Lake and discharged to Buffalo Creek, and ultimately the American River. Storm-water discharges to Buffalo Creek/American River are regulated through the National Pollution Discharge Elimination System (NPDES). Aerojet also discharges treated groundwater from the American River GET (ARGET) facility into Buffalo Creek which comprises the bulk of its flow. The ARGET discharge is regulated through a separate NPDES permit. Most storm-water generated on the western half of the Aerojet Site infiltrates locally and does not leave Aerojet property.

Rebel Hill Ditch traverses the facility from northeast to southwest and was constructed to provide water for the gold dredging activities. Aerojet currently discharges treated groundwater from its GET B facility to Rebel Hill Ditch. The treated groundwater from GET B infiltrates into the ground at the end of the ditch along the southern boundary and does not leave the Aerojet Site.

The areas northwest of the Site are developed and there are no known areas where runoff from the Aerojet Site enters these areas, except for Buffalo and Alder Creeks as noted above. The Sacramento County Department of Public Works - Water Resources Division manages surface water runoff from the developed areas in Rancho Cordova. Storm-water runoff from these areas enters the County's storm-water drainage system and ultimately the American River.

Morrison Creek originates south of GET B and the former Ehnisz property and flows southeast through the southern portion of the IRCTS (Figure 2-4). The upper portions of Morrison Creek are ephemeral, and water is rarely present in the summer.

2.7 Regional Geology (Site Conceptual Model)

The Regional Site Conceptual Geologic model is shown on Figure 2-5 and a site-wide geologic cross-section is included as Figure 2-6. The Study Area is located near the eastern edge of the Sacramento Valley near the contact between the Sierra Nevada metamorphic basement rocks and the valley sediments. This area is characterized by shallow-dipping (generally less than 1 degree) Cretaceous-, Tertiary-, and Quaternary-age marine and fluvial sediments overlying steeply dipping Jurassic crystalline basement rocks (Department of Water Resources [DWR], 1974). The erosional surface of the basement rock dips to the west beneath the Study Area at approximately 4 degrees.

The sedimentary sequence includes undifferentiated Quaternary sediments and the Laguna, Mehrten, Valley Springs, Ione, and Chico Formations. These sediments generally strike north-south and form a wedge that thickens from tens of feet at the eastern Aerojet Site boundary to greater than 2,000 feet near the western Aerojet property boundary. The sediments of interest include the undifferentiated Quaternary sediments, the Laguna, Mehrten, and Valley Springs Formations, and contain hydrostratigraphic Layers A through F as described in later sections of this report. Descriptions of each of these geologic formations are provided in the Scoping Report (ICF Technology, 1989) and the various GET Effectiveness Evaluation Reports (Aerojet, 1992) prepared for the Site.

2.8 Regional Hydrostratigraphic Site Conceptual Model

Stratigraphic correlation was completed on a site-wide and local basis during previous groundwater investigations. At least two different aquifer nomenclatures have been used

in the past to identify saturated sediments beneath the Site. The current nomenclature, and the one followed in this report, has assigned the saturated sediments to descending Layers A through F (A - F). These layers were initially developed locally for the GET Effectiveness and Hydrologic Evaluation Reports prepared for Sectors A through G. The layer assignments in each Sector were recently correlated site-wide and some of the earlier layer and monitoring well assignments were changed.

Layers A through F were defined based on lithologic descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thickness. Layer A is the shallowest and Layer F is the deepest layer. The Site-wide Conceptual Hydrogeologic Model is presented on Figure 2-5. Data collected from numerous aquifer tests conducted at GETs A, B, D, E and F and in the ARSA were used to confirm and refine the hydrogeologic model for the Site. Each layer is comprised of relatively continuous lenses of permeable sediments separated by relatively lower permeability aquicludes or aquitards. The continuity of the low permeability sediments varies, and in some areas portions of the permeable sediments (i.e., Layers) are probably connected.

Appendices A through D present groundwater data from the Stage 1 RI that was reported using a different aquifer nomenclature. Hydrostratigraphic Units 1 through 7 (1 – 7) were defined as part of a site-wide groundwater flow model prepared for the Stage 1 RI/FS, but not intended nor designed at the scale necessary to evaluate the GETs. There is no direct correlation between the unit and layer nomenclature, although they contain some similar classifications. The approximate correlation between Layers A - F that primarily applies in Zones 1 and 2 is presented below. This correlation does not apply to the sediments in Zones 3 and 4, where some of the units and layers are absent.

Approximate Correlation of Current and Historic Hydrostratigraphic Units

Current Hydrostratigraphic Nomenclature	Stage 1 RI Nomenclature
Layer	Unit
A	1
B	2
C	3U,3M
D	3L
E	4, 5
F	6, 7

2.9 Summary of Relevant Previous Investigations

The characterization of soil and groundwater beneath the Aerojet Site has been ongoing since the early 1980s. Since that time, many investigations have been conducted for defining the nature and extent of contaminants, pilot testing of technologies that may be applicable for remediating soil and groundwater, and evaluating the effectiveness of

existing remedial systems. The following list summarizes the most significant historical remedial investigations and remedial actions conducted in the PGOU Study Area:

- Early1980's: Initial perimeter groundwater hydrologic evaluations prepared to support construction of six on-site perimeter GET facilities (i.e., GETs A, B, D, E, and F-North and F-South).

- Early 1980's: Miscellaneous initial source site investigations. Soil sampling and monitor well installations in source areas. Generated the historical soils data referenced in the Stage 1 RI's.

- 1989-1991: Scoping Report and Phase I RI/FS Work Plan identified and summarized existing history of potential source sites; evaluated chemical use and disposal; proposed analytical methods for sampling and analysis, including an analytical approach to evaluate the non-standard chemicals and included the sampling and analysis plans for the Stage 1 RI.

- 1989 –2001: GET Effectiveness Reports were prepared periodically for each GET facility to assess the effectiveness of each facility in intercepting the migration of chemicals in groundwater at or near the Aerojet property boundary. The reports contain abundant hydrologic data and research and presented the basis for the current hydrogeologic model. Some of the reports contained recommendations to improve hydraulic capture or add groundwater monitoring wells which were then implemented over the subsequent years.

- 1993: Stage 1 RI Reports contain the results of comprehensive Site-wide soil gas, soil, and groundwater chemical sampling and screening.

- 1995 through 2000: Stage 2 RI Sampling and Analysis Work Plans. Work Plans to complete RI/FS activities at source areas. Most recommendations involve completing the characterization of non-volatile organic compounds (nVOCs) detected in soil or groundwater.

- 1993 through present: Annual Groundwater Monitoring Plan: Contain recommended monitor well locations, analytes, and sampling frequencies for monitoring downgradient extent of chemical plumes and effectiveness of GET systems. Often included recommendations for new monitoring wells for monitoring the downgradient migration of chemicals.

- 1996: Final Engineering Evaluation/Cost Analysis (EE/CA) for the American River Study Area downgradient of GET D. Recommended the installation of a groundwater extraction system on the north and south sides of the American River, conveyance of the water to a location on the Aerojet Site for treatment of the extracted groundwater, and discharge of the treated water to Buffalo Creek under an NPDES permit.

- 2000: Western Groundwater OU RI/FS completed for groundwater along western perimeter and area west of the Aerojet Site. Agencies issued Record of Decision in July 2001 that selected multiple-corridor and aquifer groundwater pump and treat remedy.

3 INITIAL EVALUATION

In this section, the initial evaluations of existing data completed as part of the Work Plan scoping process are presented. These evaluations include a preliminary site conceptual model, known and suspected sources of contamination, potential chemical transport and routes of chemical migration, potential receptors and exposure pathways, a preliminary analysis of potential ARARs, discussions of existing Interim Actions and current treatability studies, and a preliminary identification of response objectives and technologies/process options.

3.1 Preliminary Site Conceptual Model

This Preliminary Site Conceptual Model (SCM) was developed for the Study Area to evaluate potential risks to human health and the environment (Figure 3-1). Soil-gas, soil, and groundwater samples were collected and analyzed for various constituents from over 200 potential source sites within or upgradient of the Study Area. The analytical data show that chemicals have been released to the environment from ponds, tanks, sumps, and spills and during industrial operations such as rocket testing, propellant milling, and waste disposal by burial or burning. Most chemicals were reportedly released during the course of normal operations and the majority of source sites are associated with former waste disposal facilities (e.g., ponds, tanks).

Chlorinated solvents are the most common chemicals in groundwater and trichloroethene (TCE) is the most prevalent. Other VOCs in groundwater include 1,1,1-trichloroethane (1,1,1-TCA); 1, 1-dichloroethane (1,1-DCA); 1,2-dichloroethane (1,2-DCA); 1,1-dichloroethylene (1,1-DCE): 1,2-dichloroethylene (1,2-DCE); vinyl chloride, Freon-113, Freon –11, bromoform, carbon tetrachloride, methylene chloride, and acetone. Rocket fuel and propellant constituents were also detected in groundwater including perchlorate and n-nitrosodimethylamine (NDMA). Other chemicals reported in groundwater less frequently include trace metals, hydrocarbon fuels, 1,4-dioxane, poly-aromatic hydrocarbons, nitrate, trace metals, and other miscellaneous anions and cations. While similar in nature, the sources and types of chemicals are different at each of the Site perimeters.

Some chemicals released to the ground have percolated into groundwater through mainly loose sediments that were historically dredged for gold. Some chemicals in groundwater have migrated towards and beyond the Site perimeters. This PGOU RI/FS addresses those chemicals in groundwater that are approaching or are already beyond the Site perimeters.

The conceptual hydrogeologic model for the Study Area has been refined over a 20-year period of continual groundwater investigations. Groundwater beneath the Aerojet

property generally flows radially from the east side of the property, towards the southern, western, and northern property boundaries. Most of the aquifer is comprised of fluvial sediments contained within the regional geologic formations. The upper 600 feet of the aquifer has been subdivided into seven hydrostratigraphic layers (Layers A through F and bedrock) differentiated primarily by lithology, resistivity, depth, and aquifer test data.

The fate of chemicals released to groundwater at the Site is transport with the bulk of groundwater flow to points of groundwater withdrawal or discharge. Chemicals are transported in groundwater through advective and dispersive processes. When groundwater velocities are high, such as at the Aerojet Site, advective groundwater flow is the dominant transport mechanism.

The Site is used for industrial purposes and the land use surrounding the Site is mixed residential, commercial, agricultural, and industrial. Potential human receptors on-site include site workers, tenants, and visitors, and potential human receptors off-site include residents, workers, and visitors to the adjacent communities. The potential exposure pathways for both on-site and off-site receptors may include the use of groundwater for residential, industrial, or agricultural water supply, discharge of groundwater to surface water, and migration of VOCs from groundwater through the unsaturated zone and into ambient or indoor air.

Groundwater is not used on-site, but is provided to residences off-site. Monitoring of public and domestic water supply wells is conducted in accordance with the Exhibit IV PCD Groundwater Monitoring Plan and California Department of Health Services (DHS) requirements.

3.2 Known and Suspected Sources of Contamination

Historical practices resulted in the release of chemicals to soil and groundwater. There were greater than 300 potential source areas identified during the initial Site reconnaissance and investigated during the Stage 1 RI (ICF Kaiser Engineers, 1993a-c). Most chemicals at the Site were reportedly released during normal waste operating procedures, and are generally present below evaporation ponds, sumps, burn areas, landfills, cleaning slabs, or other waste disposal features. Accidental spills and leaks may have occurred at some of the above- and underground chemical and fuel storage tanks and drums located throughout the Site. The sources of most chemicals were identified and characterized during the Stage 1 RI.

More specific information regarding known and suspected sources of contamination in each Zone is contained in the "Remedial Investigation Background" sections of Appendices A through D.

3.3 Types of Chemicals Detected in Groundwater

Some of the chemicals detected at the source areas in the vadose zone have migrated into PGOU groundwater. Solvents and rocket fuel components are the most widely distributed chemicals in groundwater, probably because they were handled in large quantities and are relatively water-soluble. With the exception of perchlorate and hydrocarbon fuels, most non-VOCs detected in soil were not detected in the underlying groundwater (e.g., PCBs, dioxins/furans, and metals). The following list summarizes the most common chemicals previously detected in groundwater upgradient of or within the PGOU:

Solvents	Rocket Fuel-Related Compounds	Petroleum-Related Compounds
PCE	Perchlorate	Diesel fuel
TCE	NDMA	Motor oil
1,2-DCE	Nitrate	Kerosene
1,1-DCE		Benzene, toluene, ethylbenzene, xylene
Vinyl chloride		Poly-aromatic hydrocarbons (PAHs)
1,2-DCA		Poly-nuclear aromatic hydrocarbons (PNAs)
1,1-DCA		
Freon 113		
Methylene chloride		
Carbon tetrachloride		

Three chemicals, TCE, perchlorate, and NDMA are the most common and widely distributed compounds in groundwater. Figures showing the distribution of these chemicals in the various hydrostratigraphic layers in each Zone are presented in Appendices A through D. TCE is the most widely distributed chemical in PGOU groundwater and was detected in all Zones on-site, and in groundwater downgradient of Zones 1, 2 and 3. There are several suspected on-site sources of TCE that may be present as dense non-aqueous phase liquid (DNAPL) occurrences. These suspected occurrences, based on the Phase I RI/FS (ICF Kaiser Engineers, 1993a-c), include Area 20 and the Central Disposal Area (CDA) in Zone 1, Site 57F in Line 4 in Zone 2, Area 40 in Zone 3, and Sites 66A and 12A in Zone 4. Other chemicals common in groundwater include components of rocket propellant and fuel. Perchlorate is an oxidizer that was used in solid rocket propellants produced primarily in Zones 1 and 2, but was detected in groundwater in Zones 1, 2, and 3, and off-site. NDMA is a potential impurity or combustion product of hydrazine-based liquid rocket fuels. The majority of NDMA was reported in the eastern areas in Zones 3 and 4 where liquid rocket operations were conducted; however, NDMA has been detected in Zones 1 and 2 groundwater in the west.

Summary discussions regarding the types of chemicals detected in groundwater in Zones 1 through 4 based on evaluations of information available from previous and on-going groundwater investigations are included in the following sections. More detailed discussions of chemical occurrences along with the specific evaluations that were completed to assess data needs for the PGOU RI/FS are included in Appendices A through D of this Work Plan.

3.3.1 Zone 1 Study Area: Existing Data Summary and Data Gap Analysis

The Zone 1 Study Area is located in the northern portion of the Site, and includes Sector D and the GET D interim remedial system on-site, and the ARSA and the ARGET interim remedial system off-site.

The specific initial evaluation that was performed to assess the types of chemicals detected and map the extent of chemicals in groundwater in the Zone 1 Study Area is provided in Section 5 – Characterization of Chemicals in Groundwater of Appendix A. A summary of the status of the groundwater investigation for the Zone 1 Study Area and recommendations for collecting data necessary to complete the PGOU RI/FS are provided in this section.

The preliminary assessment of the Zone 1 Study Area groundwater shows that VOCs, perchlorate, 1,4-dioxane, dibenzofuran, metals, PAHs and PNAs, total petroleum hydrocarbons (TPH), and nitrate were recently or historically detected in groundwater in Sector D. VOCs, perchlorate, NDMA, and 1,4-dioxane were recently detected in the ARSA groundwater. Groundwater samples will be collected from the GET D influent to identify the types of chemicals in Zone 1. The GET D influent will be analyzed for PAHs/PNAs (semi-volatile organic compound [SVOC] analysis), 1,4-dioxane, and metals.

The extent of chemicals in Zone 1 along the northwestern property boundary is characterized, and no sampling is recommended to define the extent of chemicals on-site. In the ARSA, the extent of chemicals is defined north of the American River. However, the extents of TCE and perchlorate are undefined south of the river. The TCE and perchlorate in this area are being addressed by two extraction wells planned for construction in 2002. Additionally, the potentiometric surface and cross sections prepared for this area will be expanded west to include data from OU-3 to assist with stratigraphic correlation and the interpretation of groundwater flow between the Western Groundwater and Perimeter Groundwater Operable Units.

The chemicals in the Zone 1 Study Area groundwater are distributed in Sector D and the ARSA in Layers A through D. TCE and perchlorate were the most common chemicals and were distributed over the largest area. In general, chemicals were observed to migrate vertically into deeper layers as they migrated laterally to the northwest. The highest chemical concentrations and greatest lateral extent of chemicals were observed in

Layer A, and the concentrations and extents of chemicals decreased in each successive underlying layer. The base of contamination was observed in Layer D; however, limited samples were collected in Layer E.

The specific activities to complete the RI/FS for the Zone 1 Study Area are described below. These activities are also listed in Section 5.3 (RI/FS Task 3: Field Investigation) and Section 5.5 (Task 5: Data Evaluation) of this Work Plan and in Appendix A.

Additional data proposed to be collected to assess the Zone 1 Study Area physical characteristics are listed below. With respect to the nomenclature for each data collection activity proposed below, the Z1 refers to Zone 1 and the succeeding number (e.g., -1) is the unique sequential number representing the specific data collection activity.

Z1-1. Future growth predictions for eastern Sacramento and western El Dorado County will be reviewed to assess future development plans in the area. Census data will be reviewed and compiled for the risk assessment. A figure will be prepared showing the current land uses in the developed areas, and showing the projected land uses in the undeveloped areas.

Z1-2. Lithologic data from newly installed Layer E Wells 30176 and 30179 will be added to existing cross-section A-A'.

Z1-3. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Z1-4. The area covered by the potentiometric surface maps will be expanded south of Folsom and west of Sunrise Boulevards to combine data from the PGOU and the WGOU.

Z1-5. A southwest-trending cross-section, extending into Layer E, will be constructed roughly parallel to Folsom Boulevard, extending from Hazel Avenue to Sunrise Boulevard.

Z1-6. Water level elevation data from Wells 30176 and 30179 will be added to the Layer E potentiometric surface map.

The following activities will be completed to support the FS and evaluation of hydraulic containment at GET D:

Z1-7. Historical and recent chemical concentrations will be plotted to assess chemical concentration trends.

Z1-8. All existing cross-sections will be updated with the most recent chemical and water level data and additional cross-sections will be prepared.

Z1-9. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

Additional data that will be collected to characterize chemicals in the Zone 1 Study Area groundwater include:

Z1-10. Samples of the influent to the GET D treatment facility will be collected and analyzed for TPH-related compounds using EPA Method 602 [benzene, toluene, ethylbenzene, and xylenes (BTEX)] and EPA Method 8270.

Z1-11. Groundwater samples will be collected and analyzed for aromatic VOCs and SVOCs (EPA Methods 602 and 8270, respectively), from Layer A monitoring Wells 3094, 346, and 347.

Z1-12. Samples of the influent to the GET D treatment facility will be collected and analyzed for 1,4-dioxane using EPA Method 8270. Collecting samples of the GET D influent are appropriate as there are no known point sources of 1,4-dioxane in the Study Area, and sampling of monitor wells could miss 1,4-dioxane, if it is present.

Z1-13. Samples of the influent to the GET D treatment facility will be collected and analyzed for the following metals: arsenic, cadmium, chromium, lead, selenium, and thallium. The analytical methods, respective reporting limits (RLs), and lowest Water Quality Objectives (WQOs) for these metals are listed on Table A-1.

3.3.2 Zone 2 Study Area: Existing Data Summary and Data Gap Analysis

The Zone 2 Study Area is located in the southern portion of the Site, and includes Sector G and areas upgradient of the Zone 2 portion of the PGOU and extends south to the southern property boundary at White Rock Road.

The specific initial evaluation that was performed to assess the types of chemicals detected and map the extent of chemicals in groundwater in the Zone 2 Study Area is provided in Section 5 – Characterization of Chemicals in Groundwater of Appendix B. A summary of the status of the groundwater investigation for the Zone 2 Study Area and the data necessary to complete the PGOU RI/FS are provided in this section.

The preliminary data assessment for the Zone 2 Study Area indicates that VOCs, primarily TCE, and perchlorate are present in the Study Area groundwater. Groundwater flows southeast from potential source sites located in eastern Line 04, towards the southern property boundary. There are no interim actions in the Zone 2 Study Area. Chemicals present south of White Rock Road and the southern property boundary are

being addressed by the State's Imminent and Substantial Endangerment Order (ISEO) issued for the IRCTS.

Additional characterization of chemicals in groundwater is needed in the Zone 2 Study Area. The lateral extent of TCE and perchlorate in Layers B and C near the southern property boundary requires additional data collection. Metals were detected in groundwater near potential upgradient source sites during a previous investigation. Some metals detected previously have not been analyzed recently and samples are needed to assess potential metals in groundwater. Data are also needed to assess whether nitrate and cyclotetramethylenetetranitramine (HMX), detected in soil during the Stage 1 RI, are present in groundwater. HMX is an explosive that was detected in soil at one source site in eastern Line 04.

The specific activities proposed to complete the RI/FS for the Zone 2 Study Area are described below. These activities are also listed in Section 5.3 (RI/FS Task 3: Field Investigation) and Section 5.5 (Task 5: Data Evaluation) of this Work Plan and in Appendix B.

Additional data proposed to be collected to assess the Zone 2 Study Area physical characteristics include the following:

Z2-1. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Z2-2. Historic groundwater data from Layer B monitor will be evaluated during the PGOU RI/FS.

Z2-3. Historic groundwater data from Layer C monitor wells will be evaluated during the PGOU RI/FS.

Additional data proposed to be collected to characterize chemicals in the Zone 2 Study Area groundwater include:

Z2-4. Temporal chemical concentration trends will be prepared and evaluated.

Z2-5. All existing cross-sections will be updated with the most recent chemical and water level data.

Z2-6. All chemical-isoconcentration maps will be finalized and all data will be reviewed during the RI/FS.

Z2-7. Samples will be collected from monitoring wells 410, 415, and 3119 and analyzed for various metals as specified on Table B-1.

Z2-8. Samples will be collected from Wells 50, 411, 415, 3076-8, 3357-8, 3381 and 3392 and analyzed for nitrates (Table B-1).

Z2-9. Samples will be collected from monitoring Wells 412 and 413 and analyzed for various metals as specified on Table B-1.

Z2-10. A groundwater sample will be collected from Well 412 to identify if HMX is present in groundwater (Table B-1).

Z2-11. Groundwater samples will be collected from Wells 3460 and 3500-1 and analyzed for VOCs and perchlorate (Table B-1).

Z2-12. Data collected from the RCRA closure at Site 11G will be assessed.

Z2-13. Groundwater samples will be collected from Wells 111, 4395, and 314-5 and analyzed for VOCs and perchlorate (Table B-1).

Z2-14. Samples will be collected from Layer E Wells 3074-5 and analysed for VOCs and perchlorate (Table B-1).

3.3.3 Zone 3 Study Area: Existing Data Summary and Data Gap Analysis

The Zone 3 Study Area is located in the southeastern portion of the Site, and includes groundwater beneath Sector B, the GET B interim remedial systems on-site and off-site at GET B South, and groundwater beneath Area 39 and Area 40.

The specific initial evaluation that was performed to assess the types of chemicals detected and map the extent of chemicals in groundwater in the Zone 3 Study Area is provided in Section 5 – Characterization of Chemicals in Groundwater of Appendix C. A summary of the status of the groundwater investigation for the Zone 3 Study Area and recommendations for collecting data necessary to complete the PGOU RI/FS are provided in this section.

The preliminary assessment of the Zone 3 Study Area groundwater shows that VOCs, perchlorate, NDMA, nitrate, metals, phenol, and TPH were recently or historically detected in groundwater in Sector B. Recent data indicate that VOCs, NDMA, and perchlorate are present in the Zone 3 Study Area in Sector B and at GET B South. The chemicals are distributed within Layers A through F. Additional hydrologic characterization is needed to identify potential groundwater flow paths from the potential source sites located in northern Zone 3 to GET B South. Additional hydrologic characterization of Layers E and F is also needed.

Chemicals at concentrations approaching WQOs are present at the south end of GET B South. One additional monitor well is recommended to assess the downgradient extents of these chemicals. There are five groundwater extraction wells located near the southern GET B South boundary, and the effectiveness of the hydraulic capture will be assessed during the RI/FS.

The effectiveness of the GET B groundwater extraction and treatment system will be evaluated during the RI/FS. The evaluation will consist of both a hydraulic containment analysis and an analysis of the treatment facilities. Groundwater samples of the GET B

influent will be sampled to further characterize the groundwater, and to identify chemicals present that may require treatment.

Additional field investigation is needed in Areas 39 and 40. Hydrologic assessment and chemical characterization are needed for both areas. The concentrations of TCE detected in Area 40 groundwater suggest DNAPL may be present, and the practicability of restoring the groundwater in Area 40 will be assessed during the RI/FS.

The specific activities to complete the RI/FS for the Zone 3 Study Area are described below. These activities are also listed in Section 5.3 (RI/FS Task 3: Field Investigation) and Section 5.5 (Task 5: Data Evaluation) of this Work Plan and Appendix C.

Additional data proposed to be collected to assess the Zone 3 Study Area physical characteristics include the following:

Z3-1. Two north-south trending cross-sections will be constructed in Sector B, one from Gate 7 to Well 97 and a second from Well 344-5 to Well 97. Two east-west trending cross sections will be constructed perpendicular to the direction of groundwater flow in the northern and southern areas in Sector B. The monitor wells proposed to be included on each cross-section are listed in Table C-1.

Z3-2. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Z3-3. Water levels will be collected quarterly from all auger and monitor wells in Area 40 for a period of one year to compare water level elevations between wells and to evaluate seasonal water level trends.

Z3-4. Three cross-sections will be constructed to compare the lithology, depth-to-water, chemical concentrations, and depth of screened intervals for the monitor wells in Area 39. The monitor wells included on the cross-sections are identified in Table C-1.

Z3-5. Water levels will be collected quarterly from all auger and monitor wells in Area 39 for a period of one year to compare water level elevations between wells and to evaluate seasonal water level trends.

Additional data proposed to be collected to characterize chemicals in the Zone 3 Study Area groundwater or other activities proposed to support evaluations in the FS include:

Z3-6. Temporal chemical concentration trends will be prepared and evaluated.

Z3-7. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

Z3-8. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

Z3-9. Samples will be collected from monitor wells 145-7, 3488-90, 378, 379, and 3506 and analyzed for 1,4-dioxane, naphthalene, TPH-kerosene, phenol, aluminum, antimony, arsenic, cadmium, total chromium, chromium^{+6}, and lead.

Z3-10. Samples will be collected from monitor wells 154-56 and analyzed for aluminum, antimony, arsenic, cadmium, total chromium, chromium^{+6}, and lead.

Z3-11. Samples will be collected and analyzed for metal and dioxins/furans from alluvial monitor wells 1696, 817, 822, 1515, and 798, and from bedrock monitor wells 30060 and 1514 (Table C-1). The samples will also be analyzed for SVOCs to address uncertainties regarding the nature of waste materials deposited in Area 40.

Z3-12. Samples will be collected and analyzed for VOCs, perchlorate, and NDMA from monitor wells 1575, 1577, 1578, 1318, 791, 796, 1317, and 1337.

Z3-13. One monitor well (P1) will be installed approximately 1,000 feet southeast and southwest of Well 30168, with one screened interval in Layer C and two screened intervals in Layer D.

Z3-14. The two north-south cross-sections (E-E' and F-F') will be constructed in Sector B and GET B South. The stratigraphy near Well 1549 will be assessed and additional cross-sections may be prepared to assess the structure of Layers E and F at GET B South.

Z3-15. One groundwater sample will be collected and analyzed for VOCs, perchlorate, NDMA, and SVOCs from alluvial wells 1695, 30061, 1515, 1694, 821, 812,817, 798, 818, 822, 813, and from bedrock wells 30060, 1537, 1514, 1536, 1513, and 1512. A second sample will be collected approximately 3 months after the first sample and analyzed for VOCs, perchlorate, and all other chemicals reported in the first samples.

Z3-16. The size of the area where a TI Waiver or CZ designation is appropriate will be assessed.

Z3-17. A Site Conceptual Model will be developed for Area 40 including the site geology, hydrogeology, groundwater contamination sources, chemical fate and transport characteristics, exposure pathways, and potential receptors.

Z3-18. The feasibility of restoring groundwater in Area 40 will be assessed by conducting a technical and economic comparison of potential remedial alternatives.

Z3-19. A Management Plan will be prepared if a TI Waiver or CZ designation is appropriate for Area 40. The contents of the Plan will be further assessed pending the collection of the additional RI data.

3.3.4 Zone 4 Study Area: Existing Data Summary and Data Gap Analysis

The Zone 4 Study Area is located in the northeastern area of the Site, and includes areas upgradient of Sector A, the GET A interim remedial system, and Sector C.

The specific initial evaluation that was performed to assess the types of chemicals detected and map the extent of chemicals in groundwater in the Zone 4 Study Area is provided in Section 5 – Characterization of Chemicals in Groundwater of Appendix D. A summary of the status of the groundwater investigation for the Zone 4 Study Area and recommendations for collecting data necessary to complete the RI/FS for the PGOU RI/FS are provided in this section.

Recent groundwater data are available from the dredged layer (Sector C), Layers A and B (Sectors A and C), and the underlying bedrock (Sector A). The data show that the majority of the chemicals are present in Layer A in Sector A. NDMA, Freon-113, and TCE were the predominant chemicals in Sector A groundwater, which flows towards the northern Site boundary and is intercepted by the GET A extraction wells at Alder Creek. TCE and NDMA were detected in Layer A in Sector C.

The vertical and lateral extents of VOCs and NDMA were characterized in Sector A, and there are no samples proposed to evaluate the extent of chemicals. There are no recent data for 1,4-dioxane, nitrate, and perchlorate and sampling is proposed to assess their potential presence. The GET A groundwater treatment facility influent will be sampled for 1,4-dioxane, and the GET A groundwater treatment facility effluent will be sampled for 1,4-dioxane, perchlorate, and nitrate (see Section 5.3 of this Work Plan).

In Sector C, the recent data are sufficient for characterizing the dredged layer and no additional sampling is proposed. However, additional samples are proposed to evaluate the extent of metals (in Layer A) and NDMA (Layers A and B) detected in groundwater downgradient of Area 46 and the landfill. Samples will be collected from three monitor wells in Sector C for perchlorate and 1,4-dioxane analysis because they were historically detected or handled in Area 46.

The specific activities to complete the RI/FS for the Zone 4 Study Area are described below. These proposed activities are also listed in Section 5.3 (RI/FS Task 3: Field Investigation) and Section 5.5 (Task 5: Data Evaluation) of this Work Plan and Appendix D. The following general data needs have been identified to characterize the nature and extent of chemicals in the Zone 4 Study Area groundwater.

Additional data proposed to be collected to assess the Zone 4 Study Area physical characteristics include the following:

Z4-1. Lithologic data from wells near Alder Creek and creek bed elevation data will be used to re-evaluate or reconstruct cross-sections A-A' and B-B'.

Z4-2. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with groundwater data collected on October 2001.

Z4-3. Potentiometric surface maps for Layer A will be compared to the elevations of Alder Creek as part of the evaluation of whether Alder Creek is a gaining or losing stream.

Z4-4. The length of Alder Creek will be walked to identify seeps or springs potentially discharging into the creek.

Z4-5. Historical and recent chemical concentrations will be plotted to assess chemical concentration trends.

Z4-6. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

Z4-7. All chemical-iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

Additional data proposed to be collected to identify chemicals in Zone 4 groundwater include:

Z4-8. Samples from the influent to the GET A groundwater treatment facility will be analyzed for 1,4-dioxane, perchlorate, and nitrate.

Z4-9. Samples will be collected from Wells 3387 and 3386 and analyzed for 1,4-dioxane and perchlorate.

Z4-10. Water quality data collected from the upstream and downstream portions of Alder Creek during 1998 through 2001 will be reviewed and included in the ecological risk assessment evaluation.

Z4-11. Any groundwater seeps identified near Alder Creek (activity Z4-1) will be sampled and analyzed for perchlorate, VOCs, and NDMA.

Z4-12. Wells 449 and 453 will be sampled and the sample analyzed for NDMA.

Z4-13. Well 79 will be sampled and the sample analyzed for arsenic, lead, and nickel.

Z4-14. Well 454 will be sampled and the sample analyzed for NDMA to evaluate the vertical extent of NDMA from Layer A.

3.4 Chemical Transport and Routes of Migration

Based on the Preliminary Site Conceptual Model described in Section 3.1, several transport and migration mechanisms were identified for chemicals in groundwater. These include the following:

- Horizontal and vertical migration of chemicals in groundwater as a consequence of advection and dispersion;
- Discharge of chemicals in groundwater to surface water; and

- Migration of VOCs from the groundwater table via soil vapor through the unsaturated zone and into air.

These mechanisms were considered in the identification of potential exposure pathways presented in the following section (Section 3.5).

3.5 Preliminary Identification of Potential Receptors and Exposure Pathways

The Aerojet site is currently used for industrial purposes, and activities are confined to specific manufacturing areas within the property. With the exception of these well-defined manufacturing areas, large parts of the property are not currently used. Some portions of the site are available for redevelopment, and future use of these areas may involve residential, commercial, or industrial activities.

Adjacent to the Aerojet site, the land use is mixed. Areas north of the site are characterized by both residential development (in the vicinity of the Gold River community) and commercial development (along Folsom Boulevard). To the south and east, the Aerojet site is bordered largely by agricultural land. These areas could be developed for residential, commercial, or industrial purposes.

This land use information was used, together with site information presented earlier in Section 3, to make a preliminary identification of potential receptors and exposure pathways. The following text briefly describes these analyses for both human and ecological receptors.

3.5.1 Potential Receptors and Exposure Pathways (Human Health)

Under current and realistic future use conditions, on-site receptors may include industrial workers, commercial workers, construction workers, maintenance/utility workers, visitors, and residents (adults and children) if residential use is considered as part of the future land use for the site. Off-site receptors include these same populations, as well as commercial workers and patrons of commercial establishments (e.g., shoppers or other visitors).

General exposure pathways that may be associated with groundwater include the following:

- Use of groundwater for residential, industrial, or agricultural water supply;
- Discharge of groundwater to surface water;
- Uptake of groundwater by food crops;

- Migration of VOCs from groundwater through the unsaturated zone into either ambient air or indoor air; and

- Contact with groundwater during excavation or other intrusive activities.

Of these various exposure pathways, the use of groundwater for residential water supply provides the most realistic opportunity for potential exposure[1] to chemicals in PGOU groundwater. Several domestic and municipal supply wells are located in the vicinity of the Aerojet Site (Figure 2-3). Furthermore, in the absence of institutional controls, future developers of off-site properties may use groundwater as their primary source of drinking water supply. On-site, groundwater use is restricted.

The opportunity for exposure to occur via the other pathways listed above is considered less likely, for the reasons discussed below:

Use of groundwater for industrial or agricultural water supply: Exposures via this pathway are considered possible and, as discussed in Appendix D, will be evaluated during the RI.

Discharge of groundwater to receiving surface water bodies: Based on current site information, it is not known whether perimeter groundwater discharges to surface water in the vicinity of the site. This unlikely opportunity for exposure will be confirmed through additional field activities undertaken as part of the RI.

Uptake of groundwater by crops: Exposure via this pathway is considered unlikely, based on the depth to groundwater in those areas where agricultural use could occur. In addition, the current and realistic future land uses for the site make exposure via this pathway unlikely.

Migration of VOCs from groundwater into air: Exposure via this pathway will be evaluated during the RI.

Contact with groundwater during construction activities: Again, the depth to groundwater makes exposure via this pathway unlikely in most locations in the Study Area. For the lands removed from the Superfund site boundary, construction activities involving dewatering of groundwater will be conducted in accordance with the environmental restrictions.

Thus, based on this preliminary evaluation of potential exposure pathways, the use of groundwater for residential water supply represents the primary pathway by which

[1] Routes of exposure associated with the use of groundwater for residential supply include the following: ingestion, dermal contact during showering or bathing; and inhalation of VOCs released from water during household activities (e.g., showering, washing dishes, etc.). Additional exposure may occur if groundwater is used to irrigate home gardens, or if bioaccumulative constituents are present in breast milk.

exposure to constituents in Perimeter OU groundwater may occur. This conclusion will be verified in the human health risk assessment, based on additional data that will be collected as part of the RI.

3.5.2 Potential Receptors and Exposure Pathways (Ecological Health)

Various ecological receptors, including both terrestrial and aquatic species, are present in the vicinity of the Aerojet site, particularly in undeveloped or unused areas. The information currently available indicates that exposures by ecological receptors to constituents in perimeter groundwater are limited or prevented by the following site characteristics:

- The depth to groundwater; and
- The absence of any groundwater discharge to surface water.

As noted above, additional data will be collected in the RI to confirm the absence of any complete exposure pathway for ecological receptors. In the event that the additional data suggest the presence of one or more complete exposure pathways for ecological receptors, then the pathway(s) will be evaluated in the screening level ecological risk assessment (Task 6; Section 5.6).

3.6 Preliminary Analysis of Applicable or Relevant and Appropriate Requirements

This section identifies requirements associated with other environmental laws and regulations that may potentially be ARARs to the evaluation of possible remedial alternatives for the PGOU FS. Potential ARARs for the PGOU were identified based on the results of the ARARs evaluation presented in the WGOU RI/FS (EMSI et al., 2000) and EPA and RWQCB comments on the WGOU RI/FS (USEPA, 2001a).

The purpose of including an evaluation of potential ARARs as part of this Work Plan is to assist with the identification of potential data needed to complete the PGOU RI/FS. A complete evaluation of potential ARARs will be presented in the FS report. Final selection of ARARs applicable or relevant and appropriate to the PGOU remedy will be made by EPA as part of the Proposed Plan and Record of Decision for the PGOU.

Section 121(d) of CERCLA states that remedial actions on CERCLA sites must attain (or justify the waiver of) any federal or more stringent State environmental standards, requirements, criteria, or limitations that are ARARs. Applicable requirements are those cleanup standards, criteria, or limitations promulgated under federal or State law that specifically address the type of situation present at a particular CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated

under federal or State law that while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are well-suited to the conditions of the particular site.

Pursuant to EPA guidance, ARARs generally are classified into three categories: chemical-specific, location-specific, and action-specific requirements. Chemical-specific ARARs include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemicals. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. Location-specific ARARs are those requirements that relate to the geographical or physical position of the site, rather than the nature of the site chemicals or the proposed site remedial actions. Action-specific ARARs are requirements that define acceptable handling, treatment, and disposal procedures for hazardous substances.

A requirement may not meet the definition of an ARAR, but still may be useful in assessing whether to take action at a site or to what degree action is necessary. This can be particularly true when there are no ARARs for a site, action, or contaminant. Such requirements are called to-be-considered (TBC) criteria. TBC criteria are nonpromulgated advisories or guidance issued by a federal or State government that are not legally binding, but that may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they are considered together with ARARs to establish the required level of cleanup for protection of human health or the environment. The critical difference between a TBC and an ARAR is that one is not required to comply with or meet a TBC when deciding on a remedial action. However, should a TBC be established as a cleanup standard in the ROD, then the TBC effectively produces the same results as an ARAR.

The PGOU RI/FS is focused solely on groundwater contamination at and beyond the boundary of the Aerojet Site that is not addressed by the WGOU, Area 41 Soil and Groundwater OU, or the remedial program for the IRCTS. The PGOU does not include investigation of potential or actual source areas and internal groundwater control on property within the Aerojet Site, or an evaluation of potential remedial alternatives for these on-site areas. Source areas and onsite groundwater will be addressed as part of future OU RI/FS efforts. Consequently, this ARARs evaluation does not identify or evaluate potential ARARs for source areas.

3.6.1 Potential Chemical-specific ARARs

Table 3-1 presents a summary of potential chemical-specific ARARs. Numerical limits associated with potential ARARs or TBCs for chemical occurrences in groundwater are summarized on Table 3-2.

Several regulations contain numeric limits for which consideration as potential ARARs would only be triggered by particular actions. For example, consideration of the surface water WQOs would only be triggered by a remedial action that included discharge of treated water to surface water. Numerical limits associated with potential ARARs or TBCs related to discharge of treated groundwater to surface water are discussed further under potential action-specific ARARs. Similarly, consideration of numeric limits promulgated under the Clean Air Act or State air quality regulations would only be considered if the treatment process to be employed result in emissions of regulated substances. Consequently, numeric limits established for surface water, air emissions, hazardous waste management and other regulations that would only be potential ARARs if the selected remedy includes a particular action(s) or results in a generation or discharge that is covered by these regulations, are discussed further as part of the evaluation of potential action-specific requirements.

3.6.2 Potential Location-specific ARARs

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations. Location-specific ARARs differ from chemical-specific or action-specific ARARs in that they are not closely related to the chemicals of concern or the specific remedial alternative under consideration. Location-specific ARARs are concerned with the area in which the site or remedial action component is located. To the extent that the remedial action will affect historical resources, streams, flood plains, or wetlands, EPA requires that the potential remedial alternatives comply with the location-specific requirements. Potential location-specific ARARs and TBC criteria for the PGOU RI/FS are summarized in Table 3-3.

3.6.3 Potential Action-specific ARARs

Remedial alternatives have not yet been identified for the PGOU; therefore potential action-specific ARARs cannot be identified at this time. As the possible remedial alternatives for the PGOU RI/FS are expected to generally be similar to the remedial alternatives previously developed and evaluated for the WGOU RI/FS, the federal and State potential action-specific ARARs for the alternatives evaluated in the WGOU RI/FS are summarized in Table 3-4.

3.7 Existing Interim Actions

Several Interim Action remedial systems located within the PGOU Study Area were installed and are currently operated and maintained by Aerojet to contain contaminated groundwater at the boundary of the Aerojet Site or to collect off-site contaminated groundwater. These Interim Actions include the GET D and ARGET systems in Zone 1,

GETs E and F in Zone 2 (included in OU-3), GET B in Zone 3, and GET A in Zone 4. These systems are described in the following sections.

3.7.1 Zone 1

The two interim action remedial systems in Zone 1 are the GET D and ARGET groundwater extraction and treatment systems located on- and off-site, respectively (Figure 2-2). GET D was constructed in 1981 to contain and treat VOCs at the Sector D Site perimeter. GET D in the 4900 Area includes 10 extraction wells in Layer A, 10 extraction wells screened in both Layers A and B and one extraction well screened in Layer C. GET D in Area 20 includes one extraction well screened in Layers A and B (well number 4001), one extraction well screened only in Layer B (4035) and three extraction wells screened in Layer C (4017, 4210, and 4220). Groundwater from these extraction wells is blended in a 20,000 gallon surge tank prior to treatment. The current combined groundwater flowrate from the GET D extraction wells averages approximately 1,000 gallons per minute (gpm). Treatment at GET D consists of air stripping (two pairs of packed column, counter-current towers) for VOCs removal, addition of carbon dioxide for pH adjustment, and bag filtration. The treated water from GET D is recharged through a series of six recharge wells located southwest of the extraction wells at depths ranging from 80 to 160 ft bgs.

The ARSA contains extraction wells on the north and south sides of the American River including 5 wells screened in Layer A, five wells screened in Layer B, and five wells screened in Layer C. There are currently no extraction wells operating in Layer D in Zone 1, although two Layer D extraction wells have been installed in the ARSA (one north of and one south of the river) and are scheduled to be online during 2002. The combined groundwater flowrate from the ARSA extraction wells is currently approximately 2,000 gpm and is anticipated to be 2,400 gpm with the operation of the Layer D extraction wells. Extracted groundwater is conveyed from the ARSA to the ARGET treatment facility that is located on-site, as shown on Figure 2-2. The ARGET treatment facility includes ultraviolet (UV)/chemical oxidation pretreatment for removal of VOCs for groundwater from extraction wells 4325, 4330, and 4335. Following pretreatment, the groundwater from extraction wells 4325, 4330, and 4335 is combined with groundwater from the other 12 ARSA extraction wells and passed through a single packed column air stripper for removal of the remaining VOCs. The treated water from the ARGET treatment facility is discharged to Buffalo Creek under an NPDES permit (CA 0083861).

Several smaller remedial efforts have been completed at a few source areas and for some groundwater in Zone 1. A free-product recovery system was installed in Area 20 to remove diesel fuel downgradient of Sites 3D/52D in the early 1980's. The system is no longer operating. Some perchlorate and TCE in groundwater downgradient of the CDA were removed during two pilot tests conducted to evaluate enhanced intrinsic

bioremediation in 2000 and 2001, respectively (GeoSyntec, 2001a), one of which is still ongoing.

3.7.2 Zone 2

Interim action remedial systems in Zone 2 include the GET E groundwater extraction wells, the GET F extraction wells, and the GETs E/F groundwater treatment facility (Figure 2-2). These systems provide containment of groundwater upgradient of the western boundary of the Site and were included in the WGOU RI/FS.

3.7.3 Zone 3

The interim action remedial system located in the southeastern section of the Aerojet Site in Zone 3 is the GET B groundwater extraction and treatment system (Figure 2-2). GET B was placed into operation in September 1986 pumping groundwater from offsite extraction wells 1198, 4080, 4085, and 4090. In 1988 extraction wells 4095, 4195, and 4215 were added (Wells 4095 and 4195 replaced 1198). Offsite extraction well 4303 and onsite wells 98, 4011, and 4304 were installed in 1995. Offsite extraction wells 4460, 4465, 4410, 4400, and 4405 and onsite extraction wells 4475 and 4480 were added in 1998. The current total number of operational extraction wells associated with GET B is 21, ranging in depth from 115 to 260 feet. Groundwater from the WRND Interim Action (extraction wells 4505, 4510, 4515, 4520, and 4525) is also directed to the GET B treatment facility for VOCs removal. Current combined influent flowrate to the GET B treatment facility averages approximately 1,400 gpm.

The GET B treatment facility originally consisted of a 10-acre solar UV treatment pond, a chemical feed system, two induced draft cross-current air stripping columns operated in series, and an effluent infiltration area. The effluent infiltration area is located along Rebel Hill Ditch. The treatment system now consists of seven 90 kilowatt (KW) UV/chemical oxidation reactors operated in parallel followed by two packed tower counter current air stripping towers operated in parallel.

3.7.4 Zone 4

The interim action remedial system located in the northeastern section of the Aerojet Site in Zone 4 is the GET A groundwater extraction and treatment system (Figure 2-2). GET A was placed into operation in 1986 (extraction wells 4100, 4105, 4110, 4115, 4120, 4125, and 4130) with an initial flow of 360 gpm to contain and treat chemicals in on-site Layer A groundwater, downgradient of Management Areas 30, 31, and 32 and near a suspected source. In February 1995, extraction wells 4012 and 4013 were added to also intercept contaminated groundwater near a suspected source. In 1997, extraction wells 4500 and 4430 were installed to replace extraction well 4115, bringing the current total

number of operational extraction wells to 10. The extraction wells range in depth from 67 to 150 feet. Current combined flow from the wells averages approximately 250 gpm.

The GET A treatment facility originally consisted of a 1.5-acre solar UV treatment pond, a chemical feed system, one induced draft cross-current air stripping column, and an effluent infiltration area. The effluent infiltration area is located along Rebel Hill Ditch. The current treatment system consists of one 90 KW UV/chemical oxidation reactor and one counter-current packed tower air stripper for VOCs removal.

3.8 Current Treatability Studies

Aerojet is currently in the progress of conducting bench- and pilot-scale treatability tests for several technologies for removal of VOCs, perchlorate, and NDMA. These include use of ion exchange (both resin loading and regeneration studies) for removal of perchlorate; and several in-situ treatability studies for perchlorate, NDMA (bench-scale study), and/or VOCs removal. A description of each of these studies and the estimated schedule for completion are presented below.

3.8.1 Ion Exchange (and regeneration) for Perchlorate Removal

Ion exchange resins are, by definition, insoluble solids containing fixed cations or anions capable of reversible exchange with mobile ions of the opposite sign in the solutions with which they are brought into contact. Selective ion exchange is one of the preferred treatment technologies for removing low levels of perchlorate from contaminated groundwater because of its high efficiency and minimal impact on water quality through the addition or removal of chemicals and nutrients. However, the exceptionally high affinity of perchlorate for anion exchange resins makes regeneration of the perchlorate-laden ion exchange resins with conventional sodium chloride brine difficult and costly for practical applications. A regeneration methodology employing tetrachloroferrate anions formed in a solution of ferric chloride and hydrochloric acid was recently found in bench-scale studies to effectively displace perchlorate anions using as little as five bed volumes of the regenerant solution. This new regeneration methodology may offer a cost-effective means to regenerate perchlorate loaded resins with improved regeneration efficiency, recovery, and waste minimization in comparison with conventional brine regeneration techniques (Gu, et al., 2001).

Aerojet is participating in pilot-scale treatability studies being conducted at Oak Ridge National Laboratory (ORNL) using a bifunctional ion exchange resin and the regeneration methodology discussed above. These studies are also evaluating the destruction of perchlorate in concentrated acidic regenerant solutions using electrochemical reduction and hydrothermal decomposition as means to further minimize the amount of waste brine. The treatability studies are currently projected to be complete in December 2002.

An on-site pilot ion exchange treatability study is also planned for the late Spring and Summer of 2002 using currently-available conventional ion exchange equipment, ion exchange resin, and regeneration technology. The ion exchange process will be added to the treatment train at the GET D groundwater treatment facility to remove perchlorate prior to recharge of the treated groundwater. Design and cost information regarding the ion exchange system will be generated during the testing.

3.8.2 In-situ Treatability Studies

In an attempt to significantly reduce the potential unreasonably long groundwater restoration timeframes as compared to traditional groundwater pump and treat technologies and because of the potential for significant operation and maintenance (O&M) cost savings over traditional groundwater pump and treat technologies, Aerojet is conducting several in-situ pilot-scale treatability studies for removal of VOCs and/or perchlorate. A bench-scale study for in-situ treatment of NDMA and VOCs is also being considered. These in-situ technologies appear to be particularly favorable technologies because they all have the potential to destroy the contaminants rather than transferring them to another media that would require further treatment or disposal. The in-situ technologies being tested include in-situ redox manipulation for NDMA and VOCs removal and several in-situ perchlorate biodegradation pilot tests. These technologies are described below.

3.8.2.1 In-Situ Redox Manipulation

Developed at the Pacific Northwest National Laboratory (PNNL), in-situ redox manipulation (ISRM) is based on creating a permeable reactive barrier within an aquifer to immobilize or destroy contaminants in the groundwater. Reagents and buffers are injected into the aquifer, reducing the valence state of naturally-occurring iron in sediments where the plume flows. The treatment zone is emplaced using conventional monitoring or recharge wells and a series of treatment zones can be coalesced to form a large-scale permeable barrier.

To form a treatment zone, sodium dithionite ($Na_2S_2O_4$) along with pH buffers are injected through a well and allowed to react with the groundwater or formation surfaces. Groundwater containing reaction byproducts and any remaining reagent is pumped out and disposed. Contaminated groundwater then flows naturally through the treatment zone where the contaminants react with the reduced iron sediment and are destroyed or immobilized by interactions with the reduced structural Fe(II) in the ISRM redox zone (PNNL, 2002).

Aerojet is considering participating in a bench-scale treatability test to assess whether ISRM is applicable to Site sediments. The testing would be conducted in the June through December 2002 timeframe. This technology is of specific interest to Aerojet for

in-situ treatment to remove chlorinated solvents (primarily TCE) and NDMA in the GET B area.

3.8.2.2 In-Situ Bioremediation for Perchlorate Removal

Perchlorate biodegradation results from microbially-mediated redox reactions, whereby perchlorate serves as the electron acceptor, and is reduced via chlorate to chlorite. Chlorite then undergoes a biologically mediated dismutation/disproportionation reaction, releasing chloride and oxygen. The oxygen is subsequently reduced to carbon dioxide (CO_2), provided electron donors are available. Both chlorate and chlorite are transient intermediates, and are typically not observed (half-life is too short) during perchlorate reduction. A variety of electron donors have been used to stimulate perchlorate reduction, including alcohols (e.g., ethanol), sugars (molasses) and volatile fatty acids (e.g., acetate, lactate). A variety of perchlorate-reducing microorganisms have been isolated from natural subsurface soil and groundwater environments, including various *Dechlorosoma*, *Dechloromonas*, *Rhodocyclus*, and *Ferribacterium* species. Based on the results of continuing research, perchlorate-reducing bacteria appear to be ubiquitous in subsurface environments (GeoSyntec, 2001a).

The addition of electron donors to groundwater environments to promote in-situ bioremediation can be accomplished through several configurations, including:

- Active in-situ biobarrier systems that capture impacted groundwater, amend it with an optimized concentration of a soluble electron donor such as food-grade acetate (e.g., vinegar) or sugars (e.g., molasses), and recharge the amended groundwater to the aquifer;

- Passive in-situ biobarriers established through injection of immobile slow-release electron donors such as edible oils or hydrogen release compounds; or

- Semi-passive (i.e., batch) injection of large doses of sugars such as molasses.

Each of these electron donor delivery approaches has specific benefits and limitations. For example, the benefit of the active approach (groundwater capture, amendment and recharge) is that it permits a balance between the amount of added electron donor and the amount of perchlorate (and oxygen and nitrate) in the groundwater, thus reducing electron donor waste and avoiding the production/mobilization of undesirable sulfides, methane and dissolution of metals. By comparison, the passive or semi-passive approaches that inject substantial volumes of carbon substrates result in the production of highly anaerobic and reducing redox conditions that can mobilize metals (e.g., arsenic and manganese) and produce sulfides and methane, adversely impacting secondary groundwater quality (GeoSyntec, 2001b).

Aerojet has conducted or is in the process of conducting several in-situ biological remediation treatability tests. Tests have been completed or are ongoing in Area 20, in

the GET D recharge well field, and the GET B area. A pilot test is also scheduled for a location downgradient of the former GET F Sprayfield.

Area 20 Testing. To date, two perchlorate bioremediation field demonstrations have been conducted at Area 20. The first demonstration, initiated in May 2000 and completed in April 2001 (GeoSyntec, 2001a) involved a closed loop recirculation system whereby groundwater was extracted, amended with electron donor (either acetate or lactate), and recharged to the aquifer to promote in-situ biodegradation of perchlorate and TCE. Using acetate as the electron donor, perchlorate concentrations in the Area 20 groundwater were reduced from about 12,000 µg/L to less than the Practical Quantitation Limit (PQL) of 4 µg/L in performance monitoring wells located 15 and 35 feet downgradient from the electron donor addition well. Perchlorate biodegradation half-lives calculated from the field pilot test data ranged from 0.2 to 1.8 days. Of note, perchlorate biodegradation (which is a mildly reductive process) was stimulated within the bulk aerobic/oxidizing conditions of the groundwater without significantly impacting secondary groundwater quality. Specifically, perchlorate (and nitrate) was reduced to below the PQL within 15 feet of the electron donor delivery well, while dissolved oxygen (DO) was still present at 1 to 2 mg/L and the oxidation-reduction potential remained near 0 millivolts, suggesting that perchlorate bioremediation in-situ can be accomplished with minimal impact on water quality parameters (i.e., depletion of oxygen, production of dissolved metals, sulfides and methane).

The second demonstration, initiated in July 2001 as part of a United States Department of Defense (DoD) Strategic Environmental Research & Development Program (SERDP), has involved creation of an active biobarrier across the core of the perchlorate plume at Area 20 using a series of extraction and injection wells. This second pilot is still in progress and is scheduled for completion in April 2002. Using ethanol as electron donor, perchlorate concentrations in the groundwater declined rapidly from about 8,000 µg/L to less than 4 µg/L in performance monitoring wells located 35 to 65 feet downgradient from the electron donor addition well. Perchlorate biodegradation half-lives (in-situ) calculated from the data from the first demonstration of this active biobarrier ranged from 0.2 to 1.2 days, which is consistent with the results of the first demonstration. Groundwater chemistry data are still being collected as part of this demonstration to assess impacts to groundwater quality within and downgradient from Area 20 (GeoSyntec, 2002).

Perchlorate Biodegradation in GET D Recharge Water.

A pilot test of in-situ bioremediation of perchlorate in groundwater recharged from GET D was conducted from March 2001 through January 2002. The purpose of the testing was to demonstrate that perchlorate, present at concentrations ranging from 200 to 250 ug/L in the recharge water, can be biodegraded in-situ to an acceptable level by augmenting the recharge water with an environmentally-acceptable electron donor, without adversely impacting secondary water quality and to generate design and cost

information for potential scale-up of the approach to full-scale for perchlorate treatment at the GET D facility

The pilot testing included installation of downgradient performance monitoring wells and four trials involving the dosing of acetate, ethanol, and citric acid/ethanol electron donor into existing recharge wells 5040 and 5105. Two of the trials also involved the dosing of biofouling control reagents (chlorine dioxide and pH reduction using citric acid) into the recharge wells. Results of the testing indicated that perchlorate concentrations can be reduced to less than the PQL of 4 ug/L within short distances (25 to 75 feet) from the recharge wells, perchlorate biodegradation half-lives were rapid (0.2 to 1.8 days), nitrate is also removed (average of 10 mg/L to non-detect at 0.5 mg/L), mobilization of metals appears to be limited to manganese and iron, and weekly or bi-weekly shock doses of chlorine dioxide can provide effective control of biofouling in recharge wells without impacting water quality.

Follow-on pilot testing is proposed to assess the potential dissolved manganese impacts. This testing is currently projected to be conducted from May through August 2002.

GET B Area.

The ongoing pilot testing for in-situ bioremediation of perchlorate in groundwater in the southern GET B area involves the semi-passive dosing of electron donor. Arcadis G&M's In-Situ Reactive Zone (IRZ) technology is being employed to establish an in-situ, biologically induced reactive zone in which perchlorate in the groundwater is reduced (Arcadis G&M, 2001). This zone is established at GET B upgradient of extraction well 4410 through use of 10 upgradient electron donor wells (one donor well each completed in Layers C and D at five locations). Several hundred gallons of the electron donor (a 10% corn syrup solution) are added to the donor wells once per month. The goals of the pilot testing are to reduce the concentration of perchlorate in groundwater (150 – 200 ug/L) to below the detection limit prior to the groundwater being extracted at well 4410 and to develop potential full-scale design, operating, and cost information for the technology. Pilot testing is scheduled for completion in September 2002.

Radial Biobarrier Downgradient from Former GET F Sprayfield. A pilot test of in-situ bioremediation using a Radial Biobarrier design concept to treat perchlorate-impacted groundwater downgradient from the former GET F Sprayfield has not begun and is currently projected to begin in May 2002 and be completed in November 2002. The Radial Biobarrier approach consists of periodically (annually or less frequent) charging groundwater extraction wells at desired compliance boundaries with slow-release carbon-based electron donors such as oleate or edible oils to create a radial biobarrier around the extraction well. Sufficient volumes of electron donor are added to achieve a radius of influence around the well that approximately coincides with the time required (residence time) to biodegrade the perchlorate before extraction.

The specific Sprayfield pilot test involves the "charging" of a groundwater extraction well at the Sprayfield with specific slow-release electron donors (i.e., oleate and/or edible oils such as vegetable or canola oil) that have potential to remain in place around the well to create a radial biobarrier. The radial biobarrier will promote perchlorate reduction as groundwater flows into the extraction well, and the resulting water, free of perchlorate, can be either (1) recirculated (with electron donor amendments) to the source area at the Sprayfield via an infiltration gallery to accelerate flushing and in-situ bioremediation of perchlorate that may be remaining in the unsaturated zone in the source area, or (2) discharged at the surface through storm drains or sanitary sewers, depending on the water chemistry and pending regulatory approvals (GeoSyntec, 2001b).

3.9 Preliminary Identification of Response Objectives and Technologies/Process Options

No decisions have been made regarding the need for additional remedial action for the PGOU study area beyond the interim actions that are currently being operated, maintained, and monitored. However, as required by the RI/FS guidance (EPA, 1988) for purposes of preparing the FS, preliminary response objectives and technologies/process options that may be included in remedial action alternatives are identified in this Work Plan.

3.9.1 Preliminary Response Objectives

The initial step in identifying remedial alternatives in the FS is to formulate Remedial Action Objectives (RAOs). RAOs are media-specific goals designed to protect human health and the environment. RAOs specify the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of alternatives to be developed on the basis of chemical-specific ARARs and site-specific risk-related factors.

As discussed previously, the only media currently of concern for the PGOU is groundwater. The identified chemicals of concern include chlorinated VOCs, perchlorate, NDMA, and 1,4-dioxane. Other chemicals of concern may be identified as a result of implementation of this Work Plan. The only potential future exposure pathways are associated with potential ingestion of contaminated water that may enter drinking water supply wells located downgradient of the Site boundaries, and inhalation of VOCs that may volatilize from the groundwater.

The overall goal of any remedial alternative is to protect human health and the environment. In order to achieve this goal for the PGOU Study Area, the following preliminary RAOs were identified:

- Protect human health and the environment from exposure to contaminated groundwater;

- Minimize offsite migration of chemicals where practicable to protect long term beneficial uses;

- Reduce contaminant concentrations in already contaminated groundwater in an efficient cost-effective manner; and

- Protect public drinking water wells and provide treatment or alternate supply, as appropriate, for those drinking water wells that have been or potentially may become impacted by chemicals at unacceptable levels.

3.9.2 Preliminary Technologies/Process Options

Given the initial evaluation information contained in Sections 3.1 through 3.7, if remedial action beyond that provided by the current interim actions is determined to be necessary after completion of the RI, risk assessment, and ARARs evaluation, there are several potential technologies/process options that can be identified at this time that may be components of possible remedial alternatives to be developed and analyzed in the FS.

These potential technologies/process options include the following:

- Institutional controls;

- Monitoring;

- No further action (other than continued operation of existing Interim Actions and monitoring);

- Technical impracticability;

- Monitored natural attenuation (MNA);

- Groundwater extraction, treatment, and disposition of treated groundwater; and

- In-situ treatment.

Each of these potential technologies/process options is discussed further below.

3.9.2.1 Institutional Controls

The institutional controls process options are nonengineering methods by which federal, state, and local governments or private parties can prevent or limit access to affected environmental media and are applicable in conjunction with other response actions (USEPA, 1998c). Institutional controls do not reduce contaminant mobility, toxicity, or

volume, but they can reduce the potential for exposure to contaminated material. The NCP contains the following "expectation" regarding the use of institutional controls (USEPA, 1990):

> *"EPA expects to use institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants or contaminants. Institutional controls may be used during the conduct of the remedial investigation/feasibility study (RI/FS) and implementation of the remedial action and, where necessary, as a component of the completed remedy. The use of institutional controls shall not substitute for active response measures (e.g., treatment and/or containment of source material, restoration of ground waters to their beneficial uses) as the sole remedy unless such active measures are determined not to be practicable, based on the balancing of trade-offs among alternatives that is conducted during the selection of remedy."*

More commonly, institutional controls are used because treatment and containment measures do not address risks entirely so that the remedy must include activity restrictions to ensure that it is fully protective. For example, over the time that is required to pump and treat contaminated groundwater, other measures may be needed to ensure that residents are not inadvertently exposed by drilling new wells. Containment remedies may have to be supplemented with institutional controls to ensure that future land users are aware of the wastes left on site and that they do not take actions that might interfere with the containment system (USEPA, 1998c).

Institutional control measures that apply solely to groundwater, such as groundwater use restrictions, may be used to prohibit or limit the drilling of new wells, prohibit the temporary use of existing wells, or require the shutdown of public water supply wells if monitoring indicates the presence of chemicals above enforceable concentrations. While implementation of these process options alone may not attain the RAOs, they will most likely be necessary to maintain the integrity of any active remediation system that may be selected and will therefore be considered in combination with other process options during the development of alternatives in the FS.

Land purchase, land use restrictions, covenants or easements restricting future land use or prohibiting activities, servitudes, deed restrictions, deed notices, groundwater use restrictions and advisories, well construction restrictions, and zoning and tailored ordinances are examples of institutional controls that may be included as process options within remedial alternatives considered in the FS.

3.9.2.2 Monitoring

Groundwater monitoring is a process option that is expected to be a component of any remedial alternative considered in the FS. Groundwater monitoring may serve the purpose of evaluating the migration of chemicals of concern and, depending upon the remedial alternative selected, to evaluate the effectiveness of any hydraulic containment

and of any treatment processes. Groundwater monitoring is integral to monitored natural attenuation, establishing a CZ, or assessing technical impracticability, all which may be part of a selected remedial alternative.

3.9.2.3 No Further Action (continue to operate existing Interim Actions and monitoring)

Under this remedial action response activity, no additional action, beyond continuing operation of the existing groundwater extraction/treatment and monitoring programs would be implemented. Consideration of the no further action response activity would be based on a demonstration that the existing groundwater extraction activities are capable of containing all of the chemicals of concern above potential action levels.

3.9.2.4 Technical Impracticability

Although restoration of groundwater to background or a quality that allows for beneficial uses is a goal for the PGOU, complete restoration may not be achievable in all areas due to site conditions and the limitations of existing technologies. Specifically, due to the presence of DNAPLs, the potential for contamination to be present in fractured bedrock, and/or the shear size and volume of contaminated groundwater, restoration of groundwater quality to background or even to water quality standards that would allow for all identified beneficial uses may not be achievable within any reasonably projected timeframe.

EPA has developed guidance for estimating the potential for DNAPL occurrence based on information on site history and site characterization data. Based on this approach, one area where DNAPL may be present and where it may be technically impracticable to restore groundwater is Area 40 ("Gladys Gray" area) located along the eastern boundary of the Aerojet site. Portions of Area 40 were formerly used to burn chemical waste and separate TCE sludges. Groundwater in this area flows back toward the Aerojet facility. Although the locations and amount of existing monitoring data in Area 40 are limited, the available data combined with what is known about the historic uses of this area indicate that DNAPL contamination is likely in this area.

A sample obtained from a shallow alluvial well (Well 1696), located just downgradient of the potential source area, contained 59,000 ug/l of TCE. The solubility of pure TCE is approximately 1,000 mg/l. Therefore, the reported concentration of 59,000 ug/l (59 mg/l) is equivalent to approximately 5% of the theoretical solubility of TCE. The presence of other solvents and dissolved phase constituents may act to lower the actual solubility of TCE below the theoretical value. EPA has indicated that presence of solvents at levels above 1% of their solubility indicates a potential presence of DNAPL contamination. Combining this information with the information on the historic uses of Area 40 indicates that this area has a high to moderate potential for DNAPL occurrence.

Remediation technologies currently available have not demonstrated an ability to remove DNAPL from the subsurface. The continued presence of DNAPL will act as an ongoing source of groundwater contamination and will prevent complete restoration of

groundwater within and potentially immediately downgradient of Area 40. Therefore, it may be technically impracticable to completely restore groundwater in this area.

Restoration of the beneficial uses of groundwater, where practical, is also an overall goal of the NCP. Evaluation of the relative time frames over which various possible remedial alternatives may restore groundwater quality is a factor the NCP requires to be considered in the development of remedial alternatives. Although it will probably be one of the RAOs considered in the PGOU FS evaluations, restoration of groundwater beneath or downgradient of the Aerojet site may not considered to be practical within any reasonable time frame.

EPA has developed criteria for evaluation of the technical practicality or impracticality of groundwater restoration that are contained in the *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration* (OSWER Directive 9234.2-25) [USEPA, 1993]. Portions of the PGOU may meet some or many of the criteria EPA considers for "technical impracticability" of groundwater restoration including:

- The nature of the release was a large volume, continual release over a long period of time;
- The primary contaminants of concern (e.g., NDMA) are not readily subject to biological decay and are not volatile;
- The volume of contaminated groundwater is large and of great depth; and
- The stratigraphy of the aquifer is complex, containing discontinuous sand lenses within an extensive silt/clay matrix resulting in extremely heterogeneous conditions.

Although groundwater restoration is a desirable goal, as a result of these site/contaminant conditions there is a high degree of uncertainty regarding the ultimate restoration potential of the aquifer, particularly the portion of the aquifer on-site. If restoration is possible, the time frames for achieving restoration may be extremely long, regardless of the alternative selected. The projected long timeframes for achieving restoration result from the hydrologic and contaminant conditions described above along with the overall large area and volume of the contaminant plume and the uncertain but likely numerous pore flushes that will be necessary to reduce the levels of contamination within the offsite portions of the aquifer. Consequently, it may not be possible to develop reasonably reliable estimates of the time required to completely remove all of the contamination from the offsite portions of the aquifer.

Due to the potential presence of DNAPLs and the extensive extent and volume of groundwater contamination in some portions of the PGOU, complete restoration of groundwater within any reasonable timeframe may not be possible. In these areas, use of remedial alternatives based on containment of groundwater rather than direct restoration

may need to be considered. Although groundwater restoration is the preferred goal, containment of contaminated groundwater is a remedial alternative recognized in both the NCP and the Central Valley Basin Plan. The RWQCB has developed a policy for identification of containment zones (CRWQCB, 1997). Use of groundwater containment may be necessary alone or in conjunction with active groundwater restoration measures.

3.9.2.5 Monitored Natural Attenuation (MNA)

MNA may be an appropriate response for some areas in the PGOU. MNA is the use of naturally occurring, contaminant degradation and dispersion processes combined with environmental monitoring to remediate contaminated groundwater. Natural attenuation processes occur in all groundwater systems, but their effectiveness varies considerably from site to site and among different kinds of contaminants. The EPA Office of Solid Waste and Emergency Response (OSWER) define monitored natural attenuation as (USEPA, 1999b):

> *The term "monitored natural attenuation", as used in this Directive, refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The "natural attenuation processes" that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater.*

The EPA goes further to state:

> *These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants.*

As suggested by this definition, mechanisms for natural attenuation of chlorinated compounds such as TCE include advection, dispersion, dilution from recharge, sorption, volatilization, abiotic degradation, and biodegradation (USEPA, 1998d, Wiedemeier et al., 1999, and Wiedemeier and Chapelle, 2000). Of these processes, biodegradation commonly is the primary mechanism working to transform contaminants into innocuous byproducts. Contaminant destruction occurs through natural attenuation when indigenous microorganisms work to bring about a reduction in the total mass of contamination in the subsurface without the addition of nutrients. Patterns and rates of natural attenuation can vary markedly from site to site depending on governing physical and chemical processes. For this reason, a site-specific analysis will need to be made for all potentially applicable processes listed above.

Multiple distinct but converging lines of evidence, in various forms have been used in recent years to demonstrate natural attenuation (National Research Council, 1993; Wiedemeier et al. 1995 and 1996; USEPA, 1998d; Wiedemeier et al., 1999). The most common lines of evidence used to demonstrate natural attenuation of organic compounds dissolved in groundwater include:

- Historical trends in contaminant data showing plume stabilization and/or loss of contaminant mass over time.

- Analytical data showing that geochemical conditions are suitable for biodegradation and that active biodegradation has occurred as indicated by the consumption of electron acceptors and/or the production of metabolic byproducts. This chemical and analytical data can include evidence of;

    - depletion of electron acceptors and donors
    - increasing metabolic byproduct concentrations
    - decreasing parent compound concentrations
    - increasing daughter compound concentrations

- Microbiological data that support the occurrence of biodegradation.

The first line of evidence involves using historical contaminant data to show that the contaminant plume is shrinking, stable, or growing at a rate slower than predicted by conservative (slow) groundwater seepage velocity calculations. In some cases a biologically recalcitrant (conservative) tracer present in measurable concentrations within the contaminant plume can be used in conjunction with aquifer hydrogeologic parameters such as seepage velocity and dilution to show that a reduction in contaminant mass is occurring and to estimate biodegradation rate constants. Although the first line of evidence can be used to show that a contaminant plume is being attenuated, it does not necessarily show that contaminant mass is being destroyed.

When microorganisms degrade organic contaminants in the subsurface they cause measurable changes in soil and groundwater chemistry. The second line of evidence involves documenting these changes and can be used to show that contaminant mass is being destroyed, not just being diluted or sorbed to the aquifer matrix. Chemical changes in groundwater can also be used to infer which contaminant degradation mechanisms are occurring at a site.

The third line of evidence, microbiological laboratory or field data, can be used to show that indigenous biota are capable of degrading Site contaminants. The microcosm study is the most common technique used for this purpose. Microcosm studies should be used very selectively when assessing natural attenuation. In general, such studies should only be undertaken when a specific biodegradation process is not known or understood.

In addition to these lines of evidence, analytical or numerical solute transport models can be used to examine the processes influencing the transport of organic contaminants in groundwater and to estimate the influence of natural attenuation mechanisms on solute fate and transport. Although not a line of evidence, analytical or numerical solute fate and transport models can prove valuable when evaluating natural attenuation. For example, models can be used to evaluate the relative importance of natural attenuation mechanisms if sufficient historical data are available. The dominant transport mechanisms affecting the transport of dissolved organic contaminants in many subsurface systems are advection, dispersion, sorption, and degradation (biotic or abiotic). Thus, observed changes in contaminant concentrations downgradient from the source area will represent the sum of the influences exerted by these processes. Solute transport models that incorporate these mechanisms can be a valuable tool for estimating the relative importance of the various attenuation mechanisms.

In order to assess the potential applicability of MNA to the VOC, and/or perchlorate and NDMA occurrences, geochemical data are necessary to evaluate whether microbial degradation of chlorinated solvents is currently occurring in an area or potentially can occur in an area or the conditions are conducive to degradation of the chemical of concern in an area. Specifically, measurements of dissolved oxygen, oxidation-reduction potential (ORP), and ferrous iron are necessary to assess whether aerobic or anaerobic processes are dominant in an area. Data are also required to assess the availability of sulfate and nitrate for use as substrate for microbial respiration. Analyses of dissolved gases (methane, ethane and ethene) are necessary to assess the potential for methanogenesis. Total organic carbon (TOC) data are required to assess the potential for co-metabolism. Alkalinity and chloride data are required to evaluate whether microbial degradation is currently occurring under existing conditions in an area.

A significant amount of the specific geochemical data mentioned above needed to assess the potential applicability of MNA has been collected previously across the Aerojet Site (e.g., CDA, Chemical Plant 1, and the former WRND) as a result of previous investigations and/or treatability studies. These data should be representative for most areas that may be considered for MNA within the PGOU. As discussed in Section 5, the MNA-related geochemical data collected to-date will be evaluated along with those areas where the technology may be applicable.

3.9.2.6 Groundwater Extraction, Ex-situ Treatment, and Management of Treated Water

Groundwater extraction is a common technology used for hydraulic containment/control of groundwater containing dissolved chemicals or as a method to collect groundwater containing dissolved chemicals for purposes of restoration of a contaminated aquifer. Once contaminated groundwater is extracted above-ground, it typically must be treated to remove the dissolved chemicals. Following treatment, the treated water then must be managed or disposed. Based on the information available as of the date of preparation of this Work Plan, the various groundwater extraction, treatment, and management of treated groundwater process options/technologies that can be considered as components of any remedial alternatives for the PGOU FS are described below. Other technologies

not described below may be considered during preparation of the FS as additional information becomes available through preparation of the RI, risk assessment, and results of treatability studies.

3.9.2.6.1 Groundwater Extraction

Extraction of groundwater using vertical or horizontal pumping wells or a groundwater collection trench followed by above ground treatment is a common technology for containment and removal of dissolved chemicals from groundwater and is currently in use at GET D, ARGET, GET B, GET A, GET E/F and as part of the remedial action selected in the ROD for OU-3.

Extraction wells involve drilling vertical or horizontal wells that are screened within the hydrogeologic layer where contamination is known to exist or is projected to be present. The wells are pumped and a hydraulic barrier is established to control contaminant migration. If contaminants are present in the groundwater, they are physically removed with the groundwater. Selection of horizontal extraction wells over vertical wells would be decided during the remedial design phase and be based on the depth of the contamination, the hydrologic and geologic characteristics of the subsurface material, and property access and existing utility limitations. Horizontal wells offer some advantage over vertical wells depending on the subsurface conditions since they allow for recovery in circumstances of limited overlying access, extraction well surface area is maximized, and it is possible to orient well screens in closer proximity to the bulk of the chemicals in groundwater.

A combination of extraction and recharge wells can also be used for containment and collection of groundwater. Under this process option, a hydraulic containment barrier or groundwater collection system would be comprised of a combination of both extraction wells pumping contaminated groundwater and injection wells where treated groundwater is recharged to the subsurface. The recharged water would serve as a hydraulic barrier and direct groundwater to the extraction wells.

A groundwater collection trench can also be used to collect contaminated groundwater. Because of construction limitations and cost, use of a collection trench is generally limited to those areas where the depth of contaminated groundwater is approximately 75 feet or less. This technology involves construction of a trench perpendicular to groundwater flow using conventional trench construction techniques or, depending on the trench depth and surrounding materials, using biopolymer or one-pass trenching techniques. The trench usually contains a perforated drain/collection pipe and one or more collection sumps and is backfilled with gravel that is more permeable than the surrounding subsurface material.

3.9.2.6.2 Ex-situ Groundwater Treatment

Preliminary ex-situ groundwater treatment technologies/process options that may be included in remedial action alternatives for the Perimeter OU FS and/or have been

employed previously in Interim Actions at the Aerojet site include liquid phase granular activated carbon (LPGAC), air stripping, and UV/chemical oxidation for VOCs removal; ion exchange and cometabolic reactors (biological reduction) for removal of perchlorate; and UV/chemical oxidation for removal of NDMA. Various membrane technologies may also be applicable to remove constituents and/or concentrate contaminants in untreated groundwater flow streams. Filtration and pH adjustment are also ancillary process options that may be required as part of a liquid phase treatment train, depending on which main process option is, or process options are, selected for removal of contaminants.

LPGAC. LPGAC is a commonly used method of removing VOCs and other organics. Activated carbon, when contacted with water containing organic material, will remove the organic compounds selectively by a combination of adsorption of the less polar molecules, filtration of the larger particles, and partial deposition of colloidal material on the exterior surface of the activated carbon. Most carbon-adsorption systems utilize granular activated carbon in flow through column reactors which can be employed as an upflow-countercurrent type operated with packed or expanded carbon beds or as an upflow or downflow fixed-bed unit having two or three columns in series.

Air Stripping. Air stripping is a physical unit process in which dissolved molecules are transferred from a liquid, such as groundwater, into a flowing gas or vapor stream, such as air. The driving force for mass transfer is provided by the concentration gradient between the liquid and gas phases, with solute molecules moving from the liquid to the gas until equilibrium is reached. The most common configuration for application of air stripping to groundwater treatment for removal of VOCs is the counter current packed tower air stripper. The water flows downward by gravity and air is forced upward. The untreated water is usually distributed on the top of the packing with sprays or distribution trays and the air is blown through the tower in forced or induced draft. Depending on the air quality requirements where air stripping is to be employed, offgas emissions from the air stripper may require treatment. The process options for air stripper offgas treatment are discussed later in this section.

UV/Chemical Oxidation. UV/chemical oxidation is a generic name for a family of advanced oxidation technologies that use ultraviolet light either alone or in conjunction with standard oxidants such as hydrogen peroxide or ozone to achieve greatly increased treatment performance over that obtained with either hydrogen peroxide or ozone alone. The most common UV/oxidation process is the use of UV with hydrogen peroxide. Ultraviolet light is used to split the hydrogen peroxide molecule, producing very reactive hydroxyl radicals (OH^-). These hydroxyl radicals then quickly react with organic contaminants in the water, eventually breaking them down into carbon dioxide and water. UV/oxidation is currently being used at GET facilities to remove NDMA, VOCs and 1,4 dioxane.

Ion Exchange. Ion exchange resins are, by definition, insoluble solids containing fixed cations or anions capable of reversible exchange with mobile ions of the opposite sign in the solutions with which they are brought into contact. Perchlorate and other anionic

contaminants (if any) in groundwater are effectively removed by ion exchange, a process where contaminant anions are exchanged and replaced by an innocuous anion, typically chloride. Ion exchange is reversible. Once the ion exchange resin is loaded with the perchlorate and/or other anions, it is regenerated with a sodium chloride salt or other solution and the perchlorate and other anions are removed. Once the resin is re-loaded with chloride, it is placed back in service, and the ion exchange cycle is repeated. Several ion exchange equipment designs are currently employed including relatively simple fixed bed downflow or upflow contactor systems that can be operated in either concurrent or countercurrent (service flow in the direction opposite to the regeneration), continuous moving bed systems, and continuous multi-port rotating distributor systems. With respect to regeneration, waste streams generated when the ion exchange media is regenerated include rinse and backwash waters and a concentrated regenerant brine solution that contains perchlorate, nitrate, and sulfate ions in significantly higher concentrations than in the untreated groundwater feed.

Cometabolic Bioreactors (Biological Reduction). The biological reduction process is currently used at the GETs E/F treatment facility to remove perchlorate from Zone 2 groundwater. This technology can be described as a biological reduction process using a fixed-film bioreactor. A fixed-film of biomass is attached to granular activated carbon operated as a fluidized bed (GAC/FB). Groundwater, amended with an organic substrate (e.g., ethanol) and nutrients (nitrogen and phosphorus) is introduced into the influent stream. As groundwater passes through the system, the microorganisms derive energy from the oxidation of the organic substrate, simultaneously destroying the perchlorate, reducing it to chloride and oxygen. The end products for the process are biomass (sludge), carbon dioxide, water, chloride, and nitrogen (HLA, 1998). The biomass is typically discharged to a POTW or dewatered and disposed in a non-hazardous landfill.

Membrane Technologies. The major membrane technologies may be considered as potential processes to remove contaminants from extracted groundwater or to concentrate contaminants in smaller flowstreams for subsequent treatment. Membrane processes employ a semipermeable (selective) membrane and a driving force (pressure, concentration, etc.) across the membrane to separate target constituents from a feed liquid. Water passes through the membrane, forming a treated water stream (permeate) and leaving behind the other constituents in a concentrate. Different types of membrane processes can remove dissolved and colloidal constituents in the size range of 0.0001 to 1 microns. The commercially-available membrane processes include reverse osmosis (RO), nanofiltration, ultrafiltration, and microfiltration.

RO is a high-pressure, energy-efficient technique for dewatering process streams, concentrating low-molecular-weight substances in solution, or purifying wastewater. It has the ability to concentrate all dissolved and suspended solids. The permeate contains a very low concentration of dissolved solids. RO is widely used in the desalination of seawater. Nanofiltration is a special process selected when RO and UF are not the ideal choice for separation. Nanofiltration can perform separation applications that are not otherwise economically feasible, such as demineralization, color removal, and desalination. In concentration of organic solutes, suspended solids, and polyvalent ions,

the permeate contains monovalent ions and low-molecular-weight organic solutions like alcohol. Ultrafiltration is a selective fractionation process utilizing pressures up to 145 psi. It concentrates suspended solids and solutes of molecular weight greater than 1,000. The permeate contains low-molecular-weight organic solutes and salts. Microfiltration is a low-pressure cross-flow membrane process for separating colloidal and suspended particles in the range of 0.05-10 microns.

Filtration. This ancillary process option is employed to remove particulates that may be generated by other processes and need to be removed prior to the groundwater undergoing treatment by another process or prior to management/reuse of the treated groundwater. There are many common configurations of filters available including dual-media gravity and pressure filters, continuous upflow sand filters, and in-line bag filters. The configuration of filter is selected based on the specific filter application.

pH Adjustment. If necessary, this ancillary process option is used to adjust the pH of groundwater undergoing treatment. An acid (e.g., sulfuric or hydrochloric acid solutions or carbon dioxide gas) or caustic (e.g., sodium hydroxide solution or lime) can be added using chemical metering pumps upstream of another process option to enhance the performance of the process option or downstream of a process option where pH changes through the process option to adjust the pH to within a normal value for water quality (i.e., around 7.0 standard pH units).

3.9.2.6.3 Management of Treated Water

Several possible process options are available for management and/or possible reuse of treated groundwater produced by any hydraulic containment or groundwater collection/treatment components that may be part of remedial alternatives developed in the PGOU FS. There are several water resource management opportunities and actions that are available in or near the Study Area in connection with this PGOU. Regional and local water resource planning includes consideration of the water flows in the American River and the Folsom South Canal, as well as the current and projected future potable and nonpotable water demands of existing development in Sacramento County and various planned development areas in the eastern and southern portions of the County. Possible process options for management or reuse of treated groundwater include direct potable water supply, indirect potable supply, non-potable water reuse, streamflow augmentation, discharge to a Publicly-Owned Treatment Works (POTW), and groundwater recharge.

3.9.2.7 In-situ Treatment

A preliminary list of in-situ groundwater treatment technologies/process options that may be included in remedial action alternatives for the PGOU FS includes permeable treatment walls, in-well aeration/stripping, in-situ oxidation, and enhanced biological reduction.

Permeable Treatment Walls. Like a sieve, water-permeable treatment walls installed across the flow path of a contaminant plume allow groundwater to move passively

through while precipitating, sorbing, or degrading the contaminants. This treatment method is most commonly used for chlorinated solvents, with zero-valent metals such as iron as the reactive media. Bench-scale treatability studies conducted for Aerojet show that this technology will also be effective for removal of NDMA. Reductive dechlorination occurs by reaction of surface-bound Fe(II) at the iron-water interface. Chlorinated molecules passing through a bed of iron filings or other zero-valent metal are reduced to harmless hydrocarbons, thus remediating the contaminated groundwater. The iron may be installed as pure iron filings or mixed with sand or gravel to improve permeability. Permeable treatment walls are most commonly installed using traditional excavation/backfilling or one-pass trenching methods at shallow depths (ie., less than 50 ft bgs).

In-well Aeration/Stripping. In-well vapor stripping technology involves the creation of a groundwater circulation pattern and simultaneous aeration within the stripping well to volatilize VOCs from the circulating groundwater. Air is injected into a double screened well, lifting the water in the well and forcing it out the upper screen. Simultaneously, additional water is drawn in the lower screen. Once in the well, some of the VOCs in the contaminated ground water are transferred from the dissolved phase to the vapor phase by air bubbles. Air-lift pumping is used to lift groundwater and strip it of contaminants. Contaminated vapors may be drawn off for aboveground treatment or released to the vadose zone for biodegradation. Partially treated groundwater is forced out of the well into the vadose zone where it reinfiltrates to the water table. Untreated groundwater enters the well at its base, replacing the water lifted through pumping. Eventually, the partially treated water is cycled back through the well through this process until contaminant concentration goals are met.

A variation of this process, called Unterdruck-Verdampfer Brunner, has been used at sites in Germany and has been introduced recently into the U.S. Stanford University has developed another variation of this process, called NoVOCs, an in-well sparging system, which is currently being evaluated as part of DOE's Integrated Technology Demonstration Program. The Stanford system combines air-lift pumping with a vapor stripping technique. Wasatch Environmental, Inc. has also developed and patented another type of in-well vapor stripping system known as Density Driven Convection (DDC). The DDC system emphasizes the enhancement of bioremediation and involves the discharge of extracted vapors into the vadose zone for degradation by naturally-occurring microorganisms. (Miller and Diane, 1997)

In-situ Oxidation. In-situ oxidation (ISO) is an effective method to remediate groundwater contaminated with chlorinated solvents and can facilitate natural attenuation further downgradient in an aquifer. ISO involves injection of strong oxidants into the contaminated subsurface, in some cases with other chemicals that function as catalysts. The oxidants chemically break down the chlorinated organics upon contact to inert materials such as carbon dioxide, chloride and water. ISO can be applied using different types of oxidizers such as ozone, hydrogen peroxide, Fenton's reagent, potassium permanganate, and sodium permanganate. Oxidation is dependent on achieving adequate contact between oxidants and contaminants, and subsurface heterogeneities, preferential

flow paths, and poor mixing in the subsurface can result in pockets of untreated contaminants.

There are two primary methods for ISO treatment. The first method involves injection of the oxidant on one side of the contaminated zone while extracting groundwater on the other side. Extraction creates a negative pressure zone, causing the oxidant to migrate more quickly through the contaminated zone. The second method uses injection without extraction, whereby the oxidant is injected into the contaminant and allowed to migrate through the contaminated zone. This second method can be accomplished in a horizontal or radial configuration.

Enhanced Biological Reduction. Bioremediation is a managed or spontaneous process in which microbiological processes are used to degrade or transform contaminants to less toxic or nontoxic forms, thereby mitigating or eliminating environmental contamination. In the presence of sufficient oxygen (aerobic conditions) and nutrients, microorganisms will ultimately convert many organic contaminants to carbon dioxide, water and microbial cell mass. In the absence of oxygen (anaerobic conditions), the electron acceptor is a compound other than molecular oxygen, such as sulfate, nitrate, or carbon dioxide, and the contaminants will be ultimately metabolized to methane, limited amounts of carbon dioxide, and a trace amount of hydrogen gas. The in-situ biological reduction process for the removal of perchlorate is being tested extensively at the Aerojet Sacramento site and is further discussed in Section 3.8.2.2.

4 WORK PLAN RATIONALE

Additional information will be necessary to support the development of the RI, risk assessment and FS. These data requirements are presented in this section and were developed as a result of the initial evaluations discussed in Section 3. The initial evaluations were conducted on an area-by-area (zone) basis, are presented in Appendices A through D, and were summarized in Section 3.3. EPA's Data Quality Objectives (DQO) process was considered in the identification of data requirements for the RI, risk assessment, and FS and in the overall development of this RI/FS Work Plan. A general discussion of EPA's DQO process is included at the beginning of this section. The specific data needs for the RI, risk assessment, and FS follow the general DQO discussion.

4.1 General Data Quality Objectives

This section describes how data collection activities were developed to obtain the data needed to complete the RI, risk assessment, and FS for the PGOU RI/FS. The EPA DQO process was used as guidance to identify the type, quality, and quantity of data that are commensurate with the intended use of the data (USEPA, 1993a and 1994).

The DQO process includes a series of the following seven steps:

1. State the Problem
2. Identify the Decision
3. Identify Inputs to the Decision
4. Define Study Boundaries
5. Develop a Decision Rule
6. Specify Limits on Decision Errors
7. Optimize the Design for Obtaining Data

These steps were considered generically for each of the general data needs identified in Appendices A through D for completing the PGOU RI/FS. The data collected as a result of this Work Plan represent a small percentage of the total data that will be incorporated into the PGOU RI/FS. Furthermore, it is probable that additional data will be collected after the RI/FS, and those data could change the findings in the RI/FS. Therefore, the DQO process was applied to the common data needs for the RI, risk assessment, and FS,

rather than evaluating every data collection activity individually. The following paragraphs present the results of the seven-step DQO process as applied to the data needs for the PGOU RI/FS.

Step 1: State the Problem:

The groundwater "problem" in the PGOU is presented in the Preliminary Site Conceptual Model (Section 3.1), and in the background information presented in Appendices A through D. In summary, chemicals are present in the PGOU groundwater at concentrations exceeding "potential action levels" identified by potential chemical-specific ARARs or TBCs. In general, the nature and extent of most chemicals is defined to the laboratory reporting limit concentrations, although additional characterization is needed in some areas. Adequate characterization is necessary to identify potential risk and evaluate remedial alternatives.

Step 2: Identify the Decision:

The decisions that will be made based on the data collection are:

1. Are the nature and extent of chemicals in groundwater defined to "potential action levels" identified by potential chemical-specific ARARs or TBCs?

2. Is there a risk to human health and the environment from chemicals in PGOU groundwater?

3. Are the current interim remedial actions achieving their expected goals?

4. Are additional remedial actions warranted?

Step 3: Identify Inputs to the Decision:

All of the data collection necessary for making the decisions listed above can obtained through the collection and laboratory analysis of groundwater samples following the Standard Operating Procedures (SOPs) and Quality Assurance Project Plan (QAPP) [Aerojet, 2001] for the Aerojet Site or by evaluating data that have already been collected.

Step 4: Define Boundaries of the Study:

The boundaries of the Study Area include all areas where Site-related chemicals are present in off-site groundwater, excluding the areas addressed by the WGOU.

Step 5: Develop a Decision Rule:

The goal of the groundwater investigations is to describe the extent of occurrences of Site-related chemicals that occur at levels above potential chemical-specific ARARs or TBCs or risk-based criteria. The analytical laboratory method detection and reporting limits will determine the numerical levels for the sample analytical results which will be compared to the potential chemical-specific ARARs and TBCs identified on Table 3-2. In general, groundwater samples will be obtained along transects oriented parallel to the facility property boundaries and perpendicular to the direction of groundwater flow. Data obtained from wells located along the property boundary will be used to assess the effectiveness of the existing remedial measures and to evaluate whether additional remedial measures are necessary to prevent offsite migration of Site-related chemicals. Groundwater samples will also be collected from monitoring wells located downgradient of the facility property boundary to assess the potential extent of offsite contamination, if any.

In the case of groundwater samples obtained from wells located along the facility boundary, the decision rule to be applied is relatively simple: that is, are the levels of site-related chemicals in the outermost wells above or below the potential chemical-specific ARARs and TBCs? If the levels are above, then additional wells may need to be installed and/or sampled to ascertain the lateral extent of contamination above potential action levels. If the outermost wells do not contain levels of site-related chemicals at levels above potential chemical-specific ARARs or TBCs, then additional wells are unlikely to be necessary to meet the RI/FS objectives.

Evaluation of downgradient groundwater sampling results will necessarily be more interpretive. The decision rule to be applied to downgradient groundwater sample results will be as follows: can the lateral and longitudinal extent of the area currently containing groundwater with levels of site-related chemicals above potential chemical-specific ARARs or TBCs be approximately defined? If the answer is yes, then no additional groundwater monitoring well installations or sampling should be necessary. If the answer is no, then additional groundwater monitoring well installations and/or sampling may be necessary.

Step 6: Specify Limits on Decision Errors:

Potential remedial action for both perimeter groundwater containment and any offsite remediation might involve groundwater extraction and ex-situ treatment or in-situ biological treatment. The areal extent of groundwater containment or collection associated with in an individual extraction well is determined by the radius of influence. The radius of influence is the lateral extent of groundwater drawdown achieved by pumping a groundwater extraction well.

Under steady-state conditions, the radius of influence is a function of the pumping rate, aquifer transmissivity, the saturated thickness, the length of well screen/open interval relative to the overall saturated thickness, and regional hydraulic gradient. Based on the results of ongoing groundwater extraction being performed at the Site, the approximate extent of the radius of influence of groundwater extraction wells ranges from several hundred to several thousand feet. Therefore, the level of precision of the assessment of the nature and extent of contamination should be similar to the radius of influence ranges.

Step 7: Optimize the Design for Obtaining Data:

Due to the depth of the groundwater at the Site, the nature of the subsurface materials and the properties of specific chemicals of interest, the only reliable method for characterization of the nature and extent of groundwater contamination at the Site is installation and sampling of groundwater monitoring wells and sampling of water supply wells. The locations and previous water quality data obtained from the existing groundwater monitoring and water supply wells in the PGOU area were evaluated to assess their adequacy in defining the nature and extent of contamination along the facility boundary and offsite. Areas with insufficient well coverage or where the existing analytical results are insufficient due to high detection limits achieved during prior sampling events were identified. The presence and adequacy of existing monitoring and water supply wells that have not been sampled were evaluated to ascertain whether they could be used to provide the necessary information. In some instances, re-sampling or first time sampling of existing wells may provide sufficient information. However, the results of the evaluations indicated that additional monitoring well installations will be required to meet the RI objectives.

4.2 Remedial Investigation Data Needs

A significant amount of data and information has been collected and assembled from previous investigations and evaluations have been performed in order to prepare Section 3 - Initial Evaluation such that the majority of the data needs for preparation of the RI have been satisfied. In particular, existing data assessments were conducted for Zones 1 through 4 and are provided in Appendices A through D. Specific additional data needs with respect to completing the RI are included in the DQO sections within Section 3 of each of the Appendices.

General data needs with respect to characterizing the physical aspects of the PGOU include:

- Additional hydrologic evaluation is needed to assess the continuity of the hydrostratigraphic layers in some areas. Geologic cross-sections are needed parallel and perpendicular to plumes at property boundaries and off-site;

- Continued collection and evaluation of water level measurements are needed to assess lateral and vertical hydraulic gradients at property boundaries and off-site. The frequency of measurements may be increased in areas where new extraction wells begin operating;

- Additional aquifer test data are needed from newly constructed extraction wells in the PGOU;

- Additional data are needed to assess potential groundwater discharge to surface water; and

- Historic and recent water level data are needed to assess water level trends.

The following general data needs have been identified to characterize the nature and extent of chemicals in the PGOU groundwater:

- Additional data are needed to assess the types of chemicals present in groundwater at the property boundaries and off-site;

- Additional data are needed to assess the extent of chemicals at the property boundaries and off-site;

- Additional groundwater sampling data are needed to evaluate trace metals at the concentrations identified as potential chemical-specific ARARs or TBCs; and

- Historic and recent chemical data are needed to evaluate chemical concentration trends.

4.3 Risk Assessment Data Needs

Based on a review of available site data, additional information will be necessary to support the development of the risk assessment (Task 6) described in Section 5.6. These data needs include the following:

- Additional data are needed to confirm realistic future land uses for the Aerojet site.

- Additional data are needed to confirm current and realistic future land uses in the vicinity of the Aerojet site.

- Additional data are needed to confirm current and realistic future uses of groundwater in off-site areas.

- Additional groundwater sampling are necessary to determine the chemicals of concern in perimeter groundwater. As discussed previously in Section 3, previous sampling has generally focused on the presence of VOCs, perchlorate, and NDMA in groundwater. However, additional sampling is required in selected areas to assess whether other constituents (e.g., some SVOCs and metals) may also be present. The basis for this additional sampling is more fully described in Section 3.3 and Appendices A through D.

- Additional water level measurements are necessary to better characterize the depth to groundwater in all portions of the PGOU. This information will be used to identify potential exposure pathways[2] in the risk assessment.

- Additional data are needed to assess the potential for groundwater to discharge to surface water. Specific data that will be necessary to support this assessment include the following: (1) collection of water level measurements in the vicinity of receiving surface water bodies (e.g., Alder Creek), and (2) field surveys to identify the presence of springs, seeps, and other temporal events. In the event that these data suggest that groundwater may be discharging to surface water, then surface water samples may need to be collected to better assess potential exposure.

Finally, it should be noted that additional data may be necessary to characterize ecological habitats and potential ecological receptors in the vicinity of the Site. As discussed in Section 3, no complete exposure pathways have been identified for ecological receptors. Thus, detailed characterization of ecological habitat and ecological receptors is not warranted at this time. However, in the event that a complete exposure pathway is identified for ecological receptors (e.g., discharge of groundwater to surface water), then additional information may need to be collected to support the development of an ecological risk assessment. If required, this work will be addressed in a proposed modification to this Work Plan.

4.4 Treatability Study Data Needs

Based on review of the initial evaluations contained in Section 3, in particular the data summaries and data gap analyses, summaries of existing treatability studies currently being conducted or planned, and the preliminary identification of technologies/process options, treatability study data needs include the following:

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[2] Additional information regarding the depth to groundwater will be used to assess the likelihood of various exposure pathways, including the potential for VOCs in groundwater to migrate through the subsurface into ambient or indoor air and the potential for groundwater to discharge to surface water. Information regarding depth to groundwater will also be used to determine whether direct contact with groundwater may reasonably occur during excavation or other intrusive activities.

- Additional data are needed to assess the viability, implementability, effectiveness, and costs associated with in-situ technologies for removal of VOCs, perchlorate, and NDMA; and

- Additional data are needed to assess the viability, implementability, effectiveness, and costs associated with the use of ion exchange resin for removal of perchlorate. In particular, additional data are needed regarding cost-effective regeneration of resin loaded with perchlorate and minimization of waste volumes from the regeneration process.

It is expected that these data needs will be addressed at the conclusion of the various in-situ treatment and ion exchange treatability testing projects described in Section 3.8. No additional treatability testing is proposed at this time.

4.5 Feasibility Study Data Needs

Based on review of the initial evaluations contained in Section 3, in particular the preliminary data assessments and proposed data collection reports included as Appendices A through D, summaries of existing treatability studies currently being conducted or planned, summaries of the existing Interim Actions, and the preliminary identification of technologies/process options, additional information will be necessary to support the development of the FS. These data needs include the following:

- Completion of the characterization of the lateral and vertical extent of chemicals in groundwater at the perimeter and off-site (if any);

- Geologic and hydrologic properties such as hydraulic conductivity, porosity, storativity, and transmissivity to (1) evaluate potential rates of groundwater flow if any groundwater extraction or in-situ remediation technology is to be considered a part of a remedial alternative, and (2) evaluate the relative time frames over which various possible remedial alternatives may restore groundwater quality;

- Direction and rate of groundwater flow to identify pathways of chemical migration and assess maximum potential migration rate and dispersion of chemicals;

- Groundwater quality information including specific contaminant concentrations as well as the concentrations of other constituents in groundwater that are necessary to assess the viability of in-situ or ex-situ treatment of groundwater to remove the specific contaminants;

- Groundwater monitoring is a probable component of remedial alternatives that will be developed and analyzed in the FS. Information is needed regarding the

physical characteristics (depth, screened interval length, location of screened interval[s]) of existing monitor wells and the costs associated with monitoring;

- For technical impracticability of groundwater restoration to be considered as a remedial alternative, information will be needed regarding the criteria EPA considers for technical impracticability (see Section 3.9.2.4), including whether the release of a contaminant was of a large volume, continual release over a long period of time; whether the primary contaminants of concern are not readily subject to biological decay and are not volatile; whether the volume of contaminated groundwater is large and of great depth; and whether the stratigraphy of the aquifer is complex, resulting in extremely heterogeneous conditions;

- For MNA to be considered as a component of a remedial alternative, information will be needed regarding the lines of evidence and various parameters discussed in Section 3.9.2.5; and

- Information to evaluate the effectiveness of the existing Interim Actions in terms of their ability to contain contaminated groundwater and prevent off site migration (GETs A, B, and D) or prevent further migration of existing offsite contamination (ARGET) and in terms of the ability of the respective Interim Action treatment systems to remove the known contaminants and achieve treatment goals. Also, if additional chemicals of concern are identified as a result of the RI investigations, additional data will be needed to evaluate the effectiveness of the existing treatment processes with respect to removing the additional chemicals.

5 RI/FS TASKS

The following tasks have been identified for completion of the PGOU RI/FS:

- Task 1: Project Planning (Project Scoping)
- Task 2: Community Relations
- Task 3: Field Investigation
- Task 4: Sample Analysis/Data Validation/Data Management
- Task 5: Data Evaluation
- Task 6: Risk Assessment
- Task 7: Treatability Studies
- Task 8: Remedial Investigation Report
- Task 9: Remedial Alternatives Development/Screening
- Task 10: Detailed Analysis of Alternatives
- Task 11: Feasibility Study Report

The activities necessary to complete these tasks are described below.

5.1 Task 1: Project Planning (Project Scoping)

Project planning includes preparation of this draft Work Plan, subsequent review of the draft Work Plan by the regulatory agencies, and preparation of a final Work Plan. Upon submittal of this draft Work Plan, EPA, the RWQCB, and DTSC will review the draft Work Plan. For the purposes of development of a schedule for completion of the PGOU RI/FS (see Section 6 below), it is anticipated that the agency review will be completed within 30 days of submittal of this draft Work Plan as specified in Exhibit II of the modified PCD. After receipt of agency comments on the draft, responses to agency comments and a final version of this Work Plan will be prepared and submitted to the agencies in accordance with the schedule presented in Section 6.

Recommendations are included in this Work Plan (Section 5.3) for field investigation activities including groundwater level measurement, groundwater monitor well

installation and development, groundwater sampling, sampling of interim action treatment systems influent and effluent, and surface water sampling. Therefore, the means, methods, and SOPs for these field investigation activities need to be included in this Work Plan. Aerojet maintains site-wide standard supporting documents that address the means, methods, and SOPs for all field activities conducted at the Site. These standard supporting documents are incorporated in this Work Plan by reference as addenda and include the Aerojet Site QAPP (Aerojet, 2001) and the Aerojet Site Health and Safety Plan (Aerojet, 2000b).

5.2 Task 2: Community Relations

In accordance with paragraph 8 of the modified PCD, community relations/public participation activities will be developed, conducted, and managed by the Agencies in accordance with the Community Relations Plan and with support from Aerojet. At a minimum, CERCLA requires publication of a notice of any proposed remedial action (Proposed Plan) in a local newspaper of general circulation and a "reasonable opportunity" for the public to comment on the Proposed Plan and other contents of the Administrative Record, particularly the RI and FS. In addition, a public meeting on the Proposed Plan will be held.

5.3 Task 3: Field Investigation

The proposed data collection recommendations for each Zone are summarized in this section and are intended to be used by field personnel to determine the water level measurement, sampling, or other field activity locations as well as the chemical analyses that samples will be subjected to in the analytical laboratory. This section does not contain specific groundwater sampling or laboratory standard operating procedures, methods, or protocol, which are contained in the Site QAPP (Aerojet, 2001). Samples will be collected following Aerojet's standard sampling protocols contained in the SOPs and in accordance with any previously approved Stage 2 sampling plans. In addition, field personnel will follow various pre-existing Aerojet and Contractor-prepared site-specific Health and Safety Plans when conducting field investigation activities.

Data collection activities listed in this section are enumerated by the same unique number assigned to the activity in Section 3.3 and in the various Appendices (e.g., Z1-1).

5.3.1 Zone 1

Field investigation activities proposed in Zone 1 to fill specific data gaps include the following (see Section 6 in Appendix A):

Z1-10. Samples of the influent to the GET D treatment facility will be collected and

analyzed for TPH-related compounds using EPA Method 602 (BTEX) and EPA Method 8270.

Z1-11. Groundwater samples will be collected and analyzed for aromatic VOCs and SVOCs (EPA Methods 602 and 8270, respectively), from Layer A monitoring Wells 3094, 346, and 347.

Z1-12. Samples of the influent to the GET D treatment facility will be collected and analyzed for 1,4-dioxane using EPA Method 8270.

Z1-13. Samples of the influent to the GET D treatment facility will be collected and analyzed for the following metals: arsenic, cadmium, chromium, lead, selenium, and thallium. The analytical methods, respective RLs, and lowest WQOs for these metals are listed on Table A-1.

The specific proposed activities are listed in Table A-1 in Appendix A. For those activities involving sampling, the specified number of samples, target analytes, and EPA analytical methods are also included on Table A-1.

5.3.2 Zone 2

Field investigation activities proposed in Zone 2 to fill specific data gaps include the following (see Section 6 in Appendix B):

Z2-1. Semi-annual plant-wide water level measurements will continue to be collected each April and October.

Z2-7. Samples will be collected from monitoring wells 410, 415, and 3119 and analyzed for various metals as specified on Table B-1.

Z2-8. Samples will be collected from Wells 50, 411, 415, 3076-8, 3357-8, 3381 and 3392 and analyzed for nitrates (Table B-1).

Z2-9. Samples will be collected from monitoring Wells 412 and 413 and analyzed or various metals as specified on Table B-1.

Z2-10. A groundwater sample will be collected from Well 412 to identify if HMX is present in groundwater (Table B-1).

Z2-11. Groundwater samples will be collected from Wells 3460 and 3500-1 and analyzed for VOCs and perchlorate (Table B-1).

Z2-13. Groundwater samples will be collected from Wells 111, 4395, and 314-5 and analyzed for VOCs and perchlorate (Table B-1).

Z2-14. Samples will be collected from Layer E Wells 3074-5 and analyzed for VOCs

and perchlorate (Table B-1).

The specific proposed activities are listed in Table B-1 in Appendix B. For those activities involving sampling, the specified number of samples, target analytes, and EPA analytical methods are also included on Table B-1.

5.3.3 Zone 3

Field investigation activities proposed in Zone 3 to fill specific data gaps include the following (see Section 6 in Appendix A).

Z3-2. Semi-annual plant-wide water level measurements will continue to be collected.

Z3-3. Water levels will be collected quarterly from all auger and monitor wells in Area 40 for a period of one year to compare water level elevations between wells and to evaluate seasonal water level trends.

Z3-5. Water levels will be collected quarterly from all auger and monitor wells in Area 39 for a period of one year to compare water level elevations between wells and to evaluate seasonal water level trends.

Z3-9. Samples will be collected from monitor wells 145-7, 3488-90, 378, 379, and 3506 and analyzed for 1,4-dioxane, naphthalene, TPH-kerosene, phenol, aluminum, antimony, arsenic, cadmium, total chromium, chromium^{+6}, and lead.

Z3-10. Samples will be collected from monitor wells 154-56 and analyzed for aluminum, antimony, arsenic, cadmium, total chromium, chromium^{+6}, and lead.

Z3-11. Samples will be collected and analyzed for metal and dioxins/furans from alluvial monitor wells 1696, 817, 822, 1515, and 798, and from bedrock monitor wells 30060 and 1514 (Table C-1). The samples will also be analyzed for SVOCs to address uncertainties regarding the nature of waste materials deposited in Area 40.

Z3-12. Samples will be collected and analyzed for VOCs, perchlorate, and NDMA from monitor wells 1575, 1577, 1578, 1318, 791, 796, 1317, and 1337.

Z3-13. One monitor well (P1) will be installed approximately 1,000 feet southeast and southwest of Well 30168, with one screened interval in Layer C and two screened intervals in Layer D.

Z3-15. One groundwater sample will be collected and analyzed for VOCs, perchlorate, NDMA, and SVOCs from alluvial wells 1695, 30061, 1515, 1694, 821, 812,817, 798, 818, 822, 813, and from bedrock wells 30060, 1537, 1514, 1536, 1513, and 1512. A second sample will be collected approximately 3 months after the first sample and analyzed for VOCs, perchlorate, and all other chemicals reported in the first samples.

The specific proposed activities are listed in Table C-1 in Appendix C. For those activities involving sampling, the specified number of samples, target analytes, and EPA analytical methods are also included on Table C-1.

5.3.4 Zone 4

Field investigation activities proposed in Zone 4 to fill specific data gaps include the following (see Section 6 in Appendix D):

Z4-2. Semi-annual plant-wide water level measurements will continue to be collected each April and October.

Z4-4. The length of Alder Creek will be walked to identify seeps or springs potentially discharging into the creek.

Z4-8. Samples from the influent to the GET A groundwater treatment facility will be analyzed for 1,4-dioxane, perchlorate, and nitrate.

Z4-9. Samples will be collected from Wells 3387 and 3386 and analyzed for 1,4-dioxane and perchlorate.

Z4-11. Any groundwater seeps identified near Alder Creek (activity Z4-1) will be sampled and analyzed for perchlorate, VOCs, and NDMA.

Z4-12. Wells 449 and 453 will be sampled and the sample analyzed for NDMA.

Z4-13. Well 79 will be sampled and the sample analyzed for arsenic, lead, and nickel.

Z4-14. Well 454 will be sampled and the sample analyzed for NDMA to evaluate the vertical extent of NDMA from Layer A.

The specific proposed activities are listed in Table D-1 in Appendix D. For those activities involving sampling, the specified number of samples, target analytes, and EPA analytical methods are also included on Table D-1.

5.4 Task 4: Sample Analysis/Data Validation/Data Management

Groundwater samples will be analyzed by Aerojet's Analytical Laboratory (AAL), or by other appropriate analytical laboratories following published analytical protocols and contracted with in accordance with the Aerojet site-wide QAPP and quality assurance/quality control (QA/QC) program. Tables A-1, B-1, C-1, and D-1 include the parameters that will be analyzed for the samples collected under Task 3. Details of analytical method, container size and type, preservation method, and sample holding times are included in the QAPP.

AAL will provide electronic data deliverables upon completion of the analyses. Upon receipt of the analytical laboratory results, the analytical data will be reviewed, checked and validated in accordance with the standard data validation protocols and frequency specified in the QAPP. Following validation, the data qualifiers for analytical data will be entered into the Aerojet Environmental Remediation site-wide chemical database.

5.5 Task 5: Data Evaluation

Evaluation of the data generated from the field investigation will begin during the performance of the field activities and be completed after receipt of the final analytical laboratory results (anticipated to occur no later than 30 days after sample submittal). General PGOU-wide data evaluation tasks will include the following:

- Review of the geologic conditions encountered in the boring associated with the new monitor well proposed for Zone 3 and revision of the cross-sections as necessary;

- Review of the water level data obtained from the bi-annual site-wide and specific water level measurements obtained to evaluate the effectiveness of the existing GET systems, assessment of the representativeness (stability) of the water level results and hydraulic gradients in the various areas, and revision of the potentiometric surface maps;

- Comparison of the water quality data to the existing water quality data to assess the representativeness of the results and to update the water quality plots/maps; and

- Evaluations of the nature and extent of chemical occurrences above potential chemical-specific ARARs and assessment of the fate and transport of these chemicals. These evaluations will include updating the discussions presented in Appendices A through D of this Work Plan based on the boring log, water level measurements, and analytical results generated during the field investigations.

Specific data evaluation tasks proposed to assess the Zone 1 physical characteristics include the following:

Z1-1. Future growth predictions for eastern Sacramento and western El Dorado County will be reviewed to assess future development plans in the area. Census data will be reviewed and compiled for the risk assessment. A figure will be prepared showing the current land uses in the developed areas, and showing the projected land uses in the undeveloped areas.

Z1-2. Lithologic data from newly installed Layer E Wells 30176 and 30179 will be added to existing cross-section A-A'.

Z1-3. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Z1-4. The area covered by the potentiometric surface maps will be expanded south of Folsom and west of Sunrise Boulevards to combine data from the PGOU and the WGOU.

Z1-5. A southwest-trending cross-section, extending into Layer E, will be constructed roughly parallel to Folsom Boulevard, extending from Hazel Avenue to Sunrise Boulevard.

Z1-6. Water level elevation data from Wells 30176 and 30179 will be added to the Layer E potentiometric surface map.

Z1-7. Historical and recent chemical concentrations will be plotted to assess chemical concentration trends.

Z1-8. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

Z1-9. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

Specific data evaluation tasks proposed to assess the Zone 2 physical characteristics include the following:

Z2-1. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Z2-2. Historic groundwater data from Layer B monitor will be evaluated during the PGOU RI/FS.

Z2-3. Historic groundwater data from Layer C monitor wells will be evaluated during the PGOU RI/FS.

Z2-4. Temporal chemical concentration trends will be prepared and evaluated.

Z2-5. All existing cross-sections will be updated with the most recent chemical and water level data.

Z2-6. All chemical-isoconcentration maps will be finalized and all data will be reviewed during the RI/FS.

Z2-12. Data collected from the RCRA closure at Site 11G will be assessed.

Specific data evaluation tasks proposed to assess the Zone 3 physical characteristics include the following:

Z3-1. Two north-south trending cross-sections will be constructed in Sector B, one from Gate 7 to Well 97 and a second from Well 344-5 to Well 97. Two east-west trending cross sections will be constructed perpendicular to the direction of groundwater flow in the northern and southern areas in Sector B. The monitor wells proposed to be included on each cross-section are listed in Table C-1.

Z3-2. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Z3-3. Water levels will be collected quarterly from all auger and monitor wells in Area 40 for a period of one year to compare water level elevations between wells and to evaluate seasonal water level trends.

Z3-4. Three cross-sections will be constructed to compare the lithology, depth-to-water, chemical concentrations, and depth of screened intervals for the monitor wells in Area 39. The monitor wells to be included on the cross-sections are identified in Table C-1.

Z3-5. Water levels will be collected quarterly from all auger and monitor wells in Area 39 for a period of one year to compare water level elevations between wells and to evaluate seasonal water level trends.

Z3-6. Temporal chemical concentration trends will be prepared and evaluated.

Z3-7. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

Z3-8. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

Z3-14. The two north-south cross-sections (E-E' and F-F') will be constructed in Sector B and GET B South. The stratigraphy near Well 1549 will be assessed and additional cross-sections may be prepared to assess the structure of Layers E and F at GET B South.

Z3-16. The size of the area where a TI Waiver or CZ designation is appropriate will be assessed.

Z3-17. A Site Conceptual Model will be developed for Area 40 including the site geology, hydrogeology, groundwater contamination sources, chemical fate and transport characteristics, exposure pathways, and potential receptors.

Z3-18. The feasibility of restoring groundwater in Area 40 will be assessed by conducting a technical and economic comparison of potential remedial alternatives.

Z3-19. A Management Plan will be prepared if a TI Waiver or CZ designation is appropriate for Area 40. The contents of the Plan will be further assessed pending the collection of the additional RI data.

Specific data evaluation tasks proposed to assess the Zone 4 physical characteristics include the following:

Z4-1. Lithologic data from wells near Alder Creek and creek bed elevation data will be used to re-evaluate or reconstruct cross-sections A-A' and B-B'.

Z4-2. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with groundwater data collected on October 2001.

Z4-3. Potentiometric surface maps for Layer A will be compared to the elevations of Alder Creek as part of the evaluation of whether Alder Creek is a gaining or losing stream.

Z4-5. Historical and recent chemical concentrations will be plotted to assess chemical concentration trends.

Z4-6. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

Z4-7. All chemical-iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

Z4-10. Water quality data collected from the upstream and downstream portions of Alder Creek during 1998 through 2001 will be reviewed and included in the ecological risk assessment evaluation.

In addition to the data evaluation tasks proposed to assess the physical characteristics, the following evaluations are recommended to support the FS:

- Expand the scale for cross-section A-A' to evaluate chemicals in groundwater in the vicinity of GET D extraction and recharge wells;
- Chemical concentration trends in groundwater will be evaluated using historic and recent data;
- For those areas where TI of groundwater restoration may be considered as a remedial alternative, as TI evaluation will be prepared in accordance with the *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration* (USEPA, 1993b); and
- For those areas where MNA may be considered as a remedial alternative, the existing MNA-related geochemical data collected throughout the Aerojet Site will be evaluated along with the geologic and hydrologic properties of the areas where MNA may be considered with respect to the lines of evidence used to demonstrate natural attenuation of chemicals dissolved in groundwater (see lines of evidence discussion in Section 3.9.2.5).

5.6 Task 6: Risk Assessment

A risk assessment will be conducted for the PGOU. The risk assessment will follow current guidance developed by USEPA and the California Environmental Protection Agency (Cal-EPA). Using data collected during the RI, the risk assessment will assess potential risks to both human and ecological receptors. The steps associated with these two evaluations are described in the following subsections.

5.6.1 Human Health Risk Assessment

The human health risk assessment will involve four principal steps, in accordance with current risk assessment guidance (USEPA, 1989; USEPA, 1998a; and California EPA, 1992) and the risk assessment requirements specified in Exhibit II of the modified PCD. These steps are described below.

(1) Data Evaluation: The first step of the human health risk assessment will involve a review of site conditions and an evaluation of the chemical data to be used in the risk assessment. This evaluation will consider both the adequacy and the quality of the analytical data, following USEPA guidance (USEPA, 1989; USEPA, 1992a; USEPA, 1998a). Based on this evaluation, hazard sources will be identified, in accordance with Exhibit II of the modified PCD, and chemicals of concern will be selected. Summary tables will be prepared in accordance with USEPA's *Risk Assessment Guidance for Superfund/Part D* (1998a).

(2) Exposure Assessment: The next step of the human health risk assessment involves the development of the exposure assessment. The exposure assessment will rely on the Site Conceptual Model and other site characterization information developed in the RI to identify potential receptors and exposure pathways. As part of the identification of exposure pathways, the potential for chemicals to migrate will be considered. Based on the analysis of receptors and exposure pathways, the exposure assessment will include an evaluation of the likelihood for exposure to occur and an estimation of the magnitude of that exposure, utilizing assumptions consistent with an evaluation of reasonable maximum exposure (USEPA, 1989; USEPA, 1991a). Again, summary tables will be prepared in accordance with USEPA guidance (1998a).

(3) Toxicity Assessment: The human health risk assessment will include a toxicity or dose-response assessment, in which the toxicity of each of the chemicals of concern is briefly described. The toxicity assessment will consider both carcinogenic and noncarcinogenic effects of the chemicals of concern, utilizing toxicity information published by USEPA and California EPA. As part of the toxicity assessment, numeric indices of toxicity (i.e., carcinogenic slope factors and noncarcinogenic reference doses) will be identified and tabulated, in accordance with USEPA guidance (1998a).

(4) Risk Characterization: In the final step of the human health risk assessment, information from the exposure and toxicity assessments will be combined to derive quantitative estimates of potential risk. Carcinogenic and noncarcinogenic risks will be assessed separately, in accordance with methods developed by USEPA. For each effect category (i.e., carcinogenic and noncarcinogenic effects), cumulative risks will be estimated to address cumulative exposures to multiple chemicals of concern via concurrent routes of exposure and/or exposure pathways. Summary tables will be prepared to present the derived risk estimates, in accordance with USEPA guidance (1998a). The risk characterization will include discussion of the sources of uncertainty and the limitations associated with each aspect of the human health risk assessment.

Following completion of the risk characterization step, a preliminary draft human health risk assessment report will be prepared, which will include a description of each step of the human health risk assessment and present the results of the various analyses. The human health risk assessment report will summarize the conclusions of the analysis for use in developing the FS for the PGOU. After agency review of the preliminary draft human health risk assessment report, a final draft version of the report will be prepared and submitted to EPA, the RWQCB, and DTSC as part of the draft OU RI/FS Report.

5.6.2 Screening Level Ecological Risk Assessment

Based on the current understanding of site conditions, there are no complete pathways by which ecological receptors may be exposed to constituents in perimeter groundwater. This conclusion will be further assessed through a screening level ecological risk assessment, utilizing the additional site characterization information collected during Task 3 (Field Investigation). In the event that no complete exposure pathways are identified in the ecological risk assessment, then no further action will be required to address ecological receptors.

The screening level ecological risk assessment will include ten steps, in accordance with current risk assessment guidance (USEPA, 1997; USEPA, 1998b; USEPA, 1999c; USEPA, 2001b; California EPA, 1996a; California EPA, 1996b) and the requirements of Exhibit II of the modified PCD. These ten steps support screening level problem formulation and ecological effects characterization, in accordance with USEPA's recently issued *ECO Update: The Role of Screening Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA, 2001b). However, it should be emphasized that if no complete exposure pathways are identified for ecological receptors, then many of these steps may involve little or no detailed analysis. The ten steps are outlined below.

(1) Identification of Hazard Sources: Utilizing site characterization information from the RI, chemicals of concern will be identified for ecological receptors.

(2) Dose-Response Assessment: Selection of chemicals of concern will consider the intrinsic toxicity of detected constituents, based on information published by USEPA. No additional toxicity studies will be undertaken as part of the screening level ecological risk assessment.

(3) Conceptual Exposure/Pathway Analysis: Site characterization data, including the additional information to be collected as part of Task 3, will be reviewed to identify any pathways by which ecological receptors may be exposed to chemicals of concern. As noted above, review of available information indicates that there are no complete exposure pathways by which ecological receptors may be exposed to constituents in perimeter groundwater.

(4) Characterization of Site and Potential Receptors: In the event that complete exposure pathways are identified for ecological receptors, then these pathways will be characterized, using information collected for the RI.

(5) Selection of Chemicals, Indicator Species, and Endpoints: In the event that complete exposure pathways are identified, then indicator species and appropriate toxicity endpoints will be selected for more detailed evaluation.

(6) Exposure Assessment: In the event that complete exposure pathways are identified, then an evaluation of the magnitude, frequency, and duration of exposure will be performed for the indicator species selected in the preceding step. This analysis will include an evaluation of the likelihood for any such exposure to occur.

(7) Toxicity Assessment/Ecological Effects Assessment: In the event that complete exposure pathways are identified for ecological receptors, then published information characterizing constituent toxicity will be reviewed for each chemical of concern to determine the relationship between the level of exposure and the degree of adverse effect.

(8) Risk Characterization: In the event that complete exposure pathways are identified for ecological receptors, then information from the exposure and toxicity assessments will be combined in order to characterize the potential for adverse effects to occur in ecological receptors as a result of exposure to chemicals of concern in detected in perimeter groundwater.

(9) Identification of Limitations and Uncertainties: The screening level ecological risk assessment will include discussion of the uncertainties and limitations associated with the screening level ecological risk assessment.

(10) Ecological Risk Model: Conclusions from the screening level ecological risk assessment will be developed and presented. These conclusions will describe the potential for chemicals of concern to pose a risk to ecological receptors.

As described in Section 6, a working session with the regulatory agencies will be held to present the preliminary screening-level ecological risk assessment results.

5.7 Task 7: Treatability Studies

As discussed in Section 4.3, it is expected that any additional treatability study data needs will be addressed at the conclusion of the various in-situ treatment and ion exchange treatability testing projects that are currently being conducted or are planned to be completed in 2002. No additional treatability testing is proposed at this time. However, it is proposed that after this Work Plan is approved and prior to completion of the current treatability studies, an evaluation of treatability data needs be conducted to identify any additional treatability studies that may be appropriate for the PGOU FS. At the conclusion of the evaluation of treatability data needs, a working session will be held with the Agencies to discuss the findings of the evaluation. If additional treatability studies are identified, a Treatability Study Work Plan and schedule will be prepared for Agency review and approval, the treatability studies will be performed, an evaluation of the results of the treatability studies will be conducted, and a treatability study report will be prepared and submitted as part of the draft OU RI/FS Report.

5.8 Task 8: Remedial Investigation Report

Following completion of site characterization and data evaluation activities, it is anticipated that a working session with the Agencies will be conducted to discuss the preliminary RI conclusions. A draft RI Report will then be prepared and submitted to the regulatory agencies for review. The draft RI Report will be one of the three major components of the draft OU RI/FS Report. The draft OU RI/FS Report will consist of the draft RI Report, draft Risk Assessment, and draft FS Report.

Information contained in Appendices A through D of this Work Plan will be updated based on the results of the field investigation activities and assembled into a comprehensive report. It is anticipated that the format of the report will follow the suggested RI report format contained in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988a) and include the following sections:

Executive Summary
1. Introduction
2. Study Area Investigation
3. Physical Characteristics of the Study Area
4. Nature and Extent of Contamination
5. Contaminant Fate and Transport
6. Summary and Conclusions

Following regulatory agency review of the draft OU RI/FS report, a final OU RI/FS report will be prepared upon receipt of any agency comments on the draft report.

5.9 Task 9: Remedial Alternatives Development/Screening

The first step in preparation of the FS will involve development and screening of remedial alternatives. This task will include development of RAOs, evaluation of potential ARARs, identification and screening of General Response Actions (GRAs) and technologies, evaluation of the effectiveness of the existing Interim Actions, and development and screening of remedial action alternatives.

5.9.1 Development of RAOs and Evaluation of Potential ARARs

The initial step in identifying and screening remedial alternatives is to formulate RAOs. RAOs are media-specific or operable unit-specific goals designed to protect human health and the environment. RAOs specify the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of alternatives to be developed on the basis of chemical-specific ARARs and site-specific risk-related factors.

As specified in the modified PCD, the only media of concern for the PGOU is groundwater.

Section 121(d) of CERCLA states that remedial actions on CERCLA sites must attain (or justify the waiver of) any federal or more stringent State environmental standards, requirements, criteria, or limitations that are ARARs. Applicable requirements are those cleanup standards, criteria, or limitations promulgated under federal or State law that specifically address the type of situation present at a particular CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or State law that while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are well-suited to the conditions of the particular site.

Pursuant to EPA guidance, ARARs generally are classified into three categories: chemical-specific, location-specific, and action-specific requirements. Chemical-specific ARARs include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. Location-specific ARARs are those requirements that relate to the geographical or physical position of the site, rather than the nature of the chemicals or the proposed site remedial actions. Action-specific ARARs are requirements that define acceptable handling, treatment, and disposal procedures for hazardous substances.

A requirement may not meet the definition of an ARAR, but still may be useful in assessing whether to take action at a site or to what degree action is necessary. This can be particularly true when there are no ARARs for a site, action, or contaminant. Such requirements are called TBC criteria. TBC criteria are nonpromulgated advisories or guidance issued by a federal or State government that are not legally binding, but that may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they are considered together with ARARs to establish the required level of cleanup for protection of human health or the environment. The critical difference between a TBC and an ARAR is that one is not required to comply with or meet a TBC when deciding on a remedial action. However, should a TBC be established as a cleanup standard in the ROD for the PGOU, then the TBC effectively produces the same results as an ARAR.

Based on information that is available at this time, preliminary RAOs and a preliminary analysis of ARARs were previously discussed in Sections 3.9 and 3.6, respectively. After the RI and risk assessment are completed, the list of RAOs and analysis of ARARs will be revised as the initial steps in identifying and screening remedial alternatives in the FS.

5.9.2 Identification and Screening of General Response Actions and Technologies

After the RAOs are established and the ARARs analysis is revised for the PGOU, the second step in identifying and screening remedial alternatives in the FS will involve developing media-specific GRAs to satisfy the RAOs. GRAs describe those actions that will satisfy the RAOs. For example, GRAs may include extraction, containment, treatment, disposal, institutional actions, or a combination of these (USEPA, 1988a). Like RAOs, GRAs are medium-specific.

For each GRA, broad technology groups and specific process options that could be used to implement the actions are then identified. Technologies refer to general categories (e.g., chemical treatment or biological treatment). Process options refer to the specific processes within each technology type (e.g., air stripping or cometabolic bioreactors).

The universe of potential remedial action technologies/process options associated with each GRA that may be applicable to the PGOU and the RAOs will be first identified and then screened based on technical implementability. The resultant technologies/process options will then be evaluated based on anticipated effectiveness, implementability and relative cost to identify the most applicable technologies. Following this evaluation of technologies and based on the evaluation of the effectiveness of the existing PGOU Interim Actions (see discussion in section below), the resultant technologies will then be combined to develop remedial action alternatives for the PGOU.

5.9.3 Evaluation of Effectiveness of Existing Interim Actions

Aerojet previously installed several interim actions to control the offsite migration of chemicals in groundwater. These interim actions include GET systems located at the perimeter of the Aerojet property. These systems include GET A, GET B, and GET D systems located along portions of the eastern, northern, and southern perimeters of the Aerojet Site as well as the ARGET system located near the American River. GETs E and F, located on the western perimeter of the Aerojet site, were addressed under the WGOU. These interim actions consist of groundwater extraction wells to collect and contain contaminated groundwater prior to offsite migration or, in the case of the ARGET, to collect existing offsite contamination. The interim actions also include treatment systems (described in Section 3.7) and either groundwater recharge or surface water discharge of treated groundwater.

As part of the PGOU FS, the effectiveness of these existing systems will be evaluated in terms of their ability to contain contaminated groundwater. Specifically, the three perimeter systems (GET A, GET B and GET D) will be evaluated in terms of their ability to prevent the offsite migration of chemicals in groundwater at the Aerojet boundary. The ARGET system will be evaluated in terms of its ability to prevent further downgradient migration of existing contamination in the ASRA.

The evaluation of the effectiveness of the existing groundwater interim actions detailed in the PGOU RI/FS Report will include the following:

1. Complete description of each system;
2. Description of the subsurface conditions at each system;
3. Evaluation of the effectiveness of the groundwater extraction component of each system;
4. Evaluation of the effectiveness of the treatment component of each system; and
5. Evaluation of the role and effectiveness of the groundwater recharge or surface water discharge component of each system.

System Description. Description of the various GET systems will be developed from existing information. These descriptions will include the following information:

- System location;
- System components;
- History of system implementation and operation;
- Design and operational parameters;
- System operation (both current and historic);
- System schematics, drawings, layout, etc.;
- Operation and maintenance requirements and history; and
- Monitoring requirements and results.

Due to the age of some of the systems, it is anticipated that some of the above information may not be available or well-documented. For example, documentation of the original design criteria may no longer be available or due to changes in system goals, may no longer be relevant. In these cases, the above information will be developed from the available information to the extent possible.

Subsurface Conditions. Description of the subsurface conditions at the various GET systems will be developed from existing information and the results of any additional investigations that may be performed in each area in support of the RI. Descriptions of subsurface conditions will include the following information:

- Assembly of available well and boring logs and well construction records;
- Development of hydrogeologic cross-sections located approximately parallel and perpendicular to the Aerojet boundary;
- Tabulation of water level data and/or development of well hydrographs;
- Summary of hydraulic properties and hydraulic parameter values; and
- Plan and/or section plots of water quality results.

Most of this information has been or will be developed as part of the RI evaluations and therefore may be only summarized as part of the evaluation of the effectiveness of the various GET systems.

Groundwater Extraction. The effectiveness of the groundwater extraction component of each system will be evaluated in terms of its ability to maintain hydraulic control and prevent offsite migration of contaminated groundwater. As part of this evaluation the following information will be developed:

- Location and distribution of extraction wells;
- Tabulation and/or plots of pumping rates and pumping histories;
- Analysis of combined drawdown effects;
- Delineation of groundwater capture area (for each groundwater layer/depth);
- Comparison of groundwater capture zone to extent of contamination; and
- Evaluation of the minimum pumping rate required to maintain capture (may include computer modeling).

Treatment System. The treatment system for each interim action will be evaluated in terms of its ability to treat the known contaminants in each Management Area/Zone and the ability of the treatment system to achieve treatment goals. The following factors will be considered as part of the treatment system evaluation:

- Description of existing treatment processes;
- Tabulation of treatment plant flow rates over time;
- Tabulation of available influent and effluent monitoring results; and
- Comparison of effluent results to performance standards/permit limits.

Recharge/Discharge Component. The role that groundwater recharge plays in supporting, reinforcing or maintaining hydraulic control will be evaluated as part of the evaluation of the groundwater extraction effectiveness.

As discussed in Section 6, at the completion of the evaluation of the effectiveness of the existing Interim Actions, it is anticipated that a working session with the regulatory agencies will be held to present the findings of the evaluation.

5.9.4 Development and Screening of Remedial Alternatives

Technologies and process options retained as discussed above will then be assembled or combined to form remedial alternatives that will satisfy the RAOs. Because of the unique characteristics of the groundwater conditions within each Zone/Management Area within the PGOU, at this time it is anticipated that remedial alternatives will be developed for each Zone/Management Area within the PGOU, rather than for the PGOU as a whole. Detailed descriptions of each alternative will be prepared. Each alternative will be sufficiently defined in regards to quantitative information to allow differentiation among alternatives with respect to effectiveness, implementability, and cost.

A screening evaluation of the defined alternatives will then be conducted using the three broad criteria of effectiveness (both short- and long-term aspects), implementability, and cost. The purpose of the screening evaluation will be to reduce the number of alternatives that will undergo a more thorough and extensive analysis using nine specific criteria under Task 10: Detailed Analysis of Alternatives. The defined alternatives will be evaluated more generally during this screening evaluation than they will under the detailed analysis (Task 10). Alternatives with the most favorable composite evaluation using the three broad criteria will be retained for further consideration during the detailed analysis. In accordance with EPA Guidance (USEPA, 1988a), alternatives that include innovative technologies are normally carried through the screening process if there is reason to believe that the innovative technology will offer significant advantage such as better treatment performance or implementability, fewer adverse impacts, or lower costs for similar levels of performance over other available approaches.

It is anticipated that once the alternatives screening process is completed, Aerojet will meet with EPA and the State to discuss each of the alternatives being considered for detailed analysis. The purpose of the meeting will be to agree upon the alternatives that will be considered further, to document that the results of the alternative screening are complete, and identify any additional investigations that may be necessary. Also, at this point, the need for additional treatability tests (not identified earlier or if new technologies emerge) can be determined for process options that might require additional data for detailed analysis.

5.10 Task 10: Detailed Analysis of Alternatives

This task will involve subjecting the alternatives that survive the screening process to a detailed analysis. The purpose of this detailed analysis will be to provide sufficient information to allow for comparisons among the alternatives based on the standard criteria specified in the NCP. The detailed evaluation of final alternatives for a remedial action is a two-stage process. During the first stage of evaluation, each of the alternatives will be assessed against the nine individual evaluation criteria. Each alternative will be evaluated independently without a consideration of the other alternatives.

For the second stage of the evaluation process, the evaluation criteria will be grouped into a tiered system to reflect their interrelationships and different levels of significance. During this second-stage evaluation, the alternatives will be initially evaluated according to the threshold criteria, which must be met, and then compared with each other to identify relative advantages and disadvantages and trade-offs among the different primary balancing criteria. The purpose of the comparative analysis will be to provide information for a balanced remedy selection. This comparative analysis will identify the advantages and disadvantages of each alternative to assist in the decision-making process leading to the Proposed Plan. The comparative analysis will include a narrative discussion describing the strengths and weaknesses of the alternatives relative to one another with respect to each criterion and how reasonable variations of key uncertainties could change the expectations of their relative performance.

The nine NCP evaluation criteria include:

Threshold Criteria:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

Primary Balancing Criteria:

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

Modifying Criteria:

- State Acceptance
- Community Acceptance

The NCP [40 CFR Section 300.430(e)(9)(iii)] categorizes these nine criteria into three groups: threshold criteria, primary balancing criteria, and modifying criteria. Each type of criteria has its own weight when it is evaluated. Threshold criteria are requirements that each alternative must meet to be eligible for selection as the preferred alternative, and include overall protection of human health and the environment and compliance with ARARs (unless a waiver is obtained).

Primary balancing criteria are used to weigh effectiveness and cost tradeoffs among alternatives. The primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The primary balancing criteria represent the main technical criteria upon which the alternative evaluation is based.

Modifying criteria include State acceptance and community acceptance, and may be used by EPA to modify aspects of the preferred alternative when preparing the Proposed Plan. Modifying criteria are generally evaluated after public comment on the RI/FS report and the Proposed Plan. Accordingly, only the seven threshold and primary balancing criteria are used in the detailed analysis phase of the FS.

5.11 Task 11: Feasibility Study Report

Upon completion of the detailed analysis of alternatives, a draft FS Report in accordance with the suggested FS report format contained in Table 6-5 of the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988a) will be prepared. The draft FS Report will be one of the three major components of the draft OU RI/FS Report. The draft OU RI/FS Report will consist of the draft RI Report, draft Risk Assessment, and draft FS Report. Following regulatory agency review of the draft OU RI/FS report, a final OU RI/FS report will be prepared upon receipt of any agency comments on the draft report.

6 SCHEDULE

Exhibit II of the modified PCD requires that this Work Plan include (1) a schedule for submission of a draft and final OU RI/FS Report and for any other submittals that will be prepared to support the OU RI/FS, and (2) target dates, for planning purposes only (and not subject to approval, or action or dispute resolution), of the projected schedule after approval of the Final OU RI/FS Report through selection and implementation of the remedy. These two schedule requirements are discussed in the following sections.

6.1 Schedule for Submission of Draft and Final OU RI/FS Report

A Gantt (bar) chart proposed schedule to complete the PGOU RI/FS is included as Figure 6-1. This schedule has been developed based on the requirements in the modified PCD, specifically the requirements contained in the Exhibit II, paragraph 13, Deliverables and Schedule. These requirements specify the following schedule for the PGOU RI/FS:

Exhibit II Submittal	Submittal Date
Draft OU RI/FS Workplan	6 months after lodging PCD modifications
Final OU RI/FS Workplan	8 months after lodging PCD modifications

The proposed schedule provided in Figure 6-1 includes the 11 major tasks described in Section 5 of this Work Plan. It also includes notable subtasks and highlights the interdependencies among the various tasks and subtasks. The schedule allows for the following assumed review time periods contained in Exhibit II of the modified PCD:

- 30 day Agency review and comment period on draft OU RI/FS Work Plan;
- 30 day Aerojet revision and submittal of final OU RI/FS Work Plan;
- 60 day Agency review and comment period on draft OU RI/FS Report; and
- 60 day Aerojet revision and submittal of final OU RI/FS Report.

As shown in Figure 6-1, following Agency approval of the final OU RI/FS Work Plan, an approximate 30-day contracting/contractor-mobilization period will occur prior to commencement of field investigation activities. Field investigation activities are scheduled to be completed at the beginning of November 2002. Sample analysis and data validation, review, management, and evaluation are proposed to be completed from mid-August 2002 through mid-January 2003.

With respect to the ecological risk assessment task, the screening-level problem formulation and ecological effects evaluation will take place after the conclusion of the field investigation activities, particularly after the evaluation of whether groundwater discharges to Alder Creek is completed. The schedule currently contemplated for the ecological risk assessment task assumes that no ecological risk assessment beyond a screening-level problem formulation and ecological effects evaluation will be necessary. If the results of the screening-level evaluation indicate that additional ecological risk assessment activities are necessary, Aerojet will submit a proposed schedule modification to the Agencies.

The contaminant identification and exposure and toxicity evaluation activities associated with the human health risk assessment will begin following the contracting/contractor-mobilization period. However, the human health risk assessment risk characterization activities will not commence until after the results from the field investigation activities are available.

Aerojet is currently conducting or participating in several treatability studies, which are currently scheduled for completion in mid-April 2003. No additional treatability studies are contemplated at this time. However, an evaluation of treatability data needs will be conducted immediately after the identification/screening of technologies task under the FS and the need for additional treatability studies may be identified. If additional treatability studies are needed, a Treatability Study Work Plan will be prepared and treatability studies conducted. The schedule currently contemplated for development and analysis of remedial alternatives will need to be adjusted if additional treatability studies are conducted. Should this result in a modification to the proposed schedule to complete the PGOU RI/FS, Aerojet will submit a proposed schedule modification to the Agencies.

With respect to the activities associated with preparation of the FS report, the development of RAOs, evaluation of potential ARARs, and identification and screening of GRAs/technologies are estimated to begin following the contracting/contractor-mobilization period. Evaluation of the effectiveness of the existing Interim Actions and development of remedial alternatives cannot begin until the results from the water level monitoring and monitor well/GET influent and effluent sampling activities are available.

As discussed in Section 5 and shown on Figure 6-1, specific working sessions among the regulatory agencies, Aerojet, and their respective contractors are proposed at the following project milestones:

- To present the preliminary screening-level ecological risk results;
- To discuss the preliminary draft human health risk assessment results;
- At the conclusion of the treatability data needs evaluation;

- After the GET effectiveness evaluations are completed;
- To discuss preliminary RI conclusions; and
- After remedial alternatives have been developed.

The proposed schedule contained in Figure 6-1 deviates from Exhibit II, paragraph 13, in one aspect. The Exhibit II schedule contemplates submittal of one OU RI/FS report. As shown on Figure 6-1, it is assumed that a preliminary draft human health risk assessment report will be submitted for Agency review prior to submittal of the draft OU RI/FS Report. Submittal of a separate preliminary draft human health risk assessment report prior to the draft RI/FS Report will allow any regulatory agency risk assessment review comments to be considered or incorporated in the draft RI/FS report.

6.2 Target Date Schedule – Selection and Implementation of Remedy

Exhibit II of the modified PCD requires that target dates, for planning purposes only (and not subject to approval, or action or dispute resolution, under the Program Plan), of the projected schedule after approval of the Final OU RI/FS Report through selection and implementation of the remedy for the PGOU be included in this Work Plan. A Gantt (bar) chart showing estimated target dates is provided as Figure 6-2.

The following assumptions were used in preparing the target date schedule:

- Agency approval of the Final OU RI/FS Report will occur approximately 14 days after the report is submitted;
- EPA preparation of the Proposed Plan, public comment on the Proposed Plan, and EPA preparation of the ROD will each take approximately 60 days;
- EPA preparation of the draft Consent Decree (CD) and CD Statement of Work will require approximately 60 days, CD negotiations will take approximately 120 days, public notice will require 60 days, response to public comment will require 30 days, and filing of the CD with the Court will require approximately 30 days;
- With respect to remedial design/remedial action (RD/RA) work plans, preparation of draft work plans, EPA review of draft work plans, finalization of RD/RA work plans, and EPA review/approval of the final work plans will require approximately 210 days;
- Remedial design, including design investigations, a basis of design memorandum, and preliminary (30 %), intermediate (60%), pre-final (95%), and final (100%) design submittals and EPA review of design submittals is estimated to require approximately 490 days; and

- Construction of any remedial action, including bidding, negotiation of construction contracts, mobilization, construction and start-up, and final inspections, is estimated to require approximately 600 days.

7 PROJECT MANAGEMENT

This section of the Work Plan addresses the personnel who will conduct the various activities involved in preparing the PGOU RI, risk assessment, and FS. The roles and responsibilities of the individuals and the various organizations that will be involved are also discussed. Project communications and reporting requirements are also presented in this section. A project organization chart is included as Figure 7-1.

7.1 Project Personnel and Organization Roles/Responsibilities

7.1.1 Regulatory Agency Representatives

Agency oversight of the PGOU RI/FS will be managed jointly between the USEPA Region IX, the California RWQCB, and the California DTSC. As shown on Figure 7-1, Charles Berrey, Alex MacDonald, and Ed Cargile will serve as the respective remedial project managers for these agencies. It is anticipated that Don Hodge, EPA Community Involvement Coordinator will serve in the lead role with respect to any community relations activities conducted over the course of the RI/FS activities.

7.1.2 Aerojet Environmental Remediation Department

The overall RI/FS effort will be managed by Cindy Caulk of Aerojet's Environmental Remediation Department. In this role she will be responsible for directing the efforts of the three contractors and the various project team members within the Environmental Remediation Department (Figure 7-1). She will coordinate the activities that will be conducted by Aerojet during the RI/FS including field investigation, treatability studies, and laboratory analysis of samples. She will also serve as the point of contact with the respective regulatory agency project managers.

As indicated on Figure 7-1, Kerik Kouklis will be lead hydrogeologist for Aerojet during the preparation of the RI/FS and will provide technical oversight of RI activities and evaluations/summaries. He will also provide support for data management, generation of data tables, data evaluation and hydrologic interpretation, and data/graphics generation (potentiometric surface maps and plotting of chemical data).

Scott Goulart is Aerojet's PCD coordinator and responsible for overall scheduling and implementation of PCD requirements. He will be involved in coordinating this PGOU RI/FS with other PCD-related projects and status meetings with the regulatory agencies. Other Aerojet Environmental Remediation Department members who manage the various on-going treatability studies and have specific knowledge of previous and on-going

remedial investigation activities will also be involved from time to time during the project.

7.1.3 Central Valley Environmental, Inc.

Central Valley Environmental, Inc. (CVEI) will be responsible for preparation of the RI. Marc Silva, Principal Geologist, will serve as CVEI's lead investigator and project manager for the RI. He will be supported by Robert Fagerness, Principal Engineer. Both Mr. Silva and Mr. Fagerness were lead investigators conducting the fieldwork and associated data evaluation and interpretation during preparation of the Stage 1 RI at the Aerojet Site. Mr. Silva prepared the RI and was Aerojet's project manager during preparation of the WGOU RI/FS.

7.1.4 Engineering Management Support, Inc.

Engineering Management Support, Inc. (EMSI) will be responsible for preparation of the FS. Robert Jelinek, Principal Engineer, will serve as EMSI's lead engineer and project manager for the FS. He will be supported by Paul Rosasco, Principal Engineer. Both Mr. Jelinek and Mr. Rosasco were principal authors of the WGOU FS and have prepared numerous RIs and FSs under CERCLA. Mr. Rosasco will also coordinate the risk assessment efforts with those of the RI and FS and will direct the analytical or numerical groundwater modeling efforts, if modeling is deemed necessary.

7.1.5 Environmental Resources Management

Environmental Resources Management (ERM) will be responsible for preparation of the human health and ecological (if any) risk assessments to support the FS. Robin Streeter, Principal Toxicologist, will serve as the principal author of the human health baseline risk assessment. She will be supported by other ERM risk assessment staff, as necessary. Ms. Streeter will also direct preparation of the screening-level problem formulation and ecological effects evaluation. She has conducted or managed over 140 risk assessments for sites throughout the U.S., many of these for complex industrial facilities in California, Arizona, and Nevada.

7.2 Project Communications

The activities described in this Work Plan and the estimated schedule for completion of the RI/FS were derived from the Preliminary Data Assessment Reports contained in Appendices A through D and current knowledge of the existing Interim Actions. It is anticipated that as results from the various field and treatability study activities are evaluated, working sessions will be held with the regulatory agencies to discuss the

results and assess if the field work is complete or if additional field investigation or treatability studies are necessary and, as a result, any modifications to the schedule are necessary. These working sessions will be conducted within the regular monthly meetings held between Aerojet and the regulatory agencies regarding all PCD activities at the Site. As discussed in Section 6, specific working sessions are proposed to present the preliminary screening-level ecological risk results, to discuss the preliminary draft human health risk assessment results, at the conclusion of the treatability data needs evaluation, after the GET effectiveness evaluations are completed, to discuss preliminary RI conclusions, and after remedial alternatives have been developed.

Direct communication will be maintained throughout the preparation of the PGOU RI/FS between Aerojet's project manager or PCD coordinator and the respective regulatory agency remedial project managers on a frequent basis.

7.3 Reporting under Program Plan Progress Reports

The PCD requires quarterly progress reports be submitted to the Agencies addressing the status of all PCD tasks completed in accordance with approved RI/FS Work Plans. A section of the progress report will be devoted to the PGOU RI/FS activities and will provide a brief description of the field investigation, report preparation, and project management-related activities that occurred during the quarter. Work planned for the next quarter will also be presented.

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Tables

Table 2-1: Relationships among the Various Site Divisions

Zone	Sector	Management Areas	Existing GET Facility
1	D	Areas 20, 46, 49, and Central Disposal Area	GET D, ARGET
2	E	Line 00, 02, 05, 06, Chemical Plant 1	GET E/F*
	F	Lines 01, 03, 04, Chemical Plant 2	GET E/F*
	G	Line 04	None
3	B	Areas 34, 37, 38, 39, 40	GET B
4	A	Areas 30, 31, 32	GET A
	C	Area 46, Solid Waste Landfill	None

* Note: GETs E/F included in Western Groundwater Operable Unit (OU-3).

Table 3-1: Summary of Potential Chemical Specific Requirements

Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Safe Drinking Water Act (40 CFR 141)	Establishes national drinking water standards in the form of Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)	Applicable – at the point groundwater is delivered to a drinking water distribution system. Relevant and Appropriate – for in-situ groundwater that is or has a potential to be used for drinking water .	Applicable to water systems serving over 25 persons. Relevant and appropriate for smaller systems. Establishes MCLs that apply to many of the site-related chemicals (see also Table 3-2). All MCLs (organic, inorganic, etc.) are potentially applicable if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
CCR Title 22 Chapter 15, Section 64400 et seq.	Establishes California primary and secondary MCLs		
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR)	Defines beneficial uses for surface water and groundwater in the basin. Establishes water quality objectives, including narrative and numeric standards, to protect the beneficial uses and water quality objectives (WQOs) of surface and ground waters in the region. Describes implementation plans and other control measures designed to ensure compliance with statewide plans and policies.	Groundwater uses and WQOs are potentially applicable for development of ground-water cleanup levels and remedial actions. These are also potentially applicable if the selected remedial action includes reinjection of treated water. Surface water uses and WQOs are potentially applicable if the selected remedial action includes discharge of treated water to surface water Basin Plan policies and procedures for establishment of cleanup levels are not applicable, relevant and appropriate or TBCs as CERCLA sets methods for identification of cleanup levels at NPL sites	Specific portions of the Basin Plan that are potentially applicable include: • Beneficial uses of waters in the basin including: *Ground water:* – municipal and domestic supply (MUN), – agricultural supply (AGR), – industrial service supply (IND), and – industrial process supply (PRO). *Surface water:* – MUN, AGR, IND, – Recreation (REC), and – Freshwater habitat (WARM) and (COLD), Wildlife habitat (WILD), Migration of aquatic organisms (MIGR), and Spawning (SPWN). • Water quality objectives to protect these uses including: *Ground water:* – Numerical standards for bacteria, chemical constituents (MCLs), and radioactivity – Narrative standards for tastes and odors and toxicity *Surface water:* • Numerical limits for bacteria, chemical constituents, dissolved oxygen, pH, radioactivity, salinity, temperature and turbidity.

Table 3-1: Summary of Potential Chemical Specific Requirements (cont.)

Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR) cont.			• Narrative standards for biostimulatory substances, color, floating material, oil and grease, sediment, settleable material, suspended material, tastes and odor, and toxicity. Basin Plan also requires that any activity, including, but not limited to, the discharge of contaminated soils or waters or in-situ treatment or containment of contaminated soils or waters, must not result in actual water quality exceeding water quality objectives.
State Water Resources Control Board Resolution No. 88-63 "Sources of Drinking Water Policy" (contained in the RWQCB's Water Quality Control Plan)	Specifies that, with certain exceptions, all ground and surface waters must have the beneficial use of municipal or domestic water supply.	Potential TBC with respect to beneficial uses Potential TBC with respect to basis for exceptions from the general designations of beneficial uses	This policy is used by the Regional Water Board in determining beneficial uses for waters. The beneficial uses established in the Basin Plan are based on this policy. The beneficial uses in the Basin Plan represent a site-specific determination and therefore are more appropriate than this general policy. This policy also establishes the basis for exceptions to the general designation of beneficial uses.
State Water Resources Control Board Resolution No. 68-16 "Statement of Policy With Respect to Maintenance of High Quality of Waters in California " ("Anti-degradation Policy").	Requires that quality of high quality surface and ground waters be maintained to the maximum extent possible. Degradation of waters will be allowed only if : – It is consistent with the maximum benefit to the people of the state, – It does not unreasonably affect present and anticipated beneficial uses, and – It does not result in water quality less than that prescribed in RWQCB and SWRCB policies. If degradation is allowed, the discharge must meet best practicable treatment or control, which must prevent pollution or nuisance and result in the highest water quality consistent with maximum benefit to the people of the state.	Potentially applicable if the selected remedial action includes disposal of wastes into waters of the State	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.

Table 3-1: Summary of Potential Chemical Specific Requirements (cont.)

Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
RWQCB, CVR Basin Plan "Antidegradation Implementation Policy"	Defines the RWQCB policy with respect to implementation of the SWB Antidegradation Policy contained in SWB Resolution 68-16	Potentially applicable for disposal of wastes into waters of the State	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.
RWQCB, CVR Basin Plan, "Policy for Application of Water Quality Objectives"	This policy requires achievement of water quality objectives at all points within a surface water or groundwater resource for which beneficial uses have been designated rather than just at the points of use. This policy also explains how the Regional Water Board applies numeric and narrative water quality objectives to ensure the reasonable protection of beneficial uses of water. This policy also explains how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high-quality waters.	WQOs are potentially applicable for development of ground-water cleanup levels and remedial actions. Also potential TBCs if the selected remedial action includes reinjection of treated water. Surface water WQOs are potential TBCs if the selected remedial action includes discharge of treated water to surface water	This policy requires maintenance of background water quality to comply with the antidegradation policy. This policy requires WQOs to be the least stringent limits to be imposed on water quality and indicates that background represents the most stringent limits to be imposed on ambient water quality. The Basin Plan includes both numeric and narrative water quality objectives. This policy explains how the RWQCB evaluates compliance with the narrative WQOs through use of other standards, criteria, advisories, etc. as presented in *"A Compilation of Water Quality Goals"*. This policy also presents a methodology for assessing compliance with the narrative WQO for toxicity.

Table 3-1: Summary of Potential Chemical Specific Requirements (cont.)

Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
State Water Resources Control Board Resolution No. 92-49 (As amended April 21, 1994 and October 2, 1996) "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304" Also Title 23 CCR Chapter 22, Section 2907	Establishes requirements for investigation and cleanup and abatement of discharges. Among other requirements, dischargers must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality, or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of Title 23, CCR, Section 2550.4 requirements to groundwater cleanups.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	These policies and procedures require cleanup of a discharge and abatement of effects of past, current or possible discharges of waste that creates or threatens to create a condition of pollution or nuisance. These policies and procedures establish procedures for investigation, evaluation of cleanup and abatement alternatives, implementation of cleanup and abatement actions including conformance with Resolution No. 68-16. These policies and procedures require cleanup and abatement that promotes attainment of either background water quality, or the best water quality which is reasonable (but not greater than that prescribed in the Water Quality Control Plans and Policies adopted by the State and Regional Water Boards) if background levels cannot be restored. Note: These policies and procedures also address designation and implementation of containment zones, which are discussed in Table C-4 under potential action-specific requirements.
RWQCB, CVR Basin Plan, "Policy for Investigation and Cleanup of Contaminated Sites."	This policy establishes and describes the RWQCB required procedures for investigation and remediation of contaminated sites. This policy also describes the RWQCB requirements for cleanup levels for groundwater and soil contamination.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	This policy requires establishment of cleanup levels for groundwater based on: – Background concentrations – Water quality objectives – Concentrations that do not pose a significant risk to human health or the environment – Technologic and economic feasibility of attaining background. *This policy requires achievement of background levels when feasible. Otherwise, this policy requires achievement of water quality objectives and risk-based levels that do not pose a significant risk to human health or the environment.* This policy also requires compliance with groundwater cleanup levels throughout the pollutant plume.

Table 3-1: Summary of Potential Chemical Specific Requirements (cont.)

Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Title 23, CCR, Chapter 15, Section 2550.4.	This regulation presents procedures for identifying concentration limits for cleanup and abatement of discharges from facilities that treat, store or dispose of hazardous waste at Class I waste management units. SWB Resolution 92-49 also requires use of these regulations for development of cleanup levels other than background.	Potentially Applicable for identification of ground water cleanup levels. As this regulation does not contain numeric standards, it is not a chemical-specific ARAR but may be an action-specific ARAR.	This regulation requires cleanup to background concentration levels, or a concentration limit greater than background if – It is technologically and economically infeasible to achieve background, and – The constituent will not pose a substantial present or potential hazard to human health or the environment as long as the concentration limit greater than background is exceeded. This regulation lists the various factors to be considered in setting a concentration limit greater than background. This regulation also requires concentration limits that are greater than background to be set at the lowest levels that are economically and technologically achievable.
"A Compilation of Water Quality Goals"	Provides guidance on selecting numeric values to implement narrative water quality objectives contained in the Basin Plan.	As an individual document, this information is a "To Be Considered" criteria. As previously discussed, due to its direct reference in the Basin Plan, this document is potentially applicable as part of the Basin Plan.	This document is not a promulgated regulation and therefore in itself is not an ARAR but may be a TBC. This document should be considered in selecting appropriate numeric values to implement the narrative WQOs in the Basin Plan. The numeric values contained in the staff report may be ARARs or TBCs depending on the source of the values. As this document is referenced by the Basin Plan, it is considered to be potentially applicable as part of the Basin Plan which is potential applicable.
National Pollutant Elimination Discharge System (NPDES Permit)	These regulations set forth the requirements for discharge to surface water and the Establishment of numeric limits and monitoring requirements for such discharges.	Applicable – if the selected remedial action includes discharge of treated water to surface water.	Discharge of treated groundwater to surface water may require obtaining a new NPDES permit or revision of Aerojet's existing NPDES permit. The NPDES permit will specify the numeric standards required to be met in water that is to be discharged to surface water as well as the monitoring requirements for such a discharge.
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) Also Title 22 CCR Chapter 3 Section 12000 et seq.	These regulations identify chemicals known to cause cancer or reproductive toxicity. This act prohibits discharge or release of significant amounts of the identified chemicals.	The numeric limits and notification requirements are potentially relevant and appropriate if the selected remedial action includes use of treated groundwater as drinking water supply..	These regulations make it illegal to expose persons to significant amounts of chemicals known to cause cancer or reproductive toxicity without prior notification, or to discharge significant amounts of these chemicals to sources of drinking water. The numeric limits and notification requirements are applicable to the water suppliers at the point that groundwater is delivered to a water system for public consumption.

Table 3-1: Summary of Potential Chemical Specific Requirements (cont.)

Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) cont.	Significant amounts are generally defined as levels that pose no significant risk of cancer. For drinking water, significant levels are defined as California MCLs, drinking water action levels when MCLs don't exist, or discharge limits allowed by a Basin Plan or waste discharge permit.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge or reinjection of treated water.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge of treated water to surface water or reinjection of treated groundwater. The numeric limits and notification requirements are applicable to remedial actions, if any, that include use of treated water for municipal or domestic supply.
National Ambient Water Quality Criteria	Establishes water quality criteria, which are non-enforceable guidance developed under CWA §304 and are used by the State, in conjunction with designated use for a stream segment, to establish water quality standards under CWA §303.	Neither applicable nor relevant and appropriate for groundwater. Potentially relevant but likely not appropriate for discharge of treated water to surface water.	These criteria are published by EPA to protect human health and welfare and freshwater and marine aquatic life from pollutants in surface waters and therefore are not applicable to groundwater. Ambient water quality criteria are based on consumption of drinking water and aquatic organisms (primarily fish) and consumption of fish alone and therefore are not relevant to groundwater in the WGOU. Although potentially relevant, ambient water quality criteria are not appropriate requirements as the RWQCB has adopted numeric standards for the surface waters in the area which represent site-specific water quality standards which are more appropriate requirements.
US EPA Region 9 Preliminary Remediation Goals (PRGs)	EPA has developed preliminary remediation goals that are risk-based levels that are used to screen sites that may require additional investigation or possible remediation. PRGs are also used to screen lists of site-related chemicals to identify potential chemicals of concern.	To Be Considered	EPA Region 9 PRGs are guidance levels, not promulgated standards, and therefore are not an ARAR; however, the PRGs may be TBCs for identification of potential groundwater cleanup levels.

Table 3-1: Summary of Potential Chemical Specific Requirements (cont.)

Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Department of Health Services (DHS) Drinking Water Action Levels	DHS has established action levels based mainly on health effects but in some cases based on organoleptic (taste and odor-based) values	To Be Considered	Action levels (ALs) are advisory to water suppliers and therefore would not be ARARs. They are potential TBCs for identifying potential groundwater cleanup levels. Of particular interest in this matter are the ALs for perchlorate and NDMA.
California Public Health Goals (PHGs)	The California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA) has adopted PHGs for chemicals in drinking water. PHGs are levels of drinking water contaminants at which adverse health effects are not expected to occur from a lifetime of exposure.	To Be Considered	PHGs are non-enforceable risk-based goals and therefore are not ARARs but are TBCs for identifying potential groundwater cleanup levels.
EPA Integrated Risk Information System (IRIS)	A non-promulgated database of health effects that may result from exposure to various substances found in the environment.	To be considered	IRIS values were considered in the development of the Baseline Risk Assessment for the WGOU.
EPA Drinking Water Health Advisories and NAS Suggested No Adverse Response Levels (SNARLs)	Non-promulgated values published by USEPA and the National Academy of Sciences for toxicity other than cancer or incremental cancer risk estimates	To be considered	EPA drinking water health advisories and incremental cancer risk estimates and NAS SNARLs and incremental cancer risk estimates were considered in the development of the Baseline Risk Assessment for the WGOU.

Table 3-2: Summary of Preliminary Potential Chemical-Specific ARARs and TBCs for Contaminants of Concern in Groundwater

Contaminant of Concern	Federal Primary MCL (mg/L)	Federal MCLG (mg/L)	California Primary MCL (mg/L)	California DHS Action Levels (mg/L)	California Proposition 65 Levels (mg/L)[a]	California PHGs (mg/L)	USEPA Region 9 PRGs (mg/L)[b]
1,1,2-Trichloroethane	0.005	0.003	0.005	NA	0.005	NA	0.0002
1,1-Dichloroethane	NA	NA	0.005	NA	0.05	NA	0.81
1,1-Dichloroethene	0.007	0.007	0.006	NA	NA	0.01 [d]	0.000046
1,2-Dichloroethane	0.005	0	0.0005	NA	0.005	0.004 [d]	0.00012
1,2-Dichloroethene (cis)	0.07	0.07	0.006	NA	NA	NA	0.061
1,2-Dichloroethene (trans)	0.1	0.1	0.01	NA	NA	NA	0.12
Carbon tetrachloride	0.005	0	0.0005	NA	0.0025	NA	0.00017
Chloroform	0.1 [c]	0	0.1 [c]	NA	0.01	NA	0.00016
Freon-113	NA	NA	1.2	NA	NA	4	59
Tetrachloroethene	0.005	0	0.005	NA	0.007	NA	0.0011
Trichloroethene	0.005	0	0.005	NA	0.025	0.0008 [d]	0.0016
Vinyl chloride	0.002	0	0.0005	NA	0.0015	NA	0.00002
1,4-Dioxane	NA	NA	NA	0.003	0.015	NA	NA
Perchlorate	NA	NA	NA	0.0018	NA	NA	0.018
NDMA	NA	NA	NA	0.00002	0.00002	NA	0.0000013
Nitrate [d]	10	NA	45 [e]	NA	NA	NA	NA
Nitrite [d]	1	NA	1	NA	NA	NA	NA
Total Nitrate and Nitrite [d]	10	NA	10	NA	NA	NA	NA

[a] Converted to concentration based on 2 liters per day consumption.
[b] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
[c] For total trihalomethanes (sum of bromoform, bromodichloromethane, chloroform, and dibromochloromethane).
[d] Expressed as N.
[e] Expressed as NO_3.
NA = not available.

Table 3-2: Summary of Preliminary Potential Chemical-Specific ARARs and TBCs for Chemicals of Concern in Groundwater (cont.)

Chemical of Concern	IRIS RfD as drinking water levels	IRIS $1x10^{-6}$ incremental cancer risk	EPA DWHAs or SNARLs – non-carcinogenic	EPA DWHAs or SNARLs – carcinogenic	NAS SNARLs – non-carcinogenic	NAS SNARLs - carcinogenic	Taste & odor thresholds
1,1,2-Trichloroethane	2.8	0.6	3				
1,1-Dichloroethane							
1,1-Dichloroethene	6	0.06	7		100		1,500
1,2-Dichloroethane		0.4	700 / 2,600	0.4		0.71	7,000
1,2-Dichloroethene (cis)			70				
1,2-Dichloroethene (trans)	140		100				260
Carbon tetrachloride		0.3	70 / 300	0.3	200	4.5	520
Chloroform		6	100 / 400	6		0.26 / 56	2,400
Freon-113	210,000						
Tetrachloroethene	70		2,000	0.7		3.6	170
Trichloroethene				3		1.5	310
Vinyl chloride			10 / 50	0.015		1.1	3,400
1,4-Dioxane							
Perchlorate							
NDMA		0.0007					
Nitrate [d]	11,000		10,000				
Nitrite [d]	700		1,000				
Total Nitrate and Nitrite [d]							

Notes: All values are in units of ug/L. NA = not available.
[a] Converted to concentration based on 2 liters per day consumption.
[b] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
[c] For total trihalomethanes (sum of bromoform, bromodichloromethane, chloroform, and dibromochloromethane).
[d] Expressed as N.

Table 3-3: Preliminary Potential Location-Specific ARARs

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Within floodplain	40 CFR Part 6, Appendix A, Fish and Wildlife Coordination Act (16 USC 661 et seq.), and 40 CFR Part 6.302	Require avoidance of adverse effects, minimization of potential harm, and restoration and preservation of natural and beneficial values of floodplains.	Potentially Applicable to any actions that may be conducted within the floodplain.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within 100-year flood plain	40 CFR 264.18(b) and 22 CCR 66264.18(b)	A RCRA facility located in a 100-year flood plain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	Potentially Applicable if groundwater treatment involves treatment or storage of hazardous wastes.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	National Archaeological and Historical Preservation Act (16 USC Section 469); 36 CFR Part 65	Alteration of terrain that threatens significant scientific, prehistoric, historic, or archaeological data may require actions to recover and preserve artifacts.	Potentially applicable if significant artifacts are encountered during construction	The proposed remedial alternatives will not alter or destroy any known prehistoric or historic archeological features west of the Aerojet Sacramento facility site. Areas west of the Aerojet Sacramento facility are essentially completely developed. However, because there is always a possibility that buried historic or prehistoric remains could be discovered during construction, this regulation would require action to recover and preserve artifacts.
Historic project owned or controlled by a federal agency	National Historic Preservation Act (NHPA) Section 106 (16 USC Section 470 et seq.); 36 CFR Part 800	Property included in or eligible for the National Register of Historic Places may require action to preserve historic properties.	Neither applicable nor relevant and appropriate	The anticipated remedial actions do not include any activities on properties included on, or eligible for inclusion on the National Register of Historic Places. If it is determined that properties subject to NHPA are present and could be impacted during the implementation of the remedial action, these requirements may be applicable and would require mitigation measures to protect or preserve such properties.

Table 3-3: Preliminary Potential Location-Specific ARARs (continued)

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Critical habitat upon which endangered species or threatened species depend	Substantive portions of the Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR Part 200, 50 CFR Part 402 Substantive portions of the California Endangered Species Act Substantive portions of the Native Plant Protection Act	Requires action to conserve endangered species or threatened species, including consultation with the Department of the Interior, Fish and Wildlife Service.	Potentially applicable if critical habitat for endangered species could be affected during implementation of the selected remedy	Two endangered floral species are known to occur within Sacramento County: the Sacramento Orcutt grass (Orcuttia Viscida) and the Boggs Lake hedge hyssop (Gratiola Heterosepala). Four endangered wildlife species are expected to occur within 25 miles of the Aerojet Sacramento facility: Bald Eagle, Peregrine Falcon, Giant Garter Snake, and the Valley Elderberry Longhorn Beetle. The Aerojet Sacramento facility may be a habitat for the Burrowing Owl, a species of concern in California. Consultations between Department of Toxic Substances Control (DTSC) and Department of Fish and Game may be conducted if such species are affected by remedial actions.
Wetlands	40 CFR Part 6 Appendix A	Actions must be taken to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	Potentially applicable if any remedial action components are constructed in or otherwise affect wetland areas	Requires actions to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.
	Fish and Game Commission Wetlands Policy (adopted 1987) included in Fish and Game Code Addenda	Actions must be taken to ensure that "no net loss" of wetlands acreage or habitat value occurs. Actions must be taken to restore and enhance California's wetland acreage and habitat value.	TBC	This policy is not a regulatory program but may be considered a TBC criteria.
Areas affecting stream or river	Fish and Wildlife Coordination Act (16 USC 661 et seq.) and 40 CFR Part 6 §302	Restrictions on diversion, channeling or other activity that modifies a stream or river and affects fish or wildlife.	Potentially applicable to any remedial action components that may be constructed in or along a creek or river	Requires action to protect fish or wildlife.

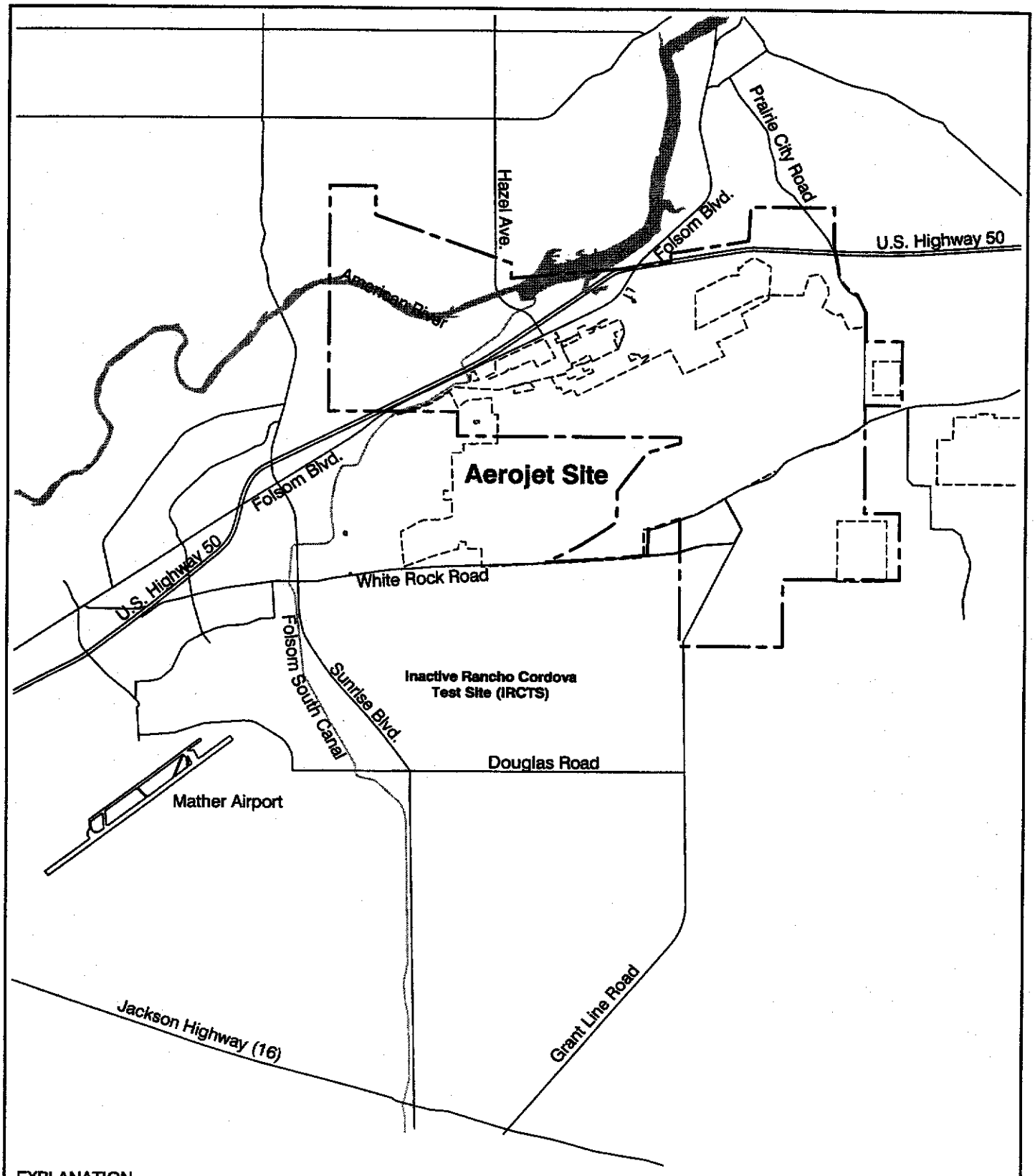
Table 3-4: Preliminary Potential Action-Specific ARARs

Action	Potential Requirement	Citation	Description	Potential ARAR Determination	Comments
Generation of waste from operation of a groundwater treatment plant	RCRA and State standards for identification and classification of hazardous wastes	40 CFR Part 261 and 22 CCR §66261	Establishes procedures and numeric limits for identification of characteristic hazardous wastes, listed hazardous wastes, and State-only (non-RCRA) hazardous wastes.	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the selected remedial action or operation of a groundwater treatment plant.
	RCRA Generator Standards – hazardous waste determination	40 CFR § 262.11 and 22 CCR §66262.11,	Requires waste generators to determine if wastes are hazardous wastes and establishes procedures for such determinations	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action or operation of a groundwater treatment plant.
Shipment of hazardous wastes for treatment or disposal offsite	RCRA Generator Standards – hazardous waste shipment	40 CFR § 262.30 – 33 and 22 CFR 66262.30 through 66262.33	Prior to transportation, containers should be packaged, labeled, marked, and placarded in accordance with RCRA and Dept of Transportation requirements.	Potentially applicable	These requirements are applicable if containers are used to contain hazardous waste to be sent for offsite treatment or disposal.
	RCRA Generator Standards – hazardous waste accumulation	40 CFR § 262.34 and 22 CCR §66262.34	Specifies maximum amounts and maximum periods for accumulation of hazardous waste onsite under generator status	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action and operation of any groundwater treatment plant if these waste materials are hazardous wastes.
Discharge to surface water and/or reinjection of groundwater	Basin Plan – beneficial uses, WQOs and policies and procedures	SWB Resolution 68-16 ("Anti-degradation policy")	Requires maintenance of existing water quality that is better than that required by other policies.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
		SWB Resolution Nos. 68-16 and 92-49	Allow for the use of mixing zones as part of a determination of whether water quality is being maintained in the receiving water.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.

Table 3-4: Preliminary Potential Action-Specific ARARs (cont.)

Action	Potential Requirement	Citation	Description	Potential ARAR Determination	Comments
	NPDES discharge requirements	40 CFR Parts 122 and 125 and 23 CCR 2235 et seq.	Establishes permit, treatment and monitoring requirements for discharges to surface water	Potentially applicable	This requirement is potentially applicable if the selected remedial action includes discharge of treated water to surface water.
Stormwater management	NPDES stormwater requirements	40 CFR Parts 122.26 23 CCR 2235 et seq.	Establishes permitting, monitoring, and pollutant control requirements for stormwater from industrial activities.	Potentially applicable	These requirements would be applicable if construction activities associated with the remedial action disturb an area of 5 acres.
Groundwater containment	Containment Zone (CZ) requirements	SWB Resolution No. 92-49 and related Containment Zone Application Requirements	Defines requirements to support use of a containment zone and for delineation and implementation of a containment zone for groundwater contamination.	Potential TBC	The SWB Resolution is potential TBC if the selected remedial action includes physical or hydraulic containment of contaminated groundwater. The Containment Zone Application Requirements are a TBC.
Groundwater extraction and treatment	Evaluation of alternatives for reuse of treated water	Basin Plan – wastewater reuse policy	Requires evaluation of potential water reuse options and identifies potential reuse options that should be considered prior to disposal of treated groundwater	Potential TBC	This policy is a potentialTBC for remedial actions that include disposal of treated groundwater. This requirement is being addressed through consideration of the various remedial alternatives including potential groundwater reuse options as part the FS evaluation.
Use of treated groundwater for domestic use	Criteria for domestic use of impacted groundwater	DHS Policy Guidance for Direct Domestic Use of Extremely Impaired Source	Sets forth DHS policy for approval of use of treated groundwater for domestic use	TBC	This policy establishes criteria related to use of treated groundwater for domestic supply and is a TBC criteria for remedial actions that include wellhead treatment or other direct use of treated groundwater.

Figures



EXPLANATION

- Aerojet Site
- Perimeter Groundwater Operable Unit Study Areas

N

Scale: 1" = 8000'

0 4000 8000

AEROJET
Environmental Remediation

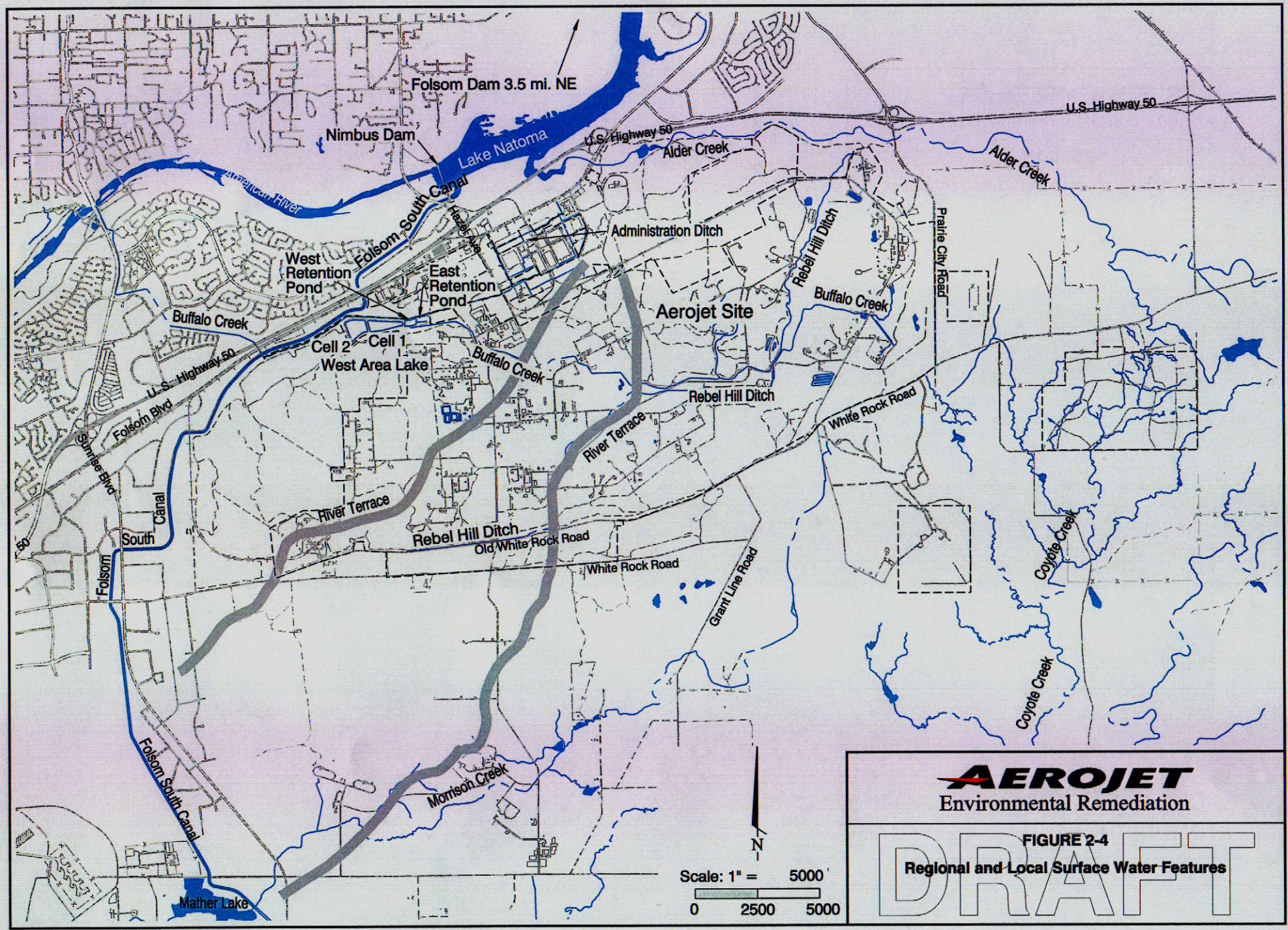
FIGURE 1-1
Perimeter Groundwater Operable Unit Site Vicinity Map

DRAFT

4/10/02 ah SR10111949

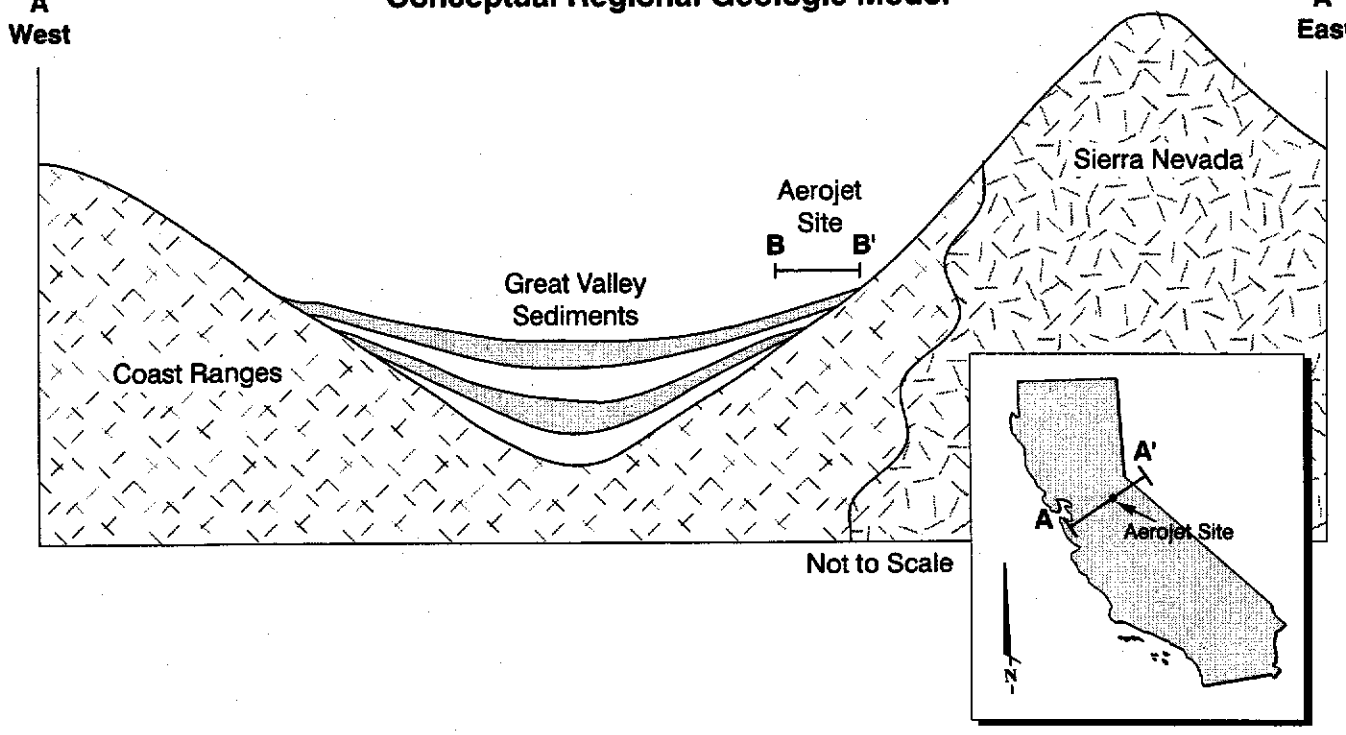
PAGES OF OVERSIZED MAPS

(SEE BINDER)

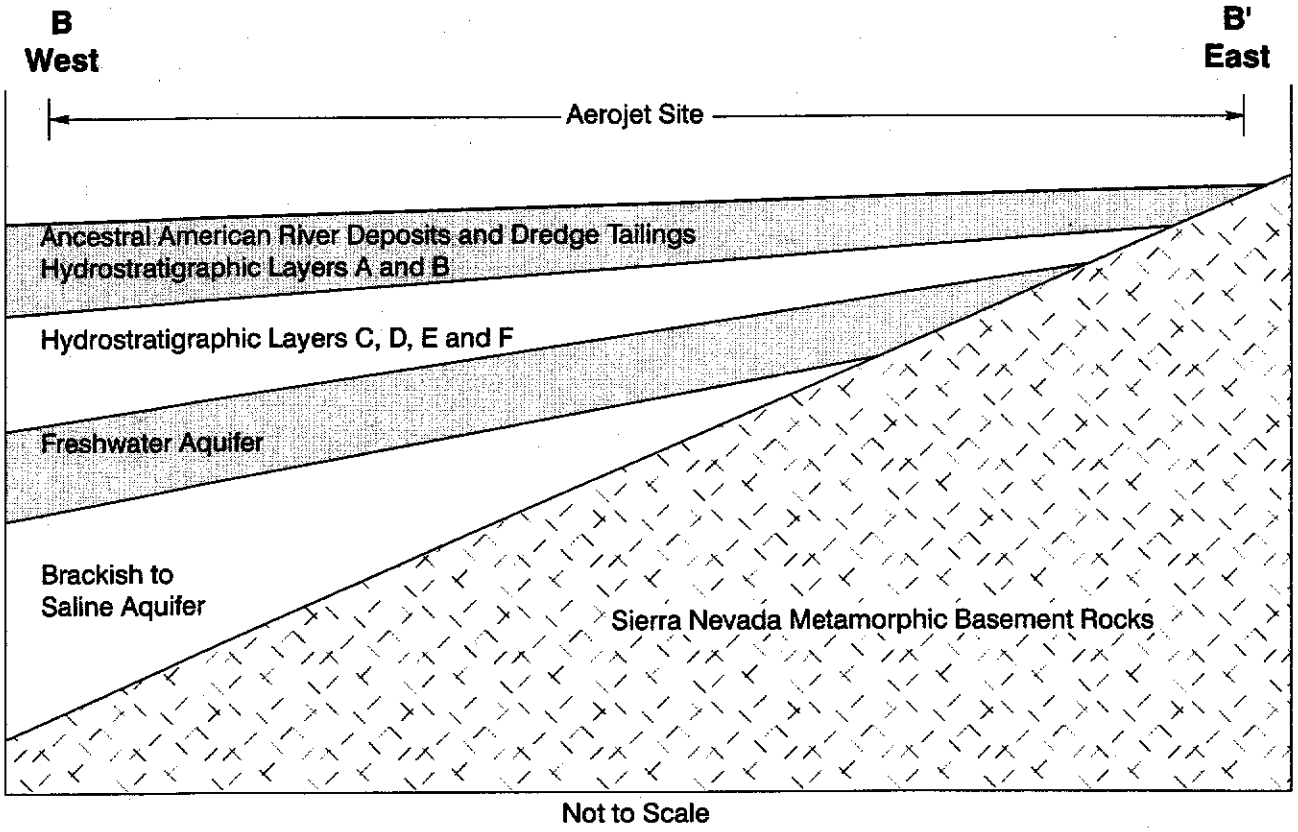


4/10/02 ah SR1011742

Conceptual Regional Geologic Model



Conceptual Regional Hydrogeologic Model



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Environmental Remediation

FIGURE 2-5
Conceptual Regional Geologic and Hydrogeologic Models

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PAGES OF OVERSIZED MAPS

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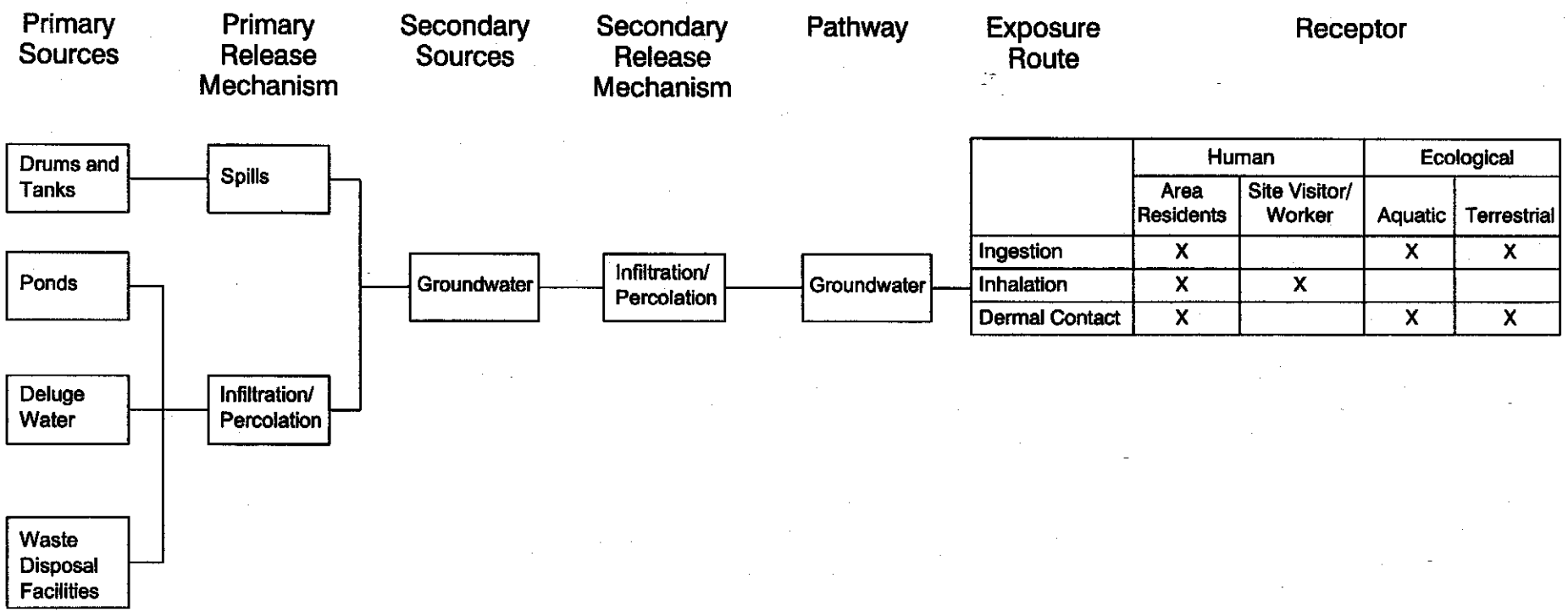

	Human		Ecological	
	Area Residents	Site Visitor/ Worker	Aquatic	Terrestrial
Ingestion	X		X	X
Inhalation	X	X		
Dermal Contact	X		X	X

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FIGURE 3-1
Preliminary Site Conceptual Model

4/10/02 ah SR10111942

PAGES OF OVERSIZED MAPS

(SEE BINDER)

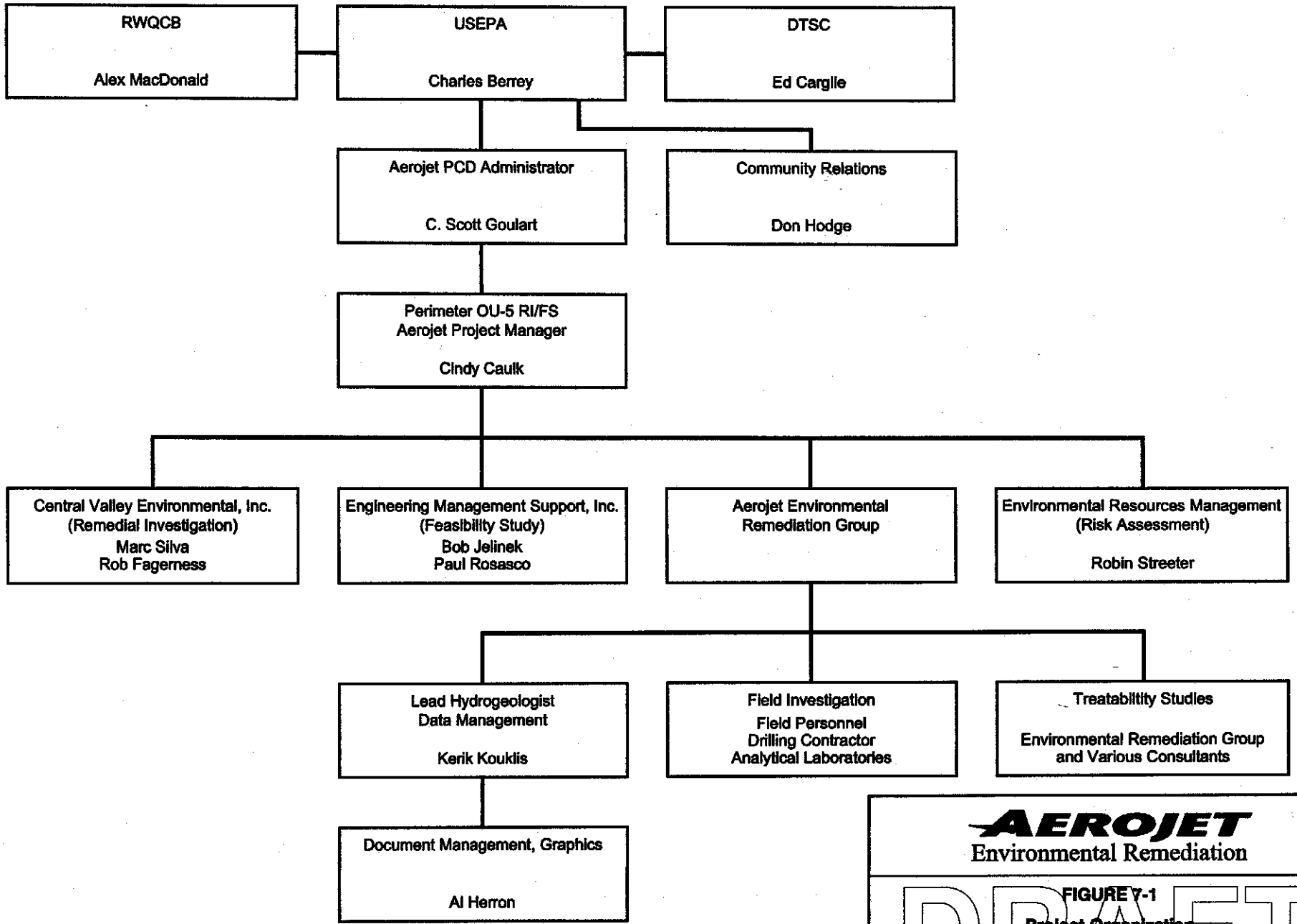

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FIGURE 7-1
Project Organization

4/4/02 ah SR10111943

APPENDIX A
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 1 STUDY AREA

AEROJET GENERAL SUPERFUND SITE SACRAMENTO, CALIFORNIA

Prepared for:

AEROJET
A GenCorp Company

Aerojet General Corporation
Sacramento, California

Prepared by:

CENTRAL VALLEY ENVIRONMENTAL, INC.

With assistance from:

Aerojet General Corporation
Environmental Remediation Department

April 16, 2002

APPENDIX A
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 1 STUDY AREA

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April 16, 2002

APPENDIX A
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LIST OF ACRONYMS

ACWS	Arden-Cordova Water Service
ARAR	Applicable or relevant and appropriate requirement
ARGET	American River groundwater extraction and treatment system
ARSA	American River Study Area
bgs	Below the ground surface
BRA	Baseline Risk Assessment
CDA	Central Disposal Area
CVEI	Central Valley Environmental, Inc.
DQO	Data Quality Objective
DCA	Dichloroethane
DCE	Dichloroethene
DNAPL	Dense non-aqueous phase liquid
EE/CA	Engineering Evaluation/Cost Analysis
EMSI	Engineering Management Support, Inc.
EPA	U.S. Environmental Protection Agency
Fair Oaks Water District	FOWD
Freon-113	1,1,2-trichloro-1,2,2-trifluoroethane
FS	Feasibility Study
ft	Foot
ft/day	foot per day
gpm	Gallons per minute
GET	Groundwater extraction and treatment
GMP	Groundwater Monitoring Plan
HVOCs	Halogenated volatile organic compounds
µg/L	Micrograms per liter
mg/l	Milligrams per liter
msl	Mean sea level
NPDES	National Pollutant Discharge Elimination System
NDMA	n-Nitrosodimethylamine
OU	Operable Unit
PCB	Poly-chlorinated biphenyls
PAHs	Poly-aromatic hydrocarbons
PNAs	Poly-nuclear aromatic
PCE	Tetrachloroethene
PGOU	Perimeter Groundwater Operable Unit
QAPP	Quality Assurance Project Plan
RL	Reporting Limit
RI	Remedial Investigation
RWQCB	Regional Water Quality Control Board
SCM	Site Conceptual Model
TBC	To-be-Considered Criteria
TCA	Trichloroethane
TCE	Trichloroethene
TIC	Tentatively Identified Compound
TPH	Total Petroleum Hydrocarbons
VOC	Volatile organic compound
WGOU	Western Groundwater Operable Unit
WQO	Water Quality Objectives

APPENDIX A
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 1 STUDY AREA

1.0 INTRODUCTION

This *Draft Data Assessment and Data Collection Activities Report* (Report) addresses the portion of Zone 1 that is located within the Perimeter Groundwater Operable Unit (PGOU). Zone 1 is located in the northeastern area of the Aerojet property, and is one of four zones (Zones 1 through 4) included in the PGOU Remedial Investigation/Feasibility Study (RI/FS)(Figure A-1). The Zone 1 Study Area (Study Area) includes Sector D and the groundwater extraction and treatment [(GET) D] facility on-site, and the American River Study Area (ARSA) and the American River GET (ARGET) off-site (Figure A-1).

This Report, combined with the *PGOU RI/FS Work Plan* (*Work Plan*), includes the elements identified in the "*United States Environmental Protection Agency (EPA) General Guidelines for Conducting an RI/FS*" (EPA, 1988). The *Work Plan* describes the common regional characteristics of the Zones, including the Work Plan Rationale, Data Quality Objectives (DQOs), Preliminary Site Conceptual Model (SCM), fate and transport, exposure pathways, and potential remedial alternatives [Engineering Management Support, Inc. (EMSI) et. al., 2002]. This Report describes the local characteristics of the Study Area including local physical characteristics, hydrogeology, remedial investigation background, and the distribution of chemicals in groundwater.

1.1 Objectives

The objectives of this Report are to assess available data and develop Data Collection Activities for the *Work Plan* to obtain the data necessary for completing the Zone 1 portion of the PGOU RI/FS. The Data Collection Activities were developed by comparing the available data with the data needed (Data Gaps) to complete the RI, FS, or Baseline Risk Assessment (BRA), following the EPA DQO Process (EPA, 1994). Each section of this report describes the data needs and how the data apply to the PGOU RI/FS. Identified Data Gaps are bulleted and their associated Data Collection Activities are numbered (e.g., Z1-1) and forwarded to the *Work Plan*.

1.2 Organization

The descriptions in this Report provide information to support the Data Collection Activities. The analytical data referenced in this Report are included on a CD-ROM. This Report is organized into the following sections:

Section 1: Introduction - Describes the location of the portion of Zone 1 in the PGOU and describes the Zone 1 Study Area. Introduces the objectives for this Report, and outlines the report organization.

Section 2: Physical Study Area Characteristics – Background summary of the physical characteristics in the Study Area that will be used to develop the SCM in the PGOU RI/FS.

Section 3: Local Hydrogeology - Discusses the Study Area stratigraphy, groundwater flow conditions, and identifies Data Gaps. Data Collection Activities are proposed to fill those Data Gaps that will support the RI, FS, and BRA.

Section 4: Remedial Investigation Background - Summarizes the previous investigations in the Study Area and describes the industrial practices, chemical use, handling, and disposal, at the upgradient source sites. This section also describes previous cleanup actions within the Study Area.

Section 5: Characterization of Chemicals in Groundwater - Describes the types and extents of chemicals detected in Study Area groundwater. Data Gaps are identified and Data Collection Activities are developed to obtain the data.

Section 6: Summary of Data Collection Activities - Summarizes the Data Collection Activities to be carried forward into the *Work Plan*.

Section 7: References - Lists references cited in this Report.

2.0 STUDY AREA PHYSICAL DESCRIPTION

The physical characteristics of the Study Area, including the size, topography, land use, groundwater use, and local surface water bodies are discussed in this Section. The regional descriptions were summarized from descriptions in the *Work Plan* (Sections 2 and 3). The following information will be incorporated into the SCM prepared during the PGOU RI/FS.

The portion of Zone 1 within the PGOU begins at the northern property boundary and extends west and southwest to the furthest extent of Site-related chemicals in groundwater (Figure A-1). A larger area, the Zone 1 Study Area (Study Area) was assessed to consider data collected upgradient of the PGOU. The Study Area includes Sector D located in the north-central portion of the Aerojet property, and the ARSA located off-site (Figure A-1). The northern property boundary divides Sector D and the ARSA, and is parallel to and just south of Folsom Boulevard. The length of the northern property boundary is approximately 11,000 feet. The Western Groundwater Operable Unit (WGOU) is located west of the PGOU boundary, and the Zone 4 Study Area is located east of the Zone 1 Study Area (Figure A-1).

Sector D encompasses approximately 2,100 acres, including Area 20, the 4600 Area (Area 46), the 4900 Area (Area 49), the Central Disposal Area (CDA), and portions of Lines 01 and 02 in northern Zone 2 (Figure A-1). The CDA and Area 46 are located 3,000 to 8,000 feet upgradient of the northwestern property boundary, and Areas 20 and 49 are located adjacent to the northern property boundary.

The ARSA extends from the northern property boundary to the north side of the American River (Figure A-1). The western ARSA boundary is approximately 5,000 feet in length and is approximately 2.2 miles downgradient of the northern property boundary. The WGOU is located west of the ARSA; Lake Natoma and the City of Fair Oaks are located east of the ARSA.

2.1 Land Use

The Aerojet property upgradient of the PGOU boundary is zoned for industrial use, and the industrial activities are described in Section 4.1. Most of the land surrounding the source sites is undeveloped and was not used for industrial operations. Unused buffer land surrounding Areas 20, 49, and the CDA was recently removed from the Sacramento Superfund Site boundaries following a Site Assessment approved by the over-sight Agencies.

The Aerojet property was designated as a "Special Planning Area" by Sacramento County Ordinance, Title V, Chapter 8, Article 3 of the Zoning Code of Sacramento County. This ordinance identifies existing permitted uses and "provides a regulatory mechanism for making land use decisions that maintain a safe environment in which the subject property can be used given the special requirements of the property owner".

Land use in the ARSA is mixed residential, commercial, industrial, and recreational. Residential areas are located south of the American River in the community of Gold River and north of the river in Fair Oaks. The Gold River area is zoned approximately 90 percent residential and 10 percent commercial. Potential sources of industrial chemicals are located just north of Highway 50 in the Gold River area and include a Former Sacramento County landfill and other industrial facilities nearby. Land used for recreation include the State and Federal lands of the American River, Nimbus Fish Hatcheries, and the Sacramento County Sailor Bar Park (Figure A-1). The southern limits of the City of Folsom extend to the northern property boundary, upgradient of the Study Area.

- Data Gap: Data are needed to assess the potential for future development in the Study Area.

Z1-1. Future growth predictions for eastern Sacramento and Western El Dorado County will be reviewed to assess future development plans in the area. Census data will be reviewed and compiled for the BRA. A figure will be prepared showing the current land uses in the developed areas, and showing the projected land uses in the developed areas (Table A-1).

2.2 Groundwater Use

Groundwater is not currently used in Sector D for domestic or industrial purposes, but groundwater is extracted and recharged at GET D. Future groundwater use in lands removed from the Superfund Site boundary is limited by environmental restrictions. The GET D extraction wells withdraw approximately 1,000 gallon per minute (gpm) of groundwater that is treated for VOCs and recharged into the aquifer southwest of GET D.

Groundwater in the ARSA is used for public and domestic water supply, irrigation and industrial water supply, and remediation. The water supply wells located within a one-mile radius of the PGOU are shown in the *Work Plan* on Figure 2-3. The Arden-Cordova Water Service (ACWS) provides water to the Gold River area through three water supply wells (Wells AC-21, -17, and -22A) located south of the American River (Figure 2-3, *Work Plan*). A fourth well (AC-22B) is being constructed adjacent to Well AC-22A, and three wells are located in the WGOU, just west of the PGOU (AC15, -16, and -20). The Fair Oaks Water District (FOWD) provides potable water to customers within the ARSA, however, the two municipal wells are located on the north side of the American River, just north of the PGOU boundaries.

Three private wells at Lake Natoma are used for irrigation and domestic water supply (Wells 1154, 1221, and 1084). Well 1156 supplies water to a pond in Sailor Bar County Park, and is equipped with an aqueous-phase carbon filtration system to remove volatile organic compounds (VOCs). There are several private wells on Folsom Boulevard that are no longer used including Well 1008 (County Fire Station), 1064 (Becks Furniture), and 1035 (Schnitzer Steel). The ARGET extraction wells withdraw approximately 2,000 gpm of groundwater that is treated and surface discharged to Buffalo Creek.

2.3 Topography

Sector D and the ARSA are located in the current and ancestral American River flood plain that is relatively flat and dips gently to the west. The flood plain is bounded on the north and southeast by the American River bluffs and ancestral American River terrace, respectively. These areas are 30 to 100 feet higher than the flood plain with cliff-faces that slope steeply towards the central Study Area. The elevation of the highest terrace is approximately 260 feet above mean sea level (ft msl). Surface elevations along the flood plain decrease from 160 to 120 ft msl from east to west.

2.4 Local Surface Water

Regional and local surface water bodies are discussed the *Work Plan* (Section 2.6, Figure 2-4). Local surface water in the Study Area includes the American River, Lake Natoma, the Folsom South Canal, Alder Creek, and the Area 20 Administration Ditches. Flows in the American River are controlled by Folsom Dam and to a lesser extent, Lake Natoma. The American River exits Lake Natoma above the Nimbus Fish Hatchery and meanders through the ARSA in a general southwest direction. The Folsom South Canal originates at Lake Natoma and conveys water to the southwest.

Storm-water runoff from the Study Area is collected by the Area 20 Administration Ditches and is directed to the Westlake Storm-water Retention Basins in Zone 2. The storm-water is sampled and discharged to Buffalo Creek (Zone 2) under an existing National Pollutant Discharge Elimination System (NPDES) permit. Treated groundwater from the ARGET is also discharged to Buffalo Creek under a separate NPDES permit and comprises the bulk of its flow. Alder Creek discharges into Lake Natoma near the northeastern boundary of the Study Area.

3.0 LOCAL HYDROGEOLOGY

The following sections discuss the general lithology and define the hydrostratigraphic layers beneath the Study Area, followed by a discussion of groundwater flow directions and hydraulic gradients. The data presented in this section will be used to prepare the chemical iso-concentration maps, analysis of fate and transport, and the GET D and ARGET effectiveness evaluations that will be conducted during the PGOU RI/FS.

The lithologic descriptions below are summarized from previous reports prepared for the Study Area. The groundwater flow discussions are based on recent measurements collected in April 2001. The following descriptions of the hydrostratigraphic layers are largely from the "*Aerojet Site – Part 2 GET Effectiveness Report, GET D Evaluation*", the "*Final Revised Engineering Evaluation/Cost Analysis (EE/CA) for the American River Study Area*", and the "*ARGET Effectiveness Evaluation Report*" (Aerojet, 1992, 1996, and 1999, respectively). The ARSA EE/CA identified hydrostratigraphic units labeled as the Upper, Middle, Lower, and Deeper aquifers. The GET D report labeled the same units as Layers A, B, C, and D, respectively. The GET D nomenclature was followed in this Report to describe the aquifer conditions in the Study Area. Monitor wells interior to the Aerojet property were recently assigned to hydrostratigraphic layers. The continuity of the layers has not been thoroughly investigated in Sector D, and some well layer assignments may be revised during the PGOU RI/FS.

3.1 Hydrostratigraphy

The sediments beneath the Study Area were divided into five hydrostratigraphic layers based on lithologic descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thickness. Layer A is the shallowest layer and is underlain by Layers B, C, D, and E. A sixth Layer, Layer F, is present in parts of the Study Area, but is not addressed because it is below the depths of contamination, and subsequently not investigated. The following sections describe the general lithology of Layers A through E, followed by a summary of the groundwater flow directions, hydraulic gradients, and pumping test data. There may be local variations to the descriptions provided below.

The general lithology and hydrostratigraphic layer boundaries are presented on five cross-sections originally presented in the GET D and ARSA Reports that were merged to create three transects through the Study Area (Figures A-2 to A-4). Cross-section A-A' trends northwest from Sector D through the ARSA, parallel to the direction of groundwater flow (Figure A-2). Cross-section B-B' trends in the same direction from the CDA to the northern property boundary (Figure A-3). Cross-section C-C' trends northeast/southwest, perpendicular to the direction of groundwater flow, along the northern property boundary (Figure A-4). These cross-sections will be updated for evaluation of the effectiveness of the GET D and ARGET extraction systems.

3.1.1 Layer A

Layer A is the upper-most water-bearing layer and consists of higher permeability sands and gravel with lenses of inter-bedded sediments of lower permeability. Layer A extends to depths of approximately 25 to 100 feet below ground surface (ft bgs)(Figures A-2, -3, and –4). Layer A is extensively dredged in the central portion of the Study Area, and is discontinuous, primarily in the Administration Area and the CDA (Figure A-4).

Although there is some hydraulic connection with the American River, the presence of chemicals in Layer A on the north side of the river, the configuration of the potentiometric surface indicates that the river is not a significant barrier to chemical migration or groundwater flow. Water level elevations are discussed relative to the American River in Section 3.2.1.

3.1.2 Layer B

Layer B is separated from Layer A by a relatively continuous aquitard ranging in thickness from approximately 10 to 55 feet, and consisting predominantly of silt and clay. The aquitard is less continuous in the Administration Area and the CDA (Figure A-3). In general, Layer B consists of sand, gravel, and silty sands and ranges from 10 to 100 ft in thickness. The top of Layer B generally dips to the west and occurs at depths of 70 to 100 ft bgs.

3.1.3 Layer C

Layer C is present throughout the Study Area and ranges in thickness from 10 to 130 feet. Layer C is separated from Layer B by an aquitard ranging in thickness from approximately 15 to 50 feet. In general, Layer C consists of sand, gravel, silty sand, and some partially cemented sand. However, Layer C also contains lower permeability units, which may account for up to two-thirds of its thickness locally. The top of Layer C generally dips to the west and occurs at depths of approximately 100 to 150 ft bgs (Figure A-3).

3.1.4 Layer D

The water-bearing zones below Layer C were previously grouped together as Layer D. The layers are now distinguished by an aquitard ranging in thickness from approximately 15 to 100 feet. In general, Layer D consists of loose and partially cemented sand, and some gravel inter-bedded with finer-grained sand, silt, and clay mixtures.

3.1.5 Layer E

There are seven monitor wells screened in Layer E in the ARSA, including relatively new Wells 30176 and 30179. There are three wells in Zone 2, one well in the Study Area, and one well just southwest of the Study Area screened in Layer E (Wells 56, 85, 3302 and 3303)(Figure A-9). Layer E is comprised of sandy clay materials, inter-bedded with quartz sand stringers. Lithologic data collected from Wells 30176 and 30179 have not been added to the existing cross-sections in the ARSA (Figure A-2).

- Data Gap: Data are needed to assess the continuity and structure of Layer E in the ARSA.

Z1-2. Lithologic data from newly installed Layer E Wells 30176 and 30179 will be added to existing cross-section A-A' (Table A-1).

3.2 Groundwater Flow

The following sections describe the groundwater flow directions and lateral hydraulic gradients in Layers A through E. The data presented in this section will be used during the PGOU RI/FS to for the following purposes:

1. Evaluate temporal and seasonal water level trends, and

2. Identify groundwater flow directions and calculate hydraulic gradients that will be used in part to estimate groundwater velocities, contaminant migration rates, and potential cleanup times.

- Data Gap: Historical and recent groundwater elevation data are needed to evaluate water-level trends.

Z1-3. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001 (Table A-1).

Potentiometric surface maps were created for each layer with water level data collected during the plant-wide monitor well sounding in April 2001 using Surfer® for Windows (Version 7)(Figures A-5, -6, -7, and –8, respectively). The contour lines were not changed from the Surfer® output except that some contours lines were trimmed near the border areas where the data did not support the extension of the contour lines. Suspected anomalous data from a few monitor wells are not included on the maps. The average water levels were used in cases where more than one well was screened in the layer, and the water levels from the GET D and ARGET extraction and recharge wells were not used to prepare the maps.

The potentiometric surface maps prepared for the Study Area show that the groundwater generally flows northwest in Layers A through D, although groundwater flow in Layers D and E flows slightly more to the west. There are local deviations in flow directions apparently associated with groundwater withdrawal and recharge at GET D and groundwater withdrawal at the ARGET. The average hydraulic gradient across the Study Area in Layers A through D was approximately 0.010 foot/foot (ft/ft) with the steepest gradients (0.013 to 0.02 ft/ft) observed near eastern upgradient and western downgradient boundaries. The shallowest gradients (0.004 to 0.009 ft/ft) were observed in the central portion of the Study Area, near the GET D extraction and recharge wells and the ARGET extraction wells. The effects of groundwater pumping are evident in Layers A through D in Areas 49 and 20, and in the ARSA.

3.2.1 Layer A

Groundwater elevations in Layer A ranged from 236 ft msl in the northeast to 32 ft msl in the southwest (Figure A-5). The contoured potentiometric surface for Layer A generally slopes to the west-northwest across the Study Area. Groundwater in the eastern upgradient Study Area flows west-northwest through Area 46, and then beneath the CDA. Groundwater from the western CDA flows west-northwest towards Area 49, and groundwater from the eastern CDA flows northwest towards Area 20. Groundwater in the ARSA generally flows northwest under the American River. The groundwater flow direction is to the southwest in the adjacent WGOU.

- Data Gap: Data are needed to interpret the groundwater flow direction between the southern ARSA and the WGOU.

Z1-4. The area of the potentiometric surface maps will be expanded to include data from monitor wells in the northeastern area of the WGOU (Table A-1).

Z1-5. A southwest-northeast trending cross-section extending into Layer E, will be constructed roughly parallel to Folsom Boulevard from Hazel Avenue to Sunrise Boulevard (Table A-1).

The hydraulic gradient in Layer A averages 0.010 ft/ft, with locally flatter gradients in Sector D and the ARSA (Figure A-5). The steepest gradient (0.02 ft/ft) was observed in Sector D between the CDA and Area 20, coincident with the ancestral river terrace. The gradient decreases to 0.005 ft/ft near the GET D extraction wells in Areas 20 and 49. The water level elevation in Well 3094 was 77 ft msl, which appears to be an errant measurement because the water level elevations are 40 to 50 feet higher in the surrounding wells (Figure A-5). The hydraulic gradient is relatively flat (i.e., 0.005 to 0.006 ft/ft) north and south of the American River near four ARGET extraction wells screened in Layer A.

The potential for groundwater discharge from Layer A to Lake Natoma and the American River was evaluated by comparing the elevations contours for Layer A with the elevations of Lake Natoma and the American River. The normal pool elevation of Lake Natoma is 126 ft msl (Figure A-5). Projecting the contour lines for Layer A to the north, the 120-foot contour line intersects Lake Natoma near the outfall of Alder Creek. Alder Creek is upgradient of the Study Area. The normal pool elevation for Lake Natoma is higher than the potentiometric surface elevation for Layer A in the Study Area, suggesting that Lake Natoma may recharge the groundwater.

In the ARSA, the American River ranges in elevation from approximately 75 ft msl near Hazel Avenue to approximately 60 ft msl at the western ARSA boundary (Figure A-5). The elevations of the potentiometric surface contours range from 76 to 33 ft msl over the same area. The potentiometric surface for Layer A is close to the elevation of the American River from Nimbus Dam to approximately 6,000 feet down-river. Further southwest, the American River elevation is above Layer A and there is a downward vertical potential from the American River to Layer A.

3.2.2 Layer B

Groundwater elevations in Layer B ranged from 217 ft msl in the southeast to 32 ft msl in the northwest (Figure A-6). The contoured potentiometric surface for Layer B is similar to Layer A. The groundwater flow direction in Layer B is west-northwest, with local variations caused by groundwater extraction and recharge at GET D and groundwater extraction in the ARSA. Groundwater from northern Line 02 and eastern Line 01 may also flow towards Area 49. In the ARSA, groundwater flows northwest. The ARGET extraction wells appear to have flattened the hydraulic gradient and altered local groundwater flow directions.

The hydraulic gradients in Layer B are similar to Layer A. The average hydraulic gradient across the Study Area is 0.009 ft/ft. The steepest gradient (0.019 ft/ft) was located between the CDA and Area 20 (Figure A-6). Groundwater extraction has reduced the gradient to approximately 0.004 ft/ft in Areas 20 and 49. In the ARSA, the hydraulic gradient ranges from 0.003 to 0.005 ft/ft, with the flattest gradient observed near the ARGET extraction wells.

3.2.3 Layer C

Groundwater elevations in Layer C ranged from 219 ft msl in the southeast to 27 ft msl in the northwest (Figure A-7). The contoured potentiometric surface for Layer C is similar to Layers A and B (Figures A-5, -6, and –7, respectively). The groundwater flow direction is northwest, with local deviations due to groundwater extraction in Areas 20, 49, and the ARSA. Groundwater flow in the northern ARSA is northwest, but may trend to the west south of the American River.

The average hydraulic gradient across the Study Area is 0.009 ft/ft, about the same as in Layers A and B. The steepest gradient in the Study Area was 0.02 ft/ft, between the CDA and Area 20. The gradients are relatively flat in Areas 20, 49 and the ARSA, ranging from 0.003 to 0.005 ft/ft.

3.2.4 Layer D

The groundwater elevation in Layer D ranges from 216 ft msl in the southeast to 21 ft msl in the northwest (Figure A-8). The groundwater flow direction in Layer D is slightly more to the west than in overlying Layers A, B, and C (Figures A-5, -6, and –7, respectively). Groundwater from the eastern Study Area flows west to northwest through Areas 20 and 49. Groundwater flow is almost due west from Sector D to the ARSA, but trends slightly west-northwest in the ARSA.

The average hydraulic gradient across the Study Area in Layer D is 0.010 ft/ft. The steepest gradients were located between the CDA and Areas 20 and 49. Relatively flatter hydraulic gradients (0.006 to 0.007 ft/ft) were observed in Area 49 and the ARSA. There are no extraction wells in Sector D, Layer D. Although, there are two new extraction wells on the north and south sides of the American River that are scheduled to be connected to the ARGET system in 2002.

3.2.5 Layer E

The water level elevations in Layer E ranged from 106 ft msl in the northeast to 21.7 ft msl downgradient in the southwest (Figure A-9). The direction of groundwater flow appears to be to the west. The hydraulic gradient is consistent across the Study Area, averaging approximately 0.006 ft/ft.

- Data Gap: Water level data from newly installed Layer E Wells 30176 and 30179 are needed to support the interpretations of groundwater flow directions and gradients in Layer E.

Z1-6. Water level elevation data from Wells 30176 and 30179 will be added to the Layer E potentiometric surface maps and contoured (Table A-1).

3.3 Potentiometric Surface Head Differences

Potential vertical gradients were assessed by evaluating the differences in the elevations of the potentiometric surfaces of the layers (head differences). Groundwater and contaminants may move upwards or downwards between layers if there are sufficient head differences and permeable sediments between the layers. The potentiometric surface elevation for Layer A is approximately 1 to 5 feet higher than the potentiometric surface elevation for Layer B, suggesting groundwater could migrate downwards into Layer B from Layer A. Groundwater could also migrate downwards from Layer B to Layer C. The potentiometric surface elevation for Layer B is two to three feet higher than Layer C in most areas, but is 5 to 15 feet higher around the extraction wells in Area 20 and the ARSA (Figures A-6 and A-7).

The head differences between Layers C and D vary across the Study Area. There is an upward potential gradient from Layer D to Layer C in the CDA, and there is a downward potential gradient from Layer C to Layer D in Areas 20 and 49. The potentiometric surface in Layer D is 1 to 2 feet lower than in Layer C suggesting a weak downward vertical gradient near the Nimbus Fish Hatchery south of the American River. Vertical gradients are upwards from Layer D to Layer C on the north side of the American River. The potentiometric surface elevations are about the same in Layers D and E, suggesting there is minimal to little potential for migration between these two layers.

3.4 Aquifer Test Data

Hydraulic properties of the aquifer including hydraulic conductivity, storativity, and transmissivity were calculated from data collected during aquifer testing. Data will be presented that will be used to identify aquifer hydrologic properties such as groundwater flow directions and hydraulic gradients, hydraulic conductivity, storativity, and transmissivity, to estimate groundwater velocity, contaminant migration rates, and potential cleanup times.

Table A-2 lists the range of transmissivities, storativities, and hydraulic conductivities calculated from aquifer testing on extraction and recharge wells completed in Layers A/B, B and C. The aquifer test data indicate that there are hydraulic conductivity differences within and between the layers. The highest hydraulic conductivities were observed in the Layer B extraction wells, and ranged from approximately 32 to 206 feet per day (ft/day)(Table A-2). The hydraulic conductivities calculated from two Layer C wells ranged from 26 to 40 ft/day, which is lower than the range of conductivities observed in Layer C at adjacent GET E (i.e., 63.5 to 145.6 ft/day)(Aerojet, 2001).

4.0 REMEDIAL INVESTIGATION BACKGROUND

The historical operations conducted at the source sites upgradient of the PGOU are summarized in this Section. The descriptions are largely from the *Aerojet Site - Stage 1 RI Report Zone 1*, and include new data where available (ICF Kaiser, 1993). This discussion identifies the historical activities, materials handled, waste type and handling, previous investigations, suspected source areas, previous cleanup actions, and the existing data available for the Study Area. This information supports the evaluation of the distribution of chemicals in groundwater and the SCM.

4.1 Historical Activities

Historical and recent operations in Sector D were conducted in Areas 20, 49, 46, and the CDA. Operations in these areas primarily supported the development, manufacturing, and testing of rocket motors and engines (ICF Kaiser, 1993). The following industrial activities were conducted in each area:

Area 20: Liquid rocket engine manufacturing; plating, pickling, and anodizing; sewage treatment; aluminum foundry; dye penetrating operations; steel cutting; radiographic facility; chemical drum storage; and administration and engineering offices.

Area 46: Solid rocket motor testing, rocket engine component testing, instrumentation, a machine shop, and vibration and structural testing.

Area 49: Chemical sampling, degreasing, bulk chemical storage, calibration and repair facilities, sand blasting, liner application, inert chamber processing, and non-destructive testing.

CDA: Inert solid waste, septage waste, radioactive waste, and tar disposal; chemical waste burning.

4.2 Materials Handled

Numerous chemicals were reportedly handled in Sector D, including solvents, fuels, oxidizers, oils, acids, metals, and other miscellaneous materials. The *Scoping* and *Stage 1 RI Reports* summarized the materials handled at each source site (ICF Kaiser, 1989 and 1993). The following list is not all-inclusive, but summarizes the primary materials historically handled in Sector D.

Solvents: PCE, TCE, 1,1,1-TCA, Freon-113, Freon-114, chloroform, ethanol, acetone, methylene chloride, methyl ethyl ketone, methyl isobutyl ketone, toluene, xylene, and methanol.

Fuels & Oxidizers: unsymmetrical dimethyl hydrazine, hydrazine, kerosene, diesel, ammonium perchlorate, beryllium propellant, strontium perchlorate, nitrogen oxide, lithium oxide, aluminum oxide, titanium oxide, antimony oxide.

Oils: fuel oil, hydraulic oil, PCB oil, cutting oil, lubricating oil, mineral oil, motor oil, vacuum oil, castor oil.

Metals:	aluminum, cadmium, copper, chromium, manganese, nickel, silver, beryllium, strontium, lead, mercury.
Acids:	sulfuric, nitric, phosphoric, boric, chromic, hydrochloric, acetic.
Miscellaneous:	toluene diisocyante, epoxy, paint, adhesives, dyes, alcohol, asbestos, caustics, plating and pickling solutions.

4.3 Waste Type and Handling

Waste management practices varied during historical operations. Liquid wastes were often directed to sumps, lined and unlined evaporation ponds, or chemical storage tanks. Solid waste propellants and other chemicals unsafe for off-site transport and disposal were burned in various areas, including the CDA in Sector D. Inert solid waste was typically land-filled on- or off-site. The majority of source sites in Sector D were associated with liquid disposal (e.g., evaporation ponds) or landfill activities.

4.4 Previous Investigations

The geologic and hydrologic conditions, distribution of chemicals in groundwater, and evaluation of source areas in the Study Area have been studied since the mid-1980's. The background information in the *Work Plan* and the most recent interpretations of geologic, hydrologic, and chemical conditions in the Study Area groundwater were presented in the following reports:

- ""*Scoping Report and Phase 1 RI/FS Workplan*": Identified and summarized history of potential source sites; evaluated chemical use and disposal; proposed analytical methods for sampling and analysis, including an analytical approach to evaluate non-standard chemicals for the Stage 1 RI/FS (ICF Technology, 1989).

- "*Aerojet Site - Stage 1 RI/FS Report – Zone 1*": Soil-gas, soil, and groundwater data collected from source sites, and results of site-wide groundwater screening (ICF Kaiser Engineers, 1993).

- "*GET D Effectiveness Evaluation Report*": Interpretation of geologic and hydrogeologic conditions in Sector D and evaluation of the effectiveness of the GET D remedial system. (Aerojet, 1992).

- "*Final Revised Engineering Cost Evaluation/Cost Analysis (EE/CA) for the ARSA*"- Evaluation of geologic and hydrogeologic conditions, chemical distribution, and remedial alternatives for the ARSA. Resulted in the selection of the ARGET pump and treat remedy for the ARSA (Aerojet, 1996).

- "*Technical Memorandum – Evaluation of Perchlorate and N-Nitrosodimethylamine (NDMA) in Groundwater – Aerojet Site – Zone 1 and Western Zone 2 Study Areas*" - Results of perchlorate and NDMA groundwater sampling conducted using newly lowered Reporting Limits (RLs) (Aerojet, 1998).

- "*Western Groundwater OU RI/FS*" – First RI/FS completed for western perimeter groundwater on-site and off-site west of Aerojet (Aerojet, 2001).

- *"Revised Phase 1 RI/FS Stage 2 Sampling Plan – Zone 1 – Tables and Maps"* - Work Plan approved by the Agencies defining soil and groundwater sampling for completing the vadose zone and shallow groundwater investigations at the source sites (Aerojet, 1999).

4.5 Suspected Source Areas

There are approximately 58 source sites in Sector D and no known Aerojet-related source sites in the ARSA (Figure A-1). The chemical concentrations detected at many of the source sites shown on Figure A-1 were low or non-detect. However, the chemical concentrations were elevated at other source sites that may be the primary contributors of chemicals to groundwater. VOC concentrations suggesting the potential presence of dense non-aqueous phase liquid (DNAPL) were reported in soil gas samples collected from the vadose zone at the following source sites (EPA, 1992; ICF Kaiser, 1993):

Potential Source Site	Suspected DNAPL	Management Area
3D/51D	TCE, PCE, Freon-113	Area 20
38D	TCE	Area 49
41D	TCE and Freon-113	CDA

With the exception of the CDA, the maximum concentrations of TCE, PCE, and Freon-113 in groundwater were lower than one percent of their respective solubility, a general guideline used to assess the presence of DNAPL in groundwater (Schwille, 1988).

Hydrocarbon fuel components were detected in Areas 20, 46, 49 and the CDA (e.g., TPH, oil and grease, PNAs/PAHs, dibenzofuran). PCBs were detected in soil samples collected from Areas 20, 46, and the CDA, and in one perched groundwater sample collected from Area 20 (ICF Kaiser, 1993). The characterization of PCBs was completed in all but one area (Site 11D –Area 20), where additional surface soil sampling is proposed (Aerojet, 1999). However, there are no Stage 2 or other recommendations to sample for PCBs in groundwater. Perchlorate was detected in soil and groundwater beneath the CDA and it appears to be a source of perchlorate in groundwater at the property boundary.

4.6 Previous Cleanup Actions

The two existing groundwater remedial systems in the Study Area are the GET D and ARGET systems. GET D was constructed in 1981 to limit the off-site migration of VOCs at the northern property boundary and to treat the VOCs in the extracted groundwater. In Area 49, there are 10 extraction wells in Layer A, 10 extraction wells screened in both Layers A and B, and one extraction well screened in Layer C. In Area 20, there is one extraction well screened in Layers A and B (4001), one extraction well screened in Layer B (4035), and three extraction wells screened in Layer C (4017, 4210, and 4220). The GET D treatment plant removes VOCs with an air-stripper. Effluent from GET D is recharged into six recharge wells which are variously screened in Layers B, C, and D at the west end of Area 49, southwest of the extraction wells. Perchlorate was recently detected in the effluent at approximately 200 µg/l. A pilot test is on-going to evaluate the feasibility of adding nutrients to biodegrade the perchlorate in the treated groundwater (Section 3.8.2.3 *Work Plan*).

In the ARSA, extraction wells are located north and south of the American River. There are 5 wells screened in Layer A, 5 wells screened in Layer B, 5 wells screened in Layer C, and two new wells screened in Layer D scheduled to be on-line on 2002. Additionally, four extraction wells (two in Layer A and two in Layer B) have been proposed south of the American River to capture perchlorate from the GET D recharge wells. Treatment of the water from these wells is anticipated to be conducted at the wellhead or at ARGET. The extracted groundwater for ARGET is piped to the Aerojet property to the ARGET treatment plant located west of Line 05. The treated water from the ARGET is discharged to Buffalo Creek via an NPDES permit.

Several shorter-term remedial efforts have been completed at source areas and for some groundwater in Sector D . A free-product recovery system was installed in Area 20 to remove diesel fuel downgradient of Sites 3D/52D in the early 1980's. Perchlorate and TCE in groundwater downgradient of the CDA were removed by one completed and one ongoing pilot test, that were conducted to evaluate enhanced intrinsic bioremediation (Section 3.8.2.3, *Work Plan*). A study of enhanced in-situ biodegradation was conducted for the vadose zone at Site 41D in the CDA to degrade TCE, 1,2-DCE, and vinyl chloride to ethene with the addition of a carbon source (Beak, 1996).

4.7 Existing Data Summary

The PGOU RI/FS for the Study Area will utilize historical, Stage 1 RI, and recent data collected from the early 1980's through 2001. The types of analytes and uses of the available data include:

Historical Data: Groundwater data collected from the early 1980s through 1991; this data will be used to assess chemical concentration trends. The data contain a range of analytical parameters including VOCs, NDMA, and perchlorate. NDMA and perchlorate were reported at their respective RLs of 0.10 and 400 µg/l, which are higher than the current RLs of 0.0075 and 4 µg/l, respectively.

Stage 1 RI Data: Soil and groundwater data collected from the source areas in 1991 through 1993. The Stage 1 RI data represent soil and groundwater conditions at source sites upgradient of the Study Area. The Stage 1 RI identified the type and extents of chemicals by analyzing soil and groundwater samples for a wide range of parameters. The sampling plan was developed based on historical operations, chemical use, handling and disposal. These data will be used as the basis for selecting analytical parameters for groundwater samples collected in the PGOU.

Recent Data: Recent groundwater data were collected from 1998 through the present. The recent data include the results of sampling in accordance with the Annual Groundwater Monitoring Plans (GMPs), and other miscellaneous sampling (Aerojet, 2001). These recent data are available:

Sector D:	VOC and perchlorate data from Study Area boundary monitor and extraction wells.
ARSA:	VOC, semi-volatile organic compound (SVOC), perchlorate, and limited NDMA data from monitor and extraction wells.
Public Water Supply Wells:	HVOC, perchlorate, and NDMA data are collected quarterly to monthly from water supply wells in the ARSA.

Groundwater samples were also periodically analyzed for other purposes, including samples collected to evaluate NDMA in the ARSA, and samples collected to evaluate tentatively identified compounds (TICs) at GET D and the ARSA. The GMPs prepared for the Study Area did not typically include analytical methods for non-VOCs that were detected infrequently.

5.0 CHARACTERIZATION OF CHEMICALS IN GROUNDWATER

The following sections present analysis with respect to identifying the types (Section 5.1) and extents (Section 5.2) of chemicals in groundwater. The information is presented to identify Data Gaps or show that sufficient data are available to achieve the following RI/FS objectives:

1. Identify the types of chemicals in groundwater.
2. Assess the extent of chemicals in the groundwater at concentrations identified by potential chemical-specific applicable or relevant and appropriate requirement (ARARs) or To-be-Considered Criteria (TBCs).
3. Assess chemical concentration trends in groundwater.
4. Evaluate fate and transport of chemicals in groundwater.
5. Identify other general water quality parameters that may affect in-situ or ex-situ treatment alternatives.

The first two objectives are assessed in Sections 5.1 and 5.2. Recent groundwater data are summarized and Data Gaps are identified. Chemicals are described as "defined" or "characterized" if the lateral and vertical extent was assessed to the RL. Differences between RLs and WQOs are discussed in the *Work Plan* (EMSI, 2002). Data Collection Activities are developed from the DQOs and are numbered and forwarded to the *Work Plan*.

The FS will assess changes in groundwater chemical concentrations during the effectiveness evaluation for GET D and ARGET.

- Data Gap: Historical and recent groundwater chemical data are needed to assess chemical concentrations over time.

Z1-7. During the PGOU RI/FS, historical and recent chemical concentrations will be plotted to assess chemical concentration trends.

The GET D and ARGET effectiveness evaluations will assess contaminant distribution, fate, and transport near the GET D and ARGET extraction wells.

- Data Gap: Data are needed regarding the lateral and vertical extents of chemicals near the extraction wells, to evaluate hydraulic and chemical capture of the GET D and ARGET remedial systems.

Z1-8. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

- Data Gap: Quality Control/Quality Assurance steps are needed to ensure the data are representative for the RI/FS figures and tables.

Z1-9. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

The fate and transport of chemicals in groundwater will be assessed using available physical, hydrologic, and chemical data. These data will be used to estimate groundwater velocities, chemical migration rates, potential extraction well locations, flow rates, and cleanup times. Chemical concentration data are available to support the treatability evaluation in the FS. Data for various water quality parameters (e.g., anions) are available to evaluate in-situ and ex-situ remedial alternatives. No other analytical data needs were identified for the FS, although data may be needed depending on the results of the RI.

The following sections present the rationale for the data collection activities that will be conducted to identify the type (Section 5.1) and to assess the lateral and vertical extent (Section 5.2) of chemicals in groundwater.

5.1 Types of Chemicals in Groundwater

The following section describes the available data, the Data Gaps, and the Data Collection Activities to assess the types of chemicals in the Study Area groundwater. The objective is to ensure that recent data are available for chemicals previously detected in groundwater. The analytical data collected during the Stage 1 RI were used as the basis for defining the types of chemicals previously detected in the Study Area (Table A-3). This data set was selected because samples collected during the Stage 1 RI were analyzed using greatest variety of analytical methods from the largest number of wells.

Data Collection Activities will be conducted for those chemicals detected in groundwater during the Stage 1 RI, but not analyzed recently. Metals will be assessed if they were reported above the reported site background levels in soil, and above current Regional Water Quality Control Board - Central Valley Region (RWQCB – CVR) Water Quality Objectives (WQOs). Metals will also be sampled if they were analyzed with an RL that was higher than the current WQOs.

VOCs, NDMA, perchlorate, and nitrate have been recently analyzed in the Study Area groundwater, and there are no data needed to identify these chemicals. In addition, the recent data are sufficient to identify SVOCs potentially present in the ARSA. However, groundwater in Sector D was not recently analyzed for several chemicals detected in groundwater during the Stage 1 RI.

TPH-diesel was historically detected in groundwater upgradient of the Study Area. TPH-diesel will be assessed by collecting and analyzing groundwater samples for aromatic VOCs (EPA Method 602) and SVOCs (EPA Method 8270). The target analyte lists for these analyses include the regulated components of TPH. The potential sources of TPH are located in Area 20, and further upgradient in the CDA and Area 46.

- Data Gap: Additional data are needed in Sector D to assess TPH-diesel detected in groundwater during the Stage 1 RI. The following Data Collection Activities will be conducted :

Z1-10. The GET D treatment plant influent will be sampled and analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX) using EPA Method 602 and for SVOCs using EPA Method 8270(Table A-1).

The TPH-diesel detected closer to the property boundary in Area 20 will be assessed as follows:

Z1-11. Groundwater samples will be collected from Layer A Wells 3094, 346, and 347 and analyzed for aromatic VOCs and SVOCs (EPA Methods 602 and 8270, respectively)(Table A-1).

1,4-Dioxane was previously detected in the Study Area groundwater but not in soil (Table A-3). Groundwater from the ARSA was sampled for SVOCs recently, including 1,4-dioxane, and there are sufficient data to confirm the presence of 1,4-dioxane. Most groundwater in Sector D was not recently sampled for SVOCs, and there are limited data to assess 1,4-dioxane.

- Data Gap: Data are needed to assess the presence of 1,4-dioxane in Sector D.

Z1-12. Samples of the GET D influent will be collected and analyzed for 1,4-dioxane (Table A-1). Samples of the GET D influent are appropriate as there are no known point sources of 1,4-dioxane in Sector D, and selecting monitor wells to sample could miss 1,4-dioxane, if it is present.

The following Data Collection Activities will be conducted to evaluate metals that were previously detected above the presumed Site background levels in shallow soils (Table A-3). Most of these metals were not detected in groundwater but were analyzed with RLs above the current WQOs.

Z1-13. Samples of the influent to the GET D treatment plant will be collected and analyzed for the following metals: arsenic , cadmium, chromium, lead, selenium, and thallium (Table A-1).

5.2 Lateral and Vertical Extent of Chemicals in Groundwater

The extent of chemicals recently detected in the Study Area groundwater is evaluated in this section. TCE, 1,2-DCE, and perchlorate were the most common and widely distributed compounds in groundwater, and their extents encompass the extents of all other chemicals. The following evaluation primarily discusses the extents of TCE, 1,2-DCE, and perchlorate since the remaining chemicals fall within those extents. Data are shown for the relatively commonly detected chemicals, Freon-113 and 1,4-dioxane, to show their distribution relative to TCE, 1,2-DCE, and perchlorate.

The shallowest groundwater (Layer A) is discussed first, followed by the deeper groundwater in Layers B, C, D, and E.

5.2.1 Layer A

Iso-concentration maps were prepared for TCE, 1,2-DCE, Freon-113, 1,4-dioxane, and perchlorate in Layer A (Figures A-10 to A-14, respectively). The analytical results for NDMA sampling in Layer A are posted on Figure A-15 as there weren't enough data to contour. TCE was the most common and widely distributed VOC in Layer A, and its extent encompasses 1,2-DCE, Freon-113, and all other VOCs in the Study Area (Figures A-10, -11, and –12, respectively).

In Sector D, the highest TCE concentrations were detected downgradient of the CDA (13,000 µg/l in Well 3456)(Figure A-10). TCE emanating from the CDA attenuates to less than 10 µg/l near the upgradient boundary of Area 20. TCE concentrations increase in underlying Layer B in the same area (Figure A-16). The lateral extent of TCE in Sector D is defined in the northeast by Well 3109 (>0.5 µg/l) and in the southwest by Well 270 (<0.5 µg/l). Groundwater southwest of Wells 270 and 3298 flows towards the WGOU and is not addressed in this Report. There are no additional Data Collection Activities to assess the extent of VOCs in Sector D in Layer A.

The highest TCE concentrations in the ARSA were detected near the Nimbus Fish Hatchery (up to 870 µg/l in Well 1469)(Figure A-10). The lateral extent of TCE is characterized to non-detect (<0.5 µg/l) in the ARSA, with the exception of the area west of Well 30143 (Figure A-10).

- Data Gap: Data are needed to assess the lateral and vertical extent of TCE downgradient of Well 30143.

The cross-sections and potentiometric surface maps prepared to assess the groundwater flow between the PGOU and WGOU should provide the needed data (Activity Numbers Z1-4 and Z1-5).

All wells in the ARSA were sampled routinely for SVOCs, and limited SVOC data were collected in Sector D (Figure A-13). 1,4-Dioxane, the only regularly detected SVOC, was detected in the ARSA near the Nimbus Fish Hatchery. The lateral extent of 1,4-dioxane was defined to the RL, and there are no data needed to assess its extent (Figure A-13). 1,4-Dioxane was not sampled recently in Sector D and will be assessed as described in Section 5.1 (Activity Number Z1-12).

The distribution of perchlorate in Sector D is similar to the distribution observed for TCE (Figures A-14 and A-10, respectively). The highest perchlorate concentration (34,000 µg/l in Well 3456) was detected in the CDA and attenuated to less than 10 µg/l east of Area 20 (Figure A-14). Perchlorate was detected in underlying Layer B in the same area (Figure A-20). The lateral extent of perchlorate in Sector D is defined to the north by Well 3109 (<4 µg/l). Perchlorate was not characterized to the RL near Westlake; however, groundwater in this area flows towards the WGOU. There are sufficient data to evaluate the lateral extent of perchlorate in Layer A in Sector D, and there are no additional Data Collection Activities.

The distribution of perchlorate in the ARSA is similar to TCE, except that perchlorate was not detected north of the American River (Figures A-14 and A-10, respectively). Perchlorate is defined to the RL (< 4µg/l) north of the river. South of the river, perchlorate was reported at 56 µg/l in Well 30143, the only well in the ARSA where NDMA was detected (0.021 µg/l).

- Data Gap: Data are needed to assess the western extents of NDMA and perchlorate near Well 30143.

The cross-sections and potentiometric surface maps prepared to assess the groundwater flow between the PGOU and WGOU should provide the needed data (Activity Numbers Z1-4 and Z1-5). There were no other Data Gaps identified and there are no additional Data Collection Activities for Layer A.

5.2.2 Layer B

Iso-concentration maps were prepared for TCE, 1,2-DCE, Freon-113, 1,4-dioxane, and perchlorate in Layer B (Figures A-16 to A-20). NDMA was not detected in Layer B and the wells sampled for NDMA are shown on Figure A-21. The lateral extent of TCE in Sector D is smaller in Layer B than in Layer A (Figures A-10 and A-16, respectively). North of the American River, TCE is distributed further west in Layer B than in Layer A. The maximum TCE concentration in Layer B was 2,500 µg/l (Wells 100 and 30101). The extents of 1,2-DCE and Freon-113 are within the extent of TCE in Sector D and the ARSA (Figures A-17, -18, and 16, respectively). The lateral extent of VOCs is characterized and there are no additional Data Collection Activities for VOCs in Layer B.

1,4-Dioxane was detected in the ARSA at concentrations up to 17 µg/l (Well 1405), near the Nimbus Fish Hatchery (Figure A-19). The lateral extent of 1,4-dioxane in the ARSA was characterized to the RL (10 µg/l), and there are additional Data Collection Activities for 1,4-dioxane in the ARSA. 1,4-Dioxane was not sampled recently in Sector D, and the GET D influent will be sampled as described in Section 5.1 (Activity Number Z1-12).

The perchlorate in Layer B is distributed from Area 20 in the northeast to the WGOU in the southwest (Figure A-20). Extraction well 4530 was recently installed near the western extent of perchlorate in Sector D for the WGOU (Figure A-20). In the ARSA, perchlorate was detected south of the American River at concentrations up to 200 µg/l

(Figure A-20). Perchlorate was not detected north of the American River. Perchlorate was also detected at 50 µg/l in Well 30144, near the WGOU.

- Data Gap: Data are needed to evaluate the extent of perchlorate west of Well 30144.

The cross-sections and potentiometric surface maps prepared to assess the groundwater flow between the PGOU and WGOU should provide the needed data (Activity Numbers Z1-4 and Z1-5).

NDMA was not detected (<0.0075 µg/l) in the Layer B monitor wells sampled in Sector D or the ARSA. There are no additional Data Collection Activities to assess the extent of NDMA at the current RLs.

5.2.3 Layer C

The chemicals detected in Layer C were the same as those detected in Layer A and B, although the concentrations were lower and the extents smaller. Iso-concentration maps were prepared for TCE, 1,2-DCE, Freon-113, 1,4-dioxane, and perchlorate (Figures A-22 to A-26, respectively). NDMA was not detected in Layer C, and the wells sampled for NDMA are shown on Figure A-27.

The lateral extent of TCE in Sector D is defined by Well 272 to the southwest and by Well 3111-2 in the northeast (Figure A-22). 1,2-DCE was detected in a few wells in Sector D, and Freon-113 was primarily detected downgradient of Area 20 (Figures A-23 and A-24, respectively). There are no additional Data Collection Activities to characterize the extent of VOCs in Sector D.

TCE, 1,2-DCE, and Freon-113 were detected north of the American River in the ARSA (Figures A-22, -23, and –24, respectively). The downgradient extent of VOCs is defined by Well 1593 (<0.5 µg/l) and no additional data are needed to characterize the lateral extent of VOCs north of the American River. TCE was defined to approximately 1 µg/l south of the American River (0.6 µg/l in Well 30145), and there are no additional Data Collection Activities to evaluate the extent of TCE in the ARSA.

The extent of 1,4-dioxane in the ARSA in Layer C is slightly larger than the extent in overlying Layer B (Figures A-19 and A-25, respectively). 1,4-Dioxane was not detected north of the American River, and no additional data are needed to assess the extent of 1,4-dioxane in the ARSA. Data collection to assess 1,4-dioxane in Sector D is discussed in Section 5.1 (Activity Number Z1-12).

Perchlorate was detected in Sector D and the ARSA, north and south of the American River (Figure A-26). The perchlorate in Sector D extends along the property boundary from the WGOU boundary to west of Area 20. The perchlorate near Westlake is addressed by the WGOU. The lateral extent of perchlorate near the Nimbus Fish Hatchery is defined to non-detect (<4 µg/l). Additional data are needed to assess the

perchlorate detected in Well 31045 and will be collected as discussed in Section 3.2.1 (Activity Numbers Z1-4 and Z1-5).

5.2.4 Layer D

The analytical results for TCE, 1,2-DCE, 1,4-dioxane, perchlorate, and NDMA in Layer D are shown on Figures A-28 to A-32, respectively. Neither 1,4-dioxane nor NDMA were detected in Layer D, and no additional data are needed to assess the extent of these chemicals (Figures A-30 and A-32, respectively). NDMA was detected southwest of Westlake and is addressed by the WGOU (Figure A-32).

TCE was detected up to 4.2 µg/l in Sector D and up to 780 µg/l in the ARSA (Figure A-28). The highest TCE concentration in Layer D was approximately ½ of the highest concentration in Layer C (1,600 µg/l). The lateral extent of TCE was defined to approximately one µg/l near wells 1408-9 and 1588-90 in the ARSA. There are no additional Data Collection Activities for characterizing the extent of VOCs in Layer D in the ARSA.

Perchlorate was detected (up to 190 µg/l) west of the GET D recharge wells. Groundwater in this area flow southwest towards extraction well 4535, recently constructed for the WGOU (Figure A-31). Further north, perchlorate was reported at 9.2 µg/l in Well 1402 in the ARSA but was not detected downgradient. There are no additional Data Collection Activities for characterizing the extent of perchlorate above the RL (4 µg/l).

5.2.5 Layer E

Limited sampling has been conducted in Layer E since few chemicals were detected in Layer D. There are no recent data in Sector D, and data are not needed since the chemicals in Layer D are characterized to relatively low concentrations (Section 5.2.4).

The Layer E wells in the ARSA were sampled for VOCs, SVOCs, and perchlorate. TCE was reported at concentrations ranging from non-detect (<0.5 µg/l) to 71 µg/l in a cluster of three wells located near the Fish Hatchery (Figure A-33). TCE was detected at 1.4 µg/l in Well 30176 and was not detected further downgradient in Well 30179. 1,2-DCE (5.9 µg/l) was reported in samples from Well 1471, the same well with the highest TCE concentration. Freon-113, 1,4-dioxane, and perchlorate were not detected in the ARSA. NDMA was analyzed in one monitor well (Well 30176) and one water supply well (Well 2066/AC-21) but was not reported (<0.0075 µg/l). There are no additional Data Collection Activities for Layer E.

5.2.6 Water Supply Wells

The water supply wells in the ARSA are sampled at varying frequencies based on the concentrations of chemicals present. Samples are collected quarterly from water supply well 2066/AC-21 and analyzed for halogenated volatile organic compounds (HVOCs), perchlorate, and NDMA. Well 2067/AC-22 is sampled monthly for HVOCs and quarterly for perchlorate (Aerojet, 2001). TCE (up to 0.51 µg/l) and chloroform (up to 0.61 µg/l) were detected in Well 2067 in March and May 2000. Subsequent samples did

not contain these chemicals above the reporting limit (0.5 µg/l). Perchlorate and NDMA were not reported above their respective analytical detection limits of 4 and 0.0075 µg/l. VOCs were not detected in the FOWD wells when sampled.

5.2.7 American River Sampling Results

Samples are collected for VOC analysis from various locations along the American River, including the Sunrise Bridge and near intake pumps for several water purveyors located south of the Study Area. VOCs have not been detected in the samples and there are no additional Data Collection Activities to assess the American River.

6.0 SUMMARY OF DATA COLLECTION ACTIVITIES

The Data Collection Activities described below were developed based on the Data Needs described in the preceding sections.

This Section and Table A-1 will be provided to the field and laboratory personnel for implementation. The standard operating procedures for sample collection, handling, and analyses will be followed as specified in the Site-wide Quality Assurance Project Plan (QAPP)(Aerojet, 2001). The Data Collection Activities for the Zone 1 Study Area include the following:

Z1-1. Future growth predictions for eastern Sacramento and western El Dorado County will be reviewed to assess future development plans in the area. Census data will be reviewed and compiled for the BRA. A figure will be prepared showing the current land uses in the developed areas, and showing the projected land uses in the developed areas.

Z1-2. Add lithologic data from newly installed Layer E Wells 30176 and 30179 to existing cross-section A-A'.

Z1-3. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepaed with data collected in October 2001.

Z1-4. The area covered by the potentiometric surface maps will be expanded south of Folsom and west of Sunrise Boulevards to combine data from the PGOU and the WGOU.

Z1-5. A southwest-trending cross-section, extending into Layer E, will be constructed roughly parallel to Folsom Boulevard, extending from Hazel Avenue to Sunrise Boulevard.

Z1-6. Water level elevation data from Wells 30176 and 30179 will be added to the Layer E potentiometric surface map.

Z1-7. Historical and recent chemical concentrations will be plotted to assess chemical concentration trends.

Z1-8. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

Z1-9. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

Z1-10. The GET D influent will be sampled and analyzed for TPH-related compounds using EPA Method 602 [benzene, toluene, ethylbenzene, and xylenes (BTEX)] and EPA Method 8270.

Z1-11. Groundwater samples will be collected and analyzed for aromatic VOCs and SVOCs (EPA Methods 602 and 8270, respectively), from Layer A monitoring Wells 3094, 346, and 347.

Z1-12. The GET D influent will be sampled and analyzed for 1,4-dioxane. Samples of the GET D influent are appropriate as there are no known point sources of 1,4-dioxane in Study Area, and selecting monitor wells to sample could miss 1,4-dioxane, if it is present.

Z1-13. The GET D influent will be sampled and analyzed for arsenic, cadmium, chromium, lead, selenium, and thallium. The analytical methods, RLs, and lowest WQOs for these metals are listed on Table A-1.

7.0 REFERENCES

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TABLE A-1: RI/FS Data Collection Activities - Zone 1 Study Area

PRELIMINARY DRAFT

Activity Number	Location	Data Collection Activity	Layer	Target Analytes	EPA Method	Reporting Limit (ppb) [1]	Lowest WQO (ppb) [2]	Number Samples	Rationale
Z1-1	ARSA	Future growth predictions for eastern Sacramento and Western El Dorado County will be reviewed.. Census data will be reviewed and compiled for the BRA. A figure will be prepared showing the current land uses in the developed areas, and showing the projected land uses in the developed areas.	NA	NA	NA	NA	NA	NA	Assess future development in the Study Area.
Z1-2	ARSA	Add Lithologic data from newly installed Layer E Wells 30176 and 30179 to existing cross-section A-A'.	E	NA	NA	NA	NA	NA	Assess continuity and structure of Layer E in the ARSA.
Z1-3	All	Compile historical and recent groundwater data to prepare hydrographs. Prepare new potentiometric surface maps with data collected in October 2001.	All	NA	NA	NA	NA	NA	Assess water level trends and potential for migration between layers.
Z1-4	ARSA	Combine data from PGOU and WGOU to increase the area covered by the potentiometric surface maps.	All	NA	NA	NA	NA	NA	Assess groundwater flow direction and hydraulic gradient between the PGOU and WGOU.
Z1-5	ARSA	Construct a southwest-trending cross-section roughly parallel to Folsom Boulevard, extending from Hazel Avenue to Sunrise Boulevard, and extendind into Layer E.	E	NA	NA	NA	NA	NA	Assess continuity and structure of layers between PGOU and WGOU.
Z1-6	ARSA	Add water level elevation data from Wells 30176 and 30179 to the Layer E potentiometric surface maps.	E	NA	NA	NA	NA	NA	Assess groundwater flow direction/gradient in Layer E.
Z1-7	All	Plot temporal chemical concentration trends.	All	NA	NA	NA	NA	NA	Assess chemical concentration trends and potential cleanup times.
Z1-8	All	Update all existing and proposed cross-sections with the most recent chemical and water level data.	All	NA	NA	NA	NA	NA	Assess vertical distribution of chemicals and evaluate effectiveness of GET facilities.
Z1-9	All	Finalize chemical iso-concentration maps and review data.	All	NA	NA	NA	NA	NA	Ensure the representativeness of all data for the RI/FS.
Z1-10	GET D	Sample influent to the GET D treatment plant.	Influent	Aromatic VOCs	602	0.5	0.14 [3]	1 [4]	Assess TPH detected in Areas 46, 49 and the CDA.
				PNAs/PAHs	8270	2	0.004 [3]		

TABLE A-1: RI/FS Data Collection Activities - Zone 1 Study Area

PRELIMINARY DRAFT

Activity Number	Location	Data Collection Activity	Layer	Target Analytes	EPA Method	Reporting Limit (ppb) [1]	Lowest WQO (ppb) [2]	Number Samples	Rationale
Z1-11	Area 20	Sample Wells 3094, 346, and 347.	A	Aromatic VOCs	602	0.5	0.14 [3]	1 [4]	Assess the presence of TPH related compounds reported in Area 20.
				SVOCs	8270	2	0.004 [3]		
Z1-12	GET D	Sample influent to the GET D treatment plant.	Influent	1,4-Dioxane	8270	10	NA	1 [4]	Assess 1,4-dioxane in GET D influent.
Z1-13	GET D	Sample influent to the GET D treatment plant.	Influent	Arsenic	7060	5	50	1 [4] [5]	Assess metals detected in shallow soils in Areas 20 and 49.
				Cadmium	213.2 Mod	1	0.07		
				Chromium	218.2 Mod.	1	2.5		
				Lead	239.2 Mod	3	2		
				Selenium	7740	5	50		
				Thallium	7841	5	0.1		

Notes:

(1) Reporting Limits are the lowest analytical reporting limit that the proposed method and analytical laboratory are capable of achieving.

(2) WQO - Water Quality Objective is the lower of the primary Federal or State maximum contaminant level (MCL) verses State Public Health Goal (PHG).

(3) Listed value is for benzene for aromatic hydrocarbons and benzo(a)pyrene for PNA/PAHs.

(4) Propose 1 sample to be collected. If target analyte is detected then resample within 30 days to confirm/verify initial result.

(5) All groundwater samples collected for metal analyses will be field filtered prior to laboratory submittal.

NA = Not Applicable

ARSA = American River Assessment Area

TABLE A-2: Summary of Aquifer Test Data - Zone 1 Study Area

PRELIMINARY DRAFT

Pumping Well	Date(s) of Test	Transmissivity (gpd/ft)	Storativity	Hydraulic Conductivity (ft/day)	Hydrostratigraphic Layer
Zone 1					
4017	Mar-88	12,000 - 56,000	$2.6 - 5.1 \times 10^{-4}$	12.1 - 40	C
4035	Mar-88	190,000 - 230,000	Not Calculated	143.5 - 183.0	B
4001	May-81 & Mar-88	42,000 - 240,000	$1.0 \times 10^{-4} - 3.0 \times 10^{-3}$	35.5 - 205.7	B
4210	Dec-88	4,273 - 15,757	$1.8 \text{ to } 4.6 \times 10^{-4}$	Not Calculated	C
4150	Jun-87	13,623	Not Calculated	Not Calculated	A/B
4155	Sep-87	13,000 - 19,000	49.7 - 81.9	49.7 - 81.9	A/B
4205	Apr-88	1,150 - 2,900	$2.2 \times 10^{-4} - 1.6 \times 10^{-3}$	1.8 - 4.4	A/B
5020	Feb-83	29,000 - 31,400	$1.1 \times 10^{-5} - 5.6 \times 10^{-4}$	38.7 - 51.9	B
5025	Mar-83	20,400 - 40,700	$1.9 - 2.2 \times 10^{-4}$	31.7 - 63.3	B
5030	Mar-83	44,700 - 87,300	$1.5 - 2.2 \times 10^{-4}$	34.2 - 153.6	B
5035 Upper	Mar-83	9,200	1.6×10^{-4}	34.2	B
5035 Lower	Mar-83	17,900	$2.0 - 2.7 \times 10^{-4}$	26.5	C
5040	Mar-83	231	2.0×10^{-4}	58.9 - 65.2	B
ARGET					
To be completed during RI/FS					

TABLE A-3: Summary of Chemicals Detected Stage 1 RI- Zone 1 Study Area

PRELIMINARY DRAFT

CLASS / Compound	Detected in Soil [1]	Potential Source Site(s) Detected [2]	Detected in Groundwater [3]	Hydrostratigraphic Layer Detected	Comments	Potential Study Area Analyte
AREAS 20/21						
SVOCs						
Di-n-butyl phthalate	No	Not applicable	Yes	C	Suspected laboratory contaminant [4]	No
Bis-2-ethylhexyl phthalate	No	Not applicable	Yes	Perched, A, B, C, D	Suspected laboratory contaminant [4]	No
1,2-diphenylhydrazine	No	Not applicable	Yes	A	Suspected laboratory misidentification [4]	No
1,4-dioxane	No	Not applicable	Yes	A, B[5], C[5], D[5]	Potential TCE impurity/stabilizer	Yes
PAHs/PNAs	Yes	50D, 3D/51D	Yes	A	Several different compounds detected	Yes
Dibenzofuran	Yes	3D/51D	Yes	A		Yes
NON-VOCs						
Perchlorate	No	Not applicable	Yes	A, B, C, D	Upgradient source(s)	Yes
NDMA	No	Not applicable	No[6]	Not applicable	Upgradient source(s)	Yes
PCBs	Yes	3D/51D	Yes	Perched	No Stage 2 groundwater sampling proposed	No
PCBs	Yes	11D	Not analyzed	Not applicable	No Stage 2 groundwater sampling proposed	No
PCBs	Yes	52D	No	Not applicable	No Stage 2 groundwater sampling proposed	No
TPH	Yes	3D/51D	Yes	Perched, A, B, C	Aromatic VOC/SVOC sampling?	Yes
TPH	Yes	50D	No	Not applicable		No
TPH	Yes	52D/BLDG. 20009	Yes	Perched	Aromatic VOC/SVOC sampling?	Yes
Oil & Grease	Yes	6D, 3D/51D	No	Not applicable	Replaced with TPH analysis	No
METALS						
Arsenic	Yes	5D, 6D, 7D, 11D, & FCS	No[7]	A	Metals reported above background in soils	Yes
Barium	Yes	3D	No	A	in the Zone 1 Stage 1 Report are based on	No
Beryllium	Yes	8D & D(c)	No	A	background concentrations evaluated	No
Cadmium	Yes	3D, 4D, 5D, 6D, 7D, 8D, 10D, 11D, 12D, & 52D	No[7]	A	before the Stage 1 RI was complete. The	Yes
Chromium	Yes	3D, 5D, 6D, 10D, 11D, & Bldg. 20009/52D	No[7]	A	Stage 1 metals data were not screened	Yes
Copper	Yes	3D, 4D, 5D, 6D, 7D, 8D, 11D, 52D, & FCS	No	A	against the most recent background metals	No
Lead	Yes	3D, 4D, 5D, 6D, 7D, 8D, 9D, 10D, 11D, 12D, 52D, & FCS	No[7]	A	survey completed after Stage 1 (Aerojet, 1994)	Yes
Mercury	Yes	3D, 4D, 5D, 6D, 7D, 8D, 9D, 10D, 11D, 12D, & 52D	No	A		No
Nickel	Yes	3D, 5D, 6D, 8D, 52D, & FCS	No	A		No
Selenium	Yes	5D & 8D	No[7]	A	Naturally occurring metal	No
Thallium	Yes	3D, 7D, 8D, & 10D	No[7]	A		Yes
Zinc	Yes	3D, 4D, 6D, 7D, 8D, 10D, 11D, 12D, 52D, & FCS	No	A		No

TABLE A-3: Summary of Chemicals Detected Stage 1 RI- Zone 1 Study Area

PRELIMINARY DRAFT

CLASS / Compound	Detected in Soil [1]	Potential Source Site(s) Detected [2]	Detected in Groundwater [3]	Hydrostratigraphic Layer Detected	Comments	Potential Study Area Analyte
AREA 49						
SVOCs						
Di-n-butyl phthalate	Yes	32D, 33D, 35D, 36D, 37D, 38D, & 39D	No	Not applicable	Suspected laboratory contaminant [4]	No
Bis-2-ethylhexyl phthalate	No	35D	Yes	Perched, A, B	Suspected laboratory contaminant [4]	No
1,4-dioxane	No	Not applicable	Yes	A, B[5], C[5], D[5]	Potential TCE impurity/stabilizer	Yes
PAHs/PNAs	No	Not applicable	Yes	Perched, A	Former Chevron Station upgradient	Yes
NON-VOCs						
Perchlorate	No	Not applicable	Yes	A, B, C, D, E	Potential upgradient source(s)	Yes
NDMA	No	Not applicable	No[6]	Not applicable	Potential upgradient source(s)	Yes
TPH	Yes	35D/upgradient source	Yes	A, B, C, D	Evaluate w/r to treatment	Yes
Oil & Grease	Yes	35D	No	Not applicable		No
METALS						
Cadmium	Yes	33D & 35D	No[7]	A		Yes
Lead	Yes	39D	No[7]	A		Yes
Mercury	Yes	36D & 37D	No	A		No
Selenium	Yes	35D & 39D	No[7]	A	Metal not used at Aerojet	No
Zinc	Yes	35D	No	A		No
CENTRAL DISPOSAL AREA						
SVOCs						
Di-n-butyl phthalate	Yes	40D, 41D, 42D, 43D, 44D, 45D, 46D, & 47D	No	Not applicable	Suspected laboratory contaminant [4]	No
Bis-2-ethylhexyl phthalate	No	Not applicable	Yes	A, B, C	Suspected laboratory contaminant [4]	No
1,2-Diphenylhydrazine	Yes	41D	Yes	A	Suspected laboratory misidentification[4]	No
1,4-dioxane	No	Not applicable	Yes	A	Potential TCE impurity/stabilizer	Yes
Non-VOCs						
Perchlorate	Yes	44D, 46D	Yes	A, B, C		Yes
NDMA	No	Not applicable	No[6]	Not applicable		Yes
PCBs	Yes	41D	No	Not applicable	Compound generally immobile in water	No
Dioxins	Yes	44D	No	Not applicable	Compound generally immobile in water	No
Furans	Yes	44D	No	Not applicable	Compound generally immobile in water	No
TPH	No	Not applicable	Yes	A, B	Potential upgradient source	Yes
PAHs/PNAs	No	Not applicable	Yes	A	Potential upgradient source	Yes
Metals						
Barium	Yes	45D	No	A		No
Cadmium	Yes	41D & 43D	No	A		No
Chromium	Yes	48D	No[7]	A		Yes
Copper	Yes	41D, 42D & 44D	No	A		No
Lead	Yes	41D, 42D, 43D, & 44D	No	A		No
Mercury	Yes	41D, 42D, 43D, 44D, 45D, 46D, 47D, & 48D	No	A		No
Nickel	Yes	40D, 46D, & 48D	No	A		No
Thallium	Yes	48D	No[7]	A		Yes
Zinc	Yes	40D, 41D, 42D, 43D, 44D, 45D, & 46D	No	A		No

TABLE A-3: Summary of Chemicals Detected Stage 1 RI- Zone 1 Study Area

PRELIMINARY DRAFT

CLASS / Compound	Detected in Soil [1]	Potential Source Site(s) Detected [2]	Detected in Groundwater [3]	Hydrostratigraphic Layer Detected	Comments	Potential Study Area Analyte
AREA 46						
SVOCs						
Bis-2-ethylhexyl phthalate	No	Not applicable	Yes	E	Suspected laboratory contaminant [4]	No
Non-VOCs						
Perchlorate	No	Not applicable	No	Yes		Yes
NDMA	No	Not applicable	No[6]	Yes		Yes
PCBs	Yes	20D	No	No	Compound generally immobile in water	No
TPH	Yes	20D, 27D, 28D, 30D, 1C, 2C, & D(h)	Yes	Perched, A		Yes
Metals						
Arsenic	Yes	13D	No[7]	A		Yes
Beryllium	Yes	15D	No	A		No
Cadmium	Yes	27D,	No	A		No
Lead	Yes	27D	No[7]	A		Yes
Mercury	Yes	13D, 14D/D(i), & 28D	No	A		No
Thallium	Yes	14D/D(i)	No[7]	A		Yes
Zinc	Yes	13D, D(h), & 27D	No	A		No

Notes:

1 Metals reported if above presumed site background levels, Borch, 1994.
2 Source: Stage 1 Report - Zone 1, ICF Kaiser Engineers, 1993.
3 Metals reported if above Primary MCLs or RWQCB Public Health Goals.
4 Aerojet, Special Contaminant Investigation, 1994.
5 Detected offsite in ARGET Study Area.
6 Method Detection Limit = 0.10 µg/l
7 Reporting limits above Primary MCLs and/or PHGs.

FCS Former Company Store
PAH Poly-aromatic hydrocarbon
PNA Poly-nucleaulic hydrocarbon
NDMA N-Nitrosodimthylamine
TIC Tentatively identified compound

PAGES OF OVERSIZED MAPS

(SEE BINDER)

APPENDIX B
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 2 STUDY AREA

AEROJET GENERAL SUPERFUND SITE SACRAMENTO, CALIFORNIA

Prepared for:

AEROJET
A GenCorp Company

Aerojet General Corporation
Sacramento, California

Prepared by:

CENTRAL VALLEY ENVIRONMENTAL, INC.

With assistance from:

Aerojet General Corporation
Environmental Remediation Department

April 16, 2002

APPENDIX B
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 2 STUDY AREA

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April 16, 2002

APPENDIX B
DATA ASSESSMENT
AND DATA COLLECTION ACTIVITIES REPORT
PERIMETER GROUNDWATER OPERABLE UNIT RI/FS
AEROJET SITE - ZONE 2 STUDY AREA

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LIST OF ACRONYMS

ARAR	Applicable or relevant and appropriate requirement
bgs	Below the ground surface
BRA	Baseline Risk Assessment
CAO	Cleanup and Abatement Order
DQO	Data Quality Objective
DNAPL	dense non-aqueous phase liquid
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
ft	Feet
ft/day	Feet per day
ft/ft	Foot per foot
GET	Groundwater extraction and treatment
GMP	Groundwater monitoring plan
IRCTS	Inactive Rancho Cordova Test Site
MDL	Method detection limit
µg/L	Micrograms per liter
mg/l	Milligrams per liter
msl	Mean sea level
NDMA	N-nitrosodimethylamine
PAHs	Poly-aromatic hydrocarbons
PNAs	Poly-nuclear aromatic
PGOU	Perimeter Groundwater Operable Unit
PQL	Practical Quantitation Limit
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RHD	Rebel Hill Ditch
RL	Reporting Limit
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RWQCB	Regional Water Quality Control Board, Central Valley Region
SCM	Site Conceptual Model
SVOCs	Semi-volatile organic compounds
TBC	To-Be-Considered criteria
TCA	Trichloroethane
TCE	Trichloroethene
TPH	Total Petroleum Hydrocarbons
VOC	Volatile organic compound
WGOU	Western Groundwater Operable Unit
WRND	White Rock North Dump
WRSD	White Rock South Dump
WQOs	Water Quality Objectives

APPENDIX B
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 2 STUDY AREA

1.0 INTRODUCTION

This *Draft Data Assessment and Data Collection Activities Report* (Report) addresses the portion of Zone 2 that is located within the Perimeter Groundwater Operable Unit (PGOU). Zone 2 is located in the southern area of the Aerojet property, and is one of four zones (Zones 1 through 4) included in the PGOU Remedial Investigation/Feasibility Study (RI/FS)(Figure B-1). The Zone 2 Study Area (Study Area) includes Sector G and areas upgradient of the Zone 2 portion of the PGOU (Section 2.1).

This Report, combined with the *PGOU RI/FS Work Plan* (*Work Plan*), include the elements identified in the "*United States Environmental Protection Agency (EPA) General Guidelines for Conducting an RI/FS*" (EPA, 1988). The *Work Plan* describes the common regional characteristics of the Zones, including the Work Plan Rationale, Data Quality Objectives (DQOs), Preliminary Site Conceptual Model (SCM), fate and transport, exposure pathways, and potential remedial alternatives [Engineering Management Support, Inc. (EMSI) et. al., 2002]. This Report describes the local characteristics of the Study Area including local physical characteristics, hydrogeology, remedial investigation background, and the distribution of chemicals in groundwater.

1.1 Objectives

The objectives of this Report are to assess available data and develop Data Collection Activities for the *Work Plan* to obtain the data necessary for completing the Zone 2 portion of the PGOU RI/FS. The Data Collection Activities were developed by comparing the available data with the data needed (Data Gaps) to complete the RI, FS, and Baseline Risk Assessment (BRA), following the EPA DQO Process (EPA, 1993). Each section of this report describes the data needs and how the data apply to the PGOU RI/FS. Identified Data Gaps are bulleted and their associated Data Collection Activities are numbered (e.g., Z2-1) and forwarded to the *Work Plan*.

1.2 Organization

The descriptions in this Report are intended to provide information to support the proposed Data Collection Activities. The analytical data referenced in this Report are included on a CD-ROM. This Report is organized into the following sections:

Section 1: Introduction - Describes the location of the portion of Zone 2 in the PGOU and describes the Zone Study Area. Introduces the objectives for this report and outlines the report organization.

Section 2: Physical Study Area Characteristics - Summarizes the physical characteristics of the Study Area that will be used to develop the SCM in the PGOU RI/FS.

Section 3: Local Hydrogeology - Discusses Study Area stratigraphy and groundwater flow conditions and identifies Data Gaps. Data Collection Activities are developed to obtain the data to complete the RI, FS, and BRA in the PGOU RI/FS.

Section 4: Remedial Investigation Background - Summarizes the previous investigations in the Study Area and describes the industrial practices, chemical use, handling, and disposal at the upgradient potential source sites. This section also describes previous cleanup actions within the Study Area.

Section 5: Characterization of Chemicals in Groundwater - Describes the types and extents of chemicals detected in Study Area groundwater. Data Gaps are identified and Data Collection Activities are developed to obtain the data.

Section 6: Summary of Data Collection Activities - Summarizes the Data Collection Activities forwarded to the *Work Plan*.

Section 7: References - Lists references cited in this Report

2.0 PHYSICAL STUDY AREA CHARACTERISTICS

This section provides background information regarding the physical characteristics in the Study Area, including the size, topography, land use, groundwater use, and local surface water bodies. The regional descriptions are summarized from the *Work Plan* (Sections 2 and 3). The following information will be incorporated into the SCM during the PGOU RI/FS.

The boundary of the Zone 2 portion of the PGOU is located along the southern property boundary and extends east from Nimbus Road to the eastern boundary of the White Rock North Dump (WRND)(Figure B-1). The PGOU boundary parallels the western and approximately one-half of the northern boundary of the WRND, to the Zone 3 Study Area. The PGOU boundary is approximately 2.3 miles in length.

A larger area, the Zone 2 Study Area (Study Area), was assessed to consider upgradient data. The Study Area includes Sector G and the Exhibit III Potential Source Sites (source site) in Eastern Line 04, and eastern Sector F and source sites in Central Line 04 (Figure B-1). The Study Area encompasses approximately 600 acres.

In accordance with Exhibit II, 11.(C) of the modified Partial Consent Decree, Zone 2 does not include the remaining plumes of chemicals in the groundwater at and beyond the Aerojet Site that are addressed by the remedial program for the Inactive Rancho Cordova Test Site (IRCTS) under the Department of Toxic Substances Control (DTSC) Order No. I&/SE 93/94-016 and Regional Water Quality Control Board, Central Valley Region (RWQCB) Cleanup and Abatement Order (CAO) No. 97-093.

2.1 Land Use

The Study Area is zoned for industrial use and was used for the activities described in Section 4.1. Most of the Study Area is undeveloped and was dredged. The industrial buildings are widely distributed and are generally located between Nevada Street and New York Road (Figure B-1).

The Aerojet property is designated as a "Special Planning Area" by Sacramento County Ordinance, Title V, Chapter 8, Article 3 of the Zoning Code of Sacramento County. This ordinance identifies existing permitted uses and "provides a regulatory mechanism for making land use decisions that maintain a safe environment in which the subject property can be used given the special requirements of the property owner".

Land south of White Rock Road is zoned for industrial use, is predominantly undeveloped, and is mostly dredged. Current land uses south of the Study Area include open-pit aggregate mining, cattle grazing, and industrial facilities. The inactive WRND and White Rock South Dump (WRSD) are located east and south of the Study Area, respectively (Figure B-1). The IRCTS is the former McDonnell-Douglas rocket manufacturing facility (subsequently purchased by The Boeing Company) located southwest of the Study Area.

2.2 Groundwater Use

Groundwater is not currently used on-site for either domestic or industrial purposes. Groundwater south of White Rock Road is used for limited domestic, industrial and agricultural purposes. There is one active and two inactive former domestic or industrial water supply wells south of White Rock Road (Wells 1029, 1054 and 1056)(Figure 2-3, *Work Plan*). Well 1029 was used for cattle watering, but is no longer connected to electricity and is not functional. Well 1054 provides water for cattle, and Well 1056 is solely used for groundwater monitoring.

2.3 Topography

The Study Area is located west of the ancestral American River Flood Plain and is relatively flat with a gentle dip to the west-southwest. The ground surface elevation decreases from approximately 320 feet above mean sea level (ft msl) in the east to approximately 200 ft msl in the west. The dredge tailings are the dominant surface feature in the Study Area. The dredge tailings are comprised of alternating rows of linear cobble windrows that are 10 to 20 feet higher than the clay/silt bottom (slickens). The eastern ancestral American River terrace is located in the western portion of the Study Area. This northeast-southwest trending scarp is approximately 20 to 40 feet higher in elevation on the east than in the west.

2.4 Local Surface Water

Regional and local surface water bodies are discussed in the *Work Plan* (Section 2.6, Figure 2-4). The only surface water within the Study Area is Rebel Hill Ditch (RHD)(Figure B-1). RHD is a man-made canal that originates near the southern portion of the Zone 4 Study Area, and conveyed water for the dredging. The ditch currently receives treated groundwater from the Groundwater Extraction and Treatment [(GET)A] and GET B remedial systems in the Zone 4 and 3 Study Areas, respectively. The treated groundwater flows into the Study Area and infiltrates RHD, but does not leave the Aerojet property.

3.0 LOCAL HYDROGEOLOGY

The following sections discuss the general lithology and define the hydrostratigraphic layers beneath the Study Area, followed by a discussion of groundwater flow directions and hydraulic gradients. The data presented in this section provides the basis for preparing the chemical iso-concentration maps, and the analysis of fate and transport that will be conducted during the PGOU RI/FS.

The following lithologic descriptions are from the "*Aerojet Site – Hydrogeologic Evaluation Update, Southeastern Zone 2*", (Aerojet, 1996). Some monitor wells in the interior of the Site were recently evaluated and assigned to hydrostratigraphic layers. Data needed to verify the continuity and structure of the layers, and the data collection activities that will be conducted during the PGOU RI/FS, are identified in the following sections.

3.1 Hydrostratigraphy

The sediments beneath the Study Area were divided into five hydrostratigraphic layers based on lithologic descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thickness. The following sections summarize the lithology and structure of the hydrostratigraphic layers. Layer A is the shallowest layer and is underlain by Layers B, C, D, and E. A sixth layer, Layer F, is present in parts of the Study Area but is not discussed because it is below the depths of contamination and has not been investigated in the Study Area. There may be local variations to the general descriptions provided below.

The general lithology and hydrostratigraphic layer boundaries were presented in six cross-sections in the *Hydrogeologic Update*. Two cross-sections were combined and a third cross-section was updated for this Report. Cross-section A-A' trends west-southwest, parallel to the direction of groundwater flow, and shows the hydrogeologic conditions along the plume axes (Figure B-2). Cross-section B-B' trends north-northwest and is approximately perpendicular to the groundwater flow direction in the western portion of the Study Area (Figure B-3). These cross-sections will be used in part, to aid in the evaluation of remedial alternatives.

3.1.1 Layer A

Layer A is present within the Study Area but is not continuous with Layer A identified at the WRND (EMSI, et. al., 2001). Layer A is predominantly coarse-grained and is composed of sand, gravel and cemented sand. Layer A has been disturbed by dredging throughout Study Area, and perched water is often present. The base of Layer A is encountered at depths ranging from approximately 185 ft msl in the east to approximately 80 ft msl in the west. Layer A ranges from 25 to 110 feet in thickness (Figures B-2 and B-3).

3.1.2 Layer B

Layer B is present in the western portion of the Study Area but is absent in the east (Figure B-2). Layer B is separated from Layer A by an aquitard that is predominantly clay and silt, with some sandy clay and sandy silt. The thickness of the A/B aquitard is between 5 to 55 feet. In the east, the A/B aquitard may have been removed by dredging or may be absent due to the eastward thinning of the sedimentary wedge (Aerojet, 1996). Layer B (where present) has a saturated thickness of 10 to 65 feet and is composed of cemented sand, sand, and gravel; although, lenses of silt and clay can comprise up to 40 percent of the overall thickness. Layer B is encountered at approximate depths of 60 to 130 feet bgs (Figure B-2).

3.1.3 Layer C

Layer C is present throughout the Study Area (Figures B-2 and B-3). Layer C is separated from Layer B by a 10- to 70-foot thick aquitard which is composed of predominantly clay, silt, siltstone, and claystone. Where Layer B is not present, the aquitard separates Layer C from Layer A (Figure B-2). Layer C is composed of sand and cemented sand, although lenses of silt and clay may comprise up to 70 percent of its 25- to 125-foot thickness. Layer C is encountered at an approximate depth of 95 feet bgs along the eastern portion of the PGOU to approximately 160 feet bgs near the western portion of the PGOU (Figure B-2).

3.1.4 Layer D

Layer D is present in the western portion of the Study Area but is absent in the east (Figures B-2 and B-3). Layer D (where present) is separated from Layer C by a 5- to 45-foot thick aquitard predominantly composed of clay, silt, siltstone, and claystone. The C/D aquitard does not extend to the northeastern portion of the Study Area and Layers C and D were previously combined (Layer C)(Figure B-2). Layer D is composed of sand and cemented sand, and lenses of silt and clay may comprise up to 60 percent of its overall 40- to 60-foot thickness. Layer D is encountered at depths ranging from approximately 225 to 250 ft bgs along the southern property boundary (Figure B-2).

3.1.5 Layer E

Layer E is present throughout the Study Area (Figures B-2 and B-3). Layer E is separated from Layer D (or Layer C where Layer D is absent) by a 5 to 50 foot thick aquitard composed predominantly of clay and claystone. Layer E is predominantly composed of sand, cemented sand, and gravel, although lenses of clay may comprise as much as 40 percent of its 50- to 100-foot thickness. Layer E is encountered at approximately 280 feet bgs in the east to 355 feet bgs southwest of the Study Area. The thickness of Layer E has not been identified in the Study Area (Figures B-2 and B-3).

3.2 Groundwater Flow

The following sections describe the groundwater flow directions and lateral hydraulic gradients in Layers A through E. The data presented in this section will be used during the PGOU RI/FS for the following purposes:

1. Evaluate temporal and seasonal water level trends, and

2. Assess groundwater flow directions and hydraulic gradients that will be used in part to estimate groundwater velocities, contaminant migration rates, and potential cleanup times.

- Data Gap: Historic and recent groundwater elevation data are needed to evaluate water-level trends.

Z2-1. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Potentiometric surface maps were created for each layer with water level data collected during the plant-wide monitor well sounding in April 2001 using Surfer® for Windows (Version 7) (Figures B-4 through B-8). The contour lines were not changed from the Surfer® output except that some contours lines were trimmed near the border areas where the data did not support the extension of the contour lines. Suspected anomalous data from a few monitor wells are not included on the maps. The average water levels were used in cases where more than one well was screened in the same layer.

The overall groundwater flow direction is generally to the southwest in Layers A through E; although, local variations are observed in several locations across the Study Area (Figures B-4 through B-8). The hydraulic gradient ranged from approximately 0.010 foot/foot (ft/ft) to 0.014 ft/ft. The following sections describe groundwater flow in each of the hydrostratigraphic layers.

3.2.1 Layer A

Layer A is saturated throughout the Study Area (Figure B-4). The groundwater elevations in Layer A ranged from approximately 230 ft msl in the eastern portion of the Study Area, to approximately 130 ft msl near the intersection Nimbus Road and the southern property boundary (Figure B-4). The overall direction of groundwater flow in Layer A is southwest with an approximate hydraulic gradient of 0.010 ft/ft. In the northern portion of the Study Area, groundwater flows in a westerly direction with an average hydraulic gradient of approximately 0.007 ft/ft.

3.2.2 Layer B

As mentioned in Section 3.1.2, Layer B is absent in the eastern portion of the Study Area and is present in the west (Figure B-5). The groundwater elevation in Layer B ranged from approximately 200 ft msl near Central Line 04 to approximately 130 ft msl near the intersection of Nimbus Road and the southern property boundary. An apparent groundwater mound is located near Wells 314 and 315. The historic water level data should be reviewed to assess whether the groundwater mound is real or an anomaly.

- Data Gap: Data are needed to assess the relatively high groundwater elevations in portions of Layer B near the southern property boundary.

Z2-2. Historic groundwater elevation data will be reviewed from Layer B, and the potentiometric surface maps will be updated accordingly.

The groundwater flow direction in Layer B is to the southwest, and the hydraulic gradient is approximately 0.014 ft/ft. The hydraulic gradient is steeper in the southeastern Study Area and is approximately 0.027 ft/ft. In the northern portion of the Study Area, groundwater flow is to the west with an hydraulic gradient of approximately 0.022 ft/ft.

3.2.3 Layer C

Layer C is present across the Study Area. Groundwater elevations in Layer C ranged from approximately 190 ft msl in the east to approximately 100 ft msl in the west (Figure B-6). The potentiometric surface for Layer C is similar to Layer B (Figure B-5). Groundwater flows west, southwest, and south away from the northeastern portion of the Study area. The hydraulic gradient averages approximately 0.014 ft/ft with local variations. Groundwater elevations were slightly higher than expected in Wells 3329 and 3341.

- Data Gap: Data are needed to assess the relatively high groundwater elevations in portions of Layer C near the southern property boundary.

Z2-3. Historic groundwater elevation data will be reviewed from Layer C and the potentiometric surface maps will be updated accordingly.

3.2.4 Layer D

As discussed in Section 3.1.4, Layer D is absent in the eastern Study Area. Where present, the groundwater elevation in Layer D decreased from approximately 190 ft msl in the east to approximately 90 ft msl in the west (Figure B-7). The area of relatively high groundwater elevations observed in Layer C was not observed in Layer D. The groundwater flow direction in Layer D is generally to the southwest with an hydraulic gradient of approximately 0.013 ft/ft.

3.2.5 Layer E

Groundwater elevations in Layer E ranged from approximately 195 feet msl in the east to approximately 90 ft msl in the west (Figure B-8). The groundwater flow direction in Layer E is similar to overlying Layers B, C, and D. Groundwater in Layer E flows southwest with an average hydraulic gradient of approximately 0.014 ft/ft.

3.3 Potentiometric Surface Head Differences

The relative differences in the elevations of the potentiometric surfaces between layers (head difference) can indicate the potential for vertical movement between layers. In general, the groundwater surface elevations suggest that downward groundwater head potential from Layers A through E within the Study Area. The potentiometric surface elevation of Layer A is from zero to 30 feet higher than the potentiometric surface elevation of Layer B suggesting the possible downward migration of groundwater. The potentiometric surface elevation for Layer B is 10 to 20 feet higher than the potentiometric surface elevation for Layer C. The differences in head potential from

Layers C to D and D to E are relatively small, and indicate a slightly downward vertical gradient.

3.4 Aquifer Test Data

Pump/aquifer test data were reviewed from five extraction wells and four recharge wells installed along the southern property boundary but never used. The ranges of transmissivity, storativity, and hydraulic conductivity are summarized on Table B-2. The hydraulic conductivities in the extraction and recharge wells that are screened in Layers B/C, C/D and D ranged from 4.8 to 29 feet per day (ft/day). The extraction wells screened in Layers A and A/B had lower hydraulic conductivities, ranging from less than one to 3.9 ft/day.

4.0 REMEDIAL INVESTIGATION BACKGROUND

The following sections summarize historical operations conducted at the source sites upgradient of the PGOU. The descriptions are largely from the *Stage 1 RI Report Zone 2*, and includes new data where available (ICF Kaiser, 1993). This discussion identifies the historical activities, materials handled, waste type and handling, previous investigations, suspected source areas, previous cleanup actions, and the existing data available for the Study Area. This information supports the evaluation of the distribution of chemicals in groundwater and the SCM.

4.1 Historical Activities

Historical and recent operations were conducted in Central and Eastern Line 04. These areas supported operations associated with the development and manufacturing of solid rocket motors. The industrial activities in Line 04 included fuel preparation, motor inert processing, oxidizer conditioning, propellant mixing, propellant removal operations (Minuteman Hogout) and thermal treatment.

4.2 Materials Handled

Numerous chemicals were reportedly handled in the Study Area including solvents, fuels, oxidizers, oils, metals, acids, and other miscellaneous materials. The *Scoping* and *Stage 1 RI Reports* summarized the materials handled at each source site (ICF Kaiser, 1989, 1993). The following list is not all inclusive, but summarizes the primary materials historically handled in the Study Area.

Solvents:	Trichloroethylene (TCE), 1,1,1-Trichloroethane (TCA), glycol, dichloromethane, and nonspecific solvents.
Fuels & Oxidizers:	Ammonium perchlorate, HMX, RDX, explosives, polyurethane fuels, polyurethane propellants, propellants, oxidizers, and nitroglycerine.
Petroleum & Oils:	Fuel oil and diesel fuel.
Metals:	Aluminum, ferric acetylacetonate, and lead-based paint.
Acids:	Formic acid, and monochloroaecetic acid.
Miscellaneous:	Carbon black, toluene diisocyante, epoxy, paint, adhesives, dioctyl azelate, irridite, developing solution, fixer solution, x-ray film, and silicone.

4.3 Waste Type and Handling

Waste management practices varied during historic operations. Liquid wastes were often directed to sumps, lined and unlined evaporation ponds, or chemical storage tanks. Solid waste propellants and other chemicals unsafe for off-site transport and disposal were burned in various areas, including Site 11G (thermal treatment area, Eastern Line 04). Inert solid waste was typically land-filled on- or off-site including the Aerojet Landfill (Zone 4). Burn residues from Area 41 were disposed at the G-9 Dump (Site 4G, Central Line 04). The majority of source sites in the Study Area are associated with liquid disposal, propellant hogout, and thermal treatment activities.

4.4 Previous Investigations

The geologic and hydrologic conditions, distribution of chemicals in groundwater, and evaluation of source areas in the Study Area have been studied since the mid-1980's. The background information for the RI/FS and the most recent interpretations of geologic, hydrologic, and chemical conditions in the Study Area groundwater were presented in the following reports:

- "*Scoping Report and Phase 1 RI/FS Workplan*": Identified and summarized existing history of potential source sites; evaluated chemical use and disposal; proposed analytical methods for sampling and analysis, including an analytical approach to evaluated non-standard chemicals for the Stage 1 RI/FS (ICF Technology, 1989).
- "Aerojet Site - *Stage 1 Report – Zone 2*": Results of soil-gas, soil, and groundwater samples collected from source sites in Zone 2 and results of site-wide groundwater screening (ICF Kaiser, 1993).
- "*Aerojet Site - Hydrogeologic Evaluation - Southeastern Zone 2*": Presents a hydrogeologic evaluation of the Study Area (Aerojet, 1994).
- "*Aerojet Site, Hydrogeologic Evaluation Update, Southeastern Zone 2*": Provides an update to the 1994 evaluation of hydrogeologic conditions in Southeastern Zone 2 (Kleinfelder, Inc., and Aerojet, 1996).
- "*Draft Groundwater Cleanup and Abatement Plan for the White Rock North Dump*": Summarized recent groundwater data associated with WRND and provided a remedial alternative selection for groundwater containment and restoration (EMSI et. al., 2001).
- "*Technical Memorandum – Evaluation of Perchlorate –Southeastern Zone 2*": Results of perchlorate groundwater sampling and groundwater potentiometric measurements used to evaluate the lateral and vertical extent of perchlorate in southeastern Zone 2 (Aerojet, 1997).
- "*Revised Phase 1, Stage 2 RI/FS Sampling Plan – Zone 2 - Tables and Maps*": Work plans to complete RI/FS activities at source areas. Recommended primarily for completing the characterization of non-volatile organic compounds detected in soil or groundwater during the Stage 1 RI/FS (Aerojet, 1999).

4.5 Suspected Source Areas

There are approximately 25 source sites in the Study Area (Figure B-1). TCE and perchlorate were the most common chemicals detected in the Study Area. Potential sources of TCE to groundwater include Sites 3G and 57F, where TCE concentrations suggested that dense non-aqueous phase liquid (DNAPL) may be present in the vadose zone (EPA, 1992)(ICF Kaiser, 1993). A former municipal waste dump referred to as White Rock #2A is a potential source of VOCs downgradient of Sites 8G/9G (ICF Kaiser 1993). The thermal treatment area (Site 11G)may also be a source of TCE.

Perchlorate was detected in soil samples at several source sites in the Study Area during the Stage 1 RI/FS (ICF Kaiser, 1993). The highest perchlorate concentrations in soil were detected at the Hogout (propellant removal) facility (Site 50F). Perchlorate was also detected in soil samples collected near a propellant mix station (Sites 8G/9G) and the thermal treatment area (Site 11G).

Metals concentrations exceeded the presumed Site background levels in soil at several source sites. HMX, an explosive, was detected in soil at Site G(a) in Eastern Line 04. Nitrate was detected above WQOs in groundwater near the Hogout area.

Remedial investigations are ongoing or completed at several sites located adjacent to or near the PGOU and the Aerojet property. These sites include the WRND, the IRCTS, the Western Groundwater Operable Unit (WGOU), and the WRSD (Figure B-1). Chemicals in groundwater beneath these sites are addressed under other regulatory programs and are not addressed in this Report.

4.6 Previous Cleanup Actions

There are no interim remedial actions in the Study Area. A pilot project to study the remediation of perchlorate by adding a carbon source to the groundwater and/or vadose zone was been proposed for the Hogout area, and implementation is expected soon.

4.7 Existing Data Summary

The PGOU RI/FS for the Study Area will utilize historic, Stage 1 RI, and recent data collected from the early 1980's through 2001. The types of analytes and uses of the available data include:

Historical Data: Groundwater data collected from the early 1980s through 1991; this data will be used to assess chemical concentration trends. The data contain a range of analytical parameters but are primarily for VOC and perchlorate. Perchlorate data are reported at the Reporting Limit (RL) of 400 µg/l, which is higher than the current RL of 4 µg/l.

Stage 1 RI Data: Soil and groundwater data collected from the source areas in 1991 through 1993. The Stage 1 RI identified the type and extents of chemicals by collecting soil and groundwater samples for a wide range of analytical parameters. The sampling plan was developed based on historic operations, chemical use, handling and disposal. The Stage 1 RI data represent the soil and groundwater conditions at the source sites upgradient of the Study Area. These data will be used as the basis for selecting analytical parameters for groundwater samples collected in the PGOU.

Recent Data: Recent groundwater data were collected from 1998 through the present. The recent data include the results of sampling in accordance with the *Annual Groundwater Monitoring Plans* (GMPs), and other miscellaneous sampling (Aerojet, 2001). Data collection in the Study Area primarily addressed VOCs and perchlorate. Groundwater samples were also periodically analyzed for nitrate, metals, semi-volatile organic compounds (SVOCs), and n-nitrosodimethylamine (NDMA).

5.0 CHARACTERIZATION OF CHEMICALS IN GROUNDWATER

The following sections present analysis with respect to identifying the types (Section 5.1) and extents (Section 5.2) of chemicals in groundwater. The information is presented to identify Data Gaps or show that sufficient data are available to achieve the following RI/FS objectives:

1. Identify the types of chemicals in groundwater.
2. Assess the extent of chemicals in the groundwater at concentrations identified by potential chemical-specific applicable or relevant and appropriate requirement (ARARs) or To-be-Considered Criteria (TBCs).
3. Assess chemical concentration trends in groundwater.
4. Evaluate fate and transport of chemicals in groundwater.
5. Identify other general water quality parameters that may affect in-situ or ex-situ treatment alternatives.

The first two objectives are assessed in Sections 5.1 and 5.2. Recent groundwater data are summarized and Data Gaps are identified. Chemicals are described as "defined" or "characterized" if the lateral and vertical extent was assessed to the RL. Differences between RLs and WQOs are discussed in the *Work Plan* (EMSI, 2002). Data Collection Activities are developed from the DQOs and are numbered and forwarded to the *Work Plan*.

The FS will evaluate chemical concentration trends as part of the assessment of chemical fate and transport.

- Data Gap: Historical and recent groundwater chemical data are needed to assess chemical concentrations over time.

Z2-4. Temporal chemical concentration data will be plotted and evaluated.

The FS will evaluate potential remedial alternatives for the Study Area near the southern property boundary.

- Data Gap: Data are needed to evaluate the lateral and vertical extents of chemicals along the southern property boundary.

Z2-5. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

- Data Gap: Quality Assurance /Quality Control (QA/QC) steps are needed to ensure the data are representative for the RI/FS figures and tables.

Z2-6. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

The fate and transport of chemicals in groundwater will be assessed using available physical, hydrologic, and chemical data. These data will be used to estimate groundwater velocities, chemical migration rates, and remedial alternatives for the Study Area. There are sufficient chemical data available to support the evaluation of remedial alternatives in the FS. Data for most other water quality parameters (e.g., anions) are available to evaluate in-situ and ex-situ remedial alternatives.

5.1 Types of Chemicals in Groundwater

The following section describes the available data, the Data Gaps, and the Data Collection Activities to assess the types of chemicals in the Study Area groundwater. The objective is to ensure that recent data are available for chemicals previously detected in the Study Area. The Stage 1 RI data were used as the basis for identifying the types of chemicals previously detected in the Study Area. This data includes the most comprehensive suite of analytical parameters sampled in the Study Area.

Data Collection Activities will be conducted for those chemicals detected in groundwater during the Stage 1 RI, but not analyzed recently. Metals will be sampled if they were reported above the reported site background levels in soil, and they were reported above current WQOs in groundwater. Metals will also be sampled if they were analyzed during the Stage 1 RI or recently with a RL above the current WQO.

5.1.1 Central Line 04

Metals were detected in soil and groundwater in Central Line 04 during the Stage 1 RI. Cadmium, lead and thallium were reported in soil samples above the presumed background levels at Sites 44F/53F, 8G/9G, and the G9 Dump (Site 4G)(Table B-3). Hexavalent chromium (chromium^{+6}) was detected in groundwater collected from Well 410. The RLs for antimony, beryllium, lead and mercury exceeded the current WQOs during the Stage 1 RI. Groundwater samples have not been analyzed for metals recently.

- Data Gap: Data are needed to assess the Stage 1 detects, or analyses conducted with RLs above the WQOs, for antimony, beryllium, cadmium, chromium^{+6}, lead, mercury, and thallium.

Z2-7. Wells 410, 415, and 3119 will be sampled for the metals listed on Table B-1.

5.1.2 Eastern Line 04

Nitrate was detected in shallow groundwater during the Stage 1 RI near the Hogout facility at Sites 50F and 51F (Figure B-1). Recent groundwater samples were not analyzed for nitrate.

- Data Gap: Data are needed to assess nitrate in Layers A through D in Eastern Line 04.

Z2-8. Wells 50, 411, 415, 3076-8, 3357-8, 3381 and 3392 will be sampled for nitrate (Table B-1).

Metals (arsenic, cadmium, lead, and mercury) were reported above the presumed background levels in shallow soil samples collected from Sites 2G, 3G, and 11G. Additionally, chromium^{+6} was detected in a groundwater sample collected from Well 413, downgradient of Site 11G. These metals were not detected during the Stage 1 RI; however, the RLs exceed current WQOs and no recent groundwater samples were collected.

- Data Gap: Data are needed to assess arsenic, cadmium, chromium^{+6}, lead, and mercury downgradient of potential source sites.

Z2-9. Wells 413 and 412 will be sampled for the metals listed on Table B-1.

HMX was reported in the soil at Site G(a) in Eastern Line 04 but was not sampled in groundwater.

- Data Gap: Data are needed to evaluate the presence of HMX in shallow groundwater downgradient of a suspected source site.

Z2-10. Well 412 will be sampled for HMX (Table B-1).

5.1.3 Miscellaneous Chemicals

NDMA was not analyzed in the Study Area during the Stage 1 RI because there were no suspected sources of NDMA. Some monitor wells were sampled recently to assess NDMA with a lower RL than used during the Stage 1 RI (0.0075 vs 0.10 µg/l). In addition, treated groundwater from the GET B treatment plant in Zone 3 is currently discharged to RHD that flows through the Study Area where it infiltrates.

NDMA was recently detected in Well 84 (0.18 µg/l), located near RHD, but was not detected (0.0075 µg/l) in sidegradient Well 413. NDMA was not detected (<0.0075 µg/l) in recent groundwater samples collected from Wells 50, 52, and 416. These data are sufficient to assess NDMA and there are no additional Data Collection Activities for NDMA.

5.2 Lateral and Vertical Extent of Chemicals in Groundwater

The extent of chemicals recently detected in the Study Area groundwater is evaluated in this section. TCE and perchlorate were the most common and widely distributed compounds in groundwater, and their extents encompass the extents of all other chemicals. The following evaluation primarily discusses the extents of TCE and perchlorate as representative of the "worst-case" extents for the remaining chemicals.

The shallowest groundwater (Layer A) is discussed first, followed by the deeper groundwater in Layers B, C, D, and E.

5.2.1 Layer A

Iso-concentration maps were prepared for TCE and perchlorate in Layer A (Figures B-9 and B-10, respectively). TCE was sampled at a few Layer A wells, primarily located

near the property boundaries. The maximum TCE groundwater concentrations of were detected just above the primary Maximum Contaminant Level (MCL) of 5 µg/l. TCE was detected a 6 µg/l in Well 3067 and at 7.2 µg/l in Well 3579 (Figure B-9). Samples were not analyzed for TCE from monitor wells located near the source sites where the highest concentrations were historically detected. Additional data are needed to evaluate the extent of TCE at the southern property boundary and will be collected as discussed below.

Perchlorate is distributed over a wider area in Layer A than TCE (Figures B-9 and -10). Perchlorate appears to originate in eastern Line 04 and in Line 01 (Figure B-10). The 4 µg/l contour was drawn surrounding these two areas because there are insufficient data to delineate the plumes. In addition, the southern extent of the perchlorate at the southern property boundary is uncertain.

- Data Gap: Additional data are needed to assess the downgradient extent of perchlorate and TCE at the southern property boundary.

Z2-11. Wells 3460 and 3500-1 will be sampled for VOCs and perchlorate (Table B-1).

A Resource Conservation and Recovery Act (RCRA) closure was recently conducted at Site 11G in eastern Line 04. Perchlorate data were collected during the closure, but were unavailable at the time this Report was written.

- Data Gap: Perchlorate data collected during the RCRA closure at Site 11G are needed to assess potential groundwater impacts.

Z2-12. Perchlorate data collected during the RCRA closure will be included in the PGOU RI/FS (Table B-1).

5.2.2 Layer B

Iso-concentration maps were prepared for TCE and perchlorate in Layer B (Figures B-11 and B-12). TCE and perchlorate are distributed over a similar area in Layer B. Both chemicals are present in southwest trending plumes that appear to originate downgradient of the Hogout Facilities (Sites 50F and 51F). The highest detected TCE concentration was 3,700 µg/l, and the highest perchlorate concentration was 4,500 µg/l, both detected in Well 3068. TCE and perchlorate concentrations attenuate to the southwest and were detected at 150 and 1,000 µg/l, respectively in Well 3076 1,300 feet downgradient. The lateral extents of TCE and perchlorate downgradient of Well 3076 are uncertain.

- Data Gap: Additional data are needed to assess TCE and perchlorate near the southern property boundary.

Z2-13. Wells 111, 4395, and 314-5 will be sampled for VOCs and perchlorate (Table B-1).

5.2.3 Layer C

Iso-concentration maps were prepared for TCE and perchlorate, the most common chemicals detected in Layer C (Figures B-13 and B-14). The TCE and perchlorate in Layer C is distributed similarly to Layer B. TCE and perchlorate were detected in southwest trending plumes that extend from downgradient of the Hogout Area to the southern property boundary. TCE and perchlorate concentrations attenuated from the maximum of 3,800 and 4,300 µg/l in Well 3069, respectively, to 180 and 1,100 µg/l, respectively in Well 3329. TCE and perchlorate potentially present south of White Rock Road and the PGOU will be addressed by the remedial programs at the IRCTS and the WRND. The majority of monitor wells located along the southern property boundary were sampled recently and there are no additional Data Collection Activities proposed for Layer C groundwater.

5.2.4 Layer D

The analytical results for TCE and perchlorate are shown on Figures B-15 and B-16, respectively. The concentrations of TCE and perchlorate observed in Layer D are substantially less than in Layer C. TCE was detected over the MCL in one well (32 µg/l in Well 3073) and the TCE data were not contoured. The TCE in Well 3073 appears to migrate south beneath the WRND, and will be addressed by the remedial program implemented at that site. Perchlorate was detected in a similar area, although the highest perchlorate concentration was detected further downgradient (Figure B-16). The lateral extents of TCE and perchlorate are defined at the southern property boundary, and there are no additional Data Collection Activities for these chemicals in Layer D.

5.2.5 Layer E

There are eight monitor wells screened in Layer E along the southern property boundary and five of the wells were recently sampled for perchlorate and TCE (Figures B-17 and B-18, respectively). Neither TCE (<1 µg/l) nor perchlorate (<4 µg/l) were detected in the samples, and no additional data are needed to assess the lateral extent of chemicals in Layer E. However, Wells 3074-5 were not sampled recently, and TCE and perchlorate were detected in overlying Layer D Well 3073.

- Data Gap: TCE and perchlorate data are needed from Wells 3074-5 to assess the vertical distribution of these compounds detected in Layer D.

Z2-14. Wells 3074-5 will be sampled for VOCs and perchlorate (Table B-1).

6.0 SUMMARY OF DATA COLLECTION ACTIVITIES

The Data Collection Activities described below were developed based on the Data Gaps described in the preceding Sections.

This section and Table B-1 will be provided to the field and laboratory personnel for implementation. The standard operating procedures for sample collection, handling, and analyses will be followed as specified in the Site-wide Quality Assurance Project Plan (QAPP)(Aerojet, 2001. Data Collection Activities proposed to characterize the extent of chemicals in groundwater in the Zone 2 Study Area include the following:

Z2-1. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Z2-2. Historic groundwater data from Layer B monitor will be evaluated during the PGOU RI/FS.

Z2-3. Historic groundwater data from Layer C monitor wells will be evaluated during the PGOU RI/FS.

Z2-4. Temporal chemical concentration trends will be prepared and evaluated.

Z2-5. All existing cross-sections will be updated with the most recent chemical and water level data.

Z2-6. All chemical-isoconcentration maps will be finalized and all data will be reviewed during the RI/FS.

Z2-7. Wells 410, 415, and 3119 will be sampled for metals listed on Table B-1.

Z2-8. Wells 50, 411, 415, 3076-8, 3357-8, 3381 and 3392 Samples will be sampled for nitrate.

Z2-9. Wells 413 and 412 will be sampled for metals listed on Table B-1.

Z2-10. Well 412 will be sampled for HMX.

Z2-11. Groundwater samples will be collected from Wells 3460 and 3500-1 and analyzed for VOCs and perchlorate.

Z2-12. Data collected from the RCRA closure at Site 11G will be assessed during the PGOU RI/FS.

Z2-13. Wells 111, 4395, and 314-5 will be sampled for VOCs and perchlorate.

Z2-14. Wells 3074-5 will be sampled for VOCs and perchlorate.

7.0 REFERENCES

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TABLE B-1: RI/FS Data Collection Activities - Zone 2 Study Area

PRELIMINARY DRAFT

Activity Number	Location	Data Collection Activity	Layer	Target Analytes	EPA Method	Reporting Limit (ppb) [1]	Lowest WQO (ppb) [2]	Number Samples	Rationale
Z2-1	Sector G	Prepare hydrographs using historical and recent GW data. Prepare potentiometric surface maps with data collected in October 2001.	All	NA	NA	NA	NA	NA	Evaluate temporal and seasonal trends of groundwater elevations.
Z2-2	Sector G	Historic groundwater data will be evaluated.	B	NA	NA	NA	NA	NA	Assess groundwater mound in Layer B.
Z2-3	Sector G	Historic groundwater data will be evaluated.	C	NA	NA	NA	NA	NA	Assess groundwater mound in Layer C.
Z2-4	Sector G	Temporal chemical concentration trends will be plotted.	All	NA	NA	NA	NA	NA	TBD
Z2-5	Sector G	All existing cross-sections will be updated with the most recent chemical and water level data.	All	NA	NA	NA	NA	NA	Assessment of vertical distribution of chemicals.
Z2-6	All	Finalize chemical iso-concentration maps and review data.	All	NA	NA	NA	NA	NA	Ensure the representativeness of all data for the RI/FS.
Z2-7	Central Line 04	Sample Well 410.	A	$Chromium^{+6}$	7196	5	0.2	1 [3] [4]	Assess metals downgradient of potential source sites.
				Cadmium	213.2 Mod.	1	0.07		
				Lead	239.2 Mod.	3	2		
				Thallium	279.2 Mod.	1	0.1		
		Sample Well 415.	A	Cadmium	213.2 Mod.	1	0.07	1 [3] [4]	
		Sample Well 3119.	A	Antimony	7041	5	6	1 [3] [4]	
				Beryllium	210.2 Mod.	3	4		
				Mercury	7470	0.2	1.2		
				Lead	239.2 Mod.	3	2		
Z2-8	Eastern Line 04	Sample Wells 50, 411, 415 and 3076.	A	Nitrate	300	50	45,000	1 [3]	Assess nitrate downgradient source areas.
		Sample Wells 3077, 3357 and 3381.	B						
		Sample Wells 3078, 3358 and 3392.	C						
Z2-9	Eastern Line 04	Sample Well 412.	A	Cadmium	213.2 Mod.	1	0.07	1 [3] [4]	Assess metals downgradient of potential source sites.
				Lead	239.2 Mod.	3	2		
				Mercury	7470	0.2	1.2		
		Sample Well 413.	A	$Chromium^{+6}$	7196	5	0.2	1 [3] [4]	
				Arsenic	7060	5	50		
				Lead	239.2 Mod	3	2		

TABLE B-1: RI/FS Data Collection Activities - Zone 2 Study Area

PRELIMINARY DRAFT

Activity Number	Location	Data Collection Activity	Layer	Target Analytes	EPA Method	Reporting Limit (ppb) [1]	Lowest WQO (ppb) [2]	Number Samples	Rationale
Z2-10	Eastern Line 04	Sample Well 412.	A	HMX	TBD	TBD	NA	1 [3]	Assess HMX downgradient of potential source site.
Z2-11	Central Line 04	Sample Wells 3460 and 3500-1.	A	VOCs	8260	Varies	Varies	1 [3]	Assess lateral extent of contaminants.
				Perchlorate	EA-0040	4	4		
Z2-12	Eastern Line 04	Assess data collected from RCRA closure at Site 11G.	A	Perchlorate	EA-0040	NA	NA	NA	Assess lateral extent of perchlorate.
Z2-13	Central Line 04	Sample Wells 111, 314-5 and 4395 .	A	VOCs	8260	Varies	Varies	1 [3]	Assess lateral extent of VOCs and perchlorate.
				Perchlorate	EA-0040	4	4		
Z2-14	Eastern Line 04	Sample Wells 3074-5.	E	VOCs	8260	Varies	Varies	1 [3]	Assess vertical extent of perchlorate and TCE in overlying Layer D.
				Perchlorate	EA-0040	4	4		

Notes:

(1) Reporting Limits are the lowest analytical reporting limit that the proposed method and analytical laboratory are capable of achieving.

(2) WQO - Water Quality Objective is the lower of the primary Federal or State maximum contaminant level (MCL) verses State Public Health Goal (PHG).

(3) Propose 1 sample to be collected. If target analyte is detected then resample within 30 days to confirm/verify initial result.

(4) All groundwater samples collected for metal analyses will be field filtered prior to laboratory submittal.

NA = Not Applicable

TBD = To Be Determined

WRND = White Rock North Dump

TABLE B-2: Summary of Aquifer Test Data - Zone 2 Study Area **PRELIMINARY DRAFT**

Pumping Well	Date of Test	Transmissivity (gpd/ft)	Storativity	Hydraulic Conductivity (ft/day)	Hydrostratigraphic Layer(s)
Sector G, Extraction Wells - Inactive					
4015	1/15/82	1011	0.0003	3.9	A
4390	10/30/95	6.7 - 6.9	NA	1.7	A
4395	8/29/95	30.7 - 125	$4x10^{-5}$ - 0.44	4.8 - 19.4	B/C
4415	10/5/95	0.8 - 18	$3.9x10^{-7}$ - 0.06	0.1 - 2.4	A/B
4420	10/2/95	28 - 172	$2x10^{-4}$ - 0.81	4.6 - 28	C/D
Sector G, Recharge Wells - Inactive					
5060	9/13/83	5,800 - 12,500	$8x10^{-5}$ - $3.4x10^{-4}$	6.6 - 10.5	D
5065	10/5/83	8,700 - 16,000	$7x10^{-5}$ - 0.0074	10.9 - 20.1	D
5070	10/20/83	18,900 - 26,400	$7.9x10^{-4}$	21.5 - 28.9	D
5075	10/31/83	15,400 - 28,900	$1.3x10^{-4}$ - $5.1x10^{-4}$	12.4 - 25.9	C/D

TABLE B-3: Summary of Chemicals Detected During Stage 1 RI - Zone 2 Study Area **PRELIMINARY DRAFT**

CLASS / Compound	Detected in Soils [1]	Potential Source Site(s) Detected [2]	Detected in Groundwater [3]	Hydrostratigraphic Layer Detected	Comments	Potential Study Area Analyte
Central and Eastern Line 04						
SVOCs						
Di-n-butyl phthalate	Yes	3G, 4G, 9G, & 10G	Yes	A	Suspected laboratory contaminant.[4]	No
1,4-Dioxane	No	Not applicable	No	Not Applicable	Potential TCE impurity/stabilizer.	No
NON-VOCs						
Perchlorate	Yes	50F, 51F, 52F, & 9G	Yes	A, B, C	Hogout Facility in Eastern Line 4.	Yes
NDMA	No	Not applicable	No	Not Applicable	Possible upgradient source.	Yes
Nitrate	No	50F & 51F	Yes	A,B,C		Yes
Dioxin/Furans	Yes	4G	Not Analyzed	Not Applicable	Soil concentrations did not exceed residential PRGs.	No
HMX	Yes	G(a)	Not Analyzed	Not Applicable	Stage 2 sampling recommended.	Yes
Oil & Grease	Yes	9G	Not Analyzed	Not Applicable	Compound generally immobile in water.	No
Diesel	Yes	50F	No	Not Applicable	Compound generally immobile in water.	No
TPH	Yes	44F, 50F, & 53F	Yes	Not Applicable	Detected with limited extent near suspected source.	No
METALS						
Antimony	Yes	4G	Not Analyzed	A		Yes
Arsenic	Yes	9G & 11G	No [5]	A		Yes
Beryllium	Yes	4G	Not Analyzed	A		Yes
Cadmium	Yes	44F, 53F, 2G, 8G & 9G	No [5]	A	Not analyzed down gradient of 44F/53F.	Yes
Chromium (total)	Yes	11G	No	A	Sample not filtered.	No
Hexavalent Chromium	No	Not applicable	Yes	A	No known sources.	Yes
Cobalt	Yes	3G	No	A	Naturally occurring metal.	No
Copper	Yes	9G & 11G	No	A		No
Lead	Yes	2G, 4G, 9G, & 11G	No [5]	A	Not analyzed down gradient of 44F/53F.	Yes
Manganese	Yes	3G	No	A	Naturally occurring metal.	No
Mercury	Yes	2G & 4G	Not Analyzed	A		Yes
Nickel	Yes	3G & 11G	No	A		No
Selenium	Yes	9G & 11G	No [5]	A	Naturally occurring metal.	No
Silver	Yes	44F & 53F	No	A		No
Thallium	Yes	8G & 9G	No [5]	A		Yes

Notes:

1 Metals reported if above presumed site background levels, Borch, 1994.
2 Source: Stage 1 Report - Zone 1, ICF Kaiser Engineers, 1993.
3 Metals reported if above 1991 Primary MCLs or DHS Public Health Goals.
4 Aerojet, Special Contaminant Investigation, 1994.
5 Stage 1 reporting limits above current primary MCLs and/or PHGs.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

APPENDIX C
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 3 STUDY AREA

AEROJET GENERAL SUPERFUND SITE SACRAMENTO, CALIFORNIA

Prepared for:

AEROJET
A GenCorp Company

Aerojet General Corporation
Sacramento, California

Prepared by:

CENTRAL VALLEY ENVIRONMENTAL, INC.

With assistance from:

Aerojet General Corporation
Environmental Remediation Department

April 16, 2002

APPENDIX C
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 3 STUDY AREA

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APPENDIX C
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 3 STUDY AREA

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LIST OF ACRONYMS

ARAR	applicable or relevant and appropriate requirement
Bgs	Below the ground surface
BRA	Baseline Risk Assessment
CAO	Cleanup and Abatement Order
CVEI	Central Valley Environmental, Inc.
DQO	Data Quality Objective
DCA	Dichloroethane
DCE	Dichloroethene
DNAPL	dense non-aqueous phase liquid
EMSI	Engineering Management Support, Inc.
EPA	U.S. Environmental Protection Agency
Freon-113	1,1,2-trichloro-1,2,2-trifluoroethane
ft	foot
FS	Feasibility Study
gpm	gallons per minute
GET	Groundwater extraction and treatment
GMP	Groundwater monitoring plan
HVOCs	Halogenated volatile organic compounds
µg/L	Micrograms per liter
mg/l	Milligrams per liter
msl	Mean sea level
NPDES	National Pollutant Discharge Elimination System
NDMA	n-nitrosodimethylamine
OU	Operable Unit
PCB	Poly-chlorinated biphenyls
PAHs	Poly-aromatic hydrocarbons
PNAs	Poly-nuclear aromatic
PCE	Tetrachloroethene
PGOU	Perimeter Groundwater Operable Unit
SVRA	Prairie City State Vehicle Recreational Area
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RL	Reporting Limit
RI	Remedial Investigation
RWQCB – CVR	Regional Water Quality Control Board – Central Valley Region
SCM	Site Conceptual Model
SWRCB	State Water Resources Control Board
TBC	To-be-Considered Criteria
TCA	Trichloroethane
TCE	Trichloroethene
TI	Technical Impracticability
TPH	Total Petroleum Hydrocarbons
VOC	Volatile organic compound
WGOU	Western Groundwater Operable Unit
WQO	Water Quality Objectives

APPENDIX C
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 3 STUDY AREA

1.0 INTRODUCTION

This *Draft Data Assessment and Data Collection Activities Report* (Report) addresses the portion of Zone 3 that is located within the Perimeter Groundwater Operable Unit (PGOU). Zone 3 is located in the southeast area of the Aerojet property, and is one of four zones (Zones 1 through 4) included in the PGOU Remedial Investigation/Feasibility Study (RI/FS)(Figure C-1). The Zone 3 Study Area (Study Area) includes groundwater beneath Sector B, the Groundwater Extraction and Treatment [(GET) B] remedial systems on-site and off-site at GET B South, and groundwater beneath Area 39 and Area 40.

This Report, combined with the *PGOU RI/FS Work Plan* (*Work Plan*), contain analysis identified in the "*United States Environmental Protection Agency (EPA) General Guidelines for Conducting an RI/FS*" (EPA, 1988). The *Work Plan* describes the common regional characteristics of the Zones, including the Work Plan Rationale, Data Quality Objectives (DQOs), Preliminary Site Conceptual Model (SCM), fate and transport, exposure pathways, and potential remedial alternatives [Engineering Management Support, Inc. (EMSI) et. al., 2002]. This Report describes the local characteristics of the Study Area including local physical characteristics, hydrogeology, remedial investigation background, and the distribution of chemicals in groundwater.

1.1 Objectives

The objectives of this Report are to assess available data and develop Data Collection Activities for the *Work Plan* to obtain the data necessary for completing the Zone 3 portion of the PGOU RI/FS. The Data Collection Activities were developed by comparing the available data with the data needed (Data Gaps) to complete the RI, FS, or Baseline Risk Assessment (BRA), following the EPA DQO Process (EPA, 1994). Each section of this Report describes the data needs and how the data apply to the PGOU RI/FS. Identified Data Gaps are bulleted and their associated Data Collection Activities are numbered (e.g., Z3-1) and forwarded to the *Work Plan*.

1.2 Organization

The descriptions in this Report are intended to provide information to support the Data Collection Activities. The analytical data referenced in this Report are included on a CD-ROM. This Report is organized into the following sections:

Section 1: Introduction - Describes the location of the portion of Zone 3 in the PGOU and describes the Zone 3 Study Area. Introduces the objectives for this Report, and outlines the report organization.

Section 2: Physical Study Area Characteristics - Summarizes the physical characteristics of the Study Area that will be used to develop the SCM in the PGOU RI/FS.

Section 3: Local Hydrogeology - Discusses Study Area stratigraphy and groundwater flow conditions and identifies Data Gaps. Data Collection Activities are developed to fill the Data Gaps that will support the RI, FS, and BRA.

Section 4: Remedial Investigation Background - Summarizes the previous investigations in the Study Area and describes the industrial practices, chemical use, handling, and disposal at the upgradient source sites. This section also describes previous cleanup actions within the Study Area.

Section 5: Characterization of Chemicals in Groundwater - Describes the types and extents of chemicals in the Study Area groundwater. Data Gaps are identified and Data Collection Activities are developed to obtain the data.

Section 6: Summary of Data Collection Activities - Summarizes the Data Collection Activities forwarded to the *Work Plan*.

Section 7: References - Lists references cited in this Report.

2.0 PHYSICAL STUDY AREA CHARACTERISTICS

The physical characteristics of the Study Area, including the size, topography, land use, groundwater use, and local surface water bodies are described in this Section. The descriptions of regional features in the Study Area were summarized from the detailed descriptions in the *Work Plan* (Sections 2 and 3). The following information will be incorporated in the SCM during the PGOU RI/FS.

The portion of Zone 3 within the PGOU begins at the eastern and southern property boundaries and extends east, south, and southwest to the furthest extent of Site-related chemicals in groundwater (Figure C-1). A larger area, The Zone 3 Study Area (Study Area) was assessed to consider data collected upgradient of the PGOU. The on-site Study Area is in Sector B and includes the groundwater between the Exhibit III Potential Source Sites (source sites) in Zone 3 and the on-site GET B remedial system. GET B South is located south of White Rock Road, and includes the Aerojet-owned former Ehnizs property, the GET B South remedial system, and private property south of the former Ehnizs property. Area 39 is located within the Prairie City State Vehicle Recreation Area (SVRA) in eastern GET B South. Area 40 is Aerojet property east of the eastern property boundary and Prairie City Road.

The southern property boundary is parallel to White Rock Road and extends approximately 9,000 feet from Prairie City Road to Grant Line Road (Figure C-1). The eastern property boundary is parallel to Prairie City Road and the portion that is in the Zone 3 Study Area extends approximately 5,000 feet north of White Rock Road. Sector B encompasses approximately 1,000 acres on-site, and GET B South encompasses approximately 2,000 acres.

2.1 Land Use

Land uses in the Study Area include the industrial activities in Sector B, and the various land uses at GET B South. Aerojet property upgradient of the PGOU is zoned for industrial use and was used primarily to test liquid rocket engines and supporting activities (Section 4.1). Most of the land west of the rocket test stands was dredged and is undeveloped. The land east of the test stands is mostly undredged and is undeveloped.

The Aerojet property was designated as a "Special Planning Area" by Sacramento County Ordinance, Title V, Chapter 8, Article 3 of the Zoning Code of Sacramento County. This ordinance identifies existing permitted uses and "provides a regulatory mechanism for making land use decisions that maintain a safe environment in which the subject property can be used given the special requirements of the property owner".

GET B South is mostly undeveloped and is located in unincorporated Sacramento County, outside of the County's General Services Boundaries. A small trailer park is located north of the SVRA. There are no other residents in the Study Area. The nearest residence is located on Grant Line Road, approximately one mile south of White Rock Road.

Most of the SVRA is undeveloped and is used for off-road recreation. Aerojet leased a portion of the SVRA to burn chemical and propellant waste (Area 39). The Teichert Construction Company conducts aggregate mining northeast of the SVRA and south of the Ehnizs property by. The Aerojet-owned former Ehnizs property is undeveloped and formerly used to graze cattle and for agriculture.

The White Rock North Dump (WRND) and White Rock South Dump (WRSD) are located west of the Study Area (Figure C-1). The WRND is being investigated under Regional Water Quality Control Board–Central Valley Region (RWQCB-CVR) Cleanup and Abatement Order 96-150. Groundwater migrating south of the WRND is not addressed in this Report.

2.2 Groundwater Use

Groundwater is not currently used in Sector B for either domestic or industrial purposes; however, groundwater is extracted at GET B and GET B South. There are no public water supply wells at GET B South, but there are several domestic and industrial water supply wells (Figure 2-3, *Work Plan*). Well 1059 is located at the Prairie City SVRA and provides water for gravel washing operations and to the Prairie City SVRA. Well 1943 is located on Grant Line Road, south of White Rock Road, and supplies water to the southern Teichert aggregate mining operations. An air-stripper is currently being installed on Well 1943 for VOCs believed to have originated at the WRND (EMSI and CVEI, 2001). Domestic water supply Wells 1159, 1299, and 1816 are located south of the Study Area and serve individual residences. Analytical testing of the domestic water supply wells is discussed in Section 5.2.7.

The GET B remedial system is the largest use of groundwater in the Study Area. The GET B system currently extracts approximately 1,500 gallons per minute (gpm) from the southern property boundary and from GET B South.

2.3 Topography

Sector B features a topographic surface that dips gently to the south and west. The boundary between Zones 3 and 4 marks the highest elevation in Sector B [approximately 300 feet above mean sea level (ft msl)]. The land-surface is trough-shaped and dips south towards the southern property boundary where the elevation is approximately 270 ft msl. Bedrock is exposed east of Sector B and dips west where it is covered by sediments in Sector B. Linear, east west trending dredge tailings characterize the topography in the western area of Sector B.

Most of the land surface at GET B South is relatively flat, and gently dips to the south and west. The majority of GET B South drains towards the American River Watershed or to the Sacramento River via Morrison Creek. The land surface east of the Prairie City SVRA dips southeast and drains to Coyote Creek and the Consumnes River Watershed.

2.4 Local Surface Water

The *Work Plan* (Section 2.6, Figure 2-4) discusses regional and local surface water bodies. There are two surface water bodies in Sector B, Buffalo Creek and Rebel Hill Ditch (Figure C-1). Buffalo Creek flows south from the dredge tailings in Zone 4, through eastern Sector B, and then northwest into Zone 1 (Figure C-1). Test stand deluge water was formerly treated and discharged to Buffalo Creek.

Rebel Hill Ditch is man-made and was formerly used to provide water for gold dredging operations. Rebel Hill Ditch currently receives treated groundwater from the GET B treatment facility. Rebel Hill Ditch trends west from Sector B, into Zone 2, where the treated water percolates into the ground. Surface-water runoff generally does not flow off the property boundaries, but flows onto the property east of Gate 7 from the areas south of Prairie City Road.

The Cosumnes River Watershed is located east of the Study Area (Figure 2-4, *Work Plan*). Runoff from some of Area 39 may enter this watershed; however, the majority of runoff is to the southwest and towards the American River Watershed. The headwaters for Morrison Creek, an ephemeral stream, are located near Grant Line Road, approximately 5,000 feet south of White Rock Road (Figure 2-4, *Work Plan*).

3.0 LOCAL HYDROGEOLOGY

The following sections discuss the general lithology and define the hydrostratigraphic layers beneath the Study Area, followed by a discussion of groundwater flow directions and hydraulic gradients. The data presented in this section provide the basis for the chemical iso-concentration maps, analysis of fate and transport, and hydraulic containment at GET B and GET B South during the PGOU RI/FS.

The lithologic descriptions were summarized from the "*Aerojet Site – GET B Effectiveness Evaluation Report*", (GET B Report)(Aerojet, 1995). The hydrostratigraphic layers described in the GET B Report were changed recently to match the site-wide layer designations. The change resulted in the division of the former Layer C into current Layers C and D, and the division of the former Layer D into newly defined Layers E and F. Data needed to verify the continuity and structure of the layers, and the Data Collection Activities that will be conducted are identified in the following sections.

3.1 Hydrostratigraphy

The sediments beneath the Study Area were divided into six hydrostratigraphic layers (Layers A through F) based on lithologic descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thickness. The following sections summarize the lithology and structure of the layers beneath the Study Area. Layer A is the shallowest layer and is underlain by Layers B, C, D, E, and F. There may be local variations to the general descriptions provided below.

The general lithology and hydrostratigraphic layer boundaries are presented on three cross-sections originally presented in the GET B Report (Figures C-2, -3, and -4) and one new cross-section (Figure C-5). The layers shown on the Figures C-2, -3, and –4 are the current layer designations. Cross-sections A-A' and B-B' are oriented northeast/southwest and show a general thickening of the sediments from north to south. Layers E and F are shown to "pinch out" near the southern property boundary. Cross-sections C-C' and D-D' are oriented east-west, perpendicular to the direction of groundwater flow (Figures C-4, and C-5, respectively). These cross-sections will be used as part of the evaluation of the effectiveness of the GET B extraction system during the PGOU RI/FS.

3.1.1 Layer A

Layer A is the upper-most layer and is dry or absent throughout most of the Study Area. Monitor wells assigned to Layer A in northern Sector B, Area 40, the WRND, and Area 39 contain water, although it is unlikely that Layer A is hydraulically connected between these areas.

Layer A is predominantly coarse-grained and is composed of sand and gravel. Layer A has been dredged in the northwest area of Sector B, at the WRND, and in portions of Area 39. The wells assigned to Layer A near the source sites in northern Sector B are not in dredged materials. The top of Layer A occurs at depths of 50 to 70 ft bgs. Layer A ranges in thickness from 15 to 70 feet.

3.1.2 Layer B

Layer B is discontinuous and unsaturated in eastern Sector B and eastern GET B South (Figure C-7). One monitor well (Well 1544) assigned to Layer B is saturated near the intersection of Grant Line and White Rock Roads. The top of Layer B occurs at depths of 50 to 80 ft bgs in Sector B, and at depths of 80 to 140 ft bgs at GET B South. Layer B is comprised of sand, gravel, silt and cemented silt, and ranges in thickness from approximately 20 to 65 feet. Layer B is separated from Layers C and D by a relatively fine-grained sequence of silt and clay with occasional inter-bedded sands. The silt layer is designated as the B/C aquitard and ranges from less than 10 feet to as many as 50 feet thick.

3.1.3 Layer C

Layer C is saturated throughout the Study Area with the exception of two wells at GET B South (Figure C-8). The top of Layer C is typically present at depths of 90 to 135 ft bgs in Sector B, and at depths of 100 to 190 ft bgs at GET B South. Layer C is 20 to 50 feet thick in Sector B, and is over 100 feet thick at GET B South (Figures C-3 and C-4). Layer C is predominantly comprised of poorly graded mafic sands and gravel inter-bedded with silt and cemented-silt lenses. Layers C and D are separated by a silt aquitard that may or may not be continuous.

3.1.4 Layer D

Layer D is saturated throughout the Study Area. The top of Layer D is typically encountered at depths of 140 to 180 ft bgs in Sector B, and at depths of 200 to 260 ft bgs at GET B South. Layer D is 20 to 50 feet thick in Sector B and 20 to 80 feet thick at GET B South. Layer D is comprised of mafic sand and gravel and is lithologically similar to Layer C. Layers D and E are separated by a color change from brown and black mafic materials to green-hued clayey sands. The D/E aquitard is typically reported as a fat or sticky clay and is up to 140 feet thick.

3.1.5 Layer E

Layer E was recently defined in the Study Area and has only been encountered beneath GET B South (Figures C-2 and C-3). The top of Layer E is typically encountered at depths ranging from 230 to 400 ft bgs. Layer E is primarily comprised of lean and fat clays, clayey sand, and a clay quartz sand that appears to produce the majority of water. Organic materials and sulfides have been noted in drill cuttings from Layer E. Layer E has not been encountered at the southern property boundary, although chemicals are present in Layer F near the property boundary.

- Data Gap: Additional data are needed to assess the continuity, structure, and groundwater flow paths in Layer E (and F) in Sector B.

Z3-1. Two north-south trending (E-E' and F-F') and two east-west trending (G-G' and H-H') cross-sections will be constructed, parallel and perpendicular to the groundwater flow direction, from the northern source sites to the southern property boundary (Table C-1). The monitor wells included on each cross-section are listed on Table C-1.

3.1.6 Layer F

Layer F was defined at GET B South and at the southern property boundary but does not appear to be present in Sector B (Figure C-3). The aquitard separating Layers E and F has only been penetrated by a few wells and the continuity of the E/F aquitard is unknown. The sediments in Layer F are described as light gray quartz sand with varying amounts of clay matrix. Layer F was encountered at depths of approximately 260 ft bgs at the Southern property boundary, and at depths up to 450 ft bgs at GET B South. The base of Layer F has not been penetrated. The cross-sections that will be constructed during the PGOU RI/FS will provide additional information to assess Layer F in Sector B (Section 3.1.5, Activity Z3-1).

3.2 Groundwater Flow

The following sections describe the groundwater flow directions and lateral hydraulic gradients in Layers A through F. The data presented in this section will be used during the PGOU RI/FS for the following purposes:

1. Evaluate temporal and seasonal water level trends, and

2. Identify groundwater flow directions and calculate hydraulic gradients that will be used in part to estimate groundwater velocities, contaminant migration rates, and potential cleanup times.

- Data Gap: Historic and recent groundwater elevation data are needed to evaluate water-level trends.

Z3-2. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Potentiometric surface maps were created for each layer with water level data collected during the plant-wide monitor well sounding in April 2001 using Surfer® for Windows (Version 7)(Figures C-6 through C-11). The contour lines were modified from the Surfer® output for Layers A and B because the Surfer® algorithm placed contour lines through dry areas. Other areas near the borders were trimmed where the data did not support the extension of the contour lines. Suspected anomalous data from a few monitor wells are not included on the maps. The average water levels were used in cases where more than one well was screened in the layer. Water levels from the GET B extraction wells were not used to prepare the maps.

The overall groundwater flow direction is south to southwest although groundwater flow directions vary on the east and west sides of the Study Area. The hydraulic gradient ranges from 0.004 foot/foot (ft/ft) in Layer E to 0.017 ft/ft in Layer C. The most commonly observed pattern of groundwater flow is the convergence of groundwater flow paths from the east and west towards the central area of GET B South.

Layers A and B are discontinuous and are unsaturated in portions of the Study Area. Layers C and D are lithologically and hydraulically similar. Layers E and F are not characterized through the Study Area, but are similar where they are characterized. The following sections describe groundwater flow in each of the hydrostratigraphic layers.

3.2.1 Layer A

As discussed previously, Layer A is discontinuous and there is no hydraulic connection between the various locations where Layer A is saturated (Figure C-6). The highest groundwater elevations in Layer A (308 ft msl) were measured in Area 40, east of Sector B. Groundwater elevations suggest that groundwater from Area 40 flows west into Sector B.

- Data Gap: Data are needed to assess the hydraulic connection between Area 40 and the eastern property boundary.

Z3-3. Water levels will be collected quarterly from all auger and monitor wells in Area 40 for a period of one year to compare water level elevations between wells and to evaluate seasonal water level trends (Table C-1).

Layer A is dry in the central and southern areas of Sector B. Layer A is saturated west of the Study Area at the WRND. Groundwater in Layer A at the WRND flows south and southwest, away from the Study Area (EMSI and CVEI, 2001). The groundwater shown for Layer A in Area 39 may be perched or may be Layer A.

- Data Gap: Data are needed to assess the hydrostratigraphic layers and the potential hydraulic connection between Area 39 and GET B South.

Z3-4. Three cross-sections will be constructed to compare the lithology, depth to water, chemical concentrations, and depth of screened intervals for the monitor wells in Area 39. The monitor wells included on the cross-sections are identified in Table C-1.

Z3-5. Water levels will be collected quarterly from all auger and monitor wells in Area 39 for a period of one year to compare water level elevations and evaluate seasonal water level trends (Table C-1).

3.2.2 Layer B

Layer B is saturated in the western area of Sector B but is dry in the east and southeast (Figure C-7). The highest groundwater elevation in Layer B was 263 ft msl in northern Sector B, and the lowest elevation was 136 ft msl at GET B South. Groundwater in Layer B generally flows north to south, with an average hydraulic gradient of approximately 0,013 ft/ft. Groundwater in Layer B beneath the WRND flows south and southwest, away from the Study Area (EMSI and CVEI, 2001).

3.2.3 Layer C

Layer C is saturated throughout the Study Area (Figure C-8). The groundwater elevations in Layer C ranged from approximately 246 ft msl in northern Sector B to approximately 125 ft msl at GET B South. Groundwater in Sector B flows southwest from eastern Sector B towards the southern property boundary with an average hydraulic gradient of approximately 0.017 ft/ft. Groundwater from western Sector B flows southeast with an approximate hydraulic gradient of 0.016 ft/ft. At GET B South, groundwater converges from the northeast and northwest with an average hydraulic gradient of approximately 0.012 ft/ft.

3.2.4 Layer D

Layer D is saturated throughout the Study Area (Figure C-9). Groundwater elevations in Layer D decrease from 247 ft msl in northern Sector B to 125 ft msl at GET B South. The groundwater flow directions and hydraulic gradients in Layer D are similar to those in overlying Layer C. Groundwater in Layer D flows generally south from central Sector B towards the southern property boundary with a hydraulic gradient of approximately 0.017 ft/ft. Groundwater from the western Sector B flows southeast with a hydraulic gradient of approximately 0.016 ft/ft Groundwater converges from the northeast and northwest at GET B South, where the overall flow direction is southwest. The hydraulic gradient at GET B South averaged 0.014 ft/ft measured from Gate 7 to the southern-most extraction wells.

3.2.5 Layer E

Layer E was encountered south of the southern property boundary (Figure C-10). The groundwater elevations in Layer E ranged from 197 ft msl at the southern property boundary to 151 ft msl at GET B South. The general direction of groundwater flow is south to southwest, although groundwater flows more westerly near the WRND. The hydraulic gradient in Layer E is approximately 0.004 to 0.008 ft/ft, lower than in overlying Layers C and D.

3.2.6 Layer F

Layer F is monitored by six monitor wells at the southern property boundary, and by 11 monitor wells at GET B South (Figure C-11). The groundwater elevation in Layer F decreases from a high of 239 ft msl at the southern property boundary to the low of 159 ft msl at GET B South. At GET B South, the groundwater flow direction is southwest from the southern property boundary to the southern boundary of GET B South. The hydraulic gradient ranges from 0.005 to 0.008 ft/ft

3.3 Potentiometric Surface Head Differences

The differences in the potentiometric surface elevations (head difference) can indicate the potential for vertical groundwater movement between layers. In most instances, where Layers A and B were saturated, they were observed to have a positive head difference, indicating the potential for a downward vertical gradient. The head differences between Layers C and D were typically less than 2 feet suggesting the potential vertical gradient is minimal. Layers D, E, and F have negative head differences suggesting the potential for an upward vertical gradient in these layers. In general, the head differences were greatest near the GET B South extraction wells where head differences were up to 25 feet.

3.4 Aquifer Test Data

Pump/aquifer test data were reviewed for two wells in Sector B and 12 wells at GET B South (Table C-2). Hydraulic conductivity ranged from 4 to 128 ft/day. Transmissivity ranged from 2,500 to 64,899 gallons per day per foot.

4.0 REMEDIAL INVESTIGATION BACKGROUND

The following sections summarize historical operations conducted at the source sites upgradient of the PGOU. The descriptions are largely from the *Aerojet Site - Stage 1 RI Report Zones 3 and 4*, and includes new data were available (ICF Kaiser, 1993). This section describes the historical activities, materials handled, waste type and handling, previous investigations, suspected source areas, previous cleanup actions, and the existing data available for the Study Area. This information supports the evaluation of the distribution of chemicals in groundwater and the SCM.

4.1 Historical Activities

Historical and recent operations in Sector B were conducted in six test areas designated as Areas 33, 34, 35, 36, 37, and 38 (Figure C-1). Operations in these areas primarily supported the testing of liquid rocket engines and components, degreasing, fuel preparation, deluge water management/treatment, metals plating, and atmospheric testing. Area 39 was used to burn various chemical, laboratory, and propellant wastes. Area 40 was used for burning chemical waste and for separating waste trichloroethylene (TCE).

4.2 Materials Handled

The primary materials handled in Sector B were fuels and oxidizers used in testing liquid rocket engines, metals, hydrocarbon fuels, and solvents. The most common fuels were hydrazine-based compounds that were combined with nitrogen tetroxide. N-Nitrosodimethylamine (NDMA) was an impurity in hydrazine, or may have formed during the combustion of hydrazine-based fuels. The *Scoping* and *Stage 1 RI Reports* summarized the materials handled at the source sites (ICF Kaiser, 1989, 1993). The following lists the primary materials historically handled in Sector B.

Solvents:	Freon-113, 1,1,1-Trichloroethane (1,1,1-TCA), TCE, 1,1-dichloroethene (1,1-DCE), tetrachloroethene (PCE), ethylene
Fuels & Oxidizers:	unsymmetrical dimethyl hydrazine, kerosene, diesel, nitrogen tetroxide, hydrazine propellants, jet fuel, hydrogen peroxide, Aerozine 50.
Metals:	copper sulfate, mercury.
Miscellaneous:	nitrates, acids, triethanolamine, caustics, metals.

4.3 Waste Type and Handling

The predominant waste generated in Sector B was deluge water used to cool liquid rocket engines during test firing. The deluge water may have contained hydrazine-based fuels and NDMA, and was directed to sumps, ponds, and holding areas via surface canals and Buffalo Creek. The deluge water was treated with hydrogen peroxide, copper sulfate, or caustic soda prior to being discharged to Buffalo Creek or the dredge tailings. Other wastes generated in Sector B include wastes from pickling operations, solvents, and spent fuels.

4.4 Previous Investigations

The geologic and hydrologic conditions, distribution of chemicals in groundwater, and evaluation of source areas in the Study Area have been studied since the mid-1980's. The background information for the PGOU RI/FS and the most recent interpretations of geologic, hydrologic, and chemical conditions in the Study Area groundwater were presented in the following reports:

- "*Scoping Report and Phase 1 RI/FS Workplan*": Identified and summarized existing history of potential source sites; evaluated chemical use and disposal; proposed analytical methods for sampling and analysis, including an analytical approach to evaluated non-standard chemicals for the Stage 1 RI/FS (ICF Technology, 1989).
- "*Aerojet Site - Stage 1 RI/FS Report – Zones 3 and 4*": Results of soil-gas, soil, and groundwater samples collected from potential source sites within Zones 3 and 4 of site-wide groundwater screening during the Stage 1 RI/FS (ICF Kaiser Engineers, 1993).
- "*GET B Effectiveness Evaluation Report*": The report contains interpretations of geology, hydrogeology, and the distribution of chemicals in the Study Area groundwater (Aerojet, 1995).
- "*Revised Phase 1, Stage 2 RI/FS Sampling Plan – Zones 3 and 4 - Tables and Maps*": Work Plans to complete RI/FS activities at source areas. Recommended completing the characterization of non-volatile organic compounds detected in soil or groundwater during the Stage 1 RI/FS (Aerojet, 1999).
- "*GET B Groundwater Flow Model*", Hydraulic assessment of groundwater capture at GET B system. Recommended installation of three extraction wells at GET B South (GeoTrans Inc., 2000).

4.5 Suspected Source Areas

There are approximately 43 source sites in Sector B upgradient of the PGOU. There are an additional six source sites in Area 39, and five source sites in Area 40 (Figure C-1). A summary of the chemicals detected in soil and groundwater at the source sites is presented on Table C-3. Most detected chemicals were associated with petroleum products, solvents, solid rocket propellant, and liquid rocket fuel including NDMA, VOCs, naphthalene, poly-aromatic hydrocarbons/poly-nuclear aromatic (PAH/PNA), perchlorate, nitrate, and Total Petroleum Hydrocarbons (TPH) as kerosene.

The highest chemical concentrations observed in Sector B were reported beneath the source sites in northern Sector B. Source sites 66B and 12A yielded Freon-113 and 1,1,1-TCA at concentrations suggesting the potential presence of dense non-aqueous phase liquid (DNAPL)(Schwille, 1988). 1,1-DCE, TCE, and kerosene were detected at high levels in northern Sector B groundwater. Aluminum, chromium, and lead were detected in unfiltered groundwater samples above WQOs.

TCE, NDMA, perchlorate, Freon-113, kerosene, and metals were detected in soil and groundwater collected from the central and southern areas of Sector B, although the reported concentrations were lower than in the northern area. Poly-chlorinated biphenols (PCBs) were detected in soils at Site 28B. PCBs were characterized vertically in the vadose zone and PCBs are not considered a potential analyte in groundwater (Table C-3).

NDMA was detected in soils near two or three sumps and drainages in northern and southern Sector B. NDMA was widely distributed in groundwater, suggesting that the test stand deluge water may have been a non-point source of NDMA.

The source sites in Areas 39 and 40 are located on property formerly owned or leased by Aerojet. TCE and perchlorate were detected in soil and groundwater beneath Area 39. Metals may be associated with Area 39; however, the metals reported in soil above the presumed site background levels may be naturally occurring (ICF Kaiser, 1993). There are six source sites in Area 40, and data suggest that DNAPL TCE may be present in the vadose zone and the alluvial aquifer. Perchlorate was also reported in Area 40 groundwater. There are no data to indicate that the DNAPL has penetrated the bedrock in Area 40.

4.6 Previous Cleanup Actions

The primary remedial action in Sector B is the GET B system. Sector B includes extraction wells at the southern property boundary and the GET B treatment facility (Figure C-1). GET B South includes several rows of extraction wells located in the northern, central, and southern areas of the former Ehnizs property (Figure C-1). The GET B treatment plant was constructed with a capacity of 1,400 gallons per minute (gpm). GET B currently has a capacity of 1,500 gpm based on achieving an effluent discharge of 0.002 micrograms per liter (µg/l) for NDMA. Treated groundwater is discharged to Rebel Hill Ditch where it infiltrates into the groundwater in Zone 2.

Several pilot and feasibility tests have been conducted in Sector B to evaluate NDMA and/or perchlorate removal. The most recent pilot test is on going at GET B South and is evaluating the in-situ biodegradation of perchlorate by adding a carbon-source to the aquifer. The details of the testing are provided in the *Work Plan* (Section 3.2.9.7).

4.7 Existing Data Summary

The PGOU RI/FS for the Study Area will utilize historical, Stage 1 RI, and recent data collected from the early 1980's through 2001. The types of analytes and uses of the available data include:

Historical Data: Groundwater data collected from the early 1980s through 1991; this data will be used to assess chemical concentration trends. The data contain a range of analytical parameters including VOCs, NDMA, and perchlorate. NDMA and perchlorate are reported at their respective RLs of 0.10 and 400 µg/l, which are higher than the current RLs of 0.0075 and 4 µg/l, respectively.

Stage 1 RI Data: Soil and groundwater data collected from the source areas in 1991 through 1993. The Stage 1 RI identified the type and extents of chemicals by collecting soil and groundwater samples for a wide range of analytical parameters. The sampling plan was developed based on historic operations, chemical use, handling and disposal. The Stage 1 RI data represent the soil and groundwater conditions at the source sites upgradient of the Study Area. These data will be used as the basis for selecting analytical parameters for groundwater samples collected in the PGOU.

Recent Data: Recent groundwater data were collected from 1998 through the present. The recent data include the results of sampling in accordance with the *Annual Groundwater Monitoring Plans* (GMPs), and other miscellaneous sampling (Aerojet, 2001). The following recent data are available:

Sector B:	VOC, perchlorate, NDMA, nitrate, and general minerals data collected near the southern property boundary monitor and extraction wells.
GET B South:	VOC, perchlorate, NDMA, nitrate, general minerals, limited SVOC, and metals data from southern monitor and extraction wells.
Domestic Supply Wells:	Quarterly to monthly halogenated VOCs (HVOCs), perchlorate, and NDMA data collected from domestic wells within and downgradient of the Study Area.

Groundwater samples were also periodically analyzed for other purposes, including samples collected to evaluate the pilot testing, and sampling of newly installed monitor and extraction wells. The GMPs prepared for the Study Area did not typically include analytical methods for non-VOCs that were infrequently detected.

5.0 CHARACTERIZATION OF CHEMICALS IN GROUNDWATER

The following sections present analysis with respect to identifying the types (Section 5.1) and extents (Section 5.2) of chemicals in groundwater. The information is presented to identify Data Gaps or show that sufficient data are available to achieve the following RI/FS objectives:

1. Identify the types of chemicals in groundwater.
2. Assess the extent of chemicals in the groundwater at concentrations identified by potential chemical-specific applicable or relevant and appropriate requirement (ARARs) or To-be-Considered Criteria (TBCs).
3. Assess chemical concentration trends in groundwater.
4. Evaluate fate and transport of chemicals in groundwater.
5. Identify other general water quality parameters that may affect in-situ or ex-situ treatment alternatives.

The first two objectives are assessed in Sections 5.1 and 5.2. Recent groundwater data are summarized and Data Gaps are identified. Chemicals are described as "defined" or "characterized" if the lateral and vertical extent was assessed to the RL. Differences between RLs and WQOs are discussed in the *Work Plan* (EMSI, 2002). Data Collection Activities are developed from the DQOs and are numbered and forwarded to the *Work Plan*.

The FS will evaluate changes in groundwater chemical concentrations during the effectiveness evaluation for GET B.

- Data Gap: Historical and recent groundwater chemical data are needed to assess chemical concentrations over time.

Z3-6. Historical and recent chemical concentrations will be plotted to assess chemical concentration trends (Table C-1).

The GET B effectiveness evaluation will assess contaminant distribution, fate, and transport near the Sector B and GET B South extraction wells.

- Data Gap: Data are needed to assess the lateral and vertical extent of chemicals near the GET B and GET B South extraction wells.

Z3-7. All existing and proposed cross-sections will be updated with the most recent chemical and water level data (Table C-1).

- Data Gap: Quality Assurance/Quality Control steps are needed to ensure the data are representative for the RI/FS figures and tables.

Z3-8. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

The fate and transport of chemicals in groundwater will be assessed using available physical, hydrologic, and chemical data. These data will be used to estimate groundwater velocities, chemical migration rates, and remedial alternatives for the Study Area. There are sufficient chemical data available to support the treatability evaluation in the FS. Data for various other water quality parameters (e.g., anions) are available to evaluate in-situ and ex-situ remedial alternatives.

5.1 Types of Chemicals in Groundwater

The following section describes the process for assessing the types of chemicals in groundwater. Data Collection Activities are developed to assess chemicals detected previously in the Study Area groundwater, but not sampled recently. The Stage 1 RI soil and groundwater data include the most comprehensive suite of analytical methods sampled in the Study Area. These data were used to identify the types of chemicals previously detected in the Study Area.

Data Collection Activities will be conducted for those chemicals detected in groundwater during the Stage 1 RI, but not analyzed recently. Metals will be sampled if they were reported above the reported site background levels in soil, and they were reported above current WQOs in groundwater. Metals will also be sampled if they were analyzed during the Stage 1 RI or recently with a RL above the current WQO.

5.1.1 Sector B

Excluding VOCs, the chemicals detected in soil and groundwater at the source sites in Zone 3 are summarized in Table C-3. Of the chemicals retained as potential Study Area analytes, VOCs, NDMA, perchlorate, and nitrate were recently sampled and there are no data needed to identify these chemicals.

The recent data are limited for naphthalene, TPH-kerosene, chromium, and lead that were detected in soil and groundwater upgradient of the PGOU (Table C-3). Recent data are also limited for 1,4-dioxane and phenol that were detected in groundwater, but not in soil (Table C-3).

- Data Gap: Data are needed to assess chemicals previously detected upgradient of the PGOU including naphthalene, TPH-kerosene, chromium, lead, 1,4-dioxane, and phenol, and to assess metals analyzed with RLs exceeding WQOs.

Z3-9. Samples will be collected from monitor wells 145-7, 3488-90, 378, 379, and 3506 and analyzed for 1,4-dioxane, naphthalene, TPH-kerosene, phenol, aluminum, antimony, arsenic, cadmium, total chromium, chromium^{+6}, and lead (Table C-1). The samples collected for metals analyses will be filtered.

Metals were handled at various locations in Sector B including the Pickling Facility Area located just north of the GET B treatment plant (Site 18B)(Figure C-1). Ten metals were reported in soils above the presumed site background levels. Lead, aluminum, and chromium were the only metals reported in groundwater above current RWQCB-CVR Water Quality Objectives (WQOs). The detection limits during the Stage 1 RI exceeded the current WQOs for antimony, arsenic, and cadmium.

- Data Gap: Data are needed to assess metals at the southern property boundary from the metals pickling facility in Sector B.

Z3-10. Filtered samples will be collected from monitor wells 154-56 and analyzed for aluminum, antimony, arsenic, cadmium, total chromium, chromium^{+6}, and lead (Table C-1).

5.1.2 Areas 39 and 40

Excluding VOCs, the chemicals detected in soil and groundwater at Areas 39 and 40 during the Stage 1 RI are summarized in Table C-2. Metals and dioxins/furans were detected in soil at Area 40, but were not analyzed in groundwater.

- Data Gap: Data are needed to verify dioxins/furans, antimony, beryllium, chromium, copper, selenium, and mercury detected in soil samples, but not analyzed in groundwater.

Z3-11. Samples will be collected and analyzed for metals (filtered) and dioxins/furans from alluvial monitor wells 1696, 817, 822, 1515, and 798, and from bedrock monitor wells 30060 and 1514 (Table C-1). The samples will also be analyzed for SVOCs to address uncertainties regarding the nature of waste materials deposited in Area 40.

A review of data collected from Area 39 shows that VOCs and perchlorate were reported in groundwater during the Stage 1 RI (Table C-3). Three (Wells 1575, 1577, and 1578) of the 11 monitor wells near Area 39 were sampled recently for VOCs, perchlorate, and NDMA. Perchlorate was the only compound detected recently, although VOCs and perchlorate were historically detected in some wells not sampled recently.

- Data Gap: Data are needed to assess historical detects of VOCs and perchlorate, and to assess NDMA analyzed previously with a RL of 0.10 µg/l.

Z3-12. Samples will be collected and analyzed for VOCs, perchlorate, and NDMA from monitor wells 1575, 1577, 1578, 1318, 791, 796, 1317, 1337 (Table C-1).

5.2 Lateral and Vertical Extent of Chemicals in Groundwater

The extent of chemicals recently detected in the Study Area groundwater is evaluated in this section. TCE, NDMA, and perchlorate were the most common and widely distributed compounds in groundwater, and their extents encompass the extents of all other chemicals. The following evaluation primarily discusses the extents of TCE, perchlorate, and NDMA since their extents encompass the remaining chemicals. The shallowest groundwater (Layer A) is discussed first, followed by the deeper groundwater in Layers B, C, D, E, and F.

Nitrate was identified as an analyte for the Study Area, however there are sufficient recent data to assess nitrate (Table C-3). Iso-concentration maps were not prepared for nitrate because nitrate exceeded WQOs within the areas where WQOs were exceeded by other chemicals. There are no Data Collection Activities for nitrate.

5.2.1 Layer A

The majority of monitor wells in Layer A are dry. Monitor wells that contained water and were sampled are located in the northern and western areas of Sector B, the WRND, and in Areas 39 and 40. The extent of chemicals in groundwater in Areas 39 and 40 is discussed in Sections 5.2.7 and 5.2.8, respectively. The distribution of TCE, perchlorate, and NDMA in Layer A is shown on Figures C-12 to C-14, respectively.

The upgradient monitor wells in northern Sector B were not sampled recently. However, monitor well 3522, located just north of the Study Area yielded TCE at 22,000 µg/l (Figure C-12). The extent of TCE in the northern area is undefined; however, Layer A is dry along the southern property boundary. TCE was reported up to 1.7 µg/l in the wells west and south of Sector B. Perchlorate was reported at 730 µg/l in Well 413, located in an area where groundwater flows southwest towards the Zone 2 Study Area (Figure C-13). NDMA was reported in Well 84 at a concentration of 0.018 µg/l, which is also located in an area where groundwater flows southwest towards Zone 2 (Figure C-14). The extent of TCE and perchlorate above WQOs in Layer A is not defined in Sector B; however, groundwater does not flow off the property in Layer A, and there are no Data Collection Activities for Layer A.

5.2.2 Layer B

Most of the wells that contained water in Sector B and at GET B South were sampled recently. The lateral extents of TCE, perchlorate, and NDMA are shown on Figures C-15 through C-17, respectively. TCE, perchlorate, and NDMA were detected in a north-south trending plume that originates north of the former GET B pond and extends beyond the southern property boundary. The highest concentrations of TCE (490 µg/l), perchlorate (82 µg/l) and NDMA (64 µg/l) in Layer B were detected at the southern property boundary near Gate 7. The monitor wells directly south of Gate 7 are dry, however perchlorate and NDMA were detected near Grant Line Road and extending into the southern area of GET B South (Figures C-16 and –17). The lateral extent of TCE, perchlorate, and NDMA is defined west of Gate 7 by Well 3443. There are no monitor wells east of Gate 7 along the southern property boundary, although upgradient wells Wells 3488 and 3369 are dry.

At GET B South, TCE (4.3 µg/l), perchlorate (33 µg/l), and NDMA (0.28 µg/l) were detected in Well 1544 (33 µg/l), the furthest downgradient monitor well in Layer B. The downgradient extent of these chemicals is not defined below WQOs, although Layer B is dry east of Well 1544. Three groundwater extraction wells were installed south of Well 1544 in Fall 2001 that which should contain chemicals in Layers B, C, and D. Besides routine monitoring that will be conducted during the startup and operation of the new extraction wells, there are no Data Collection Activities for Layer B at GET B South.

5.2.3 Layer C

The lateral extents of TCE, perchlorate, and NDMA in Layer C are shown on Figures C-18, -19, and –20, respectively. Each of these chemicals is distributed across most of the width of the southern property boundary. The highest TCE (540 µg/l) and NDMA (61 µg/l) concentrations were detected at Gate 7, and probably originated upgradient at the liquid rocket test areas. The highest perchlorate concentrations (400 µg/l) were detected west of Gate 7, downgradient of the thermal treatment area (Exhibit III Potential Source Site 11G)(Figure C-19). The western extents of TCE, perchlorate, and NDMA are defined to their respective RLs along the southern property boundary near the WRND. The eastern extents of chemicals along the southern property boundary can be inferred from the relatively low chemical concentrations reported in upgradient monitor wells 3492 and 96 (Figures C-16, -17, and –18, respectively).

There are no monitor wells screened in Layer C near the northern source areas where the highest chemical concentrations were reported during the Stage 1 RI. Analytical data from the source areas is not necessarily needed for the PGOU RI/FS; however, the groundwater flow paths from the source areas into the various hydrostratigraphic layers should be assessed.

- Data Gap: The structure, continuity, and groundwater flow paths in the hydrostratigraphic layers should be assessed from the northern source areas to the southern property boundary.

The data needed to evaluate groundwater flow paths will be obtained by the preparation of four cross-sections in Sector B (Section 3.2.5, Activity Z3-3).

At GET B South, the downgradient southern extents of NDMA and perchlorate were characterized to their respective RLs (<0.0075 and <4 µg/l, respectively)(Figures C-19 and 20). Monitor well 30068, the southern-most monitor well, yielded TCE at 13 µg/l, which is above the WQO of 0.8 µg/l.

- Data Gap: Additional data are needed to assess the southern extent of TCE in Layer C above WQOs.

Z3-13. One monitor well (P1) will be installed approximately 2,000 feet southeast of Well 30168, with one screened interval in Layer C and two screened intervals in Layer D (Table C-1).

The western extent of chemicals at GET B South is defined by monitor wells at the WRND, and there are no additional data needed. The extent of chemicals in the eastern area of GET B South can be inferred by the southwest direction of groundwater flow, and data from eastern-most monitor wells 1547 and 1262. There are no additional Data Collection Activities for Layer C at GET B South.

5.2.4 Layer D

The lateral extents of TCE, NDMA, and perchlorate are similar in Layer D as in overlying Layer C (Figures C-21, -22, and -23, respectively). The highest TCE and NDMA concentrations were detected upgradient of Gate 7 in eastern Sector B (Figure C-22). The highest perchlorate concentrations were detected west of Gate 7 at GET B South (Figure C-23). The lateral extent of chemicals is characterized along the southern property boundary, and no additional data are needed. Additional evaluation of the groundwater flow paths from the northern source areas to the southern property boundary will be conducted during the preparation of the four cross-sections discussed in Section 3.2.5 (Activity Number Z3-3).

At GET B South, the distribution of chemicals in Layer D is nearly the same as in overlying Layer C (Figures C-21, -22, and -23, respectively). The western extents of TCE, perchlorate, and NDMA are characterized to their respective RLs by monitor wells in the WRND and GET B South. The eastern extent of chemicals can be inferred from the distribution of chemicals in Sector B, and the southwest direction of groundwater flow. Water level and chemical data from newly installed Well 30185 were unavailable for this Report but will be incorporated into the PGOU RI/FS. The furthest downgradient monitor wells at GET B South yielded maximum concentrations of TCE (27 µg/l), NDMA (0.044 µg/l), and perchlorate (25 µg/l).

- Data Gap: Data are needed to assess the southern extents of TCE, NDMA, and perchlorate in Layer D to concentrations identified by WQOs.

These data will be collected by completing two screened intervals in Layer D during the installation of the monitor well that will be installed in Layer C (Section 5.2.3, Activity Z3-12)(Table C-1). There are no other Data Collection Activities for Layer D.

5.2.5 Layer E

Two monitor wells are screened in Layer E in Sector B, Well 3507 near Gate 7 and Well 354, west of gate 7 near the WRND. NDMA (0.045 µg/l) was reported in Well 3507 and TCE (<0.5 µg/l) and perchlorate (<4 µg/l) were not detected. It was interpreted that the TCE and perchlorate reported in dual-screened Extraction Wells 4475 and 4480 is in Layer F. Layer E is absent in Sector B just north of the southern Site boundary (Figure C-3).

- Data Gap: Data are needed to assess the continuity and structure of Layers E and F in Sector B.

These data will be collected during the preparation of the four cross-sections in Sector B (Section 3.1.5, Activity Number Z3-3)(Table C-1).

There are 14 monitor wells screened in Layer E at GET B South. Perchlorate was detected in the western area and perchlorate, TCE, and NDMA were detected in the eastern area (Figures C-25, -26, and –27, respectively). Towards the west, the lateral extent of perchlorate is defined to the east, west and south.

Further east, perchlorate (55 µg/l), TCE (19 µg/l) and NDMA (48 µg/l) were detected just north of the SVRA in Well 1548 (Figures C-24, -25, -26, respectively). There are no wells upgradient of Well 1548. Several borings drilled near Well 1548 encountered low-permeability sediments at the depths that Layer E is typically present, and no monitor wells were installed. Well 1548 is located near a hydrologic divide and the structure of the layers and geologic formations may be different than in western GET B South.

- Data Gap: Additional data are needed to assess the continuity, structure, and groundwater flow paths for Layers E and F at GET B South.

Z3-14. The two north-south cross-sections (E-E' and F-F') that will be constructed in Sector B will be expanded to GET B South (Activity Number Z3-3). The stratigraphy near Well 1548 will be assessed and additional cross-sections may be prepared to assess the structure of Layers E and F at GET B South.

5.2.6 Layer F

Monitor wells screened in Layer F and located in Sector B and GET B South yielded TCE, perchlorate, and NDMA (Figures C-27, -28, and –29, respectively). The monitor wells in Sector B are located along the southern property boundary, and most wells at GET B South are located 2,000-4,000 feet south of the southern property boundary. The eastern extent of chemicals along the southern property boundary is defined by Well 345, and the western extent can be inferred from the direction of groundwater flow and GET B South Wells 1445 and 1450. The groundwater flow paths from the source sites to Layer F at the southern property boundary are not characterized.

- Data Gap: Data are needed to assess the continuity, structure, and groundwater flow paths from the northern source areas to the southern property boundary in Layer F.

These data will be collected during the preparation of the four cross-sections in Sector B (Section 3.1.5, Activity Number Z3-3)(Table C-1). There are no additional Data Collection Activities for Layer F in Sector B.

At GET B South, TCE, perchlorate, and NDMA were detected centered near Wells 1495 and 1549 (Figures C-27, -28, and –29, respectively). The downgradient extent of TCE, perchlorate, and NDMA are characterized to concentrations of 25, 63, and 58 µg/l, respectively. Several borings drilled near Well 1549 encountered low-permeability sediments at the depths that Layer F is typically present, and no monitor well was installed. This area is located near a geologic/hydrologic divide and the structure of the Layers and geologic formations may be different than further to the west.

- Data Gap: Additional data are needed to assess the continuity and structure of Layer F to evaluate the potential groundwater flow paths for at GET B South.

The two north-south cross-sections (E-E' and F-F') that will be constructed in Sector B will be expanded to GET B South. Logs from borings drilled near Well 1549 will be reviewed and additional cross-sections may be prepared if needed to assess the structure of Layers E and F at GET B South (Section 3.1.5, Activity Z3-3).

The western and southwestern extents of TCE, perchlorate and NDMA are defined to their respective RLs, and there are no additional Data Collection Activities for Layer F.

5.2.7 Water Supply Wells

Wells 1059, 1159 and 1299 are sampled quarterly for HVOCs, NDMA, and perchlorate (Figure 2-4, *Work Plan*). Well 1816 is sampled monthly for HVOCs and quarterly for NDMA and perchlorate (Aerojet, 2001). TCE was reported at approximately one µg/l in Well 1816. An air-stripper is being designed for Well 1943 to remove VOCs believed to have originated at the WRND (EMSI and CVEI, 2001). VOCs, NDMA, and perchlorate were not reported in the remaining water supply wells. There are sufficient data to assess domestic water supply wells in Sector B.

5.2.8 Area 39

There are nine monitor wells screened either in perched groundwater or Layer A at the Prairie City SVRA (Area 39)(Figure C-12). Five shallow auger wells (Wells 791, 792 and 794 to 796) are located near the source sites and are screened in perched groundwater (ICF Kaiser Engineers, 1993).

None of the auger wells was sampled recently, and Wells 791 and 795 were the only wells sampled during the Stage 1 RI. Both wells yielded dichloromethane (a suspected laboratory contaminant), aluminum (up to 52 mg/l), barium (up to 0.52mg/l) chromium (up to 0.05 mg/l), and nitrate (up to 17 mg/l). Perchlorate was not detected in either well during the Stage 1 RI (<400 and <500 µg/l)(ICF Kaiser, 1993).

Auger wells 1575, 1577, and 1578 were installed after the Stage 1 RI, downgradient of potential source Sites 32B/33B, 29B, and 30B, respectively (Figure C-1). These wells replaced auger Wells 792, 794, and 796 that were not located or sampled during the Stage 1 RI. TCE (<0.5 µg/l) and NDMA (<0.05 µg/l) were not detected in samples collected from Wells 1575, 1577, and 1578 in 1998. Freon-113 was detected at 5.9 and 1.9 µg/l in Wells 1577 and 1578, respectively, well below the MCL of 1,200 µg/l.

Perchlorate (up to 7mg/kg) and nitroguanidine (0.10 mg/kg) were detected in soils during the Stage 1 RI at one location, Site 30B. Well 1578, installed downgradient of Site 30B, yielded perchlorate at a concentration of 230 µg/l when last sampled in 1998 (Figure C-13). Wells 1575 and 1577 recently yielded perchlorate at 9.9 and 69 µg/l, respectively (Figure C-13).

- Data Gap: Additional data are needed to assess the lateral and vertical extent of perchlorate in Area 39, and to assess NDMA at the current RL of 0.0075 µg/l.

The groundwater samples that will be collected for VOCs, NDMA and perchlorate analyses will provide the data necessary for evaluating the extent of chemicals in Area 39 groundwater (Section 5.1.2, Activity Number Z3-11).

There are no other Data Collection Activities for groundwater in Area 39. However, additional Data Collection Activities may be developed depending on the results of the groundwater sampling and hydrologic evaluation.

5.2.9 Area 40

Area 40 is located east of the east of Prairie City Road on Aerojet property (Figure C-30). Portions of Area 40 were formerly used to burn chemical waste and to separate TCE sludge. The geographic features in Area 40, including the source sites and roads, will be digitized onto base-maps from aerial photographs for the PGOU RI/FS.

There are two hydrostratigraphic units in Area 40, the Alluvial and Bedrock Aquifers. The Alluvial Aquifer is comprised of fine-grained silt and clay and may be weathered-in-place bedrock. The thickness of the Alluvial Aquifer varies but is typically 15- to 20-feet thick near the western property boundary. The Bedrock Aquifer underlies the alluvium and is comprised of moderately-weathered shale and slate. This is the same bedrock encountered beneath the Zone 4 Study Area.

The potentiometric surface for the Alluvial Aquifer dips west, suggesting alluvial groundwater flows onto the main Aerojet property (Figure C-6). There were not sufficient recent water level measurements to assess the hydraulic gradients in the Alluvial and Bedrock Aquifers. Data Collection Activity Z3-3 (Section 3.2.1) will provide information to assess the groundwater flow properties in Area 40. Groundwater flowing onto Aerojet appears to flow south towards GET B.

Recent and historical analytical data from Area 40 suggests that DNAPL TCE may be present in the Alluvial Aquifer. TCE was recently reported at 59,000 µg/l in Well 1696, which is approximately 5 percent of the solubility for TCE at 25° Celsius (Horvath, 1982)(Figure C-30). EPA guidance suggests the observed TCE concentrations could be indicative of "free-phase" product or DNAPL TCE (EPA, 1992). TCE was detected at 170 µg/l in the Alluvial Aquifer at the western boundary of Area 40 (Figure C-30).

The highest TCE concentration in the Bedrock wells was 300 µg/l detected in Well 30060, at the western property boundary (Figure C-31). Monitor wells screened in the Bedrock beneath the suspected source area yielded TCE ranging from non-detect (<1.0 µg/l) to 5.4 µg/l (Figure C-31).

Perchlorate was detected in the Alluvial and Bedrock wells in Area 40. Well 1696, screened in the Alluvium Aquifer yielded the highest perchlorate (and TCE) concentration at 6,600 µg/l (Figure C-32). Perchlorate was detected at 64 µg/l in Alluvial Aquifer Well 30061 at the western property boundary. Perchlorate was not analyzed in Bedrock wells located near the source areas, but was detected at 2,700 µg/l in Bedrock Well 30060 (Figure C-33).

The Data Collection Activities developed for Area 40 are based on the potential presence of DNAPL TCE in the Alluvial Aquifer. If DNAPL is present, an EPA Technical Impracticability (TI) Waiver or RWQCB Containment Zone Designation (CZ) may be requested for Area 40 groundwater. The EPA notes that DNAPL can limit the ability of a remedial action to achieve cleanup goals identified by ARARs, and has set forth criteria for evaluating the technical feasibility and reliability of potential remedial options. If EPA's criteria are met, a Technical Impracticability (TI) Waiver may be issued for the relevant ARARs (EPA, 1993b).

Similarly, State Water Resources Control Board (SWRCB) policy designates a CZ for groundwater that is technically and economically unfeasible to cleanup to the levels identified by ARARs (SWRCB, 1996). SWRCB Resolution 92-49 states that a TI Waiver issued under CERCLA meets the substantive requirements of the RWQCB-CVR Policy for a Containment Zone Designation, provided certain provisions are met, including notification by EPA (RWQCB -CVR, 1997).

EPA TI and State CZ Policies require the following:

- The specific ARARs for which the TI determination will apply;
- The spatial area over which the TI decision will apply;
- A conceptual model that describes the site geology, hydrogeology, groundwater contamination sources, transport, and fate;
- An evaluation of the restoration potential for the site that includes:
    - Evaluation of data and remedial system performance collected during previous remedial actions;
    - A predictive analyses of the cleanup times to achieve ARARs and cleanup levels;
    - A technical evaluation of potential remedial technologies; and
    - Construction and operation and maintenance costs for any proposed remedy.
- A Management Plan that includes an evaluation of source removal, a monitoring program that includes proposed monitoring locations, analytes, frequencies, and the reporting requirements and frequencies. The Management Plan includes descriptions of how to evaluate the monitoring data and contingencies for the migration of contaminants outside of the CZ.

The following Data Collection Activities will be conducted in Area 40:

The depth to water will be measured quarterly for one year in all alluvial and bedrock monitor wells as discussed in Section 3.2.1 (Activity Number Z3-3). These data will be used to assess groundwater flow directions, gradients, and seasonal water level fluctuations.

Z3-15. One groundwater sample will be collected and analyzed for VOCs, perchlorate, NDMA, and SVOCs from alluvial wells 1695, 30061, 1515, 1694, 821, 812, 817, 798, 818, 822, 813, and from bedrock wells 30060, 1537, 1514, 1536, 1513, and 1512. A second sample will be collected approximately 3 months after the first sample. The second samples will be analyzed for VOCs, perchlorate, and any other compounds detected in the first sample (Table C-1).

Z3-16. The size of the area where the TI Waiver or CZ may be appropriate will be assessed

Z3-17. A SCM will be prepared that includes the site geology, hydrogeology, groundwater contamination sources, chemical fate and transport characteristics, exposure pathways, and potential receptors.

Z3-18. A technical and economic comparison of potential remedial alternatives will be conducted.

Z3-19. A Groundwater Management Plan will be prepared if a TI Waiver or CZ designation is appropriate for Area 40. The contents of the Plan, other than those required by RWQCB, will be further assessed pending the collection the additional RI data.

6.0 SUMMARY OF DATA COLLECTION ACTIVITIES

The Data Collection Activities described below were developed based on the data needs described in the preceding Sections.

This Section and Table C-1 will be provided to the field and laboratory personnel for implementation. The standard operating procedures for sample collection, handling, and analyses will be followed as specified in the Site-wide Quality Assurance Project Plan (QAPP)(Aerojet, 2001). Data Collection Activities that will be conducted in the Zone 3 Study Area include the following:

Z3-1. Two north-south trending cross-sections will be prepared in Sector B, one from Gate 7 to Well 97 and a second from Well 344-5 to Well 97. Two east-west trending cross-sections will be constructed perpendicular to the direction of groundwater flow in the northern and southern areas in Sector B. The monitor wells on each cross-section are listed in Table C-1.

Z3-2. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with data collected in October 2001.

Z3-3. Water levels will be collected quarterly from all auger and monitor wells in Area 40 for a period of one year to compare water level elevations between wells and to evaluate seasonal water level trends.

Z3-4. Three cross-sections will be constructed to compare the lithology, depth to water, chemical concentrations, and depth of screened intervals for the monitor wells in Area 39. The monitor wells included on the cross-sections are identified in Table C-1.

Z3-5. Water levels will be collected quarterly from all auger and monitor wells in Area 39 for a period of one year to compare water level elevations between wells and to evaluate seasonal water level trends.

Z3-6. Temporal chemical concentration trends will be prepared and evaluated and may be used to assess potential cleanup times.

Z3-7. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

Z3-8. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

Z3-9. Samples will be collected from monitor wells 145-7, 3488-90, 378, 379, and 3506 and analyzed for 1,4-dioxane, naphthalene, TPH-kerosene, phenol, aluminum, antimony, arsenic, cadmium, total chromium, chromium^{+6}, and lead.

Z3-10. Samples will be collected from monitor wells 154-56 and analyzed for aluminum, antimony, arsenic, cadmium, total chromium, chromium^{+6}, and lead.

Z3-11. Samples will be collected and analyzed for metal and dioxins/furans from alluvial monitor wells 1696, 817, 822, 1515, and 798, and from bedrock monitor wells 30060 and 1514 (Table C-1). The samples will also be analyzed for SVOCs to address uncertainties regarding the nature of waste materials deposited in Area 40.

Z3-12. Samples will be collected and analyzed for VOCs, perchlorate, and NDMA from monitor wells 1575, 1577, 1578, 1318, 791, 796, 1317, 1337.

Z3-13. One monitor well (P1) will be installed approximately 1,000 feet southeast and southwest of Well 30168, with one screened interval in Layer C and two screened intervals in Layer D.

Z3-14. The two north-south cross-sections (E-E' and F-F') will be constructed in Sector B and GET B South. The stratigraphy near Well 1549 will be assessed and additional cross-sections may be prepared to assess the structure of Layers E and F at GET B South.

Z3-15. One groundwater sample will be collected and analyzed for VOCs, perchlorate, NDMA, and SVOCs from alluvial wells 1695, 30061, 1515, 1694, 821, 812,817, 798, 818, 822, 813, and from bedrock wells 30060, 1537, 1514, 1536, 1513, and 1512. A second sample will be collected approximately 3 months after the first sample for VOCs, perchlorate, and all other chemicals reported in the first samples.

Z3-16. The size of the area where a TI Waiver or CZ designation is appropriate will be assessed.

Z3-17. A Site Conceptual Model will be developed for Area 40 including the site geology, hydrogeology, groundwater contamination sources, chemical fate and transport characteristics, exposure pathways, and potential receptors.

Z3-18. The feasibility of restoring groundwater in Area 40 will be assessed by conducting a technical and economic comparison of potential remedial alternatives.

Z3-19. A Management Plan will be prepared if a TI Waiver or CZ designation is appropriate for Area 40. The contents of the Plan will be further assessed pending the collection of the additional RI data.

7.0 REFERENCES

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[redacted]

TABLE C-1: RI/FS Data Collection Activities - Zone 3 Study Area

PRELIMINARY DRAFT

Activity Number	Location	Data Collection Activity	Layer	Target Analytes	EPA Method	Reporting Limit (ppb) [1]	Lowest WQO (ppb) [2]	Number Samples	Rationale
Z3-1	Sector B	Construct Cross-sections E-E': 344-5, 96, 3491-3, 97 F-F': 145-7, 154-6, 103, 3488-90, 3369-71, 97 G-G': 3270-71, 3477-9, 103, 3488-90, 90, 344-5 H-H': 91, 3369-71, 3491-3	All	NA	NA	NA	NA	NA	Assess continuity and structure of hydrostratigraphic layers near source areas to evaluate groundwater flow paths towards southern property boundary.
Z3-2	All	Prepare hydrographs using historical and recent GW data. Prepare potentiometric surface maps with data collected in October 2001.	All	NA	NA	NA	NA	NA	Assess seasonal and temporal water level trends.
Z3-3	Area 40	Collect quarterly water level measurements, prepare potentiometric surface maps.	Alluvial Bedrock	NA	NA	NA	NA	4	Assess seasonal and temporal water level trends.
Z3-4	Area 39	Construct Cross-sections I-I': 1318, 795, 796, 1578, 791 J-J': 1575, 792, 1577, 791 K-K': 1571, 795, 796, 1337	Perched, A & B	NA	NA	NA	NA	NA	Assess the hydraulic connection, if any, between perched groundwater and Layers A and B in Area 39.
Z3-5	Area 39	Collect quarterly water level measurements, prepare potentiometric surface maps.	Perched, A, B	NA	NA	NA	NA	4	Assess seasonal and temporal water level trends.
Z3-6	All	Temporal chemical concentration trends will be plotted.	All	TCE NDMA perchlorate miscellaneous	NA	NA	NA	NA	Assess GET effectiveness and estimate potential cleanup times.
Z3-7	All	All existing and proposed cross-sections will be updated with the most recent chemical and water level data.	All	NA	NA	NA	NA	NA	Assess vertical distribution of chemicals and evaluate effectiveness of existing GET B remedial system.
Z3-8	All	Finalize chemical iso-concentration maps and review data.	All	NA	NA	NA	NA	NA	Ensure the representativeness of all data for the RI/FS.
Z3-9	Sector B	Sample wells 145, 3488 and 3506.	B	1,4-dioxane, naphthalene	8270	10	NA	1 [3] [4]	Assess chemicals detected upgradient of southern property boundary during Stage 1 RI.
				Phenol	604	2	NA		
		Sample Wells 146, 378 and 3489.	C	Aluminum	6010	100	60		
				Antimony	7041	5	6		
				Arsenic	7060	5	50		
				Cadmium	213.2 Mod.	1	0.07		
		Sample Wells 147, 379 and 3490.	D	Total chromium	218.2 Mod.	1	2.5		
				Chromium^{+6}	7196	5	0.2		
				Lead	239.2	3	2		

Activity Number	Location	Data Collection Activity	Layer	Target Analytes	EPA Method	Reporting Limit (ppb) [1]	Lowest WQO (ppb) [2]	Number Samples	Rationale
Z3-10	Sector B	Sample Well 154.	B	Aluminum	610	100	60	1 [3] [4]	Assess metals downgradient of Pickling Facility Area.
				Antimony	7041	5	6		
		Sample Well 155	C	Arsenic	7060	5	50		
				Cadmium	213.2 Mod.	1	0.07		
				Total chromium	218.2 Mod.	1	2.5		
		Sample Well 156	D	Chromium+6	7196	5	0.2		
				Lead	239.2	3	2		
Z3-11	Area 40	Sample Wells 1696, 817, 822, 1515 and 798.	Alluvial	metals	6010	Varies	Varies	1 [3] [4]	Assess chemicals previously detected in soils but not analyzed in groundwater.
				dioxins/furans	8080?	Varies	Varies		
		Sample Wells 30060 and 1514.	Bedrock	SVOCs	8270	Varies	Varies		
Z3-12	Area 39	Sample Wells 1575, 1577, 1578, 1318, 791, 796, 1317, and 1337.	Perched, A & B	VOCs	8260	Varies	Varies	1 [3]	Assess chemicals detected historically in groundwater or analyzed with reporting limits above Water Quality Objectives.
				perchlorate	EA-0040	4	4		
				NDMA	EA-0036	0.0075	0.002		
Z3-13	GET B South	Install Monitor Well (P1)	C (1 screens) D (2 screens)	NA	NA	NA	NA	NA	Assess southern extent of TCE in Layer C and TCE, NDMA, and perchlorate in Layer D.
Z3-14	Get B South	Expand cross-sections E-E' and F-F' into Get B South.	All	NA	NA	NA	NA	NA	Data are needed to assess the continuity and structure of Layer F to evaluate the potential groundwater flow paths for at GET B South.
Z3-15	Area 40	Sample Wells 1695, 30061, 1694, 821, 812, 818, and 813.	Alluvial	VOCs	8260	Varies	Varies	2 [3] [5]	Assess lateral extent of chemicals detected historically and recently; assess presence of chemicals not analyzed historically but potentially present based on activities conducted.
				NDMA	EA-0036	0.0075	0.002		
		Sample Wells 1537, 1536, 1513, and 1512.	Bedrock	Perchlorate	EA-0040	4	4		
				SVOCs	8270	Varies	Varies		
Z3-16	Area 40	Evaluate area for Containment Zone Designation.	All	NA	NA	NA	NA	NA	Conduct Technical Impracticability evaluation consistent with EPA Guidance and RWQCB Containment Zone Designation Policy.
Z3-17	Area 40	Develop Site Conceptual Model.	All	NA	NA	NA	NA	NA	
Z3-18	Area 40	Assess feasibility of groundwater restoration.	All	NA	NA	NA	NA	NA	
Z3-19	Area 40	Prepare Management Plan.	All	NA	NA	NA	NA	NA	

Notes:

(1) Reporting Limits are the lowest analytical reporting limit that the proposed method and analytical laboratory are capable of achieving.

(2) WQO - Water Quality Objective is the lower of the primary Federal or State maximum contaminant level (MCL) verses State Public Health Goal (PHG).

(3) Propose 1 sample to be collected. If target analyte is detected then resample within 30 days to confirm/verify initial result.

(4) All groundwater samples collected for metal analyses will be field filtered prior to laboratory submittal.

(5) A second round of samples will be collected approximately 3 months after the first round and analytes will be reduced to VOCs and perchlorate as well as for NDMA or SVOCs if detected during first round.

NA = Not Applicable

NDMA = N-Nitrosodimethylamine

TABLE C-2: Summary of Aquifer Test Data - Zone 3 Study Area

PRELIMINARY DRAFT

Pumping Well	Date of Test	Transmissivity (gpd/ft)	Storativity	Hydraulic Conductivity (ft/day)	Hydrostratigraphic Layer
GET B					
4011	3/28/93	12,500 to 18,336	2.2 to 6.9 x 10^{-4}	30.9 to 53.2	C
4405	9/12/95	20,000 to 28,000	1 to 2.2 x10^{-4}	38 to 53	B/lower B
GET B South					
4085	11/5/85	15535	2.2 x 10^{-4}	13	C/D
4095	4/26/88	2,500 to 4,900	1.9 x 10^{-4} to 6.2 x 10^{-5}	18.6 to 34.7	C/D
4215	11/14/88	12,900 - 11,500	1.1x 10^{-4} to 8.0 x 10^{-5}	4.0 to 19.1	C/D
4195	4/18/88	4,100-4,300	4.9 to 0.17 x 10^{-5}	4	C/D
4400	8/22/95	39,169 to 64,899	1.1 to 1.8 x 10^{-4}	77 to 128	B
4410	9/19/95	39,026 to 54,620	1.1 to 3.3 x 10^{-4}	50 to 70	B
4460	10/16/96	36,358 to 40,983	1.9 x 10^{-4}	58 to 65	B
4465	10/31/96	54,200 to 62,230	1.5 x 10^{-4}	101 to 116	B
4450	10/23/96	9,200 to 41,000	1.1 to 5.6 x 10^{-4}	9 to 41	B
4455	10/9/96	20,000 to 46,000	1.4 x10^{-4} to 1.7 x10^{-3}	22 to 42	B
4475	1/28/97	21,000 to 46,000	1.7 x 10^{-3} to 1.4 x 10^{-4}	14 to 55	D
4480	12/3/96	10,000 to 37,000	4x10^{-4} to 1.2x10^{-6}	10 to 37	C

TABLE C-3: Summary of Chemicals Detected During Stage 1 Remedial Investigation - Zone 3 Study Area

PRELIMINARY DRAFT

CLASS / Compound	Detected in Soil [1]	Potential Source Site(s) Detected [2]	Detected in Groundwater [3]	Hydrostratigraphic Layer Detected	Comments	Potential Study Area Analyte
On-Site Zone 3 (Sector B)						
SVOCs						
1,4-dioxane	No	NA	Yes	A, Perched	Northern and Central Zone 3 Wells	Yes
Napthalene	NA	NA	Yes	A	Northern Area Well 363	Yes
PAHs/PNAs	Yes	18B	No	A		No
NON-VOCs						
Perchlorate	Yes	14B & 22B	Yes	A		Yes
NDMA	Yes	12A/1B, 28B, 23B, 25B & 16B	Yes	A		Yes
PCBs	Yes	26B	Not Analyzed	A	Shallow soils only - characterized at depth.	No
TPH - kerosene	Yes	12A/1B, 9B, A(e), 8B, 14B, Pickling Facility Area, & 28B	Yes	A	Southern Zone 3 Wells	Yes
Nitrate	No	NA	Yes	A	Southern Zone 3 Wells	Yes
Phenol	No	NA	Yes	A	Historical data in southern wells	Yes
METALS						
Aluminum	No	NA	Yes	A	Northern Zone 3 wells - unfiltered sample	Yes
Antimony	Yes	12A/1B	No[4]	NA		No
Arsenic	Yes	12A/1B, 14B, 27B, 7B, 23B, & 66B	No[4]	NA		No
Barium	Yes	66B, Pickling Facility Area, & 27B	No	NA		No
Cadmium	Yes	12A/1B, 14B, & 27B	No[4]	NA		No
Chromium	Yes	66B	Yes	A	Northern Zone 3 wells -unfiltered sample	Yes
Cobalt	Yes	27B	No	NA		No
Copper	Yes	12A/1B, 14B, 27B, & 12B	No	NA		No
Lead	Yes	12A/1B, & 14B	Yes	A	Southern Zone 3 wells - unfiltered sample	Yes
Mercury	Yes	66B, 23B, & 27B	No	NA		No
Area 40						
SVOCs						
Dioxins/Furans	Yes	38B, 39B, & 40B	Not Sampled	NA		No
METALS						
Antimony	Yes	38B, 39B, & 40B	Not Sampled	NA		Yes
Beryllium	Yes	38B, 39B, & 40B	Not Sampled	NA		Yes
Chromium	Yes	38B, 39B, & 40B	Not Sampled	NA		Yes
Copper	Yes	38B, 39B, & 40B	Not Sampled	NA		Yes
Selenium	Yes	38B, 39B, & 40B	Not Sampled	NA		Yes
Mercury	Yes	38B, 39B, & 40B	Not Sampled	NA		Yes

TABLE C-3: Summary of Chemicals Detected During Stage 1 Remedial Investigation - Zone 3 Study Area

PRELIMINARY DRAFT

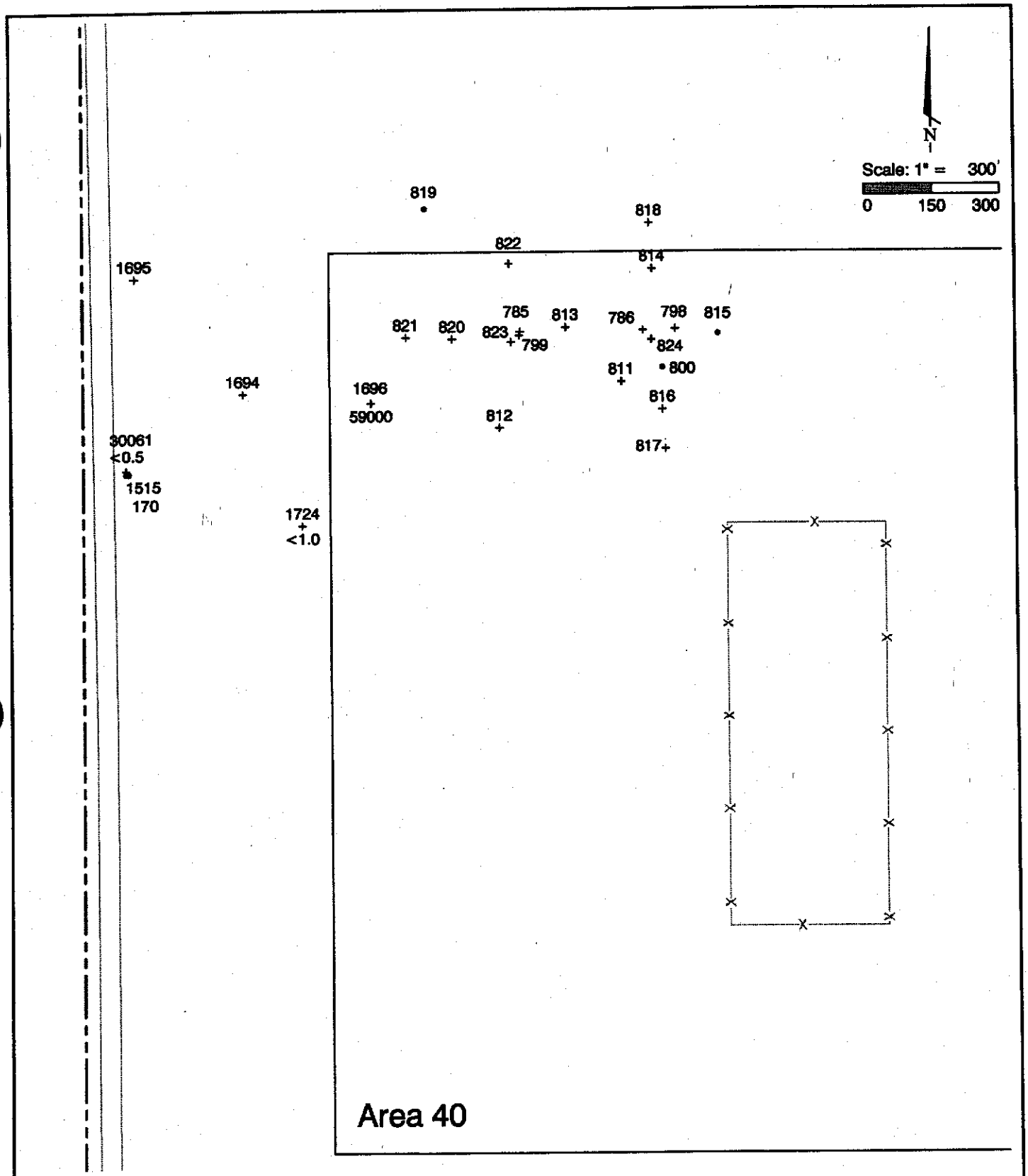
CLASS / Compound	Detected in Soil [1]	Potential Source Site(s) Detected [2]	Detected in Groundwater [3]	Hydrostratigraphic Layer Detected	Comments	Potential Study Area Analyte
AREA 39						
Non-VOCs						
Perchlorate	Yes	30B, & 35B[5]	Yes[5]	A		Yes
Nitroguanidine	Yes	30B	Not Sampled	NA	Characterized in shallow soils	No
Dioxins/Furans	Yes	30B, 31B, 32B, & 34B	Not Sampled	NA	Characterized in shallow soils	No
Metals						
Aluminum	Yes	NA	Yes	A	Unfiltered sample at 791/795	No
Antimony	Yes	29B & 35B[5]	No[4]	NA		No
Arsenic	Yes	30B [5] & 35B[5]	No[4]	NA		No
Beryllium	Yes	34B[5]	No[4]	NA		No
Cadmium	Yes	29B	No[4]	NA		No
Copper	Yes	29B	No	NA		No
Lead	Yes	30B [5]	No[4]	NA		No
Mercury	Yes	29B & 35B[5]	No	NA		No

Notes:

1 Metals reported if above presumed site background levels, Borch, 1994.
2 Source: Stage 1 Report - Zone 1, ICF Kaiser Engineers, 1993.
3 Metals reported if above Primary MCLs or RWQCB Public Health Goals.
4 Reporting limits above Primary MCLs and/or PHGs.
5 Historical data (1985) - Not sampled during Stage 1 RI.
PAH Poly-aromatic hydrocarbon
PNA Poly-nucleaulic hydrocarbon
NDMA N-Nitrosodimethylamine
NA Not Applicable

PAGES OF OVERSIZED MAPS

(SEE BINDER)



EXPLANATION

KEY TO WELL SYMBOLS

103 / Well Identification

+ / Well Type and Location

54 — TCE Concentration in µg/l
If Blank, No Sample During Time Period

WELL TYPES

+ Monitor Well

⊠ Abandoned Well

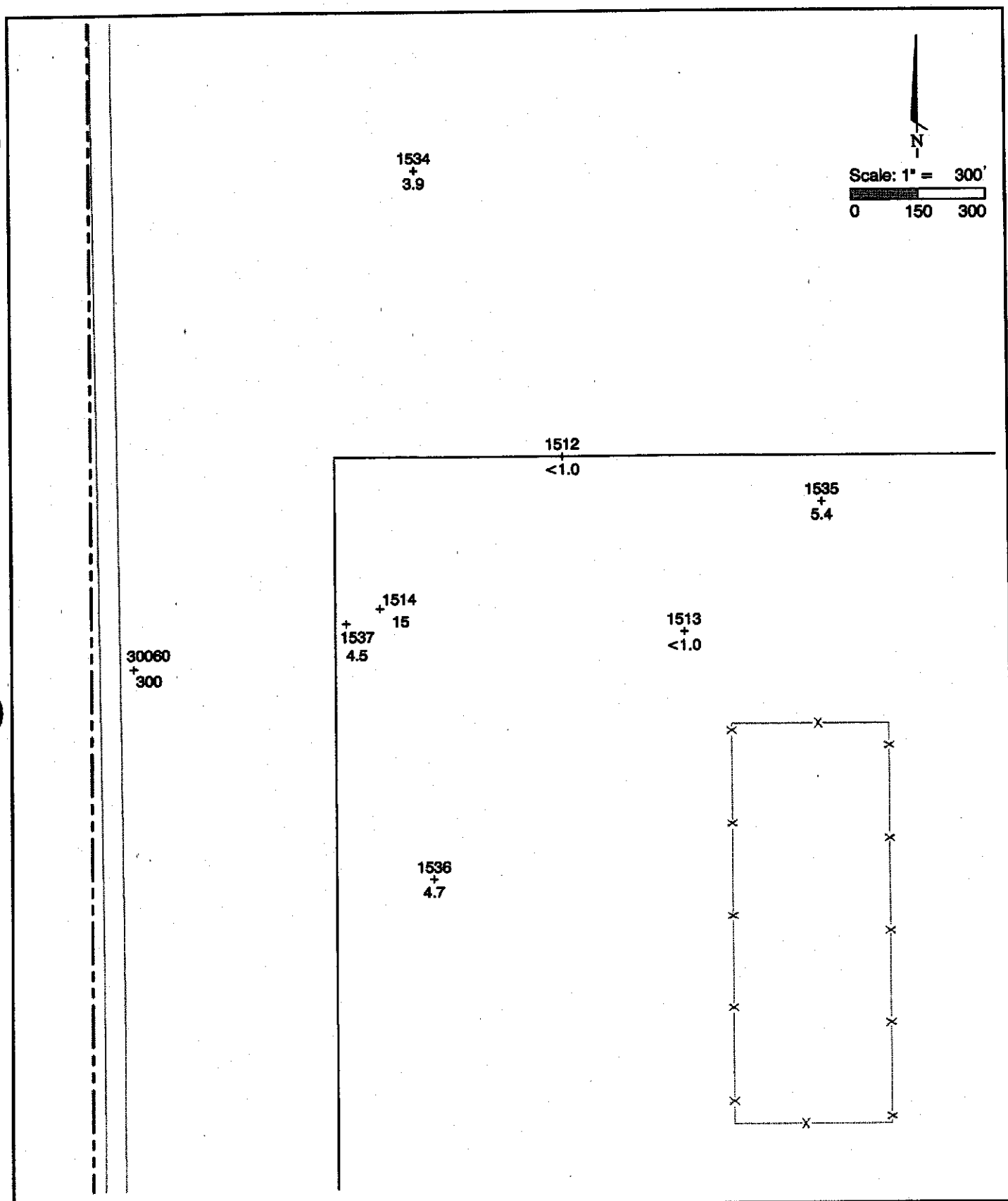
• Auger Hole

AEROJET
Environmental Remediation

DRAFT

FIGURE C-30
Area 40 Alluvial Wells
TCE in Groundwater
1994-2001 Most Recent Results

1/25/02 kk SR10111708



EXPLANATION

KEY TO WELL SYMBOLS

103 / + / 54 — Well Identification / Well Type and Location / TCE Concentration in µg/l
If Blank, No Sample During Time Period

WELL TYPES

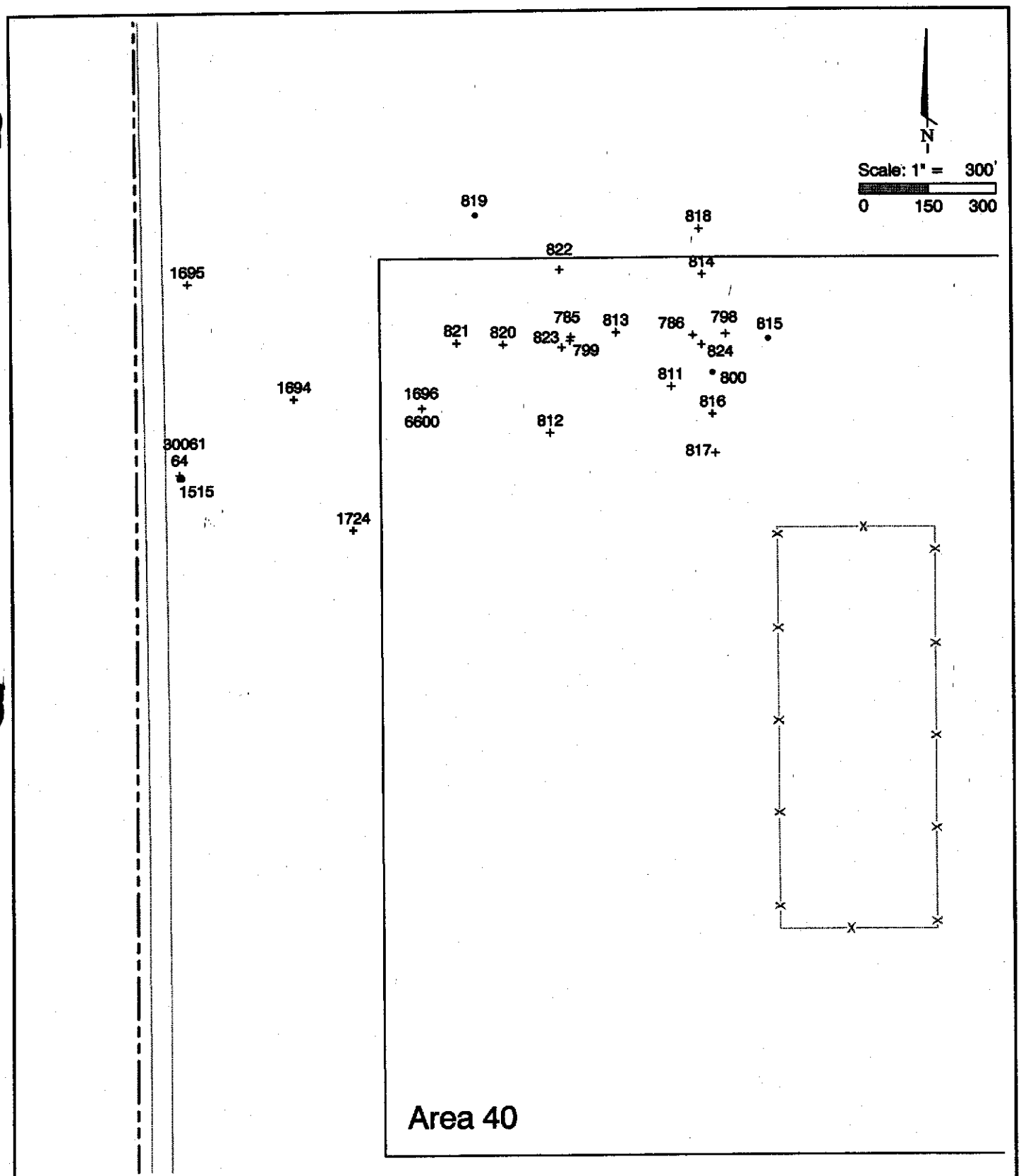
+ Monitor Well

AEROJET
Environmental Remediation

DRAFT

FIGURE C-31
Area 40 Bedrock Wells
TCE in Groundwater
1994-2001 Most Recent Results

3/27/02 kk SR10111711



EXPLANATION

KEY TO WELL SYMBOLS

103 — Well Identification
+ — Well Type and Location
54 — Perchlorate Concentration in µg/l
If Blank, No Sample During Time Period

WELL TYPES

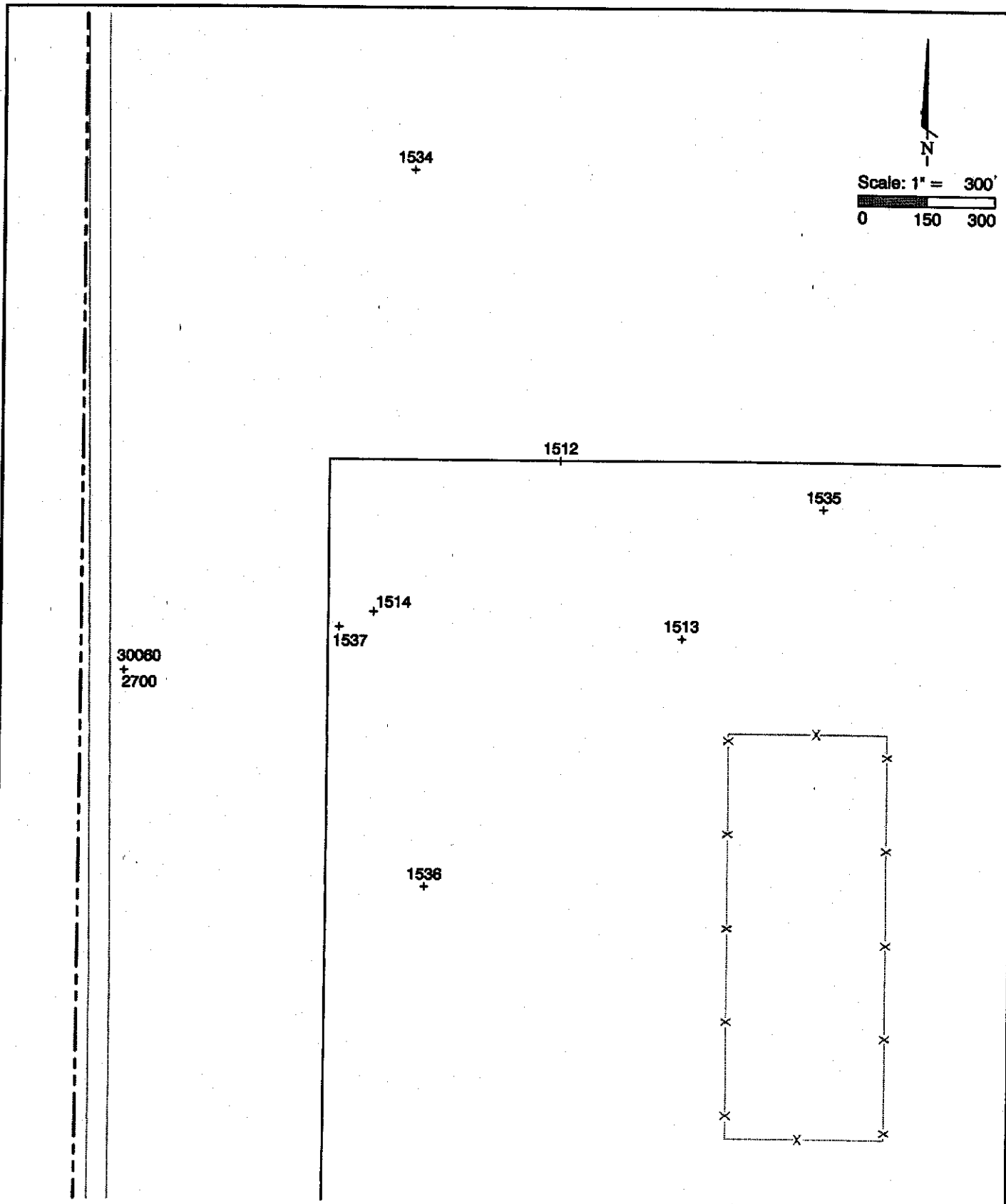
+ Monitor Well
⊠ Abandoned Well
• Auger Hole

AEROJET
Environmental Remediation

DRAFT

FIGURE C-32
Area 40 Alluvial Wells
Perchlorate in Groundwater
1994-2001 Most Recent Results

3/27/02 kk SR10111709



EXPLANATION

KEY TO WELL SYMBOLS

103 / + / 54 — Well Identification / Well Type and Location / Perchlorate Concentration in µg/l If Blank, No Sample During Time Period

WELL TYPES

+ Monitor Well

AEROJET
Environmental Remediation

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FIGURE C-33
Area 40 Bedrock Wells
Perchlorate in Groundwater
1994-2001 Most Recent Results

3/27/02 kk SR10111710

APPENDIX D
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 4 STUDY AREA

AEROJET GENERAL SUPERFUND SITE
SACRAMENTO, CALIFORNIA

Prepared for:

AEROJET
A GenCorp Company

Aerojet General Corporation
Sacramento, California

Prepared by:

CENTRAL VALLEY ENVIRONMENTAL, INC.

With assistance from:

Aerojet General Corporation
Environmental Remediation Department

April 16, 2002

APPENDIX D
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 4 STUDY AREA

AEROJET GENERAL SUPERFUND SITE SACRAMENTO, CALIFORNIA

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April 16, 2002

APPENDIX D
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 4 STUDY AREA

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LIST OF ACRONYMS

ARAR	applicable or relevant and appropriate requirement
bgs	Below the ground surface
BRA	Baseline Risk Assessment
DQOs	Data Quality Objectives
DCA	Dichloroethane
DCE	Dichloroethene
DNAPL	dense non-aqueous phase liquid
EPA	U.S. Environmental Protection Agency
Freon-113	1,1,2-trichloro-1,2,2-trifluoroethane
FS	Feasibility Study
ft	Feet
ft/day	Feet per day
ft/ft	Feet per feet
gpm	gallons per minute
GET	Groundwater extraction and treatment
GMP	Groundwater monitoring plan
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
msl	Mean sea level
NPDES	National Pollutant Discharge Elimination System
NDMA	n-nitrosodimethylamine
PCB	Poly-chlorinated biphenyl
PCE	Tetrachloroethene
PGOU	Perimeter Groundwater Operable Unit
PQL	Practical Quantitation Limit
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RL	Reporting Limit
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RWQCB	Regional Water Quality Control Board
SCM	Site Conceptual Model
TBC	To-Be-Considered Criteria
TCA	Trichloroethane
TCE	Trichloroethene
TPH	Total Petroleum Hydrocarbons
VOCs	Volatile organic compounds
WGOU	Western Groundwater Operable Unit
WMUs	Waste management units
WQOs	Water Quality Objectives

APPENDIX D
DRAFT DATA ASSESSMENT AND DATA COLLECTION ACTIVITIES REPORT PERIMETER GROUNDWATER OPERABLE UNIT RI/FS AEROJET SITE - ZONE 4 STUDY AREA

1.0 INTRODUCTION

This *Draft Data Assessment and Data Collection Activities Report* (Report) addresses the portion of Zone 4 that is located within the Perimeter Groundwater Operable Unit (PGOU). Zone 4 is located in the northeast area of the Aerojet property, and is one of four zones (Zones 1 through 4) included in the PGOU Remedial Investigation/Feasibility Study (RI/FS)(Figure D-1). The Zone 4 Study Area (Study Area) includes areas upgradient of Sector A and the groundwater extraction and treatment [(GET) A] system and Sector C.

This Report, combined with the *PGOU RI/FS Work Plan* (*Work Plan*), includes the elements identified in the "*United States Environmental Protection Agency (EPA) General Guidelines for Conducting an RI/FS*" (EPA, 1988). The Work Plan describes the common regional characteristics of the Zones, including the Work Plan Rationale, Data Quality Objectives (DQOs), Preliminary Site Conceptual Model (SCM), fate and transport, exposure pathways, and potential remedial alternatives [Engineering Management Support, Inc. (EMSI) et. al., 2002]. This Report describes the local characteristics of the Study Area including local physical characteristics, hydrogeology, remedial investigation background, and the distribution of chemicals in groundwater.

1.1 Objectives

The objectives of this Report are to assess available data and develop Data Collection Activities for the *Work Plan* to obtain the data necessary for completing the Zone 4 portion of the PGOU RI/FS. The Data Collection Activities were developed by comparing the available data with the data needed (Data Gaps) to complete the Remedial Investigation (RI), feasibility study (FS) or Baseline Risk Assessment (BRA), following the EPA DQO Process (EPA, 1994). Each section of this Report describes the data needs and how the data apply to the PGOU RI/FS. Identified Data Gaps are bulleted and their associated Data Collection Activities are numbered (e.g., Z4-1) and forwarded to the *Work Plan.*

1.2 Organization

The descriptions in this Report are brief and intended to provide enough information to support the Data Collection Activities. The analytical data referenced in this Report are included on a CD-ROM. This Report is organized into the following sections:

Section 1: Introduction - Describes the location of the portion of Zone 4 in the PGOU, and describes the location of the Zone 4 Study Area. Introduces the objectives for this Report, and outlines the report organization.

Section 2: Physical Study Area Characteristics – Background summary of the physical characteristics in the Study Area that will be used to develop the SCM in the PGOU RI/FS.

Section 3: Local Hydrogeology - Discusses the Study Area stratigraphy and groundwater flow conditions and identifies Data Gaps. Data Collection Activities are developed to fill those Data Gaps that will support the RI, FS, and BRA.

Section 4: Remedial Investigation Background - Summarizes the previous investigations in the Study Area, describes the industrial practices, chemical use, handling, and disposal at the upgradient source sites. This section also describes previous groundwater cleanup actions within the Study Area.

Section 5: Characterization of Chemicals in Groundwater - Describes the types and extents of chemicals detected in Study Area groundwater. Data Gaps are identified and Data Collection Activities are developed to obtain the data.

Section 6: Summary of Data Collection Activities - Summarizes the Data Collection Activities forwarded to the *Work Plan*.

Section 7: References - Lists references cited in this Report.

2.0 PHYSICAL STUDY AREA DESCRIPTION

This section provides background information regarding the physical characteristics of the Study Area, including the size, topography, land and groundwater use, and local surface water bodies. The regional descriptions were summarized from the *Work Plan* (Sections 2 and 3). The following information will be incorporated into the SCM prepared during the PGOU RI/FS.

The PGOU boundaries generally include all Aerojet-related chemicals in groundwater at and beyond the property boundaries. However, chemicals do not appear to be present at or beyond the property boundaries in the Study Area, so Alder Creek and the GET A extraction wells were selected as practical boundaries for the PGOU (Figure D-1). A larger area, the Zone 4 Study Area (Study Area), was assessed to consider data collected upgradient of the PGOU. The Study Area includes Sector A and the GET A remedial system, and Areas 30, 31, and 32 (Figure D-1). The Study Area also includes Sector C, the northern portion of Area 46, and the closed Aerojet Landfill (Figure D-1). Area 21, a former water filtration plant, is located in the northwest area of Sector C (Figure D-1). Chemicals were not detected in Area 21 during the Stage 1 RI/FS, and this area is not addressed further in this Report (ICF Kaiser, 1993).

The northern and eastern property boundaries of the PGOU roughly parallel US Highway 50 and Prairie City Road, respectively (Figure D-1). The Zone 1 and 3 Study Areas are located west and south of the Zone 4 Study Area, respectively. The northern and eastern property boundaries are approximately 3.5 miles long, and the Study Area encompasses approximately 1,200 acres.

2.1 Land Use

Aerojet property upgradient of the PGOU is zoned for industrial use, and the industrial activities are described in Section 4.1. The closed Aerojet Landfill encompasses approximately 190 acres of formerly dredged sediments (Minshew Engineering, 1997). Most of the land surrounding the source sites is undeveloped and was not used for industrial operations. This undeveloped buffer land surrounding the management areas was recently removed from the Sacramento Superfund Site boundaries following a Site Assessment approved by the over-sight Agencies (Figure D-1).

Sacramento County Ordinance, Title V, Chapter 8 designate the Aerojet property as a "Special Planning Area", Article 3 of the Zoning Code of Sacramento County. This ordinance identifies existing permitted uses and "provides a regulatory mechanism for making land use decisions that maintain a safe environment in which the subject property can be used given the special requirements of the property owner".

US Highway 50 parallels the northern property boundary (Figure D-1). The area north of US Highway 50 supports mixed land uses including areas of undeveloped land skirting industrial, commercial, and residential land use associated with the southwestern limits of the City of Folsom. The land west of the Study Area is used for residential, commercial

and recreational purposes (Appendix A). The land east of the Study Area is undeveloped pastureland.

2.2 Groundwater Use

Groundwater is not currently used for domestic or industrial purposes in the Study Area; although groundwater is extracted at GET A. Future groundwater use in lands removed from the Superfund Site boundary is limited by environmental restrictions. There are no water supply wells located within one mile of the Study Area, and the nearest water supply wells are located at Lake Natoma in the Zone 1 Study Area (Figure 2-3, *Work Plan*).

The only identified groundwater use in the Study Area is the water extracted from the GET A remedial system. The GET A extraction wells currently withdraws approximately 250 gallon per minute (gpm) of groundwater. The extracted groundwater is treated and discharged to Rebel Hill Ditch where it infiltrates prior to reaching Buffalo Creek.

2.3 Topography

The land surface in the Study Area dips gently to the southwest. Surface elevations range from approximately 350 feet above mean sea level (ft msl) in the east to approximately 150 ft msl in the west, where Alder Creek enters Lake Natoma. Alder Creek has incised a westward-dipping, east-west trending valley that is 40 to 70 feet below the elevation of the adjacent slopes. The slope of the creek banks range from 3.5- to 5-percent and dip towards the creek from the north and south. The high area south of Alder Creek appears to be associated with the Ancestral American River terrace scarps present in Zones 1 and 2. The majority of dredging in the Study Area occurred on the terrace south of Alder Creek. The dredging has created an undulating topography of tailing piles (highpoints) and slickens areas (low points).

2.4 Local Surface Water

Regional and local surface water bodies are discussed the *Work Plan* (Section 2.6, Figure 2-4). Alder Creek and Rebel Hill Ditch are local surface water bodies in the Study Area. Rebel Hill Ditch is a man-made canal that originates in southern Zone 4 and extends south into Zone 3. Alder Creek flows west from its entry point near the northeastern Site boundary and discharges into Lake Natoma just west of Folsom Boulevard. The creek receives surface water runoff from the undeveloped land to the north and south, and may receive runoff from the closed Aerojet Landfill and Areas 30 and 31. The creek typically flows year round at its exit point; however, it is often dry during the summer where it enters the Aerojet property. Data Gaps regarding the possible discharge of shallow groundwater to Alder Creek are discussed in Sections 3.2.2 and 5.2.2. Lake Natoma is west of the Study Area in the Zone 1 Study Area, and is identified because it is the receiving water body for Alder Creek.

3.0 LOCAL HYDROGEOLOGY

The following sections discuss the general lithology and define the hydrostratigraphic layers beneath the Study Area, followed by a discussion of groundwater flow directions and hydraulic gradients. The data presented in this section provide the basis for the chemical iso-concentration maps, analysis of fate and transport, and the GET A effectiveness evaluation and optimization that will be conducted during the PGOU RI/FS.

The following descriptions of the hydrostratigraphic layers in Sectors A and C are from the *Zone 4 GET Effectiveness Report* (GET A Report), and was updated where new information was available (Aerojet, 1995). The groundwater flow discussions are based on recent groundwater data collected in April 2001.

3.1 Hydrostratigraphy

The sediments beneath the Study Area were divided into three hydrostratigraphic layers defined based on lithologic descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thickness. The Dredged Layer is the shallowest layer and is underlain by Layers A and B. In addition, a crystalline shale bedrock has been identified beneath the sediments. The following sections present the general lithologic descriptions of the layers in the Study Area, followed by an evaluation of groundwater flow directions, gradients, and pumping test data. There may be local variations to the descriptions provided below.

The general lithology and hydrostratigraphic layer boundaries are presented on three cross-sections originally presented in the GET A Report, and presented in this evaluation as Cross-sections A-A' to C-C' (Figures D-2 to D-4, respectively). Cross-section A-A' trends north-northwest to south-southeast across Sector C, parallel to the direction of groundwater flow (Figure D-2). Cross-section B-B' trends west-east, parallel to Alder Creek, and approximately perpendicular to groundwater flow direction in the northern Study Area (Figure D-3). Cross-section C-C' trends north/south along the eastern portion of Sector A, and roughly parallels groundwater flow direction in this portion of the Study Area (Figure D-4). These cross-sections will be included in the evaluation of the effectiveness of GET A and the evaluation of remedial alternatives.

3.1.1 Dredged Layer

The Dredged Layer is composed predominantly of sands and gravel with lenses of inter-bedded clay and silt. Dredging extended to depths of approximately 40 to 120 feet below ground surface (ft bgs)(Figures D-2 and D-3). The Dredged Layer is present primarily in Sector C, and is present in Sector A beneath the terrace south of Alder Creek. The Dredged Layer is present beneath portions of the former Aerojet Landfill and Area 46.

3.1.2 Layer A

Layer A is present in Sectors A and C and is composed of clay, silt, sand, partially cemented sand, and locally abundant gravel (Figure D-3). The silt and clay materials comprise over half the 30 to 120-foot thickness of Layer A. The silt and clay appears to have been dredged, and separates the Dredged Layer from Layer A in Sector C (Figures

D-2 and D-3). In the eastern portion of the Study Area, the Dredged Layer is absent and Layer A is the upper-most layer (Figures D-3 and D-4). The top of Layer A is present at depths ranging from 25 ft bgs near Alder Creek in Sector A to 100 ft bgs in Sector C (Figure D-3). Layer A is underlain by clay that overlies shale bedrock in Sector A. Layer A is underlain by an approximately 50-foot thick aquitard that overlies Layer B in the western portion of Sector C (Figure D-2).

- Data Gap: Data are needed regarding the continuity of hydrostratigraphic layers near Alder Creek to assess potential groundwater discharge to the creek.

Z4-1. Two cross-sections (A-A' and B-B') will be updated/constructed near Alder Creek to evaluate the hydrostratigraphic continuity and structure of Layer A (Table D-1).

3.1.3 Layer B

Layer B is present below Layer A in Sector C, west of Wells 89, 3396, and 3505 (Figure D-2). Layer B is absent in Sector A (Figures D-3 and D-4). The saturated portions of Layer B are comprised predominantly of sand, gravel and shale fragments. The base of Layer B has not been reached by the seven wells screened in this layer, although it is at least 30 to 50 feet thick. The top of Layer B is encountered at approximately 90 ft bgs near Alder Creek, to as deep as 150 ft bgs beneath the Aerojet Landfill.

3.1.4 Bedrock

The sediments beneath the Study Area overlie Bedrock that was encountered during the construction of five monitoring wells (Wells 483, 3263, 3373, 3376, and 3467) in Sector A, but has not been reached in Sector C (Figures D-3 and D-4). Bedrock outcrops at the eastern property boundary along Alder Creek, and dips three to four degrees to the west under the sediments (ICF Kaiser, 1994). Bedrock was encountered at depths down to 200 ft bgs in Sector A. The bedrock is predominantly composed of shale and slate.

3.2 Groundwater Flow

The following sections discuss the groundwater flow directions and lateral hydraulic gradients in the Dredged Layer through the Bedrock. The data presented in this section will be used for the following purposes in the PGOU RI/FS:

1. Evaluate temporal and seasonal water level trends, and

2. Identify groundwater flow directions and calculate hydraulic gradients that will be used in part to estimate groundwater velocities, contaminant migration rates, and potential cleanup times.

- Data Gap: Historic and recent groundwater elevation data are needed to evaluate water-level trends.

Z4-2. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with groundwater data collected on October 2001.

Potentiometric surface maps were created for each layer with water level data collected during the plant-wide monitor well sounding in April 2001 using Surfer® for Windows (Version 7)(Figures D-5, -through D-8, respectively). The contour lines were not changed from the Surfer® output except that some contours lines were trimmed near the border areas where the data did not support the extension of the contour lines. The average water levels were used in cases where more than one well was screened in the layer, and the water levels from the GET A extraction wells were not used to prepare the maps.

The overall groundwater flow direction is to the northwest in the Dredged Layer, Layer A, and Layer B; however, the groundwater within bedrock appears to flow more to the north. There are local deviations in groundwater flow directions apparently associated with surface water features and groundwater withdrawal at GET A.

3.2.1 Dredged Layer

The Dredged Layer is saturated within a small portion of Sector A and the majority of Sector C. The highest groundwater elevation in the Dredged Layer was 261 ft msl observed in the southeast, and the lowest elevation was 210 ft msl northwest of the Aerojet Landfill (Figure D-5). Groundwater in the Dredged Layer flows northwest with an average hydraulic gradient of approximately 0.012 feet per feet (ft/ft). The hydraulic gradient increases to 0.020 ft/ft near the northern portion of the Aerojet Landfill. The sediments comprising the Dredged Layer are absent along Alder Creek, and it is anticipated that groundwater from the Dredged Layer migrates vertically into Layer A.

3.2.2 Layer A

Layer A is saturated throughout the Study Area. Groundwater elevations in Layer A ranged from approximately 257 ft msl in the southeast to 170 ft msl in the northwest (Figure D-6). Groundwater mounding is apparent near Area 32 and appears to separate Zones 4 and 3 (Figure D-6). In the east, groundwater in Layer A flows north-northwest towards GET A extraction wells with an hydraulic gradient of approximately 0.009 ft/ft. Groundwater north of Alder Creek (where measured) appears to flow southwest towards Alder Creek and the GET A extraction wells with an hydraulic gradient of approximately 0.007 ft/ft.

In the west, groundwater flows northwest with a hydraulic gradient of approximately 0.009 ft/ft. Groundwater flow appears to follow topography south of Alder Creek where it flows northwest towards Alder Creek, with an approximate hydraulic gradient of 0.019 ft/ft. Seasonal seeps have been observed on the hillside between the Aerojet Landfill and Alder Creek.

- Data Gap: Data are needed to evaluate the possible discharge of Layer A groundwater to Alder Creek.

Z4-3. Potentiometric surface maps for Layer A will be compared to the elevations of Alder Creek to assess whether Alder Creek is a gaining or losing stream.

Z4-4. Alder Creek will be traversed to identify seeps or springs that could discharge to the creek. Sampling of the creek is discussed in Section 5.

3.2.3 Layer B

Layer B sediments are only present in the western portion of Sector C. Groundwater elevations in Layer B ranged from approximately 220 ft msl in the east to 180 ft msl near the northwestern Study Area boundary (Figure D-7). The contoured potentiometric surface of Layer B shows that the groundwater flow direction is generally to the northwest with an average hydraulic gradient of approximately 0.012 ft/ft.

3.2.4 Bedrock

Groundwater elevations in Bedrock wells ranged from approximately 266 ft msl near Area 32, to 223 ft msl near Alder Creek and the GET A extraction wells (Figure D-8). The contoured potentiometric surface of the Bedrock shows that the groundwater flows in a north-northwesterly direction with an average hydraulic gradient of approximately 0.008 ft/ft. There are no groundwater monitoring wells completed in Bedrock west of Sector A.

3.3 Potentiometric Surface Head Differences

Potential vertical gradients were assessed by evaluating the differences in the elevations of the potentiometric surfaces of the layers (head differences). Groundwater and contaminants may move upwards or downwards between layers if there are sufficient head differences and permeable sediments between the layers. The potentiometric surface elevation of the Dredged Layer is approximately 5 to 10 feet higher than the potentiometric surface elevation of underlying Layer A, suggesting groundwater could migrate downwards from the Dredged Layer into Layer A. The head differences are generally reversed in Layers A and B, where the potentiometric surface elevation of Layer B ranged from 7 to 9 feet above the potentiometric surface elevation of Layer A. The potentiometric surface elevation for the bedrock wells is approximately the same as the potentiometric surface elevation for overlying Layer A in most of the Study Area. Near Alder Creek, the potentiometric surface of the Bedrock is approximately 5 feet higher than the potentiometric surface elevation of Layer A, suggesting the potential for discharge from the Bedrock into Layer A.

3.4 Aquifer Test Data

Hydraulic properties of the aquifer including hydraulic conductivity, storativity, and transmissivity were calculated from data collected during aquifer testing. Data will be presented that will be used to identify aquifer hydrologic properties such as groundwater flow directions and hydraulic gradients, hydraulic conductivity, storativity, and

transmissivity, to estimate groundwater velocity, contaminant migration rates, and potential cleanup times.

The extraction wells near Alder Creek yielded higher conductivities than the extraction wells located in Area 30. The conductivities in Wells 4001 and 4010 ranged from 200 to 890 ft/day, compared to a maximum of 9 ft/day in Area 30 at Wells 4012 and 4013 (Table D-2).

4.0 REMEDIAL INVESTIGATION BACKGROUND

The following sections summarize historical operations conducted at the source sites upgradient of the PGOU. The descriptions are largely from the *Aerojet Site - Stage 1 RI Report Zones 3 and 4*, and includes new data where available (ICF Kaiser, 1993). This discussion identifies the historical activities, materials handled, waste type and handling, previous investigations, suspected source areas, previous cleanup actions, and the existing data available for the Study Area. This information supports the evaluation of the distribution of chemicals in groundwater and the SCM.

4.1 Historical Activities

Historical and recent operations were conducted in Areas 30, 31, and 32 in Sector A (Figure D-1). Sector C includes the Aerojet Landfill and the northern portion of Area 46. The following activities were conducted in these areas:

Aerojet Landfill:	The Aerojet Landfill consisted of four waste management units (WMUs) located within an approximate 190-acre area. Three of the WMUs operated as Class III inert solid waste repository from 1966 through 1989. The fourth WMU was operated as a Class III repository for asbestos materials from 1981 through 1990 (Minshew Engineering, 1997).
Area 30:	Liquid rocket engine and component testing; closed loop pump testing and solvent storage.
Areas 31 & 32:	Titan and Apollo engine cleaning and closed loop propulsor testing.
Area 46:	Solid rocket motor testing, instrumentation, and vibrational and structural testing.

4.2 Materials Handled

Chemicals reportedly handled in the Study Area included solvents, fuels and oxidizers, metals, acids, oils, and other miscellaneous compounds. The *Scoping and Stage 1 RI Reports* summarized the materials handled at each source site (ICF Kaiser, 1991, 1993). The following list is not all-inclusive, but summarizes the primary materials historically handled in the Study Area:

Solvents:	Trichloroethane (TCA), trichloroethene (TCE), tetrachloroethene (PCE), 1,1,2-trichloro-1,2,2-triflouroethane (Freon-113), methanol, methylene chloride, and isopropyl alcohol.
Fuels & Oxidizers:	Unsymmetrical dimethyl hydrazine, hydrazine, kerosene, hydrazine propellants, liquid hydrogen, liquid oxygen, nitrogen tetroxide, nitrates, JP-4, RP-1, and hydrogen peroxide.
Metals:	Aluminum, copper sulfate, mercury, and silver.
Acids:	Nitric, and hydroxyacetic.
Oils:	Hydraulic oil, oils, and PCB oil.

Miscellaneous: sodium hydroxide, sodium hyposulfate, sodium sulfite, detergents, ethylene glycol, and photo chemicals.

4.3 Waste Type and Handling

Waste management practices varied during historic operations. Liquid wastes were often directed to sumps, lined and unlined evaporation ponds, or chemical storage tanks. Inert solid wastes were typically land-filled on- or off-site. The majority of source sites are associated with liquid waste handling and disposal and include sumps, drainages, low areas, and/or ponds.

4.4 Previous Investigations

The geologic and hydrologic conditions, distribution of chemicals in groundwater, and evaluation of source areas in the Study Area have been studied since the mid-1980's. The background information for the RI/FS and the most recent interpretations of geologic, hydrologic, and chemical conditions in the Study Area groundwater were presented in the following reports:

- "*Scoping Report and Phase 1 RI/FS Workplan*": Identified and summarized existing history of potential source sites; evaluated chemical use and disposal; proposed analytical methods for sampling and analysis, including an analytical approach to evaluate non-standard chemicals for the Stage 1 RI/FS (ICF Technology, 1989).
- "*Stage 1 RI/FS Report – Zones 3 and 4*": Results of soil-gas, soil, and groundwater samples collected from source sites in Zones 3 and 4 (ICF Kaiser Engineers, 1993).
- "*Zone 4 GET Effectiveness Report*": Summary of geologic and hydrologic conditions near GET A were provided in this report (Aerojet, 1995).
- "*Hydrogeologic Evaluation of Western Zone 4*": An unpublished technical report regarding the hydrogeology of western Zone 4 (Aerojet, 1994).
- "*Aerojet Landfill, Solid Waste Assessment Test (SWAT) Report*": Initial investigation of soil, surface water, and groundwater at the Aerojet Landfill (McLaren Environmental Engineering, 1987).
- "*Final Closure and Post Closure Maintenance Plan for the Aerojet Landfill*": Describes closure and post-closure monitoring. Summarizes waste, vadose zone (soil-gas and soil sampling) and groundwater sampling conducted in 1994-1995 at the closed Aerojet Landfill (Minshew Engineering, 1997).
- "*Stage 2 RI/FS Sampling and Analysis Work Plan*": Work plans to complete RI/FS activities at source areas. Characterization primarily for non-volatile organic compounds detected in soil or groundwater during the Stage 1 RI/FS (GenCorp Aerojet, 1999).

4.5 Suspected Source Areas

There are approximately 39 source sites in the Study Area (Figure D-1). There are different sources of chemicals for Sectors A and C, although some chemicals detected in eastern Sector C may be from Sector A. A summary of the chemicals detected in soil and

groundwater during the Stage 1 RI is presented on Table D-3. The following discussions briefly summarize the background chemical investigations conducted in the Study Area relative to identifying the types and locations of chemicals in groundwater.

4.5.1 Area 46

Portions of Area 46 are located within and upgradient of Sector C (Figure D-1). Area 46 does not appear to be a primary source of chemicals to groundwater within Sector C. TCE and total petroleum hydrocarbons were the only site-related chemicals detected in the vadose zone in northern Area 46 (Sites 1C and 2C). TCE was reported at 2.0 µg/l in soil-gas and TPH was detected up to 20,900 mg/kg in soil samples collected at Site 1C and up to 48 mg/kg in surface soils from Site 2C. The extent of TPH in the vadose zone was not defined at Site 1C and additional characterization for TPH was recommended (Aerojet, 1999). TPH and TCE were detected in groundwater at relatively low concentrations beneath Area 46.

4.5.2 Area 30

TCE was detected in soil-gas samples from Site 2A during the Stage 1 RI at concentrations that suggest the possible presence of dense non-aqueous phase liquid (DNAPL) TCE (Schwille, 1988). Additional volatile organic compounds (VOCs) detected in soil gas at lower concentrations than TCE included Freon-113, 1,2-dichlorothene (DCE), and PCE. N-nitrosodimethylamine (NDMA) was detected in one soil sample collected during the Stage 1 RI at Site 1A, which may be a source of NDMA to groundwater. Metals were not reported above Regional Water Quality Control Board - Central Valley Region (RWQCB–CVR) Water Quality Objectives (WQOs) in shallow groundwater (ICF Kaiser, 1993). Freon-113, TCE, and NDMA were the most common chemicals observed in groundwater downgradient of Area 30.

4.5.3 Areas 31 and 32

Soil gas samples collected during the Stage 1 RI from Source Sites 9A/10A yielded 1,1,1-TCA and Freon-113 at concentrations suggesting the potential presence of DNAPL. 1,1-DCE and TCE were also detected at elevated concentrations at those sites. In the groundwater, 1,1,1-TCA (37,000 micrograms per liter [µg/l]), Freon-113 (36,000 µg/l), 1,1-DCE (13,000 µg/l) and TCE (3,000 µg/l) were the VOCs detected at the highest concentrations. NDMA was not detected in the vadose zone, but was the most common non-VOC reported in groundwater beneath Areas 31 and 32.

4.6 Previous Cleanup Actions

The primary remedial action in the Study Area is GET A. GET A began operating 1986 with 7 extraction wells and an initial flow-rate of 360 gpm. GET A extracts groundwater from Layer A downgradient of Areas 30, 31, and 32, and near a suspected source site in Area 30 (Figure 2-2, *Work Plan*). Extraction wells were added in February 1995, (Wells 4012 and 4013), and extraction Well 4500 was constructed in 1998 to replace extraction Well 4115.

4.7 Existing Data Summary

The PGOU RI/FS for the Study Area will utilize historic, Stage 1 RI, and recent data collected from the early 1980's through 2001. The types of analytes and uses of the available data include:

Historical Data: Groundwater data collected from the early 1980s through 1991; this data will be used to assess chemical concentration trends. The data contain a range of analytical parameters including VOCs, NDMA, and perchlorate. NDMA and perchlorate are reported at their respective RLs of 0.10 µg/land 400 µg/l, which are higher than the current RLs of 0.0075 µg/l and 4 µg/l, respectively.

Stage 1 RI Data: Soil and groundwater data collected from the source areas in 1991 through 1993. The Stage 1 RI identified the type and extents of chemicals by collecting soil and groundwater samples for a wide range of analytical parameters. The sampling plan was developed based on historic operations, chemical use, handling and disposal. The Stage 1 RI data represent the soil and groundwater conditions at the source sites upgradient of the Study Area. These data will be used as the basis for selecting analytical parameters for groundwater samples collected in the PGOU.

Recent Data: Recent groundwater data were collected from 1998 through the present. The recent data include the results of sampling in accordance with the *Annual Groundwater Monitoring Plans* (GMPs), and other miscellaneous sampling (Aerojet, 2001). The following recent data are available:

Sector A: VOCs and NDMA data from Study Area boundary monitor and extraction wells.

Sector C: Groundwater monitoring wells within and downgradient of the closed Aerojet Landfill are analyzed for "landfill analytes". The analytical suite includes VOCs, aromatic volatiles, metals, total organic carbon, alkalinity, chloride, nitrate, sulfate, total dissolved solids, pH, and conductivity.

5.0 CHARACTERIZATION OF CHEMICALS IN GROUNDWATER

The following sections present analysis of the types (Section 5.1) and extents (Section 5.2) of chemicals in groundwater. The information is presented to identify Data Gaps or show that sufficient data are available to achieve the following RI/FS objectives:

1. Identify the types of chemicals in groundwater.
2. Assess the extent of chemicals in the groundwater at concentrations identified by potential chemical-specific applicable or relevant and appropriate requirement (ARARs) or To-Be-Considered-Criteria (TBCs).
3. Assess chemical concentration trends in groundwater.
4. Evaluate fate and transport of chemicals in groundwater.
5. Identify the other general water quality parameters that may affect in-situ or ex-situ treatment alternatives.

The first two objectives are assessed in Sections 5.1 and 5.2. Recent groundwater data are summarized and Data Gaps are identified. Chemicals are described as "defined" or "characterized" if the lateral and vertical extent was assessed to the RL. Differences between RLs and WQOs are discussed in the *Work Plan* (EMSI, 2002). Data Collection Activities are developed from the DQOs and are numbered and forwarded to the *Work Plan*.

The FS will evaluate chemical concentration trends during the effectiveness evaluation for GET A.

- Data Gap: Historic and recent groundwater chemical data are needed to assess chemical concentrations over time.

Z4-5. During the PGOU RI/FS, historical and recent chemical concentrations will be plotted to assess chemical concentration trends.

The GET A effectiveness evaluation will assess contaminant distribution, fate, and transport near the GET A extraction wells.

- Data Gap: Data are needed regarding the lateral and vertical extent of chemicals in the vicinity of the extraction wells to evaluate hydraulic and chemical capture of the GET A remedial system.

Z4-6. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

- Data Gap Quality Assurance /Quality Control (QA/QC) steps are needed to ensure the data are representative for the RI/FS figures and tables.

Z4-7. All chemical iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

The fate and transport of chemicals in groundwater will be assessed using available physical, hydrologic, and chemical data. These data will be used to estimate groundwater velocities, chemical migration rates, and remedial alternatives for the Study Area. There are sufficient chemical data available to support the treatability evaluation in the FS. Data for various other water quality parameters (e.g., anions) are available to evaluate in-situ and ex-situ remedial alternatives.

5.1 Types of Chemicals in Groundwater

The following section describes the available data, the Data Gaps, and the Data Collection Activities to assess the types of chemicals in the Study Area groundwater. The objective is to ensure that recent data are available for chemicals previously detected in the Study Area. The Stage 1 RI were used as the basis for identifying the types of chemicals previously detected in the Study Area. Those data include the most comprehensive suite of analytical parameters sampled in the Study Area.

Data Collection Activities will be conducted for those chemicals detected in groundwater during the Stage 1 RI, but not analyzed recently. Metals will be sampled if they were reported above the site background levels in soil (Borch, 1994), or if they were reported above current WQOs or analyzed during the Stage 1 RI with RLs above WQOs.

5.1.1 Sector A

The types of chemicals detected in Sector A soil and groundwater during the Stage 1 RI are summarized on Table D-3. Of these chemicals, there are sufficient recent data to verify that VOCs and NDMA are present in the Study Area groundwater, and there are no additional Data Collection Activities for theses chemicals in Sector A. 1,4-Dioxane and nitrate were detected during the Stage 1 RI but were not analyzed recently. In addition, perchlorate, which was not detected (<400 µg/l) during the Stage 1 RI, was not sampled recently. There are no known sources of perchlorate or 1,4-dioxane in the Study Area, although perchlorate was reported in Area 46, and 1,4-dioxane may be associated with TCE.

- Data Gap: Data are needed to assess the potential presence of 1,4-dioxane, perchlorate, and nitrate in the Study Area groundwater.

Z4-8. GET A influent will be sampled and analyzed for 1,4-dioxane, perchlorate, and nitrate. Sampling of the influent is appropriate as there are no known sources in the Study Area (Table D-1).

5.1.2 Sector C

The types of chemicals detected in soil and groundwater in Sector C during the Stage 1 RI are summarized on Table D-3. Of these chemicals, there are sufficient recent data for VOCs, NDMA, metals, and nitrate. However, there are no recent data for 1,4-dioxane or

perchlorate. Perchlorate was handled in Area 46 and has been detected in groundwater downgradient to the west, and 1,4-dioxane was detected during the Stage 1 RI.

- Data Gap: Data are needed to assess 1,4-dioxane and perchlorate in Sector C.

Z4-9. Wells 3387 and 3386 will be sampled and analyzed for 1,4-dioxane and perchlorate (Table D-1).

5.2 Lateral and Vertical Extent of Chemicals in Groundwater

The extent of chemicals recently detected in the Study Area groundwater is evaluated in this section. TCE, Freon-113, and NDMA were the most commonly detected and widely distributed compounds in groundwater and their extents encompass the extents of the other chemicals. The following evaluation primarily discusses the extents of TCE, Freon-113, and NDMA as representative of the "worst-case" extents for the remaining chemicals.

The shallowest groundwater (Dredged Layer) is discussed first, followed by the deeper groundwater in Layers A, B, and the Bedrock.

5.2.1 Dredged Layer

In the Dredged Layer, nine of 17 wells were recently sampled for VOCs and eight of 17 wells were recently sampled for NDMA (Figures D-9 through D-11). VOCs detected included TCE at 4.0 µg/l in Well 3497; 1,2-DCE at 4.8 µg/l in Well 3497, chloroform at 12 µg/l in Well 77, and Freon-11 at 2.1 µg/l in Well 3185. These VOCs concentrations are slightly above or below their respective WQOs, and there are no additional Data Collection Activities for VOCs. NDMA was not detected in the wells sampled and there are no additional Data Collection Activities for NDMA.

5.2.2 Layer A

Most of the Layer A wells within the Study Area were sampled recently for VOCs and NDMA. The lateral extents of TCE, Freon-113, and NDMA in Layer A are shown on Figures D-12 through D-14, respectively. In Sector A, TCE and Freon-113 are distributed in north-south trending plumes that appear to originate from Area 32 and extend north to the GET A extraction wells (Figures D-12 and D-13, respectively). The lateral extents of VOCs were defined to the RLs near the GET A extraction well field. NDMA is distributed from the southern source sites to the GET A extraction wells, and is distributed up to approximately 1,500 feet further west than TCE or Freon-113 (Figure D-14). The lateral extents of TCE, Freon-113, and NDMA are characterized to their respective RLs (0.5 µg/l, 0.5 µg/l, and 0.0075 µg/l). There are no additional data needed to characterize the lateral extent of chemicals.

In Sector C, TCE, and Freon-113 were detected side-gradient and west of Sector A (Figure D-12 and D-13, respectively). The potential sources of VOCs in this area could be located in Area 46 or Sector A. Based on the low levels of VOCs in the overlying Dredged Layer, the Aerojet Landfill does not appear to be the source of VOCs in Layer

A. The lateral extents of TCE and Freon-113 are defined north of Alder Creek by Well 3503 where Freon-113 was not detected (<0.5 µg/l) and TCE was detected below the MCL at 2.3 µg/l. TCE was not detected in Well 3383 located north of Alder Creek and northwest (and downgradient) of the TCE detected in Well 3188 (Figure D-12). No data are needed to assess the extents of VOCs in Layer A; however, additional data are needed to evaluate the potential for Layer A groundwater to discharge to Alder Creek.

- Data Gap: Data are needed to evaluate potential chemical impacts from the discharge of groundwater from Layer A to Alder Creek.

Z4-10. Water quality data was collected from the upstream and downstream portions of Alder Creek during 1998 through 2001 under an existing NPDES permit. These data, that include perchlorate, VOC and NDMA analyses, will be reviewed and included in the ecological risk assessment evaluation (Table D-1).

Z4-11. In concurrence with Activity Number Z4-4, any identified groundwater seeps will be sampled and analyzed for perchlorate, VOCs and NDMA (Table D-1).

NDMA was detected in Layer A up to 0.018 µg/l in the furthest monitoring well downgradient of Area 46 (Figure D-14).

- Data Gap: Additional data are needed to characterize the lateral extent of NDMA in Layer A groundwater.

Z4-12. Wells 449 and 453 will be sampled and analyzed for NDMA (Table D-1).

Arsenic (61 µg/l), lead (59 µg/l) and nickel (160 µg/l) were recently detected above WQOs in Well 451. Well 451 is downgradient of the Aerojet Landfill in Sector C.

- Data Gap: Additional Layer A groundwater data are needed to assess the lateral extent of arsenic, lead and nickel down gradient of Well 451.

Z4-13. Well 79 will be sampled for arsenic, lead, and nickel (Table D-1).

5.2.3 Layer B

Layer B is present in Sector C and is beneath Layer A. The monitor wells screened in Layer B provide data for assessing the vertical extent of the chemicals detected in Layer A. TCE, Freon-113, and NDMA were not detected above their respective reporting limits (Figures D-15, through D-17, respectively). Well 454, which was not sampled for NDMA, is downgradient of Wells 3389-90, where NDMA detected in overlying Layer A.

- Data Gap: Additional NDMA data are needed from Layer B to assess the vertical extent of NDMA detected in overlying Layer A.

Z4-14. Well 454 will be sampled and analyzed for NDMA (Table D-1).

5.2.4 Bedrock

There are five monitoring wells (Wells 483, 3263, 3373, 3467, and 3496) screened in the Bedrock, which is overlain by Layer A, in Sector A (Figure D-8). Well 483 and Well 3467 were sampled recently for NDMA and VOCs. Trace concentrations of VOCs [1,1-DCE (1.4 µg/l), 1,2-DCA (0.89 µg/l), Freon-113 (0.77 µg/l), and TCE (0.66 µg/l)] were detected in Well 3467. VOCs were not detected above RLs in downgradient Well 483. NDMA was not detected above RLs in either well. No additional analytical data are needed for the bedrock wells.

6.0 SUMMARY OF DATA COLLECTION ACTIVITIES

The activities described below were developed based on the data needs described in the preceding Sections.

This section and Table D-1 will be provided to the field and laboratory personnel for implementation. The standard operating procedures for sample collection, handling, and analyses will be followed as specified in the Site-wide Quality Assurance Project Plan (QAPP)(Aerojet, 2001). Activities proposed to characterize the extent of chemicals in groundwater in the Zone 4 Study Area and include the following:

Z4-1. Lithologic data from wells near Alder Creek and creek bed elevation data will be used to re-evaluate or reconstruct Cross-sections A-A' and B-B'.

Z4-2. Hydrographs will be prepared using historical and recent groundwater data. Potentiometric surface maps will be prepared with groundwater data collected on October 2001.

Z4-3. Potentiometric surface maps for Layer A will be compared to the elevations of Alder Creek as part of the evaluation of whether Alder Creek is a gaining or losing stream.

Z4-4. The length of Alder Creek will be walked to identify seeps or springs potentially discharging into the creek.

Z4-5. During the PGOU RI/FS, historical and recent chemical concentrations will be plotted to assess chemical concentration trends.

Z4-6. All existing and proposed cross-sections will be updated with the most recent chemical and water level data.

Z4-7. All chemical-iso-concentration maps will be finalized and all data will be reviewed during the RI/FS.

Z4-8. GET A influent will be analyzed for 1,4-dioxane, perchlorate, and nitrate.

Z4-9. Wells 3387 and 3386 will be sampled for 1,4-dioxane and perchlorate.

Z4-10. Water quality data was collected from the upstream and downstream portions of Alder Creek during 1998 through 2001 will be reviewed and included in the ecological risk assessment evaluation.

Z4-11. Groundwater seeps identified near Alder Creek (Activity Number Z4-1) will be sampled for perchlorate, VOCs, and NDMA.

Z4-12. Wells 449 and 453will be sampled for NDMA.

Z4-13. Well 79 will be sampled for arsenic, lead, and nickel.

Z4-14. Well 454 will be sampled for NDMA to evaluate the vertical extent of NDMA from Layer A.

7.0 REFERENCES

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TABLE D-1: RI/FS Data Collection Activities - Zone 4 Study Area

PRELIMINARY DRAFT

Activity Number	Location	Data Collection Activity	Layer	Target Analytes	EPA Method	Reporting Limit (ppb) [1]	Lowest WQO (ppb) [2]	Number Samples	Rationale
Z4-1	Sector C	Lithologic data from wells near Alder Creek and creek bed elevation data will be used to re-evaluate or reconstruct Cross-sections A-A' and B-B'	All	NA	NA	NA	NA	NA	Assess if shallow groundwater is seeping into Alder Creek.
Z4-2	All	Prepare hydrographs using historical and recent GW data. Prepare potentiometric surface maps with data collected in October 2001.	All	NA	NA	NA	NA	NA	Assess seasonal and temporal water level trends.
Z4-3	All	Compare Layer A potentiometric surface elevation to the elevations of Alder Creek.	A	NA	NA	NA	NA	NA	Assess if Alder Creek is a gaining or losing stream.
Z4-4	All	Walk Alder Creek to visually identify any groundwater seeps or springs.	A	NA	NA	NA	NA	NA	Assess seeps that can be sampled to evaluate threat from groundwater contamination.
Z4-5	All	Historical and recent chemical concentrations will be plotted to assess chemical concentration trends.	All	TCE Freon-113 NDMA miscellaneous	NA	NA	NA	NA	Assess effectiveness of existing GET A remedial system and estimate potential aquifer restoration times.
Z4-6	All	Update existing and proposed cross-sections with the most recent chemical and water level data.	All	TCE Freon-113 NDMA	NA	NA	NA	NA	Assess vertical distribution of chemicals and evaluate effectiveness of existing GET A remedial system.
Z4-7	All	Finalize chemical iso-concentration maps and review data.	All	NA	NA	NA	NA	NA	Ensure the representativeness of all data for the RI/FS.
Z4-8	Sector A	Sample GET A influent.	NA	1,4-Dioxane	8270	10	NA	1[3]	Assess if additional treatment is needed at GET A Treatment Facility.
				Perchlorate	EA-0040	4	4		
				Nitrate	300	50	45,000		
Z4-9	Sector C	Sample Wells 3387 and 4486.	A	1,4-Dioxane	8270	10	NA	1[3]	Assess results of Stage 1 sampling with recent analyses.
				Perchlorate	EA-0040	4	4		
Z4-10	All	Review NPDES Alder Creek Data, 1998 through 2001.	NA	VOCs NDMA Perchlorate	NA	NA	NA	(4)	Needed for ecological risk assessment.
Z4-11	All	Sample groundwater seeps identified in Activity Number Z4-4.	NA	VOCs	601	0.5	Varies	1[3]	Assess identified groundwater seeps for contaminants of concern.
				NDMA	EA-0036	0.0075	0.002		
				Perchlorate	EA-0040	4	4		

TABLE D-1: RI/FS Data Collection Activities - Zone 4 Study Area

PRELIMINARY DRAFT

Activity Number	Location	Data Collection Activity	Layer	Target Analytes	EPA Method	Reporting Limit (ppb) [1]	Lowest WQO (ppb) [2]	Number Samples	Rationale
Z4-12	Sector C	Sample Wells 449 and 453.	A	NDMA	EA-0036	0.0075	NA	1[3]	Assess downgradient extent of NDMA identified in Wells 3389, 3390, 3419 and 3420.
Z4-13	Sector C	Sample Well 79.	A	Arsenic	206.2	5	50	1[3][5]	Assess lateral extent of these metals identified in Well 451.
				Lead	239.2 Mod.	3	2		
				Nickel	249.2 Mod	5	1		
Z4-14	Sector C	Sample Well 454.	B	NDMA	EA-0036	0.0075	0.002	1[3]	Assess vertical extent of NDMA detected in overlying Layer A.

Notes:

(1) Reporting Limits are the lowest analytical reporting limit that the proposed method and analytical laboratory are capable of achieving.

(2) WQO - Water Quality Objective is the lower of the primary Federal or State maximum contaminant level (MCL) verses State Public Health Goal (PHG).

(3) Propose 1 sample to be collected. If target analyte is detected then resample within 30 days to confirm/verify initial result.

(4) Presently sampled quarterly under NPDES program.

(5) All groundwater samples collected for metal analyses will be field filtered prior to laboratory submittal.

NA = Not Applicable

NDMA = N-Nitrosodimethylamine

TABLE D-2: Summary of Aquifer Test Data - Zone 4 Study Area **PRELIMINARY DRAFT**

Pumping Well	Date of Test	Transmissivity (gpd/ft)	Storativity	Hydraulic Conductivity (ft/day)	Hydrostratigraphic Layer
Sector A, GET A Extraction Wells					
4100	6/14/91	125 – 557	3.4×10^{-4} – 0.0017	199 – 890	A
4110	6/10/91	130 - 421	1.4×10^{-4} – 0.009	208 – 673	A
4012	9/29/93	874 - 6,056	0.002 - 0.1	1.0 – 9.0	A
4013	9/17/93	94 - 277	0.04	0.13 – 0.41	A

TABLE D-3: Summary of Chemicals Detected During Stage 1 RI and Landfill Closure - Zone 4 Study Area **PRELIMINARY DRAFT**

CLASS / Compound	Detected in Soils [1]	Potential Source Site(s) Detected [2]	Detected in Groundwater [3]	Hydrostratigraphic Layer Detected	Comments	Potential Study Area Analyte
Sector A (Areas 30, 31 and 32)						
SVOCs						
Bis-2-ethylhexyl phthalate	No	Not Applicable	Yes	A	Suspected laboratory contaminant [4]	No
1,4-dioxane	No	Not Applicable	Yes	A	Potential TCE impurity/stabilizer	Yes
NON-VOCs						
Perchlorate	No	Not Applicable	No	A	Potential upgradient source(s)	Yes
NDMA	Yes	1A	Yes	A	Potential upgradient source(s)	Yes
Nitrate	No	Area 30	Yes	A	Possible NDMA association	Yes
Hydrocarbons	Yes	8A & A(d)	No	Not Applicable	No proposed Stage 2 groundwater sampling	No
Kerosene	Yes	Not Applicable	No	Not Applicable	No proposed Stage 2 groundwater sampling	No
METALS						
Copper	Yes	3A & 7A	No	Not Applicable		No
Mercury	Yes	A(a) & A(b)	No	Not Applicable		No
Sector C (Aerojet Landfill)						
SVOCs						
Bis-2-ethylhexyl phthalate	Yes	WMU 1 (Blueprint paper)	Not Analyzed	Not Applicable	Suspected laboratory contaminant. [4]	No
di-n-butyl phthalate	Yes	WMU 1 (Blueprint paper)	Not Analyzed	Not Applicable	Suspected laboratory contaminant. [4]	No
4-Methylpehnol	Yes	WMU 1 (Blueprint paper)	Not Analyzed	Not Applicable	Not detected in soil samples.	No
PCBs	Yes	WMU 2 (soil)	Not Analyzed	Not Applicable	Confirmation soil sampling could not repeat.	No
1,4-dioxane	NA	Not Applicable	Not Analyzed	Not Applicable	Potential TCE impurity/stabilizer.	Yes
NON-VOCs						
Perchlorate	NA	Not Applicable	No	Not Applicable	Potential upgradient source(s).	Yes
NDMA	NA	Not Applicable	Yes	A & B	Potential upgradient source(s).	Yes
Nitrate	NA	Not Applicable	Yes	A	Below MCL or PHG.	No
METALS						
Arsenic	No	Not Applicable	Yes	A	Above MCL in Well 451.	Yes
Lead	No	Not Applicable	Yes	A	Above MCL in Wells 451, 453, 3420 & 3395.	Yes
Nickel	No	Not Applicable	Yes	A	Above PHG in Wells 449 and 451.	Yes

TABLE D-3: Summary of Chemicals Detected During Stage 1 RI and Landfill Closure - Zone 4 Study Area **PRELIMINARY DRAFT**

CLASS / Compound	Detected in Soils [1]	Potential Source Site(s) Detected [2]	Detected in Groundwater [3]	Hydrostratigraphic Layer Detected	Comments	Potential Study Area Analyte
Sector C (Area 46)						
SVOCs						
Bis-2-ethylhexyl phthalate	No	Not applicable	Yes	A	Suspected laboratory contaminant. [4]	No
Non-VOCs						
Perchlorate	No	Not applicable	No	Yes		Yes
NDMA	No	Not applicable	No[5]	Yes	Detected downgradient of Area 46.	Yes
TPH	Yes	1C & 2C	Yes	Dredged, A	Over 3000 feet to Zone 4 property boundary.	No
Metals						
None Identified	NA	Not Applicable	NA	Not Applicable	Not Applicable	No

Notes:

1 Metals reported if above presumed site background levels, Borch, 1994.
2 Source: Stage 1 RI/FS Report - Zones 3 and 4, ICF Kaiser Engineers, 1993.
3 Metals reported if above Primary MCLs or DHS Public Health Goals.
4 Aerojet, Special Contaminant Investigation, 1994.
5 Method Detection Limit = 0.10 µg/l.
NDMA = N-Nitrosodimethylamine
NA = Not Applicable

PAGES OF OVERSIZED MAPS

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ARCSWEST

GROUNDWATER CAPTURE ZONE ANALYSIS AND MODELING SIMULATIONS

AMERICAN RIVER STUDY AREA
RANCHO CORDOVA, CALIFORNIA

AGC Exhibit 7

CH2MHILL

GROUNDWATER CAPTURE ZONE ANALYSIS AND MODELING SIMULATIONS

AMERICAN RIVER STUDY AREA RANCHO CORDOVA, CALIFORNIA

EPA CONTRACT NO. 68-W9-0031
WORK ASSIGNMENT NO. 31-31-9L16
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Appendix A: Theoretical Basis for the MLU Program Code

Groundwater Capture Zone Analysis and Modeling Simulations

Purpose

The purpose of this report is to present the results of groundwater modeling simulations performed to estimate the extent of capture zones created by several proposed groundwater extraction wells in the vicinity of the American River near Rancho Cordova, California. The interpretations of aquifer tests performed at the site are also described as they relate to the refinement of the hydraulic properties assumed for input to the groundwater model.

CH2M HILL performed this effort in an oversight role to investigate the validity of the assumptions and conclusions presented in the May 1993 Engineering Evaluation/Cost Analysis (EE/CA) for the American River Study Area produced by Aerojet. It is intended as a management tool to focus future remedial activities in the American River Study Area and is not intended to be an exhaustive analysis of the hydrogeologic conditions that currently exist, or will exist in the future as a result of response actions.

A response action is necessary in the American River Study Area because groundwater contamination presents a potential threat to the long-term beneficial use of groundwater resources in the area.

Introduction

A plume of contaminated groundwater has been detected offsite from the Aerojet Facility and it is continuing to move northwesterly toward and beneath the American River. This plume is composed predominantly of trichlorethene (TCE) and it is the target of a planned response action to remediate the contaminated aquifers in the area. Current data shows that the three uppermost aquifers in the vicinity of the American River contain levels of TCE that exceed the State of California Maximum Contaminant Levels (MCLs). A description of the hydrogeologic and water quality data is available in the document titled *Engineering Evaluation and Cost Analysis for the American River Study Area,* produced by Aerojet General Corporation, May 1993. Additional aquifer testing data collected since May 1993 were also used in this analysis.

Conclusions and Recommendations

The main conclusions reached from the groundwater capture zone analysis and modeling simulations, and the recommended course of action, are as follows.

1. The continued migration of the American River Study Area plume is a potential threat to municipal wells of the Fair Oaks Water District (FOWD).

2. The implementation of the removal action recommended in Aerojet's May 1993 EE/CA is an environmentally sound first step in an iterative approach to control the migration of the contaminant plume in the American River Study Area.

3. A significantly higher extraction rate than discussed in the EE/CA, on the order of 2,000 gallons per minute (gpm), may be required to completely capture the TCE target area in the upper, middle, and lower aquifers. The estimated pumping rate is higher than had been contemplated in the EE/CA because the aquifers have been tested and found to be more transmissive. The model used in this analysis assumes that the aquifer properties disclosed in the testing at Well Cluster 4300-02 extend throughout the modeled area. The assumption was made because there are no other quantitative data on the properties of the upper or middle aquifers. The travel times shown on the figures, as indicated by the tic marks, do not reflect actual groundwater contaminant migration observed at the site. This discrepancy should be continually evaluated through implementation of this project.

4. An extraction well network, designed to contain the observed contamination, will require additional upper, middle, and lower aquifer wells on the north and south sides of the American River.

5. On the basis of groundwater monitoring data collected, including data from the newly installed Greenvale (Aerojet Well No. 1559-61) and Oak Glenn (Aerojet Well No. 1556-8) wells, the modeling shows that the recharge of groundwater in the proposed locations of the May 1993 EE/CA will not accelerate the identified contaminant target area toward the FOWD water supply wells.

6. Recent groundwater quality data collected from Aerojet Well No. 1407 by Aerojet and the Central Valley Regional Water Quality Control Board (RWQCB) indicate that TCE concentrations above MCLs (at 7.7 µg/l) have been detected (RWQCB Inspection Report dated April 27, 1994). These data were not received in time for inclusion in this analysis. Previous sampling rounds for Well No. 1407 have consistently produced results below MCLs. Additionally, data collected from Aerojet Well No. 1526, located between the TCE plume and Well No. 1407, have yielded samples that have been consistently "nondetect" for TCE in previous sampling rounds. Until this situation is fully evaluated, we recommend that recharge in the vicinity of Well No. 1407 be in the deeper aquifer.

7. Therefore, Aerojet should initiate action to produce future phases of groundwater extraction in the northern and southern areas of the American River.

We recommend that Aerojet implement the following course of action in the American River Study Area:

- Installation of the proposed system as identified in the May 1993 EE/CA, with the exception of an increased design flow rate.

- Evaluation and implementation of extraction, treatment, and disposal of groundwater in the southern portion of the American River Study Area.

- Continue monitoring and studying the actual response of the aquifer and influence on the contaminant plume in the American River Study Area from groundwater extraction. This study should be the basis for using a phased approach to address the groundwater contamination in the vicinity. It should include the collection of actual data, as well as the refining of the model with newly collected data.

All groundwater models are simplified versions of real world systems that approximately simulate the relevant reactions of a real world system. Models are only as precise as the data and assumptions upon which they are based. Because real world systems are very complex, as is the case with the American River Study Area, the modeling results presented in this report should be viewed as an exercise and as a useful tool to help facilitate removal and response action decisions.

In general, the results of this modeling exercise, when compared to the known real world movement of the contaminant plume in the American River Study Area, are not in complete agreement. Of specific concern is that the travel times and resultant flow rates are extremely high values. In reality, the historically monitored groundwater movement in the American River Study Area has not proved to be this rapid. Therefore, the actual capture of groundwater contaminants estimated in this report may differ from the actual capture zones realized in real world operations. If the actual transmissivity of the aquifers is less than what was used in the model, then less pumping from potentially more wells may be required.

Aquifer Test Evaluation

Aquifer Test Description

Several aquifer tests have been performed in Extraction Wells 4300, 4301, and 4302 which were screened specifically in the upper, middle, and lower aquifers, respectively. This well cluster, located north of the American River, is shown on Figure 1. Initially, three separate aquifer tests were conducted at the well cluster during November 1993. Each test consisted of pumping one well in the cluster for approximately 4 days, and monitoring the water level response in the adjacent extraction wells and in surrounding monitoring wells. An additional aquifer test was conducted in December 1993, consisting of pumping all three extraction wells concurrently for a period of 10 days, and monitoring the water level response in surrounding monitoring wells.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Aquifer Test Analysis

The method used to interpret the data from the two sets of aquifer tests varied depending on the test design. The single-well pumping tests were evaluated using the computer program MLU developed by C.J. Hemker, 1993. The results from the multiple well test were evaluated using the groundwater model MicroFem, also written by Hemker, et al, 1987 to 1994. A more detailed description of these analysis methods is presented below.

Single-Well Test Analysis

The computer program MLU was used to calculate hydraulic parameter estimates from the single-well aquifer tests. MLU is a transient, multi-aquifer simulation that uses a least squares, curve-fitting algorithm to calculate aquifer and aquitard parameters (aquifer transmissivity [T], aquifer storage coefficient [S], aquitard resistance [R], and aquitard storage coefficient [S']) on the basis of time-drawdown data collected during aquifer tests. The solution technique accounts for both leakage between aquifers and storage of water in the aquitards and aquifers. Any number of parameters can be fixed based on prior knowledge of their approximate values; the program then estimates the values of the remaining parameters.

A more complete description of this program, including the governing equations and the solution technique is presented in Appendix A. In Table 1, the results of the MLU analysis are summarized and compared to the estimates of aquifer parameters presented in the EE/CA. The EE/CA estimates were based on an aquifer test of a long-screened water supply well that was located approximately 1 mile to the southeast of short-screened Wells 4300, 4301, and 4302.

Table 1
Comparison of Aquifer Properties Used In Groundwater Modeling Simulations With Estimates Presented in the EE/CA

	EE/CA Data	Single-Well Tests	Multiple-Well Tests
Aquifer Transmissivity (ft^2/d)			
Upper Aquifer	2,000	22,000[a]	16,000[a]
Middle Aquifer	550	1,830[a]	4,000[a]
Lower Aquifer	1,730	90[a]	125[a]
Aquitard Vertical Resistance (days)			
Upper/Middle	N/A	80[a]	80[a]
Middle/Lower	N/A	900[a]	900[a]

[a]Parameter Values in the Vicinity of Wells 4300, 4301, and 4302
N/A = Not available

Multiple-Well Test Analysis

Because the MLU program can evaluate only one pumped aquifer at a time, a three-dimensional groundwater flow model was used to evaluate the multiple-well test results. A finite element MicroFem groundwater model was developed by CH2M HILL to estimate the capture zones that would be produced by operating the proposed extraction wells located near the American River. This model was based on the results of the single-well tests and the stratigraphic data presented in the American River Study Area EE/CA. The results of the 10-day multiple-well aquifer test provided an additional opportunity to test the validity of the existing groundwater model, and provided another data set with which the model could be further calibrated. A more complete discussion of the groundwater model construction and development is provided in the following section.

The 10-day multiple-well aquifer test was simulated using the finite element groundwater model and, following small adjustments to the assumed aquifer transmissivities, produced a good match between observed and simulated drawdown in the vicinity of the extraction wells. The observed water levels at the end of the 10-day test were increased by 0.5 foot to approximately account for a regional rising water level trend of about 0.5 foot observed during the course of the test. Comparisons of observed and simulated drawdown at various distances from the pumping wells are shown on Figures 2 through 4. The agreement between simulated and observed drawdown improves as radial distance from the pumping well increases. Because the objective of this modeling effort is to define the extent of the capture zone created by extraction wells, it is more important to match the observed drawdown at the distant edges of the cone of depression. The aquifer parameters determined from the multiple-well aquifer test were similar to those obtained from the single-well tests. Table 1 presents the aquifer parameter estimates that are based on the multiple-well test.

Groundwater Model Construction and Calibration

The groundwater model selected to evaluate the extent of capture produced by the proposed extraction wells in the American River Study Area is MicroFem. This finite element model was selected because it is capable of simulating transient groundwater flow in multiple aquifer systems, and includes leakage between adjacent aquifers at the site. It is capable of generating three dimensional flowlines that allow for the evaluation of capture zones in three dimensions. The capability of incorporating the leakage between aquifers, and the influence of leakage on the capture of contaminated groundwater by extraction wells, was needed for the evaluation of the leaky aquifer system that exists in the study area.

Groundwater Model Assumptions and Limitations

The conclusions presented in this report are based on a groundwater model that was constructed using many assumptions regarding the distribution of aquifer properties across the American River Study Area. The uncertainty associated with our current understanding of

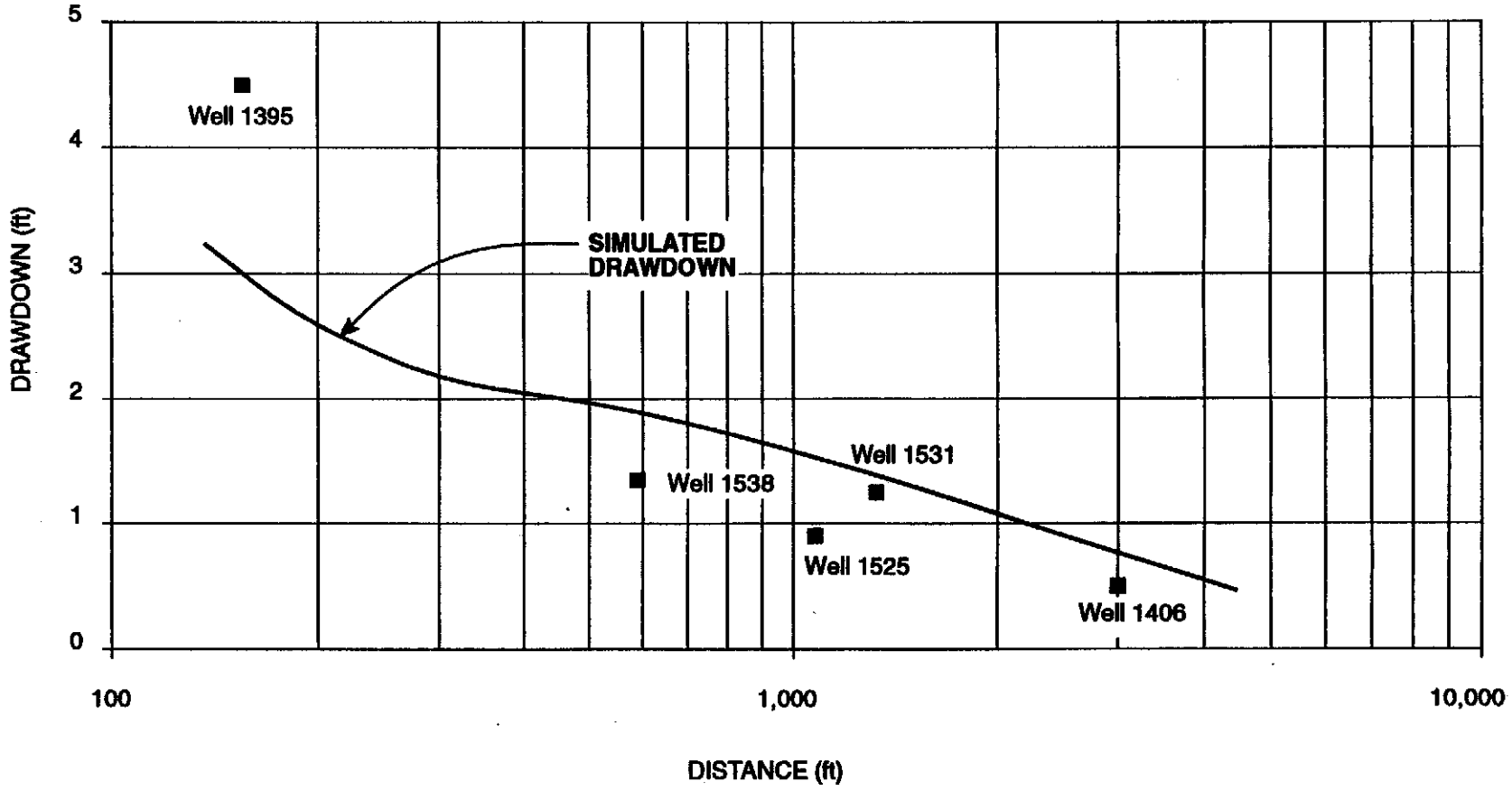

FIGURE 2
SIMULATED VERSUS OBSERVED DRAWDOWN IN THE UPPER AQUIFER AFTER 10 DAYS OF PUMPING
AEROJET-AMERICAN RIVER AREA
RANCO CORDOVA, CALIFORNIA

RDD1494_03

CHEMHILL

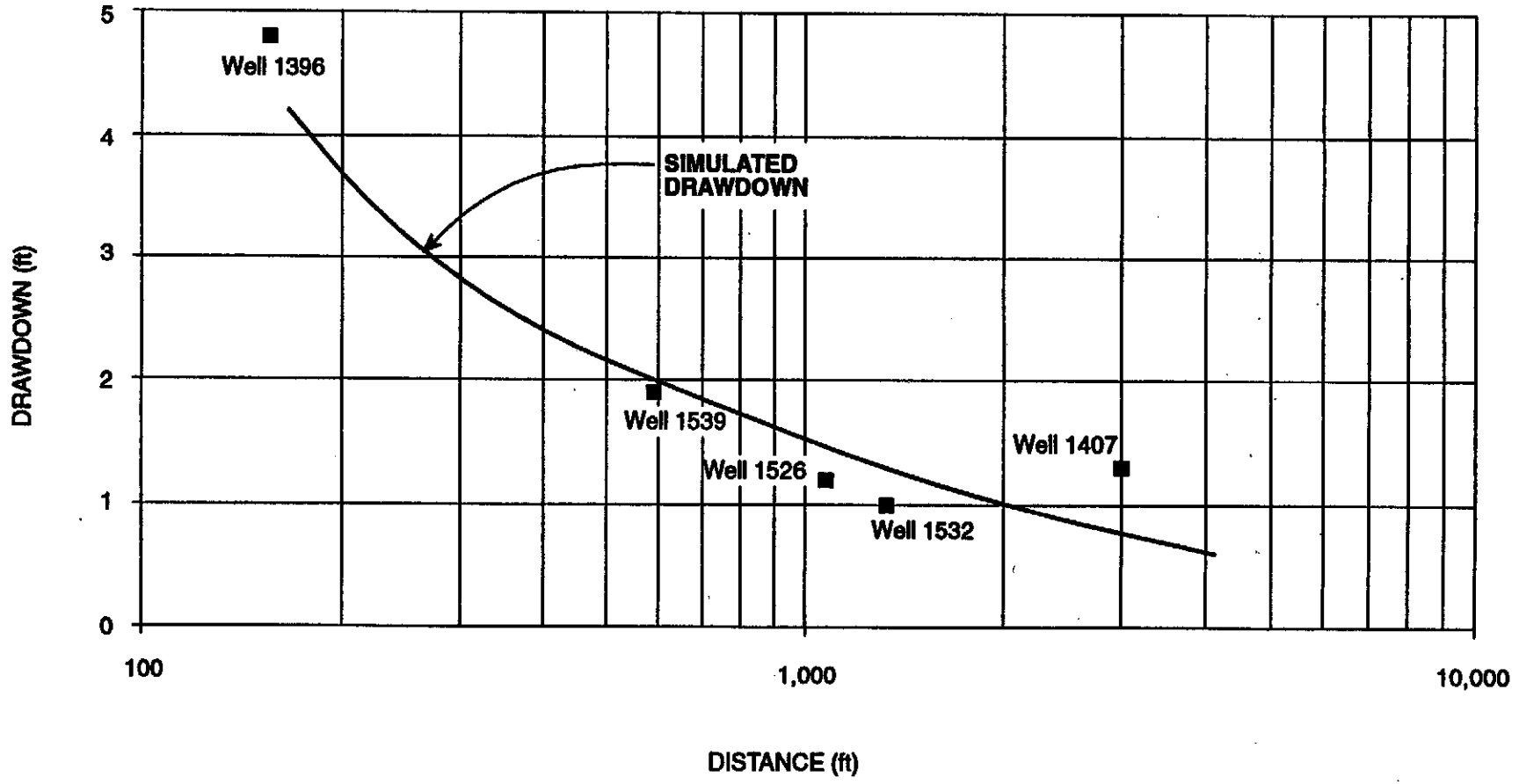

FIGURE 3
SIMULATED VERSUS OBSERVED DRAWDOWN IIN THE MIDDLE AQUIFER AFTER 10 DAYS OFPUMPING
AEROJET-AMERICAN RIVER AREA
RANCHO CORDOVA, CALIFORNIA

RDD1494_02

CH2MHILL

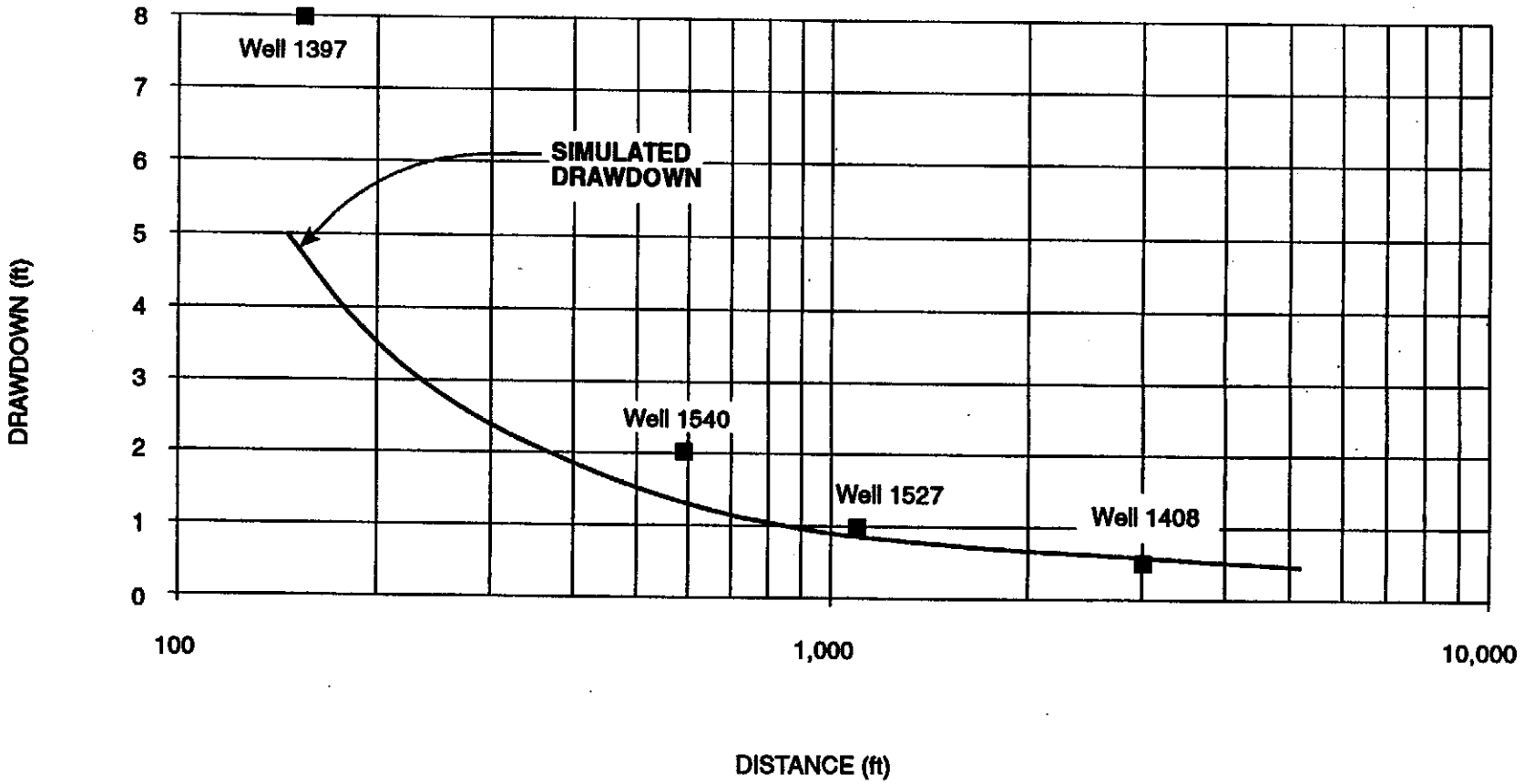

FIGURE 4
SIMULATED VERSUS OBSERVED DRAWDOWN IN THE LOWER AQUIFER AFTER 10 DAYS OF PUMPING
AEROJET-AMERICAN RIVER AREA
RANCHO CORDOVA, CALIFORNIA

RDD1494_01

CH2MHILL

the actual aquifer properties at the site is still large. As such, these predictions of aquifer response to extraction well pumping also contain significant uncertainty. The construction of any response action at the site must be associated with sufficient field information, collected during operation, to confirm that the desired extent of capture is being achieved by the system in place.

The capture zone simulations presented in this analysis were performed assuming steady-state conditions. This neglects the inclusion of transient influences on the groundwater system such as seasonal fluctuations in groundwater levels and recharge rates. However, the use of a steady-state model is appropriate because the objective of the groundwater modeling effort is to evaluate the long-term performance of an extraction system at containing and extracting contaminated groundwater.

Groundwater Model Construction

The principal objective of the model prepared for this analysis was to test the assumptions and conclusions presented in the EE/CA. Thus, CH2M HILL performed this modeling effort primarily in an oversight role. The model should not be considered to be an exhaustive analysis of the hydrogeologic conditions in the American River area. However, the model is useful for evaluation of hydrogeologic conditions in the study area to determine the need and scope of response action to control the movement of contaminated groundwater.

The groundwater model used in this analysis has evolved since September 1993, as additional field data have been collected. The original groundwater model was a five-layer model and was based entirely on the aquifer and aquitard geometries, and the aquifer properties presented in the May 1993 EE/CA Report. The upper three model layers represent the upper, middle, and lower aquifers at the site. The fourth and fifth layers combine to represent the regional deeper aquifer, which was subdivided into two layers to allow greater vertical resolution of deep flow paths. The original aquifer properties obtained from information presented in the EE/CA are summarized in Table 1.

The lateral boundary conditions of the model were defined as constant heads in all layers, and are based on water level contour maps presented in the Aerojet EE/CA (Figures 2-10 through 2-12). The upper and lower boundaries were defined as no flow boundaries.

Groundwater Model Calibration

The original calibration of the groundwater model was based on comparing the simulated groundwater levels across the study area with the observed water levels measured in monitoring wells. The calibration procedure consisted of setting the constant heads, located at the model perimeter, to produce groundwater flow directions and gradients to match the observed values. This procedure resulted in a close agreement between the simulated and the observed water levels.

Revisions to Groundwater Model

After completion of the single-well tests at Wells 4300, 4301, and 4302, the model was revised to reflect the findings from these tests. These tests suggested that the transmissivity of the upper aquifer was significantly higher than the values estimated for the EE/CA, and that the transmissivity of the lower aquifer was significantly lower. The thickness of each of the aquifer units was presented in the EE/CA (Figures 2-7 through 2-9), and the influence of aquifer thickness on transmissivity was retained in the refined version of the groundwater model. The aquifer thickness was accounted for by adjusting all transmissivity values in a single layer by a common factor. This approach is equivalent to adjusting the hydraulic conductivity of the aquifer materials while retaining the original estimates of aquifer thickness. The leakance values assigned between model layers were based on the results of the MLU analysis described above (see Table 1).

The material properties assigned to the groundwater model were further refined on the basis of the 10-day aquifer test conducted at the site. As previously discussed, the 10-day multiple-well test was simulated using the MicroFem groundwater model. Following small adjustments to the assumed aquifer transmissivities, a good match between the observed and the simulated drawdown in the vicinity of the extraction wells was obtained (see Figures 2 through 4). The results of this calibration effort were critical because the purpose of constructing the groundwater model was to evaluate the response of the aquifer system to proposed extraction well networks. These results suggest that the groundwater model produces simulated water levels in response to pumping that are close to those that will be observed in the vicinity of Wells 4300, 4301, and 4302.

However, in areas remote from the Well 4300 series, where little field data are available, model predictions are less certain. As the capture wellfield is constructed, a program of aquifer testing and model refinement should be performed to enhance the predictive capability of the model.

Groundwater Capture Evaluation

The following groundwater capture evaluation considers two potential wellfields designed to remediate contaminated groundwater in the vicinity of the American River. Wellfield 1 was proposed by Aerojet in the EE/CA, and consisted of two extraction well clusters pumping at the rates presented in Table 2. The Aerojet wellfield was based on the results of the two-dimensional model, Flowpath, which relied on aquifer parameters from a well located approximately 1 mile to the southeast of Wells 4300-4302. The extraction rates in Table 2 were based on the pumping tests in November and December 1993, and not on the assumed extraction rates in the EE/CA.

Wellfield 2 was designed by CH2M HILL to capture the entire plume of contaminated groundwater north of the American River. The extraction rates for this wellfield are also listed in Table 2.

Table 2 Assumed Extraction Rates for the Groundwater Modeling Simulations			
Well Name	**Upper Aquifer**	**Middle Aquifer**	**Lower Aquifer**
EE/CA Wellfield 1			
Wells 4300 to 4302	224	197	34
Cluster 1	224	197	34
Total Wellfield Pumpage			910
Wellfield 2			
Wells 4300 to 4302	285	195	35
Cluster 1	240	200	35
Cluster 2	240	105	35
Cluster 3	235	105	35
Upper Well 4	285	0	0
Total Wellfield Pumpage			2,030
Notes: All Values in gpm Well Locations Shown on Figures 5 through 7 and 9 through 11			

Wellfield 1 (Wellfield Proposed by Aerojet in EE/CA)

Configuration and Extraction Rates

The original extraction network proposed by Aerojet consisted of two extraction well clusters located on the downgradient edge of the TCE plumes. The locations of these well clusters are shown on Figure 5. Wells 4300 through 4302 have been constructed and were used to define aquifer parameters. The pumping rates for the second well cluster were assumed to be equal to the rates of Wells 4300 through 4302 during the 10-day aquifer test. Because all three wells will be pumping when the final extraction network is in operation, these are appropriate pumping rates for use in the capture zone simulation. The pumping rate is a combined 455 gpm from the well cluster as follows: 224 gpm from the upper aquifer, 197 gpm from the middle aquifer, and 34 gpm from the lower aquifer. The assigned pumping rates used in the capture zone simulations are summarized in Table 2.

Capture Zone Extent

The results of these simulations suggest that the extraction well configuration proposed by Aerojet will need to be augmented by additional extraction wells to capture the TCE plume north of the American River in all three contaminated aquifers. The extraction well locations, and the groundwater pathlines indicating the extent of capture from these wells for the upper, middle, and lower aquifers, are shown on Figures 5 through 7. The significant difference between the capture zones presented in the EE/CA Report and those presented here is mainly a result of the differences in the assumed transmissivities of the aquifer units. The transmissivity of the upper aquifer used in the EE/CA analysis is eight to ten times lower than the value used in this analysis, and the transmissivity of the middle aquifer used

PAGES OF OVERSIZED MAPS

(SEE BINDER)

in the EE/CA analysis is almost four times lower than the value used here (See Table 1). The lower assumed transmissivities used in the EE/CA resulted in much larger capture zones being predicted with similar assumed extraction rates.

Treated Groundwater Recharge

For the purposes of this analysis, the recharge of treated groundwater was assumed to occur to the deeper regional aquifer beneath the contaminated aquifers at the site. The results of the simulations suggest that the recharge of treated groundwater has no significant impact on the extent of capture achieved by the extraction wells. In all of the simulations performed, the quantity of recharge water was equal to the total extraction rate from the extraction wells; 910 gpm for Wellfield 1, and 2,030 gpm for Wellfield 2. The locations of the recharge wells are shown on Figures 5 through 12.

Impacts on Town and Chicago Wells

Another objective of this analysis was to investigate the potential impacts of the planned response action on nearby groundwater production wells. Two FOWD wells are located downgradient of the TCE target area in the American River Study Area. These wells are known as the Town Well and the Chicago Well, and their locations are shown on Figure 1. Well logs obtained for both the Town and Chicago Wells indicate that the total depth of each well is 600 feet. These wells produce water from deeper regional aquifers, below the contaminated portions of the upper, middle, and lower aquifers.

FOWD records indicate that these wells are currently operated only in peak demand periods during the summer months. Total pumpage from the Town Well was 0, 3.1 and 1.0 acre-feet (ac-ft) in 1990, 1991, and 1992, respectively. Total pumpage from the Chicago Well was 9.0, 3.7, and 1.2 ac-ft in 1990, 1991, and 1992 respectively. These production quantities correspond to average pumping rates of between 0 and 5.6 gpm assuming continuous pumping throughout the year. In actuality, the wells were pumped at significantly higher rates for limited durations of time. Actual 1990 through 1992 production rates for the Town and Chicago Wells are not available. Because this analysis was performed assuming steady state conditions, a constant pumping rate had to be assigned to the production wells. The pumping rates assigned to these wells was 600 gpm for the Chicago Well and 1,050 gpm for the Town Well. These values were obtained from well testing data collected at the time of well construction.

We concluded that for the purposes of this analysis it was more appropriate to simulate the hydraulic conditions that will actually result from the operation of these wells than use an artificially low average annual pumping rate. The groundwater pathlines that provide water to both the Town Well and the Chicago Well are shown in Figure 8. It should be noted that this figure is based on conservative assumptions and most of the time the Town and Chicago Wells will be shut down.

Wellfield 2

Configuration and Extraction Rates

Because Wellfield 1 proposed by Aerojet in the EE/CA will not likely capture the TCE plume, the model was used to develop a groundwater extraction network that was capable of capturing the TCE plume that exists in the aquifers north of the American River. None of the extraction networks evaluated here are intended to address contamination that resides in aquifers south of the American River. These zones of contamination will be addressed in future response actions.

The configuration of the extraction network required to capture the TCE plume is shown on Figures 9 through 11. This extraction network consists of four well clusters along with one additional upper aquifer well, and pumps a total of 2,030 gpm; including 1,285 gpm from the upper aquifer (240 to 285 gpm per well), 605 gpm from the middle aquifer (100 to 200 gpm per well), and 140 gpm from the lower aquifer (35 gpm per well). The assumed pumping rates in this capture zone simulation are summarized in Table 2. Because of the low transmissivity of the lower aquifer, much of the groundwater flowing into the extraction wells screened in the lower aquifer originates from deeper units (see Figure 11). However, the analysis indicates that the majority of the lower aquifer contamination is pulled toward, and eventually would be removed by the proposed well network.

Small gaps in the modeled capture zones still persist but are not deemed significant within the context of this report. In the model such gaps could be filled by increased pumping from the area between Well Cluster 4300-02 and Cluster 2. Such fine tuning of the capture zone was not performed for this evaluation because there are still large uncertainties in the assumed aquifer properties, and the precision of the existing groundwater model cannot definitively determine whether these small gaps in the capture zones will actually exist once the system is installed. Field measurements should be performed during the construction and operation of the extraction system to confirm that the extraction system is actually capturing the desired target area.

Treated Groundwater Recharge

Associated recharge of the total extraction rate from Wellfield 2 (2,030 gpm) was simulated at the reinjection location proposed by Aerojet in the western portion of Sailor Bar Park. The locations of these recharge wells are shown on Figure 12.

Impacts on Town and Chicago Wells

The impacts of Wellfield 2 on downgradient production wells were evaluated using the groundwater model. The flowlines associated with the Town Well and Chicago Well under

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(SEE BINDER)

Wellfield 2 conditions are presented on Figure 12. As in the previous recharge simulation, most of the water pumped from the Town Well appears to originate from the reinjection wellfield.

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Appendix A
Theoretical Basis for the MLU Program Code

Journal of Hydrology, 90 (1987) 231–249
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

[5]

UNSTEADY FLOW TO WELLS IN LAYERED AND FISSURED AQUIFER SYSTEMS

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ABSTRACT

Hemker, C.J. and Maas, C., 1987. Unsteady flow to wells in layered and fissured aquifer systems. J. Hydrol., 90: 231–249.

A solution has been developed for the calculation of drawdowns in leaky and confined multi-aquifer systems, pumped by a well of constant discharge penetrating one or more of the aquifers. In contrast to earlier solutions the effects of elastic storage in separating and bounding aquitards have now completely been accounted for.

The computing technique is based on the numerical inversion of the Laplace transform. Two different methods are used and results are compared with an analytical solution. Both Stehfest's[1] algorithm and Schapery's[2] least squares method yield accurate results in a fraction of the computation time required for the analytical evaluation.

Selected sets of time-drawdown and distance-drawdown curves are plotted to illustrate multiple-aquifer well flow and to compare new solutions with results which were previously published. The analogy with flow is unconfined and fissured aquifers is demonstrated by multilayer models, representing multiple-porosity formations with linear and diffusive crossflow.

INTRODUCTION

Practical groundwater investigations often show that an entire system of interconnected, more or less permeable layers responds to the withdrawal of water from one of its components. Some hydrogeological environments may be really complex indeed, but it is frequently found that these systems can be characterized as a sequence of alternating aquifers and aquitards of relatively large horizontal extent. In order to analyse the drawdown distribution caused by pumping wells in such leaky multiple-aquifer systems, several analytical solutions have been recently developed (Hemker, 1984, 1985; Hunt, 1985; Maas, 1986). The resulting analytical expressions may appear simple in matrix notation, but especially transient flow solutions require much computational effort when drawdowns are evaluated with some precision.

[1] Stehfest, 1970.
[2] Schapery, 1962.

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NOTATION

a_i	$(pS_{si}/K_i')^{1/2}$	L^{-1}
A	system matrix as defined by eqn. (6)	L^{-2}
b_i	$a_iD_i' = (pS_i'c_i)^{1/2}$	–
c_i	hydraulic resistance of ith aquitard (D_i'/K_i')	T
d_i	pS_i/T_i	L^{-2}
D_i, D_i'	thickness of ith aquifer, ith aquitard	L
e_{ij}	$(b_i \coth b_i)/c_iT_j$	L^{-2}
f_{ij}	$b_i/(c_iT_j \sinh b_i)$	L^{-2}
K	diagonal matrix with elements $K_0(r\sqrt{w_i})$	–
K_0	zero-order modified Bessel function of the second kind	
K_i, K_i'	hydraulic conductivity of ith aquifer, ith aquitard	LT^{-1}
n	total number of aquifers in a multiple-aquifer system	
p	parameter of Laplace transform	T^{-1}
q	discharge vector	L^2T^{-1}
Q_i	pumping rate from ith aquifer	L^3T^{-1}
r	radial distance from pumping well	L
R	eigenvector matrix	–
S_i, S_i'	storage coefficient of ith aquifer $(S_{si}D_i)$, ith aquitard $(S_{si}D_i')$	–
S_{si}, S_{si}'	specific storage of ith aquifer, ith aquitard	L^{-1}
s_i, s_i'	drawdown in ith aquifer, ith aquitard	L
$\bar{s}_i$, $\bar{s}_i'$	Laplace transform of s_i, s_i'	LT
s_D	dimensionless drawdown $(4\pi T_1 s/Q_1)$	–
t	time since pumping started	T
t_D	dimensionless time (T_1t/S_1r^2)	–
T	diagonal matrix with elements T_i	L^2T^{-1}
T_i	transmissivity of ith aquifer (K_iD_i)	L^2T^{-1}
V	$T^{-1/2}R$	$L^{-1}T^{1/2}$
w_i	eigenvalues of system matrix	L^{-2}
z	vertical coordinate	L

Computer programs for the estimation of hydraulic characteristics from aquifer-test data generally take hundreds or thousands of function evaluations, which renders the application of analytical solutions for transient multiple-aquifer flow less suitable. Confronted with this practical problem, both authors found a solution by turning to the technique of numerical inverse Laplace transformation. Since different inversion methods were used, viz. Schapery's least squares (1962) and Stehfest (1970), this provided a good opportunity for comparing their performances, in particular the accuracy of results.

Another important advantage of the numerical inversion technique is that the effects of elastic storage of the aquitards are now no longer neglected but can be fully incorporated in the mathematical formulation. In this respect the presented solution can be regarded as the n-aquifer generalization of the single and two-aquifer solutions given by Hantush (1960) and Neuman and Witherspoon (1969a) respectively. The applicability of the presented n-layer transient flow solution is further enhanced by demonstrating how well flow problems of double and multiple-porosity formations can be treated in a likewise manner.

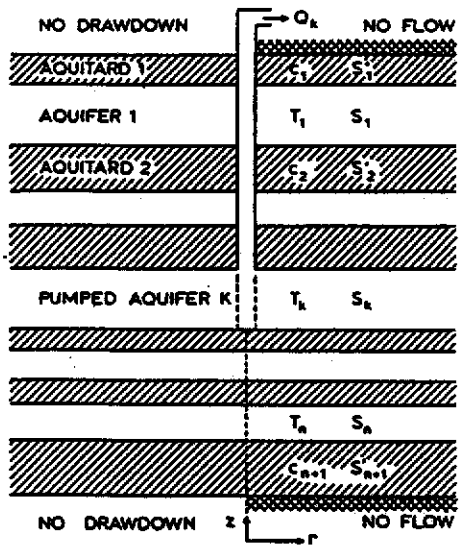

Fig. 1. Schematic diagram of a well in a leaky or confined multiple-aquifer system.

STATEMENT OF THE PROBLEM

The objective can be stated as finding a relatively fast and sufficiently accurate computing method to determine the drawdown s in all the aquifers of a leaky multiple-aquifer system as a function of time t and distance to a pumped well r. The aquifer system consists of n aquifers and $n + 1$ aquitards, as shown schematically in Fig. 1. Actually this diagram represents different systems, as both no-drawdown and impervious (no-flow) boundaries are considered at the top and (or) base of the system. All aquifers and aquitards are horizontal and of infinite extent, homogeneous, isotropic and individually compressible. The well is of infinitesimal radius, fully penetrates one or more of the aquifers and discharges at a constant rate Q. It is further assumed that the system layers show sufficiently contrasting conductivities to neglect horizontal flow in the aquitards and resistance to vertical flow in the aquifers (Hemker, 1985).

The multi-aquifer well flow problem can now be formulated by a system of $2n$ simultaneous partial-differential equations with initial and boundary conditions for the unknown drawdown. When the radial flow component in the aquifers is considered, $s(r, t)$ must satisfy the equation:

$$\frac{\partial^2 s_i}{\partial r^2} + \frac{1}{r}\frac{\partial s_i}{\partial r} = -\frac{K_i'}{T_i}\frac{\partial s_i'}{\partial z}\bigg|_{z=z_i} + \frac{K_{i+1}'}{T_i}\frac{\partial s_{i+1}'}{\partial z}\bigg|_{z=z_{i+1}} + \frac{S_i}{T_i}\frac{\partial s_i}{\partial t},$$

$$i = 1, 2, \ldots, n \qquad (1)$$

$$s_i(r, 0) = 0$$

$$s_i(\infty, t) = 0$$

$$\lim_{r \to 0} r \frac{\partial s_i}{\partial r} = -\frac{Q_i}{2\pi T_i}$$

while vertical flow in the aquitards is governed by:

$$\frac{\partial^2 s_i'}{\partial z^2} = \frac{S_{si}}{K_i'} \frac{\partial s_i'}{\partial t}, \qquad i = 1, 2, \ldots, n \tag{2}$$

$$s_i'(r, z, 0) = 0$$

$$s_i'(r, z_{i-1}, t) = s_{i-1}(r, t)$$

$$s_i'(r, z_i', t) = s_i(r, t)$$

where K = hydraulic conductivity; S_s = specific storage; T = aquifer transmissivity; S = storage coefficient, and indices are used to indicate the succession of layers, while primes refer to aquitards (Figs. 1 and 5).

When a leaky system is considered $s_0 = 0$ and $s_{n+1} = 0$, but if top and (or) base of the system are impervious, no-flow system boundary conditions must be used instead:

$$\frac{\partial}{\partial z} s_i'(r, z_0, t) = 0$$

and (or):

$$\frac{\partial}{\partial z} s_{n+1}'(r, z_{n+1}', t) = 0. \tag{3}$$

SOLUTION IN THE LAPLACE DOMAIN

With the aid of Laplace transformation, the systems of partial differential eqns. (1) and (2) can be reduced to systems of ordinary differential equations, which may be treated by appropriate analytical techniques to find a solution in the Laplace domain. Each author independently developed an answer to the same problem. Although the methods are essentially the same, they differ in approach, notation and final formulation. In terms of matrix functions the solution may be written (Appendix A):

$$\bar{s}(r, p) = \frac{1}{2\pi p} K_0[r\sqrt{A(p)}]T^{-1}q \tag{4}$$

which is equivalent to the result of eigenvalue analysis (Appendix B):

$$\bar{s}(r, p) = \frac{1}{2\pi p} VKV^T q \tag{5}$$

The calculation of the Laplace transformation of the drawdown vector $\bar{s}$ is based on the construction of the tridiagonal system matrix A, which is defined by:

$$A = \begin{bmatrix} e_{11} + e_{21} + d_1 & -f_{21} & 0 & \dots & 0 & 0 \\ -f_{22} & e_{22} + e_{32} + d_2 & -f_{32} & & & \cdot \\ 0 & -f_{33} & e_{33} + e_{43} + d_3 & & & \cdot \\ \cdot & & & & & \\ \cdot & & & & & -f_{n,n-1} \\ 0 & 0 & 0 & \dots 0 & -f_{nn} & e_{nn} + e_{n+1,n} + d_n \end{bmatrix} \quad (6)$$

where: $d_i = pS_i/T_i$; $e_{ij} = (b_i \coth b_i)/c_i T_j$, $f_{ij} = b_i/(c_i T_j \sinh b_i)$; $b_i = a_i D_i'$; and $a_i = (pS_{fi}/K_i')^{1/2}$. Diagonal matrix T contains the transmissivities, while q is simply the discharge vector $(Q_1, Q_2, \dots Q_n)^T$. To calculate the square matrices V and K, the system matrix is first transformed into a symmetric matrix D and then decomposed into its eigenvalues w_i and normalized eigenvectors r_i: $T^{1/2}AT^{-1/2} = D = RWR^{-1}$. Diagonal matrix K is given by its non-zero elements $K_0(r\sqrt{w_i})$ and matrix V is defined by $V = T^{-1/2}R$. More details are given with the derivation of eqns. (4) and (5) in Appendices A and B.

NUMERICAL INVERSION OF THE LAPLACE TRANSFORMED SOLUTION

As it is the purpose of the authors to obtain a formula which is easy to evaluate, analytical inversion of the Laplace transformed solution has not been attempted. A large number of different numerical inversion techniques are available at present, suggesting that no single method suits all purposes. A bibliography listing over 260 titles on the subject has been compiled by Piessens (1975). Systematic comparative studies were conducted by Cost (1964) and by Davies and Martin (1979). The latter paper has the widest scope, but the former should be of interest to the hydrologist too, as the type of problem investigated by Cost shows similarities to the hydraulic head problem of groundwater flow.

Davies and Martin suggest that more than one method should be used on any unknown function, because every method breaks down on some functions.

Undoubtedly, the easiest method of numerical Laplace inversion is due to Ter Haar (1951) and Schapery (1962). It states that:

$$f(t) \approx [p\bar{f}(p)]_{p = (\alpha/t)} \quad (7)$$

Ter Haar chooses $\alpha = 1$, while Schapery proposes $\alpha = 0.5$ (more properly: $\alpha = \exp(-\gamma)$, γ = Euler's number = 0.57721. . .). It is readily verified that Ter Haar's method is exact when:

$$f(t) = at + b \quad (8)$$

where a and b are arbitrary constants, while Schapery's method is exact when:

$$f(t) = a \ln t + b \quad (9)$$

For the methods to be applicable it turns out that the conditions (8) or (9) have to be satisfied only approximately in a certain interval around t.

Sternberg (1969), Brutsaert and Corapcioglu (1976) and Barents (1982) used Schapery's method to solve problems that are closely related to the problem of the present paper. The method indeed yields good results in many practical cases. For the problem at hand, however, deviations were found for small values of time, which were considered to be unacceptable by the authors.

Two other numerical inversion methods are selected, viz. a second method by Schapery (1962) (known as Schapery's least squares), and the algorithm presented by Stehfest (1970). In both cases evaluation of the transformed function is required in the real p-domain only. Stehfest's method is found by Davies and Martin (1979) to be accurate on a fairly wide range of functions. Schapery's least squares method, on the other hand, is stated to be rarely accurate. Nevertheless Cost (1964) finds the latter method to be very promising, at least for viscoelastic stress analysis.

In this paragraph both methods are briefly described. Their performances are shown for an arbitrarily chosen testcase and the results are compared with a recently developed analytical solution (Maas, 1987).

The numerical inversion method by Stehfest requires a fixed number N of $\bar{f}(p)$ evaluations for each value of t. The approximate value $f^*(t)$ at t of the function $f(t)$ is obtained by:

$$f(t) \approx f^*(t) = \frac{\ln 2}{t} \sum_{i=1}^{N} v_i \bar{f}\left(\frac{i \ln 2}{t}\right) \tag{10}$$

where N must be an even number. The weighting coefficients v_i depend on N only and need to be calculated once:

$$v_i = (-1)^{i+N/2} \sum_{k=\mathrm{INT}[(i+1)/2]}^{\mathrm{Min}(i,\,N/2)} k^{N/2}(2k)!/((N/2-k)!k!(k-1)!(i-k)!(2k-i)!) \tag{11}$$

An optimal value for N should be chosen, as it depends on the type of function to be evaluated and the precision with which this is done (eigenvalues, hyperbolic and Bessel functions were computed with a relative accuracy of at least twelve digits). Greater values for N improve the result theoretically, but rounding errors limit this value in practice. Calculations with different values for N therefore form an essential part of testing this method.

Stehfest's method has also been successfully applied to problems in groundwater hydrology by Moench and Ogata (1981, 1984), Moench (1984) and Streltsova (1982, 1984).

Schapery's least squares method assumes the original function $f(t)$ to be well approximated by m exponential terms:

$$f(t) \approx f^*(t) = \sum_{i=1}^{m} g_i e^{-\alpha_i t} \tag{12}$$

where g_i and α_i are parameters. After choosing the α_i judiciously the g_i are determined by minimizing the total square error E^2 between $f(t)$ and $f^*(t)$, given by:

$$E^2 = \int_0^\infty [f(t) - f^*(t)]^2 \, dt$$

so:

$$\frac{\partial E^2}{\partial g_i} = \int_0^\infty 2[f(t) - f^*(t)]e^{-t/\alpha_i} \, dt = 0$$

or:

$$[\bar{f}(p)]_{p=1/\alpha_i} = [\bar{f}^*(p)]_{p=1/\alpha_i}, \qquad (i = 1, m)$$

In other words; in order to minimize E^2, $\bar{f}(p)$ and $\bar{f}^*(p)$ should coincide in m points. In view of eqn. (12):

$$\bar{f}^*(p) = \sum_{j=1}^{m} g_j \frac{1}{p + 1/\alpha_j}$$

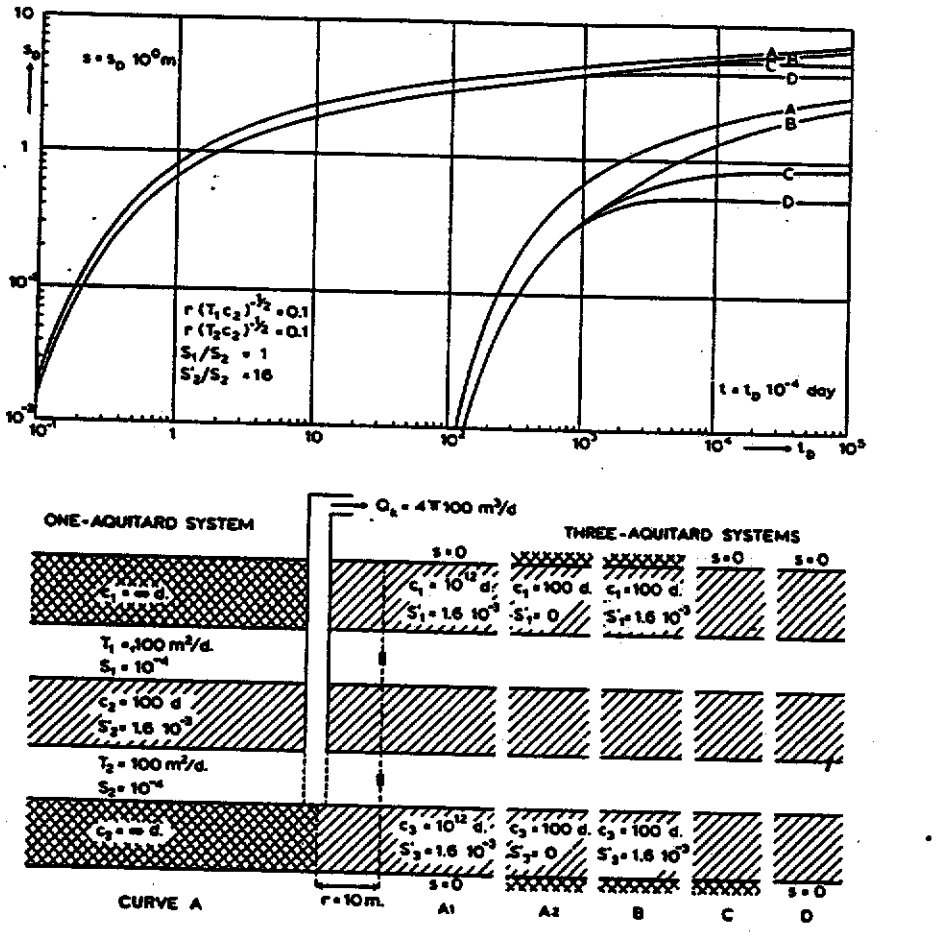

Fig. 2. Time-drawdown curves for two-aquifer systems with different top and base conditions.

TABLE 1

Stehfest's algorithm tested against an analytical solution of the problem shown in Fig. 2, model D

Time (days)	Stehfest $N = 8$		Stehfest $N = 10$		Stehfest $N = 12$		Analytical solution [Maas, 1987, eqn. (26)]	
	s_1 (m)	s_2 (m)	s_1 (m)	s_2 (m)	s_1 (m)	s_2 (m)	s_1 (m)	s_2 (m)
1.10^{-6}	0	0.0164	0	0.0165	0	0.0165	0	0.0164
2	0	0.0962	0	0.0957	0	0.0956	0	0.0956
5	0	0.3591	0	0.3590	0	0.3591	0	0.3591
1.10^{-4}	0	0.6584	0	0.6585	0	0.6586	0	0.6585
2	−0	1.0043	0	1.0044	−0	1.0045	0	1.0044
5	−0	1.4871	0	1.4872	−0	1.4872	0	1.4872
1.10^{-3}	−0	1.8540	−0	1.8541	0	1.8541	0	1.8541
2	0	2.2167	0	2.2168	−0	2.2168	0	2.2168
5	0	2.6890	0	2.6891	0	2.6891	0.0000	2.6890
1.10^{-2}	0.0027	3.0417	0.0030	3.0419	0.0030	3.0419	0.0030	3.0419
2	0.0361	3.3921	0.0358	3.3921	0.0357	3.3921	0.0356	3.3921
5	0.1824	3.8383	0.1822	3.8382	0.1822	3.8383	0.1822	3.8383
1.10^{-1}	0.3403	4.0990	0.3404	4.0997	0.3404	4.0998	0.3404	4.0998
2	0.4674	4.2486	0.4679	4.2488	0.4681	4.2487	0.4681	4.2487
5	0.5315	4.3131	0.5315	4.3130	0.5314	4.3129	0.5314	4.3129
1.10^{0}	0.5365	4.3180	0.5362	4.3178	0.5362	4.3177	0.5362	4.3177
2	0.5363	4.3178	0.5362	4.3178	0.5363	4.3178	0.5363	4.3178
5	0.5363	4.3178	0.5363	4.3178	0.5363	4.3178	0.5363	4.3178

so:

$$\bar{f}^*\left(\frac{1}{\alpha_i}\right) = \sum_{j=1}^{m} g_j \frac{1}{1/\alpha_i + 1/\alpha_j}, \qquad (i = 1, m)$$

Choosing m values α_i and equating:

$$\bar{f}\left(\frac{1}{\alpha_i}\right) = \sum_{j=1}^{m} g_j \frac{1}{1/\alpha_i + 1/\alpha_j}, \qquad (i = 1, m) \tag{13}$$

a system of m linear equations is obtained, which can be solved for g_j.

From eqn. (12) it appears that m evaluations of $\bar{f}(p)$ suffice to calculate $f^*(t)$ for any value of t. Schapery makes plausible (and it is confirmed by our experiments) that $f^*(t)$ tends to $f(t)$ as m tends to infinity.

From the form of eqn. (12) it follows that Schapery's method, when applied to well hydraulics, is better suited for the recovery period than for the drawdown period. For this reason it is profitable to subtract the available steady-state solution from eqn. (3) before inversion.

For the geohydrological scheme depicted in Fig. 2, model D, results of Stehfest's and Schapery's algorithms are presented for a selected number of time values (Tables 1 and 2). The tables also display the results obtained with an analytical formula that was derived using a generalized Fourier transform technique (Maas, 1987). It appears from the tables that the number of function-

TABLE 2

Schapery's method tested against an analytical solution of the problem shown in Fig. 2, model D

Time (days)	Schapery $m = 25$		Schapery $m = 50$		Schapery $m = 100$		Analytical solution [Maas, 1987, eqn. (26)]	
	s_1 (m)	s_2 (m)	s_1 (m)	s_2 (m)	s_1 (m)	s_2 (m)	s_1 (m)	s_2 (m)
1.10^{-4}	0.0814	1.3985	0.0004	0.0196	0	0.0164	0	0.0164
2	0.0807	1.4029	0.0003	0.0974	0	0.0956	0	0.0956
5	0.0788	1.4157	−0.0004	0.3570	0	0.3591	0	0.3591
1.10^{-4}	0.0757	1.4369	0.0002	0.6597	−0	0.6586	0	0.6585
2	0.0697	1.4784	0.0002	1.0052	−0	1.0044	0	1.0044
5	0.0530	1.5964	−0.0002	1.4863	−0	1.4872	0	1.4872
1.10^{-3}	0.0291	1.7731	0.0004	1.8557	0	1.8541	0	1.8541
2	−0.0057	2.0639	−0.0004	2.2155	0	2.2168	0	2.2168
5	−0.0463	2.6108	0.0004	2.6903	0.0000	2.6891	0.0000	2.6890
1.10^{-2}	−0.0278	3.0358	0.0027	3.0417	0.0031	3.0419	0.0030	3.0419
2	0.0536	3.4194	0.0360	3.3914	0.0356	3.3921	0.0356	3.3921
5	0.2089	3.8755	0.1819	3.8386	0.1822	3.8383	0.1822	3.8383
1.10^{-1}	0.3322	4.0866	0.3408	4.0992	0.3404	4.0998	0.3404	4.0998
2	0.4513	4.2257	0.4677	4.2492	0.4681	4.2487	0.4681	4.2487
5	0.5358	4.3192	0.5315	4.3127	0.5314	4.3129	0.5314	4.3129
1.10^{0}	0.5399	4.3226	0.5362	4.3179	0.5362	4.3177	0.5362	4.3177
2	0.5363	4.3178	0.5363	4.3178	0.5363	4.3178	0.5363	4.3178
5	0.5355	4.3168	0.5363	4.3179	0.5363	4.3178	0.5363	4.3178

al evaluations (N and m, respectively) are decisive for the accuracy of the results. The authors suggest that for practical purposes Stehfest's method be used with $N = 10$ and that of Schapery with $m = 100$. Which of the two algorithms is to be preferred depends primarily on the number of time values for which the original function $f(t)$ is required. Roughly speaking the two algorithms are competitive when this number equals ten. It is safe, however, to use both methods together and compare the outcome. From a computational point of view the analytical solution shown in the last columns of Tables 1 and 2 is far inferior to the approximate ones, especially for small values of time. It should not be employed unless high accuracy is necessary for theoretical reasons.

EXAMPLES OF WELL FLOW IN MULTIPLE AQUIFERS

The computing technique described in the previous sections can be used to analyse the drawdown behaviour of simple or rather complex multiple-aquifer systems with leaky or confined boundaries. However, unconfined and heterogeneous aquifer problems can also be treated, as will be discussed in the next section. Calculations for all examples given are carried out by the same interactive program, written in double precision GW-BASIC, compiled and run on an Olivetti M24 microcomputer. Processing speed appeared to be no serious

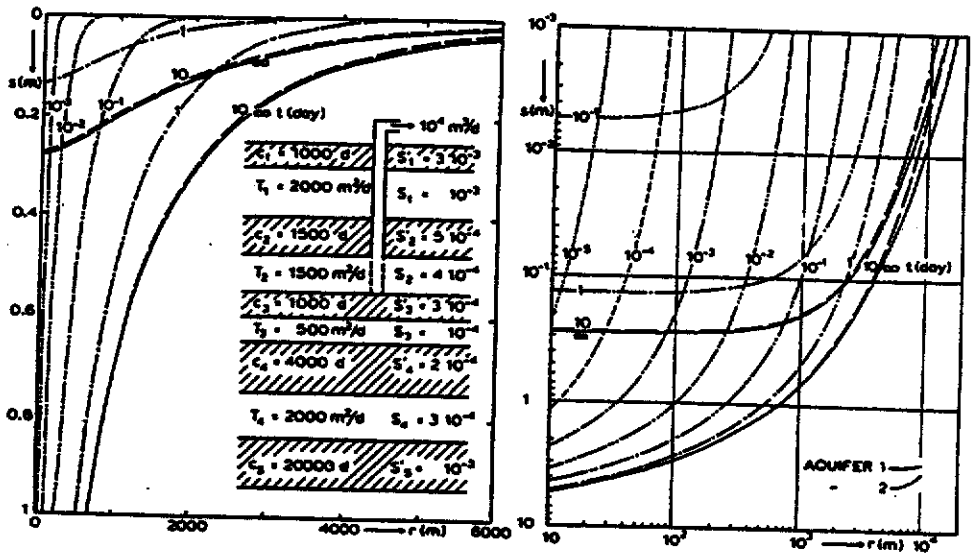

Fig. 3. Development of the piezometric depressions in the pumped and top aquifer of a leaky four-aquifer system.

limitation since, for example, the computation of 400 drawdowns in a four-aquifer system (Fig. 3) only required 8 min.

As a first example the two-aquifer and interjacent aquitard system, used by Neuman and Witherspoon (1969b) to show the effects of unpumped aquifers and aquitard storage, is modified to include aquitards at the top and base of both aquifers. The original time-drawdown curves were obtained in two different ways: a leaky system with high hydraulic resistances of the upper and lower aquitard and a confined system with zero-storage of these aquitards produced the same results (Fig. 2, model A1 and A2). Alternative pairs of drawdown curves were computed for three cases, all with identical characteristics for both aquifers and aquitards, but differing with respect to the applied boundary conditions (Fig. 2, model B, C and D). Upper and lower aquifer drawdowns are found to be considerably reduced by these alterations, showing the effect of each individual adjustment to the model.

For a better comparison with published results and to allow any set of consistent units, the use of dimensionless parameters may be preferred. Since the present solution only assumes horizontal flow in aquifers and vertical flow in aquitards, a selected set of dimensionless parameters should be based on the related hydraulic characteristics: T, S and c, S', respectively. In a multiple-aquifer system comprising n aquifers and $(n + 1)$ aquitards dimensionless drawdown s_D can be expressed as a function of $(4n + 1)$ dimensionless parameters: t_D = dimensionless time for the pumped kth aquifer $(T_k t/S_k r^2)$, $2n$ dimensionless leakage parameters $(r^2/T_i c_i)^{1/2}$ and $(r^2/T_i c_{i+1})^{1/2}$ and $2n$ dimensionless storage parameters S_i/S_k $(i \neq k)$ and S_i'/S_k, where s_D is defined by $s_D = 4\pi T_k s/Q_k$. Apart from these parameters the top and base conditions of the

system should be given as no-drawdown or no-flow boundaries. Although the drawdown curves in Fig. 2 are given on a dimensionless scale, actual computation has been carried out using the parameters indicated in the lower part of this figure.

A second example to illustrate the application of the presented solution technique concerns the visualization of a developing cone of depression around a pumped well in the second aquifer of a leaky four-aquifer system (Fig. 3). It represents the fresh and brackish groundwater system in the polder area around a well field at Lexmond in The Netherlands (Hemker, 1984). The used set of hydraulic parameters is only partly based on aquifer test results; especially storativity values are estimates only. The induced potentiometric depression in the upper aquifer is shown in the same figure, clearly demonstrating its delayed development.

EXTENSION TO FISSURED AQUIFER SYSTEMS

As explained by Streltsova-Adams (1978) and Streltsova (1982, 1984) there is an obvious similarity between well flow solutions for layered systems and fissured formations. Hence it is of interest to determine to what extent the applicability of the presented multiple-aquifer technique can be expanded to include the related solutions for heterogeneous systems. Most solutions for groundwater flow in fissured formations are based on the double-porosity concept and assume either a linear (also referred to as : pseudo-steady state, lumped) or a diffusive (transient, capacitive, distributed) type of block-to-fissure flow behaviour (Streltsova, 1984; Barker, 1985). Linear crossflow implies that the rate of flow is proportional to the average difference in heads between fissures and blocks, while diffusive crossflow is based on the development of a head distribution in the matrix material of the blocks.

The influence of double-porosity with linear crossflow can be simulated by adding a zero-transmissivity aquifer and an interjacent zero-storativity aquitard to the system. Unconfined conditions of multiple-aquifer systems can be modelled in exactly the same way (Hemker, 1985). When, for example, an unconfined fissured aquifer is considered, drawdown behaviour can be reproduced by a confined three-aquifer model. A quantitative confirmation was sought in the type curves presented by Boulton and Streltsova-Adams (1978). However, although five parameters are given for each set of curves, while four are sufficient, not enough information is provided for a reconstruction. With the aid of published drawdown values for the same curves (Streltsova-Adams, 1978) it was found that the unknown aquifer transmissivity is probably $1\,m^2 day^{-1}$. Table 3 shows the results of calculations obtained from the analytical solution for unconfined flow in a fissured formation, the analytical solution for confined flow in a three-aquifer system and the corresponding Stehfest numerical inversion approximation.

When the block geometry of a double-porosity formation can be idealized as infinite slabs, solutions for diffusive block-to-fissure flow are identical to an

TABLE 3

Drawdown values for comparable triple-porosity models

t (day)	$\frac{4\,T_2\,t}{r^2\,S_2}$	Dimensionless drawdown		
		Streltsova[1]	Hemker[2]	Hemker and Maas[3]
$5\ 10^{-6}$	0.2	0.0010	0.0011	0.0010
$1.25\ 10^{-5}$	0.5	0.0446	0.0444	0.0446
$2.5\ 10^{-5}$	1	0.1882	0.1854	0.1854
$5\ 10^{-5}$	2	0.4255	0.4218	0.4217
$1.25\ 10^{-4}$	5	0.7334	0.7309	0.7307
$2.5\ 10^{-4}$	10	0.8876	0.8860	0.8860
$5\ 10^{-4}$	20	1.0340	1.0316	1.0318
$1.25\ 10^{-3}$	50	1.3735	1.3683	1.3683
$2.5\ 10^{-3}$	100	1.8013	1.7937	1.7937
$5\ 10^{-3}$	200	2.3592	2.3501	2.3499
$1.25\ 10^{-2}$	500	3.1650	3.1560	3.1559
0.025	1000	3.7422	3.7348	3.7348
0.05	2000	4.2370	4.2329	4.2329
0.125	5000	4.6772	4.6813	4.6812
0.25	10^4	4.8200	4.8343	4.8343
0.5	$2\ 10^4$	4.8595	4.8900	4.8902
1.25	$5\ 10^4$	4.8886	4.9627	4.9626
2.5	10^5	4.9353	5.0752	5.0751

[1] Streltsova-Adams, 1978: table IV, $r = 1$.
[2] Hemker, 1985: Eqn. (11), $r/(T_2c_2)^{1/2} = 0.1$, $r/(T_2c_2)^{1/2} = 1$, $S_1/S_2 = 100$, $S_3/S_2 = 10$.
[3] Using Stehfest ($N = 10$): see Fig. 4, model A, $r = 1\,m$.

aquifer–aquitard system with no-flow boundaries. Similarly, triple-porosity media with diffusive flow and slab-shaped blocks correspond with confined layered systems of two aquitards and one aquifer. To illustrate these analogies, the multilayer counterparts of: (A) an unconfined double-porosity formation with linear crossflow; (B) an unconfined double-porosity formation with diffusive crossflow; and (C) a confined triple-porosity formation with diffusive crossflow are shown in Fig. 4. For each model dimensionless drawdown curves are plotted to demonstrate their different hydraulic behaviour.

Thus far only double- and triple-porosity single formations have been discussed. There is, however, no restriction to also include multiple-porosity layered formations. The solution is found in the composition of the proper system matrix. To include diffusive crossflow in some layer, the corresponding diagonal element of the system matrix is extended with a source term to account for contribution from the matrix blocks: $(b_j \tanh b_j)/c_j T_i$. Two extra block parameters are introduced (c_j, S_j') when one such term is added; in case of multiple-porosity the procedure of adding terms can be repeated.

Linear crossflow can be included in a multilayer model in a similar way by adding the term $b_j^2/[c_j T_i(1 + b_j^2)]$ to the appropriate diagonal element. If the matrix block drawdown is of interest an alternative solution is found by increasing the number of aquifers considered. The block storativity value is

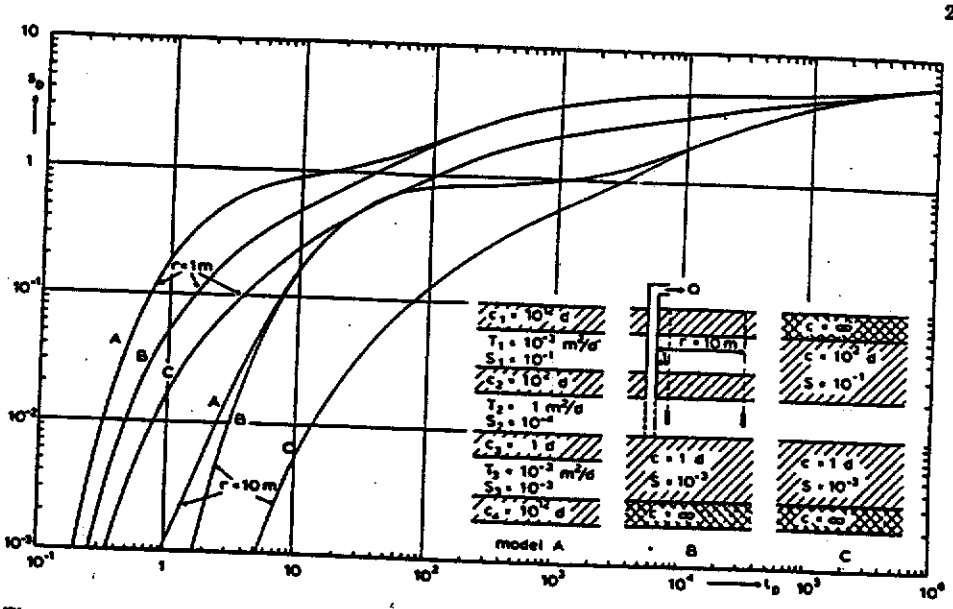

Fig. 4. Time-drawdown curves for triple-porosity formations with linear and/or diffusive crossflow.

assigned to an aquifer of (nearly) zero-transmissivity, while the additional zero-storativity aquitard accounts for the block resistance (Fig. 4, model A). If the fissured formation is no top or base aquifer, however, the simple structure of aquifer succession is broken. As a result the tridiagonal property of the system matrix will be lost, but this doesn't impede the application of the presented matrix solution method.

CONCLUSIONS

The main object of this paper has been to develop an efficient solution to the transient multiple-aquifer well flow problem, accounting for elastic storage in aquifers as well as in aquitards. Following essentially the same techniques, the authors independently arrived at comparable results, using the Laplace transform and numerical Laplace inversion. The two approaches prove to be competitive from an economical point of view. Being essentially approximate, the methods are recommended to be used together in order to check each other. A comparison of the results with those obtained by a fully analytical solution shows that high accuracy is attainable.

It has been shown by examples that the solutions are well suited to theoretically investigate the dynamical behaviour of multiple-aquifer systems. Features such as double or multiple porosity are easily incorporated in the models.

The primary stimulus of the research reported in this paper has been its application to computerized evaluation of pumping tests. Multiple-aquifer tests have been successfully interpreted by both authors. The subject is felt to be of sufficient practical interest to justify publication as a separate paper.

APPENDIX A. DERIVATION OF EQN. (4) IN TERMS OF MATRIX FUNCTIONS

The reader who is not familiar with the use of matrix differential calculus is advised to consult Maas (1986). A stratified porous medium is considered, containing an infinite number of layers. The following (infinite) matrices are defined:

(a) column matrices:

$s \quad \{s_i\} = s_i$

$s' \quad \{s'_i\} = s'_i$

$q \quad \{q_i\} = Q_i$

(b) diagonal matrices:

$K \quad \{K_{ii}\} = K_i$

$K' \quad \{K'_{ii}\} = K'_i$

$S \quad \{S_{ii}\} = S_i$

$S' \quad \{S'_{ii}\} = S'_i$

$D' \quad \{D'_{ii}\} = D'_i$

$C \quad \{C_{ii}\} = c_i$

$T \quad \{T_{ii}\} = T_i$

(c) superdiagonal matrix:

$H \quad \{H_{i,i+1}\} = 1$

The matrix H, being introduced for operational purposes, is defined to have the following property:

$$H^T H = I$$

where H^T is the transpose of H and I is the infinite unit matrix.

The matrix differential equation describing the hydraulic head in the aquitards reads:

$$K' \frac{\partial^2}{\partial z^2} s'(r, z, t) = S' \frac{\partial}{\partial t} s'(r, z, t) \tag{A1}$$

Putting $\zeta = (z_i - z)/D'_i$ for each aquitard, eqn. (A1) can be written:

$$\frac{\partial^2}{\partial \zeta^2} s'(r, \zeta, t) = CS' \frac{\partial}{\partial t} s'(r, \zeta, t) \tag{A1'}$$

(notice that ζ runs from 0 to 1). The boundary conditions with respect to ζ are given by:

$$s'(r, 1, t) = Hs'(r, 0, t) = s(r, t) \tag{A2a}$$

$$C^{-1} \frac{\partial}{\partial \zeta} s'(r, \zeta \uparrow 1, t) = HC^{-1} \frac{\partial}{\partial \zeta} s'(r, \zeta \downarrow 0, t) \tag{A2b}$$

When the initial condition is taken to be:

$$s'(r, \zeta, 0) = 0 \tag{A2c}$$

the Laplace transform of eqn. (A1') is given by:

$$\frac{\partial^2}{\partial \zeta^2} \bar{s}'(r, \zeta, p) = pCS' \bar{s}'(r, \zeta, p) \tag{A1''}$$

Equations (A2a, b) remain unaltered under Laplace transformation, except for a bar appearing above s' and s. By inspection the solution of eqn. (A1″), using eqn. (A2a), is found to be:

$$\bar{s}'(r, \zeta, p) = \sinh^{-1}\{\sqrt{pCS'}\}[\sinh\{(1 - \zeta)\sqrt{pCS'}\}H^{\mathrm{T}} + \sinh\{\zeta\sqrt{pCS'}\}]\bar{s}(r, p) \tag{A3}$$

Using Darcy's law the downward flux $\bar{i}$ through the aquitards is found from eqn. (A3):

$$\bar{i}(r, \zeta, p) = -C^{-1}\frac{\partial}{\partial\zeta}\bar{s}'(r, \zeta, p) = -C^{-1}\sinh^{-1}\{\sqrt{pCS'}\}\sqrt{pCS'} \cdot$$

$$[-\cosh\{(1 - \zeta)\sqrt{pCS'}\}H^{\mathrm{T}} + \cosh\{\zeta\sqrt{pCS'}\}]\bar{s}(r, p) \tag{A4}$$

With regard to the aquifers the matrix differential equation describing the hydraulic head is:

$$T\nabla_r^2 s(r, t) - H\bar{i}(r, 0, t) + \bar{i}(r, 1, t) = S\frac{\partial}{\partial t}s(r, t) \tag{A5}$$

where:

$$\nabla_r^2 = \frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r}$$

The boundary conditions are:

$$\lim_{r\to 0} -2\pi r\, T\frac{\partial}{\partial r}s(r, t) = q \tag{A6a}$$

$$s(\infty, t) = 0 \tag{A6b}$$

With the initial condition:

$$s(r, 0) = 0 \tag{A6c}$$

the Laplace transform of eqns. (A5) and (A6a, b) reads:

$$T\nabla_r^2\bar{s}(r, p) - H\bar{i}(r, 0, p) + \bar{i}(r, 1, p) = pS\bar{s}(r, \zeta) \tag{A5′}$$

$$\lim_{r\to 0} -2\pi r\, T\frac{\partial}{\partial r}\bar{s}(r, p) = \frac{1}{p}q \tag{A6a′}$$

$$\bar{s}(\infty, p) = 0 \tag{A6b′}$$

In view of eqn. (A4), eqn. (A5′) can be written:

$$T\nabla_r^2\bar{s}(r, p) + B(p)\bar{s}(r, p) = pS\bar{s}(r, p) \tag{A5″}$$

where:

$$B = HC^{-1}\sinh^{-1}\{\sqrt{pCS'}\}\sqrt{pCS'}\,[-\cosh\{\sqrt{pCS'}\}H^{\mathrm{T}} + I]$$

$$\cdot\ -C^{-1}\sinh^{-1}\{\sqrt{pCS'}\}[-H^{\mathrm{T}} + \cosh\{\sqrt{pCS'}\}] \tag{A7}$$

The matrix B is seen to be symmetrically tridiagonal. In scalar notation:

$$\{B_{ii}\} = -\frac{1}{c_i}\frac{\sqrt{pc_iS_i'}}{\tanh\sqrt{pc_iS_i'}} - \frac{1}{c_{i+1}}\frac{\sqrt{pc_{i+1}S_{i+1}'}}{\tanh\sqrt{pc_{i+1}S_{i+1}'}}$$

$$\{B_{i,i+1}\} = \frac{1}{c_{i+1}}\frac{\sqrt{pc_{i+1}S_{i+1}'}}{\sinh\sqrt{pc_{i+1}S_{i+1}'}} \tag{A7′}$$

$$\{B_{i+1,i}\} = \{B_{i,i+1}\}$$

The general solution of eqn. (A5") is given by:

$$\bar{s}(r, p) = K_0\{r\sqrt{A(p)}\}c_1 + I_0\{r\sqrt{A(p)}\}c_2 \tag{A8}$$

where:

$$A(p) = T^{-1}[pS - B(p)]$$

c_1 and c_2 are column matrices containing constants of integration. c_1 and c_2 are solved by using eqn. (A8) and the boundary conditions (A6a') and (A6b'). It is found that:

$$c_1 = \frac{1}{2\pi p} T^{-1} q \tag{A9a}$$

$$c_2 = 0 \tag{A9b}$$

so the final solution reads:

$$\bar{s}(r, p) = \frac{1}{2\pi p} K_0\{r\sqrt{A(p)}\}T^{-1} q \tag{A8'}$$

A finite system of n aquifers and $n + 1$ aquitards can be obtained by setting:

$$\bar{s}_0(r, p) = 0 \tag{A10a}$$

$$\bar{s}_{n+1}(r, p) = 0 \tag{A10b}$$

Alternatively, an impervious base may be introduced by setting:

$$\{B_{nn}\} = -\frac{1}{c_n}\frac{\sqrt{pc_nS_n'}}{\tanh\sqrt{pc_nS_n'}} \tag{A11a}$$

and an impervious top layer is obtained likewise by:

$$\{B_{11}\} = -\frac{1}{c_1}\frac{\sqrt{pc_1S_1}}{\tanh\sqrt{pc_1S_1'}} \tag{A11b}$$

Numerical evaluation of the matrix function $K_0\{r\sqrt{A}\}$ is performed as described by Maas (1986).

APPENDIX B. DERIVATION OF EQN. (5) BY EIGENVALUE ANALYSIS

The application of the Laplace transform to the boundary value problem given by eqns. (1) and (2) yields a system of $2n$ ordinary differential equations.

Vertical flow in the aquitards is described by n equations:

$$\frac{\partial^2 \bar{s}_i'}{\partial z^2} = p\frac{S_{si}'}{K_i'}\bar{s}_i', \qquad i = 1, 2, \ldots, n \tag{B1}$$

$$\bar{s}_i'(r, z_{i-1}, p) = \bar{s}_{i-1}(r, p)$$

$$\bar{s}_i'(r, z_i', p) = \bar{s}_i(r, p)$$

while $\bar{s}_0 = \bar{s}_{n+1} = 0$ when a leaky system is considered. By substituting $a_i^2 = pS_{si}/K_i'$ and $b_i = a_i D_i'$ the solution obtained can be written:

$$\bar{s}_i' = \frac{\sinh(a_i z - a_i z_i')}{\sinh b_i}\bar{s}_{i-1} + \frac{\sinh(a_i z_{i-1} - a_i z)}{\sinh b_i}\bar{s}_i$$

from which it follows that:

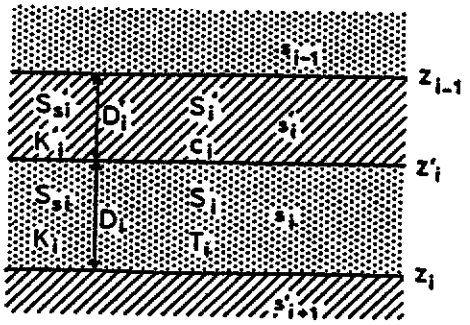

Fig. 5. Definition sketch.

$$\frac{\partial \bar{s}'_i}{\partial z} = \frac{a_i \cosh(a_i z - a_i z'_i)}{\sinh b_i} \bar{s}_{i-1} - \frac{a_i \cosh(a_i z_{i-1} - a_i z)}{\sinh b_i} \bar{s}_i \tag{B2}$$

If, however, the base of aquitard i is impervious, the second boundary condition of eqn. (B1) should be replaced by:

$$\frac{\partial}{\partial z} \bar{s}'_i(r, z'_i, p) = 0$$

which leads to a solution of the form:

$$\bar{s}'_i = \frac{\cosh(a_i z - a_i z'_i)}{\cosh b_i} \bar{s}_{i-1}$$

and hence:

$$\frac{\partial \bar{s}'_i}{\partial z} = \frac{a_i \sinh(a_i z - a_i z'_i)}{\cosh b_i} \bar{s}_{i-1} \tag{B3}$$

When, subsequently, the system of differential equations for horizontal flow is considered, eqn. (2), Laplace transformation will yield:

$$\frac{\partial^2 \bar{s}_i}{\partial r^2} + \frac{1}{r}\frac{\partial \bar{s}_i}{\partial r} + \frac{K'_i}{T_i}\frac{\partial \bar{s}'_i}{\partial z}\bigg|_{z=z'_i} - \frac{K'_{i+1}}{T_i}\frac{\partial \bar{s}'_{i+1}}{\partial z}\bigg|_{z=z_i} - p\frac{S_i}{T_i}\bar{s}_i = 0, \quad i = 1, 2, \ldots, n \tag{B4}$$

$$\bar{s}_i(\infty, p) = 0$$

$$\lim_{r \to 0} r \frac{\partial \bar{s}_i}{\partial r} = -\frac{Q_i}{2\pi p T_i}$$

Substituting eqn. (B2) into the third and fourth term of eqn. (B4) and rearranging leads to the following expression:

$$\frac{\partial^2 \bar{s}_i}{\partial r^2} + \frac{1}{r}\frac{\partial \bar{s}_i}{\partial r} = -\frac{b_i}{c_i T_i \sinh b_i} \bar{s}_{i-1} + \left(\frac{b_i \coth b_i}{c_i T_i} + \frac{b_{i+1} \coth b_{i+1}}{c_{i+1} T_i} + \frac{pS_i}{T_i}\right) \bar{s}_i - \frac{b_{i+1}}{c_{i+1} T_i \sinh b_{i+1}} \bar{s}_{i+1}$$

At this stage the system of n equations is readily expressed in matrix notation:

$$L\bar{s} = A\bar{s} \tag{B5}$$

where L is the Laplace operator $\partial^2/\partial r^2 + 1/r\partial/\partial r$, $\bar{s}$ is the vector of transformed drawdowns and A is the tridiagonal $n \times n$ system matrix, as defined by eqn. (6). From eqns. (B3) and (B4) it follows that systems with no-flow boundaries only require that e_{11} and (or) $e_{n+1,n}$ of matrix A are replaced by $(b_1 \tanh b_1)/c_1 T_1$ and (or) $(b_{n+1} \tanh b_{n+1})/c_{n+1} T_n$.

Solving eqn. (B5) for $\bar{s}$ is essentially similar to the steady well flow multiple-aquifer solution (Hemker, 1984). A slightly different approach will be used, however, to fully benefit from the nearly symmetric property of A. We define a symmetric tridiagonal matrix D and then calculate its n eigenvalues and eigenvectors:

$$T^{1/2} A T^{-1/2} = D = RWR^{-1} \tag{B6}$$

where T is a diagonal matrix with T_i along the main diagonal, W is the $n \times n$ diagonal matrix with the eigenvalues ω_i, and R is the $n \times n$ matrix containing the corresponding eigenvectors in its columns. Since D is symmetric, the eigenvectors can be normalized to achieve an orthonormal matrix R, thus $R^{-1} = R^T$. Let matrix V be defined by $V = T^{-1/2} R$, then:

$$V^{-1} = R^{-1} T^{1/2} = R^T T^{1/2} = V^T T \tag{B7}$$

Substituting eqns. (B6) and (B7) into (B5) leads to:

$$L\bar{s} = VWV^{-1}\bar{s} \tag{B8}$$

This system of differential equations can be uncoupled and solved for the boundary conditions, just like the steady-flow problem, to obtain:

$$\bar{s} = \frac{1}{p} VKV^{-1} g \tag{B9}$$

where K is the $n \times n$ diagonal matrix with $K_0(r\sqrt{w_i})$ as non-zero elements and g is the vector given by $Q_i/2\pi T_i$, $i = 1, 2, \ldots, n$. By further simplification the final solution may be written:

$$\bar{s} = \frac{1}{2\pi p} VKV^T q \tag{5}$$

where q is simply the discharge vector $(Q_1, Q_2, \ldots, Q_n)^T$. This last equation shows that its numerical evaluation only implies the eigenvalue decomposition of a symmetric tridiagonal matrix and the calculation of hyperbolic and Bessel functions.

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NOTICE OF INTENT TO APPEAR

Southern California Water Company plans to participate in the water right hearing regarding:
(name of party or participant)

Petition to Revise
Declaration of Fully Appropriated Stream Systems
Regarding
the American River, Sacramento County

Scheduled for
May 31, 2002

☐ I/we intend to present a policy statement only:
☒ I agree to accept electronic service:
☒ I/we plan to call the following witnesses to testify at the hearing:

NAME	SUBJECT OF PROPOSED TESTIMONY	ESTIMATED LENGTH OF DIRECT TESTIMONY	EXPERT WITNESS (YES/NO)
SCWC - Jim Carson	History of Groundwater Production by Arden Cordova Water Services (ACWS). Key Issues (1) and (2).	20 minutes	Non-Expert
SCWC - Rob Hanford	Technical Background Regarding Groundwater Production by Arden Cordova Water Services. Key Issues (1) and (2).	20 minutes	Expert
Komex - Stephen Ross - Anthony Brown	Relationship of groundwater to Lower American River, impact of groundwater treatment operations. Key Issues (1) - (4).	20 minutes each	Expert
Stetson Engineers - Stephen Johnson - Jeff Helsley	Groundwater operations; water usage of Lower American River. Key Issues (3) and (4).	20 minutes each	Expert
Kennedy-Jenks - Lynn Takaichi - Morris Taylor	Groundwater operations; water usage of Lower American River. Key Issues (3) and (4).	20 minutes each	Expert

(If more space is required, please add additional pages or use reverse side)

Name, Address, Phone Number and Fax Number of Attorney or Other Representative

Signature: _____ Dated April 9, 2002

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Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

BEFORE THE

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	**OPENING STATEMENT OF SOUTHERN CALIFORNIA WATER COMPANY**

HATCH AND PARENT
21 East Carrillo Street
Santa Barbara, CA 93101

I.

INTRODUCTION

Southern California Water Company ("SCWC"), is before you today in a quest to preserve its water supply for the benefit of the existing residents and businesses within an unincorporated area of Sacramento County commonly referred to as Rancho Cordova.

SCWC operates in Sacramento County as Arden-Cordova Water Services and provides water to the 40,000 residents of Rancho Cordova. Recently, however, the water supply for this community has been threatened by groundwater contamination originating from property owned by the Aerojet-General Corporation. To date, more than half of the wells in the Cordova System have been shut down because of this contamination. Additional wells are anticipated to be lost, and eventually SCWC expects that virtually no groundwater will be directly available to supply this community.

At the same time, Aerojet has been ordered by the Environmental Protection Agency ("EPA") and the California Regional Water Quality Control Board, Central Valley Region ("RWQCB") to

construct facilities to pump the contaminated groundwater in the Rancho Cordova area and treat it. One of these facilities, the American River Groundwater Extraction and Treatment ("ARGET") facility, is currently discharging its treated water into the Lower American River. In the future, it is anticipated that two other sets of facilities, the existing GET E and GET F facilities, and the future facilities described by Alternative 4(c) in the *Western Operable Unit Remedial Investigation/Feasibility Study (April 17, 2000)* (*see* SCWC Exhibit 17, figure 4-6), will also discharge treated water directly or indirectly into the American River.

In general, the purpose of this hearing is for the Board to decide whether there is reasonable grounds to believe that there is unappropriated water available for appropriation in the Lower American River under circumstances that support a limited revision of the Declaration of Fully Appropriated Streams ("FAS Declaration"). To assist in making this determination, the SWRCB has identified four key issues. A fair short summary statement of these issues is (1) whether there has been a change in circumstances; (2) how much of discharged groundwater was *not* considered in the prior FAS Declaration; (3) how much have flows been affected by the extraction and discharge and (4) is there sufficient data to support the a determination that there is unappropriated water?

Resolution of these key issues turns on an inquiry that has temporal, source and materiality components. First, the activity must have occurred subsequent in time to the initial FAS Declaration. Second, the source of the water must be truly additive to the pre-existing supply. Third, the added quantity must be material. The evidence will show that: groundwater discharged by Aerojet is later in time to the FAS declaration; the groundwater discharge was not considered under the earlier FAS declaration because it is both (a) non-tributary to the Lower American River, and (b) previously consumptively used by SCWC, among others; there is no adverse impact on the Lower American River because the supply is not tributary; and there is unappropriated water available because the groundwater discharged is actually serving to augment the flows of Buffalo Creek and the Lower American River.

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II.

THE PUMP AND DISCHARGE OF GROUNDWATER BY AEROJET IS SUBSEQUENT IN TIME TO THE EARLIER SWRCB DECISIONS FINDING THAT THE LOWER AMERICAN RIVER IS FULLY APPROPRIATED: THEREFORE THERE HAS BEEN A MATERIAL CHANGE IN CIRCUMSTANCES.

The Lower American River was included in the original Declaration of Fully Appropriated Stream Systems adopted by the SWRCB in 1989. (*See* Order WR 89-25.) The Lower American River has remained on this list and was included in the most recent revision to the FAS Declaration which was adopted by the SWRCB in 1998. (*See* Order WR 98-08.) Order WR 89-25 cited two earlier decisions as the basis for including the Lower American River in the FAS Declaration. These were D-1108 and D-1211, which were adopted by the SWRCB in 1963 and 1965, respectively. The prior finding of no unappropriated water available in Decision 1211 is based upon findings made in previous decisions (e.g., D-893, D-1045, D-1082, D-1098), the earliest of which was adopted in 1958 (D-893).

SCWC will offer uncontroverted evidence to show Aerojet did not begin discharging treated groundwater to the American River until August of 1998, over 30 years after the most recent of the decisions that found the Lower American River to be fully appropriated. As such, the timing of the discharge of groundwater by Aerojet is a relatively new occurrence and dispositive as to Key Issue Number One because there has been a change in conditions since the FAS Declaration.

III.

THE SOURCE OF THE GROUNDWATER DISCHARGED BY AEROJET IS NON-TRIBUTARY TO THE AMERICAN RIVER AND WOULD BE OTHERWISE PRODUCED AND DISTRIBUTED BY SCWC: THEREFORE IT WAS NOT CONSIDERED AT THE TIME OF THE PRIOR FAS PETITION AND THE EXTRACTION AND DISCHARGE OF THIS WATER HAS NO EFFECT ON THE LOWER AMERICAN RIVER.

In summary, given the undisputed timing of the discharges, if the groundwater discharged by Aerojet was non-tributary to the American River, it could *not* have been considered at the time

of the FAS Declaration. Moreover, the extraction and discharge of this groundwater could, by definition, have no adverse impact on the Lower American River. In addition, the discharge of this added foreign water would augment the native supply.

On the other hand, if contrary to the substantial evidence submitted by Petitioner, the groundwater discharged by Aerojet is found to have some limited hydrologic connection to the Lower American River, Mr. Robert Hanford will testify that the groundwater now being discharged by Aerojet is and has been pumped and consumed by SCWC within its existing service territory. Accordingly, it follows that if there were some interconnection between groundwater and the surface supply of the Lower American River, to whatever degree SCWC is forced to forebear from extracting groundwater that same quantity of groundwater also serves to add new water to the Lower American River. The quantity of the addition would be equivalent to the amount of SCWC's reduced groundwater production.

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A. Substantially All The Groundwater Pumped and Discharged by Aerojet is Not a Part of the Natural Flow of Buffalo Creek and the Lower American River.

Substantial, credible evidence will be presented to this Board showing that the groundwater currently discharged and planned and approved to be discharged by Aerojet into Buffalo Creek and the American River is substantially all non-tributary. In fact, the total amount of water from the groundwater treatment operations that *may* be considered tributary, is less than 2% of the total water identified by the Petition.

In summary, evidence presented by SCWC will demonstrate the following:

1. <u>The weight of historical studies demonstrate that the Lower American River is a losing stream and that groundwater from the SCWC well-field and the Aerojet points of extraction draw non-tributary groundwater.</u>

There is a plethora of historical reports authored by public agencies that have consistently and uniformly indicated that the Lower American River is a losing stream. SCWC commissioned a study of groundwater flow conditions by Komex, to determine whether the groundwater pumped by Aerojet and discharged into Buffalo Creek and the American River should be considered tributary

to these surface streams. (*See* SCWC Exhibit 9(a).)

The testimony of Mr. Anthony Brown and Mr. Stephen Ross will be that they surveyed the professional papers and literature referenced previously and concluded that the prevailing opinion is that substantially all of the water is "non-tributary." These reports demonstrate that the River loses flow into the surrounding groundwater basin and the observations of these conditions have been constant and unchanged for decades. For example, the Department of Water Resources Bulletin 133, dated March 1964, analyzed groundwater conditions in the South Sacramento Groundwater Basin and found that:

> A comparison of the 1953 groundwater elevations to the 1963 ground water elevations shows a general decline throughout the entire area of investigation, with the least amount of change occurring where the American River is influencing recharge. The greatest change, approximately 20 feet, occurs in the Rancho Cordova area where intense urban development has taken place . . .

(Bulletin 133, p.18, *see* SCWC Exhibit 12.) The decisions upon which the FAS Declaration were based were adopted in 1963 and 1965. It is almost certain, therefore, that these decisions took into account these lowered groundwater elevations.

2. Independent Study Confirms These Historical Conclusions.

Mr. Stephen Ross will confirm the reported historical conclusions and further testify that the lowered groundwater elevations in the Rancho Cordova area demonstrate that the groundwater does not constitute a part of the baseflow of the Lower American River. The historical nature of this condition shows also that this groundwater was not a part of the baseflow of the River at the time of the decisions which form the basis for the FAS Declaration. The addition of groundwater from the Aerojet treatment operation thus constitutes a change of circumstances insofar as groundwater from the Rancho Cordova area is now contributing to the flow of the Lower American River.

In some instances, Komex confirmed the data provided through these professional sources with their own field investigations. They looked at a variety of factors, including: groundwater elevations in comparison to the elevation of the Lower American River, the direction of the flow of the groundwater, well tests performed in the Rancho Cordova area, the movement of contaminants

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through the groundwater basin, and finally chemical comparisons between the groundwater and the water in the Lower American River. Having completed their study, they have formed an opinion that "substantially all water" pumped and discharged by Aerojet is non-tributary water that was not considered at the time the Lower American River was declared to be fully appropriated.

3. The groundwater treatment operations, including both pumping and discharging, will add substantial flows to the American River that are additive to the flows considered when the American River system was included in the FAS Declaration.

The groundwater that is the subject to the Petition is described in terms of three general sets of facilities. The ARGET facilities, which are currently in operation, are permitted to pump and discharge over 5,000 acre-feet of water per year. The GET E and GET F facilities are anticipated to pump and discharge as much as 9,600 acre-feet per year. The facilities described by Alternative 4(c) in the Aerojet Feasibility Study (*see* SCWC Exhibit 17) are anticipated to pump and discharge almost 10,000 acre-feet per year for a planned total of approximately 24,600 acre-feet per year.

B. The Groundwater Pumped and Discharged by Aerojet Comes From the Same Source as SCWC's Historical Production.

Even assuming, for the sake of argument only, that some portion of the groundwater discharged by Aerojet was initially interconnected with the Lower American River, the fact remains that the Aerojet wells pump groundwater that "but for" the presence of contamination, would have been produced by SCWC. In the strictest sense, but for the contamination, SCWC would have pumped and delivered to its customers the same groundwater that is now contaminated and so is being treated and discharged by Aerojet. If, contrary to the evidence submitted by SCWC and corroborated by others, it is found that the groundwater being pumped and discharged by Aerojet initially contributed to the flow of the Lower American River, then any groundwater which SCWC is no longer able to pump must also be considered to be adding water to the Lower American River. The evidence will show that SCWC has produced as much as approximately 14,000 acre-feet of groundwater in a single year to meet its service territory demands.

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C. The Quantity of the Augmentation Provided by the Discharge of Groundwater Can be Adequately Measured and Determined.

The groundwater that is being pumped, treated and discharged by Aerojet can be metered and quantified and is now actually adding water to the Lower American River. While the flows from the ARGET facilities are not currently at their maximum permitted amount, SCWC's testimony will describe an actual field investigation performed by Komex on between April 25, 2002 and May 8, 2002 (*See* SCWC Exhibit 9(a) chapter 6). Of the 2100 gpm of water leaving the Aerojet property through Buffalo Creek, 1,500 gpm was measured actually entering the Lower American River.

IV.

CONCLUSION

This Petition must be understood in its peculiar context. The water that Petitioner seeks to make available for appropriation is water that it would have otherwise produced through its groundwater wells. The SWRCB has expressly limited a revision of a FAS Declaration for the benefit of specific parties. (*See In the Matter of Petitions to Revise Declaration of Fully Appropriated Streams to Allow Processing Specified Applications to Appropriate Water From the Santa Ana River*, Order WR 2000-12 (revising the FAS Declaration regarding the Santa Ana River to allow for processing of two specific applications to appropriate water).) And SCWC is proposing such a limitation in this case.

In summary, the discharge of groundwater by Aerojet occurred after the prior decisions of the SWRCB establishing the FAS Declaration. The groundwater in the South Sacramento Groundwater Basin did not constitute a part of the baseflow of the Lower American River at the time that the River was determined to be fully appropriated. Nor has pumping from this basin had any effect upon the flows of the River either historically or currently. To this extent, the groundwater was not relied upon by other Lower American River interests. In fact, substantially all the groundwater discharged by Aerojet is actually from a source that is non-tributary to the Lower American River. The quantities are significant and measurable.

On this basis, SCWC contends that the evidence will conclusively demonstrate that reasonable cause exists to partially modify the FAS Declaration for the Lower American River.

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Consistent with the intent expressed by the EPA and the RWQCB, the discharge of this groundwater to the Lower American River should, "allow for the greatest potential for reuse of the treated groundwater to provide replacement water supplies for those lost due to contamination in the Rancho Cordova and surrounding areas." (RWQCB, *Tentative Revised NPDES Permit, American River Study Area and GET E/F, Information Sheet,* p.2 (March 2002) (*See* SCWC Exhibit 25). SCWC's Petition is in furtherance of this objective.

DATED: May 31, 2002

HATCH AND PARENT

By _____
SCOTT SLATER
MICHAEL FIFE
Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

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Exhibit Identification Index

Participant_____

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
SCWC Exhibit 1	Map Showing Rancho Cordova System and Other Area Water Suppliers			
SCWC Exhibit 2	Map of Existing Cordova System			
SCWC Exhibit 3	Map of Rancho Cordova Area Water Facilities			
SCWC Exhibit 4	Map of Aerojet Well Fields			
SCWC Exhibit 5	Rancho Cordova System Aerial Photo			
SCWC Exhibit 6	Chart Showing Cordova System Wells			
SCWC Exhibit 7	Chart Showing Date of Construction of Cordova System Wells			
SCWC Exhibit 8	Testimony of Mr. Robert Hanford			
SCWC Exhibit 8a	Mr. Robert Hanford CV			
SCWC Exhibit 9	Testimony of Mr. Stephen Ross			
SCWC Exhibit 9a	Komex Report			
SCWC Exhibit 9b	Mr. Steven Ross CV			
SCWC Exhibit 9c	Mr. Anthony Brown CV			
SCWC Exhibit 9d	Tadeusz L. Dabrowski CV			
SCWC Exhibit 9e	Komex Company Brochure			
SCWC Exhibit 9f	Richard E. Chandler, R.G.			

Exhibit Identification Index

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
SCWC Exhibit 10	Stetson Testimony			
SCWC Exhibit 10a	Mr. Jeffrey D. Helsley CV			
SCWC Exhibit 11	Department of Water Resources, Evaluation of Ground Water Resources: Sacramento County. Bulletin No. 118-3 (July 1974).			
SCWC Exhibit 12	Department of Water Resources, Folsom-East Sacramento Ground Water Quality Investigation. Bulletin No. 133 (March 1964).			
SCWC Exhibit 13	Sacramento County Water Agency, County Groundwater Model-Model Development and Basin Groundwater Yield (June 1993).			
SCWC Exhibit 14	Herschy, R.W., *Streamflow Measurement* (2nd Ed., 1995)			
SCWC Exhibit 15	Aerojet General Corporation, Document W: Off-site Northwest Groundwater Investigation (June 19, 1983).			
SCWC Exhibit 16	Aerojet General Corporation, Document V: American River Investigation of August 1983.			
SCWC Exhibit 17	Aerojet General Corporation, Western Operable Unit Remedial Investigation/ Feasibility Study, Vol. I & II (April 17, 2000) (Aerojet, 2000a).			

Exhibit Identification Index

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
SCWC Exhibit 18	Aerojet General Corporation, GET Effectiveness Evaluation for the American River Study Area (February, 2000) (Aerojet, 2000b).			
SCWC Exhibit 19	United States Department of the Interior Geological Survey, Folsom, California 7.5 minute Series (1980) (Topographic Map).			
SCWC Exhibit 20	United States Department of the Interior Geological Survey, Citrus Heights, California 7.5 minute Series (1992) (Topographic Map).			
SCWC Exhibit 21	United States Department of the Interior Geological Survey, Carmichael, California, 7.5 minute Series (1992) (Topographic Map).			
SCWC Exhibit 22	Practical Handbook of Ground-Water Monitoring (David M. Nielsen, ed., 1991).			
SCWC Exhibit 23	Bernard W. Pipkin and D.D. Trust, Geology and the Environment (3rd Ed.)			
SCWC Exhibit 24	Aerojet Environment Remediation - CD Rom			
SCWC Exhibit 25	Tentative Revised NPDES Permit, American River Study Area and GET E/F, Aerojet - General Corporation, Order No. 98-113 (NPDES No. CA0083861)			

Exhibit Identification Index

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
SCWC Exhibit 26	American River Study Area Well Location Map			
SCWC Exhibit 27	Hem, J.D. Study and Interpretation of the Chemical Characteristics of Natural Water. USGS Water Supply Paper 2254 (3rd Edition dated 1992)			
SCWC Exhibit 28	United States Environmental Protection Agency, 2000. Aerojet Superfund Site, Rancho Cordova, CA: EPA Proposes a Plan to Address Groundwater Contamination in the Western Area of the Aerojet Site. November.			
SCWC Exhibit 29	Laura Masters-Bevan, National Weather Service Office, *Climate of Sacramento*			

PROOF OF SERVICE

I am a resident of the State of California, over the age of eighteen years, and not a party to the within action. My business address is HATCH AND PARENT, 21 East Carrillo, Santa Barbara, California 93101. On May 9, 2002 , I served the within document:

EXHIBIT BINDERS REGARDING AMERICAN RIVER FAS HEARING

☐ by transmitting via facsimile the document listed above to the fax number set forth below on this date before 5:00 p.m.

☐ by placing the document listed above in a sealed envelope with postage thereon fully prepaid, in the United States mail at Santa Barbara, California, addressed as set forth below.

☒ by causing delivery of the document listed above to the person at the address set forth below by Federal Express.

☐ by personally delivering the document listed above to the person at the address set forth below.

See Attached List

I am readily familiar with the firm's practice of collection and processing correspondence for mailing. Under that practice it would be deposited with the U.S. Postal Service on that same day with postage thereon fully prepaid in the ordinary course of business. I am aware that on motion of the party served, service is presumed invalid if postal cancellation date or postage meter date is more than one day after date of deposit for mailing in affidavit.

☒ *(State)* I declare under penalty of perjury under the laws of the State of California that the above is true and correct.

Executed on May 9, 2002, at Santa Barbara, California.

Brenda Torres

HATCH AND PARENT
21 East Carrillo Street
Santa Barbara, CA 93101

VIA FEDERAL EXPRESS

Ronald M. Stork
915 20th Street
Sacramento, CA 95814

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San Diego, CA 92101

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400 Capitol Mall, Suite 1900
Sacramento, CA 95814

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Los Angeles, California 90067

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PSW Region
2800 Cottage Way, E-1712
Sacramento, CA 95825

Jean McCue (5 Binders)
State Water Resources Control Board
1001 "I" Street
Sacramento, CA 95812

HATCH AND PARENT
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SCOTT S. SLATER, ESQ. (SBN 117317)
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Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

BEFORE THE

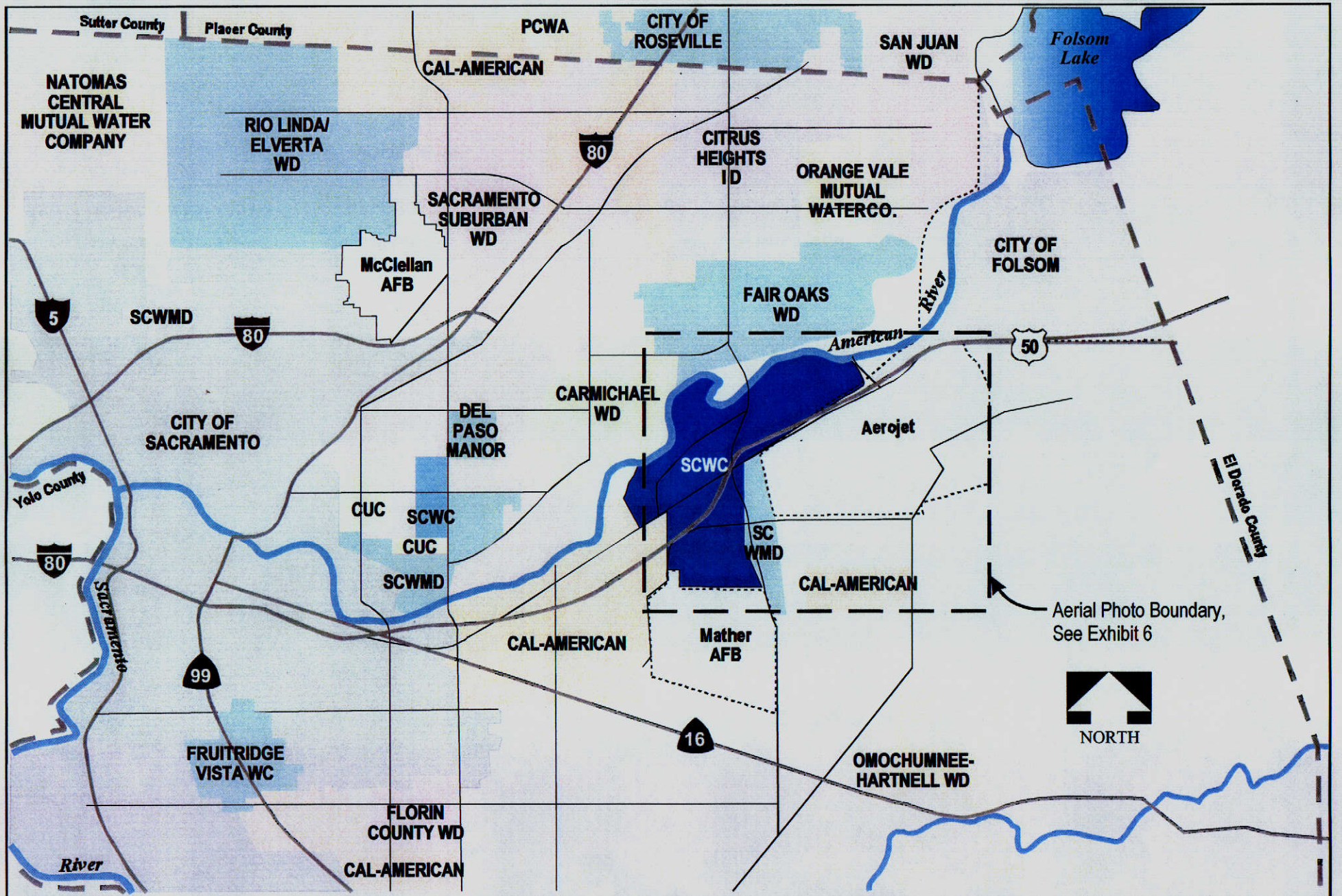
STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	))))))

Hatch and Parent
21 E. Carrillo Street
Santa Barbara, CA 93101

SCWC EXHIBIT 1



SOUTHERN CALIFORNIA WATER COMPANY	DATE: April 2002 PROJECT: 18878	Rancho Cordova System, Region 1, SCWC TITLE: Area Water Suppliers	EXHIBIT 1

Declaration of Robert Hanford

I, Robert Hanford, declare that:

1. I am the Engineering and Planning Manager for Region I of the Southern California Water Company (SCWC), in Rancho Cordova, California. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Area Water Suppliers," dated April 2002, is a true and accurate map of the region, which indicates the location of the Cordova System in relation to its neighboring water service utilities. This map was created by Brown and Caldwell (engineering consultant to SCWC) with reference to a similar map included in SCWC's 2000 Urban Water Management Plan, also produced by Brown and Caldwell.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Robert Hanford

SCOTT S. SLATER, ESQ. (SBN 117317)
MICHAEL T. FIFE ESQ. (SBN 203025)
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Attorneys for Petitioner,
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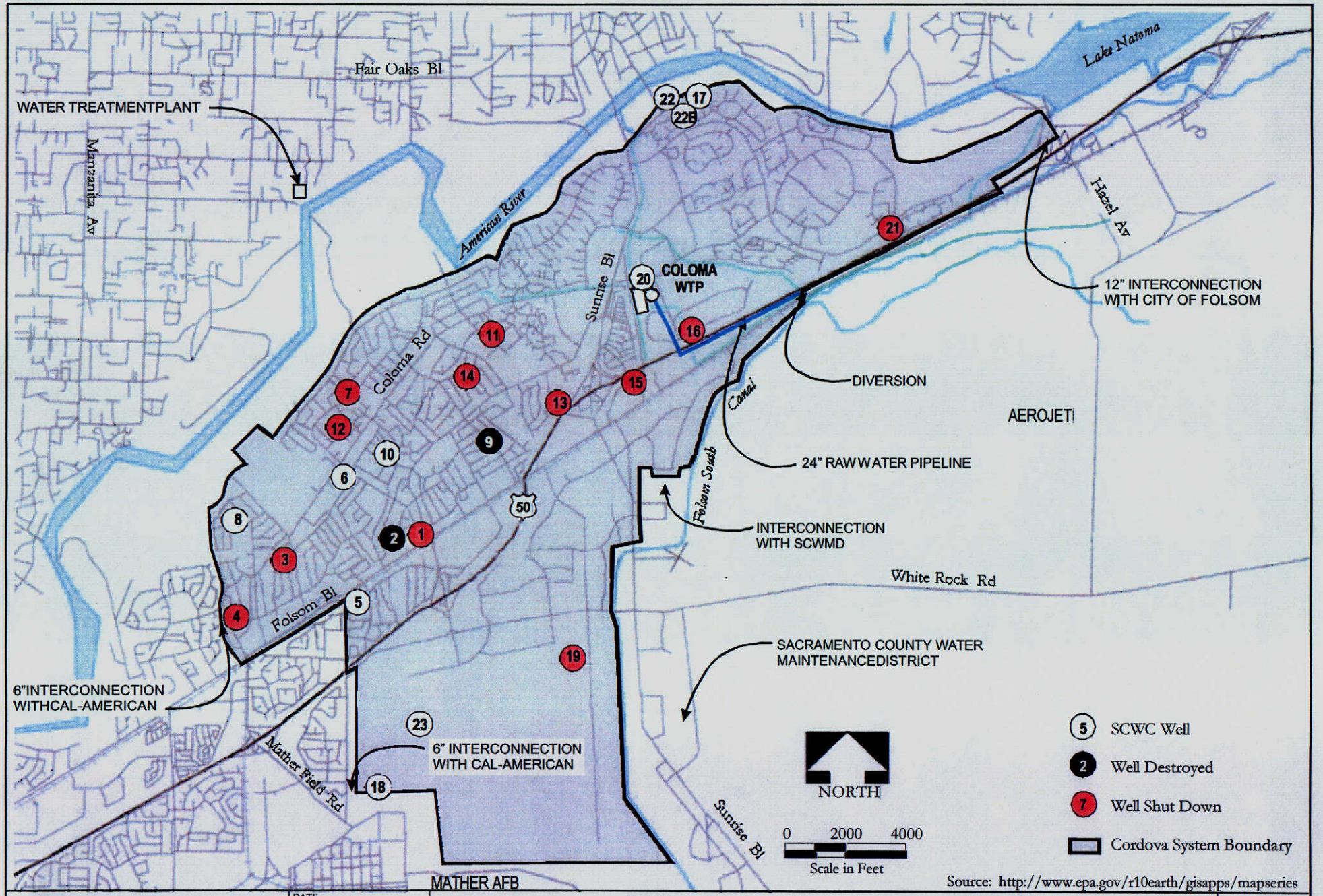
BEFORE THE

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	))))))

SCWC EXHIBIT 2



SOUTHERN CALIFORNIA WATER COMPANY	DATE: April 2002	Rancho Cordova System, Region 1, SCWC	EXHIBIT
	PROJECT: 18878	TITLE: Existing Cordova System Map	2

Declaration of Robert Hanford

I, Robert Hanford, declare that:

1. I am the Engineering and Planning Manager for Region I of the Southern California Water Company, in Rancho Cordova, California. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Existing Cordova System Map," dated April 2002, is a true and accurate map of the Cordova System, indicating the location of water supply infrastructure within the Cordova System. This map was created by Brown and Caldwell (engineering consultant to SCWC) with reference to a similar map included in SCWC's 2000 Urban Water Management Plan, also produced by Brown and Caldwell.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Robert Hanford

SCOTT S. SLATER, ESQ. (SBN 117317)
MICHAEL T. FIFE ESQ. (SBN 203025)
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Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

BEFORE THE

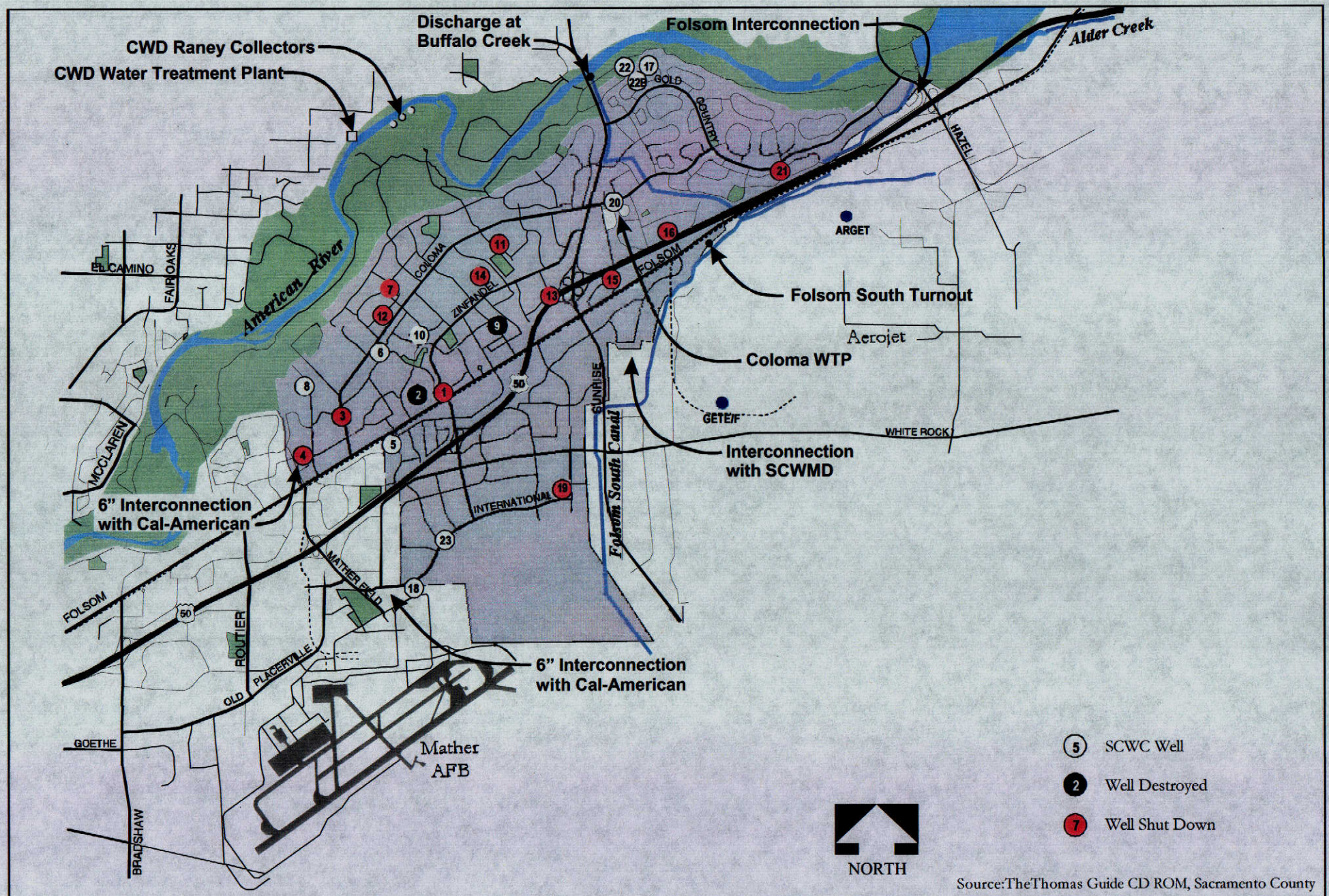
STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	)

Hatch and Parent
21 E. Carrillo Street
Santa Barbara, CA 93101

SCWC EXHIBIT 3



Source:TheThomas Guide CD ROM, Sacramento County

SOUTHERN CALIFORNIA WATER COMPANY	DATE April 2002	Rancho Cordova System, Region 1, SCWC	EXHIBIT 3
	PROJECT 18878	TITLE Area Water Facilities	

Declaration of Robert Hanford

I, Robert Hanford, declare that:

1. I am the Engineering and Planning Manager for Region I of the Southern California Water Company, in Rancho Cordova, California. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Area Water Facilities," dated April 2002, is a true and accurate map of the Cordova System, indicating the location of various water facilities within and adjacent to the Cordova System. This map was created by Brown and Caldwell (engineering consultant to SCWC) with reference to a similar map included in SCWC's 2000 Urban Water Management Plan, also produced by Brown and Caldwell.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Robert Hanford

SCOTT S. SLATER, ESQ. (SBN 117317)
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Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

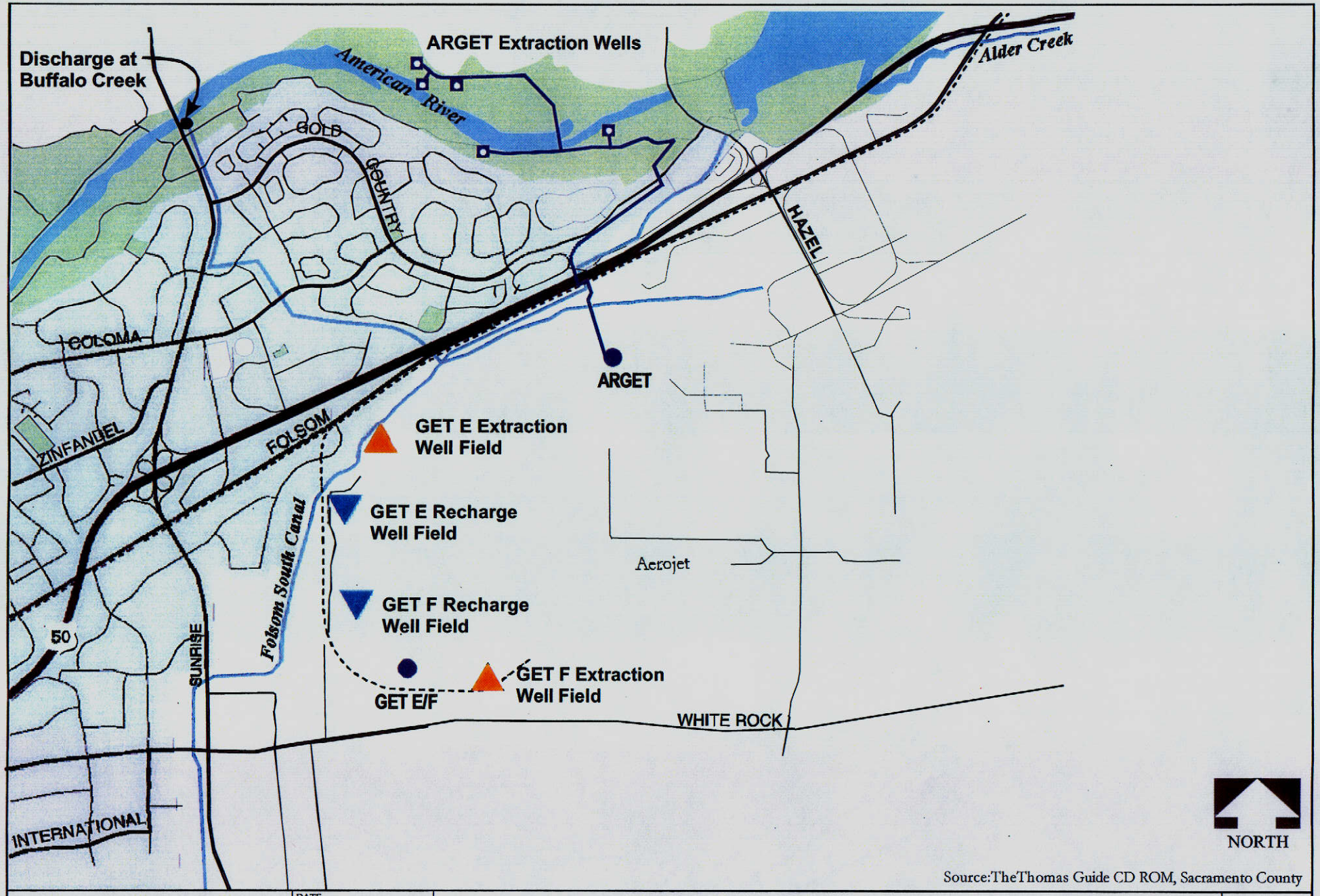
BEFORE THE

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	))))))

SCWC EXHIBIT 4



Source:TheThomas Guide CD ROM, Sacramento County

SOUTHERN CALIFORNIA WATER COMPANY	DATE: April 2002	Rancho Cordova System, Region 1, SCWC	EXHIBIT
	PROJECT: 18878	TITLE: Aerojet Well Fields	4

Declaration of Robert Hanford

I, Robert Hanford, declare that:

1. I am the Engineering and Planning Manager for Region I of the Southern California Water Company, in Rancho Cordova, California. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Aerojet Well Fields," dated April 2002, is a true and accurate map of the location of Aerojet's production wells. This map was created by Brown and Caldwell (engineering consultant to SCWC).

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Robert Hanford

SCOTT S. SLATER, ESQ. (SBN 117317)
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Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

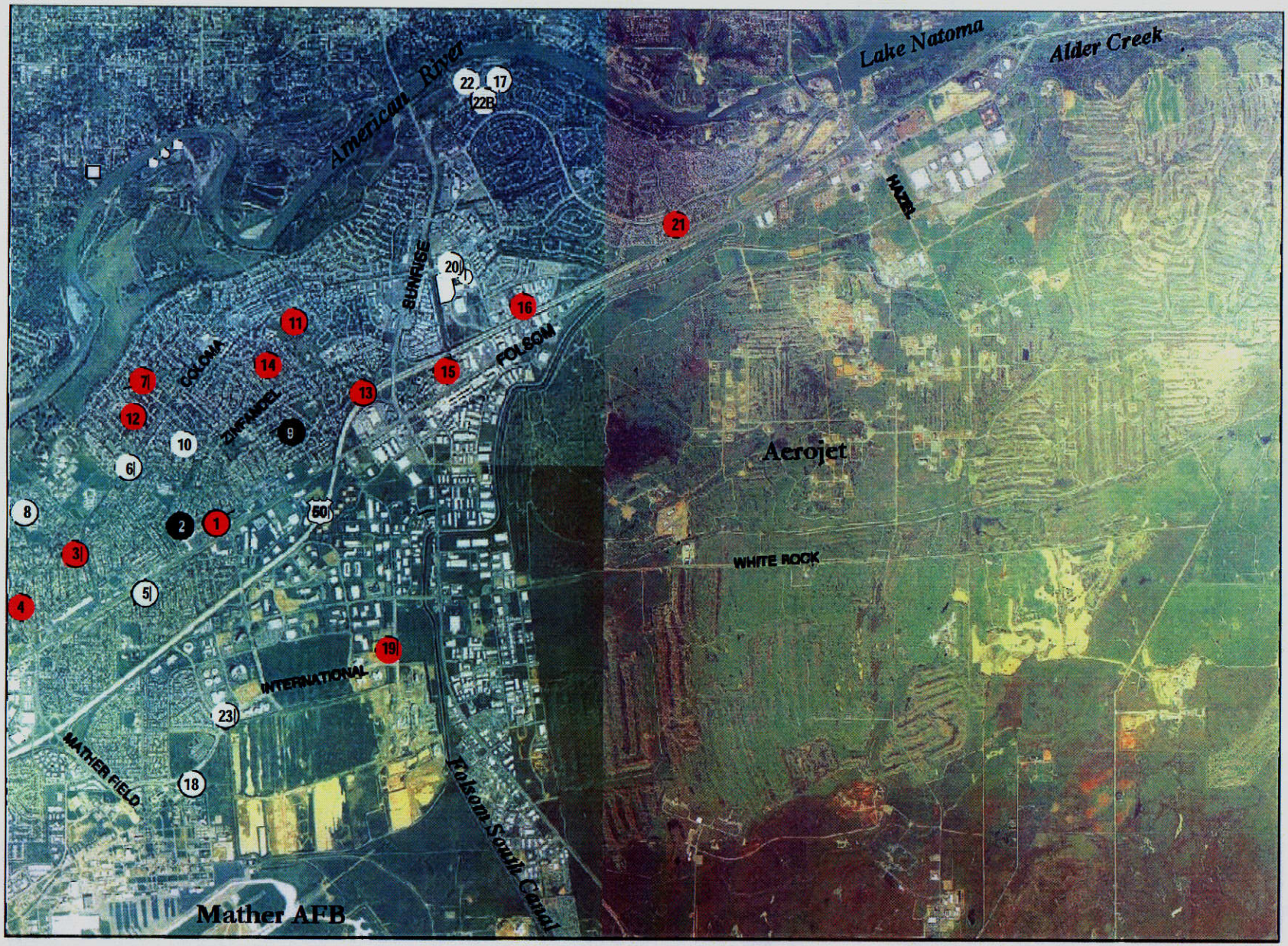
BEFORE THE

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	)

SCWC EXHIBIT 5



NORTH

5 SCWC Well

2 Well Destroyed

7 Well Shut Down

SOUTHERN CALIFORNIA WATER COMPANY	DATE April 2002	Rancho Cordova System, Region 1, SCWC	EXHIBIT 5
	PROJECT 18878	TITLE Aerial Photo	

Declaration of Robert Hanford

I, Robert Hanford, declare that:

1. I am the Engineering and Planning Manager for Region I of the Southern California Water Company, in Rancho Cordova, California. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Aerial Photograph of Rancho Cordova Area," is a true and accurate aerial photograph of the Cordova System. This photograph was taken by American Aerial Surveys, Inc. on February 11, 1999,

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Robert Hanford

STATUS OF CORDOVA SYSTEM

PRODUCTION WELLS

Well	Well capacity Active well, (gpm)	Well capacity Inactive well, (gpm)	Remarks
Alicante Well No. 1		**400**	**Shut down**
Gilbert Well No. 3		**700**	**Shut down**
El Segundo Well No. 4		**350**	**Shut down**
Marcel Well No. 5	700		
Dolecetto Well No. 6	700		
Georgetown Well No. 7		**650**	**Shut down**
Agnes Well No. 8	500		
Negara Well No. 10	700		
Cristobal Well No. 11		**700**	**Shut down**
Woodcliff Well No. 12		**675**	**Shut down**
Citrus Well No. 13		**1,000**	**Shut down**
Whistler Well No. 14		**850**	**Shut down**
Folsom Well No. 15		**750**	**Shut down**
Pyrites Well No. 16		**1,000**	**Shut down**
Park Well No. 17	1,500		
Mather Well No. 18	1,700		
Kilgore Well No. 19		**1,600**	**Shut down**
Coloma Well No. 20	2,600		
Gold Country Well No. 21		**1,000**	**Shut down**
South Bridge Street Well No. 22	3,000		
Capital Well No. 23	1,600		
Total	13,000	9,675	
Well water supply including closed wells	22,675 (32.7mgd)		

Declaration of Robert Hanford

I, Robert Hanford, declare that:

1. I am the Engineering and Planning Manager for Region I of the Southern California Water Company, in Rancho Cordova, California. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Status of Cordova System Production Wells" dated April 17, 2002, is a true and accurate table indicating the current status of each of SCWC's 21 wells in the Cordova System. This table was created by myself with reference to documents maintained in our files.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Robert Hanford

CONSTRUCTION DATE OF CORDOVA SYSTEM WELLS

ACQUIRED FROM NATOMAS WATER COMPANY

Well Name	**Design Capacity** (gpm)	**Year Built**	**Well No.**
Alicante	400	1951	Well No. 1
Charbono	400	unknown	Well No. 2
Gilbert	700	1955	Well No. 3
El Segundo	350	1955	Well No. 4
Marcel	700	1956	Well No. 5
Dolecetto	700	1956	Well No. 6
Georgetown	650	1958	Well No. 7
Agnes Circle	500	1958	Well No. 8
MacGregor	550	1959	Well No. 9
Negrara	700	1959	Well No. 10
Cristobal	700	1959	Well No. 11
Wood Cliff	675	1959	Well No. 12
Whistler	850	1962	Well No. 14
Total Capacity	7,875		

Declaration of Robert Hanford

I, Robert Hanford, declare that:

1. I am the Engineering and Planning Manager for Region I of the Southern California Water Company, in Rancho Cordova, California. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Construction Date for Cordova System Wells Acquired from Natomas Water Company," dated April 17, 2002, is a true and accurate table indicating the date of construction for each of the 13 wells acquired by SCWC in the Cordova System. This table was created by myself with reference to documents maintained in our files.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Robert Hanford

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MICHAEL T. FIFE ESQ. (SBN 203025)
HATCH AND PARENT
21 E. Carrillo Street
Santa Barbara, CA 93101
Telephone: (805) 963-7000
Facsimile: (805) 965-4333

Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

BEFORE THE

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	**EXPERT WITNESS TESTIMONY OF ROBERT HANFORD**

Hatch & Parent
21 East Carrillo Street
Santa Barbara, CA 93101

I. EXPERT QUALIFICATIONS

My name is Robert Hanford. I am an Engineering and Planning Manager for Region I of the Southern California Water Company (SCWC). My responsibilities for SCWC include: providing day-to-day management of engineering design responsibilities for the fourteen water systems in Region I of SCWC that provide water service to approximately 265,000 customers.

I have 23 years experience in civil engineering, including design, construction management and project management of water, and wastewater projects. I have a Bachelor of Science degree in Civil Engineering from the University of Nevada, Reno, and a Masters in Business Administration from the University of Santa Clara. I have been registered as a Professional Engineer in Civil Engineering by the State of California since July 1981. I am certified with the California Department of Health Services with a D1 certification.

II. HISTORY AND BACKGROUND OF CORDOVA SYSTEM

A. Cordova System

The Cordova System is part of SCWC's Arden-Cordova Customer Service Area. The Cordova System serves the unincorporated community of Rancho Cordova in Sacramento County, which includes a mixture of primarily residential, commercial, and some industrial land use. The system contains approximately 12,000 connections, which serves a residential population of about 40,000 people as well as a significant transient work force.

The Cordova System is bounded by Hazel Avenue to the east, Mather Air Force Base to the south, Mather Field Road to the west, and the American River to the north. The terrain is essentially flat, with the western side of the service area at an elevation of 75 feet, and the eastern side at an elevation of 140 feet.

SCWC's ownership and operation of the Cordova System commenced with its acquisition of the Natomas Water Company ("Natomas") in 1963. Natomas, or its predecessor-in-interest, began providing water service to the area as early as 1851.

B. The Cordova System's Water Supply

The Cordova System's water supply is presently derived from surface water from the American River and groundwater from the South Sacramento Groundwater Basin (Basin).[1] SCWC owns 21 wells in the Cordova System. However, twelve of the wells have been shut down since 1997 as a result of industrial contamination of the Basin caused by the Aerojet-General Corporation ("Aerojet"), a large manufacturer of liquid and solid propellant rocket engines located adjacent to the Cordova System. SCWC will lose additional wells as the Aerojet pollution plume spreads. Indeed, it is anticipated that most if not all of the Cordova System wells will be lost within five to ten years. The loss of these wells threatens to impede SCWC's ability to fulfill its obligation to serve the current and future water users within Rancho Cordova.

The Cordova System also receives surface water from the Folsom South Canal (Canal) through a contract with the United States Bureau of Reclamation that authorizes SCWC to divert

[1] The Basin underlies the southern portion of Sacramento County and is roughly bounded by the American River on the north, by the Sacramento River on the west, by the Cosumnes River on the south, and by the Sacramento/El Dorado County line on the east.

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10,000 acre-feet of water per year (afy). SCWC leased 5,000 acre-feet of this right to the City of Folsom on December 6, 1994 before SCWC became aware of the threat to its groundwater by the Aerojet contamination.

C. Historical Use of the Basin

Natomas drilled its first well for the Rancho Cordova service area in 1951, and consistently added wells to satisfy the increasing demand as the community developed. This growth gained additional momentum around the time that SCWC acquired the service area from Natomas in 1963. At the time of its acquisition, Natomas owned 13 wells, and two additional wells were planned or under construction. Since this time SCWC has increased its reliance on the Basin, and has constructed an additional eight wells to satisfy a substantial part of its growing demand.

D. Arden-Cordova's Attempts to Safeguard its Water Supply

In response to the current threats to SCWC's groundwater supply from the Basin, SCWC is using a variety of methods to ensure a safe and reliable source of water for the communities it serves.

SCWC is currently pursuing litigation in Sacramento County against Aerojet in *Southern California Water Company v. Aerojet-General Corporation, Inc.*, Sacramento County Superior Court Case No. 99AS05949, in order to replace the water supply that has been lost. To date, however, SCWC has not been successful in obtaining replacement water through this litigation.

SCWC has also participated in a variety of cooperative efforts to safeguard the Basin, including participation in the Sacramento County Water Forum, signing the 1995 Water Forum Agreement, and working with the Sacramento Groundwater Authority.

In 1995, the California Regional Water Quality Control Board ("RWQCB") issued Cleanup and Abatement Order No. 95-715, which required Aerojet to submit a plan designed to minimize the spread of the plume of contaminated groundwater. Pursuant to this goal, the RWQCB has issued a number of orders that have resulted in Aerojet building a treatment plant and discharging treated groundwater into the Lower American River at a point near Rancho Cordova. Aerojet pumps this water from the same groundwater basin from which the Cordova System pumps its groundwater supply.

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III. TECHNICAL DESCRIPTION OF THE CORDOVA SYSTEM

The following is a more thorough description of the groundwater wells, surface water supply and treatment, storage reservoirs, and distribution system.

A. Water Supply Facilities

As noted, groundwater from the nine active wells and surface water from the American River are the sources of water supply for the Cordova System. The Coloma Water Treatment Plant (WTP) provides treatment of the surface water supply. Interconnections with adjacent water purveyors are limited. There is a 6" interconnection with the California-American Water Company's (Cal-Am) system in the southwest corner of the Cordova system, and a 12" interconnection with the City of Folsom at the eastern edge of the Cordova system. There is also an interconnection with the Sacramento County Water Maintenance District (SCWMD) in the Sunrise Industrial Park. The Cordova System does not routinely purchase treated water from either Cal-Am or the City of Folsom, and is in fact, the primary source of supply for the northern portion of the SCWMD system.

B. Wells

As noted, twelve wells have been shut down since 1997 because of the spread of the contamination plume. These closed wells represent a pumping capacity of 9,675 gallons per minute (gpm). The remaining nine wells in operation provide a combined capacity of 13,000 gpm or 18.7 million gallons per day (mgd). SCWC has been able to maintain its level of historical extraction from the Basin by: drilling two new wells, 22 and 23; upgrading equipment at wells 5 and 17; and the installation of pressure reducing valves (PRV's) establishing a zone break. These measures combined have created 5,600 gpm of additional supply. However, SCWC's ability to meet maximum day demands in the summer is now at its limit. Thus, as the contamination plume spreads to additional wells, SCWC will be challenged to meet peak day demands.

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Santa Barbara, CA 93101

Except for Well 20, all of the wells pump water directly to the distribution system. Coloma Well 20 is located at the Coloma WTP, and therefore the WTP's finished water boosters deliver the water from this well to the distribution system. All of the wells have chlorination facilities and several wells provide additional treatment. Negrara Well 10 has granular activated carbon (GAC). Wells 12, 20, and 21 have iron and manganese treatment, though wells 12 and 21 have subsequently been taken offline.

C. Surface Water Facilities

The Cordova System has pre-1914 water rights to 10,000 acre-feet per year (ac-ft/yr) from the American River via the Folsom South Canal at a maximum withdrawal rate of 20 cubic feet per second (cfs) or 13 mgd., though SCWC has leased 5,000 acre-feet of this right to the City of Folsom. This lease was made on December 6, 1994, before SCWC became aware of the threat to its groundwater by the Aerojet contamination.

Four raw water diversion pumps pump surface water from the Folsom South Canal on the south side of Highway 50 to the Coloma WTP on the north side of Highway 50 via a 24-inch pipeline.

Based on the current filtration rate, the Coloma WTP has a treatment capacity of about 7,700 gpm or 11.09 mgd. The treatment process at the Coloma WTP consists of pre-oxidation, coagulation, flocculation, sedimentation, filtration, and disinfection. Currently, the WTP has two flocculation/sedimentation basins, ten pressure filters, and chemical storage and feed facilities, and facilities for ancillary administration, laboratory and spare parts storage. The five settled water booster pumps convey settled water from the sedimentation basins to the pressure filters. The WTP uses cationic polymer as a primary coagulant, and nonionic polymer as a coagulant aid. Both polymers are added ahead of the mixers. Gaseous chlorine is used as a disinfectant, and it is converted to chlorine solution in the chlorine storage room.

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D. Distribution System

The Cordova distribution system consists of two pressure zones. The service area east of Sunrise Boulevard is maintained at a pressure that is approximately 10 pounds per square inch (psi) higher than the service area west of Sunrise Boulevard to compensate for the gently sloping terrain. Pressure regulating valves have been installed to allow water to flow from the eastern to the western pressure zone as necessary. Flow through these pressure-regulating valves can be reversed if there is a large fire demand in the eastern zone.

The distribution system consists mostly of 6-inch to 12-inch and some recently installed 16-inch and 24-inch pipeline. Two 1-million gallon (mg) and one 2-mg reservoir, located at the Coloma WTP, store treated water from the WTP and water from Coloma Well 20 (located at the WTP site) to provide disinfection contact time, and to meet peak-hour demands. A 5.0 mg tank is currently under construction adjacent to the existing tanks at the WTP. A 0.50 mg welded steel elevated tank is also under construction near the intersection of White Rock Road and Kilgore Ave. Six booster pumps currently pump water from the three reservoirs to the distribution system. Two additional booster pumps, which are currently under construction, will be powered by natural gas engines at the WTP, and therefore will be available for use during electrical power outages. The maximum pumping capacity from the reservoirs will be increased from 12,000 gpm to approximately 20,000 gpm upon completion of construction,

Executed on April 25, 2002, at Rancho Cordova, California.

Robert N. Hanford, P.E.
Southern California Water Company

Hatch & Parent
21 E[illegible]llo Street
Santa Barbara, CA 93101

Southern California Water Company
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Southern California Water Company

Curriculum Vitae

Dated: April 25, 2002

Robert N. Hanford, P.E.

Manager, **Engineering and Planning**

Disciplines:

Water Resources, Construction Management, Public Works Financing, Engineering Management.

Education:

University of Nevada, Reno; B.S. Civil Engineering, 1978

University of Santa Clara; M.B.A., 1985

Continuing education courses: Management and Labor Relations; U.C. Davis and University of Santa Clara

Registration:

Professional Engineer, Nevada, No. 6172

Civil Engineer, California, No. 33072

Professional Affiliations:

American Society of Civil Engineers

American Water Works Association

American Public Works Association

Professional Experience:

Professional experience includes the finance, design, construction management and program management of water facilities in Northern California and Nevada. Expertise in trenchless technology applications and computerized asset management incorporating GIS technology.

- Annually oversee the design of an annual capital improvement program (CIP) of $3 million for new construction and upgrades to water source, transmission and storage facilities.

- Supervised the design of special $6.5 appropriation that provided for a 5.0 million gallon (mg) storage tank and property acquisition, 4,000-foot 24" diameter pipeline, 8,000 gallon per minute (gpm) booster pump station and a new 3,000 gpm well.

- Performed role of program manager supervising design and construction of ten standby emergency power facilities in a four-month period prior to Y2K.

- Oversaw design and construction management of civil infrastructure for commercial, industrial and residential projects, including $350 million Silver Legacy Casino, one million square foot IGT Manufacturing Facility, Eldorado Casino Expansion and over 15 residential subdivisions.

- Performed design and construction management for a one million dollar road widening and utility extension project in the City of Folsom.

- Developed water system infrastructure financing programs for two cities and one utility district, with a 16 million dollar total construction cost.

- Implemented standardized construction management forms and procedures for projects totaling 15 million dollars.

- Designed new treatment processes for stormwater runoff.

- Concluded successful $3.5 million dollar bond sale for water system rehabilitation.

- Completed design and oversaw projects in compliance with strict regulatory requirements of the Tahoe Basin.

- Supervised design and construction management (C.M.) for 10-mile 24-inch pipeline with 350 p.s.i. operating pressure, which included crossing of active earthquake faults and the underground crossing of the Carson River.

- Oversaw design and C.M. for 800-acre wetlands project with four dams.

- Directed design and C.M. for complete rehabilitation for 500-connection water system, while maintaining current service.

- Prepared water rate studies for a general improvement district in western Nevada. 28% rate increase was approved without litigation.

- Assisted as District Engineer for 3 mgd wastewater treatment plant (WWTP). Supervised ongoing Five Year Capital Improvement Plan for WWTP
- Directed design and construction services for six erosion control projects, totaling $2 million that were completed during a five-month building season.
- Designed drainage and site improvements to obtain NPDES compliance for Harrah's Casino.
- Administered annual $350,000 operating and $1,000,000 capital budgets for a public utility district that provides water, wastewater and recreation facilities in eastern Placer and El Dorado counties.
- Implemented 14 tank UST monitoring program, oversaw tank testing and abandonment.
- Designed odor control station using chlorine dioxide.
- Supervised dual sewer siphon and water main crossing of Truckee River.
- Designed 6,000 lineal foot spring water collection system successfully excavated through granite bedrock.
- Oversaw 280,000-gallon water tank recoating and sewage lift station VFD retrofit projects.
- Principal Civil Engineer for design of San Jose Transit mall, 30 million dollar LRT and downtown urban renovation project.
- Designed track geometry, grading utility and LRT station facilities – Segment 7 Guadalupe Corridor LRT project.
- Designed eight-mile transmission and distribution system for San Benito County Water System, Subsystem 7.

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Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

BEFORE THE

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	**EXPERT WITNESS TESTIMONY OF STEPHEN ROSS**

Hatch and Parent
21 East Carrillo Street
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I. EXPERT QUALIFICATIONS

My name is Stephen Ross and I am a professional geologist specializing in water resources and water quality studies. I received a B.Sc. from the University of Waterloo in 1988 and a M.Sc. from the University of Waterloo in 1992. At Komex, H2O Science I am responsible for investigations in the areas of physical and contaminant hydrogeology. I have been involved in the application of local and regional groundwater flow and transport models to a variety of hydrogeological problems including: groundwater and surface water interaction, design, implementation and monitoring of pump and treat systems. I have published extensively on the subject of hydrogeology and water quality issues including study of river-connected aquifers. My experience is further detailed in the attached curriculum vitae.

My testimony concerns the relationship between the surface water of the Lower American River and the groundwater that is present in the general vicinity of the Lower American River. The

purpose of this testimony is to assist the Board in its determination that the Aerojet discharges to the Lower American River constitute a change in circumstances that justify a limited revision of the Fully Appropriated Streams Declaration. My testimony is based upon a Report that was prepared by Komex that analyzes this issue in detail.

I was assisted in the preparation of this Report by Anthony Brown, Dr. Tadeusz Dabrowski, and Mr. Richard E. Chandler, R.G.

Anthony Brown is the President and principal hydrologist for Komex, H20 Science. He is also the Chief Operating Officer, Director of US and Latin America for Komex Environmental Ltd. He received a BA with Honors in Physical Geography from King's College, University of London and a postgraduate diploma in civil engineering from Imperial College. He has also received a M.Sc. in engineering hydrology from the Imperial College of Science, Technology and Medicine, University of London. He has extensive experience in hydrology, hydrogeology, groundwater modeling, fate and transport of organic contaminants, groundwater remediation, water resources evaluation, and water supply engineering. His experience is further detailed in the attached curriculum vitae.

Tadeusz Dabrowski has over 40 years of experience in the planning, management, development and remediation of groundwater resources. He received a M.Sc. in Hydrogeology and Engineering Geology from the University of Warsaw, Poland, in 1962 and a Doctor of Natural Sciences, Polish Academy of Sciences, Laboratory of Geologic Sciences, Warsaw, Poland in 1973. Since 1982 he has been the Senior Vice President for Komex International Ltd., in Calgary, Alberta. His experience is further detailed in the attached curriculum vitae.

Mr. Chandler is a Senior Geologist and Project Manager with over 14 years of professional experience as an environmental consultant. Mr. Chandler has extensive experience performing and supervising field investigation work. He has prepared geologic maps, collected soil and groundwater samples, prepared soil boring and rock core logs, overseen the installation and removal of groundwater monitoring wells, conducted ground pumping and soil vapor extraction tests, operated various types of soil and groundwater treatment systems, and supervised the excavation of impacted soil. His experience is further detailed in the attached curriculum vitae.

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Despite such assistance, I am fully qualified to describe and comment upon all aspects of this Report.

II. SUMMARY OF CONCLUSIONS:

A. SUBJECT OF THIS TESTIMONY

It is my understanding that Aerojet's American River Groundwater Extraction and Treatment (ARGET) facilities are currently permitted to extract groundwater, treat it, and discharge as much as 3450 gpm to Buffalo Creek and ultimately to the American River. It is also my understanding that Aerojet's permit is currently in the process of being revised to allow Aerojet to discharge an additional 6000 gpm whose source will be the facilities known as GET E and GET F. Finally, a future expansion is contemplated whereby an additional 8000 gpm will be discharged to the American River whose source is generally the Western Operable Unit (OU-3) and is described with more particularity by the United States Environmental Protection Agency's Record of Decision (ROD)(2001) Alternative 4C.

Expressed as acre-feet, these quantities are as follows:

3,450 gpm = 5,564 acre-feet/year
6,000 gpm = 9,676 acre-feet/year
8,000 gpm = 12,902 acre-feet/year

I was asked to analyze whether this discharged water constitutes "new water" in the American River. My opinion is that substantially all of this groundwater was not tributary to the American River at the time that the River was declared to be fully appropriated and that this condition has persisted to the present. As such, the addition of this water to the American River constitutes the addition of an increment of water that is not otherwise a part of the River and that was not considered a part of the River at the time when the River was declared to be fully appropriated.

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B. BASIS FOR THIS OPINION

In the preparation of Komex's Report, we performed a detailed examination of the many recent and historical analyses of groundwater and surface water in the vicinity of the Lower American River. We also performed our own field surveys to confirm the validity of some of the data upon which we relied.

We found that, in general, groundwater levels in the vicinity of the Lower American River are well below the River water surface. This results in a condition where water flows out of the River and in to the geological formations which are recharging the groundwater. We also found, however, that sediments between the bottom of the River and the uppermost level of the groundwater is most likely in an unsaturated state. This means that the rate of loss of water from the American River is governed by factors other than the elevation of the groundwater. This interpretation is confirmed by an analysis of the movement of the plume of contaminated groundwater and by other tests that have been performed as part of the Aerojet groundwater remediation process.

The only exception to this situation occurs in the area of groundwater withdrawals that is closest to Nimbus Dam where groundwater levels are the closest to the River water surface. Withdrawals from this area consitute a small percentage of the total water discharged to the American River and are described in greater detail below.

C. CONCLUSION REGARDING WATER FROM GET E AND GET F

The Regional Water Quality Control Board is currently processing a permit revision which would permit Aerojet to discharge up to an additional 6000 gpm of treated groundwater into the American River. Based upon my analysis of the relationship between the groundwater and the American River as detailed in Komex's Report, there is no potential that the groundwater withdrawn from either GET E or GET F is tributary to the American River.

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D. CONCLUSION REGARDING WATER FROM OU-3 AS DESCRIBED BY ALTERNATIVE 4C

It is anticipated that in the future an additional 8000 gpm of treated groundwater will be discharged to the American River from OU-3 as described by Alternative 4C of EPA's ROD. Based upon my analysis of the relationship between the groundwater and the American River as detailed in the Komex's Report , there is no potential that the groundwater withdrawn under Alternative 4C is tributary to the American River.

E. CONCLUSION REGARDING WATER FROM ARGET FACILITY

The ARGET facilities include fifteen extraction wells that are located on the North and South side of the American River. Komex's Report analyzes in detail the interaction between the groundwater in this area and the flow of the American River. We found that there is a potential for interaction between the groundwater and the American River only at the easternmost edge of the area where two of the wells are located. That is, only two of the fifteen ARGET wells are potentially affected by this interaction. Even with regard to these two wells, the amount of water that could be considered tributary to the American River is only a portion of the total water withdrawn from the wells.

Thus, based upon my analysis of the relationship between the groundwater and the American River as detailed in Komex's Report, there is no potential that the groundwater withdrawn from thirteen of the ARGET wells is tributary to the American River. There is a potential that a portion of the water withdrawn from the other two wells could at times be considered tributary to the River.

F. CONCLUSIONS REGARDING HISTORICAL CONDITIONS

As part of the research conducted for Komex's Report, we analyzed historical descriptions of the interaction between the Lower American River and the groundwater basin. Some of these descriptions covered the exact period during which the River was declared to be fully appropriated.

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These descriptions indicated that the conditions which today lead to the conclusion that there is no significant hydraulic communication between the River and the groundwater basin also existed at the time that the River was declared to be fully appropriated.

G. CONCLUSIONS REGARDING CONTRIBUTION OF FLOW TO THE AMERICAN RIVER

Komex performed recent field surveys and determined that a significant portion of the treated groundwater discharged by Aerojet into Buffalo Creek, does, in fact, reach the American River. The details of our investigation and specific quantities of water measured are described in Komex's Report.

I declare under penalty of perjury pursuant to the laws of the State of California that the foregoing is true and correct.

Executed on May 8, 2002, at Roseville, California.

Stephen Ross, Komex H2O Science

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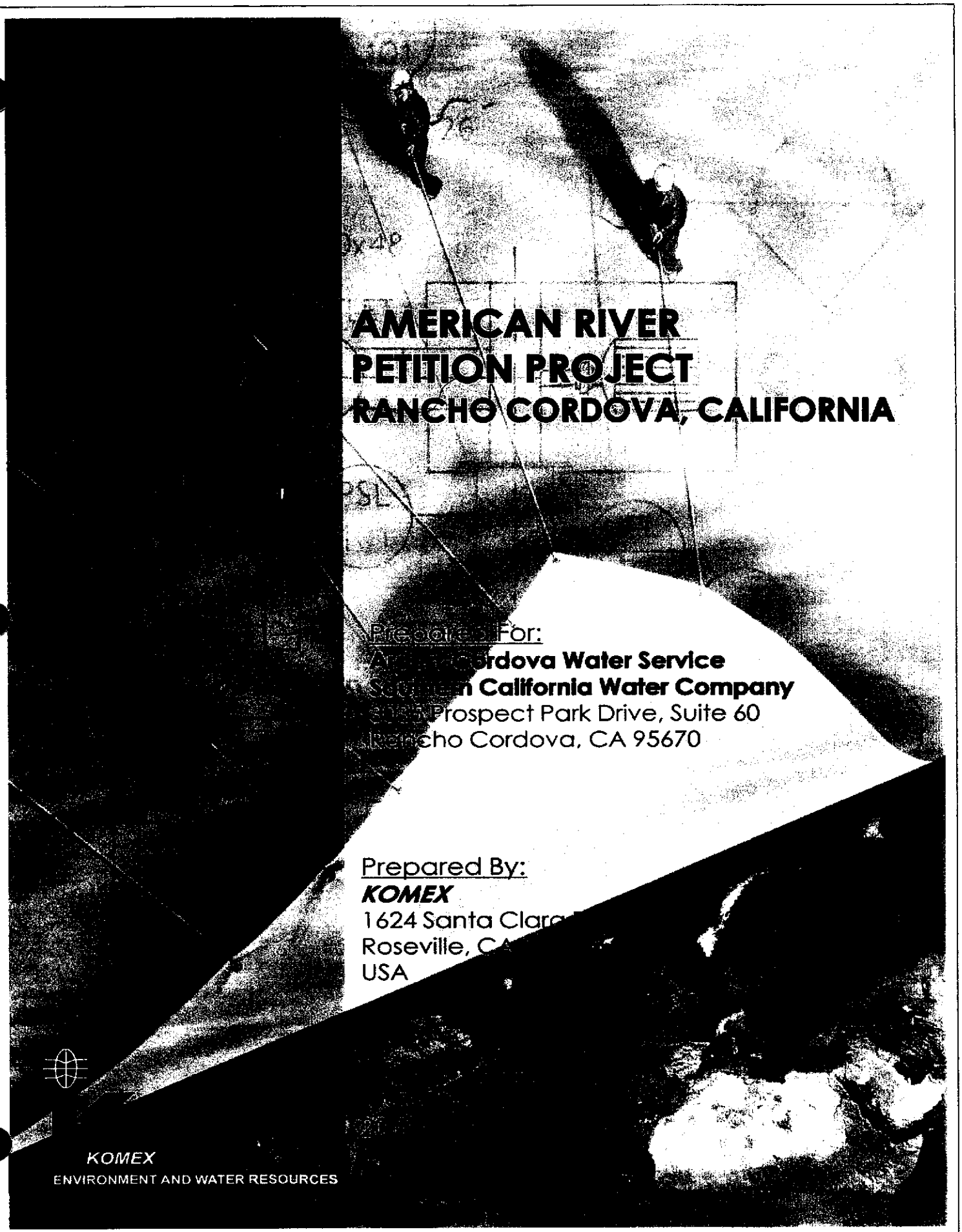

AMERICAN RIVER PETITION PROJECT
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ENVIRONMENT AND WATER RESOURCES

EXECUTIVE SUMMARY

A petition to revise the Declaration of the Fully Appropriated Stream System for the American River in Sacramento County (Declaration) has been filed by the Southern California Water Company to the State Water Resources Control Board (SWRCB). The SWRCB has determined that the American River system in Sacramento County is fully appropriated from July 1 through October 31 from its confluence with the Sacramento River upstream. The American River system was included in the original Declaration adopted by SWRCB Order WR 89-25, and it remains listed in the most recent Declaration adopted by SWRCB Order WR 98-08. Order 89-25 cited the State Water Rights Board Decisions 1108 and 1121 for the finding that no unappropriated water is available from the American River system from July 1 to October 31.

Komex has performed a hydrogeologic evaluation as part of the American River Petition Project to assess whether any of the following groundwater is non-tributary to the American River:

- Groundwater extracted from the Aerojet General Corporation (Aerojet) American River Groundwater Extraction and Treatment system (ARGET);
- Groundwater extracted from the Groundwater and Extraction (GET) E and F systems; and,
- Groundwater proposed for future extraction under the Record of Decision (ROD) Alternative 4C.

The Aerojet facility is located south of US Highway 50 near Rancho Cordova, California, which is located approximately 15 miles (24 km) east of downtown Sacramento. The American River Study Area is located north of US Highway 50, and west of Hazel Avenue, approximately half a mile (0.8 km) north of the Aerojet facility boundary. The GET E and F systems and proposed Record of Decision (ROD) Alternative 4C are located in the Western Operable Unit OU-3 (OU-3).

The purpose of the evaluation was to determine the hydrogeologic conditions within the American River Study Area and OU-3 from available data and a limited field investigation. Specifically, the evaluation focused on the interaction between water in the American River and shallow groundwater to develop an understanding of the water loss and/or gain to and from the American River.

This evaluation included the following tasks:

- Review of geologic literature pertaining to the American River Study Area and OU-3;
- Evaluation of hydrogeologic literature;
- Evaluation of contaminant distribution;
- Review of existing data, including reports prepared by Aerojet, the California State Department of Water Resources (DWR), and various databases; and
- A streamflow gauging program of Buffalo Creek.

Based upon our independent analysis and our review of previous reports and data, it is our opinion that substantially all of the groundwater extracted by the ARGET system originates from sources other than direct hydraulic communication from the American River. In addition, it is our opinion that the water discharged by the ARGET system into Buffalo Creek actually discharges into the Lower American River and may ultimately add to the flow within the mainstream of the River. As discharge increases, the level of contribution is also likely to increase.

We also conclude the groundwater extracted by the GET E and F systems in OU-3 would not discharge to the American River under non-pumping conditions, and that the new off-site extraction wells for the ROD will extract groundwater that would not discharge to the American River.

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1 INTRODUCTION

A petition to revise the Declaration of the Fully Appropriated Stream System for the American River in Sacramento County (Declaration) has been filed by Southern California Water Company to the State Water Resources Control Board (SWRCB). The SWRCB has determined that the American River system in Sacramento County is fully appropriated from July 1 through October 31 from its confluence with the Sacramento River upstream. The American River system was included in the original Declaration adopted by SWRCB Order WR 89-25, and it remains listed in the most recent Declaration adopted by SWRCB Order WR 98-08. Order 89-25 cited the State Water Rights Board Decisions 1108 and 1121 for the finding that no unappropriated water is available from the American River system from July 1 to October 31.

This hydrogeologic evaluation is being conducted as part of the American River Petition Project to assess whether any of the following groundwater is non-tributary to the American River:

- Groundwater extracted from the Aerojet General Corporation (Aerojet) American River Groundwater Extraction and Treatment system (ARGET);
- Groundwater extracted from the Groundwater and Extraction (GET) E and F systems; and,
- Groundwater proposed for future extraction under the Record of Decision (ROD) Remedy 4C system.

The Aerojet facility is located south of US Highway 50 near Rancho Cordova, California, which is located approximately 15 miles (24 km) east of downtown Sacramento (Figure 1-1 of Aerojet, 2000a). The American River Study Area is located north of US Highway 50, and west of Hazel Avenue, approximately half a mile north of the Aerojet facility boundary (**Figure 1-1**). The GET E and F systems and proposed ROD 4C remedy system are located in the Western Operable Unit OU-3 [OU-3] (Figures ES-1 and 4-6 of Aerojet, 2000b).

The purpose of this evaluation is to determine the hydrogeologic conditions within the American River Study Area and OU-3 from available data. Specifically, the evaluation focuses on the interaction between water in the American River and shallow groundwater to develop an understanding of the water loss and/or gain to and from the American River.

This evaluation includes the following:

- Review of geologic literature pertaining to the American River Study Area and OU-3;
- Evaluation of hydrogeologic literature;
- Evaluation of contaminant distribution;
- Review of existing data, including reports prepared by Aerojet, the California State Department of Water Resources, and various databases; and
- A streamflow gaging program of Buffalo Creek.

This report describes our findings and conclusions.

2 BACKGROUND

The Aerojet facility has developed and manufactured solid and liquid rocket fuel motors, carried out rocket engine testing and manufacturing, and manufactured chemicals. Materials associated with these activities include chlorinated solvents, propellants, metals, oxidizers, and various other chemicals. Historical operations at the Aerojet site have resulted in the discharge of chemicals to the vadose zone (*i.e.* the unsaturated soil above the groundwater surface), and these have migrated to the underlying groundwater. The chemicals have been detected in either soil or groundwater, or both, at and in the vicinity of the Aerojet facility. Remedial activities at two of the impacted areas, the American River Study Area and OU-3, are summarized below.

2.1 AMERICAN RIVER STUDY AREA

Volatile and semi-volatile organic compounds (VOCs/SVOCs; primarily trichloroethene [TCE], 1,1 dichloroethene [1,1 DCE], 1,2 dichloroethene [1,2 DCE], Freon 113, tetrachloroethene [PCE], and 1,4 dioxane) and perchlorate has been detected in groundwater at the Nimbus Fish Hatchery property (Aerojet, 2000a). TCE is the most prevalent contaminant, and Aerojet has chosen it as the indicator to evaluate the configuration of the VOC plume in groundwater. TCE has been detected in four aquifer units (Aquifers A, B, C and D as defined by Aerojet, 2000a), and it has been detected in groundwater on the north side of the American River for a distance of at least one mile (1.6 km) downgradient of the Aerojet Facility (Figures 3-29 to 3-36 of Aerojet, 2000a). The contaminants have been attributed to releases associated with Aerojet's operations. Therefore, in response to the United States Environmental Protection Agency's (USEPA) Unilateral Order No. 95-16, Aerojet commissioned the installation of the ARGET system to remediate affected groundwater.

The ARGET system includes 15 groundwater extraction wells. Five sets of three extraction wells are located within the Study Area, three sets north of the river and two sets south of the river (Figure 2-1 of Aerojet, 2000a). The extraction well sets consist of three wells, each screened in one of the three aquifer units (Aquifer A, B, and C) described in Section 5. The rationale of the location of the extraction well sets is as follows (Aerojet, 2000a, p.3):

- Extraction wells 4325, 4330, and 4335 are located in the area of highest contaminant concentrations, at the eastern end of the Study Area. These wells are intended to remove contaminant mass from the groundwater.
- All other extraction wells are located downgradient of (*i.e.*, to the west and west-northwest of) the contaminants and are placed to maximize the zone of capture for all contaminants.

The 15 groundwater extraction wells associated with the ARGET system are completed in:

- Aquifer A: 4300, 4325, 4340, 4355, and 4370;
- Aquifer B: 4301, 4330, 4345, 4360, and 4375; and
- Aquifer C: 4302, 4335, 4350, 4365, and 4380.

From August 1998 to August 1999, the average water extraction rates (sum of all the wells in each aquifer) in Aquifers A, B, and C were 1,129; 1,259; and 351 gallons per minute (gpm), respectively (Aerojet, 2000a). The average total ARGET extraction rate for August 1998 to August 1999 was 2,739 gpm. The average total extraction rate for the ARGET system has decreased from August 1999 to present and averages about 2,100 gpm (**Figure 2-1**). The groundwater extraction rate was decreased since Aerojet has demonstrated to the satisfaction of the regulatory agencies that the system can effectively capture or impede the flow of impacted groundwater (personal communication with Mr. Alex MacDonald of the California Regional Water Quality Control Board on April 25, 2002).

The remedial system infrastructure consists of conveyance piping, a chemical-feed system, an ultra-violet (UV) treatment system, and an air-stripping system (Figure 2-1 of Aerojet, 2000a). The treatment system is designed to remove VOCs and SVOCs from the extracted groundwater. The ARGET system began full-scale operation in August 1998. Treated groundwater is discharged to Buffalo Creek on the Aerojet property. Buffalo Creek is a tributary of the American River (Figure 2-1 of Aerojet, 2000a).

2.2 WESTERN OPERABLE UNIT OU-3

As a result of former chemical disposal practices at the Aerojet site, groundwater became contaminated with a variety of chemicals, and the contaminated groundwater has migrated off site to the west. A remedial investigation and feasibility study (RI/FS) was undertaken by Aerojet to address this contamination (Aerojet, 2000b). The area of concern for the RI/FS was defined as the OU-3, which includes a western portion of the Aerojet site, the

northwestern corner of the Inactive Rancho Cordova Test Site (IRCTS), and approximately 10 square miles of commercially and residentially developed areas in the Rancho Cordova community to the west.

The main contaminants of concern in OU-3 groundwater were identified as perchlorate, n-nitrosodimethylamine (NDMA), TCE, and other VOCs (USEPA, 2000).

In the mid 1980s, before the RI/FS was carried out, Aerojet installed two GET facilities on the western side of its property to contain and treat VOCs. The general direction of groundwater flow is toward the west in OU-3, so contaminants originating from within the Aerojet site and transported by groundwater towards the west would be intercepted by these GET systems before they were able to migrate off site. The GET E facility extracts groundwater from the northwestern part of the property, and GET F extracts groundwater from the southwestern area. Water is extracted predominantly from the most contaminated zones beneath the site, known as Layers C and D in Aerojet's nomenclature (see Section 5.2). The most areally impacted unit is Layer C (Figure 1-9 of Aerojet, 2000b). Treated water is returned to the ground (again to Layers C and D) via a series of injection wells located in the central western Aerojet property, from where it will migrate off site predominately to the west.

The extraction and injection wells associated with GETs E and F are as follows:

- GET E extraction wells: 4070, 4075, 4200;
- GET F extraction wells: 4007, 4060, 4140, 4145, 4310, 4315; and
- GET E/F injection wells: 4014, 5015, 5045, 5050, 5055, 5080, 5085, 5090, 5095, 5100.

In 1997, perchlorate was detected in water supply wells to the west of the Aerojet property. In 1998, NDMA was detected in water supply wells. Perchlorate has since been detected in groundwater samples collected at least 8,000 feet (2,438 m) to the west of Aerojet's western property boundary (Figure 1-10 of Aerojet, 2000b). Prior to these dates, laboratory analytical method detection limits were unable to quantify perchlorate and NDMA at the relatively low concentrations at which they are present. The detections of these contaminants resulted in several public water supply wells being shut down to safeguard public health. Aerojet added a perchlorate removal process to the GET-F facility in 1998, and in 1999, GETs E and F were combined with new processes to remove both perchlorate and NDMA.

The RI/FS for OU-3 was completed in October 2000 (USEPA, 2000). The study presented and evaluated ten alternatives for clean up of the groundwater contamination associated with the OU-3 (Aerojet, 2000b). The alternative preferred by the EPA, termed Alternative 4C, main components include the following:

- GET E and GET F extraction wells will be retained.
- Additional extraction wells will be installed off site in Layers C, D, and E.
- Treatment of all extracted groundwater will be carried out on the Aerojet site and will include perchlorate, NDMA, and VOCs.
- Treated water will be discharged via Buffalo Creek to the American River.

A Record of Decision was prepared by the USEPA (USEPA, 2001). The EPA's preferred remedy, Alternative 4C, is designed to contain groundwater contamination and restore groundwater to beneficial uses within a timeframe of 240 years.

3 GROUNDWATER-SURFACE WATER INTERACTION: GENERAL CONCEPTS

3.1 GROUNDWATER RECHARGE

Rivers that contribute water to the uppermost groundwater-bearing zone are termed "losing" rivers (**Figures 3-1 and 3-2**). This means water seeps or infiltrates from the river and recharges the adjacent and underlying formations. A groundwater recharge condition may occur when the following conditions are met:

- The groundwater surface is below the river's surface.
- A confining layer (low permeability material) is not present between the bottom of the river and the underlying aquifer(s).
- The pressure (hydraulic head) in the aquifer is less than the river.

3.2 GROUNDWATER DISCHARGE

Shallow groundwater may discharge and contribute to the flow of the river. When this condition occurs, the river is termed "gaining" (**Figure 3-3**). This means the river is gaining water as a result of groundwater discharge from adjacent and underlying formations. This situation may occur when some or all of the following conditions are met:

- The groundwater surface elevation in adjacent and underlying formations (aquifers) is higher than the elevation of the river surface water.
- A confining layer (low permeability material) is not present between the bottom of the stream/river and the underlying aquifer(s).
- The pressure (hydraulic head) in the aquifer is greater than surface water body.

3.3 OTHER GROUNDWATER FLOW CHARACTERISTICS

A river may be in both a gaining and losing situation, depending on seasonal variations in the elevation of the groundwater surface, and in stream/river surface elevations.

In addition, rivers commonly act as a groundwater divide/boundary for the uppermost groundwater bearing zone. A groundwater divide is a boundary which flow does not occur. A groundwater divide can be present in either a recharge and discharge area (**Figures 3-1 and 3-3**). Groundwater on either side of a divide is isolated. For example, in a

discharge area, groundwater on either side of the divide would be moving toward the river. In the central portion below the river groundwater flow would be almost vertical. Thus, in this situation, shallow groundwater possibly containing contaminants would not flow below the river to the other side.

Groundwater pumping can affect river flow by inducing groundwater recharge or by diverting groundwater-inflow that would have contributed to stream flow.

4 GEOLOGY

The geology of the Study Area is characterized by shallow-dipping (at generally less than one degree) Cretaceous, Tertiary, and Quaternary marine and fluvial sediments overlying steeply dipping Jurassic crystalline basement rocks (Department of Water Resources [DWR], 1974). The sedimentary sequence includes undifferentiated Quaternary sediments and the Victor Formation, Arroyo Seco Gravels, and Fair Oaks Formation of the Quaternary age; the Laguna and Mehrten Formations (Pliocene); the Valley Springs Formation (Miocene); and the Ione Formation (Eocene). The primary water-producing zones are included in the undifferentiated Quaternary sediments, Laguna, and Mehrten Formations; therefore, these formations are discussed in detail below.

Undifferentiated Quaternary Sediments. The uppermost sequence consists of sediments deposited in southwesterly trending channels of the ancestral American River. Sediments were deposited during the glacial and inter-glacial periods of the Pleistocene, and grain sizes range from clays and fine silts to cobbles and boulders. Various formations are present within the Quaternary sediments; however, these formations are not differentiated as historic gold dredging has obliterated much of the evidence required to make such distinctions. In general, the sequences range from zero to 125 feet (38 m) in thickness.

Laguna Formation. The late Pliocene to early Pleistocene Laguna Formation underlies the undifferentiated deposits. Sediments of the Laguna Formation were derived from granitic and metamorphic parent rocks and were deposited in a low-energy fluvial environment (DWR, 1974). The Formation is primarily composed of interbedded silts and clays with less common interbeds of poorly-sorted sands and gravels. The Laguna Formation ranges in thickness from 125 to 400 feet [38 to 122 m] (DWR, 1974).

Mehrten Formation. The middle Miocene to middle Pliocene Mehrten Formation underlies the Laguna Formation. It is comprised of primarily andesitic lavas, clays, and sands and is generally darker in color than the overlying Laguna Formation. The Mehrten Formation thickens from 30 feet (9.1 m) in the vicinity of the Study Area to over 1,300 feet (396 m) in the Sacramento-San Joaquin Delta (DWR, 1974).

5 HYDROGEOLOGY

5.1 AMERICAN RIVER STUDY AREA

Aerojet defined hydrogeologic units (Aquifers A through D) in the American River Study Area were based on lithologic descriptions, water levels, geophysical data, pumping test data, and relative depths and thickness (Aerojet, 2000a). Aquifers A through D do not necessarily correlate with the regional geologic formations previously discussed; however, Aquifers A and B are commonly associated with the undifferentiated Quaternary sediments. Aquifers A through D are impacted by VOCs. Three aquifer units (Aquifers A, B, and C) have ARGET extraction wells to either remove the contaminants or attempt to halt their migration. Therefore, the emphasis of the hydrogeology section will focus on these three aquifer units.

Aquifer A. Aquifer A is the uppermost water-bearing zone. It is composed of higher permeability sands and gravels with lenses of interbedded sediments of lower permeability and extends to a depth of approximately 25 to 100 feet (7.6 to 30.5 m) below ground surface (bgs). Groundwater in Aquifer A exists under both unconfined and semi-confined conditions as determined by local geology. The groundwater flow direction in Aquifer A, prior to start-up of the ARGET system, was toward the west-northwest. Generally, during operation of the ARGET system, the predominant groundwater flow direction is still toward the west-northwest; however, a radial flow pattern toward the extraction wells is observed (Figure 3-15 of Aerojet, 2000a).

Aquifer B. Aquifer B occurs within the basal sands and gravels of the Quaternary sediments. Aquifer B is separated from Aquifer A by a relatively continuous aquitard ranging from approximately 10 to 55 feet (3 to 17 m) in thickness. In general, Aquifer B consists of sands, gravels, and silty sands, similar to those observed in the Aquifer A. Aquifer B ranges in thickness between 10 and 70 feet (3.1 to 21.3 m). The groundwater flow direction in Aquifer B, prior to start-up of the ARGET system, was toward the west-northwest. Generally, during operation of the ARGET system, the predominant groundwater flow direction is still toward the west-northwest. Locally, groundwater has a radial flow pattern toward the operating groundwater extraction wells (Figure 3-16 of Aerojet, 2000a).

The vertical gradient between Aquifers A and B ranges from –0.02 to 0.18 feet/feet with an average value of 0.01 under non-pumping conditions (Aerojet, 2000a). A positive value indicates a potential for groundwater to flow downward, while a negative gradient indicates a potential for groundwater to flow upward. Values close to zero indicate little or no potential for vertical groundwater movement. A negative, or upward, gradient is present near Lake Natoma to approximately 500 feet (152 m) west of Hazel Avenue (Figure 3-22 of Aerojet, 2000a). The vertical gradient in this area is measured from groundwater levels in monitoring well nests 1375/1376 and 1472/1382. The negative gradient indicates the potential for groundwater to move upward from Aquifer B to A. Groundwater levels in Aquifer A appear to be above the elevation of the river in this area, thus indicating Aquifer A could be discharging to the American River (Figure 3-22 of Aerojet, 2000a). Approximately 500 feet (152 m) west of monitoring wells 1375 and 1376, the vertical hydraulic gradient is near zero, indicating little potential for vertical groundwater movement. According to Aerojet, a positive vertical gradient is present (*i.e.*, groundwater moves down from Aquifer A to Aquifer B) in the vicinity of the American River approximately 1,500 feet (457 m) west of monitoring wells 1375 and 1376, and extending west along the length of the river outside of the Study Area (Figure 3-22 of Aerojet, 2000a).

Aquifer C. Aquifer C is composed primarily of mafic sand, sandstone, and minor gravel with varying degrees of cementation. Interbeds of siltstone and clay are common and vary in thickness from one to ten feet (0.3 to 3.1 m). Aquifer C ranges in thickness from 50 to 125 feet (15.2 to 38.1 m) with an average thickness of 80 feet (24.4 m).

The groundwater flow direction for Aquifer C, prior to start-up of the ARGET system, was generally toward the west-northwest. Groundwater generally has a radial flow pattern inward to the operating groundwater extraction wells (Figure 3-17 of Aerojet, 2000a).

The vertical gradients between Aquifers B and C range from –0.04 to 0.24 feet/feet with an average value of 0.035 feet/foot under non-pumping conditions. Under pumping conditions, the gradient ranges from –0.17 to 0.38 feet/feet with an average of 0.04 feet/feet, indicating that pumping generally increases the downward vertical gradient between Aquifers B and C.

Aquifer D. Aquifer D is composed of sand and sandstone with some gravel and ranges in thickness from 30 to 150 feet (9.1 to 45.7 m). Aquifer D is separated from Aquifer C by a relatively continuous 15- to 100-foot (4.6- to 30.5-m) thick clay and siltstone layer (Aerojet,

2000a). The groundwater flow direction in Aquifer D prior to and after start-up of the ARGET system is generally toward the west.

5.2 WESTERN OPERABLE UNIT OU-3

Aerojet recognizes six hydrostratigraphic layers (Layers A through F) within OU-3, which have been defined based on lithological descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thickness. These layers do not necessarily equate to Aquifers A to D defined by Aerojet for the American River Study Area. The terms "Layer" and "Aquifer" are, however, essentially interchangeable in this context. The following description is summarized from Aerojet investigations (Aerojet, 2000b).

Aerojet's hydrostratigraphic interpretation does not account for the entire 2,000 feet (610 m) of sediments present in OU-3. The Ione and Chico Formations, present between around 1,000 and 1,500 feet (305 and 457 m) bgs, contain brackish water that would not be suitable for human consumption. The deepest contamination at the Aerojet site has been observed in Layer E at depths of approximately 400 to 500 feet (122 to 152 m) bgs. Therefore, there are approximately 500 feet (152 m) of freshwater sediments below the deepest observed contamination and above the brackish formations.

Layer A. Layer A, the uppermost hydrostratigraphic layer, is discontinuous on the Aerojet site and is observed primarily in the GET F area. It is composed predominantly of unconsolidated sand and gravel consisting of granitic, metamorphic, and volcanic clasts eroded from the Sierra Nevada. Grain sizes range from large boulders and cobbles to sands, silt, and clay. The primary bedding features have been disturbed to depths of 20 to 80 feet (6.1 to 24.4 m) bgs by historical gold dredging activities throughout much of the area. Consequently, precipitation will readily infiltrate into the dredged areas, and storm water runoff is minimal compared to that in undredged areas.

The saturated thickness of Layer A ranges from zero to approximately 20 feet (6.1 m). The depth to the top of Layer A ranges from 40 to 50 feet (12.2 to 15.2 m) bgs in the east to 80 to 100 feet (24.4 to 30.5 m) bgs near the western Aerojet site boundary near GET F. Layer A is generally unsaturated in the north, south (IRCTS), and west portions of OU-3. In the vicinity of GET F, the groundwater elevation in Layer A ranges from 90 feet (27.4 m) above mean sea level (amsl) in the east to 40 feet (12.2 m) amsl in the west. Groundwater flow is generally to the west-southwest with an average lateral hydraulic gradient of approximately 0.005 feet/feet.

Layer B. Layer B occurs within the basal sands and gravels of the Quaternary sediments, and appears to be continuous beneath most of the Aerojet site and the IRCTS. The sediments designated as Layer B grade from relatively coarse-grained materials in the east to relatively finer-grained materials near GET F and in the western off-site area. The westward "fining" of Layer B is coincident with an observed increase in thickness of the underlying B/C aquitard (low permeability layer). This aquitard increases in thickness (from tens of feet to over 100 feet [30.5 m]) and depth (from 50 to 180 feet [15.2 to 54.8 m] bgs) from the western Aerojet site boundary to the western OU-3 boundary.

Groundwater elevations in Layer B decrease from approximately 100 feet (30.5 m) amsl in the east to 15 feet (4.6 m) amsl in the west. The groundwater flow direction is generally to the west or west-southwest, and the average lateral hydraulic gradient is 0.004 feet/feet.

Layer C. Layer C is composed predominantly of sand and minor gravel with varying degrees of cementation. Thin (one to ten feet [0.3 to 3.1 m]) interbeds of brown siltstone and clay are common. Layer C ranges in thickness from 50 to 125 feet (15.2 to 38.1 m) with an average thickness of approximately 80 feet (24.4 m). Layer C is saturated and continuous throughout the OU-3. The top of Layer C reportedly forms a relatively planar surface with a strike of NI2°W and a southwesterly dip of approximately 1°. This attitude is consistent with the attitudes of regional geological formations which are reported to strike generally north-south and dip to the west at 1° to 3° (DWR, 1974). The shallow dip is toward the west (Figures A-4 and A-5 of Aerojet, 2000b).

Groundwater elevations in Layer C decrease from approximately 75 feet (22.9 m) amsl in the east to -10 feet (-3.1 m) amsl in the west in OU-3. The groundwater flow direction is generally to the west-southwest, although deviations may be observed in the vicinity of the GET E and F extraction and recharge wells. The average hydraulic gradient is 0.004 foot/feet.

Layer D. Layer D is composed of mafic sands and sandstone with some gravel. On the Aerojet site, Layer D ranges in thickness from 30 to 150 feet (9.1 to 45.7 m). The base of Layer D is present at depths of approximately 360 to 400 feet (110 to 122 m) bgs. Layer D is separated from Layer C by a 10 to 45 feet (3.1 to 13.7 m) thick clay and siltstone layer.

Groundwater elevations in Layer D decrease from approximately 100 feet (30.5 m) amsl in the east to zero feet amsl in the west. The groundwater flow direction is generally to the

west or west-southwest, although deviations may be observed in the vicinity of the GET E and F extraction and recharge wells. The average hydraulic gradient is 0.004 feet/feet.

Layer E. Layer E is comprised of sand, sandstone, and some gravel with interbedded silt and clay lenses. In general, the silt and clay lenses are more abundant and thicker in Layer E than observed in overlying Layers C and D. The sediments in Layer E are dominantly black or greenish. The top of Layer E occurs at depths of 350 to 400 feet (107 to 122 m) bgs near the western Aerojet boundary. The available data indicate Layer E is at least 100 feet (30.5 m) thick.

Groundwater elevations in Layer E decrease from approximately 70 feet (21.3 m) amsl in the east to -10 feet (3.1 m) amsl in the west in OU-3. The groundwater flow direction is generally to the west, and the average hydraulic gradient is 0.004 feet/feet.

The depth to groundwater generally increases from 40 feet (12.2 m) to approximately 100 feet (30.5 m) bgs from east to west across OU-3. Locally, perched groundwater may be present at a shallower depth.

A strong downward vertical hydraulic gradient (15 to 40 feet [4.6 to 12.2 m]) exists between Layers A and B. A less strong (5 to 15 feet [1.5 to 4.6 m]) downward potential exists between Layers B and C. Vertical head differences between Layers C, D, and E are relatively minor (Aerojet, 2000b).

6 BUFFALO CREEK STREAMFLOW MEASUREMENTS

6.1 INTRODUCTION

Buffalo Creek (the Creek) has its headwaters within the Aerojet Rancho Cordova Site. Buffalo Creek exits the western property boundary south of West Lakes, passes over the Folsom Canal in a concrete channel, and then immediately under US Highway 50 as it flows predominantly north and northwest towards the American River (Figure 2-1 of Aerojet, 2000a). The Creek is an engineered channel due its straight alignment and steep banks. For most of its length (except at the canal and road crossings) the stream is lined with native soil material. The stream passes through numerous residential developments with several stormwater drains emptying into it. The approximate locations of all stormwater outfalls identifiable during the week of April 24, 2002 are shown in **Figure 6-1**.

The ARGET system discharges treated water to Buffalo Creek, inside the perimeter of the Aerojet Facility (Figure 2-1 of Aerojet, 2000a). From August 1998 to August 1999 the ARGET system extracted approximately 2,740 gpm (173 liters per second [L/sec]) (Table 2-1 of Aerojet, 2000a). **Figure 2-1** shows the variability of ARGET extraction rates from August, 1998 to March, 2002 (Aerojet, 2002). These data show that in recent months groundwater extraction flowrates from the ARGET system have averaged 2,100 gpm (132 L/sec).

6.2 PURPOSE

The purpose of collecting flow measurements of Buffalo Creek was to estimate the rate of water discharge to the American River. Infiltration and evaporation result in conveyance losses from the original volume of water that enters the Creek at the Aerojet Facility. These losses were estimated indirectly by measuring the streamflow in Buffalo Creek leaving the Aerojet western property boundary and comparing the volumetric flowrates discharging to the American River.

6.3 METHODOLOGY

6.3.1 FLOW MEASUREMENT AND ANALYSIS

6.3.1.1 Equipment

The Marsh McBirney flow meter is an electromagnetic device that is calibrated to make velocity measurements of water flow over its detection bulb. Electromagnetic flow meters produce a magnetic field in the fluid surrounding this bulb. The velocity is measured by detecting changes in this magnetic field caused by the moving water (Herschy, 1995). The device infers a velocity and sends this velocity to a digital display. The flow meter was factory calibrated by Marsh-McBirney Inc. (Calibration Certificate #4384 – Appendix A) to ensure its accuracy.

The depth of the probe may be adjusted up or down as dictated by the total depth of the stream; however, the wading rod to which the probe is attached rests on the stream bottom for stability. A digital read-out and timer provides a running average over a prescribed length of time after which the timer is reset and the running average begins again. Use of this device is described below.

6.3.1.2 Stream Gaging

Weather during all streamflow measurements was generally clear with some cloudy periods. No rain was experienced during the measurements, however, some relatively light scattered showers occurred between stream flow gaging events. Flow observed from stormwater outfalls was either non-existent or extremely low during each gaging event. Stormwater inputs into Buffalo Creek during the streamflow measurements were minimal (likely less than 50 gpm 0.1 cubic feet second in total) from all visible surface water sources downstream of the Aerojet facility.

When choosing a site for stream gaging, a section of the Creek was chosen that had a steady flow and enough depth to ensure full coverage of the velocity probe. In addition, uniform and smooth cross-sections were chosen (*i.e.*, sections of uniform streambed and the inside of a large diameter culvert). Flow measurements at all sites were repeated three times at different times and dates to ensure consistency.

All water flowing in a stream is not moving at the same velocity. Generally, water moving slightly below the surface has the highest velocity and water flowing near the stream-bed

has the lowest velocity as a result of friction between the flowing water and the streambed material. This distribution of velocity through the depth of the stream makes up what is known as a velocity profile. Stream gaging involves taking representative velocity measurements in a stream and combining them with the stream's cross-sectional area to calculate the flowrate.

Streamflow velocity measurements taken during this study were completed using the Marsh McBirney flow meter. After adjusting the height of the probe and positioning the wading rod in the appropriate location, the operator stood downstream and to one side while the flow reached a steady-state. When the flow was back to its undisturbed condition, the time averaging feature of the flow device was activated and a running average was collected over a period of 25 seconds. For all samples, the average velocity reached a stable value within the 25 second time period. The velocities, depth and distance across the stream was recorded in a measurement form. Field measurements and associated stream flowrates are presented in Appendix A.

6.3.1.3 Velocity-Area Method

The simplest and most effective way of determining streamflow with a single, handheld gage is using the velocity-area method. This method involves dividing a cross-section of the stream into a minimum of 20 equal sections. Representative velocity measurements are taken in each section and are applied over that section's flow area. Usually one or two measurements are made in the velocity profile (depending on the depth) and assumed to represent the average velocity for that section. To completely eliminate the error associated with this type of averaging, one would have to take an infinite number of velocity measurements covering the entire velocity profile and apply these velocity measurements to an infinite number of flow area cross-sections (Herschy, 1995), which is not possible. The velocity-area method uses an approach based on this principle but uses a finite number of measurements.

First, the Creek is transected perpendicular to the streamflow direction, then divided into at least 20 sections along its width. As many as 30 sections can be used for very wide streams or streams with a highly variable bottom (Herschy, 1995). In all cases, each section should generally contain less than 10% of the total stream flow (Herschy, 1995). In nearly all cases during the present study, 6-inch (0.15 m) sections were used resulting in 20 to 24 sections. A velocity measurement is then taken to represent the flow in that section.

Based on analysis of many vertical velocity profiles, the velocity which occurs at 60% of the stream depth (in any one section) is usually a good representation of the average velocity for the specific profile (Herschy, 1995). For example, if a stream were 10 inches (0.25 m) deep, the average velocity would be found at approximately six inches below the surface.

If the stream is over 30 inches (0.76 m) deep, the 20% - 80% method should be used. This method uses two velocity measurements that would be taken for each section – at 20% depth and at 80% depth. The average of these two velocities would then be taken as representative of the mean velocity in that section (Herschy, 1995). None of the measurement locations on the Buffalo Creek include depths that would justify using the 20% - 80% method for determining the average velocity.

The velocity of the water in each section is multiplied by the area of that section to provide a volumetric discharge rate. The sum of the discharges for all the sections is then calculated to provide a total discharge for the stream. This procedure was repeated three times at each site on the dates shown in **Table 6-1** to ensure accuracy and precision. In general, streamflow measurements using this methodology tend to have an approximate error of ± 15% from the actual flow in the stream.

6.4 MITIGATION OF ERRORS

Errors in streamflow gaging are usually expressed as a percentage of the total measurement. Because of this, the relative error associated with choosing 20 sections is the same regardless of the width of the stream being measured. The absolute error will however increase as the stream width increases and the number of sections remains the same (Herschy, 1995).

Errors in flow measurement can result from the following:

- complex hydraulics resulting from bed roughness (rocks, weeds and/or drops);
- non-parallel flow lines (flow around bends in the river alignment or around obstructions); and,
- poor calibration of the flow measurement device.

Only locations with a straight channel alignment were considered. Errors introduced by rocks and weeds on the stream bottom were avoided by selecting areas with relatively smooth streambeds, and without vegetation overgrowing into the channel. Sites were also chosen to avoid streambeds with thick mud and weed beds.

6.5 RESULTS AND DISCUSSION

The water flowrates in Buffalo Creek calculated during this measurement program are summarized in **Table 6-1**. The detailed calculation/field note sheets are shown in Appendix A. **Figure 6-1** shows the location for all monitoring sites along Buffalo Creek.

6.5.1 STREAMFLOW NEAR WESTERN AEROJET PROPERTY BOUNDARY

Measurements #3, #6 and #7

These measurements were taken north of US Highway 50 (**Figure 6-1**) at the closest available and appropriate location to evaluate flow leaving the Aerojet facility. A site located approximately 1,080 feet (330 m) from the Aerojet property boundary was found that was clear of weeds and had a consistent streambed with consistent width and bed material over a length of approximately 8 feet (2.4 m) upstream and 4 feet (1.2 m) downstream. The data collected at this point were found to be repeatable and consistently close to the location average of 2,030 gpm (4.52 cubic feet second [cfs]) (maximum deviation of 130 gpm [0.29 cfs]). This number is considered a good representation of the volumetric flowrate of water leaving the Aerojet facility in Buffalo Creek during the time of streamflow measurement events.

6.5.2 STREAMFLOW APPROXIMATELY HALFWAY TO THE AMERICAN RIVER

Measurements #1, #4 and #8

Buffalo Creek crosses under Coloma Rd. through a single, corrugated steel culvert approximately 10 feet (3.1 m) in diameter. This location is approximately 4,200 feet (1,280 m) from the Aerojet boundary (**Figure 6-1**). The water depth and flow conditions in this culvert provided good conditions for streamflow gaging. The culvert floor prevents the growth of weeds and provides a uniform bottom that minimizes non-parallel flow paths. All depth measurements were made from the top of one corrugation. The average flowrate at this location is 1,630 gpm (3.63 cfs) with good clustering of data around this point (maximum deviation of 70 gpm [0.16 cfs]). Data collected at this location are expected to be good representations of the actual flow in the stream at that point during the period of measurements.

6.5.3 STREAMFLOW AT OUTLET TO THE AMERICAN RIVER

Measurements #2, #5 and #9

Just before the confluence of Buffalo Creek and the American River (10,560 feet [3,219 m] along the Creek's path from the Aerojet boundary), the Creek flows through several culverts that convey water under a county park road and the bike path. Just before these culverts a short section of weedless stream provided a very good flow measurement location. The data point collected on the first measurement event (April 25, 2002) appears to be a minor outlier to the conservative (lower flow) side. This means that the average of the three measurement locations will be slightly skewed in this direction. The average flow of 1,500 gpm (3.34 cfs) (maximum deviation of 200 gpm [0.45 cfs]) can be considered a conservative (low) estimate of the flow entering the American River.

6.6 CONCLUSIONS

Based on the above measurement data collected between April 25 and May 2, 2002 when the ARGET system was producing approximately 2,100 gpm (4.68 cfs), approximately 1,500 gpm (3.34 cfs) was reaching the American River. The flowrate entering the river can be more reliably tied to the flowrate entering the Creek from the ARGET system after ARGET flow data becomes available for the measurement dates. As expected, some of the water exiting the Aerojet site is being lost to infiltration and evaporation. Groundwater conditions and evaporation will cause losses to vary.

7 INTERPRETATION OF AMERICAN RIVER SURFACE ELEVATION

7.1 INTRODUCTION

The American River surface elevation needs to be interpreted along approximately 9,000 feet (2,743 m) of its path downstream of the USGS gaging station (ARGET Reach) for different points in time. This data will be used to compare groundwater elevations with river surface elevations to determine groundwater flow directions.

The United States Geological Survey (USGS) has been operating a flow monitoring station (#11446500) at Fair Oaks (eastern Study Area) on the American River since 1904. The gage datum (zero height) is set at 71.53 feet (21.80 m) amsl [National Geodetic Vertical Datum 1929] (Appendix B and http://waterdata.usgs.gov/nwis/sw). Aerojet performed the "American River and Groundwater Investigation" in 1983 (Aerojet, 1983a). As part of this study, three water surface elevations on the American River downstream of the Nimbus Dam were surveyed on April 21 and 22, 1983. The flow during the time of the survey in 1983 was relatively high, recorded at approximately 8,545 cfs and corresponds to a stage of 80.2 feet (24.4 m) amsl at the USGS gaging station. The annual average flowrate and elevation at the gaging station is approximately 3,350 cfs and 77.67 feet (23.7 m) amsl, respectively (Appendix B and http://waterdata.usgs.gov/nwis/sw).

Another river level survey was completed by Komex on May 2, 2002 (**Figure 7-1**). On the day of this survey the water level elevation at the USGS gaging station was recorded at approximately 77.43 feet amsl (23.6 m) or 3,000 cfs (Appendix B and http://waterdata.usgs.gov/nwis/sw). The Komex survey results are shown in Appendix B. A comparison of the two survey results is shown graphically in **Figure 7-2**.

Using the 2002 survey data, the survey completed by Aerojet in 1983, and the historical river level data available from the USGS, a methodology for interpreting river water levels within the ARGET Reach was developed.

7.2 METHODOLOGY

Based on the available data, it was assumed that the river water levels at locations within the ARGET Reach can be interpreted as being parallel to the Aerojet survey for other river flowrates. This means that if the river level at the USGS gaging station is one foot lower on another date, it is assumed that on the same date the river level is one foot lower at each of the three points presented in the Aerojet survey. Thus, a simple proportional relationship can be postulated and applied to the historical data record collected by the USGS gage to provide interpreted levels at the 1983 surveyed locations. Other positions between these data points in the ARGET Reach are linearly interpolated to estimate river surface elevations at locations closest to each monitoring well. From this interpolation an offset from the USGS gage height was assigned to each monitoring well.

Figure 7-2 shows a line approximately parallel to the Aerojet data as it is used to interpret the downstream river levels for the date of the survey (May 2, 2002). Correlation is good in the upper part of the river where the actual river slope matches the assumed overall bedslope. This correlation decreases at some downstream sections where the bedslope appears to be milder. Overall, the error associated with this methodology provides acceptable estimates of river stage over the ARGET Reach.

This simple approach is used to determine river levels for all river elevations recorded at the USGS gaging station since 1980. Weekly average river elevations were extracted from the USGS historical data and adjusted with the offset assigned to each monitoring well.

7.3 SUPPORTING ASSUMPTIONS AND ASSOCIATED ERROR

The methodology described above makes the following assumptions:

1. the channel cross section is uniform over the ARGET Reach;
2. the slope of the river is constant and equal to the average slope of the river over the ARGET Reach as estimated by the surveyed slope of the water surface (*i.e.*, approximately 0.1%); and,
3. no significant changes in channel geometry have occurred since 1983.

The American River bed slope is mild and typical of a mature river, in which channel geometry tends to be less variable than in younger, steeper rivers. While the 2002 survey data indicates some flattening of the river slope in the middle segment of the ARGET Reach,

the backwater effect is relatively small and the straight line approximation to the water surface provides water level estimates of sufficient accuracy for this study (*i.e.*, maximum errors of ± 1.5 feet [0.46 m]). Over most of the ARGET Reach, errors are less than 0.5 feet (0.15 m).

7.3.1 HYDRAULIC JUMP

Hydraulic jumps are common features in many river systems where there are abrupt changes from steep to mild slopes. Water flowing down a steep slope often moves with greater velocity and at a shallower depth than it will when flowing on a mild slope. The transition between the fast-moving shallow flow (super-critical) and the deeper, slower-moving flow (sub-critical) is a standing wave known as a hydraulic jump. Where a hydraulic jump occurs, the river level could drop or rise significantly over a short distance.

For the range of flowrates and the average streambed slope observed in the American River, the flow will be sub-critical and hydraulic jumps are not expected.

7.3.2 RANGE OF FLOWRATES

The flowrates that occurred during the two American River elevation surveys covered nearly half of the expected range of flowrates in the American River (Appendix B and http://waterdata.usgs.gov/nwis/sw). Because this data gives good coverage of the expected range of flowrates in the river and a parallel projection of the 1983 data gives a good prediction of the 2002 data, interpreting in a similar way between the two flowrates and slightly below the 2002 survey flowrate will provide a reasonable approximation of American River surface elevations.

7.4 CONCLUSIONS

Although very limited data are available to generate accurate estimates of river surface level over the ARGET Reach, the assumptions stated above are reasonable, and the simple methodology adopted for determining American River water surface elevations for approximately 9,000 feet (2,743 m) downstream of the USGS gaging station is adequate. The data collected on May 2, 2002 and April 21 and 22, 1983 can be used to produce acceptable estimates of river surface elevations corresponding to known elevations at the gaging station for the purposes of this study. The simple methodology permits an approximate historical estimation of river elevations at different points downstream of the gaging station.

The comparison of river surface elevations to the groundwater elevations in nearby monitoring wells is presented in Section 8.2.1 of this report.

8 STUDY AREA OPINIONS

The following section presents pertinent data and opinions by Komex and various authors.

8.1 OPINIONS OF OTHERS

8.1.1 AMERICAN RIVER STUDY AREA

Groundwater Recharge and Discharge

Many studies of the American River have been undertaken by the DWR, private consulting companies, and industries over the past 60 years. The vast majority these studies have indicated that the American River is recharging adjacent and underlying formations (*i.e.*, groundwater is not discharging to the river) with the exception of a short stretch of the river below the Nimbus Dan near the Fish Hatchery. The following are pertinent excerpts from these studies:

- "Ground water replenishment for the area of investigation occurs from infiltration of rainfall, surface streams..." (DWR, 1964, p.21).
- Referring to stream channel seepage: "...percolation of the American River, between the Folsom Bridge and the confluence of the American River with the Sacramento River, would account for approximately 64,000 acre-feet of water per season" (DWR, 1964, p.22).
- "...[R]echarge waters move through the formations, or a single formation, lenticularly or in laminar flow patterns..." (DWR, 1964, p.32).
- "Recharge to this formation [the Laguna Formation] is also from direct contact with the American River, infiltration of imported water from the American River, and the infiltration of precipitation" (DWR, 1964, p.34).
- "In areas where the water table is in contact with water in the streambed, there is direct hydraulic continuity of the stream with the water table through these coarse deposits" (DWR, 1964, p.A-17).
- "Four river water samples taken from below the Fish Hatchery facility (6023, 6028, 6029, and 6030) had slightly increased electrical conductivities in the range of 43 to 49 micromhos/cm which indicated that the flow in this reach has been augmented by inflow of higher conductivity groundwater. All of these samples had detectable levels of trichloroethylene in the range 9 to 27 ppb" (Aerojet, 1983b).

- "...[T]he average annual groundwater recharge from the rivers and streams is approximately 207,000 acre-feet. As previously discussed, the Sacramento River, American River and Cosumnes River are the primary sources of this recharge..." (Sacramento County Water Agency, 1993, p.5-5).
- "Groundwater enters the model area through infiltration of precipitation, mountain-front recharge, recharge wells, and to a lesser extent from the American River" (Aerojet General Corporation, 2000b, Appendix D, p.D5).
- "In areas where groundwater levels are lower than the water levels in the American River, recharge of river water may occur. The amount of recharge is dependent on the permeability of the riverbed" (Aerojet General Corporation, 2000b, Appendix D, p.D6).
- "Discharge to the American River occurs when groundwater levels are higher than the river level. Consistently this occurs in the vicinity of Lake Natoma. Discharge to other parts of the American River has decreased with time as regional water levels have declined" (Aerojet General Corporation, 2000b, Appendix D, p.D6).
- "River bed conductance [calculated by multiplying the assumed vertical hydraulic conductivity of the river bed by the estimated channel area] ranges from approximately 180 ft^2/day for the American River..." (Aerojet General Corporation, 2000b, Appendix D, p.D10).
- "Leakage from the American River varies along the length of the river and is dependent on the head difference between river stage and groundwater levels...Leakage, as calculated by the groundwater flow model, increases from about 4,000 ac-ft/yr in 1980 to 6,000 ac-ft/yr in 1998" (Aerojet General Corporation, 2000b, Appendix D, p.D12). *It should be noted that these figures apply to a numerical model covering an approximate 13-mile stretch of the American River, and are therefore not comparable with the DWR (1964) percolation figure of 64,000 acre-feet of water per season noted above, which applies to a much longer stretch of the American River.*
- "Discharge to the American River is dependent on water level differences between groundwater and river stage. More discharge of groundwater to the river occurred in the past when groundwater levels were higher. Discharge to the river, as calculated by the groundwater flow model, has ranged from a high of approximately 5,000 ac-ft/yr in the past to a low of 800 ac-ft/yr in recent years" (Aerojet General Corporation, 2000b, Appendix D, p.D13). *It should be noted that these figures apply to a numerical model covering an approximate 13-mile stretch of the American River, and are therefore not comparable with the DWR (1964) percolation figure of 64,000 acre-feet of water per season noted above, which applies to a much longer stretch of the American River.*

- "Although the unconfined to semi-confined nature of Aquifer A suggests that some hydraulic connection exists between the American River and Aquifer A, the presence of chemicals in Aquifer A on the north side of the river and the configuration of the potentiometric surface of Aquifer A indicate that the river is not a significant barrier to chemical migration or groundwater flow" (Aerojet General Corporation, 2000a; Section 3.2.2, p.11).

In summary, the opinions of others generally agree that the American River is losing water into the subsurface, thus recharging adjacent and underlying formations. The exceptions noted above, particularly the 1983 program conducted by Aerojet, took place at very high groundwater levels. During the period of the high groundwater levels, dissolved-phase TCE would discharge to the American River.

Historical information indicates that the American River is recharging the uppermost water-bearing unit along the majority of the river's course with the exception of near Nimbus Dam/Lake Natoma. Aerojet has conducted numerous hydrogeological investigations in the area, and they also concur with the findings of Sacramento County and the DWR that the American River is recharging the subsurface. Aerojet further states that the American River is not a significant hydraulic barrier to groundwater flow.

Historical Groundwater Levels in the Vicinity of the American River Study Area

Opinions related to historical groundwater levels in the vicinity of the Study Area are as follows:

- "A comparison of the 1953 ground water elevations to the 1963 ground water elevations shows a general decline throughout the entire area of investigation, with the least amount of change occurring where the American River is influencing the recharge. The greatest change, approximately 20 feet, occurs in the Rancho Cordova area where intense urban development has taken place and in the southeastern portion of the area where recharge is very minor" (DWR, 1964, p. 18).
- "From 1940 to 1968 the average ground water level in Sacramento County has been dropping more than one foot per year" (DWR, 1974, p. 1).
- "According to DWR, groundwater levels were fairly stable at an average of 30 feet above mean sea level between 1930 and 1940. Between 1941 and 1970, however, the county-wide average elevations declined to about five feet below mean sea level. Three distinct groundwater cones of depression have developed due to localized intensive groundwater pumping. These areas of lowered groundwater levels are located in the

northern County (adjacent to McClellan Air Force Base), in the Elk Grove area, and in the Galt area" (Sacramento County Water Agency, 1993, p.2-4).

The groundwater surface elevations from these studies are from water wells likely completed in several aquifers; thus, the contoured elevations reflect a composite of water levels for the different aquifer systems. In the American River Study Area, groundwater levels are reported not to be declining to the same degree as in other portions of the basin due to the recharge from the American River.

8.1.2 WESTERN OPERABLE UNIT OU-3

Groundwater Recharge and Discharge

Aerojet has conducted numerous groundwater investigations in OU-3 since the early 1980s. Aerojet has concluded the following from these investigations:

- "Groundwater elevations range from approximately 85 feet above mean sea level (msl) in the east to approximately sea level in the west. Groundwater does not discharge to the American River or any other surface water body within the Study Area boundaries" (Aerojet, 2000b, p.9).
- "Potentiometric surface elevations measured in Layer A typically range from 15 to 40 feet above those measured in underlying Layer B. This relatively high vertical head potential suggests there is a strong potential for downward vertical groundwater migration from Layer A to Layer B. A similar but less strong (5 to 15 feet) vertical head potential exists between Layers B and C" (Aerojet, 2000b, p.9).
- "The CoPCs [contaminants of potential concern] that remain in Layer A have not migrated to the western offsite area. The offsite CoPC migration is inhibited by extraction wells screened in Layer A at GET F, and by relatively strong downward vertical head potentials from Layer A to underlying Layer B" (Aerojet, 2000b, p.13).
- "The saturated thickness of Layer A ranges from zero to approximately 20 feet. The depth to the top of Layer A ranges from 40 to 50 feet below ground surface (bgs) near the source areas located in the east to 80 to 100 feet bgs in the central portion of the Study Area near GETs F. Layer A is generally unsaturated on the Aerojet Site to the north, south and west of GET F. At these locations, groundwater from Layer A probably infiltrates downward into Layer B, and does not discharge to surface waters" (Aerojet 2000b, Volume II, p.7).

- "The potentiometric surface maps illustrate that Layer A is only present in a relatively small area on the Aerojet Site (Figure A-7). Groundwater is extracted from Layer A by two extraction wells at GET F; Layer A is dry at GET E" (Aerojet 2000b, Volume II, p. 9).

In the western portion of OU-3 the groundwater surface identified as the "water table" was reported to be at a higher elevation adjacent to the American River and declining to the south in the spring of 1963 (Plate 3 of DWR, 1964). A similar condition is also reported approximately 10,000 feet to the west in a north-south geological cross-section (Plate 3 of DWR, 1964). Thus, in the spring of 1963 the American River water was recharging adjacent and underlying formations in this area. This condition persists today.

Historical Groundwater Levels in Western Operable Unit OU-3

See Section 8.1.1 for opinions of others regarding groundwater level fluctuations over time in the vicinity of OU-3. It is the opinion of others that groundwater levels have been declining in the OU-3 area since the 1940s.

8.2 KOMEX OPINIONS

Komex has formed the following opinions with respect to the Study Area, based on a review of the material listed in Section 11.

8.2.1 AMERICAN RIVER STUDY AREA

1. ***Shallow groundwater does not discharge substantially all of the time to the American River along two thirds of the Study Area .***

Groundwater Monitoring

The following selected monitoring wells are completed in Aquifer A, or the upper-most water-bearing unit close to the American River:

- Eastern Study Area monitoring wells 1357, 1370, 1375, 1469, 1478, 1516, 1518, and 30100;
- Central Study Area monitoring wells 1481, 1487, 1522, 1567, and 1571; and,
- Western Study Area monitoring wells 1406, 1506, 1564, 1585, and 1591.

Monitoring well completion details and groundwater elevations measured in these wells are summarized on **Table 8-1**, which was compiled from Aerojet's groundwater database (Aerojet, 2002). Hydrographs of the groundwater elevation recorded in each selected

monitoring well, compared with the interpreted American River surface elevation, are contained in Appendix C. The river data are represented on the hydrographs as average elevations for the river water surface near the monitoring well location, as described in Section 7. The following provides a commentary on selected, representative hydrographs.

Western Study Area

At Monitoring Well 1506, in the western Study Area south of the American River, groundwater elevations were measured on 57 occasions between 1992 and 2001. The levels show a marked drop following the start of ARGET pumping, from which time onwards the groundwater level has been over 25 feet (7.6 m) below the American River surface. Before ARGET pumping, the groundwater was about 20 feet (6.1 m) below the river level.

At Monitoring Well 1564 (north of the American River), groundwater elevations were measured on 47 occasions between 1994 and 2001. The groundwater levels in this well also show a marked drop following the start of ARGET pumping, from which time onwards the groundwater level has been at least 30 feet (9.1 m) below the American River surface. Before ARGET pumping, the groundwater was more that 15 feet (4.6 m) below the American River level.

At Monitoring Well 1585, north of the American River near the western edge of the Study Area, groundwater elevations are available for 44 occasions from 1995 to 2001. The hydrograph shows that groundwater levels were at least 25 feet (7.6 m) below that of the American River, increasing to over 30 feet (9.1 m) following ARGET pumping.

In summary, in the western Study Area, groundwater is well below the American River water surface; thus, the river has the potential to recharge adjacent and underlying formations in this area.

Central Study Area

At Monitoring Well 1487, in the central Study Area south of the American River, groundwater elevations were measured on 63 occasions between 1991 and 2001. During this period, the elevation was generally about five feet (1.5 m) below the river level, except for one monitoring event in 2000 when it was above the river elevation.

In Monitoring Well 1571, further west along the southern bank of the American River, data are available for 44 groundwater elevation measurements from 1994 to 2001. During this

period, groundwater levels were at least nine feet (2.7 m) below the American River water level, increasing to approximately 12 feet (3.7 m) or more after commencement of ARGET pumping.

At Monitoring Well 1481, in the central Study Area north of the American River, groundwater elevations were measured on 49 occasions between 1991 and 2001. At no time was the groundwater elevation higher than the river surface; in general, it was lower by approximately five feet (1.5 m).

At Monitoring Well 1522 (north of Monitoring Well 1481) groundwater elevations were measured on 43 occasions between 1992 and 2001. During this period, groundwater elevations were between approximately eight feet (2.4 m) and 15 feet (4.6 m) below that of the American River surface elevation.

In summary, in the central Study Area groundwater levels are generally about five to 15 feet (1.5 to 4.6 m) below the American River surface, and thus the river will be recharging adjacent and underlying formations in this area.

Eastern Study Area

Monitoring Well 1375 is located at the eastern end of the Study Area, on the southern side of the river. Groundwater levels have been measured in this well on more than 90 occasions between September 1985 and April 2001. Comparison of the groundwater and river elevations shows that, prior to 1996, the groundwater elevation was generally above the river elevation by approximately one to two feet (0.3 to 0.6 m). Post-1996, the groundwater and river surface elevations have been similar. The data suggest that there is potential for groundwater to discharge to the river in this area.

At Monitoring Well 1469, located on the south side of the river towards the western end of the eastern Study Area, groundwater measurements are available for 46 occasions between 1991 and 2001. During this period, the groundwater and river levels were approximately equal, indicating that there is no potential (*i.e.,* no lateral hydraulic gradient) for groundwater to discharge to the river in the area.

At Monitoring Well 1516, in the eastern Study Area just north of the American River, groundwater elevations were measured on 32 occasions between 1992 and 2001. During this period, the groundwater elevation was consistently below the river surface elevation by at least two to three feet (0.6 to 0.9 m), except for one period early in 1993. This indicates

that in the vicinity of Monitoring Well 1516, groundwater is generally not discharging to the American River.

In Monitoring Well 1518, to the north of Monitoring Well 1516, data are available for 38 groundwater elevation measurements collected between 1992 and 2001. The hydrograph shows that during this period, the groundwater elevation was approximately five to six feet (1.5 to 1.8 m) below the surface of the river and increasing to around nine feet [2.7 m] after the start of ARGET pumping. This indicates that groundwater is not discharging to the river in this vicinity.

In summary, on the south side of the American River in the eastern Study Area, groundwater levels range from slightly above river levels in the east, to approximately equal to the river surface levels in the west. On the north side of the river, where data are available, groundwater levels are at least two feet (0.6 m) below the river level. Therefore, there is potential for groundwater to be discharging to the American River on its south side, particularly in the eastern portion of the eastern Study Area.

2. ***The American River is recharging adjacent and underlying formations along two thirds of the Study Area.***

Two Recharge Scenarios

For the American River to recharge shallow groundwater, the elevation of the river water must be higher than the groundwater surface in the adjacent aquifer. This assumes the subsurface is relatively permeable and barriers to groundwater flow are not present (*i.e.* low permeability units such as clays or silts). This is the case, as the majority of near surface sediments in the vicinity of the river have been defined by Aerojet as aquifer materials composed of cobbles, gravels, sands, silty or clayey sands, sandy silts, and sandy clays (Figures 3-2, 3-4, 3-5, and 3-6 of Aerojet, 2000a). Therefore, water that would leak from the river would not be impeded due to low permeability layers. The following two scenarios could be present with a river recharging adjacent and underlying formations:

- The groundwater and river water are in hydraulic connection, indicating that the subsurface is saturated below the river to the first confining layer (**Figure 3-1**). In this situation, the river would be a hydraulic barrier. Under this scenario, groundwater could not flow from one side of the river to the other. This type of hydraulic barrier is commonly used to halt salt-water intrusion in coastal aquifers. Groundwater is pumped

into the subsurface to create a groundwater mound or divide that would halt the intrusion of saline water inland.

- In the second scenario, the recharged river water may not be in direct hydraulic communication with groundwater (**Figure 3-2**). In this situation, an unsaturated zone where all the spaces between the grains are not completely filled with water will be present between the bottom of the river and uppermost groundwater surface. In this scenario the recharging river water would not act as a hydraulic barrier or groundwater divide but would simply be adding water to the aquifer. This appears to be the case for the western portion of the Study Area.

It is possible that the recharge scenario could be a combination of the above. That is, on some occasions the groundwater surface is hydraulically connected with the river, while at other times it is not.

American River as a Source of Groundwater Recharge

As indicated previously, groundwater levels historically have been below American River water surface throughout most of the Study Area. The groundwater levels are on average about 25 feet (7.6 m) below the American River surface in the western Study Area. In the central Study Area, groundwater levels are about five to 15 feet (4.6 m) below the water surface. At the eastern portion of the Study Area, groundwater levels on the south side of the American River are slightly above the river and equal to the river in the west. On the north side of the American River, groundwater surface elevation is about two feet below the river water surface.

Thus, the American River is recharging adjacent and underlying formations along approximately two thirds of the Study Area. The recharge potential declines in the eastern Study Area where locally a reverse process may take place.

Overall Distribution of Groundwater Elevations

The overall pattern of the groundwater surface in Aquifer A is also indicative of a stream losing water. Groundwater elevation contours are deflected downstream, indicating groundwater is being recharged by the American River (Figure 3-15 of Aerojet, 2000a). This pattern is well recognized in the hydrogeologic literature. It should be noted that one contour line, elevation contour 80 feet (24.4 m) amsl near Hazel Avenue Bridge, illustrates a

groundwater discharge pattern (Figure 3-15 of Aerojet, 2000a). The other 50- to 75-feet-amsl groundwater-elevation contours are indicative of a losing stream.

Aquifer Test Results

An eight-hour aquifer test was conducted on August 29, 1995 at Extraction Well 4325 located in the eastern part of the Study Area (Aerojet, 2000a). The aquifer test was designed to assess the hydraulic properties of Aquifer A. This test involved groundwater extraction and monitoring from Well 4325 and nearby Monitoring Wells 1357, 1358, 1370, 1371, 1388, 1404, 1469, and 1478 to observe the decrease in groundwater surface with time. One of the monitoring wells (Well 1478) is located on the north side of the American River. Extraction Well 4325, located on the south side of the American River, was pumped at 434.8 gpm. Groundwater levels were observed to decline in all monitoring wells, even in Well 1478, located on the north side of the American River approximately 1,000 feet (305 m) from Extraction Well 4325. A decline in the groundwater level on the north side of the American River from pumping on the south side could only occur if the river was not significantly hydraulically connected to Aquifer A. If the American River was a groundwater discharge zone and thus hydraulically connected to Aquifer A, a groundwater divide would be present. Alternatively, if a groundwater recharge condition was present and Aquifer A was hydraulically connected to the American River, a groundwater divide would also be present. If a groundwater divide was present, groundwater levels on one side of the groundwater divide would not fluctuate as a result of groundwater extraction on the other side.

We have assessed that American River water is at a similar elevation to Aquifer A in the eastern Study Area, indicating that locally depending on the season recharging and discharging conditions could be occurring. However, the river did not appear to be a significant barrier to groundwater flow within Aquifer A during the time of the aquifer test. It is possible that a recharge/discharge scenario may account for drawdown on the north side of the river from groundwater extraction on the south side. If the rate of groundwater extraction exceeds the rate of river recharge or the rate of groundwater discharge, then the groundwater surface within the divide zone may decline permitting flow under the river bed. When pumping ceases, the groundwater divide would return.

Hydrochemical Nature of American River Water and Groundwater

The hydrochemical nature of the groundwater and the American River water were assessed. This evaluation included comparing the concentration of main ions (calcium, magnesium, sodium, potassium, chloride, sulfate, and bicarbonate) from water samples collected from the American River and groundwater in the American River Study Area. **Table 8-2** summarizes American River and groundwater water quality sample results (Aerojet, 2002 and USGS website http://waterdata.usgs.gov/nwis/). The American River water quality samples were collected from Fair Oaks, within the Study Area, and downstream near California State University Sacramento (CSU). Since water quality sampling of the American River at Fair Oaks ended in 1962, recent water quality data were required for comparison to groundwater. The CSU location has American River water quality information from 1960 to 1998.

The variation in American River water quality from Fair Oaks and CSU was assessed. In 1962, the last period of overlap for water quality sampling at both locations, the results were very similar (*e.g.* in September 1962; **Table 8-2**). Thus, American River quality results from later samples collected in 1998 can be compared to the groundwater in the Study Area.

In the western Study Area, main ion analytical results are not available for Aquifers A and B (Aerojet, 2002). Groundwater was analyzed for main ions at Monitoring Wells 1587 (Aquifer C), 1588 (Aquifer D), and 1589 (Aquifer D). The main ion results indicate a low degree of mixing between the water from the American River and Aquifers C and D. This opinion is based on the higher degree of mineralization in Aquifers C and D and the higher concentrations of chloride in the groundwater as compared to the American River (Appendix D and **Table 8-2**).

In the central Study Area, groundwater analytical results for main ions were available for the following monitoring wells:

- Aquifer A – 1571, 4370, 1519, 1522, 4300;
- Aquifer B – 1562, 1563, 1570, 1572, 1574, 4375, 1519*, 1523, 4301;
- Aquifer C – 1573, 4380, 1520, 4302; and,
- Aquifer D – 1521, 1524.

* Note: Observation Well 1519 listed as both Aquifer A and B monitoring well (Aerojet, 2000a, Table 3-2). Reported as an Aquifer A monitoring well in this report.

The main ion results are similar both north and south of the American River with respect to concentration in milliequivalent/L (meq) and mineralization. In the central Area, the results from Aquifer A in meq composition and mineralization are between the surface waters and the groundwater from the deeper Aquifers B and C. This is demonstrated by the distribution of the analytical results on the main ion plot (Appendix D). Thus, a portion of the Aquifer A groundwater appears to be composed of American River water, indicating that recharging conditions are present.

In the eastern Study Area, monitoring wells with examined chemistry data included the following:

- Aquifer A – 1357, 4325, 1516;
- Aquifer B –1358, 1382, 1383, 4330; and,
- Aquifer C – 1359, 1384, 4335.

These results suggest a distinct difference in the main ion chemistry and mineralization between the groundwater and the American River with the exception of Monitoring Well 1516 (Appendix D). A portion of the groundwater from Monitoring Well 1516 is likely from the American River. This result is consistent with groundwater levels that are consistently below the American River water surface, indicating that recharge conditions are present.

Distribution of Contaminants in Aquifer A

Chemicals, primarily VOCs, have been identified dissolved in groundwater within the Study Area. Isoconcentration contours of dissolved phase TCE detected in Aquifer A groundwater show the dissolved phase TCE plume is present on both the north and south sides of the American River (Figure 3-30 of Aerojet, 2000a). This observation is also consistent with Aquifers B and C, as evidenced by TCE isoconcentration contours (Figures 3-32 and 3-34 of Aerojet, 2000a).

The level of TCE dissolved in groundwater in Aquifer A decreases from an area of high concentration near Monitoring Wells 1370 and 30068 on the south side of the river, to the north side of the American River in the downgradient direction. This is typical of most contaminant plumes and thus suggests a source of TCE is not present on the north side of the river.

Another possible migration pathway for contaminants to move from the south to the north side of the American River could be through the lower Aquifers B and C. This could only be

the case if downward vertical gradients were observed on the south side of the American River with an upward gradient immediately on the north side. In this scenario, dissolved-phase TCE could migrate downward from Aquifer A into Aquifers B and C. In Aquifers B and C, the dissolved phase TCE could move laterally under the American River and then move vertically upward into Aquifer A. Multilevel monitoring wells are not present on the north side of the American River near the area of high dissolved phase TCE on the south side of the river. Thus, the direction of the vertical gradient between Aquifers A and B is not known in this area. On the south side of the American River at Monitoring Well Nest 30100 to 30103, a slight downward to slight upward gradient has been measured between Aquifers A and B (**Table 8-1**). The majority of the time from December 11, 1997 to August 1998, prior to ARGET extraction, the vertical gradient was downward, indicating potential for dissolved phase TCE to migrate from Aquifer A to B.

Given that in 1983 dissolved phase TCE was observed in groundwater samples taken from seeps along the river and from three to 15 feet below the bottom of the river, it would appear that Aquifer A is contaminated below the river (Aerojet, 1983a). The groundwater flow direction in Aquifer A is toward the northwest from the area of high dissolved phase TCE, or toward the north side of the American River. On the north side of the American River, dissolved-phase TCE has been detected. Therefore, it is our opinion that the impact on the north side of the American River in Aquifer A is likely from contamination on the south side in Aquifer A.

It should be noted that when dissolved phase TCE was detected in the American River and in seeps in 1983 the groundwater surface was very high. This is due to the very high amount of precipitation in the area in 1983. According to the National Weather Service office 1982 to 1983 was the wettest year on record since 1849 (Master-Beavan, 2000). Monitoring Well 41 located in the southeast portion of the Study Area has had groundwater levels monitored since about 1980 (**Figure 1-1**). In 1983, groundwater levels were at a historical highs for the period monitoring period (Appendix C and Aerojet, 2002). The high groundwater levels at Monitoring Well 41 suggest that groundwater would be discharging to the American River. Recent information from Monitoring Well 1469 in the eastern portion of the Study Area indicate groundwater levels are at about the same elevation of the American River water surface (Appendix C and Aerojet, 2002). Therefore, since 1991 until the ARGET system started operation in August 1998, very high groundwater levels similar to what occurred in 1983 were not observed.

Other than the anomalously high precipitation period in 1983, these data suggest that the American River is not a significant hydrogeologic barrier and that groundwater flows under the river. This situation was also stated by Aerojet: " ...the presence of chemicals in Aquifer A on the north side of the river and the configuration of the potentiometric surface of Aquifer A indicate that the river is not a significant barrier to chemical migration or groundwater flow" (Aerojet, 2000a).

3. ***Groundwater from the Shallow Aquifer is not discharging to the American River downstream of the ARGET Facility.***

In the area from Hazel Avenue to Sunrise Boulevard along the American River, the elevation of the surface of the American River decreases by approximately 11 feet (3.4 m) from near Hazel Avenue (average 78 feet [24 m] amsl) to near Sunrise Boulevard (interpreted average 67 feet [20 m] amsl). The uppermost groundwater-bearing surface of Aquifer A decreases in elevation by at least 35 feet (10.7 m) across the same distance (Figure 3-15 of Aerojet, 2000a). Groundwater elevation data for Aquifer A is not known west of Sunrise Boulevard, but in the western portion of the Study Area near Monitoring Wells 1585 and 1406, the groundwater elevation in Aquifer A is approximately 45 feet (13.7 m) amsl. The American River turns southwestwards in this area. If we assume that the Aquifer A lateral hydraulic gradient is 0.0 feet/feet (which is actually impossible for groundwater movement), then projecting the groundwater at 45 feet (13.7 m) amsl out towards the southwest would result in it intersecting the bottom of the American River approximately four miles downstream of the western Study Area. Since the groundwater flow direction in Aquifer A is toward the west-northwest, or away from the American River, and the elevation of groundwater in Aquifer A is substantially below the base of the river, Aquifer A groundwater does not likely discharge to the American River further downstream, outside the ARGET area.

4. ***Groundwater elevations in the vicinity of the American River Study Area have not changed significantly since the late 1950s.***

As discussed in Section 8.1.1, groundwater levels have been declining in the area since the 1940s. The least amount of groundwater level decline is near the American River since it is mostly a recharge zone. A comparison of groundwater levels in the spring of 1962 and 1963 indicate seasonal variations on the range of 5 to 10 feet [1.5 to 3.1 m] (Plate 6 in DWR, 1964). In the vicinity of the Study Area, groundwater elevation contours are between 80 (spring 1962) and 90 (spring 1963) feet amsl just below Nimbus Dam. It should be noted that these

groundwater surface elevation contours are from water wells likely completed across several aquifers and represent a composite groundwater level. In the central portion of the Study Area, the composite groundwater surface elevation was about 70 feet (21.3 m) amsl in the spring of 1963. The present groundwater levels in Aquifers A, B and C below Nimbus Dam are between 80 and 90 feet (24.4 and 27.4 m) amsl and in the central Study Area are about 70 feet (21.3 m) amsl (Figures 3-15, 3-16 and 3-17 of Aerojet 2000a). Therefore, the groundwater levels do not appear to have declined more than seasonal variability in the immediate vicinity of the American River since 1953.

8.2.2 WESTERN OPERABLE UNIT OU-3 AND GET E AND F SYSTEMS

1. ***Groundwater extracted from the GET E and F systems would not have discharged to the American River.***

GET E. The GET E system extracts groundwater from Layers C and D beneath the Aerojet site (Aerojet nomenclature; see Section 5.2). The most shallow layer, Layer A, is not present as a saturated aquifer in the vicinity of GET E, and none of the GET E extraction wells is screened in Layer B (Aerojet, 2000b). In OU-3, groundwater elevations in Layer C range from approximately 75 feet (22.9 m) amsl in the east to –10 feet (-3.1 m) amsl in the west (Aerojet, 2000b). The groundwater flow direction is towards the southwest, at a hydraulic gradient of approximately 20 feet per mile.

The northern-most of the GET E extraction wells, Well 4200, is located about 8,000 feet (2,438 m) south of the American River. If this well were not operating, groundwater would flow past the well in the direction of groundwater flow. The southwest groundwater flow direction calculated by Aerojet indicates that groundwater would not flow toward the American River; thus, groundwater could not discharge to the river. If we assume a "worst case scenario" that the groundwater flow direction in Layer C was due west, groundwater would need to travel at least 15,000 feet (4,572 m) downgradient before reaching a point at which it could potentially discharge to the American River. However, at this location the groundwater potentiometric surface in Layer C is approximately 15 feet (4.6 m) amsl (Figure A-9 of Aerojet, 2000b). The groundwater elevation can be compared to the river bottom elevation of about 50 feet (15.2 m) amsl (USGS, 1992). The groundwater surface is more than about 35 feet (10.7 m) below the bottom of American River; therefore, under this scenario, groundwater could not discharge to the river.

As noted by Aerojet (Figure A-8 of Aerojet, 2000b), even though there are no GET E extraction wells screened in Layer B, pumping in Layer C does appear to cause drawdown in Layer B. The worst-case scenario in this case is that pumping at Well 4200 actually extracts Layer B groundwater. Using the same argument as detailed above, by the time the Layer B groundwater reaches a point at which it could potentially discharge to the American River off site to the west, its potentiometric surface is at approximately 20 feet (6.1 m) amsl, approximately 30 feet (9.1 m) below the interpreted bottom of American River. Thus, there appears to be no potential for this groundwater to discharge to the river.

GET F. Groundwater is extracted from the shallowest aquifer, Layer A, by two extraction wells at GET F (4007 and 4310) (Aerojet, 2000b Vol. II p. 9). The northern-most of these wells, 4310, is located about 12,500 feet (3,810 m) south of the American River. If extraction well 4310 was not pumping, then the Layer A water would flow past the well in the direction of groundwater flow (west-southwest; see Section 5.2). Assuming a worst-case scenario of a due-west flow direction, this water would have to flow approximately 26,000 feet (7,925 m) before it would meet the course of the American River. At this point, the groundwater potentiometric surface is unknown (due to a lack of data), but a highly conservative estimate from Figure A-7 of Aerojet (2000b) would be –20 feet (-6.1 m) amsl. This is approximately 70 feet (21.3 m) below the bottom American River at this point (50 feet [15.2 m] amsl) (USGS, 1992). Based upon these conditions there appears to be no potential for the groundwater to discharge to the river.

2. ***Groundwater extracted for ROD 4C remedy would not have discharged to the American River.***

Several alternatives have been evaluated to clean up groundwater contamination in OU-3 (Aerojet, 2000b). According to the ROD, Alternative 4C will be implemented (USEPA, 2001). This alternative includes continued use of the existing GET E and F facilities, together with the installation of additional extraction wells off the Aerojet property in OU-3.

The new off-site extraction wells will extract groundwater from Layers C, D, and E (Aerojet, 2000b). The modeled capture zones in Layers C, D, and E of the proposed Alternative 4C extend to the American River in the northwest portion of OU-3 (Figure 5-11 of Aerojet, 2000b). At this point, the bottom of the American River is estimated to be approximately 65 feet (19.8 m) amsl (USGS, 1992). The groundwater potentiometric surface for Layer C at this point is approximately 25 feet (7.6 m) amsl (Figure A-9 of Aerojet, 2000b). Thus, this groundwater is approximately 40 feet (12.2 m) below the bottom of the American River and

there is little potential for it to discharge to the river. It is possible that Layer B groundwater could be extracted by the wells pumping in Layer C (as is presently the case at GET E), but this water would also not likely discharge to the American River, since at that point the potentiometric surface in Layer B is approximately 30 feet (9.1 m) amsl (Figure A-8 of Aerojet, 2000b), approximately 35 feet (10.6 m) below the bottom of the American River surface.

It should be noted that in the spring of 1963 the western portion of OU-3, the American River was recharging adjacent and underlying formations (Plate 3 of DWR, 1964). Therefore, since in general the groundwater surface has been declining in OU-3 area the American River would be losing water to the subsurface.

3. Groundwater levels have declined in the OU-3 Area by approximately 50 feet since 1953.

South of the American River Study Area in OU-3, groundwater levels have been documented to have decreased by about 20 feet (6.1 m) between spring 1953 and 1963 (Plate 8 in DWR, 1964). A state water well, Well number 09N07E31G01M located in the OU-3, has had groundwater levels monitored from 1962 to present (Appendix E). Again, these groundwater surface elevation contours and levels are from water wells likely completed across several aquifers and represent a composite groundwater surface. In general, the groundwater surface in State Well number 09N07E31G01M has dropped about 30 feet (9.1 m) from 1962 to date. Thus, groundwater levels have declined approximately 50 feet (15.2 m) in OU-3 since 1953.

9 CONCLUSIONS

9.1 HISTORIC AND RECENT STUDIES

Hydrologic studies have been conducted by the DWR in the area of the ARGET system, including the study published as Bulletin 133 in 1964. These studies were conducted prior to and during the period when it was determined that there was no additional water available for appropriation from the American River. It was concluded that the groundwater levels in the vicinity of the Lower American River were sufficiently low in that portion of the river below Folsom Bridge to the confluence of the Sacramento River that approximately 64,000 acre-feet per year of river water recharged the uppermost groundwater-bearing zone. Therefore, no discharge of groundwater to the American River was identified, with the exception of possible influence at the eastern-most portion of the Study Area immediately downstream of Lake Natoma. Subsequent studies indicate that this condition has persisted to the present.

The present groundwater levels in Aquifers A, B, and C below Nimbus Dam are between 80 and 90 feet (24.4 to 27.4 m) amsl and in the central Study Area are approximately 70 feet (21.3 m) amsl (Figures 3-15, 3-16 and 3-17 of Aerojet, 2000a). The present groundwater surface elevations are similar to what was measured in the 1953 to 1963 timeframe in water wells. Therefore, the groundwater levels due not appear to have declined more than from seasonal variability in the immediate vicinity of the American River since 1953.

South of the American River Study Area in OU-3, groundwater levels have been documented to have decreased about 20 feet (6.1 m) between spring 1953 and 1963 (Plate 8 in DWR, 1964). A state water well (Well number 09N07E31G01M) located in the OU-3 has had groundwater levels monitored since about 1962 (Appendix E). In general, the groundwater level in this well has dropped about 30 feet (9.1 m) since 1962. Thus, groundwater levels have declined approximately 50 feet (15.2 m) in OU-3 since 1953.

9.2 AMERICAN RIVER STUDY AREA

General Overview

The upper-most groundwater surface in the vicinity of the American River gradually declines in elevation from east to west. The groundwater levels are on average about 25 feet

below the American River surface in the western Study Area. In the central Study Area, groundwater levels are about five to 15 feet (1.5 to 4.6 m) below the water surface. At the eastern Study Area, groundwater levels on the south side of the American River are slightly above the river in the east and equal to the river in the west. On the north side of the American River in the eastern Study Area, the groundwater surface elevation is approximately two feet below the river water surface. The groundwater surface elevation in the upper-most aquifer is at a lower elevation than the American River in approximately two-thirds of the Study Area. Thus, in this portion of the Study Area, river water will likely be recharging the adjacent and underlying formations.

Groundwater levels in 13 of the 15 extraction wells under non-pumping conditions are located well below the river water surface; thus, all of the groundwater produced by the ARGET system does not contribute to the flow of the American River. Because of higher groundwater levels at the eastern end of the Study Area, it is likely that a portion of the water extracted from Wells 4325 and 4330 originates from the American River. Therefore, only two of the 15 wells located closest to Lake Natoma may extract a small portion of the total produced water directly from the American River.

The overall pattern of the distribution of the groundwater surface in Aquifer A is indicative of the river recharging adjacent and underlying formations. Groundwater elevation contours are deflected downstream, indicating groundwater is being recharged by the river.

As previously discussed, the groundwater surface in the vicinity of the ARGET is below the American River. Therefore, based upon the data reviewed in the Study Area, groundwater is not discharging to the American River, with the possible exception in the eastern portion of the Study Area near Lake Natoma. The groundwater flow direction in Aquifer A is toward the west-northwest, while the American River's course is toward the southwest. Therefore, groundwater would likely not discharge to the American River within the vicinity of the Study Area.

Aquifer Test Results

Extraction Well 4325, completed in Aquifer A, was pumped, and groundwater levels from nearby monitoring wells were measured. Monitoring Well 1478, located on the opposite side of the American River to the extraction well, responded due to pumping. In an eight-hour aquifer test the groundwater level decreased 0.22 feet (0.067 m). This strongly suggests

that American River was not significantly hydraulically connected to Aquifer A at the time of the test.

Hydrochemical Nature of American River water and Groundwater

The hydrochemical nature of groundwater in Aquifers C and D is different from the American River in the western Study Area. In the central Area, Aquifer A hydrochemical composition is between the surface waters and the groundwater from the deeper Aquifers B and C. Thus, a portion of the Aquifer A groundwater is composed of American River, confirming that recharging conditions are present in this area. In the eastern Study Area, the hydrochemical characteristics and mineralization of the groundwater and the American River are different with the exception of Monitoring Well 1516 (Appendix D). A portion of the groundwater from Monitoring Well 1516 is likely from the American River.

Distribution of Contaminants in Aquifer A

The migration of the dissolved phase VOC contaminated groundwater plume over time indicates that a significant hydraulic communication between the American River and the groundwater does not exist. Recent observations of the migration of the contaminant plume show that the plume has migrated from the south side under the American River. Groundwater containing TCE has been detected on the north side of the American River extending about one mile downgradient of the area of high groundwater concentration. This represents strong evidence that the uppermost water-bearing unit is not significantly hydraulically connected with the river and groundwater is not discharging to the American River. If sufficient river recharge were occurring, a hydraulic divide/barrier would form that would impede the flow of groundwater.

Summary

Given the historical and present range of groundwater levels in the area, there is no indication that the operation of the ARGET system has had an impact on the quantity of flow in the American River except as previously described by Extraction Wells 4325 and 4330. The water produced from the groundwater basin by the ARGET system is thus not a component of the flow of the American River except to the extent that the treated groundwater is discharged directly to the river via Buffalo Creek.

Based upon our independent analysis and our review of previous reports and data, it is our opinion that substantially all of the groundwater extracted by the ARGET system originates

from sources other than direct hydraulic communication from the American River. In addition, it is our opinion that the water discharged by the ARGET system into Buffalo Creek actually discharges into the American River and may ultimately add to the flow within the mainstream of the River. As discharge into Buffalo Creek increases, the amount of water contributing to the American River will also likely increase.

9.3 WESTERN OPERABLE UNIT OU-3

The groundwater from GET E and F systems would not have discharged to the American River. The groundwater surface in Layers A (if present), B, C, and D would be well below the American River if the groundwater flow direction was west toward the river. The actual groundwater flow direction is toward the southwest diverting away from the river. Thus, the groundwater could not discharge to the American River. This condition has existed since 1963.

The new off-site extraction wells for the ROD will extract groundwater from Layers C, D, and E (Aerojet, 2000b). Groundwater that would be produced from these Layers would not discharge to the American River downgradient of the extraction wells. The groundwater surface of these units would be well below the American River.

10 CLOSURE / LIMITATIONS

Komex has prepared this report based on an interpretation of the information listed in Section 11 and referenced as appropriate throughout the report. In regard to geologic, hydrogeologic, hydrologic, and contaminant conditions, it should be noted that our professional opinions are based in part on interpretation of data supplied by others. We do not warrant the accuracy of such information, and the validity of our opinions is limited by the accuracy of this information.

The opinions contained in this report apply to conditions existing when services were performed. Our services have been performed using that degree of care and skill ordinarily exercised under similar circumstances by reputable, qualified environmental consultants practicing in this or similar locations. No other warranty, either expressed or implied, is made as to the professional advice included in this report. These services were performed consistent with our agreement with our client.

Respectfully submitted,

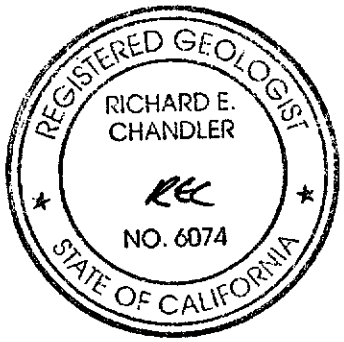
KOMEX

Stephen Ross

for Anthony Brown

Dr. Tad Dabrowski

Rich Chandler, R.G.



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9A

Tables

Table 6-1
Buffalo Creek Flowrate Measurements

Approximate Distance Downstream of Aerojet Boundary (feet)	Measured Flowrate in gpm (cfs)			Average Flowrate in gpm (cfs)
	4/25/02	4/27/02	5/2/02	
Near Western Aerojet Property Boundary				
1,080	*	1,900 (4.2)[3] 2,100 (4.7)[6]	2,100 (4.7)[7]	**2,030 (4.52)**
Approximately Halfway to American River (from Aerojet Property Boundary)				
4,200	1,600 (3.6)[1]	1,700 (3.8)[4]	1,600 (3.6)[8]	**1,630 (3.63)**
Outlet to American River				
10,560	1,300 (2.9)[2]	1,600 (3.6)[5]	1,600 (3.6)[9]	**1,500 (3.34)**

NOTES:
1. ' superscript denotes Measurement Number (see Appendix A for Measurement Data Sheets)
2. * denotes measurement not recorded due to low water level in concrete channel. Subsequent measurement locations relocated.

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
Eastern Study Area							
1357	88.30	94.10	33.00	8 to 40	07/17/1985	14.20	79.90
					07/18/1985	14.24	79.86
					07/18/1985	14.20	79.90
					07/23/1985	14.72	79.38
					07/24/1985	14.82	79.28
					07/24/1985	14.68	79.42
					07/24/1985	14.72	79.38
					07/25/1985	14.78	79.32
					07/29/1985	14.24	79.86
					08/07/1985	15.03	79.07
					08/23/1985	15.33	78.77
					08/27/1985	15.00	79.10
					09/03/1985	14.91	79.19
					09/03/1985	14.90	79.20
					09/25/1985	14.97	79.13
					09/27/1985	15.05	79.05
					10/01/1985	15.03	79.07
					10/24/1985	15.51	78.59
					11/07/1985	15.71	78.39
					12/20/1985	15.64	78.46
					12/23/1985	15.63	78.47
					12/23/1985	15.62	78.48
					12/24/1985	15.70	78.40
					12/26/1985	15.70	78.40
					12/27/1985	15.70	78.40
					12/27/1985	15.67	78.43
					12/27/1985	15.72	78.38
					12/27/1985	15.70	78.40
					12/27/1985	15.68	78.42
					12/27/1985	15.67	78.43
					12/27/1985	15.65	78.45
					12/27/1985	15.62	78.48
					12/27/1985	15.61	78.49
					12/27/1985	15.62	78.48
					12/27/1985	15.65	78.45
					12/28/1985	15.70	78.40
					12/28/1985	15.70	78.40
					12/29/1985	15.72	78.38
					12/30/1985	15.71	78.39
					12/30/1985	15.70	78.40
					12/31/1985	15.65	78.45
					12/31/1985	15.67	78.43
					01/02/1986	15.67	78.43
					01/08/1986	15.55	78.55
					04/28/1986	13.30	80.80
					07/02/1986	13.30	80.80
					08/14/1986	13.37	80.73

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					09/23/1986	13.81	80.29
					12/16/1986	15.22	78.88
					01/20/1987	15.61	78.49
					02/17/1987	15.46	78.64
					04/15/1987	15.35	78.75
					06/17/1987	15.19	78.91
					09/01/1987	15.25	78.85
					11/17/1987	15.86	78.24
					02/17/1988	16.00	78.10
					05/03/1988	16.03	78.07
					07/12/1988	15.25	78.85
					07/20/1988	14.87	79.23
					12/07/1988	16.85	77.25
					03/23/1989	14.85	79.25
					04/25/1990	16.01	78.09
					03/18/1991	17.74	76.36
					04/24/1991	17.56	76.54
					07/08/1991	16.09	78.01
					08/08/1991	16.04	78.06
					10/18/1991	16.95	77.15
					11/05/1991	17.33	76.77
					01/22/1992	17.56	76.54
					04/14/1992	17.43	76.67
					07/13/1992	15.83	78.27
					10/19/1992	17.96	76.14
					10/21/1992	18.00	76.10
					01/25/1993	13.74	80.36
					04/22/1993	16.02	78.08
					06/09/1993	14.38	79.72
					07/29/1993	15.22	78.88
					10/20/1993	16.24	77.86
					04/18/1994	17.41	76.69
					07/19/1994	16.99	77.11
					10/24/1994	18.02	76.08
					04/25/1995	13.84	80.26
					10/24/1995	16.32	77.78
					12/05/1995	16.60	77.50
					02/01/1996	16.34	77.76
					02/22/1996	11.85	82.25
					04/16/1996	14.41	79.69
					05/28/1996	14.41	79.69
					07/16/1996	16.02	78.08
					08/26/1996	16.41	77.69
					10/22/1996	16.69	77.41
					11/19/1996	16.35	77.75
1370	115.26	115.26	90.00	74 to 95	09/03/1985	36.91	78.35
					09/04/1985	36.79	78.47
					09/06/1985	36.96	78.30

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					09/12/1985	37.10	78.16
					10/01/1985	37.24	78.02
					10/02/1985	37.09	78.17
					10/24/1985	37.68	77.58
					11/07/1985	37.81	77.45
					12/11/1985	37.70	77.56
					12/20/1985	37.86	77.40
					12/23/1985	37.82	77.44
					12/23/1985	37.81	77.45
					12/24/1985	37.87	77.39
					12/26/1985	37.87	77.39
					12/27/1985	37.86	77.40
					12/27/1985	37.90	77.36
					12/27/1985	37.87	77.39
					12/27/1985	37.90	77.36
					12/27/1985	37.86	77.40
					12/27/1985	37.87	77.39
					12/27/1985	37.82	77.44
					12/27/1985	37.83	77.43
					12/27/1985	37.87	77.39
					12/27/1985	37.87	77.39
					12/28/1985	38.96	76.30
					12/28/1985	37.90	77.36
					12/29/1985	37.89	77.37
					12/30/1985	37.91	77.35
					12/30/1985	37.95	77.31
					12/31/1985	37.86	77.40
					12/31/1985	37.90	77.36
					01/02/1986	37.87	77.39
					01/08/1986	37.85	77.41
					02/27/1986	32.28	82.98
					03/18/1986	32.29	82.97
					04/24/1986	34.84	80.42
					07/02/1986	35.49	79.77
					07/09/1986	35.30	79.96
					08/13/1986	35.54	79.72
					09/23/1986	36.21	79.05
					12/11/1986	37.60	77.66
					02/17/1987	38.20	77.06
					04/15/1987	37.89	77.37
					06/18/1987	37.69	77.57
					09/01/1987	37.43	77.83
					11/17/1987	38.68	76.58
					02/16/1988	38.81	76.45
					05/03/1988	38.99	76.27
					05/24/1988	38.81	76.45
					07/12/1988	38.30	76.96
					11/25/1988	39.70	75.56
					12/07/1988	39.98	75.28

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					10/25/1989	38.05	77.21
					04/18/1990	38.53	76.73
					10/08/1990	39.80	75.46
					03/27/1991	40.25	75.01
					04/24/1991	40.10	75.16
					05/07/1991	39.92	75.34
					07/03/1991	38.70	76.56
					08/06/1991	39.00	76.26
					10/15/1991	39.55	75.71
					11/04/1991	39.87	75.39
					01/22/1992	40.22	75.04
					04/14/1992	39.81	75.45
					08/10/1992	38.86	76.40
					10/19/1992	40.61	74.65
					11/24/1992	40.56	74.70
					02/08/1993	38.60	76.66
					04/22/1993	38.24	77.02
					06/10/1993	37.04	78.22
					07/29/1993	37.85	77.41
					10/20/1993	38.92	76.34
					04/18/1994	39.99	75.27
					07/19/1994	39.92	75.34
					08/23/1994	40.01	75.25
					10/24/1994	40.69	74.57
					01/23/1995	37.93	77.33
					04/24/1995	35.90	79.36
					09/07/1995	37.60	77.66
					10/24/1995	38.51	76.75
					04/16/1996	36.66	78.60
					07/15/1996	37.94	77.32
					08/27/1996	38.46	76.80
					10/22/1996	39.01	76.25
					01/09/1997	32.31	82.95
					04/15/1997	37.63	77.63
					07/15/1997	38.63	76.63
					10/07/1997	39.39	75.87
					01/14/1998	38.09	77.17
					04/21/1998	35.66	79.60
					07/28/1998	36.48	78.78
					10/21/1998	39.54	75.72
					01/19/1999	39.34	75.92
					04/06/1999	39.33	75.93
					07/14/1999	40.00	75.26
					07/27/1999	40.12	75.14
					10/20/1999	41.33	73.93
					01/11/2000	41.71	73.55
					04/18/2000	39.65	75.61
					10/24/2000	41.06	74.20
					01/22/2001	41.68	73.58

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					04/03/2001	41.63	73.63
					04/24/2001	41.70	73.56
1375	101.96	101.76	42.00	26 to 50	09/12/1985	27.45	74.31
					09/16/1985	24.08	77.68
					09/26/1985	23.71	78.05
					10/01/1985	23.70	78.06
					10/03/1985	24.08	77.68
					10/24/1985	24.46	77.30
					11/07/1985	24.57	77.19
					12/17/1985	24.53	77.23
					12/20/1985	24.56	77.20
					12/23/1985	24.49	77.27
					12/23/1985	24.53	77.23
					12/24/1985	24.56	77.20
					12/26/1985	24.56	77.20
					12/27/1985	24.56	77.20
					12/27/1985	24.56	77.20
					12/27/1985	24.54	77.22
					12/27/1985	24.54	77.22
					12/27/1985	24.54	77.22
					12/27/1985	24.54	77.22
					12/27/1985	24.55	77.21
					12/27/1985	24.55	77.21
					12/27/1985	24.56	77.20
					12/27/1985	24.57	77.19
					12/27/1985	24.58	77.18
					12/28/1985	24.58	77.18
					12/28/1985	24.58	77.18
					12/29/1985	24.58	77.18
					12/30/1985	24.54	77.22
					12/30/1985	24.53	77.23
					12/31/1985	24.55	77.21
					12/31/1985	24.55	77.21
					01/02/1986	24.58	77.18
					01/02/1986	24.58	77.18
					01/08/1986	24.13	77.63
					02/27/1986	18.29	83.47
					04/04/1986	21.04	80.72
					04/24/1986	22.45	79.31
					07/02/1986	22.13	79.63
					07/24/1986	21.88	79.88
					08/14/1986	22.11	79.65
					09/12/1986	24.90	76.86
					09/23/1986	22.07	79.69
					10/28/1986	23.76	78.00
					12/11/1986	23.78	77.98
					01/06/1987	24.53	77.23
					01/15/1987	24.65	77.11

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					01/16/1987	24.66	77.10
					01/19/1987	24.68	77.08
					02/17/1987	24.66	77.10
					04/15/1987	24.50	77.26
					06/17/1987	24.05	77.71
					09/01/1987	23.30	78.46
					11/17/1987	24.68	77.08
					02/16/1988	24.73	77.03
					05/03/1988	24.74	77.02
					07/12/1988	23.30	78.46
					11/29/1988	25.10	76.66
					12/07/1988	25.30	76.46
					03/23/1989	22.33	79.43
					10/25/1989	22.23	79.53
					04/18/1990	23.84	77.92
					10/08/1990	25.10	76.66
					03/28/1991	25.97	75.79
					04/24/1991	25.82	75.94
					05/29/1991	25.20	76.56
					07/03/1991	23.12	78.64
					10/15/1991	23.59	78.17
					11/01/1991	25.01	76.75
					01/21/1992	25.25	76.51
					04/14/1992	25.41	76.35
					08/11/1992	24.04	77.72
					10/19/1992	25.77	75.99
					11/24/1992	25.61	76.15
					02/26/1993	21.17	80.59
					04/22/1993	24.57	77.19
					06/10/1993	22.12	79.64
					07/29/1993	22.85	78.91
					10/20/1993	23.94	77.82
					04/19/1994	25.35	76.41
					07/19/1994	24.47	77.29
					10/24/1994	25.65	76.11
					04/25/1995	21.59	80.17
					07/20/1995	17.35	84.41
					10/24/1995	24.54	77.22
					04/16/1996	21.73	80.03
					07/11/1996	24.49	77.27
					07/16/1996	24.25	77.51
					10/22/1996	24.45	77.31
					01/09/1997	15.24	86.52
					04/15/1997	24.60	77.16
					07/15/1997	24.70	77.06
					07/30/1997	24.93	76.83
					10/07/1997	24.85	76.91
					01/14/1998	21.65	80.11
					04/21/1998	22.19	79.57

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					06/01/1998	21.51	80.25
					07/31/1998	23.58	78.18
					10/21/1998	24.84	76.92
					01/19/1999	24.77	76.99
					04/06/1999	23.61	78.15
					07/19/1999	23.50	78.26
					07/27/1999	23.59	78.17
					10/21/1999	24.44	77.32
					01/11/2000	25.23	76.53
					04/18/2000	23.29	78.47
					07/20/2000	23.97	77.79
					10/24/2000	24.64	77.12
					01/22/2001	25.54	76.22
					04/24/2001	25.55	76.21
1469	115.74	115.74	52.00	30 to 60	05/01/1991	41.22	74.52
					06/25/1991	40.45	75.29
					07/08/1991	40.45	75.29
					08/07/1991	39.77	75.97
					11/06/1991	40.65	75.09
					01/21/1992	41.51	74.23
					04/14/1992	40.40	75.34
					08/14/1992	40.45	75.29
					10/19/1992	41.84	73.90
					02/26/1993	37.75	77.99
					04/22/1993	39.28	76.46
					06/28/1993	38.66	77.08
					07/29/1993	39.09	76.65
					10/20/1993	39.90	75.84
					04/18/1994	41.12	74.62
					07/19/1994	40.93	74.81
					08/17/1994	41.55	74.19
					04/03/1995	36.35	79.39
					04/24/1995	36.98	78.76
					10/24/1995	39.78	75.96
					04/16/1996	38.04	77.70
					07/15/1996	39.24	76.50
					08/21/1996	39.90	75.84
					10/22/1996	40.26	75.48
					01/09/1997	32.51	83.23
					04/16/1997	39.11	76.63
					07/16/1997	39.96	75.78
					08/25/1997	40.42	75.32
					10/07/1997	40.62	75.12
					01/14/1998	39.66	76.08
					04/21/1998	37.22	78.52
					08/19/1998	38.79	76.95
					10/21/1998	40.62	75.12
					01/19/1999	40.82	74.92

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					04/06/1999	40.10	75.64
					07/27/1999	40.85	74.89
					08/05/1999	41.00	74.74
					10/20/1999	42.00	73.74
					01/11/2000	42.21	73.53
					04/18/2000	40.19	75.55
					05/11/2000	39.84	75.90
					07/10/2000	40.95	74.79
					10/03/2000	41.83	73.91
					10/24/2000	40.98	74.76
					01/22/2001	42.28	73.46
					04/24/2001	43.32	72.42
1478	90.55	90.55	62.00	42 to 66	04/24/1991	18.42	72.13
					04/30/1991	18.53	72.02
					06/27/1991	16.46	74.09
					07/08/1991	13.11	77.44
					08/07/1991	17.83	72.72
					11/04/1991	18.44	72.11
					01/21/1992	18.47	72.08
					04/14/1992	18.48	72.07
					08/19/1992	18.25	72.30
					10/19/1992	19.09	71.46
					02/25/1993	15.49	75.06
					04/23/1993	17.02	73.53
					07/14/1993	16.85	73.70
					07/29/1993	16.97	73.58
					10/18/1993	17.54	73.01
					04/18/1994	18.65	71.90
					07/18/1994	18.70	71.85
					08/11/1994	19.00	71.55
					10/27/1994	19.42	71.13
					04/04/1995	15.97	74.58
					04/24/1995	15.15	75.40
					09/14/1995	17.73	72.82
					10/23/1995	17.69	72.86
					12/05/1995	17.70	72.85
					03/05/1996	16.64	73.91
					04/15/1996	16.25	74.30
					06/10/1996	17.00	73.55
					07/15/1996	17.38	73.17
					09/10/1996	30.37	60.18
					09/10/1996	18.17	72.38
					10/21/1996	18.36	72.19
					12/03/1996	18.92	71.63
					01/09/1997	11.77	78.78
					03/17/1997	16.22	74.33
					04/14/1997	17.12	73.43
					06/11/1997	18.45	72.10

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					07/14/1997	18.12	72.43
					09/16/1997	18.22	72.33
					10/06/1997	18.65	71.90
					12/09/1997	18.70	71.85
					01/13/1998	17.15	73.40
					03/09/1998	15.65	74.90
					04/20/1998	15.43	75.12
					09/04/1998	17.30	73.25
					10/20/1998	18.72	71.83
					12/03/1998	18.83	71.72
					01/18/1999	19.17	71.38
					03/05/1999	16.51	74.04
					04/05/1999	18.27	72.28
					06/01/1999	18.94	71.61
					07/26/1999	19.42	71.13
					10/19/1999	20.47	70.08
					12/07/1999	20.58	69.97
					01/10/2000	20.57	69.98
					03/03/2000	16.91	73.64
					04/17/2000	18.53	72.02
					06/28/2000	19.66	70.89
					09/20/2000	20.24	70.31
					10/23/2000	20.52	70.03
					12/15/2000	20.60	69.95
					01/23/2001	20.72	69.83
					03/06/2001	20.10	70.45
					04/23/2001	20.62	69.93
1516	88.30	88.37	33.00	8 to 40	03/25/1992	14.80	73.57
					04/14/1992	14.73	73.64
					07/09/1992	15.21	73.16
					10/19/1992	16.47	71.90
					01/14/1993	14.06	74.31
					03/30/1993	10.85	77.52
					04/23/1993	13.59	74.78
					06/21/1993	13.85	74.52
					07/29/1993	14.37	74.00
					10/18/1993	15.02	73.35
					04/18/1994	15.54	72.83
					07/18/1994	16.23	72.14
					10/27/1994	16.73	71.64
					04/24/1995	11.45	76.92
					10/23/1995	14.67	73.70
					04/15/1996	13.14	75.23
					07/15/1996	14.53	73.84
					08/05/1996	14.83	73.54
					10/21/1996	15.68	72.69
					09/09/1997	16.00	72.37
					10/06/1997	16.13	72.24

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					04/20/1998	11.93	76.44
					09/14/1998	14.53	73.84
					07/26/1999	15.91	72.46
					08/06/1999	16.27	72.10
					10/18/1999	16.98	71.39
					10/18/1999	16.98	71.39
					01/10/2000	16.98	71.39
					04/19/2000	14.38	73.99
					09/14/2000	17.16	71.21
					10/23/2000	17.19	71.18
					01/23/2001	16.90	71.47
					04/23/2001	16.94	71.43
1518	130.70	130.71	75.00	40 to 80	05/19/1992	60.90	69.81
					07/07/1992	61.09	69.62
					10/19/1992	62.23	68.48
					01/25/1993	59.58	71.13
					03/02/1993	58.10	72.61
					04/22/1993	59.38	71.33
					06/22/1993	60.00	70.71
					07/29/1993	60.35	70.36
					10/18/1993	61.32	69.39
					04/18/1994	61.77	68.94
					07/18/1994	62.25	68.46
					10/27/1994	62.87	67.84
					04/24/1995	57.75	72.96
					10/23/1995	60.42	70.29
					04/15/1996	58.79	71.92
					07/15/1996	60.23	70.48
					08/05/1996	60.44	70.27
					10/21/1996	61.79	68.92
					01/09/1997	55.74	74.97
					04/14/1997	59.27	71.44
					07/14/1997	61.15	69.56
					08/25/1997	61.35	69.36
					10/06/1997	62.02	68.69
					01/13/1998	61.56	69.15
					04/20/1998	57.99	72.72
					09/01/1998	59.95	70.76
					10/20/1998	61.61	69.10
					01/18/1999	62.68	68.03
					04/05/1999	61.39	69.32
					07/26/1999	63.39	67.32
					08/06/1999	63.53	67.18
					10/18/1999	64.45	66.26
					01/10/2000	64.32	66.39
					04/19/2000	62.70	68.01
					09/14/2000	64.49	66.22
					10/23/2000	64.64	66.07

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					01/23/2001	64.58	66.13
					04/23/2001	64.16	66.55
30100	99.98	99.98	79.00	unknown	12/11/1997	23.14	76.84
					01/14/1998	21.55	78.43
					03/16/1998	21.12	78.86
					04/06/1998	20.15	79.83
					04/21/1998	20.09	79.89
					06/11/1998	20.23	79.75
					10/21/1998	26.84	73.14
					12/09/1998	26.90	73.08
					01/19/1999	27.02	72.96
					03/08/1999	23.80	76.18
					04/06/1999	26.71	73.27
					06/04/1999	26.87	73.11
					07/27/1999	27.09	72.89
					09/23/1999	28.20	71.78
					10/20/1999	28.08	71.90
					12/07/1999	28.38	71.60
					01/11/2000	29.39	70.59
					03/07/2000	26.00	73.98
					04/18/2000	26.28	73.70
					06/27/2000	26.90	73.08
					09/27/2000	27.76	72.22
					10/24/2000	27.65	72.33
					12/14/2000	27.66	72.32
					01/22/2001	28.29	71.69
					03/13/2001	28.21	71.77
					04/24/2001	28.19	71.79
30101	99.88	99.88	114.00	unknown	12/11/1997	23.10	76.78
					01/14/1998	21.43	78.45
					03/16/1998	20.85	79.03
					04/06/1998	20.01	79.87
					04/21/1998	19.93	79.95
					06/11/1998	20.05	79.83
					10/21/1998	27.15	72.73
					12/09/1998	27.15	72.73
					01/19/1999	27.22	72.66
					03/08/1999	23.90	75.98
					04/06/1999	27.29	72.59
					06/07/1999	27.66	72.22
					07/27/1999	27.83	72.05
					09/23/1999	29.00	70.88
					10/20/1999	28.71	71.17
					12/07/1999	29.13	70.75
					01/11/2000	29.05	70.83
					03/07/2000	26.60	73.28
					04/18/2000	27.09	72.79
					06/27/2000	27.59	72.29

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					09/27/2000	28.73	71.15
					10/24/2000	28.45	71.43
					12/14/2000	28.58	71.30
					01/22/2001	29.05	70.83
					03/13/2001	28.98	70.90
					04/24/2001	29.01	70.87
30102	99.88	99.88	170.00	unknown	12/11/1997	35.46	64.42
					01/14/1998	35.05	64.83
					03/16/1998	32.10	67.78
					04/06/1998	31.27	68.61
					04/21/1998	31.17	68.71
					06/11/1998	33.62	66.26
					10/21/1998	53.70	46.18
					12/09/1998	52.44	47.44
					01/19/1999	51.32	48.56
					03/08/1999	51.46	48.42
					04/06/1999	49.93	49.95
					06/07/1999	54.02	45.86
					07/27/1999	53.93	45.95
					09/23/1999	57.35	42.53
					10/20/1999	56.64	43.24
					12/07/1999	53.35	46.53
					01/11/2000	53.55	46.33
					03/07/2000	51.69	48.19
					04/18/2000	51.52	48.36
					06/27/2000	54.21	45.67
					09/27/2000	55.43	44.45
					10/24/2000	54.95	44.93
					12/14/2000	55.61	44.27
					01/22/2001	55.67	44.21
					03/13/2001	53.46	46.42
					04/24/2001	54.05	45.83
30103	99.88	99.88	250.00	unknown	12/11/1997	27.20	72.68
					01/14/1998	25.86	74.02
					03/16/1998	24.80	75.08
					04/21/1998	23.49	76.39
					06/11/1998	23.17	76.71
					10/21/1998	27.61	72.27
					12/09/1998	28.26	71.62
					01/19/1999	29.39	70.49
					03/08/1999	26.22	73.66
					03/09/1999	8.72	91.16
					04/06/1999	29.46	70.42
					06/07/1999	29.70	70.18
					07/27/1999	31.05	68.83
					09/23/1999	32.40	67.48
					10/20/1999	33.02	66.86
					12/07/1999	32.30	67.58

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					01/11/2000	32.00	67.88
					03/07/2000	30.73	69.15
					04/18/2000	30.26	69.62
					06/27/2000	29.80	70.08
					09/27/2000	29.81	70.07
					10/24/2000	31.41	68.47
					12/14/2000	31.72	68.16
					01/22/2001	32.21	67.67
					03/13/2001	32.41	67.47
					04/24/2001	32.05	67.83
Central Study Area							
1395	116.29	116.19	93.00	77 to 94	11/18/1985	56.54	59.65
					11/18/1985	56.71	59.48
					11/19/1985	56.74	59.45
					12/05/1985	56.36	59.83
					12/09/1985	55.95	60.24
					12/20/1985	55.91	60.28
					12/23/1985	55.75	60.44
					12/23/1985	55.85	60.34
					12/24/1985	55.86	60.33
					12/26/1985	55.85	60.34
					12/27/1985	55.89	60.30
					12/27/1985	55.92	60.27
					12/27/1985	55.90	60.29
					12/27/1985	55.88	60.31
					12/27/1985	55.86	60.33
					12/27/1985	55.85	60.34
					12/27/1985	55.85	60.34
					12/27/1985	55.85	60.34
					12/27/1985	55.88	60.31
					12/27/1985	55.89	60.30
					12/27/1985	55.89	60.30
					12/27/1985	55.92	60.27
					12/27/1985	55.92	60.27
					12/27/1985	55.86	60.33
					12/28/1985	55.88	60.31
					12/28/1985	55.89	60.30
					12/29/1985	55.87	60.32
					12/30/1985	55.95	60.24
					12/30/1985	55.89	60.30
					12/31/1985	55.85	60.34
					12/31/1985	55.91	60.28
					01/02/1986	55.85	60.34
					01/09/1986	55.90	60.29
					02/27/1986	49.43	66.76
					04/24/1986	51.76	64.43
					07/10/1986	54.04	62.15
					07/31/1986	54.44	61.75

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					09/24/1986	55.40	60.79
					12/03/1986	56.48	59.71
					12/12/1986	56.69	59.50
					12/17/1986	56.60	59.59
					01/06/1987	56.70	59.49
					02/17/1987	56.68	59.51
					04/14/1987	55.88	60.31
					06/17/1987	57.29	58.90
					10/02/1987	58.30	57.89
					10/09/1987	58.28	57.91
					11/19/1987	58.60	57.59
					02/16/1988	57.98	58.21
					04/25/1988	58.50	57.69
					04/28/1988	58.40	57.79
					05/03/1988	58.29	57.90
					07/12/1988	58.83	57.36
					07/21/1988	58.92	57.27
					12/01/1988	59.90	56.29
					12/07/1988	60.07	56.12
					10/27/1989	59.98	56.21
					04/19/1990	59.73	56.46
					10/09/1990	60.87	55.32
					03/28/1991	60.59	55.60
					04/24/1991	59.67	56.52
					06/05/1991	60.60	55.59
					07/08/1991	61.00	55.19
					08/12/1991	62.25	53.94
					10/15/1991	61.65	54.54
					11/07/1991	61.73	54.46
					01/21/1992	62.15	54.04
					01/23/1992	46.92	69.27
					04/14/1992	59.95	56.24
					08/12/1992	61.87	54.32
					10/19/1992	62.56	53.63
					03/03/1993	58.34	57.85
					04/23/1993	58.94	57.25
					07/12/1993	60.54	55.65
					07/30/1993	60.01	56.18
					08/04/1993	60.99	55.20
					10/18/1993	62.59	53.60
					04/18/1994	62.82	53.37
					07/19/1994	63.84	52.35
					08/22/1994	64.22	51.97
					10/27/1994	64.79	51.40
					10/23/1995	62.21	53.98
					12/04/1995	62.77	53.42
					02/26/1996	60.00	56.19
					04/15/1996	59.34	56.85
					04/24/1996	57.21	58.98

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					05/29/1996	59.51	56.68
					07/15/1996	61.42	54.77
					08/26/1996	62.66	53.53
					10/21/1996	67.73	48.46
					11/25/1996	67.73	48.46
					01/09/1997	62.19	54.00
					02/24/1997	58.58	57.61
					04/14/1997	62.76	53.43
					05/12/1997	63.60	52.59
					07/14/1997	65.60	50.59
					08/18/1997	63.49	52.70
					10/06/1997	67.29	48.90
					11/17/1997	63.96	52.23
					01/13/1998	63.52	52.67
					04/07/1998	58.55	57.64
					04/20/1998	58.67	57.52
					08/24/1998	67.42	48.77
					10/20/1998	75.08	41.11
					11/05/1998	75.65	40.54
					01/18/1999	76.68	39.51
					02/12/1999	74.73	41.46
					04/07/1999	76.32	39.87
					05/28/1999	77.62	38.57
					07/26/1999	78.98	37.21
					08/10/1999	79.20	36.99
					10/18/1999	79.36	36.83
					11/04/1999	79.00	37.19
					01/10/2000	77.56	38.63
					02/04/2000	77.60	38.59
					04/19/2000	73.21	42.98
					05/04/2000	73.83	42.36
					08/28/2000	76.52	39.67
					10/23/2000	75.19	41.00
					11/10/2000	76.22	39.97
					01/23/2001	75.94	40.25
					02/07/2001	75.96	40.23
					04/23/2001	75.52	40.67
1396	116.29	116.19	136.00	120 to 142	11/18/1985	56.58	59.61
					11/18/1985	56.38	59.81
					11/19/1985	56.60	59.59
					12/05/1985	56.23	59.96
					12/11/1985	55.91	60.28
					12/20/1985	55.93	60.26
					12/23/1985	55.74	60.45
					12/23/1985	55.83	60.36
					12/24/1985	55.86	60.33
					12/26/1985	55.80	60.39
					12/27/1985	55.91	60.28

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					12/27/1985	55.94	60.25
					12/27/1985	55.90	60.29
					12/27/1985	55.87	60.32
					12/27/1985	55.86	60.33
					12/27/1985	55.85	60.34
					12/27/1985	55.86	60.33
					12/27/1985	55.87	60.32
					12/27/1985	55.90	60.29
					12/27/1985	55.88	60.31
					12/27/1985	55.91	60.28
					12/27/1985	55.90	60.29
					12/27/1985	55.90	60.29
					12/27/1985	55.87	60.32
					12/28/1985	55.89	60.30
					12/28/1985	55.78	60.41
					12/28/1985	55.90	60.29
					12/29/1985	55.90	60.29
					12/30/1985	55.96	60.23
					12/30/1985	55.92	60.27
					12/31/1985	55.85	60.34
					12/31/1985	55.90	60.29
					01/02/1986	55.82	60.37
					01/03/1986	55.94	60.25
					01/09/1986	55.90	60.29
					02/27/1986	49.82	66.37
					04/24/1986	51.87	64.32
					07/10/1986	54.03	62.16
					07/31/1986	54.46	61.73
					09/24/1986	55.38	60.81
					12/03/1986	56.36	59.83
					12/12/1986	56.57	59.62
					12/17/1986	56.53	59.66
					01/06/1987	56.57	59.62
					02/17/1987	56.59	59.60
					04/14/1987	56.10	60.09
					06/17/1987	57.20	58.99
					10/02/1987	58.11	58.08
					10/09/1987	58.04	58.15
					11/19/1987	58.46	57.73
					02/16/1988	57.92	58.27
					04/25/1988	58.47	57.72
					04/28/1988	58.29	57.90
					05/03/1988	58.17	58.02
					07/12/1988	58.65	57.54
					07/21/1988	58.76	57.43
					12/01/1988	59.68	56.51
					12/07/1988	59.86	56.33
					10/27/1989	59.62	56.57
					04/19/1990	59.60	56.59

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					10/09/1990	60.70	55.49
					03/28/1991	60.55	55.64
					04/24/1991	59.78	56.41
					06/05/1991	60.54	55.65
					07/08/1991	60.84	55.35
					08/12/1991	61.01	55.18
					10/15/1991	61.40	54.79
					11/07/1991	61.54	54.65
					01/21/1992	62.00	54.19
					04/14/1992	60.19	56.00
					08/12/1992	61.69	54.50
					10/19/1992	62.36	53.83
					03/03/1993	58.53	57.66
					04/23/1993	59.07	57.12
					07/12/1993	60.36	55.83
					07/30/1993	60.84	55.35
					08/04/1993	60.87	55.32
					10/18/1993	62.32	53.87
					04/18/1994	62.76	53.43
					07/19/1994	63.65	52.54
					08/22/1994	64.25	51.94
					10/27/1994	64.58	51.61
					04/24/1995	57.51	58.68
					10/23/1995	62.07	54.12
					12/04/1995	62.56	53.63
					02/26/1996	59.85	56.34
					04/15/1996	59.46	56.73
					05/29/1996	59.53	56.66
					07/15/1996	61.41	54.78
					08/26/1996	62.78	53.41
					10/21/1996	66.16	48.03
					11/25/1996	66.10	48.09
					01/09/1997	62.61	53.58
					02/24/1997	58.30	57.89
					04/14/1997	63.54	52.65
					05/12/1997	64.31	51.88
					07/14/1997	66.32	49.87
					08/18/1997	63.30	52.89
					10/06/1997	67.93	48.26
					11/17/1997	63.95	52.24
					01/13/1998	63.34	52.85
					04/07/1998	58.70	57.49
					04/20/1998	58.89	57.30
					08/24/1998	66.27	49.92
					10/20/1998	74.40	41.79
					11/05/1998	75.00	41.19
					01/18/1999	75.83	40.36
					02/12/1999	72.00	44.19
					04/07/1999	75.56	40.63

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					05/28/1999	76.03	40.16
					07/26/1999	77.63	38.56
					08/10/1999	77.86	38.33
					10/18/1999	78.44	37.75
					11/04/1999	78.02	38.17
					01/10/2000	76.47	39.72
					02/04/2000	76.21	39.98
					04/19/2000	75.69	40.50
					05/04/2000	73.28	42.91
					08/28/2000	75.66	40.53
					10/23/2000	76.51	39.68
					11/10/2000	75.30	40.89
					01/23/2001	75.21	40.98
					02/07/2001	75.28	40.91
					04/23/2001	75.06	41.13
1397	116.29	116.19	192.00	167 to 196	11/18/1985	57.54	58.65
					11/18/1985	57.54	58.65
					11/19/1985	56.50	59.69
					12/05/1985	57.25	58.94
					12/11/1985	57.00	59.19
					12/20/1985	57.04	59.15
					12/23/1985	56.78	59.41
					12/23/1985	56.85	59.34
					12/24/1985	56.88	59.31
					12/26/1985	56.78	59.41
					12/27/1985	56.91	59.28
					12/27/1985	57.12	59.07
					12/27/1985	57.03	59.16
					12/27/1985	56.99	59.20
					12/27/1985	56.95	59.24
					12/27/1985	56.92	59.27
					12/27/1985	56.91	59.28
					12/27/1985	56.91	59.28
					12/27/1985	56.91	59.28
					12/27/1985	56.91	59.28
					12/27/1985	56.90	59.29
					12/27/1985	56.90	59.29
					12/27/1985	56.90	59.29
					12/27/1985	56.90	59.29
					12/28/1985	57.18	59.01
					12/28/1985	57.04	59.15
					12/28/1985	57.19	59.00
					12/29/1985	57.20	58.99
					12/30/1985	57.29	58.90
					12/30/1985	57.25	58.94
					12/31/1985	56.96	59.23
					12/31/1985	57.03	59.16
					01/02/1986	56.82	59.37

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					01/03/1986	56.95	59.24
					01/09/1986	56.93	59.26
					02/27/1986	51.63	64.56
					04/24/1986	54.60	61.59
					07/10/1986	55.14	61.05
					07/31/1986	55.50	60.69
					09/24/1986	56.44	59.75
					12/03/1986	57.30	58.89
					12/12/1986	57.45	58.74
					12/17/1986	57.49	58.70
					01/06/1987	57.33	58.86
					02/17/1987	57.52	58.67
					04/14/1987	57.31	58.88
					06/17/1987	58.37	57.82
					08/11/1987	58.73	57.46
					10/02/1987	59.19	57.00
					10/09/1987	59.02	57.17
					11/19/1987	59.35	56.84
					02/16/1988	58.87	57.32
					04/25/1988	59.43	56.76
					04/28/1988	59.31	56.88
					05/03/1988	59.30	56.89
					07/12/1988	59.84	56.35
					07/21/1988	59.89	56.30
					12/01/1988	60.64	55.55
					12/07/1988	60.84	55.35
					10/27/1989	59.38	56.81
					04/19/1990	60.77	55.42
					10/09/1990	61.80	54.39
					03/28/1991	61.70	54.49
					04/24/1991	61.17	55.02
					06/05/1991	61.92	54.27
					07/08/1991	62.08	54.11
					08/12/1991	62.23	53.96
					10/15/1991	62.68	53.51
					11/07/1991	62.88	53.31
					01/21/1992	63.05	53.14
					04/14/1992	61.72	54.47
					08/12/1992	63.05	53.14
					10/19/1992	63.60	52.59
					03/03/1993	60.40	55.79
					04/23/1993	60.59	55.60
					07/12/1993	61.88	54.31
					07/30/1993	62.47	53.72
					08/04/1993	62.51	53.68
					10/18/1993	63.58	52.61
					04/18/1994	64.21	51.98
					07/19/1994	65.15	51.04
					08/22/1994	65.48	50.71

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					10/27/1994	65.90	50.29
					04/24/1995	59.79	56.40
					10/23/1995	63.61	52.58
					12/04/1995	63.95	52.24
					02/26/1996	61.30	54.89
					04/15/1996	61.31	54.88
					05/29/1996	61.71	54.48
					07/15/1996	63.29	52.90
					08/26/1996	64.68	51.51
					10/21/1996	72.39	43.80
					11/25/1996	71.76	44.43
					01/09/1997	67.46	48.73
					02/24/1997	60.47	55.72
					04/14/1997	68.19	48.00
					05/12/1997	68.82	47.37
					07/14/1997	71.04	45.15
					08/18/1997	65.28	50.91
					10/06/1997	72.42	43.77
					11/17/1997	65.74	50.45
					01/13/1998	65.15	51.04
					04/07/1998	61.00	55.19
					04/20/1998	61.11	55.08
					08/24/1998	67.17	49.02
					10/20/1998	76.83	39.36
					11/05/1998	76.96	39.23
					01/18/1999	77.77	38.42
					02/12/1999	71.65	44.54
					04/07/1999	77.21	38.98
					05/28/1999	77.89	38.30
					07/26/1999	79.18	37.01
					08/10/1999	79.54	36.65
					10/18/1999	80.13	36.06
					11/04/1999	79.42	36.77
					01/10/2000	78.72	37.47
					02/04/2000	78.03	38.16
					04/19/2000	73.79	42.40
					05/04/2000	75.40	40.79
					08/28/2000	77.24	38.95
					10/23/2000	76.11	40.08
					11/10/2000	76.29	39.90
					01/23/2001	76.43	39.76
					02/07/2001	76.66	39.53
					04/23/2001	76.41	39.78
1398	116.29	116.19	238.00	221 to 246	11/18/1985	65.49	50.70
					11/19/1985	65.69	50.50
					12/05/1985	65.47	50.72
					12/10/1985	65.36	50.83
					12/20/1985	65.50	50.69

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					12/23/1985	65.22	50.97
					12/23/1985	65.18	51.01
					12/24/1985	65.22	50.97
					12/26/1985	65.06	51.13
					12/27/1985	65.25	50.94
					12/27/1985	65.36	50.83
					12/27/1985	65.34	50.85
					12/27/1985	65.29	50.90
					12/27/1985	65.26	50.93
					12/27/1985	65.25	50.94
					12/27/1985	65.44	50.75
					12/27/1985	65.24	50.95
					12/27/1985	65.23	50.96
					12/27/1985	65.21	50.98
					12/27/1985	65.21	50.98
					12/27/1985	65.21	50.98
					12/27/1985	65.21	50.98
					12/27/1985	65.24	50.95
					12/28/1985	65.67	50.52
					12/28/1985	65.54	50.65
					12/28/1985	65.69	50.50
					12/29/1985	65.80	50.39
					12/30/1985	65.89	50.30
					12/30/1985	65.88	50.31
					12/31/1985	65.70	50.49
					12/31/1985	65.55	50.64
					01/02/1986	65.20	50.99
					01/03/1986	65.29	50.90
					01/09/1986	65.32	50.87
					02/27/1986	61.37	54.82
					04/24/1986	62.98	53.21
					07/10/1986	64.83	51.36
					07/31/1986	65.46	50.73
					09/24/1986	64.38	51.81
					12/03/1986	66.31	49.88
					12/12/1986	66.26	49.93
					12/17/1986	66.06	50.13
					01/06/1987	65.49	50.70
					02/17/1987	65.55	50.64
					04/14/1987	68.18	48.01
					06/17/1987	68.23	47.96
					08/11/1987	69.19	47.00
					10/02/1987	68.84	47.35
					10/09/1987	68.85	47.34
					11/19/1987	68.55	47.64
					02/16/1988	67.80	48.39
					04/25/1988	68.62	47.57
					04/28/1988	68.50	47.69
					05/03/1988	67.94	48.25

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					07/12/1988	69.35	46.84
					07/21/1988	69.53	46.66
					08/09/1988	69.64	46.55
					12/01/1988	69.68	46.51
					12/07/1988	69.30	46.89
					10/27/1989	70.12	46.07
					04/19/1990	70.27	45.92
					10/09/1990	72.00	44.19
					03/28/1991	71.13	45.06
					04/24/1991	69.65	46.54
					06/05/1991	70.26	45.93
					07/08/1991	70.80	45.39
					08/12/1991	71.13	45.06
					10/15/1991	71.44	44.75
					11/07/1991	72.08	44.11
					01/21/1992	70.34	45.85
					04/14/1992	69.11	47.08
					08/12/1992	72.09	44.10
					10/19/1992	71.38	44.81
					03/03/1993	68.41	47.78
					04/23/1993	67.70	48.49
					07/12/1993	71.04	45.15
					07/30/1993	61.54	54.65
					08/04/1993	71.70	44.49
					10/18/1993	72.51	43.68
					04/18/1994	74.07	42.12
					07/19/1994	76.05	40.14
					08/22/1994	76.27	39.92
					10/27/1994	75.49	40.70
					04/24/1995	71.33	44.86
					09/08/1995	74.06	42.13
					10/23/1995	72.60	43.59
					11/30/1995	72.84	43.35
					02/26/1996	69.45	46.74
					04/15/1996	70.90	45.29
					05/29/1996	22.90	93.29
					07/15/1996	74.37	41.82
					08/30/1996	78.17	38.02
					10/21/1996	75.00	41.19
					11/25/1996	74.82	41.37
					01/09/1997	70.77	45.42
					02/24/1997	59.72	56.47
					04/14/1997	72.50	43.69
					05/12/1997	73.38	42.81
					07/14/1997	74.68	41.51
					08/18/1997	74.88	41.31
					10/06/1997	75.16	41.03
					11/17/1997	73.23	42.96
					01/13/1998	72.95	43.24

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					04/20/1998	69.84	46.35
					08/24/1998	77.41	38.78
					10/20/1998	76.60	39.59
					11/05/1998	75.50	40.69
					01/18/1999	77.93	38.26
					02/12/1999	75.95	40.24
					04/07/1999	77.68	38.51
					05/28/1999	80.26	35.93
					05/28/1999	80.26	35.93
					07/26/1999	81.17	35.02
					08/10/1999	81.90	34.29
					10/18/1999	82.15	34.04
					11/04/1999	80.28	35.91
					01/10/2000	80.05	36.14
					02/04/2000	79.00	37.19
					04/19/2000	78.19	38.00
					05/04/2000	78.38	37.81
					08/28/2000	80.26	35.93
					10/23/2000	78.01	38.18
					11/10/2000	77.93	38.26
					01/23/2001	79.45	36.74
					02/07/2001	80.68	35.51
					04/23/2001	80.24	35.95
1399	116.29	116.19	288.00	273 to 298	11/18/1985	53.46	62.73
					11/19/1985	53.59	62.60
					12/05/1985	53.34	62.85
					12/10/1985	53.14	63.05
					12/20/1985	53.79	62.40
					12/23/1985	53.68	62.51
					12/23/1985	53.67	62.52
					12/24/1985	53.47	62.72
					12/26/1985	53.37	62.82
					12/27/1985	53.91	62.28
					12/27/1985	54.20	61.99
					12/27/1985	54.07	62.12
					12/27/1985	54.00	62.19
					12/27/1985	53.94	62.25
					12/27/1985	53.98	62.21
					12/27/1985	54.45	61.74
					12/27/1985	53.83	62.36
					12/27/1985	53.90	62.29
					12/27/1985	53.91	62.28
					12/27/1985	53.93	62.26
					12/27/1985	53.90	62.29
					12/27/1985	53.90	62.29
					12/27/1985	53.94	62.25
					12/28/1985	55.47	60.72
					12/28/1985	55.39	60.80

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					12/26/1985	55.80	60.39
					12/29/1985	56.85	59.34
					12/30/1985	57.74	58.45
					12/30/1985	57.83	58.36
					12/31/1985	56.82	59.37
					12/31/1985	56.53	59.66
					01/02/1986	54.15	62.04
					01/09/1986	53.26	62.93
					02/27/1986	48.66	67.53
					04/24/1986	50.70	65.49
					07/10/1986	51.74	64.45
					07/31/1986	52.56	63.63
					09/24/1986	53.89	62.30
					12/03/1986	54.83	61.36
					12/12/1986	54.56	61.63
					12/17/1986	54.72	61.47
					01/06/1987	53.35	62.84
					02/17/1987	53.40	62.79
					04/14/1987	55.00	61.19
					06/17/1987	56.05	60.14
					08/11/1987	56.79	59.40
					10/02/1987	56.89	59.30
					10/09/1987	56.91	59.28
					11/19/1987	55.78	60.41
					02/16/1988	55.24	60.95
					04/25/1988	55.99	60.20
					04/28/1988	55.80	60.39
					05/03/1988	55.85	60.34
					07/12/1988	57.53	58.66
					07/21/1988	57.80	58.39
					12/01/1988	57.05	59.14
					12/07/1988	57.97	58.22
					10/27/1989	56.52	59.67
					04/19/1990	56.84	59.35
					10/09/1990	59.22	56.97
					03/28/1991	58.03	58.16
					04/24/1991	58.79	57.40
					06/05/1991	59.54	56.65
					07/08/1991	60.15	56.04
					08/12/1991	59.98	56.21
					10/15/1991	60.14	56.05
					11/07/1991	60.23	55.96
					01/21/1992	59.65	56.54
					04/14/1992	58.40	57.79
					08/12/1992	61.03	55.16
					10/19/1992	61.51	54.68
					03/03/1993	57.15	59.04
					04/23/1993	57.78	58.41
					07/12/1993	60.50	55.69

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					07/30/1993	61.39	54.80
					08/04/1993	61.28	54.91
					10/18/1993	62.01	54.18
					04/18/1994	61.68	54.51
					07/19/1994	64.04	52.15
					08/22/1994	63.50	52.69
					10/27/1994	64.18	52.01
					04/24/1995	59.21	56.98
					09/08/1995	61.15	55.04
					10/23/1995	62.06	54.13
					11/30/1995	61.66	54.53
					02/26/1996	57.35	58.84
					04/15/1996	59.19	57.00
					05/29/1996	61.57	54.62
					07/15/1996	64.18	52.01
					08/29/1996	65.37	50.82
					10/21/1996	64.68	51.51
					11/25/1996	63.94	52.25
					01/09/1997	60.00	56.19
					02/24/1997	59.77	56.42
					04/14/1997	61.68	54.51
					05/12/1997	59.90	56.29
					07/14/1997	64.12	52.07
					08/18/1997	64.41	51.78
					10/06/1997	64.57	51.62
					11/17/1997	63.23	52.96
					01/13/1998	61.08	55.11
					04/20/1998	57.58	58.61
					08/21/1998	66.74	49.45
					08/24/1998	66.74	49.45
					10/20/1998	67.38	48.81
					11/05/1998	64.94	51.25
					01/18/1999	67.30	48.89
					02/12/1999	66.38	49.81
					04/07/1999	66.26	49.93
					05/28/1999	70.00	46.19
					05/28/1999	70.00	46.19
					07/26/1999	71.71	44.48
					08/10/1999	72.88	43.31
					10/18/1999	73.71	42.48
					11/04/1999	71.01	45.18
					01/10/2000	69.38	46.81
					02/04/2000	68.38	47.81
					04/19/2000	67.32	48.87
					05/04/2000	66.02	50.17
					08/28/2000	70.41	45.78
					10/23/2000	69.13	47.06
					11/10/2000	69.44	46.75
					01/23/2001	69.83	46.36

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					02/07/2001	73.20	42.99
					04/23/2001	69.69	46.50
1481	95.84	95.83	62.00	40 to 69.5	04/24/1991	26.56	69.27
					04/30/1991	27.13	68.70
					05/02/1991	27.28	68.55
					06/28/1991	27.62	68.21
					07/08/1991	27.67	68.16
					08/07/1991	27.27	68.56
					11/06/1991	28.72	67.11
					01/22/1992	29.17	66.66
					04/15/1992	27.43	68.40
					04/21/1992	29.98	65.85
					08/18/1992	28.26	67.57
					10/19/1992	29.48	66.35
					03/04/1993	22.75	73.08
					04/23/1993	26.10	69.73
					06/22/1993	26.79	69.04
					07/30/1993	26.96	68.87
					10/18/1993	27.61	68.22
					04/18/1994	29.25	66.58
					07/18/1994	29.16	66.67
					08/31/1994	29.76	66.07
					10/24/1994	30.03	65.80
					02/27/1995	24.36	71.47
					04/24/1995	23.00	72.83
					09/18/1995	27.45	68.38
					10/23/1995	28.52	67.31
					04/15/1996	25.04	70.79
					07/15/1996	27.90	67.93
					08/21/1996	28.61	67.22
					10/21/1996	29.30	66.53
					01/09/1997	16.39	79.44
					04/14/1997	26.79	69.04
					07/14/1997	29.92	65.91
					08/05/1997	29.10	66.73
					10/06/1997	29.60	66.23
					01/13/1998	28.06	67.77
					04/20/1998	24.39	71.44
					07/31/1998	27.66	68.17
					10/20/1998	30.33	65.50
					01/18/1999	30.73	65.10
					04/05/1999	28.93	66.90
					07/19/1999	30.42	65.41
					07/26/1999	30.56	65.27
					10/18/1999	31.86	63.97
					01/10/2000	32.09	63.74
					04/17/2000	28.01	67.82
					10/05/2000	32.11	63.72

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					10/23/2000	31.78	64.05
					01/23/2001	32.18	63.65
					04/04/2001	31.20	64.63
1487	109.00	108.66	75.00	40 to 79	04/24/1991	40.15	68.51
					04/29/1991	40.35	68.31
					07/07/1991	39.10	69.56
					11/06/1991	39.86	68.80
					01/21/1992	40.29	68.37
					04/14/1992	39.74	68.92
					04/22/1992	39.95	68.71
					08/19/1992	39.32	69.34
					10/21/1992	40.36	68.30
					03/01/1993	37.92	70.74
					04/23/1993	38.37	70.29
					06/21/1993	38.02	70.64
					07/29/1993	38.18	70.48
					10/20/1993	38.98	69.68
					04/18/1994	40.10	68.56
					07/19/1994	40.20	68.46
					08/15/1994	40.28	68.38
					10/27/1994	45.25	63.41
					03/02/1995	38.18	70.48
					04/25/1995	36.90	71.76
					09/19/1995	38.45	70.21
					10/24/1995	38.85	69.81
					12/06/1995	39.10	69.56
					04/16/1996	37.41	71.25
					06/11/1996	37.30	71.36
					07/15/1996	38.51	70.15
					09/11/1996	39.11	69.55
					10/22/1996	39.41	69.25
					12/05/1996	39.56	69.10
					01/09/1997	32.62	76.04
					03/14/1997	37.12	71.54
					04/15/1997	38.28	70.38
					06/16/1997	38.86	69.80
					07/15/1997	39.23	69.43
					09/23/1997	39.70	68.96
					10/07/1997	39.81	68.85
					12/06/1997	39.72	68.94
					01/14/1998	38.83	69.83
					03/12/1998	37.11	71.55
					04/06/1998	36.54	72.12
					04/21/1998	36.67	71.99
					09/08/1998	39.11	69.55
					10/21/1998	39.93	68.73
					12/04/1998	39.87	68.79
					01/19/1999	40.44	68.22

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					03/05/1999	38.14	70.52
					04/06/1999	39.98	68.68
					06/01/1999	40.38	68.28
					07/27/1999	40.43	68.23
					09/22/1999	41.45	67.21
					10/20/1999	41.60	67.06
					12/10/1999	41.74	66.92
					01/11/2000	42.19	66.47
					03/06/2000	40.00	68.66
					04/18/2000	40.53	68.13
					06/26/2000	40.85	67.81
					07/20/2000	30.98	77.68
					09/20/2000	41.44	67.22
					10/24/2000	41.38	67.28
					12/18/2000	41.42	67.24
					01/22/2001	41.85	66.81
					03/08/2001	42.43	66.23
					04/24/2001	42.41	66.25
1522	102.00	101.90	82.00	72 to 85	11/09/1992	38.54	63.36
					01/08/1993	38.40	63.50
					04/06/1993	34.11	67.79
					04/23/1993	35.26	66.64
					07/15/1993	36.10	65.80
					07/30/1993	36.39	65.51
					10/18/1993	37.50	64.40
					02/14/1994	37.89	64.01
					04/18/1994	38.27	63.63
					07/18/1994	38.70	63.20
					08/15/1994	39.62	62.28
					10/24/1994	39.52	62.38
					10/27/1994	39.51	62.39
					03/27/1995	32.20	69.70
					04/24/1995	33.40	68.50
					09/01/1995	37.00	64.90
					10/23/1995	37.30	64.60
					04/15/1996	34.88	67.02
					08/05/1996	37.90	64.00
					10/21/1996	39.01	62.89
					01/09/1997	32.42	69.48
					04/14/1997	35.65	66.25
					07/14/1997	37.64	64.26
					08/06/1997	37.11	64.79
					10/06/1997	38.80	63.10
					01/13/1998	37.96	63.94
					04/20/1998	34.09	67.81
					07/29/1998	36.30	65.60
					10/20/1998	40.08	61.82
					01/18/1999	42.28	59.62

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					04/05/1999	40.41	61.49
					07/21/1999	42.54	59.36
					07/26/1999	42.39	59.51
					10/19/1999	43.80	58.10
					01/10/2000	43.41	58.49
					04/05/2000	40.48	61.42
					04/19/2000	40.52	61.38
					05/05/2000	40.48	61.42
					07/07/2000	42.16	59.74
					10/23/2000	43.11	58.79
					01/23/2001	43.15	58.75
					04/04/2001	42.53	59.37
					04/23/2001	42.74	59.16
1571	103.00	102.90	78.00	61 to 84	07/19/1994	39.38	63.52
					08/30/1994	40.12	62.78
					10/27/1994	40.18	62.72
					11/28/1994	40.00	62.90
					02/28/1995	37.77	65.13
					04/25/1995	35.38	67.52
					10/24/1995	38.06	64.84
					12/14/1995	39.43	63.47
					03/11/1996	37.32	65.58
					04/16/1996	36.34	66.56
					06/14/1996	37.10	65.80
					07/15/1996	37.63	65.27
					09/17/1996	39.76	63.14
					12/10/1996	37.83	65.07
					01/09/1997	31.79	71.11
					03/24/1997	37.00	65.90
					04/15/1997	36.94	65.96
					06/17/1997	38.88	64.02
					07/15/1997	38.33	64.57
					09/08/1997	38.72	64.18
					10/07/1997	39.04	63.86
					12/15/1997	38.35	64.55
					01/14/1998	38.05	64.85
					03/12/1998	35.90	67.00
					04/21/1998	35.38	67.52
					06/02/1998	35.28	67.62
					09/09/1998	38.70	64.20
					10/21/1998	39.75	63.15
					12/07/1998	39.54	63.36
					01/19/1999	40.14	62.76
					03/16/1999	38.36	64.54
					04/06/1999	39.61	63.29
					06/10/1999	40.27	62.63
					07/27/1999	40.51	62.39
					09/21/1999	41.70	61.20

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					10/20/1999	41.58	61.32
					01/11/2000	42.35	60.55
					03/14/2000	40.10	62.80
					04/18/2000	40.20	62.70
					09/28/2000	41.80	61.10
					10/24/2000	41.20	61.70
					01/22/2001	41.92	60.98
					03/16/2001	42.70	60.20
					04/24/2001	42.79	60.11
1572	103.00	102.90	139.00	125 to 142	05/26/1993	41.62	61.28
					07/19/1994	41.52	61.38
					08/30/1994	42.23	60.67
					10/27/1994	42.24	60.66
					11/28/1994	41.90	61.00
					02/28/1995	39.07	63.83
					04/25/1995	37.05	65.85
					10/24/1995	40.05	62.85
					12/14/1995	41.34	61.56
					03/11/1996	38.95	63.95
					04/16/1996	37.97	64.93
					06/14/1996	39.55	63.35
					07/15/1996	39.58	63.32
					09/17/1996	41.86	61.04
					12/10/1996	40.20	62.70
					01/09/1997	34.14	68.76
					03/24/1997	39.43	63.47
					04/15/1997	38.77	64.13
					06/17/1997	40.57	62.33
					07/15/1997	40.31	62.59
					09/08/1997	40.75	62.15
					10/07/1997	41.21	61.69
					12/15/1997	40.50	62.40
					01/14/1998	40.00	62.90
					03/12/1998	37.50	65.40
					04/21/1998	37.08	65.82
					06/02/1998	36.95	65.95
					09/09/1998	40.85	62.05
					10/21/1998	42.06	60.84
					12/07/1998	41.58	61.32
					01/19/1999	42.22	60.68
					03/16/1999	40.68	62.22
					04/06/1999	41.79	61.11
					06/10/1999	42.62	60.28
					07/27/1999	43.03	59.87
					09/21/1999	44.00	58.90
					10/20/1999	44.18	58.72
					01/11/2000	44.66	58.24
					03/14/2000	42.23	60.67

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					04/18/2000	42.59	60.31
					09/28/2000	44.11	58.79
					10/24/2000	43.53	59.37
					01/22/2001	44.16	58.74
					03/16/2001	44.75	58.15
					04/24/2001	44.98	57.92
1573	103.00	102.90	190.00	177 to 193	05/26/1993	43.98	58.92
					07/19/1994	43.98	58.92
					08/30/1994	44.55	58.35
					10/27/1994	44.77	58.13
					11/28/1994	45.25	57.65
					02/28/1995	41.57	61.33
					04/25/1995	39.32	63.58
					10/24/1995	42.51	60.39
					12/14/1995	43.77	59.13
					03/11/1996	41.38	61.52
					04/16/1996	40.55	62.35
					06/14/1996	42.22	60.68
					07/15/1996	42.47	60.43
					09/17/1996	44.88	58.02
					12/10/1996	43.34	59.56
					01/09/1997	37.51	65.39
					03/24/1997	41.34	61.56
					04/15/1997	40.33	62.57
					06/17/1997	43.54	59.36
					07/15/1997	43.06	59.84
					09/08/1997	43.70	59.20
					10/07/1997	44.13	58.77
					12/15/1997	43.04	59.86
					01/14/1998	42.67	60.23
					03/12/1998	39.90	63.00
					04/21/1998	39.43	63.47
					06/02/1998	39.62	63.28
					09/09/1998	43.90	59.00
					10/21/1998	45.07	57.83
					12/07/1998	44.20	58.70
					01/19/1999	44.92	57.98
					03/16/1999	43.70	59.20
					04/06/1999	44.61	58.29
					06/10/1999	45.67	57.23
					07/27/1999	46.35	56.55
					09/21/1999	47.44	55.46
					10/20/1999	47.58	55.32
					01/11/2000	47.84	55.06
					03/14/2000	45.41	57.49
					04/18/2000	45.75	57.15
					09/28/2000	47.31	55.59
					10/24/2000	46.41	56.49

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					01/22/2001	47.19	55.71
					03/16/2001	47.75	55.15
					04/24/2001	48.40	54.50
1574	103.00	102.90	112.00	99 to 112	05/26/1994	39.93	62.97
					07/19/1994	40.13	62.77
					08/30/1994	40.60	62.30
					10/27/1994	40.91	61.99
					02/28/1995	38.40	64.50
					04/25/1995	35.97	66.93
					10/24/1995	38.76	64.14
					12/08/1995	38.79	64.11
					03/12/1996	36.44	66.46
					04/16/1996	36.70	66.20
					06/17/1996	37.50	65.40
					07/15/1996	38.29	64.61
					09/18/1996	39.22	63.68
					12/11/1996	37.47	65.43
					01/09/1997	32.61	70.29
					04/15/1997	37.55	65.35
					06/18/1997	38.50	64.40
					07/15/1997	38.95	63.95
					09/08/1997	39.30	63.60
					10/07/1997	39.74	63.16
					01/14/1998	38.45	64.45
					03/12/1998	36.25	66.65
					04/21/1998	35.92	66.98
					09/09/1998	39.30	63.60
					10/21/1998	40.43	62.47
					01/19/1999	40.79	62.11
					03/15/1999	39.28	63.62
					04/06/1999	40.22	62.68
					06/10/1999	41.16	61.74
					07/27/1999	41.35	61.55
					09/21/1999	42.30	60.60
					10/20/1999	42.35	60.55
					01/11/2000	43.00	59.90
					03/14/2000	40.74	62.16
					04/18/2000	41.02	61.88
					09/28/2000	42.49	60.41
					10/24/2000	42.05	60.85
					01/22/2001	42.35	60.55
					03/19/2001	43.30	59.60
					04/24/2001	43.39	59.51
1567	96.00	95.76	61.00	41.5 to 65.5	07/19/1994	38.32	57.44
					10/27/1994	39.23	56.53
					11/28/1994	38.81	56.95
					04/24/1995	30.95	64.81

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					09/12/1995	36.18	59.58
					12/08/1995	37.15	58.61
					03/08/1996	33.76	62.00
					04/15/1996	33.29	62.47
					06/18/1996	35.45	60.31
					07/15/1996	36.32	59.44
					09/18/1996	38.90	56.86
					10/21/1996	39.12	56.64
					12/12/1996	36.14	59.62
					01/09/1997	26.28	67.48
					03/17/1997	32.35	63.41
					04/14/1997	34.14	61.62
					06/13/1997	36.70	59.06
					07/14/1997	37.05	58.71
					09/10/1997	38.40	57.36
					10/06/1997	38.56	57.20
					12/12/1997	37.92	57.84
					01/13/1998	36.56	59.20
					03/11/1998	31.20	64.56
					04/20/1998	32.50	63.26
					09/02/1998	39.67	56.09
					10/20/1998	42.43	53.33
					12/03/1998	43.75	52.01
					01/18/1999	43.16	52.60
					03/08/1999	40.38	55.38
					04/05/1999	42.19	53.57
					04/07/1999	42.37	53.39
					06/09/1999	44.02	51.74
					07/26/1999	44.56	51.20
					08/21/1999	45.49	50.27
					08/31/1999	45.49	50.27
					10/19/1999	45.59	50.17
					01/10/2000	45.18	50.58
					03/13/2000	38.63	57.13
					04/19/2000	41.15	54.61
					09/29/2000	44.55	51.21
					10/23/2000	43.97	51.79
					01/23/2001	44.30	51.46
					03/12/2001	42.85	52.91
					04/23/2001	43.86	51.90

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
Western Study Area							
1406	102.75	102.73	105.00	90 to 108	01/05/1900	69.66	33.07
					12/16/1985	51.75	50.98
					12/17/1985	51.88	50.85
					12/19/1985	51.67	51.06
					12/19/1985	51.67	51.06
					12/20/1985	51.61	51.12
					12/23/1985	51.65	51.08
					12/23/1985	51.55	51.18
					12/24/1985	51.68	51.05
					12/27/1985	51.62	51.11
					12/27/1985	51.66	51.07
					12/27/1985	51.60	51.13
					12/27/1985	51.60	51.13
					12/27/1985	51.63	51.10
					12/27/1985	51.65	51.08
					12/27/1985	51.65	51.08
					12/27/1985	51.61	51.12
					12/28/1985	51.60	51.13
					12/28/1985	51.60	51.13
					12/29/1985	51.58	51.15
					12/30/1985	51.66	51.07
					12/30/1985	51.58	51.15
					12/31/1985	51.52	51.21
					12/31/1985	51.57	51.16
					01/02/1986	51.55	51.18
					01/02/1986	51.55	51.18
					01/09/1986	51.78	50.95
					01/17/1986	51.42	51.31
					02/27/1986	46.69	56.04
					04/24/1986	47.79	54.94
					07/02/1986	49.87	52.86
					09/23/1986	51.38	51.35
					12/04/1986	52.08	50.65
					12/12/1986	52.15	50.58
					02/17/1987	52.22	50.51
					04/14/1987	52.32	50.41
					06/17/1987	53.57	49.16
					10/09/1987	54.59	48.14
					11/19/1987	54.59	48.14

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					02/16/1988	53.99	48.74
					05/03/1988	54.45	48.28
					07/12/1988	55.00	47.73
					07/20/1988	55.09	47.64
					07/21/1988	55.24	47.49
					12/07/1988	57.14	45.59
					10/27/1989	55.99	46.74
					04/19/1990	56.28	46.45
					10/09/1990	57.35	45.38
					04/02/1991	57.60	45.13
					04/24/1991	57.17	45.56
					06/04/1991	57.62	45.11
					07/08/1991	57.86	44.87
					10/15/1991	58.50	44.23
					11/07/1991	58.56	44.17
					01/22/1992	59.50	43.23
					04/03/1992	48.75	53.98
					04/14/1992	57.57	45.16
					08/19/1992	59.07	43.66
					10/19/1992	59.65	43.08
					03/03/1993	57.00	45.73
					04/23/1993	56.62	46.11
					07/13/1993	57.75	44.98
					07/30/1993	58.37	44.36
					10/18/1993	60.23	42.50
					03/23/1994	59.73	43.00
					04/18/1994	60.18	42.55
					07/19/1994	61.61	41.12
					08/29/1994	62.22	40.51
					10/26/1994	62.73	40.00
					04/24/1995	57.25	45.48
					05/11/1995	56.53	46.20
					07/14/1995	58.09	44.64
					10/20/1995	60.95	41.78
					10/23/1995	60.53	42.20
					11/21/1995	61.18	41.55
					01/11/1996	60.90	41.83
					04/04/1996	58.64	44.09
					04/15/1996	58.27	44.46
					07/02/1996	59.19	43.54
					07/15/1996	59.78	42.95

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation	Datum Elevation (top of PVC casing)	Depth of Well (below ground)	Depth Interval of Gravel Pack (below ground)	Date	Depth To Water Below Datum	Groundwater Surface Elevation
	(feet amsl)	*(feet amsl)*	*(feet)*	*(feet)*	*(m-d-y)*	*(feet)*	*(feet amsl)*
					10/01/1996	61.70	41.03
					10/21/1996	62.13	40.60
					01/24/1997	58.32	44.41
					04/03/1997	57.47	45.26
					04/14/1997	58.06	44.67
					07/14/1997	60.76	41.97
					07/28/1997	61.61	41.12
					10/06/1997	63.10	39.63
					01/13/1998	62.66	40.07
					01/19/1998	62.55	40.18
					04/20/1998	58.61	44.12
					07/21/1998	60.37	42.36
					10/20/1998	64.44	38.29
					10/21/1998	64.45	38.28
					01/06/1999	65.01	37.72
					01/18/1999	65.17	37.56
					04/05/1999	65.27	37.46
					04/19/1999	65.54	37.19
					07/22/1999	67.74	34.99
					07/26/1999	67.58	35.15
					10/11/1999	69.00	33.73
					10/19/1999	68.99	33.74
					01/04/2000	69.66	33.07
					01/10/2000	69.22	33.51
					04/17/2000	67.09	35.64
					04/18/2000	67.33	35.40
					07/06/2000	68.47	34.26
					09/28/2000	68.85	33.88
					10/09/2000	68.67	34.06
					01/05/2001	68.21	34.52
					01/23/2001	68.30	34.43
					04/06/2001	68.68	34.05
					04/23/2001	68.76	33.97
1506	104.20	104.23	104.00	80 to 111	01/15/1992	54.64	49.59
					03/29/1992	53.98	50.25
					04/14/1992	53.96	50.27
					06/30/1992	54.26	49.97
					01/18/1993	55.12	49.11
					04/20/1993	52.08	52.15
					04/23/1993	52.22	52.01

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					06/23/1993	52.95	51.26
					07/29/1993	54.15	50.06
					10/20/1993	55.81	48.42
					04/18/1994	56.25	47.98
					04/18/1994	56.25	47.98
					07/19/1994	58.03	46.20
					08/18/1994	58.61	45.62
					02/01/1995	56.00	48.23
					04/25/1995	52.20	52.03
					09/20/1995	55.90	48.33
					10/24/1995	56.16	48.07
					12/07/1995	56.35	47.88
					03/07/1996	53.74	50.49
					04/16/1996	53.83	50.40
					06/13/1996	54.50	49.73
					07/15/1996	55.69	48.54
					09/17/1996	57.16	47.07
					10/22/1996	57.66	46.57
					12/06/1996	57.24	46.99
					01/09/1997	52.65	51.58
					03/25/1997	52.68	51.55
					04/15/1997	53.48	50.75
					06/16/1997	55.68	48.55
					07/15/1997	56.34	47.89
					09/17/1997	57.60	46.63
					10/07/1997	58.61	45.62
					12/09/1997	58.04	46.19
					01/14/1998	57.55	46.68
					03/10/1998	53.55	50.68
					04/21/1998	53.28	50.95
					06/01/1998	52.96	51.27
					09/02/1998	58.34	45.89
					10/21/1998	59.24	44.99
					12/04/1998	58.60	45.63
					01/19/1999	59.68	44.55
					03/09/1999	58.80	45.43
					04/06/1999	59.80	44.43
					06/08/1999	60.83	43.40
					07/27/1999	61.91	42.32
					09/22/1999	63.24	40.99
					10/20/1999	63.13	41.10

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					01/11/2000	63.65	40.58
					03/08/2000	61.28	42.95
					04/18/2000	61.62	42.61
					06/26/2000	62.48	41.75
					09/27/2000	62.65	41.58
					10/24/2000	61.19	43.04
					01/22/2001	62.41	41.82
					03/07/2001	63.08	41.15
					04/24/2001	64.11	40.12
1564	90.00	89.69	66.00	46 to 70	05/24/1994	38.98	50.71
					08/26/1994	40.37	49.32
					10/24/1994	40.26	49.43
					02/13/1995	35.00	54.69
					04/24/1995	32.62	57.07
					05/22/1995	33.00	56.69
					07/13/1995	35.33	54.36
					10/19/1995	38.37	51.32
					10/23/1995	38.22	51.47
					01/08/1996	38.75	50.94
					04/02/1996	36.00	53.69
					04/15/1996	35.52	54.17
					07/03/1996	36.73	52.96
					07/15/1996	37.49	52.20
					10/04/1996	39.23	50.46
					10/21/1996	40.17	49.52
					01/09/1997	31.19	58.50
					01/31/1997	29.30	60.39
					04/04/1997	35.38	54.31
					04/14/1997	36.01	53.68
					07/14/1997	38.75	50.94
					07/30/1997	39.25	50.44
					03/11/1998	35.89	53.80
					04/06/1998	36.60	53.09
					04/20/1998	37.45	52.24
					06/17/1998	37.91	51.78
					07/21/1998	39.62	50.07
					10/16/1998	50.54	39.15
					10/20/1998	50.65	39.04
					01/07/1999	51.00	38.69
					01/18/1999	51.63	38.06

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					04/05/1999	51.79	37.90
					04/12/1999	52.12	37.57
					07/23/1999	53.65	36.04
					07/26/1999	53.53	36.16
					10/18/1999	54.30	35.39
					01/10/2000	53.69	36.00
					01/12/2000	53.87	35.82
					04/17/2000	50.12	39.57
					04/20/2000	50.30	39.39
					07/06/2000	51.92	37.77
					10/04/2000	52.42	37.27
					10/23/2000	51.72	37.97
					01/03/2001	51.96	37.73
					01/23/2001	52.50	37.19
					04/06/2001	52.74	36.95
					04/23/2001	52.66	37.03
1585	98.00	97.68	100.00	72 to 104	05/16/1995	47.69	49.99
					06/20/1995	48.64	49.04
					08/31/1995	51.11	46.57
					10/23/1995	52.08	45.60
					11/30/1995	52.88	44.80
					02/21/1996	51.43	46.25
					04/15/1996	49.97	47.71
					05/22/1996	50.00	47.68
					07/15/1996	51.55	46.13
					08/19/1996	52.47	45.21
					10/21/1996	53.93	43.75
					11/11/1996	53.92	43.76
					01/09/1997	49.89	47.79
					02/14/1997	47.67	50.01
					04/14/1997	49.73	47.95
					05/13/1997	50.91	46.77
					07/14/1997	52.56	45.12
					10/06/1997	54.87	42.81
					11/18/1997	54.33	43.35
					01/13/1998	54.25	43.43
					02/11/1998	52.30	45.38
					04/20/1998	49.93	47.75
					06/16/1998	49.62	48.06
					08/24/1998	54.42	43.26

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					10/20/1998	57.47	40.21
					11/09/1998	57.85	39.83
					01/18/1999	58.39	39.29
					02/10/1999	58.70	38.98
					04/05/1999	58.51	39.17
					05/24/1999	59.80	37.88
					07/26/1999	60.60	37.08
					08/13/1999	61.03	36.65
					10/19/1999	61.98	35.70
					11/04/1999	61.64	36.04
					01/10/2000	62.21	35.47
					02/10/2000	61.57	36.11
					04/17/2000	59.50	38.18
					05/04/2000	59.41	38.27
					08/14/2000	61.65	36.03
					10/23/2000	59.98	37.70
					11/14/2000	59.75	37.93
					01/23/2001	61.00	36.68
					02/02/2001	61.30	36.38
					04/23/2001	61.51	36.17
1586	98.00	97.68	149.00	139.5 to 150.5	05/17/1995	48.12	49.56
					06/20/1995	48.53	49.15
					08/31/1995	51.44	46.24
					10/23/1995	52.39	45.29
					11/30/1995	52.75	44.93
					02/21/1996	51.56	46.12
					04/15/1996	50.29	47.39
					05/22/1996	50.06	47.62
					07/15/1996	51.85	45.83
					08/19/1996	52.82	44.86
					10/21/1996	54.23	43.45
					11/11/1996	54.28	43.40
					01/09/1997	50.16	47.52
					02/14/1997	47.55	50.13
					04/14/1997	50.04	47.64
					05/13/1997	51.01	46.67
					07/14/1997	52.89	44.79
					10/06/1997	55.15	42.53
					11/18/1997	54.57	43.11
					01/13/1998	54.41	43.27

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					02/11/1998	52.63	45.05
					04/20/1998	50.29	47.39
					06/16/1998	50.12	47.56
					08/24/1998	54.82	42.86
					10/20/1998	57.68	40.00
					11/09/1998	58.02	39.66
					01/18/1999	58.60	39.08
					02/10/1999	58.95	38.73
					04/05/1999	58.58	39.10
					05/24/1999	59.78	37.90
					07/26/1999	60.80	36.88
					08/13/1999	61.30	36.38
					10/18/1999	62.10	35.58
					11/04/1999	61.78	35.90
					01/10/2000	62.40	35.28
					02/10/2000	61.88	35.80
					04/17/2000	59.80	37.88
					05/04/2000	59.70	37.98
					08/14/2000	61.94	35.74
					10/23/2000	60.63	37.05
					11/14/2000	60.04	37.64
					01/23/2001	61.29	36.39
					02/02/2001	61.55	36.13
					04/23/2001	61.81	35.87
1587	98.00	97.68	174.00	164.5 to 177	05/18/1995	48.46	49.22
					06/20/1995	48.43	49.25
					08/31/1995	51.66	46.02
					10/23/1995	52.79	44.89
					11/30/1995	52.83	44.85
					02/21/1996	51.41	46.27
					04/15/1996	50.50	47.18
					05/22/1996	50.07	47.61
					07/15/1996	52.12	45.56
					08/19/1996	53.00	44.68
					10/21/1996	54.42	43.26
					11/11/1996	54.37	43.31
					01/09/1997	50.43	47.25
					02/14/1997	47.48	50.20
					04/14/1997	50.33	47.35
					05/13/1997	51.52	46.16

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					07/14/1997	53.13	44.55
					10/06/1997	55.36	42.32
					11/18/1997	54.98	42.70
					01/13/1998	54.69	42.99
					02/11/1998	52.82	44.86
					04/20/1998	50.43	47.25
					06/16/1998	50.30	47.38
					08/24/1998	55.27	42.41
					10/20/1998	57.81	39.87
					11/09/1998	58.17	39.51
					01/18/1999	58.74	38.94
					02/10/1999	59.00	38.68
					04/05/1999	58.67	39.01
					05/24/1999	59.82	37.86
					07/26/1999	60.96	36.72
					08/13/1999	61.35	36.33
					10/18/1999	62.35	35.33
					11/04/1999	61.90	35.78
					01/10/2000	62.56	35.12
					02/10/2000	62.00	35.68
					04/17/2000	60.02	37.66
					05/04/2000	59.90	37.78
					08/14/2000	62.06	35.62
					10/23/2000	60.61	37.07
					11/14/2000	60.00	37.68
					01/23/2001	61.38	36.30
					02/02/2001	61.58	36.10
					04/23/2001	61.96	35.72
1591	97.00	97.48	112.00	86.5 to 116	06/06/1995	51.17	46.31
					09/01/1995	54.37	43.11
					10/23/1995	55.59	41.89
					12/01/1995	55.89	41.59
					02/12/1996	53.85	43.63
					04/15/1996	52.94	44.54
					05/17/1996	53.24	44.24
					07/15/1996	54.67	42.81
					08/19/1996	56.22	41.26
					10/21/1996	56.93	40.55
					11/13/1996	56.68	40.80
					01/09/1997	53.12	44.36

Table 8-1
Groundwater Monitoring Well Installation Details and Groundwater Surface Measurements

Monitoring Well	Ground Elevation (feet amsl)	Datum Elevation (top of PVC casing) (feet amsl)	Depth of Well (below ground) (feet)	Depth Interval of Gravel Pack (below ground) (feet)	Date (m-d-y)	Depth To Water Below Datum (feet)	Groundwater Surface Elevation (feet amsl)
					02/13/1997	50.85	46.63
					04/14/1997	52.81	44.67
					05/14/1997	53.47	44.01
					07/14/1997	55.61	41.87
					08/15/1997	56.50	40.98
					10/06/1997	58.02	39.46
					11/18/1997	57.75	39.73
					01/13/1998	57.39	40.09
					02/09/1998	55.86	41.62
					08/25/1998	57.50	39.98
					10/20/1998	58.92	38.56
					11/06/1998	58.64	38.84
					01/18/1999	59.63	37.85
					02/16/1999	59.05	38.43
					04/05/1999	59.68	37.80
					05/27/1999	61.70	35.78
					07/26/1999	61.99	35.49
					08/25/1999	62.72	34.76
					10/18/1999	63.30	34.18
					01/10/2000	63.79	33.69
					01/28/2000	63.67	33.81
					04/19/2000	61.73	35.75
					08/23/2000	63.91	33.57
					10/23/2000	62.02	35.46
					01/22/2001	62.85	34.63
					02/12/2001	63.22	34.26
					04/23/2001	63.59	33.89

NOTES:

1. *All data from the Aerojet Groundwater Database (Aerojet, 2002).*
2. *Elevation data have been rounded to two decimal places.*

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks												
	21-Jan-51	78	7.3	7.1	3.5	2.4	1.2	40	2	5.2	32	59
	2-Mar-51	80[A]	7.4[A]	7.4[A]	3.50[A]	3.1[A]	2.00[A]	41[A]	3.0[A]	5.3[A]	33[A]	58[A]
	11-Mar-51	72	7.4	6.8	3.1	2.9	2	40	2.6	4.6	30	54
	21-Mar-51	60	7.1	6.3	2.2	1.5		33	1.6	3	25	46
	1-Apr-51	54	7.2	5.8	1.9	2		29	1.8	2.6	22	44
	11-Apr-51	44	6.9	4.9	2.1	1.3	2.6	22	1		21	35
	21-Apr-51	49	7.3	5.3	2.1			27	1.4	2.3	22	39
	3-May-51	55	6.9	5.5	2.5	2.1	3.5	29	1.4	2.9	24	45
	11-May-51	42	7	4.5	1.8	1.8	1.5	23	1.4	1.8	19	31
	1-Jun-51	50	6.8	5.6	1.6	2.4	2.2	26	1.6	2.3	21	40
	11-Jun-51	52	6.8	5.6	1.5	2.5	1.9	27	2.3	3	20	41
	21-Jun-51	62	7	7.6	1.8	2.5	2.9	31	3	2.7	26	46
	1-Jul-51	75	7.2	9.7	2.2	3.4	2.2	39	2.6	3.8	33	56
	11-Jul-51	89	7.2	10	2.6	4.1	2.7	43	3.7	4.4	36	63
	21-Jul-51	94	6.8	9.4	3.3	3.2	2.4	46	4.2	4	37	65
	1-Aug-51	101	6.9	11	3.3	3.3	2.4	50	4.4	4.2	41	68
	11-Aug-51	102	6.9	11	3.4	3.3	2.4	50	4.8	4.1	41	68
	21-Aug-51	103	6.9	11	3.3	3.4	2.4	49	5.6	4.1	41	69
	1-Sep-51	102	6.9	11	3.4	3.2	2.4	49	4.9	4.9	41	67
	11-Sep-51	104	7.1	10	3.5	3.9	2.1	50	5	4.9	39	69
	21-Sep-51	102	7.3	10	3.4	3.9	2.4	50	4.9	4.9	39	68
	1-Oct-51	84	7.2	8.8	3.2	3.6	1.4	39	4	4.8	35	58
	11-Oct-51	79	7.1	7.9	2.8	3.1	1.6	36	3.2	5.8	31	54
	21-Oct-51	82	7.1	8.4	3.1	3	1.2	37	3.6	5.2	34	58
	1-Nov-51	77	7.2	7.9	3.1	2.9	1.2	38	3.4	4.7	32	53
	11-Nov-51	76	7.2	8.8	3.1	3.6	1.7	34	3.6	8.6	35	57
	21-Nov-51	81	7.3	7.9	3.1	2.4	2.9			4.8	32	61
	1-Dec-51	69	7.3	7	2.9	2	2.7	30	4	6	29	53
	11-Dec-51	71	7.4	7.3	3	2.2	2.7	30	3	5.5	31	53
	21-Dec-51	71	7.1	6.4	2.9	2.5	1	35	2.4	4.2	28	56
	1-Jan-52	76	7.1	7.2	3	2.7	1.6	38	2.5	4.7	30	59
	11-Jan-52	79	7.2	7	3.5	3.9	1.9	42	2.9	5.4	32	67
	1-Feb-52	69	7.4	6.8	2.8	2.1	1.2	35	1.8	3.9	28	53
	11-Feb-52	72	7.1	6.2	2.8	2.4	1.4			4	27	56

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks (cont'd)												
	21-Feb-52	78	7.2	6.8	3.2	2.5	1.3	37	3.4	4.6	30	59
	1-Mar-52	73	7	6.5	3.1	2.8	1.5	37	1.9	4.7	29	56
	11-Mar-52	89	7.6	7.4	4.2	3.2	0.7			5.3	36	64
	21-Mar-52	74	7.5	7	3.5	3	0.7	38	2	4.3	32	56
	1-Apr-52	55	7.1	5.2	2.1	2.3	1.1	26	3.1	2.4	22	42
	11-Apr-52	47	7.2	4.6	1.8	2	0.8	24	1.4	2.1	19	38
	21-Apr-52	42	7.1	4.2	1.5	1.7	0.5	22	0.8	2.4	17	35
	1-May-52	40	7	4	1.2	1.7	0.5	20	1.1	2.2	15	34
	11-May-52	38	6.9	4.8	2.5	1.4	0.5	22	2.4	2.1	22	33
	21-May-52	36	6.8	5	2.1	1.2	0.7	20	3.1	2.1	21	31
	1-Jun-52	31	6.7	5	2	1	0.8	22	0.8	1.8	21	29
	11-Jun-52	34	6.9	4	1.5	2.5	0.7	24	1	2.2	16	34
	21-Jun-52	36	6.9	4.2	1.5	1.6	0.6	20	0.9	1.8	17	32
	1-Jul-52	37	6.7	3.9	1.6	1.6	0.9	20	1.1	1.7	16	34
	11-Jul-52	42	6.7	5	1.7	1.7	1.1	24	1.2	2.8	20	40
	21-Jul-52	49	6.9	5.7	1.9	2	1.4	28	1.8	2.5	22	42
	1-Aug-52	56	7	6	2.1	2.2	0.9	30	1.9	2.8	24	44
	11-Aug-52	74	7.1	8.2	2.5	3	0.9	38	2.9	3.5	31	54
	21-Aug-52	78	7	8.4	2.7	3.3	1.4	39	3.4	3.7	32	55
	1-Sep-52	78	7.1	8.5	2.8	3.3	1.4	40	3.3	3.9	33	55
	11-Sep-52	81	7.2	8.5	2.8	3.4	1.4	40	3.6	4.6	33	56
	21-Sep-52	77	7	7.8	2.6	3.4	1.4	38	3.4	3.8	30	53
	1-Oct-52	75	7.4	8	2.5	4.5	1	38	4	4	30	54
	11-Oct-52	79	7.3	9.6	2.8	3	1.1	38	3.7	3.7	35	54
	21-Oct-52	82	7.3	8.8	2.9	3.2	0.8	39	3.7	3.7	34	56
	1-Nov-52	96	7.4	11	3.1	3.8	1.1	45	5	5	40	65
	11-Nov-52	99	7.2	10	3	5	1	43	5.8	5.8	37	64
	21-Nov-52	92	7.4	10	4	2.6	1	43	4.8	4.8	41	61
	1-Dec-52	88	7.3	10	3.5	2.6	1	40	6.1	6.1	39	61
	11-Dec-52	85	7.2	9.6	3.5	2.6	0.9	40	6.7	6.7	38	58
	21-Dec-52	88	7.4	9.1	3.5	3.8	0.7	40	6.2	6.2	37	60
	1-Jan-53	94	7.2	9	3.8	4.3	0.8	42	6.7	6.7	38	66
	10-Jan-53	57	7.2			0.8	0.8	28			36	
	11-Jan-53	64	7.3	7.4	2.7	2.8	0.7	32	4.4	4.4	30	50
	21-Jan-53	66	7.3	8.1	2.9	1.3	0.7	34	3.8	3.8	32	51
	1-Feb-53	66	7.4	7	2.5	2.8	0.6	34	3.9	3.9	28	48

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks (cont'd)												
	11-Feb-53	62	7.1	7.3	2.2	1.5	0.7	30	3.4	3.4	27	46
	21-Feb-53	64	7.4	7.3	2.3	3.4	1.1	32	3.9	3.9	28	49
	1-Mar-53	63	7.3	7.3	2.3	3.1	1.1	32	3.8	3.8	28	46
	11-Mar-53	64	7.2	6.9	2.6	3.6	1	33	3.7	3.7	28	48
	21-Mar-53	60	7.4	6.6	2.4	3.1	0.7	31	4.8	4.8	26	46
	1-Apr-53	46	7.3	5.6	1.5	2.2	0.5	25	2.6	2.6	20	38
	11-Apr-53	52	7.2	6.5	1.7	2.8	0.8	27	2.4	2.4	23	41
	21-Apr-53	44	7.1	4.7	1.5	2	0.5	22	2.1	2.1	18	34
	1-May-53	49	7.2	5.2	1.5	2.4	0.6	24	2.2	2.2	19	38
	11-May-53	46	6.8	4.8	1.7	2	0.5	23	2.6	2.6	19	35
	21-May-53	42	6.9	4.4	1.5	2	0.6	22	2.1	2.1	17	34
	1-Jun-53	39	7	4.4	1.2	3.1	0.8	23	1.6	1.6	16	34
	11-Jun-53	36	6.8	4.4	1.2	1.8	0.5	17	3.8	1.6	16	32
	21-Jun-53	32	7.2	3.8	1.1	2	0.5	19	1.8	1.3	14	29
	1-Jul-53	39	6.9	4.2	1.4	2	0.7	22	1.8	1.4	16	32
	11-Jul-53	46	7.3	5	1.3	2.8	0.8	23	3	1.8	18	35
	21-Jul-53	61	7.4	7.3	1.7	3.4	0.9	32	4	2.3	25	49
	1-Aug-53	76	7.5	8.9	2.4	3.1	0.8	38	4	3.7	32	55
	11-Aug-53	88	7.4	9.7	2.8	3.4	1.1	42	5.2	3.8	36	60
	21-Aug-53	89	7.3	9.7	3.1	3.8	1	43	6	4.1	37	61
	1-Sep-53	86	7.3	9.3	2.8	3.8	0.9	41	5.2	4.1	35	59
	11-Sep-53	75	7.1	7.9	2.2	3.1	0.9	33	3	3.6	29	51
	21-Sep-53	81	7	8.4	2.2	3.4	1	37	3.2	3.5	30	54
	1-Oct-53	78	7	7.7	2.6	3.4	1	35	4	3.5	30	52
	11-Oct-53	88	6.9	8.8	2.5	3.6	1	38	3.2	4.6	32	56
	21-Oct-53	69	7.1	7.6	2.7	3.4	0.8	33	4	4.3	30	52
	1-Nov-53	80	7.2	8.5	2.6	3.8	0.4	37	5	4.1	32	58
	11-Nov-53	85	7.2	8.9	3.1	4.1	0.4	39	5	5.2	35	66
	21-Nov-53	77	7	7.5	3.2	3.1	0.7	34	3.8	4.4	32	50
	1-Dec-53	78	7.3	7.3	2.8	2.8	0.7	33	3.8	4.6	30	54
	11-Dec-53	69	7.3	7.3	2.4	2.8	1.5	33	4	3.9	28	48
	21-Dec-53	68	7.3	7.1	2.2	3.1	0.7	32	3.2	4	27	47
	1-Jan-54	74	7.2	7.5	2.5	3.2	0.7	34	3.5	4.3	29	51
	11-Jan-54	84	7.4	8.2	3.1	3.8	0.7	38	3.5	5.3	33	61
	21-Jan-54	74	7.1	7.3	3.3	2.6	0.7	36	3.2	5	32	60
	1-Feb-54	69	7.1	7.8	2.3	3.4	0.6	34	3.2	4.4	29	50
	11-Feb-54	72	7	7.3	3.1	2.4	0.7	35	2.8	4.8	31	55

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks (cont'd)												
	21-Feb-54	69	7.3	6.9	2.9	2.8	0.7	35	3.2	4	29	50
	1-Mar-54	62	7.2	6.4	2.6	2	0.7	31	2.8	3.2	27	48
	11-Mar-54	66	7.2	6.4	2.9	2.4	0.6	31	2.5	3.4	28	49
	21-Mar-54	77	7.1	7.3	3.3	3.1	0.7	36	3.5	5	32	56
	1-Apr-54	66	7.1	6.7	3	2.4	0.7	34	2.5	3.5	29	51
	11-Apr-54	49	7	4.9	2.4	1.8	0.8	26	2	2.4	22	46
	21-Apr-54	42	7	4.3	1.5	1.5	1	21	1.8	1.7	17	36
	1-May-54	44	6.9	4.3	2.3	1.2	0.6	22	1.5	2.2	20	34
	11-May-54	37	6.8	3.8	1.8	1.2	0.6	20	1.5	1.6	17	32
	21-May-54	47	6.8	4.7	1.7	1.8	0.8	23	2	2.4	19	35
	1-Jun-54	51	6.8	7.4	2	2.2	0.8	27	5.5	3	27	50
	11-Jun-54	55	7.4	6.1	2.4	2.4	0.8	30	2.5	2.2	25	43
	21-Jun-54	66	7.1	6.8	2	2.7	0.9	32	2.8	2.6	25	47
	1-Jul-54	79	7.1	8.5	3.1	3	0.9	38	4	3.3	34	54
	11-Jul-54	92	7.3	9.6	3.4	3.6	1.1	44	5	4	38	62
	21-Jul-54	94	7.3	11	2.6	4.1	1.4	46	5.2	4.4	38	65
	1-Aug-54	101	7.1	11	3.1	4.7	1.5	48	6	4.7	40	69
	11-Aug-54	102	7.2	11	3.2	4.7	1.4	49	6.2	4.9	41	83
	21-Aug-54	100	7	11	2.8	3.8	1.2	46	5.5	4.5	39	65
	1-Sep-54	90	7	9.6	2.9	3.5	1.2	42	5	4	36	59
	11-Sep-54	87	7.1	8.9	2.6	3.4	0.9	39	4.8	3.8	33	57
	21-Sep-54	75	7.2	8	2.9	3.2	0.8	37	4.2	3.2	32	54
	1-Oct-54	72		7.8	2.1	3.2					28	55
	11-Oct-54	70		7.8	2	3					28	53
	21-Oct-54	81		8.9	1.9	3					30	56
	1-Nov-54	68		7.5	2	2.7					27	49
	11-Nov-54	82		8.9	2.3	3.1					32	58
	21-Nov-54	72		8	2.1	2.8					28	54
	1-Dec-54	75		7.8	2.4	2.7					30	57
	3-Dec-54	89		8.9	3.1	3.1					35	70
	4-Dec-54	75		7.8	2.4	2.7					30	57
	6-Dec-54	89		8.9	3.1	3.1					35	70
	8-Dec-54	75		7.8	2.4	2.7					30	57
	10-Dec-54	89		8.9	3.1	3.1					35	70
	11-Dec-54	87		8.9	3.2	2.9					36	65
	21-Dec-54	86		8.6	3.1	3.1					34	62
	1-Jan-55	80		7.8	3.2	3.2					32	63

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks (cont'd)												
	11-Jan-55	92		8.4	3.7	3.4					36	67
	21-Jan-55	97		9.6	3.9	4					40	64
	1-Feb-55	92		9.1	3.5	3.8					37	60
	11-Feb-55	92	7.3	8.5	3.4	3.5		43			35	62
	21-Feb-55	83	7.5	7.9	3.2	3.4		41			33	60
	1-Mar-55	94	7.4	8.8	3.9	3.6		45			38	67
	11-Mar-55	75	7.5	7.4	2.8	2.9		37			30	59
	21-Mar-55	81	7.1	8.1	3.1	3.3		40			33	66
	1-Apr-55	80	7.1	8.1	2.6	3.3		38			31	59
	11-Apr-55	78	7.2	7.9	2.5	3.2		36			30	60
	21-Apr-55	62	7.3	8.1	1.7	2.8		31			27	46
	1-May-55	62	7.2	6.6	1.8	2.4		31			24	44
	11-May-55	59	7.1	5.1	3	2.6		30			25	43
	21-May-55	51	7.1	5.1	2	2.2		25			21	34
	1-Jun-55	44	6.8	5	1.8	2.1		24			20	37
	11-Jun-55	40	6.9	4.4	1.7	2.1		24			18	34
	21-Jun-55	40	6.8	4.4	1.2	1.8		24			16	34
	1-Jul-55	42	6.8	5	0.9	1.9		23			16	36
	11-Jul-55	43	6.7	4.6	1.1	1.9		23			16	38
	21-Jul-55	46	6.6	4.8	1	1.9		24			16	37
	1-Aug-55	50	7	4.6	1.6	2.1		25			18	38
	11-Aug-55	52	7.3	5	1.6	2.2		25			19	48
	21-Aug-55	54	6.9	5.4	1.6	2.2		28			20	46
	1-Sep-55	58	6.7	6	2	2.3		30			23	50
	11-Sep-55	64	6.7	7	1.8	2.3	1.2	32	2.2	2	25	52
	21-Sep-55	70	6.9	7.6	1.7	2.4		34			26	55
	1-Oct-55	72	7.5	7.8	2	2.9		37			28	54
	11-Oct-55	70	7.6	8	2	2.8		38			28	50
	21-Oct-55	72	7.4	8	2.2	2.8		38			29	48
	1-Nov-55	74	7.6	8.2	2	2.9		38			28	48
	11-Nov-55	71	7.5	8	2.1	2.8		37			28	48
	21-Nov-55	71	7.5	8	1.8	2.6		37			28	48
	1-Dec-55	72	7.5	8	2.2	2.8		36			29	52
	11-Dec-55	77	7.4	8.6	2.2	3		37			30	56
	23-Dec-55	50	7.1	6	1.1	1.8		25			20	47
	1-Jan-56	54	7.2	6.2	1.6	1.8		28			22	48
	11-Jan-56	58	7.3	6.2	1.8	2.1		29			23	50

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks (cont'd)												
	21-Jan-56	56	7.2	6.4	1.6	2.1		30			22	50
	1-Feb-56	63	7.6	6.4	2.1	2.3		36			25	50
	11-Feb-56	64	7.5	6.7	2.2	2.4		37			26	48
	21-Feb-56	62	7	6.6	2.2	2.3		37			25	48
	1-Mar-56	65	7.1	6.8	2.2	2.3		37			26	50
	11-Mar-56	67	7.2	7	2.4	2.4		38			27	53
	21-Mar-56	69	7.1	6.8	2.4	2.5		39			27	50
	1-Apr-56	69	6.8	5.6	2.9	2.2		38			26	50
	11-Apr-56	61	6.8	6	2.4	2.2		36			25	48
	21-Apr-56	58	6.9	4.8	2.7	2		32			23	44
	1-May-56	51	6.9	5.2	2.2	2		30			22	41
	11-May-56	57	6.9	5.8	1.2	2		29			19	40
	21-May-56	46	6.7	5.7	1	1.8		27			18	37
	1-Jun-56	48	6.7	5	1.7	1.9		27			20	34
	7-Jun-56	42	7.2	4.4	1.3	1.6	0.6	26	0.5	0	16	38
	16-Jun-56	42	6.7	4.8	1.2	1.9		25			17	34
	1-Jul-56	40	6.6	4.2	1.2	1.6		23			16	37
	16-Jul-56	38	7	3.8	1.3	1.7		22			15	38
	1-Aug-56	39	6.8	4	1.3	1.8	1	24	0.5		15	36
	16-Aug-56	42	6.7	4.8	1	2	0.9	25	1.2		16	38
	22-Aug-56	36	6.7	4	1.2	1.5	0.7	24	1	0	15	33
	1-Sep-56	42	6.8	5.4	0.8	1.9	0.9	25	1		17	38
	16-Sep-56	46	6.7	5.2	1.2	2	1	27	1		18	38
	1-Oct-56	60	6.8	6	2.4	2.1		35			25	42
	1-Nov-56	63	6.9	6	2.4	2.4		37			25	44
	4-Nov-56	62	6.7	6.8	1.7	2.4		28			24	42
	1-Dec-56	67	6.5	6.8	1.9	2.4		29			25	43
	16-Dec-56	65	6.6	7.2	1.5	2.4		30			24	44
	1-Jan-57	63	6.6	7.2	1.7	2.8		29			25	41
	11-Jan-57	66	6.6	7	1.8	2.7		29			25	42
	21-Jan-57	67	6.8	7.4	2.1	2.7		31			27	44
	1-Feb-57	71	7.8	7.6	2.2	2.5		34			28	46
	25-Feb-57	65	7.1	7.4	2.8	2.4		30			30	50
	5-Mar-57	58	7.1	6.6	2.1	2.1		27			25	44
	10-Mar-57	60	7	6.6	2.1	2.1		26			25	43
	1-Apr-57	61	7	6.8	1.6	2.7		28			24	46
	13-Apr-57	59	7	6.5	1.6	2.3		27			23	47

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks (cont'd)												
	27-Apr-57	58	7	6.7	1.3	2.4		26			22	47
	1-May-57	58	7	6.8	1.2	2.4		28			22	44
	14-May-57	56	6.7	5.2	2.2	2.4		26			22	40
	20-May-57	52	6.6	5.8	1.1	2.9		22			19	42
	1-Jun-57	50	7.2	4.8	1.7	2.3		24			19	34
	12-Jun-57	52	6.9	4.8	1.8	2.5		25			20	38
	18-Jun-57	52	6.8	5	1.7	2.4		24			20	34
	1-Jul-57	51	6.8	5	1.7	2.4		23			20	36
	19-Jul-57	50	7	4.4	1.9	2.1		23			19	36
	1-Aug-57	49	7	5.6	1.9	2.1		26			22	42
	10-Aug-57	47	6.7	5.2	1.7	2		25			20	34
	21-Aug-57	59	6.8	6.4	1.7	2.5		24			23	47
	1-Sep-57	49	6.7	4.8	1.9	2.3		22			20	36
	11-Sep-57	49	6.5	2.8	2.7	2.4	1	22	1	4.8	18	42
	21-Sep-57	52	6.9	5.2	1.7	2		24			20	36
	1-Oct-57	56	6.7	6	1.5	2.1		24			21	39
	4-Oct-57	60	6.9	6.4	2.4	2.3		28			26	42
	24-Oct-57	69	6.8	6.8	2.2	2.6		30			26	48
	1-Nov-57	64	6.7	6.7	2.2	2.1		30			25	45
	24-Nov-57	87	6.6	11	1.7	2.6		31			34	61
	25-Nov-57	65	6.9	7	2.1	2.2		30			26	46
	1-Dec-57	67	6.8	7.1	2.3	2.4		30			27	47
	18-Dec-57	68	6.7	7.3	2.3	2.4		31			28	48
	1-Jan-58	76	7.1	8	2.9	2.5		30			32	53
	10-Jan-58	73	6.7	7.6	3.2	2.5		30			32	51
	27-Jan-58	79	6.8	8.4	2.4	2.5		31			31	55
	29-Jan-58	82	6.6	8.8	2.4	2.6		31			32	57
	1-Feb-58	72	7.1	7.2	2.7	2.6		31			29	50
	19-Feb-58	73	6.9	7.6	2.2	2.8		32			28	51
	22-Feb-58	69	7.1	6.8	2.3	2.6		30			26	48
	25-Feb-58	68	6.8	6.4	2.3	2.6		31			25	48
	4-Mar-58	65	7.1	6.5	1.9	2.2		28			24	46
	24-Mar-58	68	7.7	6.6	2.2	2.4		32			25	48
	1-Apr-58	69	7.3	6.2	2.6	2.7		31			26	48
	11-Apr-58	71	7.3	6.3	2.7	2.7		33			27	50
	19-Apr-58	64	7.2	6.4	1.8	2.2		30			24	45
	1-May-58	55	7.2	5.7	1.1	2		26			18	38

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks (cont'd)												
	14-May-58	47	7	4.8	1	2.1		22			16	33
	24-May-58	42	6.9	4.6	0.2	1.7		20			12	29
	1-Jun-58	48	6.3	4.4	1.7	2	0.4	17			18	34
	4-Jun-58	39	6.6	3.2	1.5	2	0.4	18			14	27
	1-Jul-58	45		4.4	1.3	2.1	0.4	18			16	32
	1-Aug-58	63	8	4	2.1	4.6	0.6	34			18	44
	2-Aug-58	39	6.7	4.8	0.5	2.1	0.6	16			14	27
	1-Sep-58	40	6.5	2.8	1.9	1.7	0.6	18			15	28
	17-Sep-58	57	6.7	4.4	2.1	3.6	0.6	28			20	40
	19-Sep-58	41	6.5	4.4	1.2	1.7	0.6	18			16	29
	18-Nov-59	74	6.6	8	2.7	2.6	1.1	29	4.2	7	31	52
	1-Dec-59	73	6.7	8	2.7	2.6	0.7	31	4	6	31	51
	16-Dec-59	74	6.7	7.2	2.9	2.6	0.8	31	4.8	3	30	52
	1-Jan-60	78	6.8	8	2.9	2.8		34			32	55
	16-Jan-60	77	7.4	8.8	2.4	2.6		34			32	54
	1-Feb-60	76	6.4	8.2	2.8	2.4		16			32	53
	13-Feb-60	63	7.2	7.6	2.2	2.1		24			28	44
	1-Mar-60	69	7.2	12	0	2.4		28			30	48
	16-Mar-60	63	7	10	0.2	2.1		26			26	44
	1-Apr-60	64	7.4	7.2	1.9	2.2		32			26	45
	10-Apr-60	59	7.2	7.2	1.7	1.9		31			25	41
	19-Apr-60	60	7.2	6.4	1.9	2.1		30			24	42
	1-May-60	58	7.1	4.8	2.2	1.9		29			21	41
	11-May-60	56	7.2	4.8	2.9	1.9		29			24	39
	21-May-60	54	7.2	5.6	2.4	1.9		29			24	38
	1-Jun-60	55	7.1	6	1.9	2		28			23	38
	10-Jun-60	55	6.5	5.6	2.1	2		30			22	38
	21-Jun-60	53	6.7	5.2	2.2	1.9		27			22	37
	1-Jul-60	53	7.6	5.6	1.5	2.1		25			20	37
	12-Jul-60	52	7.6	5.2	1.9	2.2		25			21	36
	21-Jul-60	52	7.5	6.4	1	2.8		25			20	36
	1-Aug-60	52	7.3	8	0.2	2.5		25			21	36
	11-Aug-60	52	7.2	8	0.2	2.2		24			21	36
	21-Aug-60	52	7.5	8	0.5	2.4		26			22	36
	1-Sep-60	54	6.7	5.6	1.5	2.4		22			20	38
	13-Sep-60	54	6.6	6	1.2	2.4		21			20	38
	21-Sep-60	55	6.6	5.2	1.7	2.2		23			20	38

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks (cont'd)												
	1-Oct-60	71	7.8	6.5	2.8	3.9		37			28	50
	11-Oct-60	71	7.8	6.3	2.8	4.2		37			27	50
	21-Oct-60	63	7.6	6.2	2.3	2.9		31			25	44
	1-Nov-60	64	7.2	6	2.9	2.7		32			27	45
	11-Nov-60	64	7.2	6.3	2.4	3.1		32			26	45
	22-Nov-60	65	7.3	6.7	2.6	2.7		33			27	46
	1-Dec-60	67	6.4	6.4	2.4	2.6		26			26	47
	11-Dec-60	68	6.5	7.2	2.4	2.6		28			28	48
	21-Dec-60	66	6.7	8	1.5	2.6		28			26	46
	1-Jan-61	68	6.6	8	1.5	2.6		28			26	48
	10-Jan-61	67	6.7	8	1.5	2.9		28			26	47
	21-Jan-61	68	6.7	8	1.5	2.9		28			26	48
	1-Feb-61	73	7.4	7.4	2.9	2.8		35			30	51
	11-Feb-61	75	7.4	7.8	2.1	4.6		35			28	52
	21-Feb-61	79	7.1	7.7	3.2	3.3		35			32	55
	1-Mar-61	77	7.1	8.8	2.4	3.3		33			32	54
	11-Mar-61	77	7.1	8.8	2.4	3.3		32			32	54
	21-Mar-61	78	6.9	8.8	2.4	3.2		32			32	55
	1-Apr-61	78	6.7	8.8	2.2	3.1		32			31	55
	11-Apr-61	78	6.9	8.8	2.4	3.6		32			32	55
	21-Apr-61	77	7.1	8.8	2.2	3.1		31			31	54
	1-May-61	76	6.9	8	3.4	2.1		32			34	53
	11-May-61	75	6.7	8	3.9	1.7		30			36	52
	21-May-61	73	6.8	8	2.9	2		32			32	51
	1-Jun-61	68	7.4	7.2	2.4	2.7		28			28	48
	1-Jul-61	59	6.8	6.4	1.9	2.4		26			24	41
	1-Aug-61	56	7.2	5.6	2.4	2.1		26			24	39
	1-Sep-61	62	7.3	6.4	2.4	2.9		29			26	43
	1-Oct-61	68	7.5	7.2	2.9	2.6		30			30	48
	1-Nov-61	72	7.2	7.2	3.4	2.7		32			32	50
	1-Dec-61	76	7	8	2.4	2.8		34			30	53
	31-Jan-62	80	7.6	8.1	2.7	4		38			31	56
	1-Feb-62	80	7.3	9.1	2.6	4.1		35			33	56
	10-Feb-62	76	7.1	7.5	2.8	3.7		32			30	53
	17-Feb-62	70	7.3	7.3	2.4	3.3		30			28	49
	1-Mar-62	74	7.2	9.6	1.4	3.1		28			30	52
	1-Apr-62	75	7.4	11	0.9	3.3		34			31	52

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River at Fair Oaks (cont'd)												
	16-Apr-62	62	7.2	8.8	0.7	3.2		28			25	43
	1-May-62	56	7.4	6.8	1	3.2		24			21	39
	9-May-62	49	7.1	5.2	2.2	2.3		23			22	34
	1-Jun-62	46	7.4	5.5	0.6	2.2		21			16	32
	1-Jul-62	45	7.3	4	1.5	2.3		21	2.9		16	32
	1-Aug-62	47	7.5	5.4	0.9	2.1		24	2.1		17	33
	1-Sep-62	46		4.9	1.2	2.3	0.5	20	1.2	0.6	17	32
American River Sacramento USGS 11447000												
	7-Oct-60	58	7.2			2.1		27	3.2		24	
	4-Nov-60	62	7.3			2		30	1.2		25	
	19-Dec-60	66	7.5			2.3		34	2.2		29	
	6-Jan-61	64	7.5			2		32	1.2		26	
	9-Feb-61	71	7.7			3		35	2.4		29	
	3-Mar-61	81	7.7			3.4		34	5.2		33	
	6-Apr-61	78	7.7			1.6		35	3.8		34	
	5-May-61	76	7.6	8.4	2.3	3.3	1	33	3.8	4	31	
	2-Jun-61	70	7.4			2.7		29	3		28	
	5-Jul-61	61	7.5			2.1		27	2.5		25	
	7-Aug-61	54	7.5			1.9		24	4		20	
	11-Sep-61	59	7.4	6.8	1.7	1.9	0.7	26	4	2	24	
	9-Oct-61	68	7.5			2.7		32	2		26	
	9-Nov-61	73	7.4			2.6		32	3		29	
	4-Dec-61	73	7.3			2.8		36	3.4		30	
	8-Jan-62	80	7.5			2.5		37	3.5		33	
	6-Feb-62	81	7.7			3.3		34	5.1		34	
	5-Mar-62	68	7.5			2.2		30	2		28	
	4-Apr-62	74	7.8			2.9		34	3.5		33	
	10-May-62	48	7.4	6	1.2	1.8	0.9	22	2.5	4	20	
	6-Jun-62	44	7.1			1.8		21	1.5		19	
	5-Jul-62	43	7.4			2.4		21	2.2		17	
	8-Aug-62	53	7.1			2.8		18	3		16	
	11-Sep-62	43	7	4.7	1.2	1.9	0.5	21	1	0.8	17	
	2-Oct-62	52	7.3			2.6		22	4		18	
	7-Nov-62	54	7			1.8		24	1.8		22	
	3-Dec-62	58	7.3			2.6		26	2.8		23	
	14-Jan-63	63	7.4			2.3		29	4.5		28	

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River Sacramento USGS 11447000 (cont'd)												
	7-Feb-63	53	6.9			1.9		24	3.2		21	
	18-Mar-63	61	7.7			2.5		29	2.8		25	
	16-Apr-63	69	7.7			2.6		34	1.7		29	
	15-May-63	64	7.2	7.2	2.4	2.4	0.5	32	1.6	3.2	28	
	3-Jun-63	58	7.4			2.4		28	1.1		25	
	8-Jul-63	53	7.3			2.2		26	1.4		21	
	6-Aug-63	55	7.4			2.4		28	1		22	
	12-Sep-63	58	7.2	5.8	1.9	2.4	0.8	26	1.6	2.8	23	
	9-Oct-63	63	7.2			2.2		30	3.1		25	
	4-Nov-63	56	7.4			2		26	3		22	
	6-Dec-63	65	7.5			2.3		30	2		26	
	6-Jan-64	65	7.7			2.5		28	4.2		26	
	7-Feb-64	70	7.8			4.5		30	3.2		27	
	2-Mar-64	73	7.4			3.6		30	4		28	
	10-Apr-64	74	7.7			3.4		33	3		29	
	4-May-64	72	7.8	8.4	1.8	2.8	0.5	32	4	5	28	
	12-Jun-64	64	7.7			3		28	2.5		25	
	7-Jul-64	64	7.8			2.9		27	1.5		23	
	3-Aug-64	56	7.4			3.2		26	2		22	
	1-Sep-64	56	7.4	6	1.7	2.6	1.2	26	2	3	22	
	6-Oct-64	61	7.7			2.9		27	1.6		24	
	12-Nov-64	65	7.4			3.1		27	2		24	
	7-Dec-64	78	7.7			3.8		31	3.1		28	
	6-Jan-65	56	7.2			2.3		25	0.8		21	
	1-Feb-65	59	7.7			2.3		26	1.5		24	
	3-Mar-65	60	7.8			2.4		27	1.4		24	
	5-Apr-65	62	7.6			2.7		28	1.6		24	
	5-May-65	62	7.5	7.2	1.5	2.3	0.9	28	1.3	3	24	
	16-Jun-65	55	7.8			2.6		25	1.3		21	
	13-Jul-65	49	7.8			2.8		22	1.1		18	
	9-Aug-65	48	7.7			2.9		22	1		18	
	15-Sep-65	52	7.2	7.4	0.2	2.1	0.9	24	1.2	3	20	
	4-Jun-76	60	8.1	6	1.9	2.9	1		2.5	4.2	23	
	27-Sep-77	119	7.4	10	2.7	6.4	1.7	46	7.9	3.3	36	
	11-Oct-77	138	7.2	14	3.6	9.7	2.2	41	10	12	50	
	24-Oct-77	144	7.9	13	3.1	9.3	2	48	12	7.4	45	

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River Sacramento USGS 11447000 (cont'd)												
	8-Nov-77	133	7.4	9.8	2.8	9.7	2.1	49	14	7.2	36	
	22-Nov-77	122	6.9	9.5	2.6	7.9	2.2		9.1	9.4	34	
	6-Dec-77	138	7.3	11	3.6	9.3	2.1	52	10	9.1	42	
	20-Dec-77	135	6.5	13	3	8.2	2.1	41	9.6	7.9	45	
	3-Jan-78	150	6.8	13	3.3	8.6	2.2	50	11	11	46	
	18-Jan-78	103		12	3.9	4.4	1.5	38	11	11	46	
	31-Jan-78	78	6.6	11	2.8	3	0.9	34	3	8.1	39	
	13-Feb-78	76	7	9.3	2.6	2.8	0.9	33	2.5	5.9	34	
	28-Feb-78	83	6.6	8.3	2.7	3	0.8	36	3.4		32	
	13-Mar-78	74	6.9	7.9	3	2.6	0.7	34	2.7	4	32	
	27-Mar-78	75	6.7	9.3	3	2.8	0.8	35	2.8	5.1	36	
	10-Apr-78	76	7.3	6.6	2.8	2.7	0.7	32	2.8	1.8	28	
	24-Apr-78	64	6.9	7.1	2.8	2.5	0.7	32	2.8	9.6	29	
	8-May-78	64	7.2	6.4	2.7	2.2	0.7	32	2.4	3.2	27	
	22-May-78	66	7.7	6.1	2.3	2.4	0.6	31	2.2	4.4	25	
	5-Jun-78	55	7.5	6.2	1.8	2.7	0.6	28	2.1	1.8	23	
	19-Jun-78	56	7	4.6	2.1	2.7	0.7	25	2.5	1.9	20	
	10-Jul-78	56	7.1	5.6	2	2.8	0.8	24	2.5	3.9	22	
	24-Jul-78	55	7.1	5	1.8	3	0.8	410	2.5	3.9	20	
	7-Aug-78	48	7.1	4.6	1.6	2.4	0.7	20	2.4	1.7	18	
	21-Aug-78	59	7	5	1.8	3.3	0.9	25	3.3	4	20	
	5-Sep-78	49	6.9	4.9	1.5	1.5	0.6	24	1.8	2.6	18	
	18-Sep-78	52	7.1	5	1.6	2.1	0.7	25	2.2	2	19	
	3-Oct-78	53	6.6	5.9	1.7	2.5	0.7		2.7	3.3	22	
	24-Oct-78	61	6.7	5.7	1.9	3.9	0.9		3.7	3.8	22	
	6-Nov-78	58	6.8	5.5	1.8	3.2	0.9		3.3	5.1	21	
	22-Nov-78	61	6.3	5	1.6	2.9	1		3.4	2.9	19	
	4-Dec-78	70	6.4	5.8	1.9	3.7	0.9		3.5	5.8	22	
	18-Dec-78	62	7.2	5.6	1.9	3.6	1.2		2.6	3.8	22	
	8-Jan-79	68	7.3	5.7	1.8	3.8	0.9		3.5	4.3	22	
	22-Jan-79	58	7.9	5.3	1.9	2.6	0.6		2.7	4	21	
	5-Feb-79	76	7.2	5.9	2.3	3.6	0.7		4.4	4.2	24	
	22-Feb-79	57	7.5	8.7	2.1	2.1	0.6		2.1	8.3	30	
	5-Mar-79	61	7.2	7	2.4	2.6	0.6		2.4	5.1	27	
	19-Mar-79	60	7.3	7.6	2.6	2.7	0.6		2.5	5.8	30	

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River Sacramento USGS 11447000 (cont'd)												
	9-Apr-79	68	7.7	5.7	2.4	2.4	0.6		2.8	5.2	24	
	23-Apr-79	77	7.5	7	2.8	2.7	0.7		2.5	5	29	
	7-May-79	74	7.4		2.6	2.9	0.7		2.6	5		
	22-May-79	68	7.8	7.1	1.4	2.6	0.8		1.8	7.1	24	
	4-Jun-79	60	8.1	6	1.9	2.9	1		2.5	4.2	23	
	25-Jun-79	50	7.4	5.6	2.1	3.1	0.8		2.4	5.1	23	
	9-Jul-79	56	7.1	4.9	1.8	2.7	0.9		2.5	5.4	20	
	23-Jul-79	51	7.3	4.4	1.7	2.6	0.8		2	0.9	18	
	16-Aug-79	57	6.8	5.2	1.7	2.6	0.8		2.4	5.9	20	
	27-Aug-79	57	7.3	4.5	1.5	2.7	0.8		2.3	3.6	17	
	10-Sep-79	49	6.6	4.8	1.6	2.6	0.7		1.6	4.9	19	
	24-Sep-79	56	6.7	5.5	1.7	2.6	0.7		2.1	4	21	
	2-Oct-79	86	6.9									
	10-Oct-79	50	7.5	4.5	1.7	2.4	0.6		1.6	2.4	18	
	2-Apr-80	59	7									
	1-May-80	56	6.9									
	5-Jun-80	56	7.7									
	1-Jul-80	49	7									
	7-Aug-80	50	7.4									
	3-Sep-80	49	6.8									
	3-Nov-95	43	6.7									
	21-Feb-96	58	7.5	5.6	2	2.4	0.7		2	2		
	18-Mar-96	57	7.4	5.3	2.3	2.3	0.6		1.9	2.1		
	5-Apr-96	54	7	5.4	2.1	2.4	0.6		1.7	1.8		
	15-May-96	50	7.5	5	1.7	2.2	0.5		1.5	2		
	12-Jun-96	40	7.4	4	1.4	1.7	0.6		1	1.4		
	19-Jul-96	42	7.5	4.2	1.4	1.8	0.7		1.2	1.3		
	13-Aug-96	44	7.2	4.4	1.4	1.9	0.7		1.3	1.5		
	13-Sep-96	46	7.4	4.9	1.5	1.9	0.6		1.4	1.5		
	11-Oct-96	45	7.3	4.9	1.5	1.8	0.6		1.3	1.4		
	12-Nov-96	48	7.3	5	1.4	2	0.6		1.4	1.6		
	6-Dec-96	47	7.7	5.3	1.6	2	0.7		1.7	1.6		
	10-Jan-97	45	7.6	5	1.6	1.4	1		0.9	1.7		
	5-Feb-97	56	7.5	4.9	2.2	2.1	0.8		1.4	2.1		
	24-Mar-97	52	7.5	5.15	1.78	2	0.74		1.3	2.1		
	25-Apr-97	54	7.6	5.78	1.75	2.1	0.73		1.5	2.2		

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River Sacramento USGS 11447000 (conf'd)												
	15-May-97	51	7.6	5.33	1.62	2	0.74		1.4	1.9		
	12-Jun-97	49	7.4	5.14	1.56	2	0.69		1.3	1.7		
	25-Jul-97	47	7.5	4.49	1.31	1.8	0.73		1.4	1.5		
	19-Aug-97	48	7.2	4.74	1.4	1.9	0.74		1.4	1.5		
	15-Sep-97	47	7.3	4.96	1.4	1.9	0.79		1.4	1.6		
	24-Oct-97	47	7.4	4.94	1.4	1.9	0.76		1.3	1.7		
	21-Nov-97	50	7.4	5.35	1.53	1.9	0.73		1.4	1.5		
	11-Dec-97	57	7.4	6.07	1.77	2.2	0.83		1.9	2.4		
	23-Jan-98	59	7.5	5.71	2.18	2.1	0.67		1.9	2.5		
	12-Feb-98	62	7.6	6.17	2.55	2.2	0.66		2.3	3		
	12-Mar-98	68	7.5	6.42	3.02	2.6	0.66		2	0.9		
	16-Apr-98	57	7.6	5.98	2.37	2.3	0.61		1.6	2.2		
American River Study Area - Groundwater												
1357	18-Mar-91			88	33	20	3.8	230	96	24		
	30-May-91			81	33	22	4.9	230	94	24		
	8-Aug-91			84.9	33.8	20.4	<5		110	22		
	5-Nov-91			85	31	21	4.2		99	22		
	27-Jan-92			73	28	17	4.3		98	21		
	13-Jul-92			85	34	22	4.9		97	24		
	25-Jan-93			85	31	19	5.5		100	23		
1358	19-Mar-91			47	17	13	2.5	160	19	15		
	3-Jun-91			49	18	14	3.6	170	17	15		
1359	19-Mar-91			42	18	13	3.6	160	15	15		
	3-Jun-91			41	17	15	4.6	170	15	15		
1382	18-Mar-91			36	15.9	18.3	2.7	150	13.2	16.6		
	4-Jun-91			35	16	18	2.4	150	13	17		
1383	27-Mar-91			42	19	14	2.8	160	24	17		
	10-Jun-91			42	18	16	4.7	150	20	17		
1384	27-Mar-91			48	21	15	3.7	170	28	18		
	11-Jun-91			47	21	17	5.1	180	34	18		

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River Study Area - Groundwater (cont'd)												
1516	30-Mar-93			14	5.4	5	<1.		2.1	3.1		
1519	9-Nov-92			27	6.1	11	8.2		9.2	9.3		
1520	9-Nov-92			35	2.0	8	5.1		21	8.3		
1521	9-Nov-92			33	3.0	19	20		14	21		
1522	10-Nov-92			19	1.6	11	6.4		22	8		
1523	10-Nov-92			75	23	15	12		160	8.4		
1524	9-Nov-92			25	8.8	13	11		16	12		
1562	25-May-94			11	4.2	3	1.6		2.4	2.8		
1563	25-May-94			22	3	5.2	3		3.1	7.8		
1570	24-May-94			44	0.9	16.3	6.5		6.4	5.6		
1571	24-May-94			8.9	2.8	3.2	1.3		2.7	3.2		
1572	26-May-94			34	0.88	13	6.1		32	13		
1573	26-May-94			19	1.4	17	6		20	17		
1574	26-May-94			7.5	1.9	10	2.4		3.2	10		
1587	18-May-95			55	0.5	18	9		52	18		
1588	1-Jun-95			26	4.6	17	6.8		17	17		
1589	2-Jun-95			22	4.6	29	6.5		21	29		
4300	10-Oct-96			29	12	8.3	2.3		9.7	9.8		
4301	10-Oct-96			23	7.1	5.8	3		18	5.3		
4302	10-Oct-96			29	9.8	8.5	4.9		37	6.2		

Table 8-2
Water Quality: Indicator Parameter Concentrations

Monitoring Station	Date	Specific Conductance	pH	Calcium:D	Magnesium:D	Sodium:D	Potassium:D	Bicarbonate	Chloride:D	Sulfate:D	Tot Hard as $CaCO_3$	TDS
	(d-m-y)	(µS/cm)	(units)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
American River Study Area - Groundwater (cont'd)												
4325	29-Aug-96			70	28	63	3.7	240	140	20		490
4330	25-Aug-96			63	25	18	4.9	200	51	20		350
4335	22-Aug-96			50	17	16	6	180	17	15		270
4370	4-Aug-95			9.3	3.3	6.2	2.1	42	3.7	3.7		84
4375	2-Aug-95			18	6.3	10	3.2	76	8.8	5.7		120
4380	17-Jul-95			26	9.4	13	4.1	110	7.7	8.2		190
	29-Aug-95			69	29	65	4.1	240	110	21		490

Notes:

1. The superscript A denotes mean value.
2. Blank cells denote analytical result could not be found at either the USGS website (http://waterdata.usgs.gov/nwis/) or the Aerojet Database (Aerojet, 2002).

9A

Oversized Maps

(see binder)

APPENDIX A

BUFFALO CREEK FLOWRATE MEASUREMENTS AND CALIBRATION CERTIFICATE

KOMEX INTERNATIONAL LTD.
Suite 100, 4500 - 16 th Avenue N.W.
Calgary, Alberta, T3B 0M6 CANADA
Tel: (403) 247-0200
FAX: (403) 247-4811

CURRENT METER NOTES

PROJECT #: Sacramento Job 205-01
PROJ NAME: ARGET
LOCATION: Buffalo Creek Meas. #1 - Coloma Rd. Crossing
CLIENT: Hatch and Parent

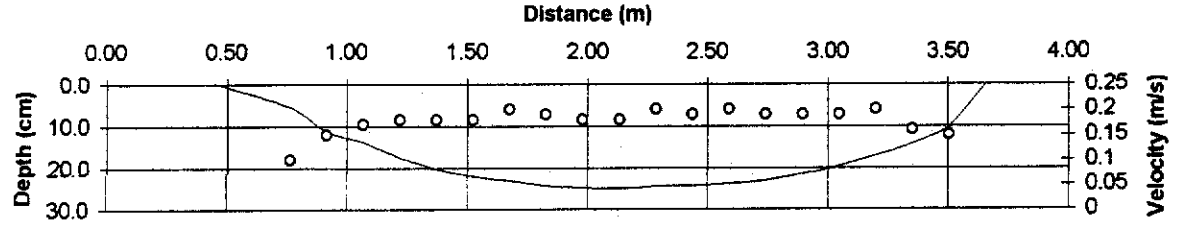
DATE: 25-Apr-02 (YY/MM/DD) TIME: 11:30 AM (HH:MM) RECORDED BY: RKS / DJF
DATALOGGER READING: N/A DATALOGGER #/ID: Ashtead Technology
MANUAL DEPTH TO WATER: N/A STAGE GAUGE READING: N/A m
METER: Marsh McBirney CREST GAUGE READING: N/A m
COMMENTS: Measured upstream of Waypoint 003 TOTAL STREAM WIDTH: 3.60 m
UTM 0651505 4276266

DISCHARGE: 0.1028 m^3/s CALC. ELEVATION (from manual depth): N/A m
CALCULATED ELEVATION (from datalogger): N/A m

OBSERVATIONS					COMPUTATIONS			
MEASURE POINT #	DISTANCE FROM INITIAL POINT (m)	TOTAL DEPTH (cm)	VELOCITY (m/s)	ANGLE OF FLOW (degrees)	WIDTH (m)	AREA (m^2)	DISCHARGE (m^3/s)	% OF TOTAL DISCHARGE
1	0.46	0.0		N/A				
2	0.76	5.4	0.10	N/A	0.229	0.0123	0.0012	1.2
3	0.91	11.2	0.15	N/A	0.152	0.0171	0.0026	2.5
4	1.07	13.8	0.17	N/A	0.152	0.0210	0.0036	3.5
5	1.22	17.5	0.18	N/A	0.152	0.0267	0.0048	4.7
6	1.37	20.2	0.18	N/A	0.152	0.0308	0.0055	5.4
7	1.52	22.0	0.18	N/A	0.152	0.0335	0.0060	5.9
8	1.68	23.2	0.20	N/A	0.152	0.0354	0.0071	6.9
9	1.83	24.3	0.19	N/A	0.152	0.0370	0.0070	6.8
10	1.98	24.8	0.18	N/A	0.152	0.0378	0.0068	6.6
11	2.13	25.0	0.18	N/A	0.152	0.0381	0.0069	6.7
12	2.29	24.5	0.20	N/A	0.152	0.0373	0.0075	7.3
13	2.44	24.3	0.19	N/A	0.152	0.0370	0.0070	6.8
14	2.59	23.9	0.20	N/A	0.152	0.0364	0.0073	7.1
15	2.74	23.2	0.19	N/A	0.152	0.0354	0.0067	6.5
16	2.90	21.5	0.19	N/A	0.152	0.0328	0.0062	6.1
17	3.05	19.5	0.19	N/A	0.152	0.0297	0.0056	5.5
18	3.20	17.0	0.20	N/A	0.152	0.0259	0.0052	5.0
19	3.35	14.2	0.16	N/A	0.152	0.0216	0.0035	3.4
20	3.51	10.0	0.15	N/A	0.152	0.0152	0.0023	2.2
21	3.66	0.0		N/A				
22								
23								
Total							0.1028	100.0

Channel Flowrate: 1630 gallons per minute

Channel Cross-section



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CURRENT METER NOTES

PROJECT #: Sacramento Job 205-01
PROJ NAME: ARGET
LOCATION: Buffalo Creek Meas. #2 - Before Emptying into American River
CLIENT: Hatch and Parent

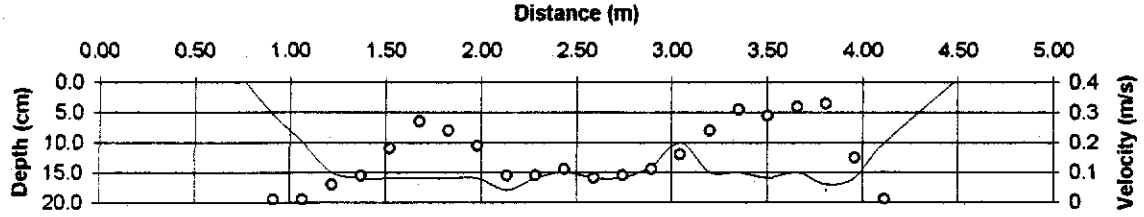
DATE: 25-Apr-02 (YY/MM/DD) TIME: 1:30 PM (HH:MM) RECORDED BY: RKS / DJF
DATALOGGER READING: N/A DATALOGGER #/ID: Ashtead Technology
MANUAL DEPTH TO WATER: N/A STAGE GAUGE READING: N/A m
METER: Marsh McBirney CREST GAUGE READING: N/A m
COMMENTS: Measured at Waypoint 010 TOTAL STREAM WIDTH: 3.72 m
UTM 0650746 4277433

DISCHARGE: 0.0808 m^3/s CALC. ELEVATION (from manual depth): N/A m
CALCULATED ELEVATION (from datalogger): N/A m

OBSERVATIONS					COMPUTATIONS			
MEASURE POINT #	DISTANCE FROM INITIAL POINT (m)	TOTAL DEPTH (cm)	VELOCITY (m/s)	ANGLE OF FLOW (degrees)	WIDTH (m)	AREA (m^2)	DISCHARGE (m^3/s)	% OF TOTAL DISCHARGE
1	0.76	0.0		N/A				
2	0.91	5.5	0.01	N/A	0.152	0.0084	0.0001	0.1
3	1.07	10.0	0.01	N/A	0.152	0.0152	0.0002	0.2
4	1.22	15.0	0.06	N/A	0.152	0.0229	0.0014	1.7
5	1.37	16.0	0.09	N/A	0.152	0.0244	0.0022	2.7
6	1.52	16.0	0.18	N/A	0.152	0.0244	0.0044	5.4
7	1.68	16.0	0.27	N/A	0.152	0.0244	0.0066	8.1
8	1.83	16.0	0.24	N/A	0.152	0.0244	0.0059	7.2
9	1.98	16.0	0.19	N/A	0.152	0.0244	0.0046	5.7
10	2.13	18.0	0.09	N/A	0.152	0.0274	0.0025	3.1
11	2.29	16.0	0.09	N/A	0.152	0.0244	0.0022	2.7
12	2.44	15.0	0.11	N/A	0.152	0.0229	0.0025	3.1
13	2.59	16.0	0.08	N/A	0.152	0.0244	0.0020	2.4
14	2.74	16.0	0.09	N/A	0.152	0.0244	0.0022	2.7
15	2.90	14.0	0.11	N/A	0.152	0.0213	0.0023	2.9
16	3.05	10.0	0.16	N/A	0.152	0.0152	0.0024	3.0
17	3.20	15.0	0.24	N/A	0.152	0.0229	0.0055	6.8
18	3.35	15.0	0.31	N/A	0.152	0.0229	0.0071	8.8
19	3.51	16.0	0.29	N/A	0.152	0.0244	0.0071	8.8
20	3.66	15.0	0.32	N/A	0.152	0.0229	0.0073	9.1
21	3.81	17.0	0.33	N/A	0.152	0.0259	0.0085	10.6
22	3.96	16.0	0.15	N/A	0.152	0.0244	0.0037	4.5
23	4.11	10.0	0.01	N/A	0.259	0.0259	0.0003	0.3
24	4.48	0.0		N/A				
25								
Total							0.0808	100.0

Channel Flowrate: 1281 gallons per minute

Channel Cross-section



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CURRENT METER NOTES

PROJECT #: Sacramento Job 205-01
PROJ NAME: ARGET
LOCATION: Buffalo Creek Meas. #3 - Just Downstream of Hwy #50
CLIENT: Hatch and Parent

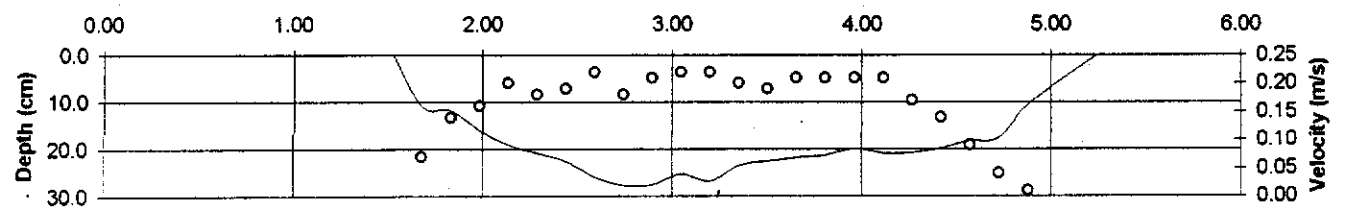
DATE: 27-Apr-02 (YY/MM/DD) TIME: 1:30 PM (HH:MM) RECORDED BY: RKS / DJF
DATALOGGER READING: N/A
MANUAL DEPTH TO WATER: N/A
METER: Marsh McBirney
COMMENTS: Measured at Waypoint 012
UTM 0652480 4275969
DATALOGGER #/ID: Ashtead Technology
STAGE GAUGE READING: N/A m
CREST GAUGE READING: N/A m
TOTAL STREAM WIDTH: 3.72 m

DISCHARGE: 0.1222 m^3/s
CALC. ELEVATION (from manual depth): N/A m
CALCULATED ELEVATION (from datalogger): N/A m

OBSERVATIONS					COMPUTATIONS			
MEASURE POINT #	DISTANCE FROM INITIAL POINT (m)	TOTAL DEPTH (cm)	VELOCITY (m/s)	ANGLE OF FLOW (degrees)	WIDTH (m)	AREA (m^2)	DISCHARGE (m^3/s)	% OF TOTAL DISCHARGE
1	1.52	0.0		N/A				
2	1.68	11.0	0.07	N/A	0.152	0.0168	0.0012	1.0
3	1.83	11.8	0.14	N/A	0.152	0.0180	0.0025	2.1
4	1.98	16.0	0.16	N/A	0.152	0.0244	0.0039	3.2
5	2.13	19.0	0.20	N/A	0.152	0.0290	0.0058	4.7
6	2.29	20.8	0.18	N/A	0.152	0.0317	0.0057	4.7
7	2.44	22.5	0.19	N/A	0.152	0.0343	0.0065	5.3
8	2.59	26.0	0.22	N/A	0.152	0.0396	0.0087	7.1
9	2.74	27.7	0.18	N/A	0.152	0.0422	0.0076	6.2
10	2.90	27.5	0.21	N/A	0.152	0.0419	0.0088	7.2
11	3.05	25.3	0.22	N/A	0.152	0.0386	0.0085	6.9
12	3.20	26.8	0.22	N/A	0.152	0.0408	0.0090	7.4
13	3.35	23.5	0.20	N/A	0.152	0.0358	0.0072	5.9
14	3.51	22.5	0.19	N/A	0.152	0.0343	0.0065	5.3
15	3.66	21.7	0.21	N/A	0.152	0.0331	0.0069	5.7
16	3.81	21.3	0.21	N/A	0.152	0.0325	0.0068	5.6
17	3.96	19.8	0.21	N/A	0.152	0.0302	0.0063	5.2
18	4.11	21.0	0.21	N/A	0.152	0.0320	0.0067	5.5
19	4.27	20.8	0.17	N/A	0.152	0.0317	0.0054	4.4
20	4.42	19.8	0.14	N/A	0.152	0.0302	0.0042	3.5
21	4.57	18.3	0.09	N/A	0.152	0.0279	0.0025	2.1
22	4.72	17.7	0.04	N/A	0.152	0.0270	0.0011	0.9
23	4.88	10.7	0.01	N/A	0.259	0.0277	0.0003	0.2
24	5.24	0.0						
25								
Total							0.1222	100.0

Channel Flowrate: 1936 gallons per minute

Channel Cross-section



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CURRENT METER NOTES

PROJECT #: Sacramento Job 205-01
PROJ NAME: ARGET
LOCATION: Buffalo Creek Meas. #4 - Coloma Rd. Crossing
CLIENT: Hatch and Parent

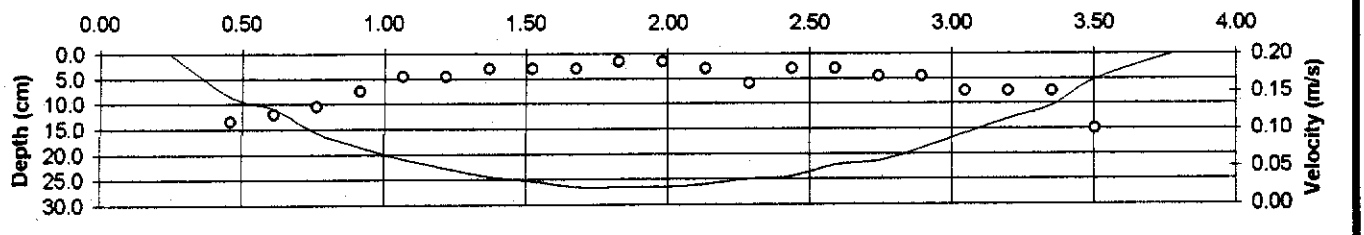
DATE: 27-Apr-02 (YY/MM/DD) TIME: 2:30 PM (HH:MM) RECORDED BY: RKS / DJF
DATALOGGER READING: N/A DATALOGGER #/ID: Ashtead Technology
MANUAL DEPTH TO WATER: N/A STAGE GAUGE READING: N/A m
METER: Marsh McBirney CREST GAUGE READING: N/A m
COMMENTS: Measured upstream of Waypoint 003 TOTAL STREAM WIDTH: 3.54 m
UTM 0651505 4276266 (In Repition of Meas. #1 - Same Location)

DISCHARGE: 0.1054 m^3/s CALC. ELEVATION (from manual depth): N/A m
CALCULATED ELEVATION (from datalogger): N/A m

OBSERVATIONS					COMPUTATIONS			
MEASURE POINT #	DISTANCE FROM INITIAL POINT (m)	TOTAL DEPTH (cm)	VELOCITY (m/s)	ANGLE OF FLOW (degrees)	WIDTH (m)	AREA (m^2)	DISCHARGE (m^3/s)	% OF TOTAL DISCHARGE
1	0.24	0.0		N/A				
2	0.46	8.5	0.11	N/A	0.183	0.0155	0.0017	1.6
3	0.61	11.0	0.12	N/A	0.152	0.0168	0.0020	1.9
4	0.76	15.7	0.13	N/A	0.152	0.0239	0.0031	3.0
5	0.91	18.5	0.15	N/A	0.152	0.0282	0.0042	4.0
6	1.07	21.0	0.17	N/A	0.152	0.0320	0.0054	5.2
7	1.22	22.8	0.17	N/A	0.152	0.0347	0.0059	5.6
8	1.37	24.5	0.18	N/A	0.152	0.0373	0.0067	6.4
9	1.52	25.3	0.18	N/A	0.152	0.0386	0.0069	6.6
10	1.68	26.5	0.18	N/A	0.152	0.0404	0.0073	6.9
11	1.83	26.5	0.19	N/A	0.152	0.0404	0.0077	7.3
12	1.98	26.5	0.19	N/A	0.152	0.0404	0.0077	7.3
13	2.13	26.0	0.18	N/A	0.152	0.0396	0.0071	6.8
14	2.29	25.0	0.16	N/A	0.152	0.0381	0.0061	5.8
15	2.44	24.5	0.18	N/A	0.152	0.0373	0.0067	6.4
16	2.59	22.3	0.18	N/A	0.152	0.0340	0.0061	5.8
17	2.74	21.5	0.17	N/A	0.152	0.0328	0.0056	5.3
18	2.90	19.0	0.17	N/A	0.152	0.0290	0.0049	4.7
19	3.05	16.0	0.15	N/A	0.152	0.0244	0.0037	3.5
20	3.20	13.0	0.15	N/A	0.152	0.0198	0.0030	2.8
21	3.35	10.5	0.15	N/A	0.152	0.0160	0.0024	2.3
22	3.51	5.2	0.10		0.213	0.0111	0.0011	1.1
23	3.78	0.0						
24								
25								
Total							0.1054	100.0

Channel Flowrate: 1670 gallons per minute

Channel Cross-section



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CURRENT METER NOTES

PROJECT #: Sacramento Job 205-01
PROJ NAME: ARGET
LOCATION: Buffalo Creek Meas. #5 - Before Emptying into American River
CLIENT: Hatch and Parent

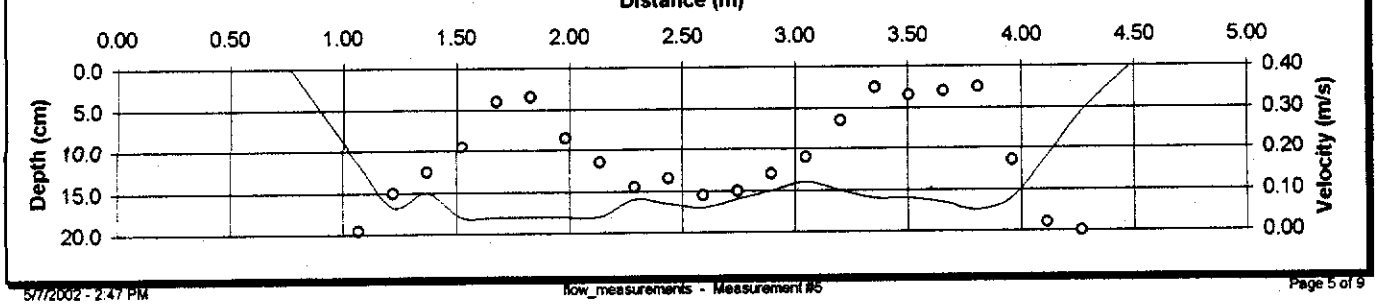
DATE: 27-Apr-02 (YY/MM/DD) TIME: 3:30 PM (HH:MM) RECORDED BY: RKS / DJF
DATALOGGER READING: N/A DATALOGGER #/ID: Ashtead Technology
MANUAL DEPTH TO WATER: N/A STAGE GAUGE READING: N/A m
METER: Marsh McBirney CREST GAUGE READING: N/A m
COMMENTS: Measured at Waypoint 010 TOTAL STREAM WIDTH: 3.72 m
UTM 0650746 4277433 (In Repition of Meas. #2 - Same Location)

DISCHARGE: 0.1037 m^3/s CALC. ELEVATION (from manual depth): N/A m
CALCULATED ELEVATION (from datalogger): N/A m

OBSERVATIONS					COMPUTATIONS			
MEASURE POINT #	DISTANCE FROM INITIAL POINT (m)	TOTAL DEPTH (cm)	VELOCITY (m/s)	ANGLE OF FLOW (degrees)	WIDTH (m)	AREA (m^2)	DISCHARGE (m^3/s)	% OF TOTAL DISCHARGE
1	0.76	0.0		N/A				
2	1.07	11.5	0.01	N/A	0.229	0.0263	0.0003	0.3
3	1.22	16.8	0.10	N/A	0.152	0.0256	0.0026	2.5
4	1.37	15.0	0.15	N/A	0.152	0.0229	0.0034	3.3
5	1.52	18.0	0.21	N/A	0.152	0.0274	0.0058	5.6
6	1.68	18.0	0.32	N/A	0.152	0.0274	0.0088	8.5
7	1.83	18.0	0.33	N/A	0.152	0.0274	0.0091	8.7
8	1.98	18.0	0.23	N/A	0.152	0.0274	0.0063	6.1
9	2.13	18.0	0.17	N/A	0.152	0.0274	0.0047	4.5
10	2.29	16.0	0.11	N/A	0.152	0.0244	0.0027	2.6
11	2.44	16.5	0.13	N/A	0.152	0.0251	0.0033	3.2
12	2.59	17.0	0.09	N/A	0.152	0.0259	0.0023	2.2
13	2.74	16.0	0.10	N/A	0.152	0.0244	0.0024	2.4
14	2.90	15.0	0.14	N/A	0.152	0.0229	0.0032	3.1
15	3.05	14.0	0.18	N/A	0.152	0.0213	0.0038	3.7
16	3.20	15.0	0.27	N/A	0.152	0.0229	0.0062	6.0
17	3.35	16.0	0.35	N/A	0.152	0.0244	0.0085	8.2
18	3.51	16.0	0.33	N/A	0.152	0.0244	0.0080	7.8
19	3.66	16.5	0.34	N/A	0.152	0.0251	0.0085	8.2
20	3.81	17.5	0.35	N/A	0.152	0.0267	0.0093	9.0
21	3.96	16.0	0.17	N/A	0.152	0.0244	0.0041	4.0
22	4.11	11.0	0.02	N/A	0.152	0.0168	0.0003	0.3
23	4.27	5.5	0.00	N/A	0.183	0.0101	0.0000	0.0
24	4.48	0.0		N/A				
25								
Total							0.1037	100.0

Channel Flowrate: 1644 gallons per minute

Channel Cross-section



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CURRENT METER NOTES

PROJECT #: Sacramento Job 205-01
PROJ NAME: ARGET
LOCATION: Buffalo Creek Meas. #6 - Downstream of Hwy #50
CLIENT: Hatch and Parent

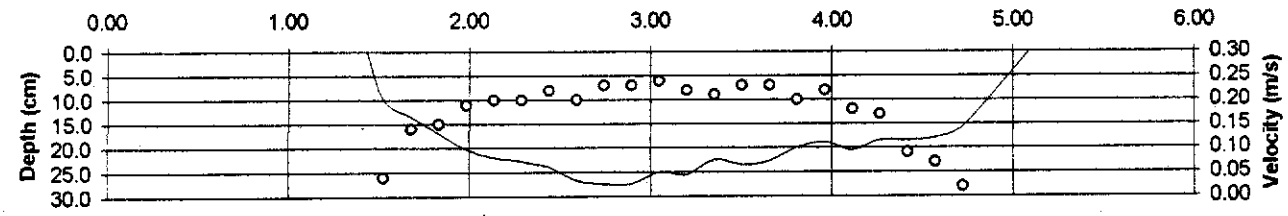
DATE: 27-Apr-02 (YY/MM/DD) TIME: 5:30 PM (HH:MM) RECORDED BY: RKS / DJF
DATALOGGER READING: N/A DATALOGGER #/ID: Ashtead Technology
MANUAL DEPTH TO WATER: N/A STAGE GAUGE READING: N/A m
METER: Marsh McBirney CREST GAUGE READING: N/A m
COMMENTS: Measured at Waypoint 012 TOTAL STREAM WIDTH: 3.66 m
UTM 0652480 4275969 (In Repetition of Meas. #3 - Same Location)

DISCHARGE: 0.1314 m^3/s CALC. ELEVATION (from manual depth): N/A m
CALCULATED ELEVATION (from datalogger): N/A m

OBSERVATIONS					COMPUTATIONS			
MEASURE POINT #	DISTANCE FROM INITIAL POINT (m)	TOTAL DEPTH (cm)	VELOCITY (m/s)	ANGLE OF FLOW (degrees)	WIDTH (m)	AREA (m^2)	DISCHARGE (m^3/s)	% OF TOTAL DISCHARGE
1	1.43	0.0		N/A				
2	1.52	10.0	0.04	N/A	0.122	0.0122	0.0005	0.4
3	1.68	13.5	0.14	N/A	0.152	0.0206	0.0029	2.2
4	1.83	17.0	0.15	N/A	0.152	0.0259	0.0039	3.0
5	1.98	20.3	0.19	N/A	0.152	0.0309	0.0059	4.5
6	2.13	22.0	0.20	N/A	0.152	0.0335	0.0067	5.1
7	2.29	22.7	0.20	N/A	0.152	0.0346	0.0069	5.3
8	2.44	24.0	0.22	N/A	0.152	0.0366	0.0080	6.1
9	2.59	26.7	0.20	N/A	0.152	0.0407	0.0081	6.2
10	2.74	27.5	0.23	N/A	0.152	0.0419	0.0096	7.3
11	2.90	27.4	0.23	N/A	0.152	0.0418	0.0096	7.3
12	3.05	25.0	0.24	N/A	0.152	0.0381	0.0091	7.0
13	3.20	25.5	0.22	N/A	0.152	0.0389	0.0085	6.5
14	3.35	22.5	0.21	N/A	0.152	0.0343	0.0072	5.5
15	3.51	23.5	0.23	N/A	0.152	0.0358	0.0082	6.3
16	3.66	22.7	0.23	N/A	0.152	0.0346	0.0080	6.1
17	3.81	20.0	0.20	N/A	0.152	0.0305	0.0061	4.6
18	3.96	19.0	0.22	N/A	0.152	0.0290	0.0064	4.8
19	4.11	20.5	0.18	N/A	0.152	0.0312	0.0056	4.3
20	4.27	18.5	0.17	N/A	0.152	0.0282	0.0048	3.6
21	4.42	18.5	0.09	N/A	0.152	0.0282	0.0025	1.9
22	4.57	18.0	0.07	N/A	0.152	0.0274	0.0019	1.5
23	4.72	15.7	0.02	N/A	0.259	0.0407	0.0008	0.6
24	5.09	0.0		N/A				
25								
Total							0.1314	100.0

Channel Flowrate: 2083 gallons per minute

Channel Cross-section



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CURRENT METER NOTES

PROJECT #: Sacramento Job 205-01
PROJ NAME: ARGET
LOCATION: Buffalo Creek Meas. #7 - Downstream of Hwy #50
CLIENT: Hatch and Parent

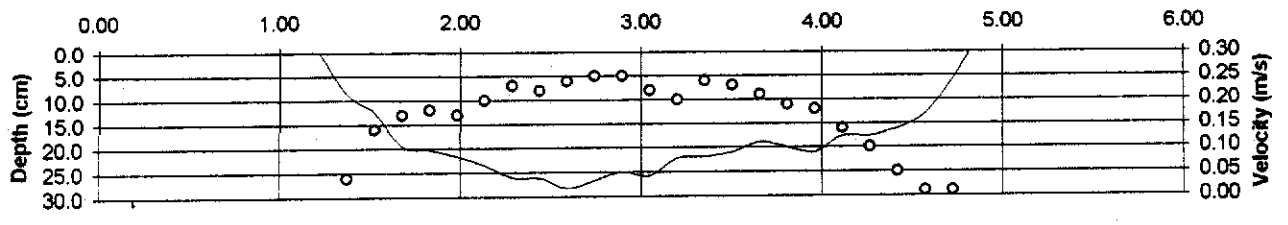
DATE: 2-May-02 (YY/MM/DD) TIME: 8:30 AM (HH:MM) RECORDED BY: RKS / RC
DATALOGGER READING: N/A DATALOGGER #/ID: Ashtead Technology
MANUAL DEPTH TO WATER: N/A STAGE GAUGE READING: N/A m
METER: Marsh McBirney CREST GAUGE READING: N/A m
COMMENTS: Measured at Waypoint 012 TOTAL STREAM WIDTH: 3.60 m
UTM 0652480 4275969 (In Repetition of Meas. #3 and #6 - Same Location)

DISCHARGE: 0.1310 m^3/s CALC. ELEVATION (from manual depth): N/A m
CALCULATED ELEVATION (from datalogger): N/A m

OBSERVATIONS					COMPUTATIONS			
MEASURE POINT #	DISTANCE FROM INITIAL POINT (m)	TOTAL DEPTH (cm)	VELOCITY (m/s)	ANGLE OF FLOW (degrees)	WIDTH (m)	AREA (m^2)	DISCHARGE (m^3/s)	% OF TOTAL DISCHARGE
1	1.22	0.0		N/A				
2	1.37	8.7	0.04	N/A	0.152	0.0133	0.0005	0.4
3	1.52	12.5	0.14	N/A	0.152	0.0191	0.0027	2.0
4	1.68	19.5	0.17	N/A	0.152	0.0297	0.0051	3.9
5	1.83	20.3	0.18	N/A	0.152	0.0309	0.0056	4.3
6	1.98	21.7	0.17	N/A	0.152	0.0331	0.0056	4.3
7	2.13	23.5	0.20	N/A	0.152	0.0358	0.0072	5.5
8	2.29	26.0	0.23	N/A	0.152	0.0396	0.0091	7.0
9	2.44	26.2	0.22	N/A	0.152	0.0399	0.0088	6.7
10	2.59	28.3	0.24	N/A	0.152	0.0431	0.0104	7.9
11	2.74	26.7	0.25	N/A	0.152	0.0407	0.0102	7.8
12	2.90	25.0	0.25	N/A	0.152	0.0381	0.0095	7.3
13	3.05	25.8	0.22	N/A	0.152	0.0393	0.0087	6.6
14	3.20	22.3	0.20	N/A	0.152	0.0340	0.0068	5.2
15	3.35	22.0	0.24	N/A	0.152	0.0335	0.0080	6.1
16	3.51	21.0	0.23	N/A	0.152	0.0320	0.0074	5.6
17	3.66	19.0	0.21	N/A	0.152	0.0290	0.0061	4.6
18	3.81	20.0	0.19	N/A	0.152	0.0305	0.0058	4.4
19	3.96	21.0	0.18	N/A	0.152	0.0320	0.0058	4.4
20	4.11	17.7	0.14	N/A	0.152	0.0270	0.0038	2.9
21	4.27	17.7	0.10	N/A	0.152	0.0270	0.0027	2.1
22	4.42	16.0	0.05	N/A	0.152	0.0244	0.0012	0.9
23	4.57	13.0	0.01	N/A	0.152	0.0198	0.0002	0.2
24	4.72	5.8	0.01	N/A	0.122	0.0071	0.0001	0.1
25	4.82	0.0		N/A				
Total							0.1310	100.0

Channel Flowrate: 2076 gallons per minute

Channel Cross-section



KOMEX INTERNATIONAL LTD.
Suite 100, 4500 - 16 th Avenue N.W.
Calgary, Alberta, T3B 0M6 CANADA
Tel: (403) 247-9200
FAX: (403) 247-4911

CURRENT METER NOTES

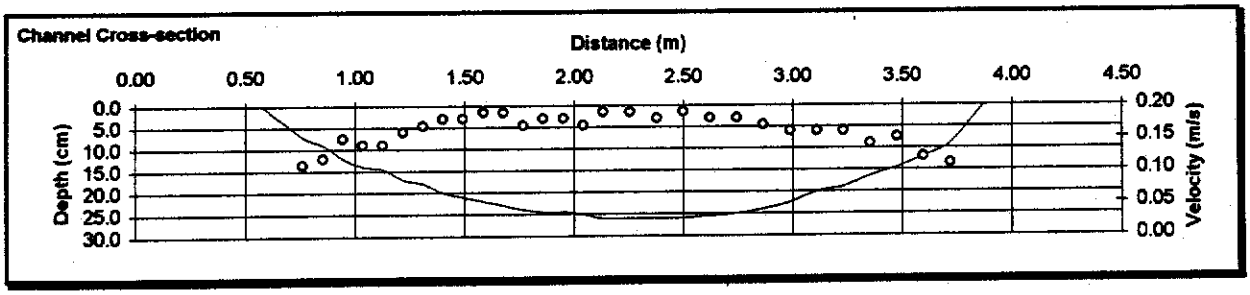
PROJECT #: Sacramento Job 205-01
PROJ NAME: ARGET
LOCATION: Buffalo Creek Meas. #8 - Coloma Rd. Crossing
CLIENT: Hatch and Parent

DATE: 2-May-02 (YY/MM/DD) TIME: 9:30 AM (HH:MM)
RECORDED BY: RKS / RC
DATALOGGER READING: N/A
DATALOGGER #ID: Ashtead Technology
MANUAL DEPTH TO WATER: N/A
STAGE GAUGE READING: N/A m
METER: Marsh McBirney
CREST GAUGE READING: N/A m
COMMENTS: Measured upstream of Waypoint 003
TOTAL STREAM WIDTH: 3.11 m
UTM 0651505 4276266 (In Repition of Meas. #1 and #4 - Same Location)

DISCHARGE: 0.1025 m^3/s
CALC. ELEVATION (from manual depth): N/A m
CALCULATED ELEVATION (from datalogger): N/A m

OBSERVATIONS					COMPUTATIONS			
MEASURE POINT #	DISTANCE FROM INITIAL POINT (m)	TOTAL DEPTH (cm)	VELOCITY (m/s)	ANGLE OF FLOW (degrees)	WIDTH (m)	AREA (m^2)	DISCHARGE (m^3/s)	% OF TOTAL DISCHARGE
1	0.58	0.0		N/A				
2	0.76	7.0	0.11	N/A	0.137	0.0096	0.0011	1.0
3	0.85	9.0	0.12	N/A	0.091	0.0082	0.0010	1.0
4	0.94	12.0	0.15	N/A	0.091	0.0110	0.0016	1.6
5	1.04	14.0	0.14	N/A	0.091	0.0128	0.0018	1.7
6	1.13	14.5	0.14	N/A	0.091	0.0133	0.0019	1.8
7	1.22	17.0	0.16	N/A	0.091	0.0155	0.0025	2.4
8	1.31	18.0	0.17	N/A	0.091	0.0165	0.0028	2.7
9	1.40	20.0	0.18	N/A	0.091	0.0183	0.0033	3.2
10	1.49	21.0	0.18	N/A	0.091	0.0192	0.0035	3.4
11	1.58	22.0	0.19	N/A	0.091	0.0201	0.0038	3.7
12	1.68	23.0	0.19	N/A	0.091	0.0210	0.0040	3.9
13	1.77	24.0	0.17	N/A	0.091	0.0219	0.0037	3.6
14	1.86	24.5	0.18	N/A	0.091	0.0224	0.0040	3.9
15	1.95	24.5	0.18	N/A	0.091	0.0224	0.0040	3.9
16	2.04	25.0	0.17	N/A	0.091	0.0229	0.0039	3.8
17	2.13	26.0	0.19	N/A	0.107	0.0277	0.0053	5.1
18	2.26	26.0	0.19	N/A	0.122	0.0317	0.0060	5.9
19	2.36	26.0	0.18	N/A	0.122	0.0317	0.0057	5.6
20	2.50	26.0	0.19	N/A	0.122	0.0317	0.0060	5.9
21	2.62	25.5	0.18	N/A	0.122	0.0311	0.0056	5.5
22	2.74	25.0	0.18	N/A	0.122	0.0305	0.0055	5.4
23	2.87	24.0	0.17	N/A	0.122	0.0293	0.0050	4.9
24	2.99	22.5	0.16	N/A	0.122	0.0274	0.0044	4.3
25	3.11	20.0	0.16	N/A	0.122	0.0244	0.0039	3.8
26	3.23	19.0	0.16	N/A	0.122	0.0232	0.0037	3.6
27	3.35	16.5	0.14	N/A	0.122	0.0201	0.0028	2.7
28	3.47	14.5	0.15	N/A	0.122	0.0177	0.0027	2.6
29	3.60	12.0	0.12	N/A	0.122	0.0146	0.0018	1.7
30	3.72	9.0	0.11	N/A	0.137	0.0123	0.0014	1.3
31	3.87	0.0		N/A				
Total							0.1025	100.0

Channel Flowrate: 1625 gallons per minute



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Calgary, Alberta, T3B 0M6 CANADA
Tel: (403) 247-0200
FAX: (403) 247-4811

CURRENT METER NOTES

PROJECT #: Sacramento Job 205-01
PROJ NAME: ARGET
LOCATION: Buffalo Creek Meas. #9 - Before Emptying into American River
CLIENT: Hatch and Parent

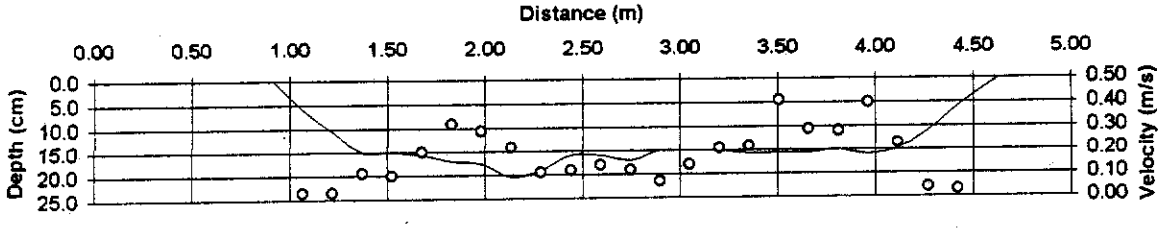
DATE: 2-May-02 (YY/MM/DD) TIME: 10:30 AM (HH:MM) RECORDED BY: RKS / RC
DATALOGGER READING: N/A DATALOGGER #/ID: Ashtead Technology
MANUAL DEPTH TO WATER: N/A STAGE GAUGE READING: N/A m
METER: Marsh McBirney CREST GAUGE READING: N/A m
COMMENTS: Measured at Waypoint 010 TOTAL STREAM WIDTH: 3.72 m
UTM 0650746 4277433 (In Repition of Meas. #2 and #5 - Same Location)

DISCHARGE: 0.0995 m^3/s CALC. ELEVATION (from manual depth): N/A m
CALCULATED ELEVATION (from datalogger): N/A m

OBSERVATIONS					COMPUTATIONS			
MEASURE POINT #	DISTANCE FROM INITIAL POINT (m)	TOTAL DEPTH (cm)	VELOCITY (m/s)	ANGLE OF FLOW (degrees)	WIDTH (m)	AREA (m^2)	DISCHARGE (m^3/s)	% OF TOTAL DISCHARGE
1	0.91	0.0		N/A				
2	1.07	6.0	0.03	N/A	0.152	0.0091	0.0003	0.3
3	1.22	10.5	0.03	N/A	0.152	0.0160	0.0005	0.5
4	1.37	15.0	0.11	N/A	0.152	0.0229	0.0025	2.5
5	1.52	15.0	0.10	N/A	0.152	0.0229	0.0023	2.3
6	1.68	15.7	0.20	N/A	0.152	0.0239	0.0048	4.8
7	1.83	17.0	0.32	N/A	0.152	0.0259	0.0083	8.3
8	1.98	17.5	0.29	N/A	0.152	0.0267	0.0077	7.8
9	2.13	20.4	0.22	N/A	0.152	0.0311	0.0068	6.9
10	2.29	19.0	0.11	N/A	0.152	0.0290	0.0032	3.2
11	2.44	16.0	0.12	N/A	0.152	0.0244	0.0029	2.9
12	2.59	16.0	0.14	N/A	0.152	0.0244	0.0034	3.4
13	2.74	17.0	0.12	N/A	0.152	0.0259	0.0031	3.1
14	2.90	15.0	0.07	N/A	0.152	0.0229	0.0016	1.6
15	3.05	15.0	0.14	N/A	0.152	0.0229	0.0032	3.2
16	3.20	15.0	0.21	N/A	0.152	0.0229	0.0048	4.8
17	3.35	15.7	0.22	N/A	0.152	0.0239	0.0053	5.3
18	3.51	15.5	0.41	N/A	0.152	0.0236	0.0097	9.7
19	3.66	15.5	0.29	N/A	0.152	0.0236	0.0069	6.9
20	3.81	15.0	0.28	N/A	0.152	0.0229	0.0064	6.4
21	3.96	16.0	0.40	N/A	0.152	0.0244	0.0098	9.8
22	4.11	14.7	0.23	N/A	0.152	0.0224	0.0052	5.2
23	4.27	11.0	0.04	N/A	0.152	0.0168	0.0007	0.7
24	4.42	6.0	0.03	N/A	0.163	0.0110	0.0003	0.3
25	4.63	0.0		N/A				
26								
27								
Total							0.0995	100.0

Channel Flowrate: 1578. gallons per minute

Channel Cross-section



4384

CALIBRATION CERTIFICATE

Model: 2000-21 Serial Number: 2004057

Unit Gain Ratio: _____ Time Constant: _____

Type of Reading

Velocity:
- ☑ FPS
- ☐ CMS
- ☐ ____

Level:
- ☐ IN
- ☐ CM
- ☑ N/A

	Static Velocity	Dynamic Velocity	Level
Standard:	Zero	5.51	N/A
Measured:	0.00	5.51	N/A

☑ Factory Calibration

☐ Field Profile Calibration;
Site Coefficient or Velocity Multiplier: _____

Calibration Technician: [signature] Date: 5-31-01

QA Technician: [signature] Date: 5-31-01

This document certifies that the described instrument has been calibrated. Verification is indicated by the measured results shown above. Velocity calibration is traceable to the National Institute of Standards and Technology, (NIST), Gaithersburg, MD. For product information, service, or calibration, please contact the Customer Service Department.

MARSH-McBIRNEY, INC.
4539 Metropolitan Ct., Frederick, MD 21704-8364
(301) 874-5599 • 800-368-2723 • FAX (301) 874-2172

P/N 101001301

APPENDIX B

AMERICAN RIVER WATER SURFACE INTERPRETATION INFORMATION

1. MAY 2, 2002 ELEVATION SURVEY OF AMERICAN RIVER WATER SURFACE
2. USGS GAGING STATION#11446500

AMERICAN RIVER WATER ELEVATIONS BETWEEN HAZEL AVENUE AND SOUTH SIDE SUNRISE BRIDGE

HORIZONTAL: NAD 83 UTM, ZONE 0010, METERS

VERTICAL: NGVD 29, U.S. SURVEY FEET

Descriptor	Northing	Easting	Elevation	Offset (from marker)	Time (PDT)	Comments
REFERENCE MARKER						
RBR01	4277719.329	654285.143	79.14			At fish hatchery
RBR02	4277513.222	653846.434	76.13			
SPK03	4277395.314	653342.130	74.25			
RBR04	4277525.608	652848.973	72.50			
RBR05	4277802.980	652426.179	71.70			
RBR06	4277974.060	651932.634	71.38			
RBR07	4277991.364	651373.993	67.47			
RBR08	4277795.140	651005.320	68.02			West of Bridge Street bridge
RBR09	4277476.261	650635.542	65.81			West of Sunrise Blvd. Bridge
ADDITIONAL POINTS						
STA BM	4277822.999	654259.285	87.05			USBR bronze disk "GAUGING STATION"
POST 3	4277817.480	654258.199	79.13			Elevation at 7.80 mark
RIDGE	4278358.872	655112.562				RIDGE RESET
CANAL	4276426.671	653958.467	132.81			FOLSOM SOUTH CANAL MP 1.29 R
WATER ELEVATIONS MAY 2, 2002						
H2O01	4277720.757	654284.111	77.17	5.7	16:29	At fish hatchery
H2O02	4277514.158	653845.783	75.16	3.7	16:10	
H2O03	4277396.508	653342.259	73.29	3.9	15:48	
H2O04	4277527.021	652849.713	71.17	5.2	15:18	
H2O05	4277806.550	652427.892	70.64	12.9	14:53	
H2O06	4277974.442	651932.593	70.54	1.2	14:22	
H2O07	4278001.966	651371.877	65.77	35.4	13:51	
H2O08	4277796.371	651004.399	65.73	5.0	13:20	West of Bridge Street Bridge
H2O09	4277479.631	650632.392	64.77	15.1	12:50	West of Sunrise bridge

REGISTERED PROFESSIONAL ENGINEER
RICHARD ROZUMOWICZ
No. 28217
Exp. 3-31-02
CIVIL
STATE OF CALIFORNIA

5/16/2002

1 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EXPANDED RATING TABLE TYPE: LOG

11446500 DATE PROCESSED: 04-26-2002 @ 09:42 BY smithson

AMERICAN R A FAIR OAKS CA DD: 3 TYPE: 001 RATING NO: 0033

OFFSET: 2.50 START DATE/TIME: 10-01-1998 (0015)

BASED ON __ DISCHARGE MEASUREMENTS, NOS ___, AND ____, AND IS ___ WELL DEFINED BETWEEN __ AND _____ CFS

COMP BY _____ DATE _____ CHK. BY _____ DATE _____

Same as Rating 32 above 20.5 ft (63.940 CFS).

GAGE DIFF IN Q

HEIGHT DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)

GAGE HEIGHT (FEET)	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	TENTH FT
3.6						530 *	537.3	544.7	552.1	559.6	74.2
3.7	567.1	574.6	582.2	589.8	597.4	605.1	612.8	620.5	628.3	636.1	76.9
3.8	644	651.9	659.8	667.7	675.7	683.8	691.8	699.9	708.1	716.2	80.4
3.9	724.4	732.7	741	749.3	757.6	766	774.4	782.8	791.3	799.8	84
4	808.4	816.9	825.6	834.2	842.9	851.6	860.3	869.1	877.9	886.8	87.3
4.1	895.7	904.6	913.5	922.5	931.5	940.5	949.6	958.7	967.8	977	90.5
4.2	986.2	995.4	1005	1014	1023	1033	1042	1052	1061	1070	93.8
4.3	1080	1090	1099	1109	1118	1128	1138	1147	1157	1167	97
4.4	1177	1187	1197	1206	1216	1226	1236	1246	1257	1267	100
4.5	1277	1287	1297	1307	1318	1328	1338	1348	1359	1369	103
4.6	1380	1390	1401	1411	1422	1432	1443	1453	1464	1475	105
4.7	1485	1496	1507	1518	1529	1539	1550	1561	1572	1583	109
4.8	1594	1605	1616	1627	1638	1650	1661	1672	1683	1694	112
4.9	1706	1717	1728	1740	1751	1763	1774	1785	1797	1808	114
5	1820*	1832	1844	1856	1867	1879	1891	1903	1915	1927	119
5.1	1939	1952	1964	1976	1988	2000	2013	2025	2037	2049	123
5.2	2062	2074	2087	2099	2112	2124	2137	2149	2162	2174	125
5.3	2187	2200	2212	2225	2238	2251	2263	2276	2289	2302	128
5.4	2315	2328	2341	2354	2367	2380	2393	2406	2419	2433	131
5.5	2446	2459	2472	2486	2499	2512	2526	2539	2552	2566	133
5.6	2579	2593	2606	2620	2633	2647	2661	2674	2688	2702	136
5.7	2715	2729	2743	2757	2771	2785	2798	2812	2826	2840	139
5.8	2854	2868	2882	2897	2911	2925	2939	2953	2967	2982	142
5.9	2996	3010	3024	3039	3053	3068	3082	3096	3111	3125	144
6	3140*	3155	3169	3184	3199	3213	3228	3243	3258	3273	148
6.1	3288	3302	3317	3332	3347	3362	3377	3392	3407	3423	150
6.2	3438	3453	3468	3483	3499	3514	3529	3544	3560	3575	152
6.3	3590	3606	3621	3637	3652	3668	3683	3699	3715	3730	156
6.4	3746	3761	3777	3793	3809	3824	3840	3856	3872	3888	158
6.5	3904	3920	3936	3951	3967	3984	4000	4016	4032	4048	160
6.6	4064	4080	4096	4113	4129	4145	4161	4178	4194	4210	163
6.7	4227	4243	4260	4276	4293	4309	4326	4342	4359	4375	165
6.8	4392	4409	4425	4442	4459	4476	4492	4509	4526	4543	168
6.9	4560	4577	4594	4611	4628	4645	4662	4679	4696	4713	170
7	4730*	4747	4765	4782	4800	4818	4835	4853	4870	4888	176
7.1	4906	4923	4941	4959	4977	4995	5012	5030	5048	5066	178
7.2	5084	5102	5120	5138	5156	5174	5192	5210	5229	5247	181
7.3	5265	5283	5301	5320	5338	5356	5375	5393	5411	5430	183
7.5	5634	5653	5672	5690	5709	5728	5747	5766	5785	5803	188
7.6	5822	5841	5860	5879	5898	5917	5937	5956	5975	5994	191
7.7	6013	6032	6052	6071	6090	6109	6129	6148	6168	6187	193
7.8	6206	6226	6245	6265	6284	6304	6323	6343	6363	6382	196
7.9	6402	6422	6441	6461	6481	6501	6521	6540	6560	6580	198
8	6600*	6620	6640	6661	6681	6701	6722	6742	6762	6783	203

GAGE HEIGHT (FEET)	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	TENTH FT
8.1	6803	6823	6844	6864	6885	6905	6926	6947	6967	6988	205
8.2	7008	7029	7050	7071	7091	7112	7133	7154	7175	7196	208
8.3	7216	7237	7258	7279	7300	7321	7342	7363	7385	7406	211
8.4	7427	7448	7469	7490	7512	7533	7554	7576	7597	7618	213
8.5	7640	7661	7683	7704	7726	7747	7769	7790	7812	7833	215
8.6	7855	7877	7898	7920	7942	7964	7985	8007	8029	8051	218
8.7	8073	8095	8117	8139	8160	8182	8205	8227	8249	8271	220
8.8	8293	8315	8337	8359	8382	8404	8426	8448	8471	8493	222
8.9	8515	8538	8560	8583	8605	8627	8650	8673	8695	8718	225
9	8740	8763	8785	8808	8831	8854	8876	8899	8922	8945	227
9.1	8967	8990	9013	9036	9059	9082	9105	9128	9151	9174	230
9.2	9197	9220	9243	9266	9290	9313	9336	9359	9382	9406	232
9.3	9429	9452	9476	9499	9523	9546	9569	9593	9616	9640	234
9.4	9663	9687	9711	9734	9758	9781	9805	9829	9852	9876	237
9.5	9900*	9924	9949	9974	9998	10020	10050	10070	10100	10120	250
9.6	10150	10170	10200	10220	10250	10270	10300	10320	10340	10370	240
9.7	10390	10420	10440	10470	10500	10520	10550	10570	10600	10620	260
9.8	10650	10670	10700	10720	10750	10770	10800	10820	10850	10870	250
9.9	10900*	10920	10950	10970	11000	11020	11050	11070	11100	11120	240
10	11140	11170	11190	11220	11240	11270	11290	11320	11340	11370	250
10.1	11390	11420	11440	11470	11490	11520	11540	11570	11590	11620	250
10.2	11640	11670	11690	11720	11740	11770	11790	11820	11840	11870	250
10.3	11890	11920	11940	11970	11990	12020	12040	12070	12090	12120	250
10.4	12140	12170	12200	12220	12250	12270	12300	12320	12350	12370	260
10.5	12400*	12430	12460	12490	12520	12550	12580	12610	12640	12670	300
10.6	12700	12720	12750	12780	12810	12840	12870	12900	12930	12960	290
10.7	12990	13020	13050	13080	13110	13140	13170	13200	13240	13270	310
10.8	13300	13330	13360	13390	13420	13450	13480	13510	13540	13570	300
10.9	13600	13630	13660	13690	13720	13750	13790	13820	13850	13880	310
11	13910	13940	13970	14000	14030	14060	14100	14130	14160	14190	310
11.1	14220	14250	14280	14320	14350	14380	14410	14440	14470	14500	320
11.2	14540	14570	14600	14630	14660	14690	14730	14760	14790	14820	310
11.3	14850	14890	14920	14950	14980	15010	15050	15080	15110	15140	330
11.4	15180	15210	15240	15270	15300	15340	15370	15400	15430	15470	320
11.5	15500*	15530	15570	15600	15640	15670	15710	15740	15770	15810	340
11.6	15840	15880	15910	15950	15980	16020	16050	16090	16120	16160	350
11.7	16190	16230	16260	16300	16330	16370	16400	16440	16470	16510	350
11.8	16540	16580	16610	16650	16680	16720	16750	16790	16820	16860	360
11.9	16900	16930	16970	17000	17040	17070	17110	17150	17180	17220	350
12	17250	17290	17330	17360	17400	17430	17470	17510	17540	17580	370
12.1	17620	17650	17690	17720	17760	17800	17830	17870	17910	17940	360
12.2	17980	18020	18050	18090	18130	18170	18200	18240	18280	18310	370
12.3	18350	18390	18420	18460	18500	18540	18570	18610	18650	18690	370
12.4	18720	18760	18800	18840	18870	18910	18950	18990	19020	19060	380
12.5	19100*	19140	19180	19210	19250	19290	19330	19370	19400	19440	380
12.6	19480	19520	19560	19590	19630	19670	19710	19750	19790	19820	380
12.7	19860	19900	19940	19980	20020	20060	20100	20130	20170	20210	390
12.8	20250	20290	20330	20370	20410	20450	20480	20520	20560	20600	390
12.9	20640	20680	20720	20760	20800	20840	20880	20920	20960	21000	400
13	21040	21080	21120	21160	21200	21240	21280	21310	21350	21390	390
13.1	21430	21470	21510	21560	21600	21640	21680	21720	21760	21800	410
13.2	21840	21880	21920	21960	22000	22040	22080	22120	22160	22200	400
13.3	22240	22280	22320	22370	22410	22450	22490	22530	22570	22610	410
13.4	22650	22690	22730	22780	22820	22860	22900	22940	22980	23020	420
13.5	23070	23110	23150	23190	23230	23270	23310	23360	23400	23440	410

GAGE HEIGHT (FEET)	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	TENTH FT
13.6	23480	23520	23570	23610	23650	23690	23730	23780	23820	23860	420
13.7	23900	23940	23990	24030	24070	24110	24160	24200	24240	24280	430
13.8	24330	24370	24410	24450	24500	24540	24580	24630	24670	24710	420
13.9	24750	24800	24840	24880	24930	24970	25010	25060	25100	25140	440
14	25190	25230	25270	25320	25360	25400	25450	25490	25530	25580	430
14.1	25620	25670	25710	25750	25800	25840	25880	25930	25970	26020	440
14.2	26060	26100	26150	26190	26240	26280	26330	26370	26410	26460	440
14.3	26500	26550	26590	26640	26680	26730	26770	26820	26860	26910	450
14.4	26950	26990	27040	27080	27130	27170	27220	27260	27310	27350	450
14.5	27400*	27450	27500	27540	27590	27640	27690	27740	27780	27830	480
14.6	27880	27930	27980	28020	28070	28120	28170	28220	28270	28310	480
14.7	28360	28410	28460	28510	28560	28610	28660	28700	28750	28800	490
14.8	28850	28900	28950	29000	29050	29100	29150	29200	29240	29290	490
14.9	29340	29390	29440	29490	29540	29590	29640	29690	29740	29790	500
15	29840	29890	29940	29990	30040	30090	30140	30190	30240	30290	500
15.1	30340	30390	30440	30490	30540	30590	30640	30690	30750	30800	510
15.2	30850	30900	30950	31000	31050	31100	31150	31200	31250	31310	510
15.3	31360	31410	31460	31510	31560	31610	31660	31720	31770	31820	510
15.4	31870	31920	31970	32030	32080	32130	32180	32230	32290	32340	520
15.5	32390	32440	32490	32550	32600	32650	32700	32750	32810	32860	520
15.6	32910	32960	33020	33070	33120	33180	33230	33280	33330	33390	530
15.7	33440	33490	33550	33600	33650	33700	33760	33810	33860	33920	530
15.8	33970	34020	34080	34130	34180	34240	34290	34350	34400	34450	540
15.9	34510	34560	34610	34670	34720	34780	34830	34880	34940	34990	540
16	35050	35100	35160	35210	35260	35320	35370	35430	35480	35540	540
16.1	35590	35650	35700	35760	35810	35870	35920	35980	36030	36090	550
16.2	36140	36200	36250	36310	36360	36420	36470	36530	36580	36640	550
16.3	36690	36750	36810	36860	36920	36970	37030	37090	37140	37200	560
16.4	37250	37310	37360	37420	37480	37530	37590	37650	37700	37760	570
16.5	37820	37870	37930	37980	38040	38100	38150	38210	38270	38330	560
16.6	38380	38440	38500	38550	38610	38670	38720	38780	38840	38900	570
16.7	38950	39010	39070	39130	39180	39240	39300	39360	39410	39470	580
16.8	39530	39590	39640	39700	39760	39820	39880	39930	39990	40050	580
16.9	40110	40170	40220	40280	40340	40400	40460	40520	40580	40630	580
17	40690	40750	40810	40870	40930	40990	41050	41100	41160	41220	590
17.1	41280	41340	41400	41460	41520	41580	41640	41700	41760	41820	590
17.2	41870	41930	41990	42050	42110	42170	42230	42290	42350	42410	600
17.3	42470	42530	42590	42650	42710	42770	42830	42890	42950	43010	600
17.4	43070	43130	43200	43260	43320	43380	43440	43500	43560	43620	610
17.5	43680	43740	43800	43860	43920	43990	44050	44110	44170	44230	610
17.6	44290	44350	44410	44480	44540	44600	44660	44720	44780	44840	620
17.7	44910	44970	45030	45090	45150	45220	45280	45340	45400	45460	620
17.8	45530	45590	45650	45710	45780	45840	45900	45960	46030	46090	620
17.9	46150	46210	46280	46340	46400	46460	46530	46590	46650	46720	630
18	46780	46840	46910	46970	47030	47090	47160	47220	47280	47350	630
18.1	47410	47480	47540	47600	47670	47730	47790	47860	47920	47990	640
18.2	48050	48110	48180	48240	48310	48370	48430	48500	48560	48630	640
18.3	48690	48760	48820	48880	48950	49010	49080	49140	49210	49270	650
18.4	49340	49400	49470	49530	49600	49660	49730	49790	49860	49920	650
18.5	49990	50050	50120	50180	50250	50320	50380	50450	50510	50580	650
18.6	50640	50710	50770	50840	50910	50970	51040	51100	51170	51240	660
18.7	51300	51370	51440	51500	51570	51630	51700	51770	51830	51900	670
18.8	51970	52030	52100	52170	52230	52300	52370	52430	52500	52570	670
18.9	52640	52700	52770	52840	52900	52970	53040	53110	53170	53240	670
19	53310	53380	53440	53510	53580	53650	53710	53780	53850	53920	680

GAGE HEIGHT (FEET)	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	TENTH FT
19.1	53990	54050	54120	54190	54260	54330	54390	54460	54530	54600	680
19.2	54670	54740	54800	54870	54940	55010	55080	55150	55220	55290	680
19.3	55350	55420	55490	55560	55630	55700	55770	55840	55910	55980	700
19.4	56050	56110	56180	56250	56320	56390	56460	56530	56600	56670	690
19.5	56740	56810	56880	56950	57020	57090	57160	57230	57300	57370	700
19.6	57440	57510	57580	57650	57720	57790	57860	57930	58000	58070	700
19.7	58140	58220	58290	58360	58430	58500	58570	58640	58710	58780	710
19.8	58850	58920	59000	59070	59140	59210	59280	59350	59420	59490	720
19.9	59570	59640	59710	59780	59850	59920	60000	60070	60140	60210	710
20	60280	60360	60430	60500	60570	60640	60720	60790	60860	60930	730
20.1	61010	61080	61150	61220	61300	61370	61440	61510	61590	61660	720
20.2	61730	61810	61880	61950	62020	62100	62170	62240	62320	62390	730
20.3	62460	62540	62610	62680	62760	62830	62910	62980	63050	63130	740
20.4	63200	63270	63350	63420	63500	63570	63640	63720	63790	63870	740
20.5	63940*	64010	64090	64160	64240	64310	64390	64460	64540	64610	750
20.6	64690	64760	64840	64910	64990	65060	65140	65210	65290	65360	750
20.7	65440	65510	65590	65660	65740	65810	65890	65960	66040	66120	750
20.8	66190	66270	66340	66420	66490	66570	66650	66720	66800	66870	760
20.9	66950	67030	67100	67180	67250	67330	67410	67480	67560	67640	760
21	67710	67790	67870	67940	68020	68100	68170	68250	68330	68410	770
21.1	68480	68560	68640	68710	68790	68870	68950	69020	69100	69180	770
21.2	69250	69330	69410	69490	69570	69640	69720	69800	69880	69950	780
21.3	70030	70110	70190	70270	70340	70420	70500	70580	70660	70740	780
21.4	70810	70890	70970	71050	71130	71210	71290	71360	71440	71520	790
21.5	71600	71680	71760	71840	71920	72000	72070	72150	72230	72310	790
21.6	72390	72470	72550	72630	72710	72790	72870	72950	73030	73110	800
21.7	73190	73270	73350	73430	73510	73590	73670	73750	73830	73910	800
21.8	73990	74070	74150	74230	74310	74390	74470	74550	74630	74710	800
21.9	74790	74870	74950	75030	75120	75200	75280	75360	75440	75520	810
22	75600	75680	75760	75840	75930	76010	76090	76170	76250	76330	810
22.1	76410	76500	76580	76660	76740	76820	76910	76990	77070	77150	820
22.2	77230	77320	77400	77480	77560	77640	77730	77810	77890	77970	830
22.3	78060	78140	78220	78300	78390	78470	78550	78630	78720	78800	820
22.5	79720	79800	79880	79970	80050	80130	80220	80300	80380	80470	830
22.6	80550	80640	80720	80800	80890	80970	81060	81140	81220	81310	840
22.7	81390	81480	81560	81650	81730	81810	81900	81980	82070	82150	850
22.8	82240	82320	82410	82490	82580	82660	82750	82830	82920	83000	850
22.9	83090	83170	83260	83340	83430	83520	83600	83690	83770	83860	850
23	83940	84030	84110	84200	84290	84370	84460	84540	84630	84720	860
23.1	84800	84890	84970	85060	85150	85230	85320	85410	85490	85580	870
23.2	85670	85750	85840	85930	86010	86100	86190	86270	86360	86450	860
23.3	86530	86620	86710	86800	86880	86970	87060	87150	87230	87320	880
23.4	87410	87500	87580	87670	87760	87850	87930	88020	88110	88200	880
23.5	88290	88370	88460	88550	88640	88730	88810	88900	88990	89080	880
23.6	89170	89260	89340	89430	89520	89610	89700	89790	89880	89970	880
23.7	90050	90140	90230	90320	90410	90500	90590	90680	90770	90860	900
23.8	90950	91040	91120	91210	91300	91390	91480	91570	91660	91750	890
23.9	91840	91930	92020	92110	92200	92290	92380	92470	92560	92650	900
24	92740	92830	92920	93010	93100	93190	93280	93380	93470	93560	910
24.1	93650	93740	93830	93920	94010	94100	94190	94280	94370	94470	910
24.2	94560	94650	94740	94830	94920	95010	95100	95200	95290	95380	910
24.3	95470	95560	95650	95750	95840	95930	96020	96110	96210	96300	920
24.4	96390	96480	96570	96670	96760	96850	96940	97040	97130	97220	920
24.5	97310	97410	97500	97590	97680	97780	97870	97960	98060	98150	930
24.6	98240	98330	98430	98520	98610	98710	98800	98890	98990	99080	930
24.7	99170	99270	99360	99460	99550	99640	99740	99830	99920	100000	930

GAGE HEIGHT (FEET)	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	TENTH FT
24.8	100100	100200	100300	100400	100500	100600	100700	100800	1	900	101000	1000
24.9	101100	101100	101200	101300	101400	101500	101600	101700	1	1800	101900	900
25	102000*	102100	102200	102300	102400	102500	102600	102700	1	2800	102900	1000
25.1	103000	103100	103200	103300	103400	103500	103600	103700	1	3800	103900	1000
25.2	104000	104100	104200	104300	104500	104600	104700	104800	1	4900	105000	1100
25.3	105100	105200	105300	105400	105500	105600	105700	105800	1	5900	106000	1000
25.4	106100	106200	106300	106400	106500	106600	106700	106800	1	6900	107000	1000
25.5	107100	107300	107400	107500	107600	107700	107800	107900	1	8000	108100	1100
25.6	108200	108300	108400	108500	108600	108700	108800	108900	1	9000	109100	1000
25.7	109200	109300	109500	109600	109700	109800	109900	110000	1	10100	110200	1100
25.8	110300	110400	110500	110600	110700	110800	110900	111000	1	11200	111300	1100
25.9	111400	111500	111600	111700	111800	111900	112000	112100	1	12200	112300	1000
26	112400	112500	112600	112800	112900	113000	113100	113200	1	13300	113400	1100
26.1	113500	113600	113700	113800	113900	114000	114200	114300	1	14400	114500	1100
26.2	114600	114700	114800	114900	115000	115100	115200	115300	1	15500	115600	1100
26.3	115700	115800	115900	116000	116100	116200	116300	116400	1	16500	116700	1100
26.4	116800	116900	117000	117100	117200	117300	117400	117500	1	17600	117800	1100
26.5	117900	118000	118100	118200	118300	118400	118500	118600	1	18700	118900	1100
26.6	119000	119100	119200	119300	119400	119500	119600	119700	1	19800	120000	1100
26.7	120100	120200	120300	120400	120500	120600	120700	120900	1	21000	121100	1100
26.8	121200	121300	121400	121500	121600	121700	121900	122000	1	22100	122200	1100
26.9	122300	122400	122500	122600	122800	122900	123000	123100	1	23200	123300	1100
27	123400	123500	123700	123800	123900	124000	124100	124200	1	24300	124400	1200
27.1	124600	124700	124800	124900	125000	125100	125200	125400	1	25500	125600	1100
27.2	125700	125800	125900	126000	126200	126300	126400	126500	1	26600	126700	1100
27.3	126800	127000	127100	127200	127300	127400	127500	127600	1	27800	127900	1200
27.4	128000	128100	128200	128300	128500	128600	128700	128800	1	28900	129000	1100
27.5	129100	129300	129400	129500	129600	129700	129800	130000	1	30100	130200	1200
27.6	130300	130400	130500	130700	130800	130900	131000	131100	1	31200	131400	1200
27.7	131500	131600	131700	131800	131900	132100	132200	132300	1	32400	132500	1100
27.8	132600	132800	132900	133000	133100	133200	133300	133500	1	33600	133700	1200
27.9	133800	133900	134100	134200	134300	134400	134500	134600	1	34800	134900	1200*

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - CA INSTALLATION 04/30/2002

STATION NUMBER 11446500 AMERICAN R A FAIR OAKS CA STREAM SOURCE AGENCY USGS
LATITUDE 383808 LONGITUDE 1211336 DRAINAGE AREA 1888.00 DATUM 71.53 STATE 06 COUNTY 067

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 2000 TO SEPTEMBER 2001
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1410	2010	2390	2400	1520	1530	1470	1490	2420	2140	1740	1560
2	1680	2030	2370	2380	1510	1510	1480	1500	e3110	2100	1720	1530
3	1690	1720	2360	2390	1520	1520	1580	1470	e3050	2110	1600	1520
4	1700	1650	2370	2360	1490	1490	1960	1470	e3040	2150	1530	1550
5	1670	1650	2350	2210	1490	1510	1990	1500	e3030	2090	1540	1550
6	1720	1660	2300	1960	1480	1520	2000	1480	3020	2110	1530	1540
7	1710	1640	2300	1900	1480	1490	1640	1490	3010	2140	1580	1540
8	1660	1680	2310	2250	1530	1490	1480	1500	3000	2090	1570	1520
9	1680	1660	2300	2940	1510	1520	1510	1480	3020	2140	1540	1520
10	1690	1630	2290	3030	1500	1520	1520	1490	2570	2120	1530	1530
11	1710	1680	2310	2990	1550	1510	1510	1490	2090	2130	1600	1540
12	1680	1680	2310	3030	1570	1470	1500	1790	2000	2110	1550	1530
13	1670	1690	2340	2510	1550	1510	1500	1820	2000	2130	1540	1520
14	2150	1900	2330	2130	1510	1540	1520	1820	1980	2120	1550	1540
15	2190	1940	2320	2040	1490	1520	1490	1820	1970	2130	1540	1510
16	2130	2150	2340	2020	1470	1540	1520	1810	1980	2160	1560	1520
17	2100	2360	2370	2020	1490	1500	1490	1810	1970	2150	1530	1530
18	2140	2380	2410	1970	1480	1490	1480	1800	1990	2150	1570	1520
19	2150	2430	2370	1780	1490	1520	1480	1820	1990	2130	1540	1310
20	2130	2400	2390	1580	1500	1540	2200	1810	2150	2140	1570	1530
21	2130	2360	2400	1520	1510	1520	2080	1810	2580	2130	1560	1530
22	2120	2360	2380	1500	1510	1540	1610	1820	2620	2130	1550	1540
23	2140	2390	2390	1480	1520	1520	1460	1830	2620	2130	1580	1540
24	2140	2390	2400	1490	1510	1540	1470	1820	2590	2130	1550	1510
25	2100	2420	2390	1490	1520	1500	1480	1810	2620	2130	1540	1520
26	2120	2380	2320	1550	1520	1540	1470	1810	2600	2150	1540	1530
27	2140	2390	2310	1550	1470	1500	1470	1820	2600	2130	1540	1500

28	2130	2360	2340	1530	1500	1470	1470	2400	2600	2130	1530	1520
29	2190	2370	2310	1540	---	1460	1480	2410	2600	2160	1530	1530
30	2130	2380	2350	1540	---	1470	1480	2410	2240	2160	1580	1510
31	2110	---	2360	1560	---	1470	---	2410	---	1890	1550	---
TOTAL	60110	61740	72780	62640	42190	46770	47790	55010	75060	65810	48480	45640
MEAN	1939	2058	2348	2021	1507	1509	1593	1775	2502	2123	1564	1521
MAX	2190	2430	2410	3030	1570	1540	2200	2410	3110	2160	1740	1560
MIN	1410	1630	2290	1480	1470	1460	1460	1470	1970	1890	1530	1310
AC-FT	119200	122500	144400	124200	83680	92770	94790	109100	148900	130500	96160	90530

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1956 - 2001, BY WATER YEAR (WY)

MEAN	1940	2422	3900	5472	5798	5147	4240	4287	3769	3626	2739	2252
MAX	4102	11700	19360	31780	31140	19340	17760	14270	9828	10710	4500	4014
(WY)	1970	1984	1965	1997	1986	1983	1982	1995	1983	1995	1983	1998
MIN	284	272	252	350	408	273	258	520	1135	869	855	602
(WY)	1978	1978	1978	1962	1991	1977	1977	1977	1977	1977	1977	1977

SUMMARY STATISTICS	FOR 2000 CALENDAR YEAR		FOR 2001 WATER YEAR		WATER YEARS 1956 - 2001	
ANNUAL TOTAL	1299190		684020			
ANNUAL MEAN	3550		1874		3791	
HIGHEST ANNUAL MEAN					8854	1983
LOWEST ANNUAL MEAN					778	1977
HIGHEST DAILY MEAN	24100	Feb 15	3110	Jun 2	131000	Feb 19 1986
LOWEST DAILY MEAN	1410	Oct 1	1310	Sep 19	215	Apr 20 1977
ANNUAL SEVEN-DAY MINIMUM	1440	Sep 7	1470	Apr 23	237	Jan 7 1978
MAXIMUM PEAK FLOW			3360	Jun 8	134000	Feb 19 1986
MAXIMUM PEAK STAGE			6.15	Jun 8	27.96	Feb 19 1986
ANNUAL RUNOFF (AC-FT)	2577000		1357000		2747000	
10 PERCENT EXCEEDS	5950		2390		7610	
50 PERCENT EXCEEDS	2410		1690		2500	
90 PERCENT EXCEEDS	1480		1490		937	

STATISTICS COMPUTED BY: smithson DATE: 11/03/2001 AT: 12:25:49

e Estimated

STATION NUMBER 11446500 AMERICAN R A FAIR OAKS CA STREAM SOURCE AGENCY USGS
LATITUDE 383808 LONGITUDE 1211336 DRAINAGE AREA 1888.00 DATUM 71.53 STATE 06 COUNTY 067
PROVISIONAL DATA SUBJECT TO REVISION

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 2001 TO SEPTEMBER 2002
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1520	1000	962	1420	1420	1430	3000	---	---	---	---	---
2	1550	984	1180	1420	1470	1430	2920	---	---	---	---	---
3	1500	967	1190	1420	1420	1930	2920	---	---	---	---	---
4	1500	969	1240	1420	1440	1950	3260	---	---	---	---	---
5	1500	968	1400	1440	1440	1900	3300	---	---	---	---	---
6	1260	975	1410	1450	1440	1860	3320	---	---	---	---	---
7	1220	980	1420	1420	1460	1880	3310	---	---	---	---	---
8	1230	988	1420	1410	1470	3110	3300	---	---	---	---	---
9	1220	989	1440	1420	1450	3950	3900	---	---	---	---	---
10	1220	987	1430	1410	1440	3960	4000	---	---	---	---	---
11	1220	963	1430	1430	1430	3930	4010	---	---	---	---	---
12	1230	965	1420	1410	1440	3930	3990	---	---	---	---	---
13	1240	984	1420	1410	1480	3960	3990	---	---	---	---	---
14	1240	985	1440	1420	1460	3590	4000	---	---	---	---	---
15	1230	985	1420	e1440	1460	3560	4000	---	---	---	---	---
16	1230	986	1430	e1430	1450	3080	4000	---	---	---	---	---
17	1210	986	1440	e1430	1460	2940	4000	---	---	---	---	---
18	1220	989	1440	1430	1470	2930	4010	---	---	---	---	---
19	1210	997	1430	1420	1460	3010	4020	---	---	---	---	---
20	1220	971	1430	1400	1440	3030	4000	---	---	---	---	---
21	1220	980	1430	1430	1400	2980	4010	---	---	---	---	---
22	1210	984	1420	1430	1400	2990	4020	---	---	---	---	---
23	1200	985	1430	1430	1460	2960	3630	---	---	---	---	---
24	1210	990	1420	1430	1460	2930	3520	---	---	---	---	---
25	1210	995	1420	1420	1460	2970	3540	---	---	---	---	---
26	1210	977	1440	1430	1450	2510	3520	---	---	---	---	---
27	1230	970	1420	1420	1430	2310	3510	---	---	---	---	---

28	1210	970	1410	1410	1430	2310	3510	---	---	---	---	---
29	1210	969	1430	1420	---	2340	3530	---	---	---	---	---
30	1160	969	1420	1420	---	2860	---	---	---	---	---	---
31	1080	---	1420	1470	---	2960	---	---	---	---	---	---
TOTAL	39120	29407	43052	44160	40490	87480	---	---	---	---	---	---
MEAN	1262	980	1389	1425	1446	2822	---	---	---	---	---	---
MAX	1550	1000	1440	1470	1480	3960	---	---	---	---	---	---
MIN	1080	963	962	1400	1400	1430	---	---	---	---	---	---
AC-FT	77590	58330	85390	87590	80310	173500	---	---	---	---	---	---

e Estimated

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - CA INSTALLATION 04/30/2002

STATION NUMBER 11446500 AMERICAN R A FAIR OAKS CA STREAM SOURCE AGENCY USGS
LATITUDE 383808 LONGITUDE 1211336 DRAINAGE AREA 1888.00 DATUM 71.53 STATE 06 COUNTY 067

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 2000 TO SEPTEMBER 2001
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1410	2010	2390	2400	1520	1530	1470	1490	2420	2140	1740	1560
2	1680	2030	2370	2380	1510	1510	1480	1500	e3110	2100	1720	1530
3	1690	1720	2360	2390	1520	1520	1580	1470	e3050	2110	1600	1520
4	1700	1650	2370	2360	1490	1490	1960	1470	e3040	2150	1530	1550
5	1670	1650	2350	2210	1490	1510	1990	1500	e3030	2090	1540	1550
6	1720	1660	2300	1960	1480	1520	2000	1480	3020	2110	1530	1540
7	1710	1640	2300	1900	1480	1490	1640	1490	3010	2140	1580	1540
8	1660	1680	2310	2250	1530	1490	1480	1500	3000	2090	1570	1520
9	1680	1660	2300	2940	1510	1520	1510	1480	3020	2140	1540	1520
10	1690	1630	2290	3030	1500	1520	1520	1490	2570	2120	1530	1530
11	1710	1680	2310	2990	1550	1510	1510	1490	2090	2130	1600	1540
12	1680	1680	2310	3030	1570	1470	1500	1790	2000	2110	1550	1530
13	1670	1690	2340	2510	1550	1510	1500	1820	2000	2130	1540	1520
14	2150	1900	2330	2130	1510	1540	1520	1820	1980	2120	1550	1540
15	2190	1940	2320	2040	1490	1520	1490	1820	1970	2130	1540	1510
16	2130	2150	2340	2020	1470	1540	1520	1810	1980	2160	1560	1520
17	2100	2360	2370	2020	1490	1500	1490	1810	1970	2150	1530	1530
18	2140	2380	2410	1970	1480	1490	1480	1800	1990	2150	1570	1520
19	2150	2430	2370	1780	1490	1520	1480	1820	1990	2130	1540	1310
20	2130	2400	2390	1580	1500	1540	2200	1810	2150	2140	1570	1530
21	2130	2360	2400	1520	1510	1520	2080	1810	2580	2130	1560	1530
22	2120	2360	2380	1500	1510	1540	1610	1820	2620	2130	1550	1540
23	2140	2390	2390	1480	1520	1520	1460	1830	2620	2130	1580	1540
24	2140	2390	2400	1490	1510	1540	1470	1820	2590	2130	1550	1510
25	2100	2420	2390	1490	1520	1500	1480	1810	2620	2130	1540	1520
26	2120	2380	2320	1550	1520	1540	1470	1810	2600	2150	1540	1530
27	2140	2390	2310	1550	1470	1500	1470	1820	2600	2130	1540	1500

28	2130	2360	2340	1530	1500	1470	1470	2400	2600	2130	1530	1520
29	2190	2370	2310	1540	---	1460	1480	2410	2600	2160	1530	1530
30	2130	2380	2350	1540	---	1470	1480	2410	2240	2160	1580	1510
31	2110	---	2360	1560	---	1470	---	2410	---	1890	1550	---
TOTAL	60110	61740	72780	62640	42190	46770	47790	55010	75060	65810	48480	45640
MEAN	1939	2058	2348	2021	1507	1509	1593	1775	2502	2123	1564	1521
MAX	2190	2430	2410	3030	1570	1540	2200	2410	3110	2160	1740	1560
MIN	1410	1630	2290	1480	1470	1460	1460	1470	1970	1890	1530	1310
AC-FT	119200	122500	144400	124200	83680	92770	94790	109100	148900	130500	96160	90530

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1956 - 2001, BY WATER YEAR (WY)

MEAN	1940	2422	3900	5472	5798	5147	4240	4287	3769	3626	2739	2252
MAX	4102	11700	19360	31780	31140	19340	17760	14270	9828	10710	4500	4014
(WY)	1970	1984	1965	1997	1986	1983	1982	1995	1983	1995	1983	1998
MIN	284	272	252	350	408	273	258	520	1135	869	855	602
(WY)	1978	1978	1978	1962	1991	1977	1977	1977	1977	1977	1977	1977

SUMMARY STATISTICS	FOR 2000 CALENDAR YEAR		FOR 2001 WATER YEAR		WATER YEARS 1956 - 2001	
ANNUAL TOTAL	1299190		684020			
ANNUAL MEAN	3550		1874		3791	
HIGHEST ANNUAL MEAN					8854	1983
LOWEST ANNUAL MEAN					778	1977
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LOWEST DAILY MEAN	1410	Oct 1	1310	Sep 19	215	Apr 20 1977
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MAXIMUM PEAK FLOW			3360	Jun 8	134000	Feb 19 1986
MAXIMUM PEAK STAGE			6.15	Jun 8	27.96	Feb 19 1986
ANNUAL RUNOFF (AC-FT)	2577000		1357000		2747000	
10 PERCENT EXCEEDS	5950		2390		7610	
50 PERCENT EXCEEDS	2410		1690		2500	
90 PERCENT EXCEEDS	1480		1490		937	

STATISTICS COMPUTED BY: smithson DATE: 11/03/2001 AT: 12:25:49

e Estimated

STATION NUMBER 11446500 AMERICAN R A FAIR OAKS CA STREAM SOURCE AGENCY USGS
LATITUDE 383808 LONGITUDE 1211336 DRAINAGE AREA 1888.00 DATUM 71.53 STATE 06 COUNTY 067
PROVISIONAL DATA SUBJECT TO REVISION

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 2001 TO SEPTEMBER 2002
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1520	1000	962	1420	1420	1430	3000	---	---	---	---	---
2	1550	984	1180	1420	1470	1430	2920	---	---	---	---	---
3	1500	967	1190	1420	1420	1930	2920	---	---	---	---	---
4	1500	969	1240	1420	1440	1950	3260	---	---	---	---	---
5	1500	968	1400	1440	1440	1900	3300	---	---	---	---	---
6	1260	975	1410	1450	1440	1860	3320	---	---	---	---	---
7	1220	980	1420	1420	1460	1880	3310	---	---	---	---	---
8	1230	988	1420	1410	1470	3110	3300	---	---	---	---	---
9	1220	989	1440	1420	1450	3950	3900	---	---	---	---	---
10	1220	987	1430	1410	1440	3960	4000	---	---	---	---	---
11	1220	963	1430	1430	1430	3930	4010	---	---	---	---	---
12	1230	965	1420	1410	1440	3930	3990	---	---	---	---	---
13	1240	984	1420	1410	1480	3960	3990	---	---	---	---	---
14	1240	985	1440	1420	1460	3590	4000	---	---	---	---	---
15	1230	985	1420	e1440	1460	3560	4000	---	---	---	---	---
16	1230	986	1430	e1430	1450	3080	4000	---	---	---	---	---
17	1210	986	1440	e1430	1460	2940	4000	---	---	---	---	---
18	1220	989	1440	1430	1470	2930	4010	---	---	---	---	---
19	1210	997	1430	1420	1460	3010	4020	---	---	---	---	---
20	1220	971	1430	1400	1440	3030	4000	---	---	---	---	---
21	1220	980	1430	1430	1400	2980	4010	---	---	---	---	---
22	1210	984	1420	1430	1400	2990	4020	---	---	---	---	---
23	1200	985	1430	1430	1460	2960	3630	---	---	---	---	---
24	1210	990	1420	1430	1460	2930	3520	---	---	---	---	---
25	1210	995	1420	1420	1460	2970	3540	---	---	---	---	---
26	1210	977	1440	1430	1450	2510	3520	---	---	---	---	---
27	1230	970	1420	1420	1430	2310	3510	---	---	---	---	---

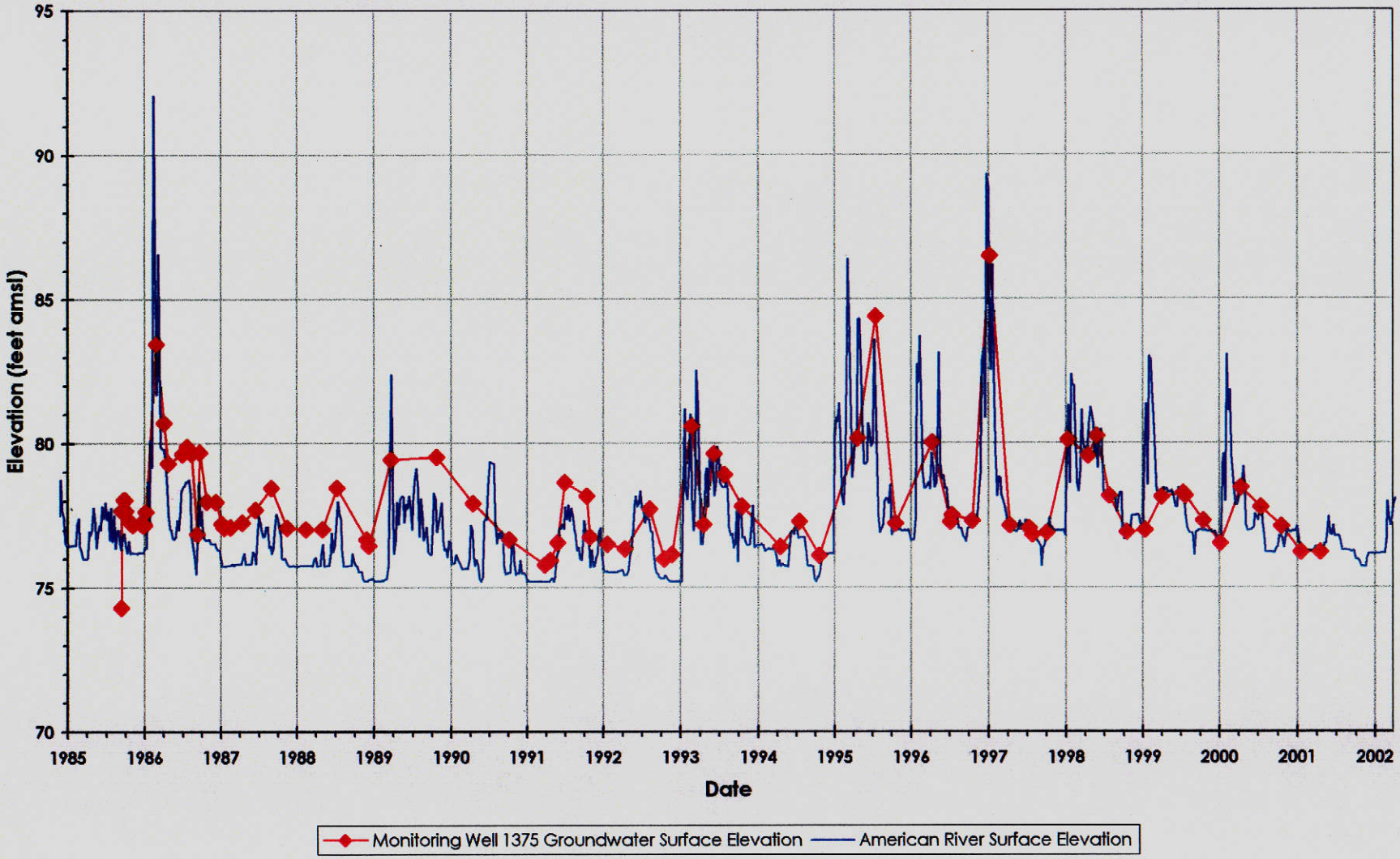
28	1210	970	1410	1410	1430	2310	3510	---	---	---	---	---
29	1210	969	1430	1420	---	2340	3530	---	---	---	---	---
30	1160	969	1420	1420	---	2860	---	---	---	---	---	---
31	1080	---	1420	1470	---	2960	---	---	---	---	---	---
TOTAL	39120	29407	43052	44160	40490	87480	---	---	---	---	---	---
MEAN	1262	980	1389	1425	1446	2822	---	---	---	---	---	---
MAX	1550	1000	1440	1470	1480	3960	---	---	---	---	---	---
MIN	1080	963	962	1400	1400	1430	---	---	---	---	---	---
AC-FT	77590	58330	85390	87590	80310	173500	---	---	---	---	---	---

e Estimated

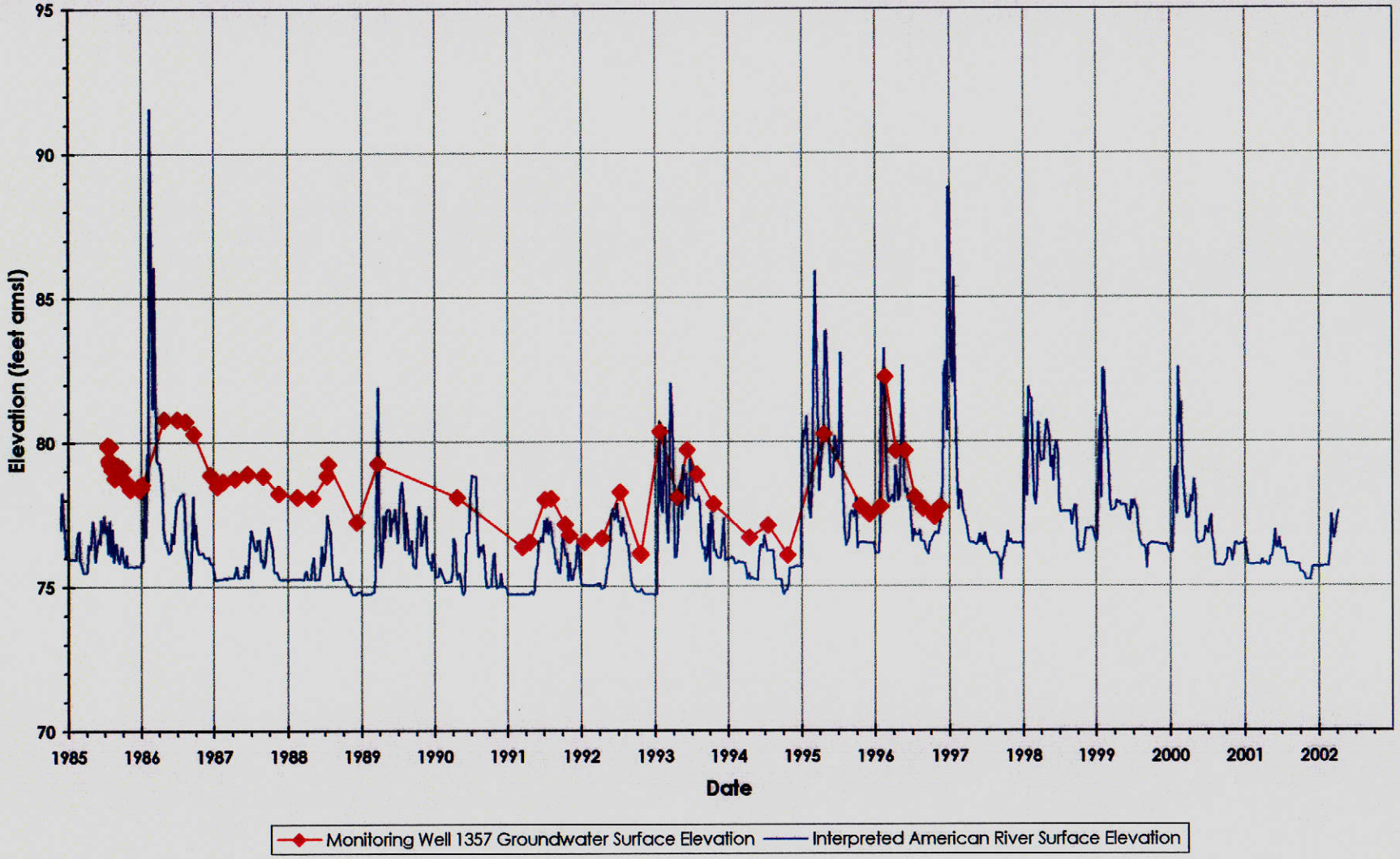
APPENDIX C

HYDROGRAPHS OF GROUNDWATER WATER ELEVATIONS FROM SELECTED MONITORING WELLS IN THE AMERICAN RIVER STUDY AREA

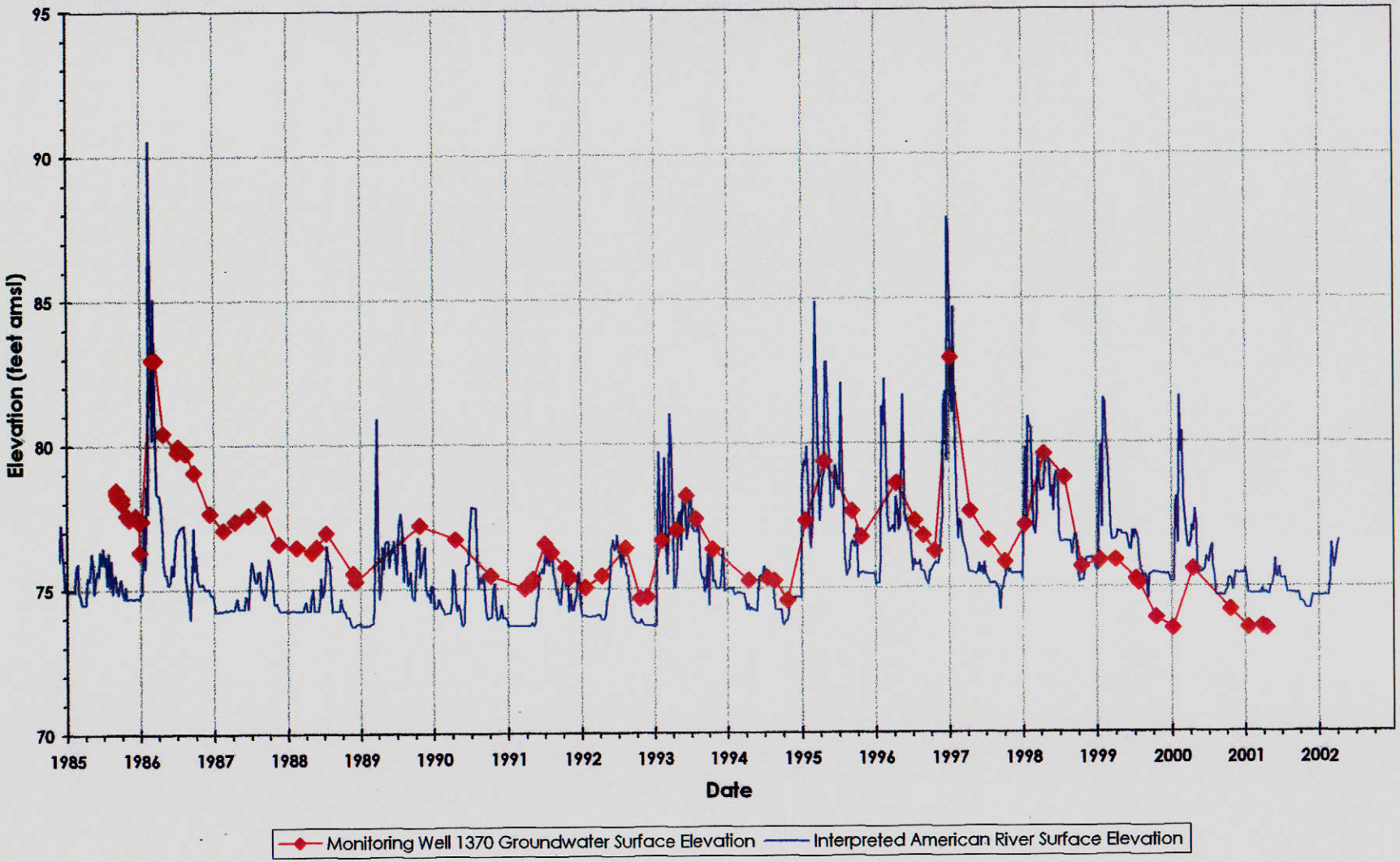
Comparison of Groundwater Surface Elevation in Well 1375 with the American River Surface Elevation



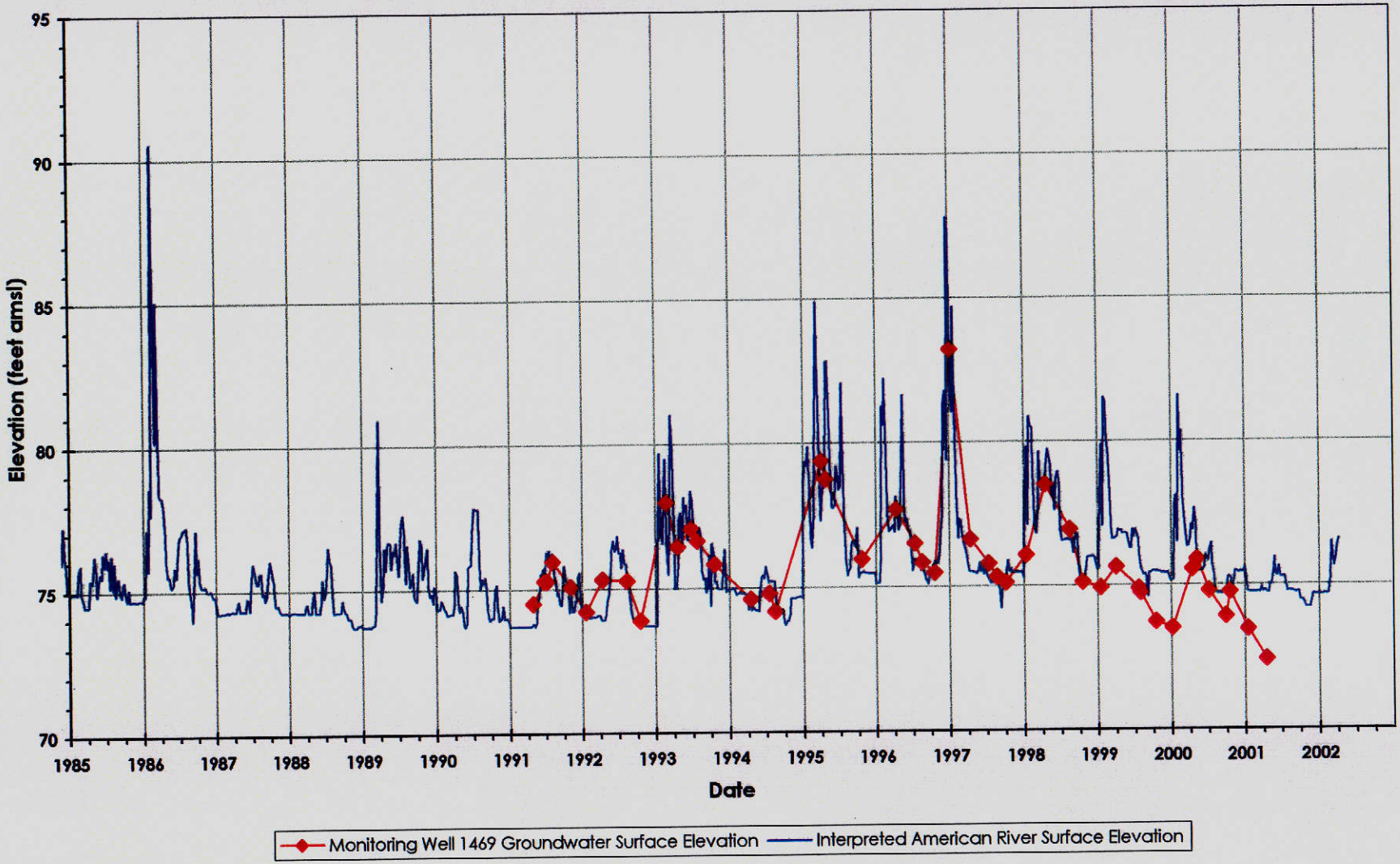
Comparison of Groundwater Surface Elevation in Well 1357 with the Interpreted American River Surface Elevation



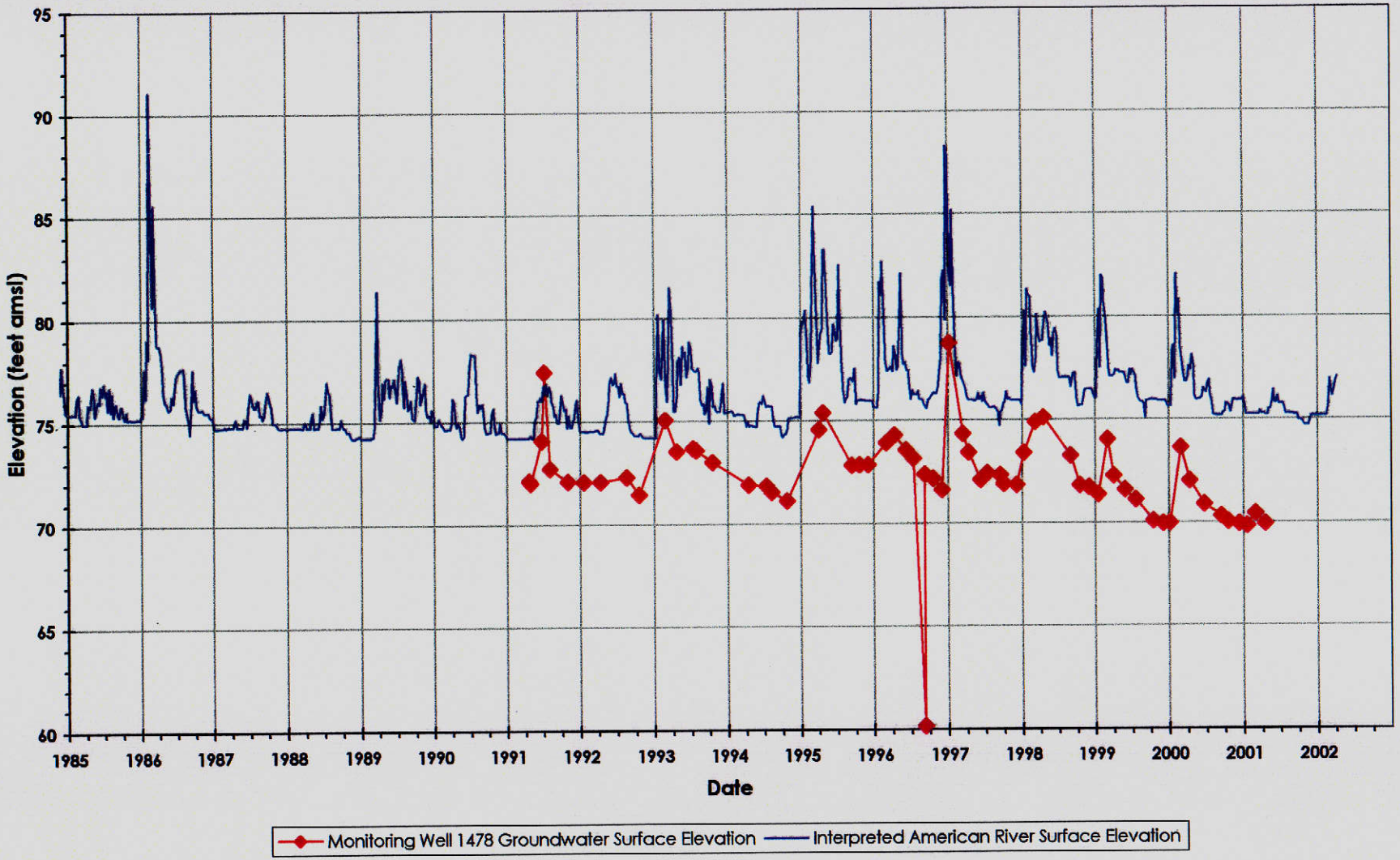
Comparison of Groundwater Surface Elevation in Well 1370 with the Interpreted American River Surface Elevation



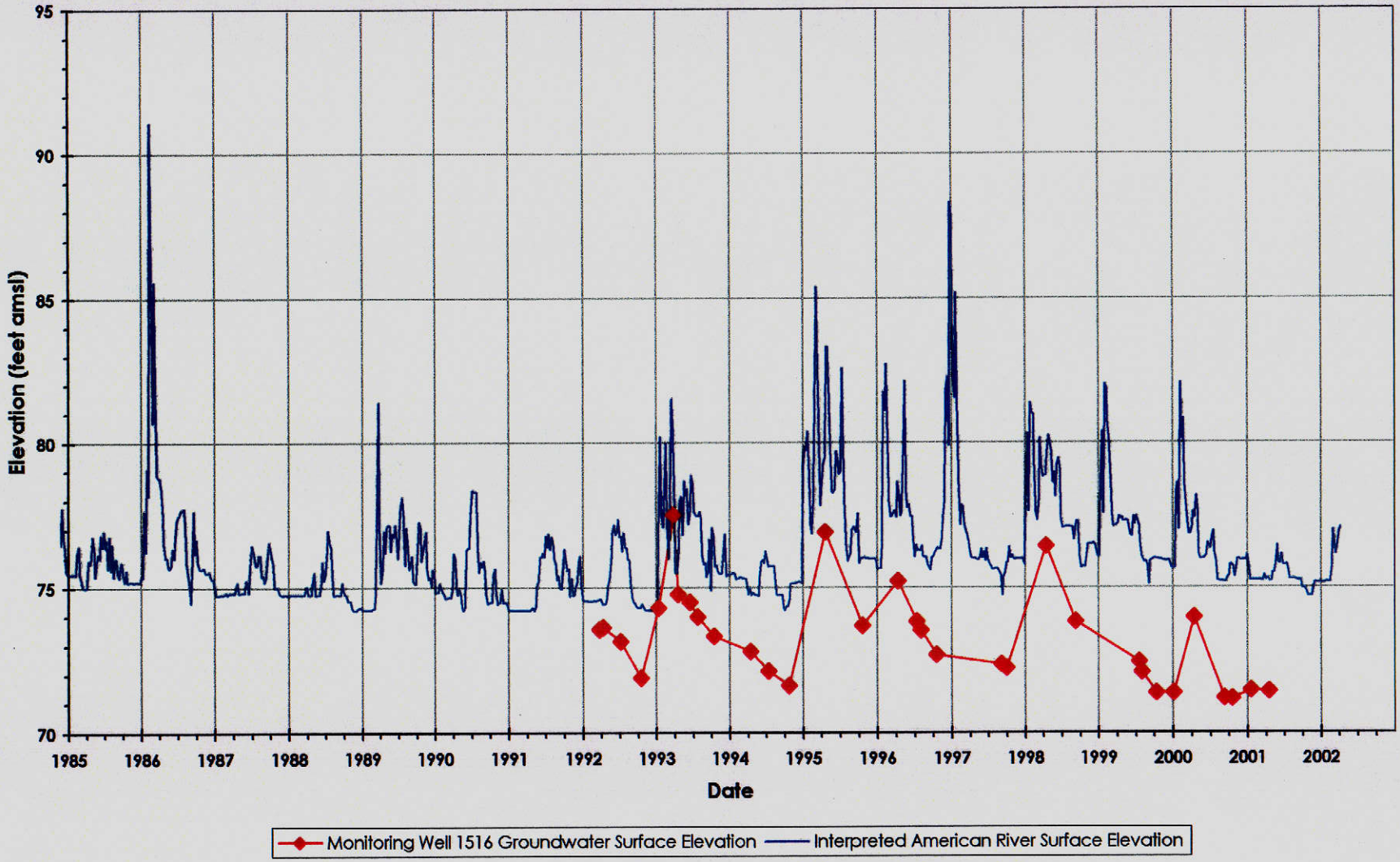
Comparison of Groundwater Surface Elevation in Well 1469 with the Interpreted American River Surface Elevation



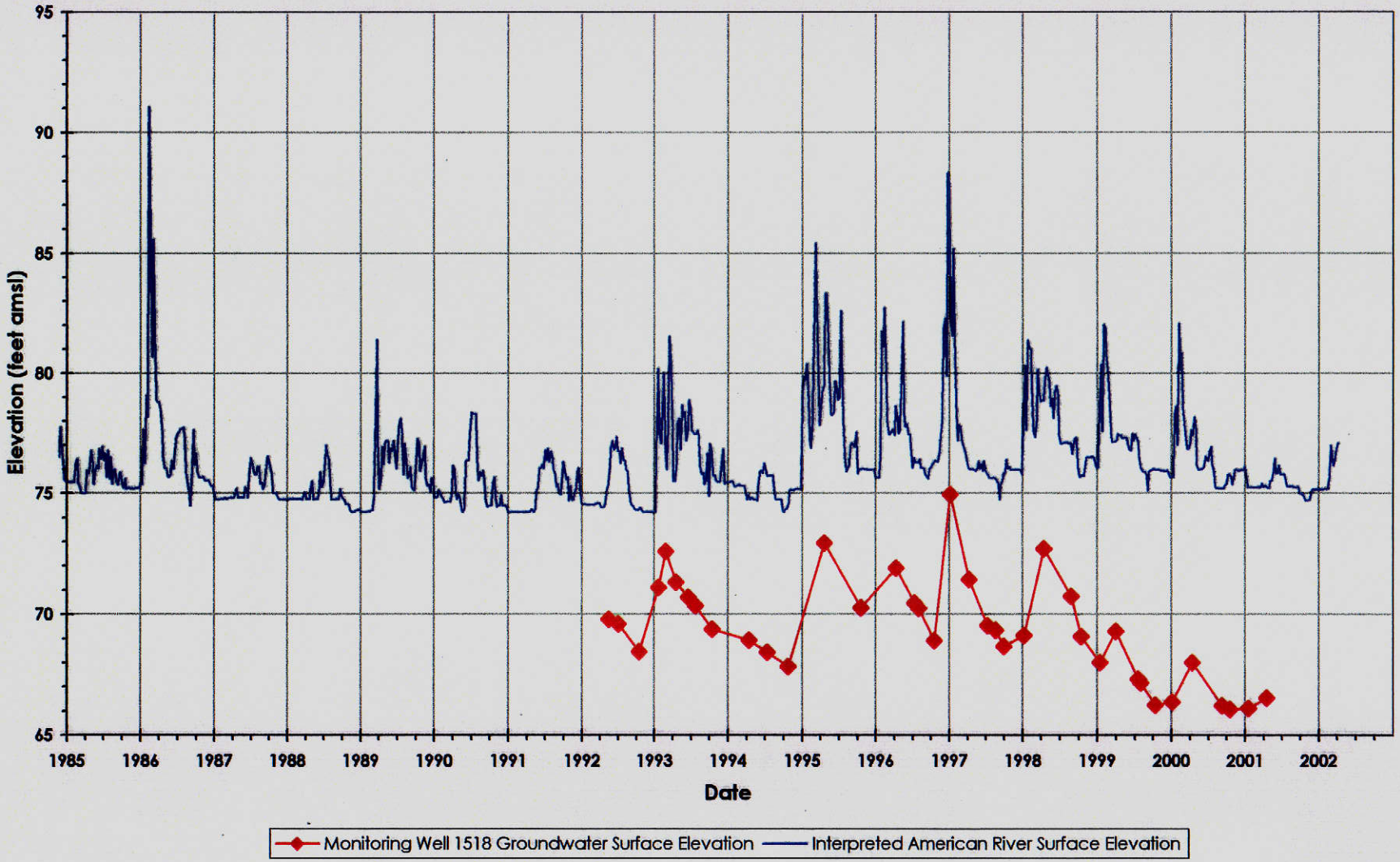
Comparison of Groundwater Surface Elevation in Well 1478 with the Interpreted American River Surface Elevation



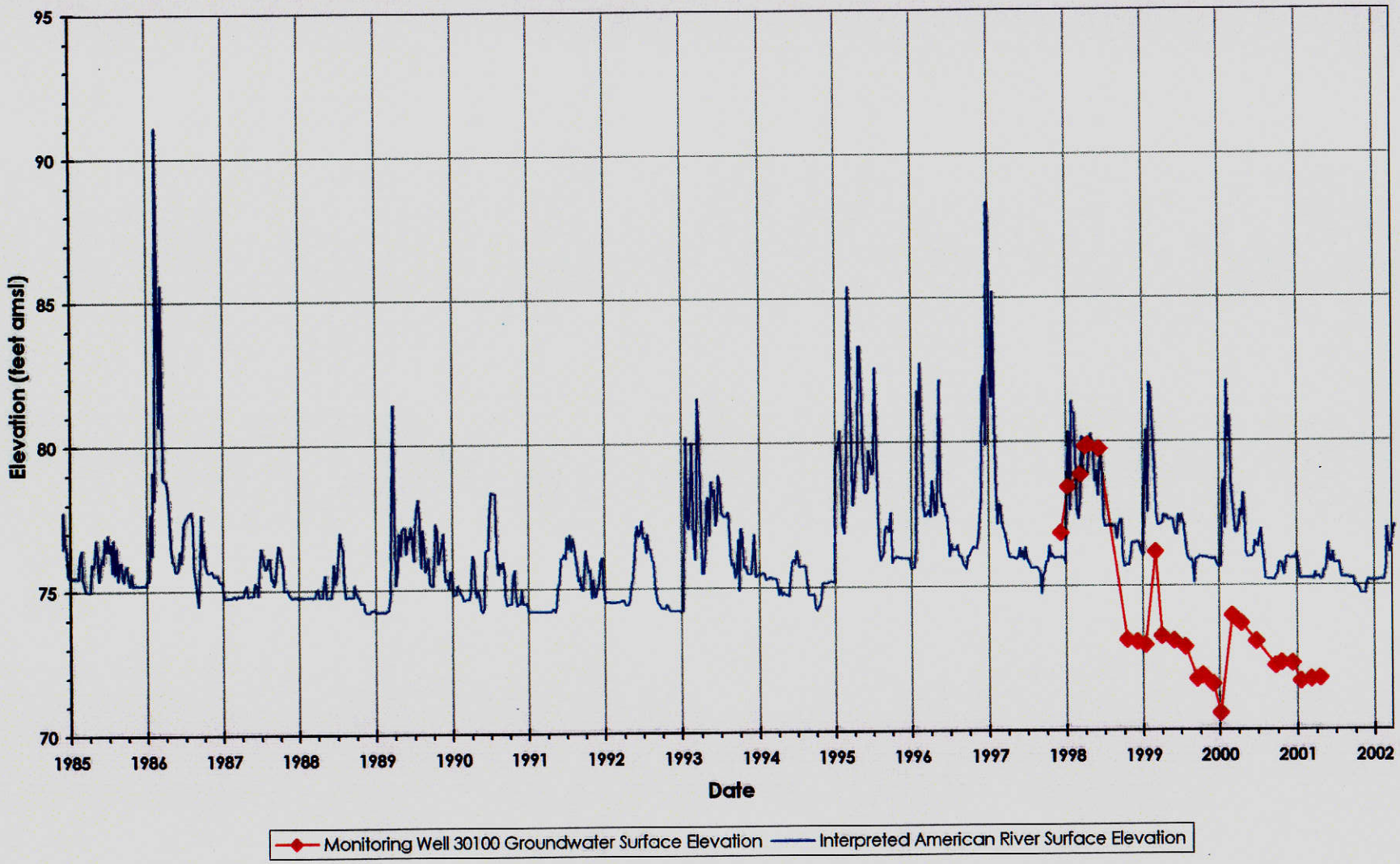
Comparison of Groundwater Surface Elevation in Well 1516 with the Interpreted American River Surface Elevation



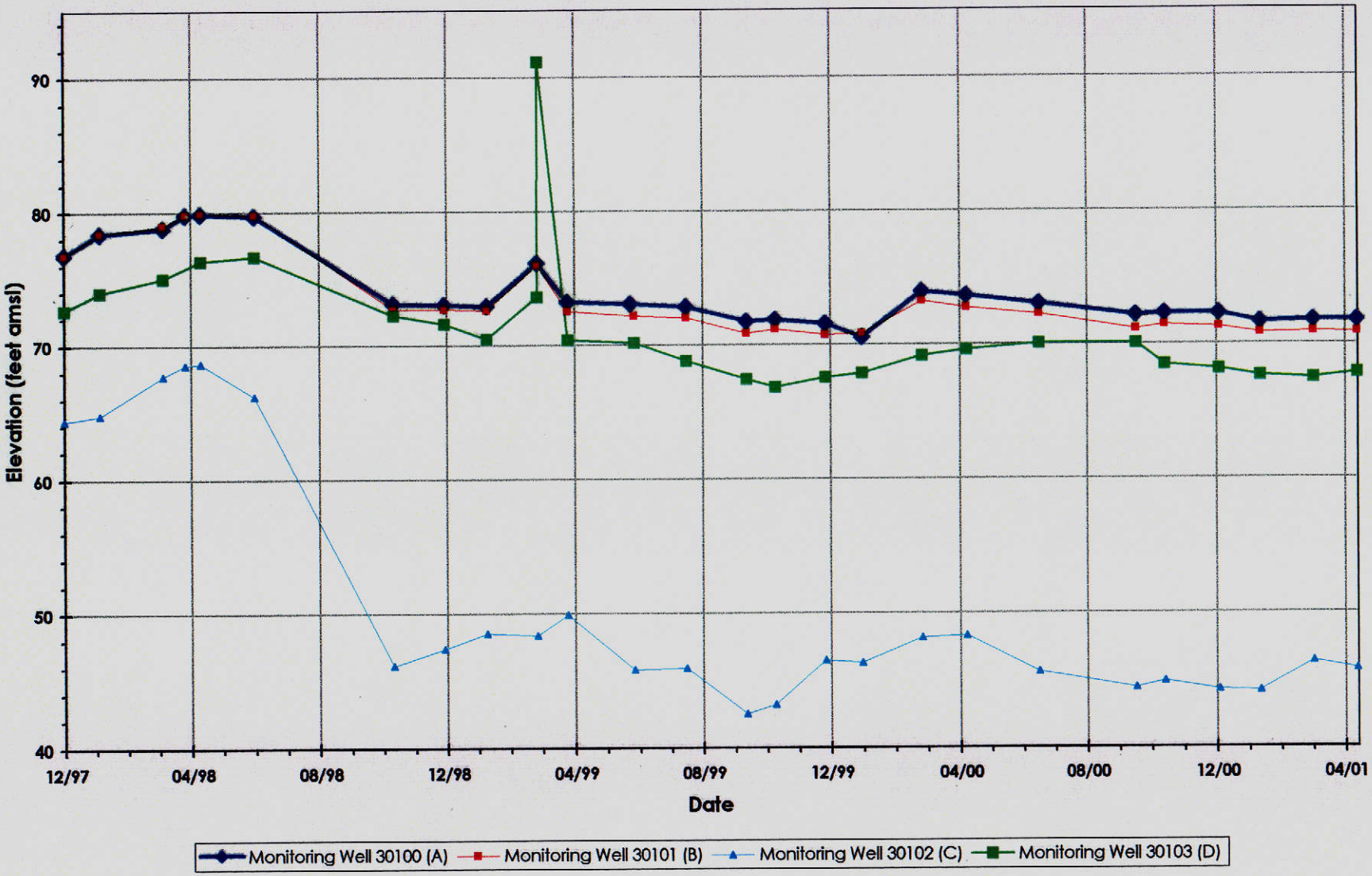
Comparison of Groundwater Surface Elevation in Well 1518 with the Interpreted American River Surface Elevation



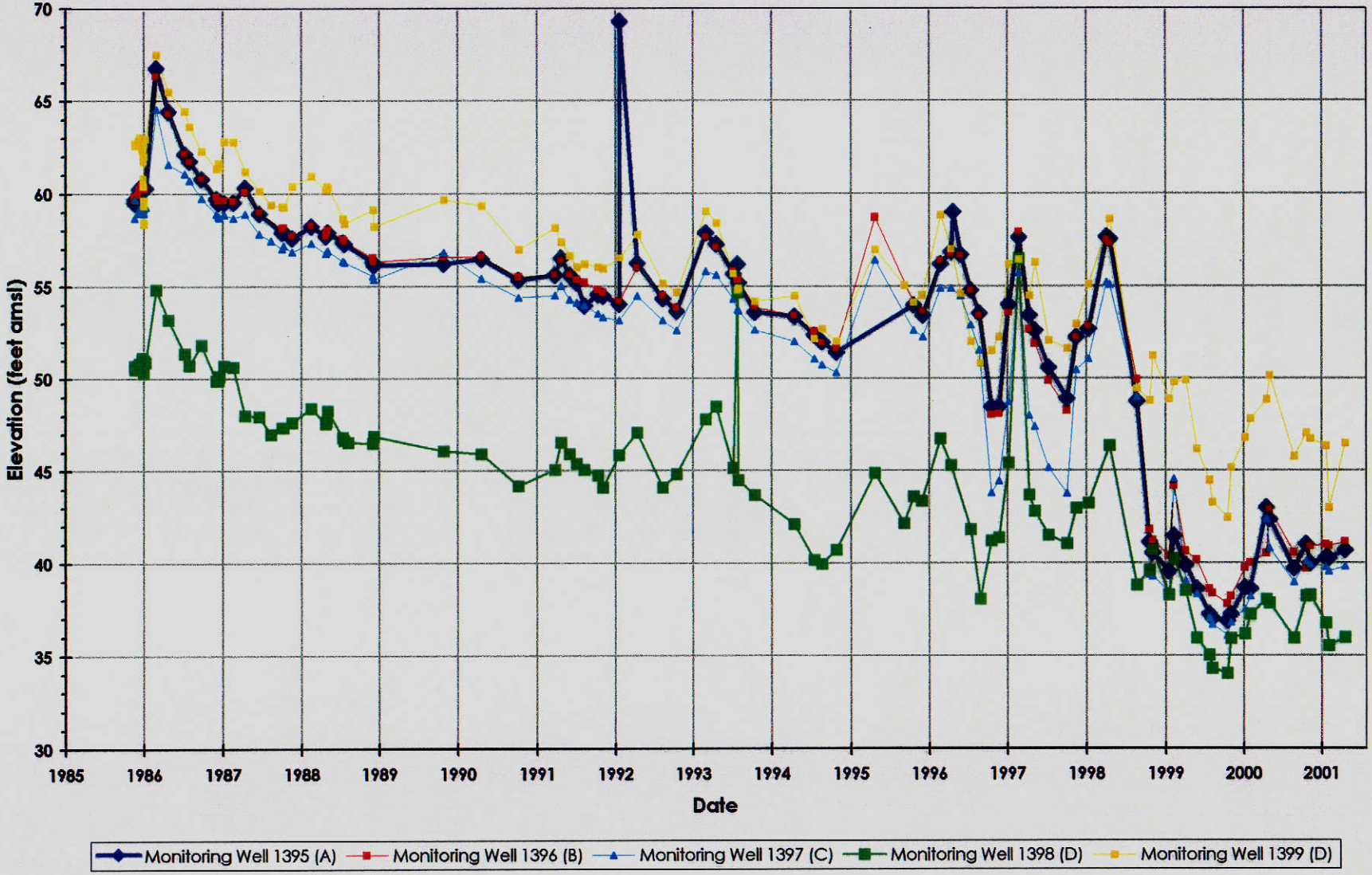
Comparison of Groundwater Surface Elevation in Well 30100 with the Interpreted American River Surface Elevation



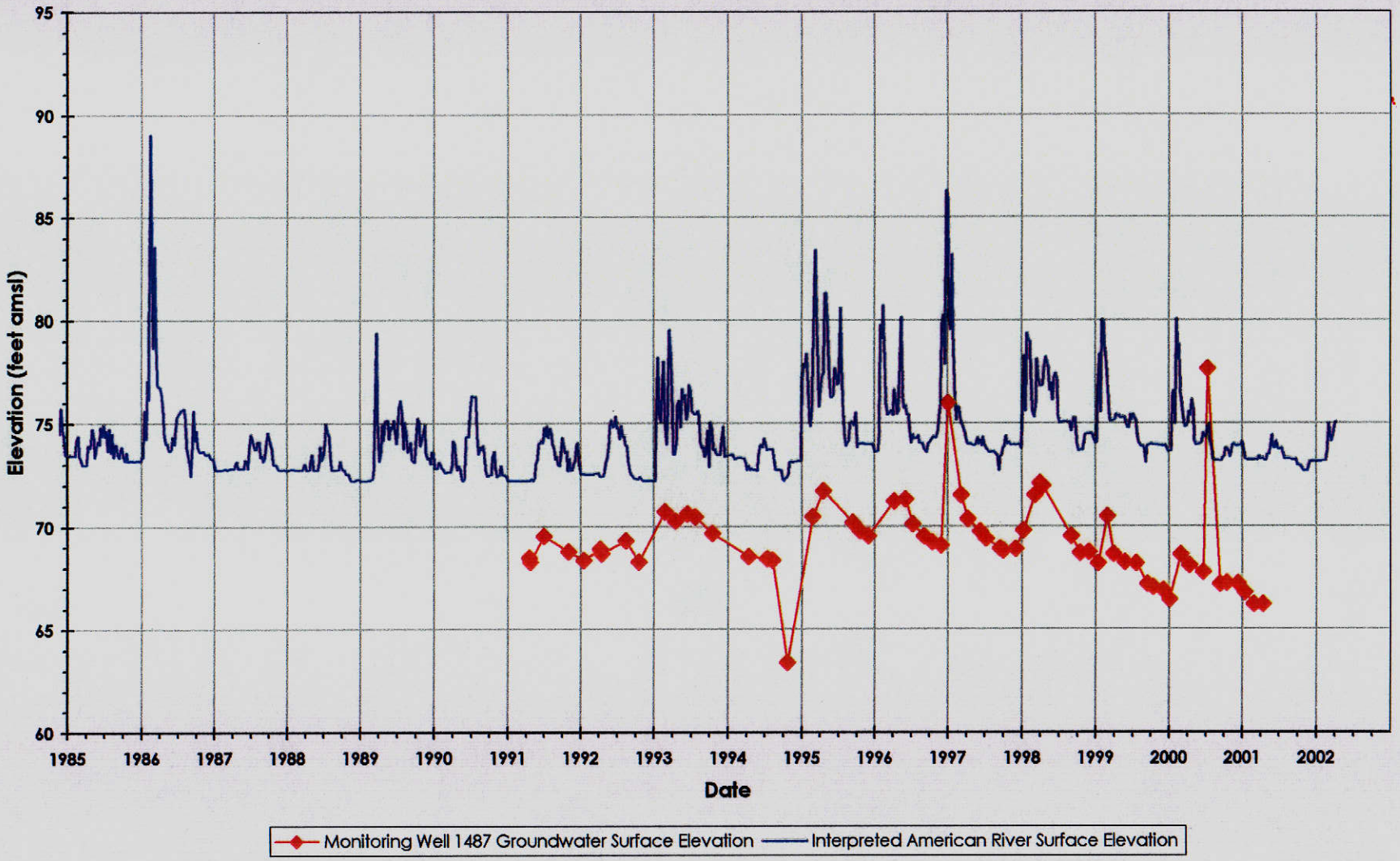
Groundwater Surface Elevation in Wells 30100 to 30103



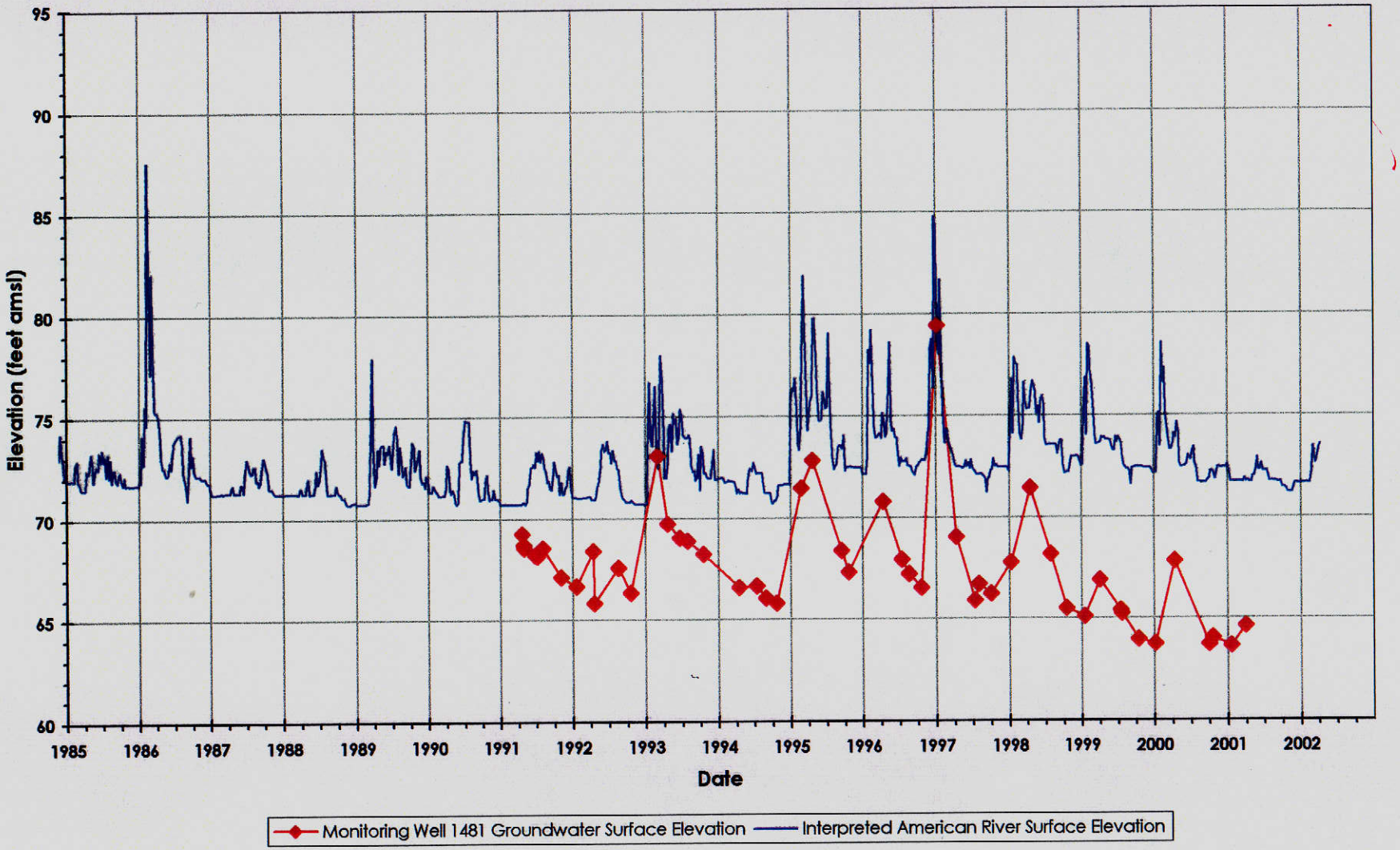
Groundwater Surface Elevation in Wells 1395 - 1399



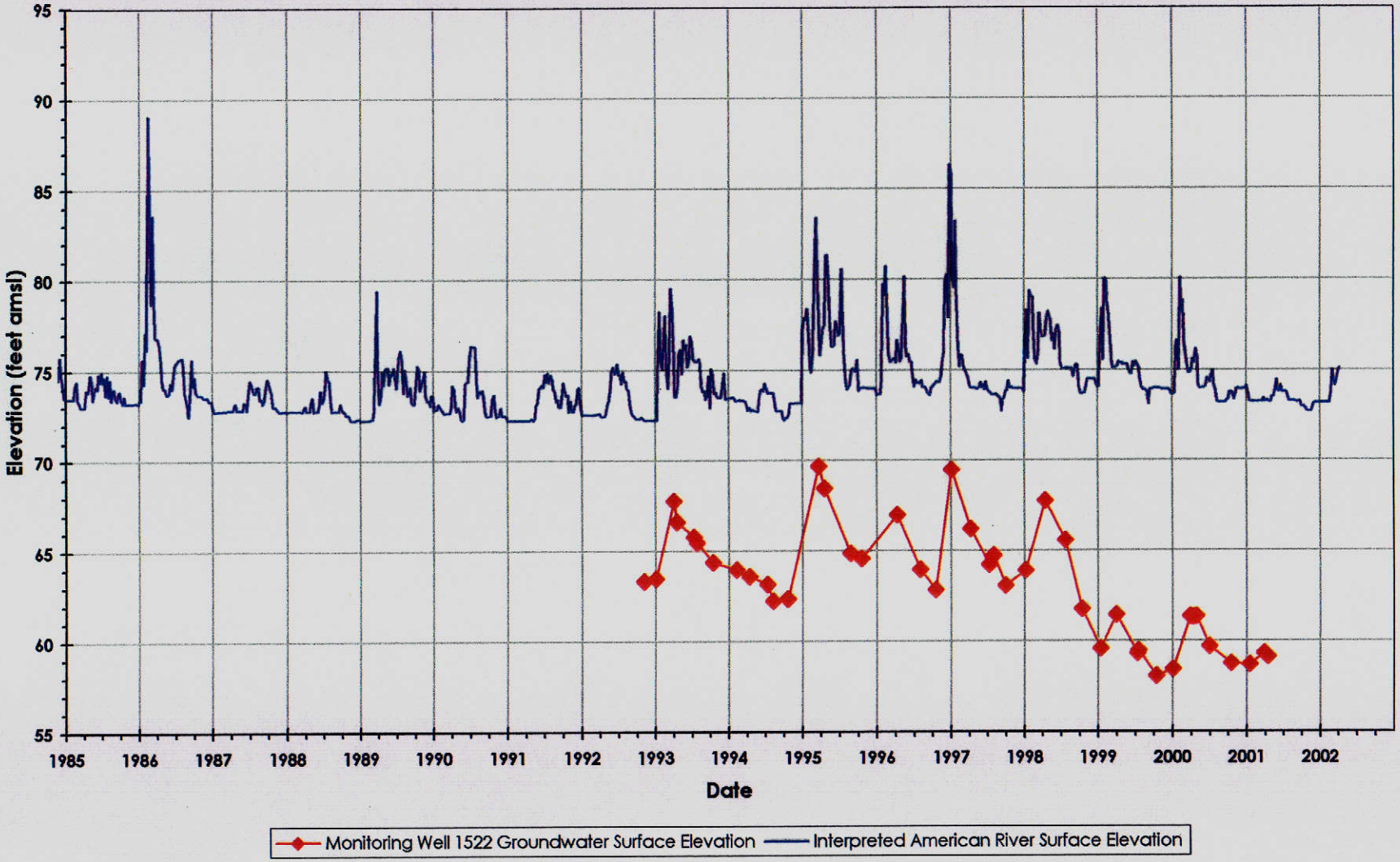
Comparison of Groundwater Surface Elevation in Well 1487 with the Interpreted American River Surface Elevation



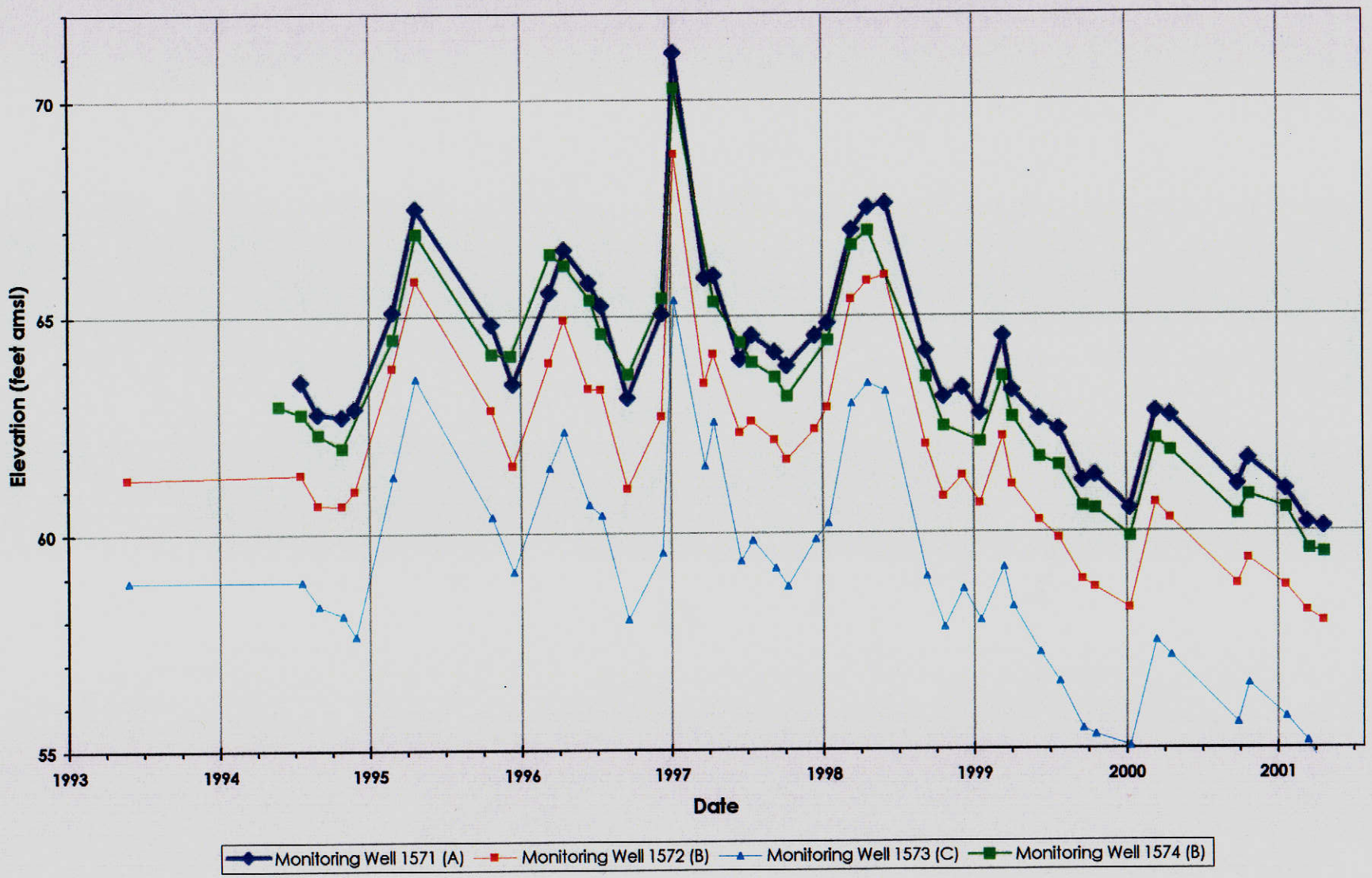
Comparison of Groundwater Surface Elevation in Well 1481 with the Interpreted American River Surface Elevation



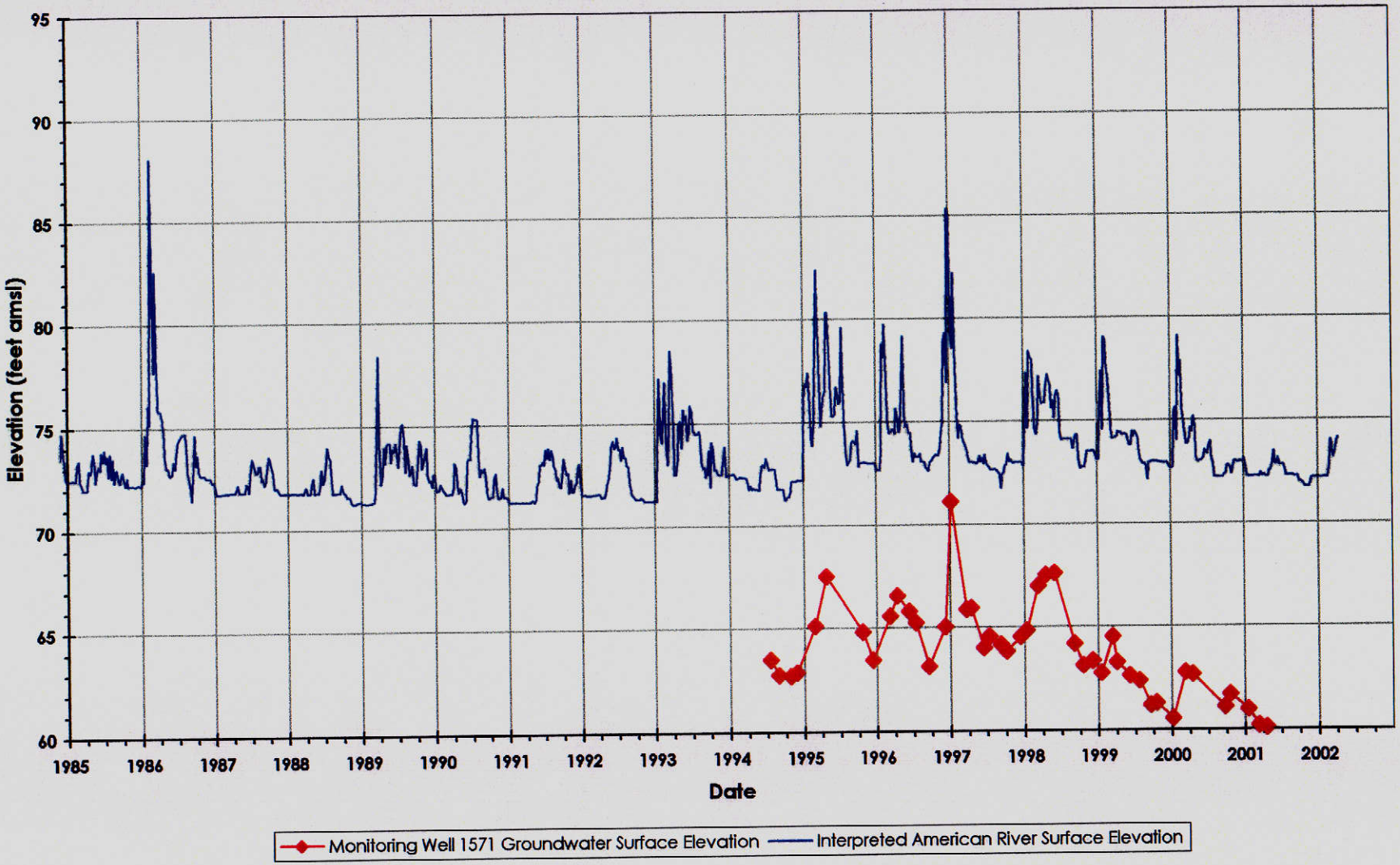
Comparison of Groundwater Surface Elevation in Well 1522 with the Interpreted American River Surface Elevation



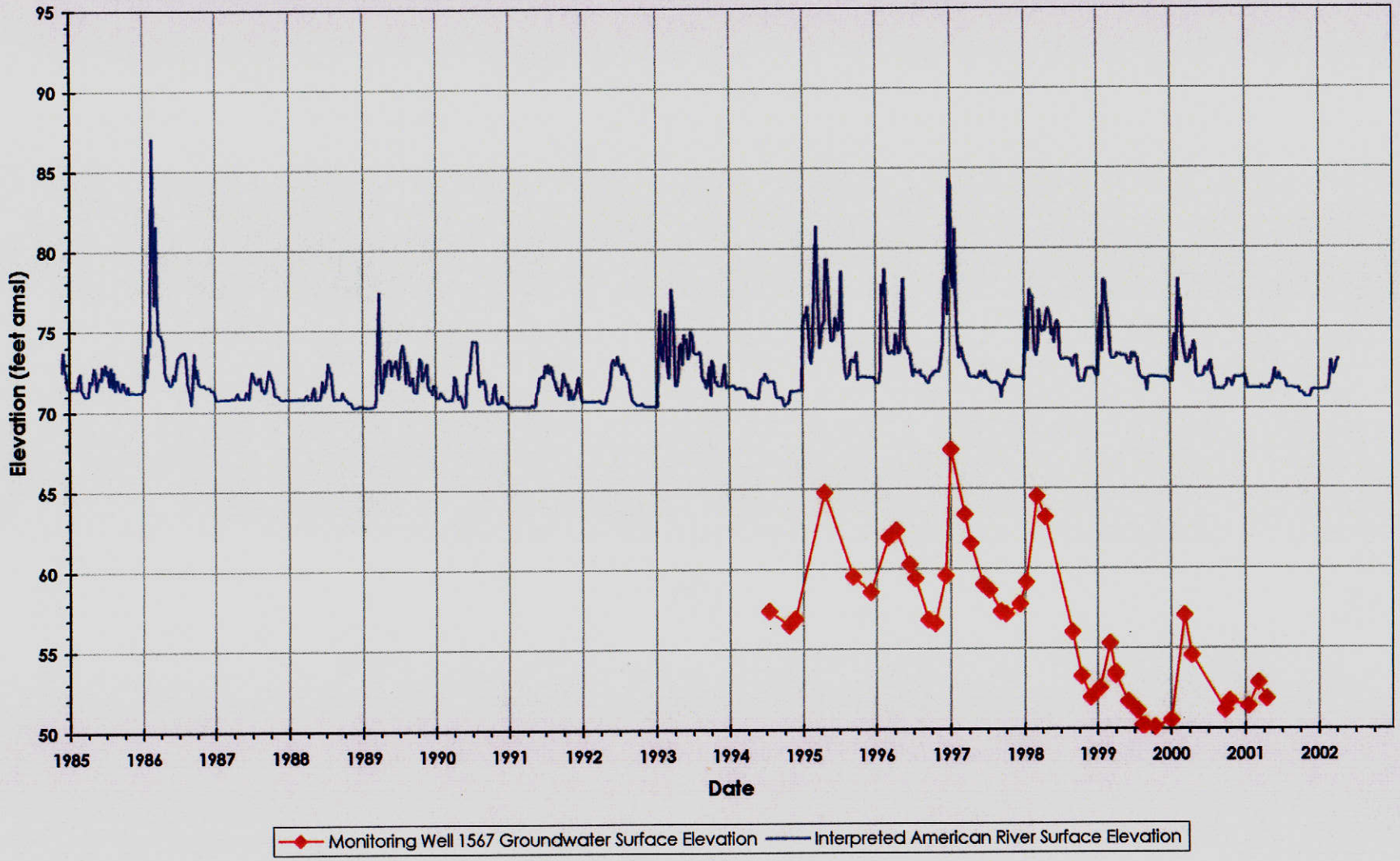
Groundwater Surface Elevation in Wells 1571 - 1574



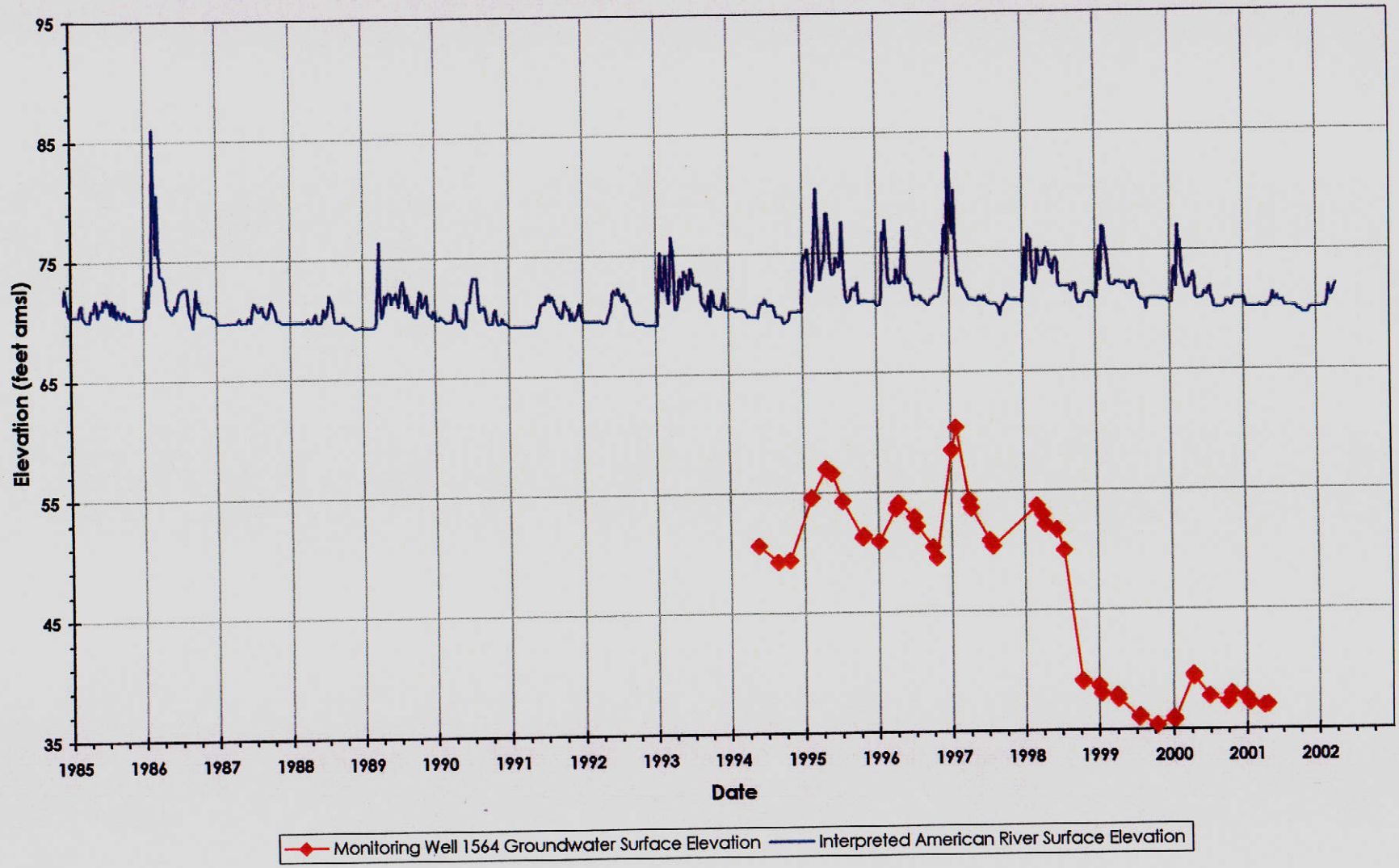
Comparison of Groundwater Surface Elevation in Well 1571 with the Interpreted American River Surface Elevation



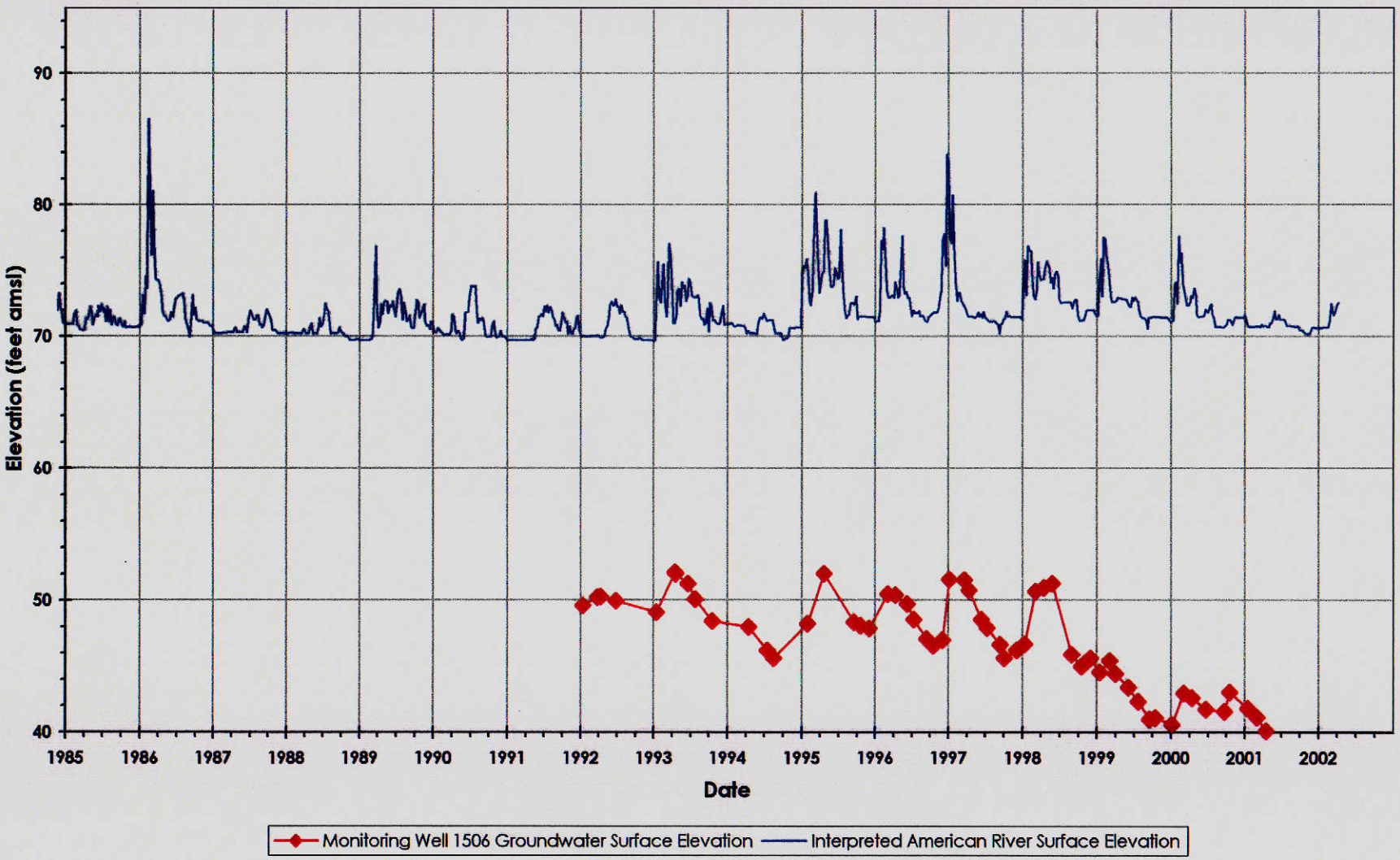
Comparison of Groundwater Surface Elevation in Well 1567 with the Interpreted American River Surface Elevation



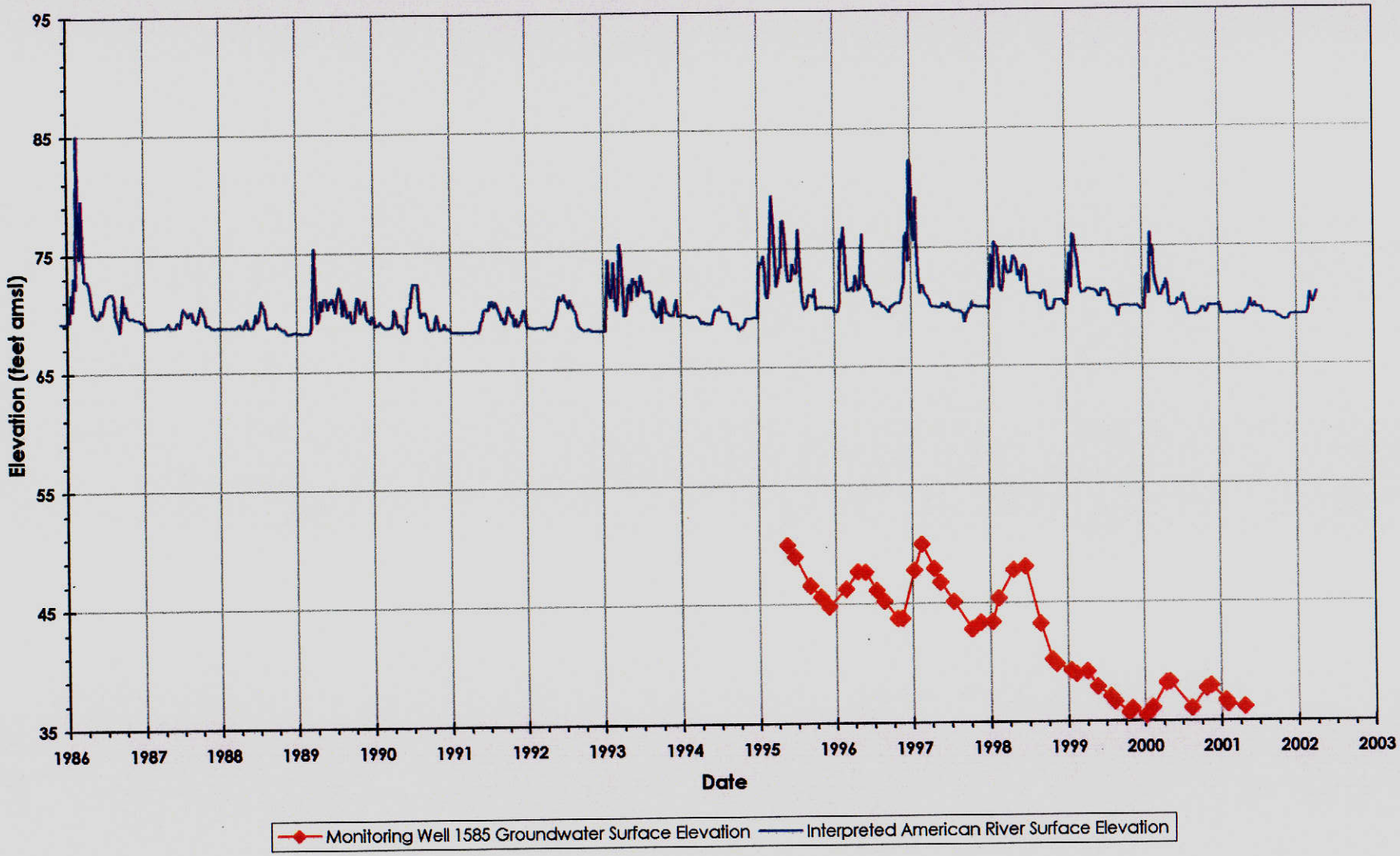
Comparison of Groundwater Surface Elevation in Well 1564 with the Interpreted American River Surface Elevation



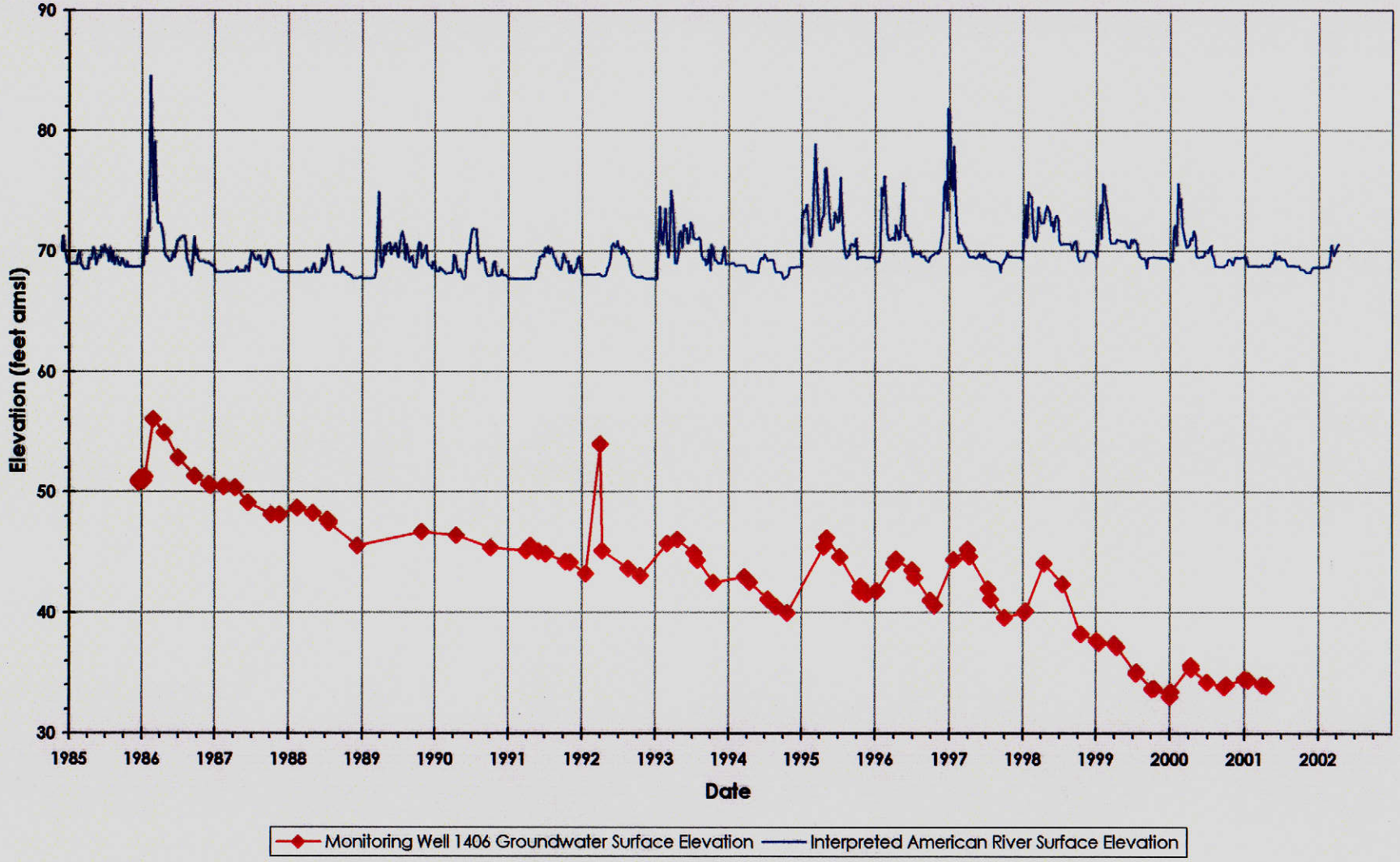
Comparison of Groundwater Surface Elevation in Well 1506 with the Interpreted American River Surface Elevation



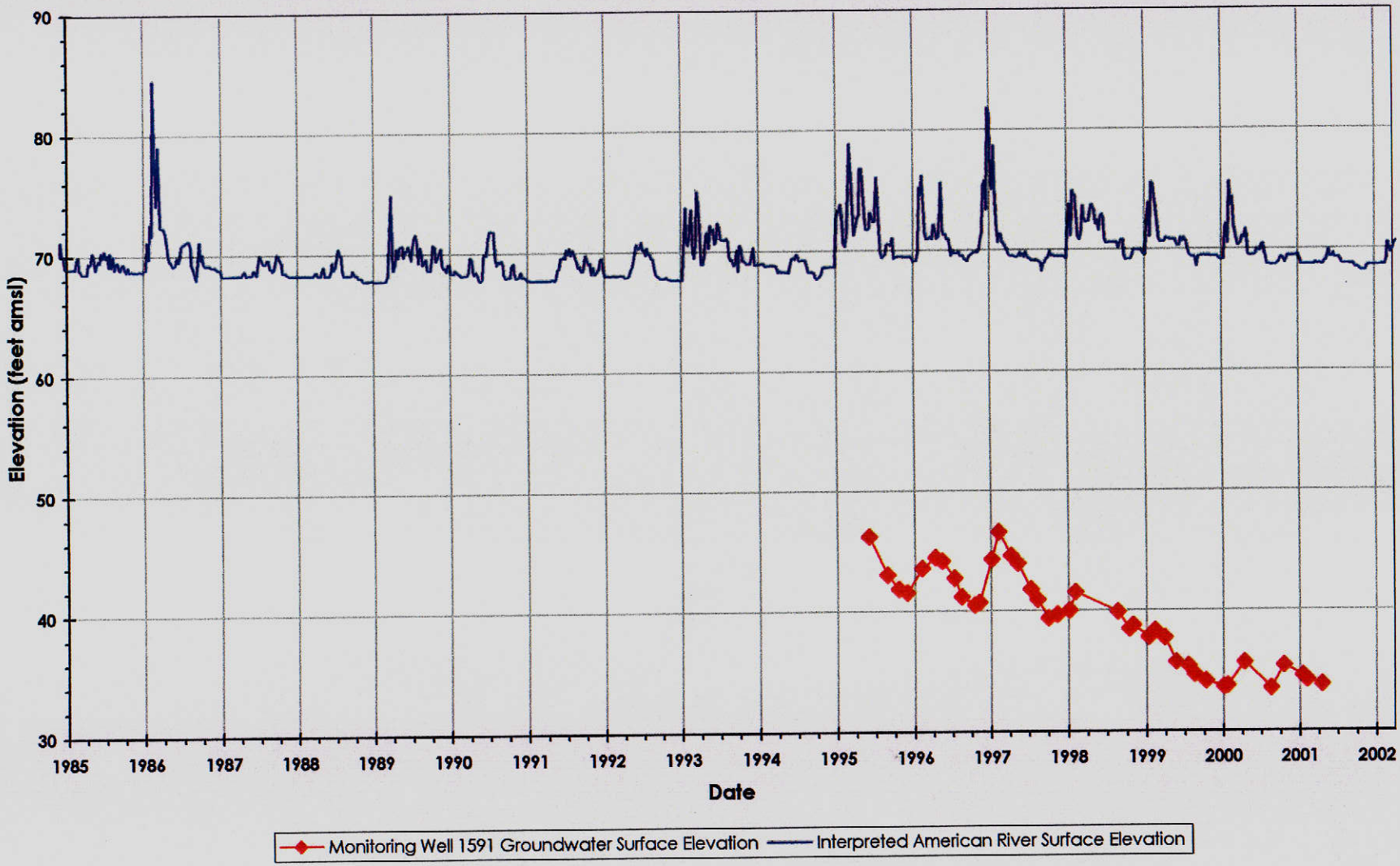
Comparison of Groundwater Surface Elevation in Well 1585 with the Interpreted American River Surface Elevation



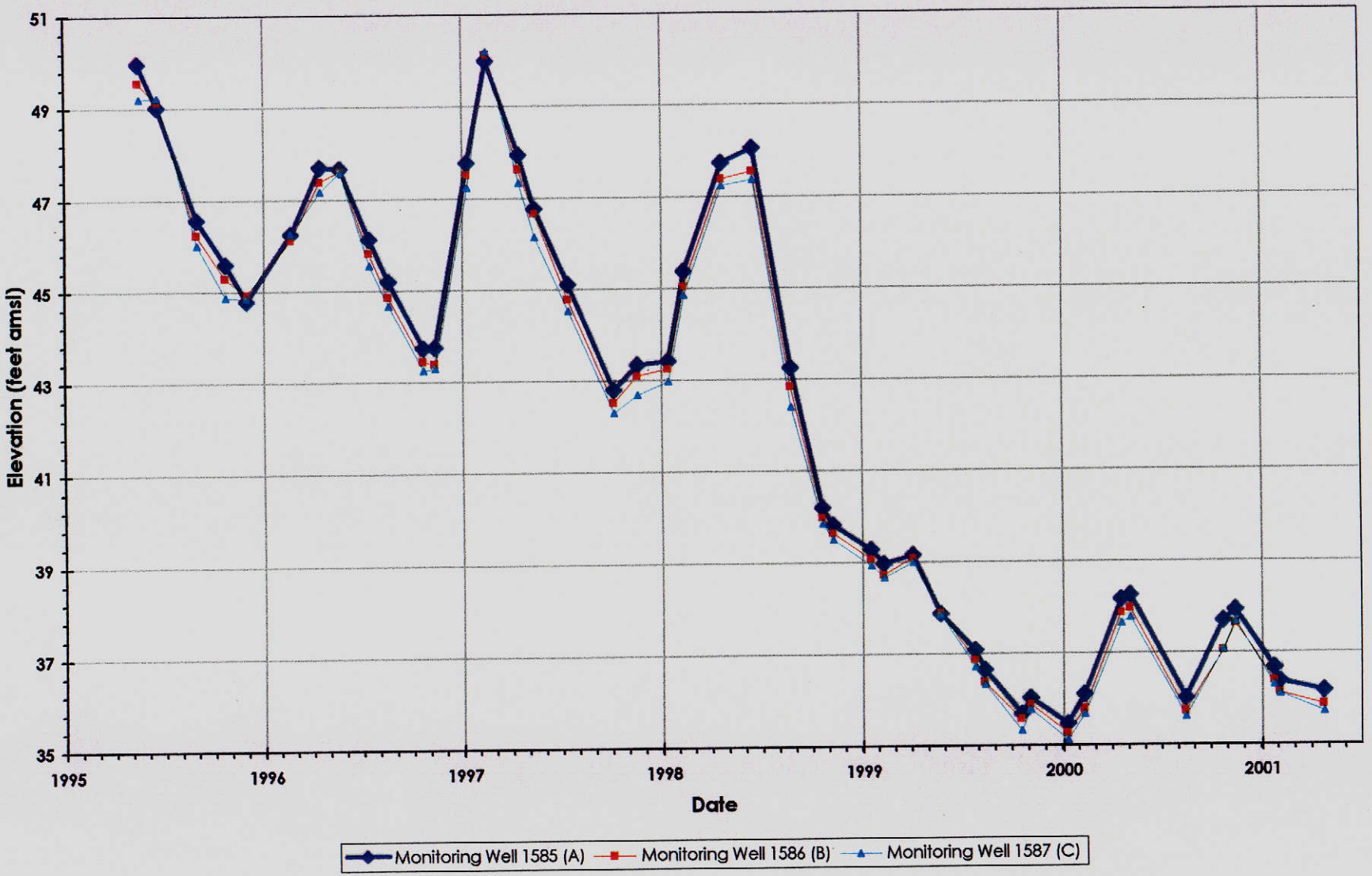
Comparison of Groundwater Surface Elevation in Well 1406 with the Interpreted American River Surface Elevation



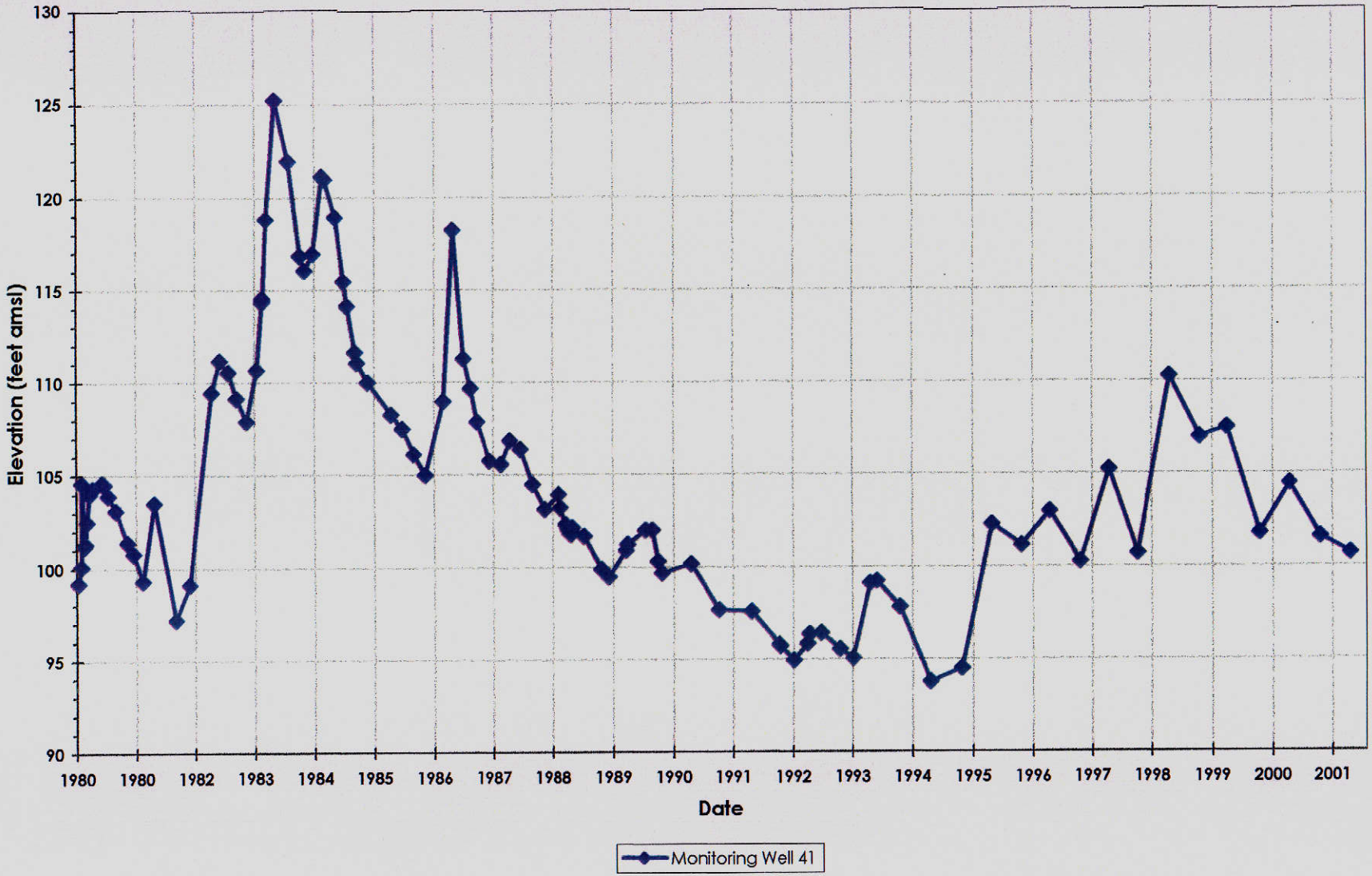
Comparison of Groundwater Surface Elevation in Well 1591 with the Interpreted American River Surface Elevation



Groundwater Surface Elevation in Wells 1585 - 1587



Groundwater Surface Elevation in Well 41



APPENDIX D

MAIN ION CHEMISTRY: DATA AND GRAPHS

Data presentation and processing was completed for the hydrochemical analysis.

1. All of the main ion plots have consistent symbol use: Aquifer A – circles; Aquifer B – diamonds; Aquifer C – squares; and AquiferD – triangles.
2. Base data for calcium, magnesium, sodium, potassium, chloride, sulphate and nitrate as provided by Aerojet (milligram/Liter [mg/L] units) (Aerojet, 2002).
3. Bicarbonate concentration was approximated by calculating the ion balance using the above listed analytes and adjusting the bicarbonate concentration (converting from mg/L to milliequivalents) such that the ion balance was approximately 1.00. Conversion factors used to calculate millequivalents from mg/L (Hem, 1985, p. 56).
4. Mineralization (expressed as total dissolved solids [TDS]) was calculated by summing the concentrations of the above-listed analytes, (except for bicarbonate) expressed as mg/L. The bicarbonate contribution to the TDS was estimated by multiplying the approximated bicarbonate concentration by 0.4917 and adding the result to the TDS (Hem, 1985).
5. Two markedly different analytical results are provided in data at Monitoring Well 4380 (17-Jul-95 and 29-Aug-95). Both of these are plotted on the main ion "Central Study Area" diagram, with the 17-Jul-95 data denoted as 4380 and the 29-Aug-95 data denoted as 4380A.
6. Analytical results from multiple sampling events were averaged including:

- 1357 and 1382 (data from seven sampling events each); and,
- 1358, 1359, 1383, and 1384 (data from two sampling events each).

7. Analytical results for American River at Fair Oaks dated 09/01/1962, American River Sacramento dated 09/11/1962. These data were picked to represent a time period of sampling overlap at both water quality sampling sites for comparison.
8. Analytical results reported as not detected above the laboratory method detection limit were approximated for the mineralization calculations as follows:

- sample 1357, 08-Aug-91, potassium reported as <5.00 mg/L, 4.00 mg/L used in calculation of average.
- sample 1382, 02-Aug-91, potassium reported as <5.00 mg/L, 2.5 mg/L used in calculation of average.
- sample 1516, 30-Mar-93, potassium reported as <1.00 mg/L, 1.0 mg/L used in calculations.
- sample 1521, 09-Nov-92, nitrate reported as <0.10 mg/L, 0.10 mg/L used in calculations.

Main Ion Plot Chemistry Data

			American R.		Eastern Study Area									
meq		Fair Oaks (1962)	CSU (1962)	CSU (04/16/1998)	1357	1358	1359	1382	1383	1384	4325	4330	4335	1516
1	Ca	0.245	0.235	0.298	4.148	2.395	2.071	1.841	2.096	2.370	3.493	3.144	2.495	0.699
2	Mg	0.099	0.099	0.195	2.631	1.440	1.440	1.309	1.522	1.728	2.304	2.057	1.399	0.444
3	Na+K	0.113	0.095	0.116	0.983	0.665	0.714	0.810	0.748	0.809	2.835	0.908	0.849	0.243
4	Cl	0.034	0.028	0.045	2.797	0.508	0.423	0.388	0.621	0.875	3.949	1.439	0.480	0.059
5	SO4	0.012	0.017	0.046	0.471	0.312	0.312	0.353	0.354	0.375	0.416	0.416	0.312	0.065
6	HCO3	0.410	0.385	0.524	4.343	3.524	3.360	3.065	3.278	3.557	3.934	4.016	3.802	1.246
	NO3	0.000	0.000	0.000	0.165	0.152	0.141	0.158	0.133	0.099	0.339	0.210	0.155	0.008
	Bal	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
mg/L		Fair Oaks (1962)	CSU (1962)	CSU (04/16/1998)	1357	1358	1359	1382	1383	1384	4325	4330	4335	1516
1	Ca	4.9	4.7	6.0	83.1	48.0	41.5	36.9	42.0	47.5	70.0	63.0	50.0	14.0
2	Mg	1.2	1.2	2.4	32.0	17.5	17.5	15.9	18.5	21.0	28.0	25.0	17.0	5.4
3	Na	2.3	1.9	2.3	20.2	13.5	14.0	17.3	15.0	16.0	63.0	18.0	16.0	5.0
4	K	0.5	0.5	0.6	4.1	3.1	4.1	2.3	3.8	4.4	3.7	4.9	6.0	1.0
5	Cl	1.2	1.0	1.6	99.1	18.0	15.0	13.7	22.0	31.0	140.0	51.0	17.0	2.1
6	SO4	0.6	0.8	2.2	22.6	15.0	15.0	16.9	17.0	18.0	20.0	20.0	15.0	3.1
7	HCO3	25.0	23.5	32.0	265.0	215.0	205.0	187.0	200.0	217.0	240.0	245.0	232.0	76.0
	NO3				10.2	9.4	8.8	9.8	8.3	6.2	21.0	13.0	9.6	0.5
	TDS	32									490	350	270	
	TDS Calc	23	22	31	402	230	217	205	225	251	464	315	245	68

Main Ion Plot Chemistry Data

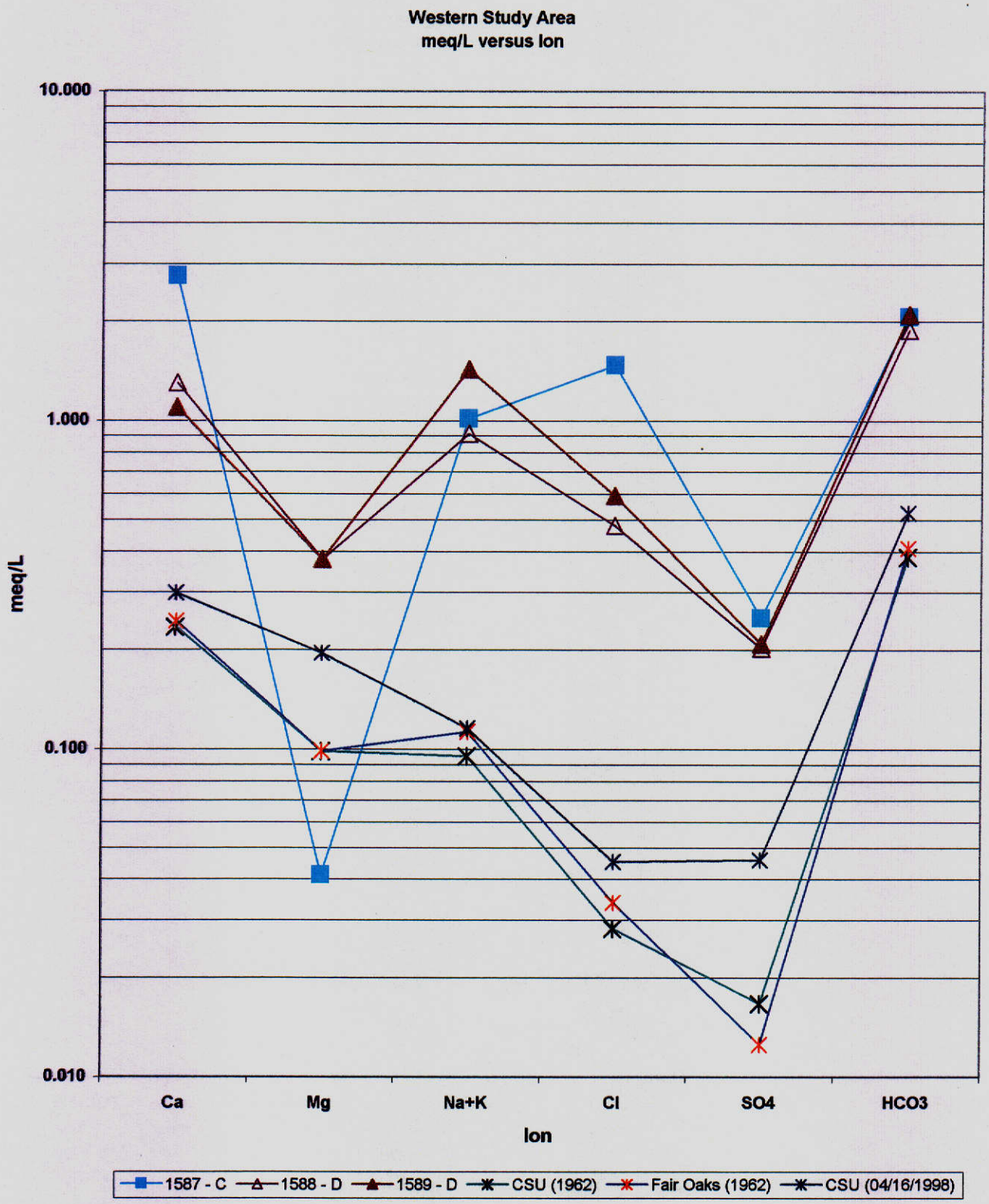
Central Study Area

meq		4370	4375	4380	4380A	1519	1520	1521	1522	1523	1524	1562	1563	1570
1	Ca	0.464	0.898	1.297	3.443	1.347	1.747	1.647	0.948	3.743	1.248	0.549	1.098	2.196
2	Mg	0.272	0.518	0.774	2.386	0.502	0.165	0.247	0.132	1.893	0.724	0.346	0.247	0.074
3	Na+K	0.323	0.517	0.670	2.932	0.688	0.478	1.338	0.642	0.959	0.847	0.171	0.303	0.875
4	Cl	0.104	0.248	0.217	3.103	0.260	0.592	0.395	0.621	4.514	0.451	0.068	0.087	0.181
5	SO4	0.077	0.119	0.171	0.437	0.194	0.173	0.437	0.167	0.175	0.250	0.058	0.162	0.117
6	HCO3	0.860	1.524	2.245	4.917	2.049	1.623	2.393	0.934	1.868	2.131	0.934	1.393	2.835
	NO3	0.019	0.040	0.098	0.339	0.044	0.011	0.002	0.006	0.069	0.073	0.003	0.001	0.003
	Bal	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.00	1.00	1.00

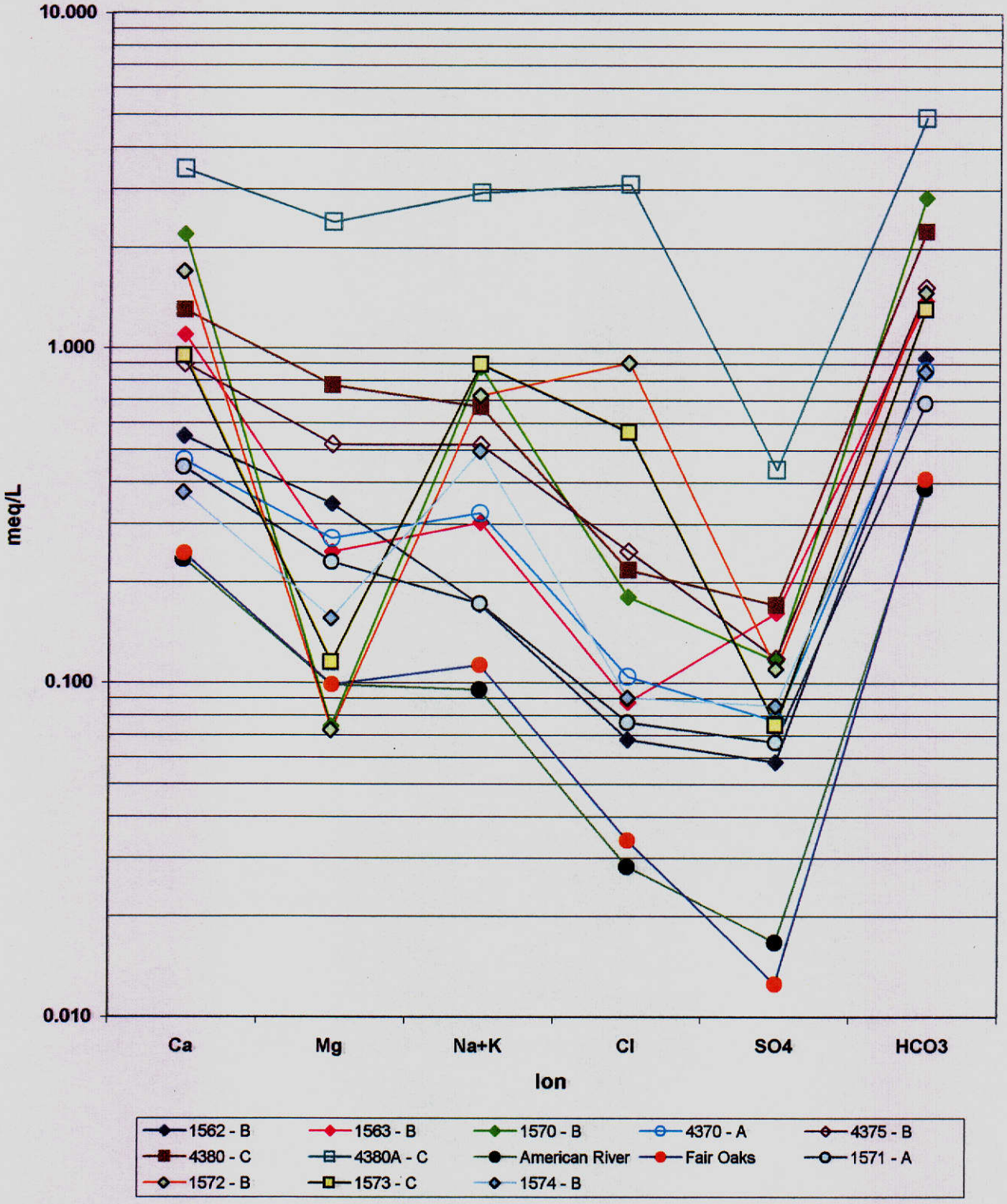
mg/L		4370	4375	4380	4380A	1519	1520	1521	1522	1523	1524	1562	1563	1570
1	Ca	9.3	18.0	26.0	69.0	27.0	35.0	33.0	19.0	75.0	25.0	11.0	22.0	44.0
2	Mg	3.3	6.3	9.4	29.0	6.1	2.0	3.0	1.6	23.0	8.8	4.2	3.0	0.9
3	Na	6.2	10.0	13.0	65.0	11.0	8.0	19.0	11.0	15.0	13.0	3.0	5.2	16.3
4	K	2.1	3.2	4.1	4.1	8.2	5.1	20.0	6.4	12.0	11.0	1.6	3.0	6.5
5	Cl	3.7	8.8	7.7	110.0	9.2	21.0	14.0	22.0	160.0	16.0	2.4	3.1	6.4
6	SO4	3.7	5.7	8.2	21.0	9.3	8.3	21.0	8.0	8.4	12.0	2.8	7.8	5.6
7	HCO3	52.5	93.0	137.0	300.0	125.0	99.0	146.0	57.0	114.0	130.0	57.0	85.0	173.0
	NO3	1.2	2.5	6.1	21.0	2.7	0.7	0.1	0.4	4.3	4.5	0.2	0.1	0.2
	TDS	84	120	190	490									
	TDS Calc	*55*	*100*	*142*	*467*	*135*	*129*	*182*	*96*	*354*	*154*	*53*	*86*	*165*

Main Ion Plot Chemistry Data

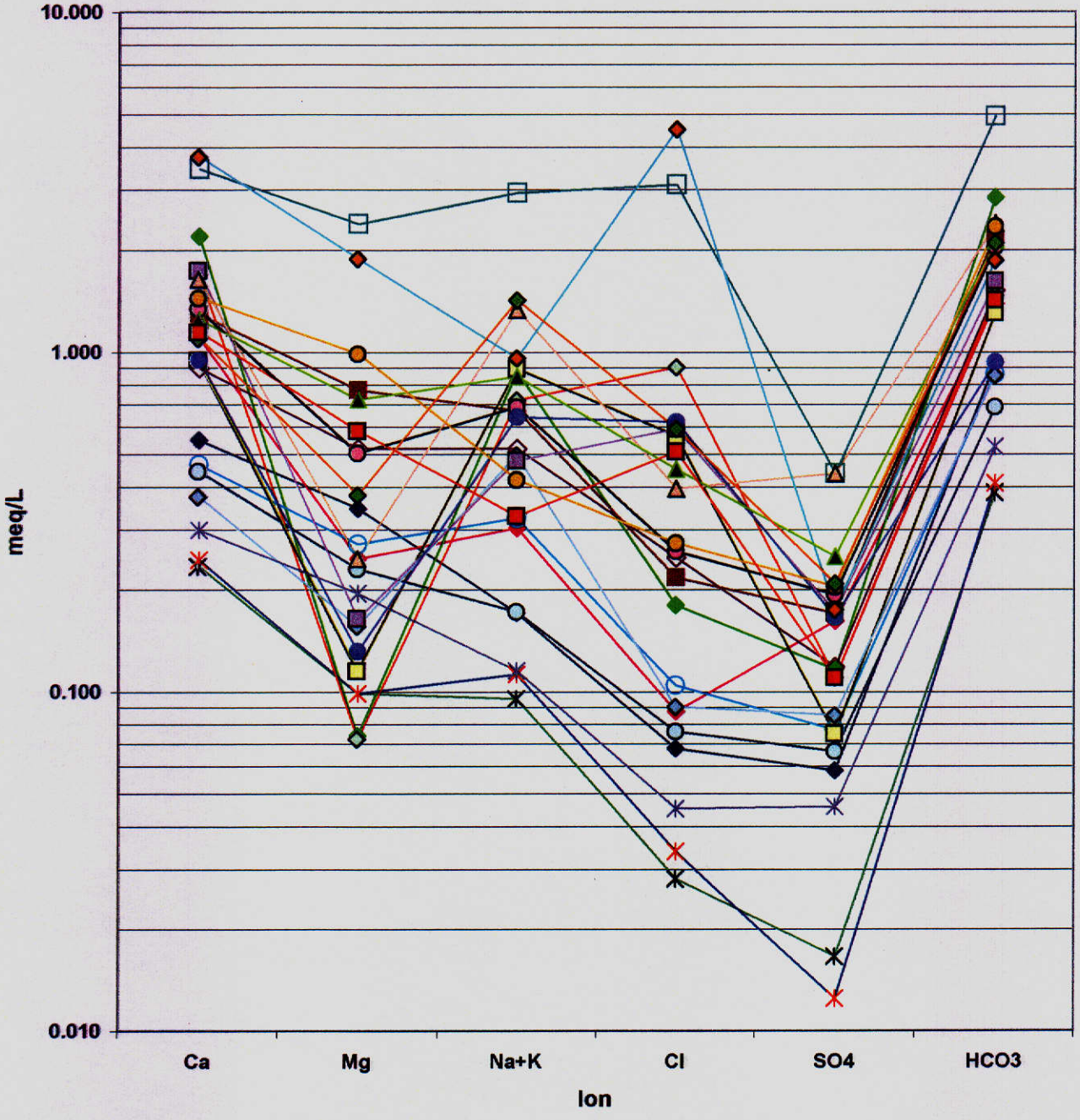
		Central Study Area							Western Study Area		
meq		**1571**	**1572**	**1573**	**1574**	**4300**	**4301**	**4302**	**1587**	**1588**	**1589**
1	**Ca**	0.444	1.697	0.948	0.374	1.447	1.148	1.447	2.745	1.297	1.098
2	**Mg**	0.230	0.072	0.115	0.156	0.987	0.584	0.806	0.041	0.379	0.379
3	**Na+K**	0.172	0.722	0.893	0.496	0.420	0.329	0.495	1.013	0.913	1.428
4	**Cl**	0.076	0.903	0.564	0.090	0.274	0.508	1.044	1.467	0.480	0.592
5	**SO4**	0.067	0.110	0.075	0.085	0.204	0.110	0.129	0.250	0.202	0.208
6	**HCO3**	0.688	1.475	1.311	0.852	2.344	1.426	1.541	2.065	1.885	2.098
	NO3	0.015	0.003	0.007	0.009	0.045	0.021	0.037	0.031	0.021	0.009
	Bal	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00
mg/L		**1571**	**1572**	**1573**	**1574**	**4300**	**4301**	**4302**	**1587**	**1588**	**1589**
1	**Ca**	8.9	34.0	19.0	7.5	29.0	23.0	29.0	55.0	26.0	22.0
2	**Mg**	2.8	0.9	1.4	1.9	12.0	7.1	9.8	0.5	4.6	4.6
3	**Na**	3.2	13.0	17.0	10.0	8.3	5.8	8.5	18.0	17.0	29.0
4	**K**	1.3	6.1	6.0	2.4	2.3	3.0	4.9	9.0	6.8	6.5
5	**Cl**	2.7	32.0	20.0	3.2	9.7	18.0	37.0	52.0	17.0	21.0
6	**SO4**	3.2	5.3	3.6	4.1	9.8	5.3	6.2	12.0	9.7	10.0
7	**HCO3**	42.0	90.0	80.0	52.0	143.0	87.0	94.0	126.0	115.0	128.0
	NO3	0.9	0.2	0.4	0.6	2.8	1.3	2.3	1.9	1.3	0.5
	TDS										
	TDS Calc	***44***	***136***	***107***	***55***	***144***	***106***	***144***	***210***	***139***	***157***


Western Study Area
meq/L versus Ion
10.000
1.000
0.100
0.010
meq/L
Ca
Mg
Na+K
Cl
SO4
HCO3
Ion
1587 - C
1588 - D
1589 - D
CSU (1962)
Fair Oaks (1962)
CSU (04/16/1998)

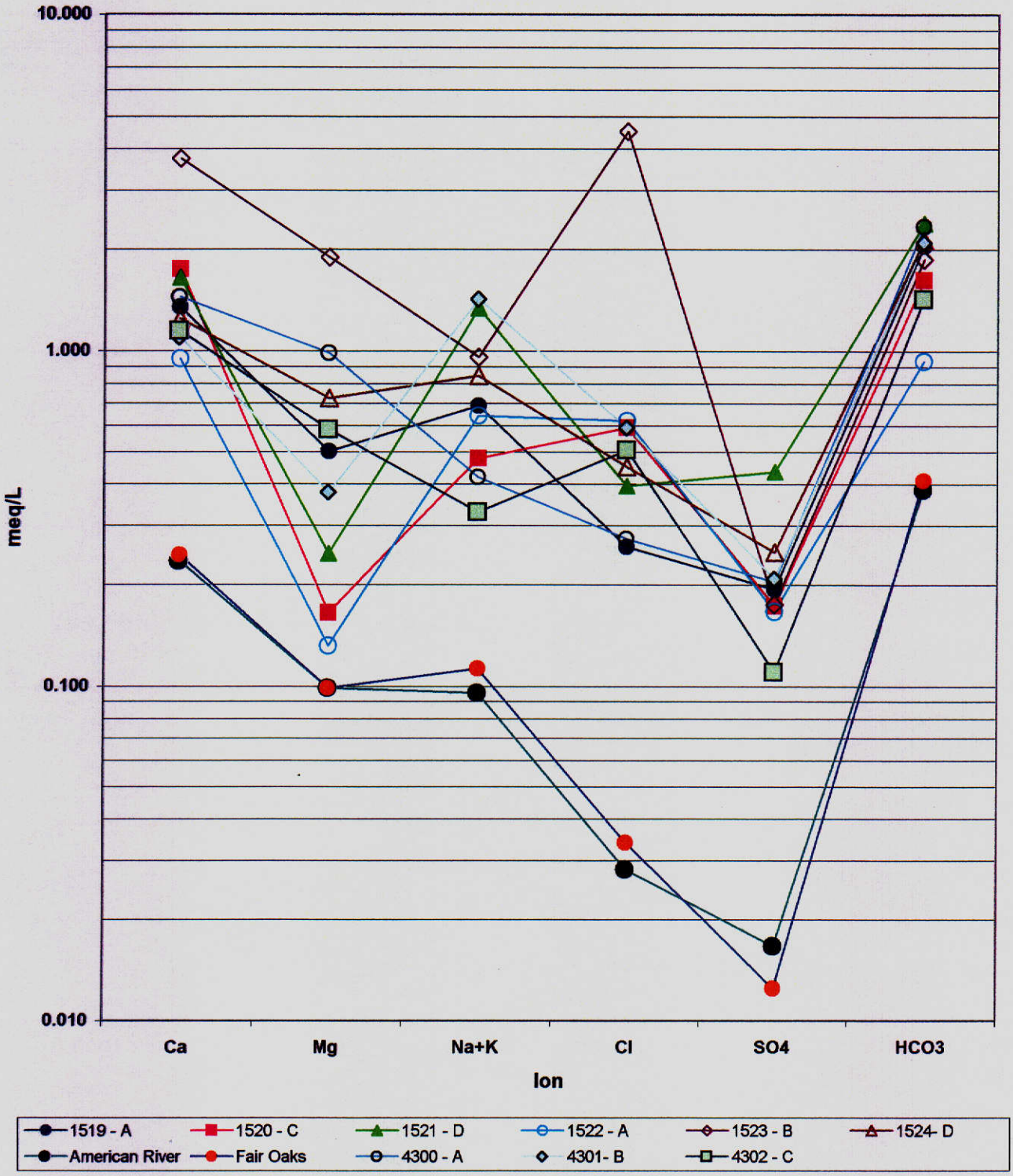
Central Study Area, South and North of American River
meq/L versus Ion

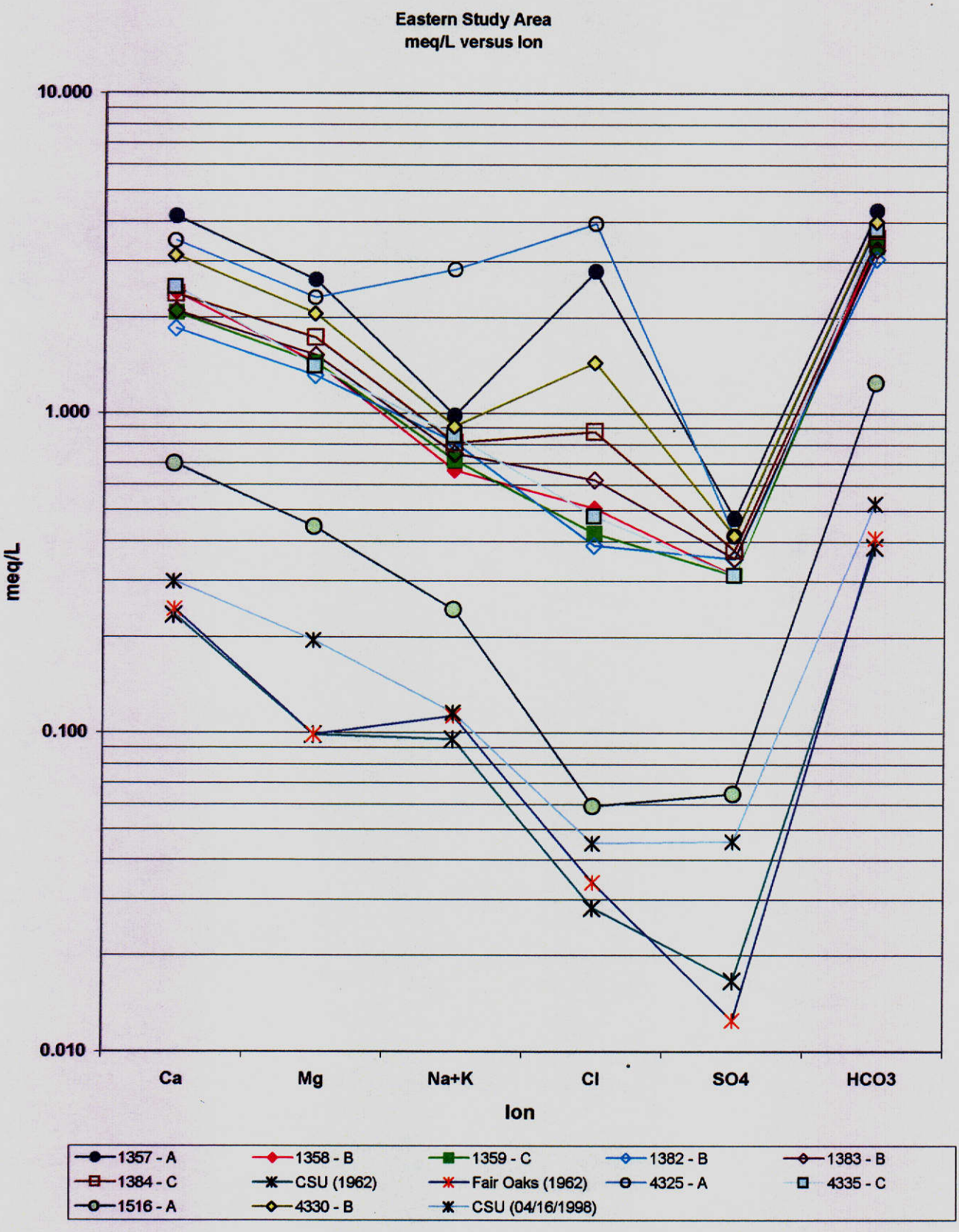


Central Study Area
meq/L versus Ion



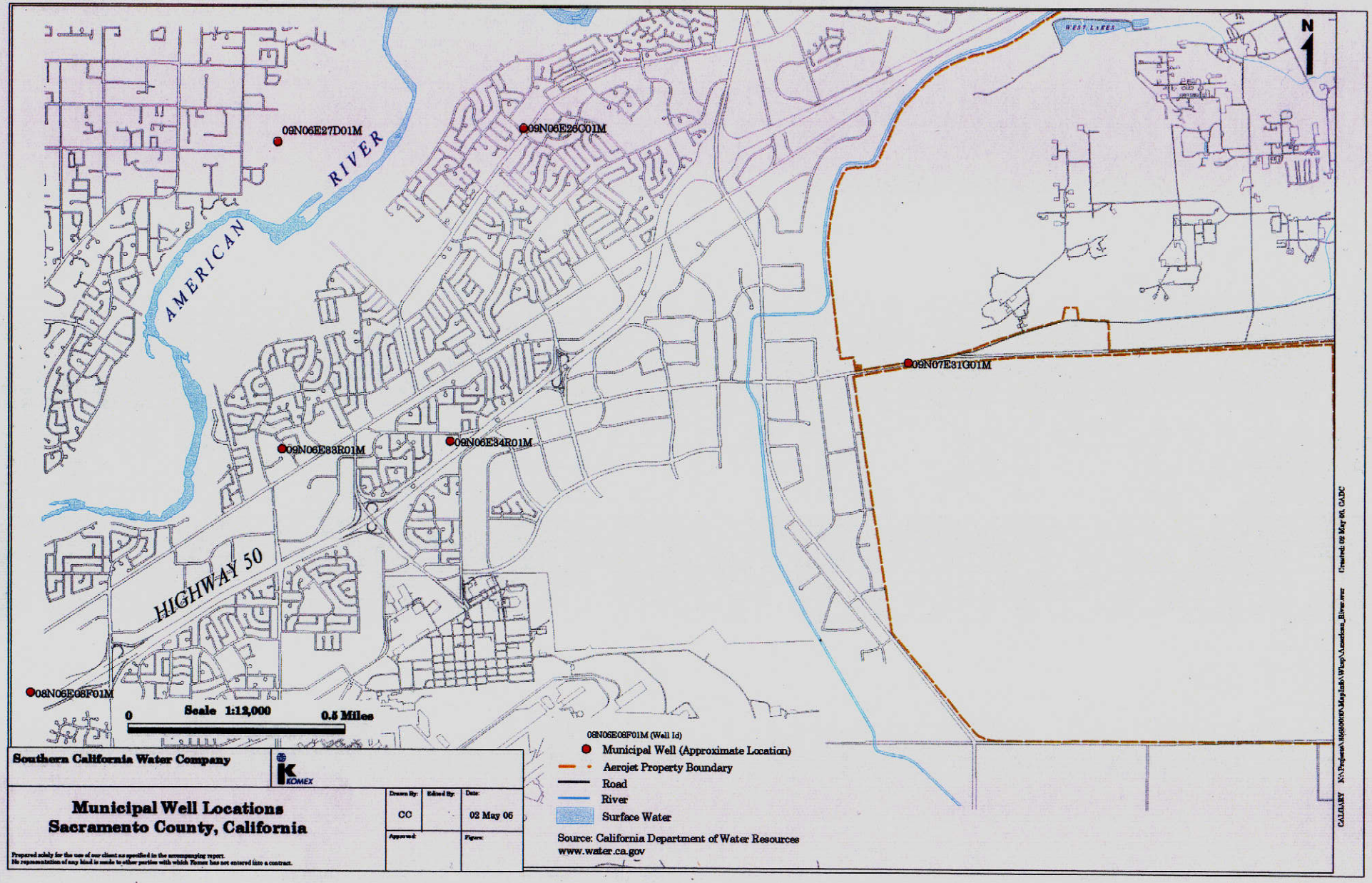
Central Study Area, North of American River
meq/L versus Ion

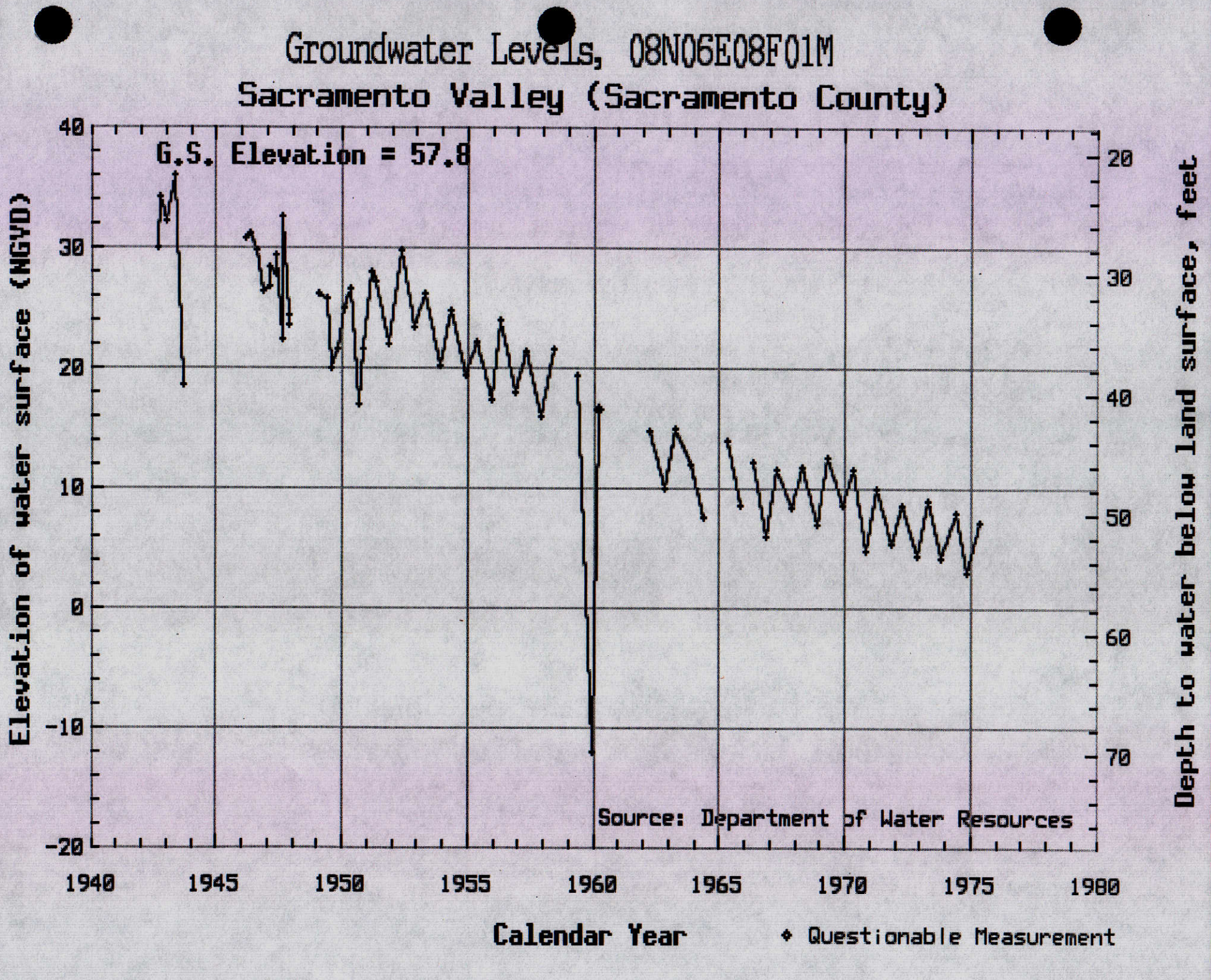



Eastern Study Area
meq/L versus Ion
10.000
1.000
0.100
0.010
meq/L
Ca
Mg
Na+K
Cl
SO4
HCO3
Ion
1357 - A
1358 - B
1359 - C
1382 - B
1383 - B
1384 - C
CSU (1962)
Fair Oaks (1962)
4325 - A
4335 - C
1516 - A
4330 - B
CSU (04/16/1998)

APPENDIX E

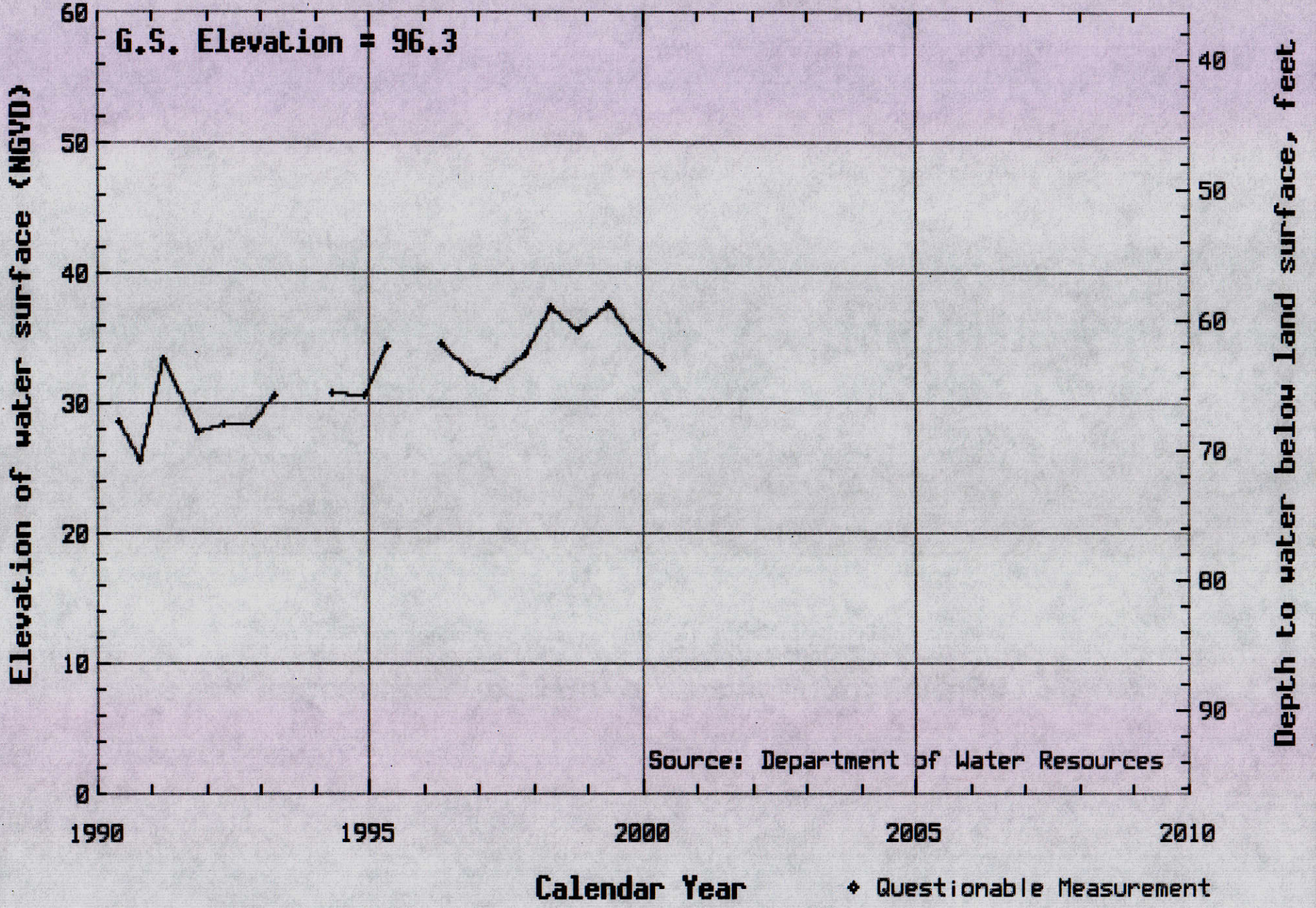
HYDROGRAPHS OF SELECTED STATE WELLS


09N06E27D01M
09N06E26C01M
09N07E31G01M
09N06E33R01M
09N06E34R01M
08N06E08F01M
AMERICAN RIVER
HIGHWAY 50
WEST LAKES
N
0
Scale 1:12,000
0.5 Miles
08N06E08F01M (Well Id)
Municipal Well (Approximate Location)
Aerojet Property Boundary
Road
River
Surface Water
Source: California Department of Water Resources
www.water.ca.gov
Southern California Water Company
KOMEX
Municipal Well Locations
Sacramento County, California
Drawn By: CC
Edited By:
Date: 02 May 06
Approved:
Figure:
Prepared solely for the use of our client as specified in the accompanying report.
No representation of any kind is made to other parties with which Komex has not entered into a contract.
CALGARY
X:\Projects\0660000\Maplab\Wksp\American_River.mxd
Created: 02 May 06, CADC


Groundwater Levels, 08N06E08F01M
Sacramento Valley (Sacramento County)
G.S. Elevation = 57.8
Elevation of water surface (NGVD)
Depth to water below land surface, feet
40
30
20
10
0
-10
-20
20
30
40
50
60
70
1940
1945
1950
1955
1960
1965
1970
1975
1980
Source: Department of Water Resources
Calendar Year
◆ Questionable Measurement

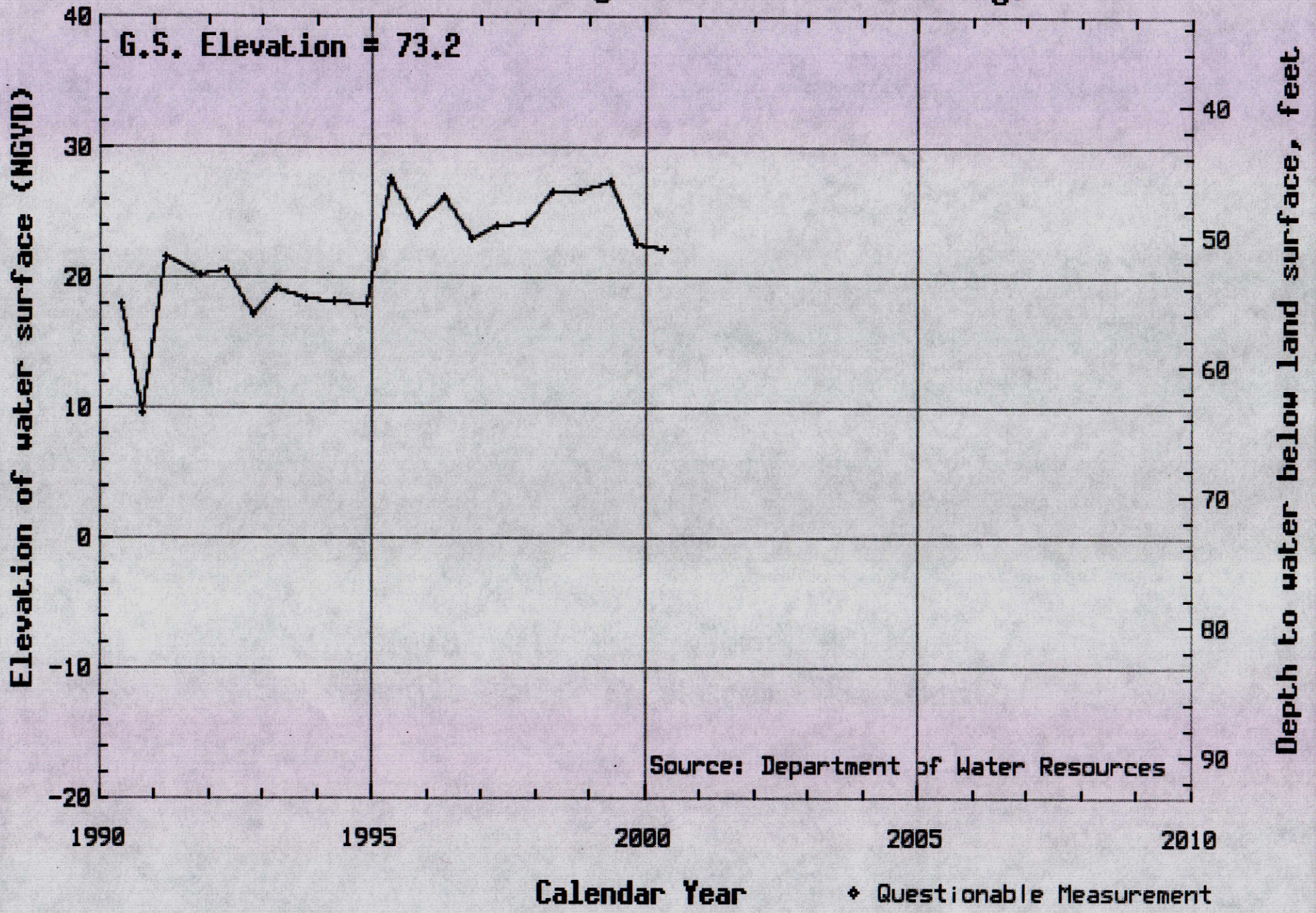
Groundwater Levels, 09N06E26C01M

Sacramento Valley (Sacramento County)



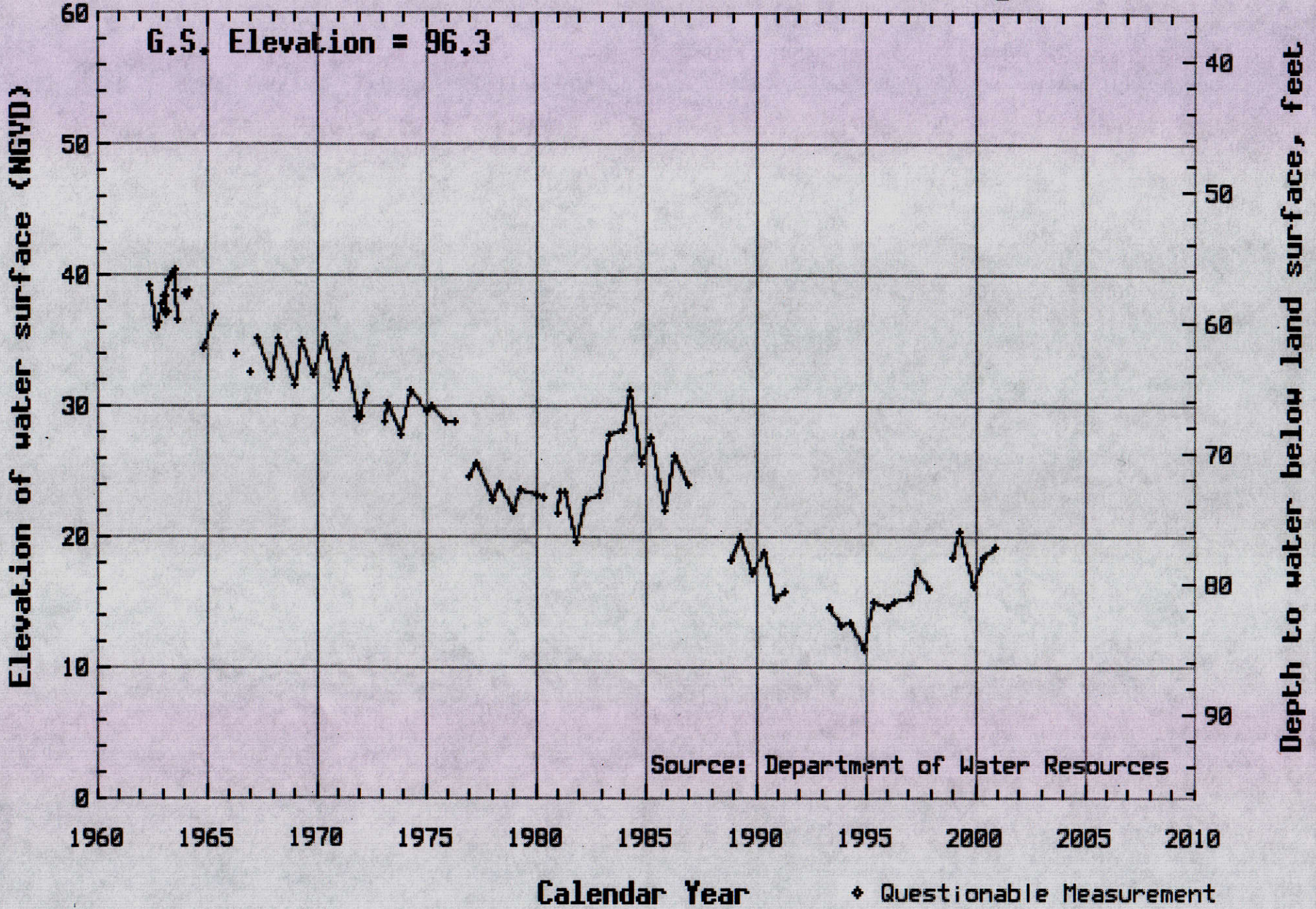
Groundwater Levels, 09N06E33R01M

Sacramento Valley (Sacramento County)



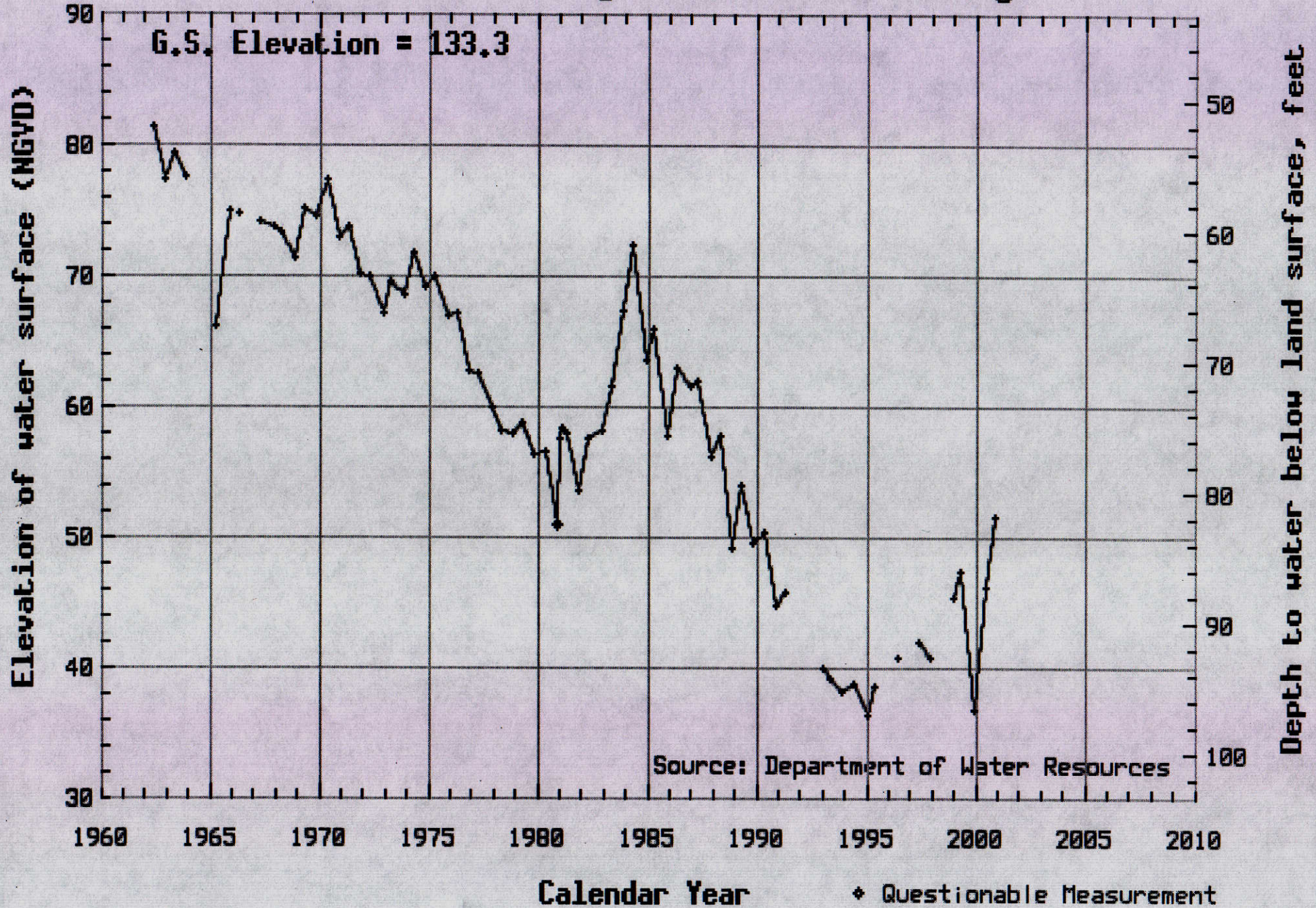
Groundwater Levels, 09N06E34R01M

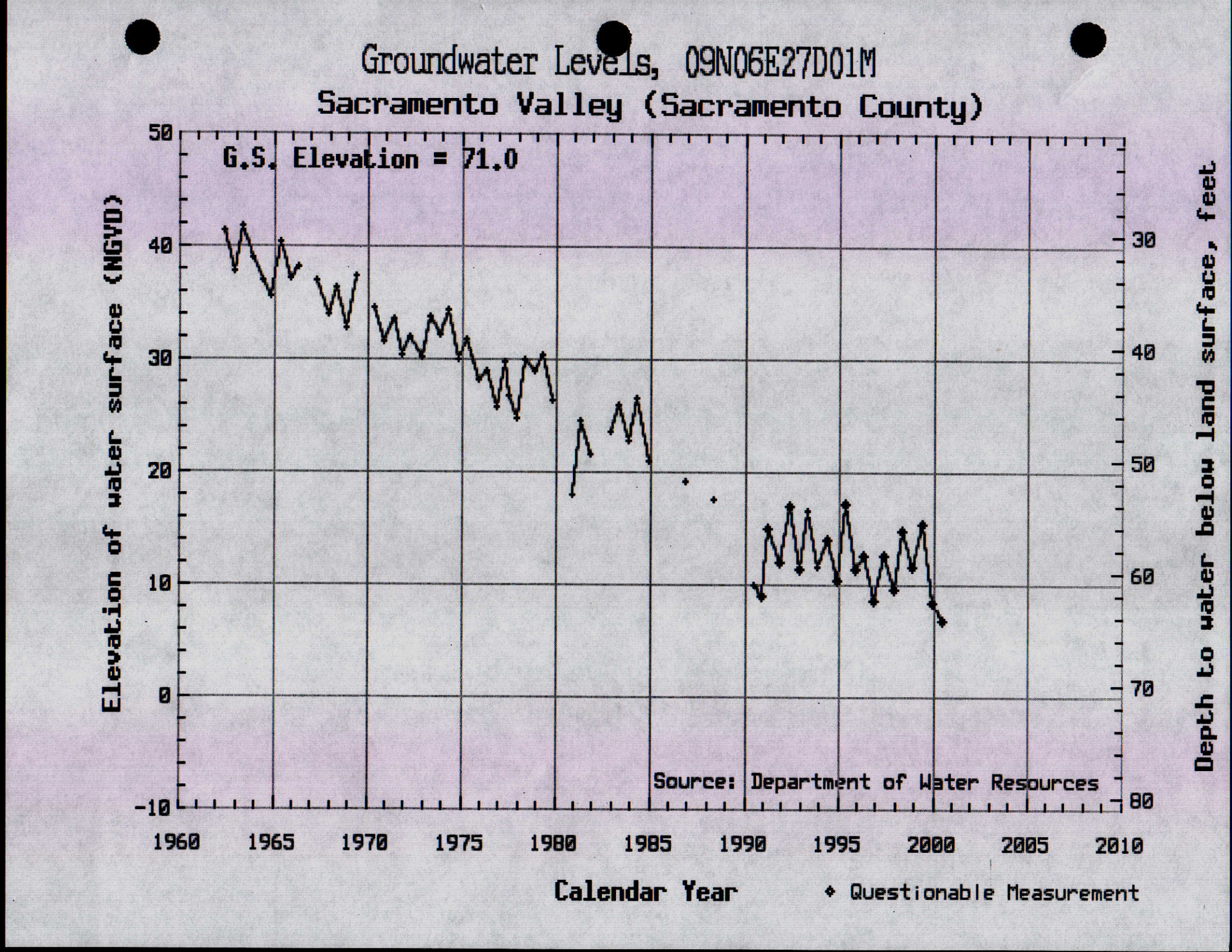
Sacramento Valley (Sacramento County)



Groundwater Levels, 09N07E31G01M

Sacramento Valley (Sacramento County)




Groundwater Levels, 09N06E27D01M
Sacramento Valley (Sacramento County)
G.S. Elevation = 71.0
Elevation of water surface (NGVD)
Depth to water below land surface, feet
50
40
30
20
10
0
-10
30
40
50
60
70
80
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Source: Department of Water Resources
Calendar Year
◆ Questionable Measurement

KOMEX
ENVIRONMENT AND WATER RESOURCES

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Curriculum Vitae

Dated: January 2, 2002

Stephen Ross

Associate, **KOMEX•H2O SCIENCE•INC.**

Disciplines:

Water Resources, Water Quality, Contaminant Fate and Transport, Soil and Groundwater Remediation

Education:

M.Sc.,	Earth Science, University of Waterloo, Ontario, 1991
B.Sc., (Honours)	Earth Science, University of Waterloo, 1988.

Registration:

Professional Geologist (Alberta, Canada) M54594

Professional Experience:

Responsible for investigations in the areas of physical and contaminant hydrogeology. Designed and supervised the installation of various types of soil and groundwater remediation systems. These systems have included vertical/horizontal wells and trenches for hydraulic containment, soil vapour extraction/air sparging/bioventing and multiphase extraction for contaminant removal or destruction. Involved in developing innovative cost effiective treatment technologies for contaminanted groundwater such as engineered wetlands and trench and gate system. Involved in application of local and regional groundwater flow and transport models to a variety of hydrogeological problems including: groundwater and surface water interaction, design, implementation and monitoring of pump and treat systems. Recent work includes groundwater plume delineation and impact assessment studies on groundwater due to leaching of chemical wastes from industrial facilities. Reporting related to annual groundwater monitoring program at gas plants. Involved in hydrogeological investigations related to groundwater supply assessment and development as required for water flooding of hydrocarbons. Supervised installation of water wells and conducted numerous aquifer tests in various geological environments.

PROJECT EXPERIENCE:

- Rancho Cordova, California: Project manager for ongoing litigation support services against the State of California and Aerojet General Corporation (Aerojet). The Aerojet site located in Rancho Cordova is more than 6,800 acres in size with approximately 1,000 monitoring wells. Responsible for providing opinions on the site hydrogeology, origin of contaminants and fate and transport of tetrachloroethene, trichloroethene, ammonium-perchlorate, 1,4 dioxane and n-nitrosodimethylamine found in groundwater.

- South Lake Tahoe, California: Project manager litigation for support case of methyl tertiary-butyl ether (MTBE) impacted water supply aquifer in South Lake Tahoe. Project involves preparing site summarizes for a number of potentially responsible parties and assessment of site characterization and remediation program data deficiencies by other consulting firms.

- Lodi, California: Providing litigation support for a site impacted by tetrachloroethene and trichloroethene from plating operations.

- Refinery Edmonton, Alberta: Responsible for the design, contractor procurement, installation and testing of a horizontal groundwater extraction well for hydraulic containment. Performed cost benefit analyses of horizontal versus vertical extraction wells with the aid of a numerical simulator (Modflow).

- Gas Processing Facility Nordegg, Alberta: Designed, supervised and the installed a large scale pump and treat remediation system in fractured sandstone. Remediation system involved installing a hanging grout curtain with a series of pneumatic groundwater surface depression and hydrocarbon skimming pumps. Involved in site characterization phase of the investigation involved using innovative techniques to understand contaminant transport through the fractured sandstone unit.

- Gas Processing Facility Rocky Mountain House, Alberta: Designed, supervised and installed a large scale pump and treat system at a gas plant. System involves five groundwater extraction wells coupled to a water treatment facility consisting of free phase hydrocarbon separation, air stripping and disposal in an injection trench. The position of the groundwater extraction wells was directed by predictive modelling using the program FLOWPATH. An innovative groundwater treatment system consisting of a constructed wetland is currently being evaluated at this facility.

- Gas Processing Facility Rocky Mountain House, Alberta: Involved in a CAPP funded research project to demonstrate and assess various remediation strategies. These strategies included: pump-and-treat, soil vapour extraction (vertical wells and horizontal trench), bioventing, and air sparging.

- Refinery Colombia, Barrancabermeja: Designed and implemented a pilot remediation testing program at Colombia's oldest and largest refinery. Pre-pilot testing program included pnuematic skimming (single and dual pumping), soil vapour extraction, and multi-phase extraction.

- Gas Processing Facility, Central, Alberta: Involved in design and implementation of a funnel and trench remediation program to treat dissolved phase hydrocarbons from an active facility.

- Gas Processing Facility, Central Alberta: Designed and implemented the construction of interception trench. A numerical simulator (Winflo) was used to evaluate the optimum trench configuration for the design.

- Los Angeles, California: Conducted site characterization studies at several contaminated gasoline stations. Designed remedial solutions for the underground storage tank clean-ups at numerous site.

- São Paulo, Brazil: Conducted an investigation into river and groundwater interaction to determine contamination potential under various water production scenarios. Installed piezometers, water well and conducted an aquifer test. HT3D a fully 3-D finite element flow and transport model was used to predict various contamination scenarios.

- Masila-Hadramout, Yemen: Involved a major regional groundwater resource assessment project for rural and city water supplies. Program includes data collection, aquifer testing, and installation of water wells.

- Okotoks, Alberta: Designed, installed and sampled a deep monitoring well (350 m depth) to detect potential contamination from a venting gas well. A highly specialized drilling program was developed and implemented to reduce the introduction of organics into the borehole.

- Crestomere Lake, Alberta: Designed, installed and tested two production wells for water flooding scheme.

- Alberta: Designed and installed groundwater monitoring networks at more than 50 facilities to detect contamination from industrial activities.

- Ottawa, Ontario: Supervised drilling and installation of a construction dewatering well and observation wells to determine the feasibility of dewatering a sewage pumping station construction site.

PUBLICATIONS:

Ross, S.D., D.L. Rudolph, N. Ellert, R.N. Farvolden, J.P. Greenhouse, and A.C. Reboucas, 1990. "Hydrogeological Study of River-Connected Aquifers in Greater São Paulo, Brazil." Sixth Congresso Brasileiro De Aquas Subterraneas, Port Alegie, Brazil.

Ross, S.D., D.L. Rudolph, N. Ellert, R.N. Farvolden, J.P. Greenhouse, and A.C. Reboucas. 1991. "Hydrogeological Study of River-Connected Aquifers in Greater São Paulo, Brazil." Geological Association of Canada, Toronto.

Hardisty, P.E., S.D. Ross, P.M. Johnston, 1994. "Characterization of LNAPL in Fractured Sedimentary Rock: Techniques, Behaviour and Implications for Remediation," in *Proceeding of the GASREP 4th Symposium on Groundwater and Soil Remediation.* Calgary, September 1994.

Hardisty, P.E., S.D. Ross, T.L. Dabrowski, and A. Brown, 1995. "Remediation of LNAPL in Fractured Rock: Theory and Application," in *Proceedings of the International Association of Hydrogeologists, Solutions '95,* Edmonton, Alberta, June 1995.

Hardisty, P.E., S.D. Ross, P.M. Johnston, 1995. "Characterizing LNAPL Contamination in Fractured Sedimentary Rock" in *The Hazardous Waste Consultant,* May/June 1995.

Maccagno, M.D., S.D. Ross, and P.E. Hardisty, and M.D. Maccagno. 1996. "Containment of Dissolved Phase Plume Using a Horizontal Well." Outdoor Action Conference, Las Vegas, May 1996.

Ross, S.D., 1997. "Choosing a Remediation Technology," in *Hazardous Materials Management,* Volume 9, Number 2.

Moore, B.J., S.D. Ross, L. Callow, and D. Gibson, 1999. "Constructed Wetlands for the Treatment of Dissolved Phase Hydrocarbons" Battelle Wetlands Remediation Conference, Salt Lake City, UT.

Moore, B.J., S.D. Ross, and D. Gibson, 1999. "Constructed Wetlands for the Treatment of Dissolved Phase Hydrocarbons" 1st Environment Canada Phytoremediation Conference, Calgary, Alberta.

Moore, B.J., S.D. Ross, and D. Gibson, 2000. "Constructed Wetlands for the Treatment of Condenstate Hydrocarbons in Cold Climates" 2st Environment Canada Phytoremediation Conference, Vancouver, British Columbia.

Moore, B.J., S.D. Ross, and D. Gibson, 2001. "Constructed Wetlands for Condensate Hydrocarbon Treatment" Can-Am 6th Annual Conference of National Groundwater Association Banff, Alberta, Canada.

Ross, S.D., A. Gray , and A.Brown 2001. Remediation of Ether Oxygenates at Drinking Water Supplies and Release Sites. Can-Am 6th Annual Conference of National Groundwater Association Banff, Alberta, Canada.

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ENVIRONMENT AND WATER RESOURCES

Curriculum Vitae

Anthony Brown

President and Principal Hydrologist, **KOMEX•H2O SCIENCE•INC.**
Chief Operating Office, Director of US and Latin America, **KOMEX ENVIRONMENTAL LTD.**

Disciplines:
Hydrology, Water Resources, Water Quality, Environmental Management, Contaminant Fate and Transport, Soil and Groundwater Remediation, Drinking Water Treatment

Education:

M.Sc.,	Engineering Hydrology, Imperial College of Science, Technology and Medicine (Imperial College), University of London, 1989
D.I.C.,	Postgraduate diploma in Civil Engineering, Imperial College, 1988
B.A. Hons.,	Physical Geography, King's College, University of London, 1985

Registration:
California Registered Environmental Assessor (REA) #04693, 1992.
General Engineering Contractor (A License) #729766, 1996.

Professional Experience:
Anthony is a versatile and proficient environmental professional with experience in hydrology, hydrogeology, groundwater modeling, fate and transport of organic contaminants, groundwater remediation, water resources evaluation, and water supply engineering. He has conducted and managed a variety of hazardous waste site investigations, including sites with multiple responsible parties, complex hydrogeology and fate and transport, fractured rock, multiple contaminants, and co-mingled plumes. This work has included Phase I Environmental Site Assessments, detailed Phase II characterization studies, groundwater flow and solute transport modeling, Preliminary Endangerment Assessments, Human Health Risk Assessments, and remedial system feasibility evaluations, design and implementation. In addition, Anthony has also conducted liability assessments for the acquisition of major property portfolios, and corporate mergers and acquisitions. He has also used environmental economic analysis to support remedial decision-making.

Anthony has provided expert services to several prominent environmental law firms, the State of California Attorney General's Office, the Orange County District Attorney's Office, Los Angeles City Attorneys Office, and the City of Santa Monica Attorneys Office. Through his work for water utilities impacted by the gasoline additive methyl Tertiary Butyl Ether (MTBE) and chlorinated solvents, Anthony has become a recognized expert in the fate, transport, and remediation of MTBE and chlorinated compounds, and the protection of source waters from contamination by MTBE and other recalcitrant chemicals. Amongst other technical areas of expertise, he has also provided expert advice related to the environmental impact of oil field contaminants and their mitigation, and the assessment and remediation of

perchlorate, N-nitrosodimethylamine (NDMA), hexavalent chrome and other metals, and bacteria and fecal contamination.

Through his extensive experience on "high-profile" projects, Anthony has developed a good working relationship with private and public sector clients, Federal, State and local elected officials and government agency staff, the legal community, professional organizations, non-profit environmental organizations, and his colleagues in the environmental and water resources professions. He has also briefed White House staff, federal, State and local elected officials and regulators, independent commissions, professional groups, academic institutions, and the news media (including CBS 60 Minutes, National Public Radio [NPR] and local newspapers) on the impact of MTBE, other VOCs, and bacteria on water quality

In addition to his US experience, Anthony has worked on projects in the United Kingdom, Eire, Canada, Mexico, Costa Rica, Columbia, Ecuador, Yemen, Egypt and Nepal. He is currently the Director of all US and Latin American operations for Komex.

Anthony has acted as the Principal in Charge, Project Manager, quality assurance and quality control (QA/QC) Manager and/or Principal Review for the following ongoing or recently completed projects:

Petroleum Hydrocarbon Contaminants

- Impact and Mitigation of Oil Field Contaminants at the Belmont Learning Center – Los Angeles Unified School District (LAUSD), Belmont Commission
- Investigation, Remediation and Restoration of Municipal Well Fields Impacted by Methyl-tertiary Butyl Ether (MTBE) Contamination – City of Santa Monica (Charnock Well Field), South Lake Tahoe Public Utility District (STPUD), Santa Clara Valley Water District (SCVWD), Great Oaks Water Company
- Complete Restoration of Municipal Water Supply Wells Contaminated with MTBE – City of Santa Monica (Arcadia Well Field) and ExxonMobil Corporation
- Preliminary Environmental Assessment (PEA) at the Hull Middle School - Torrance Unified School District (TUSD)
- Oversight and Investigation of Remediation of MTBE Contamination Impacting Drinking Water Supplies in the Towns of Cambria and Los Osos/Baywood Park – Cambria Community Services District (CCSD), Los Osos Community Services district (LOCSD)
- Assessment of the Impact of an MTBE Release on Water Supply Wells, Sewers and a Wastewater Treatment Plant – City of Morro Bay
- Investigation and Remediation of an MTBE Release in the Immediate Vicinity of a Drinking Water Supply Well - City of Cerritos
- Assessment of the Impact of MTBE on Drinking Water Supply Wells in Santa Clara County – Great Oaks Water Company (GOWC)
- Assessment of Data Gaps and Research Needs Regarding MTBE Impact to Water Resources – UK Environment Agency
- Identification of Multiple Potentially Responsible Parties (PRPs) Responsible for MTBE Contamination at Municipal Well Fields – City of Santa Monica (40+ PRPs), STPUD (10+ PRPs), and SCVWD (2 PRPs)
- Investigation and Mitigation of the Impact of Oil Field Contaminants on a Large Apartment Complex in Marina del Rey, Los Angeles – Confidential Client

- Investigation and Remediation of Methane and Hydrogen Sulfide as Part of the Redevelopment of a Former Oil Field in Carson - Dominguez Energy/Carson Companies
- Assessment of Methane and Petroleum Hydrocarbon Contamination at a Former Oil Field in Santa Fe Springs – General Petroleum
- Natural Resource Damage Assessment (NRDA) at the Guadalupe Oil Field - State of California (Department of Fish and Game [DFG], Oil Spill Prevention and Response [OSPR], Attorney General and Regional Water Quality Control Board [RWQCB])
- Assessment of the Impact of Oil Field Activities on Surface Water and Groundwater Resources in the Central Coast of California – State of California
- Groundwater Investigation and Remediation at Four Petroleum Terminals in Wilmington, Carson, and San Pedro - GATX
- Research into Technologies for Treatment of MTBE in Water - Association of California Water Agencies (ACWA) / Western States Petroleum Association (WSPA) / Oxygenated Fuels Association (OFA)
- Characterization and Remediation of a Hydrocarbon Release (including MTBE) in Fractured Bedrock in Illinois – Shell
- Investigation and Remediation of Petroleum Hydrocarbon Contamination Beneath a City Maintenance Yard and City Bus Yard – City of Santa Monica
- Investigation and Remediation of a Gasoline Release (including MTBE) in Fractured Bedrock Resulting From a Catastrophic Tank Failure – Intrawest Ski Resorts, California
- Pipeline Leak Investigation and Remedial Design - Mobil Pipeline, Ft. Tejon, California
- Investigation of a Petroleum Release in Fractured Bedrock - Chevron, Julian, California
- Contribution of Multiple Sources to Groundwater Contamination - Confidential Client, La Palma, California
- Forensic Assessment of a Gasoline Release - Confidential Client, Santa Monica.
- Investigation of a Diesel Fuel Release - Confidential Client, Point Hueneme, California
- Service Station Investigations and Remediation (> 60 sites) - Mobil Oil Corporation, World Oil, Los Angeles County Metropolitan Transportation Authority (LACMTA), and Others
- Assessment of a Crude Release from a Former Pipeline - Mobil Oil, Gorman, California
- Canadian Association of Petroleum Producers (CAPP) Remediation Demonstration Program, Remediation of 500,000 gal. LNAPL Spill in Fractured Bedrock - Gulf Nordegg Gas Plant
- Remediation of 2,000,000 gallon (7,560 m^3) LNAPL Spill - Gulf Strachan Gas Plant

Chlorinated Hydrocarbons and Other Contaminants

- Investigation and Remediation of Chlorinated Solvent Contamination in Soil and Groundwater Beneath at a Metal Finishing Facility in Inglewood – Bodycote Hinterliter and Joseph Collins Estate.
- Investigation of Hexavalent Chrome Contamination at the Suva School in Montebello – Communities for a Better Environment
- Investigation of Bacteria and Fecal Contamination in Groundwater Beneath the Downtown Area of Huntington Beach – City of Huntington Beach
- Investigation and Remediation Hexavalent Chrome and Trichloroethene (TCE) Contamination at the Jefferson New Middle School – Jefferson Site PRP Group
- Evaluation of the Fate and Transport of Perchlorate and NDMA Contamination and its Impact on Water Supplies in Rancho Cordova – Southern California Water Company

- Investigation of the Source(s) and Transport of Enterococcus and Fecal Bacteria to the Near Shore Waters of Huntington Beach – City of Huntington Beach, County of Orange, Orange County Sanitation District (OCSD)
- Evaluation of Groundwater and Contaminant Conditions at an Active Municipal Landfill in Los Angeles County – Browning Ferris Industries (BFI)
- Investigation of Chlorinated Solvent Contamination in Groundwater Beneath a Municipal Airport – City of Santa Monica
- Resource Conservation and Recovery Act (RCRA) Facility Assessment and Closure for a Large Aerospace Facility – Northrop Grumman Corporation (NGC)
- Investigation of Soil and Groundwater Contamination at a Municipal Airport – City of Santa Monica
- Identification of Major (53), Minor (>800) and de Minimus (>9,000) PRPs at a Federal Superfund Site – Confidential Client
- Characterization of complex hydrogeology and contaminant fate and transport (with Poly-chlorinated Biphenyls [PCBs] and Chlorinated Solvents) in Karstic Bedrock at a Site on the National Priority List (NPL) in Missouri – PRP Steering Committee
- Design of a Groundwater Remediation Program for Chlorinated Solvent, Perchlorate and Other Contaminants Utilizing Existing Drinking Water Wells – San Gabriel Valley Water Company (SGVWC)
- Investigation of a Chlorinated Solvent Release in Fractured Bedrock - Confidential Client, San Diego, California
- Investigation of a Chlorinated Solvent Release at an Active Chemical Terminal - GATX, San Pedro, California
- Investigation and Remedial Design for a Chlorinated Solvent Release - Confidential Client, Los Angeles, California
- Remediation of Chlorinated Solvents in Groundwater - Port of Los Angeles, California
- Remedial Evaluation of Tetrachloroethene (PCE) Contamination - Confidential Client, Irvine, California
- Evaluation of a Chlorinated Solvent Release at a Dry Cleaners - Los Angeles City Attorney, West Los Angeles, California
- Assessment of a Chlorinated Solvent Release from Former Dry Cleaners - Confidential Client, Santa Barbara
- Phase I Environmental Site Assessments - Various Clients, Southern California
- Characterization and Remediation, Former Town Gas Sites - British Gas Properties, U.K.
- Characterization of a Chlorinated Solvent and Styrene Release - Confidential Client, U.K.
- Characterization and Remediation of LNAPL at an Active Chemical Refinery - ICI, Teeside, UK

Computer Modeling

- Three-dimensional Regional Groundwater Flow and Solute Transport Modeling as Part of the NRDA at the Guadalupe Oil Field - State of California
- Three-dimensional Groundwater Flow Modeling to Support the Design of a Slurry Wall and De-watering System - Port of Los Angeles
- Two-Dimensional Groundwater Flow Modeling to Support Remedial Design at Service Station and Petroleum Terminals - Various Clients
- Multi-layer, Two-Dimensional Groundwater Flow Model for Plume Capture Analysis - Mobil, Santa Barbara
- Fate And Transport Modeling in Support of Risk Assessments and Risk-Based Closure at Sites In Southern California - Various Clients
- Modeling of Vapor Phase Solvent Migration to Evaluate Groundwater Contaminant Distribution and in Support of Risk Assessments - Various Clients

Other Projects

- Negotiation of Private Agreements Between Water Utilities and PRPs – City of Santa Monica, STPUD, CCSD, City of Morro Bay, SGVWC, GOWC
- Development of Source Water Assessment and Protection Programs – City of Santa Monica
- Development of Guidelines for Source Water Assessment Programs - State of California
- Aquifer Characterization, Slurry Wall Design and Installation, Soil Excavation and Water Treatment System Design - Port of Los Angeles

If desired, descriptions for these projects can be provided.

Professional History:

Komex•H2O Science•Inc., Huntington Beach, CA: President and Principal Hydrologist, 1992 to present.
Komex Environmental Ltd., Chief Operating Officer and Director of US and Latin America, 1999 to present.
Remedial Action Corporation, Santa Ana, CA: Project Manager and Geohydrologist, 1989 to 1992.
Lanco Engineering, Torrance, CA: Project Manager, 1985 to 1987, and 1988.

Affiliations:

American Association for the Advancement of Science (AAAS)
American Bar Association (ABA)
American Chemical Society (ACS)
American Society for Testing and Materials (ASTM)
American Water Resources Association (AWRA)
American Water Works Association (AWWA)
Association of California Water Agencies (ACWA)
Association of Groundwater Agencies (AGWA)
California Groundwater Association (CGA)
California Water Environment Association (CWEA)
Groundwater Resource Association (GRA) of California
Hazardous Materials Control Resources Institute (HMRCI)
International Association of Hydrogeologists (IAH)
International Right of Way Association (IRWA)
Los Angeles County Bar Association (LACBA)
National Groundwater Association (NGWA) - Association of Groundwater Scientists and Engineers (AGWSE)
Water Environment Federation (WEF)

Teaching:

Anthony has recently taught the following classes:

- Environmental Aspects of Soil Engineering and Geology, a ten week course at the University of California, Irvine;
- Site Characterization and Remediation of Environmental Pollutants, two lectures as part of the course at Imperial College London;

- Methyl Tertiary Butyl Ether: Implications for European Groundwater, a one day seminar for the UK Environment Agency (UKEA);
- Understanding Environmental Contamination in Real Estate, and one day class for the International Right-of-Way Association (IRWA);
- Project Development and the Environmental Process, a one day class for the IRWA;
- Environmental Awareness, a one day class for the IRWA; and
- Regional Fuels Management Workshop, a two-day workshop for the US Environmental Protection Agency (USEPA).

Publications:

In addition to his teaching experience, Anthony has prepared over 1000 written project reports, and has written, presented and published many articles regarding the following:

- Contamination of groundwater and drinking water supplies by MTBE and other VOCs
- Contaminant fate and transport in fractured or heterogeneous media
- The impact of oil field activities on the environment
- Source water assessment and protection
- Public health and toxicology
- Risk analysis and assessment
- Environmental economics
- General water resources and environmental issues

The following is a list of recent publications and presentations:

Hardisty, P.E., G.M. Hall, A. **Brown** and H.S. Wheater, 2000. Natural Attenuation of MTBE in Fractured Media. 2nd National Conference on Natural Attenuation in Contaminated Land and Groundwater. Sheffield, U.K., June, 2000.

Gray, A.L. and A. **Brown**, 2000. The Fate, Transport, and Remediation of Tertiary-Butyl-Alcohol (TBA) in Ground Water. Proceedings of the NGWA/API 2000 Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Remediation. Anaheim, November 14-17, 2000.

Hardisty, P.E., J. Dottridge and A. **Brown**, 2000. MTBE in Ground Water in the United Kingdom and Europe. Proceedings of the NGWA/API 2000 Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Remediation. Anaheim, November 14-17, 2000.

Brown, A., 2000. Treatment of Drinking Water Impacted with MTBE. Mealey's MTBE Conference. Marina del Rey, California. May 11-12, 2000.

Brown, A., 2000. Other Fuel Oxygenates in Groundwater. Mealey's MTBE Conference. Marina del Rey, California. May 11-12, 2000.

Brown, A., 2000. The Fate, Transport and Remediation of TBA in Groundwater. Mealey's MTBE Conference. Marina del Rey, California. May 11-12, 2000.

Brown, A., 2000. MTBE Contamination of the City of Santa Monica Water Supply: Recap. Mealey's MTBE Conference. Marina del Rey, California. May 11-12, 2000.

Mooder, R.B., M.D. Trudell, and A. **Brown**, 2000. A Theoretical Analysis of MTBE Leaching from Reformulated Gasoline in Contact with Groundwater. American Chemical Society (ACS), Division of Environmental Chemistry, 219th ACS National Meeting. San Francisco, March 26-30, 2000.

Trudell, M.D., K.D. Mitchell, R.B. Mooder, and A. **Brown**, 2000. Modeling MTBE Transport for Evaluation of Migration Pathways in Groundwater. American Chemical Society (ACS), Division of Environmental Chemistry, 219th ACS National Meeting. San Francisco, March 26-30, 2000.

Brown, A., 1999. How LUST Policy Lead to the Current MTBE Problem. Submitted for the Government Conference on the Environment. Anaheim, CA. August, 1999.

Brown, A., P.E. Hardisty, and H. Wheater, 1999. The Impact of Fuel Oxygenates on Water Resources. A one-day course for the UK Environment Agency. London, UK. June, 1999

Brown, A., 1999. LUST Policy and Its Part in the MTBE Problem. USEPA National Underground Storage Tank Conference. Daytona Beach, FL. March 15-17, 1999.

Brown, A., 1999. Moderator of a Panel Session - Judging Oil Spill Response Performance: The Challenge of Competing Perspectives. International Oil Spill Conference. Seattle, WA. March 8-11, 1999.

Brown, A., 1999. MTBE: Asleep at the Wheel! Editorial in the Newsletter of the Los Angeles County Bar Association, Environmental Section. February, 1999.

Brown, A., T.E. Browne and R.A. Rodriguez, 1999. Restoration Program for MTBE Contamination of the City of Santa Monica Arcadia Well Field. Submitted to the Ninth Annual Conference on Soil and Groundwater Contamination, Oxnard, CA. March, 1999.

Brown, A., J.S. Devinny, T.E. Browne and R.A. Rodriguez, 1998. Restoration of a Public Drinking Water Supply Impacted by Methyl *tertiary* Butyl Ether (MTBE) Contamination. Proceedings of the NGWA/API 1998 Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Remediation, November 11-13, 1996, Houston, TX.

Brown, A., 1998. Petroleum and the Environment: A Consultants Perspective. USEPA Regional Fuels Management Workshop, November 3-4, 1998, Shell Beach, CA.

Brown, A., 1998. How Much Does Remediation Really Cost. Presented at the Southern California Chapter of the Appraisal Institute, Summer Seminar Spectacular: Damages, Diminution and Mitigation. Anaheim, California, August 13, 1998.

Brown, A., J.S. Devinny, A.L. Gray and R.A. Rodriguez, 1998. A Review of Potential Technologies for the Remediation of Methyl *tertiary* Butyl Ether (MTBE) In Groundwater. International Petroleum and the Environment Conference, Albuquerque, NM. October, 1998.

Brown, A., A.L. Gray, and T.E. Browne, 1998. Remediation of MTBE at Leaking Underground Storage Tank (LUST) Sites. The State UST Clean-up Fund Conference, Austin, TX. June 22, 1998.

Brown, A., J.R.C. Farrow, R.A. Rodriguez, and B.J. Johnson, 1998. Methyl *tertiary* Butyl Ether (MTBE) Contamination of the City of Santa Monica Drinking Water Supply: An Update. Proceedings of the National Ground Water Association (NGWA) Southwest Focused Conference: MTBE and Perchlorate, June 3-5, 1998, Anaheim, California.

Patterson, G, B. Groveman, J. Lawrence, and **A. Brown**, 1998. The Legal Implications, Claims, and Courses of Action for Water Purveyors Impacted by MTBE and Perchlorate. Proceedings of the NGWA Southwest Focused Ground Water Conference: Discussing the Issue of MTBE and Perchlorate in Ground Water. June 3-4, 1998, Anaheim, California.

Clark, J.J., **A. Brown**, And R.A. Rodriguez, 1998. The Public Health Implications of MTBE and Perchlorate in Water: Risk Management Decisions for Water Purveyors. Proceedings of the NGWA Southwest Focused Ground Water Conference: Discussing the Issue of MTBE and Perchlorate in Ground Water. June 3-4, 1998, Anaheim, California.

Brown, A., J.S. Devinny, M.K. Davis, T.E. Browne, And R.A. Rodriguez, 1997e. A Review of Potential Technologies for the Treatment of Methyl *tertiary* Butyl Ether (MTBE) in Drinking Water. Proceedings of the NGWA/API 1997 Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Remediation, November 12-14, 1996, Houston, TX.

Brown, A., J.R.C. Farrow, R.A. Rodriguez, B.J. Johnson And A.J. Bellomo, 1997d. Methyl *tertiary* Butyl Ether (MTBE) Contamination of the City of Santa Monica Drinking Water Supply. Proceedings of the National Groundwater (NGWA) and American Petroleum Institute (API) 1997 Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Remediation, November 12-14, 1996, Houston, Texas.

Brown, A., J.S. Devinny, M.K. Davis, T.E. Browne, And R.A. Rodriguez, 1997c. A Review of Treatment Technologies for Methyl *tertiary* Butyl Ether (MTBE) in Drinking Water. Proceedings of the American Chemical Society (ACS) Conference on Chemistry and Spectroscopy, October 1997, Irvine, California.

Brown, A., J.S. Devinny, T.E. Browne and D. Chitwood, 1997. A Review of Alternative Technologies for the Removal of Methyl tertiary Butyl Ether (MTBE) from Drinking Water. Association of California Water Agencies (ACWA) Workshop on MTBE, March 13, 1997, Ontario Airport Hilton, California.

Brown, A., 1997. Methyl tertiary Butyl Ether (MTBE) in Groundwater and its Impact on the City of Santa Monica Drinking Water Supply. California Groundwater Resource Association (GRA), January 22, 1997, Wyndham Garden Hotel, Costa Mesa, California.

Brown, A. and P.E. Hardisty, 1996. Use of Technical and Economic Analyses for Optimizing Technology Selection and Remedial Design: Examples from Hydrocarbon Contaminated Sites. Sixth West Coast Conference on Contaminated Soils and Groundwater, AEHS, March, 1996.

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Bauman, P.B., **A. Brown**, M. Brewster and M. Lockhart, 1994. The use of Borehole Geophysics in the Characterization of Both Vadose and Saturated Zone Lithologies at LUST Sites. Proceedings from the USEPA Technology Transfer at LUST Sites Conference, Urbana, Illinois. May, 1994.

Bauman, P.B., J. Sallomy, **A. Brown** and M. Brewster, 1994. Unconventional Applications of Terrain Conductivity Logging to Groundwater Investigations. Proceedings of the Symposium on the Application of Geophysics at Environmental and Engineering Projects (SAGEEP), Boston, Massachusetts, 1994.

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Anthony has also briefed the following on the impact of MTBE, other VOCs, oil field activities, perchlorate, NDMA and bacteria on groundwater:

- U.S. Environmental Protection Agency (USEPA) staff (Region IX and headquarters), including Assistant Administrators
- White House Officials
- US Senators and Representatives
- State Senators and Assembly-women/men
- State regulators
- Local officials (Mayors, council and board members, City attorneys, etc.)
- Independent Commissions
- Professional bodies (ABA, ACS, ACWA, AEHS, AGWA, NGWA, GRA, etc.)
- Academic institutions and many other organizations

TADEUSZ L. DABROWSKI, M.Sc., Ph.D., P.Eng.

Principal Hydrogeologist

SPECIAL FIELDS OF COMPETENCE:

- Regional and local hydrogeological evaluations leading to the identification and development of groundwater resources.
- Hydrogeological studies for planned and operating mining projects, including dewatering/depressurizing operations for large open pit and underground mines.
- Contaminant situation assessments for various industrial facilities (oil refineries, gas plants, fertilizer plants), including aquifer remediation.
- Evaluation of the impact of large projects on groundwater regime, design of dewatering systems for major excavation in soil and rock.
- Groundwater studies related to radioactive and industrial waste disposal.
- Expert witness testimony.

EDUCATION:

- M.Sc., Hydrogeology and Engineering Geology, University of Warsaw, Poland, 1962.
- Doctor of Natural Sciences, Polish Academy of Sciences, Laboratory of Geological Sciences, Warsaw, Poland, 1973.
- Diploma, Project Management for Developing Countries, University of Warsaw, Poland, 1973.

POSITIONS HELD:

- 1982-present. Senior Vice President, Komex International Ltd., Calgary, Alberta.
- 1980-1982. Senior Hydrogeologist, Alsands Energy Ltd., Calgary, Alberta.
- 1977-1980. Senior Groundwater Hydrologist, EBA Engineering Consultants Ltd., Edmonton, Alberta.
- 1974-1977. Senior Groundwater Geologist, Acres Consulting Services, Niagara Falls, Ontario.
- 1968-1974. Principal Specialist - Hydrogeology, Geological Research Bureau of Oil Industry, Warsaw, Poland.
- 1967-1968. Geologist, H.G. Acres and Company Limited, Niagara Falls, Ontario.
- 1961-1967. Associate and Assistant Professor, University of Warsaw, Warsaw, Poland.

LANGUAGES:

- Written: English, Polish, Spanish (fair) and Russian (fair).
- Spoken: English, Polish, Spanish (fair) and Russian (fair).

CITIZENSHIP:

- Canadian

PROFESSIONAL AFFILIATIONS:

- Assoc. of Professional Engineers, Geologists & Geophysicists of Alberta
- International Association of Hydrogeologists
- Canadian Society for Professional Engineers
- Canadian Institute of Mining and Metallurgy
- International Mine Water Association
- American Institute of Hydrology

- Association of Geoscientists for International Development
- Association of Groundwater Scientists and Engineers

SUMMARY OF EXPERIENCE:

Dr. Dabrowski has over thirty-five years of experience in the planning, management, development and remediation of groundwater resources. This includes:

- Review hydrogeological reports and provided technical support on a number of projects related to hydrocarbon, MTBE, VOC and dissolved metals contamination for a number of projects in California. Selected projects include:
  - Jefferson New Middle School, Los Angeles, CA
  - Southern California Water Company, Rancho Cordova, CA
  - South Lake Tahoe, CA
  - Charnock Well Field, Santa Monica, CA
  - Harbor Terminal, Los Angeles, CA
  - Carson Terminal, Los Angeles, CA
  - South Broadway Terminal, Los Angeles, CA
  - Anaheim Street Properties, Long Beach, CA
  - Mammoth Mountain Ski Area, CA
  - City of Santa Monica, Corporate Yard and Main Library
  - Ackel Properties, Lodi, CA

- Regional and local hydrogeological evaluations leading to the identification of potential sources of groundwater supply (Canada, Poland, Guatemala, Colombia, Yemen). Exploratory drilling, aquifer testing and assessment of long-term aquifer production potential. Design and construction of production wells and well systems.

- Water supply projects for small rural communities (peak water demand lower than 5 m^3/h), large collective farms, municipalities and cities, as well as industrial facilities (demand over 1000 m^3/h).

- Environmental impact assessments (hydrogeological component) and hydrogeological evaluations for large open pit oil sands mines (Syncrude, Suncor, Alsands, OSLO, Canstar, Sandalta), coal mines (Cardinal River, Coalspur, Byron Creek, Line Creek, Gregg River Mine, Cheviot Mine), and major petroleum industry facilities in western Canada.

- Civil engineering projects include evaluation of the impact of large projects on the groundwater regime, design of dewatering systems for major excavations in soil and rock, hydrogeological aspects related to hydro-electric projects, and groundwater studies related to radioactive, industrial and municipal waste disposal.

- Numerous hydrogeological studies related to coal and oil sands studies, including Monkman Pass, AOSTRA, Syncrude, Suncor, Canstar, Fording Coal, Gulf and Alberta Environment.

- Provided technical input into over 350 contaminant situation assessment projects related to the petroleum industry in Canada (Alberta, Saskatchewan, Quebec, Yukon). Participated in major aquifer remediation programs.

- Responsible for conducting hydrogeological studies for a number of mining projects. These included a wide range of dewatering/depressurizing operations for large open pit and underground mines, environmental impact assessments and hydrogeological evaluation related to tailings disposal.

- Served as an expert witness in the field of hydrogeology before the Court of Queen's Bench, Energy Resources Conservation Board and Alberta Energy and Utilities Board, Public Health Appeal and Advisory Board and Independent Belmont High School Commission (Los Angeles Unified School District).

- Published a number of technical papers in the field of hydrogeology.

- Taught hydrogeology at the university level. Prepared and delivered numerous courses on various aspects of hydrogeology.

International experience includes numerous hydrogeological projects in Central, South and North America, as well as Asia, Africa, Middle East, and Europe. A few select examples of these experiences follow:

- Groundwater resources assessment in the Hadramout-Masila Region in Yemen (1994 -1997).

- Evaluation of mineral water resources in the Matanzas Department, Cuba, for Canada Northwest Energy Limited (1994 - 1996).

- Hydrogeological assessment for an EIA relating to the CanOxy Masila Block and pipeline to Mukalla development in Yemen, (1992 - 1993).

- Development of the baseline hydrogeological data collection for the Hadramout Province, Yemen. Client: CanOxy, (1992).

- Assessed regional and local groundwater conditions in the area of a proposed underground coal mine, Ombilin II (Sumatra, Indonesia). Outlined short-and long-term hydrogeological exploration program. Client: Norwest Resource Consultants (1986 -1987), for World Bank.

- Provided design and overview of a dewatering system operation in residual soils causing uplift of a penstock at Finchaa Hydroelectric Project in Ethiopia. Client: Ethiopian Electric Light and Power Authority (1982 - present), for World Bank.

- Reviewed hydrogeological aspects of the Río Chixoy (Guatemala) tailrace tunnel construction and operation. Client: Dr. L. Wolofsky (1987), for the Guatemalan Instituto Nacional de Electrificación.

- Designed a groundwater monitoring system for the largest Colombian oil refinery and petro-chemical complex at Barrancabermeja. Assisted in program organization, provided technology transfer during initial phase of the field exploration program, data evaluation and report preparation. Client: Petro-Canada International Assistance Corporation (1988 -1991).

- Development of the aquifer remediation programs at different sites of the Barrancabermeja Industrial Complex. Training of Colombian personnel. Client: Empresa Colombiana de Petróleos, ECOPETROL, (1991 - present).

- Reviewed the hydrogeological aspects of the environmental impact assessment of the New Refinery Project (Colombia, Middle Magdalena River). Client: Empresa Colombiana de Petróleos, ECOPETROL, (1990).

- Assessed groundwater supply potential (over 1000 m^3/hr) for the New Refinery Project, including five site assessments (Colombia, Middle Magdalena River). Client: ECOPETROL (1990).

- Prepared and delivered a one week course on "Groundwater Resources and Petroleum Industry Interactions" for petroleum industry and scientific institutions personnel in Cartagena, Colombia. Client: Petro-Canada International Assistance Corporation (1986 -1987).

- During a one and a half year assignment, provided hydrogeological input into a national plan related to the development of rural potable water supply in Guatemala. As part of the program, conducted field assessment of the feasibility of using groundwater as a source of water supply for more than sixty communities. Client: Canadian International Development Agency (1978 - 1979).

- Research on the utilization of hydrogeological methods for oil and gas prospecting in Poland, including application of hydrochemical data. Principal specialist, hydrogeology. Geological Research Bureau of Oil Industry, Warsaw, Poland.

- Responsible for range of teaching, research and consulting activities including: regional studies on potential utilization of groundwater for supply of small communities, local industry and large government farms; hydrogeological balances. (University of Warsaw, Poland, 1961 - 1967).

PROFESSIONAL HISTORY:

Komex International Ltd., Calgary, Alberta - Exec. V.P., Hydrogeology, 1982 to Present.

- Responsible for groundwater studies conducted at more than 350 petroleum industry facilities in Alberta, Saskatchewan, Quebec, Northwest Territories and Yukon. These include refineries, sour and sweet gas plants, straddle gas plants, batteries, and compressor stations.

- International experience includes hydrogeological projects (water resources developments and contaminant studies) in Central, South and North America as well as Asia, Africa, Middle East and Europe.

- Expert witness experience includes over twenty-five interventions considered in the Court of Queen's Bench, Alberta Energy and Utilities Board, Public Health and Advisory Board, or settled out of court.

- Hydrogeological support for major soil and groundwater remediation programs at various industrial facilities (oil refineries, gas plants, fertilizer plants, chemical plants, landfills).

- Hydrogeological studies for cement and fertilizer plants.

- Participated in a major study on "Effectiveness of Subsurface Treatment Technology at Alberta Sour Gas Plants" (Phases I and II) for Canadian Petroleum Association and Environment Canada.

- Involved in a number of major aquifer remediation projects entailing the recovery of dissolved organic and inorganic compounds, as well as free hydrocarbon liquids.

- Coordinated development of a groundwater data base for the Yukon and NWT on contract with the Department of Indian Affairs and Northern Development.

- Conducted a study on "Groundwater Resources Protection from Drilling Wastes, Northwest Territories and Yukon" on contract with the Department of Indian Affairs and Northern Development.

- Participated in hydrogeological work and studies in the permafrost terrains, *e.g.*, artificial island, Beaufort Sea and oil refinery at Norman Wells.

- Provided hydrogeological input for Shell Caroline Gas Development environmental impact assessment and conducted aquifer exploration program to assess potential for using groundwater as a plant water supply. Participated in the induced infiltration system design and construction. The well system placed along the Red Deer River is capable of producing over 150 m^3/hr.

- Hydrogeological studies for Line Creek (Crows Nest Resources/Line Creek Resources), Byron Creek (Esso Minerals), Telkwa (Manalta), Monkman Pass (Petro-Canada), Luscar (Cardinal River Coals), Cheviot Mine Project (Cardinal River Coals) and Gregg River Mine (15-year, Sphinx West, West Extension) coal mines.

- Hydrogeological evaluations of Esso Minerals OSLO Project, Petro Canada Canstar Lease, Suncor Groundwater Control in the buried Mildred Channel, Gulf Canada Sandalta, Mobil Oil Canada and Shell Canada Oil Sand Leases.

- Member of the Twin Butte Soils and Water Evaluations Task Force, appointed by the Alberta Minister of the Environment to study the impact of gas plant operations on soil and groundwater conditions.

- Evaluation of groundwater conditions in the Athabasca Oil Sands area for a proposed AOSTRA Underground Test Facility.

- Review of the Athabasca Oil Sands groundwater monitoring network for Alberta Environment.

- Review of the groundwater exploration results and development of the hydrogeological exploration program related to the proposed Slave River Hydro Project for R.L. Walker & Partners Ltd.

Alsands Energy Ltd., Calgary, Alberta — Senior Hydrogeologist, 1980 - 1982.

- Responsible for conducting hydrogeological exploration programs related to the development of a large open pit oil sands mine near Fort McMurray, Alberta. This included the following:

- Evaluation of the groundwater conditions and development of a long term hydrogeological exploration program required for design depressurizing and dewatering systems.

- Supervision and coordination of field exploration programs.

- Preparation of a groundwater hydrology report for the Alsands Development and Reclamation plan (1981).

- Preparation of a hydrogeological report for the Alsands Preliminary Mine Plan (1980).

- Coordination of the geotechnical studies on stability of slopes and trafficability conditions in the proposed mine. Providing geotechnical input into mine planning and waste disposal activities.

EBA Engineering Consultants Ltd., Edmonton, AB — Sr. Groundwater Hydrologist, 1977 - 1980.

- Review of the hydrogeological conditions connected with Shell Canada Ltd.'s proposed refinery and marketing terminal, East Edmonton, Alberta.
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- Hydrogeological study of the Luscar Freehold Area, Cardinal River Coals, Alberta.
- Hydrogeological input for the supply of potable water to rural communities in the Republic of Guatemala, 1.5 year program in Guatemala.
- Supervision of groundwater and geotechnical monitoring at Syncrude oil sands mine, Alberta.

Acres Consulting Services, Niagara Falls, Ontario — Senior Groundwater Geologist, 1974 - 1977.

- Radioactive waste repository study - hydrogeology and waste containment, Canadian Shield area.
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- Supervision of dewatering of major excavation in soil and rock at Arnprior Generating Station, Ontario.
- Evaluation of geotechnical data connected with the disposal of tailings produced during the Great Canadian Oil Sands mining operation, Alberta.
- Hydrogeological investigations and design of dewatering system for Newfoundland Zinc Mine at Daniel's Harbour, Newfoundland.

Hydrogeology Geological Research Bureau of Oil Industry, Warsaw, Poland — Principal Specialist, 1969 - 1974.

- Research on the utilization of hydrogeological methods for oil and gas prospecting in Poland, including application of hydrochemical data.
- Coordination of all hydrogeological projects within the Bureau.

Geological Evaluation Commission, Ministry of Mining and Power, Warsaw, Poland — Member, 1969 - 1974.

- Responsible as part of twenty-member commission for review of projects having hydrogeological and geotechnical content. Includes open pit lignite mines, underground coal mines, hydroelectric and thermal electric projects, oil and gas exploration.

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- Planning and development of hydrogeological methods for oil and gas prospecting in Poland.

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- Site geologist at Lower Notch Hydroelectric Project.

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Acres Consulting Services, Niagara Falls, Ontario — Senior Groundwater Geologist, 1974 - 1977.

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Hydrogeology Geological Research Bureau of Oil Industry, Warsaw, Poland — Principal Specialist, 1969 - 1974.

- Research on the utilization of hydrogeological methods for oil and gas prospecting in Poland, including application of hydrochemical data.
- Coordination of all hydrogeological projects within the Bureau.

Geological Evaluation Commission, Ministry of Mining and Power, Warsaw, Poland — Member, 1969 - 1974.

- Responsible as part of twenty-member commission for review of projects having hydrogeological and geotechnical content. Includes open pit lignite mines, underground coal mines, hydroelectric and thermal electric projects, oil and gas exploration.

Central Board for Oil Industry, Warsaw, Poland —Principal Specialist, Hydrogeology, 1968.

- Planning and development of hydrogeological methods for oil and gas prospecting in Poland.

Acres and Company Limited, Niagara Falls, Ontario —Geologist, H.G., 1967 - 1968.

- Site geologist at Lower Notch Hydroelectric Project.

University of Warsaw, Warsaw, Poland — Assistant Professor, 1961 - 1967.

- Responsible for range of teaching, research and consulting activities including: regional studies on potential utilization of groundwater for supply of small communities, local industry and large government farms; hydrogeological balances.

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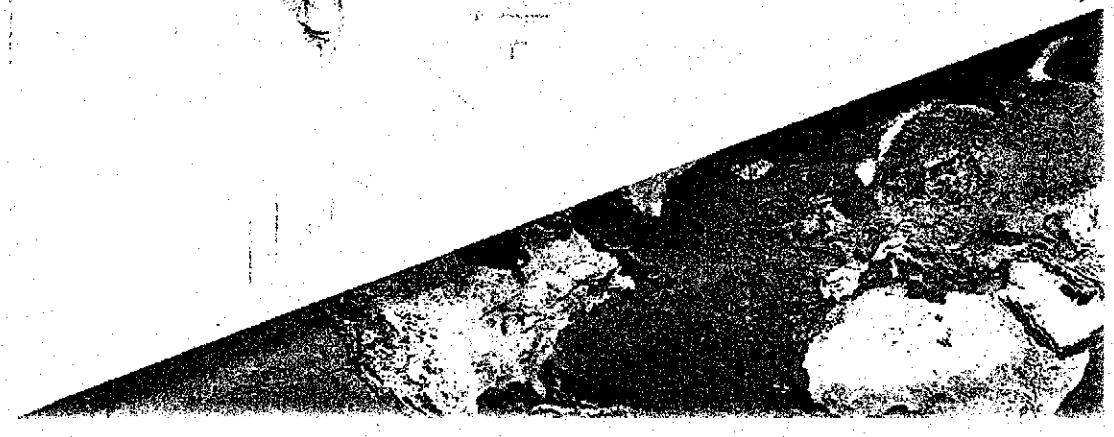
Statement of Qualifications

KOMEX



ENVIRONMENT AND WATER RESOURCES

Our Vision

A successful, employee-owned, global company
Providing our clients with long-term value and solutions,
and our staff with opportunities and growth.

Our Mission

To make a difference.

Our Commitment

Embrace and promote the company's core principles.
Support the goals of our clients and staff.
Care for the environment.
Encourage new ideas.

Our Principles

Excellence • Integrity • Enthusiasm • Leadership • Enjoyment • Safety

Why Choose KOMEX?

The best people have better ideas.
Better ideas provide the best solutions.
The best solutions lead to better value.

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The team of professionals at KOMEX is committed to the application of technological and scientific solutions that effectively meet the needs of our clients while contributing to the protection and preservation of the environment. By combining exceptional technical capability with a personal approach to service, Komex has proven itself as a global leader in environmental and engineering consulting services.

1 Introduction

1.1 OUR MISSION

Komex is a successful, employee-owned, global company, providing our clients with long-term value and solutions, and our staff with opportunities and growth. Our success is based on commitments made by the founding partners:

- To embrace and promote the company's core principles – excellence, integrity, enthusiasm, leadership, enjoyment and safety;
- To support the goals of our clients and staff;
- To care for the environment; and
- To encourage new ideas.

Our mission is simple – "To Make a Difference" – in everything we do. We want to make a positive contribution to the lives of our staff, the projects we work on, the challenges facing our clients, and the environmental issues facing the planet.

1.2 STAFF

Komex's most important resource is the quality of its professional employees. We hire the best, and we keep the best – our turnover is consistently less than 3%! But in a world filled with consultants all claiming to be the best, what separates Komex from the competition is our attitude. We love what we do, and our enthusiasm, talent, skill, and confidence are contagious.

Our confidence is built upon a level of expertise in the hydrogeologic and earth sciences, water resources, and environmental engineering that far exceeds that of most consulting firms. In particular, most of our professional staff has a Masters degree or Ph.D. and/or professional registration. Senior staff hold registrations in geology, hydrogeology, engineering (civil, mechanical, and chemical), environmental assessment, and general engineering contracting.

1.3 SERVICE

Komex has always provided our clients with the highest level of service and responsiveness, developing excellent working and even personal relationships with our client's staff. In addition to technical advice, we have provided our clients with valuable input in the regulatory, legislative, and legal aspects of their projects. Our ability to work as a team with our client's staff, counsel and other technical or regulatory consultants has been critical to the success of these projects.

"Komex is ahead of the pack when it comes to applying new technology to environmental and engineering problems."

Bill Corbett
The PEGG
The Association of Professional Engineers, Geologists and Geophysicists

1.4 QUALITY

The following is a list of Komex's unique qualifications:

- Demonstrated ability to conduct large, complex projects in an efficient and timely manner, while maintaining the highest quality;
- Dedicated project personnel that include highly trained and skilled environmental professionals with many of our senior personnel offering over 30 years of service-related experience;
- Employees committed to the foundations upon which the company's success is based - technical excellence, leadership, integrity, enthusiasm, enjoyment in your work, and respect for the profession and all those they work with;
- Superior expertise in water resources evaluation, soil and groundwater characterization, risk assessment, and remediation;
- Extensive and detailed local knowledge and experience;
- Ability to collect and analyze representative and defensible data;
- Immediate response to needs and mobilization on short notice;
- Excellent working relationships with Federal, State, and local regulatory agencies; and
- Overall understanding of the objectives and requirements of environmental projects with valuable input in the regulatory, legislative, and legal aspects of projects.

"The Port of Los Angeles would like to thank you and your team for your demonstrated technical skills and knowledge as well as your response to the needs of the Port for the last two years as environmental assessment and remediation consultants."

Donald W. Rice
Director of Environmental Management
The Port of Los Angeles

1.5 CORPORATE ORGANIZATION

Komex was founded in 1977 to provide environmental and water resources consulting services to clients in Western Canada. Over the last 25 years, the proportion of our work in the environmental sector has increased and we have expanded our services throughout the world. Today, our main offices are located in Huntington Beach, California; Calgary, Canada; and Bristol, United Kingdom. We have many local branch offices in the US, Canada and the UK. Smaller offices in countries throughout the world ensure local sensitivity and content. Komex is committed to using the staff best suited for a project.

Since February 1992, Komex has been providing environmental consulting services in California, and has grown from 30 to over 350 employees worldwide. The reasons why Komex is growing are simple – we are very good at our job, we have fun (it's contagious), and we provide our clients with exceptional service.

Our California offices include Huntington Beach, West Los Angeles, San Luis Obispo, Bakersfield, Sacramento and Lake Tahoe. We serve the environmental needs of several Federal, State, and local government agencies, water utilities, law firms, institutional clients, and petrochemical and other industrial companies.

1.6 GENERAL SERVICE AREAS

Komex has developed multi-disciplinary teams of academically specialized, experienced individuals who focus on providing personalized and reliable responses to our clients. These teams provide service in the following areas:

Water Resources and Water Supply

Watershed Management
Water Supply System Design
Water Quality Monitoring
Marine and Estuary Studies
Water Resource Development
Sediment Yield and Transport
Irrigation and Agricultural Supply
Hydrological System Modeling

Environmental Geology and Hydrology

Site Characterization
Contaminant Hydrogeology
Groundwater Flow Modeling
Oil and Gas Sector Assessments
Regional Pollution Evaluation
Aquifer Testing
Resource Damage Assessments
Mining Related Assessments

Environmental Planning and Management

Environmental Impact Assessment
Environmental Compliance Audits
Habitat Restoration
Resource Evaluation
Protected Area Management
Wildlife and Botanical Surveys

Remediation Engineering

Groundwater Remediation
Ex-situ and In-situ Soil Remediation
Treatability Laboratory
Landfill Siting and Design
Wastewater Process Design
Drinking Water Treatment
Remediation Pilot Studies
Landfill Assessment

Environmental Economics and Risk Management

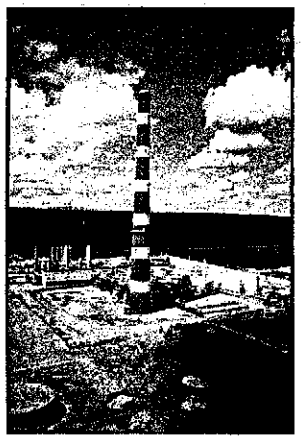
Remediation Feasibility Studies
Ecological Risk Assessment
Toxicology
Environmental Risk Management
Cost-Benefit Evaluation
Health-based Risk Assessment
Preliminary Endangerment Assessments
Industrial Hygiene

Well installation
MTBE investigation

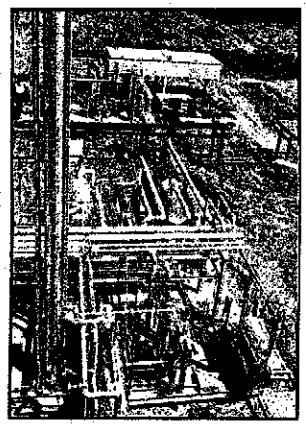
Cr(VI) Sampling
school site

Drilling in harsh
environments

Bacteriological investigation



Gas processing plant remediation



Gas processing facility design

Geotechnical and Earth Sciences

Earth and Rock Structures
Waste Containment Structures
Terrain Stability
Mining Geotechnics
Reclamation and Stabilization
Geological Hazard Evaluation

Geophysical Investigations

Contaminant Investigations
Well Design
Geologic Resource Assessment
Archaeology and Forensics
Groundwater Remediation
Groundwater Exploration
Geotechnical Engineering

Marine Sciences

Urban runoff
Sediment quality, fate & transport
Coastal zone management
Wetland & estuary management
Offshore structure inspection & monitoring
Microbial & chemical impacts to groundwater

Indoor Air Quality

Litigation support
Remediation design
Remediation installation
Modeling
Inspection auditing & monitoring
Permitting

Specialist Environmental Consulting

Independent Review
Expert Witness
Forensic Engineering
Regulatory Strategy
Litigation Support
Regional Assessments
Environmental Training
Institutional Strengthening

2 Professional Staff

The outstanding quality of Komex's professional staff is what distinguishes us from other firms. Curriculum Vitae (CV) for key personnel and testifying experts are available upon request. The following are brief introductions to the professional staff at Komex.

2.1 PRINCIPALS

Tadeusz L. Dabrowski, Ph.D.—*Principal Hydrogeologist, Chief Executive Officer, Director*
Tad received a Ph.D. degree in hydrogeology and has over 35 years of experience in water resources and contaminant hydrogeology, specializing in groundwater contamination problems in the petroleum industry. Tad founded Komex in 1977.

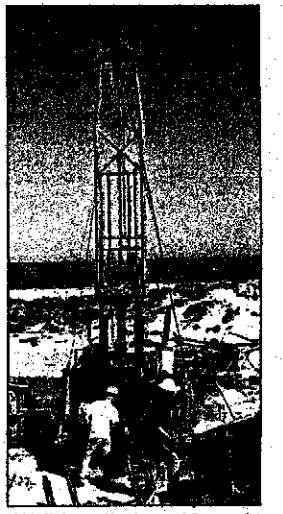
Anthony Brown—*Principal Hydrologist, Chief Operating Officer, Director of US operations.*
Anthony received a M.Sc. degree in hydrology and has extensive experience in environmental and hydrological science, specializing in water quality issues and the characterization and remediation of industrial contaminants in soil and groundwater.

James Bonyai—*Chief Financial Officer*
Jim is a Chartered Accountant in Canada. He has worked as CFO or in senior financial and accounting positions for international oil and gas companies, and as a Manager with Price Waterhouse.

Frederic B. Claridge—*Principal Geotechnical Engineer, Director of International Development*
Fred obtained an M.S. in geotechnical engineering and has over 30 years of experience in all aspects of geotechnical engineering, specializing in construction of petroleum industry facilities, including pipelines and offshore drilling platforms. Fred founded Komex in 1977.

Paul E. Hardisty, Ph.D.—*Principal Ground Water Engineer, Director of Europe and Middle East*
Paul received his Ph.D. degree in hydrogeology and has extensive experience, specializing in the characterization and remediation of contaminants in fractured media. Paul is also an associate professor at Imperial College London.

Gordon Johnson—*Principal Remediation Engineer, Director of Canada*
Gord received his M.S. in Civil Engineering from UC Berkeley and has considerable experience in the remediation of soil and groundwater contaminants.



Well installation – Natural Resource Damage Assessment

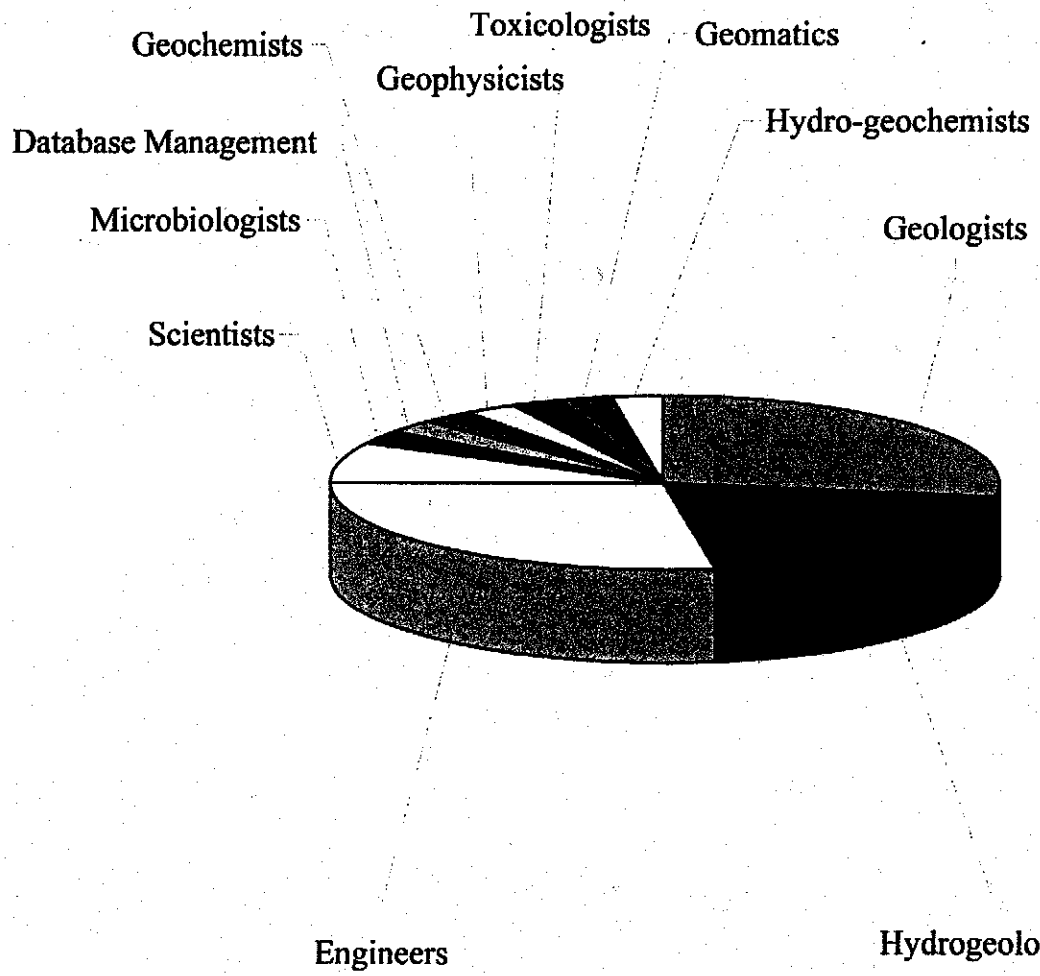
Mine reclamation

ExxonMobil

"Thank Goodness for caring and involved citizens such as yourself.... you definitely make this a better place for our children!"

Carolyn Keith,
Public Affairs,
ExxonMobil Corporation

2.2 Staff Composition



3 Selected Project Experience

The following are selected active or recently completed Komex projects:

3.1 MTBE

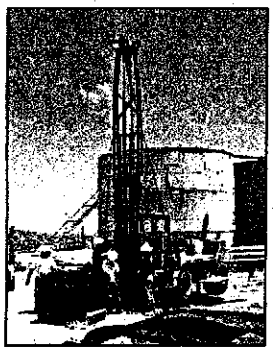
- Investigation, remediation and restoration of municipal well fields impacted by methyl tertiary-butyl ether (MTBE) contamination—City of Santa Monica (Charnock Well Field), South Tahoe Public Utility District (STPUD), Santa Clara Valley Water District (SCVWD), Great Oaks Water Company, and Yosemite Springs Park Utility Company (YSPUC)
- Restoration of municipal water supply wells contaminated with MTBE—City of Santa Monica (Arcadia Well Field) and ExxonMobil Refining and Supply Company
- Oversight and investigation of remediation of MTBE contamination impacting drinking water supplies in the towns of Cambria and Los Osos/Baywood Park—Cambria Community Services District (CCSD), Los Osos Community Services District (LOCSD)
- Investigation and remediation of a gasoline release (including MTBE) in fractured volcanic rock resulting from a catastrophic fuel system failure, Eastern Sierra location—Confidential Client
- Characterization and remediation of a hydrocarbon release (including MTBE) in fractured bedrock from a pipeline rupture in Illinois—Shell Oil

3.2 OTHER PETROLEUM HYDROCARBONS

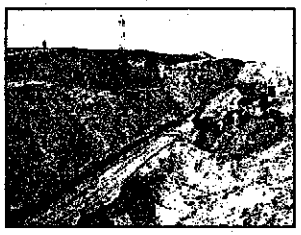
- Environmental assessment and remediation at over 500 oil and gas facilities worldwide, including oil fields, refineries, pipelines, terminals and service stations
- Impact and mitigation of oil field contaminants at the Belmont Learning Center—Los Angeles Unified School District (LAUSD), Belmont Commission
- Investigation and remediation of methane and hydrogen sulfide as part of the redevelopment of a former oil field in Carson—Dominguez Energy/Carson Companies
- Natural Resource Damage Assessment (NRDA) at the Guadalupe Oil Field—State of California (Department of Fish and Game [DFG], Office of Spill Prevention and Response [OSPR], Attorney General and Regional Water Quality Control Board [RWQCB])
- Groundwater investigation and remediation at petroleum terminals in Wilmington, Carson, Barstow, Colton, and San Pedro—GATX Terminals Pipeline leak investigation and remedial design—Mobil Pipeline, Ft. Tejon, California

"I have enjoyed working with you and with the other members of your firm. I believe your assistance was invaluable in helping me achieve favorable settlements of both matters on which you worked with me. I was most impressed with the high caliber of work and integrity evidenced by all the people with whom I came in contact at Komex and look forward to working with you again in the future."

Linda L. Northrup Esq.,
Law Offices of Linda L. Northrup



Drilling and sampling contaminant investigation



Former oil field

Three-dimensional geophysical mapping of a contaminated aquifer

3.3 CHLORINATED COMPOUNDS AND OTHER CONTAMINANTS

- Investigation and remediation of hexavalent chromium and trichloroethene (TCE) contamination at Jefferson New Middle School, Los Angeles—PRP Group
- Development of remedial programs for chlorinated solvent, perchlorate and hexavalent chromium contamination, San Gabriel Valley Superfund Site—San Gabriel Valley Water Company
- Investigation and remediation of chlorinated solvent contamination in soil and groundwater beneath at a metal finishing facility in Inglewood—Bodycote Hinterliter and Joseph Collins Estate
- Investigation of bacteria and fecal contamination in groundwater beneath the downtown area of Huntington Beach—City of Huntington Beach
- Characterization of complex hydrogeology and contaminant fate and transport (with polychlorinated biphenyls [PCBs] and chlorinated solvents) in karstic bedrock at a site on the National Priority List (NPL) in Missouri—PRP Steering Committee
- Investigation and remediation of chlorinated solvent and petroleum solvent releases at an active chemical terminal—GATX Terminals Corporation, San Pedro, California

3.4 COMPUTER MODELING

- Three-dimensional modeling of groundwater flow and solute transport (perchlorate, NDMA, TCE) to evaluate the impact on water supply wells—Southern California Water Company
- Three-dimensional groundwater flow modeling to identify contamination migration pathways in a drinking water basin—City of Santa Monica, ExxonMobil Corporation, and US Army Corps of Engineers (USACOE)
- Three-dimensional regional groundwater flow and solute transport modeling as part of the NRDA at the Guadalupe Oil Field—State of California
- Evaluation of the groundwater modeling of radionuclide transport in porous media and fractured bedrock in Siberia—USDOE
- Three-dimensional groundwater flow modeling to support the design of a slurry wall and dewatering system—Los Angeles Harbor Department

3.5 OTHER PROJECTS

- **Phase I Environmental Site Assessments**—Various Clients, Southern California
- **Negotiation of agreements between water utilities and PRPs**—Santa Monica, STPUD and SGVWC
- **Aquifer characterization, slurry wall design and installation, soil excavation and water treatment system design in support of rail construction activities**—Los Angeles Harbor Department, Shimmick and Obayashi Construction
- **Development of guidelines for source water assessment programs**—State of California
- **Development of source water assessment and protection programs**—City of Santa Monica

3.6 INTERNATIONAL PROJECTS

- Komex has provided environmental and water resources consulting services for projects throughout the world. We currently have offices and/or projects in the following regions and countries:
- Latin America—Mexico, Cuba, Barbados, Dominican Republic, Costa Rica, Colombia, Ecuador, Venezuela, Bolivia, Peru and Brazil;
- Middle East—Cyprus, Jordan, Palestine, Syria, Oman, United Arab Emirates, and Yemen;
- Africa—Egypt, Libya, Ethiopia, Nigeria, Benin, Togo, Malawi, Namibia and Zambia; and
- Asia—Russia, Kazakhstan, India, Nepal, Bangladesh, China, Mongolia and Indonesia.

3.7 PUBLICATIONS AND BRIEFINGS

In addition to specific project experience, Komex staff has written, presented, and published articles regarding the following:

- VOC contamination of groundwater and drinking water supplies;
- Contaminant fate and transport in fractured or heterogeneous media;
- The impact of oil field activities on the environment;
- Source water assessment and protection;
- Public health and toxicology;
- Risk analysis and assessment; and
- General water resources and environmental issues.

City of Santa Monica

"I, Robert Holbrook, Mayor of the City of Santa Monica, on behalf of the Members of the City Counsel, do hereby commend Anthony Brown [Komex] for extraordinary service to the citizens of Santa Monica and tremendous efforts to ensure the restoration of Santa Monica's precious water resources."

Robert Holbrook
Mayor
City of Santa Monica

Water supply operations and maintenance training

Komex principals have briefed the following on the impact of MTBE, other VOCs, oil field activities, perchlorate, NDMA, bacteria, and pharmaceuticals on groundwater:

- US Environmental Protection Agency (EPA) staff (Region IX and Federal headquarters), including Assistant Administrators;
- White House Officials;
- US Senators and Representatives;
- State Senators and Assemblywomen/men;
- State regulators;
- Local officials (Mayors, council and board members, City attorneys, etc.);
- Academic institutions;
- Professional societies; and
- CBS 60 Minutes, National Public Radio (NPR), local news stations, and news print media.

3.8 REGULATORY INTERACTION

Komex also has experience in negotiating with Federal and State regulators, including the USEPA and various State agencies. Many of these negotiations have focused on limiting our client's liability for contaminated groundwater and reaching cooperative agreements for the restoration of natural resources. We have successfully conducted human health and ecological risk assessments to support alternative clean-up standards, and have implemented risk-based corrective action programs. Many Federal, State, and local public agencies are current or former Komex clients. This gives us a high degree of credibility when negotiating with these agencies on behalf of our private-sector clients. Some of our staff members were formerly employees of Federal and State environmental agencies.

ExxonMobil

"Again, I want to thank you for your efforts to-date and the working relationship we have developed over the years of doing business together. I am sure that working together to improve safety on the job site is just another step in ensuring this joint, productive relationship continues on in the years ahead of us."

C.D. Stevens
Regional Manager
U.S. Retail Projects
ExxonMobil Corporation

The following is a list of selected clients we have served throughout the USA and the world.

4.1 USA

GOVERNMENT

California Attorney General
Cambria Community Services District (CCSD)
City of Burbank
City of Carpenteria
City of Cerritos
City of Huntington Beach
City of Los Angeles
City of Morro Bay
City of Murrieta
City of Santa Monica
Coastal Conservancy
Department of Fish and Game
Environmental Protection Agency
Great Oaks Water Company
LA Unified School District
LA County Department of Public Works
LA County Metropolitan Transportation Authority
National Oceanic and Atmospheric Administration
Orange County District Attorney
OC Public Facilities and Resources Department
Orange County Sanitation District
Southern California Water Company
San Gabriel Valley Water Company
State Water Resouces Control Board
Torrance Unified School Disitrict
United States Coast Guard
United States Navy
United States Fish and Wildlife Service

PETROLEUM

Chevron USA Products Company
ExxonMobil Corporation
GATX Terminals Corporation
Kinder Morgan Energy Partners
Shell Oil Company
Tosco Corporation
Unocal Corporation
Western States Petroleum Association (WSPA)

LEGAL

Barron and Budd
Cooper and Scully
Fitzgerald, Abbott and Beardsley
Hatch and Parent
Haight, Brown and Bonesteel
Latham and Watkins
LeBoeuf, Lamb, Greene and MacRae
Lewis Saul and Associates
Lieff, Cabraser, Heiman and Bernstein
Lopez Hodes Milman & Restaino
Luce Forward Hamilton & Scripps, LLP
McKenna and Cuneo
Miller, Sher and Sawyer
Musick, Peeler and Garrett
Orange County District Attorney's Office
Rose Klein and Marias
Robinson, Calcagnie & Robinson
Somach, Simmons and Dunn
Weston, Benshoof, Rochefort, Rubalcava and MacCuish
Wulfsberg, Reese and Sykes

4 Selected Clients

INDUSTRIAL

Browning-Ferris Industries (BFI)
Bodycote Hinderliter
Consolidated Electrical Distributors, Inc. (CED)
Jefferson PRPs
Northrop-Grumman
Union Bank
Waste Disposal Inc.
Weber Industries

4.2 INTERNATIONAL

Amoco
British Gas
British Petroleum (BP)
Broken Hills Properties (BHP)
Canadian International Development Agency (CIDA)
Carboquimica
Duke Energy
ECOPETROL (Colombian National Petroleum Company)
El Paso
Environment Canada
Esso
European Development Bank
Government of Saudi Arabia
Gulf
Imperial Chemical Industries (ICI)
Inter-American Development Bank (IADB)
La Farge
Occidental Petroleum
PEMEX
Petro-Canada
Petro-Ecuador
Petro-Peru
Royal Dutch Shell
Texaco (South America)
Unilever
Union Fenosa
United Nations Development Program (UNDP)
World Bank

CALIFORNIA, USA OFFICE LOCATIONS:

1 WESTMINSTER (US HEAD OFFICE)

5455 Garden Grove Blvd., Suite 200
Westminster, CA 92683
Email: info@losangeles.komex.com

Tel: (714) 379-1157
Fax: (714) 379-1160

Contact: Rob Traylor

2 WEST LOS ANGELES

11040 Santa Monica Blvd., Suite 300
Los Angeles, CA 90025
Email: info@losangeles.komex.com

Tel: (310) 914-5901
Fax: (310) 914-5959

Contact: James Farrow

3 BAKERSFIELD

5401 Business Park South Suite 210
Bakersfield, CA 93309
Email: info@bakersfield.komex.com

Tel: (661) 325-5544
Fax: (661) 322-2941

Contact: Debbie Soukup

4 SAN LUIS OBISPO

2146 Parker Street, #B-2
San Luis Obispo, CA 93401
Email: info@slo.komex.com

Tel: (805) 787-0307
Fax: (805) 787-0309

Contact: Jon Rohrer

5 SACRAMENTO

1624 Santa Clara Drive, Suite 120
Roseville, CA 95661
Email: info@sacramento.komex.com

Tel: (916) 797-7283
Fax: (916) 797-1101

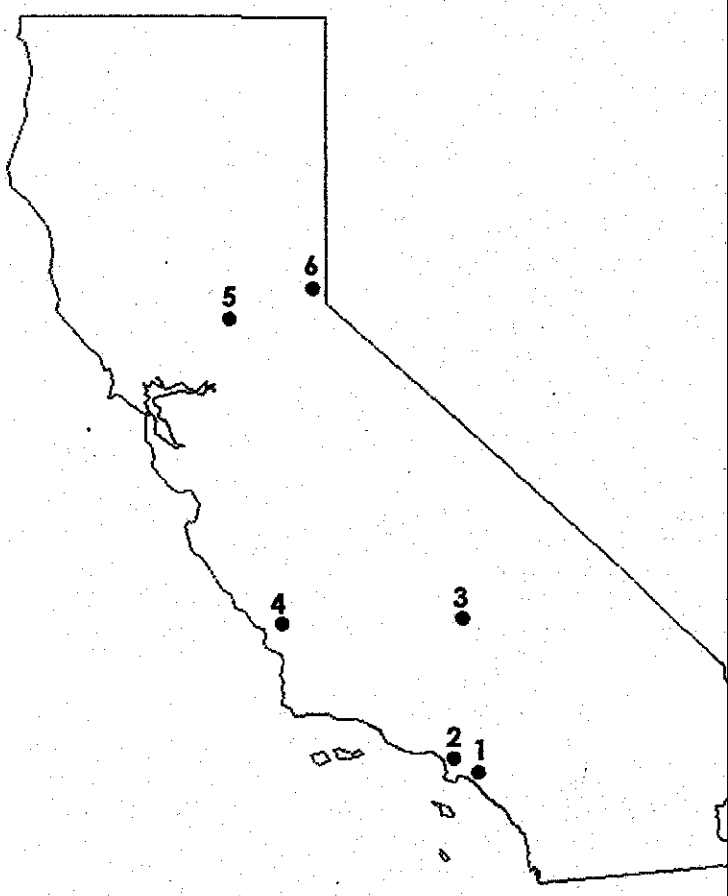
Contact: Steve Ross

6 TAHOE

P.O. Box 647
Tahoma, CA 96142
Email: hshepherd@wineintowater.komex.com

Tel: (800) 770-7222
Fax: (801) 761-3681

Contact: Heather Shepherd



5 Conclusion

We appreciate this opportunity to present our qualifications to you. We hope that the people and projects described provide the information needed to assist you in selecting a consultant. Komex may not be the largest environmental consulting firm, however we offer the benefits of both a small and large consulting company with a focus on the following:

- ***QUALITY*** *- a commitment to technical excellence*
- ***UNDERSTANDING*** *- attention to the needs of our clients*
- ***COMMUNICATION*** *- a personal approach to service*
- ***RESOURCES*** *- staff capable of satisfying any clients needs*
- ***SUCCESS*** *- a proven track record*
- ***KNOWLEDGE*** *- participation in applied research and academic training*
- ***LEADERSHIP*** *- a history of conquering new challenges*
- ***INTEGRITY*** *- respect for the profession and all those we work with*
- ***RESPONSIBILITY*** *- a promise to protect human health and the environment*
- ***ENJOYMENT*** *- making work fun*

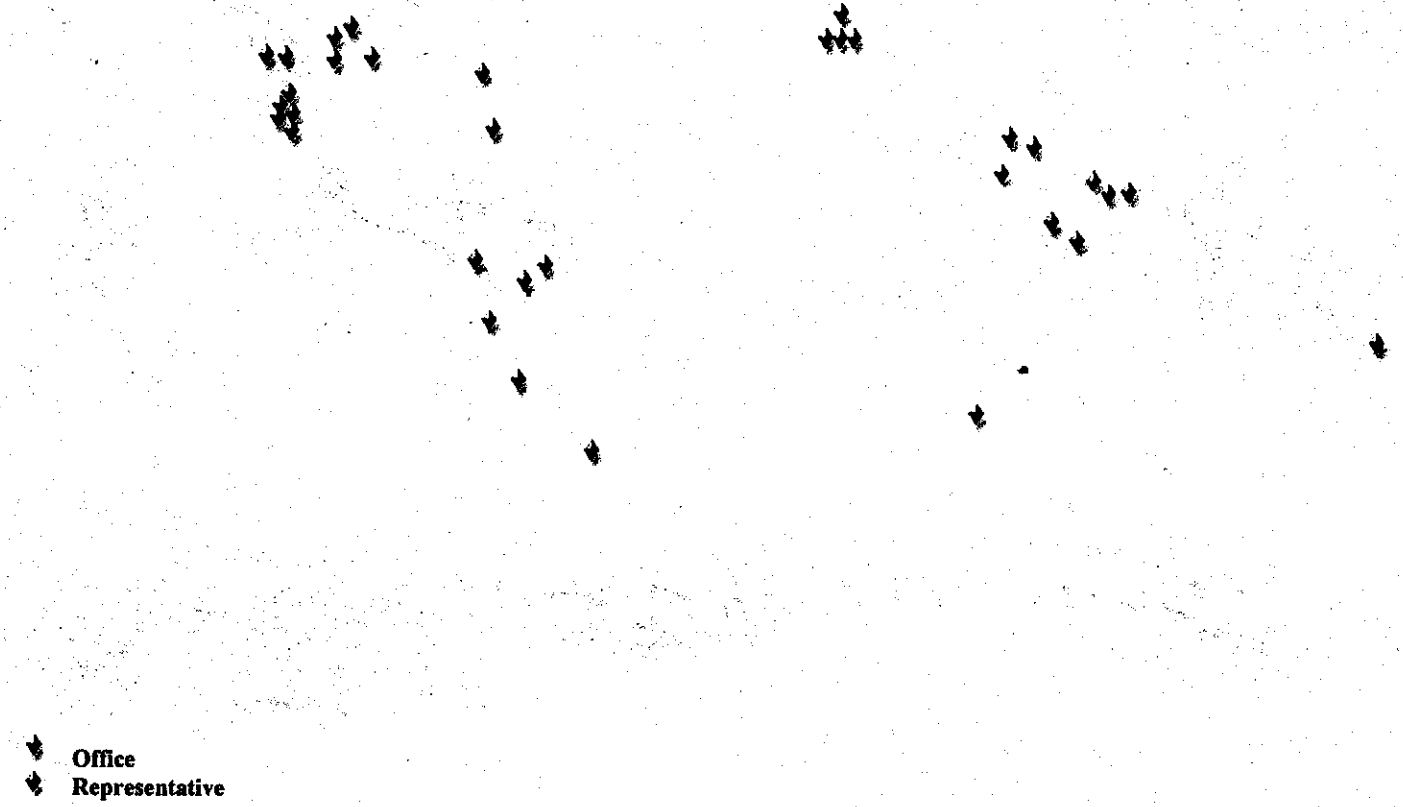
We have demonstrated these qualities to our existing clients, and we would be happy to provide you with a list of client references. We are confident that Komex can provide you with the high level of quality service you demand. If you have any questions regarding this SOQ, Komex, or would like to discuss a project, please contact me at (714) 379-1157, via facsimile at (714) 379-1160, or via e-mail at info@losangeles.komex.com. Thank you for your time and consideration.

Respectfully submitted,
KOMEX

Anthony Brown
Principal Hydrologist

"Your understanding of both federal and state regulations have been invaluable in helping us develop project strategies, control costs, and to understand and address potential environmental issues and liabilities."

Donald W. Rice
Director of Environmental Management
The Port of Los Angeles



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Representative

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EUROPE

Cyprus • Dublin • London • Bristol • Harrogate

INTERNATIONAL

Colombia • Costa Rica • Ecuador • Egypt • Indonesia • Oman • Qatar • United Arab Emirates • Saudi Arabia • Yemen • Zambia

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Web site: www.komex.com

ENVIRONMENT AND WATER RESOURCES

Curriculum Vitae

Richard E. Chandler, R.G.

Senior Geologist

Disciplines:
Geology, Environmental Assessment, Soil and Groundwater Remediation

Education:
B.A., Geology, Humboldt State University, Arcata, California, 1986

Registration:
Registered Geologist: California #6074

Professional Experience:
Mr. Chandler is a Senior Geologist and Project Manager with over 14 years of professional experience as an environmental consultant. He has been involved primarily in projects relating to the assessment and remediation of impacted soil and groundwater, and has supervised geotechnical construction projects. His responsibilities have included the preparation of work plans and reports, evaluation of pilot test results and analytical laboratory data, groundwater modeling, aerial photograph interpretation, risk-based corrective action assessment for site closure, interface with regulatory personnel, and oversight review of work performed by other consultants. Mr. Chandler has also conducted numerous Phase I Environmental Site Assessments for real estate transactions at sites located throughout California.

Mr. Chandler has managed subsurface investigations related to a wide variety of potential contaminants, including petroleum products, solvents, metals, acids, nitrate, pesticides, and brine. He has participated in environmental investigations at Superfund sites, industrial facilities, gasoline service stations, military bases, oil fields, mines, agricultural properties, landfills, and sewage treatment facilities. Mr. Chandler has extensive experience performing and supervising field investigation work. He has prepared geologic maps, collected soil and groundwater samples, prepared soil boring and rock core logs, overseen the installation and removal of groundwater monitoring wells, conducted ground pumping and soil vapor extraction tests, operated various types of soil and groundwater treatment systems, and supervised the excavation of impacted soil.

Some of the projects that Mr. Chandler has been involved in are summarized below.

Petroleum Hydrocarbon Contaminants

- Groundwater Quality Investigation - Project Manager for an assessment of potential impacts to groundwater quality in the Santa Maria Valley due to oil field activities - Regional Water Quality Control Board, Central Valley Region, Santa Barbara County, California

- Oil Field Remediation - Field Geologist for assessment and remediation of a former oil field – Confidential Client, Los Angeles County, California
- Mitigation of Fuel Oil Impacted Soil - Supervised the excavation of soil impacted by the release of fuel oil at a mining facility, assessed the potential for an impact to groundwater, and obtained site closure - Confidential Client, Santa Barbara County, California
- Assessment of Aviation Fuel in Groundwater - Project Manager for an investigation of the concentration and distribution of aviation fuel in groundwater - Confidential Client, Santa Barbara, California
- Underground Storage Tank (UST) Investigations - Project Manager and Field Geologist for numerous UST projects in all phases of assessment, remediation, and closure - Various Clients, California and Washington

Chlorinated Hydrocarbons

- Assessment of Potential Soil and Groundwater Contamination - Project Manager for an investigation of possible subsurface contamination from previous site use at a military installation - U.S. Air Force, Vandenberg Air Force Base, California
- Investigation of Volatile Organic Compounds in Groundwater - Project Manager for an investigation that established baseline soil and groundwater conditions at a chemical production facility prior to a sale of the property - Confidential Client, Oxnard, California
- Assessment of Chlorinated Solvents in Groundwater - Project Manager for the assessment of the distribution of chlorinated solvents in groundwater beneath a former industrial facility location - Confidential Client, San Fernando Valley, California
- Environmental Assessment - Performed a literature review and site inspection for a semiconductor production facility designated as a U.S. EPA Superfund Site - Confidential Client, Sunnyvale, California
- Assessment and Remediation of Chlorinated Solvents in Groundwater - Project Manager for the investigation and remediation of a solvent release from a dry cleaning facility - Confidential Client, Sacramento, California
- Assessment of Regional Solvent Plume - Field Geologist for an investigation of the extent of a large solvent plume using passive sampling techniques - State Water Resources Control Board, Bakersfield, California

Other Contaminant Assessments

- Assessment of DDT and Other Agricultural Chemicals in Soil - Project Geologist for an assessment of agricultural chemicals in the subsurface at an aerial spraying facility - Confidential Client, Tulare County, California
- Assessment of Groundwater Contamination - Supervised sampling of groundwater monitoring wells and operated the groundwater treatment system at a former hazardous waste disposal facility once designated as a U.S. Superfund Site - Confidential Client, Santa Barbara County, California
- Health and Safety Monitoring - Monitored workplace safety for a project in which storm drain pipelines were installed in soils known to be impacted by volatile organic compounds - U.S. Army Corps of Engineers, Sierra Army Depot, California
- Assessment of Volatile Organic Compounds and Metals in the Subsurface - Field Geologist for an investigation of impacted soil and groundwater at a former industrial facility - Confidential Client, Los Angeles, California

Geotechnical Investigations and Other Projects

- Hydrogeologic Investigation - Supervising Field Geologist for an investigation of subsurface conditions at a proposed site for a sulfur containment facility - Confidential Client, Central Wyoming
- Landslide Repairs - Site Supervisor for the repair of landslide damaged roads including the drilling and installation of horizontal drains to prevent future slides - U.S. Navy, Point Mugu, California
- Assessment of Earth and Water Resources - Assisted in preparation of the draft Development Compliance Plan document for the North Cantonment Area of Vandenberg Air Force Base - U.S. Air Force, Vandenberg Air Force Base, California
- Phase I Environmental Site Assessments - Performed numerous Phase I Environmental Site Assessments for commercial, industrial, and agricultural properties - Various Clients, California

Professional History:

Komex•H2O Science•Inc., San Luis Obispo, California: Senior Geologist, December 2000 – Present.
Century West Environmental, Inc., Ventura, California: Principal Geologist, March 1999 -December 2000.
Valenzuela Engineering, Inc., Santa Maria, California: Senior Project Geologist, April 1997 - March 1999.
Woodward-Clyde Consultants, Santa Barbara, California: Project Geologist, September 1995 - April 1997.
Delta Environmental Consultants, Rancho Cordova, California: Geologist, April 1991 - September 1995.
BSK & Associates, Visalia, California: Staff Geologist, October 1987 - April 1991.

Affiliations:

Central Coast Geological Society, Vice President
National Ground Water Association
American Association of Petroleum Geologists
Groundwater Resources Association of California

EXHIBIT 10 PROVIDED UNDER SEPARATE COVER

Education:

M.S. Environmental Engineering, 1983
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Los Angeles, California

B.S. Civil Engineering, 1981
California State University, Los Angeles (CSULA)
Los Angeles, California

Licenses:

California Civil Engineer No. 039599, 1985

Professional Affiliations:

Member - American Society of Civil Engineers, ASCE
Member - Central Basin Water Association

Experience:

Mr. Helsley's experience includes employment with the Los Angeles County Department of Public Works in the Hydraulic/Water Conservation Division. As a Supervising Civil Engineer I in the Planning Unit, he was responsible for studies to develop improvements to the County's injection barriers to prevent seawater intrusion, and studies of groundwater recharge optimization.

Mr. Helsley was also formerly the District Engineer and Assistant General Manager of the Water Replenishment District of Southern California, where he was responsible for the development and implementation of programs to enhance groundwater recharge, improve groundwater basin management, and protect groundwater quality.

At Stetson Engineers Inc. Mr. Helsley is responsible for numerous studies and design projects. Mr. Helsley has been project manager for water rights quantification and valuation studies, alternative water supply studies, water resource management studies, and groundwater recharge feasibility studies.

Some of the major projects Mr. Helsley has participated in include:

1. Los Angeles County Department of Public Works (LACDPW) Alamitos Barrier Project - Seawater Barrier
   a. Deficiency/Feasibility Study
   b. Injection Well Design
   c. Injection Well Construction

2. LACDPW Dominguez Gap Barrier - Seawater Barrier, Deficiency/Feasibility Study

3. LACDPW West Coast Barrier Project - Seawater Barrier
   a. Geophysical Exploration
   b. Deficiency/Feasibility Study

4. Landfill Gas Mitigation measures

5. County Solid Waste Management Plan

6. Antelope Valley Groundwater Recharge Study

7. Montebello Forebay Groundwater Recharge Study

8. National Pollution Discharge Elimination System (NPDES) Permit Modifications

9. Injection Well Maintenance Study

10. Adjudication of the Mojave River Groundwater Basins

11. Identification of available water supplies for land development in San Bernardino County

12. Quantification and Valuation of Water Rights at various locations in Los Angeles, San Bernardino and Sacramento Counties

STEPHEN B. JOHNSON — *Vice-president*

Education:

California State Polytechnic University, Pomona, California
B.S. Civil Engineering, 1976

California State University, Long Beach, California

Licenses:

California Civil Engineer No. 32396, 1981

Professional Affiliations:

American Society of Civil Engineers, ASCE
American Society for Testing and Material, ASTM (Corporate)
American Water Works Association, AWWA (Corporate)
National Society of Professional Engineers, NSPE

Experience:

Mr. Johnson is a principal and Vice President in charge of the West Covina office of Stetson Engineers Inc. Mr. Johnson supervises, directs or performs a wide variety of projects. Mr. Johnson's responsibilities typically include overall project management. On design projects, this may encompass pre-design feasibility studies, design plans and specifications, contractor solicitation and selection, construction management including supervision of inspection, progress reports and pay estimates, final inspection and startup. Mr. Johnson is also familiar with and has prepared environmental documents in compliance with the California Environmental Quality Act, CEQA.

Mr. Johnson has been involved in numerous studies and reports. The studies have included water system master plans, water system valuations, water rights quantification and valuation, supplemental water requirement studies, alternate water supply studies, annual reports, water quality monitoring reports, ground-water management studies, and project feasibility studies.

Mr. Johnson has supervised the use of computer modeling in water system evaluation and design. This typically includes pressure zone evaluation, reservoir size and location, pump system requirements, pipe sizing and operational studies.

Mr. Johnson has been integrally involved with the management of both water production and water quality within the Main San Gabriel Basin (Basin). Mr. Johnson was involved with the development and implementation of the groundwater monitoring plan in accordance with Assembly Bill 1803. That monitoring plan developed into and

on-going groundwater monitoring plan for the entire Basin. He oversees the preparation of annual reports for the Main San Gabriel Basin Watermaster (Watermaster) and the Area Agency Water Quality Monitoring Plan for the San Gabriel Valley.

Mr. Johnson works continually in the on-going effort in cleanup of groundwater contamination in the Basin with Watermaster, water producers, the Environmental Protection Agency and the Potential Responsible Parties.

Since the early 1980s, Mr. Johnson has been heavily involved with engineering solutions to contamination of drinking water supplies. This work involves a wide range of experience and expertise, including site and regional characterization of soil and groundwater contamination, hydrogeologic studies, groundwater basin modeling, development of cleanup and water supply plans, remediation studies, development and full implementation of treatment projects, and coordination with all regulatory agencies. The contaminants of concern include volatile organic compounds (VOCs), Perchlorate, NDMA, 1-4 Dioxane, Chromium and others. This work has been performed in full cooperation with the U.S. Environmental Protection Agency, the State Department of Toxic Substance Control, the Department of Health Services, the State Water Resources Control Board, and the Regional Water Quality Control Board.

The following projects are representative of Mr. Johnson's experience:

1. City of Los Angeles, Department of Water and Power, Supplemental Water Study.
2. City of Los Angeles, Department of Water and Power, continuing studies on Hoover Dam Power Contracts.
3. Upper San Gabriel Valley Municipal Water District
    a. Supervision of District Engineering Duties
    b. Area Wide Water Quality Monitoring Plan
    c. AB 1803 Water Quality Monitoring Plan
    d. AB 797 Water Conservation Plan
    e. Feasibility Studies - Use of Reclaimed Water
    f. Supervision of EPA Superfund Sub-Contract
    g. Drought Studies
    h. Puente Hills Landfill Investigation
    i. District Mapping
    j. Reclaimed Water Study
4. San Gabriel River Watermaster, Supervision of Office Duties to Watermaster.
5. East Pasadena Water Company, Design of Water Main Extensions for Fire Service.
6. Kaiser Steel, Valuation of Water Related Holdings at Fontana Plant.
7. City of Bakersfield
    a. Design of Turnout Structure - Kern River
    b. Design of Turnout Structure - Canal
    c. Water System Master Plan
    d. Review of New Development Plans

   e. Design of Box Culvert
   f. Acquisition of New Facilities
   g. Water System Operations Study
8. Santa Ynez River Water Conservation District
   a. Design of Reservoir Renovation
   b. Design of Lake Cachuma Intake Facility
   c. Design of Well Fields (6.0 cfs, 4.0 cfs and 1.73 cfs)
   d. Design of Booster Station
   e. Administration of State Loan and Grant
   f. Supervision of Cathodic Protection
   g. Design of Well No. 15 Pumping Equipment
   h. Lake Cachuma Intake Maintenance
   i. Zone III Reservoir Design
   j. Cachuma Pipeline Rehabilitation
   k. SWP Facilities Design
9. City of Solvang
   a. Design of Wells No. 7 and 8 Water Supply
10. San Gabriel Valley Municipal Water District
   a. Feasibility Study Hydroelectric Generation Stations
   b. Continuing Developer Interaction Responsibilities
   c. Supervision of Periodic Pipeline As-Built Updates
   d. Feasibility Study and Acquisition for Turnout Structure
   e. Transmission Pipeline Rehabilitation Project
   f. State Water Project Entitlement Report
   g. Urban Water Management Plans
   h. Pipeline Extension Project
11. City of Industry, Master Plan of Development
12. Main San Gabriel Basin Watermaster
   a. Supervision of Engineering Duties
   b. Basin Water Quality Studies
   c. Basin Modeling
   d. Enforcement of Pumping Control
   e. Operable Unit Cleanup Plans
   f. Cleanup Projects
   g. Full Compliance Permitting
13. Puente Basin Watermaster, Supervision of Engineering Duties
14. Buellton Community Services District
   a. Water System Design
   b. Sewer System Design
15. City of Torrance, Feasibility Study on Hydroelectric Generation
16. Mr. Riley Metz, Site Drainage Study and Improvement
17. Mr. Redmond, Flood Damage Study
18. Boy Scouts of America, Flood Damage Study
19. Rapid Transit District, Waste Discharge Study
20. Mr. Lapin, Flood Damage Study

21. U.S. Department of Navy, Camp Pendleton
    a. Water System Study
    b. Water System Design
22. City of Claremont, Representative on Proposed Quarry Development
23. Cabazon Water Company, Valuation Study
24. HLM Water System, Valuation Study
25. Citizens Utilities Company, Valuation of Jackson Water Works
26. County of San Bernardino, Safe Yield Study
27. Walsh v. State of California, Flood Damage Study
28. Three Valleys Municipal Water District, Subagency Report
29. Morongo Water System, Valuation Study
30. La Quinta Water System, Valuation Study
31. City of Ontario, Flood Damage Study
32. Serrano Park Homeowners Association, Flood Plain Improvements
33. California Department of Fish and Game, Valuation of Water Rights at Indian Joe Spring
34. Sunnymead Ranch Lake Reconstruction
35. City of Livermore and California Water Service, Trade of Service Areas - Arbitration
36. Sparkletts Water, Water Supply Study
37. Cancun Racquet Club, Subsidence Evaluation
38. East Highlands Ranch, Water Rights and Consultation Work
39. Covina Irrigating Company Valuation
40. Hartman Farms (Ohio), Coordination of basin recharge with rock and sand operations
41. Turner Ranches Valuation of Sanitary System
42. City of Barstow
    a. Water Rights
    b. Mohave River Water Quality Evaluations
    c. Contaminant Investigations
43. City of Glendora, Conjunctive Use Study
44. Lewis Homes Management Corp., Water Resources and Supply Studies
45. City of Oceanside Water Resources Study
46. City of Upland, Water Rights Evaluation
47. San Gabriel Basin Water Quality Authority
    a. Consulting Services
    b. Arrow Well Project
    c. Big Dalton Project
    d. Monrovia Project
48. City of Bullhead City, Wastewater Treatment Plant Evaluation
49. Azusa Valley Water Company Valuation
50. American Water Works, Well Design
51. City of Covina, Valuation of Covina Irrigating Company
52. Suburban Water Systems, Valuation of Facilities
53. City of Whittier Urban Water Plans
54. Lewis Homes, Monrovia Nursery Water Resources

55. Beverly Acres Mutual Water User's Association Valuation
56. Southern California Water Company, Staff Projects
57. City of Oceanside - Water Resources Study
58. Prado Dam Flood Damage - Perrizo
59. Chino Basin Watermaster - Engineering
60. Santa Margarita Water District - Appraisal
61. San Gabriel Valley Water Co. v. Sanitation Districts
62. Tri-Cities/Camp Pendleton - Economic Evaluation of Conjunctive Use Water Supply Project
63. Three Valleys Water District - General Engineering
64. San Gabriel River Water Committee - General Engineering
65. City of Beverly Hills - Water Distribution System Analysis
66. Valley County Water District - Urban Water Management Plan
67. Valley County Water District - General Engineering
68. Montebello Land and Water Company
69. City of Oceanside - Water Rights and System Modeling
70. City of Oxnard - Water Quality
71. Raymond Basin - Perchlorate Study
72. Star Kist Foods - Water Rights Evaluation
73. Orange County Water District - Prado Basin Constructed Wetlands
74. East Highlands Ranch - Water Supply
75. Elsinore Water District Well Interference
76. LPVCWD Perchlorate/NDMA Facility
77. Tejon Ranch Water/Sanitation
78. City of San Diego Studies
79. DHS Permitting - Policy 97-005
80. Baldwin Park Operable Unit Cleanup Plans
81. South El Monte Operable Unit Cleanup Plans
82. SCWC SEMOU Water Supplies
83. San Gabriel Valley Water Company v. CalTrans

State of California
The Resources Agency
Department of Water Resources

I, Vicki Price, Certification Clerk for the Department of Water Resources, State of California, do hereby certify that the attached copy of Bulletin No. 118-3, Evaluation of Ground Water Resources: Sacramento County, dated July 1974, Reprinted April 1980, is a true, full and correct copy, of the records on file in this office.

WITNESS my hand and the seal of the Department of Water Resources, State of California, this 25th day of April, 2002

Certification Clerk
Department of Water Resources

STATE OF CALIFORNIA

The Resources Agency

Department of Water Resources

in cooperation with
County of Sacramento

BULLETIN No. 118-3

EVALUATION OF GROUND WATER RESOURCES:

SACRAMENTO COUNTY

Copies of this bulletin at $4.00 each may be ordered from:

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JULY 1974

(REPRINTED APRIL 1980)

NORMAN B. LIVERMORE, JR.
Secretary for Resources
The Resources Agency

RONALD REAGAN
Governor
State of California

JOHN R. TEERINK
Director
Department of Water Resources

FOREWORD

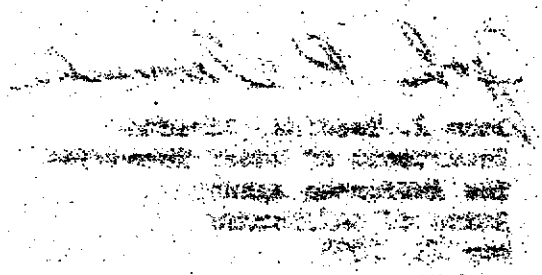
The ground water basin underlying Sacramento County has played an important role in the domestic, agricultural, and urban water supply of the area since the mid-1800s. Since 1940, extractions have exceeded recharge and have caused a gradual lowering of ground water levels and a reduction of ground water in storage. This cooperative study of the water resources of Sacramento County was undertaken in 1968 to provide the Sacramento County Water Agency information needed to implement its water policy guidelines and to provide the State with information on the ground water resources needed for statewide planning.

This report provides detailed information on the geology and hydrology of the ground water system underlying Sacramento County in sufficient detail to permit management studies. Included is a detailed inventory of the water resources during the period 1961 to 1970.

The information contained in this report and the mathematical model of the ground water system developed and verified during this study is being used in this cooperative study, which is the development and evaluation of alternative ways to manage the water resources of Sacramento County. The results of the alternative plans will be published in 1974 in the Bulletin 104 Series (Planned Utilization of Water Resources).

John R. Teerink

John R. Teerink, Director
Department of Water Resources
The Resources Agency
State of California
May 29, 1974



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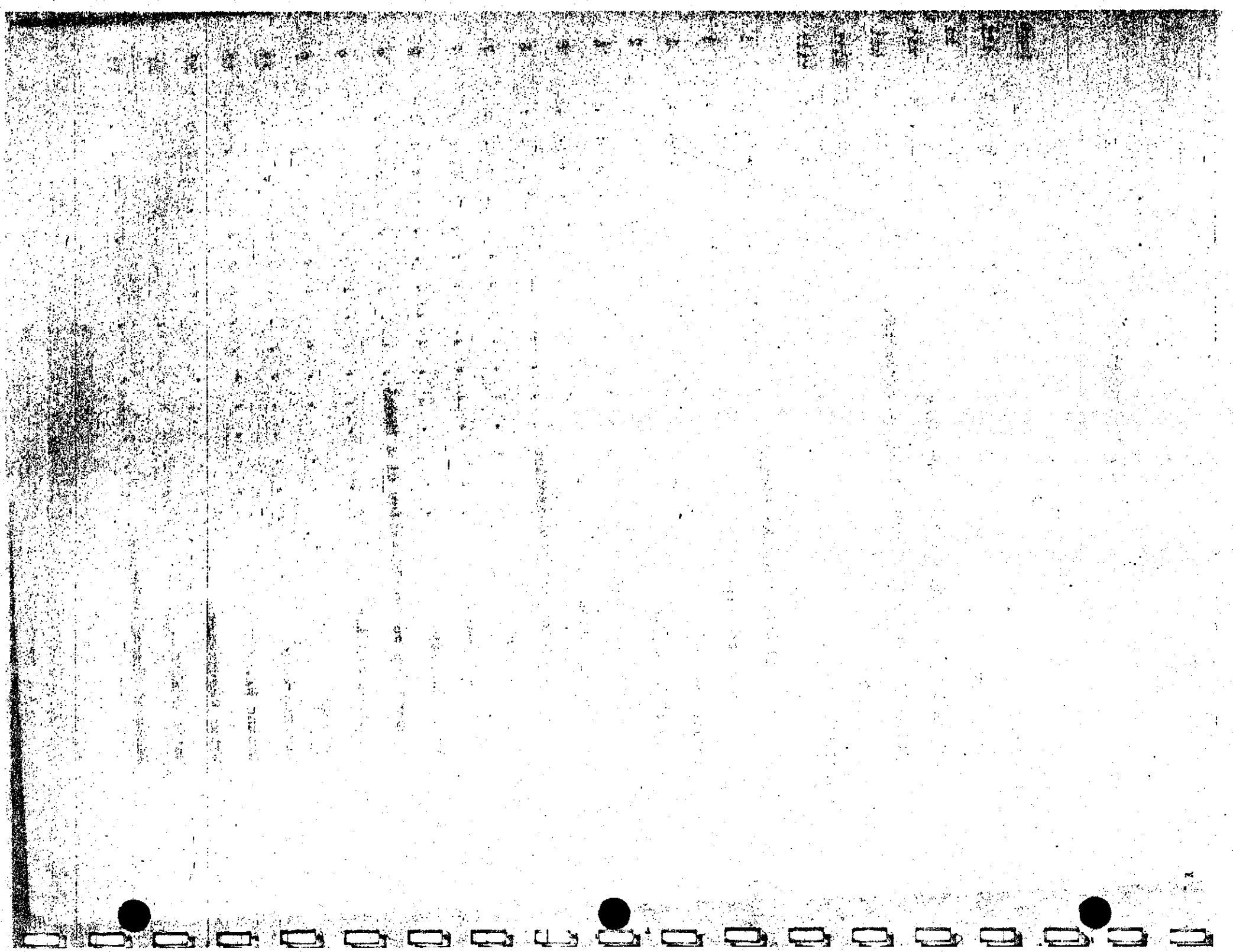

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Areal Geology . . . . . .In Pocket at End of Report

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

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This investigation was conducted
under the supervision of

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Assisted by

Gerald D. Cox . . . . . Assistant Engineering Geologist

In cooperation with

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ACKNOWLEDGMENT

The Department of Water Resources acknowledges with thanks the information and advice provided by the Ground Water Advisory Committee during the preparation of this bulletin.

Ground Water Advisory Committee

The Ground Water Advisory Committee, which was consulted on significant items in the investigation at a series of meetings held from January 1970 to June 1973, was established within the study area to give guidance to the investigators. Its members are from the following organizations:

Arcade County Water District
Arvin Water Company
Carmichael Irrigation District
Citizens Utilities Company of California
Citrus Heights Irrigation District
City of Sacramento
Del Paso Manor County Water District
Fair Oaks Irrigation District
Florin County Water District
Fruitridge Vista Water Company
Galt Irrigation District
Northridge Park County Water District
Omochumnes-Hartnell Water District
Orangevale Mutual Water Company
Rio Linda County Water District
San Juan Suburban Water District
Southern California Water Company
Arden Water Service
Cordova Water Service

ABSTRACT

Sacramento County is located in the lower portion of the Sacramento Valley and immediately north of the San Joaquin Valley. Since 1940, water demand has exceeded supply and ground water levels have declined. Concern over the continuing trend prompted local and state agencies to begin investigation of the water resources of the area as the first step in development of alternative plans for water resource management.

This bulletin contains the results of a cooperative study by the Department of Water Resources and the County of Sacramento of geologic and hydrologic conditions affecting the occurrence and movement of ground water and the relation between recharge to and withdrawals from the ground water system. The bulletin also contains a description of a mathematical model developed during the study to simulate the reactions of the ground water system to actions of man. The study is continuing and will evaluate alternate plans of water resource management.

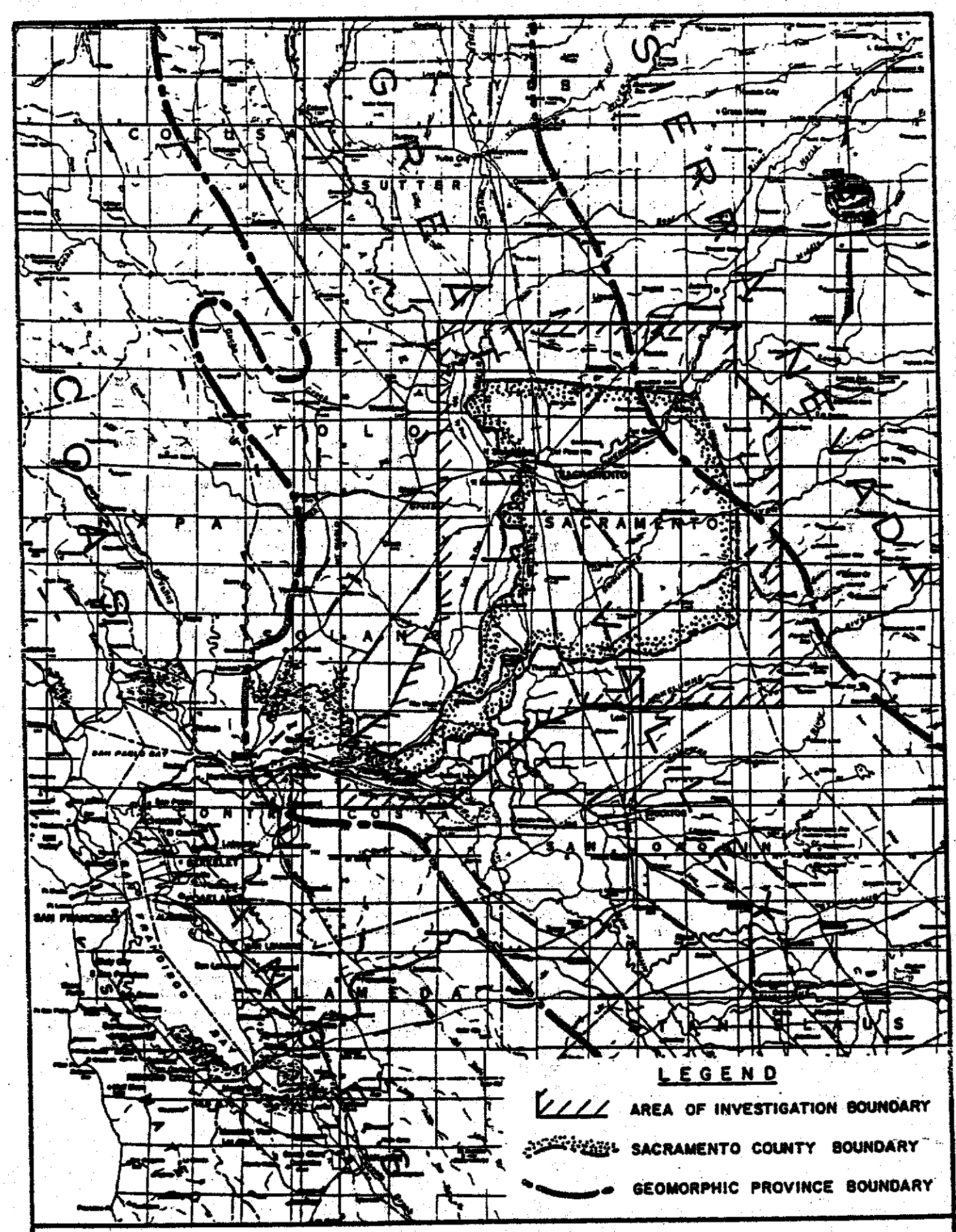


Figure I. AREA OF INVESTIGATION AND GEOMORPHIC PROVINCES

CHAPTER I. INTRODUCTION AND SUMMARY

Use of ground water in Sacramento County has increased steadily from the early domestic wells of the 1850's, through the expanding irrigated agriculture of the early 1900's, to the rapid increase in urbanization of the 1950's and 1960's. The present use of ground water represents 47 percent of the total water supply of Sacramento County.

From 1940 to 1968 the average ground water level in Sacramento County has been dropping more than one foot per year. By 1968 the average pumping lift was about 60 feet. The continuing steady decline of ground water levels throughout Sacramento County was a cause for concern to the Board of Supervisors. In 1968 the Board entered into an agreement with the Department of Water Resources to direct a cooperative investigation of the ground water resource. The conduct of the study has been on a cooperative basis, and accomplishes two goals. First, it develops the thorough understanding of the ground water resource needed by the County to implement water policy guidelines on management of the water resources of the County and needed by the Department to evaluate the possible roles of the ground water basin in the planning for adequate water supplies on a statewide basis. Second, the cooperative study insures that planning takes local conditions into account and that local agencies are completely involved in the planning effort.

Description of the Area

The area of investigation, shown on Figure 1, includes the Sacramento County portion of the Great Valley, as well as a perimeter zone about six miles wide extending into adjacent counties. Inclusion of the six-mile-wide zone around the County was necessary in order to properly arrive at ground water conditions at the county boundaries.

Sacramento County is but one portion of the Great Valley of California, a complex ground water basin which extends from Red Bluff on the north, south some 400 miles to Bakersfield; the valley averages 40 miles in width. Sacramento County is located in the north-central part of the Great Valley and in the southeastern part of the Sacramento Valley. It is bounded by Sutter and Placer Counties on the north, El Dorado and Amador Counties on the east, San Joaquin and Contra Costa Counties on the south, and Yolo County and the Sacramento River on the west. The approximate total area of the county is 644,000 acres. Of this, 528,000 acres are valley land (6 percent or less slope), 100,000 acres are hilly land (20 percent or less slope), and 16,000 acres are mountainous (greater than 20 percent slope).

Objective and Scope

The overall objective of this two-phase study is to evaluate the alternative ways that the ground water basin may be used in conjunction with surface, imported, and reclaimed waters to satisfy the future water needs of the area. To accomplish

this objective it first is necessary to determine how the ground water basin accepts, stores, and transmits water and, in particular, how it reacts to use by man.

The study has been divided into two phases, viz: geohydrology and meeting water demands. The first phase included:

1. Data collection
2. Ground water geology
3. Hydrology and water quality
4. Development of a mathematical model of the basin
5. Verification of the model.

The results of the first phase are reported in this bulletin and are used as the starting point for the second phase, which will be considered subsequently and reported separately. The second phase will include:

1. Projection of land use patterns
2. Projection of water supply and demand
3. Review of future water supply sources
4. Development of future conjunctive operation plans
5. Evaluation of alternate plans.

History of Water Use

The history of Sacramento County is colorful, centering around Captain John Sutter's fort and the beginnings of the Gold Rush of 1849.

Captain Sutter first landed on the banks of the American River on August 12, 1839, near what is now 28th and "B" Streets in Sacramento. His dream was to build a colony named after his homeland, Switzerland. He called this settlement New Helvetia. Here he planted wheat and rice and established orchards using water from the Sacramento and American Rivers for limited irrigation.

The discovery of gold in 1848 in the Sierran foothills near what is now the town of Coloma ended Sutter's dream for New Helvetia and brought with it a great influx of people. The first water supply facilities to serve this increased population were constructed in 1849 and 1850 at what is now the foot of "I" Street in Sacramento. This facility consisted of pumps which lifted water from the Sacramento River to elevated storage tanks. Water was dispensed from these tanks into water wagons and sold by the gallon.

During this period several fires occurred which could not be successfully contained because of an inadequate water supply, and in 1852, a fire destroyed a

large portion of Sacramento, causing the citizens to organize the first municipal water company on the west coast. This company began operation in April 1854, after acquisition of the 1850 water system. Its main physical works were located at Front and "I" Streets.

At the same time that water supplies were being developed for fire demands in Sacramento, water supplies also were being developed for hydraulic mining in the eastern section of the County. In 1854 the American Ditch Company was organized, and a diversion of American River water was made to supply water for mining along a 33-mile canal which terminated near Folsom. When the profitability of hydraulic mining declined, attempts were made to put this water to irrigation uses in the lands of the San Juan Grant. In the 1880's the cattle firm of Cox and Clarke acquired most of the lands of the San Juan Grant and the physical works of the American Ditch Company, which the firm reorganized into the North Fork Ditch Company. This private company was the sole supplier of surface waters to what is now the wholesale water service area of the San Juan Suburban Water District.

The demand for irrigation water increased in the latter part of the last century, as the large land grants were subdivided into 10- and 20-acre parcels for small farms. The first area to be developed in this manner was the Orangevale Colony in 1889. This was followed by Fair Oaks in 1898, Carmichael in 1909, and Citrus Heights in 1910. Dissatisfaction with the distribution system of the North Fork Ditch Company led to the formation of other water companies and irrigation districts. The first of these was Orangevale Mutual Water Company, organized in 1896, followed by Carmichael Irrigation District in 1916, Fair Oaks Irrigation District in 1917, and Citrus Heights Irrigation District in 1921. Water from the American River was supplied to these water purveyors by the North Fork Ditch Company until 1954, when the San Juan Suburban Water District was formed and purchased the North Fork Ditch Company.

Wells were used for domestic and stock watering supplies from the time of the earliest settlements, but owing to the lack of efficient pumps and power plants, wells were not used for irrigation purposes until 1879. In that year a well 18 inches in diameter and 24 feet in depth was drilled on the Blowers Ranch near Woodland. The success of this well encouraged further drilling.

During the period from 1890 to 1910, more advanced well drilling, well construction, and pumping techniques were developed. This, coupled with the increasing demand for irrigation waters on the small 10- and 20-acre farms beyond the reach of surface irrigation canals, resulted in increasing quantities of ground water being used.

In 1900, 7 wells ranging in depth from 114 feet to 190 feet, located in what is now the Oak Park area of the City of Sacramento, had a standing water surface of 12 feet below ground level. In 1914, after 14 years of use, these same wells had a standing water level of 25 feet below ground level.

In 1913 approximately 10,700 acres of land in Sacramento County were irrigated by ground water, and the continued use of ground water (probably in the south county) was resulting in a lowering of the water table at the rate of one foot per year. By 1928, 28 percent of the irrigated land was using ground water, and the water table was reported to be continuing to decline.

The Depression of the 1930's slowed the spread of farming until the war years of the early 1940's. However, shortly thereafter, the water needs of Carmichael, Citrus Heights, and Fair Oaks Irrigation Districts exceeded their surface supplies and they began utilizing ground water to meet peak demands. Carmichael Irrigation District canceled its contract with the North Fork Ditch Company in 1941 and began pumping directly from the American River as well as using ground water. In 1959 and 1960 the district constructed radial infiltration galleries along the river to be used as intake structures.

The City of Sacramento began utilizing ground water in the 1940's in order to irrigate parks and provide water to isolated areas in the system. It also acquired, by annexation, other areas served by ground water. At present, 20 percent of the City of Sacramento's peak demand is supplied from the ground water resource.

During the rapid urbanization following World War II, several small water districts were formed. Some have subsequently been taken over by larger districts, while others have merged. Most of the newer districts depend upon ground water for their supply. At present, 23 separate water districts, agencies, or companies supply water to Sacramento County residents.

The use of ground water in Sacramento County has increased steadily from the early domestic wells of the 1850's, through the expanding irrigated agriculture of the early 1900's, to the increased urbanization of the 1950's and 1960's, until at the present time ground water represents 47 percent of the total water supply of Sacramento County.

Previous Investigations

Ground water has been a major source of domestic, irrigation, and municipal water in the Central Valley for many years. Geology and hydrology as they relate to water supply have been the subject of a number of publications and technical papers. Those which bear a relationship to the current study are described below. The Bibliography in Appendix A lists those reports dealing with the ground water geology and hydrology of Sacramento County.

"Folsom-East Sacramento Ground Water Quality Investigation", State Department of Water Resources Bulletin 133, March 1966, is the most recent study in Sacramento County made by the Department. This investigation was undertaken in cooperation with other state and local agencies and industries to determine if waste water disposal from the rapidly increasing residential and industrial development east of the City of Sacramento had affected the ground water quality in the surrounding area. The quality levels as reported will serve as a base line against which to measure the effects of future development.

"Folsom North Unit - CVP - Reconnaissance Studies of Water Problems", U. S. Bureau of Reclamation, March 1956, is a report made in compliance with the enabling legislation for the construction of Folsom Dam and its subsequent distribution of surplus water. The report indicated that continuing the use of ground water would be more economical than either a surface water supply or a combined surface and ground water supply. However, this indication cannot be regarded as conclusive, since many factors were not or could not be fully evaluated until the desires of the local people are more fully known.

"American River Basin Investigation — Report on Development Proposed for the California Water Plan", State Water Resources Board Bulletin 21, June 1955, reports on a development plan for the American River Basin. Proposed facilities to supply irrigation for valley floor service units of the American River include 22 reservoirs, 19 power plants, 300 miles of conduit, and 150 miles of main canal. The main storage units would include: (1) Auburn, Cedars, and Foresthill Divide Projects on the North Fork; (2) Middle Fork and Georgetown Projects on the Middle Fork; and (3) Silver Creek, Silver Fork, and Salmon Falls Projects on the South Fork. The estimated gross capacity of all units proposed for the Basin is 3,346,000 acre-feet. The plan for full development of the American River Basin includes in addition to water for irrigation and export, ground water replenishment, flood control, salinity control in the Delta, hydroelectric power, and recreation. Development of the Basin is an integral part of the California Water Plan. Total estimated cost of full development is $418,000,000.

Bulletin 21 reports on a conjunctive operation study to increase the yield of the projects. The basic postulate is that the water-bearing materials of the Great Valley could be used and operated as a conservation reservoir. The study estimated direct ground water replenishment by the American River to be 63,600 acre-feet per year. The estimated mean seasonal safe ground water yield, or replenishment of ground water storage, in the area of the ground water study is 964,800 acre-feet. The ground water study area includes portions of seven counties, viz: San Joaquin, Sacramento, Sutter, Placer, El Dorado, Amador, and Calaveras. The study area includes about 1800 square miles.

"Soil Survey, Sacramento Area, California", U. S. Department of Agriculture, August 1954, presents soil classification and soil maps of the Sacramento area. The bulletin was published for agriculturalists and others interested in soil management practices. For the various types of soil present, the suitability of different crops is projected considering the climatic requirements and probable yield.

"Report to Sacramento Regional Area Planning Commission on Preliminary Water and Waste Management Plan", Metcalf and Eddy, Engineers, November 1969, is a culmination of previous studies involving an inventory of water and waste management systems and the formulation of alternative plans. It covers the development of preliminary plans for water, sewerage, and drainage, and includes short range plans and programs over the next five to ten years.

"Geologic Features and Ground Water Storage Capacity of the Sacramento Valley, California", U. S. Geological Survey Water-Supply Paper 1497, 1961, was prepared in cooperation with the State Department of Water Resources and contains a dissertation on the reconnaissance geology of the water-bearing deposits with respect to their physical and hydrologic character, thickness, distribution, and structural features. Estimates were made of the total ground water storage capacity of the water-bearing deposits between a depth of 20 and 200 feet. The total ground water storage of the Sacramento Valley was estimated to be 33.5 million acre-feet. This paper provided the basis of the detailed surficial geologic survey made for this investigation.

"Water Investigation for Districts of Northern Sacramento County", Clendenan and Associates, February 1961, reports a comprehensive study of all of the public water service agencies in the northeastern portion of Sacramento County. The study investigated the water supply, physical plant, and organizational structures of the respective agencies. The report concluded that: (1) all districts except Del Paso Manor County Water District will have an increase in water requirements in the next 50 years; (2) safe yield of the ground water basin is 123,000 acre-feet per year; (3) ground water levels have and will continue to decline, but this is not cause for alarm; (4) ground water pumping is the most economical source of supplemental water for all districts except San Juan Suburban Water District; (5) the water table decline would average about 59 feet in the next 50 years under existing operating conditions, but by utilizing interties, the water table decline could be reduced to an average of only 45 feet over the next 50 years; (6) the average total cost of water would be $14.10 per acre-foot, which would be an increase of about 36 percent above the 1961 cost; and (7) ground water recharge is from both precipitation and from infiltration from the American River and tributary streams.

Current Investigation

The current study has been made in four phases, viz: data collection and organization, geology, hydrology and water quality, and modeling. A description of the work completed is contained in this section.

Data Collection and Organization

The first step in this study was the collection and organization of all readily available information on precipitation, water quality, pump efficiency tests, surface water flows, ground water pumpage and water levels, land use, water rights, population, municipal and industrial water use, and water well logs. The information was reviewed to determine what additional data were required. The data described below have become a data base for the County. Collection of additional data is continuing through the duration of the study and has become a continuing activity of the County. About 75 precipitation station records were gathered, duplicated, and filed. Continuous records are available for the City of Sacramento since 1849 in several locations.

Over 2,000 mineral analyses of ground water were gathered from previous investigations, hydrologic data files, and the files of the State Department of Public Health, Bureau of Sanitary Engineering. These data were encoded and punched onto machine computation cards, then the data were sorted and listed by an existing computer program.

Pump efficiency tests made by the Sacramento Municipal Utility District (SMUD) through 1971 were copied and recorded on microfilm.

There are 47 active and inactive stream gaging stations in the County. The longest term continuous record is American River at Fair Oaks, for which records are available since November 1904.

Municipal pumpage information was collected from the various water purveyors. Quantities of agricultural pumpage were estimated from power consumption records by the U. S. Geological Survey (USGS) for the years 1967, 1968, and 1969 as part of a cooperative program with the Department.

Water level measurements for all stations within the County and one township north, west, and south were keypunched on machine computation cards. The cards then were fed into a computer program which sorts and lists these data. About 18,000 measurements through 1970 were listed.

Land use surveys were available for Sacramento County for the years 1961 and 1968. The data were recorded on USGS quadrangle sheets and were duplicated for the study.

Water rights listings were prepared by the State Water Resources Control Board.

Historic and projected population figures were obtained from the Sacramento County Planning Department, Sacramento Regional Area Planning Commission, California Department of Finance, and U. S. Census reports.

Municipal and industrial water use figures were collected from all water purveyors in the County.

A file of water well logs was created by combining data from the Department and the County Department of Public Health. A master well file containing about 7,500 listings was created from the data contained in the well logs and includes the well location, purpose, owner's name, depth, diameter, county, and well driller.

Geologic Study

Surface exposure of geologic formations was investigated by compiling all available geologic mapping of the County and field checking critical areas. A map detailing all of these exposures was then developed.

Subsurface geologic features were determined with the aid of a computer by a technique utilizing a three-dimensional display of information from drillers' logs. The technique places the driller's call, or description of a subsurface material, into a standard group of materials. By assigning numeric values to these groups the results are printed out by the computer as an areal display of subsurface information for predetermined horizontal slices of the subsurface. The computer output was printed on transparent film and then stacked in their relative order of elevation for interpretation. The traces of the buried stream channels, areas of fine grained material, were identified and zones of hydraulic continuity between various levels were identified.

Hydrologic Study

The objective of the hydrologic element of the current study was to determine values for the parameters that control recharge, movement, and discharge of ground water. These values were used to determine annual amounts of ground water

recharge, withdrawal, and change in storage over a period representative of normal climatic conditions. A base period of seven years, 1962 through 1968, was selected as the best representation of average climate and current development.

It was not possible to determine the surface outflow from the area of study because of tidal influences, therefore an accounting or balance of hydrologic items was made only by considering the changes to the mass of ground water. This type of computation is not independent of the amounts of water flowing in the streams, but does not use differences between surface inflow and outflow as a check on the hydrology.

Computation of the amounts of water available at the ground surface, the amount lost to evapotranspiration at the surface, the net amount available for recharge, the net change in the amount of water in storage, as well as the determination of pumpage were made.

Water Quality

Water quality was evaluated by review of the analyses of surface water and ground water for mineral quality. From the analyses, general characteristics of both ground water and surface water were derived. In addition, water quality hazard areas were identified by use of such quality parameters as sodium percentage, chloride ion, and elemental boron.

Preparation and Verification of a Model

After a satisfactory hydrologic balance had been attained over the seven-year base period, a mathematical model of the ground water system was designed. The design of the model entailed the division of the study area into a number of nodes, within each of which there were essentially like hydrologic characteristics. In this way Sacramento County and its adjacent area were subdivided into 102 nodes. The average nodal area thus derived comprised 8.89 square miles, or 5,693 acres. Quarter townships were selected as nodal areas because of the ease in preparing and tabulating data for the model. In addition there were no known geologic faults which transected the water-bearing materials. The western and southern boundaries of the ground water model lap into the adjacent counties. The southwestern portion of the County, that which extends into the Delta region, was excluded from the model because its principal water supply for irrigation purposes comes from rivers and sloughs. The ground water level for each node was derived by estimating the water level for the centroid of each node from annual ground water contour maps. Ground surface elevations were estimated in a similar manner.

In the model, connections between nodes are called branches, and the ability of water to move between nodes along the branches is expressed as transmissivity. Transmissivity values for each branch in the model were estimated from the relationship of specific yield values to transmissivity values. These values were computed for each 10-foot increment of elevation for the entire depth of water-bearing materials. For each branch, the transmissivity values were modified,

depending on the angle between the branch and the axis of deposition of the subsurface materials. A ratio between flows in the direction of deposition and normal to that direction was also developed.

The mathematical model uses net recharge (recharge minus pumpage) values as input, together with initial water levels, storage coefficients, and transmissivity values. Program output is a change in storage represented by water levels. The mathematical model used was the latest version of a series of department ground water models programmed for processing on a digital computer. The computer simulates subsurface flow between the nodes and outputs the theoretical water levels over the study period. When the computer output was in agreement with the actual historical water levels, the model was considered verified and representative of the actual ground water basin.

Investigation Results

Geology

The Sacramento Valley is underlain by a sequence of layers, or strata, of sand, silt, and clay many thousands of feet in thickness. These deposits have been slowly accumulating over the last 100 million years. Underneath this accumulation is a floor of bedrock of a type not unlike that exposed today in the Sierra Nevada.

About 100 million years ago, during the early part of the Cretaceous Period (see Figure 2), an arm of the sea covered what is now the Sacramento Valley. This sea lapped onto hills to the east, which were composed of ancient rocks which at that time were nearly 100 million years old. These ancient rocks had been heated and squeezed so that they were reconstituted (metamorphosed) from sand and clay to hard rock. Sediment-laden rivers flowed out of the ancient mountains and deposited their load of gravel, sand, and clay on the floor of the Cretaceous sea. Eventually, over 15,000 feet of sediments accumulated. Since that time these sediments have become compacted and now form the marine sandstones and shales found deep beneath the valley. Because the sandstones were formed in a salt water environment, some of that salt water was entrapped at the time of deposition. Today, the Cretaceous sandstones still contain much of this salt water and consequently they are considered of no value for the production of usable ground water.

During the Eocene Epoch, some 50 million years ago, the inland sea became fresh to brackish. Sand and clay deposited on and near the beaches of this sea are now present as sandstone and shale belonging to the Ione Formation, the lowermost source rock for usable ground water. Although not as good quality as that contained in younger materials, ground water in the Ione Formation may be usable under certain conditions. For the next 30 million years the then-soft Ione sediments were sun-baked and eroded until a thickness of less than 500 feet was left.

During the early to middle parts of the Miocene Epoch, a great outpouring of rhyolitic volcanic debris took place in the ancestral Sierra Nevada to the east. Much of this debris was deposited as beds of ash, volcanic sand, silt, and clay

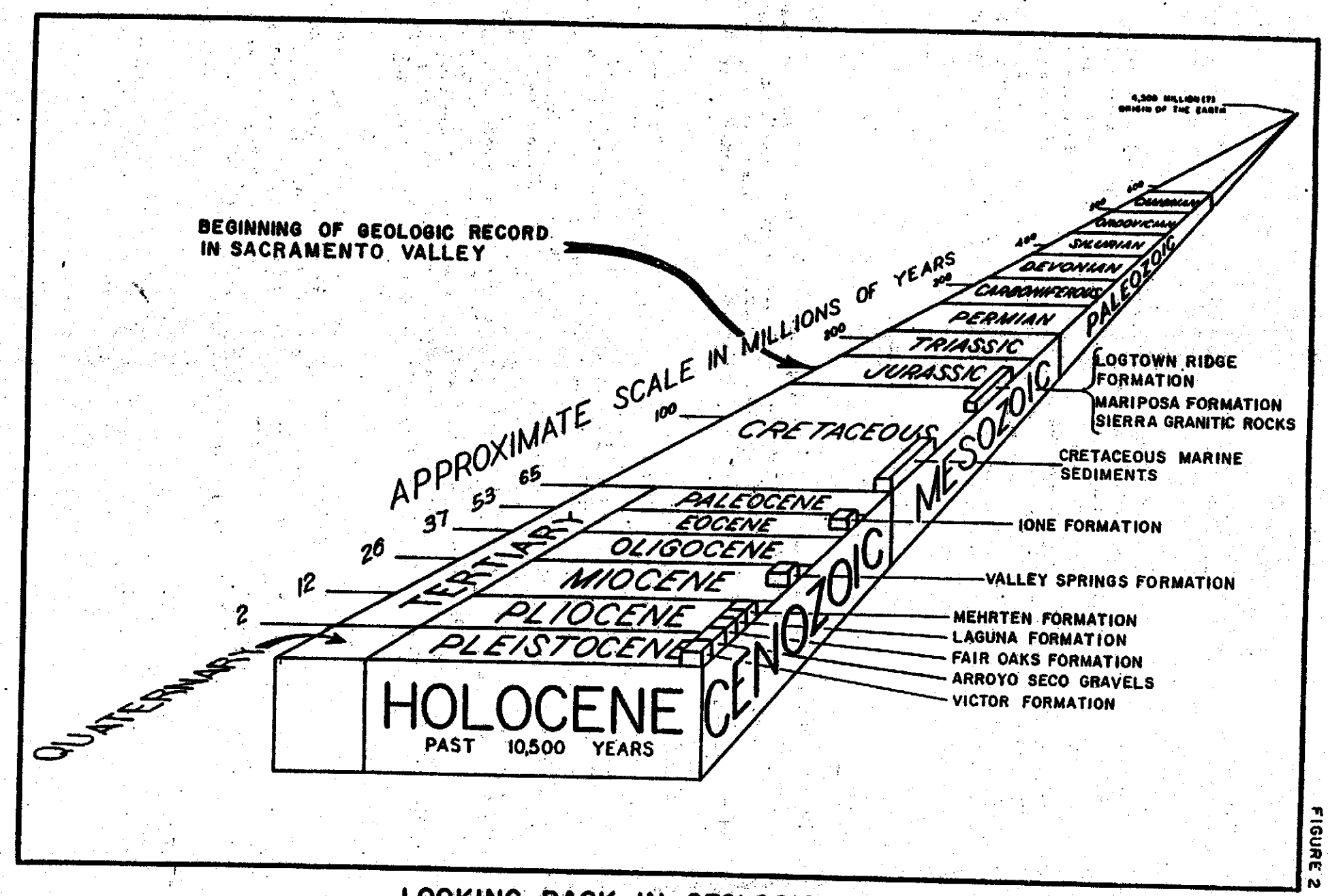


FIGURE 2

LOOKING BACK IN GEOLOGIC TIME

burying the surface made up of Ione sediments. This sequence of volcanic materials is now identified as the Valley Springs Formation.

Again there was a period of erosion, as the land stood above sea level. For about 10 million years the upper surface of the Valley Springs Formation was eroded until, during the late Miocene and early Pliocene, volcanic activity again broke out to the east. This time the volcanism was of the andesitic type which produced the "lavas" (tuff-breccia) and associated black sands of the Mehrten Formation common to many parts of the County.

By the close of the Mehrten volcanic period, about 8 million years ago, a broad volcanic plain laced by many streams stretched westward from the Sierran foothills to an inland sea. Another period of quiescence ensued for the next five million years. During this time the volcanic sediments were eroded into many lava-topped mesas, many of which became buried beneath younger sediments.

After this period of erosion deposition of continental sediments began anew. This time the materials were nonvolcanic, and have been named the Laguna and Fair Oaks Formations. These latter deposits date from the end of the Pliocene Epoch to the early part of the Pleistocene Epoch, about two million years ago. Deposition of these materials was accomplished by the American River and other streams, which by that time had become major streams entering the Sacramento Valley. Over the succeeding thousands of years the rivers meandered across the valley floor. Time and time again river courses shifted and river channel deposits became cut off and subsequently buried. It is these now buried stream channels which are of vast importance as conveyance channels and sources of ground water.

During the Pleistocene Epoch, when the great glaciers mantled the Sierra Nevada, floods on the American River swept boulders, gravel, and glacial debris onto the plain composed of Laguna and Fair Oaks sediments. These great outpourings of sediment-laden glacial meltwater created a river that was much larger than the American River of today. In places this riverbed was as much as 8,000 feet across. At one time this ancestral river flowed from the vicinity of Folsom southwesterly along a line somewhat parallel to Bradshaw Road to what is now the Cosumnes River. This ancestral channel, now buried under 20 to 30 feet of younger materials, comprises a major southward trending ground water conduit. Later in the Pleistocene Epoch the river changed its course and flowed southwesterly from near Mather Field toward Franklin. This middle channel also is an important ground water conduit. Once again the river changed course to the north, and flowed from Mather Field westerly toward South Land Park. It is this latter channel that provides the copious quantities of sand and gravel extracted near Brighton. Like the older channels, this latter channel also is a major supplier of ground water. Near the close of the Pleistocene Epoch, about 10,000 years ago, the American River, for a fourth time, changed its channel. It moved north again, this time to its present location.

Surface exposures of the geologic formations are shown on Plate 1. The locations and elevations of the buried stream channels and the relationship of aquifers to each other are discussed in detail and shown on maps and figures in Chapter II.

Surface Water

The average runoff from the American River, Cosumnes River, and Sacramento River watersheds was 1,473, 726, and 647 acre-feet per square mile, respectively. These figures show that the American River is twice as productive per square mile of drainage area as the Sacramento River or the Cosumnes River.

The effect of construction of Folsom Dam on the American River has enhanced fisheries and recreation downstream from Folsom Dam.

Ground Water

The average elevation of the ground water potentiometric surface from 1930 through 1940 remained steady at 30 feet. From 1941 to 1970 this level declined to about 5 feet below sea level. This represented a decline of about 35 feet in 30 years, or slightly over one foot per year.

The available fresh water in storage computed to the base of the Mehrten Formation, which is considered for this investigation to coincide with the base of fresh water, is 35,500,000 acre-feet in 1968. From 1930 to 1968 the ground water basin was depleted by 1,500,000 acre-feet. The average annual loss of water in storage during the study period 1962 to 1968 was 22,300 acre-feet.

For the period 1962-1969 for Sacramento County, ground water supplied 45 percent, or 250,100 acre-feet, of the agricultural water requirement; 48 percent, or 108,200 acre-feet, of the municipal and industrial water requirement; and 45 percent, or 358,300 acre-feet, of the total water requirement.

Water Requirement

The average annual total water requirement for Sacramento County during the period 1962-1969 was about 800,000 acre-feet.

Water Quality

Surface waters in the stream systems in the Sacramento County area are of excellent mineral quality and are suitable for all but the most exacting industrial uses. These waters are of bicarbonate type, with either calcium or magnesium being the predominant major cation.

Ground water in the water-bearing materials underlying most of Sacramento County is suitable for irrigation and most industrial purposes. Iron and manganese are a ground water quality problem in Sacramento County. It was found that ground water from many wells had amounts of iron and manganese which were not consistent over a period of time. In some cases a well might be sampled and the analysis would show that iron and manganese concentrations were below the USPHS limits. On resampling at a later date, one or both of

these constituents would be in excess of the recommended limits. The presence of iron and manganese in ground water is attributed to leaching action from soils containing excessive amounts of these constituents.

Like the surface water, the ground water is of bicarbonate type, with calcium, magnesium, and sodium being the dominant cations. The ground water body ranges in depth from several hundred feet near the eastern portion of the County to an estimated 2,000 feet near the Sacramento River. Underlying this body of usable ground water is poor quality saline water which occurs mostly in the Valley Springs and older formations.

The Delta area contains a body of poor quality ground water, which ranges from sodium bicarbonate to sodium chloride in composition. In many areas this water is unusable for either domestic or irrigation purposes. The boundary between the poor quality water found in the Delta area and the good quality water is roughly along the boundary separating Townships 4 and 5 North. There are areas containing sodium chloride water occurring along the Sacramento River from the Delta north to Township 11 North and also along the Feather River in Township 11 North. This poor quality water is believed to be due to two causes. First, near surface saline water occurs along many buried stream channel deposits in the Delta. In the geologic past, some of this water may have migrated upstream during periods of low riverflow. Or, the areas of high salinity may be caused in a manner similar to the rising connate waters found in the central Delta area and also in southern Sutter County.

Ground water to the west of the Sacramento River has been derived from recharge along eastward flowing streams that drain the marine sediments to the west of the Great Valley. This water is predominantly a magnesium and magnesium-sodium bicarbonate water and is of poorer overall quality than that derived from the east.

Recharge Characteristics

Only a relatively small portion of the land area of Sacramento County is underlain by materials with sufficient infiltration capability to provide natural recharge to the ground water body. In the eastern foothill region, slopes are too steep and consequently precipitation in excess of evapotranspiration becomes runoff. The Victor plain and Delta area are underlain by soils containing hardpan or organic clays; the low permeability of these materials inhibits infiltration. It is only along active stream channels that sands and gravels occur of sufficient areal extent and depth that significant quantities of surface water may infiltrate to recharge the ground water body.

Most of the stream channel deposits in Sacramento County occur along the courses of the Cosumnes and American Rivers. Along the former, studies have shown that there is an annual recharge of 17,000 acre-feet along the river reach from Bridgehouse (east edge of the ground water basin) to McConnell. Downstream from McConnell, recharge is insignificant due to an abundance of clayey materials in the subsurface.

The gravel pits near Perkins and the broad expanse of tailings near Nimbus a composed of older stream channel deposits. In the case of the pits, where s gravels have been exposed, precipitation may pond and infiltrate downward and laterally into presently buried deposits that are hydraulically contiguous. Th tailings deposits have been churned up by gold dredgers, and they are now of lower permeability than the undisturbed stream channel materials. Even so, rainfall rapidly infiltrates and becomes ground water which moves down-gradient

CHAPTER II. GEOLOGY

Sacramento County is situated in two geomorphic provinces, the Great Valley and the Sierra Nevada. By far the larger portion of the County is within the Great Valley province; only the eastern portion is within the Sierra Nevada province.

The portion of the County within the Great Valley province has been subdivided into four subunits: the Sacramento-San Joaquin Delta, the river floodplain, the alluvial plains, and the low foothills, as shown on Figure 1.

The Sacramento-San Joaquin Delta includes the southwestern portion of Sacramento County. Under historic conditions, the Delta was a tidal marsh traversed by meandering sloughs and waterways of the Sacramento, San Joaquin, and Mokelumne River systems. Reclamation of the Delta area has created many islands enclosed by levees. These islands are underlain by peat and related organic sediments. The islands are typically bowl-shaped, with the lowest elevations being near the center. The lowest land elevations in Sacramento County occur in the Delta area. Andrus and Brannan Islands each have elevations of seventeen feet below sea level (-17) at their centers, even though the water surface in the adjacent waterways fluctuates between minus three (-3) feet and plus five (+5) feet.

Although the maximum extent of the Delta area is not sharply defined in a geologic sense, for the geologic phase of this study it has been arbitrarily fixed at the zero-elevation contour, which roughly coincides with the contact between the organic and nonorganic soils.

Adjacent to the Delta area is an area identified as the river floodplains. Materials underlying this subunit consist principally of unconsolidated inorganic soils. Elevations range from near sea level adjacent to the Delta and 20 feet above sea level in the American Basin, in the northwest part of the County, to as much as 150 feet along the upper reaches of streams such as the American and Cosumnes Rivers.

To the east of the river floodplains is an extensive area of slightly disected alluvial plains. These areas slope gently upward from the Sacramento River and form a broad area which extends from Rio Linda south to Galt. This alluvial plain is a part of the larger "Victor Alluvial Plain" originally described by Piper and others [1939]. The alluvial plain is underlain by older soils which characteristically contain extensive layers of hardpan. The plain ranges in elevation from about 10 feet near Point Pleasant in the southwestern portion of the County to over 100 feet near Clay. It underlies much of the City of Sacramento, where it has an average surface elevation of about 20 feet.

Drainage across this plain exhibits many degrees of downcutting. Morrison Creek, as well as larger streams such as the American River, has areas where downcutting through layers of hardpan has produced near-vertical streambanks which range from 8 to 15 feet in height.

A low foothill area borders the alluvial plains to the east. Much of the area is presently undeveloped; however in the Sacramento area, the suburban communities of Carmichael, Fair Oaks, and Orangevale are situated on this subunit. This subunit is typified by rolling topography underlain by a variety of continental materials ranging from moderately consolidated silts, sands and clays, to the bouldery plains of the Arroyo Seco pediment.

Elevations in the low foothills range from 75 feet northeast of Elk Grove to about 300 feet south of Folsom. Drainage across this subunit is along well established watercourses, with streams confined to well defined valleys. Relief from streambed to hillcrest becomes bold, attaining as much as 170 feet at the bluffs near Nimbus Dam.

Only the northeastern part of Sacramento County is within the Sierra Nevada geomorphic province. This is an area underlain by hard, nonwater-bearing rock, and is characterized by steep sided hills and narrow, rocky stream channels. Elevations in this area are the highest in the County, attaining a maximum of 828 feet north of White Rock. Stream patterns in the area are well established and are controlled principally by bedrock features.

Geologic History

The earliest event of importance to the geologic history of Sacramento County was the formation of an ancestral Sierra Nevada range during the Nevadan Orogeny, which took place in late Jurassic and early Cretaceous periods (see Figure 2). This orogeny created the range by a process of folding, faulting, and igneous intrusion. Remnants of this range are present today as the steeply dipping metamorphic rocks found near the eastern side of the County. The ancient range was moderately high, as the intrusive rocks which formed deep within the core of the range were exposed by erosion at the close of the Cretaceous period. It is not known how far west this ancient range extended but it undoubtedly extended far to the west of the present foothill line. Seismic evidence suggests that the ancient Sierran block extends at depth at least as far as the western part of the Great Valley.

During the Cretaceous period enormous quantities of rock were eroded from the ancient range and were deposited as thick marine sediments in the adjacent Cretaceous Sea. While this erosion was going on, the sea slowly transgressed over the old eroded surface, and Cretaceous marine sediments were deposited on the granitic rocks emplaced during the Nevadan Orogeny. This eastward marine transgression was accompanied by a gradual subsidence of the eroded ancestral Sierra Nevada.

Marine deposition continued during the Paleocene and into the Eocene epoch. The shoreline at that time was relatively stable along a north-south line running through the eastern part of Sacramento County. A warm and humid climate developed during this time and a lush cover of broad-leaved vegetation formed on the hills east of the Eocene Sea. Lignite seams and severely weathered lateritic sediments attest to this tropical environment.

Commencing in the latter part of the Eocene epoch and continuing into the Miocene epoch, volcanic eruptions formed a variety of rocks along the present crest of

the Sierra. Much of this volcanic ejecta was eroded and redeposited subaqueously farther to the west.

By middle Miocene time, the sea apparently had withdrawn from the Sacramento Valley area and, after a period of relative quiescence, volcanic activity began anew along the Sierran crest. These eruptions were andesitic in nature and sent a flood of mudflow breccias down the slopes to blanket the adjacent valley areas. Streams continually reworked these easily erodable deposits and deposited them over broad areas to the west. Eventually all but the highest of the foothills were submerged in this flood of volcanic debris, and drainage repeatedly was disrupted as old stream canyons became filled and new, consequent drainage patterns developed.

During this period of volcanic activity, which lasted from Miocene time into the Pliocene, the Sierran block was slowly being uplifted and tilted toward the west. Also during this time the climate of the area became milder than at present. Annual precipitation was about the same, but paleontological evidence suggests that rainfall was much greater during the summer months.

By the middle to late part of the Pliocene epoch, volcanic activity ceased and the Sierra Nevada again underwent a period of erosion, the products of which were deposited in the Great Valley. The present drainage patterns were established during that time. During the early to middle part of the Pliocene epoch, the Sierra Nevada underwent a series of uplifts which elevated it to nearly its present elevation.

The high Sierra was repeatedly mantled by glaciers during the Pleistocene epoch, and there were also long interglacial periods when the snow and ice all but disappeared. Four glacial and three interglacial periods have been recognized during this epoch. All during these periods, westward flowing streams cut deep canyons into the underlying bedrock of the Sierra Nevada. The material removed from these canyons was deposited on the floor of the valley as an extensive gravel pediment.

Sea level fluctuated during these glacial and interglacial periods. When the glaciers were at their greatest areal extent, sea level was about 300 feet lower than at present. Drainage into and across the Great Valley was in a state of degradation. It was during these periods of lowered sea level that the deep gorges of Carquinez Strait and the Golden Gate were cut. During the interglacial periods, sea level stood about 100 feet higher than at present and streams were in a state of aggradation. It was during those latter periods that shorelines were at or near the central part of Sacramento County. Along these ancient shorelines, near the mouths of rivers and streams, extensive deposits of near-shore materials accumulated.

During the latter part of the Pleistocene epoch, regional upwarping with an associated change in base level brought about dissection of the gravel pediment and its underlying sediments. The sediments which were accumulating in the valley trough lapped eastward, burying some of the older landforms.

Under the present regimen, streams are eroding the low alluvial plains and dissected uplands and are aggrading the adjacent floodplains, flood basins, and stream channel areas.

Stratigraphy

The geologic formations of Sacramento County have been divided into two gr... nonwater-bearing and water-bearing. This division is based on the ability of the formation to yield significant quantities of water to wells. As used in this report, water-bearing materials are those that absorb, transmit, and yield wate readily to wells. Conversely, nonwater-bearing materials are those from which wells produce only limited quantities of usable water or produce water that is of unusable quality. In general, this division also can be based on age, becau the water-bearing materials generally include formations that are geologically young while the nonwater-bearing group includes those that are older than Tertiary. The surficial extent of the water-bearing and nonwater-bearing rocks in Sacramento County is presented on Plate 1 and described in the general strat graphic section, Table 1. Each unit is discussed in some detail below.

Nonwater-Bearing Rocks

Rock types of the nonwater-bearing series are exposed only in the far eastern portion of Sacramento County. These rock types also underlie the more recent water-bearing series at depths ranging from a few feet on the east to over 1,500 feet in the central and western parts of the County.

All of the rock types comprising the nonwater-bearing series are consolidated of low permeability; most of them do not have primary openings large enough to allow an appreciable movement of ground water. Ground water contained in these rock types exists largely in secondary openings formed by fractures, joints, shear zones, and faults. The secondary openings provide minimal storage s... and avenues for movement of ground water. This explains the ability of rocks of this group to provide small quantities of water to wells. Because secondary openings are not present uniformly in any given rock type, the ability of the rock to yield water to wells is variable and is dependent largely on local con... tions. The hydrologic importance of the rocks of the nonwater-bearing series lies primarily in their ability to yield small amounts of ground water to springs, thus providing perennial flow in many streams draining the highlands that would otherwise be dry in summer.

The quality of water contained in the nonwater-bearing rocks often is poor. Nonwater-bearing rocks of Cretaceous age are of marine origin and consequently contain water that is of connate origin, that is, deposited at the time the sed... ments were laid down. As these deposits were formed in a saline environment, connate water contained therein is also highly saline.

Metamorphic Rocks

Metamorphic rocks are exposed in the northeastern part of Sacramento County from Highway 16 (Jackson Road) east of the Cosumnes River north to the American River at Folsom (Plate 1). These rocks are a part of the baseme... complex and were formed prior to the Nevadan Orogeny.

The major portion of this metamorphic suite of rocks is composed of amphibolite, greenstone, and other meta-igneous rocks belonging to the

TABLE 1

GEOLOGIC FORMATIONS IN SACRAMENTO COUNTY

	Geologic Age	Formation	Thickness (feet)	Physical Characteristics	Water-Bearing Characteristics
CENOZOIC / QUATERNARY	HOLOCENE	Alluvium	0-100±	Unconsolidated gravel, sand, silt and clay deposited along stream channels, on terraces and floodplains, and in basins.	Gravels and sands act as important recharge areas and yield large amounts of water to wells. Silts and clays are of low permeability and yield little water.
CENOZOIC / QUATERNARY	PLEISTOCENE	Victor Formation	0-100+	Unconsolidated sand, silt, and clay. Hardpan present. Sand and gravel along old stream courses.	Generally yields little water. Yields larger amounts of water if old stream channels tapped.
CENOZOIC / QUATERNARY	PLEISTOCENE	Arroyo Seco Gravel	20-50	Sand and gravel in iron-cemented clay matrix.	Of relatively low permeability and thus would yield only small amounts of water to wells.
CENOZOIC / TERTIARY	PLIOCENE to PLEISTOCENE	Fair Oaks Formation	0-225+	Sand, silt, and clay. Hardpan present. Found principally north of American River. Cemented gravels south of the river.	Similar to the Victor Formation.
CENOZOIC / TERTIARY	PLIOCENE to PLEISTOCENE	Laguna Formation	125-200	Bedded silts, clays, and sands. Nonvolcanic.	Sand beds will yield moderate amounts of water to wells; clays yield little water.
CENOZOIC / TERTIARY	PLIOCENE	Mehrten Formation	200-1200	Beds of black volcanic sand, brown clay and sand; zones of volcanic tuff-breccia (lava). All of andesitic origin.	Volcanic sands yield large quantities of water to wells. Brown sands yield lesser amounts; clays yield little water. Tuff-breccias yield no water.
CENOZOIC / TERTIARY	MIOCENE	Valley Springs Formation	75-125	Beds of light colored sand and ash, beds of greenish brown silty sand, few beds of gravel. All of rhyolitic origin.	Of low overall permeability. Yields only small amounts of water to wells.
CENOZOIC / TERTIARY	EOCENE	Ione Formation	100-400	Medium-grained quartz sandstone, thick beds of white to red clay, blue to gray clay with lignite.	Of low overall permeability. Yields only small amounts of fresh to brackish water to wells.
MESOZOIC	CRETACEOUS	Chico Formation	200-15,000±	Brown marine fossiliferous sandstone and shale. Occurs principally in the subsurface.	Usually nonwater-bearing; contains salt water. Local areas may be flushed and now contain usable ground water.
Pre-TERTIARY		Basement Complex	?	Slate and sandstone of the Mariposa Formation. Greenstone, schist, and assorted metavolcanics of the Logtown Ridge Formation. Granodiorite and other intrusive rocks of the Sierra Nevada.	Essentially nonwater-bearing. Where sufficiently decomposed and/or fractured may yield small quantities of water to wells.

Logtown Ridge Formation of Carboniferous age. Distinctive outcroppings of white quartz, for which the community of White Rock was named, occur as steeply dipping veins up to 10 feet in thickness. Occurring as discontinuous belts within the Logtown Ridge Formation are beds of slate and shale belonging to the Mariposa Formation of Jurassic age. All of the metamorphic rocks have been deformed into isoclinal folds and now dip nearly vertically. Their strike is roughly parallel to the axis of the Sierra Nevada.

Because of the relative resistance of most of the metamorphic rocks to weathering, they develop only a scant soil cover. Resistant masses such as amphibolite form steep-sided ridges, exhibiting prominent outcroppings of white quartz. Lower areas are underlain at shallow depth by the planed off beds of Mariposa slate and shale.

Because of the thin soil mantle, runoff from precipitation is large and little or no water infiltrates the ground. These rocks yield little if any water to wells except in a few areas such as fractured quartz veins. Wells which tap fracture systems probably yield only a few gallons per hour. The quality of this ground water is expected to be acceptable for most domestic purposes.

Granitic Rocks

Significant outcrops of granitic rocks occur only north of the American River, in the northeastern portion of Sacramento County. Minor exposures of this rock type also occur to the south near the Cosumnes River and along Scott Road.

The granitic rocks are a portion of the Sierran batholith which was emplaced during late Jurrassic and early Cretaceous time. These rocks range in composition from granite to gabbro, with granodiorite and quartz being the most common. The granitics north of the American River are part of a pluton which extends to beyond Auburn Ravine, and 20 miles to the north. The upper surface of this pluton has been named the Roseville Surface by Schlemon [1967b] and has been undergoing weathering and erosion since before the Pleistocene epoch. This weathering has produced, in many areas, up to five feet of decomposed granite and associated residual soil. The decomposed material is characteristically pale colored and is composed of a coarse sandy clay, with the sand fraction being essentially quartzose and the clay fraction made up of decomposed feldspar. South of the American River, the scattered exposures are relatively fresh and unweathered. Rock types here are similar to those north of the American River with the addition of a small area of hard, resistant hornblende gabbro along Scott Road.

Yields of wells drilled into the granitic rocks are generally meager. Wells tapping the fracture systems may yield as little as one gallon per minute. Shallow wells drilled into areas of decomposed granite may expect only a few gallons per minute as an average yield. The quality of water derived from the fractures systems and from the decomposed granite generally is good to excellent.

Marine Sediments

There are only two areas of outcrop of marine sediments in Sacramento County. One is to the northwest of Folsom, in the vicinity of the intersection of Greenback Lane and Auburn-Folsom Road. The other is along Scott Road, north of Carson Creek.

At the Folsom location, the marine sediments are composed of fairly soft brown sandstone containing abundant mollusks and pelecypods, which indicate a Cretaceous age. The sediments here appear to have a stratigraphic thickness of about 50 feet and rest on an eroded surface of granitic rocks. They are overlain by volcanic sediments of Miocene age, indicating that this exposure is but an erosional remnant of a much thicker section of sediments at this location. The sediments along Scott Road are of similar lithology and also contain abundant fossils. They unconformably overlie the metamorphic rocks and are in turn overlain by Eocene sediments.

These marine sediments represent portions of the eastern edge of a Cretaceous wedge of sediments. To the west these sediments dip beneath the floor of the Great Valley and thicken appreciably. They attain thicknesses of upwards of 12,000 feet where they are exposed to the west in the Coast Ranges.

Although the Cretaceous sediments are somewhat permeable, wells tapping them would be expected to yield saline water. Exceptions may occur in areas of outcrop where flushing has removed the saline water and replaced it with fresh water derived from precipitation and runoff. In such limited areas these sediments may be expected to yield small quantities of fair to good quality ground water, suitable for most domestic purposes.

Water-Bearing Rocks

The formations comprising the water-bearing sequence range in age from Eocene to Holocene, and in lithology from sandstone to clay and conglomerate. The mode of origin is as varied as the lithology, as the sequence includes sediments of subaqueous and subaerial deposition as well as those of volcanic origin. Most, if not all of these water-bearing units yield moderate to copious quantities of water of good to excellent quality. Exceptions are certain beds which yield brackish water or water locally degraded by deleterious minerals. Also an exception are the massive volcanic beds which more closely resemble a nonwater-bearing rock due to their extremely low permeability.

Ione Formation

Location and Age. The Ione Formation, of middle Eocene age, is exposed in eastern Sacramento County from Carbondale Road north to Folsom. In this area the formation is present as low rounded hills, presenting a subdued topography. It unconformably overlies the older metamorphic and marine sedimentary rocks to the east. To the west it is unconformably overlain by younger sediments. In some areas of

younger sediments, it occurs as erosional windows along the bottoms of ravines. Similarly, toward the east bedrock areas are commonly exposed along stream bottoms in areas where the Ione is relatively thin. Near the eastern limit of the Ione, it also may occur as isolated outliers, capping hills composed of the older rocks. The Ione Formation is considered to be of Eocene age and to have been deposited contemporaneously with the auriferous gravels of the Sierra Nevada (Allen, 1929).

Lithology. The Ione Formation is divisible into three distinct members, only the upper two of which are exposed in Sacramento County. The uppermost member of the formation is composed principally of a uniformly graded, medium to coarse-grained quartz sandstone. This sandstone, which ranges from soft to very hard, diagnostically contains abundant flakes of white anauxite, a micaceous clay product derived from the weathering of Sierran granodiorite. Included with the sandstone, which is not everywhere present, are discontinuous lentils of white milky quartz. Stratigraphically, below the sandstone is a thick bed of white clay of ceramic quality. Like the sandstone, anauxite is abundant, indicating deposition in quiet water. In some areas this clay has been stained red to yellow. Where the staining is intense, the clay has become iron cemented and is present as ocher. The staining is derived from the precipitation of limonite from ground water moving from areas of deeply weathered bedrock. The deeply weathered areas were probably once extensive swamps and bogs which existed in a subtropical climate.

Although not exposed on the surface in Sacramento County, the Ione Formation also contains a thick lower member composed of blue to gray clay and occasional seams of brown coal and lignite. At the base of the formation is reported to be a zone of gravel composed of quartz and metamorphic fragments.

Structure. In outcrop, the Ione Formation appears to have a stratigraphic thickness of about 400 feet. As the exposed surface is one of erosion, it can be assumed that the original thickness of the formation was much greater. The Ione has a monoclinal dip of about 5 degrees to the west. In the subsurface it persists at least as far as the Sacramento River, when it apparently merges with contemporaneous marine sediments of the Domengine and other formations.

To the east the Ione is apparently contemporaneous with the Auriferous Gravels of the Sierra Nevada. In certain areas outside of Sacramento County, deposits of the Ione merge eastward with these gravels. Thus the mode of origin of the Ione appears to be of a deltaic and littoral, or near-shore nature.

Water-bearing Properties. In many areas of California the Ione Formation is considered to be nonwater-bearing. That is true because much of the formation was deposited in a marine environment. Deep

wells entering the marine portions of this formation yield water having chloride concentrations of as much as 775 mg/l and total dissolved solids content of up to 1,800 mg/l.

In the eastern part of Sacramento County, where the Ione deposits are of a near-shore or on-shore nature, the formation yields fresh to brackish water to wells. In these areas yields are low because of the low permeability of the Ione sediments. Well 9N/7E-36N1 has half of its perforated interval in the Ione Formation. On test the well yielded about 500 gpm and had a specific capacity of 8 gpm per foot of drawdown. In some areas north of Sacramento County wells drawing entirely from the Ione yielded only 50 gpm and had specific capacities of less than 3 gpm per foot of drawdown.

That the Ione Formation can provide water from great depths is demonstrated by Well 4N/7E-12A1, which intercepted fresh water-bearing Ione sands at depths of 1,341 feet and 1,540 feet.

Valley Springs Formation

Location and Age. The Valley Springs Formation is exposed along the eastern side of Sacramento County from the southeastern corner, along Dry Creek, northward to the headwaters of Carson Creek. The formation generally is exposed over an area of from one to two miles in width. Its widest exposure is along Arkansas Creek, where it is exposed for four and one-half miles from east of Ione Road west to the Cosumnes River.

The Valley Springs Formation is generally believed to be of middle Miocene age. Work by Piper and others [1939] suggested that portions of the formation may be as old as late Eocene or early Oligocene. Recent work by Schlemon [1967b] indicates that age dating by radiometric methods on samples of biotite and sanidine from this formation show a range of ages from 19.9 to 21.9 million years, which would place the age as late Oligocene to early Miocene. These dates are for the formation of the particles themselves and it is reasonable to assume that the age of deposition of these particles is somewhat later, making a middle Miocene age valid.

Lithology. The Valley Springs Formation typically exhibits a somewhat greenish cast to the clayey members. This, in addition to the presence of acidic volcanic ejecta, serves to distinguish it from the underlying nonvolcanic Ione Formation and the overlying basic volcanic units. The formation typically contains varying amounts of rhyolite ash, vitreous tuff, quartz sand containing abundant glass shards, and pale colored beds of ashy clay. Frequently sediments of the formation contain fragments of pumice, some of which may be as much as one-quarter inch in diameter.

The following table presents a measured section of the Valley Springs Formation as reported by Piper and others [1939]. The section is near Stone House School Road in the southwest quarter of the southeast quarter, Section 33, Township 8 North, Range 8 East, and represents the entire thickness of the formation at this locality.

Description	Thickness (in feet)
Mehrten Formation, fine andestic sandstone	46
Valley Springs Formation:	
Silt and clay, siliceous, greenish gray, thin discontinuous bed of conglomerate at top	26
Conglomerate, pebbles of metamorphics and shards of pumice in matrix of silt	6
Silt and clay, greenish gray, little pumice	11½
Gravel and coarse sand, chiefly greenstone and quartz; pumice common; bed not present to south	8½
Silt and clay, siliceous, greenish gray, little pumice	2
Concealed	13
Sand with thin beds of clay, greenish gray	8
Total thickness of Valley Springs sediments	75
Ione Formation, gray anauxitic sand	25

In the above section the elevation of the top of the Valley Springs is about 230 feet. The base of the measured section is about 25 feet above the bed of a creek.

Structure. The Valley Springs Formation lies unconformably over the older Ione Formation and metamorphic rocks. It dips west at a generally uniform rate of 1½ to 2 degrees. In the area of outcrop it has a stratigraphic thickness of at least 75 feet and in other areas it attains a thickness of about 125 feet. In the subsurface, certain wells have indicated a total thickness of about 200 feet of greenish gray sandy clay. The preserved thickness of the formation may not be the entire thickness deposited during Valley Springs time. As the materials are fairly easily erodable, a large part of the upper portion

of the formation may have been stripped off prior to the deposition of the overlying Mehrten Formation. This may account for the absence of this formation both in outcrop and in the subsurface in the northern part of Sacramento County.

Water-bearing Properties. In and near its areas of outcrop the Valley Springs Formation is considered to be a producer of good quality ground water. Yields are generally low due to the presence of clay and pumiceous materials which tend to lower the overall permeability. In the subsurface, much of the Valley Springs lies below the present depth of water wells. However, data developed by the U. S. Geological Survey shows that portions of the Valley Springs Formation lying below an elevation of -1,500 feet contain highly mineralized water not generally suitable for use. The source of this mineralized ground water is not presently known.

Mehrten Formation

Location and Age. The Mehrten Formation is exposed discontinuously along a broad belt in eastern Sacramento County. The belt extends from the south county boundary at Dry Creek, where it is four miles wide, to the north county boundary west of Folsom Lake, where it is less than a mile wide. In the subsurface, the Mehrten Formation extends westward from the area of outcrop at least as far as the Sacramento River. The formation is a major water producer in Sacramento County and is the source of much municipal water in the North Area. To the south, deeper irrigation wells draw in part from the Mehrten.

Based on radiometric dating of volcanic fragments in the Mehrten Formation, an age of middle Miocene to middle Pliocene has been estimated. As the lower portion of the formation is principally sedimentary in nature and thus composed of erosion products of prior volcanic activity, it would be reasonable to assume that much of the Mehrten Formation in Sacramento County is of early Pliocene age.

Lithology. The Mehrten Formation is divisible into two strikingly different units. One is a sedimentary unit composed of gray to black andesitic sands reported by well drillers as "black sand" and interbedded blue to brown clay. The other is a hard, gray tuff-breccia reported by well drillers as "lava".

The black sands generally are fairly soft and are well sorted. They were formed as fluvial deposits having been derived from andesitic detritus washed down the slopes of the mountains. Frequently laminated, the beds of black sand are commonly about five feet thick, although beds up to twenty feet or more have been reported. Where exposed in road cuts, these beds exhibit cross-bedding and foreset bedding, indicating a beach or deltaic mode of origin. Pebbles and cobbles of

hard andesite are common along certain horizons. These fragments are well rounded and are locally spoken of as "fossilized goose eggs".

Associated with the black sands are lenticular beds of stream gravel containing andesitic cobbles and boulders up to several feet in diameter. Also associated with the sands are beds of brown to blue clay and silt.

Near the base of the Mehrten Formation is a fairly thick bed, or series of beds, of hard gray sandstone. This sandstone is not over 25 feet thick and is even grained, being composed of quartz and dark minerals. The gray cast is given by grain coatings of authigenic montmorillonoid, a translucent fibrous clay. The clay coating has precipitated from solutions permeating the sandstone and probably was derived from the solution of andesitic rock fragments contained in parts of the sedimentary mass. Associated with the gray sandstone are thin, irregular beds of subaqueous laminated tuff which was deposited in bodies of quiet water. Some of the tuffaceous material was probably derived by reworking of the underlying Valley Springs tuffs.

The second major unit of the Mehrten Formation is the tuff-breccia. This rock is very dense and hard. It is composed of angular pieces and blocks of black, gray, and red fine-grained to porphyritic andesite which range from less than an inch to over several feet in diameter. The fragments are contained in a highly cemented ground mass composed of andesite lapilli and tan to gray ash.

The tuff-breccia was derived from andesitic eruptions to the east in the Sierra Nevada. During these eruptions, great quantities of highly mobile ash flowed down the then existing stream channels. In moving westward the ash picked up blocks of andesite debris which was incorporated into the mass. Moving into the valley, the mass spread out over the westward sloping plains and solidified as a pavement of hard, concrete-like rock which ranged from only a few feet to over 30 feet in thickness.

Flow patterns are readily evident where the upper surface of the tuff-breccia is now exposed. On this surface soil cover is scant or non-existent, with the blocks of andesite usually standing out in bold relief giving the appearance of a boulder-strewn field. Because of the nature of the rocky surface, runoff from precipitation is nearly 100 percent. The only infiltration is along thin vertical fractures which developed normal to the direction of flow.

The presence of the flat-lying beds of tuff-breccia gives rise to the many "haystack" hills or mesas commonly found in the eastern part of the County. The table lands, which have only a thin soil cover supporting annual grasses, have relatively steep sides composed of the underlying softer sediments. Intervening swale areas frequently contain a pavement of tuff-breccia representing an earlier episode of volcanism.

The following measured section of Mehrten sediments has been described by Piper and others [1939]. The section is located south of Stone House School Road in the Southwest Quarter of the Southeast Quarter, Section 33, Township 8 North, Range 8 East.

Description	Thickness (in feet)
Sandstone, dark gray, fine-grained, andesitic	7
Silt or clay, white, laminated	5
Sandstone and silt, dark gray, massive	24
Sandstone, very fine, laminated in beds 1/8-inch to 10 inches thick	10
Total thickness	46
Underlain by sediments of Valley Springs Formation	

Structure. In the area of outcrop the Mehrten Formation is about 200 feet thick. It dips westward at from one to two degrees. It also thickens to the west so that along the axis of the Great Valley, where it is essentially horizontal, it attains a thickness of from 400 to 500 feet. It may attain even greater thicknesses under the Sacramento-San Joaquin Delta area at MacDonald Island, where logs of gas wells indicate a thickness of about 1,300 feet of andesitic material.

The Mehrten Formation truncates all of the older formations and although being essentially conformable, overlaps them and progressively overlies older rocks to the east. In some areas a slight angular discordance has been reported but as it was less than one degree, it was hardly distinguishable.

After deposition of the entire Mehrten sequence, a long period of erosion ensued, resulting in a fairly rugged topography extending west to about the middle of Sacramento County. Younger sediments generally are deposited unconformably over this buried topography; but in certain areas, principally where Mehrten black sands exhibit cross-bedding and other aspects of stream deposition, younger materials interfinger and are deposited in a more conformable nature, indicating that axes of deposition during Mehrten time persisted into the later Laguna epoch.

Water-Bearing Properties. The Mehrten Formation provides copious quantities of ground water to many wells in Sacramento County. The water yielded by these sediments is generally of good to excellent quality.

It has been found that many wells derive their supply from the "black sands" reported on the drillers' logs. The tuff-breccias, or "lavas", conversely yield little water. Many wells bottom when the lava is reached. Wells that pass through the tuff-breccias reportedly have entered highly permeable materials and obtained large yields from the underlying sediments.

Because of the impermeable nature of the tuff-breccia and the low permeability of many of the clay beds, much of the water in the volcanic sands is in a state of semiconfinement. It has been reported that some of the deeper strata yield water of poor quality. Wells drilled by the Sacramento Natural Gas Company in 1892 and 1909 just south of Sacramento intercepted mineralized water below a depth of 1,500 feet, presumably in volcanic sediments of the Mehrten. It also was reported that the water was quite "gassy", possibly indicating the presence of methane.

Citrus Heights Irrigation District Well No. 2 (State Well 10N/6E-13N1) produces entirely from Mehrten sediments. It is reported that the well produces 1,000 gpm with a drawdown of 10 feet; the specific capacity is 100 gpm per foot of drawdown. Fair Oaks Irrigation District Well No. 2 (State Well 9N/7E-7H1) also produces from Mehrten volcanic sands. It yields 1,440 gpm with a drawdown of 31 feet; its specific capacity is 46 gpm per foot of drawdown. Citrus Heights Well No. 2 is an unusually good producer; however, Fair Oaks Well No. 2 is more nearly typical of wells producing from the Mehrten Formation.

Good production wells are not always obtained in the Mehrten Formation. Where most of the materials intercepted are sediments, production should be good, but where much of the strata is made up of tuff-breccia, yields are substantially less. This is illustrated by noting Well 9N/7E-12P2, located in the outcrop area of the Mehrten Formation south of Folsom. On test this well produced 20 gpm with a drawdown of 40 feet; the specific capacity was 0.5 gpm per foot of drawdown. Examination of the log of this well indicated that over half of the producing interval was tuff-breccia, and the remainder was reported as cemented volcanic sand and gravel.

Laguna Formation

Location and Age. The Laguna Formation is exposed in the eastern part of Sacramento County where it comprises much of the low, rolling foothills. In outcrop it extends northward from Dry Creek, where its area of exposure is about six miles wide, to its northernmost exposure, a road cut along Prairie City Road about one mile south of Highway 50. The Laguna Formation has not been identified north of the American River.

The Laguna Formation was deposited as a westward thickening wedge by consequent distributaries draining the Sierra Nevada. It rests conformably over the older Mehrten Formation, although irregularities in the eroded Mehrten surface may produce areas of local unconformities.

The age of the Laguna Formation ranges from late Pliocene to early Pleistocene. A portion of the formation has been identified as Pliocene based on the identification of an early Pliocene horse tooth obtained from a depth of 58 feet from Well 5N/7E-18H (Piper and others, 1939).

Lithology. The Laguna Formation is strikingly different from the underlying Mehrten Formation. Whereas the Mehrten Formation is andesitic in character and generally dark colored, the Laguna Formation is nonvolcanic and generally is a tan to brown in color. It is composed of a heterogeneous assemblage of beds of silt, clay, and sand with lenticles of gravel deposited on westward sloping floodplains by meandering, sluggish streams. Some of the sands are clean and well sorted; conversely, some of the gravels are extremely silty and poorly sorted.

The mineralogy of the particles in the Laguna Formation is decidedly granitic. Flakes of mica are locally abundant and serve as a distinguishing characteristic of much of the formation. The gravels are mostly from granitic and metamorphic rocks; little or no volcanics are present.

The nature of the sediments of the Laguna is locally variable. For example, in one area the formation consists of compact silt, clay, and lenses of poorly sorted gravel, sand, and silt. In other areas the Laguna contains sand with only a few interbeds of clay and silt.

The type locality of the Laguna Formation is on a southward facing bluff along Hadselville Creek, 3/4-mile northeast of Clay, in southern Sacramento County. Schlemon [1967b] presented the following measured section of the formation from its type locality in the northeast quarter of the northeast quarter, Section 25, Township 6 North, Range 7 East.

Description	Thickness (in feet)
Sand, medium grained, reddish-brown, granitic	39.9
Sand, medium grained, reddish-brown, abundant biotite, interbedded lenses of metamorphic pebbles	2.0
Sand, very coarse grained, red to reddish-brown, lenses laterally into granitic siltstone	6.5
Conglomerate, subrounded, quartzitic; coarse grained, granitic sand matrix; numerous scour and fill channels	5.2
Clay, reddish-brown, blocky	3.3
Siltstone, reddish-brown, slightly micaceous, weathers chalky gray	6.1
Sandstone, fine grained, gray, poorly sorted, slightly micaceous	5.5
Siltstone, granular, gray-brown	1.8
Total	70.3

The lower portion of the Laguna Formation is in gradational contact with the underlying Mehrten Formation. This gradational zone has been named the Laguna-Mehrten Transitional Zone by Schlemon [1967b]. In this zone beds of nonvolcanic, micaceous Laguna sediments are interbedded with volcanic Mehrten sediments. The type section of this transitional zone is along a cut on Dillard Road near the Cosumnes River Bridge in the southwest quarter of Section 1, Township 7 North, Range 7 East. The following measured section was presented by Schlemon from that location.

Description	Thickness (in feet)
Laguna Formation	
Sandstone, medium to coarse grained, gray-brown, granitic, slight cross-bedding	13.8
Siltstone, grayish-white	6.1
Laguna-Mehrten Transitional Zone	
Sand, coarse grained, black, poorly indurated, andesitic	1.7
Sandstone, very fine grained, grayish-white	0.2
Sand, fine grained, gray, massive, granitic, moderately indurated	5.1
Sand, fine grained, reddish-brown, granitic	1.8
Sand, fine grained, gray, massive, granitic, contains lenses of medium grained, micaceous sand	17.8
Sandstone, very fine grained, gray, granitic	0.8
Mehrten Formation	
Sand, very coarse grained, dark blue to black andesitic, strongly cross-bedded	12.3
Conglomerate, pebbles 2 inches in diameter, sand matrix coarse grained, granitic. Grades into gray very coarse grained andesitic sand	2.7
Silt, gray compact	2.8
Total	65.1

amphibolite, greenstone, and other metamorphic rocks belonging to the

Structure. The Laguna Formation laps eastward onto the Mehrten Formation. At only a very few localities does it directly overlie the older Valley Springs or Ione Formations. In its area of outcrop, the Laguna Formation is estimated to be not over 200 feet thick. It dips westward toward the trough of the Sacramento Valley at an average gradient of about 90 feet per mile, a slope of slightly less than one degree. In the subsurface the Laguna thickens to not over 400 feet. It apparently interfingers with the Tehama Formation near the axis of the valley.

Water-Bearing Characteristics. Where fine grained, the Laguna Formation will yield only moderate quantities of water to wells. In areas where soft, well sorted granitic sands predominate yields will be high.

Olmstead and Davis [1961] reported the yield of Well 6N/6E-2D1, which was 455 feet deep, as 1,840 gpm with a drawdown of 37 feet. The well produced nearly entirely from the Laguna and had a specific capacity of 50 gpm per foot of drawdown. The overall yield factor[1] of the well was 12. However, much of the saturated thickness was clay and the adjusted yield factor for the sand portion only was 67. From the yield factor, the permeability of the sand can be estimated to be in the range of from 1,000 to 1,350 gallons per day per square foot of material.

Recharge to the Laguna Formation is afforded both by streams crossing the outcrop area and by direct precipitation. Much of the Laguna is fairly fine grained, resulting in low recharge rates. In certain areas the coarse grained granitic sands outcrop and here recharge rates are expected to be fairly high.

Fair Oaks Formation

Location and Age. The Fair Oaks Formation is exposed in outcrop only to the north of the American River. Here it forms a broad area of rolling topography extending from the American River north to beyond the north county line and from Orangevale west to beyond the Southern Pacific Railroad. The formation was named by Schlemon from a type locality described along the bluffs near the old Fair Oaks Bridge.

Schlemon [1967b] states that the Fair Oaks is coeval with the upper part of the Laguna Formation and that it does not occur south of the American River except for some low gravel deposits described by him as "Upper Fair Oaks". Based on well log data collected during this investigation it would appear that the Fair Oaks Formation extends in the subsurface to the west at least as far as the Sacramento River and to the southwest as far as Florin Road and Stockton Boulevard.

[1]Yield factor: Specific capacity per unit thickness of saturated material times 100 (Thomasson and others, 1960).

The Fair Oaks apparently is early Pleistocene in age, although some of the lower portions may be as old as very late Pliocene.

Lithology. The Fair Oaks Formation is composed of poorly bedded silts, clays, and sands with occasional lenses of gravel. The sediments bear a strong resemblance to those of the Laguna Formation. A diagnostic feature of the Fair Oaks appears to be numerous beds of white to gray-white tuff and tuffaceous silts. These beds are up to one foot thick and are exposed in road cuts throughout the area of outcrop. No beds of a similar nature have been noted in the exposures of the Laguna Formation. Beds of this type appear to be a distinguishing feature of the Fair Oaks Formation.

In naming the Fair Oaks Formation, Schlemon [1967b] described the type section as found along the bluffs between the old Fair Oaks Bridge and the Sunrise Avenue Bridge in Section 13, Township 9 North, Range 6 East. The description of the type section is given below.

Description	Thickness (in feet)
Obscured, probably silt and sand	20.0
Buried soil horizon, sandy loam to clay loam, yellow-brown to dark brown	3.3
Siltstone, micaceous, yellow-brown	6.3
Sandstone, medium to coarse grained, gray-brown	5.9
Siltstone, light gray	1.8
Buried soil horizon, sandy loam to clay loam, yellow-brown to dark reddish brown	4.6
Siltstone, micaceous, subangular quartz grains, light gray	9.7
Sandstone, medium grained, granitic, micaceous, pale brown	2.4
Siltstone, some medium grained sand, micaceous, yellow-brown to light gray	5.9
Siltstone, micaceous, light gray, blocky	2.2
Siltstone, micaceous, light gray, weathered	9.2
Sandstone, silty, fine grained, light gray, cross-bedded	±25
Sandstone, fine grained, granitic, light gray	±25
Sandstone, fine grained, subangular quartz biotite, yellow brown	7.9
Clay, silty, light gray, ferruginous	17.5
Total	±146

Tracing of the Fair Oaks Formation in the subsurface has been accomplished mainly by correlating the numerous thin beds of white material. These are reported on logs of water wells as "white clay". Similar materials, reported on some logs as "dun clay" or "tan clay", may be the same beds. Well logs from the area of outcrop show quite a few horizons of the white clay, as do wells south of the American River from the vicinity of Mercy Hospital south to Florin Road.

Structure. The Fair Oaks Formation appears to have a generally westward dip of about 15 feet per mile. Local undulations in the bedding produce dips as great as one degree. With material this flat-lying, it is nearly impossible to get reliable attitudes and thus the tracing of beds from one outcrop to another is not always possible.

It appears that the Fair Oaks Formation is about 225 feet thick in its outcrop area. It apparently wedges westward and in the subsurface may be as much as 400 feet thick. It probably interfingers with the uppermost part of the Tehama Formation and/or the lowermost portion of the Red Bluff Formation near the central part of the valley.

Water-Bearing Characteristics. The water-bearing characteristics of the Fair Oaks Formation are similar to that of the Laguna Formation. Wells tapping only the Fair Oaks Formation yield up to 3,500 gpm with drawdowns on the order of 30 feet; specific capacities of such wells range from 80 to 120 gpm per foot of drawdown. Many wells in excess of 300 feet in depth also tap the underlying Mehrten Formation. Yields from these latter wells generally are in the same range as those which tap only the Fair Oaks Formation.

Arroyo Seco Gravels

Location and Age. The Arroyo Seco Gravels, which for this investigation include both the Arroyo Seco Gravels and the Gravels of Uncertain Age described by Piper and others [1939], occur as a thin veneer capping hills in the east-central part of Sacramento County. The gravels overlie sediments of the Laguna Formation and rise from an elevation of about 150 feet to over 320 feet at their eastern extremity. At a few locations sediments of the Mehrten, Valley Springs, or Ione Formations underlie the Arroyo Seco Gravels.

A broad area of Arroyo Seco gravels trends southwest from Folsom. This area is at most about three miles wide and extends nearly as far as Florin Road and Bradshaw Road. Southwest of that intersection several patches of Arroyo Seco Gravels cap a southward trending hill of Laguna sediments. This hill, called the Elk Grove Outlier by Schlemon [1967b], is the farthest west exposure of the Arroyo Seco. According to extensive work done by Schlemon [1967b], the Arroyo Seco Gravels appear to be of early Pleistocene age.

Lithology. The Arroyo Seco Gravels are composed of discontinuous beds and lentils of stream laid detritus. This material was deposited as a pediment, or constructional plain, by many rivers and streams of great competence which drained the Sierra Nevada during the middle and latter parts of the Plaistocene epoch.

The Arroyo Seco is easily distinguished from the underlying materials by the coarseness of the particles and the red color of the iron oxide cement. The Arroyo Seco is made up of well rounded pebbles and cobbles of dark colored metamorphic rocks (about 40 percent of total), weathered Mehrten andesite (about 30 percent of total) with lesser amounts of white quartz, dark chert, and other rocks. Occasional fragments of granitic rocks weathered to grus also occur. All of these rock fragments are contained in a matrix of iron-cemented granitic sand and clay.

Piper and others [1939] described a measured section of Arroyo Seco gravels from the west wall of a gravel pit near the Elk Grove Cemetery in the southeast quarter, Section 31, Township 7 North, Range 6 East.

Description	Thickness (in feet)
Sand, unsorted, fine to medium, with unsorted gravel	5
Sand, unsorted, fine to medium, iron-stained	5
Gravel, less than 1 inch, some cobbles to 4 inches in matrix of unsorted silty sand that is iron-stained	9
Total	19

Schlemon [1967b] measured a section of the Arroyo Seco Gravels on the north side of Jackson Road, 3/4-mile west of Sloughhouse in the southwest quarter of Section 34, Township 8 North, Range 7 East.

From the following it would appear that there were two episodes of pediment construction, separated by a period of normal sedimentation. Apparently to the east the upper and lower conglomerate members merge into one thicker unit. To the west the conglomerate members may separate and thus account for some of the varied "red sandy gravels" reported in well drillers' logs west of the area of outcrop of the gravels.

Description	Thickness (in feet)
Conglomerate, dark metamorphic, quartzite and chert; sand, coarse grained, red granitic	11.8
Siltstone, white blocky	5.5
Sand, medium grained, red, granitic, micaceous, slightly cross-bedded	10.9
Sand, medium to coarse grained, red, granitic, micaceous, noncalcareous cemented crust	2.9
Siltstone, reddish-brown, andesitic near base, weathers to variegated red and gray	0.8
Silt, gray, weathers blocky, grading to white clay near base	1.7
Sand, very fine grained, grayish-white, granitic	0.3
Sand, very fine grained, reddish-brown, granitic	4.5
Sand, fine to medium grained, thin stringers of quartzite and dark metamorphic conglomerate	8.0
Conglomerate, dark metamorphic and chert, angular, pebbles less than one inch diameter, coarse grained, reddish-brown granitic sand matrix	6.1
Total	52.5

Structure. The Arroyo Seco Gravels slope about 20 feet per mile in a direction that is about S60°W. They are slightly unconformable over the underlying materials, there being a discordance of about 80 feet per mile. The gravels range in thickness from about 50 feet as measured along Jackson Road, to 19 feet at the Elk Grove Outlier. It is reported that Well 7N/6E-8P1 went through 33 feet of hard gravel in a red sandy matrix.

Water-Bearing Characteristics. The Arroyo Seco Gravels are relatively unimportant as a source of ground water. This is because they are relatively thin and usually are located above the zone of saturation. In those portions of the valley where the gravels are within the zone of saturation, they would be expected to yield little water to wells because of their impermeable nature caused by their iron oxide cementation.

It is believed that the gravels have a low recharge potential because where exposed they exhibit soils having a high percentage of hardpan and thus would have low infiltration rates.

Gravels of Uncertain Age

Small areas of Gravels of Uncertain Age occur capping hilltops east of Folsom and at other localities in the eastern part of Sacramento County. These gravels are similar to the Arroyo Seco gravels, and in fact may be related to them. As no diagnostic evidence has been developed that definitely links them to any other gravel deposit in Sacramento County, they are termed as being of uncertain age.

Because these gravels are perched above the surrounding lowlands, they are considered as being nearly devoid of ground water. Thus, as they have no hydraulic connection with any water-bearing unit, they are of little importance to ground water in Sacramento County.

South Fork Gravels

Location and Age. A discontinuous belt of partially cemented channel gravels extends southwesterly from Mormon Island Dam nearly to Elk Grove. These deposits, herein named the South Fork Gravels, occur as a sinuous deposit which is about one mile in width. The gravels have previously been mapped by Schlemon [1967b] as three separate units, viz: South Fork American River Gravels, which occur in the area from Mormon Island Dam to Folsom; Arroyo Seco Gravels, which occur in the area north of the American River; and Upper Fair Oaks Formation, which occurs in the area from Mather Field southwest to Gerber Road. The deposits are herein concluded to have been deposited contemporaneously by the same river system due to the similarity of materials and the nearly even gradient from Mormon Island Dam to Elk Grove.

The age of the South Fork Gravels has not been definitely established. Based on correlation with adjacent materials, the gravels appear to be younger than the Arroyo Seco Gravels and older than the Victor Formation. This would place the South Fork Gravels as probably mid-Pleistocene in age.

Lithology. The South Fork Gravels are composed of deposits of rounded pebbles and cobbles in a medium to coarse grained granitic sand matrix. Surface soils on this unit are mostly in the Corning series which is identified by a dark reddish-brown color and an absence of a hardpan layer. Some sandy micaceous clays are present as a binder to the larger fragments.

Structure. The South Fork gravels have an upper surface that slopes from 5 to over 20 feet per mile. In the vicinity of Mormon Island Dam, the gravels trend southerly, being situated in a dry valley formed in pre-Cretaceous rocks. Here the slope is about 5 feet per mile, which can be assumed to be about the original gradient of the river which once occupied the valley. About a mile south of Mormon Island Dam, the channel of this river turns to the west and the gradient increases to about 20 feet per mile. This steeper gradient undoubtedly has been produced by subsequent westward tilting of the Sierran block. South of the American River, where the channel gravels again trend toward the south, the gradient decreases to a uniform 7 to 10 feet per mile.

Water-Bearing Characteristics. Areas of South Fork gravels north of the American River and in the vicinity of Folsom are relatively unimportant as sources of ground water. This is due to their relative thinness, the presence of clay and iron cement which reduces their overall permeability, and the lack of any appreciable areas for recharge. Local supplies of ground water may be produced from the South Fork gravels in areas along Blue Ravine Road. Here the gravels appear to be about 50 feet thick and in some areas may produce sufficient water for domestic uses.

South of the American River the South Fork gravels are recharged from the tailings deposits found near Nimbus. Downstream from this point some ground water flows through the gravels. Although not very thick, the gravels are of sufficient thickness and permeability to produce domestic supplies of ground water to shallow wells.

Victor Formation

Location and Age. The Victor Formation underlies a broad alluvial plain, termed the Victor Plain, which occupies the central portion of Sacramento County from Dry Creek north to the northern county line. In the vicinity of Elk Grove, the Victor Plain is about 10 miles wide from west to east. To the east it laps onto older materials composed of the Laguna Formation and the Arroyo Seco Gravels. To the west it is in turn overlain by younger alluvial materials. North of the American River the Victor Plain is only about 5 miles wide. Here it laps eastward onto sediments of the Fair Oaks Formation. To the west it dips beneath the American Basin and surfaces near the Sacramento River as a low ridge having a maximum elevation of 26 feet.

The City of Sacramento is situated on the Victor Plain and in this locality the sediments of the Victor Formation extend westward to the Sacramento River.

The Victor Formation was deposited on a plain of aggradation that has been partly dissected. The upper surface of this plain, in most places, represents the upper surface of the Victor Formation. Streams cutting

across the plain have cut trenches into it in which sediments of Holocene age have been deposited.

The upper surface of the Victor Formation is characterized by a gently undulating surface. Local variations in relief are as much as 15 feet, such as along Poverty Ridge and at Whisky Hill in Sacramento.

The age of the Victor Formation ranges from middle to late Pleistocene. It is probably correlative to the Donner Lake advance of Sierran glaciation. Three fossils have been reported from the Victor Formation. Piper and others [1939] reported the finding of the left shoulder blade (scapola) of a Pleistocene horse (Equus?) at a depth of 17½ feet in a gravel pit 1½ miles north of Elk Grove in the northeast quarter of the southwest quarter, Section 30, Township 7 North, Range 6 East. Schlemon [1967b] reports the finding of Pleistocene horse teeth (Equus) and a femur from a Pleistocene camel (Camelops) from a gravel pit north of Jackson Road in the north half of the southwest quarter, Section 13, Township 8 North, Range 5 East.

Lithology. The Victor Formation is composed of interbedded granitic sand, silt, and clay with lenses of metamorphic channel gravels. The lithology bears a striking similarity to that in the Laguna and Fair Oaks Formations, making it nearly impossible to differentiate the formations on the basis of well log data. The lithology of the Victor is heterogeneous and laterally and vertically discontinuous, indicating a fluviatile environment. The apparent extreme variability of grain size also is the result of many intricately braided stream channels. For this reason it is usually not possible to correlate from well to well, even though well spacing may be as close as 1,000 feet.

Well log data indicate that the grain size in the Victor Formation tends to decrease toward the west. The percentage of reduced clay also increases toward the west, suggesting a mode of deposition in a shallow body of water.

The surface soils of the Victor Formation diagnostically contain a layer of hardpan. The occasional stringers of gravel contain an average of 80 percent dark metamorphic gravels and less than 5 percent each of quartzite, light metamorphics, dark igneous, and chert.

Structure. The Victor Formation has a homoclinal dip of about 5 feet per mile toward the west along its uppermost surface. This surface is assumed to represent the top of the formation. The base of the formation dips westward at about 11 feet per mile, indicating a gradual wedging to the west. Throughout most of Sacramento County the Victor Formation is up to 90 feet thick. To the west, where it dips beneath a cover of younger materials, it probably attains thicknesses of about 150 feet.

Water-Bearing Properties. The Victor Formation has a moderate overall permeability. Most of the domestic and shallow irrigation wells located on the Victor Plain draw from this formation. The Victor frequently has a higher permeability than the underlying Laguna sediments.

Alluvial Sequence

The alluvial sequence, of Holocene age, is divisible into six separate units. The various units occur along present stream channels and also underlie the islands of the Sacramento-San Joaquin Delta. Certain alluvial units also occur in other areas of recent sedimentation such as the American Basin. Each of these units is briefly described below.

Floodplain Deposits. Unconsolidated deposits of clay, sand, and silt occur as floodplain deposits adjacent to the Sacramento River. The deposits were formed from winter overwash of the river and are part of the natural sedimentation taking place in the Sacramento Valley. These deposits overlie sediments of the Victor Formation and are at most about 50 feet thick.

Basin Deposits. Basin deposits, consisting of unconsolidated beds of clay, occur under the American Basin and at other localities in the western part of Sacramento County. The deposits were formed in local sink areas and represent the finest grained materials deposited from winter overwash. The deposits interfinger with the floodplain deposits; they overlie the Victor Formation.

Muck and Peat. Deposits of muck, peat, and related organic clay occur in nearly all of the islands of the Sacramento-San Joaquin Delta. Although containing a moisture content upwards of 200 percent, the deposits are of very low permeability. They were formed in backwater areas at or near sea level and represent an accumulation of tules, reeds, and other vegetative matter. The deposits commonly overlie the Victor Formation. Near the central part of the Delta they may overlie river deposits or other alluvial materials of varying permeability.

Sand Deposits. Isolated deposits of aeolian sand occur throughout the Delta area. These deposits are composed of wind-blown river sand that is heaped into small dunes. The deposits are usually underlain by alluvial or organic sediments. They are highly permeable and provide infiltration areas for precipitation.

Stream Channel Deposits. Deposits of unconsolidated sand and gravel occur as streambed deposits and point bar deposits. The deposits overlie those of the Victor Formation, as well as other alluvial materials.

Being generally very permeable, the deposits afford large areas for infiltration of surface water to the ground water body.

Valley Alluvium. Stringers of valley alluvium extend along the many westward draining stream courses. These materials, such as found along the Cosumnes River and along Dry Creek, consist of unconsolidated deposits of sand, silt, clay, and occasional lenses of water-worn gravel. Permeabilities vary from fairly high to low, and in certain areas the valley alluvium acts as an important recharge area for percolating surface water to enter the ground water body.

Gravel Pits

Gravel pits are located throughout Sacramento County. The greatest concentration is in the area of Perkins, where Teichert Aggregates and other operators maintain gravel extraction plants. The opening of a gravel pit entails the stripping off of a cover of Victor Formation materials, usually about 10 to 15 feet thick. Beneath this cover is a deposit of river gravels that at places is up to 75 feet thick. The gravels are composed of well rounded particles of acid intrusive, basic intrusive, and volcanic rocks which grade from sand size to over 6 inches in diameter. The deposits were formed in the various channels of the American and other rivers as they meandered over the Victor floodplain.

Gravel pits are important as possible artificial recharge areas. Because of their high natural infiltration capacity, they should be ideal for the recharge of water to the ground water body. Although gravel pits tend to silt up on the bottom, high infiltration rates through the sides of the pits are maintained long after the recharge rate through the bottom of the pit has been reduced.

Tailings

Deposits of tailings occur south of the American River near Nimbus and at other scattered localities in the central and eastern portions of Sacramento County. The largest single expanse of tailings extends from near Folsom southwesterly nearly to Mather Air Force Base, a distance of about 12 miles; it has a width which ranges from 1 to 4 miles and covers an estimated 12,000 acres. These tailings are the result of gold dredge operations and consist of windrows of gravel, cobbles, boulders, sand, and silt. Tailings are considered to be quite pervious and, as such, should make an excellent recharge area. Also, being permeable, they are good sources of ground water in spite of the fact that it may be extremely difficult to construct a well thereon due to the presence of numerous cobbles and boulders.

Geologic Structure

Sacramento County is situated on the eastern side of the structural trough which makes up the Great Valley. To the east is the Sierra Nevada, a block mountain range which has been tilted upward on the east and dips westward beneath the Great Valley. To the west of the Great Valley are the Coast Ranges, a complexly folded and faulted mountain range oriented nearly parallel to the axis of the Great Valley.

The Great Valley is a large structural basin which has become filled with sedimentary rocks ranging from early Cretaceous to Holocene. The older rocks have become uplifted and deformed to the west of the valley and now form the eastern part of the Coast Ranges. The valley trough is asymmetrical; the deepest part of the basin is near the western edge, west of the present axis. The valley deposits thin eastward and overlap the crystalline basement complex rocks of the Sierra Nevada block.

Throughout Cretaceous time and during most of the Tertiary, the axis of thickest marine sedimentation was to the west of the present axis of the valley. A westward projection of the slope of the Sierra Nevada basement complex suggests that the marine sediments may be more than 20,000 feet thick along the southwestern margin of the valley. Here the Cretaceous sediments are estimated to be at least 10,000 feet thick. Post-Cretaceous marine rocks, mostly Eocene in age, are about 3,000 feet thick, although exposures some 7,000 feet thick occur in the Coast Ranges to the west. Post-Eocene sediments in the valley are mostly nonmarine. They are about 3,000 feet thick, but in places may attain thicknesses of about 4,000 feet.

All of the sediments of the Sacramento County portion of the Great Valley have a uniform westerly dip. Dips range from as much as 300 feet per mile to as little as 5 feet per mile. The sediments in this area are essentially devoid of either folds or faults. The only feature that can be attributed to folding is a somewhat indistinct monoclinal feature having a northwesterly orientation located to the east of Roseville. This feature, which is identifiable only on the basis of examining the gradients of the ancestral channels of the American River, appears to have a southwesterly dip which changes from 60 feet per mile to 100 feet per mile across the inferred monoclinal axis. Whether this is truly a monoclinal feature or is an apparent change in fall of the river cannot be determined at this time. There apparently are no major faults transecting Sacramento County.

Subsurface Geology

The identification of horizontal and vertical boundaries of aquifers is extremely difficult in most alluvial-filled valleys of California. In the past this identification has been accomplished only on a gross scale and has been derived through the construction of geologic sections using drillers' logs of water wells as well as electric logs of oil and gas wells. Using this method, generalized formational boundaries and member boundaries can usually be determined.

This method of analysis does not provide the degree of detail that is required for operational studies of ground water basins, particularly those in which older buried stream channels provide the media through which the major portion of

ground water moves. Consequently a new approach utilizing computer methods developed to determine the continuity of the various aquifer systems present in Sacramento County. In the construction of a depositional feature such as the Sacramento Valley, the contributing streams have meandered back and forth across the surface of the valley, depositing stream-borne materials which range in size from coarse gravel and boulders down to clay. During periods of normal runoff, a stream course is established which contains the coarsest grained materials. These materials grade from large gravels and boulders near the foothills to sand and silt near the axis of the valley. Adjacent to the stream channel are clays and silts which grade outward to even finer grained materials. Periodically, during periods of storm runoff, a stream will abandon its course and seek a new route. It also may meander over short distances of less than a thousand feet, thus forming braided channel deposits. In time, as deposition continues, the abandoned stream channels become covered with younger materials. These materials usually are fine grained, thus isolating the old stream channel and converting it into a tabular aquifer. In a few cases younger stream channels may form along or across older channels, thus creating areas of hydraulic continuity between different channel deposits. In a few cases the older, buried channels may subsequently become warped or cut off due to regional tilting or faulting.

In Sacramento County a special program was developed to utilize information on the subsurface materials derived principally from logs of water wells. In analyzing these logs it was found that the "calls" used by various drillers differed for the same material. It also was found that drillers' calls may be grouped, and thus a statistical analysis may be made based on these calls. The same approach was used by the U. S. Geological Survey, which grouped the drillers' calls by specific yield values in its study of the San Joaquin Valley. This grouping of calls, modified for the Sacramento County area, is presented on Table 2. The steps in the geologic analysis which utilized this grouping are briefly described below.

1. The deepest well per quarter-quarter section (a one-quarter mile spacing) in the study area was identified and the values of the equivalent specific yield (ESY) tabulated for each material reported on the log. Equivalent specific yield is defined as being equal to the specific yield of a given material under unconfined conditions. The ESY of a material is a pure number and remains the same whether the material contains ground water under confined or unconfined conditions, as it relates to the relative grain size and not to the quantity of ground water which could be derived from it.

2. The ESY values were averaged for 10-foot increments of elevation for each well used.

3. The averaged ESY values were then converted to symbolic form for utilization in graphic presentation. Four symbols were used which represent the main types of depositional material:

Symbol	Range of ESY Values	Typical Material
.	1 to 7	Clay and Silt
-	8 to 12	Clay with Fine Sand
+	13 to 17	Sand with Clay Streaks
0	18 to 25	Gravel and Coarse Sand

TABLE 2

SPECIFIC YIELD VALUES
FOR DRILLERS CALLS

General Material Type and Specific Type	Drillers Calls		
Crystalline Bedrock Specific Yield = 00 Percent	Granite Lava	Hard Rock Rock	
Clay and Shale Specific Yield = 03 Percent	Adobe Boulders in Clay Cemented Clay Clay Clayey Loam Decomposed Shale	Granite Clay Hard Clay Hard Pan Hard Sandy Shale Hard Shell Muck Mud	Shale Shaley Clay Shell Rock Silty Clay Loam Soapstone Smearey Clay Sticky Clay
Clayey Sand and Silt Specific Yield = 05 Percent	Chalk Rock Clay and Gravel Clayey Sand Clayey Silt Conglomerate Decomposed Granite Gravelly Clay Lava Clay Loam	Peat Peat and Sand Pumice Stone Rotten Conglomerate Rotten Granite Sand and Clay Sand and Silt Sand Rock Sandstone	Sandy Clay Sandy Silt Sediment Shaley Gravel Silt Silty Clay Silty Loam Silty Sand Soil
Cemented or Tight Sand or Gravel Specific Yield = 10 Percent	Arcade Sand Black Blue Sand Caliche Cemented Boulders Cemented Gravel	Cemented Sand Cemented Sand and Gravel Dead Gravel Dead Sand Dirty Pack Sand Hard Gravel	Hard Sand Heavy Rocks Lava Sand Soft Sandstone Tight Boulders Tight Coarse Gravel Tight Sand
Gravel and Boulders Specific Yield = 15 Percent	Cobbles and Gravel Coarse Gravel Boulders Broken Rocks	Gravel and Boulders Heaving Gravel Heavy Gravel Large Gravel	Rocks Sand & Gravel, Silty Tight Fine Gravel Tight Medium Gravel Muddy Sand
Fine Sand Specific Yield = 15 Percent	Fine Sand	Quicksand	Sand, Gravel, and Boulders
Sand and Gravel Specific Yield = 20 Percent	Dry Gravel Loose Gravel	Gravelly Gravelly Sand Medium Gravel	Sand and Gravel Sand Water Gravel
Coarse Sand and Fine Gravel Specific Yield = 25 Percent	Coarse Sand	Fine Gravel	Medium Sand Sand and Pea Gravel

Based on Geological Survey Water Supply Paper 1469, "Ground Water Conditions and Storage Capacity in the San Joaquin Valley, California", 1959.

4. The symbolic ESY values then were plotted on maps having a horizontal s of 1 inch equals 4,000 feet for each 10-foot elevation increment from interval +150 to +140 feet down to -280 to -290 feet. Values were plotte for each 20-foot increment of elevation from the interval -290 to -310 fe down to -450 to -470 feet. Using 20-foot increments for the deeper interv was necessitated by a lack of well data. Each of these incremental maps then was printed on transparent media and prepared for viewing and analys

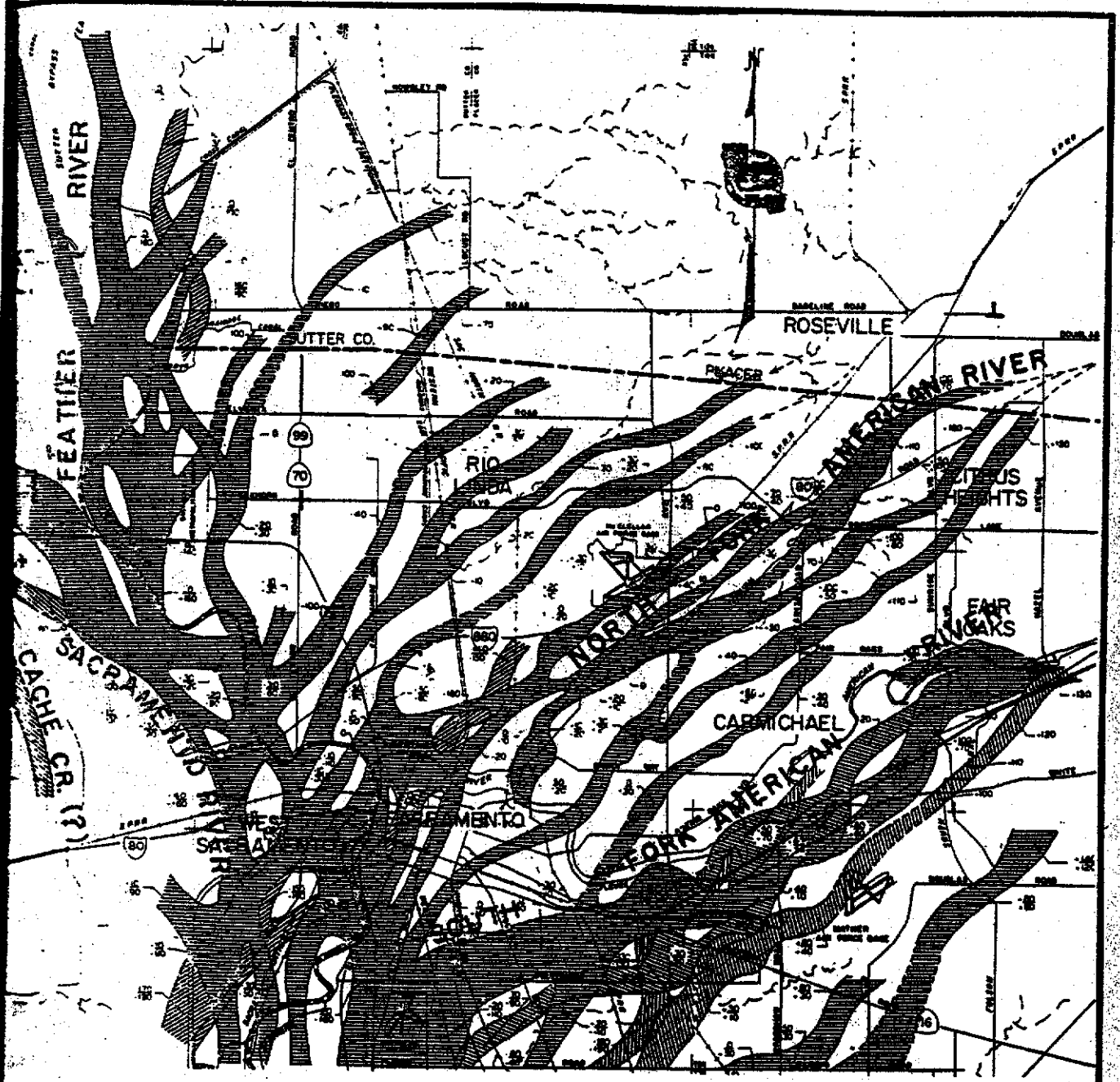
5. Geologic interpretation of the several maps was then made by stacking ther in ascending order of elevation. By viewing the maps from above, the tra of the buried stream channels could be seen meandering down through the various levels. Also, areas of fine grained material could be identified as well as zones of hydraulic continuity between various levels.

The water-bearing sequence beneath Sacramento County is divisible into two main sections. The superjacent, or upper series, is composed of the Fair Oaks, Lag and Victor Formations, as well as the overlying Holocene deposits. The subjac or lower series, is composed of the Mehrten Formation and those water-bearing materials underlying it (Valley Springs and Ione Formations). Separating the two series is a buried erosion surface of moderate to strong relief representi a hiatus which took place between deposition of the Mehrten and the Laguna and Fair Oaks Formations. This time interval of the hiatus is estimated to be on the order of from 3 to 5 million years.

Superjacent Series

The superjacent series includes the Laguna, Fair Oaks, and Victor Formations well as all Holocene deposits. These materials constitute a water-bearing sequence that is hydraulically isolated from the deeper aquifers. Contained in the superjacent series are a number of now-buried stream channel deposits. The deposits, which are composed of permeable sand and gravel, are enclosed by less permeable silt and clay. This has resulted in a network of meandering tabular aquifers. Figure 3 shows the areal distribution of many of these buried stream channels. The geologic cross-sections shown on Figure 4 depict the channel deposits as they are distributed vertically.

Throughout all of post-Mehrten time the Sacramento Valley has been undergoing aggradation which has resulted in a thick sequence of materials deposited by meandering, braided stream channels separated by intervals of fine grained, rel tively impervious materials. These channels, which have high transmissivities, are composed of sand, gravel, cobbles, and occasionally boulders. They were formed by streams draining the Sierra Nevada during both glacial and interstadia periods. During glacial times streams were vigorously aggrading and created channel deposits which were up to 5,000 feet across and several hundred feet de In periods such as this, coarse detritus was the rule for streams draining the mountains. Deposits of gravel extended into the valley, and thick sand deposit interbedded with fine glacial flour extended even farther. During interstadial times rivers were of smaller consequence and had less bed load. The various ri systems identified during the study are shown on Figure 3. Each is briefly discussed below.



LEGEND

0 / -30 Stream channel deposits showing elevation of top and bottom of deposit.

Figure 3, SUPERJACENT STREAM CHANNEL DEPOSITS
Sheet 1 of 2

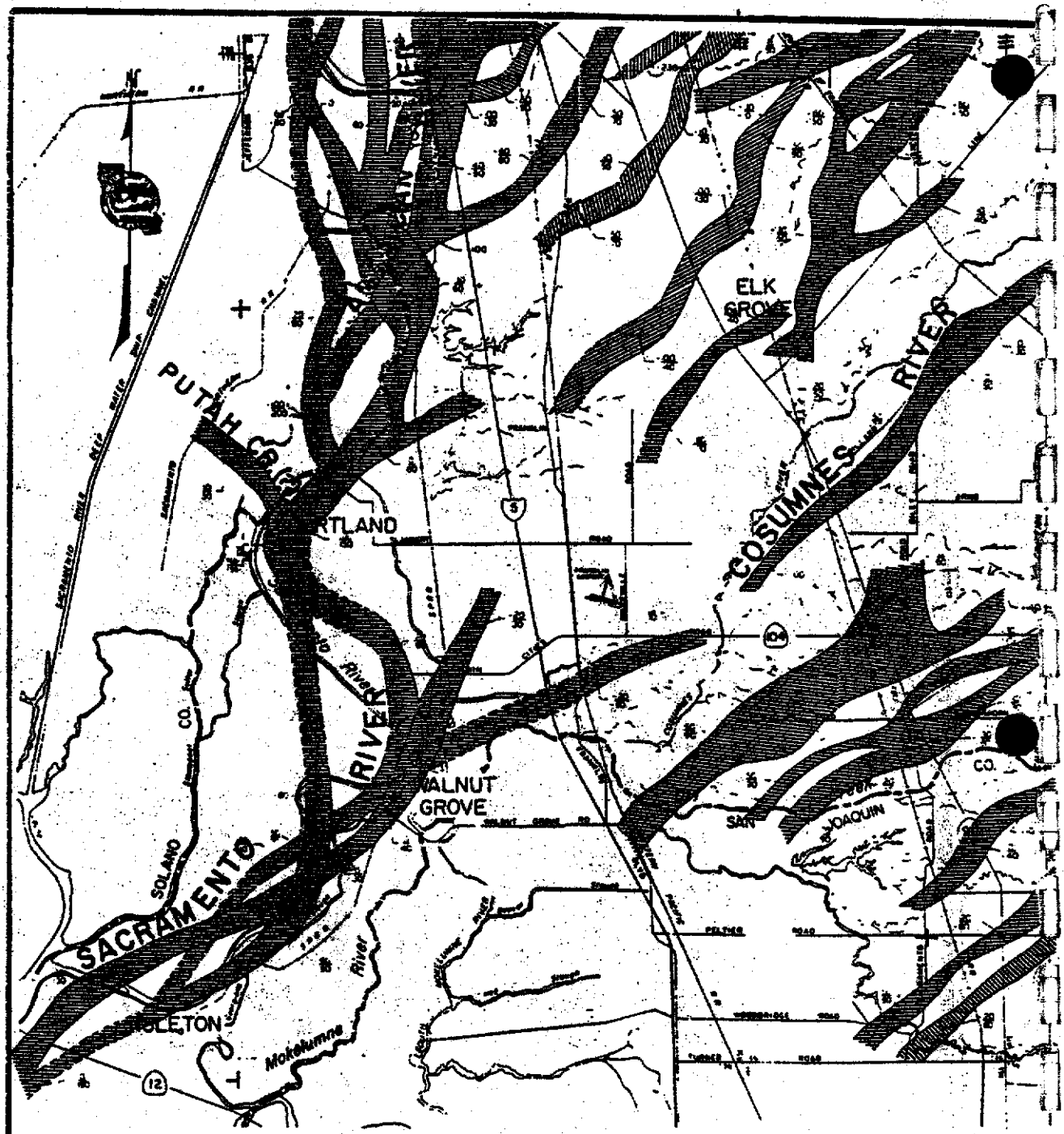


Figure 3, SUPERJACENT STREAM CHANNEL DEPOSITS
Sheet 2 of 2

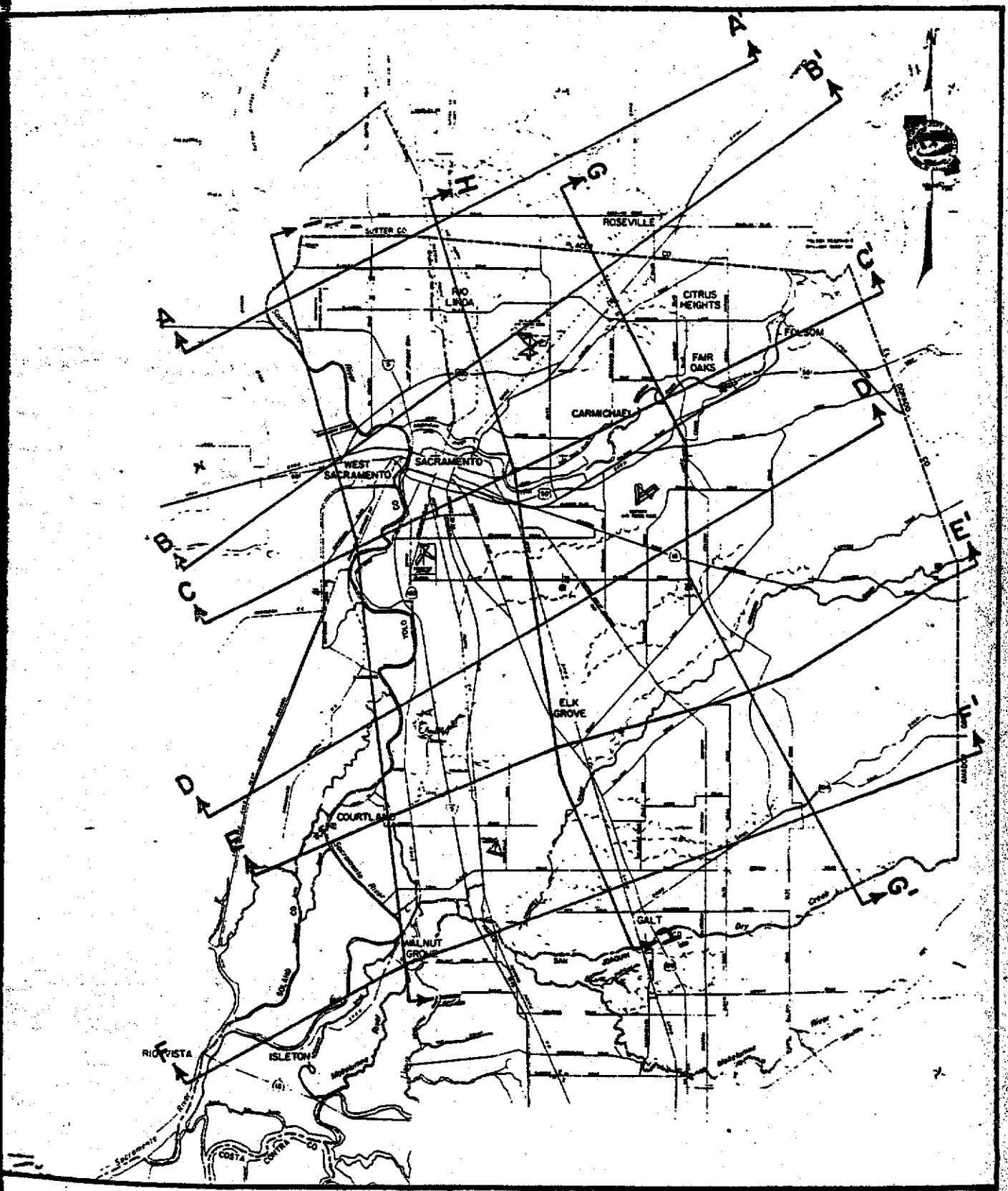
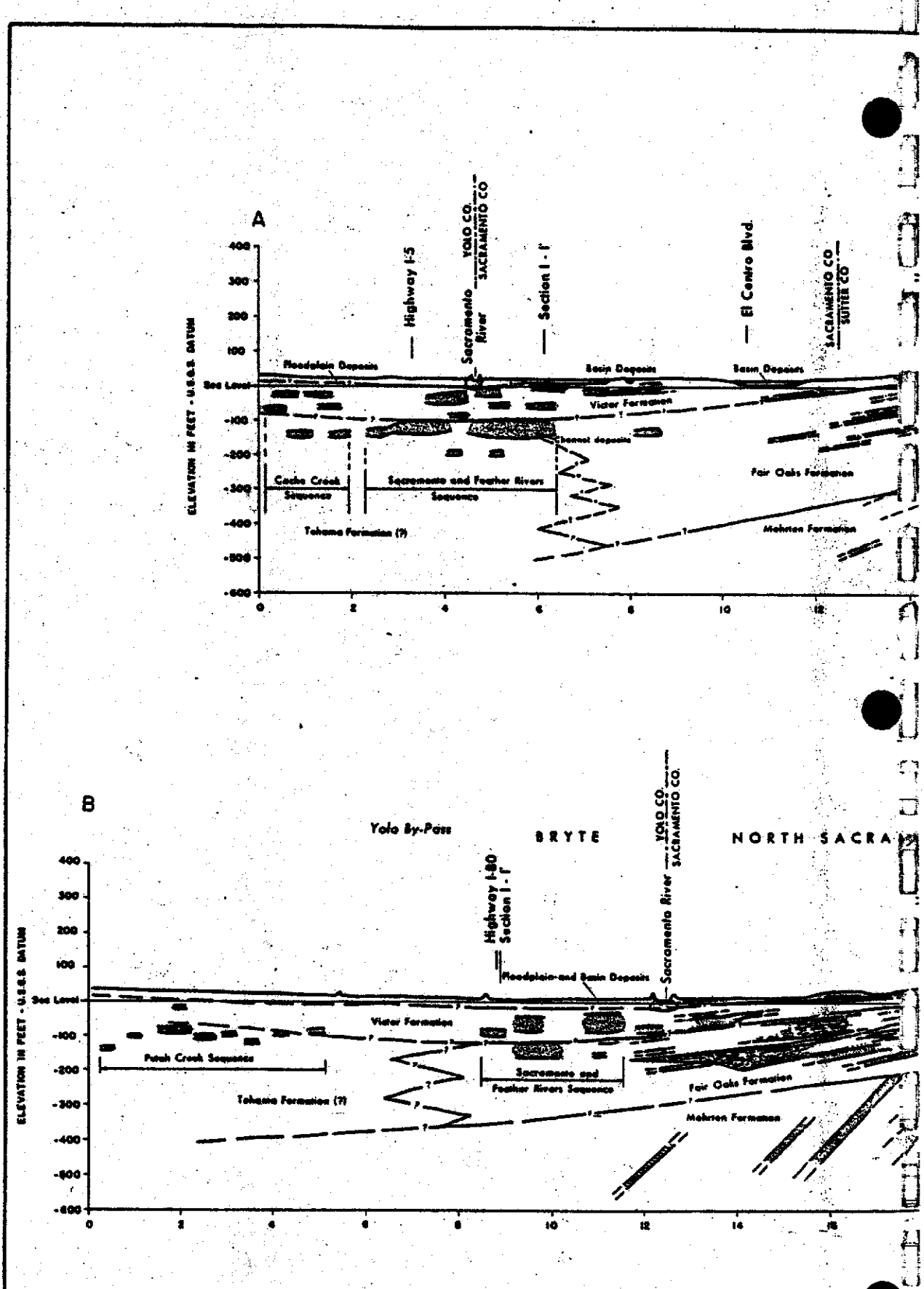
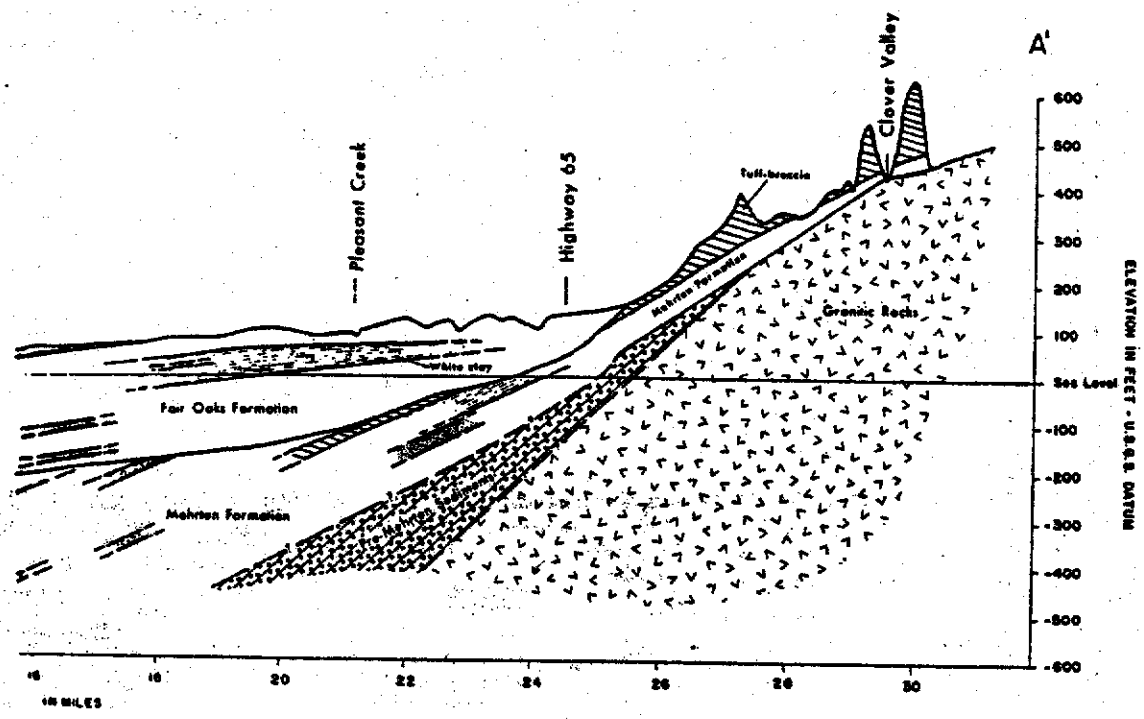


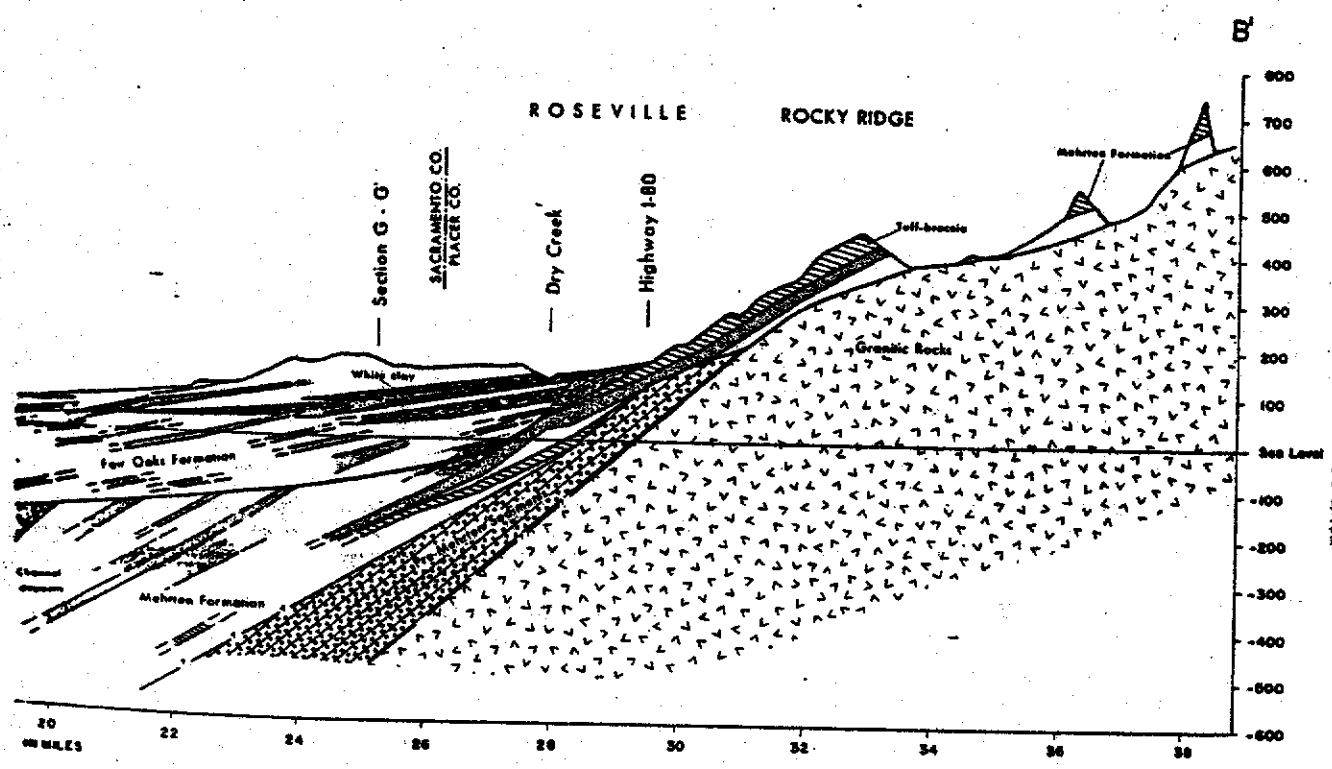
Figure 4, GEOLOGIC SECTIONS-SACRAMENTO COUNTY INDEX SHEET



GEOLOGIC SECTION

See Plate 1 for locations of sections.

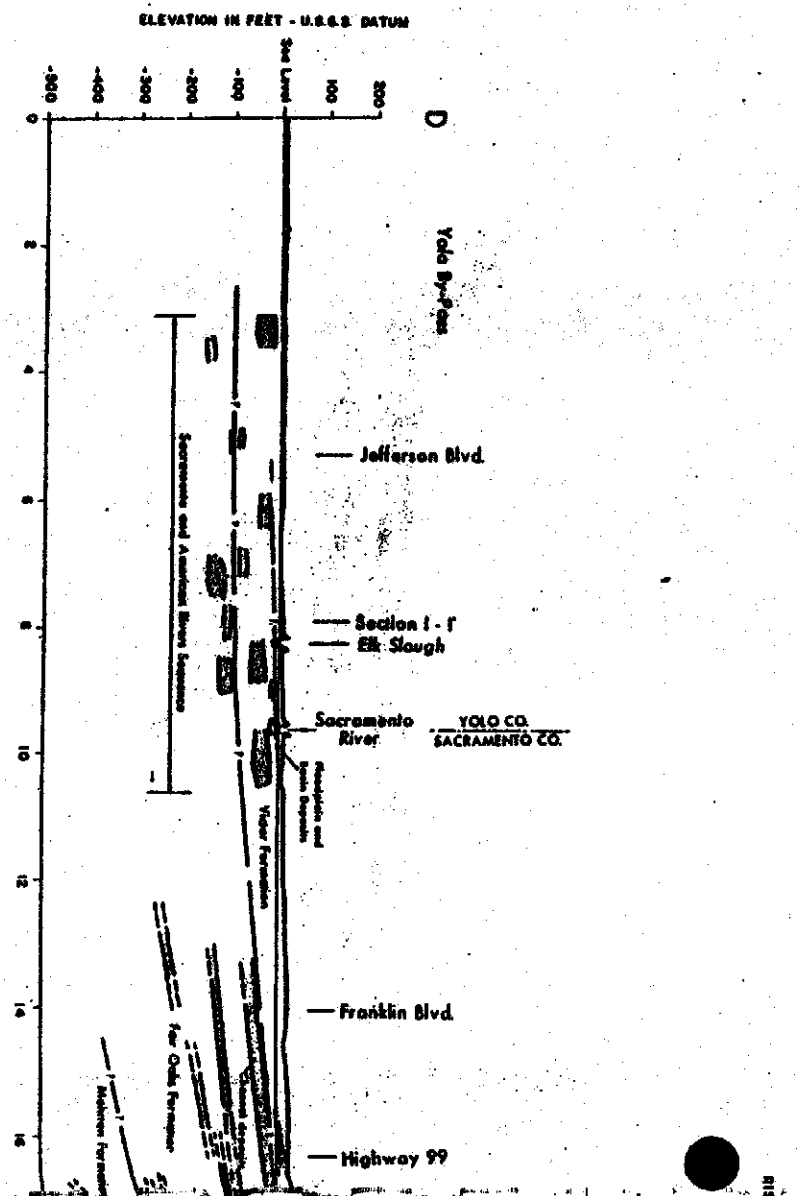


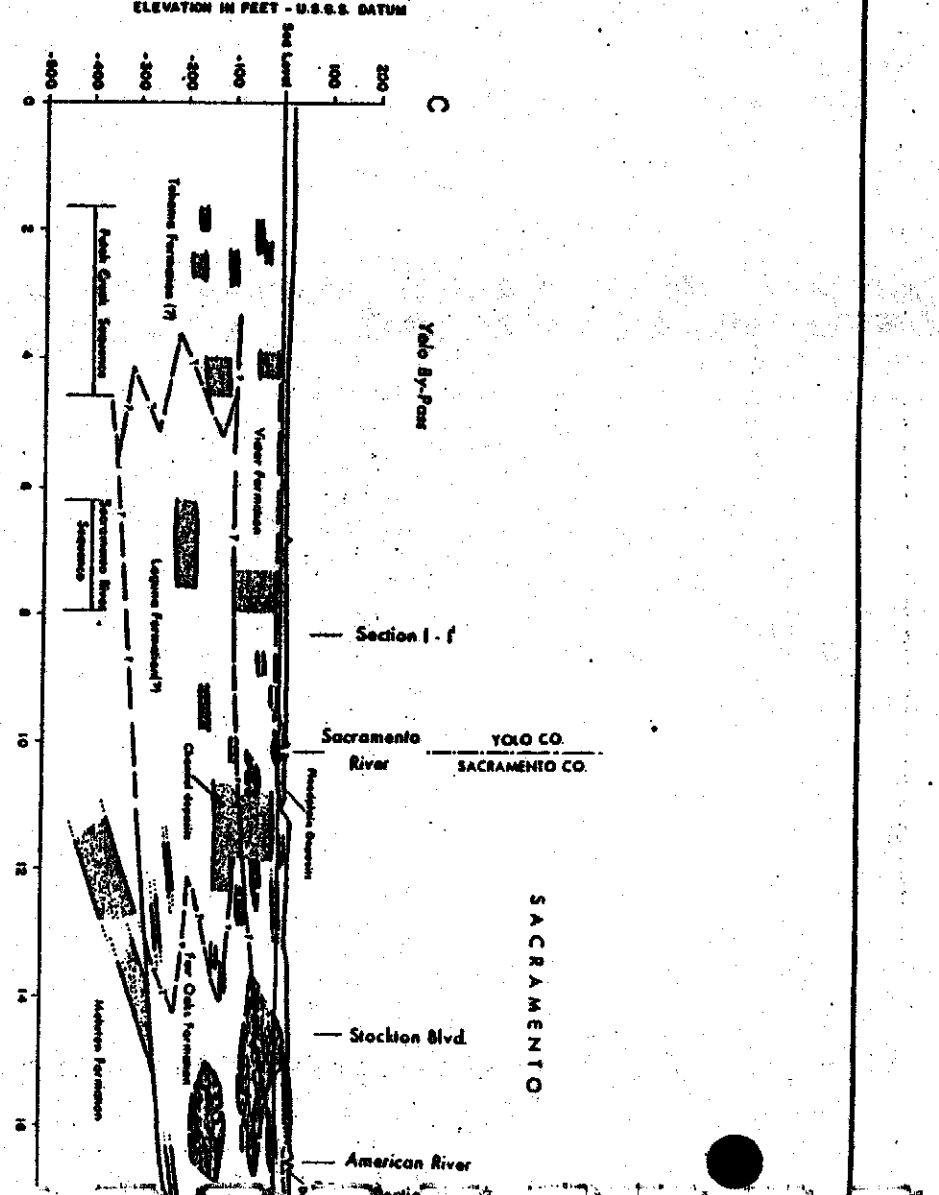


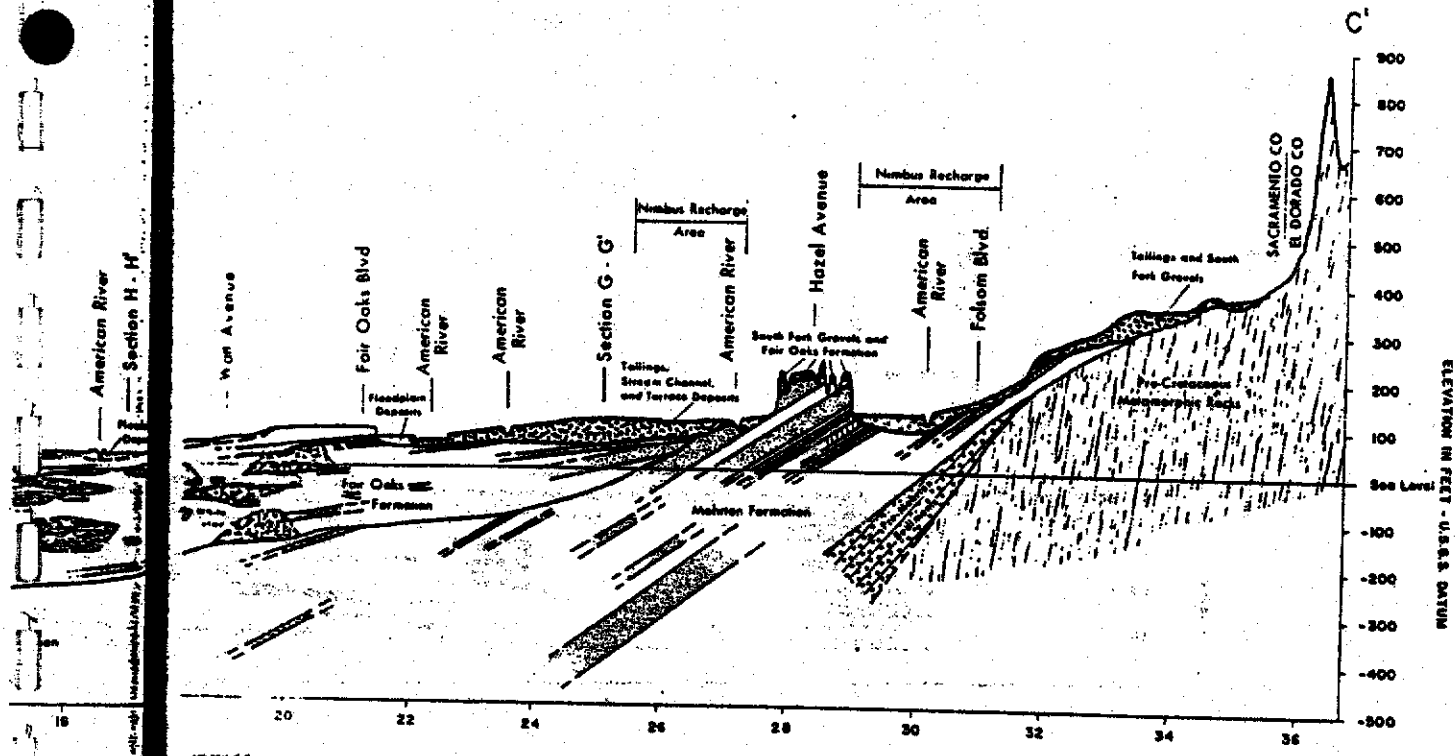
SACRAMENTO COUNTY

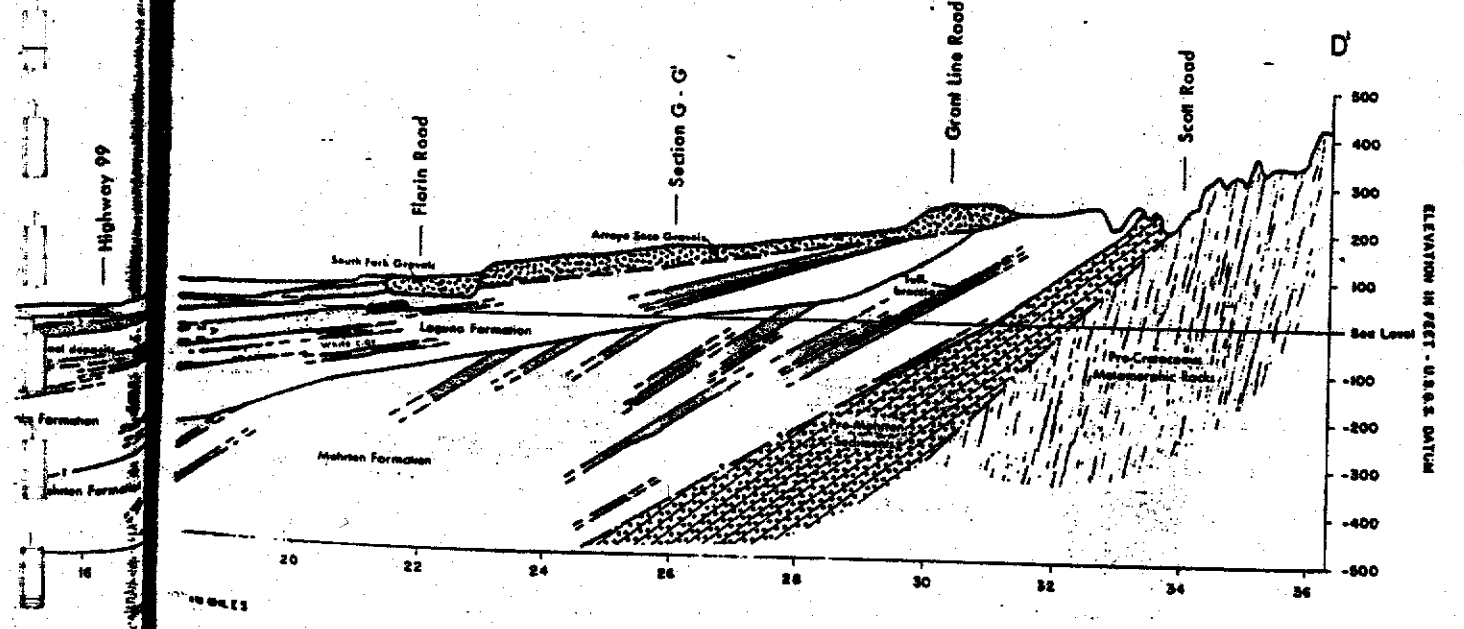
GEOLOGIC SECTIONS

See Plate 1 for locations of sections.

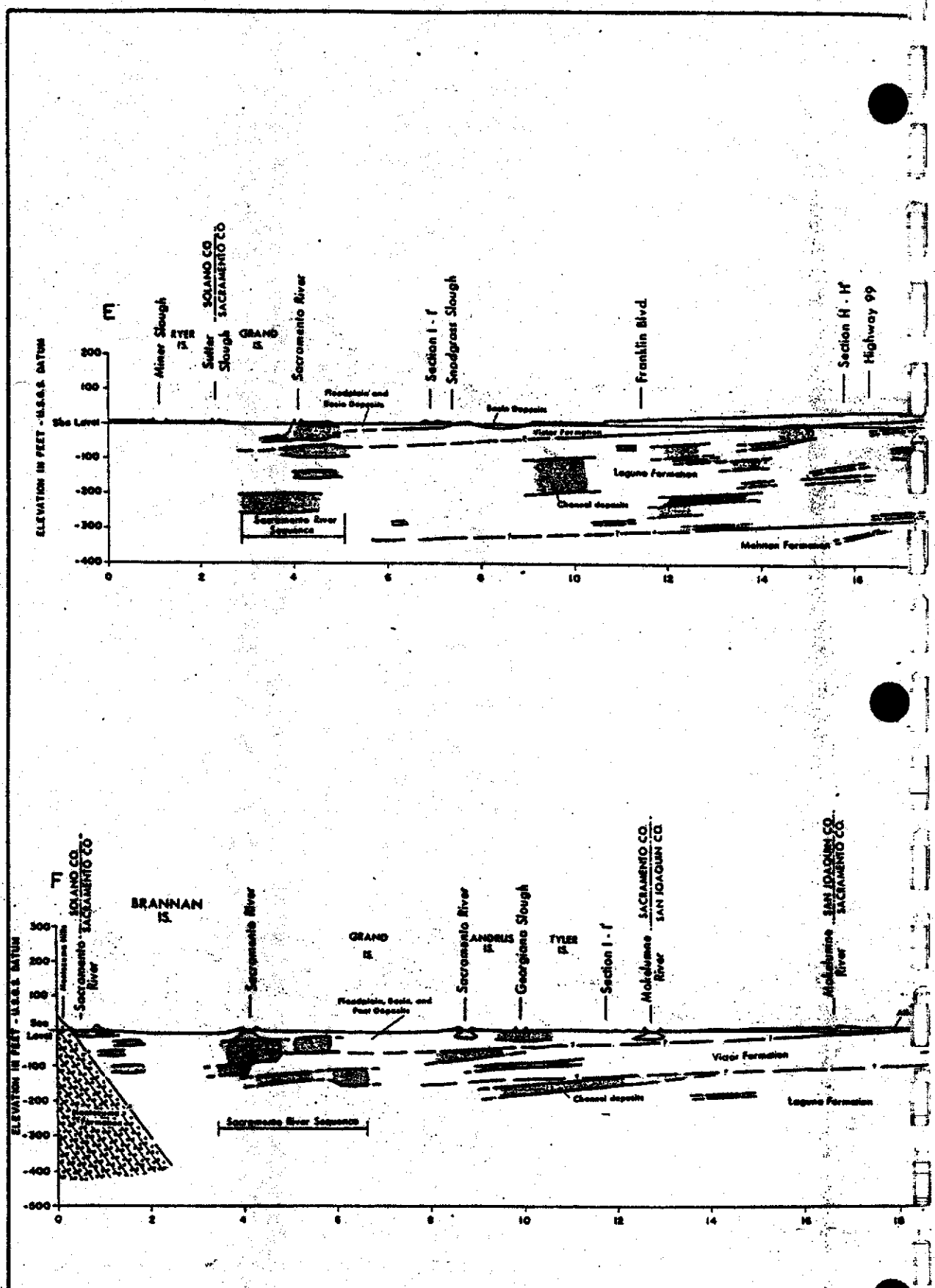






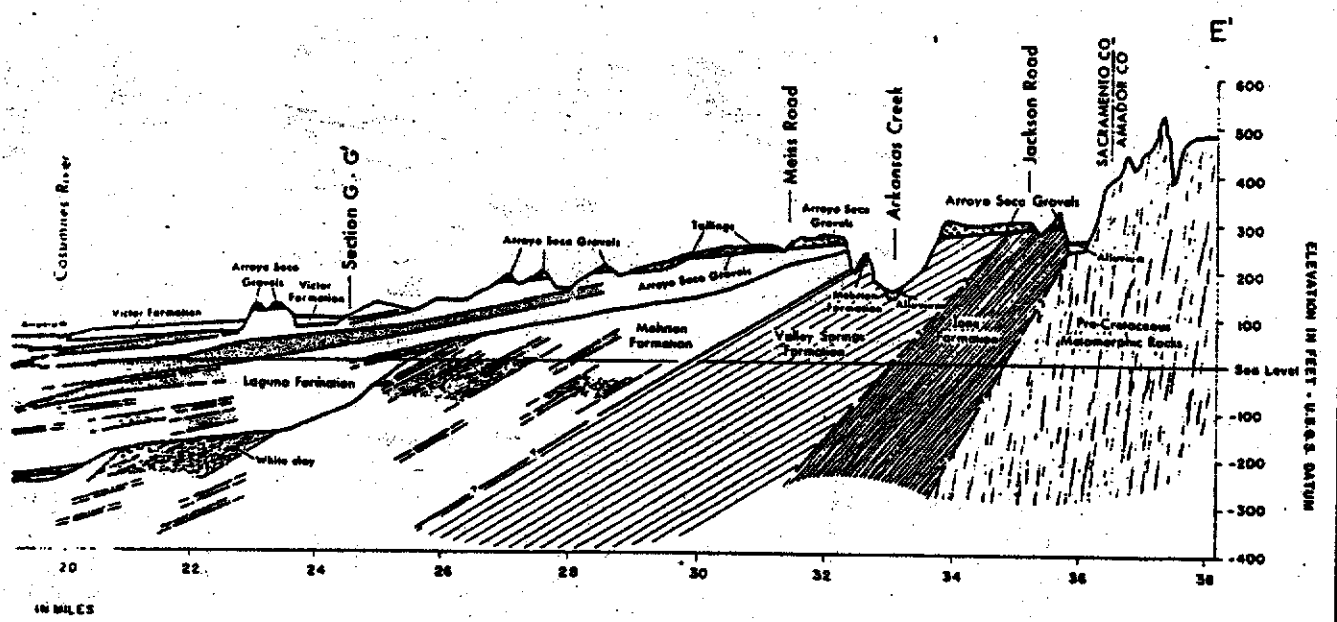


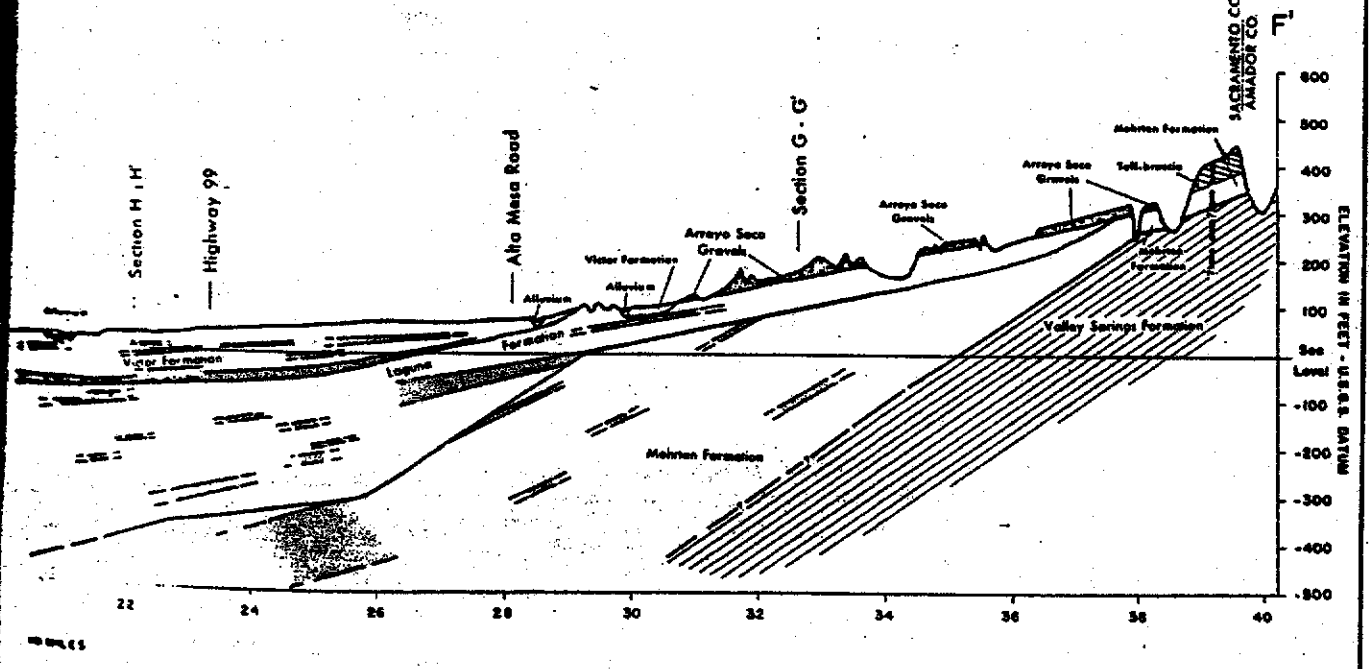
SACRAMENTO COUNTY



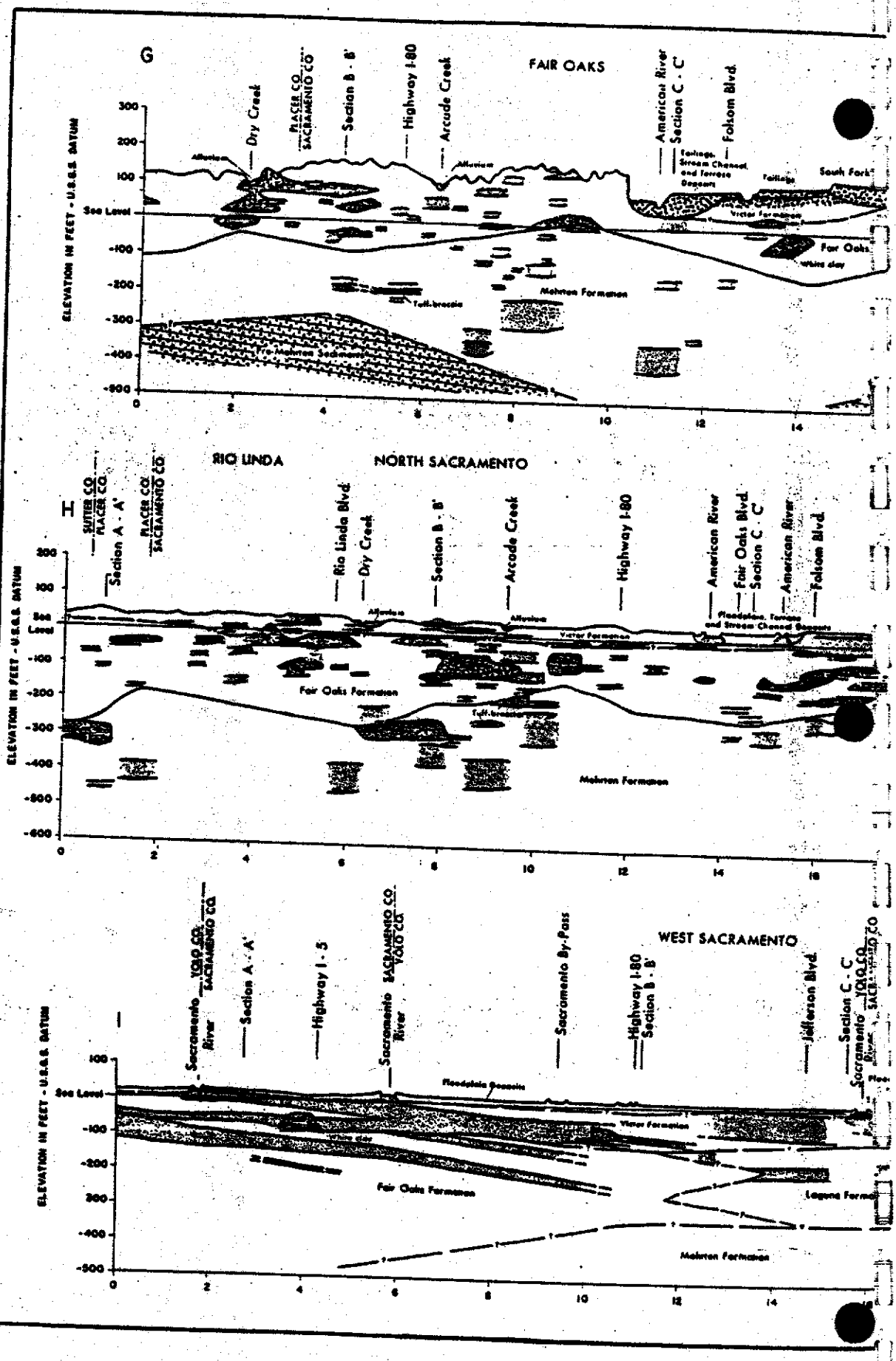
GEOLOGIC SECTION

See Plate 1 for locations of sections.



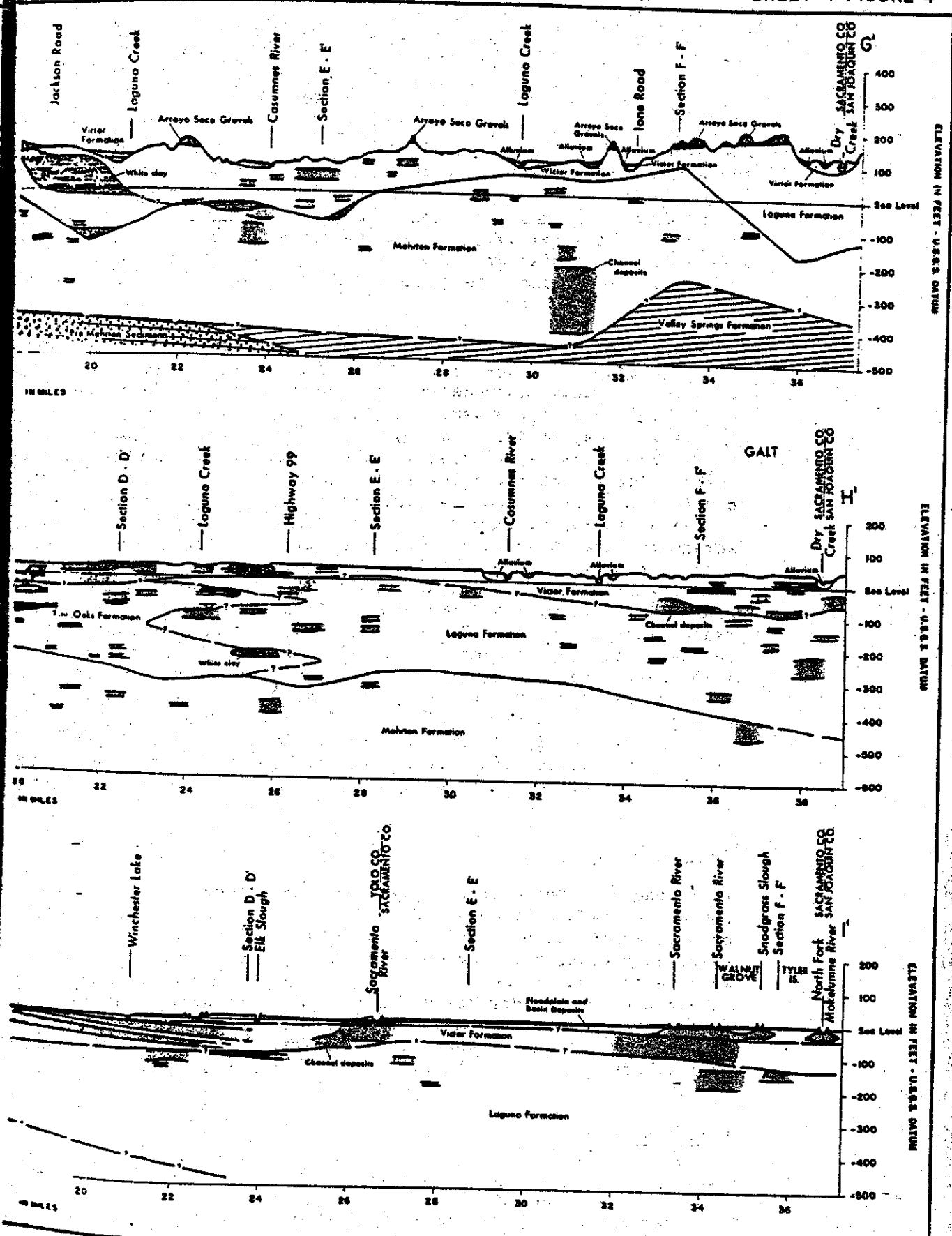


SACRAMENTO COUNTY



See Plate 1 for locations of sections.

GEOLOGIC SECTIO



SACRAMENTO COUNTY

American River

The American River has coursed its way across what is now Sacramento County since the time of deposition of the Mehrten Formation in the Pliocene epoch. During the post-Mehrten period the river has been present most of the time as two distinct forks. One was a North Fork American River, which entered the Great Valley near what is now the intersection of Douglas Boulevard and Sierra College Boulevard. This fork then flowed southwesterly along a trio of channels and joined the Sacramento River west of the present Executive Airport.

The South Fork American River apparently was a more consequent stream than was the North Fork. The South Fork flowed south and west past the Folsom area and continued southwesterly through the area now occupied by Mather Air Force Base. The fork entered the Sacramento River in the area of Clarksburg. At a later time, probably through the medium of stream capture, the course of the North Fork was altered so that it joined the South Fork northeast of Folsom. Three distinct deposits of channel material stemming from this combined river trend southwesterly from Folsom. The oldest channel heads near Hazel Avenue at elevation +40 and meanders southwest to enter the Sacramento River near Clarksburg at elevation -100. A younger channel also heads near Hazel Avenue and flowed southwest toward Hood, where it entered the Sacramento River at elevation -50. Both of these channel deposits are about 2,000 feet wide and represent a river of about the same size as the present American River. The youngest American River deposit, which has been described by Schlemon [1967b] as being late Pleistocene in age, also begins near Hazel Avenue, at an elevation of +100 feet. These deposits t widen and meander southwesterly to the vicinity of Land Park, where the river joined the Sacramento River. At this point American River deposits are from 8,000 to 10,000 feet wide, indicating a river of great competancy. With all probability the American was the greater of the two rivers, as the Sacramento River deposits appear to be only about 6,000 feet wide.

Cosumnes River

Two channels of the Cosumnes River have been identified. The earliest, a Laguna-age channel, flows roughly from the vicinity of Dillard and Alta Mesa Roads at an elevation of +30 feet, southwest toward the confluence of the present-day river with the Mokelumne River, where the Laguna-age channel has an elevation of about -100 feet. A second, younger channel exists between the present-day channel and Twin Cities Road, where it is present at elevation 0, and the Walnut Grove area, where it is present below elevation -20. This channel apparently was formed by a Holocene channel of the Cosumnes River prior to its capture by the Mokelumne River.

Feather River

A major, braided channel of the Feather River trends southerly from north of Sacramento County south to West Sacramento. In the past the Feather River has flowed into the Sacramento River at numerous locations, from the

vicinity of Bryte Bend south as far as Broderick. Elevations of the channel deposits at the various confluences range from elevation -30 to -50 feet. Throughout much of its course, the Feather River appears to have been a stream of major consequence. Its channel deposits range in width from 2,000 feet to as much as 6,000 feet.

Sacramento River

The course of the Sacramento River appears to have been essentially in the same location throughout much of the time from the late Pliocene to the present. Entering the Sacramento County area, the river flowed southeasterly toward a confluence with the Feather River near Bryte Bend. The course of the river then turned southerly, and it picked up the various channels of the American River from there to Walnut Grove. In this interval meandering channels of low gradient were the rule, with channels being on the order of 2,000 feet across. South of Walnut Grove the river made a swing to the west. In this latter area the channel deposits are about 1,500 to 2,500 feet across and range in depth up to 200 feet.

Subjacent Series

The subjacent series includes the Mehrten Formation and a portion of the underlying Valley Springs and Ione Formations. This series is the principal water producer to deep wells in the North Area, as well as along the eastern portion of the County. The series is composed of numerous channels of sands and gravels derived from the erosion of volcanic material. The channels located during the study are shown on Figure 5. Overlying some of the channel deposits, or occurring separately within the series, are sinuous beds of tuff-breccia which flowed down preexisting watercourses during periods of volcanic eruption to the east.

During Mehrten time, major river systems entered the Great Valley at different locations than at present as shown on Figure 5. Three separate forks of the American River have been identified by Lindgren [1911] and others working in this part of California. The northernmost of these is the North Fork American River which is identifiable on the surface, due to topographic inversion, as a sinuous ridge capped by tuff-breccia that begins near Newcastle, where it has a base elevation of about 800 feet. From this point the channel trends southwesterly to just north of Roseville where it passes beneath the ground surface. The channel apparently continues in a southwesterly direction across the southwestern portion of Placer County. All identifiable components of this channel are to the north of the area covered by Figure 5.

The trace of the Mehrten Middle Fork American River enters the Great Valley east of Roseville. Forming the full extent of Rocky Ridge, the channel plunges beneath the ground surface at Douglas Boulevard, where its upper surface has an elevation of 175 feet. During Mehrten time this river flowed in a 3,000-foot-wide meandering course across a terrain composed of low granitic hills. Channel deposits formed by this river consist of cobbles and boulders of volcanics and granitics all encased in a matrix of partly cemented sand. Near Douglas Boulevard a layer of tuff-breccia occurs within the gravels, indicating a brief

episode of volcanism when fluid agglomerate flowed down the river channel only to become buried by younger stream gravels. Capping the channel deposits is a bed of highly resistant tuff-breccia that is about 20 feet thick. Apparently when this flow moved down the riverbed it displaced the stream, as no overlying gravels have been noted.

Southwest of Douglas Boulevard, the channel deposits of the Middle Fork American River continue for several miles. Gravel deposits directly related to this channel are present in the subsurface as far as North Highlands, where they are present at elevation -430 feet. The tuff-breccia forming the upper surface of Rocky Ridge appears also to plunge southwestward and spread out so that it forms a broad apron in the subsurface, southwest of Douglas Boulevard.

A sinuous ridge of tuff-breccia marks a large portion of the channel of the Mehrten South Fork American River. This feature can be traced from Mooney Ridge near Folsom Lake, at elevation 550 feet, southwest to near Sailor Bar. At Mooney Ridge the channel apparently was about 1,000 feet wide; here, gravels are about 50 feet deep. At Sailor Bar the channel deposits plunge beneath the ground surface. At this locality the elevation of the upper surface is 125 feet.

In the subsurface a number of channels of the South Fork American River are identifiable. One such channel apparently trends southwestward from the vicinity of Greenback and Hazel Avenues, where it is present at elevation 80 feet. Southwest of this location the channel apparently divides into a number of distributaries. One passes beneath Manzanita Avenue north of Fair Oaks Boulevard at elevation -290 feet, another passes beneath Watt Avenue north of Arden Way at elevation -210 feet, while a third passes beneath Arden Way and Interstate 80 also at elevation -210 feet.

Well log data indicate that in addition to the above described river channels, many other channels of the American River existed during Mehrten time. These other channels occur either stacked above or below those described above or occur as separate meanders at one side or the other and at somewhat differing elevation than those previously described.

In addition to all of the above described American River channels, many channels of other streams and rivers occur throughout the Mehrten Formation. Many of these are of major importance, being up to 50 feet thick, but because they cannot be traced over any great distance, they cannot be accurately defined nor identified. In addition, because deposition of the Mehrten Formation occurred over a long period of time, many episodes of erosion and deposition took place. This produced a thick sequence of strata separated by many local disconformities and unconformities. Easily erodable sediments, coupled with meandering stream channels, created many instances where previously deposited channel materials were cut out. Also, periods of high runoff caused massive flooding of the aggrading alluvial fans and caused many previously established river channels to be abandoned and new channels to be formed. Hence, it is seldom possible to trace a particular channel any great distance.

Two thick sand deposits occur within the Mehrten Formation in the southern part of the County: one northwest of Clay; the other east of Galt, south of the area shown on Figure 5. These sand deposits range from 250 to 300 feet in thickness and consist of black volcanic sand. The one near Clay occurs between elevati

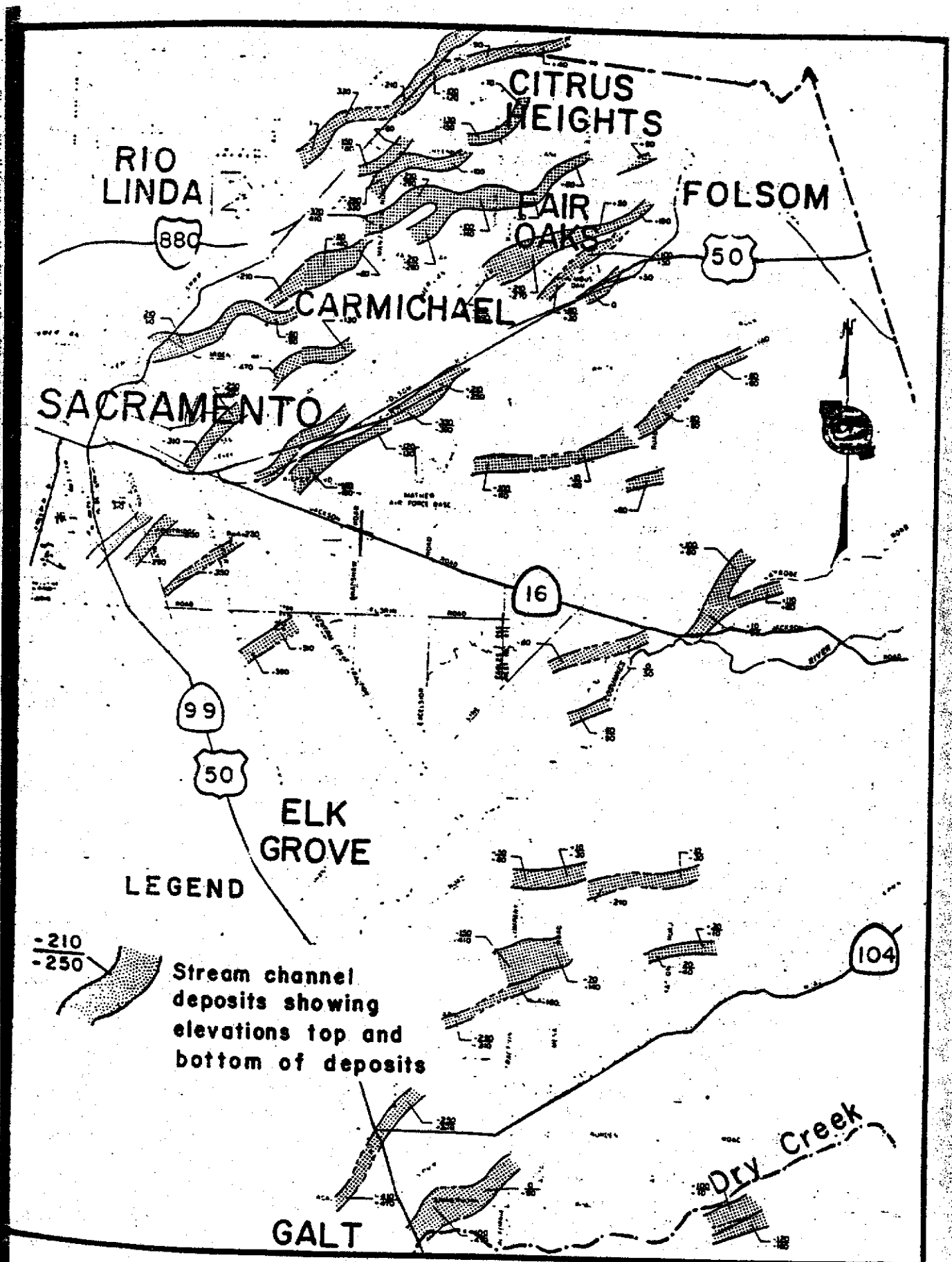


Figure 5, SUBJACENT STREAM CHANNEL DEPOSITS

-150 to -410 feet; the Galt sand occurs between elevations 0 to -330 feet. of the sand deposits is not definitely known. However, deposits of this nat could have been formed under beach or strand conditions when the Miocene sea occupied the region to the west.

Influence of West Side Streams

During the time of deposition of the subjacent and superjacent series, the Sacramento River apparently was to the west of the present course. Streams flo in a generally southwesterly direction across a plain of aggradation, and all f direction in the area of Sacramento County was in a direction toward the Sacramento River, that is, to the southwest. Streams draining the ancestral Coast Ranges, which at that time probably existed merely as a group of low hill entered the Sacramento River far to the west.

During post-Mehrten time, as the Coast Ranges increased in height, streams draining them increased in competancy. This caused the Sacramento River to migrate eastward so that today its course is parallel to and somewhat east of its original position. During this period the Cache Creek and Putah Creek drainages were established. These two streams debouched onto the plain at abou the same location as they do today. An ancestral channel of Cache Creek has bee identified as entering the Sacramento River near Bryte Bend at elevation -160 f (see Figure 3, Sheet 1). A second probable channel of Cache Creek enters the Sacramento River at elevation -10 feet southeast of West Sacramento. Data are lacking to identify the ancestral channels of Putah Creek. However, a southeast trending channel that may be associated with Putah Creek enters the Sacramen River channel at elevation -10 feet near Courtland (see Figure 3, Sheet 2).

Because of the general southwesterly direction of flow of the ancestral streams in the Sacramento County area, it is doubtful if any westside stream systems ha any effect on deposition in the Sacramento County area.

Discontinuous Confining Beds: The White Clay

The northern half of Sacramento County is underlain by a series of discontinuou confining beds identified by well drillers as "white clay, dun clay, or white ash". These clay-like materials occur in individual flat-lying beds which range in thickness from a few feet to 30 to 50 feet. In aggregate thickness the beds range up to 200 feet. The white clay beds are relatively dense and act as confining beds to ground water occurring below in permeable sands and gravels. They also inhibit any downward percolation of water available for recharge.

There is much speculation as to the composition and origin of the white clays. Some of the white clay beds occur below zones of tuff-breccia and black sands, placing them positively within the Mehrten Formation. These Mehrten white clay beds have dips of from one to two feet per mile, similar to those of other Mehrten beds. Origin of the Mehrten white clay is probably volcanic, being either primary, that is deposited as the result of ash falls during Mehrten time, or secondary, being an erosion product of then-soft Valley Springs tuffaceous material. In the eastern part of Sacramento County, at Rancho

Marietta, deposits of light-colored tuff interbedded with hard gray Mehrten sands were observed. The tuff appeared to have been deposited in a subaqueous environment. It was located about 30 feet stratigraphically above Valley Springs material.

Beds of white clay also occur in the superjacent series. These have a nearly uniform valleyward dip of 5 to 50 feet per mile, typical of beds of the Fair Oaks, Laguna, and Victor Formations. These beds also are probably of tuffaceous origin, although Schlemon [1967b] is of the opinion that many of them are composed of glacial flour. Exposures of white to very light tan tuffaceous beds have been noted in much of the area of outcrop of the Fair Oaks Formation. These materials previously were described by Schlemon [1967b] as white silt.

Microscopic examination of samples of this white silt showed them to be composed predominantly of glass shards, making them definitely tuffaceous in nature. It would appear from the abundance of white tuffaceous beds within the Fair Oaks Formation that the presence of such beds is a diagnostic feature of the formation. Only a few similar beds have been identified from areas definitely belonging to the Laguna Formation.

Based on the above conclusions, it would appear that the Fair Oaks Formation extends in the subsurface at least as far south as Meadowview Road, with a tongue extending farther south to Elk Grove. It also appears that the Fair Oaks Formation is a product of deposition from the various forks of the American River during the late Pliocene and early Pleistocene.

CHAPTER III. EVALUATION OF HISTORIC WATER SUPPLY AND USE

To understand how the ground water system underlying Sacramento County works, estimates of its ability to receive, transmit, and store water must be made and verified.

The ability of a ground water basin to store and transmit water is investigated by first determining transmissivity, ground water storage capacity and yield factors for the ground water system and then determining the reaction of that system to development by superimposing historic water development and use on natural hydrologic events, such as precipitation, recharge, and consumptive use.

A schematic representation of the entire hydrologic system in Sacramento County is shown in Figure 6. That portion of the hydrologic system below the land surface is considered to constitute the ground water basin.

An analysis of a ground water system is made over a historic period by taking inventory of recharge to and withdrawals from the ground water body. The result is an estimate of the change in amount of ground water in storage. The accuracy of the analysis, which is performed by a computer, can be gaged by how close the simulated response of the basin, in the form of water level fluctuations, compares with the historic record. The relationship of recharge and withdrawals to change in water levels is shown by the equation:

$$R - W = \Delta S \qquad (1)$$

where R = recharge to the ground water body by precipitation, streamflow, artificial recharge, and delivered water;

W = withdrawals of ground water by pumpage, consumptive use, springs and flowing wells, and water from nonreversible compaction of clays; and

ΔS = reversible change of the potentiometric surface of ground water in storage.

Some of the items in the inventory can be measured directly, some are calculated indirectly, and some can be measured only for a part of the study period and are calculated for the remainder of the period.

Study Period

The major rivers in Sacramento County are controlled by man and have continuous sustained flow. Smaller streams respond to seasonal precipitation. Therefore, the amount of precipitation on the County and its adjacent region serves as an index to the water supply available to the study area. By analysis of long-term

precipitation records, a relatively short, recent study period can be selected which represents the long-time average water supply. Such a period is needed for study purposes because long-term records are not available for all of the data items required to make a hydrologic inventory.

Hydrologic conditions during a study period should reasonably represent long-term conditions and include normal, wet, and dry years. The study period should be within the period of available records and should include recent years so that the effects of development on the basin can be included. The climatic and basin conditions preceding the beginning and ending year of a study period should be similar so that the amount of water in transit between the bottom of the root zone and the water table prior to each of these two years will be of about the same magnitude. Large differences in depths to water at the beginning and end of the period also should be avoided in order to reduce differences in amounts of water in transit.

The chosen study period was water years 1962 through 1968 on the basis of the criteria presented earlier. It begins and ends on a dry year, includes recent man-made works, and the study period mean corresponds closely with the long-term mean. The 1962-68 study period also is best suited to the available data. The availability of data is:

Agricultural Pumpage	1967, 1968, 1969
Municipal Pumpage	1961-1969
Detailed Land Use	1960-61, 1968-69
Water Levels	Prior to 1960 to date
Stream Diversions	Prior to 1960 to 1969

Precipitation

The Galt, Represa, and Sacramento Weather Bureau City precipitation stations shown on Figure 7 were selected to represent the rainfall situation for Sacramento County because they are strategically located so as to provide an excellent mean annual rainfall value for Sacramento County and also have long continuous records. The Sacramento Weather Bureau City records date back to 1849; Galt to 1878; and Represa to 1892.

The Sacramento station required adjustment because Weather Bureau records indicate that the Sacramento Weather Bureau City gage had been located at nine different locations since the record began. In addition, an analysis of an accumulated precipitation graph indicated that a significant change occurred in the rainfall catchment between approximately 1908 and 1935. The adjustment to the record was made by multiplying the annual precipitation by 1.32 for years 1910 through 1938 and by 1.06 for years 1939 through 1970. Since the precipitation stations at Galt, Represa, and Sacramento Weather Bureau City were selected to represent the rainfall situation for the County, the longest concurrent period was required for precipitation analyses. The period used was 1890 to 1970. As the Represa gage started at 1892, two years of record were needed to fulfill the period desired. The record was extended by using the normal ratio method with the other two gages; annual precipitations for Represa for the years 1891 and 1892 were estimated to be 21.00 inches and 29.57 inches, respectively.

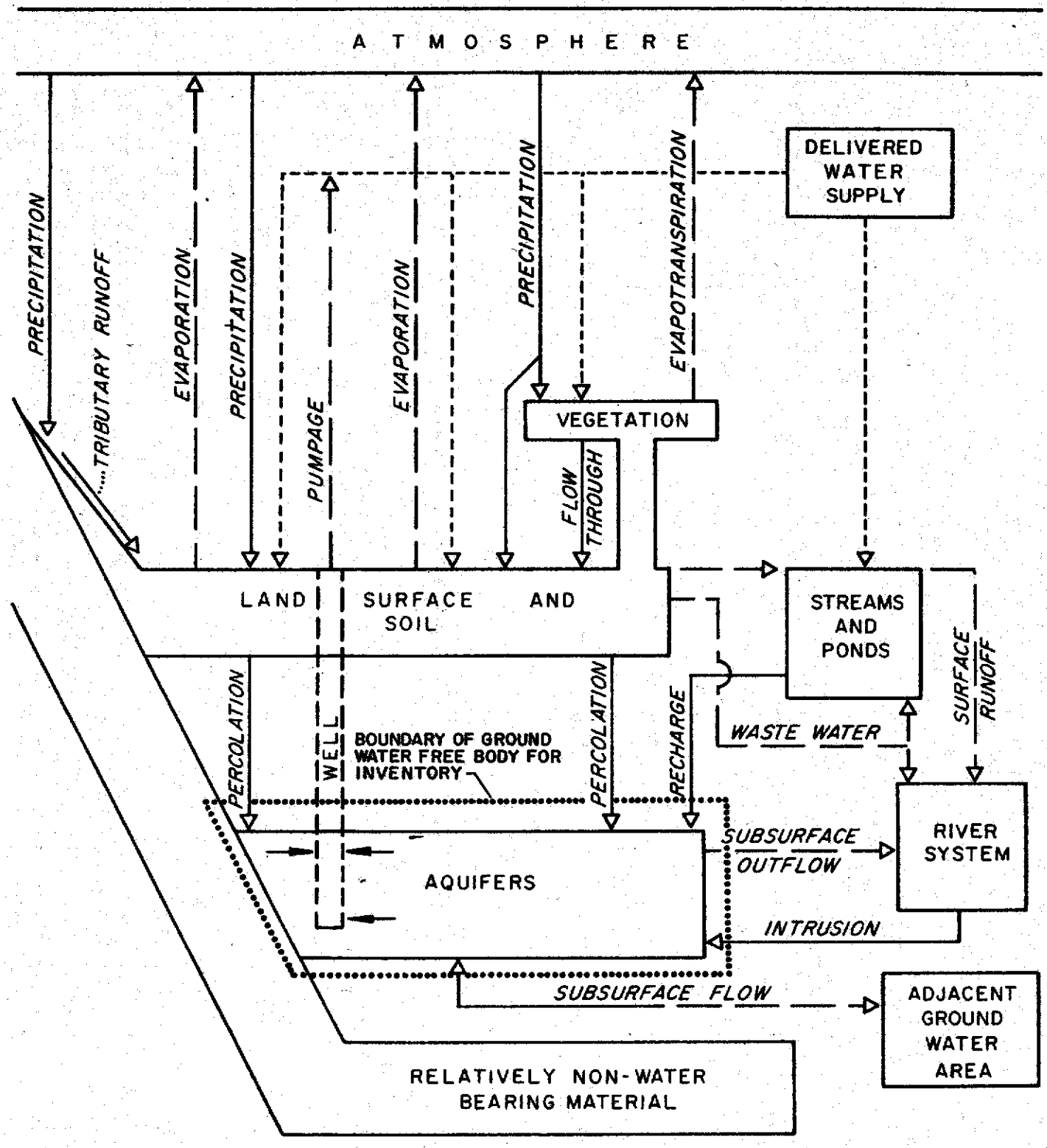


Figure 6. HYDROLOGIC SYSTEM (SCHEMATIC)

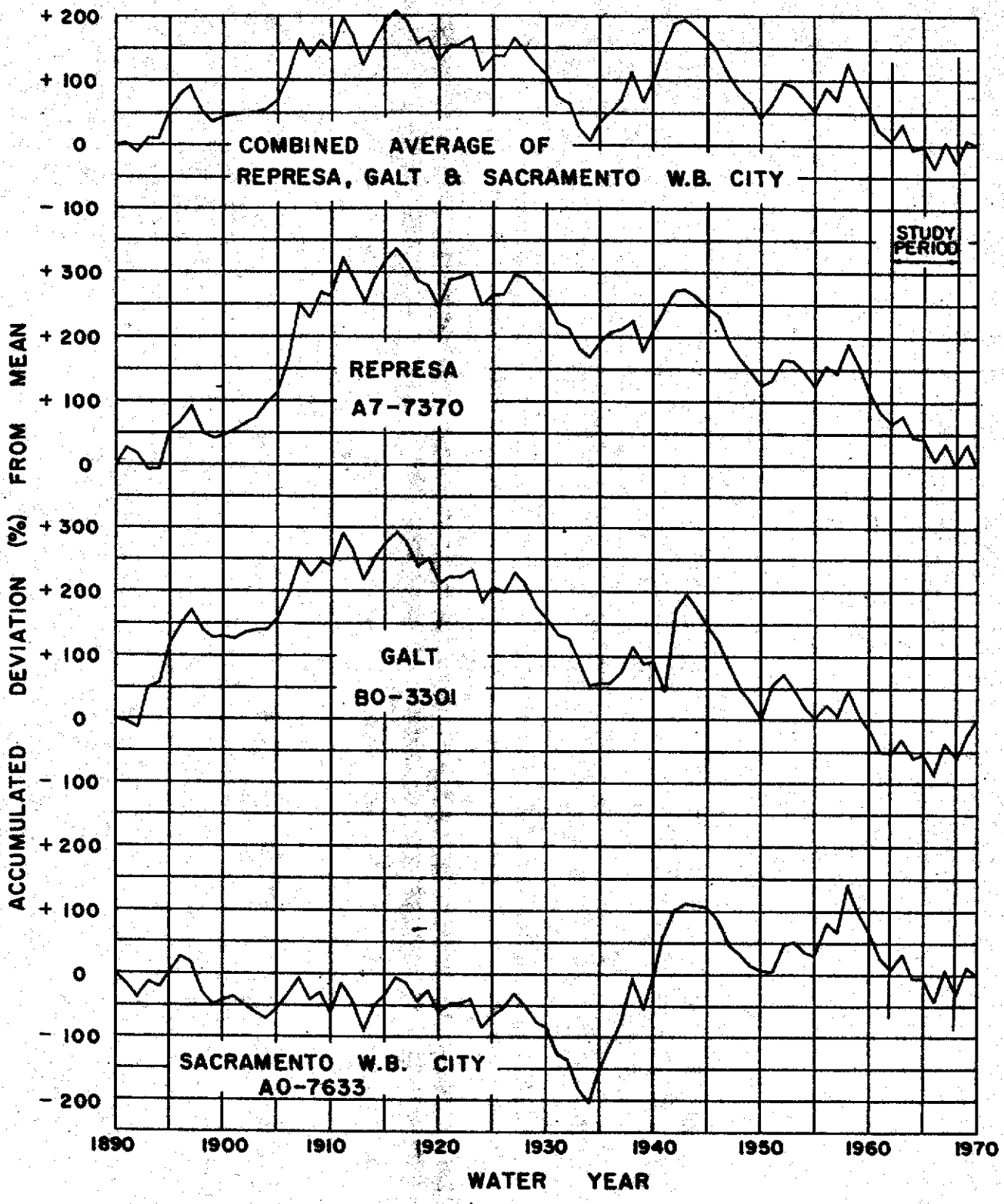


Figure 7. LONG TERM VARIATION OF PRECIPITATION PERIOD 1891-1970

Figure 7 depicts the accumulated deviation from the mean graphs of precipitation at each of the Sacramento Weather Bureau City, Galt, and Represa gages, and for their combination. Each of these graphs shows three pairs of wet and dry trends, covering progressively the periods 1890-91 through 1935-36, 1936-37 through 1960-61. The period 1961-62 through 1969-70 is rather indeterminate as to whether it is a dry or wet trend of the future. The combined mean annual rainfall of the three gages for this period is 4 percent lower than for the long-term mean.

The average precipitation of combined annual precipitation for Represa, Galt, and Sacramento Weather Bureau City gages and index of wetness for this 80-year period are shown on Table 3. The 80-year long-term average precipitation is 19.91 inches with a standard deviation of 4.86 inches. During this period the maximum precipitation occurred in 1957-58, with 31.06 inches and an index of wetness of 156 percent; the minimum precipitation occurred in 1923-24, with 10.35 inches and an index of wetness of 52 percent. For the study period 1962-1968, the average precipitation is 18.48 inches and a standard deviation of 5.76 inches. Variations in average annual and monthly amounts of precipitation are shown on Figure 8.

The mean precipitation for the 26 precipitation gages active in Sacramento County during the study period (1961-62 to 1967-68) are listed in Table 4. Their locations are shown on Figure 9. For the study period, these 26 stations are considered adequate coverage for the study area. The mean precipitation for these 26 stations is 19.49 inches per year, with a standard deviation of 3.13 inches. The normal precipitation for the Sacramento Weather Bureau City station for the period 1931 through 1960 is 18.02 inches.

The prevailing track for the storms during the rainy season from December through April is from the northwesterly direction. Storms that bring rain to the area are frontal type storms -- usually a cold front colliding with a warm front. Figure 10 shows that the amount of precipitation increases generally from west to east. This can be explained by stating that because the land surface increases in elevation from west to east, an air mass passing eastward is lifted and thus becomes unstable, causing precipitation. This lifting of air masses over mountain barriers is called orographic lifting -- hence most of the rainfall in the area is termed orographic precipitation. In addition to this type of precipitation, Sacramento County also receives rainfall from thunder storms, which are convective type storms.

Variations in precipitation are important because recharge to the ground water body is mainly a function of precipitation and secondarily of rooting depth of crop, moisture retention of the soil within the rooting depth, evapotranspiration of the crop, and the relative amount of impervious cover in the area.

Streamflow

There are 47 active and inactive stream gaging stations in Sacramento County. Only two active stations, Arcade Creek near Del Paso Heights and Morrison Creek near Sacramento, measure flows originating entirely within the County. The American River is the main stream traversing from the east to the west through the north central portion of the County. Flow measurements have been available at American River at Fair Oaks since November 1904, and correlated flows since

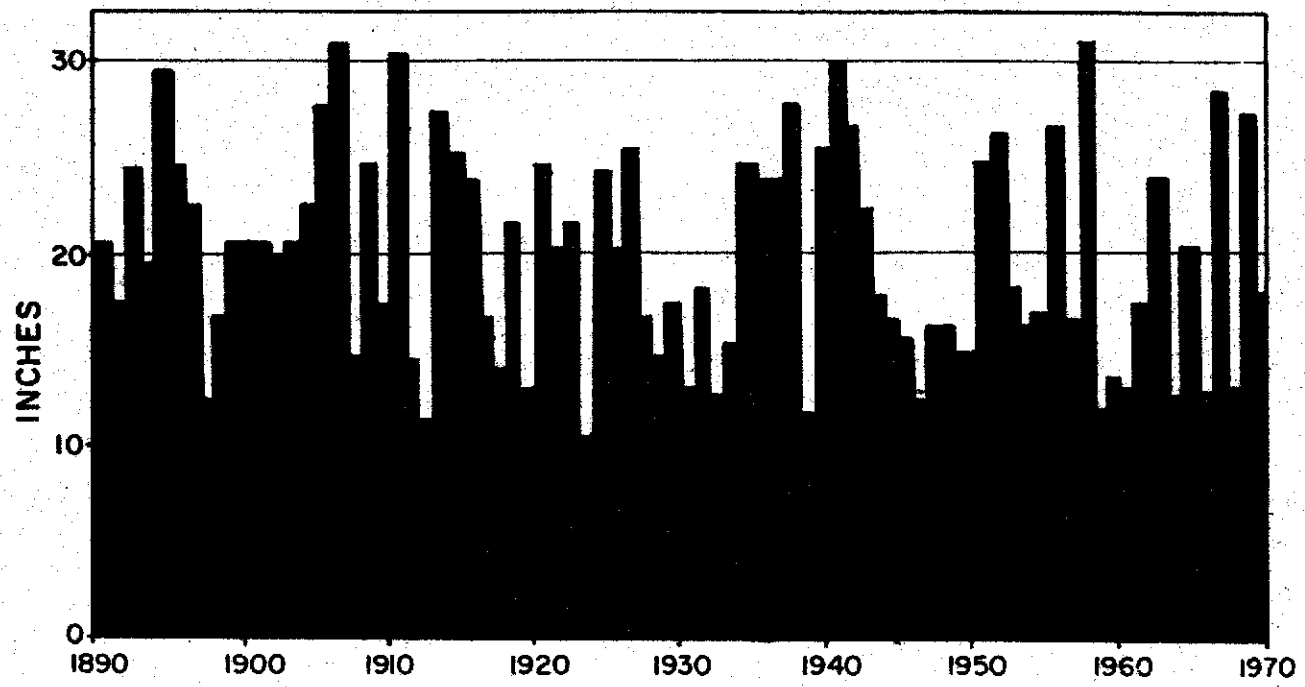
TABLE 3

Annual Precipitation[a] and
Index of Wetness
1891-1970

Fiscal Year[b]	Inches	Index of Wetness[c]	Fiscal Year	Inches	Index of Wetness	Fiscal Year	Inches	Index of Wetness
1890-91	20.51	103	1920-21	24.41	123	1945-46	15.59	78
91-92	17.04	86	21-22	20.03	101	46-47	12.07	61
92-93	24.35	122	22-23	21.90	110	47-48	16.05	81
93-94	19.31	97	23-24	10.35	52	48-49	16.05	81
94-95	29.67	149	24-25	24.01	121	49-50	14.99	75
1895-96	24.41	123	1925-26	20.17	101	1950-51	24.95	125
96-97	22.36	112	26-27	25.35	127	51-52	26.34	132
97-98	12.20	61	27-28	16.78	84	52-53	18.04	91
98-99	16.92	85	28-29	14.45	73	53-54	16.05	81
99-00	20.71	104	29-30	17.44	88	54-55	16.95	85
1900-01	20.63	104	1930-31	12.94	65	1955-56	26.74	134
01-02	20.63	104	31-32	18.12	91	56-57	16.45	83
02-03	19.91	100	32-33	12.46	63	57-58	31.06	156
03-04	20.83	105	33-34	15.39	77	58-59	11.87	60
04-05	22.76	114	34-35	24.81	125	59-60	13.74	69
1905-06	27.73	139	1935-36	23.75	119	1960-61	13.00	65
06-07	30.98	156	36-37	23.89	120	61-62	17.38	87
07-08	14.53	73	37-38	27.99	141	62-63	24.15	121
08-09	24.61	124	38-39	11.47	58	63-64	12.74	64
09-10	17.12	86	39-40	25.54	128	64-65	20.71	104
1910-11	30.26	152	1940-41	29.98	151	1965-66	12.94	65
11-12	14.20	71	41-42	26.48	133	66-67	28.47	143
12-13	11.01	55	42-43	22.16	111	67-68	13.00	65
13-14	27.28	137	43-44	17.78	89	68-69	27.54	138
14-15	25.15	126	44-45	16.84	85	69-70	18.32	92
1915-16	23.81	120						
16-17	16.45	83						
17-18	13.54	68						
18-19	21.56	108						
19-20	12.60	63						

Averages	80 years, 1891-1970	19.91	100.0
	Standard deviation =	4.86	
	7 years, 1962-1968	18.48	92.8
	Standard deviation =	5.76	

[a] Average of combined annual precipitation for Represa, Galt, and Sacramento WB City gages.
[b] July thru June.
[c] Index of wetness is the percent of 80-year average.



AVERAGE ANNUAL PRECIPITATION
1890-91 to 1969-70

(Average of combined annual precipitation for Represa, Galt, and Sacramento WB City gages.)

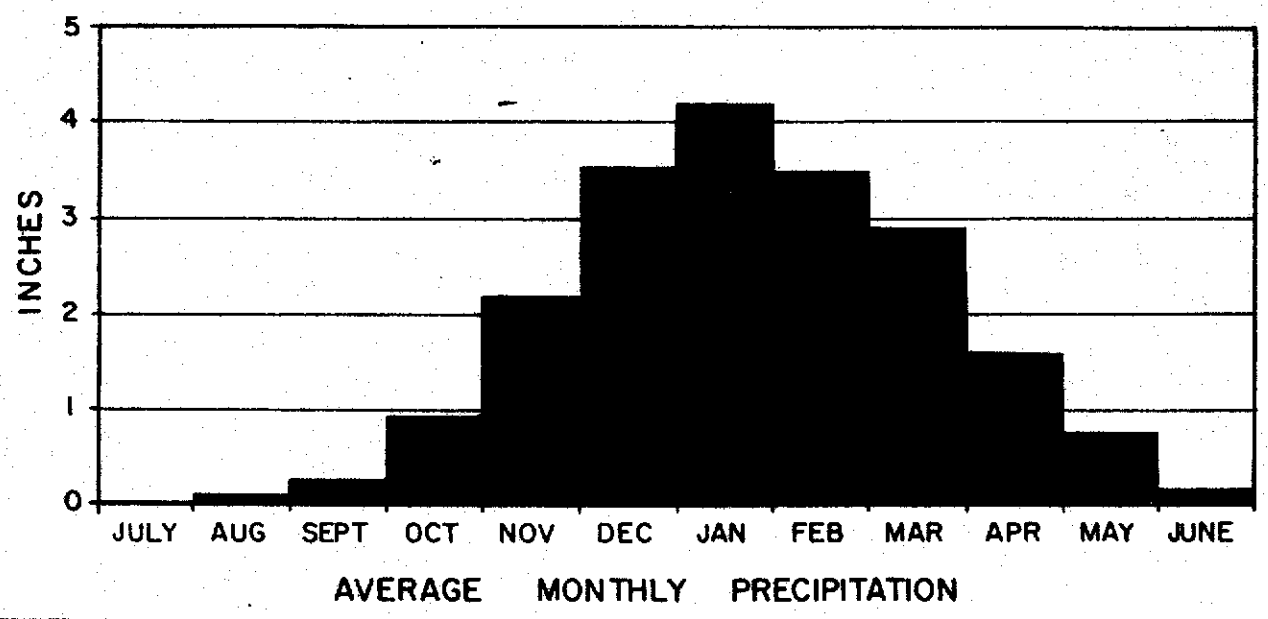


Figure 8. AVERAGE ANNUAL AND MONTHLY PRECIPITATION

TABLE 4

PRECIPITATION STATIONS IN SACRAMENTO COUNTY
MEAN PRECIPITATION DURING STUDY PERIOD 1962-68
IN INCHES

	Station Name	Station Number	Mean Precipitation During Base Period 1962-1968 in Inches
1.	Aerojet F.S.	A0-0039-34	24.04
2.	Arden & Mission	A0-0255	17.95
3.	Arden Park Bailey	A0-0256	21.73
4.	Brannan Island State Park	B9-1043	15.17
5.	Central Valley Hatchery	B0-1635-01	19.04
6.	Citrus Heights	A0-1773	23.53
7.	Clay 1 N.W.	B0-1785	17.05
8.	Country Club Center	A0-2073-34	19.39
9.	Del Paso Park	A0-2367	19.35
10.	Dewey & Winding	A0-2414	23.20
11.	Elkhorn Ferry	A0-2744	18.06
12.	Folsom Dam	A7-3113	25.77
13.	Fruitridge & Hedge	A0-3266-11	17.43
14.	Galt	B0-3301	18.11
15.	Grand Island RD3	B9-3541	18.30
16.	Herald F.S.	B0-3919	15.20
17.	Mather AFB	A0-5403	20.84
18.	McClellan	A0-5447	18.75
19.	North Sacramento	A0-6271	18.02
20.	Orangevale Beach	A0-6481	23.21
21.	Rancho Cordova F.S.	A0-7247-01	18.19
22.	Represa	A7-7370	22.14
23.	Sacramento WB AP	A0-7630	18.36
24.	Sacramento City W.B.	A0-7633	18.96
25.	Town & Country, Mitchell	A0-8984-34	20.54
26.	Walnut Grove	B9-9428	14.50
		Mean	= 19.49
		Standard Deviation	= 3.13

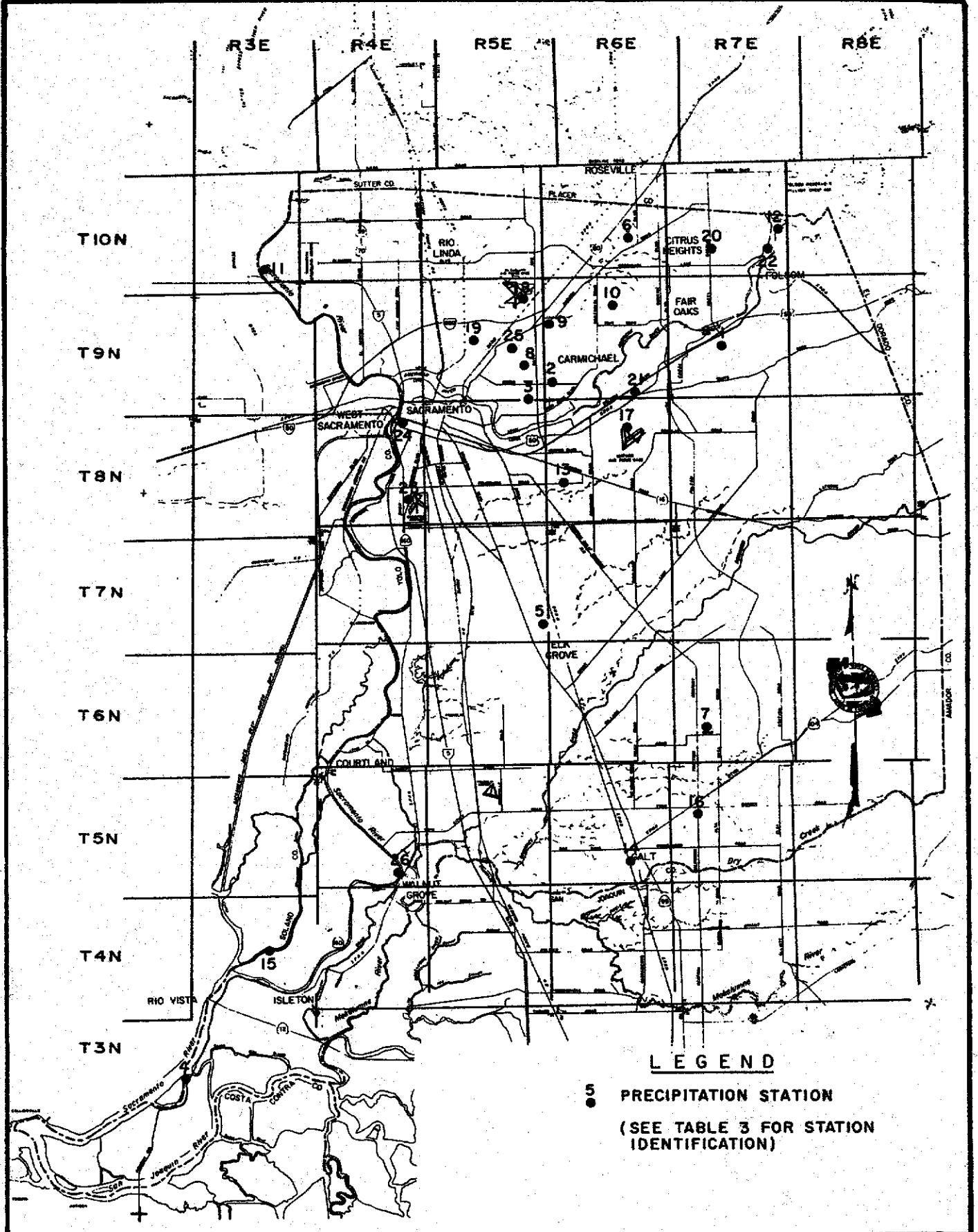


Figure 9. LOCATION OF PRECIPITATION STATIONS

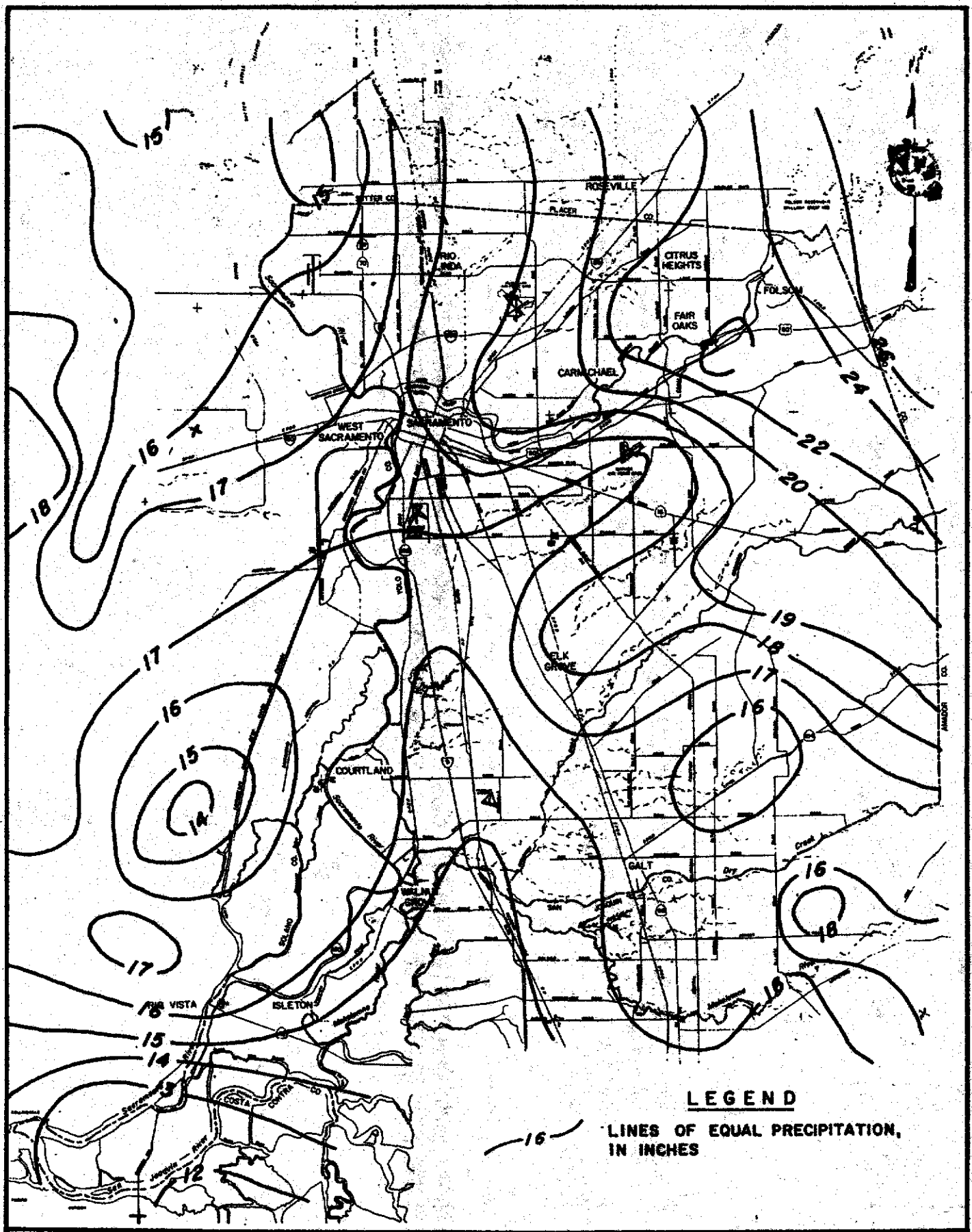


Figure 10. 50 YEAR AVERAGE ISOHYETAL MAP 1910-11 TO 1959-60

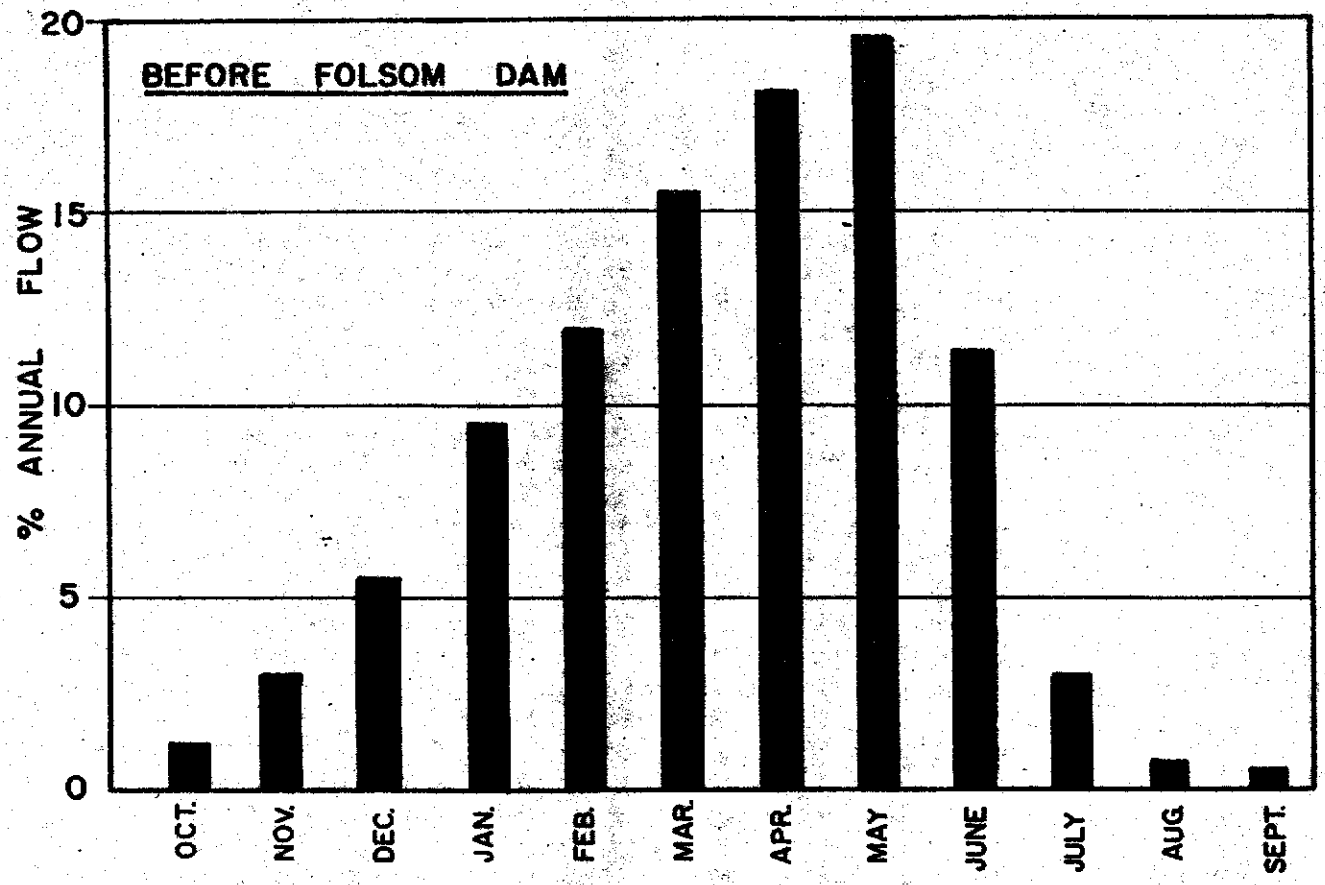
October 1900. The drainage area at this site tributary to the American River is 1,889 square miles. The mean annual unimpaired flow for this station is 2,782,800 acre-feet for the period 1900-01 through 1969-70. Cosumnes River flows through the southeastern corner of the County and has been gaged at Michigan Bar since October 1907. The drainage area at this site is 537 square miles. The average unimparied flow from the Cosumnes River at Michigan Bar from 1907-08 through 1969-70 is 347,380 acre-feet. The Sacramento River, which forms the western county boundary, has been gaged at the Sacramento "I" Street Bridge on an intermittent basis since May 1924, and on a continuous basis since January 1939. The drainage area above this gage is 23,508 square miles. The average annual gaged water year flow for the period 1940 through 1970 is 17,059,000 acre-feet. Based on the above information, the average runoff from the American River, Cosumnes River, and Sacramento River watersheds was 1,473, 726, and 647 acre-feet per square mile, respectively. These figures show that the American River drainage basin is twice as productive in runoff as are the drainage basins of the Sacramento River or the Cosumnes River.

The effect of construction of Folsom Dam on the monthly flows of the American River is depicted on Figure 11 by two graphs. The upper chart shows the unregulated gaging station at Fair Oaks (prior to Folsom Dam) and the lower chart shows the regulated American River at Fair Oaks (after Folsom Dam). Unregulated flows varied from 0.6 percent in September to a maximum of 19.7 percent in May. Regulated minimum flows still occur in September, but have increased threefold to 1.9 percent of the annual flow. The regulated maximum flow occurs in May, and is 14.8 percent. The decrease in the maximum percentage month of some 5 percentage points, or about 25 percent, provides flood protection. Increased flows during low-flow months provide enhancement of fisheries and recreation. The October flow was increased about fivefold (from 1.1 percent to 6.0 percent) to enhance salmon spawning downstream from Folsom Dam and mitigate the lack of spawning upstream of the dam. Due to regulation there now are two peak flows in the river: one in January due to releases from the reservoir to gain more flood reservation to control the peak snowmelt runoff, and one in the peak snowmelt runoff month, which occurs in May.

Figure 12 depicts monthly flows as percent of average annual flows for the Sacramento River at Sacramento and the Cosumnes River at Michigan Bar. The bar chart for the Sacramento River is more typical of a predominantly rainfall watershed than a snowpack watershed. Although perennial snowpacks do occur around Mount Shasta and Mount Lassen, many unregulated streams contribute to the Sacramento River downstream from Battle Creek (the main tributary originating from Mount Lassen), and the unregulated stream runoff due to rainfall overshadows the snowmelt runoff. Because of the large watershed, the percent flow dropoff from February to May is gradual rather than steep.

The monthly variation of the Cosumnes River indicates a combination of a rainfall and a snowmelt watershed. The sharp increase and decline of the flows indicate a small watershed and small baseflow.

Monthly streamflow data are contained in Supporting Data Reports on file in the offices of the County and the Department.



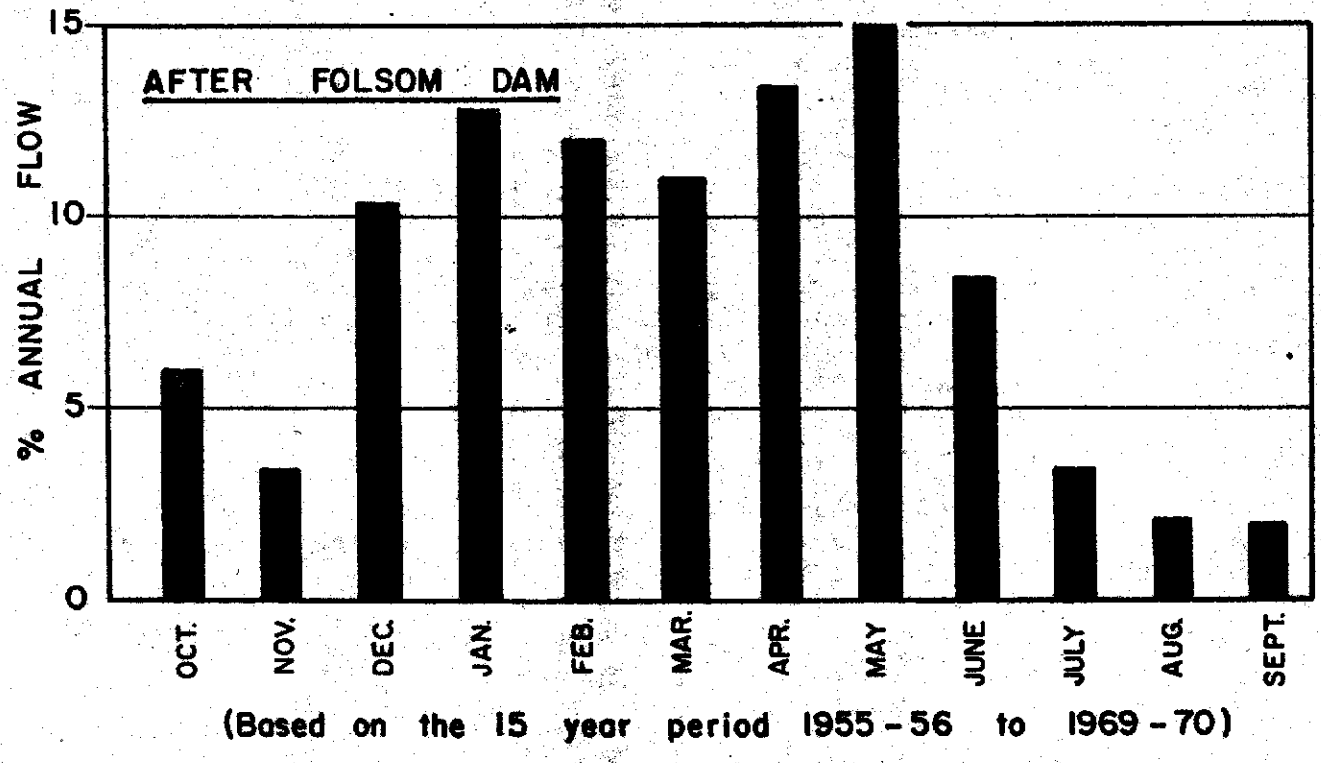
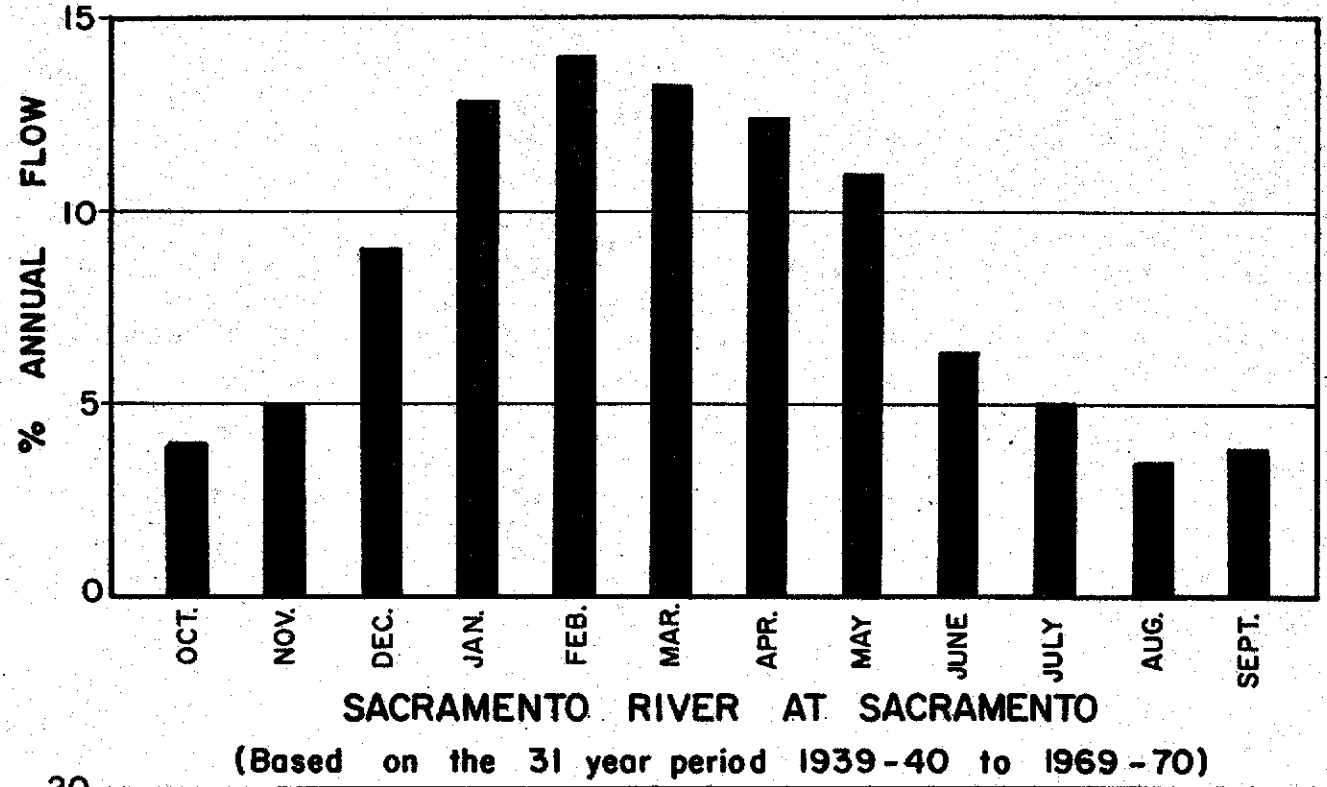
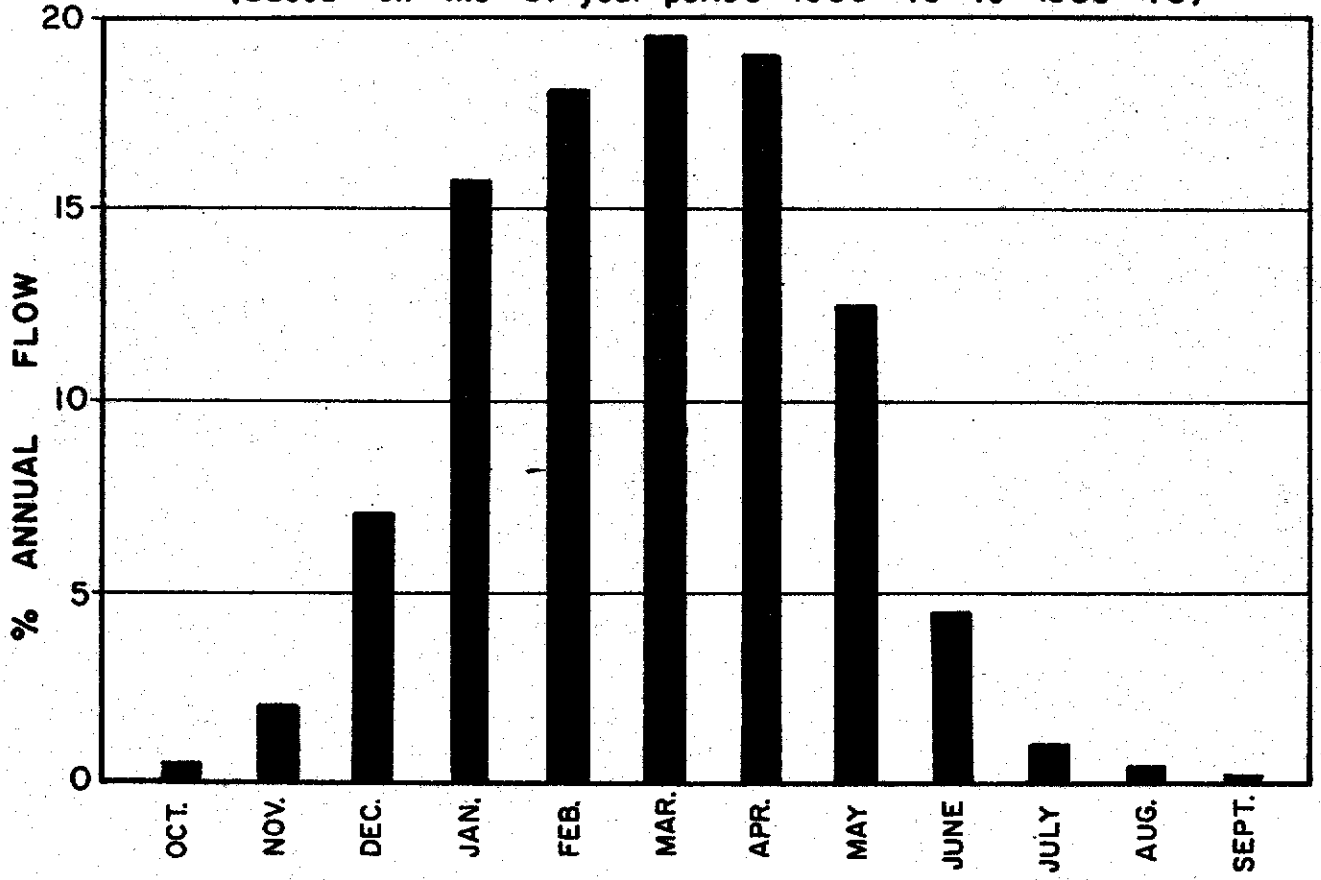


Figure 11. PERCENT AVERAGE ANNUAL FLOW
AMERICAN RIVER AT FAIR OAKS



SACRAMENTO RIVER AT SACRAMENTO

(Based on the 31 year period 1939-40 to 1969-70)



COSUMNES RIVER AT MICHIGAN BAR

(Based on the 63 year period 1907-08 to 1969-70)

Figure 12. PERCENT AVERAGE ANNUAL FLOW SACRAMENTO AND COSUMNES RIVERS

Surface Water Quality

Analyses of surface water of the American River, Cosumnes River, and Sacramento River indicate that they are of a bicarbonate type of excellent mineral quality with either calcium or magnesium as the predominant major cation. Representative analyses are shown in Table 5. The total hardness varies from soft (16 mg/1) to moderately hard (72 mg/1). For irrigation use, the water is classified as Class 1. For municipal and industrial uses, the water meets all drinking water requirements for mineral content and is suitable for all but the most exacting industrial uses.

Water quality at Nimbus Dam station of the American River is very similar to the quality at those stations located upstream on the Middle Fork and South Fork. On the Cosumnes River, only very minor increases in conductivity were noted between Michigan Bar and McConnell station, indicating no significant sources of degradation. On the Sacramento River, the mineral concentration at Sacramento is lower than at Knights Landing due to the influence of inflow from the American and Feather Rivers.

Ground Water

Ground water is defined as subsurface water occurring in the zone of saturation (below the water table) and moving under control of the water table slope or gradient. Below the ground surface there are two zones: an unsaturated zone and a saturated zone. The unsaturated zone is that zone between the land surface and the water table and includes the capillary fringe. Perched water bodies may exist within the unsaturated zone. The saturated zone is that part of the water-bearing material in which all voids, large and small, are filled with water.

Precipitation, applied water, and streamflow enter the unsaturated zone from the surface and flow by gravity toward the saturated zone. The rate at which this water reaches the saturated zone depends on factors which include: the amount of precipitation or applied water available; the type of soil (sandy or hardpan) and moisture content of the soil belt; and vertical permeability of the unsaturated zone. If only a small amount of water is applied or is available through precipitation, it may be consumed by evapotranspiration of the vegetative growth in the soil zone. Water that passes through the soil zone moves downward through the unsaturated zone. Water that reaches the saturated zone is considered as deep percolation and is treated as an increment to the ground water supply.

The time of travel through the unsaturated zone is unknown due to the variation of soil type and varying distance to the water table. Actual field measurements have been made at several localities in the San Joaquin Valley. In the Mendota area, Poland [1958] found that water traveled 128 feet in 6 months and 150 feet in 15 months, through a deep and dry unsaturated zone. Near Woodville, Tulare County, the U. S. Department of Agriculture found that ground water could be sensed at 35 feet below ground surface 5 days after application began.

In the Natomas area the response of the water table to precipitation or irrigation should be several days. However, in the southern part of the County it would be considerably longer. For this study it is assumed that recharge water takes less than a year to travel to the water table.

Pumpage

Ground water pumpage consists of agricultural, municipal, and industrial pumpage. Only a few individual ground water users keep records on their pumpage. Agricultural pumpage was estimated for the Department by the USGS in a cooperative study for the years 1967, 1968, and 1969, from electric power consumption records obtained from Sacramento Municipal Utility District (SMUD) for the Sacramento County area and Pacific Gas and Electric Company (PG&E) for the Yolo County area. Power records were not available to estimate pumpage for prior years in the Sacramento County area. Agricultural pumpage for years prior to 1967 were estimated from land use and water use data discussed later in this chapter. Municipal pumpage records were available for a number of districts. Unrecorded municipal pumpage was estimated using population and water use data. Estimates of water pumped by individual industries was estimated from records of water use, production or sales. The annual amounts of pumpage by use are listed in Table 6. The average annual pumpage for the study period is 358,000 acre-feet, with agriculture accounting for two-thirds of the total.

Ground Water Quality

Ground water contained in the water-bearing materials underlying most of Sacramento County is of excellent quality for irrigation and domestic use. Its character is principally calcium, magnesium, and calcium-sodium bicarbonate and reflects its origin, having been derived by recharge from streams draining the crystalline and metamorphic rock areas to the east. The main ground water body in Sacramento County ranges in thickness from several hundred feet near the eastern portion of the County to an estimated 2,000 feet near the Sacramento River. Underlying this body of ground water is one of poorer quality sodium sulfate water which occurs mostly in the Valley Springs and Ione formations; this deeper ground water is tapped by a few wells in the eastern foothill areas. According to studies by the U. S. Geological Survey [1973], the base of fresh water is defined as that zone of water having an electrical conductivity of 3,000 micromhos. The USGS found that the base of fresh water in Sacramento County slopes from elevation -800, near Sloughhouse, to -2,000 feet along the Sacramento River.

The Delta area contains a separate body of poor quality ground water, which ranges from sodium bicarbonate to sodium chloride in composition and in many areas is unusable for either domestic or irrigation purposes. The boundary between this Delta water and the good quality water is roughly along the common boundary separating Townships 4 and 5 North. There are areas containing sodium chloride ground water along the Sacramento River from the Delta as far north as Township 11 North and also along the Feather River in Township 11 North. The presence of this poor quality water is believed to be due to two causes. First, near surface saline water occurs along many buried channel deposits in the Delta area. This water may be present due to upstream saline migration during periods of low riverflow in the geologic past. The high salinity also may be attributed to rising connate water found generally throughout the central Delta area and in the southern part of Sutter County.

Ground water to the west of the Sacramento River has been derived from recharge along eastward flowing streams that drain the marine sediments west of the Great Valley. This water is predominantly magnesium and magnesium-sodium bicarbonate,

and is of poorer quality than that derived from the east. Most of this water type occurs in Yolo County. Figure 13 shows the water characteristic types in and adjacent to the study area. On the figure it may be noted that the magnesium bicarbonate water occurs west of the Sacramento River and calcium bicarbonate water occurs to the east of the river. Because the Yolo Bypass appears to be a ground water mixing area, this feature may serve as a ground water subbasin boundary.

In February 1973, a 1,550-foot well was drilled in Yolo County (8N/4E-9L). Water samples were taken at the 1,000-foot level, 1,350-foot level, and 1,550-foot level. The water characteristics were sodium-calcium chloride, magnesium-sodium bicarbonate, and sodium chloride, respectively, corresponding to the 1,000-foot, 1,350-foot, and 1,550-foot levels. The 1,350-foot aquifer is distinctly eastside water, while the other two are mostly sodium chloride. This is probably due to upstream migration of saline water in geologic past.

Table 7 lists the analyses of the foregoing samples, an analysis of a sample taken at 1,700 feet by Brown and Caldwell Laboratory from the same well, and an analysis of a sample taken from a 1,400-foot deep well (8N/2E-21Q) at the University of California at Davis. The well at UCD was gravel packed at selected intervals. The water at UCD is sodium bicarbonate type, which is distinctly different from that at the Yolo County well. Based on the water quality analysis at 8N/4E-9L, the well is in the ground water mixing area, where stream deposits from the eastside stream and valley trough are interfingered together. There is no evidence of the westside stream channel, based on the UCD water characteristics.

Each mineral constituent that is present in the ground water of Sacramento County in undesirable quantities is summarized below.

Iron and Manganese

The only water quality problem in Sacramento County study area is one of excessive amounts of iron and manganese in ground water. The 1962 Drinking Water Standards of the U. S. Public Health Service included a recommended limit of 0.3 mg/l for iron and 0.05 mg/l for manganese. These limits are for esthetic and taste considerations because iron and manganese tend to precipitate as insoluble hydroxides and stain laundry and porcelain fixtures. Large concentrations of these minerals could discolor the water. However, the concentrations of iron and manganese found in ground water in the study area do not constitute a public health hazard.

Of 304 wells sampled for iron and manganese, a total of 216 showed an iron concentration in excess of 0.3 mg/l and/or a manganese concentration in excess of 0.05 mg/l. Many wells sampled over a period of time showed a wide range in concentration of these constituents. For example, Well 9N/4E-27K1 was sampled on April 30, 1958; the mineral analysis of the ground water showed a concentration of 0.29 mg/l of iron and 0.96 mg/l of manganese. The well was sampled again on September 16, 1959; the mineral analysis of this later sample indicated 0.94 mg/l of iron and 0.00 mg/l of manganese. Not all wells in Sacramento County have been

TABLE 5

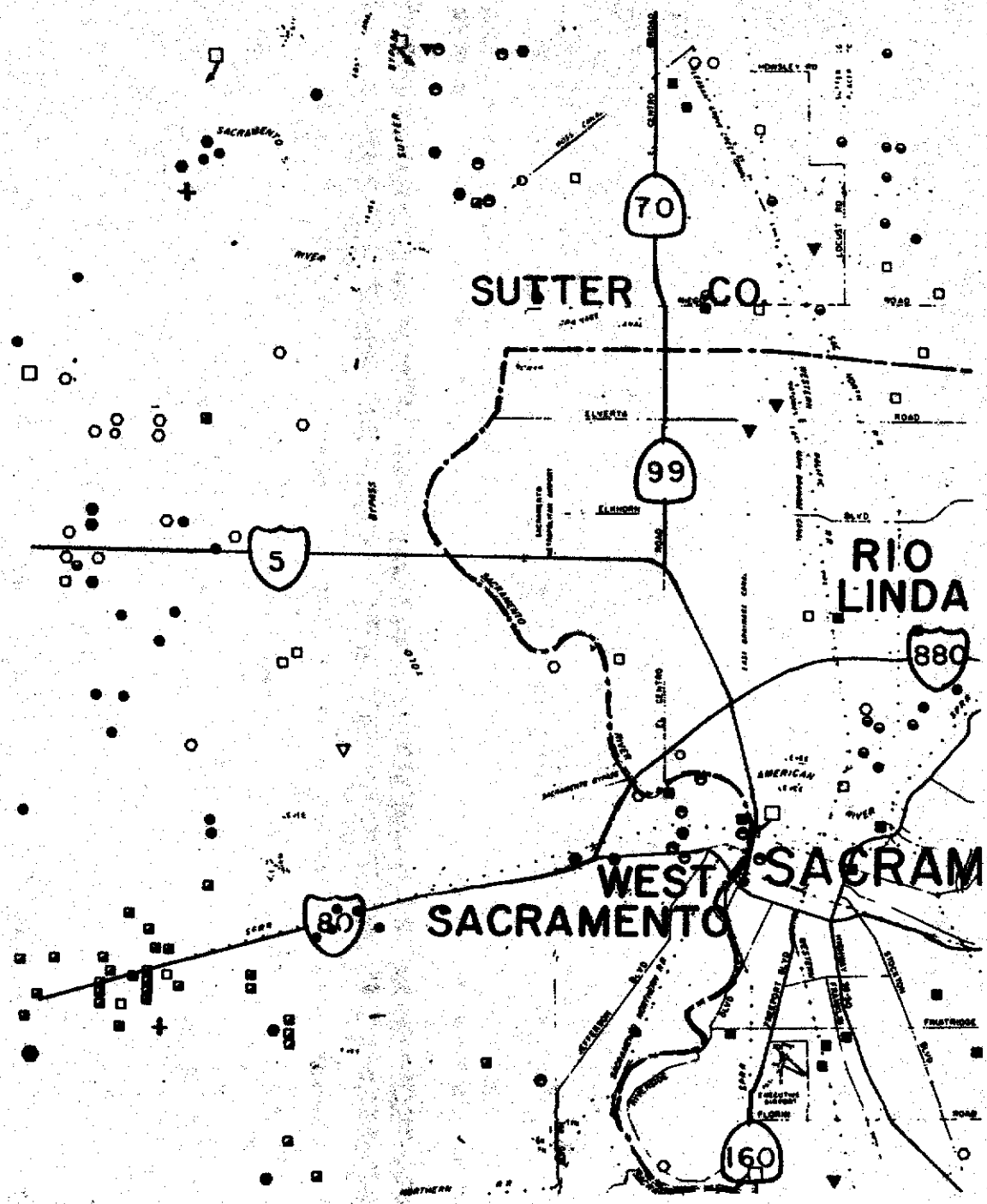
SURFACE WATER QUALITY FROM REPRESENTATIVE STATIONS

Station Number	A0 7175.00	B0 1125.00	B9 1849.80
Station Name	American River at Fair Oaks	Cosumnes River at McConnell	Sacramento River at Freeport
Date	10-27-69	04-29-70	06-08-66
Time	0730	0730	1445
Temperature	58°F	51°F	69°F
pH	6.8	7.3	7.7
Electrical Conductivity (Micromhos at 25°C)	40	75	208
Turbidity	5E	3E	--
Chemical Constituents in Milligrams per Liter:			
Calcium	4.7	5.9	17
Magnesium	1.1	3.6	7.2
Sodium	1.6	3.9	15
Potassium	0.8	1.2	1.0
Carbonate	0.0	0.0	2.0
Bicarbonate	20	40	89
Sulfate	0.0	9.4	15
Chloride	1.4	0.4	10
Nitrate	0.1	0.0	1.9
Boron	0.00	0.00	0.00
Total Dissolved Solids	36	66	131
Total Hardness	16	29	72

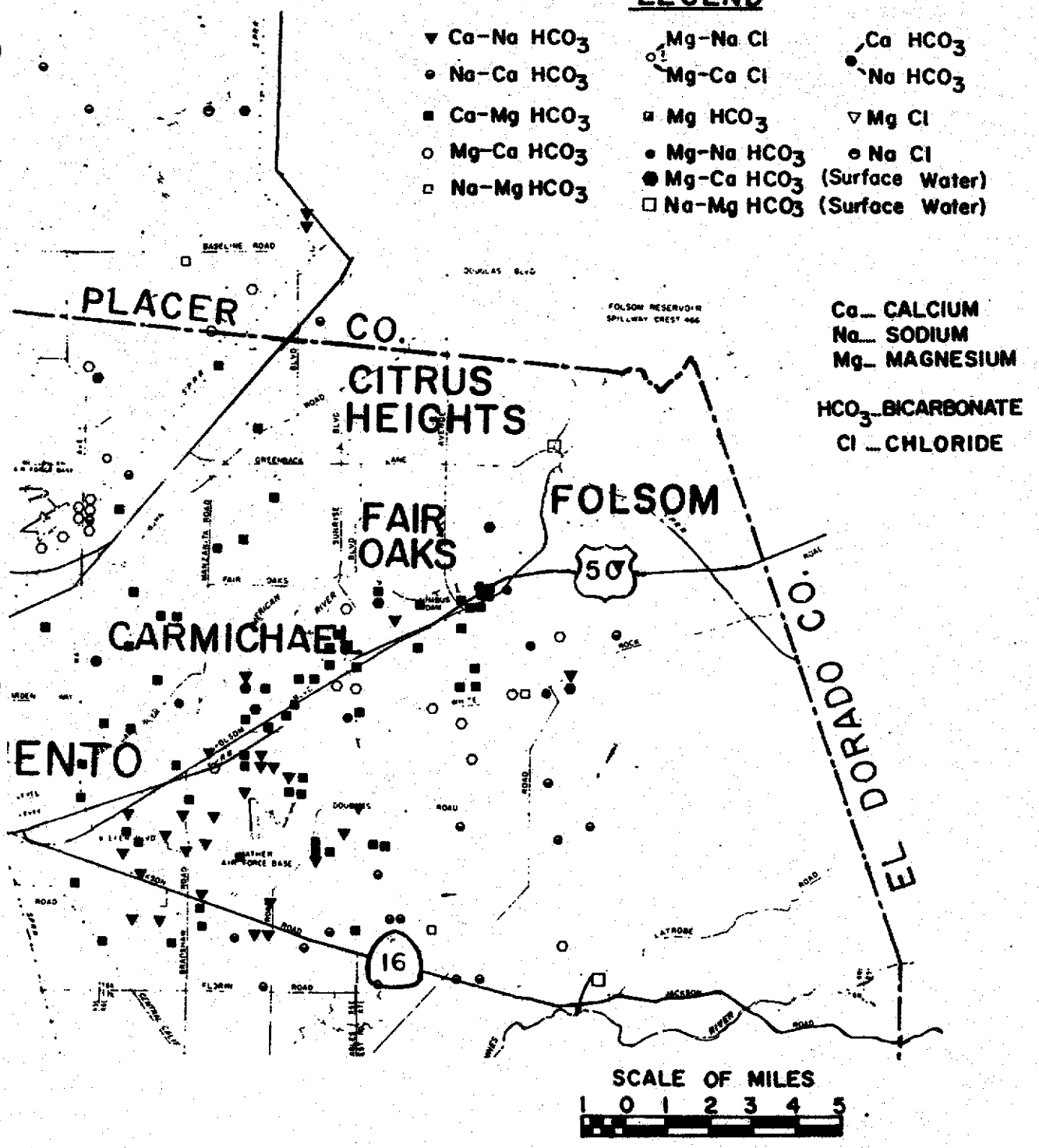
TABLE 6

TOTAL ESTIMATED PUMPAGE FOR SACRAMENTO COUNTY
1962 THROUGH 1969
(in Acre-Feet)

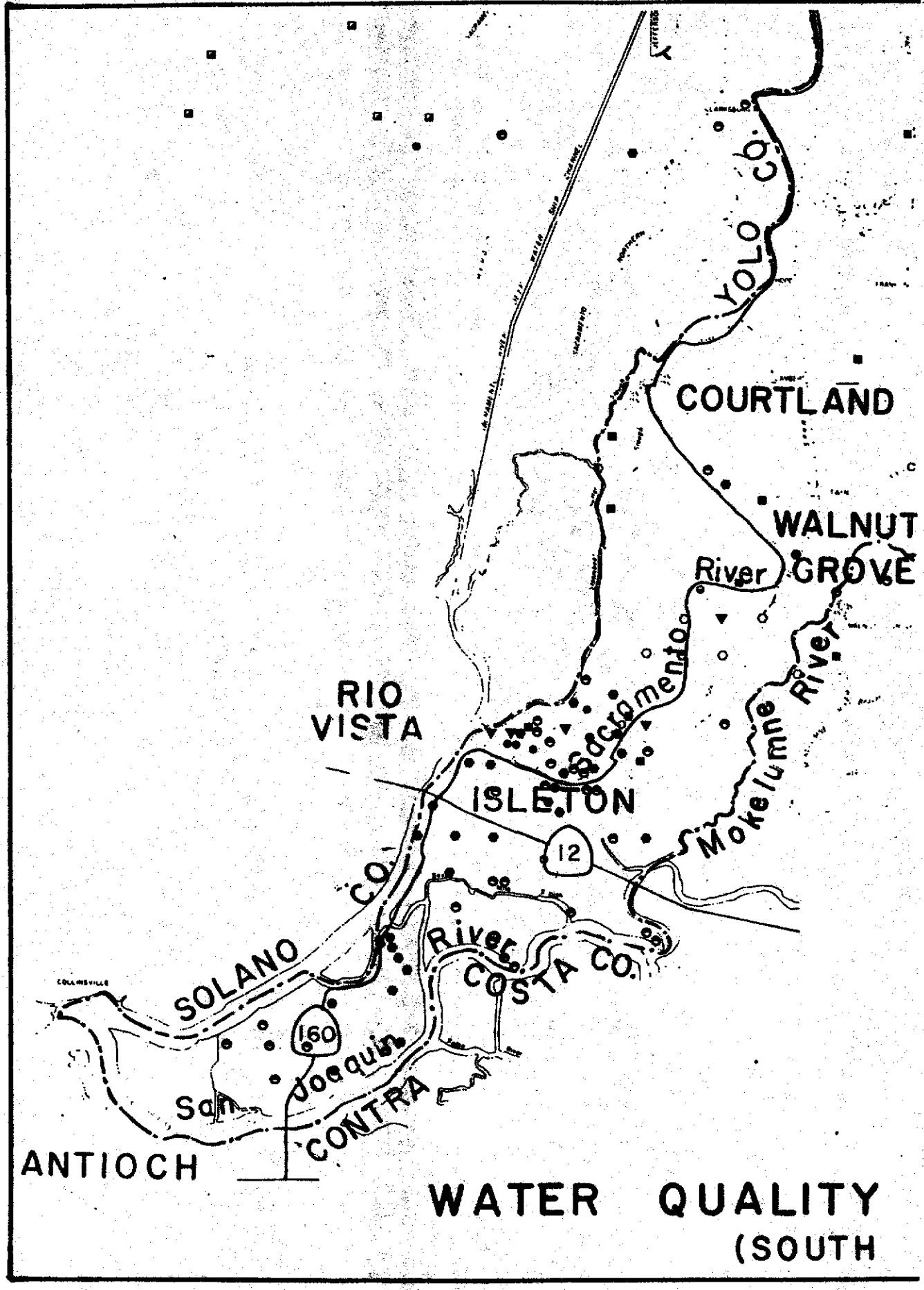
Calendar Year	Agricultural	Municipal and Industrial			Total Estimated Pumpage
		Water Purveyors	Industrial Self-Produced	Rural Domestic	
1962	293,000	73,400	19,200	10,800	396,400
1963	199,000	63,100	17,400	9,100	288,600
1964	297,000	67,300	19,800	10,500	394,600
1965	249,800	69,900	20,700	10,700	351,100
1966	296,000	82,400	23,400	12,300	414,100
1967	189,200	77,200	21,500	11,200	299,100
1968	232,100	85,200	24,800	12,600	354,700
1969	244,800	87,200	23,400	12,500	369,900
Average	250,100	75,700	21,300	11,200	358,300
% of Total	69.8	21.1	6.0	3.1	100.0



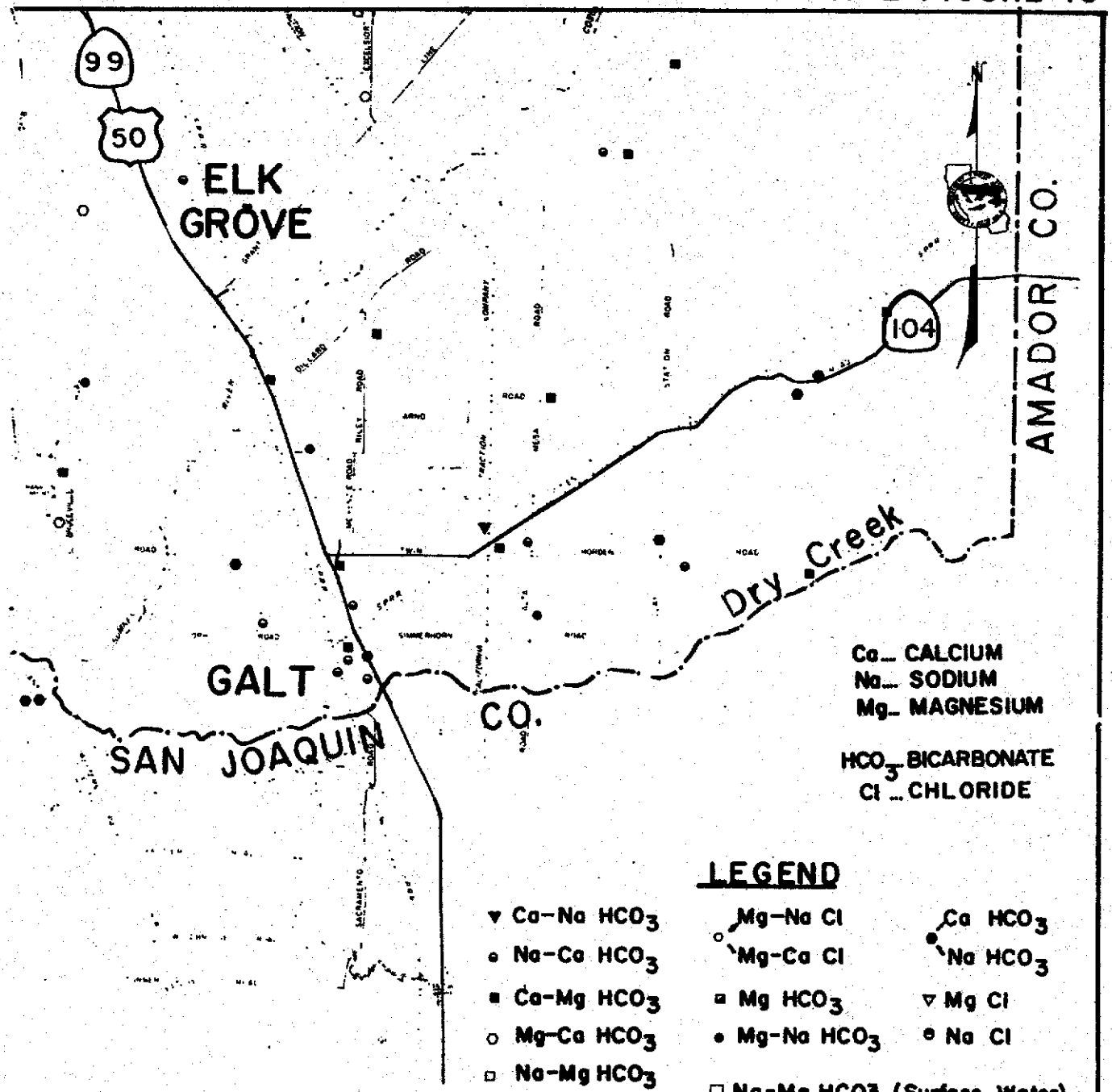
WATER QUALITY
(NORTH


LEGEND
Ca-Na HCO3
Na-Ca HCO3
Ca-Mg HCO3
Mg-Ca HCO3
Na-Mg HCO3
Mg-Na Cl
Mg-Ca Cl
Mg HCO3
Mg-Na HCO3
Mg-Ca HCO3 (Surface Water)
Na-Mg HCO3 (Surface Water)
Ca HCO3
Na HCO3
Mg Cl
Na Cl
Ca... CALCIUM
Na... SODIUM
Mg.. MAGNESIUM
HCO3..BICARBONATE
Cl ...CHLORIDE
PLACER CO.
CITRUS HEIGHTS
FAIR OAKS
FOLSOM
CARMICHAEL
EL DORADO CO.
50
16
SCALE OF MILES
1 0 1 2 3 4 5

TYPES
SHEET)



WATER QUALITY
(SOUTH


99
50
ELK GROVE
104
AMADOR CO.
Dry Creek
GALT
SAN JOAQUIN
CO.
Ca... CALCIUM
Na... SODIUM
Mg.. MAGNESIUM
HCO3.. BICARBONATE
Cl ... CHLORIDE
LEGEND
Ca-Na HCO3
Na-Ca HCO3
Ca-Mg HCO3
Mg-Ca HCO3
Na-Mg HCO3
Mg-Na Cl
Mg-Ca Cl
Mg HCO3
Mg-Na HCO3
Ca HCO3
Na HCO3
Mg Cl
Na Cl
Na-Mg HCO3 (Surface Water)
SCALE OF MILES
1 0 1 2 3 4 5

TYPES

SHEET)

TABLE 7

GROUND WATER QUALITY ANALYSES

Chemical Constituents in ppm	8N/4E-9L Sample at 1000 ft	1350 ft	1550 ft	1770 ft*	8N/2E-21Q 1400 ft
Hardness as CACO3	368	299	101	88	96
Calcium	89	41	27		16
Magnesium	36	48	8.3		14
Sodium	142	50	229		79
Potassium	9	1.6	5.8		1.9
Bicarbonate	148	284	232		256
pH	7.7	7.3	7.8	8.0	8.1
Sulfate	2.8	82	0.8		34
Chloride	403	69	308	349	19
Nitrate	0.1	0.0	0.2		0.9
Boron	0.6	1.0	2.0		0.8
Total Dissolved Solids	1000	464	761		319
Specific Conductance (Micromhos at 25°C)	1500	801	1360	1780	510
Arsenic	0.00	0.00	0.00		0.0
Cadmium	0.00	0.00	0.00		0.0
Copper	0.00	0.00	0.00		0.0
Iron	0.16	0.01	0.01	2.35	0.01
Lead	0.01	0.01	0.01		0.01
Manganese	0.93	0.90	0.90	0.06	0.02
Zinc	0.29	0.32	0.32		0.02

*Brown & Caldwell Laboratory

sampled for iron and manganese. This is partly due to sampling techniques which require stabilizing these two constituents by acidizing the water sample immediately after obtaining it.

The statistic of 216 samples out of 304 samples, or about 71 percent, exceeding the USPHS standards for iron and manganese is not as significant as it indicates. This is due to bias that the water was suspected to contain a high iron and manganese concentration before the analysis was ordered. If all water samples were analyzed for iron and manganese, the percentage would have been a lot lower.

Because of wide variations of concentrations of iron and manganese at sampled wells, it is not possible to delineate areas of Sacramento County which consistently produce ground water exceeding U. S. Public Health standards for these two constituents. Examples of this wide variation over a period of time are presented on Table 8.

TABLE 8

VARIATIONS OF IRON AND MANGANESE CONCENTRATIONS WITH TIME

	Date Sampled	Iron (mg/1)	Manganese (mg/1)
Well 08N/04E-36R	12/28/53	4.30	1.50
	06/28/57	0.28	0.00
	08/20/58	0.01	0.00
	06/17/59	0.07	0.00
	08/14/60	0.00	0.00
	07/27/60	0.04	0.00
	01/11/61	0.07	0.00
	07/18/61	0.00	0.00
	08/27/62	0.02	0.00
	08/29/62	0.02	0.00
	00/00/68	0.00	0.10
	08/06/69	0.06	0.51
	08/14/69	0.06	0.51
	07/06/71	0.01	0.06
Well 08N/05E-15M01	06/03/61	0.04	0.06
	05/15/61	0.63	0.15
	05/15/61	0.50	0.28
	09/17/62	0.04	0.00
Well 09/05E-35Q	04/09/58	0.40	0.05
	04/15/58	0.40	0.05
	09/19/58	0.20	0.50
	10/30/58	0.26	0.70
	01/25/60	0.10	0.80
	01/09/68	0.06	0.05

Large concentrations of iron and manganese are not normally found in surface water. Iron and manganese usually precipitate as chlorides, nitrates, and hydroxides because they are only sparingly soluble. For this reason, manganese ions seldom are present in surface waters in concentrations above 1.0 mg/l. In ground water subject to reducing conditions, manganese can be leached from the soil and may occur in high concentrations. Iron frequently accompanies manganese in such ground waters.

The solution of iron- and manganese-bearing minerals is attributed to the action of carbon dioxide in ground waters. Carbon dioxide is generated by bacterial decomposition of organic matter leached from soil and swamp areas. These minerals enter into solution under anaerobic conditions and in the presence of certain reducing agents change from the higher oxide state (ferric and manganic ion) to the lower state (ferrous and manganous ions). (From American Water Works Association Water Quality and Treatment, 1971.)

Well logs are available from four of the locations of iron concentrations exceeding the USPHS drinking water standards recommended limit of 0.3 mg/l. These logs are from Wells 9N/5E-13P, 9N/5E-16Q3, 9N/5E-19F, and 9N/5E-25C. It was noted that the perforations were at or just below a clay layer -- white, yellow, and dun clay. It is suspected that during the leaching process, water percolating into the ground water basin carried ferrous and manganous ions along with it. Since the ferrous and manganous ions are relatively heavy, they tend to settle in the ground water body until they are concentrated on top of a clay lens. In the process of well design and construction where perforations are to be placed in the well casing, probably to insure good production, most wells are over-perforated into the clay layers. If this postulation is correct -- and there is no inexpensive method to verify it -- presumably the concentrations of iron and manganese should diminish with time.

Sodium

Sodium is a very active metal which does not occur in its native state in nature. Sodium compounds constitute 2.83 percent of the crust of the earth. Most sodium salts are extremely soluble in water, therefore, any sodium that is leached from soil or discharged to streams will remain in solution. Sodium ion in ground water is derived from the decomposition of sodic feldspar by water containing carbon dioxide. One of the products of this decomposition is sodium bicarbonate, which is present in water in its dissociated state, that is, in the ionic form (Na^+ and HCO_3^-). Large amounts of sodium also are derived from the intrusion of sea water and from migration of formation waters from marine sediments. Both of these types of water are sodium chloride in character.

For many years the percent sodium has commonly been reported in analyses of irrigation water because the presence of sodium ion was known to adversely affect the tilth and permeability of certain soils. The opposite is true

for calcium and magnesium ions, which in proper proportions will maintain soil in good condition of tilth and structure. When a soil containing exchangeable calcium and magnesium ions is irrigated with a water containing large amounts of sodium ion, a decrease in tilth and permeability results due to base exchange. This is because sodium ion has been adsorbed by the soil minerals, replacing the calcium and magnesium ions.

In the Delta region the average sodium ion concentration in ground water was found to be 208 mg/1, from 261 samples; the range of values was from 9 mg/1 to 587 mg/1. For Townships 5, 6, and 7 North, the average concentration was only 26 mg/1 from 168 samples; the range of concentration was from 6 to 277 mg/1. For Townships 8, 9, and 10 North, the average sodium ion concentration was 22 mg/1 from 745 samples; the concentration ranged from 1 mg/1 to 1,480 mg/1.

Figure 14 depicts percent sodium contours that are more or less parallel with the Sacramento, American, and Cosumnes Rivers. The percent sodium increases with distance away from the recharge sources, which appear to be the rivers. Qualitatively, the rivers are recharging the ground water basin, but it cannot be quantified. This verifies that the rivers are losing streams, thereby recharging the ground water basin. From the standpoint of the percent sodium, the Delta portion of the County is distinctly different from the rest of the County.

The U. S. Salinity Laboratory [1954] revised the concept of sodium percentage and adopted the Sodium Adsorption Ratio, or SAR. The SAR values are used to describe the sodium (alkali) hazard of irrigation water. This ratio expresses the relative activity of sodium ion in the exchange reactions with soil. Hem [1959] has defined the SAR value as follows:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{1}{2}\,(Ca^{++} + Mg^{++})}}$$

where Na^{+}, Ca^{++}, and Mg^{++} are concentrations of the respective ions in equivalents per liter of water.

The SAR value for a water is related to the adsorption of sodium by a soil to which water is added. As a means of estimating the possible results of using water for irrigation, the SAR value is more directly significant than the percent sodium value.

Figure 15 is modified from the chart derived by the U. S. Salinity Laboratory [1954]. Based on an SAR scale from 0 to 30 and conductivity values of 100 to 5,000 micromhos per cm at 25°C, this diagram classifies irrigation waters with respect to sodium and salinity hazards.

On Figure 16, sodium hazard areas for Sacramento County have been delineated. All of the County, with the exception of the Delta area, lies within the zone of low sodium hazard. In the Delta area the sodium hazard ranges from medium, near Isleton, to very high on Sherman Island.

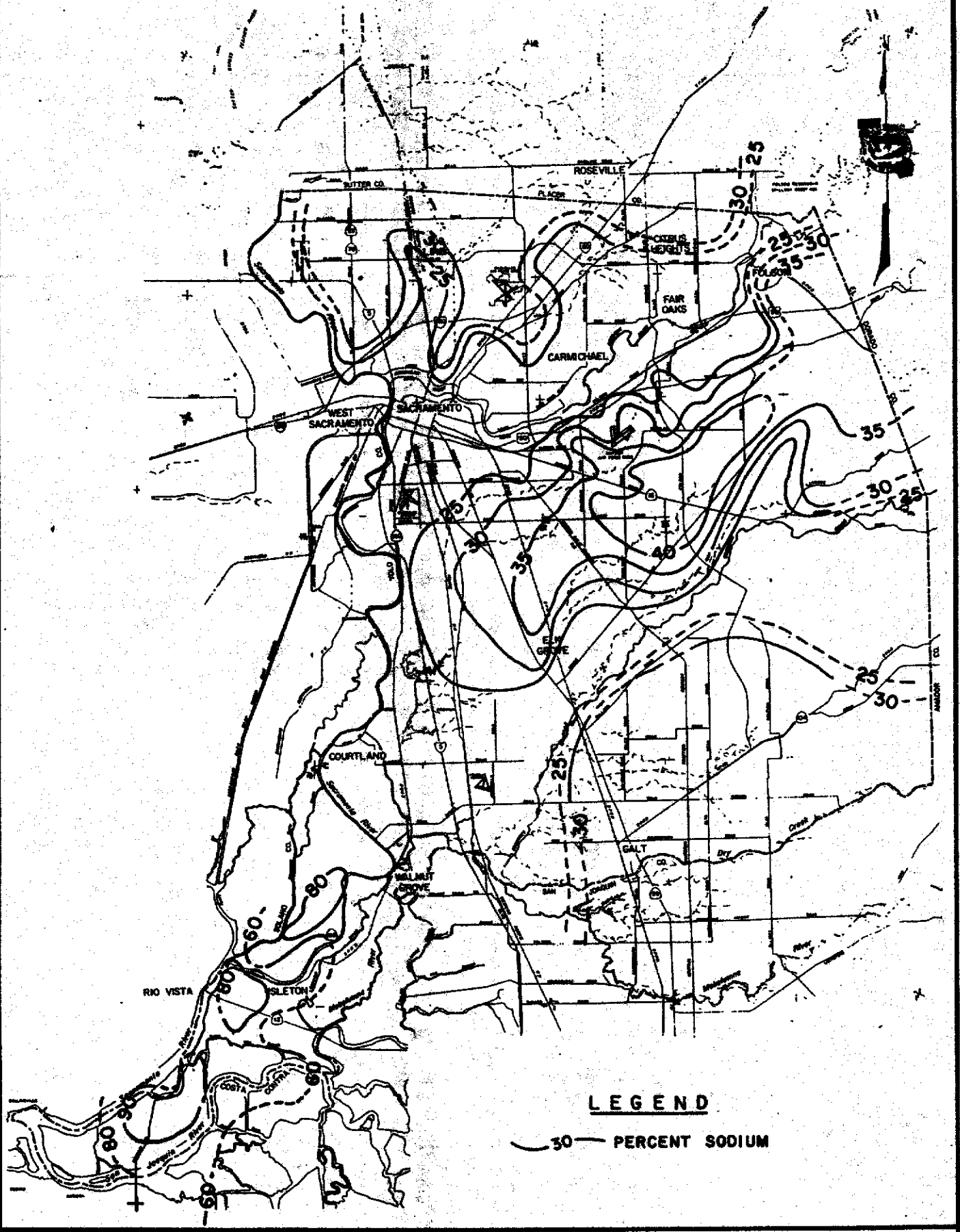


Figure 14. CONTOURS OF EQUAL SODIUM PERCENTAGE

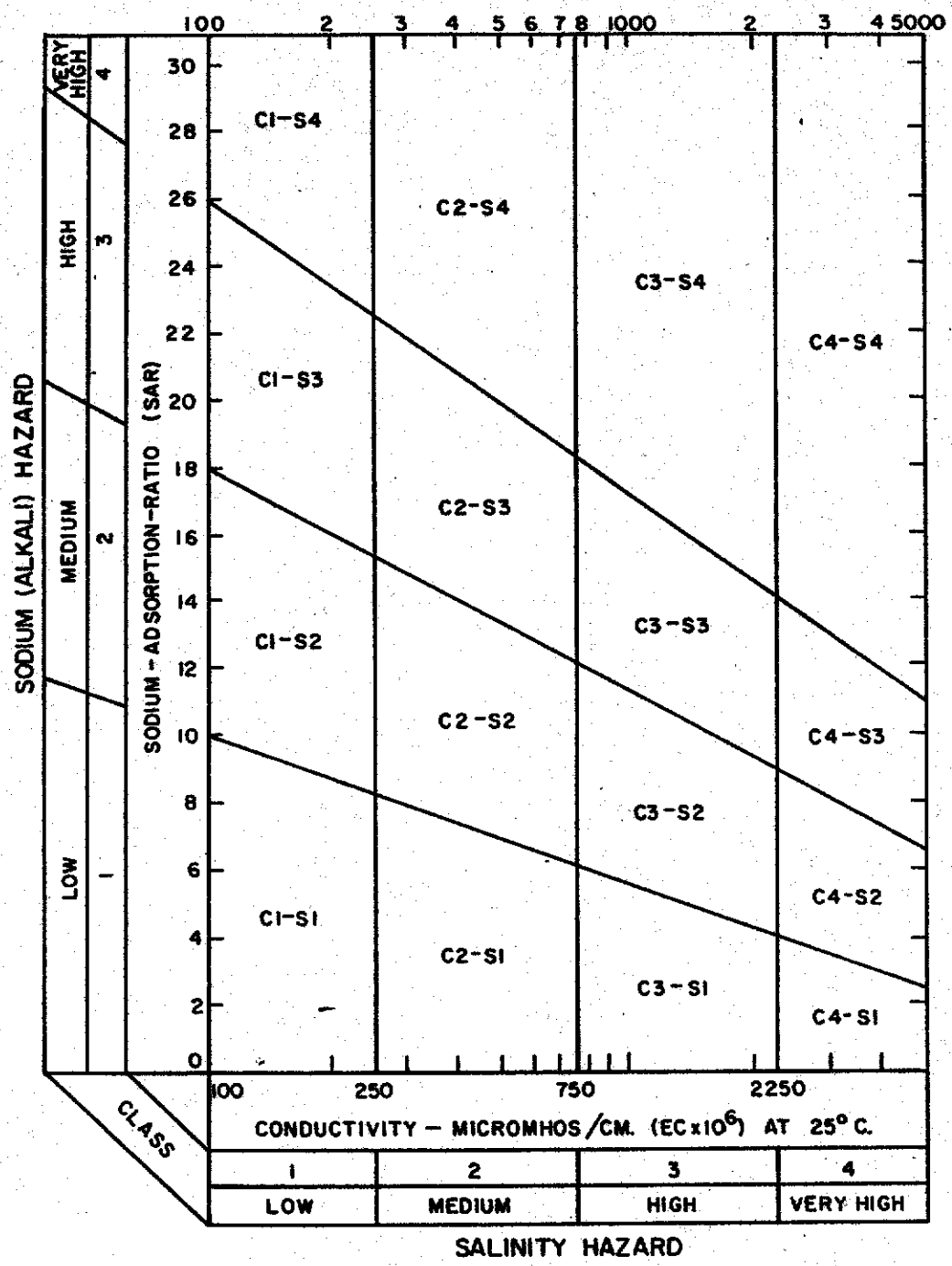


Figure 15. CLASSIFICATION OF IRRIGATION WATERS

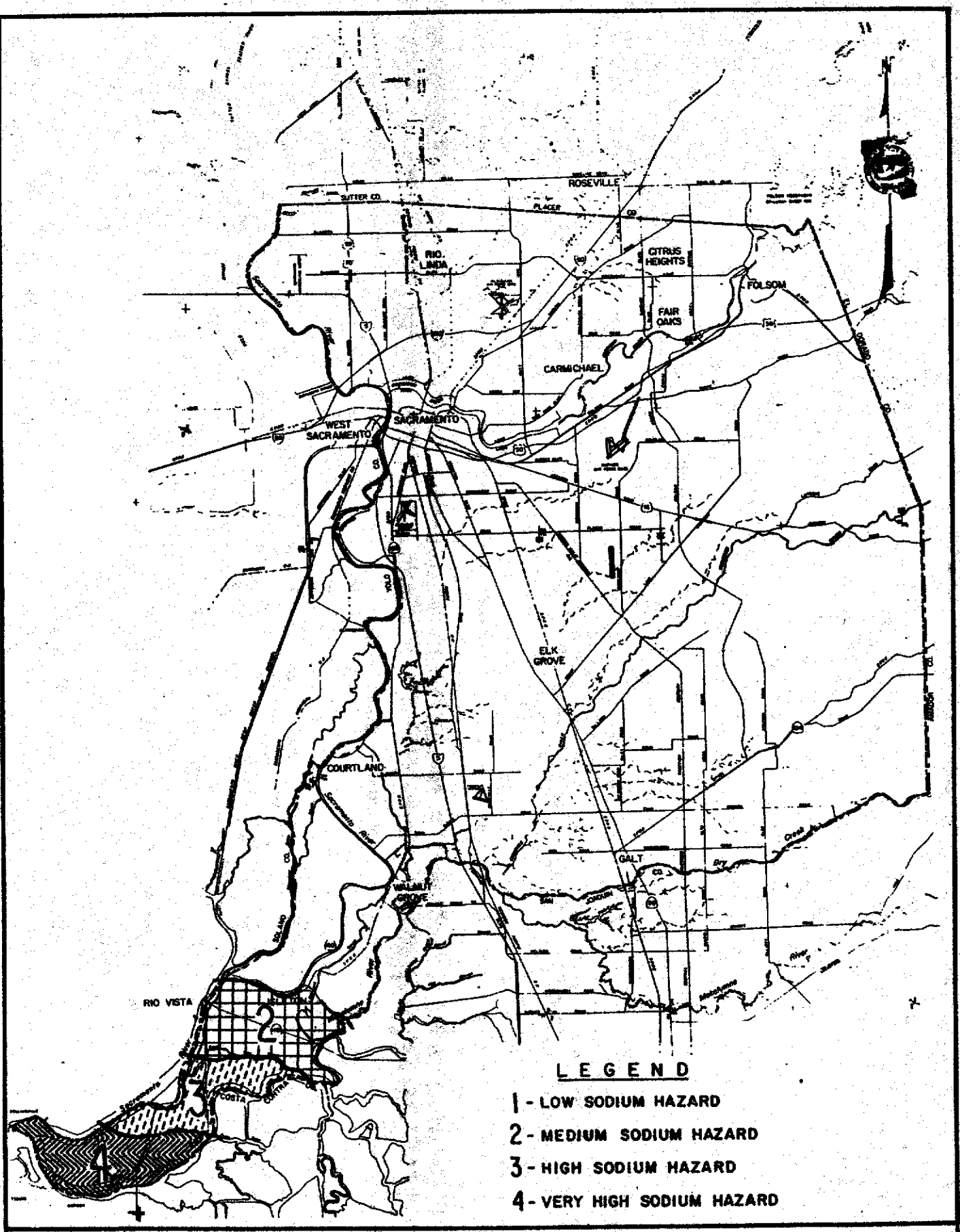


Figure 16 SODIUM HAZARD AREAS

Chloride

Chlorine is a member of the halogen group of elements, and it is the most important and widely distributed member of this group. It is highly soluble in water where it occurs as chloride ion (Cl^-). Chloride ion is present in oceanic waters in great abundance where it is the principal anion. Chloride ion also is present in large quantities in marine connate waters.

Ground water with high chloride concentration occurs only in the Delta area. Here the average chloride ion concentration is 132 mg/l, with the range of concentration being from 6 to 904 mg/l for 261 samples. This relatively high chloride concentration also affects the electrical conductivity and total dissolved solids (TDS) of the ground water. The average conductivity was found to be 872 micromhos, with the range being from 114 to 3,250 micromhos for the 151 samples tested. The average TDS value was found to be 509 mg/l, with the range being from 100 to 1,740 for 103 samples.

Boron

Boron is essential in trace quantities to plant nutrition, but it becomes toxic to certain plants when present in amounts in excess of 0.5 mg/l in irrigation water. Certain other plants are more tolerant, being able to survive boron concentrations of up to 2.0 mg/l.

Excessive boron in ground water usually is derived from the intrusion of sea water and from rising marine connate waters. In Sacramento County most of the boron problem occurs in the Delta area. Here the average concentration of elemental boron is 0.8 mg/l; the concentration in 82 samples was found to range from 0.0 mg/l to 3.1 mg/l. Excessive concentrations of boron usually are associated with high concentrations of chloride ion.

Water Levels

In 1970, the Department listed in Bulletin 130-70 the water level measurements for 336 wells in Sacramento County. Of these wells, 17 were measured monthly. Five different agencies are responsible for these measurements. They are: (1) Sacramento County, (2) Arcade County Water District, (3) Sacramento Municipal Utility District, (4) U. S. Bureau of Reclamation, and (5) California Department of Water Resources.

These measurements are of sufficient coverage to draw annual ground water contours for the model period, 1962 through 1968, in the areas of greatest concern. Because there were only a few wells in the eastern foothills areas, ground water contours were not as accurate as for the remainder of the County. However, in the eastern foothills, where the depth of alluvium is fairly small, the amount of pumpage is also small and therefore large errors in the assumed ground water level did not affect the overall ground water storage.

From inspection of driller's logs it was noted that pressure conditions exist locally throughout the County, indicating a certain degree of confinement caused by lenses of clay. The largest rise in pressure levels was for Well 9N/6E-20N2,

where water was first encountered at 92 feet; after development of the well, the standing water level was 66 feet, indicating a potentiometric rise of 26 feet. Throughout the County the average rise in water levels amounts to less than 10 feet. Ground water contour maps were drawn for each year of the study period, using 398 wells located within the study area. Water level contours for spring 1968 are shown on Figure 17, and the net change in water levels from spring 1962 to spring 1968 are shown on Figure 18. Because of the complex subsurface geology of Sacramento County, these water level measurements represent combinations of unconfined, semiconfined, and confined conditions within each well, with the actual degree of confinement in each well remaining unknown.

Recognizing the fact that each geologic formation should have its own potentiometric surface, an attempt was made to group the water level measurements by formation and thus contour the potentiometric surface for each formation. However, it was found that in most cases the potentiometric surfaces of the various formations coincided, and thus a separation of the ground water body on the basis of water level measurements could not be made. For this reason it was decided that the ground water system could be considered as a single layer of water-bearing materials.

Four hydrographs of water level fluctuations are shown on Figure 19. The top graph represents an average for the entire county area. From 1930 through 1940, ground water levels have remained fairly steady, therefore during this period ground water pumpage was fairly constant. From 1940 to date, the decline in the water table is fairly uniform, being about one foot per year. The average ground water surface elevation decreased from 30 feet (mean sea level) in 1940 to about minus 5 feet in 1970, or a decrease of about 35 feet in 30 years.

The second graph, Well 6N/5E-10G1, of unknown depth, is located just north of Franklin, in the pumping depression in southwestern Sacramento County. The ground water surface elevation for this well has declined from minus 20 feet in 1950 to minus 70 feet in 1970. The rate of decline was in excess of 2½ feet per year from 1950 to 1970 and then appeared to asymptotically approach an equilibrium level. This suggests that the lowering of the ground water level increased the slope or gradient from the Sacramento River, thereby increasing infiltration from the river.

The third graph, Well 6N/7E-28E1, of unknown depth, is located in the southeastern part of the County. The ground water level has steadily declined at this well from an elevation of 31 feet in 1951 to minus 10 feet elevation in 1970, an average decline of over a foot and a half per year. The rate of decline appears to be unchanged in 1970.

The last graph on Figure 19 shows Well 9N/5E-21M1, of 94 feet depth, located in the northern portion of the County. The water levels at this well have declined steadily from an elevation of 9 feet in 1950 to minus 10 elevation in 1970. This decline of about one foot per year appears to be continuing.

The first two wells are located in agricultural areas, while the third well is located in an urban area. The ratio of agricultural pumpage to municipal and industrial pumpage is approximately two to one in the County.

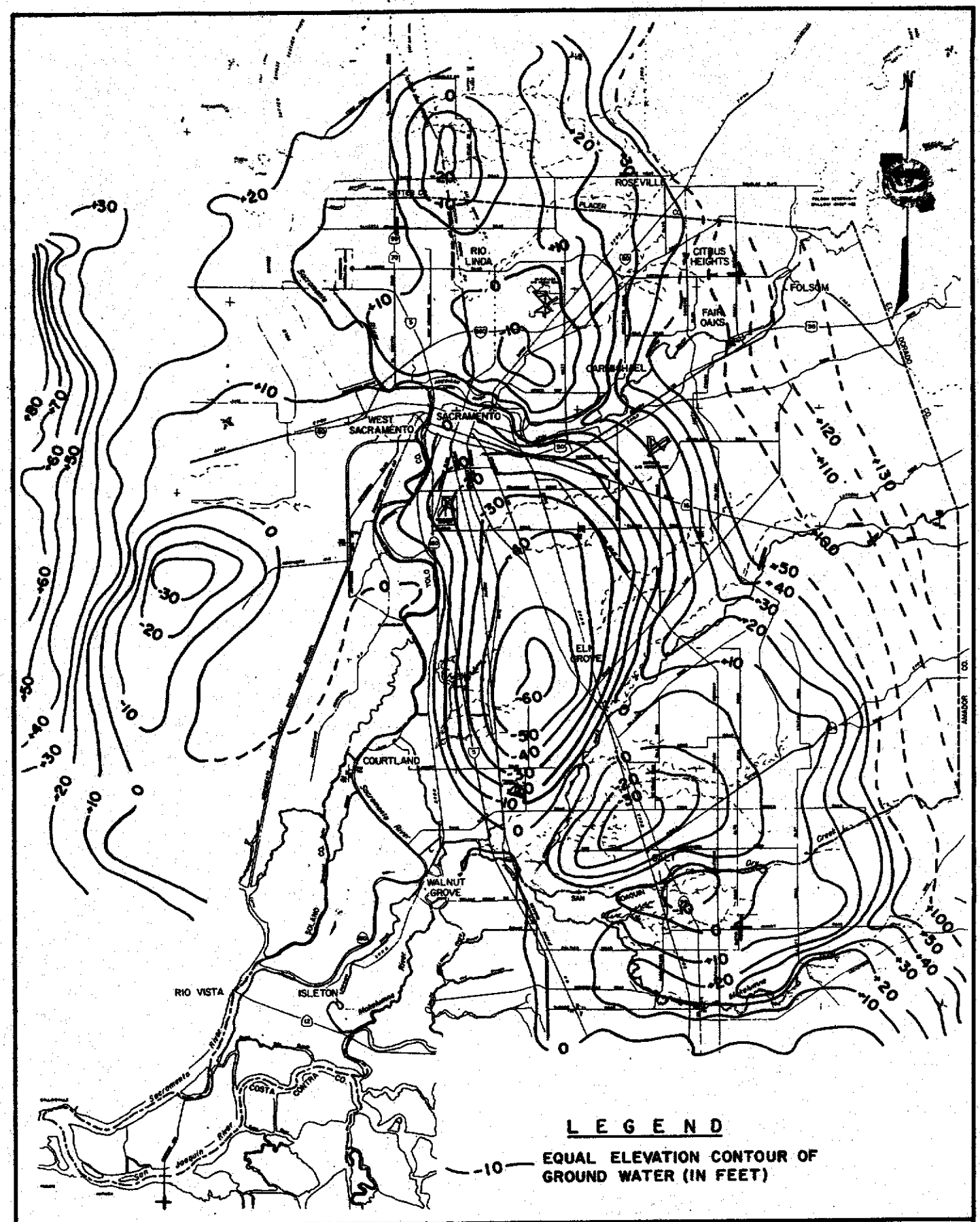


Figure 17. CONTOURS OF EQUAL ELEVATION OF GROUND WATER, SPRING 1968

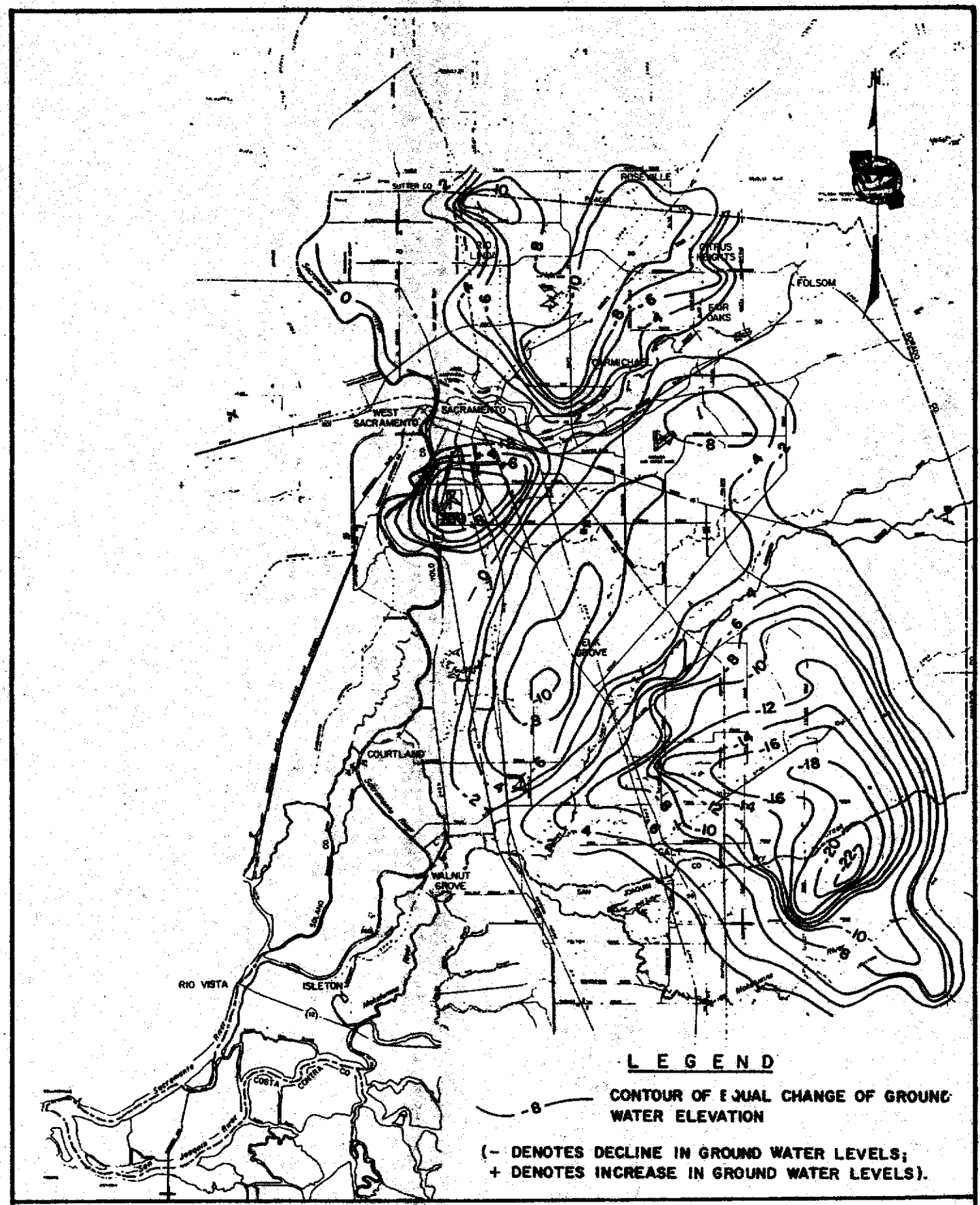


Figure 18. CONTOURS OF EQUAL CHANGE IN GROUND WATER LEVELS - SPRING 1962 TO SPRING 1968

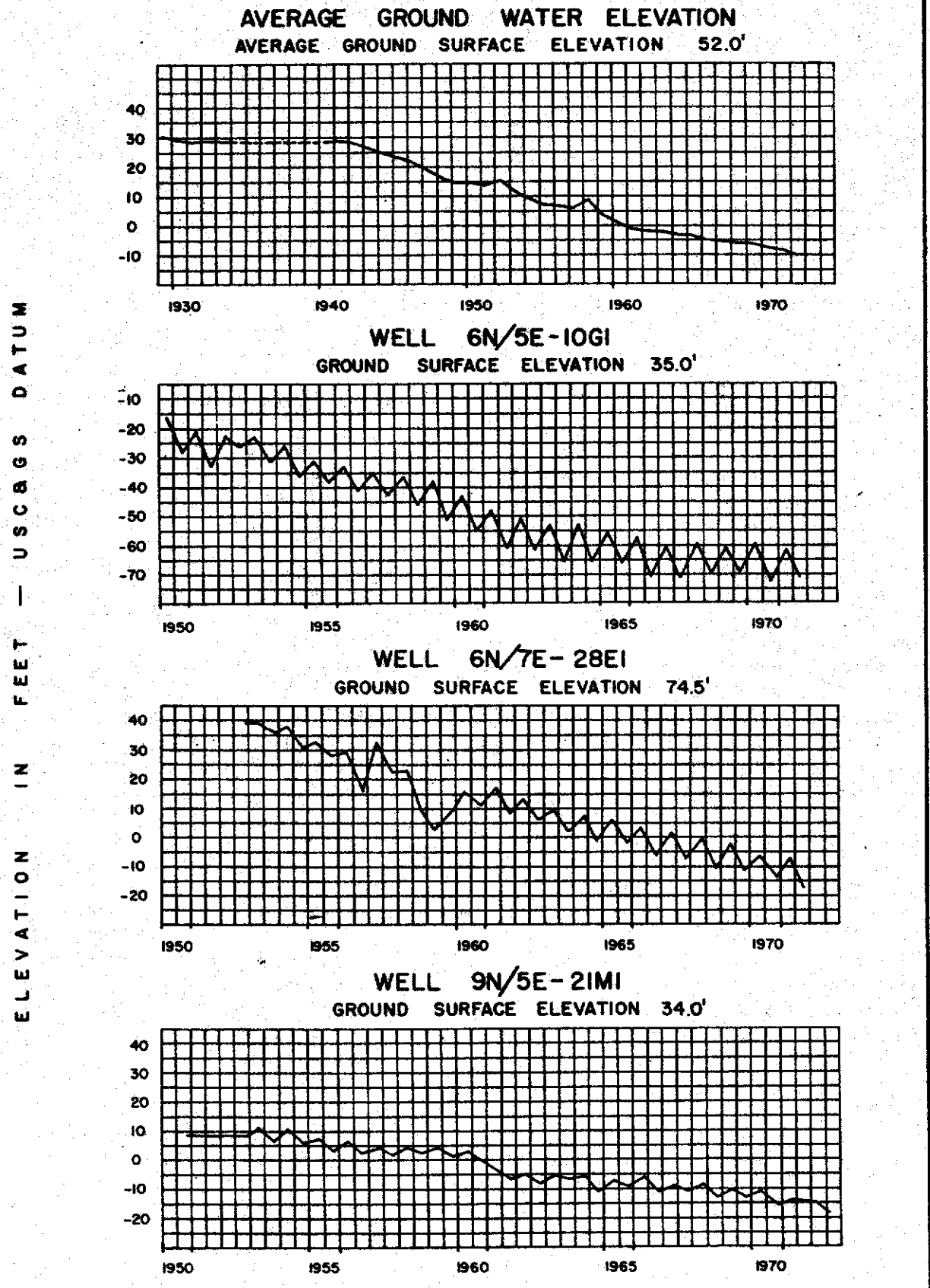


Figure 19. FLUCTUATION OF WATER LEVEL IN WELLS

Land Use

In the late 1940's, the Department initiated a survey activity designed to identify the nature, location, and extent of present land use and lands suitable for various kinds of water-using development. After completing these surveys for most of the State and meeting the then-current data needs, the Department initiated a continuing survey program to monitor land use changes on a cycle of 5 to 10 years.

The Department makes two kinds of surveys: (1) land use surveys to record the nature and extent of present water-related land development; and (2) land classification surveys to determine the location and extent of lands with physical characteristics suited to specific kinds of uses. The nature of land characteristics identified is such that the data are useful in determining alternative uses for the land.

The land use surveys are accomplished through interpretation of current aerial photography supplemented by field inspections. The acreage of each specific category of land use is presented on Table 9 for 1968.

The land classification surveys involve field examination of soil characteristics such as depth, texture, salinity, etc., and land features such as slope, microrelief, physiographic position, etc. Table 10 lists acreage in each category of land class. The type of land use and classification information recorded during surveys is shown by the land use and land classification legends presented on Figures 20 and 22. Examples of completed land use and land classification maps are shown on Figures 21 and 23. These are reductions of the original maps, which were on 22 X 27-inch U. S. Geological Survey 7½-minute quadrangles at a scale of 1:24,000. The areal extent of irrigated agricultural lands and urban lands for 1968 is shown on Figure 24.

Population

Population data are needed for analysis of historic water use and are available from the U. S. Census, taken every decade, and also from the California Department of Finance. Population is available both for small areas and for the County as a whole. Estimates made by the California State Department of Finance on July 1 of the following years for Sacramento County are given below:

Year	Population	Year	Population
1961	533,300	1966	606,500
1962	554,400	1967	612,600
1963	574,600	1968	614,800
1964	587,300	1969	622,000
1965	598,300	1970	634,800

TABLE 9

1968 LAND USE SUMMARY FOR SACRAMENTO COUNTY
(In Acres)

Land Use Symbol*	Irrigated Lands	Nonirrigated Lands
G	2,735	
R	11,904	
F	2,053	339
F1	50	
F2	9,701	
F5	3,809	
F6	27,231	
F7	15,794	
P	87	
P1	14,725	
P2	231	
P3	62,237	
P4	5	1,814
P5	36	
T	257	8
T2	2,230	
T3	295	
T6	92	
T9	25	
T10	45	
T11	134	
T13	224	
T15	12,295	
T16	156	
T18	498	
T20	12	
D	7,406	405
D6	2,482	
V	330	12
S	7	
S1	85	
S2	131	
S4	10	
S4 (P)	296	
S5	8	4
E (M)		9,310
NV		343,999
NV (P)		945
NR		6
NR1		27
NR2		33
NW		738
U		80,770
U (P)		147
UR		29
UR01		4
UI		1,465
UI2		34
UV		9,199
UV1		10,529
Total	177,616	459,817
GRAND TOTAL	637,433	

*See Figure 20

TABLE 10

LAND CLASSIFICATION SUMMARY FOR SACRAMENTO COUNTY

Land Class Symbol*	Acres
V	67,756
VB	54,646
V2	5,853
V4	1,728
VW	241
VWB	406
VH	19,192
VH2	490
VH4	64
VL	225
VL2	81
VP	110,992
VPB	4,553
VP2	71,302
VP4	18,866
VP6	302
VR	258
VPR	8
VPR2	203
Total V	357,166
H	427
HL	42
HP	99,808
HPL	19
HPR	380
Total H	100,676
M	78
MP	14,772
MPH	97
MPL	150
MPR	781
MPM	11
MPRH	37
MPRL	50
MPRM	291
Total M	16,267
UD	90,668
Total UD	90,668
RR1	25
RC	67
Total R	92
PP	914
Total PP	914
VM	4,071
VM2	13
Total VM	4,084
N	67,058
NW	6,746
Total N	73,804
COUNTY TOTAL	643,671

*See Figure 22

AGRICULTURE

Each parcel of agricultural land use is labeled with a notation consisting basically of three symbols. The first of these is a lower case "i" or "n" indicating whether the parcel is irrigated or nonirrigated. This is followed by a capital letter and number which denote the use group and specific use as shown below.

C SUBTROPICAL FRUITS

1 Grapefruit
2 Lemons
3 Oranges
4 Dates
5 Avocados
6 Olives
7 Miscellaneous subtropical fruits

D DECIDUOUS FRUITS AND NUTS

1 Apples
2 Apricots
3 Cherries
5 Peaches and Nectarines
6 Pears
7 Plums
8 Prunes
9 Figs
10 Miscellaneous or mixed deciduous
12 Almonds
13 Walnuts

G GRAIN AND HAY CROPS

1 Barley
2 Wheat
3 Oats
6 Miscellaneous and mixed hay and grain

F FIELD CROPS

1 Cotton
2 Safflower
3 Flax
4 Hops
5 Sugar beets
6 Corn (field or sweet)
7 Grain sorghums
8 Sudan
9 Castor beans
10 Beans (dry)
11 Miscellaneous field

T TRUCK AND BERRY CROPS

1 Artichokes
2 Asparagus
3 Beans (green)
4 Cole crops
6 Carrots
7 Celery
8 Lettuce (all types)
9 Melons, squash, and cucumbers (all kinds)
10 Onions and garlic
11 Peas
12 Potatoes
13 Sweet potatoes
14 Spinach
15 Tomatoes
16 Flowers and nursery
18 Miscellaneous truck
19 Bushberries
20 Strawberries
21 Peppers (all types)

P PASTURE

1 Alfalfa and alfalfa mixtures
2 Clover
3 Mixed pasture
4 Native pasture

V VINEYARDS

R RICE

I IDLE

1 Land cropped within the past three years but not tilled at time of survey
2 New lands being prepared for crop production

S SEMIAGRICULTURAL AND INCIDENTAL TO AGRICULTURE

1 Farmsteads
2 Feed lots (livestock and poultry)
3 Dairies
4 Lawn areas

Special conditions are indicated by the following additional symbols and combinations of symbols.

A ABANDONED ORCHARDS AND VINEYARDS
F FALLOW (tilled but not cropped at time of survey)
S SEED CROPS
Y YOUNG ORCHARDS AND VINEYARDS
X PARTIALLY IRRIGATED CROPS

INTERCROPPING (or interplanting) is indicated as follows: $i\frac{D13\text{-}y}{T9}$ = a melon crop planted between rows of young walnut trees

URBAN

UC - URBAN COMMERCIAL

UC 1 Miscellaneous establishments (offices and retailers)
UC 2 Hotels
UC 3 Motels
UC 4 Apartments, barracks (three family units and larger)
UC 5 Institutions (hospitals, prisons, reformatories, asylums, etc., having a reasonably stable 24-resident population)
UC 6 Schools (yards mapped separately if large enough)
UC 7 Municipal auditoriums, theaters, churches, buildings, and stands associated with race tracks, football stadiums, baseball parks, rodeo arenas, etc.
UC 8 Miscellaneous high water use (indicates a high water use not covered above)

UI - URBAN INDUSTRIAL

UI 1 Manufacturing, assembling, and general processing
UI 2 Extractive industries (oil fields, rock quarries, gravel pits, public dumps, rock and gravel processing plants, etc.)
UI 3 Storage and distribution (warehouses, substations, railroad marshalling yards, tank farms, etc.)
UI 6 Saw mills
UI 7 Oil refineries
UI 8 Paper mills
UI 9 Meat packing plants
UI 10 Steel and aluminum mills
UI 11 Fruit and vegetable canneries and general food processing
UI 12 Miscellaneous high water use (indicates a high water use not covered above)

UV - URBAN VACANT

UV 1 Miscellaneous unpaved areas
UV 4 Miscellaneous paved areas

UR - URBAN RESIDENTIAL

One and two family units, including trailer courts

RECREATION

RR RESIDENTIAL

Permanent and summer home tracts within a primarily recreational area. (The estimated number of houses per acre is indicated by a number in the symbol.)

RC COMMERCIAL

Commercial areas within a primarily recreational area (includes motels, resorts, hotels, stores, etc.)

RT CAMP AND TRAILER SITES

Camp and trailer sites in a primarily recreational area

P PARKS

NATIVE

NV NATIVE VEGETATION

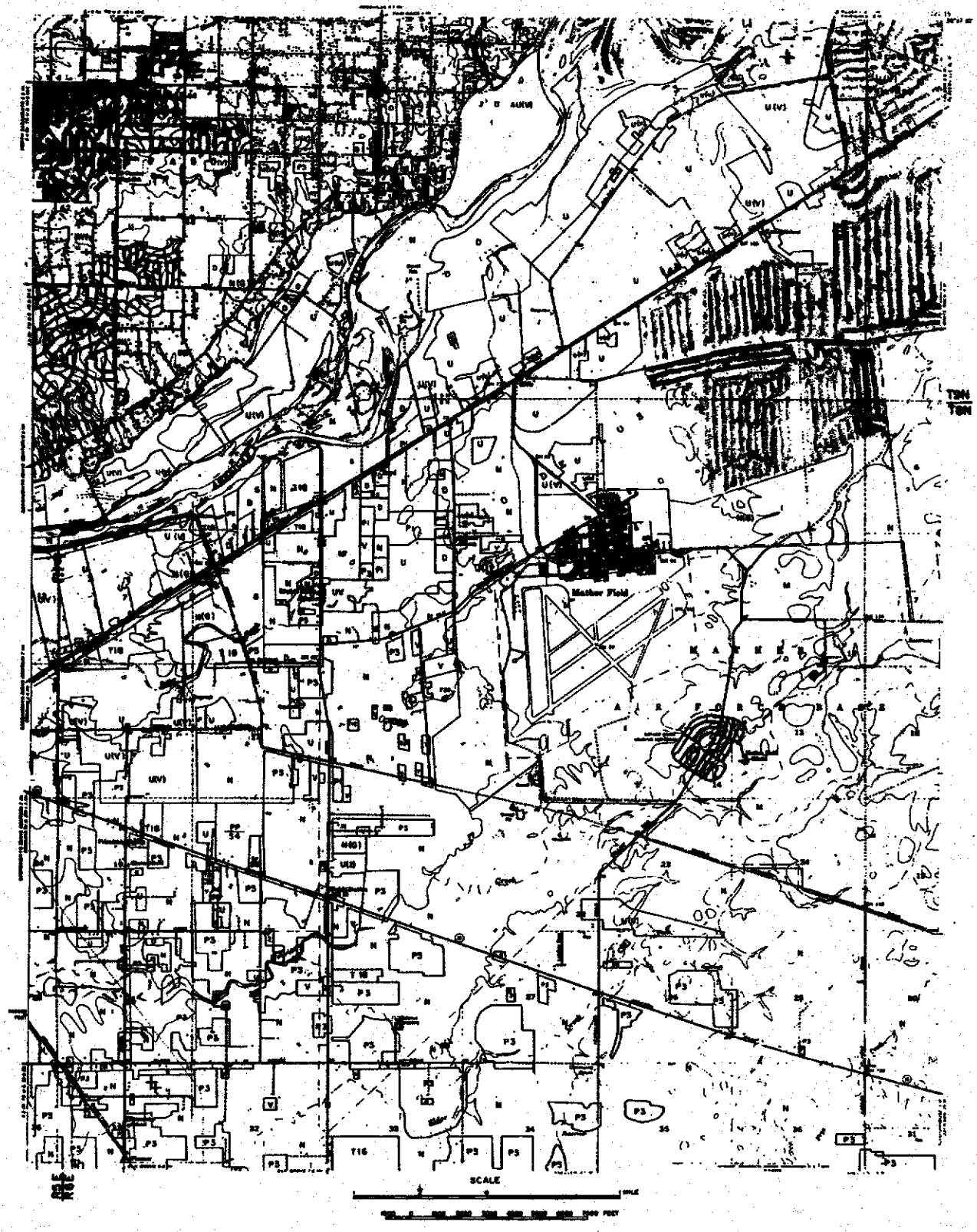
NR RIPARIAN VEGETATION

NR 1 Swamps and marshes
NR 2 Meadowland

NW WATER SURFACE

NC NATIVE CLASSES UNSEGREGATED

Figure 20. LAND USE LEGEND



CARMICHAEL QUADRANGLE 1969

Figure 21. TYPICAL LAND USE QUADRANGLE

URBAN AND RECREATIONAL LANDS

RR Existing and potential permanent and summer home tracts within a primarily recreational area. The estimated number of houses, under conditions of full development, is indicated by a number in the symbol, i.e., RR-3 is suitable for three houses per acre.

RT Existing and potential picnic, camp and trailer sites within a primarily recreational area.

RC Existing and potential commercial areas which occur within a primarily recreational area and which include motels, resorts, hotels, stores, etc.

PP Existing race tracks, fairgrounds, and private, city, county, state, and federal parks.

UD The total area of cities, towns and small communities presently used for residential commercial, recreational, and industrial purposes.

IRRIGABLE LANDS

Irrigable lands are identified by notations which begin with a letter "V", "H", or "M". These symbols indicate the general slope conditions, and may appear along or followed by (other) modifying symbols. The slope conditions indicated by these letters are:

V These lands are level or slightly sloping and vary from smooth to hummocky or gently undulating relief. The maximum slope is 6 percent for smooth, reasonably large bodies lying in the same plane.

H These are lands with greater slope and/or relief than those of the "V" class. They vary from smooth to moderately rolling or undulating relief. The maximum slope is 20 percent for smooth, reasonably large bodies lying in the same plane.

M These are lands with greater slope and/or relief than those of the "H" class. They vary from smooth to steeply rolling or undulating relief. The maximum slope is 30 percent for smooth, reasonably large bodies lying in the same plane.

The description below applies to all "V", "H", and "M" lands on which these slope symbols appear by themselves:

Have soils of medium or deep effective root zones; are permeable throughout; are relatively free of salinity, alkalinity, rock, or other conditions which would limit crop adaptability; are suitable for all climatically adapted crops, being limited only by topographic conditions.

The symbols below, appended to "V", "H", or "M", indicate the described modifying conditions.

S Indicates the presence of an excess of soluble salts or exchangeable sodium in slight amounts.

SS Indicates the presence of an excess of soluble salts or exchangeable sodium in moderate amounts.

SA Indicates the presence of an excess of soluble salts or exchangeable sodium in large amounts.

P Indicates shallow depth of the effective root zone.

W Indicates the presence of a high water table.

L Indicates fairly coarse textures and low moisture-holding capacities.

H Indicates very fine textures.

R Indicates enough rock on the surface or within the plow zone to limit use of the land for cultivated crops.

-B Indicates low-lying basin and seep areas.

-2, -4, -6, or -8 Number indicates, in feet, the average difference between highs and lows due to microrelief.

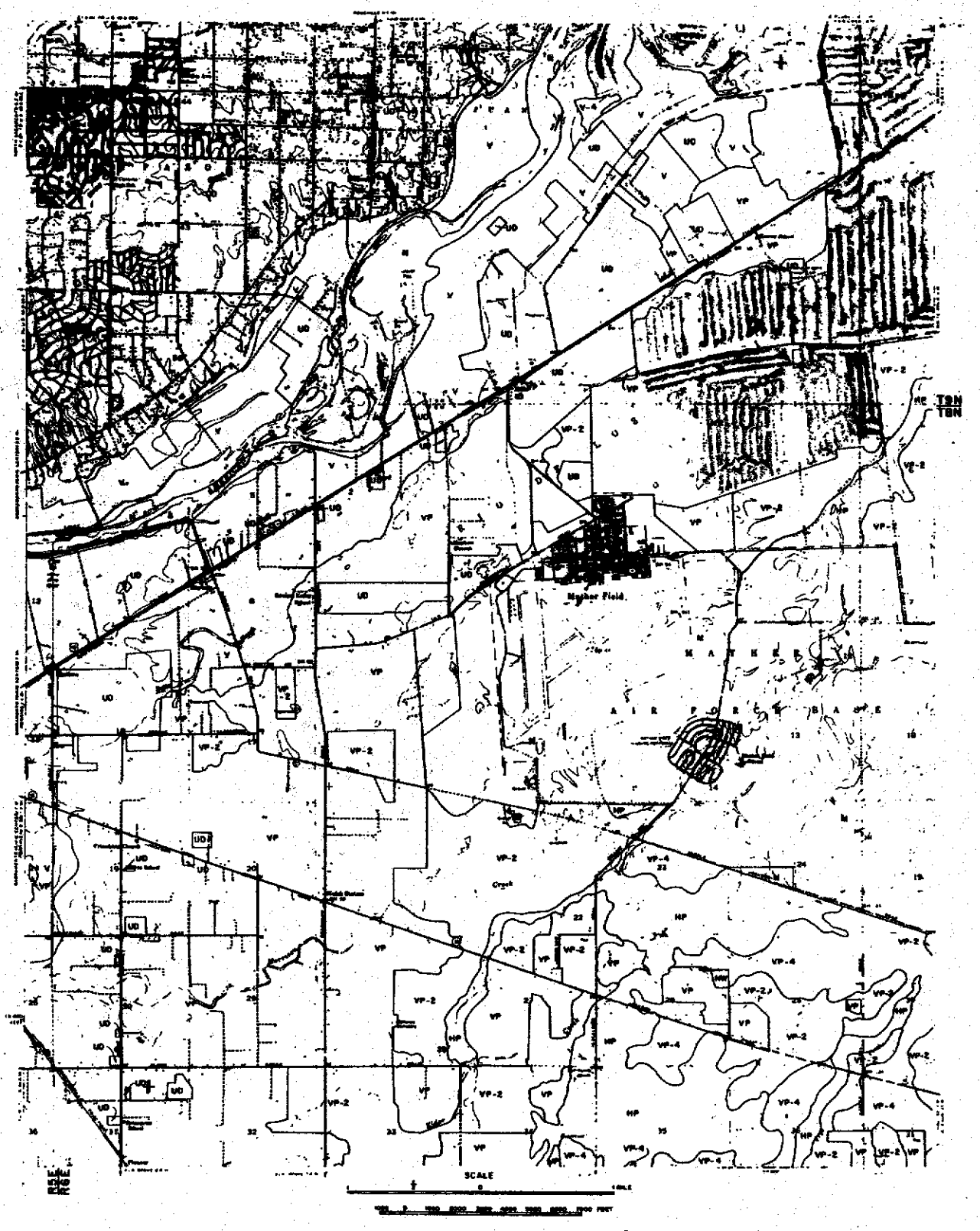
MISCELLANEOUS LANDS

F Presently forested lands, or lands subject to forest management, which meet the requirements for irrigable land but which, because of climatic conditions and physiographic position, are better suited for timber production or some type of forest management program rather than for irrigated agriculture.

VM Swamp and marsh lands which usually support a heavy growth of phreatophytes and are covered by water most of the time.

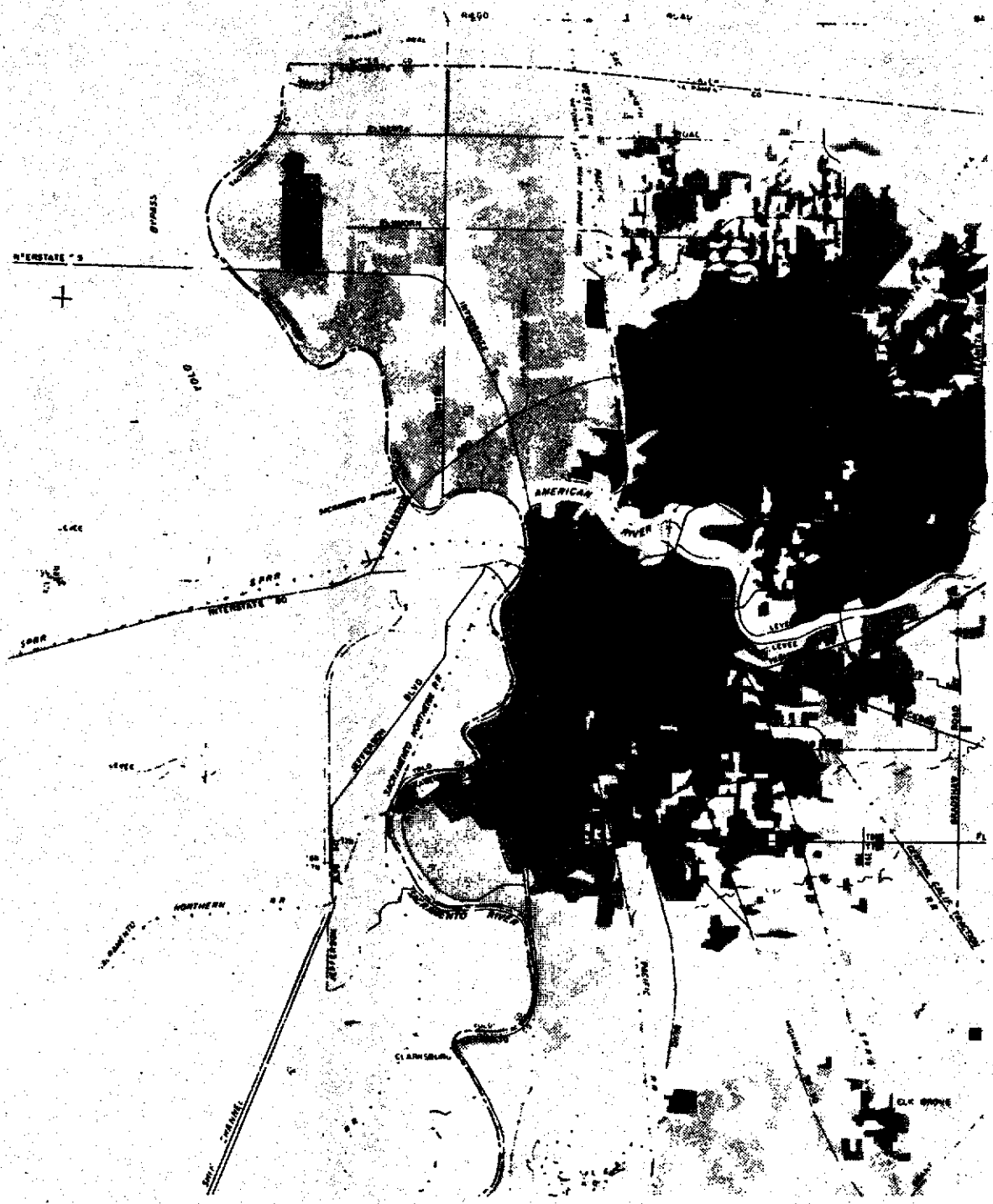
N Includes all lands which fail to meet the requirements of any of the foregoing classes.

Figure 22 LAND CLASSIFICATION LEGEND

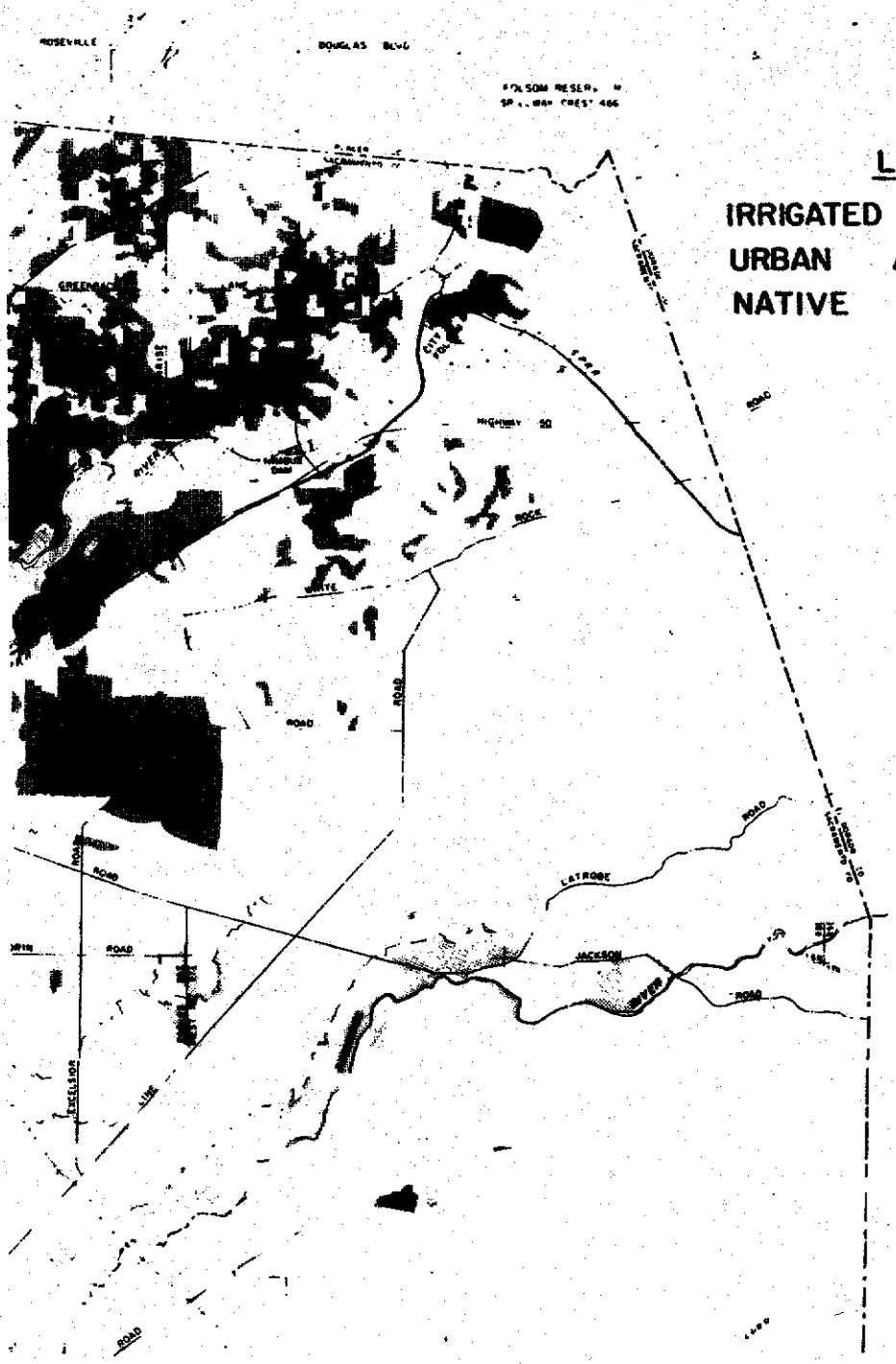


CARMICHAEL QUADRANGLE 1963

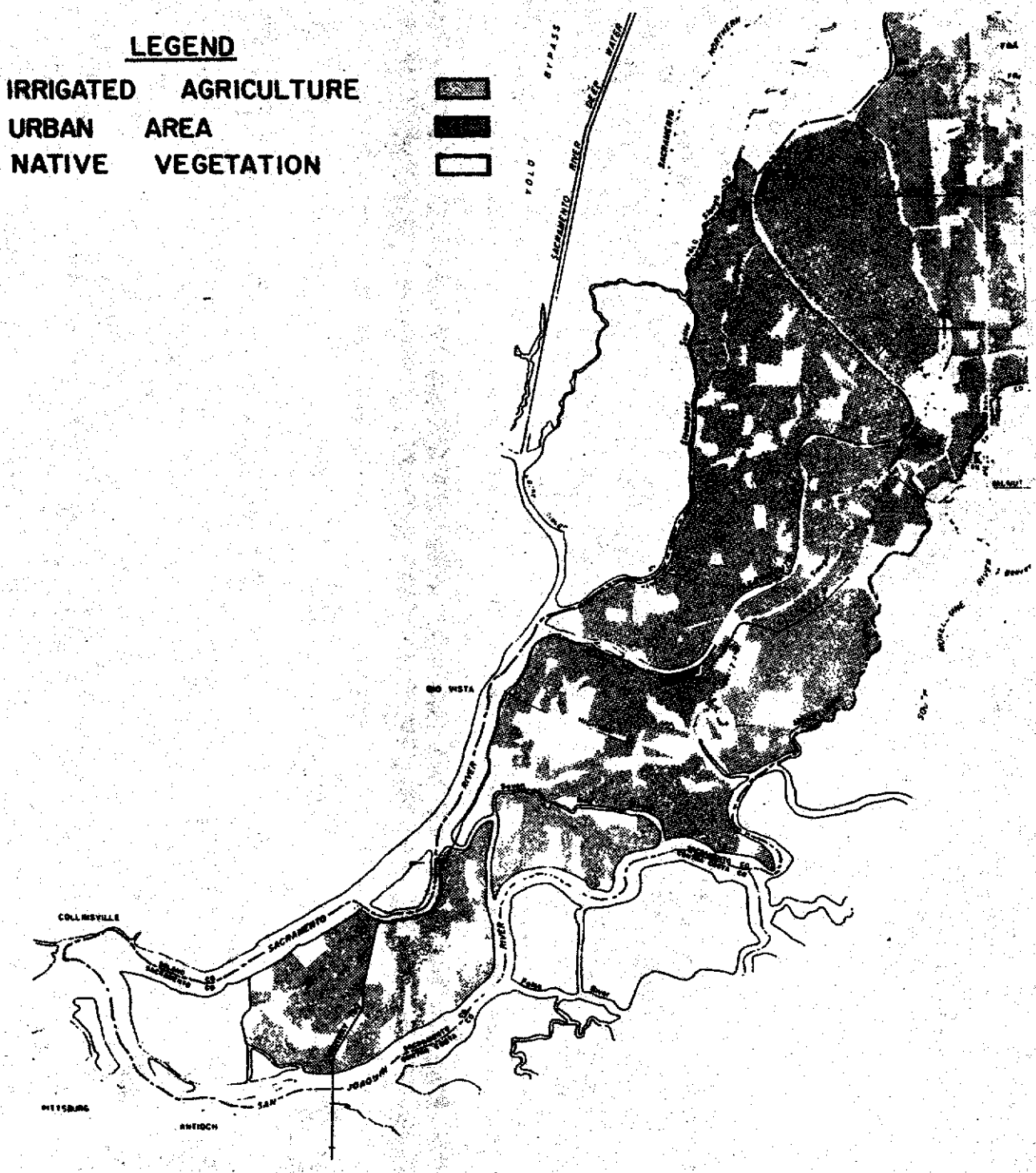
Figure 23. TYPICAL LAND CLASSIFICATION QUADRANGLE



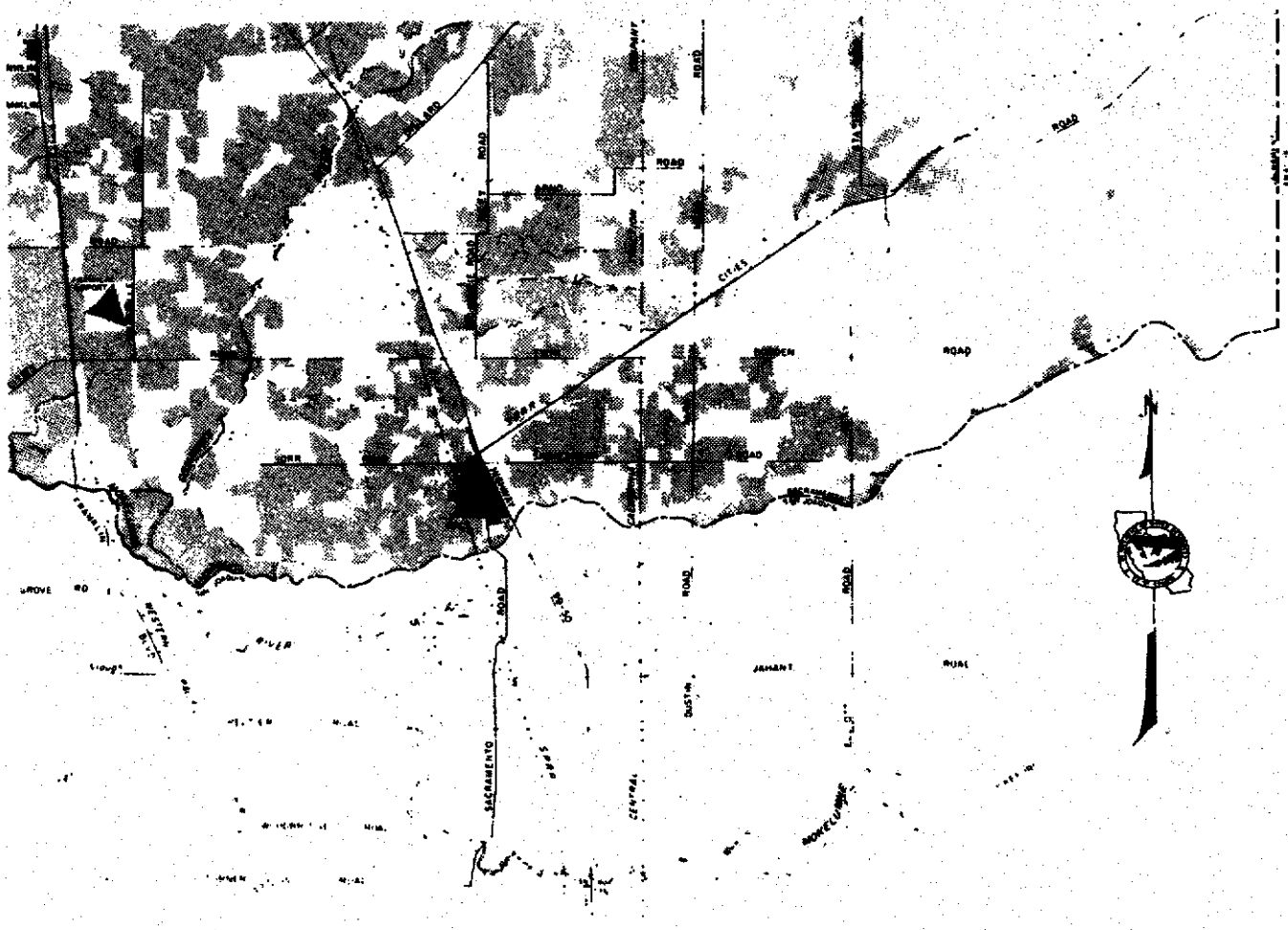
IRRIGATED AGRICULTURE



8 URBAN AREAS



IRRIGATED AGRICULTURE



& URBAN AREAS

Water Use

The following is a list of all water purveyors in Sacramento County. Those distributing only surface water or a mixture of surface water and ground water are noted; all others distribute ground water.

Publicly Operated:

- Arcade County Water District[1/]
- Carmichael Irrigation District[1/]
- Citrus Heights Irrigation District[1/]
- City of Sacramento[1/]
- City of Galt
- City of Folsom[1/]
- Clay Water District
- County Maintenance Districts
  - Arcade Oaks Terrace Water M.D.
  - Arden Park Bluffs M.D.[1/]
  - Arden Park Vista Water M.D.
  - Southwest Tract Water M.D.[1/]
  - Valley Hi Greens Water M.D.
- Del Paso Manor County Water District
- Elk Grove Water Works
- Fair Oaks Irrigation District[1/]
- Florin County Water District
- Galt County Water District
- Galt Irrigation District
- Northridge Park County Water District
- Omochumnes-Hartnell Water District[1/]
- Rio Linda County Water District
- San Juan Suburban Water District[2/]

Privately and Mutually Operated:

- Alex Brown Water Company
- Arvin Water Company
- Citizens Utilities Company of California
  - Citizens Arden Company
  - Citizens Suburban Company
  - Isleton Water Company
  - Lincoln Oaks Water Company
  - Parkway Water Company
  - Royal Oaks Water Company
- El Ranchito Mutual Water Company
- Fruitridge Vista Water Company
- Hood Improvement Water Company
- Locke Mutual Water Company
- Natomas Mutual Water Company[2/]
- Orangevale Mutual Water Company[2/]
- Southern California Water Company
  - Arden Water Service
  - Cordova Water Service
- Tokay Park Water Company
- Walnut Grove Estate Water Company

[1/]Distribute both surface water and ground water.
[2/]Distribute only surface water.

Unit Water Use

Unit water use figures were developed for the five basic land use groupings at the beginning of the study. These groupings are on the basis of rooting depth of crops and were made for the ease of handling and computing the land use data for the nodal areas. These basic groups of crops and their average unit applied water are listed in Table 11.

The applied water figures are representative of irrigation practices in the Sacramento area and measured headgate deliveries of 2 million acre-feet of water to nearly 9,700 land parcels comprising 820,000 acres. The data cover a span of four or more years, with the latest year 1969.

Future municipal and industrial water requirements are usually based on unit per capita water use and population projections. There are many possible sources to obtain this information. The Department has determined unit per capita water use for many areas of the State, including Sacramento County. With information gathered by this investigation, unit per capita water use figures were calculated for years 1961 through 1969. Table 12 lists these unit use figures, which range in value from 293 gallons per capita per day (gpcpd) to 377 gpcpd, with an average of 343 gpcpd. For estimating future water requirements, 340 gpcpd was used in this study.

The per capita water use figures included water used for many purposes other than domestic or industrial use. Some of these are flushing of sewers and hydrants, hydrant tapping for use of water on construction jobs, leakage in the system, and fire fighting. The foregoing may amount to 10 to 15 percent of the per capita use. Since these things which have occurred in the past most probably will occur again in the future, they should be included in the per capita water use figure.

TABLE 11

LAND USE GROUPS AND UNIT APPLIED WATER

LAND USE GROUP	CROPS	AVERAGE UNIT APPLIED WATER (Feet)
A	Beans, field, orchard, tomatoes	2.5
B	Corn, pasture, alfalfa, sugar beets	3.2
C	Truck, grain sorghum	1.8
D	Safflower and grain	0.5
E	Rice	7.8
F	Native vegetation	---
G	Urban	---

In DWR Bulletin 166-1, "Municipal and Industrial Water Use", August 1968, the reported per capita water use was 278 gpcpd in 1960. Using the average per capita water use of 343 gpcpd and the Bulletin 166-1 figure of 278 gpcpd, this increase is over 23 percent. Projecting this increase into the future by decades, the 1980 unit use will be over 400 gpcpd. This increase may be possible, but in the present period of environmental concern, it is difficult to justify. As noted previously, the unit use of water is expected to level off or slightly decrease with smaller subdivision lots and a greater concentration of apartment complexes. It is anticipated that programs of public education on the more efficient use and the value of water and even greater use of metering may be necessary to stop the increase in per capita use. Also, with the issuance of stricter waste discharge requirements, it may become an economic necessity for industry to reclaim and reuse water.

Surface Water Diversions

Surface water diversions for municipal purposes are listed in Table 13 by political subdivision. The City of Sacramento is the largest surface water purveyor, using about 50 percent of the municipal diversions. Estimates of diversions for agricultural purposes are discussed along with pumpage.

Pumpage

To augment the agricultural pumpage data for 1967-69, agricultural pumpage estimates were needed for years 1962 through 1966. These estimates were based on land use surveys. Straight line interpolations were made between the available land use surveys of 1961 and 1968 to estimate the crop pattern for each of the years. It was assumed that crops along the Sacramento River were being irrigated from surface water.

For the study, the various crops were placed into the seven crop groups based mainly on rooting depth of the crops (see Table11). In 1961 and 1968 there were 180,623 acres and 186,759 acres, respectively, under irrigation in the Sacramento ground water basin model area, or about a 3 percent increase in irrigated agriculture. The dramatic increase was in urban land, from 63,097 acres in 1961 to 93,384 acres in 1968, or a 48 percent increase. Most of the new urban acreage came from land previously classified as native vegetation.

The computation of annual agricultural pumpage is shown in Table 14. An initial average water requirement is calculated as the product of the acreages for the various groupings and the appropriate unit water duty (Column 2, Table 14). The average ground water pumpage is calculated as the requirement not satisfied by surface water and is obtained by subtracting the sum of (1) average water requirement for the area assumed to be irrigated by Sacramento River water and (2) measured surface water diversions from the other streams in the County, from (3) the average water requirement. The final estimated ground water pumpages for the missing years 1962-66 were obtained by modifying the average ground water pumpages by a factor due to weather conditions. The weather modifying factors were based on the assumption that crops are normally irrigated about five times during the growing season. If it is a dry weather year an extra application must

TABLE 12

ESTIMATED TOTAL AND PER CAPITA
MUNICIPAL AND INDUSTRIAL USE

Year	Surface Water Diversion Acre-Feet (1)	Municipal Pumpage Acre-Feet (2)	Surface Water Diversion and Pumpage Acre-Feet[1] (3)	Self Produced Water by Private Companies[2] (4)
1961	105,300	71,000	176,300	18,800
1962	106,600	73,400	180,000	19,200
1963	98,600	63,100	161,700	17,400
1964	116,400	67,300	183,700	19,800
1965	122,900	69,900	192,800	20,700
1966	134,900	82,400	217,300	23,400
1967	123,100	77,200	200,300	21,500
1968	136,600	85,200	221,800	24,800
1969	129,900	87,200	217,100	23,400

Year	Total Municipal and Industrial Water Use Acre-Feet[3] (5)	Population Served by Public & Private Water Purveyors (6)	Per Capita Water Use (gpdcp) (7)
1961	195,100	508,000	342
1962	199,200	526,000	338
1963	179,100	547,000	293
1964	203,500	558,000	326
1965	213,500	570,000	334
1966	240,700	577,000	372
1967	221,800	583,000	339
1968	246,600	585,000	377
1969	240,500	593,000	363

Average gallons per capita per day = 340

1/ Summation of Columns 1 and 2

2/ 10.7% of Column 3

3/ Summation of Columns 3 and 4

be made; consequently the factor 6/5 or 1.2 is derived for a dry year. Conversely, during a wet year, one less application is made -- 4/5 or 0.8.

Municipal pumpages for years 1961 through 1969 are shown in Table 15. These pumpage figures include those supplied by the various districts on request and pumpages estimated by power consumption records. The figures with footnotes have been estimated through correlation, that is, relating the pumpage of one district with that of another district.

An example of this type of correlation is shown on Figure 25 for Arcade County Water District, Northridge Park County Water District, and Citizens Utilities Company. The Y-axis represents the annual pumpage of Arcade County Water District in thousands of acre-feet; the X-axis represents pumpage for Northridge Park County Water District and Citizens Utilities Company in thousands of acre-feet. After plotting the corresponding annual pumpages for the five years 1965 through 1969, the correlative lines of best fit were drawn. The correlative equations are:

$$\text{Northridge P.C.W.D.} = -2{,}190 + 0.376 \text{ Arcade C.W.D.}$$

$$\text{Citizens Utilities Co.} = -6{,}360 + 0.832 \text{ Arcade C.W.D.}$$

where Arcade, Northridge, and Citizens Utilities annual pumpage are in acre-feet. These equations were used to estimate annual pumpages for from 1961 through 1964 for Northridge P.C.W.D. and Citizens Utilities Co.

The estimated pumpages for Mather and McClellan Air Force Bases were estimated by using their mean values. Because no relationship could be established between other districts that have records for the years 1961 to 1969 and the military bases, the mean values were used for the missing years. In cases such as these where no correlative relationship could be established, the mean of the values is the best estimate of the missing data.

Figure 26 is a bar chart depicting the percentage of 1968 municipal and industrial pumpage by water purveyors in Sacramento County. Arcade County Water District is by far the biggest ground water user, with 23.9 percent, or almost one-quarter of total M&I ground water pumpage. The second largest user is Citizens Utilities, with 14.2 percent, followed closely by the City of Sacramento, with 13.8 percent. Mather and McClellan Air Force Bases had a combined pumpage of 11.0 percent. Northridge Park County Water District is fifth largest ground water user, with 7.4 percent, followed by Southern California Water Company (Cordova and Arden Water Service), with 7.0 percent.

Annual Water Use

Agricultural water use is 68 percent of the total water use in Sacramento County, or about 557,000 acre-feet annually during the study period 1962-1968. An average annual ground water pumpage of 250,900 acre-feet per year is 45 percent of the agricultural water use, with the remainder of the use being an annual surface water use of about 306,000 acre-feet per year. The total irrigated land in the County for 1968 is 177,616 acres, which includes 11,904 acres of rice. The

TABLE 13

MUNICIPAL SURFACE WATER DIVERSIONS[1/]
SACRAMENTO COUNTY
(in Acre-Feet)

Year[2/]	City of Sacramento		Arcade Water District	Carmichael Irrigation District	City of Folsom	San Juan Suburban Water District	State of California	Total Municipal Surface Water Diversions
	Sacramento River	American River						
1961	41,940	—	—	8,129	23,647	31,546	—	105,300
1962	41,230	—	—	8,311	25,420	31,666	—	106,600
1963	44,424	—	—	6,653	20,189	27,300	—	98,600
1964	37,536	18,770	—	7,694	20,966	31,409	—	116,400
1965	30,075	31,489	—	9,276	20,722	31,293	—	122,900
1966	33,168	32,864	—	9,557	24,983	34,342	—	134,900
1967	31,177	30,375	1,435	8,014	20,403	31,709	—	123,100
1968	35,357	30,311	2,139	9,779	21,361	36,015	1,660	136,600
1969	34,590	30,380	2,280	8,345	18,790	35,430	1,674	129,900

1/ Data obtained from Bulletin 130, except for Arcade Water District, which were supplied by the District.
2/ Water year, October through September.

TABLE 14

ESTIMATED AGRICULTURAL PUMPAGE
SACRAMENTO COUNTY, 1962-69
(in Acre-Feet)

Calendar Year	Average Water Requirement	Average Surface Water Irrigation[a/]	Surface Water Diversion[b/]	Average Ground Water Pumpage	Weather Modifying Factors	Total Estimated Agricultural Pumpage
1962	565,800	304,800	17,000	244,000	1.2 (Dry)	293,000
1963	567,700	305,100	14,300	248,300	0.8 (Wet)	199,000
1964	569,600	305,300	17,000	247,300	1.2 (Dry)	297,000
1965	571,400	305,500	16,100	249,800	1.0 (Normal)	249,800
1966	573,300	305,800	20,900	246,600	1.2 (Dry)	296,000
1967	561,400	306,000	18,900	236,500	0.8 (Wet)	189,200[c/]
1968	527,000	306,300	27,300	193,400	1.2 (Dry)	232,100[c/]
1969	639,300	306,800	26,500	306,000	0.8 (Wet)	244,800[c/]

a/ Estimated amounts from Sacramento River.
b/ American River, Cosumnes River, Mokelumne River, and Snodgrass Slough.
c/ Estimated by USGS from power consumption.

TABLE 15

SACRAMENTO COUNTY
ESTIMATED MUNICIPAL PUMPAGE IN ACRE-FEET

	1961	1962	1963	1964	1965	1966	1967	1968	1969
Rio Linda County Water District	670[a]	630[a]	650[a]	651	885	815	944	962	939
Citizens Utilities Co.	7,200[b]	7,600[b]	7,030[b]	9,049	9,580	11,448	11,647	12,117	12,678
Citrus Heights Irrigation District	1,670[c]	2,037	1,880	1,970	1,229	1,649	1,268	1,762	1,557
Arcade Water District	16,277	16,766	16,108	18,878	18,848	22,101	19,269	20,346	20,557
Sacramento County Maintenance District	2,880[b]	3,020[b]	2,850[b]	3,540[b]	3,530[b]	4,350[b]	3,980[b]	4,300	4,440
Fruitridge Vista Water Company	2,780[d]	2,830[d]	2,800[d]	2,721	2,890	3,279	3,060	3,137	3,409
Del Paso Manor County Water District	1,465	1,520	1,480	1,430	1,680	1,850	1,670	1,840	1,920
Northridge Park County Water District	3,940[b]	4,120[b]	3,880[b]	4,910[b]	4,900	5,930	5,540	6,250	6,645
Elk Grove Water Works	650	608	629	773	752	896	841	911	975
Mather AFB	4,000[c]	4,000[c]	4,000[c]	4,000[c]	3,499	4,114	3,855	4,460	4,008
McClellan AFB	4,655[c]	4,655[c]	4,668	4,592	4,390	4,585	4,467	4,936	4,948
Carmichael Irrigation District	400[f]	400[f]	400[f]	400[f]	466	492	636	897	1,073
City of Sacramento South of American River	12,000	13,300	4,750	455	445	660	670	700	580
City of Sacramento North of American River	3,000[a]	2,000[a]	2,500[a]	4,000	5,820	7,850	7,970	9,360	10,000
City of Sacramento Northgate	690[d]	830[d]	720[d]	1,450	1,080	1,190	970	1,730	1,730
Fair Oaks Irrigation District	1,300[d]	1,320[d]	1,310[d]	1,290[d]	1,380[d]	1,400[d]	1,377	1,537	1,378
Arvin Water Company	1,790[d]	1,880[d]	1,820[d]	1,780[d]	2,020	2,310	2,250	2,470	2,660
Arden Water Service	490[d]	600[d]	520[d]	420[d]	910[d]	1,240[d]	889	1,310	1,299
Cordova Water Service	3,750[d]	3,900[d]	3,790[d]	3,660[d]	4,207	4,891	4,418	4,689	4,994
Miscellaneous[e]	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
Total[g]	71,000	73,400	63,100	67,300	69,900	82,400	77,200	85,200	87,200

a - Correlated with Elk Grove
b - Correlated with Arcade
c - Estimated using mean value
d - Correlated with Del Paso Manor
e - Estimated pumpage for Del Paso and Northridge Golf and Country Clubs and Tokay Park Water Company
f - Assumed values
g - Rounded to the nearest hundred

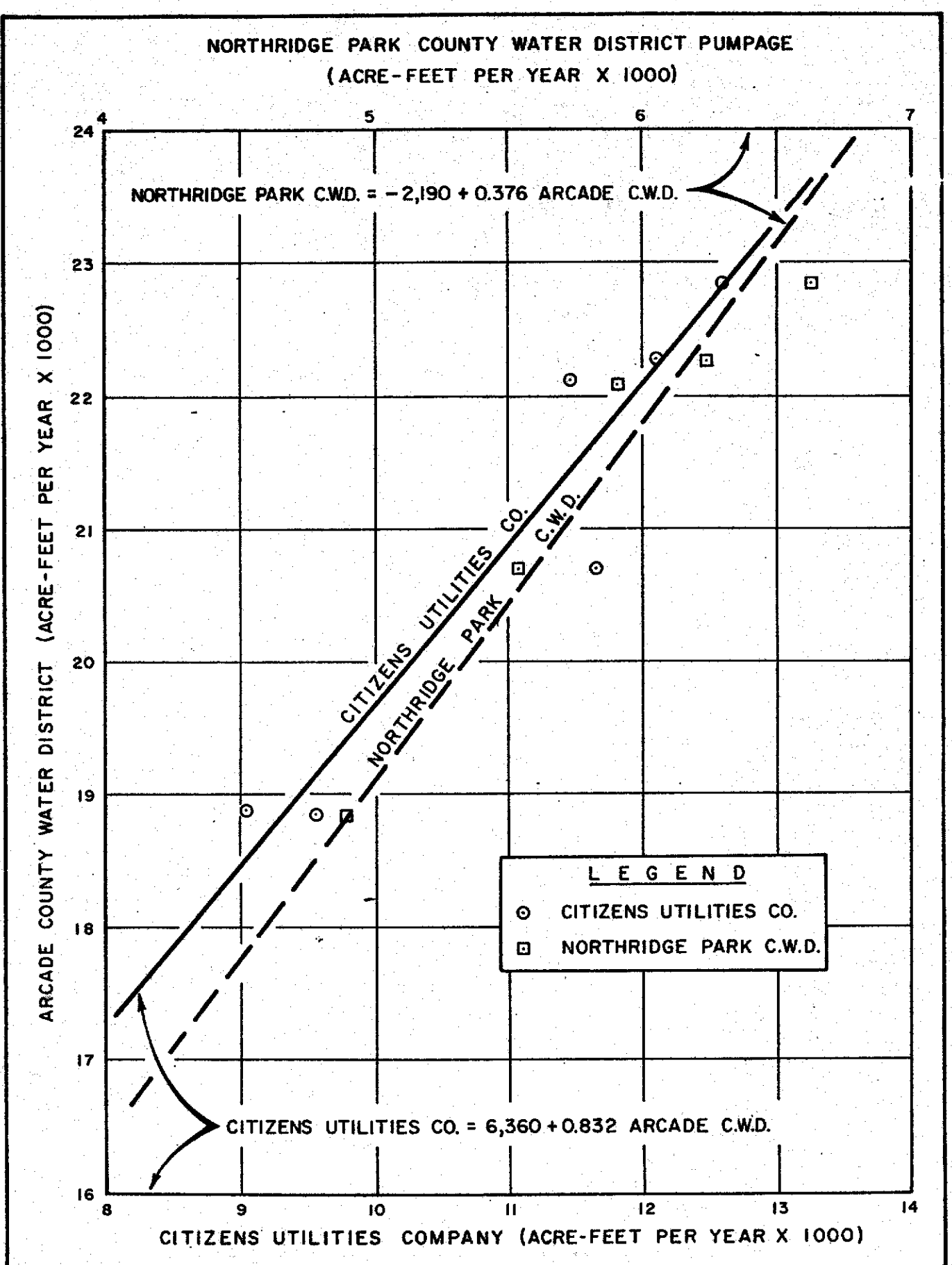


Figure 25. ANNUAL PUMPAGE CORRELATION

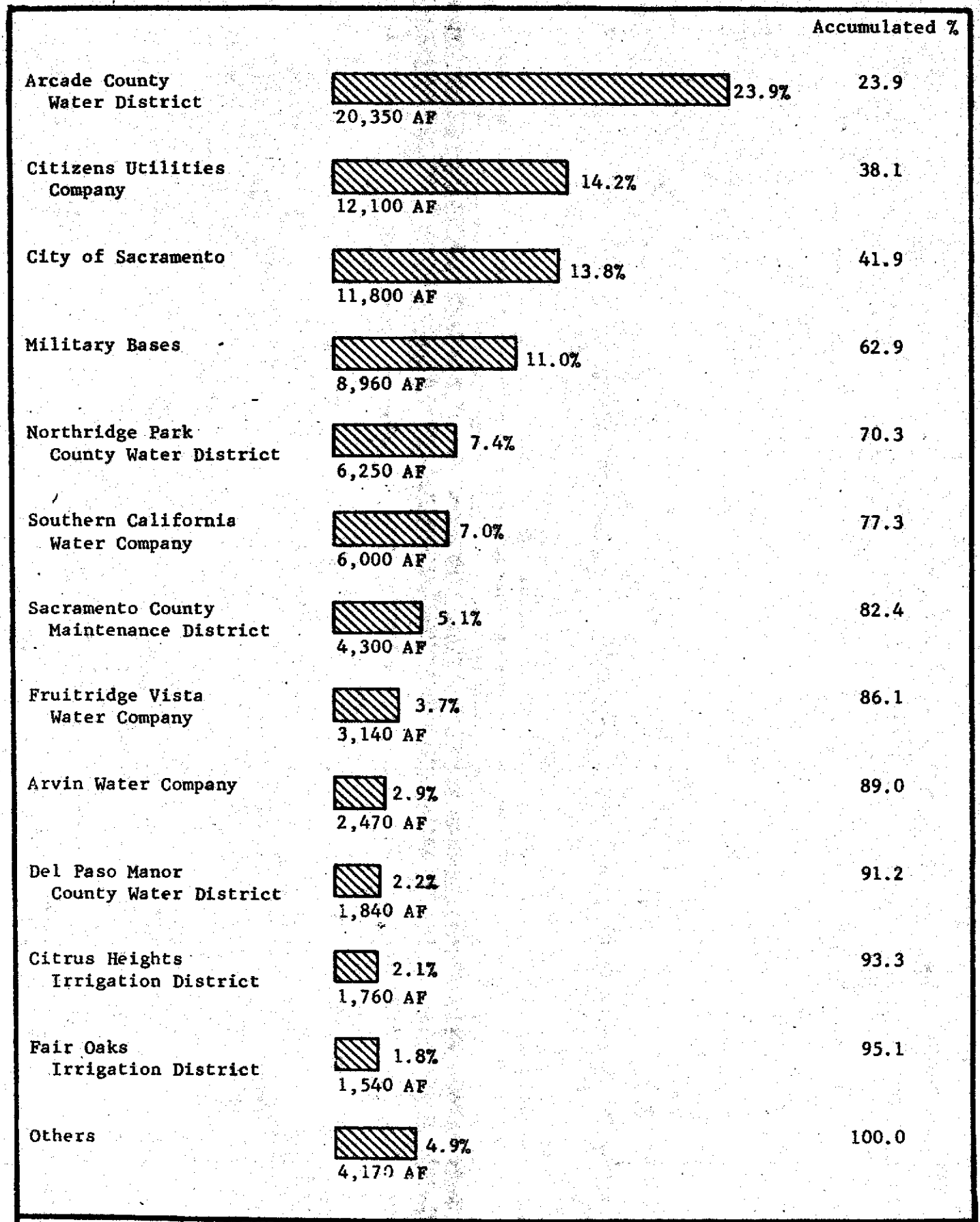


Figure 26. 1968 MUNICIPAL AND INDUSTRIAL PUMPAGE

average unit water use is about 3.1 acre-feet per year if the rice water requirement is included. If the above average rice water requirement is excluded, the unit water requirement is 2.8 acre-feet per year.

Municipal and industrial water use is about 258,100 acre-feet per year, with ground water supplying 53.5 percent of the M&I use, or 138,000 acre-feet.

Recharge

Recharge to the ground water basin is derived from three major components — precipitation, applied water, and streamflow. Precipitation is the general term for all forms of moisture emanating from the clouds and falling to the ground. In Sacramento County precipitation usually occurs as rainfall. Once the rain hits the ground, it can evaporate, become streamflow, or infiltrate.

Applied water is a general term for all forms of water applied by man to the ground to irrigate crops. In general, about 65 percent of all irrigation water is consumptively used by plants for vegetative growth. Thus, about 35 percent of all irrigation water is available for percolation, evaporation, runoff, etc. Depending on the soil, about 10 to 25 percent of the irrigation water infiltrates the ground water basin.

Streamflow will usually recharge an underlying ground water basin. Since the ground water elevations throughout the County are lower than the stream water surface elevation, all the rivers and streams in the County should theoretically recharge the ground water body if no impervious surface impedes the downward flow path. Due to the tidal regimen of the lower portions of the main rivers, they cannot be gaged for outflow, and hence a direct measurement of total stream recharge within the study area is not possible.

Recharge from Rain and Applied Water

A soil moisture balance was used for computing unit deep percolation for each crop according to its potential evapotranspiration, rooting depth, and unit applied water. Applied water was adjusted for each year according to the index of wetness. Because this program calculated the unit deep percolation for individual crops, a subsequent breakdown of Land Use Group A and Group B was made. Land Use Group A was divided into field, deciduous (orchard), and tomatoes, and Land Use Group B was divided into pasture, sugar beets, and corn.

Data input required for the soil moisture balance program are: (1) potential evapotranspiration; (2) rainfall; (3) evaporation of rain on impervious soil; (4) evaporation of rain on pervious soil; (5) evaporation of irrigation water on pervious soil; (6) applied water; (7) rooting depth; (8) moisture per foot of soil; (9) irrigation efficiency; and (10) percent impervious area.

In the foregoing list, the first six items required monthly data from October through April; during the growing season it is taken care of as a whole. The potential evapotranspiration data was based on Department Bulletin 132-2, "Vegetative Water Use", dated August 1967, and applied water data was based on

a Department Memorandum Report dated August 1970, "Irrigation Use and Practices in Central District".

Average precipitation varies from 15 inches to 26 inches in Sacramento County. In order to take the precipitation variation into account, the study area was divided into four sectors -- northwest, northeast, southwest, and southeast -- as shown in Figure 27. Elkhorn Ferry, Represa, Central Valley Fish Hatchery, and Sloughhouse rain gages represent the northwest, northeast, southwest, and southeast, respectively.

Different crops have different root depths and varying rooting depth is directly related to the ability of the plant to gather moisture from the soil profile. The computer program compares the available water from rainfall and irrigation against the water required for evapotranspiration and soil moisture deficiency. If there is any excess water on pervious land, it is considered to be deep percolation. Percolation was computed by month during the rainy season, October through April. The growing season, May through September, was considered as a single unit.

The unit values of deep percolation for various crops were checked and increased where necessary to include a minimum of 20 percent of the applied water. This was necessary to compensate for more of the irrigation water infiltrating at the beginning of the growing season due to shallow rooting depths of the new plants.

The rainfall on impervious areas remaining after evaporation was assumed to be runoff. Ten percent of the agricultural and native vegetation areas is estimated to be impervious and 50 percent of the urban area is impervious. In the urban area, 20 percent of the runoff from the impervious area ran onto adjacent pervious areas and was used by the plants, evaporated, or became deep percolation.

The annual unit values of deep percolation from the combination of rain and applied water for each of the five agricultural groups of land uses is listed in Table 16.

Recharge from Streamflow

The traditional method to calculate streamflow recharge is to subtract the upstream gage and local inflows from the downstream gage. For the County there are two such sets of stream gaging stations from which recharge could be calculated. These are on the American River and Cosumnes River. On the American River, flow measurements are made at the American River at Fair Oaks gage, which is downstream from Nimbus Dam. A continuous stage recorder is installed at H Street for flood forecasting. Supplemental measurements to determine flows at this station were discontinued in 1960. In order to obtain the flow at H Street, it was necessary to establish a relationship between gage readings (height of flow) and quantity of flow. Because the H Street recorder is affected by tidal backwater, a downstream gage is necessary to determine the hydraulic gradient downstream from the H Street gage. A stage recorder was installed on the American River at the Elvas Railroad Crossing to ascertain if backwater was affecting the flow at the H Street gage. If there were tidal effects at Elvas, it would reflect a small hydraulic gradient between H Street and Elvas, thereby decreasing the streamflow.

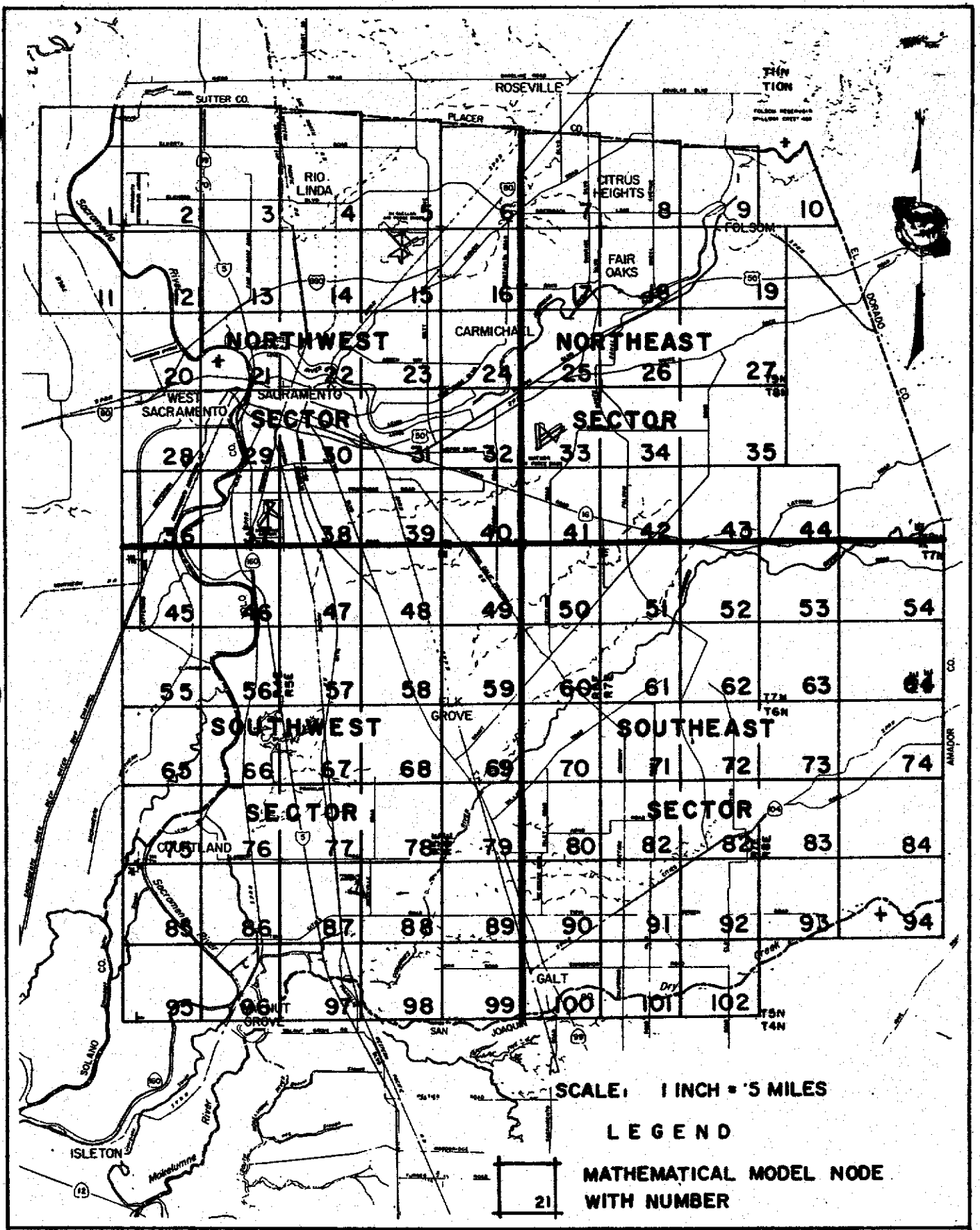


Figure 27. SECTORS FOR DEEP PERCOLATION VALUES AND NODAL PATTERN

TABLE 16

UNIT DEEP PERCOLATION

NORTHWEST SECTOR
In Feet

Land Use Symbol	LUA			LUB			LUC	LUD	LUE
	F	D	T15	P	F5	F6	T&F7	FZ&G	R
1961	0.33	0.10	0.19	0.76	0.96	0.76	0.33	0.01	2.31
1962	0.61	0.58	0.40	0.86	1.28	0.86	0.61	0.36	2.39
1963	0.90	0.88	0.66	0.62	1.00	0.62	0.90	0.61	1.41
1964	0.09	0	0.17	0.49	1.12	0.49	0.09	0.22	2.13
1965	0.36	0	0.27	0.56	0.94	0.56	0.36	0.25	1.20
1966	0.12	0	0.18	0.52	1.10	0.52	0.12	0	2.13
1967	0.94	0.60	0.72	0.97	1.04	0.97	0.94	0.63	1.36
1968	0	0	0.19	0.45	0.73	0.45	0	0.04	1.88
1969	1.01	0.81	1.01	1.35	1.53	1.35	1.01	0.73	1.93
1970	0.58	0.58	0.69	1.03	1.21	1.03	0.58	0.38	1.68

NORTHEAST SECTOR
In Feet

Land Use Symbol	LUA			LUB			LUC	LUD	LUE
	F	D	T15	P	F5	F6	T&F7	FZ&G	R
1961	0.40	0.09	0.40	0.62	0.62	0.62	0.40	0.18	2.13
1962	0.58	0.60	0.58	0.73	0.73	0.73	0.58	0.45	2.22
1963	0.51	0.73	0.51	0.40	0.51	0.51	0.51	0.37	0.96
1964	0.24	0.11	0.24	0.49	0.49	0.49	0.24	0.18	2.08
1965	0.48	0.63	0.48	0.59	0.59	0.59	0.48	0.54	1.19
1966	0.32	0.36	0.32	0.54	0.54	0.54	0.54	0.28	2.04
1967	0.72	0.97	0.72	0.76	0.76	0.72	0.76	0.90	1.16
1968	0	0	0	0.21	0	0	0	0.11	0.80
1969	0.91	0.85	0.91	1.16	1.16	1.16	0.91	1.25	1.68
1970	0.27	0.36	0.27	0.53	0.53	0.53	0.27	0.49	1.06

Table 16 (continued)

SOUTHEAST SECTOR
In Feet

Land Use Symbol	LUA			LUB			LUC	LUD	LUE
	F	D	T15	P	F5	F6	T&F7	F2&G	R
1961	0.64	0.27	0.64	0.84	1.35	1.35	0.64	0.18	2.40
1962	0.95	0.93	0.95	1.11	1.69	1.69	0.95	0.56	2.65
1963	0.75	0.85	0.75	0.63	0.99	0.99	0.75	0.36	1.29
1964	0.40	0.15	0.40	0.61	1.34	1.34	0.40	0.40	2.26
1965	1.09	1.17	1.09	1.19	1.80	1.80	1.09	0.86	1.95
1966	0.59	0.57	0.59	0.75	1.35	1.35	0.75	0.36	2.31
1967	1.36	1.47	1.36	1.35	1.35	1.35	1.26	1.26	1.95
1968	0.22	0	0.22	0.45	0.91	0.45	0.45	0.25	1.89
1969	1.62	1.53	1.62	1.79	2.30	1.79	1.79	1.56	2.43
1970	0.78	0.78	0.78	0.94	1.35	0.94	0.94	0.76	1.59

SOUTHWEST SECTOR
In Feet

Land Use Symbol	LUA			LUB			LUC	LUD	LUE
	F	D	T15	P	F5	F6	T&F7	F2&G	R
1961	0.44	0	0	0.44	0.73	0.44	0.33	0	2.02
1962	0.71	0.22	0.45	0.71	1.26	0.71	0.61	0.06	2.27
1963	0.45	0.58	0.45	0.45	0.67	0.45	0.90	0.38	1.05
1964	0.36	0	0	0.36	0.99	0.36	0.09	0.07	1.99
1965	0.54	0.31	0	0.54	1.03	0.54	0.36	0.35	1.27
1966	0.37	0.13	0	0.37	0.98	0.37	0.12	0	1.96
1967	0.67	0.63	0.22	0.67	0.71	0.67	0.94	0.34	1.10
1968	0.15	0	0	0.45	0.91	0.45	0	0.04	1.89
1969	1.02	0.37	0.49	1.02	1.44	1.02	1.01	0.51	1.68
1970	0.49	0.23	0.23	0.49	0.84	0.49	0.58	0.04	1.11

Under backwater effects, the flow discharge at the H Street gage is calculated with a ratio discharge curve developed by the U. S. Geological Survey in 1958. Using their methods and their rating curve, dated 1958, the flows of the American River at H Street were calculated for the period 1962 through 1969.

The incremental drainage area between the Fair Oaks gage and the H Street gage is some 30,000 acres. Local inflows, including local runoff and sewage outflow from the sewage treatment plants, and outflows, such as diversions out of the river by Carmichael Irrigation District, the City of Sacramento, and farmers for irrigation, must be accounted for. In addition, there are natural outflows in the riverbank area consisting of water consumed by over 600 acres of phreatophyte growth and evaporation from the water surface. Sewer outflows were obtained from the County. Diversion records from the river were obtained from DWR Bulletin 130. There were many unnamed tributary areas into the American River in this incremental area. Flows in these channels were computed using the rational method based on runoff factors developed from Arcade Creek at Del Paso Park gage.

By accounting for all of the inflows and outflows from the American River, the annual recharge for the years 1962 through 1969 were estimated; these are shown on Table 17.

TABLE 17

FIRST APPROXIMATION OF STREAM RECHARGE
AMERICAN AND COSUMNES RIVERS
(in acre-feet)

YEAR	AMERICAN RIVER	COSUMNES RIVER
1962	185,600	39,900
1963	370,800	80,000
1964	229,800	28,500
1965	409,500	106,800
1966	390,600	33,600
1967	449,100	132,700
1968	540,400	34,800
1969	689,400	123,300
Average	408,200	72,500

For the Cosumnes River the situation is similar to that of the American River. There is an upstream gage at Michigan Bar and a downstream gage at McConnell Station. The records at these two gages are considered accurate by the U. S. Geological Survey, except during the summer months. There are diversions for irrigation purposes between the two stations; the incremental drainage area is 188 square miles. Table 16 presents estimated stream recharge for the American and Cosumnes Rivers for the years 1962 through 1969.

Subsurface Flow

The 1968 ground water surface contours shown on Figure 17 indicate that there is no subsurface flow in or out of the County on its western and southern boundaries because the Sacramento River and Dry Creek both are losing streams. On the eastern boundary there is no subsurface inflow due to the presence of nonwater-bearing crystalline and metamorphic rocks. Along the eastern half of the north county boundary, ground water contours are more or less normal to the county line, indicating a no-flow boundary. There is a pumping depression along the western portion of the north county line. The center of the depression is in Sutter County, with the ground water gradient sloping northward from Sacramento County. This is the only subsurface outflow from the County.

Available Storage

The available storage capacity is computed from the ground surface to the bottom of the Mehrten Formation, which is considered to be the base of fresh water for this investigation. The bottom of the Mehrten Formation is defined in the eastern foothill through interpretation of well drillers logs; however, the western boundary could not be defined due to a lack of data. By projecting the angle of dip of the Mehrten Formation, the bottom of the formation could be estimated for the center of each quarter township. Figure 28 shows the contoured base of the Mehrten Formation as projected. The thickness of alluvium was calculated for each quarter section and an average thickness of 880 feet was calculated for the model area. There are 559,365 acres in Sacramento County. Using an average specific yield of 7.5 percent, the total ground water storage capacity of the County is about 37,000,000 acre-feet, exclusive of the Delta area. In the Delta, which encompasses 45,008 acres, the storage capacity is about 1,000,000 acre-feet, based on a depth of 300 feet to the base of fresh water and an average specific yield of 7.5 percent. The amounts of ground water in storage in the 1930 to 1968 interval are shown in Table 18.

TABLE 18

GROUND WATER IN STORAGE ABOVE BASE OF MEHRTEN FORMATION

YEAR	AVERAGE DEPTH TO WATER (feet)	GROUND WATER IN STORAGE (million acre-feet)
1930	22	37.0
1932-1942	24	36.9
1968	58	35.5

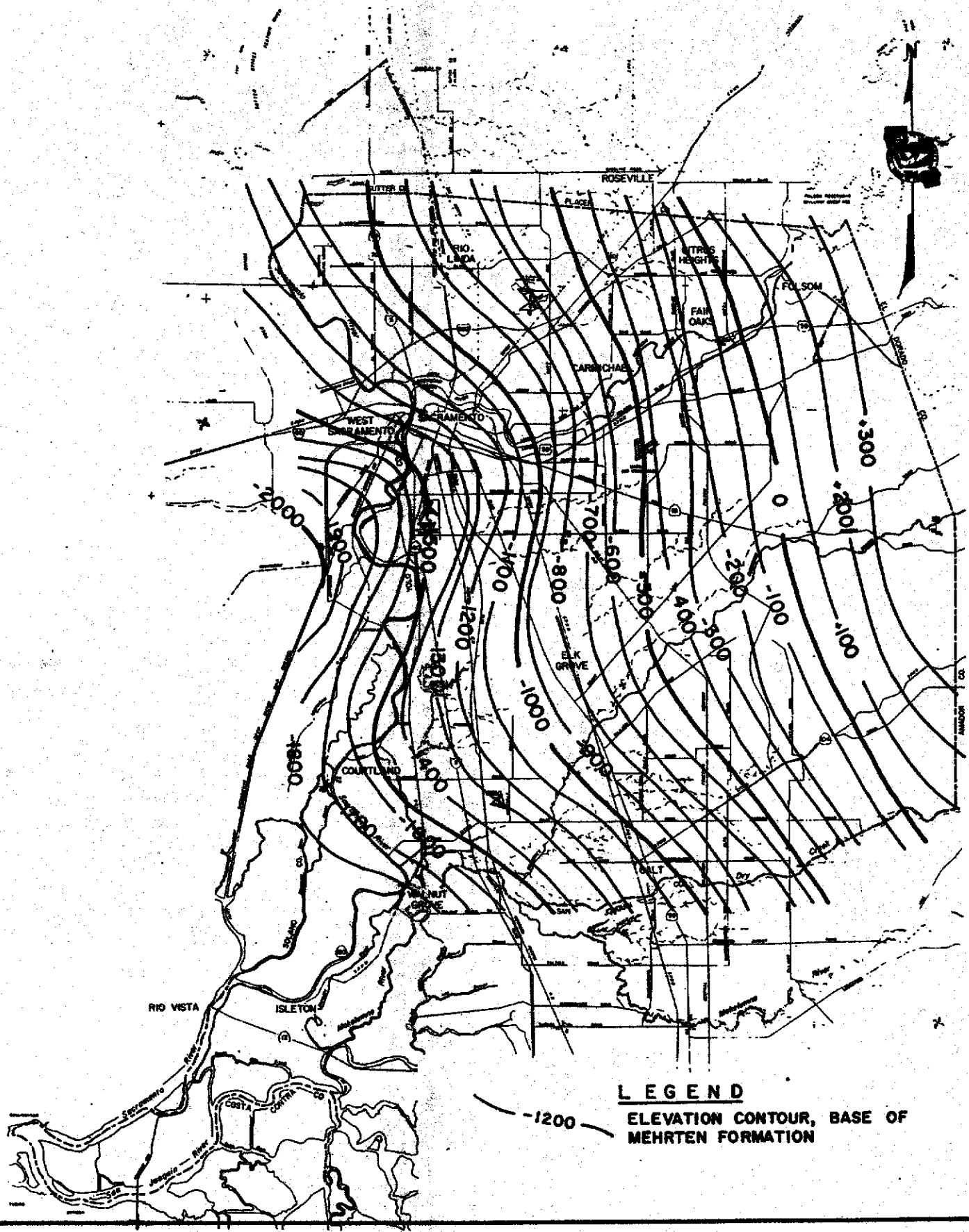


Figure 28. ELEVATION CONTOURS ON BASE OF MEHRTEN FORMATION

Change in Storage

Change in storage can be computed from the change in water levels. The method used in determining the change in storage was sum the products of the average specific yield value times the annual changes in water levels for quarter section. The average specific yield values were determined by a computer program for each nodal area. The change in water level elevations was determined from spring water level contour maps. Estimated annual changes in storage in acre-feet for the study period 1962 through 1968 are listed on Table 19. Using the average specific yield of 7.5 percent, the average decline in water level is about 0.5 foot per year.

Hydrologic Balance

Hydrology is an earth science concerned with the distribution and occurrence of water on and under the earth's surface, that is, with "what happens to the rain". A hydrologic balance is concerned with the supply and disposal of water within that system. In making a hydrologic balance, there are three different references or concepts which may be used. These three concepts, shown on Figure 29, are: (1) watershed, (2) ground water basin, and (3) ground water body. Each of these concepts has its particular advantages and uses. The watershed concept eliminates most of the need for streamflow data, but makes necessary, reliable estimates of consumptive use of native vegetation. The ground water basin concepts require streamflow data, but not pumpage information. The ground water concept eliminates all surface water items but requires deep percolation data.

TABLE 19

ANNUAL CHANGE IN STORAGE
FOR STUDY AREA

Water Year	Annual Change in Storage (acre-feet)
1962	- 19,650
1963	51,510
1964	-170,960
1965	29,560
1966	-196,200
1967	303,440
1968	-157,700
Summation	-160,000
Average Annual	- 22,860

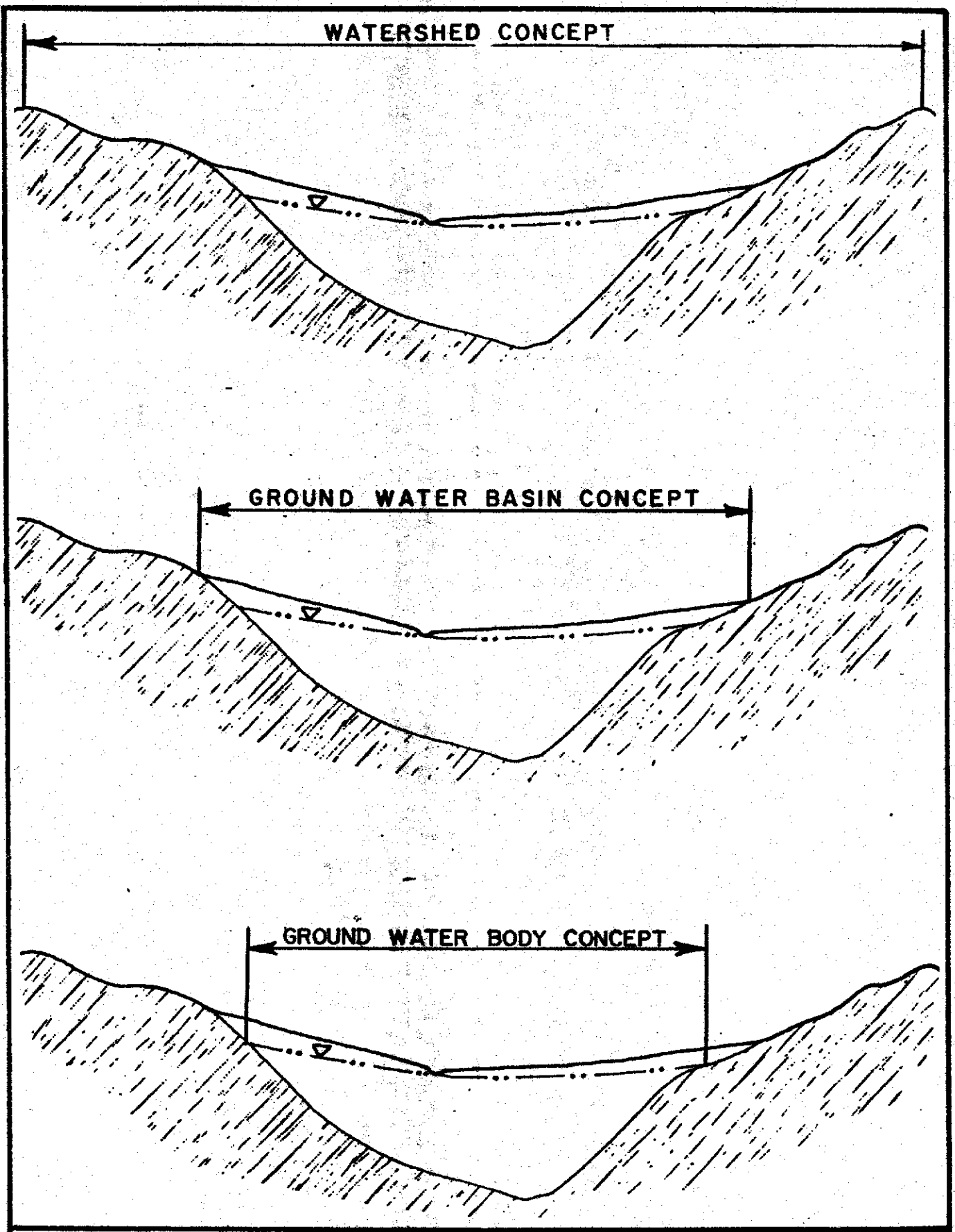


Figure 29. THREE CONCEPTS FOR HYDROLOGIC BALANCE

Since surface outflow data are not available, the reference chosen is the ground water body. The data required to determine the hydrologic equation are: (1) the change in storage of the ground water basin; (2) deep percolation (water reaching the ground water basin from precipitation, applied water, and streamflow); (3) ground water withdrawals (pumpage by all pumping plants — municipal, agricultural, industrial, etc.); and (4) net amounts of subsurface flow into and from adjacent ground water areas.

The initial hydrologic balance shown on Table 20 was made, taking into account the relative reliability of the various data. The most reliable data are annual changes in the amount of water in storage, since this is based on measured water levels and estimated specific yields. The probable error in specific yields is slight.

Annual amounts of pumpage also are considered reliable, particularly during the last three years, because municipal and industrial pumpage is metered and the last three years of agricultural pumpage is based on power records. Earlier years of agricultural pumpage is an extension of the last three years, taking into account land use changes and weather changes. Domestic pumpage is relatively small and errors hence would be minimal.

Recharge from rain and applied water is considered less accurate than change in storage and pumpage. The annual amounts of recharge are the product of the unit depths of recharge and the acreage of the appropriate land use. The unit recharge values contain adjustments for the amount of water applied as a function of monthly rainfall, but are not adjusted for micro-climatic effects. The unit recharge values assume no impedence of percolation by the subsoil, a condition which may not prevail over the majority of the study area.

TABLE 20

INITIAL HYDROLOGIC BALANCE
(in 1,000 Acre-Feet)

Year	Pumpage	Change in Storage	Recharge			
			Irrigated Agriculture	Urban	Native	Stream
1962	417.2	- 19.7	161.4	17.4	165.0	53.7
1963	317.6	51.5	137.4	14.9	124.5	92.3
1964	422.2	-171.0	93.0	8.0	82.8	67.4
1965	385.6	29.6	121.8	14.1	203.2	76.1
1966	449.4	-196.2	98.8	4.7	86.7	63.0
1967	337.5	303.4	160.1	48.7	336.7	95.4
1968	397.1	-157.7	80.0	4.9	71.6	82.9
Average	389.5	- 22.9	121.8	16.1	152.9	75.8

The least accurate item is the recharge from streams and runoff. Poor accuracy in estimates of runoff is due primarily to inaccuracy of some stream gages and the lack of gaging stations to measure total surface outflow from the study area. The stream and runoff recharge was therefore computed as the residual item in the initial hydrologic balance.

Mathematical Model

A mathematical model is a method of describing a physical system. It should react to stimuli exactly as does the real system. In the case of a ground water basin, it is often too expensive to operate on a trial and error basis. Some other means of determining how the ground water basin will react to differing conditions is necessary. Using a high speed digital computer and sophisticated modeling techniques, a mathematical model computer program was developed to simulate the ground water basin.

The model is a set of linear differential equations that define the flow and storage of ground water. The equations are used to determine the reaction of water levels in a ground water basin to annual amounts of net recharge (water inflow minus outflow). Items of inflow are recharge from precipitation, irrigation, and streamflow. Items of outflow are pumpage and subsurface outflow. To form the equations, the basin and its hydrologic history are subdivided into nodes, flow paths, and time increments. Given the initial water levels and a set of net recharge values, the model will operate over the study period.

A generalized ground water equation that could define the storage, transmissivity, and water inflow-outflow characteristics first was developed for the Los Angeles Coastal Plain study. A discussion of the details of the computer application and the derivation of the generalized ground water equation is presented in Attachment 5 to Appendix C, Bulletin 104, "Planned Utilization of Ground Water Basins: Coastal Plain of Los Angeles County", dated December 1966. The equation shown on Figure 30 defines the storage and transmissive characteristics of any unit area of the ground water basin.

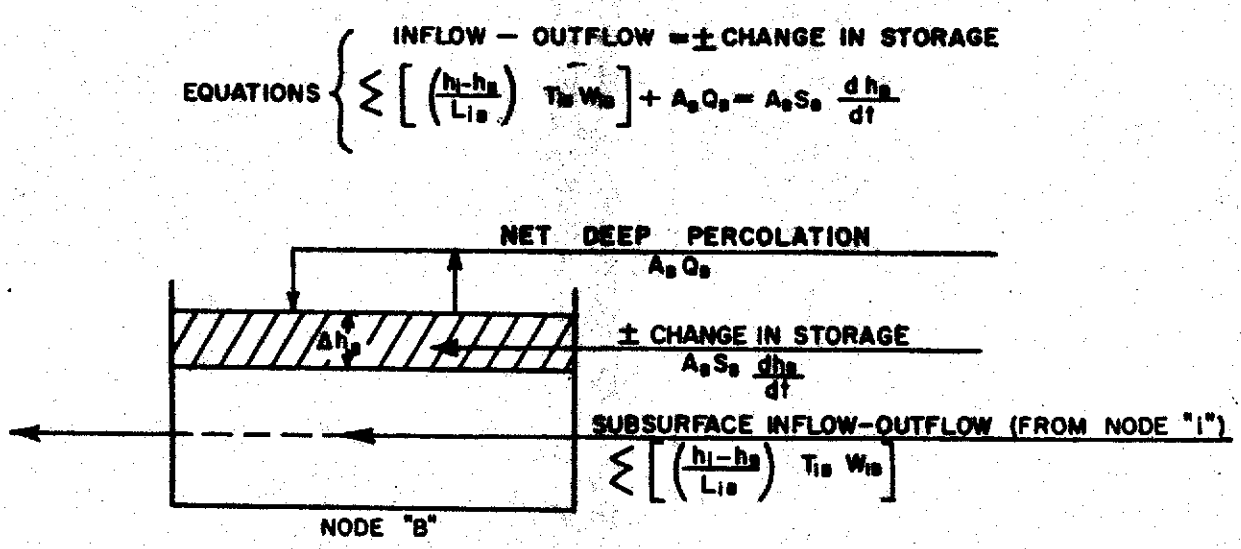


Fig. 30. SCHEMATIC SKETCH OF GENERALIZED GROUND WATER FLOW EQUATION

Figure 30 also shows the relation of the items in the equation. The symbol definitions are as follows:

h_i = water level elevation associated with node i, in feet

h_B = water level elevation associated with node B, in feet

$T_{i,B}$ = transmissivity at midpoint between nodes i and B, in $\frac{\text{acre-feet}}{\text{year foot}}$

$W_{i,B}$ = length of perpendicular bisector associated with nodes i and B, in feet

$L_{i,B}$ = distance between nodes i and B, in feet

A_B = area associated with node B, in acres

Q_B = flow rate net deep percolation per unit area at node B, in $\frac{\text{acre-feet}}{\text{year acre}}$

S_B = storage coefficient of polygonal zone associated with node B (dimensionless)

t = time, in years

The first term on the left-hand side of the equation shown in Figure 30 is the summation of the subsurface flows between a given unit area and its surrounding areas. The second term describes the surface flow rate from the ground surface into or out of the zone of saturation of the given unit area. The rate of change in storage is given by the right-hand expression. A set of these differential equations, one for each unit within the basin, with proper coefficients, forms the mathematical model of the ground water basin.

The mathematical model for Sacramento County contains 102 polygonal areas or nodes. The entire modeled area contains 618,860 acres, of which 59,495 acres are in Yolo County. The model has an average nodal area of 6,067 acres. Figure 31 shows the nodal pattern. The original pattern was on a 3-mile by 3-mile grid. As the study progressed, this pattern was modified to its present form by combining standard size nodes with very small nodes along the edges. The nodes on the northern boundary are irregular because of the irregular county line. Nodes along the eastern boundary are irregular because of the contact between the water-bearing and nonwater-bearing rocks.

The model treats the County as a free ground water body. This is not strictly correct because there are areas in the County where drillers have found a rise in water levels after further drilling, a condition indicative of some confinement of ground water. Due to insufficient water level and pumpage data, input for a model of two or more layers could not be developed. Analysis of water levels for separate aquifers indicated very small differences in water levels, thus modeling

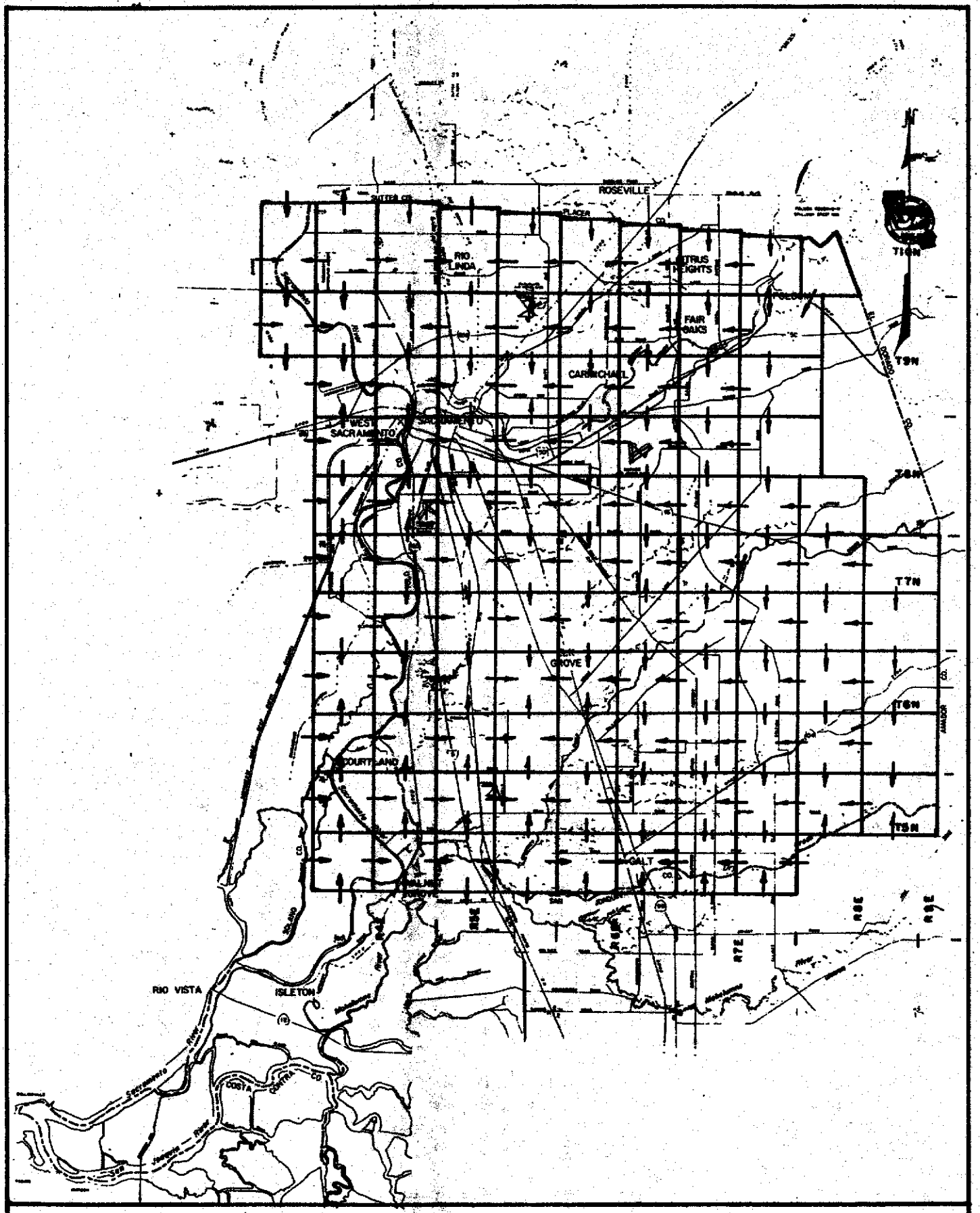


FIGURE 31. DIRECTIONAL FLOW OF BRANCHES FOR THE GROUND WATER MODEL

the ground water system as a single-layer free ground water body is reasonable, particularly when the time interval between data points is one year.

Transmissivity values were estimated using a relationship between specific yield and permeability. This relationship was derived for the digital model of Livermore Valley and is described in some detail in Department of Water Resources Bulletin 118-2, "Livermore and Sunol Valleys: Evaluation of Ground Water Resources", January 1974. The values for permeability which were used in the current study are presented on Table 21.

TABLE 21

PERMEABILITY

Specific Yield (percent)	Permeability (gal/day/ft^2)
3	1
5	30
10	400
15	800
20	1,200
25	1,500

If the above values for permeability are plotted on a chart, a curve results. Equations describing the curve were derived for input into the computer. The curved portion of the graph, for specific yield values from 3 to 10, is described by the equation:

$$\Delta T = \Delta D \cdot 10^{3.5319 - \frac{7.16288}{|SY| - 0.84}}$$

and the straight-line portion, for specific yield values greater than 10, is described by the equation:

$$\Delta T = \Delta D \cdot (100\ |SY| - 500)$$

where: ΔT = incremental transmissivity,
ΔD = incremental depth, and
$|SY|$ = absolute value for average specific yield for given interval.

A computer program was written to accept the specific yield data which had been coded for the geological deposition program. Output of the program was transmissivity values for each node to the bottom of the data. These transmissivity values were for flows along the depositional channels; these were modified to

apply to each nodal branch. For this study a transmissivity modifying ratio of ten to one was adopted, i.e. ten in the direction of the deposition channel to one at right angles to that direction.

For most of the nodes there were insufficient well data to define the transmissivity values to the bottom of the Mehrten Formation, which is considered the base of fresh water. In these cases, the data to extrapolate the transmissivity values to the base of the Mehrten Formation were obtained from the upstream or upslope nodes.

Development and Verification of Mathematical Model

The general steps taken in the development and verification of the mathematical model were as follows:

1. The Sacramento County ground water area was subdivided into nodes on 3-mile by 3-mile centers (see Figure 31).

2. Geologic data were analyzed and the transmissivity factors between nodes and the storage factors within each node were determined, using the directional stream channel deposition patterns shown on Figures 3 and 5.

3. Historical surface hydrologic data were analyzed and the seasonal net deep percolation at each node was determined for the period 1961-62 through 1967-68. Also, hydrographs of representative ground water level fluctuations during the same period were prepared for each node based on measurements of historic ground water level elevations.

4. Using the DWR computer (CDC-3300), problem parameters were placed in the computer and the model was tested. The testing process consisted of matching the water level elevations generated by the computer, using historic hydrologic input data, with historic water level elevations.

5. Based on the information developed during the testing period, final verification was achieved when machine-computed water level elevations and historic water level elevations matched.

The method used by the Department for verification is a "trial and error" method, however, for the Sacramento County model the method was more "rational" than "trial and error". Many parameters are utilized by the model. Each of these parameters was estimated separately. The model integrates all parameters together in attempting to duplicate the historic water levels for the study period. There may be numerous possible combinations to reproduce the historic water levels for each node. By varying only a few values of a single parameter at one time, a "feel" for the sensitivity of the model can be obtained. Once that feeling is imparted to the verifier, the verification process is made by varying only those parameters which are sensitive to changing water levels.

For this model the net recharge values are the most sensitive parameter because of the discontinuous layers of hardpan which impede downward percolation. In estimating the unit rates of percolation from irrigation and precipitation, the

hardpan layers were disregarded; although it was suspected from the beginning that the resulting net recharge values were too high. For those nodes requiring small changes in net recharge values, the assumption can be made that the hardpan layer is nonexistent. On the other hand, if large changes are required, a continuous hardpan layer probably exists.

After the first modeling run, computed water levels in some nodes differed 80 to 90 feet from historic water levels. In the eastern part of the County, nodes 75 through 84, computed water levels appeared to be building up. This caused a decline in the computed water levels to the west. At first it was believed that intervening transmissivity values were too low. Transmissivity values subsequently were increased, but the resulting increase in water movement was minimal. From this it was postulated that the values of net recharge needed to be modified.

Maps in "Soils of Sacramento County, California", by Walter W. Weir, April 1950, were used to determine if the infiltration portion of the net recharge should be changed. The soil maps showed that much of the southeastern portion of the County was underlain by San Joaquin, Redding, and Pentz-Redding soils, which diagnostically contain hardpan. In addition, the geologic portion of this study revealed that much of the hardpan area also contains an iron cemented topsoil. Thus there is very little chance for water to infiltrate the topsoil and reach the ground water body. Because of this, percolation values for native vegetation in the southeastern foothill nodes were modified to one-tenth foot per year. The deleted percolation then was added to stream percolation in the downstream nodes to the west. Nodes in the northeast quadrant of the County also were checked for soil infiltration characteristics. Here, nodes 34, 35, 41, 42, 43, and 44 were modified.

Table 22, "Ground Water Inventory", tabulated the revised recharge from the foregoing changes. Note the subsurface inflow as computed by the model is an average of 4,700 acre-feet annually for the study period. Originally the subsurface inflow was estimated qualitatively to be small with no quantitative estimate. Figure 32 plots the accumulative net recharge and change in storage.

After reviewing the printout which reflected the one-tenth foot per year infiltration rate, it was found that some further changes or adjustments still were necessary. It was decided that a limiting factor of one-tenth foot per month should be used as a maximum infiltration value. This would increase the infiltration during the wet years. With this adjustment, the computed water levels matched the historical levels fairly well.

After the above manipulations, transmissivity values were increased or decreased in each node to increase or decrease subsurface flow and thus match computed water levels with historic levels. In this study a threefold change of transmissivity values was used. Figure 33 presents the initial computer output for nodes 78 and 82; Figure 34 presents the output after all adjustments have been made.

The verified model had an average error of closure of plus 0.56 foot, with a range of minus 10 to plus 21 feet. The larger errors were in the foothill nodes where historic water levels were incomplete and ill-defined. It would have been possible to further adjust the historic water levels in these areas in order to

decrease the error of closure. However, the foothill nodes have thin alluvium and only small ground water storage capacities. Therefore there was little need for a smaller error of closure in these areas. The model as it now exists with its present parameters is of sufficient accuracy to be used as a workable management tool for the study of the response of the ground water basin to any operational scheme that may be imposed upon it.

TABLE 22

GROUND WATER INVENTORY
SACRAMENTO COUNTY GROUND WATER BASIN
(In Thousand Acre-Feet)

Water Year	Recharge: Agricultural Water	Recharge: Urban Areas	Recharge: Native Areas	Recharge: Stream	Sub-Surface Inflow	Pumpage	Net Recharge	Change in Storage
1962	161.4	17.4	112.0	119.9	3.6	417.2	- 2.9	- 19.7
1963	137.4	14.9	94.4	109.7	3.5	317.6	42.3	51.5
1964	93.0	8.0	48.0	105.2	4.1	422.2	-163.9	-171.0
1965	121.8	14.1	121.3	158.7	5.4	385.6	35.6	29.6
1966	98.8	4.7	61.6	95.1	6.0	449.4	-183.2	-196.2
1967	160.1	48.7	220.0	172.1	5.9	337.5	269.3	303.4
1968	80.0	4.9	60.2	89.7	4.5	397.1	-157.8	-157.7
Average	121.8	16.1	102.5	121.5	4.7	389.5	- 22.9	- 22.9

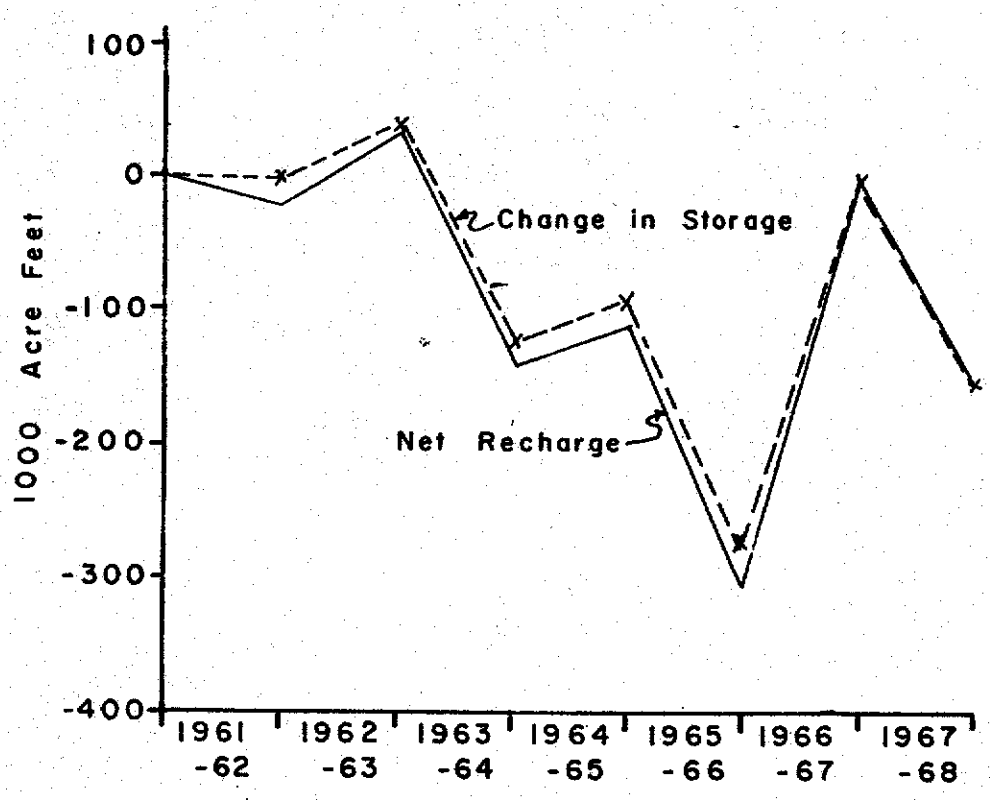


FIGURE 32. ACCUMULATED NET RECHARGE AND CHANGE IN STORAGE

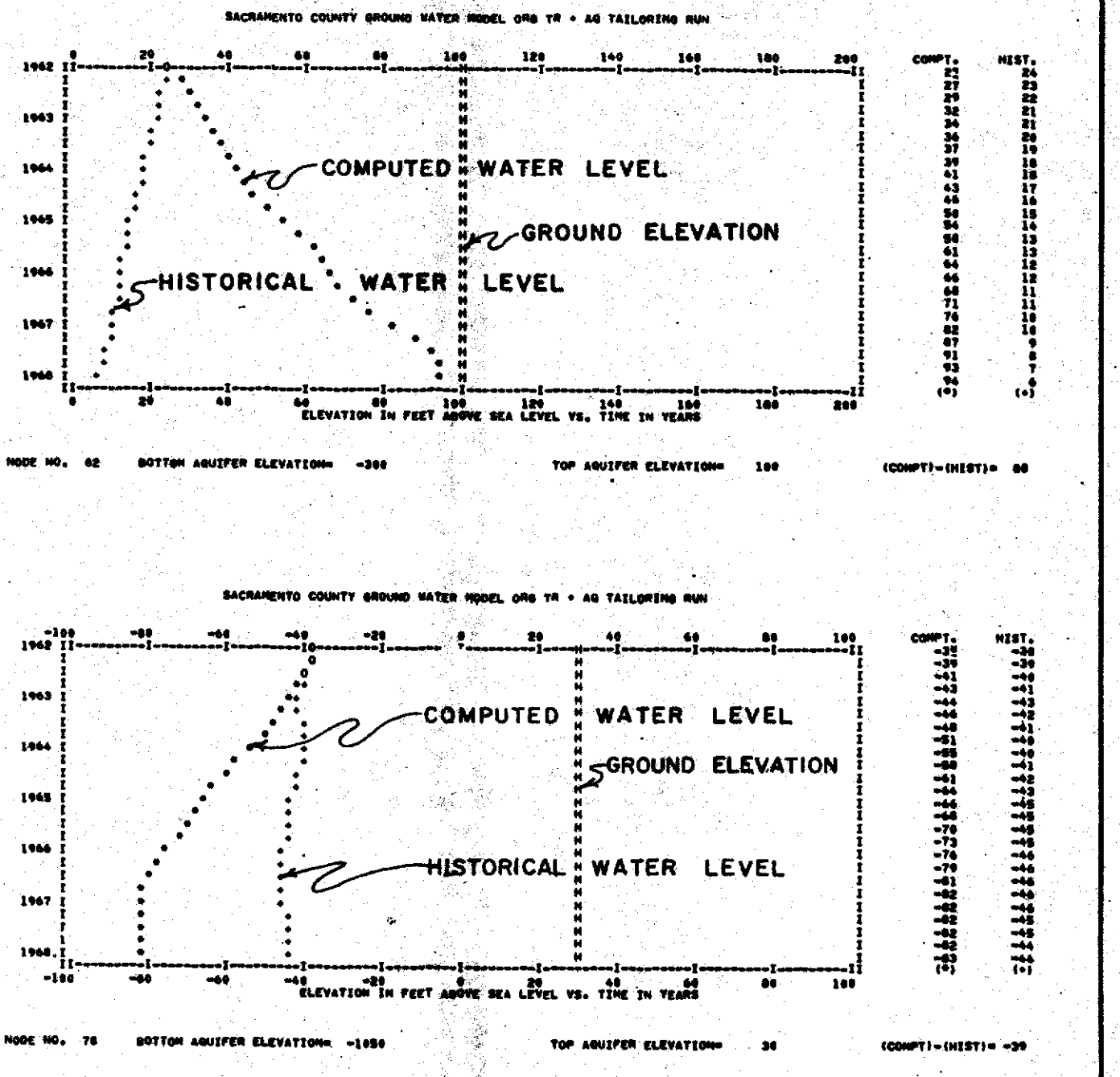
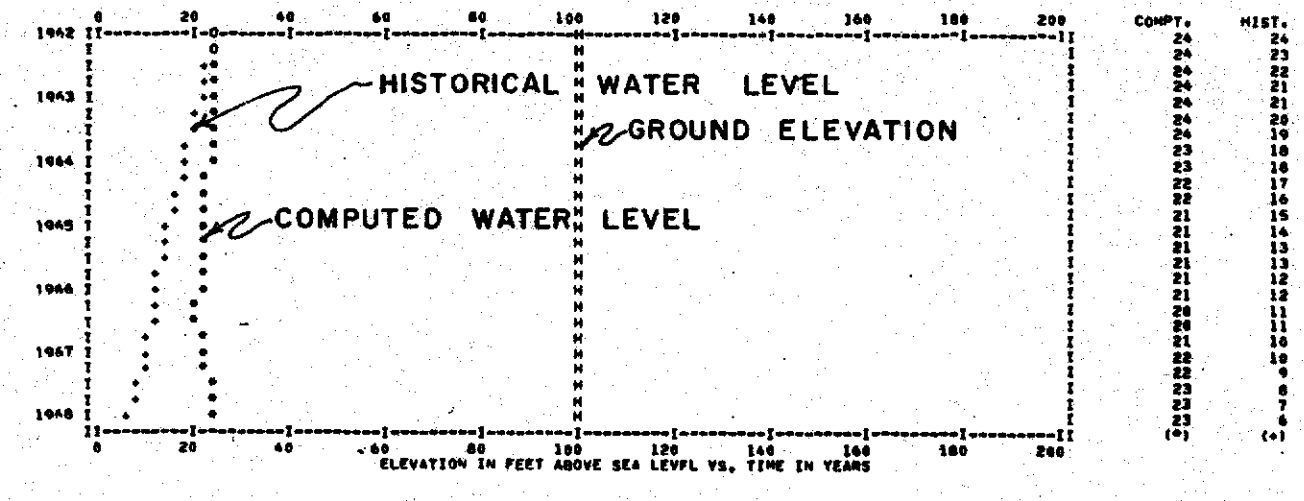
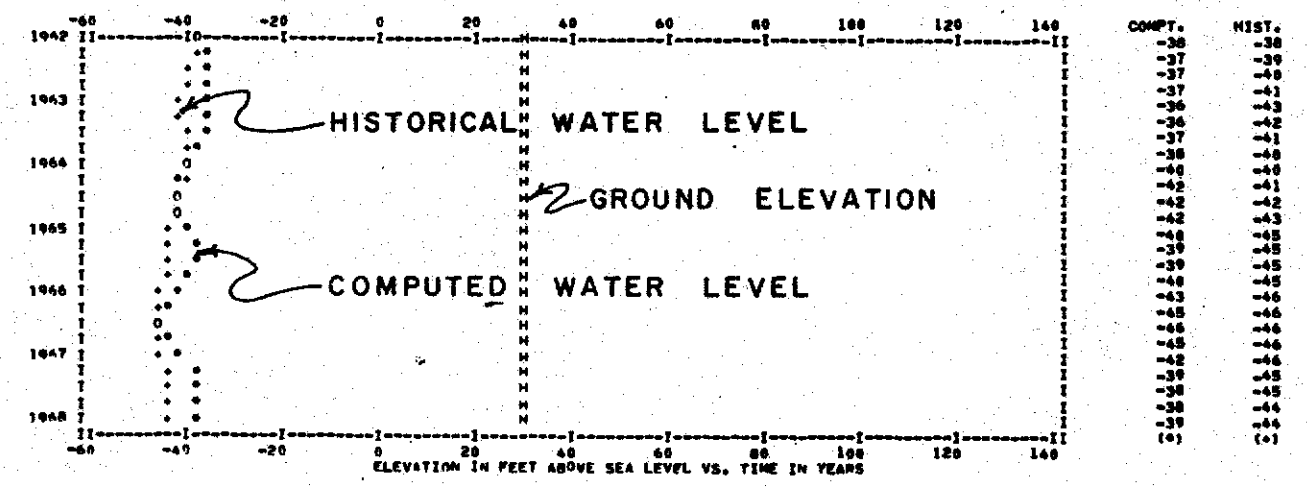


FIGURE 33. INITIAL RUN COMPUTER OUTPUT FOR NODES 78 AND 82



NODE NO. 82 BOTTOM AQUIFER ELEVATION= -300 TOP AQUIFER ELEVATION= 100 (COMPT)-(HIST)= 17



NODE NO. 78 BOTTOM AQUIFER ELEVATION= -1850 TOP AQUIFER ELEVATION= 30 (COMPT)-(HIST)= 5

FIGURE 34. FINAL RUN COMPUTER OUTPUT FOR NODES 78 AND 82

APPENDIX A

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State of California
The Resources Agency
Department of Water Resources

I, Vicki Price, Certification Clerk for the Department of Water Resources, State of California, do hereby certify that the attached copy of Bulletin No. 133, Folsom-East Sacramento Ground Water Quality Investigation, dated March 1964, is a true, full and correct copy, of the records on file in this office.

WITNESS my hand and the seal of the Department of Water Resources, State of California, this 25th day of April, 2002

Vicki Price

Certification Clerk
Department of Water Resources

THE RESOURCES AGENCY OF CALIFORNIA

Department of Water Resources

83 pp

BULLETIN No. 133

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

MARCH 1964

HUGO FISHER
Administrator
The Resources Agency of California

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Director
Department of Water Resources

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4	Geologic Section C-C'
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7 Lines of Equal Depth to Water in Wells Spring 1963

8 Lines of Equal Change of Elevation of Water in Wells - Spring 1953 to Spring 1963

9 Urban and Industrial Development, 1963

10 Sewer Maintenance and Water Service Districts

11 Mineral Characteristics of Ground Water

AUTHORIZATION

This investigation was conducted in accordance with the provisions of Section 229 of the California Water Code.

> "Section 229. The department, either independently or in cooperation with any person or any county, state, federal or other agency, to the extent that funds are allocated therefor, shall investigate conditions of the quality of all waters within the State, including saline waters, coastal and inland, as related to all sources of pollution of whatever nature and shall report thereon to the Legislature and to the appropriate regional water pollution control board annually, and may recommend any steps which might be taken to improve or protect the quality of such waters."

WILLIAM E. WARNE
Director of Water Resources
ROTH GOLDBERG
Deputy Director
HAROLD C. PRICE
Deputy Director Policy
KELLY GARDNER
Deputy Director Administration
FRED B. GOLZE
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EDMUND G. BROWN
GOVERNOR OF CALIFORNIA

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ADMINISTRATOR
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ADDRESS REPLY TO
P. O. Box 388
Sacramento 2, Calif.

THE RESOURCES AGENCY OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

1120 N. STREET, SACRAMENTO

May 18, 1964

Honorable Edmund G. Brown, Governor
and Members of the Legislature of
the State of California

Gentlemen:

I have the honor to transmit herewith Bulletin No. 133 of the State Department of Water Resources, "Folsom-East Sacramento Ground Water Quality Investigation."

This investigation was undertaken in cooperation with other State and local agencies and industries to insure that waste disposal from the rapid residential and industrial development east of Sacramento had not affected ground water quality in the area. This report discusses many aspects of ground water quality and establishes present quality levels as measured during the course of the investigation. These data will serve as a base line against which to measure the effects of future development.

The results of this study have shown that present waste disposal practices in the area have not affected the ground water quality and the water pumped within the area is satisfactory for all beneficial uses. Continuation of the Department of Water Resources' ground water monitoring program, together with the waste dischargers' monitoring program being conducted for the Water Pollution Control Board, should be instrumental in insuring the future protection of this ground water resource.

Sincerely yours,

William E. Warne

Director

CALIFORNIA WATER COMMISSION

RALPH M. BRODY, Chairman, Fresno

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- - - - - - o - - - - - -

WILLIAM M. CARAH
Executive Secretary

ORVILLE ABBOTT
Engineer

x

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

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Natomas Dredging Company

United States Bureau of Reclamation

United States Geological Survey

State Department of Public Health, Bureau of Sanitary Engineering

State of California, Central Valley Regional Water Pollution Control Board (No. 5)

County of Sacramento

D. Hedman and Company

Wayne Drilling Company

Cornelius Drilling Company

Grateful acknowledgement is also made to the many property owners who granted department personnel access to their wells and well records.

CHAPTER I. INTRODUCTION

The Folsom-East Sacramento area, shown on Plate 1, "Area of Investigation," lies to the east of the City of Sacramento, and south of the American River. While the area is outside the city limits it is sociologically and demographically a part of the city. Many who work in the industrial plants within the area of investigation live in the city or its surrounding suburbs. Many who live within the area of investigation work in the city. Traffic to and from the area moves equally in both directions.

Although Sacramento became a major urban center at the time of the California gold rush, a plentitude of land surrounded the built up areas. Until World War II extensive mounds of dredger tailings, left over from the gold mining of an early day, lay to the east of the city as a waste land suitable only for children playing "wild west." Until the mid 1950's the only development in the area was Mather Air Force Base. Now, in 1964, the area is a barbed-wire, control-towered complex on which giant plants such as Aerojet-General and Douglas Aircraft base their operations. Mather Field covers approximately 6,000 acres of the area.

As industry developed in the area, housing developments kept pace. Mather Field was the centroid of the first large development. Smaller developments soon followed and the pace of new residential construction still has not slackened. The 1960 census showed a total of

23,332 persons in the area. Some three years later it was informally estimated that this figure had increased to 30,000.[1/]

The water used by both industrial and domestic users is primarily ground water of high quality. As development proceeded, the industrial and domestic wastes generated were disposed of within the same ground water basin. The control of these wastes is under the jurisdiction of the Central Valley Regional Water Pollution Control Board (No. 5).

While there was no direct evidence of degradation of the ground water supply because of the introduction of waste waters, by 1961 logic forced the inference that if waste waters continued to be introduced into the basin such degradation would be inevitable. One of the larger waste dischargers had in fact, requested waste discharge requirements from the Pollution Control Board some time prior to 1961. However, the Pollution Control Board, with very little data at their command, found it difficult to establish waste discharge requirements. In order to obtain additional data on present ground water quality, hydrology, and geology, on which to base waste discharge requirements for this rapidly developing area, the Pollution Control Board requested that a study be undertaken to furnish this information.[2/] Utilization of these data would enable the Pollution Control Board to establish requirements which would insure the continuing protection of ground water quality in this

---

1/ By Phillip Warren, Staff Demographer, Department of Water Resources; based on an estimated average annual increase of 8½%.

2/ Memorandum, October 30, 1961, to the Department of Water Resources from Central Valley Regional Water Pollution Control Board, Subject: Proposed Investigation of the Folsom-East Sacramento Ground Water Basin.

basin and, at the same time, would permit maximum development of this area consistent with the safeguarding of the water supply.

It was therefore proposed that the Department of Water Resources, on behalf of the Pollution Control Board, develop the descriptive data of the area upon which a logical, fair, and equitable set of criteria could be based.

Boundaries of the Area

In order to define the boundaries of the area of investigation it was assumed that any effects waste water might have on the ground water body would be limited to the area south of the American River and west of the impermeable formations comprising the foothill structure of the Sierra Nevada. These formations follow roughly along the line between Ranges 7 and 8 East.[1/] The line between Townships 7 and 8 North, where the U. S. Geological Survey had contoured the depth to fresh water, was chosen as the southern boundary. This same line had been the northern boundary of a former U. S. Geological Survey ground water survey. The western limit of the area was established as the midline between Ranges 5 and 6 East. The area thus defined contains approximately 60,000 acres.

1/ All Ranges and Townships, unless otherwise described, are Mount Diablo Base & Meridian.

Types of Data Collected

Once the area was defined, the investigators set about to develop the data that would be needed. These data fell into six groups:

1. The historic and present quality of ground waters in the various aquifers.

2. Occurrence, direction, and velocity of ground water movement.

3. Areas and sources of recharge of ground water.

4. Occurrence and quality of underlying connate waters in the deeper marine formations.

5. Storage capacity of the ground water basin underlying the area of investigation.

6. Industrial, municipal, and domestic waste disposal practices.

Since ground water is so intimately associated with the subsurface structure, geologic data were gathered. The area had not been thoroughly geologized and literature was scanty and scattered. A field study, therefore, was conducted, which included a drilling program. Chapter II presents a summary of the findings of this program. The detailed information gathered during the field studies is included in Appendix A.

CHAPTER II. GEOLOGY

The Folsom-East Sacramento area lies within the structural trough of the Sacramento Valley. The sedimentary formations within this structural trough control the movement and quality of ground water in and through the area. Plate 2, "Areal Geology," shows the surface distribution of the formations. Ground water within these sedimentary formations ranges from good to poor quality. Beneath the sedimentary formations are the nonwater-bearing metamorphic and granitic rocks which crop out in the bedrock series of the Sierra Nevada. As shown on Plate Nos. 3 and 4, "Geologic Section A-A,' B-B,' and C-C,'" the formations in the area dip toward the west. Fresh ground water is found in the Victor, Laguna, and Mehrten Formations which extend from ground surface to about 1,000 feet in depth. The bottom contact of the Mehrten Formation is considered to be the lower boundary of the fresh ground water zone. Below the Mehrten Formation are the relatively impermeable Ione, Valley Springs, and Chico Formations. The latter formation is of marine origin and contains small quantities of poor quality water. beneath the Chico Formation are the impervious metamorphic and granitic rocks which make up the Sierra Nevada bedrock series.

The water-bearing characteristics of the various formations have been determined almost entirely through interpretation of well data. These data show that the deeper wells generally have greater pump discharges and higher specific capacities. The laguna and Mehrten Formations are the main producers of domestic, irrigation, and industrial ground water. Wells in the Victor Formation have the highest average specific

capacity of wells in the various formations in the area, but because of the limited depth of the Victor sediments, production there from is from the other fresh water-bearing formations.

The tabulation below summarizes the characteristics of wells pumping fresh ground water from various formations in the area.

	FORMATION		
	Victor	Laguna	Mehrten
Average Well Depth (feet)	204	339	416
Gallons Per Minute (gpm)	659	898	1098
Specific Capacity	58	35	38

The ground water-bearing formations are naturally recharged by infiltration of rain water, irrigation water, and seepage from the American River Numbus Reservoir. Previous dredging operations in the area imported a considerable amount of water for the hydraulic dredges. Most of this water was allowed to percolate, thus raising the ground water level at this time.

A more detailed discussion of the geology of the area of investigation is included as Appendix A of this report.

CHAPTER III. HYDROLOGY

Many factors affect the quality of the ground waters within a geographic area. Not the least of these is the water dynamics within the area. Water may be brought to the area on the surface or through underground sources. Some of the surface water seeps into the ground and some runs off through rivers and channels. As man builds on the land, he reduces the area of infiltration, diverting the waters which might have percolated to ground water and increasing the runoff through the natural or man-made watercourses.

In addition to changing the original hydrologic balance of the area, man changes the water itself. Chemicals or solids may be added to the water; it may be used repeatedly for irrigation and thus increase its content of dissolved solids; or the original dissolved solids may be removed.

Lands Within the Area

The rates and amounts of percolation to ground water depend upon the types, extent, and permeability of the soils which receive the waters. Within the Folsom-East Sacramento area there are three major soil classes:

1. Alluvial soils which are deep and permeable.
2. Hardpan lands which are quite impermeable.
3. River wash and dredger tailings having a wide range of permeabilities.

Urban expansion, however, is not inhibited by the percolation characteristics of the land. The hardpan soils will ultimately require surface drainage facilities but this is not expected to be an impediment to almost complete urbanization of the area. The dredger tailings are highly permeable, and will require treatment before serving as the foundations of structures heavier than private residences. It is doubtful, however, that land permeability will even enter into the calculations of land developers.

Land Use Pattern

The land use pattern within the area of investigation has exhibited a startlingly rapid changeover during the last two decades. An area once used primarily for dry range grazing and row crop agriculture is now becoming another appendage to the general Sacramento urban complex. This change in the land use pattern brings with it a markedly altered water regime. Lands that were once productive permeable agricultural lands are now covered by rooftops or other impermeable materials. As long as the land use remains in agriculture, rainfall and high quality waters used in irrigation can easily percolate to the water-bearing strata beneath. Today, the open permeable area is being rapidly reduced, and the percolant from urban and industrial usage may seriously lower the quantity and quality of the flows returning to the ground water reservoir.

As urbanization of the area increases, it is expected that land values and accompanying taxes will increase concurrently. For this reason agriculture, as it exists today, will undoubtedly not be able to compete

for the use of lands in this area in the future. It is reasonable to expect that by the end of the century no agricultural lands will be left in the area.

Land Use Survey

A land use survey conducted in 1961 indicated that nearly 5,400 acres of land within the Folsom-East Sacramento area were then being irrigated. Assuming a water requirement for irrigation of three feet per acre per year, the total use of both ground and surface water for irrigation would have been about 16,200 acre-feet annually. The results of the 1961 land use survey are shown in Table No. 1, on Page 10.

TABLE NO. 1

PATTERN OF LAND USE, 1961

(In Acres)

Irrigated Lands	Acres
Forage Crops	3,570
Truck Crops	400
Field Crops	220
Orchard	770
Vineyard	410
Subtotal	5,370
Urban Lands	
Military	6,060
Commercial	90
Industrial	1,490
Residential	1,450
Miscellaneous	670
Subtotal	9,760
Vacant Lands	44,000
TOTAL	59,130

As the irrigation requirement diminishes, the need for municipal and industrial water will increase. Studies indicate that before the year 2,000 agriculture will have ceased in the Folsom-East Sacramento area and all available water will be utilized by industry and municipalities. Figure No. 1 shows the expectation graphically.

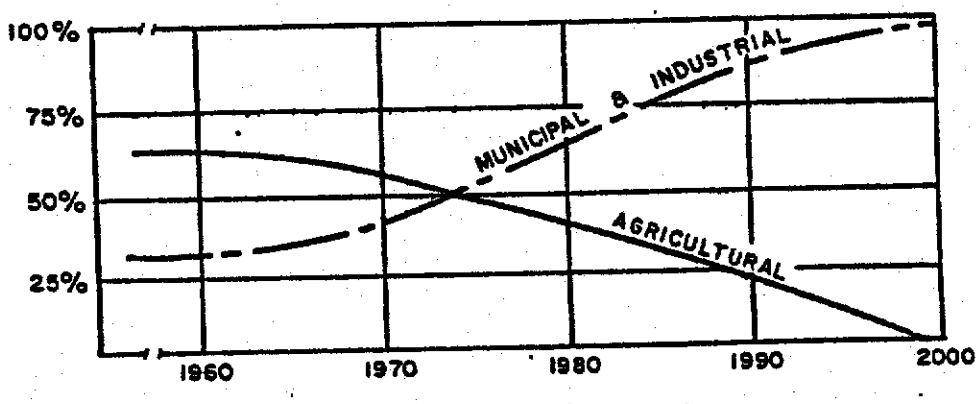

Figure 1, CHANGES IN WATER USE THROUGH TIME

Soil Classification Survey

A soil classification survey of the area was conducted during the summer and fall of 1962. The results of this survey are shown in Table No. 2, "Classification of Soils." The soils within the area can be classified by permeabilities. Highly permeable materials are composed largely of coarse river wash and dredger tailings. Permeable materials include most of the recent alluvial soils that are now under irrigation, generally within one mile of the American River. Slightly permeable materials include the claypan-hardpan terrace soils found extensively south of Highway 50. The soil classification survey showed a close correlation between permeabilities and geologic units shown on Plate No. 2.

TABLE NO. 2

CLASSIFICATION OF SOILS

Class	Acreage	Percent
Highly Permeable Materials	17,770	30
Permeable Materials	3,270	6
Slightly Permeable Materials	38,090	64
TOTAL	59,130	100

Ground Water

Ground water is available throughout the entire area of investigation, occurring in four geologic formations--the Mehrten, Laguna, Victor, and Recent alluvium. All four formations contain unconfined ground water, though confined ground water does occur locally in the Mehrten and Laguna Formations. Unconformable contacts exist between several of these formations, but the character of the contacts is such that they do not impede the movement of ground water.

Storage Capacity

The availability of ground water depends, in part, upon the amount stored. The net storage depends upon inflow, outflow, pumping, and other hydrologic factors.

Before the storage capacity of an area can be determined, or estimated, certain data must be known, or assumed. These include specific yield,[1/] depth, and extent of water-bearing strata. As a first step in computing the ground water storage capacity of the Folsom-East Sacramento area, the area within each section was measured to the nearest five acres. Twenty-foot depth intervals were established, and each interval was classified in one of five materials categories. The categories were taken almost entirely from drillers' logs, which in many instances had entries simply as gravel, sand, and clay. In actual fact, these three types include many subtypes and combinations of types. For practical purposes, it was

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1/ Specific yield is defined as the ratio of the volume of water drained by gravity from a saturated sample to the total volume of the sample, expressed as a percentage. It is assumed in this report, for example, that a cubic foot of saturated gravel would yield 25 percent of a cubic foot of water.

necessary to restrict the driller's log entries into five general classes and assign a specific yield to each. The classes, and the specific yield assigned to each were:

TYPE	SPECIFIC YIELD
Gravel; or sand and gravel mixed	25%
Sand, not packed	20%
Sand packed tight or hard	10%
Cemented gravel, clay and gravel, sandstone or silt	5%
Clay	3%

Each of these terms, it should be emphasized, included as many as 19 different designations used by drillers, which might or might not refer to the same material. The average specific yield of each depth zone, to a depth of 420 feet, was then calculated for each section.[1/] While well depths varied from less than 150 to about 600 feet, few water wells has been drilled below 400 feet and data pertaining to lower depths were scanty. In many cases specific yields and capacities below the 400 foot depth were extrapolated from data developed through the 0 to 400 foot zone. A summary of average specific yields from each horizontal layer from 0 to 420 feet is presented in Table No. 3. The complete data, from which the averages were derived, are included in Appendix B.

The storage capacity for each section was calculated from the specific yield for that section. A summary of the storage capacity of each layer is presented in Table No. 4. The complete data are included in Appendix B.

1/ Section lines were taken from U. S. Geological Survey 7½ minute quadrangle sheets.

TABLE NO. 3

AVERAGE SPECIFIC YIELDS AT VARIOUS DEPTHS

Depth Interval (feet)	Specific Yield (percent)	Depth Interval (feet)	Specific Yield (percent)
0-20	11	220-240	9
20-40	12	240-260	7
40-60	11	260-280	6
60-80	11	280-300	6
80-100	9	300-320	6
100-120	9	320-340	6
120-140	7	340-360	6
140-160	7	360-380	7
160-180	6	380-400	7
180-200	8	400-420	7
200-220	8		

TABLE NO. 4

STORAGE CAPACITIES OF SUBSURFACE ZONES

WITHIN AREA OF INVESTIGATION

Depth Interval (feet)	Storage Capacity (acre-feet)	Depth Interval (feet)	Storage Capacity (acre-feet)
0-20	138,500	220-240	101,500
20-40	146,400	240-260	83,400
40-60	124,700	260-280	69,100
60-80	118,200	280-300	62,100
80-100	112,700	300-320	70,800
100-120	103,100	320-340	78,600
120-140	86,700	340-360	67,300
140-160	92,300	360-380	74,500
160-180	90,000	380-400	87,600
180-200	99,000	400-420	85,300
200-220	93,000		

Total Storage Capacity -- 1,985,000 acre-feet

Change of Storage

Calculations of change of ground water storage depend upon measurements of the fluctuation in depths to ground water under different seasonal and hydrologic conditions. Such measurements are also used to calculate rates of change in storage, direction of ground water flow, and slope of the ground water surface. To obtain these data an extensive well canvass was conducted throughout the area of investigation to locate and determine the construction and depth of all wells. Upon completion of this canvass, a number of wells were selected that would best allow the measurement of water levels to indicate the direction of movement of ground water and the gain in, or loss of, stored water. These wells are listed in Table No. 5 (at the end of this report). Locations of the wells selected for measurement are shown on Plate No. 1.

To provide a basis for comparison, elevations of the reference points used for measurements were determined by differential leveling methods. All water level measurements were converted to mean sea level, U. S. Geological Survey datum. Prior to this investigation, the U. S. Bureau of Reclamation had made ground water measurements for a portion of the investigated area. The lines of equal elevation of the ground water determined from these data are shown on Plate No. 5, "Lines of Equal Elevation of Water in Wells, Spring 1946 and Spring 1953."

Measurements of the water level elevations were made during the spring of 1962 and spring of 1963 and are presented in Plate No. 6, "Lines of Equal Elevation of Water in Wells, Spring 1962 and Spring 1963."

The measurements made of the depth to ground water in the spring of 1963 are presented in Plate No. 7, "Lines of Equal Depth to Water in Wells, Spring 1963."

A comparison of the 1953 ground water elevations to the 1963 ground water elevations shows a general decline throughout the entire area of investigation, with the least amount of change occurring where the American River is influencing the recharge. The greatest change, approximately 20 feet, occurs in the Rancho Cordova area where intense urban development has taken place and in the southeastern portion of the area where recharge is very minor. These changes are illustrated on Plate No. 8, "Lines of Equal Change of Elevation of Water in Wells, Spring 1953 to Spring 1963."

During the decade 1953-63, the ground water storage was reduced approximately 67,000 acre-feet, or an average of 6,700 per year. The rate of reduction has apparently been intensified during later years. Between the time that ground water measurements were made in the spring of 1962 and the spring of 1963, ground water storage was reduced by approximately 11,500 acre-feet. This reduction, at an accelerated rate, reflects the increased urban and industrial use of water within the area coupled with a decreasing amount of recharge. The reduced recharge is probably due mainly to the cessation of dredger operations, but also reflects the decrease in land available to receive precipitation as a result of urban and industrial development.

Ground Water Withdrawals

The recent urban and industrial expansion within the area of investigation shown on Plate No. 9, "Urban and Industrial Developments, 1963," requires that a firm and plentiful supply of water be available now and in the future. Though surface water is available, the

largest supply is from ground water principally because ground water of high quality is available throughout the area and extensive conveyance and treatment facilities are not needed. Table No. 6 shows ground water extractions by all users during the 1961-62 fiscal year.

As urbanization developed within the area of investigation, water companies were formed. Large corporations and public groups, such as Aerojet-General Corporation and Mather Air Force Base, developed their own ground water supplies. Individuals and small industrial users outside the area served by the water companies usually developed their own supplies and ordinarily did not keep records of the amount withdrawn. The quantity pumped outside the service areas of the organized water companies was determined by listing and estimating each individual use.

The amount of water used for agricultural purposes was determined by using an estimated figure of 3.0 feet per acre per year on 5,370 acres of irrigated lands within the area of investigation. Agriculture presently requires about twice the amount of water as all other uses combined require. This situation will change, however, as urbanization increases at the expense of agriculture.

TABLE NO. 6

AMOUNTS OF GROUND WATER EXTRACTED

(July 1, 1961 - June 30, 1962)

	Million Gallons Per Day	Acre-Feet Per Year
Water Companies	7.5	8,370
Individual residences	0.6	670
Industrial (outside of the service area)	0.2	220
Agricultural	14.4	16,110
TOTAL	22.7	25,370

Table No. 7 shows the amounts of ground water withdrawn from the basin by the four largest users in the area from July 1, 1961 to June 30, 1962. The areas served by the users listed in Table No. 7 are shown on Plate No. 10, "Sewer Maintenance and Water Service Districts."

TABLE NO. 7

GROUND WATER WITHDRAWALS BY FOUR LARGEST USERS

(July 1, 1961 to June 30, 1962)

User	Yearly Withdrawal (acre-feet)
Natomas Water Company 1/	3,138
Citizens Suburban Water Company	1,027
Mather Air Force Base	2,801
Aerojet-General Corporation	1,400 2/
TOTAL	8,366

Recharge

If a ground water body is not to be depleted, there must be a balance between the amount of water withdrawn and the amount replaced. It is quite obvious that if more water is removed than replaced, the water table will drop. Ground water replenishment for the area of investigation occurs from infiltration of rainfall, surface streams, unconsumed applied water, and imported water.

Precipitation. The amount of infiltration from precipitation, a major source of recharge to ground water, depends on many factors such as precipitation intensity, soil characteristics, and vegetative cover.

Average annual precipitation in the area of investigation ranges from 17 inches in the western portion of the area to 22 inches in the northeastern portion. Practically all of the rainfall occurs

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1/ Serving 3,125 connections at an average of 897 gallons per day per connection.

2/ Estimated

from November to April. Plate No. 1 shows lines of equal average seasonal rainfall within the area of investigation from 1910 to 1960.

For purposes of this investigation is was assumed that 67 percent of the precipitation falling on the highly permeable materials and 10 percent falling on the remainder of the area would infiltrate to ground water. Infiltration from 20 inches of precipitation per year on 17,700 acres of highly permeable materials and from 18.5 inches on the 41,300 acres of other lands contributes approximately 26,000 acre-feet of recharge to the ground water supply each year.

Stream Channel Seepage. Prior investigations of infiltration in the area estimated that, after completion of upstream controls, percolation of the American River, between the Folsom Bridge and the confluence of the American River with the Sacramento River, would account for approximately 64,000 acre-feet of water per season.1/

The Folsom-East Sacramento area embraces less than one-fourth of the area receiving seepage from the American River. While the infiltration rate may vary within different reaches of the river, data generated during the investigation were not sufficiently detailed to determine the actual infiltration rate at each point within the area of investigation. The simplifying assumption was therefore made that the rates of infiltration were invariant and about 16,000 acre-feet of water is percolating annually into the ground water basin underlying the Folsom-East Sacramento Area.

Seepage from the beds of the annual streams in the area is probably small.. Runoff is generally rapid, the period of flow seldom

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1/ Bulletin No. 21, State Water Resources Board, 1955.

lasts more than a few days after a storm. Attempts at determining the amount of seepage on two of the major streams were not successful.

Imported Water. At the turn of the century, the Natomas Dredging Company, needing a reliable supply of water for their operation, constructed a dam on the American River above the City of Folsom. This dam diverted the necessary water to maintain the company's operations and supplied irrigation water to lands under cultivation. The creation of the dam resulted in diversions of at least 26,000 acre-feet of water per year.1/

Gold dredging operations required water throughout the year and the percolation of this water from the dredger ponds was a major source of recharge to the ground water basin, amounting to more than 20,000 acre-feet per year. Since the cessation of dredging operations in 1961, diversions to the dredging ponds have been stopped, ending the recharge to the ground water basin from this source.

One of the principal water users in the area, Aerojet-General Corporation, estimates that it has a potential use of ten million gallons of water per day (30.6 acre-feet) and purchases this amount from the Natomas Dredging Company. This water is delivered in a continuous flow by the same conveyance system that formerly supplied the dredging operations. The amount, however, is usually more than is currently needed and the excess is discharged to the old dredger ponds, where it eventually evaporates or infiltrates to the ground water.

1/ The amount of water diverted by the Natomas Dredging Company was of such magnitude that when their dam was removed by the Bureau of Reclamation to allow the construction of Folsom Dam, established water rights were firm enough to cause more than 26,000 acre-feet of water to be relased annually for the use of rights holders.

To reduce this wastage and eliminate maintenance costs on the conveyance system, plans have been made to construct a ten million gallon holding basin. This would allow the amount of water delivered to be reduced to the actual amount needed.

In addition to the ten million gallons furnished by the water company, Aerojet pumps about 1¼ million gallons of water (3.8 acre-feet) daily from local wells. Although most of the imported ten million gallons per day are allowed to waste to the dredger tailings, it is more economical for Aerojet to pump the additional 1¼ million gallons than to build conveyance systems to outlying test facilities. Of the total water supplied to the Aerojet-General Corporation, about 1½ million gallons of water per day[1/] are returned to the American River via Buffalo Creek as wastes from their sewage treatment plant. An attempt was made to determine the recharge from Buffalo Creek; however, the results of field measurements were inconclusive.

Present recharge to the ground water body from the infiltration of imported water amounts to approximately 8,000 acre-feet per year. If the proposed storage basin is constructed, all recharge to the ground water from the surplus water presently delivered will cease. Recharge to the ground water table will then amount to approximately 2,000 acre-feet per year.

Some of the land bordering the American River have been irrigated in the past by pumping water directly from the river. This

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1/ Determined from flow records at the Aerojet-General Corporation sewage treatment plant July 1961 to June 1962 inclusive.

practice has almost stopped and recharge from this source is now negligible.

Unconsumed Urban Water. Data collected from nine cities in the Central Valley indicate that approximately 50 percent of the water delivered to urban areas is consumed while approximately 70 percent of the balance flows to the sewers, with the remainder infiltrating to the ground water table.[1/] In short, only 15 percent of the water delivered to urban areas becomes available for infiltration.

Applying this ratio to the amount of water supplied to the Folsom-East Sacramento sewered urban areas by the water companies, as shown in Table No. 7, recharge to the ground water basin from this source amounts to approximately 1,250 acre-feet per year. In 1962, there were approximately 500 homes in the area that were unsewered and discharged their wastes to septic tanks. It is estimated that each of these septic tanks contributes 200 gallons of water per day to infiltration. Recharge from these septic tanks amounted to approximately 100 acre-feet of water during 1962.

The infiltration of waste waters from sewage treatment plants is believed to be negligible and is not considered as a source of recharge in this area. All the plants serving the area of investigation discharge their wastes to watercourses that flow from the area of investigation. The sewage treatment plants and amounts discharged by each during the 1961-62 fiscal year are listed in the following tabulation:

1/ Bulletin No. 21, State Water Resources Board, 1955.

	Effluent Disposal Point	Design Capacity MGD	Discharge MGD	Discharge AF/Year
Rancho Cordova	American River	4.0	1.10	1,232
Manlove S.M.D.	Morrison Creek	1.2	0.25	280
Mather A.F.B.	Morrison Creek	1.5	0.97	1,087
Aerojet-General Corp.	Buffalo Creek		0.38	426
TOTAL			2.70	3,025

Unconsumed Irrigation Water. In the Folsom-East Sacramento area, five inches of water may be expected to percolate to the ground water table for every 18 inches of water applied for irrigation.[1/] Assuming an average application of three feet per acre per year,[2/] of which ten inches percolate to ground water, 4,500 acre-feet of water per year is recharged to the area's ground water table from applied irrigation water.

Unconsumed Industrial Water. Many of the waste waters from industrial or manufacturing plants unserviced by sewer systems are discharged to septic tanks or holding ponds. Infiltration from these sources can be significant, depending on the amount discharged and method of disposal. Individual discharges of industrial waste were listed and infiltration rates were assigned to each discharge based on amounts discharged and methods of disposal. It is estimated that the recharge from these unsewered industrial and manufacturing plants amounted to approximately 250 acre-feet of water during 1962.

1/ Bulletin No. 21, State Water Resources Board, 1955.
2/ See discussion in Land Use Survey on Page 9.

Subsurface Outflow

Though subsurface inflow to the ground water basin does not occur through the impermeable formations of the Sierras, subsurface outflow does occur. Consequently the area of investigation is not a closed ground water basin.

Ground water elevations indicate that on a front approximately nine miles in length, ground water is leaving the area with a hydraulic gradient of approximately .0025, a slope of 13.2 feet per mile.

Geologic observations indicate that the sediments through which the water flows average 800 feet in depth and have an estimated permeability of 400 gallons per day per square foot. These dimensions result in a computed subsurface outflow of 42,600 acre-feet per year.

Outflow was computed by means of Darcy's formula ($Q=kiA$) where:

Q = quantity of subsurface outflow

k = permeability

A = cross sectional area

i = hydraulic gradient

This principle was first stated by Darcy as: 1/ "The volume of water which passes through a bed of sand of a given nature is proportional to the pressure and inversely proportional to the thinkness of the bed traversed."

Exported Water

The term "exported water", as used in the report, reflects the waste discharges and irrigation runoff that enter surface watercourses to eventually leave the area of investigation.

1/ Todd, David Keith; Ground Water Hydrology; John Wiley & Sons, Inc., 1959.

Cordova and Manlove sewage treatment plants discharge their wastes to watercourses at points where they flow rapidly from the area. Wastes from the Mather Air Foce Base and Aerojet-General Corporation sewage disposal plants traverse watercourses for some distance before leaving the area. The volume of wastes discharged from these plants amounts to approximately 3,000 acre-feet per year. Irrigation runoff eventually enters the same watercourses and contributes approximately 2,700 acre-feet per year.

The total 5,700 acre-feet of water per year which leaves the area in this manner originate as ground water and represent a direct loss from the ground water basin. This loss is accounted for in estimates of withdrawals and is presented here only for reference.

Hydrologic Summary

A balance of the quantities estimated for these sources of supply and withdrawal was made to reflect the accuracy of the estimates. This balance is summarized in Table No. 8.

TABLE NO. 8

SUMMARY OF ESTIMATED AMOUNTS OF SUPPLY

AND

WITHDRAWALS TO GROUND WATER BODY - 1962

Source	Amount in acre-feet per year
Supply	
Precipitation infiltration[1/]	26,000
Stream channel seepage	16,000
Imported water infiltration	8,000
Unconsumed irrigation, urban and industrial water	6,000
TOTAL	56,000
Withdrawal	
Irrigation use	16,100
Urban and industrial use	9,300
Subsurface outflow	42,600
TOTAL	68,000 [2/]

1/ Based on 50-year average of precipitation.
2/ Includes water removed from storage, see discussion on Page 18.

CHAPTER IV. WATER QUALITY

Ground and surface waters within the Folsom-East Sacramento area are, at present, of excellent quality. However, with the rapid buildup of industry and residences in the area, the opportunities and probabilities for the ground water basin to become degraded will increase. Fortunately, industry and all the agencies of government concerned with the area are aware of the possibilities of contamination and are working together to insure the continuance of a water supply of excellent quality.

Classification of Waters

There are numerous systems of water classification. The system used in this report uses the predominant cation and anion as the primary elements of classification. The units of this system are expressed as a percent of the reacting value of the equivalents per million. Where no ion clearly predominates, a system of hyphenated adjectives is used.[1/]

Waters collected from 96 wells within the study area were classified and found to fall into one of five classifications. These classifications were:

1. Calcium Bicarbonate
2. Sodium-Calcium Bicarbonate

1/ See Fair & Geyer, Water Supply and Waste Water Disposal; and Geological Survey Water-Supply Paper 1473, Study and Interpretation of the Chemical Characteristics of Natural Water.

3. Calcium-Sodium Bicarbonate

4. Calcium-Magnesium Bicarbonate

5. Magnesium-Calcium Bicarbonate

Each class of water is usually found within a certain locality. Plate No. 11, "Mineral Characteristics of Ground Water," shows the locations of the wells producing the various classes of water and the predominant ion groupings. These groupings are usually well balanced. Except for a few wells of a predominately calcium bicarbonate type, within a small locality in the extreme western part of the area of investigation, all wells produce water having two or more of the cations of calcium, magnesium, and sodium. Generally, two are predominant, making up about 80 percent of the reacting value. Table No. 9 (located at the end of this report) shows the concentrations of these cations and anions in both parts per million and equivalents per million. Not all possible combinations exist.

Normally, waters from the same formation may be expected to be of the same classification. In the Folsom-East Sacramento area, however, this is not true. Recharge waters within the area vary in type and in place, ranging from precipitation to waste water. These recharge waters move through the formations, or a single formation, lenticularly or in laminar flow patterns and could be accessible to one well and not another. For this reason, waters drawn from the same formation may be different types.

This phenomenon is illustrated by two wells, 9N/7E-17N1 and 9N/7E-24H1, both penetrating and producing water from the Mehrten Formation only. Well 9N/7E-17N1, located within one-quarter of a mile of the American River, its source of recharge, produces a calcium-magnesium bicarbonate water, the same type of water as is found in the well's source of recharge. Well 9N/7E-24H1 is located away from the influence of recharge of the American River. Infiltration and percolation of precipitation and waste water is its only source of recharge. This well produces a sodium-calcium bicarbonate water.

Most wells producing this class of water (sodium-calcium bicarbonate) are located in the southeastern portion of the area of investigation, with the northernmost well located on Aerojet-General Corporation property in T9N, R7E, Sec. 24. The wells in the southeastern portion of the area of investigation penetrate both the Laguna and Mehrten Formations. The Laguna Formation is now dewatered in this locality and the wells obtain their water from the Mehrten Formation only.

There are wells in the south-central area which produce the same class of water. These wells, however, are probably not deep enough to penetrate the Mehrten Formation. Other wells in the same area, however, produce a calcium-sodium bicarbonate water.

Calcium-sodium bicarbonate water is also obtained from wells located in the southwestern part of the area of investigation. Wells producing this type of water are not drilled deep enough to penetrate the Mehrten Formation, but obtain their waters from the Laguna and Victor

Formations. Many of the wells that supply the individual residences are relatively shallow, penetrating just the Victor Formation, which is seldom at a depth of more than 100 feet. The water from this formation shows no predominant cation. The chemical constituents of this water are so low as to pose a problem to laboratory techniques. Recharge to the Victor Formation is from the American River, which is in direct hydraulic contact with the formation, and from infiltration of precipitation and applied waters.

The calcium-magnesium bicarbonate water is pumped from wells located in the north-central area of investigation. Shallow wells that obtain their supply from the Mehrten Formation, where it is under recharge from the American River, produce this type of water. Deeper wells, located in the Rancho Cordova and Mather Air Force Base areas, that obtain their supply from the three major aquifers, the Mehrten, Laguna, and Victor, also produce a calcium-magnesium bicarbonate water.

Wells producing a magnesium-calcium bicarbonate type of water are located in the northeastern section of the area of investigation. These wells are relatively shallow, drawing from the Laguna Formation only. Recharge to this formation is also from direct contact with the American River, infiltration of imported water from the American River, and the infiltration of precipitation. Though the source of recharge to the various formations is essentially the same, the base exchange properties of each formation are different and account for the different classes of water produced.

The following tabulation summarizes the classification of water found in the various localities within the area of investigation.

General Location Within Area of Investigation	Classification of Water	Remarks
Extreme Western	Calcium Bicarbonate	
Southeastern	Sodium-Calcium Bicarbonate	Water produced from Mehrten Formation
South-Central	Sodium-Calcium Bicarbonate and Calcium-Sodium Bicarbonate	Water produced from Laguna and Victor Formations
Southwestern	Calcium-Sodium Bicarbonate	Water obtained primarily from Laguna and Victor Formations
North-Central	Calcium-Magnesium Bicarbonate	Shallow wells produce from Mehrten Formation. Deeper wells produce from Mehrten, Laguna, and Victor Formations
Northeastern	Magnesium-Calcium Bicarbonate	Shallow wells producing from Laguna Formation

There are a number of wells throughout the area of investigation that obtain their water from more than one aquifer. Knowing the characteristics of the water produced from individual aquifers, it is sometimes possible to determine which aquifers are contributing to each well and to arrive at a determination of the amount each aquifer contributes. This is accomplished by using a method outlined by Piper 1/ involving the use of the trilinear graph.

1/ Piper, A. M., 1944; Transactions of American Geophysical Union, Volume 25, pages 914 - 923.

Piper, and other writers who have proposed trilinear graphs, have pointed out that where an analysis shows a mixture of two original waters, this mixture will plot on a straight line between the original two. For mixtures of more than two waters, the analyses of the mixture would plot within a figure bounded by the components.

An example of a mixture of two waters is shown in the analyses of water produced from well 9N/7E-28K1 owned by the Aerojet-General Corporation. The driller's log of this well shows that the well is supplied from both the Laguna and Mehrten formations. Figure No. 2 indicates that water of different qualities is available from the separate aquifers. The characteristics of water obtained from the Laguna Formation and Mehrten Formation can be observed in the plot of the analyses of water obtained from wells 9N/7E-24H1 and 9N/7E-23L1. Well 24H1 produces water from the Mehrten Formation and well 23L1 from the Laguna Formation. The analysis from 28K1 plots midway between the two analyses from 24H1 and 23L1. It is thereby indicated that each aquifer is contributing approximately the same amount of water to the well. Simple mixtures such as this occur throughout the area of investigation where wells are drilled deep enough to penetrate two formations. These pairs are usually the Laguna and Mehrten Formations, or the Victor and Laguna Formations.

More complex mixtures are obtained only from those wells that are deep enough to penetrate all three of the water producing formations. Such wells are located in a belt running in a north-south line through the

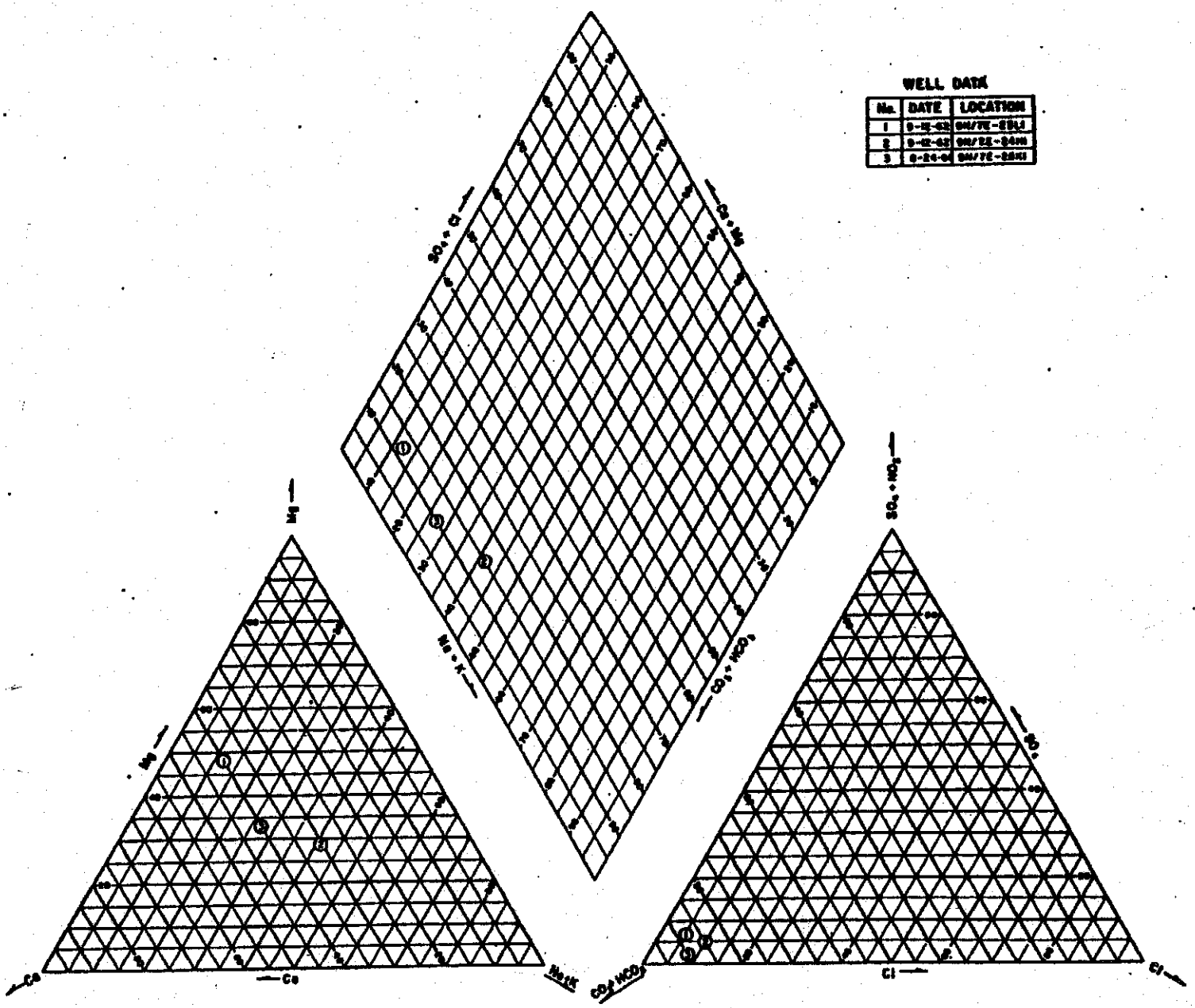

Figure 2, COMPARISON OF ANALYSES OF THREE SELECTED WELLS

central part of the area of investigation. These wells are the largest producers in the area, developed mainly for municipal and industrial use by water supply agencies.

It has been determined that wells producing a mixture of water from all three aquifers are producing a calcium-magnesium bicarbonate type of water, the same type derived from the Mehrten Formation where it is recharged by the American River.

Analyses of Water

The common chemical constituents generally reported in water analyses are the cations: calcium, magnesium, sodium, and potassium, and the anions: bicarbonate, carbonate, sulfate, and chloride. Colloidal constituents generally occur as silica, and iron and aluminum oxides. Lesser constituents, which are limiting factors in the usability of water for agricultural or domestic uses are boron, fluoride, and nitrate. A more thorough discussion of limiting constituents and water quality criteria are included in Appendix C of this report.

Mineral Analyses

The ground water throughout the area of investigation is of excellent quality. Table No. 10 presents the range of mineral constituents of 203 available mineral analyses of ground water throughout the area. These analyses are included in Table No. 9, located at the end of this report.

TABLE NO. 10

RANGE OF MINERAL CONSTITUENTS OF GROUND WATER

Mineral Constituents	Parts Per Million[1]		
	High	Low	Average
Calcium	63	6.2	21
Magnesium	36	0.5	11
Sodium	27	4.7	13
Potassium	7.3	0.0	1.9
Bicarbonate	322	38	122
Sulfate	35	0.0	6.9
Chloride	87	1.0	9.6
Nitrate	48	0.0	4.4
Fluoride	2.8	0.0	0.2
Boron	0.22	0.00	0.02
Silica	84	5.6	53
Hardness (total)	288	23	95
Total Dissolved Solids	405	73	178
EC x 10^6 (Mhos)	658	94	247
Percent Sodium	47%	5.0%	25%

[1] Except EC x 10^6 and Percent Sodium.

It should be noted that only one well (9N/7E-15M3) had a nitrate concentration which exceeded U. S. Public Health Service standards for drinking water. The limiting nitrate concentration for such water is

45 ppm. A concentration of 48 ppm was reported on the analyses collected on August 13, 1958, though samples taken previous to and after this sample had no concentration higher than 12 ppm.

Well No. 8N/6E-4K1 showed an increase from 26 ppm on December 18, 1961, to 39 ppm on January 10, 1963. Well No. 8N/6E-5K2 showed the concentration increasing from 16 ppm on June 12, 1955, to 20 ppm on September 19, 1958, and to 29 ppm on January 16, 1963. These two wells are located in an area devoted to intensive agriculture. These increases could be attributed to the nitrates applied as fertilizers, especially since both wells are rather shallow.

Some of the deeper wells that penetrate the Laguna and Mehrten Formations have been reported to have a hydrogen sulfide odor and iron problem. Well No. 8N/6E-14K1, one of the wells supplying the housing area of Mather Air Force Base, has been reported as giving off such odors. Analysis of the water from this well showed concentrations of 4.2 ppm of total iron on January 6, 1958, and 0.19 ppm on June 21, 1962. The Aerojet-General Corporation has also reported a similar problem in their Well No. 9N/7E-28K1.

Organic Analyses

Organic concentrations in ground water, in amounts measured in parts per billion, can cause taste and odor problems. Progress in understanding and evaluating organic contaminants is hampered by the difficulty of detecting these low concentrations and by identification of the complex varieties. Methods for concentrating, isolating and identifying these organic materials have been under study by the U. S. Public Health Service

at the Robert A. Taft Sanitary Engineering Center where, as a result of this study, the "Carbon Adsorption Method for Organics in Water," was perfected.

Tests have shown that activated carbon has unique adsorptive characteristics and can be used to recover organics from water and wastes. The organics can then be elutriated from the carbon by solvent extraction. Basically, the collection procedure is to pass a large amount of sample water at a slow rate through a column of activated carbon, with the objective of isolating all of the organic materials present by adsorption to the carbon. The carbon is then removed and dried and the adsorbed organics extracted with chloroform and ethanol. The chloroform extract may then be separated into fractions by means of differential solubility and chromatography.

The organics that are extractable by chloroform are usually man-made; whereas, the ethanol, or alcohol extractables usually occur naturally. Chloroform extractables are separated into ether insolubles, water insolubles, amines, strong acids, weak acids, and neutrals. Since the neutral fraction usually contains the most important taste and odor producing compounds, this fraction is further separated into aliphatic, aromatic, and oxygenated fractions by use of the column chromatograph.

The U. S. Public Health Service drinking water standards have set limits on the organic concentrations and recommend that chloroform extractables do not exceed 0.2 ppm.

Ten representative wells were selected during this investigation to establish present organic concentrations and provide data for future reference. Geologic factors, direction and movement of ground water, and expected life and availability of the well were considered in determining which wells to select as "representative."

The results of the analyses for organic concentrations of the waters from these wells are shown in Table No. 11. Infrared spectrographs of these samples are on file with the California Department of Public Health, and Department of Water Resources.

The data show that the greatest concentrations of the chloroform extractables appear in the phenol-indicating weak acids and the aliphatic (petroleum type hydrocarbons) fraction of the neutrals. This would indicate that the organic constituent could be oil; however, present knowledge of this analytical procedure has not developed to the point where this supposition can be confirmed.

Sources of Possible Impairment

Until recently the area of investigation was largely devoted to agriculture and the few industries located within the area were small. What few ground water quality problems might have existed were local and minor.

In the early 1950's the Aerojet-General Corporation purchased a plot of barren land littered with extensive dredger tailings. The land has now been developed as a site for an industrial complex devoted to the development and production of rocket engines. This development brought

with it many smaller, related industries and increased the demand for housing in the area. The resulting demand on the water supply has multiplied the wastes sufficiently to indicate the need for larger facilities and stricter control of disposal practices to prevent possible impairment of ground water quality.

Domestic Sewage

To meet the disposal needs of the domestic wastes of this growing area, four sewage disposal plants have been built thus far. All discharge their effluent to a watercourse that eventually returns either to the American or to the Sacramento River. Plate No. 10 outlines the areas served by these plants. Waste discharges outside these service areas, and some of the discharges within the service areas, are disposed of by direct discharge to land surface, cesspools, or septic tanks with leach lines.

Industrial Sewage

Industrial wastes are the largest source of possible impairment in the area. Whenever harmful industrial wastes are discharged into stream channels, the ground, or unlined sumps, they constitute a threat to the ground water in that area.

Sources of industrial wastes include the aerospace industry, liquid rocket fuel industry, solid rocket fuel industry, an oil refinery, an olive packing plant, a winery, and a tallow works. There is also a refuse disposal site in the area, the Sacramento County Dump, which could create noxious wastes by precipitation filtering down through accumulated layers of trash, tin cans, grass clippings, and other refuse.

Aerospace Industries. Two corporations in the area are directly involved in the aerospace industry, Aerojet-General Corporation and the Douglas Aircraft Company. The Aerojet-General Corporation, the larger of the two in area and number of employees, is involved in developing and assembling rocket engines and fuels.

Sources of wastes from the Aerojet-General Corporation facilities consist of wastes from 18,000 employees, and from the laboratories, processes, machine and assembly shops, clean-up water from solid propellant production lines, and deluge water used for cooling rocket test-firing pads.

Potential pollutants are removed by trapping and physical separation, or by treatment with neutralizing agents at the point of origin. The residual water is then collected in leaching basins, or ponds, where it is subjected to aeration before infiltration. Domestic wastes are conveyed through conventional water-borne sewage systems to activated-sludge disposal plants or to septic tanks in the outlying areas.

Certain compounds that may degrade ground waters or cannot be safely disposed of, such as ammonium and potassium perchlorate and contaminated trichlorethylene, are collected and sealed in approved containers and dumped at sea in an approved dumping area. During the course of this investigation a pilot operation was initiated to dispose of certain of these wastes by detonation and burning.

The Douglas Aircraft Company uses their facilities mainly for the testing of rocket engines. The only liquid waste from this process is the large amount of deluge water used for cooling purposes which can

pick up soluble products of combustion. This water is allowed to infiltrate to the ground water after ponding to allow oxidation of any contaminant to occur. The small amount of wastes generated by manufacturing processes is discharged to septic tanks. Domestic wastes, after passing through a catch basin to allow skimming of any solvent used, are diverted into the same septic tanks.

Liquid Rocket Fuel Industry - Liquid oxygen and liquid nitrogen are major constituents of the liquid fuel used as a rocket propellant. Both these liquids are manufactured by the Air Products and Chemicals Company on Folsom Boulevard near the Nimbus overpass. Water used to cool the compressors and refrigeration equipment used in the manufacturing process is treated with algicides and corrosion inhibitors. Oil from the machinery enters the water as it flows through a closed circuit which has a provision for the diversion of overflow water. The overflow water passes into a catch basin where the oil and solvents are trapped. The water then flows into a septic tank which also receives domestic wastes. The possibility of pollution from this source would be insignificant if it were not for the algicides and corrosion inhibitors in the wastes.

Solid Rocket Fuel Industry - The manufacture of solid rocket fuels usually creates highly toxic wastes which must be disposed of without injury to ground or surface waters. Several methods have been used for disposal of these wastes. Until recently the most effective (and costly) method was to store the wastes in large drums which were dumped into the ocean.

The natural gas and oil industries, however, had been pumping their toxic wastes into underlying saline and other unusable aquifers for many years. In 1961, the Aerojet-General Corporation requested permission from the Central Valley Regional Water Pollution Control Board to determine the feasibility of disposing of highly toxic wastes in a similar manner.

A pilot test hole was drilled to a depth of approximately 1,600 feet, where formation samples and water samples were obtained. Analysis of the samples confirmed the presence of confined formations that contained unusable connate water. Permission was then granted by the Regional Water Pollution Control Board for the design and construction of an injection well that would allow these wastes to be disposed of in these formations in such a manner as to obviate any possibility of mixing the wastes with usuable waters. The injection well has been in operation since 1963.

Reclaimed Oil Processing. The Brighton Oil Company, located at the intersection of White Rock Road and Kilgore Road, reprocesses used or waste oils consisting primarily of crank case drainage collected from service stations and industrial plants.

Cooling water makes up nearly the entire volume of waste water from this operation and is disposed of to a pond. A trap is used to skim off oils and solvents that might have entered the cooling waters.

Food Packing Plants. The only food packing plant within the area of investigation is owned by the Libby, McNeil, & Libby Company and is used exclusively for the curing of olives.

Waste products from this plant include brine, lye, and dilute sulfurous acid. This waste amounts to an annual discharge of approximately 175 tons of sodium chloride, 30 tons of sodium hydroxide and 18 tons of sulfur dioxide and lime. All wastes from this plant are discharged to dredger tailings bordering the American River.

For many years engineers were perplexed about the disposal of highly saline wastes from this source. It was anticipated that local ground water quality would be affected, yet chloride concentrations in wells down gradient from the plant showed no apparent increase. Upon review of data obtained in our surface water monitoring program it was noticed that an apparent betterment in quality existed in the American River between the Nimbus Dam sampling station and the downstream Fair Oaks Bridge station. Upon investigation it was found that the upstream station was adjacent to the left bank and a short distance downstream from the Libby, McNeil, and Libby Company's plant. Review of the data indicated that lateral seepage of the saline wastes may have increased mineral concentrations along the left bank and caused the high reading at this point.

A field check made in May of 1963 noted that wastes from the plant were ponding throughout the dredger tailings as far as one-half mile distant from the point of discharge. One pond, located within 500 feet of the American River, contained water with a conductivity of 2355 micromhos and a chloride concentration of 500 ppm.

Wineries. The Mills Winery, located on Folsom Boulevard between Bradshaw and Routier Road, is the only winery located within the area of investigation. Since 1959, the winery has restricted its operation to the aging and bottling of wines, importing the fermented juices from another winery where the crushing and initial fermentation has taken place. Wastes from this plant, consisting of domestic sewage and washdown water from the aging vats and bottling operations, are discharged to a septic tank with leach lines.

Tallow Works. The Sacramento Reduction and Tallow Works, located on Kiefer Boulevard (formerly Middle Jackson Road) between Eagle Nest Road and Connor Road, produces over 180 tons of tallow per month. Wastes from this plant consist of boiler blowdown water and rendering vat wash water, which are disposed of to seepage ponds. Domestic wastes are discharged to septic tanks.

Refuse Disposal Sites

The County of Sacramento maintains a refuse disposal site at the intersection of White Rock Road and Grant Line Road on land that had been previously worked by dredgers. It is a Class II dump,[1/] which accepts all types of trash, and a special area has been set aside for the disposal of cleanings from cesspools and septic tanks. The liquid and solid refuse dumped contains mineral and organic substances in quantities capable of seriously damaging ground water. Aerobic and anaerobic

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1/ Standards for Dumps, California Department of Water Resources

decomposition of the organic matter produces large volumes of carbon dioxide and methane gas. Carbon dioxide dissolves calcium, manganese, iron, and other substances which, in high concentrations, are undesirable in water.

Abandoned Wells

Improperly constructed, defective, or abandoned wells could be a factor in the degradation, pollution, or contamination of the usable ground waters if they permitted surface waters, or the leachate from septic tanks or cesspools, to percolate into the ground water reservoir.

Wells were originally drilled in the area where they would be convenient for both irrigation and domestic purposes. These older wells had to supply large amounts of water. They were therefore drilled deep enough to penetrate a number of water-bearing strata. The casings were usually large enough to allow installation of a large irrigation pump as well as a smaller domestic pump. Even though agriculture might since have ceased and the irrigation pumps left to rust, the domestic pumps usually were kept in operation. A number of wells which otherwise would have been abandoned have been kept in operation for domestic uses.

The usual reason given for abandoning a well is that the water table has dropped and the well no longer produces. The casing may have deteriorated to a point where it is no longer safe to place pumping equipment in the well, or the existing casing may be too small to allow installation of the size of pump desired. In a few cases, wells that were drilled for a particular industry have been abandoned after the industry ceased to exist.

In the eastern area of investigation, some hand-dug, brick-lined wells have been abandoned because they penetrate formations which no longer contain water. One of these, located in T8N, R7E, Sec. 22K, is five feet in diameter and 131 feet deep.

For the purposes of this report, those wells which have had their pumping equipment removed, or are obviously unusable, have been classified as abandoned and are listed in Table No. 5.

Naturally Occurring Impaired Water

Ground water of good quality can become degraded or impaired by natural sources as well as from industrial, agricultural, and domestic wastes.

Though the readily accessible ground waters within the area of investigation are of excellent mineral quality, deeper formations contain highly mineralized waters. These poorer quality waters are not necessarily adjacent to the better quality water, but may be separated by one or more other formations.

As an example, the Mehrten Formation, which contains water of excellent quality is underlain by the impermeable formation called the Valley Springs, or Ione Formation. This formation is composed of silts and clays about 500 feet thick. Below the Ione Formation lie formations of Cretaceous Age, which contain poor quality (highly mineralized) waters. Nature has effectively separated these two aquifers, but poorly constructed deep wells could allow the waters to comingle, degrading the good water in the Mehrten Formation.

As discussed under the heading "Solid Rocket Fuel Industry," the deep formations are being used to receive highly toxic wastes injected by the Aerojet-General Corporation. Table No. 12 presents the analysis of one such mineralized water taken from Well No. 9N/7E-32D1 which was developed as a test hole to determine the feasibility of waste injection into deep underlying formations.

TABLE NO. 12

QUALITY OF WATER AT 1,000 FEET [1]

Well No. 9N/7E-32D1

Cations	ppm	Other Characteristics	
Calcium	74	Caustic alkalinity	208 ppm
Magnesium	0	Total alkalinity	236 ppm
Sodium	268	Hardness as $CaCO_3$	200 ppm
Potassium	3	Total dissolved solids	952 ppm
Anions		Percent sodium	80 %
Chloride	410	pH	11.1
Sulfate	2.6		
Nitrate	0.3		
Boron	6.0 + (Lab scale of 4.0 exceeded)		

[1] This water is beyond the limits recommended by the U. S. Public Health Service drinking water standards for total dissolved solids and chlorides, and falls in Class III irrigation water because of the boron and chloride concentration and the percent sodium.

Monitoring Program

The Department of Water Resources is authorized by Section 229 of the California Water Code to investigate the quality of all waters within the State in relation to all sources of pollution and report to the Legislature and to the appropriate Regional Water Pollution Control Board any recommendations or steps which might be taken to improve or protect the quality of these waters.

To carry out the objectives of the section of the Code, a program was established in the summer of 1951 to provide information on the prevailing mineral quality of waters throughout the State. An intensive, continuing check of water quality to detect any significant changes and ascertain the area affected by such changes was also incorporated into this investigative program.

Surface Water

There is only one surface water quality monitoring station within the area of investigation, located on the American River below Nimbus Dam. Samples are collected monthly and analyzed for alkalinity, boron, chloride, conductance, dissolved oxygen, hardness, pH, sodium, and turbidity. Complete mineral, heavy metal, and radiological analyses are made on samples collected during the months of May and September. Samples are also collected quarterly from Morrison Creek below Mather Air Force Base and analyzed for radiological activity. Table No. 13 includes the latest available analyses for surface water within the area of investigation.

Ground Water

The ground water quality monitoring program has concentrated on those wells in the vicinity of the Aerojet-General Corporation plant. When the program began in 1953, 14 wells were monitored. These were sampled annually and analyzed for the standard mineral constituents and for ammonium and perchlorate concentrations. Only five wells are now monitored and analyzed for the same constituents. It is felt that this number of wells provides a network intensive enough to detect any significant, sudden change in the quality of ground waters within the area of investigation. The following tabulation lists the wells now being monitored.

Well No.	Owner	Years of Sampling Record	Analyses
9N/7E-21D1	Air Products and Chemicals, Incorporated	1958-63	Standard Mineral - Ammonium-Perchlorates
9N/7E-26H1	Capitol Dredging	1953-63	Standard Mineral - Ammonium-Perchlorates
9N/7E-28K1	Aerojet-General Corporation	1956-63	Standard Mineral - Ammonium-Perchlorates
9N/7E-32B1	J. A. Rodgers	1955-63	Standard Mineral - Ammonium-Perchlorates
9N/7E-33E1	Ben Petrucci	1955-63	Standard Mineral - Ammonium-Perchlorates

Analyses of water from these and other wells monitored appear in Table No. 14.

Waste Water

The present waste water monitoring program includes annual sampling of those plants discharging more than 0.5 MGD. This involves only three plants within the area of investigation which are listed in the following tabulation.

Plant	Treatment	Design Capacity MGD	Effluent Disposal Point
Cordova S.M.D.	Secondary	4.0	American River
Manlove S.M.D.	Secondary	1.25	Morrison Creek
Mather Air Force Base	Secondary	1.5	Morrison Creek

Samples from the three waste discharge plants are now being analysed periodically for mineral constituents. 1/ Those collected from Mather Air Force Base are occasionally analyzed for mineral constituents, for heavy metals, and gross radioactivity. Analyses of samples collected from these plants are included in Table No. 14.

In addition to the monitoring program conducted by the Department of Water Resources, the Central Valley Regional Water Pollution Control Board (No. 5) has adopted waste discharge requirements for the Aerojet-General Corporation, Libby, McNeil and Libby Company, and Mather

1/ Mineral constituents analyzed for are Ca, Mg, Na, K, SO_4, Cl, NO_3, B, as well as NH_4, PO_4, and ABS.

Air Force Base. One of the requirements is that a ground water sampling program be maintained to determine any degradation that might occur from waste discharges.

The samples are collected periodically and analyzed for constituents associated with the type of discharge. The analyses are submitted to the Central Valley Regional Water Pollution Control Board (No. 5).

CHAPTER V. RECOMMENDATIONS

The department finds that water pumped within the area of investigation is satisfactory for all beneficial uses, and that its quality is unaffected by present waste disposal practices. Ground water monitoring programs, both those conducted by the department and those conducted for the Water Pollution Control Board by waste dischargers within the area, will continue. The department recommends that future water quality measurements from the area be compared with those cited in this report to enable detection of any degradation in ground water quality which may result from increased waste discharges.

TABLE 5

WELL DATA

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E- 2N1	South of U. S. 50 on Mather Field Dr. to Mather Air Force Base, Base Well #3.	Mather Air Force Base	1941	Mun.	90	12	531		X		X
8N/6E- 2P1	South of Folsom Blvd. on Mather Field Dr. to Mather Air Force Base, Base Well #4.	Mather Air Force Base		Mun.	95	12					X
8N/6E- 3N1	South side of Winchester Way in Cordova Town, south of of Folsom Blvd.	Citizens Suburban Co.	1956	Mun.	85	20" 72 14" 166 12" 377	377	250-262 278-306 310-326 330-372 [c]	X	X	X
8N/6E- 3N2	0.95 mile south of Folsom Blvd. on Mather Field Dr. northeast of apartment building complex - east of swim-pool in shed.	James Selinger	1957	Dom.		12	445	0-138	X	X	X
8N/6E- 3N3	0.9 mile south of Folsom Blvd. on Mather Field Dr., 0.15 mile east on Rockingham Dr., fence enclosure 50 feet south of road.	Citizens Suburban Co.		Mun.	91	14	500		X	X	X
8N/6E- 3N4	0.3 mile north of Mather AFB main gate on Mather Field Dr. - well in carwash building east of road.	James Selinger	1959	Ind.	90	10	864		X		
8N/6E- 3N5	0.95 mile south of Folsom Blvd. on Mather Field Dr. - northeast of apartment building complex - east of swim-pool in shed.	James Selinger	1959	Dom.	89	12	380		X		
8N/6E- 3N6	0.3 mile north of Mayhew Church on Routiere Rd., 0.3 mile east of house, pumphouse 30 feet northwest of house.	Dain Domich		Irr.	86	10				X	
8N/6E- 3N7	0.75 mile south of Folsom Blvd. on Routiere Rd. & 600 feet east of Routiere Road.	Citizens Suburban Co.		Dom.	80					X	
8N/6E- 3N8	500 feet north of Mather Air Force Base main gate on Mather Field Dr., well behind Hancock Service Station.	Hancock Oil Co.	1954	Ind.	90	10	98		X		
8N/6E- 4A1	220 feet south of Folsom Blvd. and 100 feet west of Routiere Rd. in pumphouse 6 feet east of house.	Orangevale Glass Co.	1958	Dom.	74	10" 180 14" 56	850				X
8N/6E- 4A2	500 feet south of Folsom Blvd. and 300 feet west of Routiere Rd. in clothes line area next to swim-pool.	R. E. Frost	1958	Dom.	71	10" 180	800		X	X	X
8N/6E- 4A3	250 feet south of Folsom Blvd. and 100 feet east of Routiere Rd. behind old winery (Van & Storage now).	L. P. Noonan	1947	Dom.	73	12	125			X	
8N/6E- 4A4	0.9 mile east of Hazeldene Rd. and 200 feet west of Mather Auto Movie Entrance on Folsom Blvd., 35 feet north of U. S. 50	Bartolini & Rachot		Dom.	71		67.5			X	
8N/6E- 4C1	0.3 mile west of Routiere Rd. on Folsom Blvd., 150 feet south of Folsom Blvd. (near Routiere Station - Rancho Realty).	Manuel Souza		Dom.	70					X	
8N/6E- 4H2	500 feet west of Routiere on Folsom Blvd., 0.2 mile south on drive, 100 feet north of house and north of water tower.	John Horn	1948	Dom.	75	12	141		X		

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Lvs)

b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E- 4N2	0.4 mile west of Routiers Rd. and 0.3 mile south of Folsom Blvd., well 20 feet south of house.	C. A. Mohl		Dom.	72	10	140			X	X
8N/6E- 4L6	0.55 mile east of Bradshaw Rd. on Folsom Blvd., 300 feet south of road and 25 feet southwest of building.	Paul Kershaw	1947	Ind.	67	12	162		X		
8N/6E- 4M1	0.25 mile east of Bradshaw Rd. and 200 feet south of Folsom Blvd., in garage.	Helen B. Osheaver		Aband.	65	12	100			X	
8N/6E- 4N2	200 feet east of intersection of Bradshaw Rd. and Folsom Blvd., northwest of Great Orange Dyard north side of hwy.	Jim Gore	1956	Dom.	63	10			X		
8N/6E- 4N3	0.25 mile east of Bradshaw Rd and 300 feet south of Folsom Blvd., 20 feet south of garage.	Helen B. Osheaver	1956	Dom.	65	12	145		X		
8N/6E- 5N1	0.4 mile north of Folsom Blvd. on Bradshaw Rd. and 75 feet north of road where road turns west.	A. Hanke		Dom.	66	12	110			X	
8N/6E- 5N3	200 feet north of intersection of Bradshaw Rd. and Folsom Blvd., 200 feet west of Bradshaw Rd. on north side of shed.	Koni Tomeo	1951	Dom.	62	12	143		X		
8N/6E- 5N4	0.5 mile west of Bradshaw Rd. and 0.4 mile north of Folsom Blvd.	Catholic Church		Aband.	62		70			X	
8N/6E- 5N2	0.5 mile west of Bradshaw Rd. on Folsom Blvd., 0.15 mile north and 0.15 east and 0.1 mile north on drive, well northwest of house.	Joe Saiki	1954	Irr. & Dom.	60		180				X
8N/6E- 5N4	0.5 mile west of Bradshaw Rd. on Folsom Blvd., 0.15 mile north, 0.15 mile east and 0.3 mile north on drive to pump-house in field.			Irr.	65		78			X	
8N/6E- 5L1	0.6 mile west of Bradshaw Rd. on Folsom Blvd., 0.25 mile north on drive to corrugated metal pumphouse.			Irr.	58					X	
8N/6E- 5N1	0.3 mile north of intersection of Mayhew Rd. and Folsom Blvd. Well northeast of house.	Kumamoto	1950	Dom. & Irr.	58	12				X	
8N/6E- 5Q8	0.45 mile west of Bradshaw Rd. on Folsom Blvd., 175 feet north on drive, well north of shed, west of drive.	Lee Wright Casa Linda Motel		Dom.	58		80			X	
8N/6E- 5Q10	0.45 mile west of Bradshaw Rd. on Folsom Blvd., 300 feet north on drive, well west of drive.	M Billman		Dom.	58		73			X	
8N/6E- 5N1	500 feet south of Folsom Blvd. on Bradshaw Rd., 850 feet east of road and 6 feet east of shed.	Jim Gore	1956	Dom.	61	10	146		X		
8N/6E- 5N6	0.8 mile west of Bradshaw Rd. on Folsom Blvd., 125 feet north on drive, well 50 feet north of house.	Mrs. J. P. Didion	1954	Dom.	60	10	127		X	X	
8N/6E- 5N7	30 feet northwest of house at northwest corner of Bradshaw Rd. and Folsom Blvd.	Mrs. J. P. Didion		Dom.	59		110			X	
8N/6E- 5N8	250 feet south of Folsom Blvd. on Bradshaw Rd., 100 feet east of Bradshaw Rd. in yard.	Southern Pacific Pipeline		Dom.	63					X	

[a] Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

[b] U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E- 5N9	800 feet north of Folsom Blvd. on Bradshaw Rd. to drive, well in orchard south of house.	Knai Tumno		Irr.	60					X	
8N/6E- 7G1	0.5 mile west of Hayhew Rd. on Folsom Blvd., 250 feet north on drive, 125 feet east of house.	Ruth Coleman		Dom.	55					X	
8N/6E- 7K1	0.85 mile west of Hayhew Rd. on Folsom Blvd., 35 feet south of railroad tracks in metal pumphouse.	Beltrein Brothers		Irr.	55					X	
8N/6E- 7K1	0.5 mile east of Manlove Rd. on Folsom Blvd. to drive, well 1000 feet east of drive by power line.	Levie Coleman	1958	Irr.	52	12	174		X	X	
8N/6E- 7K2	0.35 mile east of Manlove Rd. on Folsom Blvd. to drive, 475 feet north of Folsom Blvd.	J. D. Duenhoser		Irr.	49					X	
8N/6E- 7K2	0.1 mile east of Manlove Rd. on Folsom Blvd. to drive, well 15 feet northeast of building.	M. Ball		Irr.	46		130			X	
8N/6E- 7K3	1000 feet east of house, house 300 feet east of Manlove Rd. and south of Folsom Blvd.			Dom. & Irr.	48					X	
8N/6E- 7P2	0.6 mile east of Manlove Rd. on Folsom Blvd. to drive, well south of old tank house.	Ruth Coleman		Irr.	52				X		
8N/6E- 8A1	0.3 mile south of Folsom Blvd. on Bradshaw Rd., 250 feet west on drive, well in center of circular drive.	Miller		Irr. & Dom.	64		104			X	
8N/6E- 8A1	0.96 mile west of Bradshaw Rd. on Folsom Blvd., 265 feet south of Folsom Blvd. at southwest corner of shed.	Bob Ichimto		Dom.	60	10				X	
8N/6E- 8C1	0.15 mile east of Manlove Rd. on Folsom Blvd. to drive, north on drive, well north of tin shed.	Robert Scholz		Irr.	59					X	
8N/6E- 8N2	800 feet north of Folsom Blvd. on Hayhew Rd., 70 feet east on drive, well 30 feet south of drive.	T. J. Niederost		Dom.	57	10				X	
8N/6E- 8N2	0.1 mile south of Folsom Blvd. on Hayhew Rd. to drive, west on drive to well west of water tank.	Beltrein Brothers	1950	Dom. & Irr.	57					X	
8N/6E- 8P1	0.15 mile south of Folsom Blvd. on Hayhew Rd., 360 feet east of road in old shed.	Beltrein Brothers	1950	Irr.	58	12	122		X	X	
8N/6E- 8P4	0.3 mile west of Bradshaw Rd. on Folsom Blvd., 0.3 mile south on private road, 600 feet east in field.	Sam Ichimto		Irr.	60		120			X	
8N/6E- 8P4	0.3 mile south of Folsom Blvd. on Bradshaw Rd., well in garage west of road.	J. F. Kennedy	1946	Irr. & Dom.	55	8	84		X		
8N/6E- 8P9	0.6 mile south of Folsom Blvd. on Bradshaw Rd., west of buildings by pressure tank.	Chet Scudder	1956	Dom. & Irr.	57	10	117		X		X
8N/6E- 8R7	South of Hilly School on Bradshaw Rd. in first garage west of road.	D. Cordano		Dom.	62		173			X	

[a] Domestic (Dom.), Municipal (Mun.), Irrigation (Irr.), Industrial (Ind.), and Livestock (Stk)

[b] U.S. Geological Survey datum (feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E- 8J8	0.15 mile north of Old Placerville Rd. on Bradshaw Rd., in garage 150 feet west of road.	Stanley Beyer	1950	Dom.	64		75			X	
8N/6E- 8K1	0.75 mile south of Folsom Blvd. on Bradshaw Rd. to drive, 0.3 mile west on drive to well in shed.	Mikael Cordano		Aband.	60					X	
8N/6E- 8M1	0.85 mile south of Folsom Blvd. on Mayhew Rd., 350 feet west on drive, 160 feet south of drive in orchard.	Beltrain Brothers		Irr.	56					X	
8N/6E- 8P2	0.1 mile north of Goethe on Mayhew Rd., 150 feet west of road in shed.	William Young		Irr.	56	12	84			X	
8N/6E- 8R1	0.1 mile west of Bradshaw Rd. on Goethe Rd., 20 feet north of road at edge of orchard.	Bader Realty		Irr.	70					X	
8N/6E- 9M1	120 feet northwest on the northwest corner of Saturn Dr. and Vanguard Dr.	Lynn Hanson	1954	Irr.	73	12	125			X	
8N/6E- 9N2	South of General A. M. Winn School on Explorer Dr. in Lincoln Village, fence enclosure	Citizens Suburban Co.	1959	Mun.	70	14	434		X	X	X
8N/6E- 9N1	0.2 mile east of Bradshaw Rd. on Old Placerville Rd., 300 feet north of road and 75 feet east of garage.	H. O. Brugger	1958	Dom.	70	10	145		X		
8N/6E- 9P3	0.35 mile east of Bradshaw Rd. on Old Placerville Rd., well east of drive and 75 feet north of road.	W. F. Noble	1961	Dom.	74	12	150			X	X
8N/6E- 9Q2	0.55 mile east of Bradshaw Rd. on Old Placerville Rd., 100 feet north of road, east of house behind tank tower.	J. B. Robinson		Dom.	76					X	
8N/6E- 9Q3	0.65 mile east of Bradshaw Rd. on Old Placerville Rd., 150 feet south of road behind water tower - pumphouse.	Tom Tokoi	1939	Dom. & Irr.	75	12	175			X	
8N/6E- 9R2	0.85 mile south of intersection of Routiere Rd. and Old Placerville Rd., 30 feet south of house.	Dave Northrop	1946	Dom.	77	12	130			X	
8N/6E-10D1	0.5 mile north of Old Placerville Rd. on Routiere Rd., pumphouse behind Mayhew Baptist Church, 600 feet east of road.	R. Gator	1959	Dom. & Irr.	80	12	180			X	
8N/6E-11C1	South of Folsom Blvd. on Mather Drive to Mather Air Force Base, Building #3975, Base Well #1	Mather Air Force Base	1949	Mun.	90	12	530		X	X	X
8N/6E-11C2	South of Folsom Blvd. on Mather Drive to Mather Air Force Base, Building #3975, Base Well #2	Mather Air Force Base	1941	Mun.	92	12	584		X	X	X
8N/6E-13R1	AG & W Well	Mather Air Force Base	1950	Mun.	133	10	850		X		X
8N/6E-13R2	Wherry #3	Mather Air Force Base		Mun.	123	12	500			X	X
8N/6E-13P1	Wherry #5	Mather Air Force Base	1951	Mun.	123	12	400		X	X	X
8N/6E-14J1	Wherry #1	Mather Air Force Base	1951	Mun.	112	12	500		X	X	X
8N/6E-14K1	Wherry #2	Mather Air Force Base	1951	Mun.	104	12	400		X		X

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E-14N1	Cherry Pk.	Mather Air Force Base	1951	Dom.	117	12	500		X	X	X
8N/6E-15P1	0.7 mile east of Happy Lane on Kieffer Blvd., 700 feet east of road behind hot plant and 75 feet east of wash plant.	McGillivray Const. Co.		Aband.	73	12	825			X	
8N/6E-15Q1	0.9 mile west of Excelsior Rd. on Kieffer Blvd., 1500 feet north of road and 250 feet west of fenceline	McGillivray Const. Co.		Aband.	71					X	
8N/6E-16B1	0.45 mile south of Old Placerville Rd. on Happy Lane, 100 feet west of road and 85 feet northeast of house.	C. E. Reed	1951	Dom.	77	10	97		X	X	
8N/6E-16B2	0.35 mile south of Old Placerville Rd. on Happy Lane, 150 feet east of road and 15 feet south of barn.	Fred Matsumoto		Dom. & Irr.	78	12				X	
8N/6E-16B3	0.55 mile south of Old Placerville Rd. on Happy Lane, 150 feet east of road in pumphouse	T. Furuike	1948	Dom. & Irr.	76	12	95			X	
8N/6E-16B4	0.4 mile south of Old Placerville Rd. on Happy Lane, 175 feet west of road in pumphouse.	L. Matsumoto	1948	Dom. & Irr.	77	12	110			X	
8N/6E-16B5	0.65 mile south of Old Placerville Rd. on Happy Lane, 600 west of road and 15 feet south of fenceline.	T. Tanaka	1947	Dom. & Irr.	75	12	92			X	
8N/6E-16D3	0.8 mile south of Old Placerville Rd. on Happy Lane, 300 feet west of road and 50 feet south of driveway.	Tod Kubota	1956	Irr.	73		145		X	X	X
8N/6E-16D1	0.8 mile north of Kieffer Blvd. on Bradshaw Rd., 500 feet east of road and 30 feet north of drive.	M. Hashimoto	1951	Dom. & Irr.	72	12	160			X	
8N/6E-16E1	0.1 mile east of Bradshaw Rd. on Kieffer Blvd., 800 feet south of road near storage tank	J. E. Fairbairn		Dom. & Irr.	71					X	
8N/6E-16Q1	0.5 mile east of Bradshaw Rd. on Kieffer Blvd., 150 feet south of road and 40 feet west of drive.	Jack Kusumura	1939	Dom. & Irr.	71	12	280			X	
8N/6E-16Q2	0.5 mile east of Bradshaw Rd. on Kieffer Blvd., 800 feet north of road in tin pumphouse.	Roy S. Kusumura	1937	Dom. & Irr.	70	12	300			X	
8N/6E-16R1	0.15 mile north of Kieffer Blvd. on Happy Lane, 400 feet east of Happy Lane and 100 feet west of Service Rd.	Mather Air Force Base		Aband.	73	12	801			X	
8N/6E-16R2	Mather Engine Test Area at southwest end of runway, in northeast corner of building south of water tank.	Mather Air Force Base	1961	Dom. & Ind.	70		89		X		X
8N/6E-17A1	0.8 mile west of Bradshaw Rd. on Goethe Rd., 300 feet south of road through yard in field.	C. E. Kersey		Dom.	71	12	150			X	
8N/6E-17B1	0.1 mile east of Mayhew Rd. on Goethe Rd., 60 feet southeast of house which is 50 feet south of road.	W. Uplander	1959	Dom.	55	10	184		X		X
8N/6E-17B2	0.85 mile south of Goethe Rd. on Mayhew Rd., 50 feet east of house on east side of road in shed.	W. W. Healy	1933	Dom.	69	10	130		X		
8N/6E-17B3	0.8 mile east of Mayhew Rd. on Goethe Rd., 40 feet east of house on south side of road.	H. K. Uring	1958	Dom.	63		84			X	

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 6 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E-17Q1	0.15 mile south of Gootke Rd. on Nyhow Rd., 45 feet west of house which is 250 feet west of road.	Ted Kobata	1957	Irr.	57	10	160			X	
8N/6E-17R2	0.5 mile west of Nyhow Rd. on Kieffer Blvd., north of garage on north side of road.	Percy Brown	1958	Dom.	62	6	98		X		
8N/6E-17R5	0.5 mile west of Nyhow Rd. on Kieffer Blvd., well north of house on north side of road.	Leyde E. Slatter	1961	Dom.	62	6	104		X		X
8N/6E-17R6	0.45 mile west of Nyhow Rd. on Kieffer Blvd., 600 feet north through orchard to house, in shed northeast of house.	V. Bainbire		Dom.	68		161			X	
8N/6E-17P1	0.3 mile south of Gootke Rd. on Nyhow Rd., 400 feet west at northeast corner of garage.	H. J. Fairbairn	1956	Dom.	67		138		X		
8N/6E-17R1	Northeast corner of Kieffer Blvd. and Bradshaw Rd.	Sacramento County	1962	Mun.	73	12	310		X	X	
8N/6E-17Q1	0.2 mile west of Bradshaw Rd. on Kieffer Blvd., 800 feet south to house and 50 feet south to tank house.	Masami Iwase		Dom. & Irr.	78	12	116			X	
8N/6E-17J3	0.25 mile west of Bradshaw Rd. on Kieffer Blvd., 150 feet south of road at southwest corner of garage.	M. Ogye	1959	Dom.	76	8	175		X		X
8N/6E-18B1	South of U.S. 50 on Manlove Rd. to Sutter's Gold Dr., east to Tunge St., fence enclosure at northwest corner.	Citizens Suburban Co.	1955	Mun.	90	12	268		X		X
8N/6E-18P1	Rossmont Subdivision south of Folsom Blvd. on Manlove Rd. Fence enclosure on Montezuma Way.	Citizens Suburban Co.	1959	Mun.	90	14	378		X		X
8N/6E-18J1	0.45 mile west of Nyhow Rd. on Kieffer Blvd., 70 feet south on drive to pumphouse.	T. Matsumoto	1961	Dom. & Irr.	63	8	170		X		
8N/6E-18J3	0.6 mile west of Nyhow Rd. on Kieffer Blvd., south on drive, well in loop of drive.	M. R. Hernandez	1938	Dom.	62	8	78			X	
8N/6E-18R2	50 feet west of Southport Dr. on Kieffer Blvd., 0.1 mile south on private drive, well west side of drive.	C. A. Williamson		Irr.	54					X	
8N/6E-18N1	160 feet south of Kieffer Blvd. on Manlove Rd., 30 feet east of road.	Lauer		Abnd.	53		76			X	
8N/6E-18N2	0.15 mile east of Manlove Rd. on Kieffer Blvd., 0.20 mile south on private drive, 160 feet east of drive.	Pauline Oates		Irr.	55	12	182			X	
8N/6E-18N1	0.25 mile east of Manlove Rd. on Jackson Rd., 0.1 mile north of road in field.	W. T. Pierson		Irr. & Stk.	55	12	259		X	X	X
8N/6E-18P1	50 feet west of Southport Dr. on Kieffer Blvd., 0.35 mile south on private drive, south of house on drive.	C. A. Williamson	1960	Dom. & Irr.	58		201			X	
8N/6E-19Q1	0.1 mile east of Hedge Ave. on Jackson Rd., 300 feet north on drive, pumphouse 65 feet east of house.	T. Tsumoto		Dom. & Irr.	58		240			X	
8N/6E-19Q2	0.1 mile east of Hedge Ave. on Jackson Rd., pumphouse 150 feet north of road and 40 feet east of drive.	Sam Kono	1953	Dom.	60	10	116		X	X	

[a] Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

[b] U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E-19B3	0.1 mile east of Hedge Ave. on Jackson Rd., 350 feet north of road and at the northeast corner of shed.	Sam Kono	1955	Aband.	60	10	151		X	X	
8N/6E-19B4	0.1 mile east of Hedge Ave. on Jackson Rd., 350 feet north of road and at the northeast corner of shed.	Sam Kono	1961	Irr.	61	12	240		X		X
8N/6E-19C2	0.88 mile east of Nanlove Rd. on Jackson Rd., 500 feet south of road, 50 feet south of garage.	H. H. O'Hara	1951	Dom.	54		190			X	
8N/6E-19D1	0.85 mile east of Nanlove Rd. on Jackson Rd., 0.85 mile south on dirt road, pumphouse west side of road.	W. T. Pierson		Irr.	55					X	
8N/6E-19F1	0.85 mile south of Jackson Rd. on Hedge Ave., 150 feet west of road and 100 feet north of drive.	William J. Franklin, Sr	1955	Dom.	57	10	144		X	X	
8N/6E-19G1	800 feet south of Jackson Rd. on Hedge Ave., house 200 feet east of road, well 50 feet southwest of house.	William B. Easton	1955	Dom.	57	12	156		X		
8N/6E-19G2	0.2 mile east of Hedge Ave. on Jackson Rd., 350 feet south of road, pumphouse east of fenceline.	M. Shiro	1959	Irr.	57	12	225		X		
8N/6E-19H2	0.55 mile east of Hedge Ave. on Jackson Rd., house 150 feet south of road and well 150 feet south of house.	F. J. Shiro	1959	Dom.	62	10	110		X		
8N/6E-19K3	0.45 mile east of Hedge Ave. on Jackson Rd., 250 feet south of road and south of house.	Sam DeGregorio	1959	Dom.	61	8	123		X	X	
8N/6E-19L1	0.43 mile south of Jackson Rd. on Hedge Ave., 20 feet west of house on west side of road.	A. G. Vanderboom	1955	Irr.	58	10	187		X	X	
8N/6E-19L2	0.43 mile south of Jackson Rd. on Hedge Ave., 12 feet southeast of garage on west side of road.	A. G. Vanderboom		Dom.	58	8				X	
8N/6E-19P1	0.35 mile south of Jackson Rd. on Hedge Ave., 40 feet west of road and south of drive.	Gunter and Farris		Dom.	58		80			X	
8N/6E-19P2	200 feet north of Fruitridge Rd. on Hedge Ave., 70 feet west of road on south side of house.	T. H. Endaya	1957	Dom.	56		244		X	X	
8N/6E-19P5	850 feet north of Fruitridge Rd. on Hedge Ave., 530 feet west on dirt road, north of dirt road and 200 feet east of house.	J. Seehont	1956	Dom. & Irr.	50	8	148		X		
8N/6E-19Q1	400 feet north of Fruitridge Rd. on Hedge Ave., pumphouse northeast of Sierra Enterprise School and east of road.	Elk Grove Unified School District	1955	Dom.	55	12	310		X		
8N/6E-19Q2	1200 feet east of Hedge Ave. on Fruitridge Rd., pumphouse 500 feet north of road in field.	T. H. Endaya		Irr.	58					X	
8N/6E-19R1	0.5 mile east of Hedge Ave. on Fruitridge Rd., 200 feet north of Fruitridge Rd. and 50 feet west of private road.	Leon Bryant	1960	Dom.	56	10	135		X	X	
8N/6E-20D1	0.6 mile east of Hedge Ave. on Jackson Rd., 0.2 mile north on drive, 300 feet northeast of office building and west of plant.	United Concrete Pipe	1960	Ind.	63	12	853			X	

[a] Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

[b] U.S. Geological Survey datum (feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM – EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E-20D2	0.7 mile east of Hedge Ave. on Jackson Rd., 0.2 mile north on drive, south of parking lot.	E. P. Garcia		Dom.	65		268			X	
8N/6E-20E2	0.55 mile east of Hedge Ave. on Jackson Rd., 220 feet south on drive, 75 feet east of drive.	L. E. Ruth	1956	Dom.	62	10	115		X		
8N/6E-20E5	0.3 mile west of Mayhew Rd. on Jackson Rd., house north of road, 40 feet west and 35 feet north of house.	W. M. Kashivagi	1952	Dom.	63	8	132			X	
8N/6E-20F1	0.85 mile west of Mayhew Rd. on Jackson Rd., house north of road, pumphouse 30 feet north of house.	Y. Kashivagi		Aband.	63		80			X	
8N/6E-20F3	0.9 mile east of Hedge Ave. on Jackson Rd., 650 feet north of road in field, east of fenceline.	Van Cook Estate		Irr.	66					X	
8N/6E-20F6	0.3 mile north of Jackson Rd. on Mayhew Rd., 200 feet southwest of house on west side of road.	LaMame	1955	Dom.	61	12	144		X		
8N/6E-20H1	0.35 mile north of Jackson Rd. on Bradshaw Rd., 210 feet west of road and 30 feet southwest of house.	J. H. Fairbairn		Irr.	69					X	
8N/6E-20H2	0.6 mile east of Hedge Ave. on Jackson Rd., 600 feet north of road and 225 feet north of house.	Nils Olson	1959	Dom.	63	10	150		X		
8N/6E-20J3	400 feet north of Jackson Rd. on Bradshaw Rd., 150 feet west of house on west side of road in a shed.	L. Magnussen		Dom. & Irr.	65	12	90			X	
8N/6E-20J5	0.1 mile west of Bradshaw Rd. on Jackson Rd., 50 feet south on drive and 50 feet east of drive in pumphouse.	E. P. Morgan	1959	Dom.	63	12	110		X		
8N/6E-20K1	0.4 mile west of Mayhew Rd. on Jackson Rd., 800 feet south of road, well on west side of old tank house.	K. Kunitake	1959	Irr.	64	12	232		X	X	
8N/6E-20M1	0.3 mile west of Mayhew Rd. on Fruitridge Rd., 700 feet north of paved road, 50 feet west of house, 75 feet west of road.	King	1961	Dom.	60		125			X	
8N/6E-20M2	0.3 mile west of Mayhew Rd. on Fruitridge Rd., 700 feet north on paved road, pumphouse east of house east side of road.	William Newton	1959	Dom.	60	10	205		X	X	
8N/6E-20N4	0.62 mile east of Hedge Ave. on Fruitridge Rd., pumphouse 60 feet north of house on north side of road.	J. Sherudovani	1959	Dom.	55	10	130		X		
8N/6E-20N1	0.32 mile south of Jackson Rd. on Bradshaw Rd., 180 feet west of road and 40 feet northwest of house.	McDaniel	1953	Dom.	58	10	94		X	X	
8N/6E-21C1	0.4 mile south of Kieffer Blvd. on Bradshaw Rd., 0.4 mile east, 350 feet north to pumphouse.	J. Kawamura	1926	Dom. & Irr.	71	12	350			X	
8N/6E-21C2	0.4 mile south of Kieffer Blvd. on Bradshaw Rd., 0.4 mile east, 600 feet south to pumphouse.	G. Bobo		Dom. & Irr.	68	12	170			X	
8N/6E-21F1	0.5 mile south of Kieffer Blvd., 0.36 mile east of road, pumphouse 40 feet south of house.	M. M. Tokuhara		Irr.	70	12				X	

a Domestic (Dom), Municipal (Muni, Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E-21L1	0.25 mile east of Hazelnut Rd. on Jackson Rd., 1700 feet north of road in corner of field	H. Nielsen		Irr.	65	12				X	
8N/6E-21M2	200 feet east of Hazelnut Rd. on Jackson Rd., north of road and west of house.	F. Takehara	1961	Dom.	66	12					X
8N/6E-21M1	0.25 mile east of Hazelnut Rd. on Jackson Rd., 200 feet south of road in shed.	F. Ueda		Irr.	63	12	250			X	X
8N/6E-21N2	80 feet south and 55 feet east of intersection of Hazelnut Rd. and Jackson Rd., northwest corner of paved area.	Hancock Oil Co.		Dom.	63					X	X
8N/6E-22R1	0.8 mile west of Excelsior Rd. on Kiefer Blvd., 350 feet south of road and 300 feet east of fenceline.	McGillivray Const.		Ind.	75	12				X	
8N/6E-22N1	0.75 mile north of Jackson Rd. on Excelsior Rd., 220 feet west to house, well west of house.	E. Nivison	1956	Dom. & Irr.	58	12	158		X	X	X
8N/6E-25Q1	0.8 mile south of Kiefer Blvd. on Eagles Nest Rd., 200 feet west of road and 25 feet south west of house.	L. Reedy	1953	Dom.	140						X
8N/6E-25Q2	0.5 mile west of Eagles Nest Rd. on Jackson Rd., 0.45 mile north to house, 200 feet north of house.	R. Clemens		Aband.	140	4	127			X	
8N/6E-25P1	0.68 mile west of Eagles Nest Rd. on Jackson Rd., pumphouse 150 feet north of road.	J. Hutcheson	1947	Dom.	135	8	130		X	X	
8N/6E-26K1	1.05 mile west of Eagles Nest Rd. on Jackson Rd., 0.35 mile north drive, 65 feet north of house and south of reservoir.	C. Barry	1950	Irr.	131	12	160			X	
8N/6E-26K2	1.05 mile west of Eagles Nest Rd. on Jackson Rd., 0.35 mile north on drive, pumphouse 35 feet west of Westerly Cabin.	C. Barry	1955	Dom.	128	12	192		X		X
8N/6E-26K1	0.85 mile west of Eagles Nest Rd. on Jackson Rd., 110 feet north of road and east of house.	F. Ben		Dom. & Irr.	124	8				X	
8N/6E-25Q1	0.25 mile east of Excelsior Rd. on Jackson Rd., 50 feet south of road and 6 feet south of abandoned well.	J. Parker		Dom. & Irr.	121		560			X	
8N/6E-25Q2	0.25 mile east of Excelsior Rd. on Jackson Rd., 50 feet south of road and 5 feet north of operating well.	J. Parker		Aband.	121		134			X	
8N/6E-27P1	0.8 mile west of Excelsior Rd. on Jackson Rd., 300 feet south of road and 30 feet west of house.	E. Tenneo		Dom. & Irr.	85					X	
8N/6E-27Q2	0.4 mile west of Excelsior Rd. on Jackson Rd., south of road and 3 feet west of windmill, southwest of house.	J. Craig		Dom.	87					X	X
8N/6E-27Q3	0.4 mile west of Excelsior Rd. on Jackson Rd., south of road under windmill and southwest of house.	J. Craig		Aband.	88					X	
8N/6E-27Q4	0.35 mile west of Excelsior Rd. on Jackson Rd., 250 feet north of road and at northwest corner of house.	M. Tufts		Dom.	87	8	127		X	X	

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E-27E1	0.2 mile west of Excelsior Rd. on Jackson Rd., 300 feet south of road in northwest corner of shed.	F. Koenig	1921	Aband.	93		165			X	
8N/6E-27E2	0.2 mile west of Excelsior Rd. on Jackson Rd., 300 feet south of road and 5 feet north of tank on wood stand.	F. Koenig	1955	Dom. & Irr.	94	12	425		X	X	X
8N/6E-27J1	0.2 mile south of Jackson Rd. on Excelsior Rd., 700 feet west of road near stream.	E. Stout	1955	Dom. & Irr.	85	10	143		X		
8N/6E-27L1	0.7 mile west of Excelsior Rd. on Elder Creek Rd., 0.4 mile north of road in field.	R. Harry		Irr.	82					X	
8N/6E-27M1	0.7 mile west of Excelsior Rd. on Elder Creek Rd., 150 feet north of road on west side of drive.	R. Harry		Dom.	80					X	
8N/6E-27M2	0.7 mile west of Excelsior Rd. on Elder Creek Rd., 0.25 mile north of road in field.	R. Harry		Irr.	86					X	
8N/6E-27N1	0.3 mile south of Jackson Rd. on Excelsior Rd., 200 feet west of road and 20 feet southwest of shed.	P. Ritchie		Dom.	117					X	
8N/6E-28A1	0.85 mile east of Bradshaw Rd. on Jackson Rd., 100 feet south of road and west of water tower.	G. Corpe		Dom.	63					X	
8N/6E-28C1	0.55 mile east of Bradshaw Rd. on Jackson Rd., 400 feet south of road and south side of porch on house.	E. Agrusti		Dom. & Irr.	64					X	
8N/6E-28D1	0.8 mile north of Elder Creek Rd. on Bradshaw Rd., 200 feet east of road in open field.	J. Kawamichi		Dom. & Irr.	99	12				X	
8N/6E-28E1	0.65 mile north of Elder Creek Rd. on Bradshaw Rd., 300 feet east of road in field behind garage.	F. Souza, Jr.		Dom.	98	12	147		X		X
8N/6E-28F1	0.70 mile north of Elder Creek Rd. on Bradshaw Rd., 0.45 mile east on drive in field.	N. Tokuoka		Irr.	68					X	
8N/6E-28L1	0.5 mile east of Bradshaw Rd. on Elder Creek Rd., 0.3 mile north on drive at entrance to old cemetery.	C. Reyero	1961	Irr.	67	10	800			X	X
8N/6E-28L2	0.25 mile north of Elder Creek Rd. and 600 feet west of road to cemetery in field.	N. Cruise	1960	Irr.	64		386		X	X	
8N/6E-28M1	0.4 mile north of Elder Creek Rd. on Bradshaw Rd., 100 feet east of road and south of house.	R. Jones		Dom. & Irr.	60	12	275			X	
8N/6E-28M2	0.3 mile north of Elder Creek Rd. on Bradshaw Rd., east of road in northwest corner of fenced field.	G. Anna	1955	Aband.	61	10	157		X	X	
8N/6E-28P1	0.35 mile east of Bradshaw Rd. on Elder Creek Rd., 50 feet north of road and east of drive.	J. Knight	1955	Irr.	70	12	320		X	X	
8N/6E-28P2	0.45 mile east of Bradshaw Rd. on Elder Creek Rd., 100 feet north of road between house and barn.	N. Cruise		Dom.	71					X	

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E-28F3	0.45 mile east of Bradshaw Rd. on Elder Creek Rd., 100 feet north of road, in pumphouse west of barn.	M. Cruise		Dom.	72					X	
8N/6E-29C1	1000 feet west of Mayhew Rd. on Fruitridge Rd., 500 feet south of road and 20 feet south of house.	O. Artz	1953	Dom. & Irr.	60	14	78		X	X	
8N/6E-29D1	0.5 mile east of Hedge Ave. on Fruitridge Rd., 400 feet south on drive, 200 feet east in field.	O. Artz	1953	Irr.	55	12	840		X		
8N/6E-29E2	0.5 mile east of Hedge Ave. on Fruitridge Rd., 0.35 mile south, 0.1 mile east and 0.1 mile south on drive, southwest of house.	S. Smith		Dom.	53	10	150		X		
8N/6E-29F1	0.5 mile east of Hedge Ave. on Fruitridge Rd., 0.35 mile south and 0.1 mile east on drive, 500 feet east of house in field.	L. Cook		Dom. & Irr.	55					X	X
8N/6E-29H1	0.55 mile north of Elder Creek Rd. on Bradshaw Rd., 500 feet west of road at southeast corner of vineyard	F. Mahal		Dom. & Irr.	59	12				X	
8N/6E-29J2	0.48 mile north of Elder Creek Rd. on Bradshaw Rd., 1200 feet west of road on drive.	J. Rusich Realty		Aband.	61	12	98			X	
8N/6E-29L1	0.47 mile north of Elder Creek Rd. on Mayhew Rd., 150 feet west of road, pumphouse south side of drive	J. Legare		Dom. & Irr.	54	12				X	
8N/6E-29M2	0.5 mile east of Hedge Ave. on Elder Creek Rd., 65 feet north of road and 50 feet east of house.	L. Garrett		Dom.	55	10	87			X	
8N/6E-29P1	330 feet west of Mayhew Rd. on Elder Creek Rd., 50 feet north of road on north side of garage.	Gov Realty		Dom.	59	10	108			X	
8N/6E-29P2	800 feet west of Mayhew Rd. on Elder Creek Rd., 130 feet north of road, 50 feet north of house.	W. Franklin	1959	Dom.	58		110		X		X
8N/6E-29Q1	0.85 mile west of Bradshaw Rd. on Elder Creek Rd., 125 feet north of road and 25 feet north of house.	B. Fletcher		Dom.	59					X	
8N/6E-29Q2	Northeast corner of intersection of Mayhew Rd. and Elder Creek Rd., 50 feet northeast of house.	J. Colangelo	1961	Dom.	59					X	
8N/6E-30A1	0.85 mile south of Fruitridge Rd. on Hedge Ave., 0.35 mile east on dirt road, 60 feet east of last house.	L. Hise		Dom.	56						
8N/6E-30A2	0.85 mile east of Hedge Ave. on Fruitridge Rd., south of road in garage.	A. Smith		Dom.	53	12	94			X	
8N/6E-30B1	0.16 mile east of Hedge Ave. on Fruitridge Rd., 60 feet south of road and 50 feet east of house.	B. Caldwell		Dom.	52	12	90			X	
8N/6E-30B5	0.13 mile south of Fruitridge Rd. on Hedge Ave., 70 feet east of road and 80 feet south of house.	M. Rodriquez	1959	Irr.	58	12	150		X		
8N/6E-30C1	0.8 mile south of Fruitridge Rd. on Hedge Ave., 80 feet west of road inside fence of sewage plant.	Sacramento County	1955	Dom.	50	8	164		X		X

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/6E-30K1	0.3 mile north of Elder Creek Rd. on Hedge Ave., 240 feet west of road in pumphouse.	B. Orrick		Dom.	56	8	115			X	
8N/6E-30Q1	0.25 mile north of Elder Creek Rd. on Hedge Ave., west on drive, well 100 feet south of house.	V. Tuiasoso		Irr.	60		150			X	
8N/6E-30R1	0.5 mile east of Hedge Ave. on Elder Creek Rd., 0.2 mile north on drive, 25 feet east of house	J. Hicks		Irr. & Dom.	57					X	
8N/6E-33B1	0.8 mile east of Bradshaw on Elder Creek Rd., 0.25 mile south on drive, south of barn by corral.	R. Sharp		Dom. & Irr.	77					X	X
8N/6E-33H1	0.3 mile north of Florin Rd. on Bradshaw Rd., 100 feet east of road in concrete pit north of drive.	G. Ishi		Dom.	61					X	
8N/6E-33M1	150 feet east of Bradshaw Rd. and 50 feet north of Florin Rd., between house and barn.	Bowers		Dom. & Irr.	66					X	
8N/6E-33R1	0.75 mile east of Bradshaw Rd. on Florin Rd., 0.2 mile north on drive by shed.			Aband.	76	16				X	
8N/6E-34C1	0.55 mile west of Excelsior Rd. on Elder Creek Rd., 250 feet south of road behind house.	E. Seely		Dom.	91		150			X	
8N/6E-34L2	0.5 mile west of Excelsior Rd. on Florin Rd., 900 feet north, 600 feet west and 0.2 mile north on drive in field.	Salvadori		Irr.	92					X	
8N/6E-34N1	1.0 mile west of Excelsior Rd. on Florin Rd., 0.5 mile north of drive, 250 feet east of drive in field.	S. Eng		Irr.	82					X	
8N/6E-34P1	0.5 mile west of Excelsior Rd. on Florin Rd., 900 feet north of drive, west side of ditch.	Salvadori		Irr.	79					X	
8N/6E-34P2	0.55 mile west of Excelsior Rd. on Florin Rd., 180 feet north of road and 20 feet west of house.	Salvadori		Dom.	81					X	
8N/6E-34R1	0.25 mile west of Excelsior Rd. on Florin Rd., 150 feet north of road behind garage.	T. Dutra		Dom. & Irr.	106		300			X	X
8N/6E-35P1	0.25 mile south of Elder Creek Rd. on Excelsior Rd., 0.35 mile east of road in field.	B. Barsby		Irr.	120		240			X	
8N/6E-36R2	0.35 mile west of Eagles Nest Rd. on Jackson Rd., 100 feet south of road behind building.	Eagles Nest Tavern		Dom.	141		150			X	
8N/7E- 2N1	2.5 miles north on Grant Line Rd. from bend in road, 100 feet east of road and 130 feet south of house in shed.	J. Tracy	1956	Irr.	258	14	675		X	X	X
8N/7E- 4P1	1.4 miles north of Douglas Rd. on Plant road, 2000 feet west on paved road, north side of road.	Douglas Aircraft	1961	Ind.	200	12	175			X	X
8N/7E- 8N1	0.8 mile east of Citrus Rd. on Douglas Rd., 600 feet south of road in open field.	D. Sapp		Aband.	178	10	102			X	

[a] Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

[b] U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 8 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/7E- 9H1	0.15 mile north of Douglas Rd. on plant road, 30 feet north of tank on west side of road.	Douglas Aircraft	1956	Dom. & Ind.	212	12	320		X	X	
8N/7E- 9H2	800 feet north of Douglas Rd. on plant road, 1000 feet west of plant road in metal pumphouse.	Douglas Aircraft	1956	Dom. & Ind.	207	12	296		X	X	X
8N/7E- 9H3	0.3 mile south of Douglas Rd. on Dary Rd., 0.1 mile east and 150 feet north on drive, 6 feet south of house.	F. O'Hanneson		Dom.	190					X	X
8N/7E-12H1	0.4 mile south of Douglas Rd. on Grant Line Rd., 1.2 mile east on Farm road.			Dom.	210						X
8N/7E-14C1	0.4 mile south of Douglas Rd. on Grant Line Rd., 0.45 mile east on dirt road to windmill.	Russel Brothers	1936	Stk.	255	8	208		X	X	X
8N/7E-18H1	Golf Course Well No. 1	Mather Air Force Base		Irr.	185	12					
8N/7E-18P1	Golf Course Well No. 2	Mather Air Force Base	1957	Irr.	137	12	403		X		
8N/7E-19D1	Sta. Ord. Well	Mather Air Force Base		Dom. & Irr.	151						
8N/7E-22G1	2.5 miles north of Jackson Rd. on Grant Line Rd., 0.85 mile west on dirt road, north side of road.	Climah Trustees	1963	Test Hole	222	10	210		X	X	X
8N/7E-26Q2	0.45 mile west of Jackson Rd. on Kieffer Blvd., 0.2 mile north on dirt road 0.7 mile west, 30 feet south of reservoir.	Tokeshe Brothers		Irr.	148						X
8N/7E-29L1	0.5 mile north of Jackson Rd. on Conner Rd. east thru gate on farm rd., 800 feet west of windmill.	N. Hagell	1963	Test Hole	185	12	130		X	X	X
8N/7E-29P1	0.6 mile north of Jackson Rd.on Conner Rd., 0.4 mile east of road in field by tank.	N. Hagell		Stk.	122					X	
8N/7E-30A1	0.85 mile west of Conner Rd. on Kieffer Blvd., 300 feet south of road and west of building.	Sacramento Rendering Company	1956	Dom. & Ind.	148	12	420		X		X
8N/7E-31H1	0.2 mile west of Conner Rd. on Jackson Rd., 400 feet south of road and 75 feet east of drive in building	Grotch		Dom.	122		280			X	
8N/7E-31J1	0.2 mile south of Jackson Rd. on Conner Rd., 100 feet west of road in field.	Grotch	1952	Irr.	116	14	300			X	
8N/7E-31L1	0.4 mile south of Jackson Rd. on Eagles Nest Rd., 0.5 mile east and 500 feet south on dirt road, at northeast corner of reservoir.	E. Curli	1951	Irr.	122		300			X	
8N/7E-31M1	0.5 mile south of Jackson Rd. on Eagles Nest Rd., 70 feet east of road and 50 feet northwest of house.	E. Curli		Dom. & Irr.	126	12	340			X	X
8N/7E-31M2	0.5 mile south of Jackson Rd. on Eagles Nest Rd., 800 feet east of road and 800 feet north of reservoir.	E. Curli	1941	Irr.	124		340			X	
8N/7E-33N1	0.8 mile north of Jackson Rd. on Grant Line Rd., 125 feet east of road and 40 feet north of house.	W. Thoma		Dom. & Irr.	145	10	130			X	

[a] Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)
[b] U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 2 (cont'd)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
8N/7E-33M1	300 feet east of Great Line Rd. on Jackson Rd., 200 feet north of road.	W. Bryant	1952		146	12	187				X
8N/7E-33N1	100 feet south of Jackson Rd. and 225 feet west of Sheldon Rd., 100 feet north of house.	T. Murphy		Dom.	197	10	185			X	
9N/6E-13J3	0.1 mile east of Old Fair Oaks Bridge, 6 feet north of Old Citrus Rd., 30 feet east of house.	R. Loehr	1949	Dom.	101	8	65			X	
9N/6E-13Q1	200 feet south of Old Fair Oaks cut off by New Fair Oaks Bridge, 400 feet west of Citrus Rd. and 75 feet north of trailer house.	Natomas Land Company		Dom.	99	8	108			X	X
9N/6E-23Q2	0.67 mile northeast of Cordova Lane on Coloma Rd., 120 feet south of road in garage.	J. Lowery	1946	Dom.	100	10	125		X	X	X
9N/6E-24J1	0.2 mile south of Coloma Rd. on Citrus Rd., 0.15 mile east of Citrus Rd., east side of laundry.	Piner House, Inc.	1962	Dom.	115	16	410		X	X	X
9N/6E-24M2	200 feet north of Coloma Rd. and 300 feet west of Citrus Rd. Pumphouse 10 feet north of shed.	Henry Leavett	1958	Dom.	113		147		X		
9N/6E-24N1	0.5 mile west of Citrus Rd. on Coloma Rd., 260 feet south of road between houses.	D. Beach		Aband.	108		45		X		
9N/6E-24N2	0.5 mile west of Citrus Rd. on Coloma Rd., 290 feet south of road and 35 feet south of house.	D. Beach	1958	Dom.	108	10	140		X		X
9N/6E-25B1	150 feet west of Kinneto Dr. on Napoli Way, north side in fence enclosure, Natomas No. 11	Natomas Water Company	1959	Mun.	102	12	468		X	X	X
9N/6E-25D1	400 feet east of Citrus Rd. and 120 feet south of Folsom Blvd. Pumphouse 15 feet west of building.	J. Bolinger	1951	Dom.	114	12	105		X	X	
9N/6E-25E1	500 feet west of railroad crossing on Folsom Blvd., 150 feet north of road and northeast of Edwards Motel	J. Edward	1913	Dom.	115	7				X	X
9N/6E-25L1	0.45 mile west of Citrus Rd. on Folsom Blvd., pumphouse 150 feet south of road and 15 feet northwest of house.	W. Riggs			108	12	410			X	
9N/6E-25L2	1100 feet east of Kilgore Rd. on Folsom Blvd., pumphouse 130 feet south of road and 300 feet east of building.	J. Marshall	1955	Ind.	108	12	117		X		
9N/6E-25L3	150 feet east of Kilgore Rd. and 200 feet south of Folsom Blvd., pumphouse at southeast corner of main building.	J. Tulley Estate	1958	Ind.	108	10	188		X		
9N/6E-25M1	850 feet south of Folsom Blvd. on Kilgore Rd., 110 feet west of road in tank house behind old school	Folsom Unified School District		Dom.	113					X	
9N/6E-25P1	0.2 mile south of Folsom Blvd. on Kilgore Rd., 250 feet east of road on east side of drive between buildings	Van Valkenburgh and Company	1961	Ind.	115	10	180			X	X
9N/6E-25Q1	200 feet north of Mather Kilgore Cemetary on Kilgore Rd., 600 feet east of road in gravel pit.	Brighton Sand & Gravel	1959	Ind.	87	12	191		X	X	

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
9X(X) 9N/6E-25R1	0.35 mile south of Folsom Blvd. on Citrus Rd., 300 feet east of road in fence enclosure at south side of building.	International Association of Machinists	1959	Dom.	123	12	230		X	X	X
9N/6E-26B1	150 feet west of Pinture Way on Campana Way, 75 feet south of road.	F. Williamson	1946	Irr.	100	12	110			X	
9N/6E-26C1	0.1 mile east of Cordova Lane on Coloma Rd., 120 feet south of road in pumphouse west side of garage.	O. Peterson	1942	Dom. & Irr.	96	6	87 e			X	
9N/6E-26G1	West of Blackstone Dr. on Georgetown Dr., south side of road in fence enclosure, Natoma No. 7	Natoma Water Company	1959	Mun.	95	12	556		X	X	
9N/6E-26G2	0.14 mile southwest of Cordova Lane on Coloma Rd., 175 feet north of road, pumphouse north side of garage.	F. Williamson		Dom.	93	12	98		X	X	
9N/6E-26J1	Southeast corner of McGregor Dr. and Glenhaven Way south of swimming pool in fence enclosure, Natoma No. 9.	Natoma Water Company	1959	Mun.	100	12	460		X	X	X
9N/6E-26L1	North of Zibibbo Way on Negrare Way south side of road in fence enclosure, Natoma No. 10.	Natoma Water Company	1959	Mun.	93	12	416		X	X	X
9N/6E-27E1	North of Woodbridge Way on Wakefield Dr. east side of road in fence enclosure, Natoma No. 12.	Natoma Water Company		Mun.	90					X	
9N/6E-27K1	0.25 mile north of Coloma Rd. through Sierra Shire Apts., 25 feet east of old house.	Cordova Apartment Corporation		Dom.	86	12	120			X	
9N/6E-27L1	North end of Chase Drive.	Rancho Cordova Sewage Treatment Plant	1955	Dom.	70	8	184		X		X
9N/6E-27R1	West of Chardonay Dr. on Dolcetto Dr., north side of road in fence enclosure, Natoma No. 6.	Natoma Water Company	1956	Mun.	88	12	405		X	X	X
9N/6E-33R1	0.35 mile north of Folsom Blvd. through Water Service Lot, 5 feet east of shed at north side of lot.	W. Elliot		Dom.	74	8	85			X	
9N/6E-33R2	800 feet north of intersection of Folsom Blvd. and Routiers Rd.	W. Elliot		Irr.	74	12				X	
9N/6E-33R3	0.45 mile west of Mather Field Dr. on Folsom Blvd., north on palm lined drive, 50 feet north of house.	J. Dauenhauer	1959	Dom.	74	12	130		X		
9N/6E-34C1	North of Rimin Dr. on Agnes Circle, south of road in fence enclosure, Natoma No. 8.	Natoma Water Company	1959	Mun.	81	12	470		X	X	
9N/6E-34R1	0.35 mile west of Mather Field Drive on Folsom Blvd., 0.35 mile north, 0.85 mile east of Farm Rd., 0.1 mile north in field.	J. Dauenhauer		Irr.	65	12	60			X	
9N/6E-34R2	South of Dolcetto Dr. on Gilbert Way, west side of road in fence enclosure, Natoma No. 3.	Natoma Water Company	1955	Mun.	86	12	240		X	X	X
9N/6E-34L1	North of Malaga Way on El Segundo Dr., west side of street in fence enclosure, Natoma No. 4.	Natoma Water Company	1955	Mun.	80		121		X	X	

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)
b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
9N/6E-34N2	South of Malaga Way on Las Tunas Court to end of street, west of street near pressure tank.	Citizens Suburban Co.	1962	Mun.	60	14	308		X	X	
9N/6E-34N1	0.45 mile west of Mather Field Dr. on Folsom Blvd., 800 feet north of road and 60 feet east of palm lined drive.	J. Dannenhauer		Irr.	74	10	135			X	
9N/6E-34P1	400 feet south of Folsom Blvd. on Mather Field Dr., 150 feet east of road under windmill frame.	F. Hayman	1946	Dom.	82	12	82			X	
9N/6E-34P6	400 feet east of Mather Field Dr. on Folsom Blvd., northeast of Standard Service Station.	W. Dannenhauer	1954	Dom.	76	10	101		X		
9N/6E-34P7	150 feet west of Mather Field Dr. on Folsom Blvd., 50 feet northeast of Air Flight Drive-In Restaurant.	H. Hageman	1956	Dom.	77	10	106		X		
9N/6E-34R1	0.5 mile east of Folsom Blvd. on White Rock Rd., 150 feet south of road across from White Rock School	Cordova Recreation and Park District	1950	Dom.	97	10	112		X	X	
9N/6E-34R2	0.5 mile east of Folsom Blvd. on White Rock Rd., south of road in shed south of house.	V. Parrish		Dom.	97						X
9N/6E-35Q2	West of Zinfandel Dr. at intersection of Zinfandel Dr. and Alicante Way in fence enclosure, Natomas No. 1.	Natomas Water Company		Mun.	97					X	X
9N/6E-35Q3	North side of Rancho Cordova Post Office in Cordova Village Shopping Center, Natomas No. 2.	Natomas Water Company		Mun.	97					X	X
9N/6E-35R1	East of Mills Park Dr. on Marcel Way, south of street in fence enclosure, Natomas No. 3.	Natomas Water Company	1956	Mun.	94	12	480		X	X	X
9N/6E-36J1	150 feet east of Citrus Rd. and 150 feet north of White Rock Rd. at north side of paved area of service station.	Aerojet General	1958	Dom.	116	12	181		X	X	X
9N/6E-36K1	80 feet south of White Rock Rd. at intersection of Kilgore Rd., 50 feet west of drive and north of oil refinery.	E. McDuffee	1954	Ind.	113	12	110		X	X	X
9N/7E-10Q1	700 feet northeast of Folsom Blvd. from intersection U.S. 50 and Folsom cutoff, 500 feet north on drive, pumphouse 40 feet south of garage.	Department of Parks and Recreation, State of California	1936	Dom.	170	8	318			X	
9N/7E-10Q2	500 feet north of Folsom Blvd. and 175 feet east of U.S. 50, 300 feet west of park residence by Hinkson Lake.	Department of Parks and Recreation, State of California		Aband.	167		139			X	
9N/7E-12K1	0.36 mile north of U. S. 50 on Prairie City Rd., 60 feet west of road and south of storage pond.	M. Brown	1949	Aband.	893	12	100			X	
9N/7E-12Q1	400 feet north of U. S. 50 on Prairie City Rd., 300 feet east of road and 50 feet south of house.	M. Brown	1949	Dom.	900	10	130			X	X
9N/7E-12Q2	950 feet west of Prairie City Rd. on U. S. 50, 50 feet north of hwy. and west of siphon.	Department of Parks and Recreation, State of California	1947	Aband.	895		60		X		

[a] Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

[b] U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE 5 (Cont.)

WELL DATA

FOLSOM – EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
9N/7E-15R1	200 feet west of Alder Creek on Folsom Blvd., 20 feet north of road in Trailer Park.	Shady Oaks Investment Company		Dom.	143	12	185			X	
9N/7E-15P4	0.38 mile southwest of Folsom cutoff on Folsom Blvd., 150 feet south of road across railroad tracks.	V. Canton		Dom.	157	8	95			X	
9N/7E-15P5	0.42 mile southwest of Folsom cutoff on Folsom Blvd., 850 feet southwest of Natomas Ditch and 40 feet north of road.	Y. Ehrhardt	1947	Dom.	156	10	50			X	
9N/7E-15N3	0.92 mile southwest of Folsom cutoff on Folsom Blvd., 100 feet north of road between houses.	H. Rodgers		Dom.	148	10	83				X
9N/7E-16A1	800 feet north of U. S. 50 and west of Alder Creek, 100 feet north of chicken house	Department of Parks and Recreation, State of California		Aband.	132	12				X	
9N/7E-16G1	North of U. S. 50 on Hinkus Rd. to Fish Hatchery, 0.85 mile east, north of drive in shed.	Department of Parks and Recreation, State of California		Dom.	132					X	X
9N/7E-16H1	600 feet north of U. S. 50 on west bank of Alder Creek, northeast of building.	Department of Parks and Recreation, State of California		Dom.	130	12					X
9N/7E-16J1	8000 feet east of Hinkus on Folsom Blvd., 500 feet north of road and 175 feet north of house.	W. Clarkson C.U.		Dom.	150	8	180				X
9N/7E-16K1	0.1 mile west of Aerojet General Corporation Gate #2 on Folsom Blvd., 450 feet north of road and 20 feet west of house.	H. Greenhalgh			150						X
9N/7E-16P1	250 feet west of Libbys Cannery at Hinkus Rd. on Folsom Blvd. 150 feet north of road behind houses.	Natomas Land Company		Dom.	145	6					X
9N/7E-16P2	300 feet west of Hinkus Rd. on Folsom Blvd., 40 feet north of road and 30 feet east of Jet Club.	R. Thompson		Dom.	143						X
9N/7E-16Q1	150 feet east of Hinkus Rd. and 50 feet north of Folsom Blvd. in pumphouse.	Libby, McNiel & Libby Company	1950	Ind.	144		185			X	X
9N/7E-16Q2	East of Hinkus Rd. on Folsom Blvd., 50 feet north of road and east of main building at easterly fenceline	Libby, McNiel & Libby Company	1956	Ind.	145	12	138		X	X	X
9N/7E-17H1	Gravel plant east of Old Fair Oaks Bridge, 0.5 east on East Bnal Road, 100 feet west on hill.	Pacific Cement and Aggregate Company	1963	Test Hole	112	12	72		X	X	X
9N/7E-18H1	In gravel plant yard, east of office and washer plant, 100 feet south of Griselle.	Pacific Cement and Aggregate Company	1960	Ind.	113	16	502		X		X
9N/7E-19R1	0.9 mile south of gravel plant yard on South Bnal Rd., 150 feet southeast of and in V of road.	Pacific Cement and Aggregate Company	1963	Test	102	12	80		X	X	X
9N/7E-21R1	2,800 feet west of Hinkus Rd. on Folsom Blvd., south of road	Air Products and Chemical Incorporated	1956	Ind.	141	10	450		X	X	X

[a] Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)
[b] U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

TABLE I (Cont.)

WELL DATA

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
9N/7E-27L1	High thrust fold, north of Buffalo Creek and west of road leading into Line 4 from the northeast.	Aerojet General Corporation	1962	Test Well	250	8	67		X	X	X
9N/7E-24R1	Liquid area, east of railroad spur and west of Prairie City Road.	Aerojet General Corporation	1962	Test Well	299	8	60		X	X	X
9N/7E-25D1	0.9 mile west of Prairie City Rd. on White Rock Rd., 100 feet north of road and 200 feet east of Aerojet Entrance No. 7.	Aerojet General Corporation		Aband.	288					X	
9N/7E-26R1	7.9 miles east of Mills on White Rock Rd., south side of road in green octagonal house.	F. Olson		Dom.	280		25				X
9N/7E-26Q1	0.4 mile east of Grant Line Rd. on White Rock Rd., 500 feet south of road on east side of drive in pumphouse.	F. Olson		Dom. & Irr.	281					X	X
9N/7E-26M1	County disposal site at northeast corner of Grant Line Rd. and White Rock Rd., near building on hill.	Sacramento County		Dom.	245						X
9N/7E-27P1	1.0 mile west of Grant Line Rd. on Old White Rock Rd., 80 feet south of road under windmill frame.	H. R. Culver		Dom.	226	8				X	X
9N/7E-28R1	800 feet north of road to Line No. 4 on Hinkus Rd., east of road in pump plant.	Aerojet General Corporation	1951	Ind.	191	12	325		X		X
9N/7E-28Q1	1.5 miles south of Hinkus, northeast of Hinkus Rd. and road to Line No. 4.	Aerojet General Corporation	1956	Ind.	197	12	335		X		X
9N/7E-28H1	Magazine area, south of main road and southwest of contractors area.	Aerojet General Corporation	1962	Test Well	185	8	100			X	X
9N/7E-29G1	1.6 miles east of Citrus Rd. and 0.5 mile southeast of Folsom Blvd. West Test Well.	Aerojet General Corporation	1962	Test Well	142	8	78		X	X	X
9N/7E-31H1	0.65 mile east of Fitzgerald Rd. on White Rock Rd., south of road and east of water tank.	T. F. Kirby		Dom.	134	6				X	
9N/7E-31N1	100 feet east of Fitzgerald Rd. and 80 feet south of White Rock Rd., north of barn by tank.	H. H. Davies	1951	Dom. & Irr.	124	12	250			X	
9N/7E-32R1	4.3 miles east of Mills on White Rock Rd., 100 feet south of road.	J. A. Rodgers		Dom.	175		130				X
9N/7E-32C1	1.6 miles east of Citrus Rd. on White Rock Rd., 900 feet northeast of entrance to Nitroplasticer Plant and 150 feet south of SP tracks.	Aerojet General Corporation	1958	Aband.	178	12	258		X	X	
9N/7E-32C2	1.6 miles east of Citrus Rd. on White Rock Rd., 200 feet north of Aerojet entrance gate.	Aerojet General Corporation	1958	Ind.	179	12	258		X	X	
9N/7E-32R1	1.6 miles east of Citrus Rd. on White Rock Rd., south of Nitroplasticer Plant, Stauffer Injection.	Aerojet General Corporation	1961	Ind.	150		1,560		X		
9N/7E-33R1	4.8 miles east of Mills on White Rock Rd., 500 feet south of road by dry feed plant	B. Petrucci		Dom. & Irr.	173						X

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum (Feet above mean sea level unless otherwise indicated)

MINERAL ANALYSIS OF GROUND WATER
FOLSOM—EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Mineral constituents in parts per million / equivalents per million

Source	Well number	Date sampled	Temp in °F	Specific conductance (micromhos at 25°C)	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents[a]	Total[b] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Remarks
Mather No. 3	8N/6E- 2R1	6-21-62	68	121	7.4	2.9 / 0.49	4.0 / 0.33	8.4 / 0.37	1.9 / 0.05		56 / 0.92	1.6 / 0.03	4.2 / 0.12	4.0 / 0.06	2.8 / 0.15	0.0	22	Fe 0.02	124	30	41	0	
Mather No. 4	8N/6E- 2P1	6-21-62	68	113	7.9	2.0 / 0.45	4.3 / 0.35	6.8 / 0.30	2.0 / 0.05		61 / 1.00	0.0 / 0.00	3.0 / 0.08	2.9 / 0.05	0.2 / 0.01	0.0	61	Fe 0.00	119	26	40	0	
Citizens Suburban	8N/6E- 3R1	4-25-60			7.9	13 / 0.65	4.0 / 0.33	10 / 0.43	1.9 / 0.05		56 / 0.92	2.4 / 0.05	5.0 / 0.14	8.2 / 0.13	0.15 / 0.01			Fe 0.00	127		46	0	
		1-15-63		139	8.0	15 / 0.75	2.3 / 0.19	11 / 0.48	1.6 / 0.04		75 / 1.23	0.0 / 0.00	3.2 / 0.09	9.6 / 0.09	0.1 / 0.00	0.04	40	ABS 0.0; ClO_4 2	116	33	47	0	
J. Bolinger	8N/6E- 3Q1	10-13-58		313	7.9	12 / 0.58	4.0 / 0.31	9.0 / 0.40	1.5 / 0.04		61 / 1.00	1.0 / 0.03	7.0 / 0.20	6.0 / 0.10	0.2 / 0.01	0.16	33	Fe 0.01	244	30	44	0	
		5-21-59	69	140	7.8	16 / 0.80	0.9 / 0.04	11 / 0.48	1.5 / 0.04		70 / 1.15	2.3 / 0.05	2.2 / 0.06	6.9 / 0.11	0.1 / 0.00	0.16	32	NH_4 0.0; ClO_4 0	130	35	42	0	
		5-11-60	68	137	7.8	13 / 0.65	2.8 / 0.23	10 / 0.44	1.6 / 0.04		71 / 1.16	0.0 / 0.00	2.4 / 0.06	5.2 / 0.08	0.0 / 0.00	0.08	29	ClO_4 0	99	32	44	0	
Citizens Suburban Rockingham Well	8N/6E- 3R1	4-25-60			7.9	13 / 0.65	2.0 / 0.16	12 / 0.52	2.6 / 0.07		58 / 0.95	0.4 / 0.01	3.0 / 0.08	4.6 / 0.07	0.10 / 0.01			Fe 0.2	117		48	0	
R. E. Proom	8N/6E- 4A2	1-16-63	62	242	8.1	23 / 1.15	8.1 / 0.67	15 / 0.65	2.0 / 0.05		126 / 2.06	2.1 / 0.04	9.1 / 0.26	6.2 / 0.10	0.1 / 0.00	0.02	32	ABS 0.0; ClO_4 0	167	26	91	0	
C. Mohl	8N/6E- 4K1	12-18-61		297	7.1	23 / 1.15	16 / 1.35	11 / 0.48	1.4 / 0.04		129 / 2.11	13 / 0.27	8.7 / 0.24	26 / 0.42	0.0 / 0.00	0.06	26	ABS 0.0; Phenol 0.000	218	16	125	19	
		1-10-63	57	349	7.7	27 / 1.35	18 / 1.45	14 / 0.61	1.3 / 0.03		135 / 2.21	15 / 0.31	9.8 / 0.28	39 / 0.63	0.1 / 0.00	0.04	31	ABS 0.0; ClO_4 0	241	18	140	29	
J. Smith	8N/6E- 5R2	6-12-55	64	336	8.2	33 / 1.65	15 / 1.27	14 / 0.61	1.7 / 0.04		176 / 2.85	15 / 0.31	7.8 / 0.22	16 / 0.26	0.1 / 0.01	0.00	24		263	17	146	3	
		9-19-58		397	8.2	34 / 1.69	19 / 1.56	16 / 0.72	1.5 / 0.04		189 / 2.98	24 / 0.50	10 / 0.27	20 / 0.32	0.0 / 0.00	0.04	38		294	17	164	0	
		1-16-63	50	295	8.2	24 / 1.20	15 / 1.24	12 / 0.52	1.3 / 0.03		112 / 1.84	20 / 0.42	8.3 / 0.23	29 / 0.47	0.1 / 0.00	0.05	39	ABS 0.0; ClO_4 1	214	17	122	30	
R. Coleman	8N/6E- 7P1	12-20-61	66	165	8.0	18 / 0.90	4.1 / 0.34	9.5 / 0.41	2.8 / 0.07		90 / 1.48	3.0 / 0.06	3.2 / 0.09	1.8 / 0.03	0.1 / 0.01	0.10	45	ABS 0.0; Phenol 0.000	132	24	62	0	
C. Scudder	8N/6E- 8R9	1-10-63	60	128	7.7	9.1 / 0.45	5.2 / 0.43	8.0 / 0.35	1.0 / 0.02		58 / 0.95	1.2 / 0.02	3.6 / 0.10	8.5 / 0.14	0.1 / 0.00	0.04	49	ABS 0.0; ClO_4 0	114	28	44	0	
U. Noble	8N/6E- 9P5	1- 4-62	65	120	7.9	8.8 / 0.44	4.9 / 0.40	8.8 / 0.38	0.9 / 0.02		55 / 0.90	1.0 / 0.02	4.5 / 0.13	9.7 / 0.16	0.1 / 0.01	0.1	45	ABS 0.0; Phenol 0.000	111	31	48	0	
		1-10-63	51	124	7.7	9.1 / 0.45	4.2 / 0.35	9.0 / 0.39	1.0 / 0.02		56 / 0.92	0.2 / 0.00	2.5 / 0.07	11 / 0.18	0.2 / 0.01	0.03	43	ABS 0.0; ClO_4 1	108	32	40	0	
Mather AFB No. 1	8N/6E-11C1	6-21-62	68	118	7.1	8.5 / 0.42	4.9 / 0.40	8.1 / 0.35	1.3 / 0.03		52 / 0.85	1.4 / 0.03	4.8 / 0.14	5.0 / 0.08	0.9 / 0.05	0.00	39	CO_2 6.8; Fe 0.00	121	29	41	0	

a Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol)

b Determined by addition of constituents.

TABLE 9 (Cont.)

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total dissolved solids in ppm	Percent sodium (calculated)	Hardness as $CaCO_3$: In ppm	In grains per gallon	Remarks
Mather AFB No. 2 500'	8N/6E-11Q2	6-21-62	68	119	7.7	9.6 / 0.48	4.3 / 0.35	7.6 / 0.33	1.8 / 0.05		62 / 1.02	0.2 / 0.0	3.2 / 0.09	4.4 / 0.07	0.2 / 0.01	0.0	22	CO_2 2.0 Fe 0.00	121	37	42	0	
Mather AFB ACAW	8N/6E-13B1	1- 8-62	68	111	7.7	8.4 / 0.42	3.9 / 0.32	8.5 / 0.37	0.6 / 0.02		46 / 0.75	1.0 / 0.02	4.8 / 0.14	9.0 / 0.14	0.1 / 0.02	0.0 / 0	22	ABS 0.0 Phenol 0.000	115	33	37	0	
		6-21-62		118	7.4	8.2 / 0.41	4.1 / 0.34	8.6 / 0.37	1.0 / 0.03		48 / 0.79	2.2 / 0.05	4.8 / 0.14	18 / 0.29	0.1 / 0.02	0.0	22	CO_2 3.0 Fe 0.00	120	32	37	0	
Mather AFB Thorry No.3 500'	8N/6E-13Q1	1- 6-58		206	7.7	18 / 0.90	10 / 0.82	11 / 0.48	4.1 / 0.11		122 / 2.00	1.0 / 0.02	8.9 / 0.25	0.0 / 0.0	0.1 / 0.01	0.0	26	Fe 0.06; CO_2 3.9; Fe (Total) 1.8	169	21	86	0	
		6-21-62		198	7.8	17 / 0.85	8.1 / 0.68	11 / 0.48	3.5 / 0.09		114 / 1.87	0.8 / 0.02	8.2 / 0.23	1.0 / 0.03	0.2 / 0.01	0.0	64	CO_2 2.8 Fe 0.00	172	23	76	0	
Mather AFB Thorry No.1 500'	8N/6E-14A1	1- 6-58		164	8.1	14 / 0.70	6.2 / 0.51	14 / 0.61	3.0 / 0.08		100 / 1.64	1.0 / 0.02	7.0 / 0.20	0.2 / 0.00	0.2 / 0.01	0.04	22	Fe 0.07; CO_2 1.3; Fe (Total) 0.13	154	32	60	0	
		6-21-62	68	169	7.4	14 / 0.70	6.6 / 0.54	11 / 0.48	2.8 / 0.07		97 / 1.59	0.0 / 0.0	7.0 / 0.20	0.1 / 0.0	0.2 / 0.01	0.0	28	CO_2 5.1 Fe 0.01	148	27	62	0	
Mather AFB Thorry No.2 500'	8N/6E-14K1	1- 6-58		206	7.7	16 / 0.80	11 / 0.91	12 / 0.52	2.8 / 0.07		128 / 2.10	0.0 / 0.0	6.0 / 0.17	0.0 / 0.0	0.1 / 0.01	0.2	22	Fe (Dis) 0.04; Fe (Total) 5.2; CO_2 4.1	166	23	85	0	
		6-21-62	68	214	7.5	19 / 0.95	9.2 / 0.76	12 / 0.52	2.7 / 0.07		130 / 2.13	1.0 / 0.02	6.4 / 0.18	0.2 / 0.01	0.2 / 0.03	0.0	65	CO_2 6.3 Fe 0.01	180	23	85	0	
Mather AFB Thorry No.4	8N/6E-14N1	1- 6-58		156	8.1	12 / 0.60	7.8 / 0.64	11 / 0.48	2.6 / 0.07		90 / 1.48	1.9 / 0.04	6.6 / 0.19	1.8 / 0.05	0.1 / 0.01	0.01	66	Fe (Dis) 0.0; Fe (Total) 0.0; CO_2 1.2	155	27	62	0	
		6-21-62	68	153	7.7	14 / 0.70	4.7 / 0.39	9.8 / 0.43	2.4 / 0.06		83 / 1.36	0.0 / 0.0	7.2 / 0.20	1.7 / 0.03	0.2 / 0.01	0.0	60	CO_2 2.7 Fe 0.00	141	27	54	0	
Ted Kubota	8N/6E-16Q3	1-14-63	67	130	7.7	10 / 0.50	1.2 / 0.26	11 / 0.48	1.0 / 0.02		57 / 0.93	0.5 / 0.01	3.7 / 0.10	13 / 0.21	0.1 / 0.00	0.03	34	ABS 0.0; ClO_4 0	104	38	38	0	
Mather AFB Sacramento Test Stand 80	8N/6E-16N2	1-10-62	64	181	9.0	15 / 0.75	7.7 / 0.63	11 / 0.48	2.0 / 0.03		86 / 1.41	1.0 / 0.06	9.0 / 0.25	6.1 / 0.16	0.1 / 0.01	0.1	43	ABS 0.0 Phenol 0.001	138	25	69	0	
W. Velander	8N/6E-17B1	1-10-63	48	114	7.9	8.5 / 0.42	4.1 / 0.34	8.0 / 0.35	0.9 / 0.02		56 / 0.92	0.0 / 0.00	3.1 / 0.09	4.8 / 0.08	0.2 / 0.01	0.01	49	ABS 0.0; ClO_4 1	107	31	38	0	
L. Slatter	8N/6E-17E5	1-10-63	57	117	7.7	7.7 / 0.38	4.1 / 0.34	10 / 0.44	1.0 / 0.02		58 / 0.95	1.8 / 0.02	3.9 / 0.11	4.3 / 0.07	0.2 / 0.01	0.02	43	ABS 0.0; ClO_4 4	103	37	36	0	
M. Dove 175-	8N/6E-17J3	12-28-61	65	179	8.0	20 / 1.00	2.9 / 0.24	14 / 0.61	1.7 / 0.04		103 / 1.69	0.0 / 0.0	4.8 / 0.12	1.8 / 0.02	0.1 / 0.01	0.1	21	ABS 0.0 Phenol 0.000	126	32	62	0	
Citizens Suburban 264'	8N/6E-18D1	1-11-56			7.9	26 / 1.27	6.1 / 0.50	9.9 / 0.42	4.1 / 0.11		142 / 1.86	0.6 / 0.01	6.8 / 0.19	1.2 / 0.17	0.1 / 0.01				194		91	0	
		4-19-60			8.1	24 / 1.20	6.1 / 0.50	11.0 / 0.47	1.6 / 0.04		121 / 1.94	0.7 / 0.02	6.0 / 0.17	0 / 0.0	0.1 / 0.01				161		83	0	

a Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol)

b Future use to be made of these wells

MINERAL ANALYSIS OF GROUND WATER

MINERAL ANALYSIS OF GROUND WATER
FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents[a]	Total[b] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: NCH	Remarks
Citizens Suburban	8N/6E-18P1	4-19-60			8.1	37 / 1.77	12.1 / 0.99	12.5 / 0.55	3.7 / 0.15		185 / 2.96	0.4 / 0.01	12.0 / 0.30	0 / 0.0	0.1 / 0.01				286		139	0	
V. T. Pierson	8N/6E-18R1	1-10-63	66	175	8.1	22 / 1.10	2.2 / 0.18	11 / 0.48	2.8 / 0.07		100 / 1.64	0.8 / 0.02	4.2 / 0.12	1.7 / 0.03	0.0 / 0.00	0.04	40	ABS 0.0; ClO_4 0	134	26	64	0	
San Kang	8N/6E-19N4	1-10-63	67	176	8.2	18 / 0.90	5.1 / 0.42	10 / 0.44	2.6 / 0.07		108 / 1.67	0.0 / 0.00	4.8 / 0.14	0.6 / 0.01	0.1 / 0.00	0.02	43	ABS 0.0; ClO_4 1	134	24	66	0	
P. Takehara	8N/6E-21H2	12-19-61		162	7.7	17 / 0.85	4.8 / 0.35	9.9 / 0.43	2.0 / 0.05		90 / 1.48	1.2 / 0.02	4.3 / 0.12	2.3 / 0.04	0.0 / 0.00	0.04	38	ABS 0.0 Phenol 0.000	143	26	60	0	
F. Ueda	8N/6E-21N1	8-12-59	66	161	7.5	14 / 0.70	5.8 / 0.48	9.5 / 0.41	1.9 / 0.04		82 / 1.34	2.4 / 0.05	5.8 / 0.16	4.7 / 0.08	0.1 / 0.01	0.00	41		145	25	59	0	
		7-24-59		156	8.0	13 / 0.65	6.8 / 0.51	9.7 / 0.42	2.8 / 0.07		82 / 1.34	1.0 / 0.02	5.3 / 0.16	3.8 / 0.05	0.3 / 0.02	0.0	43		145	25	58	0	
		9-12-61	67	157	7.9	15 / 0.75	4.5 / 0.37	9.8 / 0.40	1.6 / 0.04		80 / 1.31	1.3 / 0.03	4.6 / 0.13	4.0 / 0.06	0.2 / 0.01	0.04	44		143	26	56	0	
Rivieson	8N/6E-22P1	12-19-61	65	185	7.7	14 / 0.70	5.6 / 0.46	16 / 0.70	1.6 / 0.04		94 / 1.54	1.8 / 0.04	5.8 / 0.16	6.5 / 0.10	0.2 / 0.01	0.04	45	ABS 0.0 Phenol 0.000	164	37	58	0	
Hoody	8N/6E-25J1	12-19-61	65	164	7.6	11 / 0.55	6.4 / 0.53	12 / 0.52	2.7 / 0.08		73 / 1.20	0.8 / 0.02	11 / 0.31	3.0 / 0.05	0.4 / 0.02	0.03	49	ABS 0.0 Phenol 0.000	150	38	54	0	
Berry	8N/6E-26R2	12-19-61		233	7.9	13 / 0.65	7.2 / 0.59	24 / 1.04	0.9 / 0.02		89 / 1.46	4.0 / 0.08	16 / 0.45	18 / 0.29	0.2 / 0.01	0.00	46	ABS 0.0 Phenol 0.000	187	45	62	0	
Craig 175'	8N/6E-27Q2	12-19-61	64	168	7.8	15 / 0.75	5.0 / 0.41	13 / 0.56	2.5 / 0.06		96 / 1.57	1.6 / 0.03	4.8 / 0.14	0.1 / 0.0	0.1 / 0.0	0.02	24	ABS 0.0 Phenol 0.000	143	31	58	0	
Koenig	8N/6E-27R2	1- 9-63	67	166	7.9	14 / 0.70	4.6 / 0.38	13 / 0.56	2.4 / 0.06		93 / 1.52	2.1 / 0.04	5.6 / 0.16	0.6 / 0.01	0.1 / 0.00	0.02	22	ABS 0.0	140	33	54	0	
F. Souza	8N/6E-28R1	1- 9-63	49	174	7.9	14 / 0.70	6.8 / 0.56	13 / 0.56	1.7 / 0.04		92 / 1.51	0.6 / 0.01	6.0 / 0.17	4.8 / 0.08	0.1 / 0.00	0.04	40	ABS 0.0; ClO_4 1	150	27	63	0	
C. Meyers	8N/6E-28Q1	1- 9-63	49	181	7.9	11 / 0.55	6.2 / 0.51	19 / 0.83	1.4 / 0.04		104 / 1.70	0.5 / 0.01	5.0 / 0.14	1.9 / 0.03	0.1 / 0.00	0.04	39	ABS 0.0; ClO_4 0	146	43	53	0	
Lee Cook	8N/6E-29P1	1- 3-63		183	8.0	14 / 0.70	7.3 / 0.60	14 / 0.61	2.5 / 0.06		107 / 1.75	1.0 / 0.02	4.5 / 0.13	0.8 / 0.0	0.0 / 0.01	0.1	42	ABS 0.0 Phenol 0.001	150	31	65	0	
V. Franklin	8N/6E-29P2	1- 9-63	51	174	8.0	14 / 0.70	7.0 / 0.58	11 / 0.48	1.8 / 0.05		91 / 1.49	0.5 / 0.01	6.6 / 0.19	4.6 / 0.07	0.1 / 0.00	0.04	36	ABS 0.0; ClO_4 1	146	27	64	0	
Manlove Sewage Plant	8N/6E-30C1	1- 4-62	66	159	8.0	16 / 0.80	5.1 / 0.42	9.7 / 0.42	2.8 / 0.05		80 / 1.44	0.0 / 0.00	7.0 / 0.20	1.4 / 0.02	0.1 / 0.01	0.0	41	ABS 0.0 Phenol 0.000	146	25	61	0	
Dick Barry	8N/6E-33B1	1- 4-62		173	8.2	11 / 0.55	5.8 / 0.43	19 / 0.83	1.4 / 0.04		99 / 1.52	0.0 / 0.00	8.8 / 0.25	1.6 / 0.03	0.1 / 0.01	0.1	46	ABS 0.0 Phenol 0.000	153	45	49	0	
Dutra Depth 300'	8N/6E-34N1	1- 4-62	69	179	8.1	12 / 0.60	6.6 / 0.54	16 / 0.70	1.6 / 0.04		87 / 1.43	1.0 / 0.02	13 / 0.37	0.9 / 0.01	0.0 / 0.01	0.1	32	ABS 0.0 Phenol 0.001	149	37	57	0	

a Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol).

b Determined by addition of constituents.

TABLE 9 (Cont.)

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: Non-carb. ppm	Remarks
John Tracy	8N/7E-29Q	7-13-59	70	218	6.8	11 / 0.55	6.4 / 0.53	22 / 0.96	1.0 / 0.03		92 / 1.51	4.1 / 0.08	14 / 0.39	1.4 / 0.02	0.4 / 0.02	0.08	13	NH_4 0.0; ClO_4 0	120	46	54	0	
		5-21-59	70	225	8.0	12 / 0.75	4.8 / 0.35	22 / 0.96	1.7 / 0.04		91 / 1.52	7.4 / 0.15	14 / 0.39	3.1 / 0.05	0.3 / 0.02	0.00	10	NH_4 0.0; ClO_4 0	192	46	55	0	
		5-11-60	69	221	7.5	13 / 0.65	5.7 / 0.47	21 / 0.91	1.5 / 0.04		92 / 1.51	6.0 / 0.14	14 / 0.39	4.4 / 0.07	0.3 / 0.02	0.21	17	ClO_4 0; NH_4 0.0	189	44	56	0	
Douglas Air 175'	8N/7E-4P1	12-26-61		202	7.7	13 / 0.75	9.6 / 0.79	14 / 0.61	1.4 / 0.04		117 / 1.92	2.0 / 0.13	3.0 / 0.11	0.8 / 0.03	0.3 / 0.02	0.1	45	ABS 0.0 Phenol 0.002	152	28	77	0	
Douglas Air 200+	8N/7E-9R1	12-26-61	68	174	7.3	13 / 0.65	6.7 / 0.55	14 / 0.61	1.4 / 0.04		100 / 1.64	1.0 / 0.02	4.0 / 0.11	0.6 / 0.01	0.3 / 0.02	0.1	28	ABS 0.0 Phenol 0.000	148	33	60	0	
P. O'Hannesson	8N/7E-9R1	1- 9-63	50	104	7.3	6.2 / 0.31	2.6 / 0.21	11 / 0.48	0.8 / 0.02		52 / 0.90	1.2 / 0.02	3.0 / 0.08	0.0 / 0.00	0.2 / 0.01	0.02	40	ABS 0.0; ClO_4 0	92	47	26	0	
	8N/7E-12R1	1- 4-62	66	172	7.9	10 / 0.50	4.9 / 0.40	18 / 0.78	1.4 / 0.04		67 / 1.10	14 / 0.29	7.8 / 0.22	2.4 / 0.04	0.3 / 0.02	0.0	84	ABS 0.0 Phenol 0.000	176	45	49	0	
Russel Brothers	8N/7E-14C1	1-11-63	66	144	7.8	7.7 / 0.38	4.9 / 0.40	14 / 0.61	1.1 / 0.03		68 / 1.02	1.0 / 0.06	7.6 / 0.21	4.4 / 0.07	0.3 / 0.02	0.03	69	ABS 0.0; ClO_4 1	142	43	39	0	
Mather AFB Golf Course No.1	8N/7E-16R1	6-21-62	68	161	7.8	12 / 0.60	7.8 / 0.59	11 / 0.48	2.4 / 0.06		98 / 1.61	0.4 / 0.01	4.5 / 0.13	0.0 / 0.00	0.1 / 0.01	0.0	69	CO_3 0.8; Fe (dis.) 0.01; Fe (total) 0.02	146	48	60	0	
Mather AFB Golf Course No.2	8N/7E-18P1	6-21-62	68	165	7.3	13 / 0.65	6.8 / 0.57	11 / 0.48	2.4 / 0.06		99 / 1.62	0.2 / 0.00	4.8 / 0.14	1.6 / 0.03	0.0 / 0.01	0.0	69	CO_3 7.2; Fe (dis.) 0.01; Fe (total) 0.02	149	47	61	0	
Mather AFB Rec Ord Well	8N/7E-19R1	6-21-62	68	173	8.0	12 / 0.60	7.2 / 0.45	16 / 0.70	1.0 / 0.03		100 / 1.64	0.0 / 0.00	6.7 / 0.19	0.0 / 0.01	0.1 / 0.02	0.0	28	CO_3 1.6; Fe (dis.) 0.00; Fe (total) 0.00	150	39	52	0	
Folsom	8N/7E-26Q2	1- 3-62	68	237	8.0	19 / 0.95	13 / 1.09	18 / 0.52	1.0 / 0.03		182 / 2.00	2.0 / 0.19	2.0 / 0.08	1.5 / 0.02	0.2 / 0.01	0.1	67	ABS 0.0 Phenol 0.000	193	20	100	0	
Sacramento Rendering Plant	8N/7E-30A1	1- 9-63	65	178	7.8	11 / 0.55	6.0 / 0.49	16 / 0.70	2.5 / 0.06		90 / 1.48	1.6 / 0.03	6.2 / 0.17	2.6 / 0.04	0.2 / 0.01	0.08	73	ABS 0.0; ClO_4 1	163	39	52	0	
Carli	8N/7E-31R1	1- 4-62	67	170	7.8	11 / 0.55	6.4 / 0.53	15 / 0.65	1.5 / 0.04		81 / 1.33	2.0 / 0.04	11 / 0.31	1.4 / 0.02	0.3 / 0.02	0.1	68	ABS 0.0 Phenol 0.000	157	37	54	0	
Wade Bryant	8N/7E-33H1	12-26-61	66	146	7.6	9.2 / 0.46	8.1 / 0.68	11 / 0.57	0.6 / 0.02		71 / 1.16	1.0 / 0.02	6.0 / 0.17	0.5 / 0.01	0.0 / 0.01	0.1	81	ABS 0.0 Phenol 0.001	134	39	44	0	
Sacramento County Boys Ranch	8N/8E-18K	1- 3-62	70	179	7.7	13 / 0.65	8.4 / 0.69	10 / 0.44	0.3 / 0.01		64 / 1.05	17 / 0.35	8.5 / 0.24	7.0 / 0.08	0.0 / 0.01	0.0	20	ABS 0.0 Phenol 0.000	144	85	67	15	
Al Pilliton	8N/8E-23R1	8-29-61		197	7.7	13 / 0.65	5.8 / 0.43	15 / 0.65	1.0 / 0.02		41 / 0.67	34 / 0.71	14 / 0.39	0.4 / 0.01	0.3 / 0.02	0.08	64		167	37	54	20	
Wilson	8N/8E-30B	1- 3-62	64	382	8.0	34 / 1.70	19 / 1.58	19 / 0.83	7.3 / 0.19		230 / 3.77	7.0 / 0.15	8.0 / 0.23	0.0 / 0.00	0.0 / 0.0	0.1	22	ABS 0.0 Phenol 0.001	263	19	164	0	
Peasant: Harris	9N/6E-13Q1	12-20-61	54	415	8.1	38 / 1.90	25 / 2.06	12 / 0.52	1.6 / 0.04		201 / 3.29	20 / 0.58	8.0 / 0.23	15 / 0.24	0.1 / 0.01	0.1	28	ABS 0.0 Phenol 0.000	306	12	197	30	

a Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenol, Temperature (Temp.)

b Temperature not by same number of constituents

TABLE 9 (Cont.)

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents[a]	Total[b] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: Non-carb.	Remarks
J. W. Lowery	9N/6E-23Q2	12-18-61		326	7.2	83 / 1.15	17 / 1.41	12 / 0.52	1.6 / 0.04		121 / 1.98	16 / 0.33	20 / 0.56	14 / 0.22	0.2 / 0.01	0.07	27	ABS 0.0 Phenol 0.000	280	17	128	29	
Pines Homes, Inc. Mobile Country Club	9N/6E-24J1	8-15-62			7.6	19.8 / 0.99	10.1 / 0.81	16.0 / 0.69	1.9 / 0.05		132 / 2.11	9.4 / 0.20	4.6 / 0.11	4.4 / 0.07	0.05 / 0.01				179		91		
		1-14-63	64	222	8.2	20 / 1.00	8.3 / 0.68	14 / 0.61	1.7 / 0.04		121 / 2.02	7.1 / 0.15	4.3 / 0.12	3.5 / 0.06	0.1 / 0.00	0.02	46	ABS 0.0; ClO_4 2	165	26	84	0	
Beach	9N/6E-24R2	12-18-61		327	7.5	89 / 1.45	15 / 1.21	13 / 0.65	2.8 / 0.07		175 / 2.87	14 / 0.29	4.8 / 0.14	6.7 / 0.11	0.1 / 0.0	0.07	43	ABS 0.0 Phenol 0.000	216	19	133	0	
Natoma No. 11	9N/6E-25R1	1-14-63	66	248	8.1	24 / 1.20	10 / 0.84	12 / 0.52	1.0 / 0.00		133 / 2.18	8.4 / 0.17	5.0 / 0.14	5.6 / 0.09	0.1 / 0.00	0.03	32	ABS 0.0; ClO_4 1	183	20	102	0	
Rivards Hotel	9N/6E-25N1	3-23-55		181	7.5	15 / 0.75	7.3 / 0.60	9.8 / 0.43	1.3 / 0.03		96 / 1.54	5.3 / 0.09	4.0 / 0.11	2.1 / 0.03		0.16		NH_4 0.3; ClO_4 0 NO_2 0.01		23	68	0	
		7-26-55	70	182									3.3 / 0.09	1.8 / 0.03				NH_4 1.6; NO_2 0.02; ClO_4 1					
		5-21-56	69	186	7.8	17 / 0.85	11 / 0.87	11 / 0.48	1.3 / 0.03		105 / 1.72	18 / 0.38	4.0 / 0.11	1.7 / 0.03	0.0 / 0.00	0.16	22	NH_4 0.0	176	21	86	0	
		9-16-57	68	182	7.4	16 / 0.80	6.8 / 0.56	11 / 0.48	1.5 / 0.04		96 / 1.58	8.6 / 0.18	3.0 / 0.11	2.1 / 0.03	0.1 / 0.01	0.02	28	NH_4 0.0 ClO_4 1	149	26	68	0	
		7-14-58	67	178	7.2	15 / 0.75	7.2 / 0.59	9.6 / 0.42	0.7 / 0.02		93 / 1.52	4.8 / 0.10	3.3 / 0.10	1.8 / 0.02	0.1 / 0.0	0.01	43	NH_4 0.0 ClO_4 0	133	24	67	0	
		5-21-59		178	7.7	18 / 0.90	2.1 / 0.42	10 / 0.44	1.0 / 0.03		90 / 1.51	7.0 / 0.15	2.8 / 0.08	2.8 / 0.04	0.0 / 0.01	0.02	49	NH_4 0.0 ClO_4 0	141	24	66	0	
		7- 9-59		168														NH_4 0.1 ClO_4 0.8					
		5-11-60	66	170	7.8	15 / 0.75	6.8 / 0.51	9.0 / 0.39	1.0 / 0.03		87 / 1.42	2.5 / 0.05	3.0 / 0.11	1.7 / 0.03	0.0 / 0.01	0.01	29	ClO_4 0	133	23	63	0	
Walker Berg & Co.	9N/6E-25P1	1- 9-63	49	216	7.5	13 / 0.75	12 / 1.01	10 / 0.44	1.2 / 0.03		124 / 2.03	4.8 / 0.10	4.1 / 0.12	0.8 / 0.01	0.1 / 0.00	0.00	47	ABS 0.0; ClO_4 0	156	20	88	0	
Inter. Ass. of Machinest	9N/6E-25Q1	1- 9-63	65	246	7.9	19 / 0.95	13 / 1.07	12 / 0.52	1.6 / 0.04		138 / 2.26	8.9 / 0.18	4.6 / 0.13	1.8 / 0.02	0.1 / 0.00	0.01	31	ABS 0.0; ClO_4 0	179	20	101	0	
Natoma No. 9	9N/6E-26J1	1-14-63	67	244	8.2	23 / 1.15	9.6 / 0.79	12 / 0.52	1.8 / 0.05		129 / 2.11	2.5 / 0.05	6.7 / 0.19	2.0 / 0.03	0.1 / 0.00	0.04	27	ABS 0.0; ClO_4 1	167	20	97	0	
Natoma No. 10	9N/6E-26L1	1-14-63	66	260	8.1	24 / 1.20	11 / 0.88	12 / 0.52	5.0 / 0.13		138 / 2.26	3.1 / 0.06	10 / 0.28	4.3 / 0.07	0.1 / 0.00	0.04	27	ABS 0.0; ClO_4 1	194	19	104	0	
Rancho Cordova Sewage Plant	9N/6E-27L1	7-14-58	66	246	7.2	24 / 1.20	7.5 / 0.62	15 / 0.65	2.8 / 0.06		138 / 2.26	5.8 / 0.12	7.1 / 0.20	2.8 / 0.04	0.1 / 0.00	0.1	32	NH_4 0.0 ClO_4 0	160	26	91	0	
		5-21-59		247	7.8	27 / 1.35	5.5 / 0.45	15 / 0.65	2.0 / 0.05		130 / 2.16	5.5 / 0.11	6.6 / 0.19	4.3 / 0.07	0.1 / 0.00	0.01	30	NH_4 0.0 ClO_4 0	169	26	90	0	

a Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol).

b Determined by addition of constituents

TABLE 9 (Cont.)

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total dissolved solids in ppm	Specific conductance	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
Rancho Cordova Sewage Plant	9N/6E-27L1	9-11-62	66	838	8.1	85 / 4.25	6.7 / 0.55	14 / 0.61	1.8 / 0.05		126 / 2.06	3.0 / 0.06	7.8 / 0.22	2.7 / 0.04	0.1 / 0.00	0.00	51	NH$_4$ 0.0 ClO$_4$ 0	153	85	90	0	
Natoma No. 6	9N/6E-27R1	12-17-56			8.3	87 / 4.35	12.1 / 1.01	12.4 / 0.53	1.5 / 0.04		110 / 2.14	2.1 / 0.11	7.0 / 0.20	2.7 / 0.19	0.0 / 0.00				211		118		
		1-14-63	64	891	8.3	86 / 4.06	12 / 1.02	14 / 0.61	1.8 / 0.05		147 / 2.41	2.1 / 0.11	7.2 / 0.20	14 / 0.22	0.2 / 0.01	0.02	49	ABS 0.0; ClO$_4$ 2	206	20	121	1	
Natoma No. 3	9N/6E-34Q1	10- 9-56			8.3	88.1 / 4.41	10.6 / 0.87	12.4 / 0.53	1.7 / 0.04		144 / 2.36	2.4 / 0.11	8.1 / 0.23	2.0 / 0.16	0.0 / 0.00				219		114		
		1-14-63	64	302	8.3	33 / 1.65	9.6 / 0.79	15 / 0.65	2.0 / 0.05		132 / 2.59	8.2 / 0.17	9.4 / 0.26	11 / 0.18	0.1 / 0.00	0.03	62	ABS 0.0; ClO$_4$ 1	205	21	122	0	
Citizens Suburban Cordova Meadows #1	9N/6E-34N2	10- 9-58			8.3	83 / 1.13	9.5 / 0.78	12 / 0.52	1.7 / 0.04		121 / 1.97	7.0 / 0.15	6.9 / 0.19	0.9 / 0.06	0.1 / 0.01			Fe (total) 0.10	187		96		
Virgil Parrish	9N/6E-34N2	12-20-61	66	838	7.7	19 / 0.95	11 / 0.93	11 / 0.48	1.1 / 0.03		91 / 1.49	11 / 0.27	16 / 0.45	4.7 / 0.08	0.0 / 0.01	0.1	59	ABS 0.0 Phenol 0.000	170	20	94	19	
Natoma No. 1	9N/6E-35C2	8- 4-54			7.6	24.0 / 1.20	9.6 / 0.79	13 / 0.56	1.5 / 0.04		139 / 2.28	1.6 / 0.03	9.3 / 0.27	7.0 / 0.11	0 / 0.00			Fe (total) 0.02	206		107		
Natoma No. 2	9N/6E-35C3	8- 4-54			8.0	20 / 1.00	8.3 / 0.69	19 / 0.82	0 / 0.00		134 / 2.18	2.5 / 0.05	3.0 / 0.08	0 / 0.00	0.4 / 0.01			Fe (total) 0.80	187		84		
Natoma No. 5	9N/6E-35R1	12-17-56			8.1	14.6 / 0.73	3.0 / 0.01	9.2 / 0.01	2.1 / 0.05		79 / 1.27	4.1 / 0.09	3.0 / 0.08	0.32 / 0.04	0 / 0.00			Fe (total) 0.04	180		57		
Aero D	9N/6E-36Q1	1- 9-63	60	189	7.7	19 / 0.75	7.9 / 0.65	11 / 0.48	1.2 / 0.03		86 / 1.41	4.7 / 0.09	6.0 / 0.17	17 / 0.27	0.2 / 0.01	0.05	58	ABS 0.0; ClO$_4$ 0	163	85	78	0	
McDuffee	9N/6E-36K1	12-20-61	66	284	7.8	17 / 0.85	12 / 0.95	10 / 0.44	1.4 / 0.04		110 / 1.80	2.0 / 0.10	3.0 / 0.13	10 / 0.16	0.1 / 0.02	0.1	36	ABS 0.0 Phenol 0.000	171	19	90	0	
Mabel Brown	9N/7E-12Q1	12-20-61	67	117	7.9	9.8 / 0.46	3.4 / 0.28	10 / 0.44	0.6 / 0.02		63 / 1.03	2.0 / 0.06	3.0 / 0.08	0.2 / 0.00	0.4 / 0.02	0.1	84	ABS 0.0 Phenol 0.000	145	37	31	0	
Bettie Rodgers	9N/7E-13M3	11-18-53	63	338	7.1	27 / 1.35	16 / 1.48	12 / 0.52	1.6 / 0.04		169 / 2.77	6.3 / 0.13	16 / 0.45	2.9 / 0.05	0.0 / 0.00	0.01	22		219	15	141	3	
		11- 4-55	67	360	8.4	30 / 1.50	21 / 1.72	14 / 0.61	1.9 / 0.05		178 / 2.92	8.4 / 0.18	18 / 0.51	12 / 0.19	0.0 / 0.00	0.00	23		246	16	161	15	
		7-11-57	76	349	6.8	30 / 1.50	20 / 1.66	12 / 0.52	1.8 / 0.03		169 / 2.77	8.9 / 0.21	18 / 0.51	8.8 / 0.14	0.1 / 0.01	0.04	44		227	14	138		
		9-16-57	64	364	6.9	28 / 1.40	21 / 1.76	14 / 0.61	1.7 / 0.04		171 / 2.80	7.7 / 0.16	19 / 0.54	12 / 0.19	0.0 / 0.00	0.00	34	NH$_4$ 0.4 ClO$_4$ 1.0	243	16	137	17	
		7-13-58		472	6.9	34 / 1.70	27 / 2.26	14 / 0.61	1.8 / 0.03		147 / 2.41	11 / 0.23	27 / 0.76	48 / 0.77	0.2 / 0.01	0.00	46	NH$_4$ 0.0 ClO$_4$ 0	308	13	198	78	
		5-21-59	69	346	8.2	30 / 1.48	16 / 1.36	12 / 0.52	1.8 / 0.03		164 / 2.69	8.4 / 0.17	17 / 0.48	6.7 / 0.11	0.1 / 0.00	0.04	23	NH$_4$ 0.0	207	14	144	11	

MINERAL ANALYSES OF GROUND WATER

FOLSOM–EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents[a]	Total[b] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
Hattie Rodgers	9N/7E-15Q3	5-11-60	66	316	7.3	84 / 1.80	19 / 1.58	12 / 0.52	1.0 / 0.02		158 / 2.59	6.1 / 0.13	16 / 0.45	2.8 / 0.04	0.1 / 0.00	0.08	51	ClO_4 0	210	16	139	9	
USBR	9N/7E-16Q1	8-26-58		477	7.6	90 / 2.50	22 / 1.78	14 / 0.61	3.3 / 0.08		210 / 3.44	17 / 0.35	40 / 1.13	0.4 / 0.01	0.0 / 0.00	0.09	28		308	12	214	42	
		6-18-58		458	8.4	90 / 2.50	21 / 1.74	13 / 0.57	3.1 / 0.08		191 / 3.13	17 / 0.35	40 / 1.13	2.2 / 0.04	0.0 / 0.00	0.1	21		267	12	212	46	
		7- 7-61		393	8.2			14 / 0.61					24 / 0.68	2.6 / 0.04									
Tenant: Carlin	9N/7E-16Q1	11-12-53	66	399	8.1	37 / 1.85	20 / 1.64	14 / 0.61	3.3 / 0.08		183 / 3.03	35 / 0.73	12 / 0.34	1.3 / 0.02	0.0 / 0.00	0.05	60		274	15	175	23	
William Clarkson	9N/7E-16Q1	2-26-58		400	7.2	36 / 1.80	24 / 2.00	15 / 0.65	2.3 / 0.06		208 / 3.41	27 / 0.56	13 / 0.37	0.5 / 0.01	0.0 / 0.00	0.00	64		284	14	190	19	
		6-18-58		391	7.8	34 / 1.70	21 / 1.75	16 / 0.70	2.4 / 0.06		203 / 3.33	21 / 0.44	12 / 0.34	2.2 / 0.04	0.0 / 0.00	0.00	69		274	17	172	6	
Howard Greenhalgh	9N/7E-16Q1	11-12-53	63	257	7.6	23 / 1.15	13 / 1.07	7.6 / 0.33	1.8 / 0.05		100 / 1.77	2.6 / 0.05	24 / 0.68	1.8 / 0.03	0.1 / 0.01	0.03	46		173	13	111	22	
Potomac Dredging Company	9N/7E-16P1	11-12-53	64	349	8.1	22 / 1.75	18 / 1.48	12 / 0.52	2.0 / 0.05		158 / 2.24	13 / 0.27	6.2 / 0.18	1.8 / 0.03	0.0 / 0.00	0.03	46		238	14	161	0	
		8-26-58		99	7.0	7.6 / 0.38	5.4 / 0.44	4.7 / 0.20	0.7 / 0.02		47 / 0.77	9.6 / 0.20	3.0 / 0.08	0.0 / 0.00	0.0 / 0.00	0.00	30		84	19	41	2	
		6-18-58		278	7.3	23 / 1.15	16 / 1.29	9.0 / 0.39	1.3 / 0.03		133 / 2.18	9.6 / 0.20	16 / 0.45	2.2 / 0.04	0.0 / 0.00	0.00	36		177	14	122	3	
		7- 7-61		94	7.4			5.1 / 0.22					3.0 / 0.08	0.7 / 0.01									
Jet Cafe	9N/7E-16P2	2-26-58		336	7.2	36 / 1.80	16 / 1.30	12 / 0.52	2.0 / 0.05		170 / 2.82	18 / 0.37	8.4 / 0.24	6.4 / 0.10	0.0 / 0.00	0.00	40		222	15	150	9	
		6-18-58		345	7.3	31 / 1.55	14 / 1.13	16 / 0.70	2.1 / 0.05		119 / 1.95	32 / 0.67	14 / 0.39	29 / 0.47	0.0 / 0.00	0.10	36		233	20	134	36	
		7- 7-61		182	8.4			13 / 0.57					7.0 / 0.20	10 / 0.16									
Libby, McNeill and Libby Co.	9N/7E-16Q1	8-27-52		399	7.2	40 / 2.00	21 / 1.73	14 / 0.61	3.0 / 0.03		218 / 3.57	14 / 0.29	16 / 0.45	2.0 / 0.03	0.0 / 0.00	0.01	23		269	14	186	8	
		11-12-53	64	490	8.0	48 / 2.40	25 / 2.06	14 / 0.61	2.1 / 0.05		221 / 3.62	14 / 0.29	40 / 1.13	2.7 / 0.04	0.0 / 0.00	0.04	24		309	12	223	42	
		3-23-55		646	7.8	59 / 2.95	34 / 2.76	18 / 0.78	2.5 / 0.06		232 / 3.80	3.2 / 0.07	88 / 2.31	4.8 / 0.08		0.02		NH_3 0.7; NO_2 0.01; ClO_4 0		12	183	95	
		7-26-55	64	466									32 / 0.90	6.0 / 0.10				NH_3 1.4; NO_2 0.00; ClO_4 0					

a Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol).

b Determined by addition of constituents.

TABLE 9 (Cont.)

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total[B] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
Libby, McNeill and Libby Co.	9N/7E-16Q1	11- 4-55	62	523	8.3	53 / 2.64	26 / 2.12	18 / 0.78	2.3 / 0.06		210 / 3.44	14 / 0.29	52 / 1.47	3.0 / 0.05	0.0 / 0.00	0.06	56	NO$_3$ 0.2; ClO$_4$ 2	330	14	238	53	
		8-30-56	66	403				14 / 0.61					19 / 0.54			0.00					189		
		9-18-57	64	476	8.0	43 / 2.15	23 / 1.89	18 / 0.78	2.3 / 0.06		210 / 3.44	12 / 0.25	40 / 1.13	3.4 / 0.09	0.0 / 0.00	0.0	22	NO$_3$ 0.0; ClO$_4$ 2	303	16	202	30	
		8-26-58		658	8.2	59 / 2.96	32 / 2.66	27 / 1.17	2.7 / 0.07		230 / 3.92	17 / 0.35	87 / 2.45	3.0 / 0.08	0.0 / 0.00	0.00	27		405	17	280	84	
		7-14-59		404	7.2	37 / 1.85	20 / 1.65	16 / 0.70	2.2 / 0.06		206 / 3.61	13 / 0.27	13 / 0.42	1.2 / 0.03	0.0 / 0.01	0.01	45	NO$_3$ 0.0; ClO$_4$ 0	254	16	173	5	
		5-21-59	70	416	7.8	45 / 2.24	18 / 1.46	13 / 0.56	2.0 / 0.05		209 / 3.42	13 / 0.27	19 / 0.54	2.5 / 0.04	0.1 / 0.00	0.02	26	NO$_3$ 0.0; ClO$_4$ 0	272	13	185	14	
		5-11-60	69	372	8.5	38 / 1.90	20 / 1.68	11 / 0.48	2.0 / 0.05		190 / 3.11	9.0 / 0.19	12 / 0.34	1.6 / 0.02	0.1 / 0.00	0.03	22	ClO$_4$ 0	252	12	179	7	
		7- 7-61		377	8.4			15 / 0.65					16 / 0.45	3.0 / 0.05									
	9N/7E-15Q2	8-26-58		380	7.1	36 / 1.78	21 / 1.74	15 / 0.65	2.2 / 0.06		195 / 3.20	17 / 0.35	17 / 0.48	2.1 / 0.03	0.0 / 0.00	0.00	60		265	16	172	12	
		6-18-59		381	8.3	34 / 1.70	20 / 1.66	12 / 0.83	2.3 / 0.06		188 / 3.08	20 / 0.42	12 / 0.34	1.8 / 0.06	0.1 / 0.01	0.1	60		273	20	168	7	
		7- 7-61		377	8.4			12 / 0.65					16 / 0.45	3.5 / 0.06									
Pac. Gas & Agg.	9N/7E-10Q1	1-10-63	61	208	8.0	22 / 1.10	8.7 / 0.70	6.8 / 0.30	2.3 / 0.06		110 / 1.80	9.4 / 0.20	3.5 / 0.10	1.4 / 0.02	0.1 / 0.00	0.03	42	ABS 0.0; ClO$_4$ 1	150	14	90	0	
Air Products, Inc.	9N/7E-21Q1	8-26-58		316	7.7	39 / 1.95	13 / 1.02	14 / 0.61	2.3 / 0.16		166 / 2.72	19 / 0.40	9.6 / 0.27	0.0 / 0.00	0.00 / 0.00	0.00	62		240	18	136	0	
		6-18-59		313	7.7	24 / 1.20	16 / 1.32	13 / 0.57	5.0 / 0.13		160 / 2.62	12 / 0.25	11 / 0.31	1.8 / 0.03	0.0 / 0.00	0.00	62		224	18	126	0	
		7-14-59		320	7.6	30 / 1.50	14 / 1.18	12 / 0.52	4.0 / 0.10		166 / 2.72	18 / 0.37	3.0 / 0.08	0.8 / 0.01	0.0 / 0.01	0.00	60	NO$_3$ 0.0; ClO$_4$ 0	224	16	131	0	
		5-21-59		331	7.8	34 / 1.70	11 / 0.92	14 / 0.61	5.0 / 0.13		167 / 2.74	13 / 0.27	10 / 0.28	2.4 / 0.04	0.1 / 0.00	0.05	61	NO$_3$ 0.0; ClO$_4$ 0	232	18	131	0	
		5-11-60		314	8.6	32 / 1.60	13 / 1.06	11 / 0.48	5.1 / 0.13		151 / 2.47	12 / 0.25	10 / 0.28	1.1 / 0.02	0.1 / 0.00	0.02	61	ClO$_4$ 0	226	15	133	0	
		8-24-61		308	7.2	31 / 1.55	13 / 1.09	13 / 0.56	4.8 / 0.12		164 / 2.69	12 / 0.25	2.9 / 0.08	2.2 / 0.04	0.2 / 0.01	0.02	62		232	17	130	0	
		8-10-62		326	8.2	31 / 1.55	13 / 1.07	14 / 0.61	4.8 / 0.12		162 / 2.72	13 / 0.27	10 / 0.28	2.7 / 0.06	0.1 / 0.00	0.04	62	ClO$_4$ 0	224	18	132	0	

[B] Any [illegible] (SiO$_2$), Aluminum (Al), Iron (Fe), [illegible]

TABLE 9 (Cont.)

MINERAL ANALYSIS OF GROUND WATER

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents[a]	Total[b] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: Non-carbonate	Remarks
Aerojet Test Thief	9N/7E-23L1	9-12-62	66	541	6.6	48 / 2.40	39 / 3.05	16 / 0.70	1.1 / 0.03		318 / 5.21	19 / 0.40	10 / 0.28	0.0 / 0.00	0.1 / 0.00	0.01	47		339	12	265	4	
Aerojet Test M.P.U.	9N/7E-23L1	9-12-62	66	509	7.4	48 / 2.40	38 / 2.66	15 / 0.65	0.9 / 0.02		306 / 5.02	18 / 0.37	8.7 / 0.24	0.4 / 0.01	0.4 / 0.02	0.01	44		317	11	250	0	
Aerojet Thief	9N/7E-24M1	9-12-62		412	7.2	26 / 1.30	19 / 1.82	41 / 1.78	1.5 / 0.04		202 / 3.31	7.7 / 0.16	16 / 0.45	0.6 / 0.01	0.7 / 0.04	0.14	18		236	41	126	0	
Aerojet M.P.U.	9N/7E-24M1	9-12-62		394	7.4	24 / 1.20	13 / 1.10	43 / 1.87	1.3 / 0.03		210 / 3.44	8.7 / 0.18	16 / 0.45	4.5 / 0.07	0.8 / 0.04	0.10	22		243	44	115	0	
Capital Dredging	9N/7E-26K1	11-18-53	68	115	7.7	6.2 / 0.31	3.2 / 0.32	7.4 / 0.32	1.0 / 0.03		43 / 0.70	4.2 / 0.10	2.0 / 0.14	0.2 / 0.14	0.1 / 0.00	0.02	52		121	29	38	3	
		3-23-55		115	7.5	6.2 / 0.31	3.6 / 0.32	6.5 / 0.28	0.7 / 0.02		39 / 0.64	7.0 / 0.15	2.0 / 0.14	0.6 / 0.14		0.02		NH_3 0.6; NO_2 0.0; ClO_4 0		26	38	6	
		7-26-55	69	121									4.6 / 0.13	0.2 / 0.14				NH_3 1.3; NO_2 0.01; ClO_4 0					
		11- 4-55	66	123				6.0 / 0.26					4 / 0.11								43		
		5-21-56	63	122	7.2	6.6 / 0.48	3.7 / 0.30	7.5 / 0.33	0.8 / 0.02		46 / 0.75	3.0 / 0.06	2.0 / 0.14	0.2 / 0.14	1.0 / 0.05	0.16	66	NH_3 0.0	126	29	39	1	
		9-16-57	68	119	6.6	8.0 / 0.44	3.8 / 0.31	8.0 / 0.35	1.2 / 0.03		44 / 0.72	4.0 / 0.10	6.7 / 0.19	0.1 / 0.13	0.1 / 0.01	0.0	53	NH_3 0.0; ClO_4 0	126	31	38	2	
		7-13-58	67	118	6.7	9.0 / 0.45	4.2 / 0.35	6.8 / 0.30	0.7 / 0.02		41 / 0.67	8.6 / 0.18	6.0 / 0.17	2.9 / 0.10	0.2 / 0.01	0.00	23	NH_3 0.0 ClO_4 0	114	27	40	6	
		5-21-59	66	124	6.7	12 / 0.60	2.2 / 0.18	6.8 / 0.30	0.8 / 0.02		38 / 0.62	5.4 / 0.11	4.8 / 0.14	11 / 0.18	0.1 / 0.00	0.04	61	NH_3 0.0 ClO_4 0	123	27	39	0	
		5-11-60	63	116	7.4	9.1 / 0.45	3.8 / 0.31	6.0 / 0.26	0.4 / 0.01		38 / 0.62	4.8 / 0.10	3.7 / 0.10	7.3 / 0.12	0.1 / 0.01	0.06	28	ClO_4 0	114	25	38	7	
		8-24-61		126	6.6	10 / 0.50	3.6 / 0.30	7.4 / 0.32	0.7 / 0.02		41 / 0.67	5.6 / 0.12	2.4 / 0.15	10 / 0.16	0.2 / 0.01	0.02	62		129	28	40	6	
		8-10-62	64	136	7.7	14 / 0.70	2.4 / 0.20	8.6 / 0.37	1.0 / 0.02		53 / 0.88	5.4 / 0.11	3.0 / 0.16	5.0 / 0.18	0.1 / 0.00	0.06	32	ClO_4 0	123	29	45	1	
Brighton S. & G.	9N/7E-26J1	3-23-55		237	7.8	13 / 0.65	7.9 / 0.65	27 / 1.17	1.3 / 0.03		120 / 2.10	6.4 / 0.13	6.0 / 0.17	3.8 / 0.09		0.2		NH_3 0.4; NO_2 0.0; ClO_4 0		46	65	0	
		7-26-55	72	238									6.0 / 0.25	0.3 / 0.04				NH_3 2.1; NO_2 0.0; ClO_4 0					
County Dump	9N/7E-26N1	1-11-63		227	8.0	18 / 0.90	11 / 0.92	14 / 0.61	1.0 / 0.02		132 / 2.16	7.6 / 0.16	3.6 / 0.10	0.2 / 0.00	0.2 / 0.01	0.01	36	ABS 0.0; ClO_4 0	177	25	91	0	
E. Culyer	9N/7E-27F1	11-18-53	66	166	7.8	8.0 / 0.41	6.2 / 0.52	14 / 0.61	0.6 / 0.02		71 / 1.16	15 / 0.31	3.0 / 0.14	0.8 / 0.01	0.1 / 0.00	0.04	22		136	38	67	0	

a - Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol).

b Determined by addition of constituents.

TABLE 9 (Cont.)

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents [a]	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
E. Colyer	9N/7E-27P1	3-23-55		191	7.8	44 / 0.55	8.0 / 0.67	16 / 0.70	0.6 / 0.02		88 / 1.44	6.4 / 0.13	6.5 / 0.18	1.6 / 0.03		0.02		NH_4 0.2; ClO_4 0/2; NO_2 0.0;		35	61	0	
		7-26-55		217									2.0 / 0.05	2.2 / 0.06				NH_4 1.4; ClO_4 1/2; NO_2 0.0;					
		9-21-56	69	214	7.9	52 / 0.65	11 / 0.93	17 / 0.74	0.7 / 0.02		106 / 1.74	16 / 0.33	8.5 / 0.24	3.1 / 0.06	1.0 / 0.05	0.02	60	NH_4 0.0	183	32	79	0	
		9-16-57	65	232	7.1	54 / 0.70	11 / 0.87	17 / 0.74	0.9 / 0.02		102 / 1.67	13 / 0.27	9.3 / 0.26	6.6 / 0.07	0.1 / 0.01	0.00	24	NH_4 0.0; ClO_4 1/2	175	32	78	0	
		7-14-58	66	252	6.8	46 / 0.88	12 / 0.96	16 / 0.70	0.6 / 0.02		100 / 1.64	22 / 0.46	11 / 0.31	2.0 / 0.03	0.1 / 0.00	0.02	32	NH_4 0.0; ClO_4 0/2	184	26	68	6	
		9-21-59	74	255	7.6	59 / 0.95	9.1 / 0.75	16 / 0.70	0.6 / 0.02		106 / 1.74	19 / 0.40	9.4 / 0.26	6.6 / 0.11	0.0 / 0.01	0.04	24	NH_4 0.0; ClO_4 0/2	188	31	85	0	
		9-11-60	65	260	8.0	52 / 0.75	12 / 1.01	16 / 0.70	0.3 / 0.01		106 / 1.74	16 / 0.33	9.7 / 0.27	3.2 / 0.06	0.1 / 0.00	0.06	28	ClO_4 0	183	28	88	1	
Aerojet	9N/7E-28R1	7-29-53	70	245	7.3	84 / 1.20	6.8 / 0.78	14 / 0.61	2.6 / 0.07		149 / 2.33	2.6 / 0.05	6.5 / 0.18	0.0 / 0.00	0.0 / 0.01	0.07	13		202	83	96	0	
		11-26-54	70	243									7.0 / 0.20					NH_4 0.7; ClO_4 0					
		3-23-55		250	7.8	57 / 0.85	14 / 1.11	14 / 0.61	2.3 / 0.06		143 / 2.31	10 / 0.25	7.5 / 0.21	0.4 / 0.01		0.12		NH_4 0.2; ClO_4 1/2; NO_2 0.0;		83	98	0	
		7-26-55		247									7.1 / 0.20	0.8 / 0.00				NH_4 1.2; ClO_4 1/2; NO_2 0.02;					
		11-4-55	69	245	8.4	84 / 1.20	8.8 / 0.73	15 / 0.65	0.7 / 0.02		136 / 2.23	3.0 / 0.06	7.0 / 0.20	0.8 / 0.00	0.1 / 0.01	0.02	13	NH_4 0.2; ClO_4 0/2	205	85	96	0	
		9-21-56		247	8.0	83 / 1.15	2.5 / 0.63	14 / 0.61	2.6 / 0.07		131 / 2.08	3.0 / 0.06	8.0 / 0.23	0.8 / 0.00	1.0 / 0.03	0.08	24	NH_4 6.8; ClO_4 2/2	208	83	86	0	
		9-16-57	67	185	7.5	54 / 0.70	8.8 / 0.86	12 / 0.52	1.8 / 0.05		98 / 1.61	1.0 / 0.02	2.8 / 0.16	2.0 / 0.03	0.1 / 0.01	0.0	22	NH_4 0.0; ClO_4 1/2	169	67	68	0	
		7-13-58		254	7.3	84 / 1.20	2.7 / 0.22	14 / 0.61	2.2 / 0.06		144 / 2.36	1.8 / 0.04	8.0 / 0.22	0.1 / 0.00	0.0 / 0.01	0.02	32	NH_4 0.0; ClO_4 0/2	200	83	100	0	
		9-21-59	68	263	7.7	84 / 1.20	7.5 / 0.62	14 / 0.61	2.2 / 0.06		149 / 2.33	1.0 / 0.02	3.1 / 0.15	0.6 / 0.01	0.0 / 0.01	0.04	22	NH_4 0.0; ClO_4 0/2	193	84	91	0	
		9-11-60	70	244	8.1	84 / 1.20	9.1 / 0.75	13 / 0.56	2.3 / 0.06		138 / 2.26	1.6 / 0.03	7.0 / 0.22	0.8 / 0.00	0.0 / 0.01	0.02	21	NH_4 0.0; ClO_4 0/2	197		98	0	
Aerojet	9N/7E-28R2	4- 3-56		266	8.0	83 / 1.15	14 / 1.17	10 / 0.52	1.4 / 0.04		122 / 2.31	3.0 / 0.08	7.0 / 0.20	4.2 / 0.07	1.0 / 0.03	0.03	256	NH_4 1.1	199	18	116	0	Sampled 89-90' Cased off below 125'
		4-23-56		219	7.3	57 / 0.85	10 / 0.99	16 / 0.70	2.1 / 0.05		133 / 2.18	6.0 / 0.12	10 / 0.28	0.3 / 0.01	0.7 / 0.04	0.13	57	NH_4 0.6	196	27	92	0	Sampled 198-204' Plugged later at 160'

a Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol)

b Determined by addition of constituents

TABLE 9 (Cont.)

MINERAL ANALYSIS OF GROUND WATER

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents [a]	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
Aerojet	9N/7E-8M1	9-16-57	67	244	7.4	23 / 1.15	8.8 / 0.72	14 / 0.61	1.0 / 0.03		140 / 2.29	8.9 / 0.06	8.0 / 0.23	0.2 / 0.00	0.1 / 0.01	0.00	72	NH_3 0.0; ClO_4 0	202	24	94	0	
		7-14-58		226	7.6	18 / 0.90	9.2 / 0.76	14 / 0.61	2.1 / 0.05		129 / 2.11	1.3 / 0.03	3.4 / 0.15	0.3 / 0.00	0.2 / 0.01	0.01	68	NH_3 0.0; ClO_4 0	176	26	83	0	
		5-21-59	69	242	7.1	24 / 1.20	7.3 / 0.60	14 / 0.61	2.3 / 0.06		130 / 2.26	1.0 / 0.02	5.5 / 0.16	0.8 / 0.01	0.2 / 0.01	0.01	74	NH_3 0.0; ClO_4 0	197	25	90	0	
		5-11-60	69	241	7.8	20 / 1.00	10 / 0.84	13 / 0.56	2.0 / 0.05		126 / 2.25	0.0 / 0.00	5.9 / 0.17	0.4 / 0.01	0.2 / 0.01	0.01	73	NH_3 0.2; ClO_4 0	198	23	92	0	
		8-16-61		241	7.1	20 / 1.00	9.7 / 0.80	14 / 0.61	2.0 / 0.05		135 / 2.21	1.6 / 0.03	5.7 / 0.16	1.3 / 0.02	0.2 / 0.01	0.02	73		194	25	90	0	
		8- 3-62		235	7.7	21 / 1.15	7.9 / 0.65	14 / 0.61	2.3 / 0.06		131 / 2.15	1.4 / 0.07	7.1 / 0.20	0.0 / 0.00	0.2 / 0.01	0.02	61	ClO_4 0	189	25	90	0	
Aerojet Test Well	9N/7E-8M1	9-13-62	68	274	7.1	25 / 1.25	13 / 1.07	14 / 0.61	1.4 / 0.04		161 / 2.67	2.2 / 0.12	3.8 / 0.11	1.6 / 0.02	0.3 / 0.02	0.04	55		190	20	116	0	Chlorinated
		9-13-62	68	265	7.2	24 / 1.20	13 / 1.08	13 / 0.56	1.3 / 0.03		157 / 2.57	5.4 / 0.11	3.6 / 0.10	0.4 / 0.01	0.0 / 0.01	0.04	20		188	20	114	0	Bubble pump unit
Aerojet Test Well	9N/7E-8M1	9-13-62		256	7.3	26 / 1.30	9.2 / 0.76	12 / 0.65	1.7 / 0.04		146 / 2.39	2.0 / 0.19	4.2 / 0.12	0.2 / 0.00	0.3 / 0.02	0.08	15		153	24	103	0	Chlorinated
		9-13-62	67	273	7.3	27 / 1.35	10 / 0.85	17 / 0.76	1.7 / 0.04		161 / 2.64	8.9 / 0.18	3.1 / 0.09	0.6 / 0.01	0.3 / 0.02	0.02	31		179	25	110	0	Bubble pump unit
J. A. Rodgers	9N/7E-3R1	5-23-55		102	7.3	7.6 / 0.38	2.1 / 0.18	4.8 / 0.21	0.3 / 0.01		47 / 0.77	3.1 / 0.06	3.0 / 0.08	4.0 / 0.06		0.12		NH_3 0.2; NO_3 0.0; ClO_4 0		20	40	1	
		7-26-55	69	102									3.0 / 0.09	2.9 / 0.05				NH_3 1.3; NO_3 0.0; ClO_4 0					
		11- 4-55	57	105				8.0 / 0.35					2.0 / 0.06								41		
		5-21-56	69	103	7.5	7.6 / 0.38	7.6 / 0.62	2.5 / 0.24	0.8 / 0.01		61 / 1.00	3.0 / 0.10	4.0 / 0.11	1.9 / 0.06	1.0 / 0.05	0.14	22	NH_3 1.1	185	18	30	0	
		9-16-57	66	116	7.2	8.2 / 0.41	2.5 / 0.05	6.2 / 0.27	0.8 / 0.02		55 / 0.90	1.9 / 0.04	4.0 / 0.11	2.9 / 0.10	0.0 / 0.00	0.00	24	NH_3 0.0; ClO_4 0	116	23	43	0	
		7-14-58	70	133	6.8	18 / 0.88	5.4 / 0.44	3.4 / 0.23	0.6 / 0.02		39 / 0.97	4.3 / 0.09	3.3 / 0.09	2.7 / 0.05	0.1 / 0.00	0.00	20	NH_3 0.0; ClO_4 0	154	18	58	4	
		5-21-59	66	149	7.4	13 / 0.65	6.0 / 0.49	6.0 / 0.26	0.6 / 0.02		65 / 1.06	4.4 / 0.09	3.4 / 0.10	10 / 0.15	0.1 / 0.00	0.02	22	NH_3 0.0; ClO_4 0	148	18	57	4	
		5-11-60	68	147	7.8	11 / 0.55	7.4 / 0.61	6.2 / 0.27	0.6 / 0.02		68 / 1.11	2.3 / 0.07	3.9 / 0.11	5.4 / 0.09	0.1 / 0.00	0.04	28	ClO_4 0	123	19	50	2	
		8-24-61		201	6.8	16 / 0.80	10 / 0.86	8.0 / 0.35	0.6 / 0.02		96 / 1.57	6.6 / 0.14	5.0 / 0.14	7.0 / 0.11	0.0 / 0.01	0.04	33		153	17	82	3	

a Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol).

b Determined by addition of constituents

TABLE 9 (Cont.)

MINERAL ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Mineral constituents in parts per million / equivalents per million

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total dissolved solids in ppm	Non-carbonate sodium	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: N.C. ppm	Remarks
J. A. Rodgers	9N/7E-32B1	8-10-62	67	181	7.3	15 / 0.75	9.4 / 0.77	8.0 / 0.35	0.5 / 0.01		90 / 1.48	4.6 / 0.10	5.4 / 0.15	3.4 / 0.05	0.1 / 0.00	0.06	46	ClO_4 0	138	19	76	0	
Don Petrucci	9N/7E-33B1	3-23-55		192	7.8	12 / 0.60	13 / 1.08	7.9 / 0.34	0.9 / 0.02		105 / 1.72	17 / 0.35	1.0 / 0.03	0.2 / 0.00		0.04		Mn 0.1; ClO_4 0; SiO_2 0.01		17	84	0	
		7-26-55	69	205									4.1 / 0.12	0.1 / 0.00				Mn 1.3; ClO_4 0; SiO_2 0.0;					
		5-21-56	69	351	8.2	33 / 1.65	23 / 1.85	11 / 0.48	1.0 / 0.03		218 / 3.57	9.0 / 0.19	10 / 0.28	0.0 / 0.00	1.0 / 0.03	0.06	46	Mn 0.0	241	12	175	0	
		9-16-57	68	414	7.0	39 / 1.95	24 / 2.01	12 / 0.52	1.4 / 0.04		236 / 3.87	6.7 / 0.14	16 / 0.45	0.0 / 0.00	0.0 / 0.00	0.09	43	Mn 0.0; ClO_4 3	261	12	190	4	
		7-14-58		566	7.2	58 / 2.89	33 / 2.86	6.3 / 0.27	1.0 / 0.03		317 / 5.20	3.0 / 0.06	26 / 0.73	0.1 / 0.00	0.1 / 0.00	0.01	42	Mn 0.0; ClO_4 0	384	9	270	18	
		5-21-59		593	7.0	63 / 3.14	32 / 2.61	13 / 0.56	1.3 / 0.03		322 / 5.28	8.1 / 0.17	31 / 0.87	0.3 / 0.00	0.0 / 0.00	0.02	44	Mn 0.0; ClO_4 0	351	9	288	24	
		5-21-60	65	450	8.1	26 / 1.30	16 / 2.92	10 / 0.39	1.2 / 0.03		232 / 3.86	4.9 / 0.10	12 / 0.90	0.1 / 0.00	0.0 / 0.00	0.02	43	ClO_4 0	269	11	221	21	
		8-24-61		403	6.9	28 / 1.90	23 / 1.86	11 / 0.48	1.0 / 0.02		220 / 3.60	7.1 / 0.15	16 / 0.45	0.9 / 0.01	0.1 / 0.00	0.02	43		240	11	186	8	
		8-10-62		342	7.7	33 / 1.55	18 / 1.47	11 / 0.48	0.9 / 0.02		186 / 3.05	6.4 / 0.13	11 / 0.31	0.0 / 0.00	0.1 / 0.00	0.02	38	ClO_4 0	207	14	151	0	

[a] Alkyl Benzene Sulfonate (ABS), Ammonium (NH_4), Carbon Dioxide (CO_2), Iron (Fe), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol).

[b] Values not by addition of constituents.

TABLE 9

MINERAL ANALYSIS OF GROUND WATER FROM TEST HOLES

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

MINERAL ANALYSES OF GROUND WATER FROM TEST WELLS

FOLSOM–EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents[a]	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: Non-carbonate	Remarks
Clinch Trustees	8N/7E-22Q1	2- 6-63	70	132	7.8	6.6 / 0.33	1.6 / 0.13	20 / 0.87	1.0 / 0.02		55 / 0.90	0.0 / 0.00	8.6 / 0.24	9.3 / 0.15	0.5 / 0.03	0.09	80	ABS 0.0; ClO_4 0	159	64	23	0	Chlorinated
H. Skogell	8N/7E-25L1	2- 6-63	68	237	8.1	14 / 0.70	8.8 / 0.72	22 / 0.96	2.4 / 0.06		126 / 2.06	0.5 / 0.01	13 / 0.37	0.1 / 0.00	0.4 / 0.02	0.04	8.8	ABS 0.0; ClO_4 0	132	39	71	0	Chlorinated
Pacific Cement & Agg.	9N/7E-17R1	2- 6-63	64	329	8.2	35 / 1.75	12 / 1.01	15 / 0.65	2.7 / 0.07		184 / 3.02	12 / 0.25	4.3 / 0.12	1.4 / 0.02	0.1 / 0.00	0.04	28	ABS 0.0; ClO_4 1	200	19	138	0	Chlorinated
Pacific Cement & Agg.	9N/7E-19B1	2- 6-63	62	98	7.8	8.7 / 0.43	3.3 / 0.27	5.9 / 0.26	1.5 / 0.04		52 / 0.85	3.0 / 0.06	2.8 / 0.08	0.1 / 0.00	0.0 / 0.00	0.05	22	ABS 0.0; ClO_4 0	73	26	35	0	Chlorinated

a Alkyl Benzene Sulfonate (ABS), Perchlorate (ClO_4).

b Determined by addition of constituents.

TABLE II

ORGANIC ANALYSIS OF GROUND WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Location of Sampling Point	Date Sampled	Total Extract		Chloroform Extractables		Alcohol Extractables		Group Separation of Chloroform Extractables														Group Separation of Neutrals									
								Ether Insolubles		Water Solubles		Amines		Strong Acids		Weak Acids		Neutrals (see breakdown)		Total		Loss		Aliphatics		Aromatics		Oxygenates		Total		Loss	
		ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%	ppb	%
SR/6E- 308	3- 8-63 3-21-63	173		114	65.9	59	34.1	0	0.1	2	1.7	0	0.4	4	3.3	48	41.6	49	43.1	103	90.4	11	9.6	21	42.4	9	18.5	18	36.2	48	97.1	1	2.9
SR/6E- 889	2-15-63 3- 1-63	-				38		0		0		0		0		0										0		1				1	
SR/6E-1381	3- 7-63 3-21-63	22		11	69.6	11	50.4	0	0.5	0	3.9	2	19.0	0	4.0	2	14.2	6	56.9	10	98.5	1	1.5	3	69.3	1	14.3	2	31.2	6	96.8	0	3.2
SR/6E-2182	3- 7-63 3-21-63	108		48	44.5	60	55.5	0	0.6	3	5.2	1	2.1	1	3.1	8	17.0	31	63.4	44	91.4	4	8.6	13	41.0	6	19.7	11	34.3	30	95.0	1	5.0
SR/6E-2702	3-22-63 3- 7-63					5		0		0		0		0		0						1				0		1				0	
SR/6E-2913	2-15-63 3- 1-63					27		0		0		0		0		0										0		1				0	
SR/7E- 911	4- 4-63 4-19-63					42		0		1		0		1		4						0				1						0	
SR/7E- 911	2-14-63 2-28-63	25		12	51.8	11	48.2	0	0.0	0	3.7	0	1.2	0	3.7	3	21.5	7	56.8	10	86.9	2	13.1	3	38.0	1	18.4	3	37.3	7	93.9	0	5.9
SR/7E-3041	3- 7-63 3-21-63	434		376	82.8	88	17.2	0	0.0	2	0.5	17	4.5	6	1.6	125	33.3	193	51.4	343	91.3	33	8.7	166	75.7	19	9.6	25	12.6	190	98.1	3	1.9
SR/6E-2302	4- 2-63 4-19-63					218		0		4		0		2		1						6				0		1				2	
SR/6E-2631	2-14-63 2-28-63	47		6	12.5	41	87.5	0	0.0	1	21.6	0	1.7	0	4.6	1	10.5	3	49.5	5	87.9	1	12.1	0	16.9	0	12.2	2	68.0	2	97.1	1	2.9
SR/7E-2191	3- 6-63 3-20-63					38		0		1		0		0		0						4				0		1				2	
SR/7E-2138	2-18-63 3- 5-63	43		8	18.3	35	81.7	0	0.6	1	12.0	0	2.6	1	8.7	2	18.9	4	44.8	8	87.6	0	12.4	0	6.8	0	10.2	3	75.5	3	92.5	1	7.5
SR/7E-2631	3-15-63 3-29-63					79		1		8		1		17		34						30										0	
SR/7E-2631	7-25-63 8-13-63	114		57	49.8	57	50.2	0	0.0	1	1.4	0	0.2	0	0.6	5	9.0	7	12.6	13	23.8	44	76.2	3	42.7	1	11.5	3	42.0	7	96.2	0	3.8
SR/7E-2883	2-14-63 2-28-63	31		19	60.3	12	39.7	7	36.6	0	1.8	0	0.8	0	1.0	1	3.0	9	50.1	17	95.3	2	4.7	6	56.8	1	8.2	2	21.6	9	96.6	0	3.4
SR/7E-3102	3-12-63 3-26-63					50		1		2		0		1		0						7				0		1				1	
SR/7E-3281	2-14-63 2-28-63	151		40	26.4	111	73.6	1	2.3	5	13.3	0	0.7	6	13.6	4	11.1	7	17.3	23	40.7	17	39.3	2	26.1	1	10.0	4	66.1	7	96.2	0	3.8

TABLE 18

MINERAL ANALYSIS OF SURFACE WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Location number	Date sampled	Discharge in cfs	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents[a]	Total[b] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
American River, 1.4 mile downstream from new Fair Oaks Bridge, south bank.	1- 5-62		49	100	7.3	9.6 / 0.48	4.4 / 0.36	3.1 / 0.13	1.3 / 0.03		49 / 0.80	6.0 / 0.12	3.0 / 0.09	0.4 / 0.01	0.0 / 0.00	0.00	8.2	Mn 0.1; Mo 0.00; ClO_4 0; Cd 0.0; Phenol 0.001; Zn 0.00; Al 0.01; <0.0010; 0.001; <0.000; 0.015; <0.000; <0.000; 0.005; <0.015; <0.000; <0.000; <0.000; 0.005; <0.0002; <0.0010; 20.0005; Zn <0.020	61	13	42	2	1500 ppm
American River, 1.0 mile downstream from new Fair Oaks Bridge, south bank.	1- 5-62		47	77	7.2	7.6 / 0.38	3.0 / 0.25	2.4 / 0.10	1.1 / 0.03		35 / 0.57	4.0 / 0.08	3.0 / 0.08	0.8 / 0.00	0.0 / 0.00	0.00	2.2	Mn 0.0; Mo 0.00; ClO_4 0; Cd 0.00; Phenol 0.001; Cu 0.0; Al 0.030; <0.001; <0.000; <0.000; <0.000; <0.000; <0.000; 0.005; <0.010; <0.000; <0.000; <0.000; 20.0005; <0.000; 0.002; <0.0005; <0.020	44	13	32	3	1310 ppm

a Ammonium (NH_4), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol), Aluminum (Al), Copper (Cu), Cyanide (CN), Beryllium (Be), Bismuth (Bi), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Iron (Fe), Gallium (Ga), Germanium (Ge), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Titanium (Ti), Vanadium (V), Zinc (Zn).

b Determined by addition of constituents.

TABLE 13 (Cont.)

MINERAL ANALYSIS OF SURFACE WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Location number	Date sampled	Discharge in cfs	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: Non-carb. ppm	Remarks
Morrison Creek, 1.0 mile upstream from Sacramento Signal Depot		4-24-62			312	7.0	11 / 0.55	9.8 / 0.81	32 / 1.39	11 / 0.28		106 / 1.74	17 / 0.35	23 / 0.65	8.5 / 0.14	0.7 / 0.04	0.30	32	As 0.01; CN 0.0; Al 0.05; Be <0.0010; Bi <0.0010; Cd <0.0050; Co <0.0050; Cr <0.0020; Fe 0.005; Ga <0.020; Ge <0.0010; Mn 0.014; Mo <0.0010; Ni 0.005; Pb <0.0050; Ti <0.0020; V 0.0040; Zn <0.030;	217	46	48	0	1100 mhr
Morrison Creek, 100 feet east of Hedge Avenue	1-16-63		40	279	7.8	11 / 0.55	6.7 / 0.55	32 / 1.39	7.0 / 0.18		80 / 1.31	16 / 0.33	18 / 0.51	29 / 0.48	0.9 / 0.01	0.26	31	ABS 0.0; CCl_4 0	207	52	55	0	1030 mhr

a Ammonium (NH_4), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol), Aluminum (Al), Copper (Cu), Cyanide (CN), Beryllium (Be), Boron (B), Cadmium (Cd), Cobalt (Co), Aluminum (Al), Gallium (Ga), Germanium (Ge), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Titanium (Ti), Vanadium (V), Zinc (Zn)

b Determined by addition of constituents

MINERAL ANALYSIS OF SURFACE WATER

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Source	Location number	Date sampled	Discharge in cfs	Temp in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents[a]	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
Buffalo Creek at confluence with American River		1- 5-62		43	149	7.1	2.8 0.14	1.3 0.11	2.3 0.10	1.8 0.05		43 0.70	7.0 0.15	12 0.34	23 0.37	0.2 0.01	0.00	8.3	Phenol 0.005; Cd 0.0; NH_4 4.3; ClO_4 0; NO_3 1.2; Cu 0.00; Al 0.03; Be <0.0010; Bi <0.000?; Cd ≥0.005; Co 0.003; Cr ≥0.005; Cn <0.0005; Fe 0.025; Ga <0.0010; Ge 0.0005; Mn >0.150; Mo ≥0.0005; Ni 0.0045; Pb <0.0005; Ti ≥0.0010; V 0.0035; Zn <0.020	98	17	40	5	1330 PPM
Buffalo Creek at Citrus Road		1- 5-62		44	150	7.1	2.6 0.13	1.4 0.11	2.2 0.10	1.7 0.04		38 0.62	5.0 0.10	10 0.28	27 0.44	0.0 0.00	0.00	8.4	NH_4 1.2; NO_3 1.10; ClO_4 0; Cu 0.00; Phenol 0.006; Cd 0.0; Al 0.01b; Be <0.0010; Bi <0.000?; Cd ≥0.005; Co <0.005; Cr <0.005; Fe 0.01?; Ga <0.010; Mn 0.210; Ge <0.0005; Mo 0.0011; Pb <0.0005; V 0.0015; Zr <0.001; Zn <0.020; Mo <0.0005;	98	15	42	11	1515 PPM

a Ammonium (NH_4), Nitrogen Dioxide (NO_2), Perchlorate (ClO_4), Phenolic Compounds (Phenol), Aluminum (Al), Copper (Cu), Cyanide (CN), Beryllium (Be), Bismuth (Bi), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Iron (Fe), Gallium (Ga), Germanium (Ge), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Titanium (Ti), Vanadium (V), Zinc (Zn).

b Determined by addition of constituents

TABLE 14

MINERAL ANALYSIS OF WASTE WATER

FOLSOM - EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Number	Source	Date Sampled	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Ammonium (NH_4)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Phosphate (PO_4)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Total dissolved solids (ppm)	Percent sodium	Hardness as $CaCO_3$: Total (ppm)	Hardness as $CaCO_3$: N.C. (ppm)	Remarks
	Cordova Sewage Treatment Plant, Hoehe Cordova (final effluent)	9- 2-59 8-hour composite	640	7.5	33 / 0.55	20 / 1.61	59 / 2.57	13 / 0.33	21 / 1.16	0 / 0.00	238 / 3.90	23 / 0.52	47 / 1.32	2.7 / 0.07	43		0.4	26	413	43	168	0	
	(final effluent)	8- 2-60 24-hour composite	669	7.7	31 / 0.55	18 / 1.51	51 / 2.22	13 / 0.33	31 / 1.72	0 / 0.00	261 / 4.28	23 / 0.48	49 / 1.38	0.5 / 0.01	44		0.2	23	359	35	143	0	
	(final effluent)	1-31-61 24-hour composite	694	7.6	19 / 0.95	13 / 1.09	56 / 2.44	16 / 0.36	2.4 / 0.13	0 / 0.00	293 / 4.80	20 / 0.42	37 / 1.04	1.9 / 0.03	43	0.2 / 0.01	0.2	18	364	49	102	0	
	(final effluent)	1-25-63 24-hour composite	797	7.9	22 / 1.10	11 / 0.90	46 / 2.78	15 / 0.38	4.3 / 2.38	0 / 0.00	209 / 3.04	27 / 0.56	46 / 1.35	1.3 / 0.02	48	0.2 / 0.01	0.4	26	397	37	99	0	ABS 0.0
	Natomas Sewage Treatment Plant South of Fruitridge Road on Hedge Avenue (final effluent)	1-24-63 24-hour composite	780	7.7	21 / 1.05	11 / 0.91	63 / 2.70	13 / 0.38	4.3 / 2.33	0 / 0.00	226 / 4.52	25 / 0.52	48 / 1.92	1.4 / 0.02	32	0.2 / 0.01	0.3	22	399	37	90	0	ABS 7.6
	Mather Air Force Base Sewage Treatment Plant South of runways (outlet from secondary digester)	6-28-56 24-hour composite	359	7.2	8.8 / 0.44	8.5 / 0.70	36 / 1.57	2.1 / 0.19	0.1 / 0.01	0 / 0.00	140 / 2.30	25 / 0.52	16 / 0.46	8.0 / 0.13			0.23	22	236	54	57	0	ABS 3.4
	(pond effluent)	6- 3-59 24-hour composite	265	9.4	3.6 / 0.18	3.6 / 0.46	77 / 1.61	8.3 / 0.21	2.3 / 0.16	22 / 0.73	22 / 0.36	10 / 0.21	23 / 0.65	0.6 / 0.01	22	0.6 / 0.04	0.35	45	207	55	47	11	
	(final effluent)	9- 3-59 24-hour composite	370	7.3	11 / 0.55	7.7 / 0.63	35 / 1.52	6.6 / 0.17	14 / 0.78	0 / 0.00	141 / 2.31	19 / 0.40	18 / 0.51	7.4 / 0.12	22		0.2	22	207	42	59	0	
	* (chlorine contact chamber)	11-15-62 24-hour composite	510	7.4	16 / 0.80	6.1 / 0.50	44 / 1.91	8.4 / 0.21	21 / 1.16	0 / 0.00	190 / 3.11	21 / 0.44	23 / 0.65	4.2 / 0.68	3.8	0.7 / 0.04	0.6	40	315	39	69	0	ABS 5.4; 0.6 0. 29; Al 0.01; As 0.00; Cu 0.01; Fe 0.03; Mn 0.04; Zn 0.09; Cr^{+6} 0.01; Fe (total) 0.11

a Alkyl Benzene Sulfonate (ABS), Grease and Oil (G.& O.), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), Hexavalent Chromium (Cr^{+6}), Iron (Fe).
b Determined by addition of constituents.

APPENDIX A

GEOLOGY

APPENDIX A

GEOLOGY

The Sacramento Valley, in which the area of investigation lies, is a structural trough bounded on the east and west by mountainous areas. On the east the Sierra Nevada rises gradually from the valley floor, while the Coast Ranges to the west rise more abruptly.

The Sierra Nevada is a tilted fault block with a sharp escarpment facing the east and a gentle decline to the west. The uplands grade gradually westward through low foothills, alluvial fans and basin lowlands. The basement rock of the Sierra Nevada, consisting largely of igneous and metamorphic rock, extends westward beneath the valley floor, underlying the younger sedimentary rocks.

The sedimentary deposits, on which the recent topography has been developed, are the most important as water-bearing units. These deposits comprise older sedimentary formations and younger alluvium. The older deposits are exposed along the edges of the valley in the low, rolling foothills. These formations dip gently toward the center of the valley. Between the edges of the valley and its center, the older formations pass beneath younger alluvium, which occurs as low-lying alluvial fans and plains. In the center of the valley adjacent to the Sacramento River, low, flat, floodplain deposits exist. These are occasionally covered by flood waters and may have high water tables and alkaline soils. Stream channel deposits crossing the older alluvial and rock units are found along the major streams extending from the Sierras toward the low floodplains.

The valley has been a structural trough since Pre-Cretaceous time, bounded roughly by the same highland areas which enclose it today. During Cretaceous time and much of the Tertiary, marine waters covered the valley. These waters were connected with the open sea by embayments and channels which frequently changed their positions as the landmasses rose and were eroded away. It was during this time that the bulk of the sediments now filling the valley trough were deposited. This material was derived from the ancestral Sierras on the east and peninsular and island landmasses on the west. Intermittent vulcanism furnished volcanic debris and became more frequent in the Sierras in middle and late Tertiary time.

During late Tertiary time rising landmasses forced the extension of the sea covering the valley to begin a gradual retreat leaving brackish and fresh water lakes covering the valley floor. Erosion of the rising landmasses was accelerated and continental deposits spread into the valley with contemporaneous deltaic and lacustrine sediments being deposited in the center of the valley area. In recent time the lakes have diminished and erosion from renewed uplift has led to the dominance of continental deposits.

Along the eastern edge of the area of investigation the dissected alluvial uplands make up a rather distinct topographic surface. The surface is underlain by the water-bearing Laguna and Mehrten formations. It is bounded on the east by nonwater-bearing marine sediments, metamorphic, and granitic rocks. While the alluvial uplands are a series of dissected terraces whose surface slopes are somewhat variable, the surfaces generally slope about 20 feet per mile toward the southwest. These

terraces differ in altitude by 25 to 50 feet, with the most prominent ones occurring at elevations of about 125,150, 200, and 225-275 feet. The highest erosion surface is indicative of a time of plantation of the Laguna surface, and the lower surface represent subsequent terracing developed during northwestward lateral movements of the American River. This process has resulted in the present sharp bluff immediately bordering the north bank of the river and the lack of any major bluff along the southern bank of the river. The American River in its northward downcutting movements has cut into the Laguna formation and has partially backfilled with sands, clays, and gravels which today make up the low alluvial plains of the Victor Formation.

Dissection of the upland surface has reduced its probably nearly planar original terraces to a series of rolling highs and lows. From the west, Morrison and Elder Creeks have cut re-entrant notches into the lower terrace, while on the south, Laguna Creek has cut northeastward into the surface. These alluvial uplands, commonly called "red lands," are characterized by mound and hollow, or "hog wallow" topography and are covered in many areas by a surface layer of quartzose gravels.

The low alluvial plain, overlying in part and butting against the dissected uplands, is commonly known as the Victor plain in this area for the underlying Victor Formation. Subsequent to the period of downcutting and channeling of the American River across the Laguna surface, a period of deposition resulted in the formation of a flat, featureless surface spreading outward from the major drainage streams of the east side. The Victor plain originally resulted from the

formation of coalescing alluvial fans with their apices at or near the point where the streams entered the valley proper. The general slope of the fans is toward the southwest at about 5 to 10 feet per mile. Dissection of these plains is not nearly so advanced as is that of the uplands, in part due to the lesser slopes of the former and in part to their younger age. In general, the low plains have been constructional features until recent time and only recently has degradation begun to shape the topographic surface they exhibit today. Minor terracing is observed superimposed on the Victor plain, mainly in connection with the recent entrenchment of the American River into its present channel.

Stream channel and flood plain deposits are found in the immediate vicinity of the major streams of the area. Flowing across and entrenched in the entire section is the American River. The channel and flood plain deposits of this stream vary in width from a few hundred feet, in the vicinity of Folsom where the river leaves the basement rock, to about a mile at the western edge of the area of investigation. The surface of this flood plain slopes toward the west at about the same gradient as the stream, approximately five feet per mile, characterized by abandoned channels and extensive bar deposits. Containment of the river by levees will further entrench it in its present channel.

In the eastern part of the area, Deer Creek and its tributaries, Coyote and Carson Creek, have cut deeply into the Laguna surface in the process of becoming graded with the Cosumnes River and have cut a broad erosional trench between the dissected uplands and the bedrock complex of the foothills. Deer Creek has constructed a flood plain of alluvial material averaging 3/8 of a mile in width.

Piles of dredge tailings from 20 to 75 feet thick are found throughout the area. Where the dredges have traversed the boundaries between the different physiographic units, the breaks in slopes and geology have been masked or destroyed. These surfaces are characterized by the serpentine-like piles of tailings and remnant ponds. Destruction of the tailings is now taking place by commercial development within the area.

Stratigraphy

The geologic formations within the area of investigation range in age from Pre-Cretaceous to Recent. Pre-Cretaceous granitic and metamorphic rocks forming the basement complex are exposed in the eastern edge of the area and, from the few wells which have reached to them at depth, appear to dip about 3 to 4 degrees beneath the overlying sediments. Overlying the basement rocks are Cretaceous marine sediments which crop out sporadically in the vicinity of Folsom, the Eocene Ione Formation which crops out in a narrow band south from White Rock Road, and the Valley Springs Formation which is found slightly north of the Cosumnes River. These formations are all considered as nonfreshwater-bearing. Either they do not have sufficient permeability to transmit other than minor amounts of water or they contain connate salt water.

Freshwater-bearing units overlie the nonfreshwater-bearing formations. The freshwater-bearing formations are the Mio-Pliocene Mehrten Formation, the Plio-Pleistocene Laguna Formation, and the Pleistocene Victor Formation.. Recent stream deposits, and dredge tailings are also considered in this report as freshwater-bearing units.

Formations

Three principal geologic formation directly underlie the Folsom-East Sacramento area. These are the Mehrten, Laguna, and Victor Formations which are shown on Plate 2. The vertical sections at lines A-A' and B-B' are shown on Plate 3. The reader will find it helpful to have these plates before him while reading the stratigraphy portion of this report.

Mehrten Formation. The lowest freshwater-bearing formation on the east side of the valley is the Mehrten Formation. It extends discontinuously from the vicinity of Oroville on the north to the Merced-Madera county line to the south. It overlies the impervious Valley Springs Formation and can be traced in the subsurface to the center of the valley. Outcrops of the formation are found along the eastern border of the valley. This formation strikes to the northwest with a dip of from 50 to 100 feet per mile and can usually be recognized in the logs of both oil and water well drillers when they penetrate it.

The Mehrten Formation, as it is found in the valley, is essentially composed of medium to coarse andesitic sandstone beds with interspersed light-colored tuffaceous silty and clayey beds. These sands are usually easily recognizable by their iron-gray to black coloration and predominance of fragments of andesite. Brecciated andesitic mudflow material or agglomerates are found capping some of the more resistant ridges at the surface and are found occasionally in the subsurface. These agglomerates contain blocks of fresh andesite up to two feet through and are quite hard and impervious.

The origin of the material composing the Mehrten Formation appears to have been the volcanic ejecta and debris from the period of

Mio-Pliocene vulcanism in the high Sierra. Streams flowing westward across this terrain swept the loose material out into the valley depositing it as well-sorted, loose to consolidated sands and clays, which reach a thickness of about 500 feet.

The Mehrten Formation is tapped by irrigation and industrial wells rather extensively along the eastern border of the valley. Most of the deeper wells show some sign of the "black sands", as they are termed by most drillers, that are indicative of the Mehrten Formation. Very few of these wells, however, tap only the Mehrten and most represent a composite yield from the overlying material and the Mehrten.

The permeability of the Mehrten Formation is quite variable due to its changing lithologic character both horizontally and vertically. The formation is less consolidated and the number of hard tuff-breccia beds decreases in its western portion. The upper part of the formation may have a higher percentage of clay and fine-grained sediments than the middle or lower part. The presence of these clay and tuff-breccia beds, together with the overlying Laguna Formation, confines the water in the underlying more permeable sands, thus creating pressure conditions throughout most of the formation. The sand and gravel strata within the formation are generally moderately to highly permeable.

During the drilling of test hole 9N/7E-17N1, samples were gathered and sent to the Department of Water Resources Laboratory for mechanical analysis and permeability tests. Two constant-head permeability tests were conducted on these samples. The tests showed permeabilities of 501 and 438 gallons per day per square foot. The samples

had a porosity of 49-50 percent, yet would probably be shown in drillers logs as "hard" or "cemented black sand." The sand is consolidated but not cemented.

An indication of the well characteristics within the Mehrten Formation may be seen from the following summary of average conditions of 18 wells which are perforated partially or wholly within the formation.

Well Depth	416 feet
Gallons per minute (gpm)	1,098
Specific Capacity 1/	38
Yield Factor (saturated thickness) 2/	14
Yield Factor (aquifer sands only) 3/	50

1/ The specific capacity of a well is the discharge (gpm) divided by the drawdown (feet).
2/ The specific capacity divided by the thickness in feet of saturated material penetrated by a well, multiplied by 100.
3/ The specific capacity divided by the thickness of water-bearing aquifers only which are open to the well, multiplied by 100.

Natural recharge to the Mehrten Formation is effected in the outcrop areas, primarily where major streams cross the outcrops and secondarily where rainfall infiltrates the permeable sands. The rates of recharge are not known, but it is probable that infiltration rates are generally fairly high.

The Mehrten Formation underlies Nimbus Reservoir and this may contribute heavily to the recharge of the more permeable zones. In the southern part of the area, Deer Creek and the unnamed creek immediately west of Deer Creek flow across Mehrten exposures, and percolation from these streams, primarily during the winter months, enters the Mehrten

aquifers. The Cosumnes River flows over a considerable outcrop area of the Mehrten Formation and no doubt contributes to the recharge in the southern area.

Laguna Formation. The Laguna Formation, which in this report includes the Arroyo Seco Gravels, is a sequence of predominantly fine-grained, poorly bedded, somewhat compacted continental sedimentary deposits laid down after the major andesitic episode in the late Miocene and early Pliocene and before the last major tilting of the Sierra Nevada in the Pleistocene period. The Arroyo Seco Gravels and other gravels of uncertain age are coarse-grained, poorly sorted deposits that form a discontinuous cap on the Laguna and older formations.

At many places, it is difficult to determine the subsurface boundaries between the Laguna Formation or the underlying volcanic rocks from the Sierra Nevada and the overlying Victor Formation and related deposits, particularly near the axis of the valley, where deposition may have continued during the hiatuses represented by unconformities near the valley margin.1/

The thickness of the Laguna Formation varies from east to west. Along the western border of the area, where the formation outcrops, it has been partially eroded and pinches out against the underlying formations. The base of the formation dips in a westerly direction, and lies about 650 feet below the surface at the western edge of the area of investigation. In effect, the Laguna is a wedgeshaped deposit, thinning near the Sierras, and thickening to probably more than 1,000 feet near the axis of the valley.

1/ After Olmsted, F. H., and Davis, G. H., Geologic Features and Groundwater Storage Capacity of the Sacramento Valley, California, Geological Survey Water-Supply Paper 1497, Washington, D.C., 1961.

The physical characteristics of the Laguna Formation are extremely varied. The formation probably was deposited as a series of stream deposits, reworked channel deposits, and flood plain deposits forming coalescing alluvial fans that spread westward across the area of investigation. This resulted in an extremely heterogeneous group of silts, clays, sands, and gravels. From the well logs available, it appears that the finer grained material predominates with lenticular sands and gravels interspersed. Yellow-brown, brown, and minor red and white clays, sandy clays, and fine sands are the most common units shown in the drillers' logs representing the Laguna Formation. Gravels are more common toward the east and sometimes are referred to as clayey or cemented. There are indications of somewhat continuous water-bearing gravel strata that dip toward the west at about 25 feet per mile.

The Laguna Formation is tapped by domestic, irrigation, and industrial wells throughout the area. Most wells, however, do not draw all their water from this formation, but are perforated or gravel packed so that they may also receive part of their yield from the underlying Mehrten and overlying Victor Formations. Due to the heterogenity of the deposits of the Laguna Formation, it is difficult to predict the yields of wells in different parts of the area. As reported in U. S. Geological Survey Water Supply Paper No. 1497, yields of 1,500 gpm or more are not uncommon from the more permeable beds. The highest yield reported was from a well slightly west of the area of investigation, perforated in Laguna sediments only. This well had a specific capacity (gpm per foot of drawdown) of 53.6, with a yield factor of 21 for the total saturated thickness, and 357 for the perforated aquifer only. This well was drilled

by cable tool methods, cased to 300 feet, and perforated in the interval between 277-290 feet below land surface in a coarse gravel zone. The tabulation below gives the average depths, gpm, and other values of the 21 wells within the area of investigation that derive water from the Laguna only, or have a major part of the perforated zone within the Laguna Formation.

Well Depth	339 feet
GPM	898
Specific Capacity	35
Yield Factor (saturated thickness)	16
Yield Factor (aquifer only)	93

Most of these wells produce from coarse sands and gravels at depths of more than 250 feet. From west to east across the area of investigation, the Laguna thins and becomes progressively less important as a water-bearing unit.

Recharge to the Laguna Formation is probably effected through three major means. The first is by means of recharge from the American River, where the coarse sediments lie below the river bottom and its related gravels. The second is by direct percolation of rainfall throughout the area; though light, a significant proportion penetrates the permeable dredge tailings overlying much of the outcrop area. The third is by waste water from the now defunct dredging operations within the area of investigation which was allowed to percolate to the ground water body.

Victor Formation. The Victor Formation covers the western part of the area of investigation and extends in a tongue-like deposit south

of the American River toward the foothills. During the periods of erosion and terracing of the Laguna Formation, Victor sediments were being deposited near the axis of the valley. With a rise in base level, these sediments began building up and spreading eastward toward the present Victor-Laguna contact line, choking the erosional trenches cut into the Laguna and older formations. When the Victor plain had reached its present form, a minor decrease in base level forced the rivers to entrench themselves into their present channels, where they have deposited the Recent flood plain deposits. Only minor dissection of the Victor plain has taken place since its deposition; the shallow channels cut into the nearly level plain give mute witness to the youth of the sediments.

The Victor Formation dips very slightly toward the west, with the present topographic surface closely approximating its subsurface dip. Due to its position overlying the Laguna and Mehrten Formation and its near lack of dip, it truncates both these formations as it follows upstream in the lowlands bordering the American River. This puts it in continuity with water-bearing strata of both formations in that portion of its outcrop area. Within the western part of the area, though, it is separated from the deeper water-bearing zones by fine grained Laguna deposits.

The Victor Formation consists for the most part of coarser material than does the Laguna Formation. Sands and gravels are prominent with interbedded clayey silts and sandy clays. From a study of well logs, it would appear that nearly the whole portion of the area covered by the Victor Formation contains a shallow sand and gravel layer which is either at the surface or within 30 feet of the surface and ranges in thickness

from 10 to 50 feet. This layer is not of particular importance as an aquifer because the water table in general intercepts only the lower portion of it, but as a means of recharge from irrigation, rainfall, or the river or river gravels, it is quite important. The top of this gravel is generally less than 10 feet deep to the east of a line along Bradshaw Avenue, deepening toward the west. It may be that this gravel layer constitutes the base of the Victor Formation, lying as it does upon finer grained sediments which are indicative of the Laguna Formation, and indicating a period of renewed uplift and erosion. If such is the case, then the Victor Formation would have a maximum thickness in this area of less than 100 feet and would average about 50 feet thick.

The Victor Formation is made up of sediments similar to those of the Laguna Formation. The sands and gravels are derived chiefly from granitic and metamorphic rocks of the Sierras and from reworked Laguna sediments. In driller's logs, these are chiefly referred to as brown and yellow-brown in color, loose to caving sands, with buried hardpan zones. Seldom are the gravels in the Victor referred to as cemented, or clay and gravel, as the Laguna gravels frequently are. The reddish clays commonly described by drillers in this area are nearly all found in the Laguna section, with yellow-brown clays predominating in Victor sediments. Bluish-colored sediments are very seldom reported in Victor sediments within this area as it appears to be at the eastern edge of the flood basin or lake depositional environment. Blue colored sediments that are found in the area if investigation may be within the Ione Formation, the Mehrten Formation, or the lower part of the Laguna Formation, depending upon where the well is located.

Of the three major water-bearing formations, the Victor is probably the most permeable. It is seldom that any well drilled in the Victor plain will not penetrate some well-sorted sand or gravel deposits, and nearly all domestic wells draw at least part of their yield from this formation. Unfortunately, its thickness is limited, and in areas where only the lower part is saturated, it is necessary to drill deeper wells into the Laguna and Mehrten Formations. Most irrigation and other high capacity wells do this and, as previously stated, draw from one or more formational units. As pumping tests and other capacity tests are not usually performed by the utility companies on small domestic wells, it is difficult to find data that are applicable only to the Victor Formation. An indication of the well characteristics of the formation may be seen, however, from the following tabulation giving averages from eight shallow wells which probably penetrate through the Victor into the upper part of the Laguna.

Well Depth	204 feet
GPM	659
Specific Capacity	58
Yield Factor (saturated thickness)	40
Yield Factor (aquifer sands only)	225

These values represent an increase over the corresponding figures for the Laguna and the Mehrten Formations. The increase in amount of coarse grained material is also reflected in the higher average specific yields for the depth interval representing the Victor Formation.

Recharge to the Victor Formation is effected in much the same manner as to the Laguna Formation. The most important factors are inflow from the American River, irrigation return water, and rainfall penetration.

Stream Deposits

Stream deposits consist of Recent sands, gravels, and minor amounts of clay in the lowlands bordering the American River along the northern border of the area. These occupy, at present, two depositional environments: the low stream channels and the slightly more elevated flood plains.

The low water channels are floored with relatively coarse grained sands and gravels which, during times of high water, are shifting and moving downstream. In areas where the water table is in contact with water in the streambed, there is direct hydraulic continuity of the stream with the water table through these coarse deposits.

The elevation of the surface of the adjacent flood plain deposits is slightly higher than the stream channel and somewhat lower than the surface of the older Victor and Laguna deposits. These flood plain deposits have been built up by the deposition of finer material such as sands and silts, during times of flood in slack high water areas. This smaller grain size is accompanied by a reduction in permeability, though in general the flood plain deposits are good water producing areas. This is in part due to underlying coarse stream channel deposits left as the stream has shifted its course in the past. An insufficient number of wells were found penetrating the flood plain deposits to determine their average well characteristics.

Dredge Tailings

Scattered over the surface of the eastern part of the area are large piles of gold dredger tailings. These are primarily derived from the Laguna and Victor Formations, though some of the Recent stream gravels have been worked. The tailings have a maximum thickness of about 100 feet and probably average about 50 feet. In areas where the Mehrten Formation is at shallow depth, it was customary to use that formation as marker of the base of the gold-bearing materials.

In the action of dredging, the normal structure of the dredged interval is destroyed completely, along with the vertical and horizontal continuity of water-bearing strata. In dredging, the fine waste material from the dredge is dumped into the pond immediately behind the dredge and the coarse material, by means of a conveyor system, some distance behind. This allows the clays and silts to coat the bottom of the pond and leaves the coarse cobbles exposed at the surface. This leads to occasional inaccurate estimates of the permeability of the overall deposits. The permeability is further decreased by silts and clays resulting from dirty water pumped into low areas in the tailings. Ground water is often perched on the layers of fines, making water levels within the tailings fluctuate widely. Wells drilled through the tailings to the underlying water-bearing strata reflect the levels of the regional ground water body.

The dredge tailings are important in that they are a large scale infiltration area and have been receiving imported water while the dredging operation has been in progress.

Rainfall received by the dredged areas can percolate through the coarse upper gravels immediately in most areas and thus be removed

from the zone of evaporation. Water received in this manner can then slowly percolate through the finer underlying strata to reach the regional water table.

APPENDIX B

TABLES OF ESTIMATED SPECIFIC YIELD BY SECTIONS AND ESTIMATED GROUND WATER STORAGE CAPACITY BY SECTIONS

TABLE B-1

ESTIMATED SPECIFIC YIELD BY SECTIONS

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

[illegible]	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300
[illegible]	1	1	1-7	1-9	1-9	1-4	1-7	1-3	1-4	1-7	4-10	4-10	4-9	4-3	4-3	4-3	4-4
	2	1	1-9	1-4	1-9	1-5	1-6	1-10	1-10	1-10	1-10	1-10	1-9	1-3	1-3	1-3	1-1
	3	9	9-14	8-19	8-4	8-8	8-7	7-13	7-13	7-4	7-4	7-4	7-4	6-4	6-4	3-4	3-3
	4	6	4-13	5-12	5-9	6-11	5-6	5-7	6-3	3-10	1-7	1-3	1-3	1-3	1-3	1-3	4-4
	5	6	6-13	6-14	6-13	6-14	6-8	6-11	5-8	4-13	4-7	4-5	4-5	4-5	4-5	4-5	4-5
	6	4	4-5	4-9	4-13	4-10	4-11	3-9	3-10	3-10	4-11	4-8	4-7	4-5	4-5	4-5	4-5
	7	1	1-14	1-14	1-9	1-13	1-3	1-7	1-3	1-4	4-5	4-10	4-10	4-5	4-5	4-5	4-5
	8	3	3-15	3-11	3-10	3-10	2-8	1-6	4-5	4-5	4-5	4-10	4-10	4-5	4-5	4-5	4-5
	9	2	2-16	2-13	2-10	2-6	2-10	2-7	2-5	1-3	1-5	1-13	1-10	1-3	1-3	1-3	1-4
	10	0	4-15	4-10	4-8	4-5	4-7	4-6	4-6	4-4	4-4	4-5	4-6	4-4	4-3	4-6	4-5
	11	2	2-15	2-13	2-4	2-4	2-5	2-6	2-6	2-6	2-3	2-5	2-5	2-4	2-3	2-11	2-10
	12	0	4-10	4-15	4-9	4-6	4-7	4-5	4-4	4-5	4-7	4-9	4-15	4-14	4-3	4-7	4-7
	13	9	8-9	8-18	8-10	3-5	3-18	3-5	3-4	3-5	3-10	3-13	3-15	3-14	4-3	4-7	4-7
	14	4	4-10	4-6	4-5	4-4	4-7	4-7	4-6	4-4	4-4	4-3	4-3	4-4	4-3	4-3	4-6
	15	0	4-11	4-11	4-4	4-6	4-5	4-6	4-5	4-4	4-4	4-3	4-3	4-4	4-3	4-2	4-6
	16	3	3-13	3-11	3-4	3-7	3-3	3-5	2-3	4-5	4-15	4-15	4-15	4-15	4-4	4-4	4-4
	17	9	8-17	8-8	8-10	8-14	7-13	7-10	3-7	3-10	3-20	3-20	3-15	3-11	3-4	3-4	3-4
	18	6	5-7	6-16	6-14	6-12	5-10	5-5	5-5	5-6	3-9	3-6	3-10	3-16	3-15	3-3	3-3
	19	26	22-9	22-19	22-16	22-10	22-9	20-8	17-7	7-5	4-5	4-6	4-6	3-3	3-3	3-3	3-3
	20	10	10-10	10-15	10-13	10-10	10-8	6-9	3-6	3-3	3-4	2-3	1-6	4-4	4-3	4-4	4-5
	21	1	1-14	1-15	1-5	1-10	1-8	4-9	4-6	4-5	4-4	4-3	4-6	4-4	4-3	4-4	4-5
	22	0	4-10	4-7	4-6	4-7	4-6	4-4	4-4	4-6	4-7	4-6	4-5	4-3	4-3	4-5	4-4
	23	6	4-10	4-7	4-6	4-7	4-6	4-4	4-4	4-6	4-7	4-6	4-5	4-3	4-3	4-5	4-4

[illegible]	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			300-320	320-340	340-360	360-380	380-400	400-420	420-440	440-460	460-480	480-500	500-520	520-540	540-560	560-580	580-600
[illegible]	1	1	4-5	4-6	4-9	4-5	4-10	4-7	4-10	4-10	4-7	4-9	4-5	4-5	4-5	4-5	4-5
	2	1	1-5	1-6	1-9	1-5	1-10	1-7	1-10	1-10	1-7	1-9	4-5	4-5	4-5	4-5	4-5
	3	9	3-5	3-5	3-7	3-5	3-5	3-9	3-14	8-4	8-9	8-9	3-5	4-5	4-5	4-5	4-5
	4	6	4-3	4-3	4-3	4-4	4-6	4-10	4-16	4-11	4-10	4-8	4-7	4-7	4-7	4-7	4-7
	5	6	4-5	4-6	4-7	4-5	4-6	4-10	4-15	4-10	4-10	4-8	4-7	4-7	4-7	4-7	4-7
	6	4	4-5	4-6	4-6	4-5	4-6	4-8	4-15	4-10	4-10	4-8	4-8	4-7	4-7	4-7	4-7
	7	1	4-5	4-5	4-5	4-5	4-7	4-5	4-15	4-15	4-10	4-8	4-10	4-8	4-8	4-8	4-8
	8	3	4-5	4-5	4-5	4-5	4-7	4-5	4-15	4-15	4-10	4-8	4-10	4-8	4-8	4-8	4-8
	9	2	3-3	3-3	3-3	3-3	3-7	3-3	4-10	4-10	4-10	4-8	4-10	4-8	4-8	4-3	4-3
	10	0	4-9	4-5	4-9	4-12	4-11	4-11	4-11	4-10	4-12	4-8	4-11	4-8	4-8	4-3	4-3
	11	2	2-9	2-5	2-9	2-12	2-11	2-11	2-11	2-10	2-11	2-8	2-11	2-8	2-8	2-3	2-3
	12	0	4-7	4-7	4-10	4-12	4-13	4-12	4-12	4-13	4-12	4-10	4-10	4-10	4-10	4-10	4-10
	13	9	4-7	4-7	4-10	4-12	4-13	4-12	4-12	4-13	4-12	4-10	4-10	4-10	4-10	4-10	4-10
	14	4	4-6	4-11	4-10	4-12	4-12	4-11	2-13	2-6	2-14	2-12	4-10	4-10	4-10	4-10	4-10
	15	0	4-6	4-11	4-10	4-12	4-12	4-11	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8
	16	3	4-6	4-6	4-6	4-6	4-11	4-10	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8
	17	9	4-6	4-7	4-7	4-7	4-10	4-10	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8
	18	6	3-7	3-10	4-7	4-7	4-10	4-10	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8
	19	26	3-7	4-7	4-7	4-7	4-10	4-10	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8
	20	10	4-5	4-5	4-5	4-5	4-10	4-10	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8
	21	1	4-5	4-5	4-5	4-5	4-10	4-10	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8
	22	0	4-5	4-6	4-5	4-5	4-14	4-12	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8
	23	6	4-5	4-6	4-5	4-5	4-14	4-12	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8	4-8

* of specific yield estimated from nearest wells

TABLE B-1 (Cont.)

ESTIMATED SPECIFIC YIELD BY SECTIONS

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

SACRAMENTO GROUN

Township and range M.D.B.&M.	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			0–20	20–40	40–60	60–80	80–100	100–120	120–140	140–160	160–180	180–200	200–220	220–240	240–260	260–280	280–300
8N/6E	04	0	0–10	0–7	0–6	0–7	0–6	0–6	0–6	0–7	0–7	0–10	0–5	0–5	0–5	0–5	0–6
	05	3	3–13	3–10	3–5	3–5	3–6	3–5	5–1	5–6	5–6	5–12	3–5	0–5	0–5	0–5	0–6
	06	2	5–7	5–5	5–13	5–9	5–5	5–6	5–1	5–10	5–11	3–6	3–6	3–5	1–5	3–5	3–6
	07	3	3–7	3–6	3–6	3–10	3–5	3–6	3–7	3–5	3–6	3–5	3–5	3–5	3–6	3–5	3–5
	08	5	3–10	3–12	3–6	3–6	3–9	3–6	3–5	3–7	3–7	3–7	3–15	3–10	3–10	3–5	3–6
	09	3	3–10	3–10	3–16	3–12	3–11	5–5	3–6	3–5	3–5	3–5	3–5	3–7	0–10	0–5	0–5
	10	6	6–5	6–17	6–7	6–5	3–6	3–6	3–10	3–6	0–5	0–5	0–5	0–5	0–10	0–5	0–5
	15	14	14–7	14–15	14–10	14–10	14–6	11–5	5–6	5–5	3–5	3–5	3–5	0–5	0–10	0–5	0–5
	16	8	5–7	5–15	5–15	5–15	5–5	5–6	5–6	3–10	3–6	3–6	3–5	3–6	0–6	0–5	0–5
	21	0	0–6	0–15	0–15	0–17	0–7	0–6	0–7	0–7	0–6	0–6	0–5	0–6	0–5	0–5	0–5
	28	0	0–6	0–10	0–10	0–17	0–7	0–6	0–5	0–7	0–6	0–6	0–5	0–6	0–5	0–5	0–5
	33	0	0–6	0–7	0–7	0–17	0–7	0–5	0–6	0–5	0–6	0–5	0–5	0–6	0–5	0–5	0–6
	34	2	2–5	2–5	2–5	2–15	2–10	2–5	2–6	2–5	2–6	2–5	2–5	0–6	0–5	0–5	0–6
8N/7E	1	0	0–9	0–5	0–5	0–5	0–5	0–5	0–5	0–10	0–5	0–5	0–5	0–5	0–6	0–5	0–6
	2	1	1–9	1–5	1–5	1–5	1–5	1–5	1–5	1–10	1–5	1–5	1–5	1–5	1–6	1–5	1–6
	3	0	0–10	0–8	0–10	0–8	0–6	0–6	0–5	0–10	0–5	0–5	0–5	0–5	0–6	0–5	0–6
	4	0	0–12	0–10	0–15	0–12	0–6	0–6	0–6	0–8	0–5	0–5	0–5	0–5	0–6	0–5	0–6
	5	3	3–10	3–13	3–14	3–10	3–6	3–6	0–6	0–6	0–6	0–5	0–5	0–8	0–6	0–6	0–6
	6	0	0–15	0–10	0–14	0–15	0–8	0–6	0–6	0–6	0–6	0–6	0–6	0–8	0–8	0–8	0–6
	7	0	0–10	0–10	0–14	0–15	0–8	0–6	0–6	0–8	0–8	0–6	0–6	0–10	0–8	0–10	0–6
	8	3	3–11	3–13	3–10	0–11	0–9	0–8	3–15	3–7	3–11	3–10	3–9	3–10	3–7	3–7	3–10
	9	2	0–9	0–9	0–5	0–7	0–11	0–8	0–9	0–14	0–9	0–5	0–6	0–10	0–15	0–21	3–6

Township and range M.D.B.&M.	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			300–320	320–340	340–360	360–380	380–400	400–420	420–440	440–460	460–480	480–500	500–520	520–540	540–560	560–580	580–600
8N/6E	04	0	0–5	0–6	0–5	0–5	0–16	0–10	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	05	3	0–5	0–6	0–5	0–5	0–16	0–10	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	06	2	3–5	3–6	3–5	3–5	3–16	3–10	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	07	3	3–5	3–5	3–5	3–6	3–5	3–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	08	5	3–5	3–5	3–5	3–6	3–5	3–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	09	3	0–5	0–5	0–5	0–6	0–5	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	10	6	0–5	0–5	0–5	0–6	0–5	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	15	14	0–5	0–5	0–5	0–6	0–5	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	16	8	0–5	0–5	0–5	0–6	0–5	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	21	0	0–5	0–5	0–5	0–6	0–5	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	28	0	0–5	0–5	0–5	0–6	0–5	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	33	0	0–5	0–5	0–5	0–6	0–5	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
	34	2	0–5	0–5	0–5	0–6	0–5	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6	0–6
8N/7E	1	0	0–5	0–5	0–5	0–16	0–10	0–10	0–5	0–5	0–5	0–5	0–5	0–6	0–5	0–5	0–5
	2	1	1–5	1–5	1–5	1–16	1–10	1–10	1–5	1–5	1–5	1–5	1–5	1–6	1–5	1–5	1–5
	3	0	0–6	0–5	0–5	0–10	0–10	0–10	0–5	0–5	0–5	0–5	0–5	0–6	0–5	0–5	0–5
	4	0	0–6	0–5	0–5	0–10	0–10	0–10	0–5	0–5	0–5	0–5	0–5	0–6	0–5	0–5	0–5
	5	3	0–6	0–6	0–5	0–7	0–7	0–6	0–5	0–5	0–5	0–5	0–5	0–6	0–5	0–5	0–5
	6	0	0–6	0–6	0–5	0–6	0–6	0–6	0–5	0–5	0–5	0–5	0–5	0–6	0–5	0–5	0–5
	7	0	0–6	0–6	0–5	0–5	0–5	0–6	0–5	0–5	0–5	0–5	0–5	0–6	0–5	0–5	0–5
	8	3	1–5	1–6	1–5	1–5	1–10	1–10	1–10	1–5	1–10	0–5	0–5	0–6	0–5	0–5	0–5
	9	2	1–7	0–7	0–6	0–5	0–5	0–5	0–5	0–5	0–5	0–5	0–5	0–6	0–5	0–5	0–6

@ Value of specific yield estimated from nearest wells.

TABLE B-1 (Cont.)

ESTIMATED SPECIFIC YIELD BY SECTIONS

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Township and range M.D.B.&M.	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			0–20	20–40	40–60	60–80	80–100	100–120	120–140	140–160	160–180	180–200	200–220	220–240	240–260	260–280	280–300
8N/7E	10	0	0.8	0.8	0.5	0.7	0.8	0.8	0.8	0.10	0.9	0.6	0.6	0.15	0.12	0.17	0.6
	11	0	0.8	0.8	0.8	0.7	0.8	0.7	0.8	0.8	0.10	0.7	0.8	0.10	0.15	0.12	0.5
	12	0	0.6	0.6	0.8	0.7	0.6	0.6	0.8	0.8	0.10	0.10	0.10	0.12	0.15	0.10	0.5
	13	0	0.5	0.5	0.10	0.7	0.5	0.5	0.8	0.7	0.11	0.11	0.11	0.15	0.15	0.10	0.5
	14	1	1.5	1.5	1.12	1.7	1.5	1.5	1.8	1.7	1.11	1.11	0.10	0.17	0.15	0.10	0.6
	15	0	0.5	0.5	0.10	0.10	0.7	0.7	0.8	0.6	0.8	0.10	0.10	0.17	0.15	0.8	0.5
	16	0	0.5	0.5	0.15	0.10	0.12	0.8	0.6	0.6	0.7	0.10	0.10	0.18	0.20	0.5	0.5
	17	1	1.5	1.6	1.05	1.13	1.10	1.10	1.5	1.5	1.5	1.17	1.05	1.05	1.15	1.5	1.5
	18	1	1.5	1.17	1.11	1.7	1.14	1.6	1.3	1.6	1.5	1.6	1.3	1.10	1.8	1.6	1.5
	19	0	0.5	0.15	0.10	0.6	0.14	0.8	0.5	0.6	0.5	0.8	0.6	0.15	0.8	0.6	0.5
	20	0	0.5	0.10	0.8	0.6	0.10	0.8	0.5	0.8	0.10	0.10	0.10	0.10	0.8	0.6	0.6
	21	0	0.6	0.8	0.6	0.5	0.9	0.10	0.5	0.10	0.12	0.12	0.12	0.12	0.9	0.6	0.8
	28	1	1.6	1.5	1.5	1.5	1.9	1.13	1.7	1.13	1.09	1.13	0.12	0.10	0.9	0.8	0.8
	27	0	0.8	0.5	0.5	0.5	0.8	0.10	0.6	0.8	0.10	0.10	0.10	0.10	0.10	0.8	0.10
	26	0	0.10	0.10	0.6	0.10	0.8	0.5	0.8	0.8	0.10	0.10	0.8	0.8	0.10	0.6	0.8
	25	1	1.11	1.09	1.10	1.8	1.11	1.10	0.10	0.10	0.12	0.10	0.7	0.7	0.10	0.6	0.6
	30	1	1.9	1.5	1.5	1.9	1.5	1.07	1.10	1.16	1.13	1.13	1.5	1.7	1.11	1.5	1.5
	31	0	0.5	0.10	0.12	0.5	0.6	0.15	0.8	0.10	0.9	0.6	0.6	0.7	0.12	0.8	0.5
	32	1	1.3	1.07	1.01	1.3	1.7	1.3	1.3	1.3	1.3	1.1	1.3	0.7	0.11	0.10	0.6
	33	0	0.6	0.15	0.10	0.6	0.7	0.6	0.8	0.6	0.5	0.8	0.6	0.8	0.10	0.15	0.7

Township and range M.D.B.&M.	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			300–320	320–340	340–360	360–380	380–400	400–420	420–440	440–460	460–480	480–500	500–520	520–540	540–560	560–580	580–600
8N/7E	10	0	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	11	0	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	12	0	0.6	0.6	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	13	0	0.6	0.6	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	14	1	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	15	0	0.5	0.6	0.6	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	16	0	0.5	0.10	0.7	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	17	1	1.5	0.15	0.7	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	18	1	1.13	1.05	1.5	1.5	1.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	19	0	0.12	0.20	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	20	0	0.10	0.15	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	21	0	0.6	0.6	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	28	1	0.6	0.6	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	27	0	0.10	0.10	0.8	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	26	0	0.6	0.7	0.7	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	25	0	0.6	0.6	0.7	0.7	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	30	1	0.6	0.6	0.7	0.7	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	31	0	1.5	1.5	1.7	1.7	1.5	1.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	32	1	0.5	0.5	0.7	0.7	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	33	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

[1] Set of specific yield estimated from nearest wells.

TABLE B-1 (Cont.)

ESTIMATED SPECIFIC YIELD BY SECTIONS

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

SACRAMENTO GROUN

Township and range M.D.B.&M.	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300
9N/6E	12	0	0-20	0-15	0-10	0-7	0-5	0-6	0-5	0-6	0-5	0-6	0-5	0-10	0-10	0-7	0-5
	11	0	0-20	0-15	0-10	0-7	0-5	0-6	0-5	0-6	0-5	0-6	0-5	0-10	0-10	0-7	0-5
	13	0	0-20	0-15	0-10	0-7	0-5	0-6	0-5	0-6	0-5	0-6	0-5	0-10	0-10	0-7	0-5
	24	3	3-25	3-10	3-10	3-6	3-5	3-7	5-5	3-5	3-5	3-5	3-5	3-10	3-10	3-7	3-5
	25	6	6-20	6-10	6-10	6-8	6-5	5-6	6-5	6-6	5-6	5-5	5-15	5-10	5-10	5-8	5-5
	26	3	3-15	3-9	3-7	3-15	3-10	3-6	3-6	3-6	3-6	3-6	3-6	3-7	3-9	3-5	3-5
	27	2	2-10	2-15	2-15	2-15	2-10	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5
	28	0	0-10	0-15	0-15	0-15	0-10	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5
	33	0	0-15	0-10	0-8	0-7	0-6	0-10	0-9	0-5	0-5	0-11	0-6	0-8	0-5	0-6	0-6
	34	9	6-15	8-16	9-8	9-7	9-8	6-10	6-9	5-5	5-5	5-11	6-6	6-9	5-5	5-6	5-6
	35	1	1-25	1-20	1-5	1-5	1-5	1-25	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5
	36	2	2-25	2-15	2-6	2-7	2-6	1-5	1-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5
9N/7E	10	0	0-5	0-6	0-9	0-16	0-12	0-20	0-8	0-5	0-5	0-6					
	11	0	0-5	0-6	0-9	0-16	0-12	0-20	0-8	0-5	0-5	0-6					
	12	5	5-5	5-6	5-9	5-16	5-12	5-25	0-10	0-5	0-5	0-6					
	13	0	0-5	0-6	0-10	0-16	0-12	0-20	0-12	0-8	0-5	0-6					
	14	0	0-10	0-8	0-10	0-25	0-15	0-15	0-15	0-10	0-6	0-5					
	15	0	0-10	0-10	0-12	0-16	0-16	0-15	0-15	0-10	0-8	0-5					
	16	3	3-16	3-13	3-13	3-18	3-18	3-27	0-20	0-12	0-8	0-6					
	17	1	1-75	1-9	1-10	0-15	0-15	0-15	0-10	0-12	0-8	0-8	0-8	0-8	0-8	0-7	0-6
	18	2	2-25	2-20	2-15	2-20	2-8	2-16	2-7	2-27	2-9	2-8	2-9	2-8	2-8	2-7	2-20
	19	1	1-20	1-8	1-9	1-20	0-8	0-20	0-8	0-12	0-7	0-7	0-9	0-12	0-12	0-7	0-20

Township and range M.D.B.&M.	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			300-320	320-340	340-360	360-380	380-400	400-420	420-440	440-460	460-480	480-500	500-520	520-540	540-560	560-580	580-600
9N/6E	12	0	0-5	0-5	0-5	0-5	0-10	0-5	0-5	0-5	0-5	0-7	0-5	0-5	0-5	0-5	0-5
	11	0	0-5	0-5	0-5	0-5	0-10	0-5	0-5	0-5	0-5	0-7	0-5	0-5	0-5	0-5	0-5
	13	0	0-5	0-5	0-5	0-5	0-10	0-5	0-5	0-5	0-5	0-7	0-5	0-5	0-5	0-5	0-5
	24	3	3-5	3-5	3-5	3-8	3-10	3-5	3-5	3-5	3-5	3-9	3-5	0-5	0-5	0-5	0-5
	25	6	8-5	8-6	8-5	8-7	8-5	3-20	3-10	3-5	0-5	0-6	0-5	0-5	0-5	0-5	0-5
	26	3	3-5	3-6	3-6	3-6	3-5	2-6	2-6	2-6	3-5	3-5	3-5	3-5	0-5	0-5	0-5
	27	2	2-5	2-20	2-20	2-5	2-15	0-6	0-6	0-6	0-5	0-5	0-5	0-5	0-5	0-5	0-5
	28	0	0-5	0-10	0-20	0-5	0-15	0-6	0-6	0-6	0-5	0-5	0-5	0-5	0-5	0-5	0-5
	33	0	0-6	0-5	0-7	0-5	0-5	0-5	0-15	0-20	0-5	0-5	0-5	0-5	0-5	0-5	0-5
	34	9	8-6	8-5	8-7	5-5	5-5	5-5	5-15	5-20	0-5	0-5	0-5	0-5	0-5	0-5	0-5
	35	1	1-5	1-5	1-5	1-5	1-5	1-5	1-7	1-7	1-6	0-5	0-5	0-5	0-5	0-5	0-5
	36	2	0-5	0-5	0-5	0-5	0-5	0-5	0-7	0-7	0-6	0-5	0-5	0-5	0-5	0-5	0-5
9N/7E	10	0															
	11	0															
	12	5															
	13	0															
	14	0															
	15	0															
	16	3															
	17	1	0-6	0-10	0-10	0-6	0-10	0-10	0-10	0-10	0-10	0-10	0-8	0-6	0-5	0-6	0-6
	18	2	2-5	5-10	5-10	5-7	5-10	5-15	5-10	5-11	5-10	5-10	0-10	0-8	0-6	0-5	0-5
	19	1	0-10	0-10	0-10	0-7	0-10	0-10	0-10	0-10	0-15	0-10	0-8	0-5	0-5	0-5	0-5

(1) Value of specific yield estimated from nearest wells

TABLE B-1 (Cont.)

ESTIMATED SPECIFIC YIELD BY SECTIONS

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Township and range M.D.B.&M.	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300
9N/7E	20	0	0-20	0-12	0-6	0-15	0-10	0-8	0-10	0-8	0-9	0-5	0-9	0-10	0-10	0-7	0-8
	21	1	1-25	1-17	1-6	1-5	1-14	1-5	1-11	1-5	1-6	1-5	1-9	1-[illegible]	1-[illegible]	1-6	1-7
	22	0	0-20	0-16	0-7	0-6	0-14	0-7	0-11	0-8	0-8	0-7	0-10	0-10	0-10	0-6	0-7
	23	1	1-27	1-12	1-7	0-6	0-15	0-10	0-12	0-10	0-10	0-10	0-10	0-10	0-10	0-5	0-6
	24	1	1-13	1-7	1-6	0-6	0-15	0-15	0-12	0-12	0-12	0-10					
	25	0	0-10	0-6	0-6	0-7	0-10	0-10	0-13	0-14	0-14	0-12					
	26	2	1-5	1-5	1-5	1-8	1-17	1-10	1-13	2-16	2-16	2-14	2-10	2-7	2-5	2-4	2-5
	27	0	0-5	0-6	0-10	0-8	0-15	0-12	0-10	0-10	0-10	0-8	0-8	0-6	0-6	0-4	0-5
	28	3	3-11	3-7	3-10	3-9	3-7	3-4	3-5	3-5	3-4	3-8	3-7	3-4	3-4	3-4	3-4
	29	1	1-5	1-9	1-9	0-9	0-7	0-5	0-4	0-4	0-4	0-8	0-7	0-6	0-4	0-4	0-5
	30	0	0-15	0-9	0-7	0-10	0-8	0-6	0-4	0-5	0-5	0-8	0-8	0-10	0-6	0-6	0-6
	31	1	1-25	1-9	1-5	0-10	0-8	0-6	0-5	0-7	0-6	0-8	0-8	0-10	0-4	0-8	0-8
	32	3	3-23	3-[illegible]	3-12	3-17	3-11	3-12	3-5	3-11	3-7	3-10	3-9	3-11	3-4	3-10	3-14
	33	2	2-10	2-10	2-11	2-5	2-4	0-13	0-7	0-9	0-7	0-7	0-7	0-10	0-8	0-10	0-12
	34	3	3-15	3-15	3-15	3-15	3-15	3-16	2-9	2-8	2-8	1-6	1-5	1-10	1-10	1-9	1-10
	35	0	0-10	0-12	0-14	0-16	0-15	0-15	0-12	0-10	0-10	0-10	0-10	0-10	0-10	0-8	0-9
	36	3	3-7	3-8	3-14	3-[illegible]	3-16	3-19	3-17	3-13	3-10	3-14	3-17	3-9	3-13	3-8	3-7

Township and range M.D.B.&M.	Section	Number of wells	Specific yield, in percent, for indicated depth zone, in feet														
			300-320	320-340	340-360	360-380	380-400	400-420	420-440	440-460	460-480	480-500	500-520	520-540	540-560	560-580	580-600
9N/7E	20	0	0-10	0-12	0-10	0-9	0-10	0-10	0-10	0-10	0-12	0-8					
	21	1	1-10	1-12	1-10	1-10	1-10										
	22	0															
	23	1															
	24	1															
	25	0															
	26	2															
	27	0	0-8	0-8	0-8	0-8	0-8										
	28	3	3-6	0-6	0-6	0-8	0-5										
	29	1	0-6	0-6	0-6	0-8	0-5	0-4	0-8	0-8	0-5	0-4					
	30	0	0-6	0-6	0-7	0-8	0-5	0-5	0-7	0-7	0-6	0-5	0-5	0-5	0-5	0-4	0-4
	31	1	0-8	0-8	0-8	0-8	0-5	0-5	0-7	0-7	0-6	0-6	0-5	0-5	0-4	0-4	0-4
	32	3	3-17	3-4	3-16	3-[illegible]	3-[illegible]	3-[illegible]	3-[illegible]	3-12	3-3	3-[illegible]	3-6	3-3	3-5	3-5	3-5
	33	2	0-10	0-10	0-9	0-9	0-5										
	34	3	0-10	0-10	0-10	0-10	0-4										
	35	0	0-10	0-10	0-10	0-10	0-4										
	36	3															

* Value of specific yield estimated from nearest wells.

TABLE B-2
ESTIMATED GROUND WATER STORAGE CAPACITY BY SECTIONS
FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Township and range M.D.B.&M.	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet																
			0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130	130-140	140-150	150-160	160-170
8N/6E	1	640	896	640	640	512	896	384	512	896	*1280	*1280	*1152	*384	*640	*384	*512	*640	*768
	2	640	640	512	1152	640	768	1664	2688	1664	1664	1664	1152	384	640	384	512	640	768
	3	640	1792	1536	768	1664	896	1664	1664	512	512	512	512	512	512	384	512	384	384
	4	320	1152	1024	256	1152	832	768	384	1024	2496	512	512	384	384	256	*416	*512	*512
	5	320	1024	384	1024	384	384	384	384	*1024	*1024	*320	*320	*320	*320	*320	*320	*320	*320
	6	30	30	30	128	384	128	30	384	384	*128	480	960	*30	*30	*30	*30	*30	*30
	7	885	1730	1730	1152	1664	384	960	384	384	*640	*1280	*1280	*640	*640	*640	*640	*640	*640
	8	640	1280	1408	1280	1280	1664	768	768	640	*640	*640	*1280	2944	1536	384	384	384	384
	9	640	2048	2944	1280	768	1280	896	640	640	640	640	*640	*640	*640	*640	*512	384	384
	10	640	*1280	*896	*1664	*640	*896	*768	*512	*512	*512	384	640	640	512	384	*768	*640	*640
	11	640	1280	1664	512	512	640	768	512	512	384	640	640	512	384	*640	*1152	1536	1152
	12	640	*1280	*1280	*1152	*512	*896	*640	*512	*640	*896	*1152	*1280	*1792	*384	*896	*896	*896	*896
	13	640	1152	2304	896	384	1280	640	512	640	1536	1664	2048	2048	*384	*896	*896	*896	*896
	14	640	1280	768	640	512	896	896	768	512	512	384	384	512	384	384	768	768	1408
	15	640	*1408	*1408	*512	*768	*640	*768	*640	*512	*512	*384	*384	*384	*512	*384	*384	*512	*768
	16	640	1664	1408	512	896	384	640	384	*640	*1280	*2048	*2048	*2048	*1280	*512	*512	*768	*1408
	17	640	2176	1664	1280	1792	1664	1280	896	1792	2560	2560	2944	2688	512	512	512	*768	*896
	18	640	896	2176	1792	1536	1280	640	640	768	1152	768	1536	2048	1280	384	384	896	1280
	19	640	1152	2048	2048	1280	1152	1664	896	640	640	768	768	640	384	384	1152	896	*896
	20	640	1280	2560	1664	1280	1664	1152	768	640	512	640	768	*512	*384	*512	*640	*640	*640
	21	640	1792	2560	640	1280	1664	*768	*640	*512	*640	*640	*768	*512	*384	*512	*640	*640	*640
	22	640	*1280	*896	*1664	*896	*768	*512	*512	*1280	*896	*1664	*640	*384	*384	*640	*512	* 384	*768
	23	640	*1280	*896	*1664	*896	*768	*512	*512	*1280	*896	*1664	*640	*384	*384	*640	*512	*384	*768

Township and range M.D.B.&M.	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet													Depth to water table	Storage Capacity Tcum-feet		
			340-360	360-380	380-400	400-420	420-440	440-460	460-480	480-500	500-520	520-540	540-560	560-580	580-600		Above water table	Below water table	All zones
8N/6E	1	640	*1152	*640	*1280	*896	*2304	*1280	*896	*1152	*640	*640	*640	*640	*640	78	8896	38,830	47,726
	2	640	1152	640	1280	896	2304	1280	896	1152	*640	*640	*640	*640	*640	85	8448	34,160	42,608
	3	640	896	640	640	1152	2688	512	1152	1152	640	*640	*640	*640	*640	91	6400	32,000	38,400
	4	320	*512	*416	*448	*1280	*1664	*1344	*1040	*832	*768	*768	*768	*768	*768	43	8832	22,720	31,552
	5	320	*480	*320	*448	*768	*1024	*768	*768	*384	*480	*480	*480	*480	*480	46	8320	16,320	24,640
	6	30	*48	*30	*48	*48	*128	*128	*128	*48	*48	*78	*78	*78	*78	46	240	2,370	2,610
	7	885	*885	*885	*973	*885	*1973	*1973	*1328	*1280	*1280	*1280	*1280	*1280	*1280	43	3660	39,301	42,960
	8	640	*640	*640	*896	*640	*1280	*1280	*1280	*1280	*1280	*1280	*1280	*1280	*1280	43	3840	25,600	29,440
	9	640	384	384	896	384	*1280	*1280	*1280	*1280	*1280	*1280	*1280	*1280	*1280	50	3520	26,624	30,144
	10	640	*1152	*1536	*1408	*1408	*1408	*1408	*1408	*1408	*1408	*1408	*1408	*1408	*1408	50	3520	27,904	31,424
	11	640	1152	1536	1408	1408	1408	1408	1408	1408	1408	1408	1408	1408	1408	50	3520	27,904	31,424
	12	640	*1280	*1536	*1408	*1536	*1536	*1280	*1536	*1280	*1280	*1280	*1280	*1280	*1280	60	4096	27,904	32,000
	13	640	*1280	*1536	*1408	*1536	*1536	*1280	*1536	*1280	*1280	*1280	*1280	*1280	*1280	65	3968	31,776	35,744
	14	640	1280	1536	1536	1664	2688	2688	2304	1664	*1280	*1280	*1280	*1280	*1280	58	6912	25,856	32,768
	15	640	*1280	*1536	*1536	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	73	3072	28,928	32,000
	16	640	*768	*768	*1408	*1280	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	97	3072	24,704	27,776
	17	640	*896	*896	*1280	*1280	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	98	3328	28,160	31,488
	18	640	*896	*896	*1280	*1280	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	66	4480	24,064	28,544
	19	640	*896	*896	*1280	*1280	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	95	3456	28,288	31,744
	20	640	*896	*896	*1280	*1280	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	88	4864	24,576	29,440
	21	640	*640	*640	*1280	*1280	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	85	4480	27,648	32,128
	22	640	*640	*640	*1792	*1536	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	68	3328	23,168	26,496
	23	640	*640	*640	*1792	*1536	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	65	3968	22,144	26,112

* Storage capacity from assumed specific yield.

TABLE B-2 (Cont.)

ESTIMATED GROUND WATER STORAGE CAPACITY BY SECTIONS

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Township and range	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet																
			0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300	300-320	320-340
8N/6E	34	640	*1280	*960	*320	*960	*960	*320	*320	*960	*960	*1280	*640	*384	*384	*640	*320	*384	*960
	35	640	1664	1920	384	640	320	640	384	960	320	1536	640	*384	*384	*640	*320	*384	*960
	36	640	896	640	1664	1152	1152	320	640	1536	1408	320	960	384	384	640	320	384	960
	31	640	896	1664	1664	1280	1152	320	896	640	320	640	384	640	960	384	384	1152	640
	32	640	1536	1536	320	1664	1152	960	640	896	896	896	1920	2304	1536	640	320	640	*640
	33	640	1280	2816	1792	1536	1408	384	320	640	384	320	384	896	*1280	*640	*640	*640	*640
	34	640	640	2176	896	640	1664	960	1920	960	*640	*640	*640	*640	*640	*1280	*640	*640	*640
	35	640	896	1920	1280	1280	1664	640	960	640	384	384	384	*640	*640	*1280	*640	*640	*640
	36	640	896	2560	2816	1280	640	320	1664	1920	320	320	384	320	*640	*960	*640	*640	*640
	33	640	*960	*1280	*1280	*2176	*896	*320	*896	*896	*320	*320	*384	*320	*640	*640	*640	*640	*640
	34	640	*320	*1280	*1280	*2176	*896	*320	*640	*896	*320	*320	*384	*320	*640	*640	*640	*640	*640
	35	640	*320	*896	*896	*2176	*896	*320	*320	*640	*320	*384	*384	*320	*640	*640	*640	*320	*640
	36	640	384	384	384	2304	2560	384	320	384	320	384	384	*320	*640	*640	*640	*320	*640
8N/7E	1	640	*1280	*640	*640	*640	*640	*384	*384	*1280	*640	*640	*640	*640	*640	*320	*640	*320	*640
	2	640	1280	640	640	640	640	384	384	1280	640	640	640	640	640	320	640	320	640
	3	640	*1280	*1280	*1280	*1280	*960	*320	*384	*1280	*640	*640	*640	*640	*640	*320	*640	*320	*640
	4	640	*1536	*1280	*1280	*1536	*960	*320	*320	*1664	*640	*640	*640	*640	*640	*320	*640	*320	*640
	5	640	2304	2944	3072	2304	960	960	*960	*960	*960	*640	*640	*640	*1664	*960	*960	*320	*960
	6	640	*1280	*2304	*3072	*1280	*1664	*960	*960	*960	*960	*320	*320	*1664	*1664	*1664	*1664	*320	*960
	7	640	*1536	*2304	*3072	*1280	*1664	*960	*960	*1664	*1664	*320	*320	*1280	*1664	*1664	*1280	*320	*960
	8	640	1408	1664	2560	1408	1152	1664	1280	896	1408	2304	1152	896	896	1280	640	960	960
	9	640	1152	1152	640	896	1408	1664	896	2560	1152	384	320	896	1664	1280	320	896	*896

Township and range	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet													Depth to water table	Storage Capacity (acre-feet)		
			340-360	360-380	380-400	400-420	420-440	440-460	460-480	480-500	500-520	520-540	540-560	560-580	580-600		Above water table	Below water table	All zones
8N/6E	34	640	*640	*640	*1792	*1536	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	100	4352	21,632	25,984
	35	640	*640	*640	*1792	*1536	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	100	4864	23,936	28,800
	36	640	640	640	1792	1536	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	75	3904	23,872	27,776
	31	640	640	1664	640	1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	65	3840	25,344	29,184
	32	640	*640	*1664	*640	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	65	4160	26,752	30,912
	33	640	*640	*1664	*640	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	65	4160	26,496	30,656
	34	640	*640	*1664	*640	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	75	4928	25,408	30,336
	35	640	*640	*1664	*640	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	75	3904	23,552	27,456
	36	640	*640	*1664	*640	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	75	3904	25,408	29,312
	33	640	*640	*1664	*640	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	80	4160	23,040	27,200
	34	640	*640	*1664	*640	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	87	4992	20,224	25,216
	35	640	*640	*1664	*640	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	100	5407	19,201	24,608
	36	640	*640	*1664	*640	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	*1664	100	5376	18,688	24,064
8N/7E	1	640	*640	*1792	*1664	*1664	*640	*384	*384	*384	*384	*384	*512	*384	*384	*384	140	4480	15,616	20,096
	2	640	640	1792	1664	1664	640	384	384	384	384	384	512	384	384	384	130	4480	15,808	20,288
	3	640	*640	*1536	*1664	*1664	*640	*384	*384	*384	*384	*384	*512	*384	*384	*384	100	5888	15,872	21,760
	4	640	*640	*1664	*1664	*1664	*640	*384	*384	*384	*384	*384	*512	*384	*384	*640	80	6912	14,848	21,760
	5	640	*640	*896	*896	*1664	*640	*384	*384	*384	*384	*384	*512	*640	*640	*640	70	8192	14,656	22,848
	6	640	*640	*768	*768	*768	*640	*384	*384	*384	*384	*384	*512	*640	*640	*640	70	8256	14,720	22,976
	7	640	*640	*640	*640	*768	*640	*384	*384	*384	*384	*384	*640	*640	*640	*640	80	8832	14,080	22,912
	8	640	640	640	2816	1280	1280	640	1280	*640	*640	*640	*640	*640	*640	*640	70	6336	19,328	25,664
	9	640	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	115	6016	22,784	28,800

* Storage capacity from assumed specific yield

TABLE B-2 (Cont.)

ESTIMATED GROUND WATER STORAGE CAPACITY BY SECTIONS

FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Township and range M.D.B.&M.	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet																	
			0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300	300-320	320-340	340-360
8N/7E	36	640	*185	*185	640	*455	*185	*185	*185	*185	*320	*320	*320	*185	*185	*185	*320	*455	*455	*455
	31	640	*185	*185	640	*455	*185	455	*185	*185	*185	*185	*185	*185	*185	*185	640	*455	*455	*455
	30	640	*455	*455	*185	*455	*455	*455	*185	*185	*185	*185	*185	*185	*185	*185	640	*455	*455	*455
	25	320	*320	*320	640	448	*320	*320	448	448	*320	*320	*320	*320	*320	*320	640	*455	*455	*455
	26	640	640	640	1535	896	640	640	384	896	448	448	448	448	448	448	640	*455	*455	*455
	35	640	*640	*640	*1535	*1280	*455	*455	*185	*185	*185	*185	*185	*185	*185	*185	*185	*455	*455	*455
	34	640	*640	*640	*1535	*1280	*1280	*185	*185	*185	*185	*185	*185	*185	*185	*185	*185	*455	*455	*455
	27	640	640	320	2560	1664	1535	1280	640	640	640	640	640	640	640	640	640	640	640	*1280
	28	640	640	1576	1448	896	2688	768	384	384	384	1576	768	384	2688	2688	640	640	640	*1280
	29	640	*640	*1280	*1280	*768	*2688	*1280	*640	*768	*640	*1280	*1280	*1280	*1280	*185	320	640	1664	1664
	32	640	*640	*1280	*1280	*768	*1280	*1280	*640	*1280	*1280	*1280	*1280	*1535	*1535	*1535	*1535	*1535	*1535	*1535
	33	640	*768	*1280	*768	640	*1152	*1280	*640	*1280	*1280	*1280	*1535	*1535	*1535	*1280	*1152	*1152	*1280	*1280
	4	640	768	640	640	640	1152	1664	896	1664	1664	1664	1664	*1535	*1535	*1280	*1280	*1280	*1280	*1280
	5	640	*512	*384	*384	*384	*512	*640	*384	*512	*512	*768	*768	*512	*512	*640	*512	*512	*512	*512
	8	640	*640	*640	*384	*640	*512	*384	*512	*512	*512	*640	*640	*512	*512	*640	*512	*384	*512	*512
	9	640	*1280	*1280	*1664	*1664	*1280	*1280	*1280	*1280	*1280	*1280	*1535	*512	*512	*1280	*768	*768	*768	*768
	16	640	1448	2560	1664	1664	1664	1664	1536	1664	*1535	*1535	*1535	*512	*512	*1664	*640	*768	*768	*768
	17	640	640	640	640	640	640	896	2176	1664	*1280	*1280	1664	*512	*512	640	640	640	640	640
	20	640	*640	*1280	*1280	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	21	320	384	2560	1664	896	384	384	384	384	384	384	384	384	384	384	384	384	384	384
	28	640	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384

Township and range M.D.B.&M.	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet													Depth to water table	Storage Capacity (acre-feet)		
			340-360	360-380	380-400	400-420	420-440	440-460	460-480	480-500	500-520	520-540	540-560	560-580	580-600		Above water table	Below water table	All zones
8N/7E	36	640	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	130	6144	88,480	88,480
	31	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	140	6400	89,440	89,840
	30	640	*640	*512	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	145	6272	89,712	89,984
	25	320	*320	*256	*320	*320	*320	*320	*320	*320	*320	*320	*320	*320	*320	130	3584	89,280	13,632
	26	640	*512	*512	*768	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	140	6656	89,280	89,280
	35	640	*384	*384	*768	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	140	6400	81,632	88,544
	34	640	*384	*384	*768	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	115	4992	83,968	39,296
	27	640	384	384	768	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	75	3456	87,456	33,056
	28	640	*384	*384	*768	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	90	6016	88,256	88,960
	29	640	*640	*640	*768	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	95	4352	81,888	38,880
	32	640	*896	*896	*768	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	75	3968	83,648	87,104
	33	640	*896	*896	*768	*768	*640	*640	*640	*640	*640	*640	*640	*640	*640	110	5376	88,832	38,208
	4	640	*512	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	193	6656	88,960	89,960
	5	320	448	448	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	*384	145	3584	11,904	11,904
	8	640	*896	*896	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	141	5760	9,856	13,376
	9	640	*896	*896	*640	*512	*640	*640	*640	*640	*640	*640	*640	*640	*640	115	4992	88,736	88,928
	16	640	896	896	640	384	*640	*640	*640	*640	*640	*640	*640	*640	*640	45	2304	83,840	88,544
	17	640	*896	*896	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	85	5120	88,960	87,680
	20	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	85	6400	88,960	85,760
	21	320	*320	*320	*320	*320	*320	*320	*320	*320	*320	*320	*320	*320	*320	78	2496	37,344	73,888
	28	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	200	8000	9,600	12,288

* Storage capacity from reversed specific yield.

TABLE B-2 (Cont.)

ESTIMATED GROUND WATER STORAGE CAPACITY BY SECTIONS
FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Township and range M D B & M	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet																
			0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300	300-320	320-340
9N/6E	13	634	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	24	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	25	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	36	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
9N/7E	30	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	31	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	32	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	33	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	34	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	35	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640
	36	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640

Township and range M D B & M	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet													Depth to water table	Storage Capacity (acre-feet)		
			340-360	360-380	380-400	400-420	420-440	440-460	460-480	480-500	500-520	520-540	540-560	560-580	580-600		Above water table	Below water table	Total
9N/6E	13	634	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	35	1,280	7,680	8,960
	24	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	35	3,840	6,400	7,040
	25	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	40	4,480	10,880	15,360
	36	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	40	5,120	10,240	15,360
9N/7E	30	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	45	7,680	10,240	17,920
	31	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	35	3,840	10,880	14,720
	32	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	45	7,680	15,360	23,040
	33	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	40	5,120	10,240	15,360
	34	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	40	5,120	10,240	15,360
	35	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	40	5,120	10,240	15,360
	36	640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	*640	40	5,120	10,240	15,360

* Storage capacity from assumed specific yield.

TABLE B-2 (Cont.)

ESTIMATED GROUND WATER STORAGE CAPACITY BY SECTIONS
FOLSOM-EAST SACRAMENTO GROUND WATER QUALITY INVESTIGATION

Township and range M.D.B.&M.	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet															
			0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300	300-320	UP to ...
9N/7E	20	640	*2560	*1535	*1024	*1280	*1280	*1024	*1280	*1024	*640	*640	*1152	*1280	*2560	*896	*1024	*1280	*11,0
	21	640	2000	1276	768	640	2752	640	1408	640	640	640	1152	2944	2560	768	896	1280	11,5
	22	640	*2560	*2048	*896	*768	*1792	*896	*1408	*1024	*1024	*896	*1280	*1280	*2560	*768	*896		
	23	640	2176	2432	2176	*768	*1280	*1024	*1536	*1280	*1280	*1280	*1280	*1280	*2560	*640	*768		
	24	640	1664	896	768	*768	*1280	*1792	*1536	*1536	*1536	*1280							
	25	640	*1280	*768	*768	*896	*1024	*896	*1664	*1792	*1792	*1536							
	26	640	640	640	640	1664	2816	2304	1664	2048	2048	1792	1536	896	384	512	640		
	27	640	*640	*768	*1280	*1024	*1280	*1536	*1792	*1280	*1280	*1024	*1024	*768	*512	*512	*640	*1024	*1024
	28	640	1408	896	1792	1152	896	512	384	384	512	1024	896	512	512	512	512	768	*768
	29	640	640	1152	1152	*1152	*896	*640	*512	*512	*512	*1024	*896	*768	*512	*640	*768	*768	*768
	30	640	*1280	*1152	*896	*1280	*1024	*768	*512	*640	*640	*1024	*1024	*1280	*768	*768	*768	*768	*768
	31	640	2000	1152	640	*1536	*1024	*768	*640	*896	*768	*1024	*1024	*1536	*512	*1024	*1024	*1024	*1024
	32	640	2304	2560	1664	2176	1408	1408	896	1408	896	1280	1152	1664	512	1280	2752	2176	512
	33	640	2432	2304	1408	640	512	*1280	*896	*1024	*896	*896	*896	*1536	*1024	*1280	*1280	*1280	*1280
	34	640	1280	1280	1280	1280	1280	1024	1152	1024	1024	768	640	1280	1280	1152	1280	*1280	*1280
	35	640	*1280	*1536	*1792	*1536	*1280	*1024	*1536	*1280	*1280	*1280	*1280	*1280	*1280	*1024	*1152	*1280	*1280
	36	640	896	1024	2752	2560	2048	2176	1664	2176	2752	2752	2176	1152	1664	1024	896		

Township and range M.D.B.&M.	Section	Area (acres)	Storage capacity, in acre-feet, for indicated zone, in feet													Depth to water table	Storage Capacity (acre-feet)		
			340-360	360-380	380-400	400-420	420-440	440-460	460-480	480-500	500-520	520-540	540-560	560-580	580-600		Above water table	Below water table	All zones
9N/7E	20	640	*1280	*1152	*1280	*1280	*1280	*1280	*1536	*1024						35	1664	27,904	29,568
	21	640	1280	1280	1280											40	6144	23,808	29,952
	22	640														45	9856	20,096	29,952
	23	640														70	7296	24,256	31,552
	24	640														85	4352	9,344	13,696
	25	640														207	6912	8,384	15,296
	26	640														180	5760	13,824	19,584
	27	640	*1024	*1024	*1024											73	3328	27,392	30,720
	28	640	*768	*1024	*640											46	4352	11,648	15,872
	29	640	*768	*1024	*640	*512	*1024	*1024	*640	*512						80	8960	10,752	19,712
	30	640	*896	*1024	*640	*640	*896	*896	*768	*640	*640	*640	*640	*512	*512	60	3968	21,376	25,344
	31	640	*1024	*1024	*640	*640	*896	*896	*768	*768	*640	*640	*512	*512	*512	65	5376	22,144	27,520
	32	640	2048	2560	2560	2560	2560	1536	384	2560	768	384	640	640	640	65	7552	27,648	35,200
	33	640	*1152	*1152	*640											70	6656	27,392	34,048
	34	640	*1280	*1280	*512											100	9600	27,200	36,800
	35	640	*1280	*1280	*512											115	10872	27,392	37,776
	36	640														105	10400	13,736	23,936
															TOTAL		136,149	9,844,139	9,981,288

* Storage capacity from saturated reserve yield

APPENDIX C

WATER QUALITY CRITERIA

APPENDIX C

WATER QUALITY CRITERIA

In all activities dealing with measurement and observation of physical data, there must be a yardstick or standard by which the observer, planner, and user can judge or classify the information gathered. With regard to water quality, the problem becomes one of determining whether or not the water is suitable for the anticipated use. Domestic water supplies should protect the health and promote the well-being of individuals and the community. Irrigation waters should not contain high concentrations of minerals harmful to plant life.

The Public Health Service Drinking Water Standards were first adopted in 1914 to protect the health of the traveling public. The general and widespread use of these standards since that time has led to a series of revisions which have been applicable to water supplies generally.

The following standards were promulgated by the Public Health Service, U. S. Department of Health, Education, and Welfare, effective April 5, 1962, for potable water used by carriers subject to the Federal Quarantine Regulations.

Physical Characteristics

Drinking water should contain no impurity which would cause offense to the sense of sight, taste, or smell. Under general use, the following limits should not be exceeded:

Turbidity	5 units
Color	15 units
Threshold Odor Number	3

Chemical Characteristics

Drinking water shall not contain impurities in concentrations which may be hazardous to the health of the consumers. It should not be excessively corrosive to the water supply system. Substances used in its treatment shall not remain in the water in concentrations greater than required by good practice. Substances which may have deleterious physiological effect, or for which physiological effects are not known, shall not be introduced into the system in a manner which would permit them to reach the consumer.

The following chemical substances should not be present in a water supply in excess of the listed concentrations where, in the judgment of the reporting agency and the certifying authority, other more suitable supplies are or can be made available.

Substance	Concentration in mg/l
Alkyl Benzene Sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250.
Copper (Cu)	1.
Carbon Chloroform Extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride (F)	(See Footnote 1/)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate 2/ (NO_3)	45.
Phenols	0.001
Sulfate (SO_4)	250.
Total Dissolved Solids	500.
Zinc (Zn)	5.

1/ Though the U. S. Department of Public Health has recommended limits for fluoride concentrations, the California State Board of Public Health has defined the maximum safe amounts of the fluoride ion in drinking water to be used in California. These limits are included in Table C-1.

2/ In areas in which the nitrate content of water is known to be in excess of the listed concentrations, the public should be warned of the potential dangers of using the water for infant feeding.

The presence of the following substances in excess of the concentrations listed shall constitue grounds for rejection of the supply:

Substance	: Concentration in mg/l
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Hexavalent) (Cr^{+6})	0.05
Cyanide (CN)	0.2
Fluoride (F)	(See Footnote 1/)
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

1/ Though the U. S. Department of Public Health has recommended limits for fluoride concentrations, the California State Board of Public Health has defined the maximum safe amounts of the fluoride ion in drinking water to be used in California. These limits are included in Table C-1.

TABLE C-1

Mean Annual Temperature	Mean monthly fluoride ion concentration
50° F	1.5 ppm
60° F	1.0 ppm
70° F - above	0.7 ppm

Criteria for the mineral quality of irrigation water have been developed at the University of California at Davis and at the Regional Salinity Laboratory of the United States Department of Agriculture. Because of diverse climatological conditions and the variation in crops and soils in California, only general limits of quality for irrigation waters, as given in the following tabulation, can be suggested.

QUALITATIVE CLASSIFICATION OF IRRIGATION WATERS

Chemical properties	Class 1 excellent to good	Class 2 good to injurious	Class 3 injurious to unsatisfactory
Specific electrical conductance in micromhos at 25°C	Less than 1,000	1000 - 3000	More than 3000
Total dissolved solids, in ppm	Less than 700	700 - 2000	More than 2000
Chlorides, in ppm	Less than 175	175 - 350	More than 350
Sodium, in percent of base constituents	Less than 60	60 - 75	More than 75
Boron, in ppm	Less than 0.5	0.5 - 2.0	More than 2.0

These criteria are subject to limitations in actual practice. In many instances a water may be wholly unsuitable for irrigation under certain conditions of use, and yet be satisfactory under other circumstances. Additional physical factors such as soil permeability, drainage, temperature, humidity, rainfall, and other similar conditions can alter materially the response of a crop to a particular quality of water.

Specific electrical conductance (denoted as $EC \times 10^6$) is a chemical property of a given water providing an approximate measure of the quantity of total dissolved solids (TDS) in solutions containing mineral matter. This determination is simple and inexpensive and the measured values of electrical conductance are a very useful index to the classification of water supplies. Throughout the investigational area, total dissolved solids, expressed in parts per million, usually range from 55 to 70 percent of the "conductivity" (as it is often referred to) expressed in micromhos.

Chlorides (Cl) are considered to be among the most troublesome anions found in irrigation water supplies. At certain levels of concentration, chlorides are toxic to most plants and therefore are an important consideration in classifying waters for use in irrigation. The determination of the quantity of chlorides contained in a water supply is relatively simple and accurate in modern laboratory practice.

For many years, leading agricultural experts have used the measure known as "percent sodium" (% Na) to identify waters which might induce the undesirable characteristics associated with alkali soils. When irrigation water containing an overabundance of sodium ions is applied to soils containing exchangeable calcium and magnesium ions, these ions tend to be replaced by the sodium. Continued application of such water could cause the soil to be impaired in both tilth and permeability. The effect indicated by the percent sodium, the percentage relationship of the sodium concentration to the total cation concentration, are generally minor until the percentage rises considerably above 50 percent.

Boron (B) is found in almost all waters used for irrigation in this area. While minute traces of boron are essential for plant growth, many plants are very sensitive to boron and even small concentration, barely in excess of the tolerance level, may produce plant injury. Plants vary in their sensitivity to boron, and in classifying waters according to their boron content, the tolerance of the crop to which the water is to be applied should be considered.

APPENDIX D

RELATED INVESTIGATIONS AND REPORTS

RELATED INVESTIGATIONS AND REPORTS

State of California, State Water Resources Board. "Bulletin No. 21, American River Investigation." June 1955.

State of California, Central Valley Regional Water Pollution Control Board. "Pollution Study of American River, Sacramento River Watershed." January 1952.

Dewante and Stowell. "Sacramento County Sewage Survey, 1959-60."

Aerojet-General Corporation. "Industrial and Domestic Waste Control System - Sacramento Plant." 1961.

Velz, C. J., "Report on Lower American River Water Uses and Quality Conditions." March 1959.

United States Department of the Interior, Bureau of Reclamation. "Folsom South Unit, A Central Valley Project, California. A Report on the Feasibility of Water Supply Development." January 1960.

United States Department of the Interior, Geological Survey. Geological Water Supply Paper 1497. "Geologic Features and Ground Water Storage Capacity of the Sacramento Valley, California." 1961.

10 PAGES
OF
OVERSIZED
MAPS

Declaration of Stephen Ross

I, Stephen Ross, declare that:

1. I am a senior hydrogeologist for Komex, which is an environmental and engineering consulting firm. My office is located in the Komex 's Sacramento Branch. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "County Groundwater Model-Model Development and Basin Groundwater Yield," produced by Montgomery Watson for the Sacramento County Water Agency, and dated June 1993, is a true and correct copy of this report. As an environmental and engineering consulting firm, which is routinely engaged in water resource issues, our office regularly maintains files of reports pertaining to the state of Sacramento County groundwater resources. This report was taken and copied from these files.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Stephen Ross

Sacramento County Water Agency

County Groundwater Model

Model Development and Basin Groundwater Yield

June 1993

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Section 1

SECTION 1

REPORT SCOPE AND MODELING OBJECTIVES

In order to achieve maximum utilization of the groundwater and surface water resources available to users within the County of Sacramento, it was determined by staff of the Sacramento County Water Agency (Agency) that an analytical tool is required which adequately simulates the many components of the hydrologic system, including the movement of water from the surface to the groundwater basin, as well as the movement of groundwater within the individual aquifers of the basin. Further, such a tool should have the ability to evaluate the impacts of alternative land use development and groundwater management strategies. The analytical tool developed for the Sacramento County area that satisfies these requirements is the Integrated Groundwater-Surface Water Model (IGSM).This report summarizes the development of the county-wide model for the Agency by Montgomery Watson, including the overall model characteristics; the extensive data collection effort involved; the model calibration procedure; groundwater quality; and the preliminary analysis of basin yield. More detailed model documentation is available in a separate document. The report is organized into the following sections:

- **Report Scope and Modeling Objectives**
- **Study Area Characteristics**
- **Model Overview**
- **Model Input Data**
- **Model Calibration**
- **Groundwater Quality**
- **Basin Water Resource Analysis**
- **Summary and Recommendations**
- **Appendices**

PREVIOUS WORK

The water resources associated with Sacramento County have been studied extensively, especially during the last twenty years. While there is currently no physical water shortage in the County, groundwater has been overdrafted in several areas. Some areas depend entirely on groundwater, while others have access to surface water. Although unused surface water entitlements may be available, there is often no existing conveyance connection between users having excess water and those in an overdraft condition. The recent seven-year drought has increased dependence on groundwater. Further, surface water rights on such major streams as the Sacramento and American Rivers have become issues over the years due to their impact on the Delta. Major previous work pertinent to the development of the Sacramento County model include the following:

- The 1974 DWR Sacramento County Groundwater Study
- The 1978 DWR Sacramento Valley Groundwater Study
- The Central Valley Integrated Ground-Surface Water Model
- The City of Sacramento Integrated Ground-Surface Water Model
- The 1987 Montgomery Zone 40 Master Water Supply Plan
- The 1989 Boyle Water Plan Supplement and Follow-up Demand Updates

The key work contained in these prior studies is summarized below. A more detailed explanation of some of the work previously conducted was discussed in a County inter-office memorandum (Appendix C).

Report Scope and Modeling Objectives

The 1974 DWR Sacramento County Groundwater Study

The California Department of Water Resources (DWR) published Bulletin No. 118-3, titled "Evaluation of Ground Water Resources: Sacramento County in July 1974. The study included the development of a finite difference computer simulation of 967 square miles of groundwater basin covering most of Sacramento County and part of Yolo County. The model treated the entire basin as a single freebody (no aquifer layers), and contained 102 elements with an average grid size of three-by-three miles. The modeled period was 1962 to 1968. The database included land use, agricultural pumping (based on power records), municipal pumping, stream diversions, and groundwater levels. Although water quality was not simulated in the model, the study included an inventory of quality data and statistical analysis at selected locations. Useful information includes geologic sections, land use, water use, and groundwater levels.

The 1978 DWR Sacramento Valley Groundwater Study

Increasing dependence of Sacramento Valley on groundwater prompted DWR and the US Geological Survey (USGS) to develop a hydrological simulation model and a series of maps that were required as model input. The study report was published in August 1978 as DWR Bulletin No. 118-6, titled "Evaluation of Groundwater Resources: Sacramento Valley", with several USGS Open File Reports, as listed in Appendix B of the bulletin. The model covered 4,900 square miles, including Sacramento County and areas to the north and south. The model elements ranged in size fro one-by-three miles to three-by-three miles. The study period was from 1961 to 1970. Water budget components were generated by township. Useful information includes geologic sections, land use, water use, and groundwater levels.

The Central Valley Integrated Ground-Surface Water Model

In order to satisfy the planning needs of the U.S. Bureau of Reclamation (Reclamation), the California DWR, and the California State Water Resources Control Board (SWRCB), James M. Montgomery, Consulting Engineers, Inc. updated a 1987 model by Boyle Engineering Corporation that covered the entire Central Valley of California. An extensive data collection effort was organized for this model update in order to enhance modeling accuracy. The finite element model developed was acronymed IGSM for Integrated Groundwater-Surface Simulation Model, and more specifically CVGSM for Central Valley Groundwater-Surface Water Simulation Model. The model contained 1,392 elements with an average size of 14 square miles. The study period used was from 1922 to 1980. Due to the extensive data collection effort performed for this model update, there is particular useful information on stratigraphy (drill logs, geologic sections), land use (maps), water use (pumping and surface diversions), and groundwater levels. In addition, the key value of this model is that local, site-specific models can be linked to the behavior of regional groundwater basins, which may exert very significant impacts on the local groundwater basin.

The City of Sacramento Integrated Ground-Surface Water Model

In August 1992, James M. Montgomery, Consulting Engineers, Inc. completed a draft report titled "Groundwater Management Study" for the City of Sacramento, which included the development of a finite element computer simulation of the Place of Use (POU) for the city's Sacramento and American River water. The model used was the IGSM, linked to the CVGSM, as described above. The model developed for the city covered 176 square miles. There are 269 finite elements, both triangular and quadrilateral, with an average size of 0.66 square miles. Several nodes of the regional CVGSM were matched to the city model. Grid lines match the major rivers - the American and Sacramento, and the other major secondary streams. The data collection effort focused on obtaining historical pumping and water quality information on a well-by-well basis so that problem areas could be characterized with respect to meeting drinking water standards. In addition to the city, major water suppliers within the POU were also contacted. Considerable effort was expended

to convert the database into electronic format, to verify the database, and in developing a procedure for filling in and extending data. The local model was used to evaluate alternative water management strategies. The city model configuration was directly incorporated into the County model. Much of the city database was utilized in the expanded County-wide model.

The 1987 Montgomery Zone 40 Master Water Supply Plan

In February 1987, James M. Montgomery, Consulting Engineers, Inc. completed the report "Zone 40 Master Water Supply Plan" for the Sacramento County Water Agency. The study covered an area of 28,000 acres south of the City of Sacramento representing the ultimate boundaries of the County's existing Zone 40 service area. The work involved development of future water requirements; definition of the existing sources of water supply, including an assessment of groundwater conditions by Luhdorff and Scalmanini; a summary of source water quality and required treatment to meet drinking water standards; development and evaluation of alternatives to balancing water requirements and existing water resources; and a discussion of financing. Useful information for the County-wide model included the groundwater resources and water quality assessments.

The 1989 Boyle Water Plan Supplement and Follow-up Demand Updates

The December 1989 "Water Plan Supplement - 1989" prepared by Boyle Engineering Corporation for the Sacramento County Water Agency was intended to supplement information in the Sacramento County Water Plan. The supplement was to serve primarily as an informational document to be used with other work, such as environmental documents. A Memorandum of Understanding between the City and County of Sacramento highlighted Sacramento County's immediate need for further planning for water resource management including the need to update future water needs; to develop costs and impacts of various diversion alternatives; and the opportunities for conjunctive use of surface and groundwater supplies. The report presents useful background information on the current water supply situation within the County, analyzed by sixteen subareas. These subareas served as the starting point for the 31 County-wide model subregions. Information on hydrologic budgets was reviewed during the County-wide model calibration. During model development, Boyle Engineering Corporation was consulted on their follow-up demand updates with an effort made to coordinate the model subregions. Future demand projections were also obtained to run preliminary evaluations of basin yield.

REPORT SCOPE

The scope of work was defined in Exhibit A of the engineering services agreement of March 9, 1992 between Sacramento County and James M. Montgomery Consulting Engineers, Inc. (the predecessor company to Montgomery Watson). The agreement was originally focused on developing the County-wide model and then applying it to the Zone 40 area to determine groundwater yield because of the immediate need to update a previous master plan for that area. It was concluded that application of the model to the Zone 40 area would be more beneficial if performed as part of the master plan update work. Therefore, this report is entirely focused on development of the County-wide model and preliminary analysis of County-wide basin yield. The report scope was defined as a series of tasks contained in Exhibit A, summarized below, with the modification discussed above.

Task 1 - Identify Modeling Criteria and Data Requirements

The features of the computer simulation are determined by the specified model boundaries, surface land and subsurface geological characteristics, data availability, and the objective of modeling. Summarize modeling criteria, including the following:

- Model Characteristics
- Geography/Geohydrology
- Hydrology/Climatology
- Land Use
- Water Use

Based on these criteria, evaluate the adequacy of the existing database and define the specific needs for additional data.

Task 2 - Collect Additional Data

Collect, in association with County staff, additional data, as defined in Task 1.

Task 3 - Configure Model

Based on the modeling criteria identified in Task 1, develop a base map covering the study area and lay out the plan elements with an approximate average area of one square mile. Match plan grid with key rivers and streams of the study area, including the Sacramento, American, and Cosumnes River. Provide for analysis of portions of the study area through the definition of subregions that generally conform to the major political and water supply agency boundaries. Based on a review of available stratigraphic data, establish the vertical layering of the model with a minimum of three layers.

Task 4 - Adjust Input Data Files

Review input files available from the previous City of Sacramento model and revise and refine to accommodate the study area. These files include those pertinent to the model characteristics, hydrology, and land and water use. All files to be developed on a monthly step.

Task 5 - Calibrate Model

Check the accuracy of the model simulation by comparing output against actual measured data. The period 1970 - 90 will be the calibration period based on data availability. Refine model parameters and present comparison of modeled and historical data. Discuss potential discrepancies, including modeling, input data, and measured data.

Task 6 - Summarize Groundwater Quality

Collect available data that is pertinent to establishing the suitability of groundwater as a potable urban water supply, including mineralization (iron and manganese) and local contamination from hazardous waste. Summarize the water quality data and highlights of regulatory standards.

Task 7 - Estimate Safe Yield of Area

Determine the amount of groundwater that may be withdrawn without producing undesirable conditions such as a long-term decline in groundwater storage (level) or a degradation of existing water quality.

Although the engineering services agreement specified determination of "safe yield," after discussion with County staff, it was agreed that the yield analysis would consist of IGSM runs determining the response of the County groundwater basin to alternative land use and pumping distribution scenarios.

Task 8 - Prepare Model Documentation

Summarize the work conducted in Tasks 1 through 7 in a report that includes the following:

- Overview of Model
- Theoretical Basis for Model
- Input Data File Structure with Sample Input
- Output Description with Sample Output
- Calibration

Task 9 - Train County Staff

Discuss and demonstrate to County staff the physical, conceptual, and theoretical basis of the model, as well as the calibration process and development of groundwater safe yield.

Task 10 - Project Management and Quality Control

Provide the necessary management and quality control for development of the model and determination of groundwater safe yield.

MODELING OBJECTIVES

Modeling of the groundwater and surface water resources of Sacramento County allows the definition of a sustainable groundwater extraction rate and analysis of alternative water management strategies. Specific objectives of developing the Sacramento County groundwater model are to allow:

- understanding the complex interactive nature of surface water and groundwater conditions, County-wide, and for defined subareas
- determining the sustainable groundwater yield rate of the County and its subareas from an analysis of alternative water management strategies
- determining which areas, or which aquifers, may have to be subject to reduced groundwater extraction in order to preserve groundwater quality and maximize regional production
- analyzing opportunities to enhance groundwater recharge.

Section 2

SECTION 2

STUDY AREA CHARACTERISTICS

The study area, historical land and water use, and key hydrogeologic aspects that impact groundwater conditions are summarized in this section.

STUDY AREA LOCATION AND GENERAL FEATURES

Sacramento County is located within the southeastern portion of Sacramento Valley of California. The County encompasses the Cities of Sacramento, Folsom, and Galt as well as the unincorporated areas of Rancho Cordova, North Highlands, Fair Oaks, Citrus Heights, Carmichael, Rio Linda, Elk Grove, and Orangevale. The County is bounded by the Sacramento River and Yolo County to the west, Placer and Sutter Counties to the north, San Joaquin County to the South, and the Sierra Nevada foothills to the east (El Dorado and Amador Counties). The study (modeled) area is smaller than the County, specifically excluding the "Delta Leg" (southwest corner of County), and portions of the Eastern County. (See Section 4 for precise model boundaries.) See Figure 2-1 for definition of study area.

With the exception of the eastern foothills, the County is relatively flat and has an average elevation of approximately 50 feet mean sea level. Ground elevations in the County range from 900 feet in the eastern foothills to ten feet below sea level in the Delta Islands.

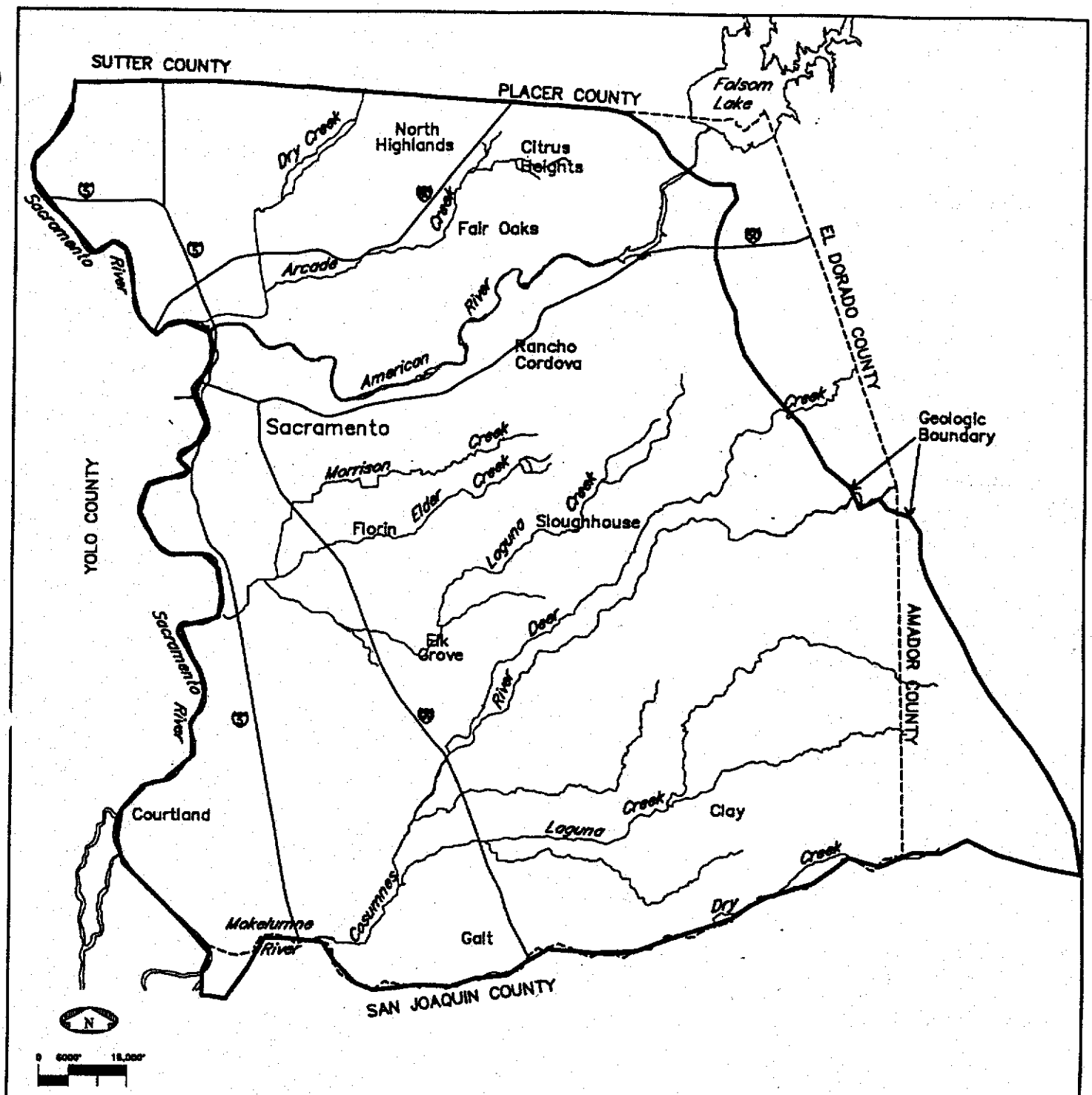
The mean annual precipitation within the County is geographically variable due primarily to the Sierra Nevadas and foothills east of the County. In the vicinity of Folsom and Folsom Lake (north eastern area of the County) the mean annual rainfall is approximately 27 inches, however, along the western boundary adjacent to the Sacramento River, the mean annual rainfall is approximately 16 to 17 inches. The mean annual precipitation in the City of Sacramento is approximately 17.5 inches. The precipitation in the area is highly seasonal with over 75 percent of the rainfall occurring in the winter months between November and March.

The primary rivers in Sacramento County are the Sacramento River, American River, and Cosumnes River. The Sacramento River drains the entire Sacramento Valley and its flows are largely regulated by many upstream reservoirs and diversions. The Sacramento River flows along the western boundary of Sacramento County before ultimately discharging into the San Francisco Bay-Delta. The American River and Cosumnes River both drain the eastern side of the Sierra with a flow direction of east to west. The American River is the larger of these two rivers and its flow is regulated by Folsom Reservoir located in northeastern Sacramento County. The Cosumnes River watershed is largely unregulated and in most years the downstream flows are intermittent with no flow occurring in the summer months. There are numerous other smaller streams and creeks that drain Sacramento County. In general, the flow direction of these creeks is from east to west and they ultimately drain to the Sacramento River. These streams are primarily intermittent streams, with little or no upstream regulation.

HISTORICAL LAND AND WATER USE

Land and water use patterns are key parameters used in model development and calibration. The historical land and water use within Sacramento County are summarized below.

Land use directly affects water use, and it also impacts the amount of surface runoff and percolation into the soils from rainfall and irrigation applied water. The principal land use categories incorporated in the County model are agriculture, urban (including residential, commercial and industrial areas), native vegetation and riparian. The primary agricultural areas are



STUDY AREA

FIGURE 2-1

in the south and southeastern parts of Sacramento County and in the Natomas area of the northern County. Urban areas are concentrated in the City of Sacramento (north and south of the American River) as well as much of the area adjacent to and north of the American River. Native vegetation consists of undeveloped areas and previously cultivated lands that are now fallow. Most undeveloped areas are located in the eastern and southern parts of the County. Riparian areas consists of swamps and marshes, meadow lands, and water surfaces, most of which are along waterways and water bodies, including major Rivers, and minor streams and creeks.

Over the past twenty years there has been a general trend of increasing urban areas and decreasing agricultural areas. At present (1990), DWR has estimated a total County agricultural acreage of 97,500 acres. The total 1990 urban acreage is estimated to be approximately 173,000 acres.

The two primary categories of water users in the County are agriculture and urban. In accordance with the land use trends discussed above, over the past twenty years the general trend has been that of increasing urban water use and decreasing agricultural water use. At present the total urban use is estimated to be approximately 390,000 acre-feet and the total agricultural use is estimated to be 361,000 acre-feet. This estimate of agricultural water use for 1990 is somewhat less than estimates for the 1990 level of average annual agricultural use due to the above-average rainfall that occurred in the spring of 1990.

WATER SUPPLY

Sacramento County is served by numerous water agencies and districts who obtain water through either surface sources, groundwater or a combination. The City of Sacramento is the largest water purveyor in the County, and it supplies both groundwater (from numerous wells located within the city area), as well as surface water (from surface water diversions along the American and Sacramento Rivers). The urban areas in the northeast portion of the County (San Juan, Fair Oaks, Orangevale, Citrus Heights) are supplied largely by surface water diversions from Folsom Lake, whereas urban districts to the west rely heavily on groundwater (Citizens Utilities, Northridge Arcade, etc.).

The Folsom South Canal diverts water from the American River and has historically supplied Rancho Seco Nuclear Power Plant, as well as a limited supply to the irrigation districts located adjacent to the canal. However, most of the irrigation districts located within the County area rely heavily on groundwater pumping for water, with the exception of Natomas Mutual Irrigation District and the Courtland area which utilize diversions from the Sacramento River for most of their agricultural water needs.

HYDROGEOLOGIC CONDITIONS

This section describes the regional hydrogeology of the continental deposits that yield groundwater and the stratigraphy of the geologic units.

Regional Hydrogeology

Sacramento County lies primarily in the Great Valley geomorphic province of the Sacramento Valley. Some of the foothill areas in the eastern part of the county lie in the Sierra Nevada geomorphic province. The Sacramento Valley is an asymmetric northwest trending structural basin that is filled with up to eight miles of Tertiary and younger marine and continental sedimentary deposits. In Sacramento County, the ground surface elevation ranges from ten feet below sea level to about 900 feet above sea level. In contrast to this, the mountains of the Sierra Nevada east of Sacramento County rise to 13,000 feet above sea level.

Study Area Characteristics

The basement of the Great Valley geomorphic province consists of Pre-Tertiary igneous and metamorphic rocks of the Sierra Nevada that continue west beneath the valley floor. About 20,000 feet of marine sediments overlie the basement rocks and generally contain saline water. Continental deposits overlie the marine rocks and act as the primary fresh water aquifer in the study area. In local areas fresh water may be present in both marine and continental deposits; and saline water may be found in continental deposits. The geologic description provided in this report is primarily concerned with the continental Post-Eocene deposits that yield fresh water to wells.

DWR Bulletin 118-6 identifies the usable aquifer in Sacramento County as the continental deposits of Post -Eocene and younger age. The usable aquifer in Sacramento County includes the Valley Springs, Mehrten, Laguna, and Fair Oaks Formations, and some Pleistocene gravels and alluvium. The thickness of the usable aquifer ranges from 400 feet in the eastern edge of the County to over 2800 feet in the southwestern edge. Figure 2-2 shows that the usable aquifer increases in thickness from east to west at a fairly constant rate. Not all of the usable aquifer is filled with fresh water.

Fresh groundwater is defined as having a total dissolved solids (TDS) concentration of less than 2000 mg/l. DWR Bulletin 118-6 defines the base of fresh groundwater in Sacramento County as ranging from 400 to 1600 feet below sea level as shown in Figure 2-3. In the northwest and southern parts of the county fresh groundwater continues to depths greater than 1600 feet below sea level. Just east of the Sacramento River near Beach Lake the base of fresh water rises to 800 feet below sea level, and just south of there along the county boundary it rises to 400 feet below sea level.

In the eastern third of the county fresh water exists below the base of the usable aquifer, usually in the Eocene Ione Formation. The permeability of the Ione Formation is too low to produce large quantities of water. Through out the rest of the study area the base of fresh water is above the base of the usable aquifer.

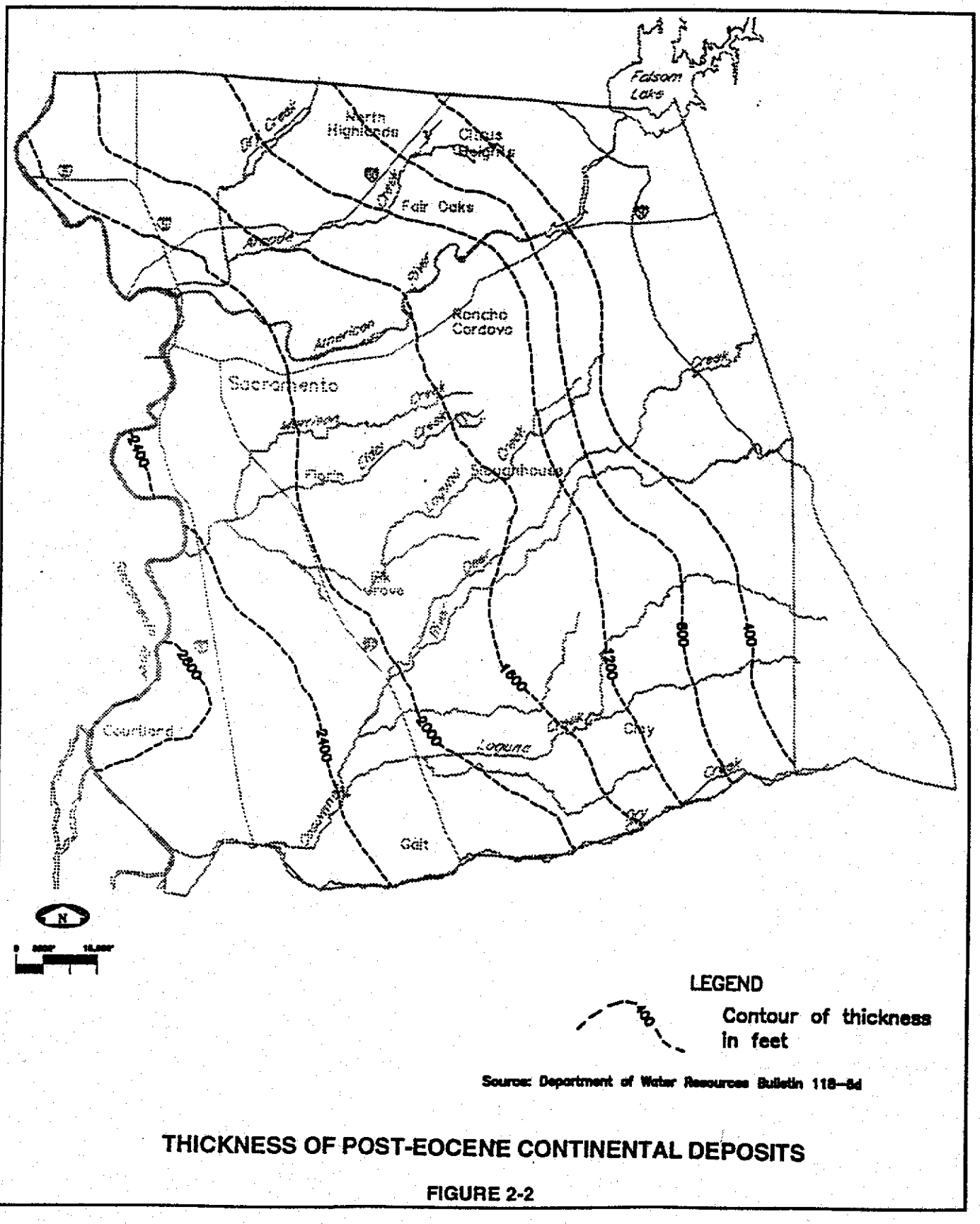
Stratigraphy

The interbedded sand and clay of the late Pliocene to Pleistocene deposits appear very similar in well logs, preventing easy identification of the geologic units. The key characteristics of each of the formations are summarized below, arranged as follows:

- Miocene Valley Springs
- Pliocene Mehrten
- Pleistocene - Pliocene Laguna
- Pleistocene - Pliocene Fair Oaks
- Pleistocene Arroyo Seco Gravels
- Pleistocene Victor
- Holocene Alluvium

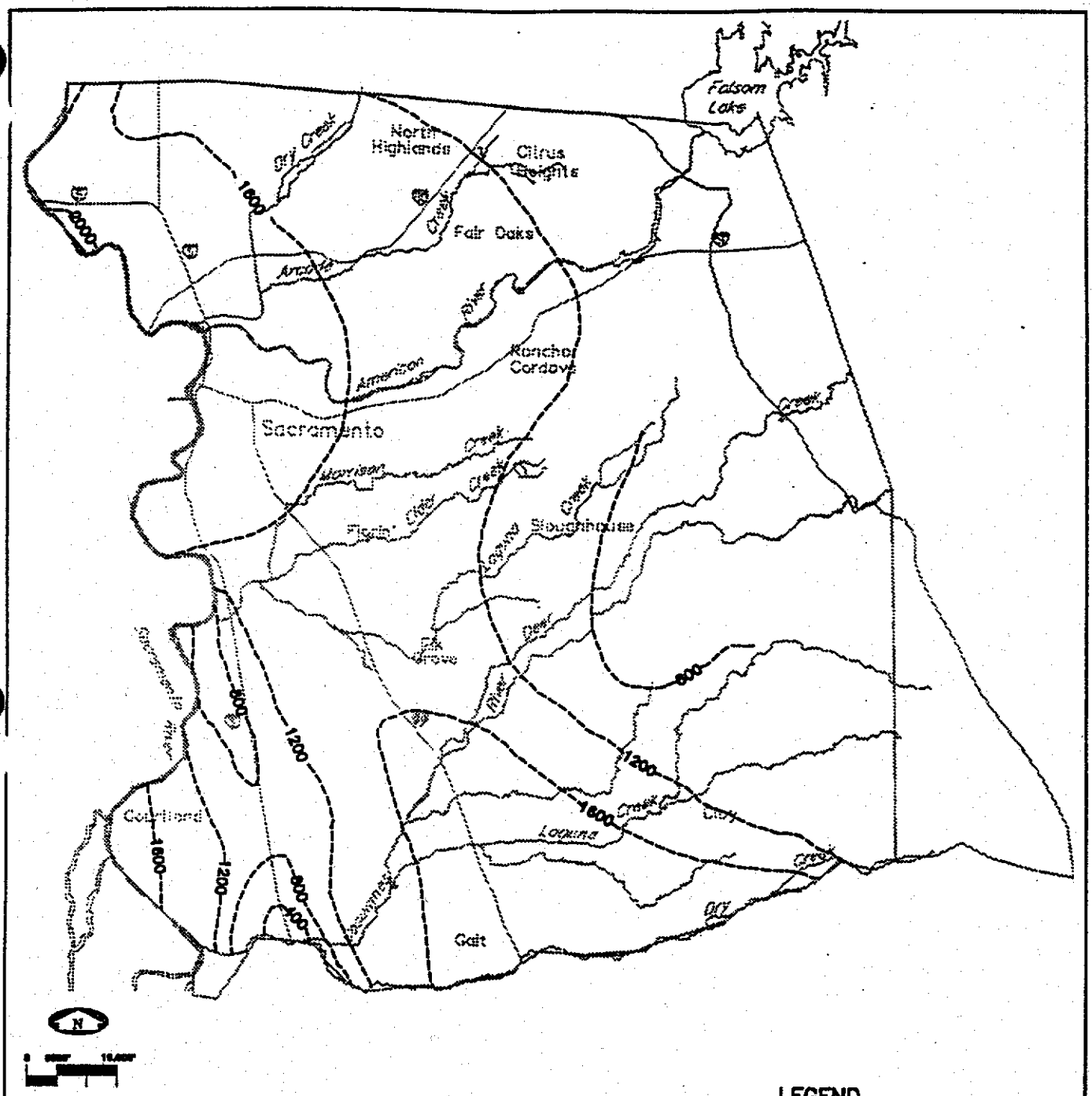
The oldest water-bearing formation in Sacramento County is the Miocene Valley Springs Formation. It consists of light colored beds of sand and ash interbedded with greenish brown beds of silty sands of volcanic origin. The Valley Springs Formation ranges in thickness from 75 to 125 feet. It generally yields small amounts of water to wells due to its overall low permeability. Lower portions of the Valley Springs Formation contain highly mineralized groundwater.

The Pliocene Mehrten Formation is the primary water-bearing deposit in Sacramento County and ranges from 200 to 1200 feet thick. It is identified by black volcanic sands and layers of volcanic tuff-breccia and also contains interbedded layers of brown sand and clay. The black volcanic sands yield large amounts of water wells while the brown sands yield less water. The clay layers yield little water while the tuff-breccia layers yield no water to wells. Wells tapping the water



THICKNESS OF POST-EOCENE CONTINENTAL DEPOSITS

FIGURE 2-2



LEGEND

Contour in feet below mean sea level

Source: Department of Water Resources Bulletin 118-6d

BASE OF FRESH GROUNDWATER

FIGURE 2-3

bearing portions of the Mehrten Formation yield 1000 to 1400 gpm at a specific capacity of 46 to 100 gpm/ft of drawdown.

The Pleistocene-Pliocene Laguna Formation consists of non-volcanic bedded sands silts and clays with some lenticular gravel deposits. It ranges in thickness from 125 to 200 feet. The sand layers yield moderate amount of water to wells while the clays yield little water. Wells primarily tapping the sorted sands and gravels of the Laguna Formation yield up to 1840 gpm with specific capacity up to 50 gpm/ft.

The Pleistocene-Pliocene Fair Oaks Formation consists of poorly bedded sands silts and clays with occasional gravel lenses. It appears similar to the Laguna Formation except for the presence of a white to gray tuffaceous silt bed about one foot thick. The Fair Oaks Formation is primarily found north of the American River where is ranges in thickness from 0 to 225 feet. Wells tapping the Fair Oaks Formation yield up to 3500 gallons per minute with specific capacities ranging from 80 to 120 gallons per minute per foot of drawdown. Many of the deep wells tapping the Fair Oaks Formation also extract water from the Mehrten Formation.

The Pleistocene Arroyo Seco Gravels consist of discontinuous beds of stream laid deposits. It contains primarily well rounded metamorphic and andesitic rocks that are contained in a matrix of iron-cemented sand and clay. Because the deposit is thin and is above the water table it is of little hydrogeologic significance.

The Pleistocene Victor Formation is composed of granitic sands, silts, and clays with some gravel lenses. It appears very similar to the Laguna and Fair Oaks Formations. Surface soils of the Victor Formation characteristically contain a hard pan layer. The formation ranges from 0 to 100 feet thick and generally yields little water to wells except where buried stream deposits are tapped.

The Holocene alluvium consists of unconsolidated sand, gravel, silt ,and clay. The sands and gravels act as recharge areas and do yield water to wells. The clays and silts have low permeability and yield little water to wells.

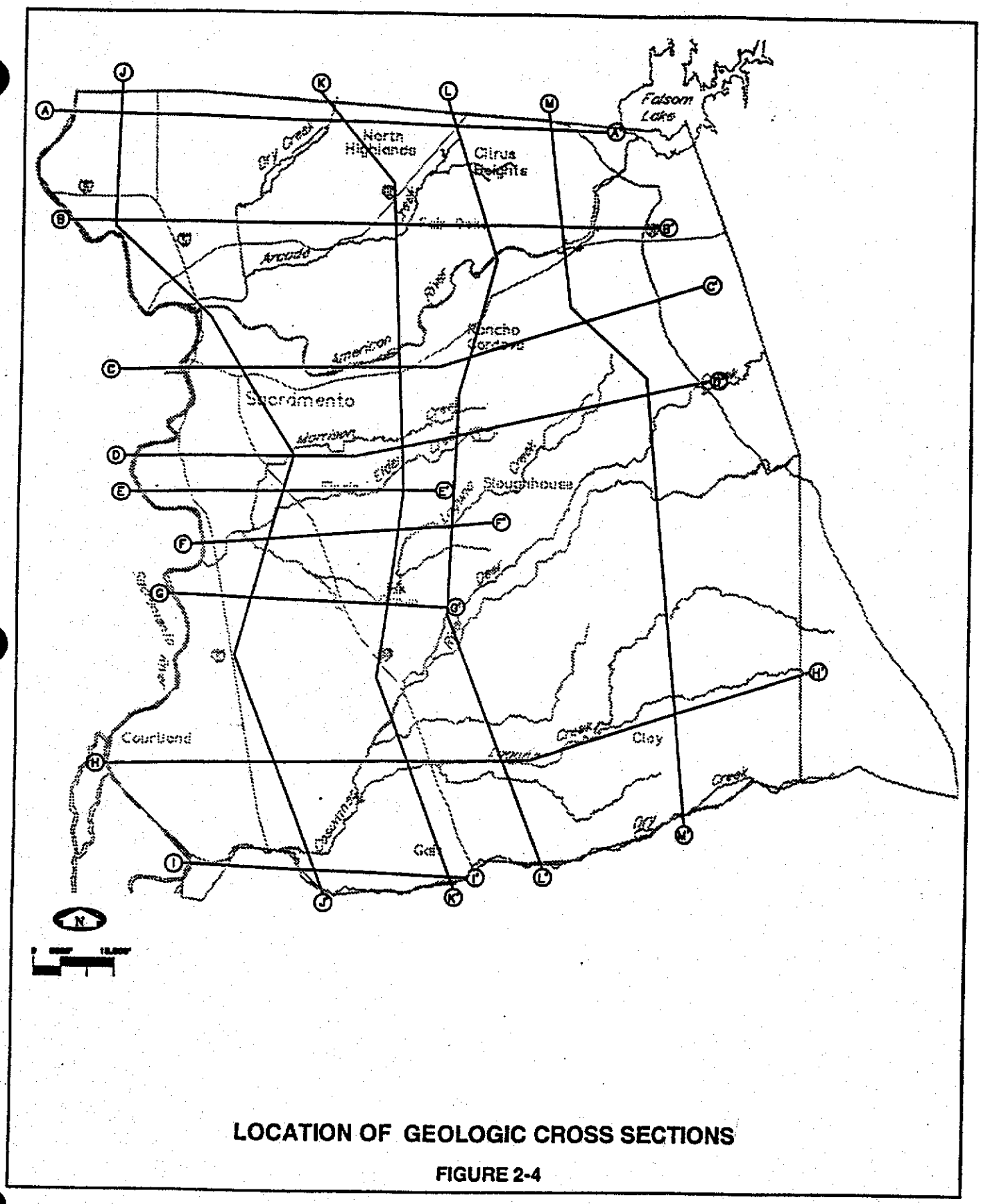
Selected geologic cross sections (for location see Figure 2-4) are presented on Figures 2-5a through 2-5m.

Historical Groundwater Levels

Groundwater has been and will continue to remain an important supply source for both urban and agricultural uses in Sacramento County. It accounted for an average of 58 percent of the total water supply in the model area between 1970 and 1990. An important consequence of continued reliance on groundwater is the impact of pumping on groundwater elevations. Generally, groundwater levels decline when extractions (through pumping, for example) exceed inflows (through recharge from streams and deep percolation from precipitation and applied water for irrigation) into the aquifer. Some locations in the County which have historically relied heavily on pumping have experienced significant groundwater level declines.

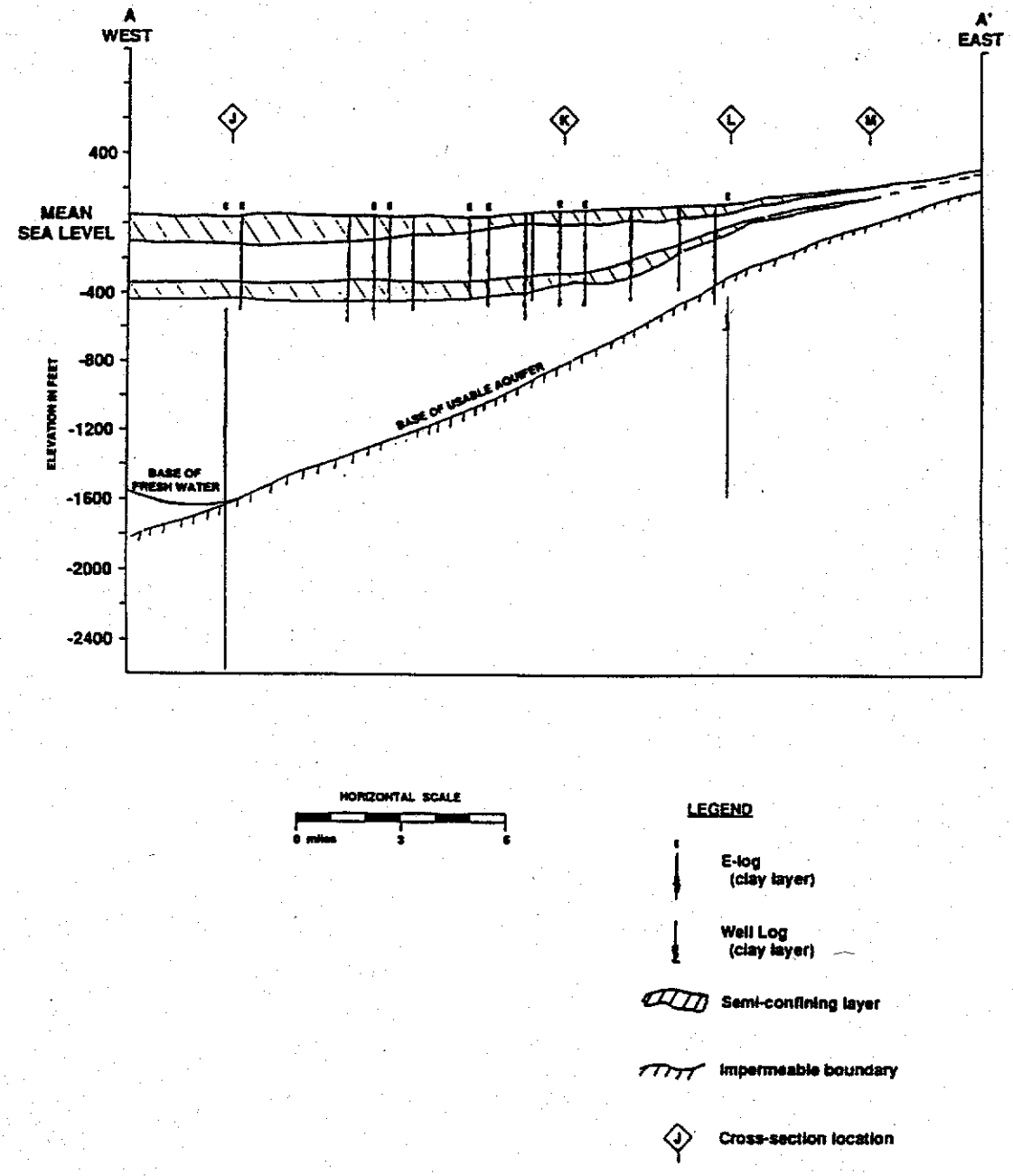
According to DWR, groundwater levels were fairly stable at an average of 30 feet above mean sea level between 1930 and 1940. Between 1941 and 1970, however, the county-wide average elevations declined to about five feet below mean sea level. Three distinct groundwater cones of depression have developed due to localized intensive groundwater pumping. These areas of lowered groundwater levels are located in the northern County (adjacent to McClellan Air Force Base), in the Elk Grove area, and in the Galt area.

Figures 2-6 and 2-7 show the 1991 spring and fall groundwater level contours in the County, respectively, and represent more recent conditions. These maps, developed by the SCWA, are



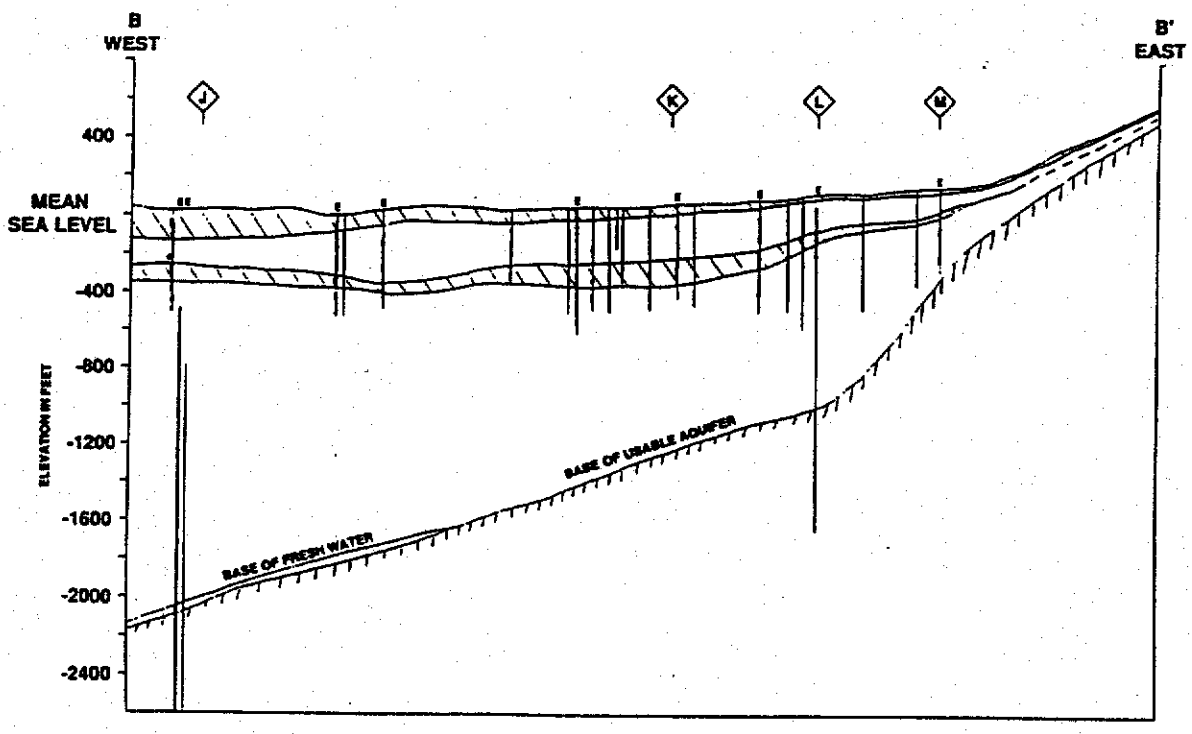
LOCATION OF GEOLOGIC CROSS SECTIONS

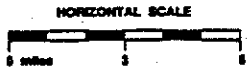
FIGURE 2-4



GEOLOGIC CROSS SECTION A-A'

FIGURE 2-5a





LEGEND

E-log
(clay layer)

Well Log
(clay layer)

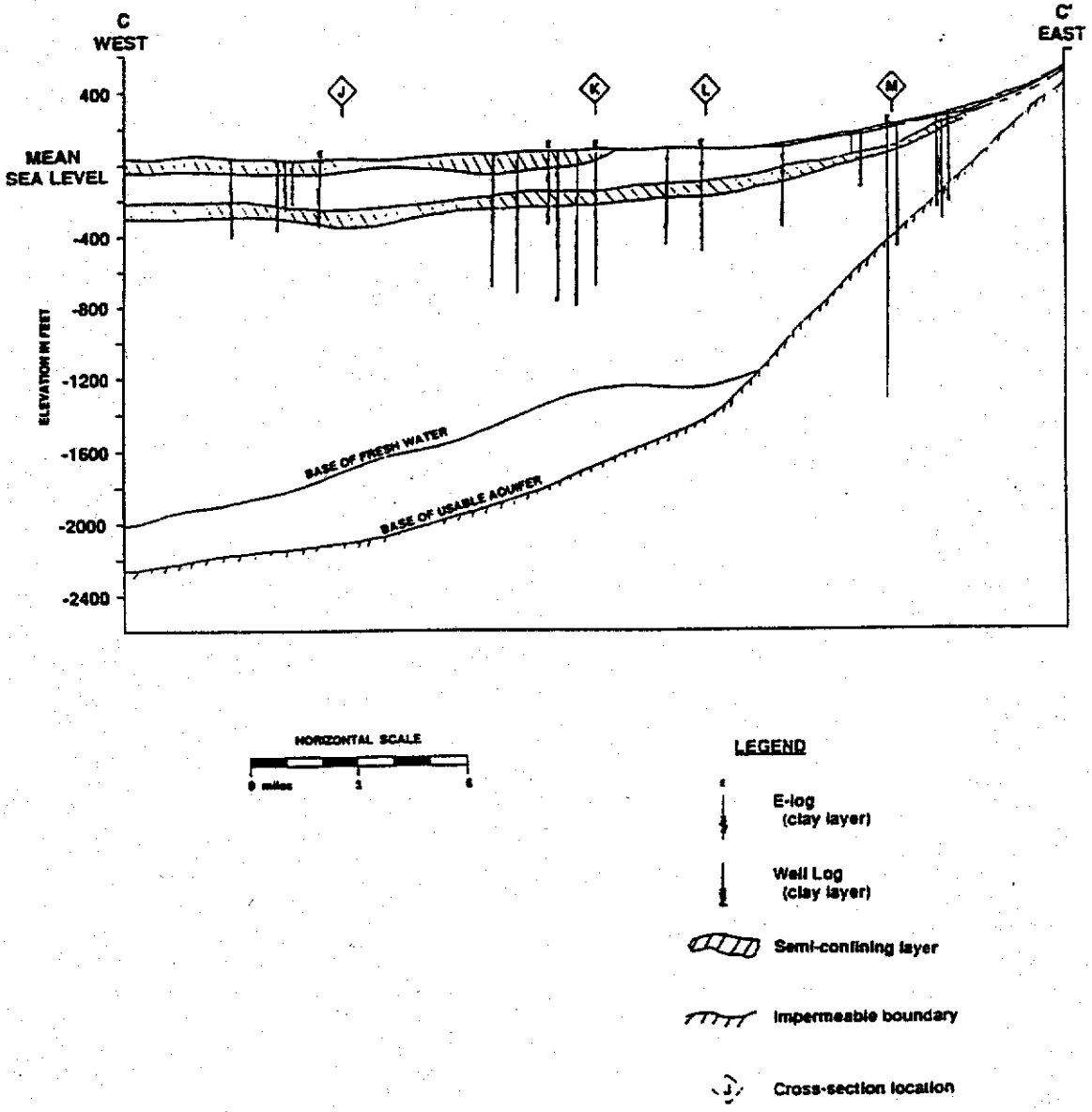
Semi-confining layer

Impermeable boundary

Cross-section location

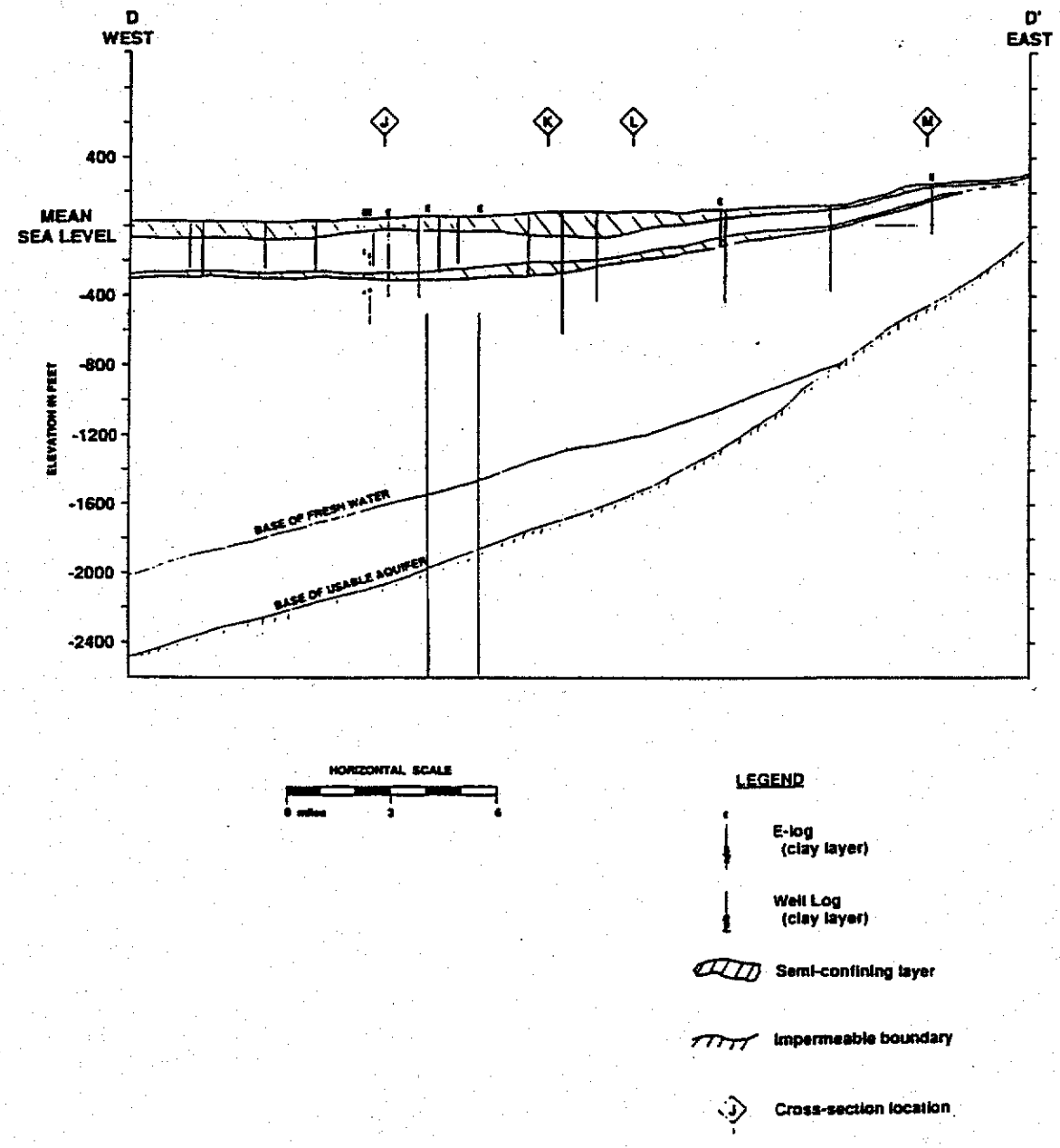
GEOLOGIC CROSS SECTION B-B'

FIGURE 2-5b



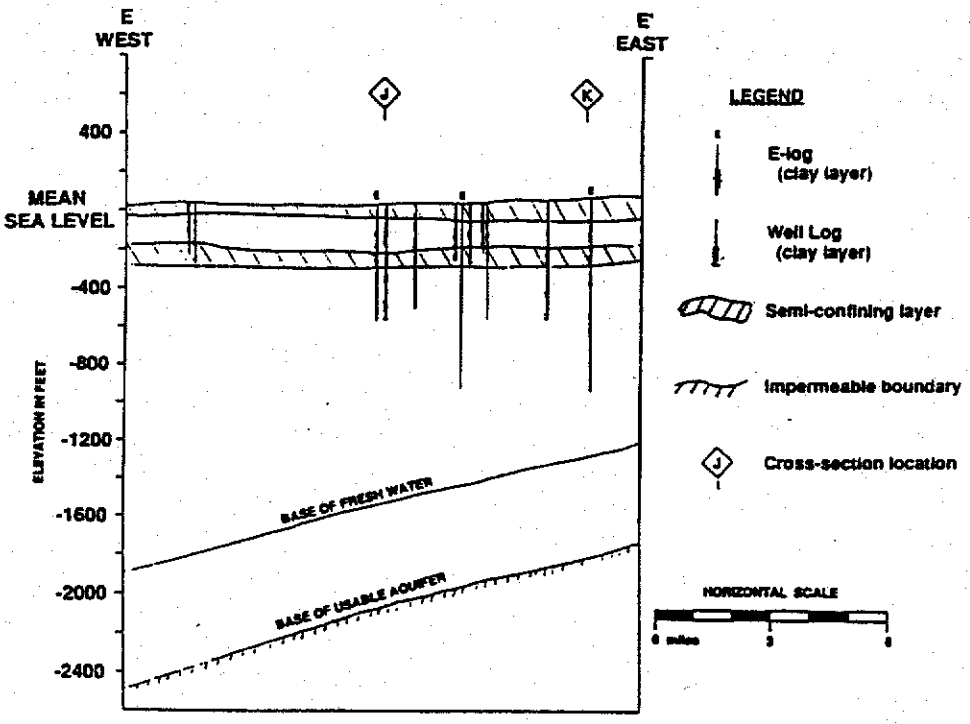
GEOLOGIC CROSS SECTION C-C'

FIGURE 2-5c



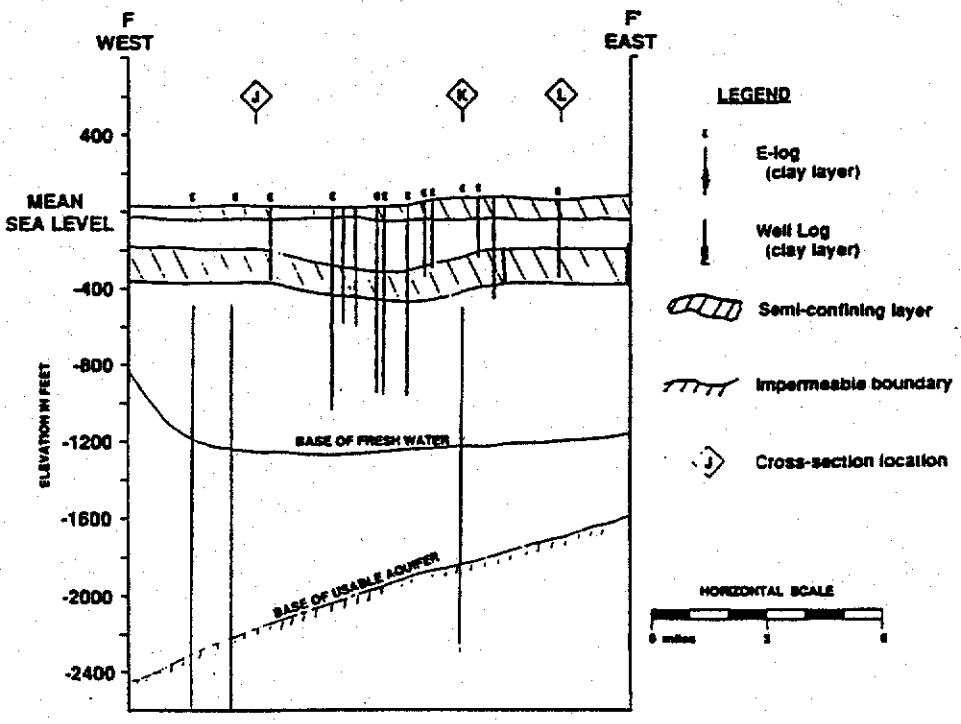
GEOLOGIC CROSS SECTION D-D'

FIGURE 2-5d



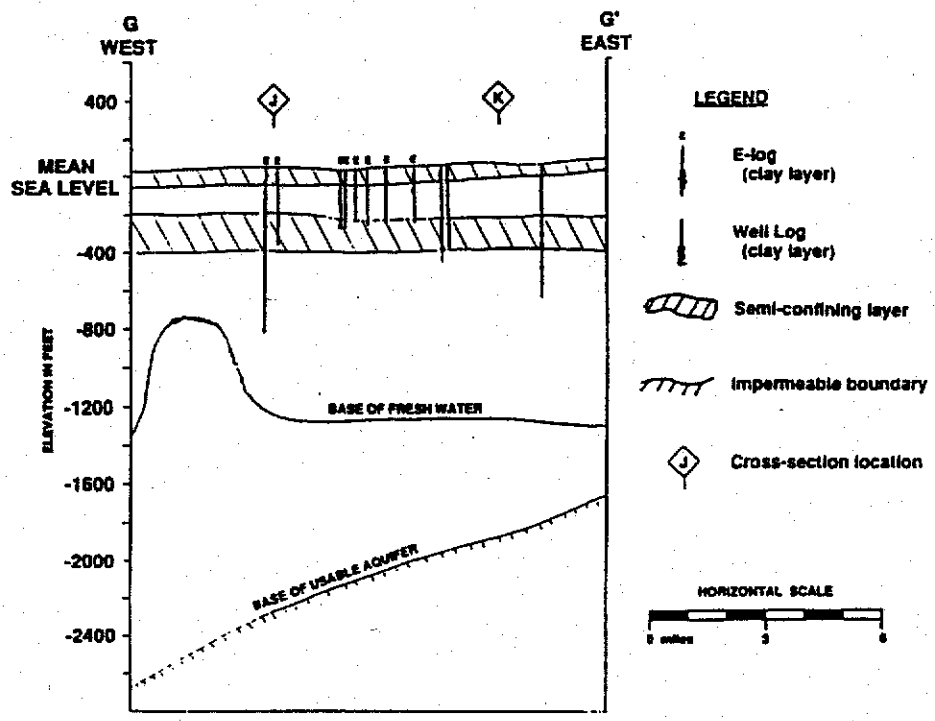
GEOLOGIC CROSS SECTION E-E'

FIGURE 2-5e



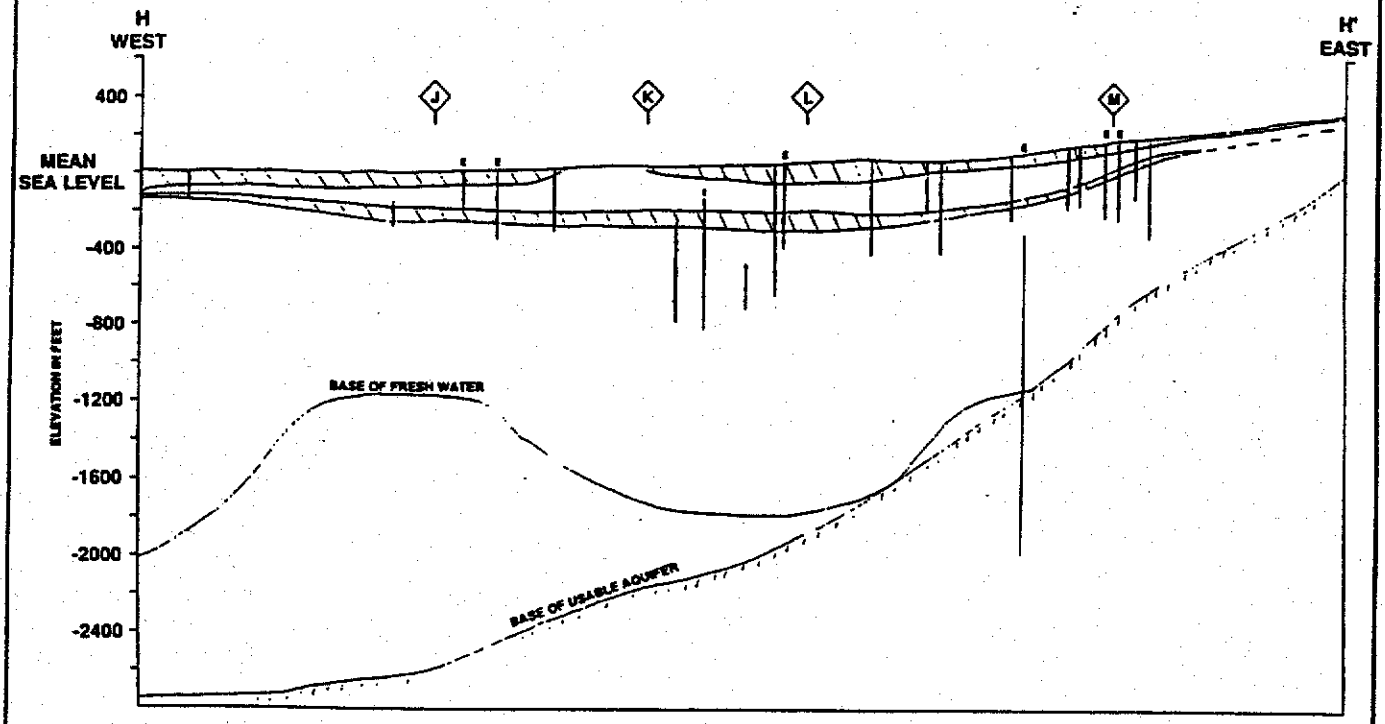
GEOLOGIC CROSS SECTION F-F'

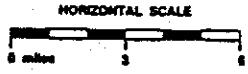
FIGURE 2-5f

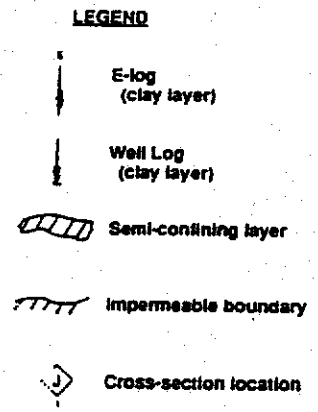


GEOLOGIC CROSS SECTION G-G'

FIGURE 2-5g

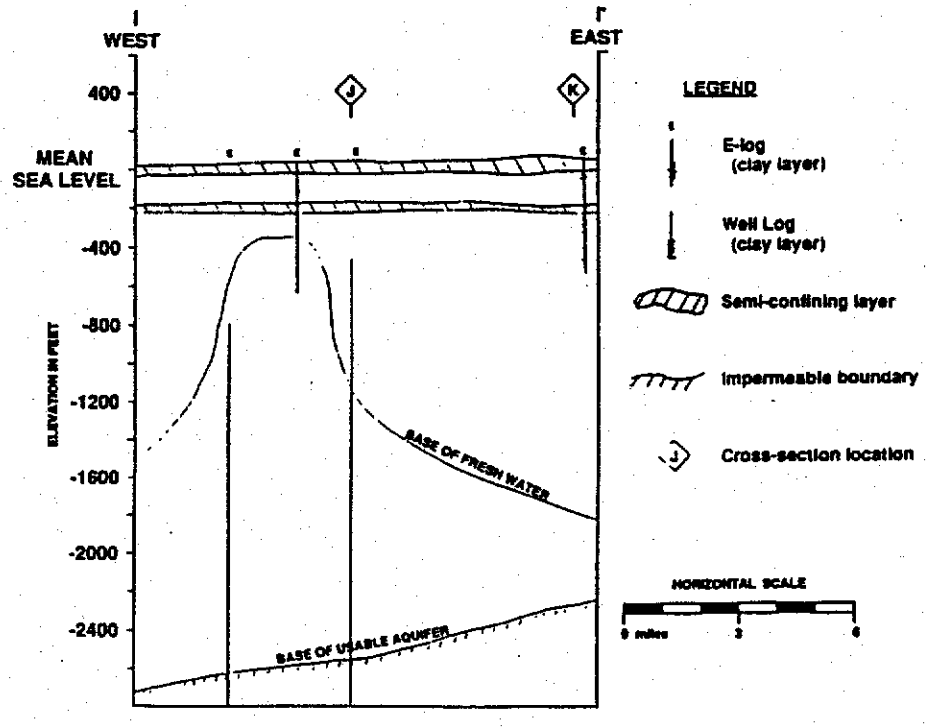






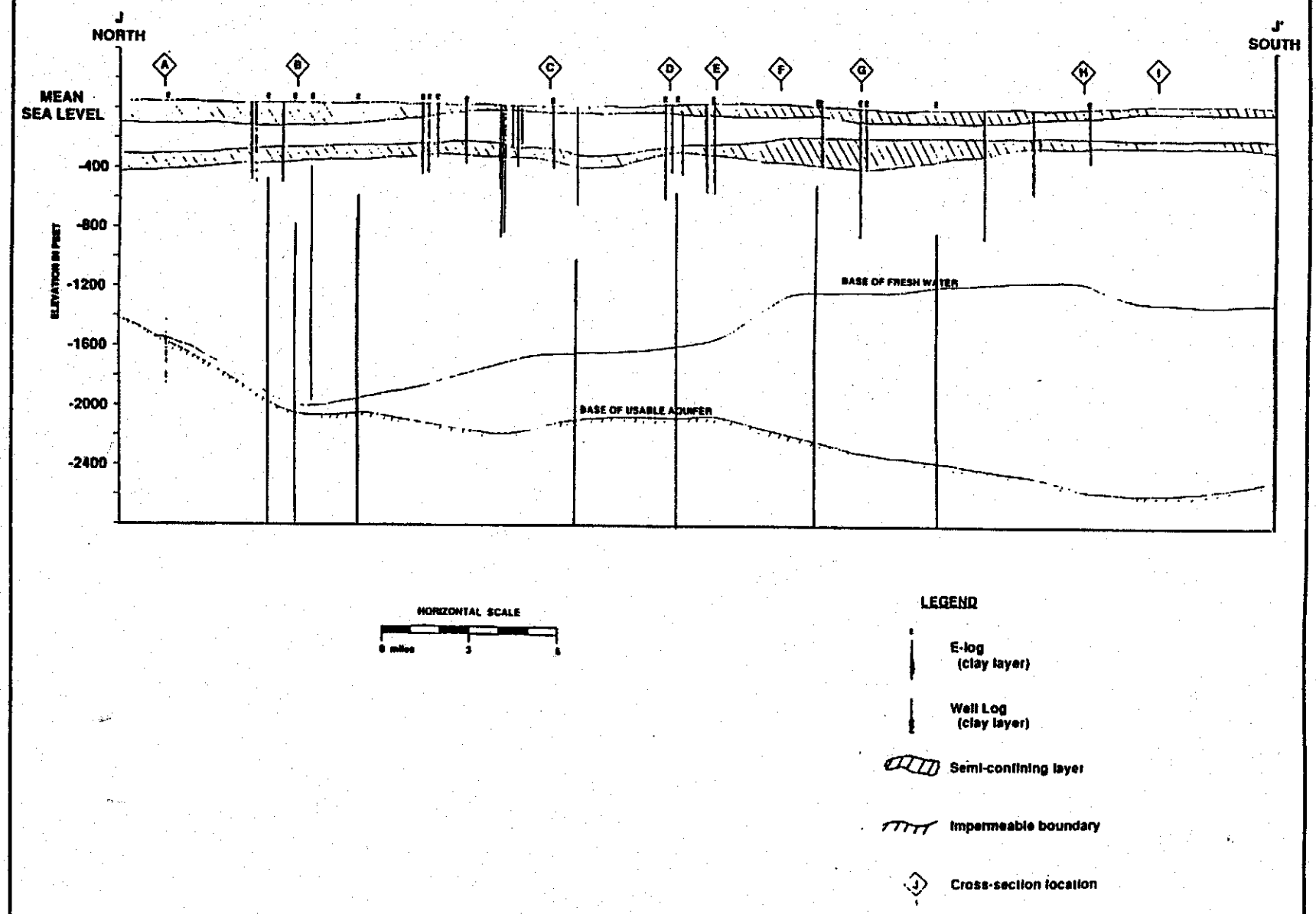
GEOLOGIC CROSS SECTION H-H'

FIGURE 2-5h



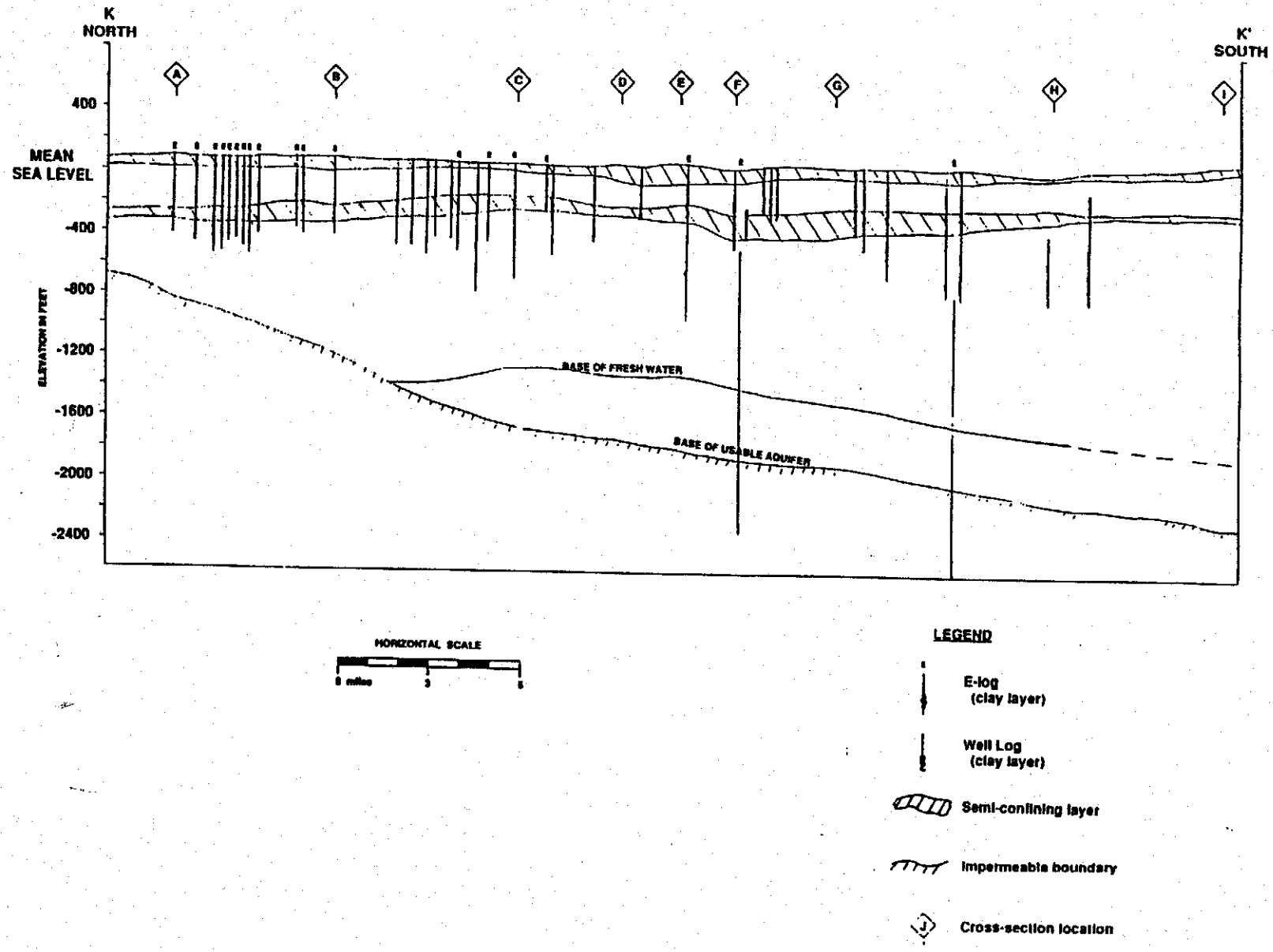
GEOLOGIC CROSS SECTION I-I'

FIGURE 2-5I



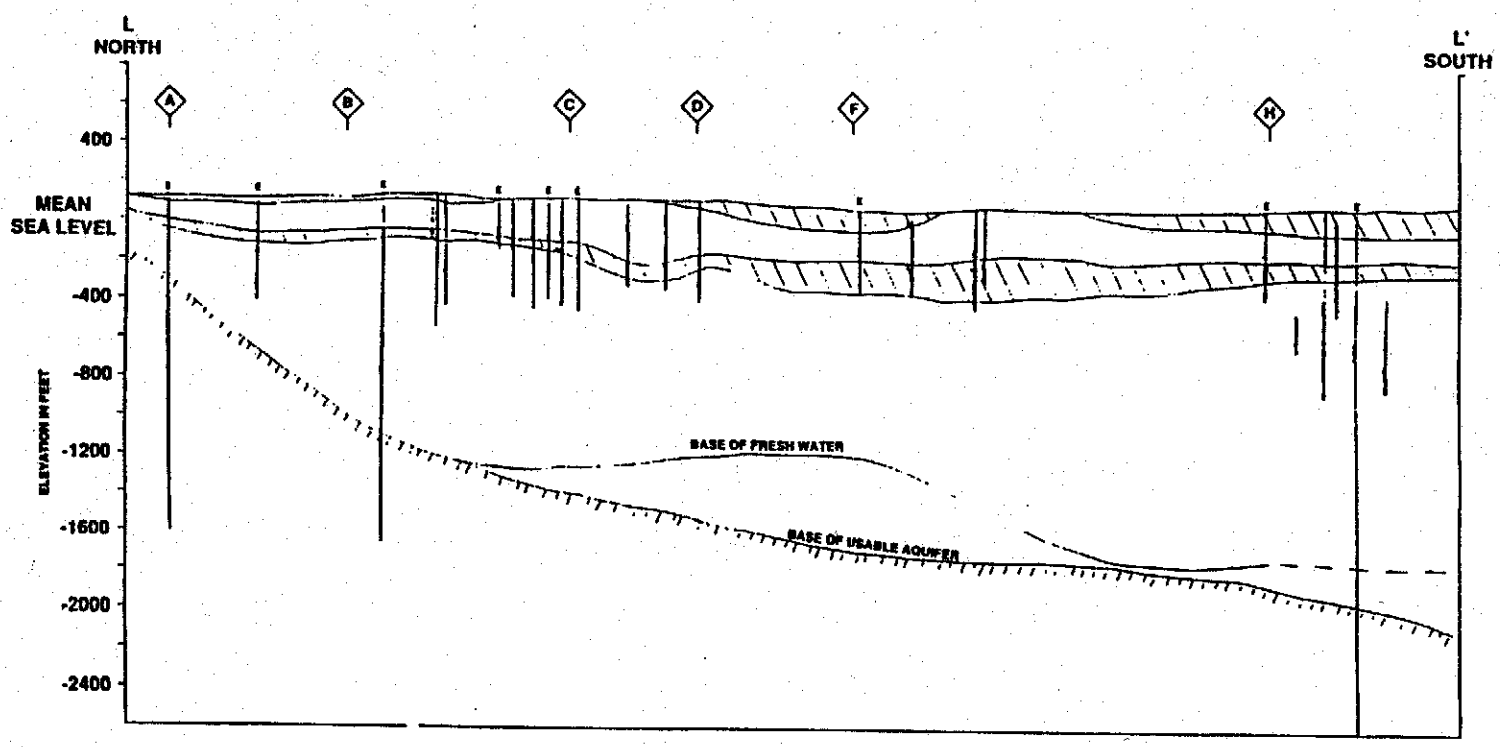
GEOLOGIC CROSS SECTION J-J'

FIGURE 2-5J



GEOLOGIC CROSS SECTION K-K'

FIGURE 2-5k



HORIZONTAL SCALE

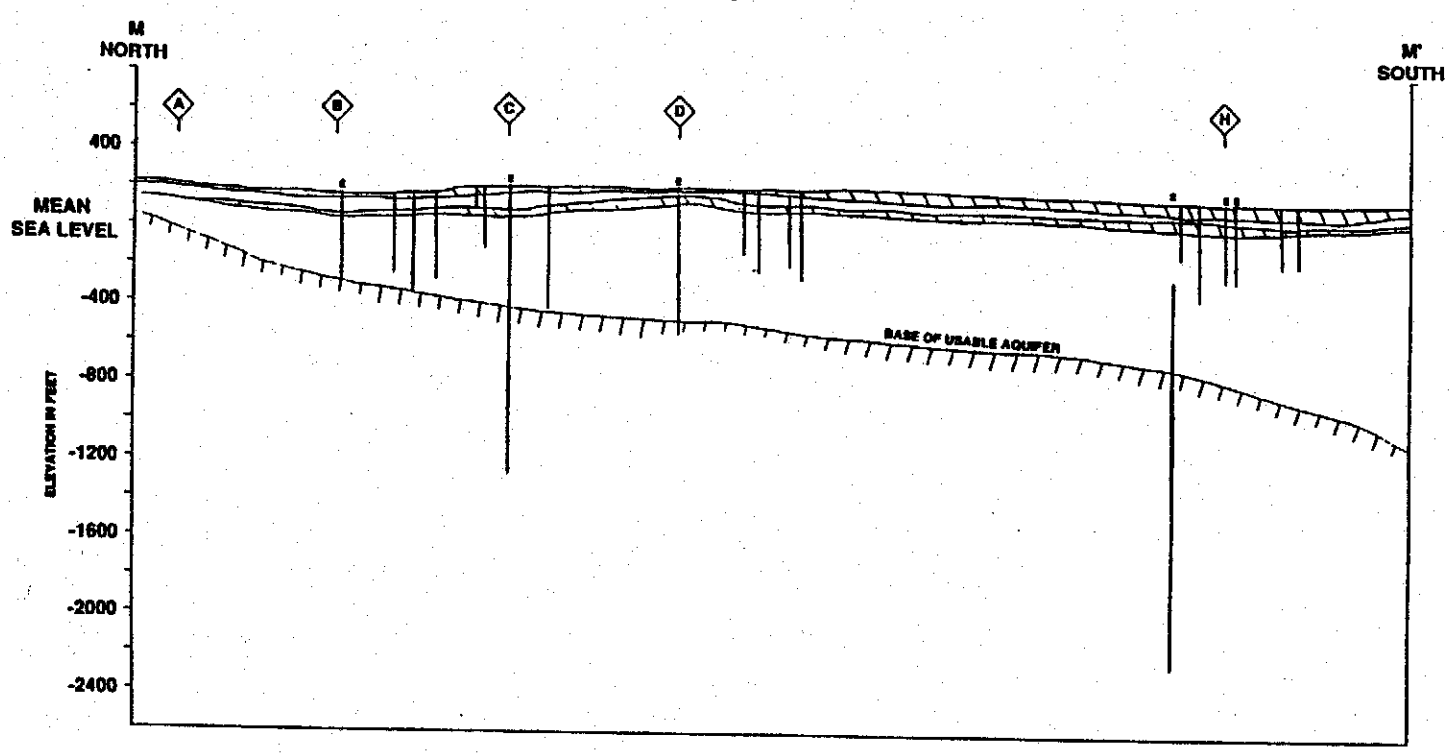
0 miles 3 6

LEGEND

- E-log (clay layer)
- Well Log (clay layer)
- Semi-confining layer
- Impermeable boundary
- J — Cross-section location

GEOLOGIC CROSS SECTION L-L'

FIGURE 2-5I



HORIZONTAL SCALE

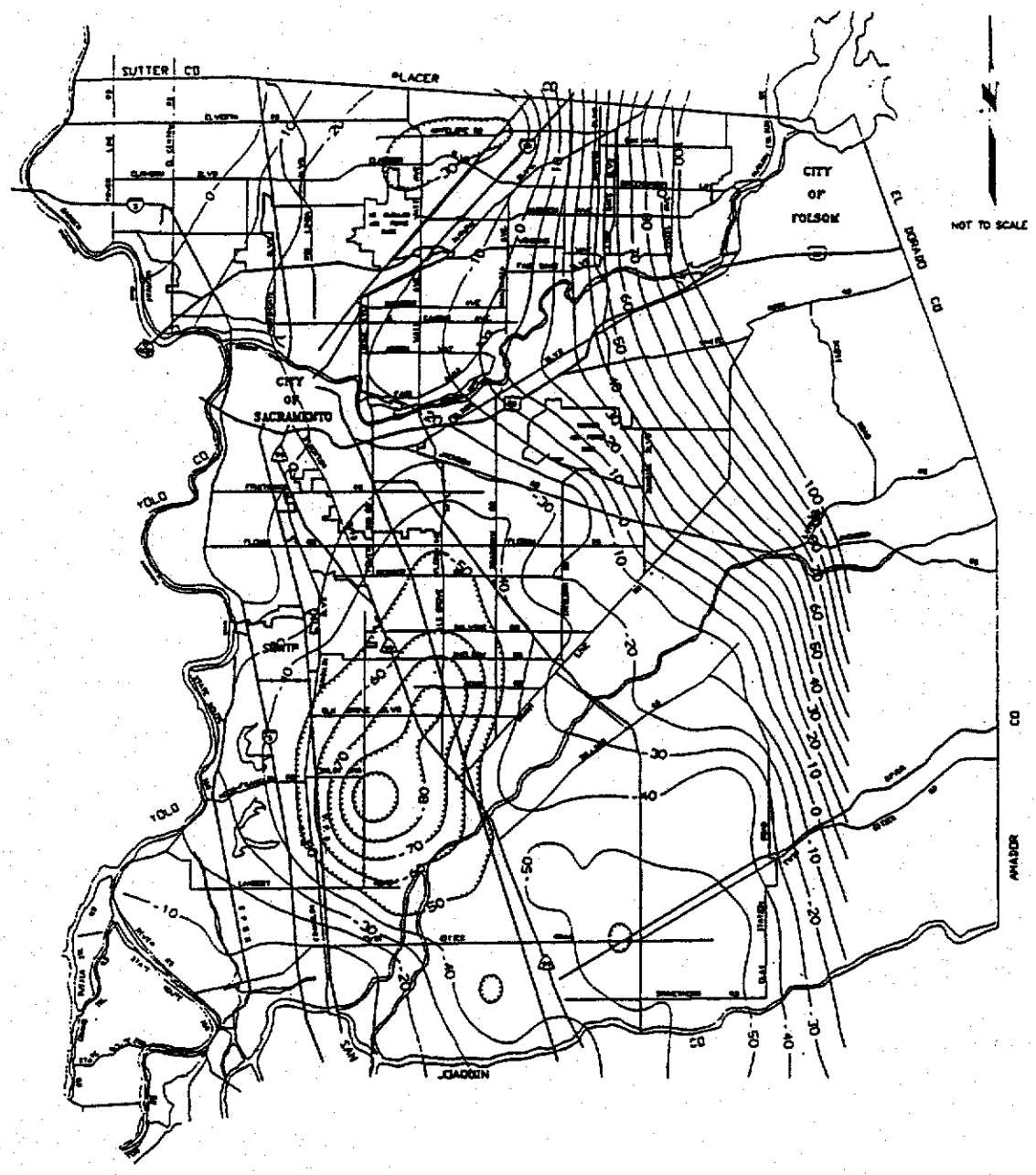
0 miles 3 6

LEGEND

- E-log (clay layer)
- Well Log (clay layer)
- Semi-confining layer
- Impermeable boundary
- J — Cross-section location

GEOLOGIC CROSS SECTION M-M'

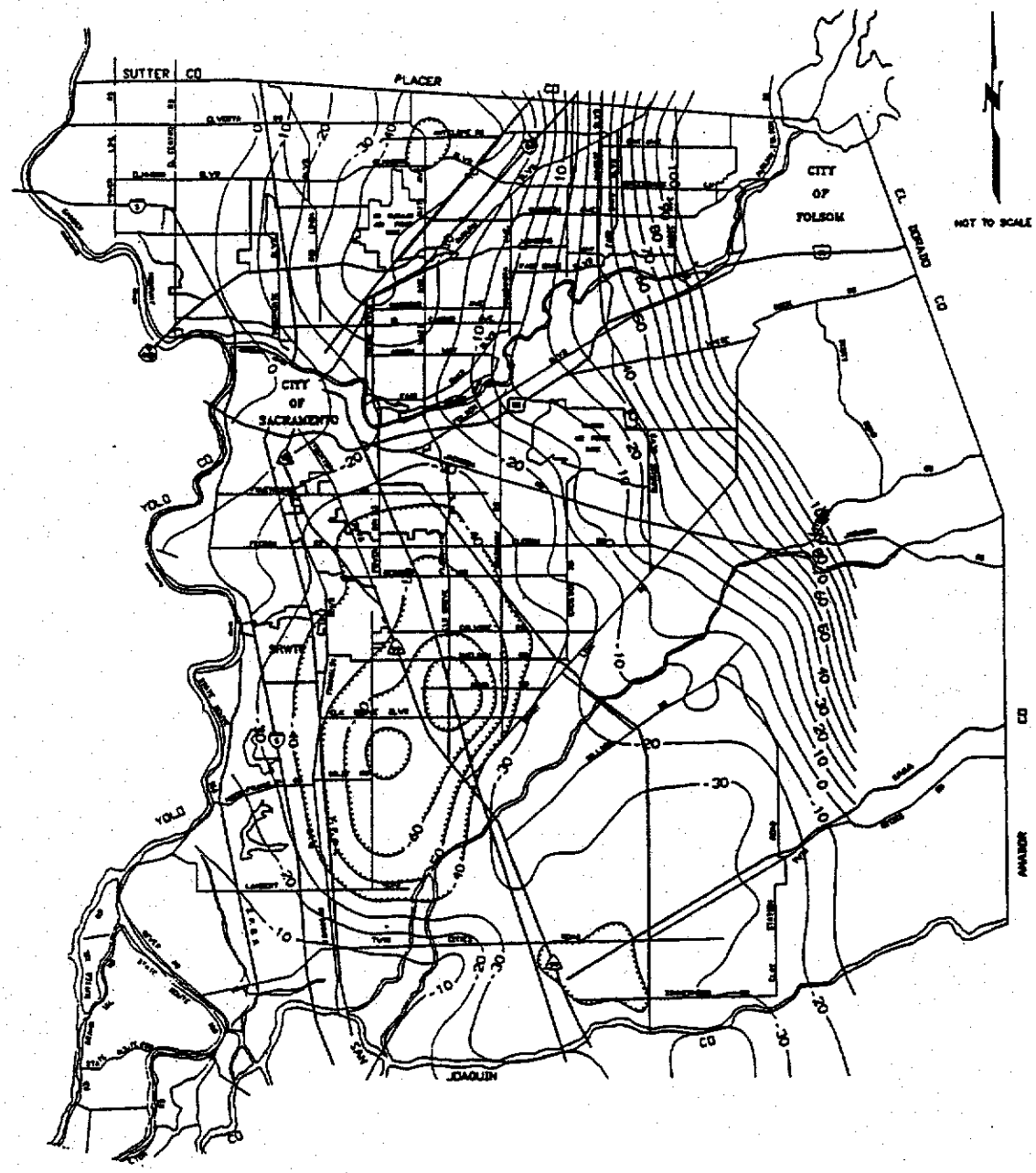
FIGURE 2-5m



-MEAN SEA LEVEL-

SACRAMENTO COUNTY GROUNDWATER ELEVATIONS, SPRING 1991

FIGURE 2-6



SACRAMENTO COUNTY GROUNDWATER ELEVATIONS, FALL 1991

FIGURE 2-7

based on water level measurements taken at numerous wells located throughout the county. Because the level measurements are not restricted to a single aquifer, the contours represent a composite of water levels from the different aquifer systems. Spring elevations normally represent conditions when groundwater levels have recovered from increased recharge following the period of heaviest annual precipitation and reduced urban and agricultural demand. Fall elevations represent the lowest groundwater level conditions for both urban and agricultural areas that are largely dependent on pumping to meet the increased demands during the summer months. Urban demands are typically the highest during the summer months when landscaping requirements increase. Agricultural demands are also high during this time because the growing season for most crops extends over the late spring and summer months.

Figure 2-7 shows the location of the major cones of depression around McClellan Air Force Base, Zone 40 and Galt Irrigation District. Groundwater levels around McClellan Air Force Base were 40 feet below mean sea level, with one area north of the base at more than 50 feet below mean sea level. Groundwater elevations in Zone 40 were 60 feet below mean sea level. The two pockets between Sheldon Road and Elk Grove Boulevard, and Elk Grove Boulevard and Billy Road, had groundwater elevations 70 feet below mean sea level. Groundwater levels near Galt Irrigation District were 40 feet below mean sea level.

Section 3

SECTION 3

MODEL OVERVIEW

The Integrated Groundwater Surface Water Model (IGSM) is a comprehensive finite element computer model that simulates all the major components of the hydrologic cycle of a groundwater basin including precipitation, runoff, groundwater recharge, evaporation, consumptive use, pumping, and subsurface inflows and outflows, as shown schematically in Figure 3-1. Comprehensive data input files are the key to the model's successful calibration. Output includes hydrologic budgets and groundwater level and streamflow variation.

This section provides an overview of the model, organized as follows:

- History of Model Development
- Major Model Features
- Model Input Data
- Model Output
- Model Calibration and Accuracy

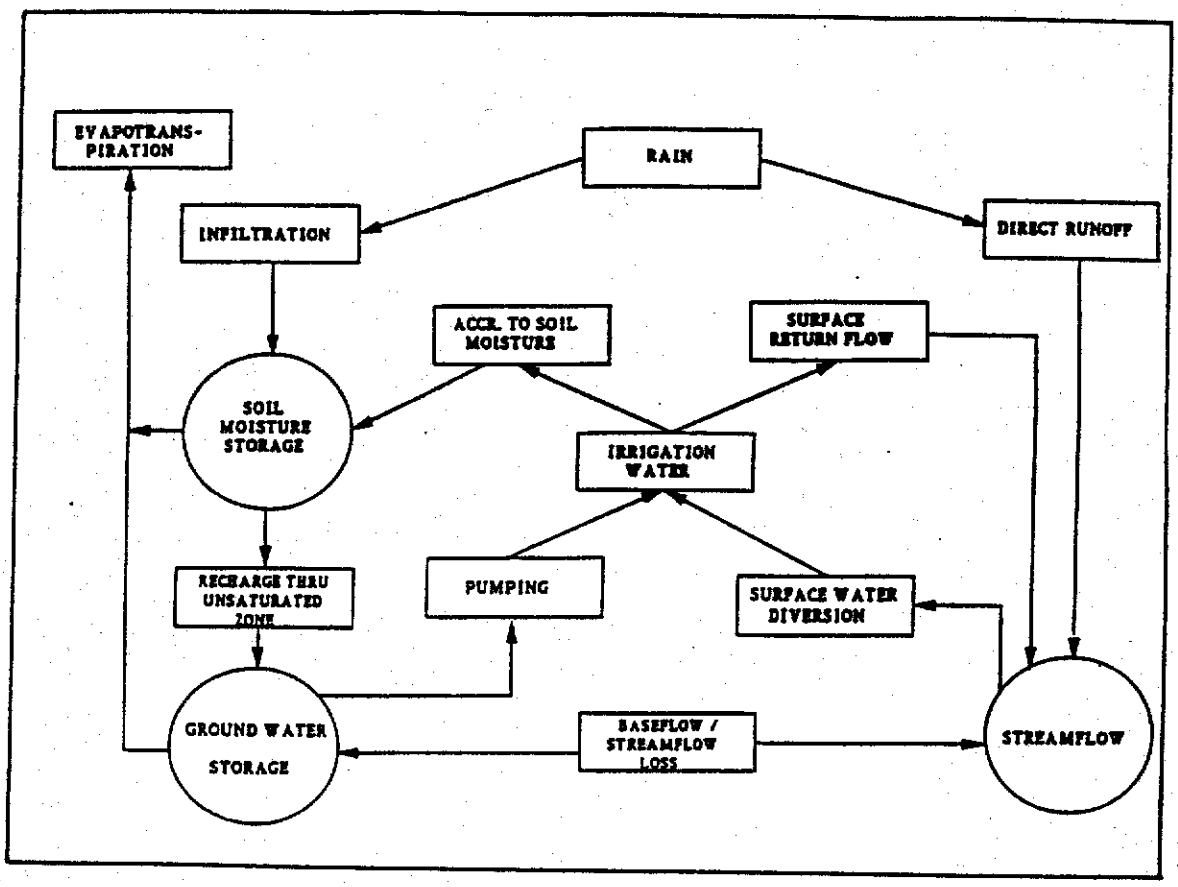
HISTORY OF MODEL DEVELOPMENT

The original version of the IGSM model was developed in 1976 at the University of California at Los Angeles. Since then, the model has undergone a number of revisions to accommodate the various geologic and hydrologic conditions that have been encountered in applying it to practical problems. In 1987, a major step was taken when the model was refined and applied to the entire California Central Valley (about 20,000 square miles) to assess streamflow depletion caused by surface and groundwater, in work done for the California State Water Resources Control Board. A six by six mile horizontal finite element grid and three layers to approximate the vertical variations of the aquifer in the Central Valley were used. Subsequently, in work completed in 1990 for the US Bureau of Reclamation, California Department of Water Resources, California State Water Resources Control Board, and the Contra Costa Water District, the model CVGSM (Central Valley Groundwater-Surface Water Model) was produced. A comprehensive database was assembled during this work, and the finite element grid was refined to a mesh with an average element size of 14 square miles. The IGSM has been applied over the years to other California areas.

For agencies within the California Central Valley, such as Sacramento County, it is the larger CVGSM version of the model that can be used with site-specific, local-area IGSM models to obtain groundwater and surface water assessments that incorporate the often interdependent nature of local and regional water resources. See Figure 3-2 for an overview of the application of the site-specific model to the County.

MAJOR MODEL FEATURES

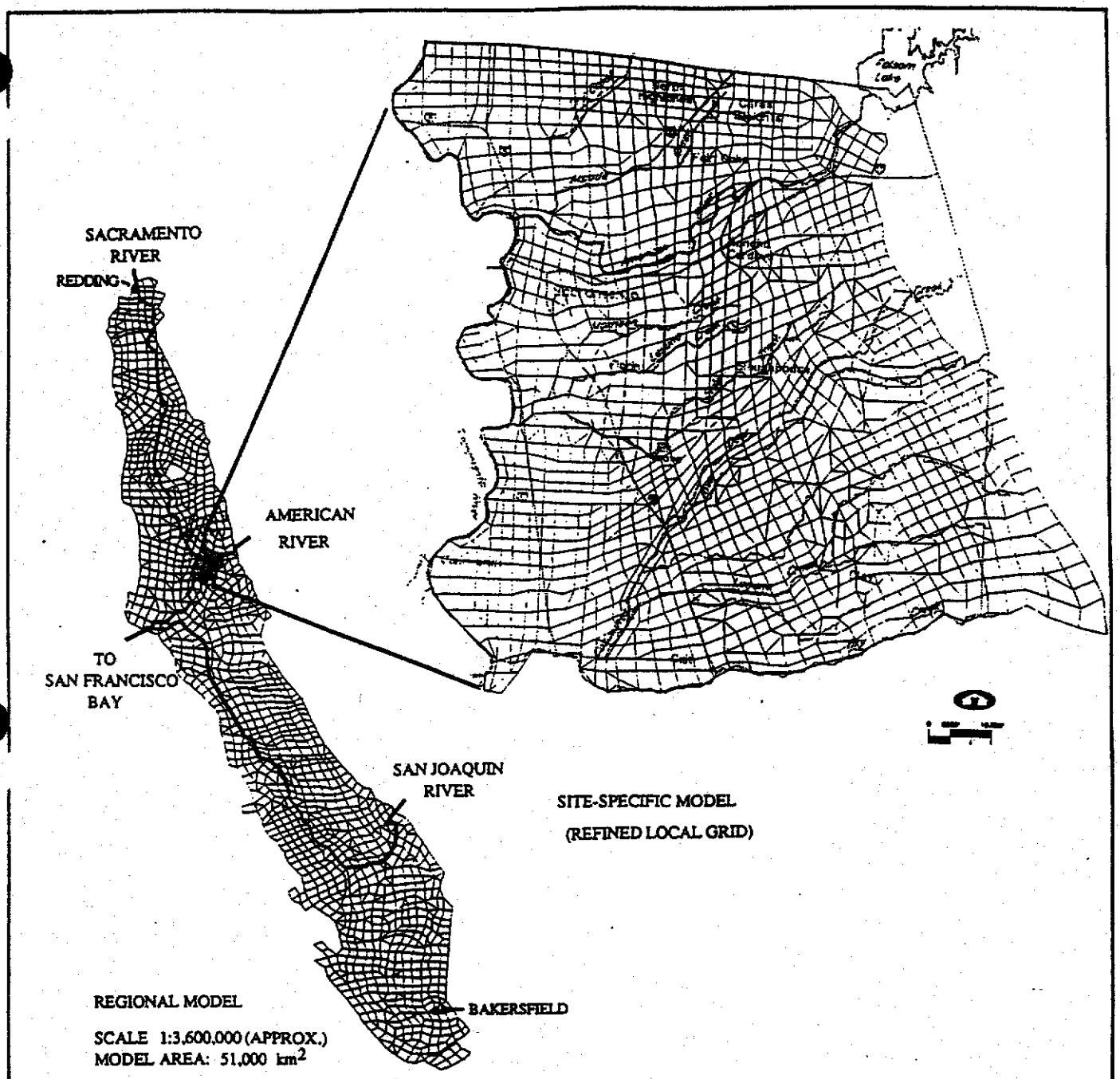
IGSM can simulate complex stream and multiple layered aquifer systems using the basic principle of tracking the movement of water from location to location of each of the components mentioned above and the interaction of flows between streams and groundwater aquifers, all in accordance with mass balance and water budget accounting procedures. IGSM requires a comprehensive set of geologic, hydrologic, and land and water use input data. Key output of the model is streamflow and groundwater levels, as well as hydrologic budgets. The model is written in Fortran-77 and is set up to operate on IBM-compatible personal computers. The model is very data intensive, with a considerable amount of time and effort required for collection, compilation, preparation, and validation of the input data. See Figure 3-3 for an overview of input data needed and output produced.



The model provides comprehensive simulation capabilities for surface water hydrology and its interaction with groundwater system. It includes a soil moisture accounting technique capable of simulating direct runoff, evapotranspiration, and deep percolation resulting from rain and irrigation applied water. It also includes a comprehensive data management system which allows for easy evaluation of various surface water diversion and pumping schemes.

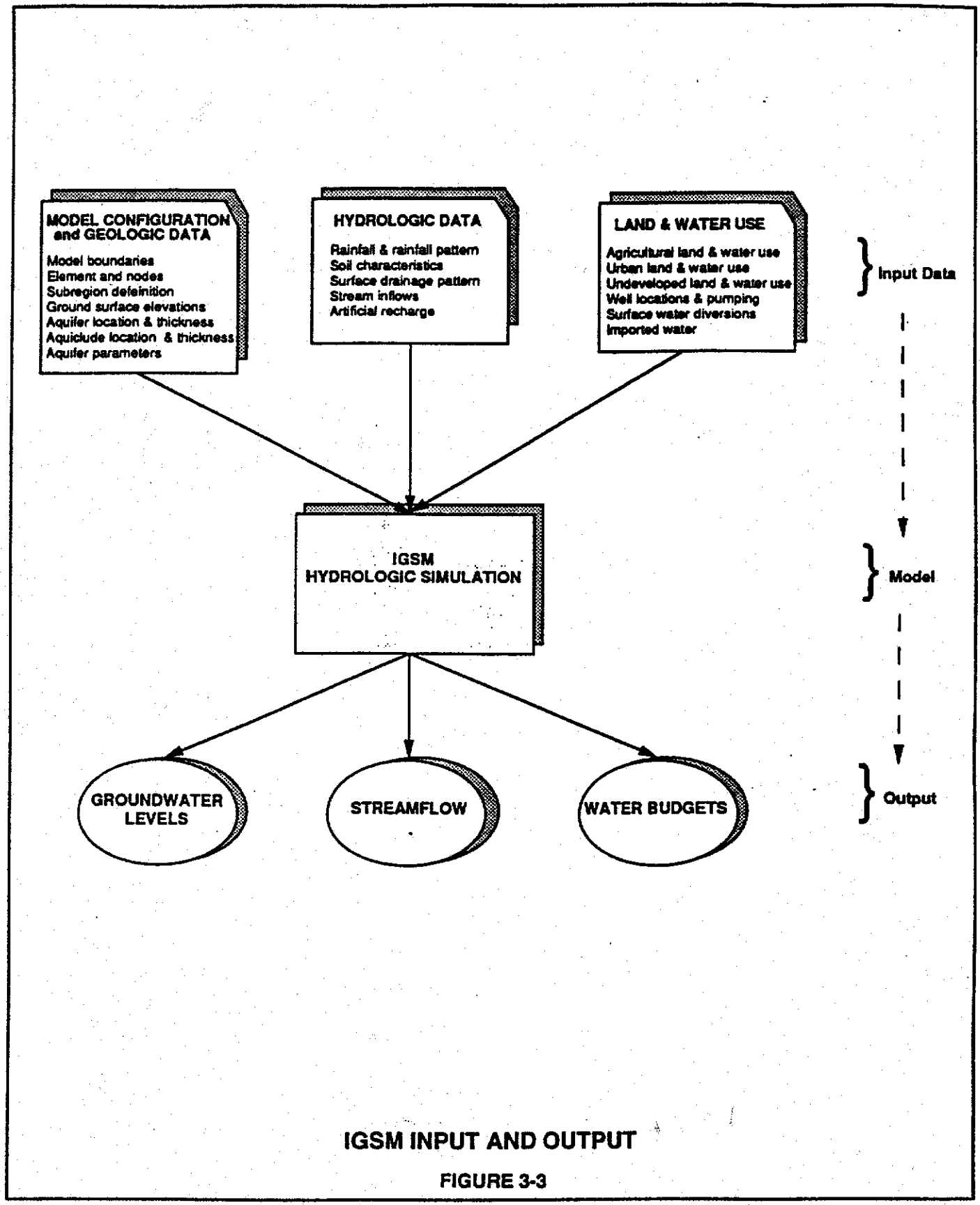
IGSM REPRESENTATION OF HYDROLOGIC SYSTEM

FIGURE 3-1



REGIONAL AND SITE SPECIFIC MODELS

FIGURE 3-2



IGSM INPUT AND OUTPUT

FIGURE 3-3

The development of the Sacramento County model was facilitated because of the prior completion of an IGSM site-specific model for the City of Sacramento's currently authorized Place of Use (POU) for Sacramento and American River water. The POU covers an area of about 150 square miles, including 104 square miles within the City of Sacramento limits, as well as portions of service areas of several other water purveyors. The POU was selected for the modeled area for the City because of the regional nature of water management involving groundwater and surface waters (conjunctive use). The City model, developed by refining the CVGSM and establishing links along the boundaries, is comprised of a grid with an average area of 0.66 square miles, and covers 176 square miles. This model grid served as the starting point for development of the County model, which has the following features:

- Area Covered - 900 square miles
- Finite Elements
  - Number of Elements - 1637
  - Number of Nodes - 1552
  - Average Element Size - 0.6 square miles
- Number of Subregions - 31
- Number of Streams Modeled - 12
- Number of Peripheral Watersheds Modeled - 8
- Number of Precipitation Stations Used - 11
- Number of Aquifers Modeled - 3
- Land Use Maps - DWR Surveys of 1976 and 1984
- Crop Data - by Region (1976, 1984, and 1990)
- Water Use - Surface Diversion and Municipal and Industrial based on historical data; Agricultural Use estimated based on crop acreage and crop consumptive use.
- Hydrologic Soil Class for Surface Soils - Soil Conservation Service (four)
- Calibration Period - 1970 to 1990

MODEL INPUT DATA

The collection and processing of the over twenty input data files was the most extensive work item required in the development of the Sacramento County model. The input data came from a variety of sources and in different forms (maps, tabulations, hard copy and disk). A data processing program analyzed the data and identified missing and inconsistent data. Then the data was processed on the computer in a consistent format and model input data files were then developed from the processed data.

Input data can be categorized as model configuration and geologic, hydrologic, and land and water use, as shown in Figure 3-3. Input data files are divided into two sections: Part One - Model Configuration Files; and Part Two - Flow Simulation Data Files. Part One is concerned with defining the structural characteristics of the model (model configuration), that is, the lateral and vertical dimensions of the model finite elements, and the simulation of streams, canals, and wells. This data is fixed once the coverage of the model is decided upon and will not vary with the runs performed later. Upon completion of this part, model output includes plan views of the model grid and vertical sections showing the simulated groundwater aquifers. Part Two, on the other hand, contains all information that is time-dependent, including land use, water demand, rainfall, boundary inflows, and historical stream or canal diversions and groundwater pumping. Part Two information is on a monthly basis, except for land use, which is on an annual basis. Each of the input data files has extensive self-documentation to allow for easy checking of the data by category type, thereby minimizing errors in file development. See Figure 3-4 for sample input data file documentation.

```
C*****************************************************************************
C
C                  INTEGRATED GROUND AND SURFACE WATER MODEL (IGSM)
C
C-----------------------------------------------------------------------------
C
C                  ELEMENT CHARACTERISTIC DATA FILE
C                            PART 1
C-----------------------------------------------------------------------------
*        Project:  Sacramento County - Groundwater Model
*        Filename: SCNCHRC.DAT
C
C*****************************************************************************
C                        File Description
C
C  This data file contains the hydrologic characteristics of each element
C  including the rainfall station to be used, a rainfall factor  to relate
C  rainfall at the element  to the rainfall station, stream node where
C  runoff drains to, the sub-region corresponding to the element, and the
C  hydrologic  soil type.
C
C*****************************************************************************
C                     Element Characteristics Data
C
C  The following lists the hydrologic charactersitics of each element:
C
C  IE:     Element number
C  IRNE:   Rainfall station assigned to the element IE
C  FRNE:   Factor to convert rainfall at the assigned rainfall station to
C          rainfall at the element IE
C  ISTE:   Stream node to which surface water from element IE drains to
C  IRGE:   Sub-region number to which element IE belongs to
C  ISGE:   Sub-group number to which element IE belongs to
C  HSOIL:  Hydrologic soil property of the element (ie. A=1, B=2, C=3, D=4)
C          (Reference : National Engineering  Handbook, Section 4, SCS)
C
C-----------------------------------------------------------------------------
C   Element  Rainfall   Rainfall  Drainage  Sub-region   Element  Soil
C              station   factor    node      Sub-grp      Type
C     IE       IRNE      FRNE      ISTE      IRGE         ISGE     HSOIL
C-----------------------------------------------------------------------------
        1        1       1.206      71         1           1        4
        2        1       1.213      71         1           1        4
        .        .         .         .         .           .        .
        .        .         .         .         .           .        .
        .        .         .         .         .           .        .
     1636        8       1.107     228        30          30        4
     1637        9        .932       0        29          29        3
C*****************************************************************************
C  End of file
C*****************************************************************************
```

SAMPLE INPUT DATA FILE DOCUMENTATION

FIGURE 3-4

MODEL OUTPUT

Model output includes the grid configuration, the location of major streams, canals, and wells, and vertical sections, as described above upon completion of Part One. Areas of the grid can be enlarged, and sections can be developed through selection of any series of element nodes. In addition, geologic contour maps can be printed out for the various aquifers (upper and lower levels of each aquifer). Upon completion of Part Two, tabulated hydrologic budgets become available for the entire model area (see Figure 3-5 for sample model output), and its defined subregions. Hydrographs of wells and groundwater level contour maps can then be printed out.

MODEL CALIBRATION AND ACCURACY

The validity of the computer simulation of Sacramento County's groundwater basin and its associated surface characteristics is accomplished through a comparison of simulated hydrologic budgets and groundwater levels and corresponding historical values, and by adjustment of model parameters to conform simulated and recorded conditions.

The first stage of calibration involves the regional and subregional hydrologic budgets. These budgets are intended to properly account for all inflows and outflows to the basin, as well as the hydrologic processes within the basin. In short, the availability of groundwater over a period of time must conform to a mass balance which states that inflow minus outflow to the basin are equal to the change in storage of the groundwater basin. Four budgets are considered: groundwater, streamflow, soil moisture, and water use. A primary component of the water budget calibration is the amount of deep percolation, that is, the amount of water percolating through the soil and recharging the groundwater. Key factors include: rainfall, soil characteristics, evapotranspiration rates, irrigation and applied water, runoff, and land use. Some of the key model parameters adjusted at this stage of calibration include field capacity, soil hydraulic conductivity, SCS curve numbers, root zone depth, and streambed hydraulic conductivity.

The second stage of model calibration involves the comparison of longer-term regional groundwater patterns (flow directions) and levels. Unless the database warrants and specific well pump tests are available to allow focusing on a local area, it is the purpose of this stage of calibration to check the regional behavior of groundwater levels. The availability of maps prepared by the County for spring and fall groundwater levels has facilitated the calibration of the model for this stage. This calibration focused on adjusting regional aquifer parameters including: hydraulic conductivity, specific storage, specific yield, leakance between aquifers, and aquifer boundary conditions. Hydrographs of wells with good records and for which the source aquifer can be identified are used for comparison of groundwater levels.

Discrepancies between simulated and historical groundwater levels may be attributed to model configuration and mathematical representation, input data error (raw data or processing of data), and measurement error. Because the model is now well established as a tool for simulating regional groundwater levels, quality assurance focused on the large database that is required for the model.

GROUND WATER BUDGET IN AC.-FT. FOR ENTIRE MODEL AREA
TOTAL AREA: 562744. ACRES

TIME	DEEP PERC.	NET DEEP PERC. (+)	GAIN FROM STREAM (+)	RECHARGE (+)	OTHER INFLOW (+)	BOUNDARY INFLOW (+)	SUBSURF. INFLOW (+)	PUMPING (-)	CHANGE IN STORAGE (=)	END STORAGE 1000 AF
1970	208492.	185047.	222798.	0.	0.	137942.	0.	564867.	-19079.	48758.4
1971	201695.	203022.	213484.	0.	0.	125995.	0.	548330.	-5829.	48752.6
1972	168025.	165570.	179449.	0.	0.	117330.	0.	564057.	-101708.	48651.0
1973	266867.	250334.	223299.	0.	0.	117842.	0.	562854.	28620.	48679.7
1974	213056.	223418.	235587.	0.	0.	121679.	0.	544239.	36444.	48716.3
1975	182655.	186853.	205620.	0.	0.	114308.	0.	548269.	-41487.	48674.9
1976	151535.	149381.	145021.	0.	0.	109485.	0.	574510.	-170622.	48504.3
1977	138672.	133989.	111849.	0.	0.	102763.	0.	585595.	-236995.	48267.4
1978	233811.	217738.	251313.	0.	0.	107820.	0.	538705.	38166.	48305.6
1979	211165.	211585.	211137.	0.	0.	112683.	0.	565412.	-30007.	48275.6
1980	237724.	236460.	243955.	0.	0.	114454.	0.	533549.	61321.	48337.1
1981	169667.	179075.	176027.	0.	0.	113604.	0.	564455.	-95749.	48241.4
1982	276305.	265860.	284239.	0.	0.	115129.	0.	503432.	161795.	48403.3
1983	308431.	311617.	290868.	0.	0.	121963.	0.	485166.	239281.	48642.7
1984	206018.	223559.	212695.	0.	0.	119694.	0.	554302.	1647.	48644.5
1985	169051.	177013.	194821.	0.	0.	109583.	0.	528617.	-47200.	48597.3
1986	244652.	235487.	242177.	0.	0.	105478.	0.	512172.	70969.	48668.4
1987	149850.	160895.	165015.	0.	0.	101759.	0.	524528.	-96859.	48571.6
1988	162100.	163736.	169284.	0.	0.	95006.	0.	491106.	-63080.	48508.6
1989	149369.	150031.	191558.	0.	0.	92939.	0.	467971.	-33443.	48475.2
1990	137774.	145727.	185124.	0.	0.	91314.	0.	451569.	-29404.	48445.8
AVERAGE	199377.	198876.	207396.	0.	0.	111846.	0.	533986.	-15868.	48445.8

SAMPLE MODEL OUTPUT

FIGURE 3-5

Section 4

SECTION 4

MODEL INPUT DATA

The hydrologic model developed for Sacramento County requires an extensive amount of input data which describes the County's geology, hydrology, geography, and land and water use characteristics. The input data files, as shown in Table 4-1, are divided into two sections: Part 1 - Model Configuration Files; and Part 2 - Flow Simulation Data Files. Part 1 is concerned with defining the structural characteristics of the model (model configuration). This includes the specification of the model grid, aquifer system, stream and river systems, surface drainage patterns, and soils. The data is fixed once the coverage of the model is decided and, in general, will not vary with the runs performed later. Upon completion of this part, model output includes plan views of the model and grid and vertical sections showing the simulated groundwater aquifer layers. Part 2 data files (flow simulation), on the other hand, contains all information that is time-dependent, including land use, water demand, rainfall, boundary stream inflows, and historical stream or canal diversions and groundwater pumping. These data files are required for the model simulation of groundwater levels, streamflows, and aquifer recharge. Part 2 information is on a monthly basis, except for land use, which is on annual basis. The following describes the individual input data incorporated in the model, divided into the two parts.

PART 1 - MODEL CONFIGURATION FILES

The delineation of the model boundaries and subregions; configuration of the model grid in plan and elevation (stratigraphy) and streams and drainage pattern, are the key tasks in development of the model configuration files.

Model Boundaries

The definition of a model's boundaries should ideally reflect physical conditions that isolate water basins from one another, such as surface or subsurface drainage divides or barriers (earthquake fault zones, for example, composed of materials that impede groundwater movement). However, because model boundaries must often conform to non-physical boundaries such as governmental or other public agency jurisdiction lines, establishing the boundary conditions becomes a key initial modeling work item. For this project, the model boundaries were developed to encompass the entire groundwater basin underlying the County with the exception of the Delta leg portion of the County (south of the Mokelumne River). This area was not included in the model since it receives most of its water from the Sacramento River via riparian water rights. Each of the model boundaries is discussed in greater detail below.

- The western boundary of the model is the Sacramento River which is also the border between Sacramento County and Yolo County. The Sacramento River is also an important source of groundwater recharge to the groundwater basin and acts as a groundwater divide for the upper aquifer system.

- The southern boundary of the model is the Mokelumne River and Dry Creek which also borders Sacramento County and San Joaquin County. Dry Creek is an intermittent stream (does not typically flow year round), and hence, does not serve as an effective groundwater boundary.

- The eastern border of the model is the geologic boundary of the water bearing and non-water bearing formations that outcrop at the base of the

TABLE 4-1

INTEGRATED GROUNDWATER SURFACE WATER MODEL
SUMMARY OF INPUT DATA FILES

Data Group	Data Item	Spatial Scale	Time Scale	Input File Name
Model Characterization	Element Configuration	Element	Invariant	SCNELEM.DAT
	Nodal Coordinates	Node	Invariant	SCNXY.DAT
	Stream Configuration	Stream Node	Invariant	SCNSTRM.DAT
	Sub region Definition	Element	Invariant	SCNCHRC.DAT
	Well Locations	x,y coordinates	Invariant	SCNWELLS.DAT
Geohydrology/Geography	Stratigraphy	Node	Invariant	SCNSTRA.DAT
	Stream Cross-sections	Stream Node	Invariant	SCNSTRM.DAT
	Drainage Patterns	Element	Invariant	SCNCHRC.DAT
	Aquifer Parameters	Node/Element	Invariant	SCNPARM.DAT
Hydrology/Climatology	Rainfall	Gaging Station /Subregion	Monthly	SCNPRCP.DAT
	Rainfall Distribution	Element	Invariant	SCNCHRC.DAT
	Soil Classification	Element	Invariant	SCNCHRC.DAT
	Evapotranspiration	Subregion	Monthly	SCNET.DAT
	Upstream Inflow	Stream Node	Monthly	SCNINFL.DAT
Land Use	Land use Distribution	Element	Annual	SCNLU.DAT
	Crop Acreage	Subregion	Annual	SCNCROP.DAT
	Irrigation Efficiency	Subregion	Monthly	SCNDEM.DAT
	Minimum Soil Moisture	Subregion	Monthly	SCNDEM.DAT
Water Use	Surface Water Diversions	Stream Node	Invariant	SCNSWDV.DAT
	Groundwater Pumping	Entity/Subregion	Monthly	SCNPUMP.DAT
	Pumping Distribution	Element/Layer	Invariant	SCNSPEC.DAT
	Urban Water Use	Subregion	Monthly	SCNURBN.DAT
Other	Initial Conditions	Node	Invariant	SCNINIT.DAT
	Boundary Conditions	Node	Invariant	SCNBOND.DAT

Sierra Nevada foothills. This boundary was determined from a 1:250,000 scale geologic map prepared by the California Division of Mines and Geology (Geologic Map of the Sacramento Quadrangle, 1987). This eastern border does not match the actual County border. In the north the geologic boundary is to the west of the County border and in the south the geologic boundary extends east beyond the County line into Amador County.

- The northern boundary of the model is the Sacramento County/Placer County and Sacramento County/Sutter County border which extends from the Sacramento River in the west to Folsom Lake in the east. This model boundary is based solely on the County northern border and does not represent a hydrologic boundary.

Finite Element Grid

A two dimensional finite element network have been developed for the entire model area as shown in Figure 4-1. Because Montgomery Watson had already developed a site-specific model for the City of Sacramento, an extension of the existing ride was developed for the County-wide model. Hence, the County model grid includes the original City model grid.

The total model area is approximately 879 square miles (562,000 acres). The model grid consists of 1,637 elements and 1,552 nodes. The average size of the model element is approximately 0.6 square miles (400 acres).

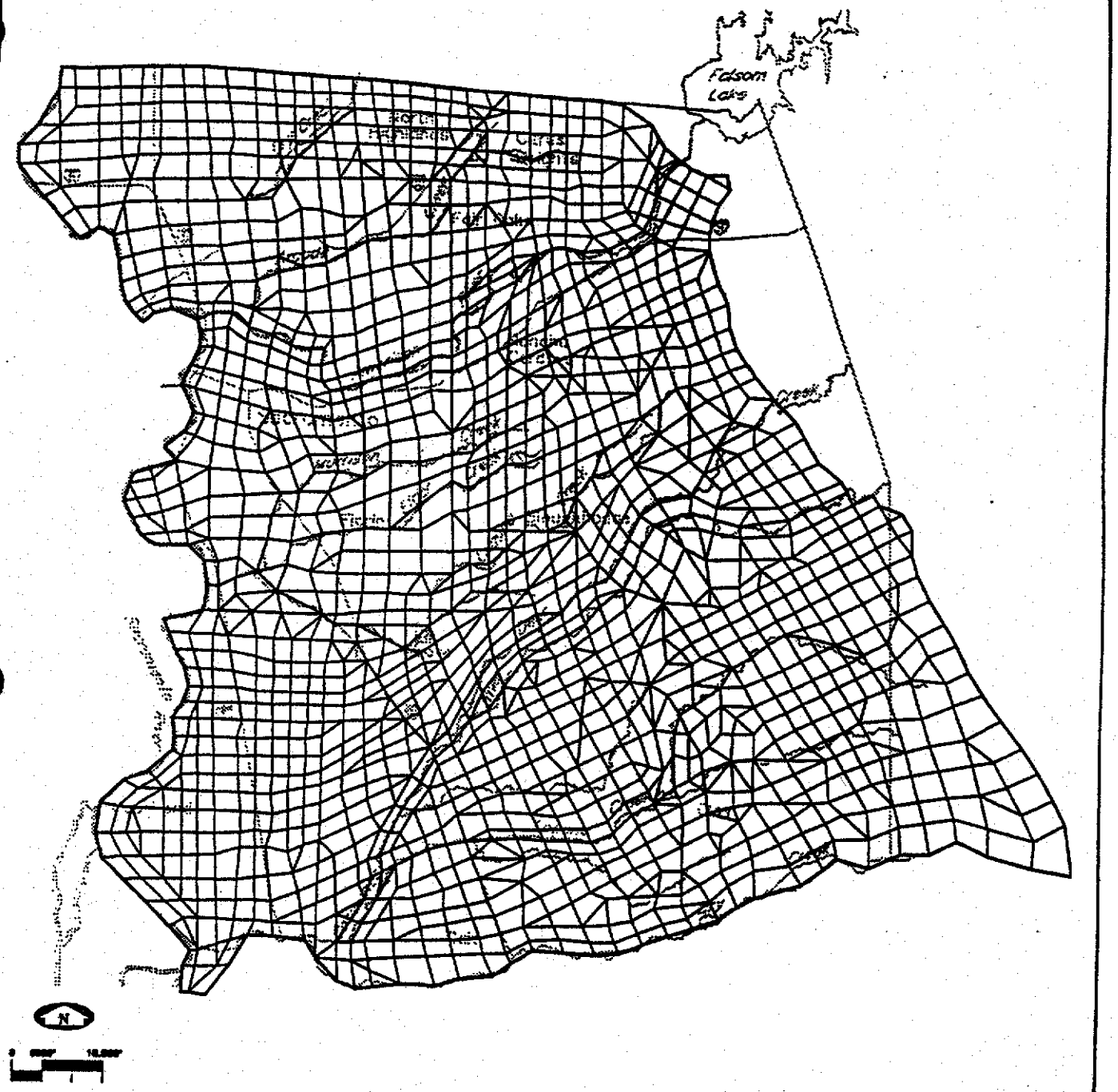
The general criteria used in the model grid development for both the County and City models are described below.

- The grid boundaries follow the model boundaries as described above.
- The grid orientation follows the general direction of groundwater flow in the model area. Groundwater level maps provided by Sacramento County were used to determine the dominant flow direction.
- The grid orientation is consistent with the general surface water drainage patterns of the major stream systems within the model area.
- The finite element grid generally follows the boundaries of the Place of Use (divided into North Sacramento and South Sacramento), Zone 40, and other individual water districts within Sacramento County.

River and Drainage System

A total of eleven streams and rivers were incorporated in the model. These streams and rivers are:

- Sacramento River
- American River
- Cosumnes River
- Dry Creek - North (inflows from Placer County)
- Morrison Creek
- Elder Creek
- Laguna Creek (Morrison Creek Group)
- Deer Creek



MODEL GRID

FIGURE 4-1

- Arcade Creek
- Natomas Drain
- Laguna Creek (Cosumnes River Tributary)
- Dry Creek - South (Sacramento/San Joaquin County Border)

Each stream reach was designated by a series of stream nodes with each stream node corresponding to a groundwater node as described earlier. A total of 360 stream nodes were modeled in the representation of the eleven stream/rivers.

In addition to the stream locations, streambed elevations and streamflow rating tables were assigned to each stream node. The rating tables incorporate depth of streamflow versus wetted perimeter and discharge. This information is used by the model in determining streamflow gain/loss to the groundwater system through streambed infiltration. The rating tables and streambed elevations were obtained from previous drainage modeling studies for most of the major rivers and creeks. Additional information was obtained from USGS gaging stations and topographic maps. Where information was not available for smaller streams, rating tables were developed based on field inspection and/or comparison with streams of similar characteristics.

In order to establish the drainage pattern for surface water runoff, USGS topographic maps were utilized in conjunction with watershed maps provided by Sacramento County. Each model element was assigned a stream node to which the surface water drains to. If the drainage was to outside the model area through drainage channels, this was also specified.

Model Subregions

In addition to being divided into elements, the model area has also been divided into 31 subregions. The division of the model area into subregion allows for the independent analysis of water budgets and hydrologic conditions for each subregion. For instance, model results of detailed groundwater budgets (including pumping, percolation, stream recharge, etc.) can be prepared for each individual model subregion as well as the entire model area.

The model subregions incorporated in the model include the Place of Use (divided into North and South Sacramento), Zone 40, and the numerous other municipal urban and irrigation water districts located within the model boundary. It should be noted that North and South Sacramento (Place of Use) as well as Zone 40 overlap other water districts. For instance, the Zone 40 subregion incorporates all of Elk Grove Water Works, and partially incorporates Omochumne-Hartnell Water District. Hence, the Omochumne-Hartnell model subregion does not represent the entire district boundaries. Table 4-2 lists all of the model subregions and provides a general description of the area they encompass. Figure 4-2 shows the location of the model subregions.

Soil Classification

Rainfall entering the model area is converted either to direct runoff or infiltration. Direct runoff is drained into local streams or rivers, while rainfall in excess of direct runoff, combined with irrigation-applied water, infiltrates into the soil. The allocation between runoff and infiltration is related to the magnitude of rainfall and a retention parameter that depends upon the soil type, land use, and land management practices. Soil types, as classified by the US Soil Conservation Service (SCS), fall into four hydrologic soil groups:

TABLE 4-2

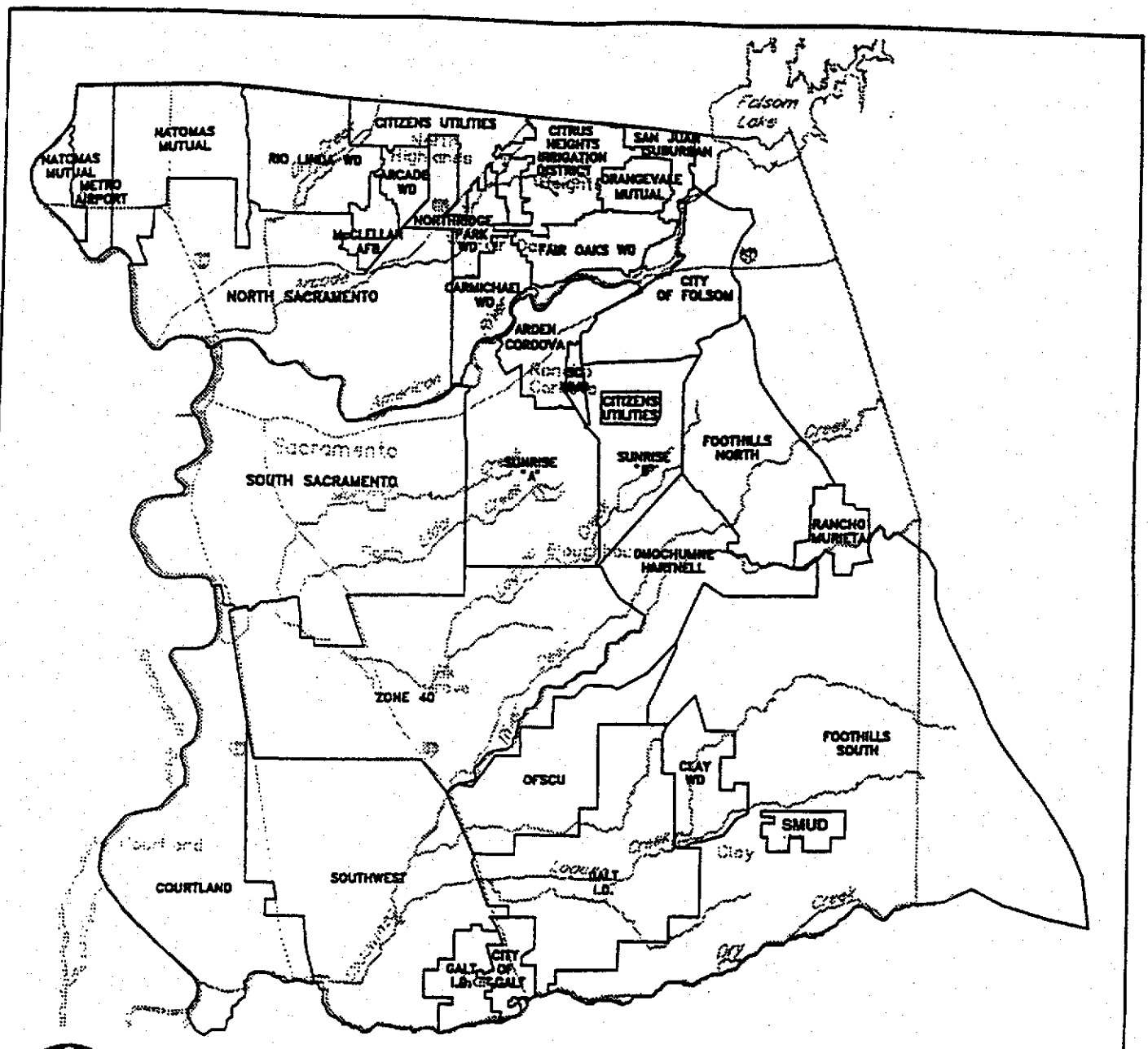
MODEL SUBREGIONS

Model Subregion	Subregion Area (acres)	Comments
1. North Sacramento	45,759	Incorporates North Sacramento POU including City of Sacramento (partial), Citizens Utilities (partial), Arcade WD (partial), Arden Cordova (partial), Del Paso Manor (partial), SCWMD (partial).
2. South Sacramento	59,549	Incorporates South Sacramento POU including City of Sacramento (partial), Fruitridge Vista Florin County, Citizens Utilities (partial), Tokay Park, and SCWMD (partial).
3. Zone 40	48,456	Incorporates an expanded Zone 40 groundwater management area including SCWMD (partial), Elk Grove Water Works, Omochumne-Hartnell (partial), and Southwest Area (partial).
4. Southwest	42,460	Incorporates portion of Southwest outside of Zone 40.
5. Galt ID	32,848	
6. City of Galt	3,363	
7. Other Folsom South Canal Users (OFSCU)	15,076	
8. SMUD	2,939	Includes Rancho Seco Nuclear Power Plan (shutdown).
9. Clay WD	7,679	
10. Omochumne-Hartnell	19,709	Incorporates portion of Omochumne-Hartnell outside of Zone 40.
11. Rancho Murieta	3,646	
12. Sunrise "A"	18,798	Incorporates Mather AFB and portion of Citizens Utilities.
13. Sunrise "B"	10,641	
14. Citizens Utilities	10,939	Incorporates portion of Citizens Utilities outside of North Sacramento, South Sacramento, Zone 40, and Sunrise "A".

TABLE 4-2

MODEL SUBREGIONS (continued)

Model Subregion	Subregion Area (acres)	Comments
15. City of Folsom	13,879	Incorporates portion of Folsom within model area and Aerojet Facilities.
16. Arden Cordova	9,761	Incorporates portion of Arden Cordova outside Place of Use.
17. Fair Oaks	7,692	
18. Orangevale	3,243	
19. San Juan	1,205	Incorporates portion of San Juan Suburban WD within model area.
20. Carmichael	4,695	
21. Citrus Heights	7,864	
22. Northridge	5,563	Incorporates portion of Northridge outside Place of Use.
23. SCWMD	915	Incorporates portion of SCWMD outside Place of Use and Zone 40 in the Sunrise Service Area.
24. McClellan AFB	1,887	
25. Arcade WD	2,547	Incorporates portion of Arcade WD outside Place of Use.
26. Rio Linda	10,917	
27. Natomas Mutual	14,874	
28. Metro Airport	5,461	
29. Courtland	32,294	Incorporates primarily agricultural area adjacent to Sacramento River west of the Southwest subregion.
30. Foothills North	18,497	Primarily undeveloped area.
31. Foothills South	99,589	Primarily undeveloped area including portion of Amador County.
Total Model Area	562,744	



1.North Sacramento
2.South Sacramento
3.Zone 40
4.Southwest
5.Galt ID
6.City of Galt
7.OFSCU
8.SMUD
9.Clay W.D.
10.Omocuhmne–Hartnell
11.Rancho Murieta
12.Sunrise "A"
13.Sunrise "B"
14.Citizens Utilities
15.City of Folsom
16.Arden Cordova
17.Fair Oaks WD
18.Orangevale
19.San Juan
20.Carmichael
21.Citrus Heights
22.Northridge
23.SCWMD
24.McClellan AFB
25.Arcade WD
26.Rio Linda
27.Natomas Mutual
28.Metro Airport
29.Courtland Area
30.Foothills North
31.Foothills South

MODEL SUBREGIONS

FIGURE 4-2

- **Group A.** Low runoff potential - mainly sands and gravels that are deep and well- to excessively-drained; high transmissivity.
- **Group B.** Low to moderate runoff potential - soils of moderately-fine to moderately-coarse texture, moderately deep and drained; medium transmissivity.
- **Group C.** Moderate to high runoff potential - soils of moderately-fine to fine texture with an impeding clay layer; low transmissivity.
- **Group D.** High runoff potential - mainly clay soils with a high swelling potential; shallow soils over nearly impervious materials and soils with a permanently high water table; poor transmissivity.

County soil survey maps show the geographical distribution of these hydrologic soil groups. Based on these maps, each finite element is assigned a weighted number between 1 (entire element area is Group A soil) and 4 (entire element is in Group D soil). The soils within Sacramento County are predominantly Group C and Group D (characterized as clay or silt with poor recharge potential), with the exception of areas adjacent to the Cosumnes River, American River, and other smaller creeks. These soils are generally associated with river and flood plain deposits and have higher recharge capacities (Group B soils). In addition, a relatively large area in the upper Morrison Creek watershed has soils which are classified as "disturbed" which refers to the removal of top soil for gravel mining operations. In these areas, for modeling purposes, the soil has been classified as Group B, to reflect the higher recharge capabilities associated with removal of the top soil.

Aquifers

The model representation of the groundwater system is achieved by assigning to each model node a surface ground elevation and the thickness of succeeding aquifers and impervious layers (aquicludes). The elevation of the ground at each node was obtained from USGS 7.5-minute topographic quadrangle maps (quads). The aquifer delineation was based on an extensive review of DWR Bulletin 118-3, USGS reports, and numerous well logs, and California Division of Oil and Gas geophysical logs. A three-layer aquifer system has been incorporated in the model as follows:

- Ground Surface (source: USGS 7.5-minute quad sheets)
- Aquiclude 1: Confining layer near the ground surface. (Source: Sacramento County hydrologic soil maps, well logs, E-logs)
- Aquifer 1: Water-bearing deposits overlain by Aquiclude 1. (Source: well logs, E-logs, well construction data)
- Aquiclude 2: Thick clay layer that ranges in color from blue to brown. (Source: well logs, E-logs, Luhdorff and Scalmanini, 1990)
- Aquifer 2: Water bearing deposits between Aquiclude 2 and base of fresh water. (Source: E-logs, well logs, Division of Oil and Gas logs, DWR Bulletin 118-6)
- Aquifer 3: Non-fresh water bearing deposits (TDS exceeds 2,000 ppm) above the base of the usable aquifer. (Source:

Division of Oil and Gas logs, well logs, E-logs, DWR Bulletin 118-6)

Figures 4-3a to 4-3g present selected cross-sections depicting the vertical configuration of the aquifers and aquicludes as contained in the model input data. The location of each of the model aquifer cross-sections is the same as the geologic cross sections (see Figure 2-4).

Well Locations

In order to model the location of groundwater pumping, the location and physical characteristics of all municipal wells were collected from the various agencies and water districts within the study area. The information collected and incorporated into the model include the location of the wells, the depth of perforations, and the well diameter. The depth of well perforations is an important model input in that it is used by the model to specify which aquifer layer (or combination of layers) the particular well draws its water from. Figure 4-4 shows the location of all the municipal wells incorporated in the model. As indicated by the figure, a significant number of the wells are concentrated in the area north of the Sacramento River. This area is largely urbanized and served by water districts which rely on groundwater (Citizens Utilities, Arcade, Northridge, McClellan AFB, etc.).

It should be noted that the above well information is for municipal wells and does not include smaller domestic wells or agricultural wells. There are potentially thousands of agricultural wells within the study area. However, because these wells are not metered, their location was estimated by the model based on land use (see section below on Agricultural Water Use for discussion of agricultural pumping estimates).

PART 2 - FLOW SIMULATION DATA FILES

The delineation of time-variant parameters including rainfall, stream inflows, and land and water use, represent the key tasks in development of the flow simulation files.

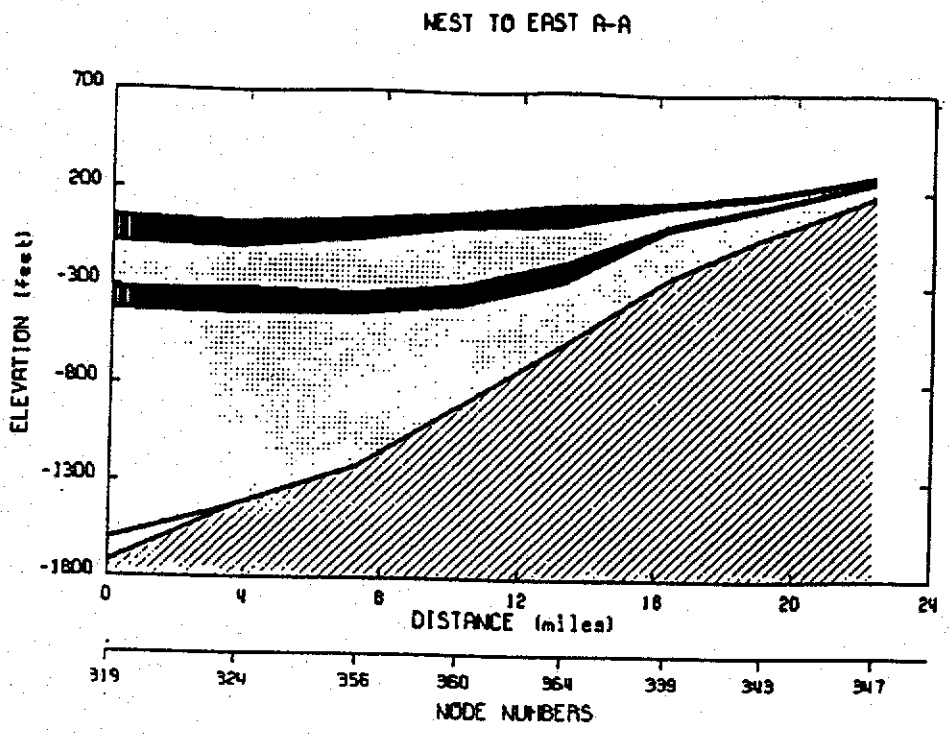
Rainfall

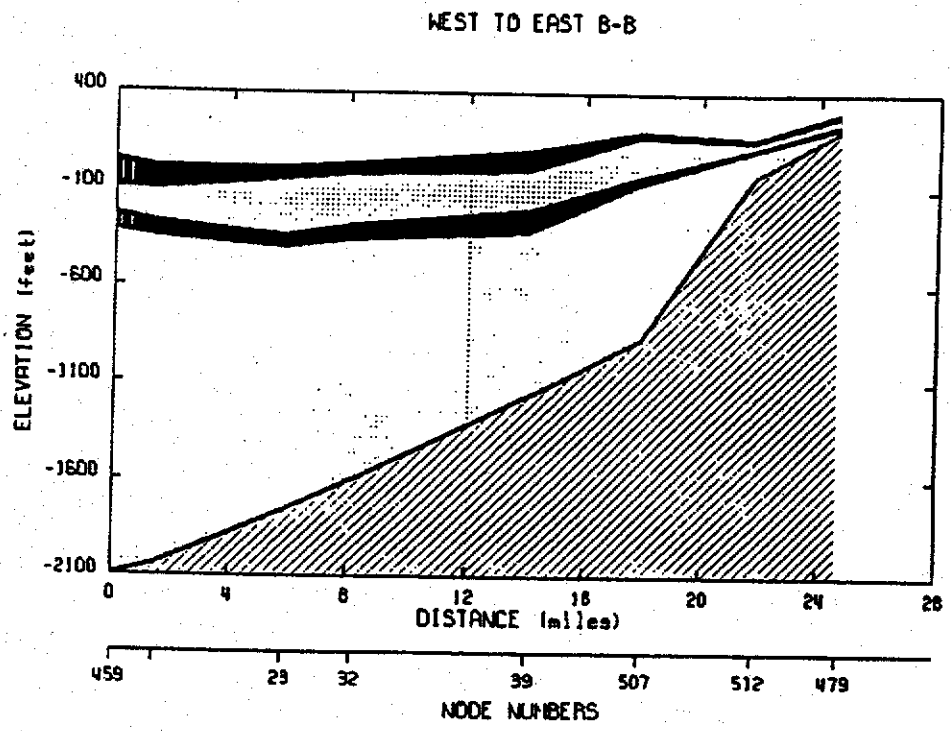
Rainfall is a significant driving force for all hydrologic operations within the model, as it is one of the primary sources of water to the basin. Rainfall in the Sacramento Valley is characterized by a marked seasonal distribution - most rainfall occurs between December and March. In addition, the annual rainfall in the Valley exhibits extreme variations from year to year, as well as geographic variations. In determining historical monthly rainfall over the entire model area, data from 11 rainfall stations was utilized. The general criteria utilized in selecting these rainfall stations was to obtain stations with good, long-term records, and to obtain stations with a wide geographic distribution throughout the County. Each of the rainfall stations is listed in Table 4-3 and the locations are shown in Figure 4-5.

In order to further refine the representation of the spatially variable rainfall pattern within the model area, each model element was assigned a weighing factor by which the monthly rainfall at the appropriate rainfall station was adjusted. The weighing factor was determined as follows:

$$\text{rainfall weight factor at element i} = \frac{\text{mean annual precipitation at the element}}{\text{mean annual precipitation at the rainfall station}}$$

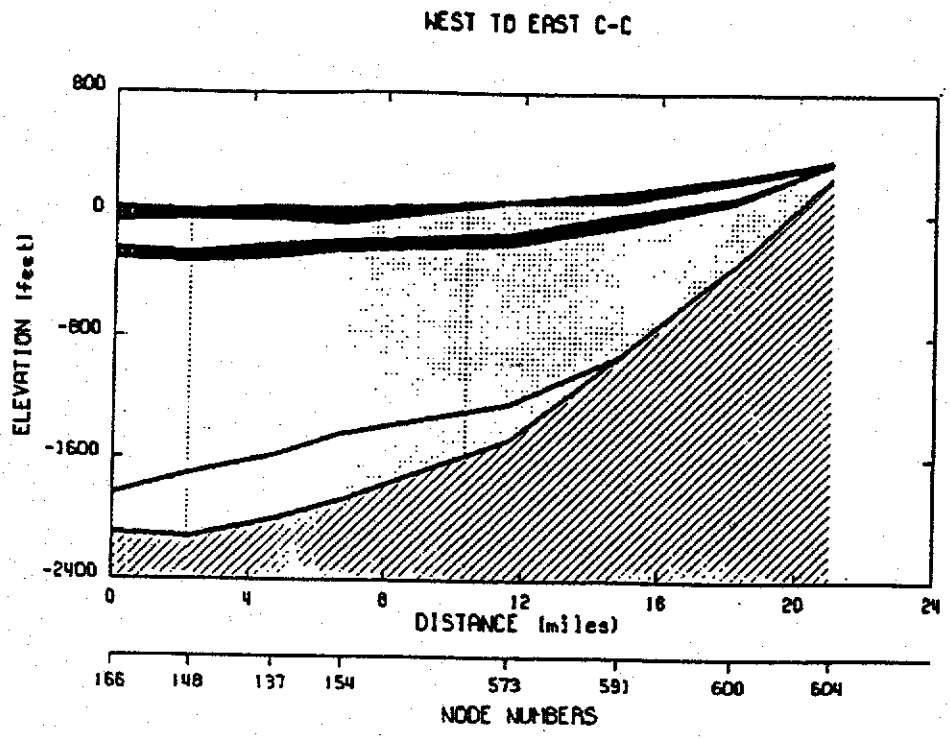
The long term mean annual rainfall at each element was determined from an isohyetal map of the County area prepared by Sacramento County as is presented in Figure 4-6.

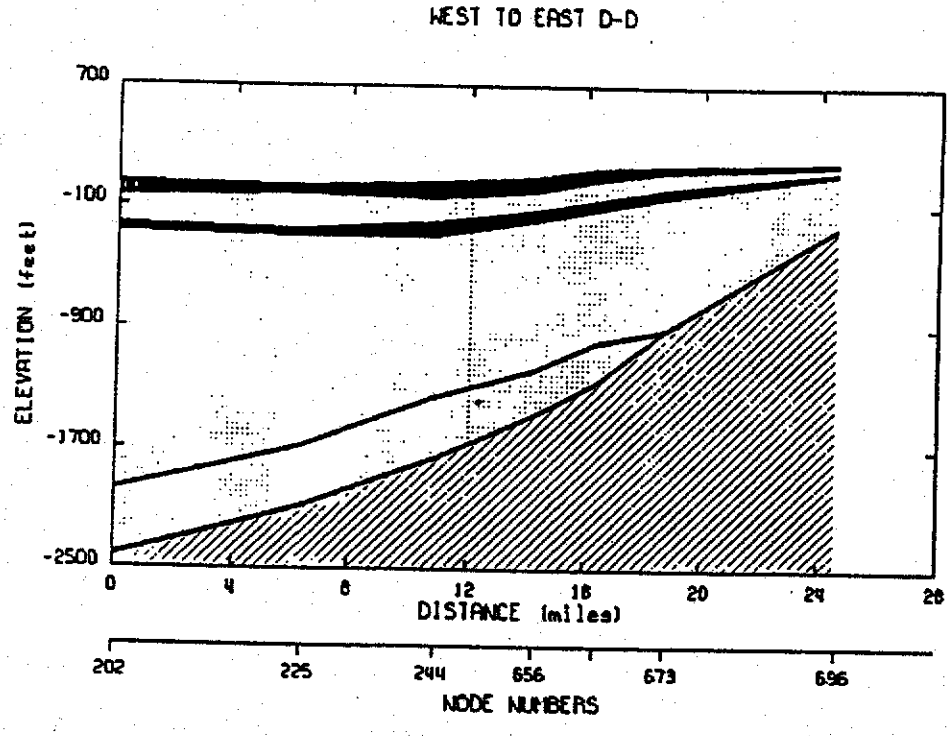




AQUIFER CROSS SECTIONS A-A AND B-B

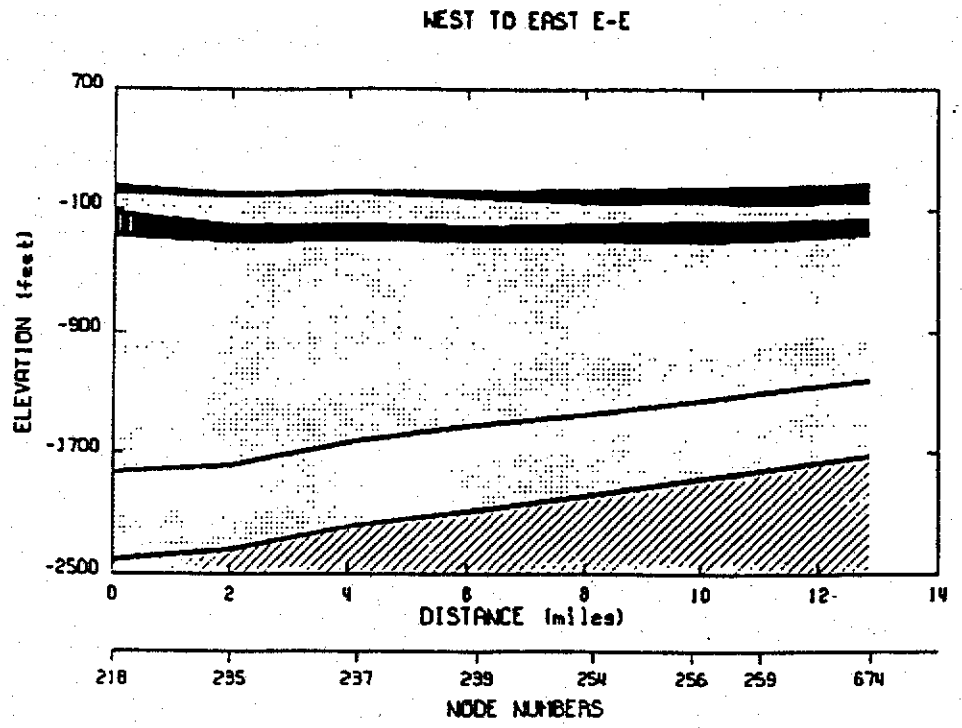
FIGURE 4-3a

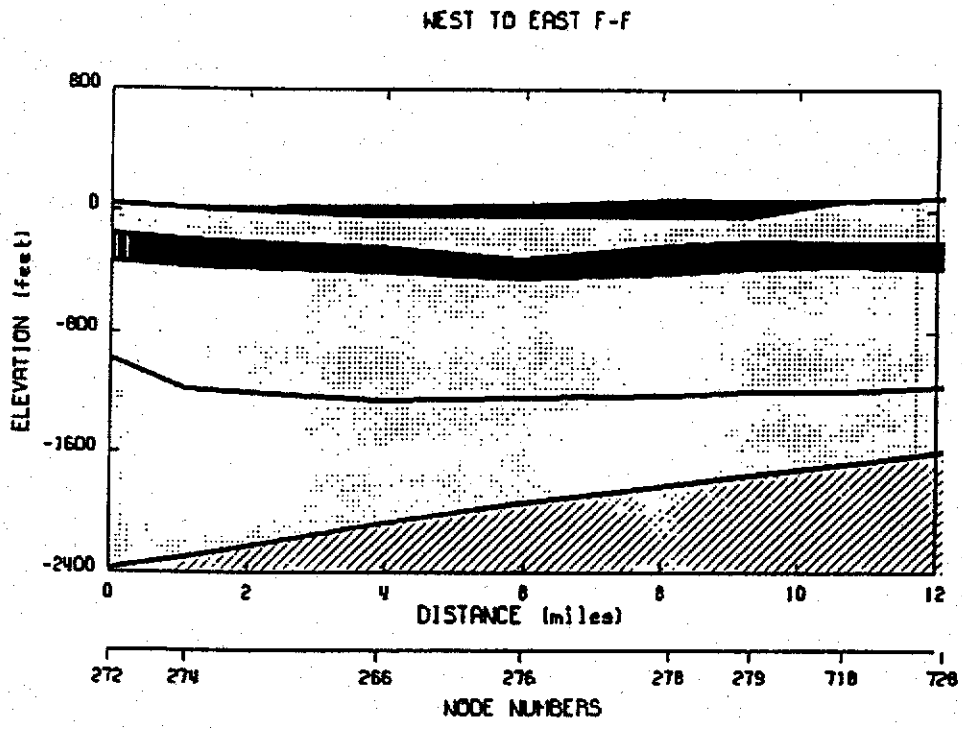




AQUIFER CROSS SECTIONS C-C AND D-D

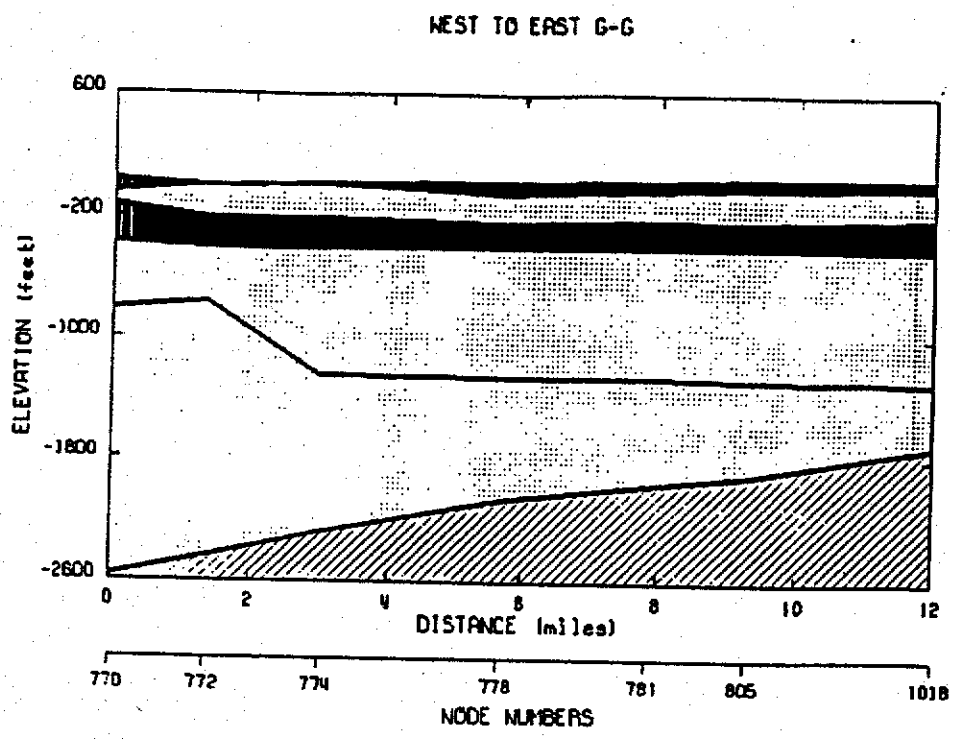
FIGURE 4-3b

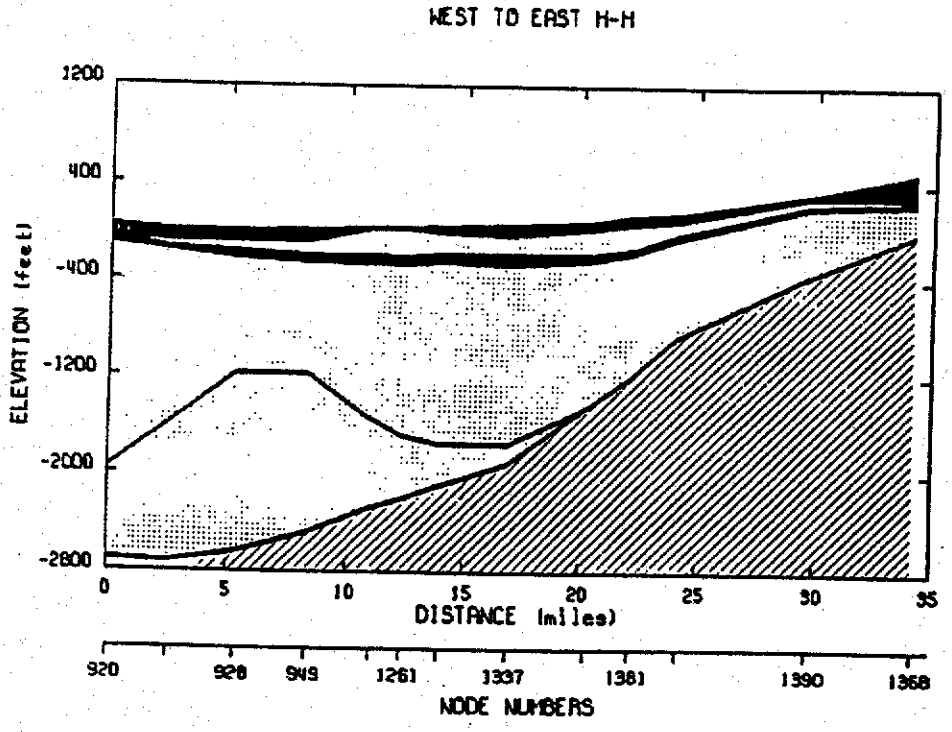




AQUIFER CROSS SECTIONS E-E AND F-F

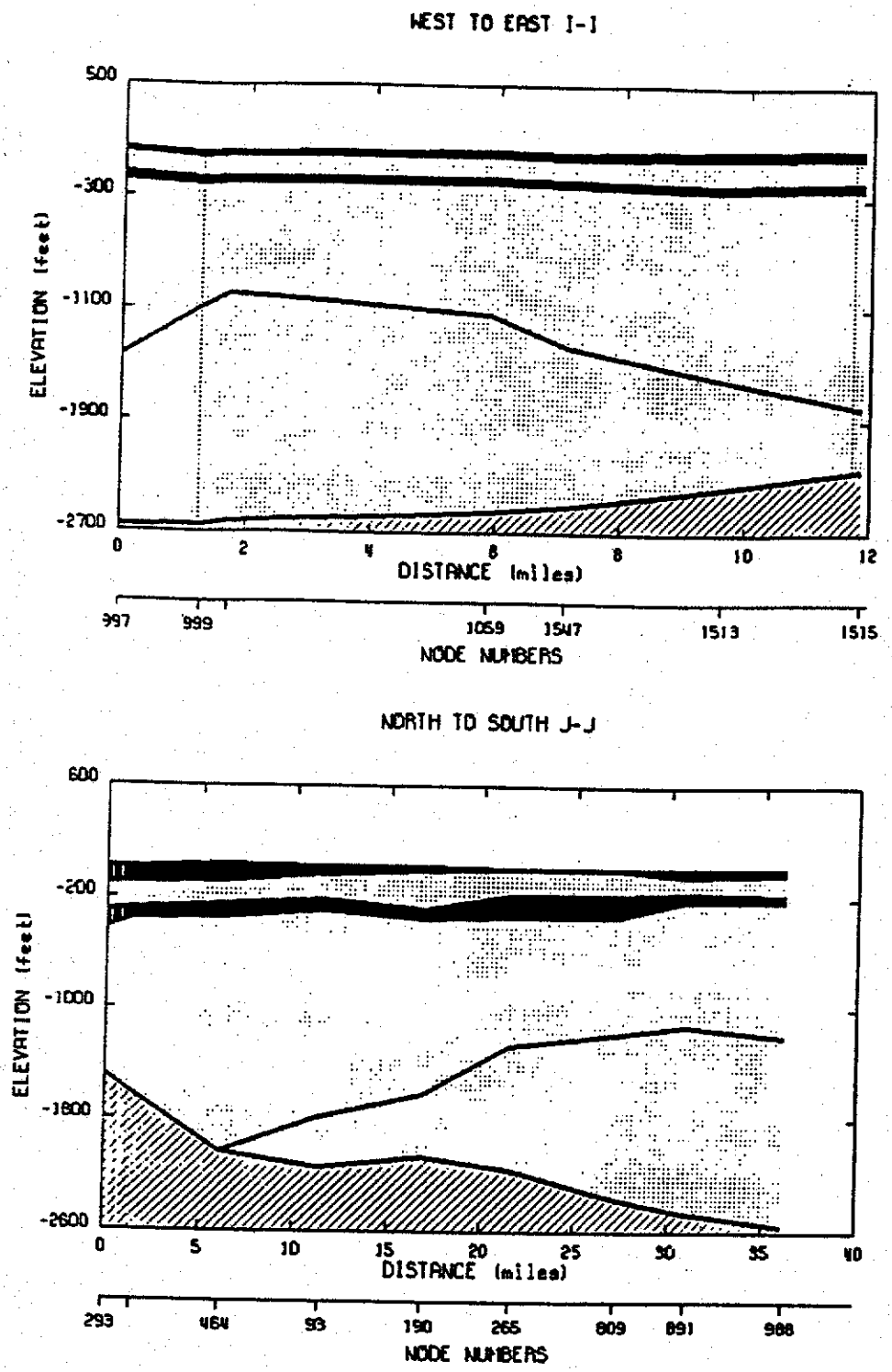
FIGURE 4-3c





AQUIFER CROSS SECTIONS G-G AND H-H

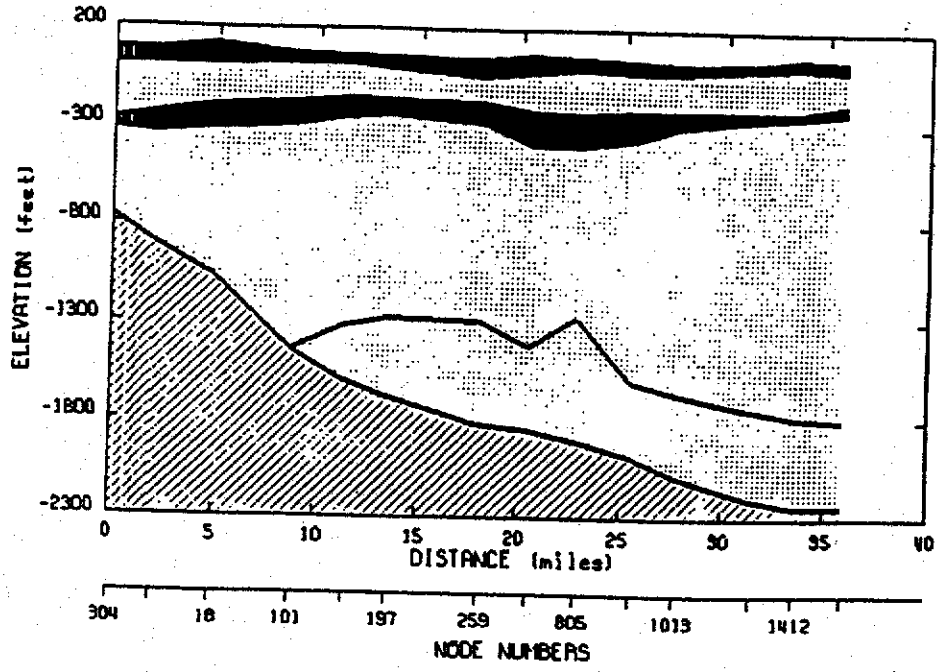
FIGURE 4-3d



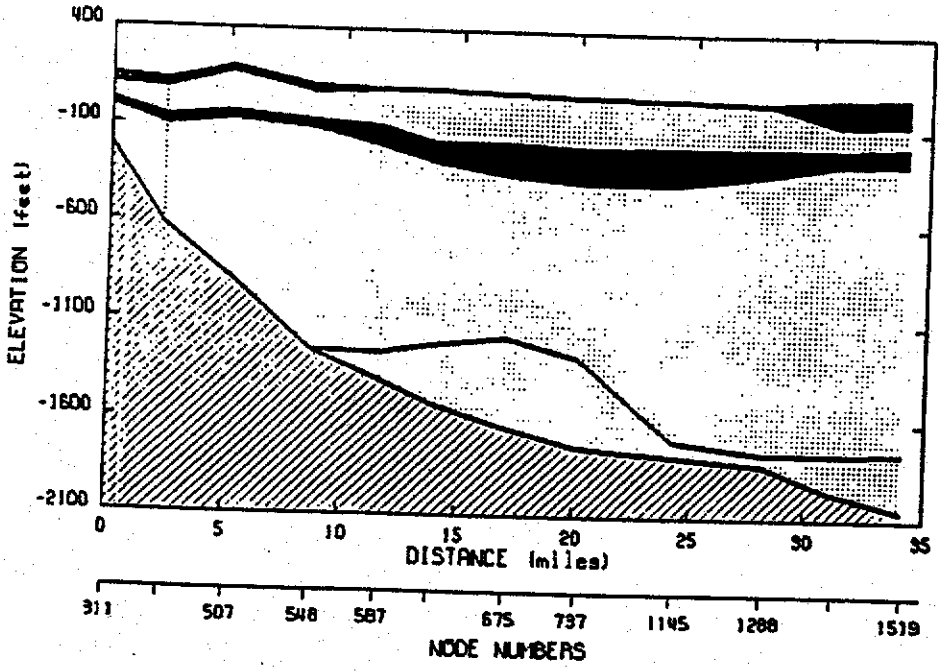
AQUIFER CROSS SECTIONS I-I AND J-J

FIGURE 4-3e

NORTH TO SOUTH K-K

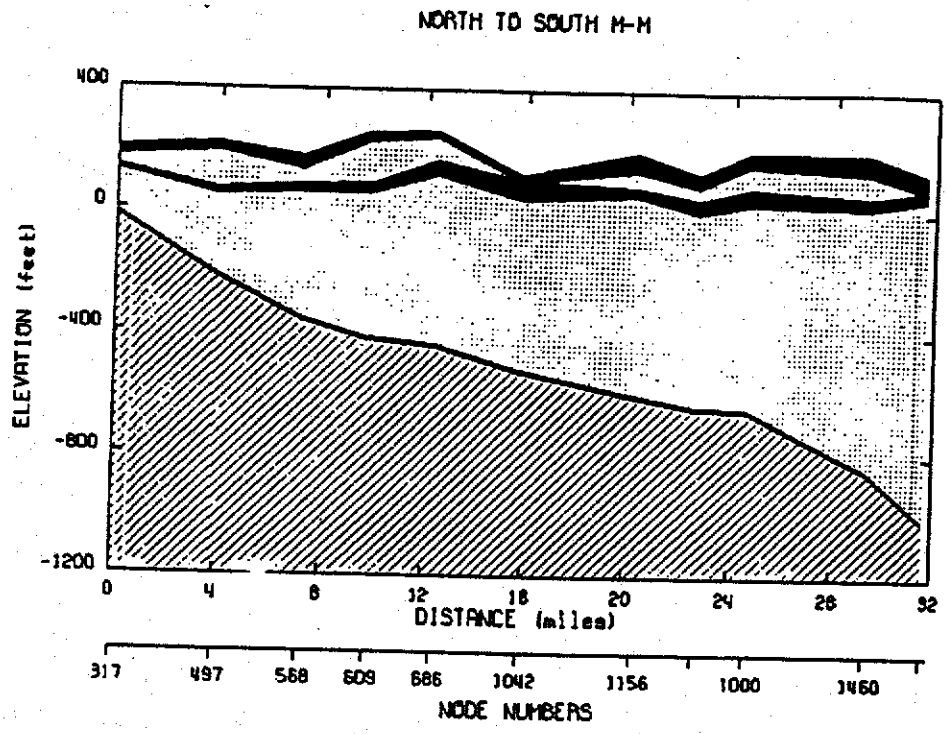


NORTH TO SOUTH L-L



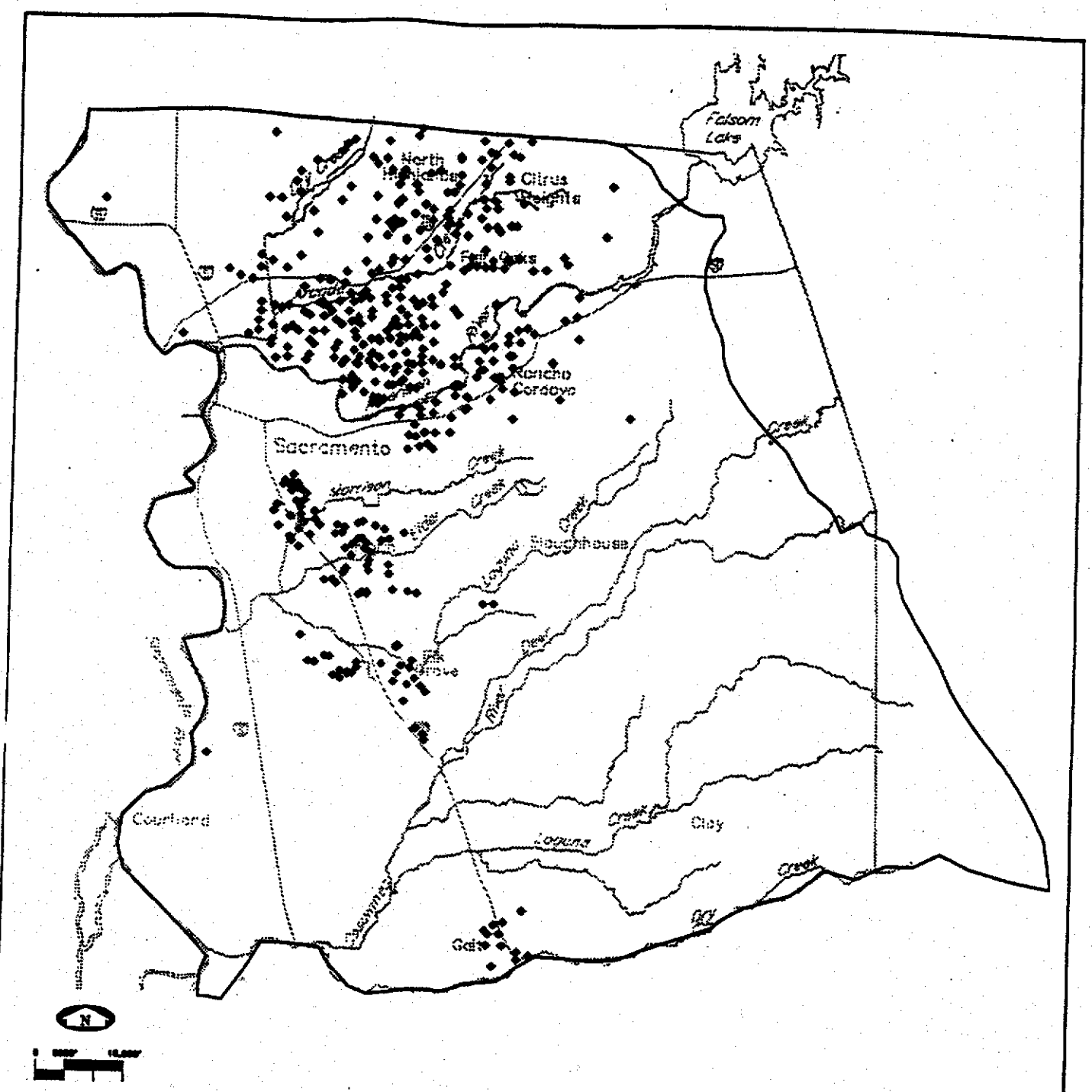
AQUIFER CROSS SECTIONS K-K AND L-L

FIGURE 4-31



AQUIFER CROSS SECTION M-M

FIGURE 4-3g



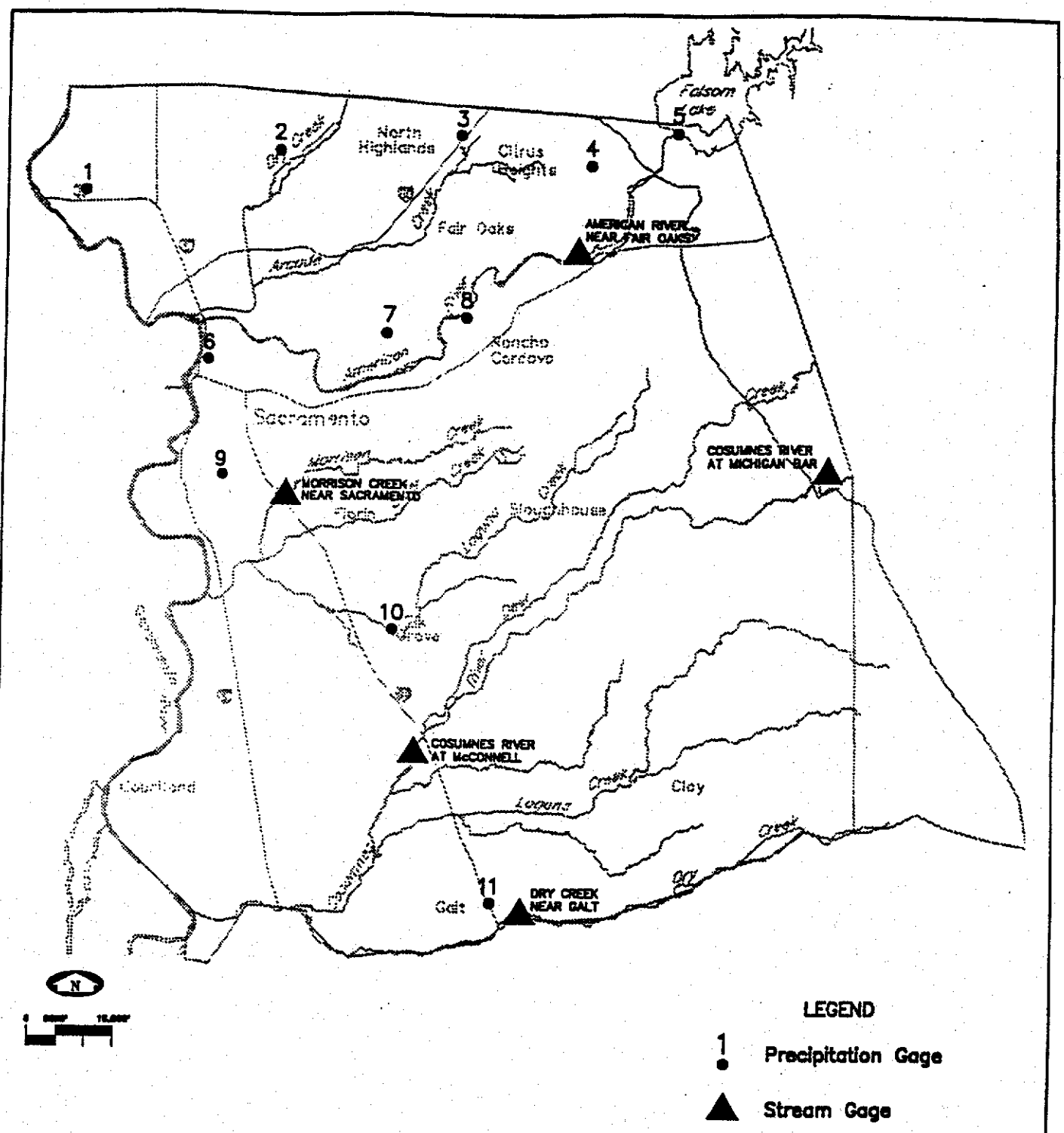
LOCATION OF MUNICIPAL WELLS

FIGURE 4-4

TABLE 4-3

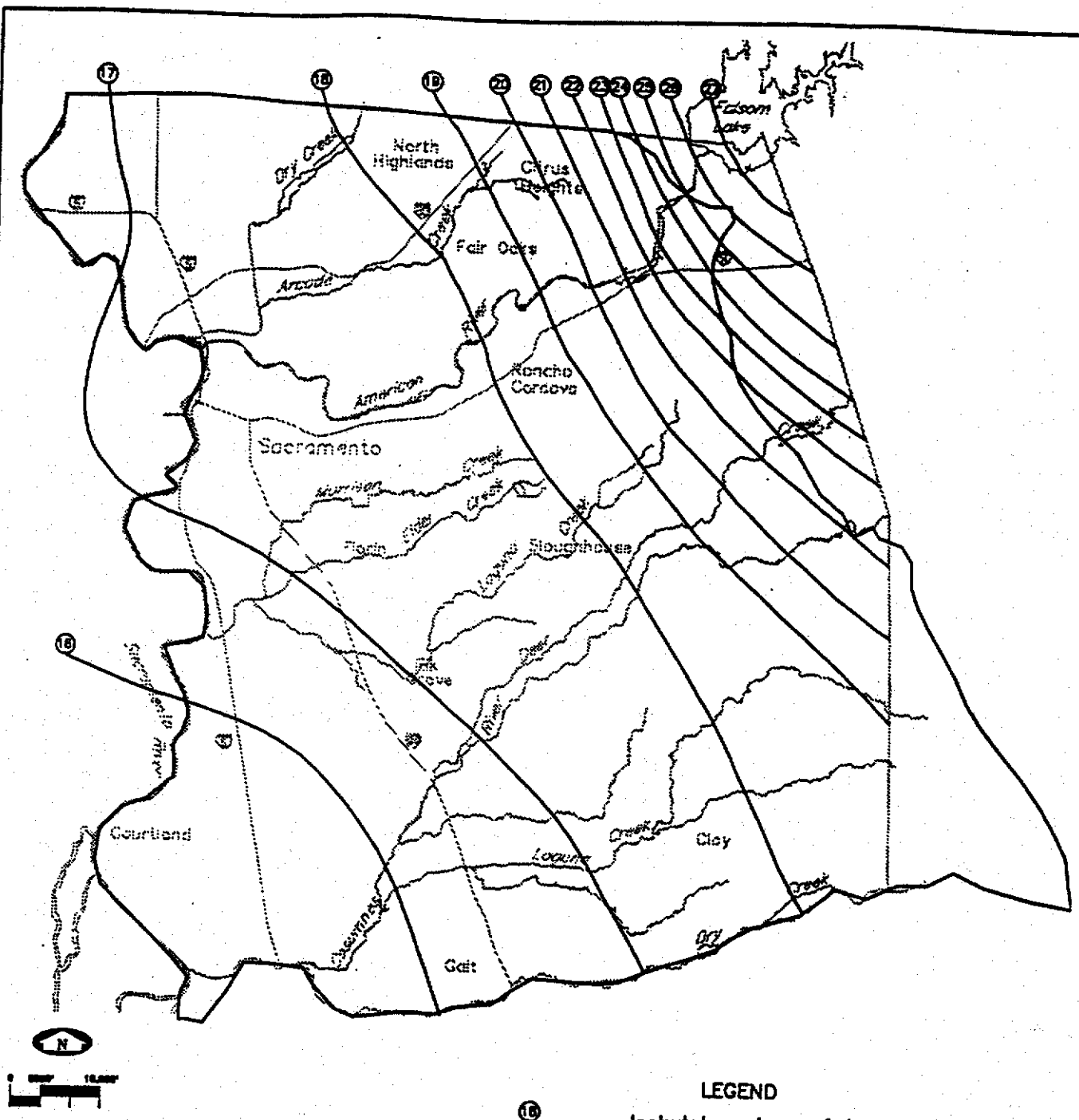
MODEL RAINFALL STATIONS

Rainfall Station	Data Source	Period of Record	Average Annual Rainfall for Period of Record (inches)
1. Metro Airport	Sacramento County	1962-1991	15.6
2. Rio Linda	Sacramento County	1970-1991	17.8
3. Navion	Sacramento County	1970-1991	22.9
4. Orangevale	Sacramento County	1961-1991	20.9
5. Folsom Dam	DWR/NOAA	1956-1991	21.3
6. Sacramento WSO	NOAA	1922-1991	17.6
7. Cresta Park	Sacramento County	1960-1991	18.9
8. Rancho Cordova	Sacramento County	1961-1991	18.9
9. Sacramento FAA	NOAA	1948-1991	16.2
10. Elk Grove	Sacramento County	1962-1991	17.3
11. Galt	DWR/NOAA	1922-1989	16.7



LOCATION OF PRECIPITATION AND STREAM GAGING STATIONS

FIGURE 4-5



ISOHYETAL MAP

FIGURE 4-6

Stream Inflow

In addition to rainfall, stream and river flows originating outside the model area are also a significant source of water to the model area. The primary sources of upstream inflows are the Sacramento, American, and Cosumnes Rivers. However, there are several smaller streams and creeks that contribute surface inflows to the model area.

Upstream inflow into the model area is specified in two separate methods. For the larger streams and rivers, historical monthly inflow was specified at the location where the stream/river entered the model area. This inflow information was specified for the Sacramento River, Cosumnes River, American River, Dry Creek (North), and Dry Creek (south).

The second method of determining historical streamflow into the model area was the ungaged inflows to the basin from smaller watersheds that originate in the Sierra Nevada Foothills and flow westward into the model area. In order to simulate surface inflows from this area, eight small watersheds which drained into the model area were delineated from USGS topographic maps. The runoff from these watersheds was simulated by IGSM based on the monthly rainfall, watershed area, soil and drainage characteristics, and evapotranspiration rates. Table 4-4 lists the drainage area and the model node to which it drains in each of these small watersheds.

Potential Evapotranspiration

Evapotranspiration (ET) is a common measure of crop water use and is an important component of soil moisture accounting (and the corresponding runoff and percolation rates) for all of the land uses within the study area (i.e. agricultural, urban, undeveloped). The rate of evapotranspiration not only varies for different crop and plant types, but it also varies with time and geographic location. There have been several efforts to document the geographic variation of potential evaporative demands for entire counties or regions within California. DWR (1975a) has divided the entire state into 11 zones of similar evaporative demand and provided monthly evaporation rates for principal crops that are grown in the corresponding region. MacGillivary (1976) reevaluated the crop evapotranspiration values used in the DWR's Consumptive Use Model and presented monthly crop evapotranspiration values for different zones as a function of long-term mean annual precipitation in the corresponding zone. DWR's revised Consumptive Use Model used these values in determining the crop ET demand for its study areas which are different than the aforementioned zones. The local area model incorporates these monthly potential evapotranspiration demand data from the revised Consumptive Use Model for all of the crop types and land uses incorporated in the model (see Land and Water Use discussion of this Section).

Land Use

Land use patterns play a major role in the basin hydrology in that the type of land use has a significant impact on the runoff-recharge potentials of the areas within the County. For instance, runoff from rainfall in urbanized areas is greater than runoff in undeveloped areas due to the large percentage of impervious surfaces such as streets, parking lots, and buildings. In addition, recharge rates from deep percolation may be higher in agricultural areas than in undeveloped areas due to applied irrigation water that is not utilized by crops and percolates into the groundwater system.

For the Sacramento County model, land uses were separated into four categories:

TABLE 4-4

SMALL WATERSHEDS OUTSIDE MODEL AREA

Creek Name	Drainage Area (square miles)	Drains to Groundwater Node
1. Willow Creek	3.0	488
2. Alder Creek	6.5	503
3. Carson Creek	21.5	639
4. Deer Creek	47.0	696
5. Crevis Creek	4.0	1047
6. Arkansas Creek	3.5	1192
7. Willow Creek	18.0	1357
8. Laguna Creek South	2.5	1359

- Agricultural (irrigated crops and pasture land)
- Urban (municipal and urban)
- Riparian Vegetation (heavily vegetated areas adjacent to rivers)
- Undeveloped (natural vegetation and/or non-irrigated fallow)

For each model element, the percent of each land use category was specified for the years 1976 and 1984 from land use maps prepared by DWR. These land use maps contain the most readily available information on the geographical distribution of land use. The maps are prepared as a result of surveys conducted by the DWR for each county in California through the interpretation of aerial photography which is supplemented by field inspection. These surveys are based on the standard USGS 7.5-minute topographic quads (use of overlays) and have been conducted since the late 1940s on a mandated cycle of five to ten years, averaging approximately seven years. DWR Bulletin No. 176 "Land Use in California" discusses the surveys and contains an extensive set of classifications for agriculture and urban areas.

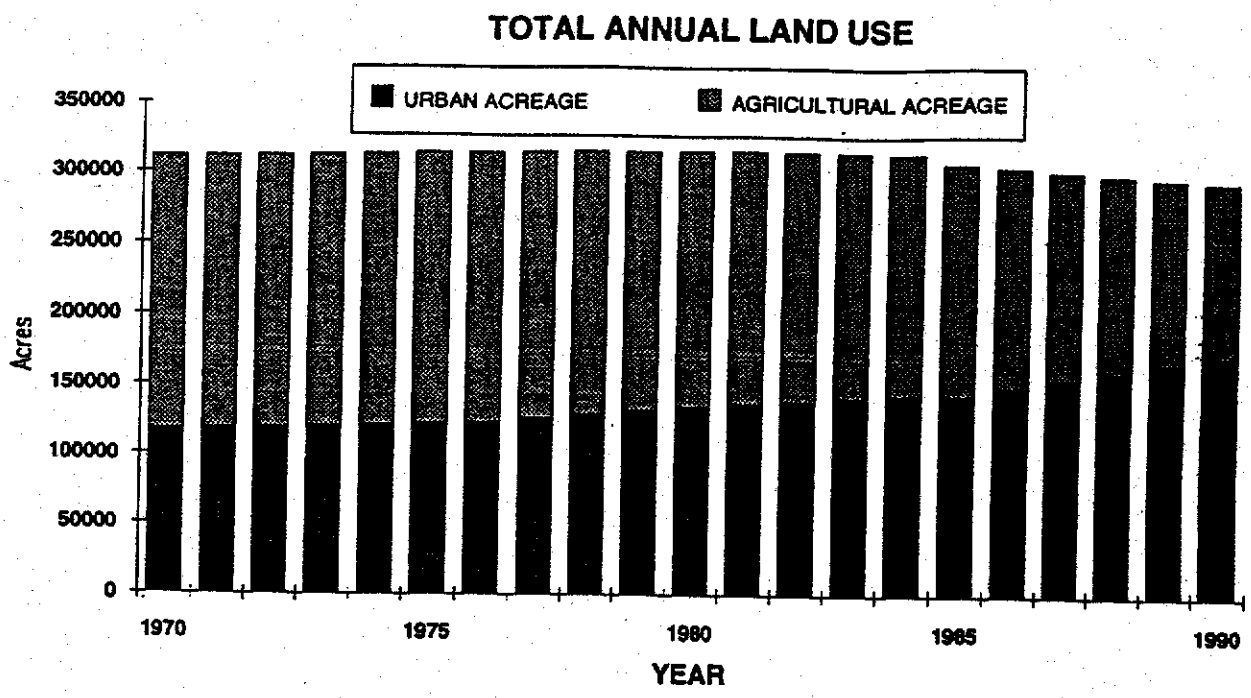
Crop Acreage

In order to estimate agricultural water use and to simulate the various amounts of applied water (and associated consumptive use, field runoff, and percolation), annual crop acreage must be defined for each model subregion. The crop types have been grouped into the following categories.

- Field Crops
- Truck Crops
- Orchard
- Vineyards
- Citrus and Olives
- Tomatoes
- Irrigated Pasture
- Sugar Beets
- Alfalfa
- Rice
- Grain
- Urban Areas

The total annual crop acreage for each crop type was determined from the DWR land use/crop survey maps for 1976 and 1984. In addition, DWR has recently estimated the 1990 crop acreage; however, these estimates are not based on actual surveys, and although the 1990 estimates are incorporated in the model, they have not been verified through field checking or other means. The 1990 urban acreage was not available from the DWR and was developed from assessor parcel information for the Sacramento County area by Boyle Engineering Corporation (1992).

For years between the surveys and the 1990 estimates, the crop acreage was estimated based on a linear interpolation of the acreage for the years with data. The crop acreage from 1970-1975 was assumed to remain constant at the 1976 levels. Figure 4-7 presents the 1970-1990 annual agricultural and urban acreage. In general, the urban acreage within the County has been steadily increasing over the past twenty years. The land use surveys from the DWR indicate that the crop acreage decreased slightly between 1976 and 1984.



TOTAL ANNUAL LAND USE

FIGURE 4-7

However, the 1990 crop acreage estimated by DWR indicates a significant reduction in crop acreage over the past seven years. This estimate was substantiated by the Sacramento County Agricultural Commissioner's annual reports on crop production.

Water Use

For modeling purposes, water use in the model area is divided into two categories: urban and agricultural water use. The separation of water use into these categories is required due to the differences in the land uses and in the amounts of percolation and runoff that occurs as a result of these water uses. The percentage of agricultural water that is available for percolation into the groundwater system is much higher than that of urban water use due to the fact that virtually 100 percent of the agricultural water is applied directly to the land surface. In contrast, much of the urban water supply is used indoors and then routed directly to a wastewater treatment facility.

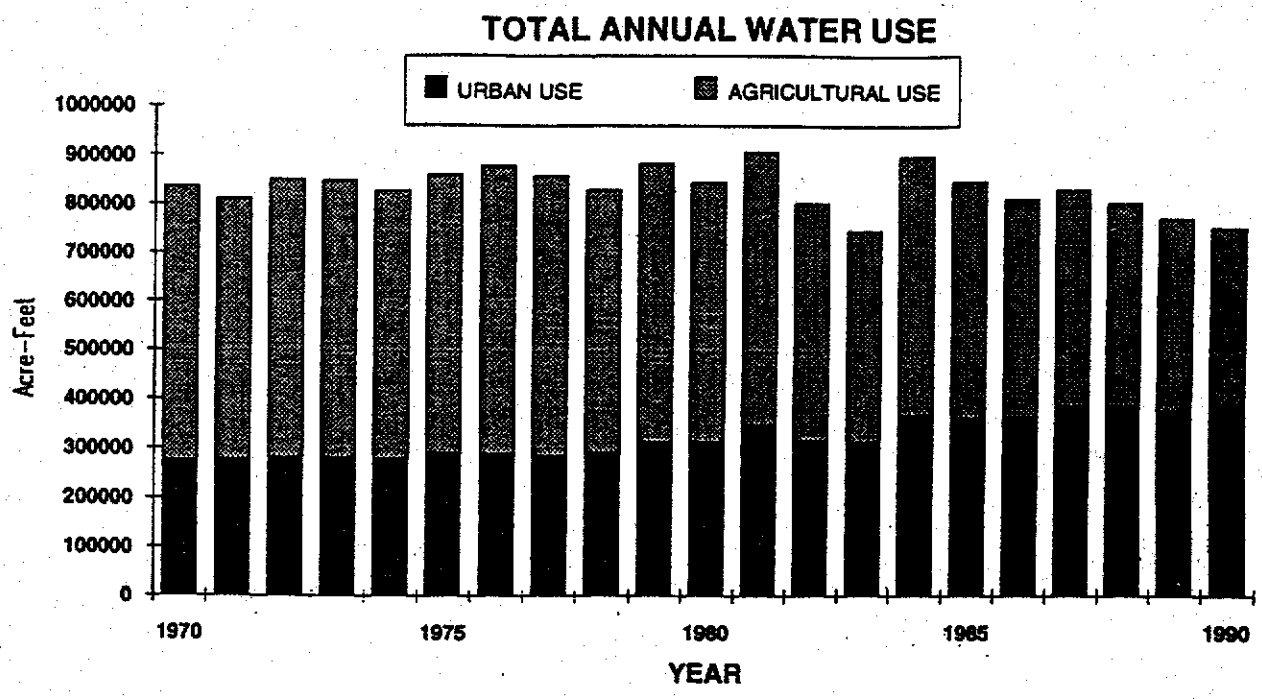
The historical urban and agricultural water use is specified on a monthly basis for each model subregion as discussed below.

Urban Water Use. Urban water use in the Sacramento County area is defined to include both municipal and industrial water use. As previously discussed, the source of urban water to the numerous water districts and agencies is from both surface water and groundwater. The model input data for urban water use incorporated both of these sources. The data was obtained from Sacramento County which has collected urban water use for most areas within the County over the past 15 years. In addition, individual water districts, such as the City of Galt and Rancho Murieta, were contacted separately to obtain water use data if it was not available from the County. In order to estimate the urban water use for the years prior to the initiation of Sacramento County's data collection program, the 1969 urban water uses reported in the DWR Bulletin 118-6 were utilized, and any missing years were estimated by using linear interpolation. It should be noted that the urban water use incorporated in the model not only includes water supplied by purveyors, but also water used by both the Aerojet Facility adjacent to Folsom and the Rancho Seco Nuclear Power Plant owned and operated by Sacramento County Municipal Utility District (SMUD).

The total urban water use for the model area is presented in Figure 4-8. In general, the urban water use has increased over the past twenty years which reflects the increased urban growth in the County. However, there are year to year variations in the general trend in which water use has decreased. These variations are attributed in large part to response to drought conditions during which water conservation measures have decreased the overall water use, such as in 1976-77 and 1987-90.

Agricultural Water Use. Agricultural water use data was not as readily available for the Sacramento County area as it was for urban water use. As discussed earlier, agricultural water supply for the Sacramento County area is from both groundwater and surface water diversions. However, with the exception of some surface water diversions, agricultural water supply is not measured or metered. Therefore, due to the lack of data, historical agricultural water use was estimated by the model IGSM based on historical crop acreage, soil moisture requirements, effective rainfall (that portion of total rainfall that becomes available for crop consumptive use), potential evapotranspiration, and irrigation efficiency.

The 1970-1990 estimated annual agricultural water use for the model area is presented in Figure 4-8. The annual agricultural water use fluctuates from year to year due to differences in the amounts and timing of rainfall over any given year, and also to changes



TOTAL ANNUAL WATER USE

FIGURE 4-8

in crop acreage from year to year. As evident from the figure, from 1984 to 1990 there has been a significant reduction in agricultural water use in the study area. This is attributed to the decrease in crop acreage between the 1984 DWR survey and the 1990 crop acreage estimates made by the DWR. It should be noted that these historical agricultural water demand estimates are based largely on the historical crop acreage obtained from DWR. However, as discussed earlier, the 1990 crop estimates have not been verified and it is possible that these estimates do not adequately represent the actual 1990 crop acreage. In turn, the 1990 agricultural water use estimates may also not accurately reflect the actual agricultural water use.

Water Supply

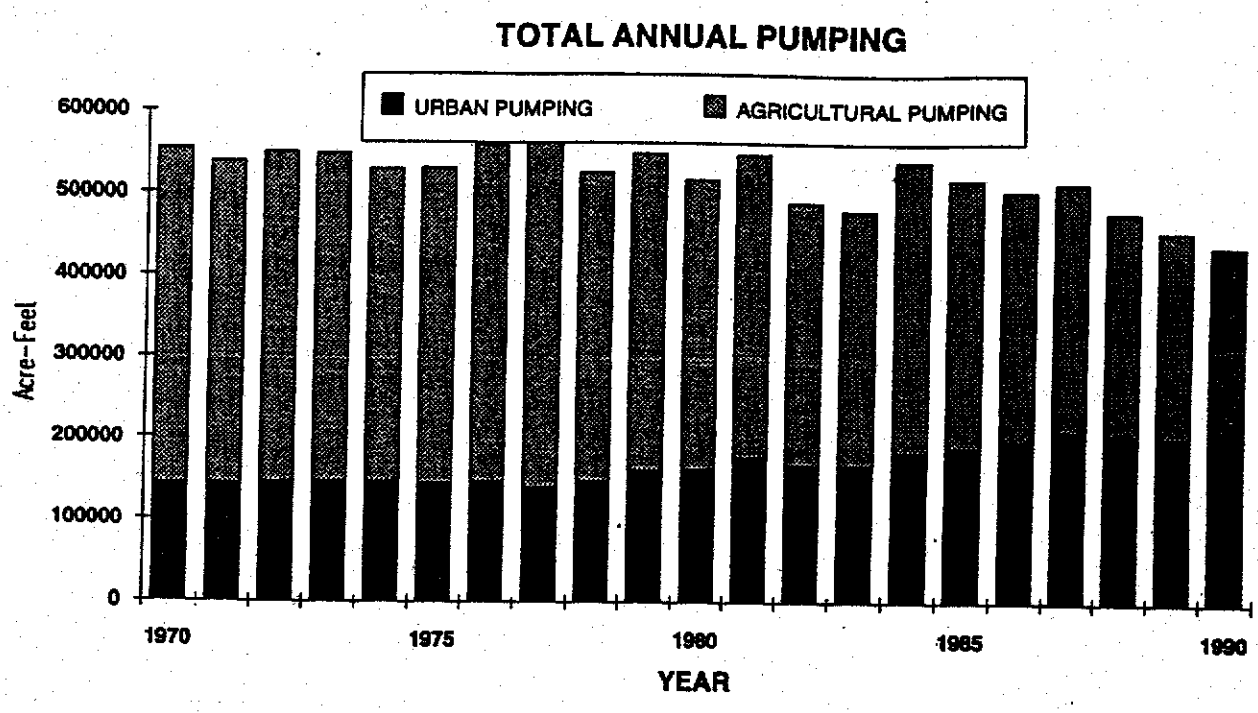
The water supply for the study area is from two sources: groundwater pumping and surface water diversions. Both of these sources may have a significant impact on the overall hydrologic conditions of the model area; groundwater pumping can have a direct impact on groundwater levels and overdraft whereas surface water diversions have a direct impact on streamflow. Each individual water district/agency may rely solely on either groundwater or surface water, or may be supplied from a combination. The source of water supply for each individual district is presented in Table 4-5. The following paragraphs discuss the input data incorporated in the model for both groundwater pumping and surface water diversions.

Groundwater Pumping. Monthly groundwater pumping for urban water use was specified for each municipal well within the study area. In general, urban water districts and agencies have maintained good records on historical pumping. Hence, as part of this study an extensive data collection effort was conducted and each individual urban water agency was contacted to obtain monthly groundwater pumpage by well. In the years where monthly pumping data was not available, the total monthly pumping for the particular district (as previously obtained by Sacramento County) was used to estimate the individual well pumpage.

In addition to urban groundwater pumping, agricultural groundwater pumping represents a significant portion of the total groundwater pumping in Sacramento County. Unfortunately, no historical records are available for the location or amount of agricultural pumping within the study area. Hence, as described earlier, the total agricultural demand was estimated by the model IGSM and that portion of the agricultural demand not satisfied by surface water was assumed to be supplied by groundwater. Using this procedure, agricultural pumping was estimated for each model subregion on a monthly basis and set as input data to the model.

Besides the lack of information on the amount of agricultural pumping, there is also a lack of information on the location of the pumping. Therefore, for modeling purposes, it was assumed that the agricultural pumping for any given model subregion was distributed evenly over the agricultural land in that subregion. This assumption was based on the fact that most agricultural pumping in the Sacramento County area occurs within the agricultural areas, and that there is minimal conveyance of pumped agricultural water from one area to another.

See Figure 4-9 for a summary of the total annual urban and agricultural pumping for the period 1970-1990.



TOTAL ANNUAL PUMPING

FIGURE 4-9

TABLE 4-5

SOURCE OF HISTORICAL WATER SUPPLY FOR MODEL SUBREGIONS

Model Subregion	Groundwater	Surface Water
1. North Sacramento	X	X
2. South Sacramento	X	X
3. Zone 40	X	
4. Southwest	X	
5. Galt ID	X	
6. City of Galt	X	
7. OFSCU	X	X
8. SMUD		X
9. Clay WD	X	X
10. Omochumne-Hartnell	X	X
11. Rancho Murieta		X
12. Sunrise "A"	X	
13. Sunrise "B"	X	
14. Citizens Utilities	X	
15. Folsom/Aerojet		X
16. Arden Cordova	X	X
17. Fair Oaks		X
18. Orangevale		X
19. San Juan		X
20. Carmichael	X	X
21. Citrus Heights		X
22. Northridge	X	
23. SCWMD	X	
24. McClellan AFB	X	
25. Arcade	X	X
26. Rio Linda	X	
27. Natomas	X	X
28. Metro Airport	X	X
29. Courtland		X
30. Foothills North	X	
31. Foothills South	X	

Surface Water Diversions

Many water districts within the model area rely on surface water to meet all or part of their agricultural or urban water demands. The primary source of surface supplies in the study area are the American River, Cosumnes River, Sacramento River, Folsom Reservoir, and Folsom South Canal (diversion from Lake Natomas on the American River below Folsom Reservoir). In contrast to groundwater pumping, surface water diversions are largely regulated by water rights, and hence, good data is typically available for amounts of historical diversions. Monthly surface water diversion data was collected for all primary diversions in the study area and incorporated into the model. The location of each diversion point was also specified in the model. This includes specific location along a river or from a source outside the model area such as Folsom Lake. Table 4-6 lists each surface water diversion incorporated in the model. The total annual surface water diversions for urban and agricultural use are presented in Figure 4-10.

Boundary Conditions

Three types of boundary conditions were used to specify groundwater conditions at the boundaries of the model area:

- No flow conditions
- Constant head conditions
- General head conditions

Each boundary condition is associated with a specific type of interface between the groundwater basin and the geologic and hydrologic conditions at its boundaries. No flow conditions were used at nodes at geologic boundaries along the eastern side of the model area (Sierra Nevada Foothills).

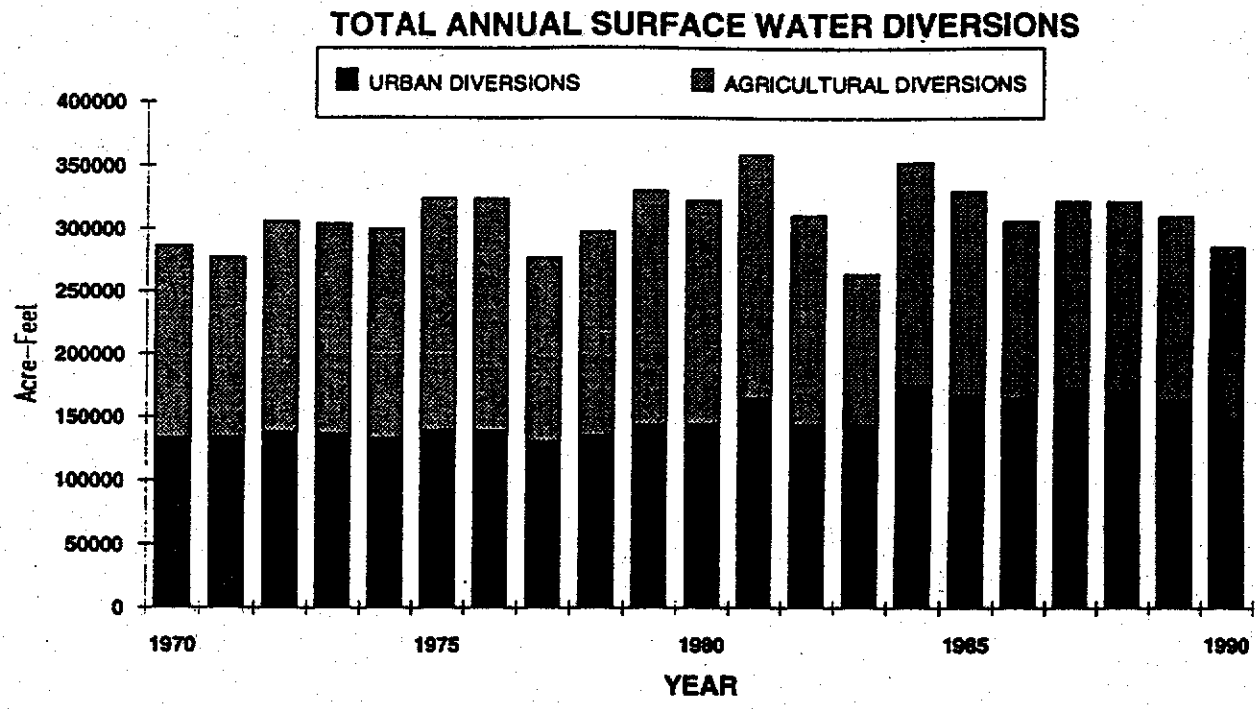
Constant head conditions were set for the lower Sacramento River (the upper aquifer only) where the streambed elevation is at or below sea-level. These conditions were incorporated to simulate the constant levels (sea level) that occur in this stretch of the river. Daily fluctuations due to tidal cycles are not accounted for in the model.

General head boundary conditions were utilized for the rest of the western boundary nodes and all of the northern and southern boundary nodes. In these areas, groundwater inflows and/or outflows may occur depending on the direction of the groundwater gradient at the model boundary. The model was linked with the regional Central Valley Ground- Surface Water Model (CVGSM) in order to provide information regarding historical water levels outside of the model boundaries.

Model Parameters

The primary parameters required for the model are:

Soil Parameters
- Hydraulic Conductivity
- Field Capacity
- Wilting Point
- Curve Number
- Root Zone Depth



TOTAL ANNUAL SURFACE WATER DIVERSIONS

FIGURE 4-10

TABLE 4-6

SURFACE WATER DIVERSIONS INCORPROATED IN THE MODEL IGSM

Diversion Source	Model Subregion	Data Source
Folsom South Canal	Omochumne-Hartnell	USBR
	Galt ID	USBR
	Clay WD	USBR
	SMUD	USBR
Folsom Lake	San Juan Suburban	Sacramento County
	Citrus Heights	Sacramento County
	Orangevale	Sacramento County
	Fair Oaks	Sacramento County
	Folsom / Aerojet	Sacramento County
American River	Carmichael	Sacramento County
	Arcade	Sacramento County
	City of Sacramento	City of Sacramento
Sacramento River	City of Sacramento	City of Sacramento
	Natomas	USBR
	Courtland	DWR, M-W estimates
Cosumnes River	Rancho Murieta	Rancho Murieta CSD
	Omochumne - Hartnell	DWR, M-W estimates
	Zone 40 (O-H area)	DWR, M-W estimates

Model Input Data

Aquifer Parameters
- Hydraulic Conductivity
- Specific Yield
- Specific Storage
- Leakance

Unsaturated Zone Parameters
- Hydraulic Conductivity
- Effective Porosity

Streambed Parameters
- Hydraulic Conductivity

The Curve Number is a function of vegetative cover and hydrologic soil group. It also incorporates the effects of land use including agricultural practices such as terracing and tillage.

The soil parameters were initially estimated based on County soil surveys by the Soil Conservation Service. The aquifer parameters wee derived from previous hydrogeologic investigations by the Department of Water Resources, US Geological Survey, and the City of Sacramento and Central Valley modeling studies previously completed by Montgomery - Watson. All of these parameters were later adjusted through calibration.

MODEL SIMULATION AND INITIAL CONDITIONS

The simulation period used in this study for model calibration is October 1969 to September 1990. The model calibration period was chosen based on data availability and that it contains successive dry years (1976-1977, 1987-1990), as well as successive wet years (1982-1983).

In order to determine starting water levels in October 1969, water level maps provided by Sacramento County were utilized to assign initial groundwater levels to each groundwater node. These values were later refined by running the model to obtain steady-state conditions for this initial time period. Water levels in the new initial conditions were checked against actual water levels measurements in calibration wells in order to verify the accuracy of the new initial conditions.

Section 5

SECTION 5

MODEL CALIBRATION

With the completion of the data collection and processing for the model input files, Part 2 of the model is run, and the calibration process begins. The intent of calibration is to compare model output such as hydrologic budgets, and streamflow and groundwater level variations with actual recorded values, and by adjustment of model parameters, seek to conform the simulated and recorded conditions. Model calibration results include historical soil moisture, groundwater, and stream flow budgets, as well as comparisons of historical groundwater levels with levels simulated by the model. These model results also provide insight to the key components of the groundwater basin including historical amounts of recharge and changes in groundwater storage. The model calibration period selected for the model is October 1969 to September 1990.

CALIBRATION PROCEDURE

Model calibration for the Sacramento County Model was performed in the following stages:

- Calibrate overall water budgets (inflows and outflows)
- Adjust aquifer properties to simulate groundwater levels

Water Budget Calibration

The first stage is intended to ensure that the model is accurately simulating the key components of the groundwater basin's hydrologic water balance. The water balance is nothing more than the requirement that the availability of groundwater over a period of time must conform to a mass balance. This concept simply states that inflow minus outflow to the basin is equal to the change in storage of the groundwater basin. The model IGSM tracks the movement of all of the primary sources of water coming into and leaving the basin, including rainfall, streamflows, applied water, consumptive use, and subsurface inflows and outflows. The model output that is reviewed during this phase of calibration includes annual and monthly water budgets for groundwater, streamflow, soil moisture, and land and water use for the entire modeled area and selected subregions. The key components for each of these budgets are listed below:

- Groundwater Budget
  - Deep Percolation
  - Stream Recharge
  - Boundary Inflows/Outflows
  - Pumping
  - Overdraft
- Streamflow Budget
  - Upstream Inflow
  - Direct Runoff from Rain
  - Gain from Groundwater
  - Diversions
  - Agricultural and Urban Return Flows
  - Downstream Flow
- Soil Moisture Budget
  - Rainfall
  - Irrigation
  - Evapotranspiration

Direct Runoff
Percolation
Return Flows

- Water Use Budget
  - Agricultural Water Use
  - Urban Water Use
  - Groundwater Pumping
  - Surface Water Diversions
  - Imports
  - Shortages

Some of the key model parameters adjusted during this phase include soil moisture parameters (field capacity, soil hydraulic conductivity, SCS curve numbers, and root zone depth); and streambed parameters (hydraulic conductivity, thickness).

Groundwater Level and Streamflow Calibration

The second stage of calibration involves comparison of simulated and measured groundwater levels. The initial water level calibration effort is focused on conforming on a regional scale, the model-generated groundwater level contours to those developed by the County of Sacramento for each spring and fall, and thereby ensuring that overall groundwater movement is accurate.

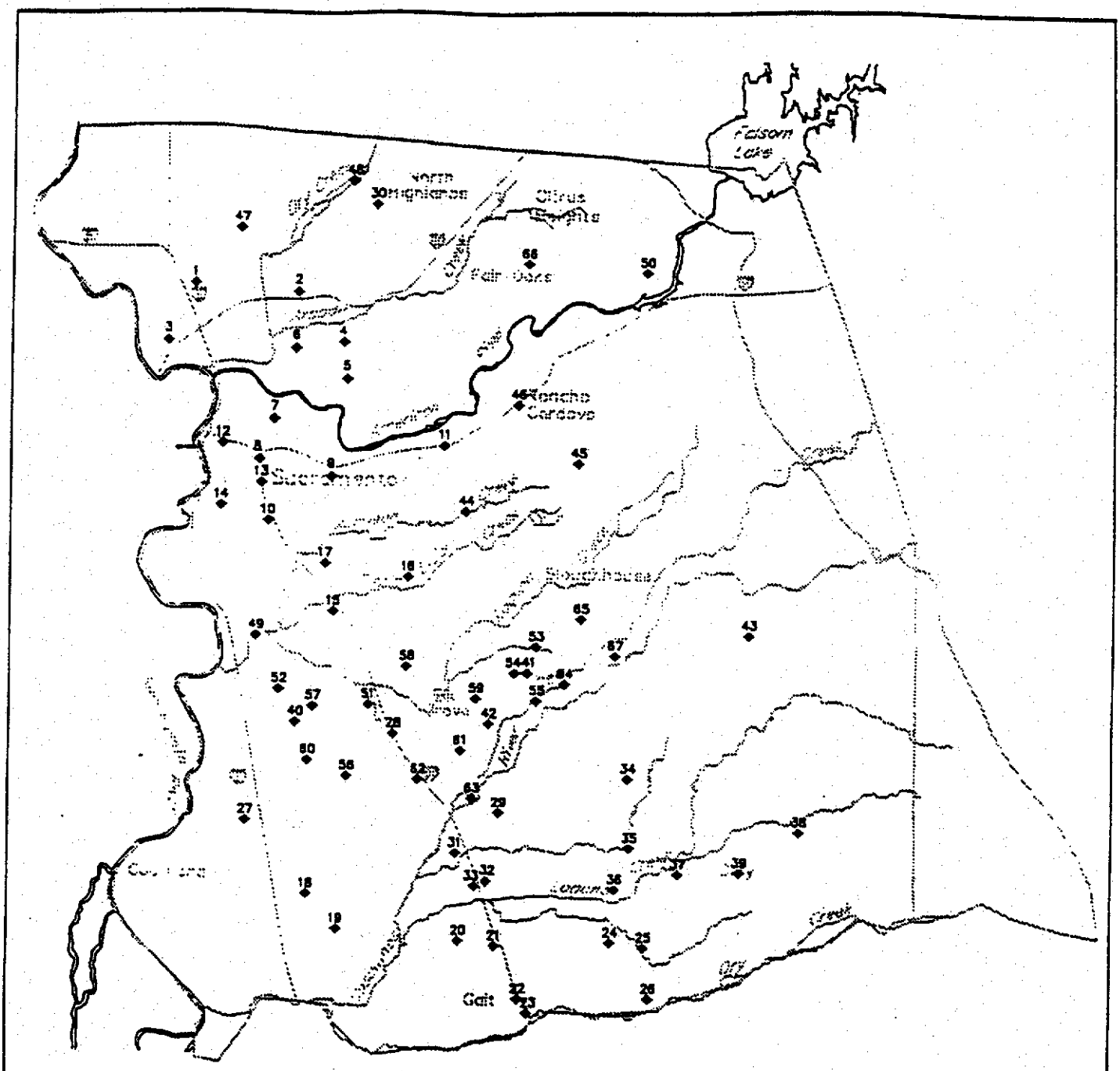
Once the model reasonably simulates the regional groundwater levels, the model results for groundwater levels are compared with historical groundwater level measurements at specific wells. Water level measurements were obtained from 67 wells within the study area so that the model-simulated water levels could be compared with the actual measurements at these wells. The location of these wells is presented in Figure 5-1. These wells were chosen as calibration wells based on the following criteria:

- **Well Locations**. In general, a wide geographic range in the location of the wells is desirable so that the model results can be compared with actual measurements throughout the study area.
- **Period of Record**. Many of the wells for which monitoring data is available have short periods of record or have been discontinued. For comparison purposes with model results, wells with long continuous periods of record are more useful as calibration wells.

During this phase of calibration, adjustments are made to model aquifer and confining layer parameters, including: hydraulic conductivity, specific storage, specific yield, leakance between aquifers, and aquifer boundary conditions. These model parameters were originally developed from previous studies and reports (USGS, Central Valley Ground - Surface Water Model, City of Sacramento Groundwater Management Plan, etc.) and refined as necessary during the calibration process. It should be noted that all refinements to aquifer parameters were done such that the parameter values were maintained within a reasonable range for aquifers within the study area.

MODEL CALIBRATION RESULTS

Model results for annual water budgets (soil moisture, groundwater, stream flow, water use) for the entire model area are presented in tabular form in Tables 5-1 to 5-3. The following presents a brief summary of the model results for these key water budgets.



LOCATION OF CALIBRATION WELLS

FIGURE 5-1

TABLE 5-1
MODEL CALIBRATION RESULTS - SOIL MOISTURE BUDGET

SOIL MOITURE BUDGET IN INCHES FOR ENTIRE MODEL AREA
TOTAL AREA: 562744. ACRES

	AGRICULTURAL AREA							MUNICIPAL AREA						UNDEVELOPED AREA			
TIME	RAIN	IRIG.	C.U.	ET	D.R.	RETURN	PERC.	RAIN	IRIG.	ET	D.R.	RETURN	PERC.	RAIN	ET	D.R.	PERC.
1970	18.2	34.6	24.5	32.9	7.6	4.1	8.6	16.8	28.1	16.8	11.3	11.0	5.6	18.8	14.6	3.5	0.7
1971	18.4	33.0	23.7	33.4	6.2	3.4	8.5	17.7	28.0	17.9	11.0	11.0	5.7	19.3	16.3	2.5	0.4
1972	11.0	35.3	24.8	32.7	1.8	4.5	7.1	11.5	28.2	17.3	6.1	11.2	5.0	12.0	11.1	0.3	0.2
1973	24.9	35.2	24.1	33.5	11.4	4.9	10.2	25.0	28.0	17.8	17.7	11.1	6.4	25.4	16.8	7.1	1.8
1974	19.9	34.1	23.3	33.7	7.0	4.8	8.6	21.9	27.6	18.0	14.4	11.0	6.0	21.4	17.4	3.5	0.6
1975	16.9	35.4	23.5	33.0	5.8	5.7	7.8	17.9	28.5	17.6	11.8	11.9	5.1	18.0	14.8	2.9	0.3
1976	7.6	36.8	26.2	32.4	0.9	4.6	6.5	8.2	28.0	16.5	3.8	11.6	4.4	7.8	7.5	0.0	0.0
1977	6.0	36.2	26.8	32.2	0.6	3.6	6.1	5.8	27.0	14.3	2.7	12.1	3.9	5.7	5.7	0.0	0.0
1978	25.1	34.5	23.7	33.4	11.9	5.2	9.0	26.4	27.0	17.3	19.3	11.2	5.6	26.5	17.5	7.5	1.6
1979	17.7	37.1	25.2	33.6	6.6	5.5	9.1	18.5	28.3	17.2	12.5	11.7	5.3	18.8	15.0	3.3	0.6
1980	22.9	35.0	23.6	33.8	9.3	5.1	9.8	24.7	27.8	18.0	17.1	11.6	5.7	24.2	17.2	5.8	1.2
1981	12.7	37.3	25.2	33.2	3.3	5.6	7.7	13.8	30.5	18.4	8.6	12.8	4.4	13.4	11.9	1.1	0.2
1982	31.5	33.0	22.1	34.5	14.0	5.1	10.7	35.0	27.0	19.4	24.9	11.1	6.5	33.7	20.9	9.7	2.1
1983	38.5	29.5	20.7	34.0	19.5	3.9	11.0	40.7	26.6	19.5	30.1	10.8	6.9	41.5	22.8	15.9	3.3
1984	18.6	37.0	26.0	34.5	7.3	4.5	9.1	17.7	30.6	18.7	11.4	12.9	5.1	20.1	16.1	3.7	0.7
1985	14.9	35.4	25.0	34.5	4.2	4.1	7.8	15.0	30.2	18.9	8.9	12.7	4.8	15.5	13.8	1.4	0.3
1986	30.4	34.1	23.8	34.2	15.2	4.4	10.7	29.3	29.2	19.1	21.4	12.1	5.9	31.5	18.2	11.5	1.5
1987	12.5	36.0	26.1	33.6	3.9	3.8	7.4	12.6	29.8	17.8	8.0	12.5	4.2	13.6	12.1	1.6	0.2
1988	14.8	35.7	25.5	34.2	3.6	3.8	8.6	14.2	28.8	18.1	8.1	12.5	4.2	15.0	13.7	1.0	0.2
1989	16.2	35.9	25.2	34.4	5.0	4.2	8.0	17.8	27.1	18.0	10.9	11.8	4.0	17.3	13.7	1.8	0.3
1990	13.8	35.0	24.3	34.4	3.3	4.6	7.4	15.1	27.2	18.0	8.7	11.9	3.9	14.3	15.0	0.6	0.2
AVERAGE	18.7	35.1	24.4	33.6	7.1	4.5	8.6	19.3	28.3	17.8	12.8	11.7	5.2	19.7	14.9	4.0	0.8

TABLE 5-2
MODEL CALIBRATION RESULTS - STREAMFLOW BUDGET

STREAMFLOW BUDGET IN AC.-FT. FOR ENTIRE MODEL AREA
TOTAL AREA: 562744. ACRES

TIME	UPSTREAM FLOW (+)	TRIB. FLOW (+)	D.R. FROM RAIN (+)	AG/URBAN SW RETURN (+)	GAIN FROM GW (+)	SW DIVERSION (-)	BY-PASS FLOW (+)	ERROR ADJUST. (+)	DOWNSTRM FLOW (=)	DIVERSION SHORT
1970	20421166.	26328.	279393.	162975.	-222798.	207561.	0.	0.	20459500.	0.
1971	23628840.	14028.	240113.	154036.	-213484.	196400.	0.	0.	23627130.	0.
1972	13387651.	2992.	90046.	174741.	-179449.	222209.	0.	0.	13253773.	0.
1973	20594686.	40175.	464733.	178940.	-223299.	220928.	0.	0.	20834304.	0.
1974	30323314.	34451.	306829.	176489.	-235587.	215669.	0.	0.	30389826.	0.
1975	20303150.	22784.	252394.	190345.	-205620.	233858.	0.	0.	20329198.	0.
1976	11174696.	0.	49848.	176335.	-145021.	222137.	0.	0.	11033721.	0.
1977	6302831.	0.	35914.	149559.	-111849.	187859.	0.	0.	6188596.	12.
1978	17805764.	54964.	504354.	178336.	-251313.	212204.	0.	0.	18079902.	0.
1979	13180127.	20937.	284416.	191139.	-211137.	233015.	0.	0.	13232469.	0.
1980	19592270.	37630.	417677.	187148.	-243955.	231371.	0.	0.	19759402.	0.
1981	12619663.	11419.	159924.	207240.	-176027.	242907.	0.	0.	12579311.	0.
1982	22064760.	60359.	645699.	185844.	-284239.	215779.	0.	0.	22456640.	0.
1983	33114338.	85195.	885421.	166697.	-290868.	176752.	0.	0.	33784028.	0.
1984	26317548.	15702.	295058.	192440.	-212695.	242105.	0.	0.	26365946.	0.
1985	12821586.	7797.	180550.	186471.	-194821.	219908.	0.	0.	12781676.	0.
1986	17854468.	53330.	654281.	187576.	-242177.	207796.	0.	0.	18299684.	0.
1987	7295045.	11712.	172539.	191878.	-165015.	215644.	0.	0.	7290515.	49.
1988	9903149.	1.	165026.	191174.	-169284.	215231.	0.	0.	9874835.	0.
1989	10391103.	19514.	231814.	179551.	-191558.	209363.	0.	0.	10421061.	24.
1990	10441111.	2856.	164660.	194729.	-185124.	213142.	0.	0.	10405091.	0.
AVERAGE	17120822.	24865.	308604.	181126.	-207396.	216278.	0.	0.	17211744.	4.

TABLE 5-3
MODEL CALIBRATION RESULTS - GROUNDWATER BUDGET

GROUND WATER BUDGET IN AC.-FT. FOR ENTIRE MODEL AREA
TOTAL AREA: 562744. ACRES

TIME	DEEP PERC.	NET DEEP PERC. (+)	GAIN FROM STREAM (+)	RECHARGE (+)	OTHER INFLOW (+)	BOUNDARY INFLOW (+)	SUBSURF. INFLOW (+)	PUMPING (-)	CHANGE IN STORAGE (=)	END STORAGE 1000 AF
1970	208492.	185047.	222798.	0.	0.	137942.	0.	564867.	-19079.	48758.4
1971	201695.	203022.	213484.	0.	0.	125995.	0.	548330.	-5829.	48752.6
1972	168025.	165570.	179449.	0.	0.	117330.	0.	564057.	-101708.	48651.0
1973	266867.	250334.	223299.	0.	0.	117842.	0.	562854.	28620.	48679.7
1974	213056.	223418.	235587.	0.	0.	121679.	0.	544239.	36444.	48716.3
1975	182655.	186853.	205620.	0.	0.	114308.	0.	548269.	-41487.	48674.9
1976	151535.	149381.	145021.	0.	0.	109485.	0.	574510.	-170622.	48504.3
1977	138672.	133989.	111849.	0.	0.	102763.	0.	585595.	-236995.	48267.4
1978	233811.	217738.	251313.	0.	0.	107820.	0.	538705.	38166.	48305.6
1979	211165.	211585.	211137.	0.	0.	112683.	0.	565412.	-30007.	48275.6
1980	237724.	236460.	243955.	0.	0.	114454.	0.	533549.	61321.	48337.1
1981	169667.	179075.	176027.	0.	0.	113604.	0.	564455.	-95749.	48241.4
1982	276305.	265860.	284239.	0.	0.	115129.	0.	503432.	161795.	48403.3
1983	308431.	311617.	290868.	0.	0.	121963.	0.	485166.	239281.	48642.7
1984	206018.	223559.	212695.	0.	0.	119694.	0.	554302.	1647.	48644.5
1985	169051.	177013.	194821.	0.	0.	109583.	0.	528617.	-47200.	48597.3
1986	244652.	235487.	242177.	0.	0.	105478.	0.	512172.	70969.	48668.4
1987	149850.	160895.	165015.	0.	0.	101759.	0.	524528.	-96859.	48571.6
1988	162100.	163736.	169284.	0.	0.	95006.	0.	491106.	-63080.	48508.6
1989	149369.	150031.	191558.	0.	0.	92939.	0.	467971.	-33443.	48475.2
1990	137774.	145727.	185124.	0.	0.	91314.	0.	451569.	-29404.	48445.8
AVERAGE	199377.	198876.	207396.	0.	0.	111846.	0.	533986.	-15868.	48445.8

Model Calibration

Soil Moisture Budget

The model IGSM incorporates a sophisticated accounting program to track all of the hydrologic processes within the soil zone. The modeling results for soil moisture are a key component to the overall model in that the amounts of surface water runoff, evapotranspiration, and groundwater recharge through deep percolation are directly impacted by the hydrologic processes that occur in the soil zone. The primary components of the soil moisture budget for agricultural, urban and undeveloped areas, as simulated by IGSM, are described below:

Rain:	Precipitation over each land use type
Irrigation:	Irrigation applied water for agricultural or urban purposes
CU:	Amount of irrigation applied water consumptively used to satisfy ET or soil moisture deficiencies
ET:	Actual evapotranspiration for each land use type
DR:	Direct runoff due to rainfall
Return:	Surface water return flow from agriculture and urban water use (such as tailwater, field runoff, etc.)
Perc:	Percolation from the soil zone to the unsaturated zone as a result of rainfall and applied water.

The two primary sources of water to the soil zone in agricultural and urban areas are rainfall and applied water. In undeveloped areas, the sole source of water is rainfall. As indicated by the model results, urban areas have the highest amount of direct runoff over a given area (12.8 inches) primarily due to the impervious areas (i.e. paved streets and parking lots, buildings) that are associated with the urban areas. Agricultural areas, however, have the largest relative amount of percolation (8.6 inches) due largely to the approximately three feet (35.1 inches) of irrigation water that is applied to the soils in addition to the natural rainfall. In comparison, the amount of percolation from undeveloped areas is relatively small (0.8 inches). This small amount of deep percolation is attributed both to the clay and silt soils within the County area which are more conducive to runoff than infiltration; and the relatively high evapotranspiration rates that utilizes most of the rainfall that eventually percolate into the soil.

Streamflow Budget

The streams and rivers that flow through the Sacramento County area provide a source of water for urban and agricultural use (through stream flow diversions) and also are a key source of recharge to the groundwater basin. The model IGSM simulates all of the major components that affect flow in rivers. This includes rivers that originate both outside the study area (i.e. Sacramento River) as well as smaller streams that originate within the study area (i.e. Morrison Creek). The components of the stream flow budgets, as incorporated in IGSM, are summarized below:

Upstream flow:	Amount of surface water flow entering the model area from rivers, creeks and smaller tributaries.
D.R. from Rain:	Direct runoff from the land surface that enters the stream system as a result of rainfall

Ag/Urban SW Return:	Agricultural and urban surface water return flows entering the stream system
Gain/Loss from Groundwater:	Gains or losses of the stream system to the groundwater system (i.e. seepage of river flows through the streambed into the aquifer system)
SW Diversions:	Surface water diversions which remove water from the stream system
Downstream Flow:	Amount of surface water flow leaving the model area (i.e. Sacramento River flow to the Delta)

The largest component of the stream flow budget for the Sacramento County area is the volume of water that enters the study area through the Sacramento River, American River, and Cosumnes River. Within the model area, the model results indicate that stream flows are augmented both by direct runoff from rainfall (annual average 309,000 acre-feet per year) and return flows from applied water (annual average 181,000 acre-feet per year). It should be noted that the return flows include both return flows from irrigation as well as return flows from waste water discharges to Sacramento River from the Sacramento Regional Wastewater Treatment Facility (which serves a significant portion of the urbanized areas within the County).

Surface water diversions and river seepage to the groundwater system are the two primary sources of stream flow depletion in the study area. The average annual seepage loss to groundwater is estimated by the model to be approximately 207,00 acre-feet per year, most of which originates from the Sacramento, American and Cosumnes Rivers (see Groundwater Budget Results for further discussion). The average annual surface water diversions for the study period is 216,000 acre-feet which also occur entirely from the Sacramento, American and Cosumnes Rivers. Additional surface water is supplied to the study area from Folsom Reservoir, however, the reservoir is upstream of the groundwater basin and hence, these diversions are not shown in the total stream flow diversions.

Groundwater Budget

The model IGSM incorporates all of the key hydrologic processes that impact the groundwater system in the study area including recharge from percolation and stream seepage, groundwater pumping, and boundary inflows/outflows. The model simulation of these components of the groundwater budget is vital to the overall simulation of groundwater levels throughout the study area. The primary components of the groundwater budget, as simulated by the IGSM, are described below:

Deep Perc:	Amount of water percolating through the soil zone and entering the unsaturated zone.
Net Deep Perc:	Amount of water percolating through the unsaturated zone and entering the aquifer system.

Gain from Stream: Amount of water lost from rivers/streams that enters the aquifer system.

Boundary Inflow: Amount of groundwater that enters the model area from surrounding areas primarily north, west and south of the model area.

Change in Storage: Amount of change in groundwater storage. An increase in storage implies that pumping is less than the total recharge to the basin and groundwater levels have risen.

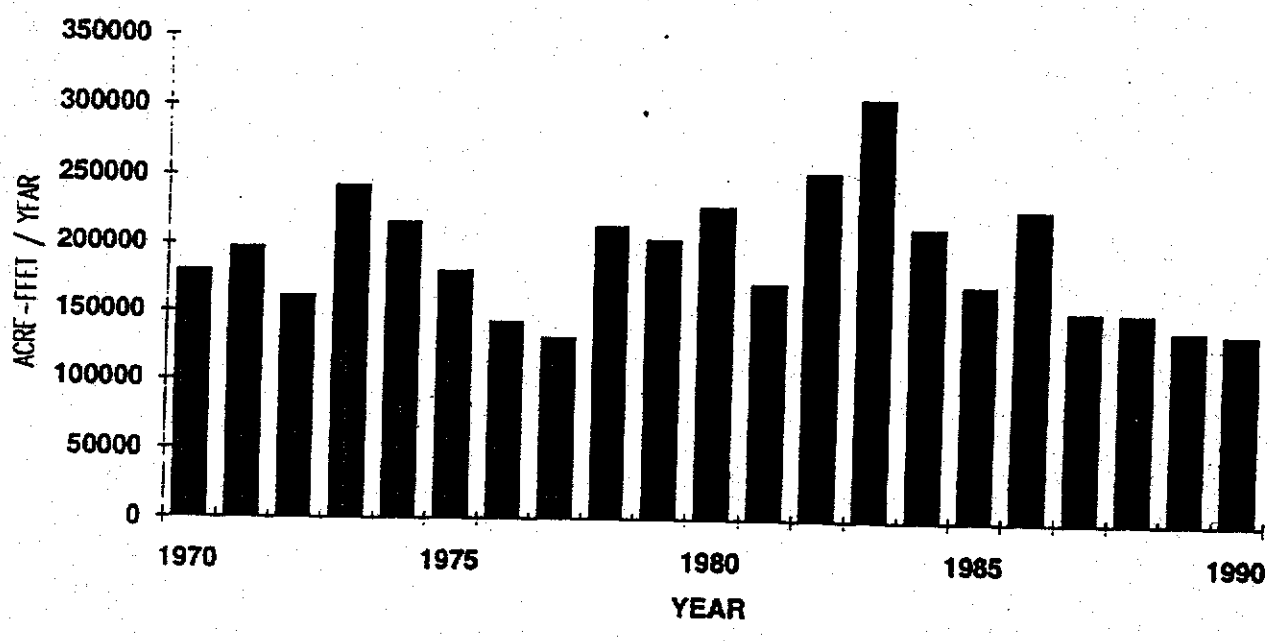
End Storage: Total groundwater storage within all aquifers within the study area.

As indicated by model results, the three primary sources of aquifer recharge within the study area are deep percolation, stream/river seepage, and subsurface boundary inflows. The 1970 - 1990 average annual recharge from deep percolation is estimated to be approximately 198,000 acre-feet. As discussed previously, a significant source of the groundwater percolation in the study area is from percolation of applied water in agricultural and urban areas. However, as indicated in Figure 5-2, the annual amounts of percolation vary significantly from year to year. During wet years up to 300,000 acre-feet of percolation has occurred (1982-83) and in dry years as little as 130,000 acre-feet of recharge has occurred (1976-77, 1987-90). These results indicate that the amount of rainfall occurring within the study area does have a significant impact on the groundwater recharge from deep percolation.

The model estimate for the average annual groundwater recharge from the rivers and streams is approximately 207,000 acre-feet. As previously discussed, the Sacramento River, American River and Cosumnes River are the primary sources of this recharge, however, smaller streams and creeks also contribute to the groundwater system. Model results for the annual stream recharge within the study area are presented in Figure 5-3. These results indicate that the amount of recharge from streams is highly dependent on the amount of stream flow occurring within a given year. During the extreme drought years of 1976-77 the gain from streams was reduced to approximately 111,000 acre-feet. However, during wet years, the gain from streams exceeded 280,000 acre-feet.

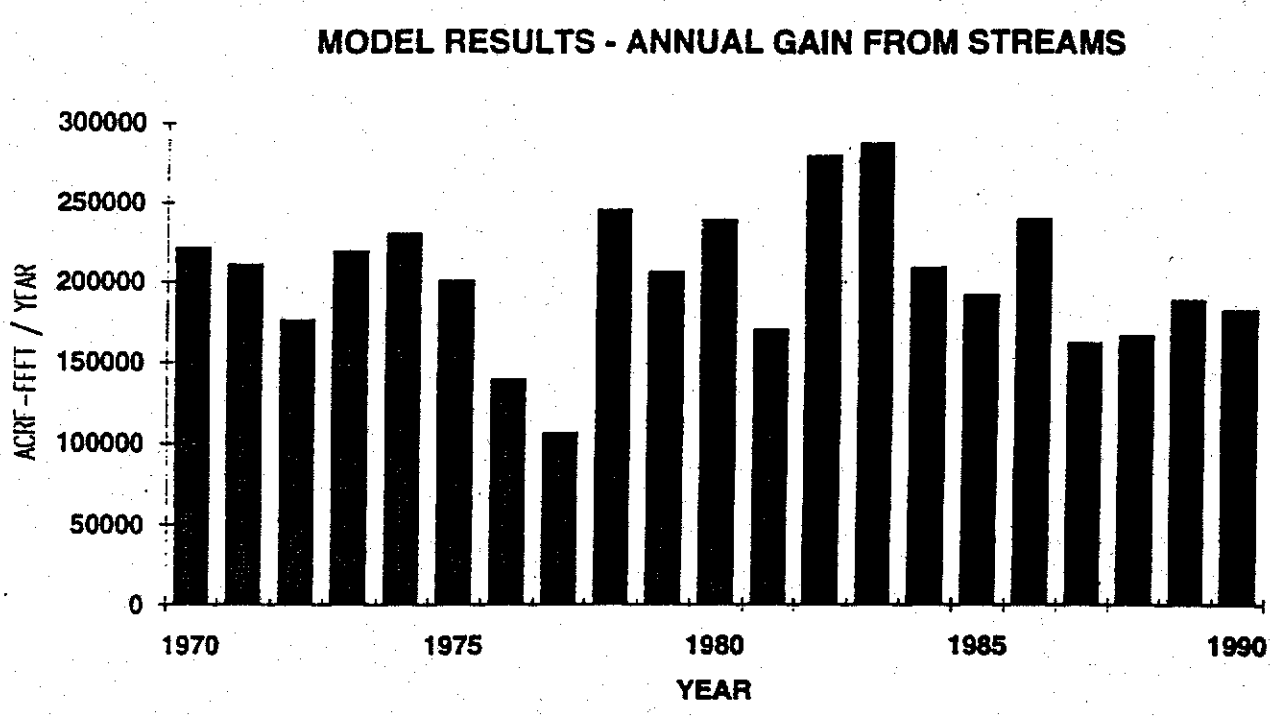
It should be noted that groundwater recharge through rivers and streams is simulated in two ways by the IGSM. If the river is in direct contact with the groundwater system (i.e. Sacramento River, American River and upper Cosumnes River, which flow year-round), the groundwater recharge is in part a function of the gradient between the groundwater levels and the water levels in the river. Hence, a steeper gradient (due to lower groundwater levels) will induce more recharge from the river system. However, in the case where the groundwater system is not in contact with a stream (i.e. the numerous smaller creeks in the study area and the lower Cosumnes River which often goes dry in the summer months), the amount of stream recharge is primarily a function of the streambed properties (hydraulic conductivity and thickness) and is not a function of groundwater levels.

It should also be noted that the stream recharge values described above do not include the recharge from the lower Sacramento River. This is due to the fact that the streambed elevation of the lower Sacramento River is below sea-level, and hence, for modeling purposes, it is assumed that a fixed or "constant head" condition exists along this section of the River (which is coincident with the southwestern boundary of the model). Therefore, this lower stretch of the Sacramento River is treated, for modeling purposes, as a boundary condition and model results for inflows from this source are also reported as "boundary inflows".



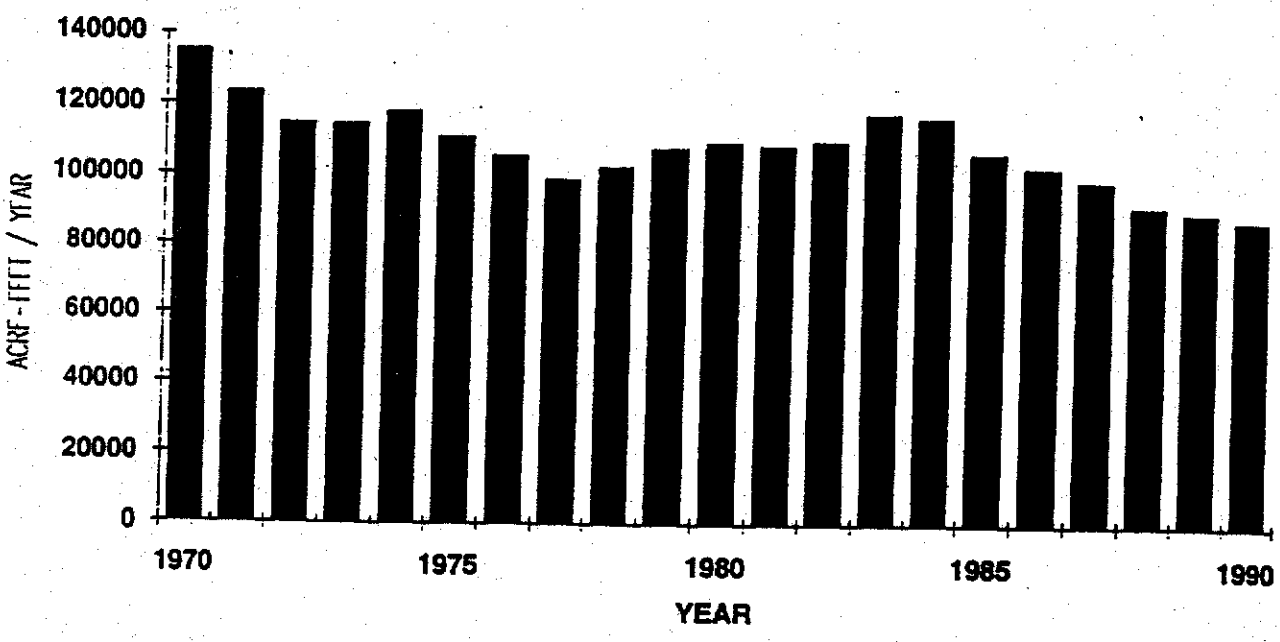
MODEL RESULTS - ANNUAL NET DEEP PERCOLATION

FIGURE 5-2



MODEL RESULTS - ANNUAL GAIN FROM STREAMS

FIGURE 5-3



MODEL RESULTS - ANNUAL SUBSURFACE BOUNDARY INFLOW

FIGURE 5-4

Model Calibration

Subsurface boundary inflows for the model consist of two components: (1) groundwater inflows associated with baseflows and stream percolation of small watersheds that originate in the Sierra Nevada foothills; (2) subsurface groundwater inflows from the groundwater basins to the north. west and south of the study area and (3); a portion of the lower Sacramento River seepage losses to the groundwater system as described above. As discussed earlier, the groundwater basin in Sacramento County is part of a regional aquifer system that encompasses the entire California Central Valley. As such, groundwater inflows (or outflows) may be induced to occur based on the groundwater gradients occurring across the study area's boundaries. In order to simulate this groundwater movement, the model was linked with the Central Valley Ground- Surface Water Model which provided simulated historical water levels just outside of the model area. With this method the model estimate for the average annual subsurface inflows to the study area is approximately 111,000 acre-feet. As shown in Figure 5-4, the annual subsurface inflows to the study area have decreased in the years from 1970 to 1977 and have remained relatively constant from 1977 to 1990.

Model results for the annual change in ground water storage as well as the total annual groundwater storage are presented in Figures 5-5 and 5-6. As indicated by these figures the annual change in groundwater storage is largely influenced by the wetness of the year. During the drought years of 1976-77 · pumping exceeded the groundwater basin's replenishment by up to 240,000 acre-feet per year. However, during the wet years of 1982-83, the groundwater recharge exceeded the pumping by up to 240,000 acre-feet. The model results for average annual change in storage for 1970-1990 is a net decrease of approximately 16,000 acre-feet per year.

Simulated Groundwater Levels

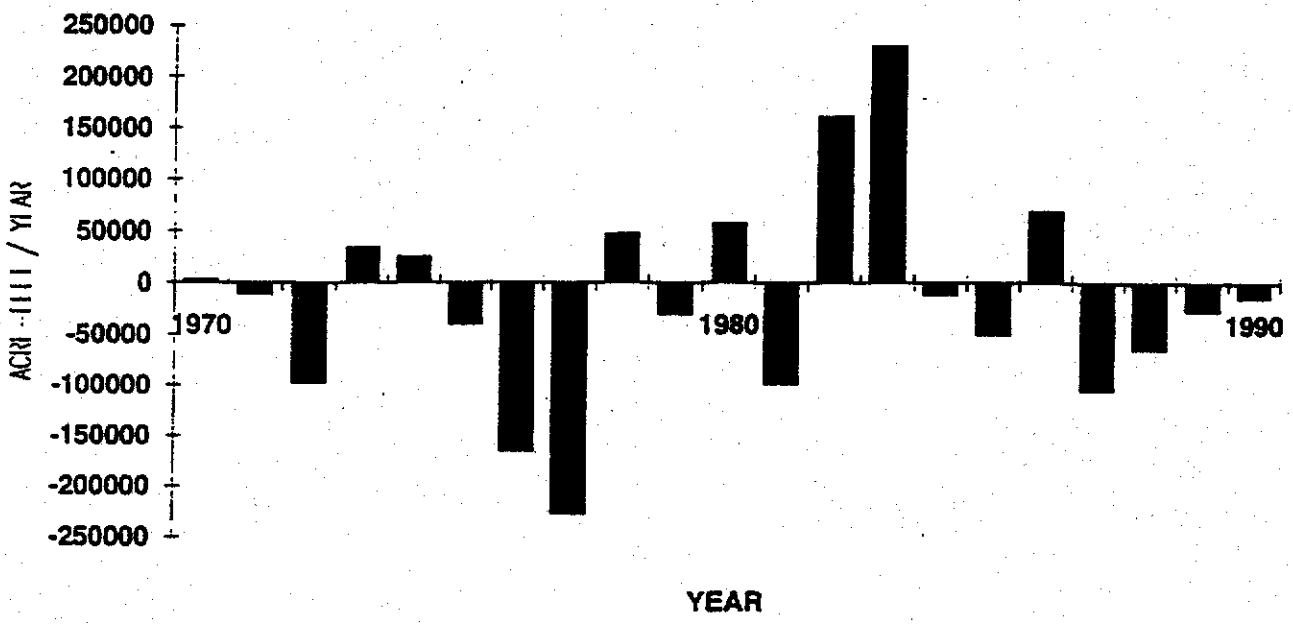
A comparison of simulated and measured groundwater levels at all calibration wells is presented in Appendix B. Overall, the simulated water levels were found to be in good agreement with measured water levels. Figure 5-7 summarizes the overall accuracy of the model. Approximately 90% of the model simulated values are within 10 feet of the actual measurements and 70% of the simulated measurements are within five feet of the actual measurements.

Discrepancies between historical and simulated groundwater levels may be attributed to one of the following types of error: modeling, input data, and measurement, as described below.

- **Modeling Error.** The simulation model represents physical processes by a series of mathematical formulas. Due to the random nature of physical processes, a precise mathematical representation is never possible without introducing certain assumptions. For example, the grid size used in the model average 0.6 square miles, and the time step used is one month. Consequently, it should be expected that the model predicts hydrologic consequences on a macro scale by replicating regional and historical trends. Certain discrepancies should be expected on a local scale.

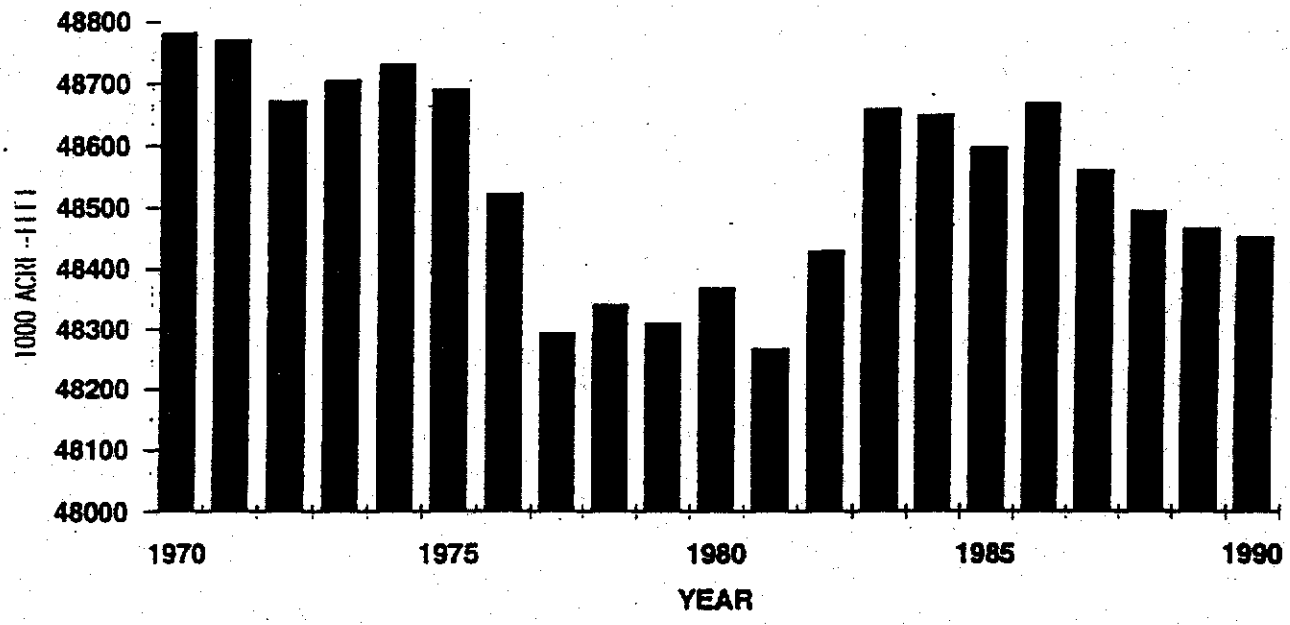
- **Input Data Error.** Input data used in the model represents the best information available at this time. Where data was not available, it was estimated based on engineering judgment or inferred from other sources. one critical set of input data affecting the response of groundwater levels in the study area is agricultural pumping. As discussed previously, this data was estimated. Many of the discrepancies between measured and simulated levels occurs during the pumping periods.

- **Measurement Error**. It is probable that some observed water levels are influenced by pumping and do not represent regional water conditions, or may actually be in error.



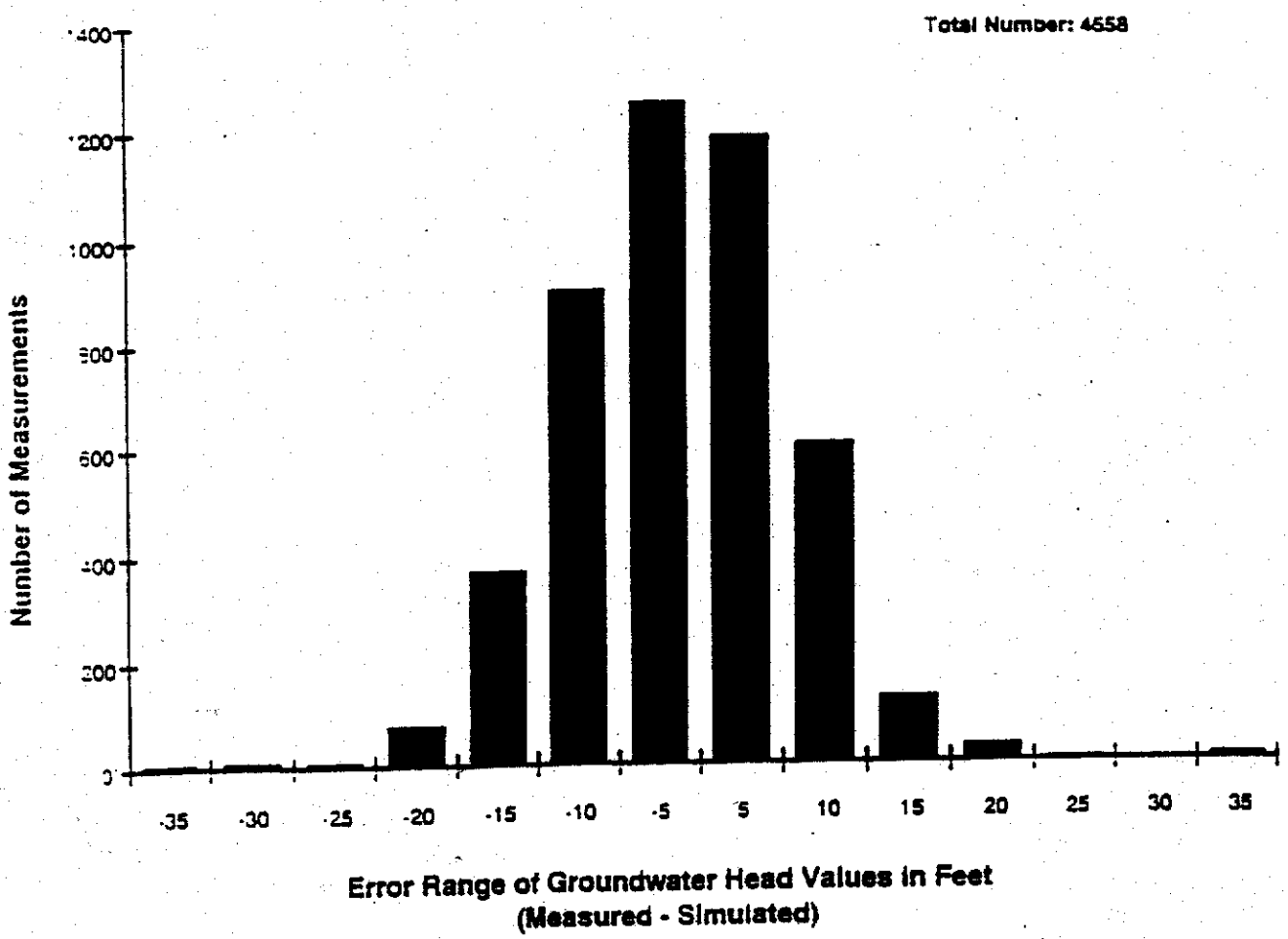
MODEL RESULTS - ANNUAL CHANGE IN STORAGE

FIGURE 5-5



MODEL RESULTS - ANNUAL GROUNDWATER STORAGE

FIGURE 5-6



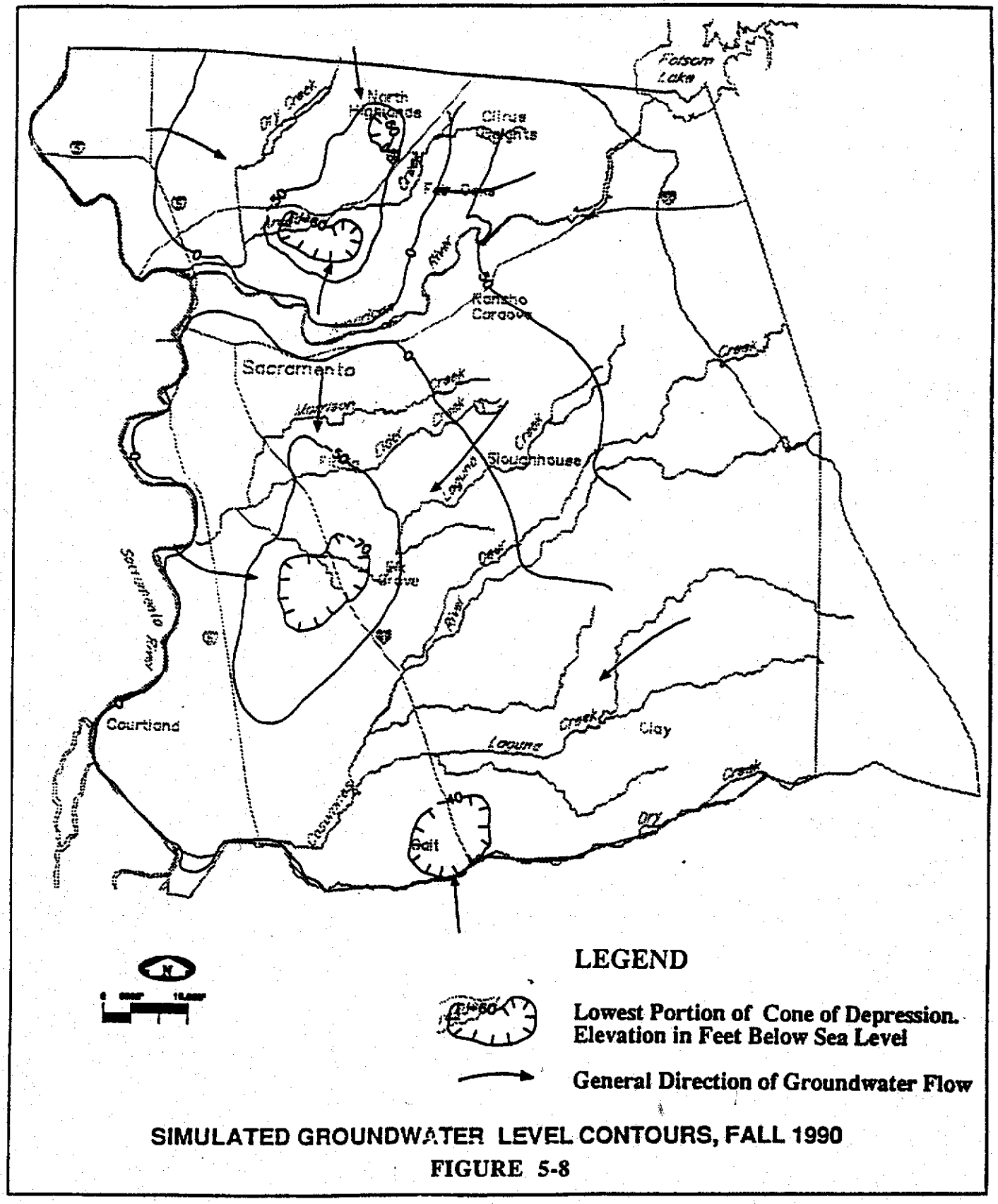
SACRAMENTO COUNTY GROUNDWATER MODEL,ACCURACY OF RESULTS

FIGURE 5-7

As an example of simulated groundwater level contours in the County, see Figure 5-8. As indicated by the figure, the model results closely match the regional groundwater elevation maps prepared by the County.

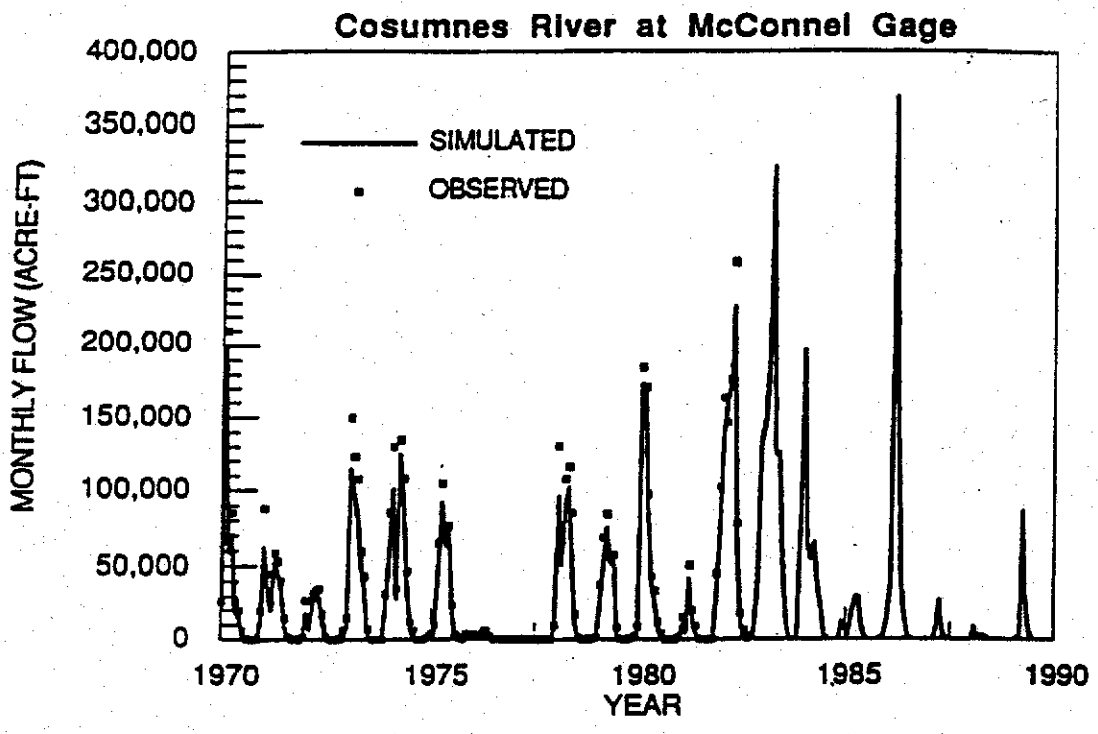
Simulated Streamflow

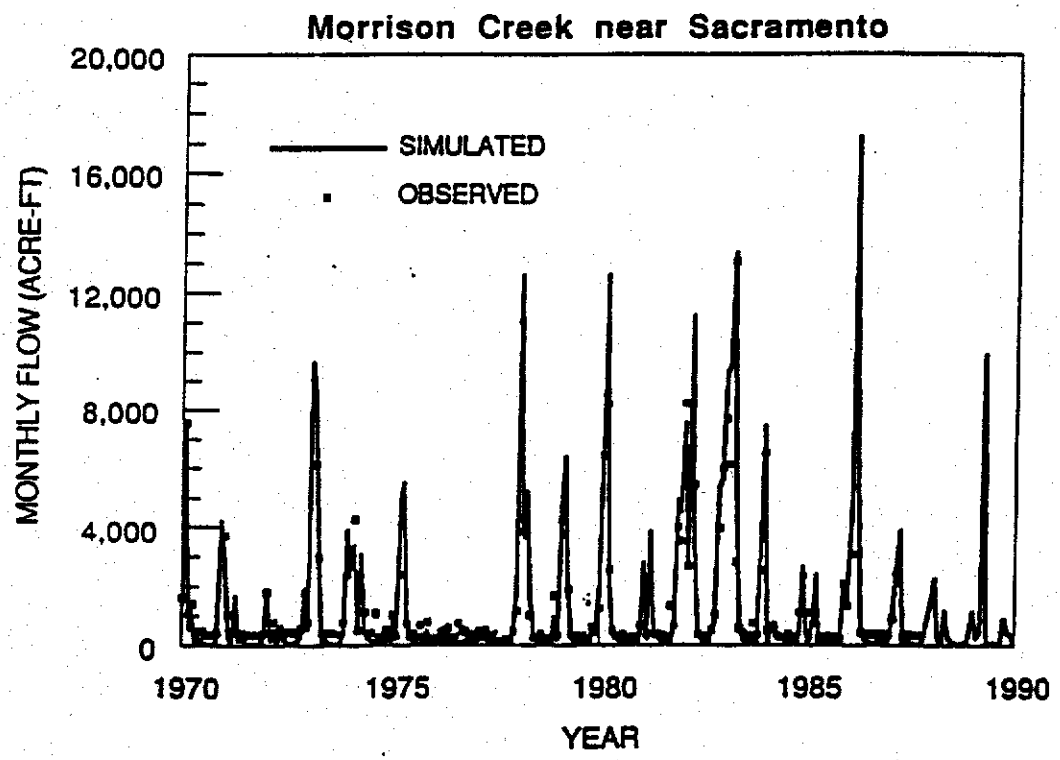
In order to ensure that the model was accurately simulating stream flows as well as groundwater levels, simulated streamflow values were compared with measured values for stream gage locations where data was available from the USGS. The two stream gages utilized for this comparison were the Cosumnes River near Highway 99 and Morrison Creek near Sacramento, as shown in Figure 5-9. In general, simulated streamflows were in good agreement with the measured values.



SIMULATED GROUNDWATER LEVEL CONTOURS, FALL 1990

FIGURE 5-8





STREAMFLOW CALIBRATION RESULTS

FIGURE 5-9

Section 6

SECTION 6

GROUNDWATER QUALITY

Although an adequate quantity of groundwater may be available, its use for potable urban purposes may be limited by its quality. Such quality may depend on mineralization of the water as it migrates through the ground or it may result from activities such as fertilizer and pesticide application onto agricultural lands; storm drainage from urbanized areas; or wastewater and industrial pollution. It was the intent in this modeling work to collected available quality data that is pertinent to making an assessment of potability and to establish the general relationship, if any, between selected quality parameters and the amount of pumping.

BACKGROUND

The quality of Sacramento County groundwater above the base of the fresh water is suitable for all beneficial uses. Fresh groundwater is defined as water which has a specific conductance of less than 3000 umhos/cm, or approximately 2000 mg/l of dissolved solids (Berkestresser 1973). The depth of the base of fresh water in the eastern part of the County approximates 800 feet below mean sea level, and in the western part of the County, it exceeds 1800 feet below mean sea level. The groundwater is derived mainly from recharge of streams draining the crystalline and metamorphic rock areas to the east and typically comprises of calcium, magnesium and calcium-sodium bicarbonate water types. Underlying the base of fresh water is poor quality sodium sulfate water, occurring mostly in the Valley Springs and Ione Formations.

Sacramento County groundwater generally meets all Title 22 drinking water quality standards, except for iron and manganese which have exceeded the secondary drinking water quality standards at several locations. High concentrations of iron and manganese do not pose a health hazard, but constitute an aesthetic concern. Concerns have also been raised recently over elevated levels of radon and arsenic in County groundwaters. Radon is presently not regulated, however, the US Environmental Protection Agency (USEPA) is currently reviewing standards for radon and is expected to set a primary maximum contaminant limit (MCL) of 300 pCi/l. Arsenic, on the other hand, a regulated parameter with a MCL of 50 µg/l, is being reevaluated by the USEPA because of recent information linking arsenic ingestion to liver, lung, kidney, and bladder cancers.

Groundwater quality was examined primarily to identify areas where the quality is poor or degraded, with the purpose of determining the extent to which it would affect basin yield. Constituents of concern occurring naturally such as iron, manganese, arsenic, radon and total dissolved solids in M&I wells and pollutants from industrial and agricultural activities at major sites in the County where groundwater is contaminated were reviewed and analyzed. The data were obtained from the County of Sacramento, the Sacramento Area Water Works Association (SAWWA) Well Testing Committee, the City of Sacramento and other purveyors in the County, as well as the Central Valley Regional Water Quality Control Board (CVRWQCB).

DRINKING WATER QUALITY PROBLEM AREAS

Iron, manganese, TDS, arsenic and radon data from M&I wells in Sacramento County were compiled in electronic spreadsheets, which are tabulated in Appendix A. The spreadsheets also contain information on well inside diameter, agency and subarea in which each well is located, well depth and the layer(s) in which each well was perforated. The agencies are the water purveyors in the County and subareas correspond to those used in the groundwater model. The five layer types assigned refer to the aquifer (s) in which the wells were perforated. Layer 1 wells are perforated in the shallow aquifer above the blue clay and perforations in layer 1(B) wells extend from the shallow aquifer into the blue clay. Layer 2 wells are perforated only in the deep aquifer. Layer 3 wells are perforated in both the shallow and deep aquifers. Wells whose depths and construction

detail were not known were assigned Layer 4.

Each spreadsheet was sorted by subareas, layers and agencies. Most M&I wells in the County are perforated only in the shallow aquifer or in both the shallow and deep aquifers. Very few wells are perforated in only the deep aquifer. Because Layer 2 wells were too few to constitute a representative sample for defining the quality of the deep aquifer basinwide, it was inferred from a combination of Layer 2 and Layer 3 wells, which from hereon are referred as "deep" wells. Combining Layer 2 and 3 wells however ignores the affects of water co-mingling from multiple perforations across the aquifers. Thus, it should be noted that the samples representing the deep aquifer (Layer 2 and 3 wells) and the shallow aquifer (Layer 1 and 1(b) wells) are not strictly independent, introducing a bias in the analysis below.

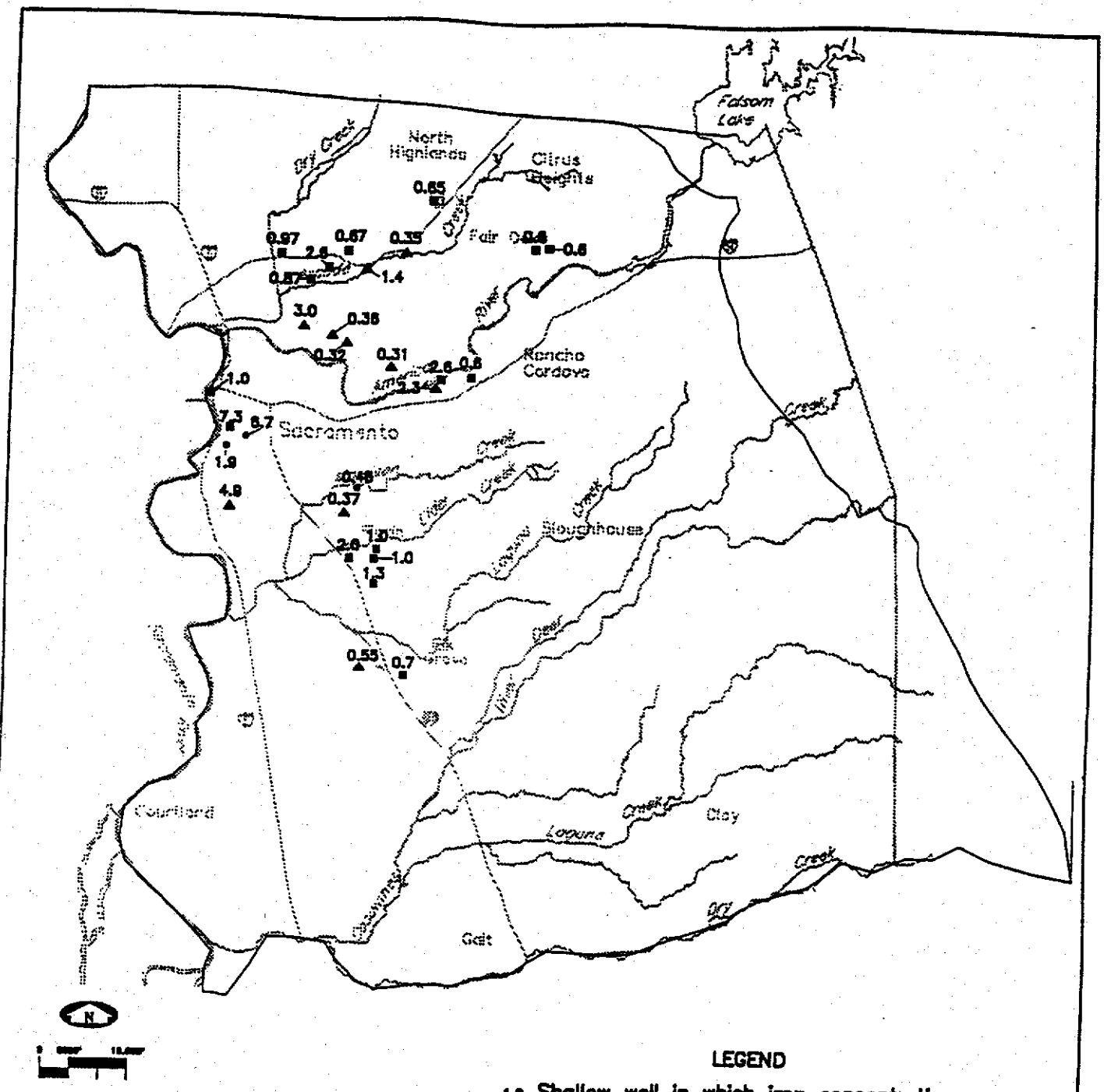
Iron

The recommended California State drinking water standard for iron is 300 µg/l. Elevated iron concentration is objectionable aesthetically because it discolors water. Iron concentrations greater than 100 µg/l precipitates when exposed to air, causing turbidity and staining plumbing fixtures, laundry and cooking utensils, and also imparts tastes and color to food and drinks.

Iron data from M&I wells in Sacramento County measured between 1970 and 1991 are listed in Table A-1 in Appendix A. Values reported below the detection limit (<30 µg/l) in Table A-1 were assigned the value of 29 µg/l to facilitate the analysis. The 778 iron values in Table A-1 range between 4 µg/l and 7300 µg/l, have an average concentration of 107 µg/l, a median value of <30 µg/l, and a standard deviation of 460 µg/l. Assigning a numerical value to observations below the detection limit may have skewed both the mean and the standard deviation. The wide range shows how varied groundwater iron concentration is basinwide. The median value is below the detection limit and the mean value is below the MCL. The wide range, the large difference between the median and mean concentration, a result of few extreme values, as well as the large standard deviation, indicate that iron is not a widespread problem in County groundwaters, but a localized one.

Figure 6-1 shows the locations of 28 wells in which the iron MCL was exceeded at least once between 1970 and 1991. The average and maximum iron concentrations measured at each of the 28 wells are also shown. Some of these wells are clustered while others are scattered. High iron well clusters are located adjacent to the American and Sacramento Rivers, and in the vicinity of the cones of depression north and south of the American River. The shallow Haggin Oak Golf Course wells, and nearby well (in the 300 to 400 feet depth range) had iron concentrations between 1400 and 2600 µg/l. Rosemont wells (having depths of 840 and 450 feet) had iron concentrations of 2300 and 2600 µg/l. Parkway wells which are located east of Highway 99 (in the depth range of: 400-600 feet) had iron concentration between 910 and 2000 µg/l. The William Land Park wells had iron concentrations between 1900 µg/l and 7300 µg/l. City well 1 is 307 feet deep. The depths of other William Land Park wells are not known. In scattered wells north of the American River, high iron concentration range from 670 µg/l and 3000 µg/l, and South of the American River, they were between 1000 µg/l and 4900 µg/l. In Zone 40, high iron concentrations of 550 µg/l and 700 µg/l were measured in a shallow SCWMD well and a deep Elk Grove well, respectively.

Table 6-1 summarizes the statistics for iron data in shallow and deep wells for different subareas. Iron concentration varies between different subareas and between the shallow and deep aquifers in each subarea. In all subareas, most median values in both the shallow and deep wells are below the detection limit. Although most mean values in both the shallow and deep wells in all subareas are below the MCL, the higher mean values occur in deep wells, with the highest three in Subareas POU north and south of the American River and Zone 40. Deep wells in the POU south of the American had the highest mean iron concentration of 714 µg/l.



LEGEND

1.0 ▲ Shallow well in which iron concentration of 1.0 mg/l was measured

2.6 ■ Deep well in which iron concentration of 2.6 mg/l was measured

6.7 ● Well with unknown depth in which iron concentration of 6.7 mg/l was measured

LOCATION OF HIGH IRON CONCENTRATION WELLS

FIGURE 6-1

TABLE 6-1

SUMMARY OF IRON CONCENTRATION STATISTICS IN SHALLOW AND DEEP M&I WELLS IN SACRAMENTO COUNTY *

(ug/l)

	SHALLOW WELLS						DEEP WELLS					
Subarea	Obs	Min	Max	Mean	Median	Std Dev	Obs	Min	Max	Mean	Median	Std Dev
POU-North	186	4	3000	72	29	246	175	10	2600	75	29	231
POU-South	97	10	4900	125	29	546	27	29	7300	714	40	1470
Zone 40	51	5	550	59	29	91	28	29	700	67	29	128
Rio Linda	17	10	170	37	29	25	6	29	120	44	29	37
Citizens A	32	29	160	41	29	31	11	29	60	32	29	9
Arcade	4	29	29	29	29	0	13	29	29	29	29	0
Citrus Height	-	-	-	-	-	-	3	29	29	29	29	0
Northridge	3	29	29	29	29	0	20	29	220	44	29	46
Orangevale	-	-	-	-	-	-	3	29	29	29	29	0
Fair Oaks	-	-	-	-	-	-	18	29	600	113	29	183
Carmichael	-	-	-	-	-	-	-	-	-	-	-	-
Arden Cordova	1	29	29	29	29	0	13	29	51	31	29	61
Citizens B	3	29	150	69	29	70	13	29	600	73	29	159
Sunrise	-	-	-	-	-	-	7	29	100	39	29	27

Note: * Values reported below detection limit (<30 ug/l) were assigned as 29 ug/l

A separate-variance test (based on the t' statistic) was performed to determine if mean iron concentrations varied significantly between the shallow and deep wells in each subarea. The mean iron values in the shallow wells in the POU North of the American River, Zone 40, Rio Linda, Citizens A, Arcade, Arden Cordova, and Citizens B were statistically similar to those in deep wells at 95 percent significance level. However, mean iron concentration in deep wells of the POU south of the American River was greater than in shallow wells at the same level of significance. For other subareas, data was inadequate for drawing any conclusions.

Manganese

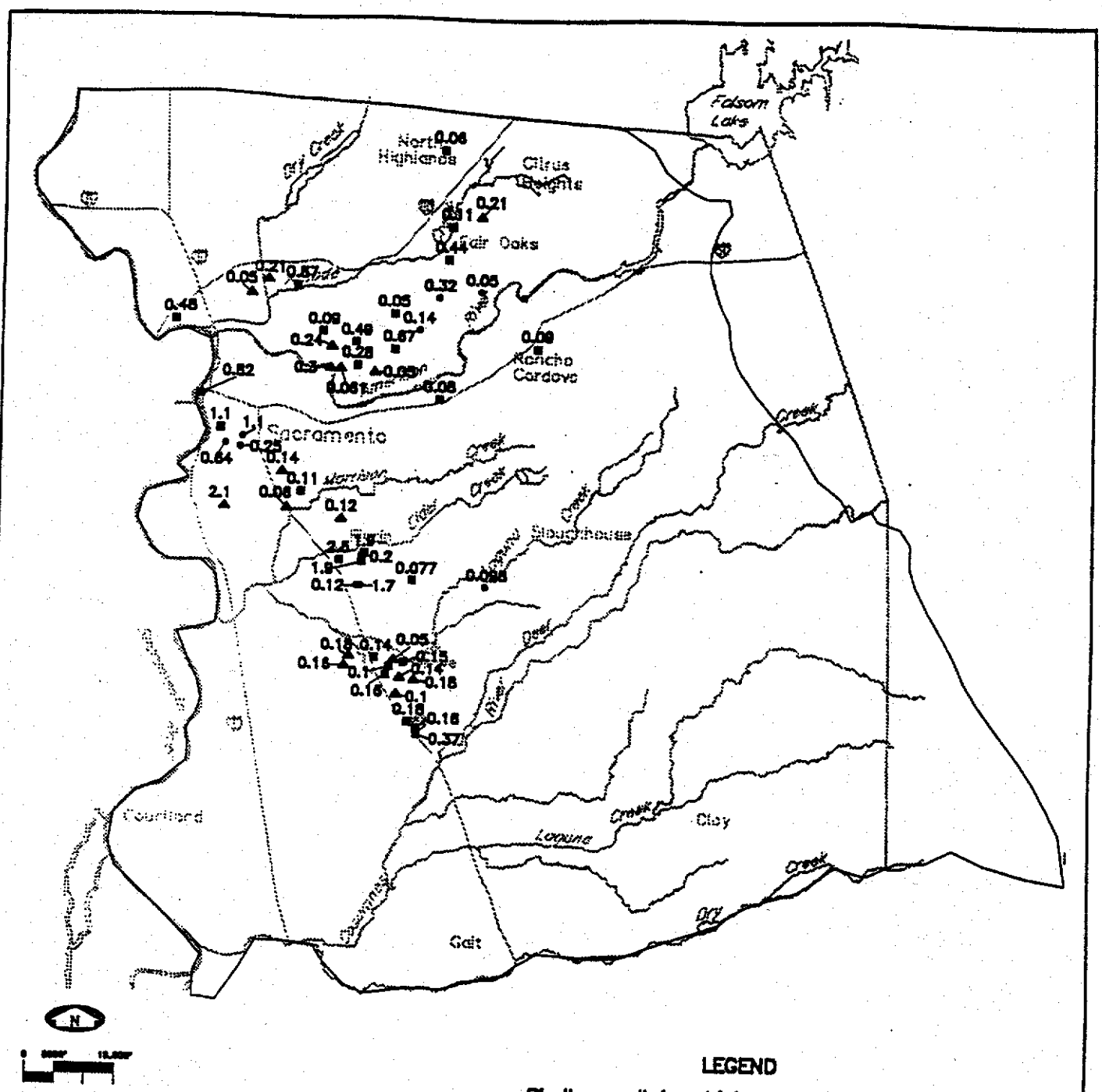
In groundwater subject to reducing conditions, manganese can leach from the soil and may occur in high concentrations. Iron frequently accompanies manganese in such groundwaters. The recommended State drinking water standard for manganese is 50 µg/l. Manganese, like iron, does not constitute a health hazard, but is an aesthetic problem. Excessive manganese precipitates upon oxidation and causes undesirable tastes, deposits on foods during cooking, stains plumbing fixtures and laundry, and fosters growth in distribution systems.

Manganese data from M&I wells in Sacramento County measured between 1970 and 1991 are listed in Table A-2 in Appendix A. Values reported below the detection limit (<10 µg/l) in Table A-2 were assigned the value of 9 µg/l to facilitate the analysis. The 775 manganese values in Table A-2 range between 1 µg/l and 2500 µg/l, have a mean of 58 µg/l, a median of <10 µg/l and a standard deviation of 216 µg/l. Assigning a numerical value to observations below the detection limit may have skewed both the mean and the standard deviation. Like iron, manganese concentration in County groundwaters varies significantly and the median manganese value is below the detection limit. But unlike iron, the mean value for manganese exceeds the MCL. Note that the numerical values assigned to observations below the detection limit may skew the manganese mean more than the iron mean. Notwithstanding the above, manganese appears to be a more widespread problem than iron.

Figure 6-2 shows the locations of 55 M&I wells in which manganese MCL was exceeded between 1970 and 1991. The average and maximum manganese concentrations measured in each of these wells are also shown. Some of these wells are clustered near the Sacramento River, north of the American River around the cone of depression, and south of the American River both within and around the cone of depression. Arden wells (depth range: 250-460 ft) had manganese concentration between 50 to 400 µg/l. William Land Park wells had manganese concentration between 170 and 1200 µg/l. Parkway wells had manganese concentration between 70 and 2500 µg/l. In Zone 40, high manganese concentrations in 6 shallow wells ranged between 50 - 100 µg/l and in seven deep wells between 100 and 370 µg/l. In scattered wells north and south of the American River, high manganese concentrations were between 70 and 2100 µg/l, with the higher end measured in the Bing Maloney Golf Course well.

Table 6-2 summarizes the manganese statistics in shallow and deep wells for different subareas. Manganese concentration varies more between subareas and between shallow and deep wells compared to iron concentration. On a subarea basis, more median manganese values are above the detection limit than median iron values. Also, more mean manganese values exceed the MCL compared to mean iron values. Mean manganese concentrations in deep wells of the POU south of the American River and Zone 40 exceed the MCL.

A comparison of the mean manganese values in the shallow and deep aquifers for the subareas produced the following results. Deep wells in three subareas-POU north of the American River, POU south of the American River and Zone 40, have a higher mean manganese concentration than shallow wells (at a 95 percent significance level). In other subareas (including Rio Linda, Citizens A, Arcade, Northridge), there was no significant difference between mean manganese concentrations in deep and shallow wells. Subareas Citrus Height, Orangevale, Fair Oaks,



LOCATION OF HIGH MANGANESE CONCENTRATION WELLS

FIGURE 6-2

TABLE 6-2

SUMMARY OF MANGANESE CONCENTRATION STATISTICS IN SHALLOW AND DEEP M&I WELLS IN SACRAMENTO COUNTY *
(ug/l)

	SHALLOW WELLS						DEEP WELLS					
Subarea	Obs	Min	Max	Mean	Median	Std Dev	Obs	Min	Max	Mean	Median	Std Dev
POU-North	178	1	301	19	9	34	165	9	870	45	9	120
POU-South	94	9	2100	80	9	342	27	9	2500	458	94	695
Zone 40	52	4	180	33	9	46	38	9	370	74	74	74
Rio Linda	17	9	49	13	9	11	7	9	49	19	9	17
Citizens A	33	9	210	18	9	36	13	4	49	17	9	16
Arcade	4	9	14	11	10	2	12	9	29	12	9	7
Citrus Height	-	-	-	-	-	-	4	9	9	9	9	0
Northridge	3	9	40	29	39	18	24	9	440	38	9	89
Orangevale	-	-	-	-	-	-	3	9	49	22	9	23
Fair Oaks	-	-	-	-	-	-	21	9	49	14	9	11
Carmichael	-	-	-	-	-	-	-	-	-	-	-	-
Arden Cordova	-	-	-	-	-	-	7	9	11	9	9	1
Citizens B	2	9	9	9	9	0	12	9	49	13	9	12
Sunrise	-	-	-	-	-	-	8	1	88	46	49	29

Note: * Values reported below detection limit (<10 ug/l) were assigned as 9 ug/l

Carmichael, Arden Cordova, Citizens B, and Sunrise did not have sufficient data to evaluate the difference in quality in the shallow and deep wells. Excessive pumping in deep wells near the cones of depression, and the resulting head differential may be inducing iron and manganese to leach from the soils under the blue clay layer.

Total Dissolved Solids

Groundwater contains a wide variety of dissolved inorganic constituents as a result of chemical and biochemical interactions with geological materials through which it flows. The major constituents in groundwater: TDS (sodium, magnesium, calcium, chloride, bicarbonates, and sulfates) occur in ionic form and normally comprise more than 90 percent of the TDS. The recommended state drinking water standard for TDS is 500 mg/l. Higher concentrations of dissolved solids in drinking water are objectionable because of possible physiological effects, unpalatable tastes, and corrosion and encrustation of water-supply systems.

TDS data from M&I wells in Sacramento County measured between 1967-1991 are listed in Table A-3 in Appendix A. The 462 TDS observations in Table A-3 are between 24 mg/l and 581 mg/l, have a mean value of 221 mg/l, a median value of 215 mg/l, and a standard deviation of 79 mg/l. Overall, Sacramento County groundwater TDS meets the drinking water quality standard. TDS concentrations measured in three wells which exceeded the MCL are 581 mg/l measured in City Well No. 159 in 1984, 570 mg/l measured in Fruitridge Vista Well No. 15 measured in 1990, and 508 mg/l measured in Northridge Well No. 28 in 1982. High TDS values in some wells along the Sacramento River were reported by the U.S. Geological Survey (USGS 1985).

Arsenic

Arsenic is insoluble in water, but several arsenites are quite soluble. Arsenic can be traced in water originated by natural processes or by industrial activities-industrial waste, arsenical pesticides and smelting operations (De Zuanne, 1990: 55-56). In nature, arsenic is found in sulfides, arsenides and sulfarsenides of heavy metals, oxides and arsenates. Groundwater is expected to contain higher arsenic concentrations than surface water because of its presence in geological material.

Arsenic is regulated by the California Department of Health Services (DOHS) at a primary drinking water standard of 50 µg/l. The USEPA is currently reevaluating the Arsenic standard in light of new evidence linking its ingestion to liver, lung, kidney, and bladder cancers. The USEPA, under an extended a court ordered deadline, has until mid-January 1993 to propose a revised standard for arsenic.

The 434 arsenic observations listed in Table A-4 in Appendix A are between 2 µg/l to 41 µg/l, all below current drinking water quality standards. Mean arsenic concentration is 3.5 µg/l, with a standard deviation of 0.7 µg/l. USGS reported arsenic concentrations of 80 µg/l and 120 µg/l measured in Well No. 005N/005E-03P01 and Well No. 004N/004E-02J01, respectively, located in southwest Sacramento County (1985). In Zone 40 wells, arsenic levels were between 3 and 41 µg/l, with higher levels observed over the past six years. Increased pumping during the drought years may have influenced arsenic levels to increase in some Zone 40 wells. Some Zone 40 wells may be affected if more stringent drinking water standards for arsenic are imposed.

Radon

Radon is a radioactive, colorless, gaseous, chemical element formed as a first product in the atomic disintegration of radium. Except in cases of contamination, radon is generally present in higher concentrations in groundwaters compared to surface waters. Radon is thought to cause lung, stomach and other cancers in human beings. The USEPA is currently reviewing standards for radon and is expected to set a primary MCL of 300 pCi/l.

Table A-5 in Appendix A lists radon values measured in SAWWA wells in 1991. They ranged from 50 pCi/l to 1,700 pCi/l, and have a mean value of 517 pCi/l and a standard deviation of 269 pCi/l. Table 6-3 summarizes the radon results for twelve SAWWA purveyors. 85% of the 129 wells tested had radon values greater than 300 pCi/l, the proposed MCL. Radon values in excess of 300 pCi/l were measured in all wells tested for Del Paso Manor Water District (8 wells), Elk Grove Water Works (10 wells), Florin County Water District (8 wells), Fruitridge Vista Water Company (13 wells), Orangevale Mutual Water Company (1 well), Rio Linda Water District (10 wells), and Sacramento County Water Maintenance District (14 wells); 10 out of 12 wells tested for Carmichael Irrigation District; 13 out of 20 wells tested for Citizens Utilities Company of California; 3 out of 6 wells tested for Fair Oaks Water District; and, 20 out of 26 wells tested for Northridge Water District.

North of the American River, high radon values were noted in more deep than shallow wells located east of McClellan Air Force Base. South of the American River, high radon values were noted in more shallow than deep wells. Also, 11 shallow and 5 deep wells in Zone 40 had high radon values. Radon in the County groundwater is due to natural occurrence. Many wells in Sacramento County will be affected once the USEPA sets its proposed MCL for radon.

AREAS WITH CONTAMINATED GROUNDWATER

Figure 6-3 shows the locations of the major industrial sites and pesticide application where groundwater is, or may potentially be, contaminated. The pesticide application areas were delineated by SAWWA. Figure 6-3 also shows the locations of 32 contaminated wells within the County. The contamination at each major site is summarized below from groundwater elevation levels, key contaminants, depth of contamination (where it is known) and the status of remedial activities. Contamination in the 32 wells is also discussed. The description below is at a very general level; detailed discussion is beyond the scope of this study. Additional information on groundwater contamination at each site is available at the CVRWQCB.

Pacific, Gas and Electric Company (PG&E)

Groundwater at the site is 35 to 40 feet below the ground surface and it flows from north to east. The flow direction may be influenced by the Ranney collectors (located about 400 feet from the site) which pump between 3 and 13 mgd. The major classes of chemicals found in the groundwater are polycyclic aromatic hydrocarbons (PAH), phenolic compounds, light aromatic hydrocarbons, inorganic sulfur and nitrogen compounds, and to a lesser extent, trace metals. The depth of contamination is approximately 80 feet below the ground surface. The feasibility study recommended on-site remediation of soils containing elevated concentrations of gas plant residues that are migrating to the groundwater and of the groundwater itself. Groundwater monitoring would be used for assessing the effectiveness of source control and groundwater extraction. The final feasibility study will be completed after PG&E addresses regulatory agency comments.

The Southern Pacific Transport Company (SPTC)

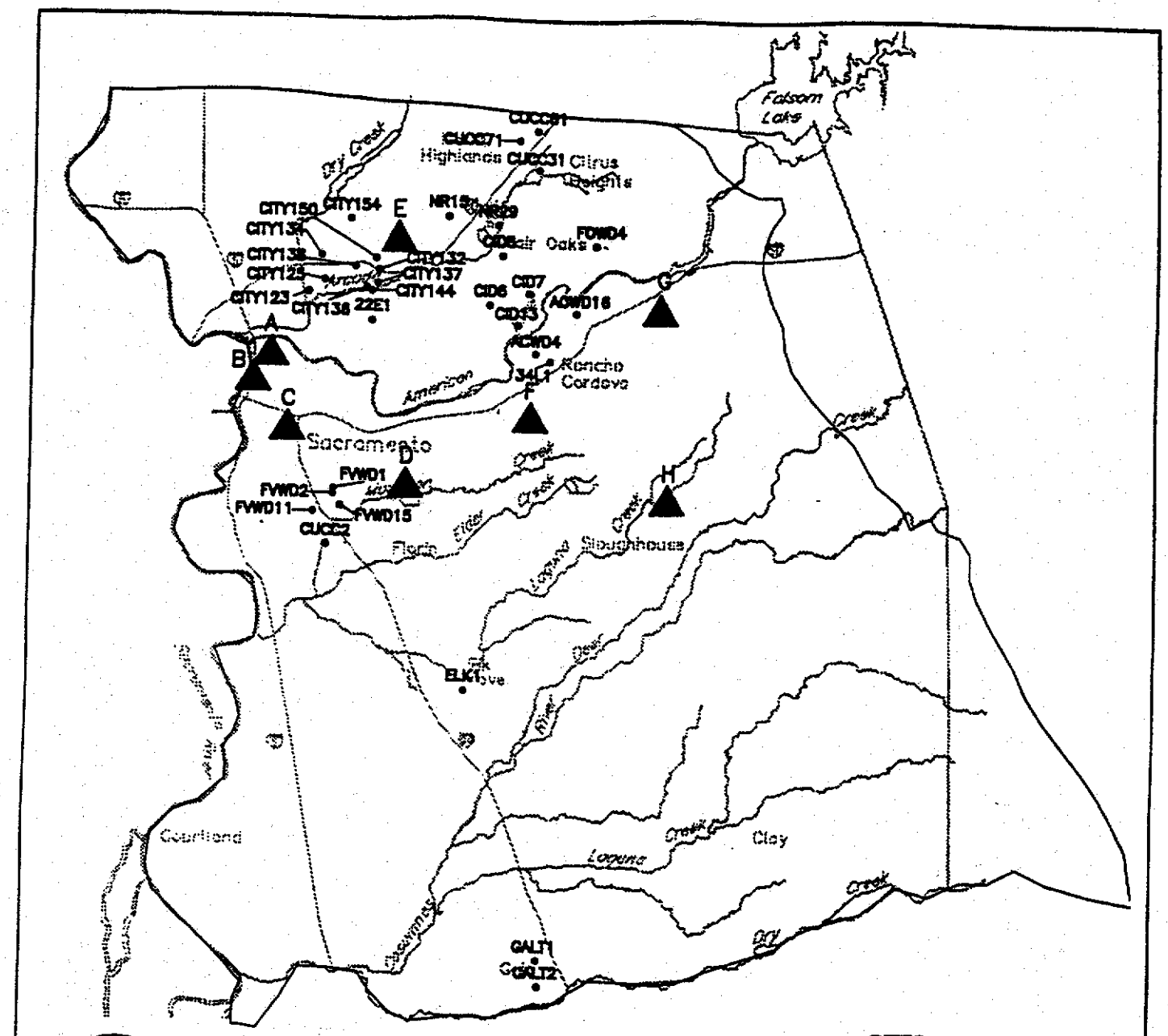
Groundwater at this site is 15 to 22 feet below the ground surface. It is contaminated with volatile (VOCs) and semi-volatile organic compounds. Four common VOCs found are 1,1-dichloroethane, 1,2-dichloroethene, vinyl chloride and 1,1-dichloroethene. The depth of contamination is about 65 feet below the ground surface, with the plume moving in the southwest direction. The California Department of Health Services approved the Remedial Action Plan for the site on December 8, 1989. Final remediation was deferred until contamination at the site was more completely characterized.

TABLE 6-3

SACRAMENTO AREA RADON WELL TESTING SUMMARY *
(Spring 1991 Results)

Agency	No. of Samples	No. >=300 (pCi/l)	% >=300 (pCi/l)	Average (pCi/l)	Std. Dev. (pCi/l)
Arcade WD	0	0	n/a	n/a	n/a
Carmichael ID	12	10	83%	779	516
Citizens UCC	20	13	65%	421	189
Citrus Heights WD	1	0	0%	100	0
Del Paso MWD	8	8	100%	493	134
Elk Grove WD	10	10	100%	473	103
Fair Oaks WD	6	3	50%	400	339
Florin County WD	8	8	100%	586	82
Fruitridge VWD	13	13	100%	572	149
Northridge WD	26	20	77%	462	212
Orangevale WD	1	1	100%	140	0
Rio Linda WD	10	10	100%	570	82
SCWMD	14	14	100%	469	112

Note: * Source: 1991 SAWWA Report (page 11)



GROUNDWATER CONTAMINATED WELLS AND SITES

FIGURE 6-3

Groundwater Quality

Sacramento Army Depot (SAD)

Groundwater occurs at 34 to 40 feet below the ground surface, and flows in the north-south direction. The primary contaminants in the groundwaters are trichloroethylene (TCE), tetrachloroethene, 1,2-dichloroethene, and trans-1,2-dichloroethene. The depth of contamination is about 230 feet below ground surface. Groundwater extraction wells and a treatment plant were completed in November 1989. Monitoring is ongoing through 61 on-site wells and 23 off-site wells in four zones: 79-107 ft, 110-148 ft, 156-188 ft and 195-230 ft, below the ground surface.

Union Pacific Railroad Yard (UPRRY)

Groundwater at this site is about 30 feet below ground surface. The major categories of contaminants found in the soil and groundwater are metals, petroleum hydrocarbons, volatile organic compounds, polychlorinated biphenyls and asbestos. Although their distribution varies considerably within the soil and groundwater, metals (lead and arsenic) appear to be concentrated in the upper two feet of the soil and hydrocarbons in the upper six feet of the soil. The plume appears to be moving in the southwest direction. Interim remedial measures at the site include: removal and off-site disposal of approximately 1,600 cubic yards of wood debris and soil; removal of 18,000-gallon and 1,000-gallon underground storage tanks and the contents of all underground storage tanks; and, the cleaning of the 72,000-gallon underground storage tank. Further investigations, including the installation of 150 feet deep monitoring wells, are currently proceeding to evaluate the extent of off-site migration of contaminants.

McClellan Air Force Base

Groundwater at this site, typically 80 to 110 feet below ground surface, is contaminated by organic solvents in four areas on the base. Common contaminants found in the groundwater are TCE, tetrachloroethene, 1,1,1 trichloro-ethane, total 1,2-dichloroethene, 1,2 dichloroethane, 1,1-dichloro-ethene, 1,1 dichloroethane and chloroform. The depth of contamination has exceeded 150 feet below ground surface. Some contaminants have migrated off base in the direction of the cone of depression, toward City Well No. 132. Interim remedial measures taken at the site include converting residences with affected water wells from private to municipal water supplies, installing a synthetic liner and clay cap at one on base location, installing groundwater extraction systems at two on base locations. Ongoing Remedial Investigation/Feasibility Study activities, which began in 1979, include groundwater sampling and analysis, the construction of 400 feet deep monitoring wells, and evaluation of other remediation measures.

Mather Air Force Base

Groundwater at this site is located between 70 ft and 170 ft below ground surface. Major contaminants found in the groundwater are 1,2-DCE, TCE, PCE, dichloropropane, benzene, vinyl chloride, xylene, chlorobenzene, ethyl benzene, toulene, chloroform and lead. Groundwater contamination has been noted at depths up to 280 feet below ground surface. 1,2-Dichloroethane level of 2.8 ug/l (MCL-1.00 ug/l) was measured in a drinking water well FH-01 at the base. FH-01 is 400 feet deep and is perforated between 330 and 374 feet below ground surface. Four separate Installation Restoration Programs (IRP) have been completed at Mather Air Force Base to identify and evaluate the extent of soil and groundwater contamination at the site. Groundwater monitoring is continuing from 76 wells drilled at depths between 82 and 280 feet below ground surface.

Aerojet

Groundwater at this site is located 60 ft to 200 ft below ground surface, and flows from the east to west. Groundwater contamination is extensive. Upper limits of measured concentration of some

volatile organic compounds such as trichloroethylene are 80,000 µg/l, Freon 113 21,000 µg/l, perchloroethlylene 58,000 µg/l, and 1,1,1-trichloroethane over 1,000 µg/l. Contaminants in the groundwater also include pesticides, PCBs, and heavy metals. The depth of contamination is approximated at 300-600 feet. Since 1979, Aerojet has collected and analyzed thousands of samples from about 1,000 on and off-site monitoring wells. Phase 1 Remedial Investigation/Feasibility Study is ongoing at the site. Interim remedial measures taken at the site include provision of bottled water to property owners, excavation of contaminated soil for off-site disposal, air stripping and activated carbon treatments, and groundwater monitoring.

Kiefer Landfill

Groundwater at the site is 70 ft to 170 ft below ground surface and it flows from east to west. Groundwater contamination is from municipal waste disposed at the site and agricultural wastes stored at the site. Kiefer Landfill is a municipal waste disposal site, but in 1973, it was also used as a temporary storage site for pesticides with the approval of the Sacramento County Agriculture Commissioner, Department of Public Health and Sacramento County Public Works Department. The site covering 652 acres includes an active waste disposal area of 160 acres. 11 pesticides were measured at concentrations between 0.1 mg/l and 160 mg/l in soil samples taken 8 to 12 feet below ground surface. Contaminants in the groundwater include vinyl chloride, trichloroethylene, tetrachloroethene, and freon. As part of the ongoing study at the site, the Phase II Verification Monitoring Facilities were installed in June 1992.

Contaminated Drinking Water Wells

30 out of the 32 contaminated wells shown in Figure 6-3 are known M&I wells. The two other wells are identified by their state well numbers. Most contaminants found in the 32 wells are regulated volatile organic compounds or synthetic organic compounds. Table 6-4 lists these wells, the contaminant concentrations measured in each well, the respective drinking water standard for each contaminant, and the dates when the wells were sampled. Contaminant concentrations in most wells, except Arden Cordova Water District Well No. 16, do not exceed drinking water standards. Arden Cordova Water District Well No. 16 had a TCE concentration of more than five times the primary MCL. Although the contaminant concentrations in most of the wells shown in Figure 6-3 did not exceed the drinking water standards, the presence of organic compounds indicates that the groundwaters of those areas are already contaminated from industrial and agricultural activities. Moreover, because some organic compounds are transported at rates slower than the flow of groundwater, some of these wells may be effected further even under current pumping conditions. The areas in the vicinity of these wells would certainly be vulnerable to new development of groundwater.

SUMMARY

Although Sacramento County groundwaters presently meet most Title 22 drinking water standards, except for iron and manganese, the existing pumping levels and forthcoming regulations may pose new constraints on the continued use of groundwater, requiring additional investments for water treatment. Elevated levels of iron and manganese were measured in wells adjacent to the American and Sacramento Rivers, and in the vicinity of the cones of groundwater depression. Arsenic levels above the detection limit were also noted in several Zone 40 wells. Excessive pumping, especially in wells near the cones of depression, and the resulting hydraulic head differentials, may be inducing iron and manganese to leach from the soils under the blue clay layer. Increased pumping over the past few years may also have induced higher arsenic levels in some wells. If more stringent standards for arsenic are imposed, some wells, especially in Zone 40, may be affected and may require additional treatment. Similarly, most M&I wells in the County will be affected when new standards for radon are imposed.

TABLE 6-4

CONTAMINATED WELLS IN SACRAMENTO COUNTY (a)

Agency	Well ID	Parameter	Standard (ug/l)	Sample Value (ug/l)	Date Sampled
Arcade WD	16	Trichloroethylene	5	27	4/16/85
	4	Trichloroethylene	5	0.88	8/23/89
	4	Chloroform	100	0.54	7/20/89
City of Sacramento	123	Methyln Chloride	(b)	0.8	6/15/89
	125	Methyln Chloride	(b)	2.6	6/15/89
	125	Bromoform	100	0.8	6/21/89
	132	Bromoform	100 (c)	4.2	2/5/88
	132	Dibromochloromethane	100 (c)	0.5	2/5/89
	134	Methyln Chloride	(b)	0.9	6/13/89
	136	Tetrachloroethene	5	1.1	6/13/89
	137	Methyln Chloride	(b)	0.5	6/13/89
	138	Bromoform	100	1.1	4/12/88
	144	Dichloroethene	5	0.52	7/8/87
	150	Dichloroethylene	7	2.6	7/25/85
	150	Trichloroethylene	5	4	7/25/85
	154	Dichloroethane	5	0.68	8/15/87
	09N/05E-22E01M (d)	Methyln Chloride	(b)	1.9	6/21/89
Citizens UCC	Glass	Trichloroethylene	5	1.08	8/23/89
	Treelark	Tetrachloroethene	5	0.7	10/2/89
	Sandalwood	Tetrachloroethene	5	2.09	8/23/89
	A Parkway	Carbon Tetrachloride	5	0.64	7/24/89
	A Parkway	Chloroform	100	88.4	7/24/89
Carmichael ID	7	Tetrachloroethene	5	0.8	1/19/90
	La Vista	Tetrachloroethene	5	0.97	7/19/89
	09N/06E-22B02M (d)	Toluene	2000	0.7	11/9/88
	09N/06E-34L01M (d)	Bromodichloromethane	100 (c)	1.86	7/12/89
	09N/06E-34L01M (d)	Chloroform	100 (c)	16.4	7/12/89
	09N/06E-34L01M (d)	Chloroform	100	0.54	7/20/89
	09N/06E-34L01M (d)	Trichloroethylene	5	0.88	8/23/89
Elk Grove WD	07N/05E-04D00M (d)	Tetrachloroethene	5	0.76	7/18/89
Fair Oaks WD	09N/07E-07F01M (d)	Chloroform	100	5.8	7/19/89
Fruitridge VWD	1	Tetrachloroethene	5	1.43	8/11/89
	1	Chloroform	100	1.19	7/18/89
	2	Chloroform	100	0.89	7/18/89
	11	Chloroform	100 (c)	0.5	7/17/89
	08N/05E-28N02M (d)	Bromoform	100 (c)	2.44	7/18/89
	08N/05E-28N02M (d)	Dibromochloromethane	100 (c)	0.88	7/18/89
City of Galt	1	Endrin	0.2 (e)	0.1	7/18/89
	1	Lindane	0.2	0.1	7/18/89
	1	Methoxychlor	400	1	7/18/89
	1	Silvex	5	0.2	7/18/89
	1	Toxaphene	5	2	7/18/89
	2	Dichlorophenoxyacetic Acid	70	2	7/18/89
	2	Endrin	0.2 (e)	0.1	7/18/89
	2	Lindane	0.2	0.1	7/18/89
	2	Methoxychlor	400	1	7/18/89
	2	Silvex	5	0.2	7/18/89
	2	Toxaphene	5	2	7/18/89
Northridge WD	15	Ethyl Benzene	700	0.7	9/12/89
	15	Toluene	2000	1.7	10/24/88
	15	Xylenes	10000	1.2	10/24/88
	09N/06E-04G01M (d)	Bromodichloromethane	100 (c)	2.02	9/12/89
	09N/06E-04G01M (d)	Bromoform	100 (c)	0.94	9/12/89
	09N/06E-04G01M (d)	Chloroform	100 (c)	1.48	9/12/89
	09N/06E-04G01M (d)	Dibromochloromethane	100 (c)	1.76	9/12/89

Notes
(a) Data Source: Central Valley Regional Water Quality Control Board
(b) Under consideration for inclusion in the National Primary Drinking Water Regulations
(c) Total Trihalomethanes
(d) State well Number, Agency well ID not provided
(e) USEPA (1975) RMCL

Groundwater Quality

Sacramento County groundwater is also contaminated locally at several sites from organic compounds and metals from past military, industrial and agricultural activities. The contamination at the PG&E, SPTC, SAD and UPRRY sites, and the Kiefer Landfill appears to be confined to the shallow aquifer. The contamination at McClellan and Mather Air Force Bases may have extended into the deep aquifer. The contamination at Aerojet is extensive and has extended into the deep aquifer. At all the sites, remedial activities are either underway or being planned. Besides these sites, the 32 contaminated wells indicate the locations where County groundwaters may be affected further even under current pumping conditions because some compounds are transported at rates slower than the flow of groundwater. These areas would also be vulnerable to new development of groundwater.

Section 7

SECTION 7

BASIN WATER RESOURCE ANALYSIS

Proper management and allocation of common resources generally balances availability, demand, and direct and indirect costs. If these variables are not well defined, the resource may be exploited through overuse or degradation. When a community, such as Sacramento County, is dependent on groundwater for a substantial portion of its water needs, it is critical to define the amount of water that can be withdrawn annually from a groundwater basin without producing an undesirable result such as a long-term decline of groundwater levels ("overdraft") or a deterioration in water quality. This sustainable extraction rate is often referred to as the "safe yield". However, as explained below, this conventional definition for "overdraft" or "safe yield" does not recognize that groundwater basin recharge varies as a function of basin pumping, and that the "safe yield" is not a unique, fixed number. Because IGSM tracks all the components of the complex groundwater and surface water hydrologic balance, the response of the basin (groundwater levels, streamflows, etc.) to alternative land use and pumping scenarios may be predicted. This section discusses the concept of groundwater yield, the factors that must be considered in analyzing alternative water supply scenarios, and the results of two model runs.

THE CONCEPT OF GROUNDWATER SAFE YIELD

A primary management objective for Sacramento County might be to satisfy beneficial water demands with an optimum combination of sustainable or safe yield groundwater extractions and surface water supplies. The sustainable yield is the groundwater extraction rate that does not cause long-term depletion of groundwater storage.

In areas unlike the Sacramento groundwater basin where recharge from streams and boundary inflows are small, the groundwater sustainable yield can be determined based on an estimation of deep percolation from rainfall and applied water. Land use changes, such as an increase in impervious area, will alter the runoff-infiltration proportion, thereby altering the amount of deep percolation potentially reaching the groundwater basin. However, in areas such as the Sacramento groundwater basin where stream recharge and boundary inflows are major groundwater recharge sources, groundwater sustainable yield is more complicated because recharge is also affected by the groundwater extraction pattern (location of pumps, and amount and variation of extraction rates). That is, the availability of groundwater varies because the basin recharge-extraction relationship varies. For example, increased pumping extraction at certain locations would lower groundwater levels. This lowering will in turn induce more groundwater recharge from streams or adjacent areas that are beyond the study area. Such an increase in recharge may continue with further increased withdrawals until a new recharge-extraction balance is attained, and groundwater levels stabilize at some lower level.

In order to determine the most appropriate volume of groundwater that should be pumped from the Sacramento County groundwater basin, the cost and risk of pumping groundwater from various elevations should be analyzed and compared with the cost and risk of utilizing alternative supplies, such as surface water. These costs and risks may include:

- Increased pumping costs
- Causing public and private wells to become inoperative
- In-migration of poorer-quality water
- Impacting streamflows and boundary flows from surrounding areas
- Land subsidence

Determining the appropriate Sacramento County groundwater yield requires an exhaustive analysis of alternative combinations of groundwater and local and imported surface water supplies.

ANALYSIS OF ALTERNATIVE WATER SUPPLY SCENARIOS

As discussed above, there are numerous factors that may impact groundwater levels in the Sacramento County area. These factors include:

- Hydrologic Conditions
- Land and Water Use Conditions
- Groundwater Pumping Rates
- Well Location

In order to assess the impacts that these factors may have on the groundwater basin, two case studies were performed and are presented in this section:

- Case No. 1, existing conditions, assuming present land use and historical water use patterns.
- Case No. 2, future conditions, assuming future land use (buildout General Plan) and future water demands.

The assumptions and input data used in the model runs are described below.

Hydrologic Conditions

Hydrologic conditions (i.e., rainfall, river inflow) are an important consideration in the modeling analysis of alternative water supply scenarios. The amount of rainfall and stream inflow has a direct impact on groundwater recharge and hence it is important to provide as input a long-term hydrologic record that incorporates both wet years as well as periods of extended drought. For the purpose of these model runs, the historical 1922-1990 hydrologic record was used as the long-term period. This period covers the severe critical droughts of the late 1920s and early 1930s; the 1976-1977 short-duration drought; and a good portion of the recent 1987-1992 drought. In addition, wet years, such as 1982-1983 and 1985-1986, are also incorporated in this period of record.

It should be noted that historical hydrologic records were not available for all rainfall stations and stream gaging stations used in the model. Where data was lacking, it was estimated by correlation techniques within stations with long term measured data. The exception to this was the stream inflows for the Sacramento River and American River. Both of these rivers are regulated by upstream reservoirs and diversions many of which did not exist prior to the 1940s. Hence, the historical streamflows do not adequately represent the current level of development in these watersheds. In light of this, the streamflow projections made by the California Department of Water Resources reflecting 1995 development conditions were used as the stream inflows for the American and Sacramento Rivers. These projections may be revised by DWR in the future.

Land and Water Use Conditions

As previously discussed, land and water use conditions may have a significant impact on groundwater recharge and groundwater levels in the study area. In general, the conversion of agricultural land to urban land results in increased surface water runoff (due to the large percent of impervious areas associated with urban development), and a decrease in aquifer recharge from deep percolation (due to a decrease in applied irrigation water). In order to analyze the impact of changing land and water use conditions, Cases No. 1 and 2, as defined above, were evaluated over the 1922-90 historical period of record using IGSM.

Case No. 1, representing existing land use conditions, was based on the 1990 level of development. For this analysis it was assumed that the annual urban demand was fixed (i.e., it did not vary from year to year due to conservation in drought years, etc.). The monthly agricultural water demand was estimated by the consumptive use method, utilizing DWR's estimated crop acreage for 1990, in conjunction with the historical rainfall. It should be noted that the annual agricultural demand estimated by this method may vary from year to year based on the amount of rainfall and available soil moisture at the beginning of the growing season.

Case No.2, representing future conditions, was based on the "Buildout of General Plan" land and water use. This scenario assumed a small decrease in agricultural acreage and associated agricultural water demand. However, under this scenario the urban land and water use increased significantly over present conditions. The overall land and water use distribution to the model subregions is based on the analysis made by Boyle Engineering Corporation (1993), which provides the projected urban water demand, urban acreage, and crop acreage in the various water and agricultural districts throughout the County.

Table 7-1 shows the water supply and demands used for both the existing and future condition model runs.

TABLE 7-1
CONDITIONS FOR ALTERNATIVE WATER SUPPLY SCENARIOS

	Case No. 1 Existing Conditions (acre feet/year)	Case No. 2 Future Conditions (acre feet/year)
Water Demand	785,000	1,009,000
Surface Water Supply	314,000	314,000
Groundwater Supply	471,000	695,000

The water demand and supply used for Case No. 1 are similar to existing conditions. For Case No. 2, the increase in water supply to meet the increased water demand for buildout conditions is assumed to come entirely from groundwater. This assumption may not be realistic, however it may represent a potential worst-case scenario for future groundwater conditions.

Other Major Assumptions

Other major factors influencing the response of the Sacramento County groundwater basin include the location of pumping. Both cases used the existing geographical distribution of the pumping. The other major factor is the groundwater use pattern in the areas adjacent to Sacramento County. It was assumed that the future pumping patterns in those areas will remain the same as existing patterns.

Discussion Of Model Runs

In order to demonstrate the analysis of alternative water supply scenarios by IGSM, two model runs were performed, as described above and summarized in this section. Figure 7-1 shows the long-term trend of basin wide average groundwater elevations. The average groundwater elevations were taken to be the average of the groundwater elevations at each model node. Figure 7-2 shows the long-term trend of the lowest groundwater levels in the County. Under Case No. 1 (present conditions), there will be no long-term overall basin groundwater storage decrease, even though the water levels will decline slightly in the worst location. If pumping increases in the future as assumed for Case No. 2, the groundwater levels in the basin will undergo a significant

decline from present conditions and will eventually stabilize at the lower elevations. The average decline is estimated to be 50 feet and the decline in the worst location is estimated to be 150 feet. Table 7-2 summarizes the water budget under stabilized conditions for both Case No. 1 and Case No. 2.

TABLE 7-2
WATER BUDGET UNDER PRESENT AND FUTURE GROUNDWATER CONDITIONS

	Case No. 1 Existing Conditions	Case No. 2 Future Conditions
INFLOW (AF/YR)		
Deep Percolation	168,000	155,000
Stream Recharge	214,000	315,000
Boundary Inflow	92,000	223,000
Subtotal	474,000	693,000
PUMPING(AF/YR)	471,000	695,000
Groundwater Level Decline from Present Conditions (feet)		
Average	0	50
Maximum	30	150

Deep percolation under future conditions decreases from the present condition as a result of increased imperviousness associated with urbanization. Recharge from streams and boundary inflow will substantially increase as a result of lowered groundwater elevations in the basin. It should be emphasized that the water levels and impacts on streamflow and surrounding counties under future conditions might not be acceptable, and it may be necessary to maintain higher groundwater levels to reduce these impacts. In that case, groundwater pumping in the future may have to be reduced from the assumed levels.

FIGURE 7-1

BASIN-WIDE AVERAGE GROUNDWATER LEVELS

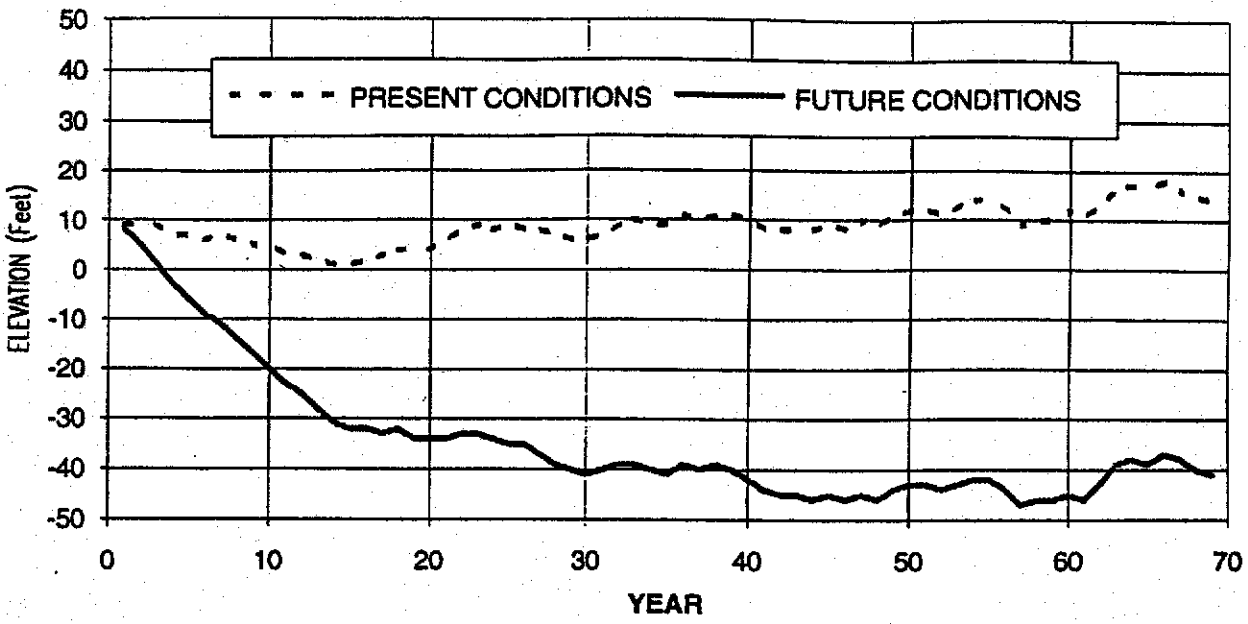
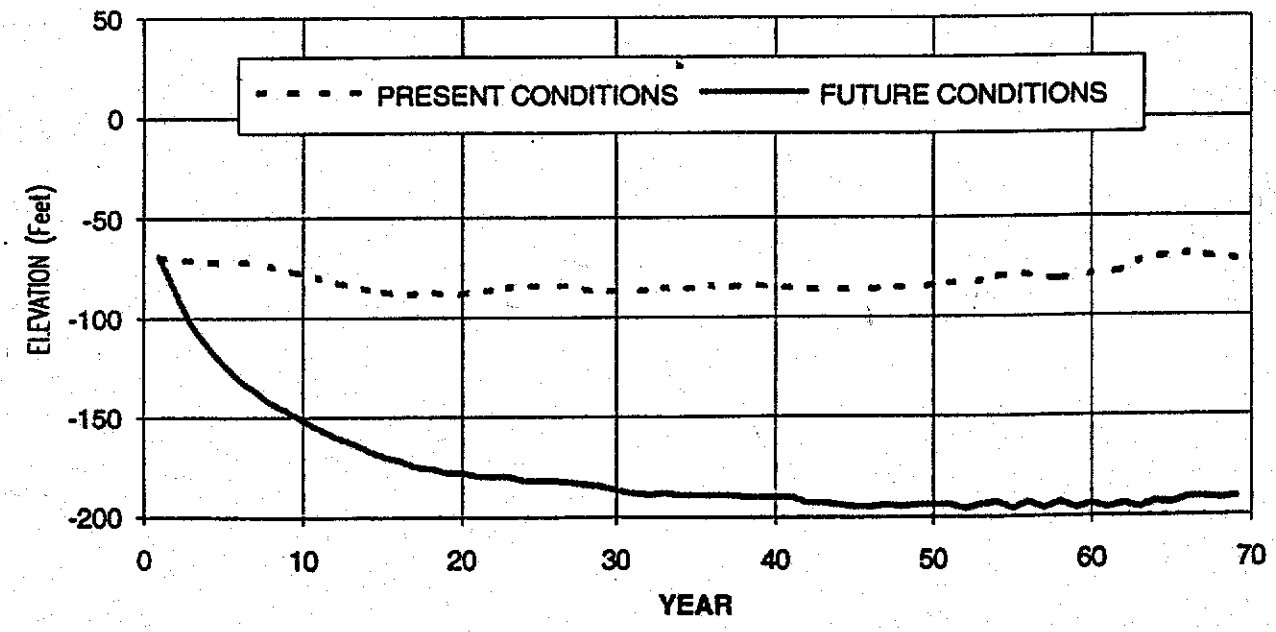


FIGURE 7-2

BASIN-WIDE MINIMUM GROUNDWATER LEVELS



Section 8

SECTION 8

SUMMARY AND RECOMMENDATIONS

8.1 SUMMARY

A hydrologic model has been developed and calibrated for the Sacramento County Water Agency. The model is capable of simulating groundwater flows and levels as well as surface water flows and runoff. Results of the model calibration indicate that the model is capable of reproducing long-term trends as well as seasonal fluctuations in water levels. The difference between simulated water levels and observed water levels averaged less than five feet for the twenty-one year calibration period (1970-1990).

The hydrologic model developed of the Sacramento County groundwater basin, titled the Integrated Groundwater - Surface Water Model-IGSM, is a comprehensive hydrologic model which incorporates all of the key hydrologic components of the basin. Hence, in the development and calibration of the model, these key hydrologic components have been reviewed and analyzed in detail. The following is a summary of these components:

Rainfall: The average annual rainfall in the basin is approximately 19 inches. The greatest amount of rainfall occurs in the eastern foothills and the least amount in the southwest long the Sacramento River. The rainfall in the area is seasonal (most rainfall occurs from November to March) and the amount of rainfall is highly variable from year to year. Due to the small amounts of rainfall, groundwater recharge resulting from rainfall is relatively small as compared to other sources of groundwater recharge.

Streamflow: One of the primary groundwater recharge sources in the Sacramento area groundwater basin is seepage losses from streams. The primary rivers in Sacramento County are the Sacramento River, American River, and Cosumnes River. The Sacramento River drains the entire Sacramento Valley and its flows are largely regulated by many upstream reservoirs and diversions. The Sacramento River is the largest river in California and flows along the western boundary of Sacramento County before ultimately discharging into the San Francisco Bay-Delta.

The American River and Cosumnes River both drain the eastern side of the Sierra with a flow direction of east to west. The American River is the larger of these two rivers and its flow is regulated by Folsom Reservoir, located in Northeastern Sacramento County. The Cosumnes River watershed is largely unregulated and in most years the downstream flows are intermittent with no flow occurring in the summer months.

There are numerous other smaller streams and creeks that drain Sacramento County. In general, the flow direction of these creeks is from east to west and they ultimately drain to the Sacramento River. These streams are primarily intermittent streams, with little or no upstream regulation.

Summary and Recommendations

Land Use: Land use is a key factor in the hydrology of Sacramento County as the type of land cover has an impact on the amount of surface water runoff and percolation into the soils. Over the past twenty years, many areas in Sacramento County have undergone a transition from agricultural and rural areas to urban and residential areas. The primary areas of urban development have been in the City of Sacramento (north and south of the American River) as well as much of the area adjacent to and north of the American River. These areas include North Highlands, Citrus Heights, Rancho Cordova, Orangevale, and Fair Oaks. Recent urban development has been focused in the Natomas, Elk Grove, and Sunrise areas.

The primary agricultural areas of the County are in the northwest portion of the County (Natomas Mutual Irrigation District), and in the south and central County (Galt Irrigation District, Clay Water District, Omochumne-Hartnell Water District, Southwest, and Courtland areas. The eastern side of the County is largely undeveloped.

Water Supply: Sacramento County is served by numerous water agencies and districts who obtain water through either surface sources, groundwater or a combination. The City of Sacramento is the largest water purveyor in the County, and it supplies both groundwater (from numerous wells located within the city area), as well as surface water (from surface water diversions along the American and Sacramento Rivers). The urban areas in the northeast portion of the County (San Juan, Fair Oaks, Orangevale, Citrus Heights), are supplied largely by surface water diversions from Folsom Lake, whereas urban districts to the west rely heavily on groundwater (Citizens Utility, Northridge Arcade, etc.).

The Folsom South Canal diverts water from the American River and has historically supplied Rancho Seco Nuclear Power Plant as well as the irrigation districts located adjacent to the canal. However, most of the irrigation districts located within the County area rely heavily on groundwater pumping for water, with the exception of Natomas Mutual Irrigation District and the Courtland area which utilize diversions from the Sacramento River for most of their agricultural water needs.

Soils: As with land use, soil types play a key role in the amount of surface water runoff and percolation that occurs as a result of rainfall. Soils with high runoff potential allow for little infiltration whereas soils with low runoff potential allow for higher infiltration rates. In general, the soils within Sacramento County have high runoff and low infiltration capacities. An exception to this is along the American and Cosumnes River where the infiltration capacities of the soils tend to be higher.

Groundwater Levels: Groundwater level measurements have been available in the Sacramento County area since the early 1900s. These early measurements indicated a positive groundwater gradient sloping from the Sierra foothills towards the Sacramento River. DWR had estimated the average County-wide groundwater levels to be at 30 feet above mean sea level in the 1930s. However, between 1940 and the early 1970s the County-wide average declined to about five feet below

sea level. In addition, three distinct groundwater cones of depression have developed due to localized intensive groundwater pumping. These areas of lowered groundwater levels are located in the northern County (adjacent to McClellan Air Force Base), in the Elk Grove area, and in the Galt area. The groundwater levels in these areas had been declining at the rate of one to three feet per year until the 1970s. However, it appears that these declining rates are somewhat smaller in recent years. It is probably due to recent decreases in groundwater pumping in association with agricultural irrigation acreage reduction, and also increased streamflow recharge and boundary inflows caused by lowered groundwater tables.

Aquifer Recharge:

The primary sources of aquifer recharge in the Sacramento County area are stream recharge, deep percolation, and subsurface boundary inflow. Deep percolation is highly dependent on land use, soil types, and amount of rainfall. The greatest proportion of percolation in the County occurs in agricultural areas. In these areas, both the natural rainfall, and the applied irrigation water contribute an average of approximately seven inches of deep percolation. However, in undeveloped areas, deep percolation is on the average less than one inch, due primarily to the relatively low amounts of rainfall, high evapotranspiration rates, and relatively tight, clayey soils.

Subsurface boundary inflow is also a significant source of groundwater recharge. The aquifers in Sacramento County are part of the regional aquifer system which extends throughout California's Central Valley. As such, the local aquifer system is hydrologically connected to the aquifer system in the surrounding counties including Placer, Sutter, Yolo, and San Joaquin Counties. This hydraulic connection, in conjunction with depressed water levels in many areas of the County, has resulted in the potential for movement of groundwater from outside the County towards the cone of depressions within the County area.

RECOMMENDATIONS

The hydrologic model developed for the Agency is to be utilized both as a planning and analysis tool. The model can be used as an analysis tool to increase the knowledge of the County groundwater basin's hydrology and the interaction between the various hydrologic components of the basin. In addition, the model can be used as a planning tool to evaluate the response of the basin to various land use and groundwater management scenarios.

The data from which the model was developed represents the best use of available information. Where data did not exist, engineering judgment and experience were required. The Agency has implemented various programs, such as monthly urban water use and spring/fall well monitoring reports, that have significantly contributed to the development of the model. It is recommended that this program be continued and utilized to update the model and verify the reliability of the model. However, as described below, there are several areas where the data collection efforts of the Agency should be expanded.

Hydrogeologic Data: One of the most significant data sets for any groundwater model is the stratigraphic data. This is also the data where accurate, hard data is most often lacking. For the model of the Sacramento County basin, the stratigraphic data developed was based on an exhaustive review of well logs and previous hydrogeologic investigations. However, much of the stratigraphic data was interpolated based on the best available information; nevertheless, much data was lacking, especially for the deeper aquifers. As more information on the basin's geology becomes available, it is recommended that the data be reviewed and the model refined accordingly.

Land Use/Crop Acreage Data: The land use and crop acreage data incorporated in the model was based on 1976 and 1984 DWR land use surveys. In addition, DWR estimates for 1990 crop acreages were also incorporated in the model. The Agency should maintain close coordination with the DWR such that future land use surveys and/or revisions to the 1990 crop acreage estimates are incorporated into the model.

Urban Water Use Data: The Agency presently collects urban water use data for most water supply agencies within the County. This data is tabulated and maintained by agency for both total groundwater, and total surface water supplies. In order to update the model in the future, it is recommended that the Agency include all water purveyors in the study area (including Rancho Murieta and the City of Galt). In addition, more detailed information should be collected on:

- Total monthly pumping at each well
- Total monthly surface water diversion for each diversion point.

Agricultural Water Use Data: With the exception of agricultural water diversions in the Natomas area and deliveries by the Folsom South Canal, most of the agricultural water use data (surface water and groundwater) was estimated based on the consumptive use method. This method of estimating agricultural water use is based on crop types and acreage, potential evapotranspiration, and soil moisture deficiencies. While this method of estimating agricultural water use is generally reliable, the results should be confirmed through either the analysis of power data or through actual metering of agricultural production wells. Due to the vast number of agricultural wells in the area, it is recommended that a data collection effort be coordinated with Sacramento Municipal Utility District to obtain power records for agricultural wells. These power records, used in conjunction with estimated and measured pumping efficiencies, should be used to confirm model estimates of agricultural pumping. In addition, a data collection effort should be coordinated with the U.S. Bureau of Reclamation, DWR, and individual irrigation districts to obtain monthly surface water diversions for agricultural use.

Appendix A

Table A-1

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	AWD	4	285	1																60						
POU-North	AWD	7	210	1																			20		20	20
POU-North	AWD	8	306	1																		20			20	
POU-North	AWD	9	270	1													20	20							20	
POU-North	AWD	10	285	1																			20		20	20
POU-North	AWD	11	310	1																		20				
POU-North	AWD	12	284	1																		20			20	
POU-North	AWD	25	318	1																			20			
POU-North	AWD	28	370	1																		20			20	
POU-North	AWD	34	400	1																			20			20
POU-North	AWD	35	287	1																		20			20	20
POU-North	AWD	47	350	1																						20
POU-North	AWD	48	336	1													20							20		
POU-North	AWD	49	335	1																		20			20	
POU-North	AWD	50	160	1																				20		
POU-North	AWD	51	370	1																			20			20
POU-North	AWD	68	300	1																					20	20
POU-North	AWD	70	285	1																			20			
POU-North	CUCC	25	380	1														20					20			20
POU-North	CUCC	36	400	1							70													320		
POU-North	CUCC	37	340	1																				310		
POU-North	CUCC	66	325	1																		20			20	
POU-North	CUCC	86	295	1																			20			20
POU-North	CITY	46		1							20	1400	10													
POU-North	CITY	80	180	1								10	20	10												
POU-North	CITY	93	318	1																			20	20	20	
POU-North	CITY	94	351	1														20	20	20	20	20				
POU-North	CITY	112	380	1														20	20		470		3000			
POU-North	CITY	114	380	1																		80		40		
POU-North	CITY	123	305	1																110				20		
POU-North	CITY	124	308	1																70				20		
POU-North	CITY	125	300	1															180	20						
POU-North	CITY	129	300	1														20		20		20		80		
POU-North	CITY	131	280	1														20	120	20		20		20		
POU-North	CITY	132	232	1														20	220	70		120		130		
POU-North	CITY	137	410	1														20	20	20		20			20	
POU-North	CITY	186	380	1														180	20	20		20		100		
POU-North	NWD	1	815	1																			20			67
POU-North	NWD	3	285	1										70						20			20		20	

Table A-1
(Continued)

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	SCWMD	AW2	246	1					29																	
POU-North	SCWMD	AW3	244	1																			29			29
POU-North	SCWMD	AW4	264	1					29													29			29	
POU-North	SCWMD	AW7	296	1					29														29			29
POU-North	SCWMD	AW9	248	1					29								30							29	29	
POU-North	SCWMD	AW11	317	1					30															29	29	
POU-North	SCWMD	AW22	265	1					60						4		29					29			29	
POU-North	AWD	5	425	1(B)										29								29	29		29	29
POU-North	AWD	22	360	1(B)																			29			29
POU-North	AWD	32	380	1(B)																		29			29	
POU-North	AWD	33	320	1(B)																				29		
POU-North	AWD	36	336	1(B)																					29	
POU-North	AWD	54	560	1(B)																				29		
POU-North	AWD	65	347	1(B)																		29			29	
POU-North	AWD	66	396	1(B)																		29			29	
POU-North	CITY	91	370	1(B)																		29		29		
POU-North	CITY	92	422	1(B)															29	29	29	150				
POU-North	CITY	110	340	1(B)														120	29	29			29	40	29	
POU-North	CITY	118	340	1(B)																	29	29	29	70	29	
POU-North	CITY	119	340	1(B)														29	29	280		29			29	
POU-North	CITY	143	330	1(B)														29	220	29				29	29	
POU-North	CITY	151	346	1(B)																						
POU-North	CITY	152	331	1(B)								40	40	360					360	29		50				
POU-North	CITY	158	328	1(B)																		29			29	
POU-North	DPMWD		360	1(B)																			29			
POU-North	DPMWD		422	1(B)											29							29	29		29	
POU-North	NWD	21	426	1(B)					80																	29
POU-North	SCWMD	AW5	340	1(B)					29													29		29	29	
POU-North	SCWMD	AW35	371	1(B)																						
POU-North	AWD	63																				29			29	
POU-North	AWD	14	480	2																		29			29	29
POU-North	AWD	30	480	2																			29			
POU-North	DPMWD		404	2														29								29
POU-North	NWD	20	602	2										130												140
POU-North	AWD	13	374	3											29								29			
POU-North	AWD	16	374	3																				29		
POU-North	AWD	19	395	3																			29		29	
POU-North	AWD	20A	475	3																			29			29

Table A-1
(Continued)

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	AWD	23	360	3																				29		
POU-North	AWD	24	380	3																			29			29
POU-North	AWD	26	360	3																				29		
POU-North	AWD	27	320	3																		29			29	29
POU-North	AWD	37	405	3																				29		
POU-North	AWD	38	375	3																				29		
POU-North	AWD	40	425	3																				29		
POU-North	AWD	41	425	3																				29		
POU-North	AWD	42	410	3																				29		
POU-North	AWD	43	380	3																			29		29	
POU-North	AWD	45	395	3																				29		
POU-North	AWD	46R	410	3																		29			29	
POU-North	AWD	55	375	3																		29			29	29
POU-North	AWD	56	645	3																		29	29	29		
POU-North	AWD	60	450	3																			29			29
POU-North	AWD	2A	800	3																		120			29	
POU-North	AWD	3A	440	3													29					90			29	64
POU-North	CUCC	29	386	3																			29			29
POU-North	CITY	61	360	3								10	30	10												
POU-North	CITY	120	440	3																670		370		29		
POU-North	CITY	122	422	3														29	29	29			29		29	
POU-North	CITY	126	462	3																				10		
POU-North	CITY	127	401	3																130			20		50	
POU-North	CITY	133	514	3															29	970		60		29		
POU-North	CITY	134	515	3																29		60				
POU-North	CITY	135	450	3								10	2600	10												
POU-North	CITY	136	395	3														29	29	29		29		29		
POU-North	CITY	138	375	3														29	29	29		29		29		
POU-North	CITY	139		3																		29	10	20	60	
POU-North	CITY	142	394	3																	110		29		29	
POU-North	CITY	144	372	3														29	29	29		190		29		
POU-North	CITY	150	372	3																		670				
POU-North	CITY	153	600	3																				29	29	
POU-North	CITY	154	412	3																29		29		29		
POU-North	CITY	155	427	3														29	29	29		29		50		
POU-North	CITY	157	377	3																29			29		29	
POU-North	CITY	158	376	3														29		29		40				
POU-North	CITY	161	400	3																250						
POU-North	DPMWD		500	3																		29	29		29	

Table A-1
(Continued)

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	DPMWD		400	3																					29	
POU-North	DPMWD		460	3																					29	
POU-North	DPMWD		380	3																					29	
POU-North	DPMWD		390	3										30								29			29	
POU-North	NWD	6	609	3																			64			29
POU-North	NWD	7	469	3																						29
POU-North	NWD	9	535	3																		29	29			29
POU-North	NWD	10	533	3												29							29			29
POU-North	NWD	11	565	3															850				630			
POU-North	NWD	13		3																			60			
POU-North	NWD	14	580	3									29										29			29
POU-North	NWD	15	534	3									29									29	29			29
POU-North	NWD	17	560	3									29									29	29			29
POU-North	NWD	18	576	3													29						120			160
POU-North	NWD	19	621	3									190		29								62			47
POU-North	NWD	23	553	3																		29	29			29
POU-North	SCWMD	AW8	404	3			30		80								29					29			29	
POU-North	SCWMD	AW14	428	3					30															29	29	
POU-North	SCWMD	AW21	432	3					70															29	29	
POU-North	SCWMD	NW1	480	3										29										29	29	29
POU-North	SCWMD	NW15	480	3																				29		
POU-North	SCWMD	NW36	530	3										29										29		
POU-North	SCWMD	NW37	800	3																			29			29
POU-North	CITY	111		4																		29				
POU-South	CUCC	2	268	1																			29			29
POU-South	CUCC	6	295	1																				370		
POU-South	CUCC	14	450	1																		2300			29	
POU-South	CUCC	16	302	1																		29		29		
POU-South	CUCC	24	494	1																		100			29	
POU-South	CUCC	41	168	1																		29			29	
POU-South	CUCC	43	368	1																			29	29		29
POU-South	CUCC	44	324	1													29						29			36
POU-South	CUCC	45	465	1												29							29			
POU-South	CUCC	52	332	1																		60			29	
POU-South	CUCC	55	276	1																						29
POU-South	CUCC	57	382	1												29						30			29	
POU-South	CUCC	64	284	1																			29			29

Table A-1
(Continued)

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-South	CUCC	86	284	1																						
POU-South	CUCC	88	391	1																		40			29	
POU-South	CUCC	87	316	1																		29	29			29
POU-South	CUCC	89	358	1																		29			29	
POU-South	CUCC	91	490	1																		29			29	29
POU-South	CUCC	94	388	1														29				40			29	
POU-South	CUCC	97	406	1																			29			29
POU-South	CITY	46	178	1						320	420		4900									100			29	
POU-South	CITY	83	256	1																						
POU-South	CITY	85	300	1							10		460	30							29		29		29	
POU-South	CITY	107	210	1																						
POU-South	CITY	108	140	1							30	90	10												29	
POU-South	CITY	160	220	1							130	180	210	40												
POU-South	FCWD	1	252	1																						
POU-South	FCWD	3	282	1																29			29			29
POU-South	FCWD	5	180	1																			29			29
POU-South	FCWD	6	270	1																		29			29	
POU-South	FCWD	8	270	1																						29
POU-South	FVWD	2	224	1																		29			29	
POU-South	FVWD	4	270	1																			29		29	
POU-South	FVWD	9	272	1														29								29
POU-South	FVWD	10	315	1																					29	
POU-South	FVWD	11	270	1																		29			29	
POU-South	FVWD	12	236	1																		29			29	29
POU-South	FCWD	7	305	1(B)																					29	
POU-South	FVWD	1	321	1(B)													29								29	
POU-South	FVWD	3	315	1(B)																			29		29	
POU-South	FVWD	5	320	1(B)																			29		29	
POU-South	FVWD	7	278	1(B)										29											29	
POU-South	FVWD	8	284	1(B)																		29			29	
POU-South	FVWD	14	345	1(B)																		29			29	29
																							29			29
POU-South	CUCC	7	340	2												29						2800			400	
POU-South	CUCC	8	486	3																		29			29	
POU-South	CUCC	33	395	3																			29	2000		
POU-South	CUCC	27	395	3																		130			29	
POU-South	CUCC	49	530	3																			29			29
POU-South	CUCC	80	460	3																				1000		
POU-South	CUCC	82	462	3																		1000	960	910		29

Table A-1
(Continued)

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-South	FVWD	6	400	3																					29	
POU-South	FVWD	19	405	3																		29			29	29
POU-South	FVWD	15	300	3																						29
POU-South	CITY	1	307	3						250	40		7300													
POU-South	CITY	8	325	3						570		730	1000													
POU-South	CITY	2		4						90	100		1900													
POU-South	CITY	3		4						10	70		6700													
POU-South	CITY	4		4						20	60		230													
POU-South	CITY	20		4							10	230	30													
Zone 40	EGWD	1	283	1										29										29		29
Zone 40	EGWD	3	336	1														29						29		29
Zone 40	EGWD	5	492	1												29										60
Zone 40	EGWD	7	264	1											110											
Zone 40	SCWMD	LW40	280	1																		29		29	29	29
Zone 40	SCWMD	LW41	280	1																		280		29	29	29
Zone 40	SCWMD	LW42	247	1																		60		29	29	29
Zone 40	SCWMD	LW43	285	1																		29		29	29	29
Zone 40	SCWMD	LW44	310	1																		160		29	29	32
Zone 40	SCWMD	LW45	295	1																		29			29	29
Zone 40	SCWMD	LW46	280	1																	29				550	29
Zone 40	SCWMD	LW50	301	1																		29			29	29
Zone 40	SCWMD	LW51	285	1																		29			250	29
Zone 40	SCWMD	LW52	285	1																		60			5	
Zone 40	SCWMD	NW16	400	1												240								29		
Zone 40	SCWMD	VW02	307	1																					29	
Zone 40	SCWMD	H19	225	1																						
Zone 40	SCWMD	H20	140	1																						
Zone 40	EGWD	4	330	1(B)													29									29
Zone 40	SCWMD	LW49	302	1(B)																	29				29	29
Zone 40	SCWMD	LW32	420	1(B)																						
Zone 40	SCWMD	LW39	400	1(B)																						
Zone 40	EGWD	11	680	2																						60
Zone 40	SCWMD	VW00	980	2																				29	29	29
Zone 40	SCWMD	VW01	980	2																			29		29	29
Zone 40	EGWD	6	680	3																		700			35	
Zone 40	EGWD	9	495	3											70					29						

Table A-1
(Continued)

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Zone 40	EGWD	9	585	3											110										20	
Zone 40	EGWD	12	500	3																			20			20
Zone 40	SCWMD	GW27	470	3																				20		
Zone 40	SCWMD	GW28	800	3																				20	150	
Zone 40	SCWMD	GW29	480	3																			20			35
Zone 40	SCWMD	LW46	800	3																				20	20	20
Zone 40	SCWMD	LW47	800	3																		95		60	20	20
Zone 40	SCWMD	VW83	800	3																					41	
Zone 40	CUCC	17		4																				120		
Zone 40	CUCC	18		4																				1300		
Zone 40	CUCC	77	306	4																						58
Rio Linda	RLWD	1	453	1										20								100			20	
Rio Linda	RLWD	2	210	1												20										20
Rio Linda	RLWD	3	257	1																					20	
Rio Linda	RLWD	5	512	1													20									20
Rio Linda	RLWD	7	395	1																						20
Rio Linda	RLWD	8	393	1																			10			20
Rio Linda	RLWD	10	575	1																		20				20
Rio Linda	RLWD	9	522	1(B)																		50				20
Rio Linda	RLWD	11	417	1(B)																			100			20
Rio Linda	RLWD	4	492	3																					20	
Rio Linda	RLWD	6	570	3																	20		20			20
Rio Linda	RLWD	12	595	3																			120			20
Citizens-A	CUCC	13	384	1																		80			20	
Citizens-A	CUCC	31	304	1														20				70	20		20	
Citizens-A	CUCC	34	484	1																			20			20
Citizens-A	CUCC	48	306	1																30						
Citizens-A	CUCC	59	318	1											20											
Citizens-A	CUCC	60	367	1										20									20			20
Citizens-A	CUCC	61	349	1																			20			20
Citizens-A	CUCC	9	353	1(B)																		80			20	
Citizens-A	CUCC	19	396	1(B)																		20			20	
Citizens-A	CUCC	22	410	1(B)																		160			20	
Citizens-A	CUCC	28	398	1(B)																			20			20

Table A-1
(Continued)

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Citizens-A	CUCC	35	354	1(B)																			20			47
Citizens-A	CUCC	38	332	1(B)																					20	
Citizens-A	CUCC	40	338	1(B)																						20
Citizens-A	CUCC	58	459	1(B)																		130			20	20
Citizens-A	CUCC	63	312	1(B)																			20			20
Citizens-A	CUCC	15	495	3												20							20			20
Citizens-A	CUCC	39	436	3																		60			20	20
Citizens-A	CUCC	53	495	3																			20			20
Citizens-A	CUCC	54	547	3														20								
Citizens-A	CUCC	68	540	3										20												
Citizens-A	CUCC	79	540	3																			20			
Citizens-A	CUCC	5		4																			20			20
Citizens-A	CUCC	11	510	4																		120			20	
Citizens-A	CUCC	21	505	4																			20			20
Citizens-A	CUCC	51	445	4																			20			20
Arcade	AWD	60R	427	1																			20	20		
Arcade	AWD	39	395	1(B)																			20			20
Arcade	AWD	31A	600	3																			20			20
Arcade	AWD	52	600	3																20		20			20	20
Arcade	AWD	57	655	3																				20		
Arcade	AWD	59	600	3																		20			20	
Arcade	AWD	64	630	3										20								20			20	20
Citrus Height	CHWD	2	421	2																			20			20
Citrus Height	CHWD	3	402	3																					20	
Citrus Height	CHWD	6	804	3																			20		20	
Northridge	NWD	32	342	1																						20
Northridge	NWD	30	405	1(B)																			20			20
Northridge	NWD	8	620	2																			220			120
Northridge	NWD	5	632	3																		20	20			20

Table A-1
(Continued)

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Northridge	NWD	12	530	3																		20				20
Northridge	NWD	24	524	3																		40	35			20
Northridge	NWD	25	554	3																			20			
Northridge	NWD	26	465	3																		20	20			20
Northridge	NWD	27	509	3																			20			20
Northridge	NWD	28	454	3													20									
Northridge	NWD	29	525	3																						20
Northridge	NWD	31	524	3																						20
Northridge	NWD	33		3																			20			
Orangevale	OMWCD	1	315	2											20							20			20	
Fair Oaks	FOWD	6	475	2										600												20
Fair Oaks	FOWD	7	603	2										110												
Fair Oaks	FOWD	8	492	2																		20				
Fair Oaks	FOWD	1	600	3										600						20		20				130
Fair Oaks	FOWD	3	904	3										180									20			20
Fair Oaks	FOWD	4	600	3										60		20				20					20	
Fair Oaks	FOWD	5	700	3														20					20			20
Carmichael	CWD	1		4												20									20	
Carmichael	CWD	2		4																			20			
Carmichael	CWD	3		4																		160			20	
Carmichael	CWD	4		4																					20	
Carmichael	CWD	5		4										20									20		20	
Carmichael	CWD	6		4																						20
Carmichael	CWD	7	600	4																			20			20
Carmichael	CWD	8		4																						20
Carmichael	CWD	9		4																					34	20
Carmichael	CWD	10		4													20					20				20
Carmichael	CWD	13		4																						52
Carmichael	CWD	14		4																						20
Arden-Cordova	ACWD	9	240	1(B)																			20			

Table A-1
(Continued)

IRON CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

SubArea	Agency	Well ID	Depth	Layer	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Arden-Cordova	ACWD	18	980	2																			29			
Arden-Cordova	ACWD	1	306	3																			29			
Arden-Cordova	ACWD	11	466	3																			29			
Arden-Cordova	ACWD	5	480	3																			29			
Arden-Cordova	ACWD	7	388	3																			29			
Arden-Cordova	ACWD	12	556	3																			51			
Arden-Cordova	ACWD	6	425	3																			29			
Arden-Cordova	ACWD	9	460	3																			29			
Arden-Cordova	ACWD	15	568	3																			29			
Arden-Cordova	ACWD	14	446	3																			29			
Arden-Cordova	ACWD	8	405	3																			29			
Arden-Cordova	ACWD	16	586	3																			29			
Arden-Cordova	ACWD	17	502	3																			29			
Citizens-B	CUCC	42	308	1																		150			29	
Citizens-B	CUCC	80	324	1																				29		
Citizens-B	CUCC	32	432	3																29			600			
Citizens-B	CUCC	46	525	3																			29			29
Citizens-B	CUCC	70	384	3																		29			29	
Citizens-B	CUCC	76	700	3																		29			29	
Citizens-B	CUCC	85	377	3												29							29			29
Citizens-B	CUCC	12	276	4																			29			29
Citizens-B	CUCC	88	800	4																			29			29
Sunrise	SCWMD	SW18	380	3										100						29	29		29			29
Sunrise	SCWMD	SW17	315	3																				29	29	

Note: * Values assigned 29 ug/l were reported below detection limit (<30 ug/l)

Table A-2

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	AWD	4	265	1																		9	9
POU-North	AWD	7	210	1						29							10			9		9	
POU-North	AWD	8	305	1										49	29							9	
POU-North	AWD	9	270	1																			9
POU-North	AWD	10	265	1															9	9			
POU-North	AWD	11	310	1																		9	
POU-North	AWD	25	318	1																9			
POU-North	AWD	28	370	1															9			9	
POU-North	AWD	34	400	1																9			9
POU-North	AWD	35	297	1															9			9	9
POU-North	AWD	47	350	1																		9	
POU-North	AWD	49	335	1											49				9			9	
POU-North	AWD	51	370	1																9			9
POU-North	AWD	68	300	1																		60	61
POU-North	AWD	70	285	1																9			12
POU-North	CUCC	25	360	1											49					9			9
POU-North	CUCC	36	403	1					9												240		
POU-North	CUCC	37	340	1																	53		
POU-North	CUCC	86	325	1															40			9	
POU-North	CUCC	88	295	1																			9
POU-North	CITY	48		1					9		9												
POU-North	CITY	50	190	1					9		9												
POU-North	CITY	93	316	1														9	50	9		9	
POU-North	CITY	94	351	1											9	9	9		9	9	9		
POU-North	CITY	112	380	1											9			9		9		9	
POU-North	CITY	114	380	1															9		9		
POU-North	CITY	123	305	1														9			210		
POU-North	CITY	124	306	1														9			9		
POU-North	CITY	125	300	1												9	9			9			
POU-North	CITY	129	300	1											9		9		9				
POU-North	CITY	131	280	1											9	9	9		9		9		
POU-North	CITY	137	410	1											20	9	9		9			9	
POU-North	CITY	156	380	1											9	9	9		9		9		
POU-North	NWD	1	315	1													10			9			18
POU-North	NWD	3	285	1						40						9				9			9

Table A-2
(Continued)

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	SCWMD	AW2	246	1		59														9			9
POU-North	SCWMD	AW3	244	1		59													9			9	
POU-North	SCWMD	AW4	264	1		59		11												9			9
POU-North	SCWMD	AW7	296	1																49			
POU-North	SCWMD	AW9	249	1		59	20	10						9						49		9	
POU-North	SCWMD	AW11	317	1		59														49			
POU-North	SCWMD	AW22	265	1		59		301											9			9	
POU-North	AWD	5	425	1(B)																9		9	9
POU-North	AWD	22	350	1(B)																9			9
POU-North	AWD	32	360	1(B)															9			9	
POU-North	AWD	36	335	1(B)																9		9	
POU-North	AWD	54	550	1(B)													9						
POU-North	AWD	65	347	1(B)															9			9	
POU-North	AWD	66	398	1(B)															9			9	
POU-North	CITY	91	370	1(B)															9		9	9	
POU-North	CITY	92	422	1(B)												9	9				9		
POU-North	CITY	110	340	1(B)																	9	9	
POU-North	CITY	116	340	1(B)											9	9	9			9		9	
POU-North	CITY	117	340	1(B)															9		9		
POU-North	CITY	119	340	1(B)														9		9		9	
POU-North	CITY	143	330	1(B)											9	9	9		9		9		
POU-North	CITY	151	346	1(B)											9	9	9			9		9	
POU-North	CITY	152	331	1(B)					10		10												
POU-North	CITY	158	326	1(B)													9		9				
POU-North	DPMWD		360	1(B)																		9	
POU-North	DPMWD		422	1(B)																9		9	
POU-North	NWD	21	426	1(B)						9									9	9			9
POU-North	SCWMD	AW5	340	1(B)		59		1												49		9	
POU-North	SCWMD	AW35	371	1(B)		59		1					10	9					9			9	
POU-North	AWD	30	460	2																89			
POU-North	DPMWD		404	2											49				10				9
POU-North	NWD	20	602	2							29	100											69
POU-North	AWD	2A	600	3															9			14	
POU-North	AWD	3A	440	3										49					40			67	490
POU-North	AWD	13	374	3							49								9	9		9	9

Table A-2
(Continued)

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	AWD	19	365	3																9		9	
POU-North	AWD	20A	475	3																9			9
POU-North	AWD	24	360	3																9			9
POU-North	AWD	27	320	3															9			9	9
POU-North	AWD	41	425	3												20							
POU-North	AWD	43	390	3																9		9	
POU-North	AWD	46R	410	3															280			150	
POU-North	AWD	55	375	3															9			9	9
POU-North	AWD	56	645	3															9	9			
POU-North	AWD	60	450	3																9			9
POU-North	CUCC	29	396	3																9			9
POU-North	CITY	61	390	3					9		9												
POU-North	CITY	120	440	3												9	870		9		9		
POU-North	CITY	122	422	3											9	9	9			9		9	
POU-North	CITY	126	452	3																	9		
POU-North	CITY	127	401	3														9		9		9	
POU-North	CITY	133	514	3												9	40		9		9		
POU-North	CITY	134	515	3												9	9		9		9		
POU-North	CITY	135	450	3				9		9													
POU-North	CITY	136	385	3											9	9	9		9		9		
POU-North	CITY	139	375	3											9	9	9		9		9		
POU-North	CITY	142	384	3														9		9		9	
POU-North	CITY	144	372	3											9	9	9		9		9		
POU-North	CITY	150	372	3															10				
POU-North	CITY	153	600	3																9		9	
POU-North	CITY	154	412	3												9	9		9		9		
POU-North	CITY	155	427	3											9	9	9		9		9		
POU-North	CITY	157	377	3														10		9		30	
POU-North	CITY	159	375	3											9	9	9		9				
POU-North	CITY	161	400	3													480						
POU-North	DPMWD		500	3															50			22	
POU-North	DPMWD		400	3																9		9	
POU-North	DPMWD		490	3																		9	
POU-North	DPMWD		390	3																		9	
POU-North	DPMWD		390	3															9			9	
POU-North	NWD	6	508	3																9			9

Table A-2
(Continued)

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	NWD	7	469	3																			9
POU-North	NWD	8		3																			57
POU-North	NWD	9	535	3										49					9	30			25
POU-North	NWD	10	533	3																9			9
POU-North	NWD	11	585	3												390				730			
POU-North	NWD	13	623	3																290			
POU-North	NWD	14	560	3						9										9			9
POU-North	NWD	15	534	3						9									9	9			9
POU-North	NWD	17	550	3						9				49					9	9			9
POU-North	NWD	18	575	3																90			100
POU-North	NWD	19	621	3						80		100								140			140
POU-North	NWD	23	553	3															9	22			18
POU-North	SCWMD	NW37	500	3																9			9
POU-North	SCWMD	AW8	404	3		59		10											9			9	
POU-North	SCWMD	AW14	428	3		59		20													670	9	
POU-North	SCWMD	AW21	432	3		59														49		9	
POU-North	CITY	139		4															9		9		
POU-North	SCWMD	AW10		4		59		10						9								9	
POU-South	CUCC	2	268	1																9			9
POU-South	CUCC	6	295	1																	120		
POU-South	CUCC	14	450	1															10			9	
POU-South	CUCC	16	302	1															9				
POU-South	CUCC	24	434	1															9			9	
POU-South	CUCC	41	158	1															9			9	
POU-South	CUCC	43	358	1																9			9
POU-South	CUCC	44	324	1										49						9			9
POU-South	CUCC	45	455	1									49							9			
POU-South	CUCC	52	332	1															9			9	
POU-South	CUCC	55	276	1										49						9			9
POU-South	CUCC	57	282	1															9			9	
POU-South	CUCC	64	284	1																9			9
POU-South	CUCC	65	284	1															40	9		9	
POU-South	CUCC	66	391	1															9				9
POU-South	CUCC	67	316	1															9			9	
POU-South	CUCC	69	268	1															9			9	9

Table A-2
(Continued)

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-South	CUCC	81	490	1											49				9			9	
POU-South	CUCC	84	368	1												10				9			9
POU-South	CUCC	87	406	1															9			9	
POU-South	CITY	46	176	1				1730	2000		2100												
POU-South	CITY	83	255	1														9		9		9	
POU-South	CITY	85	300	1				9		9	9												
POU-South	CITY	107	210	1														9		9			
POU-South	CITY	108	140	1				30	9		9												
POU-South	CITY	160	220	1					40	70	40												
POU-South	FCWD	1	252	1													9			9			9
POU-South	FCWD	3	262	1																9			9
POU-South	FCWD	5	180	1															9				
POU-South	FCWD	6	270	1																			9
POU-South	FCWD	8	270	1										49					30				
POU-South	FVWD	2	224	1																9		9	
POU-South	FVWD	4	270	1											19								9
POU-South	FVWD	9	272	1																		9	
POU-South	FVWD	10	315	1															9			57	
POU-South	FVWD	11	270	1															9			9	9
POU-South	FVWD	12	236	1																		17	
POU-South	FCWD	7	305	1(B)																			
POU-South	FVWD	1	321	1(B)																9		9	
POU-South	FVWD	3	315	1(B)																9		9	
POU-South	FVWD	5	320	1(B)						140												9	
POU-South	FVWD	7	278	1(B)															9			9	
POU-South	FVWD	8	294	1(B)															60			61	56
POU-South	FVWD	14	345	1(B)																9			9
POU-South	CUCC	7	840	2							49								40			94	
POU-South	CUCC	8	485	3															9			9	
POU-South	CUCC	23	385	3																9	2500		
POU-South	CUCC	27	285	3															9			9	
POU-South	CUCC	49	530	3																9	81		9
POU-South	CUCC	50	460	3																	1900		
POU-South	CUCC	82	452	3																	1900		
POU-South	CUCC	83	500	3															190	200			170
POU-South	FVWD	13	405	3															9			9	9

Table A-2
(Continued)

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-South	FVWD	15	300	3																			110
POU-South	CITY	1	307	3				1200	450		1100												
POU-South	CITY	8	325	3				710		820	760												
POU-South	CITY	2		4				640	300		9												
POU-South	CITY	3		4				460	300		1100												
POU-South	CITY	4		4				250	190		70												
POU-South	CITY	20		4					9	9	9												
POU-South	FVWD	6	400	4																		9	
Zone 40	TIZENS UT	76	306	1																			9
Zone 40	EGWD	1	283	1							4									9			13
Zone 40	EGWD	3	336	1							50									9			10
Zone 40	EGWD	5	492	1									130										140
Zone 40	EGWD	7	264	1								100											
Zone 40	SCWMD	LW40	290	1															9	49		9	9
Zone 40	SCWMD	LW41	280	1															9	49		9	9
Zone 40	SCWMD	LW42	247	1															9	49		9	9
Zone 40	SCWMD	LW43	265	1															15	49		9	9
Zone 40	SCWMD	LW44	310	1															20	49		9	17
Zone 40	SCWMD	LW45	295	1															15			9	9
Zone 40	SCWMD	LW48	290	1													9					160	9
Zone 40	SCWMD	LW50	301	1															9			49	9
Zone 40	SCWMD	LW51	265	1															9			180	9
Zone 40	SCWMD	LW52	285	1															9			49	
Zone 40	SCWMD	NW16	400	1									13										
Zone 40	SCWMD	VW62	307	1																		9	9
Zone 40	EGWD	4	330	1(B)										49	4								180
Zone 40	SCWMD	LW49	302	1(B)																		9	9
Zone 40	EGWD	11	680	2																			43
Zone 40	SCWMD	VW60	960	2																49		9	
Zone 40	SCWMD	VW61	980	2																80		9	77
Zone 40	EGWD	6	560	3															160			150	
Zone 40	EGWD	8	485	3								100					40						
Zone 40	EGWD	9	565	3								150										70	
Zone 40	EGWD	10	600	3												140							

Table A-2
(Continued)

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Zone 40	EGWD	12	500	3																44			74
Zone 40	SCWMD	LW46	500	3																49		9	9
Zone 40	SCWMD	LW47	500	3													9		15	9		9	9
Zone 40	SCWMD	NW1	490	3							19									49		49	
Zone 40	SCWMD	NW15	450	3																49			
Zone 40	SCWMD	NW36	530	3							14									49		9	
Zone 40	SCWMD	GW27	470	3		59														180			
Zone 40	SCWMD	GW28	500	3																180		370	
Zone 40	SCWMD	GW29	490	3																150			160
Zone 40	SCWMD	VW63	500	3																		98	77
Zone 40	CUCC	17		4																	120		
Zone 40	CUCC	18		4																	1700		
Rio Linda	RLWD	1	453	1							29		49						9			9	
Rio Linda	RLWD	2	210	1																			9
Rio Linda	RLWD	3	267	1																		9	
Rio Linda	RLWD	5	512	1																			19
Rio Linda	RLWD	7	335	1												10							9
Rio Linda	RLWD	8	393	1																9			9
Rio Linda	RLWD	10	575	1															9				9
Rio Linda	RLWD	9	522	1(B)															9				9
Rio Linda	RLWD	11	417	1(B)																9			9
Rio Linda	RLWD	4	492	3										49								9	
Rio Linda	RLWD	6	570	3													10			9			9
Rio Linda	RLWD	12	585	3																40			9
Citizens-A	CUCC	13	364	1															9			9	
Citizens-A	CUCC	31	304	1											49				9			9	
Citizens-A	CUCC	34	484	1																9			9
Citizens-A	CUCC	48	308	1													10						
Citizens-A	CUCC	59	316	1								49											
Citizens-A	CUCC	60	357	1							29									9			9
Citizens-A	CUCC	61	248	1																9			9

Table A-2
(Continued)

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Citizens-A	CUCC	9	353	1(B)															9			9	
Citizens-A	CUCC	19	395	1(B)															17			9	
Citizens-A	CUCC	22	410	1(B)															9			9	
Citizens-A	CUCC	28	396	1(B)																9			9
Citizens-A	CUCC	35	354	1(B)																9			9
Citizens-A	CUCC	38	332	1(B)																		9	
Citizens-A	CUCC	40	339	1(B)												210				9			9
Citizens-A	CUCC	58	459	1(B)															9			9	9
Citizens-A	CUCC	63	312	1(B)																9			9
Citizens-A	CUCC	15	495	3							49									9	9		9
Citizens-A	CUCC	39	436	3															9			9	9
Citizens-A	CUCC	53	495	3																4			11
Citizens-A	CUCC	54	547	3											49								
Citizens-A	CUCC	68	540	3							29												
Citizens-A	CUCC	79	540	3																9			9
Citizens-A	CUCC	5		4																			9
Citizens-A	CUCC	11	510	4															9			9	
Citizens-A	CUCC	21	506	4																9			9
Citizens-A	CUCC	51	445	4																9			43
Arcade	AWD	69R	427	1																9			14
Arcade	AWD	39	385	1(B)																10			9
Arcade	AWD	31A	660	3																9			9
Arcade	AWD	52	600	3															9	9		9	9
Arcade	AWD	59	600	3															9			9	
Arcade	AWD	64	630	3						29									9			18	21
Citrus Height	CHWD	2	421	2																			9
Citrus Height	CHWD	5	304	2																		9	
Citrus Height	CHWD	7	500	2																		9	
Citrus Height	CHWD	3	402	3																		9	

Table A-2
(Continued)

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Northridge	NWD	32	342	1																			9
Northridge	NWD	30	405	1(B)																40			39
Northridge	NWD	8	520	2												32				26			57
Northridge	NWD	5	532	3															9	9			9
Northridge	NWD	12	530	3												440			9				9
Northridge	NWD	24	524	3															9	9			9
Northridge	NWD	25	554	3																9			
Northridge	NWD	26	465	3												20			9	9			9
Northridge	NWD	27	569	3																9			9
Northridge	NWD	28	454	3										49									
Northridge	NWD	29	525	3																110			32
Northridge	NWD	31	524	3																			9
Northridge	NWD	33		3																9			
Orangevale	OWMCD	1	315	2								49							9			9	
Fair Oaks	FOWD	6	475	2										19									9
Fair Oaks	FOWD	7	603	2							9								9			9	
Fair Oaks	FOWD	8	492	2							9											15	
Fair Oaks	FOWD	1	600	3													9		9				40
Fair Oaks	FOWD	3	904	3							30									9			9
Fair Oaks	FOWD	4	600	3							9								9			9	
Fair Oaks	FOWD	5	700	3							9		49							9		9	9
Carmichael	CWD	1		4																		100	140
Carmichael	CWD	2		4																9			11
Carmichael	CWD	3		4								49					10		320			17	
Carmichael	CWD	4		4																		17	
Carmichael	CWD	5		4						29										9		9	
Carmichael	CWD	6		4																			9
Carmichael	CWD	7	600	4																9			54
Carmichael	CWD	8		4																			9

Table A-2
(Continued)

MANGANESE CONCENTRATIONS (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well ID	Depth	Layer	1970	1972	1974	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Carmichael	CWD	9		4																			16
Carmichael	CWD	10		4										49					9			9	9
Carmichael	CWD	13		4																			26
Carmichael	CWD	14		4																			9
Arden-Cordova	ACWD	19	560	2																9			
Arden-Cordova	ACWD	1	306	3																9			
Arden-Cordova	ACWD	5	480	3																9			
Arden-Cordova	ACWD	8	425	3																11			
Arden-Cordova	ACWD	9	460	3																9			
Arden-Cordova	ACWD	14	446	3																9			
Arden-Cordova	ACWD	16	565	3																9			
Citizens-B	CUCC	42	308	1															9			9	
Citizens-B	CUCC	32	432	3													9			9			
Citizens-B	CUCC	46	525	3																9			9
Citizens-B	CUCC	70	364	3															9			9	
Citizens-B	CUCC	78	700	3												10			20			9	
Citizens-B	CUCC	85	377	3										49						9			9
Citizens-B	CUCC	12	275	4																9	9		9
Citizens-B	CUCC	58	500	4																9			9
Sunrise	SCWMD	SW18	390	3							1	50						49		49			9
Sunrise	SCWMD	SW17	315	3							69									49		88	

Note: * Values assigned 9 ug/l were reported below detection limit (<10 ug/l)

Table A-3

TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/l) IN M&I WELLS IN SACRAMENTO COUNTY

Subarea	Agency	Well Name	Well ID	Depth	Layer	1967	1969	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	AWD		4	265	1																		
POU-North	AWD		7	210	1						260						236					180	190
POU-North	AWD		9	270	1									228	120								
POU-North	AWD		10	265	1																		200
POU-North	AWD		12	294	1																	220	
POU-North	AWD		28	370	1																	220	
POU-North	AWD		34	400	1																		180
POU-North	AWD		35	297	1																		150
POU-North	AWD		47	350	1																	150	
POU-North	AWD		49	335	1									274									
POU-North	AWD		51	370	1																		130
POU-North	AWD		68	300	1																		270
POU-North	CUCC	FAIRLAKE	25	360	1										120								
POU-North	CUCC	WITTKOP	86	325	1																	210	
POU-North	CUCC	WYDA WAY	88	295	1																		180
POU-North	CITY		93	316	1													205		234		268	
POU-North	CITY		94	351	1										264	271	244		263		230		
POU-North	CITY		112	380	1										314			286		219		315	
POU-North	CITY		114	380	1														432		399		
POU-North	CITY		123	305	1													251			242		
POU-North	CITY		124	306	1													311			327		
POU-North	CITY		125	300	1											232	273			225			
POU-North	CITY		129	300	1										344		239		223		244		
POU-North	CITY		131	280	1										244	205	231		210		242		
POU-North	CITY		132	232	1										193	225	190		193		177		
POU-North	CITY		137	410	1										270	309	278		257			242	
POU-North	CITY		141	315	1																	348	
POU-North	CITY		156	380	1										350	454	380		357		318		
POU-North	NWD	EVERGREEN	1	315	1						175						275			200			
POU-North	NWD	ENGLE	3	285	1											168				180			
POU-North	SCWMD	TOLENUS	AW2	246	1	163	153	224															200
POU-North	SCWMD	FIREHOUSE	AW3	244	1	165	126	166														140	
POU-North	SCWMD	FITCH	AW4	264	1	157	160	193															170
POU-North	SCWMD	LOS ALAMOS	AW7	296	1	169	166	176						166								170	
POU-North	SCWMD	LATHAM	AW9	248	1	144	139	152														110	

Table A-3
(Continued)

TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/l) IN M&I WELLS IN SACRAMENTO COUNTY

Subarea	Agency	Well Name	Well ID	Depth	Layer	1967	1969	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	SCWMD	481 CROCKER	AW11	317	1	171	169	182															
POU-North	SCWMD	NORTHRUP	AW22	265	1		167	167				140		112					220			95	
POU-North	AWD		5	425	1(B)																	180	
POU-North	AWD		22	350	1(B)																		160
POU-North	AWD		32	360	1(B)														230				
POU-North	AWD		36	335	1(B)																	180	
POU-North	AWD		65	347	1(B)																		220
POU-North	AWD		66	398	1(B)																		140
POU-North	CITY		91	370	1(B)														331		322		
POU-North	CITY		92	422	1(B)											433	301		308		327		
POU-North	CITY		110	340	1(B)																411		
POU-North	CITY		116	340	1(B)										276	227	297			242		323	
POU-North	CITY		117	340	1(B)														252		249		
POU-North	CITY		119	340	1(B)													117		194		245	
POU-North	CITY		143	330	1(B)										272	252	260		244			264	
POU-North	CITY		151	346	1(B)										343	315	337			310		312	
POU-North	CITY		158	328	1(B)												416		425				
POU-North	DPMWD	4		380	1(B)																	140	
POU-North	DPMWD	5		422	1(B)																	150	
POU-North	NWD	YUCCA	21	426	1(B)					196										180			
POU-North	SCWMD	LOS CRUS	AW5	340	1(B)	168	175	208														200	
POU-North	AWD		14	480	2																		270
POU-North	DPMWD	3		404	2										130								200
POU-North	NWD	CYPRESS	20	602	2						135												
POU-North	AWD		3A	440	3									186									230
POU-North	AWD		13	374	3							193											
POU-North	AWD		19	365	3																	150	
POU-North	AWD		24	360	3																		160
POU-North	AWD		27	320	3																		240
POU-North	AWD		20A	475	3															190			
POU-North	AWD		40	425	3											220							
POU-North	AWD		43	390	3																	120	
POU-North	AWD		55	375	3																		240
POU-North	AWD		60	450	3																		170
POU-North	AWD		46R	410	3																	210	

Table A-3
(Continued)

TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/l) IN M&I WELLS IN SACRAMENTO COUNTY

Subarea	Agency	Well Name	Well ID	Depth	Layer	1967	1969	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	CUCC	FULTON	29	396	3																		290
POU-North	CITY		120	440	3											277	250		249		252		
POU-North	CITY		122	422	3										278	238	273			238		277	
POU-North	CITY		126	452	3																265		
POU-North	CITY		127	401	3													290		391		277	
POU-North	CITY		133	514	3											217	244		222		229		
POU-North	CITY		134	515	3											204	202		217		234		
POU-North	CITY		136	385	3										274	204	263		259		240		
POU-North	CITY		138	375	3										248	242	194		227		215		
POU-North	CITY		139		3														267		292		
POU-North	CITY		142	384	3													290		291			
POU-North	CITY		144	372	3										298	238	244				259		
POU-North	CITY		150	372	3														239				
POU-North	CITY		153	600	3															223		228	
POU-North	CITY		154	412	3											185	198		190		209		
POU-North	CITY		155	427	3										242	270	229		221		217		
POU-North	CITY		157	377	3													239		306		292	
POU-North	CITY		159	375	3										310	581	490		480				
POU-North	CITY		161	400	3												490						
POU-North	DPMWD	1		500	3																		
POU-North	DPMWD	2		400	3																	140	
POU-North	DPMWD	6		490	3																	270	
POU-North	DPMWD	7		380	3																	170	
POU-North	DPMWD	9		390	3						150								160				
POU-North	NWD	PALM	6	508	3															270			
POU-North	NWD	CAMERON	9	535	3															140			
POU-North	NWD	WALNUT	10	533	3								188						160	190			
POU-North	NWD	DIABLO	11	565	3															400			
POU-North	NWD	MADISON	13		3															240			
POU-North	NWD	ORANGE	14	560	3						220									180			
POU-North	NWD	CABANA	15	534	3						205								240	200			
POU-North	NWD	OAKDALE	17	550	3						224			280						230			
POU-North	NWD	MCCLOUD	18	575	3															280			
POU-North	NWD	LARCHMONT	19	621	3					237		257								240			
POU-North	SCWMD	STEWART	AW8	404	3	162	171	202						204								180	
POU-North	SCWMD	CRESTA	AW14	428	3	159	183	208														140	

Table A-3
(Continued)

TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/l) IN M&I WELLS IN SACRAMENTO COUNTY

Subarea	Agency	Well Name	Well ID	Depth	Layer	1967	1969	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	SCWMD	BETHEL	AW21	432	3	206	230	224														180	
POU-North	AWD		63		4																	43	
POU-North	CITY		111		4														428		402		
POU-North	SCWMD	415 CROCKER	AW10		4	182	200	221															
POU-South	CUCC	A PARK	2	268	1																		350
POU-South	CUCC	CONRAD	16	302	1							214											
POU-South	CUCC	EXPLO	24	434	1														120				
POU-South	CUCC	LIPPI	41	158	1																	260	
POU-South	CUCC	MONTEZUMA	44	324	1									438						330			
POU-South	CUCC	MOONB	45	455	1								109										
POU-South	CUCC	POINT RE	52	332	1															250			
POU-South	CUCC	ROCKHURST	55	276	1								108										
POU-South	CUCC	ROGUE R	57	282	1														110				
POU-South	CUCC	SKY PARK	64	284	1																		180
POU-South	CUCC	SOUTHGATE	65	284	1														130				
POU-South	CUCC	SOUTHPORT	66	391	1																		200
POU-South	CUCC	STOCKER	67	316	1																	170	
POU-South	CUCC	SUTTERS	69	268	1																		180
POU-South	CUCC	WHITEWATER	81	490	1										110								
POU-South	CUCC	WILD ROSE	84	368	1											280							
POU-South	CUCC	WOODMAN	87	406	1																	110	
POU-South	CITY		83	255	1													144		189		225	
POU-South	FCWD	DIANA WAY	1	252	1												245						190
POU-South	FCWD	FLETCHER FARMS	2	275	1																		
POU-South	FCWD	FLORIN ROAD	3	262	1															160			
POU-South	FCWD	MCCOMBER	6	270	1																		150
POU-South	FVWD		2	224	1																	400	
POU-South	FVWD		4	270	1										240								330
POU-South	FVWD		9	272	1																	170	
POU-South	FVWD		10	315	1															180			
POU-South	FVWD		11	270	1																		330
POU-South	FVWD		12	236	1																	330	
POU-South	FCWD	POWER INN	7	305	1(B)									190									
POU-South	FVWD		1	321	1(B)																	350	

Table A-3
(Continued)

TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/l) IN M&I WELLS IN SACRAMENTO COUNTY

Subarea	Agency	Well Name	Well ID	Depth	Layer	1967	1969	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-South	FVWD		3	315	1(B)																	370	
POU-South	FVWD		5	320	1(B)						290											330	
POU-South	FVWD		8	294	1(B)																		160
POU-South	FVWD		14	345	1(B)																		250
POU-South	CUCC	BUTT	7	840	2							125											
POU-South	CUCC	FOLSOM	27	285	3																	88	
POU-South	FVWD		13	405	3																		260
POU-South	FVWD		15	300	3																		570
POU-South	CITY		107		4													186		135		205	
POU-South	FVWD		8		4																	290	
Zone 40	EGWD	MAIN PLANT	1	283	1						228												
Zone 40	EGWD	MARVALE	3	336	1										130								160
Zone 40	EGWD	EMERALD PARK	5	492	1								126										150
Zone 40	EGWD	PARKSIDE	7	264	1							170											
Zone 40	SCWMD	BRUCEVILLE	LW40	290	1														200				170
Zone 40	SCWMD	SEASONS	LW41	280	1														260				150
Zone 40	SCWMD	BANYAN	LW42	247	1														250				
Zone 40	SCWMD	DUCK SLOUGH	LW43	265	1														222				220
Zone 40	SCWMD	KILCONNEL	LW44	310	1														170				
Zone 40	SCWMD	ACROPOLIS	LW45	295	1														254				170
Zone 40	SCWMD	WADENA	LW48	290	1											200							180
Zone 40	SCWMD	BIG HORN (S)	LW50	301	1														230				200
Zone 40	SCWMD	BIG HORN (E)	LW51	265	1														170				130
Zone 40	SCWMD	BIG HORN (N)	LW52	285	1														170				
Zone 40	SCWMD	WESTGATE	NW16	400	1								224										
Zone 40	EGWD	WEBB STREET	4	330	1(B)									312									170
Zone 40	SCWMD	SOARING OAKS	LW49	302	1(B)											180							160
Zone 40	EGWD	DINO	11	680	2																		160
Zone 40	EGWD	EMERALD OAK	6	560	3																	140	
Zone 40	EGWD	WILLIAMSON RANCH	8	485	3							170					216						
Zone 40	EGWD	POLHEMUS	9	565	3							139										160	
Zone 40	EGWD	FALL BROOK	12		3															200			

Table A-3
(Continued)

TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/l) IN M&I WELLS IN SACRAMENTO COUNTY

Subarea	Agency	Well Name	Well ID	Depth	Layer	1967	1969	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Zone 40	SCWMD	N. MARKET	NW1	490	3						120											190	
Zone 40	SCWMD	NATIONAL	NW36	530	3						130												
Zone 40	SCWMD	RECYCLE RD	SW18	390	3						24							96					100
Zone 40	SCWMD	STOCKER	GW29	490	4															140			
Zone 40	SCWMD	ASHURST	LW46	500	4														270				
Zone 40	SCWMD	ACROPOLIS	LW47	500	4														214				180
Zone 40	EGWD	ADAMS STREET	2																				170
Zone 40	EGWD	FEICKART RANCH	10	600												160							
Rio Linda	RLWD		1	453	1						248								280			280	
Rio Linda	RLWD		2	210	1								207										200
Rio Linda	RLWD		3	267	1																	210	
Rio Linda	RLWD		5	512	1									376			290						200
Rio Linda	RLWD		7	335	1											220							220
Rio Linda	RLWD		10	575	1																		170
Rio Linda	RLWD		9	522	1(B)																		190
Rio Linda	RLWD		11	417	1(B)															191			
Rio Linda	RLWD		4	492	3																	200	
Rio Linda	RLWD		12	585	3															252			
Citizens-A	CUCC	CHIPPING	13	364	1																	220	
Citizens-A	CUCC	GLASS SLIPPER	31	304	1										170								
Citizens-A	CUCC	HALIFAX	34	464	1															220			
Citizens-A	CUCC	OAKBERRY	48	306	1												224						
Citizens-A	CUCC	RUSHMORE	59	316	1							220											
Citizens-A	CUCC	SALMON	60	357	1				160		160												140
Citizens-A	CUCC	SANDALWOOD	61	248	1																		310
Citizens-A	CUCC	DIABLO	22	410	1(B)																	230	
Citizens-A	CUCC	FORT SUTTER	29	396	1(B)																		250
Citizens-A	CUCC	LAUREL OAKS	38	332	1(B)																	230	
Citizens-A	CUCC	LINDA SUE	40	336	1(B)											170							190
Citizens-A	CUCC	ROSEVILLE RD	58	459	1(B)																	240	
Citizens-A	CUCC	SHENANDOAH	63	312	1(B)																		310

Table A-3
(Continued)

TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/l) IN M&I WELLS IN SACRAMENTO COUNTY

Subarea	Agency	Well Name	Well ID	Depth	Layer	1967	1969	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Citizens-A	CUCC	CROSS	20	576	3														210				
Citizens-A	CUCC	LEMANS	39	436	3																		340
Citizens-A	CUCC	PRIOR	53	495	3																	150	
Citizens-A	CUCC	RHINE	54	547	3										240								
Citizens-A	CUCC	SUMMERPLACE	69	540	3				272		272												
Citizens-A	CUCC	WATT	79	540	3															190			
Citizens-A	CUCC	ANTEL	5		4															175			
Citizens-A	CUCC	DAVIDSON	21	506	4																		180
Citizens-A	CUCC	PFE/BILLY M	51	445	4																		230
Arcade	AWD		69R	427	1															180			
Arcade	AWD		39	385	1(B)																		180
Arcade																							
Arcade	AWD		52	600	3												254						270
Arcade	AWD		59	600	3																	220	
Arcade	AWD		64	630	3					322													270
Citrus Heights	CHWD	WATSON WAY	3	402	3																	390	
Citrus Heights	CHWD	MARIPOSA	5	304	3																	210	
Citrus Heights	CHWD	VERN	7	500	3																	54	
Northridge	NWD	PORKOAKS	30	405	1(B)															290			
Northridge	NWD	FIELD	8	520	2															420			
Northridge	NWD	HILLSDALE	5	532	3															210			
Northridge	NWD	DON JULIO	24	524	3															220			
Northridge	NWD	SUTTER	25	554	3															240			
Northridge	NWD	MONUMENT	26	465	3											180				240			
Northridge	NWD	JAMESTOWN	27	569	3															220			
Northridge	NWD	OAKBROOKE	28	454	3									508						220			
Northridge	NWD	BARRETT MEADOWS	31	524	3															260			
Northridge	NWD	BEAR MEADOWS	33		3															150			

Table A-3
(Continued)

TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/l) IN M&I WELLS IN SACRAMENTO COUNTY

Subarea	Agency	Well Name	Well ID	Depth	Layer	1967	1969	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Orangevale	OWMCD	OFFICE	1	315	2							239							240				
Fair Oaks	FOWD	NEW YORK	6	475	2						84												130
Fair Oaks	FOWD	CASA BELLA	7	603	2						126											140	
Fair Oaks	FOWD	FAIR OAKS PARK	8	492	2																	140	
Fair Oaks	FOWD	TOWN	1	600	3							129					195		110				
Fair Oaks	FOWD	HAZEL	3	904	3							144								160			
Fair Oaks	FOWD	CHICAGO	4	600	3						165		134									200	
Fair Oaks	FOWD	HEATHER	5	700	3										99							190	120
Carmichael	CWD	WINDING WAY	10		4									298					260				310
Carmichael	CWD	GARFIELD AVE	3		4																	200	
Carmichael	CWD	COTTAGE WAY	1		4								130										140
Carmichael	CWD	JAN DRIVE	5		4																	240	
Carmichael	CWD	PADDOCK	8		4																		250
Carmichael	CWD	HIDDEN DRIVE	4		4																	140	
Carmichael	CWD	DEWEY DRIVE	9		4																		150
Carmichael	CWD	LA VISTA WAY	6		4																		160
Carmichael	CWD	ENGLE ROAD	2		4											250							150
Carmichael	CWD	DETER	13		4																		42
Carmichael	CWD	LANDIS AVE	14	600	4																		38
Citizens-B	CUCC	GOULD	32	432	3												130						
Citizens-B	CUCC	NUT PLAINS	46	525	3															110			
Citizens-B	CUCC	SWANSEA	70	364	3														120				
Citizens-B	CUCC	WEST LA LOMA	78	700	3											150							
Citizens-B	CUCC	WINCHESTER	85	377	3								115										
Citizens-B	CUCC	CHETTENHAM	12	275	4																		150
Citizens-B	CUCC	ROCKIN	56	500	4																		110
Sunrise	SCWMD	ARENA	NW37	500	3																		150
Sunrise	SCWMD	WHITE ROCK RD	SW17	315	3						173											150	

Table A-4

ARSENIC CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well Name	Well ID	Depth	Layer		1969	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	AWD		34	400	1																	3
POU-North	AWD		35	297	1																	3
POU-North	AWD		47	350	1																3	
POU-North	AWD		49	335	1								4									
POU-North	AWD		51	370	1																	3
POU-North	AWD		68	300	1																	3
POU-North	CUCC	FAIRLAKE	25	360	1													9				
POU-North	CUCC	HOWE	36	403	1			4														
POU-North	CUCC	WITTKOP	86	325	1																3	
POU-North	CUCC	WYDA WAY	88	295	1																	3
POU-North	CITY		93	316	1												6		4		4	
POU-North	CITY		94	351	1									9	9	5		4		4		
POU-North	CITY		112	380	1									9			4		4		4	
POU-North	CITY		114	380	1													4		4		
POU-North	CITY		123	305	1												7			4		
POU-North	CITY		124	306	1												7			4		
POU-North	CITY		125	300	1										9	6			4			
POU-North	CITY		129	300	1									9		4		4		4		
POU-North	CITY		131	280	1									9	9	4		4		4		
POU-North	CITY		132	232	1									9	9	4		4		4		
POU-North	CITY		137	410	1									9	9	5		4			4	
POU-North	CITY		156	380	1									9	9	6		4		4		
POU-North	NWD	EVERGREEN	1	315	1											3			3			
POU-North	NWD	ENGLE	3	285	1				5						6				3			
POU-North	SCWMD	TOLENUS	AW2	246	1		4															3
POU-North	SCWMD	FIREHOUSE	AW3	244	1																3	
POU-North	SCWMD	FITCH	AW4	264	1		4															5
POU-North	SCWMD	LOS ALAMOS	AW7	296	1		4														3	
POU-North	SCWMD	LATHAM	AW9	248	1		4						2								3	
POU-North	SCWMD	481 CRIOCKER	AW11	317	1		4															
POU-North	SCWMD	NORTHRUP	AW22	285	1		4				7		4								3	
POU-North	AWD		5	425	1(B)					2											3	
POU-North	AWD		22	350	1(B)																	3
POU-North	AWD		33	320	1(B)																	3
POU-North	AWD		36	335	1(B)																3	
POU-North	AWD		65	347	1(B)																3	
POU-North	AWD		66	398	1(B)																3	

Table A-4
(Continued)

ARSENIC CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well Name	Well ID	Depth	Layer		1969	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	CITY		91	370	1(B)													4		4		
POU-North	CITY		92	422	1(B)										9	5		4		4		
POU-North	CITY		110	340	1(B)													4		4		
POU-North	CITY		116	340	1(B)									9	9	4			4		4	
POU-North	CITY		117	340	1(B)													4		4		
POU-North	CITY		119	340	1(B)												4		4		4	
POU-North	CITY		143	330	1(B)									9	9	4		4			4	
POU-North	CITY		151	346	1(B)									9	9	4			4		4	
POU-North	CITY		158	328	1(B)											4		4				
POU-North	DPMWD	4		380	1(B)																3	
POU-North	DPMWD	5		422	1(B)																3	
POU-North	NWD	YUCCA	21	426	1(B)				5										3			
POU-North	SCWMD	LOS CRUS	AW5	340	1(B)		4														3	
POU-North	SCWMD	LA SIERRA	AW35	371	1(B)																	
POU-North	AWD		63																		3	
POU-North	AWD		14	480	2																	3
POU-North	AWD		67	577	2																	3
POU-North	DPMWD	3		404	2									9								3
POU-North	NWD	CYPRESS	20	602	2																	
POU-North	AWD		3A	440	3								4									3
POU-North	AWD		13	374	3						2											
POU-North	AWD		19	365	3																3	
POU-North	AWD		20A	475	3														3			
POU-North	AWD		24	360	3																	3
POU-North	AWD		27	320	3																	3
POU-North	AWD		41	425	3									4								
POU-North	AWD		43	390	3																3	
POU-North	AWD		55	375	3																	3
POU-North	AWD		60	450	3																	3
POU-North	AWD		46R	410	3																3	
POU-North	CUCC	FULTON	29	396	3																	3
POU-North	CITY		120	440	3										9	4		4		4		
POU-North	CITY		122	422	3									9	9	4			4		4	
POU-North	CITY		126	452	3															4		
POU-North	CITY		127	401	3												4		4		4	

Table A-4
(Continued)

ARSENIC CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well Name	Well ID	Depth	Layer		1969	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-North	CITY		133	514	3										9	6		4		4		
POU-North	CITY		134	515	3										9	5		4		4		
POU-North	CITY		136	385	3									9	9	4		4		4		
POU-North	CITY		138	375	3									9	9	4		4		4		
POU-North	CITY		139		3													4		4		
POU-North	CITY		142	384	3												4		4		4	
POU-North	CITY		144	372	3									9	9	4		4		4		
POU-North	CITY		150	372	3													4				
POU-North	CITY		153	600	3														4		4	
POU-North	CITY		154	412	3										9	6		4		4		
POU-North	CITY		155	427	3									9		4		4		4		
POU-North	CITY		157	377	3												4		4		4	
POU-North	CITY		159	375	3									9	9	4		4				
POU-North	CITY		161	400	3											12						
POU-North	DPMWD	2		400	3																3	
POU-North	DPMWD	6		490	3																3	
POU-North	DPMWD	7		380	3																3	
POU-North	DPMWD	8		390	3					5												
POU-North	NWD	PALM	6	508	3														3			
POU-North	NWD	CAMERON	9	535	3													3	3			
POU-North	NWD	WALNUT	10	533	3					9		2.3							3			
POU-North	NWD	DIABLO	11	565	3														3			
POU-North	NWD	MADISON	13		3														3			
POU-North	NWD	ORANGE	14	560	3				5										3			
POU-North	NWD	CABANA	15	534	3				5									3	3			
POU-North	NWD	OAKDALE	17	550	3				5				4						3			
POU-North	NWD	MCCLOUD	18	575	3														3			
POU-North	NWD	LARCHMONT	19	621	3														3			
POU-North	NWD	FREEWAY	23	553	3														3			
POU-North	SCWMD	STEWART	AW8	404	3		4						2								3	
POU-North	SCWMD	CRESTA	AW14	428	3		4														3	
POU-North	SCWMD	BETHEL	AW21	432	3		4														3	
POU-North	CITY		111		4													4		4		

Table A-4
(Continued)

ARSENIC CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well Name	Well ID	Depth	Layer		1969	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-South	CUCC	A PARK	2	268	1																	5
POU-South	CUCC	EXPLO	24	434	1													3				
POU-South	CUCC	LIPPI	41	158	1																3	
POU-South	CUCC	MONTEZUMA	44	324	1								4						3			
POU-South	CUCC	MOONB	45	455	1							3.3									3	
POU-South	CUCC	POINT RE	52	332	1																	
POU-South	CUCC	ROCKHURST	55	276	1							6.4										
POU-South	CUCC	ROGUE R	57	282	1													4				6
POU-South	CUCC	SKY PARK	64	284	1													3				3
POU-South	CUCC	SOUTHGATE	65	284	1																3	
POU-South	CUCC	SOUTHPORT	66	391	1																	3
POU-South	CUCC	STOCKER	67	316	1									9								
POU-South	CUCC	SUTTERS	69	268	1										4						3	
POU-South	CUCC	WHITEWATER	81	490	1											3	8		4		4	3
POU-South	CUCC	WILD ROSE	84	368	1														5			
POU-South	CUCC	WOODMAN	87	406	1																	3
POU-South	CITY		83	255	1																3	
POU-South	FCWD	DIANA WAY	1	252	1									9								
POU-South	FCWD	FLORIN ROAD	3	262	1													6				3
POU-South	FCWD	MCCOMBER	6	270	1																5	
POU-South	FVWD		2	224	1																	3
POU-South	FVWD		4	270	1									9							3	
POU-South	FVWD		9	272	1																	3
POU-South	FVWD		10	315	1																5	
POU-South	FVWD		11	270	1													6				
POU-South	FVWD		12	236	1																	3
POU-South	FCWD	POWER INN	7	305	1(B)								10								3	
POU-South	FVWD		1	321	1(B)																	
POU-South	FVWD		3	315	1(B)																3	
POU-South	FVWD		5	320	1(B)					6											3	
POU-South	FVWD		7	278	1(B)																3	
POU-South	FVWD		8	294	1(B)																	6
POU-South	FVWD		14	345	1(B)																	4
POU-South	CUCC	BUTT	7	840	2						2											
POU-South	CUCC	FOLSOM	27	285	3																3	

Table A-4
(Continued)

ARSENIC CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well Name	Well ID	Depth	Layer	1969	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POU-South	FVWD		13	405	3																5
POU-South	FVWD		15	300	3																10
POU-South	CITY		107		4											9		4		4	
POU-South	FVWD		6		4															3	
Zone 40	EGWD	MAIN PLANT	1	283	1				9												30
Zone 40	EGWD	MARVALE	3	336	1								9								16
Zone 40	EGWD	EMERALD PARK	5	492	1						27										17
Zone 40	EGWD	PARKSIDE	7	264	1					6											
Zone 40	SCWMD	BRUCEVILLE	LW40	290	1												6				10
Zone 40	SCWMD	SEASONS	LW41	280	1												6				5
Zone 40	SCWMD	BANYAN	LW42	247	1												7				
Zone 40	SCWMD	DUCK SLOUGH	LW43	265	1												9				6
Zone 40	SCWMD	KILCONNEL	LW44	310	1												24				
Zone 40	SCWMD	ACROPOLIS	LW45	295	1												9				4
Zone 40	SCWMD	WADENA	LW48	290	1										23						21
Zone 40	SCWMD	BIG HORN (S)	LW50	301	1												3				11
Zone 40	SCWMD	BIG HORN (E)	LW51	265	1												13				10
Zone 40	SCWMD	BIG HORN (N)	LW52	285	1												30				
Zone 40	SCWMD	WESTGATE	NW16	400	1						29										
Zone 40	EGWD	WEBB STREET	4	330	1(B)							4									15
Zone 40	SCWMD	SOARING OAKS	LW49	302	1(B)										32						29
Zone 40	EGWD	DINO	11	680	2																9
Zone 40	EGWD	EMERALD OAK	6	560	3															14	
Zone 40	EGWD	WILLIAMSON RANCH	8	485	3					6										7	
Zone 40	EGWD	POLHEMUS	9	565	3					6											
Zone 40	SCWMD	STOCKER	GW29	490	3													41			
Zone 40	SCWMD	FEATHER	LW47	500	3												9				4
Zone 40	SCWMD	N. MARKET	NW1	490	3																6
Zone 40	SCWMD	RECYCLE RD	SW18	390	3				10							9					3
Zone 40	EGWD	FEICKART RANCH	10	600										4	10						

Table A-4
(Continued)

ARSENIC CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well Name	Well ID	Depth	Layer	1969	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Rio Linda	RLWD		1	453	1				7								8			5	
Rio Linda	RLWD		2	210	1						6.8										7
Rio Linda	RLWD		3	267	1															9	
Rio Linda	RLWD		5	512	1							11									12
Rio Linda	RLWD		7	335	1									4							7
Rio Linda	RLWD		8	393	1													3.4			
Rio Linda	RLWD		10	575	1																5
Rio Linda	RLWD		9	522	1(B)																7
Rio Linda	RLWD		11	417	1(B)													3.5			
Rio Linda	RLWD		4	492	3															4	
Rio Linda	RLWD		6	570	3										3						
Rio Linda	RLWD		12	585	3													7.8			
Citizens-A	CUCC	CHIPPING	13	364	1															3	
Citizens-A	CUCC	GLASS SLIPPER	31	304	1								9								
Citizens-A	CUCC	HALIFAX	34	464	1										3			3			
Citizens-A	CUCC	OAKBERRY	48	308	1											3					
Citizens-A	CUCC	RUSHMORE	59	316	1					2											
Citizens-A	CUCC	SALMON	60	357	1				2												3
Citizens-A	CUCC	SANDALWOOD	61	249	1																3
Citizens-A	CUCC	CARR	9	353	1(B)															3	
Citizens-A	CUCC	COVER WAGON	19	395	1(B)												4				
Citizens-A	CUCC	DIABLO	22	410	1(B)															3	
Citizens-A	CUCC	FORT SUTTER	28	396	1(B)																3
Citizens-A	CUCC	LAUREL OAKS	38	332	1(B)															3	
Citizens-A	CUCC	LINDA SUE	40	338	1(B)									10							3
Citizens-A	CUCC	ROSEVILLE RD	58	459	1(B)															3	
Citizens-A	CUCC	SHENANDOAH	63	312	1(B)																3
Citizens-A	CUCC	COLONNADE	15	495	3					7											
Citizens-A	CUCC	LEMANS	39	486	3																3
Citizens-A	CUCC	PRIOR	53	495	3													2			
Citizens-A	CUCC	RHINE	54	547	3							9									
Citizens-A	CUCC	WATT	79	540	3													3			

Table A-4
(Continued)

ARSENIC CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well Name	Well ID	Depth	Layer	1969	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Citizens-A	CUCC	ANTEL	5		4																
Citizens-A	CUCC	CHERBOURG	11	510	4													2			
Citizens-A	CUCC	DAVIDSON	21	506	4															3	
Citizens-A	CUCC	PFE/BILLY M	51	445	4																3
Citizens-A	CUCC	SCOTL	62	602	4				2												3
Arcade	AWD		69R	427	1																
Arcade	AWD		39	385	1(B)													3			
Arcade	AWD		52	600	3																3
Arcade	AWD		59	600	3										3						3
Arcade	AWD		64	630	3				2											3	
Arcade	AWD		31A	660	3												3				3
Citrus Height	CHWD	WATSON WAY	3	402	3																
Citrus Height	CHWD	MARIPOSA	5	304	3															3	
Citrus Height	CHWD	VERN	7	500	3															3	
																				3	
Northridge	NWD	PORKOAKS	30	405	1(B)																
Northridge	NWD	FIELD	8	520	2													3			
Northridge	NWD	HILLSDALE	5	532	3													3			
Northridge	NWD	DON JULIO	24	524	3													3			
Northridge	NWD	SUTTER	25	554	3													3			
Northridge	NWD	MONUMENT	26	485	3													3			
Northridge	NWD	JAMESTOWN	27	569	3									10				3			
Northridge	NWD	OAKBROOKE	28	454	3													3			
Northridge	NWD	MERRIHILL	29	525	3							4									
Northridge	NWD	BEAR MEADOWS	33		3													3			
																		3			
Orangevale	OWMCD	OFFICE	1	315	2					2							3				

Table A-4
(Continued)

ARSENIC CONCENTRATION (ug/l) MEASURED IN M&I WELLS IN SACRAMENTO COUNTY *

Subarea	Agency	Well Name	Well ID	Depth	Layer	1969	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Fair Oaks	FOWD	NEW YORK	6	475	2				5												
Fair Oaks	FOWD	CASA BELLA	7	603	2				5												3
Fair Oaks	FOWD	FAIR OAKS PARK	8	492	2															4	
Fair Oaks	FOWD	TOWN	1	600	3				5						3					7	
Fair Oaks	FOWD	HAZEL	3	904	3				5									3			
Fair Oaks	FOWD	CHICAGO	4	600	3				5											3	
Fair Oaks	FOWD	HEATHER	5	700	3						3.7		9							4	3
Carmichael	CWD	DETER	13		2																3
Carmichael	CWD	LANDIS	14		2																3
Carmichael	CWD	COTTAGE WAY	1		4						5.3										5
Carmichael	CWD	ENGLE ROAD	2		4																3
Carmichael	CWD	GARFIELD AVE	3		4															3	
Carmichael	CWD	HIDDEN DRIVE	4		4															3	
Carmichael	CWD	JAN DRIVE	5		4				2											3	
Carmichael	CWD	LA VISTA WAY	6		4																3
Carmichael	CWD	LANDIS AVE	7	600	4																3
Carmichael	CWD	PADDOCK	8		4									4							3
Carmichael	CWD	DEWEY DRIVE	9		4																3
Carmichael	CWD	WINDING WAY	10		4							4					3				3
Citizens-B	CUCC	NUT PLAINS	46	525	3													3			
Citizens-B	CUCC	WEST LA LOMA	78	700	3									4							
Citizens-B	CUCC	WINCHESTER	85	377	3						2.4										
Citizens-B	CUCC	CHETTENHAM	12	275	4																3
Citizens-B	CUCC	ROCKIN	56	500	4																3
Sunrise	SCWMD	ARENA	NW37	500	3																3
Sunrise	SCWMD	WHITE ROCK RD	SW17	315	3															3	

Note: * Values assigned 3 ug/l were reported below detection limit (<4 ug/l)

Table A-5

RADON MEASURED (pCi/l) IN 1991 IN SAWWA WELLS

Subarea	Agency	Well Name	Well ID	Depth	Layer	1991
POU-North	CUCC	WITTKOP	86	325	1	500
POU-North	NWD	EVERGREEN	1	315	1	400
POU-North	NWD	ENGLE	3	285	1	600
POU-North	SCWMD	TOLENUS	AW2	246	1	600
POU-North	SCWMD	FIREHOUSE	AW3	244	1	370
POU-North	SCWMD	LOS ALAMOS	AW7	296	1	700
POU-North	SCWMD	NORTHRUP	AW22	265	1	500
POU-North	DPMWD	4		380	1(B)	300
POU-North	DPMWD	5		422	1(B)	500
POU-North	NWD	YUCCA	21	426	1(B)	600
POU-North	DPMWD	3		404	2	400
POU-North	NWD	CYPRESS	20	602	2	900
POU-North	DPMWD	1		500	3	700
POU-North	DPMWD	2		400	3	500
POU-North	DPMWD	6		490	3	400
POU-North	DPMWD	7		380	3	480
POU-North	DPMWD	8		390	3	660
POU-North	NWD	PALM	6	508	3	700
POU-North	NWD	ROSEBUD	7	469	3	600
POU-North	NWD	CAMERON	9	535	3	400
POU-North	NWD	WALNUT	10	533	3	600
POU-North	NWD	ORANGE	14	560	3	700
POU-North	NWD	CABANA	15	534	3	600
POU-North	NWD	OAKDALE	17	550	3	500
POU-North	NWD	MCCLOUD	18	575	3	200
POU-North	NWD	LARCHMONT	19	621	3	200
POU-North	NWD	RIVER CO	22	555	3	200
POU-North	NWD	FREEWAY	23	553	3	160
POU-North	SCWMD	STEWART	AW8	404	3	500
POU-South	CUCC	A PARK	2	268	1	100
POU-South	CUCC	EXPLO	24	434	1	900
POU-South	CUCC	POINT RE	52	332	1	332
POU-South	CUCC	ROGUE R	57	282	1	540
POU-South	CUCC	SOUTHGATE	65	284	1	240
POU-South	CUCC	SOUTHPORT	66	391	1	680
POU-South	CUCC	STOCKER	67	316	1	700
POU-South	CUCC	SUTTERS	69	268	1	370
POU-South	CUCC	WHITEWATER	81	490	1	650
POU-South	CUCC	WOODMAN	87	406	1	406
POU-South	FCWD	DIANA WAY	1	252	1	670
POU-South	FCWD	FLORIN ROAD	3	262	1	700
POU-South	FCWD	FRENCH ROAD	4	267	1	560
POU-South	FCWD	KARA	5	180	1	600
POU-South	FCWD	MCCOMBER	6	270	1	430
POU-South	FCWD	REESE ROAD 01	8	270	1	600
POU-South	FCWD	REESE ROAD 02	9	225	1	580
POU-South	FVWD		4	270	1	700
POU-South	FVWD		9	272	1	900
POU-South	FVWD		11	270	1	500

Table A-5
(Continued)

RADON MEASURED (pCi/l) IN 1991 IN SAWWA WELLS

Subarea	Agency	Well Name	Well ID	Depth	Layer	1991
POU-South	FVWD		12	236	1	600
POU-South	FCWD	POWER INN	7	305	1(B)	550
POU-South	FVWD		1	321	1(B)	430
POU-South	FVWD		3	315	1(B)	800
POU-South	FVWD		5	320	1(B)	400
POU-South	FVWD		7	278	1(B)	460
POU-South	FVWD		8	294	1(B)	450
POU-South	FVWD		14	345	1(B)	500
POU-South	CUCC	BUTT	7	840	2	260
POU-South	CUCC	WILBUR W	83	452	3	500
POU-South	FVWD		15	300	3	550
POU-South	FVWD		6		3	600
POU-South	FVWD		13	405	3	550
Zone 40	EGWD	MAIN PLANT	1	283	1	470
Zone 40	EGWD	MARVALE	3	336	1	330
Zone 40	EGWD	EMERALD PARK	5	492	1	360
Zone 40	EGWD	PARKSIDE	7	264	1	570
Zone 40	SCWMD	BRUCEVILLE	LW40	290	1	300
Zone 40	SCWMD	SEASONS	LW41	280	1	600
Zone 40	SCWMD	DUCK SLOUGH	LW43	265	1	470
Zone 40	SCWMD	FEATHER	LW47	500	1	360
Zone 40	SCWMD	SOARING OAKS	LW49	302	1	100
Zone 40	SCWMD	BIG HORN (S)	LW50	301	1	360
Zone 40	EGWD	WEBB STREET	4	330	1(B)	520
Zone 40	EGWD	DINO	11	680	2	370
Zone 40	SCWMD	VINTAGE	VW60	960	2	500
Zone 40	SCWMD	CAYMUS	VW61	960	2	500
Zone 40	EGWD	EMERALD OAK	6	560	3	450
Zone 40	EGWD	WILLIAMSON RANCH	8	485	3	670
Zone 40	EGWD	POLHEMUS	9	565	3	490
Zone 40	EGWD	FALL BROOK	12	500	3	500
Rio Linda	RLWD		1	453	1	450
Rio Linda	RLWD		2	210	1	500
Rio Linda	RLWD		3	267	1	650
Rio Linda	RLWD		5	512	1	600
Rio Linda	RLWD		8	393	1	500
Rio Linda	RLWD		10	575	1	650
Rio Linda	RLWD		9	522	1(B)	600
Rio Linda	RLWD		11	417	1(B)	700
Rio Linda	RLWD		4	492	3	500
Rio Linda	RLWD		6	570	3	550
Citizens-A	CUCC	CHIPPING	13	364	1	230
Citizens-A	CUCC	COVER WAGON	19	395	1(B)	250
Citizens-A	CUCC	DIABLO	22	410	1(B)	100
Citizens-A	CUCC	ROSEVILLE RD	58	459	1(B)	459

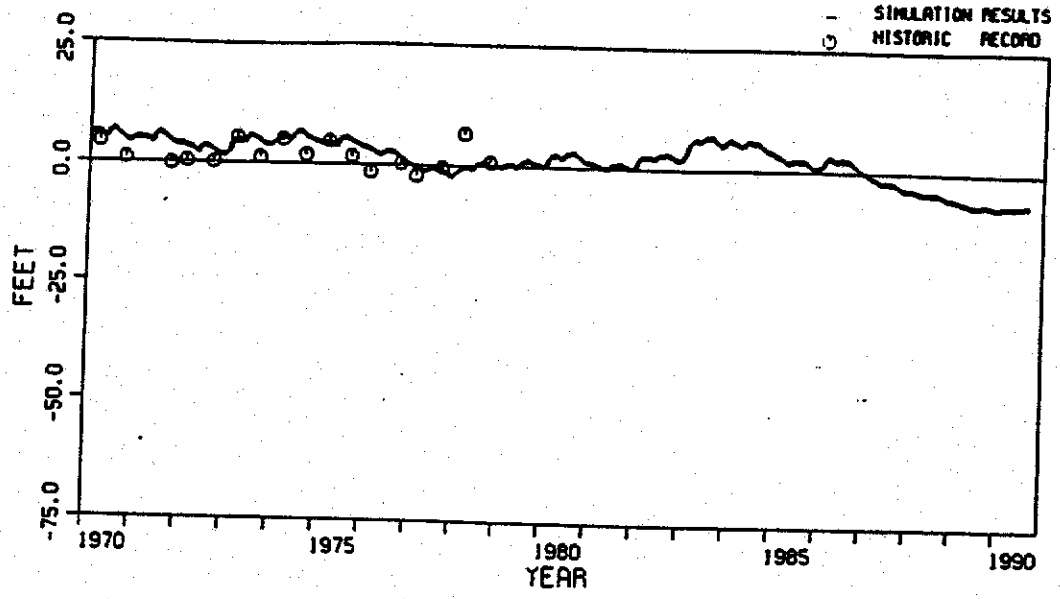
Table A-5
(Continued)

RADON MEASURED (pCi/l) IN 1991 IN SAWWA WELLS

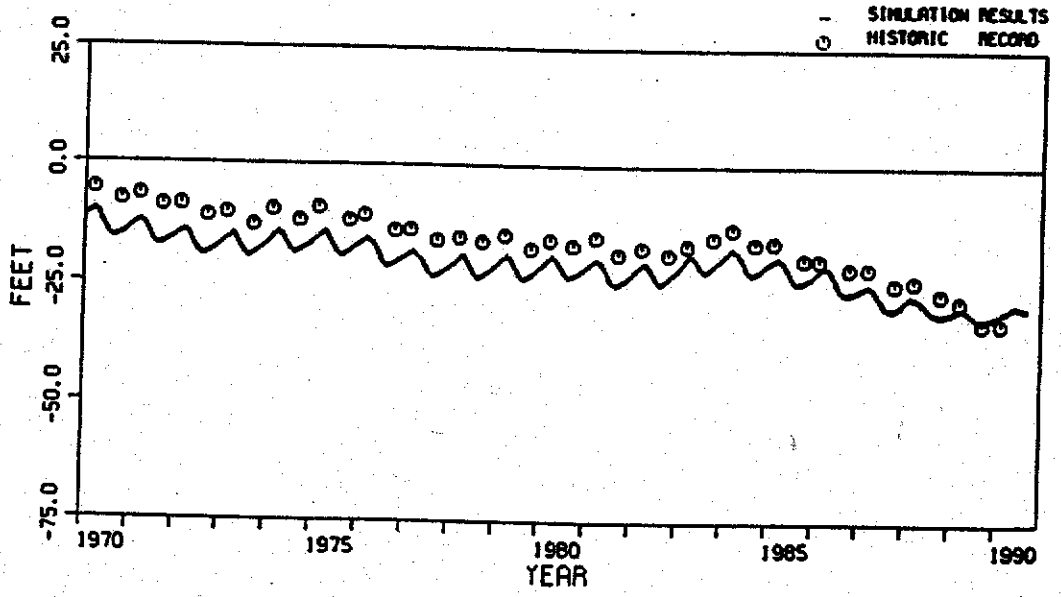
Subarea	Agency	Well Name	Well ID	Depth	Layer	1991
Citizens-A	CUCC	LEMANS	39	436	3	530
Citrus Height	CHWD	WELLS AVE	4	274	2	100
Northridge	NWD	POKER LANE(C	32	342	1	100
Northridge	NWD	PORKOAKS	30	405	1(B)	300
Northridge	NWD	FIELD	8	520	2	300
Northridge	NWD	HILLSDALE	5	532	3	500
Northridge	NWD	SAINT JOHNS	12	530	3	600
Northridge	NWD	DON JULIO	24	524	3	1600
Northridge	NWD	MONUMENT	26	465	3	650
Northridge	NWD	JAMESTOWN	27	569	3	300
Northridge	NWD	OAKBROOKE	28	454	3	400
Northridge	NWD	MERRIHILL	29	525	3	200
Northridge	NWD	BARRETT MEADOWS	31	524	3	700
Oranevale	OWMCD	OFFICE	1	315	2	140 .
Fair Oaks	FOWD	CASA BELLA	7	603	2	100
Fair Oaks	FOWD	FAIR OAKS PARK	8	492	2	750
Fair Oaks	FOWD	TOWN	1	600	3	150
Fair Oaks	FOWD	HAZEL	3	904	3	900
Fair Oaks	FOWD	CHICAGO	4	600	3	300
Fair Oaks	FOWD	HEATHER	5	700	3	200
Carmichael	CWD	BARRETT ROAD	11	550	2	1450
Carmichael	CWD	LADORA WAY	12	580	2	1700
Carmichael	CWD	ENGLE ROAD	2		4	500
Carmichael	CWD	HIDDEN DRIVE	4		4	900
Carmichael	CWD	JAN DRIVE	5		4	400
Carmichael	CWD	LA VISTA WAY	6		4	900
Carmichael	CWD	LANDIS	7		4	800
Carmichael	CWD	PADDOCK	8		4	500
Carmichael	CWD	DEWEY DRIVE	9		4	900
Carmichael	CWD	WINDING WAY	10		4	1350
Carmichael	CWD	DETER	13		4	50
Carmichael	CWD	LANDIS AVE	14	600	4	50
Citizens-B	CUCC	MALAGA	42	308	1	700
Citizens-B	CUCC	SWANSEA	70	364	3	360

Appendix B

MONTHLY GROUNDWATER LEVEL
WELL 1 (09N/04E-11E01) L1

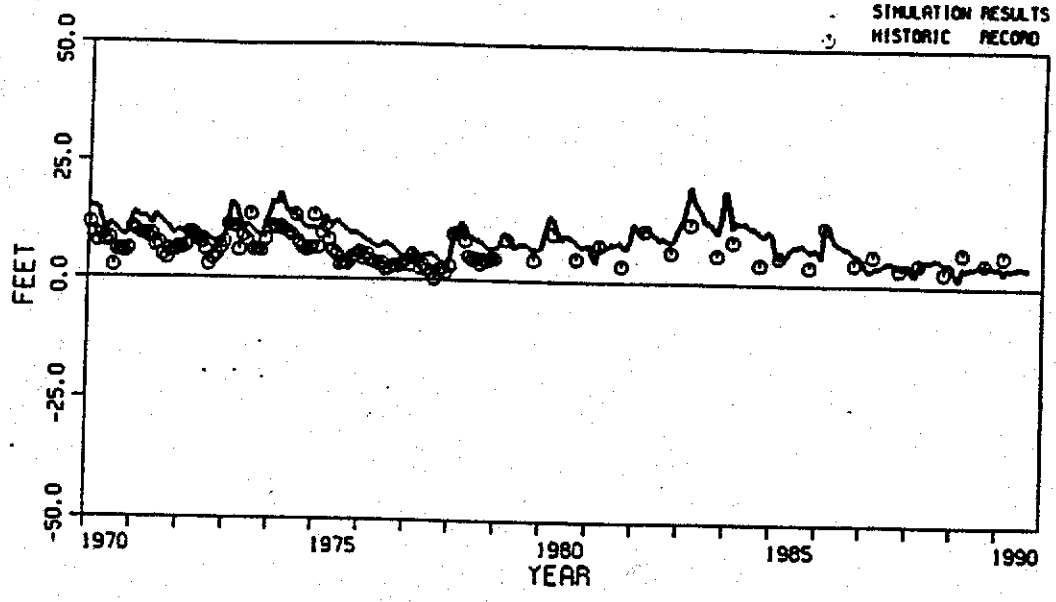


MONTHLY GROUNDWATER LEVEL
WELL 2 (09N/05E-08J02) L2



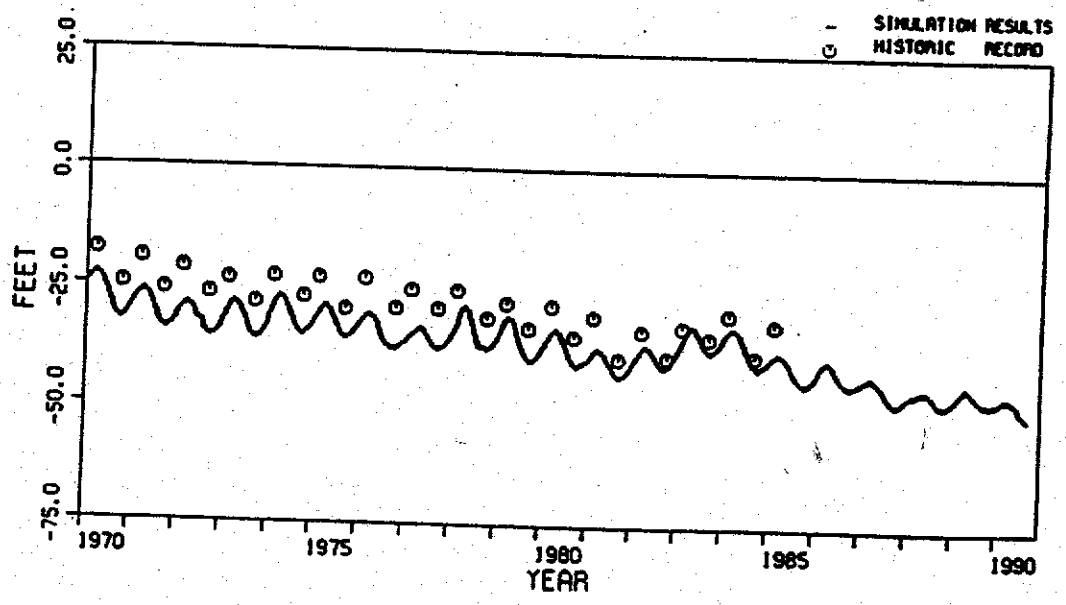
MONTHLY GROUNDWATER LEVEL

WELL 3 (09N/04E-22E01) L1

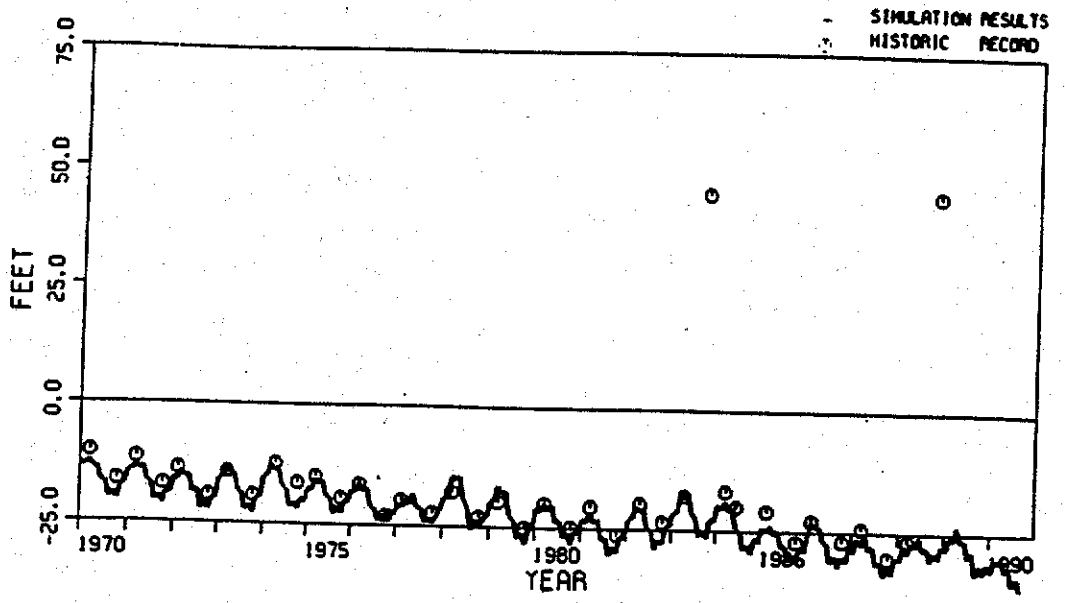


MONTHLY GROUNDWATER LEVEL

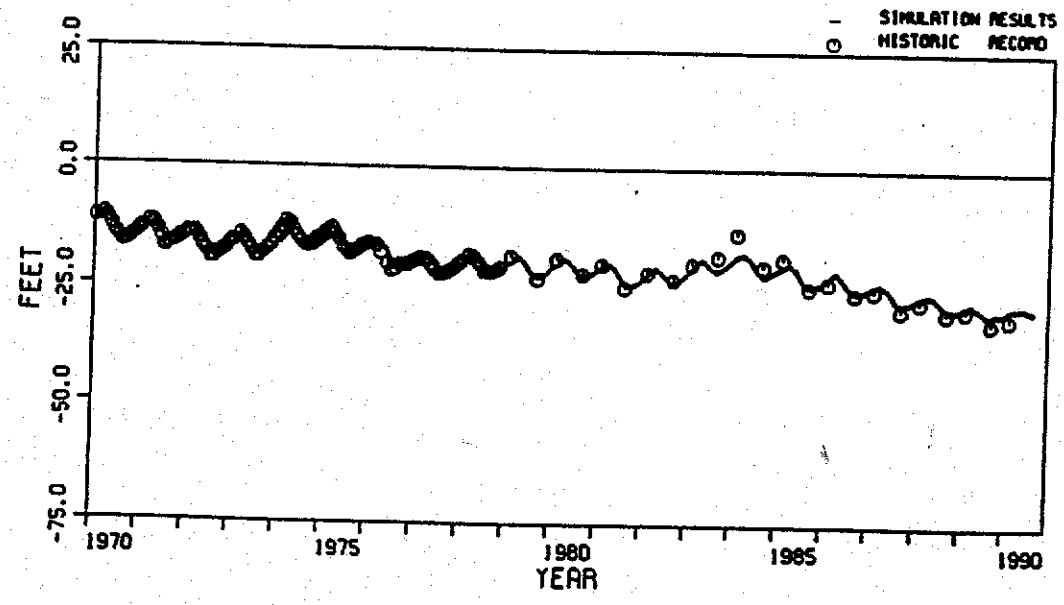
WELL 4 (09N/05E-22G02) L1



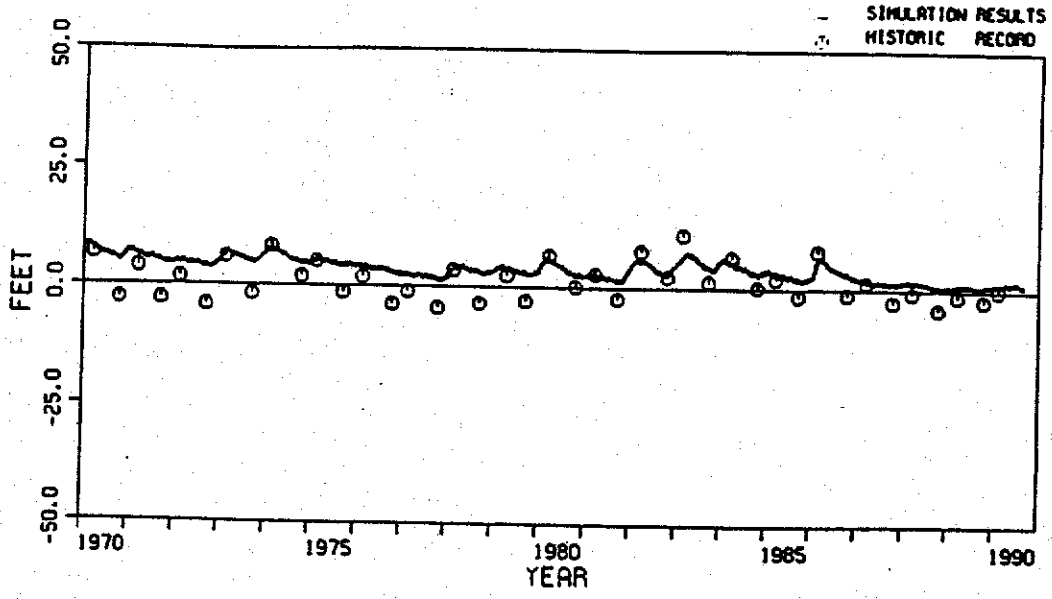
MONTHLY GROUNDWATER LEVEL
WELL 5 (09N/05E-28K01) L1



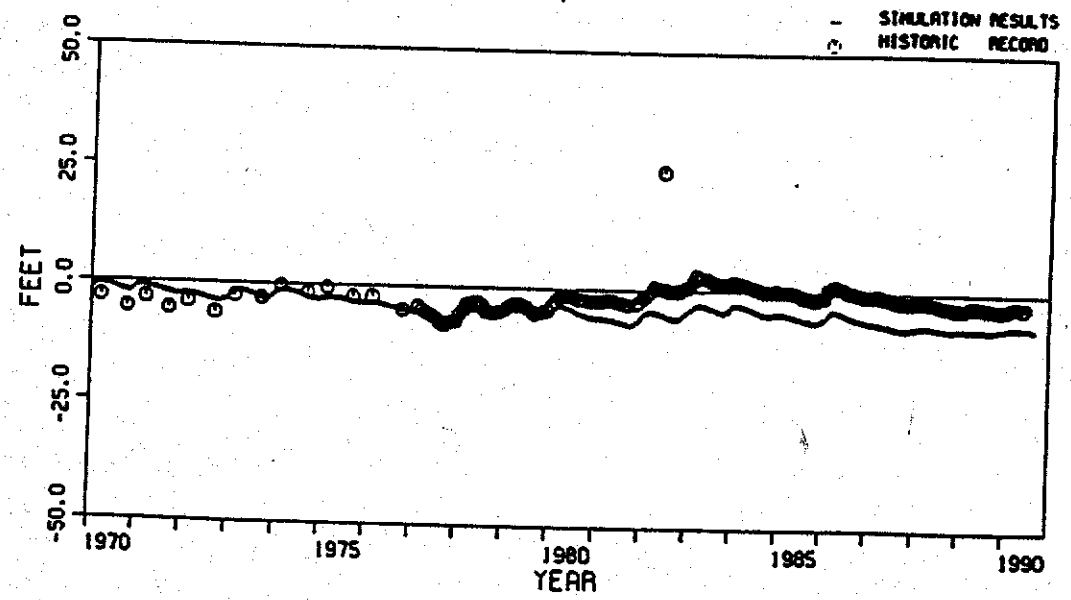
MONTHLY GROUNDWATER LEVEL
WELL 6 (09N/05E-21M01) L2



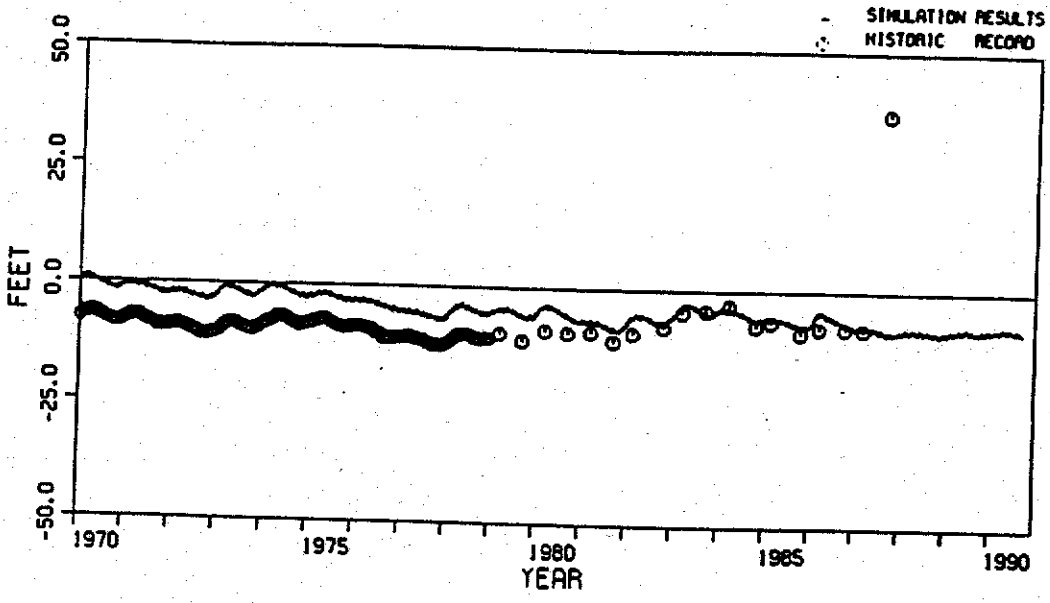
MONTHLY GROUNDWATER LEVEL
WELL 7 (DBN/05E-06H01)L2



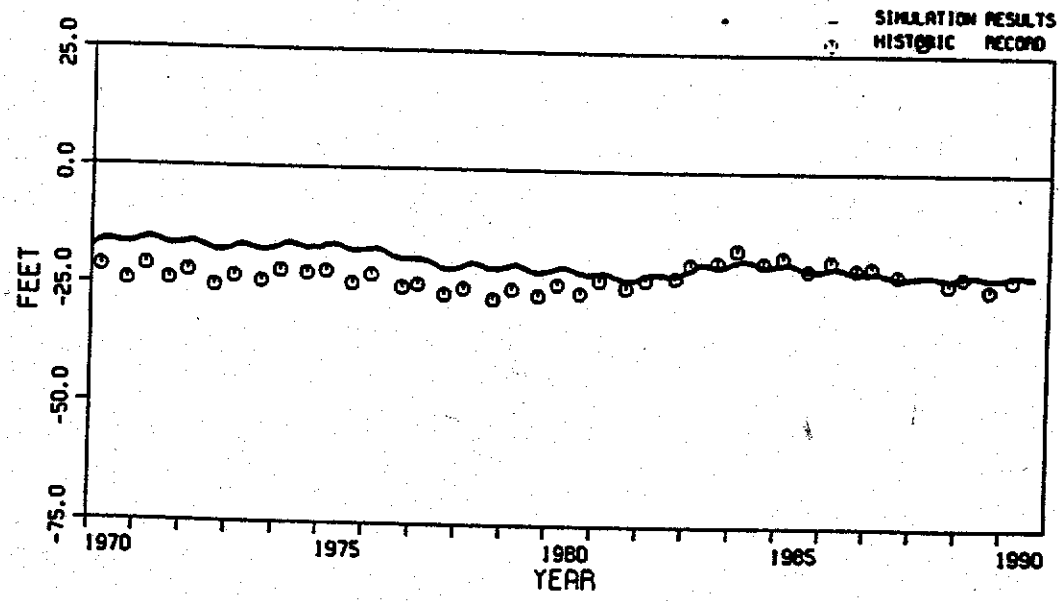
MONTHLY GROUNDWATER LEVEL
WELL 8 (DBN/05E-07P01)L1



MONTHLY GROUNDWATER LEVEL
WELL 9 10 8N/05E-15E01) L1

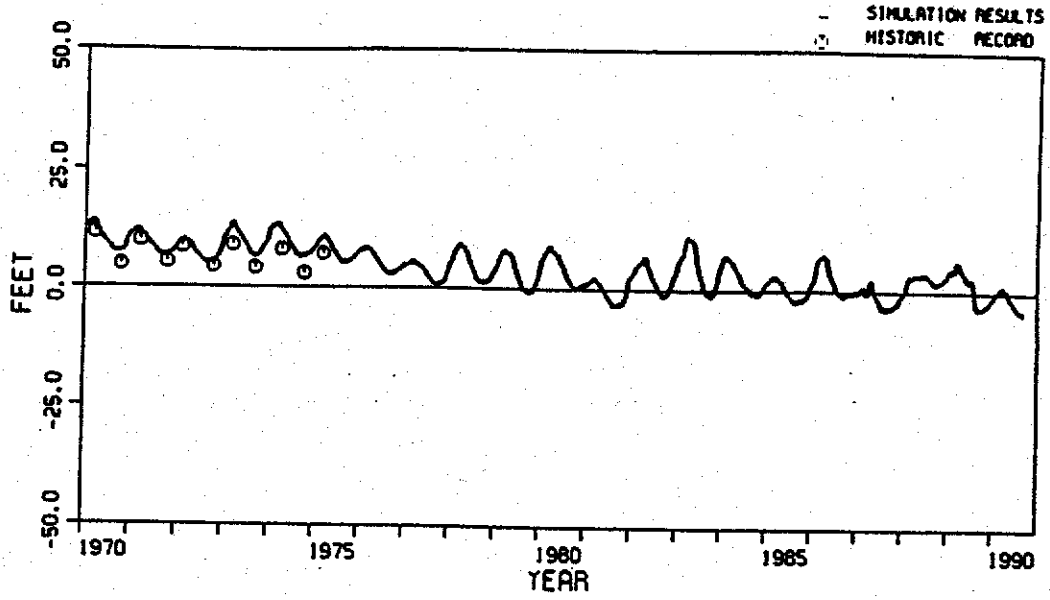


MONTHLY GROUNDWATER LEVEL
WELL 10 10 8N/05E-30A01) L2



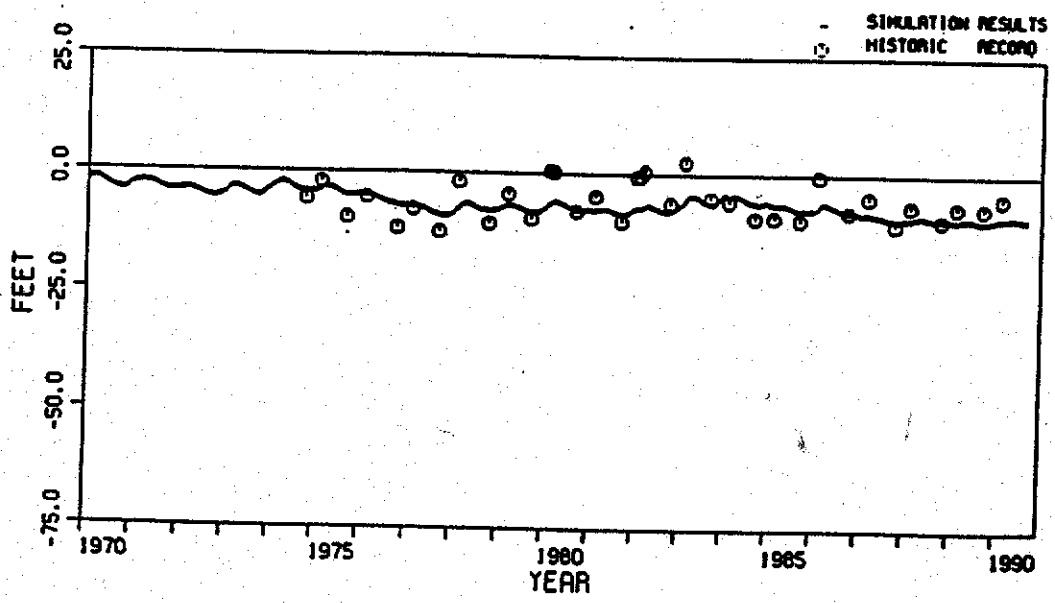
MONTHLY GROUNDWATER LEVEL

WELL 11 10BN/06E-08F01) L1



MONTHLY GROUNDWATER LEVEL

WELL 12 10BN/04E-12D01) L2



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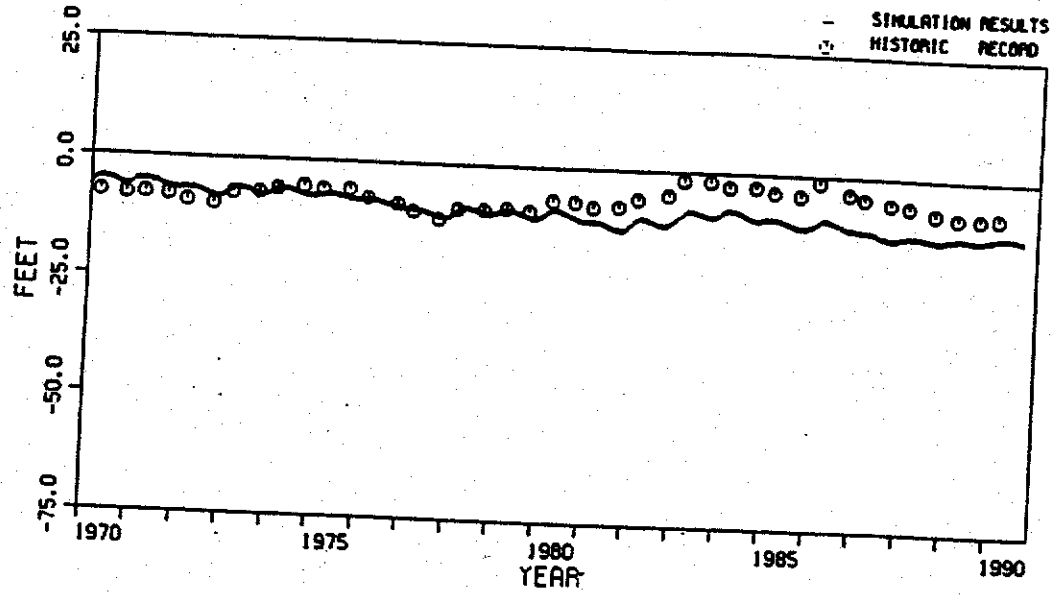
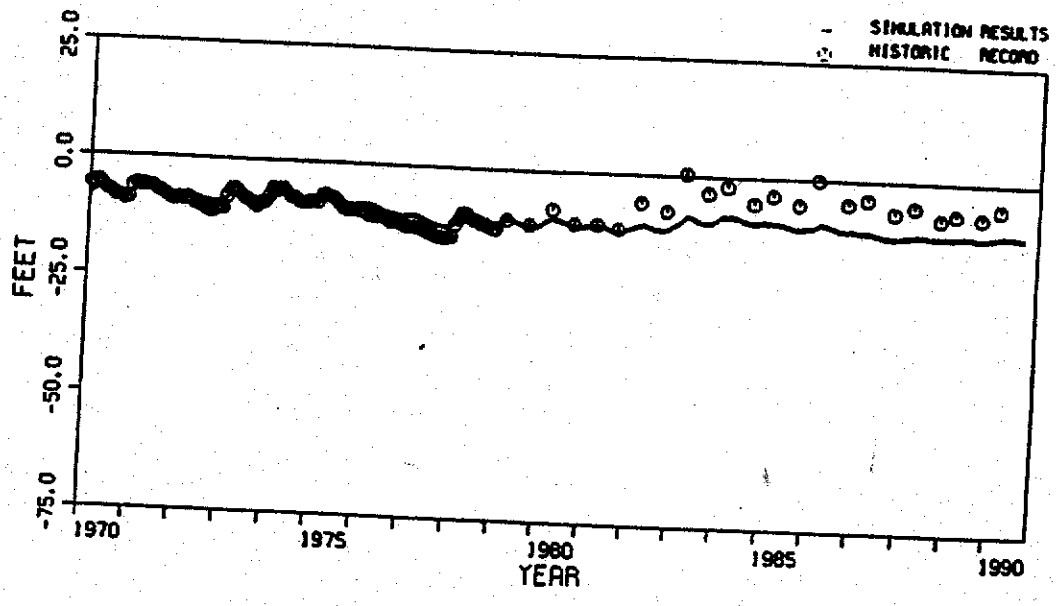
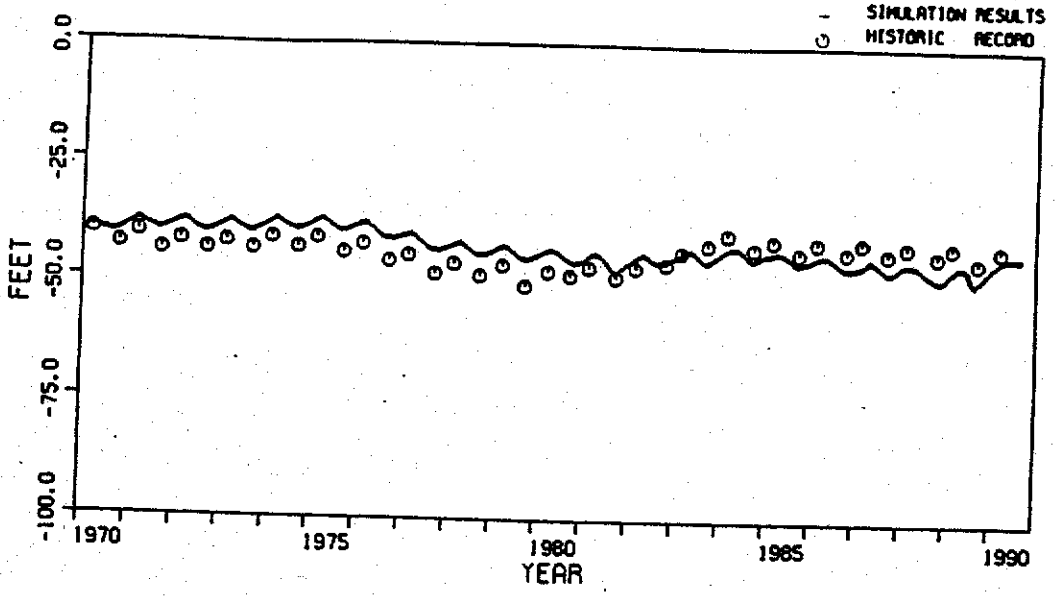
WELL 13 10BN/05E-18K01) L1



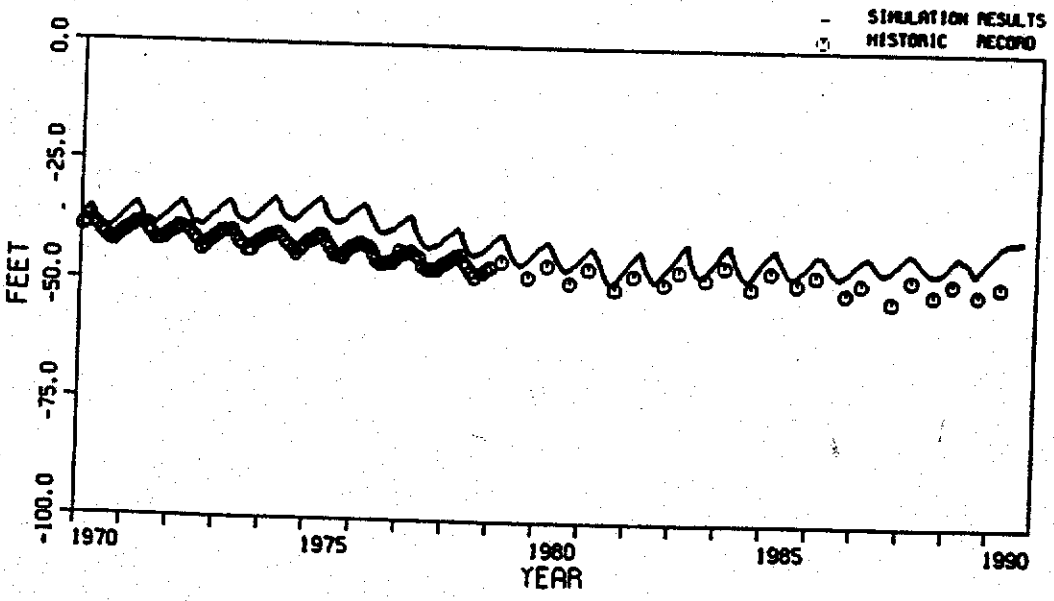
MONTHLY GROUNDWATER LEVEL
WELL 14 10BN/04E-24M01) L2



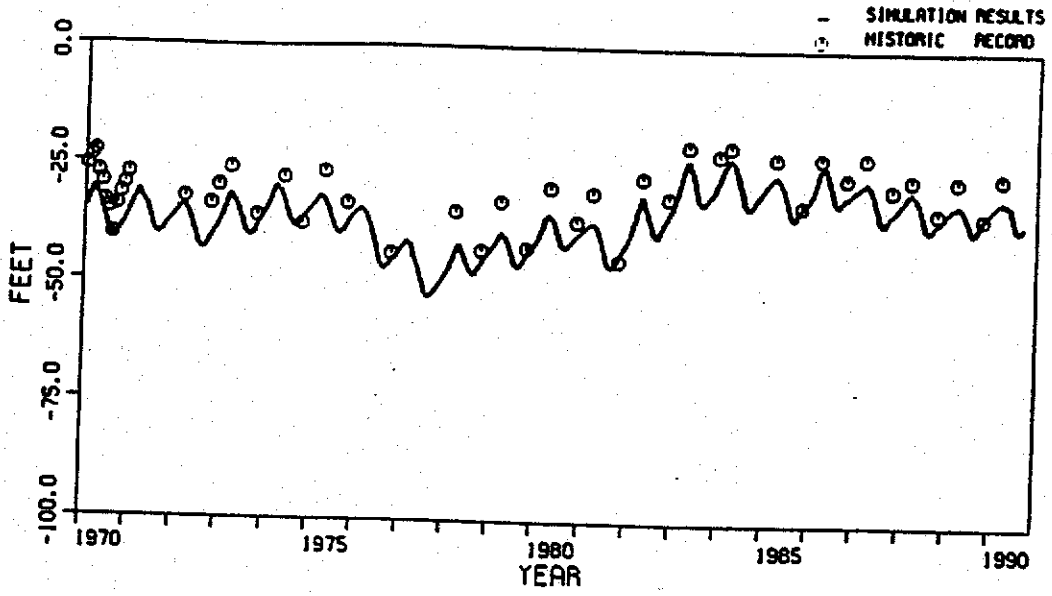
MONTHLY GROUNDWATER LEVEL
WELL 15 (07N/05E-10M01) L2



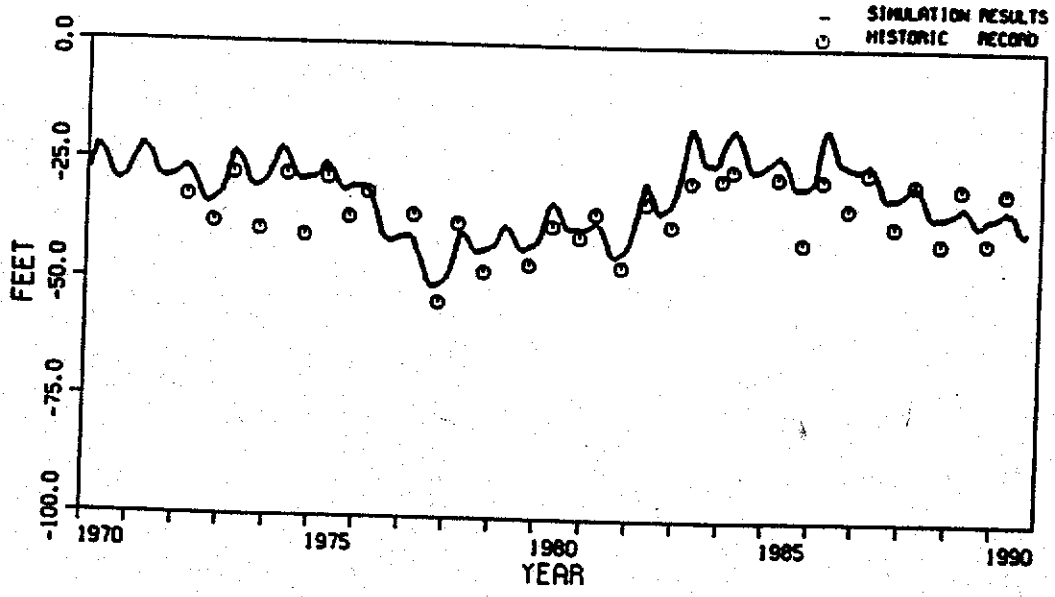
MONTHLY GROUNDWATER LEVEL
WELL 16 (07N/05E-01H02) L2



MONTHLY GROUNDWATER LEVEL
WELL 19 10SN/05E-10C03) L1

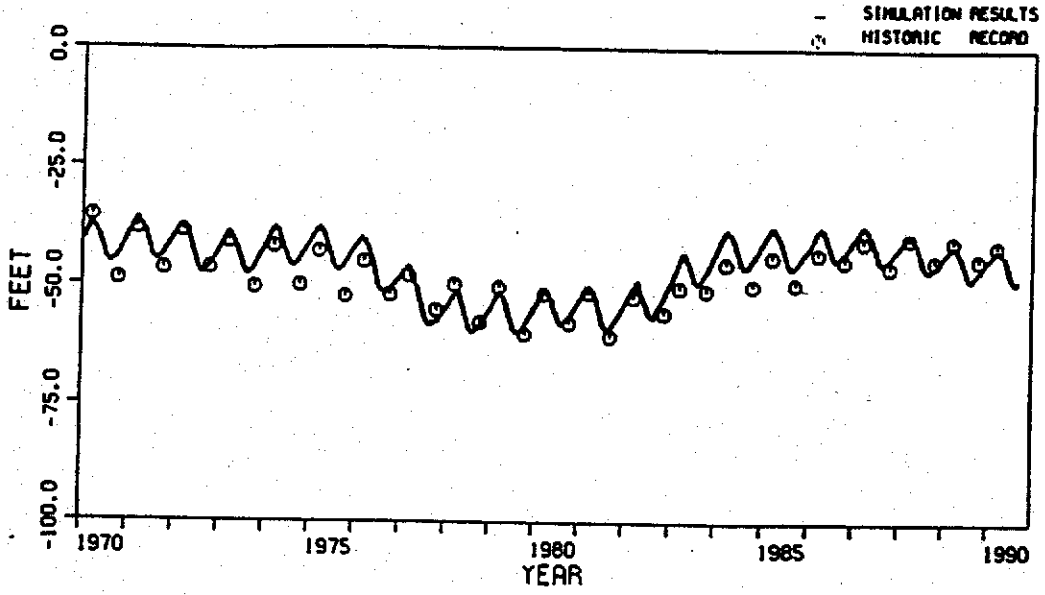


MONTHLY GROUNDWATER LEVEL
WELL 20 10SN/06E-08R01) L1



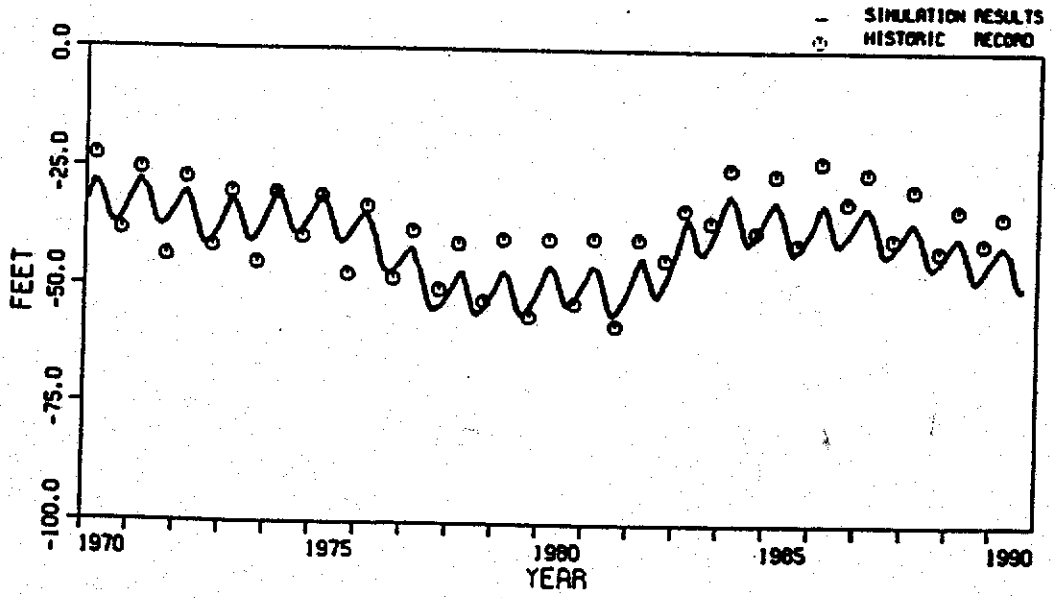
MONTHLY GROUNDWATER LEVEL

WELL 21 10SN/06E-10P01) L2

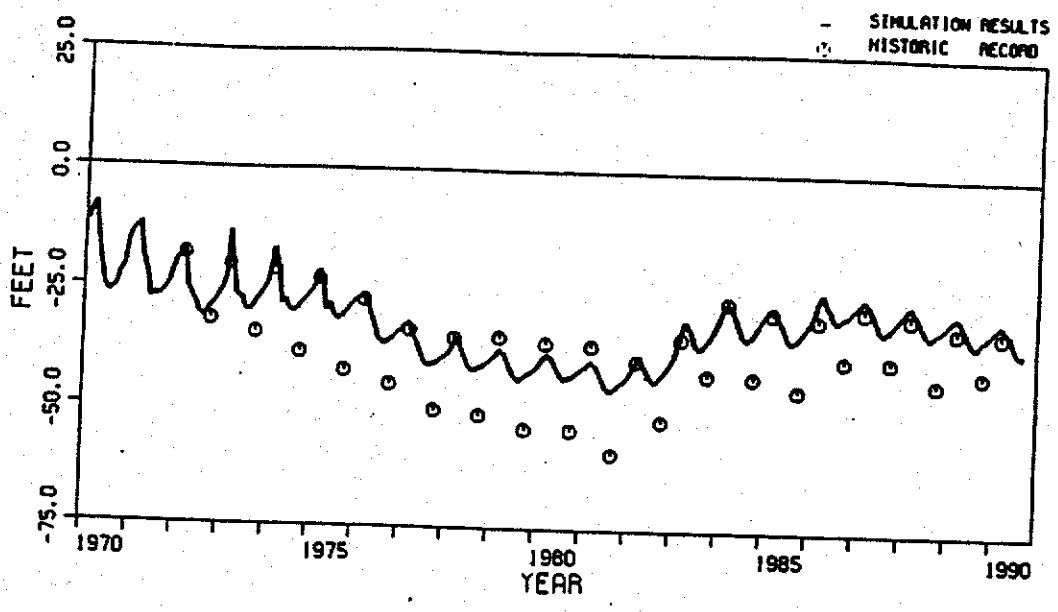


MONTHLY GROUNDWATER LEVEL

WELL 22 10SN/06E-26D01) L2



MONTHLY GROUNDWATER LEVEL
WELL 25 10SN/07E-16A01) L1



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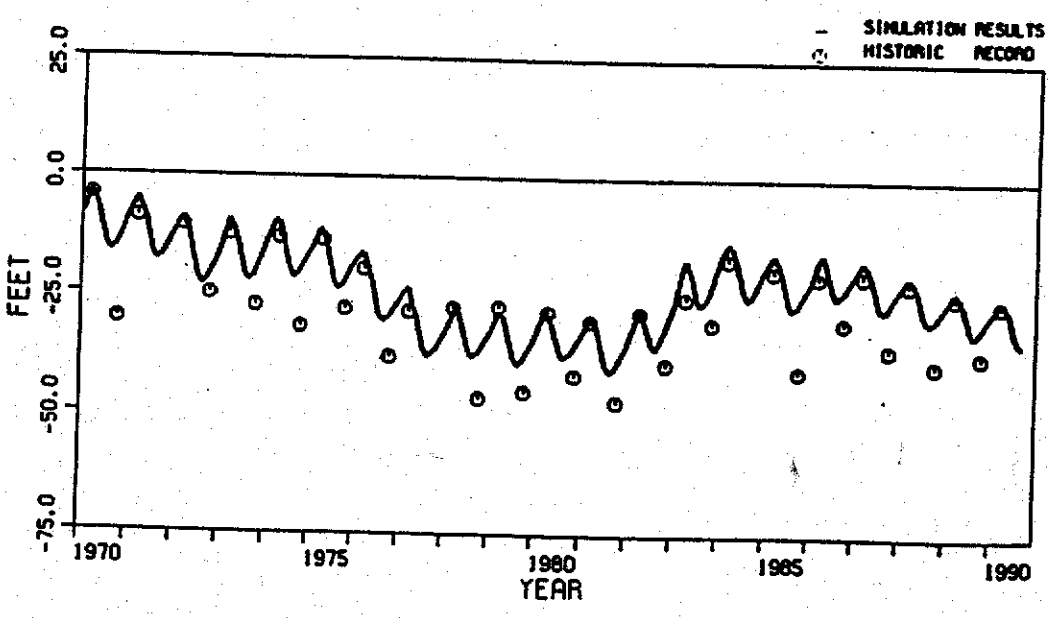
WELL 26 10SN/07E-28A01) L2



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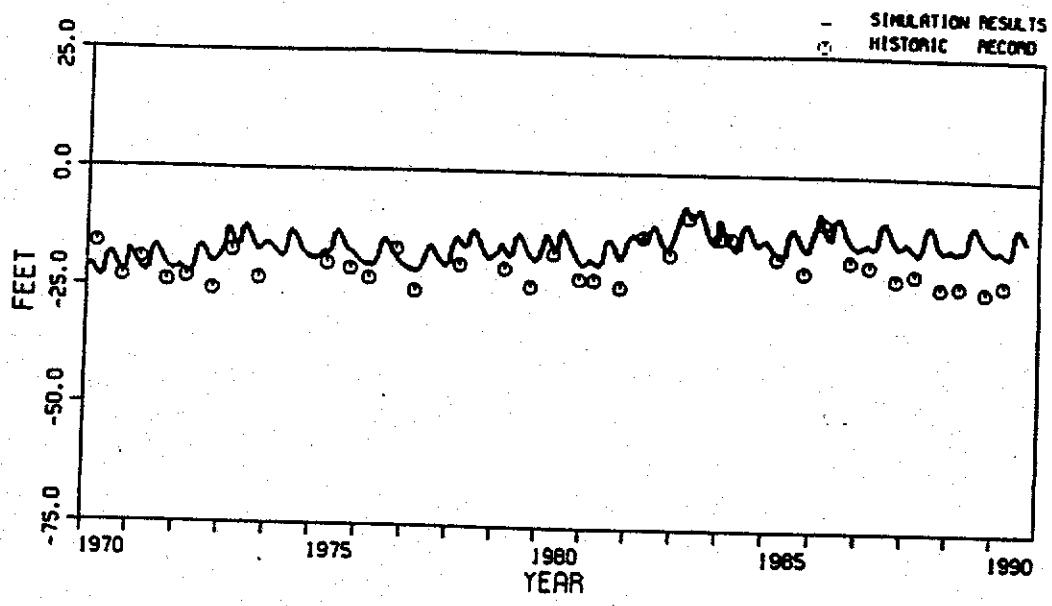
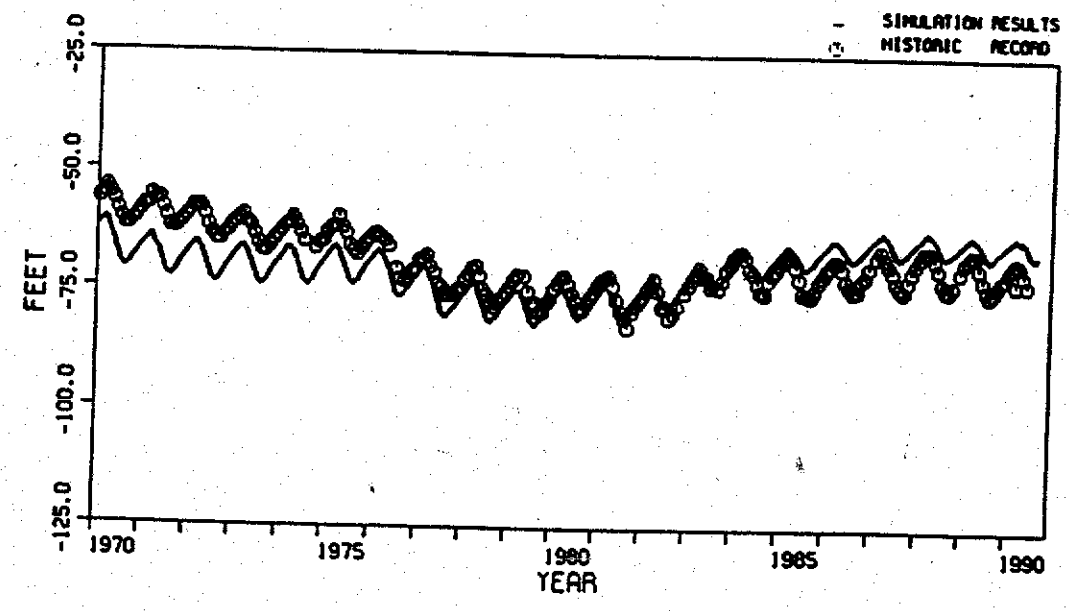
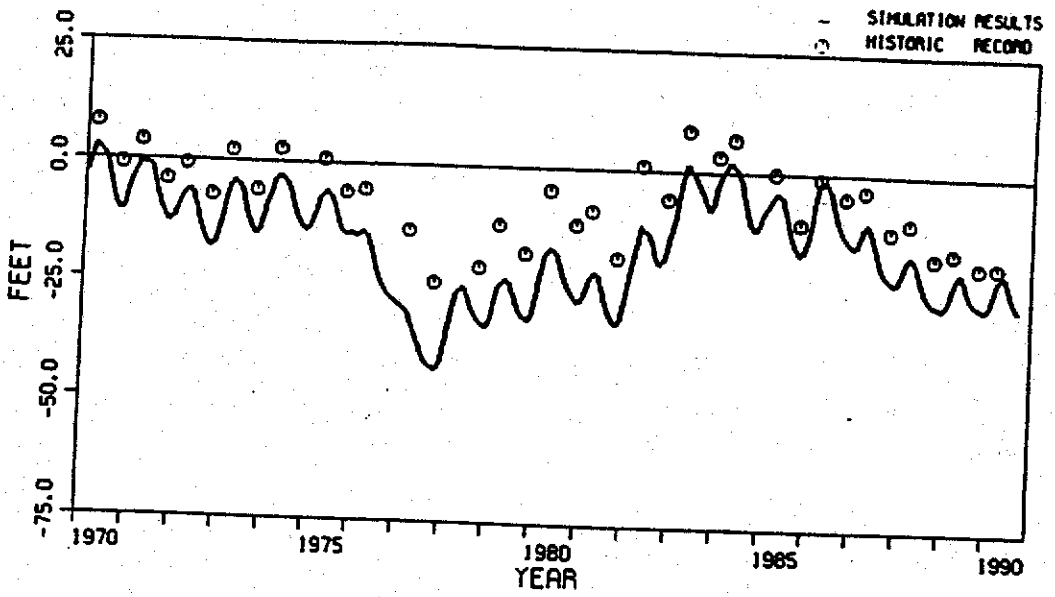
WELL 27 I06N/04E-24A01) L1



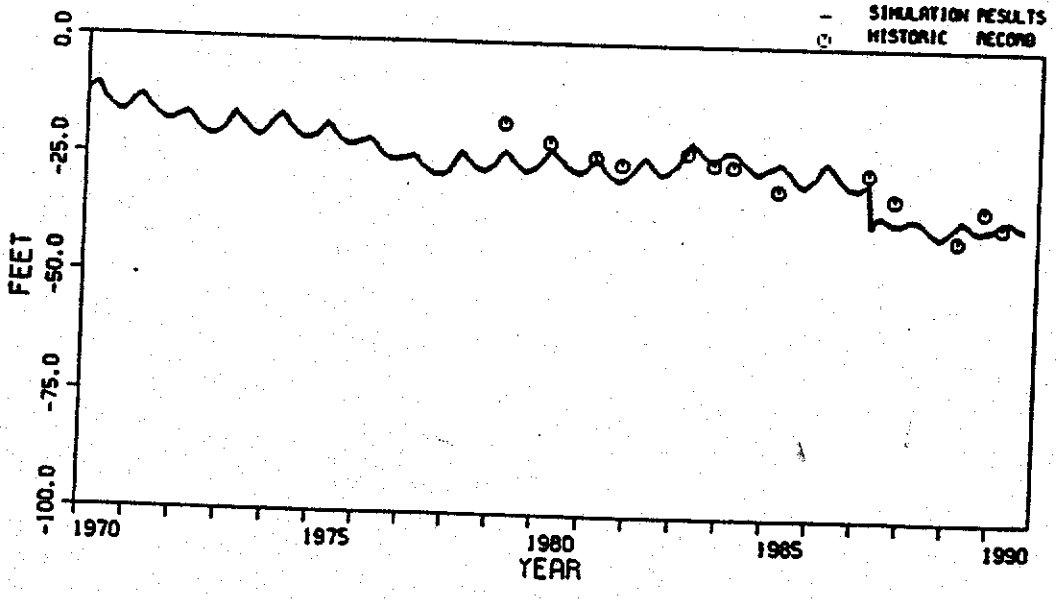
MONTHLY GROUNDWATER LEVEL
WELL 28 I06N/05E-01C01) L2



MONTHLY GROUNDWATER LEVEL
WELL 29 10N/06E-22C01 L1

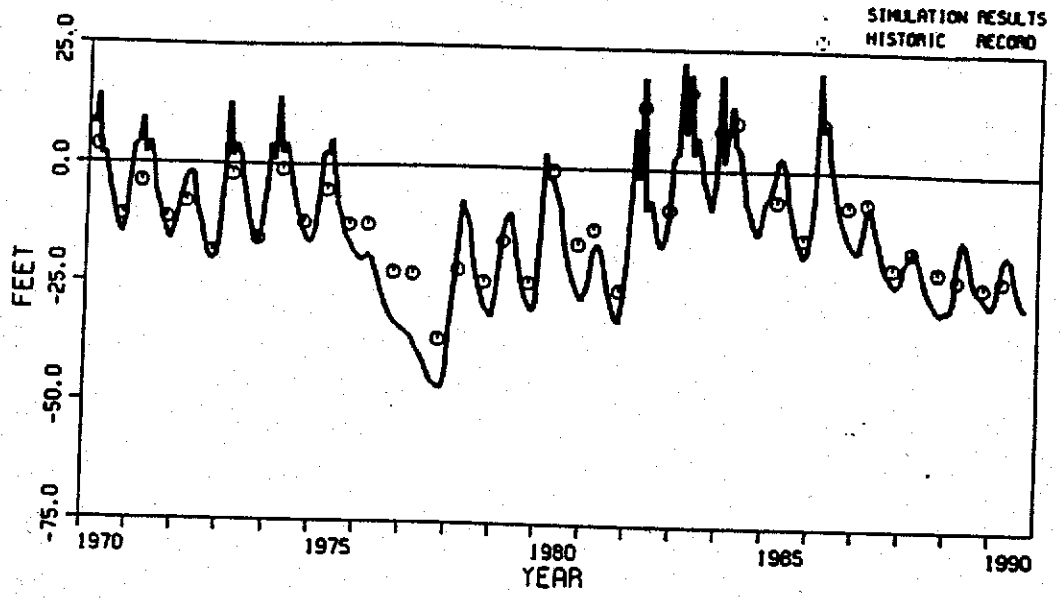


MONTHLY GROUNDWATER LEVEL
WELL 30 11DN/05E-34M01 L1



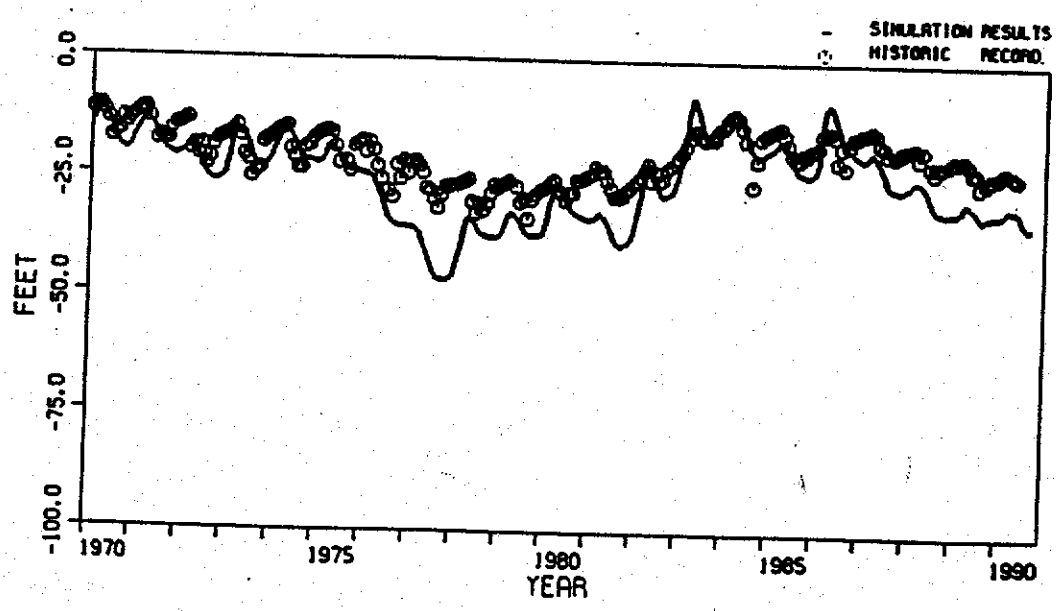
MONTHLY GROUNDWATER LEVEL

WELL 31 (06N/06E-29K01) L1

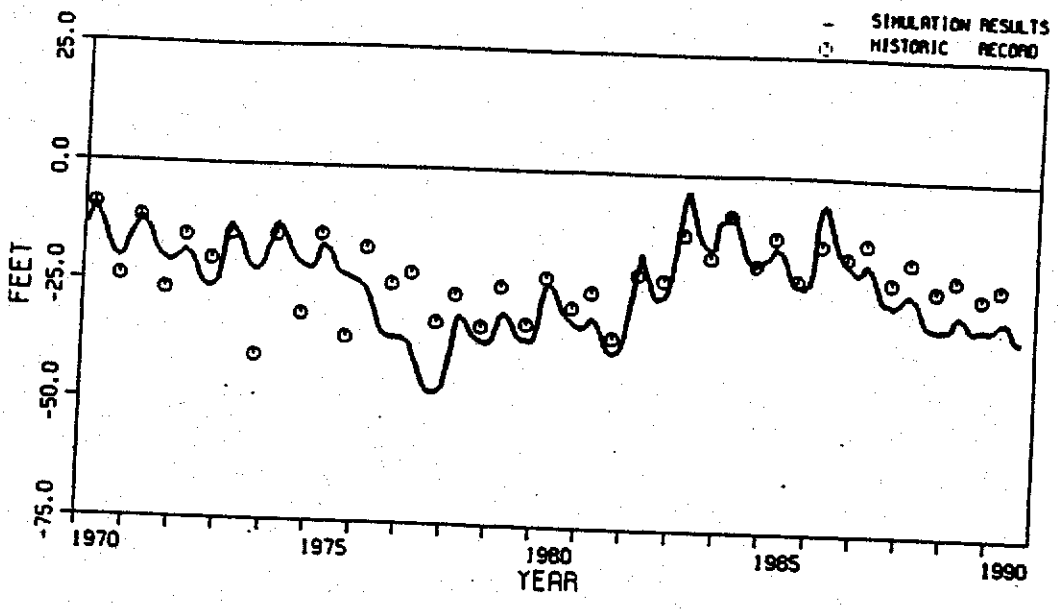


MONTHLY GROUNDWATER LEVEL

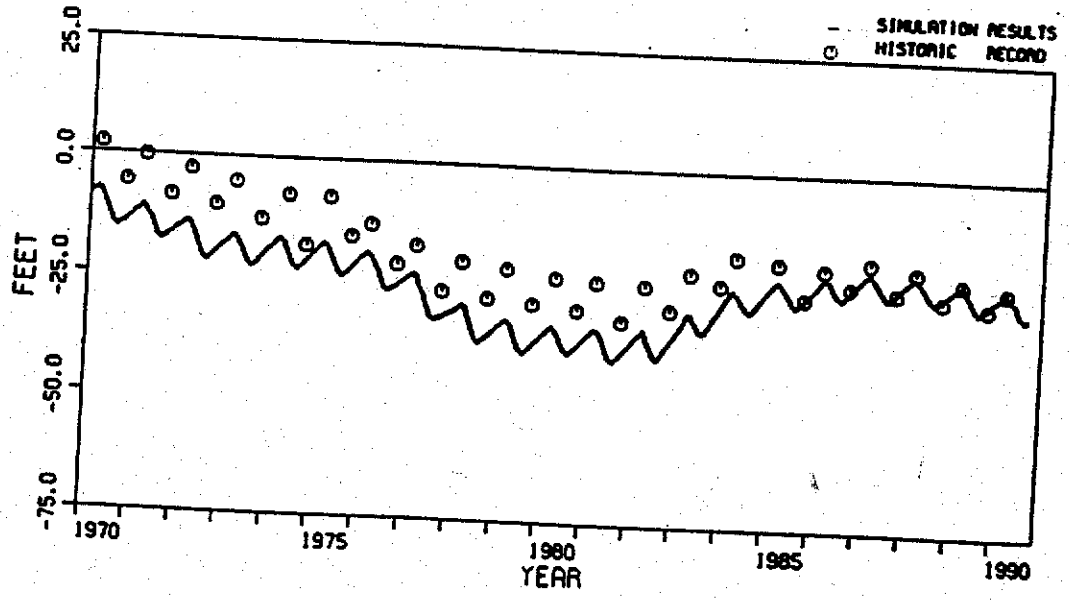
WELL 32 (06N/06E-33J02) L1



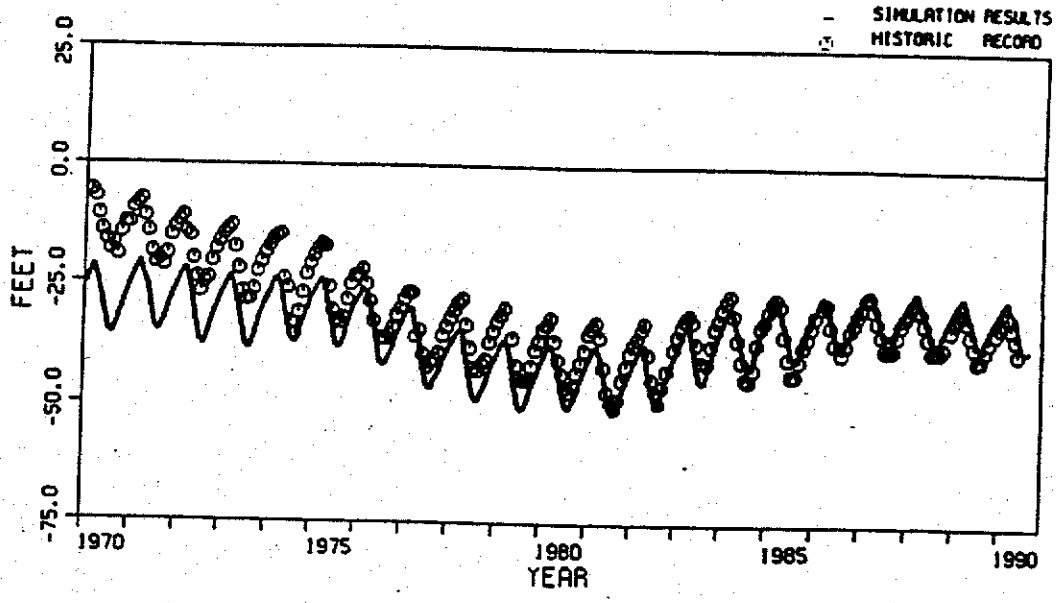
MONTHLY GROUNDWATER LEVEL
WELL 33 I06N/06E-33L01 L1



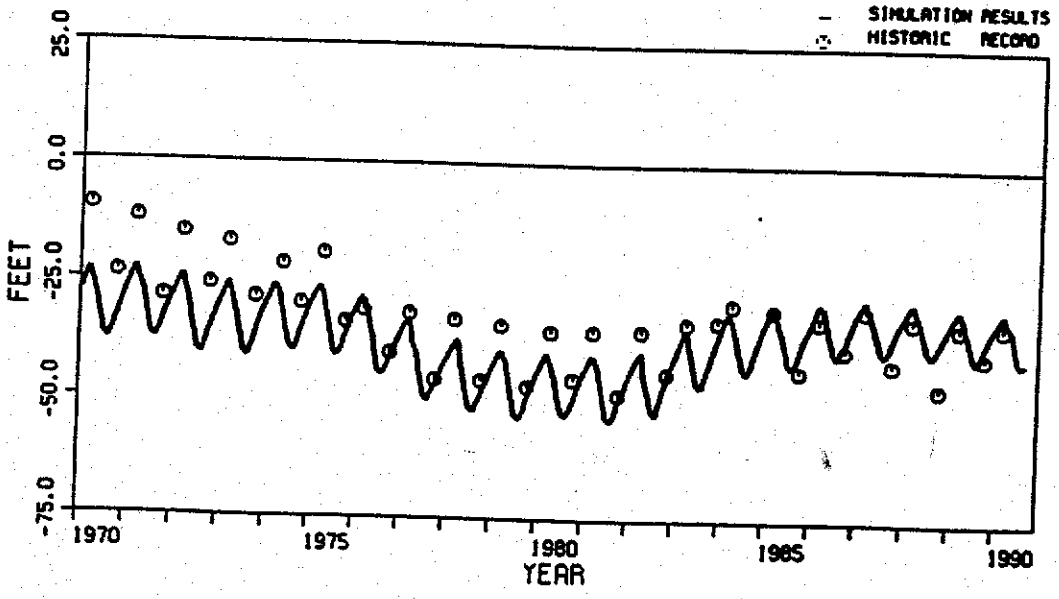
MONTHLY GROUNDWATER LEVEL
WELL 34 I06N/07E-08R01 L1



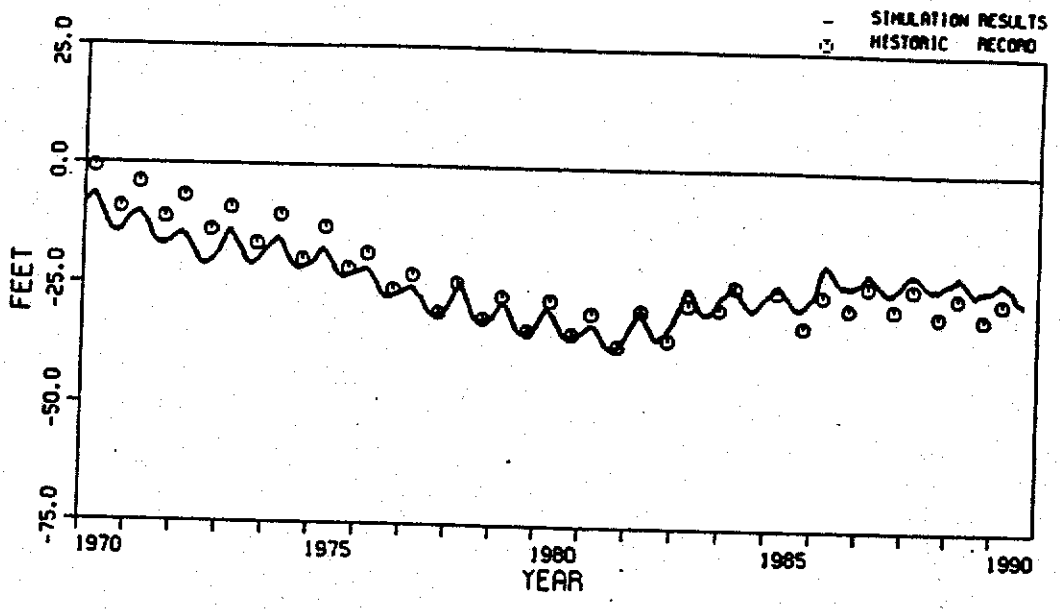
MONTHLY GROUNDWATER LEVEL
WELL 35 I06N/07E-28E01 L2



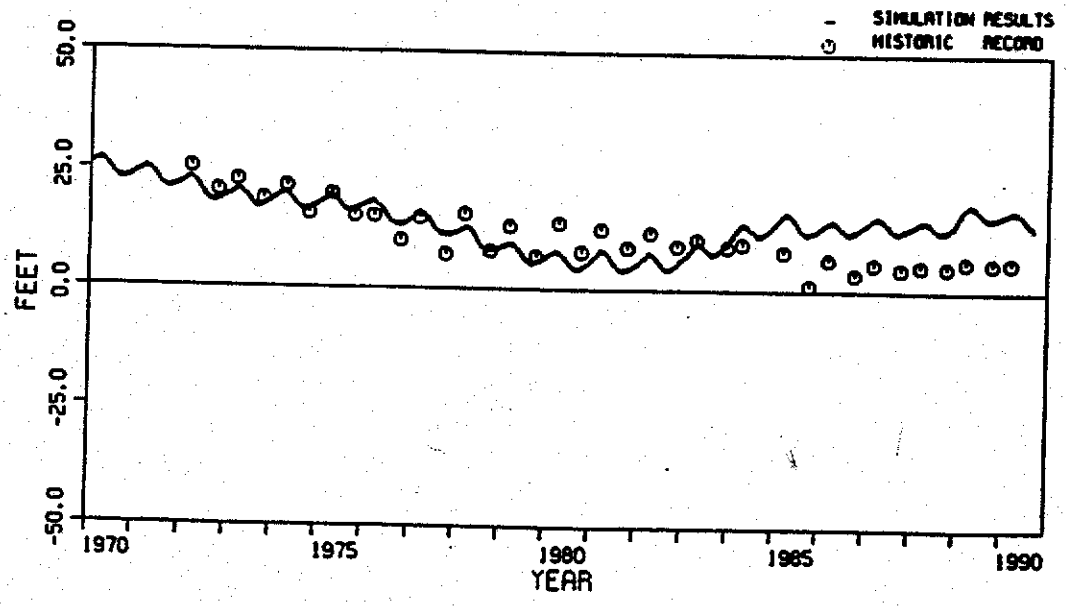
MONTHLY GROUNDWATER LEVEL
WELL 36 I06N/07E-32P01 L2



MONTHLY GROUNDWATER LEVEL
WELL 37 I06N/07E-34H01) L1

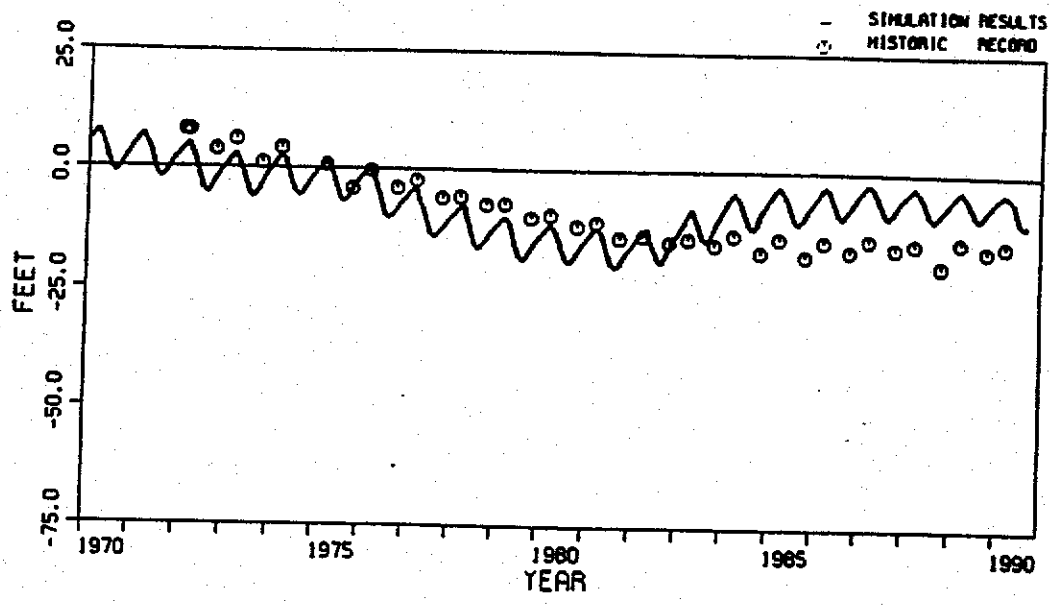


MONTHLY GROUNDWATER LEVEL
WELL 38 I06N/06E-21P03) L2



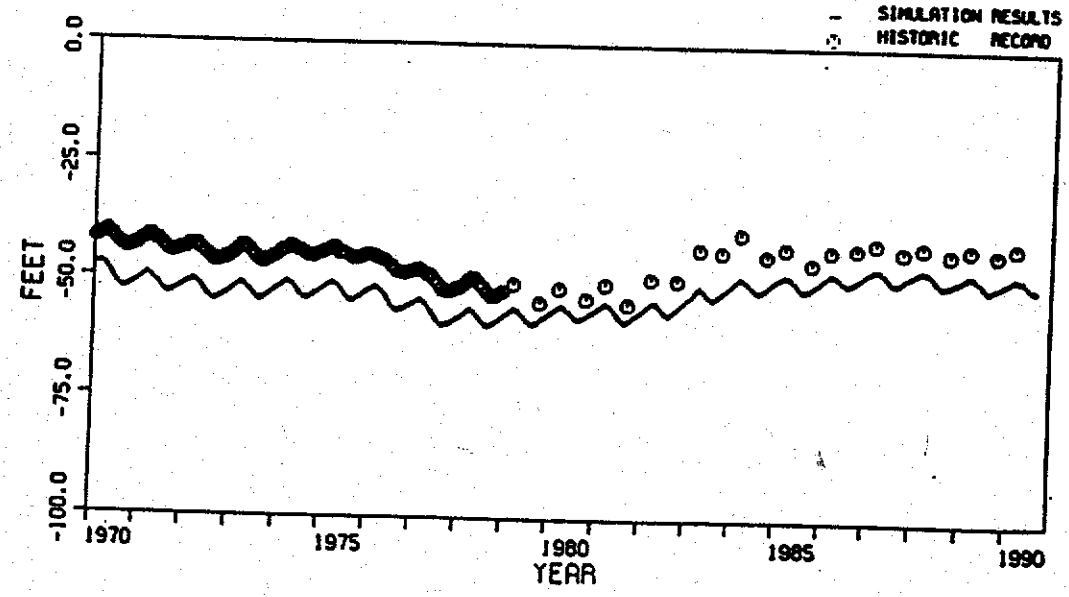
MONTHLY GROUNDWATER LEVEL

WELL 39 (06N/08E-31E02) L2

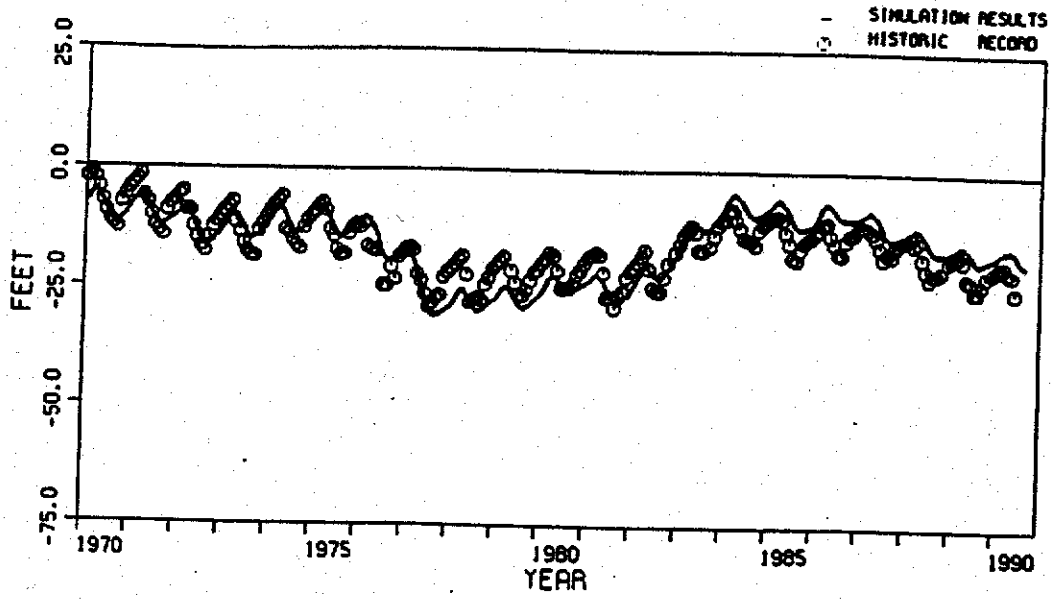


MONTHLY GROUNDWATER LEVEL

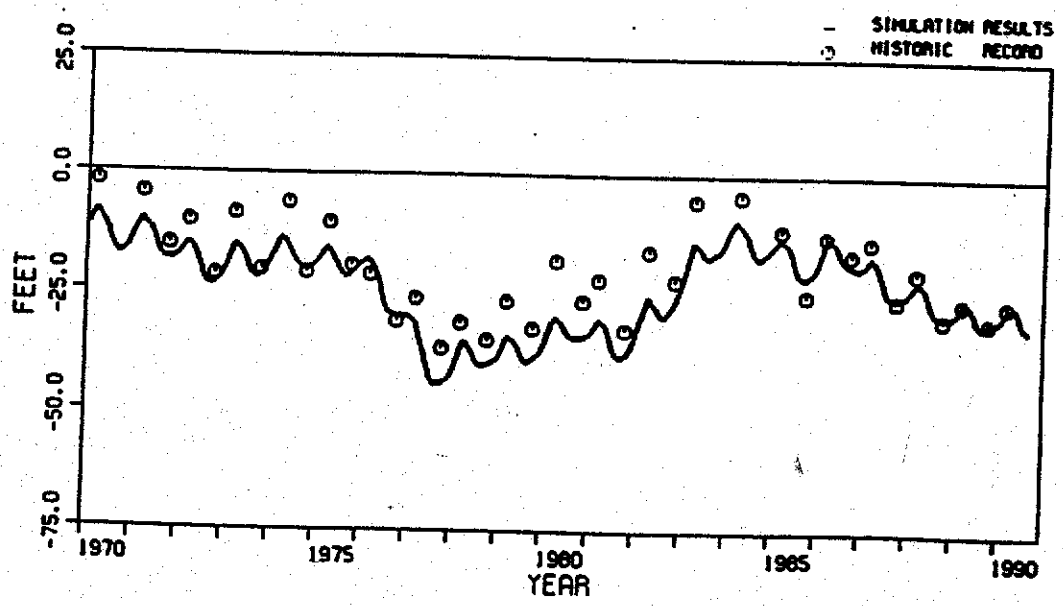
WELL 40 (07N/05E-32K01) L1



MONTHLY GROUNDWATER LEVEL
WELL 41 107N/06E-23P01 L1

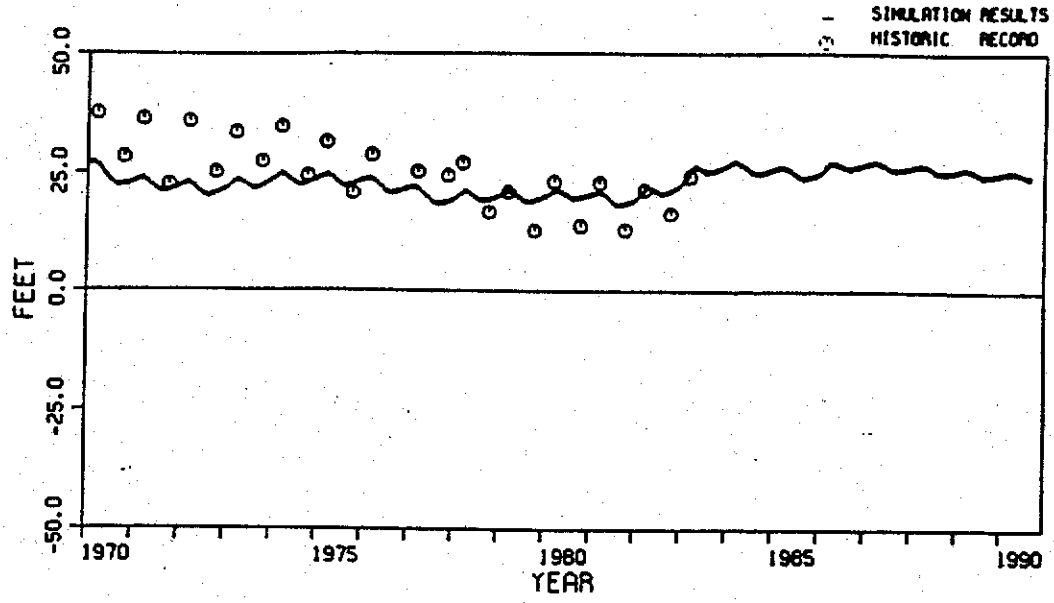


MONTHLY GROUNDWATER LEVEL
WELL 42 107N/06E-33J01 L1



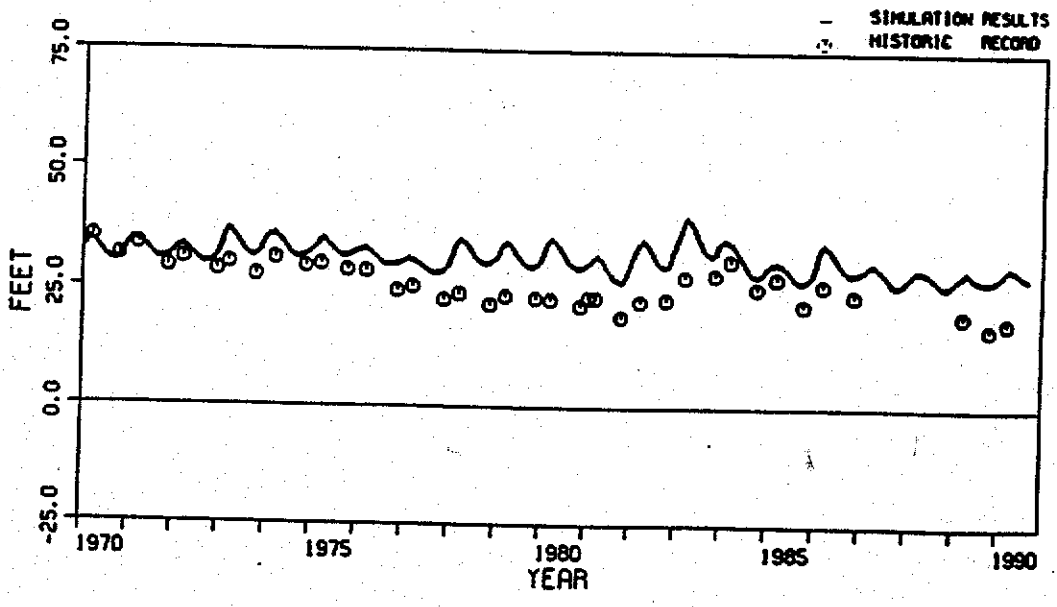
MONTHLY GROUNDWATER LEVEL

WELL 45 (08N/07E-18E01) L1

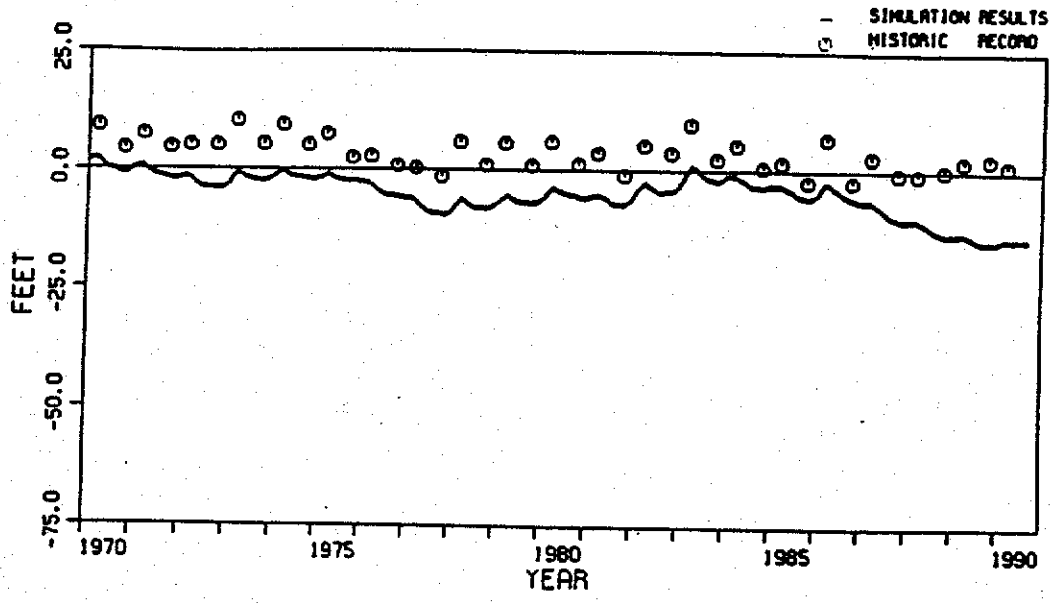


MONTHLY GROUNDWATER LEVEL

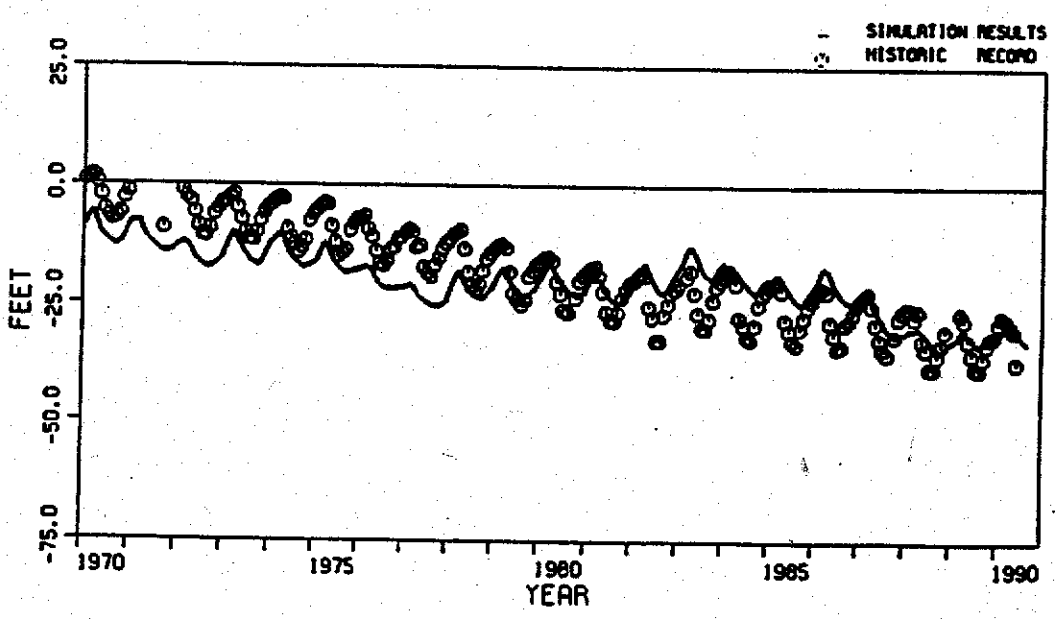
WELL 46 (09N/06E-34R01) L1



MONTHLY GROUNDWATER LEVEL
WELL 47(1DN/04E-36B01)L1

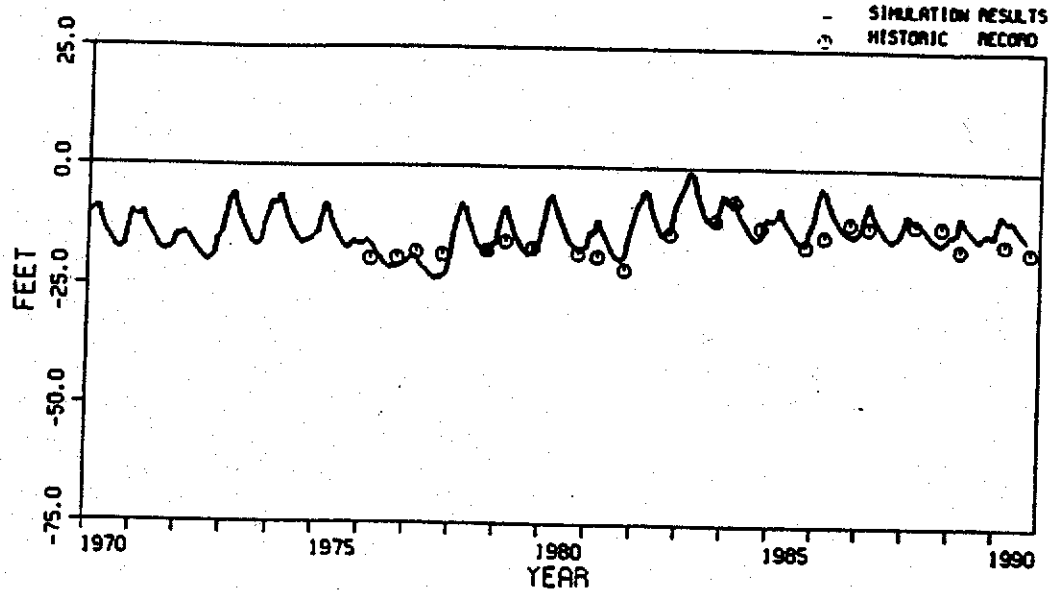


MONTHLY GROUNDWATER LEVEL
WELL 48(1DN/05E-22G01)L1



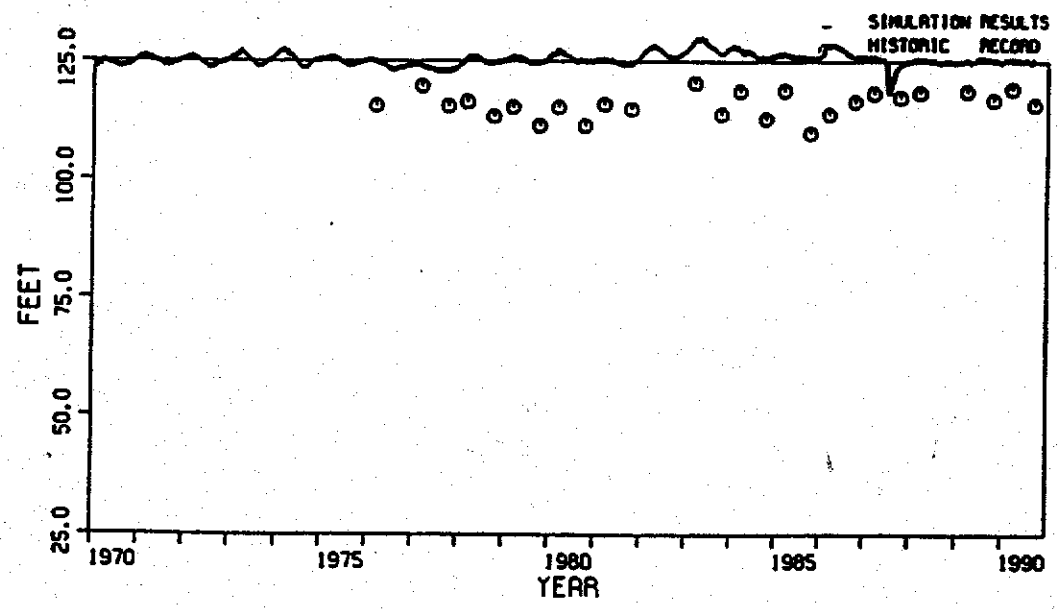
MONTHLY GROUNDWATER LEVEL

WELL 49 107N/05E-18C01) L1

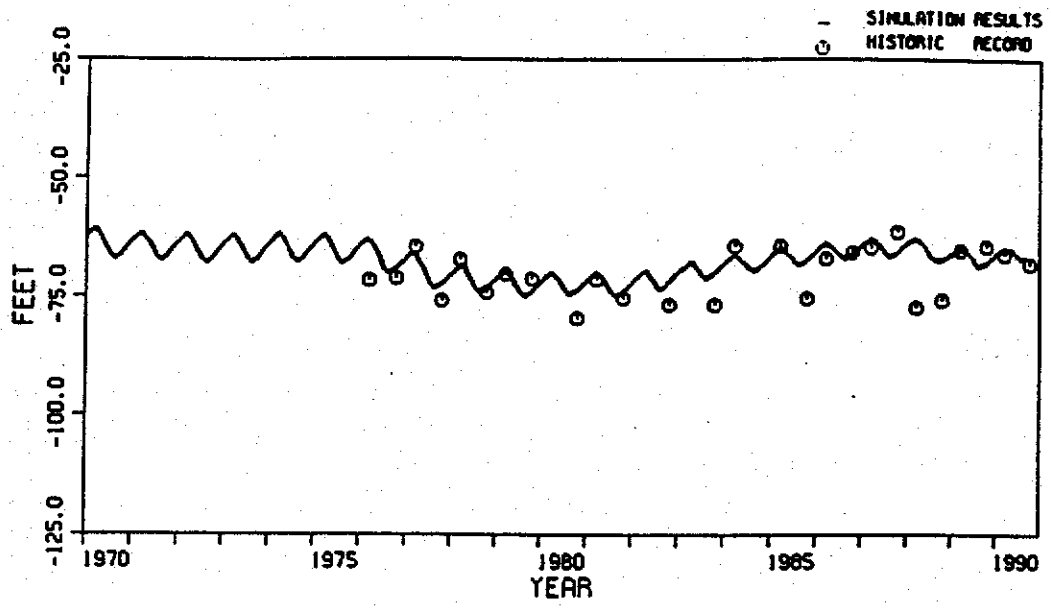


MONTHLY GROUNDWATER LEVEL

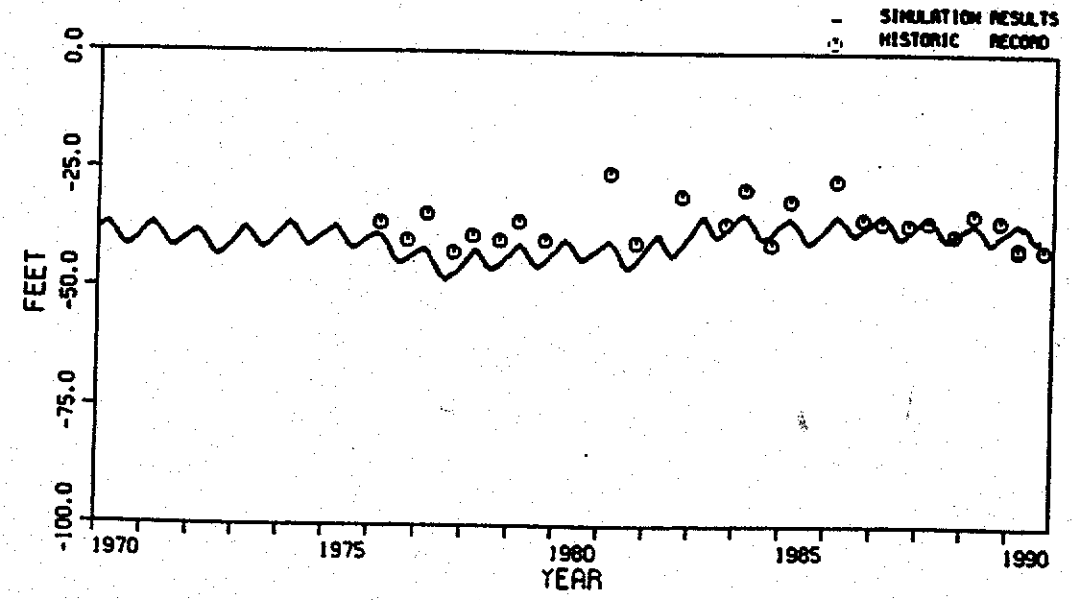
WELL 50 109N/07E-09A01) L1



MONTHLY GROUNDWATER LEVEL
WELL 51 (07N/05E-26P02) L2



MONTHLY GROUNDWATER LEVEL
WELL 52 (07N/05E-29D01) L1



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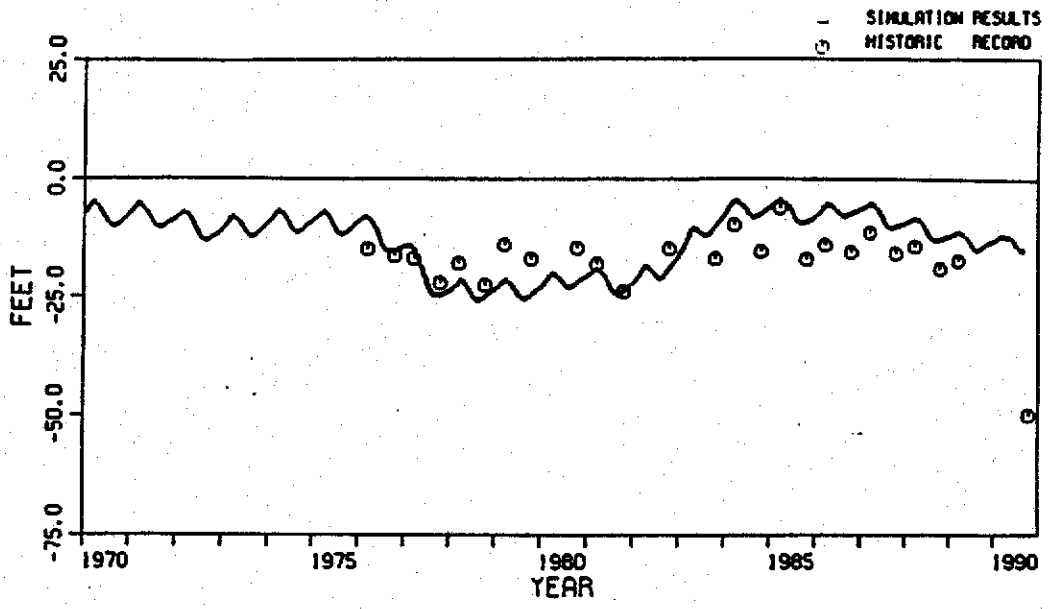
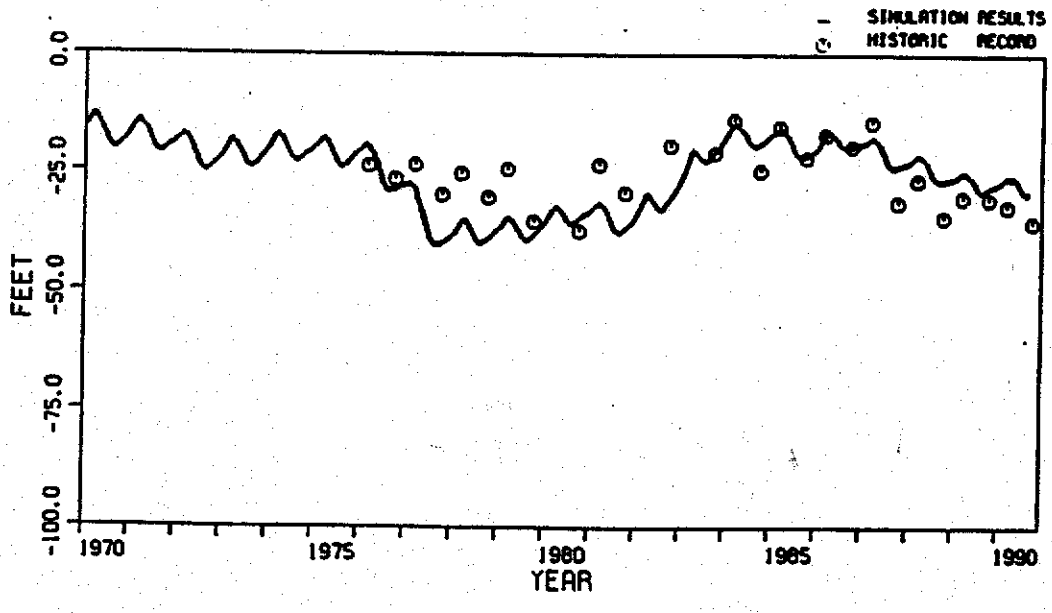
WELL 53 (07N/06E-14Q01) L1

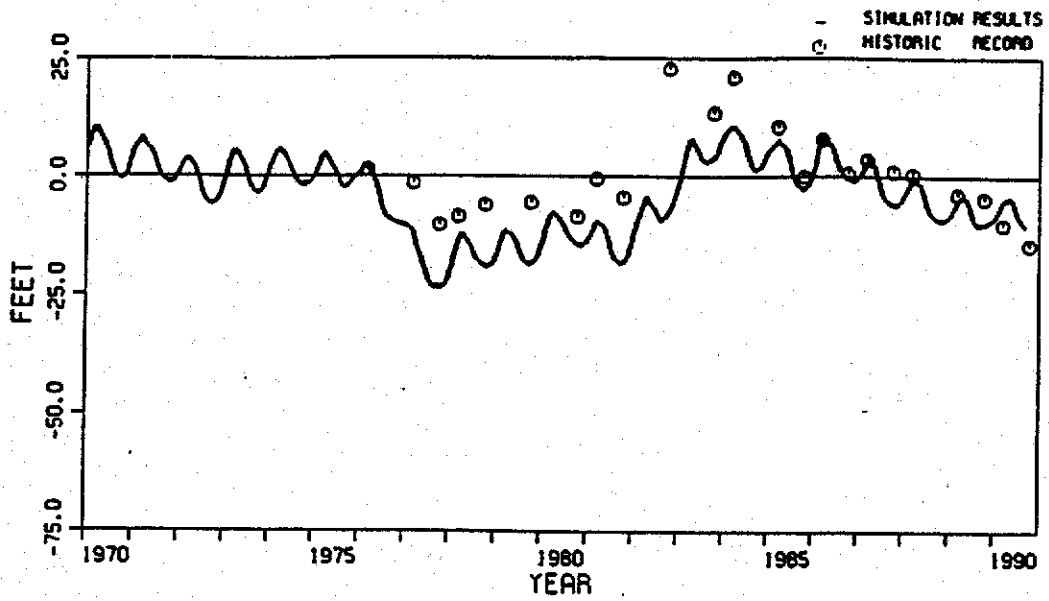


MONTHLY GROUNDWATER LEVEL
WELL 54 (07N/06E-22R02) L1



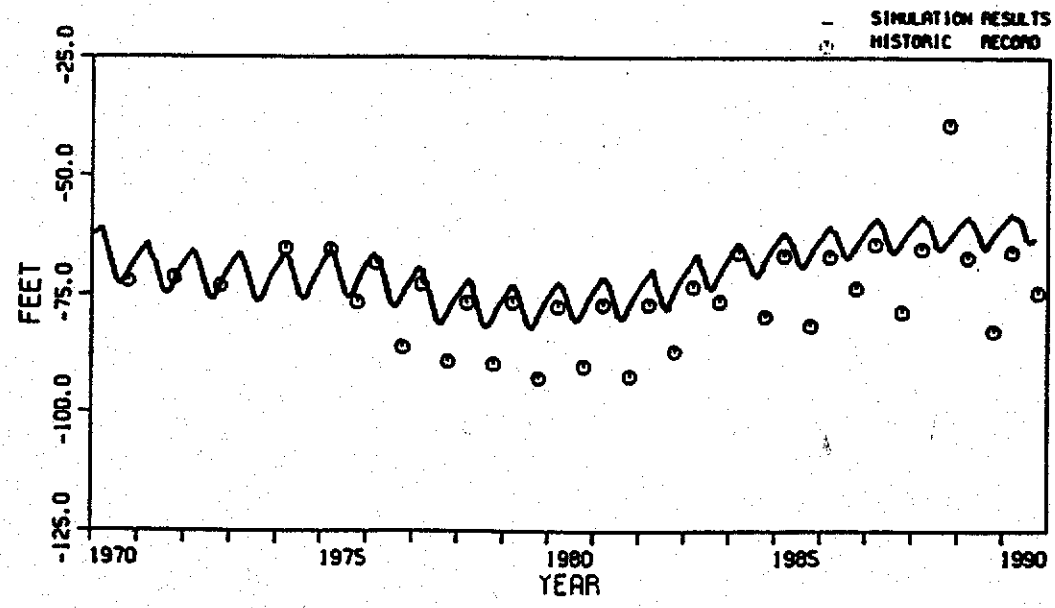
MONTHLY GROUNDWATER LEVEL

WELL 55 107N/06E-26001 L1

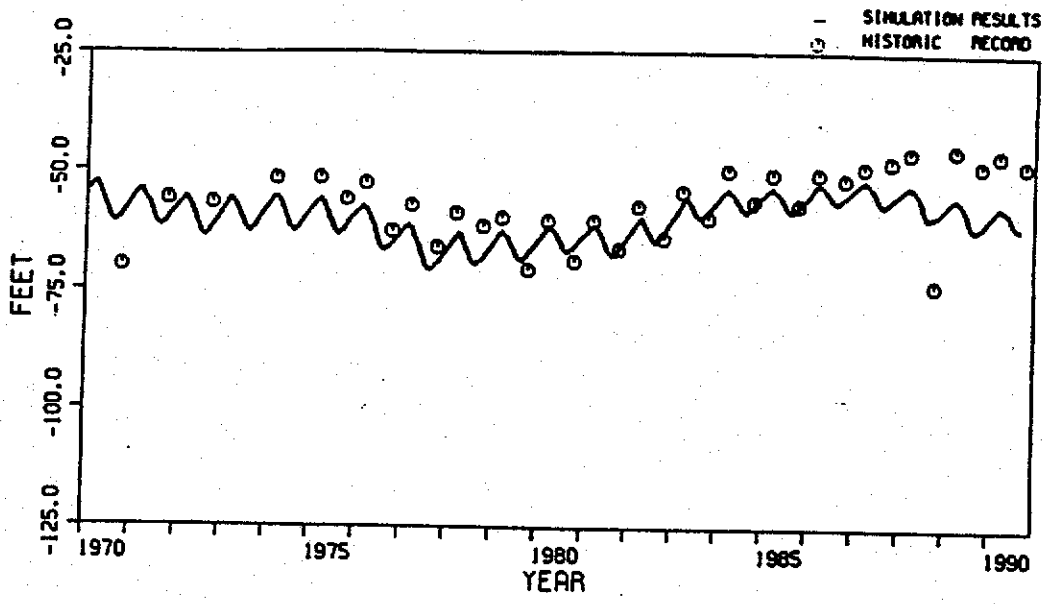


MONTHLY GROUNDWATER LEVEL

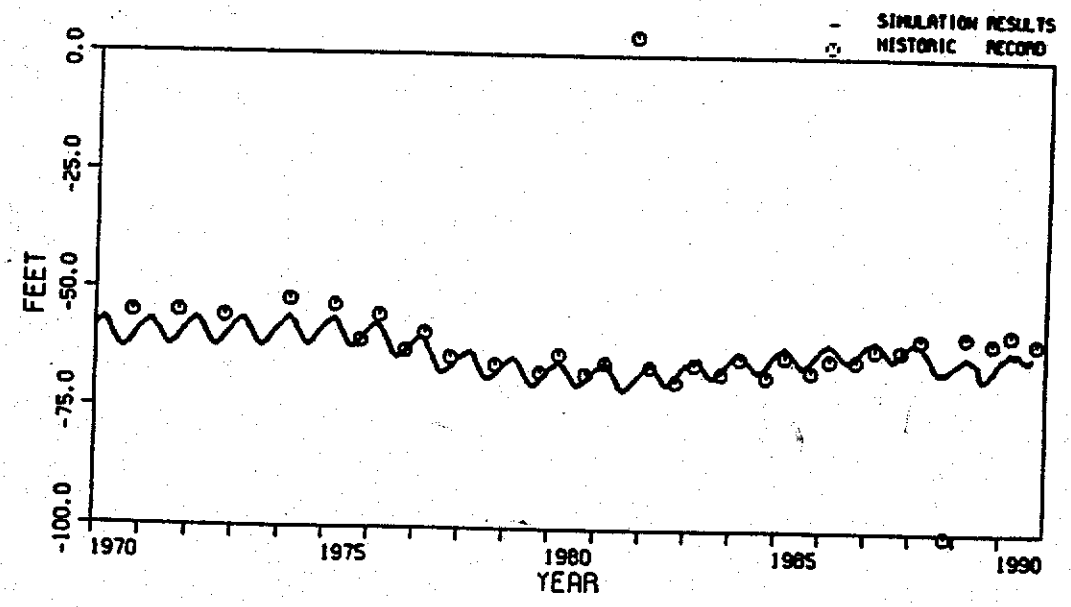
WELL 56 106N/05E-10G01 L2



MONTHLY GROUNDWATER LEVEL
WELL 57 107N/05E-28P01) L1

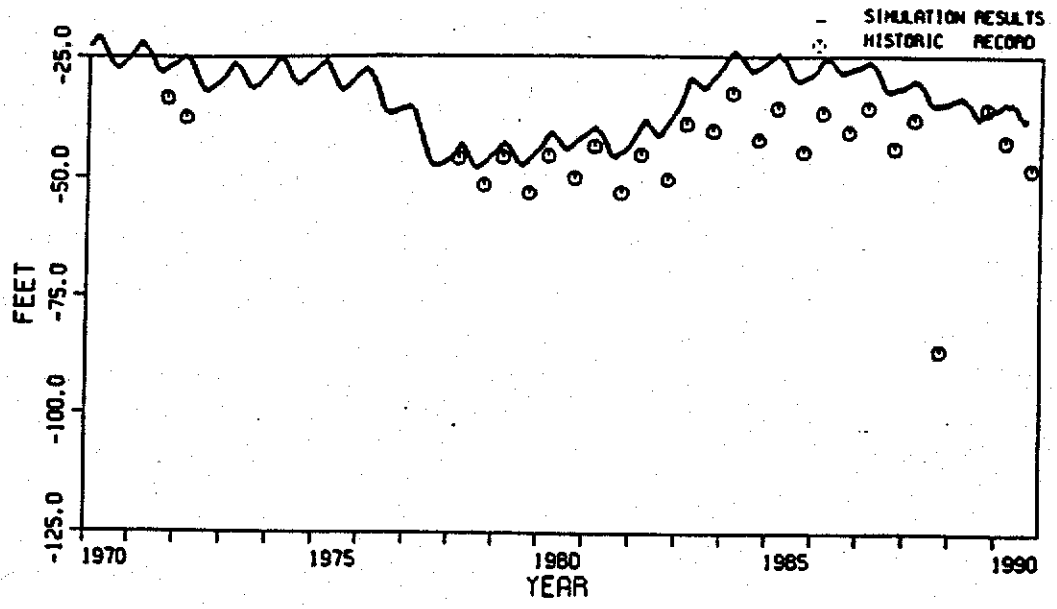


MONTHLY GROUNDWATER LEVEL
WELL 58 107N/05E-24H01) L2



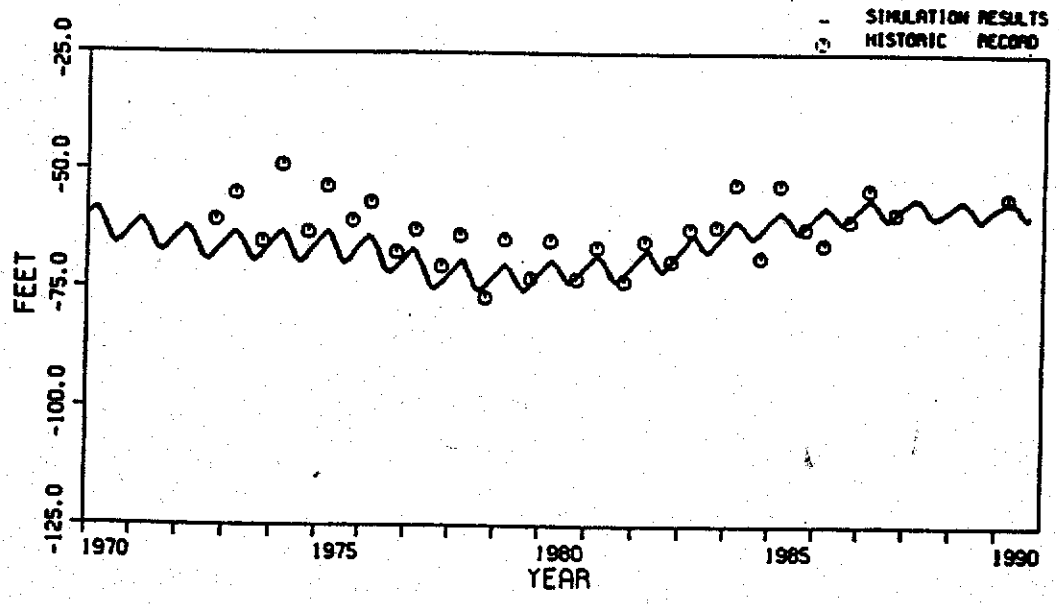
MONTHLY GROUNDWATER LEVEL

WELL 59107N/07E-28N01) L1



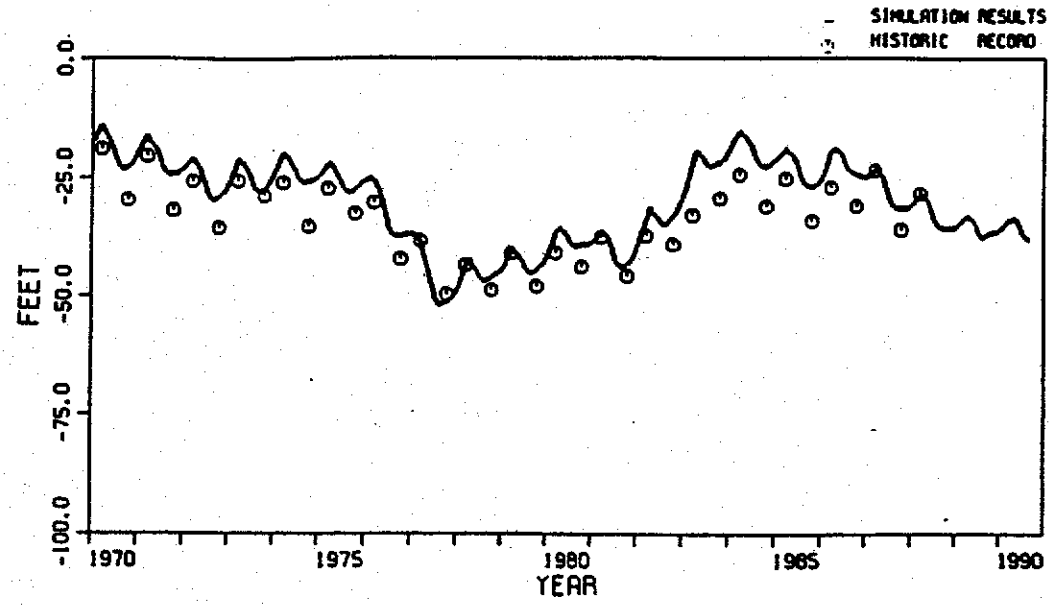
MONTHLY GROUNDWATER LEVEL

WELL 60106N/05E-04N01) L1



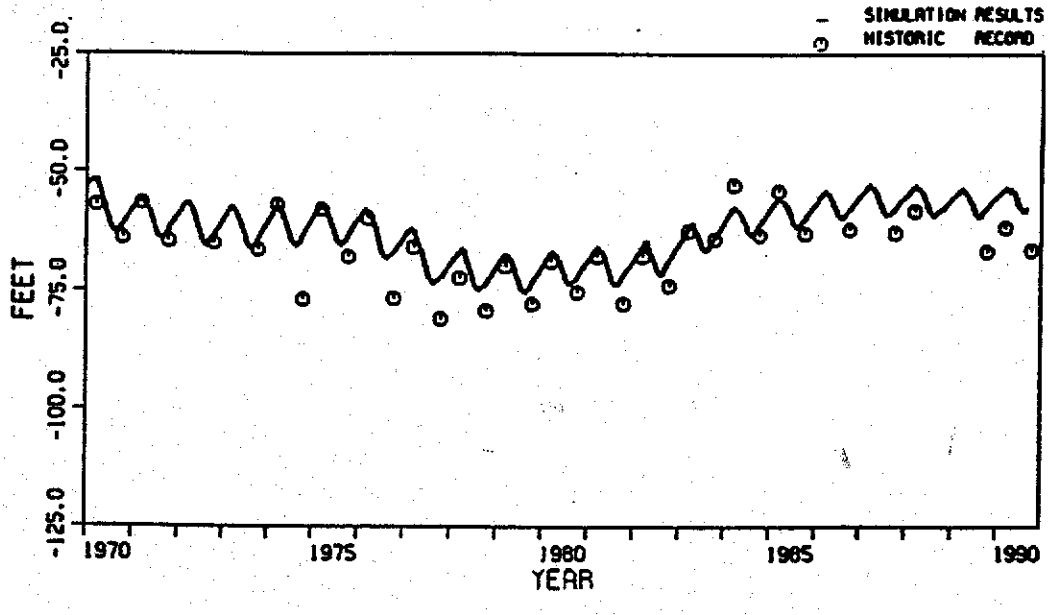
MONTHLY GROUNDWATER LEVEL

WELL 61 I06N/06E-05J01) L1



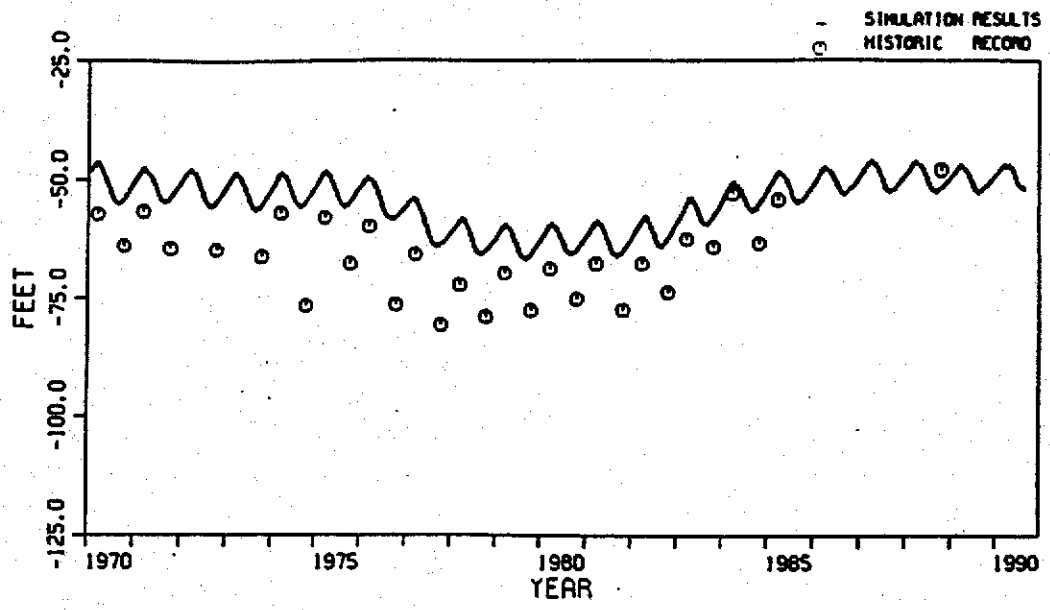
MONTHLY GROUNDWATER LEVEL

WELL 62 I06N/06E-07M01) L2



MONTHLY GROUNDWATER LEVEL

WELL 6310GN/06E-16E01) L2



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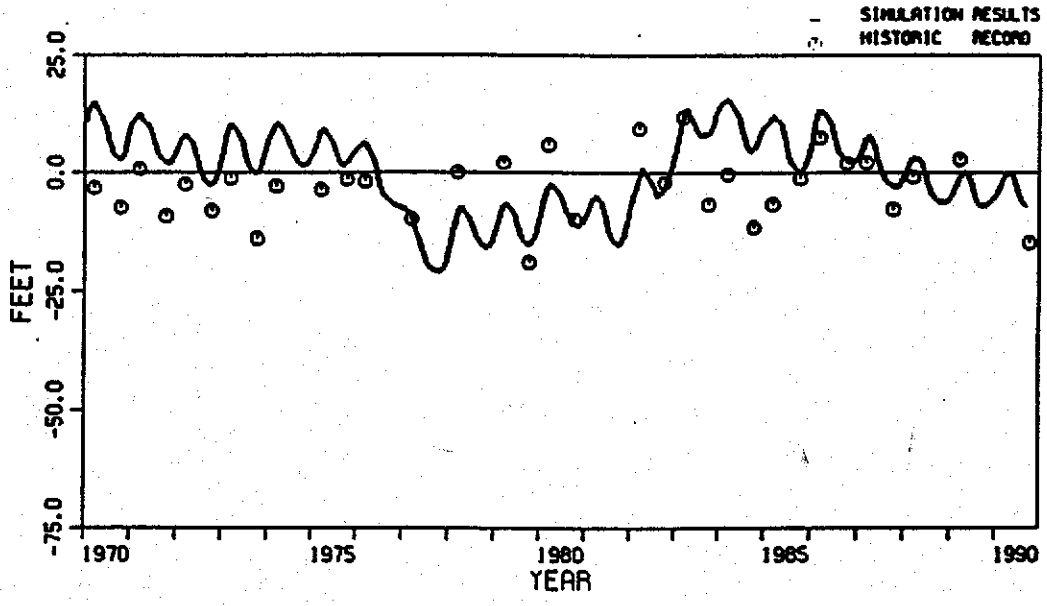
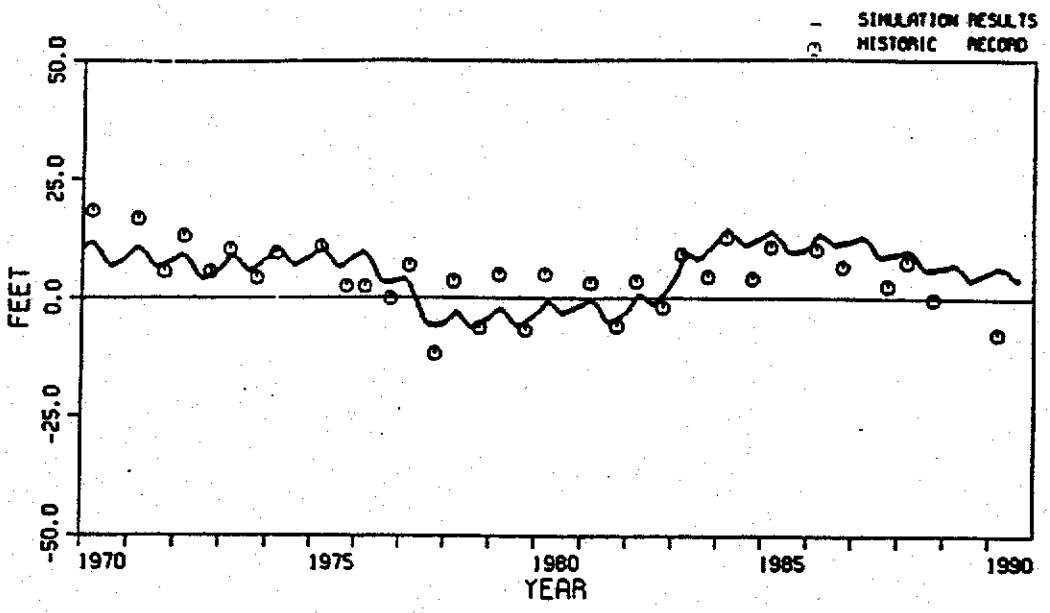
WELL 6410 7N/06E-25B01) L1



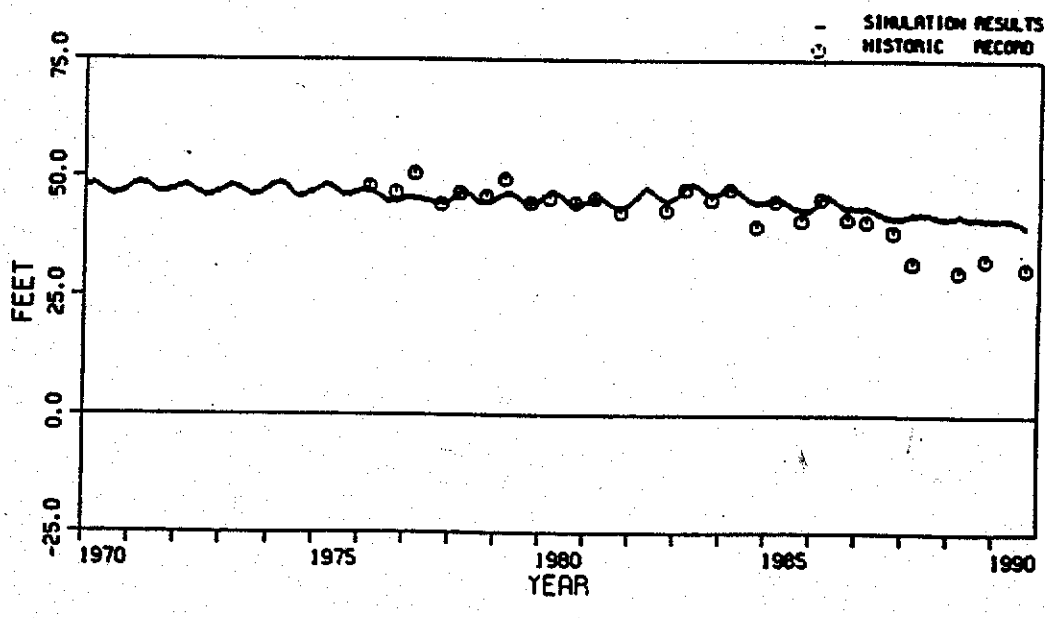
MONTHLY GROUNDWATER LEVEL

WELL 65 (07N/07E-07N01) L1



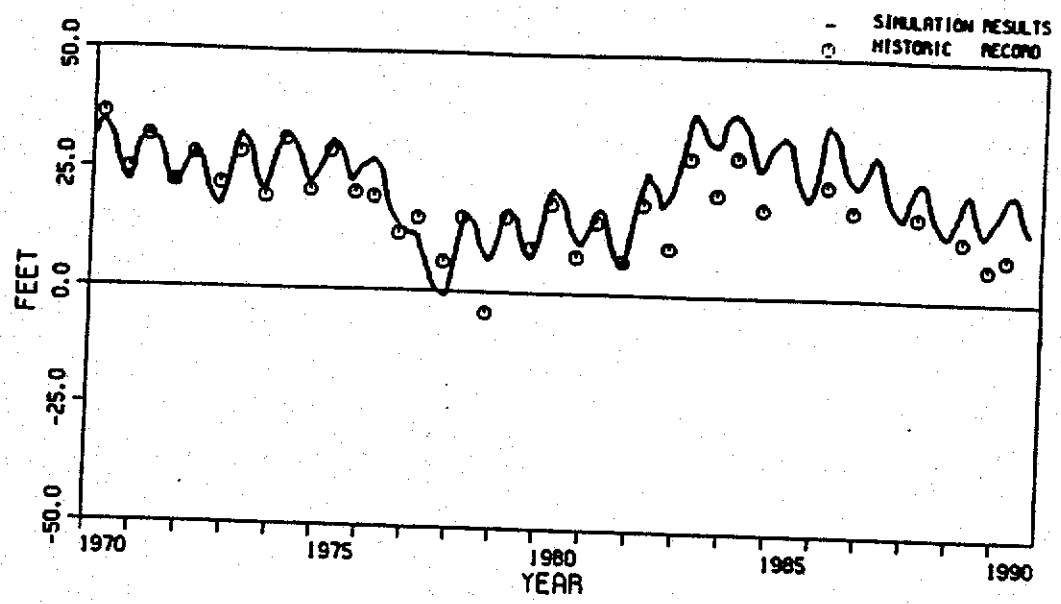
MONTHLY GROUNDWATER LEVEL

WELL 66 (09N/07E-07F01) L1



MONTHLY GROUNDWATER LEVEL

WELL 67107N/07E-20C01 L1



Appendix C

SACRAMENTO COUNTY WATER AGENCY
Inter-Office Correspondence

TO: Keith DeVore, Chief
Water Resources Division

February 18, 1993

FROM: Cort Abney
Senior Civil Engineer

SUBJECT: SACRAMENTO COUNTY INTEGRATED SURFACE-GROUNDWATER MODEL/ STAFF REPORT

Introduction: In March of 1992, the Sacramento County Water Agency retained the services of J.M. Montgomery Consultants for the purpose of developing a computer groundwater model capable of predicting the long term effects of pumping the groundwater resources underlying Sacramento County. The result of J.M.M.'s efforts is a sophisticated tool which accounts for every significant variable that influences the groundwater basin, including precipitation, streamflow, percolation, subsurface inflow and outflow, boundary conditions, pumping, and aquifer characteristics. The model also predicts the effect of precipitation and percolation on local streamflows, and thus the model name, "Integrated Surface-Groundwater Model" (ISGM).

The Sacramento County ISGM is the latest version of a hydraulic computer simulation process which originated over 16 years ago. Dr. Young Yoon began developing the concepts and principles for the model during his doctorate studies at the University of California, Los Angeles. Application of these principals has shown that Dr. Yoon's models can accurately simulate ground and surface water hydrology. Dr. Yoon's modeling successes include: 1) Groundwater investigations for Pajaro Valley, California, 2) The Salinas Valley seawater control project, 3) The Santa Rosa groundwater basin management plan, 4) The Cherry Creek well field development for the Denver Water Board, and 5) The Central Valley Groundwater-Surface Water Model.

The purpose of this report is to provide you with a description of the Sacramento County ISGM and its relationship to other groundwater studies of the Sacramento County groundwater basin, and recommendations regarding the use of the new model.

Other Studies: Although many studies have estimated safe yield and recharge capacity of the local groundwater basin, most have focused on specific areas or aquifer characteristics. State of California, Department of Water Resources (DWR) Bulletin 21 (1955) estimated the recharge capacity of the American River to portions of El Dorado, Placer, and Sacramento County. U.S.G.S. Study 1497 (1961) estimated the groundwater storage in the Sacramento Valley at 33.5

million ac-ft between the depths of 20 and 200 feet. In 1961, Clendenan & Associates determined that the safe yield of the northeast area to be 123,000 ac-ft/yr. Only two studies are known to have performed original and comprehensive investigations of groundwater recharge and safe yield for the greater Sacramento County area. The first study, titled DWR Bulletin 118-3, was completed in 1974. The second study was completed for the Sacramento County Water Agency by Boyle Engineering Corporation titled "Water Plan Supplement-1989". It should be noted that a study titled "Sacramento Area Water Resource Management Plan" was completed in 1985 by Metcalf & Eddy. This study was an extensive effort to identify the optimum groundwater and surface water combination for Sacramento County, however, the study area was limited to "urban" Sacramento County, and did not extend much further than the City of Sacramento's American River water rights place-of-use boundary. In addition, the study's identification of available groundwater (sustainable yield) was a cursory analysis which relied heavily on DWR 118-3. Even though a safe yield was proposed within the study, it will not be considered as original work because of these limitations.

DWR 118-3, "Evaluation of Groundwater Resources: Sacramento County"- The work scope of 118-3 included a thorough investigation and identification of the water bearing formations which underlie the county, and the development of a groundwater model to determine the safe yield of these formations. The greater portion of the study was dedicated to the former. Although the results of 118-3's groundwater model has been the best available information to date, certain assumptions by which the model operated may have significantly affected its accuracy:

Model Accuracy- All hydrological models are developed in a similar fashion. First the variables of the system are identified, a model is developed using these variables, and then the model is run using actual data to simulate historical values. If simulated values correspond with historical values, the model is said to be credible. It is critical that enough historical data be available to compare many precipitation cycles with the model's results in order to follow time dependent variables such as land use changes, and water use. It is equally important that the historical data contain "hydrologic extremes" to show that the model accurately depicts the groundwater system. The 118-3 model used a seven year calibration period. This is a questionable time period for proper calibration of a groundwater model. Total precipitation during the seven year period was "average", and the model seemed to be calibrated accordingly. The model did not accurately follow the extreme conditions. This is evident in 1963 and 1967 when rainfall was abundant; the model results were in error by 18% and 11%, respectively. In 1967 alone, the change in storage was in error by more than 33,000 ac-ft (pg. 133). The author of 118-3 suggests that the model was accurate since it matched the change in storage at the end of the study period. Examination of the data suggest that

a series of wet or dry years would cause the model's results to diverge from actual conditions, and thus the results shown in 118-3 provide a poor basis for concluding model accuracy.

Subsurface Inflow- For ease of calculating boundary conditions, 118-3 assumes no significant subsurface inflows from outside of the model boundaries. An evaluation of the 1968 groundwater contour map clearly indicates that the Sacramento County groundwater basin is receiving recharge from Sutter, Placer, and San Joaquin Counties. The study justifies this condition along the south boundary by stating that no groundwater flow occurs toward Sacramento County since Dry Creek is a losing stream (pg.121). Although Dry Creek does recharge Sacramento County, the equipotential contours show that the San Joaquin groundwater basin supplements this inflow. 118-3 is the only comprehensive study which made this assumption.

Confined Aquifers- According to the study, a lack of information prevented the author from developing a groundwater model which accounted for unconfined aquifers. This is an erroneous assumption, as stated by the study: "This is not strictly correct....(there exist) condition(s) indicative of some confinement of ground water" (pg 127). The author justifies this assumption as reasonable since the time interval between data points is one year. Given the method that the study used to calculate recharge, this comment appears incorrect.

Confined basins have typical storage coefficients ranging between 0.00001 and 0.001, whereas unconfined basins have coefficients of 0.05 to 0.15 (the storage coefficient of an unconfined basin is the same as its specific yield). Hence, the change in head of a confined groundwater basin is much greater (between 100 and 1000 fold) than an unconfined basin for the same volume of water pumped. Although hydraulic communication between the upper and lower basins in Sacramento County is evident, the effects on one basin by pumping another is slow. The study assumes that these effects will equalize within a years time, which may not be the case. 118-3 utilized groundwater contour maps to calculate recharge (pumping - change in storage = recharge), assuming that a change in head means the basin is being dewatered. Consequently, assuming some of the standing water readings used to develop contour maps were of confined zones, the change in storage is incorrect, and the recharge is incorrect. Therefore, the change in head values which 118-3 used to calculate recharge may have been overestimated (not as much water taken from storage), and thus the recharge would have been underestimated, which is consistent with the study's neglect of subsurface inflows.

Pumping Data- The 118-3 study did not have good information on pumping. The study states that many of the pumping records utilized for the study were based upon power consumption records (potential error of 25%) and correlations, or relating the use of one district to another (pg 110). Of course, pumping data is

extremely important to the accuracy of this type of model. The J.M.M. model did not use 1962-1968 for calibration because due to the lack of good data. This is reflected in Table 1. The estimates of water use per acre were significantly different from J.M.M. and Boyle. Assuming groundwater pumping was underestimated, the estimate of recharge was also low.

Rainfall Data- To calculate the percolation of rainfall to groundwater, 118-3 divided the Study area into 4 sections and averaged precipitation values (pg. 116). Given the variation in rainfall across the County and the significant contribution made by rainfall to recharge, this simplification could have caused errors in the model's results.

Stream Recharge- The authors of 118-3 had a difficult time determining recharge to the groundwater basin from streamflow. The first approximation of recharge from streamflow (Table 17, pg. 120) suggested that recharge from the American and Consumnes Rivers alone was 480,000 acre-feet/year. This was derived from estimating all inflows and outflows from the rivers. These values were not compatible with the results of the model, and therefore DWR decided to make stream recharge the "floating" variable, and computed stream recharge values as the residual of the hydrologic balance. Hence values of stream recharge were totally dependent on the accuracy of the pumping and aquifer storage values, which are questionable as previously discussed.

Landuse Conditions- Increasing impervious surface area throughout the County due to urbanization can reduce the total recharge from both rainfall and the reduction of applied water in agricultural areas. Since 118-3 recharge values were estimated for 1962-1968 land use conditions, and landuse has significant effects on recharge, safe yield estimates from 118-3 would become obsolete with time even if they were accurate.

I contacted staff at DWR responsible for groundwater modeling and inquired about the model used for 118-3. Toccoy Dudley, Chief of Geology & Groundwater, stated that the model used in 118-3 was primitive compared to the computer simulations of today. He said that they have not used the 118-3 model since the completion of the study, and they do not consider information produced by such a model to be very accurate. He also said that he was familiar with Dr. Yoon's work, and believes that his models may be credible.

<u>Sacramento County Water Agency, "Water Plan Supplement-1989"-</u> This study focused on current water use throughout Sacramento County and surface water sources which may be available to meet the demands which exceed the groundwater capacity. It is a good source for information pertaining to existing water use throughout the County. The study included a calculation for groundwater safe yield for the purpose of estimating the amount of supplemental

surface water required for future development. An extensive safe yield analysis was not performed; a groundwater model was not developed for the study, and much of the data used to determine a safe yield was taken directly from DWR 118-3. Consequently, some of the erroneous groundwater information found in 118-3 was carried over into the Boyle study. Use of the study for making long term groundwater decisions should be done cautiously for the following reasons:

Boundary Inflow- Boyle used the same groundwater mass balance equation that 118-3, Outflow-Inflow = Change in Recharge. Recharge from precipitation was estimated using land use and soil type information. Pumping was estimated using 118-3 information, primarily (Boyle estimated 1987 groundwater use but the study period for the groundwater estimates was 1962-1981, therefore they relied heavily on 118-3 information). As stated above, the pumping information in 118-3 was questionable. The recharge due to streamflow was taken directly from 118-3. This creates a potential error since 1) the study area for 118-3 was <u>60% greater</u> than Boyle's, yet Boyle used the same stream recharge (122,000 ac-ft/yr), and 2) the estimates for stream recharge in 118-3 is rough at best, as Boyle explains "...(118-3) is based on many generalized assumptions due to the lack of appropriate data, and it may not reliably simulate streamflow recharge. A more detailed analysis is required to validate or revise this estimate." The floating variable is subsurface inflow, derived from the difference in pumping, recharge, and change in storage. Again, Boyle qualifies the value by stating the estimate is "a rough approximation only".

Storage Coefficient- Similar to 118-3, Boyle used a storage coefficient of 0.075 and did not consider unconfined conditions. This could cause the same errors as previously explained.

Safe Yield Estimates- Even if their information was correct, safe yield values estimated by Boyle have limited use for planning purposes since 1) the estimates are based on an average land use condition between 1962-1981, and changes in land use affect recharge values, 2) the estimates of recharge are based on average water levels for the same study period and recharge is greatly affected by water table levels, and 3) Boyle assumes that since the overdraft is 23 acre-feet/year that reducing the pumping by that amount will halt the decline of groundwater, which is false. Groundwater withdrawal must be decreased by some factor greater that actual overdraft to stabilize water levels due to a simultaneous decrease in recharge.

No Model- Since Boyle did not develop a groundwater model, they had no method of checking their assumptions and estimates against reasonable aquifer characteristics and historical hydrologic data. Thus the credibility of the recharge and safe

yield estimates is unknown.

JMM Groundwater Model: The JMM model is very different from the studies listed above. The sole purpose of this work is to develop a model to simulate the reaction of the groundwater table in response to various hydrologic and man-made conditions. It did not devote time to studying geologic conditions or determining potential surface water diversion locations, like other studies. Consequently, the model represents a concentrated effort of groundwater yield analysis with capacity to account for more factors and in greater detail than 118-3. JMM estimates that there are approximately 250,000 to 300,000 individual data entries (e.g. well location, well depth, soil type, etc.) compared to 2,000 to 3,000 in the 118-3 model. The following explains how ISGM accounts for aspects of the groundwater system that the other studies did not.

Study Period- JMM used a study period of 20 years, from 1970 to 1990, over three times longer than 118-3. Not only were pumping records more reliable, but the occurrence of hydrologic extremes during this period (1976-77 and 1982-83) allowed engineers at JMM to confidently calibrate the model. The model accurately simulates the responce of shallow and deep aquifers. In addition, when simulations are run a precipitation period of 68 years is used to account for long term hydrologic cycles.

Confined Conditions- The ISGM divides the basin into three vertical levels, and associates a storage coefficient and specific yield to each so that confined and unconfined conditions may be accounted for. If a confined zone is dewatered, the model switches from the use of a storage coefficient to the use of a specific yield. It also provides a "vertical leakance" factor to simulate vertical flow in addition to horizontal flow (e.g. deep water migrating into shallow aquifers).

Land Use Conditions- The model has the capacity to simulate the change in land use and those factors that affect the groundwater basin like additional pumping and recharge modification.

Subsurface Inflow- The ISGM receives input from the CVGSM to account for inflows from groundwater basins outside of the model boundaries. This information can be updated every few years as conditions change.

Precipitation- The ISGM estimates rainfall from 11 separate rainfall stations and interpolates between each.

Probably the most valuable aspects of the ISGM are 1) its ability to become more accurate with time from regular data input and recalibrations, and 2) accounting for future conditions which

affect recharge (e.g. water table levels, impervious surface construction, well locations, etc.). The other safe yield studies conducted were "snap shots" of the groundwater basin. DWR 118-3 attempted to define safe yield for 1962-68 conditions only, and did not account for time dependent variables. Likewise, Boyle defined a safe yield for average 1962-1981 conditions, which may not accurately reflect 2015 conditions.

Just as with the other studies, I do have some reservations about some of the data in ISGM. Information regarding agricultural pumping is not readily available, so estimates were made by JMM for this input. However, I believe a system of data collection could be established with SMUD to generate good agricultural pumping values for future input. Also, I think a more detailed analysis could be conducted of the impervious surfaces in urban areas instead of using the "blanket" factor chosen by JMM. I would also like to further investigate urban land growth and associated water use. Some of this information might be improved with some additional effort.

Regarding the data by which the model now operates, I spent upwards of 12 hours discussing the data and its processing with Dr. Yoon and Mr. Eric Cartwright of JMM. During those discussions I reviewed the data for reasonableness and inquired extensively about the way the computer "thinks". Mr. Cartwright also explained the quality control and assurance procedures that he followed while developing and calibrating the model. A summary of this process is found in Exhibit "A" in the form of a memorandum from Mr. Cartwright to myself. The result of these conversations is a confidence that the model is sound, both in theory and input. I cannot say that the model will perfectly predict the groundwater table at any location for every scenario run, however, I believe it will provide us with sound information that can be used to make decisions regarding the role of groundwater in Sacramento County. Our inability to accurately predict future land use and pumping conditions will cause much greater errors in the results of simulations than faults with the data. Only time will tell whether the model is an accurate representation of the basin. The results of the long calibration period suggest it is. In the event that the simulated and actual groundwater elevations appear to diverge with time, we can enhance the model's accuracy by making minor corrections to the data, and recalibrate the model.

Recommendations: I recommend that we accept the model for use by the Agency to determine management objectives for the Sacramento County groundwater basin. During this time we should try to refine some of the model's data, including the identification of existing urban development and associated impervious surfaces, perhaps through the use of areal photography. In addition, staff time should be dedicated for establishing and compiling groundwater data for model input. This process should include the development of a management strategy for the model, and the form and frequency by

which data would be collected.

I also recommend that the Agency act as the custodian of the model. In this capacity the Agency would receive requests from other interests to run various scenarios, which could be conducted by Agency staff. I do not think it is advantageous to circulate the model through the community; baseline assumptions can be easily altered to please special interests, resulting in a variety of so-called "valid" safe yield estimates which are almost impossible to compare without an extensive and arduous review of each versions data (recall that there are 250,000 to 300,000 data entries that would have to be reviewed). By the Agency having custodial capacity, any modifications of the model can be well documented and duplicate analyses eliminated. If any interests are not comfortable with the Agency conducting these analyses, they can request the services of JMM for this purpose.

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J.P. Coppola
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Calif. State Water Resources Board

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BULLETIN NO. 21 a

AMERICAN RIVER BASIN INVESTIGATION

REPORT ON DEVELOPMENT PROPOSED FOR THE CALIFORNIA WATER PLAN

VOLUME I (Text and Related Plates)

(Seal of State of California)

JUNE, 1955

Bulletin No. 2 by the application of appropriate unit factors of consumptive use of applied water and water service area efficiencies to the pattern of present land use. The probable ultimate water requirements were similarly estimated, by the use of an ultimate pattern of land use projected from the present pattern on the basis of land classification data. It was assumed that under ultimate conditions of development, all irrigable lands would be developed as water-using areas. The estimates of present and probable ultimate water requirements, as set forth in State Water Resources Board Bulletin No. 2, are presented in Table A-7.

Ground Water Replenishment

Under the plan for conjunctive operation of surface and ground water reservoirs, ground water replenishment in the Area of Ground Water Study would be made up of deep percolation of water applied for irrigation, direct ground water recharge using surplus surface flows of the American River, deep percolation of precipitation on the overlying lands, seepage from the American River, and deep percolation of water delivered for urban use. It was estimated that the ultimate mean seasonal ground water replenishment from these sources would total about 965,000 acre-feet, as is shown in Table A-6, and illustrated on Plate 15 of the main report. Brief discussions of each of the sources of ground water replenishment, and of the estimated quantity from each source, are presented in the ensuing paragraphs.

TABLE A-7

ESTIMATED PRESENT AND PROBABLE ULTIMATE MEAN SEASONAL CONSUMPTIVE USE OF APPLIED WATER AND WATER REQUIREMENTS IN AREA OF GROUND WATER STUDY

(In acre-feet)

Land use	Hydrographic unit 28 (Carmichael)		Hydrographic unit 61 (Stockton)		Hydrographic unit 62 (Ione)		Totals	
	Present	Ultimate	Present	Ultimate	Present	Ultimate	Present	Ultimate
Consumptive use of applied water								
Irrigated lands	103,600	342,800	321,200	789,400	9,000	201,300	433,800	1,333,500
Farmsteads	800	1,400	2,700	3,500	700	1,000	4,200	5,900
Urban and suburban	28,800	126,000	12,200	54,200	100	900	41,100	181,100
Unclassified	2,000	2,000	0	0	0	0	2,000	2,000
TOTALS	135,200	472,200	336,100	847,100	9,800	203,200	481,100	1,522,500
Water requirements								
Irrigated lands	159,400	571,300	803,000	928,700	22,500	335,500	984,900	1,835,500
Farmsteads	1,600	2,800	5,400	6,900	1,300	2,000	8,300	11,700
Urban and suburban	57,600	252,000	24,400	108,400	200	1,800	82,200	362,200
Unclassified	2,000	2,000	0	0	0	0	2,000	2,000
TOTALS	220,600	828,100	832,800	1,044,000	24,000	339,300	1,077,400	2,211,400

Deep Percolation of Irrigation Applications

In the Central Valley, ground water recharge resulting from deep penetration accompanying the application of irrigation waters is highly significant for two reasons: first, under favorable conditions, relatively large quantities of water are recharged; and second, there is little or no effort or expense attributed to the recharge operation. However, expense might be incurred in connection with this means of recharge in an area of surface water service that varies in extent each year according to the amount of surface water available. In such a case, part of the service area must at times be served by surface water, and at other times by ground water, entailing the construction and operation of a distribution system that is capable of delivering water from either source.

For purposes of this study, deep percolation of applied irrigation water was considered to be that portion of the applied water that percolates below the plant root zone, and then passes into storage in the ground water body. Under the usual irrigation conditions, deep percolation may vary in amount from 20 to 60 per cent of the applied irrigation water. Common irrigation practices are extravagant of developed water in the sense that much more water is applied to the surface of the land than can be consumed by the plant. Irrigation efficiency is the ratio of consumptive use of applied irrigation water to the total amount of water applied, expressed as a percentage. In the Central Valley, irrigation efficiencies commonly range from 40 to 70 per cent, with extremes of 25 to 90 per cent, and an over-all average of perhaps 50 per cent.

In the Area of Ground Water Study an ultimate irrigation efficiency of 60 per cent was assumed. By studying the surface and subsurface drainage characteristics of soils within the area, it was estimated that about 64 per cent of the unconsumed applied water would percolate to the ground water body. Then, assuming that the surface runoff from an irrigation application could be recaptured and be used once again, it was estimated that for every 100 acre-feet of irrigation water initially applied to the land, the following would be its disposition.

Initial irrigation application - 100 acre-feet	
Consumptive use	60 acre-feet
Deep percolation	24 acre-feet
Surface runoff (captured)	16 acre-feet
Reapplication - 16 acre-feet	
Consumptive use	10 acre-feet
Deep percolation	4 acre-feet
Surface runoff (lost)	2 acre-feet

Thus, in terms of the initially applied irrigation water the ultimate service area efficiency would be about 70 per cent, with some 28 per cent of the applied water percolating to ground water, and 2 per cent flowing from the Area of Ground Water Study as an irrecoverable loss to the area. Therefore, of the estimated 2,060,000 acre-feet of water per season that would ultimately be applied to irrigable lands within the area of study, it was estimated that some 577,000 acre-feet would percolate to the ground water body seasonally.

The foregoing estimate represents an average for the entire Area of Ground Water Study. Because a large part of the irrigable lands of the area are underlain with hardpans of the Redding and San Joaquin series, additional data were collected to justify and verify the estimates of deep percolation of

applied irrigation water through these hardpan soils. As a result of the experience of representatives of several irrigation districts on the east side of the San Joaquin Valley, it was concluded that little or no water percolates through continuous nonfractured hardpans. It was also concluded that where the hardpan is fractured or discontinuous, a considerable amount of percolation takes place.

The hardpans of the area are strongly developed, and are derived from old alluvial deposits of the Sierra Nevada. However, a field inspection of railroad and highway cuts throughout the area indicated that the hardpans are lenticular and discontinuous. An indication of the amount of percolation that takes place through the iron-cemented hardpans, which are typical of the San Joaquin series, was found from the results of seepage loss tests along Coon Creek and Auburn Ravine. These two streams are largely underlain by hardpans in the investigated reaches. The average seepage losses of water were found to be about 0.16 cubic foot per square foot of wetted surface per day. This rate appears to be very low. However, if it is applied to the estimated ultimate net irrigated acreage of the Area of Ground Water Study, the indicated total quantity of potential deep percolation exceeds 100,000 acre-feet per day.

Under the plan of conjunctive operation, an estimated 577,000 acre-feet of unconsumed applied irrigation water would have to be percolated in an area of 712,000 acres during an irrigation season of more than 200 days. From these figures it can be calculated that an average percolation rate of less than 0.004 foot per day would be needed. Even during July, the month

of heaviest application of irrigation water, the required weighted average percolation rate for the entire Area of Ground Water Study would be less than 0.006 foot per day. It is indicated that these rates could be achieved over large areas of even the tighter soils. Considering the more favorable soils over much of the area, it is considered probable that ground water replenishment by deep percolation of irrigation applications, in the amounts contemplated in the plan for conjunctive operation, could be achieved.

Direct Ground Water Recharge

For purposes of this study, direct ground water recharge was considered to be that replenishment of the ground water storage which is accomplished by diverting water from surface reservoirs that would otherwise be spilled, and by delivering the water to the land for the express purpose of recharging the ground water basin.

A number of methods of direct replenishment of ground water storage might be used in the Area of Ground Water Study. However, after investigation of various methods, it was determined that the most economic method for use in the area would be by means of stream channel seepage, and by spreading on the extensive areas of dredger tailings near the American River.

Stream Channel Seepage. This method of ground water replenishment is a natural one, and is relatively inexpensive. On the valley fill, which makes up the bulk of the Area of Ground Water Study, most stream channels percolate some of their

flow to the ground water. Conservative estimates indicate that under average present conditions the seepage to ground water from streams of the area, other than the American River, totals more than 135,000 acre-feet per season.

Under the ultimate plan of conjunctive operation, it is considered probable that the present rate of stream seepage would be at least trebled. This large increase in seepage would be accomplished by maintaining more nearly constant flows in the stream channels, and by lowering the average ground water levels. The primary cause of the increased seepage from stream channels would be the lowered water tables.

To more accurately estimate the probable ultimate seepage from stream channels, a greater knowledge of the relatively impervious strata underlying each stream would have to be obtained. However, from a study of sediments in the channel deposits of the American River, it was indicated that the most probable limiting factor to stream channel percolation, other than high ground water levels, is the less permeable strata that are found in characteristic channel deposits. On the basis of present knowledge, and notwithstanding the cited limiting factors, it was estimated that water at rates up to 600 second-feet, or 36,000 acre-feet per month, could be added to the ground water storage of the Area of Ground Water Study by seepage from stream channels.

Spreading on Dredger Tailings. Because of a general lack of inexpensive lands at lower elevation, with good infiltration and percolation characteristics, in the Area of Ground

Water Study, a survey was made of the rather extensive areas of dredger tailings to determine their usefullness for storage and eventual percolation of surplus flows of American River water. After field inspection and study of the topography, it was estimated that about one-half of the 16,600 acres of tailings would not be usable because of location, topography, or depth of the tailings. In the remaining 8,300 acres, it was determined that the average depth of dredging was about 70 feet. It was estimated that an average of approximately 50 feet of this depth would be usable for storage and deep percolation of water. With an estimated 20 per cent average porosity in the 50 effective feet, a storage capacity of over 80,000 acre-feet would be available. If 0.15 of a foot of depth per day were the maximum sustained rate at which water would flow from the gravels into the ground water reservoir, then 38,000 acre-feet of water per month could be placed in ground water storage. The foregoing rate is probably conservative.

After a study of the availability of surplus surface waters, it was concluded that a limit of five months should be placed on the direct recharge operations in order to simplify the conjunctive operation criteria. Based on the foregoing conclusions and estimates, the following total quantities of water could probably be used to replenish the ground water storage of the area of study during the five-month direct recharge period.

From stream seepage at 36,000 acre-feet per month	180,000 acre-feet
From storage in dredger tailings	80,000 acre-feet
From percolation of water in dredger tailings at 38,000 acre-feet per month	190,000 acre-feet
TOTAL	450,000 acre-feet

Thus, the estimated potential rate of direct ground water recharge would be about 90,000 acre-feet per month or 1,500 second-feet.

Deep Percolation of Precipitation

Early in the study of ground water replenishment in the Area of Ground Water Study, several independent estimates were made of the amount of deep percolation to the ground water of direct precipitation on the overlying lands. The results of these estimates varied from slightly more than 100,000 acre-feet per season to more than 300,000 acre-feet per season. Since any increase in the amount of deep percolation of precipitation would cause a corresponding increase in the safe ground water yield, it was decided that the 100,000-acre-foot figure would be used throughout the study, as it was the minimum and probably a conservative estimate. This minimum figure was determined by deducting the estimated consumptive use of precipitation and the estimated runoff of precipitation originating within the area of study from the total precipitation on the area, and by assuming that the difference would all percolate to ground water.

Seepage From the American River

Estimates of deep percolation from the American River in the Area of Ground Water Study, under present conditions, indicate that about 25,000 acre-feet of water per season is seeping into the ground water basin on both sides of the river. In order to obtain an estimate of possible increased seepage under ultimate conditions of development, a study was made of

the stream flow below Fair Oaks during the 57-year mean period as it would have been under present conditions, and another study as it would have been with full upstream development and conjunctive operation. Results of this study indicate that about 64,000 acre-feet of water per season would percolate to the ground water. Though this estimate is subject to revision as more data become available, it is felt that it represents a reasonable mean seasonal value of ground water replenishment by stream channel seepage from the American River.

Deep Percolation of Water Delivered for Urban Use

In urban areas of the Central Valley the applied or delivered water supply is disposed of by consumptive use, by sewage and surface outflow, and by deep percolation to the underlying ground water. Basic data collected from nine cities in the Central Valley, to determine urban consumptive use of water, was re-evaluated to determine sewage outflow including accretions of drainage water. The results were then checked against basic data of the Raymond Basin Reference, and a reasonable correlation was found. The results indicate that approximately 50 per cent of the water delivered to urban areas in the Central Valley is consumed, and that approximately 70 per cent of the unconsumed water flows out in the sewers. It was assumed that the remaining 30 per cent of the unconsumed water would percolate to the ground water basin. While this 30 per cent factor is not conservative, the quantities of water involved are small when compared with the whole water supply of the Central Valley. In the Area of Ground Water Study, deep percolation of water

delivered to urban areas would amount to only about 54,000 acre-feet per season under ultimate conditions of development.

Ground Water Draft

At the ultimate stage of development in the Area of Ground Water Study, with complete conjunctive operation, the ground water basin would be used to meet a part of the urban and irrigation requirements of the area. In addition, a quantity of water would be pumped from the ground water basin each year to prevent adverse conditions relating to salt balance in the ground water supplies. Mean seasonal quantities of ground water draft for these purposes are shown in Table A-8.

Pumping for Irrigation

Draft on the ground water basin for irrigation would vary widely from season to season, ranging from an estimated 202,000 acre-feet in the wettest season to 1,339,000 acre-feet in the dry seasons. As is illustrated on Plate 14 of the main report, the ground water basin would be used to augment the surface irrigation diversions, so that a constant seasonal supply would be provided. During the maximum month of the dry seasons approximately 4,750 second-feet would be the required rate of draft from the ground water supplies. Since this peak rate would occur during only one month of any dry season, and during only 10 seasons out of the 57-year mean period, it was assumed that no standby wells would have to be installed. Then, assuming a pumping rate of about 2 second-feet per well, approximately 2,375 wells would be required for the ultimate ground water draft

Streamflow Measurement

Second edition

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The velocity–area method of streamflow measurement

2

2.1 GENERAL

The velocity–area method for the determination of discharge in open channels consists of measurements of stream velocity, depth of flow and distance across the channel between observation verticals. The velocity is measured at one or more points in each vertical by current meter and an average velocity determined in each vertical. The discharge is derived from the sum of the product of mean velocity, depth and width between verticals. The discharge so obtained is normally used to establish a relation between water level (stage) and streamflow. Once established this stage–discharge relation is used to derive discharge values from records of stage at the gauging station.

Not all current meter measurements, however, are made to establish a stage–discharge relation and for many purposes individual determinations or 'spot measurements' are very often required for management functions. Such measurements may not require the measurement of stage but otherwise the method of measurement is the same. At some stations, however, a record of stage only may be required for purposes such as flood warning. At most gauging stations, however, both stage and discharge are measured to establish a relation between these two variables.

2.2 SPACING OF VERTICALS

In order to describe the bed shape and the horizontal and vertical velocity distributions completely, an infinite number of verticals would be necessary; for practical reasons, however, only a finite number is possible. In practice, therefore, the cross-section is divided into segments by spacing verticals at a sufficient number of locations across the channel to ensure an adequate sample of both velocity distribution and bed profile. The spacing and number of verticals are crucial for the accurate measurement of discharge and for this reason between 20 and

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30 verticals are normally used. This practice applies to rivers of all widths except where the channel is so narrow that 20 or 30 verticals would be impracticable. We shall see in Chapter 14 that uncertainties in streamflow measurement are expressed as percentages. The percentage uncertainty therefore for using, say, 20 verticals is of the same order for all widths of river notwithstanding the width of the segments (in absolute terms the uncertainty will increase as the width of segment increases).

Verticals may be spaced on the basis of the following criteria:

(a) equidistant;
(b) segments of equal flow;
(c) bed profile.

The choice will depend largely on the flow conditions, the geometry of the cross-section and the width of river. For very wide rivers (over 300 m), for example, it is sometimes convenient to make the verticals equidistant; for rivers having an asymmetrical horizontal velocity distribution, or a significant variation in the horizontal velocity distribution, it is normally advisable to space the verticals in such a manner as to achieve segments of equal flow over the required range; for rivers having abnormalities in the bed profile, the verticals are spaced so as to make allowance for depressions or obtrusions and general irregularities of the bed. A general rule, however, for current meter measurements is to make the width of segments less as the depth and velocities become greater.

Irrespective of which criterion is followed, the spacing of the verticals is arranged so that no segment contains more than 10% of the total flow. The best measurement is normally one having no segment with more than 5% of the total flow.

2.3 COMPUTATION OF CURRENT METER MEASUREMENTS

MID-SECTION METHOD

In the mid-section method of computation it is assumed that the velocity sampled at each vertical represents the mean velocity in a segment area extends laterally from half the distance preceding vertical to half the distance to the next, and from to the sounded depth as shown by the hatched area discharge is then computed for each segment to obtain the total discharge. Referring to Fig. diagrammatically the cross-section of a stream passing through segment 5 is computed as

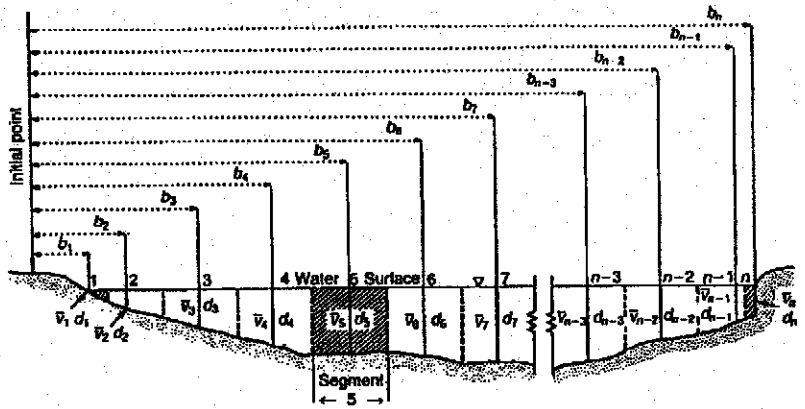

Fig. 2.1 The mid-section method of computing current meter measurements. 1, 2, 3, . . . , n, number of vertical; b_1, b_2, b_3, . . . , b_n, distance from initial point; d_1, d_2, d_3, . . . , d_n, depth of flow at verticals; $\bar{v}$, average velocity in verticals.

$$q_5 = \bar{v}_5\left(\frac{(b_5 - b_4) + (b_6 - b_5)}{2}\right)d_5 \tag{2.1}$$

$$= \bar{v}_5\left(\frac{b_6 - b_4}{2}\right)d_5 \tag{2.2}$$

where q_5 = discharge through segment 5;
$\bar{v}_5$ = mean velocity in vertical 5;
b_4, b_5, b_6 = distances from an initial point on the bank to verticals 4, 5 and 6;
d_5 = depth of flow at vertical 5.

For the end segment, 1, shown hatched, the discharge may be computed as

$$q_1 = \bar{v}_1\left(\frac{b_2 - b_1}{2}\right)d_1 \tag{2.3}$$

and the end segment, n, as

$$q_n = \bar{v}_n\left(\frac{b_n - b_{n-1}}{2}\right)d_n. \tag{2.4}$$

The preceding segment at the beginning of the cross-section is therefore considered coincident with vertical 1 and the next vertical at the end of the cross-section is considered coincident with vertical n.

In the example in Fig. 2.1, q_1 is zero because the depth at vertical 1 is zero. However, when the cross-section boundary is vertical at the edge

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of the water, the depth is not zero and the velocity at the end vertical may or may not be zero. The equations for q_1 and q_n are used whenever there is water on only one side of a vertical, such as piers, abutments and islands. It is usually necessary to estimate the velocity at the end segments as a percentage of the velocity on the adjacent vertical because it is not possible to locate the current meter close to a boundary. Alternatively, a current meter observation may be made as near the edge as possible and this velocity used in computing the discharge in the end segments. However, if the verticals 2 and $n-1$ are placed as close as possible to the banks and the cross-section is wide, the discharge in the end segments can normally be neglected. A typical computation of a current meter measurement employing the mid-section method is shown in Table 2.1. It will be noted in this example that 22 verticals have been used and that the discharge in any one segment does not exceed 10% of the total discharge.

MEAN-SECTION METHOD

Segment discharges are computed between successive verticals. An example of one such segment is shown hatched in Fig. 2.2. The velocities and depths for successive verticals are each averaged, the segment discharge being the product of the two averages.

Referring to Fig. 2.2, the discharge passing through segment 5–6 is computed as

$$q_{5-6} = \left(\frac{\bar{v}_5 + \bar{v}_6}{2}\right)\left(\frac{d_5 + d_6}{2}\right)(b_6 - b_5) \qquad (2.5)$$

where $q_{5\ 6}$ = discharge through segment 5–6;
$\bar{v}_5$, $\bar{v}_6$ = mean velocities in verticals 5 and 6;
d_5, d_6 = depth of flow at verticals 5 and 6;
b_5, b_6 = distance from an initial point on the bank to verticals 5 and 6.

It will be noted that the depth of flow at vertical 1 is zero and the problem of computing the flow in the end segments does not arise in this method nor does it arise when the bank is vertical and if the velocity can be taken as approximately zero at the end vertical. The computation is therefore carried out for the end segments in exactly the same way as for the other segments. Nevertheless this facility does not give the mean-section method an overall advantage over the mid-section method, the latter being simpler to compute and therefore quicker if the calculations are being performed manually. There is little difference in time, however, if a pocket calculator is employed for the calculation.

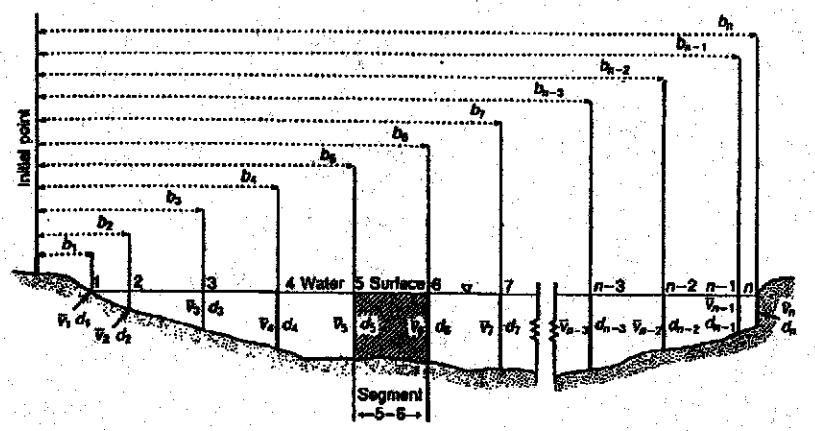

Fig. 2.2 The mean-section method of computing current meter measurements. 1, 2, 3, . . . , n, number of vertical; b_1, b_2, b_3, . . . , b_n, distance from initial point; d_1, d_2, d_3, . . . , d_n, depth of flow at verticals; $\bar{v}$, average velocity in verticals.

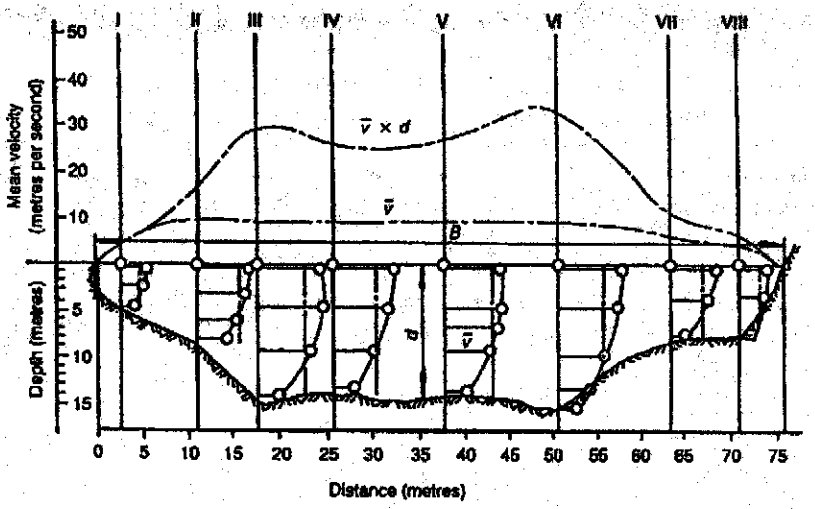

Fig. 2.3 The velocity–depth integration method of computing current meter measurements. $Q = \Sigma_0^B \bar{v} d \Delta B$.

VELOCITY–DEPTH INTEGRATION METHOD

Whereas the previous two methods may be termed arithmetical methods of computing discharge, the velocity–depth integration method is a graphical method. If sufficient current meter observations

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have been made in the verticals, a curve of mean velocity × depth of flow (area of vertical velocity curve) may be drawn over the cross-section. The area of this curve represents the total discharge.

Referring to Fig. 2.3, the procedure is as follows:

(a) Draw the vertical velocity curve for each vertical by plotting the velocity observations against their corresponding depths of flow.
(b) Measure the area contained by each curve by planimeter.
(c) Plot these areas over the water surface line of the cross-section and draw a smooth curve through the points. The area enclosed between this curve and the water surface line represents the total discharge.

The areas contained by the curves are best measured by planimeter but if graph paper with millimetre divisions is used, the 10 mm squares can be counted to calculate the area with acceptable accuracy, making allowance for scale factors.

VELOCITY–CONTOUR METHOD

This is also a graphical method and like the velocity–depth method described above requires a number of current meter observations in the verticals.

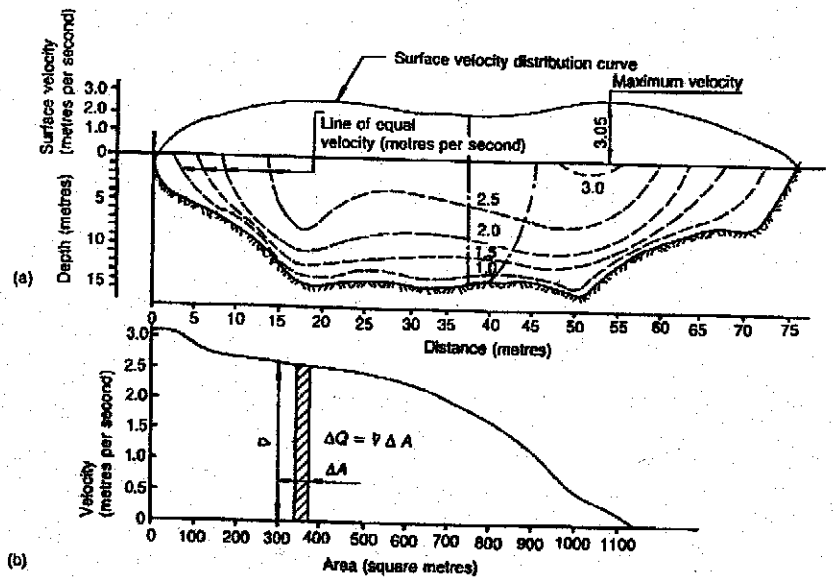

Fig. 2.4 The velocity contour method of computing current meter measurements. $Q = \Sigma_0^A \bar{v}\,\Delta A$.

Referring to Fig. 2.4, the procedure is as follows:

(a) Vertical velocity distribution curves are drawn for each vertical.
(b) These curves are interpolated for convenient intervals of velocity (e.g. 0.25, 0.5, 0.75 m s^{-1}).
(c) Curves or contours of equal velocity (isovels) are drawn as shown in Fig. 2.4(a).
(d) Starting from the maximum, the areas enclosed by successive velocity contours are measured by planimeter and plotted on a diagram, as shown in Fig. 2.4(b), with the ordinate indicating velocity and the abscissa indicating the corresponding area enclosed by the respective velocity contour. The summation of the area enclosed by this curve represents the total discharge.

It can be seen from Fig. 2.4(b) that the maximum velocity plotted on the ordinate is 3.05 m s^{-1}, which in this example is found from the surface velocity distribution curve (Fig. 2.4(a)) and the maximum area plotted on the abscissa is about 1138 m^2, being the sum of the areas enclosed by each velocity contour and the water surface line.

Of the four methods of computation of discharge described above, the mid-section and mean-section methods are used almost universally. The two graphical methods are normally employed in special studies and in the investigation of velocity distribution. The use of graphical methods, however, does not relax the rule for the number or spacing of verticals.

2.4 MEASUREMENT OF VELOCITY

The mean velocity in each vertical is determined by current meter observations by any of the following methods.

THE VELOCITY DISTRIBUTION METHOD

In this method velocity observations are made in each vertical at a sufficient number of points distributed between the water surface and bed to define effectively the vertical velocity curve, the mean velocity being obtained by dividing the area between the curve and the plotting axes by the depth. The number of points required depends on the degree of curvature, particularly in the lower part of the curve, and usually varies between six and ten. Observations are normally made at 0.2, 0.6, and 0.8 of the depth from the surface, so that the results from the vertical velocity curve can be compared with various combinations of reduced points methods, and the highest and lowest points should be located as near to the water surface and bed as possible.

This method is the most accurate if done under ideal, steady-stage

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conditions but is not considered suitable for routine gauging due to the length of time required for the field observations and for the ensuing computation. It is used mainly for checking velocity distribution when the station is first established and for checking the accuracy of the reduced points methods.

The velocity curve may be extrapolated to the bed by the use of the following equation

$$v_x = v_a\left(\frac{x}{a}\right)^{1/c} \tag{2.6}$$

where v_x is the point velocity required in the extrapolated zone at distance x from the bed;
v_a is the velocity at the last measuring point on the velocity curve at distance a from the bed;
c is a constant varying from 5 for coarse beds to 7 for smooth beds and generally taken as 6.

Note: if $x = 0$ (bed level), v_x (at bed level) $= 0$.

An example of the use of equation (2.6) is as follows. In a velocity distribution measurement the lowest observation in the vertical was at a point 0.25 m from the bed. The value of the velocity at this point was 0.15 m s^{-1}. Find the approximate velocity at a point 0.1 m from the bed in order to complete the vertical velocity curve.

From equation (2.6)

$$v_x = 0.15\left(\frac{0.10}{0.25}\right)^{1/6}$$
$$= 0.13\,\text{m s}^{-1}.$$

An alternative method of obtaining the velocity in the region beyond the last measuring point, and so to complete the vertical velocity curve, is based on the assumption that the velocity for some distance up from the bed may often be taken as being proportional to the logarithm of the distance x from the bed. If the observed values of velocities, therefore, are plotted against corresponding values of $\log x$, the best-fitting straight line through these points can be extended to the bed. The required velocities close to the bed may then be read directly from the graph.

THE 0.6 DEPTH METHOD

Velocity observations are made at a single point at 0.6 of the depth from the surface and the value obtained is accepted as the mean for the vertical. This assumption is based both on theory and on results of analysis of many vertical velocity curves, which showed that in

the majority of cases the 0.6 method produced results of acceptable accuracy. The value of the method is its essential reliability, the ease and speed of setting the meter at a single point, and the reduced time necessary for completion of a gauging.

THE 0.2 AND 0.8 DEPTH METHOD

Velocity is observed at two points at 0.2 and 0.8 of the depth from the surface and the average of the two readings is taken as the mean for the vertical. Here again this assumption is based on theory and on the study of vertical velocity curves, and experience has confirmed its essential accuracy. Generally the minimum depth of flow should be about 0.75 m when the 0.2 and 0.8 depth method is used.

SIX-POINT METHOD

Velocity observations are made by taking current meter readings on each vertical at 0.2, 0.4, 0.6 and 0.8 of the depth below the surface and as near as possible to the surface and bed. The mean velocity may be found by plotting in graphical form and using a planimeter, or from the equation

$$\bar{v} = 0.1(v_{\text{surface}} + 2v_{0.2} + 2v_{0.4} + 2v_{0.6} + 2v_{0.8} + v_{\text{bed}}) \tag{2.7}$$

where v is the velocity.

FIVE-POINT METHOD

Velocity observations are made by taking current meter readings on each vertical at 0.2, 0.6, and 0.8 of the depth below the surface and as near as possible to the surface and bed. The mean velocity may be found by plotting in graphical form and using a planimeter, or from the equation:

$$\bar{v} = 0.1(v_{\text{surface}} + 3v_{0.2} + 3v_{0.6} + 2v_{0.8} + v_{\text{bed}}). \tag{2.8}$$

Equations (2.7) and (2.8) are established from the area of a plane surface by a simple arithmetic procedure. In the six-point method, for example, the surface area of the curve ($\bar{v}D$) is approximately

$$(v_1 \times 0.1D + v_2 \times 0.2D + v_3 \times 0.2D + v_4 \times 0.2D + v_5 \times 0.2D + v_6 \times 0.1D)\,\text{m}^2\,\text{s}^{-1}$$

and the average velocity is found by dividing by D, the total depth, giving

$$0.1(v_1 + 2v_2 + 2v_3 + 2v_4 + 2v_5 + v_6)\,\text{m s}^{-1}.$$

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Similarly, equation (2.8) is established from the surface area of the curve giving

$$(v_1 \times 0.1D + v_2 \times 0.3D + v_3 \times 0.3D + v_4 \times 0.2D + v_5 \times 0.1D)\,\mathrm{m^2\,s^{-1}}$$

and dividing by D gives the average velocity as

$$0.1(v_1 + 3v_2 + 3v_3 + 2v_4 + v_5)\,\mathrm{m\,s^{-1}}.$$

THREE-POINT METHOD

Velocity observations are made by taking current meter readings on each vertical at 0.2, 0.6 and 0.8 of the depth below the surface. The average of the three values may be taken as the mean velocity in the vertical. Alternatively the 0.6 measurement may be weighted and the mean velocity obtained from the equation

$$\bar{v} = 0.25(v_{0.2} + 2v_{0.6} + v_{0.8}). \tag{2.9}$$

The origin of the average velocity occurring at 0.6 of the depth and also at the average of 0.2 and 0.8 of the depth from the surface is based essentially on the theoretical velocity distribution of velocity in an open channel. For the condition of turbulent flow over a rough boundary the vertical velocity curves have approximately the form of a parabola whose axis, coinciding with the filament of maximum velocity, is parallel with the surface and is in general situated between the surface and one-third of the depth of the water from the bed. As the depth and velocity increases, however, the curve approaches a vertical line in its limiting position (this fact is used to advantage in the moving boat method (Chapter 11) where the current meter is located at approximately 1 m from the surface).

The vertical distribution of velocity may be expressed approximately by the equation

$$v = \left(\frac{D-d}{a}\right)^{1/c} \tag{2.10}$$

where v is the velocity at depth d below the water surface, c is a coefficient usually having a value of 6 (equation (2.6)), D is the total depth of flow and a is a constant numerically equal to the distance above the bottom of the channel of a point at which the velocity has unit value.

Now integrating equation (2.10) for $\bar{v}$ (average velocity in the vertical)

$$\bar{v} = \frac{1}{D}\int_0^D v\,\mathrm{d}d$$

$$= \frac{1}{D}\int_0^D \left(\frac{D-d}{a}\right)^{1/c} \mathrm{d}d$$

$$= \frac{1}{D}\left[-\frac{ac}{c+1}\left(\frac{D-d}{a}\right)^{1/c+1}\right]_0^D \tag{2.11}$$

then

$$\bar{v} = \frac{c}{c+1}\left(\frac{D}{a}\right)^{1/c}. \tag{2.12}$$

Now making $v = \bar{v}$ in equation (2.10)

$$\frac{c}{c+1}\left(\frac{D}{a}\right)^{1/c} = \left(\frac{D-d}{a}\right)^{1/c}. \tag{2.13}$$

and

$$\left(\frac{c}{c+1}\right)^c = \frac{(D-d)}{D}.$$

Hence

$$\frac{d}{D} = 1 - \left(\frac{c}{c+1}\right)^c. \tag{2.14}$$

and substituting values of c between 5 and 8 in equation (2.14), d/D is approximately equal to 0.6.

Now if $v_{0.2}$ is the velocity at depth $0.2D$, $v_{0.8}$ is the velocity at depth $0.8D$ and $\bar{v} = \frac{1}{2}(v_{0.2} + v_d)$, then from equations (2.10) and (2.12)

$$\frac{1}{2}\left[\left(\frac{D-0.2D}{a}\right)^{1/c} + \left(\frac{D-d}{a}\right)^{1/c}\right] = \frac{c}{c+1}\left(\frac{D}{a}\right)^{1/c}$$

so

$$\frac{D-d}{a} = \frac{D}{a}\left[\frac{2c}{c+1} - (0.8)^{1/c}\right]^c$$

and

$$d = D - D\left[\frac{2c}{c+1} - (0.8)^{1/c}\right]^c \tag{2.15}$$

and substituting $c = 6$ in equation (2.15) gives d/D approximately equal to 0.82. Therefore

$$\bar{v} \doteq \tfrac{1}{2}(v_{0.2} + v_{0.8}).$$

Similarly if $\bar{v} = \frac{1}{2}(v_d + v_{0.8})$ then

$$d = D - D\left[\frac{2c}{c+1} - (0.2)^{1/c}\right]^c \qquad (2.16)$$

and substituting $c = 6$ in equation (2.16) gives d/D approximately equal to 0.27. Therefore $\bar{v} \doteq \frac{1}{2}(v_{0.2} + v_{0.8})$, as before.

The foregoing theory is normally applicable to large rivers when the time of exposure of the current meter is sufficient to equalize pulsations but in general the 0.6 and 0.2 + 0.8 depth methods are almost universally used and give acceptable results. Also it will be noted that in Chapter 14 the uncertainty in the measurement of velocity due to the limited number of points taken in the vertical, X_p, is divided by m, the number of verticals. However, many rivers do not necessarily follow the theoretical parabolic velocity distribution even when the time of exposure of the meter is several minutes. In such situations and where sufficient depth is available, special gaugings are sometimes taken using the five-point or six-point method using a single rod with five or six meters attached to it and employing a special counter box to record the current meter observations.

2.5 CURRENT METERS

The current meter is still the most universally used instrument for velocity determination. The principle is based upon the relation between the speed of the water and the resulting angular velocity of the rotor. By placing a current meter at a point in a stream and counting the number of revolutions of the rotor during a measured time interval, the velocity of the water at that point can be determined. The number of revolutions of the rotor is obtained by various means depending on the design of the meter but normally this is achieved by an electric circuit through the contact chamber. Contact points or a reed switch in the chamber are designed to complete an electric circuit at selected frequencies of revolution, normally once per revolution but also at frequencies of twice per revolution or once for five revolutions depending on design. In the case of the Braystoke propeller meter, a diametrically opposite pair of small cylindrical permanent magnets is inserted at the rear of the impeller boss. This operates an electrical reed switch enclosed in a glass envelope located in the current meter body. From the switch a twin-conductor cable carries the electric pulses generated by each revolution of the impeller to the counter device. In all types of design the electrical impulses produce either a signal which registers a unit on a counting device or an audible signal in a headphone. Intervals of time are measured by a stopwatch or by an automatic timing device. Latest developments in current meter design include the introduction by the United States Geological Survey of an optical head pick-up which improves low velocity response. This new pick-up system utilizes a pivot bearing in the head and is actuated by a rotating fibre-optic bundle. The system generates four counts per revolution.

A comparatively recent innovation is the electromagnetic current meter – a point velocity meter as distinct from the electromagnetic total flow meter described in Chapter 13. It has no moving parts and is of solid-state construction; it has the ability to measure very low velocities of the order of millimetres per second.

Another innovation is the solid-state current meter digitizer used in both the United States and the United Kingdom. This device counts the number of revolutions and at the end of the count period illuminates revolutions and seconds on a light emitting diode (LED) display. This value is held for a few seconds and then the velocity is displayed based on the time and counts recorded and the rating equations for the specific current meter in use.

CUP-TYPE AND PROPELLER-TYPE CURRENT METERS

Current meters can be classified generally into those having vertical axis rotors (Fig. 2.5) and those having horizontal axis rotors (Fig. 2.6(a)(b)&(c)), the former being known as cup-type current meters and the latter as propeller-type meters.

The cup-type current meter consists of a rotor revolving about a vertical shaft and hub assembly, bearings, main frame, a contact chamber containing the electrical contact, tail fin and means of attaching the instrument to rod or cable suspension equipment. The rotor is generally constructed of six conical cups fixed at equal angles on a ring mounted on the vertical shaft. This assembly is retained in the main frame by means of an upper shaft bearing and a lower pivot bearing.

In the latest innovation in cup-type meter design the US Geological Survey has developed a solid polymer bucket wheel made from polycarbonate. The bucket wheel is moulded in one monolithic piece and weighs much less in water than the metal bucket wheel. The minimum speed of response is reduced and the wheels are considerably tougher than the metal version. Since the polymer bucket wheel is designed with no cavity in the cups it is non-responsive to the vertical component of velocity when rigidly held. The cost of the polymer bucket wheel is much less than the metal type.

The propeller-type current meter consists of a propeller revolving about a horizontal shaft, ball-bearings in an oil chamber, the body containing the electrical contact, a tailpiece with or without a vane and

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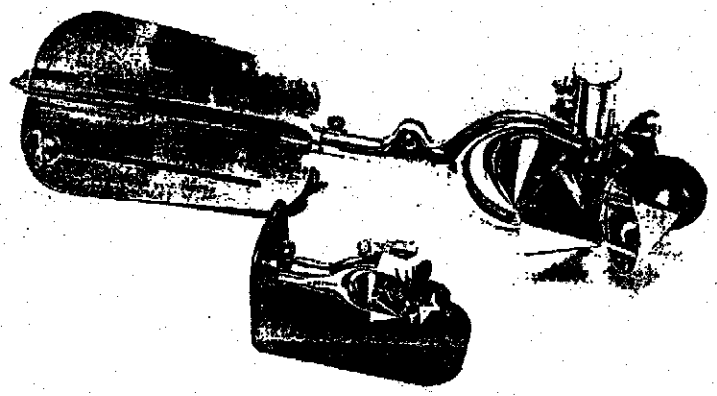
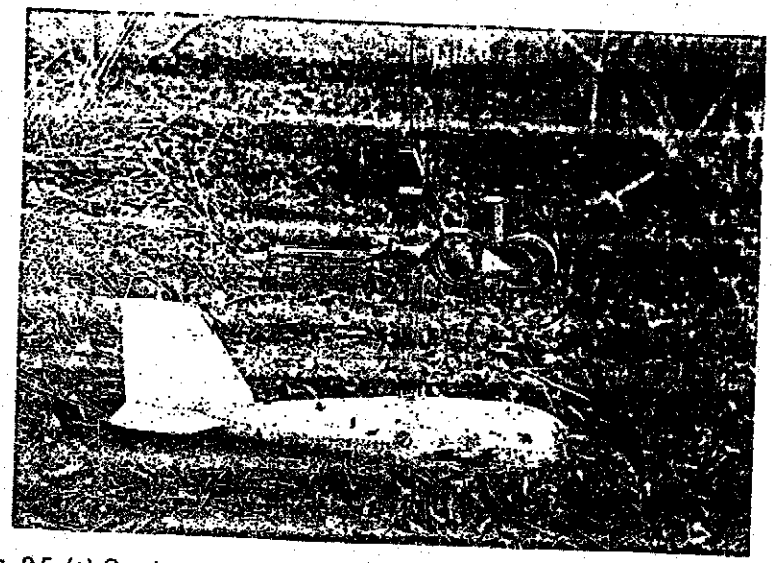


(a)

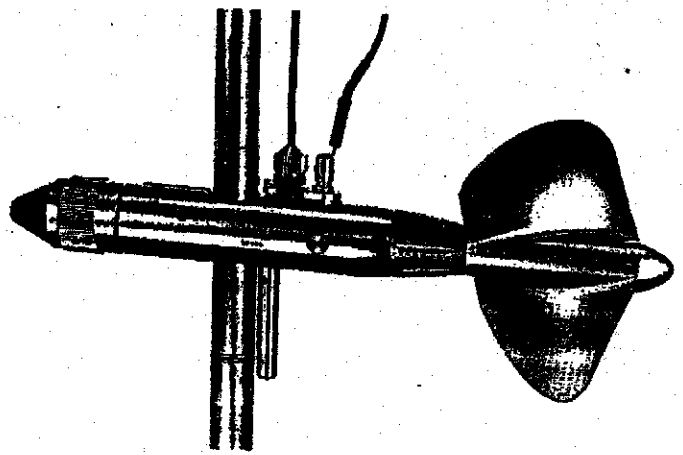


(b)

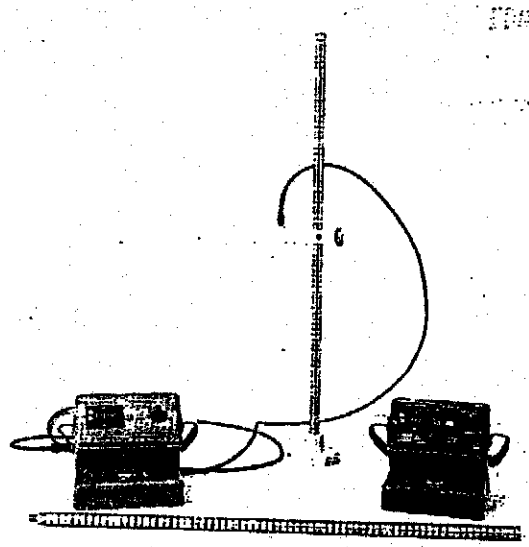
Fig. 2.5 (a) Cup-type current meter (Price) and pigmy (mini) Price. (b) Watts cup-type current meter (shown with sounding weight and hanger bar for cable suspension).

a means of attaching the instrument to the suspension equipment. The meter may be supplied with one or more propellers which differ in pitch and diameter and therefore may be used for various flow speeds.

Both types of current meter are available in miniature form (mini-



(a)

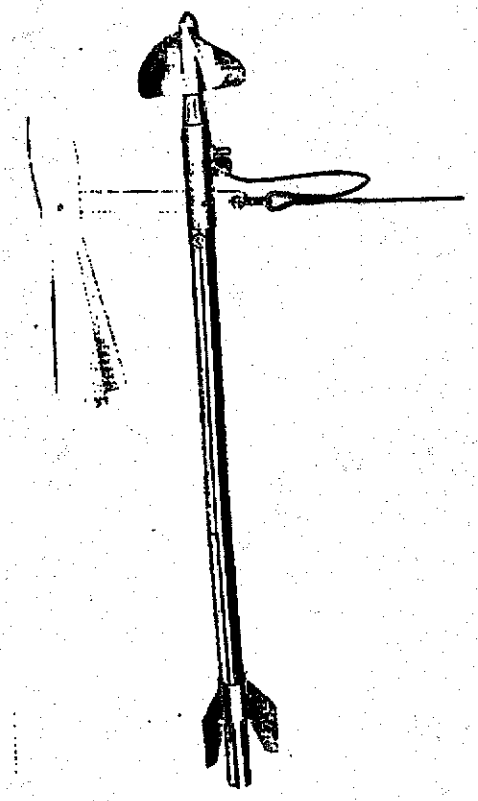


(b)

Fig. 2.6 Propeller-type current meters: (a) Ott, and (b) Braystoke with alternative counter boxes, (c) Ott meter on cableway suspension, (d) ADS electromagnetic current meter ((c) and (d) overleaf).

meters) for use in very small depths of flow (Fig. 2.7). There is generally no significant difference between the accuracies of the velocities registered by cup-type and propeller-type meters but the comparative characteristics of each meter can be summarized as follows.

(c)



(d)

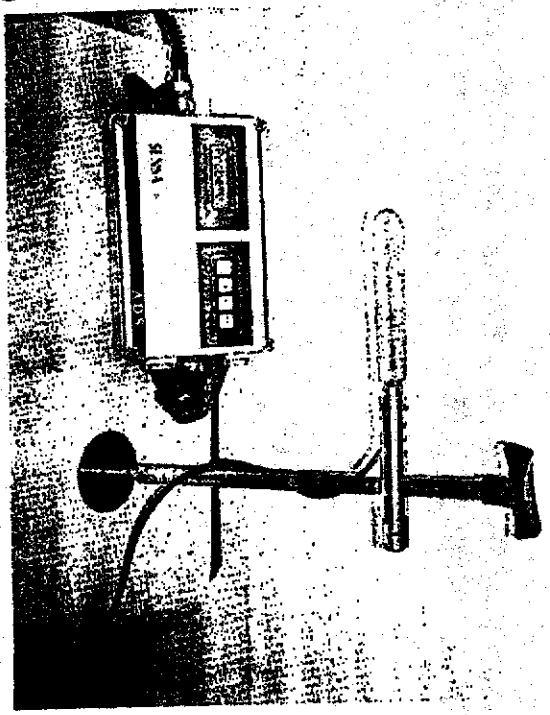
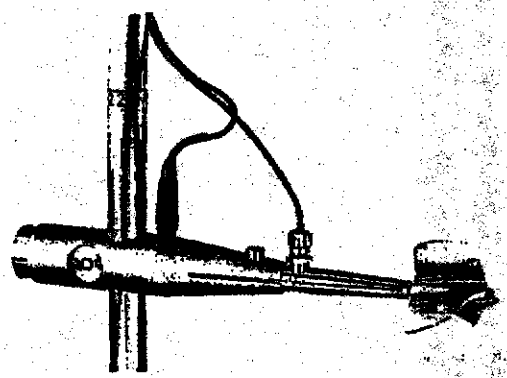
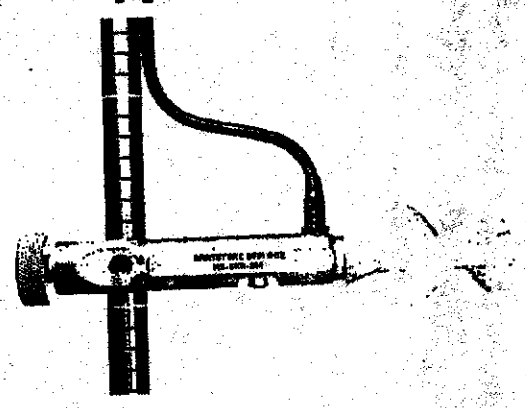


Fig. 2.6 *Continued*

(a)



(b)



(c)

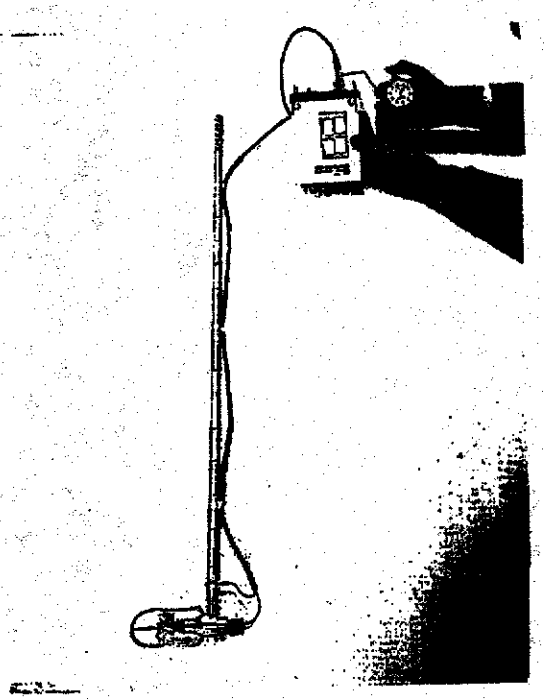


Fig. 2.7 Mini-propeller current meters: (a) Ott, (b) Braystoke, (c) Neyrtec (courtesy of Messrs Ott, Valeport and Neyrtec, respectively).

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Cup-type current meter

(a) This is a robust instrument requiring little maintenance; the rotor is replaceable in the field without affecting the rating.
(b) It operates at lower velocities than the propeller-type meter.
(c) The bearings are well protected from silty water.
(d) A single rotor serves for the entire range of velocities.
(e) When held rigidly by rod suspension and pointing upstream at right angles to the measuring section the meter will indicate a velocity which may be greater or less than the oblique stream velocity, if present, depending on the direction of the oblique flow. When supported on a cable, the meter will indicate the actual oblique velocity provided the meter is balanced and free to align itself with the stream.

Propeller-type current meter

(a) This meter disturbs flow less than the cup-type meter.
(b) The propeller is less likely to become entangled with debris than the cup-type meter.
(c) Bearing friction is less than for vertical shaft rotors because any bending moment on the rotor is eliminated.
(d) A propeller-type current meter used in oblique flow with a component propeller will register the velocity normal to the cross-section when held rigidly by road suspension at right angles to the cross-section.
(e) Propeller-type current meters are not so susceptible to vertical currents as cup-type meters and therefore give better results when used for measurements from boats. This advantage also relates to the moving boat method described in Chapter 11.

ELECTROMAGNETIC CURRENT METER

The electromagnetic current meter (Fig. 2.6(d)) employs the Faraday principle of electromagnetic induction whereby a magnetic field (in the velocity sensor) induces an electropotential in a moving conductor (the water). An alternating current is passed through a coil in the velocity probe which in turn sets up an alternating field in the probe head and surrounding water. Movement of water past the probe causes an electric potential in the water which is detected by two electrodes in the probe. This potential is then amplified and transmitted through the connecting cable to the display unit where the velocity signal is digitized and displayed in metres per second at preset intervals in the range 2–60 seconds as required. The velocity may also be continuously displayed. The range of velocities of a typical electromagnetic current meter is normally zero to $4\,m\,s^{-1}$. The meter is battery powered, one type using 10 No. C size batteries and a low-power microprocessor with alphanumeric display enabling automatic shut-off to conserve battery power. A set of 'long-life' dry alkaline batteries should normally provide about 30 hours continuous operation. A data logging facility is also available by provision of an RS 232 port. The electromagnetic meter has proved especially effective in sewage works channels to measure sewage flow. Calibration consists of establishing experimentally the relation between the velocity of the rating carriage and the velocity indicated by the meter. It should not be necessary to recalibrate an electromagnetic current meter unless its performance is suspect. Maintenance of the meter is minimal and consists of keeping the velocity probe's electrodes clean at all times. This can be done by using a mild domestic detergent solution before use. The aim is to ensure good 'wetting' of the surfaces of the electrodes. The velocity probe should be connected to the stainless steel rods whenever possible in order to obtain good 'ground earthing' (Fig. 2.6(d)). Because of the principle of electromagnetic induction the meter will not operate successfully in very low-conductivity solutions (e.g. in laboratories) unless a small amount of common salt is added to the water (say 14 mg per litre). A simple test to check the meter is to immerse the meter in perfectly still water which is properly earthed. The display should read zero or a known small zero offset.

2.6 RATING OF CURRENT METERS

In order to determine the velocity of the water from the revolutions of the rotor of the rotating-element current meter, a relation is established between the angular speed of the rotor and the speed of the water which causes it to turn. This relation is known as the current meter rating.

The usual method of rating a current meter is to tow it through still water and observe the time of travel and the number of revolutions as the meter travels a given distance. The number of revolutions per second and the corresponding velocity are then computed. When these two quantities are plotted against each other on graph paper, a series of equations will usually be necessary to fit the points. A rating table is prepared by solving these equations.

A typical rating tank is shown in Fig. 2.8. The tank is constructed of reinforced concrete and is 100 m long and 1.83 m wide. The full depth of the tank is 2.13 m of which 0.75 m is below ground level. This arrangement enables the operator to see into the tank when standing

(l) A meter which is only slightly damaged may still be usable if it is recalibrated. If, however, a group calibration is being used there will be an uncertainty whether a slightly damaged meter will continue to operate within the group tolerance. In such a case it might be better to have the meter check-rated (Section 2.6).

2.9 PROCEDURE FOR CURRENT METER MEASUREMENT OF DISCHARGE

Current meter measurements may be classified in terms of the means used to cross the river during the measurements. These are normally by wading, cableway, bridge or boat and the actual method used depends mainly on the depth of flow, the velocity and the length of the measuring section. No matter which method is used or which method is used to suspend the current meter, the principles of measurement described in the previous sections are the same.

SELECTION OF GAUGING SITE

For a stage–discharge station, the selection of the site is often dictated by the needs of water management or by the requirements of the hydrometric network. In fulfilling water management needs there is little or no freedom of choice in selecting gauging sites and frequently records need to be obtained under very adverse hydraulic conditions. This is often the case too where spot measurements are required at specified locations.

However, before a permanent stream gauging station is installed, a general reconnaissance is made in order that the most suitable site for the station may be selected. This reconnaissance normally includes an examination of geological and topographical maps of the area. Each possible site is critically examined with reference to the physical characteristics of the channel. It is often useful, if possible, to inspect potential sites during different seasons when flow conditions alter, usually significantly. It is also good practice to install a temporary staff gauge or pressure bulb recorder (Chapter 3) at selected potential sites and to carry out spot current meter gaugings from time to time for interpretation and analysis.

Generally, however, the aim is to select a reach of stream having the following characteristics:

(a) a straight reach with the threads of velocity parallel to each other;
(b) a stable streambed free of large rocks, weeds and protruding obstructions which create turbulence;
(c) a flat streambed profile to eliminate vertical components of velocity.

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If all three conditions are not satisfied the best possible reach is selected using these criteria and finally a measuring cross-section is selected.

CURRENT METER MEASUREMENTS BY WADING

Current meter measurements by wading are preferred if conditions permit. Wading measurements with the current meter supported on a graduated wading rod which rests on the bed of the stream are normally more accurate than those from cableways or bridges, as the operator has more control over the general gauging procedure. This is particularly the case in the selection of cross-section which may not be the usual station measuring section and in the selection of verticals and measurement of depth.

A measuring tape or tag line is stretched across the river at right angles to the direction of flow using 20 to 30 verticals; the spacing of these is determined so that no segment contains more than 10% of the total discharge (Section 2.2). Usually an approximate discharge for this purpose can be obtained from the stage–discharge curve or from previous current meter measurements. The positions of successive verticals used for depth and velocity are located by horizontal measurements from a reference marker (initial point) on the bank, usually defined by a pin or a monument. The gauging starts at the water edge of the near bank, where depth and velocity may or may not be zero. At each chosen vertical the depth is measured and the value used to compute the setting or settings of the current meter depending on the method to be used (usually 0.6 or 0.2 and 0.8 depth). After the meter is in position the rotor is allowed to adjust to the stream velocity before the count of rotor revolution is started – this may take only a few seconds where velocities are over about $0.3\,m\,s^{-1}$ but a longer period is necessary at lower velocities. A revolution count is then taken at each selected point for a minimum of 60 s but where it is known that the velocity is subject to short-period variations or pulsations it is advisable to continue the observation for at least 3 min., noting the revolution count at the end of each 1 min period. The velocity at the point can then be taken as the average of all the separate readings unless it is apparent that the difference is due to some cause other than pulsation of the flow.

The phenomenon of pulsation has an effect on the measurement of point velocities, and therefore on current meter gauging in general, which is not always fully appreciated. The velocity at any point in the river, even when the discharge is constant and when the surface is apparently smooth and free from surges and eddies, is continuously fluctuating with time. This pulsation is caused by secondary currents developed by hydraulic conditions upstream of the gauging site; for

example, by obstructions in the approach channel, by surging produced at riffles or rapids being continued through pooled reaches, or by the acceleration of the water at bends. Generally, the velocity at any point changes in cycles which can range from a few seconds to possibly more than 1 h, and the extent of these pulsations – both short-term and long-term – needs to be known before deciding on the duration of exposure of the meter at each velocity point. For reliable results it is necessary to observe for a time sufficient to average the effects of the pulsation or to determine the velocity limits of the cycle. This is especially important when trying to determine the relationship between mean velocity as determined by different reduced point methods and that obtained by drawing a vertical-velocity curve.

If the stage is rapidly varying, and during flood measurements, it is sometimes convenient to reduce the time of exposure of the meter to 30 s. Revolutions may be counted over a fixed time period (30 s, 60 s, 3 min, etc.), or a fixed number of revolutions may be timed, the latter method being normally more accurate because full revolutions are counted whereas in the former method part of a revolution may be lost. This could lead to an error in the observation of low velocities. For wading measurements it is often found useful to have one of the cups of a cup-type current meter painted a distinctive colour on the outside. The revolutions may then be counted manually without the need for an automatic counter. In the case of a propeller meter a spot may be painted on the impeller.

Limitations on wading are imposed by the combination of depth and velocity and by the quality of footing on the bed. The advisability of wading needs to be judged by the operator at each site.

The position of the operator is important to ensure that the operator's body does not affect the flow pattern at or approaching the current meter. The best position is to stand facing one or other of the banks, slightly downstream of the meter and an arm's length from it. The rod is kept vertical throughout the measurement with the meter parallel to the direction of flow (Fig. 2.12).

Wading rods are normally of two types: a round rod which usually consists of several sections which can be screwed together and a top setting rod which consists of a main rod for measuring depth and a round rod for setting the position of the current meter (Fig. 2.13). Both types of rod have base plates which rest on the streambed during measurements. Wading rods are usually marked in centimetres and measurements made to the nearest 5 mm. The measuring section for a wading measurement can often be modified in order to improve the conditions of flow. Often it is possible to build temporary dykes to cut off dead water and shallow flows in the measuring section, or to improve the measuring section by removing rocks or debris.

Declaration of Stephen Ross

I, Stephen Ross, declare that:

1. I am a senior hydrogeologist for Komex, which is an environmental and engineering consulting firm. My office is located in the Komex 's Sacramento Branch. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Document W Off-site Northwest Groundwater Investigation," produced by the Aerojet General Corporation, is to my knowledge a true and correct copy of this document. This copy was obtained from the law firm Bolling, Walter & Gawthrop and to our knowledge is a complete version of said document. A copy of said document is maintained at the California State University at Sacramento's Library.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Stephen Ross

DOCUMENT W

AEROJET GENERAL CORPORATION

OFF-SITE NORTHWEST GROUNDWATER INVESTIGATION

C-400.90

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DOCUMENT W

AEROJET GENERAL CORPORATION

OFF-SITE NORTHWEST GROUNDWATER INVESTIGATION

June 13, 1983

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OFF-SITE NORTHWEST GROUNDWATER INVESTIGATION

INTRODUCTION

This report is a compilation of data and a summarization of the results gathered during the drilling and sampling of eight multiple completion groundwater monitoring wells in the area northwest of the Aerojet property. The multiple completion wells A through H are located as shown on Plate 1. These wells contain a total of 31 piezometers, 3 to 6 per well, perforated in various subsurface zones which are referred to as individual numbered wells. Data from these wells are supplemented by available geologic and hydrologic data obtained for six wells completed by the State and from several private and municipal wells. The area of investigation lies between Sunrise Boulevard to the west, Hazel Avenue to the east, and the American River to the north. The sectors on the Aerojet property adjacent to the off-site northwest area are Sectors D and E (Part II, Proposal for Groundwater Quality Control Program, Document E).

The results of the investigation are as follows:

- A body of groundwater containing volatile organic chemicals exists in the easternmost part of the off-site northwest area from the Hazel Avenue interchange to the American River. At its widest extent, along the river, the body of groundwater extends from the Hazel Avenue Bridge above the fish hatchery to the river access parking area below the fish hatchery, a distance of approximately 3,500 feet. The hydraulic head contours show that this body of groundwater flows toward the American River.

- Chemicals are absent or present only in trace amounts in exploration wells to the west of the above groundwater body.

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- Chemicals, including trichloroethylene at a concentration of approximately 600 parts per billion (ppb), are reported to be present at private Well 1001 located north of Folsom Boulevard approximately 1,200 feet east of Sunrise Boulevard. Upgradient and surrounding wells contain much lower or trace amounts of trichloroethylene, suggesting that a local source affects Well 1001. Further, trace levels of volatile organic chemicals in shallow water near Well 1001 could not have originated on Aerojet property.

The following analyses of geology, hydrology, and water quality describe to the extent possible the physical conditions existing off-site northwest of the Aerojet property.

GEOLOGY

Plate 1 shows the location of geologic cross sections constructed from well drilling logs to illustrate the characteristics of surface and subsurface materials. Plates 2 through 6 show the geologic cross sections. Related on-site cross sections in the updated Sector D and E control plans provide additional information. The as-built and lithologic logs of monitoring wells A through H are presented in Appendix A.

The materials off-site, penetrated by the wells and by various State and previously existing private wells, consist of a heterogeneous series of sands, silts, and clays with an occasional gravel lens. The surface materials are Quaternary-aged fluvial deposits of the American River, reworked by dredging activities into a homogeneous mixture of cobble gravel with a sand to clay matrix. The only area where undisturbed materials appear on the surface is along the south bank of the American River from Nimbus Dam to the Sailor Bar river access. Along this reach the American River has removed the Quaternary-aged materials and incised its channel into intact Mehrten mud flow and fluvial deposits. This is shown in cross section B-B', Plate 3.

Underlying the Quaternary-aged fluvial deposits and dredge tailings is the Tertiary-aged Laguna Formation except near the river bank. Here the Quaternary-aged materials are in direct contact with the Mehrten Formation. The Laguna Formation is not seen to crop out in the off-site northwest area and is encountered in the subsurface by all wells south of the American River. See Plates 2 through 6. The Laguna Formation in this area is best described as strongly interbedded fine- and coarse-grained deposits characterized by the presence of biotite mica and a red to orange-red color. The contact with the Mehrten Formation beneath is defined as gradational (Shlemon, 1967). This contact was picked on the basis of a change in color or induration and the absence of biotite. The Laguna Formation thins in a northeast

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direction. It is approximately 110 feet thick at Well 85 (Plate 3), approximately 40 feet thick at Well LS-4, and missing entirely nearer the American River. The Laguna Formation thickens to the southwest as shown in cross section E-E', Plate 6.

The Tertiary-aged Mehrten Formation is composed of coarse sand and gravel units interbedded with units of unsorted tuffaceous silt and sand. It crops out as cliff-forming materials along both banks of the American River from Nimbus Dam to the South Sailor Bar river access. In the subsurface, the Mehrten Formation is found everywhere across the off-site northwest area where it contains the major aquifer. The Mehrten thickens from approximately 160 feet in Well LS-2, Plate 2, to approximately 400 feet in Well LS-1, Plate 6, in a northeast-southwest direction. The thickening is consistent with what has been observed on-site in Sector E to the southeast.

Below the Mehrten Formation is the Valley Springs Formation. The Valley Springs Formation is primarily composed of uniform and laterally persistent beds of predominately clay or sand. The top of the Valley Springs was encountered in all boreholes drilled. Only Well LS-1 penetrated through the Valley Springs into underlying materials, as shown on Plate 6. The Valley Springs materials are relatively impermeable and form the base of the regional aquifer in the off-site northwest area. Thus, by defining the top of the Valley Springs Formation, the thickness of the primary water-bearing materials was confirmed.

The Ione Formation underlies the Valley Springs Formation. It was found in Well LS-1 at a depth of 674 feet below ground surface and is characterized by quartz sands and white clays. Because of its great depth, the Ione has little influence on the movement of groundwater in the regional aquifer.

General geologic features shown by the cross sections are that the low, intermediate, and higher permeability beds are more laterally persistent in a northeast-southwest direction (cross sections A-A' and E-E', Plates 2 and 6) than in the northwest-southeast direction (cross sections B-B', C-C', and D-D', Plates 3, 4, and 5). This is consistent with what has been found on-site in Sectors D and E. The exception to this general condition is found in cross section B-B', where materials are unusually continuous in the northwest-southeast direction in the Mehrten Formation.

The cross sections that are parallel with the directions of flow in the various parts of the off-site northwest area are A-A', B-B', and E-E', which are shown on Plates 2, 3, and 6. These cross sections show two aspects of the stratigraphy discussed above: that is, the thinning of the Laguna towards the north between Sector D and the fish hatchery in section B-B', and the thickening of the Laguna and Mehrten Formations towards the west in sections A-A' and E-E'.

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In summary, the geologic units in the off-site northwest area can be thought of as consisting of three different layers. The first layer, which contains the water table, is composed of dredge tailings and undredged Quaternary-aged fluvial deposits. Below the Quaternary-aged fluvial deposits is the layer which contains the regional aquifer composed of the strongly interbedded Tertiary-aged Laguna and Mehrten Formations. The third layer is the underlying Tertiary-aged Valley Springs and Ione Formations which are relatively less permeable than the overlying materials. The hydrologic significance of the geologic features is further discussed in the following section.

HYDROLOGY

Plates 7 and 8 show May 1983 contours of the hydraulic head in the off-site northwest area. Contours in Plate 7 have been constructed based on data collected at wells perforated at depths which generally lie between 30 and 80 feet above mean sea level (msl). Contours in Plate 8 have been constructed based on data collected at wells perforated at depths which generally lie between 30 and 150 feet below msl. The locations of wells used to construct contour lines are shown with observed hydraulic head elevations on Plates 7 and 8. Table 1 lists perforation intervals for wells and groundwater elevations taken during May 1983, which are used in constructing the contour maps. Also shown on Plate 7 are water surface elevations in the American River as measured during April 21-22, 1983, at the steel bridge east of Sunrise Boulevard, at South Sailor Bar Access, and at Nimbus Fish Hatchery.

Contours presented in Plate 7 show groundwater elevations generally 5 to 15 feet higher than those shown in Plate 8 for deeper waters. The influence of West Area Lake is evident in Plate 7, where closed contours of 110 feet to 130 feet reflect a groundwater mound created by this surface impoundment. Contours from 80 feet to 100 feet msl pass around the western boundary of West Area Lake as a result of the groundwater mounding.

Contours shown in Plate 7 indicate that the direction of groundwater movement in this shallower zone is principally to the northwest in the area between the Aerojet property and the American River. Based upon flow paths perpendicular to the hydraulic head contour lines, groundwater movement in this area is in the direction of the American River through the reach extending from below Nimbus Dam downstream to the stretch of the river just northeast of Well 1196.

Contours in Plate 7 just west of the Aerojet property show that the principal direction of groundwater movement is westerly from the end of West Area Lake towards the Sunrise Boulevard intersection.

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TABLE 1
PHYSICAL CHARACTERISTICS AND STATIC WATER LEVELS FOR
OFF-SITE NORTHWEST AND ADJACENT ON-SITE WELLS

Well	Depth To Lower Perforation (Feet)	Elevation Of Lower Perforation (MSL)	Perforated Thickness (Feet)	Ground Surface Elevation (MSL)	May 1983 Hydraulic Head Elevation (MSL)
13	102.0	60.0	26.0	162.0	119.98
43	117.0	31.9	27.0	148.9	137.74
44	76.0	68.3	36.0	144.3	136.48
53	104.0	32.8	34.0	136.8	133.99
54	92.0	42.4	22.0	134.4	116.71
55	92.0	40.0	22.0	132.0	94.01
56	214.0	-61.5	28.0	152.5	137.98
61	210.0	-79.9	20.0	137.1	100.73
64	105.0	33.2	10.0	138.2	100.63
87	342.0	-205.7	20.0	136.3	74.13
100	100.0	49.8	15.0	149.8	139.28
104	236.0	-74.0	20.0	162.0	119.61
105	191.0	-42.0	5.0	149.0	139.20
108	195.0	-39.5	20.0	155.5	140.12
117	118.9	29.0	20.0	147.9	137.06
123	96.0	37.5	23.0	133.5	99.34
124	131.0	-0.9	23.0	130.1	71.24
125	115.0	12.2	25.0	127.2	63.65
165	170.0	-39.4	10.0	130.6	70.98
167	235.0	-104.4	10.0	130.6	69.95
168	124.0	44.0	21.0	133.0	67.57
172	261.0	-128.0	17.0	133.0	63.07
188	72.0	75.6	5.0	147.6	138.37
194	108.0	49.1	10.0	157.1	150.81
200	100.0	54.87	6.0	154.9	141.06
223	108.0	55.2	16.0	163.2	126.78
232	120.0	23.8	10.0	143.8	132.20
233	193.0	-49.2	21.0	143.8	116.33
243	225.0	-85.4	15.0	139.6	83.63
264	128.0	8.9	14.0	136.9	107.26
267	250.0	-113.1	14.0	136.9	106.20
270	133.0	4.0	21.0	137.0	109.37
272	251.0	-114.0	21.0	137.0	105.67
282	111.0	46.6	21.0	157.6	107.40
284	264.0	-106.4	10.0	157.6	108.26
287	236.0	-71.3	10.0	164.7	115.37
290	116.0	48.7	8.0	164.7	117.88
291	112.0	36.1	16.0	148.1	111.36

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TABLE 1, CONTINUED
PHYSICAL CHARACTERISTICS AND STATIC WATER LEVELS FOR
OFF-SITE NORTHWEST AND ADJACENT ON-SITE WELLS

	Well	Depth To Lower Perforation (Feet)	Elevation Of Lower Perforation (MSL)	Perforated Thickness (Feet)	Ground Surface Elevation (MSL)	May 1983 Hydraulic Head Elevation (MSL)
	1099 Natomas #2	---	---	---	102.7	55.44
	1162	105.0	32.9	10.0	137.9	103.39
F	1163	151.0	-13.1	21.0	137.9	103.46
	1164	231.0	-93.1	21.0	137.9	101.90
	1165	94.0	35.4	10.0	129.4	97.21
G	1166	226.0	-96.6	28.0	129.4	95.45
	1167	281.0	-151.6	21.0	129.4	93.14
	1168	324.0	-194.6	18.0	129.4	92.73
	1169	162.0	-50.4	42.0	111.6	64.25
C	1170	421.0	-309.4	42.0	111.6	59.53
	1171	512.0	-400.4	42.0	111.6	59.62
	1186	90.0	31.5	10.0	121.5	84.57
D	1187	160.0	-38.5	10.0	121.5	76.79
	1188	241.0	-119.5	21.0	121.5	75.97
	1189	322.0	-200.5	42.0	121.5	77.23
	1190	56.0	72.9	10.0	128.9	97.02
E	1191	120.0	8.9	21.0	128.9	98.09
	1192	218.0	-89.1	21.0	128.9	92.41
	1193	158.0	-62.1	21.0	95.9	73.22
B	1194	272.0	-176.1	21.0	95.9	68.61
	1195	312.0	-216.1	14.0	95.9	67.94
	1196	66.0	29.9	8.0	95.9	74.73
	1199	44.0	69.8	14.0	113.8	82.03
A	1200	104.0	9.8	10.0	113.8	81.31
	1201	240.0	-126.2	21.0	113.8	76.20
	1202	130.0	-16.2	10.0	113.8	81.14

AGC 0800 037775

TABLE 1, CONTINUED
PHYSICAL CHARACTERISTICS AND STATIC WATER LEVELS FOR
OFF-SITE NORTHWEST AND ADJACENT ON-SITE WELLS

Well	Depth To Lower Perforation (Feet)	Elevation Of Lower Perforation (MSL)	Perforated Thickness (Feet)	Ground Surface Elevation (MSL)	May 1983 Hydraulic Head Elevation (MSL)
1203	74.0	41.5	16.0	115.5	92.60
H 1204	181.0	-65.5	11.0	115.5	59.25
1205	244.0	-128.5	32.0	115.5	59.17
1206	300.0	-184.5	21.0	115.5	59.28
1207	378.0	-262.5	21.0	115.5	58.36
1208	514.0	-398.5	21.0	115.5	57.70
1209 LS-1	410.0	-307.1	140.0	102.9	43.94
1210 LS-1A	250.0	-137.3	160.0	102.7	48.06
1211 LS-2	155.0	-19.4	75.0	135.6	121.22
1212 LS-3	470.0	-346.2	360.0	123.8	73.07
1213 LS-3A	80.0	43.8	30.0	123.8	89.74
1214 LS-4	165.0	-33.1	95.0	131.9	90.27
1215 LS-5	290.0	-163.0	220.0	127.0	62.73
1216 LS-6	80.0	44.8	20.0	124.8	94.22
1224 Fish Hatchery	---	---	---	106.7	92.87

AGC 0800 037776

Plate 8 shows contours of the hydraulic head in a deeper zone than that considered in Plate 7. A generally northwesterly direction of groundwater movement is shown for most of the area between Folsom Boulevard and the American River. Groundwater flow directions west of a line between Wells 1164 and LS-4 are more westward than are flow directions east of this line. Groundwater to the east of this line would flow in the direction of the American River. Groundwater slightly west of this line would have a westward flow direction approximately parallel to the river. Further to the west, the contours in Plate 8 show a change in the direction of groundwater flow from northwest to nearly due west and away from the river.

Contours presented in Plate 8 in the area west of the Aerojet property show that the direction of groundwater movement is westward towards Sunrise Boulevard.

WATER QUALITY

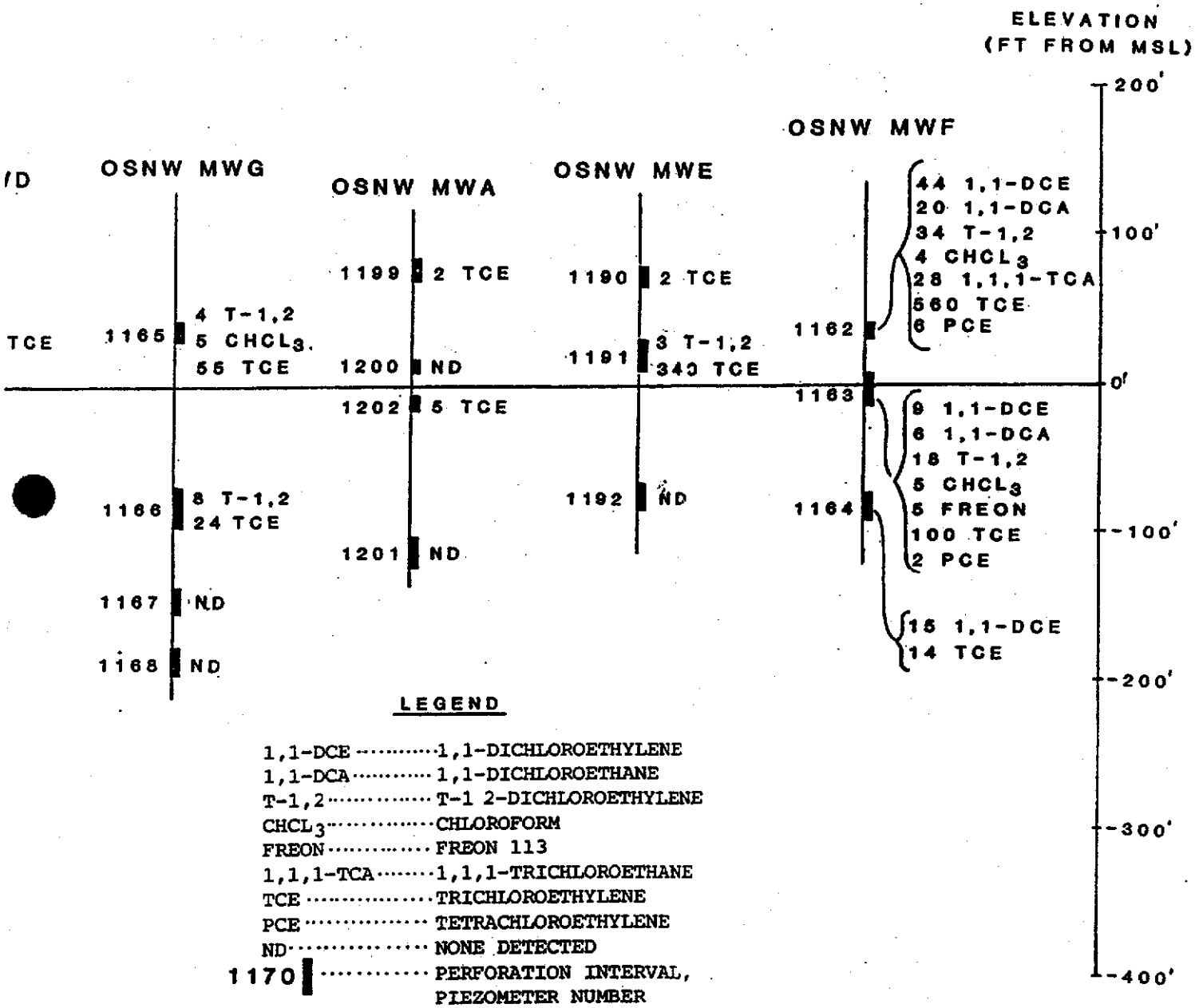
Appendix B contains the results of all samples analyzed for volatile organics. Representative values, generally the third laboratory report rounded to one significant feature, are listed in Table 2. All 31 of the off-site piezometers were tested for all non-volatile organic compounds on the EPA priority pollutant list. The compounds tested for are presented in Appendix C. In every case the finding was "none detected." Mineral analyses have not yet been completed because most of the wells show the effects of the cement grout recently used in well construction.

Figure 1 shows the representative concentrations of volatile organic chemicals detected in the various piezometers in the off-site monitoring well network. The figure portrays the information in relation to the depth below the ground surface of each piezometer. The off-site piezometers having completion intervals deeper than 100 feet below mean sea level were found to be free of volatile organic chemicals with the exception of two piezometers in off-site Well H, with completion intervals extending to -260 feet and -396 feet (msl). These piezometers were reported to contain 2 ppb chloroform which is most probably a residue from the chlorinated municipal water used in well construction.

Volatile organic chemicals in the easternmost off-site Wells E and F are considerably higher than in the wells further to the west. Well F had positive findings for a larger number of chemicals than any of the other off-site wells.

AGC 0800 037777

FIGURE 1
REPRESENTATIVE CONCENTRATI
OF VOLATILE ORGANIC CHEMIC
IN GROUNDWATER SAMPLED FR
OFF-SITE NORTHWEST WELLS



LEGEND

1,1-DCE 1,1-DICHLOROETHYLENE
1,1-DCA 1,1-DICHLOROETHANE
T-1,2 ..... T-1 2-DICHLOROETHYLENE
$CHCL_3$ ..... CHLOROFORM
FREON ..... FREON 113
1,1,1-TCA 1,1,1-TRICHLOROETHANE
TCE ..... TRICHLOROETHYLENE
PCE ..... TETRACHLOROETHYLENE
ND ..... NONE DETECTED
1170 ..... PERFORATION INTERVAL, PIEZOMETER NUMBER
CONCENTRATIONS IN PARTS PER BILLION

AGC 0800 037778

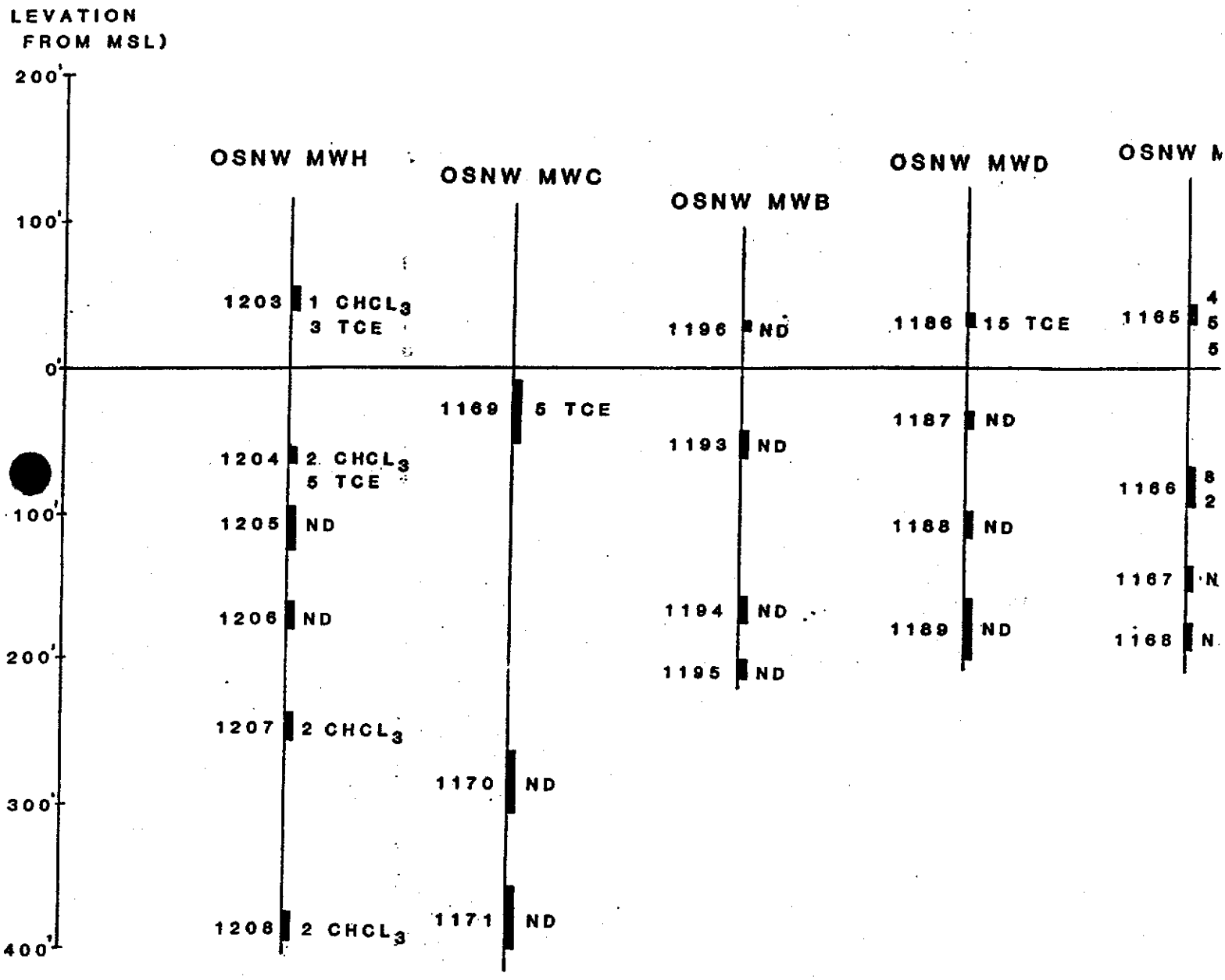

LEVATION
FROM MSL)
200'
100'
0'
100'
200'
300'
400'
OSNW MWH
1203
1 CHCL3
3 TCE
1204
2 CHCL3
5 TCE
1205
ND
1206
ND
1207
2 CHCL3
1208
2 CHCL3
OSNW MWC
1169
5 TCE
1170
ND
1171
ND
OSNW MWB
1196
ND
1193
ND
1194
ND
1195
ND
OSNW MWD
1186
15 TCE
1187
ND
1188
ND
1189
ND
OSNW M
1165
4
5
5
1166
8
2
1167
N
1168
N

TABLE 2

ESTIMATES OF WATER QUALITY FOR OFF-SITE NORTHWEST WELLS

Chloroform	Freon 113	1,2-Dichloro-ethane	1,1,1-Trichloro-ethane	Trichloro-ethylene	Tetra-chloro-ethylene
4	---	---	30	500	6
5	5	---	---	100	---
---	---	---	---	20	---
5	---	---	---	60	---
---	---	---	---	20	---
---	---	---	---	---	---
---	---	---	---	---	---
1	---	---	---	5	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	20	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	2	---
---	---	---	---	300	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---

AGC 0800 037779

TABLE 2
BEST ESTIMATES OF WATER QUALI
OFF-SITE NORTHWEST WELL

	Well	1,1-Dichloro-ethylene	1,1-Di chloro-ethane	T-1,2-Dichloro-ethylene	Chloroform	Freon 113
F	1162	40	20	40	4	---
	1163	9	6	20	5	5
	1164	10	---	---	---	---
G	1165	---	---	4	5	---
	1166	---	---	8	---	---
	1167	---	---	---	---	---
	1168	---	---	---	---	---
C	1169	---	---	1	1	---
	1170	---	---	---	---	---
	1171	---	---	---	---	---
D	1186	---	---	2	---	---
	1187	---	---	---	---	---
	1188	---	---	---	---	---
	1189	---	---	---	---	---
E	1190	---	---	---	---	---
	1191	---	---	3	---	---
	1192	---	---	---	---	---
B	1193	---	---	---	---	---
	1194	---	---	---	---	---
	1195	---	---	---	---	---
	1196	---	---	---	---	---

TABLE 2, CONTINUED
ESTIMATES OF WATER QUALITY FOR
OFF-SITE NORTHWEST WELLS

oroform	Freon 113	1,2-Dichloro-ethane	1,1,1-Trichloro-ethane	Trichloro-ethylene	Tetra-chloro-ethylene
---	---	---	---	2	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	5	---
1	---	---	---	3	---
2	---	---	---	5	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---

AGC 0800 037780

TABLE 2, CONTINUED
BEST ESTIMATES OF WATER QUALITY
OFF-SITE NORTHWEST WELLS

Well		1,1-Dichloro-ethylene	1,1-Di chloro-ethane	T-1,2-Dichloro-ethylene	Chloroform	Freon 113
A	1199	---	---	---	---	---
	1200	---	---	---	---	---
	1201	---	---	---	---	---
	1202	---	---	---	---	---
H	1203	---	---	---	---	---
	1204	---	---	---	1	---
	1205	---	---	---	2	---
	1206	---	---	---	---	---
	1207	---	---	---	---	---
	1208	---	---	---	---	---

The water level contours shown in Plate 7 indicate that the water represented by the upper two piezometers in Well F (1162 and 1163) is flowing toward the American River along a path which will carry it past the State Wells, LS-6 and LS-4 which have been reported to contain volatile organic chemicals similar to those detected in piezometers 1162 and 1163.

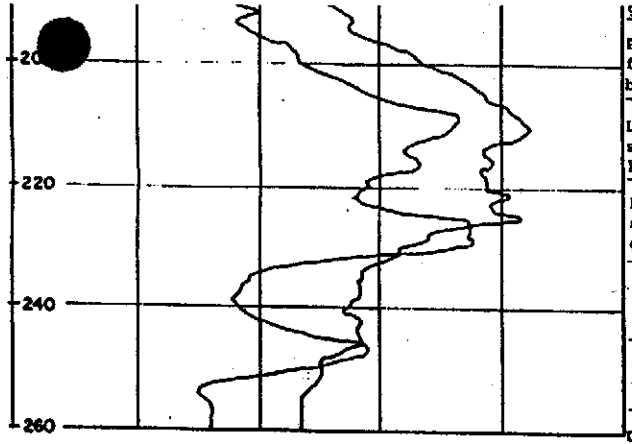
Well E slightly to the west of this flow path contains mostly trichloroethylene in the upper water zone and is free of volatile organic chemicals at depths. Water passing this site is also shown to be flowing toward the American River by the hydraulic head contours plotted on Plate 7.

Wells D and G were found to contain volatile organic chemicals also but at these locations there was no detection of 1,1-dichloroethylene and 1,1-dichloroethane as was seen in piezometers 1162 and 1163. Water flowing past Well D would eventually reach the location of off-site Well C.

Well H was reported to contain chloroform and trichloroethylene in the shallowest zone. The concentrations were small: 1 ppb chloroform and 3 ppb of trichloroethylene, but they were confirmed by repeated sampling. The shallowest piezometer (1203) is perforated from 57.5 to 41.5 feet above mean sea level. At this elevation range groundwater on the western portion of the Aerojet property is always found to be free of volatile organic chemicals. It is therefore likely that the chemicals entered the groundwater system near the location of Well H. The second piezometer in Well H, 1204, perforated from -54.5 to -65.5 (msl) also contained chloroform and trichloroethylene. Neither trace concentrations in Well H nor the relatively low concentrations found in monitoring wells near the western perimeter of Aerojet account for the high trichloroethylene concentrations consistently reported at Well 1001.

AGC 0800 037781

APPENDIX A
AS-BUILT AND LITHOLOGIC LOGS FOR OFF-SITE NORTHWEST MULTIPLE COMPLETION MONITOR WELLS



gray-brown, silty clay.

Pebble to granular gra... minor, fine-grained, well cemented, medium brown sandstone.

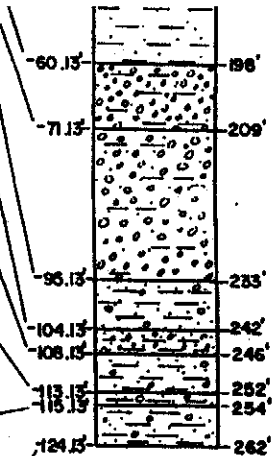
Light brown, semi-plastic, sandy, silty clay; minor, pebble to granular gravel.

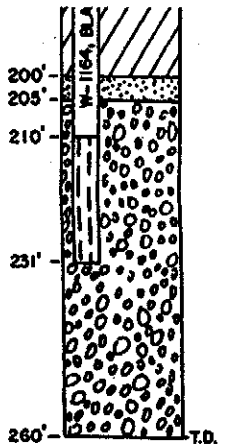
Light brown, semi-plastic, sandy, silty clay with coarse pebble to granular gravel.

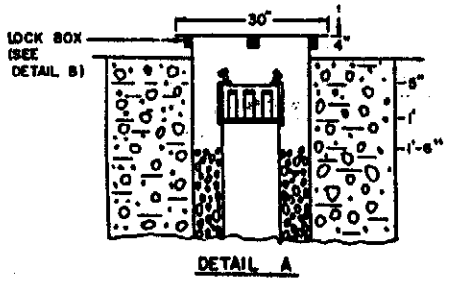
Medium brown, plastic, very silty, sandy clay; minor, medium pebble gravel.

Medium gray-green, plastic, silty sandy clay; minor, pebble gravel.

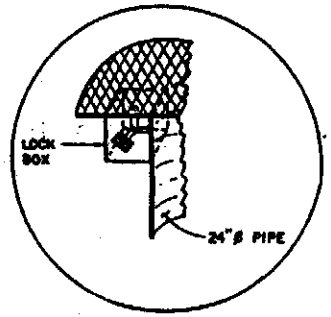
Dark gray-green, semi-plastic, silty, sandy clay; minor, dark gray-green, moderately-well indurated, silty claystone.







DETAIL A

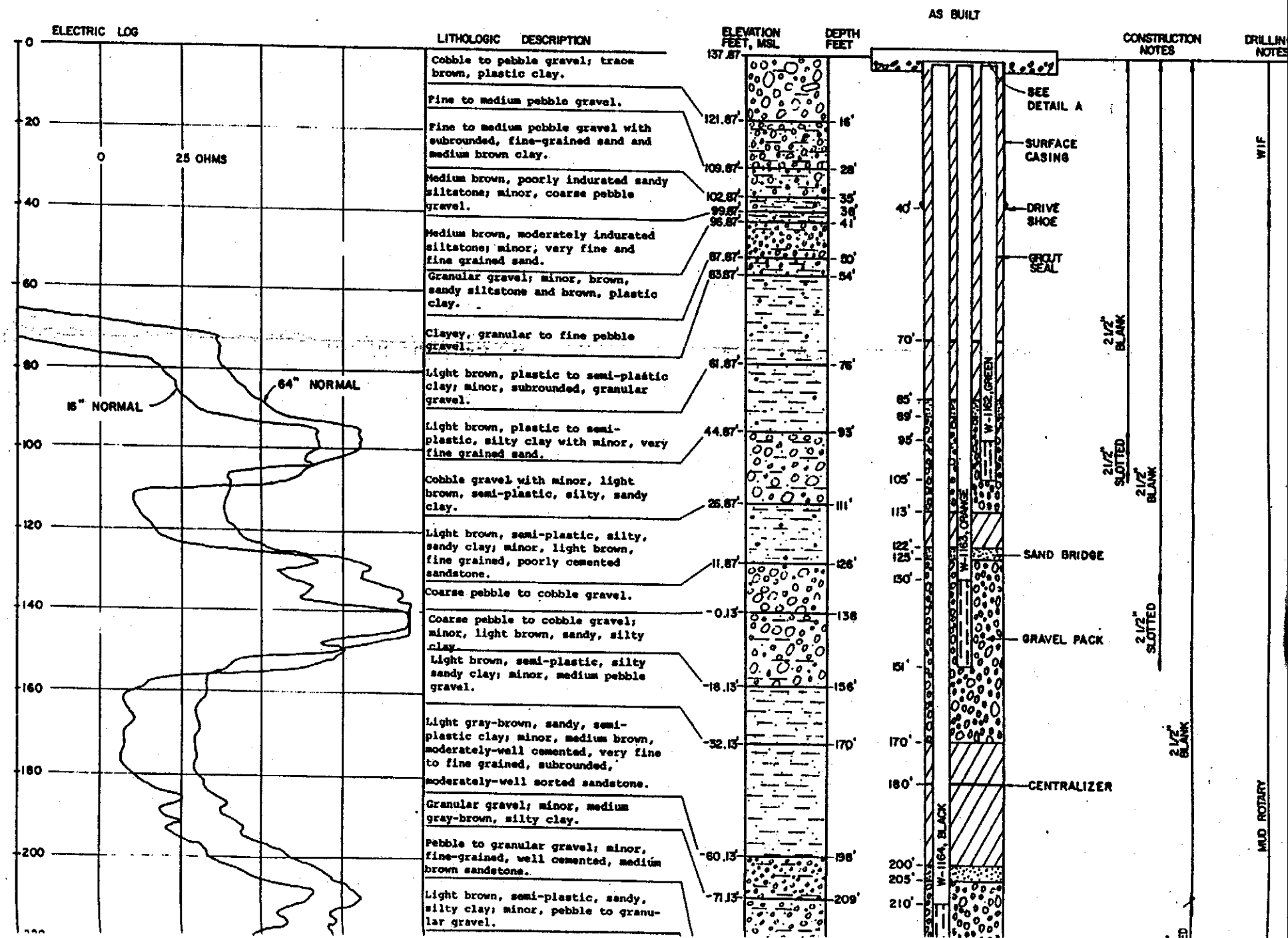


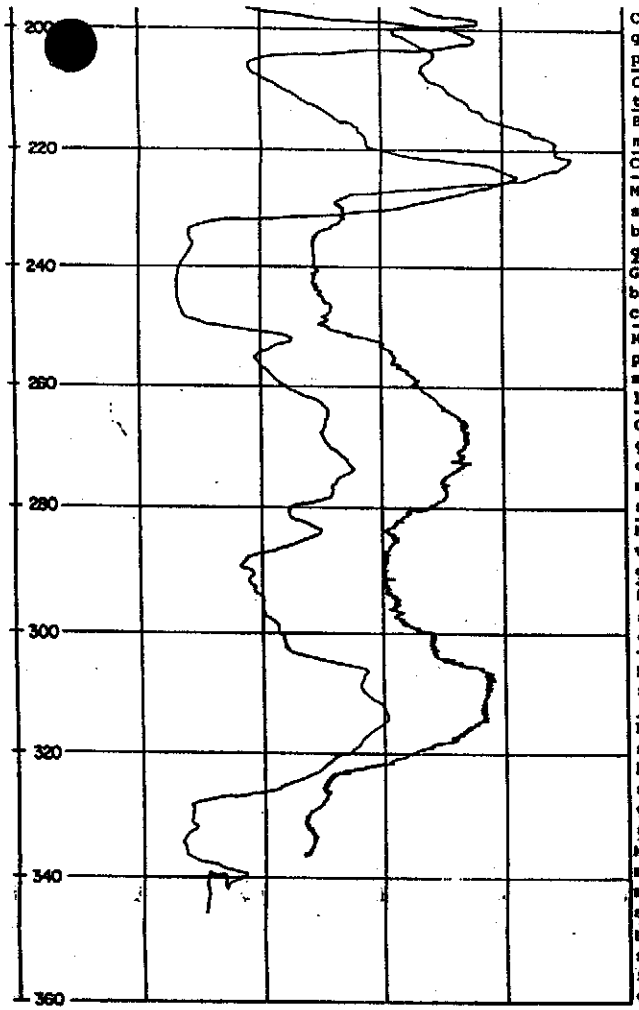
DETAIL B

10 3/4" x 1/4" LOW CARBON STEEL CASING
2 1/2" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
2 1/2" SLOTTED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" x 4" SLOTS, 4 ROWS, 8 SLOTS / FT.
WIF: WATER INJECTION WITH FOAM

AGC 0800 03

OSNW MWF
1162-1164


ELECTRIC LOG
0
25 OHMS
16" NORMAL
64" NORMAL
0
20
40
60
80
100
120
140
160
180
200
LITHOLOGIC DESCRIPTION
Cobble to pebble gravel; trace brown, plastic clay.
Fine to medium pebble gravel.
Fine to medium pebble gravel with subrounded, fine-grained sand and medium brown clay.
Medium brown, poorly indurated sandy siltstone; minor, coarse pebble gravel.
Medium brown, moderately indurated siltstone; minor, very fine and fine grained sand.
Granular gravel; minor, brown, sandy siltstone and brown, plastic clay.
Clayey, granular to fine pebble gravel.
Light brown, plastic to semi-plastic clay; minor, subrounded, granular gravel.
Light brown, plastic to semi-plastic, silty clay with minor, very fine grained sand.
Cobble gravel with minor, light brown, semi-plastic, silty, sandy clay.
Light brown, semi-plastic, silty, sandy clay; minor, light brown, fine grained, poorly cemented sandstone.
Coarse pebble to cobble gravel.
Coarse pebble to cobble gravel; minor, light brown, sandy, silty clay.
Light brown, semi-plastic, silty sandy clay; minor, medium pebble gravel.
Light gray-brown, sandy, semi-plastic clay; minor, medium brown, moderately-well cemented, very fine to fine grained, subrounded, moderately-well sorted sandstone.
Granular gravel; minor, medium gray-brown, silty clay.
Pebble to granular gravel; minor, fine-grained, well cemented, medium brown sandstone.
Light brown, semi-plastic, sandy, silty clay; minor, pebble to granular gravel.
ELEVATION FEET, MSL
DEPTH FEET
137.87'
121.87'
109.87'
102.87'
99.87'
96.87'
87.87'
83.87'
61.87'
44.87'
25.87'
11.87'
-0.13'
-18.13'
-32.13'
-60.13'
-71.13'
16'
28'
35'
38'
41'
50'
54'
76'
93'
111'
126'
138
156'
170'
198'
209'
AS BUILT
SEE DETAIL A
SURFACE CASING
DRIVE SHOE
GROUT SEAL
2 1/2" BLANK
2 1/2" SLOTTED
2 1/2" BLANK
SAND BRIDGE
2 1/2" SLOTTED
GRAVEL PACK
2 1/2" BLANK
CENTRALIZER
W-164, BLACK
W-163, ORANGE
W-162, GREEN
40'
70'
85'
89'
95'
105'
113'
122'
125'
130'
151'
170'
180'
200'
205'
210'
CONSTRUCTION NOTES
DRILLING NOTES
WIF
MUD ROTARY



Clayey, coarse pebble to cobble gravel; common, light [illegible] gray; plastic, silty, very s[illegible] clay. -68.64' 198'

Coarse pebble to cobble gravel; trace, light brown clay. -75.64' 205'

Black, subrounded, granular gravel; minor, gray-brown, silty, sandy clay. -88.64' 218'

Coarse pebble to cobble gravel. -90.64' 220'

Medium light brown, semi-plastic, silty, very sandy clay; common, black to green, fine pebble to granular gravel. -95.64' 225'

Granular gravel in light brown to blue-gray plastic, very silty, sandy clay. -105.64' 233'

Medium brown to greenish-brown, plastic, silty, very sandy clay; minor, granular gravel; very minor light brown sandstone. -120.64' 250'

Granular gravel with common gray-green, silty, semi-plastic, sandy-clay; minor, medium dark brown, moderately cemented, fine grained, subrounded sandstone. -125.64' 255'

Medium gray-green, plastic, silty, very sandy clay; minor, black granular gravel. -130.64' 260'

Medium brown, plastic, silty, very sandy clay with common granular gravel. -142.64' 272'

Medium brown, plastic, silty, very sandy clay; minor, granular gravel. -147.64' 277'

Light to medium brown, plastic, silty, sandy clay; minor, light brown, moderately-well indurated siltstone/claystone; very minor, granular gravel and light brown sandstone. -152.64' 282'

Medium brown, plastic, sandy clay; minor, granular gravel; very minor, medium brown, poorly cemented sand-stone. -157.64' 287'

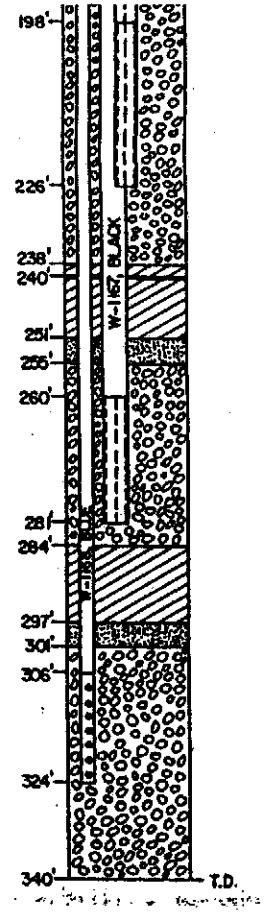
Blue-green, plastic, waxy, silty sandy clay; minor, medium brown, fine grained, subrounded, moderately cemented sandstone. -167.64' 297'

Dark blue-gray to gray-green, plastic to semi-plastic, silty, sandy clay; minor, light gray to buff, moderately-well indurated, silty, sandy claystone. -197.64' 327'

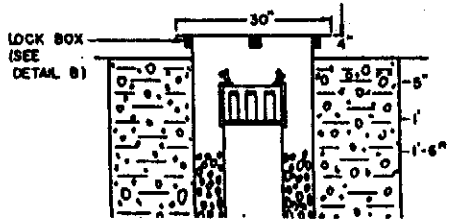
Gray-green, plastic to semi-plastic, silty, very sandy clay; minor, granular gravel. -207.64' 337'

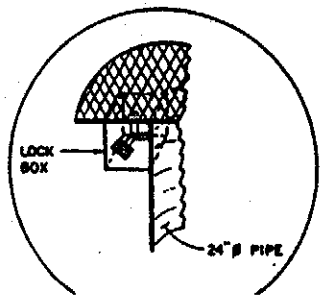
-210.64' 340'

-212.64' 342'



MUD ROTARY

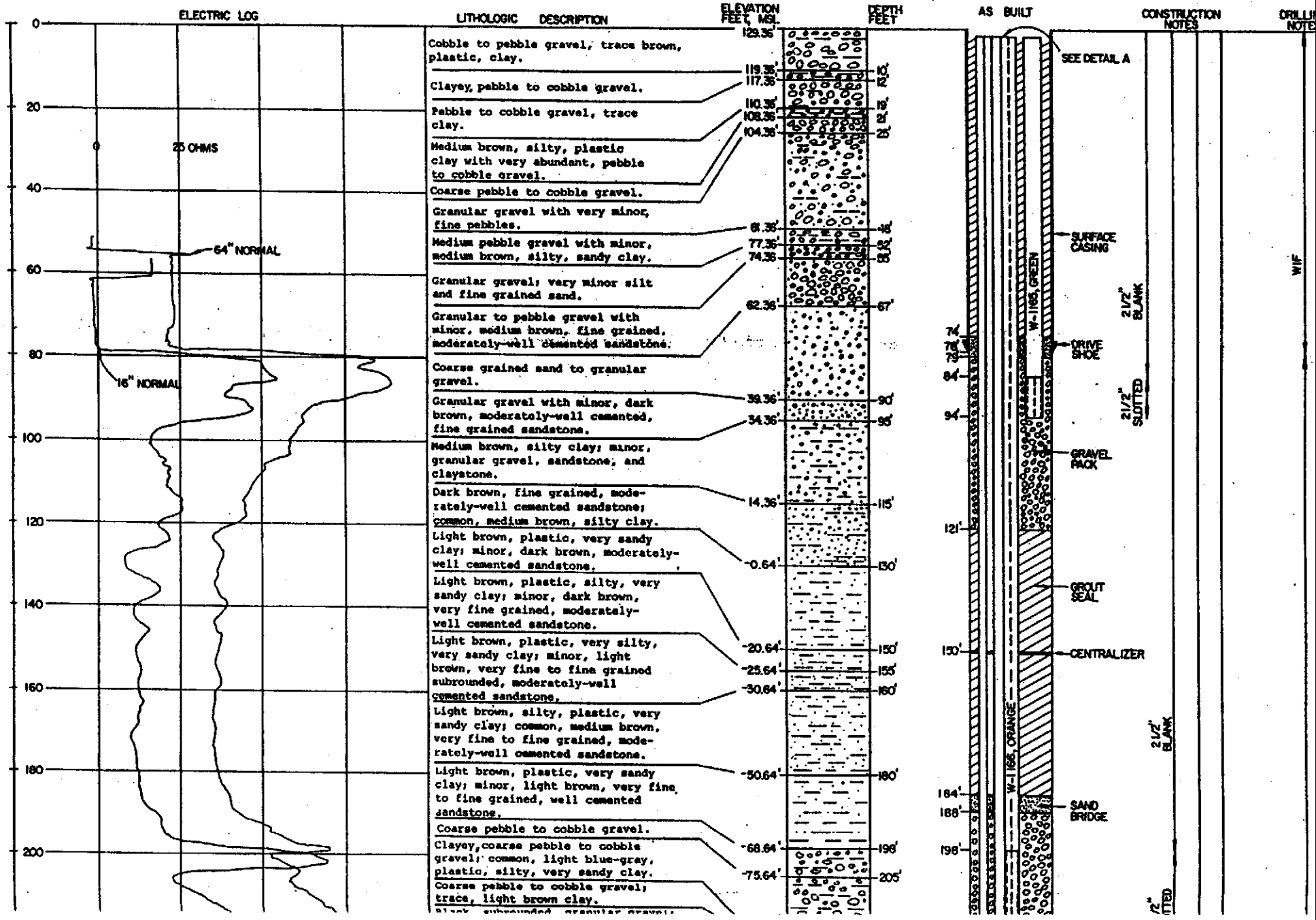


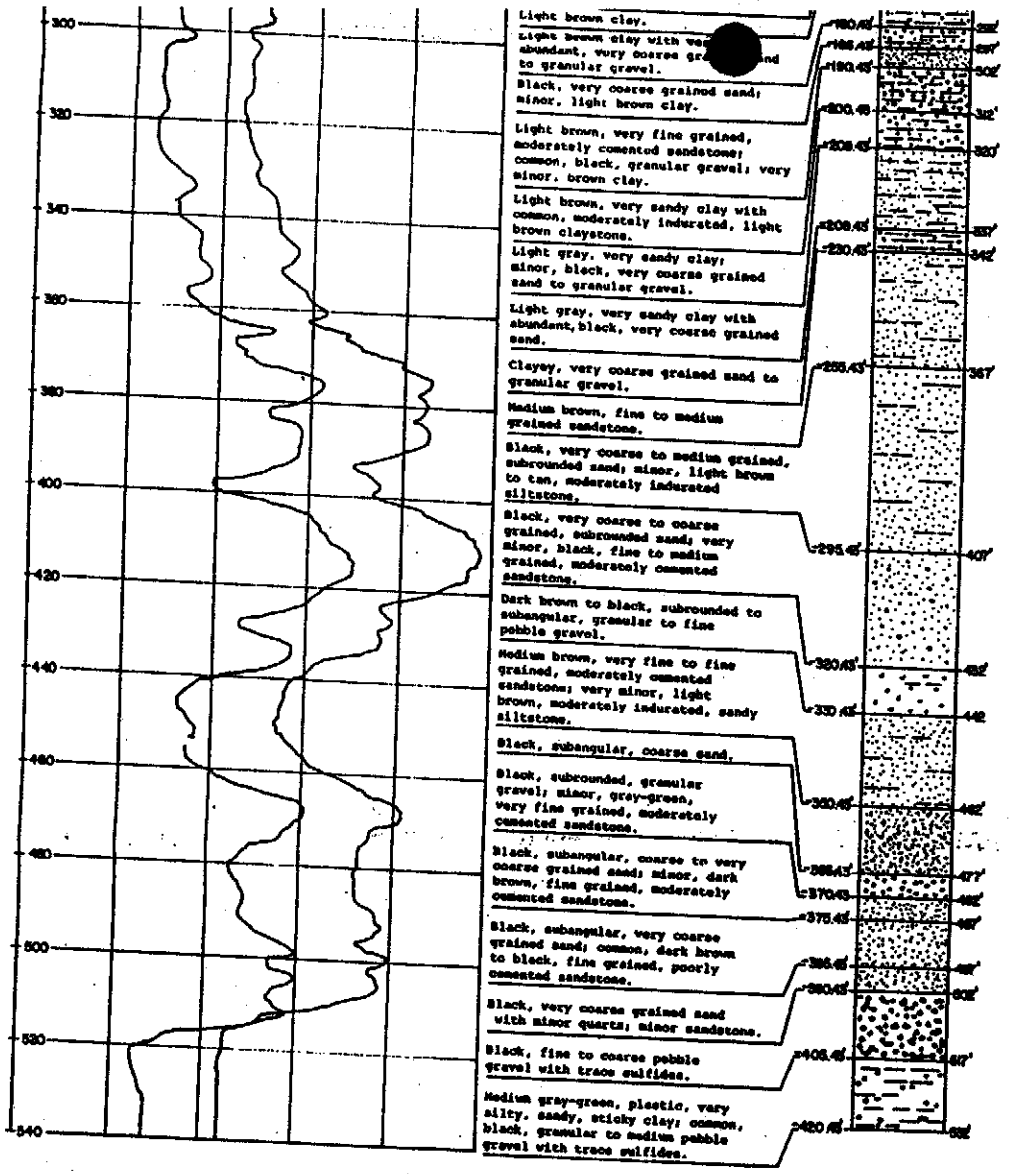


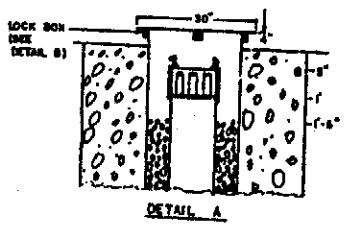
10 3/4" x 1/4" LOW CARBON STEEL CASING
2 1/2" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
2 1/2" SLOTTED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" x 4" SLOTS, 4 ROWS, 8 SLOTS / FT.
1" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
1" PERFORATED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" DRILLED HOLES, 2 ROWS, 6 HOLES / FT.
WIF: WATER INJECTION WITH FOAM

OSNW MWG
1165-1168

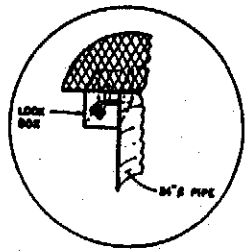
AGC 0800 0


ELECTRIC LOG
0
20
40
60
80
100
120
140
160
180
200
0
25 OHMS
64" NORMAL
16" NORMAL
LITHOLOGIC DESCRIPTION
ELEVATION FEET, MSL
DEPTH FEET
Cobble to pebble gravel, trace brown, plastic, clay.
129.36'
119.36'
10'
Clayey, pebble to cobble gravel.
117.36'
12'
Pebble to cobble gravel, trace clay.
110.36'
18'
108.36'
21'
Medium brown, silty, plastic clay with very abundant, pebble to cobble gravel.
104.36'
25'
Coarse pebble to cobble gravel.
Granular gravel with very minor, fine pebbles.
81.36'
48'
Medium pebble gravel with minor, medium brown, silty, sandy clay.
77.36'
52'
74.36'
55'
Granular gravel; very minor silt and fine grained sand.
62.36'
67'
Granular to pebble gravel with minor, medium brown, fine grained, moderately-well cemented sandstone.
Coarse grained sand to granular gravel.
39.36'
90'
Granular gravel with minor, dark brown, moderately-well cemented, fine grained sandstone.
34.36'
95'
Medium brown, silty clay; minor, granular gravel, sandstone, and claystone.
Dark brown, fine grained, moderately-well cemented sandstone; common, medium brown, silty clay.
14.36'
115'
Light brown, plastic, very sandy clay; minor, dark brown, moderately-well cemented sandstone.
-0.64'
130'
Light brown, plastic, silty, very sandy clay; minor, dark brown, very fine grained, moderately-well cemented sandstone.
Light brown, plastic, very silty, very sandy clay; minor, light brown, very fine to fine grained subrounded, moderately-well cemented sandstone.
-20.64'
150'
-25.64'
155'
-30.64'
160'
Light brown, silty, plastic, very sandy clay; common, medium brown, very fine to fine grained, moderately-well cemented sandstone.
Light brown, plastic, very sandy clay; minor, light brown, very fine to fine grained, well cemented sandstone.
-50.64'
180'
Coarse pebble to cobble gravel.
Clayey, coarse pebble to cobble gravel; common, light blue-gray, plastic, silty, very sandy clay.
-68.64'
198'
-75.64'
205'
Coarse pebble to cobble gravel; trace, light brown clay.
AS BUILT
SEE DETAIL A
W-1165, GREEN
W-1165, ORANGE
SURFACE CASING
DRIVE SHOE
GRAVEL PACK
GROUT SEAL
CENTRALIZER
SAND BRIDGE
2 1/2" BLANK
2 1/2" SLOTTED
74'
78'
79'
84'
94'
121'
150'
164'
168'
198'
CONSTRUCTION NOTES
DRILLING NOTES





DETAIL A

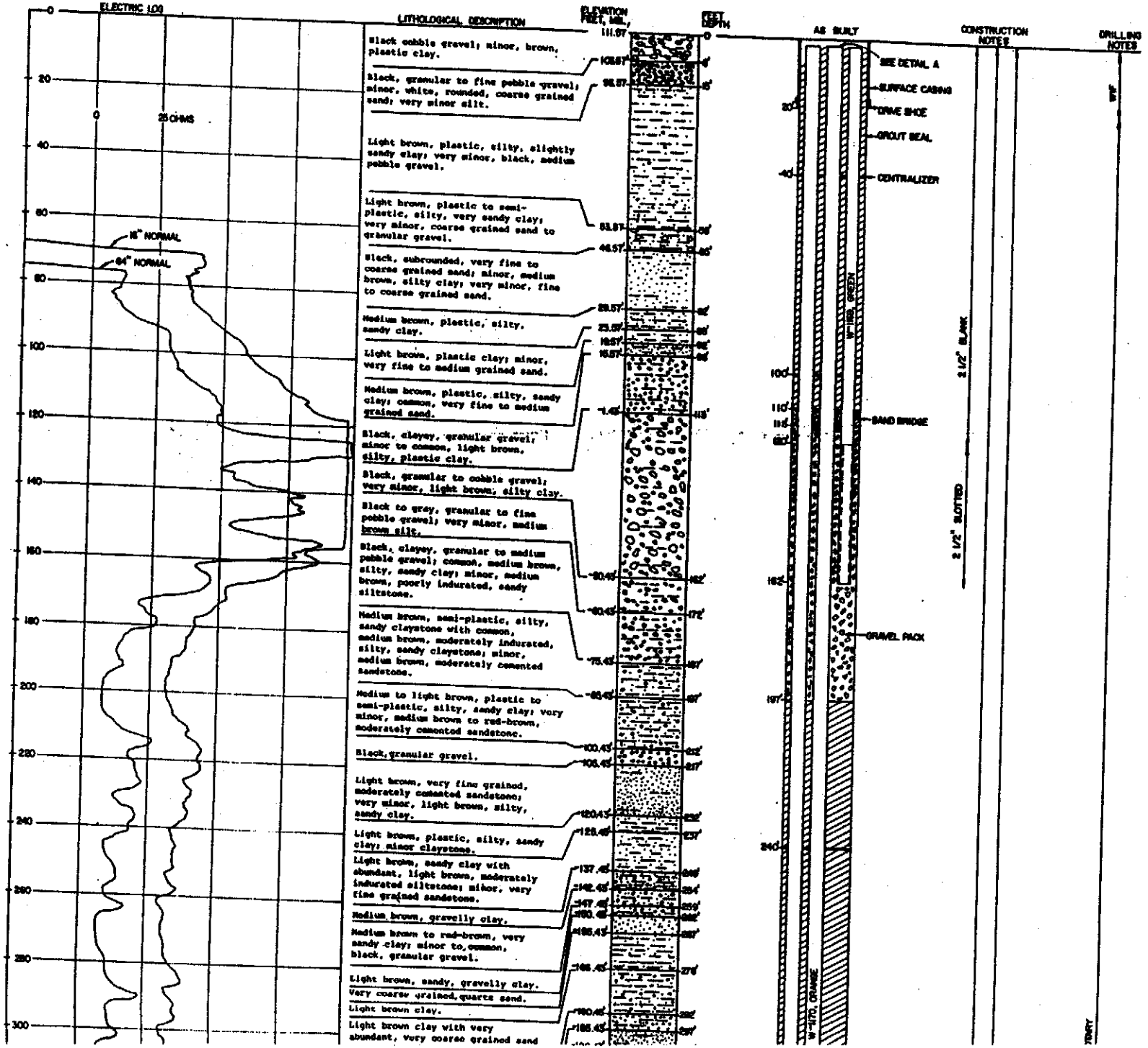


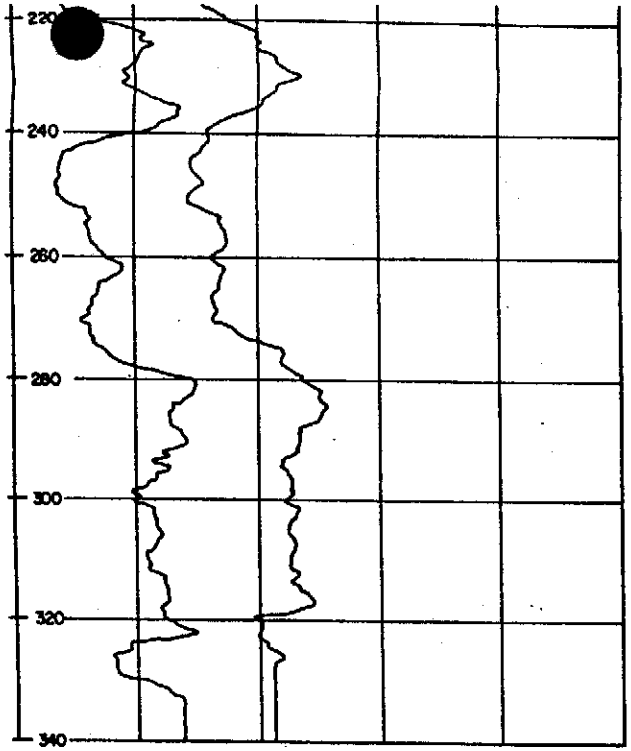
DETAIL B

10 3/4" x 1/4" LOW CARBON STEEL CASING
2 1/2" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
2 1/2" SLOTTED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" x 4" SLOTS, 4 ROWS, 8 SLOTS / FT.
WIF: WATER INJECTION WITH FOAM

OSNW MWC
1169-1171

AGC 0800 037785


ELECTRIC LOG
0
25 OHMS
16" NORMAL
64" NORMAL
LITHOLOGICAL DESCRIPTION
ELEVATION FEET, MSL
DEPTH FEET
Black cobble gravel; minor, brown, plastic clay.
Black, granular to fine pebble gravel; minor, white, rounded, coarse grained sand; very minor silt.
Light brown, plastic, silty, slightly sandy clay; very minor, black, medium pebble gravel.
Light brown, plastic to semi-plastic, silty, very sandy clay; very minor, coarse grained sand to granular gravel.
Black, subrounded, very fine to coarse grained sand; minor, medium brown, silty clay; very minor, fine to coarse grained sand.
Medium brown, plastic, silty, sandy clay.
Light brown, plastic clay; minor, very fine to medium grained sand.
Medium brown, plastic, silty, sandy clay; common, very fine to medium grained sand.
Black, clayey, granular gravel; minor to common, light brown, silty, plastic clay.
Black, granular to cobble gravel; very minor, light brown, silty clay.
Black to gray, granular to fine pebble gravel; very minor, medium brown silt.
Black, clayey, granular to medium pebble gravel; common, medium brown, silty, sandy clay; minor, medium brown, poorly indurated, sandy siltstone.
Medium brown, semi-plastic, silty, sandy claystone with common, medium brown, moderately indurated, silty, sandy claystone; minor, medium brown, moderately cemented sandstone.
Medium to light brown, plastic to semi-plastic, silty, sandy clay; very minor, medium brown to red-brown, moderately cemented sandstone.
Black, granular gravel.
Light brown, very fine grained, moderately cemented sandstone; very minor, light brown, silty, sandy clay.
Light brown, plastic, silty, sandy clay; minor claystone.
Light brown, sandy clay with abundant, light brown, moderately indurated siltstone; minor, very fine grained sandstone.
Medium brown, gravelly clay.
Medium brown to red-brown, very sandy clay; minor to common, black, granular gravel.
Light brown, sandy, gravelly clay.
Very coarse grained, quartz sand.
Light brown clay.
Light brown clay with very abundant, very coarse grained sand
AS BUILT
CONSTRUCTION NOTES
DRILLING NOTES
SEE DETAIL A
SURFACE CASING
DRIVE SHOE
GROUT SEAL
CENTRALIZER
BAND BRIDGE
GRAVEL PACK
2 1/2" BLANK
2 1/2" SLOTTED
W-RED, GREEN
W-RED, ORANGE
TONKY



Light to medium brown, plastic, silty clay, with moderately abundant to common, granular gravel and reddish-brown, fine to medium grained, moderately cemented sandstone.

-108.46' 230'

-123.46' 245'

Interbedded, medium brown, fine to medium grained, moderately cemented sandstone and light brown, plastic to semi-plastic, sandy clay.

-133.46' 255'

Light gray, plastic, very silty and sandy clay.

Medium brown, very fine to medium grained, moderately cemented sandstone.

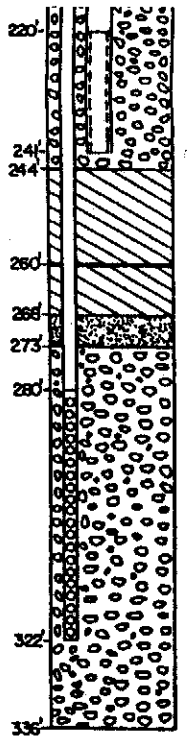
-173.46' 295'

Dark brown, fine grained, well cemented sandstone with dark brown well indurated, siltstone interbeds.

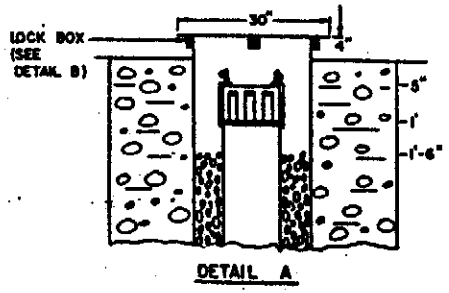
-203.46' 325'

-213.46' 335'

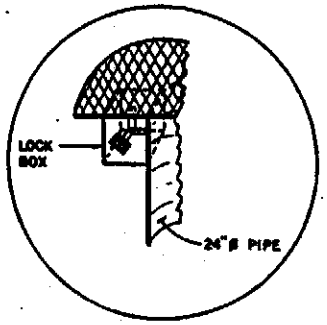
Medium gray/green, semi-plastic to moderately-well indurated, silty clay/claystone with very minor, black, anular, granular gravel.



2 1/2" SLOTTED
1" BLANK
1" PERFORATED
MUD ROTARY



DETAIL A

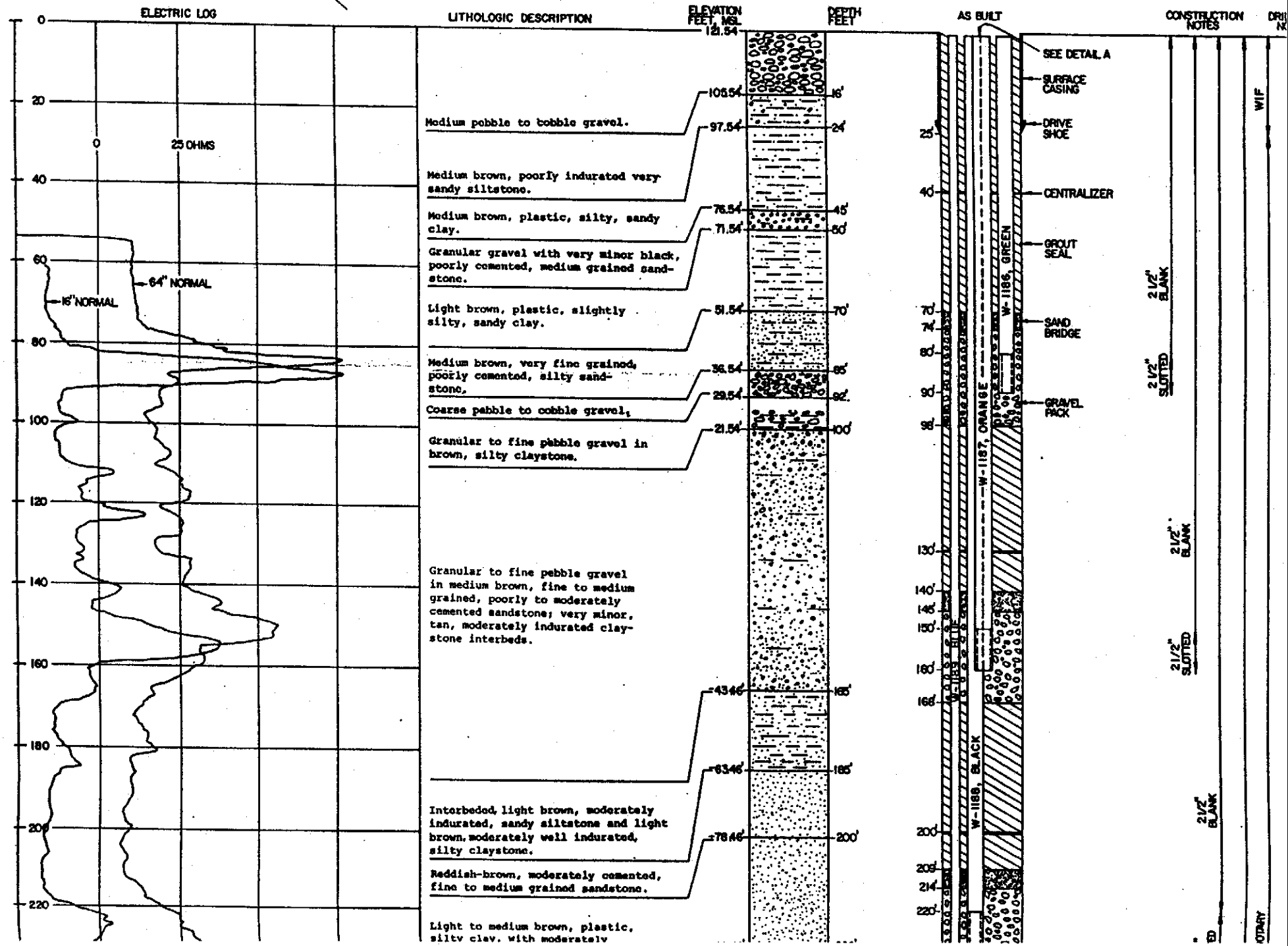


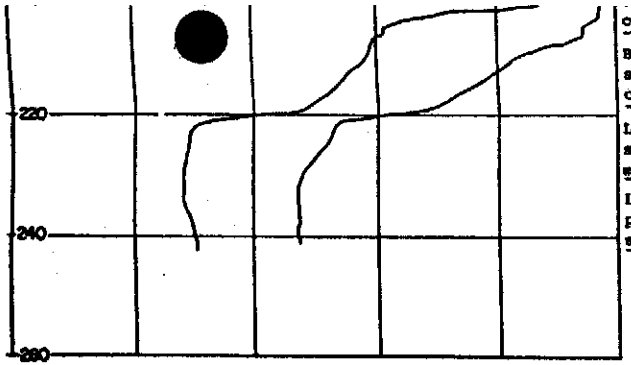
DETAIL B

10 3/4" x 1/4" LOW CARBON STEEL CASING
2 1/2" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
2 1/2" SLOTTED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" x 4" SLOTS, 4 ROWS, 8 SLOTS / FT.
1" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
1" PERFORATED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" DRILLED HOLES, 2 ROWS, 6 HOLES / FT.
WIC: WATER INJECTION WITH FOAM

AGC 0800 037786

OSNW MWD
1186-1189


ELECTRIC LOG
0
25 OHMS
16" NORMAL
64" NORMAL
0
20
40
60
80
100
120
140
160
180
200
220
LITHOLOGIC DESCRIPTION
ELEVATION FEET, MSL
DEPTH FEET
121.54'
105.54'
16'
Medium pebble to cobble gravel.
97.54'
24'
Medium brown, poorly indurated very sandy siltstone.
76.54'
45'
Medium brown, plastic, silty, sandy clay.
71.54'
50'
Granular gravel with very minor black, poorly cemented, medium grained sandstone.
51.54'
70'
Light brown, plastic, slightly silty, sandy clay.
36.54'
85'
Medium brown, very fine grained, poorly cemented, silty sandstone.
29.54'
92'
Coarse pebble to cobble gravel.
21.54'
100'
Granular to fine pebble gravel in brown, silty claystone.
Granular to fine pebble gravel in medium brown, fine to medium grained, poorly to moderately cemented sandstone; very minor, tan, moderately indurated claystone interbeds.
-43.46'
165'
-63.46'
185'
Interbedded, light brown, moderately indurated, sandy siltstone and light brown, moderately well indurated, silty claystone.
-78.46'
200'
Reddish-brown, moderately cemented, fine to medium grained sandstone.
Light to medium brown, plastic, silty clay, with moderately
AS BUILT
SEE DETAIL A
SURFACE CASING
DRIVE SHOE
CENTRALIZER
GROUT SEAL
SAND BRIDGE
GRAVEL PACK
W-1186, GREEN
W-1187, ORANGE
W-1188, BLACK
25'
40'
70'
74'
80'
90'
98'
130'
140'
145'
150'
160'
166'
200'
205'
214'
220'
CONSTRUCTION NOTES
2 1/2" BLANK
2 1/2" SLOTTED
2 1/2" BLANK
2 1/2" SLOTTED
2 1/2" BLANK
WIF
ROTARY

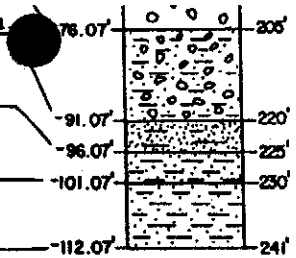


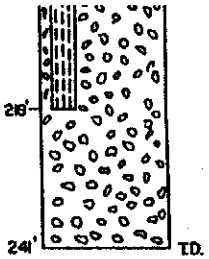
coarse grained sand to cobble gravel.

Black, medium to coarse grained, subrounded sand; very minor, buff clay.

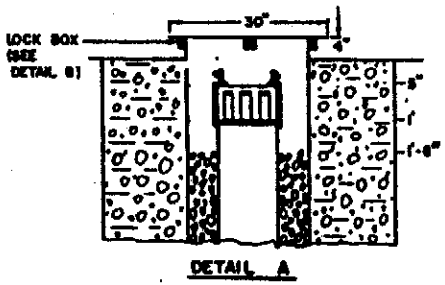
Light gray-green to blue-green, silty, sandy clay with black, medium to coarse grained sand.

Light gray-green to blue-green, plastic to semi-plastic, silty, sandy clay.

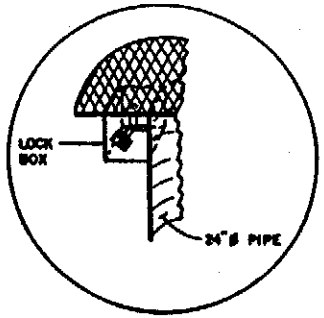




2 1/2" SLOTTED



DETAIL A

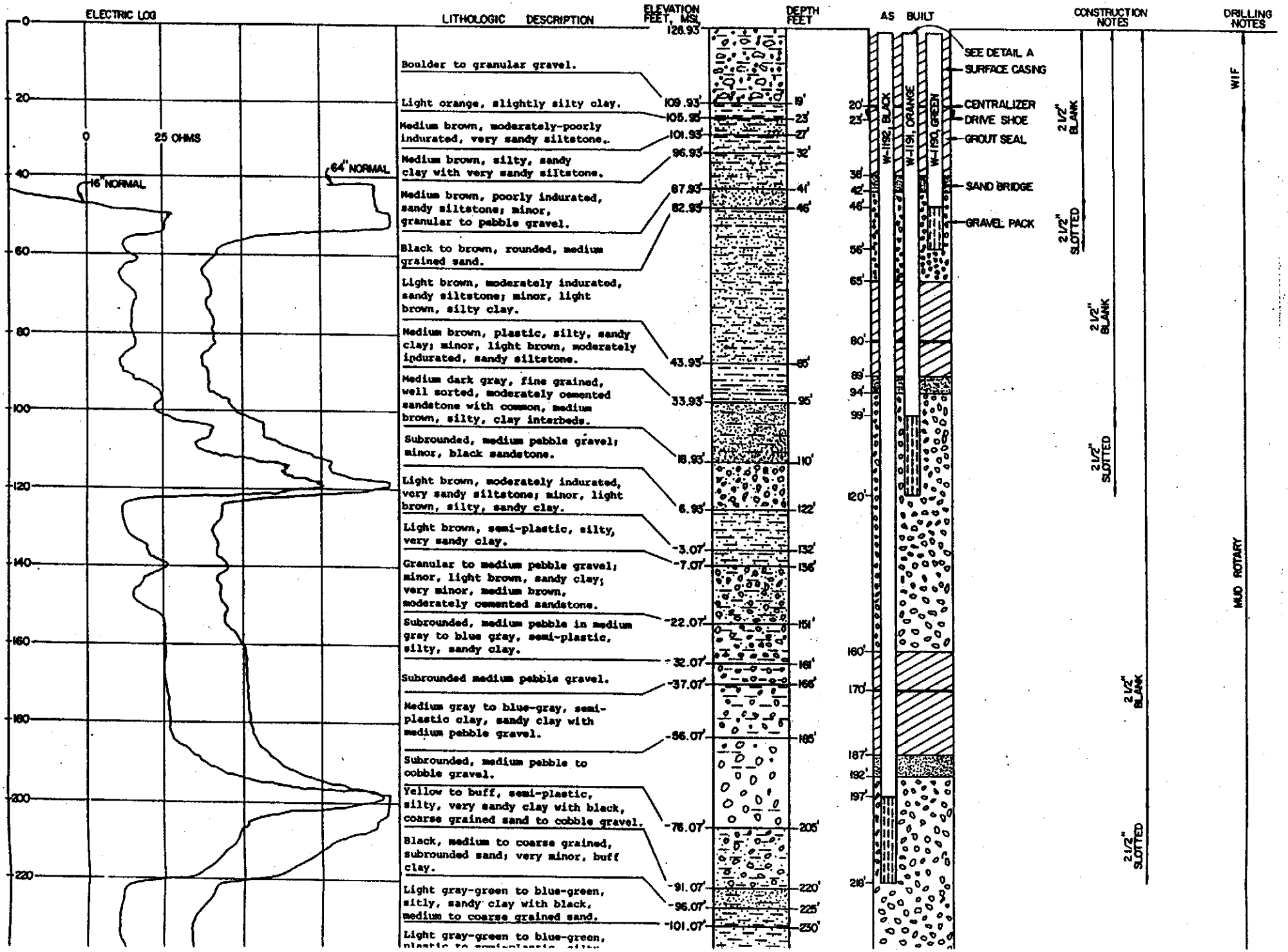


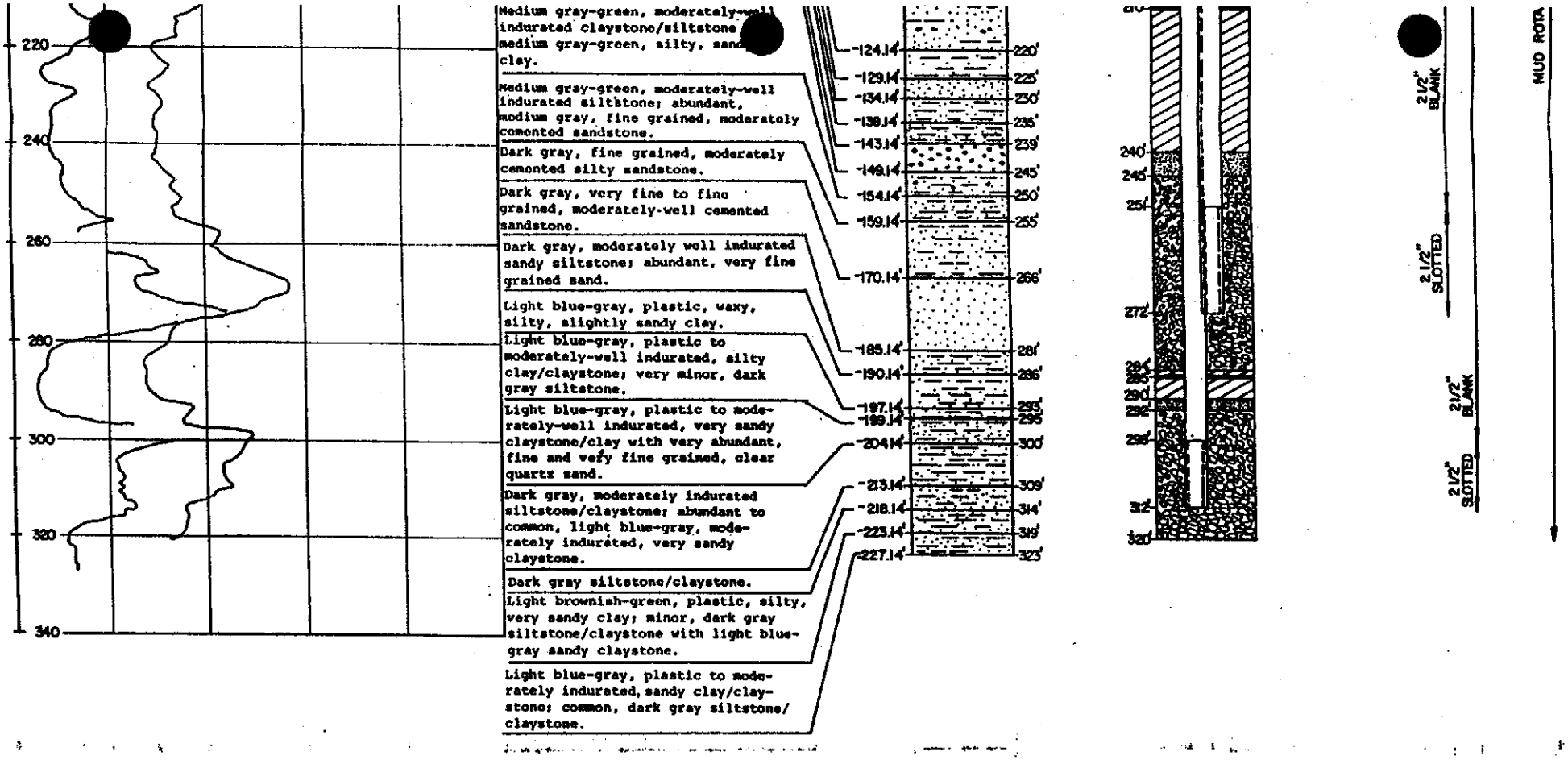
DETAIL B

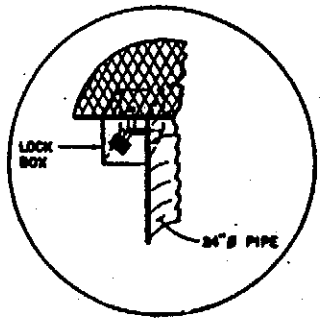
10 3/4" x 1/4" LOW CARBON STEEL CASING
2 1/2" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
2 1/2" SLOTTED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" x 4" SLOTS, 4 ROWS, 8 SLOTS / FT.
WIF: WATER INJECTION WITH FOAM

OSNW MWE
1190-1192

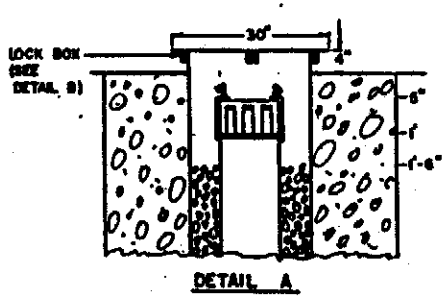
AGC 0800


ELECTRIC LOG
0
25 OHMS
16" NORMAL
64" NORMAL
0
20
40
60
80
100
120
140
160
180
200
220
LITHOLOGIC DESCRIPTION
Boulder to granular gravel.
Light orange, slightly silty clay.
Medium brown, moderately-poorly indurated, very sandy siltstone.
Medium brown, silty, sandy clay with very sandy siltstone.
Medium brown, poorly indurated, sandy siltstone; minor, granular to pebble gravel.
Black to brown, rounded, medium grained sand.
Light brown, moderately indurated, sandy siltstone; minor, light brown, silty clay.
Medium brown, plastic, silty, sandy clay; minor, light brown, moderately indurated, sandy siltstone.
Medium dark gray, fine grained, well sorted, moderately cemented sandstone with common, medium brown, silty, clay interbeds.
Subrounded, medium pebble gravel; minor, black sandstone.
Light brown, moderately indurated, very sandy siltstone; minor, light brown, silty, sandy clay.
Light brown, semi-plastic, silty, very sandy clay.
Granular to medium pebble gravel; minor, light brown, sandy clay; very minor, medium brown, moderately cemented sandstone.
Subrounded, medium pebble in medium gray to blue gray, semi-plastic, silty, sandy clay.
Subrounded medium pebble gravel.
Medium gray to blue-gray, semi-plastic clay, sandy clay with medium pebble gravel.
Subrounded, medium pebble to cobble gravel.
Yellow to buff, semi-plastic, silty, very sandy clay with black, coarse grained sand to cobble gravel.
Black, medium to coarse grained, subrounded sand; very minor, buff clay.
Light gray-green to blue-green, silty, sandy clay with black, medium to coarse grained sand.
Light gray-green to blue-green,
ELEVATION FEET, MSL
128.93
109.93'
105.93'
101.93'
96.93'
87.93'
82.93'
43.93'
33.93'
18.93'
6.93'
-3.07'
-7.07'
-22.07'
-32.07'
-37.07'
-56.07'
-76.07'
-91.07'
-96.07'
-101.07'
DEPTH FEET
19'
23'
27'
32'
41'
46'
85'
95'
110'
122'
132'
136'
151'
161'
166'
185'
205'
220'
225'
230'
AS BUILT
W-1152, BLACK
W-1151, ORANGE
W-1150, GREEN
SEE DETAIL A
SURFACE CASING
CENTRALIZER
DRIVE SHOE
GROUT SEAL
SAND BRIDGE
GRAVEL PACK
20'
23'
36'
42'
46'
56'
65'
80'
89'
94'
99'
120'
160'
170'
187'
192'
197'
216'
CONSTRUCTION NOTES
2 1/2" BLANK
2 1/2" SLOTTED
2 1/2" BLANK
2 1/2" SLOTTED
2 1/2" BLANK
2 1/2" SLOTTED
DRILLING NOTES
WIF
MUD ROTARY





DETAIL B

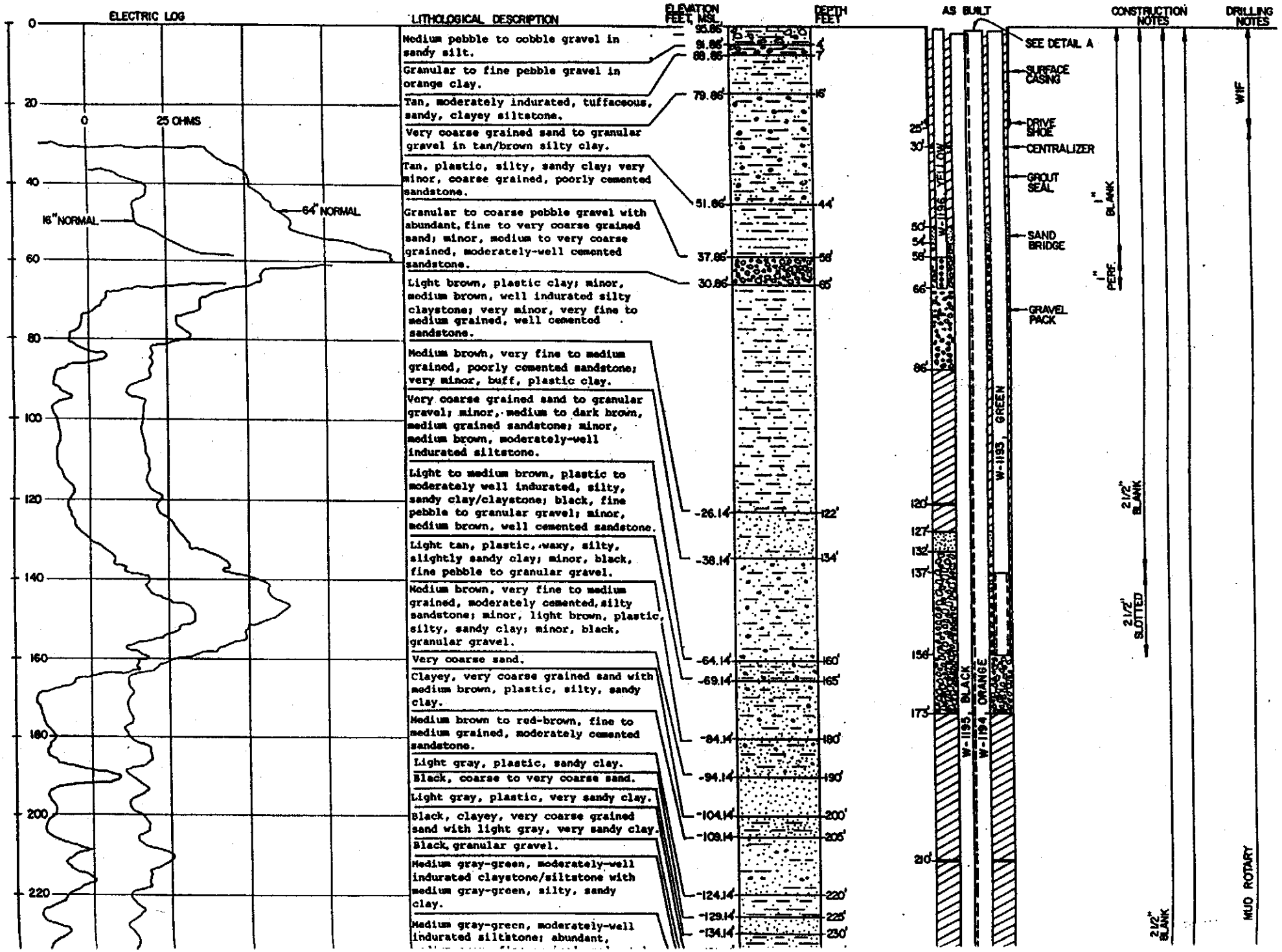


DETAIL A

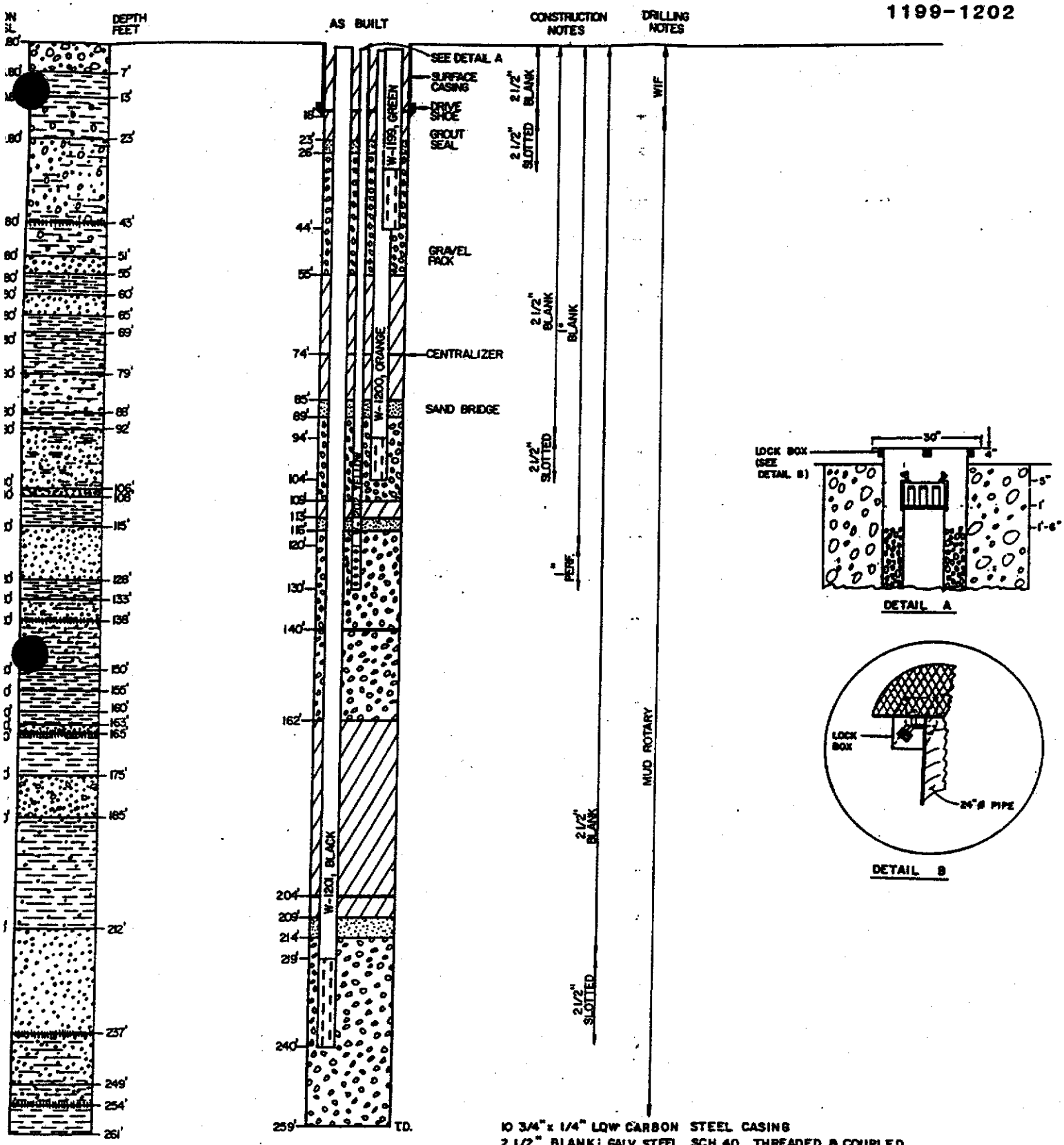
10 3/4" x 1/4" LOW CARBON STEEL CASING
2 1/2" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
2 1/2" SLOTTED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" x 4" SLOTS, 4 ROWS, 8 SLOTS / FT.
1" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
1" PERFORATED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" DRILLED HOLES, 2 ROWS.

OSNW MWB
1198-1196

AGC 0800 037


ELECTRIC LOG
0
20
40
60
80
100
120
140
160
180
200
220
0
25 OHMS
16" NORMAL
64" NORMAL
LITHOLOGICAL DESCRIPTION
ELEVATION FEET, MSL
DEPTH FEET
95.86
91.86'
88.86'
79.86'
51.86'
37.86'
30.86'
-26.14'
-38.14'
-64.14'
-69.14'
-84.14'
-94.14'
-104.14'
-109.14'
-124.14'
-129.14'
-134.14'
4'
7'
15'
44'
58'
65'
122'
134'
160'
165'
180'
190'
200'
205'
220'
225'
230'
Medium pebble to cobble gravel in sandy silt.
Granular to fine pebble gravel in orange clay.
Tan, moderately indurated, tuffaceous, sandy, clayey siltstone.
Very coarse grained sand to granular gravel in tan/brown silty clay.
Tan, plastic, silty, sandy clay; very minor, coarse grained, poorly cemented sandstone.
Granular to coarse pebble gravel with abundant, fine to very coarse grained sand; minor, medium to very coarse grained, moderately-well cemented sandstone.
Light brown, plastic clay; minor, medium brown, well indurated silty claystone; very minor, very fine to medium grained, well cemented sandstone.
Medium brown, very fine to medium grained, poorly cemented sandstone; very minor, buff, plastic clay.
Very coarse grained sand to granular gravel; minor, medium to dark brown, medium grained sandstone; minor, medium brown, moderately-well indurated siltstone.
Light to medium brown, plastic to moderately well indurated, silty, sandy clay/claystone; black, fine pebble to granular gravel; minor, medium brown, well cemented sandstone.
Light tan, plastic, waxy, silty, slightly sandy clay; minor, black, fine pebble to granular gravel.
Medium brown, very fine to medium grained, moderately cemented, silty sandstone; minor, light brown, plastic, silty, sandy clay; minor, black, granular gravel.
Very coarse sand.
Clayey, very coarse grained sand with medium brown, plastic, silty, sandy clay.
Medium brown to red-brown, fine to medium grained, moderately cemented sandstone.
Light gray, plastic, sandy clay.
Black, coarse to very coarse sand.
Light gray, plastic, very sandy clay.
Black, clayey, very coarse grained sand with light gray, very sandy clay.
Black, granular gravel.
Medium gray-green, moderately-well indurated claystone/siltstone with medium gray-green, silty, sandy clay.
Medium gray-green, moderately-well indurated siltstone; abundant,
AS BUILT
CONSTRUCTION NOTES
DRILLING NOTES
SEE DETAIL A
SURFACE CASING
DRIVE SHOE
CENTRALIZER
GROUT SEAL
SAND BRIDGE
GRAVEL PACK
1" BLANK
1" PERF.
2 1/2" BLANK
2 1/2" SLOTTED
2 1/2" BLANK
W-1196, YELLOW
W-1195, BLACK
W-1194, ORANGE
W-1193, GREEN
25'
30'
50'
54'
58'
66'
86'
120'
127'
132'
137'
156'
173'
210'
WIF
MUD ROTARY

OSNW MWA
1199-1202

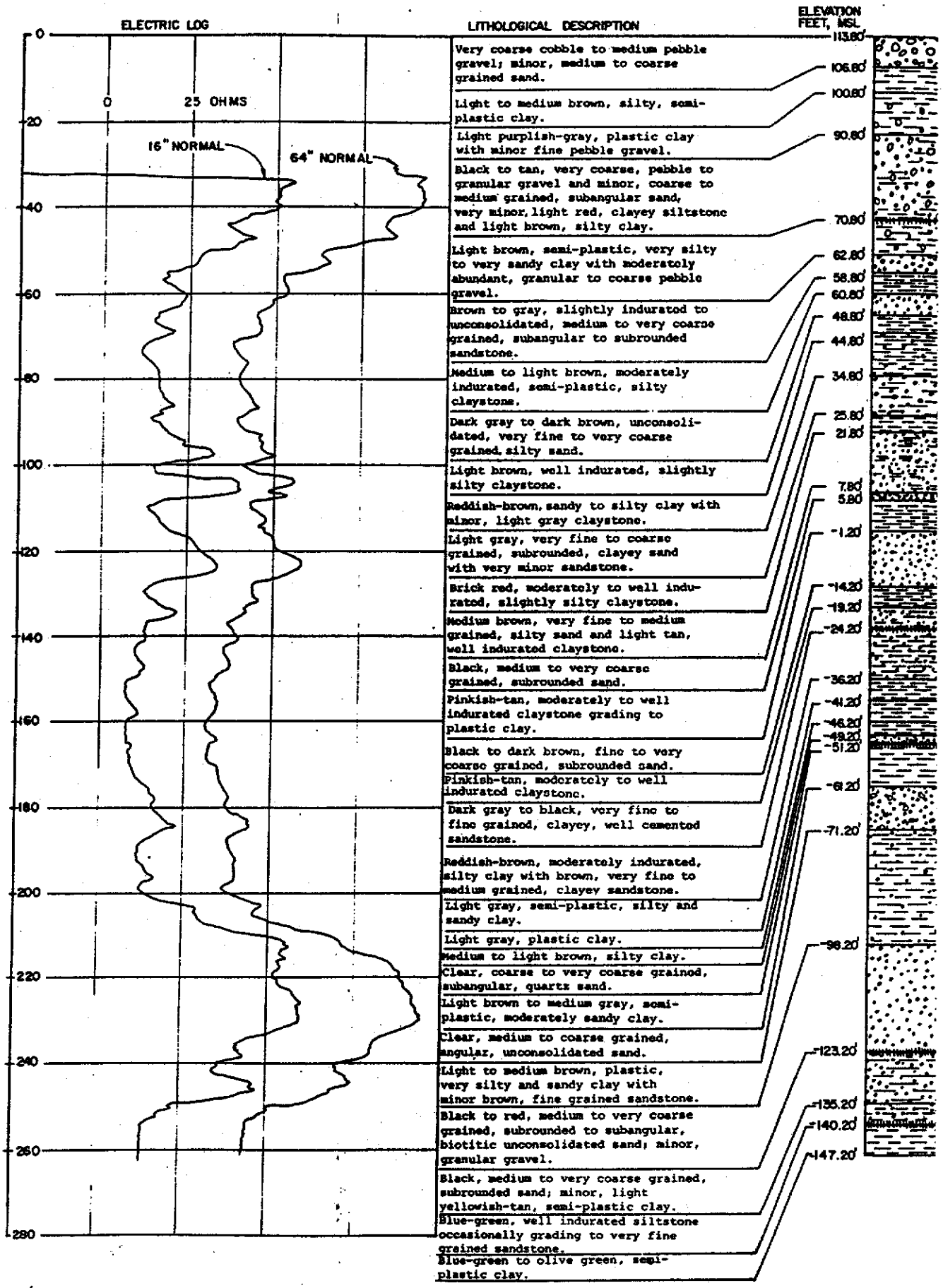


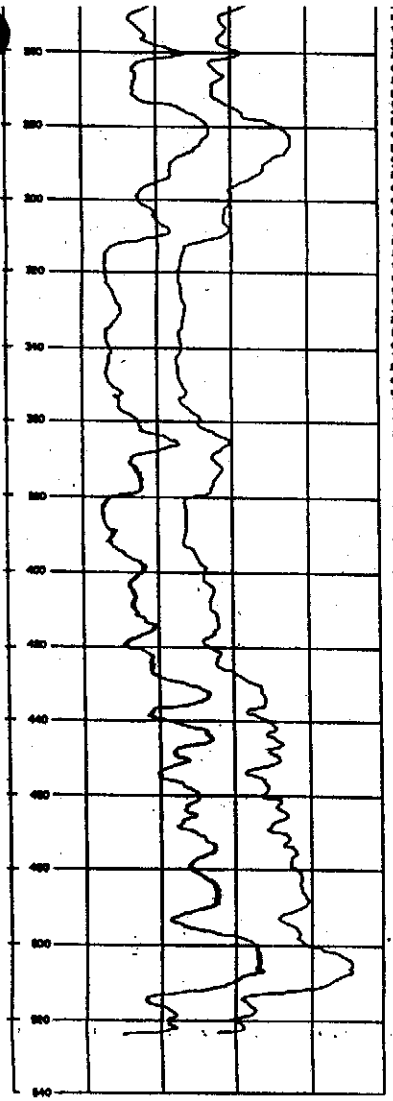
DETAIL A

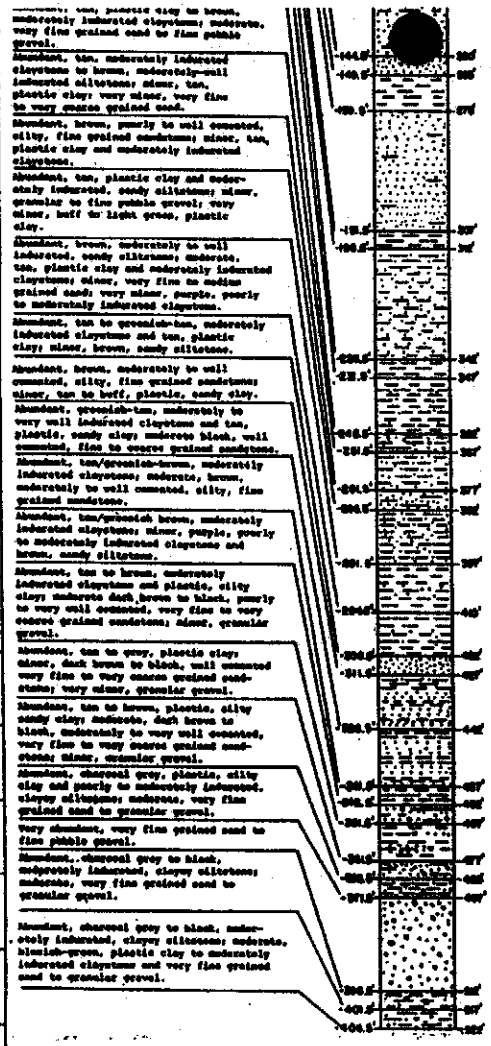
DETAIL B

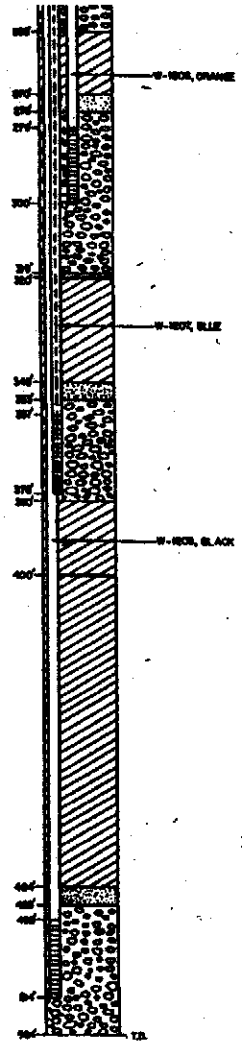
10 3/4" x 1/4" LOW CARBON STEEL CASING
2 1/2" BLANK: GALV. STEEL, SCH. 40, THREADED & COUPLED
2 1/2" SLOTTED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" x 4" SLOTS, 4 ROWS, 8 SLOTS / FT.
1" PERFORATED: GALV. STEEL, SCH. 40, THREADED & COUPLED, 1/8" DRILLED HOLES, 2 ROWS, 6 HOLES / FT.
WIF: WATER INJECTION WITH FOAM

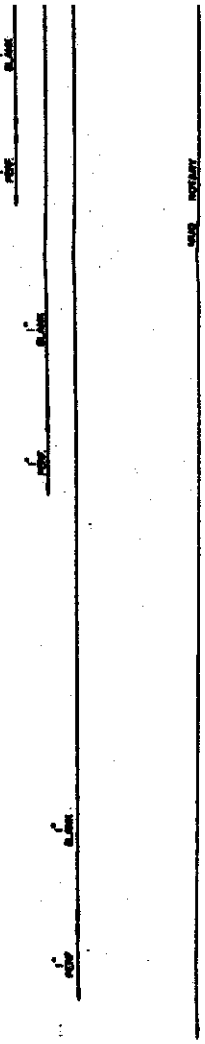
AGC 0800 037789


ELECTRIC LOG
LITHOLOGICAL DESCRIPTION
ELEVATION FEET, MSL
0
25 OHMS
16" NORMAL
64" NORMAL
20
40
60
80
100
120
140
160
180
200
220
240
260
280
Very coarse cobble to medium pebble gravel; minor, medium to coarse grained sand.
113.8'
106.8'
Light to medium brown, silty, semi-plastic clay.
100.8'
Light purplish-gray, plastic clay with minor fine pebble gravel.
90.8'
Black to tan, very coarse, pebble to granular gravel and minor, coarse to medium grained, subangular sand, very minor, light red, clayey siltstone and light brown, silty clay.
70.8'
Light brown, semi-plastic, very silty to very sandy clay with moderately abundant, granular to coarse pebble gravel.
62.8'
Brown to gray, slightly indurated to unconsolidated, medium to very coarse grained, subangular to subrounded sandstone.
58.8'
Medium to light brown, moderately indurated, semi-plastic, silty claystone.
60.8'
Dark gray to dark brown, unconsolidated, very fine to very coarse grained, silty sand.
48.8'
Light brown, well indurated, slightly silty claystone.
44.8'
Reddish-brown, sandy to silty clay with minor, light gray claystone.
34.8'
Light gray, very fine to coarse grained, subrounded, clayey sand with very minor sandstone.
25.8'
Brick red, moderately to well indurated, slightly silty claystone.
21.8'
Medium brown, very fine to medium grained, silty sand and light tan, well indurated claystone.
7.8'
Black, medium to very coarse grained, subrounded sand.
5.8'
Pinkish-tan, moderately to well indurated claystone grading to plastic clay.
-1.2'
Black to dark brown, fine to very coarse grained, subrounded sand.
-14.2'
Pinkish-tan, moderately to well indurated claystone.
-19.2'
Dark gray to black, very fine to fine grained, clayey, well cemented sandstone.
-24.2'
Reddish-brown, moderately indurated, silty clay with brown, very fine to medium grained, clayey sandstone.
-36.2'
Light gray, semi-plastic, silty and sandy clay.
-41.2'
Light gray, plastic clay.
-46.2'
Medium to light brown, silty clay.
-49.2'
Clear, coarse to very coarse grained, subangular, quartz sand.
-51.2'
Light brown to medium gray, semi-plastic, moderately sandy clay.
-61.2'
Clear, medium to coarse grained, angular, unconsolidated sand.
-71.2'
Light to medium brown, plastic, very silty and sandy clay with minor brown, fine grained sandstone.
-98.2'
Black to red, medium to very coarse grained, subrounded to subangular, biotitic unconsolidated sand; minor, granular gravel.
-123.2'
Black, medium to very coarse grained, subrounded sand; minor, light yellowish-tan, semi-plastic clay.
-135.2'
Blue-green, well indurated siltstone occasionally grading to very fine grained sandstone.
-140.2'
Blue-green to olive green, semi-plastic clay.
-147.2'

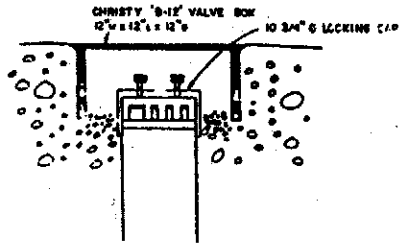








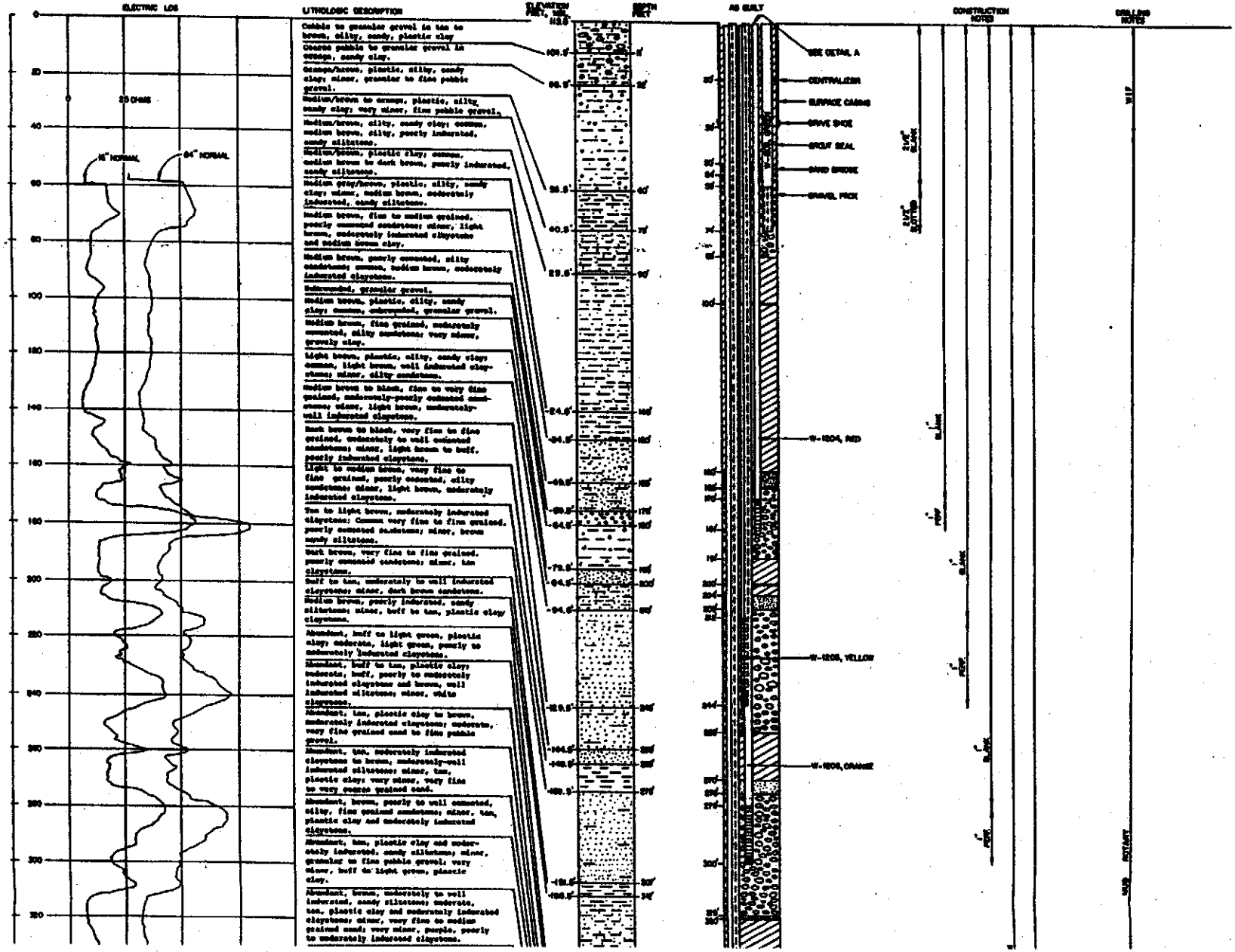
DETAIL 'A'



10 3/4" x 1/4" LOW CARBON STEEL CASING
2 1/2" BLANK: GALV STEEL, SCH 40, THREADED & COUPLED
2 1/2" SLOTTED: GALV STEEL, SCH 40, THREADED & COUPLED, 1/8" x 4" SLOTS, 4 ROWS, 8 SLOTS / FT.
4" BLANK: GALV STEEL, SCH 40, THREADED & COUPLED
4" PERFORATED: GALV STEEL, SCH 40, THREADED & COUPLED, 1/8" DRILLED HOLES, 3 ROWS, 8 HOLES / FT.
HP WATER INJECTION WITH FOAM

OSNW MWH
1203-1208

AGC 0800 037


ELECTRIC LOG
LITHOLOGIC DESCRIPTION
ELEVATION FEET, MSL
DEPTH FEET
AS BUILT
CONSTRUCTION NOTES
DRILLING NOTES
16" NORMAL
64" NORMAL
SEE DETAIL A
CENTRALIZER
SURFACE CASING
DRIVE SHOE
GROUT SEAL
SAND BRIDGE
GRAVEL PACK
W-1204, RED
W-1205, YELLOW
W-1206, ORANGE

APPENDIX B
RESULTS OF VOLATILE ORGANIC ANALYSES OF SAMPLES TAKEN FROM OFF-SITE NORTHWEST MONITOR WELLS*

*Note: All EPA priority pollutants exclusive of heavy metals were analyzed for once at each well. The non-volatile organic results were "not detected." Results of multiple analyses of volatile organic compounds are presented here.

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1162

DATE SAMPLE TAKEN	04-07-83	04-19-83	04-19-83	04-22-83	04-22-83
TESTING LAB	EDL	EDL	EDL	AUX	AUX
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE	10.0	40.0		40.0	41.0
1,1-DICHLOROETHANE	7.0	18.0		---	---
T-1,2-DICHLOROETHYLENE	8.0	35.0		45.0	45.0
CHLOROFORM				3.0	3.0
FREON 113				---	---
1,2-DICHLOROETHANE				1.0	1.0
1,1,1-TRICHLOROETHANE		31.0		---	---
TRICHLOROETHYLENE	84.0	490.0		230.0	236.0
TETRACHLOROETHYLENE		5.0		5.0	5.0
DETECTION LIMIT	2.0	1.0	1.0	2.0	2.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037792

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1162

DATE SAMPLE TAKEN	04-22-83	04-22-83
TESTING LAB	EDL	EDL
TYPE OF TEST	GC/MS	HALL
1,1-DICHLOROETHYLENE	44.0	48.0
1,1-DICHLOROETHANE	20.0	21.0
T-1,2-DICHLOROETHYLENE	34.0	37.0
CHLOROFORM	4.0	
FREON 113		
1,2-DICHLOROETHANE		
1,1,1-TRICHLOROETHANE	28.0	24.0
TRICHLOROETHYLENE	560.0	480.0
TETRACHLOROETHYLENE	6.0	4.0
DETECTION LIMIT	2.0	2.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037793

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1163

DATE SAMPLE TAKEN	04-07-83	04-19-83	04-19-83	04-19-83	04-19-83
TESTING LAB	EDL	EDL	EDL	EDL	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE	8.0	7.0	7.0	7.0	6.0
1,1-DICHLOROETHANE	5.0	4.0	5.0	5.0	4.0
T-1,2-DICHLOROETHYLENE	17.0	16.0	15.0	15.0	14.0
CHLOROFORM					1.0
FREON 113	5.0	8.0	3.0	3.0	4.0
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE					
TRICHLOROETHYLENE	79.0	92.0	88.0	91.0	95.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037794

G R O U N D W A T E R O R G A N I C A N A L Y S I S

VALUES IN PPB

WELL 1163

DATE SAMPLE TAKEN	04-19-83	04-19-83	04-19-83	04-19-83	04-19-83
TESTING LAB	EDL	EDL	EDL	EDL	EDL
TYPE OF TEST	HALL	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE	6.0	5.0	6.0	7.0	7.0
1,1-DICHLOROETHANE	5.0	5.0	4.0	5.0	5.0
T-1,2-DICHLOROETHYLENE	18.0	25.0	19.0	20.0	18.0
CHLOROFORM					1.0
FREON 113	4.0	7.0	8.0	5.0	4.0
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE					
TRICHLOROETHYLENE	99.0	88.0	96.0	94.0	119.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	1.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037795

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1163

DATE SAMPLE TAKEN	04-22-83	04-22-83	04-22-83	04-22-83
TESTING LAB	AUX	AUX	AUX	EDL
TYPE OF TEST	HALL	HALL	GC/MS	HALL
1,1-DICHLOROETHYLENE	7.0	8.0	6.0	9.0
1,1-DICHLOROETHANE	---	---	5.0	6.0
T-1,2-DICHLOROETHYLENE	20.0	20.0	12.0	18.0
CHLOROFORM				5.0
FREON 113	---	---	4.0	5.0
1,2-DICHLOROETHANE	2.0	2.0	1.0	
1,1,1-TRICHLOROETHANE	---	---		
TRICHLOROETHYLENE	107.0	110.0	86.0	100.0
TETRACHLOROETHYLENE				
DETECTION LIMIT	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037796

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1164

DATE SAMPLE TAKEN	04-07-83	04-19-83	04-22-83	04-22-83	04-22-83
TESTING LAB	EDL	EDL	AUX	AUX	AUX
TYPE OF TEST	GC/MS	HALL	HALL	HALL	GC/MS
1,1-DICHLOROETHYLENE	4.0	14.0	12.0	14.0	13.0
1,1-DICHLOROETHANE			---	---	.5
T-1,2-DICHLOROETHYLENE			1.0	1.0	.3
CHLOROFORM					
FREON 113			---	---	.5
1,2-DICHLOROETHANE			2.0	2.0	2.0
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE	7.0	15.0	19.0	20.0	18.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037797

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1164

DATE SAMPLE TAKEN	04-22-83
TESTING LAB	EDL
TYPE OF TEST	HALL
1,1-DICHLOROETHYLENE	15.0
1,1-DICHLOROETHANE	
T-1,2-DICHLOROETHYLENE	
CHLOROFORM	
FREON 113	
1,2-DICHLOROETHANE	
1,1,1-TRICHLOROETHANE	
TRICHLOROETHYLENE	16.0
TETRACHLOROETHYLENE	
DETECTION LIMIT	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037798

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1165

DATE SAMPLE TAKEN	04-06-83	04-20-83	04-22-83	04-22-83	04-22-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE	5.0	4.0	6.0	4.0	
CHLOROFORM		5.0			
FREON 113		1.0	---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE	39.0	55.0	46.0	35.0	40.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037799

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1166

DATE SAMPLE TAKEN	04-06-83	04-18-83	04-18-83	04-18-83	04-18-83
TESTING LAB	EDL	EDL	EDL	EDL	EDL
TYPE OF TEST	GC/MS	HALL	GC/MS	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE					
T-1,2-DICHLOROETHYLENE	6.0	8.0	6.0	6.0	6.0
CHLOROFORM		2.0			
FREON 113				1.0	5.0
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE					
TRICHLOROETHYLENE	19.0	22.0	18.0	17.0	20.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037800

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1166

DATE SAMPLE TAKEN	04-18-83	04-22-83	04-22-83	04-22-83
TESTING LAB	EDL	AUX	AUX	EDL
TYPE OF TEST	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE				
1,1-DICHLOROETHANE		---	---	
T-1,2-DICHLOROETHYLENE	8.0	6.0	6.0	
CHLOROFORM				
FREON 113	14.0	---	---	
1,2-DICHLOROETHANE				
1,1,1-TRICHLOROETHANE		---	---	
TRICHLOROETHYLENE	24.0	18.0	16.0	15.0
TETRACHLOROETHYLENE	1.0			
DETECTION LIMIT	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037801

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1167

DATE SAMPLE TAKEN	04-06-83	04-20-83	04-22-83	04-22-83	04-22-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLORDETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM					
FREON 113		1.0	---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037802

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1168

DATE SAMPLE TAKEN	05-02-83	05-04-83	05-06-83
TESTING LAB	EDL	EDL	EDL
TYPE OF TEST	HALL	HALL	HALL
1,1-DICHLOROETHYLENE			
1,1-DICHLOROETHANE			
T-1,2-DICHLOROETHYLENE			
CHLOROFORM			
FREON 113			
1,2-DICHLOROETHANE			
1,1,1-TRICHLOROETHANE			
TRICHLOROETHYLENE			
TETRACHLOROETHYLENE			
DETECTION LIMIT	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037803

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1169

DATE SAMPLE TAKEN	03-31-83	04-14-83	04-21-83	04-21-83	04-21-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	GC/MS	HALL	HALL	GC/MS
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE	1.0				1.0
CHLOROFORM					1.0
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE	2.0	4.0	5.0	4.0	5.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	1.0	2.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037804

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1170

DATE SAMPLE TAKEN	03-31-83	04-14-83	04-21-83	04-21-83	04-21-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	GC/MS	HALL	HALL	GC/MS
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM					
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	1.0	2.0	2.0	2.0	2.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037805

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1171

DATE SAMPLE TAKEN	03-31-83	04-14-83	04-21-83	04-21-83	04-21-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	GC/MS	HALL	HALL	HALL
1,1-DICHLORDETHYLENE					
1,1-DICHLORDETHANE			---	---	
T-1,2-DICHLORDETHYLENE					
CHLOROFORM					
FREON 113			---	---	
1,2-DICHLORDETHANE					
1,1,1-TRICHLORDETHANE			---	---	
TRICHLORDETHYLENE					
TETRACHLORDETHYLENE					
DETECTION LIMIT	1.0	2.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037806

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1186

DATE SAMPLE TAKEN	04-01-83	04-19-83	04-25-83	04-25-83	04-25-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE	2.0		4.0	4.0	
CHLOROFORM					1.0
FREON 113			---	---	
1,2-DICHLOROETHANE		2.0			
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE	7.0	15.0	22.0	16.0	18.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037807

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1187

DATE SAMPLE TAKEN	04-01-83	04-19-83	04-25-83	04-25-83	04-25-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM				1.0	
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037808

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1188

DATE SAMPLE TAKEN	04-01-83	04-19-83	04-25-83	04-25-83	04-25-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	GC/MS
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM					
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037809

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1189

DATE SAMPLE TAKEN	05-02-83	05-04-83	05-06-83
TESTING LAB	EDL	EDL	EDL
TYPE OF TEST	HALL	HALL	HALL
1,1-DICHLORDETHYLENE			
1,1-DICHLOROETHANE			
T-1,2-DICHLORDETHYLENE			
CHLOROFORM			
FREON 113		1.0	
1,2-DICHLORDETHANE			
1,1,1-TRICHLOROETHANE			
TRICHLORDETHYLENE			
TETRACHLORDETHYLENE			
DETECTION LIMIT	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037810

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1190

DATE SAMPLE TAKEN	04-07-83	04-20-83	04-26-83	04-26-83	04-26-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	GC/MS	HALL	HALL	GC/MS
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM			2.0	1.0	
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE				2.0	2.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	2.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037811

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1191

DATE SAMPLE TAKEN	04-06-83	04-18-83	04-18-83	04-18-83	04-18-83
TESTING LAB	EDL	EDL	EDL	EDL	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE					
T-1,2-DICHLOROETHYLENE	2.0	1.0	1.0	2.0	2.0
CHLOROFORM					
FREON 113					12.0
1,2-DICHLOROETHANE		1.0	2.0	1.0	
1,1,1-TRICHLOROETHANE					
TRICHLOROETHYLENE	320.0	280.0	230.0	260.0	250.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037812

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1191

DATE SAMPLE TAKEN TESTING LAB TYPE OF TEST	04-18-83 EDL HALL	04-18-83 EDL HALL	04-18-83 EDL HALL	04-18-83 EDL HALL	04-18-83 EDL HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE					
T-1,2-DICHLOROETHYLENE	1.0	2.0	2.0	2.0	1.0
CHLOROFORM					
FREON 113	1.0				
1,2-DICHLOROETHANE	2.0	2.0	2.0	2.0	2.0
1,1,1-TRICHLOROETHANE					
TRICHLOROETHYLENE	240.0	230.0	290.0	230.0	210.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	1.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037813

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1191

DATE SAMPLE TAKEN	04-26-83	04-26-83	04-26-83
TESTING LAB	AUX	AUX	EDL
TYPE OF TEST	HALL	HALL	GC/MS
1,1-DICHLOROETHYLENE			
1,1-DICHLOROETHANE	---	---	
T-1,2-DICHLOROETHYLENE	3.0	3.0	3.0
CHLOROFORM	5.0	6.0	
FREON 113	---	---	
1,2-DICHLOROETHANE			1.0
1,1,1-TRICHLOROETHANE	---	---	
TRICHLOROETHYLENE	216.0	211.0	340.0
TETRACHLOROETHYLENE			
DETECTION LIMIT	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037814

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1192

DATE SAMPLE TAKEN	04-06-83	04-20-83	04-26-83	04-26-83	04-26-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM			4.0		
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037815

G R O U N D W A T E R O R G A N I C A N A L Y S I S

VALUES IN PPB

WELL 1193

DATE SAMPLE TAKEN	04-05-83	04-20-83	04-25-83	04-25-83	04-25-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM					
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037816

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1194

DATE SAMPLE TAKEN	04-05-83	04-20-83	04-25-83	04-25-83	04-25-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM					
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037817

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1200

DATE SAMPLE TAKEN	04-13-83	04-20-83	04-26-83	04-26-83	04-26-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM			2.0		
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037818

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1201

DATE SAMPLE TAKEN	04-13-83	04-20-83	04-26-83	04-26-83	04-26-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM					
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037819

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1202

DATE SAMPLE TAKEN	05-03-83	05-04-83	05-06-83
TESTING LAB	EDL	EDL	EDL
TYPE OF TEST	HALL	HALL	HALL
1,1-DICHLOROETHYLENE			
1,1-DICHLOROETHANE			
T-1,2-DICHLOROETHYLENE			
CHLOROFORM			
FREON 113			
1,2-DICHLOROETHANE			
1,1,1-TRICHLOROETHANE			
TRICHLOROETHYLENE	5.0	4.0	5.0
TETRACHLOROETHYLENE			
DETECTION LIMIT	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037820

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 9999

DATE SAMPLE TAKEN	04-21-83	04-21-83	04-21-83	04-22-83	04-22-83
TESTING LAB	AUX	AUX	EDL	AUX	AUX
TYPE OF TEST	HALL	HALL	GC/MS	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE	---	---		---	---
T-1,2-DICHLOROETHYLENE					
CHLOROFORM	26.0	15.0	40.0		
FREON 113	---	---		---	---
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE	---	---		---	---
TRICHLOROETHYLENE	3.0				
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	2.0	2.0	2.0	2.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037821

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 9999

DATE SAMPLE TAKEN	04-22-83	04-25-83	04-25-83	04-25-83	04-26-83
TESTING LAB	EDL	AUX	AUX	EDL	AUX
TYPE OF TEST	GC/MS	HALL	HALL	GC/MS	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE		---	---		---
T-1,2-DICHLOROETHYLENE					
CHLOROFORM					5.0
FREON 113		---	---		---
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE		---	---		---
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	2.0	2.0	2.0	2.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037822

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 9999

DATE SAMPLE TAKEN	04-26-83	04-26-83	04-29-83	05-02-83	05-03-83
TESTING LAB	AUX	EDL	EDL	EDL	EDL
TYPE OF TEST	HALL	GC/MS	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE	---				
T-1,2-DICHLOROETHYLENE					
CHLOROFORM	5.0		8.0		
FREON 113	---				
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE	---				
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	2.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037823

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 9999

DATE SAMPLE TAKEN	05-04-83	05-06-83	05-06-83
TESTING LAB	EDL	EDL	EDL
TYPE OF TEST	HALL	HALL	HALL
1,1-DICHLOROETHYLENE			
1,1-DICHLOROETHANE			
T-1,2-DICHLOROETHYLENE			
CHLOROFORM			
FREON 113			
1,2-DICHLOROETHANE			
1,1,1-TRICHLOROETHANE			
TRICHLOROETHYLENE			
TETRACHLOROETHYLENE			
DETECTION LIMIT	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037824

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1195

DATE SAMPLE TAKEN	04-05-83	04-20-83	04-25-83	04-25-83	04-25-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM					
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE					
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037825

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1196

DATE SAMPLE TAKEN	04-29-83	05-03-83	05-06-83
TESTING LAB	EDL	EDL	EDL
TYPE OF TEST	HALL	HALL	HALL
1,1-DICHLOROETHYLENE			
1,1-DICHLOROETHANE			
T-1,2-DICHLOROETHYLENE			
CHLOROFORM			
FREON 113		2.0	
1,2-DICHLOROETHANE			
1,1,1-TRICHLOROETHANE			
TRICHLOROETHYLENE			
TETRACHLOROETHYLENE			
DETECTION LIMIT	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037826

GROUND WATER ORGANIC ANALYSIS

VALUES IN PPB

WELL 1199

DATE SAMPLE TAKEN	04-13-83	04-20-83	04-26-83	04-26-83	04-26-83
TESTING LAB	EDL	EDL	AUX	AUX	EDL
TYPE OF TEST	GC/MS	HALL	HALL	HALL	HALL
1,1-DICHLOROETHYLENE					
1,1-DICHLOROETHANE			---	---	
T-1,2-DICHLOROETHYLENE					
CHLOROFORM			11.0	7.0	
FREON 113			---	---	
1,2-DICHLOROETHANE					
1,1,1-TRICHLOROETHANE			---	---	
TRICHLOROETHYLENE	2.0	2.0	5.0	4.0	2.0
TETRACHLOROETHYLENE					
DETECTION LIMIT	2.0	1.0	1.0	1.0	1.0

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED.

AGC 0800 037827

APPENDIX C

OFF-SITE NORTHWEST GROUNDWATER QUALITY INVESTIGATION,
NON-VOLATILE ORGANIC PRIORITY POLLUTANTS

The priority pollutants tested for and their detection limits are contained herein. All results were "none detected."

COMPOUND	DETECTION LIMIT PARTS PER BILLION
PHENOL	2
2-CHLOROPHENOL	2
2-NITROPHENOL	5
2,4-DICHLOROPHENOL	3
4-CHLORO-3-METHYLPHENOL	2
2,4,6-TRICHLOROPHENOL	4
4-NITROPHENOL	10
2,4-DINITROPHENOL	3
2,4-DIMETHYLPHENOL	2
2-METHYL-4,6-DINITROPHENOL	10
PENTACHLOROPHENOL	5
2-CHLOROETHYLVINYLETHER	2
N-NITROSODIMETHYLAMINE	2
1,3-DICHLOROBENZENE	2
1,4-DICHLOROBENZENE	2
1,2-DICHLOROBENZENE	2

AGC 0800 037829

COMPOUND	DETECTION LIMIT PARTS PER BILLION
BIS(2-CHLOROISOPROPYL)ETHER	5
HEXACHLOROETHANE	5
N-NITROSO-DI-N-PROPLYAMINE	2
NITROBENZENE	2
ISOPHORONE	2
BIS(2-CHLOROETHYOXY)METHANE	2
1,2,4-TRICHLOROBENZENE	2
NAPHTHALENE	2
HEXACHLOROBUTADIENE	3
HEXACHLOROCYCLOPENTADIENE	10
2-CHLORONAPHTHALENE	2
ACENAPHTHYLENE	2
DIMETHYLPHTHALATE	2
2,6-DINITROTOULENE	10
ACENAPHTHENE	2
2,4-DINITROTOLUENE	10

AGC 0800 037830

COMPOUND	DETECTION LIMIT PARTS PER BILLION
FLUORENE	2
DIETHYLPHTHALATE	2
4-CHLOROPHENYLPHENYLETHER	15
N-NITROSODIPHENYLAMINE	2
1,2-DIPHENYLHYDRAZINE	2
4-BROMOPHENOXYBENZENE	2
HEXACHLOROBENZENE	2
PHENANTHRENE	2
ANTHRACENE	2
DI-N-BUTYLPHTHALATE	2*
FLUORANTHENE	2
PYRENE	2

* There were sporadic reports of 2 to 3 ppb of di-N-butylphthalate. This compound is ubiquitous in the hydrosphere.

AGC 0800 037831

COMPOUND	DETECTION LIMIT PARTS PER BILLION
BUTYLBENZYLPHTHALATE	4
BENZO(A)ANTHRACENE	2
3,3'-DICHLOROBENZIDINE	15
CHRYSENE	2
BIS(2-ETHYLHEXYL)PHTHALATE	3
DI-N-OCTYLPHTHALATE	2
BENZO(B)FLUORANTHENE	2

AGC 0800 037832

COMPOUND	DETECTION LIMIT PARTS PER BILLION
AROCLOR 1016	1
AROCLOR 1221	1
AROCLOR 1232	1
AROCLOR 1242	1
AROCLOR 1248	1
AROCLOR 1254	1
AROCLOR 1260	1
α -BHC	1
LINDANE	1
β -BHC	1
HEPTACHLOR	1
ALDRIN	1
HEPTACHLOR EPOXIDE	1
p,p' DDE	1
DIELDRIN	1
o,p' TDE	1

AGC 0800 037833

COMPOUND	DETECTION LIMIT PARTS PER BILLION
ENDRIN	1
o,p' DDT	1
p,p' TDE	1
p,p' DDT	1
2,4-D METHYL ESTER	1
2,4,5-T METHYL ESTER	1
2,4,5-TP METHYL ESTER	1
PARATHION	1
DIAZINON	1
PHORATE	1
DISULFOTON	1
METHYL PARATHION	1
MALATHION	1
ETHION	1
METHYL TRITHION	1
METHOXYCHLOR	1

AGC 0800 037834

COMPOUND	DETECTION LIMIT PARTS PER BILLION
TOXAPHENE	1
CHLORDANE	1

AGC 0800 037835

The dates that each of the wells were sampled for these compounds are as follows:

Well		Date
A	1199	04-13-83
	1200	04-13-83
	1201	04-13-83
	1202	05-09-83
B	1193	04-05-83
	1194	04-05-83
	1195	04-05-83
	1196	05-09-83
C	1169	03-31-83 and 04-14-83
	1170	03-31-83 and 04-14-83
	1171	03-13-83 and 04-14-83
D	1186	04-01-83
	1187	04-01-83
	1188	04-01-83
	1189	05-10-83
E	1190	04-08-83
	1191	04-06-83
	1192	04-06-83
F	1162	04-06-83 and 05-05-83
	1163	04-07-83 and 05-05-83
	1164	04-07-83 and 05-05-83
G	1165	04-06-83
	1166	04-06-83
	1167	04-06-83
	1168	05-10-83
H	1203	05-12-82 and 05-16-83
	1204	05-16-83
	1205	05-16-83
	1206	05-16-83
	1207	05-16-83
	1208	05-17-83

AGC 0800 037836

8 FOLDERS CONTAINING OVERSIZED MAPS

(SEE BINDER)

Declaration of Stephen Ross

I, Stephen Ross, declare that:

1. I am a senior hydrogeologist for Komex, which is an environmental and engineering consulting firm. My office is located in the Komex 's Sacramento Branch. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Document V American River Investigation of August 1983," produced by the Aerojet General Corporation, is to my knowledge a true and correct copy of this document. This copy was obtained from the law firm Bolling, Walter & Gawthrop and to our knowledge is a complete version of said document. A copy of said document is maintained at the California State University at Sacramento's Library.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Stephen Ross

DOCUMENT V

AMERICAN RIVER INVESTIGATION
OF
AUGUST 1983

AGC 0800 037140

C-400.87

DOCUMENT V

AMERICAN RIVER INVESTIGATION
OF
AUGUST 1983

Aerojet General Corporation
October 1983

AGC 0800 037141

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AGC 0800 037142

AMERICAN RIVER INVESTIGATION
OF
AUGUST 1983

This document transmits the findings of several water quality samples collected from the American River and from the unconsolidated gravels forming its bedload. The first set of findings discussed relates to samples collected on August 10, 1983, when the discharge of the river was reduced to 250 cfs for a four-hour period. On this occasion both the free flowing water of the river and the bedload water were sampled.

Some of the bedload water samples collected on August 10 were reported to have elevated electrical conductivity and to contain vinyl chloride in addition to other volatile organic chemicals. Three subsequent sampling exercises were undertaken to substantiate those findings. These exercises resulted in sample collection from five feet below the river surface, then ten feet below the river surface, and finally sixteen feet below the river surface.

LOW FLOW SAMPLING OF AUGUST 10, 1983

On August 10, 1983, the USBR reduced flow in the American River to 250 cfs for a four-hour period. During the period of low flow, samples for water quality determinations were collected from six locations in the river itself: 6015, 6017, 6023, 6028, 6029, and 6030 and from ten locations in the exposed bank materials from which water was seeping into the river: 6016, 6018, 6019, 6020, 6021, 6022, 6024, 6025, 6026, and 6027. These locations are shown on Plate 1.

Surface Water Samples. In each case the river water samples were taken from positions where the stream was flowing strongly. The samples from the pool below Nimbus Dam (6015) and from immediately above the fish ladder (6016) were free of volatile organic chemicals and were determined to have a low electrical conductivity of about 35 micromhos/cm.

Four river water samples taken from below the Fish Hatchery facility (6023, 6028, 6029, and 6030) had slightly increased electrical conductivities in the range 43 to 49 micromhos/cm which indicated that the flow in this reach had been augmented by inflow of higher conductivity groundwater. All of these samples had detectable levels of trichloroethylene in the range 9 to 27 ppb. T-1,2-dichloroethylene and Freon 113 were occasionally reported in these samples at 1 or 2 parts per billion. No vinyl chloride was detected in the running river water. Table 1 of this report summarizes the laboratory results. A tabular presentation of all laboratory results is contained in Appendix A.

Bedload Water Samples. Ten samples of water from the river's bedload were obtained by forcing three-foot lengths of three-quarter-inch aluminum electrical conduit into the normally submerged gravels and then developing them as miniature wells by pumping with a hand-held bilge pump. Once developed, seven of the ten wells from which samples were collected were flowing wells and did not require further pumping to obtain samples.

AGC 0800 037143

Electrical conductivity measurements were made on all of the bedload samples. Three of the samples: 6016 vertically driven near the fish ladder, and 6021 and 6022 which were driven vertically and horizontally respectively in the bank opposite Sailor Bar, were reported to have electrical conductivities only slightly higher than the river, 48 to 52 micromhos. 6016 had no volatile organic chemicals and 6021 and 6022 had only 1 to 3 ppb of trichloroethylene.

The remaining seven bedload water samples had elevated electrical conductivity readings. This is evidence that groundwater containing elevated levels of salts was entering the bedload at the time the river elevation was reduced. The electrical conductivity measurements on samples collected on August 10 from these seven locations ranged from 228 to 2,300 micromhos/cm. For comparison, it is noted that electrical conductivity in the Area 20 and Area 49 portion of Aerojet property is in the range 200 to 300 micromhos/cm.

The mineral composition of water collected at location 6026 which had the highest electrical conductivity was determined. The findings indicate the water is a dilute calcium magnesium chloride brine:

	mg/L	meq/L
Ca	200.0	10.0
Mg	98.0	8.1
Na	89.0	3.9
K	5.2	0.1
HCO_3	469.0	7.7
SO_4	28.0	0.6
Cl	360.0	10.2

Location 6026 was a horizontal well driven into the bank at a position northwest of the DFG building. Flow from this well contained the following volatile organic chemicals:

1,1-Dichloroethylene	20 ppb
1,1-Dichloroethane	1 ppb
T-1,2-Dichloroethylene	200 ppb
1,1,1-Trichloroethane	10 ppb
Trichloroethylene	2,000 ppb
Tetrachloroethylene	20 ppb

In Area 20 on the Aerojet property the mix of chemicals is different from the above list since Freon 113 is present in the groundwater of Area 20 at a concentration equal to or greater than trichloroethylene. The non-occurrence of Freon 113 at this and other locations at the river's edge is notable, but the significance of this observation is not yet clear.

Analyses of the other bedload samples collected on August 10 confirmed that the above mix of compounds was present in the bedload throughout a reach at least 1,000 feet long extending between sample points 6018 and 6027.

AGC 0800 037144

In general, the VOC concentrations were correlated with the electrical conductivity measurements. This finding suggests a hypothesis that the VOC's are associated with brackish water having electrical conductivity of 2,300 micromhos/cm or higher and that any particular sample is a mix of such brackish water diluted with river water. The precise origin of the brackish water is not known, but it is noted that high salinity is not a characteristic of the groundwater leaving the Aerojet property.

Six of the original ten bedload samples were reported to contain vinyl chloride. The range of concentrations reported was 1 to 90 parts per billion. When vinyl chloride was present, the electrical conductivity and total other VOC concentrations were at elevated levels, but this observation was not reciprocal. The sample which had the highest conductivity (6026) was not reported to contain vinyl chloride; the sample which had the highest trichloroethylene concentration (6024) had only 8 ppb of vinyl chloride. The sample with the highest vinyl chloride concentration (6018) was also reported to contain high levels of trichloroethylene, but it had an electrical conductivity of only 500 micromhos/cm. That conductivity is a little higher than groundwater conductivity is expected to be in that location, but it is not so extreme as was measured in samples a few hundred feet away.

FIVE-FOOT BEDLOAD SAMPLING OF AUGUST 17, 1983

In an attempt to confirm the earlier findings, two additional bedload mini-wells were constructed on August 17 to a depth of five feet below the river. These wells, 6031 and 6032, were located at water's edge at the western (downstream) end of the reach where the electrical conductivity measurements had been highest.

The electrical conductivity of samples collected on August 17 were not exceptionally high: 170 and 140 micromhos/cm. Static levels in the sampling wells were at or below the river surface at the time the samples were taken, indicating that there was greater potential for dilution of the groundwater by river water than there had been on August 10 when the river flow was reduced and most wells were flowing.

Total VOC concentrations reported for 6031 and 6032 were less than for samples taken previously in the same vicinity (6024, 6026, 6027). The mix of chemicals was the same as had been reported earlier; however, there were lower concentrations. Vinyl chloride was not detected. In general, the August 17 samples were dilute versions of the August 10 samples from approximately the same locations.

TEN-FOOT BEDLOAD SAMPLING OF AUGUST 23, 1983

On August 23, additional samples were taken nearer to the location that had previously been found to have the highest vinyl chloride concentration. Two sampling wells, 6033 and 6034, were constructed 10 feet below the river surface. In each

AGC 0800 037145

case the static level in the well was equal to the water level in the river. The electrical conductivities of samples from these two wells were 180 and 280 micromhos/cm. This is within the range expected to be normal for groundwater in this region and much greater than the conductivity of the river itself (36 micromhos/cm).

Samples from 6033 and 6034 both contained vinyl chloride. Location 6033 had the higher vinyl chloride concentration of the two (36 vs 4 ppb), but its electrical conductivity (180 micromhos/cm) and total other VOC concentration (923 ppb) were less than the corresponding values for 6034 (280 micromhos/cm and 1,567 ppb total other VOC's). This set of determinations was confirmed independently by sending a separate set of samples to a commercial laboratory, California Analytical Laboratories, Inc. From these reports it is seen that vinyl chloride concentration is independent of electrical conductivity and total other VOC concentrations.

WELL POINT SAMPLES OF AUGUST 25 THROUGH SEPTEMBER 2, 1983

Additional samples were collected on and after August 25 using an improved sample collection procedure. Well points having eighteen-inch screened intervals were driven into the gravel to depths of up to 16 feet. Samples were sometimes collected at intermediate depths during driving.

Location 6036 was a well point installed 15 feet below the river surface at the same location as the previous ten-foot sample, 6033. 6036 was reported to contain 480 parts per billion of vinyl chloride and 2,040 parts per billion of total other VOC's. Its electrical conductivity of 500 micromhos/cm is the same as was reported for 6018 which was the nearest sample location on August 10, the day the flow was lowered. This conductivity is somewhat higher than anticipated for groundwater in this region, but it is not as high as has been observed in some of the other nearby bedload samples.

Location 6037 is a well point installed 11 feet beneath the water level in the river at a location 250 feet upstream of location 6036. The electrical conductivity at this location is 550 micromhos/cm. The vinyl chloride concentration at 6037 was reported to be 280 parts per billion. The total other VOC concentration was 1,672 ppb.

Location 6038 which is 200 feet farther upstream contained a well point installed 15.5 feet beneath the river surface. In the course of driving this well point, a sample was taken at 12 feet beneath the river surface. The reported electrical conductivities at the 12-foot and 15.5-foot depths were the same, 700 micromhos/cm. This value is definitely higher than encountered in groundwater samples on the nearby portion of the Aerojet property and gives evidence that the water encountered in the bedload at this location has been influenced in a manner that is not associated with Aerojet activities.

The vinyl chloride concentration was reported to be 310 parts per billion in the 12-foot sample and 1,500 parts per billion in the 15.5-foot sample. The total other VOC's were 1,978 ppb in the 12-foot sample and 1,330 in the 15.5-foot sample. Thus, at this location, the higher vinyl chloride level was not reported to co-occur with the higher total other VOC concentrations.

AGC 0800 037146

The static level in 6038 was determined to be 0.25 feet higher than the water level in the river. This is evidence that the water sampled and characterized does have the hydraulic potential to flow into the river and mix with the surface water.

Location 6039 is located about 300 feet downstream from location 6036. A sample was taken here from 13 feet below the river surface. It had an electrical conductivity of 50 micromhos/cm and contained no VOC's. This sample apparently was river surface water that permeated the bedload.

Location 6040 is 150 feet upstream of location 6038. The well point was driven to 16 feet and samples were collected at 12 and 16 feet. The electrical conductivity was 50 micromhos/cm in the 12-foot sample and 140 micromhos/cm in the 16-foot sample. No vinyl chloride was detected at 12 feet although there were traces of the other VOC's. Two ppb of vinyl chloride were detected at 16 feet, together with 586 ppb of other VOC's.

RELATED GROUNDWATER OBSERVATIONS

Wells 1211, 1214, and 1216 (a.k.a. LS2, LS4, LS6) were sampled. No vinyl chloride was detected in these wells. They are reported to contain:

	1211 (9/21/83)	1214 (9/21/83)	1216 (8/30/83)
1,1-Dichloroethylene	50	30	130
1,1-Dichloroethane	9	5	6
T-1,2-Dichloroethylene	52	57	130
Chloroform	11	3	3
Freon	750	6	2
1,1,1-Trichloroethane	3	14	90
Trichloroethylene	950	1,100	2,400
Tetrachloroethylene	180	11	30

The electrical conductivities determined on samples from Wells 1211, 1214, and 1216 were 450, 380, and 470 micromhos/cm respectively. These conductivities are as expected for groundwater in this region. The mineral composition of the sample from Well 1216 identifies it as containing principally calcium and sodium bicarbonate which is the usual condition for groundwater in this vicinity:

	mg/L	meq/L
Ca	34.2	1.7
Mg	11.9	1.0
Na	35.9	1.6
K	2.2	0.1
HCO_3	190.0	3.1
SO_4	16.0	0.3
Cl	39.3	1.1

AGC 0800 037147

Wells on the Aerojet property proximal to the Folsom Boulevard Pilot Project have been under nearly continuous scrutiny since 1980. It is not possible that any of the Area 20 or Area 49 wells have elevated levels of vinyl chloride that somehow have escaped detection. Document U-1 summarizes all available data on vinyl chloride. Moreover, the existing wells in Area 20 and Area 49 adequately monitor Aerojet's portion of the hydrologic system associated with groundwater flow in the vicinity of the Fish Hatchery. Nowhere in Area 20 or in Area 49 has groundwater been found to contain vinyl chloride or electrical conductivity at levels such as are currently being observed in the bedload water adjacent to the Fish Hatchery.

AGC 0800 037148

TABLE 1

SUMMARY OF RESULTS OF WATER QUALITY INVESTIGATIONS
IN THE AMERICAN RIVER AND ITS BEDLOAD
(AUGUST 1983)

Location Number	Location Description	Elec. Cond.	(micrograms per liter, mean of three replicates) VC	DCE	DCA	T12	CHL	FRE	TCA	TCE	PCE
6015	River at Nimbus Dam	35	--	--	--	--	--	--	--	--	--
6017	River at Fish Ladder	37	--	--	--	--	--	--	--	--	--
6023	River at first riffle	48	--	--	--	2	--	2	--	11	--
6028	River, 200 yds below 6023	49	--	--	--	1	--	1	--	22	--
6029	River, 400 yds below 6023	45	--	--	--	--	--	2	--	11	--
6030	River, 600 yds below 6023	43	--	--	--	--	--	--	--	18	--
6016	Bedload, 3 ft, pumped	48	--	--	--	--	--	--	--	--	--
6018	Bedload, 3 ft, flowing	500	92	207	15	270	6	20	87	2,200	25
6019	Bedload, 3 ft, flowing	680	19	113	11	303	6	9	42	1,450	17
6020	Bedload, 3 ft, flowing	228	1	20	2	42	--	2	7	290	2
6021	Bedload, 3 ft, pumped	49	--	--	--	--	--	--	--	1	--
6022	Bank, 3 ft, horizontal	52	--	--	--	--	--	--	--	3	--
6024	Bedload, 3 ft, pumped	1,200	11	95	7	207	7	7	58	3,750	75
6025	Bank, 3 ft, horizontal	350	2	19	1	65	--	2	11	765	12
6026	Bank, 3 ft, horizontal	2,300	--	22	2	153	--	1	12	1,850	24
6027	Active seep	310	1	--	--	83	--	--	--	536	4
6031	Bedload, 5 ft, pumped	170	--	10	--	22	--	1	6	670	12
6032	Bedload, 5 ft, pumped	140	--	6	--	16	1	2	4	180	3
	Determinations on Single Samples										
6033	Bedload, 10 ft, pumped	180	36	49	6	120	--	8	14	720	6
6033	Same, CAL	180	20	39	2	110	--	--	13	450	4
6034	Bedload, 10 ft, pumped	280	4	42	5	180	--	14	15	1,200	11
6034	Same, CAL	280	2	38	2	180	--	--	16	860	10
6035	Active drain	40	--	--	--	--	--	--	--	--	--
6036	Bedload, 15 ft, pumped	500	480	160	21	420	--	6	21	1,400	10
6037	Bedload, 11 ft, pumped	550	280	210	23	470	2	46	34	880	7
6038	Bedload, 12 ft, pumped	700	310	100	21	890	3	81	13	860	9
6038	Same, 15.5 ft, pumped	700	1,500	77	10	390	4	79	4	760	10
6039	Bedload, 13 ft, pumped	50	--	--	--	12	--	1	--	75	--
6040	Bedload, 12 ft, pumped	50	--	2	--	3	--	10	--	24	--
6040	Same, 16 ft, pumped	140	2	17	4	160	--	50	--	350	5

AGC 0800 037149

PLATE 1

AMERICAN RIVER BEDLOAD
SAMPLING STATIONS

AGC 0800 037150

APPENDIX A

GROUND WATER ORGANIC ANALYSIS

WELL 0015

DATE	08-10-83	08-10-83	08-10-83
TIME	1500	1500	1500
LAB	EDL	EDL	EDL
TEST	111	111	108
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE			
1,1DICLETHA			
TR=1,2DICL			
CHLOROFORM			
112TRIC=TRIF			
1,2DICLETHA			
1,1,1TRICL			
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE			
DIBRDCLMTHA			
BROMOFORM	---	---	
TETCLETHYE			
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037153

GROUND WATER ORGANIC ANALYSIS

WELL 6016

DATE	08-10-83	08-10-83
TIME	0	0
LAB	EDL	EDL
TEST	11	8
DEPTH	0	0
VINYL CHLOR		
CLETHANE		
TRICLFLUMTH		
DICLMTH	---	---
1,1DICLETHYE		
1,1DICLETHA		
TR-1,2DICL		
CHLOROFORM		
112TRIC-TRIF	3.0	
1,2DICLETHA		
1,1,1TRICL		
CARBON TET		
BRODICLMTHA		
2,3DICLPRPYE		
1,2DICLPRPNE	---	
TRICLETHYE		
DIBROCLMTHA		
BROMOFORM	---	
TETCLETHYE		
CHBENZENE	---	
BENZENE	---	
ETHLBENZENE	---	
TOLUENE	---	
SENSITIVITY		

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037154

GROUND WATER ORGANIC ANALYSIS

WELL 0017

DATE	08-10-83	08-10-83	08-10-83
TIME	1515	1515	1515
LAB	EDL	EDL	EDL
TEST	111	111	108
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE			
1,1DICLETHA			
TR-1,2DICL			
CHLOROFORM			
112TRIC-TRIF			
1,2DICLETHA			
1,1,1TRICL			
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE			
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE			
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037155

GROUND WATER ORGANIC ANALYSIS

WELL 6018

DATE	08-10-83	08-10-83	08-10-83
TIME	0	0	0
LAB	EDL	EDL	EDL
TEST	11	11	8
DEPTH	0	0	0
VINYL CHLOR	91.0	100.0	84.0
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE	190.0	240.0	190.0
1,1DICLETHA	18.0	12.0	14.0
TR-1,2DICL	250.0	320.0	240.0
CHLOROFORM	3.0	7.0	8.0
112TRIC-TRIF	23.0	21.0	17.0
1,2DICLETHA			
1,1,1TRICL	89.0	95.0	77.0
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	1900.0*	2700.0	1700.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE	29.0	26.0	21.0
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	

SENSITIVITY

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

*THE LABORATORY REPORTED THIS VALUE AS EQUAL TO OR GREATER THAN 1900 BECAUSE IT WAS BEYOND THE LINEAR RANGE OF THE INSTRUMENT.

AGC 0800 037156

GROUND WATER ORGANIC ANALYSIS

WELL 0019

DATE	08-10-83	08-10-83	08-10-83
TIME	0	0	0
LAB	EDL	EDL	EDL
TEST	11	11	8
DEPTH	0	0	0
VINYL CHLOR	20.0	17.0	20.0
CLETHANE			
TRICLFLOMTH			
DICLMTH	---	---	---
1,1DICLETHYE	120.0	110.0	110.0
1,1DICLETHA	14.0	11.0	8.0
TR-1,2DICL	310.0	320.0	280.0
CHLOROFORM	1.0	12.0	5.0
112TRIC-TRIF	9.0	8.0	10.0
1,2DICLETHA	3.0		
1,1,1TRICL	47.0	42.0	38.0
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	---
TRICLETHYE	1500.0*	1600.0	1300.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE	21.0	16.0	14.0
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

*THE LABORATORY REPORTED THIS VALUE AS EQUAL TO OR GREATER THAN 1500 BECAUSE IT WAS BEYOND THE LINEAR RANGE OF THE INSTRUMENT

AGC 0800 037157

GROUND WATER ORGANIC ANALYSIS

WELL 6020

DATE	08-10-83	08-10-83	08-10-83
TIME	0	0	0
LAB	EDL	EDL	EDL
TEST	11	11	8
DEPTH	0	0	0
VINYL CHLOR		2.0	
CLETHANE			
TRICLFLOMTH			
DICLMTH	---	---	---
1,1DICLETHYE	15.0	17.0	28.0
1,1DICLETHA	2.0	1.0	2.0
TR-1,2DICL	38.0	38.0	51.0
CHLOROFORM			
112TRIC-TRIF	2.0	2.0	3.0
1,2DICLETHA	1.0	1.0	
1,1,1TRICL	6.0	7.0	7.0
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	280.0	240.0	300.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE	2.0	2.0	2.0
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037158

GROUND WATER ORGANIC ANALYSIS

WELL 6021

DATE	08-10-83	08-10-83	08-10-85
TIME	0	0	0
LAB	EDL	EDL	EDL
TEST	11	11	8
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLOMTH			
DICLMTH	---	---	---
1,1DICLETHYE			
1,1DICLETHA			
TR-1,2DICL			
CHLOROFORM			
112TRIC-TRIF			
1,2DICLETHA			
1,1,1TRICL			
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	1.0		2.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE			
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037159

GROUND WATER ORGANIC ANALYSIS

WELL 6022

DATE	08-10-83	08-10-83	08-10-83
TIME	0	0	0
LAB	EDL	EDL	EDL
TEST	11	11	8
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE			
1,1DICLETHA			
TR-1,2DICL			
CHLOROFORM			
112TRIC-TRIF			
1,2DICLETHA			
1,1,1TRICL			
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	1.0	2.0	0.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE			
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037160

GROUND WATER ORGANIC ANALYSIS

WELL 0023

DATE	08-10-83	08-10-83	08-10-83
TIME	1530	1530	1530
LAB	EDL	EDL	EDL
TEST	111	111	108
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE			
1,1DICLETHA			
TR-1,2DICL	2.0		
CHLOROFORM			
112TRIC-TRIF	2.0		
1,2DICLETHA			
1,1,1TRICL			
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	9.0	13.0	10.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE			
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037161

GROUND-WATER ORGANIC ANALYSIS

WELL 0024

DATE	08-10-83	08-10-83	08-10-83
TIME	0	0	0
LAB	EDL	EDL	EDL
TEST	11	11	8
DEPTH	0	0	0
VINYL CHLOR	15.0	8.0	
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE	110.0	100.0	75.0
1,1DICLETHA	7.0		
TR-1,2DICL	210.0	200.0	150.0
CHLORDFORM	2.0	12.0	
112TRIC-TRIF	7.0		
1,2DICLETHA			
1,1,1TRICL	65.0	58.0	51.0
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	2000.0*	4500.0	3000.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE	88.0	82.0	55.0
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

*THE LABORATORY REPORTED THIS VALUE AS EQUAL TO OR GREATER THAN 2600 BECAUSE IT WAS BEYOND THE LINEAR RANGE OF THE INSTRUMENT.

AGC 0800 037162

GROUND-WATER ORGANIC ANALYSIS

WELL 6025

DATE	08-10-83	08-10-83	08-10-83
TIME	0	0	0
LAB	EDL	EDL	EDL
TEST	11	11	8
DEPTH	0	0	0
VINYL CHLOR	1.0	4.0	2.0
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE	20.0	16.0	20.0
1,1DICLETHA	2.0		
TR-1,2DICL	68.0	65.0	63.0
CHLOROFORM			
112TRIC-TRIF	2.0	2.0	2.0
1,2DICLETHA			
1,1,1TRICL	12.0	11.0	11.0
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	820.0*	840.0	690.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE	13.0	12.0	10.0
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

*THE LABORATORY REPORTED THIS VALUE AS EQUAL TO OR GREATER THAN 820 BECAUSE IT WAS BEYOND THE LINEAR RANGE OF THE INSTRUMENT.

AGC 0800 037163

GROUND WATER ORGANIC ANALYSIS

WELL 6026

DATE	08-10-83	08-10-83	08-10-83
TIME	0	0	0
LAB	EDL	EDL	EDL
TEST	11	11	8
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE	19.0	21.0	27.0
1,1DICLETHA	2.0		
TR-1,2DICL	150.0	170.0	140.0
CHLOROFORM			
112TRIC-TRIF	1.0		
1,2DICLETHA			
1,1,1TRICL	15.0	11.0	12.0
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	1600.0*	2100.0	1600.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE	24.0	27.0	20.0
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

*THE LABORATORY REPORTED THIS VALUE AS EQUAL TO OR GREATER THAN 1600 BECAUSE IT WAS BEYOND THE LINEAR RANGE OF THE INSTRUMENT.

AGC 0800 037164

GROUND-WATER ORGANIC ANALYSIS

WELL 6027

DATE	08-10-83	08-10-83	08-10-83
TIME	0	0	0
LAB	EDL	EDL	EDL
TEST	8	11	11
DEPTH	0	0	0
VINYL CHLOR	2.0	1.0	
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE			
1,1DICLETHA			
TR-1,2DICL	91.0	79.0	79.0
CHLOROFORM			
112TRIC-TRIF			
1,2DICLETHA			
1,1,1TRICL			
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE		---	---
TRICLETHYE	530.0	500.0	580.0
DIBRUCLMTHA			
BROMOFORM		---	---
TETCLETHYE		4.0	4.0
CHBENZENE		---	---
BENZENE		---	---
ETHLBENZENE		---	---
TOLUENE		---	---
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037165

GROUND WATER ORGANIC ANALYSIS

WELL 6028

DATE	08-10-83	08-10-83	08-10-83
TIME	1550	1550	1550
LAB	EDL	EDL	EDL
TEST	111	111	108
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE			
1,1DICLETHA			
TR-1,2DICL	1.0	1.0	2.0
CHLOROFORM			
112TRIC-TRIF	2.0		
1,2DICLETHA			
1,1,1TRICL			
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	24.0	27.0	15.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE			
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037166

GROUND-WATER ORGANIC ANALYSIS

WELL 6029

DATE	08-10-83	08-10-83	08-10-83
TIME	1610	1610	1610
LAB	EDL	EDL	EDL
TEST	111	111	108
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLOMTH			
DICLMTH	---	---	---
1,1DICLETHYE			
1,1DICLETHA			
TR-1,2DICL			
CHLOROFORM			
112TRIC-TRIF	2.0	2.0	
1,2DICLETHA			
1,1,1TRICL			
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	10.0	11.0	12.0
DIBROCLMTHA			
BROMOFORM	---	---	
TETCLETHYE			
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037167

GROUND WATER ORGANIC ANALYSIS

WELL 6030

DATE	08-10-83	08-10-83	08-10-83
TIME	1625	1625	1625
LAB	EDL	EDL	EDL
TEST	111	111	108
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLOMTH			
DICLMTH	---	---	---
1,1DICLETHYE			
1,1DICLETHA			
TR-1,2DICL			
CHLOROFORM			
112TRIC-TRIF			
1,2DICLETHA			
1,1,1TRICL			
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	
TRICLETHYE	23.0	13.0	18.0
DIBRDCLMTHA			
BROMOFORM	---	---	
TETCLETHYE			
CHBENZENE	---	---	
BENZENE	---	---	
ETHLBENZENE	---	---	
TOLUENE	---	---	
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037168

GROUND WATER ORGANIC ANALYSIS

WELL 6031

DATE	08-17-83	08-17-83	08-17-83
TIME	0	1100	1101
LAB	EDL	EDL	EDL
TEST	8	11	11
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLOMTH			
DICLMTH	---	---	---
1,1DICLETHYE	11.0	9.0	10.0
1,1DICLETHA			
TR-1,2DICL	21.0	21.0	24.0
CHLOROFORM			
112TRIC-TRIF		2.0	
1,2DICLETHA			
1,1,1TRICL	6.0	7.0	6.0
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE		---	---
TRICLETHYE	620.0	660.0	730.0
DIBROCLMTHA			
BROMOFORM		---	---
TETCLETHYE	11.0	12.0	13.0
CHBENZENE		---	---
BENZENE		---	---
ETHLBENZENE		---	---
TOLUENE		---	---

SENSITIVITY

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING UP THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037169

GROUND WATER ORGANIC ANALYSIS

WELL 6032

DATE	08-18-83	08-18-83	08-18-83
TIME	1530	1535	1540
LAB	EDL	EDL	EDL
TEST	11	11	11
DEPTH	0	0	0
VINYL CHLOR			
CLETHANE			
TRICLFLUMTH			
DICLMTH	---	---	---
1,1DICLETHYE	5.0	8.0	5.0
1,1DICLETHA			
TR=1,2DICL	17.0	10.0	14.0
CHLOROFORM			1.0
112TRIC=TRIF	3.0	2.0	1.0
1,2DICLETHA			---
1,1,1TRICL	5.0	5.0	3.0
CARBON TET			
BRODICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE	---	---	---
TRICLETHYE	180.0	190.0	170.0
DIBROCLMTHA			
BROMOFORM	---	---	---
TETCLETHYE	3.0	3.0	2.0
CHBENZENE	---	---	---
BENZENE	---	---	---
ETHLBENZENE	---	---	---
TOLUENE	---	---	---
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLORUETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037170

GROUND WATER ORGANIC ANALYSIS

WELL 6033

DATE	08-23-83	08-23-83
TIME	1300	1310
LAB	EDL	CAL
TEST	11	8
DEPTH	0	10
VINYL CHLOR	36.0	20.0
CLETHANE		
TRICLFLOMTH		
DICLMTH	---	
1,1DICLETHYE	49.0	39.0
1,1DICLETHA	6.0	2.0
TR-1,2DICL	120.0	110.0
CHLOROFORM		
112TRIC-TRIF	8.0	
1,2DICLETHA		
1,1,1TRICL	14.0	13.0
CARBON TET		
BRODICLMTHA		
2,3DICLPRPYE		
1,2DICLPRPNE	---	
TRICLETHYE	720.0	450.0
DIBROCLMTHA		
BROMOFORM	---	
TETCLETHYE	6.0	4.0
CHBENZENE	---	
BENZENE	---	
ETHLBENZENE	---	
TOLUENE	---	
SENSITIVITY		

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037171

GROUND WATER ORGANIC ANALYSIS

WELL 6034

DATE	08-23-83	08-23-83
TIME	1400	1415
LAB	EDL	CAL
TEST	11	8
DEPTH	0	10
VINYL CHLOR	36.0	2.0
CLETHANE		
TRICLFLUMTH		
DICLMTH	---	
1,1DICLETHYE	42.0	38.0
1,1DICLETHA	5.0	2.0
TR-1,2DICL	180.0	180.0
CHLOROFORM		
112TRIC-TRIF	14.0	
1,2DICLETHA		
1,1,1TRICL	15.0	16.0
CARBON TET		
BRODICLMTHA		
2,3DICLPRPYE		
1,2DICLPRPNE	---	
TRICLETHYE	1200.0	860.0
DIBROCLMTHA		
BROMOFORM	---	
TETCLETHYE	11.0	10.0
CHBENZENE	---	
BENZENE	---	
ETHLBENZENE	---	
TOLUENE	---	
SENSITIVITY		

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLORUETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037172

GROUND WATER ORGANIC ANALYSIS

WELL 0035

DATE	08-25-83
TIME	0
LAB	EDL
TEST	11
DEPTH	0
VINYL CHLOR	
CLETHANE	
TRICLFLUMTH	
DICLMTH	---
1,1DICLETHYE	
1,1DICLETHA	
TR-1,2DICL	
CHLOROFORM	
112TRIC-TRIF	
1,2DICLETHA	
1,1,1TRICL	
CARBON TET	
BRODICLMTHA	
2,3DICLPRPYE	
1,2DICLPRPNE	---
TRICLETHYE	
DIBROCLMTHA	
BROMOFORM	---
TETCLETHYE	
CHBENZENE	---
BENZENE	---
ETHLBENZENE	---
TOLUENE	---

SENSITIVITY

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037173

GROUND WATER ORGANIC ANALYSIS

WELL 6030

DATE	08-25-83
TIME	0
LAB	FDL
TEST	11
DEPTH	0
VINYL CHLOR	480.0
CLETHANE	
TRICLFLOMTH	
DICLMTH	---
1,1DICLETHYE	100.0
1,1DICLETHA	21.0
TR-1,2DICL	420.0
CHLOROFORM	
112TRIC-TRIF	6.0
1,2DICLETHA	2.0
1,1,1TRICL	21.0
CARBON TET	
BRODICLMTHA	
2,3DICLPRPYE	
1,2DICLPRPNE	---
TRICLETHYF	1400.0
DIBROCLMTHA	
BRUMOFORM	---
TETCLETHYE	10.0
CHBENZENE	---
BENZENE	---
ETHLBENZENE	---
TOLUENE	---

SENSITIVITY

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037174

GROUND WATER ORGANIC ANALYSIS

WELL 6057

DATE	08-25-83
TIME	0
LAB	EVL
TEST	11
DEPTH	0
VINYL CHLOR	260.0
CLETHANE	
TRICLFLUMTH	
DICLMTH	---
1,1DICLETHYE	210.0
1,1DICLETHA	23.0
TR-1,2DICL	470.0
CHLOROFORM	2.0
112TRIC-TRIF	46.0
1,2DICLETHA	
1,1,1TRICL	34.0
CARBON TET	
BRODICLMTHA	
2,3DICLPRPYL	
1,2DICLPRPNE	---
TRICLETHYE	880.0
DIBROCLMTHA	
BROMOFORM	---
TETCLETHYE	7.0
CHBENZENE	---
BENZENE	---
ETHLBENZENE	---
TOLUENE	---

SENSITIVITY

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037175

GROUND WATER ORGANIC ANALYSIS

WELL 6036

DATE	08-29-83	08-29-83	09-02-83
TIME	930	1000	1400
LAB	EDL	EDL	EDL
TEST	8	11	11
DEPTH	12	16	0
VINYL CHLOR	310.0	1500.0	810.0
CLETHANE			
TRICLFLOMTH			
DICLMTH	---	---	---
1,1DICLETHYE	100.0	77.0	130.0
1,1DICLETHA	21.0	10.0	17.0
TR-1,2DICL	890.0	390.0	460.0
CHLOROFORM	3.0	4.0	9.0
112TRIC-TRIF	81.0	79.0	140.0
1,2DICLETHA	6.0		
1,1,1TRICL	13.0	4.0	13.0
CARBON TET			
BRUDICLMTHA			
2,3DICLPRPYE			
1,2DICLPRPNE		---	---
TRICLETHYE	860.0	760.0	1100.0
DIBROCLMTHA			
BRUMOFORM		---	---
TETCLETHYE	9.0	10.0	12.0
CHBENZENE		---	---
BENZENE		---	---
ETHLBENZENE		---	---
TOLUENE		---	---
SENSITIVITY			

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLORUETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037176

GROUND WATER ORGANIC ANALYSIS

WELL 6039

DATE	08-29-83
TIME	1030
LAB	EDL
TEST	11
DEPTH	13
VINYL CHLOR	
CLETHANE	
TRICLFLUMTH	
DICLMTH	---
1,1DICLETHYE	
1,1DICLETHA	
TR-1,2DICL	12.0
CHLOROFORM	
112TRIC-TRIF	1.0
1,2DICLETHA	
1,1,1TRICL	
CARBON TET	
BRODICLMTHA	
2,3DICLPRPYE	
1,2DICLPRPNE	---
TRICLETHYE	75.0
DIBROCLMTHA	
BROMOFORM	---
TETCLETHYE	
CHBENZENE	---
BENZENE	---
ETHLBENZENE	---
TOLUENE	---
SENSITIVITY	

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLOROETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037177

GROUND WATER ORGANIC ANALYSIS

WELL 6040

DATE	09-02-83	09-02-83
TIME	1350	1345
LAB	EDL	EDL
TEST	11	11
DEPTH	0	0
VINYL CHLOR		2.0
CLETHANE		
TRICLFLOMTH		
DICLMTH	---	---
1,1DICLETHYE	2.0	17.0
1,1DICLETHA		4.0
TR-1,2DICL	3.0	160.0
CHLOROFORM	2.0	1.0
112TRIC-TRIF	10.0	50.0
1,2DICLETHA		
1,1,1TRICL		
CARBON TET		
BRODICLMTHA		
2,3DICLPRPYE		
1,2DICLPRPNE	---	---
TRICLETHYE	24.0	350.0
DIBROCLMTHA		
BROMOFORM	---	---
TETCLETHYE		5.0
CHBENZENE	---	---
BENZENE	---	---
ETHLBENZENE	---	---
TOLUENE	---	---
SENSITIVITY		

SENSITIVITY IS THE MINIMUM DETECTION LEVEL OF TRICHLORDETHYLENE FOR THE TEST EMPLOYED, AND IS A RELATIVE INDICATOR FOR OTHER COMPOUNDS DEPENDING ON THE TEST METHOD. ZERO INDICATES NO SPECIFIED DETECTION LIMITS.

--- INDICATES NO MEASUREMENT ATTEMPTED.
BLANK INDICATES NONE DETECTED OR NO MEASUREMENT REPORTED.

AGC 0800 037178

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Declaration of Stephen Ross

I, Stephen Ross, declare that:

1. I am a senior hydrogeologist for Komex, which is an environmental and engineering consulting firm. My office is located in the Komex 's Sacramento Branch. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Western Operable Unit Remedial Investigation/Feasibility Study," produced by the Engineering Management Support, Inc. with assistance from Aerojet General Corporation and HIS Geotrans, and dated April 17, 2000 is to my knowledge a true and correct copy of this document. This copy was obtained from the United States Environmental Protection Agency library in San Francisco. A copy of said document is maintained at the California State University at Sacramento's Library.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Stephen Ross

COPY

AEROJET

Western Groundwater Operable Unit Remedial Investigation/Feasibility Stu

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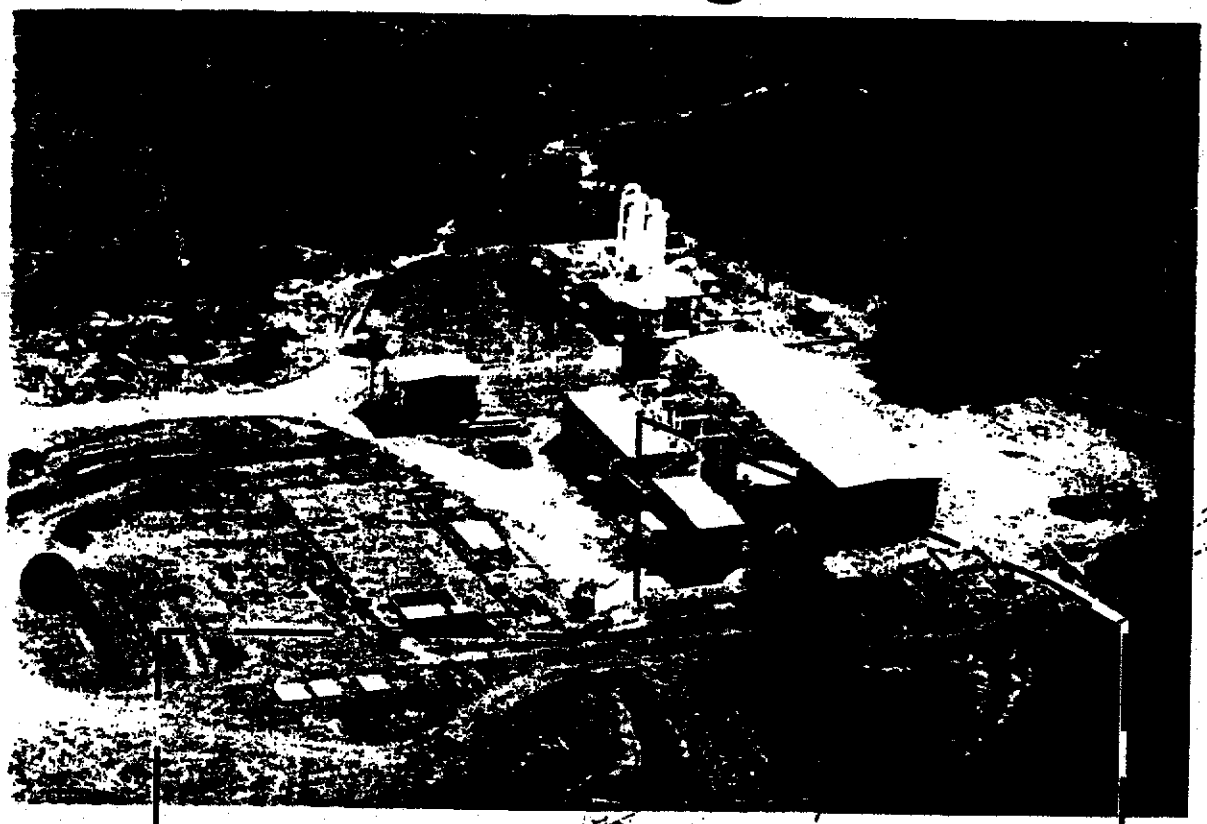

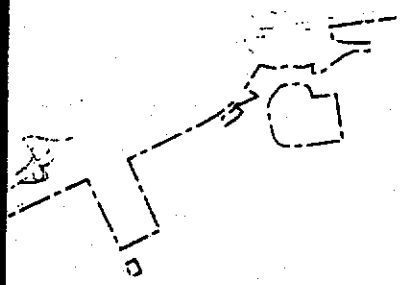

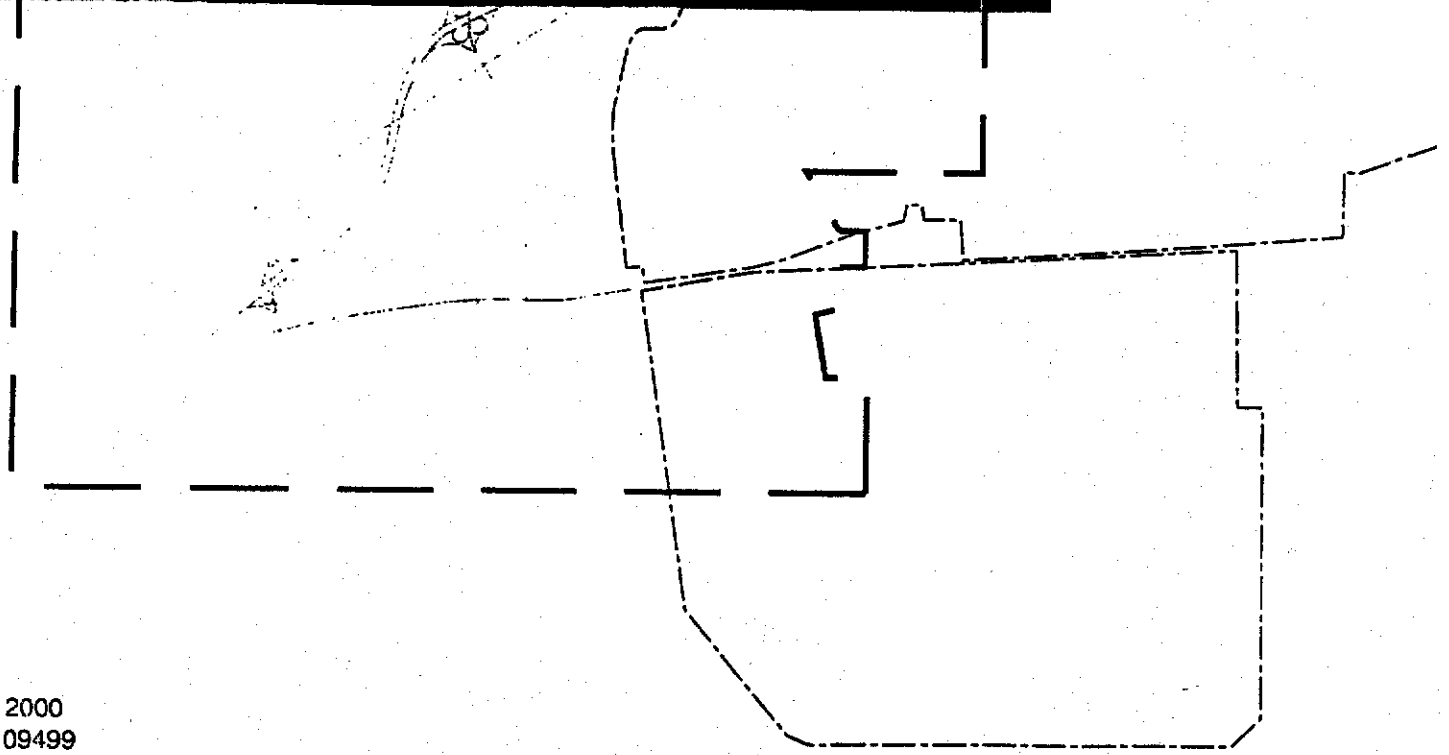

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Western Groundwater Operable Unit
Remedial Investigation/Feasibility Study

April 17, 2000

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List of Acronyms

ac ft	acre foot of water
ACWS	Arden Cordova Water Company
AFB	Air Force Base
ARAR	applicable or relevant and appropriate requirement
ARGET	American River groundwater extraction and treatment system
ATSDR	Agency for Toxic Substances Disease Registry
Basin Plan	Water Quality Control Plan for the Sacramento and San Joaquin River Basins
bgs	below the ground surface
BRA	Baseline Risk Assessment
Cal-EPA	California Environmental Protection Agency
CAO	Cleanup and Abatement Order
CatOx	catalytic oxidation
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (as amended)
CFR	Code of Federal Regulations
CoPC	contaminant of potential concern
DAA	detailed analysis of alternatives
DCA	dichloroethane
DCE	dichloroethene
DHS	California Department of Health Services
DNAPL	dense non-aqueous phase liquid
DTSC	California Department of Toxic Substances Control
ea	each
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ESD	explanation of significant difference
Freon-11	trichlorofluoromethane
Freon-113	1,1,2-trichloro-1,2,2-trifluoroethane
Freon-12	dichlorodifluoromethane
FS	Feasibility Study
ft	feet
FTE	Full-time equivalent
ft/year	feet per year
GAC	granular activated carbon
gpm	gallons per minute
GWTP	groundwater treatment plant
hp	horsepower
kW	kilowatt
I&C	instrumentation and controls
lin ft	lineal feet
LPGAC	liquid-phase granular activated carbon

List of Acronyms (continued)

LS	lump sum
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	method detection limit
MGD	million gallons per day
ug/L	micrograms per liter
MNA	monitored natural attenuation
msl	mean sea level
NCP	National Contingency Plan
NDMA	n-nitrosodimethylamine
NPL	National Priorities List
O&M	operation and maintenance
OBPA	10, 10'-oxybisphenoxarsine
OU	Operable Unit
PCD	Partial Consent Decree
PCE	tetrachloroethene
PQL	Practical quantitation limit
PRAG	Preliminary Remedial Action Goal
PVC	polyvinyl chloride
RAO	remedial action objectives
RCRA	Resource Conservation and Recovery Act of 1976 (as amended)
RfD	reference dose
RI	Remedial Investigation
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
scfm	Standard cubic feet per minute
SCWC	Southern California Water Company
SDWA	Safe Drinking Water Act
SMAQMD	Sacramento Metropolitan Air Quality Management District
TBC	To-be-considered criteria
TCA	Trichloroethane
TCE	Trichloroethene
TDH	total dynamic head
USGS	U. S. Geological Survey
UTL	upper tolerance limit
VPGAC	vapor-phase granular activated carbon
VOC	volatile organic compound
w	watt
WQO	Water Quality Objectives

EXECUTIVE SUMMARY

This executive summary presents the purpose and scope of this Operable Unit Remedial Investigation/Feasibility Study (OU RI/FS) for the Western Groundwater Operable Unit Study Area and provides summaries of the remedial investigation, baseline risk assessment, and feasibility study.

ES-1 Purpose and Scope

The Remedial Investigation/Feasibility Study (RI/FS) process is the methodology that the Superfund program has established for characterizing the nature and extent of risks posed by contaminated sites (i.e., the remedial investigation) and for evaluating potential remedial options for addressing those risks (i.e., the feasibility study). The purpose of this OU RI/FS is to perform the RI for the Western Groundwater OU Study Area (Figure ES-1) and to prepare an FS that evaluates remedial alternatives for addressing contaminants of potential concern (CoPCs) in groundwater in the Study Area.

In June 1989, Aerojet entered into a Partial Consent Decree (PCD) which requires the completion of an RI/FS for the Aerojet Sacramento site. Pursuant to the PCD, Aerojet has completed a substantial portion of the Phase I RI/FS. This Western Offsite OU RI/FS is submitted as part of the RI/FS pursuant to the PCD and focuses on an operable unit; namely, the Western Groundwater Area. This Western Groundwater OU RI/FS also meets the requirements of the California Regional Water Quality Control Board (RWQCB) Cleanup and Abatement Order (CAO) No. 96-259 to the extent applicable.

The scope of this OU RI/FS can be described as follows:

- Perform the RI for the Study Area to characterize subsurface conditions and the nature and extent of CoPCs in groundwater;

- Prepare a Baseline Risk Assessment (BRA) to identify any potential risks that may be posed to human health and the environment by CoPCs in groundwater in the Study Area; and

- Prepare an FS by developing and evaluating a range of remedial alternatives that provides for protection of human health and the environment, and that considers technical, institutional, and cost considerations in accordance with CERCLA and the NCP so that relevant information regarding the remedial alternatives can be presented to a decision-maker and an appropriate remedy can be selected for groundwater.

ES-2 Summary of Remedial Investigation

The Western Groundwater Study Area encompasses the western portion of the Aerojet Operating Plant, the northwestern corner of the Inactive Rancho Cordova Test Site (IRCTS), the Aerojet-owned land west of the IRCTS, and approximately 10 square miles of commercially and residentially developed areas to the west of the Aerojet Operating Plant in the community of Rancho Cordova (Figure 1-1). The entire Study Area measures approximately 15 square miles.

Historical operations on the Aerojet Site have resulted in the release of CoPCs to soil and groundwater. VOCs (primarily TCE) and perchlorate have been detected in soil and groundwater beneath a number of these source areas. NDMA, which was known to exist on the east side of Aerojet, was more recently detected in groundwater on the west side of the Aerojet Site. Sources of VOCs, perchlorate and NDMA may exist offsite due to activities not associated with the Aerojet facility. Chlorinated solvents, including TCE, were commonly used by different industries. Perchlorate appears to have been and nitrate is a common constituent of fertilizers. NDMA appears to be associated with various industrial and food processing industries and has been a contaminant in foods.

On the western half of the Aerojet Site, groundwater flows generally to the west-southwest through a complex, heterogeneous aquifer. The aquifer has been subdivided into hydrostratigraphic Layers A through E based on similar lithologic and hydrogeologic properties. These hydrostratigraphic layers are generally tabular bodies that increase in depth and thickness from east to west across the Study Area.

Since the mid- to late-1980s, CoPCs in groundwater flowing west from the source areas on the Aerojet Site were intercepted by two interim perimeter groundwater extraction and treatment (GET) facilities, "GETs E and F". GETs E and F captured and treated groundwater for VOCs at northwestern and southwestern locations along the perimeter of the Aerojet Site, respectively. A series of recharge wells installed in the center of the western perimeter of the Aerojet Site provided a hydraulic barrier to direct CoPCs towards the extraction wells. The recharge water contained perchlorate, and, in early 1998 using an improved analytical method, NDMA was detected in the water extracted and recharged at GET E. Treated groundwater from two of the GET F extraction wells was initially discharged after VOCs were removed via a sprayfield located on the northwestern corner of the IRCTS for a period of approximately 6 years. The treated groundwater discharged to the former sprayfield has percolated into Layers B and C beneath the northwestern corner of the IRCTS and formed a plume of perchlorate - impacted groundwater flowing to the west-southwest.

A biological reduction treatment system was added to GET F to remove perchlorate from groundwater in December 1998. The biological perchlorate removal system consists of four fluidized bed reactors each designed to treat 900 gallons per minute (gpm). During the first six months of operation, Aerojet experienced problems controlling the bed height

in one of the two operating reactors. A series of tests were run in the Summer and early Fall of 1999 to control the growth rate of filamentous bacteria that were causing the bed height growth. Bed height growth rates were controlled during these tests and each of the fluidized bed reactors achieved non-detect perchlorate effluent concentrations at full-scale operation between October and November 1999 (Harding Lawson Associates, 2000 pending). Aerojet is continuing to monitor and optimize the operation of the fluidized bed reactors.

In August 1999, Aerojet combined the GET E and F treatment facilities so that groundwater extracted from both GET E and F undergo the same treatment processes. At the same time, ultraviolet (UV)/oxidation was added to the GET E/F treatment train to remove NDMA. The NDMA removal system is designed to treat NDMA to 0.002 µg/L. On September 26, 1999, the NDMA concentration in the combined GET E/F effluent was below the NDMA method detection limit of 0.0075 µg/L.

The majority of perchlorate and NDMA offsite is present in Layers C and D, although some upward and downward migration into Layers B and E, respectively, has occurred near the western perimeter of the Aerojet Site. The perchlorate in Layer C has been detected up to 9,000 feet west of the western Aerojet property boundary. An area of groundwater containing TCE and NDMA is present in Layers C and D northwest of the Aerojet Site. The TCE and NDMA in this area may have been present before GET E began operating, may represent uncaptured groundwater flowing north of GET E, or may be from offsite non-Aerojet sources identified northeast of the intersection of Sunrise and Folsom Boulevards.

ES-3 Summary of Baseline Risk Assessment

A Baseline Risk Assessment (BRA) was prepared for the Western Groundwater Study Area. The purpose of the BRA was to evaluate potential site-specific human health risks associated with hypothetical exposure to chemicals detected in groundwater in the Study Area. Specifically, chemical propellants and solvents have been detected in groundwater samples collected from on- and offsite wells. The maximum concentration of each detected chemical was screened against EPA Region 9 PRGs to determine whether it should be retained as a CoPC, as described in EPA guidance (EPA, 1999). All chemicals whose maximum detected concentration exceeded its PRG were retained as a CoPC and evaluated in the risk assessment.

The risk assessment was conducted assuming that through use of private domestic water supply wells, future residents could potentially contact groundwater containing these chemicals. For purposes of the risk assessment, it was assumed that the groundwater that could be contacted by potential future residents would contain the same concentrations as those detected in the current offsite groundwater plume.

The risk assessment evaluated onsite risk of exposure, although no exposure to groundwater onsite currently exists. Future onsite exposures were evaluated assuming

that individual residents or public or private water purveyors could install private wells for domestic potable water supply.

The risk assessment also evaluated risk of offsite exposure. Offsite groundwater is currently used by water purveyors for residential supply. No water containing CoPCs above drinking water standards is currently served. Potential exposure to CoPCs through contact with offsite groundwater supplied by the various water purveyors is assessed by water quality monitoring pursuant to the Exhibit IV monitoring plan of the PCD. The water purveyors, in conjunction with the California DHS, determine when a water supply well should be taken out of service. Private wells also exist in the offsite areas, although most are used for industrial or agricultural purposes, not for domestic (potable) water supply. Future use of offsite groundwater was evaluated assuming individual public or private water supply wells may be installed in the plume area.

Calculated risks associated with potential future use of groundwater that might be obtained from each of the hydrostratigraphic layers beneath the onsite area were developed as part of the risk characterization effort.

Calculated risks for the onsite and offsite areas were compared to EPA's acceptable risk ranges of 10^{-6} to 10^{-4} for potential additional lifetime cancer risk and/or a hazard index greater than one for non-carcinogenic effects.

Onsite CoPCs. In summary, NDMA occurrences in Layer D onsite exceed the NCP specified acceptable risk range for carcinogenic effects. Comparison of the calculated risk to the hazard indices, indicates that perchlorate levels onsite in Layers A through E could result in a hazard index greater than one and thus potentially represent an unacceptable risk. Additional chemicals retained as CoPCs for the onsite areas include: 1,1,2-TCA, 1,2-DCE, PCE, nitrate, and nitrite in Layer A; 1,1,2-TCA, 1,1-DCE, 1,2-DCE, carbon tetrachloride, chloroform, PCE, and nitrate in Layer B; 1,1-DCE, 1,2-DCA, carbon tetrachloride, chloroform, and PCE in Layer C, and 1,1-DCE, 1,2-DCA, chloroform, and PCE in Layer D.

Offsite CoPCs. In the offsite areas, no CoPC concentrations exceeded EPA's acceptable risk range of 10^{-6} to 10^{-4} for potential additional lifetime cancer risks. However, the offsite perchlorate concentrations did exceed the non-carcinogenic hazard index of one in Layers C, D, and E. Additional chemicals retained as CoPCs for the offsite areas include: 1,1-DCE, chloroform, nitrate, and nitrite in Layer C, and vinyl chloride in Layer D.

ES-4 Summary of Feasibility Study

The FS serves as the mechanism for the development, screening, and detailed evaluation of alternative remedial actions. The development of alternatives requires identifying remedial action objectives (RAOs); identifying technologies that will satisfy these objectives; screening the technologies based on their effectiveness, implementability, and cost; and assembling technologies into OU-wide alternatives to address the contaminated

medium (in the case of this FS, groundwater). Following development of the OU-wide alternatives, the alternatives may be screened to reduce the number of alternatives analyzed in detail. After screening, alternatives are evaluated in detail with respect to nine evaluation criteria that EPA has developed to address the statutory requirements and preferences of CERCLA. The alternatives are analyzed individually against each of the criterion and then compared against one another to determine their respective strengths and weaknesses and to identify the key tradeoffs that must be balanced for the Site. The results of the detailed analysis are summarized and presented to the decision-maker so that an appropriate remedy consistent with CERCLA can be selected.

The initial step in identifying and screening remedial alternatives is to formulate RAOs. RAOs are media-specific goals designed to protect human health and the environment. RAOs specify the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of alternatives to be developed on the basis of chemical-specific applicable or relevant and appropriate requirements (ARARs) and site-specific risk-related factors. The overall goal of any remedial alternative is to protect human health and the environment. In order to achieve this goal for the Western Groundwater Study Area, the following RAOs were developed:

- Protect human health and the environment from exposure to contaminated groundwater;
- Minimize offsite migration of CoPCs where practicable to protect long term beneficial uses;
- Reduce contaminant concentrations in already contaminated groundwater in an efficient cost-effective manner; and
- Protect public drinking water wells and provide treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels.

A range of technologies to address these RAOs for the Western Groundwater Study Area were identified and screened. These technologies consisted of various institutional controls, replacement or substitute water supplies, and groundwater extraction, treatment, and treated water management/reuse options. The technologies that survived the screening process were developed into ten remedial alternatives for the OU. These alternatives were evaluated in detail with respect to the CERCLA evaluation criteria and are described below.

- Alternative 1 - No Action with Limited Groundwater Monitoring

  This alternative serves as the baseline for comparison of the other alternatives. The existing GETs E and F system would be terminated and there would be no active remediation of groundwater offsite.

- Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

  This alternative assumes continued migration of the offsite CoPC plume, shutdown of downgradient public water supply wells, and replacement of affected water supply capacity through an alternative water supply.

- Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

  Alternative 2B is the same as 2A except the onsite GETs E/F recharge field would be replaced with extraction wells.

- Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

  This alternative assumes continued migration of the offsite CoPC plume, and providing wellhead treatment on those existing water supply wells that may become affected by the CoPC plume over time.

- Alternative 3B –GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

  Alternative 3B is the same as 3A except the onsite GETs E/F recharge field would be replaced with extraction wells.

- Alternative 4A – GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

  Alternative 4A would establish an offsite hydraulic barrier of extraction wells, intended to contain the offsite plume and prevent further migration of CoPCs downgradient of the barrier in concentrations that would impair beneficial uses of the groundwater.

- Alternative 4B – GETs E and F Extraction Wells with Offsite Extraction Wells

  Alternative 4B is the same as 4A except the onsite GETs E/F recharge field would be replaced with extraction wells.

- Alternative 4C – GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors

  Alternative 4C is the same as 4B except Alternative 4C would also incorporate "multiple containment corridors" by including installation of new extraction wells closer to the estimated leading edge location of the CoPC plume in the D and E layers sooner than planned for the other alternatives.

- Alternative 5A – GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

  Alternative 5A would also provide containment of the offsite CoPC plume using a combination of new extraction and recharge wells to provide hydraulic containment.

- Alternative 5B – GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

  Alternative 5B is the same as 5A except the onsite GETs E/F recharge field would be replaced with extraction wells.

All alternatives include groundwater monitoring. All Alternatives, except Alternative 1 (No Action), involve operation of the existing GETs E and F onsite boundary containment/source control systems and assume that institutional controls would eliminate the pathway by which persons could be exposed to contaminated drinking water. These institutional controls include (1) DHS's enforcement of drinking water regulations requiring water purveyors to take action to monitor and shut down water supply wells that they or DHS consider to be inappropriate for service to customers, and (2) the proposed Consultation Zone provision to the Sacramento County comprehensive well ordinance which will provide Agency oversight of monitor and supply well drilling and use in the Study Area.

Each of Alternatives 2 though 5 include an "A" and "B" alternative (e.g., Alternative 2A and Alternative 2B) for purposes of evaluating continued use of the GETs E and F recharge wells. Alternative 4 also includes a "C" alternative. Each of the "A" alternatives involves continued operation of the GETs E and F recharge wells. Each of the "B" and "C" alternatives involves shut down of the recharge wells and installation of additional extraction wells to maintain onsite capture.

In addition, each of the "A", "B" and "C" alternatives assume that additional extraction wells will be added to the existing GETs E/F extraction system to enhance capture. A potential mechanism that could be used for early implementation of these modifications would be the material modification provision within Exhibit VI of the PCD. The modifications would involve additional extraction wells and optimization of extraction rates from existing GETs E/F extraction wells.

The conceptual design of each of the remedial alternatives was based on the results of a numerical groundwater flow model. This model was also used to assist in evaluating the alternatives with respect to the various evaluation criteria. The model was based on the final site conceptual model as presented in Section 1. Simulated groundwater flow and advective migration of dissolved CoPCs were used to compare and contrast the relative merits of each of the remedial alternatives.

The alternatives were individually analyzed against each of the CERCLA evaluation criteria and then compared against one another to determine their respective strengths and

weaknesses and to identify key tradeoffs. The evaluation criteria are categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria. Threshold criteria are requirements that each alternative must meet to be eligible for selection as the preferred alternative, and include overall protection of human health and the environment and compliance with ARARs (unless a waiver is obtained). Primary balancing criteria are used to weigh effectiveness and cost tradeoffs among alternatives. The primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. Modifying criteria, which include State acceptance and community acceptance, may be used to modify aspects of the preferred alternative when the Proposed Plan is prepared, and are generally evaluated after public comment on the OU RI/FS and the Proposed Plan. Accordingly, only the seven threshold and primary balancing criteria were used in the detailed analysis phase. The results of the detailed analysis are as follows:

Overall Protection of Human Health and the Environment

Alternative 1, which assumes no onsite or offsite containment of the CoPC plumes and no institutional controls, does not provide adequate protection to human health, as exposure to contaminated groundwater would not be prevented. Each of the remaining alternatives include actions that break the pathway through which contaminated groundwater would be supplied for potable use. First, each of the Alternatives 2A through 5B involve operation of GETs E and F at the Aerojet facility boundary, thereby establishing a hydraulic boundary to minimize the risk of the offsite migration of CoPCs. Second, Alternatives 2A through 5B eliminate exposure to unacceptable concentrations of CoPCs through various management options. Alternatives 2A and 2B involve replacement water supplies, Alternatives 3A and 3B include point of use treatment, and Alternatives 4 and 5 involve a hydraulic barrier.

Alternatives 2A and 2B do not prevent the continued migration of CoPCs already offsite and are not protective of the environment in the near-term. Each of Alternatives 3A through 5B involves offsite extraction intended to minimize CoPC migration and protect the environment.

The treated water management/reuse option selected will also be protective of human health and the environment for all alternatives. If wellhead treatment is utilized in all or a portion of the selected remedy, the treated water must meet DHS requirements for a drinking water source. Similarly, if direct reuse of treated groundwater is selected under Alternatives 4A through 5B, the treated water must comply with DHS requirements. Alternatives 4A through 5B must also be protective of the environment if recharge or surface water discharge are selected as treated water management options. This protection will be afforded through the NPDES permitting process for surface water discharge or treatment plant effluent requirements for recharge.

Alternatives 3A through 5B are sufficiently protective of public health and the environment with respect to this threshold criteria.

Compliance with ARARs

Compliance with ARARs also serves as a threshold criterion that must be met by any alternative for it to be selected as a remedy, unless an ARARs waiver is obtained. Each alternative, except Alternative 1 (No Action), has the potential to comply with ARARs.

Chemical-specific ARARs (e.g., MCLs) will be met by Alternatives 3A through 5B, since under each such alternative, impacted groundwater located both on the Aerojet facility and offsite will be treated to concentrations that meet chemical-specific ARARs prior to management/reuse. Alternatives 2A and 2B, which do not include offsite engineered groundwater controls, are less likely to achieve chemical-specific ARARs for offsite groundwater within the short term. However, they have the potential to eventually comply with ARARs through institutional controls, the operation of the GETs E/F extraction and treatment system, and natural attenuation.

Location- and action-specific ARARs do not apply to Alternative 1, the No-Action alternative. The groundwater extraction, conveyance, treatment, and treated groundwater management/reuse systems variously described under Alternatives 3A through 5B can be designed and operated to comply with all location- and action-specific ARARs.

Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence is a measure of the magnitude of residual risk and the adequacy and reliability of controls.

The Alternative 4 and 5 series would appear to provide greater long-term effectiveness and permanence than the remaining alternatives, with the Alternative 4 series, and particularly 4B, providing the greatest potential for long-term effectiveness and permanence.

Alternative 4C may be less effective at maintaining hydraulic capture than Alternatives 4A and B, and 5A and B. Under Alternative 4C, extraction wells are located in Layers D and E between the Aerojet Site and the offsite hydraulic barrier in Layer C. These extraction wells will decrease the head potential in Layers D and E and may cause the downward migration of CoPCs from Layer C into Layers D and E. If this occurs, some CoPCs located beyond the influence of the extraction wells in Layers D and E will not be captured. The CoPC concentrations are generally an order of magnitude greater in Layer C than in Layers D and E.

The Alternative 4 and 5 series are intended to minimize the migration of CoPCs by establishing onsite and offsite barriers. These barriers will permanently remove and treat

CoPCs from affected groundwater, thereby reducing the long-term potential for exposure to CoPCs in offsite groundwater. The potential long-term effectiveness and permanence of the Alternative 4 and 5 series is greater than that for the Alternatives 2 and 3 series because Alternatives 2 and 3 are not specifically designed to remove CoPCs in the offsite areas. It is difficult to accurately predict how far the CoPCs will migrate under Alternatives 2 and 3. However, Alternative 3 does provide a greater degree of long-term effectiveness than Alternative 2 because groundwater modeling indicates that a substantial portion of the offsite CoPCs would be permanently removed and treated through the use of wellhead treatment.

Among the "A", "B" and "C" alternatives, the "B" and "C" alternatives appear to provide the greatest potential to effectively control the migration of CoPCs. Replacing the recharge wells with extraction wells at the western Aerojet boundary enables the "B" and "C" alternatives to remove a greater portion of the CoPCs present in Layers C, D, and E before they migrate offsite. In addition, by eliminating recharge, the "B" and "C" alternatives reduce the total amount of water that must be contained by an offsite hydraulic barrier, thereby increasing the potential effectiveness of the offsite barrier system. Similarly, the Alternative 4 series has a greater potential for long-term effectiveness than the Alternative 5 series because hydraulic control using only extraction is more attainable than achieving hydraulic control using both extraction and recharge.

The Alternative 4 and 5 series involve more remediation and removal of the offsite portions of the CoPCs than the remaining alternatives, although Alternatives 3A and 3B will remove a substantial portion of the offsite CoPCs. Therefore, the Alternative 4 and 5 series probably have the greatest potential to eventually restore the aquifer to beneficial uses and reduce the magnitude of residual risk. However, given the complexity and heterogeneity of the aquifer system and the unknown fate and transport characteristics of some of the CoPCs (i.e., perchlorate and NDMA), there is no realistic basis for evaluating the extent to which aquifer restoration will occur and over what period of time.

Reduction in Toxicity, Mobility, or Volume through Treatment

This criterion is a measure of the statutory preference for treatment as a principal element; irreversibility of treatment; type and quantity of treatment residual; amount of hazardous material destroyed or treated; and reduction in toxicity, mobility, or volume.

With respect to offsite CoPCs, except for Alternative 2, each of the alternatives involves management of contaminated groundwater that will achieve reduction in toxicity, mobility or volume through treatment. The remaining alternatives are equal in their preference for treatment and the irreversibility of treatment processes.

Alternatives 4 and 5 include both onsite and offsite hydraulic boundaries and therefore would be expected to provide greater reduction in toxicity, mobility and volume of the offsite CoPCs than Alternatives 2 and 3, which are not designed to do so (although Alternative 3 does provide containment). Among the "A", "B" and "C" alternatives, the

"B" and "C" alternatives would be expected to provide a greater reduction in mobility of CoPCs in the offsite plume than the "A" alternatives because they would not include recharge of the GETs E/F treated groundwater.

Groundwater would be treated using various processes that are irreversible. No residuals are associated with UV/oxidation treatment because contaminants are destroyed. Air strippers produce VOCs in offgas that may require treatment prior to being emitted to the atmosphere. LPGAC does not destroy contaminants but rather collects VOCs within a carbon vessel. The carbon will periodically require regeneration and offsite treatment or disposal. The groundwater treatment component of Alternatives 3A through 5B meets the statutory preference for treatment to reduce the principal threat because contaminants are destroyed or collected and the total volume of contaminated media is reduced.

The groundwater flow model was used as a basis for comparing the relative amount of the plume area that would be removed by each alternative involving groundwater extraction (i.e., Alternatives 3A through 5B) over the 25-year FS evaluation period. The percent of plume area removed in Layer C ranges from 52 to 87 percent with Alternative 3B removing the least and Alternative 4A providing the most amount of removal. The alternatives involving an offsite hydraulic barrier and continued recharge of GETs E/F treated groundwater (i.e., Alternatives 4A and 5A) remove the greatest amount of plume area over the 25-year evaluation period because of the increased hydraulic gradients caused by recharge. The plume areas estimated to be removed in Layer D are similar for all alternatives, ranging from approximately 68 to 77 percent. The amount of plume area removed in Layer E has the greatest variability of all layers, ranging from 21 to 91 percent. The modeling indicates that Alternative 3B would remove more plume area from Layer E (91%) than any of the other alternatives because several water supply wells located closest to the Aerojet Site are screened in Layer E. Alternatives 5A and 4A would remove the least amount of plume in Layer E because recharge is continued and portions of the plume in Layer E on the west side of the Aerojet Site are not captured until they reach the offsite hydraulic barrier. Layer E comprises only 9 percent of the total plume area, so hydraulic capture of Layer E may not be a significant benefit.

The modeling indicates that Alternatives 3A and 3B would remove the least amount of the total plume area because they rely on existing water supply wells that are not optimally located for CoPC plume removal. Alternatives 4A through 5B are projected to remove between 68 and 77 percent of the total plume area over 25 years. The approximate 13 percent difference among the alternatives modeled to remove the greatest amount (4A) and least amount (5B) of plume areas is within the range of variability of the model, and suggests that plume area removal is similar for each alternative.

Short-Term Effectiveness

Short-term effectiveness is a measure of the protection afforded by each alternative during the construction and implementation process. As such, the time until remedial

response objectives are achieved is an important component of this criterion. The availability of equipment and specialists to implement the alternative is also a consideration. This criterion is typically of greater significance for source control measures. Here, all of the alternatives (except No Action) involve onsite and most involve an offsite response action. Under all alternatives, the community and the environment would be protected from potential exposure to CoPCs through existing institutional controls (i.e., DHS drinking water standards).

All remaining alternatives protect offsite human health and the beneficial uses of the aquifer by minimizing the offsite CoPC migration. Alternatives 3A through 5B involve both onsite and offsite groundwater extraction, and are more protective than Alternatives 2A and 2B that rely on natural processes to reduce CoPC concentrations already offsite. Each of the "B" alternatives and Alternative 4C may be more protective than the "A" alternatives because treated groundwater is not recharged. The complex hydrostratigraphy and uneven lateral and vertical contaminant distribution in the Study Area necessitates that some CoPCs will migrate through unaffected portions of the aquifer prior to reaching the extraction or water supply wells. Alternative 4C involves the most aggressive offsite groundwater extraction and will intercept CoPCs in portions of Layers D and E earlier than the other alternatives. The earlier extraction from Layers D and E is unlikely to effect the beneficial use of the aquifer because, until the CoPCs in Layer C are removed, public water supply wells cannot be installed in Layers D and E due to the potential for the downward migration of CoPCs from Layer C into the supply well. Layer C contains the greatest areal extent and highest CoPC concentrations and will likely have the most impact on beneficial use.

The time required to implement Alternatives 2 and 3 would be shorter than Alternatives 4 and 5, because Alternative 2 would not require substantial offsite construction. Alternative 3 would be implemented on a phased basis as public water supply wells become affected. Alternatives 4 and 5 would require significantly more planning, design, and construction activities for the offsite hydraulic containment components. Alternative 4C would probably require the greatest amount of time to implement because it would involve securing the easements and right-of-way access for two offsite pipeline corridors instead of one.

Several of the alternatives involve extraction of groundwater to achieve containment or collection and therefore have the potential to impact the operation of existing or possible future groundwater supply wells. The maximum water level drawdowns estimated to be observed in water supply wells located in the vicinity of the intersection of Zinfandel Drive and U.S. Highway 50 as a result of implementation of Alternatives 4A through 5B are approximately 35 feet or less. This is not expected to have any significant impact on the aquifer.

It is anticipated that the necessary equipment and specialists are available to implement all alternatives.

It is not technically feasible to estimate the time required to meet the RAO of reducing CoPC concentrations in already contaminated portions of the groundwater due to the aquifer and contaminant distribution complexities discussed throughout this FS. However, it may be useful to compare the amount of plume area modeled to be removed during the 25-year evaluation period among the alternatives for a relative comparison of time. The alternatives modeled to remove the greatest plume area can reasonably be expected to achieve this RAO more quickly than the other alternatives. As discussed in Sections 5 and 6.2.2, Alternatives 4A through 5B are projected to remove between 68 and 77 percent of the total plume area over 25 years. The 13 percent difference in estimated plume area removed among the alternatives is probably insignificant for a remedial action that may be implemented for the Western Groundwater OU. Alternative 2 will not attain a reduction in the offsite CoPC concentrations over any meaningful period of time.

Implementability

Implementability evaluates the technical and administrative difficulties associated with implementing each alternative. Each of the alternatives is implementable to varying degrees, as discussed in this Section. There are several technical and administrative difficulties associated with each of the alternatives. Technical implementability issues include demonstrating hydraulic capture and control of CoPC plumes and demonstrating the ability to treat extracted CoPCs. Administrative difficulties associated with implementing alternatives include obtaining easements and property for wells and pipelines, conducting a large construction project in public roads and neighborhoods, challenges associated with permitting and compliance for wellhead treatment, and exchanging water for potable and nonpotable reuse.

Alternatives 2A and 2B are implementable to the extent that DHS approves treated groundwater for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. If direct reuse is not accepted, and for the projected shortfall of treated water available under Alternative 2A, a surface water treatment plant can be constructed if a suitable location can be found, and if a private or public water purveyor is willing to operate it. It is believed that permission can be obtained from the USBR to use Folsom South Canal as a raw water conveyance system to a surface water treatment plant, if necessary. Between Alternatives 2A and 2B, Alternative 2A assumes that long-term surface water entitlements would be available on the American River, which may not be the case.

Alternatives 3A and 3B are implementable to the extent that the DHS approves wellhead treatment for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. DHS has accepted wellhead treatment at numerous locations throughout the State. If accepted, the well treatment equipment must be capable of fitting in the existing space available at impacted water supply wells, and

the treatment processes must be capable of meeting treatment standards in a demonstrable and reliable manner.

It will be difficult to implement Alternatives 4A through 5B due to the significant amount of offsite infrastructure estimated for these alternatives. Alternatives 4A through 5B are estimated to require from approximately 67,000 to 81,000 feet (approximately 13 to 16 miles) of relatively large diameter piping and from 11 to 30 offsite extraction wells. It will require a substantial effort to identify potential pipeline corridors and secure the necessary permits and easements. This amount of offsite construction may require significant input and participation from Sacramento County and the local community. It is not currently known where extraction wells that require periodic maintenance and monitoring can be located.

In comparing among the "A", "B", and "C" alternatives, the "B" and "C" alternatives should be more implementable, given the preference of using extraction rather than recharge both on and offsite to maintain the hydraulic control, and because the "B" and "C" alternatives involve more containment onsite than the "A" alternatives. With respect to the alternatives that include an offsite hydraulic barrier (Alternatives 4A through 5B), maintaining a hydraulic barrier where recharge wells are used as part of the barrier (Alternatives 5A and 5B) would probably be more difficult to implement as maintaining gradients requires more sophisticated groundwater management to optimize system operation and control

Cost

This criterion evaluates the cost of implementing each alternative. The cost of an alternative encompasses all capital (e.g., construction, equipment and materials, land purchase, insurance and permitting, engineering, construction management, and regulatory agency oversight costs) and any long-term annual operation and maintenance (O&M) costs (e.g., operating labor, maintenance materials, electrical power, chemicals, and sampling/analytical costs). The assessment against this criterion is based on the estimated present worth of these costs for each alternative. Present worth is used to estimate expenditures such as construction and O&M that occur over different lengths of time and discounting all costs to a common year. By discounting all costs to a common base year, the costs for different remedial alternatives can be compared on the basis of a single figure for each alternative. The present worth of a project represents the amount of money that, if invested in the initial year of the remedy and disbursed as needed, would be sufficient to cover all costs associated with the remedial action. Cost estimates for each alternative were prepared in accordance with current EPA guidance with respect to level of accuracy and discount rate (i.e., seven percent). The estimated total capital cost, estimated annual O&M costs, and estimated 25-year present worth cost estimates for

each of the alternatives are as follows:

Alternative	Estimated Capital Costs ($M)	Estimated Annual O&M Costs [Range] ($M/year)	Estimated 25-year Present Worth Costs ($M)
1	0	0.16	2
2A	25	2.1-3.9	48
2B	22	2.5-2.8	54
3A	64	3.5-5.3	93
3B	77	4.0-6.0	115
4A	43	3.0-3.3	78
4B	38	3.3-3.4	77
4C	42	3.5-3.6	85
5A	41	3.3-3.9	78
5B	45	3.8-4.0	87

The following potential additional costs are not included in FS-level cost estimates for Alternatives 4A through 5B, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed Preliminary Remedial Action Goals (PRAGs) and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for these alternatives in Section 4 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Replacement Water Contingency Alternative	Estimated Capital Costs ($M)	Estimated Annual O&M Costs [Range] ($M/year)	Estimated 25-year Present Worth Costs ($M)
Direct Reuse	3.9	0.13	5.5
Indirect Reuse	6.9	0.04	7.4

1 INTRODUCTION

1.1 Purpose, Scope and Organization of the Western Groundwater OU RI/FS Report

1.1.1 Purpose

The purpose of this Operable Unit (OU) remedial investigation/feasibility study (RI/FS) is to present the RI for the Western Groundwater OU Study Area (Figure 1-1) and to prepare an FS that evaluates remedial alternatives for addressing contaminants of potential concern (CoPCs) in groundwater in the Study Area. In June 1989, Aerojet entered into a Partial Consent Decree (PCD) which requires the completion of an RI/FS for the Aerojet Sacramento site. Pursuant to the PCD, Aerojet has completed a substantial portion of the Phase I RI/FS. This Western Groundwater OU RI/FS is submitted as part of the RI/FS pursuant to the PCD and focuses on an operable unit; namely, the Western Groundwater Area. This Western Groundwater OU RI/FS also meets the requirements of the California Regional Water Quality Control Board (RWQCB) Cleanup and Abatement Order (CAO) No. 96-259 to the extent applicable.

On October 6, 1998, Aerojet submitted a proposal to the PCD oversight Agencies providing for the completion of the Aerojet site RI/FS required by the PCD through the preparation and submittal of a number of sequential OUFSs. On October 27, 1998, the US Environmental Protection Agency (USEPA), California Department of Health Services (DHS), and the California RWQCB accepted this approach for completion of the Aerojet site RI/FS. Currently, Aerojet and the oversight Agencies are negotiating modifications to the PCD to allow for this revised RI/FS approach. This OU RI/FS for the Western Groundwater Study Area is the initial submittal pursuant to this revised approach. It is currently contemplated that the RI/FS for the remaining OUs will be completed through similar OU RI/FSs.

1.1.2 Scope

The scope of this OU RI/FS can be described as follows:

- Conduct the RI for the Study Area to characterize subsurface conditions and the nature and extent of CoPCs in groundwater;
- Prepare a Baseline Risk Assessment (BRA) to identify any potential risks that may be posed to human health and the environment by CoPCs in groundwater in the Study Area;
- Prepare an OU RI/FS by developing and evaluating a range of remedial alternatives that provides for protection of human health and the environment, and that considers technical, institutional, and cost considerations in accordance with CERCLA, as

amended by SARA, and the National Contingency Plan (NCP) so that relevant information regarding the remedial alternatives can be presented to a decision-maker and an appropriate remedy can be selected; and

- Integrate the OU RI/FS with all applicable RI, BRA, and treatability study activities to ensure that all remedial alternatives are developed, screened, and evaluated in a systematic and objective manner.

This OU RI/FS report has been developed to comply with guidelines prepared under the provisions of CERCLA, SARA, the latest revision to the NCP (40 Code of Federal Regulations (CFR) Part 300.430 (1990)), and the following EPA and DTSC guidance documents:

- USEPA, 1988a, Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (Interim Final), EPA/540/6-08/004, OSWER Directive 9355.3-01, October.

- USEPA, 1988b, CERCLA Compliance with Other Laws Manual, OSWER Directive 9234.1-01, August.

- USEPA, 1988c, Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites, OSWER Directive 9238.1-02, December.

- USEPA, 1989c, CERCLA Compliance with Other Laws Manual Clean Air Act, and Other Environmental Statutes and State Requirements, OSWER Directive 9234.1-02, August.

- USEPA, 1996c, Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites, OSWER Directive 9283.1-12, October.

- DTSC, 1992, Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities.

- USEPA, 1989a, Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A), Interim Final, EPA/540/I-89/002, Office of Emergency and Remedial Response, Washington, DC, December.

- USEPA, 1991, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, OSWER Directive 9355.030, Office of Solid Waste and Emergency Response. Washington, DC, April.

- USEPA, 1999b, Region 9 Preliminary Remediation Goals (PRGs) 1999, October 1.

- USEPA, 1997, Exposure Factors Handbook, Volumes I through III. EPA/600/P-95/002Fa through Fc, Office of Research and Development, National Center for Environmental Assessment, August.

- USEPA, 1998a, Risk Assessment Guidance for Superfund, Part D.

1.1.3 Organization of Report

This OU RI/FS report documents the characterization of subsurface conditions and the nature and extent of CoPCs in groundwater for the Western Groundwater Study Area, summarizes the potential risks that may be posed to human health and the environment by CoPCs in groundwater in the Study Area, documents the formulation and evaluation of remedial alternatives, and provides all data and documentation for the decision-making process in the Record of Decision (ROD). The report is organized as follows:

- Section 1 provides a summary of the site conceptual model as finalized in the RI (Aerojet, 2000a) [Appendix A] and a summary of the Baseline Risk Assessment (HSI Geotrans, 2000a) [Appendix B];

- Remedial action objectives (RAOs), potential applicable or relevant and appropriate requirements (ARARs), and preliminary remedial action goals (PRAGs) are discussed in Section 2;

- Identification and screening of general response actions (GRAs) and remedial technologies is presented in Section 3;

- Development of OU-wide remedial alternatives is discussed in Section 4;

- The detailed analysis of alternatives is presented in Section 5 and the comparative analysis of alternatives is conducted in Section 6;

- Section 7 provides the references used in this OU RI/FS report; and

- Appendices A through E provide supplemental or backup information that are the bases for the summaries and analyses presented in Sections 1 through 6. The specific Appendices include:

  - A: Western Groundwater Operable Unit Remedial Investigation Report

  - B: Western Groundwater Operable Unit Baseline Risk Assessment

  - C: ARARs for Western Groundwater OU RI/FS

- D: Western Groundwater OU RI/FS Groundwater Flow Model

- E: Detailed Cost Estimates

1.2 Study Area Description and History

1.2.1 Study Area Description and Background

The Western Groundwater Study Area encompasses a western portion of the Aerojet Operating Plant site, the northwestern corner of the Inactive Rancho Cordova Test Site (IRCTS), and approximately 10 square miles of commercially and residentially developed areas in the community of Rancho Cordova (Figure 1-1). The entire Study Area measures approximately 15 square miles. The Study Area is approximately bounded on the west by Mather Field Road.

The community of Rancho Cordova is located west and north of Aerojet. Commercial and industrial development dominates the areas south of Folsom Boulevard, east of Zinfandel Drive, and west of Aerojet. Residential developments are primarily located in the areas north of Folsom Boulevard, although, pockets of smaller residential development are present throughout the Study Area.

Arden-Cordova Water Service (ACWS), a subsidiary of the Southern California Water Company (SCWC), provides potable water to the majority of residential and industrial users in the Study Area. Sacramento County provides potable water to users in a relatively small corridor of the study area bounded by the Folsom South Canal to the west and north, and Aerojet and the IRCTS to the east. Citizens Utilities Company provides potable water to a small commercial development on the IRCTS (Security Park) and to the communities located west of the Study Area.

The Study Area is characterized by a relatively flat topographic surface gently sloping (less than 1 degree) to the west. Ground surface elevations decrease from approximately 200 feet above MSL in the east to approximately 60 feet above MSL in the west, an average slope of approximately 24 feet per mile. Several ancestral river terraces are present on the north and south sides of the American River. The majority of Rancho Cordova, the Aerojet site, and the IRCTS were dredged for gold from the early 1900's through the 1960's. Dredging involved removal and sorting of sediments from the ground surface to depths up to 80 feet. Redeposition of the dredged sediments has formed the irregular linear patterns visible in the undeveloped portions of the Study Area.

The American River meanders in a generally southwesterly direction through the northwestern portions of the Study Area. Flows in the American River are controlled by the United States Bureau of Reclamation (USBR) through Folsom Dam, located approximately 6 miles upstream (northeast) of Lake Natoma. Lake Natoma serves as the dividing line between the Upper and Lower American River Watersheds, and provides recreational facilities and hydroelectric power. The USBR also controls access and water

diversions through the Folsom South Canal that trends roughly north-south through the Study Area.

1.2.2 Site History

Since the early 1950's, the Aerojet Sacramento site has been devoted to the development of rocket propulsion systems to support national defense, space exploration, and satellite deployment. Industrial activities at the Aerojet site have included solid rocket motor manufacturing and testing, liquid rocket engine manufacturing and testing, and chemical manufacturing. Chemicals used in the manufacturing and testing areas on the Aerojet site have included chlorinated solvents, propellants, metals, oxidizers, and a variety of chemicals produced in the chemical operations areas as described in the Scoping Report (ICF Technology, 1989).

Historical operations at the Aerojet site have resulted in the discharge of chemicals of potential concern (CoPC) to the vadose zone and underlying groundwater. Although numerous types of chemicals have been used historically on the Aerojet Site, trichloroethylene (TCE), perchlorate and N-nitrosodimethlyamine (NDMA) comprise the chemicals of principal concern in the Study Area. TCE was utilized on the Aerojet Site for cleaning and degreasing purposes. Perchlorate was combined with a cation (generally ammonium or potassium) and utilized as an oxidizer in solid rocket propellants. NDMA is a semi-volatile organic compound (SVOC) that was either an impurity in hydrazine-based liquid rocket fuels or was formed as a combustion product of these fuels.

The northwestern portion of the IRCTS was included in the Study Area due to the presence of CoPCS in groundwater in the area and the potential for migration offsite within the Western Groundwater Study Area from upgradient source areas. Aerojet operated an evaporation sprayfield near the northwestern corner of the IRCTS to disperse groundwater treated at its former GET F South treatment facility. Aerojet and the former Douglas Aircraft Company (which was subsequently purchased by the McDonnell Douglas Corporation and then The Boeing Company) operated a propellant burn area on the eastern edge of the former sprayfield. This Western Groundwater OU RI/FS focuses on offsite groundwater within the Study Area that has or might become impacted by upgradient source areas, but does not resolve the relative contribution, if any, among potential source areas on the IRCTS. The IRCTS, excluding the spray field, is the subject of a Consent ISEO issued by DTSC to Boeing and Aerojet. Evaluations undertaken herein and any remedial action selected may be applicable to obligations under the ISEO.

Rocket engine/motor testing, and motor rehabilitation (propellant hogout) were conducted in other portions of the IRCTS that are being jointly investigated by Aerojet and The Boeing Company under a separate Cleanup and Abatement Order (CAO 97-093) issued by the Regional Water Quality Control Board (RWQCB). It is recognized in this FS that there are additional groundwater plumes containing perchlorate and solvents south of the Study Area boundaries that are not being evaluated by the OU RI/FS. The Regional Board Order provides that the remediation efforts under the IRCTS CAO will

be coordinated and may be combined with remediation associated with this OU RI/FS for the Western Groundwater Study Area.

There are potential sources of CoPCs within the Study Area other than the IRCTS and the Aerojet Facility. Chlorinated solvents, including TCE, were commonly used by different industries. Perchlorate appears to have been and nitrate is a common constituent of fertilizers (ES&T, 1999). NDMA appears to have been associated with various industrial and food processing industries and has been a contaminant in foods (ATSDR 1989).

1.2.3 Current Remedial Actions

Since the mid-1980's, Aerojet has installed and operated five interim perimeter groundwater extraction and treatment (GET) facilities (GETs A, B, D, E, and F) designed to remove volatile organic compounds (VOCs) and NDMA (GETs A and B only) from groundwater beneath the site. The treated water is recharged to the groundwater system via surface discharge and infiltration, or by recharge wells. A sixth GET system, the American River Groundwater Extraction and Treatment System (ARGET) began operations in July 1998 in the American River Study Area (ARSA). GET E/F is located within the Study Area on the western boundary of the Aerojet site and is included for evaluation as a final remedy in this FS.

The current configuration for the extraction wells, conveyance pipelines, groundwater treatment facilities, and recharge wells for GET E/F is shown on Figure 1-2. The extraction, treatment, and recharge facilities have been modified several times since their initial construction to increase the effectiveness of the operation and treatment of the systems. The effect of the historical operation of the GET E/F facility on the distribution of CoPCs in the Study Area is discussed in Section 1.3.4.

Approximately 2,000 gallons per minute (gpm) of groundwater is extracted via the five extraction wells previously defined as GET E (wells 4070, 4075, 4200, 4425, and 4435). The six previously defined as GET F extraction wells (4007, 4060, 4140, 4145, 4310, and 4315) extract approximately 1,400 gpm. The treated groundwater is recharged to the aquifer, either through a series of eight passive recharge wells located between the two extraction well fields (Figure 1-2) or by discharge to ground and percolation in the vicinity of the recharge wells. Groundwater recharge in this area forms a hydraulic mound that deflects CoPCs towards the GETs E/F extraction wells. The groundwater modeling simulation performed for this FS indicates that the extraction rates at GET E/F can be reduced by approximately 25 percent and still maintain the current level of capture.

In August 1999, the former GET E treatment facility was removed from service and the GETs E/F treatment systems were combined into a single new treatment facility located at the site of the GET F treatment facility. Treatment processes at the GET F location were also upgraded from only VOC removal via air stripping to include a biological reduction process for perchlorate treatment and an ultraviolet (UV)/oxidation process for

treatment of VOCs and NDMA. New air strippers were also added as a VOC-removal polishing step after the UV/oxidation process. The effluent from the combined GETs E/F treatment facility is routed through a single manifolded pipeline to its discharge point.

As part of the remedy for Western Groundwater, Aerojet is recommending upgrades to the GET E and F onsite source containment extraction well fields. Specifically, an extraction well or wells screened in hydrostratigraphic layers C, D, and E (see discussion of hydrostratigraphic layers in Section 1.3.2) is recommended for the previous GET E extraction well field. It is estimated that the flowrate from this proposed new well(s) would be approximately 1,000 gpm. Groundwater from these new extraction wells will be treated at the expanded GET E/F treatment facility. Aerojet believes it is advantageous to implement these modifications to GET E/F expeditiously and prior to the likely prolonged period of formal remedy selection and preparation of the ROD. A potential mechanism that could be used for early implementation of these modifications would be the material modification provision within Exhibit VI of the PCD.

1.3 Conceptual Model

The conceptual model for the Western Groundwater Study Area is presented in the Remedial Investigation (RI) Report (Appendix A) and is summarized in the following sections. The summary includes discussions of the conceptual regional geologic model, the conceptual regional hydrogeologic model, and the conceptual migration of CoPCs in groundwater, including the nature and extent of contamination in hydrostratigraphic layers A through E.

1.3.1 Conceptual Regional Geologic Model

The conceptual regional geologic model presents the structural and stratigraphic characteristics of the subsurface geology beneath the Study Area. Interpretations of these characteristics are based on features observed during site-wide geologic mapping, subsurface lithologic descriptions, and literature references. The Study Area is located near the eastern edge of the Sacramento Valley at the contact between the Sierra Nevada metamorphic basement rocks and the Great Valley Sequence of sediments (Figure 1-3). The erosional surface of the basement rocks outcrops on the East Side of the Aerojet Site and dips to the west at approximately 4 degrees. The Great Valley Sequence, a relatively thick series of consolidated and semi-consolidated sedimentary rock, onlaps onto the basement rocks.

The Great Valley Sequence is characterized by shallow-dipping (generally less than 1 degree) Cretaceous, Tertiary, and Quaternary-age marine and non-marine sediments (DWR, 1974). Regional geologic formations identified within this sequence include undifferentiated Quaternary sediments and the Laguna, Mehrten, Valley Springs, Ione and Chico Formations. These sediments generally strike north-south and form a wedge

that thickens from tens of feet at the eastern Aerojet Site border to greater than 2,000 feet near the western Aerojet property boundary.

The older (and deepest) geologic formations (Chico and Ione Formations) were deposited in marine and near marine environments and consequently contain saline to brackish water that is typically non-potable (DWR, 1974). The younger geologic formations were deposited in terrestrial environments and include the undifferentiated Quaternary, Laguna, Mehrten, and Valley Springs Formations. These sediments generally comprise the regional potable water aquifer, although portions of the Valley Springs Formation produce low-quality water due to the presence of sulfides, high total dissolved solids or elevated iron and manganese concentrations. The layers addressed by this study exist within the undifferentiated Quaternary, Laguna, and Mehrten Formations.

The type and distribution of sediments within the regional potable water aquifer strongly influence the aquifer characteristics. Most of the sediment in the aquifer was deposited by fluvial (river) and alluvial (deposited by running water) processes. Sediments deposited in these environments range from coarse-grained sands, gravels, and boulders typically deposited in river channels to silt, silty-sand, and clay deposited on overbanks and floodplains. These depositional environments formed heterogeneous packages of sediment that are generally horizontally and vertically discontinuous. It is often difficult to trace individual stratigraphic layers across the Study Area, although, some sedimentary sequences can be grouped based on similar lithologic and hydrogeologic characteristics. The grouping of sediments with similar hydrostratigraphic characteristics forms the basis for the conceptual regional hydrogeologic model presented below.

1.3.2 Conceptual Regional Hydrogeologic Model

The sediments comprising the regional geologic formations have been subdivided into five hydrostratigraphic layers (Layers A to E) that have been correlated across most of the Study Area (Figure 1-3). These layers were defined on the Aerojet Site based on similar lithology, relative depths and thicknesses, electrical conductivity, water levels, aquifer testing, and chemical concentrations (Aerojet, 1992a,b). The depths and thicknesses of the hydrostratigraphic layers vary across the Study Area due to the regional dip, the slope of the ground surface, and the wedge-shaped layers. The overall structure and lithology of the hydrostratigraphic units has formed an aquifer system that is generally leaky and confined to semi-confined.

Layers A and B, the uppermost layers, are present in the eastern and central portions of the Study Area extending approximately to the western Aerojet boundary. These layers are either dry or change their hydrostratigraphic characteristics in the western offsite area (Aerojet, 1996). Layers C, D, and E are more regional features and are present beneath the entire Study Area. A body of fresh-water that underlies Layer E and underlies the deepest known contamination is present above the saline to brackish water-bearing zones.

The depth to water generally increases from 40 feet to approximately 100 feet below ground surface (bgs) from east to west across the Study Area. Locally, perched groundwater may be present above these depths. The regional water table has declined from 30 to 40 feet over the past 40 years. Groundwater elevations range from approximately 85 feet above mean sea level (msl) in the east to approximately sea level in the west. Groundwater does not discharge to the American River or any other surface water body within the Study Area boundaries.

Groundwater flow directions and hydraulic gradients are similar in each of the hydrostratigraphic layers. The regional groundwater flow direction in Layers A through E is generally to the west-southwest. The average slope, or hydraulic gradient, in Layers A and B ranges from 0.004 to 0.005 ft/ft (Aerojet, 1998). The hydraulic gradient in Layers C, D and E is slightly lower, typically averaging 0.004 ft/ft. Groundwater flow directions and gradients vary in the vicinity of the GET E and F extraction and recharge wells and around public water supply wells due to pumping and recharge at these locations.

Vertical movement is a significant component of groundwater flow in portions of the Study Area, primarily in Layers A and B. Potentiometric surface elevations measured in Layer A typically range from 15 to 40 feet above those measured in underlying Layer B. This relatively high vertical head potential suggests there is a strong potential for downward vertical groundwater migration from Layer A to Layer B. A similar but less strong (5 to 15 feet) vertical head potential exists between Layers B and C. Vertical head potentials in Layers C, D and E are relatively minor (i.e., less than 5 feet) throughout the Study Area except near the GET facilities where groundwater pumping occurs. Vertical head potentials induced by groundwater extraction and recharge vary locally depending on which layer the groundwater is extracted from or recharged to.

1.3.3 Conceptual Migration of CoPCs in Groundwater

Groundwater advection is the dominant process governing the fate and transport of the dissolved-phase contaminants in the Study Area groundwater. Relatively high groundwater velocities in the Study Area minimize the effects of dispersion and retardation, although the magnitude of these effects is not clearly understood. Mechanical dispersion appears to dilute the leading edges of the contaminant plumes; however concentrations in the body of the plumes are generally not reduced to below levels of concern. The primary contaminants in the Study Area appear to be chemically and biologically stable and will likely persist in the Study Area groundwater.

The rate at which CoPCs migrate in the aquifer can be estimated from groundwater velocities. Groundwater velocities are estimated by conducting aquifer tests and applying the results of those tests to standard hydraulic equations. Aquifer testing was conducted on the majority of the GET E and F extraction wells. The extraction wells at GET E are screened in both Layers C and D, and the extraction wells at GET F are individually screened in Layers A, B, and C. The range of results obtained from these tests are

representative of conditions onsite at GETs E and F, but may not necessarily reflect conditions in the western offsite areas. The following chart presents a summary of the hydraulic parameters calculated from the onsite aquifer testing:

Summary of Hydraulic Parameters from Onsite Aquifer Testing

	GET E Area		GET F Area	
Hydraulic Parameter	Range	Median	Range	Median
Hydraulic Conductivity (ft/day)	63.5 to 145.6	123.4	7.6 to 38	18.5
Transmissivity (gpd/ft)	49,000 to 156,000	133,000	10,000 to 37,000	21,100

These data show that the median hydraulic conductivities and transmissivities are higher in the GET E area than in the GET F area. This corresponds with field observations that sediments in the vicinity of GET F are generally finer-grained than the sediments observed at GET E. Arden-Cordova Water Service has conducted several aquifer tests in the western offsite area using water supply wells AC19, AC22, and AC23. Data provided to Aerojet for the test performed at well AC22 yielded transmissivities in the range of 210,000 to 252,000 gpd/ft (CH2MHill, 1998). Data collected by Aerojet during the aquifer testing of wells AC19 and AC23 yielded transmissivities of 150,000 and 100,000 gpd/ft, respectively. The transmissivity of public water supply wells are not directly comparable to the GET E and F transmissivities because public water supply wells pump from different depths within the various layers.

Estimates of groundwater velocities can be prepared using the following equation:

$$q = k * i / n_e$$

where: q = average groundwater velocity
k = hydraulic conductivity
i = hydraulic gradient, and
n_e = effective porosity

Using a conservative effective porosity value of 0.25 (typical for clean sands), groundwater velocity estimates at GET E range from 372 to 851 feet per year. Groundwater velocity estimates at GET F range from 45 to 222 feet per year.

Dispersion and retardation of CoPCs during the advective process may increase or decrease the rates of CoPC migration. Some of the processes include molecular diffusion, mechanical dispersion, retardation, dilution, volatilization, and biological degradation. The effect of each of these processes can vary significantly from chemical to chemical, and it is difficult to quantify these effects because there are numerous location and chemical specific variables that cannot be practically measured. Although the individual and combined effects of these processes are not well understood, these effects are probably minimal compared to the effects due to the relatively high

groundwater velocities in the Study Area. The following chart summarizes the relative effects of dispersion, retardation, and destruction for solvents, NDMA, and perchlorate, the primary CoPCs in the Study Area.

Summary of Relative Retardation, Dispersion, and Destruction Effects

CoPC	Dispersion Effects: Molecular Diffusion	Dispersion Effects: Mechanical Dispersion	Retardation Effects: Sorption	Destruction Effects: Volatilization	Destruction Effects: Biological Degradation
Solvents	√√	√	√√√	√√√	√√
NDMA	√√	√√	√√	√	√
Perchlorate	√√√	√√√	√	√	√

Key: √ = No or uncertain effect
√√ = Moderate effect
√√√ = Greatest effect

1.3.4 Nature and Extent of Contamination

Background

Historical activity at the Aerojet site that potentially contributed to CoPCs is discussed in the Phase I RI/FS Zone 2 Stage 1 Report (ICF Kaiser, 1993). Potential source areas in the Study Area on the IRCTS are discussed in the Perchlorate Work Plan for the IRCTS (Aerojet and McDonnell Douglas, 1997). Further information on potential offsite sources is discussed in Appendix A to this report.

In 1984 and 1985, Aerojet initiated operation of groundwater extraction and treatment (GET) facilities E and F on the northwestern and southwestern perimeters of the Aerojet Site, respectively. These GET facilities were designed to mitigate the offsite migration of VOCs by extracting and treating VOC-impacted groundwater. The extraction, treated water discharge, and treatment processes for both GET facilities were modified several times to improve overall effectiveness.

Historical and recent operating procedures at GETs E/F have influenced the distribution of CoPCs in the Study Area. Figure 1-4 depicts the conceptual west to southwest migration of CoPCs from source areas on the Aerojet Site to the GET E/F extraction well fields. Prior to 1998-99, the treated groundwater contained varying amounts of perchlorate and NDMA. The treated groundwater is shown migrating offsite to the west and southwest from the Former GET F Sprayfield and from the GET E/F recharge well fields. In 1998-99, the treatment processes at GET E/F were upgraded to include perchlorate and NDMA removal.

Portions of the offsite CoPC plumes cannot be attributed to GET effluent. VOCs, primarily TCE, are present offsite to the north and west of the GET E extraction wells. The VOC concentrations in this area are higher than the VOC concentrations observed in monitor wells located directly downgradient of the GET E extraction wells. The available data suggest the offsite VOCs are not migrating through the GET E extraction

wells. These VOCs may have been present prior to operating the GET E extraction wells or they may have originated at one or more of the offsite sources that have been documented in this area (HSI GeoTrans, 1999b). Improved analytical detection limits have recently shown that relatively low levels of perchlorate and NDMA are likely migrating offsite northwest of the capture zone for GET E. In addition, there is the potential that there are offsite sources of perchlorate and NDMA other than from the Aerojet site or the IRCTS. For example, perchlorate appears to have been a common constituent of nitrate fertilizers (ES&T, 1999). NDMA appears to have been associated with various industrial and food processing industries and has been a contaminant in foods (ATSDR, 1989).

Trichloroethlyene (TCE), tetrachloroethylene (PCE), chloroform, perchlorate, nitrate, and NDMA have been detected in public water supply wells owned and operated by Arden-Cordova Water Service, Sacramento County, and Mather Air Force Base (currently operated by Sacramento County) west and northwest of the Aerojet Site and the IRCTS. Eight public water supply wells in the Study Area have been removed from service since March 1997 because of reported concentrations of perchlorate or NDMA in the wells. Aerojet currently monitors public water supply wells pursuant to the requirements of the PCD (Exhibit IV Groundwater Monitoring Plan (Aerojet, 1999)).

The following sections describe the distribution of CoPCs in the Study Area by hydrostratigraphic layer. Composite CoPC plume maps were created showing the maximum extent of CoPCs in each layer where the CoPC concentrations exceeded the risk-based values identified in the Baseline Risk Assessment (Appendix B). VOCs were included in the composite plume maps if their concentration exceeded EPA or State of California Primary Maximum Contaminant Levels (MCLs). Perchlorate was included in the composite plumes where its concentration exceeded 18 µg/L. NDMA was included in the composite plume map anywhere it was detected as the current method detection limit for NDMA (0.0075 µg/L) exceeds the health-based risk concentrations (0.002 µg/L).

Layer A

The combined extent of CoPCs in Layer A is presented on Figure 1-5. The CoPCs depicted in Layer A are present at depths generally ranging from 60 to 140 feet bgs, and encompass an area measuring approximately 1.5 square miles. CoPCs from the Aerojet facility originate from manufacturing areas located in Lines 01, 03, 04, 05, and Chemical Plants 1 and 2. The extent of CoPC in Layer A would be substantially greater if these source areas were included; however, most of the source areas are located east of the Study Area boundaries and will be addressed in the RI/FS at a later time.

The combined CoPC plume map for Layer A is comprised primarily of TCE, perchlorate, and NDMA (Figure 1-6). Additional CoPCs present above MCLs in the combined CoPC plume, but not contoured individually, included 1,2-DCA and chloroform.

The results from onsite source area investigations (principally the Stage I RI) suggests vadose zone and groundwater contamination in the source areas provides a continuing source of CoPCs to groundwater. Residual non-aqueous phase liquid (NAPL) TCE, 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethane (1,2-DCA), and 1,1,2-trichloroethane (1,1,2-TCA) are suspected to be present at various source sites located in Lines 01, 03, 04, 05, and Chemical Plants 1 and 2 (ICF Kaiser, 1993). Perchlorate is present in vadose zone soils in Lines 01, 03, 04, and 05. The highest CoPC concentrations in groundwater were detected in the vicinity of source areas with vadose zone contamination.

The highest concentrations of TCE (240,000 µg/L) and perchlorate (100,000 µg/L) were detected in monitor wells located in Line 03, approximately 4000 feet east (upgradient) of GET F. Downgradient concentrations of TCE (50 µg/L) and perchlorate (400 µg/L) at GET F are several orders of magnitude lower than those observed in Line 03. The decrease in CoPC concentrations onsite over a relatively short distance is primarily due to the downward migration of CoPCs into underlying Layer B.

The CoPCs that remain in Layer A have not migrated to the western offsite area. The offsite CoPC migration is inhibited by extraction wells screened in Layer A at GET F, and by relatively strong downward vertical head potentials from Layer A to underlying Layer B. TCE and related breakdown products (1,2-DCE, 1,1-DCE, and vinyl chloride) were detected offsite in Well 30065. Groundwater flow data and the suite of chemicals detected in this well indicate there is a separate source area unrelated to Aerojet activities near this monitor well (Appendix A, Section 3.1.7).

Layer B

The combined extent of CoPCs in Layer B is presented on Figure 1-7. The CoPCs depicted are generally present at depths ranging from 78 to 170 feet bgs and generally increase in depth from east to west across the Study Area. The area of the combined CoPC plume in Layer B measures approximately two square miles on the Aerojet Site, and slightly over one square mile on the IRCTS. This area does not include source areas located east of the Study Area boundaries. The stratigraphic characteristics of Layer B change west of the Aerojet Site and the IRCTS, and CoPCs present in Layer B at these locations appear to migrate vertically into underlying Layer C.

The combined CoPC plume map for Layer B is comprised primarily of TCE, perchlorate, and NDMA (Figure 1-8). Additional CoPCs present above MCLs in the combined CoPC plume, but not contoured individually, include 1,1-DCE, 1,2-DCE, carbon tetrachloride, chloroform and nitrate. The four VOCs were detected in a single monitoring well on the Aerojet Site located adjacent to an extraction well at GET F.

The combined CoPC plume east of the GET E and F extraction wells is comprised predominantly of TCE and perchlorate, although NDMA was detected in several monitor wells (Figure 1-8). Chemical and hydraulic gradient data indicate these constituents

migrated from sources located near the manufacturing line areas and chemical plants, through Layer A, and into Layer B.

The combined CoPC plume in the vicinity of and west of the recharge well field is comprised entirely of perchlorate. The absence of VOCs in this area and the presence of a recharge well partially screened in Layer B (Well 5100) indicate this portion of the plume originated from the recharge well field. The perchlorate treatment added to GETs E and F in December 1998 and August 1999, respectively, eliminate recharge as a source of perchlorate.

On that portion of the groundwater within the IRCTS evaluated as part of this Study area, the combined CoPC plume is comprised of CoPCs that originated at the Former GET F Sprayfield, the Aerojet Operating Plant andthe joint propellant burn area. Layer A is dry on the IRCTS and Layer B is the shallowest saturated layer.

Layer C

The combined extent of CoPCs in Layer C is presented on Figure 1-9. The CoPCs depicted are present at depths ranging from approximately 100 to 350 feet bgs, and increase in depth from east to west across the Study Area. The combined extent of CoPCs in Layer C is the most aerially extensive of any of the combined CoPC plumes and encompasses an area measuring approximately 9 square miles.

The combined CoPC plume for Layer C is primarily comprised of TCE, perchlorate, and NDMA (Figure 1-10). Additional CoPCs present above MCLs in the combined CoPC plume, but not contoured individually, include 1,2-DCA, chloroform and nitrate. These three compounds were detected in monitor wells located on the Aerojet Site upgradient of the GET E and F extraction wells.

Perchlorate and TCE comprise the majority of the CoPCs detected on the Aerojet Site, although NDMA was detected in a few monitor wells near Chemical Plant 1 and the Westlake area. Perchlorate and NDMA appear to have migrated offsite northeast of the existing GET E extraction wells. Aerojet is proposing additional extraction wells in this area.

Perchlorate is the predominant CoPC present in the western offsite area. The TCE and NDMA concentrations that exceed health-based criteria are encompassed by the 18-µg/L contour for perchlorate. NDMA is currently characterized using an MDL of 0.0075 µg/L.

The current distributions of perchlorate and NDMA in the western offsite area are primarily due to recharge from the GET E and F recharge well field. The addition of perchlorate and NDMA treatment at GETs E and F is eliminating this source.

The majority of chemical impacts to public water supply wells appear to be from CoPCs migrating through Layer C, although, CoPCs present in Layer D may also be contributing to the public water supply wells closest to Aerojet (e.g., AC15 and AC16). The majority of public water supply wells in the Study Area are open boreholes with sanitary surface seals. It may be beneficial to evaluate the individual borehole flow characteristics for some public water supply wells to determine if sealing portions of the boreholes may prevent CoPCs from entering some of these wells.

Layer D

The combined extent of CoPCs in Layer D is presented on Figure 1-11. The CoPCs depicted are present at depths ranging from approximately 160 to 410 feet bgs, and increase in depth from east to west across the Study Area. The area of the combined CoPC plume emanating from the Aerojet Site is approximately 4.6 square miles. An additional area measuring approximately ½ square mile is present on the IRCTS.

The combined CoPC plume in Layer D on the Aerojet Site is defined primarily by the extents of perchlorate and TCE (Figure 1-12). Additional CoPCs present above MCLs on the Aerojet Site, but not contoured individually, include 1,1-DCE, 1,2-DCA, 1,2-DCE, and chloroform. NDMA, perchlorate, and TCE were detected west of Westlake in the vicinity of the GET E extraction wells. TCE and perchlorate were detected in the vicinity of GET F. There are no extraction wells screened in Layer D at GET F, although vertical head potentials suggest there is the potential for CoPCs present in Layer D to be drawn upwards into Layer C.

In the western offsite area, perchlorate and NDMA comprise the majority of the CoPC plume. TCE was detected up to 8.5 µg/L in a few monitor wells located offsite, several hundred feet west of the GET E extraction wells. The perchlorate and NDMA present northwest of the GET E extraction wells and west and southwest of the GET E and F recharge well field appears to have originated at the recharge well field. The CoPCs emanating from the recharge wells in Layer D have not migrated as far west as the CoPCs emanating from the recharge wells in overlying Layer C.

Perchlorate and TCE are also present in a relatively small area in Layer D on the IRCTS. This portion of the CoPC plume probably represents CoPCs that have migrated vertically downward from overlying Layer C. The southern and eastern extent of perchlorate in Layer D that is south and east of the Study Area appears to be from other sources and is being evaluated under a separate CAO.

Layer E

The combined extent of CoPCs in Layer E is presented on Figure 1-13. The CoPCs depicted are present at depths ranging from approximately 300 to 500 feet bgs, and

increase in depth from east to west across the Study Area. The CoPCs in Layer E encompass an area measuring approximately 1 square mile.

The combined CoPC plume in Layer E can be divided into northern and southern areas based on the sources of chemical to each area. The northern elongated portion of the combined CoPC plume is located along the northwestern Aerojet boundary and extends approximately 4,500 feet offsite. This portion of the plume is comprised of TCE, perchlorate, and NDMA that are emanating from source areas located east of GET E (i.e., Line 05, Chemical Plant 1)[Figure 1-14]. There are no extraction wells in Layer E at this location, however, upward vertical head potential from Layer E to Layer D, suggest the extraction wells screened in Layer D are maintaining some control over offsite migration, which is supported by the relatively low CoPC concentrations detected downgradient.

The southern portion of the combined CoPC plume in Layer E is centered around the GET E and F recharge well field and is comprised of perchlorate and NDMA. The absence of TCE in this area indicates the perchlorate and NDMA originated at the recharge well field. The CoPCs from the recharge well field have not migrated as far to the west as the CoPCs in overlying Layer D. Neither of these constituents were detected offsite west of the recharge well field in Layer E.

1.4 Baseline Risk Assessment

A Baseline Risk Assessment (BRA) was prepared for the Western Groundwater Study Area. The purpose of the BRA is to evaluate potential site-specific human health risks associated with hypothetical exposure to chemicals detected in groundwater in the Study Area. Specifically, chemical propellants and solvents have been detected in groundwater samples collected from on- and offsite wells. The risk assessment was conducted assuming that through use of private domestic water supply wells, future residents could potentially contact groundwater containing these chemicals. For purposes of the risk assessment, it was assumed that the groundwater that could be contacted by potential future residents would contain the same concentrations as those detected in the current offsite groundwater plume; that is a no action scenario that assumes no future site remediation measures are implemented.

This assessment was completed according to the DTSC Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities Guidance Manual (DTSC 1992) and U.S. Environmental Protection Agency's (EPA) Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Part A (EPA 1989). Exposure assumptions for estimates of chemical intake were based on information presented in those documents as well as: DTSC Preliminary Endangerment Assessment (DTSC 1994); Exposure Factors Handbook (EPA 1997a); EPA Region IX Preliminary Remediation Goals (PRGs) (EPA 1999); and Risk Assessment Guidance for Superfund, Volume I, Part B (EPA 1991). Information on chemical toxicity was obtained from Integrated Risk Information System (IRIS) (EPA

2000) and the Toxicity Criteria Database from the Office of Environmental Health and Hazard Assessment (OEHHA), California EPA (OEHHA, 2000).

The baseline human health risk assessment follows the EPA risk assessment paradigm (EPA 1989) and consists of the following components:

- Data evaluation and identification of chemicals;
- Exposure assessment;
- Toxicity assessment; and
- Risk characterization.

The maximum concentration of each detected chemical was screened against EPA Region 9 PRGs to determine whether it should be retained as a CoPC, as described in EPA guidance (EPA, 1999). All chemicals whose maximum detected concentration exceeded its PRG were retained as a CoPC and evaluated in the risk assessment. With the exception of perchlorate, nitrate and nitrite, all inorganic chemicals were considered to be present at naturally occurring concentrations and were not included in the risk assessment

Risks were calculated based on the concentrations of each chemical as depicted by the plume isopleths. Chemicals for which a plume map was created were those most frequently detected, and those that were not laboratory contaminants. Therefore, plume maps were created for TCE, NDMA, and perchlorate. The plume maps were used as the exposure point concentrations for TCE, NDMA, and perchlorate in addition to the maximum detected concentration of each chemical detected in each hydrostratigraphic layer.

Some of the chemicals were detected too infrequently to create a plume map, but were considered potentially site related. These chemicals were evaluated for each hydrostratigraphic layer using the maximum detected concentrations from the most recent 2 years of monitoring. The following chemicals were evaluated in this manner: 1,1,2-tetrachloroethane (1,1,2-TCA) 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichoroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), carbon tetrachloride, chloroform, freon-113, nitrate, nitrite, tetrachloroethene (PCE) and vinyl chloride.

The exposure assessment for the Western Groundwater plume included the following steps:

- Characterization of the exposure setting(s) and identification of potential future receptors;
- Identification of exposure pathways and exposure routes;

- Estimation of exposure point concentrations; and

- Quantification of chemical intake for pathway specific exposures for each potential receptor.

Following EPA guidance (1989a), all complete exposure pathways were selected for evaluation unless:

- Exposure from the pathway is likely to be much less than that from another pathway involving the same medium of the same exposure point;

- The potential magnitude of exposure from a pathway is likely to be very low; or

- The probability of the exposure occurring is very low and the risks associated with the pathway are low.

No exposure to groundwater onsite currently exists as water used on site is supplied by the City of Folsom from surface water sources. Future onsite exposures were evaluated assuming that the land could be developed for residential uses and assuming that individual residents install private wells for domestic potable water supply. Offsite groundwater is currently used by water purveyors for residential supply. Potential exposure to CoPCs through contact with offsite groundwater supplied by the various water purveyors is assessed by water quality monitoring pursuant to the Exhibit IV monitoring plan under the PCD. The water purveyors, in conjunction with the California DHS, determine when a water supply well should be taken out of service. Private wells also exist in the offsite areas, typically used for non potable purposes (e.g. agricultural). Future use of offsite groundwater was evaluated assuming individual private water supply wells may be installed in the plume area.

Exposure pathways evaluated in the risk assessment included ingestion and dermal contact with groundwater containing CoPCs. (The BRA also evaluated the inhalation risk for volatile chemicals.) Exposure point concentrations were estimated from plume maps prepared for each hydrostratigraphic layer (Appendix B, Figures B-2 through B-19). The range of concentrations of CoPCs in the groundwater plumes onsite and offsite ranged from 4 to 4,000 ug/L for perchlorate, 0.01 to 1. 0 ug/L for NDMA and 5 to 5,000 ug/L for TCE. Potential intake of these and other CoPCs were estimated for the ingestion, dermal contact and inhalation (volatile chemicals only) pathways using EPA and DTSC default values for exposure frequency, exposure duration, contact rate, body weight and averaging time. The maximum concentration of each CoPC in each hydrostratigraphic layer was also evaluated in the risk assessment.

Toxicity information and EPA and DTSC-derived toxicity values were obtained for each of the CoPCs and included information regarding potential carcinogenic as well as potential non-carcinogenic effects. For chemicals which are deemed to be potential carcinogens, such as NDMA and TCE, the calculated intake was evaluated using carcinogenic slope factors that corresponded to the specific routes of exposure to estimate

the additional lifetime cancer risk corresponding to the estimated chemical intake. Non-carcinogenic effects were evaluated for all of the chemicals through comparison of potential intake to each chemical's published reference dose; that is the daily intake at which no adverse health effects are expected to occur even in sensitive receptors. The ratio of the estimated intake to each individual chemical's reference dose were calculated to develop a hazard quotient and the hazard quotients for each pathway were summed to develop a hazard index for each chemical. The chemical specific hazard indices were summed when plumes overlapped to provide a total hazard index. For perchlorate, there is uncertainty regarding the appropriate reference dose. Perchlorate toxicity is currently undergoing extensive evaluation by the United States Environmental Protection Agency and the Agency is anticipating receipt of further animal and human studies before selection of a final reference dose (Rfd) for perchlorate. A provisional "action" level of 18 ppb was developed by DHS, based upon an earlier provisional Rfd developed by EPA. Since then, EPA has considered modification of the provisional Rfd and had proposed a 32 ppb level, which was commented upon by an external panel. The BRA uses the 32 ppb level to evaluate risks.

Calculated risks associated with potential future use of groundwater that might be obtained from each of the hydrostratigraphic layers beneath the onsite area were developed as part of the risk characterization effort. The maximum risk values reported below were derived by calculating the risk from the maximum concentration of the CoPC detected over the two-year sampling period and are not indicative of the actual CoPC concentrations that would be expected if the groundwater were extracted. The calculated potential carcinogenic and non-carcinogenic risks associated with each of individual chemicals present in each of the hydrostratigraphic layers beneath the onsite area were as follows:

Summary of Potential Risks due to Hypothetical Groundwater Use from the Onsite Area

Layer	Chemical	Potential Additional Lifetime Carcinogenic Risk	Hazard Indices
A	TCE	1.0×10^{-6} to 1.7×10^{-5}	0.025 to 0.41
	Perchlorate	NA	0.22 to 4.1
	NDMA	2.4×10^{-6} to 3.9×10^{-5}	NA
B	TCE	1.0×10^{-6} to 1.9×10^{-3}	0.025 to 47
	Perchlorate	NA	0.022 to 604
	NDMA	2.4×10^{-6} to 7.7×10^{-5}	NA
C	TCE	2.1×10^{-7} to 1.1×10^{-3}	0.005 to 26
	Perchlorate	NA	0.22 to 450
	NDMA	2.4×10^{-6} to 9.4×10^{-5}	NA
D	TCE	1.0×10^{-6} to 3.1×10^{-4}	0.025 to 7.5
	Perchlorate	NA	0.22 to 480
	NDMA	2.4×10^{-6} to 3.1×10^{-4}	NA
E	TCE	1.0×10^{-6} to 1.8×10^{-5}	0.025 to 0.4
	Perchlorate	NA	0.22 to 33
	NDMA	2.4×10^{-6} to 9.2×10^{-5}	NA

NA – Not applicable

Areas of potentially higher risks were also identified in the areas where the individual chemical plumes overlap.

Comparison of the calculated risk to EPA's accepted risk range of 10^{-6} to 10^{-4} for potential additional lifetime cancer risk and a hazard index of 1, indicates that TCE occurrences in the B and C layers beneath the onsite area exceed the NCP specified acceptable risk range for both carcinogenic and non-carcinogenic effects. NDMA occurrences in Layer D onsite exceed the NCP specified acceptable risk range for carcinogenic effects. Comparison of the calculated risk to the hazard indices, indicates that perchlorate levels onsite could result in a hazard index greater than one and thus potentially represent an unacceptable risk.

Additional chemicals retained as CoPCs for the onsite areas because their maximum detected concentration exceeded EPA Region IX PRGs include: 1,1,2-TCA, 1,2-DCE, PCE, nitrate, and nitrite in Layer A; 1,1,2-TCA, 1,1-DCE, 1,2-DCE, carbon tetrachloride, chloroform, PCE, and nitrate in Layer B; 1,1-DCE, 1,2-DCA, carbon tetrachloride, chloroform, and PCE in Layer C, and 1,1-DCE, 1,2-DCA, chloroform, and PCE in Layer D.

Calculated risks associated with potential future use of groundwater that might be obtained from each of the hydrostratigraphic layers beneath the offsite area were developed as part of the risk characterization effort. The maximum risk values reported below were derived by calculating the risk from the maximum concentration of the CoPC detected over the two-year sampling period and are not indicative of the actual CoPC concentrations that would be expected if the groundwater were extracted. The calculated potential carcinogenic and non-carcinogenic risks associated with each of individual chemicals present in each of the hydrostratigraphic layers beneath the offsite areas were as follows:

Summary of Potential Risks due to Hypothetical Groundwater Use from the Offsite Area

Layer	Chemical	Potential Additional Lifetime Carcinogenic Risk	Hazard Indices
C	TCE	2.4×10^{-7} to 1.8×10^{-5}	0.005 to 0.44
	Perchlorate	NA	0.22 to 480
	NDMA	2.4×10^{-6} to 6.0×10^{-5}	NA
D	TCE	1.0×10^{-6} to 3.1×10^{-6}	0.025 to 0.074
	Perchlorate	NA	0.22 to 33
	NDMA	2.4×10^{-5} to 1.0×10^{-4}	NA
E	TCE	1.0×10^{-6} to 4.6×10^{-5}	0.025 to 1.1
	Perchlorate	NA	0.22 to 22
	NDMA	2.4×10^{-6} to 1.9×10^{-5}	NA

NA – Not applicable

Areas of potentially higher risks were also identified in the areas where the individual chemical plumes overlap.

Comparison of the calculated risk to EPA's accepted risk range of 10^{-6} to 10^{-4} for potential additional lifetime cancer risk indicates that carcinogenic risks for individual plumes are within the range of acceptable levels for all carcinogenic CoPCs. Comparison of the calculated risk to the hazard indices, indicates that perchlorate levels offsite in Layers C, D, and E, and TCE in Layer E could result in a hazard index greater than one and thus potentially represent an unacceptable risk.

Additional chemicals retained as CoPCs for the offsite areas because their maximum detected concentration exceeded EPA Region IX PRGs include: 1,1-DCE, chloroform, nitrate, and nitrite in Layer C, and vinyl chloride in Layer D.

Various uncertainties or possible biases associated with the risk assessment were also identified. Uncertainty or possible bias may be associated with the individual sample analyses and other sampling or measurement uncertainties, unknown future land and groundwater uses, use of upper-bound values for ingestion, inhalation and dermal contact rates, and use of default values for exposure duration, all which may result in conservative estimates for the exposure point concentrations and intake values. Uncertainties and conservative safety factors associated with the carcinogenic and noncarcinogenic toxicity values developed based on laboratory animal studies were also identified that may result in conservative estimates of the actual toxic effects that may result from potential exposure to the chemicals.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

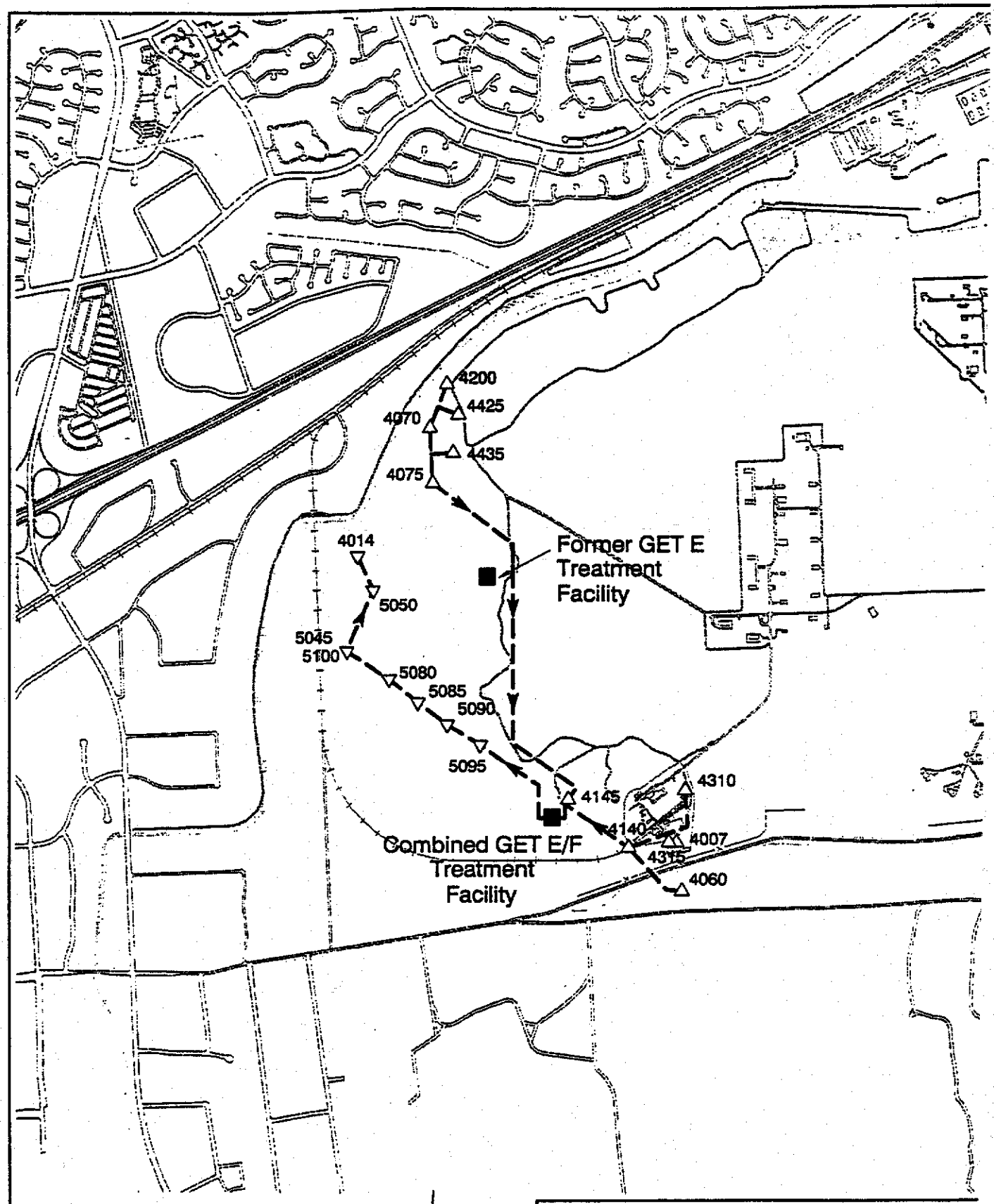

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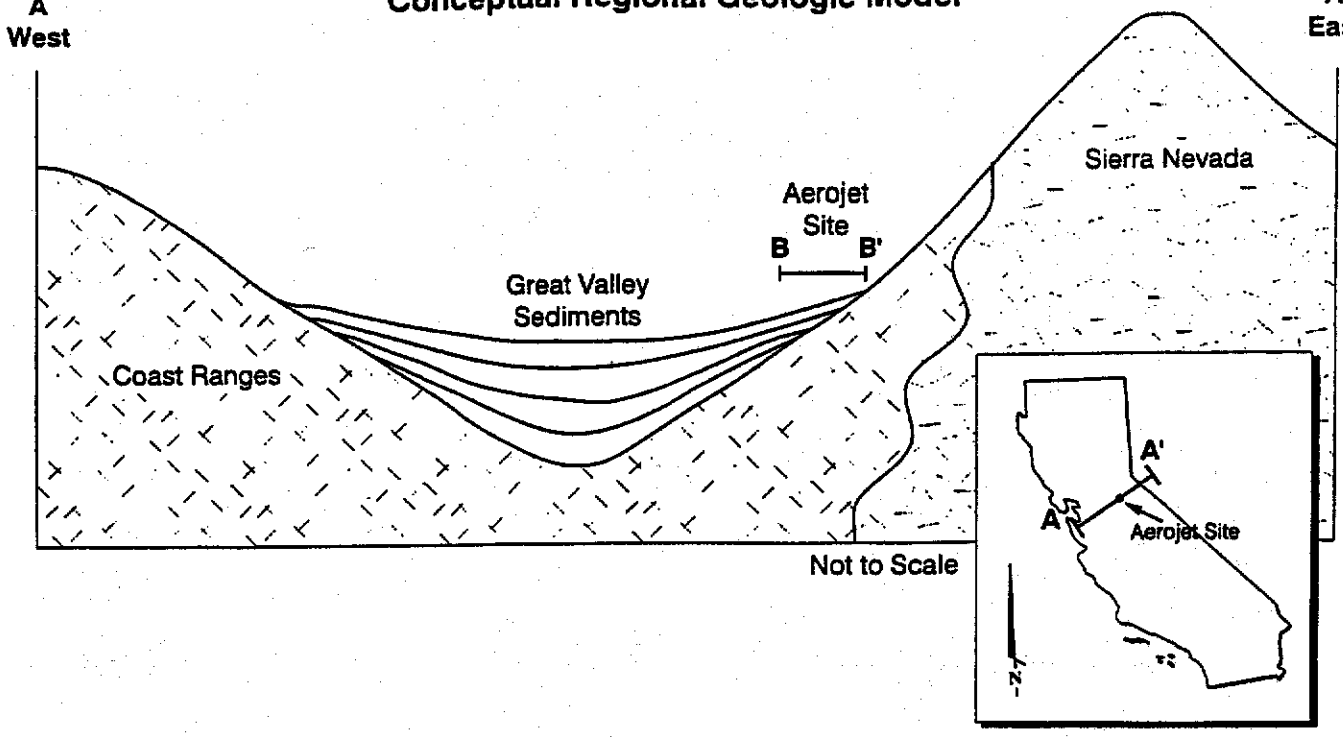
FIGURE 1-2

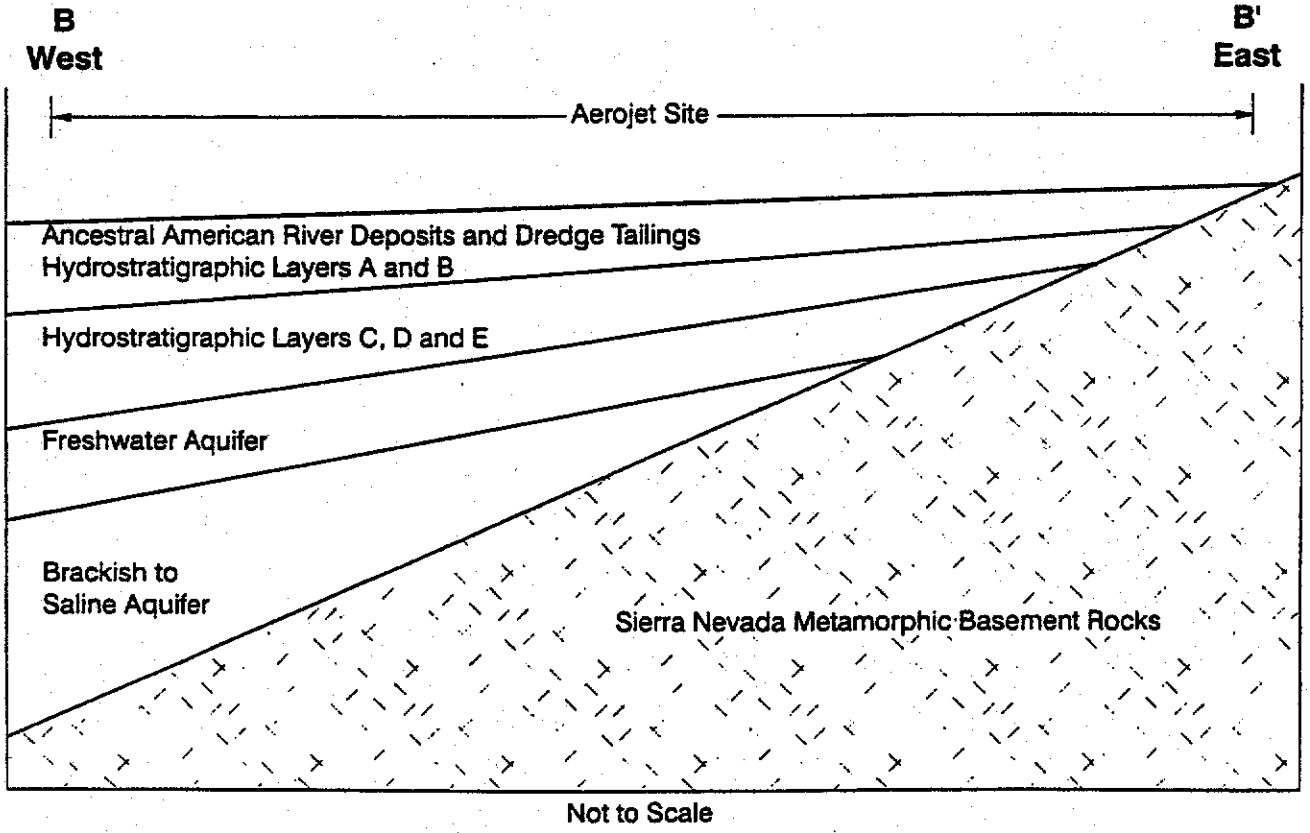
Western Groundwater Study Area
Existing On-site Containment Facilities

4/13/00 ah SR10109547

Conceptual Regional Geologic Model

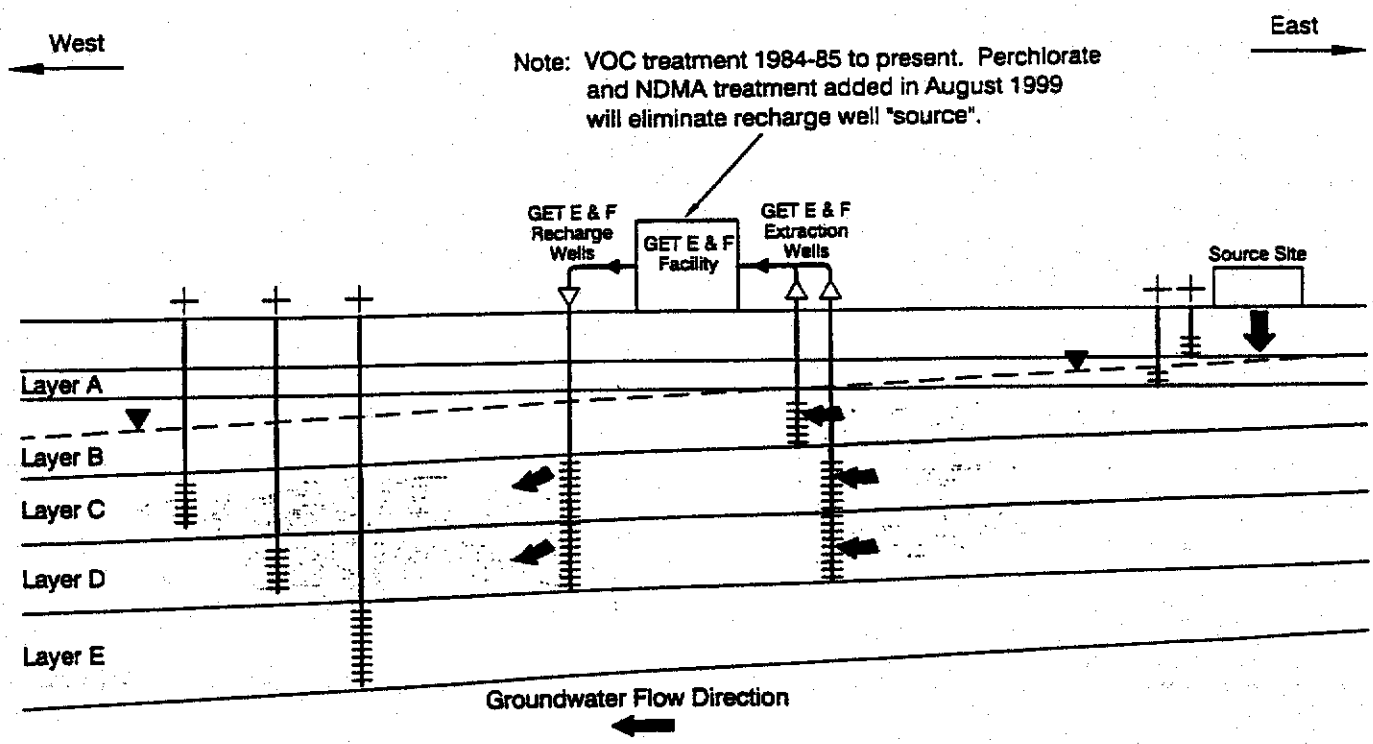


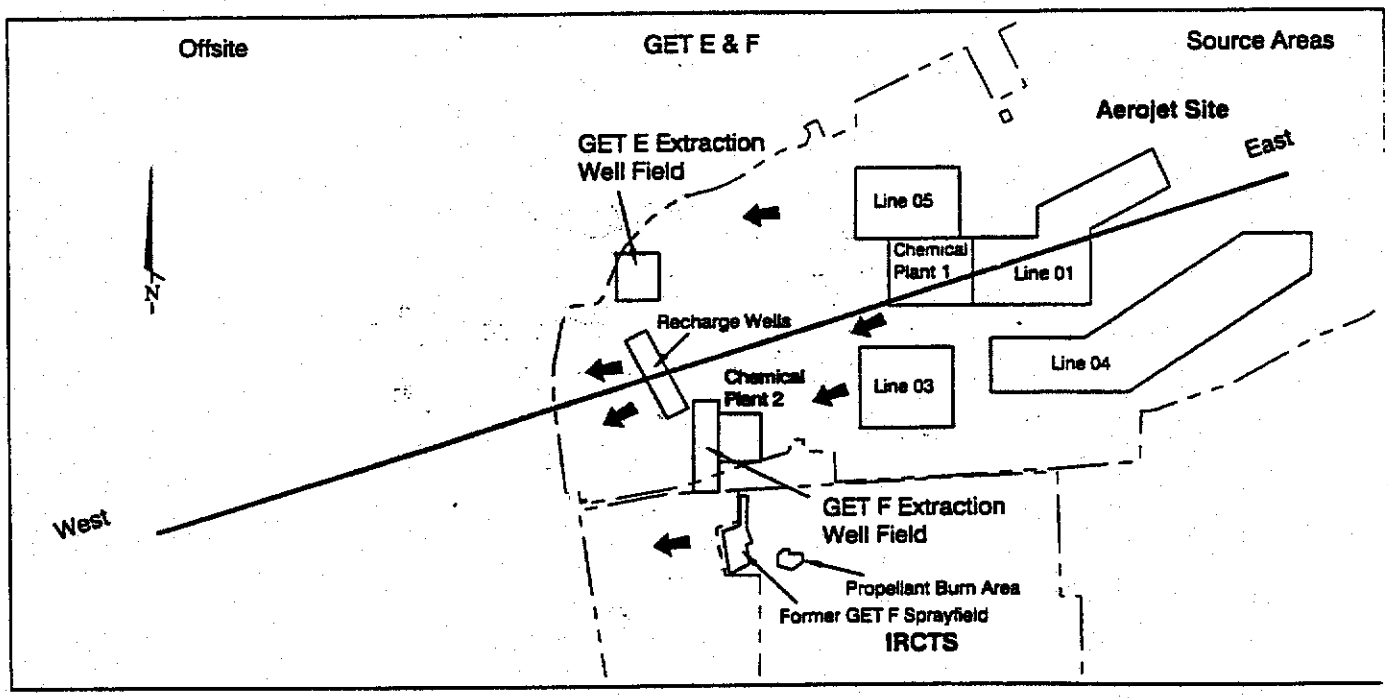
Conceptual Regional Hydrogeologic Model



AEROJET
Environmental Remediation

FIGURE 1-3
Western Groundwater Study Area
Conceptual Regional Geologic and Hydrogeologic Models





Approximate Area of Schematic
(Scale: 1" = 6,000')

EXPLANATION

Dissolved phase contaminants. Shown for illustration purposes only, does not depict contaminant type, concentration, depth, or exact location.

Conceptual Water Table

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Environmental Remediation

FIGURE 1-4

Western Groundwater Study Area
Conceptual Migration of CoPCs
in Groundwater

PAGES OF OVERSIZED MAPS

(SEE BINDER)

2 REMEDIAL ACTION OBJECTIVES, POTENTIAL ARARS and PRELIMINARY REMEDIAL ACTION GOALS

This section describes proposed remedial action objectives (RAOs) for the Western Groundwater OU. This section also presents a summary of potentially applicable or relevant and appropriate requirements (ARARs). Preliminary remedial action goals (PRAGs) are developed based on the potential ARARs described below and the risk-based levels presented in the Baseline Risk Assessment.

2.1 Remedial Action Objectives

The initial step in identifying and screening remedial alternatives is to formulate RAOs. RAOs are media-specific goals designed to protect human health and the environment. RAOs specify the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of alternatives to be developed on the basis of chemical-specific ARARs and site-specific risk-related factors.

The only media of concern for the Western Groundwater OU is groundwater. As discussed in the RI and summarized in the previous section of this FS, the contaminants of concern include chlorinated VOCs, perchlorate, NDMA, and nitrate. The only potential future exposure pathways are associated with potential ingestion of contaminated water that may enter drinking water supply wells located downgradient of the Site and inhalation of VOCs that may volatilize from the water.

The overall goal of any remedial alternative is to protect human health and the environment. In order to achieve this goal for the Western Groundwater Study Area, the following RAOs were identified:

- Protect human health and the environment from exposure to contaminated groundwater;
- Minimize offsite migration of CoPCs where practicable to protect long term beneficial uses;
- Reduce contaminant concentrations in already contaminated groundwater in an efficient cost-effective manner; and
- Protect public drinking water wells and provide treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels.

2.2 Potential ARARs

Section 121(d) of CERCLA states that remedial actions on CERCLA sites must attain (or justify the waiver of) any federal or more stringent State environmental standards, requirements, criteria, or limitations that are applicable or relevant and appropriate requirements (ARARs). Applicable requirements are those cleanup standards, criteria, or limitations promulgated under federal or State law that specifically address the type of situation present at a particular CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or State law that while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are well-suited to the conditions of the particular site.

Pursuant to EPA guidance, ARARs generally are classified into three categories: chemical-specific, location-specific, and action-specific requirements. Chemical-specific ARARs include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. Location-specific ARARs are those requirements that relate to the geographical or physical position of the site, rather than the nature of the CoPCs or the proposed site remedial actions. Action-specific ARARs are requirements that define acceptable handling, treatment, and disposal procedures for hazardous substances.

A requirement may not meet the definition of an ARAR, but still may be useful in assessing whether to take action at a site or to what degree action is necessary. This can be particularly true when there are no ARARs for a site, action, or contaminant. Such requirements are called to-be-considered (TBC) criteria. TBC criteria are nonpromulgated advisories or guidance issued by a federal or State government that are not legally binding, but that may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they are considered together with ARARs to establish the required level of cleanup for protection of human health or the environment. The critical difference between a TBC and an ARAR is that one is not required to comply with or meet a TBC when deciding on a remedial action. However, should a TBC be established as a cleanup standard in the ROD, then the TBC effectively produces the same results as an ARAR.

Tables 2-1, 2-2 and 2-3 present a summary of the evaluation of potential chemical-specific, location-specific and action-specific ARARs for the Western Groundwater OU. The complete evaluation of potential ARARs is contained in Appendix C.

2.3 Preliminary Remedial Action Goals

Preliminary Remedial Action Goals (PRAGs) are chemical concentrations in groundwater that, if contained in groundwater extracted by water purveyors, would achieve the levels of protection identified by MCLs or otherwise within risk ranges that have been identified in the risk assessment or through TBCs. PRAGs are termed preliminary remediation goals (PRGs) in EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA". In this FS document, these values are referred to as PRAGs to avoid potential confusion with the EPA Region 9 Preliminary Remediation Goals which represent screening level values for use in scoping or conducting site assessments and risk assessments.

PRAGs for the Western Groundwater OU were developed based on risk-based factors (i.e., exposure pathways, exposure assumptions, and toxicity factors) as presented in the Baseline Risk Assessment (BRA) and/or chemical-specific ARARs or TBCs (Table 2-4). PRAGs do not represent final remediation goals or cleanup levels to be achieved by remedial action. Cleanup levels to be achieved through remedial action will be defined during the remedy selection process.

For evaluating and comparing the alternatives that were developed to address CoPCs in groundwater in the Western Groundwater Study Area, PRAGs were based on risk-based criteria from the BRA and potential chemical-specific ARARs. The risk-based levels were identified using the exposure factors in the BRA and represent the lower of the concentrations reflective of a hazard quotient of 1.0 for noncarcinogenic chemicals or an additional incremental lifetime cancer risk of 1×10^{-6} for carcinogenic chemicals (EPA, 1990b). EPA has established a risk range of between 10^{-4} to 10^{-6} as being within the acceptable risk range with 10^{-6} being used as a point of departure (EPA, 1990b). Selection of risk-based levels for carcinogenic effects was based on an additional incremental lifetime cancer risk of 1×10^{-6}. Although this value is at the lower end of the point of departure used by EPA, it was selected for purposes of assessing alternatives to be more conservative. As discussed more fully in this OU RI/FS, it is not expected that any of the alternatives will result in complete restoration of the aquifer to these levels.

Numerical PRAGs for the Western Groundwater OU are summarized on Table 2-5. Many of the chemicals presented on this table were only detected in a few monitoring wells or were only detected in onsite monitoring wells. As indicated in the BRA, the primary chemicals of concern for the offsite portion of the Western Groundwater OU are perchlorate, NDMA, and TCE.

Table 2-1: Summary of Potential Chemical-Specific Requirements

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Safe Drinking Water Act (40 CFR 141)	Establishes national drinking water standards in the form of Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)	Applicable – at the point groundwater is delivered to a drinking water distribution system. Relevant and Appropriate – for in situ groundwater that is or has a potential to be used for drinking water.	Applicable to water systems serving over 25 persons. Relevant and appropriate for smaller systems. Establishes MCLs that apply to many of the site-related chemicals (see also Table C-1).
CCR Title 22 Chapter 15, Section 64400 et seq.	Establishes California primary and secondary MCLs		All MCLs (organic, inorganic, etc.) are potentially applicable if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR)	Defines beneficial uses for surface water and groundwater in the basin. Establishes water quality objectives, including narrative and numeric standards, to protect the beneficial uses and water quality objectives (WQOs) of surface and ground waters in the region. Describes implementation plans and other control measures designed to ensure compliance with statewide plans and policies.	Groundwater uses and WQOs are potential TBCs for development of ground-water cleanup levels and remedial actions. These are also potential TBCs if the selected remedial action includes reinjection of treated water. Surface water uses and WQOs are potential TBCs if the selected remedial action includes discharge of treated water to surface water Basin Plan policies and procedures for establishment of cleanup levels are not TBCs as CERCLA sets methods for identification of cleanup levels at NPL sites	Specific portions of the Basin Plan that are TBCs include: • Beneficial uses of waters in the basin including: <u>Ground water</u> – municipal and domestic supply (MUN), – agricultural supply (AGR), – industrial service supply (IND) and – industrial process supply (PRO) <u>Surface water</u> – MUN, AGR, IND, – Recreation (REC) – Freshwater habitat (WARM) and (COLD), Wildlife habitat (WILD), Migration of aquatic organisms (MIGR), and Spawning (SPWN) • Water quality objectives to protect these uses including: <u>Ground water</u> – Numerical standards for bacteria, chemical constituents (MCLs), and radioactivity – Narrative standards for tastes and odors and toxicity <u>Surface water</u> – Numerical limits for bacteria, chemical constituents, dissolved oxygen, pH, radioactivity, salinity, temperature and turbidity – Narrative standards for biostimulatory substances, color, floating material, oil and grease, sediment, settleable material, suspended material, tastes and odor, and toxicity

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR) [cont.]			• Basin Plan also requires that any activity, including, but not limited to, the discharge of contaminated soils or waters or in-situ treatment or containment of contaminated soils or waters, must not result in actual water quality exceeding water quality objectives.
State Water Resources Control Board Resolution No. 88-63 "Sources of Drinking Water Policy" (contained in the RWQCB's Water Quality Control Plan)	Specifies that, with certain exceptions, all ground and surface waters must have the beneficial use of municipal or domestic water supply.	Potential TBC with respect to beneficial uses Potential TBC with respect to basis for exceptions from the general designations of beneficial uses	This policy is used by the Regional Water Board in determining beneficial uses for waters. The beneficial uses established in the Basin Plan are based on this policy. The beneficial uses in the Basin Plan represent a site-specific determination and therefore are more appropriate than this general policy. This policy also establishes the basis for exceptions to the general designation of beneficial uses.
State Water Resources Control Board Resolution No. 68-16 "Statement of Policy With Respect to Maintenance of High Quality of Waters in California " ("Anti-degradation Policy").	Requires that quality of high quality surface and ground waters be maintained to the maximum extent possible. Degradation of waters will be allowed only if : – It is consistent with the maximum benefit to the people of the state, – It does not unreasonably affect present and anticipated beneficial uses, and – It does not result in water quality less than that prescribed in RWQCB and SWRCB policies. If degradation is allowed, the discharge must meet best practicable treatment or control, which must prevent pollution or nuisance and result in the highest water quality consistent with maximum benefit to the people of the state.	–Potential TBC if the selected remedial action includes disposal of wastes into waters of the State	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
RWQCB, CVR Basin Plan "Antidegradation Implementation Policy"	Defines the RWQCB policy with respect to implementation of the SWB Antidegradation Policy contained in SWB Resolution 68-16	Potential TBC for disposal of wastes into waters of the State.	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.
RWQCB, CVR Basin Plan, "Policy for Application of Water Quality Objectives"	This policy requires achievement of water quality objectives at all points within a surface water or groundwater resource for which beneficial uses have been designated rather than just at the points of use. This policy also explains how the Regional Water Board applies numeric and narrative water quality objectives to ensure the reasonable protection of beneficial uses of water. This policy also explains how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high-quality waters.	WQOs are potential TBCs for development of ground-water cleanup levels and remedial actions. Also potential TBCs if the selected remedial action includes reinjection of treated water. Surface water WQOs are potential TBCs if the selected remedial action includes discharge of treated water to surface water	This policy requires maintenance of background water quality to comply with the antidegradation policy. This policy requires WQOs to be the least stringent limits to be imposed on water quality and indicates that background represents the most stringent limits to be imposed on ambient water quality. The Basin Plan includes both numeric and narrative water quality objectives. This policy explains how the RWQCB evaluates compliance with the narrative WQOs through use of other standards, criteria, advisories, etc. as presented in *"A Compilation of Water Quality Goals"*. To the extent that the methodology presented in this policy uses promulgated standards, criteria or limitations, the narrative standards represent potential ARARs. To the extent that the methodology in this policy uses non-promulgated criteria, advisories, or risk-based levels, this policy represents a TBC. This policy also presents a methodology for assessing compliance with the narrative WQO for toxicity. Similar to the other narrative standard, to the extent the toxicity methodology relies on promulgated standards it may be an ARAR and to the extent that it relies on non-promulgated values it is a TBC. Note: The toxicity assessment required by this policy will be addressed in more detail and precision in the Baseline Risk Assessment.

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
State Water Resources Control Board Resolution No. 92-49 (As amended April 21, 1994 and October 2, 1996) "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304" Also Title 23 CCR Chapter 22, Section 2907	Establishes requirements for investigation and cleanup and abatement of discharges. Among other requirements, dischargers must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality, or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of Title 23, CCR, Section 2550.4 requirements to groundwater cleanups.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	These policies and procedures require cleanup of a discharge and abatement of effects of past, current or possible discharges of waste that creates or threatens to create a condition of pollution or nuisance. These policies and procedures establish procedures for investigation, evaluation of cleanup and abatement alternatives, implementation of cleanup and abatement actions including conformance with Resolution No. 68-16. These policies and procedures require cleanup and abatement that promotes attainment of either background water quality, or the best water quality which is reasonable (but not greater than that prescribed in the Water Quality Control Plans and Policies adopted by the State and Regional Water Boards) if background levels cannot be restored. Note: These policies and procedures also address designation and implementation of containment zones, which are discussed in table C-### under potential action-specific requirements.
RWQCB, CVR Basin Plan, "Policy for Investigation and Cleanup of Contaminated Sites."	This policy establishes and describes the RWQCB required procedures for investigation and remediation of contaminated sites. This policy also describes the RWQCB requirements for cleanup levels for groundwater and soil contamination.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	This policy requires establishment of cleanup levels for groundwater based on: – Background concentrations – Water quality objectives – Concentrations that do not pose a significant risk to human health or the environment – Technologic and economic feasibility of attaining background. This policy requires achievement of background levels when feasible. Otherwise, this policy requires achievement of water quality objectives and risk-based levels that do not pose a significant risk to human health or the environment. This policy also requires compliance with groundwater cleanup levels throughout the pollutant plume.

Table 2-1. Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Title 23, CCR, Chapter 15, Section 2550.4.	This regulation presents procedures for identifying concentration limits for cleanup and abatement of discharges from facilities that treat, store or dispose of hazardous waste at Class I waste management units. SWB Resolution 92-49 also requires use of these regulations for development of cleanup levels other than background.	Potentially applicable for identification of ground water cleanup levels. As this regulation does not contain numeric standards, it is not a chemical-specific ARAR but may be an action-specific ARAR.	This regulation requires cleanup to background concentration levels, or a concentration limit greater than background if – It is technologically and economically infeasible to achieve background, and – The constituent will not pose a substantial present or potential hazard to human health or the environment as long as the concentration limit greater than background is exceeded. This regulation lists the various factors to be considered in setting a concentration limit greater than background. This regulation also requires concentration limits that are greater than background to be set at the lowest levels that are economically and technologically achievable.
"A Compilation of Water Quality Goals"	Provides guidance on selecting numeric values to implement narrative water quality objectives contained in the Basin Plan.	To Be Considered	This document is not a promulgated regulation and therefore in itself is not an ARAR but may be a TBC. This document should be considered in selecting appropriate numeric values to implement the narrative WQOs in the Basin Plan. The numeric values contained in the staff report may be ARARs or TBCs depending on the source of the values.
National Pollutant Elimination Discharge System (NPDES Permit)	These regulations set forth the requirements for discharge to surface water and the Establishment of numeric limits and monitoring requirements for such discharges.	Applicable – if the selected remedial action includes discharge of treated water to surface water.	Discharge of treated groundwater to surface water may require obtaining a new NPDES permit or revision of Aerojet's existing NPDES permit (see also Table C-2). The NPDES permit will specify the numeric standards required to be met in water that is to be discharged to surface water as well as the monitoring requirements for such a discharge.
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) Also Title 22 CCR Chapter 3 Section 12000 et seq.	These regulations identify chemicals known to cause cancer or reproductive toxicity. This act prohibits discharge or release of significant amounts of the identified chemicals.	The numeric limits and notification requirements are potentially relevant and appropriate if the selected remedial action includes use of treated groundwater as drinking water supply.	These regulations make it illegal to expose persons to significant amounts of chemicals known to cause cancer or reproductive toxicity without prior notification, or to discharge significant amounts of these chemicals to sources of drinking water. The numeric limits and notification requirements are applicable to the water suppliers at the point that groundwater is delivered to a water system for public consumption.

Table 2-1. Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) cont.	Significant amounts are generally defined as levels that pose no significant risk of cancer. For drinking water, significant levels are defined as California MCLs, drinking water action levels when MCLs don't exist, or discharge limits allowed by a Basin Plan or waste discharge permit.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge or reinjection of treated water.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge of treated water to surface water or reinjection of treated groundwater. The numeric limits and notification requirements are applicable to remedial actions, if any, that include use of treated water for municipal or domestic supply.
National Ambient Water Quality Criteria	Establishes water quality criteria, which are non-enforceable guidance developed under CWA §304 and are used by the State, in conjunction with designated use for a stream segment, to establish water quality standards under CWA §303.	Neither applicable nor relevant and appropriate for groundwater. Potentially relevant but likely not appropriate for discharge of treated water to surface water.	These criteria are published by EPA to protect human health and welfare and freshwater and marine aquatic life from pollutants in surface waters and therefore are not applicable to groundwater. Ambient water quality criteria are based on consumption of drinking water and aquatic organisms (primarily fish) and consumption of fish alone and therefore are not relevant to groundwater in the Western Groundwater OU. Although potentially relevant, ambient water quality criteria are not appropriate requirements as the RWQCB has adopted numeric standards for the surface waters in the area which represent site-specific water quality standards which are more appropriate requirements.
US EPA Region 9 Preliminary Remediation Goals (PRGs)	EPA has developed preliminary remediation goals that are risk-based levels that are used to screen sites that may require additional investigation or possible remediation. PRGs are also used to screen lists of site-related chemicals to identify potential chemicals of concern.	To Be Considered	EPA Region 9 PRGs are guidance levels, not promulgated standards, and therefore are not an ARAR; however, the PRGs may be TBCs for identification of potential groundwater cleanup levels.
California Department of Health Services (DHS) Drinking Water Action Levels	DHS has established action levels based mainly on health effects but in some cases based on organoleptic (taste and odor-based) values	To Be Considered	Action levels (ALs) are advisory to water suppliers and therefore would not be ARARs. They are potential TBCs for identifying potential groundwater cleanup levels. Of particular interest in this matter are the ALs for perchlorate and NDMA.

Table 2-1: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Public Health Goals (PHGs)	The California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA) has adopted PHGs for chemicals in drinking water. PHGs are levels of drinking water contaminants at which adverse health effects are not expected to occur from a lifetime of exposure.	To Be Considered	PHGs are non-enforceable risk-based goals and therefore are not ARARs but are TBCs for identifying potential groundwater cleanup levels.
EPA Integrated Risk Information System (IRIS)	A non-promulgated database of health effects that may result from exposure to various substances found in the environment.	To be considered	IRIS values were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.
EPA Drinking Water Health Advisories and NAS Suggested No Adverse Response Levels (SNARLs)	Non-promulgated values published by USEPA and the National Academy of Sciences for toxicity other than cancer or incremental cancer risk estimates	To be considered	EPA drinking water health advisories and incremental cancer risk estimates and NAS SNARLs and incremental cancer risk estimates were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.

Table 2-2: Summary of Potential Location-Specific Requirements

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Within floodplain	40 CFR Part 6, Appendix A, Fish and Wildlife Coordination Act (16 USC 661 et seq.), and 40 CFR Part 6.302	Require avoidance of adverse effects, minimization of potential harm, and restoration and preservation of natural and beneficial values of floodplains.	Potentially Applicable to any actions that may be conducted within the floodplain.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within 100-year flood plain	40 CFR 264.18(b) and 22 CCR 66264.18(b)	A RCRA facility located in a 100-year flood plain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	Potentially Applicable if groundwater treatment involves treatment or storage of hazardous wastes.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	National Archaeological and Historical Preservation Act (16 USC Section 469); 36 CFR Part 65	Alteration of terrain that threatens significant scientific, prehistoric, historic, or archaeological data may require actions to recover and preserve artifacts.	Potentially applicable if significant artifacts are encountered during construction	The proposed remedial alternatives will not alter or destroy any known prehistoric or historic archeological features west of the Aerojet Sacramento facility site. Areas west of the Aerojet Sacramento facility are essentially completely developed. However, because there is always a possibility that buried historic or prehistoric remains could be discovered during construction, this regulation would require action to recover and preserve artifacts.
Historic project owned or controlled by a federal agency	National Historic Preservation Act (NHPA) Section 106 (16 USC Section 470 et seq.); 36 CFR Part 800	Property included in or eligible for the National Register of Historic Places may require action to preserve historic properties.	Neither applicable nor relevant and appropriate	The anticipated remedial actions do not include any activities on properties included on, or eligible for inclusion on the National Register of Historic Places. If it is determined that properties subject to NHPA are present and could be impacted during the implementation of the remedial action, these requirements may be applicable and would require mitigation measures to protect or preserve such properties.

Table 2-2: Summary of Potential Location-Specific Requirements (continued)

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Critical habitat upon which endangered species or threatened species depend	Substantive portions of the Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR Part 200, 50 CFR Part 402 Substantive portions of the California Endangered Species Act Substantive portions of the Native Plant Protection Act	Requires action to conserve endangered species or threatened species, including consultation with the Department of the Interior, Fish and Wildlife Service.	Potentially applicable if critical habitat for endangered species could be affected during implementation of the selected remedy	Two endangered floral species are known to occur within Sacramento County: the Sacramento Orcutt grass (Orcuttia Viscida) and the Boggs Lake hedge hyssop (Gratiola Heterosepala). Four endangered wildlife species are expected to occur within 25 miles of the Aerojet Sacramento facility: Bald Eagle, Peregrine Falcon, Giant Garter Snake, and the Valley Elderberry Longhorn Beetle. The Aerojet Sacramento facility may be a habitat for the Burrowing Owl, a species of concern in California. Consultations between Department of Toxic Substances Control (DTSC) and Department of Fish and Game may be conducted if such species are affected by remedial actions.
Wetlands	40 CFR Part 6 Appendix A	Actions must be taken to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	Potentially applicable if any remedial action components are constructed in or otherwise affect wetland areas	Requires actions to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.
	Fish and Game Commission Wetlands Policy (adopted 1987) included in Fish and Game Code Addenda	Actions must be taken to ensure that "no net loss" of wetlands acreage or habitat value occurs. Actions must be taken to restore and enhance California's wetland acreage and habitat value.	TBC	This policy is not a regulatory program but may be considered a TBC criteria.
Areas affecting stream or river	Fish and Wildlife Coordination Act (16 USC 661 et seq.) and 40 CFR Part 6 §302	Restrictions on diversion, channeling or other activity that modifies a stream or river and affects fish or wildlife.	Potentially applicable to any remedial action components that may be constructed in or along a creek or river	Requires action to protect fish or wildlife.

Table 2-3: Summary of Potential Action-Specific Requirements

Action	Potential Requirement	Citation	Description	Preliminary ARAR Determination	Comments
Generation of waste from operation of a groundwater treatment plant	RCRA and State standards for identification and classification of hazardous wastes	40 CFR Part 261 and 22 CCR §66261	Establishes procedures and numeric limits for identification of characteristic hazardous wastes, listed hazardous wastes, and State-only (non-RCRA) hazardous wastes.	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the selected remedial action or operation of a groundwater treatment plant.
	RCRA Generator Standards – hazardous waste determination	40 CFR § 262.11 and 22 CCR §66262.11,	Requires waste generators to determine if wastes are hazardous wastes and establishes procedures for such determinations	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action or operation of a groundwater treatment plant.
Shipment of hazardous wastes for treatment or disposal offsite	RCRA Generator Standards – hazardous waste shipment	40 CFR § 262.30 – 33 and 22 CFR 66262.30 through 66262.33	Prior to transportation, containers should be packaged, labeled, marked, and placarded in accordance with RCRA and Department of Transportation requirements.	Potentially applicable	These requirements are applicable if containers are used to contain hazardous waste to be sent for offsite treatment or disposal.
	RCRA Generator Standards – hazardous waste accumulation	40 CFR § 262.34 and 22 CCR §66262.34	Specifies maximum amounts and maximum periods for accumulation of hazardous waste onsite under generator status	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action and operation of any groundwater treatment plant if these waste materials are hazardous wastes.
Discharge to surface water and/or reinjection of groundwater	Basin Plan – beneficial uses, WQOs and policies and procedures	SWB Resolution 68-16 ("Anti-degradation policy")	Requires maintenance of existing water quality that is better than that required by other policies.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
		SWB Resolution Nos. 68-16 and 92-49	Allow for the use of mixing zones as part of a determination of whether water quality is being maintained in the receiving water.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.

Table 2-3: Summary of Potential Action-Specific Requirements (cont.)

Action	Potential Requirement	Citation	Description	Preliminary ARAR Determination	Comments
	NPDES discharge requirements	40 CFR Parts 122 and 125 and 23 CCR 2235 et seq.	Establishes permit, treatment and monitoring requirements for discharges to surface water	Potentially applicable	This requirement is potentially applicable if the selected remedial action includes discharge of treated water to surface water.
Stormwater management	NPDES stormwater requirements	40 CFR Parts 122.26 23 CCR 2235 et seq.	Establishes permitting, monitoring, and pollutant control requirements for stormwater from industrial activities.	Potentially applicable	These requirements would be applicable if construction activities associated with the remedial action disturb an area of 5 acres.
Groundwater containment	Containment Zone (CZ) requirements	SWB Resolution No. 92-49 and related Containment Zone Application Requirements	Defines requirements to support use of a containment zone and for delineation and implementation of a containment zone for groundwater contamination.	Potential TBC	The SWB Resolution is potential TBC if the selected remedial action includes physical or hydraulic containment of contaminated groundwater. The Containment Zone Application Requirements are a TBC.
Groundwater extraction and treatment	Evaluation of alternatives for reuse of treated water	Basin Plan – wastewater reuse policy	Requires evaluation of potential water reuse options and identifies potential reuse options that should be considered prior to disposal of treated groundwater	Potential TBC	This policy is a potential TBC for remedial actions that include disposal of treated groundwater. This requirement is being addressed through consideration of the various remedial alternatives including potential groundwater reuse options as part the FS evaluation.
Use of treated groundwater for domestic use	Criteria for domestic use of impacted groundwater	DHS Policy Guidance for Direct Domestic Use of Extremely Impaired Source	Sets forth DHS policy for approval of use of treated groundwater for domestic use	TBC	This policy establishes criteria related to use of treated groundwater for domestic supply and is a TBC criteria for remedial actions that include wellhead treatment or other direct use of treated groundwater.

Table 2-4: Summary of Potential Chemical-Specific ARARs and TBCs for Contaminants of Potential Concern in Groundwater

Contaminant of Potential Concern	Federal Primary MCL (mg/L)	Federal MCLG (mg/L)	California Primary MCL (mg/L)	California DHS Action Levels (mg/L)	California Proposition 65 Levels (mg/L)[a]	California PHGs (mg/L)	USEPA Region 9 PRGs (mg/L)[b]
1,1,2-Trichloroethane	0.005	0.003	0.005	NA	0.005	NA	0.0002
1,1-Dichloroethane	NA	NA	0.005	NA	0.05	NA	0.81
1,1-Dichloroethene	0.007	0.007	0.006	NA	NA	0.01	0.000046
1,2-Dichloroethane	0.005	0	0.0005	NA	0.005	0.004	0.00012
1,2-Dichloroethene (cis)	0.07	0.07	0.006	NA	NA	NA	0.061
1,2-Dichloroethene (trans)	0.1	0.1	0.01	NA	NA	NA	0.12
Carbon tetrachloride	0.005	0	0.0005	NA	0.0025	NA	0.00017
Chloroform	0.1 [c]	0	0.1 [c]	NA	0.01	NA	0.00016
Freon-113	NA	NA	1.2	NA	NA	4	59
Tetrachloroethene	0.005	0	0.005	NA	0.007	NA	0.0011
Trichloroethene	0.005	0	0.005	NA	0.025	0.0008	0.0016
Vinyl chloride	0.002	0	0.0005	NA	0.0015	NA	0.00002
Perchlorate	NA	NA	NA	0.0018	NA	NA	0.018
NDMA	NA	NA	NA	0.00002	0.00002	NA	0.0000013
Nitrate [d]	10	NA	45 [e]	NA	NA	NA	NA
Nitrite [d]	1	NA	1	NA	NA	NA	NA
Total Nitrate and Nitrite [d]	10	NA	10	NA	NA	NA	NA

[a] Converted to concentration based on 2 liters per day consumption.
[b] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
[c] For total trihalomethanes (sum of bromoform, bromodichloromethane, chloroform, and dibromochloromethane).
[d] Expressed as N.
[e] Expressed as NO_3.
NA = not available.

Table 2-4: Summary of Potential Chemical-Specific ARARs and TBCs for Contaminants of Potential Concern in Groundwater (cont.)

Contaminant of Potential Concern	IRIS RfD as drinking water levels	IRIS $1x10^{-6}$ incremental cancer risk	EPA DWHAs or SNARLs – non-carcinogenic	EPA DWHAs or SNARLs – carcinogenic	NAS SNARLs – non-carcinogenic	NAS SNARLs - carcinogenic	Taste & odor thresholds
1,1,2-Trichloroethane	2.8	0.6	3				
1,1-Dichloroethane							
1,1-Dichloroethene	6	0.06	7		100		1,500
1,2-Dichloroethane		0.4	700 / 2,600	0.4		0.71	7,000
1,2-Dichloroethene (cis)			70				
1,2-Dichloroethene (trans)	140		100				260
Carbon tetrachloride		0.3	70 / 300	0.3	200	4.5	520
Chloroform		6	100 / 400	6		0.26 / 56	2,400
Freon-113	210,000						
Tetrachloroethene	70		2,000	0.7		3.6	170
Trichloroethene				3		1.5	310
Vinyl chloride			10 / 50	0.015		1.1	3,400
Perchlorate							
NDMA		0.0007					
Nitrate [d]	11,000		10,000				
Nitrite [d]	700		1,000				
Total Nitrate and Nitrite [d]							

Notes:
All values are in units of ug/L
[a] Converted to concentration based on 2 liters per day consumption.
[b] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
[c] For total trihalomethanes (sum of bromoform, bromodichloromethane, chloroform, and dibromochloromethane).
[d] Expressed as N.
NA = not available.

Table 2-5: Preliminary Remedial Action Goals (PRAGs)

Contaminant of Potential Concern	Risk-Based Concentration[1]		Potential Chemical-Specific ARAR or TBC		Preliminary Remedial Action Goal (PRAG)	
	Value[2]	Basis	Value[2]	Source	Value[2]	Comments
1,1,2-Trichloroethane	0.9	C	3	MCLG	0.9	Risk-based value is lower
1,1-Dichloroethane	11.2	C	5	California MCL	5	MCL is lower
1,1-Dichloroethene	0.11	C	6	California MCL	0.11 (0.5)	Risk-based value adjusted for laboratory PQL of 0.5 ug/L
1,2-Dichloroethane	1.4	C	0.5	California MCL	0.5	MCL is lower
1,2-Dichloroethene (cis)	350	NC	6	California MCL	6	MCL is lower
1,2-Dichloroethene (trans)	700	NC	10	California MCL	10	MCL is lower
1,2-DCE (total)	320	NC			320	Only a risk-based level is available
Carbon tetrachloride	0.43	C	0.5	California MCL	0.43 (0.5)	Risk-based value adjusted for laboratory PQL of 0.5 ug/L
Chloroform	2.1	C	10	Proposition 65	2.1	Risk-based value is lower
Freon 113	950,000	NC	1,200	California MCL	1,200	MCL is lower
Tetrachloroethene	1.2	C	5	Federal and California MCL	1.2	Risk-based value is lower
Trichloroethene	5	C	5	Federal and California MCL	5	Risk-based level and MCL are the same
Vinyl chloride	0.24	C	0.5	California MCL	0.24 (0.5)	Risk-based value adjusted for laboratory PQL of 0.5 ug/L
Perchlorate	34	NC	18	DHS Action Level	34	Risk-based value is based on more recent toxicological data than was used for development of the Action Level
NDMA	0.0042	C	0.02	DHS Action Level and Prop 65	0.02	Action level, which equals lab PQL
Nitrate [d]	58,000	NC	10,000	Federal MCL	10,000	MCL is lower
Nitrite [d]	3,700	NC	1,000	Federal MCL	1,000	MCL is lower
Total Nitrate and Nitrite [d]			10,000	Federal MCL	10,000	Only an MCL is available

Notes:
[1]Based on BRA calculations corresponding to an additional lifetime cancer risk of one in one million or a hazard index of 1.0 for non-carcinogens.
[2]All values expressed as ug/L.
[3]C = value based on $1x10^{-6}$ incremental cancer risk. NC = value based on hazard index of 1.0 for non-carcinogenic effects.
[4]PQL = practical quantitation limit.

3 IDENTIFICATION AND SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGIES

In this section General Response Actions (GRAs), technologies, and process options are described and an overview of the process used to identify and screen technologies is provided. The overview is followed by a detailed discussion of the GRAs, and the identification and screening of technology types and possible process options. Technologies and process options are then used in Section 4 as components of potential OU-wide remedial alternatives.

The process of identifying OU-wide remedial alternatives begins with identification of the potential scope of any remedial action. GRAs that may be applicable to the OU based on the results of the site characterization (Section 1 and Appendix A) and the RAOs established in Section 2 are then identified. Potential remedial action technologies associated with each GRA that may be applicable to the OU and the RAOs are first identified and screened based on technical implementability. The resultant technologies are then evaluated based on anticipated effectiveness, implementability and relative cost to identify the most applicable technologies. These technologies are then combined to develop remedial action alternatives for the Western Groundwater OU. In Section 5 of this RI/FS, the OU-wide remedial action alternatives are subjected to detailed analysis for the various factors required for evaluation in accordance with the NCP (EPA, 1990).

3.1 General Response Actions

After RAOs are established for a site or OU, media-specific GRAs are developed to satisfy the RAOs. The RAOs for the Western Groundwater OU RI/FS are described in Section 2. On the basis of the current understanding of the CoPCs and environmental conditions associated with the Western Groundwater Study Area, the GRAs that could be implemented to achieve these RAOs include the following:

- No-Action: No attempt is made to satisfy the RAOs and no remedial measures are implemented. No-Action is required for consideration by the NCP as a basis against which the other alternatives are compared;
- Institutional controls: Non-engineering methods by which access to contaminated groundwater is physically restricted or regulated, and/or contamination is monitored;
- Monitoring;
- Replacement or substitute water supply;
- Containment of groundwater: Actions that result in contaminated groundwater being contained, thereby minimizing or eliminating the migration of CoPCs and preventing

exposure to contamination. Groundwater containment has a corollary benefit of some mass removal, although mass removal is not the primary objective;

- Treatment of groundwater; and
- Management/reuse of treated groundwater.

A summary of these GRAs is illustrated in Figure 3-1.

3.2 Technologies and Process Options

For each GRA, broad technology groups and specific process options that could be used to implement these actions are identified. Technologies refer to general categories (e.g., chemical treatment or biological treatment). Process options refers to the specific processes within each technology type (e.g., air stripping or cometabolic bioreactors). As discussed in Section 4, the No-Action GRA is included to provide a reference with which to compare the other alternatives that are developed.

Evaluation of potentially applicable technology types and process options is a key step in the FS process. The criteria for identifying potentially applicable technologies are provided in EPA guidance (EPA, 1988a) and in the NCP (EPA, 1990b). A strong statutory preference for remedies that are reliable and provide long-term protection is identified in Section 121 of CERCLA, as amended. The primary requirements for a final remedy are that it be both protective of human health and the environment and cost effective. Hence, candidate technologies and process options need to be capable of satisfying these key factors. A summary of potentially applicable remedial technology types and process options is illustrated in Figure 3-1. Information from the literature, including applicability, performance, removal efficiencies, operation and maintenance (O&M) requirements, implementability, and the relative cost of candidate technologies was considered in preparing the list of technologies and process options provided on Figure 3-1.

3.3 Screening and Evaluation of Groundwater Remediation Technologies and Process Options

The universe of potentially applicable technology types and process options applicable to each identified GRA is initially reduced through screening the options with respect to technical implementability. The results from this initial screening based on technical implementability are also included on Figure 3-1. Technologies and process options considered to be technically implementable are evaluated in greater detail on the basis of effectiveness, implementability (both technical and administrative), and relative cost as defined by the following factors:

- Effectiveness - in terms of protecting human health and the environment in both the short term and the long term;

- Implementability - in terms of technical feasibility, resource availability, and administrative feasibility; and

- Cost - in a comparative manner (i.e., low, moderate, or high) for technologies of similar performance and/or implementability.

These evaluation criteria are applied only to the GRAs and technologies being evaluated for the Western Groundwater OU and not to possible combinations of these technologies and process options that might be combined to form OU-wide remedial alternatives.

Technologies and process options that are not effective in protecting human health and the environment, that cannot be implemented because of the physical characteristics of the site or CoPCs, or that have a cost that is an order of magnitude greater than a similar technology are eliminated during this second evaluation. In accordance with USEPA guidance (1988a), effectiveness is the major emphasis of this second evaluation. Less weight is given to cost and implementability. The technologies and process options that are retained after the effectiveness, implementability, and cost evaluation are assembled into a range of OU-wide remedial alternatives in Section 4.

USEPA presumptive remedy guidance (Presumptive Remedies: Policies and Procedures; USEPA, 1993a) was used where appropriate to identify technologies and process options. Presumptive technologies were used to select ex-situ groundwater treatment process options. Eight presumptive technologies are identified in EPA's guidance document *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (EPA, 1996c.) Four of these technologies are applicable to organic contaminants (air stripping, granular activated carbon, chemical/ultraviolet oxidation, and aerobic biological reactors). When the presumptive technologies are used to treat dissolved contaminants in extracted groundwater, site-specific identification and screening of alternatives is not required. The basis for eliminating these steps is provided in the guidance listed above and EPA's *Analysis of Remedy Selection Experience for Ground Water Treatment Technologies at CERCLA Sites, Draft Final* (USEPA, 1996b). All of the presumptive technologies are well understood and have been used for many years for water, wastewater, and groundwater treatment.

3.3.1 Identification and Screening of Technologies and Process Options

In accordance with USEPA guidance (USEPA, 1988a), technologies and process options for the groundwater GRAs were identified and screened for technical implementability. Screening results are summarized on Figure 3-1.

Process options for groundwater remediation that require excavation to groundwater, placement of a physical barrier in groundwater, or phytoremediation were screened-out

based on various implementability issues discussed under screening comments on Figure 3-1 including the depth to groundwater, the vertical depth of existing or potential occurrences of CoPCs, and the difficulty of constructing a long trench through developed properties containing many buried utilities. These process options are not implementable west of the Aerojet Sacramento facility where the depth to groundwater is approximately 100 feet or greater and the vertical extent of contamination in some areas extends to depths of 300 feet or more. These include all of the process options associated with interceptor trench subsurface drains; vertical physical barriers such as slurry walls, HDPE curtain walls, and reactive in-situ metals walls; and air sparging. Air sparging was also eliminated because two of the CoPCs, perchlorate and NDMA, are not removed by this process.

Presumptive process options for ex-situ treatment of dissolved contaminants in groundwater were identified in USEPA's *Final Guidance: Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (USEPA, 1996c). Screening and evaluation of the presumptive process options is not required. However, the presumptive process options were screened to provide a comparison with other process options that were identified. Several of the presumptive process options (e.g., precipitation, electrochemical processes, and aeration) were screened out because they are not applicable to the CoPCs relative to the Western Groundwater OU.

Several other process options were eliminated in the technical implementability screening process. Electrokinetics is potentially applicable for perchlorate removal but may not be implementable due to well spacing and energy requirements given the depth to water and lateral extent of the Study Area. Membrane separation will remove the CoPCs, but was not considered because of the large flowrate of reject or concentrate sidestream anticipated to be generated (up to 10 percent of the groundwater to-be-treated flowrate). Bench-testing of an above-ground reactive metals reactor conducted by Aerojet indicated that NDMA removal is possible; however, encrustation and clogging of the media occurred, eliminating the process from consideration on a full-scale basis. Deep well injection of treated groundwater was eliminated because the permeability of the deeper groundwater units is not expected to be great enough to support this process option cost-effectively.

It should be noted that two of the CoPCs relative to the Western Groundwater OU, NDMA and perchlorate, have not historically been identified at CERCLA sites as being common CoPCs. Also, numerous presumptive technologies and process options do not exist for removal of these CoPCs from groundwater. A few processes are currently operating on a full-scale basis and several other innovative processes are currently undergoing treatability testing.

For NDMA, although several other process options have been tested (Fleming et al., 1995, and HLA, 1995), really only the ultraviolet irradiation/chemical oxidation (UV/oxidation) process option is available to remove this CoPC to concentration levels of concern in this RI/FS. According to the one manufacturer of UV/oxidation equipment for

removal of NDMA, Calgon Carbon Corporation, there are currently 14 installations in the United States and Canada removing NDMA to below current analytical method detection limits (Crawford, 2000).

For perchlorate removal, there are only two process options that are in a DHS approval review cycle: biological reduction and ion exchange. Aerojet conducted extensive full-scale pilot testing of the biological reduction process in 1997 and 1998 and is currently in full-scale operation of a 3,400 gpm system at the GET F treatment facility. The biological perchlorate removal system consists of four fluidized bed reactors each designed to treat 900 gallons per minute (gpm). During the first six months of operation, Aerojet experienced problems controlling the bed height in one of the two operating reactors. A series of tests were run in the Summer and early Fall of 1999 to control the growth rate of filamentous bacteria that were causing the bed height growth. Bed height growth rates were controlled during these tests and each of the fluidized bed reactors achieved non-detect perchlorate effluent concentrations between October and November 1999 (Harding Lawson Associates, 2000 pending). Aerojet is continuing to monitor and optimize the operation of the fluidized bed reactors.

The second process option for perchlorate removal considered in this RI/FS is ion exchange. This process, specifically the Calgon Ionic SEParation (ISEP®) ion exchange process, has undergone pilot-testing at several sites in the past two years but has yet to be installed full-scale to remove perchlorate from groundwater.

With the exception of horizontal extraction wells and several innovative process options, the majority of the process options retained as a result of the technical implementability screening have been or are currently being used at the Aerojet Sacramento facility. The GETs E/F onsite source containment system includes process options to address the same CoPCs that are found offsite in the Western Groundwater OU. A process flow schematic for this groundwater containment and treatment system is included as Figure 3-2. In August 1999, Aerojet combined the GETs E and F treatment facilities so that groundwater extracted from both of the GETs E and F extraction well systems undergo the same treatment processes. At the same time, UV/oxidation was added to the GET E/F treatment train to remove NDMA. The NDMA removal system is designed to treat NDMA to 0.002 µg/L. On September 26, 1999, the NDMA concentration in the combined GET E/F effluent was below the NDMA method detection limit of 0.0075 µg/L.

Aerojet continues to evaluate innovative treatment process options for treatment of chemicals, including VOCs, NDMA and perchlorate. As discussed previously, to date, Aerojet has demonstrated that a biological reduction process will result in perchlorate removal from groundwater. Aerojet has also identified and pilot tested an innovative NDMA treatment process that is not discussed in detail in this RI/FS because it is Confidential Business Information (CBI). In addition, Aerojet is currently evaluating (including bench and pilot scale testing) two other innovative CBI technologies for the removal of NDMA and perchlorate from groundwater.

The process options that were retained following the technical implementability screening are as follows. If sufficient information from pilot testing is obtained such that a decision can be made regarding use of a process option at full-scale, additional innovative technologies that are currently being pilot-tested may be appropriate for addition and selection in the future during the remedial design phase of any selected remedy.

General Response Action	Remedial Technology	Process Options
No Action	Not applicable	• Not applicable
Institutional Controls	Proprietary Controls	• Land purchase • Deed restrictions • Deed notices • Easements • Covenants
	Governmental Controls	• Land use restrictions • Groundwater use restrictions • Advisories
Monitoring	Monitoring	• Groundwater monitoring

Alternate/Replacement Water Supply	Alternate/Replacement Water Supply	• New water supply well
		• New water supply:
		  • Inter-ties with other water purveyors
		  • Direct reuse of treated groundwater
		  • Indirect reuse of treated groundwater
		  • New surface water supply

Monitored Natural Attenuation	Monitoring/Verification	• Groundwater monitoring
Containment	Hydraulic Barriers	• Vertical extraction wells • Horizontal extraction wells • Recharge wells
Collection	Groundwater Extraction	• Vertical extraction wells • Horizontal extraction wells • Recharge wells
In-Situ Treatment	Stripping	• In-well aeration/stripping
	Biological Treatment	• Enhanced biological reduction

General Response Action	Remedial Technology	Process Options
Liquid Phase Treatment	Ex-situ Physical Treatment	• LPGAC • Air stripping • Filtration
	Ex-situ Chemical Treatment	• Ion exchange • UV/oxidation • pH adjustment
	Ex-situ Biological Treatment	• Aerobic bioreactors • Cometabolic bioreactors • Anaerobic bioreactors
Vapor Phase Treatment for Air Stripping	Ex-situ Physical/ Chemical Treatment	• Direct discharge • VPGAC • Catalytic oxidation • Thermal oxidation
Management/Reuse of Groundwater	Treated Groundwater Management	• Direct potable water supply • Indirect potable supply • Nonpotable water reuse • Streamflow augmentation • Discharge to a Publicly-Owned Treatment Works (POTW) • Groundwater recharge
	Untreated Groundwater Management	• Discharge to POTW

3.3.2 Evaluation of Retained Process Options

The groundwater remediation process options remaining after the initial screening are further evaluated in this section using the criteria of effectiveness, implementability, and cost. The evaluation is presented on Figure 3-3 and discussed in the following sections organized by GRAs.

3.3.2.1 No Action

The No Action GRA is required to be evaluated in the FS and is therefore retained. Evaluation of the No Action alternative serves as a baseline for comparison with other remedial action alternatives. The No Action GRA is not action-based, but rather consists solely of monitoring and activities in support of monitoring.

3.3.2.2 Institutional Controls

The institutional controls process options are nonengineering methods by which federal, state, and local governments or private parties can prevent or limit access to affected environmental media and are applicable in conjunction with other response actions (USEPA 1998b). Institutional controls do not reduce contaminant mobility, toxicity, or volume, but they can reduce the potential for exposure to contaminated material. The NCP contains the following "expectation" regarding the use of institutional controls (USEPA, 1990b):

> "EPA expects to use institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants or contaminants. Institutional controls may be used during the conduct of the remedial investigation/feasibility study (RI/FS) and implementation of the remedial action and, where necessary, as a component of the completed remedy. The use of institutional controls shall not substitute for active response measures (e.g., treatment and/or containment of source material, restoration of ground waters to their beneficial uses) as the sole remedy unless such active measures are determined not to be practicable, based on the balancing of trade-offs among alternatives that is conducted during the selection of remedy."

More commonly, institutional controls are used because treatment and containment measures do not address risks entirely so that the remedy must include activity restrictions to ensure that it is fully protective. For example, over the time that is required to pump and treat contaminated groundwater, other measures may be needed to ensure that residents are not inadvertently exposed by drilling new wells. Containment remedies may have to be supplemented with institutional controls to ensure that future land users are aware of the wastes left on site and that they do not take actions that might interfere with the containment system (USEPA, 1998b).

Institutional control measures that apply solely to groundwater, such as groundwater use restrictions, may be used to prohibit or limit the drilling of new wells, prohibit the temporary use of existing wells, or require the shutdown of public water supply wells if monitoring indicates the presence of CoPCs above enforceable concentrations. While implementation of these process options alone may not attain the RAOs, they will most likely be necessary to maintain the integrity of any active remediation system that may be selected and will therefore be considered in combination with other process options during the development of alternatives.

On the basis of effectiveness, implementability, and cost, the proprietary and governmental institutional controls discussed in the following paragraphs have been retained. Land purchase and land use restrictions were not retained based on effectiveness because they are not appropriate for a groundwater action. High capital cost was also a criterion to screen-out land purchase.

Proprietary controls are based on private property law and include a variety of tools that can be implemented without the intervention of any federal, State, or local regulatory authority. Common examples include covenants or easements restricting future land use or prohibiting activities that may compromise specific engineering remedies. Governmental controls use the regulatory authority of a governmental unit to impose restrictions on citizens or sites under its jurisdiction.

Onsite Institutional Controls. Proprietary controls that can be implemented on the Aerojet property include restrictions on land use including deed restrictions, deed notices, easements, and covenants. There are deed restrictions currently on the Aerojet Site through PCD Paragraph 11. Groundwater use restrictions and advisories are governmental controls that can be implemented onsite.

Offsite Institutional Controls. Offsite institutional controls can include propriety controls such as restrictions on land use through the use of deed restrictions, deed notices, easements, and covenants. Governmental controls can include groundwater use notices/restrictions and advisories, well construction restrictions, zoning, and tailored ordinances.

An easement is a property right conveyed by a landowner to another party, which gives the second party rights with regard to the first party's land. Easements allow access to property, for example, so operation, maintenance, and monitoring can be performed; Easements may be "affirmative" or "negative". An affirmative easement allows the holder of the easement to enter upon or use another's property for a particular purpose (e.g., an access easement). A negative easement imposes limits on how the landowner can use his or her own property. For institutional controls, negative easements are most relevant. A negative easement might, for example, prohibit a particular parcel from being used for residential purposes, or prohibit well-drilling on that parcel.

It is anticipated that easements will be required if an OU-wide alternative requiring offsite construction is selected. Aerojet has attempted to obtain easements for pipelines from private property owners in the past, and has found that they are reluctant to allow the siting of infrastructure designed to carry contaminants on their property. Aerojet has also had past difficulties obtaining easements to use public utility right-of-ways from Sacramento County. Past easements were granted only after the oversight government agencies became involved with the County.

There are several departments within Sacramento County that must approve an easement application. These include the County Departments of Transportation, Water Resources, Water Quality, and Environmental Review and Assessment. The Department of Environmental Review and Assessment will require an evaluation of whether the project is exempt or must complete the California Environmental Quality Act (CEQA) process. Past experience by Aerojet (e.g., ARGET) has shown that the CEQA process may delay implementation of any selected remedy for a year or more.

Easements may also be required from the United States Bureau of Reclamation (USBR) if pipelines conveying groundwater are located adjacent to or cross the Folsom South Canal. The USBR policies for granting easements include fees based on valuing the land at its "best and highest" use. In addition, it is Aerojet's experience that USBR is hesitant to grant easements on federal property.

A covenant is a promise by one landowner to another, made in connection with a conveyance of property. Generally, a covenant is a promise by the holder of a possessory interest in property to use or refrain from using the property in a certain manner. Restrictions such as deed or access restrictions are specific provisions that apply to the use of property; for example, notifying of the potential that groundwater may be contaminated or restrictions on the use of groundwater for certain purposes. Servitudes are specific provisions that apply to the property owner and either oblige or restrict the owner from certain uses of the property that would impair an established easement.

Sacramento County is anticipated to establish a Consultation Zone provision in its existing comprehensive well drilling ordinance. Proposed Chapter 6.28.000(G) of Title 6 of the Sacramento County Code requires: "Consultation Zone. Any application for a well permit within 2000 feet of a known contaminant plume is subject to special review by appropriate regulatory agencies, including but not limited to the Sacramento County Environmental Management Department and the California Regional Water Quality Control Board, Central Valley Region, to evaluate potential impacts to public health and groundwater. The purpose of the proposed "Consultation Zone" provision is to evaluate potential impacts to public health and groundwater quality posed by the regulated activity (i.e., well construction and well decommissioning) and to prescribe appropriate procedures for these activities (based upon site-specific details available to lead regulatory agencies) that are protective of public health and groundwater quality (Sacramento County, 1999).

Descriptions of the institutional controls and the respective enforcement and monitoring activities to be included in each remedial alternative are provided in Section 4.

3.3.2.3 Monitoring

Groundwater monitoring is a process option that is expected to be a component of each remedial alternative in Section 4 and is therefore retained. Groundwater monitoring may serve the purpose of evaluating the migration of CoPCs and, depending upon the remedial alternative selected, to evaluate the effectiveness of any hydraulic containment and of any treatment processes. Groundwater monitoring is integral to monitored natural attenuation, which may be part of a selected remedial alternative.

Monitoring of water supply wells and monitor wells will also be conducted to assess potential impacts to water supply wells. The Exhibit IV process is in currently in place under a PCD for a period of three years beyond completion of the RI/FS. Exhibit IV establishes procedures for monitoring public water supply wells and procedures for

response action in the event that CoPCs are detected and exceed trigger levels. It is anticipated that a process equivalent to the Exhibit IV process would be established if the three year period were exceeded.

3.3.2.4 Alternate/Replacement Water Supply

As more fully discussed in various Water Supply Alternative Reports (Aerojet, 2000b,c) Aerojet has undertaken or paid for several projects to compensate for or replace the loss of water supply wells owned by the Arden Cordova Water Service (ACWS) and the Sacramento County Water Maintenance District (SWMD). Since the Spring of 1997, the following public water supply wells have been closed because concentrations of perchlorate and/or NDMA exceeded provisional or temporary DHS drinking water action levels :

- ACWS wells AC-13, -15, -16, -19, -11, and -14;
- SWMD Sunrise service area wells SWMD-17, and –18;
- Mather AFB wells -2, -3, and -4 (now owned by SWMD in the Mather Field service area); and
- Several privately-owned water supply wells.

In addition, ACWS has closed an additional six water supply wells (AC-1, -5, -7, -10 -12, and -21) because ACWS has analytical data which it believes showed low (i.e., <0.005 µg/L) concentrations of NDMA in these wells. However, current temporary DHS guidelines for NDMA in drinking water require that water purveyors shut down wells when NDMA concentrations exceed 0.2 µg/L. Aerojet has compensated or offered to compensate ACWS for the loss of water from wells AC-11, -13, -15, -16, and –19 as outlined in the Revised Preliminary and Final Water Supply Alternatives Reports for Arden Cordova Water Service Wells #11, 13, 15, 16, and 19 dated March 16, 2000 (Aerojet, 2000b). The lost capacity caused by the closure of AC-14 has not been addressed because the concentrations of NDMA in this well did not exceed the trigger levels specified in the PCD.

In addition, Aerojet has addressed Sacramento County Well #17 in the Preliminary Water Supply Alternative Report prepared for that well (Aerojet, 2000c). The actions financed by Aerojet and documented in this report enable the County to provide water to its Sunrise Service Area through a series of inter-ties, but do not address the question of long-term capacity replacement.

There are various short- and long-term water supply alternatives (i.e., process options) for replacing public and private water supplies that may be impacted in the future as a result of the CoPCs in groundwater in the Study Area. Short-term water replacement may be necessary in the event water supply wells are impacted prior to the implementation of a

remedy identified in the ROD for the Western Groundwater OU. Long-term water supply process options may be a component of each OU-wide alternative that is developed in Section 4 to replace impacted water supply wells or to serve as a new alternate water supply. On the basis of effectiveness, implementability, and cost, the alternate/replacement water supply alternatives of new water supply wells, inter-ties with adjacent water systems, direct reuse of treated groundwater (including wellhead treatment), indirect reuse of treated groundwater, and new surface water supply have been retained as process options.

These various water supply process options could be implemented in both the short- and long-term and could include any one or combination of the following:

- New Water Supply Well. This process option would consist of one or more new water supply wells constructed distant to the area where CoPCs are present in groundwater and transport of groundwater to the water distribution system of the affected water purveyor. The tie-in of the pipeline from the new well would be coordinated with the water purveyor with respect to whether the location of the tie-in within the water distribution system would provide sufficient flow and pressure to replace the capacity of the affected well it would be replacing.

  The construction of a new water supply well is a multi-step process that requires sufficient planning and lead-time. At a minimum, the following steps are typically completed to plan, design, and construct a new water supply well:

  - Evaluate the capacity that needs replacing;
  - Identify locations within the water distribution system where the capacity can be introduced;
  - Evaluate the hydraulic effects on contaminant plumes and existing wells from the selected new well location;
  - Locate property to site the new well;
  - Obtain the necessary permits and property owner approvals;
  - Drill and construct the well;
  - Construct the site improvements necessary to pump, control, and transmit the water to the water distribution system;
  - Conduct aquifer testing to evaluate specific capacity and well yield; and

- Collect the analytical samples required for DHS certification as a drinking water source.

In the past, the local water purveyors have constructed new water supply wells using their personnel and/or consultants and Aerojet has reimbursed them, as appropriate, for their expenses. It is estimated that the time required to conduct the above noted steps would be approximately one year. This time may be shorter in some instances where some of these steps may already be complete (e.g., property is already owned by the water purveyor).

- Inter-ties with Adjacent Water Systems. This process option would consist of water distribution pipelines being constructed between adjacent water systems and one water purveyor providing potable water to another water purveyor on an interim or long-term basis. The construction of inter-ties, if needed, requires that the unaffected water purveyor has sufficient water capacity at a rate that is acceptable to all parties. Rate negotiations and system capacity assessments can be lengthy processes requiring sufficient lead-times. Short-term water replacement may be necessary in the event water supply wells are impacted prior to the implementation of a remedy identified in this FS. Aerojet is in the process of obtaining a commitment from the City of Folsom to provide potable water to ACWS through the existing inter-tie between the two systems. This source would provide approximately 800 to 3,500 gpm for the short-term (two to three years) to ACWS. This City of Folsom commitment and other commitments are also currently being pursued for the long-term.

- Direct Reuse of Treated Groundwater. This process option would consist of placing wellhead treatment facilities on the affected water supply well to address the specific CoPCs, providing treated groundwater from one or more of the Aerojet groundwater extraction and treatment facilities, providing treated groundwater from a groundwater treatment facility that may be part of an OU-wide remedy, or a combination of these three process options. Groundwater would be treated to potable quality and directly reused in the water distribution system. If this process option were to be implemented, the California DHS impaired source issues discussed in DHS's Policy Memo 97-005 must be addressed and the water purveyor must obtain DHS approval to serve the water.

  Aerojet recognizes that there are several administrative and technical issues that must be addressed prior to obtaining DHS approval for direct reuse. The DHS policy Memo 97-005 recognizes that treated groundwater represents "a significant resource that should not be wasted". DHS guidelines also state that the when feasible sources are available, the sources presenting the least risk to public health should be utilized. Therefore, one of the steps required prior to DHS approval is an evaluation of other potential sources of drinking water.

A comprehensive evaluation of surface and ground water supplies in Sacramento County was conducted by the Water Forum and is detailed in the Water Forum Action Plan (Water Forum Proposal, January 1999). It is clear in this evaluation that surface water diversions from the American River are a sensitive issue and that there are very limited opportunities for new surface water diversions. There is a possibility of using Section 215 "spill water" during average or wetter years, however, this water is more available during the winter, when it is least needed. In the Study Area, precipitation has been above-average for the past 3-4 years and the surface water supply has been fairly abundant. However, surface water supplies may not be readily available during years of drought. In addition, currently there do not appear to be sufficient unaffected groundwater resources in the Study Area to support long term supply needs. Therefore, Aerojet believes that treated groundwater may represent the best, if not the only, source of drinking water.

If sufficient alternative drinking water sources are not available, additional steps are required prior to obtaining DHS approval for direct reuse of treated groundwater. Some of these steps have been completed in the Study Area, including a delineation of the source water capture zone, identification of contaminant sources, types, and concentration trends. Additional analytical work will be required for a full characterization of the untreated water quality, including all of the parameters outlined in the DHS guidelines.

In addition to fully characterizing the untreated groundwater, the treatment processes must be commensurate with the degree of risk associated with the contaminants present. This includes using best available treatment technologies defined by the EPA for the contaminants of concern, evaluating the reliability of the treatment systems, establishing performance standards, developing an operations plan, identifying compliance monitoring requirements, and developing a notification plan.

DHS typically approves certain treatment technology processes as acceptable for use in drinking water systems. Once the treatment technology process is accepted by DHS, its use must be approved on a site-specific basis. DHS has recently certified Calgon's ISEP® process for perchlorate removal for direct re-use. Aerojet is currently conducting a pilot test with DHS oversight to demonstrate that the treatment processes utilized at GETs E/F (biological reduction, UV-oxidation, and air-stripping) are acceptable for direct re-use.

The DHS policy memo 97-005 also outlines additional activities that must be completed prior to obtaining direct re-use approval including conducting a risk evaluation, CEQA review, permit application submission, public hearings, and DHS evaluation. Aerojet recognizes that obtaining a direct reuse permit is a necessarily complex process that will require substantial

effort on behalf of all involved parties. Nevertheless, water supply is a critical component of this FS, and direct reuse makes the best use of this resource.

- Indirect Reuse of Treated Groundwater. This process option would involve treated groundwater being piped directly to a surface water treatment facility, or indirectly via discharge to the Upper or Lower American River and exchanged for surface water in the American River that would be diverted via the Folsom South Canal (or via a direct pipeline) to an existing or new SWTP, or a combination of SWTPs. If treated groundwater from all or a portion of water treated at GETs E/F and/or potentially from any offsite remedial alternative where groundwater is extracted is discharged to the American River, this water could be used to replace affected water supplies. Aerojet has recently reached a memorandum of understanding with Sacramento County to sell it treated groundwater from its ARGET facility via discharge to Buffalo Creek and the American River. Because of the lack of available surface water entitlements on the American River, Aerojet believes the discharge of treated water to the American River and subsequent withdrawal at a SWTP clearly represents a viable means for providing replacement water to an affected purveyor.

  Influent water for the SWTP would be obtained either directly (via pipeline) or indirectly (via discharge to the American River and a corresponding diversion at the Folsom South Canal) and could involve multiple parties (e.g., Sacramento County and the Boeing Company) for the construction of the SWTP. This third party involvement would allow the Boeing Company to address its water replacement needs relating to the IRCTS Engineering Evaluation/Cost Analysis (EE/CA), and would allow the County to address water supply needs for new development in eastern Sacramento County. Aerojet and Boeing have met with Sacramento County to explore options with respect to replacement of affected water supply well capacity. Sacramento County is currently conducting an evaluation of replacement water supply options that should be available in April 2000. It is also possible for one or more water purveyors and developers to be involved in the SWTP.

- New Surface Water Supply. This process option would involve diverting Section 215 "spill water" from the Folsom South Canal in average and wetter years, diverting Arden Cordova unused entitlements from the American River, diverting Placer County Water Agency entitlements in excess of their projected long-term needs, and/or diverting other yet-to-be-identified firm upstream entitlements to a new or expanded existing SWTP or combination of SWTPs. Treated surface water would be delivered to the water distribution system of the affected water purveyor.

3.3.2.5 Monitored Natural Attenuation

Monitored natural attenuation refers to the reliance on natural attenuation processes to achieve site-specific remediation objectives within a timeframe that is reasonable compared to that offered by other more active methods. The "natural attenuation processes" that are at work in such a remediation approach include a variety of physical, chemical or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants (USEPA, 1999).

EPA expects that monitored natural attenuation will be most appropriate when used in conjunction with active remediation measures (e.g., source control), or as a follow-up to active remediation measures that have already been implemented. EPA also expects that the potential for creation of transformation products (e.g., degradation of trichloroethylene to vinyl chloride) should be evaluated to assess whether implementation of a monitored natural attenuation remedy is appropriate and protective in the long term (USEPA, 1999). The monitoring program associated with monitored natural attenuation developed for a site should be designed to accomplish the following:

- Demonstrate that natural attenuation is occurring according to expectations;
- Identify any potentially toxic transformation products resulting from biodegradation;
- Evaluate whether a plume is expanding (either downgradient, laterally or vertically);
- Ensure no impact to downgradient receptors;
- Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy;
- Demonstrate the efficacy of institutional controls that were put in place to protect potential receptors;
- Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes; and
- Verify attainment of removal action objectives.

Monitored natural attenuation has been retained to be used in conjunction with active remediation measures (e.g., groundwater containment), or as a follow-up to active

remediation measures that have already been implemented to monitor CoPCs, if any, that may migrate downgradient of any active groundwater remediation measure.

3.3.2.6 Groundwater Containment and Collection

Extraction wells were retained as a representative process option for the potential containment and collection GRAs. This process option involves drilling vertical extraction wells that are screened within the hydrogeologic layer where contamination is known to exist or is projected to be present based on modeling. The wells are pumped and a hydraulic barrier is established to control contaminant migration. If contaminants are present in the groundwater, they are physically removed with the groundwater.

The use of a combination of extraction and recharge wells was also selected as a representative process option for the containment and collection GRAs. Under this process option, the hydraulic containment barrier or collection system would be comprised of a combination of both extraction wells pumping contaminated, or projected to be contaminated groundwater, and injection wells where treated groundwater is recharged to the subsurface. The recharged water can serve as a hydraulic barrier and can direct groundwater to the extraction wells. Public water supply wells can also serve the function of extraction wells for a hydraulic barrier.

Horizontal extraction wells were also retained as a process option to be considered during the remedial design phase of any remedial action. Selection of horizontal extraction wells over vertical wells would be decided during the remedial design phase and would be based on the depth of the CoPCs, the hydrologic and geologic characteristics of the subsurface material, and property access and existing utility limitations. Horizontal wells offer some advantage over vertical wells depending on the subsurface conditions since they allow for recovery in circumstances of limited overlying access, well surface area is maximized, and it is possible to orient well screens in closer proximity to the bulk of the CoPCs in groundwater.

3.3.2.7 In-situ Treatment

All in-situ treatment process options were eliminated during the evaluation process, with the exception of in-well aeration/stripping and enhanced biological reduction innovative process options. While the in-well aeration/stripping in-situ treatment process option only removes VOCs, it was retained after the evaluation because of its potential application with alternatives that might involve groundwater containment or collection using vertical wells. As discussed in Section 1, VOCs are only present in limited areas. Thus, when assembling OU-wide alternatives that might involve extraction of groundwater using vertical wells, from a groundwater treatment perspective it may be desirable to remove the VOCs at the extraction well rather than after the groundwater is blended with groundwater from one or more other wells that may or may not contain VOCs.

The two proprietary in-well aeration or stripping processes are the NoVOCs™ process, which was developed by NoVOCs, Inc. in cooperation with the U.S. Department of Energy's (DOE's) Office of Science and Technology, Stanford University, EG&G Environmental, and the Pacific Northwest National Laboratory (Stanford University owns the patent for NoVOCs™ and has licensed the technology to EG&G), and the Unterdruck-Verdampfer-Brunnen (UVB) process, which was developed in Europe and is licensed to Roy F. Weston, Inc. and IEG Technologies in the United States (Nyer et al., 1996).

NoVOCs™ consists of a well, screened both beneath the water table and in the unsaturated zone. A compressed air line within the well runs from an above-ground supply and extends below the water table. Compressed air injected below the water table aerates the water within the well, creating a density gradient between the aerated water and the more dense water in the surrounding aquifer. As a result, dense water flows in through the lower well screen and forces the aerated water upward within the well, while becoming aerated itself. The result is a rising column of aerated water within the well, or an air-lift pump. Unlike conventional groundwater extraction and treatment systems, in-well aeration does not require ground water to be pumped to the surface for treatment. As the aerated groundwater column rises within the well, VOC mass transfer occurs from the dissolved phase to the vapor phase. Above the water table, a packer, or deflector plate, is installed at the upper screen to prevent the passage of rising water or bubbles. The rising water column hits the packer, the bubbles burst and the entrained VOC vapor is stripped off laterally through the screen by an upper vacuum casing. The VOC-rich vapor is brought to the surface for treatment while the laterally-deflected water circulates back into the aquifer. Re-infiltrating water creates a doughnut-shaped circulation pattern around the well, enabling the ground water to undergo multiple treatment cycles before flowing downgradient.

Limited operational and cost information is available for this process option. Because of the limited cost and performance data available at this time, a representative in-situ treatment process was not selected and the process option is not included in the developed alternatives. However, this innovative process option is not precluded from being implemented during remedial design of any selected remedy in the future if information becomes available to suggest that the technology can achieve significant savings in cost or time to achieve RAOs.

Treatability testing of the in-situ enhanced biological reduction innovative process option is currently being conducted by Aerojet for removal of perchlorate and VOCs. In-situ enhanced biological reduction could offer significant advantages with respect to implementability in the Weatern Groundwater Study Area over more traditional groundwater extraction and treatment technologies.

Within the context of this Western Groundwater OU RI/FS, innovative process options that were retained, but not selected as representative process options, will be considered relative to the representative process option on a case-by-case basis during the remedial

design phase as these technologies become more developed and sufficient information regarding cost and performance is available.

3.3.2.8 Liquid Phase Treatment

For ex-situ treatment of groundwater, LPGAC, air stripping, ion exchange, UV/oxidation, and cometabolic reactors (biological reduction) were retained based on effectiveness, implementability, and cost and were selected as representative process options. Filtration and pH adjustment are also ancillary process options that may be required as part of a liquid phase treatment train, depending on which main process option is, or process options are, selected for removal of the CoPC(s). With the exception of ion exchange, these technologies have been used historically to treat water from water supply wells AC-15 and AC-16 in the Western Ground Water Study Area or are currently used at the Aerojet Sacramento GET facilities to treat contaminated groundwater.

LPGAC. LPGAC is a commonly used method of removing VOCs and other organics. Activated carbon, when contacted with water containing organic material, will remove the organic compounds selectively by a combination of adsorption of the less polar molecules, filtration of the larger particles, and partial deposition of colloidal material on the exterior surface of the activated carbon. The extent of removal of soluble organics by adsorption depends on the diffusion of the particle to the external surface of the carbon and diffusion within the porous adsorbent.

Activated carbon is generally considered to consist of rigid clusters of microcrystallites, with each microcrystallite made up of a stack of graphitic planes. Each carbon atom within a particular plane is bonded to four adjacent carbon atoms, with carbon atoms at the edges of the graphitic planes having highly reactive (active) radical sites. At these sites, which consist of a heterogeneous mix of basal planes and microcrystallite edges, adsorption takes place. The adsorbent capacity of the carbon is reached when the active sites have been filled. As these sites fill, sorption equilibrium is approached, and effluent quality deteriorates to an unacceptable level. Then, the carbon is considered spent and removed for regeneration, typically to a reactivation furnace. Most carbon-adsorption systems utilize granular activated carbon (GAC) in flow through column reactors which can be employed as an upflow-countercurrent type operated with packed or expanded carbon beds or as an upflow or downflow fixed-bed unit having two or three columns in series.

Air Stripping. Air stripping is currently used at GETs A, B, D, and E/F as the main process to remove VOCs or as a VOC-removal polishing step subsequent to UV/oxidation. Air stripping has been retained as it will continue to be used in the Western Groundwater OU Study Area at the GETs E/F groundwater treatment facility and may be considered as a representative process option for VOC removal or as a polishing step for VOC removal for any OU-wide alternative.

Air stripping is a physical unit process in which dissolved molecules are transferred from a liquid, such as groundwater, into a flowing gas or vapor stream, such as air. The

driving force for mass transfer is provided by the concentration gradient between the liquid and gas phases, with solute molecules moving from the liquid to the gas until equilibrium is reached. The governing equilibrium relationship is Henry's Law. VOCs in groundwater having Henry's Law constants above 10 atmospheres (atm) are readily strippable at ambient temperatures. The economic viability of the conventional air stripping process is, however, limited to the VOCs whose Henry's Law constants are more than about 100 atm.

The most common configuration for application of air stripping to groundwater treatment for removal of VOCs is the counter current packed tower air stripper. In countercurrent packed towers, packing materials are used which provide high void volumes and high surface area. The water flows downward by gravity and air is forced upward. The untreated water is usually distributed on the top of the packing with sprays or distribution trays and the air is blown through the tower in forced or induced draft. This design results in continuous and thorough contact of the liquid with the gas and minimizes the thickness of the water layer on the packing, promoting efficient mass transfer. For removal of volatile organic compounds from groundwater, it is economically desirable to operate packed columns with a maximum water flow rate and with the minimum volume of air necessary to achieve the desired concentration of organics in the treated water.

Depending on the air quality requirements where air stripping is to be employed, offgas emissions from the air stripper may require treatment. The process options for air stripper offgas treatment are discussed later in this section.

Ion Exchange. Perchlorate and other anionic CoPCs in groundwater are effectively removed by ion exchange, a process where contaminant anions are exchanged and replaced by an innocuous anion, typically chloride. Ion exchange is an effective method for many groundwater treatment applications due to its efficiency in removing contaminants present in varying concentrations at relatively low costs. Most of the ion exchange resins manufactured are used for water treatment and strong-base anionic resins have been used to remove nitrates from drinking water for several years. Although ion exchange technology is well-known, the effectiveness of an ion exchange process depends, among other factors, on the operational configuration of the process. Key parameters that determine the efficiency and impact the economics of an ion exchange process are treatment ratio and the volume of regeneration waste generated. Treatment ratio refers to the volume of feed water that can be treated before breakthrough of the contaminant(s) is obtained. Regeneration waste volume refers to the volume of waste generated by the ion exchange process while regenerating the ion exchange resin saturated with contaminants. An effective ion exchange process is one that achieves high treatment ratios while producing low regeneration waste volume.

The following reaction is the primary ion-exchange reaction that occurs on the surface of a strong-base anionic exchange resin in the chloride form used for perchlorate removal:

$$R_4N^+Cl^- + ClO_4^- \rightarrow R_4N^+ClO_4^- + Cl^-$$

The chloride ion (Cl^-) on the surface of a quaternary amine group (R_4N^+) is exchanged for the perchlorate ion (ClO_4^-) present in the groundwater. Many other anions commonly present in groundwater will compete with the perchlorate ion for this reaction. These include sulfate (SO_4^{2-}), nitrate (NO_3^-), bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), and bromide (Br-). Other trace ions can also compete with the perchlorate ion for the resin surface (e.g., chlorate).

Ion exchange is reversible. Once the ion exchange resin is loaded with the perchlorate ion, it is regenerated with a sodium chloride salt solution and the perchlorate and other anions are removed. The following reaction illustrates how perchlorate is removed from the ion exchange resin during the regeneration process:

$$R_4N^+ClO_4^- + NaCl \rightarrow R_4N^+ClTC_4N^+Cl^- + NaClO_4$$

However, in order for the chloride to substitute for the perchlorate ion during regeneration, it has to be present at high concentrations in the brine solution. Once the resin is re-loaded with chloride, it is placed back in service, and the ion exchange cycle is repeated.

Several ion exchange equipment designs are currently employed including relatively simple fixed bed downflow or upflow contactor systems that can be operated in either concurrent or countercurrent (service flow in the direction opposite to the regeneration), continuous moving bed systems, and continuous multi-port rotating distributor systems. With respect to regeneration, waste streams generated when the ion exchange media is regenerated include rinse and backwash waters and a concentrated regenerant brine solution that contains perchlorate, nitrate, and sulfate ions in significantly higher concentrations than in the untreated groundwater feed. Depending on the method of ion exchange system operation, the volume of these waste streams can range from 2 to 8 percent of the volume of groundwater treated by ion exchange and must be disposed or reused.

Use of ion exchange for perchlorate removal using the Calgon ISEP® process has undergone recent pilot testing at the Big Dalton Well in the San Gabriel Valley area north of Los Angeles, CA (Calgon, 1998 and Montgomery-Watson, 1998) and at the Jet Propulsion Laboratory in Pasadena, CA (Calgon, 1999). The ISEP® process was recently accepted by DHS as a technology that has demonstrated its ability to remove perchlorate from source waters (DHS, 1999). DHS's acceptance is contingent upon approval by the respective DHS field office for the location where the process is proposed to be installed, conducting additional pilot testing if the water quality of the location is different from that encountered in the pilot testing, and Calgon must obtain National Sanitation Foundation (NSF) approval of the ISEP® components, ion exchange resin, and salt used for regeneration.

In the San Gabriel Valley, California, the regenerate waste streams are being evaluated for discharge to a brine sewer that serves the Los Angeles area. However, for the Western Groundwater OU RI/FS, wastestreams from the ion exchange process must be

collected and treated to remove the concentrated anions because there is no brine sewer. Two methods have been pilot-tested to treat the concentrated brine wastestream: anaerobic biological degradation (Air Force Research Laboratory, 1998) and a catalytic reduction process (Calgon, 1999) that recycles a majority of the wastestream flow. The long-term effectiveness and full-scale operating costs for both of these methods are presently unknown. Since September 1999, Calgon has been conducting pilot-testing of the ISEP® process coupled with the catalytic reduction brine regeneration process using City of Pittsburgh, PA municipal water spiked with approximately 1,200 ug/L of perchlorate (Calgon, 2000). Operating and performance results are expected in mid-2000.

In the catalytic reduction process the spent brine wastestream from the ion exchange system is routed to a catalytic reactor system to which small amounts of a reductant (such as ethanol) are added. Perchlorate and nitrate present in the brine wastestream are reduced to chloride and molecular nitrogen respectively, while the reductant is oxidized to carbon dioxide and water. This reduction-oxidation reaction occurs over a solid catalyst in the reactor at an elevated temperature and pressure. The effluent from the reactor is almost free of perchlorate and nitrate and is passed into a nanofiltration (NF) system where sulfate is removed from the brine into a small purge stream containing high concentrations of sulfate, but no perchlorate and nitrate. This purge stream from the NF system is the only wastestream from the entire brine treatment process and is estimated from pilot studies to be in the range of 0.05-0.2% of the total feed water treated by the ion exchange process. The "purified" brine is recycled back into the regeneration cycle of the ion exchange system along with a small fresh brine make-up stream.

UV/oxidation. UV/oxidation is a generic name for a family of advanced oxidation technologies (AOT) that use ultraviolet light either alone or in conjunction with standard oxidants such as hydrogen peroxide or ozone to achieve greatly increased treatment performance over that obtained with either hydrogen peroxide or ozone alone. The most common UV/oxidation process is the use of UV with hydrogen peroxide. Ultraviolet light is used to split the hydrogen peroxide molecule, producing very reactive hydroxyl radicals ($OH^{\cdot}$). These hydroxyl radicals then quickly react with organic contaminants in the water, eventually breaking them down into carbon dioxide and water. UV/oxidation is currently being used at GET facilities to remove NDMA, VOCs and 1,4 dioxane.

Photolysis involves the interaction of light with molecules to bring about their dissociation into fragments. Light is composed of tiny energy packets called photons, whose energy E is inversely proportional to the wavelength, λ, of the light.

$$E = \frac{hc}{\lambda}$$

where h is Planck's constant and c is the speed of light.

If the absorption of a photon by a molecule is to cause photolysis (dissociation), the photon energy must exceed the energy of the bond to be broken. This requires that the wavelength be in the ultraviolet region of the spectrum for most photolytic reactions. Compounds that absorb UV light and have high quantum yields of photolysis are good candidates for photodegradation using UV light only. Examples of these classes of compounds include NDMA, and various chlorinated alkenes and aromatics.

Oxidation is the chemical conversion of a contaminant to move oxygenated forms by means of reactions with oxidizing agents, such as oxygen (O_2), ozone (O_3), hydrogen peroxide (H_2O_2), or sodium hypochlorite (NaOCl). The following equation represents a general oxidation process:

Chlorinated Organic Molecules	+	O_2, O_3, $\rightarrow\rightarrow\rightarrow$ H_2O_2 or NaOCl	Oxygenated Intermediates
Oxygenated Intermediates		O_2, O_3, $\rightarrow\rightarrow\rightarrow$ H_2O_2 or NaOCl	$CO2 + H2O + Cl^-$

Each of the above reactions are actually multi-step processes. Simple oxidation involves the addition of oxidizing agents such as O_2, O_3, H_2O_2, NaOCl; however , the overall oxidation rates are usually too slow to be applied broadly for groundwater or wastewater treatment.

AOT, the overall rate of oxidation of a contaminant is greatly increased over that obtained by the simple addition of oxidizing agents. The main reason is the much greater involvement of highly reactive initiators (radicals) such as the hydroxyl radical (OH^-) created in AOT. The hydroxyl radical reacts typically a million to a billion times faster than ozone and hydrogen peroxide, aggressively attacking virtually all organic compounds.

Cometabolic Bioreactors (Biological Reduction). The biological reduction process is currently used at the GETs E/F treatment facility to remove perchlorate from GETs E and F groundwater. This technology can be described as a biological reduction process using a fixed-film bioreactor. A fixed-film of biomass is attached to granular activated carbon operated as a fluidized bed (GAC/FB). Groundwater, amended with an organic substrate (e.g., ethanol) and nutrients (nitrogen and phosphorus) is introduced into the influent stream. As groundwater passes through the system, the microorganisms derive energy from the oxidation of the organic substrate, simultaneously destroying the perchlorate, reducing it to chloride and oxygen. In a fluidized-bed bioreactor, flocculated organisms are suspended by drag forces exerted by the rising liquid. By balancing operating conditions and organism characteristics, the flocs are retained in the bioreactor while the medium flows through it continuously. Perchlorate reduction is similar to nitrate reduction. The energy-generated portion of the denitrification reaction with ethanol as the organic substrate (neglecting cell synthesis) is:

$$5C_2H_5OH + 12NO_3^- + 12H^+ \rightarrow 10CO_2 + 6N_2 + 21H_2O$$

The similar reaction for perchlorate during the biological reduction process is:

$$2C_2H_5OH + 4ClO_4^- + 8H^+ \rightarrow 4CO_2 + 4Cl^- + 10H_2O$$

Note that nitrate and perchlorate are completely destroyed, and the carbon substrate (ethanol) is oxidized by bacteria. The end products for the process are biomass (sludge), carbon dioxide, water, chloride, and nitrogen (HLA, 1998). The biomass is typically discharged to a POTW or dewatered and disposed in a non-hazardous landfill.

Aerojet is currently conducting pilot-testing at the GETs E/F groundwater treatment facility of the biological reduction process coupled with the UV/oxidation process for the purpose of obtaining approval of DHS to use the process in a direct reuse application for potable water supply.

Filtration. This ancillary process option is employed to remove particulates that may be generated by other processes and need to be removed prior to the groundwater undergoing treatment by another process or prior to management/reuse of the treated groundwater. There are many common configurations of filters available including dual-media gravity and pressure filters, continuous upflow sand filters, and in-line bag filters. The configuration of filter is selected based on the specific filter application.

pH Adjustment. If necessary, this ancillary process option is used to adjust the pH of groundwater undergoing treatment. An acid (e.g., sulfuric or hydrochloric acid solutions or carbon dioxide gas) or caustic (e.g., sodium hydroxide solution or lime) can be added using chemical metering pumps upstream of another process option to enhance the performance of the process option or downstream of a process option where pH changes through the process option to adjust the pH to within a normal value for water quality (i.e., around 7.0 standard pH units).

3.3.2.9 Vapor Phase Treatment for Air Stripping

Vapor-phase treatment refers to process options to remove VOCs in air stripper offgas in the event that concentrations of contaminants in the offgas warrant emission control. Direct discharge, VPGAC, catalytic oxidation, and thermal oxidation were retained based on effectiveness, implementability, and cost and were selected as the representative vapor-phase treatment process options.

Direct Discharge. Direct discharge of vapors entails releasing the collected vapors to the atmosphere through a stack or other device in such a manner that the resultant vapor concentrations in the atmosphere do not pose a threat to human health or the environment. Direct discharge of vapors is currently being used in conjunction with the existing air strippers at the GETs A, B, D, and E/F groundwater treatment facilities. Use

of direct discharge is a function of the flow rate and VOC concentrations in any vapor stream and the nature of other activities in the vicinity of the discharge.

VPGAC. Granular activated carbon (GAC) is the most common method of vapor phase treatment for removal of VOCs from air stripper gas. VPGAC is popular for several reasons, including its relative ease of implementation and operation, its reputation as a commonly-used treatment, its ability to be regenerated for repeated use, and its applicability to a wide range of contaminants at a wide range of flow rates. As described for the LPGAC process, VPGAC contactors are provided in standard prefabricated units that can contain up to 20,000 pounds of activated carbon. VPGAC contactors are typically operated in series and, when loaded to breakthrough with VOCs, the GAC is either replaced or regenerated onsite using a steam-based desorbing system. The costs are associated with concentrations in the emissions and the volume of air required to be treated.

The adsorption capacity of the carbon depends on several factors, including influent vapor temperature and relative humidity and, most importantly, the influent VOC types and concentrations. Isotherms, which show the mass of contaminants that can be adsorbed per unit mass of carbon, are available to predict the contaminant-specific adsorption capacity for a specific type of carbon.

Catalytic Oxidation. Catalytic oxidation is a variation of the thermal oxidation process which uses catalysts to increase the oxidation rate of contaminant vapors at lower temperature than conventional thermal oxidation processes. A catalytic oxidation process always requires a lower oxidation temperature [less than 1000°F] than thermal oxidation. The products of combustion of a catalytic oxidation reaction are the same as those of thermal oxidation. The heat of oxidation liberated by catalytic oxidation is the same as that of a thermal oxidation. Catalysts are used to increase the oxidation rate at lower temperatures.

The advantages of catalytic oxidation over thermal are the lower fuel requirement because of the lower operating temperature and less severe service requirement for materials of construction.

Thermal Oxidation. In this offgas treatment process, vapors from the air stripping process are preheated and then heated to a high temperature (typically greater than 1,400°F) in a combustion chamber, destroying the contaminant vapors. Thermal oxidation is well-suited to high concentration VOC air streams (i.e., 2,000 to 10,000 ppm; Nyer et al., 1996). Propane or natural gas is typically used as a supplemental fuel to achieve the high temperature levels necessary for thermal oxidation. Thermal oxidation of chlorinated hydrocarbons may result in formation of byproducts and hydrochloric acid, which may necessitate treatment of the combustion gases (i.e., acid scrubber). Depending on the flow rate and VOC concentrations in any vapor stream, a ceramic wheel concentrator may be used to reduce the flow rate and increase the VOC concentrations in the vapor stream directed to the thermal oxidation process.

3.3.2.10 Management/Reuse of Groundwater

Several possible process options have been identified for management and/or possible reuse of untreated or treated groundwater produced by any hydraulic containment or groundwater collection/treatment components that may be part of OU-wide alternatives developed in Section 4. There are several water resource management opportunities and actions that are available in or near the Western Groundwater Study Area in connection with this OU. Regional and local water resource planning includes consideration of the water flows in the American River and the Folsom South Canal, as well as the current and projected future potable and nonpotable water demands of existing development in Sacramento County and various planned development areas in the eastern and southern portions of the County. Quantities of untreated or treated groundwater on an average annual basis that are currently or potentially available vary among each of the OU-wide remedial alternatives described in Section 4. There also may be desirable combinations of the following management/reuse options, as matched to a given remedial alternative.

Possible process options for management or reuse of treated groundwater include direct potable water supply, indirect potable supply, non-potable water reuse, streamflow augmentation, discharge to POTW, and groundwater recharge. On the basis of effectiveness, implementability, and cost all of these possible process options have been retained. At present, the streamflow augmentation and groundwater recharge options are being used to manage treated groundwater from the GET facilities at Aerojet's Sacramento site.

Direct Potable Water Supply. Treated groundwater can be made available to meet urban water supply needs. It can be provided directly under one or more alternatives to local water supplies to a point of use within a water distribution system or directly with wellhead treatment. It can also be provided directly through regional surface water treatment facilities processing treated ground water to meet requirements of DHS. This reuse to provide a potable supply can be implemented if DHS approves the use of treated groundwater for potable use.

Indirect Potable Supply. Indirect potable water use can be achieved through treatment and discharge to surface waters, to the Folsom South Canal, or both. This indirect use would include full water treatment at the point of use by a responsible utility. The treated groundwater could be integrated with proposed residential and commercial development plans in the Eastern Sacramento County area. These development plans include Douglas/Sunrise, the villages of Zinfandel and Rio del Oro, Lewis Homes at Mather, or other proposed developments in the area that are projected to require new water supplies or will have increased water demand.

These growing potable demands can be met through treatment of water from the American River watershed delivered through the Folsom South Canal, but such deliveries are currently inconsistent with the policies of the Water Forum and Sacramento County, which require that water delivered from the American River be diverted at its mouth or from the Sacramento River. Since flows in the American River and, potentially, the

Folsom South Canal can be augmented by approved surface discharges under one or more of the alternatives in the OU, a similar amount of water could be diverted from the system without compromising the local policies with regard to water use.

The use of this water would be subject to conveyance approvals by the US Bureau of Reclamation (BOR) that could be acquired in part to offset any lost groundwater extraction capacity of existing customers. In addition, an evaluation of potential impacts to more senior or environmental rights along the River between the Nimbus Reservoir and the point of treated groundwater discharge would also need to be performed to ensure no adverse impact. Using the treated groundwater in a manner that assists in meeting the growing potable and non-potable water needs in eastern Sacramento County would be consistent with the County policies regarding American River flow management. This approach would allow remediation action efforts to be conducted in concert with water management objectives and provide economic benefits using the most efficient water resource management system possible.

Non-Potable Water Reuse. Another treated groundwater use option would be to supply water for irrigation of golf courses, parks, open space, and residential areas, or other areas currently proposed for development south and west of the OU Study Area. Sacramento has a County policy to install dual systems where economically feasible. These systems can provide different qualities of water from various sources to meet different levels of public health protection.

Treated water could be delivered directly from the OU facilities into a non-potable reuse system, provided that a dual piping system was constructed as part of all new developments that could be economically served. Permitting conditions for this source of non-potable water should be less stringent than water for potable uses and from wastewater sources.

Streamflow Augmentation. The discharge of treated water to surface waters directly or indirectly entering the American River can provide instream and downstream benefits. These discharges would be managed through an existing or new NPDES discharge. One possible process option for the management of treated water would be to discharge the treated water to the American River through the existing Buffalo Creek outlet. The discharge of treated water would need to meet all surface and receiving water requirements. Discharge to the American River would provide for enhancing streamflow for fish or downstream users. Discharge of treated water to the American River also represents an option anticipated to require the least amount of water delivery obligations, including operation and maintenance costs. Such discharge may require a State water right permit if a change of an existing amount or point of diversion for a future use occurs or if new water transfer opportunities are implemented.

Discharge to the American River may be deemed an "offsite" action and therefore requiring permitting through the NPDES program, or possibly the State regulatory activities. The flows in the American River are managed by the BOR under permits issued by the State that have been subject to recent judicial review. State permits may be

necessary to divert water that has been discharged to the American River as part of remedial action. It is also possible that water discharged to the River could be resold downstream under a water marketing/transfer proposal yet to be developed. The extent of federal and state permitting required for long-term augmentation of American River flows depends upon the proposed program and the beneficial use of such waters.

Discharge to POTW. Another management/reuse process option would be to discharge either untreated or treated groundwater to a POTW (i.e., sanitary sewer). Use of this option would depend on the capacity of the sewer in the vicinity of where the groundwater would be discharged and the willingness of the POTW to accept the discharge. This process option could be implemented on both a short-term interim basis or on a long-term basis. Discharge to a POTW of extracted untreated groundwater was retained, as under one or more OU-wide alternatives discussed in Section 4 there may be long periods of time where a containment well may be pumping uncontaminated groundwater (or pumping groundwater that contains CoPC concentrations that are less than POTW influent requirements) to achieve containment and the groundwater could be discharged to a POTW. Discharge to a POTW of treated groundwater was retained and implementability would depend on the capacity of the sanitary sewer in the vicinity of the discharge, the willingness of the POTW to accept the discharge, and the connection and users fees assessed by the POTW.

Groundwater Recharge. The groundwater resource underlying the region is replenished on an annual basis and generally flows from east to west or southwest. While local extraction may affect the performance of nearby remedial extraction facilities, the long-term yield of the basin is unaffected by the extraction and/or recharge of the quantities of water described in this report. The current recharge activities are used as part of the containment strategy. Various alternatives are considered that include recharge. The following options will change the hydrological regime of water in the groundwater basin and could substitute surface water augmentation or satisfy beneficial uses that would or could be supplied from groundwater.

Satisfying Varying Demands. It is expected that various OU-wide remedial alternatives would supply treated groundwater at a steady annual rate. It is likely that the most beneficial uses would accept water at seasonally varying rates. Accommodating this seasonal variation can be accomplished by:

- Varying the operation of extraction and treatment facilities within acceptable limits;
- Discharging increasing quantities of water in the winter months to surface waters for streamflow augmentation or downstream use;
- Providing a combination of recharge and surface water use that optimizes investments and costs; and
- Designing the use facilities to provide for local storage to meet peak demands.

One or more of these options could be employed to optimize the remediation and delivery performance.

Incorporation of the management of the treated groundwater into the overall water supply plans for the eastern portion of the County could be used to minimize potential investment by Sacramento County and would delay if not eliminate the need for a new major Sacramento River diversion and accompanying treatment and pumping facilities at least for service to the portions of eastern Sacramento County that are farthest from the river. It would allow for staged development of water supply facilities meeting all public health and environmental requirements. All costs above the basic remedial action cost would become part of the new development financing program with potentially significant cost savings to both the remediation and development efforts.

Given the benefits of a coordinated approach to the wholesale water supply and development of eastern Sacramento County in conjunction with the requirements and potential beneficial uses associated with groundwater treatment at the Site, all of the possible water management/reuse process options will be retained for consideration in the OU RI/FS. This will allow all of the interested parties to provide input on the possible alternatives for management/reuse of treated groundwater.

3.3.2.11 Results of Evaluation of Groundwater Remediation Process Options

The results of the evaluation of groundwater remediation process options using the criteria of effectiveness, implementability, and cost are shown on Figure 3-3. For some technologies, more than one process option was retained. Examples of multiple representative process options potentially applicable for the Western Groundwater Study Area OU that were retained and were used to assemble OU-wide alternatives are as follows:

Remedial Technology	Multiple Representative Process Options Retained
Proprietary Institutional Controls	• Deed restrictions • Deed notices • Easements • Covenants
Governmental Institutional Controls	• Groundwater use restrictions • Advisories

Alternate/Replacement Water Supply	• New water supply well
	• New water supply:
	  • Inter-ties with adjacent water purveyors
	  • Direct reuse of treated groundwater
	  • Indirect reuse of treated groundwater
	  • New surface water supply

Hydraulic Barriers	• Extraction wells • Extraction and recharge wells

Remedial Technology	Multiple Representative Process Options Retained
Ex Situ Physical/Chemical Treatment	• LPGAC • Air stripping • Filtration • Ion Exchange • UV/oxidation
Vapor-Phase Treatment for Air Stripping (Ex Situ Physical/Chemical/ Biological Treatment	• Direct discharge • VPGAC • Catalytic oxidation • Thermal oxidation
Treated Groundwater Management	• Direct potable water supply • Indirect potable supply • Nonpotable water reuse • Streamflow augmentation • Discharge to POTW (both untreated or treated groundwater) • Groundwater recharge

In accordance with USEPA guidance (USEPA, 1988a), representative process options are selected to simplify the development and evaluation of OU-wide alternatives. However, the specific process option used to implement a remedial action may not be selected until the remedial design phase. Selection of a representative process option for purposes of developing and evaluating OU-wide alternatives in Sections 4 and 5 of this OU RI/FS report does not preclude the application of other retained process options at the site during the remedial design phase.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

4 DEVELOPMENT AND SCREENING OF ALTERNATIVES

4.1 Introduction

Technologies and process options retained in Section 3 need to be assembled into OU-wide remedial alternatives. This section describes the remedial alternatives assembled from the technologies and process options. Often, a large number of remedial alternatives are screened against the criteria of overall effectiveness in meeting the RAOs, implementability, and cost in order to screen out certain alternatives, thereby allowing the more detailed evaluation (in Section 5) to be undertaken with a reduced number of alternatives. Here, given the limited remedial actions that are potentially viable for this groundwater system, the number of alternatives assembled are a manageable number (i.e., ten), and additional screening to eliminate alternatives was not required. All of the alternatives have been carried forward to the detailed analysis presented in Section 5.

This OU RI/FS is evaluating a groundwater remedial action for the Western Groundwater OU Study Area. It does not evaluate source control measures for specific onsite source areas. The GETs E and F facilities do provide control with respect to the offsite movement of CoPCs from source areas and are evaluated in this OU RI/FS. As discussed in Section 2, the following RAOs were developed for the Western Groundwater OU:

- Protect human health and the environment from exposure to contaminated groundwater;
- Minimize offsite migration of CoPCs where practicable to protect long term beneficial uses;
- Reduce contaminant concentrations in already contaminated groundwater in an efficient cost-effective manner; and
- Protect public drinking water wells and provide treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels.

The NCP (EPA, 1990b) requires that, at a minimum, the following alternatives be considered during development of remedial alternatives:

- A No-Action alternative;
- A limited number of remedial alternatives that attain site-specific remediation levels within different restoration time periods using one or more technologies; and

- Alternatives that include innovative treatment technologies, if those technologies offer the potential for comparable or superior performance or implementability, fewer or less adverse impacts than other available approaches, or lower costs for levels of performance similar to that of demonstrated treatment technologies.

Using the technologies and representative process options retained in Section 3 and considering the specific RAOs developed for the Western Groundwater OU as well as the alternatives required to be considered by the NCP, remedial alternatives were developed as described in the following sections.

4.2 Description of Alternatives

Figure 4-1 illustrates the assembly of ten remedial alternatives for the Western Groundwater Study Area. The ten remedial alternatives described and screened in this section are as follows:

- Alternative 1 - No Action with Limited Groundwater Monitoring
- Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply
- Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply
- Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells
- Alternative 3B –GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells
- Alternative 4A – GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells
- Alternative 4B – GETs E and F Extraction Wells with Offsite Extraction Wells
- Alternative 4C - GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors
- Alternative 5A – GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells
- Alternative 5B – GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

The following sections describe each of the alternatives. More detailed information is further provided in Section 5 where each alternative is evaluated against the NCP criteria.

All alternatives include groundwater monitoring, including monitoring of public water supply wells and monitor wells in the Study Area. The number of samples collected annually for each alternative would be approximately equivalent to the number of samples currently required by Exhibits IV and VI of the PCD (approximately 530 samples per year) plus samples collected from new monitor wells proposed for each alternative as discussed below.

All Alternatives, except Alternative 1 (No Action) involve operation of the existing GETs E/F boundary containment/source control extraction/treatment system. Each of Alternatives 2 though 5 include an "A" and "B" alternative (e.g., Alternative 2A and Alternative 2B) for purposes of evaluating continued use of GETs E and F recharge wells. Alternative 4 also has a "C" alternative. Each of the "A" alternatives involves continued operation of the GETs E and F recharge wells. Each of the "B" alternatives and the "C" alternative involve shut down of the recharge wells and installation of additional extraction wells to maintain onsite capture. For purposes of costing alternatives, the "B" alternatives and the "C" alternative assume new extraction wells would be added at the Aerojet property boundary downgradient of the shut down recharge wells. The anticipated downgradient location of the replacement extraction wells is shown in figures depicting the "B" alternatives and the "C" alternative. This configuration should enhance onsite capture in layers C, D and E and eliminate the need for offsite containment in layer E and potentially layer D west of the replacement extraction wells.

All of the alternatives except the No Action alternative assume that additional extraction wells will be added to the existing GETs E/F extraction system to enhance capture. Aerojet believes it is advantageous to implement these modifications to GET E/F expeditiously and prior to the likely prolonged period of formal remedy selection and preparation of the ROD. A potential mechanism that could be used for early implementation of these modifications would be the material modification provision within Exhibit VI of the PCD. The modifications will involve additional extraction wells and optimization of extraction rates from existing GETs E/F extraction wells. For purposes of costing alternatives, the following modifications were assumed:

- New GET E and GET F extraction wells will be added as discussed in Section 1. Specifically, a cluster of three extraction wells in the same location, one each screened through the C, D, and E layers would be added to the north of the existing GET E extraction well system. The estimated total extraction rate for these three new GET E wells is approximately 1,000 gpm. Also, a new extraction well screened in layer C will be added to the south of the existing GET F extraction well system. The estimated extraction rate for this new GET F well is approximately 250 gpm; and

- Groundwater modeling for this report indicates that GETs E and F extraction wells can be pumped more efficiently such that the overall existing extraction flow rate can

be reduced by 25 percent while maintaining hydraulic capture: from approximately 3,400 gpm to approximately 2,550 gpm. (Treatment of groundwater from the GETs E and F extraction systems is conducted at the GET F treatment facility, which has a current capacity of approximately 4,000 gpm. Thus, sufficient treatment capacity currently exists at GET F to accommodate the anticipated groundwater flow from the existing GETs E and F extraction wells (2,500 gpm) as well as the added flow from the new GET E and F extraction wells (1,250 gpm) [i.e., a total flow of approximately 3,800 gpm] after these modifications are implemented.)

The detailed description and conceptual design of each of the alternatives described below was based upon the results of the Remedial Investigation (Appendix A) and the results of a numerical groundwater flow model. A description of the model, discussion of model calibration, and the approach/results of the various model simulations for the alternatives described in this section are summarized in Appendix D.

The detailed descriptions and conceptual designs included in this section are FS-level evaluations that provide an adequate basis for evaluation of alternatives. However, it is anticipated that there may be changes to the representative process options during the period of evaluation of this FS and through any remedy design. For example, containment options being evaluated may assume use of new extraction wells, but public water supply wells may be used, as appropriate. Similarly, there may be developments in treatment technologies that will meet performance standards but at lower cost and more advantageous from an implementability perspective. Additional evaluation of design of any remedy, including facility location, actual treatment technologies and the optimal sequence and configuration of these treatment technologies, and the process option or options that will be employed for management/reuse of treated groundwater will be further evaluated in any remedial design activity. Costs of past water supply replacement actions described in Section 3.3.2.4 are not included in the scope of or estimated costs presented in these alternatives.

4.2.1 Alternative 1 - No Action with Limited Groundwater Monitoring

Alternative 1 (No Action) is included as required by the NCP to serve as a baseline for comparison of the other alternatives. For this alternative, GETs E and F extraction, treatment, and treated groundwater recharge facilities would be terminated and no further onsite remedial activities would be implemented. For the No Action alternative there would be no active remediation of groundwater. Groundwater would be monitored under this Alternative, including the lateral and vertical extent of the CoPCs within the study area and downgradient public water supply wells.

For purposes of evaluating potential impact, an FS-level groundwater flow model was used to project particle flow over a 25 year period under assumptions specified in Appendix D. Limitations on the ability of the model to predict outcomes are discussed in that Appendix and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well. The FS-level model simulation

would project for this alternative that the following currently operating regional water supply wells would be impacted by either perchlorate at a concentration of 4 ug/L or NDMA at a concentration of 0.01 ug/L within the 25-year FS evaluation period:

AC-1	Winchester	Nut Plains
AC-10	Rockingham	Countryside
AC-18	AC-6	Mather AFB 4
AC-20	AC-5	
AC-12	AC-22	

4.2.2 Alternative 2A – GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Alternative 2A involves the operation of GETs E and F, including both extraction and recharge wells.

Groundwater would be monitored under this alternative, including the lateral and vertical extent of the CoPCs within the study area and downgradient public water supply wells.

Continued migration of the offsite CoPCs can impact downgradient public water supply wells. This alternative assumes the shutdown of downgradient public water supply wells and the replacement of affected water supply capacity through an alternative water supply. For purposes of evaluating Alternative 2A, it is assumed that the water supply well capacity indicated in Appendix D (Table D8-1) that resulted from the model simulation would require replacement based upon an FS-level groundwater model simulation.

Potential sources of alternate water supply could include treated groundwater from one or more of the Aerojet GET facilities (directly or through surface water conveyance), new water supply wells, or other water sources discussed in Section 3.3.2.4. In order to complete the OU RI/FS screening and evaluation steps and develop the necessary cost estimates, it was assumed that the source of alternate water supply for Alternate 2A would be treated groundwater and surface water.

As illustrated in Figure 4-2, conceptual sources of alternate water supply could consist of one or more of the following:

- Treated groundwater from one or more of the Aerojet GET facilities. Groundwater would be treated to potable quality and introduced to the water distribution system at or near the location of the affected water supply well;

- New water supply well(s) drilled outside of the CoPC plumes along with any necessary modifications to the water distribution system to deliver groundwater from the new well;

- Interties between adjoining water purveyors; and

- Treated surface water. Treated groundwater from one or more of the Aerojet GET facilities could be exchanged for surface water in the American River. Surface water from the American River could be diverted through the Folsom South Canal to one or more surface water treatment facilities that would serve the water distribution system(s) associated with the affected water supply well(s). Depending on which water supply wells are affected, the surface water treatment facilities could consist of the existing Southern California Water Company's (SCWC's) Coloma water treatment plant or one or more new facilities located to serve the water distribution system where water supply well capacity is lost.

In addition, Alternatives 2A and 2B assume the existence of offsite governmental institutional controls; namely, the proposed Consultation Zone provision to the Sacramento County existing comprehensive well drilling ordinance and DHS oversight over public drinking water systems that requires reporting of contaminants to DHS and which establishes obligations on water purveyors to provide potable water supplies to their customers. Aerojet will also request status from the County to be a regular referral entity for any new wells that may be proposed to be drilled in the Study Area.

The specific components that were included in the estimated costs for Alternative 2A are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F groundwater treatment plant (GWTP) are assumed to occur in the year 2001;

- Optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- Continue to treat groundwater at the GET F GWTP at a flow rate of approximately 3,800 gpm (approximately 2,550 gpm from the optimized existing GETs E and F extraction wells and approximately 1,250 gpm from the new GETs E and F extraction wells) using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs. Treated groundwater would continue to be recharged using the existing GETs E and F recharge wells;

- Based on FS-level groundwater model-predicted time projections, Table D8-1 indicates that the following water supply well capacity potentially would require replacement in the following respective years (limitations on the ability of the model

to predict outcomes are discussed in Appendix D and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well):

Year	Estimated Replacement Water Needed (gpm)
2005	4,800
2009	600
2011	900
Total	6,300

Therefore, it is assumed that construction of facilities to deliver replacement water would be completed in mid-year 2004 and beginning in mid-year 2004 replacement water would be provided using a combination of treated groundwater from GETs A (250 gpm), B (3,800 gpm), and ARGET (3,400 gpm) through mid-year 2015. Currently operated GET facilities could not provide adequate water supply, unless modifications were made to current recharge practices to allow water to be discharged, after treatment, to a surface water. For purposes of costing, it was assumed that GETs A, B, and ARGET would provide a total flowrate of approximately 7,450 gpm, which is greater than the 6,300 gpm estimated to be required. The treated groundwater would be polished using LPGAC and conveyed via pipeline to the water distribution system associated with the affected water supply wells. It is assumed that the respective water purveyor would provide disinfection facilities;

- After the year 2015, Table D8-1 indicates that the following additional water supply well capacity potentially would require replacement in the following respective years:

Year	Replacement Water Needed (gpm)
2016	3,700
2019	1,000
2026	200
Total	4,900

Therefore, it is assumed that construction would be completed in mid-year 2015 and beginning in mid-year 2015 replacement water would be provided using a combination of treated groundwater from GETs A, B, and ARGET discussed previously, as well as treated groundwater from GET D (1,000 gpm). The treated groundwater would be polished using LPGAC and conveyed via pipeline to the water distribution system associated with the affected water supply wells. It is assumed that the respective water purveyor would provide disinfection facilities. GETs A, B, D, and ARGET could provide a total flowrate of approximately 8,450 gpm, which is less than the estimated 11,200 gpm to be required for replacement water during the later years of the evaluation period. For purposes of costing, the difference in replacement water estimated to be required and that available from GETs A, B, D, and ARGET, would be provided by a new surface water supply from the American River. It is assumed that unused or other long-term firm entitlements could be purchased, surface

water could be diverted to the Folsom South Canal, and a new 5.8 MGD surface water treatment plant (SWTP) would be constructed at a location west of the Folsom South Canal and south of Highway 50 at a location near the water distribution system associated with the affected water supply wells. It is also assumed that a new raw water transmission pipeline would be constructed from a diversion structure on the Folsom South Canal to the new SWTP; and

- With respect to O&M costs, Alternative 2A would include:
  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and recharge systems;
  - O&M associated with the new GET E and F extraction wells;
  - Beginning in mid-year 2004, additional O&M associated with LPGAC treatment of GETs A, B, and ARGET treated effluents and pumping of treated groundwater as replacement water;
  - Beginning in mid-year 2015, additional O&M associated with LPGAC treatment of GET D treated effluent and pumping of treated groundwater as replacement water; and
  - Beginning in mid-year 2015, additional O&M associated with purchase of surface water and use fees associated with transporting the surface water in the Folsom South Canal.

4.2.3 Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Alternative 2B contains the same components as Alternative 2A with one exception: treated groundwater from the GETs E and F control systems will not be recharged to groundwater. The treated groundwater from the GETs E and F systems will be discharged to surface water and/or reused for potable or non-potable water supply purposes. For purposes of costing Alternative 2B, it is assumed that the water supply well capacity indicated in Appendix D (Table D8-2) will require replacement.

The specific components that were included in the estimated costs for Alternative 2B are as follows:

- Modification in the of the existing GETs E/F boundary containment/source control extraction system to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to

the existing GET E/F groundwater treatment plant (GWTP) are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E layers. The anticipated downgradient location of the replacement extraction wells is shown in figures depicting the "B" alternatives. The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, expand the treatment capacity of the GET F GWTP by approximately 2,225 gpm to accommodate the additional flow from the extraction wells added to replace the GETs E and F recharge wells. The additional flow capacity was derived as follows:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New extraction wells to replace recharge wells	2,425
Subtotal – treatment capacity required	6,225
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	2,225

- Treat groundwater at the GET F GWTP at a flow rate of approximately 6,225 gpm using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs. Groundwater would be treated to NPDES requirements for discharge and discharged to Buffalo Creek for the period from mid-2001 through mid-2004;

- Based on FS-level groundwater model-predicted time projections, Table D8-2 indicates that the following water supply well capacity potentially would require replacement in the following respective years (limitations on the ability of the model to predict outcomes are discussed in Appendix D and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well):

Year	Replacement Water Needed (gpm)
2005	4,800
2009	600
2011	900
Total	6,300

It is assumed that the replacement water would be provided using treated groundwater from the GET F GWTP through the year 2015. The flowrate treated at the GET F facility would be approximately the same as the flowrate of replacement water needed. LPGAC contactors would be constructed at the GET F GWTP location in the year 2004. It is also assumed that in the year 2004, construction of a replacement water transmission pipeline from the Buffalo Creek discharge location to a location within the water distribution system where affected water supply wells are located would be completed. Starting in mid-year 2004, the treated groundwater would be polished using LPGAC and conveyed via pipeline to the water distribution system associated with the affected water supply wells. It is assumed that the respective water purveyor would provide disinfection facilities;

- After the year 2015, Table D8-2 indicates that the following additional water supply well capacity potentially would require replacement in the following respective years:

Year	Replacement Water Needed (gpm)
2016	1,100
2020	1,900
2026	200
Total	3,200

For this estimated replacement water, it is assumed that construction would be completed by mid-year 2015 and beginning in mid-year 2015 replacement water would be provided using treated groundwater from the ARGET GWTP. The treated groundwater would be polished using LPGAC and conveyed via pipeline to the water distribution system associated with the affected water supply wells. It is assumed that the respective water purveyor would provide disinfection facilities; and

- With respect to O&M costs, Alternative 2B would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction and GET F treatment systems;

  - O&M associated with the new extraction wells at GETs E and F and the new extraction wells that will replace the GETs E and F recharge wellfields;

  - Beginning in mid-year 2004, additional O&M associated with LPGAC treatment of GET F treated effluent and pumping of treated groundwater as replacement water; and

- Beginning in mid-year 2015, additional O&M associated with LPGAC treatment of ARGET treated effluent and pumping of treated groundwater as replacement water.

4.2.4 Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Alternative 3A includes continued operation of GETs E and F (extraction and recharge). It also includes monitoring and the institutional controls described previously for Alternative 2A.

Alternative 3A also includes providing wellhead treatment on those existing water supply wells that may become affected by the CoPC plumes over time. If a water supply well becomes impacted by one or more of the CoPCs at concentrations above DHS standards for public water supply systems, treatment facilities would be installed at the wellhead location to treat the respective CoPC. Groundwater from the water supply well would be treated to potable water quality prior to introduction to the water distribution system.

For Alternative 3A, it is assumed that the water supply wells in the vicinity of and downgradient of the CoPC plumes will be continued to be operated by the respective water purveyor in the same manner that they have been operated historically: i.e., based on water demand. Therefore, operation of the wellhead treatment facility(ies) will be tied into the operation of the water supply well pump and also operated based on water demand. For Alternative 3A, the model simulation assumed that all water supply wells would be operated at their historical average pumping rates. The modeled approximate times CoPCs may be present in water supply wells, which is the basis for cost estimates prepared for this alternative, are included in Appendix D (Tables D8-3 through D8-5).

For purposes of this evaluation, the treatment processes assumed to be provided for removal of the respective CoPCs include LPGAC and/or UV/oxidation for VOCs (UV/oxidation would be employed for removal of both VOCs and NDMA if NDMA is present), UV/oxidation for NDMA, and ion exchange for perchlorate. Schematics showing the various wellhead "treatment trains" assumed based on the presence of one or more of the CoPCs are included on Figure 4-3. It is assumed that the existing disinfection system at the water supply well would continue to be operated and the disinfectant added prior to introduction of the treated water to the water distribution system.

Given the location of the public water supply wells and the zones of capture associated with those wells, this alternative provides both protection from exposure to CoPCs and substantial containment of the offsite CoPC plume as more fully discussed in Section 5. CoPCs that are not captured by public water supply wells would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 3A are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F groundwater treatment plant (GWTP) are assumed to occur in the year 2001;

- Optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- Continue to treat groundwater at the GET F GWTP at a flow rate of approximately 3,800 gpm (approximately 2,550 gpm from the optimized existing GETs E and F extraction wells and approximately 1,250 gpm from the new GETs E and F extraction wells) using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs. Treated groundwater would continue to be recharged using the existing GETs E and F recharge wells;

- Based on FS-level groundwater model-predicted time projections CoPCs may be present in water supply wells (see Tables D8-3 through D8-5), capital costs for wellhead treatment were assumed to be expended in the years shown on the following table. Limitations on the ability of the model to predict outcomes are discussed in Appendix D and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well. O&M costs for treatment at the respective wells were also assumed to begin in the years shown on the following table. Based on the CoPCs modeled to be present in the wells, treatment processes are also listed.

Water Supply Well	Year Wellhead Treatment Projected	Assumed Treatment Process(es)
AC-1	2006	Ion exchange
AC-1	2023	UV/oxidation
AC-5	2001	Ion exchange
AC-6	2020	Ion exchange
AC-7	2006	Ion exchange
AC-10	2006	Ion exchange
AC-11	2001	UV/oxidation
AC-11	2017	Ion exchange
AC-13	2009	UV/oxidation
AC-13	2011	Ion exchange

Water Supply Well	Year Wellhead Treatment Projected	Assumed Treatment Process(es)
AC-14	2001	UV/oxidation and ion exchange
AC-15	2001	UV/oxidation and ion exchange
AC-16	2001	UV/oxidation and ion exchange
AC-18	2010	Ion exchange
AC-19	2001	Ion exchange
AC-20	2002	UV/oxidation
AC-20	2006	Additional UV/oxidation added
AC-20	2013	Ion exchange
AC-23	2026	Ion exchange
Chettenham	2014	Ion exchange
Rockingham	2021	Ion exchange
Winchester	2017	Ion exchange
SWMD-17	2001	Ion exchange

- With respect to O&M costs, Alternative 3A would include:
  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and recharge systems;
  - O&M associated with the new GET E and F extraction wells; and
  - O&M associated with wellhead treatment at the water supply wells listed above.

4.2.5 Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Alternative 3B contains the same components as Alternative 3A with one exception: treated groundwater from the GETs E and F control systems will not be recharged to groundwater. The treated groundwater from the GETs E and F systems will be discharged to surface water and/or reused for potable or non-potable water supply purposes.

As with Alternative 3A, the model simulation for 3B assumed that water supply wells would be operated at their historical average pumping rates. The modeled approximate times CoPCs may be present in water supply wells, which is the basis for cost estimates prepared for this alternative, are included in Appendix D (Tables D8-6 through D8-8).

The specific components that were included in the estimated costs for Alternative 3B are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E (cluster locations NEW-1, -2, and –3) layers. The anticipated downgradient locations of the replacement extraction wells are shown in figures depicting the "B" alternatives. The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, expand the treatment capacity of the GET F GWTP by approximately 2,225 gpm to accommodate the additional flow from the extraction wells added to replace the GETs E and F recharge wells. The additional flow capacity was derived as follows:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New extraction wells to replace recharge wells	2,425
Subtotal – treatment capacity required	6,225
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	2,225

- Treat groundwater at the GET F GWTP at a flow rate of approximately 6,225 gpm using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs. Groundwater would be treated to NPDES requirements for discharge and discharged to Buffalo Creek for streamflow augmentation for the evaluation period;

- Based on FS-level groundwater model-predicted time projections CoPCs may be present in water supply wells (see Tables D8-6 through D8-8), capital costs for wellhead treatment were assumed to be expended in the years shown on the following table. Limitations on the ability of the model to predict outcomes are discussed in Appendix D and it would be inappropriate to conclude that the model can predict chemical concentration outcomes for any particular well. O&M costs for treatment at the respective wells were also assumed to begin in the years shown on the following table. Based on the CoPCs modeled to be present in the wells, treatment processes are also listed.

Water Supply Well	Year Wellhead Treatment Projected	Assumed Treatment Process(es)
AC-1	2006	Ion exchange
AC-1	2023	UV/oxidation
AC-5	2001	Ion exchange
AC-6	2020	Ion exchange
AC-7	2006	Ion exchange
AC-10	2006	Ion exchange
AC-11	2001	UV/oxidation
AC-11	2017	Ion exchange
AC-13	2009	UV/oxidation
AC-13	2011	Ion exchange
AC-14	2001	UV/oxidation and ion exchange
AC-15	2001	UV/oxidation and ion exchange
AC-16	2001	UV/oxidation and ion exchange
AC-18	2010	Ion exchange
AC-19	2001	Ion exchange
AC-20	2002	UV/oxidation
AC-20	2006	Additional UV/oxidation added
AC-20	2013	Ion exchange
AC-23	2026	Ion exchange
Chettenham	2014	Ion exchange
Rockingham	2021	Ion exchange
Winchester	2017	Ion exchange
SWMD-17	2001	Ion exchange

- With respect to O&M costs, Alternative 3B would include:
  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and discharge systems;
  - O&M associated with the new GET E and F extraction wells; and
  - O&M associated with wellhead treatment at the water supply wells listed above.

4.2.6 Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Alternative 4A involves the continued operation of the GETs E and F systems, in which recharge wells would continue to be used. It also includes monitoring and institutional controls described in Alternative 2A and additional monitoring (approximately 1.5 monitoring wells for each new extraction well).

Alternative 4A also would establish an offsite hydraulic barrier, intended to contain the offsite plume and prevent further migration of CoPCs downgradient of the barrier in concentrations that would impair beneficial uses of the groundwater.

The offsite hydraulic barrier would involve extraction and treatment of groundwater. As evaluated in this OU RI/FS, it would involve using new extraction wells to provide hydraulic containment. A conceptual depiction of the alternative is contained on Figure 4-4. The actual location of groundwater extraction wells will be based upon a combination of factors, including design and construction constraints (e.g., pipeline corridors, public right of ways) and cleanup levels, and may not result in the placement of the hydraulic barrier at or downgradient of the leading edge of the plume.

Based on the model simulation performed for Alternative 4A, a total of 30 new extraction wells would be necessary over time to provide hydraulic containment offsite. Based on modeling, the assumed beginning year of operation, modeled pumping rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-9). Modeled locations of the extraction wells relative to the CoPC plumes are shown on Figure 4-4. More detailed discussion of the modeling and assumptions made are contained in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells.

For purposes of analysis, all extracted water is assumed to be treated at a single treatment location. As previously discussed in Section 3, there are many combinations of process options and technologies that could be developed and analyzed for each alternative that involves extraction of groundwater. For example, groundwater could be treated at the wellhead or at a facility location where groundwater from two or more collection or containment wells is treated. Also, several process options are available for treatment of perchlorate (biological reduction and ion exchange) and any VOCs (LPGAC, air stripping, UV/oxidation) that may be present. UV/oxidation is a proven technology for NDMA removal, but Aerojet is aggressively pursuing other innovative processes. In addition, if groundwater from multiple wells is routed to a central location for treatment, there are many possible pipe routing alternatives to consider taking into account availability of easements and rights-of-way; crossing of major highways and roads such

as US Highway 50, Folsom Boulevard, Sunrise Boulevard, Zinfandel Drive, and White Rock Road; crossing of railroad mainline/spurs and the Folsom South Canal; and the presence of other buried utilities including fiber optic telephone lines, potable water, sanitary and storm sewer, natural gas, and electrical power.

Therefore, in order to complete the OU RI/FS screening and evaluation steps and develop the necessary cost estimates, in addition to the extraction wells proposed for containment, the following offsite representative action components were assumed for Alternative 4A:

- Groundwater collected from all extraction wells would be routed to a central groundwater treatment facility located on Aerojet property adjacent to the existing GETs E/F treatment facility;

- Pipe routing located along a corridor west of the Aerojet site in the vicinity of Zinfandel Drive;

- A representative treatment system consisting of the treatment processes currently employed at the GETs E/F groundwater treatment facility (Figure 3-2) which include biological reduction for perchlorate removal, filtration for solids removal, UV/oxidation for removal of VOCs and NDMA, and air stripping for removal of any remaining VOCs following UV/oxidation; and

- Management/reuse of treated groundwater by delivery via pipeline to a location coincident for discharge to the American River via Buffalo Creek for streamflow augmentation or entry into a public water supply system.

However, inclusion of these offsite action components for Alternative 4A should in no way be construed as precluding consideration or ultimate use of other equivalent technologies during any subsequent remedial design/remedial action activities. Additional evaluation of use of water supply wells or new extraction wells as extraction wells with coincident wellhead treatment and direct reuse of treated groundwater (particularly those water supply wells located north of US Highway 50 downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate), pipe routing, whether one or more treatment facility locations need to be constructed, the actual treatment technologies and the optimal sequence and configuration of these treatment processes, and the process option or options that will be employed for management/reuse of treated groundwater will be performed during the remedial design phase.

CoPCs that are detected downgradient of the offsite hydraulic barrier will be monitored. Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use wellhead treatment. Additional extraction wells may also be added. As discussed in Section D8.3.6, the model simulation for Alternative 4A assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not captured would be

monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 4A are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F groundwater treatment plant (GWTP) are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, complete 12 new extraction wells offsite in the C layer (Figure 4-4 and Table D8-9) and one new extraction well in the D layer (coincident with new extraction well C3) and install conveyance piping from these well locations to the existing GET F GWTP location;

- In the year 2001, expand the treatment capacity of the GET F GWTP using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs by approximately 3,500 gpm to accommodate the following additional flow:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
13 new offsite containment extraction wells (2001)	3,700
Subtotal – treatment capacity required	7,500
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	3,500

Under Alternative 4A, management/reuse of treated groundwater from the onsite and offsite containment systems would involve both (1) recharge, and (2) delivery via pipeline to a location coincident for direct reuse into a public water supply system or streamflow augmentation to the American River via Buffalo Creek. Approximately 3,400 gpm of treated groundwater would continue to be recharged using the existing GETs E and F recharge wells. The remaining approximately 4,100 gpm (year 2001) would be available as long-term replacement water for water supply wells. If a long-term replacement water supply is not necessary, this remaining approximately 4,100 gpm would be discharged to Buffalo Creek for streamflow augmentation.

If the treated groundwater is needed for long-term water replacement, direct reuse is contemplated. As discussed previously regarding replacement water, for direct reuse, treated groundwater from the GETs E/F GWTP would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek. Alternatively, if the treated groundwater is not accepted by DHS for direct reuse, indirect reuse would be employed for long-term water replacement. Under indirect reuse, treated groundwater would be discharged to Buffalo Creek and exchanged for surface water from the American River. Surface water from the American River would be delivered via the Folsom South Canal and a new transmission pipeline to a new or expanded surface water treatment facility to be constructed within the water distribution system of the affected water purveyor.

If treated groundwater is not needed for long-term water replacement, for purposes of comparing costs of OU-wide alternatives on an equivalent basis, treated groundwater from the GETs E/F GWTP would be discharged to Buffalo Creek for streamflow augmentation. The discharge pipeline installed in 2001 from the GET F GWTP to Buffalo Creek would be sized to accommodate the maximum treated groundwater flow anticipated over the evaluation period. Alternatively, treated groundwater in excess of the approximately 3,400 gpm that would be recharged at the GETs E and F recharge fields could be managed/reused by (1) recharge in an area downgradient of the CoPC plume in the western portion of Rancho Cordova, or (2) non-potable reuse for developments south of the Study Area. For purposes of preparing a cost estimate for recharge, it is assumed that a conveyance pipeline would be constructed from the GETs E/F GWTP west along White Rock Road to an area west of Zinfandel Drive and recharge wells with capacities of approximately 500 gpm each would be located approximately 1,000 feet apart. O&M costs for recharge would include pumping costs to deliver the treated water to the recharge wellfield and periodic recharge well rehabilitation costs. Since development plans for non-potable reuse are out of the scope of this FS, for costing purposes, it is assumed that the developer would be responsible for the majority of the capital and O&M costs and that the costs for this option would be similar or less than the costs for offsite recharge.

If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, approximately 3,400 gpm to be discharged to Buffalo Creek may be made available as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. Based on the respective capacities (maximum daily flow) for these wells (AC-1 [400 gpm], AC-10 [700 gpm], and AC-20 [2,300 gpm]) obtained from the Revised Preliminary and Final Water Supply Alternatives Reports for Arden Cordova Water Service Wells #11, 13, 15, 16, and 19 (Aerojet, 2000a), approximately 3,400 gpm of maximum-day capacity would be necessary to replace the combined flows of these wells. Design of and capital cost estimates associated with any facilities that may be constructed relative to replacement water for these wells would likely be based on 3,400 gpm maximum-day flow. Any annual O&M costs, however, would likely be based on the annual average daily flow for these wells of 17 gpm for AC-1, 66 gpm for AC-10,

and 912 gpm for AC-20, for a total of 995 gpm for these wells. On an interim basis, short-term water replacement may be necessary in the event water supply wells are impacted prior to the implementation of a remedy identified in this FS. Aerojet has recently obtained a commitment from the City of Folsom to provide potable water to ACWS through the inter-tie between the two systems. This source would provide up to approximately 3,400 gpm for potential short-term impacts over the next two to three years. Two options would be available to provide replacement water for these water supply wells on a long-term basis: direct reuse of treated groundwater and indirect reuse of treated groundwater. These options are described below:

- Direct Reuse. Under the direct reuse option, treated groundwater from the GETs E/F GWTP would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek. As discussed in Section 3.3.2.4, direct reuse of treated groundwater would be dependent on DHS, water purveyor, and public acceptance. For costing purposes, it is assumed that the LPGAC contactors would be sized for 3,400 gpm and the water purveyor would provide disinfection facilities at the point of introduction to the water distribution system. O&M costs would be based on the 995 gpm annual average daily flow and would include pumping costs to deliver the water to the water distribution system and periodic replacement of the LPGAC.

- Indirect Reuse. Under the indirect reuse option, treated groundwater from the GETs E/F GWTP would be discharged to Buffalo Creek and exchanged for surface water from the American River. Surface water from the American River would be delivered via the Folsom South Canal and a new transmission pipeline to a new or expanded surface water treatment facility to be constructed within the water distribution system of the affected water purveyor. The transmission pipeline and surface water treatment capacity would be sized based on the maximum-day flow of 3,400 gpm. O&M costs would be based on the 995 gpm annual average daily flow and would include use fees for the Folsom South Canal and pumping costs to deliver the water from the Folsom South Canal to the new or expanded surface water treatment facility.

- In the year 2011, complete one new extraction well in the C layer (C11) and two new extraction wells in the D layer coincident with two existing C layer extraction wells (C7 and C10) and add approximately 700 gpm of treatment capacity at the GET F GWTP;

- In the year 2021, complete five new extraction wells (four in the D layer and one in the E layer, all coincident with existing C layer extraction wells) and add approximately 1,300 gpm of treatment capacity at the GET F GWTP; and

- Based on the model simulation performed for Alternative 4A, in years beyond the 25-year evaluation period complete nine new extraction wells (three in the D layer and

six in the E layer, all coincident with existing C layer extraction wells) and add approximately 2,900 gpm of treatment capacity at the GET F GWTP.

- With respect to O&M costs within the evaluation period, Alternative 4A would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and recharge systems;

  - O&M associated with the new GET E and F extraction wells; and

  - Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the 13 new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation;

  - If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing the approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

  - Beginning in mid-year 2011, additional O&M associated with extracting and conveying groundwater from the three new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation; and

  - Beginning in mid-year 2021, additional O&M associated with extracting and conveying groundwater from the five new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation.

4.2.7 Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Alternative 4B contains the same components as Alternative 4A with one exception: treated groundwater from the onsite GETs E and F boundary containment/source control systems would not be recharged to groundwater. The treated groundwater from the GETs E and F systems would be discharged to surface water for streamflow augmentation and/or reused for potable or non-potable water supply purposes.

With respect to the offsite containment component of Alternative 4B, the results of the model simulation indicate that a total of 17 new extraction wells will be necessary over time to provide offsite hydraulic containment. Based on modeling, the assumed beginning year of operation, modeled pumping rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-10). Modeled locations of the extraction wells relative to the CoPC plumes are shown on Figure 4-5. More detailed discussion of the modeling and assumptions made are contained in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells, particularly those locations north of US Highway 50 downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate.
Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use treatment. As discussed in Section D8.3.7, the model simulation for Alternative 4B assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not captured would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 4B are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E layers. The anticipated downgradient locations of the replacement extraction wells are shown in Figure 4-5 (cluster locations NEW-1, -2, and –3). The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, complete 10 new extraction wells offsite in the C layer and one new well in the D layer (Figure 4-5) and install conveyance piping from these well locations to the existing GET F GWTP location;

- In the year 2001, expand the treatment capacity of the GET F GWTP using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs by approximately 5,325 gpm to accommodate the following additional flow:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New extraction wells to replace recharge wells	2,425
11 new offsite containment extraction wells (2001)	3,100
Subtotal – treatment capacity required	9,325
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	5,325

  The entire approximately 9,325 gpm would be discharged to Buffalo Creek for streamflow augmentation. The discharge pipeline installed in 2001 from the GET F GWTP to Buffalo Creek would be sized to accommodate the maximum treated groundwater flow anticipated over the evaluation period.

  If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, a portion of this approximately 9,325 gpm to be discharged to Buffalo Creek may be used as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. As discussed for Alternative 4A, approximately 3,400 gpm would be necessary to replace the combined flows of these wells. This replacement water would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

- In the year 2011, complete one new extraction well in the D layer coincident with existing C layer extraction well C3 and add approximately 200 gpm of treatment capacity at the GET F GWTP;

- In the year 2021, complete two new extraction wells in the D layer coincident with two existing C layer extraction wells (C4 and C5) and add approximately 400 gpm of treatment capacity at the GET F GWTP; and

- Based on the model simulation performed for Alternative 4B, in years beyond the 25-year evaluation period complete three new extraction wells (two in the D layer and one in the E layer, all coincident with existing C layer extraction wells) and add approximately 900 gpm of treatment capacity at the GET F GWTP.

- With respect to O&M costs within the evaluation period, Alternative 4B would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction and treatment systems;

  - O&M associated with the new GET E and F extraction wells and the new extraction wells that will replace the GETs E and F recharge wellfields;

  - Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the 11 new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation;

  - If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

  - Beginning in mid-year 2011, additional O&M associated with extracting and conveying groundwater from the one new offsite containment well, treating the flow associated with this well at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation; and

  - Beginning in mid-year 2021, additional O&M associated with extracting and conveying groundwater from the two new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation.

4.2.8 Alternative 4C - GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors

Alternative 4C would contain the following same components as Alternative 4B:

- Establishment of an offsite hydraulic barrier, intended to contain the offsite plume and prevent further migration of CoPCs downgradient of the barrier in concentrations that would impair beneficial uses of the groundwater; and

- Continued operation of the GETs E and F systems. The treated groundwater from the GETs E and F systems would be discharged to surface water for streamflow augmentation and/or reused for potable or non-potable water supply purposes.

Alternative 4C would also incorporate "multiple containment corridors" by including installation of new extraction wells closer to the estimated leading edge location of the CoPC plume in the D and E layers sooner than planned for the other alternatives. This Alternative 4C was developed in response to USEPA, RWQCB, and DTSC comments on the draft OU RI/FS report. Based on modeling, the assumed beginning year of operation, modeled pumping rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-11). Modeled locations of the extraction wells relative to the CoPC plumes are shown on Figure 4-6.

With respect to the offsite containment component of Alternative 4C, the results of the model simulation indicate that a total of 18 new extraction wells will be necessary over time to provide offsite hydraulic containment. More detailed discussion of the modeling and assumptions made are contained in Section D8.3.8 in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells, particularly those locations north of US Highway 50 downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate.

Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use treatment. As discussed in Section D8.3.8, the model simulation for Alternative 4C assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not captured would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 4C are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E layers. The anticipated downgradient locations of the replacement extraction wells are shown in Figure 4-6 (cluster locations NEW-1, -2, and –3). The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, complete 10 new extraction wells offsite in the C layer, four new extraction wells in the D layer, and two new extraction wells in the E layer and install conveyance piping from these well locations to the existing GET F GWTP location (Figure 4-6);

- In the year 2001, expand the treatment capacity of the GET F GWTP using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs by approximately 5,975 gpm to accommodate the following additional flow:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New extraction wells to replace recharge wells	2,425
16 new offsite containment extraction wells (2001)	3,750
Subtotal – treatment capacity required	9,975
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	5,975

The entire approximately 9,975 gpm would be discharged to Buffalo Creek for streamflow augmentation. The discharge pipeline installed in 2001 from the GET F GWTP to Buffalo Creek would be sized to accommodate the maximum treated groundwater flow anticipated over the evaluation period.

If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, a portion of this approximately 9,975 gpm to be discharged to Buffalo Creek may be used as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. As discussed for Alternative 4A, approximately 3,400 gpm would be necessary to replace the combined flows of these wells. This replacement water would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

- In the year 2011, complete one new extraction well in the D layer coincident with an existing C layer extraction well (C3) and add approximately 200 gpm of treatment capacity at the GET F GWTP; and

- In the year 2021, complete one new extraction well in the D layer coincident with an existing C layer extraction well (C4) and add approximately 200 gpm of treatment capacity at the GET F GWTP.

- With respect to O&M costs within the evaluation period, Alternative 4C would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction and treatment systems;

  - O&M associated with the new GET E and F extraction wells and the new extraction wells that will replace the GETs E and F recharge wellfields;

  - Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the 16 new offsite containment wells, treating the flow associated with these wells at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation;

  - If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

  - Beginning in mid-year 2011, additional O&M associated with extracting and conveying groundwater from the new offsite containment well, treating the flow associated with this well at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation; and

  - Beginning in mid-year 2021, additional O&M associated with extracting and conveying groundwater from the new offsite containment well, treating the flow associated with this well at the expanded GET F GWTP, and conveying the treated groundwater to Buffalo Creek for streamflow augmentation.

4.2.9 Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Alternative 5A includes continued operation of the GETs E and F control systems and recharge of treated GETs E and F groundwater. It also includes monitoring and the

institutional controls described previously for Alternative 2A. In addition, Alternative 5A would also provide containment of the offsite CoPC plume using a combination of new extraction and recharge wells to provide hydraulic containment.

Modeled locations of extraction and recharge wells downgradient of the CoPC plumes are shown on Figure 4-7. As indicated on Figure 4-7, recharge wells would be located on the periphery to direct the plumes to extraction wells located in the center. The Alternative 5 series evaluates the potential impact of offsite recharge on effectiveness and flow rates of the offsite hydraulic barrier.

Based on the model simulation performed for Alternative 5A, a total of 24 new extraction wells and seven new recharge wells would be necessary to provide hydraulic containment offsite over time. Based on modeling, the assumed beginning year of operation, modeled pumping and recharge rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-12). More detailed discussion of the modeling and assumptions made are contained in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells, particularly those locations north of US Highway 50 downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate.

In addition to the extraction and recharge wells proposed for containment, the following offsite representative action components are included for purposes of preparing estimated costs for Alternative 5A:

- Routing of groundwater collected from extraction wells to a central groundwater treatment facility located southwest of the offsite extraction/recharge wells on or near Mather Field;

- Pipe routing located along a corridor west of the Aerojet site in the vicinity of Zinfandel Drive;

- A representative groundwater treatment system consisting of biological reduction for perchlorate removal, pressure filtration to remove any remaining particulates prior to recharge, UV/oxidation for removal of VOCs and NDMA, air stripping polishing to remove any remaining VOCs following UV/oxidation; and

- Management/reuse of treated groundwater via recharge to maintain a hydraulic barrier in conjunction with the offsite extraction wells.

Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use treatment. As discussed in Section D8.3.9, the model simulation for Alternative 5A assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not

captured would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 5A are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- The existing GET F GWTP will have sufficient capacity accommodate the anticipated flow from the onsite GETs E and F boundary containment/source control systems as indicated below:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
Subtotal – treatment capacity required	3,800
Existing treatment capacity at GET F	4,000

The approximately 3,800 gpm of treated groundwater would continue to be recharged using the existing GETs E and F recharge wells. If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, a portion of this 3,800 gpm to be recharged may be used as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. As discussed for Alternative 4A, approximately 3,400 gpm would be necessary to replace the combined flows of these wells. This replacement water would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek,

- In the year 2001, complete nine new extraction wells offsite in the C layer (Figure 4-7) and one new extraction well in the D layer (coincident with new extraction well C3), install conveyance piping from these well locations to a new offsite GWTP location, and construct a new offsite GWTP to remove perchlorate, NDMA, and any VOCs from groundwater extracted from offsite containment wells. From 2001 to 2011, FS modeling (Table D8-12) indicates that only 3,100 gpm of capacity would be required for the offsite GWTP. However, for purposes of this evaluation, it is

assumed that the offsite GWTP would be sized to accommodate the maximum offsite flow anticipated over the FS evaluation period, which is 4,900 gpm. If Alternative 5A were implemented, the actual initial capacity of the offsite GWTP would be determined during remedial design;

- Also in the year 2001, complete seven offsite recharge wells located where groundwater is not impacted by perchlorate or NDMA and where they can divert impacted groundwater away from operating water supply wells and toward extraction wells (Figure 4-7). Conveyance piping from the new offsite GWTP to these recharge wells would also be constructed in 2001. Groundwater treated at the offsite GWTP would be equally distributed among the seven recharge wells;

- In the year 2011, complete two new extraction wells in the D layer coincident with two existing C layer extraction wells and add 500 gpm of treatment capacity at the offsite GWTP;

- In the year 2021, complete five new extraction wells (four in the D layer and one in the E layer, all coincident with existing C layer extraction wells) and add approximately 1,300 gpm of treatment capacity at the offsite GWTP; and

- Based on the model simulation performed for Alternative 5A, in years beyond the 25-year evaluation period, complete seven new extraction wells (one in the D layer and six in the E layer, all coincident with existing C layer extraction wells) and add approximately 2,200 gpm of treatment capacity at the offsite GWTP.

- With respect to O&M costs within the evaluation period, Alternative 5A would include:

  - Operation, maintenance, and monitoring associated with existing GETs E and F extraction, treatment, and recharge systems;

  - O&M associated with the new GETs E and F extraction wells; and

  - If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing the approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

  - Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the 10 new offsite containment wells, treating the flow associated with these wells at a new offsite GWTP, conveying the treated groundwater to the seven new offsite recharge wells, and maintaining the recharge wells;

- Beginning in mid-year 2011, additional O&M associated with extracting, conveying, treating at the offsite GWTP, and recharging groundwater from the two new offsite containment wells; and

- Beginning in mid-year 2021, additional O&M associated with extracting, conveying, treating at the offsite GWTP, and recharging groundwater from the five new offsite containment wells.

4.2.10 Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Alternative 5B contains the same components as Alternative 5A with one exception: treated groundwater from the onsite GETs E/F boundary containment/source control systems would not be recharged to groundwater. The treated groundwater from the GETs E/F systems would be discharged to surface water and/or reused for potable or non-potable water supply purposes.

Similar to Alternative 5A, Alternative 5B includes containment of the offsite CoPC plumes using a combination of new extraction and recharge wells to provide hydraulic containment. Modeled locations of extraction and recharge wells downgradient of the CoPC plumes are shown on Figure 4-8. As indicated on Figure 4-8, recharge wells would be located on the periphery to direct the plumes to extraction wells located in the center.

Based on the model simulation performed for Alternative 5B, a total of 11 new extraction wells and seven new recharge wells would be necessary to provide hydraulic containment offsite over time. Based on modeling, the assumed beginning year of operation, modeled pumping and recharge rates, and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells are included in Appendix D (Table D8-13). More detailed discussion of the modeling and assumptions made are contained in Appendix D. As depicted, all extraction wells are new; however, it is possible that one or more of the extraction locations could be existing public water supply wells, particularly those locations north of US Highway downgradient of the portion of the CoPC plume that contains low concentrations of perchlorate.

Should public water supply wells be shut down due to the findings of CoPCs in concentrations that are greater than MCLs or PALs, this alternative contemplates contingent action involving either alternative water supplies or point of use treatment. As discussed in Section D8.3.10, the model simulation for Alternative 5B assumed that water supply wells AC-1, AC-10, and AC-20 turn off in the year 2001. CoPCs that are not captured would be monitored and allowed to migrate, relying on natural attenuation processes to reduce CoPC concentrations over time to acceptable levels.

The specific components that were included in the estimated costs for Alternative 5B are as follows:

- Modification of the existing GETs E and F boundary containment/source control extraction systems to enhance capture through addition of the three new clustered GET E wells (approximately 1,000 gpm total flow) and the one new GET F well (250 gpm). For costing purposes, these modifications and associated conveyance piping to the existing GET F GWTP are assumed to occur in the year 2001;

- In the year 2001, optimizing the extraction rates from the existing GETs E/F boundary containment/source control extraction wells such that the extraction flow rate can be reduced by 25 percent while maintaining hydraulic capture (i.e., reduce flow from approximately 3,400 to approximately 2,550 gpm);

- In the year 2001, shut down of the GETs E and F recharge wells and installation of additional extraction wells downgradient of the recharge well locations to maintain onsite capture. Nine new extraction wells would be added at the Aerojet property boundary at three clustered locations. At each of the three locations, three new extraction wells would be completed, one each screened through the C, D, and E layers. The anticipated downgradient locations of the replacement extraction wells are shown in Figure 4-8 (cluster locations NEW-1, -2, and –3). The extraction flowrate from the three wells in the cluster to the north is estimated at 725 gpm. The estimated flowrate from each of the middle and southern clusters is 850 gpm;

- In the year 2001, expand the treatment capacity of the GET F GWTP using the unit processes shown in Figure 3-2 of biological reduction, UV/oxidation, and air stripping for removal of perchlorate, NDMA, and VOCs by approximately 2,225 gpm to accommodate the following additional flow:

Flow Component	Capacity (gpm)
Existing GETs E and F extraction wells	3,400
Additional GET E and F extraction wells	1,250
Optimization of existing GETs E and F extraction wells	-850
New clustered extraction wells to replace recharge wells	2,425
Subtotal – treatment capacity required	6,225
Existing treatment capacity at GET F	-4,000
Total – additional treatment capacity required	2,225

The entire approximately 6,225 gpm would be discharged to Buffalo Creek for streamflow augmentation. The discharge pipeline installed in 2001 from the GET F GWTP to Buffalo Creek would be sized to accommodate the maximum treated groundwater flow anticipated over the evaluation period.

If water supply wells AC-1, AC-10, and AC-20 (and coincident wellhead treatment and direct reuse) are not substituted for extraction wells north of US Highway 50, a

portion of this approximately 6,225 gpm to be discharged to Buffalo Creek may be used as a long-term replacement water supply for wells AC-1, AC-10, and AC-20. As discussed for Alternative 4A, approximately 3,400 gpm would be necessary to replace the combined flows of these wells. This replacement water would be polished with LPGAC and delivered to a location within the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

- In the year 2001, complete seven new extraction wells offsite in the C layer (Figure 4-8), install conveyance piping from these well locations to a new offsite GWTP location, and construct a new offsite GWTP to remove perchlorate, NDMA, and any VOCs from groundwater extracted from offsite containment wells. From 2001 to 2011, FS modeling (Table D8-13) indicates that only 2,000 gpm of capacity would be required for the offsite GWTP. However, for purposes of this evaluation, it is assumed that the offsite GWTP would be sized to accommodate the maximum offsite flow anticipated over the FS evaluation period, which is 2,600 gpm. If Alternative 5B were implemented, the actual initial capacity of the offsite GWTP would be determined during remedial design;

- Also in the year 2001, complete seven offsite recharge wells located where groundwater is not impacted by perchlorate or NDMA and where they can divert impacted groundwater away from operating water supply wells and toward extraction wells (Figure 4-8). Conveyance piping from the new offsite GWTP to these recharge wells would also be constructed in 2001. Groundwater treated at the offsite GWTP would be equally distributed among the seven recharge wells;

- In the year 2011, complete one new extraction well in the D layer coincident with C layer extraction well C3 and add approximately 200 gpm of treatment capacity at the offsite GWTP; and

- In the year 2021, complete two new extraction wells in the D layer coincident with C layer extraction wells C4 and C5 and add approximately 400 gpm of treatment capacity at the offsite GWTP.

- Based on the model simulation performed for Alternative 5B, in years beyond the 25-year evaluation period, complete one new extraction well in the E layer, coincident with C layer extraction well C5 and add approximately 300 gpm of treatment capacity at the offsite GWTP.

- With respect to O&M costs within the evaluation period, Alternative 5B would include:

    - Operation, maintenance, and monitoring associated with existing GETs E and F extraction and treatment systems;

- O&M associated with the new GET E and F extraction wells, the new extraction wells that will replace the GETs E and F recharge wellfields, and the expanded GET F GWTP;

- If water supply wells AC-1, -10, and –20 are not substituted for extraction wells (and coincident wellhead treatment and direct reuse), then beginning in 2001, additional O&M costs would be associated with polishing the approximately 3,400 gpm of treated groundwater from the GET F GWTP and delivering the replacement water to the water distribution system near the intersection of US Highway 50 and Buffalo Creek;

- Beginning in mid-year 2001, additional O&M associated with extracting and conveying groundwater from the seven new offsite containment wells, treating the flow associated with these wells at a new offsite GWTP, conveying the treated groundwater to the seven new offsite recharge wells, maintaining the recharge wells, and monitoring;

- Beginning in mid-year 2011, additional O&M associated with extracting, conveying, treating at the offsite GWTP, and recharging groundwater from the one new offsite containment well; and

- Beginning in mid-year 2021, additional O&M associated with extracting, conveying, treating at the offsite GWTP, and recharging groundwater from the two new offsite containment wells.

4.3 Screening of Alternatives

In this section, the assembled alternatives are typically screened against the criteria of overall effectiveness in meeting the RAOs, implementability, and cost. The purpose is to reduce the number of alternatives that will undergo a more thorough and extensive analysis during the detailed evaluation of alternatives. This screening process was used, but all alternatives were retained.

Following are descriptions of each of the criteria used in this screening process:

- Effectiveness - The effectiveness criterion measures how well the alternative achieves the RAOs. The effectiveness of each alternative in protecting human health and the environment is a key aspect of the alternative screening evaluation. Each alternative is evaluated in terms of its effectiveness in providing protection and reducing the toxicity, mobility, and volume of contamination. Short-term (during the construction and implementation period) and long-term (after remedial action is complete) effectiveness are evaluated.

- Implementability - The implementability criterion includes evaluating both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative. Technical feasibility refers to the future operation, maintenance, and monitoring of an alternative after the remedial action has been completed. Administrative feasibility refers to the ability to obtain approvals and permits from regulatory agencies; the availability and capacity of treatment, storage, and disposal services; and the requirements for and availability of specialized technicians and equipment.

- Cost - The cost-screening criterion provides a mechanism for comparison of cost estimates among alternatives. However, cost plays a limited role in this screening process. Instead, each alternative is evaluated with respect to whether costs for the alternative are high, low, or medium relative to other alternatives.

At this stage, the screening process focuses on effectiveness factors with less effort directed at the implementability and cost evaluation.

The screened alternatives are assembled from representative technology and process options. However, the specific processes actually used to implement a remedial action may not be selected until the remedial design. At some sites, innovative or non-representative process options may be found to offer significant advantages in the form of treatment performance or implementability, fewer adverse impacts than other available approaches, or lower costs for similar levels of performance.

Because of the use of the representative process option concept for purposes of preparing cost estimates for the various alternatives, the number of alternatives assembled was able to be limited to a manageable number (i.e., ten), additional screening to eliminate alternatives was not required and all of the alternatives have been carried forward to the detailed analysis presented in Section 5.

PAGES OF OVERSIZED MAPS

(SEE BINDER)

5 DETAILED ANALYSIS OF ALTERNATIVES

In this section, the ten alternatives developed in Section 4 are subjected to detailed analysis. The purpose of this detailed analysis is to provide sufficient information to allow for comparisons among the alternatives based on the standard criteria specified in the NCP.

The detailed evaluation of final alternatives for a remedial action is a two-stage process. During the first stage of evaluation, each of the alternatives is assessed against the individual criteria. This first-stage evaluation of the final remedial action alternatives for the Western Groundwater OU is presented in this section; the evaluation is based on the conceptual descriptions of the final alternatives provided in Section 4. For the second stage of the evaluation process, the criteria are grouped into a tiered system to reflect their interrelationships and different levels of significance. During this second-stage evaluation, the alternatives are initially evaluated according to the threshold criteria, which must be met, and then compared with each other to identify relative advantages and disadvantages and trade-offs among the different balancing criteria. The purpose of the comparative analysis is to provide information for a balanced remedy selection. The second-stage evaluation of final remedial action alternatives is presented in Section 6.

The nine NCP evaluation criteria include:

Threshold Criteria:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

Primary Balancing Criteria:

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

Modifying Criteria:

- State Acceptance
- Community Acceptance

The NCP [40 CFR Section 300.430(e)(9)(iii)] categorizes these nine criteria into three groups: threshold criteria, primary balancing criteria, and modifying criteria. Each type of criteria has its own weight when it is evaluated. Threshold criteria are requirements that each alternative must meet to be eligible for selection as the preferred alternative, and include overall protection of human health and the environment and compliance with ARARs (unless a waiver is obtained).

Primary balancing criteria are used to weigh effectiveness and cost tradeoffs among alternatives. The primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The primary balancing criteria represent the main technical criteria upon which the alternative evaluation is based. Modifying criteria include State acceptance and community acceptance, and may be used to modify aspects of the preferred alternative when preparing the proposed plan.

Modifying criteria are generally evaluated after public comment on the OU RI/FS and the Proposed Plan. Accordingly, only the seven threshold and primary balancing criteria are used in the detailed analysis phase. The following sections provide descriptions of the evaluation criteria and the items considered when assessing alternatives with respect to each criterion.

5.1 Description of Evaluation Criteria

5.1.1 Overall Protection of Human Health and the Environment

This evaluation criterion assesses how each alternative provides and maintains adequate protection of human health and the environment. Alternatives are assessed to determine whether they can adequately protect human health and the environment from unacceptable risks posed by contaminants present at the site, in both the short and long term. This criterion is also used to evaluate how risks would be eliminated, reduced, or controlled through treatment, engineering, institutional controls, or other remedial activities. The considerations evaluated during the analysis of each alternative for overall protection of human health and the environment are presented in below:

Protection of human health:

- Likelihood that the alternative reduces risk to human health to below risk-based levels.

Protection of the environment:

- Likelihood that the alternative reduces the threat to unaffected groundwater by minimizing migration of contaminants. As discussed in the BRA, there are no completed exposure pathways to groundwater for ecological receptors.

5.1.2 Compliance with ARARs

This evaluation criterion is used to evaluate if each alternative would attain federal and State ARARs, or whether invoking waivers to specific ARARs is adequately justified.

Other information, such as advisories, criteria, or guidance, is considered where appropriate during the ARARs analysis. The considerations evaluated during the analysis of the ARARs applicable to each alternative are presented below. Potential action-, location-, and chemical-specific ARARs for the alternatives presented in this OU RI/FS are identified in Appendix C.

Chemical-specific ARARs:

- Likelihood that the alternative will achieve compliance with chemical-specific ARARs (e.g., MCLs) within a reasonable period of time.
- If it appears that compliance with chemical-specific ARARs will not be achieved, then evaluation of whether a waiver is appropriate.

Location-specific ARARs:

- Determination of whether any location-specific ARARs (e.g., whether facilities will be located in a floodplain and preservation of wetlands) apply to the alternative.
- Likelihood that the alternative will achieve compliance with the location-specific ARAR.
- Evaluation of whether a waiver is appropriate if the location-specific ARAR cannot be met.

Action-specific ARARs:

- Likelihood that the alternative will achieve compliance with action-specific ARARs (e.g., new source air emission rules).
- Evaluation of whether a waiver is appropriate if the action-specific ARAR cannot be met.

Other criteria and guidance:

- Likelihood that the alternative will achieve compliance with other criteria, such as risk-based criteria.

5.1.3 Long-Term Effectiveness and Permanence

This evaluation criterion addresses the long-term effectiveness and permanence of maintaining the protection of human health and the environment after implementing the remedial action imposed by the alternative. The primary components of this criterion are the magnitude of residual risk remaining at the site after remedial objectives have been met and the extent and effectiveness of controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The considerations evaluated during the analysis of each alternative for long-term effectiveness and permanence are

presented below. The components addressed for each alternative are described in more detail in the following subsections.

Magnitude of residual risks:

- Identity of remaining risks (risks from treatment residuals) as well as risks from untreated residual contamination.
- Magnitude of the remaining risks.

Adequacy and reliability of controls:

- Likelihood that the technologies will meet required process efficiencies or performance specifications.
- Type and degree of long-term management required.
- Long-term monitoring requirements.
- O&M functions that must be performed.
- Difficulties and uncertainties associated with long-term O&M functions.
- Potential need for technical components replacement.
- Magnitude of threats or risks should the remedial action need replacement.
- Degree of confidence that controls can adequately handle potential problems.
- Uncertainties associated with land disposal of residuals and untreated wastes.

5.1.3.1 Magnitude of Residual Risk

The magnitude of residual risk at the end of remedial activities is measured by numerical standards such as PRGs, or the volume or concentration of CoPCs remaining. The characteristics of the residuals remaining are also evaluated, considering their volume, toxicity, and mobility.

5.1.3.2 Adequacy and Reliability of Controls

The adequacy and reliability of controls that are used to either manage treatment residuals or untreated materials that remain after attaining PRGs are evaluated. This criterion includes an assessment of containment systems and institutional controls to evaluate the degree of confidence that they adequately handle potential problems and provide sufficient protection. The criterion also addresses long-term reliability, the need for long-term management and monitoring, and the potential need to replace technical components of the alternative.

5.1.4 Reduction of Toxicity, Mobility or Volume through Treatment

This evaluation criterion addresses the anticipated performance of the treatment technologies employed by each alternative in permanently and significantly reducing toxicity, mobility, and/or volume of CoPCs associated with the OU. The NCP prefers remedial actions where treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. The considerations evaluated during the analysis of each alternative for reduction of toxicity, mobility, or volume of CoPCs present at a given site are presented below:

Treatment process and remedy:

- Likelihood that the treatment process addresses the principal threat.
- Special requirements for the treatment process.

Relative amount of hazardous material destroyed or treated:

- Portion (mass) of CoPC that is destroyed.
- Portion (mass) of CoPC that is treated.

Reduction in toxicity, mobility, or volume:

- Extent that the total mass of CoPCs is reduced.
- Extent that the mobility of CoPCs is reduced.
- Extent that the volume of CoPCs is reduced.

Irreversibility of treatment:

- Degree that the effects of the treatment are irreversible.

Type and quantity of residuals remaining following treatment:

- Residuals that will remain.
- Quantities and characteristics of the residuals.
- Risk posed by the treatment residuals.

Statutory preference for treatment as a principal element:

- Extent to which the scope of the action covers the principal threats.
- Extent to which the scope of the action reduces the inherent hazards posed by the principal threats at the site.

5.1.5 Short-Term Effectiveness

Short-term effectiveness considers the effect of each remedial alternative on the protection of human health and the environment during the construction and implementation phase. The short-term effectiveness evaluation only addresses protection prior to meeting the RAOs. The considerations evaluated during the analysis of each alternative for short-term effectiveness are presented below:

Protection of the community during any remedial action:

- Risks to the community that must be addressed.
- How the risks will be addressed and mitigated.
- Remaining risks that cannot be readily controlled.

Protection of workers during remedial actions:

- Risks to the workers that must be addressed.
- How the risks will be addressed and mitigated and the effectiveness and reliability of measures to be taken.
- Remaining risks that cannot be readily controlled.

Environmental impacts of any remedial action:

- Environmental impacts that are expected with the construction and implementation of the alternative.
- Mitigation measures that are available and their reliability to minimize potential impacts.
- Impacts that cannot be avoided, should the alternative be implemented.

Time until RAOs are achieved:

- Time to achieve protection against the threats being addressed.
- Time until any remaining threats are addressed.
- Time until RAOs are achieved.

5.1.6 Implementability

Implementability evaluates the technical feasibility and administrative feasibility (i.e., the ease or difficulty) of implementing each alternative and the availability of required services and materials during its implementation. The following considerations are evaluated during the analysis of each alternative for implementability:

Technical Feasibility

Ability to construct and operate the technology:

- Difficulties associated with the construction.
- Uncertainties associated with the construction.

Reliability of the technology:

- Likelihood that technical problems will lead to schedule delays.

Ease of undertaking additional remedial action:

- Likely future remedial actions that may be anticipated.
- Difficulty implementing additional remedial actions.

Monitoring considerations with respect to effectiveness of the remedy:

- Migration or exposure pathways that cannot be monitored adequately.
- Risks of exposure, should the monitoring be insufficient to detect failure.

Administrative Feasibility

Coordination with other agencies:

- Steps required to coordinate with regulatory agencies to implement any remedy.
- Steps required to establish long-term or future coordination among agencies.
- Ease of obtaining permits for offsite activities, if required.

Availability of Services and Materials

Availability of treatment, storage capacity, and disposal services:

- Availability of adequate treatment, storage capacity, and disposal services.
- Additional capacity that is necessary.
- Whether lack of capacity prevents implementation.
- Additional provisions required to ensure that additional capacity is available.

Availability of necessary equipment and specialists:

- Availability of adequate equipment and specialists.
- Additional equipment or specialists that are required.
- Whether there is a lack of equipment or specialists.
- Additional provisions required to ensure that equipment and specialists are available.

Availability of prospective technologies:

- Whether technologies under consideration are generally available and sufficiently demonstrated.
- Further field applications needed to demonstrate that the technologies may be used full-scale to treat CoPCs.
- When technology should be available for full-scale use.
- Whether more than one vendor will be available to provide a competitive bid.

5.1.7 Cost

The estimated costs are presented within the accuracy range stated in RI/FS guidance (USEPA, 1988a). The cost sensitivity analysis represents an evaluation of how sensitive the cost of a given project is to changes in parameters that are not known with certainty.

Capital and O&M costs were prepared using February 1999 dollars. In preparing the capital and O&M cost estimates, a contingency of allowance of 15 percent was included to address unforeseen circumstances such as the ability to estimate the scope of any remedial alternative at this stage of the OU RI/FS, the ability to predict the schedule for implementation of a remedy, the ability to estimate costs of treatment technologies for removal of certain CoPCs, uncertainties associated with the provisional reference dose for perchlorate, and unresolved issues with respect to management of treated groundwater in concert with overall regional water management objectives. With respect to the present worth cost analyses, a discount rate of 7 percent (before taxes and after inflation) [USEPA, 1996e] and a 25 year period of performance for costing purposes were assumed.

For costing all of the alternatives involving groundwater containment or collection (except containment using existing water supply wells), treatment is assumed to occur at a central treatment facility located at the existing GETs E/F treatment facility site or at a new site to be located on or near the former Mather Air Force Base (AFB). For those alternatives involving containment using existing water supply wells, treatment would occur at the well head.

Again, for purposes of costing, the "representative treatment system" approach discussed in Section 3 will be used. Specifically, groundwater treatment processes at a central groundwater treatment facility will involve biological reduction for perchlorate removal, UV/oxidation for VOCs and NDMA removal, and air stripping polishing for removal of any residual VOCs. As to extracted water that is not recharged, the treated groundwater management option for costing purposes is assumed to be discharge to a location coincident with intake of a public water system or to surface water.

5.1.8 State Acceptance

This criterion involves technical and administrative concerns that the State may communicate in its comments concerning each alternative.

5.1.9 Community Acceptance

The preferred alternative for this OU RI/FS will be presented to the public in a Proposed Plan, which will provide a brief summary of all of the alternatives studied in the detailed analysis of alternatives section of the OU RI/FS. In accordance with the NCP, the public will have an opportunity to review and comment on the selected remedial alternative presented in the Proposed Plan. The public's comments will be addressed in the responsiveness summary and ROD for the Western Groundwater OU.

5.2 Results of the Detailed Analysis of Alternatives

The following sections present the detailed analysis of the ten remedial alternatives using the seven threshold and primary balancing criteria.

A numerical groundwater model was used to assist in evaluating the alternatives with respect to the NCP threshold criteria (protectiveness and compliance with ARARs). The model simulated groundwater flow and estimated advective migration of dissolved CoPCs and was used to evaluate the relative merits of the remedial alternatives subsequently described in this section. The groundwater model used to evaluate the remedial alternatives was based on the final site conceptual model as presented in Section 1. A complete description of the groundwater model is presented in Appendix D.

Groundwater flow was simulated using MODFLOW, a modular three-dimensional flow model developed by the United States Geological Survey (USGS). A particle-tracking model, MODPATH, was used to evaluate advective contaminant migration for each of the remedial alternatives as described in Appendix D. This objective was achieved by

starting particles and allowing them to migrate with the advective groundwater flow. Hence, mechanisms such as dispersion, decay, or chemical fate were not considered.

Because of the approximate nature of numerical solutions, the conceptual model, and hydrogeologic parameters, none of the results of the evaluation should be construed as precise predictions of future contaminant distributions. Rather, evaluative results should be viewed as tools for comparing and contrasting the relative merits of each of the remedial alternatives. Analyses were performed to evaluate whether model results were sensitive to uncertainties in various input parameters. These analyses are presented in Appendix D.

5.2.1 Alternative 1: No Action with Limited Groundwater Monitoring

This section presents the description and detailed analysis of the No Action alternative, which serves as the baseline for comparison of the effectiveness of the remaining eight alternatives. Under No Action, the current onsite source containment activities associated with operation of the GETs E and F extraction, treatment, and treated groundwater recharge facilities would be terminated and no further onsite remedial activities would be implemented. For the No Action alternative, there would be no active remediation of groundwater offsite. Also, no institutional controls would be implemented under the No Action alternative. Limited groundwater monitoring, equivalent to that currently being undertaken under Exhibits IV and VI would be undertaken.

Existing water supply wells that may be affected by the migration of CoPC plumes would be shut off, as discussed in Section 4.

5.2.1.1 Overall Protection of Human Health and Environment

Contaminated groundwater is not prevented from migrating further and affecting other groundwater resources. Except to the extent that pre-existing institutional controls prevent exposure, the No Action alternative does not eliminate, reduce, or control the potential consumption of groundwater containing site-related constituents at levels above PRAGs. The No Action alternative (as evaluated in the BRA) assumes that persons will be supplied water containing site-related constituents above risk-based levels either by private or public water providers or through use of individual domestic wells. Therefore, in theory, and for purposes of comparison to the other alternatives, the No Action alternative is assumed to provide inadequate protection to human health and the environment.

In actuality, public water purveyors take action to monitor and shut down wells that they or DHS consider to be inappropriate for service to customers. Further, the anticipated Consultation Zone provision of the Sacramento County comprehensive well drilling

ordinance will restrict drilling of new wells in the area. Consequently, although for purposes of this OU RI/FS it is assumed that the No Action alternative does not include any active or passive means to eliminate, reduce, or control the pathway by which persons could be exposed to contaminated drinking water, there are controls outside the scope of this OU RI/FS that would eliminate, restrict, or control potential use of contaminated drinking water.

Under the No Action alternative, the existing onsite GETs E/F groundwater extraction and treatment facilities that are used to contain and control the source area groundwater would be terminated. Therefore, the No Action alternative would not minimize or control migration from the source area. Similarly, the No Action alternative would not limit further migration of impacted groundwater downgradient of the source. To the extent that it would be practicable to return the regional aquifer to its beneficial uses through cost-effective remediation, the No Action alternative would not achieve the goal of returning the regional aquifer to its expected beneficial use.

As there are no active remediation measures included in the No Action alternative, it does not pose any unacceptable short-term risks or other adverse impacts beyond its theoretical failure to eliminate the use of contaminated groundwater.

5.2.1.2 Compliance with ARARs

Over time, natural flushing of the aquifer will reduce the concentrations of CoPCs in the aquifer; however, this is expected to take a substantial period of time and therefore chemical-specific ARARs will not be met within a reasonable time frame by the No Action Alternative.

As the No Action Alternative does not include any active measures, location- and action-specific ARARs do not apply to this alternative.

5.2.1.3 Long-Term Effectiveness and Permanence

All current and potential future risks remain. Untreated residual CoPCs in groundwater would pose a risk if the residential well or water supply pathways become complete.

Risks posed by CoPCs in groundwater are expected to gradually decrease as contaminant concentrations decrease over time through physical dilution by dispersion and diffusion of all CoPCs and possibly through biodegradation of any VOCs.

5.2.1.4 Reduction of Toxicity, Mobility, and Volume through Treatment

The No Action alternative would not provide any reduction in toxicity beyond the natural attenuation of CoPCs that may occur in the groundwater environment. There would be

no reduction of mobility and volume through treatment because no treatment technologies would be employed. Therefore, the No Action alternative would not address the statutory preference for treatment as a principal element. No treatment residuals would be generated.

5.2.1.5 Short-Term Effectiveness

Because no remedial action would be taken under the No Action alternative, no short-term risks to the community or to workers as a result of implementing the action would occur. Similarly, no environmental impact from construction activities would occur.

The RAOs for protecting human health and the environment from exposure to contaminated groundwater, minimizing offsite migration of CoPCs where practicable to protect long-term beneficial uses, reducing contaminant concentrations in an efficient cost-effective manner would not be met by the No Action alternative as it would not minimize offsite migration. The RAO of protecting public drinking water wells and providing treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels would not be met by the No Action alternative.

5.2.1.6 Implementability

As no active or passive remedial technologies would be implemented under the No Action alternative, there are no implementability concerns or issues associated with the No Action alternative. There are no impediments to implementing the No Action alternative.

5.2.1.7 Costs

Because the No Action alternative only includes limited groundwater monitoring, it is ranked as the least costly alternative. The assumed level of monitoring is equivalent to the current monitoring program under Exhibits IV and VI of the PCD. The annual O&M costs and 25 year present worth costs associated with implementing Alternative 1 are as follows. A present worth summary is included in Appendix E.

Estimated annual Monitoring costs:	$160,000
Estimated 25-year present worth costs:	$2,000,000

5.2.2 Alternative 2A: GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Alternative 2A includes continued operation and improvements to the onsite GETs E and F boundary containment/source control systems and onsite recharge of treated GETs E and F groundwater. A map showing the onsite capture zone is included as Figure 5-1. Alternative 2A also includes monitoring and institutional controls. Offsite, Alternative 2A involves providing an alternate water supply to replace the lost capacity of any existing water supply wells that may become effected by the offsite CoPC plume.

The potential sources of alternate water supply that would be made available by Aerojet to replace lost capacity would include treated groundwater from one or more of the Aerojet GET facilities, new water supply wells located in areas not effected by the CoPC plumes, or surface water that has been exchanged for treated groundwater from one or more of the Aerojet GET facilities.

The assumed level of monitoring is equivalent to the current monitoring program under Exhibits IV and VI of the PCD. Offsite institutional controls (DHS oversight of public drinking water systems and the proposed Consultation Zone provision of the comprehensive Sacramento County well drilling ordinance) are assumed. Aerojet will also request status from the County to be a regular referral entity for any new wells that may be proposed to be drilled in the Study Area.

Under this alternative the offsite CoPC plume will continue to migrate. For purposes of costing, it is assumed that the water supply well capacity resulting from the model simulation (Appendix D, Table D8-1) would require replacement. For purposes of analysis, maximum day water demand is assumed (Fair, Geyer, and Okun, 1966).

There are various replacement/alternative water supplies that are potentially available to replace lost well capacity. For example, treated groundwater from one or more of the existing GET facilities on the Aerojet site may be made available through direct reuse or such GET facility water may become available following discharge to surface water.

Alternative 2A assumes that treated groundwater will be available for direct reuse. Accordingly, costs are associated with piping and transfer to an assumed location in the water distribution system located to the west of the Aerojet site.

5.2.2.1 Overall Protection of Human Health and Environment

By terminating use of impacted groundwater and replacing the supply of potable water with treated groundwater and/or unimpacted surface water and maintaining and/or enhancing existing controls on well drilling and groundwater use in the affected area, Alternative 2 eliminates the potential for consumption of groundwater containing site-related constituents at levels above risk-based criteria. Under Alternative 2A, persons would be provided alternative supplies from treated groundwater or an unimpacted

surface water source. Therefore, Alternative 2A is protective of human health and the environment. Offsite groundwater and water supply well monitoring and institutional controls would contribute to public health protection.

Alternative 2A would eliminate or significantly reduce continued offsite migration offsite of contaminated groundwater from the Aerojet facility. As Alternative 2A does not include any offsite engineered groundwater controls, it would not limit further migration of impacted groundwater downgradient of the GETs E/F systems. Consequently, Alternative 2A would not minimize migration of CoPCs that have already left the Aerojet facility. However, over some very lengthy period of time, natural attenuation processes should eventually result in the restoration of the offsite regional aquifer to its expected beneficial use. As there would be no control of impacted groundwater downgradient of the source area, over the short term, Alternative 2A would allow additional portions of the aquifer to become contaminated and would probably require additional water supply wells to be shut down.

5.2.2.2 Compliance with ARARs

Alternative 2A has the potential to eventually comply with ARARs that pertain to the protection of groundwater resources and the cleanup of releases. At the Aerojet facility, contaminated groundwater captured by the GET E/F extraction wells will be treated prior to management/reuse to concentrations that meet cleanup standards based on risk-based levels and chemical-specific ARARs (e.g., MCLs and PALs if treated water is to be directly reused) where applicable or relevant and appropriate. Over time, all of the onsite groundwater containing CoPCs will be removed by the extraction wells and replaced by natural and/or artificial recharge of uncontaminated water. Thus, the onsite component of Alternative 2A is consistent with protecting the beneficial uses and maintaining the existing quality of receiving waters pursuant to State Water Resources Control Board Resolutions 68-16 and 92-49, and the Basin Plan.

As noted above, Alternative 2A does not include any offsite engineered groundwater controls, and therefore will not limit further migration of impacted groundwater supplies downgradient of the GET E/F systems. Accordingly, it is unlikely that impacted groundwater offsite can attain chemical-specific ARARs within the short term. However, the combined operation of institutional controls (e.g., the proposed Consultation Zone provision to the Sacramento County comprehensive well drilling ordinance and Aerojet's serving as a regular referral entity for any new wells that may be proposed to be drilled in the Study Area), the source control measures at the Aerojet facility, and natural attenuation processes has a reasonable potential to bring about long-term attainment with ARARs.

The GET E/F facilities will be improved and operated in a manner designed to comply with all location- and action-specific ARARs. As no active remediation measures in offsite areas are include in Alternative 2A, location- and action-specific ARARs do not apply to offsite actions under this alternative.

5.2.2.3 Long-Term Effectiveness and Permanence

For Alternative 2A, effective long-term control of the onsite CoPC plume and migration of the plume offsite would be provided through extraction and treatment of groundwater via the GETs E/F containment system. However, potential current and future risks associated with the offsite CoPC plume would remain. Untreated residual CoPCs in groundwater offsite may pose a risk if the groundwater is used as a water supply.

The fate of perchlorate and NDMA in groundwater is not well understood. There is insufficient basis, at present, to conclude that there will be significant degradation of these chemicals in groundwater. Therefore, it is assumed that these CoPCs will migrate downgradient a significant distance, and could impact water supply wells located outside of the Study Area. Offsite, this alternative relies more heavily on institutional controls than other engineered alternatives such as groundwater extraction and treatment.

5.2.2.4 Reduction of Toxicity, Mobility and Volume through Treatment

Under CERCLA guidance for selecting remedial action alternatives, preference is given to remedial technologies that significantly reduce the toxicity, mobility, or volume of the affected media through treatment. This evaluation criterion assesses the degree of reduction in toxicity, mobility, or volume of the CoPCs. Considerations include an analysis of the extent of irreversibility of the treatment and the disposition of treatment materials.

For Alternative 2A, continued operation and upgrading of the onsite GETs E/F boundary control system would capture the CoPCs onsite and prevent them from migrating offsite, reducing the toxicity, mobility, and volume of the CoPCs. VOCs, perchlorate, and NDMA would be destroyed via the UV/oxidation and biological reduction processes, which are irreversible. Use of these treatment processes would satisfy the statutory preference for treatment as a principal element of the remedial action.

Residuals remaining after treatment would include the minor volume of non-hazardous organic sludge that would be generated by the biological reduction process. This sludge would be discharged to the sanitary sewer or dewatered and disposed in a non-hazardous landfill.

Under Alternative 2A, for the portion of the CoPC plume currently offsite, no extraction and treatment of groundwater is planned. To protect human health and the environment, the offsite component of Alternative 2A includes maintaining institutional controls and providing an alternate water supply. Therefore, for the offsite component of the Alternative 2A remedy, no reduction beyond the natural biodegradation of organic compounds that occurs in the groundwater environment and physical dilution by dispersion and diffusion of all CoPCs is projected to take place, the mobility and volume

of the CoPC plume will not be reduced, and the statutory preference for treatment as a principal element will not be addressed. No treatment residuals would be generated from the offsite component of the Alternative 2A remedy.

5.2.2.5 Short-Term Effectiveness

Protection of Community and Workers. The short-term impact on the risks to the community and workers would be minimal during construction of the additional onsite extraction wells and treatment capacity associated with the GETs E/F boundary containment system. Likewise, during construction of any pipelines to convey treated groundwater, surface water treatment facilities, or new water supply wells to replace lost capacity of any existing water supply wells that may become effected, the short-term impact on the risks to the community and workers would be minimal. Workers would be adequately protected during construction by adhering to Occupational Safety and Health Administration (OSHA) practices. Workers would also be protected while operating and maintaining facilities by adhering to appropriate health and safety procedures.

Environmental Impacts. Adverse environmental impacts associated with this alternative include the continued migration of the offsite CoPC plumes.

Time until Response Objectives are Achieved. Minimizing further offsite migration of CoPCs from the Aerojet site is being achieved by the existing GETs E/F boundary control system. Human health risk due to exposure to contaminated groundwater would be eliminated immediately after affected water supply wells are shutdown and alternative water supplies are provided. Minimizing further migration of the offsite CoPC plume would not be achieved under Alternative 2A. Reducing contaminant concentrations in already contaminated groundwater in an efficient cost-effective manner would be achieved immediately for the onsite GETs E/F containment system and would not be achieved for the offsite portion of the CoPC plume.

The RAO of protecting public drinking water wells and providing treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels would be met immediately after affected water supply wells are shutdown and alternative water supplies are provided. During the period between approval of the OU RI/FS and the implementation of this remedial action, should it be selected, it is possible that CoPCs will be detected in additional public water supply wells at unacceptable levels. Public water purveyors would be expected to continue to monitor wells for CoPCs, either directly or by obtaining the results of Aerojet monitoring undertaken pursuant to Exhibit IV of the PCD. Exhibit IV currently requires Aerojet to evaluate the source of the contaminant and recommend alternatives necessary to protect public health, which process is subject to agency review and Court oversight. Such alternatives could include shutting down the well, providing alternative water supplies or providing point of use treatment, all more fully discussed in Section 3 and Section 4 of this OU RI/FS. As part of this alternative, some mechanism for monitoring and

evaluation of interim remedial measures necessary to protect public health would be appropriate, should the provisions of Exhibit IV no longer apply.

5.2.2.6 Implementability

The primary implementability issues associated with Alternative 2A would be (1) for direct reuse of treated groundwater, obtaining DHS approval; and (2) for any alternative water supplies, the routing of water supply conveyance piping from the point of availability to the appropriate pressure zone in the water distribution system.

If treated groundwater is directly used, DHS approval would be required for the water purveyor to use the water. DHS is currently evaluating direct reuse of treated water that had contained the same CoPCs and involving the same types of treatment as existing or projected at GETs E and F. It is possible that DHS will not approve or approve direct reuse only on conditions that raise implementability issues.

If treated groundwater is made available for water purveyor use through discharge to the American River or Folsom South Canal, approvals may be required by other regulatory agencies that can delay the project or impose conditions that can affect implementability.

The only future remedial action that may be necessary under Alternative 2A is the future need to provide additional alternative water supply to offset impacts to wells that may become impacted in the future and/or to provide alternative water supplies to replace wells of water providers whose wells have not been impacted but that may be impacted by further migration of the plume.

Should treated groundwater not be available as an alternative water supply, there may be implementability difficulties due to the potential unavailability of surface water entitlements or long term surface water supplies for such purpose.

As provision of an alternative water supply completely breaks the pathway through which persons could be exposed to contaminated groundwater, monitoring of water quality would not be necessary to insure protection of public health under Alternative 2A. Monitoring downgradient water supply wells that continue to be used would be necessary to identify potential future impacts and insure that contaminated water is not used for potable water supply. This type of monitoring is not expected to be difficult, as water providers are already required to routinely monitor the quality of the water they supply. Monitoring and evaluation of the location of potential new wells would also be necessary to assess and insure the effectiveness of institutional controls on future use of contaminated groundwater. Such monitoring would take the form of continued implementation of the proposed Consultation Zone provision of the Sacramento County comprehensive well ordinance and Aerojet serving in a regular referral entity for any new well that may be proposed in the Study Area. Should the institutional control fail to identify or restrict drilling of a new public water supply well in a contaminated area, it is anticipated that initial sampling of water supplied by a new well would identify the

presence of CoPCs resulting in the hypothetical new well not being used for potable supply.

The primary issues associated with coordination with other agencies would be the need to obtain approval for additional surface water diversion from Nimbus Reservoir via the Folsom South Canal and the need to obtain water purveyor support to shut down affected wells and use the alternate water supply. Coordination with local land planning and land use agencies would be necessary to implement controls on and monitoring of construction of possible new water supply wells in or downgradient of the existing CoPC plume.

Offsite, Alternative 2A does not entail any active treatment, storage or disposal of contaminated water. Therefore, no treatment, storage or disposal facilities would be necessary. The only treatment and storage needs required by this alternative are for treatment, storage and distribution of unaffected surface water supplies. Such treatment, to the extent necessary, is commonly available and routinely used by water suppliers and should require only limited evaluation prior to implementation.

5.2.2.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 2A, assuming direct reuse of GET treated groundwater are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$25,000,000
Estimated annual O&M costs:	$2,100,000-3,900,000
Estimated 25-year present worth costs:	$48,000,000

5.2.3 Alternative 2B: GETs E and F Extraction Wells with Offsite Alternate Water Supply

Alternative 2B differs from Alternative 2A only as to the shutdown of GETs E and F recharge. A map showing the onsite capture zone for this alternative is included as Figure 5-2. The discussion below does not repeat the substance of the discussion as to Alternative 2A, but simply notes any differences between the two alternatives resulting from the change from recharge to extraction onsite.

5.2.3.1 Overall Protection of Human Health and Environment

Alternative 2B is equally as protective as Alternative 2A.

5.2.3.2 Compliance with ARARs

Alternative 2B provides the same level of compliance with ARARs as Alternative 2A.

5.2.3.3 Long-Term Effectiveness and Permanence

As with Alternative 2A, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system. There are some model-projected changes that arise from replacing onsite GETs E/F recharge with extraction wells. First, the extraction wells are currently projected to be placed downgradient of the GETs E/F recharge field and are likely to contain CoPCs in Layer E and substantial portions in Layers C and D that would otherwise migrate off the Aerojet site. Accordingly, there would likely be more mass of chemicals extracted. By extracting, rather than recharging, the hydraulic gradient will decrease locally, thus potentially reducing the offsite movement. Model projections suggest fewer public water supply wells should be impacted over the same period of time.

5.2.3.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 2B is the same as for Alternative 2A discussed in Section 5.2.2.4. The only exception is that by extracting groundwater to implement hydraulic control instead of continued use of recharge wells, Alternative 2B provides greater reduction of mass of CoPCs in groundwater and potentially reduces the mobility and volume of a portion of the offsite plume.

5.2.3.5 Short-Term Effectiveness

Same as Alternative 2A.

5.2.3.6 Implementability

Same as Alternative 2A.

5.2.3.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 2B are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$22,000,000
Estimated annual O&M costs:	$2,500,000-2,800,000
Estimated 25-year present worth costs:	$54,000,000

5.2.4 Alternative 3A: GETs E and F Extraction and Recharge wells with Offsite Wellhead Treatment at Water Supply Wells

Alternative 3A involves operation of the GETs E and F control system onsite. Offsite action is assumed to be wellhead treatment using existing public water supply wells and groundwater monitoring. A map showing both onsite and offsite capture zones is included as Figure 5-3. Figure 5-4 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 3A.

Public water supply wells would be monitored for CoPCs. The assumed level of monitoring is equivalent to the current monitoring program under Exhibits IV and VI of the PCD. If monitoring indicated that a water supply well would become affected by one or more of the CoPCs at concentrations unacceptable for potable use, the well would be shut down until equipped with wellhead treatment. Groundwater from the water supply well would be treated to potable water quality prior to introduction to the water distribution system. The offsite institutional controls would consist of the proposed Consultation Zone provision to the existing comprehensive Sacramento County well drilling ordinance, the DHS groundwater use restriction requiring water purveyors to shut down water supply wells when CoPCs are detected at certain concentrations, and Aerojet serving as a regular referral entity for any new wells that may be proposed to be drilled in the Study Area.

Alternative 3A assumes that any public water supply well that might be impacted based upon FS modeling assumptions is retrofitted for wellhead treatment. This assumption likely overstates the number of wells requiring retrofit, because water purveyors can manage their systems to reduce reliance on any particular well and the decision to retrofit will be based upon water supply needs and containment needs. Public water supply wells act as a hydraulic barrier that modeling suggests can result in containment of the offsite plume.

5.2.4.1 Overall Protection of Human Health and Environment

Existing institutional controls (DHS permitting of public water purveyors and the proposed County Consultation Zone provision to the Sacramento County well ordinance) should provide adequate protection to prevent exposure due to CoPCs in groundwater. Wellhead treatment and the additional monitoring that will be required to evaluate the performance of the wellhead treatment processes will provide an additional level of

protection to prevent potential exposure. Therefore, Alternative 3A is protective of human health and the environment.

Alternative 3A also minimizes migration of CoPCs from the Aerojet facility boundary through the existing GETs E and F control systems, and would provide offsite containment through the use of existing water supply wells. Groundwater modeling suggests that, depending upon the number and location of wells retrofitted with wellhead treatment, the offsite containment of the CoPC plume may be substantial. Alternative 3A could eventually result in restoration of the currently contaminated portion of the offsite regional aquifer. However, given the complexity of the hydrogeology and the fate and effect of the CoPCs in the aquifer, it is uncertain how much restoration will occur and over what period.

5.2.4.2 Compliance with ARARs

All ARARs that pertain to the protection of groundwater resources and the cleanup of releases will be met by Alternative 3A. At the Aerojet facility, contaminated groundwater captured in the GET E/F extraction wells will be treated prior to management/reuse to concentrations that meet standards based on risk-based levels and chemical-specific ARARs where applicable or relevant and appropriate. Beyond the Aerojet facility boundary, contaminated groundwater drawn from existing water supply wells will be treated at those wells before domestic use to meet MCLs, other applicable standards or TBCs such as DHS PALs, and risk-based levels. Over the long term, this alternative will provide a permanent solution by removing CoPCs from groundwater, both at the Aerojet facility and offsite, to concentrations below risk-based criteria and chemical-specific ARARs, and therefore protect the existing beneficial uses of groundwater in the downgradient areas and prevent degradation of the downgradient water quality to the maximum extent feasible.

Water treated at the GET E/F facilities is currently recharged to the groundwater system. Under this alternative, recharge of treated water would continue. The GET E/F facilities are currently operated in accordance with the discharge requirements and effluent limitations set forth in the Partial Consent Decree (PCD). Alternative 3A includes continued characterization and proper management of waste or residual materials produced by operation of the treatment plant, including compliance with the RCRA requirements for identification and characterization of wastes and generator standards.

State Water Board Resolution 68-16 ("Antidegradation Policy") requires that discharges not reduce the quality of surface water or groundwater. Treatment and recharge of treated water under Alternative 3A would be conducted in a manner so as to protect the current beneficial uses of downgradient groundwater and to the extent practical, to avoid an impact to downgradient water. Groundwater containing CoPCs at levels greater than PRAGs will be collected and treated to levels commensurate with how the treated water will be managed/reused (e.g., drinking water standards if the water is to be directly reused). Achievement of these treatment levels will result in compliance with the

substantive requirements of State Water Board Resolution 68-16 and also with State Water Board Resolution 92-49 that requires treatment to WQOs. Design of the use of water supply wells retrofitted with wellhead treatment as a hydraulic containment system will also consider the substantive requirements of the containment zone provisions of Resolution 92-49.

The GET E/F facilities will be improved and operated in a manner designed to comply with all location- and action-specific ARARs. The same will apply to the wellhead treatment retrofitting on offsite water supply wells.

5.2.4.3 Long-Term Effectiveness and Permanence

Alternative 3A provides effective long-term control of onsite and offsite CoPC plumes through extraction and treatment of groundwater using proven or innovative technologies. Over the long term, this alternative will provide a permanent solution by removing CoPCs from groundwater to below risk-based criteria and chemical-specific ARARs.

Residual risk will remain in certain portions of onsite and offsite groundwater until all of the groundwater containing CoPCs has been removed by the extraction wells or water supply wells and has been replaced by natural and/or artificial recharge of uncontaminated water. This risk will be managed through the proposed Consultation Zone provision to the existing comprehensive Sacramento County well drilling ordinance, the DHS groundwater use restriction requiring water purveyors to shut down water supply wells when CoPCs are detected at certain concentrations, and Aerojet serving as a regular referral entity for any new wells that may be proposed to be drilled in the Study Area.

The monitor wells, monitoring equipment, extraction wells and pumps, conveyance piping and transfer pumping, treatment processes for NDMA and VOCs (if any) and associated instrumentation and control systems are common, well established remedy components that have been implemented at the Aerojet Sacramento Site and numerous other sites. The likelihood is high that containment and treatment performance specifications will be met. Equipment and spare parts are readily available. O&M functions should be routine. The only uncertainty that exists with respect to long-term treatment equipment performance and treatment residuals is associated with the ion exchange process.

Perchlorate treatment onsite is assumed to be through biological treatment, which is currently operating at GET F on the Aerojet facility. Perchlorate treatment offsite for this remedy is currently assumed to be ion exchange. The long-term effectiveness of ion exchange, including the regeneration of resins, is currently under evaluation.

5.2.4.4 Reduction of Toxicity, Mobility and Volume through Treatment

For Alternative 3A, the onsite containment system has been discussed under Alternative 2A and is not repeated.

Under Alternative 3A, the offsite portion of the CoPC plume that reaches public water supply wells can be captured by the existing offsite water supply wells in the Study Area. Wellhead treatment can be provided at affected water supply wells, reducing the toxicity, mobility, and volume of the CoPCs. If present in a water supply well, VOCs, perchlorate, and NDMA would be destroyed via the UV/oxidation (VOCs and NDMA), ion exchange (perchlorate), and LPGAC (if only VOCs are present or for VOC polishing) processes, which are irreversible. Use of these treatment processes would satisfy the statutory preference for treatment as a principal element of the remedial action.

Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-4 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-4, modeling indicates that approximately 63 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 63 percent captured, the majority (approximately 59 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 65 percent of the area in Layer E would be captured, this area represents only 9 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	61	59
D (30% of total particles)	68	32
E (9% of total particles)	65	9
Total-all layers	63	100

5.2.4.5 Short-Term Effectiveness

Protection of Community and Workers. The short-term impact on the risks to the community and workers would be minimal during construction of the additional onsite extraction wells and treatment capacity associated with the GETs E/F boundary containment system. Likewise, for this Alternative 3A, during construction of any

wellhead treatment facilities at existing water supply wells that may become effected, the short-term impact on the risks to the community and workers would be minimal. Workers would be adequately protected during construction by adhering to OSHA practices. Workers would also be protected while operating and maintaining facilities by adhering to appropriate health and safety procedures.

Environmental Impacts. There are no adverse environmental impacts associated with this alternative, other than the continued migration of CoPCs until they are extracted by a water supply well.

Time until Response Objectives are Achieved. Human health risk due to exposure to contaminated groundwater has been eliminated and would be managed in the future through monitoring and response at public water supply wells through wellhead treatment. Minimizing further offsite migration of CoPCs from source area groundwater to downgradient areas to the west (source control) is already being achieved by the existing GETs E/F boundary containment/source control system. Further migration of the offsite CoPC plume could be achieved immediately after construction of wellhead treatment facilities is complete.

With respect to the time required to reduce CoPC concentrations in already contaminated groundwater, particle tracking was used in the groundwater flow model to estimate the time required to remove one pore volume of the offsite CoPC plumes as described in Appendix D. It is not possible to accurately predict the time required to reduce CoPC concentrations due to aquifer heterogeneity and fate and transport effects. However, a model simulation of the removal of one pore volume by water supply wells was agreed upon by the Agencies for purposes of comparison among alternatives. For Alternative 3A, the model-predicted time projections are shown on Figure 5-4 and discussed previously in Section 5.2.4.4.

The fourth RAO involves protecting public drinking water wells and providing treatment or alternate supply, as appropriate, for those wells that have been or become impacted by CoPCs at unacceptable levels. During the period between approval of the OU RI/FS and the implementation of this remedial action, should it be selected, it is possible that CoPCs will be detected in additional public water supply wells at unacceptable levels. Public water purveyors would be expected to continue to monitor wells for CoPCs, either directly or by obtaining the results of Aerojet monitoring undertaken pursuant to Exhibit IV of the PCD. Exhibit IV currently requires Aerojet to evaluate the source of the contaminant and recommend replacement water alternatives necessary to protect public health, which process is subject to agency review and Court oversight. Such alternatives could include shutting down the well, providing alternative water supplies or providing point of use treatment, all as more fully discussed in Section 3 and Section 4 of the OU RI/FS. As part of this alternative, some mechanism for monitoring and evaluation of interim remedial measures necessary to protect public health would be appropriate, should the provisions of Exhibit IV no longer apply.

5.2.4.6 Implementability

Alternative 3A is implementable to the extent that the DHS approves wellhead treatment for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. DHS has accepted wellhead treatment at numerous locations throughout the State. If accepted, the well treatment equipment must be capable of fitting in the existing space available at impacted water supply wells, and the treatment processes must be capable of meeting treatment standards in a demonstrable and reliable manner.

Depending upon the well and the type of treatment required, there may be space and other physical impediments to construction and operation. It may be that replacement wells would be constructed in an acceptable location that would support wellhead treatment. Further, wellhead treatment might only be considered on larger pumping wells, thereby reducing the effectiveness of any containment barrier that would otherwise be created by Alternative 3A.

Monitoring of finished water quality would be necessary to insure protection of public health. Monitoring downgradient water supply wells that continue to be used would be necessary to identify potential future impacts and insure that contaminated water is not used for potable water supply without treatment to remove site-related constituents of concern. Monitoring and evaluation of the location of potential new wells would also be necessary to assess and insure the effectiveness of institutional controls on future use of contaminated groundwater. Such monitoring would take the form of implementation of the proposed Consultation Zone provision to the Sacramento County comprehensive well ordinance that would require a consultation zone be established for applications for a well permit in areas within 2,000 feet of a known contaminant plume. Should the institutional control fail to identify or restrict drilling of a new public water supply well in a contaminated area, it is anticipated that initial sampling of water supplied by a new well would identify the presence of CoPCs resulting in the hypothetical new well not being used for potable supply.

The primary issue associated with coordination with other agencies under Alternative 3A is the need to obtain approval from State agencies, water purveyors and the public for use of wellhead treatment. Coordination with local land planning and land use agencies will be necessary to implement controls on and monitoring of construction of possible new water supply wells in or downgradient of the existing plume.

As Alternative 3A does include active treatment of contaminated water, treatment, storage or disposal facilities will be necessary. Technologies necessary to treat the site related constituents (e.g., ion exchange for perchlorate removal and UV/oxidation for NDMA destruction) are not routinely used in the water supply industry. There are only a limited number of vendors who currently provide the equipment to specifically remove the CoPCs using the technologies proposed for wellhead treatment. While ion exchange is used extensively for industrial wastewater treatment and in many instances for removal

of nitrate from drinking water, and UV disinfection is employed routinely for municipal wastewater treatment, these technologies are less commonly employed in the water supply industry. Consequently, additional development and demonstration may be necessary to support the use of the proposed technologies for the specific application of wellhead treatment proposed for Alternative 3A.

Another administrative feasibility issue is that there are no MCLs for perchlorate and NDMA, the two primary CoPCs in the Study Area. EPA has not finalized the Rfd for perchlorate. EPA will release another preliminary Rfd for perchlorate in Fall 2000, host an external peer review, and then issue a final Rfd. It is not currently known how long this process will take. In addition, the DHS has issued a temporary action level for NDMA, primarily due to the uncertainties associated with the analytical detection limits for NDMA. It is not known if or when a permanent action level will be established for NDMA.

5.2.4.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 3A are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$64,000,000
Estimated annual O&M costs:	$3,500,000-5,300,000
Estimated 25-year present worth costs:	$93,000,000

5.2.5 Alternative 3B: GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Alternative 3B differs from Alternative 3A in that GETs E and F no longer recharge water through recharge wells. The specific differences between Alternatives 3A and 3B with respect to the onsite GETs E and F systems were discussed previously in Section 5.2.3 for Alternative 2B. A map showing both onsite and offsite capture zones is included as Figure 5-5. Figure 5-6 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 3B.

5.2.5.1 Overall Protection of Human Health and Environment

Alternative 3B is equally protective as Alternative 3A.

5.2.5.2 Compliance with ARARs

Alternative 3B provides the same level of compliance with ARARs as Alternative 3A.

5.2.5.3 Long-Term Effectiveness and Permanence

As with Alternative 3A, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system. There are some model-projected changes that arise from replacing recharge with extraction wells. First, the extraction wells are currently projected to be placed downgradient of the GETs E/F recharge field and are likely to contain CoPCs in Layer E and substantial portions in Layers C and D of CoPCs that would otherwise migrate off the Aerojet site. Accordingly, there would likely be more mass of chemicals extracted. By extracting, rather than recharging, the hydraulic gradient will decrease locally, thus potentially reducing the offsite movement. Model projections suggest fewer public water supply wells should be impacted over the same period of time.

5.2.5.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 3B is the same as for Alternative 3A discussed in Section 5.2.4.4. The only exception is that for Alternative 3B, treated groundwater from the onsite GETs E/F boundary containment/source control system would not be recharged via the GET E/F recharge field. By extracting groundwater to implement hydraulic control onsite, instead of continued use of recharge wells, Alternative 3B provides greater reduction of mass of CoPCs in groundwater and potentially reduces the mobility and volume of a portion of the offsite plume.

Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-6 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-6, modeling indicates that approximately 60 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 60 percent captured, the majority (approximately 53 percent) of the total CoPCs captured would be from Layer C. Conversely, although the

modeling indicates that 91 percent of the area in Layer E would be captured, this area represents only 14 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	52	53
D (30% of total particles)	69	34
E (9% of total particles)	91	14
Total-all layers	60	100

5.2.5.5 Short-Term Effectiveness

Same as Alternative 3A.

5.2.5.6 Implementability

Same as Alternative 3A.

5.2.5.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 3B are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$77,000,000
Estimated annual O&M costs:	$4,000,000-6,000,000
Estimated 25-year present worth costs:	$115,000,000

5.2.6 Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Alternative 4A involves the continued operation of the GETs E and F systems, in which recharge wells would continue to be used. It also includes monitoring and institutional controls. In addition, Alternative 4A would establish an offsite hydraulic barrier, intended to contain the offsite plume and prevent further migration of CoPCs downgradient of the barrier. A capture zone map for Alternative 4A showing both onsite and offsite capture zones is included as Figure 5-7. Figure 5-8 presents the percent of plume areas captured over time in layers C, D, and E for Alternative 4A.

5.2.6.1 Overall Protection of Human Health and Environment

Protection of human health and the environment would be afforded under Alternative 4A by minimizing offsite migration of CoPCs through the continued operation of the GETs E and F hydraulic containment system. As more fully discussed in Alternative 4B, offsite groundwater containment would be initiated in Layers C and D from the outset. Some CoPCs will migrate through portions of Layers C and D that do not contain CoPCs until they reach the offsite hydraulic barrier. This will occur within individual layers, and for Alternative 4A, will occur in portions of Layers D and E.

Alternative 4A would eventually result in substantial restoration of the currently contaminated portion of the offsite regional aquifer. However, given the complexity of the hydrogeology and the fate of the CoPCs in the aquifer, the extent and overall timing of the eventual restoration of the aquifer is uncertain.

Alternative 4A also relies on monitoring of public water supply wells to ensure that the public is not exposed to CoPCs potentially present above drinking water standards, advisories, or risk-based levels. For areas downgradient of the onsite containment system but upgradient of the offsite containment system where the groundwater has been contaminated, institutional controls would also protect human health until the natural flushing of the aquifer and the result of operating the onsite and offsite containment systems reduces concentrations of CoPCs in these areas. Existing institutional controls (DHS oversight of public water supply systems) should provide adequate protection of public water supplies by establishing MCLs or PALs for CoPCs. Existing public water supplies would be monitored as described in accordance with the procedures outlined in Section 3.3.2.4 to prevent exposure above MCLs or PALs. Although it is considered unlikely that a private party would drill a new water supply well in the Study Area, the proposed Consultation Zone provision to Sacramento County's existing comprehensive well drilling ordinance should provide some level of protection against a party installing a water supply well in contaminated portions of the aquifer. Also, it is recommended that the public be informed of the groundwater contamination and its unsuitability for consumption through EPA's public participation process and periodic fact sheets issued to the community. In addition, Aerojet will request status from the County to be a regular referral entity for any new wells that may be proposed to be drilled in the Study Area. Aerojet will advise the County, and well permit applicant, of any proposed locations that may be located above or near the CoPC plumes.

There are no currently completed exposure pathways for ecological receptors in the Study Area. Potential future impacts to surface water or the aquifer from treated groundwater will be managed by the NPDES permitting process and treatment facility effluent requirements, respectively. As the active remediation measures included in the offsite areas under Alternative 4A are based on standard, accepted treatment practices, this alternative does not pose any unacceptable short-term risks or other adverse impacts.

5.2.6.2 Compliance with ARARs

All ARARs that pertain to the protection of groundwater resources and the cleanup of releases will be met by Alternative 4A. Specifically, water supplied by public or private water purveyors would either be derived from unimpacted surface water or groundwater sources or would be treated to remove or reduce the levels of CoPCs to meet MCLs, other applicable standards or TBCs such as DHS PALs, and risk-based levels. Implementation of the downgradient hydraulic barrier would prevent or greatly reduce further downgradient migration of CoPCs and therefore protect the existing beneficial uses of groundwater in the downgradient areas and prevent degradation of the downgradient water quality to the maximum extent feasible.

At the Aerojet facility, contaminated groundwater captured in the GET E/F extraction wells will be treated prior to management/reuse to concentrations that meet cleanup standards based on risk-based levels and chemical-specific ARARs (e.g., MCLs, PALs if the treated water is to be directly reused) where applicable or relevant and appropriate. Beyond the Aerojet facility boundary, contaminated groundwater drawn from the offsite extraction wells will be conveyed to the onsite GET F groundwater treatment facility and treated prior to management/reuse to meet the same cleanup standards. Over the long term, this alternative will provide a permanent solution by removing CoPCs from groundwater, both at the Aerojet facility and offsite, to concentrations below risk-based criteria and chemical-specific ARARs.

Water treated at the GET E/F facilities is currently recharged to the groundwater system. Under this alternative, recharge of treated water would continue. The GET E/F facilities are currently operated in accordance with the discharge requirements and effluent limitations set forth in the Partial Consent Decree (PCD). Alternative 4A includes continued characterization and proper management of waste or residual materials produced by operation of the treatment plant, including compliance with the RCRA requirements for identification and characterization of wastes and generator standards.

State Water Board Resolution 68-16 ("Antidegradation Policy") requires that discharges not reduce the quality of surface water or groundwater. Treatment and recharge of treated water under Alternative 4A would be conducted in a manner so as to protect the current beneficial uses of downgradient groundwater and to the extent practical, to avoid an impact to downgradient water. Groundwater containing CoPCs at levels greater than PRAGs will be collected and treated to levels commensurate with how the treated water will be managed/reused (e.g., drinking water standards if the water is to be directly reused). Achievement of these treatment levels will result in compliance with the substantive requirements of State Water Board Resolution 68-16 and also with State Water Board Resolution 92-49 that requires treatment to WQOs. Design of the hydraulic containment system will also consider the substantive requirements of the containment zone provisions of Resolution 92-49.

5.2.6.3 Long-Term Effectiveness and Permanence

Alternative 4A provides effective long-term control onsite and offsite of the CoPC plumes through extraction and treatment of groundwater using proven or innovative technologies. The modeled hydraulic capture in layers C, D, and E is shown on Figure 5-8. To the extent feasible, the hydraulic barrier would be designed to contain CoPCs with concentrations exceeding PRAGs. However, due to technical uncertainties, it is likely that some CoPCs will not be contained by the hydraulic barrier. For any CoPCs detected downgradient of the hydraulic barrier, residual risk would be managed by monitoring of water supply and performance monitor wells and implementation of a response action in the event CoPCs are detected and exceed trigger levels.

In addition, it is likely that residual CoPC concentrations will remain in portions of the aquifer for many years. This risk would be managed through monitoring, Aerojet's status as a regular referral entity for the County for any new wells that are proposed to be drilled in the Study Area, the proposed Consultation Zone provisions of the Sacramento County Well Drilling ordinance, and the DHS requirement that water supply wells be shut down if certain concentrations of CoPCs are detected.

With respect to adequacy and reliability of controls, all of the technologies and associated equipment and monitoring facilities proposed for this alternative are proven and reliable. The monitor wells, monitoring equipment, extraction wells and pumps, conveyance piping, transfer pumping, treatment processes for removal of the CoPCs, treated water management facilities, and associated instrumentation and control systems are common, well established, remedy components that have been implemented at the Aerojet Sacramento Site and elsewhere.

Perchlorate treatment onsite is assumed to be through biological treatment, which is currently operating on the Aerojet facility. There are no uncertainties associated with addressing any treatment residuals generated from this remedial technology. The likelihood is high that treatment performance specifications will be met. Equipment and spare parts are readily available. O&M functions should be routine. However, because of the complexity of the hydrogeology and the fate of the CoPCs in the aquifer, the effectiveness of hydraulic containment cannot be assured.

Current and proposed institutional controls (i.e., the proposed well drilling ordinance Consultation Zone, restrictions on operations of potable water suppliers, and Aerojet being a regular referral entity for any new wells that may be proposed to be drilled in the Study Area) are based on programs currently or anticipated to be implemented and managed by Sacramento County and DHS. As these programs are current and are forseen to continue to be operated by government agencies, the long-term permanence of such measures is considered to be high.

5.2.6.4 Reduction of Toxicity, Mobility and Volume through Treatment

The toxicity of perchlorate, NDMA, and nitrate will be irreversibly reduced or eliminated by the treatment process options currently considered for these CoPCs (i.e., biological reduction, UV-oxidation). Use of these treatment processes would satisfy the statutory preference for treatment as a principal element of the remedial action. Residuals remaining after treatment would include the minor volume of non-hazardous organic sludge that would be generated by the biological reduction process. This sludge would be disposed to a sanitary sewer or dewatered and disposed in a non-hazardous landfill. The majority of VOCs will be destroyed through the UV/oxidation process; air stripping will serve as the polishing treatment process for VOCs. The mobility of CoPCs present in groundwater will not be affected by any of the treatment process options considered in this OU RI/FS.

Under Alternative 4A, the CoPCs downgradient of the GETs E/F system are intended to be contained by the offsite hydraulic barrier. Extraction of groundwater containing CoPCs will reduce the overall volume of CoPCs in the onsite and offsite groundwater. It is not possible to accurately predict the time required to reduce CoPC concentrations due to aquifer heterogeneity and fate and transport effects. Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-8 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-8, modeling indicates that approximately 76 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 76 percent captured, the majority (approximately 70 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 21 percent of the area in Layer E would be captured, this area represents only 2 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	87	70
D (30% of total particles)	72	28
E (9% of total particles)	21	2
Total-all layers	76	100

5.2.6.5 Short-Term Effectiveness

Protection of Community and Workers. During construction of the offsite hydraulic barrier it is anticipated that there will be short-term impacts to the community. These impacts could include temporary road/lane closures, traffic detours, noise associated with drilling and pipe laying equipment, and dust. These impacts would be minimized through the implementation of various abatement plans (e.g., traffic controls plans). The short-term impact on the risks to the community and workers would be minimal during construction of the additional onsite extraction wells and treatment capacity associated with the GETs E/F boundary containment system.

Workers should be adequately protected during construction by adhering to OSHA practices. Workers should also be protected while operating and maintaining facilities by adhering to appropriate health and safety procedures.

Possible impacts to existing water supply wells from water table drawdown resulting from operation of the onsite extraction and recharge wells and the offsite extraction wells proposed for Alternative 4A were also evaluated. The modeled maximum drawdowns generated by offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-4). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns in the vicinity of Zinfandel Drive and US Highway 50 are 17, 20, 20, and 15 feet, respectively, for layers AB, C, D, and E.

Environmental Impacts. There are no adverse environmental impacts anticipated to be associated with this alternative other than the temporary traffic disruptions and noise during the offsite hydraulic barrier construction. Depending on where extraction wells are proposed to be located and the groundwater conveyance piping routing, environmental permitting may be required.

Time until Response Objectives are Achieved. Human health risk due to consumption of groundwater has been eliminated and would be managed in the future through monitoring and provision of replacement water. Minimizing further offsite migration of CoPCs from source area groundwater to downgradient areas to the west (source control) is already being achieved by the existing GETs E/F boundary containment/source control system. Minimizing further migration of the offsite contaminant plume will be achieved immediately after construction of offsite extraction wells. However, given the complexity of the hydrogeology and the fate and effect of the CoPCs in the aquifer, it is uncertain how much restoration will occur and over what period.

With respect to the time required to reduce CoPC concentrations in already contaminated groundwater, particle tracking was used in the groundwater flow model to estimate the time required to remove one pore volume of the offsite CoPC plumes as described in Appendix D. It is not possible to accurately predict the time required to reduce CoPC concentrations due to aquifer heterogeneity and fate and transport effects. However, a model simulation of the removal of one pore volume by water supply wells was agreed

upon by the Agencies for purposes of comparison among alternatives. For Alternative 4A, the model-predicted time projections are shown on Figure 5-8 and discussed previously in Section 5.2.6.4.

During the period between approval of the OU RI/FS and the implementation of this remedial action, should it be selected, it is possible that CoPCs will be detected in additional public water supply wells at unacceptable levels. Public water purveyors would be expected to continue to monitor their wells for CoPCs, either directly or by obtaining the results of Aerojet monitoring undertaken pursuant to Exhibit IV of the PCD. Exhibit IV currently requires Aerojet to evaluate the source of the contaminant and recommend alternatives necessary to protect public health, which process is subject to agency review and Court oversight. Such alternatives could include shutting down the well, providing alternative water supplies or providing point of use treatment, all as more fully discussed in Section 3 and Section 4 of this OU RI/FS. As part of this alternative, some mechanism for monitoring and evaluation of interim remedial measures necessary to protect public health would be appropriate, should the provisions of Exhibit IV no longer apply.

5.2.6.6 Implementability

The primary technical implementability issues associated with Alternative 4A will be determining the hydraulic capture of the individual extraction wells and installing significant infrastructure in the offsite areas. The complex hydrogeology of the Study Area will be partially managed by phasing of well construction and pump testing to allow more detailed understanding of aquifer characteristics and chemical distribution. In addition, the performance monitoring wells recommended for this alternative should provide the data necessary to adequately assess hydraulic capture.

There are significant technical and administrative difficulties associated with the construction of the infrastructure associated with the offsite hydraulic barrier, including siting and construction of wells and pipelines. The construction would occur in already developed areas. This will involve securing the necessary easements and/or obtaining title to land required to place the extraction wells and route conveyance piping from the extraction wells to the onsite treatment facility. It will be desirable to locate extraction wells in areas where access can be maintained for future servicing/rehabilitation (i.e., not in a street or sidewalk). Piping will have to be routed through existing streets and inside existing utility easements or rights-of-way. Bridge crossings; tunneling under highways, railroads, the Folsom South Canal, and major roads; utility relocation; extensive traffic control; and night construction will probably be required during construction of the conveyance piping associated with Alternative 4A. A piping alignment engineering study will be required and depending on the proposed piping alignment, environmental permits and/or mitigation may be necessary. Potential delays in the start of implementation of this remedial alternative could result from these issues. Local agency approvals may trigger CEQA evaluation, which can significantly delay project implementation.

There may be technical and administrative implementability difficulties constructing all or portions of the offsite hydraulic barrier at or downgradient of the leading edges of the CoPC plumes. Aquifer and CoPC distribution heterogeneities may result in the discovery of CoPCs beyond the design of the hydraulic barrier. Similarly, there may be access restrictions or legal impediments that preclude the construction of wells or pipelines at the desired locations. In recognition of this fact, CoPCs that are detected downgradient of the offsite hydraulic barrier will be monitored. If the monitoring indicates that public water supply wells may become impacted by CoPC concentrations exceeding PRAGs, additional remedial actions may be warranted. These actions could consist of wellhead treatment, alternate water, or new extraction wells. If monitoring indicates that CoPC concentrations will not impact public water supply wells above PRAGs, the CoPCs will be permitted to disperse through natural attenuation.

Ongoing operation and maintenance requirements in offsite areas would involve coordination with local agencies. Among others, there may be need for traffic control and management of waters used for well rehabilitation.

Additional administrative feasibility issues would be associated with management and/or reuse of treated groundwater associated with Alternative 4A. These issues vary depending on the process option or combination of process options that would be implemented for management and/or reuse of treated groundwater under this alternative. For purposes of costing, groundwater is assumed to be treated on the Aerojet site and then piped to a location where it can either be directly reused in a public water supply system or discharged to surface water for streamflow augmentation. Each process option for management of the treated groundwater raises administrative implementability issues. Therefore, administrative feasibility issues will include short- and long-term coordination with local, State and federal agencies; coordination with local developers and water purveyors; and various probable permitting requirements.

Perchlorate and NDMA treatment processes are undergoing extensive evaluation by Aerojet and regulatory agencies, including DHS (USEPA Region 9, 1999). The technologies for the treatment of perchlorate and NDMA are innovative and will continue to be evaluated. It is assumed that these technologies would be used in this alternative. Currently, there is only one manufacturer for the UV/oxidation equipment that is used for NDMA removal.

Another administrative feasibility issue is that there are no MCLs for perchlorate and NDMA, the two primary CoPCs in the Study Area. EPA has not finalized the Rfd for perchlorate. EPA will release another preliminary Rfd for perchlorate in Fall 2000, host an external peer review, and then issue a final Rfd. It is not currently known how long this process will take. In addition, the DHS has issued a temporary action level for NDMA, primarily due to the uncertainties associated with the analytical detection limits for NDMA. It is not known if or when a permanent action level will be established for NDMA.

5.2.6.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 4A are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$43,000,000
Estimated annual O&M costs:	$3,000,000-3,300,000
Estimated 25-year present worth costs:	$78,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 4A, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 4A in Section 4.2.6 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

5.2.7 Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Offsite, Alternative 4B includes containment of the offsite CoPC plumes using new extraction wells to provide hydraulic containment. Alternative 4B differs from Alternative 4A in that GETs E and F no longer recharge water through recharge wells. The specific differences between Alternatives 4A and 4B with respect to the onsite GETs E and F systems were discussed previously in Section 5.2.3 for Alternative 2B.
A capture zone map for Alternative 4B is included as Figure 5-9. Figure 5-10 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 4B.

5.2.7.1 Overall Protection of Human Health and Environment

Alternative 4B is equally as protective as Alternative 4A.

5.2.7.2 Compliance with ARARs

Alternative 4B provides the same level of compliance with ARARs as Alternative 4A.

5.2.7.3 Long-Term Effectiveness and Permanence

As with Alternative 4A, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system. There are some model-projected changes that arise from replacing recharge with extraction wells. First, the extraction wells are currently projected to be placed downgradient of the GETs E/F recharge field and are likely to contain CoPCs in Layer E and substantial portions in Layers C and D of CoPCs that would otherwise migrate off the Aerojet site. Accordingly, there would likely be more mass of chemicals extracted. By extracting, rather than recharging, the hydraulic gradient will decrease locally, thus potentially reducing the offsite movement. Model projections suggest fewer public water supply wells should be impacted over the same period of time.

5.2.7.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 4B is similar to that for Alternative 4A discussed in Section 5.2.6.4. The only exception is that for Alternative 4B, treated groundwater from the onsite GETs E/F boundary containment/source control system would not be recharged via the GET E/F recharge field. By extracting groundwater to implement hydraulic control onsite, instead of continued use of recharge wells, Alternative 4B provides greater reduction of mass of CoPCs in the E layer, and potentially reduces the mobility and volume of the offsite plume.

For Alternative 4B, CoPCs will be destroyed via the irreversible treatment processes discussed under Alternative 4A, and only minor amounts of treatment residuals will remain following treatment.

Under Alternative 4B, the CoPCs downgradient of the GETs E/F system are intended for capture by the offsite hydraulic barrier. Extraction of groundwater containing CoPCs will reduce the overall volume of CoPCs in the onsite and offsite groundwater. It is not possible to accurately predict the time required to reduce CoPC concentrations due to aquifer heterogeneity and fate and transport effects. Particle tracking was used in the

groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-10and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-10, modeling indicates that approximately 70 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 70 percent captured, the majority (approximately 63 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 52 percent of the area in Layer E would be captured, this area represents only 7 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	72	63
D (30% of total particles)	71	30
E (9% of total particles)	52	7
Total-all layers	70	100

5.2.7.5 Short-Term Effectiveness

Same as Alternative 4A, except the modeled maximum drawdowns generated by offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-5). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns offsite in the vicinity of Zinfandel Drive and Highway 50 are 26, 30, 27, and 25 feet, respectively for layers AB, C, D, and E.

5.2.7.6 Implementability

Same as Alternative 4A.

5.2.7.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 4B are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$38,000,000
Estimated annual O&M costs:	$3,300,000-3,400,000
Estimated 25-year present worth costs:	$77,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 4B, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 4B in Section 4.2.7 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

5.2.8 Alternative 4C - GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors

Onsite, Alternative 4C is the same as Alternative 4B. Similar to Alternative 4B, offsite Alternative 4C includes containment of the offsite CoPC plumes using new extraction wells to provide hydraulic containment. Alternative 4C differs from Alternative 4B in that it would also incorporate "multiple containment corridors" by including installation of new extraction wells closer to the leading edge of the CoPC plume in the D and E layers sooner than planned for the other alternatives. The specific differences between Alternatives 4C and 4B were discussed previously in Section 4.2.8 for Alternative 4C.

A capture zone map for Alternative 4C is included as Figure 5-11. Figure 5-12 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 4C.

5.2.8.1 Overall Protection of Human Health and Environment

Alternative 4C does not provide any additional protection beyond that provided by Alternatives 4A and 4B.

5.2.8.2 Compliance with ARARs

Alternative 4C provides the same level of compliance with ARARs as Alternatives 4A and 4B.

5.2.8.3 Long-Term Effectiveness and Permanence

As with Alternative 4B, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system.

5.2.8.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 4C is similar to that for Alternative 4B discussed in Section 5.2.7.4. The only exception is that Alternative 4C is projected to provide a greater reduction of mass of CoPCs in Layers D and E over the evaluation period and therefore potentially reduces the mobility and volume of the Layer C and D portions of the offsite plume sooner.

Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-12 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-12, modeling indicates that approximately 77 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 77 percent captured, the majority (approximately 61 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 79 percent of the area in Layer E would be captured, this area represents only 9 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	77	61
D (30% of total particles)	77	30
E (9% of total particles)	79	9
Total-all layers	77	100

For Alternative 4C, CoPCs will be destroyed via the irreversible treatment processes discussed under Alternative 4A, and only minor amounts of treatment residuals will remain following treatment.

5.2.8.5 Short-Term Effectiveness

Same as Alternative 4B, except the modeled maximum drawdowns generated by offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-6). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns offsite in the vicinity of Zinfandel Drive and Highway 50 are 31, 35, 33, and 30 feet, respectively for layers AB, C, D, and E.

5.2.8.6 Implementability

Same as Alternative 4B, except additional offsite extraction wells and associated piping in the multiple corridors will render Alternative 4C more difficult to implement than Alternative 4B from both the technical and administrative implementability perspectives.

5.2.8.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 4C are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$42,000,000
Estimated annual O&M costs:	$3,500,000-3,600,000
Estimated 25-year present worth costs:	$85,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 4C, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 4C in Section 4.2.8 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

5.2.9 Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Alternative 5A includes containment of the offsite CoPC plumes using a combination of new extraction and recharge wells to provide hydraulic containment. For costing purposes Alternative 5A extraction wells would be routed to a central groundwater treatment facility located southwest of the offsite extraction/recharge wells on Mather Field. Treated groundwater would be routed back to the recharge wells to maintain a hydraulic barrier in conjunction with the offsite extraction wells.

Onsite, Alternative 5A includes continued operation and improvements to the GET E and F onsite boundary containment/source control systems and recharge of treated GETs E and F groundwater. Alternative 5A also includes monitoring and the institutional controls discussed previously for the other alternatives.

A capture zone map for Alternative 5A is included as Figure 5-13. Figure 5-14 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 5A.

5.2.9.1 Overall Protection of Human Health and Environment

Alternative 5A is equally protective as Alternative 4A.

5.2.9.2 Compliance with ARARs

Alternative 5A provides the same level of compliance with ARARs as Alternative 4A.

5.2.9.3 Long-Term Effectiveness and Permanence

Same as Alternative 4A.

5.2.9.4 Reduction of Toxicity, Mobility and Volume through Treatment

Similar to Alternative 4A. Under Alternative 5A, the CoPCs downgradient of the GETs E/F system are intended for capture by the offsite hydraulic barrier. Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-14 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-14, modeling indicates that approximately 74 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 74 percent captured, the majority (approximately 67 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 27 percent of the area in Layer E would be captured, this area represents only 3 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	81	67
D (30% of total particles)	72	29
E (9% of total particles)	27	3
Total-all layers	74	100

5.2.9.5 Short-Term Effectiveness

Same as Alternative 4A, except the modeled maximum drawdowns generated by the offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-7). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns are 6, 10, 9 and 5 feet, respectively for layers AB, C, D, and E.

5.2.9.6 Implementability

All implementability issues associated with Alternative 4A are associated with Alternative 5A. In addition, using recharge wells as part of the hydraulic barrier requires installation of more wells and piping than extraction alone. Further, it is more difficult to construct and maintain a hydraulic barrier where recharge wells are used as part of the barrier, because maintaining gradients requires more sophisticated groundwater management to optimize system operation and control.

5.2.9.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 5A are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$41,000,000
Estimated O&M costs:	$3,300,000-3,900,000
Estimated 25-year present worth costs:	$78,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 5A, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 5A in Section 4.2.9 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

5.2.10 Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Alternative 5B includes containment of the offsite CoPC plumes using a combination of new extraction and recharge wells to provide hydraulic containment.

Onsite, Alternative 5B includes continued operation and improvements to the GETs E and F onsite boundary containment/source control systems. Treated groundwater from the GETs E and F boundary containment/source control systems will not be recharged onsite to groundwater. The treated groundwater from the GETs E and F systems will be discharged to surface water and/or reused for potable or non-potable purposes. Alternative 5B also includes monitoring and the institutional controls previously discussed for the other alternatives.

A capture zone map for Alternative 5B is included as Figure 5-15. Figure 5-16 presents the modeled percent of plume areas captured over time in layers C, D, and E for Alternative 5B.

5.2.10.1 Overall Protection of Human Health and Environment

Alternative 5B is equally protective as Alternative 4A.

5.2.10.2 Compliance with ARARs

Alternative 5B provides the same level of compliance with ARARs as Alternative 4A.

5.2.10.3 Long-Term Effectiveness and Permanence

As with Alternative 5A, effective long-term control of the onsite CoPC plume and migration of the plume offsite will be provided through extraction and treatment of groundwater via the GETs E/F containment system. There are some model-projected changes that arise from replacing recharge with extraction wells. First, the extraction wells are currently projected to be placed downgradient of the GETs E/F recharge field and are likely to contain CoPCs in Layer E and substantial portions in Layers C and D of CoPCs that would otherwise migrate off the Aerojet site. Accordingly, there would likely be more mass of chemicals extracted. By extracting, rather than recharging, the hydraulic gradient will decrease locally, thus potentially reducing the offsite movement. Model projections suggest fewer public water supply wells should be impacted over the same period of time.

5.2.10.4 Reduction of Toxicity, Mobility and Volume through Treatment

Discussion of the reduction of toxicity, mobility, or volume through treatment evaluation criterion for Alternative 5B is similar to that for Alternative 5A discussed in Section 5.2.9.4. The only exception is that for Alternative 5B, treated groundwater from the onsite GETs E/F boundary containment/source control system would not be recharged via the GET E/F recharge field. By extracting groundwater to implement hydraulic control onsite, instead of continued use of recharge wells, Alternative 5B provides greater reduction of mass of CoPCs in the E layer, and potentially reduces the mobility and volume of a portion of offsite plume.

For Alternative 5B, CoPCs will be destroyed via the irreversible treatment processes discussed under Alternative 4A, and only minor amounts of treatment residuals will remain following treatment.

Under Alternative 5B, the CoPCs downgradient of the GETs E/F system are intended for capture by the offsite hydraulic barrier. Particle tracking was used in the groundwater flow model to estimate the percent of plume area captured by each alternative over the FS evaluation period (Section D8.2). Particles were placed in each layer based on the areal extent of CoPCs in the respective layer. More particles were placed in Layer C (61 percent of the total) than in Layers D (30 percent of total) and Layer E (9 percent of total) because the areal extent of CoPCs in Layer C is greater.

The analysis results are provided below and on Figure 5-16 and indicate the approximate percent of area captured by layer within the 25-year evaluation period. The percentage contribution by each layer relative to the total area captured after 25 years is also provided below. As shown on the following table and on Figure 5-16, modeling indicates that approximately 68 percent of the areal extent of the CoPCs would be captured in the 25-year evaluation period. Of this 68 percent captured, the majority (approximately 61 percent) of the total CoPCs captured would be from Layer C. Conversely, although the modeling indicates that 62 percent of the area in Layer E would be captured, this area represents only 8 percent of the total plume area removed.

Layer	Modeled Percent of Layer Area Captured after 25 years (%)	Layer Contribution to Total Area Captured (%)
C (61% of total particles)	68	61
D (30% of total particles)	72	31
E (9% of total particles)	62	8
Total-all layers	68	100

5.2.10.5 Short-Term Effectiveness

Same as Alternative 5A, except the modeled maximum drawdowns generated by offsite extraction wells in the various layers are illustrated in Appendix D (Figure D8-8). These drawdowns are in addition to any water level changes that may occur unrelated to remedial action. Model-projected maximum drawdowns offsite in the vicinity of Zinfandel Drive and Highway 50 are 18, 22, 22, and 17 feet, respectively for layers AB, C, D, and E.

5.2.10.6 Implementability

Same as Alternative 5A.

5.2.10.7 Costs

Estimated capital, annual O&M, and 25-year present worth costs for Alternative 5B are as follows. Detailed cost estimates and a present worth summary are included in Appendix E.

Estimated capital costs:	$45,000,000
Estimated annual O&M costs:	$3,800,000-4,000,000
Estimated 25-year present worth costs:	$87,000,000

The following potential additional costs are not included in FS-level cost estimate for Alternative 5B, but are provided at the request of the Agencies. The Agencies requested that cost estimates be included for costs that may be associated with providing replacement water for water supply wells AC-1, -10, and –20 if CoPC concentrations in these wells exceed PRAGs and the wells are not substituted for extraction wells with coincident wellhead treatment. Estimated additional costs under the direct reuse and indirect reuse replacement water options described for Alternative 5B in Section 4.2.10 are as follows. These estimated costs have not been adjusted for water purveyor offset or betterment and represent just two hypothetical scenarios. Actual replacement costs could be significantly lower.

Potential Estimated Additional Cost for Replacement Water	Direct Reuse	Indirect Reuse
Capital	$3,900,000	$6,900,000
Annual O&M	$130,000	$40,000
25-year present worth	$5,500,000	$7,400,000

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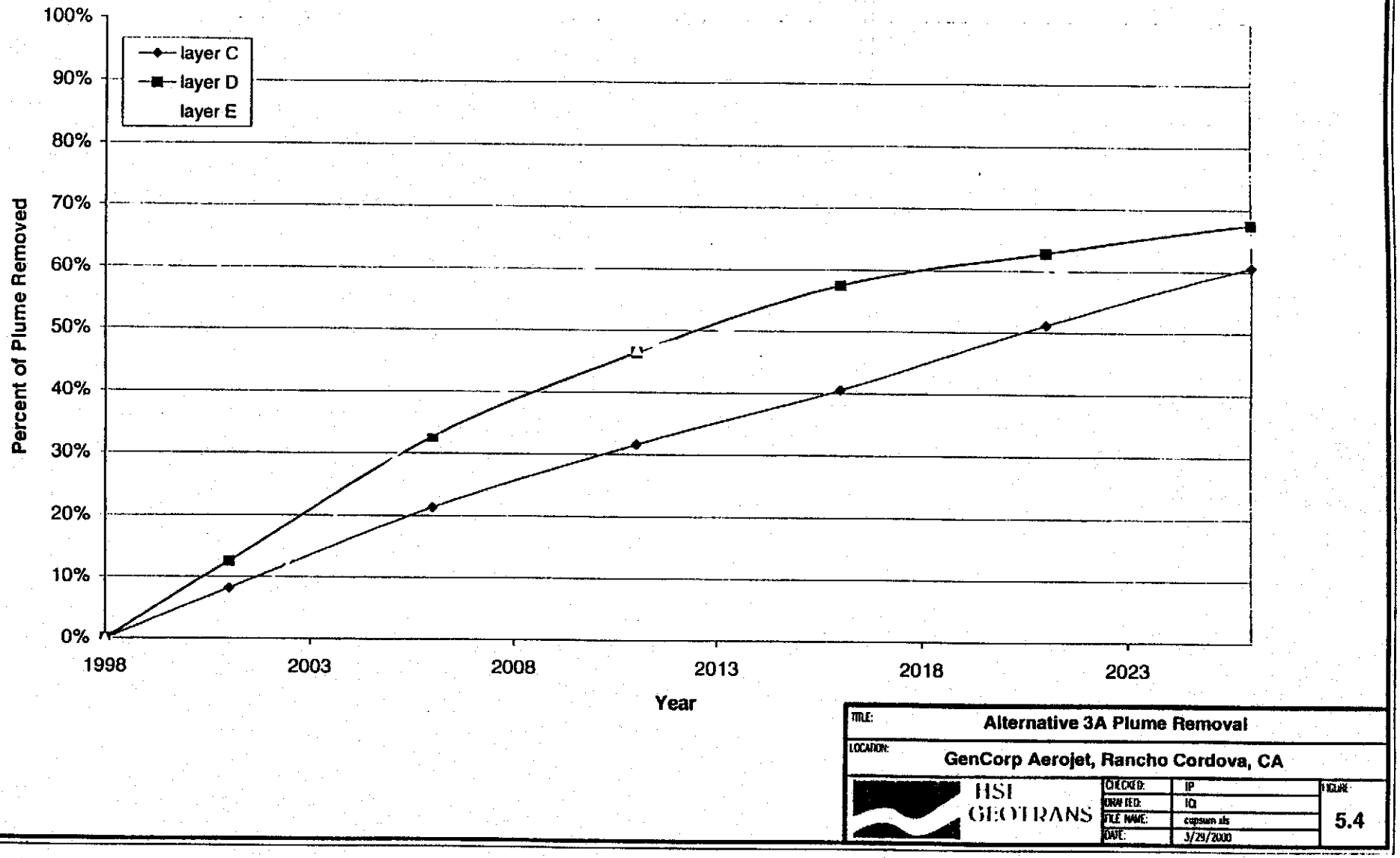
Alternative 3A Plume Removal
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Plume Removed
layer C
layer D
layer E
1998
2003
2008
2013
2018
2023
Year
TITLE: Alternative 3A Plume Removal
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HSI GEOTRANS
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DATE: 3/29/2000
FIGURE 5.4

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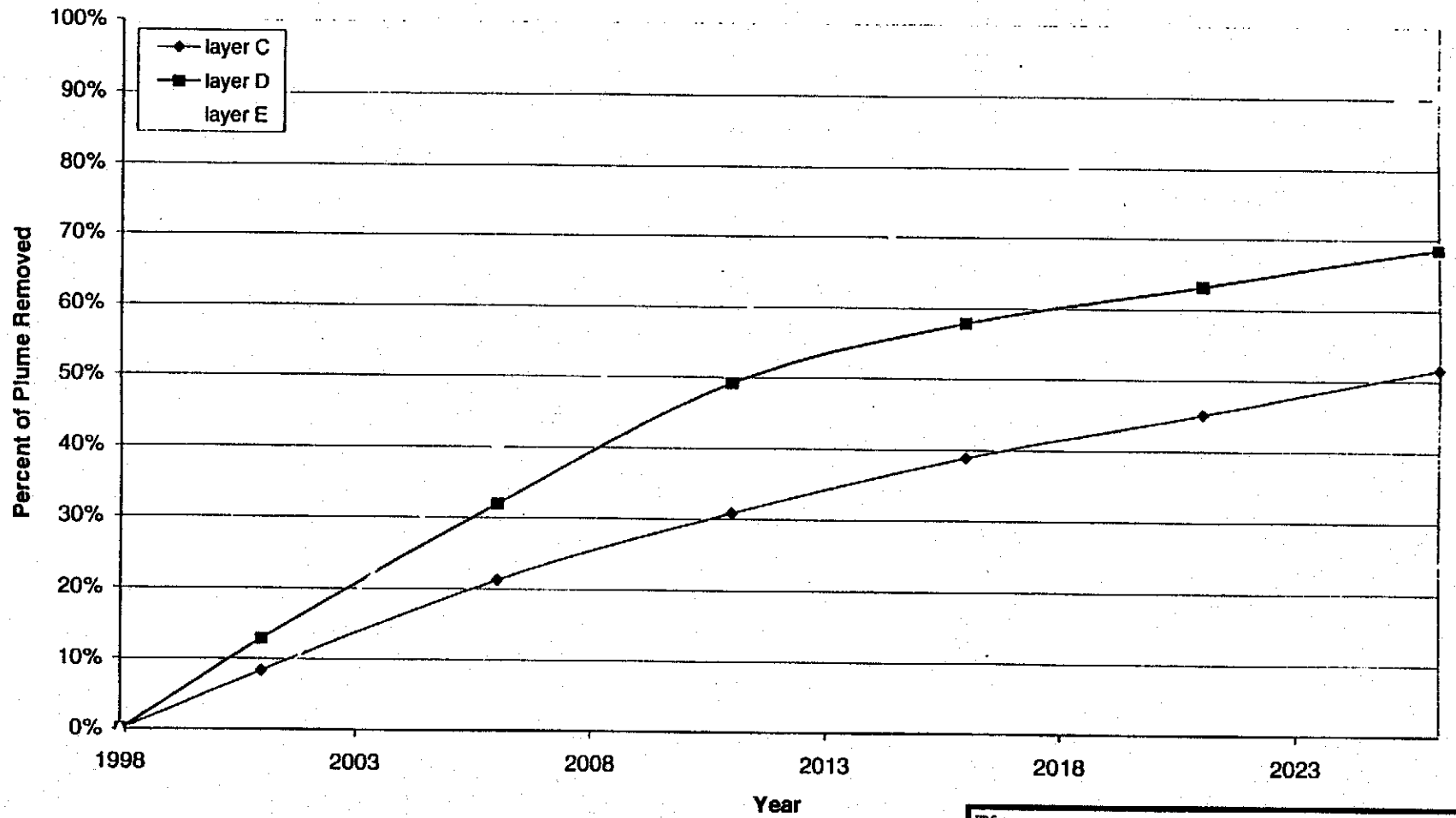

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FIGURE:	5.6

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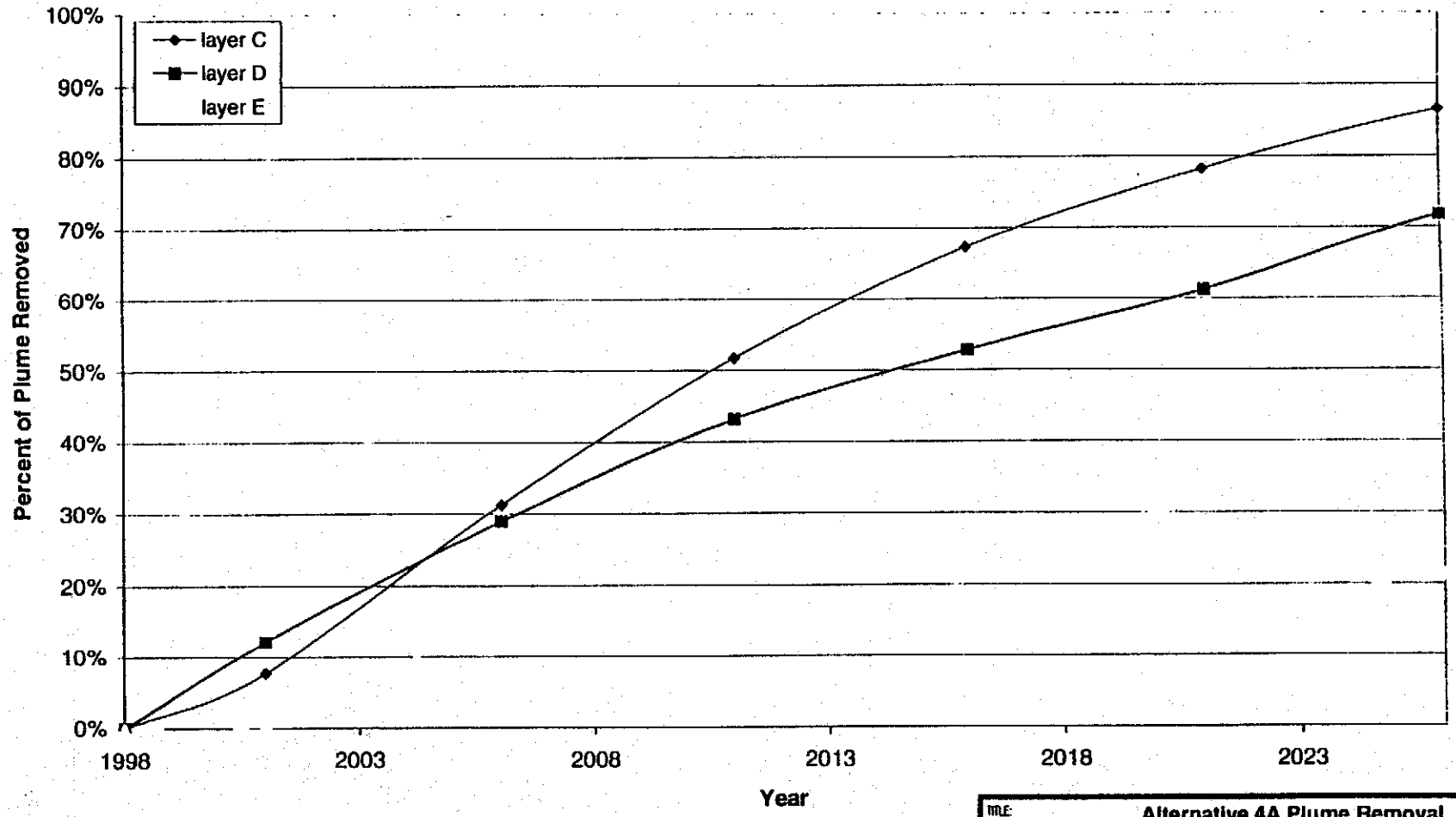
Alternative 4A Plume Removal



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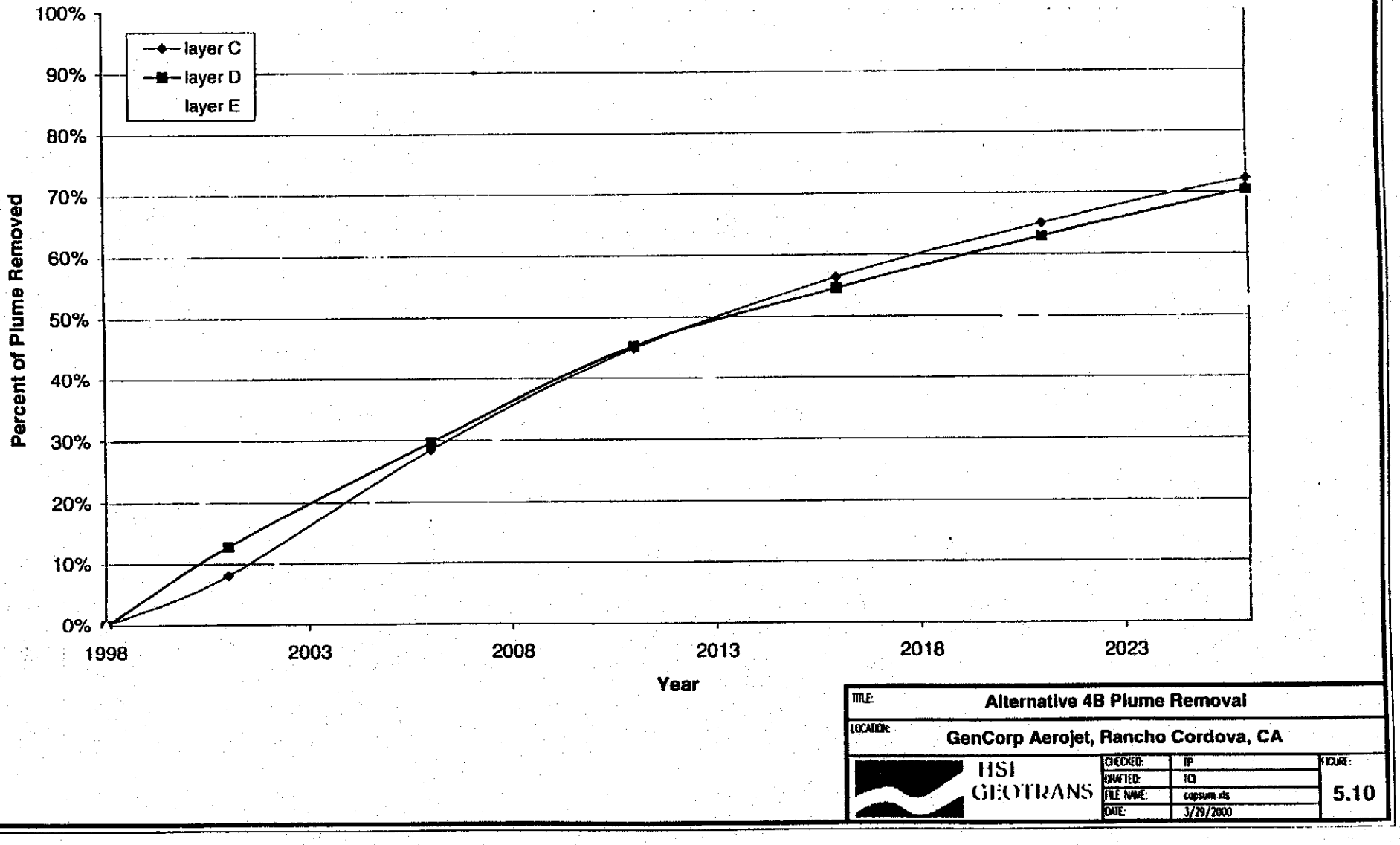
Alternative 4B Plume Removal
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Plume Removed
layer C
layer D
layer E
1998
2003
2008
2013
2018
2023
Year
TITLE: Alternative 4B Plume Removal
LOCATION: GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS
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DATE: 3/29/2000
FIGURE: 5.10

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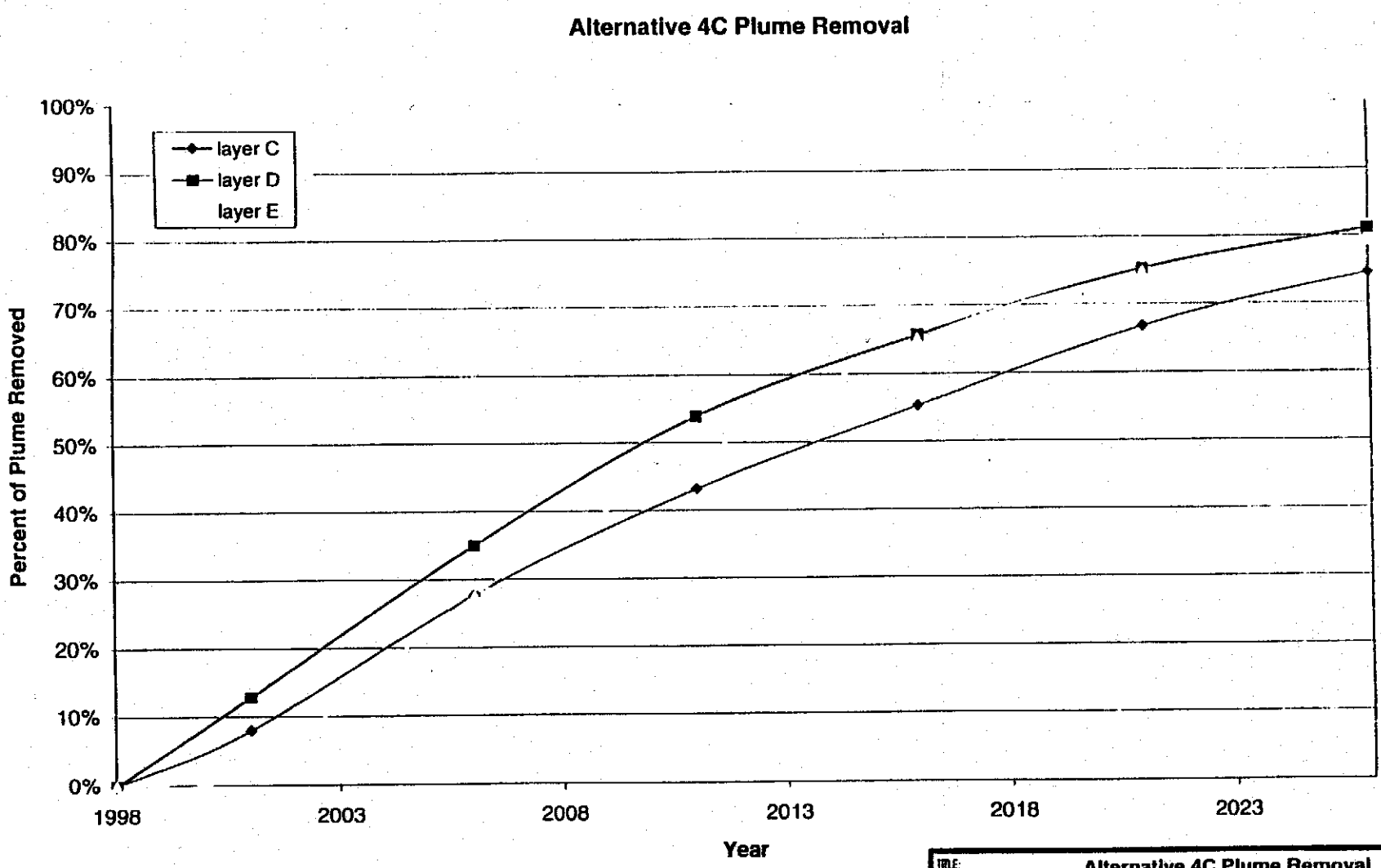

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FIGURE:	5.12

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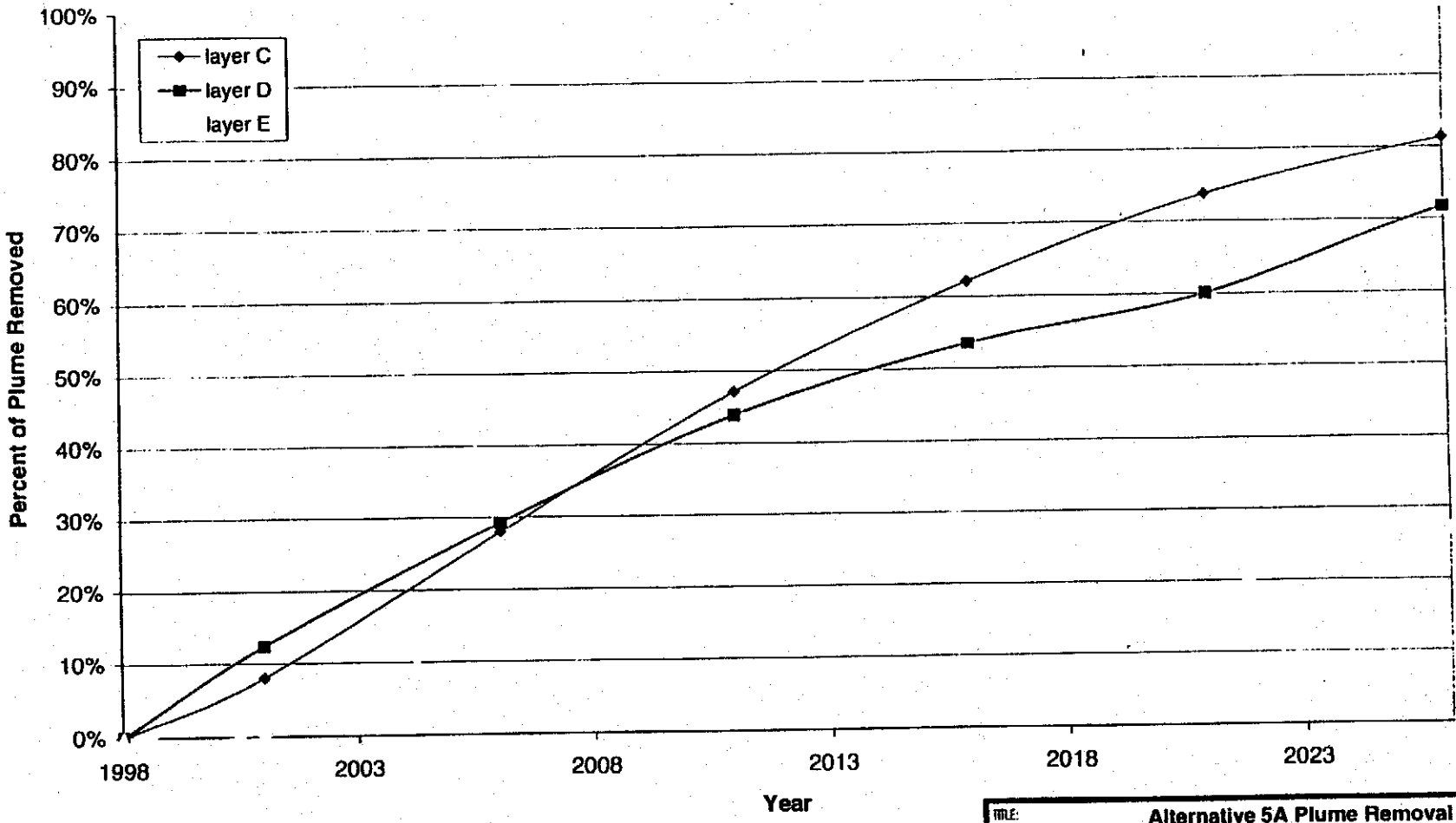
Alternative 5A Plume Removal



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DATE:	3/29/2000
FIGURE:	5.14

PAGES OF OVERSIZED MAPS

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Alternative 5B Plume Removal

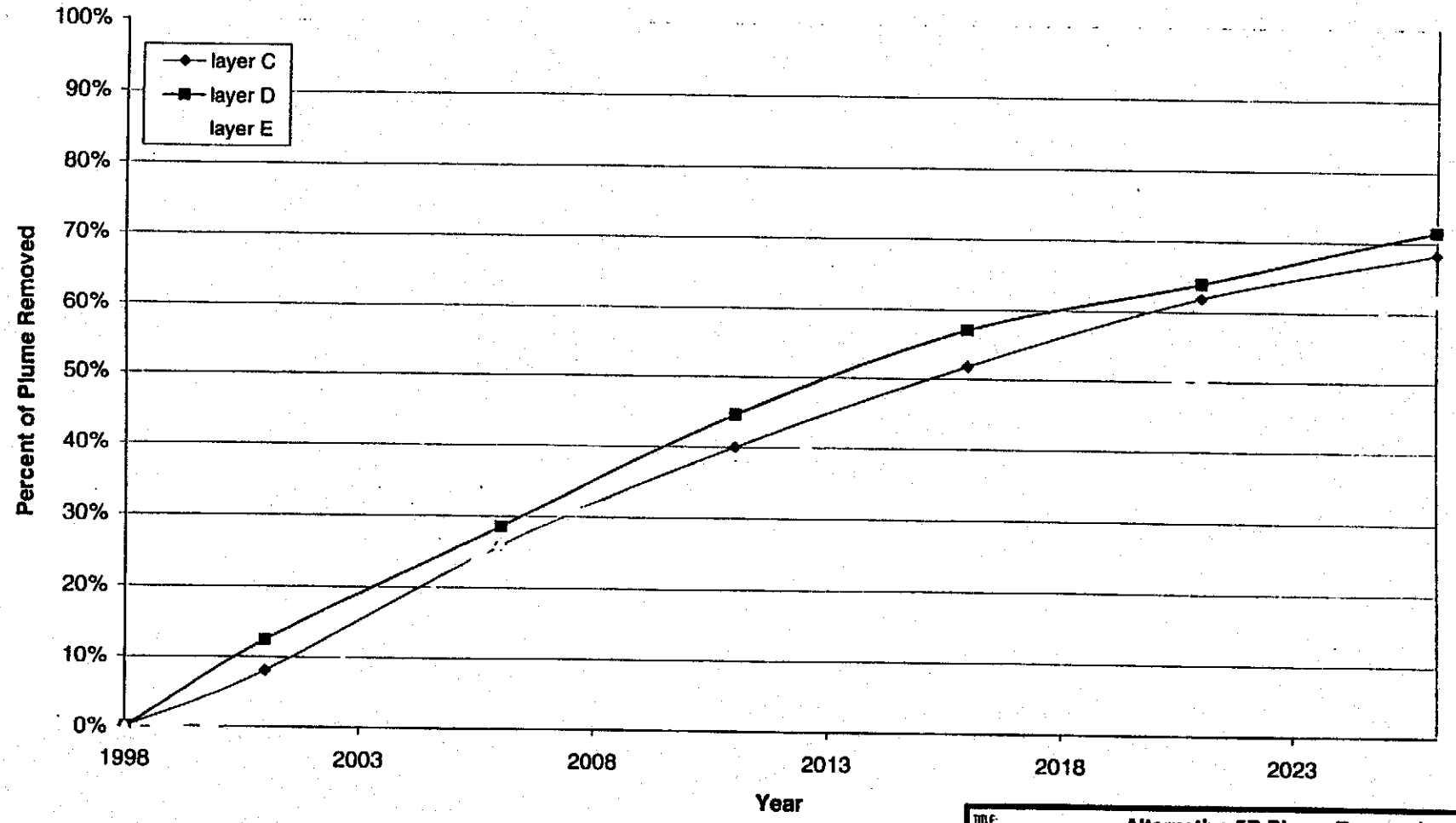

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FIGURE:	5.16

6 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents the comparative analysis for the alternatives that were evaluated in Section 5. The relative performance of each alternative is evaluated against the performance of the other alternatives for each of the threshold and primary balancing criteria. This comparative analysis identifies the advantages and disadvantages of each alternative to assist in the decision making process leading to the Proposed Plan.

6.1 Threshold Criteria

Two of the nine criteria specified in the NCP relate directly to statutory findings that must ultimately be made in the ROD. These two criteria are (1) overall protection of human health and the environment, and (2) compliance with ARARs. They are classified as threshold criteria, as each alternative must meet these two criteria.

6.1.1 Overall Protection of Human Health and the Environment

Alternative 1, which assumes the absence of the onsite GET containment facilities and institutional controls, does not provide adequate protection to human health, because it is assumed that contaminated groundwater continues to migrate offsite and it is assumed that there are no institutional controls to prevent public exposure to the groundwater. As previously discussed, existing (non-CERCLA) regulations related to public and private water supplies prevent the use of contaminated water. Therefore, it is unlikely that contaminated groundwater would be extracted for use. However, for purposes of the FS, it is assumed that under the No Action alternative, contaminated water would be used for potable supply and therefore, this alternative would not be protective of human health.

Each of the remaining alternatives include actions that break the pathway through which contaminated groundwater would be supplied for potable use. First, each of Alternatives 2A through 5B involve operation of GETs E and F at the Aerojet facility boundary, thereby establishing a hydraulic boundary to minimize the risk of the offsite migration of CoPCs. Second, Alternatives 2A through 5B eliminate exposure to unacceptable concentrations of CoPCs through various management options. Alternatives 2A and 2B involve replacement water supplies, Alternatives 3A and 3B involve point of use treatment, and Alternatives 4 and 5 involve a hydraulic barrier. Therefore, Alternatives 2A through 5B are sufficiently protective of public health.

Alternatives 2A and 2B do not prevent the continued migration of CoPCs already offsite and are not protective of the environment in the near-term. Each of Alternatives 3A through 5B involves offsite extraction intended to minimize CoPC migration and protect the environment.

The treated water management/reuse option selected will also be protective of human health and the environment for all alternatives. If wellhead treatment is utilized in all or a portion of the selected remedy, the treated water must meet DHS requirements for a drinking water source. Similarly, if direct reuse of treated groundwater is selected under Alternatives 4A through 5B, the treated water must comply with DHS requirements. Alternatives 4A through 5B must also be protective of the environment if recharge or surface water discharge are selected as treated water management options. This protection will be afforded through the NPDES permitting process for surface water discharge or treatment plant effluent requirements for recharge.

6.1.2 Compliance with ARARs

Compliance with ARARs also serves as a threshold criterion that must be met by any alternative for it to be selected as a remedy, unless an ARARs waiver is obtained. Each alternative, except Alternative 1, has the potential to eventually comply with ARARs.

Chemical-specific ARARs (e.g., MCLs) will be met by Alternatives 3A through 5B, since under each such alternative, impacted groundwater located both on the Aerojet facility and offsite will be treated to concentrations that meet chemical-specific ARARs prior to management/reuse. Alternatives 2A and 2B, which do not include offsite engineered groundwater controls, are less likely to achieve chemical-specific ARARs for offsite groundwater within the short term. However, they have the potential to eventually comply with ARARs through institutional controls, the operation of the GETs E/F extraction and treatment system, and natural attenuation.

Location- and action-specific ARARs do not apply to Alternative 1, the No-Action alternative. The groundwater extraction, conveyance, and treatment systems variously described under Alternatives 3A through 5B will be designed and operated to comply with all location- and action-specific ARARs.

Identified potential ARARs are detailed in Appendix C.

6.2 Primary Balancing Criteria

Alternatives 2A through 5B are comparatively analyzed in this section for the next five of the nine criteria, the primary balancing criteria. (Alternative 1, the No Action alternative, is not evaluated with respect to the primary balancing criteria, as it did not meet the initial threshold criteria.) These five criteria include long-term effectiveness and permanence; reduction of toxicity, mobility and volume through treatment; short-term effectiveness; implementability; and cost. These five criteria are collectively described as the primary balancing criteria as they provide the primary basis for differentiation among the various alternatives.

6.2.1 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence is a measure of the following two principal factors:

- The magnitude of residual risk; and
- The adequacy and reliability of controls.

The Alternative 4 and 5 series would appear to provide greater long-term effectiveness and permanence than the remaining alternatives, with the Alternative 4 series, and particularly 4B, providing the greatest potential for long-term effectiveness and permanence.

Alternative 4C may be less effective at maintaining hydraulic capture than Alternatives 4A and B, and 5A and B. Under Alternative 4C, extraction wells are located in Layers D and E between the Aerojet Site and the offsite hydraulic barrier in Layer C. These extraction wells will decrease the head potential in Layers D and E and may cause the downward migration of CoPCs from Layer C into Layers D and E. If this occurs, some CoPCs located beyond the influence of the extraction wells in Layers D and E will not be captured. The CoPC concentrations are generally an order of magnitude greater in Layer C than in Layers D and E.

The Alternative 4 and 5 series are intended to minimize the migration of CoPCs by establishing onsite and offsite barriers. These barriers will permanently remove and treat CoPCs from affected groundwater, thereby reducing the long-term potential for exposure to CoPCs in offsite groundwater. The potential long-term effectiveness and permanence of the Alternative 4 and 5 series is greater than that for the Alternatives 2 and 3 series because Alternatives 2 and 3 are not specifically designed to remove CoPCs in the offsite areas. It is difficult to accurately predict how far the CoPCs will migrate under Alternatives 2 and 3. However, Alternative 3 does provide a greater degree of long-term effectiveness than Alternative 2 because groundwater modeling indicates that a substantial portion of the offsite CoPCs would be permanently removed and treated through the use of wellhead treatment.

Among the "A", "B" and "C" alternatives, the "B" and "C" alternatives appear to provide the greatest potential to effectively control the migration of CoPCs. Replacing the recharge wells with extraction wells at the western Aerojet boundary enables the "B" and "C" alternatives to remove a greater portion of the CoPCs present in Layers C, D, and E before they migrate offsite. In addition, by eliminating recharge, the "B" and "C" alternatives reduce the total amount of water that must be contained by an offsite hydraulic barrier, thereby increasing the potential effectiveness of the offsite barrier system. Similarly, the Alternative 4 series has a greater potential for long-term

effectiveness than the Alternative 5 series because hydraulic control using only extraction is more attainable than achieving hydraulic control using both extraction and recharge.

The Alternative 4 and 5 series involve more remediation and removal of the offsite portions of the CoPCs than the remaining alternatives, although Alternatives 3A and 3B will remove a substantial portion of the offsite CoPCs. Therefore, the Alternative 4 and 5 series probably have the greatest potential to eventually restore the aquifer to beneficial uses and reduce the magnitude of residual risk. However, given the complexity and heterogeneity of the aquifer system and the unknown fate and transport characteristics of some of the CoPCs (i.e., perchlorate and NDMA), there is no realistic basis for evaluating the extent to which aquifer restoration will occur and over what period of time.

6.2.2 Reduction in Toxicity, Mobility, or Volume through Treatment

This criterion is a measure of the following five principal factors:

- Statutory preference for treatment as a principal element;
- Irreversibility of treatment;
- Type and quantity of treatment residual;
- Amount of hazardous material destroyed or treated; and
- Reduction in toxicity, mobility, or volume.

With respect to offsite CoPCs, except for Alternative 2, each of the alternatives involves management of contaminated groundwater that will achieve reduction in toxicity, mobility or volume through treatment. (A summary of the estimated onsite and offsite extraction flowrates under each alternative is presented in Table 6-1.) The remaining alternatives are equal in their preference for treatment and the irreversibility of treatment processes.

Alternatives 4 and 5 include both onsite and offsite hydraulic boundaries and therefore would be expected to provide greater reduction in toxicity, mobility and volume of the offsite CoPCs than Alternatives 2 and 3, which are not designed to do so (although Alternative 3 does provide containment). Among the "A", "B" and "C" alternatives, the "B" and "C" alternatives would be expected to provide a greater reduction in mobility of CoPCs in the offsite plume than the "A" alternatives because they would not include recharge of the GETs E/F treated groundwater.

Groundwater would be treated using various processes that are irreversible. No residuals are associated with UV/oxidation treatment because contaminants are destroyed. Air strippers produce VOCs in offgas that may require treatment prior to being emitted to the atmosphere. LPGAC does not destroy contaminants but rather collects VOCs within a

carbon vessel. The carbon will periodically require regeneration and offsite treatment or disposal. The groundwater treatment component of Alternatives 3A through 5B meets the statutory preference for treatment to reduce the principal threat because contaminants are destroyed or collected and the total volume of contaminated media is reduced.

The groundwater flow model was used as a basis for comparing the relative amount of the plume area that would be removed by each alternative involving groundwater extraction (i.e., Alternatives 3A through 5B) over the 25-year FS evaluation period. Figures 6-1 to 6-3 present the modeled plume area removed by each alternative in Layers C, D, and E, respectively. Figure 6-4 presents the estimated total plume area removed in all layers by alternative. Table 6-3 summarizes the percent of offsite plume area modeled to be captured under each alternative by layer and by the total plume area for each alternative.

The percent of plume area removed in Layer C ranges from 52 to 87 percent with Alternative 3B removing the least and Alternative 4A providing the most amount of removal (Figure 6-1). The alternatives involving an offsite hydraulic barrier and continued recharge of GETs E/F treated groundwater (i.e., Alternatives 4A and 5A) remove the greatest amount of plume area over the 25-year evaluation period because of the increased hydraulic gradients caused by recharge. Figure 6-2 shows that the plume areas estimated to be removed in Layer D are similar for all alternatives, ranging from approximately 68 to 77 percent. The amount of plume area removed in Layer E has the greatest variability of all layers, ranging from 21 to 91 percent (Figure 6-3, Table 6-2). The modeling indicates that Alternative 3B would remove more plume area from Layer E (91%) than any of the other alternatives because several water supply wells located closest to the Aerojet Site are screened in Layer E. Alternatives 5A and 4A would remove the least amount of plume in Layer E because recharge is continued and portions of the plume in Layer E on the west side of the Aerojet Site are not captured until they reach the offsite hydraulic barrier. Layer E comprises only 9 percent of the total plume area, so hydraulic capture of Layer E may not be a significant benefit.

The modeling indicates that Alternatives 3A and 3B would remove the least amount of the total plume area because they rely on existing water supply wells that are not optimally located for CoPC plume removal (Figure 6-4, Table 6-2). Alternatives 4A through 5B are projected to remove between 68 and 77 percent of the total plume area over 25 years. The approximate 13 percent difference among the alternatives modeled to remove the greatest amount (4A) and least amount (5B) of plume areas is within the range of variability of the model, and suggests that plume area removal is similar for each alternative.

6.2.3 Short-Term Effectiveness

Short-term effectiveness is a measure of the protection afforded by each alternative during the construction and implementation process. As such, the time until RAOs are

achieved is an important component of this criterion. The availability of equipment and specialists to implement the alternative is also a consideration.

This criterion is a measure of the following three principal factors:

- Protection of workers and the community during the remedial action;
- Environmental impacts; and
- Time until RAOs are achieved.

This criterion is typically of greater significance for source control measures. Here, all of the remaining alternatives involve onsite and most involve an offsite response action. Under all alternatives, the community and the environment would be protected during construction and implementation of the remedial action and from potential exposure to CoPCs through existing institutional controls (i.e., DHS drinking water standards).

All remaining alternatives protect offsite human health and the beneficial uses of the aquifer by minimizing the offsite CoPC migration. Alternatives 3A through 5B involve both onsite and offsite groundwater extraction, and are more protective than Alternatives 2A and 2B that rely on natural processes to reduce CoPC concentrations already offsite. Each of the "B" alternatives and Alternative 4C may be more protective than the "A" alternatives because treated groundwater is not recharged. The complex hydrostratigraphy and uneven lateral and vertical contaminant distribution in the Study Area necessitates that some CoPCs will migrate through unaffected portions of the aquifer prior to reaching the extraction or water supply wells. Alternative 4C involves the most aggressive offsite groundwater extraction and will intercept CoPCs in portions of Layers D and E earlier than the other alternatives. The earlier extraction from Layers D and E is unlikely to effect the beneficial use of the aquifer because, until the CoPCs in Layer C are removed, public water supply wells cannot be installed in Layers D and E due to the potential for the downward migration of CoPCs from Layer C into the supply well. Layer C contains the greatest areal extent and highest CoPC concentrations and will likely have the most impact on beneficial use.

The time required to implement Alternatives 2 and 3 would be shorter than Alternatives 4 and 5, because Alternative 2 would not require substantial offsite construction. Alternative 3 would be implemented on a phased basis as public water supply wells become affected. Alternatives 4 and 5 would require significantly more planning, design, and construction activities for the offsite hydraulic containment components. Alternative 4C would probably require the greatest amount of time to implement because it would involve securing the easements and right-of-way access for two offsite pipeline corridors instead of one.

Several of the alternatives involve extraction of groundwater to achieve containment or collection and therefore have the potential to impact the operation of existing or possible future groundwater supply wells. Table 6-1 summarizes the maximum water level

drawdowns estimated to be observed in water supply wells located in the vicinity of the intersection of Zinfandel Drive and U.S. Highway 50 as a result of implementation of Alternatives 4A through 5B. There would appear to be no significant impact on water levels associated with any of the offsite containment alternatives based upon the FS modeling described in Appendix D. The modeling projects potential water level drawdown of approximately 35 feet or less. This is not expected to have any significant impact on the aquifer.

It is anticipated that the necessary equipment and specialists are available to implement all alternatives.

It is not technically feasible to estimate the time required to meet the RAO of reducing CoPC concentrations in already contaminated portions of the groundwater due to the aquifer and contaminant distribution complexities discussed throughout this FS. However, it may be useful to compare the amount of plume area modeled to be removed during the 25-year evaluation period among the alternatives for a relative comparison of time. The alternatives modeled to remove the greatest plume area can reasonably be expected to achieve this RAO more quickly than the other alternatives. As discussed in Sections 5 and 6.2.2, Alternatives 4A through 5B are projected to remove between 68 and 77 percent of the total plume area over 25 years (Table 6-2). The 13 percent difference in estimated plume area removed among the alternatives is probably insignificant for a remedial action that may be implemented for the Western Groundwater OU. Alternative 2 will not attain a reduction in the offsite CoPC concentrations over any meaningful period of time.

6.2.4 Implementability

Implementability evaluates the technical and administrative difficulties associated with implementing each alternative. Each of the alternatives is implementable to varying degrees, as discussed in this section. There are several technical and administrative difficulties associated with each of the alternatives evaluated in this FS. Technical implementability issues include demonstrating hydraulic capture and control of CoPC plumes and demonstrating the ability to treat extracted CoPCs. Administrative difficulties associated with implementing alternatives include obtaining easements and property for wells and pipelines, conducting a large construction project in public roads and neighborhoods, challenges associated with permitting and compliance for wellhead treatment, and exchanging water for potable and nonpotable reuse.

Alternatives 2A and 2B are implementable to the extent that DHS approves treated groundwater for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. If direct reuse is not accepted, and for the projected shortfall of treated water available under Alternative 2A, a surface water treatment plant can be constructed if a suitable location can be found, and if a private or public water purveyor is willing to operate it. It is believed that permission can be

obtained from the USBR to use Folsom South Canal as a raw water conveyance system to a surface water treatment plant, if necessary. Between Alternatives 2A and 2B, Alternative 2A assumes that long-term surface water entitlements would be available on the American River, which may not be the case.

Alternatives 3A and 3B are implementable to the extent that the DHS approves wellhead treatment for direct reuse and the water purveyors and public would accept it. This acceptance involves demonstrating that the treated water is the best available source of water and will be protective of public health. DHS has accepted wellhead treatment at numerous locations throughout the State. If accepted, the well treatment equipment must be capable of fitting in the existing space available at impacted water supply wells, and the treatment processes must be capable of meeting treatment standards in a demonstrable and reliable manner.

It will be difficult to implement Alternatives 4A through 5B due to the significant amount of offsite infrastructure estimated for these alternatives. Table 6-3 presents the number of wells and lengths of piping estimated for each alternative. Alternatives 4A through 5B are estimated to require from approximately 67,000 to 81,000 feet (approximately 13 to 16 miles) of relatively large diameter piping and from 11 to 30 offsite extraction wells. It will require a substantial effort to identify potential pipeline corridors and secure the necessary permits and easements. This amount of offsite construction may require significant input and participation from Sacramento County and the local community. It is not currently known where extraction wells that require periodic maintenance and monitoring can be located.

In comparing among the "A", "B", and "C" alternatives, the "B" and "C" alternatives should be more implementable, given the preference of using extraction rather than recharge both on and offsite to maintain the hydraulic control, and because the "B" and "C" alternatives involve more containment onsite than the "A" alternatives. With respect to the alternatives that include an offsite hydraulic barrier (Alternatives 4A through 5B), maintaining a hydraulic barrier where recharge wells are used as part of the barrier (Alternatives 5A and 5B) would probably be more difficult to implement as maintaining gradients requires more sophisticated groundwater management to optimize system operation and control

6.2.5 Cost

A summary of the estimated costs associated with each alternative is presented in Table 6-4. The cost estimates for each alternative were prepared in accordance with current EPA guidance with respect to level of accuracy and discount rate (i.e., seven percent). For comparison purposes, the estimated total capital cost, estimated annual O&M costs, and estimated 25-year present worth cost estimates are presented in Table 6-4 for each of the alternatives. Wherever possible, actual capital and O&M costs from the Aerojet GET facilities and local area piping construction projects were used for these cost estimates.

The basis for the costs and the methodology and information used to develop the costs are provided in Appendix E.

6.3 Modifying Criteria

The final two of the nine criteria are state acceptance and community acceptance. These two criteria are evaluated following comment on the FS report and Proposed Plan and as such are termed modifying criteria.

6.3.1 State Acceptance

This criterion addresses the State's apparent preferences among or concerns about the various alternatives. This criterion will be addressed as part of the final decision-making process during the preparation of the ROD.

6.3.2 Community Acceptance

This criterion addresses the community's apparent preferences among or concerns about the various alternatives. This criterion will be addressed as part of the final decision-making process during the preparation of the ROD.

6.4 Sensitivity Analysis

Appendix D addresses the sensitivity of remedial alternatives to modeled parameters, including:

- Effects of changing recharge conditions (i.e., wet and dry years vs. long term average recharge conditions); and
- The effects on capture if hydraulic conductivity values are higher or lower.

The sensitivity evaluation did not indicate that changes in these two conditions substantially impact conclusions reached regarding the relative strengths and weaknesses of the alternatives relative to one another with respect to the various evaluation criteria, including costs.

Table 6-1: Estimated Extraction Flowrates and Anticipated Maximum Drawdowns

Alternative	Description	Estimated Extraction Flowrates (gpm)	Modeled Anticipated Maximum Drawdown Offsite (feet)
1	No Action with Limited Groundwater Monitoring	0	NA
2A	GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply	3,800 Onsite 0 Offsite 3,800 Total	NA
2B	GETs E and F Extraction Wells with Offsite Alternate Water Supply	6,225 Onsite 0 Offsite 6,225 Total	NA
3A	GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells	3,800 Onsite 11,200 Offsite 15,000 Total	NA
3B	GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells	6,225 Onsite 11,200 Offsite 17,425 Total	NA
4A	GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells	3,800 Onsite 3,700-8,600 Offsite 7,500-12,400 Total	20
4B	GETs E and F Extraction Wells with Offsite Extraction Wells	6,225 Onsite 3,100-4,600 Offsite 9,325-10,825 Total	30
4C	GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors	6,225 Onsite 3,750-4,150 Offsite 9,975-10,375 Total	35
5A	GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells	3,800 Onsite 3,200-7,200 Offsite 7,000-11,000 Total	10
5B	GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells	6,225 Onsite 2,000-2,900 Offsite 8,225-9,125 Total	22

Note: NA = not applicable.

Table 6-2: Percent of Offsite Area Modeled to be Captured After 25 Years

Alternative	Description	Layer C (61% of particles)		Layer D (30% of particles)		Layer E (9% of particles)		All Layers (100% of particles)
		Modeled Percent of Layer Area Captured After 25 Years (25%)	Layer Contribution to Total Area Captured (%)	Modeled Percent of Layer Area Captured After 25 Years (25%)	Layer Contribution to Total Area Captured (%)	Modeled Percent of Layer Area Captured After 25 Years (25%)	Layer Contribution to Total Area Captured (%)	Modeled Percent of Layer Area Captured After 25 Years (25%)
1	No Action with Limited Groundwater Monitoring	NA	NA	NA	NA	NA	NA	NA
2A	GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply	NA	NA	NA	NA	NA	NA	NA
2B	GETs E and F Extraction Wells with Offsite Alternate Water Supply	NA	NA	NA	NA	NA	NA	NA
3A	GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells	61	59	68	32	65	9	63
3B	GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells	52	53	69	34	91	14	60
4A	GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells	87	70	72	28	21	2	76
4B	GETs E and F Extraction Wells with Offsite Extraction Wells	72	63	71	30	52	7	70
4C	GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors	77	61	77	30	79	9	77
5A	GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells	81	67	72	29	27	3	74
5B	GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells	68	61	72	31	62	8	68

Table 6-3: Components of Each Alternative

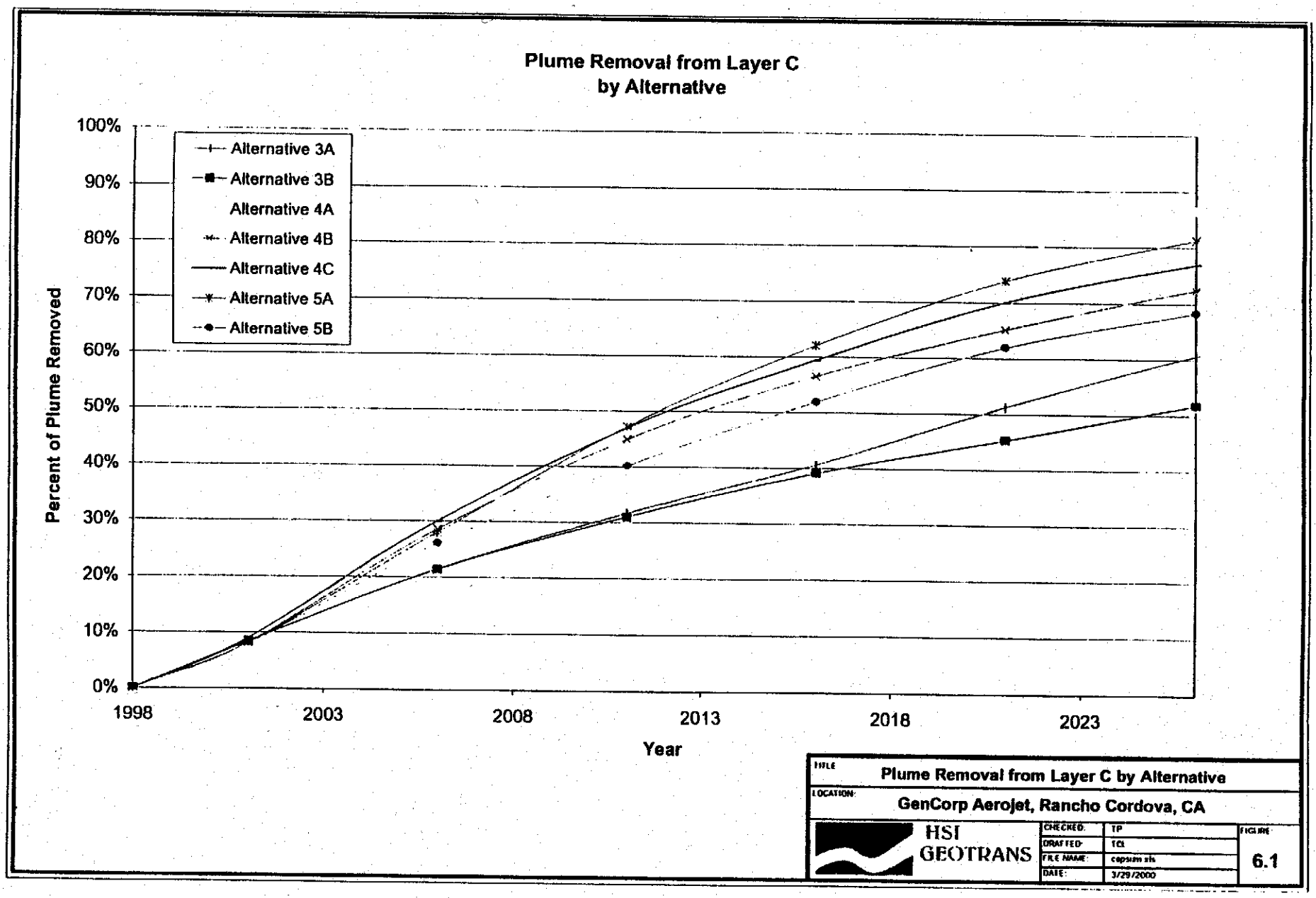
Alternative	Description	Estimated Number of New Wells			Estimated Length of Piping (ft)
		Monitor Wells	Extraction Wells	Recharge Wells	
1	No Action with Limited Groundwater Monitoring	0	0	0	0
2A	GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply	0	4[1]	0	63,000
2B	GETs E and F Extraction Wells with Offsite Alternate Water Supply	0	13[2]	0	32,000
3A	GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells	0	4[1]	0	9,000
3B	GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells	0	13[2]	0	21,000
4A	GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells	45	34[3]	0	79,000
4B	GETs E and F Extraction Wells with Offsite Extraction Wells	26	30[4]	0	67,000
4C	GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors	27	31[5]	0	77,500
5A	GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells	36	28[6]	7	81,000
5B	GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells	17	24[7]	7	79,000

Notes:
1. 4 new extraction wells in 2 locations (all onsite).
2. 13 new extraction wells in 5 locations (all onsite).
3. 34 new extraction wells in 15 (2 onsite, 13 offsite) locations.
4. 30 new extraction wells in 15 (5 onsite, 10 offsite) locations.
5. 31 new extraction wells in 21 (5 onsite, 16 offsite) locations.
6. 28 new extraction wells in 12 (2 onsite, 10 offsite) locations.
7. 24 new extraction wells in 12 (5 onsite, 7 offsite) locations.

Table 6-4: Summary of Estimated Costs

Alternative	Description	Estimated Capital Costs ($M)	Estimated Annual O&M Costs [Range] ($M/year)	Estimated 25-year Present Worth Costs ($M)
1	No Action with Limited Groundwater Monitoring	0	0.16	2
2A	GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply	25	2.1-3.9	48
2B	GETs E and F Extraction Wells with Offsite Alternate Water Supply	22	2.5-2.8	54
3A	GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells	64	3.5-5.3	93
3B	GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells	77	4.0-6.0	115
4A	GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells	43	3.0-3.3	78
4B	GETs E and F Extraction Wells with Offsite Extraction Wells	38	3.3-3.4	77
4C	GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors	42	3.5-3.6	85
5A	GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells	41	3.3-3.9	78
5B	GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells	45	3.8-4.0	87

Notes: Costs include O&M of existing onsite GETs E/F boundary source containment system, improvements to onsite GETs E/F system, and any offsite remedial alternatives.


Plume Removal from Layer C
by Alternative
Percent of Plume Removed
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1998
2003
2008
2013
2018
2023
Year
Alternative 3A
Alternative 3B
Alternative 4A
Alternative 4B
Alternative 4C
Alternative 5A
Alternative 5B
TITLE
Plume Removal from Layer C by Alternative
LOCATION
GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS
CHECKED: TP
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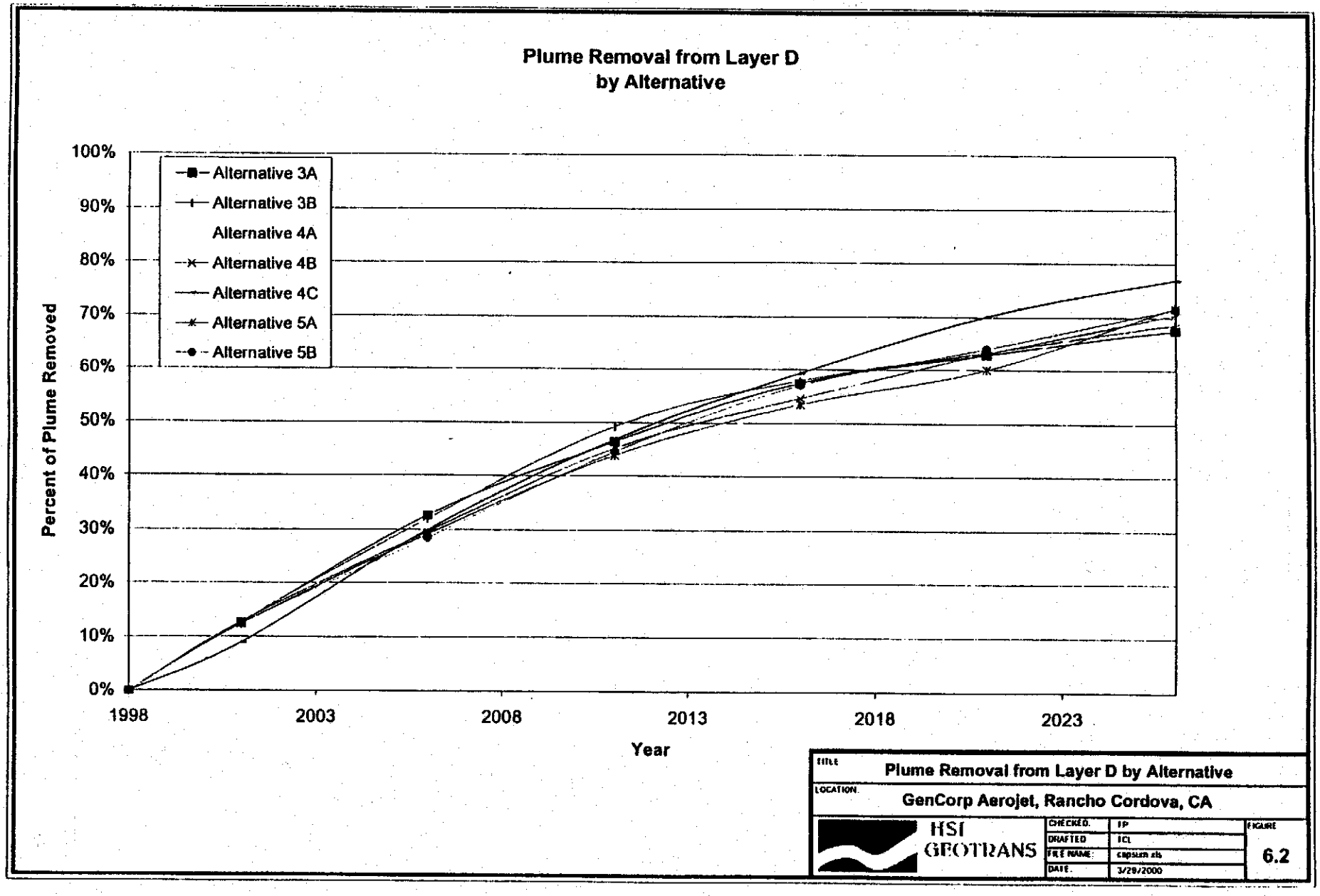
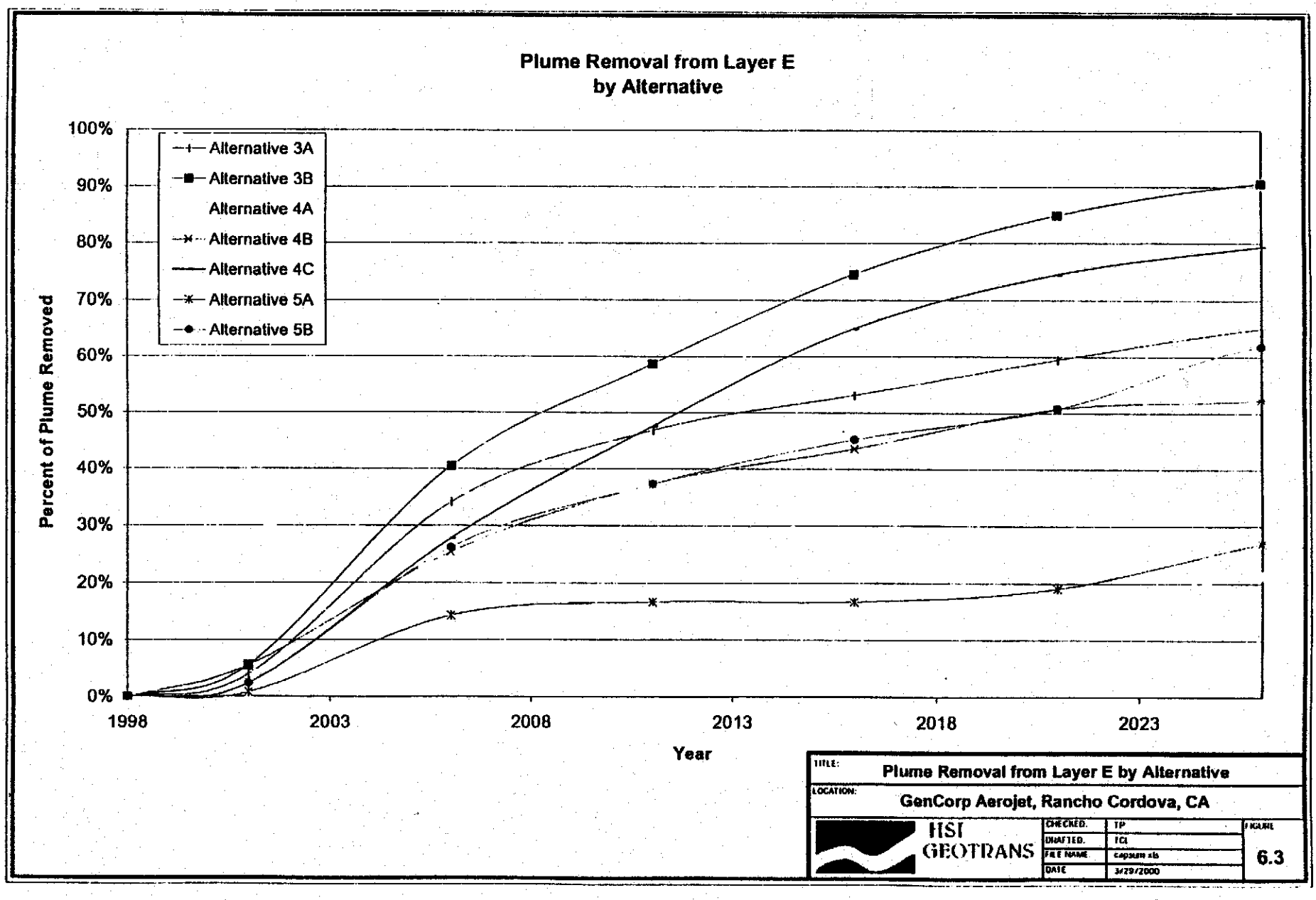
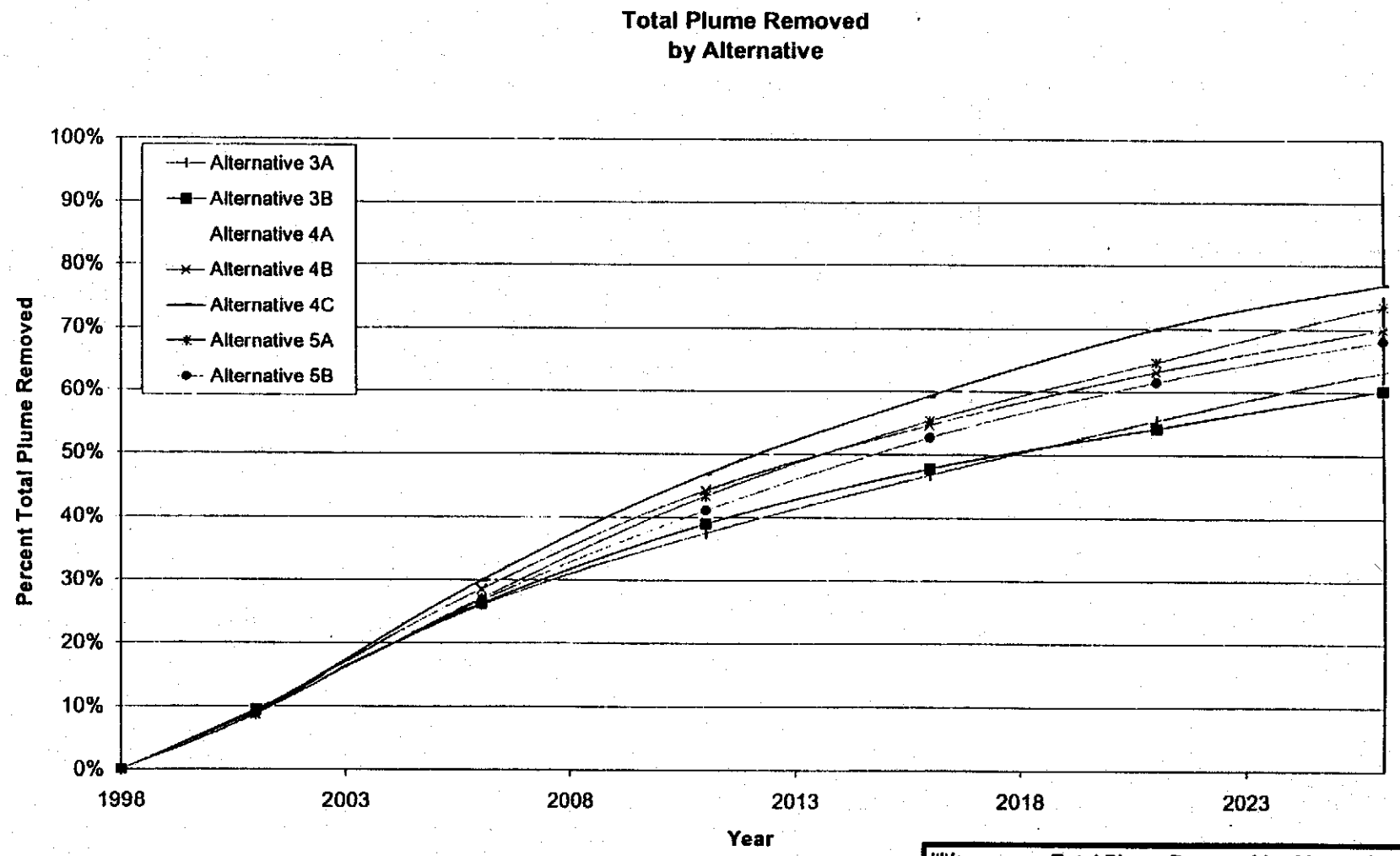
FILE NAME: capsim.xls
DATE: 3/29/2000
FIGURE
6.1


Plume Removal from Layer D
by Alternative
Percent of Plume Removed
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1998
2003
2008
2013
2018
2023
Year
Alternative 3A
Alternative 3B
Alternative 4A
Alternative 4B
Alternative 4C
Alternative 5A
Alternative 5B
TITLE
Plume Removal from Layer D by Alternative
LOCATION
GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS
CHECKED
TP
DRAFTED
TCL
FILE NAME
capsum.xls
DATE
3/29/2000
FIGURE
6.2


Plume Removal from Layer E
by Alternative
Percent of Plume Removed
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1998
2003
2008
2013
2018
2023
Year
Alternative 3A
Alternative 3B
Alternative 4A
Alternative 4B
Alternative 4C
Alternative 5A
Alternative 5B
TITLE: Plume Removal from Layer E by Alternative
LOCATION: GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS
CHECKED. TP
DRAFTED. TCL
FILE NAME capsum.xls
DATE 3/29/2000
FIGURE 6.3



TITLE:	Total Plume Removed by Alternative
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HSI GEOTRANS	
CHECKED:	TP
DRAFTED:	TCI
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FIGURE	6.4

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Appendix C

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Appendix C

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR WESTERN GROUNDWATER OU RI/FS

This appendix presents an evaluation of requirements established under federal or State environmental laws that may represent potentially applicable or relevant and appropriate requirements (ARARs) for remedial actions that may be conducted for the Western Groundwater OU. EPA will select ARARs and cleanup standards and document that selection in the Record of Decision. This FS evaluates potential ARARs to assist in the development and evaluation of alternatives in accordance with the requirements set forth in the National Contingency Plan (40 CFR 300.430).

C.1 Introduction

The development and evaluation of potential ARARs is based primarily on the following information:

- Requirements set forth in the NCP;
- EPA's guidance document "CERCLA Compliance with Other Laws Manual" (EPA, 1988) and related guidance;
- The Central Valley Regional Water Quality Control Board's May 7, 1998 general listing of ARARs for Groundwater Remediation;
- EPA, RWQCB, and DTSC comments on Aerojet's 11-23-99 draft Western Groundwater OU RI/FS; and
- The State Water Resources Control Board's July 14, 1992 Memorandum regarding "Applicable or Relevant and Appropriate Requirements (ARARs), To-Be-Considered Requirements (TBCs), and Permit Requirements of CERCLA."

This OU is focused solely on groundwater contamination in the Western Groundwater Study Area. This OU does not include investigation of potential or actual source areas and internal groundwater control on property not within the Western Groundwater Study Area, or an evaluation of potential remedial alternatives for these areas. Source areas and onsite groundwater will be addressed as part of future OU RI/FS efforts. Consequently, this ARARs evaluation does not identify or evaluate potential ARARs for source areas, even if a possible source area is located within the Western Groundwater Study Area.

The potential ARARs identified in this appendix were used in Section 2 of the FS to identify Preliminary Remedial Action Goals (PRAGs) and remedial action objectives. The evaluation of potential ARARs presented in this section does take into account the

potential remedial alternatives presented in the FS. However, the detailed evaluation of how each ARAR may potentially be applicable or relevant and appropriate for each remedial alternative and how each alternative complies with ARARs is presented as part of the detailed evaluation of the alternatives in Section 5 of the FS.

C.2 Identification and Evaluation of ARARs

Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) states that remedial actions on CERCLA sites must attain (or justify the waiver of) any federal or more stringent State environmental standards, requirements, criteria, or limitations that are determined to be ARARs. Applicable requirements are those cleanup standards, criteria, or limitations promulgated under federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site. All jurisdictional prerequisites must be met in order for the requirement to be applicable.

If a requirement is not legally applicable, the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or State law that, while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are well suited to the conditions of the site. The criteria for determining relevance and appropriateness are listed in Title 40, Code of Federal Regulations (CFR), Section 300.400(g)(2) {40 CFR 300.400(g)(2)}.

ARARs are concerned only with substantive, not administrative, requirements of a statute or regulation. The substantive portions of the regulation are those requirements that pertain directly to actions or conditions in the environment. Examples of substantive requirements include quantitative health- or risk-based restrictions upon exposure to types of hazardous substances (e.g., maximum contaminant levels [MCLs]). Administrative requirements are the mechanisms that facilitate implementation of the substantive requirements. Administrative requirements include issuance of permits, documentation, reporting, recordkeeping, and enforcement. Thus, in determining the extent to which onsite CERCLA response actions must comply with environmental laws, a distinction should be made between substantive requirements, which may be ARARs, and administrative requirements, which are not.

Furthermore, the ARARs provision in CERCLA applies to onsite actions. "Onsite" is defined as the areal extent of contamination and includes the groundwater plumes to be remediated. According to CERCLA Section 121(e), a remedial response action that takes place entirely onsite may proceed without obtaining permits. This permit exemption applies to all administrative requirements, as well as to permits. Offsite actions must comply with the substantive as well as the administrative requirements of all applicable regulations.

Pursuant to U.S. Environmental Protection Agency (EPA) guidance, ARARs generally are classified into three categories: chemical-specific, location-specific, and action-specific requirements. These classification categories were developed to help identify ARARs, some of which do not fall precisely into one group or another. These categories of ARARs are defined below:

- Chemical-Specific ARARs include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. If, in a specific situation, a chemical is subject to more than one discharge or exposure limit, the more stringent of the requirements should generally be applied.

- Location-Specific ARARs are those requirements that relate to the geographical or physical position of the site, rather than the nature of the contaminants or the proposed site remedial actions. These requirements may limit the placement of remedial action, and may impose additional constraints on the cleanup action.

- Action-Specific ARARs are requirements that define acceptable handling, treatment, and disposal procedures for hazardous substances. These ARARs generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities related to management of hazardous substances or pollutants. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Because a remedial site usually involves several alternative actions, very different action-specific requirements can apply.

Agency policies and guidance may not meet the definition of ARARs as defined above, but still may be useful in determining whether to take action at a site or to what degree action is necessary. This can be particularly true when there are no ARARs for a site, action, or contaminant (e.g., contaminants that do not have MCLs). Such agency policies and guidance that are not promulgated regulations (that is, those policies and guidance that are not formally adopted as state-wide regulations of general applicability following public notice and comment and do not appear in the California Code of Regulations) are called to-be-considered (TBC) criteria. TBC criteria may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they may be considered when developing the required level of cleanup for protection of health or the environment. The critical difference between a TBC and an ARAR is that one is not required to comply with or meet a TBC when deciding on a remedial action.

ARARS and TBCs are identified at various points throughout the CERCLA process. These criteria are identified on a site-specific basis. Therefore, as additional information is developed about the site, including special features of the site location, the specific chemicals at the site, and the actions that are being considered as remedies, more ARARs

may be identified, and the list of potential ARARs further refined. Potential ARARs are usually identified in the FS, and the final list of ARARs that any remedy must meet is established in the ROD.

C.3 Waivers of ARARs

CERCLA Section 121 provides that, under certain circumstances, an otherwise applicable or relevant and appropriate requirement may be waived. These waivers apply only to the attainment of the ARAR. Other statutory requirements, such as the requirement that remedies be protective of human health and the environment, cannot be waived. The waivers provided by CERCLA Section 121(d)(4) are listed below:

- Interim Remedy--The remedial action selected is only part of a total remedial action that will attain such a level or standard of control when completed.
- Greater Risk to Human Health or the Environment--Compliance with the requirement at the site will result in greater risk to human health and the environment than alternative options.
- Technical Impracticability--Compliance with the requirement is technically impracticable from an engineering perspective.
- Equivalent Standard of Performance--The remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation through use of another method or approach.
- Inconsistent Application of State Requirements--With respect to a State standard, requirement, criterion, or limitation, the State has not consistently applied (or demonstrated the intention to consistently apply) the standard, requirement, criterion, or limitation in similar circumstances at other remedial actions.
- Fund Balancing--In the case of a remedial action to be undertaken solely under Section 104 using the Fund, selection of a remedial action that attains the level or standard of control in the requirement will not provide a balance between the need for protection of public health and welfare and the environment at the site under consideration, and the availability of amounts from the Fund to respond to other sites that present or may present a threat to public health or welfare or the environment, taking into consideration the relative immediacy of such threats.

C.4 Potential Chemical-Specific ARARs

Chemical-specific ARARs are usually health- or risk-based numeric values or methodologies which, when applied to site-specific conditions result in the establishment

of numeric values (EPA, 1998). This section focuses on those standards, criteria or limitations that, considering site-specific conditions, contain numeric values establishing acceptable amounts or concentrations of a chemical that may be found in or discharged to the environment.

C.4.1 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) establishes national primary drinking water standards (Maximum Contaminant Levels or MCLs) to protect the quality of water in public water systems. MCLs are enforceable standards and represent the maximum concentrations of contaminants permissible in a water system delivered to the public. Because MCLs are enforced at the point where water is delivered to the public, MCLs are rarely applicable to cleanup of groundwater at Superfund sites (55 Federal Register 8750). However, MCLs are generally relevant and appropriate when determining acceptable exposure limits for groundwater that is a current or potential source of drinking water [40 CFR 300.430(e)(2)(i) (B)]. The National Contingency Plan (NCP) states that maximum contaminant level goals (MCLGs) that are set at levels above zero should also be considered to be relevant and appropriate requirements for groundwater that is a potential source of drinking water [40 CFR 300.430 (e)(2)(i)(B)].

California drinking water standards (Title 22 CCR Chapter 15, Section 64400 et seq.) establish primary MCLs for contaminants that cannot be exceeded in water supplied to the public. As with the federal drinking water standards, the California MCLs are applicable at the point where water is delivered to the public and therefore are not applicable to cleanup of groundwater. However, to the extent that the State MCLs are more stringent than the federal limits, the State requirements may be relevant and appropriate for groundwater that is, or may be, a potential source of drinking water. The California drinking water MCLs are, in some cases, more stringent than the federal MCLs and, in other cases, less stringent than the national standards. Thus, the more stringent limit is determined on a chemical-by-chemical basis.

Table C-1 presents a listing of potential CoPCs of concern for the Western Groundwater OU and their federal and state MCLs and the federal MCLGs. The MCLs are potentially applicable at the point where water is delivered to the public. MCLs are applicable to the Western Groundwater OU at the point any withdrawn groundwater is placed in a water distribution system used for drinking water supply. MCLs and non-zero MCLGs are potentially relevant and appropriate for in-place groundwater that is or may be a potential source of drinking water and therefore, are relevant and appropriate for the Western Groundwater OU.

Only the MCLs and non-zero MCLGs for the site-specific organic chemicals of concern and nitrate and nitrite are relevant and appropriate as potential cleanup levels for the Western Groundwater OU. However, these and other MCLs, such as those established for inorganic constituents, could also become applicable if the selected remedial action includes use of treated water as part of a public water supply.

C.4.2 Water Quality Control Plan (Basin Plan)

The California Water Code requires Regional Water Quality Control Boards to prepare and periodically update Water Quality Control Plans, also known as Basin Plans. The Porter-Cologne Water Quality Control Act states that basin plans consist of beneficial uses, water quality objectives and a program of implementation for achieving their water quality objectives [California Water Code Section 12050(j)].

The Basin Plan for the Sacramento and San Joaquin River Basins, dated September 15, 1998, designates beneficial uses for waters, and contains numeric and narrative water quality objectives (WQOs) to protect those beneficial uses. The Basin Plan also contains policies and procedures intended to protect beneficial uses. The Basin Plan is not a promulgated regulation. As discussed below, the policies and procedures contained in the Basin Plan may be TBCs for the Western Groundwater OU.

C.4.2.1 Beneficial Uses

State Water Board Resolution No. 88-63 specifies that all surface and ground waters of the State are considered to be suitable, or potentially suitable, for municipal or domestic water supply and should be so designated by the Regional Boards unless the water meets certain exceptions. Beneficial uses of ground water in the Sacramento and San Joaquin basin are designated in the Basin Plan. The Basin Plan states that unless otherwise designated by the Regional Water Board, all ground waters in the Region are considered as suitable or potentially suitable, at a minimum, for municipal and domestic supply (MUN), agricultural supply (AGR), industrial service supply (IND), and industrial process supply (PRO).

In making exceptions to the beneficial uses designation of municipal and domestic supply (MUN), the Regional Water Board applies the criteria in State Water Board Resolution No. 88-63, "Sources of Drinking Water Policy". One of the criteria for exceptions is stated as follows:

> "There is contamination, either by natural processes or by human activity (unrelated to the specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices..."

Based on the Basin Plan, the highest beneficial use of ground water within the Western Groundwater Study Area is MUN.

Although the Regional Water Board has not made a specific exception with respect to the current area of the contaminant plumes beneath the Western Groundwater Study Area, the presence of perchlorate and NDMA provides a basis for a possible exception to the

MUN use. Aerojet and others are currently involved in developing and demonstrating treatment technologies for these constituents that may be used to treat contaminated water to a level suitable for drinking water supplies. Treatment methods for perchlorate are currently in the demonstration phase. While treatment of perchlorate and NDMA have been effectively demonstrated, DHS has not yet certified these technologies for treatment of drinking water supplies in the Western Groundwater Study Area. Therefore, these technologies do not yet represent BMP or best economically achievable treatment practices for potential drinking water in the Study Area. Consequently, water containing perchlorate or NDMA above risk-based levels in the Western Groundwater Study Area currently is not suitable for municipal or domestic supply.

The beneficial uses for groundwater identified in the Basin Plan are TBCs with respect to the Western Groundwater OU, subject to the potential exception identified in State Water Board Resolution 88-63. The beneficial uses for surface water identified in the Basin Plan are potential TBCs with respect to any remedial action that includes discharge of treated water to surface water.

C.4.2.2 Water Quality Objectives

The Porter-Cologne Water Quality Control Act defines water quality objectives as "... the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or prevention of nuisance within a specific area [Water Code Section 13050(h)]." The Basin Plan includes water quality objectives for groundwater that apply to all groundwaters of the Sacramento and San Joaquin River Basins. The Basin Plan states that water quality objectives are relevant to the protection of designated beneficial uses. The plan also states that these objectives do not require improvement over naturally occurring background concentrations. The Plan further states that the groundwater objectives contained in the Plan are not required by the federal Clean Water Act.

The Basin Plan identifies water quality objectives for groundwater for bacteria, chemical constituents, radioactivity, tastes and odors, and toxicity. Specific numeric standards are defined for bacteria, chemical constituents and radioactivity. Narrative standards are provided for tastes, odors and toxicity.

The water quality objective for chemical constituents in groundwaters state that "Ground waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses." This objective further states, that:

> "At a minimum, ground waters designated for domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs). Specifically, the Basin Plan references the MCLs specified in the following provisions of Title 22 of the California Code of Regulations: Tables 64431-A (Inorganic Chemicals) and 64431-B (Fluoride) of Section 64431. Table 64444-A (Organic Chemicals) of Section 64444, and

Tables 64449-A (Secondary Maximum Contaminant Levels –Consumer Acceptance Limits) and 64449-B (Secondary Maximum Contaminant Levels-Ranges) of Section 64449."

MCLs were discussed in the previous section of this appendix and are summarized on Table C-1.

Only a narrative statement is provided for the water quality objectives in groundwater relative to toxicity. This objective states that "Ground waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life associated with beneficial use(s)."

Water quality objectives for groundwater presented in the Basin Plan that are not MCLs or are not otherwise promulgated standards are TBCs with respect to the Western Groundwater OU.

Water quality objectives have also been developed for surface water. Although surface water is not included within the scope of the Western Groundwater OU, it is possible that groundwater collected and treated as part of a selected remedial action for the Western Groundwater OU may be discharged to surface water. Water quality objectives for surface water that are not MCLs or are not otherwise promulgated standards would represent potential TBCs for such a discharge.

C.4.2.3 State Water Board and Regional Water Board Policies and Plans

There are several State Water Board water quality control policies and three State Water Board water quality control plans to which Regional Water Board actions must conform. These are not promulgated regulations. Several of these may represent TBCs for potential remedial actions for the Western Groundwater OU.

C.4.2.3.1 State Water Board Resolution No. 68-16, Statement of Policy with Respect to Maintaining High Quality of Water in California

This policy was adopted by the State Water Board to maintain high quality waters of the State. This resolution is also referred to as the "Anti-degradation Policy". It is not a promulgated regulation. This policy generally restricts the discharge of contaminants that reduces the water quality of surface or ground waters, even though such a reduction in water quality might still result in protection of beneficial uses Specifically this policy requires existing high quality waters to be maintained unless it is demonstrated that a change is consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses and will not result in water quality less than that prescribed in the policies. If discharge is allowed, the discharge must meet best practical treatment or control necessary to prevent pollution or a nuisance and maintain the highest water quality with maximum benefit to the people of the State.

EPA has developed specific guidance related to evaluation of state anti-degradation requirements as potential ARARs (EPA, 1989a, 1989b, 1990 and 1991). EPA considers anti-degradation requirements for groundwater to generally be prospective in nature, designed to prevent further degradation of water quality. EPA thus concludes that these requirements may potentially be ARARs for CERCLA remedial actions that involve injection of partially treated water into a pristine aquifer. EPA has determined that anti-degradation requirements would not require cleanup to the aquifer's original quality prior to contamination.

Resolution 68-16 addresses the disposal of wastes into waters of the State and therefore is a potential TBC with regard to a remedial action involving reinjection of treated groundwater or discharge of treated water to surface water. This policy does not contain any numeric standards, but does provide procedures for establishment of numeric values. Thus, to the extent this policy leads to the establishment of numeric values, it is a potential TBC with respect to addressing the existing groundwater contamination.

C.4.2.3.2 Regional Water Board Policy for Application of Water Quality Objectives

This policy was adopted by the Central Valley Regional Water Board to define the least stringent standards that the Regional Water Board will apply to regional waters in order to protect beneficial uses. This policy was also adopted to explain how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high quality waters. It is not a promulgated regulation.

Water quality objectives are defined as "the limits or levels of water quality constituents or characteristics which are established for reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." Water quality objectives may be stated in either numeric or narrative form. This policy states that "Where numerical water quality objectives are listed, these are the limits necessary for the reasonable protection of beneficial uses of the water." The Regional Water Board has not adopted numeric water quality objectives for many constituents or parameters and instead has adopted narrative water quality objectives.

To evaluate compliance with narrative water quality objectives, the Regional Water Board considers, on a case-by-case basis, direct evidence of beneficial use impacts, material and relevant information submitted by the discharger and other interested parties, and relevant information and numeric criteria and guidelines developed and/or published by other agencies and organizations. The Regional Water Board will, on a case-by-case basis, adopt numeric limitations which will implement the narrative objectives. To assist dischargers and other interested parties, the Regional Board staff have compiled many of the numeric water quality criteria from other appropriate agencies and organizations in the Central Valley Regional Water Board staff report, *A Compilation of Water Quality Goals* (see Section C.4.2.5 below).

As previously discussed, water quality objectives presented in the Basin Plan that are not MCLs or are not otherwise promulgated standards are potential TBCs with respect to the Western Groundwater OU. Narrative standards that do not contain numeric limits, but do provide procedures for establishment of numeric values, represent potential TBCs

C.4.2.3.3 State Water Board Resolution No. 92-49, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304

This resolution establishes policies and procedures that the State and Regional Water Boards follow in conducting oversight of investigations and cleanup and abatement activities resulting from discharge of hazardous substances. The principles described in this resolution reflect the requirements set forth in CCR Title 23 Division 3 Chapter 22 Section 2907.

With respect to cleanup levels, this resolution requires cleanup and abatement of the effects of discharges in a manner that promotes attainment of either background water quality, or the best water quality which is reasonable if background levels of water quality cannot be restored. Use of cleanup levels less stringent than background requires consideration of all demands being made and to be made on the waters and the beneficial, detrimental, economic, social, tangible and intangible values involved. This resolution also requires application of Section 2550.4 of Chapter 15 of the California Code of Regulations in setting alternative cleanup levels.

This resolution also requires that any

"...alternative cleanup level shall:

1. Be consistent with maximum benefit to the people of the State;

2. Not unreasonably affect present and anticipated beneficial use of such water; and

3. Not result in water quality less than that prescribed in the Water Quality Control Plans and Policies adopted by the State and Regional Boards; and

H. Consider the designation of containment zones notwithstanding any other provision of this or other policies or regulations which require cleanup to water quality objectives."

Policies and procedures related to designation of containment zones are discussed in Section C.6.4.2 as part of the evaluation of potential action-specific ARARs.

As this resolution does not contain numeric standards but rather presents policies and procedures for investigation and remediation of contaminated sites, it does not represent a

chemical-specific ARAR. As this resolution does present procedures for identification of cleanup levels, it is considered to be a TBC for the Western Groundwater OU.

Under this policy, the Regional Board could require cleanup of groundwater to background levels or alternatively could require particular evaluations to support CoPC levels greater than background. Narrative goals that require cleanup to zero are generally not considered to be chemical-specific ARARs (see previous discussion in Section C.4.2.3.1). For example, EPA has determined that MCLGs that are set at zero would not be appropriate for setting cleanup levels and therefore would not be ARARs. Consequently, although the procedures for establishment of cleanup levels established under Resolution 92-49 may potentially be relevant to the Western Groundwater OU, these procedures are not appropriate as the procedures for establishing cleanup levels under CERCLA Section 121(d) and 40 CFR 300.430 are the required and more appropriate procedures for establishment of cleanup standards at National Priority List (NPL) sites. The policies and procedures set forth in Resolution 92-49 are considered to be TBCs for the Western Groundwater OU.

Evaluation of the potential applicability or relevance and appropriateness of those portions of this resolution related to containment zones are discussed as part of the evaluation of potential action-specific requirements.

C.4.2.3.4 Regional Water Board Policy for Investigation and Cleanup of Contaminated Sites

This policy describes the Regional Water Board's strategy for managing contaminated sites and in particular describes the basis for establishing ground water (and soil) cleanup levels. It is not a promulgated regulation. Specifically this policy states that

> "Ground water cleanup levels shall be established based on
>
> *i.* background concentrations of individual pollutants;
>
> *ii.* applicable water quality objectives to protect designated beneficial uses of the water body as listed in Chapters II and III;
>
> *iii.* concentrations which do not pose a significant risk to human health or the environment, considering risks from toxic constituents to be additive across all media of exposure and, in the absence of scientifically valid data to the contrary, additive for all constituents having similar toxicological effects or having carcinogenic effects; and
>
> *iv.* technologic and economic feasibility of attaining background concentrations and of attaining concentrations lower than defined in (*ii*) and (*iii*) above.

Factors in (*i*) through (*iii*) above are used to establish ground water cleanup levels according to the following principles:

v. Pursuant to 23 CCR Section 2550.4, the Regional Water Board establishes cleanup levels that are protective of human health, the environment and beneficial uses of waters of the state, as measured by compliance with (*ii*) and (*iii*) above, and are equal to background concentrations if background levels are technologically and economically feasible to achieve. If background levels are infeasible to achieve, cleanup levels are set between background concentrations and concentrations that meet all criteria in (*ii*) and (*iii*) above. Within this concentration range, cleanup levels must be set at the lowest concentrations that are technologically and economically achievable. In no case are cleanup levels established below natural background concentrations.

vi. Technologic feasibility is determined by assessing the availability of technologies which have been shown to be effective in reducing the concentrations of the constituents of concern to the established cleanup levels. Bench-scale and/or pilot-scale studies may be necessary to make this feasibility assessment in the context of constituent, hydrogeologic, and other site-specific factors. Economic feasibility does not refer to the subjective measurement of the ability of the discharger to pay the cost of cleanup, but rather to the objective balancing of the incremental benefit of attaining more stringent levels of constituents of concern as compared with the incremental cost of achieving those levels. Factors to be considered in the establishment of cleanup levels greater than background are listed in 23 CCR, Section 2550.4(d). The discharger's ability to pay is one factor to be considered in determining whether the cleanup level is *reasonable*. However, availability of economic resources to the discharger is primarily considered in establishing reasonable schedules for compliance with cleanup levels.

vii. Compliance with (*iii*) above shall be determined through risk assessments performed by the discharger, using most current procedures authorized by the Department of Toxic Substances Control, the Office of Environmental Health Hazard Assessment, or the USEPA."

This policy sets forth procedures to be used for establishing groundwater cleanup levels at a contaminated site. This policy is a TBC for the Western Groundwater OU.

C.4.2.4 Title 23 Chapter 15 Section 2550.4 – Concentration Limits

Section 2550.4 of Chapter 15 of Title 23 of the California Code of Regulations specifies that one of the following concentration limits shall be proposed by the discharger for each hazardous constituent for each medium:

1. A concentration limit not to exceed the background value of that constituent;

2. A concentration limit equal to background; or

3. A concentration limit greater than background established pursuant to this section for a corrective action program.

Concentrations limits greater than background shall be established only if it is technologically or economically infeasible to achieve the background value for a particular constituent and the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the concentration limit greater than background is not exceeded. This regulation also specifies the factors to be considered by the Regional Board in establishing a concentration limit greater than background. Concentration limits greater than background shall not exceed the lowest concentration that is technologically and economically feasible. This regulation is not intended to allow a concentration limit to exceed the maximum concentration allowed under other applicable statutes or regulations such as the federal MCLs established under the Safe Drinking Water Act.

Although these regulations were established to address hazardous waste management, pursuant to State Board Resolution 92-49 and Section 2550.0 of these regulations, these requirements are applicable to cleanup and abatement activities. Specifically, 23 CCR 2550.0 states *"Furthermore, §2550.4 of this article also applies to all determinations of alternative cleanup levels for unpermitted discharges to land of hazardous waste pursuant to ¶III.G. of SWRCB Resolution 92-49 (Section 2907, Title 23 of this code) [§20400 of Title 27 of this code serves a similar function for unpermitted discharges to land of solid waste]."*

Therefore, Section 2550.4 may potentially be applicable to the Western Groundwater OU. As these regulations do not contain specific numeric criteria, they are not chemical specific ARARs but may potentially be applicable or relevant and appropriate action specific requirements.

C.4.2.5 Compilation of Water Quality Goals

As previously indicated, the Regional Board staff have developed a compilation of numeric water quality criteria from other appropriate agencies and organizations in the Central Valley Regional Water Board staff report, *A Compilation of Water Quality Goals*. The intent of this compilation is to provide numeric water quality limits from literature sources that may be used to ascertain compliance with water quality standards. This compilation includes promulgated standards such as MCLs as well as non-promulgated advisories such as Suggested No-Adverse-Response Levels (SNARLs). *A Compilation of Water Quality Goals* is not a promulgated regulation or standard. Moreover, many of the numeric values cited in *A Compilation of Water Quality Goals* are promulgated

values such as MCLs or are health-based criteria such as values from USEPA Integrated Risk Information System that are potential TBCs, the majority of which are addressed elsewhere in this ARARS evaluation. The only numeric values in *A Compilation of Water Quality Goals* that may be TBCs that are not otherwise addressed in this evaluation are the values for taste and odor thresholds. The taste and odor threshold values are summarized on Table C-2. As these values are not promulgated standards, they are not ARARs; however, they may be TBCs and may need to be considered to address the WQOs for taste and odor in the Basin Plan.

C.4.3 NPDES Program and Permit

New discharges of treated groundwater to the American River, Buffalo Creek, Alder Creek, or the Folsom South Canal must comply with the substantive portions of the National Pollutant Discharge Elimination System (NPDES) permit program. These requirements may include monitoring of discharges and meeting discharge requirements that have previously been issued for the existing Aerojet Site and American River GET treatment facilities by the Regional Water Quality Control Board. The numeric limits established for the American River GET facility under the NPDES program are listed in Table C-3. There are also specific requirements for inorganic constituents and other parameters in the existing discharge requirements.

An NPDES permit may be required for remedial actions that include discharge of treated groundwater to surface water. If treated groundwater from this OU is discharged to surface water as part of Aerojet's current NPDES permit, the requirements of this permit and any modifications or additions to this permit are applicable requirements.

C.4.4 California Safe Drinking Water and Toxic Enforcement Act (Proposition 65) Levels

The California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) prohibits the knowing discharge or release to a source (or potential source) of drinking water of a significant amount of a chemical which the State has identified under Proposition 65 as causing cancer or reproductive harm. Chemicals known to cause cancer or reproductive toxicity are identified in 23 CCR §12000. CoPCs identified for the Western Groundwater OU that are included on the list of chemicals known to the State to cause cancer are identified on Table C-4. None of the Western Groundwater OU CoPCs has been identified by the State as being known to cause reproductive harm.

For chemicals identified as carcinogens, a "significant amount" of that chemical means a level in a source of drinking water above which poses a significant risk of cancer, assuming lifetime exposure at the level in question. Proposition 65 sets a "no significant risk" level for carcinogenic compounds as that level which is calculated to result in not more than one excess case of cancer in an exposed population of 100,000. The "default" values are summarized on Table C-4. For drinking water, Proposition 65 also provides

that the following levels shall be deemed to be "no significant risk" levels: (1) California MCLs, if they exist for the chemical in question; (2) drinking water action levels set by the State Department of Health Services, for chemicals for which there are no California MCLs; or (3) specific numeric levels of concentration which are permitted to be discharged or released into sources of drinking water by a Regional Water Quality Control Board in a Basin Plan or in waste discharge requirements, if such levels are based on considerations of minimizing carcinogenic risk associated with such discharges or releases.

The numeric limits established under Proposition 65 are not applicable, as more appropriate standards such as MCLs exist, but the Proposition 65 limits may be relevant and appropriate if a remedial action involves supplying treated groundwater to the water system for public consumption. The identification of chemicals known to cause cancer or reproductive toxicity and the numeric limits and default values for identifying "significant amounts" are potentially applicable if the selected remedial action includes reinjection of treated water or discharge to surface water.

C.4.5 National Ambient Water Quality Criteria

USEPA has published ambient water quality criteria under section 304(a) of the Clean Water Act (CWA) to protect human health and welfare and freshwater and marine aquatic life from pollutants in surface waters. Ambient water quality criteria for human health have been developed for drinking of water and consumption of aquatic organisms and for consumption of aquatic organisms alone. Typically, ambient water quality criteria are used by the states to develop water quality standards for surface waters pursuant to section 303(c) of the CWA. They may also be used as a basis to develop numeric limits for NPDES permits. Although ambient water quality criteria are not enforceable standards, CERCLA and the NCP identified these criteria as potential ARARs.

Ambient water quality criteria were developed to protect human health and welfare and freshwater and marine aquatic life in surface water, and therefore are not applicable to groundwater. As the numeric limits contained in the water quality criteria address combined exposures from both drinking water and ingestion of aquatic organisms, they are not considered relevant to groundwater. In addition, more appropriate criteria such as MCLs exist for groundwater. Therefore, ambient water quality criteria are neither applicable nor relevant and appropriate to groundwater in the Western Groundwater OU.

Ambient water quality criteria may represent relevant and possibly appropriate requirements for discharge of treated groundwater to surface waters. EPA recently published updates to the ambient water quality criteria As discharge of treated water to surface waters is necessary to trigger consideration of ambient water quality criteria, these requirements are addressed further under potential action-specific requirements.

C.4.6 USEPA Region 9 Preliminary Remediation Goals

Region 9 of U.S. EPA has established preliminary remediation goals (PRGs) as risk-based tools for evaluating and cleaning up contaminated sites. These PRGs incorporate current toxicity values with standard exposure factors to provide estimates of contaminant concentrations in environmental media that are considered to be protective of humans over a lifetime. PRGs are intended for use in screening pollutants in environmental media, triggering further investigation and providing an initial cleanup goal if applicable.

U.S. EPA Region 9 PRGs for the Western Groundwater OU are summarized on Table C-5. The Region 9 PRGs are guidance and not promulgated standards. Consequently, the EPA Region 9 PRGs for groundwater are TBCs for the Western Groundwater OU.

C.4.7 DHS Drinking Water Action Levels

The California Department of Health Services has established health-based advisory levels (ALs) for chemicals for which primary maximum contaminant levels (MCLs) have not been adopted. An AL is a level of a contaminant in drinking water that is considered not to pose a significant health risk to people ingesting water on a daily basis. ALs are calculated using typical exposure assumptions (two-liter per day ingestion rate, a 70 kilogram adult body weight, and a 70-year lifetime) and standard federal and state assessment methodologies for noncarcinogens and carcinogens. Often the basis for an AL is an evaluation previously completed by USEPA or the Cal EPA's Office of Environmental Health Hazard Assessment (OEHHA).

ALs are advisory levels and are not enforceable standards. When an AL is exceeded, suppliers of drinking water are required to notify local governing agencies. DHS also recommends that utilities notify their customers and consumers as soon as feasible about the presence of the contaminant and its potential for adverse health effects. DHS also recommends that drinking water utilities take the source of the chemical out of service if a contaminant is present at more than 10 times the AL for ALs based on noncarcinogenic effects and 100 times the AL for those based on potential carcinogenic risk.

ALs have been established for two of the chemicals of concern for the Western Groundwater OU. An AL of 18 parts per billion (ppb) was established in 1997 for perchlorate based on a provisional oral reference dose established by USEPA for noncarcinogenic effects. EPA has subsequently revised the RfD upward to a level equivalent to 32 ppb. An AL of 0.002 ppb was established in 1998 for N-nitrosodimethylamine (NDMA) which corresponds to a theoretical 10^{-6} cancer risk; however, this level was below the detection limits of most laboratories. Because of the potential for production of NDMA in drinking water treatment processes, DHS subsequently established a temporary AL of 0.02 ppb for NDMA. The ALs and the USEPA RfD are TBCs for the Western Groundwater OU.

C.4.8 California Public Health Goals

At the end of 1997, OEHAA adopted a set of Public Health Goals (PHGs) for chemicals in drinking water. PHGs are levels of drinking water contaminants at which adverse health effects are not expected to occur from a lifetime of exposure. They are based on a 10^{-6} incremental cancer risk estimate for carcinogens and a threshold toxicity limit for other contaminants. The PHGs for the Western Groundwater OU CoPCs are summarized on Table C-6. As PHGs are only non-promulgated goals, they are not ARARs but represent potential TBCs for the Western Groundwater OU.

C.4.9 Integrated Risk Information System

The Integrated Risk Information System (IRIS) is a database prepared and maintained by the U.S. EPA of human health effects that may result from exposure to various substances found in the environment. The database includes oral reference doses and inhalation reference concentrations for chronic non-carcinogenic health effects and hazard identification, oral slope factors and oral and inhalation unit risk for carcinogenic effects. The oral reference doses (RfDs) for non-carcinogenic health effects and oral unit risk values for potential carcinogenic effects associated with the Western Groundwater OU CoPCs are summarized on Table C-7.

As IRIS is a non-promulgated database, it is not an ARAR but may potentially be a TBC. Typically, IRIS information is used in the development of toxicity data and the estimation of potential risks in a Baseline Risk Assessment. IRIS values along with other non-promulgated risk-based values were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.

C.4.10 Drinking Water Health Advisories and Suggested No-Adverse Response Levels

USEPA has published drinking water health advisories for toxicity other than cancer risk that were previously referred to as Suggested No-Adverse Response Levels (SNARLs). EPA has also published one-in-a-million incremental cancer risk estimates for various chemicals that may be present in drinking water. The National Academy of Sciences(NAS) has also published SNARLs and one-in-a-million incremental cancer risk levels for drinking water. None of the health advisories, SNARLs or incremental cancer risk estimates are promulgated standards and thus are not ARARs. These values are considered TBCs. Published drinking water health advisories, SNARLs and incremental cancer risk estimates for the CoPCs in the Western Groundwater OU are summarized on Table C-8.

C.4.11 Summary of Potential Chemical-Specific ARARs and TBCs

Table C-9 presents a summary of potential chemical-specific ARARs. Numerical limits associated with potential ARARs or TBCs for chemical occurrences in groundwater are summarized on Table C-10.

Several regulations contain numeric limits for which consideration as potential ARARs would only be triggered by particular actions. For example, consideration of the surface water WQOs would only be triggered by a remedial action that included discharge of treated water to surface water. Numeric limits associated with potential ARARs or TBCs related to discharge of treated groundwater to surface water are discussed further under potential action-specific ARARs. Similarly, consideration of numeric limits promulgated under the Clean Air Act or State air quality regulations would only be considered if the treatment process to be employed result in emissions of regulated substances. Consequently, numeric limits established for surface water, air emissions, hazardous waste management and other regulations that would only be potential ARARs if the selected remedy includes a particular action(s) or results in a generation or discharge that is covered by these regulations, are discussed further as part of the evaluation of potential action-specific requirements.

C.5 Potential Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations. Location-specific ARARs differ from chemical-specific or action-specific ARARs in that they are not closely related to the chemicals of concern or the specific remedial alternative under consideration. Location-specific ARARs are concerned with the area in which the site or remedial action component is located. To the extent that the remedial action will affect historical resources, streams, flood plains, or wetlands, EPA requires that the potential remedial alternatives comply with the location-specific requirements. Potential location-specific ARARs and TBC criteria for the Aerojet Western Groundwater OU RI/FS are summarized in Table C-11.

C.6 Potential Action-Specific ARARs

Action-specific requirements are usually technology or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved.

For the Western Groundwater OU, one of the primary potential action-specific ARARs includes the Resource Conservation and Recovery Act (RCRA) and the California hazardous waste management regulations. The Basin Plan, including beneficial uses, water quality objectives, and policies and procedures for implementation of the Plan, also contains requirements that may potentially be action-specific requirements. Some of the State and Regional Water Board policies and procedures along with DHS policies may be applicable or relevant and appropriate if treated water is discharged or reused. The National Pollutant Discharge Elimination System (NPDES) and the Underground Injection Control (UIC) regulations may potentially be action-specific ARARs depending upon the method used to discharge treated water. In addition, as previously indicated, several of the chemical-specific requirements previously discussed may also be potential ARARs for reinjection or discharge of treated water.

In addition to the various potential action-specific requirements addressed below, regulations related to air quality and control of air emissions promulgated under the federal Clean Air Act and the Sacramento Metropolitan Air Quality Management District (SMAQMD) may also represent potential chemical-specific (numeric limits) or action-specific ARARs. As currently envisioned, treatment of groundwater will either not include processes that result in air emissions or the emissions from the groundwater treatment processes will be so low so as to be exempt from the new source review requirements. In addition, construction activities associated with installation of extraction wells and conveyance piping, construction of a treatment facility, and installation of recharge wells or construction of a surface water discharge system are not anticipated to disturb an area over 5 acres, but more likely will disturb an area less than 1 acre. Consequently, requirements of the Clean Air Act, the California Air Pollution Control Laws, and the SMAQMD rules and regulations are not expected to be potential action-specific ARARs. Therefore, these requirements have not been evaluated as part of this ARARs analysis. If the nature of the selected remedial action entails air emissions at levels that would be subject to these regulations, then they could potentially be considered action-specific ARARs.

C.6.1 Resource Conservation and Recovery Act (RCRA)

Regulations (40 CFR 260 et seq.) promulgated under Subtitle C of the Resource Conservation and Recovery Act (RCRA) and the California Hazardous Waste Act (CCR Title 22 Division 4.5) contain requirements for management of hazardous wastes. Specifically, these regulations contain requirements related to the identification and classification of hazardous wastes, generator standards for management of hazardous wastes and standards for storage, treatment and disposal of hazardous wastes.

RCRA requirements are generally applicable under two scenarios: (1) sites where hazardous wastes were treated, stored, or disposed of after the effective date of RCRA; and (2) a CERCLA activity involving treatment, storage, or disposal of hazardous wastes. These two scenarios are contingent upon a determination that RCRA hazardous waste is present and on identification of the period of waste management. As previously

indicated, source areas will be addressed as part of future OU RI/FS efforts. Therefore, this FS evaluates potential action-specific requirements under RCRA with regard to wastes that potentially may be generated, stored, treated or disposed in conjunction with remedial actions for the Western Groundwater OU.

At this time, the anticipated treatment processes that may be used for treatment of groundwater from the Western Groundwater OU are not expected to entail generation or accumulation of hazardous waste, or are not expected to result in generation of hazardous wastes in amounts or for periods of accumulation greater than that allowed under the standards for generators. Consequently, the RCRA standards for treatment, storage and disposal (TSD) facilities are not expected to be action-specific ARARs for any of the remedial actions that may be taken for the Western Groundwater OU. If the selected treatment processes do result in generation of sidestreams or other residuals that are a hazardous waste and if operation of the treatment system entails treatment, storage or disposal of such hazardous wastes onsite beyond the limits allowed under generator status, then portions of the RCRA TSD standards may potentially be applicable.

C.6.1.1 Identification and Classification of RCRA Hazardous Wastes and State Hazardous Wastes

Treatment of water or air can generate waste material that must be managed before its disposal or regeneration. If the material generated is a solid waste that meets the definition of a hazardous waste, substantive requirements of the Resource Conservation and Recovery Act and Title 22 of the California Code of Regulations, Division 4.5, Chapter 11 for the management of hazardous wastes may potentially be applicable.

Specifically those portions of these regulations that require testing and characterization of wastes prior to disposal or treatment would potentially be applicable to the management of residuals. These include testing and definitions related to the characteristics of ignitability, corrosivity, reactivity, and toxicity. The numeric limits for identification of toxicity characteristic hazardous waste (40 CFR Part 261 and Title 22 CCR Chapter 11, §66261) resulting from the presence of site-related constituents such as carbon tetrachloride, chloroform, 1,2-dichloroethane, 1,1-dichloroethylene, tetrachloroethylene, and trichloroethylene or other chemicals that may be encountered, used or generated during water treatment process, are potentially applicable. Along with the numeric limits for identification of characteristic hazardous wastes, RCRA regulations related to identification and classification of listed hazardous wastes are also potential action-specific ARARs.

Operation of a groundwater treatment facility could result in production of side-streams, by-products or waste material that could potentially be hazardous wastes. Wastes that may be produced by a facility used to treat contaminated groundwater could potentially include ion exchange regeneration brine solutions, biological treatment sludges, spent granular activated carbon, or other treatment residuals or sidestreams. To the extent that any of these materials are a hazardous waste, they would have to be handled and treated

or disposed in accordance with the RCRA standards for management of hazardous wastes. The requirements in these sections of the RCRA regulations (40 CFR Parts 261 and Title 22 CCR Chapter 11, §66261.10 et seq.) are applicable in determining whether wastes materials produced through treatment of contaminated water are potentially RCRA hazardous waste.

California has adopted in entirety the federal RCRA regulations related to the identification and classification of hazardous wastes. In addition, California has developed additional regulations (Title 22 CCR Chapter 11, §66261.24) related to identification of State-only (non-RCRA) hazardous wastes. All of these requirements are potentially applicable to wastes generated during treatment of contaminated groundwater.

Requirements and numeric standards related to identification of characteristic or listed RCRA hazardous or State-only (non-RCRA) hazardous wastes are potential action-specific requirements for management of byproduct materials and wastes generated by treatment of contaminated groundwater. The numeric limits for identification of characteristic hazardous wastes and State hazardous wastes are summarized on Table C-12.

C.6.1.2 RCRA Generator Standards

RCRA regulations (40 CFR Parts 262 and Title 22 CCR Chapter 12, §66262) related to management of hazardous wastes by generators of hazardous wastes (generator standards) are also potentially applicable to management of hazardous wastes, if any, generated at a groundwater treatment facility. The substantive portions of these standards (40 CFR § 262.11 and § 262.30-34) establish minimum requirements for testing to determine whether a waste is hazardous, storage and inspection requirements, and maximum periods of accumulation of hazardous wastes for generators. Specifically, the RCRA (40 CFR §262.11) and State hazardous waste management (Title 22 CCR Chapter 12, §66262.11) regulations requiring generators to determine if a waste is hazardous, are potentially applicable. Similarly, regulations related to identification of characteristic or listed RCRA hazardous wastes (40 CFR §261.24 and Title 22 CCR Chapter 12 §66261.24) are potentially applicable to waste materials that may be generated from treatment of contaminated groundwater.

These regulations also establish minimum standards for management and storage of hazardous wastes by generators and maximum amounts and periods of accumulation for different types of generators. Specifically, these regulations establish the minimum requirements for packaging, labeling, marking and placarding of hazardous waste containers prior to shipment offsite for treatment or disposal. These regulations also establish the requirements and maximum duration over which hazardous wastes may be accumulated onsite prior to shipment without requiring permitting as a hazardous waste storage facility.

C.6.2 NPDES Regulations

The National Pollutant Discharge Elimination System (NPDES) regulations (40 CFR Parts 122 and 125) established under the Federal Water Pollution Control Act (FWPCA) and the equivalent waste discharge permit regulations established under the RWQCB Basin Plan are potential action-specific requirements. Specifically, substantive portions of the NPDES and Waste Discharge Permit requirements related to discharge of treated water would potentially be applicable if the selected remedy includes discharge of treated groundwater to surface water. The substantive portions of the NPDES stormwater regulations may also be potential action-specific requirements for the design and operation of any groundwater treatment facility.

C.6.2.1 NPDES Discharge Permits

New discharges of treated groundwater to the American River, Buffalo Creek, Alder Creek or the Folsom South Canal must comply with the National Pollutant Discharge Elimination System (NPDES) permit program. To the extent that discharge of treated water occurs onsite, as the term site is defined under CERCLA, only the substantive portions of the NPDES regulations need to be met by the selected remedial action. To the extent that discharge of treated water occurs offsite, both the substantive and administrative requirements (e.g., permitting) may apply.

NPDES requirements include monitoring of discharges and numeric limits on the quality of the discharge. Requirements for discharge of treated groundwater from the existing Aerojet American River GET treatment facility have previously been issued by the Regional Water Quality Control Board. The numeric limits established for the American River GET facility under the NPDES program are listed in Table C-3. The monitoring requirements established under the existing NPPDES permit are described on Table C-13.

An NPDES or waste discharge permit may be required for remedial actions that include discharge of treated groundwater to surface water. If treated groundwater from this OU is discharged to surface water as part of Aerojet's current NPDES permit, the requirements of this permit and any modifications or additions to this permit are applicable requirements. Alternatively, a new permit, with similar or different requirements may be issued for surface water discharge of treated groundwater if this option is included in the selected remedial action. If discharge of treated water occurs entirely onsite, only the substantive portions of these regulations may need to be met. Specifically, discharge limitations will be developed using the procedures set forth in these regulations; however, permits are not required for onsite actions.

C.6.2.2 NPDES Stormwater Regulations

The NPDES permit and stormwater regulations (40 CFR Part 122.26) promulgated under the Federal Water Pollution Control Act, as amended by the Clean Water Act are

potential action-specific ARARs. These regulations establish requirements for stormwater discharges from industrial activities.

NPDES stormwater regulations may be applicable to construction projects involving disturbance of areas of one acre or more and therefore may be potential action-specific ARARs for construction of any groundwater treatment facility. The primary substantive requirement of these regulations is the use of best management practices to control surface water runoff.

C.6.3 RWQCB Basin Plan and Related Policies and Procedures

As previously discussed, the Basin Plan establishes beneficial uses for surface water and groundwater along with water quality objectives (WQOs) to protect the beneficial uses. The State and Regional Water Quality Control Boards have adopted various policies and procedures to protect the beneficial uses. These are not promulgated regulations. WQOs and related policies and procedures established under the Basin Plan were previously discussed as potential TBCs (Section C.4.2).

C.6.3.1 State Water Board Resolution No. 68-16, Statement of Policy with Respect to Maintaining High Quality of Water in California

This policy is discussed in Section C.4.2.3.1.This policy addresses disposal of wastes into waters of the State and therefore is a TBC with regard to a remedial action involving reinjection of treated groundwater or discharge of treated groundwater to surface water.

C.6.3.2 State Water Board Resolution No. 92-49, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304

This resolution is discussed in Section C.4.2.3.3. It contains policies and procedures to address sites where waste discharges have caused or threaten to cause pollution of the waters of the state. These policies require cleanup of groundwater and soils that threaten to pollute groundwater to the extent that beneficial uses of the water are restored and protected. To comply with this resolution, pollutant concentrations must be reduced to levels that at a minimum comply with water quality objectives.

This resolution was amended in 1996 to include provision for designation of a containment zone (CZ) where compliance with water quality objectives for groundwater cannot reasonably be achieved within a reasonable period of time Requirements associated with establishing the rationale for support of a CZ, delineation of the CZ, development of a management plan for the CZ, and implementation of the CZ, are set forth in Section III.H of this resolution.

This resolution does not contain standards of performance or design criteria but rather defines the criteria that the RWQCB may consider in selecting a containment zone action. Thus, these policies and procedures are not action-specific ARARs. However, as several of the alternatives for the Western Groundwater OU may entail use of hydraulic containment to prevent further CoPC migration, the provisions of this resolution are potential TBCs.

C.6.3.3 State Water Resources Control Board Resolutions 68-16 and 92-49

In addition to the previous discussions related to the potential applicability of these resolutions to groundwater actions, these resolutions also have been evaluated with respect to the discharge of treated water to surface water. These resolutions do not set a zero-discharge standard, but rather express the State's policy that existing water quality must be maintained where it is reasonable to do so. The policy expressed in Resolutions 68-16 and 92-49, as well as the Central Valley Regional Water Quality Control Board's Water Quality Control Plan (Basin Plan) (see previous Section C.4.5) further allow the use of mixing zones when determining whether water quality is being maintained in the receiving water. These requirements are potential TBCs for discharge of treated water to surface waters.

C.6.3.4 Wastewater Reuse Policy

The Regional Board has established a policy to encourage the reclamation and reuse of wastewater, including treated groundwater from cleanup actions, where practicable. This is not a promulgated regulation. This policy requires an evaluation of reuse and land disposal options as alternative disposal methods to surface water discharge. Specific types of reuse that should be considered, depending upon the quality of the treated water and the required quality for the specific reuses, include industrial and municipal supply, crop irrigation, landscape irrigation, groundwater recharge and wetland restoration. Both year round and partial year reuse options should be examined. The requirement for evaluation of potential reuse options is a potential TBC and is addressed as part of the development of the various remedial action alternatives for the Western Groundwater OU.

C.6.4 DHS Policy Guidance for Direct Domestic Use of Extremely Impaired Sources

The California Department of Health Services (DHS) has developed a policy that potentially restricts direct domestic use of contaminated water. This is a developing policy that is not uniformly applied and is site-specific. It is not a promulgated regulation.

DHS Policy Memo 97-005 "Policy Guidance for Direct Domestic Use of Extremely Impaired Sources" states the following:

"Extremely impaired sources that contain or are likely to contain high concentrations of contaminants, multiple contaminants, or unknown contaminants (such as groundwater subject to contamination from a hazardous waste disposal site) should not be considered for direct human consumption where alternatives are available."

DHS has developed criteria for identifying an extremely impaired source. Per the DHS policy, an extremely impaired groundwater source meets one or more of the following criteria:

- exceeds 10 times an MCL or action level (AL) based on chronic health effects;
- exceeds 3 times an MCL or action level (AL) based on acute health effects;
- is extremely threatened with contamination due to proximity to known contaminating activities;
- contains a mixture of contaminants of health concern; or
- is designed to intercept known contaminants of health concern.

Although portions of the groundwater plumes in the Western Groundwater OU Study Area may meet these criteria, groundwater in portions of the area contains CoPCs at concentrations below these levels. Groundwater with concentrations less than those specified in this policy are being considered for potential use for domestic supply in the form of the wellhead treatment options. This policy is considered a TBC for the evaluation of those alternatives that include use of treated groundwater for domestic or municipal supply.

C.6.5 Summary of Potential Action-Specific ARARs

The federal and State potential action-specific ARARs for the alternatives discussed in the Western Groundwater OU RI/FS are summarized in Table C-14.

Table C-1: Primary Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) for Contaminants of Potential Concern

Contaminant of Potential Concern	Federal Primary MCL (mg/L)	Federal MCLG (mg/L)	California Primary MCL (mg/L)
1,1,2-Trichloroethane	0.005	0.003	0.005
1,1-Dichloroethane			0.005
1,1-Dichloroethene	0.007	0.007	0.006
1,2-Dichloroethane	0.005	0	0.0005
cis-1,2-Dichloroethene	0.007	0.007	0.006
trans-1,2-Dichloroethene	0.1	0.1	0.01
Carbon tetrachloride	0.005	0	0.0005
Chloroform	0.080 [a]		
Freon-113			1.2
Tetrachloroethene	0.005	0	0.005
Trichloroethene	0.005	0	0.005
Vinyl chloride	0.002	0	0.0005
Perchlorate			
NDMA			
Nitrate (as N)	10		45 [b]
Nitrite (as N)	1		1
Total Nitrate and Nitrite (as N)	10		10

[a] For total trihalomethanes (TTHM).
[b] As NO_3.
Lack of an entry denotes that MCLs or MCLGs are not available for the constituent.

Table C-2: Taste and Odor Threshold Values

Contaminant of Potential Concern	Taste & Odor Thresholds
1,1,2-Trichloroethane	NA
1,1-Dichloroethane	NA
1,1-Dichloroethene	1,500
1,2-Dichloroethane	7,000
1,2-Dichloroethene (cis)	NA
1,2-Dichloroethene (trans)	260
Carbon tetrachloride	520
Chloroform	2,400
Freon-113	NA
Tetrachloroethene	170
Trichloroethene	310
Vinyl chloride	3,400
Perchlorate	NA
NDMA	NA
Nitrate	NA
Nitrite	NA
Total Nitrate and Nitrite	NA

Notes:
All values are in units of ug/L.
NA = not available.

Table C-3: Effluent Limitations for American River Study Area Interim Groundwater Extraction and Treatment System

Constituent	Units	Daily Maximum	Monthly Average
Copper (total)	ug/L	17	11
Lead (total)	ug/L	15	2.5
Zinc (total)	ug/L	110	100
Volatile organics [a]	ug/L	0.5 [b]	
Perchlorate	ug/L	18	18
1,4-dioxane	ug/L	15	10

[a] Includes all volatile organics constituents listed in EPA Methods 8010 and 8020.
[b] The concentration of each constituent shall not exceed 0.5 ug/L.

Table C-4: California Proposition 65 "No Significant Risk" Levels

Contaminant of Potential Concern	California Proposition 65 Levels (ug/day)	California Proposition 65 Levels [a] (ug/L)
1,1,2-Trichloroethane	10	5
1,1-Dichloroethane	100	50
1,1-Dichloroethene	NA	NA
1,2-Dichloroethane	10	5
1,2-Dichloroethene (cis)	NA	NA
1,2-Dichloroethene (trans)	NA	NA
Carbon tetrachloride	5	2.5
Chloroform	20	10
Freon-113	NA	NA
Tetrachloroethene	14	7
Trichloroethene	50	25
Vinyl chloride	3	1.5
Perchlorate	NA	NA
NDMA	0.04	0.02
Nitrate	NA	NA
Nitrite	NA	NA
Total Nitrate and Nitrite	NA	NA

Notes:

[a] Converted to concentration based on 2 liters per day consumption.
NA = not available.
None of the Western Groundwater CoPCs have been identified as known to cause reproductive toxicity.

Table C-5: EPA Region 9 Preliminary Remediation Goals

Contaminant of Potential Concern	USEPA Region 9 PRGs [a]
1,1,2-Trichloroethane	0.2
1,1-Dichloroethane	810
1,1-Dichloroethene	0.046
1,2-Dichloroethane	0.12
1,2-Dichloroethene (cis)	61
1,2-Dichloroethene (trans)	120
Carbon tetrachloride	0.17
Chloroform	0.16
Freon-113	59,000
Tetrachloroethene	1.1
Trichloroethene	1.6
Vinyl chloride	0.02
Perchlorate	18
NDMA	0.0013
Nitrate	NA
Nitrite	NA
Total Nitrate and Nitrite	NA

Notes:

All values are in units of ug/L
[a] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
NA = not available.

Table C-6: California Public Health Goals

Contaminant of Potential Concern	California PHGs
1,1,2-Trichloroethane	NA
1,1-Dichloroethane	NA
1,1-Dichloroethene	10
1,2-Dichloroethane	4
1,2-Dichloroethene (cis)	NA
1,2-Dichloroethene (trans)	NA
Carbon tetrachloride	NA
Chloroform	NA
Freon-113	4,000
Tetrachloroethene	NA
Trichloroethene	0.8
Vinyl chloride	NA
Perchlorate	NA
NDMA	NA
Nitrate	NA
Nitrite	NA
Total Nitrate and Nitrite	NA

Notes:
All values are in units of ug/L
NA = not available.

Table C-7: USEPA Integrated Risk Information System (IRIS) RfDs and Incremental Cancer Risk Values

Contaminant of Potential Concern	IRIS RfDs as drinking water levels	IRIS $1x10^{-6}$ incremental cancer risk as drinking water levels
1,1,2-Trichloroethane	2.8	0.6
1,1-Dichloroethane		
1,1-Dichloroethene	6	0.06
1,2-Dichloroethane		0.4
1,2-Dichloroethene (cis)		
1,2-Dichloroethene (trans)	140	
Carbon tetrachloride		0.3
Chloroform		6
Freon-113	210,000	
Tetrachloroethene	70	
Trichloroethene		
Vinyl chloride		
Perchlorate		
NDMA		0.0007
Nitrate [a]	11,000	
Nitrite [a]	700	
Total Nitrate and Nitrite [a]		

Notes:
All values are in units of ug/L.
All values are based on consumption of 2 liters of water per day.
[a] Expressed as N.
NA = not available.

Table C-8: USEPA and NAS Drinking Water Health Advisories and Suggested No-Adverse Response Levels

Contaminant of Potential Concern	EPA DWHAs or SNARLs – non-carcinogenic	EPA DWHAs or SNARLs – carcinogenic	NAS SNARLs – non-carcinogenic	NAS SNARLs - carcinogenic
1,1,2-Trichloroethane	3			
1,1-Dichloroethane				
1,1-Dichloroethene	7		100	
1,2-Dichloroethane	700 / 2,600	0.4		0.71
1,2-Dichloroethene (cis)	70			
1,2-Dichloroethene (trans)	100			
Carbon tetrachloride	70 / 300	0.3	200	4.5
Chloroform	100 / 400	6		0.26 / 56
Freon-113				
Tetrachloroethene	2,000	0.7		3.6
Trichloroethene		3		1.5
Vinyl chloride	10 / 50	0.015		1.1
Perchlorate				
NDMA				
Nitrate [a]	10,000			
Nitrite [a]	1,000			
Total Nitrate and Nitrite [a]				

Notes:
All values are in units of ug/L
[a] Expressed as N.
NA = not available.

Table C-9: Summary of Potential Chemical-Specific Requirements

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Safe Drinking Water Act (40 CFR 141)	Establishes national drinking water standards in the form of Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)	Applicable – at the point groundwater is delivered to a drinking water distribution system.	Applicable to water systems serving over 25 persons. Relevant and appropriate for smaller systems. Establishes MCLs that apply to many of the site-related chemicals (see also Table C-1).
CCR Title 22 Chapter 15, Section 64400 et seq.	Establishes California primary and secondary MCLs	Relevant and Appropriate – for in situ groundwater that is or has a potential to be used for drinking water .	All MCLs (organic, inorganic, etc.) are potentially applicable if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR)	Defines beneficial uses for surface water and groundwater in the basin. Establishes water quality objectives, including narrative and numeric standards, to protect the beneficial uses and water quality objectives (WQOs) of surface and ground waters in the region. Describes implementation plans and other control measures designed to ensure compliance with statewide plans and policies.	Groundwater uses and WQOs are potential TBCs for development of ground-water cleanup levels and remedial actions. These are also potential TBCs if the selected remedial action includes reinjection of treated water. Surface water uses and WQOs are potential TBCs if the selected remedial action includes discharge of treated water to surface water Basin Plan policies and procedures for establishment of cleanup levels are not TBCs as CERCLA sets methods for identification of cleanup levels at NPL sites	Specific portions of the Basin Plan that are TBCs include: • Beneficial uses of waters in the basin including: <u>Ground water</u> – municipal and domestic supply (MUN), – agricultural supply (AGR), – industrial service supply (IND) and – industrial process supply (PRO) <u>Surface water</u> – MUN, AGR, IND, – Recreation (REC) – Freshwater habitat (WARM) and (COLD), Wildlife habitat (WILD), Migration of aquatic organisms (MIGR), and Spawning (SPWN) • Water quality objectives to protect these uses including: <u>Ground water</u> – Numerical standards for bacteria, chemical constituents (MCLs), and radioactivity – Narrative standards for tastes and odors and toxicity <u>Surface water</u> – Numerical limits for bacteria, chemical constituents, dissolved oxygen, pH, radioactivity, salinity, temperature and turbidity – Narrative standards for biostimulatory substances, color, floating material, oil and grease, sediment, settleable material, suspended material, tastes and odor, and toxicity

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Water Quality Control Plan (Basin Plan) for the RWQCB, Central Valley Region (CVR) cont.			• Basin Plan also requires that any activity, including, but not limited to, the discharge of contaminated soils or waters or in-situ treatment or containment of contaminated soils or waters, must not result in actual water quality exceeding water quality objectives.
State Water Resources Control Board Resolution No. 88-63 "Sources of Drinking Water Policy" (contained in the RWQCB's Water Quality Control Plan)	Specifies that, with certain exceptions, all ground and surface waters must have the beneficial use of municipal or domestic water supply.	Potential TBC with respect to beneficial uses Potential TBC with respect to basis for exceptions from the general designations of beneficial uses	This policy is used by the Regional Water Board in determining beneficial uses for waters. The beneficial uses established in the Basin Plan are based on this policy. The beneficial uses in the Basin Plan represent a site-specific determination and therefore are more appropriate than this general policy. This policy also establishes the basis for exceptions to the general designation of beneficial uses.
State Water Resources Control Board Resolution No. 68-16 "Statement of Policy With Respect to Maintenance of High Quality of Waters in California " ("Anti-degradation Policy").	Requires that quality of high quality surface and ground waters be maintained to the maximum extent possible. Degradation of waters will be allowed only if : – It is consistent with the maximum benefit to the people of the state, – It does not unreasonably affect present and anticipated beneficial uses, and – It does not result in water quality less than that prescribed in RWQCB and SWRCB policies. If degradation is allowed, the discharge must meet best practicable treatment or control, which must prevent pollution or nuisance and result in the highest water quality consistent with maximum benefit to the people of the state.	–Potential TBC if the selected remedial action includes disposal of wastes into waters of the State	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
RWQCB, CVR Basin Plan "Antidegradation Implementation Policy"	Defines the RWQCB policy with respect to implementation of the SWB Antidegradation Policy contained in SWB Resolution 68-16	–Potential TBC for disposal of wastes into waters of the State	Applicable to discharge of treated water to surface water or groundwater (reinjection) as this policy requires waste discharges to meet best practical treatment or control standards, and result in the highest water quality possible that is consistent with the maximum benefit to the people of the state.
RWQCB, CVR Basin Plan, "Policy for Application of Water Quality Objectives"	This policy requires achievement of water quality objectives at all points within a surface water or groundwater resource for which beneficial uses have been designated rather than just at the points of use. This policy also explains how the Regional Water Board applies numeric and narrative water quality objectives to ensure the reasonable protection of beneficial uses of water. This policy also explains how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high-quality waters.	WQOs are potential TBCs for development of ground-water cleanup levels and remedial actions. Also potential TBCs if the selected remedial action includes reinjection of treated water. Surface water WQOs are potential TBCs if the selected remedial action includes discharge of treated water to surface water	This policy requires maintenance of background water quality to comply with the antidegradation policy. This policy requires WQOs to be the least stringent limits to be imposed on water quality and indicates that background represents the most stringent limits to be imposed on ambient water quality. The Basin Plan includes both numeric and narrative water quality objectives. This policy explains how the RWQCB evaluates compliance with the narrative WQOs through use of other standards, criteria, advisories, etc. as presented in *"A Compilation of Water Quality Goals"*. To the extent that the methodology presented in this policy uses promulgated standards, criteria or limitations, the narrative standards represent potential ARARs. To the extent that the methodology in this policy uses non-promulgated criteria, advisories, or risk-based levels, this policy represents a TBC. This policy also presents a methodology for assessing compliance with the narrative WQO for toxicity. Similar to the other narrative standard, to the extent the toxicity methodology relies on promulgated standards it may be an ARAR and to the extent that it relies on non-promulgated values it is a TBC. Note: The toxicity assessment required by this policy will be addressed in more detail and precision in the Baseline Risk Assessment.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
State Water Resources Control Board Resolution No. 92-49 (As amended April 21, 1994 and October 2, 1996) "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304" Also Title 23 CCR Chapter 22, Section 2907	Establishes requirements for investigation and cleanup and abatement of discharges. Among other requirements, dischargers must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality, or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of Title 23, CCR, Section 2550.4 requirements to groundwater cleanups.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	These policies and procedures require cleanup of a discharge and abatement of effects of past, current or possible discharges of waste that creates or threatens to create a condition of pollution or nuisance. These policies and procedures establish procedures for investigation, evaluation of cleanup and abatement alternatives, implementation of cleanup and abatement actions including conformance with Resolution No. 68-16. These policies and procedures require cleanup and abatement that promotes attainment of either background water quality, or the best water quality which is reasonable (but not greater than that prescribed in the Water Quality Control Plans and Policies adopted by the State and Regional Water Boards) if background levels cannot be restored. Note: These policies and procedures also address designation and implementation of containment zones, which are discussed in table C-### under potential action-specific requirements.
RWQCB, CVR Basin Plan, "Policy for Investigation and Cleanup of Contaminated Sites."	This policy establishes and describes the RWQCB required procedures for investigation and remediation of contaminated sites. This policy also describes the RWQCB requirements for cleanup levels for groundwater and soil contamination.	TBC – this policy does not contain numeric standards but only presents procedures for identification of cleanup levels. CERCLA establishes procedures for identification of cleanup levels at NPL sites.	This policy requires establishment of cleanup levels for groundwater based on: – Background concentrations – Water quality objectives – Concentrations that do not pose a significant risk to human health or the environment – Technologic and economic feasibility of attaining background. This policy requires achievement of background levels when feasible. Otherwise, this policy requires achievement of water quality objectives and risk-based levels that do not pose a significant risk to human health or the environment. This policy also requires compliance with groundwater cleanup levels throughout the pollutant plume.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
Title 23, CCR, Chapter 15, Section 2550.4.	This regulation presents procedures for identifying concentration limits for cleanup and abatement of discharges from facilities that treat, store or dispose of hazardous waste at Class I waste management units. SWB Resolution 92-49 also requires use of these regulations for development of cleanup levels other than background.	Potentially Applicable for identification of ground water cleanup levels. As this regulation does not contain numeric standards, it is not a chemical-specific ARAR but may be an action-specific ARAR.	This regulation requires cleanup to background concentration levels, or a concentration limit greater than background if – It is technologically and economically infeasible to achieve background, and – The constituent will not pose a substantial present or potential hazard to human health or the environment as long as the concentration limit greater than background is exceeded. This regulation lists the various factors to be considered in setting a concentration limit greater than background. This regulation also requires concentration limits that are greater than background to be set at the lowest levels that are economically and technologically achievable.
"A Compilation of Water Quality Goals"	Provides guidance on selecting numeric values to implement narrative water quality objectives contained in the Basin Plan.	To Be Considered	This document is not a promulgated regulation and therefore in itself is not an ARAR but may be a TBC. This document should be considered in selecting appropriate numeric values to implement the narrative WQOs in the Basin Plan. The numeric values contained in the staff report may be ARARs or TBCs depending on the source of the values.
National Pollutant Elimination Discharge System (NPDES Permit)	These regulations set forth the requirements for discharge to surface water and the Establishment of numeric limits and monitoring requirements for such discharges.	Applicable – if the selected remedial action includes discharge of treated water to surface water.	Discharge of treated groundwater to surface water may require obtaining a new NPDES permit or revision of Aerojet's existing NPDES permit (see also Table C-2). The NPDES permit will specify the numeric standards required to be met in water that is to be discharged to surface water as well as the monitoring requirements for such a discharge.
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) Also Title 22 CCR Chapter 3 Section 12000 et seq.	These regulations identify chemicals known to cause cancer or reproductive toxicity. This act prohibits discharge or release of significant amounts of the identified chemicals.	The numeric limits and notification requirements are potentially relevant and appropriate if the selected remedial action includes use of treated groundwater as drinking water supply..	These regulations make it illegal to expose persons to significant amounts of chemicals known to cause cancer or reproductive toxicity without prior notification, or to discharge significant amounts of these chemicals to sources of drinking water. The numeric limits and notification requirements are applicable to the water suppliers at the point that groundwater is delivered to a water system for public consumption.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) cont.	Significant amounts are generally defined as levels that pose no significant risk of cancer. For drinking water, significant levels are defined as California MCLs, drinking water action levels when MCLs don't exist, or discharge limits allowed by a Basin Plan or waste discharge permit.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge or reinjection of treated water.	The numeric limits and prohibition on discharge of significant amounts of these chemicals are applicable to discharge of treated water to surface water or reinjection of treated groundwater. The numeric limits and notification requirements are applicable to remedial actions, if any, that include use of treated water for municipal or domestic supply.
National Ambient Water Quality Criteria	Establishes water quality criteria, which are non-enforceable guidance developed under CWA §304 and are used by the State, in conjunction with designated use for a stream segment, to establish water quality standards under CWA §303.	Neither applicable nor relevant and appropriate for groundwater. Potentially relevant but likely not appropriate for discharge of treated water to surface water.	These criteria are published by EPA to protect human health and welfare and freshwater and marine aquatic life from pollutants in surface waters and therefore are not applicable to groundwater. Ambient water quality criteria are based on consumption of drinking water and aquatic organisms (primarily fish) and consumption of fish alone and therefore are not relevant to groundwater in the Western Groundwater OU. Although potentially relevant, ambient water quality criteria are not appropriate requirements as the RWQCB has adopted numeric standards for the surface waters in the area which represent site-specific water quality standards which are more appropriate requirements.
US EPA Region 9 Preliminary Remediation Goals (PRGs)	EPA has developed preliminary remediation goals that are risk-based levels that are used to screen sites that may require additional investigation or possible remediation. PRGs are also used to screen lists of site-related chemicals to identify potential chemicals of concern.	To Be Considered	EPA Region 9 PRGs are guidance levels, not promulgated standards, and therefore are not an ARAR; however, the PRGs may be TBCs for identification of potential groundwater cleanup levels.
California Department of Health Services (DHS) Drinking Water Action Levels	DHS has established action levels based mainly on health effects but in some cases based on organoleptic (taste and odor-based) values	To Be Considered	Action levels (ALs) are advisory to water suppliers and therefore would not be ARARs. They are potential TBCs for identifying potential groundwater cleanup levels. Of particular interest in this matter are the ALs for perchlorate and NDMA.

Table C-9: Summary of Potential Chemical-Specific Requirements (cont.)

Potential Standard, Requirement, Criterion, or Limitation	Description	Preliminary ARAR Determination	Comments
California Public Health Goals (PHGs)	The California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA) has adopted PHGs for chemicals in drinking water. PHGs are levels of drinking water contaminants at which adverse health effects are not expected to occur from a lifetime of exposure.	To Be Considered	PHGs are non-enforceable risk-based goals and therefore are not ARARs but are TBCs for identifying potential groundwater cleanup levels.
EPA Integrated Risk Information System (IRIS)	A non-promulgated database of health effects that may result from exposure to various substances found in the environment.	To be considered	IRIS values were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.
EPA Drinking Water Health Advisories and NAS Suggested No Adverse Response Levels (SNARLs)	Non-promulgated values published by USEPA and the National Academy of Sciences for toxicity other than cancer or incremental cancer risk estimates	To be considered	EPA drinking water health advisories and incremental cancer risk estimates and NAS SNARLs and incremental cancer risk estimates were considered in the development of the Baseline Risk Assessment for the Western Groundwater OU.

Table C-10: Summary of Potential Chemical-Specific ARARs and TBCs for Contaminants of Potential Concern in Groundwater

Contaminant of Potential Concern	Federal Primary MCL (mg/L)	Federal MCLG (mg/L)	California Primary MCL (mg/L)	California DHS Action Levels (mg/L)	California Proposition 65 Levels (mg/L)[a]	California PHGs (mg/L)	USEPA Region 9 PRGs (mg/L)[b]
1,1,2-Trichloroethane	0.005	0.003	0.005	NA	0.005	NA	0.0002
1,1-Dichloroethane	NA	NA	0.005	NA	0.05	NA	0.81
1,1-Dichloroethene	0.007	0.007	0.006	NA	NA	0.01	0.000046
1,2-Dichloroethane	0.005	0	0.0005	NA	0.005	0.004	0.00012
1,2-Dichloroethene (cis)	0.07	0.07	0.006	NA	NA	NA	0.061
1,2-Dichloroethene (trans)	0.1	0.1	0.01	NA	NA	NA	0.12
Carbon tetrachloride	0.005	0	0.0005	NA	0.0025	NA	0.00017
Chloroform	0.1 [c]	0	0.1 [c]	NA	0.01	NA	0.00016
Freon-113	NA	NA	1.2	NA	NA	4	59
Tetrachloroethene	0.005	0	0.005	NA	0.007	NA	0.0011
Trichloroethene	0.005	0	0.005	NA	0.025	0.0008	0.0016
Vinyl chloride	0.002	0	0.0005	NA	0.0015	NA	0.00002
Perchlorate	NA	NA	NA	0.0018	NA	NA	0.018
NDMA	NA	NA	NA	0.00002	0.00002	NA	0.0000013
Nitrate [d]	10	NA	45 [c]	NA	NA	NA	NA
Nitrite [d]	1	NA	1	NA	NA	NA	NA
Total Nitrate and Nitrite [d]	10	NA	10	NA	NA	NA	NA

Table C-10: Summary of Potential Chemical-Specific ARARs and TBCs for Contaminants of Potential Concern in Groundwater (cont.)

Contaminant of Potential Concern	IRIS RfD as drinking water levels	IRIS $1x10^{-6}$ incremental cancer risk	EPA DWHAs or SNARLs – non-carcinogenic	EPA DWHAs or SNARLs – carcinogenic	NAS SNARLs – non-carcinogenic	NAS SNARLs - carcinogenic	Taste & Odor thresholds
1,1,2-Trichloroethane	2.8	0.6	3				
1,1-Dichloroethane							
1,1-Dichloroethene	6	0.06	7		100		1,500
1,2-Dichloroethane		0.4	700 / 2,600	0.4		0.71	7,000
1,2-Dichloroethene (cis)			70				
1,2-Dichloroethene (trans)	140		100				260
Carbon tetrachloride		0.3	70 / 300	0.3	200	4.5	520
Chloroform		6	100 / 400	6		0.26 / 56	2,400
Freon-113	210,000						
Tetrachloroethene	70		2,000	0.7		3.6	170
Trichloroethene				3		1.5	310
Vinyl chloride			10 / 50	0.015		1.1	3,400
Perchlorate							
NDMA		0.0007					
Nitrate [d]	11,000		10,000				
Nitrite [d]	700		1,000				
Total Nitrate and Nitrite [d]							

Notes: NA = not available.
All values are in units of ug/L
[a] Converted to concentration based on 2 liters per day consumption.
[b] Lower of the integrated cancer risk (1×10^{-6}) and chronic hazard quotient (HQ = 1) for tap water.
[c] For total trihalomethanes (sum of bromoform, bromodichloromethane, chloroform, and dibromochloromethane).
[d] Expressed as N.
[e] Expressed as NO_3.

Table C-11: Potential Location-Specific Requirements

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Within floodplain	40 CFR Part 6, Appendix A, Fish and Wildlife Coordination Act (16 USC 661 et seq.), and 40 CFR Part 6.302	Require avoidance of adverse effects, minimization of potential harm, and restoration and preservation of natural and beneficial values of floodplains.	Potentially Applicable to any actions that may be conducted within the floodplain.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within 100-year flood plain	40 CFR 264.18(b) and 22 CCR 66264.18(b)	A RCRA facility located in a 100-year flood plain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	Potentially Applicable if groundwater treatment involves treatment or storage of hazardous wastes.	Some of the locations considered for groundwater treatment facilities may be located in the 100-year flood plain. No new permanent building is proposed in the 100-year flood-plain zone.
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	National Archaeological and Historical Preservation Act (16 USC Section 469); 36 CFR Part 65	Alteration of terrain that threatens significant scientific, prehistoric, historic, or archaeological data may require actions to recover and preserve artifacts.	Potentially applicable if significant artifacts are encountered during construction	The proposed remedial alternatives will not alter or destroy any known prehistoric or historic archeological features west of the Aerojet Sacramento facility site. Areas west of the Aerojet Sacramento facility are essentially completely developed. However, because there is always a possibility that buried historic or prehistoric remains could be discovered during construction, this regulation would require action to recover and preserve artifacts.
Historic project owned or controlled by a federal agency	National Historic Preservation Act (NHPA) Section 106 (16 USC Section 470 et seq.); 36 CFR Part 800	Property included in or eligible for the National Register of Historic Places may require action to preserve historic properties.	Neither applicable nor relevant and appropriate	The anticipated remedial actions do not include any activities on properties included on, or eligible for inclusion on the National Register of Historic Places. If it is determined that properties subject to NHPA are present and could be impacted during the implementation of the remedial action, these requirements may be applicable and would require mitigation measures to protect or preserve such properties.

Table C-11: Potential Location-Specific Requirements (continued)

Location	Potential Requirement	Description	Preliminary ARAR Determination	Comments
Critical habitat upon which endangered species or threatened species depend	Substantive portions of the Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR Part 200, 50 CFR Part 402 Substantive portions of the California Endangered Species Act Substantive portions of the Native Plant Protection Act	Requires action to conserve endangered species or threatened species, including consultation with the Department of the Interior, Fish and Wildlife Service.	Potentially applicable if critical habitat for endangered species could be affected during implementation of the selected remedy	Two endangered floral species are known to occur within Sacramento County: the Sacramento Orcutt grass (Orcuttia Viscida) and the Boggs Lake hedge hyssop (Gratiola Heterosepala). Four endangered wildlife species are expected to occur within 25 miles of the Aerojet Sacramento facility: Bald Eagle, Peregrine Falcon, Giant Garter Snake, and the Valley Elderberry Longhorn Beetle. The Aerojet Sacramento facility may be a habitat for the Burrowing Owl, a species of concern in California. Consultations between Department of Toxic Substances Control (DTSC) and Department of Fish and Game may be conducted if such species are affected by remedial actions.
Wetlands	40 CFR Part 6 Appendix A	Actions must be taken to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	Potentially applicable if any remedial action components are constructed in or otherwise affect wetland areas	Requires actions to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.
	Fish and Game Commission Wetlands Policy (adopted 1987) included in Fish and Game Code Addenda	Actions must be taken to ensure that "no net loss" of wetlands acreage or habitat value occurs. Actions must be taken to restore and enhance California's wetland acreage and habitat value.	TBC	This policy is not a regulatory program but may be considered a TBC criteria.
Areas affecting stream or river	Fish and Wildlife Coordination Act (16 USC 661 et seq.) and 40 CFR Part 6 §302	Restrictions on diversion, channeling or other activity that modifies a stream or river and affects fish or wildlife.	Potentially applicable to any remedial action components that may be constructed in or along a creek or river	Requires action to protect fish or wildlife.

Table C-12: Summary of Numerical Limits for Identification of RCRA Characteristic and State (Non-RCRA) Hazardous Waste

Contaminant of Potential Concern	RCRA TCLP Level (ug/L)	State STLC Level (mg/L)	State TTLC Level (mg/kg)
1,1,2-Trichloroethane			
1,1-Dichloroethane			
1,1-Dichloroethene	700		
1,2-Dichloroethane	500		
1,2-Dichloroethene (cis)			
1,2-Dichloroethene (trans)			
Carbon tetrachloride	500		
Chloroform	6,000		
Freon-113			
Tetrachloroethene	700		
Trichloroethene	500	204	2,040
Vinyl chloride	200		
Perchlorate			
NDMA			

Notes:
TCLP = Toxicity Characteristic Leaching Procedure
STLC = Soluble Threshold Limit Concentration
TTLC = Total Threshold Limit Concentration
Lack of an entry denotes that no standard is available for the constituent.

Table C-13: Discharge Limitations for American River Study Area Interim Groundwater Extraction and Treatment System

Groundwater Treatment System (Inlet and Outlet) Monitoring

Constituents	Units	Type of Sample	Sampling Frequency
Electrical Conductivity @25°C[1]	umhos/cm	Grab	Weekly
Flow	MGD	Meter	Continuous
Total Dissolved Solids	mg/1	Grab	Monthly
Acute Toxicity[2,3]	% survival	Grab	Monthly
Volatile Organics[4]	ug/1	Grab	Weekly
Semi-volatile Organics[5]	ug/1	Grab	Monthly
1,4-dioxane[6]	ug/1	Grab	Monthly
Perchlorate[7]	ug/1	Grab	Monthly
Total Copper	mg/1	Grab	Quarterly
Total Lead	mg/1	Grab	Quarterly
Total Zinc	mg/1	Grab	Quarterly
Hardness (as $CaCO_3$)	mg/1	Grab	Quarterly
Temperature	°F/°C	Grab	Weekly
Dissolved Oxygen	mg/1	Grab	Quarterly
pH[1]	pH units	Grab	Weekly
NDMA[8]	ug/1	Grab	Monthly

Receiving Water Monitoring[9,10]

Constituents	Units	Type of Sample	Sampling Frequency
Dissolved Oxygen	mg/1	R-1,R-2	Monthly
pH	pH units	R-1,R-2	Monthly
Turbidity	NTU	R-1,R-2	Monthly
Temperature	°F/°C	R-1,R-2	Monthly
Electrical Conductivity	umhos/cm	R-1,R-2	Monthly
Total Copper	mg/1	R-1,R-2	Quarterly
Total Lead	mg/1	R-1,R-2	Quarterly
Total Zinc	mg/1	R-1,R-2	Quarterly
NDMA[8]	ug/1	R-2	Monthly
Perchlorate[7]	ug/1	R-2	Monthly
Volatile Organics[4]	ug/1	R-1,R-2	Monthly
Hardness (as $CaCO_3$)	mg/1	R-1,R-2	Monthly

Table C-13: Discharge Limitations for American River Study Area Interim Groundwater Extraction and Treatment System (continued)

Three Species Chronic Toxicity Monitoring

Chronic toxicity monitoring shall be conducted to determine whether the effluent is contributing to toxicity in the American River. The testing shall be conducted as specified in EPA 600/4-89-001. Chronic toxicity samples shall be collected at the discharge of the Ground Water Treatment Plant prior to entering Buffalo Creek. Samples collected from the outlet of the treatment unit shall be representative of the volume and quality of the discharge. The time of collection for samples shall be recorded. Chronic toxicity monitoring shall include the following:

Species:	*Pimephales promelas, Ceriodaphnia dubia, Selenastrum capriocornutum*
Frequency:	Once per Quarter for one year
Dilution Series:	100 percent effluent

Monitoring of Discharge to Sailor Bar Park

The Discharger shall sample the discharge to pond in Sailor Bar Park for volatile organic constituents and NDMA as listed above in the table for the groundwater treatment system monitoring. The sample shall be collected and analyzed on a monthly basis from the discharge prior to it entering the pond.

Table C-13: Discharge Limitations for American River Study Area Interim Groundwater Extraction and Treatment System (continued)

Notes:
All Metals analyses shall be by atomic adsorption methods or a method with an equivalent practical quantitation limit. In addition, chronic toxicity monitoring for the treatment system is also required, and detailed below.

1 Field measurements.
2 The analyses shall be performed in accordance with EPA/600/4-90/027, *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*
3 Sampling of effluent only.
4 Test method to be by EPA Methods 601 and 602, or 8010 and 8020, or 500 series with a practical quantitation level no greater than 0.5 ug/l. All concentrations between the detection level and practical quantitation level shall be reported as trace.
5 Test method to be EPA Method 8270 or equivalent. All peaks shall be reported and tentatively identified. All concentrations between the detection limit and the practical quantitation limit shall be reported as trace values.
6 A practical quantitation level of 10 ug/l. All concentrations between the detection level and quantitation level shall be reported as trace.
7 A practical quantitation level of 4 ug/l. All concentrations between the detection level and quantitation level shall be reported as trace.
8 NDMA analysis with a minimum practical quantitation level of 0.033 ug/l. All concentrations between the detection level and quantitation level shall be reported as trace.
9 All receiving water samples shall be grab samples. Receiving water monitoring shall include at least the following:

Station	Description
R-1	At least 100 feet upstream on the American River from the confluence with Buffalo Creek.
R-2	Downstream on the American River at the pedestrian bridge crossing just downstream of the Sunrise Bridge overcrossing.

10 In conducting the receiving water sampling, a log shall be kept of the receiving water conditions in the American River. Attention shall be given to the presence or absence of:

a. Floating or suspended matter
b. Discoloration
c. Bottom Deposits
d. Aquatic life
e. Visible films, sheens or coatings
f. Fungi, slimes, or objectionable growths
g. Potential nuisance conditions

Notes on receiving water conditions shall be summarized in the monitoring report.

Table C-14: Potential Action-Specific Requirements

Action	Potential Requirement	Citation	Description	Preliminary ARAR Determination	Comments
Generation of waste from operation of a groundwater treatment plant	RCRA and State standards for identification and classification of hazardous wastes	40 CFR Part 261 and 22 CCR §66261	Establishes procedures and numeric limits for identification of characteristic hazardous wastes, listed hazardous wastes, and State-only (non-RCRA) hazardous wastes.	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the selected remedial action or operation of a groundwater treatment plant.
	RCRA Generator Standards – hazardous waste determination	40 CFR § 262.11 and 22 CCR §66262.11,	Requires waste generators to determine if wastes are hazardous wastes and establishes procedures for such determinations	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action or operation of a groundwater treatment plant.
Shipment of hazardous wastes for treatment or disposal offsite	RCRA Generator Standards – hazardous waste shipment	40 CFR § 262.30 – 33 and 22 CFR 66262.30 through 66262.33	Prior to transportation, containers should be packaged, labeled, marked, and placarded in accordance with RCRA and Department of Transportation requirements.	Potentially applicable	These requirements are applicable if containers are used to contain hazardous waste to be sent for offsite treatment or disposal.
	RCRA Generator Standards – hazardous waste accumulation	40 CFR § 262.34 and 22 CCR §66262.34	Specifies maximum amounts and maximum periods for accumulation of hazardous waste onsite under generator status	Potentially applicable	These requirements are potentially applicable to management of waste materials generated as a result of construction of the remedial action and operation of any groundwater treatment plant if these waste materials are hazardous wastes.
Discharge to surface water and/or reinjection of groundwater	Basin Plan – beneficial uses, WQOs and policies and procedures	SWB Resolution 68-16 ("Anti-degradation policy")	Requires maintenance of existing water quality that is better than that required by other policies.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.
		SWB Resolution Nos. 68-16 and 92-49	Allow for the use of mixing zones as part of a determination of whether water quality is being maintained in the receiving water.	Potential TBC	This requirement is a potential TBC if the selected remedial action includes reinjection of treated water or discharge of treated water to surface water.

Table C-14: Potential Action-Specific Requirements (cont.)

Action	Potential Requirement	Citation	Description	Preliminary ARAR Determination	Comments
	NPDES discharge requirements	40 CFR Parts 122 and 125 and 23 CCR 2235 et seq.	Establishes permit, treatment and monitoring requirements for discharges to surface water	Potentially applicable	This requirement is potentially applicable if the selected remedial action includes discharge of treated water to surface water.
Stormwater management	NPDES stormwater requirements	40 CFR Parts 122.26 23 CCR 2235 et seq.	Establishes permitting, monitoring, and pollutant control requirements for stormwater from industrial activities.	Potentially applicable	These requirements would be applicable if construction activities associated with the remedial action disturb an area of 5 acres.
Groundwater containment	Containment Zone (CZ) requirements	SWB Resolution No. 92-49 and related Containment Zone Application Requirements	Defines requirements to support use of a containment zone and for delineation and implementation of a containment zone for groundwater contamination.	Potential TBC	The SWB Resolution is potential TBC if the selected remedial action includes physical or hydraulic containment of contaminated groundwater. The Containment Zone Application Requirements are a TBC.
Groundwater extraction and treatment	Evaluation of alternatives for reuse of treated water	Basin Plan – wastewater reuse policy	Requires evaluation of potential water reuse options and identifies potential reuse options that should be considered prior to disposal of treated groundwater	Potential TBC	This policy is a potential TBC for remedial actions that include disposal of treated groundwater. This requirement is being addressed through consideration of the various remedial alternatives including potential groundwater reuse options as part the FS evaluation.
Use of treated groundwater for domestic use	Criteria for domestic use of impacted groundwater	DHS Policy Guidance for Direct Domestic Use of Extremely Impaired Source	Sets forth DHS policy for approval of use of treated groundwater for domestic use	TBC	This policy establishes criteria related to use of treated groundwater for domestic supply and is a TBC criteria for remedial actions that include wellhead treatment or other direct use of treated groundwater.

Appendix D

Western Groundwater OU RI/FS

Groundwater Flow Model

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D1.0 INTRODUCTION

The purpose of this report is to document the groundwater flow model used to develop and analyze the remedial alternatives evaluated in the Western Groundwater Operable Unit Remedial Investigation/Feasibility Study (OU RI/FS).

D1.1 Objectives

The objectives of the groundwater flow model used in this OU RI/FS are to: 1) simulate groundwater flow conditions within and around the Rancho Cordova area and 2) simulate the effects of remedial alternatives under assumed future hydrologic conditions to allow further evaluation of alternatives using CERCLA criteria.

D1.2 Approach

The steps used to evaluate remedial alternatives using the groundwater flow model for this OU RI/FS consisted of: 1) development of an approximation of the hydrogeologic conceptual model; 2) transient calibration of the groundwater flow model; and 3) particle tracking to delineate capture zones and evaluate advective migration of chemical plumes.

Following this introduction, Section D2.0 describes the conceptual model of the hydrogeologic setting, Section D3.0 describes the configuration of the groundwater flow model used to incorporate the elements of the conceptual model, Sections D3.0, D4.0 and D5.0 summarize the configuration, parameters, and stresses of the numerical groundwater flow model. Model calibration is presented in Section D6.0. Section D7.0 describes model sensitivity. Section D8.0 summarizes simulations of remedial alternatives. Section D9.0 provides a list of references cited in the report.

D2.0 CONCEPTUAL MODEL

The conceptual hydrogeologic model provides an interpretation of the groundwater flow system that is simulated by the groundwater flow model. Figure D2-1 shows the region included in the groundwater flow model and pertinent features such as model boundaries, the American River, Lake Natoma, and areas of dredge tailings. The model is approximately 83 square miles in area.

The following Subsections describe the conceptual model boundaries, regional geology, and the interpretation of the groundwater occurrence and movement.

D2.1 Boundaries

The easternmost boundary of the model coincides with the contact between sedimentary formations and the basement complex comprised of metamorphosed igneous and sedimentary rocks. Mountain-front recharge to the groundwater flow system within the sedimentary formations is assumed to occur as a result of precipitation runoff from the surrounding hills.

The northeastern and southeastern boundaries represent regional flow lines and are considered as no-flow boundaries.

The western, northwestern and southern boundaries represent water-level conditions to the west of the OU RI/FS model and allows the OU RI/FS model to be hydrologically connected to the remainder of the Central Valley groundwater basin surrounding the model. This boundary allows groundwater to flow into and out of the model depending on differences in water levels at the model boundary and water levels in wells located 20,000 feet west of the model boundary and an assumed conductance of the sediments west of the model boundary.

The American River and Lake Natoma are internal boundaries that act as regions of groundwater recharge or discharge. Flows between groundwater and surface water depend on the differences in their respective water levels and the vertical hydraulic conductivity of the river and lake beds.

D2.2 Regional Geology

The Aerojet site and the Western Groundwater OU RI/FS site are located near the edge of the Sacramento Valley at the contact between the Sierra Nevada metamorphic basement rocks and valley sediments. This area is characterized by shallow-dipping (generally less than one degree) Cretaceous, Tertiary and Quaternary marine and fluvial sediments overlying a steeply dipping contact with Jurassic crystalline basement rocks (DWR, 1974). The sedimentary sequence includes undifferentiated Quaternary sediment and the Laguna, Mehrten, Valley Springs, Ione and Chico Formations. These sediments generally strike north-south and form a wedge that thickens from tens of feet at the eastern Aerojet site boundary to greater than 2,000 feet near the western Aerojet property boundary, a distance of about six miles. The sediments of interest for the groundwater flow model include the undifferentiated Quaternary, Laguna and Mehrten formations. These sediments contain water-bearing zones identified as subsurface layers A through E.

Quaternary Sediments

The uppermost sedimentary sequence consists of Quaternary-age sediments deposited in southwesterly trending channels of the ancestral American River (Shlemon, 1995). Geologic formations present within this sequence include the Modesto, Riverbank, Fair Oaks/Turlock Lake/Laguna complex, Arroyo Seco gravels, and Victor Formations. These formations are not differentiated in this report because they are unsaturated throughout most of the area, and because historic gold dredging has obliterated much of the evidence required to make the distinctions. The

Quaternary sediments were deposited during the glacial and inter-glacial periods during the Pleistocene, and clast size range from clays and fine silts to cobbles and boulders. Locally, the sequence ranges from zero to 125 feet in thickness.

Laguna Formation

The late Pliocene to early Pleistocene Laguna Formation underlies the Quaternary formations. Sediments of the Laguna Formation were derived primarily from granitic and metamorphic parent rocks and were deposited in a low-energy fluvial environment (DWR, 1974). It is primarily composed of tan and brown interbedded silts and clays with less common interbeds of poorly-sorted sands and gravels. The Laguna forms a wedge which thickens from east to west with reported thicknesses ranging from 125 to 400 feet (DWR, 1974).

Mehrten Formation

The middle Miocene to middle Pliocene Mehrten Formation underlies the Laguna Formation. The Mehrten sediments are derived primarily from andesitic lavas and mudflows and are generally darker in color than the overlying Laguna Formation. The contact between the Laguna and Mehrten is not always distinct and is informally referred to as the Laguna-Mehrten transition zone. This transition zone is characterized by relatively clean andesitic sands and interbedded silt and clay lenses. Below the transition zone, the Mehrten is characterized by two types of deposits. The most common deposits are well-sorted black sand, sandstone and gravels. These deposits are loose to weakly-cemented and generally yield abundant quantities of water. Locally, less common deposits consist of a generally non-water bearing tuff-breccia with a well-cemented andesite lapilli and ash matrix. The Mehrten thickens from a few tens of feet in the eastern portions of the Aerojet Site to over 1,300 feet in the Sacramento-San Joaquin Delta (DWR, 1974).

D2.2.1 Hydrostratigraphy

The following description of the hydrostratigraphy within the OU RI/FS area is based largely on the work presented in "Aerojet Site - GET E and F Effectiveness Evaluation Report, April 1996" (Aerojet and Hydro-Search, 1996). The hydrostratigraphic units (layers A through F) were defined at GETs E and F based on lithologic descriptions, water levels, geophysical data, pumping test data, and relative depths and thicknesses. The general descriptions presented below may vary locally due to stratigraphic heterogeneities. Layers A through F do not necessarily correlate with regional geologic formations discussed above.

Layer A

Layer A, the uppermost water bearing unit, is predominantly composed of unconsolidated sand and gravel. Much of Layer A has been disturbed by dredging in the eastern and central portions of the model area. In addition, large areas of Rancho Cordova were dredged prior to development. The saturated thickness of layer A ranges from zero to approximately 20 feet. The depth to the top of layer A ranges from 40 to 50 feet below ground surface (bgs) in the east to 80 to 100 feet in the central portion of the model area. The depth to water increases to the west and layer A is generally

unsaturated on the Aerojet Site to the north, south and west of GET F. The sediments that contain Layer A are present and may be saturated to the west of the Aerojet Site, however, the available data suggest that they are not hydraulically connected with Layer A on the Aerojet Site.

Layer B

On the Aerojet Site, layer B occurs within the basal sands and gravels of the Quaternary sediments, and appears to be continuous beneath most of the Aerojet Site. Layer B is generally unsaturated west of GET F. A relatively low permeability unit comprised of predominantly silt and clay underlies Layer B west of the Aerojet Site. This low permeability unit increases in thickness (from tens of feet to over 100 feet) and depth (from zero to 300 feet bgs) from east to west. During recent off-site drilling, thin (less than 15 feet) lenses of sand were sometimes encountered within the low permeability unit at depths of 100 to 200 feet bgs. Monitor wells constructed in these lenses were assigned to Layer B, although it is not clear that these lenses are continuous or are hydraulically connected with the monitoring wells assigned to layer B on the Aerojet Site.

Layer C

Layer C is composed primarily of mafic sand, sandstone and minor gravel with varying degrees of cementation. Interbeds of brown siltstone and clay are common and vary in thickness from one to 10 feet. Layer C ranges in thickness from 50 to 125 feet with an average thickness of approximately 80 feet. It is saturated and continuous throughout the OU RI/FS study area. The top of Layer C forms a relatively planar surface with a strike of N12°W and a southwesterly dip of approximately 1°. This attitude is consistent with the attitudes of regional geologic formations.

Layer D

Layer D is composed of sands and sandstone with some gravel. On the Aerojet Site. Layer D ranges in thickness from 30 to 150 feet. For the most part, the base of Layer D has not been reached west of the Aerojet Site. Layer D is separated from Layer C by a discontinuous 10- to 45-foot thick clay and siltstone layer.

Layer E

Layer E consists of sand, sandstone and some gravel with interbedded silt and clay. It occurs at depths of 350 to 400 feet bgs near the western Aerojet property boundary. Layer E has not been well characterized in the western portions of the Aerojet Site and there are no wells screened in Layer E west of Sunrise Boulevard. The available data indicate that Layer E is at least 100 feet thick.

Layer F

Layer F consists of similar geologic material as Layer E. The hydrostratigraphy of Layer F is not well known, as very few monitor wells have been completed in this Layer.

D2.3 Groundwater Occurrence and Movement

This section describes regional flow directions, water level differences between layers, groundwater

inflows, groundwater outflows, and historical changes in water levels.

D2.3.1 Water Levels

Groundwater flows generally from east to west. The highest groundwater elevations are found in the eastern portion of the Aerojet Site. Flowpaths radiate north, west and south from this portion of the Aerojet site.

Figure D2-2 shows 1996 water levels for each hydrostratigraphic layer. Because hydrostratigraphic layers dip at an angle steeper than the regional groundwater gradient, layers A through E all intersect the water table at different locations (see the cross-sections in Section D3.2). Water levels for layers A and B are combined. The effects of extraction and recharge at GETs E and F are evident in Layers A through D.

Figure D2-3 shows water level differences between layers AB and C, C and D, and D and E. Positive differences indicate downward vertical gradients. Negative differences indicate upward vertical gradients. Water level differences denote areas of active areal recharge and the effects of pumping and recharge at GETs E and F. Recharge areas tend to generate vertical gradients downward. Vertical gradients also are generated by pumping from selected layers.

Figure D2-4 shows a long-term water level hydrograph for well 9N6E34R1M. The long-term water level decline observed at well 9N6E34R1M is representative of water-level conditions over much of the Western Groundwater OU RI/FS area. This is likely due to increased regional groundwater pumping removing water from storage throughout the greater Sacramento Valley. Short term changes in water levels represent seasonal changes due to increased rainfall in winter months and dryer conditions in the summer months. Increased groundwater pumping occurs during summer months, which would also tend to decrease water levels. Water levels increase in the early 1980's in response to increased precipitation, and thus recharge, within the modeled area. Water levels decline between approximately 1985 and 1995 because of the combination of drought conditions and increased groundwater extractions. Water levels increased after 1995 due to increased precipitation.

D2.3.2 Groundwater Inflows

Groundwater enters the model area through infiltration of precipitation, mountain-front recharge, recharge wells, and to a lesser extent from the American River.

The amount of recharge to the groundwater system from precipitation is dependent on the spatial variability of long-term precipitation patterns, year-to-year changes in precipitation, interception by impervious surfaces, evapotranspiration and soil infiltration capacity.

Mountain-front recharge occurs as runoff from nearby highlands which infiltrates into the adjacent alluvium of the groundwater basin. Mountain-front recharge may also occur as groundwater inflow

from adjacent bedrock areas.

Recharge wells operated by Aerojet as part of the GETs E and F systems began operating in the 1980s. Water is recharged directly to Layers C and D through a series of six wells.

In areas where groundwater levels are lower than the water levels in the American River, recharge of river water may occur. The amount of recharge is dependent on the permeability of the riverbed.

D2.3.3 Groundwater Outflows

Groundwater leaves the model area through extraction wells, subsurface groundwater outflow, and to a lesser extent through the American River.

The number of extraction wells in the model area has increased steadily from the 1960s to the present as a response to development in the area. Water supply wells operated by Arden Cordova Water Service, Citizen's Utility Company, Mather Air Force Base and Sacramento County are located in the model area. Groundwater extraction and recharge wells operated by Aerojet are also located in the model area.

Subsurface groundwater outflow occurs in all layers along the western boundary of the model area. This subsurface flow occurs as groundwater flows from recharge areas near the highlands to the east toward large pumping centers located to the west of the model area.

Discharge to the American River occurs when groundwater levels are higher than the river level. Consistently this occurs in the vicinity of Lake Natoma. Discharge to other parts of the American River has decreased with time as regional water levels have declined.

D2.3.4 Changes in Groundwater Storage

Water levels have decreased approximately 40 feet between 1956 and 1980 (see Figure D2-4). This decline in water level and the corresponding decrease in storage is the result of increased groundwater extractions within the area as well as regional water level declines experienced by the larger groundwater basin in the Sacramento area.

D3.0 GROUNDWATER FLOW MODEL CONFIGURATION

The groundwater flow model is based on the U.S. Geological Survey (USGS) finite difference MODFLOW code (McDonald and Harbaugh, 1988). GWVISTAS (Environmental Simulations, Inc., 1996) was used as both a preprocessor and postprocessor in the construction and development of the model.

D3.1 Model Grid

The model grid has 92 rows and 64 columns. Grid spacings in both the X and Y directions range from 500 to 3,200 feet. Adjacent row and column dimensions do not differ by more than a factor of 1.5. Figure D3-1 shows the configuration of the model grid.

D3.2 Model Layers

The model layers are generalized representations of the complex hydrostratigraphy described in Section D2.2.1 above (Figures D3-2 through D3-4). More emphasis was placed on the representation of Layers C, D and E because NDMA and perchlorate are found in these layers within the Western Groundwater OU RI/FS area. Layers A and B are grouped into the first layer of the groundwater model and is referred to as layer AB. Model layers 2, 3, 4 and 5 generally correspond to hydrostratigraphic layers C, D, E and F, respectively. All layers dip towards the west at an angle of one degree.

Further simplification of the hydrostratigraphy occurs as uniform thicknesses are applied to each layer throughout the model area. Model layer 1 (layer AB) varies in thickness from zero at the Aerojet Site to approximately 300 feet at the western model boundary. Figure D3-5 shows an isopach map for model layer 1 for 1996. Layers 2 and 3 are each 80 feet thick. Layers 4 and 5 are each 175 feet thick.

D3.3 Parameter Zones

Hydraulic parameter zones (such as hydraulic conductivity, vertical leakance and storativity) are based on lithologic descriptions obtained from each layer and aquifer testing.

Well drillers reports and lithologic logs were reviewed to calculate the percentage of fine-grained material in layers 1 through 4. At each well site, the percentage of fine-grained material was determined by the ratio of the combined thickness of silt and clay layers to total layer thickness. Table D3-1 summarizes the results. Figure D3-6 shows the distribution of fine-grained material in layers 1 through 4. These distributions were used to aid in assigning preliminary horizontal and vertical hydraulic conductivities at the beginning of the calibration process. In general, areas of relatively high percentages of fine-grained material (>75%) were assigned relatively low values of hydraulic conductivity (5 - 30 ft/d). Likewise, areas of relatively low percentages of fine-grained material (<25%) were assigned relatively high values of hydraulic conductivity (75 - 150 ft/d). The hydraulic conductivity distribution was then modified to reflect values obtained from aquifer tests.

Specific capacity and aquifer test data also were used to aid in assigning hydraulic conductivity values. Specific capacity data from Arden Cordova Water Service and Citizen Utility Company water supply wells were used to calculate transmissivity (Figure D3-7). Aquifer test data from testing extraction wells at GET D, GET E, GET F, and ARGET as well as aquifer test data from Arden

Cordova Water Service wells 19 and 23 were also reviewed to aid in assigning hydraulic conductivity values. These aquifer tests were also reviewed to aid in assigning storativity values. Figure D3-6 shows the locations of wells for which transmissivity data were available.

D3.4 Boundary Conditions

Figure D3-8 shows the location of model boundaries within and around the model area.

Flow across the easternmost boundary is applied as areal recharge to simulate mountain-front recharge. This recharge is applied to model layer 4 because this is the highest saturated layer in this area.

The northeastern and southeastern boundaries are no-flow boundaries simulating groundwater flowpaths originating from the recharge area along the eastern boundary. The base of the model is a no-flow boundary as well and is located within the Mehrten Formation (see Figure D3-2).

The western, northwestern and southwestern boundaries are general head boundaries that are applied to all five model layers. The prescribed water levels of the general head boundary change with time.

River cells within the model area act as internal boundaries that input or remove groundwater based on the water level differences. Figure D3-8 shows river cells for each model layer. These are represented by the RIV package in MODFLOW. River cells are assigned to the uppermost saturated model layer.

The water table forms the upper boundary of the model.

D4.0 MODEL PARAMETERS

With the aid of hydrogeologic data and through the calibration process described in Section D6.0, hydrogeologic parameter values were selected for the groundwater flow model.

D4.1 Horizontal Hydraulic Conductivity

Figures D4-1 through D4-5 illustrate the zoned values of hydraulic conductivity calibrated for each model layer. Below is a summary of horizontal and vertical hydraulic conductivities in the model area.

Model Layer	Hydraulic Conductivity Horizontal (ft/d)	Vertical (ft/d)
1	30 - 300	0.04 - 2.0
2	2 - 400	0.01 - 2.0
3	2 - 150	0.001 - 2.0
4	2 - 75	0.005 - 0.2
5	2 - 60	0.005 - 0.2

Transmissivities for model layers 2 through 5 are calculated within the MODFLOW code by multiplying zoned hydraulic conductivities by the model cell layer thickness. Transmissivity for model layer 1 is determined as a function of layer saturated thickness.

Transmissivities shown in Figure D3-6 were incorporated into hydraulic conductivity zonation. The resultant model transmissivities are typically within 10 percent of observed values.

D4.2 Vertical Conductance

Vertical conductance (leakance) between model layers is calculated internally within MODFLOW as:

$$VCONT = \frac{1}{\frac{z_1/2}{K_{v1}} + \frac{z_2/2}{K_{v2}}}$$

where z is the model layer thickness and K_v is the vertical hydraulic conductivity for each pair of model layers.

Figures D4-6 through D4-9 shows the generalized distribution of vertical conductance between model layers. The values shown in Figures D4-6 through D4-9 are not input into the model because, as stated above, vertical conductance is calculated internally to MODFLOW. Internally calculated vertical conductance is much more variable than what is shown in the figures. Figures D4-6 through D4-9 are included to provide a general understanding of the spatial distribution of vertical conductance within the model area.

D4.3 Specific Yield and Storativity

Figures D4-10 through D4-13 show the distribution of specific yield and storativity for model layers

1 through 4, respectively. Values for specific yield and storativity were obtained from representative values from Freeze and Cherry (1979) and from aquifer tests conducted at GETs E and F extraction wells (Aerojet and Hydrosearch, 1996). These values were adjusted during the calibration process. Layer 5 is confined and was assigned a uniform value of storativity of $1x10^{-6}$. Calibrated specific yield values range from 0.07 to 0.15. Higher values of specific yield are assigned to areas of dredge tailings. In areas where model layers are confined, storativity values range from $1x10^{-4}$ to $1x10^{-6}$.

D4.4 Riverbed Conductance

River bed conductance is calculated by multiplying the assumed vertical hydraulic conductivity of the river bed by the estimated channel area in each river cell. Vertical hydraulic conductivity values of 0.1 to 0.2 ft/day were used for cells simulating Lake Natoma. Values of 0.07 and 0.09 ft/day were used in river cells approximately two miles downstream of Nimbus Dam. River cells farther downstream and within model layer 1 were assigned vertical hydraulic conductivity values of 0.025 ft/day. River bed conductance ranges from approximately 180 ft^2/day for the American River to 10,000 ft^2/day for Lake Natoma. Conductances differ for the two bodies of water because Lake Natoma is much wider than the American River.

D4.5 General Head Boundary Conductance

The general head boundary conductance is a function of boundary cross-sectional area, horizontal hydraulic conductivity, and the distance to an assumed water level. The distance to an assumed water level is the same for all model layers (20,000 feet). General head boundary cells in model layer 1 typically have a cross-sectional area of 200,000 ft^2 (400 ft x 500 ft) and have a hydraulic conductivity of 23 ft/day. The conductance for these cells in layer 1 is 230 ft^2/day. General head boundaries in layers 2 and 3 have cross-sectional areas of 40,000 ft^2 (80 ft x 500 ft) and have a hydraulic conductivity of 53 ft/day. General head boundaries in layers 4 and 5 have cross-sectional areas of 87,500 ft^2 (175 ft x 500 ft) and have a hydraulic conductivity of 23 ft/day. In layers 2 through 5 these cells have conductances of approximately 100 ft^2/day.

D5.0 MODEL STRESSES

Model stresses include prescribed groundwater inflows and outflows during set periods of time (stress periods). Model stresses may change from stress period to stress period. Stress periods used in the OU RI/FS model are set at five years and one year.

D5.1 Groundwater Inflows

Prescribed groundwater inflows include mountain-front recharge, areal recharge and river recharge.

D5.1.1 Areal Recharge

Areal recharge is applied to the uppermost saturated layer in the model. This may be layer 1, 2, 3 or 4. The amount of recharge applied to the model varies spatially as well as with time.

The areal distribution of recharge is based on factors such as areal distribution of precipitation, soil infiltration capacity, interception by impervious surfaces, and evapotranspiration. Figure D5-1 shows the distribution of long-term (50-yr) averages of precipitation within the model area. On average, more precipitation falls closer to the highlands to the east than in the west.

Soil infiltration capacity, interception by impervious surfaces, and evapotranspiration are accounted for in a modifying factor applied to the areal distribution of precipitation. In general, in areas disturbed by dredging it is assumed that precipitation will recharge readily. A modifying factor of 70 to 95 percent is applied to precipitation in these areas. This indicates that 70 to 95 percent of the precipitation falling in areas of dredge tailings will recharge the groundwater system. In undisturbed areas, it is assumed that soil infiltration capacity is lower, interception by impervious surfaces is higher and evapotranspiration is higher than in disturbed areas. Therefore, a low modifying factor (10 percent) is applied to these areas.

Precipitation totals for each model stress period have been recorded at a precipitation gage at Folsom Dam (Figure D5-2). The average yearly rainfall at this station since 1955 is approximately 23 inches. The equation to evaluate recharge as a function of time and location is:

$$R = P_{sp}/P_a \times P_l \times F$$

where R is the recharge rate (time and location dependent); P_{sp} is the precipitation observed at Folsom Dam for a given stress period (P_{sp} varies with time); P_a is the long-term average precipitation at Folsom Dam (23 inches); P_l is the value of long-term precipitation at a given location from Figure D5-1; and F is the modifying factor governing the amount of precipitation reaching the groundwater. The modifying factor F was adjusted during calibration.

Figure D5-2 shows annual precipitation at the Folsom Dam station and the amount of recharge applied to the model during the calibration period. Model recharge varies from 25,000 ac-ft/yr to 52,000 ac-ft/yr. These values are consistent with values presented in DWR (1964). Figure D5-3 shows the recharge zonation applied to the model. This zonation also is used during predictive simulations.

D5.1.2 Mountain-Front Recharge

Mountain-front recharge enters the model area along a portion of the eastern boundary and is applied as high areal recharge in a number of model cells along the boundary. It is assumed that mountain-front recharge originates as runoff from precipitation falling on adjacent highlands as well as

subsurface flow along the bedrock-basin boundary (see Section D6.2). Minor adjustments to this value were made during the calibration process and found to be a constant 3,600 acre-feet/year (ac-ft/yr). This value is consistent with the amount of runoff expected from the watersheds adjacent to the eastern boundary of the model area. The model cells for which mountain-front recharge is applied as areal recharge are shown in Figure D5-2.

D5.1.3 River Leakage

River stages do not change with time but vary along the stretch of the American River. A constant water level elevation of 126 feet mean sea level (ft msl) is applied to the stretch of river occupied by Lake Natoma. This is the normal pool elevation of Lake Natoma (USGS, 1980a). Downstream of Lake Natoma, water levels of the American River range from 82 ft msl just downstream of Nimbus dam to 30 ft msl near the western boundary of the model area (USGS, 1980a, 1980b). Although it is recognized that water levels of the American River change within a given year, the values used in the model represent annual averages, as do other model parameters such as pumping and areal recharge.

Leakage from the American River varies along the length of the river and is dependent on the head difference between river stage and groundwater levels. Total leakage from the river increases throughout the calibration period because groundwater levels decline. Leakage, as calculated by the groundwater flow model, increases from about 4,000 ac-ft/yr in 1980 to 6,000 ac-ft/year in 1998.

D5.1.4 Recharge Wells

Recharge wells located at the GETs D, E and F facilities began recharging water into the groundwater system in the early 1980s to offset groundwater extractions at those facilities. The majority of the recharge wells are screened in layers C and D with only a few screened in layer E at the GET D facility. The amount of recharge through wells changed on a yearly basis. Based on data collected by Aerojet, recharge ranged from a low of 3,500 ac-ft/yr in 1985 to a high of 6,700 ac-ft/yr in 1996.

D5.2 Groundwater Outflows

Extractions through pumping wells, discharge to the river and subsurface flow comprise groundwater outflows from the model.

D5.2.1 Wells

Figure D5-4 shows the location of extraction and recharge wells within the model area. Pumping data were obtained from Southern California Water Company, Citizens Utilities Company, Mather AFB, Sacramento County Water Maintenance District, and Aerojet. Figure D5-5 shows the total amount of groundwater pumping from the model area during the calibration period. Total pumping

from within the model area ranges from a low of 700 ac-ft/yr to a high of 31,000 ac-ft/yr.

Each well screened across more than one layer is weighted twice to distribute pumping among the layers. Pumping is first distributed based on the length of perforated interval in each model layer. Pumping is then weighted by the hydraulic conductivity of each model layer screened by the well.

D5.2.2 River Leakage

Discharge to the American River is dependent on water level differences between groundwater and river stage. More discharge of groundwater to the river occurred in the past when groundwater levels were higher. Discharge to the river, as calculated by the groundwater flow model, has ranged from a high of approximately 5,000 ac-ft/yr in the past to a low of 800 ac-ft/yr in recent years.

D5.2.3 Boundary Subsurface Flow

Simulated groundwater flow out of the model area is determined by the boundary conductance and the difference in water levels simulated by the model at the boundary and water levels assumed downgradient of the boundary.

The general head boundary along the western edge of the model area is divided into three sections, A, B and C (see Figure D3-7). Each section is associated with a monitor well located approximately 20,000 feet west of the boundary. Section A is associated with well 9N5E12J1M, Section B is associated with well 8N5E16C1 and Section C is associated with well 8N5E30C1

Figure D5-6 Shows the relationship between water levels in the wells and those applied to the general head boundaries. Between 1970 and 1987, water levels at 8N5E16C1 are based on observed water levels at 8N5E30C1. Between 1955 and 1965, water levels are assumed to decline by 20 to 30 feet in keeping with reported levels in DWR (1964). Initial water levels are based on those reported by DWR (1964).

D6.0 GROUNDWATER MODEL CALIBRATION

Calibration of the Western Groundwater OU RI/FS model emphasizes a match to transient groundwater levels for years 1984 to 1996. The model, however, begins simulating groundwater flow in 1956 with initial conditions derived from steady-state simulations.

Model calibration is an ongoing process as interpretations of the hydrogeologic conceptual model evolve with the availability of new data. This section presents a level of calibration judged sufficient to meet the objects of the model.

D6.1 Approach

The calibration of the Western Groundwater OU RI/FS model involved:

- Steady-state simulations to obtain initial conditions.
- Establishing five-year stress periods between 1956 and 1981 and one-year stress periods between 1981 and 1998.
- Transient, trial and error calibration to simulate water levels observed between 1984 and 1998.

D6.2 Steady-State Simulations

The objective of steady-state simulations was to provide initial conditions for the transient calibration, not to generate a calibrated steady-state model. The initial incorporation of parameters into the steady-state model was based on assumed 1960 conditions. This was a period of little groundwater development in the area. Initial model parameter estimates were derived from:

- The distribution of long-term precipitation and recharge capacities as described in Section D5.1.2.
- The distribution of hydraulic conductivity based on aquifer tests and distribution of fine grained sediments.
- Assumed water levels to the west of the model boundary and conductances based on model hydraulic conductivity adjacent to the boundary.
- Assumed river bed conductance based on silty material.
- A gross estimate of mountain-front recharge based on 27 inches of rainfall falling on a catchment area of 1200 acres (approximately 3,000 acre-ft/yr).
- Increased recharge in the vicinity of Aerojet property to account for infiltration of unused imported water.

Thirteen wells were operating during the steady-state simulations. Two of these wells were operated by Arden Cordova Water Service, seven were operated by Mather Air Force Base and four were operated by Aerojet. These wells, the layers in which they were screened and their pumping rates are summarized below:

Summary of Steady-State Extraction Wells

Well	Layers Screened	Pumping Rate (ac-ft/yr)
AC-1	1	229
AC-4	1,2	74
Aerojet No. 1	3,4	280
Aerojet No. 2	3,4	280
Aerojet No. 3	3,4	280
Aerojet No. 4	3,4	280
Mather No. 1	1,2,3	242
Mather No. 2	1,2,3,4	242
Mather No. 3	2,3	242
Family Housing No. 1	2	296
Family Housing No. 2	3,4	296
Family Housing No. 3	1,2,3	296
Family Housing No. 4	2,3	296

Figure D6-1 shows the distribution of recharge for the steady-state. Steady-state recharge reflects infiltration of unused water imported by Aerojet. The amount of unused imported water recharging to the groundwater is not well documented in DWR (1964). This amount was adjusted during the calibration process. The final value is approximately 3,700 ac-ft/yr.

Parameters in the steady-state model were updated after each transient calibration run as adjustments became necessary to achieve a transient match to water levels. This made for an iterative process that provided consistency between the two models.

Steady-state water levels were qualitatively compared to 1962 water levels presented in DWR (1964). Simulated water levels were judged to be appropriate if the following criteria were met: 1) water levels across the model area ranged from approximately 250 ft msl in the east to 30 ft msl in the west; 2) radial flow away from the vicinity of Aerojet property; and 3) water levels remain below ground surface. Figure D6-2 shows the final steady-state water level conditions.

- Actual water levels may change in response to stresses that occur over a shorter time period than the length of a model stress period (one year). This is particularly true for wells screened in confined layers.

- Changes in groundwater levels over a short distances may not be well represented by the water level averaging within a model cell

D6.3.1 Map Calibration

Figures D6-3 through D6-10 show the distribution of water level residuals (simulated water levels minus observed water levels) for the years 1984, 1986, 1988, 1990, 1992, 1994, 1996 and 1998, respectively. At locations where two wells are screened in a model layer, the observed water level is the average of both water levels. Furthermore, the majority of observed water levels are averages of spring and fall water level measurements.

Large residuals within the first model layer (layer AB) result from model cell averaging of relatively small-scale heterogeneities within layers A and B. Water levels in layer A and B monitor wells exhibit large variations over short distances due to discontinuous stratigraphy that promote perched conditions and significant vertical gradients. Because more emphasis has been placed on simulating groundwater conditions in deeper layers, layers A and B have been grouped together and treated as one model layer. Large residuals in model layer 1 are not considered significant.

Large residuals in layers 2, 3, and 4 result from calibration limitations listed above. Residuals may be greater in 1984 because of rapid rise in water levels due to short-lived recharge events that are averaged over the one-year stress periods. Large residuals also occur in areas of steep gradients because model cell averaging cannot reproduce significant water level changes over short distances.

Figure D6-11 shows 1996 simulated water level differences between layers. A comparison of Figure D6-11 to D2-3 shows that the positive head difference dominating much of the Aerojet site, indicative of a downward hydraulic gradient, is reproduced by the model. Positive and negative differences produced by extractions and recharge around the GETs E and F facilities are also reproduced.

Table D6-1 summarizes statistics describing the calibration. The mean absolute error (MAE) is highest for layer 1 for reasons discussed above. The MAE values for layers 2 through 4 show the model's ability to match observed water levels within ± 6 feet. The goodness-of-fit of the model is a statistical parameter taken from trend surface analysis (Davis, 1973) and its calculation is shown on Table D6-1. Goodness-of-fit is a measure of how well the model can reproduce the variability (or range) in observed water levels. A high goodness-of-fit value, one that is close to unity (>0.95), indicates an overall significant match to observed conditions and that the difference between simulated and observed water levels is nearly a constant value, in this case 6 feet.

How well the model fits observed water levels is also displayed in the scatter plots shown in Figures D6-12 though D6-19. The MAE is a measure of the deviation from the diagonal line representing the condition when simulated water levels equal observed water levels (MAE=0). The goodness-of-fit is a measure of how closely the data points in the scatter plots follow a trend. Ideally, that trend should be represented by the diagonal line in the figures.

D6.3.2 Hydrograph Calibration

Monitor wells having hydrographs to be used for comparison during calibration were chosen to provide a widespread distribution and because they generally have a long history of record. Figures D6-20 through D6-23 show simulated and observed hydrographs for layers AB through E, respectively.

In general, simulated hydrographs match observed hydrographs well. However, where differences in simulated and observed hydrographs occur it is for one or more of the following reasons:

1. Observed water levels may respond to stresses, such as pumping or recharge, that occur over a shorter time period than the length of a model stress period (one year). Therefore, the change in water levels cannot be simulated by the model.

2. Because model layers simplify complex hydrostratigraphy, several discrete, water-bearing layers may be represented by a single model cell. The model cell may be unconfined, however a monitor well within the model cell may be screened in a discrete layer that id confined. Therefore, simulated water levels in the model cell (unconfined) may not closely match the observed water level in the monitor well (confined).

3. Pumping rates and screened intervals of some wells are estimates because complete data were not available. Water level hydrographs at monitor wells near these pumping wells may be affected by pumping conditions that are not well represented by the model. Therefore, the simulated hydrograph cannot show the same effects of pumping as the observed hydrograph.

4. The size of model cells are too large to represent steep horizontal hydraulic gradients. Therefore, although a simulated hydrograph may appropriately represent relative changes in water levels over time, it may not match the observed water level.

D6.3.3 Groundwater Balance

The simulated groundwater balance for the calibration period is summarized in Table D6-2. The table shows all inflow to and outflow from the model as well as the change in storage (inflow - outflow) for each stress period. The simulated groundwater balance is presented to illustrate the magnitude

of changes in all the flow components during the calibration process.

D7.0 SENSITIVITY ANALYSIS

Groundwater models produce a solution dependent upon all input parameters. Because of the complexity of this groundwater flow model, many combinations of input parameters could produce reasonable results. That is, no unique solution may exist based on the information available at this time. Section D6.0 described a set of input parameters that produce a calibrated model in terms of representing observed water levels and their fluctuations through time. Other combinations of input parameters could produce similar results. This section describes analyses to evaluate the sensitivity of model results to various input parameters.

The sensitivity analysis proceeded by changing one model parameter while keeping all other input parameters the same in the calibrated model. No attempt was made to change other model input parameters to maintain model calibration during sensitivity trials. The sensitivity analysis is divided into two sections. The first section assesses the sensitivity of the groundwater flow model calibration by evaluating how changes in one parameter cause changes in computed water levels. The second section assesses the sensitivity of the effectiveness of a selected remedial alternative by evaluating how changes in one input parameter cause changes in the placement of wells and the amount of extracted water.

D7.1 Groundwater Flow Model Sensitivity Analysis

The sensitivity of the groundwater flow model was assessed by changing one parameter by one order of magnitude or less, keeping all other parameters unchanged, and computing water levels during the calibration period. The computed water levels were compared to observed water levels and the mean absolute error was determined for selected stress periods. The sensitivity of the model calibration to the parameter was judge by comparison of the MAE to those generated by the calibrated model. Parameters that were changed during the sensitivity analysis include areal recharge, horizontal hydraulic conductivity and vertical hydraulic conductivity. For each simulation of the sensitivity analysis, only one parameter was changed while all other parameters in the model remained the same. Figure D7-1 summarizes the results of each of the sensitivity analysis runs on water levels in layers 1 through 4. The results of each separate sensitivity run are shown for comparison purposes.

D7.1.1 Sensitivity to Areal Recharge

The sensitivity of the model calibration to areal recharge was investigated by varying areal recharge by factors of 0.5 and 2. Doubling areal recharge produce the greatest change in water levels by increasing water levels significantly thereby generating a large MAE. Reducing areal recharge by one half decreased water levels almost to the same degree.

D7.1.2 Sensitivity to Horizontal Hydraulic Conductivity

The sensitivity of model calibration to horizontal hydraulic conductivity was investigated by varying the horizontal hydraulic conductivity of all layers by a factor of 0.5 and 2. In general, increasing horizontal hydraulic conductivity by a factor of two caused computed heads to decrease at about the same magnitude as the increased when values were decreased by one half.

D7.1.3 Sensitivity to Vertical Hydraulic Conductivity

The sensitivity of model calibration to vertical hydraulic conductivity was assessed by varying the vertical hydraulic conductivity of all layers by an order of magnitude. Variations in this parameter produced the least effect on computed water levels. Comparatively more changes were brought about in Layers 1 and 2 than in layers 3 and 4.

D7.1.4 Summary

Model calibration is least sensitive to changes in vertical hydraulic conductivities. This implies that uncertainty in this parameter does not significantly affect the groundwater flow solution produced by the model. Vertical hydraulic conductivity could increase or decrease by one order of magnitude and still produce similar model results for the given suite of other model parameters.

Model calibration is most sensitive to areal recharge. This implies that calibration is dependent, to some extent, on the value of areal recharge. Given that there is some uncertainty in areal recharge values, it follows that different flow models may exist that have differing suites of parameters.

D8.0 REMEDIAL ALTERNATIVE EVALUATIONS USING THE GROUNDWATER FLOW MODEL

The following section describes alternative evaluations using the calibrated model.

D8.1 Transient Simulations

The calibrated model is used to perform predictive, transient simulations to evaluate remedial alternatives. All model parameters, such as horizontal and vertical hydraulic conductivity, storativity, specific yield, and river conductance remain the same for predictive uses of the model. The following parameters were changed:

- Water levels at the end of the calibration period (1998) are used as initial conditions for the predictive trials.
- Areal recharge was set to a long-term average (based on calibration results)

of approximately 33,600 ac-ft/yr. This value did not change throughout the predictive period.

- Water levels at the general head boundary decrease at a rate 0.5 feet per year.
- Regional extraction wells operate at their long-term average pumping rates.

D8.2 Particle Tracking

Particle tracking was used to evaluate groundwater flowpaths, advective migration of conservative contaminants and groundwater capture for each transient simulation. However, there are limitations to using particle tracking to evaluate contaminant migration. One limitation is that physical processes such as retardation, degradation, and dispersion are not simulated. These limitations, however, do not preclude the use of particle tracking for a comparative analysis of remedial alternatives.

MODPATH (Pollock, 1994) was used to estimate travel times of particles along transient groundwater flowpaths for each alternative. Particles in MODPATH represent conservative contaminants, not subject to retardation or degradation, and travel times predicted by the code represent the advective migration of these contaminants through the groundwater flow regime.

For each alternative, overall migration of perchlorate and NDMA plumes was simulated by tracking particles located along concentration contours. Figures 1-10, 1-12, and 1-14 show perchlorate and NDMA plumes in 1998 for layers C, D and E, respectively. For each layer, particles were placed at approximately 100 ft intervals along the 4, 40, 400, and 4,000 µg/l perchlorate contours and along the 0.01 and 0.1 µg/l NDMA contours. Each particle was located at the midpoint of the layer. The movement of each concentration contour was simulated by MODPATH. Figures D8-1 and D8-2 show the projected location of these perchlorate and NDMA contours, respectively, in 2001. The time for each concentration contour to reach each extraction well was evaluated using this methodology and the results are summarized in the descriptions of the remedial alternatives presented in this section.

Particle tracking was also used to evaluate capture zones generated by remedial alternatives. Clouds of particles located in the centers of model layers 2, 3, and 4 were released at the beginning of remedial alternative simulations and allowed to migrate forward toward the extraction wells for the period over which the alternative was simulated. Figure D8-3 shows the starting locations of particles for capture zone evaluation. These locations were used for each layer and the particles were placed at the midpoint of the layer. A map showing which particles in Figure D8-3 are captured by extraction wells (either GET E and F, remedial or regional) in each alternative represents the capture zone for the specified remedial alternative. The capture zones for the remedial alternatives are presented in Section 5.0 of Volume I of this report. The capture zones define regions of groundwater within Layers C, D and E that are removed by offsite extraction wells (remedial and/or regional water

supply wells) and GET E and F wells.

Particle tracking was also used to evaluate the percent of plume area captured by each alternative. In each layer, particles were located in the center of each model cell within the perimeter of the combined extent of CoPCs shown in Figures 1-10, 1-12, and 1-14. Particles were located at the midpoint of the layer. For each alternative, a series of MODPATH simulations were run to evaluate the number of particles, which define the extent of the combined CoPCs, that are captured by remedial extraction wells for a given time period. The length of each sequential simulation is increased by five years. The first MODPATH simulation runs from 1998 to 2006, the second runs from 1998 to 2011, the third runs from 1998 to 2016, and so forth until all particles have been removed. In this way the cumulative capture of CoPC plumes by each alternative can be evaluated. The cumulative capture of the CoPC plumes, in terms of the percentage of CoPC area captured over time, by each alternative is presented in Sections 5.0 and 6.0 of this report.

MODPATH uses hydraulic head output from MODFLOW along with effective porosities to calculate flow directions and velocities from which particle flow paths and travel times are computed. A uniform value of 0.25 was used for effective porosity for each layer in the flow model. This value is based on groundwater velocities calculated from observed migration of perchlorate from GETs E and F recharge wells.

For all MODPATH simulations, particles are specified to stop as they enter a weak sink cell. These are cells that represent low-yielding pumping wells.

D8.3 Analysis of Alternatives

The following sections describe how each alternative was modeled and present modeling results for each alternative.

D8.3.1 Alternative 1 - No Action with Limited Groundwater monitoring

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping and recharge at GETs E and F facilities stop.

2. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

3. Just prior to contacting the 4 µg/l perchlorate contour or the 0.01 µg/l contour regional water supply wells are turned off.

D8.3.2 Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternative Water Supply

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping from GETs E and F remains the same as in 1997. Recharge through GETs E and F recharge wells remains the same as in 1997. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001.

2. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

3. Just prior to contacting the 4 µg/l perchlorate contour or the 0.01 µg/l contour regional water supply wells are turned off.

4. Water not impacted by perchlorate or NDMA is recharged through the GETs E and F recharge well field beginning in 2001.

Groundwater capture maps for Alternative 2A are included as Figure 5-1 in Section 5.0 of Volume I of this report.

Under this alternative the CoPCs plume will continue to migrate. Table D8-1 summarizes the water supply well capacity that will require replacement during this alternative. The implications of water supply well capacity replacement is described in more detail in Sections 4.0 and 5.0.

D8.3.3 Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. In 2001, all pumping from GETs E and F wells is reduced by 25 percent and recharge is turned off. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001. Three new cluster wells, located between GETs E and F and west of the existing

recharge well field are screened in layers C, D and E, pump at 725 to 850 gpm per cluster well and also begin operation in 2001.

2. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

3. Just prior to contacting the 4 µg/l perchlorate contour or the 0.01 µg/l contour regional water supply wells are turned off.

Groundwater capture maps for Alternative 2A are included as Figure 5-2 in Section 5.0 of Volume I of this report.

Under this alternative the CoPCs plume will continue to migrate. Table D8-2 summarizes the water supply well capacity that will require replacement during this alternative. The implications of water supply well capacity replacement is described in more detail in Sections 4.0 and 5.0.

D8.3.4 Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping from GETs E and F remains the same as in 1997. Recharge through GETs E and F recharge wells remains the same as in 1997. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001.

2. Starting in 2001, all regional wells not in operation in 1998 begin operation again and pump at their long-term average rates. These include all wells operated by Southern California Water Company, Citizens Utilities, Sacramento County and Mather Air Force base. All regional wells remain in operation throughout the simulation.

3. Water not impacted by perchlorate or NDMA is recharged through the GETs E and F recharge well field beginning in 2001.

Groundwater capture maps for Alternative 3A are included as Figure 5-3 in Section 5.0 of Volume I of this report. The percent of plume area captured over time by this alternative is presented in Figure 5-4.

Tables D8-3, D8-4 and D8-5 indicate the approximate times resulting from the model simulation that various concentrations of NDMA and perchlorate may be present in regional water supply wells. The various CoPC concentrations shown on Tables D8-3 through D8-5 are based on multiples of the respective detection limits for NDMA and perchlorate. Table D8-3 shows the average pumping rates and modeled approximate times that CoPCs may be present in Layer C if containment of the offsite CoPC plumes is provided by existing water supply wells and wellhead treatment is added. Tables D8-4 and D8-5 indicate the model simulation results for Layers D and E, respectively.

D8.3.5 Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment of Water Supply Wells

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. In 2001, all pumping from GETs E and F wells is reduced by 25 percent and recharge is turned off. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001. Three new cluster wells, located between GETs E and F and west of the existing recharge well field are screened in layers C, D and E, pump at 725 to 850 gpm per cluster well and also begin operation in 2001.

2. Starting in 2001, all regional wells not in operation in 1998 begin operation again and pump at their long-term average rates. These include all wells operated by Southern California Water Company, Citizens Utilities, Sacramento County and Mather Air Force base. All regional wells remain in operation throughout the simulation.

Groundwater capture maps for Alternative 3B are included as Figure 5-5 in Section 5.0 of Volume I of this report. The percent of plume area captured over time by this alternative is presented in Figure 5-6.

Tables D8-6, D8-7 and D8-8 indicate the approximate times resulting from the model simulation that various concentrations of NDMA and perchlorate may be present in regional water supply wells for Alternative 3B. The various CoPC concentrations shown on Tables D8-6 through D8-8 are based on multiples of the respective detection limits for NDMA and perchlorate. Table D8-6 shows the average pumping rates and modeled approximate times that CoPCs may be present in Layer C if containment of the offsite CoPC plumes is provided by existing water supply wells and wellhead treatment is added. Tables D8-7 and D8-8 indicate the model simulation results for Layers D and E, respectively.

D8.3.6 Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Offsite extraction wells were located at the perimeters of the perchlorate and NDMA plumes in layer C at their projected locations in 2001 (Figures D8-1 and D8-2). Extraction wells were spaced along this perimeter to capture and remove particles migrating between the wells.

Pumping rates assigned to the offsite extraction wells were proportional to the hydraulic conductivity of the layers in which they were screened. Lower pumping rates (100 to 200 gpm) were assigned to wells screened where hydraulic conductivity values were relatively low (30 to 50 ft/d). Likewise, higher pumping rates (400 to 500 gpm) were assigned to wells screened where hydraulic conductivity values were relatively high (75 to 150 ft/d).

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping from GETs E and F remains the same as in 1997. Recharge through GETs E and F recharge wells remains the same as in 1997. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001.

2. All layer C wells begin operation in 2001.

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Water not impacted by perchlorate or NDMA is recharged through the GETs E and F recharge well field beginning in 2001.

6. Wells screened in Layer D are located within the same model cells as Layer C wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

7. Wells screened in Layer E are located within the same model cells as Layer C and D wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Wells screened in Layer D are located within the same model cells as Layer C wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

6. Wells screened in Layer E are located within the same model cells as Layer C and D wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

7. Operation of individual offsite extraction wells was stopped when layers were no longer impacted by chemicals.

Groundwater capture maps for Alternative 4B are included as Figure 5-9 in Section 5.0 of Volume I of this report. The percentage of plume area captured over time by this alternative is presented in Figure 5-10. Figure D8-5 shows the modeled maximum drawdown generated by offsite extraction wells in Layers C, D and E.

Based on the model simulation performed for Alternative 4B, a total of 17 new extraction wells will be necessary to provide hydraulic containment offsite in Layers C, D and E. Eleven of the new wells will be constructed in 2001, one will be constructed in 2011, two in 2021, one in 2031 and two will be constructed in later years. Table D8-10 was generated from the model simulation and summarizes the periods of operation, estimated pumping rates and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells.

D8.3.8 Alternative 4C - GETs E and F Extraction Wells with Offsite Extraction Wells in Multiple Containment Corridors

Offsite extraction wells were located at the perimeters of the perchlorate and NDMA plumes in layers C, D and E at their projected locations in 2001 (Figures D8-1 and D8-2). Extraction wells were spaced along the perimeters of these plumes in each layer to capture and remove particles migrating between the wells.

Pumping rates assigned to the offsite extraction wells were proportional to the hydraulic conductivity of the layers in which they were screened. Lower pumping rates (100 to 200 gpm) were assigned to wells screened where hydraulic conductivity values were relatively low (30 to 50 ft/d). Likewise, higher pumping rates (400 to 500 gpm) were assigned to wells screened where hydraulic conductivity

values were relatively high (75 to 150 ft/d).

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. In 2001, all pumping from GETs E and F wells is reduced by 25 percent and recharge is turned off. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001. Three new cluster wells, located between GETs E and F and west of the existing recharge well field are screened in layers C, D and E, pump at 725 to 850 gpm per cluster well and also begin operation in 2001.

2. All layer C wells begin operation in 2001.

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Wells screened in Layer D are located along the perimeters of the perchlorate and NDMA plumes in layer D and begin pumping in 2001.

6. Wells screened in Layer E are located along the perimeters of the perchlorate and NDMA plumes in layer E and begin pumping in 2001.

7. Operation of individual offsite extraction wells was stopped when layers were no longer impacted by chemicals.

Groundwater capture maps for Alternative 4C are included as Figure 5-11 in Section 5.0 of Volume I of this report. The percentage of plume area captured over time by this alternative is presented in Figure 5-12. Figure D8-6 shows the modeled maximum drawdown generated by offsite extraction wells in Layers C, D and E.

Based on the model simulation performed for Alternative 4C, a total of 18 new extraction wells will be necessary to provide hydraulic containment offsite in Layers C, D and E. Sixteen of the new wells will be constructed in 2001, one will be constructed in 2011, and one will be constructed in 2021. Table D8-11 was generated from the model simulation and summarizes the periods of operation, estimated pumping rates and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells.

D8.3.9 Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells and Recharge Wells

Offsite extraction wells were located at the perimeters of the perchlorate and NDMA plumes in layer C at their projected locations in 2001 (Figures D8-1 and D8-2). Extraction wells were spaced along this perimeter to capture and remove particles migrating between the wells.

Offsite recharge wells were located where groundwater is not impacted by perchlorate or NDMA in 2001 and where they can divert impacted groundwater away from operating water supply wells and toward extraction wells. The spacing of the offsite recharge wells is such that impacted groundwater would not migrate between them.

Pumping rates assigned to the offsite extraction wells were proportional to the hydraulic conductivity of the layers in which they were screened. Lower pumping rates (100 to 200 gpm) were assigned to wells screened where hydraulic conductivity values were relatively low (30 to 50 ft/d). Likewise, higher pumping rates (400 to 500 gpm) were assigned to wells screened where hydraulic conductivity values were relatively high (75 to 150 ft/d).

All recharge wells are located in areas of relatively high hydraulic conductivity and therefore have been assigned relatively high recharge rates (up to 500 gpm).

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. Starting in 2001, all pumping from GETs E and F remains the same as in 1997. Recharge through GETs E and F recharge wells remains the same as in 1997. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001.

2. All Layer C wells begin operation in 2001.

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Water not impacted by perchlorate or NDMA is recharged through the GETs E and F recharge well field beginning in 2001.

6. Wells screened in Layer D are located within the same model cells as Layer C wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

7. Wells screened in Layer E are located within the same model cells as Layer C and D wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

8. Offsite recharge wells are screened in layers C and D and recharge an equivalent amount of water as extracted by the offsite extraction wells.

9. The total amount of water to be recharged offsite is equally distributed among the recharge wells.

10. Operation of individual offsite extraction wells was stopped when layers were no longer impacted by chemicals.

Groundwater capture maps for Alternative 5A are included as Figure 5-13 in Section 5.0 of Volume I of this report. The percent of plume area captured over time by this alternative is presented in Figure 5-14. Figure D8-7 shows the modeled maximum drawdown generated by offsite extraction wells in Layers C, D and E.

Based on the model simulation performed for Alternative 5A, a total of 24 new extraction wells and seven new recharge wells will be necessary to provide hydraulic containment. Ten of the extraction wells and all of the recharge wells will be constructed in 2001, with the remainder constructed in 2011, 2012, 2031, and later. Table D8-12 was generated from the model simulation and summarizes the periods of operation, estimated pumping and recharge rates and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells.

D8.3.10 Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction Wells and Recharge Wells

Offsite extraction wells were located at the perimeters of the perchlorate and NDMA plumes in layer C at their projected locations in 2001 (Figures D8-1 and D8-2). Extraction wells were spaced along this perimeter to capture and remove particles migrating between the wells.

Offsite recharge wells were located where groundwater is not impacted by perchlorate or NDMA in 2001 and where they can divert impacted groundwater away from operating water supply wells

and toward extraction wells. The spacing of the offsite recharge wells is such that impacted groundwater would not migrate between them.

Pumping rates assigned to the offsite extraction wells were proportional to the hydraulic conductivity of the layers in which they were screened. Lower pumping rates (100 to 200 gpm) were assigned to wells screened where hydraulic conductivity values were relatively low (30 to 50 ft/d). Likewise, higher pumping rates (400 to 500 gpm) were assigned to wells screened where hydraulic conductivity values were relatively high (75 to 150 ft/d).

All recharge wells are located in areas of relatively high hydraulic conductivity and therefore have been assigned relatively high recharge rates (up to 500 gpm).

In addition to the elements listed in Section D8.1, the simulation of this alternative consisted of the following elements:

1. In 2001, all pumping from GETs E and F wells is reduced by 25 percent and recharge is turned off. A new extraction well (located northeast of the existing GET E extraction wells) is screened in layers C, D and E, pumps at 1,000 gpm and begins operation in 2001. Another new extraction well (located just west of existing GET F wells) is screened in layer C, pumps at 250 gpm and begins operation in 2001. Three new cluster wells, located between GETs E and F and west of the existing recharge well field are screened in layers C, D and E, pump at 725 to 850 gpm per cluster well and also begin operation in 2001.

2. All Layer C wells begin operation in 2001

3. AC-1, AC-10 and AC-20 turn off in 2001.

4. All regional wells not in operation in 1998 remain out of operation. These include AC-7, AC-11, AC-13, AC-14, AC-15, AC-16, AC-19, SCWD-17, SCWD-18, Chettenham, Malaga, and Explorer.

5. Wells screened in Layer D are located within the same model cells as Layer C wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

6. Wells screened in Layer E are located within the same model cells as Layer C and D wells and do not begin operation until the 4 µg/l perchlorate contour or the 0.01 µg/l NDMA contour migrate to them.

7. Offsite recharge wells are screened in layers C and D and recharge an equivalent amount of water as extracted by the offsite extraction wells.

8. The total amount of water to be recharged offsite is equally distributed among the recharge wells.

9. Operation of individual offsite extraction wells was stopped when layers were no longer impacted by chemicals.

Groundwater capture maps for Alternative 5B are included as Figure 5-15 in Section 5.0 of Volume I of this report. The percent of plume area captured over time by this alternative is presented in Figure 5-16. Figure D8-8 shows the modeled maximum drawdowns generated by offsite extraction wells in Layers C, D and E.

Based on the model simulation performed for Alternative 5A, a total of 11 new extraction wells and seven new recharge wells will be necessary to provide hydraulic containment. Seven of the extraction wells and all of the recharge wells will be constructed in 2001, with the remainder of the extraction wells constructed in 2011 and 2012. Table D8-13 was generated from the model simulation and summarizes the periods of operation, estimated pumping and recharge rates and the approximate times that various concentrations of NDMA and perchlorate may be present in each of the proposed offsite containment extraction wells.

D8.4 Sensitivity of Remedial Alternative Effectiveness

Sensitivity of remedial alternative effectiveness was investigated by determining how changes in hydrologic parameters affect groundwater capture, pumping rates, travel time and cost. Areal recharge and hydraulic conductivity were changed during the simulation of Remedial Alternative 4A to investigate the effects on groundwater capture, pumping rates, perchlorate and NDMA travel time and costs generated by this scenario. The assumptions used during the simulation of Remedial Alternative 4A are described in Section D8.3.6 above. The sensitivity analyses simulated conditions over a 30-year period.

D8.4.1 Sensitivity to Areal Recharge

The amount of areal recharge applied to the model area was varied by a factor of ± 25 percent for periods of ten years during the 30-year simulation. This simulated extended periods of either increased precipitation or drought. Six simulations were performed in all. In simulations one through three, recharge was increased by 25 percent in the first, second and third 10-year periods, respectively. In simulations four through six, recharge was increased by 25 percent in the first, second and third 10-year periods, respectively. Varying which 10-year period in the 30-year simulation received increased or decreased areal recharge tested the sensitivity of remedial effectiveness to the timing of hydrologic changes.

After each of the six simulations, particle tracking was used to evaluate capture of perchlorate and NDMA plumes as well as travel times of concentrations to the offsite remedial wells.

Results show that changing areal recharge conditions, regardless of which 10-year period they occur, have little effect on the remedial effectiveness of Remedial Alternative 4A. That is, groundwater capture, pumping rates, travel times and, therefore, costs would not be impacted by future changes in this hydrologic parameter.

D8.4.2 Sensitivity to Hydraulic Conductivity

The sensitivity of remedial effectiveness to hydraulic conductivity was investigated in two simulations.

In the first simulation, horizontal hydraulic conductivity was increased by a factor of two (2X) over an 18 square mile region surrounding the offsite extraction wells in Remedial Alternative 4A. No other hydrologic parameters were changed during the 30-year simulation. Particle tracking was used to evaluate capture and travel times of perchlorate and NDMA plumes to the offsite remedial extraction wells.

Results show that changes to pumping rates at the offsite extraction wells were not required to maintain groundwater capture of the chemical plumes. Travel times were decreased, however, because of the increase in hydraulic conductivity. Table D8-14 shows the results of this sensitivity analysis.

In the second simulation, horizontal hydraulic conductivity was decreased by a factor of two (0.5X) over the 18 square mile region surrounding the offsite extraction wells in Remedial Alternative 4A. No other hydrologic parameters were changed during the 30-year simulation. Particle tracking was used to evaluate capture and travel times of perchlorate and NDMA plumes to the offsite remedial extraction wells.

Results show that pumping rates at some offsite extraction wells could be reduced to maintain groundwater capture of the chemical plumes. Travel times of chemicals moving to the extraction wells increased because of the decrease in hydraulic conductivity. Table D8-15 shows the results of this sensitivity analysis.

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Table D3-1 Summary of Fine-Grained Material by Model Layer

Well	Percent Fines by Model Layer				Well	Percent Fines by Model Layer				Well	Percent Fines by Model Layer			
	layer 1	layer 2	layer 3	layer 4		layer 1	layer 2	layer 3	layer 4		layer 1	layer 2	layer 3	layer 4
Aerojet					Aerojet					Aerojet				
51A,B,C	78	32	NS	NS	3071	NS	0	62	NS	STSW-7	NS	55	100	NS
101	NS	NS	33	52	3270	NS	0	26	NS	STSW-8	NS	2	40	NS
145	NS	NS	50	81	3332-4	73	33	36	30	STSW-9	NS	43	81	NS
177	0	13	91	25	3335-7	26	23	29	44	STSW-12	NS	21	100	NS
223	NS	39	83	68	3338-40	100	27	50	72	STSW-13	100	38	49	NS
286	34	63	63	52	3363-5	29	45	58	76	STSW-14	NS	100	81	NS
294	NS	10	75	80	3388-90	NS	NS	20	15	STSW-15	100	38	81	NS
453	NS	NS	NS	68	3404-5	62	19	65	57	SCWC				
484	18	59	78	57	3408	40	25	25	42	AC-1	84	NS	NS	NS
1169	68	14	63	27	3434-6	93	27	28	NS	AC-5	90	94	45	NS
1203-8	93	69	19	63	3450-52	NS	5	41	54	AC-6	78	58	NS	NS
1246	NS	34	71	13	3453-55	NS	63	68	37	AC-8	81	73	NS	NS
1259-60	NS	16	92	27	3503-05	NS	NS	NS	100	AC-9	53	0	0	NS
1280	100	26	60	NS	3547-9	95	13	15	NS	AC-10	73	81	51	NS
1292-3	56	40	31	NS	3552-54	88	70	56	NS	AC-11	75	18	40	25
1307	NS	29	33	23	3555-57	71	30	38	20	AC-12	75	10	0	NS
1310-11	NS	6	46	19	3564-66	0	11	18	12	AC-13	91	66	50	81
1315-16	NS	36	85	73	5085-7	76	15	47	NS	AC-14	76	10	55	NS
1322-3	NS	53	48	48	30002-4	60	38	48	NS	AC-15	7	0	69	98
1327-8	NS	40	42	39	30005-07	80	25	NS	NS	AC-16	0	14	89	95
1336	NS	24	60	NS	30008-10	77	NS	NS	NS	AC-17	0	6	0	0
1375	NS	0	64	71	30016-18	70	NS	NS	NS	AC-18	62	0	0	NS
1385	NS	100	36	65	30020-22	61	23	31	NS	AC-19	72	20	18	50
1395	61	38	51	76	30044-46	71	NS	NS	NS	AC-20	80	28	78	39
1400	NS	20	21	79	30077-79	66	21	41	NS	AC-22	95	13	0	3
1406	32	33	13	33	30080-82	57	18	NS	NS	AC-23	95	13	40	9
1434-9	92	0	75	19	30083-85	65	32	NS	NS	Citizens Utility Company				
1445	NS	NS	60	19	30086-8	70	37	NS	NS	Chettenham	82	0	NS	NS
1451	NS	0	10	51	30089-91	62	48	NS	NS	Chicago	100	64	65	51
1457-9	36	12	3	51	30092-94	31	42	NS	NS	Countryside	38	19	31	NS
1460-2	48	38	41	40	30095-97	29	39	NS	NS	Explorer	70	NS	NS	NS
1463-5	91	13	8	50	30104-06	85	33	NS	NS	Folsom	70	NS	NS	NS
1466-8	63	34	51	31	30107-9	72	35	18	NS	Gould	39	NS	NS	NS
1475-7	NS	33	66	NS	30110-2	66	10	35	NS	Malaga	79	NS	NS	NS
1487	37	39	64	26	30113-15	71	21	14	NS	New York	31	13	70	NS
1506	24	66	70	64	30116-8	84	33	33	NS	Nutplains	61	56	56	NS
1509	47	18	91	42	30119-21	50	32	NS	NS	Rockingham	72	90	85	NS
1596	NS	9	46	NS	30122-24	55	0	22	NS	Swansea	62	NS	NS	NS
3005	NS	NS	NS	NS	31000-02	55	24	14	NS	Town	56	6	0	63
3026	NS	32	50	54	31003-05	41	0	5	NS	West La Loma	87	39	46	NS
3048	56	29	19	50	STSW-5	NS	70	88	NS	Winchester	75	NS	NS	NS
3067	0	29	52	33	STSW-6	NS	80	100	NS					

NS = model layer not screened by well

Table D6-1 Summary of Calibration Statistics

	Layer AB		Layer C		Layer D		Layer E	
year	MAE	Fit	MAE	Fit	MAE	Fit	MAE	Fit
1984	10.14	0.92	6.14	0.97	5.11	0.97	5.90	0.98
1986	8.53	0.90	4.86	0.99	5.05	0.97	7.75	0.97
1988	7.43	0.89	5.10	0.98	5.16	0.97	6.76	0.97
1990	9.79	0.82	5.30	0.98	5.24	0.98	6.27	0.98
1992	10.53	0.80	5.10	0.98	5.05	0.98	5.77	0.98
1994	11.32	0.78	5.85	0.98	5.51	0.98	5.40	0.99
1996	11.75	0.81	4.69	0.99	4.52	0.99	5.46	0.98
1998	11.51	0.80	5.06	0.98	3.77	0.99	6.11	0.98

MAE (Mean Absolute Error) = $\frac{1}{n} \Sigma |(Y_o - Y_s)|$

Fit = SS_s/SS_o

With: $$SS_s = \sum Y_s^2 - \frac{(\sum Y_s)^2}{n}$$

$$SS_o = \sum Y_o^2 - \frac{(\sum Y_o)^2}{n}$$

Where:
Y_s = simulated water level
Y_o = observed water level
n = number of monitor wells with observed water levels
SS_s = sum of squares of simulated water levels
SS_o = sum of squares of observed water levels

Table D6-2 Simulated Groundwater Balance

Time Step	Year	INFLOW (acre-ft/year)			OUTFLOW (acre-feet/year)			Change in Storage (acre-ft)/year
		Recharge	River	Wells	Wells	River	GHB	
1	1956-60	39,061	453		712	5,191	27,857	5,755
2	1961-65	32,941	1,281		19,136	3,298	28,759	-16,972
3	1966-70	35,781	2,863		13,413	2,427	30,174	-7,370
4	1971-75	32,810	3,887		9,689	1,960	30,808	-5,761
5	1976-80	31,841	4,640		9,736	1,565	29,812	-4,631
6	1981	35,078	4,851		11,685	1,504	29,545	-2,805
7	1982	43,618	4,722		11,249	1,678	30,303	5,110
8	1983	52,938	4,387	311	13,223	2,140	28,444	13,830
9	1984	25,666	4,660	943	17,883	1,830	27,502	-15,946
10	1985	28,811	5,067	3,496	23,485	1,499	26,653	-14,263
11	1986	36,501	5,303	3,577	26,860	1,430	24,954	-7,862
12	1987	31,635	5,533	4,072	27,388	1,311	23,691	-11,151
13	1988	25,092	5,840	3,688	27,571	1,104	25,849	-19,905
14	1989	29,821	6,189	5,970	28,788	944	24,174	-11,925
15	1990	27,043	6,416	6,760	28,329	840	22,980	-11,929
16	1991	33,792	6,531	6,051	25,436	817	23,485	-3,363
17	1992	34,252	6,430	5,489	27,227	806	22,268	-4,130
18	1993	38,177	6,678	5,452	25,574	856	21,947	1,931
19	1994	28,444	6,697	5,783	28,053	781	21,534	-9,444
20	1995	50,230	6,529	6,678	26,607	937	22,773	13,120
21	1996	46,028	6,361	6,708	28,535	1,100	24,816	4,646
22	1997	32,392	6,504	6,600	28,237	1,001	22,498	-6,240
23	1998	52,824	6,504	6,313	31,405	1,127	20,684	12,424

Table D8-1: Water Supply Well Capacity Projected to Require Replacement - Alternative 2A

Year	Capacity Projected to Require Replacement [gpm]
2005	4,800
2009	600
2011	900
2016	3,700
2019	1,000
2026	200
Total	11,200

Table D8-2: Water Supply Well Capacity Projected to Require Replacement - Alternative 2B

Year	Capacity Projected to Require Replacement [gpm]
2005	4,800
2009	600
2013	900
2016	1,100
2020	1,900
2026	200
Total	9,500

Table D8-3: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer C) - Alternative 3A

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1	17	2001	2023	2031			2006	2011	2011	2016	2016	2019	2019	2031
AC 5	27	2001					2016	2023	2023	2031				
AC 6	113	2001					2020	2026	2026	2031				
AC 7	268	2001					2006	2015						
AC 8	25	2001												
AC 9	114	2001	2008	2019	2019	2031					2001	2027	2027	2031
AC 10	44	2001					2006	2012	2012	2023	2023	2031		
AC 11	50	2001	2001	2019	2019	2031	2001	2016	2016	2019	2019	2031		
AC 12	74	2001					2011	2020						
AC 13	71	2001	2002	2011	2011	2020					2001	2020		
AC 14	212	2001	2004	2031			2001	2004	2004	2031				
AC 15														
AC 16														
AC 17	266	2001												
AC 18	627	2001					2006	2008	2008	2009	2009	2026	2026	2031
AC 19														
AC 20														
AC 21														
AC 22														
AC 23														
Chettenham	260	2001					2012	2013	2013	2019	2019	2022	2022	2031
Countryside	520	2001												
Malaga	118	2001												
Nut Plains	535	2001												
Rockingham	71	2001					2015	2016	2016	2020	2020	2031		
West Laloma														
Winchester	173	2001					2015	2016	2016	2019	2019	2026	2026	2031
SWMD-17	57	2001											2001	2017
SWMD-18	52	2001												

Table D8-4: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be present (Layer D) - Alternative 3A

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1														
AC 5	45	2001												
AC 6														
AC 7	108	2001												
AC 8	63	2001												
AC 9	114	2001	2011	2012	2012	2024	2012	2015	2015	2016	2016	2020	2020	2024
AC 10	22	2001												
AC 11	298	2001												
AC 12	74	2001												
AC 13	118	2001	2009	2013	2013	2026	2012	2013	2013	2015	2015	2023	2023	2027
AC 14	85	2001												
AC 15	75	2001			2001	2008			2001	2002	2002	2008		
AC 16	74	2001			2001	2009	2001	2002	2002	2004	2004	2009		
AC 17	320	2001												
AC 18	196	2001												
AC 19	464	2001									2017	2020	2020	2028
AC 20														
AC 21														
AC 22	476	2001												
AC 23														
Countryside														
Nut Plains														
Rockingham	348	2001												
West Laloma	623	2001												
Winchester														
SWMD-17	95	2001					2001	2015	2015	2023	2023	2026	2026	2031
SWMD-18	131	2001												

Table D8-5: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer E) - Alternative 3A

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present									
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1												
AC 5												
AC 6												
AC 7												
AC 8												
AC 9	28	2001										
AC 10												
AC 11	66	2001										
AC 12	28	2001										
AC 13	155	2001					2024	2030	2030	2031		
AC 14	29	2001										
AC 15	164	2001					2001 2017	2005 2031	2005 2015	2006 2017	2006	2015
AC 16	163	2001	2009	2020	2001	2009			2001 2004	2002 2031	2002	2004
AC 17	120	2001										
AC 18	91	2001										
AC 19	365	2001										
AC 20	912	2001	2002	2005	2005	2031	2009	2012	2012	2015	2015	2031
AC 21	312	2001										
AC 22	416	2001										
AC 23	1071	2001							2026	2030	2030	2031
Countryside												
Nut Plains												
Rockingham												
West Laloma												
Winchester												
SWMD-17												
SWMD-18												

Table D8-6: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer C) - Alternative 3B

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1	17	2001					2006	2016	2016	2022	2022	2026	2026	2031
AC 5	27	2001					2022	2031						
AC 6	113	2001					2022	2031						
AC 7	268	2001					2020	2023						
AC 8	25	2001												
AC 9	114	2001	2011	2030	2030	2031					2001	2031		
AC 10	44	2001					2008	2020	2020	2031				
AC 11	50	2001	2001	2005			2001	2002						
AC 12	74	2001					2012	2026						
AC 13	71	2001	2002	2020							2001	2031		
AC 14	212	2001	2004	2015			2001	2004	2004	2015				
AC 15														
AC 16														
AC 17	266	2001												
AC 18	627	2001					2006	2008	2008	2020	2020	2031		
AC 19														
AC 20														
AC 21														
AC 22														
AC 23														
Chettenham	260	2001					2015	2017	2017	2023	2023	2028	2028	2031
Countryside	520	2001												
Malaga	118	2001												
Nut Plains	535	2001												
Rockingham	71	2001					2017	2020	2020	2024	2024	2031		
West Laloma														
Winchester	173	2001					2026	2031						
SWMD-17	57	2001											2001	2023
SWMD-18	52	2001												

Table D8-7: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer D) - Alternative 3B

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present									
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
AC 1												
AC 5	45	2001										
AC 6												
AC 7	108	2001										
AC 8	63	2001										
AC 9	114	2001	2016	2017	2017	2031	2012	2016	2016	2019	2019	2031
AC 10	22	2001										
AC 11	298	2001										
AC 12	74	2001										
AC 13	118	2001	2013	2020	2020	2031	2013	2019	2019	2023	2023	2031
AC 14	85	2001										
AC 15	75	2001			2001	2015			2001	2002	2002	2012
AC 16	74	2001			2001	2015	2001	2002	2002	2005	2005	2031
AC 17	320	2001										
AC 18	196	2001										
AC 19	464	2001									2017	2031
AC 20												
AC 21												
AC 22	476	2001										
AC 23												
Countryside												
Nut Plains												
Rockingham	348	2001 - 2031										
West Laloma	623	2001 - 2031										
Winchester												
SWMD-17	95	2001 - 2031										
SWMD-18	131	2001 - 2031										

Table D8-8: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present (Layer E) - Alternative 3B

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present									
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L	
			Begin Yea	End Year	Begin Yea	End Year	Begin Yea	End Year	Begin Yea	End Year	Begin Yea	End Year
AC 1												
AC 5												
AC 6												
AC 7												
AC 8												
AC 9	28	2001										
AC 10												
AC 11	66	2001										
AC 12	28	2001										
AC 13	155	2001										
AC 14	29	2001										
AC 15	164	2001	2009	2017			2001 2020	2006 2031	2006 2019	2008 2020	2008	2019
AC 16	163	2001	2023	2026	2001	2023			2001 2015	2004 2031	2004	2015
AC 17	120	2001										
AC 18	91	2001										
AC 19	365	2001										
AC 20	912	2001	2002	2005	2005	2031	2012	2028	2028	2031		
AC 21	312	2001										
AC 22	416	2001										
AC 23	1071	2001										
Countryside												
Nut Plains												
Rockingham												
West Laloma												
Winchester												
SWMD-17												
SWMD-18												

Table D8-9: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present - Alternative 4A

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	400	2001					2001	2004	2004	2009	2009	2020		
C2	500	2001							2020	2080				
C3	400	2001					2001	2004	2004	2009	2009	2023	2023	2050
C4	300	2001					2001	2002	2002	2004	2004	2006	2006	2022
C5	200	2001					2022	2042						
C6	200	2001	2016	2022			2001	2002	2002	2005	2005	2008	2008	2022
C7	200	2001	2012	2015	2015	2042	2022	2031						
C8	200	2001	2013	2024	2024	2042	2001	2002	2002	2005	2005	2006	2006	2022
C9	200	2001	2015	2035	2035	2042	2022	2042						
C10	300	2001	2042	2050			2001	2002	2002	2005	2005	2006	2006	2022
C11	300	2011	2009	2022			2022	2042						
C12	300	2001	2011	2017	2017	2031	2001	2004	2004	2011	2008	2011	2011	2031
C13	300	2001	2004	2005	2005	2022	2031	2050						
			2004	2006	2006	2022	2001	2005	2005	2006	2006	2011	2011	2042
D1	200	2001	2017	2022			2001	2002	2002	2005	2005	2042		
							2001	2005	2005	2034	2034	2042		
D2	200	2021	2027	2028	2028	2050	2042	2050						
D3	200	2021	2023	2024	2024	2031	2001	2008	2008	2022				
D4	200	2021	2019	2020	2020	2042	2011	2012	2012	2017	2017	2031		
D5	200	2011	2015	2016	2016	2042	2001	2004	2004	2008	2006	2022		
D6	200	2031	2034	2035	2035	2042	2001	2004	2004	2009				
D7	200	2021	2042	2061			2009	2022						
D8	200	2051	2022	2042			2009	2012	2012	2013	2013	2016	2037	2119
D9	200	2021	2026	2030	2030	2042	2020	2022	2016	2020	2034	2037		
			2042	2061			2028	2033	2033	2034				
D10	200	2011	2022	2061			2019	2027	2027	2030	2030	2031	2031	2050
							2017	2019	2019	2023	2023	2027	2027	2031
E1	500	2021	2022	2023	2023	2050	2016	2017	2016	2019	2019	2023	2023	2031
			2050	2061			2013	2015	2015	2016	2016	2023	2023	2042
E2	500	2031	2037	2048			2028	2030	2030	2031	2031	2042		
							2042	2043	2028	2030	2030	2042		
E3	500	2051					2017	2026	2042	2045	2045	2061		
E4	400	2061	2072	2080			2027	2028	2028	2030	2030	2042		
							2042	2061						
E5	300	2061	2089	2080			2017	2026	2026	2031	2031	2042		
							2042	2061						
E6	300	2061	2087	2089	2089	2080	2022	2026	2026	2028	2028	2039		
			2080	2122					2039	2061				
E7	300	2061	2080	2083	2083	2097	2031	2038	2038	2039	2039	2053		
			2097	2122			2056	2061	2053	2056				
							2050	2122						
							2061	2067	2067	2072	2072	2083		
							2089	2122	2083	2089				
							2061	2067	2067	2072	2072	2083		
							2089	2122	2083	2089				
							2061	2067	2067	2072	2072	2083		
							2089	2122	2083	2089				
							2061	2083	2083	2086	2086	2100		
							2105	2122	2100	2105				

Table D8-10: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present - Alternative 4B

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	300	2001					2001	2006	2006	2015	2015	2050		
									2050	2089				
C2	400	2001					2001	2004	2004	2006	2006	2034	2034	2048
											2048	2069		
C3	400	2001					2001	2002	2002	2005	2005	2008	2008	2064
											2064	2089		
C4	300	2001					2001	2002	2002	2006	2006	2008	2008	2064
											2064	2089		
C5	200	2001	2019	2026	2026	2039	2001	2002	2002	2008	2008	2009	2009	2069
			2039	2042										
C6	300	2001	2016	2034	2034	2069	2001	2004	2004	2009	2009	2069		
C7	200	2001	2019	2031			2001	2004	2004	2008	2008	2031		
C8	200	2001	2012	2022			2001	2006	2006	2012				
							2012	2017						
C9	200	2001	2001	2017	2017	2031	2001	2005	2005	2023	2023	2031		
C10	300	2001	2004	2008	2008	2022	2001	2005	2005	2022				
D1	200	2011	2020	2026	2011	2015	2015	2017	2017	2024				
					2026	2050	2024	2026						
							2050	2089						
D2	200	2021	2034	2041	2041	2056	2022	2026	2026	2037	2037	2048	2048	2061
			2056	2061										
D3	200	2021	2023	2024	2024	2050	2022	2023	2023	2024	2024	2035	2035	2061
			2050	2061			2061	2171						
D4	200	2041	2034	2035	2035	2067	2031	2039	2039	2042	2042	2069		
			2067	2069			2069	2171						
D5	200	2041	2050	2059	2059	2067	2041	2080						
			2067	2080										
D6	300	2001					2001	2005	2005	2022				
E1	500	2041	2042	2045	2045	2072	2045	2050	2050	2056	2056	2080		

Table D8-11: Modeled Pumping Rates and Modeled Approximate Times CoPCs may be Present - Alternative 4C

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	200	2001					2001	2006	2006	2016	2016	2050		
									2050	2152				
C2	350	2001					2001	2004	2004	2011	2011	2097		
C3	300	2001					2001	2002	2002	2005	2002	2008	2008	2064
											2064	2097		
C4	200	2001					2001	2002	2002	2006	2006	2008	2008	2064
											2064	2097		
C5	200	2001	2023	2042			2001	2002	2002	2009	2009	2012	2010	2069
C6	200	2001	2020	2031			2001	2004	2004	2008	2008	2031		
C7	100	2001	2017	2031			2001	2004	2004	2009	2009	2031		
C8	200	2001	2012	2031			2001	2006	2006	2012				
							2012	2031						
C9	300	2001	2001	2017	2017	2031	2001	2012	2012	2023	2023	2031		
C10	350	2001	2004	2008	2008	2022	2001	2005	2005	2022				
D1	150	2001					2001	2031						
D2	200	2001	2004	2008	2008	2042			2001	2004	2004	2042		
D3	200	2001	2004	2004	2004	2050			2001	2004	2004	2037	2037	2152
D4	200	2001	2007	2011	2011	2050	2001	2007	2007	2023	2023	2152		
D5	200	2011					2012	2020	2020	2026				
							2026	2031						
D6	200	2021					2023	2026	2026	2045	2045	2097		
E1	300	2001	2012	2015	2015	2042								
E2	300	2001	2001	2023	2023	2061	2001	2045	2005	2020	2020	2031		
									2031	2061				

Table D8-12: Modeled Pumping and Recharge Rates and Modeled Approximate Times CoPCs may be Present - Alternative 5A

Extraction Wells

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	400	2001							2001 2050	2011 2122	2011	2050		
C2	500	2001					2001	2002	2002	2004	2004	2017	2017	2037
C3	400	2001					2001	2002	2002	2005	2005	2006	2006	2020
C4	300	2001					2001	2002	2002	2006	2006	2008	2008	2020
C5	200	2001	2019	2022	2020	2027	2001	2002	2002	2006	2006	2009	2009	2031
C6	200	2001	2017	2022	2022	2034	2001	2004	2004	2011	2011 2017	2013 2037	2013	2017
C7	200	2001	2013	2030	2030	2042	2001	2004	2004	2006	2006	2042		
C8	200	2001	2016	2034	2034	2050	2001 2017	2002 2028	2002 2028	2017 2005	2037	2050		
C9	400	2001	2004	2008	2008	2031	2005	2006	2006	2012	2012	2031		
D1	300	2011	2034	2042			2015	2017	2017	2034	2034	2037	2037	2050
D2	300	2001	2016	2024	2024	2031	2006	2012	2012 2020	2015 2023	2015 2023	2020 2027	2027	2039
D3	200	2021	2023	2024	2024	2031	2020	2022	2022	2023	2023	2027	2027	2039
D4	200	2021	2023	2024	2024	2031	2020	2022	2022	2023	2023	2027	2027	2039
D5	200	2021	2023	2024	2024	2031	2023	2024	2024	2026	2026	2027	2027	2050
D6	200	2021	2023	2026	2026	2050	2024	2026	2026	2027	2027	2050		
D7	200	2031	2042	2045	2045	2122	2039	2041	2041	2042	2042	2122		
D8	200	2011	2023	2026	2026	2034	2017	2024	2024	2028	2028	2034		
E1	500	2021					2050 2072	2060 2122						
E2	300	2051	2064	2069			2050 2072	2060 2122	2060 2069	2067 2072	2067	2069		
E3	300	2051	2064	2086			2050 2089	2064 2122	2064 2080	2069 2089	2069	2080		
E4	300	2051	2072 2083	2075 2086	2075	2083	2050 2105	2069 2122	2069 2102	2075 2105	2075	2102		
E5	300	2081	2083 2089	2086 2091	2086	2089	2080 2108	2086 2122	2086 2105	2087 2108	2087	2105		
E6	300	2081	2083	2089			2080 2105	2086 2122	2086 2102	2087 2105	2087	2102		
E7	500	2021	2022	2024	2024	2122	2026	2031	2031	2037	2037	2039		

Recharge Wells

Recharge Well	Layers Screened	Recharge Rate (gpm)					
		2001 - 2011	2011 - 2021	2021 - 2031	2031 - 2041	2041 - 2051	2051 - 2061
I1	C,D	443	514	600	443	286	229
I2	C,D	443	514	600	443	286	229
I3	C,D	443	514	600	443	286	229
I4	C,D	443	514	600	443	286	229
I5	C,D	443	514	600	443	286	229
I6	C,D	443	514	600	443	286	229
I7	C,D	443	514	600	443	286	229

Table D8-13: Alternative 5B - Modeled Pumping and Recharge Rates and Modeled Approximate Times CoPCs may be Present

Extraction Wells

Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Modeled Approximate Times CoPCs may be Present											
			NDMA 0.01 ug/L		NDMA 0.1 ug/L		Perchlorate 4 ug/L		Perchlorate 40 ug/L		Perchlorate 400 ug/L		Perchlorate 4,000 ug/L	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	300	2001					2001	2004	2004	2015	2015	2050		
									2050	2111				
C2	400	2001					2001	2004	2004	2011	2011	2034	2034	2056
									2056	2111				
C3	400	2001					2001	2004	2004	2005	2005	2008	2008	2061
									2056	2111				
C4	300	2001	2023	2031	2031	2072	2001	2004	2004	2006	2006	2008	2008	2061
									2061	2111				
C5	200	2001	2022	2023	2023	2072	2001	2002	2002	2009	2009	2012	2012	2072
									2072	2111				
C6	200	2001	2017	2039	2039	2072	2001	2004	2004	2012	2008	2026		
									2026	2050				
C7	200	2001	2017	2026			2001	2004	2004	2009	2009	2015		
									2015	2050				
D1	200	2011	2019	2022	2039	2045	2012	2015	2015	2020	2020	2026	2048	2072
			2035	2039					2026	2027	2042	2048		
									2039	2042				
D2	200	2021	2030	2031	2031	2072	2023	2028	2028	2034	2034	2042	2042	2072
			2072	2231										
D3	200	2021	2026	2028	2031	2072	2023	2030	2030	2034	2034	2072		
			2072	2231										
E1	300	2111	2111	2119	2119	2179	2023	2030	2160	2231				
			2179	2231										

Recharge Wells

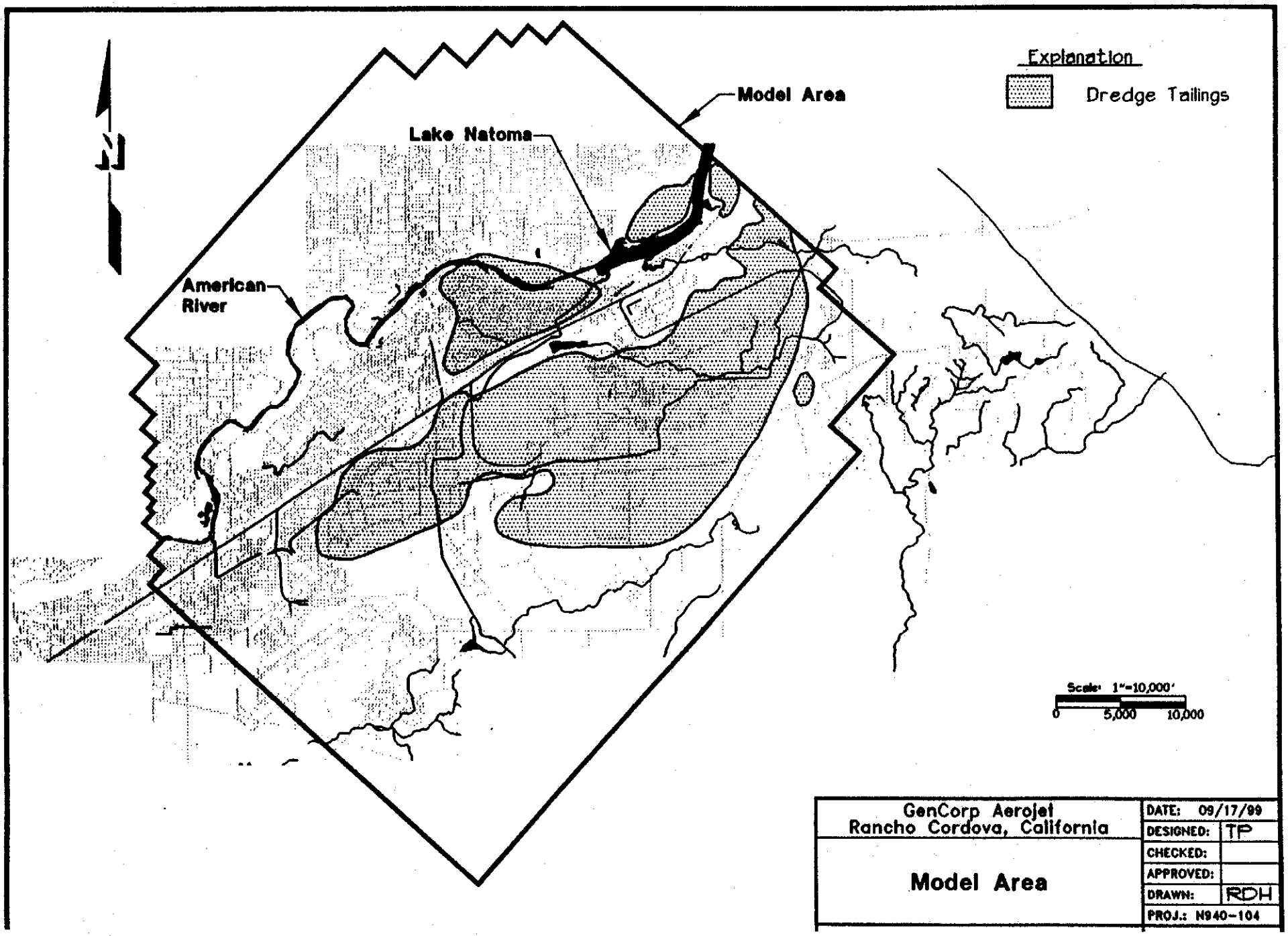
Recharge Well	Layers Screened	Recharge Rate (gpm)		
		2001 - 2011	2011 - 2021	2021 - 2071
I1	C,D	286	314	371
I2	C,D	286	314	371
I3	C,D	286	314	371
I4	C,D	286	314	371
I5	C,D	286	314	371
I6	C,D	286	314	371
I7	C,D	286	314	371

Table D8-14 Modeled Pumping Rates and Approximate Times CoPCs may be Present when Hydraulic Conductivity is High (2X)

Offsite Extraction Barrier Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Approximate Times CoPCs may be Present											
			NDMA				Perchlorate							
			0.01 ug/l		0.1 ug/l		4 ug/l		40 ug/l		400 ug/l		4000 ug/l	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	400	2001					2001	2002	2002	2008	2008	2038		
									2038	2061				
C2	500	2001					2001	2002	2002	2005	2005	2017	2017	2042
							2042	2050						
C3	400	2001					2001	2001	2001	2003	2003	2005	2005	2022
							2022	2031						
C4	300	2001					2001	2002	2002	2004	2004	2006	2006	2022
							2022	2031						
C5	200	2001					2001	2001	2001	2005	2005	2006	2006	2022
							2022	2050						
C6	200	2001	2013	2022			2001	2002	2002	2007	2007	2009	2009	2031
							2031	2050						
C7	200	2001	2010	2014	2014	2042	2001	2003	2003	2006	2006	2042		
C8	200	2001	2011	2017	2017	2042	2001	2002	2002	2005	2005	2042		
C9	200	2001	2012	2035	2035	2042	2001	2003	2003	2028	2028	2042		
			2042	2050			2042	2050						
C10	300	2001	2007	2022			2001	2006	2006	2022				
C11	300	2011	2009	2017	2017	2031	2011	2012	2012	2016	2016	2031		
C12	300	2001	2004	2004	2004	2022	2001	2003	2003	2006	2006	2206		
C13	300	2001	2004	2012			2001	2011						
D1	200	2001	2016	2018			2006	2011	2011	2012	2012	2017	2048	2061
							2018	2031	2017	2018	2040	2048		
									2031	2040				
D2	200	2011	2025	2027	2027	2050	2013	2015	2015	2016	2016	2018	2030	2045
							2020	2026	2018	2020	2028	2030		
									2026	2028				
D3	200	2011	2022	2023	2023	2031	2015	2017	2017	2019	2019	2026	2026	2031
D4	200	2011	2017	2018	2018	2031	2013	2014	2014	2016	2016	2020	2020	2031
D5	200	2011	2012	2014	2014	2042	2012	2014	2014	2016	2016	2019	2019	2037
D6	200	2031	2028	2035	2035	2042	2028	2030	2030	2031	2031	2042		
D7	200	2021	2031	2035	2035	2042	2031	2032	2032	2033	2033	2061		
			2042	2061										
D8	200	2011	2030	2034	2034	2061	2032	2035	2035	2041	2041	2061		
D9	200	2041	2052	2061			2045	2048	2048	2049	2049	2061		
D10	200	2051	2057	2061			2056	2057	2057	2058	2058	2061		
									2001					
E1	500	2021	2022	2023	2023	2050	2022	2026	2026	2028	2028	2039		
			2050	2061					2039	2061				
E2	500	2031	2037	2048			2031	2038	2038	2039	2039	2053		
							2056	2061	2053	2056				
E3	500	2051					2050	?						

Table D8-15 Modeled Pumping Rates and Approximate Times CoPCs may be Present when Hydraulic Conductivity is Low (0.5X)

Offsite Extraction Barrier Well	Modeled Pumping Rate (gpm)	Modeled Beginning Year of Operation	Approximate Times CoPCs may be Present											
			NDMA				Perchlorate							
			0.01 ug/l		0.1 ug/l		4 ug/l		40 ug/l		400 ug/l		4000 ug/l	
			Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year	Begin Year	End Year
C1	400	2001					2002	2003	2003	2009	2010	2045		
									2045	2069				
C2	500	2001					2002	2003	2003	2008	2008	2027	2027	2058
							2031	2042						
C3	300	2001					2001	2002	2002	2005	2005	2009	2009	2031
C4	225	2001					2003	2003	2003	2007	2007	2009	2009	2031
							2031	2042						
C5	150	2001					2001	2003	2003	2008	2008	2010	2010	2031
							2031	2050						
C6	150	2001	2019	2031			2001	2004	2004	2012	2012	2014	2014	2031
C7	150	2001	2015	2019	2019	2042	2002	2006	2006	2010	2010	2016	2016	2042
C8	200	2001	2017	2029	2029	2042	2001	2003	2003	2007	2007	2042		
C9	150	2001	2022	2037	2037	2050	2002	2006	2006	2034	2034	2042		
							2042	2050						
C10	225	2001	2012	2022		2001	2002	2009	2009	2022				
C11	300	2011	2011	2020	2020	2042	2009	2013	2014	2021	2021	2031		
							2031	2042						
C12	300	2001	2004	2005	2005	2022	2002	2004	2004	2006	2006	2022		
C13	300	2001	2004	2006	2006	2022	2001	2004	2004	2011				
							2009	2022						
D1	200	2001	2018	2023			2008	2013	2013	2015	2015	2021	2037	2061
							2023	2034	2021	2023	2037	2037		
							2028	2032	2034	2037				
							2061	2080						
D2	150	2021	2031	2033	2033	2037	2017	2032	2032	2033	2033	2037	2037	2050
			2037	2050										
D3	150	2021	2027	2001	2030	2038	2019	2022	2022	2025	2025	2034	2034	2037
							2037	2050						
D4	150	2021	2020	2021	2021	2028	2016	2018	2018	2023	2023	2028	2028	2031
							2031	2042						
D5	150	2011	2018	2019	2019	2034	2015	2018	2018	2023	2023	2027	2027	2037
							2037	2042						
D6	200	2031	2032	2032	2032	2042	2032	2032	2032	2034	2034	2042		
D7	150	2021	2026	2030	2030	2042	2027	2028	2028	2030	2030	2042		
			2042	2061			2042	2061						
D8	200	2011	2025	2061			2017	2026	2026	2031	2031	2042		
							2042	2061						
D9	150	2041	2052	2061			2053	2054	2054	2055	2055	2061		
D10	150	2051	2058	2080			2058	2060	2060	2061	2061	2064		
							2064	2080						
E1	500	2021	2022	2023	2023	2050	2022	2026	2026	2028	2028	2039		
			2050	2061										
E2	500	2031	2037	2048			2034	2038	2038	2039	2039	2053		
							2056	2061	2053	2056				
E3	375	2051					2058	?						


Explanation
Dredge Tailings
Model Area
Lake Natoma
American River
Scale: 1"=10,000'
0
5,000
10,000
GenCorp Aerojet
Rancho Cordova, California
Model Area
DATE: 09/17/99
DESIGNED: TP
CHECKED:
APPROVED:
DRAWN: RDH
PROJ.: N940-104

PAGES OF OVERSIZED MAPS

(SEE BINDER)

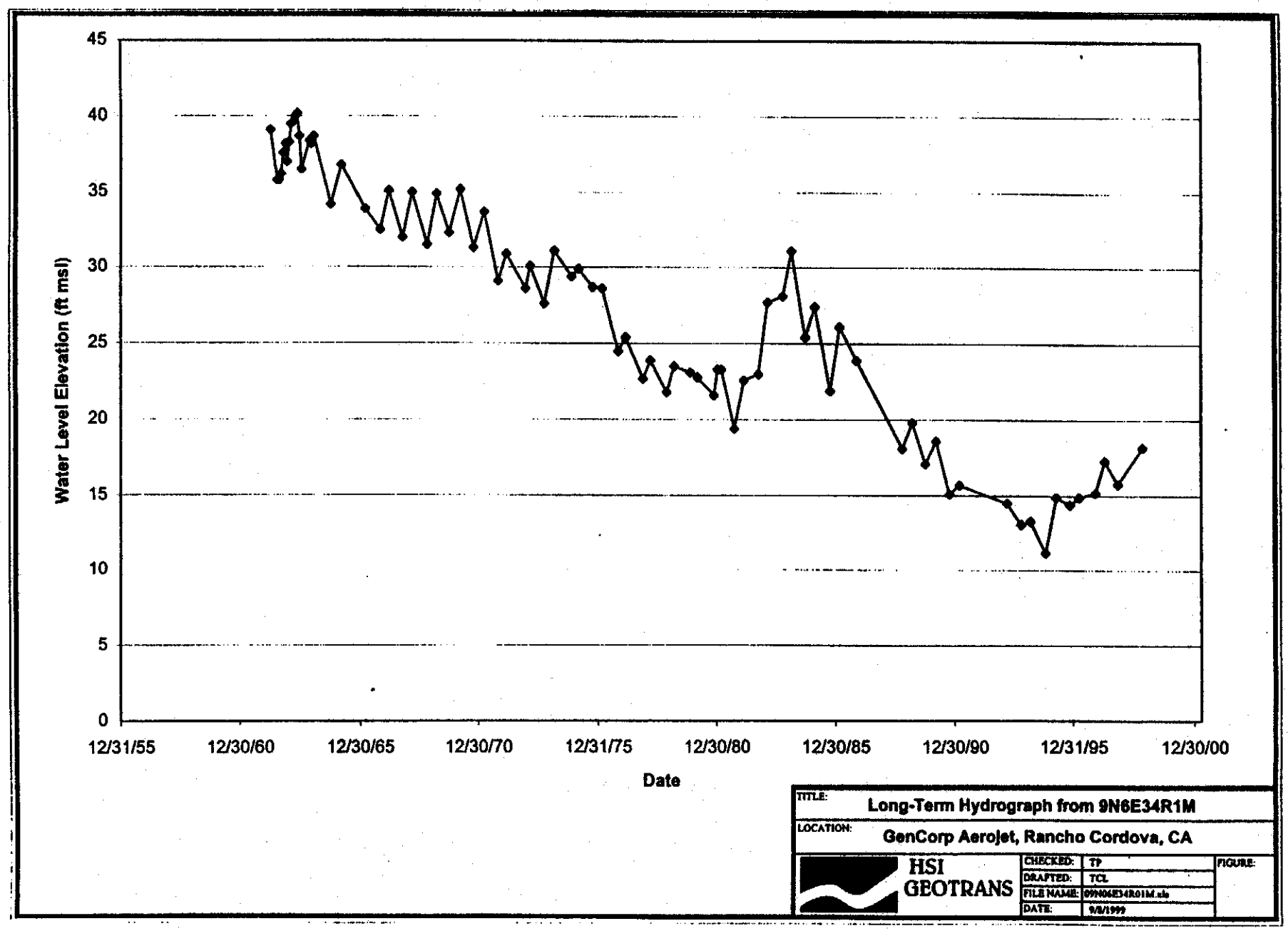
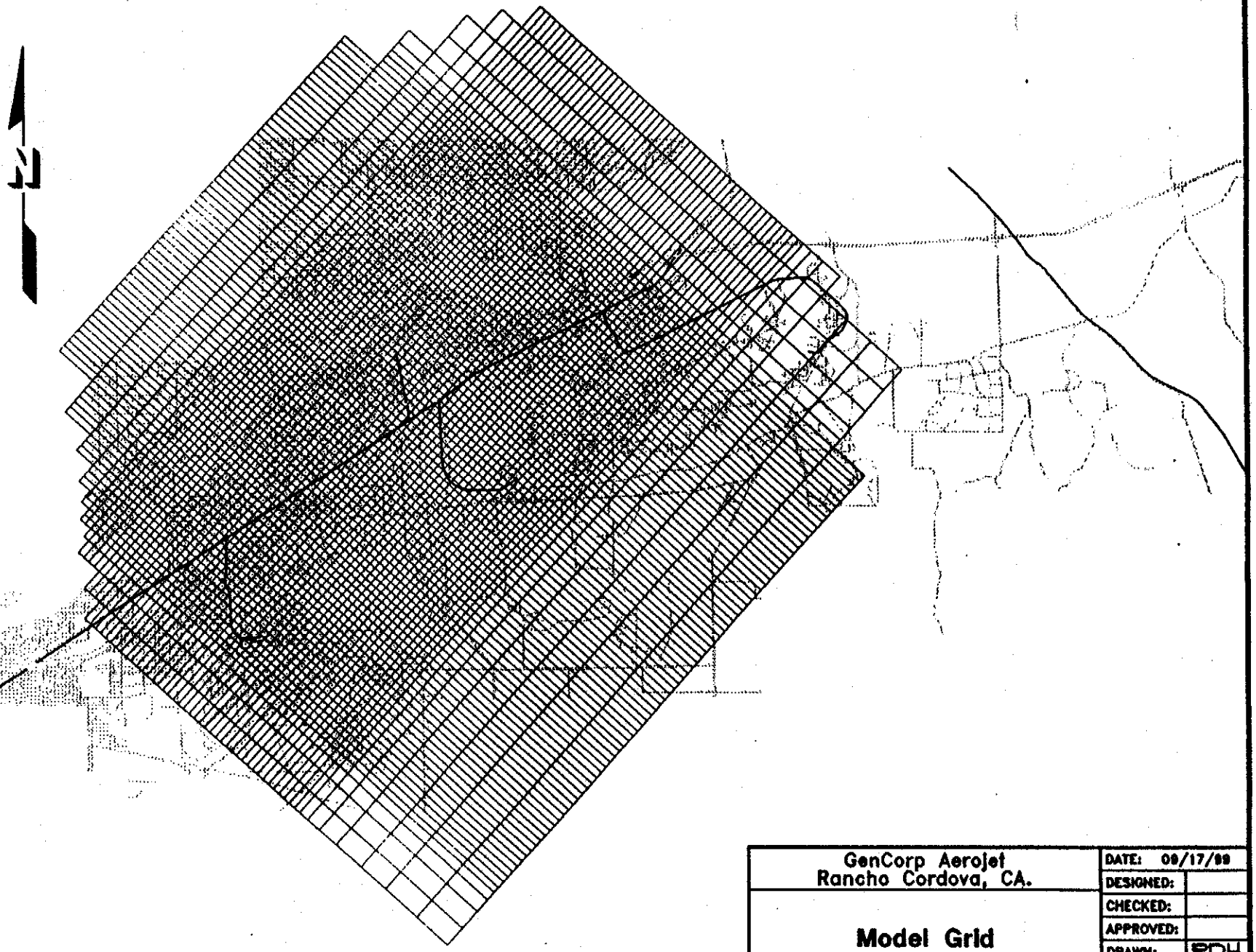

45
40
35
30
25
20
15
10
5
0
Water Level Elevation (ft msl)
12/31/55
12/30/60
12/30/65
12/30/70
12/31/75
12/30/80
12/30/85
12/30/90
12/31/95
12/30/00
Date
TITLE: Long-Term Hydrograph from 9N6E34R1M
LOCATION: GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS
CHECKED: TP
DRAFTED: TCL
FILE NAME: 09N06E34R01M.xls
DATE: 9/8/1999
FIGURE:

Figure D2-4

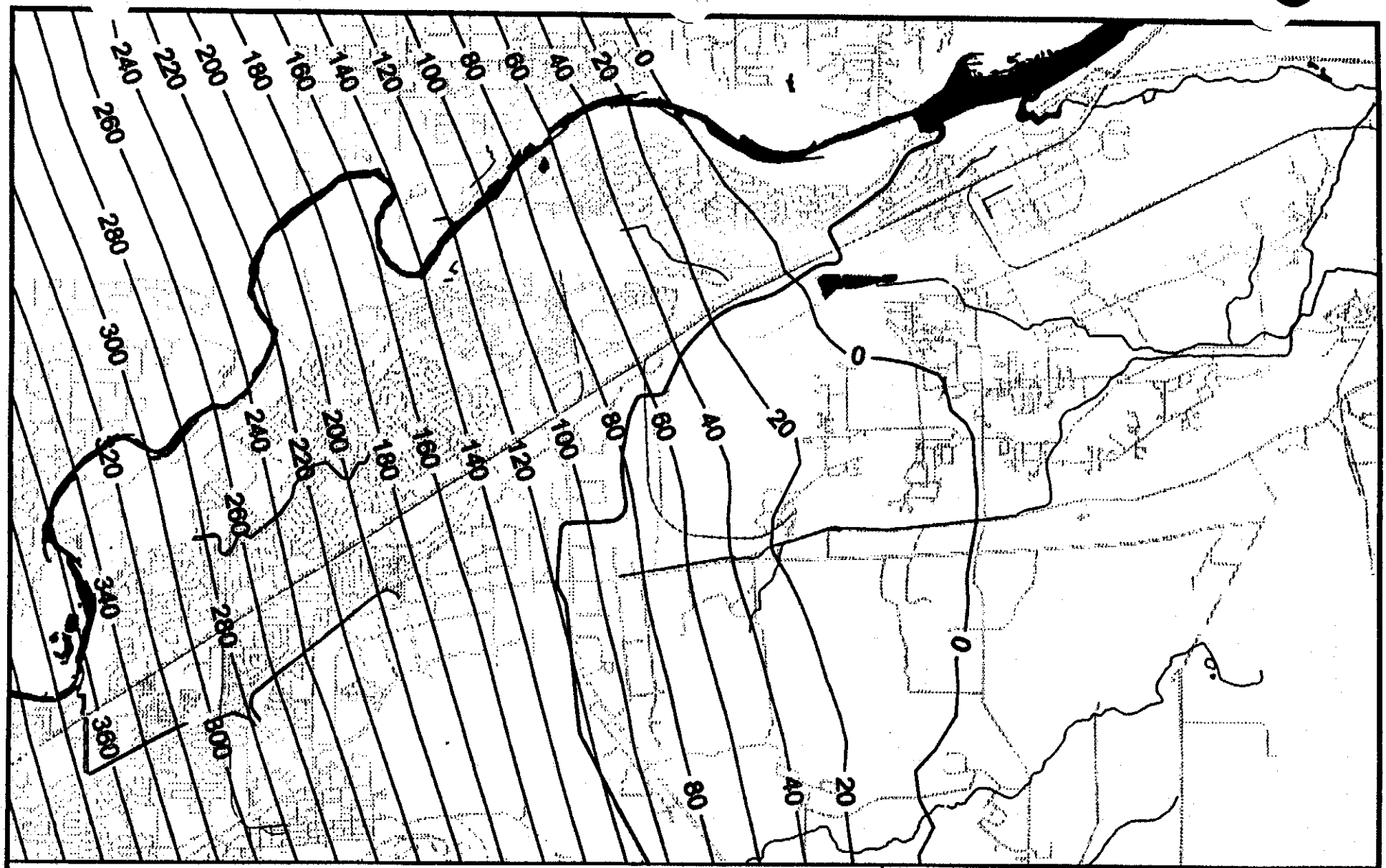


Scale: 1"=10,000'
5,000 10,000

GenCorp Aerojet Rancho Cordova, CA.	DATE: 09/17/99
	DESIGNED:
	CHECKED:
	APPROVED:
Model Grid	DRAWN: RDH
	PROJ.: N940-104
HSI GEOTRANS	Figure D3-1

PAGES OF OVERSIZED MAPS

(SEE BINDER)



Explanation

—100— Line of Equal Thickness (ft.)

Note: Simulated 1996 Water Levels Used to Calculate Layer Thickness

Scale 1"=5000'

0 2500' 5000'

GenCorp Aerojet
Rancho Cordova, CA.

Layer AB Isopach

DATE:	03/31/00
DESIGNED:	
CHECKED:	TP
APPROVED:	TP
DRAWN:	RDH
PROJ.:	N040-102

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D3-5

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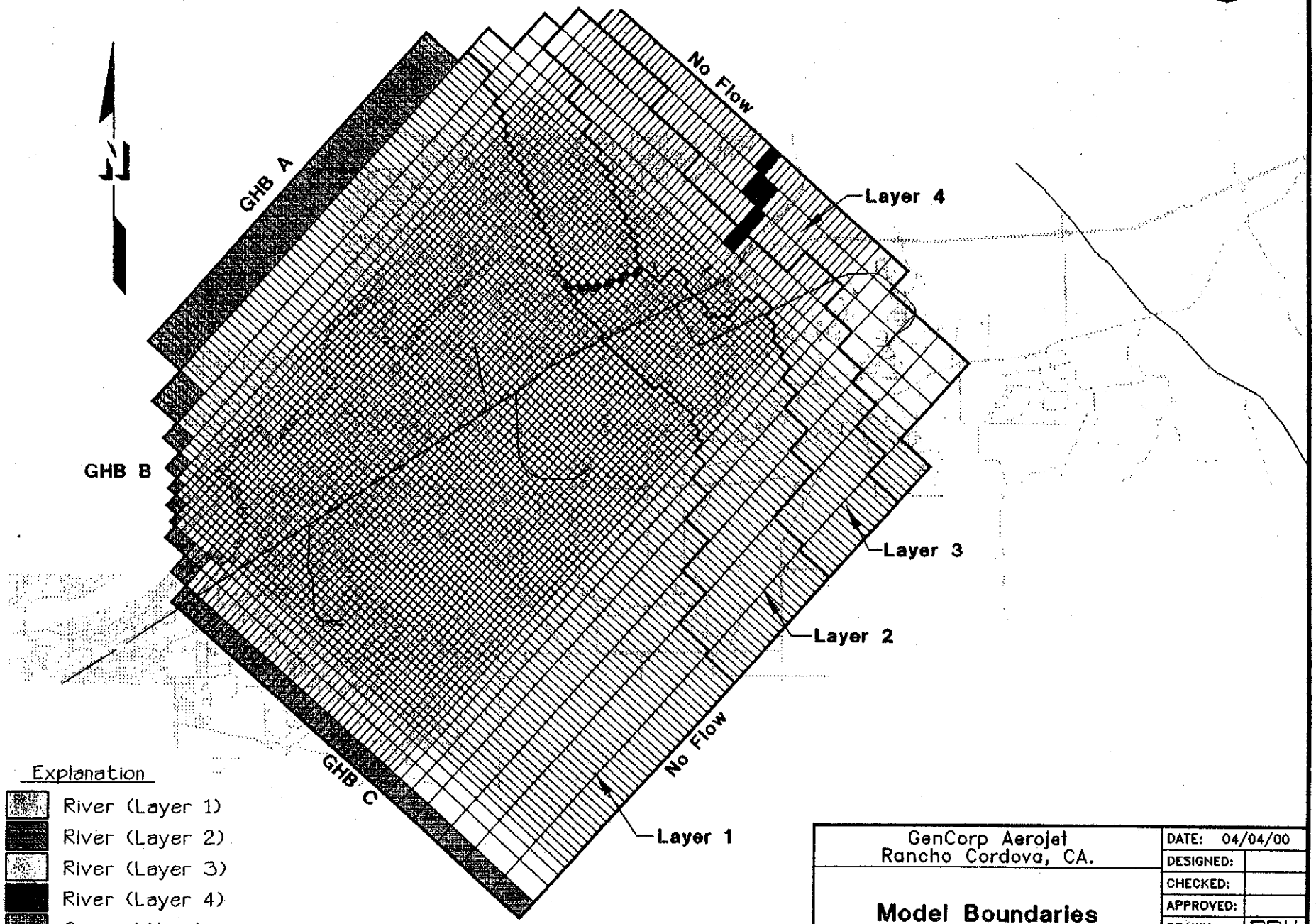
PAGES OF OVERSIZED MAPS

(SEE BINDER)



GenCorp Aerojet
Rancho Cordova, CA.

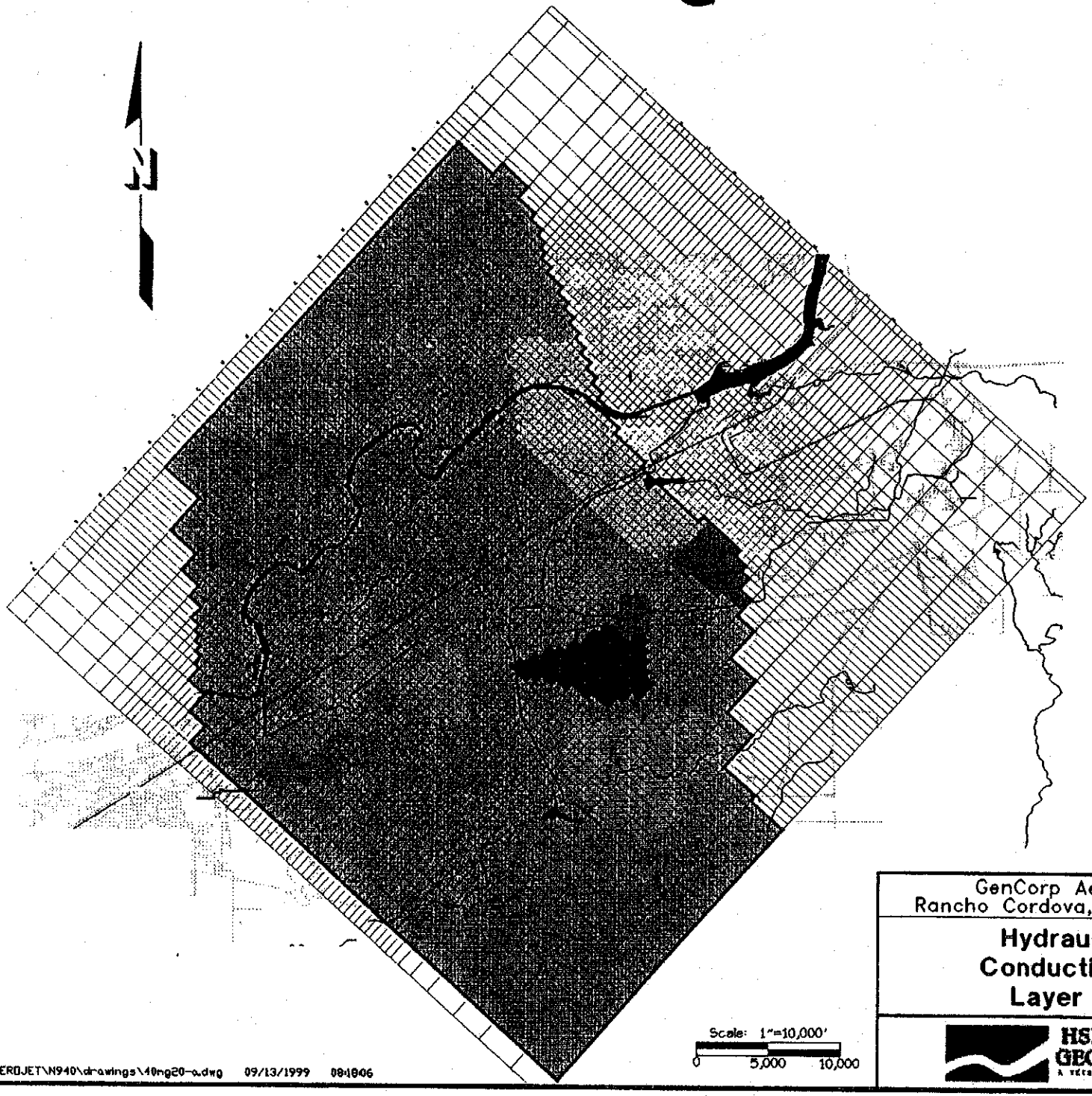
Model Boundaries

DATE:	04/04/00
DESIGNED:	
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D3-8

D:\AEROJET\N940\drawings\40gr05-a.dwg 09/15/1999 14:33:19



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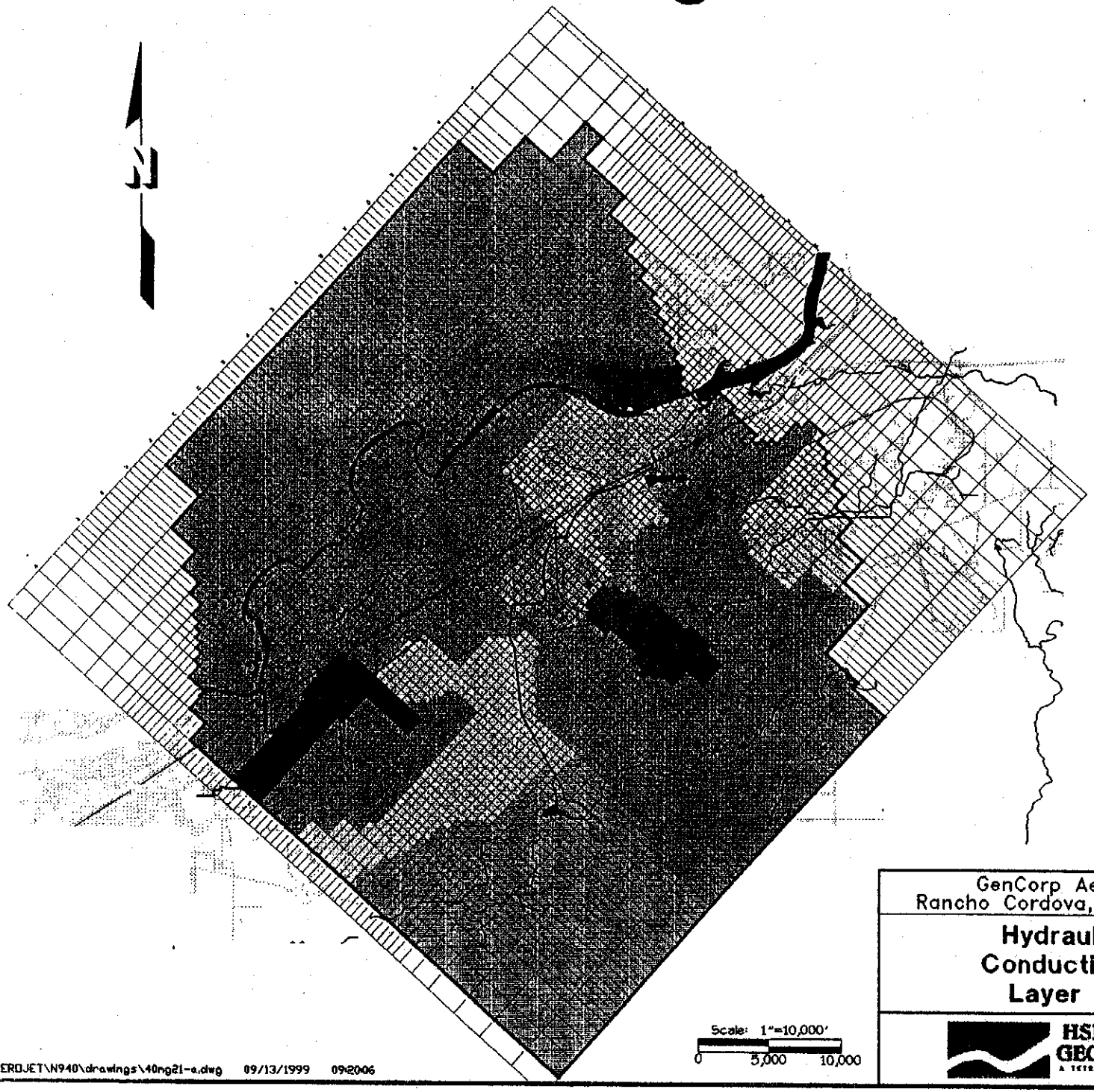
GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 1

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-1



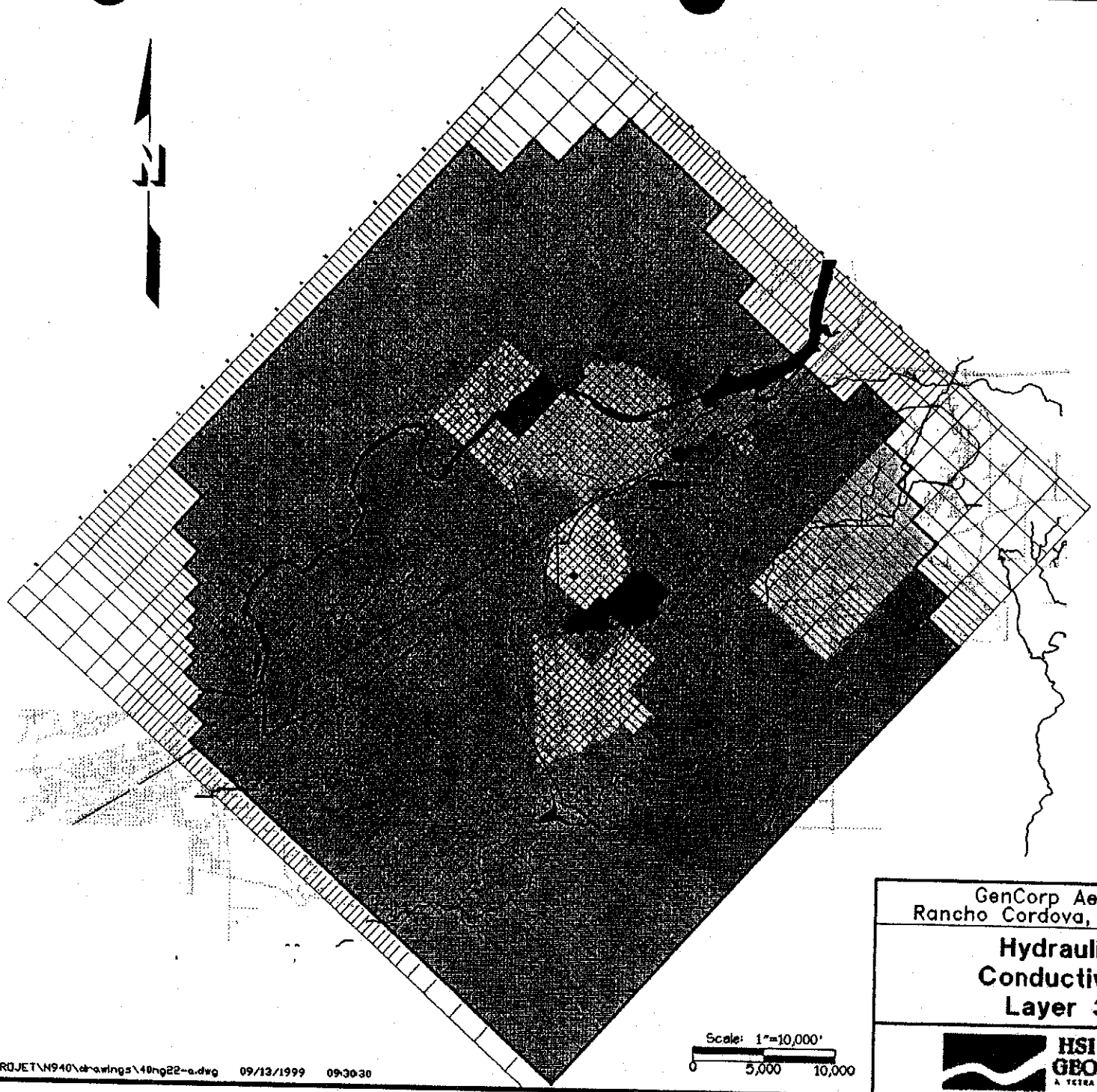
GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 2 'C'

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-2



Explanation

Hydraulic Conductivity

	(ft./day) K_h	(ft./day) K_z
	150	2.0
	150	0.5
	150	0.02
	125	0.05
	112	0.1
	75	2.0
	75	0.1
	60	2.0
	60	0.6
	50	0.05
	45	0.05
	30	0.2
	30	0.04
	15	0.02
	7.5	0.5
	7.5	0.01
	7.5	0.001
	2	0.03

Scale: 1"=10,000'

0 5,000 10,000

D:\AEROJET\N940\drawings\40hg22-a.dwg 09/13/1999 09:30:30

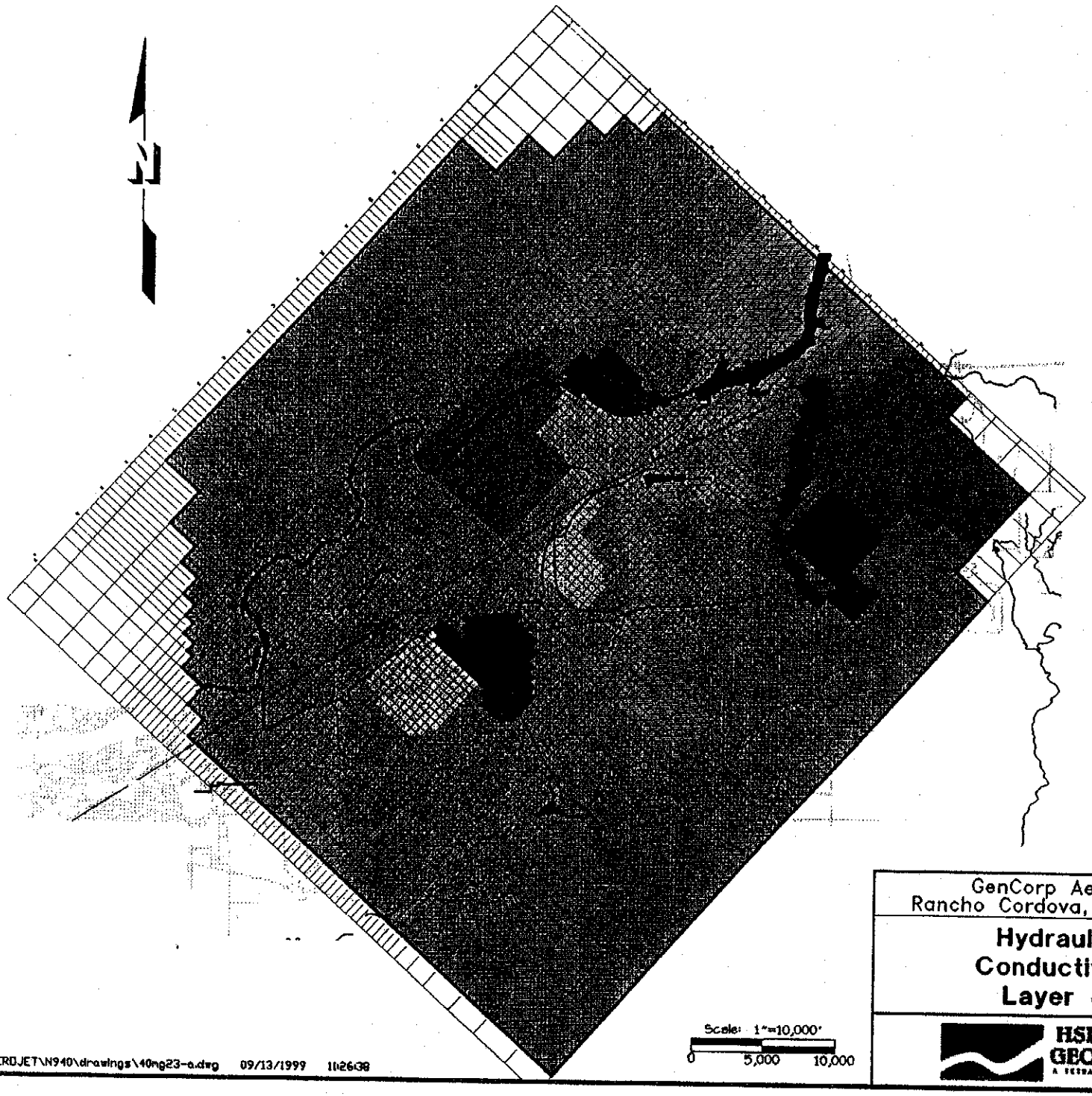
GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 3

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-3



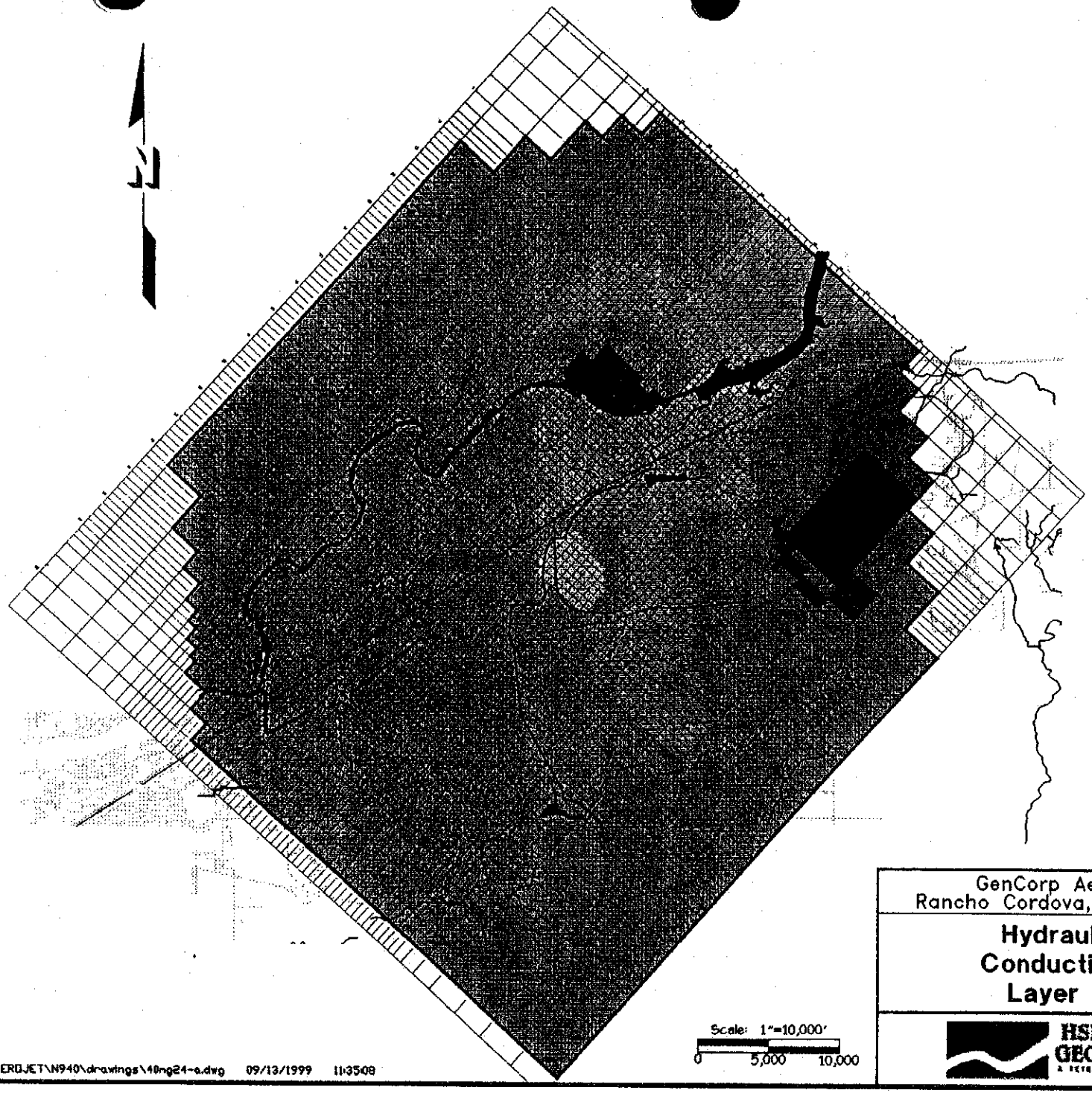
GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 4

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-4



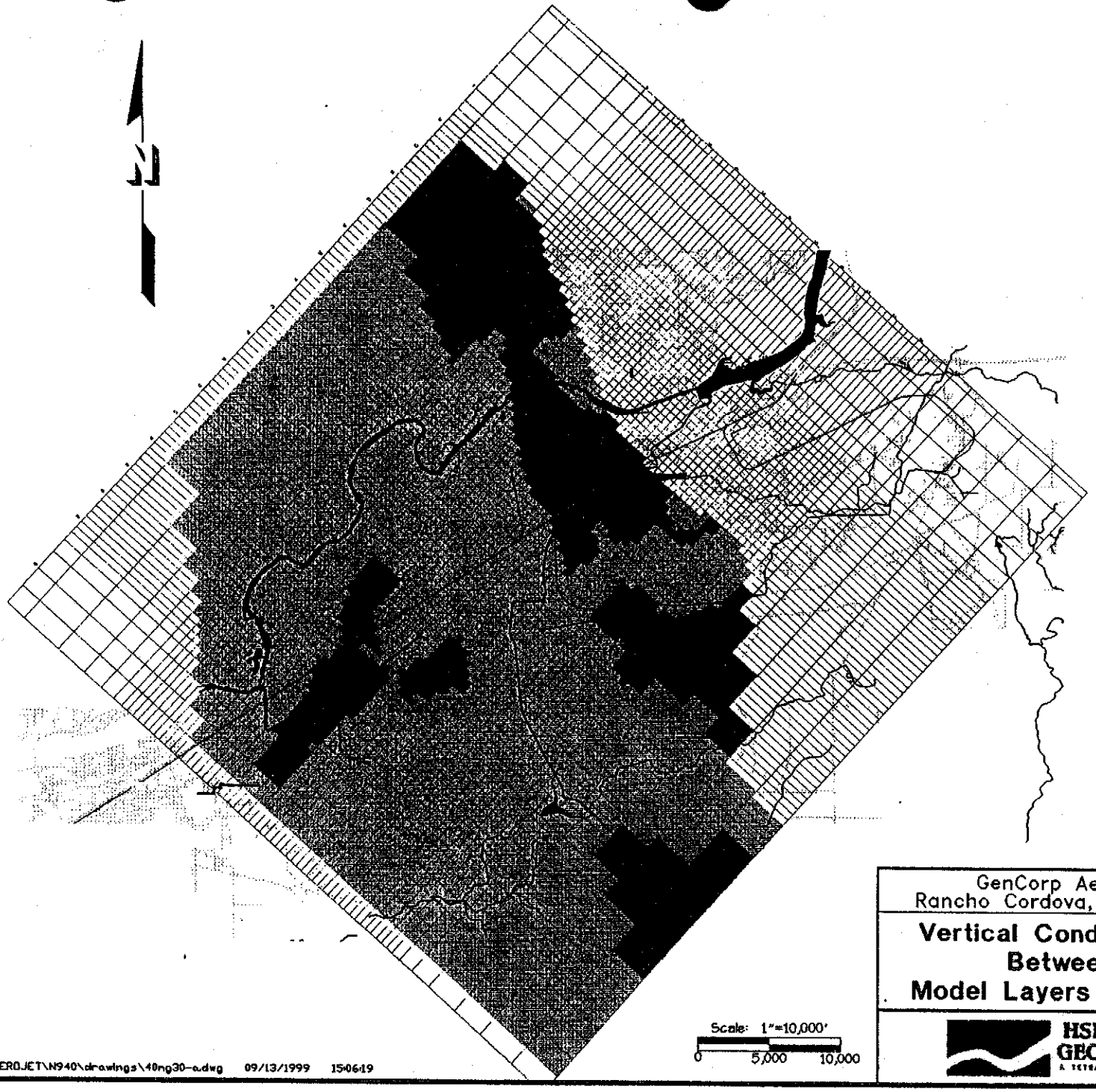
GenCorp Aerojet
Rancho Cordova, California

Hydraulic Conductivity Layer 5

HSI GEOTRANS
A PETRA TECH COMPANY

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

Figure D4-5



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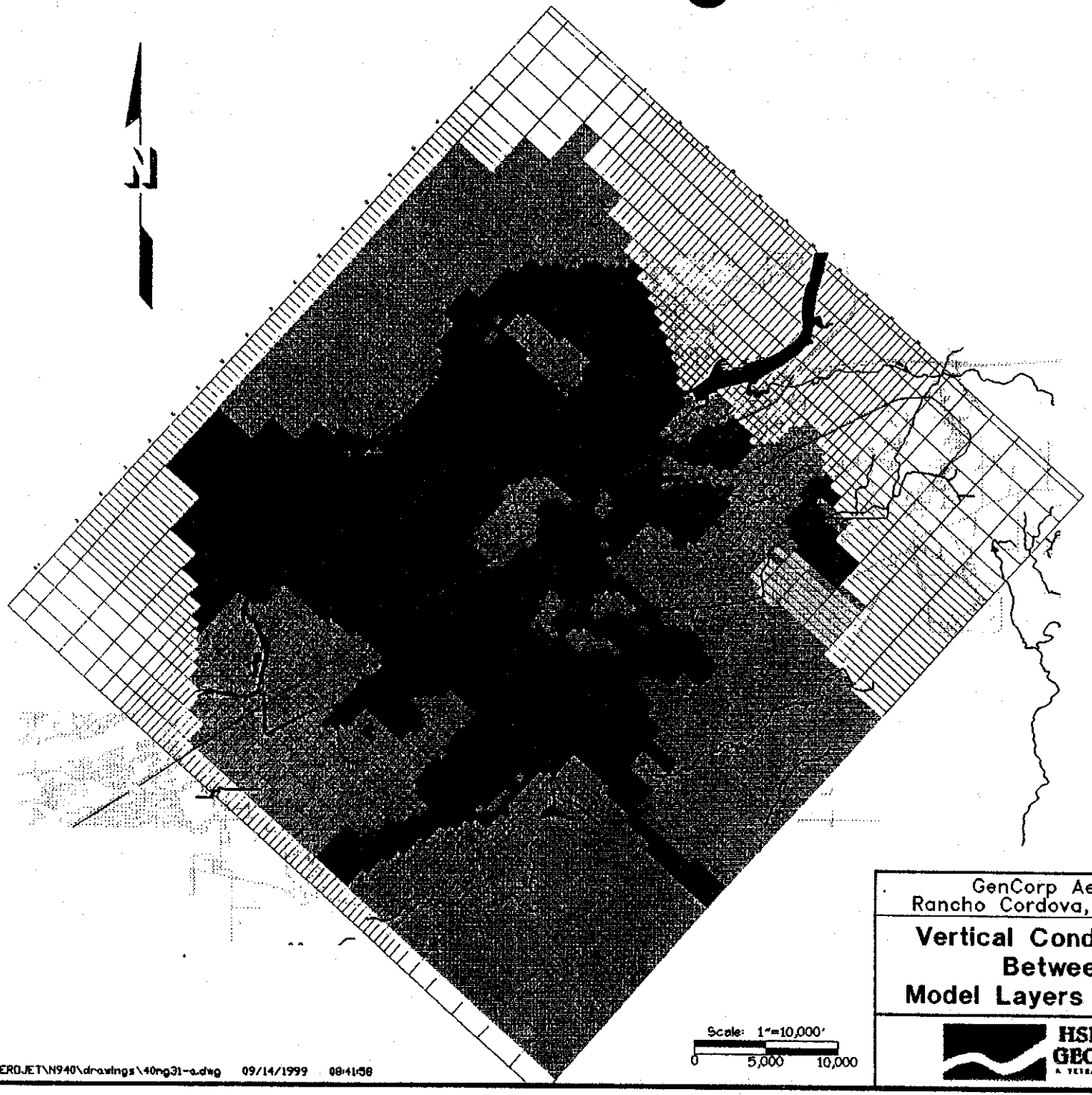
GenCorp Aerojet
Rancho Cordova, California

Vertical Conductance Between Model Layers 1 and 2

HSI GEOTRANS
A TETRA TECH COMPANY

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

Figure D4-6



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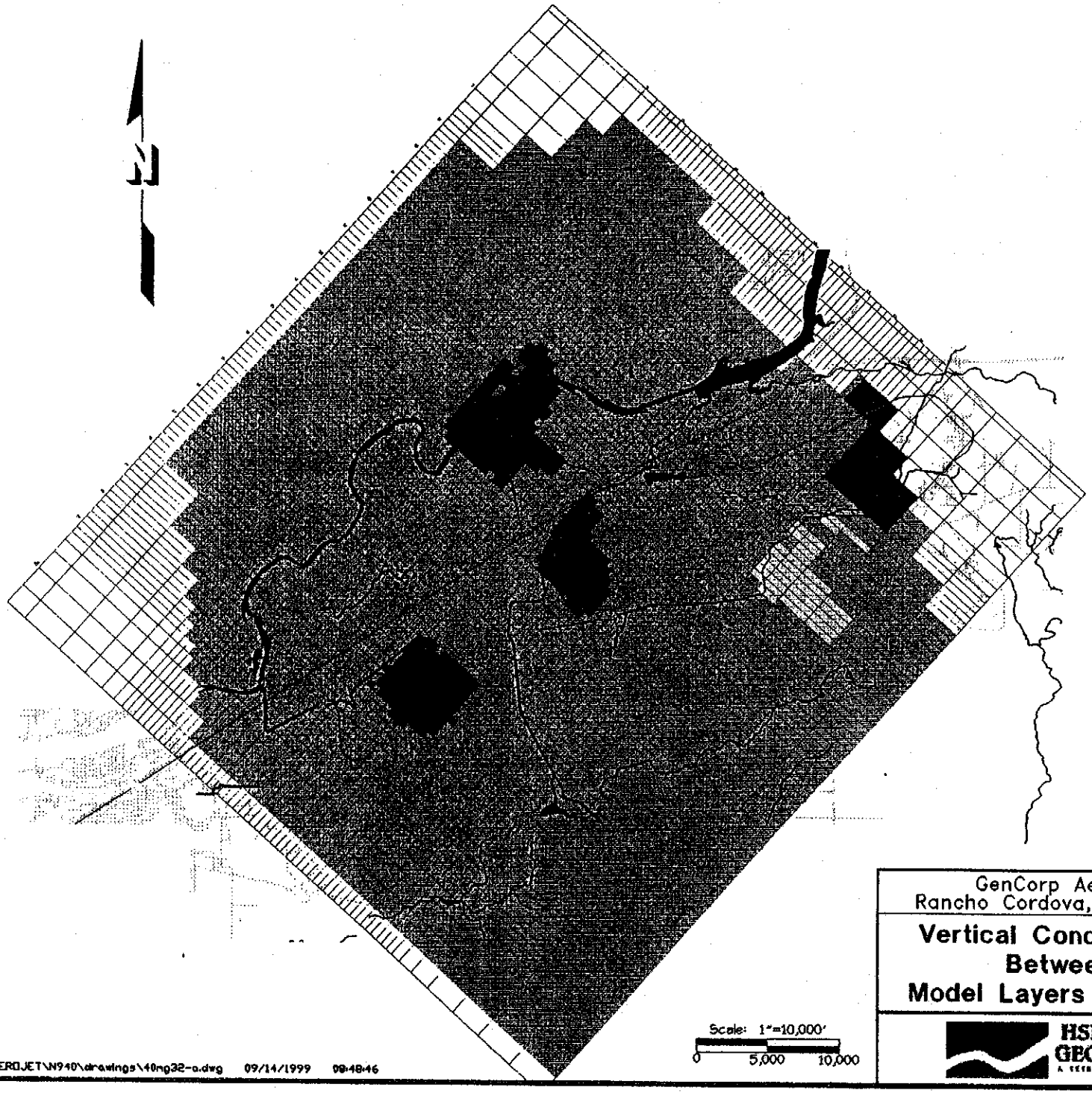
GenCorp Aerojet
Rancho Cordova, California

Vertical Conductance Between Model Layers 2 and 3

HSI GEOTRANS
A TETRA TECH COMPANY

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

Figure D4-7



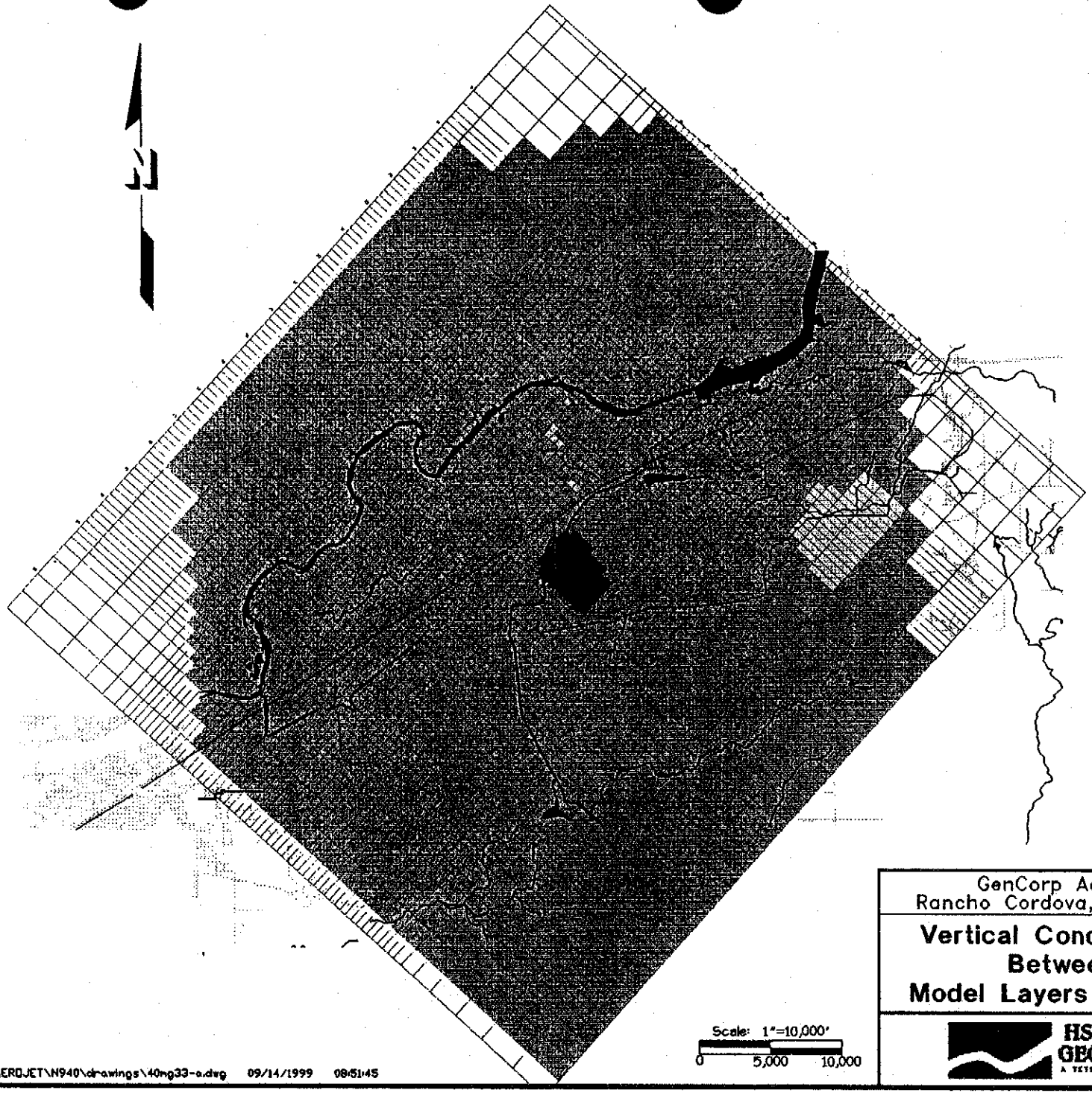
GenCorp Aerojet
Rancho Cordova, California

Vertical Conductance Between Model Layers 3 and 4

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-8



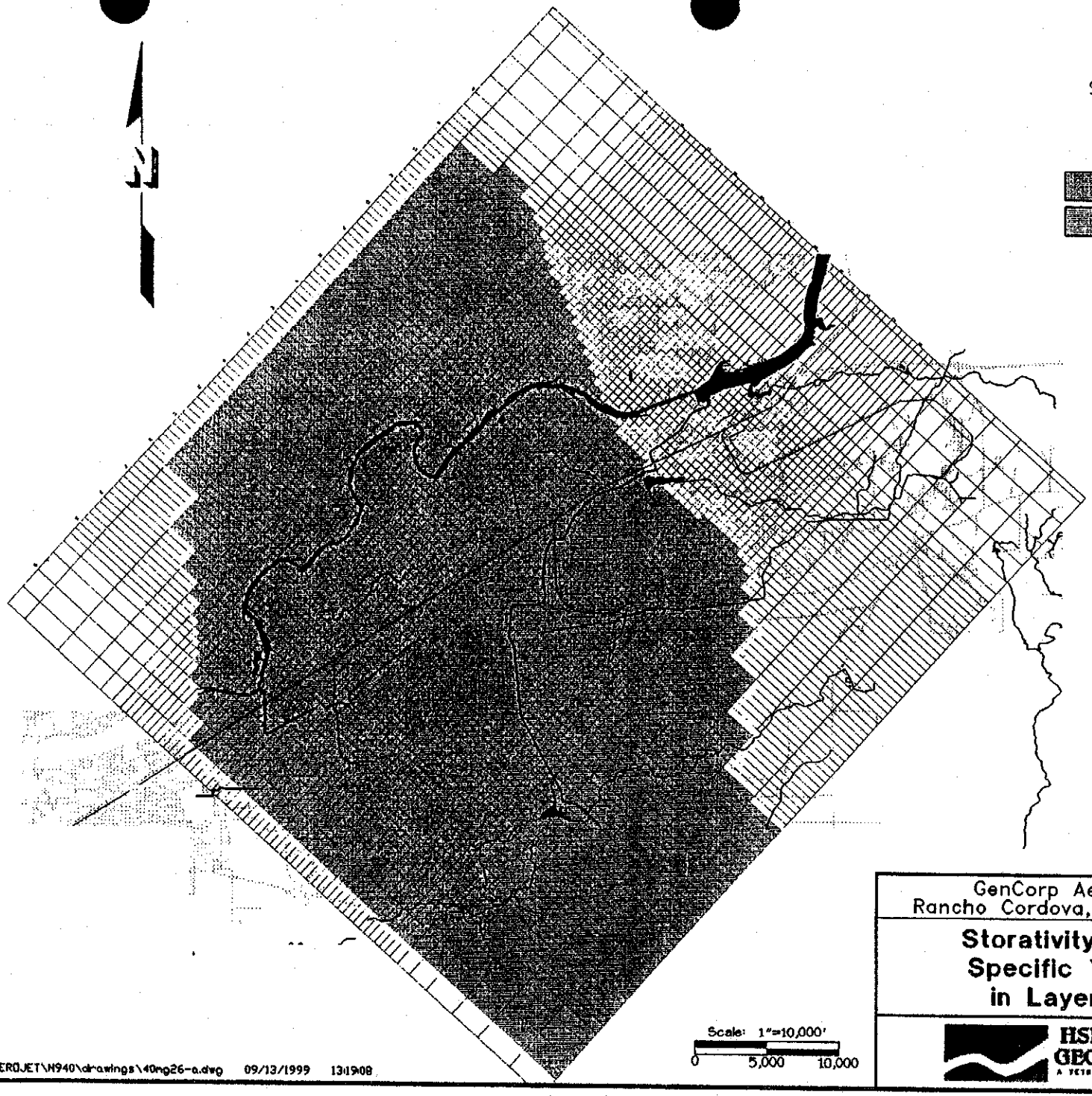
GenCorp Aerojet
Rancho Cordova, California

Vertical Conductance Between Model Layers 4 and 5

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-9



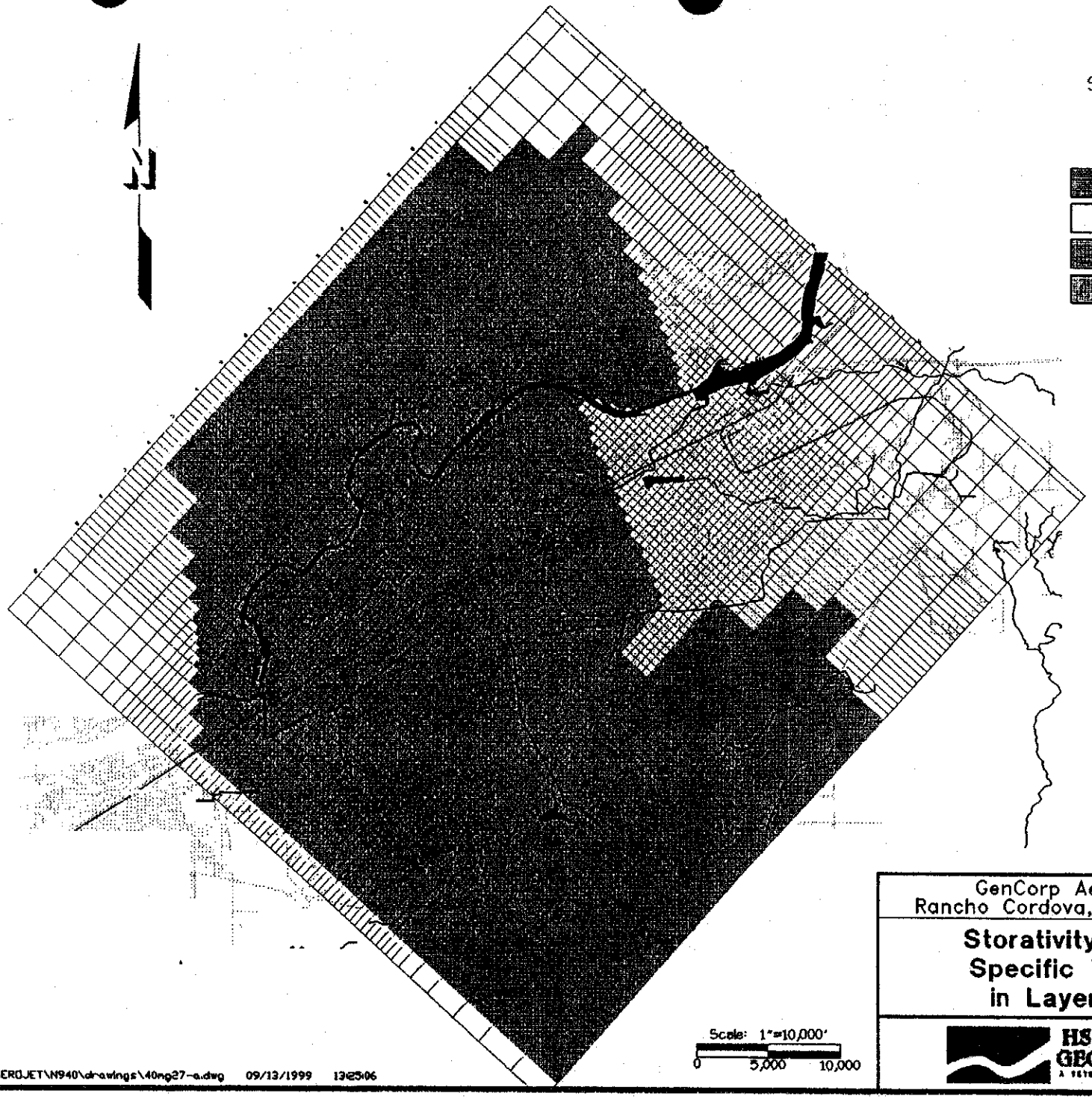
GenCorp Aerojet
Rancho Cordova, California

Storativity and Specific Yield in Layer 1

HSI GEOTRANS
A TETRA TECH COMPANY

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

Figure D4-10



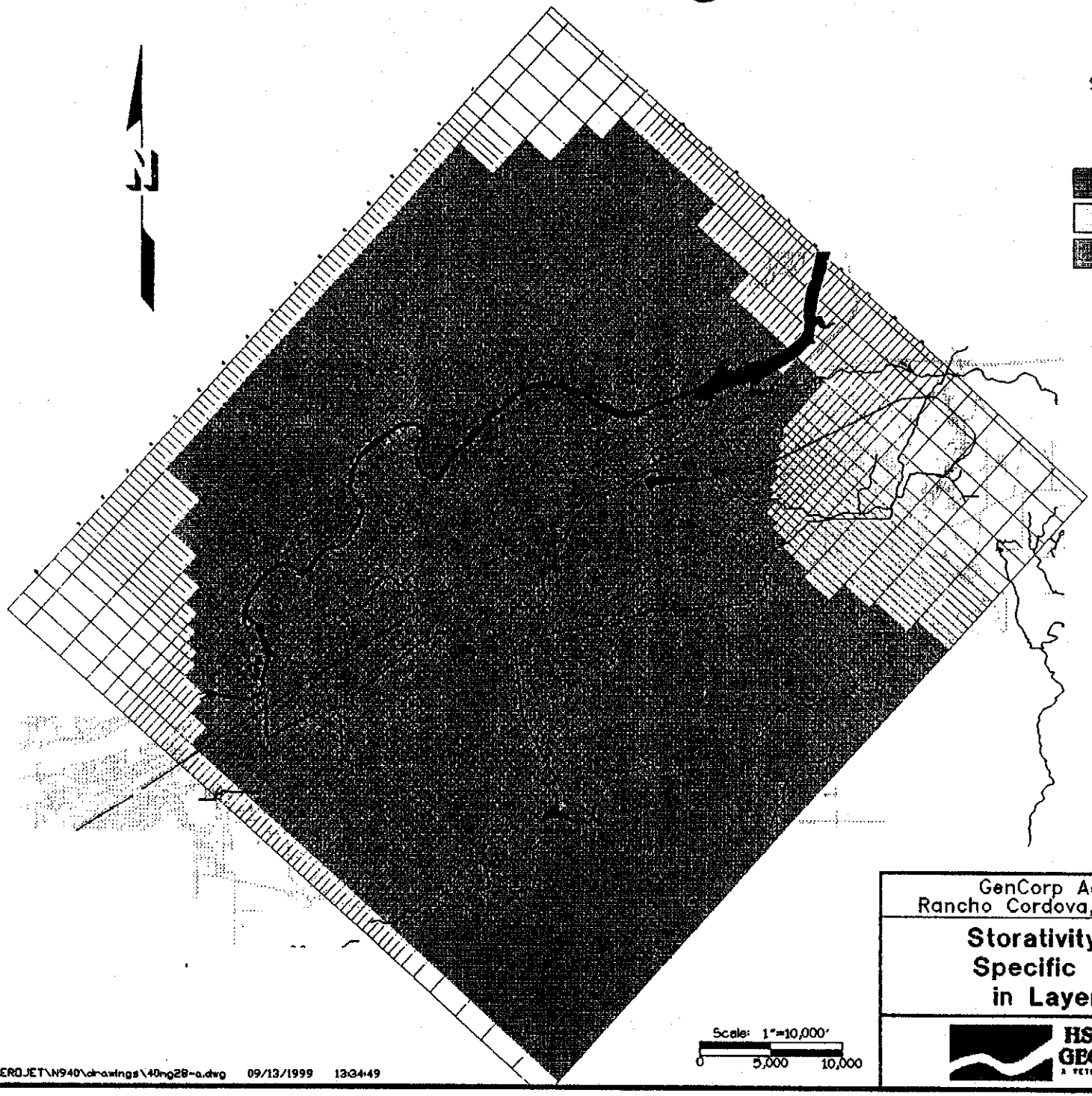
GenCorp Aerojet
Rancho Cordova, California

Storativity and Specific Yield in Layer 2

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-11



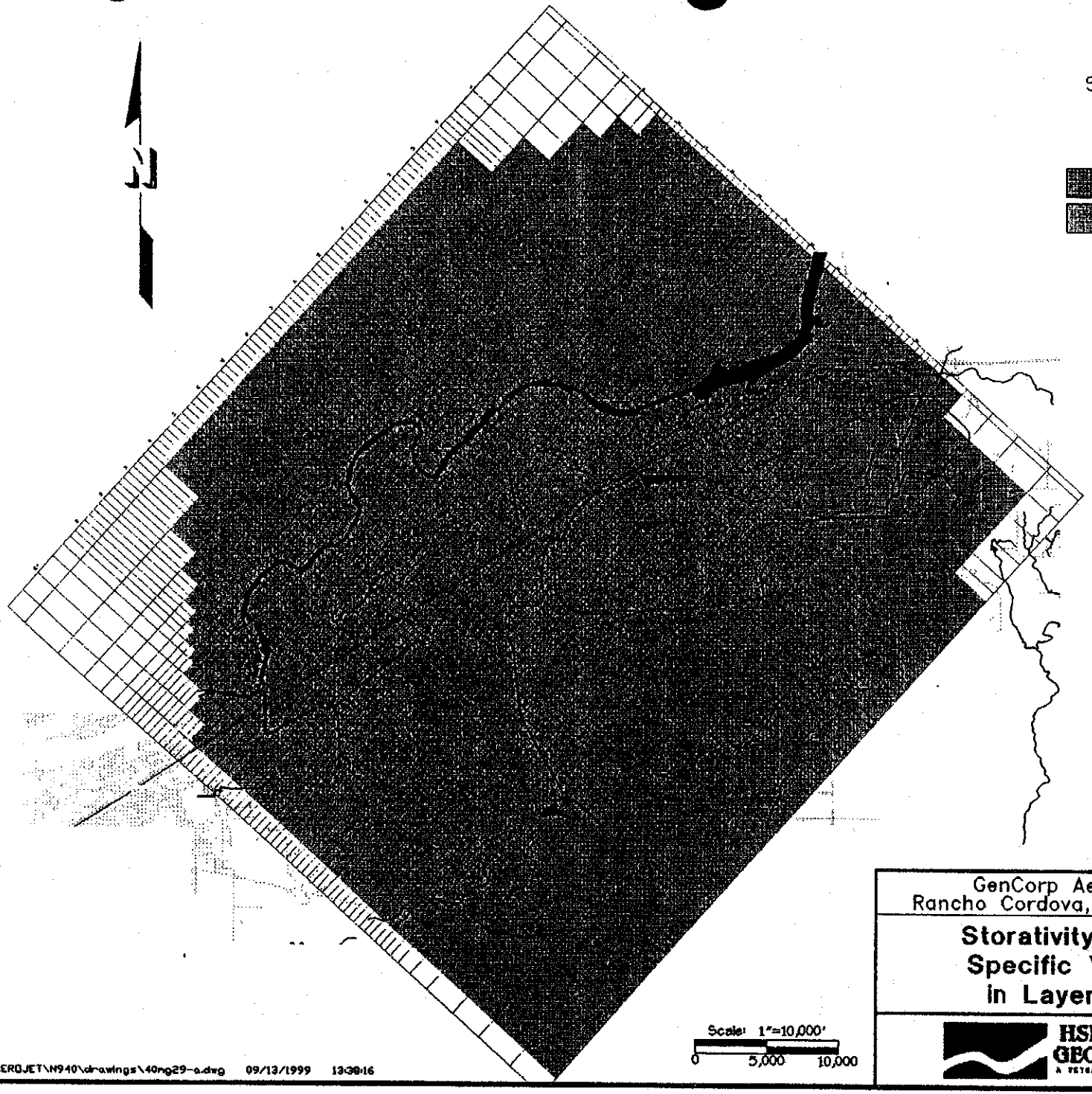
GenCorp Aerojet
Rancho Cordova, California

Storativity and Specific Yield in Layer 3

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

Figure D4-12



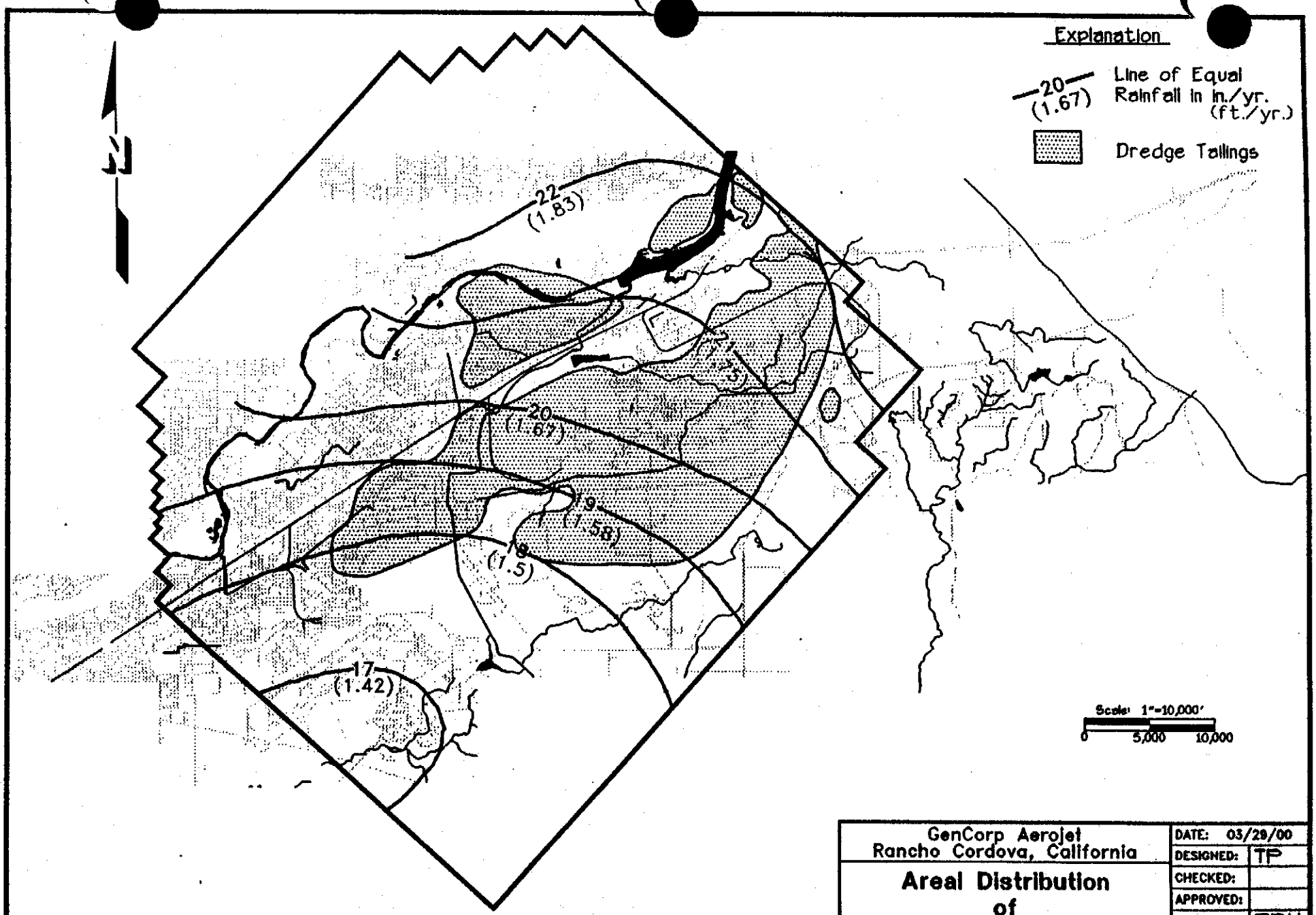
GenCorp Aerojet
Rancho Cordova, California

Storativity and Specific Yield in Layer 4

HSI GEOTRANS
A PETREX TECH COMPANY

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

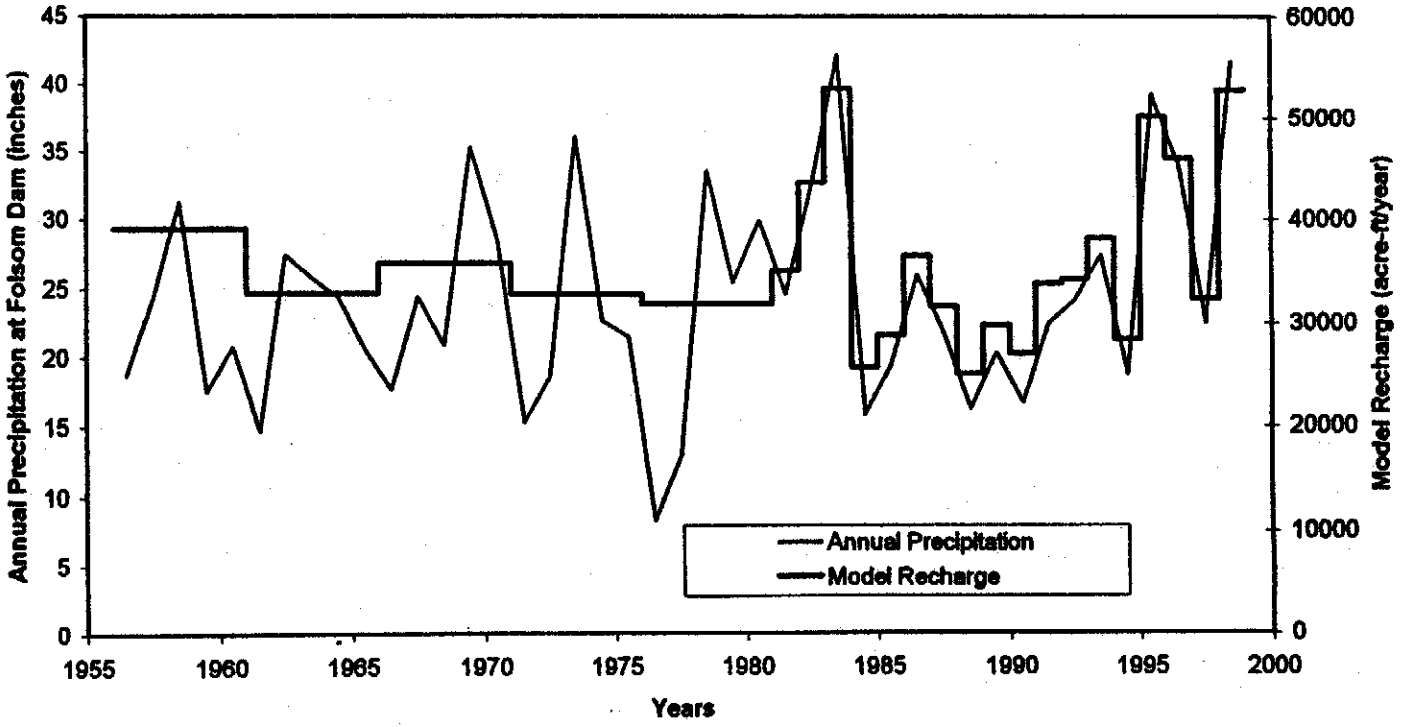
Figure D4-13



From DWR (1964)

GenCorp Aerojet Rancho Cordova, California	DATE: 03/29/00
Areal Distribution of Average Precipitation	DESIGNED: TP CHECKED: APPROVED: DRAWN: RDH PROJ.: N940-104
HSI GEOTRANS A PETRA TECH COMPANY	Figure D5-1

P:\AEROJET\N940\drawings\40mg30-a.dwg 03/29/2000 13:39:22



TITLE: Annual Precipitation and Model Recharge

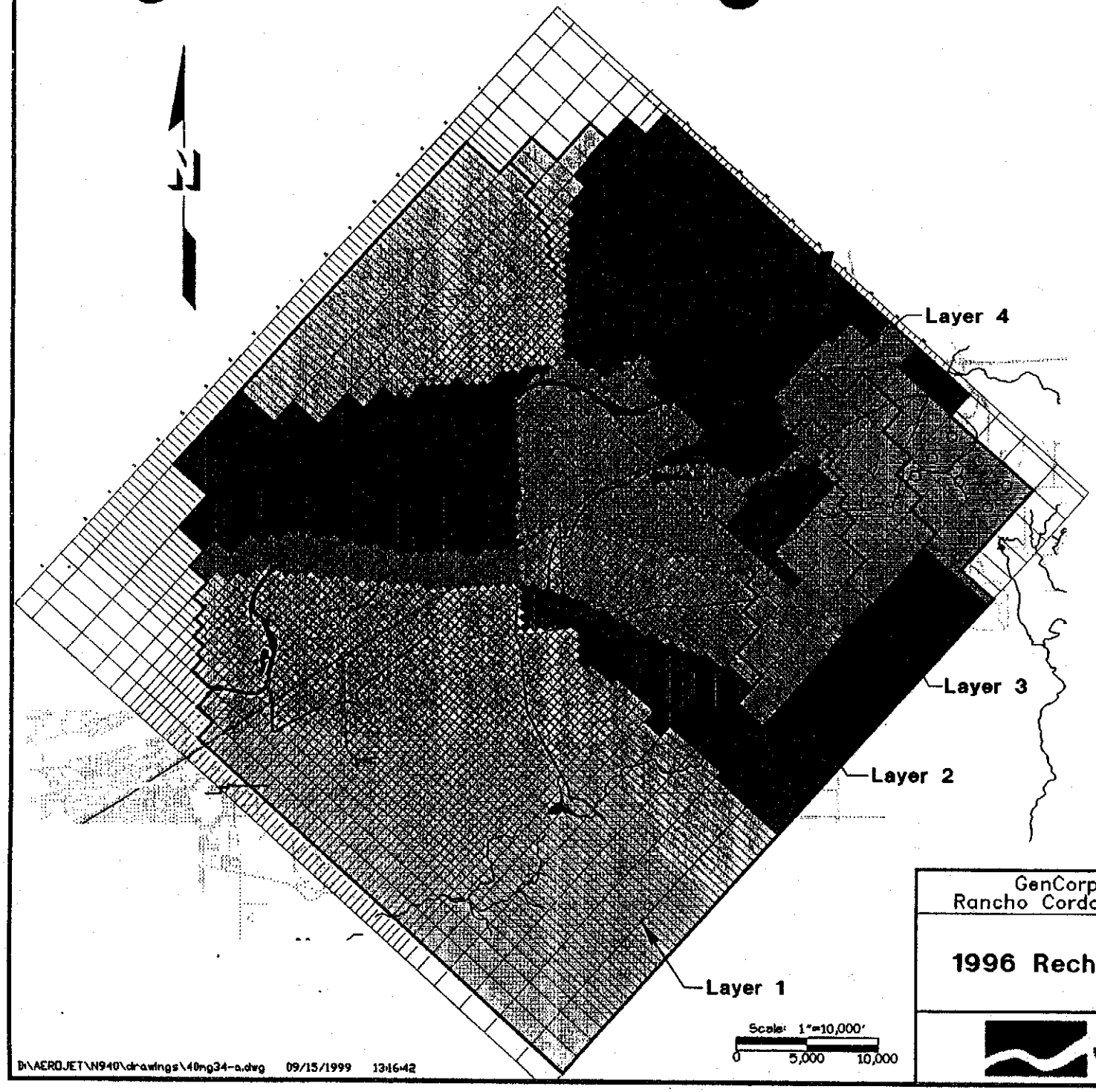
LOCATION: GenCorp Aerojet, Rancho Cordova, CA

HSI GEOTRANS

CHECKED:	TP
DRAWER:	TCL
FILE NAME:	ScatterPrecip.xls
DATE:	9/8/1999

FIGURE:

Figure D6-2



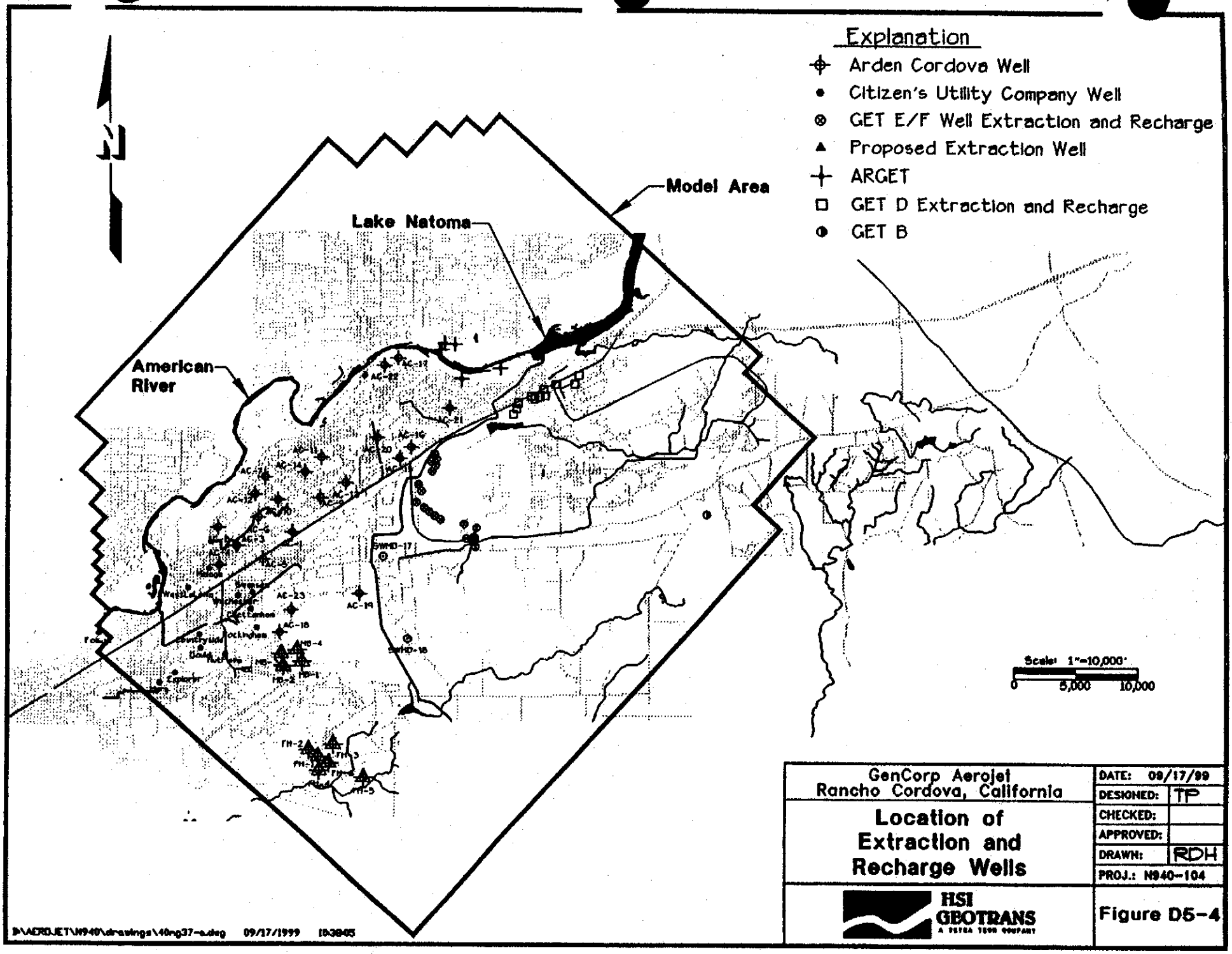
GenCorp Aerojet
Rancho Cordova, California

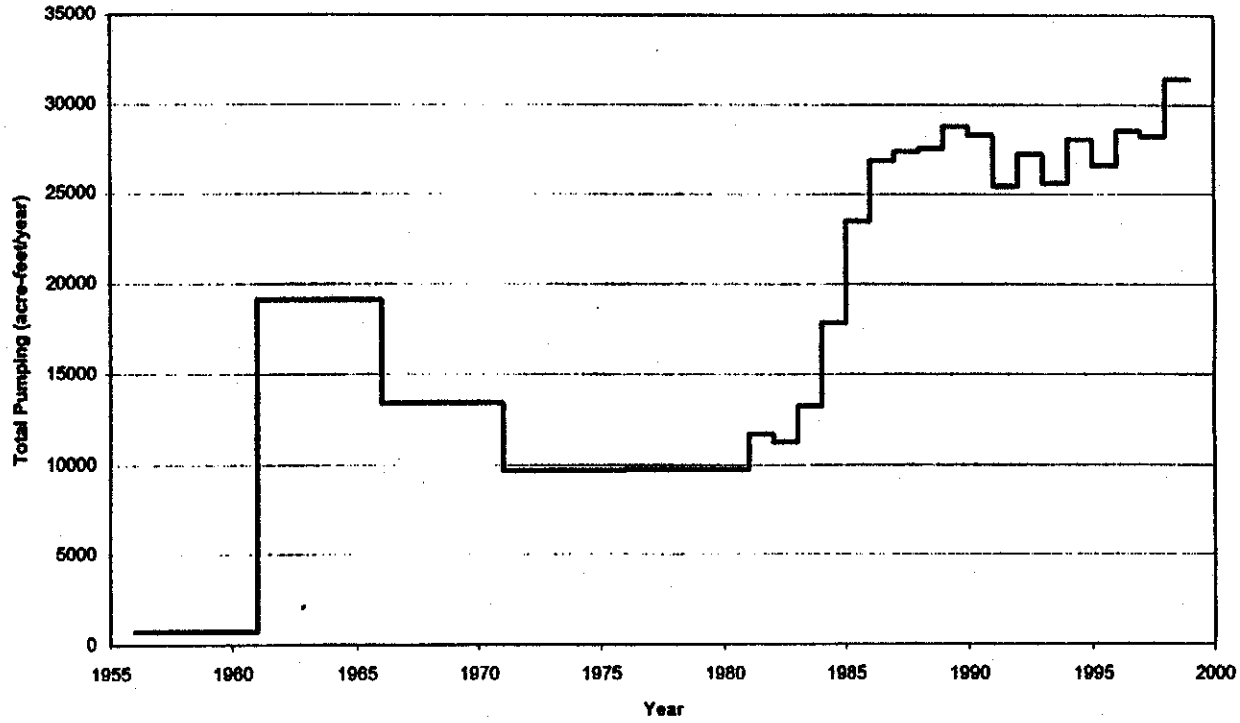
1996 Recharge Rates

DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

HSI GEOTRANS
A TETRA TECH COMPANY

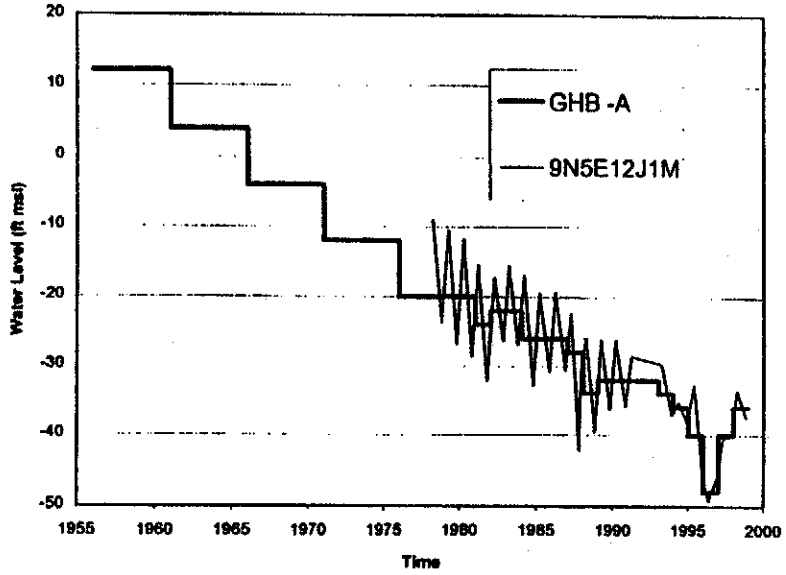
Figure D5-3

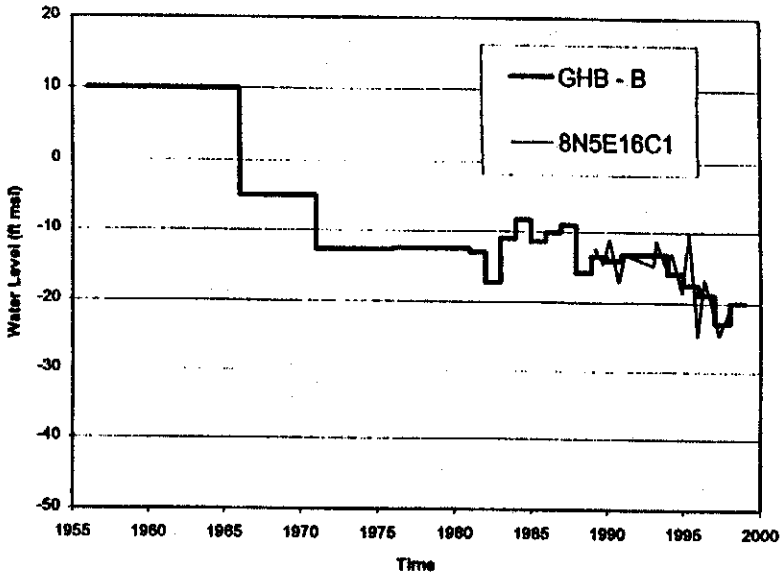

Explanation
Arden Cordova Well
Citizen's Utility Company Well
GET E/F Well Extraction and Recharge
Proposed Extraction Well
ARGET
GET D Extraction and Recharge
GET B
Model Area
Lake Natoma
American River
Scale: 1"=10,000'
0
5,000
10,000
GenCorp Aerojet
Rancho Cordova, California
Location of Extraction and Recharge Wells
DATE: 09/17/99
DESIGNED: TP
CHECKED:
APPROVED:
DRAWN: RDH
PROJ.: N940-104
HSI GEOTRANS
Figure D5-4

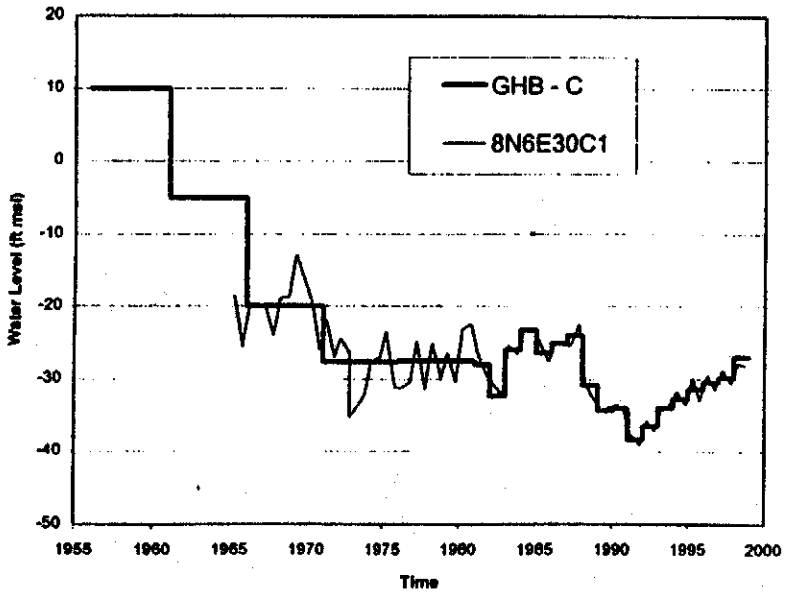


TITLE:	Total Groundwater Extractions
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS	CHECKED: IP
	DRAFTED: IQL
	FILE NAME: ScatterPlots.xls
	DATE: 9/8/1999
	FIGURE:

Figure D5-5

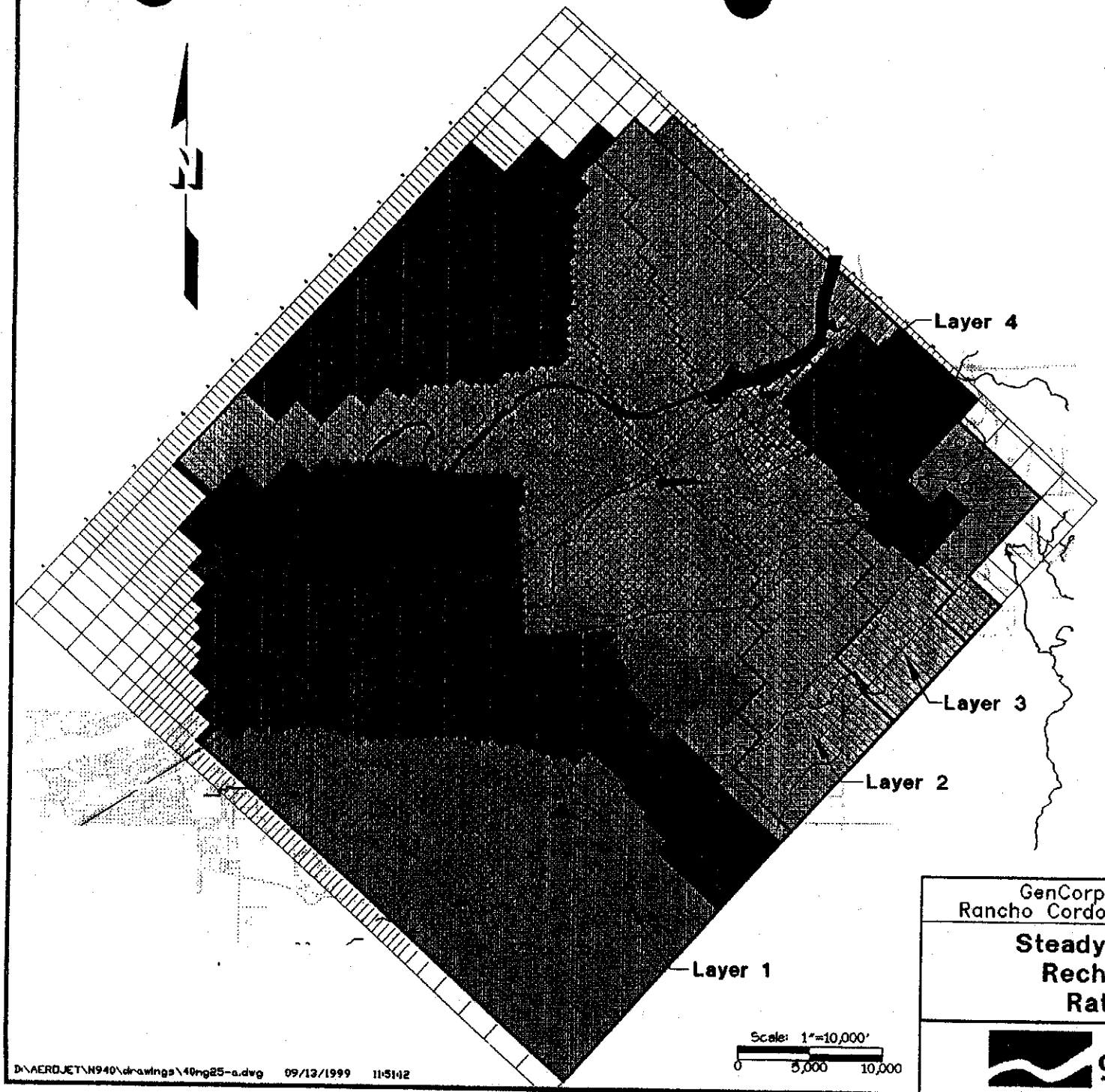






TITLE:	General Head Boundary Time Series
LOCATION	GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS	
CHECKED	TP
DRAFTED	TCL
FILE NAME	ScatterPlots.xls
DATE	9/8/1999
FIGURE	

Figure D5-6



GenCorp Aerojet
Rancho Cordova, California

Steady State Recharge Rates

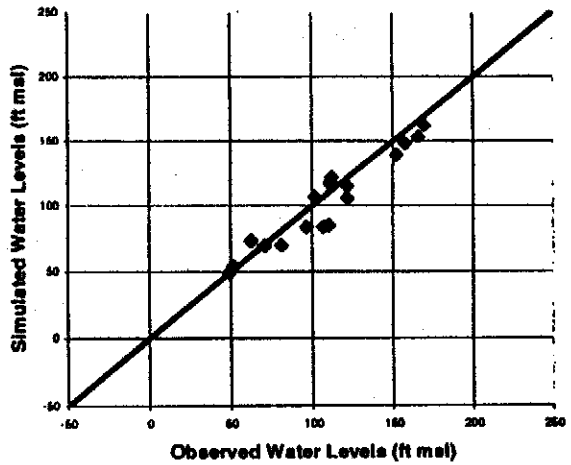
DATE:	04/03/00
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-104

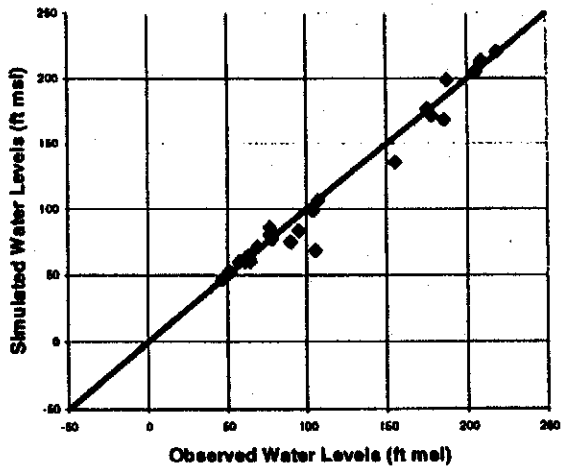
HSI GEOTRANS
A TETRA TECH COMPANY

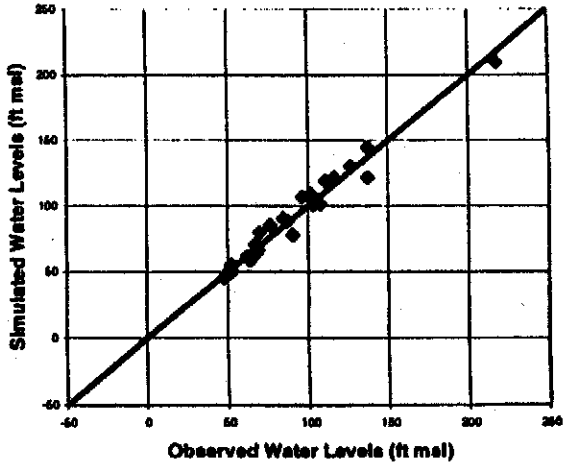
Figure D6-1

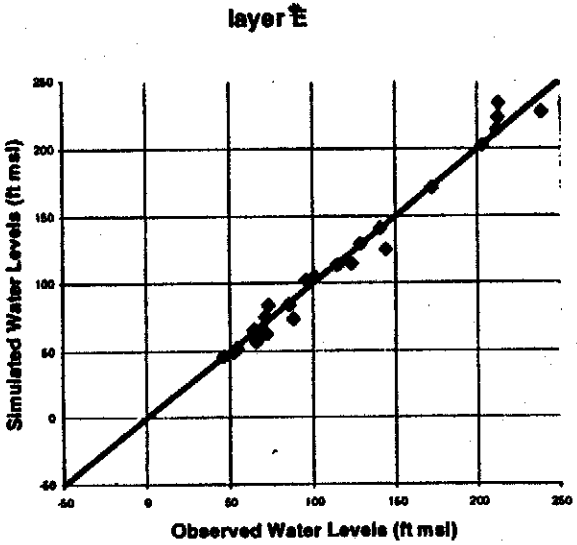
PAGES OF OVERSIZED MAPS

(SEE BINDER)





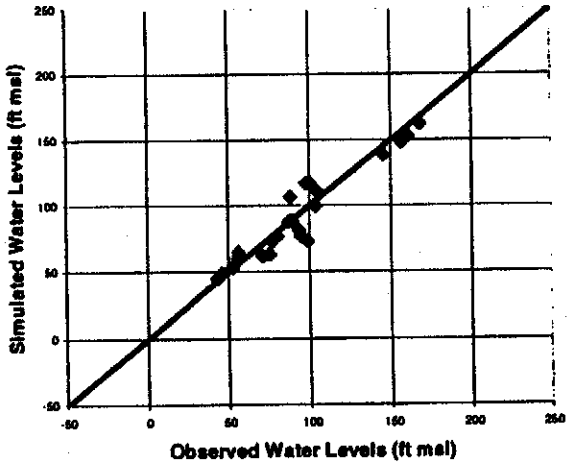




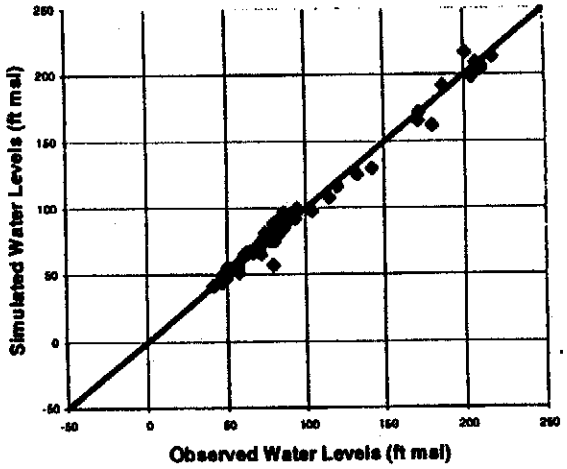
TITLE:	1984 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS	CHECKED: TP
	DRAFTED: TCL
	FILE NAME: Scatter2.xls
	DATE: 10/26/1999
	FIGURE:

Figure D6-12

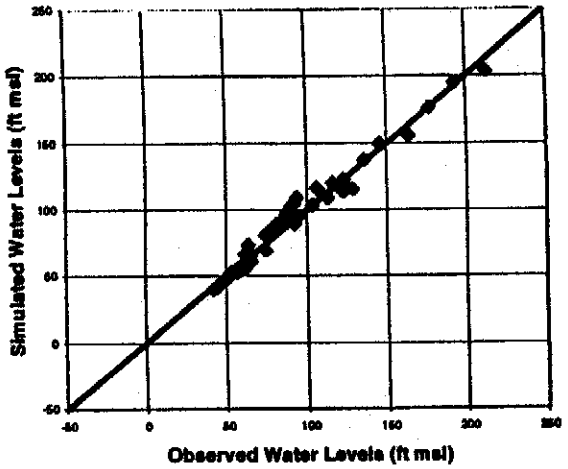
layer AB



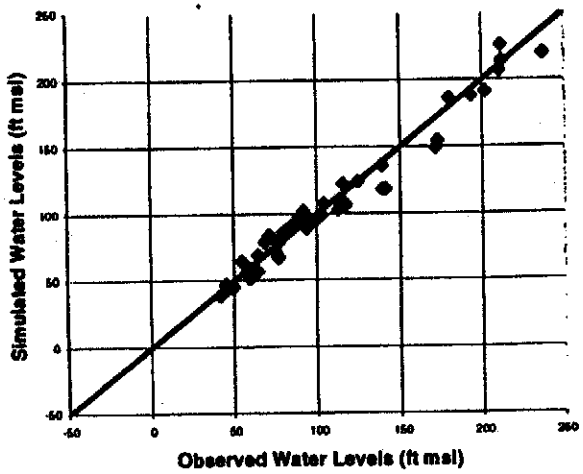
layer C



layer D



layer E



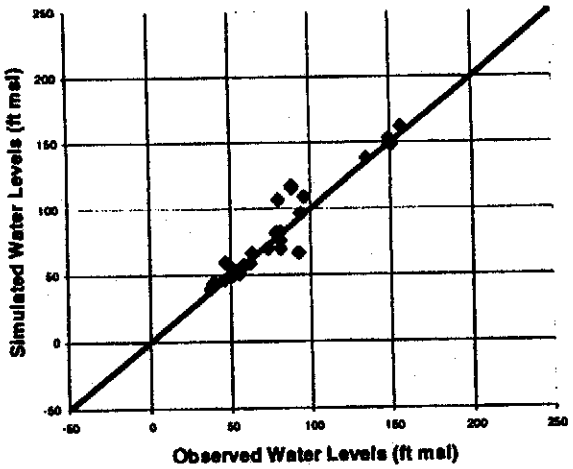
TITLE:	1986 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

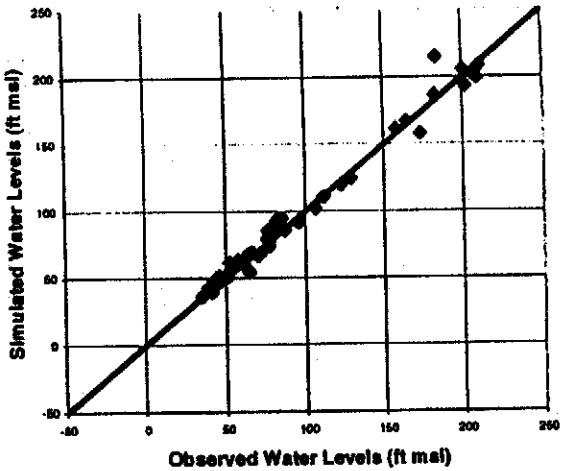
HSI GEOTRANS

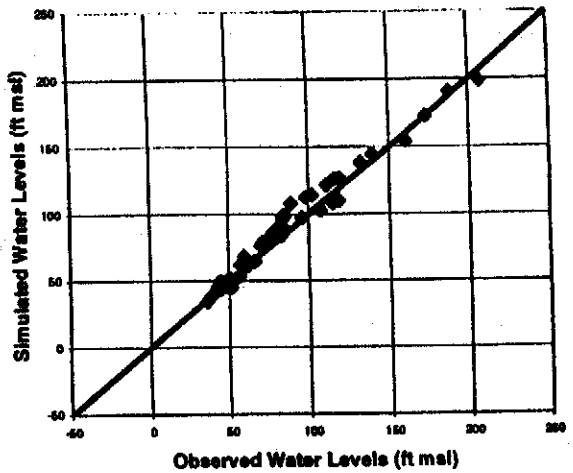
CHECKED:	TP
DRAWTED:	TCL
FILE NAME:	Scatter2.xls
DATE:	10/26/1999

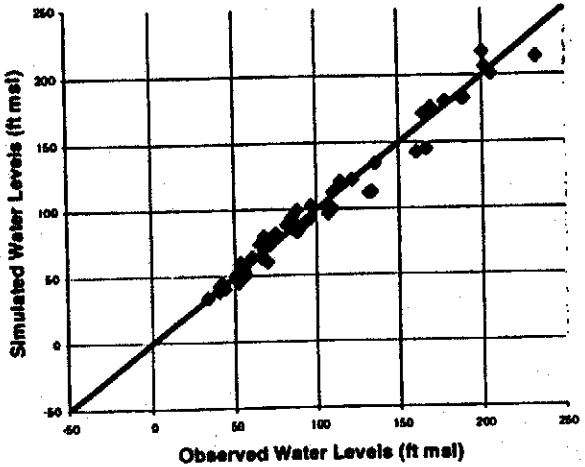
FIGURE:

Figure D6-13









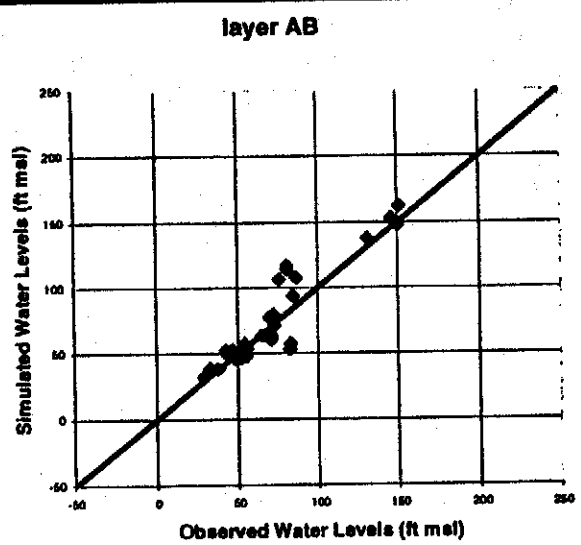
TITLE:	1988 Simulated vs. Observed Water Levels
LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

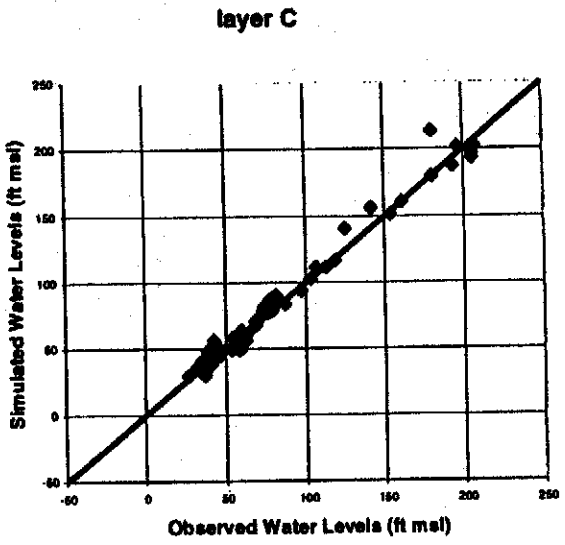
HSI GEOTRANS

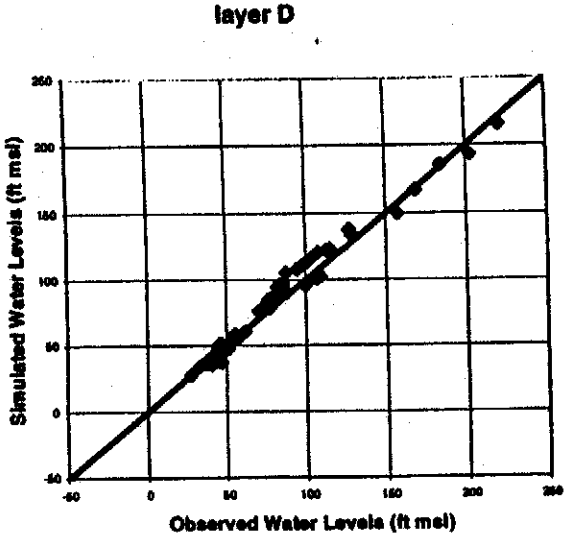
CHECKED:	TP
DRAFTED:	RQ
FILE NAME:	Scatter2.xls
DATE:	10/25/1999

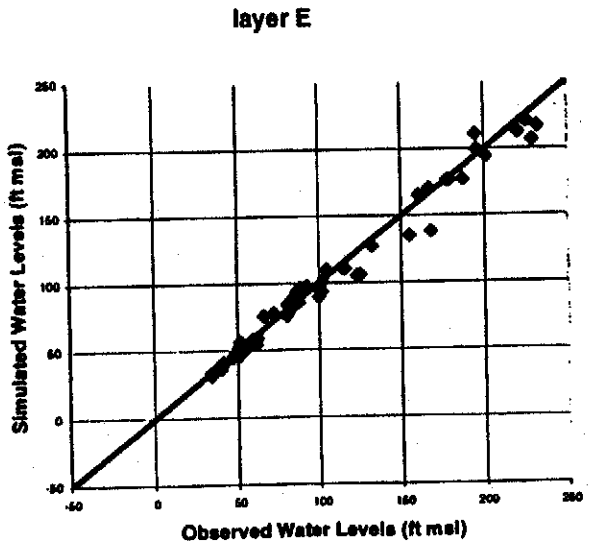
FIGURE:

Figure D6-14









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LOCATION:	GenCorp Aerojet, Rancho Cordova, CA

HSI GEOTRANS

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DRAFTED:	TCL	
FILE NAME:	Scatter2.ai	
DATE:	10/26/1999	

Figure D6-15

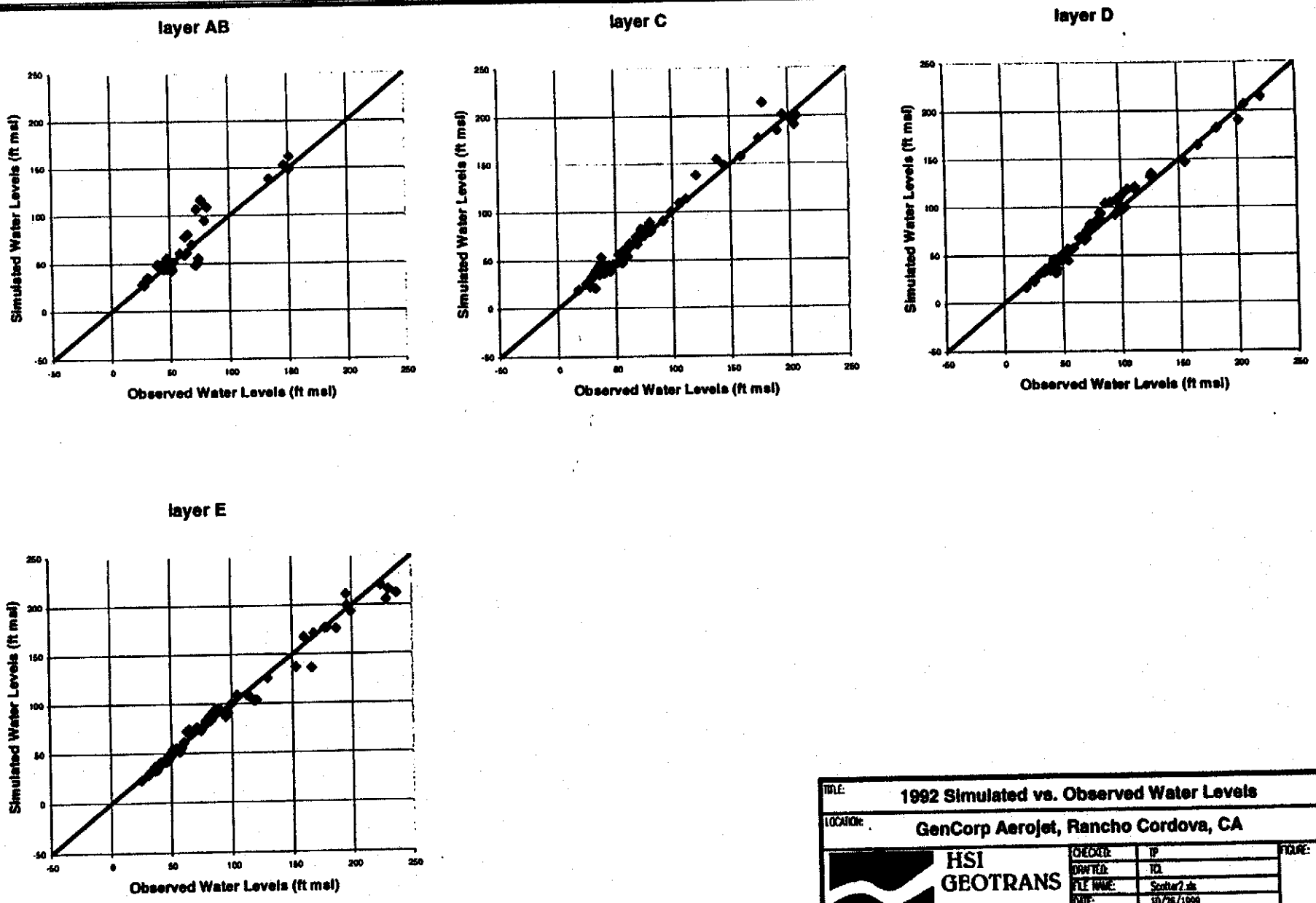

layer AB
Simulated Water Levels (ft msl)
Observed Water Levels (ft msl)
layer C
Simulated Water Levels (ft msl)
Observed Water Levels (ft msl)
layer D
Simulated Water Levels (ft msl)
Observed Water Levels (ft msl)
layer E
Simulated Water Levels (ft msl)
Observed Water Levels (ft msl)
TITLE: 1992 Simulated vs. Observed Water Levels
LOCATION: GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS
CHECKED: TP
DRAWN: TCL
FILE NAME: Scatter2.ai
DATE: 10/26/1999
FIGURE:

Figure D6-16

PAGES OF OVERSIZED MAPS

(SEE BINDER)

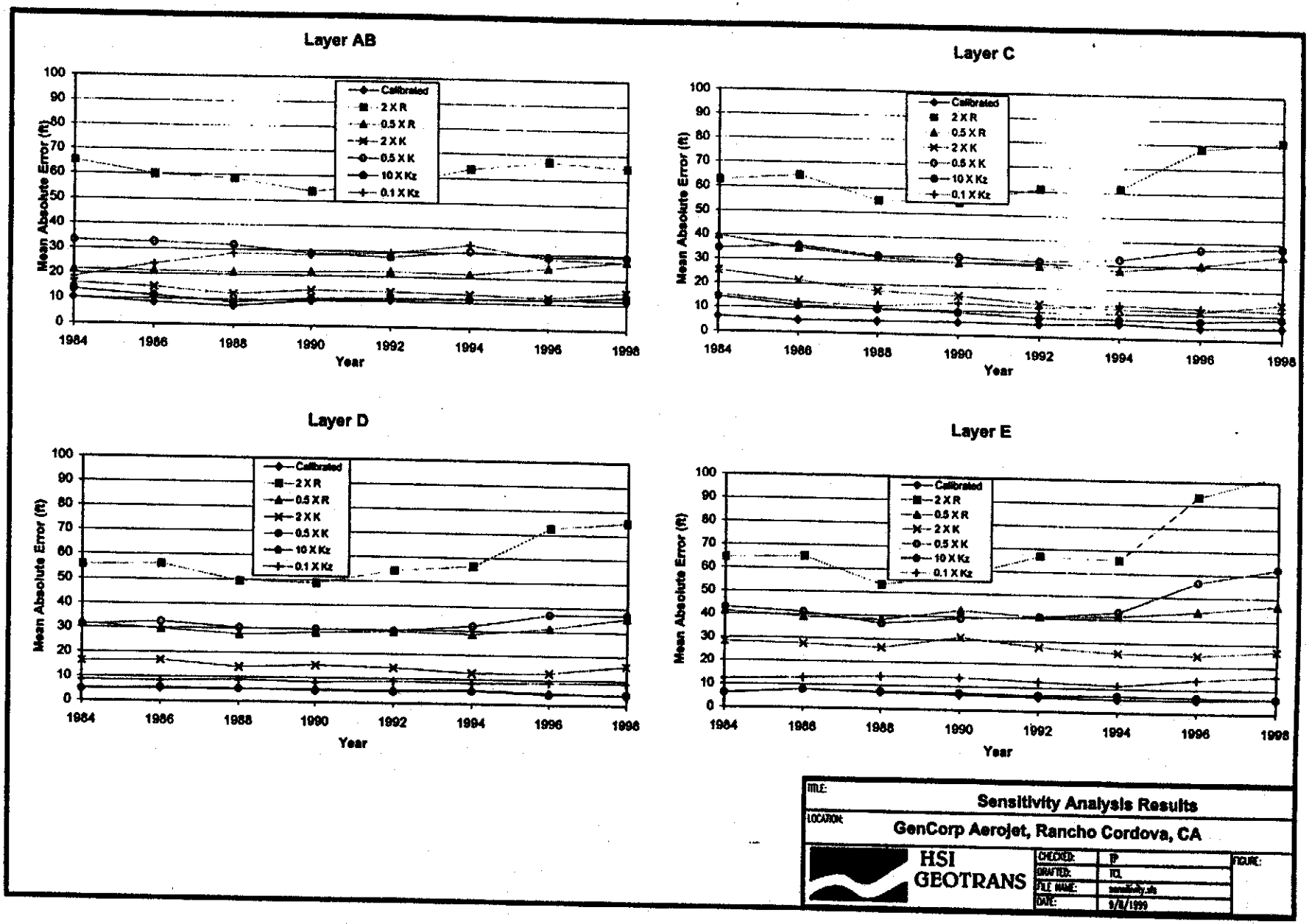
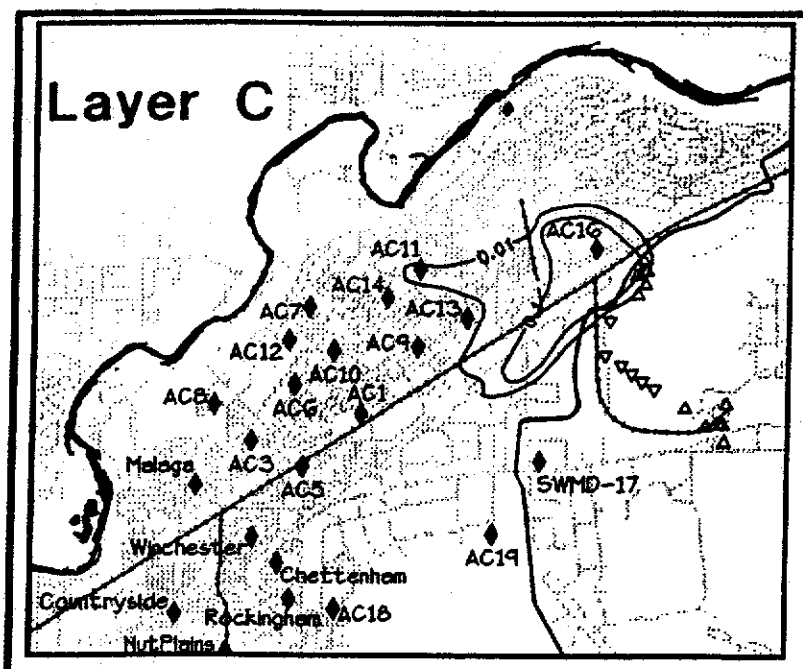
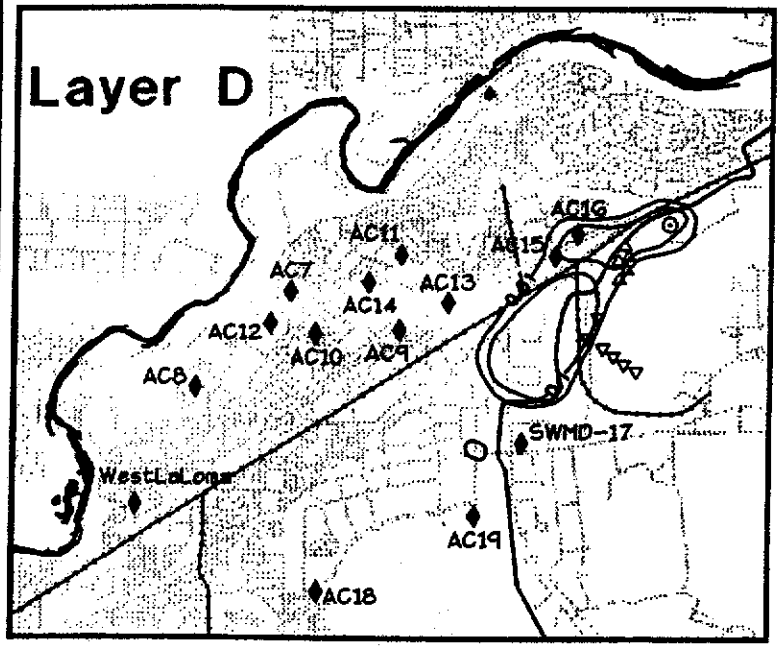
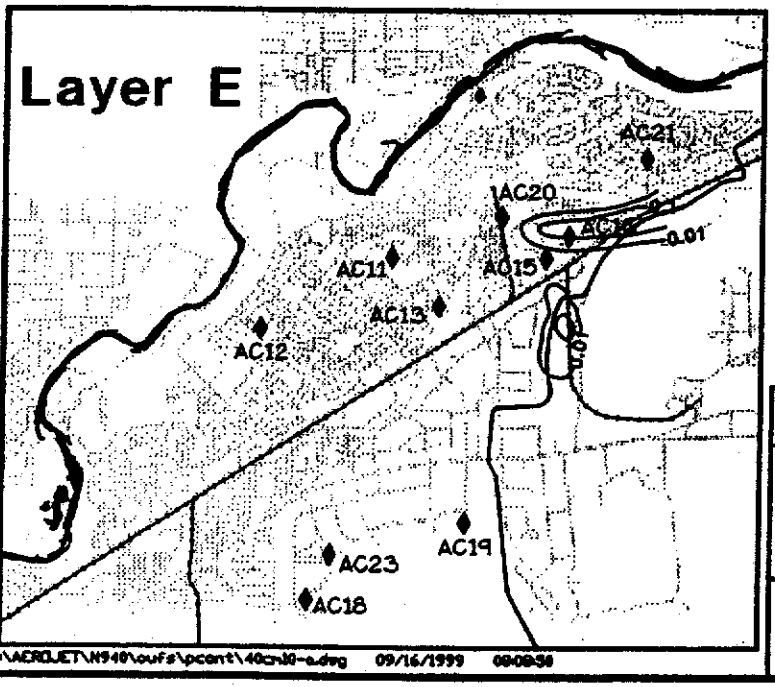

Layer AB
Layer C
Layer D
Layer E
Mean Absolute Error (ft)
Year
Calibrated
2 X R
0.5 X R
2 X K
0.5 X K
10 X Kz
0.1 X Kz
1984
1986
1988
1990
1992
1994
1996
1998
TITLE:
Sensitivity Analysis Results
LOCATION:
GenCorp Aerojet, Rancho Cordova, CA
HSI GEOTRANS
CHECKED:
DRAFTER:
FILE NAME:
DATE:
9/8/1999
FIGURE:

Figure D7-1







Explanation

- Water Supply Wells
- GET E/F Extraction Wells
- GET E/F Recharge Wells
- 0.1 NDMA Concentration (µg/l)

N

Scale 1"=8000'

0 4000' 8000'

GenCorp Aerojet
Rancho Cordova, California

Projected NDMA Migration in 2001

DATE:	04/06/0
DESIGNED:	TP
CHECKED:	
APPROVED:	
DRAWN:	RD
PROJ.:	N940-10

HSI GEOTRANS

Figure D8-

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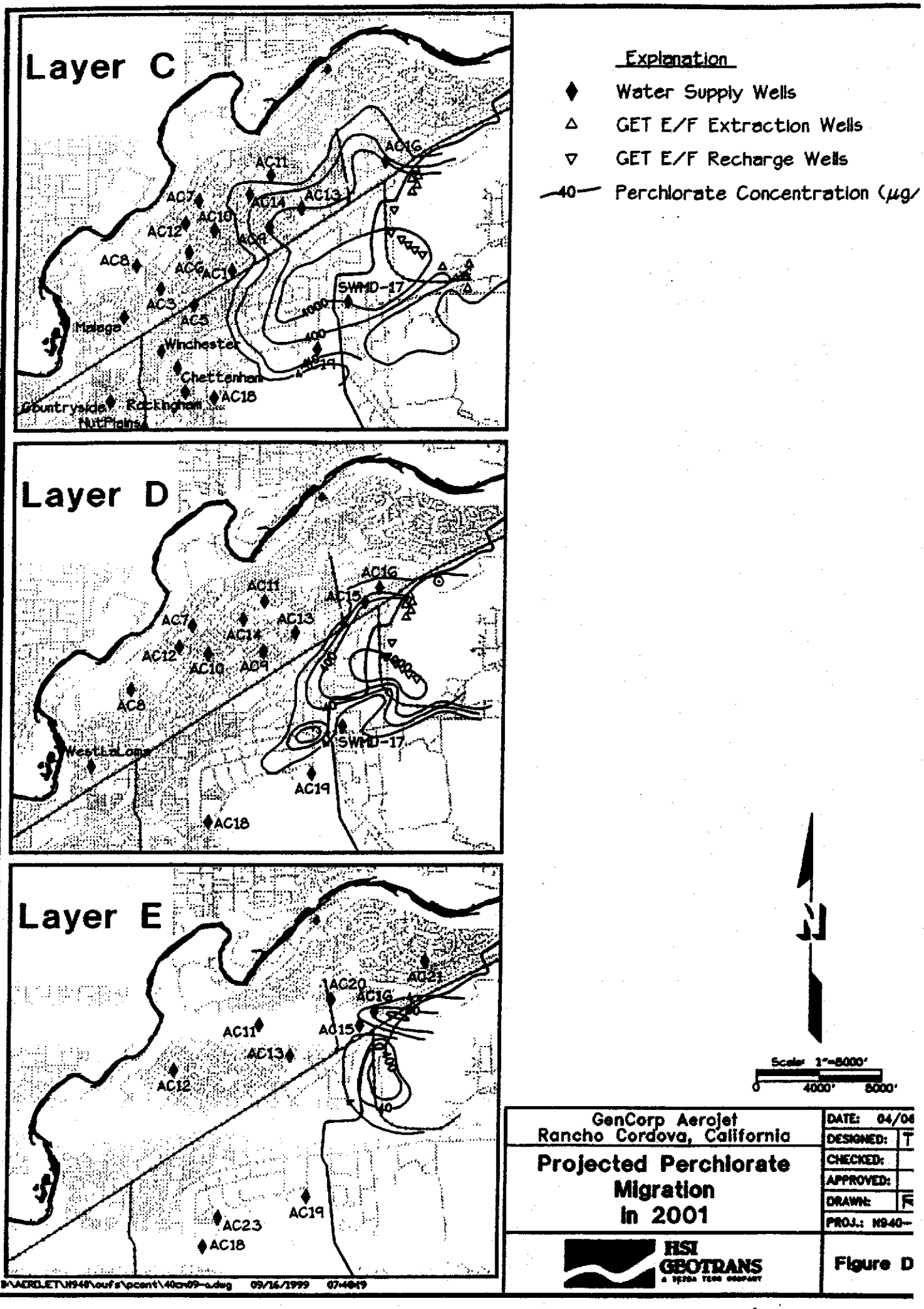
Layer C
AC16
AC11
AC7
AC14
AC13
AC10
AC12
AC9
AC8
AC6
AC15
SWMD-17
AC3
AC5
Malaga
Winchester
Chetterhan
AC18
Countryside
Rockingham
NutPlains
Layer D
AC16
AC11
AC15
AC7
AC13
AC14
AC12
AC10
AC9
AC8
SWMD-17
WestLaLoma
AC19
AC18
Layer E
AC21
AC20
AC16
AC11
AC15
AC13
AC12
AC19
AC23
AC18
Explanation
Water Supply Wells
GET E/F Extraction Wells
GET E/F Recharge Wells
Perchlorate Concentration (µg/
Scale 1"=8000'
0
4000'
8000'
GenCorp Aerojet
Rancho Cordova, California
Projected Perchlorate Migration in 2001
DATE: 04/0
DESIGNED:
CHECKED:
APPROVED:
DRAWN:
PROJ.: N940--
HSI GEOTRANS
Figure D
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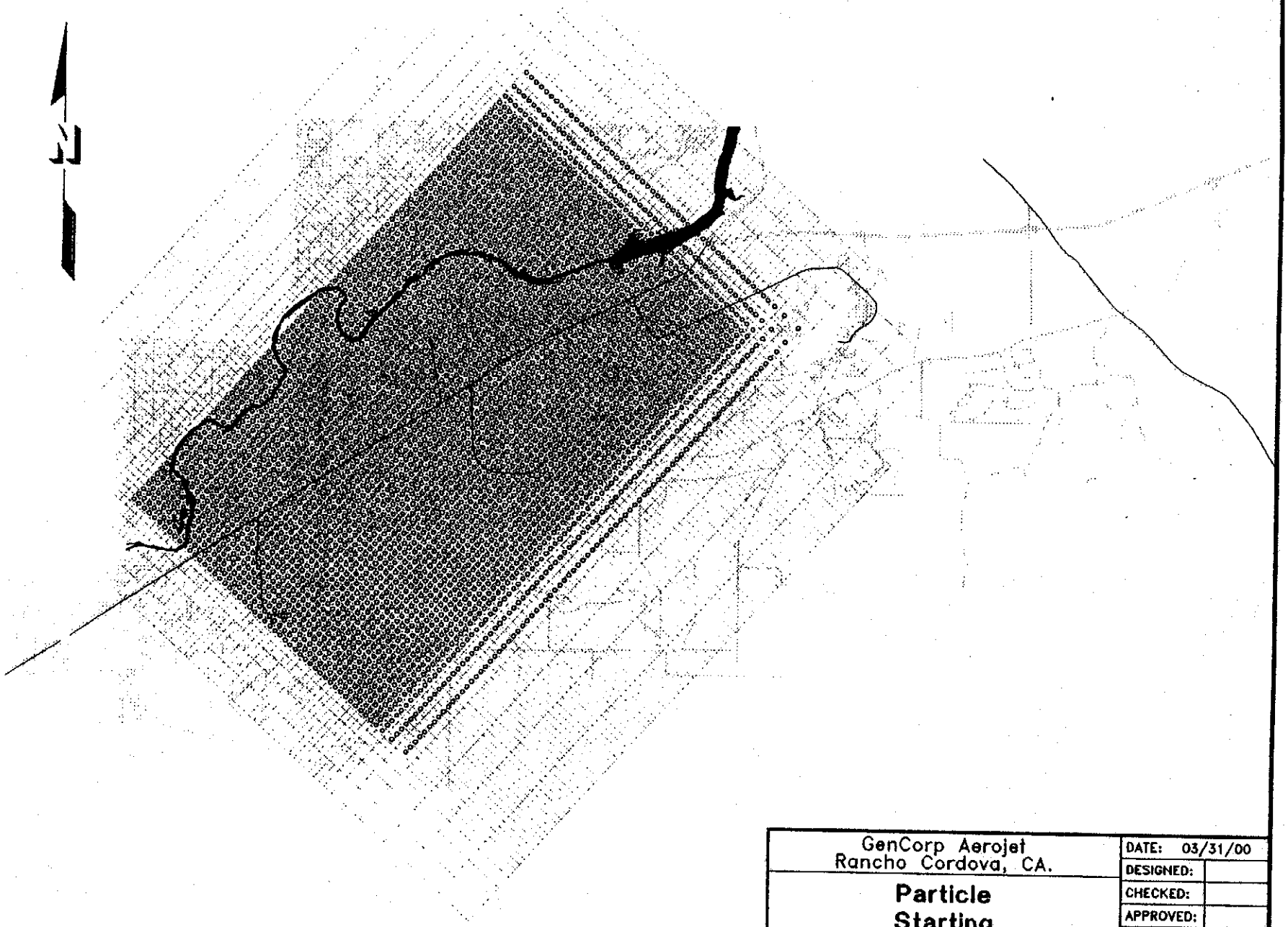

Scale: 1"=10,000'
0 5,000 10,000

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GenCorp Aerojet
Rancho Cordova, CA.

Particle Starting Locations

HSI GEOTRANS
A TETRA TECH COMPANY

DATE:	03/31/00
DESIGNED:	
CHECKED:	
APPROVED:	
DRAWN:	RDH
PROJ.:	N940-102

Figure D8-3

PAGES OF OVERSIZED MAPS

(SEE BINDER)

Appendix E

DETAILED COST ESTIMATES

Capital, operation and maintenance (O&M), and present worth cost estimates for each alternative are presented in this Appendix. A summary table of these costs for each alternative are provided at the beginning and detailed cost estimates for the components of each alternative are presented following the summary table. The summary table and detailed estimates for each alternative are provided at the end of this Appendix. Detailed costs are broken down by the various components of each alternative: groundwater monitoring, providing alternate water supply, wellhead treatment, groundwater extraction, groundwater conveyance, groundwater treatment and treated water management/reuse. Capital cost details are provided for the years in which capital costs are projected to occur. A representative O&M cost detail is included for one of the years over the 25-year period for which present worth costs are estimated.

In accordance with EPA guidance, the cost estimates for each alternative are order-of-magnitude estimates and are generally accurate within the range specified in the guidance. The accuracy of the estimates is subject to substantial variation because details of the specific design will not be known until any remedy is implemented. For example, the actual site conditions, project scope and schedule, design details, competitive market conditions, changes during construction, labor and equipment rates, and other variables are not known.

Furthermore, the selection of technologies or process options is not intended to limit flexibility during remedial design. The selection provides a basis for estimating costs. Remedial design efforts might reveal possible cost savings as a result of value engineering studies and reduce the cost of implementing the remedy. In addition treatment technologies for removal of NDMA and perchlorate that were in the developmental and full scale testing phases during preparation of this OU RI/FS may be substantially more proven at the time of design, incorporated into the remedy and provide significant cost savings.

Wherever possible, actual capital and O&M costs from construction and operation of existing monitor wells, extraction and recharge wells, conveyance piping - both onsite and offsite, groundwater treatment facilities, recharge wells, and treated groundwater recharge and surface water discharge facilities for the GET systems at Aerojet were used for these cost estimates. Construction industry standard cost estimating cost guides (RS Means *Heavy Construction Cost Data,* 13th Annual Edition, 1999, and Dodge Unit Cost Guide 2000) were also consulted. The basis for the costs is stated in the sections that follow and in the detailed tables provided at the end of this appendix.

E-1 Summary of Estimated Alternative Costs

Estimated costs for Alternatives 1 through 5B are included. The tables show the capital and O&M cost estimates for monitoring, alternate water supply, wellhead treatment, groundwater extraction, groundwater treatment, and treated water management/reuse. Costs to maintain institutional controls were assumed to be negligible. All cost estimates are shown in 1999 dollars and include a 15 percent contingency. Present worth cost estimates (assuming a 7 percent discount rate in accordance with the most recent EPA guidance [USEPA, 1996e]) are also provided.

E-2 Capital and O&M Cost Detail

E-2.1 Extraction Wells and Conveyance Piping Capital Cost Estimates

Costs for extraction wells were based on a total depth of 300 feet below ground surface (bgs) for wells screened in Layer C, a depth of 400 feet bgs for wells screened in Layer D, and 500 feet bgs for wells screened in Layer E. Several of the extraction wells that would be installed onsite would be multiple-completion wells installed in one location. These wells are designated as New GET E, New-1, New-2, and New-3 on the various figures that are referenced with respect to the various alternatives in Section 4. For monitor well capital costs, it was assumed that 1.5 monitor wells would be constructed for each extraction well. Percentage costs for contractor markup, mobilization/demobilization, insurance, engineering, construction management, regulatory oversight, and contingency are also included.

Conveyance piping costs were estimated on a per lineal foot basis based on actual groundwater and water piping project construction costs for piping associated with the Aerojet GETs E and F and ARGET facilities, recent piping projects in the Sacramento area, and recent Means and Dodge construction cost estimating guides. The per lineal foot piping construction cost estimates varied depending on the pipe diameter and whether the installation was estimated to occur in existing streets/rights-of-way or in undeveloped land within the Aerojet property boundary.

For several of the remedial alternatives, it is estimated that an extensive conveyance piping array will be required in the Study Area west of the Aerojet site. If such a piping system were to be implemented as part of a remedy for the Western Groundwater OU, a preliminary alignment study, any environmental permitting, and final alignment study would probably have to be prepared. The conveyance piping cost estimates do not reflect that an alignment study was performed, assume that piping would be constructed within existing easements and/or rights-of-way and streets, assume that parcels of land will not be taken through imminent domain, and do not include allowances for utility relocation, extensive traffic control, night construction, or bridge crossings. It is further assumed that conveyance piping would be constructed as single-walled pipe. An allowance of $20 per inch diameter of pipe was estimated for jack/bore crossings of US Highway 50,

Folsom Boulevard and associated main rail lines and spurs, and the Folsom South Canal. Following is a listing of the unit prices used to estimate conveyance piping construction costs:

Pipe Diameter (inches)	Estimated Construction Cost ($/lineal foot)
6 and 8	100
10 and 12	140
16	175
20	225
24	260
30	300
Open field areas on Aerojet site	$8 per inch-diameter

E-2.2 Extraction Wells and Conveyance Piping O&M Cost Estimates

An allowance per extraction well per year was included for extraction well O&M and includes labor and repair and replacement supplies. Electrical utility costs vary by extraction well and are based on the estimated extraction flowrate and total dynamic head estimated for each extraction well pump and the current electrical utility rate paid by Aerojet of $0.05 per kilowatt-hour (kWh). Pipeline maintenance was estimated at $10,000 per year for the alternatives that included an offsite conveyance piping system.

Costs for monitoring are based on current Aerojet-Sacramento facility costs for the PCD Exhibit IV and VI requirements for the Western Groundwater Study Area groundwater monitoring program on a per-sample basis for labor and equipment ($110 per well completion), and the following per sample analytical costs: VOCs ($50 each), SVOCs ($225 each), perchlorate ($50 each), and NDMA ($60 each). Since most samples would be analyzed for VOCs, perchlorate, and NDMA, an average per sample cost of $300 was used in the detailed cost estimates. For this cost estimate it is assumed that the per-sample costs would be the same and that the number of samples collected annually for each alternative would to be approximately equivalent to the number of samples currently required by Exhibits IV and VI of the PCD plus samples collected from new monitor wells proposed for each alternative as discussed in Section 4. The numbers of extraction and monitor wells used to calculate the monitoring costs for each alternative are shown on the detailed cost estimates that follow.

E-2.3 Alternate Water Supply Cost Estimates

Capital and O&M costs for LPGAC treatment were developed using estimates from Calgon Carbon Corporation of $140,000 for each 2-20,000 pound (operated in series) contactor system, which is capable of treating an incremental flow of approximately 750

gpm. O&M costs for LPGAC were estimated at $0.75 per pound of GAC and assuming GAC is replaced at a frequency of once every two years.

For construction of surface water treatment capacity, the HDR/CWC Water Cost Manual, Estimating Costs for Treatment Plant Construction (Qasim et. al., 1992), and EPA's Estimating Water Treatment Costs Volume 2: Cost Curves Applicable to 1 to 200 mgd Treatment Plants (USEPA, 1979) were used for a typical surface water treatment facility employing the raw water pumping, coagulation/flocculation, filtration, disinfection, and treated water storage unit processes. Costs were escalated to February 1999 dollars. From the costing model the capital costs for a 10 million gallon per day (MGD) surface water treatment facility were estimated to be $5.5 million. Water treatment O&M costs were estimated at $0.074 per 1,000 gallons. Capital costs for water treatment facilities with flowrates greater or less than 10 MGD were estimated using the capital cost estimate and the following exponential cost correlation (Perry and Green, 1984):

$$\text{Capital Cost}_{\text{Flow B}} = \text{Capital Cost}_{\text{Flow A}} (\text{Flow}_B/\text{Flow}_A)^{0.6}$$

E-2.4 Groundwater Treatment Cost Estimates

Groundwater treatment capital costs were estimated using actual equipment and installation costs for recent construction of the ARGET facility and expansions to the GET B and GET F groundwater treatment facilities. Capital and O&M costs for the biological reduction process were estimated using cost curves developed in February 1997 by EarthTech for Aerojet and escalated to 1999 dollars using the Engineering News Record Construction Cost Index (ENR, 1999). Capital and O&M cost estimates for the UV/oxidation process were obtained from preliminary quotes from Calgon Carbon Corporation for their 30 kW and 276 kW AOT units and from preliminary O&M cost estimates for an innovative NDMA removal process currently undergoing full-scale testing at Aerojet. With respect to perchlorate removal costs using ion exchange in the wellhead treatment scenario, capital and O&M costs were estimated using preliminary quotes from Calgon Carbon Corporation for their ISEP ion exchange system and perchlorate and nitrate destruction module (PNDM) regenerant brine recycling system.

O&M costs for treatment include electric utility costs at $0.05 per kWh for transfer pumping and treatment equipment, chemicals required to operate the biological reduction and UV/oxidation processes, UV bulb replacement, equipment maintenance at three percent of equipment capital costs per year, operator and management oversight labor, and monitoring of various locations within the treatment system.

For purposes of costing, it was assumed that treatment of offgas emissions from any air stripping polishing unit process for removal of any VOCs remaining after the UV/oxidation process would not be required. Specifically, it was assumed that the initial emission rate for any VOCs from the air stripping process following the UV/oxidation process would not result in a residential 70-year maximum exposed individual (MEI)

cancer risk value above the 0.1×10^{-6} *deminimus* level referenced in SMAQMD new source review air quality rules.

E-2.5 Management/Reuse of Treated Groundwater Cost Estimates

Capital costs for management/reuse of treated groundwater include estimated costs for piping to convey treated groundwater to a water distribution system to deliver treated groundwater for direct reuse (Alternatives 2A and 2B). For Alternatives 3A and 3B, it was assumed that the existing piping at the various wellhead locations could be used to convey the treated water to the water distribution system. For purposes of costing the direct reuse of treated groundwater component of Alternatives 2A and 2B, it was assumed that the groundwater treatment process train described previously with the addition of the LPGAC unit process would be sufficient. Also for the direct reuse option it was assumed that the water purveyor would provide the disinfection process.

O&M costs for management/reuse of treated groundwater include estimates of electric utility costs to convey the treated water for those alternatives where the water is conveyed to a water distribution system under the direct reuse option, discharged to surface water, or recharged. Maintenance costs associated with recharge well maintenance and monitoring costs were also included.

If the treated water management/reuse options of (1) discharge to the American River to offset surface water exchange, or (2) use for irrigation or other non-potable purposes as implemented, there may be additional capital costs associated with dual distribution system piping that may have to be shared between Aerojet and the user of the non-potable water. O&M costs and revenues associated with these options might include a difference in value between exchanged surface water and treated groundwater in the Folsom South Canal, costs to convey and store treated groundwater for irrigation or other non-potable purposes, and revenue associated with the value of treated groundwater when the groundwater is exchanged or sold for irrigation or other non-potable purposes.

Detailed Cost Estimates

Potential Estimated Additional Costs for Replacement Water for Direct Reuse and Indirect Reuse

Present Worth Cost Estimate

Replacement Water - Direct Reuse

			Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	3,909,000	66,500	3,975,500	3,976,000	3,976,000
2002	1	0.93458		133,000	133,000	124,000	4,100,000
2003	2	0.87344		133,000	133,000	116,000	4,216,000
2004	3	0.81630		133,000	133,000	109,000	4,325,000
2005	4	0.76290		133,000	133,000	101,000	4,426,000
2006	5	0.71299		133,000	133,000	95,000	4,521,000
2007	6	0.66634		133,000	133,000	89,000	4,610,000
2008	7	0.62275		133,000	133,000	83,000	4,693,000
2009	8	0.58201		133,000	133,000	77,000	4,770,000
2010	9	0.54393		133,000	133,000	72,000	4,842,000
2011	10	0.50835		133,000	133,000	68,000	4,910,000
2012	11	0.47509		133,000	133,000	63,000	4,973,000
2013	12	0.44401		133,000	133,000	59,000	5,032,000
2014	13	0.41496		133,000	133,000	55,000	5,087,000
2015	14	0.38782		133,000	133,000	52,000	5,139,000
2016	15	0.36245		133,000	133,000	48,000	5,187,000
2017	16	0.33873		133,000	133,000	45,000	5,232,000
2018	17	0.31657		133,000	133,000	42,000	5,274,000
2019	18	0.29586		133,000	133,000	39,000	5,313,000
2020	19	0.27651		133,000	133,000	37,000	5,350,000
2021	20	0.25842		133,000	133,000	34,000	5,384,000
2022	21	0.24151		133,000	133,000	32,000	5,416,000
2023	22	0.22571		133,000	133,000	30,000	5,446,000
2024	23	0.21095		133,000	133,000	28,000	5,474,000
2025	24	0.19715		133,000	133,000	26,000	5,500,000
2026	25	0.18425		66,500	66,500	12,000	5,512,000
	Total Estimated Costs:		3,900,000				5,500,000

Capital Cost Estimate
Replacement Water - Direct Reuse

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2001)					
Polishing Treatment and Treated Groundwater Piping to Water Distribution System					
GETs E/F GWTP					
LPGAC polishing contactors 750 gpm each (incl. GAC)		5	ea	140,000	700,000
General contractor installation @ % of equipment		700,000	%	20	140,000
Slab-on-grade for LPGAC contactors	5	800	sq ft	20	80,000
Transfer pumps (incl. in GET F GWTP)		0	ea	1	0
Electrical		1	ea	5,000	5,000
Instrumentation and control		1	ea	10,000	10,000
Chlorine disinfection (assumed provided by water purveyor)					
Secure easements		1	LS	20,000	20,000
Surveying		5	day	1,000	5,000
Treated groundwater piping to Water Distribution System					0
20" from GETs E/F to water distribution system (field)		8,000	lin ft	160	1,280,000
20" from GETs E/F to water distribution system (street)		1,000		225	225,000
Jack and bore:	No:				
20" under Hwy 50	1	500	lin ft	400	200,000
Subtotal					2,665,000
Estimated Construction Costs - Subtotal (year 2004)					2,665,000
Contractor Markup, Mob/demob, Insurance			%	10	267,000
Engineering, Permitting and Construction Management			%	15	400,000
Regulatory Oversight			%	2.5	67,000
Estimated Project Capital Costs - Subtotal (year 2004)					3,399,000
Contingency			%	15	510,000
Estimated Project Capital Costs - Total (year 2004)					**3,909,000**

Operation and Maintenance Cost Estimate
Replacement Water - Direct Reuse

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**			
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Treated GW pumping-GET F GWTP to water system (895 gpm annual avg) hp	37	243,453	kwh	0.050	12,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
LPGAC replacement (2 year frequency)		100,000	pound	0.75	75,000
Equip Maintenance (@ % of equip capital)		10,000	%	3	0
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F GWTP O&M)		0.00	yr	54,000	0
Management oversight and reporting (incl. in exist. GET F GWTP O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Monthly:	# mos.				
LPGAC influent	12	4	ea	500	24,000
GWTP effluent (incl in exist. GET F O&M)	12	0	ea	300	0
Estimated Project O&M Costs - Subtotal Year 2001					116,000
Contingency			%	15	17,000
Estimated Project O&M Costs - Total Year 2001					133,000

Present Worth Cost Estimate

Replacement Water - Indirect Reuse

			Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	6,895,000	22,000	6,917,000	6,917,000	6,917,000
2002	1	0.93458		44,000	44,000	41,000	6,958,000
2003	2	0.87344		44,000	44,000	38,000	6,996,000
2004	3	0.81630		44,000	44,000	36,000	7,032,000
2005	4	0.76290		44,000	44,000	34,000	7,066,000
2006	5	0.71299		44,000	44,000	31,000	7,097,000
2007	6	0.66634		44,000	44,000	29,000	7,126,000
2008	7	0.62275		44,000	44,000	27,000	7,153,000
2009	8	0.58201		44,000	44,000	26,000	7,179,000
2010	9	0.54393		44,000	44,000	24,000	7,203,000
2011	10	0.50835		44,000	44,000	22,000	7,225,000
2012	11	0.47509		44,000	44,000	21,000	7,246,000
2013	12	0.44401		44,000	44,000	20,000	7,266,000
2014	13	0.41496		44,000	44,000	18,000	7,284,000
2015	14	0.38782		44,000	44,000	17,000	7,301,000
2016	15	0.36245		44,000	44,000	16,000	7,317,000
2017	16	0.33873		44,000	44,000	15,000	7,332,000
2018	17	0.31657		44,000	44,000	14,000	7,346,000
2019	18	0.29586		44,000	44,000	13,000	7,359,000
2020	19	0.27651		44,000	44,000	12,000	7,371,000
2021	20	0.25842		44,000	44,000	11,000	7,382,000
2022	21	0.24151		44,000	44,000	11,000	7,393,000
2023	22	0.22571		44,000	44,000	10,000	7,403,000
2024	23	0.21095		44,000	44,000	9,000	7,412,000
2025	24	0.19715		44,000	44,000	9,000	7,421,000
2026	25	0.18425		22,000	22,000	4,000	7,425,000
	Total Estimated Costs:		6,900,000				7,400,000

Capital Cost Estimate
Replacement Water - Indirect Reuse

Description	Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2001)				
Surface Water Treatment Facilities (New or expanded existing 4.9 MGD [3,400 gpm] facility) and Piping				
Secure easements for piping and Canal use	1	LS	50,000	50,000
Land purchase	2	acre	200,000	400,000
Surveying for piping	3	day	1,000	3,000
Inlet structure at Folsom South Canal	1	ea	20,000	20,000
Raw water piping from Folsom South Canal				
20"	6,000	lin ft	225	1,350,000
Surface water treatment facility (4.9 MGD max day flow)	1	ea	2,880,000	2,880,000
Subtotal				4,703,000
Estimated Construction Costs - Subtotal (year 2001)				4,703,000
Contractor Markup, Mob/demob, Insurance		%	10	470,000
Engineering, Permitting and Construction Management		%	15	705,000
Regulatory Oversight		%	2.5	118,000
Estimated Project Capital Costs - Subtotal (year 2001)				5,996,000
Contingency		%	15	899,000
Estimated Project Capital Costs - Total (year 2001)				6,895,000

Operation and Maintenance Cost Estimate
Replacement Water - Indirect Reuse

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**			
Pipeline maintenance		1	LS	2,000	2,000
Electric utilities					
Raw water pumping - Folsom South Canal to Surface WTP	37	243,453	kwh	0.050	12,000
Treatment (by water purveyor)					
Equipment Maintenance (by water purveyor)					
Labor (by water purveyor)					
Monitoring (by water purveyor)					
Folsom South Canal Use Fee		1,605	ac ft	15	24,000
Estimated Project O&M Costs - Subtotal Year 2001					38,000
Contingency			%	15	6,000
Estimated Project O&M Costs - Total Year 2001					44,000

Detailed Cost Estimates

Alternative 1

Present Worth Cost Estimate

Alternative 1 - No Action

Year	*n*	P/F(*i*=7%)	Estimated Monitoring Costs ($/year)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	80,000	80,000	80,000
2002	1	0.93458	160,000	149,533	230,000
2003	2	0.87344	160,000	139,750	370,000
2004	3	0.81630	160,000	130,608	500,000
2005	4	0.76290	160,000	122,063	620,000
2006	5	0.71299	160,000	114,078	730,000
2007	6	0.66634	160,000	106,615	840,000
2008	7	0.62275	160,000	99,640	940,000
2009	8	0.58201	160,000	93,121	1,030,000
2010	9	0.54393	160,000	87,029	1,120,000
2011	10	0.50835	160,000	81,336	1,200,000
2012	11	0.47509	160,000	76,015	1,280,000
2013	12	0.44401	160,000	71,042	1,350,000
2014	13	0.41496	160,000	66,394	1,420,000
2015	14	0.38782	160,000	62,051	1,480,000
2016	15	0.36245	160,000	57,991	1,540,000
2017	16	0.33873	160,000	54,198	1,590,000
2018	17	0.31657	160,000	50,652	1,640,000
2019	18	0.29586	160,000	47,338	1,690,000
2020	19	0.27651	160,000	44,241	1,730,000
2021	20	0.25842	160,000	41,347	1,770,000
2022	21	0.24151	160,000	38,642	1,810,000
2023	22	0.22571	160,000	36,114	1,850,000
2024	23	0.21095	160,000	33,752	1,880,000
2025	24	0.19715	160,000	31,543	1,910,000
2026	25	0.18425	80,000	14,740	1,920,000
	Total Estimated Costs:				2,000,000

Detailed Cost Estimates

Alternative 2A

Present Worth Cost Estimate

Alternative 2A - GETs E and F Extraction Wells with Offsite Alternate Water Supply

			Existing GETs E/F Estimated Costs			Additional Alternative 2A Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	2,579,000	229,000	2,808,000	2,808,000	2,800,000	2,579,000	1,029,000	3,608,000	3,600,000	3,600,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		458,000	458,000	428,000	3,200,000	0	2,058,000	2,058,000	1,900,000	5,500,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		458,000	458,000	400,000	3,600,000	0	2,058,000	2,058,000	1,800,000	7,300,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000	12,168,000	664,000	12,832,000	10,475,000	14,100,000	12,168,000	2,264,000	14,432,000	11,800,000	19,100,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		664,000	664,000	507,000	14,600,000	0	2,264,000	2,264,000	1,700,000	20,800,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		664,000	664,000	473,000	15,100,000	0	2,264,000	2,264,000	1,600,000	22,400,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		664,000	664,000	442,000	15,500,000	0	2,264,000	2,264,000	1,500,000	23,900,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		664,000	664,000	414,000	15,900,000	0	2,264,000	2,264,000	1,400,000	25,300,000
2009	8	0.58201	1,600,000	930,000	10,300,000		664,000	664,000	386,000	16,300,000	0	2,264,000	2,264,000	1,300,000	26,600,000
2010	9	0.54393	1,600,000	870,000	11,200,000		664,000	664,000	361,000	16,700,000	0	2,264,000	2,264,000	1,200,000	27,800,000
2011	10	0.50835	1,600,000	810,000	12,000,000		664,000	664,000	338,000	17,000,000	0	2,264,000	2,264,000	1,200,000	29,000,000
2012	11	0.47509	1,600,000	760,000	12,800,000		664,000	664,000	315,000	17,300,000	0	2,264,000	2,264,000	1,100,000	30,100,000
2013	12	0.44401	1,600,000	710,000	13,500,000		664,000	664,000	295,000	17,600,000	0	2,264,000	2,264,000	1,000,000	31,100,000
2014	13	0.41496	1,600,000	660,000	14,200,000		664,000	664,000	276,000	17,900,000	0	2,264,000	2,264,000	900,000	32,000,000
2015	14	0.38782	1,600,000	620,000	14,800,000	9,707,000	2,284,000	11,991,000	4,650,000	22,600,000	9,707,000	3,884,000	13,591,000	5,300,000	37,300,000
2016	15	0.36245	1,600,000	580,000	15,400,000		2,284,000	2,284,000	828,000	23,400,000	0	3,884,000	3,884,000	1,400,000	38,700,000
2017	16	0.33873	1,600,000	540,000	15,900,000		2,284,000	2,284,000	774,000	24,200,000	0	3,884,000	3,884,000	1,300,000	40,000,000
2018	17	0.31657	1,600,000	510,000	16,400,000		2,284,000	2,284,000	723,000	24,900,000	0	3,884,000	3,884,000	1,200,000	41,200,000
2019	18	0.29586	1,600,000	470,000	16,900,000		2,284,000	2,284,000	676,000	25,600,000	0	3,884,000	3,884,000	1,100,000	42,300,000
2020	19	0.27651	1,600,000	440,000	17,300,000		2,284,000	2,284,000	632,000	26,200,000	0	3,884,000	3,884,000	1,100,000	43,400,000
2021	20	0.25842	1,600,000	410,000	17,700,000		2,284,000	2,284,000	590,000	26,800,000	0	3,884,000	3,884,000	1,000,000	44,400,000
2022	21	0.24151	1,600,000	390,000	18,100,000		2,284,000	2,284,000	552,000	27,300,000	0	3,884,000	3,884,000	900,000	45,300,000
2023	22	0.22571	1,600,000	360,000	18,500,000		2,284,000	2,284,000	516,000	27,900,000	0	3,884,000	3,884,000	900,000	46,200,000
2024	23	0.21095	1,600,000	340,000	18,800,000		2,284,000	2,284,000	482,000	28,300,000	0	3,884,000	3,884,000	800,000	47,000,000
2025	24	0.19715	1,600,000	320,000	19,100,000		2,284,000	2,284,000	450,000	28,800,000	0	3,884,000	3,884,000	800,000	47,800,000
2026	25	0.18425	800,000	150,000	19,300,000		1,142,000	1,142,000	210,000	29,000,000	0	1,942,000	1,942,000	400,000	48,200,000
	Total Estimated Costs:				19,000,000	24,000,000				29,000,000	24,000,000				48,000,000

Capital Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Onsite Extraction Wells (year 2001)	**[4 onsite, 2 locations]**				
Surveying		1	day	1,000	1,000
Extraction wells (drilling and development)	Depth				
C	300	2	ft	550	330,000
D	400	1	ft	550	220,000
E	500	1	ft	550	275,000
Development (incl. above)		4	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		3	ea	29,000	87,000
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	3	lin ft	100	60,000
Installation (pump, wellhead, I&C)		4	LS	5,000	20,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		4	ea	2,000	8,000
Instrumentation and control/telemetry		4	ea	2,000	8,000
Subtotal - Extraction Wells (yr 2001)					1,058,000
Untreated Groundwater Piping GETs E and F to GETs E/F GWTP (year 2001)					
Surveying		2	day	1,000	2,000
Single-walled piping system (in field)					
8"		1,300	lin ft	64	83,200
10"		7,700	lin ft	80	616,000
Subtotal - Untreated Groundwater Piping (yr 2001)		9,000			701,000
Estimated Construction Costs - Subtotal (year 2001)					1,759,000
Contractor Markup, Mob/demob, Insurance			%	10	176,000
Engineering, Permitting and Construction Management			%	15	264,000
Regulatory Oversight			%	2.5	44,000
Estimated Project Capital Costs - Subtotal (year 2001)					2,243,000
Contingency			%	15	336,000
Estimated Project Capital Costs - Total (year 2001)					**2,579,000**

Capital Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2004)					
GETs GWTP Additions and Treated Groundwater Piping to Water Distribution System					
GET A					
LPGAC polishing contactors 750 gpm each (incl. GAC)		1	ea	140,000	140,000
General contractor installation @ % of equipment		140,000	%	20	28,000
Chlorine disinfection (assumed provided by water purveyor)					
GET B					
LPGAC polishing contactors 750 gpm each (incl. GAC)		5	ea	140,000	700,000
General contractor installation @ % of equipment		700,000	%	20	140,000
Chlorine disinfection (assumed provided by water purveyor)					
ARGET					
LPGAC polishing contactors 750 gpm each (incl. GAC)		4	ea	140,000	560,000
General contractor installation @ % of equipment		560,000	%	20	112,000
Chlorine disinfection (assumed provided by water purveyor)					
Secure easements		1	LS	20,000	20,000
Surveying		5	day	1,000	5,000
Treated groundwater piping to Water Distribution System					0
8" from GET A to GET B (onsite)		9,800	lin ft	64	627,200
20" from GET B to Line 01 (onsite)		11,700	lin ft	160	1,872,000
24" from Line 01 to Buffalo Creek		18,100	lin ft	192	3,475,000
20" from ARGET discharge to water distribution system		500	lin ft	160	80,000
Jack and bore:	No:				
30" under Folsom South Canal	1	200	lin ft	600	120,000
30" under railroad and Folsom Blvd	1	200	lin ft	600	120,000
30" under Hwy 50	1	500	lin ft	600	300,000
Subtotal					8,299,000
Estimated Construction Costs - Subtotal (year 2004)					8,299,000
Contractor Markup, Mob/demob, Insurance			%	10	830,000
Engineering, Permitting and Construction Management			%	15	1,245,000
Regulatory Oversight			%	2.5	207,000
Estimated Project Capital Costs - Subtotal (year 2004)					10,581,000
Contingency			%	15	1,587,000
Estimated Project Capital Costs - Total (year 2004)					**12,168,000**

Capital Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description	Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2015)				
GETs GWTP Additions and Treated Groundwater Piping to Water Distribution System				
GET D				
LPGAC polishing contactors 750 gpm each (incl. GAC)	2	ea	140,000	280,000
General contractor installation @ % of equipment	280,000	%	20	56,000
Chlorine disinfection (assumed provided by water purveyor)				
Treated groundwater piping to Water Distribution System				
10" from GET D to Line 01 (onsite)	7,900	lin ft	80	632,000
Subtotal				968,000
Surface Water Treatment Facilities (New 5.8 MGD [4,000 gpm] facility offsite) and Piping [year 2015]				
Secure easements	1	LS	10,000	10,000
Land purchase	2	acre	20,000	40,000
Surveying	2	day	1,000	2,000
Incoming high voltage power	1,000	ft	20	20,000
Inlet structure at Folsom South Canal	1	ea	20,000	20,000
Raw water piping from Folsom South Canal				
20"	6,000	lin ft	260	1,560,000
Surface water treatment facility (5.8 MGD)	1	ea	4,000,000	4,000,000
Subtotal				5,652,000
Estimated Construction Costs - Subtotal (year 2015)				6,620,000
Contractor Markup, Mob/demob, Insurance		%	10	662,000
Engineering, Permitting and Construction Management		%	15	993,000
Regulatory Oversight		%	2.5	166,000
Estimated Project Capital Costs - Subtotal (year 2015)				8,441,000
Contingency		%	15	1,266,000
Estimated Project Capital Costs - Total (year 2015)				**9,707,000**

Operation and Maintenance Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**			
Extraction well maintenance		4	ea	1,000	4,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
UV/oxidation	51	446,760	kwh	0.050	22,000
Effluent pumping - GET A	19	122,338	kwh	0.050	6,000
Effluent pumping - GET B	262	1,712,732	kwh	0.050	86,000
Effluent pumping - GET D	0	0	kwh	0.050	0
Effluent pumping - ARGET	101	660,625	kwh	0.050	33,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement		600	85 w bulb	35	21,000
LPGAC replacement			pound	0.75	
Equip Maintenance (@ % of equip capital)		121,000	%	3	4,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qtrs.				
Extraction wells	4	4	ea	300	4,800
Monitor wells	4	6	ea	300	7,200
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)		4	ea	300	0
GWTP effluent (incl in exist. GET F O&M)		4	ea	300	0
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Sidestreams (incl in exist. GET F O&M)		2	ea	300	0
Folsom South Canal Use Fee		0	ac ft	15	0
Estimated Project O&M Costs - Subtotal Year 2001					398,000
Contingency			%	15	60,000
Estimated Project O&M Costs - Total Year 2001					458,000

Operation and Maintenance Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2004**			
Extraction well maintenance		4	ea	1,000	4,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
UV/oxidation	51	446,760	kwh	0.050	22,000
Effluent pumping - GET A	19	122,338	kwh	0.050	6,000
Effluent pumping - GET B	262	1,712,732	kwh	0.050	86,000
Effluent pumping - GET D	0	0	kwh	0.050	0
Effluent pumping - ARGET	101	660,625	kwh	0.050	33,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement		600	85 w bulb	35	21,000
LPGAC replacement		200,000	pound	0.75	150,000
Equip Maintenance (@ % of equip capital)		121,000	%	3	4,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qrtrs.				
Extraction wells	4	4	ea	300	4,800
Monitor wells	4	6	ea	300	7,200
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP effluent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Sidestreams (incl in exist. GET F O&M)		2	ea	300	0
Folsom South Canal Use Fee		0	ac ft	10	0
Estimated Project O&M Costs - Subtotal Year 2004					577,000
Contingency			%	15	87,000
Estimated Project O&M Costs - Total Year 2004					**664,000**

Operation and Maintenance Cost Estimate
Alternative 2A - GETs E and F Extraction and Recharge Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2015**			
Extraction well maintenance		4	ea	1,000	4,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
UV/oxidation			kwh	0.050	22,000
Effluent pumping - GET A	19	122,338	kwh	0.050	6,000
Effluent pumping - GET B	262	1,712,732	kwh	0.050	86,000
Effluent pumping - GET D	75	489,352	kwh	0.050	24,000
Effluent pumping - ARGET	101	660,625	kwh	0.050	33,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement					21,000
LPGAC replacement		240,000	pound	0.75	180,000
Equip Maintenance (@ % of equip capital)		121,000	%	3	4,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qrtrs.				
Extraction wells	4	4	ea	300	4,800
Monitor wells	4	6	ea	300	7,200
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP effluent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Sidestreams (incl in exist. GET F O&M)		2	ea	300	0
Raw water purchase		6,452	ac ft	200	1,290,000
Folsom South Canal Use Fee		6,452	ac ft	10	65,000
Estimated Project O&M Costs - Subtotal Year 2015					1,986,000
Contingency			%	15	298,000
Estimated Project O&M Costs - Total Year 2015					**2,284,000**

Detailed Cost Estimates

Alternative 2B

Present Worth Cost Estimate

Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

			Existing GETs E/F Estimated Costs			Additional Alternative 2B Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	15,954,000	453,500	16,407,500	16,408,000	16,400,000	15,954,000	1,253,500	17,207,500	17,200,000	17,200,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		907,000	907,000	848,000	17,300,000	0	2,507,000	2,507,000	2,300,000	19,500,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		907,000	907,000	792,000	18,000,000	0	2,507,000	2,507,000	2,200,000	21,700,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000	5,104,000	1,096,000	6,200,000	5,061,000	23,100,000	5,104,000	2,696,000	7,800,000	6,400,000	28,100,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,096,000	1,096,000	836,000	23,900,000	0	2,696,000	2,696,000	2,100,000	30,200,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,096,000	1,096,000	781,000	24,700,000	0	2,696,000	2,696,000	1,900,000	32,100,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,096,000	1,096,000	730,000	25,500,000	0	2,696,000	2,696,000	1,800,000	33,900,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,096,000	1,096,000	683,000	26,100,000	0	2,696,000	2,696,000	1,700,000	35,600,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,096,000	1,096,000	638,000	26,800,000	0	2,696,000	2,696,000	1,600,000	37,200,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,096,000	1,096,000	596,000	27,400,000	0	2,696,000	2,696,000	1,500,000	38,700,000
2011	10	0.50835	1,600,000	810,000	12,000,000		1,096,000	1,096,000	557,000	27,900,000	0	2,696,000	2,696,000	1,400,000	40,100,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,096,000	1,096,000	521,000	28,500,000	0	2,696,000	2,696,000	1,300,000	41,400,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,096,000	1,096,000	487,000	28,900,000	0	2,696,000	2,696,000	1,200,000	42,600,000
2014	13	0.41496	1,600,000	660,000	14,200,000		1,096,000	1,096,000	455,000	29,400,000	0	2,696,000	2,696,000	1,100,000	43,700,000
2015	14	0.38782	1,600,000	620,000	14,800,000	2,406,000	1,228,000	3,634,000	1,409,000	30,800,000	2,406,000	2,828,000	5,234,000	2,000,000	45,700,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,228,000	1,228,000	445,000	31,200,000	0	2,828,000	2,828,000	1,000,000	46,700,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,228,000	1,228,000	416,000	31,700,000	0	2,828,000	2,828,000	1,000,000	47,700,000
2018	17	0.31657	1,600,000	510,000	16,400,000		1,228,000	1,228,000	389,000	32,100,000	0	2,828,000	2,828,000	900,000	48,600,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,228,000	1,228,000	363,000	32,400,000	0	2,828,000	2,828,000	800,000	49,400,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,228,000	1,228,000	340,000	32,600,000	0	2,828,000	2,828,000	800,000	50,200,000
2021	20	0.25842	1,600,000	410,000	17,700,000		1,228,000	1,228,000	317,000	33,100,000	0	2,828,000	2,828,000	700,000	50,900,000
2022	21	0.24151	1,600,000	390,000	18,100,000		1,228,000	1,228,000	297,000	33,400,000	0	2,828,000	2,828,000	700,000	51,600,000
2023	22	0.22571	1,600,000	360,000	18,500,000		1,228,000	1,228,000	277,000	33,600,000	0	2,828,000	2,828,000	600,000	52,200,000
2024	23	0.21095	1,600,000	340,000	18,800,000		1,228,000	1,228,000	259,000	33,900,000	0	2,828,000	2,828,000	600,000	52,800,000
2025	24	0.19715	1,600,000	320,000	19,100,000		1,228,000	1,228,000	242,000	34,100,000	0	2,828,000	2,828,000	600,000	53,400,000
2026	25	0.18425	800,000	150,000	19,300,000		614,000	614,000	113,000	34,300,000	0	1,414,000	1,414,000	300,000	53,700,000
Total Estimated Costs:					19,000,000	23,000,000				34,300,000	23,000,000				54,000,000

Capital Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Onsite Extraction Wells (year 2001)	**[13 onsite, 5 locations]**				
Surveying		2	day	1,000	2,000
Extraction wells (drilling and development)	Depth				
C	300	5	ft	550	825,000
D	400	4	ft	550	880,000
E	500	4	ft	550	1,100,000
Development (incl. above)		13	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		9	ea	26,000	234,000
500 gpm, 300' TDH, 60 hp, 8" disch		4	ea	29,000	116,000
Discharge piping, 3" SS threaded	200	9	lin ft	40	72,000
Discharge piping, 8" SS threaded	200	4	lin ft	100	80,000
Installation (pump, wellhead, I&C)		13	LS	5,000	65,000
Incoming service power	5	500	ft	15	37,500
Pump control power and control		13	ea	2,000	26,000
Instrumentation and control/telemetry		13	ea	2,000	26,000
Subtotal - Extraction Wells (yr 2001)					3,464,000
Untreated Groundwater Piping GETs E and F, New-1 thru New-3 Wells to GET F GWTP (year 2001)					
Onsite:					
Surveying		4	day	1,000	4,000
Single-walled piping system (in field)					
10"		9,300	lin ft	80	744,000
12"		3,200	lin ft	96	307,200
16"		700	lin ft	128	89,600
Subtotal - Untreated Groundwater Piping (yr 2001)		13,200			1,145,000
Treatment Facilities - GET F (additional 2,225 gpm capacity) (year 2001)					
Surveying		1	day	1,000	1,000
Equalization tankage	2	66,750	gal	1.00	133,500
Transfer pumping	42 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		2	ea	85,000	170,000
Offgas treatment (assume not required)		0	ea	200,000	0
Perchlorate removal (biological reduction)	2,225 gpm	1	ea	2,869,000	2,869,000
UV/oxidation (KW)			ea		800,000
Transfer pumping	42 hp	3	ea	10,000	30,000
Electrical wiring		1	LS	50,000	50,000
Instrumentation and control		1	LS	50,000	50,000
Treatment building		800	sq ft	100	80,000
General contractor installation @ % of equipment		1,263,500	%	40	505,400
Subtotal - Additional Treatment at GET F (yr 2001)					4,719,000
Treated Groundwater Piping GET F GWTP to Buffalo Creek (year 2001)					
Onsite:					
Surveying		2	day	1,000	2,000
Single-walled piping system (in field)					
24"		8,000	lin ft	192	1,536,000
Monitoring manhole and facilities		1.0	ea	5,000	5,000
Discharge structure		1.0	LS	10,000	10,000
Subtotal - Untreated Groundwater Piping (yr 2001)		8,000			1,553,000
Estimated Construction Costs - Subtotal (year 2001)					10,881,000
Contractor Markup, Mob/demob, Insurance			%	10	1,088,000
Engineering, Permitting and Construction Management			%	15	1,632,000
Regulatory Oversight			%	2.5	272,000
Estimated Project Capital Costs - Subtotal (year 2001)					13,873,000
Contingency			%	15	2,081,000
Estimated Project Capital Costs - Total (year 2001)					15,954,000

Capital Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2004)					
GETs E/F GWTP Additions and Treated Groundwater Piping to Water Distribution System					
LPGAC polishing contactors 750 gpm each (incl. GAC)		9	ea	140,000	1,260,000
General contractor installation @ % of equipment		1,260,000	%	20	252,000
Chlorine disinfection (assumed provided by water purveyor)					
Secure easements		1	LS	20,000	20,000
Surveying		5	day	1,000	5,000
Treated groundwater piping from Buffalo Creek Discharge to Water Distribution System					
24" on-site open field		700	lin ft	192	134,400
24" in street		5,300	lin ft	260	1,378,000
Jack and bore:					
24" under Folsom South Canal	1	200	lin ft	480	96,000
24" under railroad and Folsom Blvd	1	200	lin ft	480	96,000
24" under Hwy 50	1	500	lin ft	480	240,000
Subtotal					3,481,000
Estimated Construction Costs - Subtotal (year 2004)					3,481,000
Contractor Markup, Mob/demob, Insurance			%	10	348,000
Engineering, Permitting and Construction Management			%	15	522,000
Regulatory Oversight			%	2.5	87,000
Estimated Project Capital Costs - Subtotal (year 2004)					4,438,000
Contingency			%	15	666,000
Estimated Project Capital Costs - Total (year 2004)					**5,104,000**

Draft O&M Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2001**				
Extraction well maintenance		13	ea	1,000	13,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
New-1	68	444,070	kwh	0.050	22,000
New-2	80	520,633	kwh	0.050	26,000
New-3	80	520,633	kwh	0.050	26,000
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:					
Air stripping	30	196,312	kwh	0.050	10,000
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps	50	326,642	kwh	0.050	16,000
Effluent pumping - 6,225 gpm to discharge	233	1,523,108	kwh	0.050	76,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement					21,000
Perchlorate biological reduction system O&M in add'n to existing		1	LS	265,000	265,000
LPGAC replacement			pound	0.75	
Onsite VPGAC regeneration system			ccf	0.5	0
Equip Maintenance (@ % of equip capital)		1,430,000	%	3	43,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qrtrs.				
Extraction wells	4	13	ea	300	15,600
Monitor wells	4	20	ea	300	23,400
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)		4	ea	300	0
GWTP effluent (incl in exist. GET F O&M)		4	ea	300	0
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Sidestreams (incl in exist. GET F O&M)		2	ea	300	0
Estimated Project O&M Costs - Subtotal Year 2001					789,000
Contingency (%)			%	15	118,000
Estimated Project O&M Costs - Total Year 2001					907,000

Capital Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description	Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2015)				
ARGET GWTP Additions and Treated Groundwater Piping to Water Distribution System (3,200 gpm)				
LPGAC polishing contactors 750 gpm each (incl. GAC)	5	ea	140,000	700,000
General contractor installation @ % of equipment	700,000	%	20	140,000
Chlorine disinfection (assumed provided by water purveyor)				
Surveying	1	day	1,000	1,000
Treated groundwater piping from ARGET Discharge to Water Distribution System				
20" on-site open field	5,000	lin ft	160	800,000
Subtotal				1,641,000
Estimated Construction Costs - Subtotal (year 2015)				1,641,000
Contractor Markup, Mob/demob, Insurance		%	10	164,000
Engineering, Permitting and Construction Management		%	15	246,000
Regulatory Oversight		%	2.5	41,000
Estimated Project Capital Costs - Subtotal (year 2015)				2,092,000
Contingency		%	15	314,000
Estimated Project Capital Costs - Total (year 2015)				**2,406,000**

Draft O&M Cost Estimate
Alternative 2B - GETs E and F Extraction Wells with Offsite Alternate Water Supply

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2015**			
Extraction well maintenance		13	ea	1,000	13,000
Pipeline maintenance		1	LS	5,000	5,000
Electric utilities:					
Extraction well pumps:	Running hp				
New-1	68	444,070	kwh	0.050	22,000
New-2	80	520,633	kwh	0.050	26,000
New-3	80	520,633	kwh	0.050	26,000
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:					
Air stripping	30	196,312	kwh	0.050	10,000
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps	50	326,642	kwh	0.050	16,000
Effluent pumping - 9,500 gpm to water distribution system	356	2,324,421	kwh	0.050	116,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement					21,000
Perchlorate biological reduction system O&M in add'n to existing		1	LS	265,000	265,000
UV service contract		0	LS	5,000	0
LPGAC replacement		280,000	pound	0.75	210,000
Onsite VPGAC regeneration system			ccf	0.5	0
Equip Maintenance (@ % of equip capital)		1,430,000	%	3	43,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Management oversight and reporting (incl. in exist. GET F O&M)		0.00	yr	100,000	0
Monitoring - included in existing:					
Quarterly:	# qrtrs.				
Extraction wells	4	13	ea	300	15,600
Monitor wells	4	20	ea	300	23,400
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP effluent (incl in exist. GET F O&M)	12	4	ea	300	14,400
GWTP intermediate locations (incl in exist. GET F O&M)		4	ea	300	0
Estimated Project O&M Costs - Subtotal Year 2015					1,068,000
Contingency (%)			%	15	160,000
Estimated Project O&M Costs - Total Year 2015					**1,228,000**

Detailed Cost Estimates

Alternative 3A

Present Worth Cost Estimate

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 3A Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	23,537,000	877,000	24,414,000	24,414,000	24,414,000	23,537,000	1,677,000	25,214,000	25,210,000	25,210,000
2002	1	0.93458	1,800,000	1,495,000	2,295,000	682,000	1,903,000	2,585,000	2,416,000	26,830,000	682,000	3,503,000	4,185,000	3,910,000	29,120,000
2003	2	0.87344	1,800,000	1,398,000	3,693,000	0	1,903,000	1,903,000	1,662,000	28,492,000	0	3,503,000	3,503,000	3,060,000	32,180,000
2004	3	0.81630	1,800,000	1,306,000	4,999,000	0	1,903,000	1,903,000	1,553,000	30,045,000	0	3,503,000	3,503,000	2,860,000	35,040,000
2005	4	0.76290	1,800,000	1,221,000	6,220,000	0	1,903,000	1,903,000	1,452,000	31,497,000	0	3,503,000	3,503,000	2,670,000	37,710,000
2006	5	0.71299	1,800,000	1,141,000	7,361,000	8,643,000	2,169,000	10,812,000	7,709,000	39,206,000	8,643,000	3,769,000	12,412,000	8,850,000	46,560,000
2007	6	0.66634	1,800,000	1,066,000	8,427,000	0	2,372,000	2,372,000	1,581,000	40,787,000	0	3,972,000	3,972,000	2,650,000	49,210,000
2008	7	0.62275	1,800,000	996,000	9,423,000	0	2,362,000	2,362,000	1,471,000	42,258,000	0	3,962,000	3,962,000	2,470,000	51,680,000
2009	8	0.58201	1,800,000	931,000	10,354,000	426,000	2,398,000	2,824,000	1,644,000	43,902,000	426,000	3,998,000	4,424,000	2,570,000	54,250,000
2010	9	0.54393	1,800,000	870,000	11,224,000	4,974,000	2,645,000	7,619,000	4,144,000	48,046,000	4,974,000	4,245,000	9,219,000	5,010,000	59,260,000
2011	10	0.50835	1,800,000	813,000	12,037,000	1,605,000	2,954,000	4,559,000	2,318,000	50,364,000	1,605,000	4,554,000	6,159,000	3,130,000	62,390,000
2012	11	0.47509	1,800,000	760,000	12,797,000	0	3,045,000	3,045,000	1,447,000	51,811,000	0	4,845,000	4,845,000	2,210,000	64,600,000
2013	12	0.44401	1,800,000	710,000	13,507,000	4,111,000	3,293,000	7,404,000	3,287,000	55,098,000	4,111,000	4,693,000	9,004,000	4,000,000	68,600,000
2014	13	0.41496	1,800,000	664,000	14,171,000	3,382,000	3,545,000	6,927,000	2,874,000	57,972,000	3,382,000	5,145,000	8,527,000	3,540,000	72,140,000
2015	14	0.38782	1,800,000	621,000	14,792,000	0	3,321,000	3,321,000	1,288,000	59,260,000	0	4,921,000	4,921,000	1,910,000	74,050,000
2016	15	0.36245	1,800,000	580,000	15,372,000	0	3,097,000	3,097,000	1,122,000	60,382,000	0	4,697,000	4,697,000	1,700,000	75,750,000
2017	16	0.33873	1,800,000	542,000	15,914,000	6,177,000	3,427,000	9,604,000	3,253,000	63,635,000	6,177,000	5,027,000	11,204,000	3,800,000	79,550,000
2018	17	0.31657	1,800,000	507,000	16,421,000	0	3,427,000	3,427,000	1,085,000	64,720,000	0	5,027,000	5,027,000	1,590,000	81,140,000
2019	18	0.29586	1,800,000	473,000	16,894,000	0	3,427,000	3,427,000	1,014,000	65,734,000	0	5,027,000	5,027,000	1,490,000	82,630,000
2020	19	0.27651	1,800,000	442,000	17,336,000	2,500,000	3,426,000	5,926,000	1,639,000	67,373,000	2,500,000	5,026,000	7,526,000	2,080,000	84,710,000
2021	20	0.25842	1,800,000	413,000	17,749,000	3,148,000	3,785,000	6,933,000	1,792,000	69,165,000	3,148,000	5,385,000	8,533,000	2,210,000	86,920,000
2022	21	0.24151	1,800,000	386,000	18,135,000	0	3,785,000	3,785,000	914,000	70,079,000	0	5,385,000	5,385,000	1,300,000	88,220,000
2023	22	0.22571	1,800,000	361,000	18,496,000	202,000	3,789,000	3,991,000	901,000	70,980,000	202,000	5,389,000	5,591,000	1,260,000	89,480,000
2024	23	0.21095	1,800,000	338,000	18,834,000	0	3,789,000	3,789,000	799,000	71,779,000	0	5,389,000	5,389,000	1,140,000	90,620,000
2025	24	0.19715	1,800,000	315,000	19,149,000	0	3,789,000	3,789,000	747,000	72,526,000	0	5,389,000	5,389,000	1,060,000	91,680,000
2026	25	0.18425	800,000	147,000	19,296,000	4,606,000	2,395,000	7,001,000	1,290,000	73,816,000	4,606,000	3,195,000	7,801,000	1,440,000	93,120,000
		Total Estimated Costs:			19,300,000	64,000,000				74,000,000	64,000,000				93,000,000

Present Worth Cost Estimate

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Year	Well AC-1 Capital Costs ($)	Well AC-1 O&M Costs ($/yr)	Well AC-5 Capital Costs ($)	Well AC-5 O&M Costs ($/yr)	Well AC-6 Capital Costs ($)	Well AC-6 O&M Costs ($/yr)	Well AC-7 Capital Costs ($)	Well AC-7 O&M Costs ($/yr)	Well AC-10 Capital Costs ($)	Well AC-10 O&M Costs ($/yr)	Well AC-11 Capital Costs ($)	Well AC-11 O&M Costs ($/yr)
2001			2,500,000	63,500							551,000	53,000
2002				127,000								106,000
2003				127,000								106,000
2004				127,000								106,000
2005				127,000								106,000
2006	2,514,000	37,000		127,000			3,093,000	106,500	2,500,000	60,000		106,000
2007		74,000		127,000				213,000		120,000		106,000
2008		74,000		127,000				213,000		120,000		106,000
2009		74,000		127,000				213,000		120,000		106,000
2010		74,000		127,000				213,000		120,000		106,000
2011		74,000		127,000				213,000		120,000		106,000
2012		74,000		127,000				213,000		120,000		106,000
2013		74,000		127,000				213,000		120,000		106,000
2014		74,000		127,000				213,000		120,000		106,000
2015		74,000		127,000				106,500		120,000		106,000
2016		74,000		127,000						120,000		106,000
2017		74,000		127,000						120,000	2,795,000	250,000
2018		74,000		127,000						120,000		250,000
2019		74,000		127,000						120,000		250,000
2020		74,000		127,000	2,500,000	82,000				120,000		250,000
2021		74,000		127,000		164,000				120,000		250,000
2022		74,000		127,000		164,000				120,000		250,000
2023	202,000	78,000		127,000		164,000				120,000		250,000
2024		78,000		127,000		164,000				120,000		250,000
2025		78,000		127,000		164,000				120,000		250,000
2026		39,000		63,500		82,000				60,000		125,000

Present Worth Cost Estimate

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Year	Well AC-13 Capital Costs ($)	Well AC-13 O&M Costs ($/yr)	Well AC-14 Capital Costs ($)	Well AC-14 O&M Costs ($/yr)	Well AC-15 Capital Costs ($)	Well AC-15 O&M Costs ($/yr)	Well AC-16 Capital Costs ($)	Well AC-16 O&M Costs ($/yr)	Well AC-18 Capital Costs ($)	Well AC-18 O&M Costs ($/yr)	Well AC-19 Capital Costs ($)	Well AC-19 O&M Costs ($/yr)	Well AC-20 Capital Costs ($)	Well AC-20 O&M Costs ($/yr)
2001			3,242,000	102,500	3,294,000	127,500	3,257,000	91,000			4,966,000	200,000		
2002				205,000		255,000		182,000				400,000	682,000	150,000
2003				205,000		255,000		182,000				400,000		150,000
2004				205,000		255,000		182,000				400,000		150,000
2005				205,000		255,000		182,000				400,000		150,000
2006				205,000		255,000		182,000				400,000	536,000	212,000
2007				205,000		255,000		182,000				400,000		212,000
2008				205,000		245,000		182,000				400,000		212,000
2009	426,000	45,500		205,000		235,000		182,000				400,000		212,000
2010		91,000		205,000		235,000		166,000	4,974,000	218,000		400,000		212,000
2011	1,605,000	182,000		205,000		235,000		166,000		436,000		400,000		212,000
2012		273,000		205,000		235,000		166,000		436,000		400,000		212,000
2013		273,000		205,000		235,000		166,000		436,000		400,000	4,111,000	460,000
2014		273,000		205,000		235,000		166,000		436,000		400,000		460,000
2015		273,000		205,000		117,500		166,000		436,000		400,000		460,000
2016		273,000		205,000				166,000		436,000		400,000		460,000
2017		273,000		205,000				166,000		436,000		400,000		460,000
2018		273,000		205,000				166,000		436,000		400,000		460,000
2019		273,000		205,000				166,000		436,000		400,000		460,000
2020		273,000		205,000				83,000		436,000		400,000		460,000
2021		273,000		205,000						436,000		486,000		460,000
2022		273,000		205,000						436,000		486,000		460,000
2023		273,000		205,000						436,000		486,000		460,000
2024		273,000		205,000						436,000		486,000		460,000
2025		273,000		205,000						436,000		486,000		460,000
2026		136,500		102,500						218,000		243,000		230,000

Present Worth Cost Estimate

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

	Well AC-23		Chettenham		Rockingham		Winchester		SWMD-17		GETs E/F Extract Wells	
Year	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)
2001									3,148,000	85,000	2,579,000	154,000
2002										170,000		308,000
2003										170,000		308,000
2004										170,000		308,000
2005										170,000		308,000
2006										170,000		308,000
2007										170,000		308,000
2008										170,000		308,000
2009										170,000		308,000
2010										170,000		308,000
2011										170,000		308,000
2012										170,000		308,000
2013										170,000		308,000
2014			3,382,000	252,000						170,000		308,000
2015				252,000						170,000		308,000
2016				252,000						170,000		308,000
2017				252,000			3,382,000	186,000		170,000		308,000
2018				252,000				186,000		170,000		308,000
2019				252,000				186,000		170,000		308,000
2020				252,000				186,000		170,000		308,000
2021				294,000	3,148,000	232,000		186,000		170,000		308,000
2022				294,000		232,000		186,000		170,000		308,000
2023				294,000		232,000		186,000		170,000		308,000
2024				294,000		232,000		186,000		170,000		308,000
2025				294,000		232,000		186,000		170,000		308,000
2026	4,606,000	500,000		147,000		116,000		93,000		85,000		154,000

Capital and O&M Cost Estimate for GETs E and F Extraction Wells

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Onsite Extraction Wells (year 2001)	**[4 onsite, 2 locations]**				
Surveying		1	day	1,000	1,000
Extraction wells (drilling and development)	Depth				
C	300	2	ft	550	330,000
D	400	1	ft	550	220,000
E	500	1	ft	550	275,000
Development (incl. above)		4	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		3	ea	29,000	87,000
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	3	lin ft	100	60,000
Installation (pump, wellhead, I&C)		4	LS	5,000	20,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		4	ea	2,000	8,000
Instrumentation and control/telemetry		4	ea	2,000	8,000
Subtotal - Extraction Wells (yr 2001)					1,058,000
Untreated Groundwater Piping GETs E and F to GETs E/F GWTP (year 2001)					
Surveying		2	day	1,000	2,000
Single-walled piping system (in field)					
8"		1,300	lin ft	64	83,200
10"		7,700	lin ft	80	616,000
Subtotal - Untreated Groundwater Piping (yr 2001)		9,000			701,000
Estimated Construction Costs - Subtotal (year 2001)					1,759,000
Contractor Markup, Mob/demob, Insurance			%	10	176,000
Engineering, Permitting and Construction Management			%	15	264,000
Regulatory Oversight			%	2.5	44,000
Estimated Project Capital Costs - Subtotal (year 2001)					2,243,000
Contingency			%	15	336,000
Estimated Project Capital Costs - Total (year 2001)					**2,579,000**

Preliminary Capital and O&M Cost Estimate for Water Supply Well AC-14
Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at well = historical average flow = 326 gpm

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	2001				
Monitor Wells	2001				
Secure permit		2	ea	100	200
Surveying		0.5	day	1,000	500
Monitor wells		2	ea	40,000	80,000
Subtotal - Monitor Wells	2001				80,700
Treatment Facilities at Wellhead	2001				
Secure easements		0	LS	5,000	0
Land purchase		0.25	acre	200,000	50,000
Surveying		0.5	day	1,000	500
Perchlorate removal via ion exchange		1	ea	980,000	980,000
Perchlorate destruction module		1	ea	805,000	805,000
UV/oxidation (KW)	16.7	1	ea	90,000	90,000
Incoming high voltage power		300	ft	20	6,000
Backup generator (not for UV)		1	ea	5,000	5,000
Electrical wiring		1	LS	10,000	10,000
Instrumentation and control		1	LS	10,000	10,000
Treatment building		600	sq ft	100	60,000
Sitework and access road		1	LS	5,000	5,000
Area lighting		1	LS	2,000	2,000
Security fencing/gates		420	lin ft	15	6,300
General contractor installation		1	LS	100,000	100,000
Subtotal - Treatment	2001				2,130,000
Estimated Construction Costs - Subtotal	2001				2,210,700
Contractor Markup, Mob/demob, Insurance			%	10	221,000
Engineering, Permitting and Construction Management			%	15	332,000
Regulatory Oversight			%	2.5	55,000
Estimated Project Capital Costs - Subtotal	2001				2,818,700
Contingency			%	15	423,000
Estimated Project Capital Costs - Total	2001				**3,242,000**

Capital and O&M Cost Estimate for GETs E and F Extraction Wells

Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs: (Years 2001 to 2026)					
Extraction well maintenance		4	ea	1,000	4,000
Pipeline maintenance		1	LS	1,000	1,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,007,733	kwh	0.050	50,000
South of F	23	150,506	kwh	0.050	8,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
UV/oxidation			kwh	0.050	22,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
UV bulb replacement					21,000
Equip Maintenance (@ % of equip capital)		113,000	%	3	3,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Monitoring - in addition to existing GETs E/F monitoring:					
Quarterly:	# qrtrs.				
Extraction wells	4	4	ea	300	4,800
Monitor wells	4	6	ea	300	7,200
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Estimated Project O&M Costs - Subtotal					268,000
Contingency			%	15	40,000
Estimated Project O&M Costs - Total					**308,000**

Preliminary Capital and O&M Cost Estimate for Water Supply Well AC-14
Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at well = historical average flow = 326 gpm

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	2001				
Monitor Wells	2001				
Secure permit		2	ea	100	200
Surveying		0.5	day	1,000	500
Monitor wells		2	ea	40,000	80,000
Subtotal - Monitor Wells	2001				80,700
Treatment Facilities at Wellhead	2001				
Secure easements		0	LS	5,000	0
Land purchase		0.25	acre	200,000	50,000
Surveying		0.5	day	1,000	500
Perchlorate removal via ion exchange		1	ea	980,000	980,000
Perchlorate destruction module		1	ea	805,000	805,000
UV/oxidation (KW)		1	ea	90,000	90,000
Incoming high voltage power		300	ft	20	6,000
Backup generator (not for UV)		1	ea	5,000	5,000
Electrical wiring		1	LS	10,000	10,000
Instrumentation and control		1	LS	10,000	10,000
Treatment building		600	sq ft	100	60,000
Sitework and access road		1	LS	5,000	5,000
Area lighting		1	LS	2,000	2,000
Security fencing/gates		420	lin ft	15	6,300
General contractor installation		1	LS	100,000	100,000
Subtotal - Treatment	2001				2,130,000
Estimated Construction Costs - Subtotal	2001				2,210,700
Contractor Markup, Mob/demob, Insurance			%	10	221,000
Engineering, Permitting and Construction Management			%	15	332,000
Regulatory Oversight			%	2.5	55,000
Estimated Project Capital Costs - Subtotal	2001				2,818,700
Contingency			%	15	423,000
Estimated Project Capital Costs - Total	2001				**3,242,000**

Preliminary Capital and O&M Cost Estimate for Water Supply Well AC-14
Alternative 3A - GETs E and F Extraction and Recharge Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at well = historical average flow = 326 gpm

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs			**(2001-2026)**			
Water supply well maintenance			1	ea	4,000	4,000
Electric utilities:						
Well pump:	(hp	49	319,485	kwh	0.050	16,000
Treatment equipment:						
UV/oxidation	(kw)		146,361	kwh	0.050	7,000
Ion exchange - ISEP facility			171,346	1,000 gal	0.020	3,400
Perchlorate destruction module (IE regeneration)			171,346	1,000 gal	0.070	12,000
Pressure drop makeup			171,346	1,000 gal	0.020	3,400
Misc. lighting and power			15,000	kwh	0.050	1,000
Chemicals						
Salt/brine			171,346	1,000 gal	0.010	1,700
Ion exchange resin			171,346	1,000 gal	0.0038	700
Ammonium			171,346	1,000 gal	0.0029	500
Catalyst			171,346	1,000 gal	0.030	5,100
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement					2,500	1,400
Waste disposal						
Brine disposal costs			171,346	1,000 gal	0.06	10,300
UV Equip Maintenance (@ 3% of equip capital)			90,000	%	3	2,700
Ion exchange maintenance labor and material			171,346	1,000 gal	0.25	42,800
Labor (incl. fringe benefits):						
Ion exchange operator labor			171,346	1,000 gal	0.13	22,000
Management oversight and reporting			0.010	yr	100,000	1,000
Monitoring:						
Quarterly:		No.				
Monitor wells		4	2	ea	500	4,000
Weekly/Monthly:						
Water supply well		1	12	ea	500	6,000
Treated water at wellhead		1	52	ea	500	26,000
Intermediate location in wellhead treatment train		1	12	ea	500	6,000
IE brine		1	12	ea	100	1,200
Estimated Project O&M Costs - Subtotal (2001-2026)						178,000
Contingency				%	15	27,000
Estimated Project O&M Costs - Total (2001-2026)						205,000

Present Worth Cost Estimate

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 3B Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	37,924,000	1,201,000	39,125,000	39,125,000	39,125,000	37,924,000	2,001,000	39,925,000	39,930,000	39,930,000
2002	1	0.93458	1,600,000	1,495,000	2,295,000	682,000	2,477,000	3,159,000	2,952,000	42,077,000	682,000	4,077,000	4,759,000	4,450,000	44,380,000
2003	2	0.87344	1,600,000	1,398,000	3,693,000	0	2,552,000	2,552,000	2,229,000	44,306,000	0	4,152,000	4,152,000	3,630,000	48,010,000
2004	3	0.81630	1,600,000	1,306,000	4,999,000	0	2,552,000	2,552,000	2,083,000	46,389,000	0	4,152,000	4,152,000	3,390,000	51,400,000
2005	4	0.76290	1,600,000	1,221,000	6,220,000	0	2,552,000	2,552,000	1,947,000	48,336,000	0	4,152,000	4,152,000	3,170,000	54,570,000
2006	5	0.71299	1,600,000	1,141,000	7,361,000	8,643,000	2,818,000	11,461,000	8,172,000	56,508,000	8,643,000	4,418,000	13,061,000	9,310,000	63,880,000
2007	6	0.66634	1,600,000	1,066,000	8,427,000	0	3,021,000	3,021,000	2,013,000	58,521,000	0	4,621,000	4,621,000	3,080,000	66,960,000
2008	7	0.62275	1,600,000	996,000	9,423,000	0	3,011,000	3,011,000	1,875,000	60,396,000	0	4,611,000	4,611,000	2,870,000	69,830,000
2009	8	0.58201	1,600,000	931,000	10,354,000	426,000	3,047,000	3,473,000	2,021,000	62,417,000	426,000	4,647,000	5,073,000	2,950,000	72,780,000
2010	9	0.54393	1,600,000	870,000	11,224,000	4,974,000	3,294,000	8,268,000	4,497,000	66,914,000	4,974,000	4,894,000	9,868,000	5,370,000	78,150,000
2011	10	0.50835	1,600,000	813,000	12,037,000	1,605,000	3,603,000	5,208,000	2,647,000	69,561,000	1,605,000	5,203,000	6,808,000	3,460,000	81,610,000
2012	11	0.47509	1,600,000	760,000	12,797,000	0	3,694,000	3,694,000	1,755,000	71,316,000	0	5,294,000	5,294,000	2,520,000	84,130,000
2013	12	0.44401	1,600,000	710,000	13,507,000	4,111,000	3,942,000	8,053,000	3,576,000	74,892,000	4,111,000	5,542,000	9,653,000	4,290,000	88,420,000
2014	13	0.41496	1,600,000	664,000	14,171,000	3,382,000	4,068,000	7,450,000	3,091,000	77,983,000	3,382,000	5,668,000	9,050,000	3,760,000	92,180,000
2015	14	0.38782	1,600,000	621,000	14,792,000	0	3,970,000	3,970,000	1,540,000	79,523,000	0	5,570,000	5,570,000	2,160,000	94,340,000
2016	15	0.36245	1,600,000	580,000	15,372,000	0	3,746,000	3,746,000	1,358,000	80,881,000	0	5,346,000	5,346,000	1,940,000	96,280,000
2017	16	0.33873	1,600,000	542,000	15,914,000	6,177,000	3,983,000	10,160,000	3,442,000	84,323,000	6,177,000	5,583,000	11,760,000	3,980,000	100,260,000
2018	17	0.31657	1,600,000	507,000	16,421,000	0	4,076,000	4,076,000	1,290,000	85,613,000	0	5,676,000	5,676,000	1,800,000	102,060,000
2019	18	0.29586	1,600,000	473,000	16,894,000	0	4,076,000	4,076,000	1,206,000	86,819,000	0	5,676,000	5,676,000	1,680,000	103,740,000
2020	19	0.27651	1,600,000	442,000	17,336,000	2,500,000	4,075,000	6,575,000	1,818,000	88,637,000	2,500,000	5,675,000	8,175,000	2,260,000	106,000,000
2021	20	0.25842	1,600,000	413,000	17,749,000	3,148,000	4,318,000	7,466,000	1,929,000	90,566,000	3,148,000	5,918,000	9,066,000	2,340,000	108,340,000
2022	21	0.24151	1,600,000	386,000	18,135,000	0	4,434,000	4,434,000	1,071,000	91,637,000	0	6,034,000	6,034,000	1,460,000	109,800,000
2023	22	0.22571	1,600,000	361,000	18,496,000	202,000	4,438,000	4,640,000	1,047,000	92,684,000	202,000	6,038,000	6,240,000	1,410,000	111,210,000
2024	23	0.21095	1,600,000	338,000	18,834,000	0	4,438,000	4,438,000	936,000	93,620,000	0	6,038,000	6,038,000	1,270,000	112,480,000
2025	24	0.19715	1,600,000	315,000	19,149,000	0	4,438,000	4,438,000	875,000	94,495,000	0	6,038,000	6,038,000	1,190,000	113,670,000
2026	25	0.18425	800,000	147,000	19,296,000	4,606,000	2,469,000	7,075,000	1,304,000	95,799,000	4,606,000	3,269,000	7,875,000	1,450,000	115,120,000
			Total Estimated Costs:		19,300,000	78,000,000				96,000,000	78,000,000				115,000,000

Summary of Capital and O&M Cost Estimates

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Year	Well AC-1 Capital Costs ($)	Well AC-1 O&M Costs ($/yr)	Well AC-5 Capital Costs ($)	Well AC-5 O&M Costs ($/yr)	Well AC-6 Capital Costs ($)	Well AC-6 O&M Costs ($/yr)	Well AC-7 Capital Costs ($)	Well AC-7 O&M Costs ($/yr)	Well AC-10 Capital Costs ($)	Well AC-10 O&M Costs ($/yr)	Well AC-11 Capital Costs ($)	Well AC-11 O&M Costs ($/yr)
2001			2,500,000	63,500							551,000	53,000
2002				127,000								106,000
2003				127,000								106,000
2004				127,000								106,000
2005				127,000								106,000
2006	2,514,000	37,000		127,000			3,093,000	106,500	2,500,000	60,000		106,000
2007		74,000		127,000				213,000		120,000		106,000
2008		74,000		127,000				213,000		120,000		106,000
2009		74,000		127,000				213,000		120,000		106,000
2010		74,000		127,000				213,000		120,000		106,000
2011		74,000		127,000				213,000		120,000		106,000
2012		74,000		127,000				213,000		120,000		106,000
2013		74,000		127,000				213,000		120,000		106,000
2014		74,000		127,000				213,000		120,000		106,000
2015		74,000		127,000				106,500		120,000		106,000
2016		74,000		127,000						120,000		106,000
2017		74,000		127,000						120,000	2,795,000	250,000
2018		74,000		127,000						120,000		250,000
2019		74,000		127,000						120,000		250,000
2020		74,000		127,000	2,500,000	82,000				120,000		250,000
2021		74,000		127,000		164,000				120,000		250,000
2022		74,000		127,000		164,000				120,000		250,000
2023	202,000	78,000		127,000		164,000				120,000		250,000
2024		78,000		127,000		164,000				120,000		250,000
2025		78,000		127,000		164,000				120,000		250,000
2026		39,000		63,500		82,000				60,000		125,000

Summary of Capital and O&M Cost Estimates

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Year	Well AC-13 Capital Costs ($)	Well AC-13 O&M Costs ($/yr)	Well AC-14 Capital Costs ($)	Well AC-14 O&M Costs ($/yr)	Well AC-15 Capital Costs ($)	Well AC-15 O&M Costs ($/yr)	Well AC-16 Capital Costs ($)	Well AC-16 O&M Costs ($/yr)	Well AC-18 Capital Costs ($)	Well AC-18 O&M Costs ($/yr)	Well AC-19 Capital Costs ($)	Well AC-19 O&M Costs ($/yr)	Well AC-20 Capital Costs ($)	Well AC-20 O&M Costs ($/yr)
2001			3,242,000	102,500	3,294,000	127,500	3,257,000	91,000			4,966,000	200,000		
2002				205,000		255,000		182,000				400,000	682,000	75,000
2003				205,000		255,000		182,000				400,000		150,000
2004				205,000		255,000		182,000				400,000		150,000
2005				205,000		255,000		182,000				400,000		150,000
2006				205,000		255,000		182,000				400,000	536,000	212,000
2007				205,000		255,000		182,000				400,000		212,000
2008				205,000		245,000		182,000				400,000		212,000
2009	426,000	45,500		205,000		235,000		182,000				400,000		212,000
2010		91,000		205,000		235,000		166,000	4,974,000	218,000		400,000		212,000
2011	1,605,000	182,000		205,000		235,000		166,000		436,000		400,000		212,000
2012		273,000		205,000		235,000		166,000		436,000		400,000		212,000
2013		273,000		205,000		235,000		166,000		436,000		400,000	4,111,000	460,000
2014		273,000		205,000		235,000		166,000		436,000		400,000		460,000
2015		273,000		205,000		117,500		166,000		436,000		400,000		460,000
2016		273,000		205,000				166,000		436,000		400,000		460,000
2017		273,000		205,000				166,000		436,000		400,000		460,000
2018		273,000		205,000				166,000		436,000		400,000		460,000
2019		273,000		205,000				166,000		436,000		400,000		460,000
2020		273,000		205,000				83,000		436,000		400,000		460,000
2021		273,000		205,000						436,000		486,000		460,000
2022		273,000		205,000						436,000		486,000		460,000
2023		273,000		205,000						436,000		486,000		460,000
2024		273,000		205,000						436,000		486,000		460,000
2025		273,000		205,000						436,000		486,000		460,000
2026		136,500		102,500						218,000		243,000		230,000

Summary of Capital and O&M Cost Estimates

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

	Well AC-23		Cheltenham		Rockingham		Winchester		SWMD-17		GETs E/F Extract Wells	
Year	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)	Capital Costs ($)	O&M Costs ($/yr)
2001									3,148,000	85,000	16,966,000	478,500
2002										170,000		957,000
2003										170,000		957,000
2004										170,000		957,000
2005										170,000		957,000
2006										170,000		957,000
2007										170,000		957,000
2008										170,000		957,000
2009										170,000		957,000
2010										170,000		957,000
2011										170,000		957,000
2012										170,000		957,000
2013										170,000		957,000
2014			3,382,000	126,000						170,000		957,000
2015				252,000						170,000		957,000
2016				252,000						170,000		957,000
2017				252,000			3,382,000	93,000		170,000		957,000
2018				252,000				186,000		170,000		957,000
2019				252,000				186,000		170,000		957,000
2020				252,000				186,000		170,000		957,000
2021				294,000	3,148,000	116,000		186,000		170,000		957,000
2022				294,000		232,000		186,000		170,000		957,000
2023				294,000		232,000		186,000		170,000		957,000
2024				294,000		232,000		186,000		170,000		957,000
2025				294,000		232,000		186,000		170,000		957,000
2026	4,606,000	250,000		147,000		116,000		93,000		85,000		478,500

Capital and O&M Cost Estimate for GETs E and F Extraction Wells

Alternative 3B - GETs E and F Extraction with Offsite Wellhead Treatment at Water Supply Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Onsite Extraction Wells (year 2001)	**[13 onsite, 4 locations]**				
Surveying		1	day	1,000	1,000
Extraction wells (drilling and development)	Depth				
C	300	5	ft	550	825,000
D	400	4	ft	550	880,000
E	500	4	ft	550	1,100,000
Development (incl. above)		13	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		4	ea	26,000	104,000
500 gpm, 300' TDH, 60 hp, 8" disch		9	ea	29,000	261,000
Discharge piping, 3" SS threaded	200	4	lin ft	40	32,000
Discharge piping, 8" SS threaded	200	9	lin ft	100	180,000
Installation (pump, wellhead, I&C)		13	LS	5,000	65,000
Incoming service power	4	500	ft	15	30,000
Pump control power and control		13	ea	2,000	26,000
Instrumentation and control/telemetry		13	ea	2,000	26,000
Subtotal - Extraction Wells (yr 2001)					3,530,000
Monitor Wells (year 2001)					
Secure permit		20	ea	100	1,950
Surveying		2.0	day	1,000	2,000
Monitor wells		20	ea	40,000	780,000
Subtotal - Monitor Wells (yr 2001)					783,950
Untreated Groundwater Piping GETs E and F to GETs E/F GWTP (year 2001)					
Surveying		2	day	1,000	2,000
Single-walled piping (open field)					
8"		1,300	lin ft	64	83,200
10"		9,300	lin ft	80	744,000
12"		1,900	lin ft	96	182,400
16"		700	lin ft	128	89,600
Subtotal - Untreated Groundwater Piping (yr 2001)		13,200			1,101,000
Treatment Facilities (2,225 gpm expanded capacity at Get F) [year 2001]					
Surveying		1	day	1,000	1,000
Equalization tankage	2	66,750	gal	1.00	133,500
Transfer pumping	42 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		2	ea	85,000	170,000
Offgas treatment (assumed not required)		0	ea		0
Perchlorate removal (biological reduction)	2,225 gpm	1	ea	2,869,000	2,869,000
UV/oxidation (KW)		2	ea	400,000	800,000
Transfer pumping	42 hp	3	ea	10,000	30,000
Electrical wiring		1	LS	50,000	50,000
Instrumentation and control		1	LS	50,000	50,000
Treatment building		800	sq ft	100	80,000
General contractor installation @ % of equipment		1,263,500	%	40	505,400
Subtotal - Treatment at GET F (yr 2001)					4,719,000

Capital and O&M Cost Estimate for GETs E and F Extraction Wells

Alternative 3B - GETs E and F Extraction with Offsite Wellhead Treatment at Water Supply Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treated Groundwater Piping from GET F to Discharge at Buffalo Creek (year 2001)					
Surveying		1	day	1,000	1,000
Single-walled piping system (open field)					
24"		7,400	lin ft	192	1,420,800
Monitoring manhole and facilities		1	ea	5,000	5,000
Discharge structure		1	LS	10,000	10,000
Subtotal - Treated Groundwater to Discharge		7,400			1,437,000
Estimated Construction Costs - Subtotal (year 2001)					11,571,000
Contractor Markup, Mob/demob, Insurance			%	10	1,157,000
Engineering, Permitting and Construction Management			%	15	1,736,000
Regulatory Oversight			%	2.5	289,000
Estimated Project Capital Costs - Subtotal (year 2001)					14,753,000
Contingency			%	15	2,213,000
Estimated Project Capital Costs - Total (year 2001)					**16,966,000**

Estimated Annual Operation & Maintenance Costs: (Years 2001 to 2026)

Extraction well maintenance		13	ea	1,000	13,000
Pipeline maintenance		1	LS	1,000	1,000
Electric utilities:					
Extraction well pumps:	Running hp				
North of E	154	1,007,733	kwh	0.050	50,000
South of F	23	150,506	kwh	0.050	8,000
New-1	68	444,973	kwh	0.050	22,000
New-2	80	523,498	kwh	0.050	26,000
New-3	80	523,498	kwh	0.050	26,000
Treatment equipment (GETs E/F) in addition to existing:	kw:				
Air stripping	30	196,312	kwh	0.050	10,000
UV/oxidation			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps (GET F)	50	326,642	kwh	0.050	16,000
Effluent pumping - add'l 2,225 gpm to discharge	25	163,321	kwh	0.050	8,000
Treatment equipment in add'n to exist. besides utilities and maintenance:					
Perchlorate biological reduction system O&M in add'n to exist:		1	LS	255,000	255,000
UV bulb replacement				35	21,000
Equip Maintenance (@ % of equip capital)		1,415,000	%	3	42,000
Labor (incl. fringe benefits)					
Operator labor (incl. in exist. GET F O&M, except add'l UV)		0.5	yr	54,000	27,000
Monitoring - in addition to existing GETs E/F monitoring:					
Quarterly:	# qrtrs.				
Extraction wells	13	13	ea	300	50,700
Monitor wells	20	20	ea	300	114,100
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Estimated Project O&M Costs - Subtotal					832,000
Contingency			%	15	125,000
Estimated Project O&M Costs - Total					**957,000**

Capital and O&M Cost Estimate for Water Supply Well AC-19

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at each well = historical average flow = 829 gpm

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	2001				
Monitor Wells	2001				
Secure permit		2	ea	100	200
Surveying		0.5	day	1,000	500
Monitor wells		2	ea	40,000	80,000
Subtotal - Monitor Wells	2001				80,700
Treatment Facilities at Wellhead	2001				
Secure easements		1	LS	5,000	5,000
Land purchase		0.25	acre	200,000	50,000
Surveying		0.5	day	1,000	500
Perchlorate removal via ion exchange		1	ea	1,500,000	1,500,000
Perchlorate destruction module		1	ea	1,431,000	1,431,000
UV/oxidation (KW)		0	ea	90,000	0
Backup generator (not for UV)		1	ea	5,000	5,000
Electrical wiring		1	LS	20,000	20,000
Instrumentation and control		1	LS	20,000	20,000
Treatment building		600	sq ft	100	60,000
Sitework and access road		1	LS	5,000	5,000
Area lighting		1	LS	2,000	2,000
Security fencing/gates		420	lin ft	15	6,300
General contractor installation		1	LS	200,000	200,000
Subtotal - Treatment 2001					3,305,000
Estimated Construction Costs - Subtotal 2001					**3,385,700**
Contractor Markup, Mob/demob, Insurance			%	10	339,000
Engineering, Permitting and Construction Management			%	15	508,000
Regulatory Oversight			%	2.5	85,000
Estimated Project Capital Costs - Subtotal 2001					4,317,700
Contingency			%	15	648,000
Estimated Project Capital Costs - Total 2001					**4,966,000**

Capital and O&M Cost Estimate for Water Supply Well AC-19

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at each well = historical average flow = 829 gpm

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs		**(2001 to 2020)**			
Water supply well maintenance		1	ea	4,000	4,000
Electric utilities:					
Well pump:	124	812,433	kwh	0.050	41,000
Treatment equipment:					
Ion exchange - ISEP facility		435,722	1,000 gal	0.020	8,714
Perchlorate destruction module (IE regeneration)		435,722	1,000 gal	0.120	52,287
Pressure drop makeup		435,722	1,000 gal	0.020	8,700
Misc. lighting and power		15,000	kwh	0.050	750
Chemicals					
Salt/brine		435,722	1,000 gal	0.020	8,714
Ion exchange resin		435,722	1,000 gal	0.010	4,357
Ammonium		435,722	1,000 gal	0.0033	1,438
Catalyst		435,722	1,000 gal	0.050	21,786
Treatment equipment (besides utilities and maintenance)					
UV bulb replacement		0	30 kw bulb	2,500	0
Waste disposal					
Truck IE regen brine to central regeneration facility			round trip	200	0
Brine disposal costs		435,722	1,000 gal	0.10	43,572
Ion exchange maintenance labor and material		435,722	1,000 gal	0.19	82,787
Labor (incl. fringe benefits):					
Ion exchange operator labor		435,722	1,000 gal	0.06	26,000
Management oversight and reporting		0.010	yr	100,000	1,000
Monitoring:					
Quarterly:	No.				
Monitor wells	4	2	ea	500	4,000
Weekly/Monthly:					
Water supply well	1	12	ea	500	6,000
Treated water at wellhead	1	52	ea	500	26,000
Intermediate location in wellhead treatment train	1	12	ea	500	6,000
IE brine	1	12	ea	100	1,200
Estimated Project O&M Costs - Subtotal (2001 to 2020)					348,000
Contingency			%	15	52,000
Estimated Project O&M Costs - Total (2001 to 2020)					**400,000**

Capital and O&M Cost Estimate for Water Supply Well AC-19

Alternative 3B - GETs E and F Extraction Wells with Offsite Wellhead Treatment at Water Supply Wells

Flowrate at each well = historical average flow = 829 gpm

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs		**(2021 to 2026)**			
Water supply well maintenance		1	ea	4,000	4,000
Electric utilities:					
Well pump:	124	812,433	kwh	0.050	41,000
Treatment equipment:					
Ion exchange - ISEP facility		435,722	1,000 gal	0.020	8,714
Perchlorate destruction module (IE regeneration)		435,722	1,000 gal	0.180	78,430
Pressure drop makeup		435,722	1,000 gal	0.020	8,700
Misc. lighting and power		15,000	kwh	0.050	750
Chemicals					
Salt/brine		435,722	1,000 gal	0.03	13,072
Ion exchange resin		435,722	1,000 gal	0.0082	3,573
Ammonium		435,722	1,000 gal	0.0063	2,745
Catalyst		435,722	1,000 gal	0.08	34,858
Treatment equipment (besides utilities and maintenance)					
UV bulb replacement		0	30 kw bulb	2,500	0
Waste disposal					
Brine disposal costs		435,722	1,000 gal	0.16	69,716
Ion exchange maintenance labor and material		435,722	1,000 gal	0.20	87,144
Labor (incl. fringe benefits):					
Ion exchange operator labor		435,722	1,000 gal	0.06	26,143
Management oversight and reporting		0.010	yr	100,000	1,000
Monitoring:					
Quarterly:	No.				
Monitor wells	4	2	ea	500	4,000
Weekly/Monthly:					
Water supply well	1	12	ea	500	6,000
Treated water at wellhead	1	52	ea	500	26,000
Intermediate location in wellhead treatment train	1	12	ea	500	6,000
IE brine	1	12	ea	100	1,200
Estimated Project O&M Costs - Subtotal (2021 to 2026)					423,000
Contingency			%	15	63,000
Estimated Project O&M Costs - Total (2021 to 2026)					**486,000**

Detailed Cost Estimates

Alternative 4A

Present Worth Cost Estimate

Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 4A Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	38,413,000	705,000	39,118,000	39,118,000	39,100,000	38,413,000	1,505,000	39,918,000	39,900,000	39,900,000
2002	1	0.93458	1,600,000	1,506,000	2,300,000		1,410,000	1,410,000	1,318,000	40,400,000	0	3,010,000	3,010,000	2,800,000	42,700,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,410,000	1,410,000	1,232,000	41,700,000	0	3,010,000	3,010,000	2,600,000	45,300,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,410,000	1,410,000	1,151,000	42,800,000	0	3,010,000	3,010,000	2,500,000	47,800,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,410,000	1,410,000	1,076,000	43,900,000	0	3,010,000	3,010,000	2,300,000	50,100,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,410,000	1,410,000	1,005,000	44,900,000	0	3,010,000	3,010,000	2,100,000	52,200,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,410,000	1,410,000	940,000	45,800,000	0	3,010,000	3,010,000	2,000,000	54,200,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,410,000	1,410,000	878,000	46,700,000	0	3,010,000	3,010,000	1,900,000	56,100,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,410,000	1,410,000	821,000	47,500,000	0	3,010,000	3,010,000	1,800,000	57,900,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,410,000	1,410,000	767,000	48,300,000	0	3,010,000	3,010,000	1,600,000	59,500,000
2011	10	0.50835	1,600,000	810,000	12,000,000	1,550,000	1,641,000	3,191,000	1,622,000	49,900,000	1,550,000	3,241,000	4,791,000	2,400,000	61,900,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,641,000	1,641,000	780,000	50,700,000	0	3,241,000	3,241,000	1,500,000	63,400,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,641,000	1,641,000	729,000	51,400,000	0	3,241,000	3,241,000	1,400,000	64,800,000
2014	13	0.41496	1,600,000	660,000	14,200,000		1,641,000	1,641,000	681,000	52,100,000	0	3,241,000	3,241,000	1,300,000	66,100,000
2015	14	0.38782	1,600,000	620,000	14,800,000		1,641,000	1,641,000	636,000	52,800,000	0	3,241,000	3,241,000	1,300,000	67,400,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,641,000	1,641,000	595,000	53,300,000	0	3,241,000	3,241,000	1,200,000	68,600,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,641,000	1,641,000	556,000	53,900,000	0	3,241,000	3,241,000	1,100,000	69,700,000
2018	17	0.31657	1,600,000	510,000	16,400,000		1,641,000	1,641,000	519,000	54,400,000	0	3,241,000	3,241,000	1,000,000	70,700,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,641,000	1,641,000	486,000	54,900,000	0	3,241,000	3,241,000	1,000,000	71,700,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,641,000	1,641,000	454,000	55,400,000	0	3,241,000	3,241,000	900,000	72,600,000
2021	20	0.25842	1,600,000	410,000	17,700,000	2,797,000	1,758,000	4,555,000	1,177,000	56,500,000	2,797,000	3,358,000	6,155,000	1,600,000	74,200,000
2022	21	0.24151	1,600,000	390,000	18,100,000		1,758,000	1,758,000	425,000	57,000,000	0	3,358,000	3,358,000	800,000	75,000,000
2023	22	0.22571	1,600,000	360,000	18,500,000		1,758,000	1,758,000	397,000	57,400,000	0	3,358,000	3,358,000	800,000	75,800,000
2024	23	0.21095	1,600,000	340,000	18,800,000		1,758,000	1,758,000	371,000	57,700,000	0	3,358,000	3,358,000	700,000	76,500,000
2025	24	0.19715	1,600,000	320,000	19,100,000		1,758,000	1,758,000	347,000	58,100,000	0	3,358,000	3,358,000	700,000	77,200,000
2026	25	0.18425	800,000	150,000	19,300,000		1,758,000	1,758,000	324,000	58,400,000	0	2,558,000	2,558,000	500,000	77,700,000
	Total Estimated Costs:				19,000,000	43,000,000				58,400,000	43,000,000				78,000,000

Capital Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	[13 offsite, 4 onsite in 2 locations]				
Secure easements		13	ea	2,000	26,000
Land purchase (1/8th acre ea wellhead)		1.625	acre	200,000	325,000
Surveying		6.5	day	1,000	6,500
Extraction wells - drilling and development	Depth				
C	300	14	ft	550	2,310,000
D	400	2	ft	550	440,000
E	500	1	ft	550	275,000
Wellhead vault: H-20 traffic rated		13	ea	5,000	65,000
Development (included with drilling)		17			
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		7	ea	26,000	182,000
500 gpm, 300' TDH, 60 hp, 6" disch		10	ea	29,000	290,000
Discharge piping, 3" SS threaded	200	7	lin ft	40	56,000
Discharge piping, 6" SS threaded	200	10	lin ft	100	200,000
Installation (pump, wellhead, I&C)		17	LS	5,000	85,000
Incoming service power	15	500	ft	15	112,500
Pump control power and control		17	ea	2,000	34,000
Instrumentation and control/telemetry		17	ea	2,000	34,000
Subtotal - Extraction Wells (yr 2001)					4,441,000
Monitor Wells (year 2001)					
Secure permit		20	ea	100	2,000
Surveying		10	day	1,000	10,000
Monitor wells		20	ea	40,000	800,000
Subtotal - Monitor Wells (yr 2001)					812,000
Untreated Groundwater Piping (year 2001)					
Secure easements		1	LS	100,000	100,000
Land purchase		1	acre	200,000	200,000
Surveying		20	day	1,000	20,000
Jack and bore	No.				
8" under railroad and Folsom Blvd	1	200	lin ft	160	32,000
20" under railroad	1	200	lin ft	400	80,000
20" under Sunrise Blvd	1	500	lin ft	400	200,000
20" under Folsom S. Canal	2	300	lin ft	400	240,000
Single-walled piping system (open field)					
8"		1,400	lin ft	64	89,600
10"		4,500	lin ft	80	366,000
12"			lin ft	96	0
16"			lin ft	128	0
20"		1,000	lin ft	160	160,000
24"		6,800	lin ft	192	1,689,600
30"			lin ft	240	0
Single-walled piping system (in street)					
8"		8,000	lin ft	100	800,000
10"		5,600	lin ft	140	784,000
12"		7,500	lin ft	140	1,050,000
16"		11,300	lin ft	175	1,977,500
20"		21,500	lin ft	225	4,837,500
24"			lin ft	260	0
30"			lin ft	300	0
Subtotal - Untreated Groundwater Piping (yr 2001)		69,700			12,628,000

Capital Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities (new 4,100 gpm facility at Get F) [year 2001]					
Surveying		1	day	1,000	1,000
Equalization tankage	2	136,500	gal	1.00	273,000
Transfer pumping	75 hp	4	ea	10,000	40,000
VOC removal					
Air stripping		4	ea	85,000	340,000
Offgas treatment (assumed not required)		0	ea		0
Perchlorate removal (biological reduction)	4,100 gpm	1	ea	3,760,000	3,760,000
UV/oxidation					800,000
Transfer pumping	75 hp	0	ea	10,000	0
Backup generator (not for UV)		1	ea	20,000	20,000
Electrical wiring		1	LS	150,000	150,000
Instrumentation and control		1	LS	150,000	150,000
Treatment building		1,600	sq ft	100	160,000
Sitework and access road		1	LS	10,000	10,000
Area lighting		1	LS	5,000	5,000
Security fencing/gates		1,200	lin ft	15	18,000
General contractor installation @ % of equipment		1,773,000	%	40	709,200
Subtotal - Treatment at GET F					6,456,000
Discharge Facilities (from GWTP at GET F to Buffalo Creek)					
Surveying		2.5	day	1,000	2,500
Single-walled piping system (open field)					
24"		9,600	lin ft	192	1,843,200
Monitoring manhole and facilities		1	ea	5,000	5,000
Discharge structure		1	LS	10,000	10,000
Subtotal - Discharge Facilities from GET F					1,861,000
Estimated Construction Costs - Subtotal (year 2001)					26,198,000
Contractor Markup, Mob/demob, Insurance			%	10	2,620,000
Engineering, Permitting and Construction Management			%	15	3,930,000
Regulatory Oversight			%	2.5	655,000
Estimated Project Capital Costs - Subtotal (year 2001)					33,403,000
Contingency			%	15	5,010,000
Estimated Project Capital Costs - Total (year 2001)					38,413,000

Capital Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2011)					
Extraction Wells					
Secure easements		3	ea	2,000	6,000
Land purchase (1/8th acre ea wellhead)		0.375	acre	200,000	75,000
Surveying		1.5	day	1,000	1,500
Extraction wells - drilling and development	Depth				
C	300	1	ft	550	165,000
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		3	ea	5,000	15,000
Development (included with drilling)		3			
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		3	ea	26,000	78,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	3	lin ft	40	24,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		3	LS	5,000	15,000
Incoming service power	3	500	ft	15	22,500
Pump control power and control		3	ea	2,000	6,000
Instrumentation and control/telemetry		3	ea	2,000	6,000
Subtotal - Extraction Wells					854,000
Monitor Wells					
Secure permit		5	ea	100	500
Surveying		2.5	day	1,000	2,500
Monitor wells		5	ea	40,000	200,000
Subtotal - Monitor Wells					203,000
Estimated Construction Costs - Subtotal	**2011**				1,057,000
Contractor Markup, Mob/demob, Insurance			%	10	106,000
Engineering, Permitting and Construction Management			%	15	159,000
Regulatory Oversight			%	2.5	26,000
Estimated Project Capital Costs - Subtotal	**2011**				1,348,000
Contingency			%	15	202,000
Estimated Project Capital Costs - Total	**2011**				**1,550,000**

Capital Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (mid 2021)					
Extraction Wells					
Secure easements		5	ea	2,000	10,000
Land purchase (1/8th acre ea wellhead)		0.625	acre	200,000	125,000
Surveying		2.5	day	1,000	2,500
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	4	ft	550	880,000
E	500	1	ft	550	275,000
Wellhead vault: H-20 traffic rated		5	ea	5,000	25,000
Development (included with drilling)		5			
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		5	ea	26,000	130,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	4	lin ft	40	32,000
Discharge piping, 8" SS threaded	200	1	lin ft	100	20,000
Installation (pump, wellhead, I&C)		5	LS	5,000	25,000
Incoming service power	5	500	ft	15	37,500
Pump control power and control		5	ea	2,000	10,000
Instrumentation and control/telemetry		5	ea	2,000	10,000
Subtotal - Extraction Wells					1,582,000
Monitor Wells					
Secure permit		8	ea	100	800
Surveying		4	day	1,000	4,000
Monitor wells		8	ea	40,000	320,000
Subtotal - Monitor Wells					324,800
Estimated Construction Costs - Subtotal	**2021**				1,906,800
Contractor Markup, Mob/demob, Insurance			%	10	191,000
Engineering, Permitting and Construction Management			%	15	286,000
Regulatory Oversight			%	2.5	48,000
Estimated Project Capital Costs - Subtotal	**2021**				2,431,800
Contingency			%	15	365,000
Estimated Project Capital Costs - Total	**2021**				**2,797,000**

Operation and Maintenance Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2001**				
Extraction well maintenance		17	ea	1,000	17,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	37	245,004	kwh	0.050	12,000
C2	47	306,255	kwh	0.050	15,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
C8	19	122,502	kwh	0.050	6,000
C9	9	61,251	kwh	0.050	3,000
C10	28	183,753	kwh	0.050	9,000
C11	28	183,753	kwh	0.050	9,000
C12	28	183,753	kwh	0.050	9,000
C13	28	183,753	kwh	0.050	9,000
D1	25	161,703	kwh	0.050	8,000
D2	0	0	kwh	0.050	0
D3	0	0	kwh	0.050	0
D4	0	0	kwh	0.050	0
D5	0	0	kwh	0.050	0
D6	0	0	kwh	0.050	0
D7	0	0	kwh	0.050	0
D8	0	0	kwh	0.050	0
D9	0	0	kwh	0.050	0
D10	0	0	kwh	0.050	0
E1	0	0	kwh	0.050	0
E2	0	0	kwh	0.050	0
E3	0	0	kwh	0.050	0
New GET E containment extraction well	154	1,004,516	kwh	0.050	50,000
New GET F containment extraction well	23	153,127	kwh	0.050	8,000
Treatment equipment:					
Air stripping hp:	60	392,623	kwh	0.050	19,600
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
VPGAC booster fans			kwh	0.050	0
Intermediate transfer pumps (GET F)	127	831,898	kwh	0.050	42,000
Effluent pumping (GET F)			kwh	0.050	0
Misc. lighting and power kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities					
Onsite VPGAC regeneration system			ccf		0
Chemicals					
Ethanol for biological reduction (incl. below)			gal		0
Acid			gal		0
Base			gal		0
Carbon dioxide			ccf		0
Polymer for sludge dewatering (incl. below)			gal		0
Treatment equipment (besides utilities and maintenance)					
UV bulb replacement (GET F)					21,000
Perchlorate biological reduction system O&M		1	LS	574,000	574,000
UV service contract		1	LS	5,000	5,000
Waste disposal					
Dewatered sludge (incl. below)			lb		0
Equip Maintenance (@ % of equip capital)		1,866,000	%	3	56,000
Labor (incl. fringe benefits):					
Operator labor (assume 1 FTE in bio. red'n)		1.0	yr	54,000	54,000
Management oversight and reporting		0.12	yr	100,000	12,000
Monitoring:					
Quarterly:	# qtrs.				
Extraction wells	4	17	ea	300	20,400
Monitor wells	4	20	ea	300	24,000
PCD Exhibit IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent	12	4	ea	300	14,400
GWTP effluent	12	4	ea	300	14,400
GWTP intermediate locations	12	4	ea	300	14,400
Sidestreams	12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2001					1,226,000
Contingency			%	15	184,000
Estimated Project O&M Costs - Total Year 2001					1,410,000

Operation and Maintenance Cost Estimate
Alternative 4A - GETs E and F Extraction and Recharge Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2015**				
Extraction well maintenance		20	ea	1,000	20,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	37	245,004	kwh	0.050	12,000
C2	47	306,255	kwh	0.050	15,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
C8	19	122,502	kwh	0.050	6,000
C9	9	61,251	kwh	0.050	3,000
C10	28	183,753	kwh	0.050	9,000
C11	28	183,753	kwh	0.050	9,000
C12	28	183,753	kwh	0.050	9,000
C13	28	183,753	kwh	0.050	9,000
D1	25	161,703	kwh	0.050	8,000
D2		0	kwh	0.050	0
D3		0	kwh	0.050	0
D4		0	kwh	0.050	0
D5	25	161,703	kwh	0.050	8,000
D6		0	kwh	0.050	0
D7		0	kwh	0.050	0
D8	25	161,703	kwh	0.050	8,000
D9	25	161,703	kwh	0.050	8,000
D10	25	161,703	kwh	0.050	8,000
E1	77	502,258	kwh	0.050	25,000
E2	77	502,258	kwh	0.050	25,000
E3	77	502,258	kwh	0.050	25,000
New GET E containment extraction well	154	1,004,516	kwh	0.050	50,000
New GET F containment extraction well	23	153,127	kwh	0.050	8,000
Treatment equipment:					
Air stripping	60	392,623	kwh	0.050	19,600
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
VPGAC booster fans			kwh	0.050	0
Intermediate transfer pumps (GET F)	154	1,003,171	kwh	0.050	50,000
Effluent pumping (GET F)			kwh	0.050	0
Misc. lighting and power kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities					
Onsite VPGAC regeneration system (assumed not required)			ccf		0
Chemicals					
Ethanol for biological reduction (incl. below)			gal		0
Acid			gal		0
Base			gal		0
Carbon dioxide			ccf		0
Polymer for sludge dewatering (incl. below)			gal		0
Treatment equipment (besides utilities and maintenance)					
UV bulb replacement (GET F)					21,000
Perchlorate biological reduction system O&M		1	LS	653,000	653,000
UV service contract		1	LS	5,000	5,000
Waste disposal					
Dewatered sludge (incl. below)			lb		0
Equip Maintenance (@ % of equip capital)		1,856,000	%	3	56,000
Labor (incl. fringe benefits):					
Operator labor (assume 1 FTE in bio. red'n)		1.0	yr	54,000	54,000
Management oversight and reporting		0.12	yr	100,000	12,000
Monitoring:					
Quarterly:	# qrtrs.				
Extraction wells	4	20	ea	300	24,000
Monitor wells	4	20	ea	300	24,000
PCD Exhibit IV and VI		1	ea	120,000	120,000
Monthly:	# mos.				
GWTP influent	12	4	ea	300	14,400
GWTP effluent	12	4	ea	300	14,400
GWTP intermediate locations	12	4	ea	300	14,400
Sidestreams	12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2015					1,427,000
Contingency			%	15	214,000
Estimated Project O&M Costs - Total Year 2015					**1,641,000**

Detailed Cost Estimates

Alternative 4B

Present Worth Cost Estimate

Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 4B Estimated Costs					Total Estimated Costs				
Year	*n*	P/F(*i*=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	35,900,000	824,500	36,724,500	36,725,000	37,000,000	35,900,000	1,624,500	37,524,500	37,500,000	37,500,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		1,708,000	1,708,000	1,596,000	38,000,000	0	3,308,000	3,308,000	3,100,000	40,600,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,708,000	1,708,000	1,492,000	40,000,000	0	3,308,000	3,308,000	2,900,000	43,500,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,708,000	1,708,000	1,394,000	41,000,000	0	3,308,000	3,308,000	2,700,000	46,200,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,708,000	1,708,000	1,303,000	43,000,000	0	3,308,000	3,308,000	2,500,000	48,700,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,708,000	1,708,000	1,218,000	44,000,000	0	3,308,000	3,308,000	2,400,000	51,100,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,708,000	1,708,000	1,138,000	45,000,000	0	3,308,000	3,308,000	2,200,000	53,300,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,708,000	1,708,000	1,064,000	46,000,000	0	3,308,000	3,308,000	2,100,000	55,400,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,708,000	1,708,000	994,000	47,000,000	0	3,308,000	3,308,000	1,900,000	57,300,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,708,000	1,708,000	929,000	48,000,000	0	3,308,000	3,308,000	1,800,000	59,100,000
2011	10	0.50835	1,600,000	810,000	12,000,000	1,066,000	1,796,000	2,862,000	1,455,000	49,000,000	1,066,000	3,396,000	4,462,000	2,300,000	61,400,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,796,000	1,796,000	853,000	50,000,000	0	3,396,000	3,396,000	1,600,000	63,000,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,796,000	1,796,000	797,000	51,000,000	0	3,396,000	3,396,000	1,500,000	64,500,000
2014	13	0.41496	1,600,000	660,000	14,200,000		1,796,000	1,796,000	745,000	52,000,000	0	3,396,000	3,396,000	1,400,000	65,900,000
2015	14	0.38782	1,600,000	620,000	14,800,000		1,796,000	1,796,000	697,000	52,000,000	0	3,396,000	3,396,000	1,300,000	67,200,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,796,000	1,796,000	651,000	53,000,000	0	3,396,000	3,396,000	1,200,000	68,400,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,796,000	1,796,000	608,000	54,000,000	0	3,396,000	3,396,000	1,200,000	69,600,000
2018	17	0.31657	1,600,000	510,000	16,400,000		1,796,000	1,796,000	569,000	54,000,000	0	3,396,000	3,396,000	1,100,000	70,700,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,796,000	1,796,000	531,000	55,000,000	0	3,396,000	3,396,000	1,000,000	71,700,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,796,000	1,796,000	497,000	55,000,000	0	3,396,000	3,396,000	900,000	72,600,000
2021	20	0.25842	1,600,000	410,000	17,700,000	1,066,000	1,855,000	2,921,000	755,000	56,000,000	1,066,000	3,455,000	4,521,000	1,200,000	73,800,000
2022	21	0.24151	1,600,000	390,000	18,100,000		1,803,000	1,803,000	435,000	56,000,000	0	3,403,000	3,403,000	800,000	74,600,000
2023	22	0.22571	1,600,000	360,000	18,500,000		1,803,000	1,803,000	407,000	57,000,000	0	3,403,000	3,403,000	800,000	75,400,000
2024	23	0.21095	1,600,000	340,000	18,800,000		1,803,000	1,803,000	380,000	57,000,000	0	3,403,000	3,403,000	700,000	76,100,000
2025	24	0.19715	1,600,000	320,000	19,100,000		1,803,000	1,803,000	355,000	58,000,000	0	3,403,000	3,403,000	700,000	76,800,000
2026	25	0.18425	800,000	150,000	19,300,000		901,500	901,500	166,000	58,000,000	0	1,701,500	1,701,500	300,000	77,100,000
	Total Estimated Costs:				19,000,000	38,000,000				58,000,000	38,000,000		122,000,000		77,000,000

Capital Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	**[10 offsite; 13 onsite in 5 locations]**				
Secure easements		10	ea	2,000	20,000
Land purchase (1/8th acre ea wellhead)		1.250	acre	200,000	250,000
Surveying		5.0	day	1,000	5,000
Extraction wells - drilling and development	Depth				
C	300	15	ft	550	2,475,000
D	400	4	ft	550	880,000
E	500	4	ft	550	1,100,000
Wellhead vault: H-20 traffic rated		10	ea	5,000	50,000
Development (included with drilling)		23	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		9	ea	26,000	234,000
500 gpm, 300' TDH, 60 hp, 8" disch		14	ea	29,000	406,000
Discharge piping, 3" SS threaded	200	9	lin ft	40	72,000
Discharge piping, 8" SS threaded	200	14	lin ft	100	280,000
Installation (pump, wellhead, I&C)		23	LS	5,000	115,000
Incoming service power	15	500	ft	15	112,500
Pump control power and control		23	ea	2,000	46,000
Instrumentation and control/telemetry		15	ea	2,000	30,000
Subtotal - Extraction Wells (yr 2001)					6,076,000
Monitor Wells (year 2001)					
Secure permit		15	ea	100	1,500
Surveying		1.88	day	1,000	1,875
Monitor wells		15	ea	40,000	600,000
Subtotal - Monitor Wells (yr 2001)					603,000
Untreated Groundwater Piping (year 2001)					
Secure easements		1	LS	100,000	100,000
Land purchase		1	acre	200,000	200,000
Surveying		20	day	1,000	20,000
Jack and bore					
10" under railroad and Folsom Blvd	0	200	lin ft	150	0
12" under railroad and Folsom Blvd	1	200	lin ft	240	48,000
8" under Sunrise Blvd	0	500	lin ft	120	0
16" under Hwy 50	1	500	lin ft	320	160,000
16" under Folsom S. Canal	0	300	lin ft	240	0
20" under Folsom S. Canal	1	300	lin ft	400	120,000
Single-walled piping system (open field)					
8"			lin ft	64	0
10"		9,300	lin ft	80	744,000
12"		3,200	lin ft	96	307,200
16"		700	lin ft	128	89,600
20"		5,000	lin ft	160	800,000
24"			lin ft	192	0
30"			lin ft	240	0
Single-walled piping system (in street)					
6"			lin ft	100	0
8"		18,000	lin ft	100	1,800,000
10"		2,500	lin ft	140	350,000
12"		1,400	lin ft	140	196,000
16"		5,300	lin ft	175	927,500
20"		13,700	lin ft	225	3,082,500
30"			lin ft	300	0
Subtotal - Untreated Groundwater Piping (yr 2001)		59,100			8,945,000

Capital Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities (new 5,325 gpm facility [in addition to existing 4,000 gpm] at Get F) [year 2001]						
Secure easements			0	LS	5,000	0
Land purchase			0	acre	200,000	0
Surveying			1	day	1,000	1,000
Equalization tankage		2	159,750	gal	1.00	319,500
Transfer pumping	hp:	55	3	ea	10,000	30,000
VOC removal						
Air stripping			4	ea	85,000	340,000
Offgas treatment			0	ea	1,000,000	0
pH adjustment			0	ea		0
Transfer pumping			0	ea	10,000	0
Perchlorate removal (biological reduction)		5,325 gpm	1	ea	4,250,000	4,250,000
Regenerant bioreduction plant, incl. general contractor			0	ea		0
Chemical feed facilities			0	ea		0
UV/oxidation			2	ea	400,000	800,000
Transfer pumping	hp:	55	3	ea	10,000	30,000
Filtration and backwash facilities			0	ea		0
Liquid phase GAC contactors			0	ea		0
Disinfection, if necessary			0	ea		0
Transfer pumping			0	ea	10,000	0
Incoming high voltage power			0	ft	20	0
Backup generator (not for UV)			1	ea	50,000	50,000
Electrical wiring			1	LS	100,000	100,000
Instrumentation and control			1	LS	150,000	150,000
Treatment building			1,600	sq ft	100	160,000
Sitework and access road			1	LS	10,000	10,000
Area lighting			1	LS	5,000	5,000
Security fencing/gates			1,200	lin ft	15	18,000
General contractor installation @ % of equipment			1,819,500	%	40	727,800
Subtotal - Treatment at GET F (yr 2001)						6,991,000
Discharge Facilities (from 9,325 gpm GWTP at GET F to Buffalo Creek) [yr 2001]						
Surveying			2.5	day	1,000	2,500
Single-walled piping system (open field)						
30"			7,700	lin ft	240	1,848,000
Monitoring manhole and facilities			1	ea	5,000	5,000
Discharge structure			1	LS	10,000	10,000
Subtotal - Discharge Facilities from GET F (yr 2001)						1,866,000
Estimated Construction Costs - Subtotal (year 2001)						24,481,000
Contractor Markup, Mob/demob, Insurance				%	10	2,448,000
Engineering, Permitting and Construction Management				%	15	3,672,000
Regulatory Oversight				%	2.5	612,000
Estimated Project Capital Costs - Subtotal (year 2001)						31,213,000
Contingency				%	15	4,682,000
Estimated Project Capital Costs - Total (year 2001)						**35,900,000**

Capital Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	(mid 2011)				
Extraction Wells					
Secure easements		2	ea	2,000	4,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		2	ea	5,000	10,000
Development (included with drilling)		2	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		2	ea	26,000	52,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	2	lin ft	40	16,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		2	LS	5,000	10,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		2	ea	2,000	4,000
Instrumentation and control/telemetry		2	ea	2,000	4,000
Subtotal - Extraction Wells					606,000
Monitor Wells					
Secure permit		3	ea	100	300
Surveying		0.38	day	1,000	375
Monitor wells		3	ea	40,000	120,000
Subtotal - Monitor Wells					121,000
Estimated Construction Costs - Subtotal (mid 2011)					727,000
Contractor Markup, Mob/demob, Insurance			%	10	73,000
Engineering, Permitting and Construction Management			%	15	109,000
Regulatory Oversight			%	2.5	18,000
Estimated Project Capital Costs - Subtotal (mid 2011)					927,000
Contingency			%	15	139,000
Estimated Project Capital Costs - Total (mid 2011)					**1,066,000**

Capital Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**(mid 2021)**				
Extraction Wells					
Secure easements		2	ea	2,000	4,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		2	ea	5,000	10,000
Development (included with drilling)		2	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		2	ea	26,000	52,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	2	lin ft	40	16,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		2	LS	5,000	10,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		2	ea	2,000	4,000
Instrumentation and control/telemetry		2	ea	2,000	4,000
Subtotal - Extraction Wells					606,000
Monitor Wells (year 2001)					
Secure permit		3	ea	100	300
Surveying		0.50	day	1,000	500
Monitor wells		3	ea	40,000	120,000
Subtotal - Monitor Wells	(mid 2021)				121,000
Estimated Construction Costs - Subtotal					**727,000**
Contractor Markup, Mob/demob, Insurance			%	10	73,000
Engineering, Permitting and Construction Management			%	15	109,000
Regulatory Oversight			%	2.5	18,000
Estimated Project Capital Costs - Subtotal	**(mid 2021)**				927,000
Contingency			%	15	139,000
Estimated Project Capital Costs - Total	**(mid 2021)**				**1,066,000**

Operation and Maintenance Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**				
Extraction well maintenance			23	ea	1,000	23,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		26	183,753	kwh	0.050	9,000
C2		37	245,004	kwh	0.050	12,000
C3		37	245,004	kwh	0.050	12,000
C4		26	183,753	kwh	0.050	9,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		19	122,502	kwh	0.050	6,000
C8		19	122,502	kwh	0.050	6,000
C9		19	122,502	kwh	0.050	6,000
C10		26	183,753	kwh	0.050	9,000
D1			0	kwh	0.050	0
D2			0	kwh	0.050	0
D3			0	kwh	0.050	0
D4			0	kwh	0.050	0
D5			0	kwh	0.050	0
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)	hp:	111	723,017	kwh	0.050	36,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	715,000	715,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,070,000	%	3	62,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	23	ea	300	27,600
Monitor wells		4	35	ea	300	41,400
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2001						1,434,000
Contingency				%	15	215,000
Estimated Project O&M Costs - Total Year 2001						**1,649,000**

Operation and Maintenance Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2015**				
Extraction well maintenance			25	ea	1,000	25,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		28	183,753	kwh	0.050	9,000
C2		37	245,004	kwh	0.050	12,000
C3		37	245,004	kwh	0.050	12,000
C4		28	183,753	kwh	0.050	9,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		19	122,502	kwh	0.050	6,000
C8		19	122,502	kwh	0.050	6,000
C9		19	122,502	kwh	0.050	6,000
C10		28	183,753	kwh	0.050	9,000
D1		25	161,703	kwh	0.050	8,000
D2			0	kwh	0.050	0
D3			0	kwh	0.050	0
D4			0	kwh	0.050	0
D5		25	161,703	kwh	0.050	8,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		111	723,017	kwh	0.050	36,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	768,000	768,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,070,000	%	3	62,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	25	ea	300	30,000
Monitor wells		4	38	ea	300	45,000
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2015						1,562,000
Contingency				%	15	234,000
Estimated Project O&M Costs - Total Year 2015						**1,796,000**

Operation and Maintenance Cost Estimate
Alternative 4B - GETs E and F Extraction Wells with Offsite Extraction Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2026**				
Extraction well maintenance			27	ea	1,000	27,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		28	183,753	kwh	0.050	9,000
C2		37	245,004	kwh	0.050	12,000
C3		37	245,004	kwh	0.050	12,000
C4		28	183,753	kwh	0.050	9,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		19	122,502	kwh	0.050	6,000
C8		19	122,502	kwh	0.050	6,000
C9		19	122,502	kwh	0.050	6,000
C10		28	183,753	kwh	0.050	9,000
D1		25	161,703	kwh	0.050	8,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4			0	kwh	0.050	0
D5		25	161,703	kwh	0.050	8,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw.	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		111	723,017	kwh	0.050	36,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw.	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	750,000	750,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,070,000	%	3	62,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	27	ea	300	32,400
Monitor wells		4	41	ea	300	48,600
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2026						1,568,000
Contingency				%	15	235,000
Estimated Project O&M Costs - Total Year 2026						1,803,000

Detailed Cost Estimates

Alternative 4C

Present Worth Cost Estimate

Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

			Existing GETs E/F Estimated Costs			Additional Alternative 4C Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	41,260,000	974,500	42,234,500	42,235,000	42,200,000	41,260,000	1,774,500	43,034,500	43,000,000	43,000,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		1,949,000	1,949,000	1,821,000	44,100,000	0	3,549,000	3,549,000	3,300,000	46,300,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,949,000	1,949,000	1,702,000	45,800,000	0	3,549,000	3,549,000	3,100,000	49,400,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,949,000	1,949,000	1,591,000	47,300,000	0	3,549,000	3,549,000	2,900,000	52,300,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,949,000	1,949,000	1,487,000	48,800,000	0	3,549,000	3,549,000	2,700,000	55,000,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,949,000	1,949,000	1,390,000	50,200,000	0	3,549,000	3,549,000	2,500,000	57,500,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,949,000	1,949,000	1,299,000	51,500,000	0	3,549,000	3,549,000	2,400,000	59,900,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,949,000	1,949,000	1,214,000	52,700,000	0	3,549,000	3,549,000	2,200,000	62,100,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,949,000	1,949,000	1,134,000	53,900,000	0	3,549,000	3,549,000	2,100,000	64,200,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,949,000	1,949,000	1,060,000	54,900,000	0	3,549,000	3,549,000	1,900,000	66,100,000
2011	10	0.50835	1,600,000	810,000	12,000,000	573,000	1,994,000	2,567,000	1,305,000	56,200,000	573,000	3,594,000	4,167,000	2,100,000	68,200,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,994,000	1,994,000	947,000	57,200,000	0	3,594,000	3,594,000	1,700,000	69,900,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,994,000	1,994,000	885,000	58,100,000	0	3,594,000	3,594,000	1,600,000	71,500,000
2014	13	0.41496	1,600,000	660,000	14,200,000		1,994,000	1,994,000	827,000	58,900,000	0	3,594,000	3,594,000	1,500,000	73,000,000
2015	14	0.38782	1,600,000	620,000	14,800,000		1,994,000	1,994,000	773,000	59,700,000	0	3,594,000	3,594,000	1,400,000	74,400,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,994,000	1,994,000	723,000	60,400,000	0	3,594,000	3,594,000	1,300,000	75,700,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,994,000	1,994,000	675,000	61,100,000	0	3,594,000	3,594,000	1,200,000	76,900,000
2018	17	0.31657	1,600,000	510,000	16,400,000		1,994,000	1,994,000	631,000	61,700,000	0	3,594,000	3,594,000	1,100,000	78,000,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,994,000	1,994,000	590,000	62,300,000	0	3,594,000	3,594,000	1,100,000	79,100,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,994,000	1,994,000	551,000	62,800,000	0	3,594,000	3,594,000	1,000,000	80,100,000
2021	20	0.25842	1,600,000	410,000	17,700,000	573,000	2,008,000	2,581,000	667,000	63,500,000	573,000	3,608,000	4,181,000	1,100,000	81,200,000
2022	21	0.24151	1,600,000	380,000	18,100,000		1,970,000	1,970,000	476,000	64,000,000	0	3,570,000	3,570,000	900,000	82,100,000
2023	22	0.22571	1,600,000	360,000	18,500,000		1,970,000	1,970,000	445,000	64,400,000	0	3,570,000	3,570,000	800,000	82,900,000
2024	23	0.21095	1,600,000	340,000	18,800,000		1,970,000	1,970,000	416,000	64,800,000	0	3,570,000	3,570,000	800,000	83,700,000
2025	24	0.19715	1,600,000	320,000	19,100,000		1,970,000	1,970,000	388,000	65,200,000	0	3,570,000	3,570,000	700,000	84,400,000
2026	25	0.18425	800,000	150,000	19,300,000		985,000	985,000	181,000	65,400,000	0	1,785,000	1,785,000	300,000	84,700,000
	Total Estimated Costs:				19,000,000	42,000,000				65,400,000	42,000,000		131,734,500		85,000,000

Capital Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	**[16 offsite; 13 onsite in 5 locations]**				
Secure easements		16	ea	2,000	32,000
Land purchase (1/8th acre ea wellhead)		2.000	acre	200,000	400,000
Surveying		8.0	day	1,000	8,000
Extraction wells - drilling and development	Depth				
C	300	15	ft	550	2,475,000
D	400	8	ft	550	1,760,000
E	500	6	ft	550	1,650,000
Wellhead vault: H-20 traffic rated		16	ea	5,000	80,000
Development (included with drilling)		29	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		12	ea	26,000	312,000
500 gpm, 300' TDH, 60 hp, 8" disch		17	ea	29,000	493,000
Discharge piping, 3" SS threaded	200	12	lin ft	40	96,000
Discharge piping, 8" SS threaded	200	17	lin ft	100	340,000
Installation (pump, wellhead, I&C)		29	LS	5,000	145,000
Incoming service power	21	500	ft	15	157,500
Pump control power and control		29	ea	2,000	58,000
Instrumentation and control/telemetry		21	ea	2,000	42,000
Subtotal - Extraction Wells (yr 2001)					8,049,000
Monitor Wells (year 2001)					
Secure permit		24	ea	100	2,400
Surveying		3.00	day	1,000	3,000
Monitor wells		24	ea	40,000	960,000
Subtotal - Monitor Wells (yr 2001)					965,000
Untreated Groundwater Piping (year 2001)					
Secure easements		1	LS	100,000	100,000
Land purchase		1	acre	200,000	200,000
Surveying		20	day	1,000	20,000
Jack and bore					
8" under railroad and Folsom Blvd	1	200	lin ft	160	32,000
8" under Hwy 50	1	500	lin ft	160	80,000
20" under Folsom S. Canal	1	300	lin ft	400	120,000
10" under railroad and Folsom Blvd	1	200	lin ft	200	40,000
10" under RR	1	200	lin ft	200	40,000
8" under Sunrise Blvd	1	300	lin ft	160	48,000
Single-walled piping system (open field)					
8"		900	lin ft	64	57,600
10"		9,000	lin ft	80	720,000
12"		2,000	lin ft	96	192,000
16"			lin ft	128	0
20"		4,800	lin ft	160	768,000
24"			lin ft	192	0
30"			lin ft	240	0
Single-walled piping system (in street)					
6"			lin ft	100	0
8"		31,600	lin ft	100	3,160,000
10"		7,000	lin ft	140	980,000
12"		1,700	lin ft	140	238,000
16"		8,300	lin ft	175	1,452,500
20"		4,500	lin ft	225	1,012,500
30"			lin ft	300	0
Subtotal - Untreated Groundwater Piping (yr 2001)		69,800			9,261,000

Capital Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities (new 6,175 gpm facility [in addition to existing 4,000 gpm] at Get F) [year 2001]						
Secure easements			0	LS	5,000	0
Land purchase			0	acre	200,000	0
Surveying			1	day	1,000	1,000
Equalization tankage		2	198,750	gal	1.00	397,500
Transfer pumping	hp:	67	3	ea	15,000	45,000
VOC removal						
Air stripping			4	ea	100,000	400,000
Offgas treatment			0	ea	1,000,000	0
pH adjustment			0	ea		0
Transfer pumping			0	ea	10,000	0
Perchlorate removal (biological reduction)		6,175 gpm	1	ea	4,660,000	4,660,000
Regenerant bioreduction plant, incl. general contractor			0	ea		0
Chemical feed facilities			0	ea		0
UV/oxidation			2	ea	400,000	800,000
Transfer pumping	hp:	67	3	ea	15,000	45,000
Filtration and backwash facilities			0	ea		0
Liquid phase GAC contactors			0	ea		0
Disinfection, if necessary			0	ea		0
Transfer pumping			0	ea	10,000	0
Incoming high voltage power			0	ft	20	0
Backup generator (not for UV)			1	ea	50,000	50,000
Electrical wiring			1	LS	200,000	200,000
Instrumentation and control			1	LS	250,000	250,000
Treatment building			2,400	sq ft	100	240,000
Sitework and access road			1	LS	10,000	10,000
Area lighting			1	LS	5,000	5,000
Security fencing/gates			1,200	lin ft	15	18,000
General contractor installation @ % of equipment			2,187,500	%	40	875,000
Subtotal - Treatment at GET F (yr 2001)						7,997,000
Discharge Facilities (from GWTP at GET F to Buffalo Creek) [yr 2001]						
Surveying			2.5	day	1,000	2,500
Single-walled piping system (open field)						
30"			7,700	lin ft	240	1,848,000
Monitoring manhole and facilities			1	ea	5,000	5,000
Discharge structure			1	LS	10,000	10,000
Subtotal - Discharge Facilities from GET F (yr 2001)						1,866,000
Estimated Construction Costs - Subtotal (year 2001)						28,138,000
Contractor Markup, Mob/demob, Insurance				%	10	2,814,000
Engineering, Permitting and Construction Management				%	15	4,221,000
Regulatory Oversight				%	2.5	703,000
Estimated Project Capital Costs - Subtotal (year 2001)						35,876,000
Contingency				%	15	5,381,000
Estimated Project Capital Costs - Total (year 2001)						**41,260,000**

Capital Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**(mid 2011)**				
Extraction Wells					
Secure easements		1	ea	2,000	2,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	1	ft	550	220,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		1	ea	5,000	5,000
Development (included with drilling)		1	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 6" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 6" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		1	LS	5,000	5,000
Incoming service power	1	500	ft	15	7,500
Pump control power and control		1	ea	2,000	2,000
Instrumentation and control/telemetry		1	ea	2,000	2,000
Subtotal - Extraction Wells					329,000
Monitor Wells					
Secure permit		2	ea	100	150
Surveying		0.50	day	1,000	500
Monitor wells		2	ea	40,000	60,000
Subtotal - Monitor Wells					61,000
Estimated Construction Costs - Subtotal (mid 2011)					390,000
Contractor Markup, Mob/demob, Insurance			%	10	39,000
Engineering, Permitting and Construction Management			%	15	59,000
Regulatory Oversight			%	2.5	10,000
Estimated Project Capital Costs - Subtotal (mid 2011)					498,000
Contingency			%	15	75,000
Estimated Project Capital Costs - Total (mid 2011)					**573,000**

Capital Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	(mid 2021)				
Extraction Wells					
Secure easements		1	ea	2,000	2,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	1	ft	550	220,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		1	ea	5,000	5,000
Development (included with drilling)		1	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		1	LS	5,000	5,000
Incoming service power	1	500	ft	15	7,500
Pump control power and control		1	ea	2,000	2,000
Instrumentation and control/telemetry		1	ea	2,000	2,000
Subtotal - Extraction Wells					329,000
Monitor Wells (year 2001)					
Secure permit		2	ea	100	150
Surveying		0.50	day	1,000	500
Monitor wells		2	ea	40,000	60,000
Subtotal - Monitor Wells	(mid 2021)				61,000
Estimated Construction Costs - Subtotal					**390,000**
Contractor Markup, Mob/demob, Insurance			%	10	39,000
Engineering, Permitting and Construction Management			%	15	59,000
Regulatory Oversight			%	2.5	10,000
Estimated Project Capital Costs - Subtotal	(mid 2021)				498,000
Contingency			%	15	75,000
Estimated Project Capital Costs - Total	(mid 2021)				**573,000**

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2001**				
Extraction well maintenance			29	ea	1,000	29,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		19	122,502	kwh	0.050	6,000
C2		33	214,378	kwh	0.050	11,000
C3		28	183,753	kwh	0.050	9,000
C4		19	122,502	kwh	0.050	6,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		9	61,251	kwh	0.050	3,000
C8		19	122,502	kwh	0.050	6,000
C9		28	183,753	kwh	0.050	9,000
C10		33	214,378	kwh	0.050	11,000
D1		19	121,277	kwh	0.050	6,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4		25	161,703	kwh	0.050	8,000
D5			0	kwh	0.050	0
D6			0	kwh	0.050	0
E1		46	301,355	kwh	0.050	15,000
E2		46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)	hp:	134	877,163	kwh	0.050	44,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	803,000	803,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,437,000	%	3	73,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.5	yr	54,000	81,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	29	ea	300	34,800
Monitor wells		4	44	ea	300	52,200
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2001						1,695,000
Contingency				%	15	254,000
Estimated Project O&M Costs - Total Year 2001						1,949,000

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2015**				
Extraction well maintenance			30	ea	1,000	30,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		19	122,502	kwh	0.050	6,000
C2		33	214,378	kwh	0.050	11,000
C3		28	183,753	kwh	0.050	9,000
C4		19	122,502	kwh	0.050	6,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		9	61,251	kwh	0.050	3,000
C8		19	122,502	kwh	0.050	6,000
C9		28	183,753	kwh	0.050	9,000
C10		33	214,378	kwh	0.050	11,000
D1		19	121,277	kwh	0.050	6,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4		25	161,703	kwh	0.050	8,000
D5		25	161,703	kwh	0.050	8,000
D6			0	kwh	0.050	0
E1		46	301,355	kwh	0.050	15,000
E2		46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		134	877,163	kwh	0.050	44,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	830,000	830,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,437,000	%	3	73,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.5	yr	54,000	81,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	30	ea	300	36,000
Monitor wells		4	45	ea	300	54,000
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	6	ea	300	26,800
GWTP effluent		12	6	ea	300	26,800
GWTP intermediate locations		12	8	ea	300	26,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2015						1,734,000
Contingency				%	15	260,000
Estimated Project O&M Costs - Total Year 2015						1,994,900

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description			Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:		**Year 2021**				
Extraction well maintenance			31	ea	1,000	31,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:		Running hp				
C1		19	122,502	kwh	0.050	6,000
C2		33	214,378	kwh	0.050	11,000
C3		28	183,753	kwh	0.050	9,000
C4		19	122,502	kwh	0.050	6,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		9	61,251	kwh	0.050	3,000
C8		19	122,502	kwh	0.050	6,000
C9		28	183,753	kwh	0.050	9,000
C10		33	214,378	kwh	0.050	11,000
D1		19	121,277	kwh	0.050	6,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4		25	161,703	kwh	0.050	8,000
D5		25	161,703	kwh	0.050	8,000
D6		25	161,703	kwh	0.050	8,000
E1		46	301,355	kwh	0.050	15,000
E2		46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		134	877,183	kwh	0.050	44,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	65 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	830,000	830,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,437,000	%	3	73,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.5	yr	54,000	81,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qtrs.				
Extraction wells		4	31	ea	300	37,200
Monitor wells		4	47	ea	300	55,800
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2021						1,746,000
Contingency				%	15	262,000
Estimated Project O&M Costs - Total Year 2021						2,008,000

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description		Running hp	Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:			**Year 2022**			
Extraction well maintenance			30	ea	1,000	30,000
Pipeline maintenance			1	LS	10,000	10,000
Electric utilities:						
Well pumps:						
C1		19	122,502	kwh	0.050	6,000
C2		33	214,378	kwh	0.050	11,000
C3		28	183,753	kwh	0.050	9,000
C4		19	122,502	kwh	0.050	6,000
C5		19	122,502	kwh	0.050	6,000
C6		19	122,502	kwh	0.050	6,000
C7		9	61,251	kwh	0.050	3,000
C8		19	122,502	kwh	0.050	6,000
C9		28	183,753	kwh	0.050	9,000
C10			0	kwh	0.050	0
D1		19	121,277	kwh	0.050	6,000
D2		25	161,703	kwh	0.050	8,000
D3		25	161,703	kwh	0.050	8,000
D4		25	161,703	kwh	0.050	8,000
D5		25	161,703	kwh	0.050	8,000
D6		25	161,703	kwh	0.050	8,000
E1		46	301,355	kwh	0.050	15,000
E2		46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)		68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)		80	520,633	kwh	0.050	26,000
North of E		154	1,004,516	kwh	0.050	50,000
South of F		23	153,127	kwh	0.050	8,000
Treatment equipment:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps (GET F)		134	877,163	kwh	0.050	44,000
Effluent pumping (GET F)				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system				ccf	0.5	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Polymer for sludge dewatering (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement (GET F)			600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M			1	LS	812,000	812,000
UV service contract			1	LS	5,000	5,000
Waste disposal						
Dewatered sludge (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			2,437,000	%	3	73,000
Labor (incl. fringe benefits):						
Operator labor (in add'n to 1 FTE in bio. red'n)			1.5	yr	54,000	81,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	30	ea	300	36,000
Monitor wells		4	45	ea	300	54,000
Equivalent to PCD Exhibits IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2022						1,713,000
Contingency				%	15	257,000
Estimated Project O&M Costs - Total Year 2022						**1,970,000**

Operation and Maintenance Cost Estimate
Alternative 4C - Offsite Containment via Extraction Wells with Multiple Containment Corridors

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2026**				
Extraction well maintenance		30	ea	1,000	30,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	19	122,502	kwh	0.050	6,000
C2	33	214,378	kwh	0.050	11,000
C3	28	183,753	kwh	0.050	9,000
C4	19	122,502	kwh	0.050	6,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	9	61,251	kwh	0.050	3,000
C8	19	122,502	kwh	0.050	6,000
C9	28	183,753	kwh	0.050	9,000
C10		0	kwh	0.050	0
D1	19	121,277	kwh	0.050	6,000
D2	25	161,703	kwh	0.050	8,000
D3	25	161,703	kwh	0.050	8,000
D4	25	161,703	kwh	0.050	8,000
D5	25	161,703	kwh	0.050	8,000
D6	25	161,703	kwh	0.050	8,000
E1	46	301,355	kwh	0.050	15,000
E2	46	301,355	kwh	0.050	15,000
New-1 (replace E/F recharge)	68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment:					
Air stripping	60	392,623	kwh	0.050	20,000
UV/oxidation kw:	51.0	446,760	kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps (GET F)	134	877,163	kwh	0.050	44,000
Effluent pumping (GET F)			kwh	0.050	0
Misc. lighting and power kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities					
Onsite VPGAC regeneration system			ccf	0.5	0
Chemicals					
Ethanol for biological reduction (incl. below)			gal		0
Polymer for sludge dewatering (incl. below)			gal		0
Treatment equipment (besides utilities and maintenance)					
UV bulb replacement (GET F)		600	85 w bulb	35	21,000
Perchlorate biological reduction system O&M		1	LS	812,000	812,000
UV service contract		1	LS	5,000	5,000
Waste disposal					
Dewatered sludge (incl. above)			lb		0
Equip Maintenance (@ % of equip capital)		2,437,000	%	3	73,000
Labor (incl. fringe benefits):					
Operator labor (ln add'n to 1 FTE in bio. red'n)		1.5	yr	54,000	81,000
Management oversight and reporting		0.12	yr	100,000	12,000
Monitoring:					
Quarterly	# qtrs.				
Extraction wells	4	30	ea	300	36,000
Monitor wells	4	45	ea	300	54,000
Equivalent to PCD Exhibits IV and VI		1	ea	120,000	120,000
Monthly:	# mos				
GWTP influent	12	8	ea	300	28,800
GWTP effluent	12	8	ea	300	28,800
GWTP intermediate locations	12	8	ea	300	28,800
Sidestreams	12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2026					1,713,000
Contingency			%	15	257,000
Estimated Project O&M Costs - Total Year 2026					1,970,000

Detailed Cost Estimates

Alternative 5A

Present Worth.Cost Estimate

Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 5A Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	35,407,000	839,500	36,246,500	36,247,000	36,200,000	35,407,000	1,639,500	37,046,500	37,000,000	37,000,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		1,738,000	1,738,000	1,624,000	37,900,000	0	3,338,000	3,338,000	3,100,000	40,100,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,738,000	1,738,000	1,518,000	39,400,000	0	3,338,000	3,338,000	2,900,000	43,000,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,738,000	1,738,000	1,419,000	40,800,000	0	3,338,000	3,338,000	2,700,000	45,700,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,738,000	1,738,000	1,326,000	42,100,000	0	3,338,000	3,338,000	2,500,000	48,200,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,738,000	1,738,000	1,239,000	43,400,000	0	3,338,000	3,338,000	2,400,000	50,600,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,738,000	1,738,000	1,158,000	44,500,000	0	3,338,000	3,338,000	2,200,000	52,800,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,738,000	1,738,000	1,082,000	45,600,000	0	3,338,000	3,338,000	2,100,000	54,900,000
2009	8	0.58201	1,600,000	930,000	10,300,000	812,000	1,793,000	2,605,000	1,516,000	47,100,000	812,000	3,393,000	4,205,000	2,400,000	57,300,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,793,000	1,793,000	975,000	48,100,000	0	3,393,000	3,393,000	1,800,000	59,100,000
2011	10	0.50835	1,600,000	810,000	12,000,000	1,022,000	1,880,000	2,902,000	1,475,000	49,600,000	1,022,000	3,480,000	4,502,000	2,300,000	61,400,000
2012	11	0.47509	1,600,000	760,000	12,800,000		1,880,000	1,880,000	893,000	50,500,000	0	3,480,000	3,480,000	1,700,000	63,100,000
2013	12	0.44401	1,600,000	710,000	13,500,000		1,880,000	1,880,000	835,000	51,300,000	0	3,480,000	3,480,000	1,500,000	64,600,000
2014	13	0.41496	1,600,000	660,000	14,200,000		1,880,000	1,880,000	780,000	52,100,000	0	3,480,000	3,480,000	1,400,000	66,000,000
2015	14	0.38782	1,600,000	620,000	14,800,000		1,880,000	1,880,000	729,000	52,800,000	0	3,480,000	3,480,000	1,300,000	67,300,000
2016	15	0.36245	1,600,000	580,000	15,400,000		1,880,000	1,880,000	681,000	53,500,000	0	3,480,000	3,480,000	1,300,000	68,600,000
2017	16	0.33873	1,600,000	540,000	15,900,000		1,906,000	1,906,000	646,000	54,100,000	0	3,506,000	3,506,000	1,200,000	69,800,000
2018	17	0.31657	1,600,000	510,000	16,400,000	812,000	1,906,000	2,718,000	860,000	55,000,000	812,000	3,506,000	4,318,000	1,400,000	71,200,000
2019	18	0.29586	1,600,000	470,000	16,900,000		1,906,000	1,906,000	564,000	55,600,000	0	3,506,000	3,506,000	1,000,000	72,200,000
2020	19	0.27651	1,600,000	440,000	17,300,000		1,906,000	1,906,000	527,000	56,100,000	0	3,506,000	3,506,000	1,000,000	73,200,000
2021	20	0.25842	1,600,000	410,000	17,700,000	2,499,000	2,094,000	4,593,000	1,187,000	57,300,000	2,499,000	3,694,000	6,193,000	1,600,000	74,800,000
2022	21	0.24151	1,600,000	390,000	18,100,000		2,044,000	2,044,000	494,000	57,800,000	0	3,644,000	3,644,000	900,000	75,700,000
2023	22	0.22571	1,600,000	360,000	18,500,000		2,044,000	2,044,000	461,000	58,200,000	0	3,644,000	3,644,000	800,000	76,500,000
2024	23	0.21095	1,600,000	340,000	18,800,000		2,044,000	2,044,000	431,000	58,700,000	0	3,644,000	3,644,000	800,000	77,300,000
2025	24	0.19715	1,600,000	320,000	19,100,000		2,044,000	2,044,000	403,000	59,100,000	0	3,644,000	3,644,000	700,000	78,000,000
2026	25	0.18425	800,000	150,000	19,300,000		1,022,000	1,022,000	188,000	59,300,000	0	1,822,000	1,822,000	300,000	78,300,000
Total Estimated Costs:					19,000,000	41,000,000				59,000,000	41,000,000				78,000,000

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	**[10 offsite, 4 onsite in 2 locations]**				
Secure easements		10	ea	2,000	20,000
Land purchase (1/8th acre ea wellhead)		1.25	acre	200,000	250,000
Surveying		5	day	1,000	5,000
Extraction wells - drilling and development	Depth				
C	300	11	ft	550	1,815,000
D	400	2	ft	550	440,000
E	500	1	ft	550	275,000
Wellhead vault: H-20 traffic rated		10	ea	5,000	50,000
Development (included with drilling)		14	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		4	ea	26,000	104,000
500 gpm, 300' TDH, 60 hp, 8" disch		10	ea	29,000	290,000
Discharge piping, 3" SS threaded	200	4	lin ft	40	32,000
Discharge piping, 8" SS threaded	200	10	lin ft	100	200,000
Installation (pump, wellhead, I&C)		14	LS	5,000	70,000
Incoming service power	14	500	ft	15	105,000
Pump control power and control		14	ea	2,000	28,000
Instrumentation and control/telemetry		14	ea	2,000	28,000
Subtotal - Extraction Wells (yr 2001)					3,712,000
Monitor Wells (year 2001)					
Secure permit		14	ea	100	1,400
Surveying		2.0	day	1,000	2,000
Monitor wells		21	ea	40,000	840,000
Subtotal - Monitor Wells (yr 2001)					843,400
Untreated Groundwater Piping (year 2001)					
Offsite Extraction Well Piping:					
Secure easements		1	LS	50,000	50,000
Land purchase		0.0	acre	200,000	0
Surveying		20	day	1,000	20,000
Jack and bore					
12" under railroad and Folsom Blvd	1	200	lin ft	240	48,000
16" under Hwy 50	1	500	lin ft	320	160,000
Single-walled piping system (in street)					
8"		9,500	lin ft	100	950,000
10"		10,200	lin ft	140	1,428,000
12"		4,000	lin ft	140	560,000
16"		5,800	lin ft	175	812,000
20"		2,100	lin ft	225	472,500
24"		3,500	lin ft	260	910,000
Onsite:					
Single-walled piping system (open field)					
8"		1,200	lin ft	64	76,800
10"		9,000	lin ft	80	720,000
Subtotal - Untreated Groundwater Piping (yr 2001)		45,300			6,207,000

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities at GET F (4,000 gpm capacity is adequate for 3,800 gpm projected) [year 2001]					
Treatment Facilities (New 4,900 gpm facility offsite) [year 2001]					
Secure easements		1	LS	10,000	10,000
Land purchase		2	acre	20,000	40,000
Surveying		2	day	1,000	2,000
Equalization tankage	2	147,000	gal	1.00	294,000
Transfer pumping	92 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		4	ea	85,000	340,000
Offgas treatment (assumed not required)		0	ea	400,000	0
Perchlorate removal (biological reduction)	4,900 gpm	1	ea	4,118,000	4,118,000
Transfer pumping	92 hp	3	ea	10,000	30,000
Incoming high voltage power		1,000	ft	20	20,000
Backup generator (not for UV)		1	ea	50,000	50,000
Electrical wiring		1	LS	100,000	100,000
Instrumentation and control		1	LS	100,000	100,000
Treatment building		1,600	sq ft	100	160,000
Sitework and access road		1	LS	30,000	30,000
Area lighting		1	LS	5,000	5,000
Security fencing/gates		1,200	lin ft	15	18,000
General contractor installation @ % of equipment		964,000	%	40	386,000
Subtotal - Treatment Offsite (yr 2001)					5,733,000
Recharge Wells (yr 2001)					
Secure easements		7	ea	10,000	70,000
Land purchase		0.875	acre	200,000	175,000
Surveying		4	day	1,000	3,500
Recharge wells	Number:				
C		400	ft	550	0
D	7	400	ft	550	1,540,000
E			ft	550	0
Wellheads/vaults		7	ea	5,000	35,000
Development		7	ea	10,000	70,000
Installation		7	LS	5,000	35,000
Instrumentation and control (w/ 500' conduit)		7	LS	3,000	21,000
Subtotal - Recharge Wells (yr 2001)					1,950,000

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treated Groundwater Piping to Recharge Wells (year 2001)					
Secure easements		1	LS	50,000	50,000
Land purchase		0.0	acre	200,000	0
Surveying		20	day	1,000	20,000
Jack and bore					
20" under railroad and Folsom Blvd	1	200	lin ft	400	80,000
16" under Sunrise Blvd	1	300	lin ft	320	96,000
20" under Hwy 50	1	500	lin ft	400	200,000
Single-walled piping system (in street - separate trench)					
8"		3,800	lin ft	100	380,000
10"		1,200	lin ft	140	168,000
12"		500	lin ft	140	70,000
16"		12,500	lin ft	175	2,187,500
20"		17,600	lin ft	225	3,960,000
Subtotal - Treated Groundwater Piping to Recharge		35,600			7,212,000
Estimated Construction Costs - Subtotal (year 2001)					25,657,000
Contractor Markup, Mob/demob, Insurance			%	10	2,566,000
Engineering, Permitting and Construction Management			%	10	2,566,000
Regulatory Oversight			%	2.5	641,000
Estimated Project Capital Costs - Subtotal (year 2001)					30,789,000
Contingency			%	15	4,618,000
Estimated Project Capital Costs - Total (year 2001)					**35,407,000**

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2009**				
Treatment Facilities Offsite					
UV/oxidation					400,000
Electrical wiring		1	LS	10,000	10,000
Instrumentation and control		1	LS	10,000	10,000
General contractor installation @ % of equipment		420,000	%	40	168,000
Subtotal - Treatment					588,000
Estimated Construction Costs - Subtotal	**2009**				588,000
Contractor Markup, Mob/demob, Insurance			%	10	59,000
Engineering, Permitting and Construction Management			%	10	59,000
Regulatory Oversight			%	2.5	15,000
Estimated Project Capital Costs - Subtotal	**2009**				706,000
Contingency			%	15	106,000
Estimated Project Capital Costs - Total	**2009**				**812,000**

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2011**				
Extraction Wells					
Secure easements		2	ea	2,000	4,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		2	ea	5,000	10,000
Development (included with drilling)		2	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		1	ea	29,000	29,000
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	1	lin ft	100	20,000
Installation (pump, wellhead, I&C)		2	LS	5,000	10,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		2	ea	2,000	4,000
Instrumentation and control/telemetry		2	ea	2,000	4,000
Subtotal - Extraction Wells					621,000
Monitor Wells					
Secure permit		2	ea	100	200
Surveying		0.25	day	1,000	250
Monitor wells		3	ea	40,000	120,000
Subtotal - Monitor Wells					120,000
Estimated Construction Costs - Subtotal	**2011**				741,000
Contractor Markup, Mob/demob, Insurance			%	10	74,000
Engineering, Permitting and Construction Management			%	10	74,000
Regulatory Oversight			%	2.5	19,000
Estimated Project Capital Costs - Subtotal	**2011**				889,000
Contingency			%	15	133,000
Estimated Project Capital Costs - Total	**2011**				**1,022,000**

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2017**				
Treatment Facilities Offsite					
UV/oxidation		1	ea	400,000	400,000
Electrical wiring		1	LS	10,000	10,000
Instrumentation and control		1	LS	10,000	10,000
General contractor installation @ % of equipment		420,000	%	40	168,000
Subtotal - Treatment					588,000
Estimated Construction Costs - Subtotal	**2017**				588,000
Contractor Markup, Mob/demob, Insurance			%	10	59,000
Engineering, Permitting and Construction Management			%	10	59,000
Regulatory Oversight			%	2.5	15,000
Estimated Project Capital Costs - Subtotal	**2017**				706,000
Contingency			%	15	106,000
Estimated Project Capital Costs - Total	**2017**				**812,000**

Capital Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2021**				
Extraction Wells					
Secure easements		5	ea	2,000	10,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	4	ft	550	880,000
E	500	1	ft	550	275,000
Wellhead vault: H-20 traffic rated		5	ea	5,000	25,000
Development (included with drilling)		5	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		4	ea	26,000	104,000
500 gpm, 300' TDH, 60 hp, 8" disch		1	ea	29,000	29,000
Discharge piping, 3" SS threaded	200	4	lin ft	40	32,000
Discharge piping, 8" SS threaded	200	1	lin ft	100	20,000
Installation (pump, wellhead, I&C)		5	LS	5,000	25,000
Incoming service power	5	500	ft	15	37,500
Pump control power and control		5	ea	2,000	10,000
Instrumentation and control/telemetry		5	ea	2,000	10,000
Subtotal - Extraction Wells					1,509,000
Monitor Wells					
Secure permit		5	ea	100	500
Surveying		1.0	day	1,000	1,000
Monitor wells		8	ea	40,000	300,000
Subtotal - Monitor Wells					301,500
Estimated Construction Costs - Subtotal	**2021**				1,811,000
Contractor Markup, Mob/demob, Insurance			%	10	181,000
Engineering, Permitting and Construction Management			%	10	181,000
Regulatory Oversight			%	2.5	45,000
Estimated Project Capital Costs - Subtotal	**2021**				2,173,000
Contingency			%	15	326,000
Estimated Project Capital Costs - Total	**2021**				**2,499,000**

Operation and Maintenance Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2001**				
Extraction Wells and Pipeline:					
Extraction well maintenance		14	ea	1,000	14,000
Recharge well maintenance		7	ea	50,000	350,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	37	245,004	kwh	0.050	12,000
C2	47	306,255	kwh	0.050	15,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
C8	19	122,502	kwh	0.050	6,000
C9	37	245,004	kwh	0.050	12,000
D1		0	kwh	0.050	0
D2	28	183,753	kwh	0.050	9,000
D3		0	kwh	0.050	0
D4		0	kwh	0.050	0
D5		0	kwh	0.050	0
D6		0	kwh	0.050	0
D7		0	kwh	0.050	0
D8		0	kwh	0.050	0
E1		0	kwh	0.050	0
E2		0	kwh	0.050	0
GET E North of E	154	1,004,516	kwh	0.050	50,000
GET F South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GET F) in addition to existing:					
Electric utilities:					
UV/oxidation	kw:		kwh	0.050	22,000
Treatment equipment (GET F) besides utilities and maintenance:					
UV bulb replacement (GET F)					21,000
Equip Maintenance (@ % of equip capital)		400,000	%	3	12,000

Operation and Maintenance Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment equipment (Offsite GWTP):						
Electric utilities:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:	0	0	kwh	0.050	0
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps		70	455,097	kwh	0.050	23,000
Effluent pumping		58	379,248	kwh	0.050	19,000
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system (assumed not required)			0	ccf	2.0	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement			0			0
Perchlorate biological reduction system O&M			1	LS	539,000	539,000
Waste disposal						
Sludge from biological reduction (incl. in bio. red'n)				lb		0
Equip Maintenance (@ % of equip capital)			860,000	%	3	26,000
Labor (incl. fringe benefits):						
Operator labor (1 FTE incl. in biological red'n)			0.5	yr	54,000	27,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	14	ea	300	16,800
Monitor wells		4	21	ea	300	25,200
Equivalent to PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2001						1,460,000
Contingency				%	15	219,000
Estimated Project O&M Costs - Total Year 2001						**1,679,000**

Operation and Maintenance Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2015**				
Extraction Wells and Pipeline:					
Extraction well maintenance		14	ea	1,000	14,000
Recharge well maintenance		7	ea	50,000	350,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	37	245,004	kwh	0.050	12,000
C2	47	306,255	kwh	0.050	15,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
C8	19	122,502	kwh	0.050	6,000
C9	37	245,004	kwh	0.050	12,000
D1	28	183,753	kwh	0.050	9,000
D2	28	183,753	kwh	0.050	9,000
D3		0	kwh	0.050	0
D4		0	kwh	0.050	0
D5		0	kwh	0.050	0
D6		0	kwh	0.050	0
D7		0	kwh	0.050	0
D8	19	122,502	kwh	0.050	6,000
E1		0	kwh	0.050	0
E2		0	kwh	0.050	0
GET E North of E	154	1,004,516	kwh	0.050	50,000
GET F South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GET F) in addition to existing:					
Electric utilities:					
UV/oxidation	kw:		kwh	0.050	22,000
Treatment equipment (GET F) besides utilities and maintenance:					
UV bulb replacement (GET F)					21,000
Equip Maintenance (@ % of equip capital)		400,000	%	3	12,000

Operation and Maintenance Cost Estimate
Alternative 5A - GETs E and F Extraction and Recharge Wells with Offsite Extraction and Recharge Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment equipment (Offsite GWTP):						
Electric utilities:						
Air stripping		60	392,623	kwh	0.050	20,000
UV/oxidation	kw:			kwh	0.050	11,000
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps		70	455,097	kwh	0.050	23,000
Effluent pumping		58	379,248	kwh	0.050	19,000
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system (assumed not required)			0	ccf	2.0	0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement						10,500
Perchlorate biological reduction system O&M			1	LS	600,000	600,000
Waste disposal						
Sludge from biological reduction (incl. in bio. red'n)				lb		0
Equip Maintenance (@ % of equip capital)			860,000	%	3	26,000
Labor (incl. fringe benefits):						
Operator labor (1 FTE incl. in biological red'n)			1.0	yr	54,000	54,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	14	ea	300	16,800
Monitor wells		4	21	ea	300	25,200
Equivalent to PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	8	ea	300	28,800
GWTP effluent		12	8	ea	300	28,800
GWTP intermediate locations		12	8	ea	300	28,800
Sidestreams		12	4	ea	300	14,400
Estimated Project O&M Costs - Subtotal Year 2015						1,635,000
Contingency				%	15	245,000
Estimated Project O&M Costs - Total Year 2015						**1,880,000**

Detailed Cost Estimates

Alternative 5B

Present Worth Cost Estimate

Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

			Existing GETs E/F Estimated Costs			Additional Alternative 5B Estimated Costs					Total Estimated Costs				
Year	n	P/F(i=7%)	O&M Costs ($/yr)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)	Capital Costs ($)	O&M Costs ($/yr)	Subtotal Costs ($)	Present Worth of Costs ($)	Cumulative Present Worth ($)
2001	0	1.00000	800,000	800,000	800,000	43,179,000	993,500	44,172,500	44,173,000	44,200,000	43,179,000	1,793,500	44,972,500	45,000,000	45,000,000
2002	1	0.93458	1,600,000	1,500,000	2,300,000		1,987,000	1,987,000	1,857,000	46,000,000	0	3,587,000	3,587,000	3,400,000	48,400,000
2003	2	0.87344	1,600,000	1,400,000	3,700,000		1,987,000	1,987,000	1,736,000	47,800,000	0	3,587,000	3,587,000	3,100,000	51,500,000
2004	3	0.81630	1,600,000	1,310,000	5,000,000		1,987,000	1,987,000	1,622,000	49,400,000	0	3,587,000	3,587,000	2,900,000	54,400,000
2005	4	0.76290	1,600,000	1,220,000	6,200,000		1,987,000	1,987,000	1,516,000	50,900,000	0	3,587,000	3,587,000	2,700,000	57,100,000
2006	5	0.71299	1,600,000	1,140,000	7,300,000		1,987,000	1,987,000	1,417,000	52,300,000	0	3,587,000	3,587,000	2,600,000	59,700,000
2007	6	0.66634	1,600,000	1,070,000	8,400,000		1,987,000	1,987,000	1,324,000	53,600,000	0	3,587,000	3,587,000	2,400,000	62,100,000
2008	7	0.62275	1,600,000	1,000,000	9,400,000		1,987,000	1,987,000	1,237,000	54,900,000	0	3,587,000	3,587,000	2,200,000	64,300,000
2009	8	0.58201	1,600,000	930,000	10,300,000		1,987,000	1,987,000	1,156,000	56,000,000	0	3,587,000	3,587,000	2,100,000	66,400,000
2010	9	0.54393	1,600,000	870,000	11,200,000		1,987,000	1,987,000	1,081,000	57,100,000	0	3,587,000	3,587,000	2,000,000	68,400,000
2011	10	0.50835	1,600,000	810,000	12,000,000	573,000	2,015,000	2,588,000	1,316,000	58,400,000	573,000	3,615,000	4,188,000	2,100,000	70,500,000
2012	11	0.47509	1,600,000	760,000	12,800,000		2,015,000	2,015,000	957,000	59,400,000	0	3,615,000	3,615,000	1,700,000	72,200,000
2013	12	0.44401	1,600,000	710,000	13,500,000		2,015,000	2,015,000	895,000	60,300,000	0	3,615,000	3,615,000	1,600,000	73,800,000
2014	13	0.41496	1,600,000	660,000	14,200,000		2,015,000	2,015,000	836,000	61,100,000	0	3,615,000	3,615,000	1,500,000	75,300,000
2015	14	0.38782	1,600,000	620,000	14,800,000		2,015,000	2,015,000	781,000	61,900,000	0	3,615,000	3,615,000	1,400,000	76,700,000
2016	15	0.36245	1,600,000	580,000	15,400,000		2,015,000	2,015,000	730,000	62,600,000	0	3,615,000	3,615,000	1,300,000	78,000,000
2017	16	0.33873	1,600,000	540,000	15,900,000		2,015,000	2,015,000	683,000	63,300,000	0	3,615,000	3,615,000	1,200,000	79,200,000
2018	17	0.31657	1,600,000	510,000	16,400,000	882,000	2,071,000	2,953,000	935,000	64,300,000	882,000	3,671,000	4,553,000	1,400,000	80,600,000
2019	18	0.29586	1,600,000	470,000	16,900,000		2,071,000	2,071,000	613,000	64,900,000	0	3,671,000	3,671,000	1,100,000	81,700,000
2020	19	0.27651	1,600,000	440,000	17,300,000		2,071,000	2,071,000	573,000	65,400,000	0	3,671,000	3,671,000	1,000,000	82,700,000
2021	20	0.25842	1,600,000	410,000	17,700,000	1,065,000	2,139,000	3,204,000	828,000	66,300,000	1,065,000	3,739,000	4,804,000	1,200,000	83,900,000
2022	21	0.24151	1,600,000	390,000	18,100,000		2,139,000	2,139,000	517,000	66,800,000	0	3,739,000	3,739,000	900,000	84,800,000
2023	22	0.22571	1,600,000	360,000	18,500,000		2,139,000	2,139,000	483,000	67,300,000	0	3,739,000	3,739,000	800,000	85,600,000
2024	23	0.21095	1,600,000	340,000	18,800,000		2,139,000	2,139,000	451,000	67,700,000	0	3,739,000	3,739,000	800,000	86,400,000
2025	24	0.19715	1,600,000	320,000	19,100,000		2,139,000	2,139,000	422,000	68,100,000	0	3,739,000	3,739,000	700,000	87,100,000
2026	25	0.18425	800,000	150,000	19,300,000		1,069,500	1,069,500	197,000	68,300,000	0	1,869,500	1,869,500	300,000	87,400,000
Total Estimated Costs:					19,000,000	46,000,000				68,000,000	46,000,000				87,000,000

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs: (year 2001)					
Extraction Wells (year 2001)	**[7 offsite, 13 onsite in 5 locations]**				
Secure easements		7	ea	2,000	14,000
Land purchase (1/8th acre ea wellhead)		0.875	acre	200,000	175,000
Surveying		3.5	day	1,000	3,500
Extraction wells - drilling and development	Depth				
C	300	12	ft	550	1,980,000
D	400	4	ft	550	880,000
E	500	4	ft	550	1,100,000
Wellhead vault: H-20 traffic rated		7	ea	5,000	35,000
Development (included with drilling)		20	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		7	ea	26,000	182,000
500 gpm, 300' TDH, 60 hp, 8" disch		13	ea	29,000	377,000
Discharge piping, 3" SS threaded	200	7	lin ft	40	56,000
Discharge piping, 8" SS threaded	200	13	lin ft	100	260,000
Installation (pump, wellhead, I&C)		20	LS	5,000	100,000
Incoming service power	12	500	ft	15	90,000
Pump control power and control		20	ea	2,000	40,000
Instrumentation and control/telemetry		20	ea	2,000	40,000
Subtotal - Extraction Wells (yr 2001)					5,333,000
Monitor Wells (year 2001)					
Secure permit		7	ea	100	700
Surveying		1.0	day	1,000	1,000
Monitor wells		11	ea	40,000	420,000
Subtotal - Monitor Wells (yr 2001)					422,000
Untreated Groundwater Piping (year 2001)					
Offsite:					
Secure easements		1	LS	50,000	50,000
Land purchase		0.0	acre	200,000	0
Surveying		20	day	1,000	20,000
Jack and bore	No.				
8" and 20" under railroad and Folsom Blvd	1	200	lin ft	160	32,000
16" under Sunrise Blvd	1	500	lin ft	320	160,000
10" and 20" under Hwy 50	1	500	lin ft	400	200,000
Single-walled piping (in street)					
8"		9,400	lin ft	100	940,000
10"		600	lin ft	140	84,000
Single-walled piping (in street)					
8"		2,400	lin ft	100	240,000
10"		4,900	lin ft	140	686,000
12"		2,900	lin ft	140	406,000
20"		3,600	lin ft	225	810,000
Onsite:					
Single-walled piping (open field)					
8"		1,300	lin ft	64	83,200
10"		9,300	lin ft	80	744,000
12"		1,900	lin ft	96	182,400
16"		700	lin ft	128	89,600
Subtotal - Untreated Groundwater Piping (yr 2001)		37,000			4,727,000
Treatment Facilities (2,225 gpm expanded capacity at Get F) [year 2001]					
Surveying		1	day	1,000	1,000
Equalization tankage	2	66,750	gal	1.00	133,500
Transfer pumping	42 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		2	ea	85,000	170,000
Offgas treatment (assumed not required)		0	ea		0
Perchlorate removal (biological reduction)	2,225 gpm	1	ea	2,869,000	2,869,000
UV/oxidation (KW)					800,000
Transfer pumping	42 hp	3	ea	10,000	30,000
Electrical wiring		1	LS	50,000	50,000
Instrumentation and control		1	LS	50,000	50,000
Treatment building		800	sq ft	100	80,000
General contractor installation @ % of equipment		1,263,500	%	40	505,400
Subtotal - Treatment at GET F (yr 2001)					4,719,000

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Treatment Facilities (New 2,600 gpm facility offsite) [year 2001]					
Secure easements		1	LS	10,000	10,000
Land purchase		2	acre	200,000	400,000
Surveying		2	day	1,000	2,000
Equalization tankage	2	78,000	gal	1.00	156,000
Transfer pumping	50 hp	3	ea	10,000	30,000
VOC removal					
Air stripping		2	ea	85,000	170,000
Offgas treatment (assumed not required)		0	ea		0
Perchlorate removal (biological reduction)	2,600 gpm	1	ea	3,038,000	3,038,000
UV/oxidation (KW)		0	ea	1	0
Transfer pumping	50 hp	3	ea	10,000	30,000
Incoming high voltage power		1,000	ft	20	20,000
Backup generator (not for UV)		1	ea	50,000	50,000
Electrical wiring (most incl. in bio. red'n)		1	LS	10,000	10,000
Instrumentation and control (most incl. in bio. red'n)		1	LS	20,000	20,000
Treatment building		0	sq ft	100	0
Sitework and access road		1	LS	10,000	10,000
Area lighting		1	LS	5,000	5,000
Security fencing/gates		1,200	lin ft	15	18,000
General contractor installation @ % of equipment		486,000	%	40	194,400
Subtotal - Treatment Offsite (yr 2001)					4,163,000
Recharge Wells (yr 2001)					
Secure easements		7	ea	10,000	70,000
Land purchase		0.875	acre	200,000	175,000
Surveying		4	day	1,000	3,500
Recharge wells	Number:				
C		400	ft	550	0
D	7	400	ft	550	1,540,000
E			ft	550	0
Wellheads/vaults		7	ea	5,000	35,000
Development		7	ea	10,000	70,000
Installation		7	LS	5,000	35,000
Instrumentation and control (w/ 500' conduit)		7	LS	3,000	21,000
Subtotal - Recharge Wells (yr 2001)					1,950,000
Treated Groundwater Piping to Recharge Wells (year 2001)					
Secure easements		1	LS	50,000	50,000
Land purchase		0.0	acre	200,000	0
Surveying		20	day	1,000	20,000
Jack and bore - see untreated groundwater piping					
Single-walled piping system (in street)					
8"		4,000	lin ft	100	400,000
10"		1,200	lin ft	140	168,000
12"		500	lin ft	140	70,000
16"		11,600	lin ft	175	2,030,000
20"		3,800	lin ft	225	855,000
Single-walled piping system (in street)					
20"		13,600	lin ft	225	3,105,000
Subtotal - Treated Groundwater Piping to Recharge		34,900			6,696,000
Treated Groundwater Piping from GET F to Discharge at Buffalo Creek (year 2001)					
Surveying		1	day	1,000	1,000
Single-walled piping system (open field)					
24"		7,400	lin ft	192	1,420,800
Monitoring manhole and facilities		1	ea	5,000	5,000
Discharge structure		1	LS	10,000	10,000
Subtotal - Treated Groundwater to Discharge		7,400			1,437,000
Estimated Construction Costs - Subtotal (year 2001)					29,449,000
Contractor Markup, Mob/demob, Insurance			%	10	2,945,000
Engineering, Permitting and Construction Management			%	15	4,417,000
Regulatory Oversight			%	2.5	736,000
Estimated Project Capital Costs - Subtotal (year 2001)					37,547,000
Contingency			%	15	5,632,000
Estimated Project Capital Costs - Total (year 2001)					43,179,000

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2011**				
Extraction Wells					
Secure easements		1	ea	2,000	2,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	1	ft	550	220,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		1	ea	5,000	5,000
Development (included with drilling)		1	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		1	ea	26,000	26,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	1	lin ft	40	8,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		1	LS	5,000	5,000
Incoming service power	1	500	ft	15	7,500
Pump control power and control		1	ea	2,000	2,000
Instrumentation and control/telemetry		1	ea	2,000	2,000
Subtotal - Extraction Wells					329,000
Monitor Wells					
Secure permit		1	ea	100	100
Surveying		0.50	day	1,000	500
Monitor wells		2	ea	40,000	60,000
Subtotal - Monitor Wells					61,000
Estimated Construction Costs - Subtotal	**2011**				390,000
Contractor Markup, Mob/demob, Insurance			%	10	39,000
Engineering, Permitting and Construction Management			%	15	59,000
Regulatory Oversight			%	2.5	10,000
Estimated Project Capital Costs - Subtotal	**2011**				498,000
Contingency			%	15	75,000
Estimated Project Capital Costs - Total	**2011**				**573,000**

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2018**				
Treatment Facilities Offsite					
UV/oxidation					400,000
Electrical wiring		1	LS	20,000	20,000
Instrumentation and control		1	LS	10,000	10,000
General contractor installation @ % of equipment		430,000	%	40	172,000
Subtotal - Treatment					602,000
Estimated Construction Costs - Subtotal	**2018**				602,000
Contractor Markup, Mob/demob, Insurance			%	10	60,000
Engineering, Permitting and Construction Management			%	15	90,000
Regulatory Oversight			%	2.5	15,000
Estimated Project Capital Costs - Subtotal	**2018**				767,000
Contingency			%	15	115,000
Estimated Project Capital Costs - Total	**2018**				**882,000**

Capital Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Capital Costs:	**2021**				
Extraction Wells					
Secure easements		2	ea	2,000	4,000
Land purchase (1/8th acre ea wellhead)		0.250	acre	200,000	50,000
Surveying		1	day	1,000	1,000
Extraction wells - drilling and development	Depth				
C	300	0	ft	550	0
D	400	2	ft	550	440,000
E	500	0	ft	550	0
Wellhead vault: H-20 traffic rated		2	ea	5,000	10,000
Development (included with drilling)		2	ea		
Pumps, incl. cable, pitless unit					
250 gpm, 300' TDH, 25 hp, 3" disch		2	ea	26,000	52,000
500 gpm, 300' TDH, 60 hp, 8" disch		0	ea	29,000	0
Discharge piping, 3" SS threaded	200	2	lin ft	40	16,000
Discharge piping, 8" SS threaded	200	0	lin ft	100	0
Installation (pump, wellhead, I&C)		2	LS	5,000	10,000
Incoming service power	2	500	ft	15	15,000
Pump control power and control		2	ea	2,000	4,000
Instrumentation and control/telemetry		2	ea	2,000	4,000
Subtotal - Extraction Wells					606,000
Monitor Wells					
Secure permit		2	ea	100	200
Surveying		0.25	day	1,000	250
Monitor wells		3	ea	40,000	120,000
Subtotal - Monitor Wells					120,000
Estimated Construction Costs - Subtotal	**2021**				**726,000**
Contractor Markup, Mob/demob, Insurance			%	10	73,000
Engineering, Permitting and Construction Management			%	15	109,000
Regulatory Oversight			%	2.5	18,000
Estimated Project Capital Costs - Subtotal	**2021**				926,000
Contingency			%	15	139,000
Estimated Project Capital Costs - Total	**2021**				**1,065,000**

Operation and Maintenance Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2001**				
Extraction Wells and Pipeline:					
Extraction well maintenance		20	ea	1,000	20,000
Recharge well maintenance		7	ea	50,000	350,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	28	183,753	kwh	0.050	9,000
C2	37	245,004	kwh	0.050	12,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
D1		0	kwh	0.050	0
D2		0	kwh	0.050	0
D3		0	kwh	0.050	0
New-1 (replace E/F recharge)	68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GET F) in addition to existing:					
Electric utilities:					
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps (GET F)	50	326,642	kwh	0.050	16,000
Effluent pumping - add'l 2,225 gpm to discharge	25	163,321	kwh	0.050	8,000
Treatment equipment (GET F) besides utilities and maintenance:					
UV bulb replacement (GET F)					21,000
Perchlorate biological reduction system O&M in add'n to exist:		1	LS	255,000	255,000
Equip Maintenance (@ % of equip capital)		1,639,000	%	3	49,000
Labor (incl. fringe benefits) - included in existing:					
Operator labor		0.5	yr	54,000	27,000
Management oversight and reporting		0.00	yr	100,000	0

Operation and Maintenance Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment equipment (Offsite):						
Electric utilities:						
Air stripping		30	196,312	kwh	0.050	10,000
UV/oxidation	kw:	0	0	kwh	0.050	0
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps		45	293,611	kwh	0.050	15,000
Effluent pumping				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system (assumed not required)				ccf		0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement						0
Perchlorate biological reduction system O&M			1	LS	441,000	441,000
UV service contract			0	LS	5,000	0
Waste disposal						
Biological sludge disposal (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			697,000	%	3	21,000
Labor (incl. fringe benefits):						
Operator labor (in additon to 1 FTE in bio. red'n)			0.5	yr	54,000	27,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	20	ea	300	24,000
Monitor wells		4	30	ea	300	36,000
Equivalent to PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2001						1,728,000
Contingency				%	15	259,000
Estimated Project O&M Costs - Total Year 2001						**1,987,000**

Operation and Maintenance Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description		Quantity	Units	Unit Rate	Estimated Cost
Estimated Annual Operation & Maintenance Costs:	**Year 2015**				
Extraction Wells and Pipeline:					
Extraction well maintenance		21	ea	1,000	21,000
Recharge well maintenance		7	ea	50,000	350,000
Pipeline maintenance		1	LS	10,000	10,000
Electric utilities:					
Well pumps:	Running hp				
C1	28	183,753	kwh	0.050	9,000
C2	37	245,004	kwh	0.050	12,000
C3	37	245,004	kwh	0.050	12,000
C4	28	183,753	kwh	0.050	9,000
C5	19	122,502	kwh	0.050	6,000
C6	19	122,502	kwh	0.050	6,000
C7	19	122,502	kwh	0.050	6,000
D1	19	122,502	kwh	0.050	6,000
D2		0	kwh	0.050	0
D3		0	kwh	0.050	0
New-1 (replace E/F recharge)	68	444,070	kwh	0.050	22,000
New-2 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
New-3 (replace E/F recharge)	80	520,633	kwh	0.050	26,000
North of E	154	1,004,516	kwh	0.050	50,000
South of F	23	153,127	kwh	0.050	8,000
Treatment equipment (GET F) in addition to existing:					
Electric utilities:					
UV/oxidation kw:			kwh	0.050	22,000
Biological reduction (incl. below)			kwh	0.050	0
Intermediate transfer pumps (GET F)	50	326,642	kwh	0.050	16,000
Effluent pumping - add'l 2,225 gpm to discharge	25	163,321	kwh	0.050	8,000
Treatment equipment (GET F) besides utilities and maintenance:					
UV bulb replacement (GET F)					21,000
Perchlorate biological reduction system O&M in add'n to exist:		1	LS	255,000	255,000
Equip Maintenance (@ % of equip capital)		1,639,000	%	3	49,000
Labor (incl. fringe benefits) - included in existing:					
Operator labor		0.5	yr	54,000	27,000
Management oversight and reporting		0.00	yr	100,000	0

Operation and Maintenance Cost Estimate
Alternative 5B - GETs E and F Extraction Wells with Offsite Extraction and Recharge Wells

Description			Quantity	Units	Unit Rate	Estimated Cost
Treatment equipment (Offsite):						
Electric utilities:						
Air stripping		30	196,312	kwh	0.050	10,000
UV/oxidation	kw:	0	0	kwh	0.050	0
Biological reduction (incl. below)				kwh	0.050	0
Intermediate transfer pumps		45	293,611	kwh	0.050	15,000
Effluent pumping				kwh	0.050	0
Misc. lighting and power	kw:	4	35,040	kwh	0.050	2,000
Natural gas utilities						
Onsite VPGAC regeneration system (assumed not required)				ccf		0
Chemicals						
Ethanol for biological reduction (incl. below)				gal		0
Treatment equipment (besides utilities and maintenance)						
UV bulb replacement						0
Perchlorate biological reduction system O&M			1	LS	455,000	455,000
UV service contract			0	LS	5,000	0
Waste disposal						
Biological sludge disposal (incl. above)				lb		0
Equip Maintenance (@ % of equip capital)			697,000	%	3	21,000
Labor (incl. fringe benefits):						
Operator labor (in additon to 1 FTE in bio. red'n)			0.5	yr	54,000	27,000
Management oversight and reporting			0.12	yr	100,000	12,000
Monitoring:						
Quarterly:		# qrtrs.				
Extraction wells		4	21	ea	300	25,200
Monitor wells		4	32	ea	300	37,800
Equivalent to PCD Exhibit IV and VI			1	ea	120,000	120,000
Monthly:		# mos.				
GWTP influent		12	4	ea	300	14,400
GWTP effluent		12	4	ea	300	14,400
GWTP intermediate locations		12	4	ea	300	14,400
Sidestreams		12	2	ea	300	7,200
Estimated Project O&M Costs - Subtotal Year 2015						1,752,000
Contingency				%	15	263,000
Estimated Project O&M Costs - Total Year 2015						**2,015,000**

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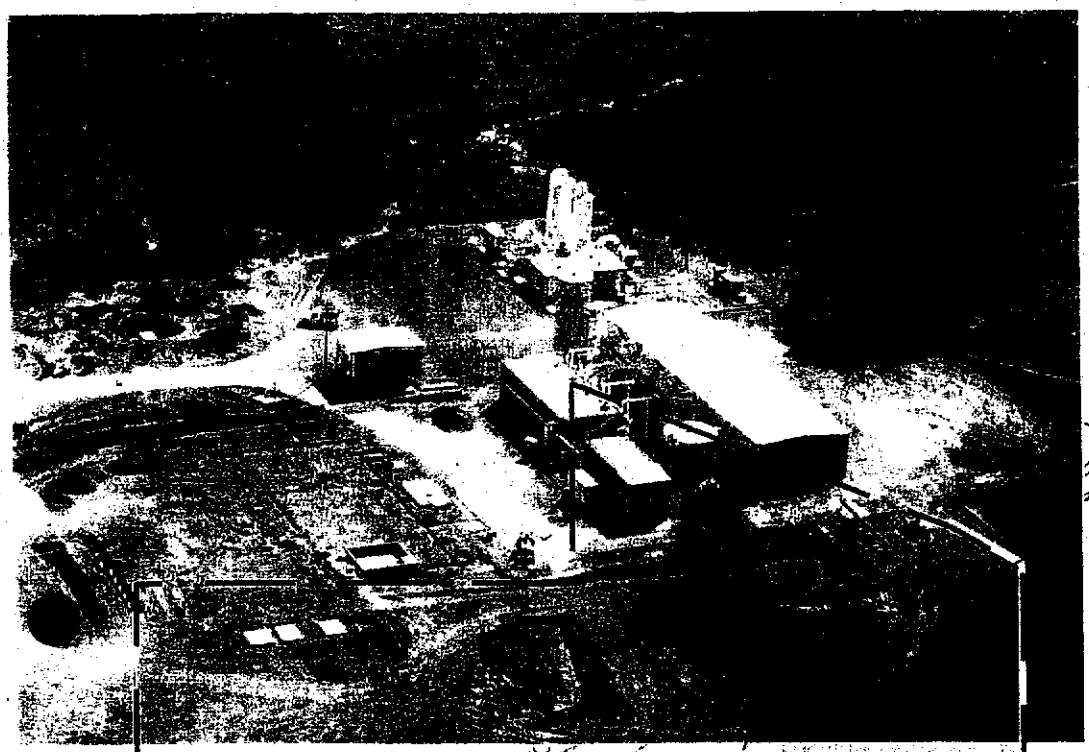

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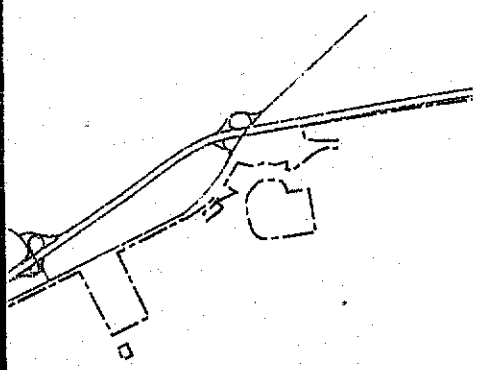

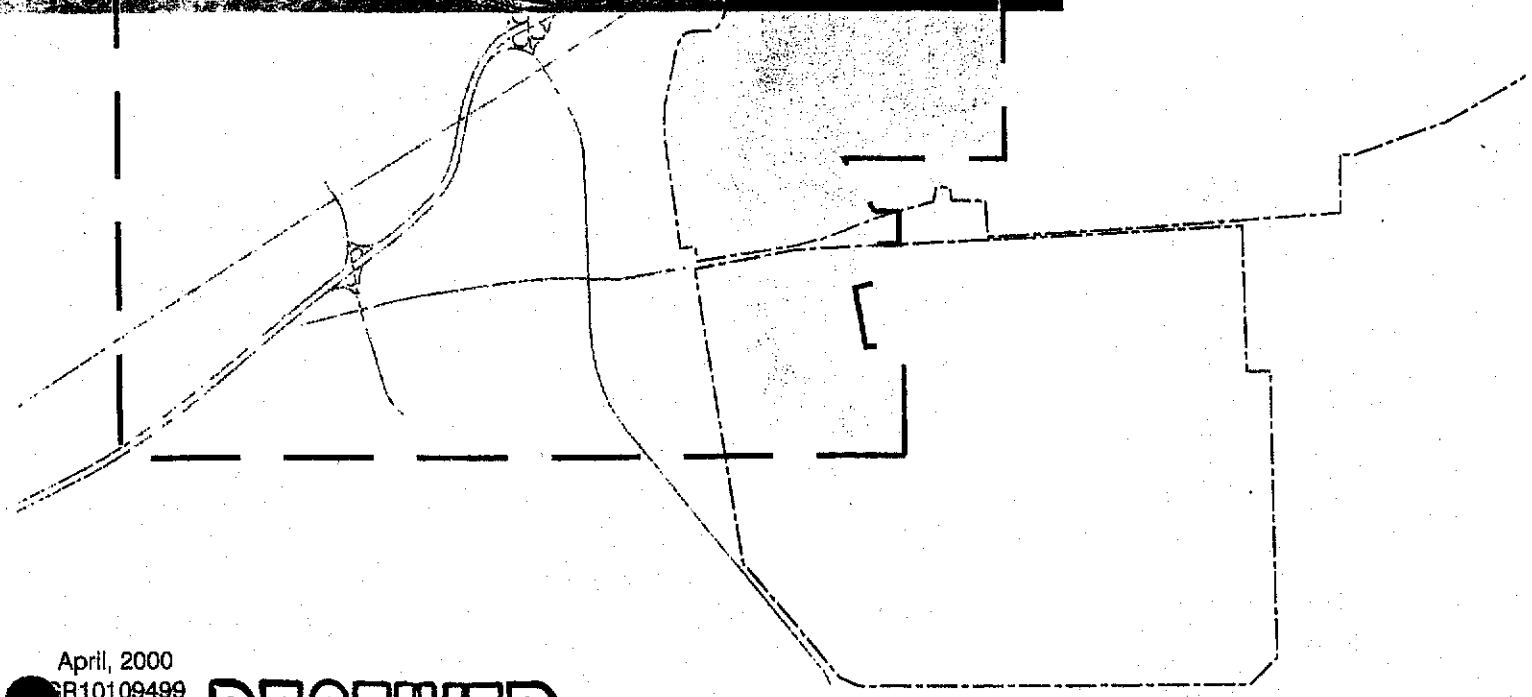

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Western Groundwater Operable Unit
Remedial Investigation Report

April 14, 2000

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Western Groundwater Operable Unit
Remedial Investigation Report

April 14, 2000

Prepared by:

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WESTERN GROUNDWATER OPERABLE UNIT
REMEDIAL INVESTIGATION REPORT

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WESTERN GROUNDWATER OPERABLE UNIT
REMEDIAL INVESTIGATION REPORT

1.0 INTRODUCTION

This remedial investigation (RI) report has been prepared by Aerojet-General Corporation (Aerojet) pursuant to certain requirements of the 1989 Partial Consent Decree (PCD), and pursuant to the schedule submitted in response to the California Regional Water Quality Control Board (CRWQCB) 1996 Cleanup and Abatement Order (CAO) Number 96-259. This report focuses on the groundwater flow conditions and distribution of chemicals in the Western Groundwater Operable Unit (Study Area). The Study Area includes the onsite areas (Aerojet property) around two existing groundwater extraction and treatment (GET) facilities (GETs E and F), the northwestern portion of the Inactive Rancho Cordova Test Site (IRCTS), as well as the western offsite area in the community of Rancho Cordova, California (Figure A-1).

Aerojet site history, chemical use and handling practices, metrology, human populations and land use, and ecological investigations are presented in the Scoping Report (ICF Technology, 1989). The Stage 1 RI Report– Zone 2, presented descriptions of source sites and chemical distributions in the vadose zone and groundwater on the Aerojet Site (ICF Kaiser Engineers, 1993a,b). Findings from these reports are summarized as necessary to explain the interpretations presented in this RI report.

The descriptions of hydrogeologic conditions and chemical distribution in groundwater presented in this report are a culmination of numerous studies conducted since the early 1980s. The nomenclature and interpretation of the hydrostratigraphic units beneath portions of the Study Area were introduced in 1992 in separate GET effectiveness evaluation reports for GETs E and F (Aerojet, 1992a,b). In 1996, the GET E and F effectiveness evaluations were combined and updated to reflect the inter-relationships between the two systems (Aerojet/Hydro-Search, 1996). The combined on- and off-site interpretation of the hydrostratigraphy and descriptions of perchlorate and N-nitrosodimethylamine (NDMA) distributions in groundwater were initially presented in a technical memorandum submitted in December 1998 (Aerojet, 1998).

1.1 Background

Since the early 1950's, the Aerojet Site has been utilized to develop rocket propulsion systems in support of national defense, space exploration, and satellite deployment. Industrial activities have included solid rocket motor manufacturing, testing, and rehabilitation (hogout); liquid rocket engine manufacturing and testing; and chemical manufacturing. Chemicals used in the manufacturing and testing areas included chlorinated solvents, propellants, metals, fuels, oxidizers, and a variety of chemicals produced in the chemical operations areas as described in the Scoping Report (ICF Technology, 1989).

Historical operations at the Aerojet Site have resulted in the discharge of chemicals to the vadose zone and underlying groundwater. Although numerous chemicals were used on the Aerojet Site, trichloroethene (TCE), perchlorate and NDMA are the primary chemicals of potential concern (CoPCs) in groundwater beneath the Study Area. TCE was primarily utilized as a solvent for cleaning and degreasing purposes. Perchlorate (ClO_4^-) was combined with various cations (primarily ammonium or potassium) and utilized as an oxidizer in solid rocket propellants. NDMA is a semi-volatile organic compound (SVOC) that was either an impurity in hydrazine-based liquid rocket fuels or was formed as a combustion product of these fuels.

Offsite source(s) of CoPCs in the Study Area have not been fully evaluated for this RI. TCE is widely used as a solvent, especially for dry cleaning and metal degreasing. Several offsite sources of TCE and/or PCE have been identified and reported to the oversight Agencies by Aerojet, and are noted in the appropriate sections of this report. NDMA is unintentionally formed during various manufacturing processes at many industrial sites and in air, water, and soil from reactions involving other chemicals called alkylamines (ATSDR 1989). According to the ATSDR, the general population may be exposed to NDMA from a variety of sources, including outdoor air. The primary sources of NDMA exposure are tobacco smoke, chewing tobacco, and foods such as cured meats, toiletry and cosmetic products, and various other household goods. In addition, NDMA can form in the stomach during the digestion of alkylamine-containing foods (alkylamines are naturally occurring compounds that are found in some drugs and a variety of foods). Occupational exposures are also possible, such as at tanneries, pesticide manufacturing plants, rubber and tire manufacturing plants, fish processing industries, foundries, and dye manufacturing plants (ATSDR, 1989). The American Water Works Association is funding studies in the year 2000 to study the factors affecting the formation and occurrence of NDMA in water. Perchlorate has recently been detected in many fertilizers (ES&T, 1999).

The presence or potential presence of some of these chemicals in the environment is a significant issue. It can be difficult to distinguish low levels of environmental contamination from low levels of ubiquitous chemicals present as background. This is particularly relevant for NDMA where concentrations in the low parts per trillion can be introduced during sampling and/or analysis. The presence of low levels of NDMA in ultra-pure laboratory grade water has prevented Aerojet's laboratory from being able to achieve California Department of Health Services (DHS) protocols for low-level NDMA analyses. Similarly, if low levels of perchlorate are present in groundwater due to past or present agricultural practices, perchlorate will be difficult to distinguish from environmental contamination. These issues are not relevant in areas of the plumes where the elevated presence of these contaminants is related to activities on the Aerojet Site.

Since the mid-1980's, Aerojet has installed and operated five interim perimeter GET facilities (GETs A, B, D, E, and F) designed to prevent or minimize the offsite migration of volatile organic compounds (VOCs) and NDMA (GETs A and B only) in groundwater. The treated water is recharged to the groundwater system via surface discharge and infiltration, or by recharge wells. A sixth GET facility, the American River Groundwater Extraction and Treatment System (ARGET) began operations in July 1998. Two of these GET facilities, GETs E and F, are located within the Western Groundwater Study Area and are included for evaluation as elements of a Feasibility Study.

1.2 Physical Description of the Study Area

The Study Area encompasses approximately the western one-third of the Aerojet Site, the northwestern corner of the IRCTS, Aerojet-owned land west of the IRCTS, and approximately 10 square miles of commercially and residentially developed areas in the community of Rancho Cordova (Figure A-1). The entire Study Area is comprised of approximately 15 square miles. The western boundary of the Study Area is located at Mather Field Road. The Study Area does not include vadose zone source sites at Chemical Plant 2, the IRCTS, or any of the manufacturing line areas on the Aerojet Site.

The Study Area is characterized by a relatively flat topographic surface gently sloping (less than 1 degree) to the west. Ground surface elevations decrease from approximately 200 feet above mean sea level (MSL) in the east to approximately 60 feet above MSL in the west. The American River meanders in a generally southwesterly direction through the northwest corner of the Study Area. Local topographic features include two ancestral American River terrace scarps that generally trend northeast-southwest

through the Aerojet Site and the IRCTS (Figure A-1). The ground surface elevation decreases 20 to 40 feet from east to west across the terrace scarps.

The majority of the Study Area was dredged for gold beginning in the early 1900's and continued through the 1960's. Evidence of dredging has been obliterated by development in most of the offsite areas. Dredge tailings are evident on the Aerojet Site, the IRCTS, and the land west of the IRCTS. The dredge tailings consist of alternating rows of cobble windrows and low areas ("slickens"). Most cobble windrows are 10 to 20 feet higher in elevation than the intervening slickens areas, although some windrows in the eastern portion of the Study Area are 40 to 60 feet higher than the slickens areas.

1.3 Surface Water Hydrology

1.3.1 Regional Surface Waters

Regional surface water bodies in the vicinity of the Study Area include Folsom Lake, Lake Natoma, the American River, and the Folsom South Canal (Figure A-2). The American River drains a substantial portion of the western Sierra Nevada east of Sacramento County. The American River is used as a municipal and agricultural water supply and provides recreational, fishery, and wildlife uses. The portion of the American River downstream of Lake Natoma serves as spawning ground for salmon, steelhead trout, and shad.

Flows on the American River are controlled by the United States Bureau of Reclamation (USBR) through Folsom Dam, and to a lesser extent, Nimbus Dam. Folsom Dam is located approximately 3.5 miles northeast (upstream) of Lake Natoma. Lake Natoma is formed by Nimbus Dam, and is located approximately ¼ to ½ mile north of Aerojet's northern property boundary. Contours of the potentiometric surface in the vicinity of Lake Natoma indicate the American River is gaining in the vicinity of Lake Natoma (i.e., groundwater discharges to the river). Lake Natoma is located northeast of the Study Area and is generally side-gradient of the Aerojet Site. Downstream of Nimbus Dam, the potentiometric surface ranges from 40 to 125 feet below the base of the American River and river water infiltrates to the groundwater (i.e., losing river)(ICF Kaiser Engineers, 1989).

The Folsom South Canal originates at the southwest end of Lake Natoma, and trends along portions of the northern and western Aerojet boundaries. Folsom South Canal is a concrete-lined canal and was intended to provide cooling water for the Sacramento Municipal Utility District's (SMUD) Rancho Seco Nuclear Power Plant and municipal water for the East Bay Municipal Utility District (EBMUD). The nuclear

power plant is being decommissioned and current use of the canal is limited to relatively small amounts by SMUD, Arden Cordova Water Service, and various agricultural water users. EBMUD maintains, but is not currently using, surface water diversion rights via the Folsom South Canal.

1.3.2 Local Surface Waters

Local surface water features include: Buffalo Creek, the Administration Ditch, West Area Lake, Alder Creek, Rebel Hill Ditch, and various man-made ditches and ponds located throughout the facility (Figure A-2). Most of these features are used to divert and control seasonal storm-water runoff from the Aerojet Site. Alder Creek is located along the northeastern Aerojet boundary and receives a minor amount of storm water runoff from undeveloped areas on and east of Aerojet. Alder Creeks flows west and drains into Lake Natoma.

Most storm-water runoff originating in the northern (Administration Area) and northeastern (Liquid Rocket Test Area) portions of the Aerojet Site flows through the Administration Ditch or Buffalo Creek into the West Area Lakes. Storm-water runoff is staged in the West Area Lakes and discharged to Buffalo Creek, and ultimately the American River. Storm-water discharges to Buffalo Creek/American River are regulated through the National Pollution Discharge Elimination System (NPDES). Aerojet also discharges treated groundwater from the ARGET facility into Buffalo Creek. The ARGET discharge is regulated through a separate NPDES permit. Most storm-water generated on the western half of the Aerojet Site infiltrates locally and does not leave Aerojet property.

Rebel Hill Ditch traverses the facility from northeast to southwest and was constructed to provide water for the gold dredging activities. Aerojet currently discharges treated groundwater from its GET B facility to Rebel Hill Ditch. The treated groundwater from GET B infiltrates into the ground along the southern boundary and does not leave the Aerojet Site. Several lakes, ponds, vernal pools, and wetlands located throughout the Aerojet Site are not differentiated in this report. Most of these features contain water only during the rainy season.

The areas west of the Aerojet Site consist of industrial and residential developments. There are no areas where runoff from the Aerojet Site enters these areas, except for Buffalo and Alder Creeks as noted above. The Sacramento County Department of Public Works - Water Resources Division manages surface water runoff from the developed areas in Rancho Cordova. Storm-water runoff from these areas enters the County's storm-water drainage system and ultimately the American River.

2.0 STUDY AREA GEOLOGY AND HYDROSTRATIGRAPHY

2.1 Regional Geology

The Study Area is located near the eastern edge of the Sacramento Valley near the contact between the Sierra Nevada metamorphic basement rocks and the valley sediments. This area is characterized by shallow-dipping (generally less than 1 degree) Cretaceous-, Tertiary-, and Quaternary-age marine and fluvial sediments overlying steeply dipping Jurassic crystalline basement rocks (Department of Water Resources [DWR], 1974). The erosional surface of the basement rock dips to the west beneath the Study Area at approximately 4 degrees.

The sedimentary sequence includes undifferentiated Quaternary sediments and the Laguna, Mehrten, Valley Springs, Ione, and Chico Formations. These sediments generally strike north-south and form a wedge that thickens from tens of feet at the eastern Aerojet Site boundary to greater than 2,000 feet near the western Aerojet property boundary (Figure A-3). The sediments of interest for this report include the undifferentiated Quaternary sediments, Laguna, Mehrten, and Valley Springs Formations, and contain hydrostratigraphic Layers A through E as described in later sections of this report. Descriptions of each of these geologic formations are provided in the Scoping Report (ICF Technology, 1989) and the GET E and F Effectiveness Evaluation Report (Aerojet/Hydro-Search, 1996).

2.2 Study Area Hydrostratigraphy

The following description of the hydrostratigraphy of the Study Area is based largely on work presented in "Aerojet Site - GET E and F Effectiveness Evaluation Report" (Aerojet/Hydro-Search, 1996b). Six hydrostratigraphic layers (Layers A through F) were defined at GETs E and F based on lithologic descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thickness. Layer F is not addressed in this RI as the deepest observed impact on- or offsite is in the upper portion of Layer E.

Data collected from numerous aquifer tests in the vicinity of GETs E and F were used to confirm and refine the hydrogeologic model on the Aerojet Site. Very few aquifer tests have been conducted in the western offsite areas, and correlation between the on- and offsite hydrostratigraphic layers was based primarily on relative depths, stratigraphy, water levels, and chemical concentrations. Hydrostratigraphic Layers A and B, that appear to be present primarily in the eastern portions of the Study Area, are not

distinct in the western offsite area. Layers C, D, and E appear to be regional features and are more easily correlated between the on- and offsite areas.

The hydrostratigraphic layers discussed in this report do not account for the entire 2,000 feet of sediments present at the western Aerojet Site boundary. The Ione and Chico Formations, estimated at 1,000 to 1,500 feet below ground surface (bgs) in the Study Area, contain saline water that would not yield potable quality. The deepest contamination at the Aerojet Site has been observed in Layer E at depths of approximately 400 to 500 feet bgs. Therefore, there are approximately 500 feet of freshwater sediments below the deepest observed contamination and above the saline formations.

Three cross sections were drawn to depict subsurface conditions in the Study Area (Figures A-4, -5, and -6). The sediments on the cross sections were grouped into relatively higher and lower permeability's to show the overall stratigraphy, potential groundwater flow paths, and the general structural characteristics of the hydrostratigraphic layers. The following sections present brief descriptions of the predominant lithologies and the typical depths and thickness for each of the hydrostratigraphic layers. These descriptions vary locally due to stratigraphic heterogeneity.

2.2.1 Layer A – Hydrostratigraphy

Layer A, the uppermost layer, is located primarily in the GET F area and is composed predominantly of unconsolidated sand and gravel consisting of granitic, metamorphic, and volcanic clasts eroded from the Sierra Nevada. Clast sizes range from large (>1 foot diameter) boulders and cobbles to sands, silt and clay. The primary bedding features have been disturbed to depths of 20 to 80 feet bgs by historic gold dredging activities throughout much of the Study Area. Consequently, precipitation will readily infiltrate into the dredged areas and storm water runoff is minimal compared to undredged areas.

The saturated thickness of Layer A ranges from zero to approximately 20 feet. The depth to the top of Layer A ranges from 40 to 50 feet below ground surface (bgs) near the source areas located in the east to 80 to 100 feet bgs in the central portion of the Study Area near GETs F. Layer A is generally unsaturated on the Aerojet Site to the north, south and west of GET F. At these locations, groundwater from Layer A probably infiltrates downward into Layer B, and does not discharge to surface waters.

2.2.2 Layer B - Hydrostratigraphy

Layer B occurs within the basal sands and gravels of the Quaternary sediments, and appears to be continuous beneath most of the Aerojet Site and the IRCTS. The sediments designated as Layer B grade from relatively coarse-grained materials in the east to relatively finer-grained materials near GET F and in the western offsite area. The westward "fining" of Layer B is coincident with an observed increase in thickness of the B/C aquitard. The B/C aquitard increases in thickness (from tens of feet to over 100 feet) and depth (from 50 to 180 feet bgs) from the western Aerojet Site boundary to the western Study Area boundary. During the recent offsite drilling program, thin (<15 feet) lenses of fine-grained sand were sometimes encountered within the aquitard material overlying Aquifer C at depths ranging from 100 to 180 feet bgs (Figures A-4, -5, and -6). Monitor wells constructed within these sand lenses were tentatively assigned to Layer B based on stratigraphy alone, although it is not clear that these lenses are continuous or are hydraulically connected with the monitoring wells assigned to Layer B on the Aerojet Site or the IRCTS.

2.2.3 Layer C - Hydrostratigraphy

Layer C is composed predominantly of sand, sandstone, and minor gravel with varying degrees of cementation. Thin (1- to 10-foot) interbeds of brown siltstone and clay are common. Layer C ranges in thickness from 50 to 125 feet with an average thickness of approximately 80 feet. It is saturated and continuous throughout the Study Area. The top of Layer C forms a relatively planar surface with a strike of N12°W and a southwesterly dip of approximately 1°. This attitude is consistent with the attitudes of regional geological formations which are reported to strike generally north-south and dip to the west at 1- to 3° (DWR, 1974).

2.2.4 Layer D - Hydrostratigraphy

Layer D is composed of mafic sands and sandstone with some gravel. On the Aerojet Site, Layer D ranges in thickness from 30 to 150 feet. The base of Layer D is present at depths of approximately 360 to 400 feet bgs. Layer D is separated from Layer C by 10- to 45-foot thick clay and siltstone layer.

2.2.5 Layer E - Hydrostratigraphy

Layer E is comprised of sand, sandstone, and some gravel with interbedded silt and clay lenses. In general, the silt and clay lenses are more abundant and are thicker in Layer E than those observed in overlying Layers C and D. The sediments in Layer E are dominantly black or greenish. The top of Layer E occurs at depths of 350 to 400 feet bgs near the western Aerojet boundary. The available data indicate Layer E is at least 100 feet thick.

2.3 Groundwater Flow in the Study Area

Groundwater flow directions and gradients have been studied for many years on the Aerojet Site and on the IRCTS. During the past several years, monitor wells installed in the western offsite areas have provided additional data to interpret groundwater flow in the offsite areas. Potentiometric contour maps dating from April 1991 through March 1998 were reviewed to assess temporal and seasonal trends in the groundwater flow directions (Figures A-7 through A-11).

The maps for each layer vary by both geographic areas covered and the number of wells used to generate the contours. In general, the more recent maps contain more data points over a broader area than the older maps and are probably more indicative of regional groundwater flow patterns. In addition, the maps prepared for April 1991 were based on a similar, but different, set of hydrostratigraphic layers than Layers A through E used on the more recent maps. All potentiometric surface contours were generated by kriging using various software packages. Nevertheless, the various approaches show that groundwater flows toward the west-southwest in each of the layers.

2.3.1 Layer A - Groundwater Flow

The potentiometric surface maps illustrate that Layer A is only present in a relatively small area on the Aerojet Site (Figure A-7). Groundwater is extracted from Layer A by two extraction wells at GET F; Layer A is dry at GET E. Note the map prepared in 1991 represents a theoretical water table map that is not based on the current hydrostratigraphic correlation and is not necessarily a comparison of the same water-bearing strata. The 1991 map does show the general groundwater flow directions for the unconfined aquifer over a much larger area than just the Study Area.

In the West Lake area on the Aerojet Site, the potentiometric surface contour elevations measured in October 1994 are approximately 20 feet lower than those measured in April 1995, suggesting a seasonal fluctuation of the water table in this area. However, the potentiometric surface elevations measured near Chemical Plant 2 are about the same during both periods. This suggests there is more recharge in the vicinity of West Lake, possibly as a result of the retention of storm water in West Lake during the rainy season.

Layer A is not saturated in the northern, southern (IRCTS), and western portions of the Study Area and Layer A is poorly defined west of the Aerojet Site. Where saturated, the groundwater elevations in Layer A range from approximately 90 feet above MSL in the east to approximately 40 feet above MSL in the west (Figure A-7). Groundwater flow directions vary locally, but generally trend to the west-southwest with an average hydraulic gradient of approximately 0.005 foot per foot (25 feet per mile).

2.3.2 Layer B - Groundwater Flow

The four potentiometric surface contour maps for Layer B show similar groundwater flow directions and gradients since 1991 (Figure A-8). Groundwater elevations in Layer B decrease from approximately 100 feet above MSL in the east to approximately 15 feet above MSL in the west. The potentiometric surface map indicates a west to west-southwest direction of groundwater that is locally affected by groundwater extraction at GET F. The groundwater depression near GET F is due to the extraction well in Layer B and probably due to the more significant pumping of Layer C. During 1998, drawdown is apparent in Layer B at GET E and would be caused by pumping in Layer C since none of the extraction wells at GET E are screened in Layer B. On the northwestern portion of the IRCTS, a groundwater mound is coincidentally located at the former GET F Sprayfield, but is probably due to leaking water mains along White Rock Road or possibly related to the dredge tailings, since the use of the sprayfield was terminated in 1990 and water levels have returned to pre-sprayfield conditions. The average hydraulic gradient across the Study Area is 0.004 foot per foot (20 feet per mile). Steeper gradients are present locally in the areas of groundwater extraction.

2.3.3 Layer C - Groundwater Flow

The potentiometric surface maps for Layer C do not show many changes in the groundwater flow directions and gradients from 1991 through 1998 (Figure A-9). Groundwater elevations in Layer C decrease from approximately 75 to -10 feet MSL from east to west across the Study Area. The

groundwater flow direction is generally west-southwest with deviations in the groundwater flow direction evident in the vicinity of the GETs E and F extraction and recharge wells, which are screened primarily within Layer C and to a lesser extent in Layer D. Groundwater elevations are approximately 20 feet higher in the vicinity of the recharge wells than in the vicinity of the GET E and F extraction wells. The groundwater recharge mound dissipates toward the west and is not apparent west of Sunrise Boulevard. The average hydraulic gradient across the Study Area is approximately 0.004 foot per foot (20 feet per mile). In general, the horizontal gradient is steepest in the east and flattens to the west.

2.3.4 Layer D - Groundwater Flow

The potentiometric surface for Layer D has not varied much since 1991 (Figure A-10). The elevation of the potentiometric surface in Layer D decreases from approximately 100 feet above MSL in the eastern portion of the Study Area to 0 feet below MSL in the west. The groundwater flow direction is west-southwest to west across most of the Study Area with deviations in the vicinity of the GET E and F extraction and recharge wells. At GET E, five extraction wells are partially screened through Layer D and create a larger groundwater depression than that observed at GET F, where no extraction wells are screened in Layer D. A groundwater mound is evident in the vicinity of the recharge well field since the recharge wells are also screened in Layer D. The hydraulic gradient averages approximately 0.004 foot per foot or 20 feet per mile across the Study Area. As with Layer C, groundwater gradients are generally steepest in the east and flatten to the west.

2.3.5 Layer E - Groundwater Flow

The potentiometric surfaces for Layer E show a more westerly direction of groundwater flow than the overlying layers (Figure A-11). This difference in the direction of groundwater flow could be due to the pumping of a water-supply wells completed in Layer E or possibly due to the relatively fewer monitor wells in Layer E. The elevation of the potentiometric surface in Layer E decreases from approximately 70 feet above MSL in the east to 10 feet below MSL in the west. The direction of groundwater flow is generally westward in the vicinity of GETs E and F. The hydraulic gradient averages approximately 0.004 foot per foot, or 20 feet per mile.

2.3.6 Vertical Head Differences

The potentiometric surface maps prepared in April 1998 for Layers A through E were compared to assess the potential for vertical migration between the layers. These comparisons were conducted by subtracting the kriged potentiometric surface of the underlying layer from the kriged potentiometric surface of the overlying layer. The resulting differences in the potentiometric surfaces were contoured to provide an aerial view of head differences. Positive numbers on the figures indicate a downward head potential, and negative numbers indicate an upward head potential. The subtraction of the layer surfaces was performed in Surfer® using the GRID, math, subtract functions. Surfer® requires that the aerial coverage for each layer be the same so, because aerial coverage for each layers is different, the grids were re-sized to fit the smallest layer being subtracted. Figures A-12 through A-15 present the contoured potentiometric head differences for Layers AB, BC, CD, and DE, respectively.

Figure A-12 indicates there is a potential for downward vertical migration from Layer A to Layer B wherever Layers A and B co-exist. This potential is greatest in the vicinity of GET F where vertical head differences of up to 34 feet were observed. The strong downward potential in this area is caused by groundwater extraction from Layer B, although a small amount of water (approximately 15 gallons per minute) is also extracted from Layer A. Layer A is dry west and north of GET F, where there are no potentiometric surface difference contours.

Figure A-13 shows the contoured potentiometric surface differences between Layers B and C. There is a potential for downward vertical migration of groundwater from Layer B to Layer C throughout most of the Study Area. The strongest downward head potentials are present in the vicinity of GET E, GET F, and along the northern portion of the IRCTS. A slightly upward potential (-2 feet) exists from Layer C to Layer B on the east and west sides of the recharge well field. As noted in Section 2.2.2, it is not clear that Layer B west of the Aerojet Site is hydraulically connected with Layer B on the Aerojet Site.

The head differences between Layers C and D vary depending on localized pumping (Figure A-14). In the vicinity of GET E, where both Layers C and D are pumped, the potentiometric surface of Layer C ranges from zero to 8 feet above the potentiometric surface of Layer D, indicating the potential for downward migration from Layer C to Layer D. However, in the vicinity of GET F, where only Layer C is pumped, there is a strong upward vertical potential (-16 feet) from Layer D to Layer C. West of the Aerojet site, the vertical head differences between Layers C and D are generally within feet. There is an

exception at one monitor well west of Coloma Road where the potentiometric surface of Layer C is 8 feet higher than the potentiometric surface of Layer D.

Figure A-15 presents the contoured potentiometric surface differences between Layers D and E. There were insufficient monitor wells completed in Layer E west of the Aerojet Site to prepare potentiometric surface contours in this area in April 1998, and the potentiometric surface difference contours between layers D and E do not extend west of Sunrise Boulevard. In the northeastern portions of the Study Area, the potentiometric surface for Layer D is up to 16 feet higher than the potentiometric surface for Layer E, suggesting the potential for downward vertical flow from Layer D to Layer E. However, groundwater extraction from Layer D at GETs E and F causes the vertical head potential to switch from downward to weakly upwards around the GET facilities.

3.0 DISTRIBUTION OF CHEMICALS IN GROUNDWATER

This section describes the types and distributions of chemicals present in groundwater beneath the Study Area. This information will be used to conduct a baseline risk assessment and to prepare engineering costs estimates for the alternatives being evaluated in the feasibility study. The discussions of chemical distribution are presented by hydrostratigraphic layer from the shallowest to the deepest layers (i.e., Layers A to E). The distributions of the various chemical classes (e.g., VOCs, perchlorate) are discussed separately within each layer. The sampling period for this RI ranges from January 1996 through December 1998, although some groundwater data collected before or after these dates are incorporated to fill data gaps as needed and to place contour lines in areas that were not sampled during the sampling period.

3.1 Remedial Investigation Approach

The Sitewide remedial investigation at Aerojet has been ongoing for over 13 years, and has included both vadose zone and groundwater investigations. The RI for the Western Groundwater Study Area is the first in a series of operable unit remedial investigation/feasibility studies for the Aerojet Site. The following sections summarize the results of the relevant site-wide work and provide background information explaining how the RI for the Study Area evolved to its current state.

Section 3.1.1 describes the methodology for placing monitor wells and presents a general chronology of monitor well installation. The development of the analytical program, including discussion of target analytes and specialty chemicals handled at Aerojet are summarized in Section 3.1.2. An approach for handling tentatively identified compounds is presented in Section 3.1.3. Section 3.1.4 describes the geographic distribution of the current data and explains the criteria for posting data on the figures prepared for Sections 3.2 through 3.7.

3.1.1 Development of Groundwater Monitoring Network

Aerojet began installing monitor wells in the Study Area in 1979. The first wells were installed at or near potential source sites east of the Study Area to evaluate whether chemicals had reached groundwater. After confirmation of groundwater contamination, Aerojet installed a series of monitor wells downgradient of the source areas and along its property boundaries from 1980 through 1991. During the

mid- to late-1980's, Aerojet constructed GETs E and F near its northwestern and southwestern property boundaries to control the flow of chemicals off-site. Monitor wells installed during the 1990s were intended to monitor GET effectiveness and for RI groundwater characterization.

In 1997, following the discovery of perchlorate in several public water supply wells, Aerojet installed a series of monitor wells to characterize the vertical and lateral extent of perchlorate west of the Aerojet Site. These wells were also used to evaluate the extent of NDMA when NDMA was discovered at GET E, and subsequently, the GET E recharge wells.

Sections 3.2 through 3.7 describe the distribution of chemicals in groundwater and have incorporated some data from wells located outside of the Study Area. Data collected from at least 483 monitor wells were evaluated, including data collected from 42, 60, 186, 127, and 68 monitor wells completed in Layers A, B, C, D, and E, respectively.

Monitor wells in the Study Area were screened in the most permeable portions of the aquifer based on the premise that the permeable units would act as preferential groundwater and contaminant pathways. These wells have provided the data necessary to construct a reasonably accurate assessment of the lateral and vertical extent of CoPCs. However, there are, and always will be, uncertainties associated with the extent of CoPCs. Some factors contributing to these uncertainties include the heterogeneous distribution of sediments within the aquifer, the large aerial and vertical extent of CoPCs in groundwater, the unknown extent of contributions from off-site sources, and the fate and transport characteristics of some CoPCs. The RI activities in the off-site areas will continue as groundwater containing CoPCs migrates and new information is collected.

3.1.2 Development of Groundwater Analytical Program

The development of an analytical program for a site like Aerojet is very difficult due to the large number of chemicals handled and the complex nature of plant operations. These difficulties are recognized in CERCLA and are addressed by following a systematic process of chemical identification, screening, and assessment. These processes at the Aerojet Site have resulted in the development and/or refinement of analytical methods for identifying unique or specialty chemicals, the formation of Target Analyte Lists (TALs) for the Study Area groundwater, and an approach for handling tentatively identified compounds (TICs).

The Scoping Report and Stage I RI identified over 400 compounds handled at the Aerojet facility based on interviews with Aerojet personnel, reviews of historical data, and reviews of Site documentation related to chemical handling and use (ICF Kaiser Engineers, 1989 and 1993). These 400 compounds were divided into two groups: 1) Chemicals for which there were standard analytical methods and 2) Chemicals for which there were no standard analytical methods. Standard analytical methods were identified for approximately 116 of the chemicals identified in the record search. These chemicals were analyzed as appropriate in soil, soil-gas, and groundwater during the Stage 1 RI.

In addition to the chemicals identified on standard analyte lists, Aerojets analytical laboratory developed methods to detect some unique or specialty chemicals manufactured and/or handled at Aerojet. These compounds include Prowl (pendimethalin), hydrazine, perchlorate, nitroguanadine, NDMA, and 10,10'-oxybisphenoxarsine (OBPA). In addition, the analytical detection limits for perchlorate and NDMA were lowered by two orders of magnitude within the past three years to provide analytical data closer to the perceived risk levels.

The chemicals for which analytical methods did not exist were placed on the non-standard chemical (NSC) list and evaluated following CERCLA and RCRA guidance. These guidance documents recognize that the development of analytical methods to detect all potential NSCs is both time consuming and expensive, and as such can paralyze the CERCLA process. Therefore, the CERCLA process recommends the use of TALs that employ standard analytical methods and look for a wide range of chemicals, but not every known chemical. The use of TALs provides a method for identifying, screening and characterizing chemicals that should be adequate to identify appropriate levels of risk and provide a basis for selection of remedies.

TALs were developed for the Aerojet Site based on historical and Stage 1 analytical data and history of chemical usage (types and volumes). Development of the TALs resulted in the formation of comprehensive analyte lists for groundwater. These lists are zone-specific and are based on chemicals handled and/or chemicals detected in soils and/or groundwater in each zone. The Study Area is located in the western portion of Zone 2. All new monitor wells installed in Zone 2 since 1991 have been initially sampled for the following analytes:

- Volatile organic compounds (VOCs)
- Semi-volatile organic comporids (SVOCs)
- Perchlorate
- Metals
- Chromium VI
- Total petroleum hydrocarbons
- Anions
- Field measurements (pH, electrical conductivity, temperature)

Beginning in 1998, NDMA was added to the initial comprehensive analyte list for new monitor wells in Zone 2. Following the initial sampling, each new well is sampled for three quarters. The analyte list for the quarterly sampling is based on the results of the initial sampling, but typically includes VOCs, perchlorate, and any other compounds detected during the initial sampling.

3.1.3 Tentatively Identified Compound (TIC) Approach

Another component of the analytical program plan development was the institution of a formal process for evaluating TICs. Analytical methods utilizing gas-chromatography/mass spectroscopy can tentatively identify compounds through the use of extensive chemical databases. The current TIC databases and those used during the Stage 1 RI included over 150,000 compounds. During Stage 1, TIC data were evaluated based on frequency of detection and repeatability. This evaluation resulted in the addition of 1,4-dioxane, 2-methyl pyrillidanone, and butyl-benzene sulfonamide to the TAL.

During recent negotiations on the Phase I RI/FS Stage 2 Sampling Plans and in response to the Agencies demands, Aerojet developed a TIC approach for use during the OU RI/FS process. For each operable unit the following TIC approach would be applied:

Step 1: Summarize TICs reported in Aerojet site database from RI/FS investigation. Create inventory and map distribution of TICs in groundwater and soil for the OU.

Step 2: Evaluate results from Step 1 and determine data gaps and necessary groundwater and soil sampling. Add sampling to OU RI/FS workplan.

Step 3: Evaluate data collected as part of OU RI/FS workplan and compare to previously existing information. Update inventory and maps.

Step 4: Evaluate retention times and goodness of fit for unknown TICs detected during OU RI/FS in soils and groundwater. For TICs with a possible identification confirmed in either soils and groundwater or in soils or groundwater, examine laboratory TIC results (mass spectra compound fingerprint) from OU RI/FS and attempt to determine probability of correct identification of TICs.

Step 5: TICs for which the mass spectra data have been reviewed and the correct identification confirmed, evaluate toxicity and risk information available.

This TIC approach was developed and approved after the sampling period evaluated for this RI (Spring 1999). However, Aerojet recently conducted an evaluation of TICs in Exhibit IV public, private and monitor wells (Aerojet, 1999). The results from this recently completed analysis are presented in Sections 3.2 to 3.7.

3.1.4 Data Distribution and Posting Criteria

After completion of the initial four quarterly samples from a new monitor well, the well may be added to a Groundwater Monitoring Program. The monitoring frequencies and analytes specified in each Groundwater Monitoring Plan vary, and as a result, the current groundwater data coverage varies throughout the Study Area. In general, the Study Area can be subdivided into four general areas based on the monitoring plan(s) implemented in each area:

1. Source areas on the Aerojet Site
2. GET E and F areas
3. Western offsite area
4. IRCTS

Figure A-16 is a generalized schematic showing the components of the monitoring plans implemented within these areas. Note the IRCTS is not depicted on Figure A-16, but has experienced a similar evolution of monitoring plans, some of which overlap with the monitoring plans implemented on the Aerojet Site (e.g., Stage 1 RI). As shown on Figure A-16, monitor wells sampled under Exhibit VI (GET effectiveness monitoring) are not routinely sampled for semi-volatile organic compounds (SVOCs), metals, or other miscellaneous compounds. Therefore, current data are not available for these analytes in some portions of the Study Area. Nevertheless, sufficient data exists to eliminate these analytes as CoPCs. It is important to note that most of the wells in the western offsite area were installed within the past three years and have been sampled for the comprehensive suite of analytes under the new monitor well sampling program.

The distributions of CoPCs in the Study Area are strongly influenced by the locations of the source areas, the direction of groundwater flow, and the operations of GETs E and F. Figure A-17 presents a conceptual model depicting the potential migration of CoPCs from source areas on the Aerojet Site to the western offsite groundwater. Dissolved CoPCs have generally migrated from source areas located east of the Study Area toward GETs E and F. For the past 12 to 15 years, GETs E and F have treated groundwater for VOCs, but not for perchlorate or NDMA. Most of the water treated at GETs E and F was recharged back into Layers C and D through a series of recharge wells. From December 1984 to February 1990 and in August 1990, groundwater extracted from GET F extraction Wells 4007 and 4060 (formerly GET F South) was treated for VOCs, and then discharged to the GET F Sprayfield located on the IRCTS.

Over forty public and domestic water supply wells are located within the Study Area west of Aerojet and IRCTS (Figure A-18). Some of the wells shown on Figure A-18 are outside (west) of the Study Area boundaries. Aerojet collects water quality samples from many of these wells in accordance with the provisions in Exhibit IV of the PCD. The PCD requires Aerojet and the Agencies to review the Exhibit IV wells, sampling frequencies, and analytes on an annual basis. Data collected from the public and domestic water supply wells (PWSWs) are incorporated into the following discussions and summarized in Section 3.7. Water quality data collected from the PWSWs were posted on the chemical isoconcentration maps for informational purposes. The PWSW data are composite samples collected over relatively long screened intervals (or open borehole), often penetrating multiple hydrostratigraphic layers. These data are not the same as chemical concentrations that are collected from a well screened in a single layer and were not used to prepare the chemical contours.

The data posted on the chemical isoconcentration maps represent the most recent primary sample result collected within the sampling period, unless historical data trends indicated the most recent data was anomalous. Many of the monitor wells in the Study Area were sampled numerous times over periods ranging from 1 to 13 years. During this period, data trends and "representative" chemical concentrations for most locations in the Study Area were evaluated. The current data were compared to previous chemical isoconcentration maps to evaluate the consistency of the data with respect to chemical concentration trends and the well location. In addition, duplicate and replicate sample results were not posted in the tables or on the figures because the results do not vary significantly from the primary sample results.

3.2 Layer A - Distribution of Chemicals in Groundwater

Groundwater chemical data from 43 wells were used in this analysis of Layer A groundwater quality. Groundwater data are presented for some Layer A wells that contained sufficient water when they were sampled, but were dry during the biannual water level measurements. The majority of monitor wells screened in Layer A are located in the eastern portion of the Study Area near source areas on the Aerojet Site. There are also monitor wells screened in Layer A in the vicinity of GETs E and F. Layer A is generally dry west of Aerojet and on the IRCTS.

The last comprehensive sampling of monitor wells screened in Layer A was conducted in 1991-93 during the Stage 1 RI. These data were reviewed to provide additional support for the conclusions reached in this analysis. In the Spring of 1999, perchlorate and TCE samples were collected from eight of the ten wells recommended for sampling in the Evaluation of Perchlorate and NDMA Technical Memorandum (Aerojet, 1998). The remaining two wells (Wells 355 and 1241) were dry or did not contain enough water to sample.

Two existing extraction wells are screened in Layer A in the Study Area (Wells 4007 and 4310) and are part of GET F, located in the southwestern portion of the Aerojet Site near Chemical Plant 2 (Figure A-19). Well 4007 has screened intervals in both Layers A and B. Within the past year, the water level in well 4310 has dropped below the top of the screen and the well has not been operating. Groundwater extracted by these wells was treated for VOCs, and then recharged. Groundwater extraction in the vicinity of GET F is ongoing and the discussion in this area focuses on the chemical distribution upgradient and downgradient of the extraction wells.

3.2.1 Layer A - Distribution of VOCs

VOC analyses were conducted on groundwater samples from 18 monitor wells screened in Layer A from January 1996 through April 1999 (Tables A-1, -2, and -3). The majority of the most recent groundwater sampling in Layer A was conducted in the vicinity of the GET F extraction wells. Many monitor wells located near VOC source sites or in areas with known high concentrations of VOCs in groundwater are not routinely sampled and were last sampled during the Stage 1 RI. These older data were reviewed to supplement the more recent data during the preparation of isoconcentration maps.

Six VOCs: TCE, 1,2-dichloroethene (1,2-DCE), 1,1-dichloroethene (1,1-DCE), vinyl chloride, 1,2-dichloroethane (1,2-DCA), and chloroform were detected above their respective MCLs in Layer A. Three of the VOCs detected above MCLs (TCE, chloroform, and 1,2-DCA) were detected on the Aerojet Site. The remaining three VOCs detected above MCLs (1,2-DCE, 1,1-DCE, and vinyl chloride) were detected off-site in an area unrelated to Aerojet activities. An isoconcentration map was prepared for TCE; the predominant VOC detected in Layer A (Figure A-19). The distribution of all other VOCs detected above their respective MCLs is presented on Figure A-20.

TCE has historically been detected in Layer A at multiple source areas located in the eastern portions of the Study Area on the Aerojet Site. The source areas nearest GETs E and F include Line 01, 03, 04, 05 and Chemical Plants 1 and 2 (Figure A-19). TCE concentrations ranging from 4,000 to 240,000 µg/L have been reported in monitor wells downgradient of Lines 03 and 05 (Aerojet/Hydro-Search, 1996). The TCE emanating from these areas forms a plume that trends roughly southwest and terminates at the GET F extraction wells. TCE concentrations in Layer A average approximately 50 µg/L near GET F. The decrease in TCE concentrations from the source areas to GET F suggests the TCE has migrated downwards into Layer B. As discussed in Section 2.3.6, the potentiometric surface of Layer A near GET F is up to 34 feet higher than the potentiometric surface of Layer B. TCE concentrations in Layer A range from non-detect (<0.5 µg/L) to a maximum of 3 µg/L (Well 75) downgradient of the GET F extraction wells.

Layer A is predominantly dry west of Line 05 and along the northwestern Aerojet Site boundary, and first groundwater is present at depths of approximately 100 feet bgs (Layer B). An area of shallow (Layer A or perched) groundwater is present off-site northeast of Sunrise and Folsom Boulevards. There are several current or former industrial facilities and a former County landfill at this location. The highest concentrations of TCE, 1,2-DCE, 1,1-DCE, and vinyl chloride detected within the sampling period in Layer A were detected in well 30065, located in this vicinity (Figures A-19 and A-20). The relatively high VOC concentrations and shallow depths to water indicate the chemicals detected in this area are emanating from a local off-site source.

Chloroform and 1,2-DCA were the only other VOCs detected above MCLs on the Aerojet Site during the current sampling period (Figure A-20). Chemical Plant 1 was identified as a source of 1,2-DCA and chloroform, and Chemical Plant 2 was identified as a source of 1,2-DCA (ICF Kaiser, 1993). The highest concentrations of 1,2-DCA (480 µg/L) were detected in monitor well 3348 located at Chemical Plant 2. 1,2-DCA was detected in only one monitor well (3.4 µg/L in Well 75) downgradient of the GET F

extraction wells. Chloroform was detected at a maximum concentration of 230 µg/L in Well 22, located west of Line 05 and Chemical Plant 1 (Figure A-20). Chloroform concentrations attenuated to approximately 2 to 10 µg/L in the vicinity of GET F, and chloroform was not detected downgradient of GET F.

3.2.2 Layer A - Distribution of Perchlorate

Perchlorate analyses were conducted on groundwater samples from 15 wells screened in Layer A during the current sampling period (Tables A-3, -4, and -5). These data are presented and contoured on Figure A-21. Several monitor wells shown as not sampled (NS) on Figure A-21 were included within the 400 µg/L contour line based on perchlorate data presented in earlier reports (Aerojet, 1998).

The distribution of perchlorate in Layer A is very similar to that observed for TCE (Figures A-19 and A-21, respectively) because the upgradient source areas in Lines 01, 03, 04, and 05 contain both TCE and perchlorate (ICF Kaiser, 1993). Perchlorate concentrations attenuate from up to 100,000 µg/L detected in Line 03 (Aerojet/Hydro-Search, 1996) to approximately 400 µg/L detected at GET F (Figure A-21). As with TCE, the attenuation of perchlorate in Layer A is probably due to the downward migration of perchlorate from Layer A to Layer B. The concentration of perchlorate downgradient of GET F ranged from non-detect (< 4 µg/L) to 14 µg/L (Well 75).

Perchlorate was detected off-site in Layer A in monitor well 30065, located north of Highway 50 and east of Sunrise Boulevard (Figure A-21). The perchlorate concentrations in this well have declined from 20 µg/L to 6.5 µg/L during the last three sampling events (Table A-4). Well 30065 is screened from 28 to 48 feet bgs in a low-producing, perched groundwater lens. The shallowest water in the vicinity of GET E is present at depths of 90 to 100 feet bgs. The apparent lack of hydraulic connection and the declining perchlorate concentrations in Well 30065 suggest that the perchlorate is likely an artifact from well construction and development.

3.2.3 Layer A - Distribution of NDMA

The investigation of NDMA is ongoing and no clear point source(s) of NDMA have been identified in the Study Area. On the Aerojet facility, NDMA is typically associated with hydrazine-based fuels and liquid rocket engine testing that occurred on the eastern portion of the Aerojet Site. Limited handling of laboratory quantities of hydrazine reportedly occurred just east of the Study Area in the Line 05/Chemical

Plant 1 area (ICF Kaiser, 1993). Several monitor wells located near Chemical Plant 1 are included in this evaluation because they provide additional upgradient information on the NDMA distribution. A summary of the NDMA analyses is presented in Tables A-5 and -6 and shown on Figure A-22.

NDMA was detected in three monitor wells completed in Layer A (Figure A-22). NDMA concentrations ranged from 0.019 to 0.81 µg/L in monitor wells located near Chemical Plant 1 (Tables A-5 and A-6). No sources of NDMA were identified at Chemical Plant 1 during the Stage 1 RI, however, the detection limits attainable during Stage 1 were at least two orders of magnitude higher than the current detection limits (i.e., MDLs of 0.10 versus 0.0075 µg/L). NDMA was not detected in the remaining wells, although, not all on-site wells completed in Layer A have been sampled for NDMA. Additional sampling for NDMA is being evaluated throughout the Study Area.

3.2.4 Layer A - Distribution of SVOCs

Most wells completed in Layer A were sampled for SVOCs during the Stage 1 RI. A summary of the SVOCs detected during the Stage 1 RI and during the current sampling period is presented in Table A-7. Phthalates, common laboratory contaminants, were the only SVOCs detected during Stage 1. The SVOC data collected during Stage 1 indicated that continued monitoring for SVOCs in Layer A was not warranted, and most SVOC sampling was discontinued. In 1996 and 1997, SVOCs were included in the analysis of groundwater samples from off-site wells 30062, 30063, and 30065. SVOCs were not detected in the samples (Table A-7).

3.2.5 Layer A - Distribution of Metals

Most monitor wells completed in Layer A were sampled for metals during the Stage 1 RI. During Stage 1, it was noted that monitor wells were yielding metals in areas where no known metals usage occurred. It was determined that field filtering of the samples was necessary to prevent metals present in sediments from being reported as dissolved metals. Aluminum, barium, cadmium, chromium, lead, and mercury were reported above MCLs in the unfiltered groundwater samples collected in the vicinity of Chemical Plant 1 (ICF Kaiser, 1993). After Aerojet began filtering samples in June 1993, groundwater samples did not yield any metals concentrations exceeding primary or secondary MCLs (ICF Kaiser, 1993). Although all wells with unfiltered metals concentrations exceeding MCLs were not re-sampled, filtered metals data collected from the deeper layers confirm that metals are not a CoPC in the Study Area (Sections 3.3.5, 3.4.5, 3.5.5, and 3.6.5).

During the current sampling period, three new offsite wells north of Highway 50 and east of Sunrise Boulevard were sampled for metals. Two of these wells yielded metals concentrations slightly above primary or secondary MCLs (Table A-8). Well 30063 yielded aluminum (1.1 mg/L) above the primary MCL (1.0 mg/L) and iron (0.32 mg/L) just above the secondary MCL (0.3 mg/L). Well 30065 yielded aluminum (0.68 mg/l) and manganese (0.12 mg/L) above their respective secondary MCLs (0.2 and 0.05 mg/L, respectively). As discussed in Section 3.2.1 it is unlikely that these wells are monitoring chemical impacts associated with the Aerojet Site.

3.2.6 Layer A - Distribution of Miscellaneous Compounds and TICs

During the Stage 1 RI, many monitor wells screened in Layer A were sampled for analytes that are not included in routine monitoring. A target analyte list was developed based on historical uses at the potential source sites, several of which are present in the vicinity of Chemical Plant 2. The target analytes identified for the Chemical Plant 2 area included OBPA and Prowl (a fungicide and herbicide manufactured at Chemical Plant 2), an anion scan, and miscellaneous petroleum hydrocarbons. The anion scan includes chloride, nitrate, total nitrogen (nitrate plus nitrite), and sulfate. The results of the Stage 1 sampling for the anions, OBPA, and Prowl are presented on Table A-9, and the results of the petroleum hydrocarbon sampling a presented on Table A-10.

OBPA and Prowl were not detected in any of the wells sampled (Table A-9). Nitrate was detected above MCLs (45 mg/L) in three of the 32 wells sampled during the Stage 1 RI (Table A-9). Nitrate exceeded MCLs in two wells sampled since the Stage I RI (Wells 3264 and 4310). Petroleum hydrocarbons were detected at 0.3 mg/L in Well 3264 in 1992, but were not detected in two subsequent analyses (Table A-10).

TICs were reported in the SVOCs analyses of three monitor wells in Layer A. Unknown hydrocarbons were detected at estimated concentrations ranging from 280 to 2,300 µg/L in offsite Wells 30062, 30063, and 30065 in 1997 (Table A-10). The presence of TICs in these wells was not confirmed by re-sampling because the Stage 2 TIC approach was developed two years after the wells were sampled. The presence of hydrocarbons in these wells, combined with the atypical suite of VOCs discussed previously, provides further evidence that an offsite source(s)(e.g., a former County Landfill, GZ Plastics) of chemicals exists in the vicinity of these wells.

3.2.7 Layer A - Summary of Chemical Distribution

Three VOCs (TCE, 1,2-DCA, and chloroform), perchlorate, nitrate, and NDMA were detected above their respective regulatory limits in monitor wells completed in Layer A on the Aerojet Site. The sources of these chemicals are located in Lines 01, 03, 04, 05, and Chemical Plants 1 and 2. Near these source areas, the chemical concentrations observed in Layer A were typically several orders of magnitude higher than those observed downgradient near the GET facilities. This is probably primarily due to the downward migration of chemicals and to dilution from recharge, but may be partially due to physical natural attenuation factors.

The offsite migration of chemicals in Layer A has not been observed in the Study Area. Layer A is currently dry along the northwestern and western perimeters of the Aerojet Site and in the vicinity of GET E and the GET E and F recharge fields (Section 2.3.1). TCE, 1,2-DCA, and perchlorate were detected at maximum concentrations of 3, 3.4, and 14 µg/L, respectively, in one monitor well (Well 75) downgradient of the GET F extraction wells; however, none of these compounds were detected in a monitor well (Well 3352) located 700 feet further downgradient. The analytical data show that the chemicals present in Layer A downgradient of the GET F extraction wells are very limited in type, quantity and extent.

North of Highway 50 and east of Sunrise Boulevard, groundwater contains four VOCs (TCE, 1,1-DCE, 1,2-DCE, and vinyl chloride) and several metals above MCLs. This suite of VOCs is suggestive of the reductive dehalogenation of TCE that is not typically observed in groundwater on the Aerojet Site. Petroleum hydrocarbons, which were rarely detected in the Study Area, were detected in this area at concentrations up to 2,300 µg/L. In addition, these chemicals are present in a monitor well (Well 30065) completed at depths of 28 to 48 feet bgs. Monitor wells located upgradient on the Aerojet Site and screened at similar depths are dry. These data indicate the chemical impacts in this area are not associated with activities on the Aerojet Site.

3.3 Layer B - Distribution of Chemicals in Groundwater

Groundwater data from over 80 monitor wells were used in this evaluation of Layer B. Two extraction wells (Wells 4007 and 4315) are screened in Layer B at the GET F facility; no extraction wells are screened in Layer B at GET E. Recharge well 5100, located at the northwest end of the recharge well field, is partially screened in Layer B.

3.3.1 Layer B - Distribution of VOCs

VOC analyses were conducted on 53 monitor wells screened in Layer B from January 1996 through April 1999 (Tables A-2, -3, and -12). Pre-1996 VOC data were reviewed to supplement the more recent data and to prepare the isoconcentration maps. Five VOCs (TCE, 1,1-DCE, 1,2-DCE, carbon tetrachloride, and chloroform) were detected above their respective MCLs in Layer B, although no VOCs were detected above MCLs off of the Aerojet Site or the IRCTS. Well 132, located near GET F, was the only well with VOCs other than TCE exceeding MCLs (Table A-12).

The distribution of TCE, the most commonly detected VOC, is presented on Figure A-23. TCE has been detected in Layer B at concentrations up to 88,000 µg/L near source areas located in Lines 03, 04, 05 and Chemical Plant 1 (Aerojet/Hydro-Search, 1996). The TCE in Layer B extends west from these source areas to GET F (Figure A-23). TCE was detected up to 4,900 µg/L in Well 132, located near GET F extraction well 4315. The lateral extent of TCE in Layer B is similar to that observed for Layer A; however, the TCE concentrations in Layer B near GET F are up to three orders of magnitude higher than those in Layer A (i.e., 50 versus 5,000 µg/L). TCE was not detected in Layer B downgradient of the GET F extraction well (Well 4315), or downgradient of the GET E and F recharge well field (Figure A-23).

TCE concentrations exceeded the MCL (5 µg/L) in four wells located within the Study Area on the northern portion of the IRCTS (Figure A-23). The TCE detected in Wells STSW-21 and STSW-03B may be related to activities at the Aerojet/McDonnell-Douglas propellant burn area (PBA).

TCE was detected at concentrations of 1.2 and 2.0 µg/L to the north and west of the Aerojet Site in Wells 30064 and 30002, respectively (Figure A-23). The TCE detected in Well 30016 is the farthest west detection of TCE in a monitor well in any of the layers. TCE was detected in three public water supply wells located along a southwest trending line roughly parallel to Folsom Boulevard and extending to Mather Field Road (Wells AC1, AC4, and AC5). PCE (Well 1011 at <0.5 to 2.1 µg/L) and chloroform

(Well 1135 at <0.5 to 1.2 µg/L) have also been detected more than one time in two of these three wells (Table A-3).

3.3.2 Layer B – Distribution of Perchlorate

Perchlorate data from 50 monitor wells screened in Layer B were reviewed for this evaluation (Tables A-2, -3, -13 and -14). The distribution of perchlorate shows three main areas of perchlorate within the Study Area. The first area consists of the plume located in Lines 03, 04, and 05 that flows roughly southwest from these source areas toward GET F (Figure A-24). The perchlorate concentrations in this plume attenuate from 100,000 µg/L near the source areas to approximately 5,000 µg/L downgradient at GET F (Aerojet, 1998). Perchlorate was not detected in two monitor wells located west (downgradient) of GET F; however, the sedimentary package designated as Layer B is typically absent west of GET F (Section 2.2.2).

A second area of perchlorate in Layer B is located on the northwestern portion of the IRCTS. The relatively high concentration portion of this plume originates at the former GET F Sprayfield and the joint propellant burn area and extends just beyond the western IRCTS boundary (Figure A-24). Layer B is the upper-most water-bearing zone in this portion of the IRCTS. Perchlorate migrating through Layer B southwest of the GET F appears to co-mingle with the perchlorate originating at the Sprayfield. These two plumes are distinguishable by the relatively higher perchlorate concentrations detected in monitor wells located within the former GET F Sprayfield. Perchlorate concentrations within the Study Area on the IRCTS range from non-detect up to 7,200 µg/L. The extent of perchlorate on the southern portion of the IRCTS appears to be undefined; however, numerous monitor wells are located to the east, south, and west of Well STSW-52A. Aerojet and The Boeing Corporation are jointly investigating this area and plume characterization will be completed under a separate CAO.

The third area of perchlorate in Layer B is located at the GET E and F recharge well field on the Aerojet Site (Figure A-24). Perchlorate concentrations up to 5,200 µg/L have been observed in this area, and are probably the result of recharge through Well 5100. Several attempts to define the western extent of perchlorate at this location yielded no substantial water-bearing units at the depths associated with Layer B in this area (typically 90 to 120 feet bgs).

3.3.3 Layer B – Distribution of NDMA

NDMA was detected in 5 monitor wells and one extraction well sampled in Layer B (Tables A-2, -3, and -15). The majority of NDMA was detected on the Aerojet Site within and downgradient of Line05/Chemical Plant 1 and near the West Lake retention ponds (Figure A-25). Groundwater flow directions indicate that the NDMA detected in well 3447, located north of West Lake, did not originate in the Line 05/Chemical Plant 1 area. There are no known or suspected source areas of NDMA upgradient of well 3447. Not all wells screened in Layer B were sampled for NDMA; however, the distribution of NDMA is scattered and is suggestive of a non-point source. The hydrostratigraphic characteristics of Layer B suggest that NDMA is not flowing offsite through Layer B (Section 2.2.2).

3.3.4 Layer B – Distribution of SVOCs

SVOC analyses were performed on samples from one new well (Well 3591) on the Aerojet Site, one existing well on the IRCTS (Well 1312), and all offsite wells except for Well 1466 (Table A-16). As discussed in Section 3.2.4, very few SVOCs were detected in overlying Layer A, and those that were detected are common laboratory contaminants (i.e., phthalates). Layer A is the primary source of chemicals to Layer B, therefore, the general absence of SVOCs in Layer A suggests that SVOCs should not be present in Layer B.

SVOCs were not detected in the wells located offsite with the exception of 25 µg/L of phenol reported in Well 30075 (Table A-16). Phenol was not detected in previous samples collected from Well 30075, and the one-time detection of 25 µg/L is well below the US EPA's Suggested No-Adverse-Response Level of 4,000 µg/L.

3.3.5 Layer - B – Distribution of Metals

Eight offsite wells west of Aerojet, three wells located on the IRCTS, and one new well located on Aerojet (Well 3591) were sampled for metals since 1996 (Table A-17). Metals concentrations have not exceeded the USEPA primary MCLs. Manganese was detected slightly above the USEPA secondary MCL (0.05 mg/l) at a concentration of 0.065 mg/l at Well 30098, located in the former GET F Sprayfield on the IRCTS.

3.3.6 Layer B – Distribution of Miscellaneous Compounds and TICs

Miscellaneous analyses of groundwater from Layer B included an anion scan that is routinely performed on new monitor wells. The anion scans included chloride, nitrate, total nitrogen (nitrate plus nitrite), and sulfate. Nitrate was not detected above MCLs (Table A-18). Chloride concentrations in Layer B ranged from 5.5 to 75 mg/L and sulfate concentrations ranged from 4.7 to 72 mg/L (Table A-18). Similarly to Layer A, unknown hydrocarbons were detected in three wells located east of Sunrise and Folsom Boulevards. Unknown hydrocarbons were reported at estimated concentrations ranging from 1,100 to 2,200 in Wells 30064, 30066 and 30075 (Table A-11). The presence of TICs in these wells was not confirmed by re-sampling because the Stage 2 TIC approach was developed two years after the wells were sampled. The presence of hydrocarbons in these wells suggests there is vertical hydraulic connection between Layers A and B at this location.

3.3.7 Layer B – Summary of Chemical Distribution

Five VOCs (TCE, 1,1-DCE, 1,2-DCE, carbon tetrachloride, and chloroform), perchlorate, and NDMA were detected above their respective regulatory limits in monitor wells completed in Layer B on the Aerojet Site. The chemicals in Layer B originate from the downward vertical migration of chemicals through overlying Layer A. This downward vertical migration appears to occur relatively close to the source areas, and was observed for TCE and perchlorate, the two most widely detected compounds.

The offsite migration of chemicals west of Aerojet and IRCTS through Layer B has not been observed to date. On the Aerojet Site, groundwater flowing through Layer B is intercepted by one extraction well at GET F. Layer B is generally absent west (downgradient) of GET F. On the IRCTS, chemicals in Layer B (primarily perchlorate and TCE) are not presently controlled by an extraction system. Monitor wells drilled west of the IRCTS to characterize Layer B did not encounter significant water-bearing units at the depths associated with Layer B, similar to the observations west of GET F to the north.

3.4 Layer C - Distribution of Chemicals in Groundwater

Groundwater data from over 190 monitor wells screened in Layer C were evaluated for this RI. Layer C is the shallowest layer present across the entire Study Area and is the most intensely monitored layer. Monitor wells screened in Layer C are utilized to evaluate chemical migration from the source areas, the effectiveness of the GET facilities, offsite plume characterization, and public water supply well

protection. There are five extraction wells at GET E, three extraction wells at GET F, and six recharge wells either entirely or partially screened in Layer C.

3.4.1 Layer C – Distribution of VOCs

VOC analyses were conducted on groundwater samples from over 150 monitor wells screened in Layer C from January 1996 through December 1998 (Tables A-2, -3, and -19). A review of the most recent VOC data from each well shows that four VOCs (TCE, 1,1-DCE, 1,2-DCA, and chloroform) were detected above USEPA and California Department of Health Services (CADHS) primary MCLs, and two VOCs (1,2-DCE and carbon tetrachloride) exceeded the CADHS primary MCL. TCE was the only VOC detected above MCLs west of the Aerojet Site or the IRCTS.

Previous investigations reported TCE concentrations up to 5,000 µg/L in the eastern portion of the Study Area near source areas (i.e., Lines 03, 05, and Chemical Plant 1) located on the Aerojet Site (Aerojet/Hydro-Search, 1996). Most of the wells located in the source areas were not sampled within the sampling period and the data are not included on Figure A-26. However, the contour lines prepared during these investigations were retained on Figure A-26 to illustrate the presence of these source areas. The natural groundwater gradient, combined with the hydraulic mound created by the GET E and F recharge well field, directs the TCE-impacted water from the source areas to the west-northwest and west-southwest towards GETs E and F, respectively. TCE was detected up to 1,000 µg/L in the vicinity of the GET E extraction wells. TCE concentrations in the vicinity of the GET F extraction wells are higher, generally ranging from 1,000 to 6,000 µg/L.

TCE concentrations off-site and downgradient of GETs E and F are substantially lower than those observed on the Aerojet Site (Figure A-26). TCE is present offsite to the north of GET E and extending approximately 12,000 feet southwest to Zinfandel Drive. In this area, TCE was detected in four public water supply wells at concentrations ranging from 1.2 to 97 µg/L. The TCE concentrations observed in well 1014/AC9 and those detected in several nearby monitor wells are higher than the TCE concentrations observed in monitor wells immediately downgradient of GET E and along the northern Aerojet property boundary. These data and groundwater flow directions suggest there may be other off-site sources of TCE in this area.

TCE was detected above the MCL in eleven monitor wells at eight locations downgradient of GET F and south of GET F on the northwestern edge of the IRCTS (Figure A-26). The majority of TCE in this area

is generally confined to the Aerojet Site and the IRCTS. although some TCE may have migrated just beyond the western IRCTS boundary. Potential sources of TCE in this area include the joint propellant burn area and upgradient sources located on Aerojet. The potential source(s) are not differentiated in this analysis. The most recent TCE result for well STSW-03C (810 µg/L) was not posted on Figure A-26 because this result is 7 times higher than any previous result from this well and appears to be anomalous (Table A-19).

TCE was detected at relatively low concentrations (up to 13 µg/L) southwest of the GET E/F recharge wells (Figure A-26). The TCE in this area appears to be limited in aerial and vertical extent.

In addition to TCE, four VOCs were detected above their respective MCLs in monitor wells located on the Aerojet Site (Figure A-27). Chloroform and 1,2-DCA were detected downgradient of Line 05/Chemical Plant 1 as far southwest as Chemical Plant 2. Both compounds were used in these areas and their detections are consistent with the identification of source sites in these areas (ICF Kaiser, 1993). 1,2-DCE and 1,1-DCE, both potential breakdown products of TCE, were also detected downgradient of Chemical Plant 1/Line 05 as far southwest as Chemical Plant 2. These compounds are probably the result of the biological breakdown of TCE that has been documented in groundwater in this area (Beak, 1997).

3.4.2 Layer C – Distribution of Perchlorate

Perchlorate analyses were conducted on groundwater samples collected from over 150 monitor wells screened in Layer C from January 1996 through April 1999 (Tables A-2, -3, -14, and -20). The perchlorate detected in Layer C has the most widespread distribution of any chemical detected in any of the hydrostratigraphic layers (Figure A-28).

On the eastern side of the Study Area, perchlorate in Layer C has "stair-stepped" down from east to west through overlying Layers A and B. Perchlorate concentrations range up to 1,500 and 8,200 µg/L in the vicinity of GETs E and F, respectively (Aerojet, 1998). Groundwater with perchlorate was extracted from Layer C through five extraction wells at GET E and three extraction wells at GET F. Prior to 1999, the extracted groundwater was treated for VOCs then recharged through the GET E and F recharge wells forming the majority of the plume observed west of the Aerojet Site. The irregular shape of the perchlorate plume in the northwestern portion of the Study Area suggests some influence from regional groundwater pumping. The maximum lateral extent of perchlorate downgradient of the recharge well field (defined by the 4 µg/l contour line) may extend west to approximately Zinfandel Drive. Figure A-4

is a cross section showing perchlorate concentrations in monitor wells from the GET F recharge well field to the furthest downgradient monitor well (Well 30116-8). This cross section shows the highest perchlorate concentrations downgradient of the GET F recharge wells are in Layer C.

In the area north of Folsom Boulevard, perchlorate data from the public water supply wells were evaluated to supplement the perchlorate data from monitor wells. In addition, four nested monitor wells were installed in December 1998/January 1999 to assess potential migration pathways for perchlorate and NDMA in this area. Figure A-5 is a cross section constructed generally parallel to Folsom Boulevard from the vicinity of GET E in the east to public water supply well 1011/AC1 in the west. The perchlorate data posted on this cross section shows that perchlorate is present in Layers C and D in the vicinity of public water supply wells 1015/AC15 and 1016/AC16. Perchlorate is present in Layer C in the vicinity of public water supply wells 1013/AC9 and 1014/AC13. Cross section H-H' (Figure A-6) was drawn from the northern end of the recharge well field northwest to the farthest public water supply well with detected perchlorate or NDMA (Wells 1142/AC14 and 1140/AC11)(Figure A-6). This cross section shows perchlorate is present primarily in Layer C.

On the IRCTS, perchlorate was detected up to 2,400 µg/l in the upper portion of Layer C within and generally downgradient of the GET F Sprayfield and the propellant burn area. The lateral extent of perchlorate in this area is relatively well defined by offsite monitoring well 30089-90, where only low concentrations (up to 13 µg/l) of perchlorate were detected (Figure A-28). As with Layer B, the western extent of the southern perchlorate plume on the IRCTS has not been delineated for this report, and is being investigated under a separate program (Aerojet and Boeing, 1998).

3.4.3 Layer C – Distribution of NDMA

The distribution of NDMA in Layer C is presented on Figure A-29 and summarized in Tables A-2, -3, and -21. NDMA was detected on the Aerojet Site near Line 05/Chemical Plant 1, along the northern and northwestern Aerojet Site boundaries, and in one extraction well (4140) located at GET F. NDMA was detected offsite downgradient of the GET E extraction and recharge wells and in two public water supply wells partially screened in Layer C.

The presence of NDMA in Layer C in the West Lake Area suggests NDMA has migrated downward from overlying Layers A and B where NDMA was also detected. Some of the NDMA in these layers has migrated to the GET E extraction wells and was recharged through the recharge well field. Portions of

the NDMA plume north of GET E do not appear to be captured by the extraction wells. The uncaptured and the recharged NDMA form the off-site NDMA plume northwest of GET E.

Characterization of NDMA in the offsite areas is complicated by the very low concentrations (i.e., part per trillion) requiring characterization and the absence of a well-defined source. The majority of NDMA in the off-site wells was detected in Layer C. The western-most detections of NDMA were 0.034 µg/L in Well 30087 and 0.015 µg/L in public water supply well 1140/AC11. NDMA was also reported in two of 20 analyses on Well 1142/AC14 (Table A-3). Nested monitor Wells 30128-30 and 30131-3 were drilled between Wells 1140/AC11 and 1142/AC14 to evaluate the layer(s) through which NDMA was migrating. NDMA was not detected in any of the six well completions (3 in Layer C, 1 in Layer D, and 2 in Layer E) at this location. The absence of NDMA in these wells and upgradient Well 30122-3, combined with the presence of NDMA in Wells 30137-8, 1204, and 1467, suggests the NDMA is present in relatively thin lense(s), probably within Layer C. Additional sampling for NDMA may be warranted, as improved detection limits become available.

3.4.4 Layer C – Distribution of SVOCs

SVOC analyses were conducted on groundwater samples from 55 monitor wells completed in Layer C, including all of the offsite wells (Table A-22). SVOCs were not detected in any of the samples.

3.4.5 Layer C – Distribution of Metals

Metals analyses were conducted on groundwater samples from 50 monitor wells completed in Layer C, including all of the off-site wells (Table A-23). Metals concentrations did not exceed USEPA primary MCLs in any of the samples. Iron was detected above the USEPA secondary MCL (0.3 mg/L) at a concentration of 0.61 mg/L in Well 30059, located on the IRCTS. Manganese was detected above the USEPA secondary MCL (0.05 mg/L) at a concentration of 0.095 mg/L in Well 30123, located north of Folsom Boulevard and west of Sunrise Boulevard.

3.4.6 Layer C – Distribution of Miscellaneous Compounds and TICs

Chloride, nitrate, total nitrogen (nitrate plus nitrite), and sulfate analyses were conducted on groundwater samples from 45 monitor wells completed in Layer C, including all of the off-site monitor wells (Tables A-11 and -24). Chloride concentrations ranged from 3.1 to 86 mg/L. Nitrate concentrations ranged from 0.16 to 9.8 mg/L which are below the USEPA primary MCL of 45 mg/L. Nitrate plus nitrite concentrations (as total nitrogen) exceeded the USEPA primary MCL (1 mg/L) in two wells (2.1 and 2.6 mg/L in Wells 30067 and 30076) located north of Folsom Blvd and east of Sunrise Blvd. Both wells are co-located near a former County landfill and an additional suspected offsite source of solvent. Sulfate concentrations ranged from 2 to 62 mg/L. The two highest sulfate concentrations (62 and 21 mg/L) were also detected in Wells 30067 and 30076.

TICs were reported in the SVOC analyses of four monitor wells completed in Layer C. Unknown hydrocarbons were reported at concentrations ranging from 960 to 1100 ppb in wells 30067 and 30076 (Table A-11). The presence of TICs in these wells was not confirmed by re-sampling because the Stage 2 TIC approach was developed two years after the wells were sampled. These wells are located east of Sunrise and Folsom Boulevards where hydrocarbons were also reported in overlying Layers A and B. The presence of hydrocarbons in Layer C combined with the existence of a local source, indicates there is hydraulic connection between layers A, B, and C in this vicinity.

2-Ethyl-1-hexanol was reported as a TIC at estimated concentrations of 4.6 and 9.5 µg/L in Wells 30122 and 30123, respectively when they were sampled on August 4, 1998 (Table A-11). Confirmation sampling was conducted on December 17, 1998 in accordance with the Stage 2 TIC approach. The reported detection of 2-Ethyl-1-hexanol was not confirmed in either well. However, a different, unknown compound was reported at estimated concentrations of 4.8 and 5.3 µg/L in both wells (Table A-11). TICs were not reported in either well in February 1999, however, PCE was reoprted as a TIC in March 1999 (Table A-11). PCE was not reported in the VOC analysis for either well (Table A-19).

3.4.7 Layer C – Summary of Chemical Distribution

Six VOCs (TCE, 1,2-DCE, 1,1-DCE, carbon tetrachloride, 1,2-DCA, and chloroform), perchlorate, NDMA, and nitrate were detected at concentrations exceeding their respective MCLs/PRGs in monitor wells screened in Layer C. All VOCs detected above MCLs, with the exception to TCE, appear to be

confined within the Aerojet Site boundary. Areas of TCE above MCLs extend from the Aerojet property almost 2 miles to the southwest. In addition, TCE is present downgradient of GET F on the Aerojet Site and on the northwestern corner of the IRCTS.

Perchlorate in Layer C had the most widespread distribution of any chemical in any of the layers. In general, NDMA and TCE were detected within areas impacted by perchlorate. Layer C is not affected by SVOCs, metals, or other anions. A small area with elevated nitrate concentrations was detected northwest of the Aerojet Site near a former County Landfill near Sunrise Boulevard and Highway 50.

3.5 Layer D - Distribution of Chemicals in Groundwater

Groundwater data from over 130 monitor wells screened in Layer D were evaluated for this RI. Layer D underlies Layer C and is present across the entire Study Area. Monitor wells screened in Layer D are utilized to evaluate chemical migration from the source areas, the effectiveness of the GET facilities, offsite plume characterization, and public water-supply well protection. There are five extraction wells at GET E and six recharge wells either entirely or partially screened in Layer D. There are no extraction wells screened in Layer D at GET F.

3.5.1 Layer D - Distribution of VOCs

VOC analyses were conducted on groundwater samples from over 100 monitor wells screened in Layer D from January 1996 to April 1999, including all offsite wells (Tables A-2, -3, and -25). Three VOCs (TCE, 1,1-DCE, and chloroform) were detected at concentrations exceeding USEPA and CADHS primary MCLs and two additional VOCs (1,2-DCE and 1,2-DCA) exceeded only the CADHS primary MCLs. TCE was the only VOC detected above MCLs offsite.

The distribution of TCE, the most commonly detected VOC, is presented on Figure A-30. TCE was detected on the Aerojet Site east of GETs E and F at concentrations up to 620 µg/L. TCE concentrations were relatively higher in the vicinity of GET E, although most wells in the vicinity of GET F were not sampled within the sampling period (Figure A-30). TCE concentrations in monitor wells downgradient (west) of GET E typically ranged from non-detect up to 10 µg/L, with the exception of Well 128 which yielded concentrations up to 280 µg/L. The TCE concentrations in Well 128 have declined three-fold since 1996 that coincides with the initiation of groundwater extraction from upgradient Well 4435 in January 1997 (Table A-25). Continued extraction at Well 4435 is expected to enhance the downward

trend in Well 128. TCE was detected up to 22 µg/L in two wells (Well 421 and 3305) located approximately 1,200 to 2,000 feet north of the northern-most GET E extraction well.

On the southern portion of the Aerojet Site, TCE was detected up to 200 µg/L in Well 401, located adjacent to a GET F extraction well screened in Layer C (Well 4145). Vertical head differences in this area suggest there is the potential for upward groundwater capture from Layer D to Layer C, and Well 401 is in the upper-most lens of Layer D (Section 2.3.6). However, TCE concentrations in Well 401 have increased during the past two years suggesting this well may be monitoring a zone of water that is not hydraulically captured by Extraction Well 4145. TCE was not detected onsite west of Well 401, or in the western offsite area, with the exception of 2.3 µg/L reported in Well 1464 (Figure A-30).

1,1-DCE and chloroform were detected above USEPA Primary MCLs, while 1,2-DCA and 1,2-DCE were detected above CADHS Primary MCLs. The distribution of wells containing one or more of these VOCs above either MCL is presented on Figure A-31. As shown on this figure, the additional VOC concentrations exceeding MCLs were in on-site wells.

3.5.2 Layer D - Distribution of Perchlorate

Perchlorate analyses were conducted on groundwater samples from over 90 monitor wells screened in Layer D from January 1996 to April 1999, including all offsite wells (Table A-2, -3, -14, and -26). The most recent perchlorate results from each well are presented on Figure A-32. The majority of perchlorate in Layer D was detected in wells located on the Aerojet Site. The perchlorate detected in the vicinity of GETs E/F probably originated at the source areas, as TCE is also present in these areas. The relatively higher perchlorate concentrations (up to 7,000 µg/L) observed near the GET E/F recharge well field was probably caused by recharge as indicated by the absence of TCE in this area. The perchlorate emanating from the recharge well field attenuates to less than 600 µg/L within 4,000 feet downgradient (west) of the recharge field. It is not clear if the perchlorate detected in Wells 1464 and 30109 migrated directly through Layer D from the recharge well field, or if it migrated downward from overlying Layer C, which contains perchlorate concentrations greater than 4,000 µg/L in that area. Public water supply well 1030, located just upgradient of Wells 1464 and 30109, may have contributed to the downward migration of perchlorate in this area. On the IRCTS, perchlorate was detected up to 300 µg/L in Wells STSW3C and –52C, located generally downgradient of the former GET F Sprayfield and the Propellant Burn Area.

3.5.3 Layer D - Distribution of NDMA

NDMA analyses were conducted on groundwater samples from over 60 monitor wells screened in Layer D from March 1998 to February 1999, including most offsite wells (Tables A-2, -3, and -27). NDMA was detected just west of West Lake southwest towards GET E and the recharge well field (Figure A-33). Prior to the summer of 1999, the NDMA captured by the GET E extraction wells was partially recharged back into Layer D through the recharge well field. The recharge wells operated as part of GET E are located along the northern portion of the recharge well field (i.e., wells 5045 and 5050 in Layer D). Recharge has formed the portion of the NDMA plume detected along the northwestern Aerojet Site boundary and extending west towards Sunrise Boulevard. Further south, NDMA was detected offsite in Well 1464, which is located just west of Sunrise and north of Folsom Boulevard. Perchlorate and TCE were also detected in this well.

3.5.4 Layer D - Distribution of SVOCs

SVOC analyses were conducted on groundwater samples from 28 monitor wells screened in Layer D from March 1998 January 1996 to February 1999, including most off-site wells (Table A-28). SVOCs were not detected in the samples.

3.5.5 Layer D - Distribution of Metals

Metals analyses were conducted on groundwater samples collected from 25 monitor wells screened in Layer D from March 1998 through April 1999 including most offsite wells (Table A-29). Metals concentrations did not exceed DHS or EPA primary of secondary MCLs in any of the off-site wells. Two wells located on the Aerojet site yielded metals concentrations exceeding secondary MCLs. During the past two years, Well 358, located just south of GET F, has consistently yielded metals concentrations above secondary MCLs. Aluminum (up to 0.39 mg/L), iron (up to 0.88 mg/L), manganese (0.22 mg/L), and zinc (up to 18 mg/L) were reported above secondary MCLs, and lead (0.15 mg/L) was reported one time above the primary MCL. The most recent sample from this well yielded only iron, manganese, and zinc at concentrations exceeding secondary MCLs (Table A-29). Well 358 is screened in blue-green sandy clay which is characteristic of the Valley Springs Formation that has been noted to yield relatively higher metals in groundwater than the overlying geologic formations. One other well screened in Layer D, Well 3593, yielded iron (0.68 mg/L) exceeding EPA's secondary MCL (0.3 mg/L).

3.5.6 Layer D - Distribution of Miscellaneous Compounds and TICs

Chloride, nitrate, nitrate plus nitrite, and sulfate analyses were conducted on groundwater samples from 25 wells completed in Layer D from January 1996 to April 1999 (Table A-30). Chloride concentrations ranged from 4.1 to 29 mg/L. Nitrate concentrations ranged from non-detect (<0.03 mg/L) to 9.4 mg/L which are below the USEPA primary MCL of 10 mg/L. Nitrate plus nitrite (total Nitrogen) was detected in three of the twenty-two wells sampled; however, no concentrations exceeded the EPA Primary MCL of 1 mg/L (Table A-30). Sulfate concentrations ranged from 0.19 to 14 mg/L. One TIC, an unknown hydrocarbon (640 µg/L), was reported in the SVOC analysis conducted on Well 3332 in 1997 (Table A-11). The presence of hydrocarbons in this well was not confirmed by re-sampling because the Stage 2 TIC approach was developed two years after the well was sampled.

3.5.7 Layer D – Summary of Chemical Distribution

Five VOCs (TCE, 1,2-DCE, 1,1-DCE, 1,2-DCA, and chloroform), perchlorate, and NDMA were detected above their respective MCLs/PRGs in monitor wells screened in Layer D. TCE was the only VOC detected above MCLs off-site. Perchlorate, NDMA, and TCE are present in the northwestern portion of the Study Area in the vicinity of GET E and may extend offsite approximately 3000 feet to the west. Perchlorate and NDMA are present west and southwest of the GET E and F recharge well field; however, TCE is not present in this area suggesting the distribution of perchlorate and NDMA is due to the recharge wells. In general, the perchlorate and NDMA may have migrated offsite approximately one-half to one-third the distance in Layer D as they have in overlying Layer C.

3.6 Layer E - Distribution of Chemicals in Groundwater

Groundwater data from approximately 68 monitor wells screened in Layer E were evaluated for this RI. Layer E underlies Layer D and is present across the entire Study Area. For this evaluation, Layer E is considered the lower-most layer. Although Layer F is present beneath Layer E, the few wells screened in Layer F have not shown any chemical impacts. There are no extraction or recharge wells screened in Layer E.

3.6.1 Layer E – Distribution of VOCs

VOC analyses were conducted on groundwater samples from 51 monitor wells screened in Layer E from January 1996 through April 1999, including most offsite wells (Tables A-3 and –31). TCE was the only VOC detected in Layer E at concentrations exceeding MCLs. The majority of TCE in Layer E was detected on the northwestern portion of the Aerojet Site; and may extend approximately 4,000 feet offsite to the west (Figure A-34). Public water supply wells 1015/AC15 and 1016/AC16 are located within this portion of the TCE plume, and public water supply Well 2065/AC20 is relatively close. These wells intersect several hydrostratigraphic layers; the relative contribution from each hydrostratigraphic layer to total production of each public water supply well has not been determined.

3.6.2 Layer E – Distribution of Perchlorate

Perchlorate analyses were conducted on groundwater samples from 49 monitor wells screened in Layer E from January 1996 to April 1999 [including seven new wells installed in early 1999](Tables A-3 and -32). Perchlorate was detected in two apparently separate areas in Layer E (Figure A-35). The first area is located on the Aerojet Site in the vicinity of the GET E extraction wells. The highest perchlorate concentrations in this area (400 µg/L) were detected in well cluster 1437-8.

A second area of perchlorate in Layer E is present in the vicinity of the recharge well field (Figure A-35). The absence of TCE and the presence of perchlorate in this area suggest the perchlorate originated at the recharge well field. There are no recharge wells screened in Layer E, so the perchlorate probably migrated downward from overlying Layer D. Perchlorate was not detected (i.e., <4 µg/L) offsite in monitor wells located west of the recharge well field.

3.6.3 Layer E – Distribution of NDMA

NDMA analyses were conducted on groundwater samples from 26 monitor wells screened in Layer E from March 1998 through May 1999 (Tables A-3 and -33). The distribution of NDMA in Layer E was very similar to the distribution of perchlorate (Figure A-36). NDMA was detected offsite along the northwestern boundary of the Aerojet Site near the GET E extraction wells, and NDMA was detected onsite in two wells located along the western Aerojet boundary west of the recharge well field. NDMA was not detected offsite west of the recharge well field in Layer E.

3.6.4 Layer E – Distribution of SVOCs

SVOC analyses were conducted on groundwater samples from 13 monitor wells screened in Layer E from January 1996 to April 1999 (Table A-34). SVOCs were not detected in the samples.

3.6.5 Layer E – Distribution of Metals

Metals analyses were conducted on groundwater samples from 12 monitor wells screened in Layer E from January 1996 to April 1999 (Table A-35). Lead exceeded the EPA Primary MCLs (0.015 mg/L) in one sample collected from Well 1280 (0.067 mg/L). Lead was not reported in four previous and two subsequent samples collected from this well. Arsenic exceeded the EPA Primary MCL (0.05 mg/L) in the only sample collected from Well 30135 (0.13 mg/L). Aluminum (2 wells), iron (5 wells), manganese (4 wells) and zinc (3 wells) concentrations exceeded EPA Secondary MCLs in several wells. There appears to be a trend of increasing metals concentrations with depth that are caused by geologic conditions and not by site-related activities.

3.6.6 Layer E – Distribution of Miscellaneous Compounds and TICs

Chloride, nitrate, and sulfate analyses were conducted on groundwater samples from 12 wells screened in Layer E from January 1996 through April 1999 (Table A-36). Chloride concentrations ranged from 3.5 to 17 mg/L. Nitrate concentrations ranged from non-detect (<0.03 mg/L) to 7.1 mg/L with no concentrations exceeding EPA Primary MCLs (10 mg/L). Sulfate concentrations ranged from non-detect (<0.05 mg/L) to 20 mg/L. One unknown TIC was reported at an estimated concentration of 4.2 µg/L in the SVOC analysis performed on Well 30126 in 1998 (Table A-11).

3.6.7 Layer E – Summary of Chemical Distribution

TCE, perchlorate, and NDMA were detected above their respective MCLs/PRGs (health-based risk data) in monitor wells screened in Layer E. All three compounds are present on the Aerojet Site in the vicinity of GET E. There are no extraction wells screened in Layer E at GET E, and there are three public water supply wells generally downgradient of GET E screened entirely or partially in Layer E. Perchlorate and NDMA were also detected in several monitor wells located on the Aerojet Site west (downgradient) of the GET E and F recharge well field. The absence of TCE in this area suggests the perchlorate and NDMA

originated at the recharge well field. Neither perchlorate nor NDMA were detected in offsite monitor wells screened in Layer E downgradient of the recharge well field.

3.7 Public Water Supply Wells

This section summarizes the sampling results from public and private water supply wells (PWSWs) in the Study Area. Arden Cordova Water Service (ACWS), Citizens Utilities Company, and the Sacramento County Water Maintenance District (SCWMD) provide water service in the Study Area. The locations of PWSWs and the boundaries of the water purveyor franchise areas are shown on Figure A-37. Most domestic and agricultural water supply wells that were abandoned or are no longer used are not shown on this figure.

This section was updated in October 1999 to incorporate analytical data collected from PWSWs through September 1999. A summary of the VOCs detected and the NDMA and perchlorate analyses from January 1997 through September 1999 are presented in Table A-3. Since March 1997, six PWSWs operated by ACWS (1014/AC13, 1015/AC15, 1016/AC16, 1140/AC11, 1142/AC14, and 1860/AC19) and one PWSW operated by SCWMD (1030/SWMD17) were removed from service because perchlorate and/or NDMA concentrations exceeded public health goals. ACWS has removed three additional wells (1137/AC7, 1141/AC12, and 2066/AC21) from service because they received data suggesting the potential presence of NDMA in these wells that could not be confirmed by Aerojet sampling.

PWSWs were included on the various isoconcentration maps presented in the Sections 3.0 to 3.5 if all or a portion of their screened interval was in the layer being depicted. In many instances, the chemical concentrations reported at the PWSW were higher or lower than isoconcentration contours at that location. This occurs because most PWSWs are screened in multiple layers and draw varying percentages of water from each layer. Figure A-37 shows the chemicals detected in each PWSW regardless of the layer(s) the wells are completed in. The results of sampling at the Mather Air Force Base main wells are not depicted on this figure because it is currently interpreted that chemicals emanating from the IRCTS are responsible for these detections.

Aerojet monitors PWSWs as required by Exhibit IV of the PCD. The Exhibit IV analyte list and sampling frequencies vary based on each wells proximity to known groundwater plumes and previous data. PWSWs in the Study Area are typically sampled for VOCs, perchlorate, and NDMA. PWSWs are periodically screened for a wider range of analytes, most recently in 1998-99. The following sections

summarize the results of the VOC, perchlorate, NDMA, SVOCs, and miscellaneous analyses conducted during the past two years.

3.7.1 Public Water Supply Wells – Distribution of VOCs

Three VOCs, TCE, PCE, and chloroform were detected in PWSWs in the Study Area. Each of these VOCs was used in varying degrees at Aerojet, although TCE appears to have been the most widely used. In some instances, the TCE and/or PCE reported in PWSWs do not appear to be migrating from the Aerojet Site. There are documented releases of TCE and PCE in the western offsite areas that are unrelated to Aerojet activities. Some of these releases are located within several hundred feet of PWSWs where TCE and/or PCE have been detected.

TCE has been reported in up to ten PWSWs in the Study Area (Table A-3). TCE concentrations exceeded MCLs (5 µg/L) in wells 1014/AC13, 1015/AC15, and 1016/AC16. These wells are located within 5,000 feet of the northwestern Aerojet boundary and are also downgradient and sidegradient of an offsite source of TCE located north of Highway 50 and east of Sunrise Boulevard (Figure A-37). Each of these wells was equipped with granular activated carbon filters to remove the TCE in the 1980s. TCE was detected in the remaining seven wells at concentrations up to 1.3 µg/L.

PCE was reported in PWSWs 1011/AC1 and 1137/AC7 at concentrations of 0.96 and 0.68 µg/L, respectively, which are below the MCL for PCE (5 µg/L)(Table A-3). These wells are located between 1.6 and 2.1 miles from the western Aerojet boundary. PCE was not reported in PWSWs located closer to Aerojet, and was rarely detected in offsite monitor wells (Figure A-37). PWSW 1011/AC1 is located within several hundred feet of a dry cleaner with documented PCE releases.

Chloroform was detected in well 1014/AC13 the last time it was sampled (December 1998), and has been historically detected in four other wells (1026, 1140/AC11, 1135AC4, and 1030/SWMD17) (TableA-3). The highest chloroform concentration reported in a PWSW (1.2 µg/L in well 1135/AC4) is well below the MCL of 100 µg/L (RWQCB, 1998). 1,2-DCA was reported one time in well 1142/AC14 at 0.53 µg/L, but was not detected in 18 subsequent samples (Table A-3).

3.7.2 Public Water Supply Wells – Distribution of Perchlorate

Perchlorate was detected in nine PWSWs at concentrations ranging from 5.6 to 410 µg/L. Five PWSWs remain off-line because the perchlorate concentration exceeds the provisional drinking water standard of 18 µg/L (Wells 1014/AC13, 1015/AC15, 1016/AC16, 1030/SWMD17, and 1860/AC19)(RWQCB, 1998). Perchlorate concentrations in the PWSWs downgradient of the closed wells may increase as the perchlorate plume migrates to the west-southwest. Four PWSWs south of the Study Area remain off-line due to perchlorate emanating from the IRCTS.

3.7.3 Public Water Supply Wells – Distribution of NDMA

NDMA has been reported in three PWSWs located within 1.5 miles of the northwestern Aerojet boundary. NDMA concentrations ranged from 0.024 to 0.22 µg/L in Wells 1140/AC11, 1142/AC14, and Well 1016/AC16 (Figure A-37). In March 1998, NDMA was detected twice in Well 1142/AC14, but has not been detected in 17 subsequent samples (Table A-3). NDMA was detected in Well 1140/AC11 in March through September 1998, but was reported in only two of eleven samples collected since (Table A-3).

NDMA characterization is limited by monitor well coverage and the current method detection limits (0.0075 µg/L). Aerojet is evaluating analytical methods to lower the NDMA detection limit to below 0.002 µg/L. The current NDMA plumes north of Highway 50 and west of Sunrise Boulevard are primarily based on data collected from PWSWs. Additional monitor wells are being evaluated in these areas to identify the specific depths and locations where NDMA is present.

3.7.4 Public Water Supply Wells – Distribution of Miscellaneous Constituents

Aerojet recently completed a comprehensive analyses of PWSWs that varied by well location, but generally included SVOCs [including a TIC analysis], hydrazines, metals, organic carbon, total dissolved solids, and pH. The comprehensive analyses did not identify any additional constituents in the PWSWs other than those routinely monitored under Exhibit IV (Aerojet, 1999). TICs were reported in several PWSWs and monitor wells, however, none of the TICs reported in the first samples were confirmed in subsequent sampling events (Table A-11).

4.0 CONTAMINANT FATE AND TRANSPORT

This section discusses the primary processes that affect the fate and transport of contaminants in groundwater. All Study Area contaminants are present in the dissolved-phase and migrate with groundwater through a process referred to as advection. During the advection process, physical, chemical, and/or biological processes act to disperse, retard, or destroy solutes. These processes affect the rate of migration, mobility, concentration and mass of the solutes. The relative effects of each of these processes are determined by the properties of the aquifer and by the properties of each contaminant. Section 4.1 summarizes the work performed to estimate groundwater migration rates (groundwater velocity). Section 4.2 discusses and compares the relative effects of the dispersion, retardation, and destruction processes for solvents, NDMA, and perchlorate.

4.1 Groundwater Advection

Groundwater advection describes the process by which dissolved-phase contaminants are carried in groundwater. The advective process is quantified by estimating the rate of movement for groundwater, or the groundwater velocity. Groundwater velocities are estimated by evaluating aquifer properties and through aquifer testing. The estimated groundwater velocities represent the average linear velocity for all permeable sediments in the aquifer. The aquifer in the Study Area is heterogeneous, and there will be sediments where groundwater velocities are higher or lower than the average linear velocity.

Aquifer testing was conducted on the majority of the GET E and F extraction wells. The extraction wells at GET E are screened in both Layers C and D, and the extraction wells at GET F are individually screened in Layers A, B, and C. The range of results obtained from these tests is representative of the conditions at GETs E and F, but may not necessarily reflect conditions in the western offsite areas. The following chart presents a summary of the hydraulic parameters calculated from the onsite aquifer testing:

Hydraulic Parameter	GET E Area		GET F Area	
	Range	Median	Range	Median
Hydraulic Conductivity (ft/day)	63.5 to 145.6	123.4	7.6 to 38	18.5
Transmissivity (gpd/ft)	49,000 to 156,000	133,000	10,000 to 37,000	21,100

These data show that the median hydraulic conductivities and transmissivities are higher in the GET E area than in the GET F area. This corresponds with field observations that sediments in the vicinity of GET F are generally finer-grained than the sediments observed at GET E.

Arden Cordova Water Service has conducted several aquifer tests in the western offsite area using water supply wells AC19, AC22, and AC23. AC19 and AC22 are screened in Layers C, D, and E, and AC23 is screened in Layer E. Data provided to Aerojet relating to the test performed at well AC22 yielded transmissivities in the range of 210,000 to 252,000 gpd/ft (CH2MHill, 1998). Data collected by Aerojet during the aquifer testing of wells AC19 and AC23 yielded transmissivities of 150,000 and 100,000 gpd/ft, respectively. These data suggest transmissivities in Layers C and D in the western offsite area may be higher than those observed at GETs E and F which is consistent with the observed westward thickening of the layers (Section 2.2).

Estimates of groundwater velocities can be prepared using the following equation:

$$q = k * i / n_e$$

where: q = average groundwater velocity (feet per day)

k = hydraulic conductivity (feet per day)

i = hydraulic gradient (foot/foot), and

n_e = effective porosity

Using an effective porosity value of 0.25 (typical for clean sands), groundwater velocity estimates at GET E range from 372 to 851 feet per year. Groundwater velocity estimates at GET F range from 45 to 222 feet per year.

Estimated groundwater velocities in the Study area are relatively high, and groundwater advection is probably the dominant process affecting contaminant migration rates. Non-reactive contaminants are transported at an average rate equal to the average linear velocity of the groundwater (Freeze and Cherry, 1979). Therefore, estimated migration rates based solely on advection are probably more reasonable for less reactive compounds such as perchlorate, but probably overestimate the migration rates for reactive compounds like TCE.

4.2 Contaminant Dispersion and Retardation

Observed contaminant migration rates are often different than the rates that would be expected based solely on advection. In most cases, contaminant migration rates are slower than groundwater movement, although some processes can cause contaminants to migrate more quickly than groundwater. Some of the processes effecting contaminant migration rates and concentrations include molecular diffusion, mechanical dispersion, retardation, dilution, volatilization, and biological degradation. The effect of each

of these processes can vary significantly from chemical to chemical, and it is difficult to quantify these effects because there are numerous location and chemical specific variables that cannot be practically measured.

It may be necessary to conduct additional studies in the future to provide the data necessary to more accurately gauge contaminant migration rates, groundwater restoration times and natural attenuation rates. Aquifer characterization completed in conjunction with groundwater monitoring and potential remedial design activities should improve the ability to predict the effect of these processes. Although the individual and combined effects of these processes are not well understood, these effects are probably minimal compared to the effects due to the relatively high groundwater velocities in the Study Area. The following paragraphs provide general descriptions of the processes effecting the fate and transport of contaminants in groundwater. Chart A-1 presents a summary of the relative effects of dispersion, retardation, and destruction for solvents, NDMA, and perchlorate.

CHART A-1: Summary of Relative Retardation, Dispersion, and Destruction Effects

	Dispersion Effects		Retardation Effects	Destruction Effects	
CONTAMINANT	Molecular Diffusion	Mechanical Dispersion	Sorption	Volatilization	Biological Degradation
Solvents	√√	√	√√√	√√√	√√
NDMA	√√	√√	√√	√	√
Perchlorate	√√√	√√√	√	√	√

Key: √ = No or uncertain effect
√√ = Moderate effect
√√√ = Greatest effect

Molecular diffusion is the movement of contaminants from areas of higher concentration to areas of lower concentration. Molecular diffusion results in lower contaminant concentrations, although contaminant mass is not changed. Diffusion can cause contaminants to migrate more quickly than the groundwater velocity. However, in areas with high groundwater velocities, the physical dispersion processes tend to dominate over molecular diffusion. Therefore, the effects of molecular diffusion are probably enhanced in the lower permeability aquitards where groundwater velocities are low, and are minimized in the more

transmissive portions of the aquifer. Molecular diffusion into and out of the less permeable sediments will likely increase the time required to achieve groundwater restoration.

Mechanical dispersion is the mixing or dilution of contaminated water with clean water as contaminants flow through porous media at different rates and along different flow paths. The effects of mechanical dispersion vary depending primarily on the pore size, path lengths, and sorting of the aquifer materials. In general, the effects of mechanical dispersion are greatest in fine-grained materials because the contaminants move through more tortuous (and longer) pathways than they do in coarse-grained materials.

Mechanical dispersion primarily dilutes the leading edges of the contaminant plumes and contaminant concentrations in the body of the plume remain relatively unchanged as the aquifer becomes "saturated" with the contaminants. This may be a significant process on the fringes of contaminant plumes, or in plumes where contaminant concentrations are low, and where a small amount of dilution may reduce concentrations below levels of concern. Mechanical dispersion is probably more significant for perchlorate than for the solvents because perchlorate is not retarded and appears to disperse relatively uninhibited.

Evaluation of the off-site portions of the Layer C perchlorate plume may provide some in-sights on the effects of dispersion. The relatively high-concentration portion of this plume is primarily related to the GET F recharge wells, where perchlorate was recharged at average concentrations of approximately 8,000 µg/L. The 4,000µg/L contour shows the approximate distance over which perchlorate concentrations were reduced by ½ of their original concentrations in the aquifer when a continuing source of perchlorate existed. The western edge of the perchlorate plume (between the 4 and 4,000µg/L) contours is an area that has either attenuated due to dispersion, molecular diffusion, dilution, and possible biological breakdown.

Organic chemicals may be sorbed to organic carbon present in the aquifer. Sorption can impede both the migration rates of organic compounds and the time required for remediation of these compounds. The Study Area aquifer has a relatively low organic carbon content and sorption is probably not a significant factor. However, where organic materials are present, the chlorinated solvents will be most affected by sorption, followed by NDMA. Recent work conducted by EPA suggests that perchlorate sorption does occur and is dependent on soil pH and organic content (Susaria, et.al., 1999). The pH (around 7) and low

organic carbon content of the Study Area aquifer are not favorable for perchlorate sorption. There may be exceptions where clays or silts are present in the aquifer.

Volatilization is the transformation of a chemical from the aqueous to the vapor phase. Volatilization only occurs for chemicals with relatively high vapor pressures and low boiling points. Neither perchlorate nor NDMA are volatile under atmospheric conditions. TCE and the solvents may volatilize from the groundwater into the vadose zone. Vapor migration through the vadose zone and into the atmosphere or the foundations of structures is a potential concern. However, the combinations of depth to groundwater (generally over 100 feet), relatively low solvent concentrations observed off-site, and the vadose zone materials, suggest that volatilization from the vadose zone to the atmosphere is highly unlikely. Volatilization may gradually reduce solvent concentrations in groundwater; however, it is not anticipated to be a significant factor.

Biological degradation is a process that, under certain conditions, can reduce contaminant mass in groundwater. A substantial amount of recent research has been devoted to evaluating the biodegradation of chlorinated solvents. Chlorinated solvents can be biodegraded anaerobically in reducing groundwater conditions, and they can be biodegraded aerobically in the presence of a cometabolite (i.e., a carbon source). Both biodegradation processes have been documented at the Aerojet Site. However, the aerobic groundwater conditions present throughout most of the Study Area do not facilitate anaerobic biodegradation and there do not appear to be sufficient carbon sources to stimulate cometabolic biodegradation. An exception occurs at an off-site source of TCE northeast of Sunrise and Folsom Boulevards, where TCE, 1,2-DCE, and vinyl chloride have been observed in groundwater. Once the biodegradation sequence has reached vinyl chloride, it will degrade aerobically to ethene and then carbon dioxide.

Very little research is available documenting the natural biodegradability of perchlorate and NDMA. Aerojet has demonstrated that perchlorate is readily biodegradable in ex-situ bio-reactors, and has recently initiated bench- and pilot-scale testing to evaluate the potential for the in-situ biodegradation of perchlorate. Aerojet conducted some preliminary evaluations on the biodegradability of NDMA in the early 1980's; however, the results were inconclusive. The biodegradability potential for both perchlorate and NDMA will likely be studied in the future as these compounds become recognized at more locations. The in-situ biodegradation of some of the contaminants in the Study Area groundwater may eventually be possible in the future by enhancing naturally occurring processes. However, natural biodegradation

processes occurring today do not sufficiently reduce contaminant concentration or mass below levels of concern.

4.3 Summary of Contaminant Fate and Transport

Groundwater advection is the dominant process governing the fate and transport of the dissolved-phase contaminants in the Study Area groundwater. Relatively high groundwater velocities in the Study Area minimize the effects of dispersion and retardation, although the magnitude of these effects is not clearly understood. Mechanical dispersion appears to dilute the leading edges of the contaminant plumes; however concentrations in the body of the plumes are generally not reduced to below levels of concern. The primary contaminants in the Study Area appear to be chemically and biologically stable and will likely persist in the Study Area groundwater.

5.0 EXPOSURE PATHWAYS ANALYSIS

This section evaluates potential pathways through which human or ecological receptors may be exposed to Study Area contaminants. Figure A-38 shows current and potentially completed exposure pathways for the on- and off-site portions of the Study Area. Human and/or ecological exposure may occur through direct or indirect contact with contaminants prior to treatment, or exposure may occur after groundwater treatment if the treated water contains residual chemicals. Figure A-39 summarizes the results of the exposure pathway analysis.

There are no significant current or future potentially completed exposure pathways on the Aerojet Site (Figure A-39). The City of Folsom supplies potable and non-potable water to Aerojet and direct use of contaminated groundwater is not a current or potentially foreseeable future completed pathway. This potential pathway is also remote for future hypothetical workers on portions of the Aerojet Site that may be sold, as institutional controls (e.g., easements) will limit access to contaminated groundwater. Construction workers excavating on the Aerojet Site will not contact contaminated groundwater because the shallowest groundwater in the Study Area is present at depths (50 feet bgs), well below the construction zone (10 feet bgs). Soil gas samples collected from hundreds of locations across the Aerojet Site have shown that vapor diffusion from groundwater into the vadose zone is negligible in areas where there are no vadose zone source sites, and there are no impacts to indoor air. The potential pathway for industrial workers at GETs E/F is not complete because the treatment plant operates as a "closed system" and there is very limited potential for workers to contact the water.

There are several potentially complete off-site exposure pathways for contaminated and/or treated groundwater (Figure A-39). Groundwater beneath the Study Area is used as a source of potable and non-potable water and the pathway for human and/or ecological receptors is potentially complete. Aerojet, the water purveyors, and the DHS monitor the public and private water supply wells to ensure that chemical concentrations do not exceed acceptable levels. There are no known large-scale agricultural or other uses of groundwater that could result in a potentially significant completed exposure pathway for ecological receptors.

The discharge option(s) selected in the FS will complete one or more potential exposure pathways. Direct potable or non-potable re-use of treated groundwater at a central treatment plant or on an individual well could result in a significant completed pathway to residents and workers. Similarly, if treated groundwater is recharged into the aquifer and subsequently used as a drinking water source, this could result in a significant completed exposure pathway to residents and workers. While both of these pathways are potentially complete, stringent monitoring and adherence to treatment standards will be required, minimizing the potential for exposure to chemicals above levels of concern.

The discharge of treated groundwater to a surface water body could result in a completed pathway for residents and ecological receptors. Residential contact could occur during recreational activities on Buffalo Creek or in the American River, although these exposures are typically limited in duration. In addition, the pathway to various ecological receptors would be complete under a surface water discharge option. The acute and chronic toxicity testing required under the NPDES process would reduce the likelihood that this pathway would result in significant exposure to ecological receptors. In addition, there will be significant dilution of the treated groundwater in the American River, further reducing the likelihood that contaminant concentrations would exceed levels of concern.

5.0 SUMMARY AND CONCLUSIONS

Historical operations on the Aerojet Site have resulted in the release of contaminants to soil and groundwater. The on-site source areas for the CoPCs detected in the Study Area groundwater are primarily located east of the Study Area in the central and eastern portions of the Aerojet Site. VOCs (primarily TCE) and perchlorate have been detected in soil and groundwater beneath a number of these source areas. NDMA, which was known to exist at source areas on the east side of Aerojet, but not known to be present on the west side, was more recently detected in groundwater on the west side of the Aerojet Site.

On the western half of the Aerojet Site, groundwater flows generally to the west-southwest through a complex, heterogeneous aquifer. The aquifer has been subdivided into hydrostratigraphic Layers A through E based on similar lithologic and hydrogeologic properties. These hydrostratigraphic layers are generally tabular bodies that increase in depth and thickness from east to west across the Study Area. Contaminant concentrations in Layers A and B have been observed to decrease significantly within relatively short distances from the source areas. Conversely, contaminant concentrations east of GETs E and F, in underlying Layers C, D, and E, reach their maximum concentrations downgradient of the source areas, and then attenuate with increased distances. This observation, combined with vertical head differences observed from Layers A and B to Layers C, D, and E, suggest vertical groundwater flow is a significant component of contaminant migration in the upper layers. The hydrostratigraphic characteristics of Layers A and B change from east to west and these layers are either dry or not present west of the Aerojet Site.

Since the mid- to late-1980s, contaminants in groundwater flowing west from the source areas were intercepted by two interim perimeter GET facilities. GETs E and F captured and treated groundwater with VOCs at northwestern and southwestern locations along the perimeter of the Aerojet Site, respectively. A relatively small area of groundwater containing VOCs apparently was not captured by the existing GET F extraction wells south of GET F. A series of recharge wells installed in the center of the western perimeter provided a hydraulic barrier to direct contaminants toward the extraction wells. The recharge water was known to contain perchlorate that was not removed since a treatment standard or economic treatment technology had not been established. In early 1998 NDMA was detected at low levels in the water extracted and recharged at GET E using an improved analytical method. Treated groundwater from two of the GET F extraction wells was initially discharged after VOCs were removed

via a sprayfield located within the northwest corner of the IRCTS for a period of approximately 6 years. The treated groundwater discharged to the former sprayfield has percolated beneath the IRCTS and formed a plume of perchlorate-impacted groundwater flowing to the west-southwest. A biological reduction treatment system was added to GET F to remove perchlorate from groundwater in December 1998. In August 1999, the treatment systems at GETs E/F were combined and perchlorate, NDMA and VOC treatment are included in the treatment processes.

The recharge well field water has contributed to the perchlorate and NDMA plumes detected in the western offsite groundwater. The majority of perchlorate and NDMA is present in Layers C and D, although some upward and downward migration into Layers B and E, respectively, has occurred near the western perimeter of the Aerojet Site. The perchlorate in Layer C has been detected up to 9,000 feet west of the western Aerojet perimeter. An area of groundwater containing TCE and NDMA is present in Layers C and D northwest of the Aerojet Site. The TCE and NDMA in this area may have been present before GET E began operating, may represent uncaptured groundwater flowing north of GET E, or may be from offsite sources identified northeast of the intersection of Sunrise and Folsom Boulevards.

The chemicals detected in the Study Area groundwater are physically and chemically stable, and are unlikely to be reduced to concentrations below levels of concern by natural processes within an acceptable time frame. Advective flow is the dominant process affecting contaminant migration, although dispersion, retardation, and biological breakdown may selectively effect some of the contaminants.

There are no significant current or reasonably foreseeable completed exposure pathways on the Aerojet Site. However, off-site exposure pathways are potentially complete where groundwater is used for potable or non-potable use. In addition, the selection of a remedy in the FS may result in the completion of additional exposure pathways if the treated groundwater is directly consumed, recharged back into the aquifer, or discharged to a surface water body.

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TABLE A-1
SUMMARY OF DETECTS - VOC ANALYSES
LAYER A - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	1,1,2-TCA (ug/l)	1,1-DCE (ug/l)	1,2-DCA (ug/l)	1,2-DCE (ug/l)	Chloroform (ug/l)	PCE (ug/l)	TCE (ug/l)	Vinyl Chloride (ug/l)
10	03/19/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
22	03/23/1999	1.3	< 0.5	1.5	10	230	0.82	44	< 0.5
24	02/21/1997	< 5	< 5	< 5	< 5	8.1	< 5	13	< 10
75	05/23/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/23/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/12/1998	< 1	< 1	2.9	< 1	< 1	< 1	< 1	< 1
	03/19/1999	< 0.5	< 0.5	3.4	< 0.5	< 0.5	< 0.5	3	< 0.5
131	05/03/1996	12	< 1	950	2.3	4	< 1	40	< 1
	10/28/1996	6.1	< 1	500	2.8	3.3	< 1	42	< 1
	02/28/1997	< 1	< 1	260	2	2.8	< 1	47	< 1
	09/11/1997	< 2	< 2	530	3.1	3.6	< 2	70	< 2
	03/09/1998	5	< 1	120	2.8	5.4	< 1	68	< 1
307	03/19/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
355	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1203	02/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	9.8	< 1
	08/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	6.7	< 1
	12/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	6.2	< 1
	02/04/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.1	< 0.5
	05/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	6.8	< 1
	01/08/1998	< 1	< 1	< 1	< 1	< 1	< 1	3.6	< 1
	05/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	8.3	< 1
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3	< 0.5
1237	05/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/1996	< 1	< 1	< 1	< 1	< 1	< 1	8.6	< 1
	09/30/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3057	06/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/03/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3348	03/24/1999	< 0.5	< 0.5	480	2.8	< 0.5	< 0.5	82	< 0.5
3352	06/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/23/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3431	03/23/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

TABLE A-1
SUMMARY OF DETECTS - VOC ANALYSES
LAYER A - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	1,1,2-TCA (ug/l)	1,1-DCE (ug/l)	1,2-DCA (ug/l)	1,2-DCE (ug/l)	Chloroform (ug/l)	PCE (ug/l)	TCE (ug/l)	Vinyl Chloride (ug/l)
30062	11/20/1996	< 0.5	< 0.5	0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30063	11/20/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/13/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.65	46	< 0.5
30065	11/21/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	12/13/1996	< 1	2.6	2.9	98	< 1	1.1	400	28
	01/13/1997	< 0.5	4.8	< 0.5	90	< 0.5	0.78	310	29
	01/13/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 10
	04/24/1997	< 0.5	2.8	< 0.5	50	< 0.5	0.59	230	8.4
	07/16/1997	< 0.5	4.1	< 0.5	100	< 0.5	2.8	370	34
	10/31/1997	< 2.5	3.7	< 2.5	190	< 2.5	4.4	630	92
	07/08/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.6	< 0.5
	09/02/1998	< 0.5	7.4	< 0.5	200	< 0.5	1.3	320	110
	09/02/1998	< 0.5	8.7	< 0.5	200	< 0.5	1.4	340	120
	10/30/1998	< 0.5	9	< 0.5	210	< 0.5	1.4	320	130

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4007	01/09/1996	< 1	< 1	< 1	140	1.3	< 1	3	< 1	< 1	40
	02/07/1996	2.3	< 1	< 1	110	1.1	< 1	2.9	< 1	< 1	41
	03/05/1996	< 1	< 1	< 1	95	< 1	< 1	2.4	< 1	< 1	39
	04/02/1996	2.2	< 1	< 1	85	1	< 1	2.6	< 1	< 1	39
	05/07/1996	3.4	< 1	< 1	75	< 1	< 1	2.5	< 1	< 1	38
	06/05/1996	2.7	< 1	< 1	81	< 1	< 1	2.5	< 1	< 1	36
	07/01/1996	1.3	< 1	< 1	75	< 1	< 1	1.7	< 1	< 1	37
	08/07/1996	< 1	< 1	< 1	76	< 1	< 1	2.4	< 1	< 1	43
	09/10/1996	2.4	< 1	< 1	120	< 1	< 1	2.7	< 1	< 1	47
	10/05/1996	1.9	< 1	< 1	71	< 1	< 1	2.7	< 1	< 1	48
	11/02/1996	< 1	< 1	< 1	75	< 1	< 1	2.2	< 1	< 1	46
	12/01/1996	1.8	< 1	< 1	61	< 1	< 1	2.7	< 1	< 1	43
	01/04/1997	1.9	< 1	< 1	65	< 1	< 1	2.8	< 1	< 1	46
	02/01/1997	1.8	< 1	< 1	61	< 1	< 1	2.4	< 1	< 1	43
	04/26/1997	2.2	< 1	< 1	82	< 1	< 1	2.2	< 1	< 1	22
	05/04/1997	1.8	< 1	< 1	120	< 1	< 1	1.9	< 1	< 1	29
	06/01/1997	< 1	< 1	< 1	160	< 1	< 1	2.2	< 1	< 1	35
	07/06/1997	1.9	< 1	< 1	160	1.2	< 1	3	< 1	< 1	43
	08/02/1997	2.6	< 1	< 1	120	< 1	< 1	2.1	< 1	< 1	42
	09/12/1997	2.3	< 1	< 1	53	< 1	< 1	2	< 1	< 1	43
	10/12/1997	2	< 1	< 1	38	< 1	< 1	2	< 1	< 1	40
	11/02/1997	2	< 1	< 1	68	< 1	< 1	2	< 1	< 1	42
	01/24/1998	< 1	< 1	< 1	61	< 1	< 1	2.4	< 1	< 1	43
	04/20/1998	2	< 1	< 1	62	1	< 1	2.5	< 1	< 1	45
	07/26/1998	1.7	< 1	< 1	51	1.1	< 1	2.9	< 1	< 1	46
	10/18/1998	< 0.5	< 0.5	< 0.5	44	1.2	< 0.5	2.4	< 0.5	0.91	49
4060	01/09/1996	< 10	< 10	17	< 10	< 10	< 10	< 10	< 10	< 10	2000
	02/07/1996	< 10	< 10	19	< 10	< 10	< 10	< 10	< 10	< 10	2100
	03/05/1996	< 10	< 10	15	< 10	< 10	< 10	< 10	< 10	< 10	1900
	04/01/1996	< 5	< 5	24	< 5	11	< 5	10	< 5	< 5	2200
	04/02/1996	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	1900

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4060 (cont.)	05/06/1996	< 10	< 10	17	< 10	< 10	< 10	< 10	< 10	< 10	2300
	06/04/1996	< 10	< 10	15	< 10	< 10	< 10	< 10	< 10	< 10	2000
	07/01/1996	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	2000
	08/07/1996	< 10	< 10	16	< 10	< 10	< 10	10	< 10	< 10	2300
	09/10/1996	< 10	< 10	14	< 10	< 10	< 10	< 10	< 10	< 10	2500
	10/05/1996	< 10	< 10	23	< 10	< 10	< 10	11	< 10	< 10	2300
	10/08/1996	< 10	< 10	21	< 10	10	< 10	< 10	< 10	< 10	2500
	11/02/1996	< 10	< 10	22	< 10	< 10	< 10	12	< 10	< 10	2100
	12/01/1996	< 10	< 10	23	< 10	< 10	< 10	12	< 10	< 10	2100
	01/04/1997	< 10	< 10	21	< 10	< 10	< 10	11	< 10	< 10	2100
	02/01/1997	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	2100
	04/26/1997	< 10	< 10	24	< 10	10	< 10	< 10	< 10	< 10	4500
	04/28/1997	< 10	< 10	32	< 10	16	< 10	< 10	< 10	< 10	3700
	05/04/1997	< 10	< 10	20	< 10	< 10	< 10	12	< 10	< 10	4400
	06/01/1997	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	3600
	07/06/1997	< 10	< 10	32	< 10	11	< 10	17	< 10	< 10	2600
	08/02/1997	< 10	< 10	12	< 10	< 10	< 10	11	< 10	< 10	2400
	09/12/1997	< 10	< 10	19	< 10	< 10	< 10	11	< 10	< 10	1700
	10/09/1997	< 50	< 50	< 50	< 50	12	< 50	11	< 50	< 50	1800
	10/11/1997	< 10	< 10	21	< 10	< 10	< 10	12	< 10	< 10	2100
	11/02/1997	< 10	< 10	18	< 10	< 10	< 10	12	< 10	< 10	2200
	01/24/1998	< 10	< 10	11	< 10	< 10	< 10	< 10	< 10	< 10	1700
	04/14/1998	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	2000
	04/20/1998	< 10	< 10	14	< 10	< 10	< 10	11	< 10	< 10	2100
	07/25/1998	< 10	< 10	< 10	< 10	< 10	< 10	12	< 10	< 10	2000
	10/18/1998	< 0.5	< 0.5	17	< 0.5	10	< 0.5	17	< 0.5	0.79	420
	10/22/1998	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	2100
4070	01/08/1996	< 5	< 5	9.9	< 5	18	< 5	10	< 5	< 5	1400
	02/07/1996	< 5	< 5	8.3	< 5	16	< 5	9.9	< 5	< 5	1300
	03/05/1996	< 5	< 5	6.9	< 5	14	< 5	8.9	< 5	< 5	1200
	04/02/1996	< 5	< 5	< 5	< 5	13	< 5	8.2	< 5	< 5	1100

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4070 (cont.)	05/07/1996	< 5	< 5	6.1	< 5	14	< 5	9	< 5	< 5	1200
	06/05/1996	< 5	< 5	5.7	< 5	13	< 5	9.5	< 5	< 5	1000
	07/02/1996	< 5	< 5	6.3	< 5	16	< 5	9.8	< 5	< 5	1100
	08/07/1996	< 5	< 5	6.7	< 5	15	< 5	9	< 5	< 5	1200
	09/10/1996	< 5	< 5	6.7	< 5	14	< 5	8.2	< 5	< 5	1100
	10/12/1996	< 5	< 5	6	< 5	15	< 5	10	< 5	< 5	1200
	11/02/1996	< 5	< 5	13	< 5	15	< 5	13	< 5	< 5	1200
	12/01/1996	< 5	< 5	9.7	< 5	15	< 5	12	< 5	< 5	1200
	01/11/1997	< 5	< 5	< 5	< 5	14	< 5	13	< 5	< 5	1300
	02/01/1997	< 5	< 5	< 5	< 5	12	< 5	8.3	< 5	< 5	1100
	03/01/1997	< 5	< 5	5.1	6.3	13	< 5	7.8	< 5	< 5	1000
	04/05/1997	< 5	< 5	7.4	< 5	12	< 5	8.2	< 5	< 5	1000
	05/15/1997	< 5	< 5	< 5	< 5	11	< 5	< 5	< 5	< 5	1000
	06/01/1997	< 5	< 5	< 5	< 5	10	< 5	6.9	< 5	< 5	880
	07/06/1997	< 5	< 5	9.5	< 5	9.6	< 5	7.8	< 5	< 5	800
	08/02/1997	< 5	< 5	7.1	< 5	7.6	< 5	7	< 5	< 5	730
	09/12/1997	< 5	< 5	< 5	< 5	5.3	< 5	< 5	< 5	< 5	700
	10/12/1997	< 5	< 5	< 5	< 5	5.9	< 5	< 5	< 5	< 5	670
	11/01/1997	< 5	< 5	< 5	< 5	5.8	< 5	< 5	< 5	< 5	660
	01/05/1998	< 2	< 2	4.4	< 2	5	< 2	4.9	< 2	< 2	510
	04/20/1998	< 2	< 2	< 2	< 2	5	< 2	4.5	< 2	< 2	410
	08/10/1998	< 2	< 2	< 2	< 2	4.8	< 2	3.9	< 2	< 2	380
	10/18/1998	< 0.5	< 0.5	2.1	< 0.5	4.7	< 0.5	4.1	< 0.5	< 0.5	280
4075	01/08/1996	< 2	< 2	5.4	< 2	11	< 2	98	< 2	< 2	590
	02/07/1996	< 2	< 2	< 2	< 2	9.9	< 2	94	< 2	< 2	550
	03/05/1996	< 2	< 2	< 2	< 2	8.6	< 2	95	< 2	< 2	460
	04/02/1996	< 2	< 2	< 2	< 2	8.5	< 2	87	< 2	< 2	450
	05/07/1996	< 2	< 2	4	< 2	9.5	< 2	87	< 2	< 2	530
	06/05/1996	< 2	< 2	3.2	< 2	10	< 2	99	< 2	< 2	450
	07/02/1996	< 2	< 2	2.9	< 2	10	< 2	96	< 2	< 2	460
	08/07/1996	< 2	< 2	3.3	< 2	11	< 2	100	< 2	< 2	530

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4075 (cont.)	09/10/1996	< 2	< 2	3.1	< 2	10	< 2	100	< 2	< 2	480
	10/12/1996	< 2	< 2	5.6	< 2	11	< 2	89	< 2	< 2	550
	11/02/1996	< 2	< 2	5.8	< 2	11	< 2	110	< 2	< 2	550
	12/01/1996	< 2	< 2	5.5	< 2	10	< 2	111	< 2	< 2	570
	01/04/1997	< 2	< 2	4.5	< 2	9	< 2	93	< 2	< 2	490
	02/01/1997	< 2	< 2	< 2	< 2	8.7	< 2	110	< 2	< 2	440
	03/01/1997	< 2	< 2	< 2	< 2	8.8	< 2	110	< 2	< 2	430
	04/05/1997	< 2	< 2	4.1	< 2	8.9	< 2	110	< 2	< 2	410
	05/15/1997	< 2	< 2	3.1	< 2	13	< 2	150	< 2	< 2	550
	06/01/1997	< 2	< 2	3.4	< 2	9.8	< 2	130	< 2	< 2	350
	07/06/1997	< 2	< 2	3.2	3.2	8.6	< 2	110	< 2	< 2	330
	08/02/1997	< 2	< 2	2.8	< 2	8.2	< 2	110	< 2	< 2	310
	09/12/1997	< 1	< 1	< 1	< 1	7.6	< 1	110	< 1	< 1	250
	10/12/1997	< 1	< 1	1.6	1.8	8.5	< 1	110	< 1	< 1	260
	11/01/1997	< 1	< 1	< 1	< 1	7.8	< 1	120	< 1	< 1	270
	01/18/1998	< 1	< 1	< 1	< 1	7.7	< 1	120	< 1	< 1	240
	04/20/1998	< 1	< 1	1.7	2.4	7.3	< 1	130	< 1	< 1	240
	07/25/1998	< 1	< 1	< 1	< 1	8.8	< 1	140	< 1	< 1	220
	10/18/1998	< 0.5	< 0.5	1.2	0.77	8.6	< 0.5	110	< 0.5	< 0.5	230
4140	01/09/1996	< 20	< 20	< 20	67	37	< 20	910	< 20	< 20	5000
	02/07/1996	< 20	< 20	< 20	52	31	< 20	840	< 20	< 20	4800
	03/05/1996	< 20	< 20	< 20	81	27	< 20	870	< 20	< 20	4700
	04/02/1996	< 20	< 20	< 20	78	38	< 20	1100	< 20	< 20	5200
	05/07/1996	< 20	< 20	< 20	32	27	< 20	750	< 20	< 20	4500
	06/05/1996	< 20	< 20	< 20	72	47	< 20	1200	< 20	55	5000
	07/01/1996	< 20	< 20	< 20	60	37	< 20	920	< 20	23	4900
	08/07/1996	< 20	< 20	< 20	47	47	< 20	1200	< 20	< 20	5900
	09/12/1996	< 20	< 20	< 20	31	34	< 20	820	< 20	< 20	4800
	10/05/1996	< 20	< 20	22	28	34	< 20	740	< 20	< 20	4700
	11/02/1996	< 20	< 20	< 20	29	32	< 20	800	< 20	< 20	4500
	12/01/1996	< 20	< 20	< 20	34	26	< 20	720	< 20	< 20	4100

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4140	01/04/1997	< 20	< 20	< 20	32	29	< 20	740	< 20	< 20	4300
(cont.)	02/01/1997	< 20	< 20	< 20	< 20	35	< 20	950	< 20	25	5400
	04/26/1997	< 20	< 20	< 20	< 20	42	< 20	1100	< 20	< 20	5400
	05/04/1997	< 20	< 20	< 20	< 20	40	< 20	1100	< 20	< 20	6200
	06/01/1997	< 20	< 20	< 20	< 20	44	< 20	990	< 20	26	5200
	07/06/1997	< 20	< 20	< 20	< 20	38	< 20	940	< 20	27	5000
	08/02/1997	< 20	< 20	< 20	< 20	36	< 20	920	< 20	< 20	5300
	09/12/1997	< 20	< 20	< 20	< 20	24	< 20	580	< 20	< 20	4100
	10/12/1997	< 20	< 20	23	< 20	34	< 20	690	< 20	< 20	4700
	11/02/1997	< 20	< 20	< 20	< 20	37	< 20	810	< 20	< 20	5200
	01/24/1998	< 20	< 20	< 20	< 20	< 20	< 20	530	< 20	< 20	4300
	04/20/1998	< 20	< 20	< 20	< 20	27	< 20	570	< 20	< 20	4400
	07/25/1998	< 20	< 20	< 20	< 20	39	< 20	640	< 20	< 20	4800
	10/18/1998	< 0.5	1.2	20	1.3	33	1.4	280	< 0.5	6.7	5000
4145	01/09/1996	< 1	< 1	1.4	< 1	1.2	< 1	74	< 1	< 1	230
	02/07/1996	< 1	< 1	1.4	< 1	1.1	< 1	79	< 1	< 1	240
	03/05/1996	< 1	< 1	1.1	< 1	< 1	< 1	69	< 1	< 1	200
	04/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	69	< 1	< 1	210
	05/07/1996	< 1	< 1	< 1	1.5	< 1	< 1	70	< 1	< 1	180
	06/05/1996	< 1	< 1	< 1	1.7	< 1	< 1	82	< 1	< 1	180
	07/01/1996	< 1	< 1	< 1	< 1	1.1	< 1	74	< 1	1.4	200
	08/07/1996	< 1	< 1	< 1	< 1	1.1	< 1	77	< 1	< 1	190
	09/12/1996	< 1	< 1	< 1	< 1	1.2	< 1	86	< 1	< 1	210
	10/05/1996	< 1	< 1	1.3	< 1	1.3	< 1	80	< 1	< 1	220
	11/02/1996	< 1	< 1	1.4	< 1	1	< 1	81	< 1	< 1	200
	12/01/1996	< 1	< 1	1.5	2.4	1.2	< 1	93	< 1	< 1	240
	01/04/1997	< 1	< 1	1.3	2.2	< 1	< 1	79	< 1	< 1	190
	02/01/1997	< 1	< 1	< 1	< 1	< 1	< 1	85	< 1	< 1	210
	04/26/1997	< 1	< 1	< 1	1.3	< 1	< 1	62	< 1	< 1	120
	05/04/1997	< 1	< 1	< 1	1.4	1.1	< 1	94	< 1	< 1	240
	06/01/1997	< 1	< 1	< 1	2	1.1	< 1	96	< 1	< 1	210

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4200 (cont.)	07/06/1997	< 1	< 1	2.1	3.3	1.8	< 1	120	< 1	< 1	240
	08/02/1997	< 1	< 1	1.9	1.6	1.4	< 1	100	< 1	< 1	240
	09/12/1997	< 1	< 1	1.2	< 1	1.5	< 1	100	< 1	< 1	230
	10/12/1997	< 1	< 1	< 1	< 1	1.1	< 1	95	< 1	< 1	230
	11/02/1997	< 1	< 1	< 1	1.7	1	< 1	94	< 1	< 1	230
	01/24/1998	< 1	< 1	< 1	< 1	< 1	< 1	95	< 1	< 1	260
	04/20/1998	< 1	< 1	< 1	< 1	1.5	< 1	100	< 1	< 1	230
	07/26/1998	< 1	< 1	< 1	< 1	1.3	< 1	89	< 1	< 1	210
	10/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	1.8	< 0.5	90	< 0.5	< 0.5	240
4200	01/08/1996	< 1	< 1	2.7	1.5	3.6	< 1	1.3	< 1	< 1	290
	02/07/1996	< 1	< 1	2.8	< 1	3.1	< 1	1.4	1.4	< 1	280
	03/05/1996	< 1	< 1	1.4	< 1	3.2	< 1	1.1	2.2	1.2	220
	04/02/1996	< 1	< 1	2.4	< 1	3.2	< 1	1.4	1.5	< 1	260
	05/29/1996	< 1	< 1	2.2	< 1	3.6	< 1	1.9	2.4	< 1	230
	06/05/1996	< 1	< 1	2.2	< 1	3.7	< 1	1.7	2.7	< 1	220
	07/01/1996	< 1	< 1	1.8	< 1	3.4	< 1	1.5	2.3	1.3	230
	08/07/1996	< 1	< 1	1.9	< 1	3.3	< 1	1.4	1.8	< 1	250
	09/10/1996	< 1	< 1	1.8	< 1	3.6	< 1	1.4	1.9	1.1	240
	10/12/1996	< 1	< 1	2.8	< 1	3.8	< 1	1.9	1.9	< 1	290
	11/02/1996	< 1	< 1	2.9	< 1	3.4	< 1	2.1	1.8	< 1	260
	12/01/1996	< 1	< 1	2.7	< 1	3.3	< 1	2.1	1.5	< 1	270
	01/04/1997	< 1	< 1	1.7	< 1	2.9	< 1	1.8	1	< 1	230
	02/01/1997	< 1	< 1	< 1	< 1	2.7	< 1	1.1	2	< 1	200
	03/01/1997	< 1	< 1	1.9	< 1	2.4	< 1	1.5	1.7	< 1	200
	04/05/1997	< 1	< 1	2	< 1	2.1	< 1	1.2	1.5	< 1	160
	05/15/1997	< 1	< 1	< 1	< 1	2.1	< 1	< 1	1.2	< 1	150
	06/01/1997	< 1	< 1	< 1	1.5	1.6	< 1	< 1	< 1	< 1	130
	07/06/1997	< 1	< 1	2	< 1	2.4	< 1	1.8	1.9	< 1	140
	08/02/1997	< 1	< 1	1.3	< 1	1.6	< 1	1.1	1.3	< 1	120
	09/12/1997	< 1	< 1	< 1	< 1	1.5	< 1	1.1	1.2	< 1	110
	10/12/1997	< 1	< 1	< 1	< 1	1.5	< 1	< 1	1.9	1.1	110

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4200 (cont.)	11/02/1997	< 1	< 1	1.1	< 1	1.6	< 1	< 1	1.3	< 1	120
	01/18/1998	< 1	< 1	< 1	< 1	1.7	< 1	1.1	2	< 1	110
	04/20/1998	< 1	< 1	< 1	< 1	1.3	< 1	< 1	1.3	< 1	90
	07/25/1998	< 1	1.2	< 1	< 1	1.6	< 1	< 1	1.5	< 1	93
	10/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	1.7	< 0.5	< 0.5	< 0.5	0.56	100
4310	01/09/1996	< 10	< 10	< 10	1400	< 10	< 10	< 10	< 10	< 10	68
	03/05/1996	< 5	< 5	< 5	1100	< 5	< 5	< 5	< 5	< 5	84
	04/02/1996	< 5	< 5	< 5	1100	< 5	< 5	< 5	< 5	< 5	85
	05/07/1996	< 5	< 5	< 5	840	< 5	< 5	< 5	< 5	< 5	83
	06/26/1996	< 5	< 5	< 5	930	< 5	< 5	75	< 5	< 5	55
	07/01/1996	< 5	< 5	< 5	1100	< 5	< 5	< 5	< 5	< 5	63
	08/07/1996	< 5	< 5	< 5	890	< 5	< 5	< 5	< 5	< 5	71
	09/10/1996	< 2	< 2	< 2	370	2.7	< 2	3.9	< 2	< 2	66
	10/05/1996	< 5	< 5	< 5	690	< 5	< 5	< 5	< 5	< 5	52
	11/02/1996	< 5	< 5	< 5	1400	< 5	< 5	7.2	< 5	< 5	72
	12/01/1996	< 5	< 5	< 5	1200	< 5	< 5	6.3	< 5	< 5	68
	01/04/1997	< 5	< 5	< 5	850	< 5	< 5	6	< 5	< 5	64
	02/01/1997	< 5	< 5	< 5	640	< 5	< 5	< 5	< 5	< 5	69
	04/26/1997	< 5	< 5	< 5	850	< 5	< 5	< 5	< 5	< 5	64
	05/04/1997	< 5	< 5	< 5	820	< 5	< 5	< 5	< 5	< 5	62
	06/01/1997	< 5	< 5	< 5	710	< 5	< 5	< 5	< 5	< 5	60
	07/06/1997	< 5	< 5	< 5	650	< 5	< 5	5.6	< 5	< 5	60
	08/02/1997	< 5	< 5	< 5	610	< 5	< 5	< 5	< 5	< 5	58
	09/12/1997	< 5	< 5	< 5	240	< 5	< 5	< 5	< 5	< 5	51
	10/10/1997	1.6	< 1	< 1	38	2.3	< 1	2.4	< 1	< 1	49
	11/07/1997	< 1	< 1	< 1	160	2.7	< 1	2.9	< 1	< 1	48
4315	01/09/1996	< 20	< 20	< 20	31	47	< 20	600	< 20	< 20	5300
	02/07/1996	< 20	< 20	< 20	< 20	45	< 20	540	< 20	< 20	5300
	03/05/1996	< 20	< 20	< 20	< 20	43	< 20	510	< 20	< 20	5100
	04/02/1996	< 20	< 20	< 20	31	60	< 20	740	< 20	< 20	5500
	05/07/1996	< 20	< 20	< 20	29	67	< 20	820	< 20	< 20	5700

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4315	06/05/1996	< 20	< 20	< 20	35	73	< 20	800	< 20	< 20	5600
(cont.)	07/01/1996	< 20	< 20	< 20	< 20	73	< 20	800	< 20	24	6000
	08/07/1996	< 50	< 50	< 50	< 50	51	< 50	620	< 50	< 50	6300
	09/10/1996	< 20	< 20	< 20	40	76	< 20	740	45	51	5500
	10/05/1996	< 20	< 20	< 20	< 20	53	< 20	520	< 20	< 20	5200
	11/02/1996	< 20	< 20	< 20	25	49	< 20	570	< 20	< 20	5000
	12/01/1996	< 20	< 20	< 20	22	46	< 20	530	< 20	< 20	4900
	01/04/1997	< 20	< 20	< 20	30	42	< 20	480	< 20	< 20	4600
	02/01/1997	< 20	< 20	< 20	49	61	< 20	620	< 20	28	6000
	04/26/1997	< 20	< 20	< 20	72	54	< 20	760	< 20	22	5600
	05/04/1997	< 20	< 20	< 20	< 20	61	< 20	710	< 20	49	5800
	06/01/1997	< 20	< 20	< 20	< 20	63	< 20	650	< 20	57	5500
	07/06/1997	< 20	< 20	< 20	< 20	70	< 20	690	< 20	< 20	5800
	08/02/1997	< 50	< 50	< 50	< 50	< 50	< 50	500	< 50	50	6200
	09/12/1997	< 50	< 50	< 50	< 50	< 50	< 50	460	< 50	< 50	6400
	10/12/1997	< 20	< 20	< 20	< 20	65	< 20	610	< 20	< 20	5600
	11/02/1997	< 50	< 50	< 50	< 50	< 50	< 50	440	< 50	< 50	6000
	01/24/1998	< 20	< 20	< 20	< 20	24	< 20	440	< 20	< 20	5400
	04/20/1998	< 20	< 20	< 20	26	61	< 20	550	< 20	< 20	5100
	07/26/1998	< 20	< 20	< 20	< 20	69	< 20	550	< 20	24	5200
	10/18/1998	4.9	< 1	13	10	66	< 1	420	< 1	10	840
4425	01/18/1997	< 1	< 1	11	< 1	28	< 1	13	6.8	2.6	1900
	02/01/1997	< 10	< 10	< 10	< 10	14	< 10	< 10	< 10	< 10	1500
	03/01/1997	< 5	< 5	5	< 5	16	< 5	8.8	< 5	< 5	1200
	04/05/1997	< 5	< 5	11	< 5	20	< 5	12	< 5	< 5	1300
	05/15/1997	< 5	< 5	< 5	< 5	16	< 5	8.7	< 5	< 5	1200
	06/01/1997	< 5	< 5	< 5	< 5	12	< 5	6.7	< 5	< 5	1000
	07/06/1997	< 5	< 5	11	< 5	15	< 5	9.5	< 5	< 5	1100
	08/02/1997	< 5	< 5	11	< 5	14	< 5	8.9	< 5	< 5	1100
	09/12/1997	< 5	< 5	8.3	< 5	15	< 5	9.7	< 5	< 5	1100
	10/12/1997	< 5	< 5	< 5	< 5	12	< 5	6.9	< 5	< 5	1100

TABLE A-2
SUMMARY OF DETECTS - VOC ANALYSES
GET E AND F EXTRACTION WELLS - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
4425 (cont.)	11/02/1997	< 5	< 5	6.1	< 5	15	< 5	10	< 5	< 5	1300
	01/18/1998	< 5	< 5	< 5	< 5	13	< 5	7.2	< 5	2.6	1100
	04/20/1998	< 5	< 5	6.9	< 5	12	< 5	8.5	< 5	< 5	1000
	07/25/1998	< 5	< 5	< 5	< 5	17	< 5	9.1	< 5	< 5	1100
	10/18/1998	< 0.5	< 0.5	6.3	< 0.5	18	< 0.5	10	4.8	3.1	420
4435	01/18/1997	< 1	< 1	7.4	6.8	28	< 1	74	7.8	2.3	1600
	02/01/1997	< 10	< 10	< 10	< 10	18	< 10	93	< 10	< 10	1600
	03/01/1997	< 10	< 10	< 10	< 10	17	< 10	87	< 10	< 10	1600
	04/05/1997	< 10	< 10	13	< 10	23	< 10	85	< 10	< 10	1700
	05/15/1997	< 10	< 10	< 10	< 10	19	< 10	80	< 10	< 10	1600
	06/01/1997	< 10	< 10	< 10	< 10	21	< 10	80	< 10	< 10	1600
	07/06/1997	< 10	< 10	11	< 10	21	< 10	78	< 10	< 10	1300
	08/02/1997	< 10	< 10	11	< 10	23	< 10	83	< 10	< 10	1500
	09/12/1997	< 10	< 10	< 10	< 10	16	< 10	66	< 10	< 10	1100
	10/12/1997	< 5	< 5	13	< 5	22	< 5	89	< 5	< 5	1200
	11/01/1997	< 5	< 5	< 5	< 5	18	< 5	75	< 5	< 5	1300
	01/18/1998	< 5	< 5	5.2	< 5	12	< 5	78	< 5	< 5	1100
	04/20/1998	< 5	< 5	5.7	< 5	14	< 5	86	< 5	< 5	1000
	08/10/1998	< 5	< 5	< 5	< 5	16	< 5	93	< 5	< 5	1000
	10/18/1998	< 0.5	< 0.5	5.6	4.9	20	< 0.5	83	< 0.5	2	410

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1011 (AC1)	01/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	01/14/1997	-	-	-	-	-	16
	01/27/1997	< 0.5	< 0.5	0.69	< 0.5	-	-
	02/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	04/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/11/1997	< 0.5	< 0.5	0.63	< 0.5	-	-
	07/09/1997	< 0.5	< 0.5	0.52	< 0.5	-	-
	08/13/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	09/10/1997	< 0.5	< 0.5	0.5	< 0.5	-	-
	10/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	11/12/1997	< 0.5	< 0.5	1.6	< 0.5	-	10
	12/11/1997	< 0.5	< 0.5	1.7	< 0.5	-	< 4
	02/11/1998	< 0.5	< 0.5	1.8	< 0.5	-	-
	03/04/1998	< 0.5	< 0.5	1.6	< 0.5	< 0.033	< 4
	03/20/1998	-	-	-	-	< 0.033	-
	04/14/1998	< 0.5	< 0.5	0.59	0.68	< 0.033	-
	05/13/1998	< 0.5	< 0.5	0.99	< 0.5	< 0.033	-
	06/10/1998	< 0.5	< 0.5	1.3	0.67	< 0.0075	< 4
	07/08/1998	< 0.5	< 0.5	1.2	1.1	< 0.0075	< 4
	07/08/1998	-	-	-	-	-	< 4
	08/19/1998	< 0.5	< 0.5	0.69	< 0.5	< 0.0075	4.3
	08/26/1998	-	-	-	-	-	< 4
	08/28/1998	-	-	-	-	-	< 4
	09/01/1998	-	-	-	-	-	< 4
	09/03/1998	-	-	-	-	-	< 4
	09/09/1998	-	-	-	-	-	< 4
	09/10/1998	-	-	-	-	-	< 4
	09/16/1998	< 0.5	< 0.5	2	0.88	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	< 4
	11/18/1998	< 0.5	< 0.5	2	0.99	< 0.0075	< 4
	12/09/1998	< 0.5	< 0.5	1.8	< 0.5	< 0.0075	-
	01/13/1999	< 0.5	< 0.5	2.1	1.2	< 0.0075	-
	02/12/1999	< 0.5	< 0.5	1.3	0.71	< 0.0075	-
	03/10/1999	< 0.5	< 0.5	1.7	0.82	< 0.0075	-
	04/14/1999	< 0.5	< 0.5	2	1.6	< 0.0075	-
	05/19/1999	< 0.5	< 0.5	1.7	0.96	< 0.0075	-
	06/16/1999	< 0.5	< 0.5	< 0.5	1.1	< 0.0075	-
	07/14/1999	< 0.5	< 0.5	0.55	1	-	-
	08/18/1999	< 0.5	< 0.5	< 0.5	0.96	-	-
	09/24/1999	< 0.5	< 0.5	0.73	1	-	5.6

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1012 (AC5)	04/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/04/1998	-	-	-	-	-	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	0.59	< 0.0075	< 4
	01/13/1999	< 0.5	< 0.5	< 0.5	1.3	-	-
	01/14/1999	< 0.5	< 0.5	< 0.5	1.3	-	-
	01/20/1999	< 0.5	< 0.5	< 0.5	1.4	-	-
	01/21/1999	< 0.5	< 0.5	< 0.5	1.3	-	-
	01/27/1999	< 0.5	< 0.5	< 0.5	1.5	-	-
	01/28/1999	< 0.5	< 0.5	< 0.5	1.5	-	-
	02/12/1999	< 0.5	< 0.5	< 0.5	0.55	-	-
	03/10/1999	< 0.5	< 0.5	< 0.5	0.62	< 0.0075	< 4
	04/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	07/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	08/18/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	09/28/1999	< 0.5	< 0.5	< 0.5	1	-	-
1014 (AC13)	01/27/1997	< 0.5	0.64	< 0.5	26	-	-
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	300
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	320
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	0.79	< 0.5	97	< 0.0075	350
1015 (AC15)	01/27/1997	< 0.5	< 0.5	< 0.5	9.7	-	-
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	140
	08/19/1998	-	-	-	-	< 0.0075	-
	08/27/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	140
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	18	< 0.0075	150

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1016	01/27/1997	< 0.5	< 0.5	< 0.5	17	-	-
(AC16)	03/24/1998	-	-	-	-	0.21	-
	04/14/1998	-	-	-	-	0.22	-
	05/13/1998	-	-	-	-	0.19	-
	06/10/1998	-	-	-	-	0.19	310
	07/08/1998	-	-	-	-	0.16	-
	08/19/1998	-	-	-	-	0.19	-
	09/16/1998	-	-	-	-	0.17	340
	10/15/1998	-	-	-	-	0.17	-
	11/18/1998	-	-	-	-	0.18	-
	12/09/1998	< 0.5	< 0.5	< 0.5	13	0.18	410
1017	01/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(Mitchell)	02/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	08/13/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	11/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	02/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/19/1998	-	-	-	-	-	5.6
	08/20/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	11/19/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/11/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	06/18/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/23/1999	< 0.5	< 0.5	< 0.5	1.1	-	11
1018	03/03/1998	-	-	-	-	-	< 4
(CUCC 27)	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	03/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	06/17/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1026	01/27/1997	< 0.5	1	< 0.5	0.84	-	-
(Private)	06/05/1998	-	-	-	-	< 0.0075	-
1030	01/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(SWMD 17)	02/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/14/1997	< 0.5	1.6	< 0.5	< 0.5	-	-
	08/13/1997	< 0.5	24	< 0.5	< 0.5	-	-
	04/23/1998	-	-	-	-	< 0.033	18
	06/25/1998	< 1	< 1	< 1	< 1	0.0081	18
	01/22/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	18
1033	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
(CUCC 40)	03/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	06/17/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	-	-	-	-	-	< 4

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1036 (Lonestar)	01/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	04/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	10/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	01/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	10/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	5.3
	01/13/1999	-	-	-	-	-	9.3
	01/14/1999	-	-	-	-	-	6.9
	01/20/1999	-	-	-	-	-	< 4
	01/21/1999	-	-	-	-	-	4
	01/27/1999	-	-	-	-	-	4.4
	01/28/1999	-	-	-	-	-	5
	02/11/1999	-	-	-	-	-	5.9
	03/11/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	04/14/1999	-	-	-	-	-	< 4
	06/18/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	5
	07/14/1999	-	-	-	-	-	< 4
	08/18/1999	-	-	-	-	-	< 4
	09/23/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1037 (Private)	01/27/1997	< 0.5	< 0.5	< 0.5	1.7	-	-
	06/05/1998	-	-	-	-	< 0.0075	-
	12/15/1998	< 0.5	< 0.5	< 0.5	3.8	< 0.0075	< 4
	01/13/1999	< 1.3	< 1.3	< 1.3	3.9	-	-
	01/14/1999	< 1.3	< 1.3	< 1.3	4	-	-
	01/20/1999	< 0.5	< 0.5	< 0.5	4.4	-	-
	01/21/1999	< 0.5	< 0.5	< 0.5	4.5	-	-
	01/27/1999	< 0.5	< 0.5	< 0.5	4.6	-	-
	01/28/1999	< 0.5	< 0.5	< 0.5	4.3	-	-
	02/11/1999	< 0.5	< 0.5	< 0.5	4.7	-	-
	03/11/1999	< 0.5	< 0.5	< 0.5	2.3	< 0.0075	< 4
	04/14/1999	< 0.5	< 0.5	< 0.5	3.6	-	-
	05/19/1999	< 0.5	< 0.5	< 0.5	1.8	-	-
	06/18/1999	< 0.5	< 0.5	< 0.5	0.61	< 0.0075	7.4
	06/29/1999	-	-	-	-	-	6.1
	07/14/1999	< 0.5	< 0.5	< 0.5	0.97	-	-
	08/18/1999	< 0.5	< 0.5	< 0.5	3.1	-	-
	09/23/1999	< 0.5	< 0.5	< 0.5	1.1	-	5.6

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1134	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC3)	03/04/1998	-	-	-	-	-	< 4
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	07/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1135	05/14/1997	< 0.5	< 0.5	< 0.5	1.5	-	-
(AC4)	03/04/1998	-	-	-	-	-	< 4
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	0.69	< 0.0075	< 4
	01/13/1999	< 0.5	1.1	< 0.5	2	-	-
	01/14/1999	< 0.5	1.1	< 0.5	2.1	-	-
	01/20/1999	< 0.5	1.1	< 0.5	2.3	-	-
	01/21/1999	< 0.5	1	< 0.5	2.3	-	-
	01/27/1999	< 0.5	1.2	< 0.5	2.3	-	-
	01/28/1999	< 0.5	1.1	< 0.5	2.2	-	-
	02/12/1999	< 0.5	0.54	0.59	1.7	-	-
	03/10/1999	< 0.5	0.51	< 0.5	1.5	-	-
	03/23/1999	< 0.5	1.1	< 0.5	2.2	-	-
	03/25/1999	< 0.5	0.95	< 0.5	2.2	-	-
	03/31/1999	< 0.5	0.94	< 0.5	2.1	-	-
	04/01/1999	< 0.5	0.95	< 0.5	2.2	-	-
	04/06/1999	< 0.5	1.1	< 0.5	2.1	-	-
	04/08/1999	< 0.5	1	< 0.5	2.1	-	-
	04/14/1999	< 0.5	< 0.5	< 0.5	2	-	-
	05/19/1999	< 0.5	< 0.5	< 0.5	1.6	-	-
	06/16/1999	< 0.5	< 0.5	< 0.5	1.5	-	-
	07/14/1999	< 0.5	< 0.5	< 0.5	1.5	-	< 4
	08/18/1999	< 0.5	< 0.5	< 0.5	1.3	-	-

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1136	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC6)	03/04/1998	-	-	-	-	-	< 4
	03/23/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/14/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	15
	03/31/1999	-	-	-	-	-	< 4
	04/01/1999	-	-	-	-	-	< 4
	04/06/1999	-	-	-	-	-	< 4
	04/08/1999	-	-	-	-	-	< 4
	04/13/1999	-	-	-	-	-	< 4
	04/15/1999	-	-	-	-	-	< 4
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1137	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC7)	03/04/1998	-	-	-	-	-	< 4
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/20/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/10/1999	< 0.5	< 0.5	0.5	< 0.5	< 0.0075	< 4
	05/04/1999	< 0.5	< 0.5	0.66	< 0.5	-	-
	05/06/1999	< 0.5	< 0.5	0.58	< 0.5	-	-
	05/11/1999	< 0.5	< 0.5	0.64	< 0.5	-	-
	05/13/1999	< 0.5	< 0.5	0.66	< 0.5	-	-
	05/18/1999	< 0.5	< 0.5	0.66	< 0.5	-	-
	05/20/1999	< 0.5	< 0.5	0.66	< 0.5	-	-
	06/16/1999	< 0.5	< 0.5	0.53	< 0.5	< 0.0075	< 4
	07/14/1999	< 0.5	< 0.5	0.65	< 0.5	-	-
	08/18/1999	< 0.5	< 0.5	0.68	< 0.5	-	-
	09/28/1999	< 0.5	< 0.5	0.69	< 0.5	-	-

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1138	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC8)	03/04/1998	-	-	-	-	-	< 4
	03/24/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	07/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1139	03/04/1998	-	-	-	-	-	< 4
(AC10)	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/14/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	01/13/1999	-	-	-	-	< 0.0075	-
	02/12/1999	-	-	-	-	< 0.0075	-
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	04/14/1999	-	-	-	-	< 0.0075	-
	05/19/1999	-	-	-	-	< 0.0075	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1140	01/08/1997	< 0.5	< 0.5	< 0.5	1.6	-	-
(AC11)	02/12/1997	< 0.5	< 0.5	< 0.5	1.5	-	-
	03/12/1997	< 0.5	< 0.5	< 0.5	1.4	-	-
	04/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/11/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/09/1997	< 0.5	0.54	< 0.5	1.5	-	-
	08/13/1997	< 0.5	< 0.5	< 0.5	1.2	-	-
	09/10/1997	< 0.5	< 0.5	< 0.5	1.6	-	-
	10/08/1997	< 0.5	0.7	< 0.5	< 0.5	-	< 4
	11/12/1997	< 0.5	< 0.5	< 0.5	0.95	-	-
	12/11/1997	< 0.5	< 0.5	< 0.5	1.3	-	4.7
	01/14/1998	< 0.5	< 0.5	< 0.5	0.65	-	5.8
	02/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/03/1998	< 0.5	< 0.5	< 0.5	1.2	0.15	< 4
	03/05/1998	-	-	-	-	< 0.033	-

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1140 (cont.) (AC11)	03/13/1998	-	-	-	-	0.13	-
	03/13/1998	-	-	-	-	0.14	-
	03/20/1998	-	-	-	-	< 0.033	-
	03/20/1998	-	-	-	-	0.072	-
	03/30/1998	-	-	-	-	0.055	-
	04/14/1998	< 0.5	< 0.5	< 0.5	0.89	0.057	-
	05/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	0.043	-
	06/10/1998	< 0.5	< 0.5	< 0.5	< 0.5	0.038	< 4
	07/08/1998	< 0.5	< 0.5	< 0.5	0.61	0.034	< 4
	08/20/1998	< 0.5	< 0.5	< 0.5	0.89	0.039	< 4
	08/27/1998	-	-	-	-	0.03	-
	08/28/1998	-	-	-	-	0.039	-
	09/01/1998	-	-	-	-	0.034	-
	09/03/1998	-	-	-	-	0.029	-
	09/09/1998	-	-	-	-	0.037	-
	09/10/1998	-	-	-	-	0.044	-
	09/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	10/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	11/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	0.024	< 4
	01/13/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	01/20/1999	< 0.5	< 0.5	< 0.5	< 0.5	0.03	-
	02/12/1999	< 0.5	< 0.5	0.55	0.51	0.019	-
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	0.011	-
	03/23/1999	< 0.5	0.68	< 0.5	< 0.5	-	-
	03/25/1999	< 0.5	0.6	< 0.5	< 0.5	-	-
	03/31/1999	< 0.5	0.6	< 0.5	< 0.5	-	-
	04/01/1999	< 0.5	0.58	< 0.5	< 0.5	-	-
	04/06/1999	< 0.5	0.57	< 0.5	< 0.5	-	-
	04/08/1999	< 0.5	0.72	< 0.5	< 0.5	-	-
	04/14/1999	< 0.5	< 0.5	< 0.5	0.55	0.015	-
	05/19/1999	-	-	-	-	0.014	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	0.012	-
	07/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	08/18/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	08/26/1999	-	-	-	-	0.017	-
1141 (AC12)	05/14/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
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Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1142 (AC14)	01/08/1997	< 0.5	< 0.5	< 0.5	0.67	-	-
	02/12/1997	< 0.5	< 0.5	< 0.5	1.1	-	-
	03/12/1997	< 0.5	< 0.5	< 0.5	1.3	-	-
	04/09/1997	< 0.5	< 0.5	< 0.5	1.8	-	-
	05/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/03/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/11/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/09/1997	< 0.5	< 0.5	< 0.5	1.2	-	-
	08/04/1997	< 0.5	< 0.5	< 0.5	0.91	-	-
	09/10/1997	< 0.5	< 0.5	< 0.5	1.4	-	-
	10/08/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	11
	11/12/1997	< 0.5	< 0.5	< 0.5	0.67	-	-
	12/11/1997	< 0.5	< 0.5	< 0.5	0.77	-	4.6
	01/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	5.9
	02/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/03/1998	< 0.5	< 0.5	< 0.5	1.7	< 0.1	4.4
	03/05/1998	-	-	-	-	0.025	-
	03/20/1998	-	-	-	-	0.051	-
	03/30/1998	-	-	-	-	< 0.033	-
	03/30/1998	-	-	-	-	< 0.033	-
	04/14/1998	0.53	< 0.5	< 0.5	< 0.5	< 0.033	-
	04/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/05/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/07/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.033	-
	05/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	05/19/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/10/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	7.1
	07/08/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	7.8
	08/19/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	9.6
	08/27/1998	-	-	-	-	-	8.6
	08/28/1998	-	-	-	-	-	9.5
	09/01/1998	-	-	-	-	-	9.4
	09/03/1998	-	-	-	-	-	8.4
	09/09/1998	-	-	-	-	-	8.3
	09/10/1998	-	-	-	-	-	6.2
	09/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	8.2
	10/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	8
	11/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	7.7
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	8.6
	01/13/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-
	02/12/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-
	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-
	04/14/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-
	05/19/1999	-	-	-	-	< 0.0075	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	-

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1144 (CUCC 32)	03/03/1998	-	-	-	-	-	< 4
	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	07/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1148 (CUCC 31)	03/03/1998	-	-	-	-	-	< 4
	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
1149 (CUCC 26)	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	06/17/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1150 (CUCC 38)	03/03/1998	-	-	-	-	-	< 4
	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	07/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1151 (CUCC 24)	03/03/1998	-	-	-	-	-	< 4
	06/12/1998	-	-	-	-	-	< 4
	09/17/1998	-	-	-	-	-	< 4
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	03/15/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	06/17/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
1800 (MAFB 1)	03/24/1998	-	-	-	-	< 0.033	-
	04/23/1998	-	-	-	-	< 0.033	-
	05/28/1998	-	-	-	-	< 0.0075	-
	07/30/1998	-	-	-	-	< 0.0075	-
	08/27/1998	-	-	-	-	< 0.0075	-
	09/22/1998	-	-	-	-	< 0.0075	20
	10/14/1998	-	-	-	-	< 0.0075	17
	11/17/1998	-	-	-	-	< 0.0075	16
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	17
	01/11/1999	-	-	-	-	-	16
	02/17/1999	-	-	-	-	-	15
	03/18/1999	-	-	-	-	< 0.0075	13
	04/27/1999	-	-	-	-	-	14
	05/25/1999	-	-	-	-	-	13
	06/24/1999	-	-	-	-	< 0.0075	24
	07/28/1999	-	-	-	-	-	26
	08/25/1999	-	-	-	-	-	22

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
1801 (MAFB 2)	03/24/1998	-	-	-	-	< 0.033	-
	04/23/1998	-	-	-	-	< 0.033	-
	05/28/1998	-	-	-	-	< 0.0075	-
	07/30/1998	-	-	-	-	< 0.0075	-
	08/27/1998	-	-	-	-	< 0.0075	-
	09/22/1998	-	-	-	-	< 0.0075	< 4
	10/14/1998	-	-	-	-	< 0.0075	< 4
	11/17/1998	-	-	-	-	< 0.0075	< 4
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	01/11/1999	-	-	-	-	-	< 4
	02/17/1999	-	-	-	-	-	< 4
	03/18/1999	-	-	-	-	< 0.0075	< 4
	04/27/1999	-	-	-	-	-	< 4
	05/25/1999	-	-	-	-	-	< 4
	06/29/1999	-	-	-	-	< 0.0075	< 4
	07/30/1999	-	-	-	-	-	< 4
	08/25/1999	-	-	-	-	-	< 4
1860 (AC19)	01/27/1997	< 0.5	< 0.5	0.86	< 0.5	-	-
	03/12/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/20/1998	-	-	-	-	< 0.033	-
	03/27/1998	-	-	-	-	-	19
	04/14/1998	-	-	-	-	< 0.033	-
2003 (AC18)	05/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/04/1998	-	-	-	-	-	< 4
	03/23/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/10/1999	< 0.5	< 0.5	< 0.5	0.52	< 0.0075	< 4
	03/25/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/31/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	04/01/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	04/13/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/24/1999	-	-	-	-	-	< 4

Note: (-) Equals not analyzed

TABLE A-3
SUMMARY OF DETECTS - PUBLIC WATER SUPPLY WELLS
JANUARY 1997 TO SEPTEMBER 1999

Well Number	Sample Date	1,2-DCA (ppb)	Chloroform (ppb)	PCE (ppb)	TCE (ppb)	NDMA (ug/l)	Perchlorate (ug/l)
2065	03/03/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC20)	05/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	03/04/1998	-	-	-	-	< 0.033	< 4
	03/20/1998	-	-	-	-	< 0.033	-
	04/14/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/10/1998	-	-	-	-	< 0.0075	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	01/13/1999	-	-	-	-	< 0.0075	-
	02/12/1999	-	-	-	-	< 0.0075	-
	04/14/1999	-	-	-	-	< 0.0075	-
	05/19/1999	-	-	-	-	< 0.0075	-
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	< 4
2066	01/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	-	-
(AC21)	03/26/1998	-	-	-	-	< 0.033	-
	05/13/1998	-	-	-	-	< 0.033	-
	06/08/1998	-	-	-	-	< 0.0075	-
	06/10/1998	-	-	-	-	-	< 4
	07/08/1998	-	-	-	-	< 0.0075	-
	08/19/1998	-	-	-	-	< 0.0075	-
	09/16/1998	-	-	-	-	< 0.0075	< 4
	10/15/1998	-	-	-	-	< 0.0075	-
	11/18/1998	-	-	-	-	< 0.0075	-
	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	03/10/1999	< 0.5	< 0.5	< 0.5	0.64	< 0.0075	< 4
	03/25/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/22/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	06/24/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	06/29/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/01/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	07/06/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
	09/27/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
2067	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
(AC22)	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/27/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-
2068	12/09/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
(AC23)	03/10/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	06/16/1999	< 0.5	< 0.5	< 0.5	< 0.5	< 0.0075	< 4
	09/27/1999	< 0.5	< 0.5	< 0.5	< 0.5	-	-

Note: (-) Equals not analyzed

TABLE A-4
SUMMARY OF PERCHLORATE RESULTS
LAYER A - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/l)
10	03/19/1999	< 4
22	03/23/1999	60
75	03/19/1999	14
303	09/11/1997	< 4
	03/23/1998	4.3
307	03/19/1999	8.5
1203	05/27/1997	< 400
	01/08/1998	< 4
	05/07/1998	6
	03/10/1999	< 4
1237	09/30/1997	< 4
	04/03/1998	< 4
3057	03/19/1999	8.7
3348	03/24/1999	75
3352	03/23/1999	< 4
3431	03/23/1999	< 4
30062	11/20/1996	< 400
	01/14/1997	< 400
	04/24/1997	< 400
	07/16/1997	< 400
	10/30/1997	< 4
	01/30/1998	< 4
	04/15/1998	< 4
	07/16/1998	< 4
	10/29/1998	< 4
30063	11/20/1996	< 400
	01/13/1997	< 400
	04/24/1997	< 400
	07/16/1997	< 400
	10/30/1997	< 4
	01/30/1998	< 4
	04/15/1998	< 4
	07/16/1998	< 4
	10/29/1998	< 4
30065	11/21/1996	< 400
	01/13/1997	< 400
	04/24/1997	< 400
	07/16/1997	< 400
	10/31/1997	20
	09/02/1998	9
	10/30/1998	6.5

TABLE A-7
SUMMARY OF DETECTS - SEMI-VOLATILE ORGANIC COMPOUNDS
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Bis(2-ethylhexyl) phthalate (ppb)	Di-n-octyl phthalate (ppb)
1	09/24/1991	< 10	< 10
	12/19/1991	18.6	< 10
	03/16/1992	< 10	< 10
	05/27/1992	< 10	< 10
	07/13/1992	< 10	< 10
	08/03/1992	< 50	< 10
	10/08/1992	10.3	< 10
	02/17/1993	45.4	< 10
	03/30/1994	< 50	< 10
3	07/15/1992	< 10	< 10
	10/08/1992	< 10	< 10
	03/30/1994	< 50	< 10
4	10/14/1992	< 10.2	< 10.2
22	05/18/1994	< 50	< 10
	03/27/1995	< 50	< 10
24	03/28/1995	< 50	< 10
131	03/26/1994	< 50	< 10
215	04/21/1994	< 50	< 10
307	02/06/1995	< 50	< 10
1203	02/04/1997	< 50	< 10
3221	08/21/1991	< 10	< 10
3264	08/22/1991	< 10	< 10
	11/25/1991	23	2.4
	02/04/1992	20	< 10
	05/04/1992	< 10	< 10
	10/06/1992	15.3	< 10
	04/19/1993	< 50	< 10
	03/30/1994	< 50	< 10
	03/30/1994	< 50	< 10
3352	08/25/1992	< 50	< 10
	03/08/1993	< 50	< 10
3476	09/28/1994	< 50	< 10
30062	11/20/1996	< 50	< 10
	01/14/1997	< 50	< 10
30063	11/20/1996	< 50	< 10
	01/13/1997	< 50	< 10
30065	11/21/1996	< 50	< 10
	01/13/1997	< 50	< 10

TABLE A-8
SUMMARY OF METALS ANALYSES (METHOD 6010)
LAYER A - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	WELL NO. / DATE:	30062 11/20/1996	30063 11/20/1996	30065 11/21/1996	30065 07/08/1998
Aluminum	(mg/l)	< 0.2	1.1[1]	0.68[2]	-
Antimony	(mg/l)	< 0.24	< 0.24	< 0.24	-
Arsenic	(mg/l)	< 0.08	< 0.08	< 0.08	-
Barium	(mg/l)	0.029	0.25	0.027	-
Beryllium	(mg/l)	< 0.001	< 0.001	< 0.001	-
Boron	(mg/l)	< 0.04	< 0.04	0.041	0.02
Cadmium	(mg/l)	< 0.004	< 0.004	< 0.004	-
Calcium	(mg/l)	43	340	39	1.5
Chromium	(mg/l)	< 0.008	0.026	0.0084	-
Cobalt	(mg/l)	< 0.008	< 0.008	< 0.008	< 0.002
Copper	(mg/l)	< 0.006	0.0092	< 0.006	-
Iron	(mg/l)	< 0.3	0.32[2]	1.7	-
Lead	(mg/l)	< 0.06	< 0.06	< 0.06	-
Magnesium	(mg/l)	7.4	0.071	14	0.25
Manganese	(mg/l)	< 0.005	< 0.005	0.12[2]	< 0.0012
Molybdenum	(mg/l)	< 0.04	< 0.04	< 0.04	< 0.01
Nickel	(mg/l)	< 0.02	< 0.02	< 0.02	-
Potassium	(mg/l)	3.7	12	3.8	21
Selenium	(mg/l)	< 0.1	< 0.1	< 0.1	-
Silver	(mg/l)	< 0.02	< 0.02	< 0.02	< 0.005
Sodium	(mg/l)	20	60	27	63
Thallium	(mg/l)	< 0.05	< 0.05	< 0.05	-
Vanadium	(mg/l)	0.011	< 0.005	0.014	< 0.0015
Zinc	(mg/l)	< 0.1	0.22	11	< 0.025

Notes: (-) Equals not analyzed
(1) Value exceeds EPA or California DHS Primary Maximum Contaminant Level
(2) Value exceeds EPA or California DHS Secondary Maximum Contaminant Level

TABLE A-9
SUMMARY OF MISCELLANEOUS ANALYSES
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Chloride (ppm)	Nitrate (ppm)	Nitrate + Nitrite (as N) (ppm)	Sulfate (ppm)	OBPA (ppb)	Prowl (ug/l)
1	12/19/1991	13.6	6.08	0.61	16.1	-	-
	03/16/1992	17	6.6	< 0.1	19	-	-
	05/27/1992	12	6.4	< 0.3	22	-	-
	07/13/1992	14	5.7	< 0.1	26	< 10	< 2
	08/03/1992	12	6.1	< 0.1	19	-	-
	10/08/1992	21	5.7	< 0.1	26	< 10	< 2
	02/17/1993	20	5.7	< 0.05	27	-	-
3	07/15/1992	7.9	6.7	< 0.1	41	< 10	< 2
	10/08/1992	6.1	8.3	< 0.1	29	< 10	< 2
	10/23/1992	-	-	-	-	-	< 2
4	07/14/1992	33	6.7	< 0.1	37	< 10	< 2
	10/14/1992	24	6.6	< 0.1	27	< 10	< 2
8	02/10/1993	-	20	< 0.05	-	-	
10	02/08/1993	-	16	< 0.05	-	-	
22	09/22/1991	-	1.9	< 1	-	-	-
	12/13/1991	-	1.79	0.54	-	-	-
	03/09/1992	-	2.5	< 0.1	-	-	-
	05/21/1992	-	2.4	< 1	-	-	-
	11/13/1992	-	2	< 0.2	-	-	-
	05/18/1994	-	-	-	-	< 10	< 0.8
	06/10/1994	-	-	-	-	< 10	-
	12/12/1994	-	-	-	-	< 10	-
	06/07/1995	-	-	-	-	< 10	-
	12/07/1995	-	-	-	-	< 5	-
24	09/22/1991	-	6.2	< 0.1	-	-	-
	12/13/1991	-	3.96	< 0.5	-	-	-
	03/02/1992	-	6	< 0.1	-	-	-
	05/19/1992	-	6.1	< 0.3	-	-	-
	11/12/1992	-	6.2	< 0.1	-	-	-
	06/10/1994	-	-	-	-	< 10	-
	12/09/1994	-	-	-	-	< 10	-
	06/07/1995	-	-	-	-	< 10	-
	12/07/1995	-	-	-	-	< 5	-
25	09/21/1991	-	19	< 0.1	-	-	-
	12/18/1991	-	15.6	< 0.5	-	-	-
	03/06/1992	-	15.1	< 0.5	-	-	-
	06/04/1992	-	17	< 0.1	-	-	-
	11/06/1992	-	23	< 0.1	-	-	-
75	09/18/1991	-	1.1	< 0.1	-	-	-
	12/17/1991	-	0.8	< 0.5	-	-	-
	02/27/1992	-	0.5	< 0.1	-	-	-
	05/26/1992	-	0.4	< 0.3	-	-	-
	11/02/1992	-	0.3	< 0.1	-	-	-
130	08/26/1991	-	1	< 0.1	-	-	-

Note: (-) Equals not analyzed

TABLE A-9
SUMMARY OF MISCELLANEOUS ANALYSES
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Chloride (ppm)	Nitrate (ppm)	Nitrate + Nitrite (as N) (ppm)	Sulfate (ppm)	OBPA (ppb)	Prowl (ug/l)
131	08/26/1991	-	7.3	< 0.5	-	-	-
	11/20/1991	-	1.1	< 0.1	-	-	-
	02/05/1992	-	11	< 0.1	-	-	-
	05/05/1992	-	20	< 0.3	-	-	-
	08/27/1992	-	14	0.2	-	-	-
	03/11/1993	-	2.9	< 1	-	-	-
215	08/21/1991	-	158.415	2.53	-	-	-
	11/20/1991	-	110	8	-	-	-
	02/11/1992	-	58	1.8	-	-	-
	04/30/1992	-	134	2.03	-	-	-
	09/14/1992	-	120	1.4	-	-	-
	03/18/1993	-	110	6	-	-	-
	04/21/1994	-	49	-	-	-	-
	01/27/1995	-	21	-	-	-	-
	06/26/1995	-	13	-	-	-	-
303	09/10/1991	-	1.2	< 0.1	-	-	-
	12/12/1991	-	0.88	< 0.5	-	-	-
	02/24/1992	-	2.8	< 0.1	-	-	-
307	09/12/1991	-	13	< 0.1	-	-	-
	12/06/1991	-	11	< 0.1	-	-	-
	02/26/1992	-	12	< 0.1	-	-	-
	05/29/1992	-	8	< 0.1	-	-	-
	11/03/1992	-	10	< 0.1	-	-	-
	02/25/1994	-	10	-	-	-	-
374	09/16/1991	-	0.7	< 0.1	-	-	-
	12/16/1991	-	2.04	0.6	-	-	-
	03/02/1992	-	0.8	< 0.1	-	-	-
1237	03/25/1991	-	1	< 0.2	-	-	-
	06/17/1991	-	0.8	< 0.2	-	-	-
	09/05/1991	-	1.6	< 0.1	-	-	-
	11/22/1991	-	1.3	< 0.1	-	-	-
	02/04/1992	-	2.1	< 0.1	-	-	-
	04/30/1992	-	3.72	< 0.5	-	-	-
	08/31/1992	-	3.2	< 0.1	-	-	-
	03/11/1993	-	2.1	< 0.05	-	-	-
3043	12/19/1991	-	0.77	< 0.5	-	-	-
3057	02/10/1993	-	11	< 0.05	-	-	-
	04/12/1993	-	8	< 0.05	-	-	-
3221	08/21/1991	-	-	-	-	-	-
	08/21/1991	5.1	0.3	< 0.05	2.8	-	-
3222	08/21/1991	-	85.85	3.28	-	-	-
	11/27/1991	-	89	22	-	-	-
	02/07/1992	-	66.9	10.6	-	-	-
	05/18/1992	-	41	12	-	-	-
	10/08/1992	-	19	21	-	-	-
	04/30/1993	-	9.2	1.6	-	-	-
	03/14/1994	-	0.26	-	-	-	-

Note: (-) Equals not analyzed

TABLE A-9
SUMMARY OF MISCELLANEOUS ANALYSES
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Chloride (ppm)	Nitrate (ppm)	Nitrate + Nitrite (as N) (ppm)	Sulfate (ppm)	OBPA (ppb)	Prowl (ug/l)
3233	09/02/1991	-	8.1	< 0.1	-	-	-
	12/02/1991	-	8.3	< 0.1	-	-	-
	02/07/1992	-	7.73	0.64	-	-	-
	05/15/1992	-	7.9	< 0.1	-	-	-
	09/30/1992	-	7.8	< 0.1	-	-	-
	04/26/1993	-	6.2	< 0.05	-	-	-
3264	08/22/1991	40	219.9	0.46	28.4	-	-
	11/25/1991	-	-	-	-	-	-
	02/04/1992	49	200	< 0.2	32	-	-
	05/04/1992	35.9	189	1.29	36.5	-	-
	10/06/1992	31	85	1.8	28	-	-
	04/19/1993	30	56	0.11	24	-	-
	03/30/1994	-	120	-	-	-	-
	08/09/1995	-	54	-	-	-	-
3292	09/03/1991	-	31	< 0.5	-	-	-
	11/26/1991	-	9.2	0.1	-	-	-
	02/17/1992	-	19	< 0.4	-	-	-
	05/19/1992	-	14	< 0.3	-	-	-
	10/20/1992	-	21	< 0.1	-	-	-
	05/12/1993	-	10	0.07	-	-	-
	04/29/1994	-	20	-	-	-	-
3348	09/13/1991	-	5.2	< 0.1	-	-	-
	09/19/1991	-	5	< 0.1	-	-	-
	12/04/1991	-	1.2	< 0.1	-	-	-
	02/23/1992	-	0.9	< 0.1	-	-	-
	05/14/1992	-	0.8	< 0.1	-	-	-
	10/28/1992	-	0.6	< 0.1	-	-	-
	05/24/1993	-	15	< 0.05	-	-	-
	04/29/1994	-	6.7	-	-	-	-
3352	08/25/1992	12	2.7	< 0.1	7.1	-	-
	02/08/1993	-	1.8	0.19	-	-	-
	03/08/1993	10	2.1	0.1	5.1	-	-
3476	09/28/1994	3	4.2	< 0.05	9	-	-
4007	09/20/1993	33	26	-	82	-	-
4310	05/18/1995	28	47	1.8	500	-	-
30062	11/20/1996	7.4	6.9	0.23	20	-	-
30063	11/20/1996	56	3.5	1.1	2.7	-	-
30065	11/21/1996	13	2.8	0.44	20	-	-
	07/08/1998	8.3	1.3	-	7.5	-	-

Note: (-) Equals not analyzed

TABLE A-10
SUMMARY OF PETROLEUM HYDROCARBON ANALYSES
LAYER A - JANUARY 1991 TO APRIL 1999

Well Number	Sample Date	Diesel (mg/l)	Gasoline (ppb)	Jet fuels (mg/l)	Kerosene (mg/l)	Stoddard solvent (mg/l)	TPH (mg/l)	TPH (as motor oil) (E5030-8015) (ppb)	Unknown Hydrocarbon (ppb)
1	09/24/1991	-	-	-	-	-	< 0.2	-	-
	12/19/1991	< 300	-	-	-	-	-	-	-
	03/16/1992	-	-	-	-	-	< 0.5	-	-
	05/27/1992	-	-	-	-	-	< 0.2	-	-
	08/03/1992	-	-	-	-	-	< 0.2	-	-
	02/17/1993	-	-	-	-	-	< 0.2	-	-
3221	08/21/1991	-	-	-	-	-	0.2	-	-
3264	08/22/1991	-	-	-	-	-	< 0.2	-	-
	11/25/1991	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 100
	02/04/1992	-	-	-	-	-	0.3	-	-
	05/04/1992	-	-	-	-	-	< 0.2	-	-
	10/06/1992	< 0.05	-	-	-	-	-	-	-
	04/19/1993	-	-	-	-	-	< 0.2	-	-
3352	08/25/1992	-	-	-	-	-	< 0.2	-	-
	03/08/1993	-	-	-	-	-	< 0.2	-	-
3476	09/28/1994	-	-	-	-	-	< 0.2	-	-
30062	01/13/1997	-	< 500	-	-	-	-	-	< 500
	01/14/1997	< 0.05	-	-	-	-	-	< 50	490
30063	01/13/1997	< 0.25	< 500	-	-	-	-	< 250	2300
30065	01/13/1997	< 0.05	< 500	-	-	-	-	< 50	280

Note (-) Equals not analyzed

03/30/2000

TABLE A-11
SUMMARY OF TIC RESULTS - ALL LAYERS
JANUARY 1996 TO MAY 1999

Well Number	Sample Date	Aquifer Designation	Compound	Flag	Retention Time	Estimated Concentration (µg/L)
1011	12/9/98	B,C	*Unknown*			5.4
AC1	3/10/99		No TICs			
	5/19/99		*Unknown*	B	4.30 min	6.7
	5/19/99		*Unknown 1*	B	4.40 min	5.3
	5/19/99		*Unknown 2*	B	4.48 min	5.4
	5/19/99		*Unknown 3*	B	4.95 min	5
1033	12/11/98	C	*Octadecanoic acid*			4.5
Chettenham	3/15/99		No TICs			
	5/19/99		*Unknown*	B	4.30 min	6
	5/19/99		*Unknown 1*	B	4.40 min	4.7
	5/19/99		*Unknown 2*	B	4.48 min	5.1
	5/19/99		*Unknown 3*	B	4.95 min	5
1135	12/9/98	B	*Octadecanoic acid*	B		9.1
AC4	12/9/98		*Unknown*		23.16 min	4.3
	3/10/99		No TICs			
	5/19/99		*Unknown*	B	4.31 min	5.8
	5/19/99		*Unknown 1*	B	4.41 min	4.6
	5/19/99		*Unknown 2*	B	4.49 min	5
	5/19/99		*Unknown 3*	B	4.96 min	5.2
3332	2/3/97	D	*Unknown hydrocarbon*			640
2003	12/9/98	C,D,E	1,2-Benzenedicarboxylic acid, 2-butoxyet			17
AC18	12/9/98		*Octadecanoic acid*	B		4.1
	3/10/99		No TICs			
	5/19/99		*Unknown*	B	4.30 min	4.8
	5/19/99		*Unknown 1*	B	4.40 min	4.9
	5/19/99		*Unknown 2*	B	4.48 min	4.9
	5/19/99		*Unknown 3*	B	4.95 min	5.4
30075	1/9/97	B	*Unknown hydrocarbon*			1100
30067	1/10/97	C	*Unknown hydrocarbon*			1100
30064	1/13/97	B	*Unknown hydrocarbon*			2200
30066	1/10/97	B	*Unknown hydrocarbon*			1100
30076	1/9/97	C	*Unknown hydrocarbon*			960
30114	1/12/99	C	*Unknown 1*	B		6.4
	1/12/99		*Unknown 2*	B		6.7
	1/12/99		*Unknown 3*	B		4.7
	1/12/99		*Unknown 4*		25.27	4
	1/12/99		*Unknown 5*		25.46	5.6
	2/11/99		*Tetrachloroethylene*			5.6
	3/15/99		No TICs			

Notes: "B" Compound detected in method blank

TABLE A-11
SUMMARY OF TIC RESULTS - ALL LAYERS
JANUARY 1996 TO MAY 1999

Well Number	Sample Date	Aquifer Designation	Compound	Flag	Retention Time	Estimated Concentration (µg/L)
30122	8/4/98	C	2-methyl-1hexanol			4.6
	12/17/98		*Unknown*		14.84,14.85	4.8
	2/2/99		No TICs			
	3/16/99		*Tetrachloroethylene*			4.8
30123	8/4/98	C	2-methyl-1hexanol			9.5
	12/17/98		Unknown		14.84,14.85	5.3
	2/2/99		No TICs			
	3/16/99		Dimexano			13
	3/16/99		Tetrachloroethylene			4.1
30124	12/17/98	C	*Unknown*		14.84,14.85	5.5
	2/2/99		No TICs			
	3/16/99		No TICs			
30126	12/18/98	E	*Unknown*			4.2

Notes: "B" Compound detected in method blank

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
132	5/3/96	< 10	< 10	48	< 10	67	< 10	13	< 10	< 10	9400
	10/23/96	< 10	< 10	27	< 10	100	< 10	31	< 10	< 10	7600
	2/28/97	< 5	< 5	13	< 5	78	< 5	350	< 5	< 5	4700
	9/11/97	1.5	1.8	17	< 10	86	1.4	36	< 10	1.2	2800
	3/9/98	< 20	< 20	< 20	< 20	120	< 20	49	< 20	< 20	4900
308	3/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1229	9/9/96	< 1	< 1	< 1	< 1	< 1	< 1	3.1	< 1	< 1	28
	12/13/96	< 1	< 1	< 1	< 1	< 1	< 1	3.1	< 1	< 1	28
	11/11/97	< 1	< 1	< 1	< 1	< 1	< 1	5.8	< 1	< 1	74
	4/10/98	< 1	< 1	< 1	< 1	< 1	< 1	5.6	< 1	< 1	82
1238	5/21/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	16
	4/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1242	6/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/25/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1243	6/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	32
	10/25/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	32
	9/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	27
	4/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	30
1251	1/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.5
	9/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.9
1266	4/25/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/16/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
1267	4/24/96	< 1	< 1	< 1	< 1	< 1	< 1	1.5	1.1	< 1	< 1
	10/16/96	< 1	< 1	< 1	< 1	< 1	< 1	2.1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	1
	10/7/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/20/98	< 1	< 1	< 1	< 1	< 1	< 1	1.1	< 1	< 1	< 1
	6/19/98	< 1	< 1	< 1	< 1	< 1	< 1	6.9	< 1	< 1	40
	12/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.97	< 0.5	< 0.5	1.1
1281	1/2/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1	< 1	3.8	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	7.2	< 1	< 1	< 1
1312	1/11/96	< 1	< 1	< 1	< 1	2.5	< 1	< 1	< 1	< 1	75
	8/20/96	< 1	< 1	< 1	< 1	1.9	< 1	< 1	< 1	< 1	65
	12/11/98	< 0.5	< 0.5	< 0.5	< 0.5	1.9	< 0.5	< 0.5	< 0.5	< 0.5	71
1329	1/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/17/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/13/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/1/98	< 1	< 1	< 1	< 1	< 1	< 1	4.2	< 1	< 1	40
1333	1/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/25/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	8/27/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1	< 1
	10/31/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/16/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1345	1/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.3
	8/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.2
	8/22/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.7
	12/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.7
	6/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.3
	12/17/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.1
	8/5/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.7

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
1466	7/26/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/10/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	5/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/27/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	7/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3044	1/9/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	18	< 1	< 1	47
3113	7/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1
	5/29/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.4
	1/14/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.2
	6/25/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3139	7/8/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/29/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/26/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3145	6/4/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/25/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3160	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/5/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3210	6/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/22/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
3278	6/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/11/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/27/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3351	7/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3409	3/25/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
3434	6/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/8/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3441	6/21/96	< 1	< 1	< 1	< 1	< 1	< 1	3.3	< 1	< 1	< 1
	10/24/96	< 1	< 1	< 1	< 1	< 1	< 1	2.9	< 1	< 1	< 1
	10/29/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3591	12/18/98	< 5	< 5	< 5		< 5	< 5	< 5	< 5	< 5	< 5
30002	1/17/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2
	4/29/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	0.89
	7/30/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.2
	11/11/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.3
	12/11/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.1
	1/15/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.2
	4/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.2
	7/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.4
	10/30/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.9
	1/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.7
	4/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.4
	10/26/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
30005	1/18/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5
	4/25/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/29/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/22/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/7/98	< 0.5	-	-	-	-	< 0.5	-	-	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.77	< 0.5
	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	< 0.5
30016	1/25/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5
	4/23/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	0.56
	7/24/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.92
	11/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.71
	12/6/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.83
	1/20/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.3
	4/21/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.78
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.89
	10/27/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.83
	7/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.53
	10/29/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
30020	1/17/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/26/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/29/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/11/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/15/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/18/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
30044	1/19/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/24/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/26/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/21/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/20/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/22/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.91	< 0.5
	7/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.84	< 0.5	0.51	< 0.5
	10/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.69	< 0.5	0.84	< 0.5
30057	10/21/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/29/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	5/5/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/8/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30064	11/20/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.74
	12/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.66
	1/13/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
	4/28/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
	7/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2
	10/30/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.5
	1/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.58
	7/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.74
	10/29/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.2
30066	11/21/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/10/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/24/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/31/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	9/2/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
30075	11/21/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	37
	12/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/9/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/24/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/97	< 0.5	< 0.5	< 0.5	< 0.5	0.59	< 0.5	< 0.5	< 0.5	< 0.5	5.6
	10/31/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	9/2/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30092	5/5/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/6/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/10/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/15/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30095	7/11/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/9/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.5
	6/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30098	7/14/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/9/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30099	7/11/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/9/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30104	12/19/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	3/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30119	6/16/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	9/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
31000	7/21/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	11/19/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DGA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
STSW-03B	9/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	12	< 0.5	< 0.5	18
	2/10/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	11	< 0.5	< 0.5	17
	5/6/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	5.9	< 0.24	< 0.2	10
	11/4/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	7.1	< 0.24	< 0.2	9.3
	11/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	7	< 0.5	< 0.5	11
STSW-04B	4/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	9/25/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/11/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	5/2/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	< 0.16
	10/3/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	< 0.16
	5/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-08A	5/1/96	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	12	< 2.5	< 2.5	110
	9/19/96	< 10	< 10	< 10	< 10	< 10	< 10	17	< 10	< 10	410
	2/5/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.5	< 0.5	< 0.5	8.2
	5/14/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	4.8	< 0.24	< 0.2	13
	11/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3.4	< 0.5	< 0.5	4.6
STSW-09A	9/11/96	< 1	< 0.4	< 0.4	< 0.4	< 0.5	< 0.4	< 0.4	< 1	< 0.4	1.5
	6/18/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	0.53
	10/29/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	2.8
	12/9/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
STSW-19	1/26/96	< 0.2	< 1.4	< 0.3	< 0.2	-	< 0.3	< 0.2	-	< 0.4	< 0.3
	9/20/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/6/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	5/12/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	< 0.16
	12/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-20	1/26/96	< 0.2	< 1.4	< 0.3	< 0.2	-	< 0.3	< 0.2	-	< 0.4	4.5
	9/18/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/6/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.7
	5/12/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	1.7
	12/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.7

Note: (-) Equals not analyzed

TABLE A-12
SUMMARY OF DETECTS - VOC ANALYSES
LAYER B - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1,2-TCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	PCE (ppb)	TCE (ppb)
STSW-21	1/26/96	< 1	< 7	< 1.5	< 1	-	< 1.5	52	-	< 2	86
	9/18/96	< 1	< 1	< 1	< 1	< 1	< 1	40	< 1	< 1	60
	2/6/97	< 1	< 1	< 1	< 1	< 1	< 1	32	< 1	< 1	43
	5/12/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	32	< 0.24	< 0.2	52
	11/25/98	< 1	< 1	< 1	< 1	< 1	< 1	33.7	< 1	< 1	57
STSW-22	9/18/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/6/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.51
	5/14/97	< 0.16	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.2	1.3
	12/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
STSW-51A	9/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-52A	8/31/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.78	< 0.5	< 0.5	3
	11/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2	< 0.5	< 0.5	3.4

Note: (-) Equals not analyzed

TABLE A-13
SUMMARY OF PERCHLORATE ANALYSES
LAYER B - JANAURY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
235	12/18/1996	5200
304	09/11/1997	15
	03/23/1998	15
305	09/11/1997	990
	03/23/1998	11000
308	03/19/1999	8
1229	11/11/1997	2500
	04/10/1998	2800
1238	09/30/1997	48
	04/02/1998	20
1251	01/03/1996	< 400
	09/06/1996	710
1266	04/25/1996	5500
	10/16/1996	5300
	10/08/1997	4300
	04/20/1998	5200
	06/19/1998	5100
	12/16/1998	4700
1267	04/24/1996	1800
	10/16/1996	2100
	10/07/1997	1800
	04/20/1998	2000
	06/19/1998	1800
	12/16/1998	1900
1281	01/02/1996	3000
	10/15/1996	1300
	10/10/1997	2900
	04/03/1998	3600
	06/24/1998	2200
1312	01/11/1996	< 400
	08/20/1996	< 400
	12/11/1998	60
1329	01/12/1996	< 400
	10/17/1996	< 400
1333	01/18/1996	< 400
	08/27/1996	< 400
	03/10/1997	< 400
1345	01/18/1996	< 400
	08/22/1996	< 400
	06/12/1997	< 400
	12/17/1997	11
	08/05/1998	11
1466	02/10/1997	< 400
	05/28/1997	< 400
	03/27/1998	< 4
	07/02/1998	< 4
3044	01/09/1998	15
3113	05/29/1997	< 400
	03/24/1999	< 4
3139	05/29/1997	< 400
	03/24/1999	310

TABLE A-13
SUMMARY OF PERCHLORATE ANALYSES
LAYER B - JANAURY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
3210	03/10/1997	< 400
3278	03/14/1997	1700
3351	06/04/1997	< 400
3409	03/25/1999	< 4
3434	03/11/1997	5000
3441	10/29/1997	5.5
	03/19/1998	< 4
3591	12/18/1998	< 4
30002	01/15/1997	< 400
	04/23/1997	< 400
	07/16/1997	< 400
	10/30/1997	< 4
	01/30/1998	< 4
	04/13/1998	< 4
	07/14/1998	< 4
	07/14/1998	< 4
	10/26/1998	< 4
30005	01/16/1997	< 400
	04/22/1997	< 400
	07/17/1997	< 400
	10/29/1997	< 4
	01/30/1998	< 4
	04/14/1998	< 4
	07/15/1998	4
	10/28/1998	< 4
30016	01/20/1997	< 400
	04/21/1997	< 400
	07/17/1997	< 400
	10/27/1997	< 20
	01/27/1998	< 4
	04/16/1998	< 4
	10/29/1998	< 4
30020	01/15/1997	< 400
	04/23/1997	< 400
	10/29/1997	< 4
	01/28/1998	< 4
	04/13/1998	< 4
	07/15/1998	< 4
	10/27/1998	< 4
30044	01/20/1997	< 400
	04/22/1997	< 400
	07/17/1997	< 400
	10/28/1997	< 4
	01/28/1998	< 4
	04/14/1998	< 4
	07/17/1998	< 4
	10/27/1998	< 4

TABLE A-13
SUMMARY OF PERCHLORATE ANALYSES
LAYER B - JANAURY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30057	10/21/1996	6100
	10/08/1997	6300
	01/29/1998	6300
	05/05/1998	3100
	10/08/1998	6400
30064	11/20/1996	< 400
	01/13/1997	< 400
	04/28/1997	< 400
	07/16/1997	< 400
	10/30/1997	< 4
	01/30/1998	< 4
	04/15/1998	< 4
	07/16/1998	< 4
	10/29/1998	< 4
30066	11/21/1996	< 400
	01/10/1997	< 400
	04/24/1997	< 400
	07/16/1997	< 400
	10/31/1997	9.3
	09/02/1998	15
	10/30/1998	15
30075	11/21/1996	< 400
	01/09/1997	< 400
	04/24/1997	< 400
	07/15/1997	< 400
	10/31/1997	< 4
	09/02/1998	< 4
	10/30/1998	< 4
30092	05/05/1997	< 400
	10/06/1997	4.1
	02/10/1998	< 4
	12/15/1998	4.2
30095	07/11/1997	3200
	10/09/1997	3500
	02/27/1998	5600
	06/17/1998	4200
30098	07/14/1997	7200
	10/09/1997	6900
	02/04/1998	7100
	12/15/1998	6700
30099	07/11/1997	610
	10/09/1997	7800
	02/04/1998	6100
30104	12/19/1997	< 4
	03/02/1998	< 4
	09/16/1998	< 4
30119	09/21/1998	< 4
31000	07/21/1997	< 400
	11/19/1997	< 4
	02/18/1998	< 4
	05/04/1998	< 4

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

[= wells within multiple-completion boring

< PQL of 100 ug/l & > MDL = 35 ug/l.

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 3A	06-May-97				6,300
STSW 3A	04-Nov-97				6,700
STSW 3A	17-Nov-98				1,400
STSW 3B	07-Feb-95		4,000		
STSW 3B	12-Apr-95		2,500		
STSW 3B	16-Jan-97				6,700
STSW 3B	10-Feb-97				7,100
STSW 3B	06-May-97				5,900
STSW 3B	04-Nov-97				5,800
STSW 3B	17-Nov-98				5,200
STSW 3B	12-May-99				4,100
STSW 3C	07-Feb-95	400			
STSW 3C	12-Apr-95	400			
STSW 3C	16-Jan-97				450
STSW 3C	10-Feb-97				470
STSW 3C	06-May-97				320
STSW 3C	17-Nov-98				250
STSW 3C	12-May-99				220
STSW 4B	17-Jan-97			35	
STSW 4B	11-Feb-97			35	
STSW 4B	02-May-97			35	
STSW 4B	03-Oct-97			4	
STSW 4B	15-May-98			4	
STSW 4B	12-Nov-98				4
STSW 4B	23-Apr-99				5
STSW 4B	09-Nov-99			4	
STSW 4C	16-Jan-97				760
STSW 4C	11-Feb-97			35	
STSW 4C	02-May-97			35	
STSW 4C	03-Oct-97				200
STSW 4C	15-May-98				14
STSW 4C	12-Nov-98				1,500
STSW 4C	23-Apr-99				1,600
STSW 4C	09-Nov-99				1,600
STSW 8A	27-Jun-94	400			
STSW 8A	11-Oct-94		1,000		
STSW 8A	16-Feb-95	400			

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

[= wells within multiple-completion boring

< PQL of 100 ug/l & > MDL = 35 ug/l.

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 8A	20-Apr-95	400			
STSW 8A	07-Dec-95	400			
STSW 8A	19-Sep-96				1,300
STSW 8A	05-Feb-97			35	
STSW 8A	14-May-97				52
STSW 8A	30-Nov-98				15
STSW 8A	26-May-99				18
STSW 8B	27-Jun-94	400			
STSW 8B	11-Oct-94	400			
STSW 8B	15-Feb-95	400			
STSW 8B	19-Apr-95	400			
STSW 8B	07-Dec-95	400			
STSW 8B	19-Sep-96			35	
STSW 8B	05-Feb-97			35	
STSW 8B	14-May-97			35	
STSW 8B	30-Nov-98			4	
STSW 8B	26-May-99				13
STSW 8C	27-Jun-94	400			
STSW 8C	11-Oct-94	400			
STSW 8C	15-Feb-95	400			
STSW 8C	19-Apr-95	400			
STSW 8C	07-Dec-95	400			
STSW 8C	19-Sep-96			35	
STSW 8C	05-Feb-97			35	
STSW 8C	14-May-97			35	
STSW 8C	30-Nov-98				13
STSW 8C	24-May-99				15
STSW 19	12-Jul-94	400			
STSW 19	13-Oct-94	400			
STSW 19	13-Feb-95	400			
STSW 19	12-Apr-95	400			
STSW 19	26-Jan-96	400			
STSW 19	20-Sep-96			35	
STSW 19	06-Feb-97			35	
STSW 19	12-May-97			35	
STSW 19	01-Dec-98			4	
STSW 19	25-Jun-99				4
STSW 20	14-Jul-94	400			
STSW 20	13-Oct-94	400			
STSW 20	14-Feb-95	400			

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

[= wells within multiple-completion boring

< PQL of 100 ug/l & > MDL = 35 ug/l.

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 20	13-Apr-95	400			
STSW 20	26-Jan-96	400			
STSW 20	18-Sep-96			35	
STSW 20	06-Feb-97			35	
STSW 20	12-May-97			35	
STSW 20	01-Dec-98				6
STSW 20	30-Apr-99				5
STSW 21	07-Jul-94	400			
STSW 21	13-Oct-94	400			
STSW 21	14-Feb-95	400			
STSW 21	18-Apr-95	400			
STSW 21	26-Jan-96	400			
STSW 21	18-Sep-96				75
STSW 21	06-Feb-97				50
STSW 21	12-May-97				56
STSW 21	25-Nov-98				330
STSW 21	30-Apr-99				810
STSW 22	07-Jul-94	400			
STSW 22	14-Oct-94		5,300		
STSW 22	14-Feb-95	400			
STSW 22	18-Apr-95	400			
STSW 22	07-Dec-95	400			
STSW 22	18-Sep-96			35	
STSW 22	06-Feb-97			35	
STSW 22	14-May-97			35	
STSW 22	01-Dec-98				8
STSW 22	30-Apr-99				11
STSW 28A	30-Apr-97			35	
STSW 28A	03-Oct-97			4	
STSW 28A	18-May-98			4	
STSW 28A	10-Nov-98			4	
STSW 28A	04-May-99			4	
STSW 28A	08-Nov-99			4	
STSW 28B	30-Apr-97				100
STSW 28B	03-Oct-97				190
STSW 28B	15-May-98				240
STSW 28B	10-Nov-98				350
STSW 28B	04-May-99				420
STSW 28B	08-Nov-99				180
STSW 28C	30-Apr-97			35	

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

[= wells within multiple-completion boring

< PQL of 100 ug/l & > MDL = 35 ug/l.

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 28C	03-Oct-97			4	
STSW 28C	15-May-98			4	
STSW 28C	10-Nov-98			4	
STSW 28C	04-May-99			4	
STSW 28C	08-Nov-99			4	
STSW 29A	20-Jan-97				1,300
STSW 29A	09-May-97				2,100
STSW 29A	13-Oct-97				1,300
STSW 29A	25-Nov-98				1,000
STSW 29A	25-Jun-99				970
STSW 29B	17-Jan-97				1,000
STSW 29B	08-May-97				920
STSW 29B	13-Oct-97				760
STSW 29B	25-Nov-98				450
STSW 29B	25-Jun-99				370
STSW 29C	17-Jan-97			35	
STSW 29C	08-May-97			35	
STSW 29C	13-Oct-97			4	
STSW 29C	25-Nov-98			4	
STSW 29C	25-Jun-99			4	
STSW 30A	21-Jan-97			35	
STSW 30A	09-May-97			35	
STSW 30A	14-Oct-97				24
STSW 30A	24-Nov-98				35
STSW 30A	07-May-99				37
STSW 30B	20-Jan-97			35	
STSW 30B	09-May-97			35	
STSW 30B	14-Oct-97			4	
STSW 30B	24-Nov-98			4	
STSW 30B	07-May-99			4	
STSW 30C	20-Jan-97			35	
STSW 30C	09-May-97			35	
STSW 30C	14-Oct-97			4	
STSW 30C	24-Nov-98			4	
STSW 30C	07-May-99			4	

Table A-14. Summary of Perchlorate Data for the Inactive Rancho Cordova Test Site

Concentrations in micrograms per liter (ug/l).

[= wells within multiple-completion boring

< PQL of 100 ug/l & > MDL = 35 ug/l.

Well	Date	Ion Specific Electrode		Ion Chromatography	
		< PQL	> PQL	< PQL	> PQL
STSW 51A	30-Jul-98				6,500
STSW 51A	01-Sep-98				6,400
STSW 51A	13-Nov-98				5,600
STSW 51A	20-Jan-99				6,600
STSW 51A	30-Apr-99				6,800
STSW 51B	30-Jul-98			4	
STSW 51B	01-Sep-98			4	
STSW 51B	13-Nov-98			4	
STSW 51B	20-Jan-99			4	
STSW 51B	30-Apr-99			4	
STSW 51C	30-Jul-98				9
STSW 51C	01-Sep-98			4	
STSW 51C	12-Nov-98			4	
STSW 51C	20-Jan-99				4
STSW 51C	30-Apr-99			4	
STSW 52A	29-Jul-98				2,200
STSW 52A	31-Aug-98				2,100
STSW 52A	16-Nov-98				1,800
STSW 52A	21-Jan-99				2,000
STSW 52A	10-May-99				2,200
STSW 52B	29-Jul-98				4
STSW 52B	31-Aug-98				6
STSW 52B	13-Nov-98			4	
STSW 52B	21-Jan-99				5
STSW 52B	10-May-99				5
STSW 52C	29-Jul-98				300
STSW 52C	31-Aug-98				320
STSW 52C	13-Nov-98				120
STSW 52C	21-Jan-99				440
STSW 52C	10-May-99				430

TABLE A-15
SUMMARY OF NDMA ANALYSES
LAYER B - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
123	05/18/1998	< 0.0075
125	05/20/1998	< 0.0075
169	05/20/1998	< 0.0075
282	05/21/1998	0.32
283	05/21/1998	0.041
291	05/21/1998	< 0.0075
441	05/26/1998	0.17
1212	07/13/1998	< 0.0075
1434	04/30/1998	< 0.02
1466	07/16/1998	< 0.0075
3017	07/09/1998	< 0.0075
3048	05/22/1998	< 0.0075
3351	05/27/1998	< 0.0075
3409	05/28/1998	< 0.0075
3447	06/04/1998	0.081
3457	07/10/1998	< 0.0075
3463	05/29/1998	0.036
30002	04/13/1998	< 0.02
	07/14/1998	< 0.0075
	07/14/1998	< 0.0075
	10/26/1998	< 0.0075
30005	04/14/1998	< 0.02
	07/15/1998	< 0.0075
	10/28/1998	< 0.0075
30016	04/16/1998	< 0.02
	07/16/1998	< 0.0075
	07/16/1998	< 0.0075
	10/29/1998	< 0.0075
30020	04/13/1998	< 0.02
	07/15/1998	< 0.0075
	10/27/1998	< 0.0075
30044	04/14/1998	< 0.02
	07/17/1998	< 0.0075
	10/27/1998	< 0.0075
30064	04/15/1998	< 0.02
	07/16/1998	< 0.0075
	10/29/1998	< 0.0075
30066	09/02/1998	< 0.0075
	10/30/1998	< 0.0075
30075	09/02/1998	< 0.0075
	10/30/1998	< 0.0075
31000	05/06/1998	< 0.02

TABLE A-16
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (METHOD 8270)
LAYER B - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	Well No: / Date:	1312 01/11/1996	3591 12/18/1998	30002 01/15/1997	30057 01/29/1998	30064 11/20/1996	30064 01/13/1997	30066 01/10/1997	30075 11/21/1996
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	-	< 10	< 10	< 10	< 10	< 10	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-16
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (METHOD 8270)
LAYER B - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	Well No: / Date:	1312 01/11/1996	3591 12/18/1998	30002 01/15/1997	30057 01/29/1998	30064 11/20/1996	30064 01/13/1997	30066 01/10/1997	30075 11/21/1996
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 10	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-16
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (METHOD 8270)
LAYER B - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	Well No: / Date:	30075 01/09/1997	30092 05/05/1997	30095 07/11/1997	30098 07/14/1997	30098 07/14/1997	30099 07/11/1997	30104 12/19/1997	30119 06/16/1998	31000 07/21/1997
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-16
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (METHOD 8270)
LAYER B - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	Well No: / Date:	30075 01/09/1997	30092 05/05/1997	30095 07/11/1997	30098 07/14/1997	30098 07/14/1997	30099 07/11/1997	30104 12/19/1997	30119 06/16/1998	31000 07/21/1997
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	25	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-17
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER B - JANUARY 1996 TO APRIL 1999

Compound	Well No. / Sample Date	30002 7/7/98	30057 1/29/98	30064 11/20/96	30066 11/21/96	30066 7/8/98	30092 5/5/97	30095 7/11/97	30098 7/14/97	30099 7/11/97	30104 12/19/97
Aluminum	(ppm)	< 0.05	< 0.2	< 0.2	< 0.2	-	< 0.2	< 0.2	< 0.2	< 0.2	
Antimony	(ppm)	-	< 0.2	< 0.24	< 0.24	-	< 0.24	< 0.24	< 0.24	< 0.24	
Arsenic	(ppm)	< 0.02	< 0.08	< 0.08	< 0.08	-	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	(ppm)	0.072	0.053	0.032	0.22	-	0.016	0.014	0.015	0.042	0.044
Beryllium	(ppm)	< 0.00025	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	(ppm)	0.16	< 0.04	< 0.04	< 0.04	-	< 0.04	< 0.04	< 0.04	0.19	< 0.04
Cadmium	(ppm)	< 0.001	< 0.004	< 0.004	< 0.004	-	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	(ppm)	-	14	16	110	-	15	43	15	14	14
Chromium	(ppm)	0.0021	< 0.008	< 0.008	< 0.008	-	< 0.008	0.0091	< 0.008	< 0.008	< 0.008
Cobalt	(ppm)	< 0.002	< 0.008	< 0.008	< 0.008	-	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	(ppm)	< 0.0015	0.01	0.016	< 0.006	-	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	(ppm)	< 0.075	< 0.3	< 0.3	< 0.3	-	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	(ppm)	< 0.015	< 0.06	< 0.06	< 0.06	-	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	(ppm)	-	8.4	3.6	0.1	-	3	0.83	9.6	8.2	5
Manganese	(ppm)	-	0.01	< 0.005	< 0.005	-	< 0.005	< 0.005	0.064	1	< 0.005
Molybdenum	(ppm)	< 0.01	< 0.04	< 0.04	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	(ppm)	< 0.005	< 0.02	< 0.02	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	(ppm)	-	< 2	11	11	-	1.8	4	1.7	2.6	2.1
Selenium	(ppm)	< 0.025	< 0.1	< 0.1	< 0.1	< 0.025	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	(ppm)	< 0.005	< 0.02	< 0.02	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	(ppm)	-	8.5	34	47	-	13	21	9.4	20	11
Thallium	(ppm)	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	(ppm)	-	< 0.006	0.0086	< 0.005	-	0.016	0.026	0.005	< 0.005	0.012
Zinc	(ppm)	< 0.025	0.32	< 0.1	< 0.1	-	< 0.1	< 0.1	4	27	< 0.1

Note: (-) Equals not analyzed

TABLE A-17
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER B - JANUARY 1996 TO APRIL 1999

Well No. / Sample Date / Compound		30119 6/16/98	31000 7/21/97	3591 12/18/98
Aluminum	(ppm)	< 0.2	< 0.2	< 0.2
Antimony	(ppm)	< 0.2	< 0.24	< 0.2
Arsenic	(ppm)	< 0.08	< 0.08	< 0.08
Barium	(ppm)	0.11	0.077	0.048
Beryllium	(ppm)	< 0.001	< 0.001	< 0.001
Boron	(ppm)	< 0.04	< 0.04	< 0.04
Cadmium	(ppm)	< 0.004	< 0.004	< 0.004
Calcium	(ppm)	19	20	50
Chromium	(ppm)	< 0.008	< 0.008	< 0.008
Cobalt	(ppm)	< 0.008	< 0.008	< 0.008
Copper	(ppm)	< 0.006	< 0.006	< 0.006
Iron	(ppm)	< 0.3	< 0.3	< 0.3
Lead	(ppm)	< 0.06	< 0.06	< 0.06
Magnesium	(ppm)	2.1	10	7.6
Manganese	(ppm)	< 0.005	< 0.005	< 0.005
Molybdenum	(ppm)	< 0.04	< 0.04	< 0.04
Nickel	(ppm)	< 0.02	< 0.02	< 0.02
Potassium	(ppm)	3.4	2.7	3.6
Selenium	(ppm)	< 0.1	< 0.1	< 0.1
Silver	(ppm)	< 0.02	< 0.02	< 0.02
Sodium	(ppm)	15	13	21
Thallium	(ppm)	< 0.05	< 0.05	< 0.05
Vanadium	(ppm)	0.015	0.0075	0.011
Zinc	(ppm)	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-18
SUMMARY OF ANION ANALYSES
LAYER B - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Chloride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
3591	12/18/1998	75	11	0.56	14
30020	07/07/1998	-	28	-	-
30044	07/07/1998	-	-	-	72
30057	01/29/1998	5.1	2.5	< 0.05	9.9
30064	11/20/1996	24	2	1.8	23
30066	11/21/1996	21	5	2.4	13
30092	05/05/1997	2.9	7.7	< 0.05	4.4
30095	07/11/1997	13	1.1	< 0.25	20
30098	07/14/1997	7.6	1.8	< 0.05	12
30099	07/11/1997	48	0.57	< 0.25	14
30119	06/16/1998	5.5	9.6	< 0.15	4.7
31000	07/21/1997	4.8	5.2	< 0.05	8.9

Notes: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
124	03/23/1999	0.67	11	0.94	32	0.66	12	2.6	< 0.5	2.8	830
127	06/27/1996	< 1	2.5	< 1	6.3	< 1	7.1	< 1	< 1	< 1	380
	11/15/1996	< 1	1.2	< 1	2.6	< 1	3.7	< 1	< 1	< 1	190
	05/16/1997	< 1	< 1	< 1	1.7	< 1	4.3	< 1	< 1	< 1	150
	01/06/1998	< 1	1	< 1	1.7	< 1	4.9	< 1	< 1	< 1	160
	06/19/1998	< 1	< 1	< 1	1.2	< 1	3.4	< 1	< 1	< 1	110
134	06/27/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/16/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
135	06/27/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
138	06/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/14/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
139	12/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
357	06/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/25/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
399	05/20/1996	< 1	< 1	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.1
	10/29/1996	< 1	< 1	< 1	< 1	< 1	1.8	< 1	< 1	< 1	1.3
	02/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.4
	09/25/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.5
	03/30/1998	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	3.1

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
420	07/01/1996	< 1	< 1	< 1	1.2	< 1	< 1	1.5	< 1	< 1	11
	11/20/1996	1.2	< 1	< 1	2.1	< 1	< 1	3	< 1	1.1	12
	02/03/1997	1.2	< 0.5	< 0.5	2	< 0.5	0.88	< 3.1	< 0.5	1.1	16
	05/21/1997	1.3	< 1	< 1	2.5	< 1	< 1	3.5	< 1	< 1	15
	01/07/1998	1.2	< 1	< 1	1.5	< 1	< 1	2.6	< 1	< 1	16
	05/20/1998	1	< 1	< 1	2	< 1	< 1	1.7	< 1	< 1	13
437	06/28/1996	< 1	< 1	< 1	1.2	< 1	1	< 1	< 1	< 1	120
	11/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	100
	05/22/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	32
	01/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	13
	06/29/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	20
438	06/28/1996	< 1	3.7	< 1	7.2	< 1	3.4	2.1	< 1	1.1	590
	11/20/1996	< 1	7.6	< 1	9.8	< 1	5.2	2.8	< 1	1.6	680
	05/22/1997	< 1	< 1	< 1	2.2	< 1	< 1	1.4	< 1	< 1	170
	01/07/1998	< 1	1.5	< 1	1.1	< 1	< 1	< 1	< 1	< 1	140
	06/29/1998	< 1	< 1	< 1	2.1	< 1	1	1.4	< 1	< 1	140
447	06/28/1996	< 1	< 1	< 1	1.2	< 1	3.3	< 1	< 1	< 1	130
	11/19/1996	< 1	< 1	< 1	< 1	< 1	2.6	< 1	< 1	< 1	69
	05/28/1997	< 1	< 1	< 1	< 1	< 1	1.4	< 1	< 1	< 1	31
	01/08/1998	< 1	< 1	< 1	< 1	< 1	1.4	< 1	< 1	< 1	16
	06/23/1998	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	< 1	13
494	05/23/1996	< 1	< 1	1.4	< 1	< 1	41	< 1	< 1	< 1	13
	10/25/1996	< 1	< 1	2.1	< 1	< 1	39	< 1	< 1	< 1	9.1
	09/12/1997	< 1	< 1	1.5	< 1	< 1	24	< 1	< 1	< 1	13
	03/13/1998	< 1	< 1	1.5	< 1	< 1	25	< 1	< 1	< 1	17
495	05/23/1996	< 1	2.1	< 1	< 1	< 1	7.9	< 1	< 1	< 1	190
	10/25/1996	< 1	3.5	< 1	< 1	< 1	10	< 1	< 1	< 1	200
	09/12/1997	< 1	< 1	< 1	< 1	< 1	34	< 1	< 1	< 1	140
	03/13/1998	< 1	1.2	< 1	< 1	< 1	26	< 1	< 1	< 1	130

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1169	01/11/1996	< 0.5	< 0.5	< 0.25	1.6	< 0.5	< 0.5	< 0.5	< 0.5	0.74	42
	04/03/1996	< 0.5	< 0.5	< 0.25	1.5	< 0.25	< 0.5	< 0.5	< 0.5	0.79	53
	07/02/1996	< 0.5	0.56	< 0.25	0.74	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	38
	01/03/1997	< 0.5	< 0.5	< 0.5	0.83	< 0.5	< 0.5	< 0.5	< 0.5	0.99	41
	02/05/1997	< 0.5	0.96	< 0.5	0.97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	39
	04/02/1997	< 0.5	< 0.5	< 0.5	0.87	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	36
	07/25/1997	< 0.5	< 0.5	< 0.5	0.83	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	36
	10/03/1997	< 0.5	< 0.5	< 0.5	0.71	< 0.5	< 0.5	< 0.5	< 0.5	0.51	40
	01/19/1998	< 0.5	1.4	< 0.5	1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	54
	06/23/1998	< 0.5	0.97	< 0.5	1.6	< 0.5	0.54	< 0.5	< 0.5	0.67	55
	07/17/1998	< 0.5	1	< 0.5	1.7	< 0.5	0.57	< 0.5	< 0.5	0.66	56
	10/09/1998	< 0.5	3.4	< 0.5	3.3	< 0.5	0.79	< 0.5	< 0.5	0.81	80
1204	02/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	07/30/1996	< 1	< 1	< 1	1.8	< 1	< 1	< 1	< 1	< 1	14
	12/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.7
	02/04/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.52
	05/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	15
	01/08/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.7
1231	12/13/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.2
	11/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	86
	04/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	77
1239	05/20/1996	< 1	< 1	< 1	3	< 1	< 1	< 1	< 1	< 1	68
	11/01/1996	< 1	< 1	< 1	3.5	< 1	< 1	< 1	< 1	< 1	22
	03/05/1997	< 1	< 1	< 1	1.8	< 1	< 1	< 1	< 1	< 1	88
	09/30/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	260
	04/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	260
1240	05/20/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	190
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	98
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	110
	09/30/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	200
	04/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	240

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1244	06/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.3
	09/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1245	06/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1252	01/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	6.2
	09/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	12
1253	01/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4
	09/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10
1268	04/24/1996	< 1	< 1	< 1	< 1	< 1	9.7	< 1	< 1	< 1	15
	10/16/1996	< 1	< 1	< 1	< 1	< 1	9	< 1	< 1	< 1	25
	10/29/1996	< 1	< 1	< 1	< 1	< 1	9.1	< 1	< 1	< 1	23
	10/07/1997	< 1	< 1	< 1	< 1	< 1	7.2	< 1	< 1	< 1	35
	04/20/1998	< 1	< 1	< 1	< 1	< 1	7.2	< 1	< 1	< 1	40
	06/19/1998	< 1	< 1	< 1	< 1	< 1	1.2	< 1	< 1	< 1	1.2
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.1	< 0.5	< 0.5	< 0.5	44
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6	< 0.5	< 0.5	< 0.5	47
1272	07/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/03/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/06/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/29/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1273	07/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/03/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/29/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.7

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1277	05/24/1996	< 1	1.4	< 1	< 1	< 1	9.1	< 1	< 1	< 1	140
	10/18/1996	< 1	< 1	< 1	< 1	< 1	8	< 1	< 1	< 1	130
	10/30/1996	< 1	< 1	< 1	< 1	< 1	8.5	< 1	< 1	< 1	130
	03/07/1997	< 1	< 1	< 1	< 1	< 1	8	< 1	< 1	< 1	94
	10/09/1997	< 1	1.1	< 1	< 1	< 1	7.8	< 1	< 1	< 1	180
	04/16/1998	< 1	< 1	< 1	< 1	< 1	6	< 1	< 1	< 1	100
1278	05/24/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/07/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/09/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1282	06/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.6
	10/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3
	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.1
	03/07/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.2
	10/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.8
	04/03/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1
1283	06/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1294	01/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/04/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.67
1295	01/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/04/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1313	01/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/20/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.8
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.7

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1330	01/12/1996	< 1	< 1	< 1	< 1	< 1	3.9	< 1	1.3	< 1	81
	06/14/1996	< 1	< 1	< 1	< 1	< 1	6.7	< 1	< 1	< 1	97
	10/17/1996	< 1	1.4	< 1	< 1	< 1	6.3	< 1	< 1	< 1	130
	10/30/1996	< 1	< 1	< 1	< 1	< 1	6.3	< 1	< 1	< 1	130
	10/13/1997	< 1	< 1	< 1	< 1	< 1	4.8	< 1	< 1	< 1	69
	04/01/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1331	06/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/13/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/01/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1334	01/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/24/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/26/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1335	01/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/25/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/28/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1346	01/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.3
	08/14/1996	< 1	1.1	< 1	< 1	< 1	< 1	< 1	< 1	1.1	8.2
	08/22/1996	< 1	1.4	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.4
	12/09/1996	< 1	2.1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.6
	06/12/1997	< 1	1.9	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.8
	12/17/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.5
	08/05/1998	< 1	1.1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.6

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1347	01/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/14/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.1	< 1
	08/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.2	< 1
	12/09/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/17/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1350	01/16/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.9
	05/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.8
	09/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	5.2
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.3
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4
	10/20/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.7
	04/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.3
1351	01/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.9
	05/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	6.2
	09/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	5.8
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.7
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.8
	10/17/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.3
1352	01/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/16/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1353	01/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3
	06/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	16
	09/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	19
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	17
	03/13/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	19
	10/21/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	19
	04/02/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	36

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1354	01/12/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	43
	06/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	62
	09/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	64
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	53
	03/13/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	42
	10/21/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	44
	04/02/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.8
1355	01/12/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/19/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/13/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/21/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	04/02/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1435	07/17/1996	< 1	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	4.6
	11/27/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.1
	05/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	1.2	< 1	< 1	3.2
	01/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	1.5	< 1	< 1	5
1457	01/15/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.1
	06/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/03/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/20/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1460	07/10/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1463	09/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
1467	07/26/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	20
	11/27/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	19
	02/07/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.66	< 0.5	< 0.5	< 0.5	19
	05/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	17
	03/27/1998	< 1	2.4	< 1	< 1	< 1	< 1	< 1	< 1	< 1	51
	07/02/1998	< 1	3.9	< 1	< 1	< 1	< 1	< 1	< 1	< 1	67
1484	09/24/1996	< 1	1.4	< 1	1.6	< 1	< 1	1.8	< 1	< 1	40
	11/22/1996	< 1	1.1	< 1	1.8	< 1	< 1	< 1	< 1	< 1	47
	02/03/1997	0.94	1.5	< 0.5	2.2	< 0.5	< 0.5	1.1	< 0.5	1.2	55
	06/03/1997	< 1	1.6	< 1	1.8	< 1	< 1	< 1	< 1	< 1	46
	01/08/1998	< 1	1.3	< 1	2.1	< 1	< 1	< 1	< 1	< 1	55
	04/30/1998	< 1	3	< 1	2.2	< 1	< 1	< 1	< 1	< 1	61
3049	05/22/1998	< 1	< 1	160	8.9	< 1	400	< 1	2.1	2.8	380
3050	05/22/1998	< 1	< 1	< 1	6.3	< 1	420	< 1	< 1	2.6	370
3058	05/31/1996	1.1	63	2.8	41	< 1	200	< 1	< 1	1.6	4200
	11/01/1996	< 5	43	< 5	21	< 5	99	< 5	< 5	5.9	5300
	02/27/1997	< 5	39	< 5	21	< 5	92	< 5	< 5	< 5	4700
	10/03/1997	< 2	< 20	4	< 20	< 20	130	< 20	< 20	< 2	4500
	03/16/1998	< 2	38	4.4	36	< 2	190	< 2	< 2	< 2	780
3059	05/31/1996	< 1	< 1	< 1	< 1	< 1	25	< 1	< 1	< 1	62
	11/01/1996	< 1	< 1	< 1	< 1	< 1	22	< 1	< 1	< 1	58
	02/27/1997	< 1	< 1	1.3	< 1	< 1	65	< 1	< 1	< 1	160
	10/03/1997	< 1	< 1	< 1	< 1	< 1	9.7	< 1	< 1	< 1	36
	03/16/1998	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	< 1	28
3060	05/31/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.2
	11/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/24/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3114	07/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/14/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/25/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3124	05/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.4
	11/04/1996	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	< 1	7
	03/03/1997	< 1	< 1	< 1	< 1	< 1	1.2	< 1	< 1	< 1	5.6
	10/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1
3125	05/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.3
3126	05/30/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	11
	11/04/1996	< 1	< 1	< 1	< 1	< 1	9	< 1	< 1	< 1	71
	02/28/1997	< 1	< 1	< 1	< 1	< 1	9.9	< 1	< 1	< 1	90
	10/12/1997	< 1	< 1	< 1	< 1	< 1	8.4	< 1	< 1	< 1	93
	03/18/1998	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	< 1	120
3140	07/08/1996	< 1	< 1	< 1	< 1	< 1	3.9	< 1	< 1	< 1	1.9
	12/03/1996	< 1	< 1	< 1	< 1	< 1	4.3	< 1	< 1	< 1	2.7
	05/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/26/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3141	07/08/1996	< 1	< 1	< 1	< 1	< 1	2.5	< 1	< 1	< 1	2
	12/03/1996	< 1	< 1	< 1	< 1	< 1	2.8	< 1	< 1	< 1	1.8
	05/28/1997	< 1	< 1	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.1
	01/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/26/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3146	06/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/03/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/25/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3147	06/03/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/03/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/24/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3161	06/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/05/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/04/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/14/1997	< 1	< 1	< 1	< 1	< 1	1.2	< 1	< 1	< 1	1.7
	03/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3211	06/12/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/10/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/22/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/17/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3228	06/04/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/12/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/23/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3279	06/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/14/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3280	06/06/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/14/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3304	01/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.1
3323	05/28/1998	< 5	< 5	< 5	< 5	< 5	670	< 5	< 5	< 5	330

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3335	07/18/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/02/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/02/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/27/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3341	05/24/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.9
	10/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3342	05/29/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/07/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/05/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.7
3353	07/17/1996	< 1	8.2	< 1	11	< 1	4.7	3.6	< 1	2.4	990
	11/26/1996	< 1	7.9	< 1	10	< 1	5.5	2.7	< 1	1.1	750
	06/04/1997	< 1	< 1	1.1	2	< 1	< 1	< 1	< 1	< 1	160
	01/16/1998	< 1	< 1	< 1	1.1	< 1	< 1	< 1	< 1	< 1	72
	06/26/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	11
3403	07/17/1996	< 1	< 1	< 1	1.1	< 1	< 1	1.3	< 1	< 1	7.5
	11/25/1996	< 1	< 1	< 1	1.1	< 1	< 1	1.5	< 1	< 1	7.3
	02/05/1997	0.72	< 0.5	1.4	1.1	< 0.5	< 0.5	1.6	< 0.5	< 0.5	8.1
	06/03/1997	< 1	< 1	< 1	1.1	< 1	< 1	< 1	< 1	< 1	6.6
	01/14/1998	< 1	< 1	< 1	1.2	< 1	< 1	< 1	< 1	< 1	7.1
	05/28/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.1
3406	08/01/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/26/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/04/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/16/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/24/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3435	06/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/08/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3436	06/11/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/08/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/11/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3438	06/13/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1
	10/25/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.3
	10/27/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2
	03/20/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1
3441	06/21/1996	< 1	< 1	< 1	< 1	< 1	3.3	< 1	< 1	< 1	< 1
	10/24/1996	< 1	< 1	< 1	< 1	< 1	2.9	< 1	< 1	< 1	< 1
	10/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3442	06/13/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3448	02/10/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.9
3517	03/19/1997	< 1	< 1	< 1	21	< 1	< 1	< 1	< 1	< 1	1200
	07/07/1997	< 1	6.6	3.5	16	< 1	6.5	< 1	< 1	2.2	1100
	10/31/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.1	610
	02/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	540
3518	03/19/1997	< 1	< 1	< 1	24	< 1	70	< 1	< 1	< 1	1000
	07/07/1997	< 1	3.7	4.7	17	< 1	72	< 1	< 1	1.1	820
	10/31/1997	< 1	< 1	< 1	< 1	< 1	77	5.4	< 1	< 1	690
	02/18/1998	< 1	< 1	< 1	< 1	< 1	45	< 1	< 1	< 1	460

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
3547	11/18/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/15/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	03/17/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	07/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3552	11/14/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/23/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/03/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3553	11/13/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/23/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/02/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/27/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3555	09/25/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3556	11/12/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/25/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3592	12/18/1998	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5
30003	01/16/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/29/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/30/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/07/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.91
	12/11/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/16/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/23/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/26/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30006	01/18/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/25/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/26/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6
	12/09/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/22/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/14/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/07/1998	-	-	< 0.5	-	-	-	-	-	-	-
	07/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30008	01/23/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/24/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/25/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.4
	12/09/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.96
	01/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/18/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30009	01/24/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/23/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/25/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.2
	12/09/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/18/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30017	01/25/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/22/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/24/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
	12/10/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/20/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30018	01/25/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/22/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/22/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	28
	12/10/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/20/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30021	01/17/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/26/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/29/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/11/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.8
	12/09/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/23/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/18/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30045	01/22/1996	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/24/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/26/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/21/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	12/11/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.2
	01/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/22/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/28/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	04/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	07/17/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30050	09/12/1996	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	03/24/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	08/08/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/01/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30058	10/21/1996	< 1	< 1	< 1	< 1	< 1	6.5	< 1	< 1	< 1	68
	10/08/1997	< 1	1.2	< 1	< 1	< 1	7.1	< 1	< 1	< 1	82
	01/29/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	28
	05/05/1998	< 1	< 1	< 1	< 1	< 1	4.8	< 1	< 1	< 1	51
	10/08/1998	< 0.5	< 0.5	0.56	< 0.5	< 0.5	4.8	< 0.5	< 0.5	< 0.5	34
30059	10/21/1996	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/08/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	01/29/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/08/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30067	11/21/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	01/10/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	9.4
	04/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	8.6
	07/16/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	7
	10/31/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.8
	09/02/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.7
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.3
30076	11/20/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.1
	12/12/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.2
	01/09/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.7
	04/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6.2
	07/15/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.6
	10/31/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.5
	07/08/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	170
	09/02/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5.1
	10/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.2
	12/17/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6
30077	04/09/1997	< 5	< 5	< 5	< 5	< 5	5.8	< 5	< 5	< 5	< 5
	10/01/1997	< 1	< 1	< 1	< 1	< 1	2.5	< 1	< 1	< 1	1.8
	02/09/1998	< 1	< 1	< 1	< 1	< 1	2.8	< 1	< 1	< 1	2.3
	05/13/1998	< 1	< 1	< 1	< 1	< 1	2.6	< 1	< 1	< 1	1.6
30078	04/09/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.3
	02/09/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30079	04/09/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/29/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.2
	02/09/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.4
	05/13/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.8

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30080	04/10/1997	< 5	< 5	< 5	< 5	< 5	6.1	< 5	< 5	< 5	< 5
	09/30/1997	< 1	< 1	< 1	< 1	< 1	4.4	< 1	< 1	< 1	3.4
	02/12/1998	< 1	< 1	< 1	< 1	< 1	4.8	< 1	< 1	< 1	3.9
	05/12/1998	< 1	< 1	< 1	< 1	< 1	4.5	< 1	< 1	< 1	3
30081	04/10/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/30/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/12/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/12/1998	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	< 1	1.1
30083	04/10/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/01/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/11/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30084	04/11/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/01/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/11/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30085	04/11/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/01/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/11/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/11/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30086	04/30/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/19/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/11/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30087	05/01/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/26/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.4
	02/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.5
	05/19/1998	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	< 1	3.8

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30089	05/06/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/07/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/22/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30090	05/05/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/07/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/22/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30093	05/06/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/06/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.53	< 0.5	< 0.5	< 0.5	< 0.5
30094	05/05/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/06/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/10/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30096	07/14/1997	< 5	< 5	< 5	< 5	< 5	11	< 5	< 5	< 5	18
	10/08/1997	< 1	< 1	< 1	< 1	< 1	14	< 1	< 1	< 1	23
	06/17/1998	< 1	< 1	< 1	< 1	< 1	13	< 1	< 1	< 1	38
30097	07/14/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	10/08/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/27/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	06/17/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30105	12/19/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30106	12/19/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/07/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	12/16/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30107	01/06/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30108	12/18/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/18/1998	< 1	< 1	< 1	< 1	< 1	3.8	< 1	< 1	< 1	4
	09/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4.9	< 0.5	< 0.5	< 0.5	6.6
30110	01/27/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	04/06/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/21/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30113	01/30/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30114	01/30/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/15/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	09/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30116	01/28/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/14/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30117	01/28/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	05/14/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30120	06/16/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/21/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30121	06/16/1998	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	09/21/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30122	08/04/1998	< 5	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5
	12/17/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30123	08/04/1998	< 5	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5
	12/17/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30131	01/14/1999	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5
30132	01/14/1999	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
30133	01/14/1999	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5
30137	02/04/1999	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	7
30138	02/04/1999	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	88
31001	07/21/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	11/19/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
31002	07/21/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	11/19/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/18/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/04/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
31003	07/22/1997	< 5	< 5	< 5	< 5	< 5	23	< 5	< 5	< 5	19
	11/18/1997	< 1	< 1	< 1	< 1	< 1	28	< 1	< 1	< 1	18
	02/18/1998	< 1	< 1	< 1	< 1	< 1	19	< 1	< 1	< 1	15
	05/05/1998	< 1	< 1	< 1	< 1	< 1	18	< 1	< 1	< 1	13
31004	07/22/1997	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
	11/18/1997	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	02/17/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	05/05/1998	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
STSW-04C	04/12/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	13	< 0.5	< 1	< 0.5	3.2
	09/30/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	14	< 0.5	< 1	< 0.5	4.7
	02/11/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	10	< 0.5	< 1	< 0.5	4.2
	05/02/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	8.3	< 0.24	< 0.1	< 0.2	4.9
	10/03/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	9.2	< 0.24	< 0.1	< 0.2	7
	05/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.5	< 0.5	< 0.5	< 0.5	3.2
	11/12/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	12.1	< 0.5	< 0.5	< 0.5	17.8
STSW-08B	05/01/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	09/19/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	02/05/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	05/14/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	1.1	< 0.1	< 0.2	0.99
	11/30/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-19
SUMMARY OF DETECTS - VOC ANALYSES
LAYER C - JANUARY 1996 TO DECEMBER 1998

Well Number	Sample Date	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Carbon Tetrachloride (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)
STSW-28A	03/13/1996	< 0.12	< 0.066	< 0.042	< 0.048	< 0.06	< 0.041	0.36	< 0.08	< 0.046	< 0.11
	04/05/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	10/01/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	01/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	04/30/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16
	10/03/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16
	05/18/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/10/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-28B	03/12/1996	< 0.12	< 0.066	< 0.042	< 0.048	< 0.06	< 0.041	0.34	< 0.08	< 0.046	< 0.11
	04/04/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	1.1
	09/30/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	1.1
	01/24/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	1.4
	04/30/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	0.82
	10/03/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	1.4
	05/15/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6	< 0.5	< 0.5	< 0.5	1.7
	11/10/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.6	< 0.5	< 0.5	< 0.5	2.1
STSW-29B	10/02/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	< 0.5	< 1	< 0.5	3
	01/17/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.3	< 0.5	< 1	< 0.5	3
	05/08/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	1.6	< 0.24	< 0.1	< 0.2	5.4
	10/13/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	2.6
	11/25/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1	< 0.5	< 0.5	< 0.5	1.9
STSW-30A	10/03/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	40
	01/21/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	22
	05/09/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	0.82
	10/14/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	17
	11/24/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	9.5
STSW-30B	10/03/1996	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	01/20/1997	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5
	05/09/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16
	10/14/1997	< 0.18	< 0.29	< 0.11	< 0.14	< 0.26	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16
	11/24/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STS51B	09/01/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.88
	11/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1
STS52B	08/31/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.56	< 0.5	< 0.5	< 0.5	1.64
	11/13/1998	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.68	< 0.5	< 0.5	< 0.5	1.68

Note: (-) Equals not analyzed

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
124	3/23/99	700
127	5/16/97	1500
134	5/16/97	7200
135	5/15/97	6400
138	3/14/97	< 400
227	5/20/98	1200
228	5/20/98	1000
236	12/18/96	2000
292	1/8/98	820
	5/21/98	770
293	1/8/98	240
	5/21/98	260
306	9/12/97	260
	3/25/98	130
357	11/24/97	< 4
	3/27/98	< 4
399	3/30/98	< 4
420	2/3/97	< 400
	5/21/97	< 400
	5/20/98	5.7
437	5/22/97	< 400
438	5/22/97	< 400
447	5/28/97	920
1169	2/5/97	< 400
	7/25/97	< 400
	10/3/97	< 4
	1/19/98	6.4
	6/23/98	5.8
	7/17/98	7.3
1204	2/4/97	< 400
	5/27/97	210[1]
1205	5/7/98	8.3
1231	11/11/97	880
	4/10/98	2000
1239	3/5/97	< 400
	9/30/97	2400
	4/13/98	2200
1240	3/5/97	1700
	9/30/97	2900
	4/13/98	2900
1244	3/5/97	< 400
1245	3/5/97	< 400
1252	1/2/96	< 400
	9/6/96	< 400
1253	1/2/96	< 400
	9/6/96	< 400

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
1268	4/24/96	1600
	10/16/96	1800
	10/7/97	1700
	4/20/98	1800
	6/19/98	1600
	12/16/98	1500
1277	10/18/96	2700
	3/7/97	2400
	10/9/97	4100
	4/16/98	2700
1278	10/17/96	< 400
	3/7/97	< 400
	10/9/97	< 4
	4/16/98	< 4
1282	10/15/96	530
	3/7/97	< 400
	10/10/97	90
	4/3/98	70
1283	3/11/97	< 400
	10/10/97	5.8
	4/3/98	< 4
1294	1/4/96	400
	10/15/96	< 400
	2/4/97	< 400
	10/14/97	190
	4/10/98	97
	12/15/98	130
1295	1/4/96	< 400
	10/11/96	< 400
	2/4/97	< 400
	10/14/97	< 4
	4/10/98	< 4
	12/15/98	< 4
1313	1/11/96	< 400
	8/20/96	< 400
	12/11/98	9.4
1330	1/12/96	< 400
	10/17/96	2100
1334	1/17/96	< 400
	8/26/96	< 400
	3/10/97	< 400
1335	1/17/96	< 400
	8/28/96	< 400
	3/10/97	< 400

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
1346	1/18/96	< 400
	8/22/96	< 400
	6/12/97	< 400
	12/17/97	32
	8/5/98	33
1347	1/18/96	< 400
	8/21/96	< 400
	6/12/97	< 400
	12/17/97	< 4
	8/5/98	< 4
1350	1/16/96	< 400
	9/4/96	< 400
	3/11/97	< 400
	3/11/97	< 400
1351	1/15/96	< 400
	9/4/96	< 400
	3/11/97	< 400
1352	1/15/96	< 400
	9/4/96	< 400
	3/11/97	< 400
1353	1/15/96	720
	9/5/96	1300
	3/13/97	1300
1354	1/12/96	2900
	9/6/96	2800
	3/13/97	2300
1355	1/12/96	< 400
	9/6/96	< 400
	3/13/97	< 400
1435	5/27/97	< 400
	4/21/98	11
1457	1/15/96	< 400
	9/3/96	< 400
	3/12/97	< 400
1460	5/29/97	490
	5/4/98	540
1463	9/24/97	2000
1467	2/7/97	< 400
	5/29/97	< 400
	3/27/98	110
	7/2/98	160
1484	2/3/97	< 400
	6/3/97	< 400
	1/8/98	24
	4/30/98	17

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
3049	5/22/98	3600
3114	5/28/97	< 400
3140	5/29/97	2000
	3/24/99	1200
3141	5/28/97	2300
3211	3/10/97	7300
3228	3/12/97	7400
3279	3/14/97	7400
3280	3/14/97	7500
3304	1/15/98	< 4
3323	5/28/98	2000
3335	7/18/96	810
	12/2/96	1000
	6/2/97	680
3341	10/24/97	< 4
	3/18/98	< 4
3342	10/24/97	< 4
	3/18/98	< 4
3353	6/4/97	< 400
	1/16/98	24
	6/26/98	16
3403	2/5/97	< 400
	6/3/97	8.1
	1/14/98	8.6
	5/28/98	9.5
3406	6/4/97	< 400
	1/16/98	82
3435	3/10/97	7600
3436	3/11/97	7800
3438	10/27/97	5900
	3/20/98	5500
3441	10/29/97	5.5
	3/19/98	< 4
3442	10/29/97	< 4
	3/19/98	< 4
3448	2/10/97	< 400
3517	3/19/97	540
	7/7/97	470
	10/31/97	310
	2/18/98	270
3518	3/19/97	410
	7/7/97	< 400
	10/31/97	420
	2/18/98	300
3547	11/18/96	3200
	9/15/97	4200
	7/15/98	5500

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
3552	11/14/96	7100
	9/23/97	5800
	2/3/98	7200
3553	11/13/96	8100
	9/23/97	7000
	2/2/98	140
3555	6/3/97	6000
	9/25/97	7000
	2/4/98	6900
3556	11/12/96	8000
	9/25/97	5900
	2/4/98	7200
3592	12/18/98	4000
30003	1/16/97	< 400
	4/23/97	< 400
	7/16/97	< 400
	10/30/97	< 4
	1/30/98	< 4
	4/13/98	< 4
	7/14/98	< 4
	10/26/98	< 4
30006	1/21/97	< 400
	4/22/97	< 400
	7/17/97	< 400
	10/29/97	< 4
	1/30/98	< 4
	4/14/98	< 4
	7/15/98	< 4
	10/28/98	< 4
30008	1/17/97	< 400
	4/21/97	< 400
	7/18/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/15/98	< 4
	7/15/98	< 4
	10/28/98	< 4
30009	1/17/97	< 400
	4/21/97	< 400
	7/18/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/15/98	< 4
	7/15/98	< 4
	10/28/98	< 4

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30017	1/20/97	< 400
	4/21/97	< 400
	7/17/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/16/98	< 4
	7/16/98	< 4
	10/29/98	< 4
30018	1/20/97	< 400
	4/21/97	< 400
	7/17/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/16/98	< 4
	7/16/98	< 4
	10/29/98	< 4
30021	1/15/97	< 400
	4/23/97	< 400
	7/18/97	< 400
	10/28/97	< 4
	1/28/98	< 4
	4/13/98	< 4
	7/15/98	< 4
	10/27/98	< 4
30045	1/17/97	< 400
	4/22/97	< 400
	7/17/97	< 400
	10/28/97	< 4
	1/28/98	< 4
	4/16/98	< 4
	7/17/98	< 4
	10/27/98	< 4
30050	9/12/96	540
	3/24/97	510
	8/8/97	540
	11/14/97	720
	5/1/98	560
30058	10/21/96	1100
	10/8/97	1100
	1/29/98	2400
	5/5/98	1600
	10/8/98	600

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30059	10/21/96	< 400
	10/8/97	< 4
	1/29/98	< 4
	5/5/98	< 4
	10/8/98	< 4
30067	11/21/96	< 400
	1/10/97	< 400
	4/24/97	< 400
	7/16/97	400
	10/31/97	440
	9/2/98	390
	10/30/98	320
	12/11/98	330
30076	11/20/96	< 400
	1/9/97	< 400
	4/24/97	< 400
	7/15/97	< 400
	10/31/97	270
	9/2/98	150
	10/30/98	170
	12/17/98	180
30077	4/9/97	3700
	10/1/97	2700
	2/9/98	3000
	5/13/98	2800
30078	4/9/97	1200
	9/29/97	1400
	2/9/98	1200
	5/13/98	1200
30079	4/9/97	< 400
	9/29/97	160
	2/9/98	180
	5/13/98	180
30080	4/10/97	6700
	9/30/97	7700
	2/12/98	7500
	5/12/98	7200
30081	4/10/97	7700
	9/30/97	8700
	2/12/98	7600
	5/12/98	8000

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30083	4/10/97	6500
	10/1/97	7200
	2/11/98	7300
	5/18/98	6100
30084	4/11/97	8100
	10/1/97	8300
	2/11/98	8600
	5/18/98	7500
30085	4/11/97	5400
	10/1/97	6400
	2/11/98	6100
	5/18/98	5200
30086	4/30/97	< 400
	9/26/97	73
	2/10/98	39
	5/19/98	14
	12/11/98	7.9
30087	5/1/97	500
	9/26/97	590
	2/10/98	1100
30089	5/6/97	< 400
	10/7/97	7.4
	2/5/98	7.2
	6/22/98	< 4
	12/16/98	< 4
30090	5/5/97	< 400
	10/7/97	4
	2/5/98	< 4
	6/22/98	4.9
	12/16/98	13
30093	5/6/97	< 400
	10/6/97	24
	2/10/98	27
	12/15/98	58
30094	5/5/97	< 400
	10/6/97	< 4
	2/10/98	< 4
	12/15/98	< 4
30096	7/14/97	1800
	10/8/97	1600
	2/27/98	2200
	6/17/98	2600
30097	7/14/97	< 400
	10/8/97	< 4
	2/27/98	< 4

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
30105	12/19/97	< 4
	5/7/98	< 4
	9/16/98	23
	12/16/98	46
30106	12/19/97	4
	5/7/98	4
	9/16/98	15
	12/16/98	25
30107	1/6/98	11
	5/18/98	87
30108	12/18/97	310
	5/18/98	680
	9/15/98	1200
30110	1/27/98	4700
	4/6/98	6000
	9/21/98	6900
30113	1/30/98	4.9
	5/15/98	20
	9/18/98	77
	1/12/99	100
30114	1/30/98	< 4
	5/15/98	< 4
	9/18/98	4.5
	1/12/99	4.9
30116	1/28/98	< 4
	5/14/98	< 4
30117	1/28/98	< 4
	5/14/98	< 4
30120	9/21/98	67
30121	6/16/98	17
	9/21/98	19
30122	8/4/98	< 4
	12/17/98	< 4
30123	8/4/98	< 4
	12/17/98	< 4
30131	1/14/99	< 4
30132	1/14/99	5.2
30133	1/14/99	< 4
30137	2/4/99	400
30138	2/4/99	340
31001	7/21/97	< 400
	11/19/97	16
	2/18/98	11
	5/4/98	8.7

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-20
SUMMARY OF PERCHLORATE ANALYSES
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
31002	7/21/97	< 400
	11/19/97	21
	2/18/98	81
	5/4/98	69
31003	7/22/97	4300
	11/18/97	4300
	2/18/98	5300
	5/5/98	5500
31004	7/22/97	< 400
	11/18/97	7.1
	2/17/98	10
	5/5/98	14

Note: (-) Equals not analyzed
(1) Data reported between PQL and MDL

TABLE A-21
SUMMARY OF NDMA ANALYSES
LAYER C - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
61	5/11/98	0.041
64	5/19/98	< 0.0075
104	7/7/98	< 0.0075
170	5/20/98	0.17
227	5/20/98	< 0.0075
228	5/20/98	< 0.0075
287	5/21/98	< 0.0075
289	5/21/98	< 0.0075
292	5/21/98	< 0.0075
293	5/21/98	< 0.0075
420	5/20/98	0.25
1169	4/29/98	< 0.0075
1204	3/10/99	0.037
1212	7/13/98	< 0.0075
1435	4/30/98	0.39
1460	5/4/98	0.16
1463	5/5/98	< 0.0075
	6/15/98	< 0.0075
1467	7/16/98	0.016
1484	4/30/98	0.25
3018	7/9/98	0.024
3049	5/22/98	< 0.0075
3050	5/22/98	< 0.0075
3082	5/22/98	< 0.0075
3083	5/22/98	0.21
3304	5/26/98	< 0.0075
3323	5/28/98	< 0.0075
3335	5/27/98	0.16
3403	5/28/98	0.25
3447	6/4/98	0.081
3448	6/4/98	< 0.0075
3453	7/10/98	< 0.0075
3552	5/27/98	< 0.0075
3553	5/27/98	< 0.0075
3555	5/27/98	< 0.0075
3556	5/27/98	< 0.0075
3592	12/18/98	< 0.0075
30003	7/14/98	< 0.0075
	10/26/98	< 0.0075
	1/13/99	< 0.0075
	3/23/99	< 0.0075

TABLE A-21
SUMMARY OF NDMA ANALYSES
LAYER C - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
30006	7/15/98	< 0.0075
	10/28/98	< 0.0075
30008	10/28/98	< 0.0075
30009	7/15/98	< 0.0075
	10/28/98	< 0.0075
30017	7/16/98	< 0.0075
	10/29/98	< 0.0075
30018	7/16/98	< 0.0075
	10/29/98	< 0.0075
30021	7/15/98	< 0.0075
	10/27/98	< 0.0075
	1/13/99	< 0.0075
	3/23/99	< 0.0075
30045	7/17/98	< 0.0075
	10/27/98	< 0.0075
30050	5/1/98	0.13
30067	9/2/98	0.17
	10/30/98	0.2
	12/11/98	0.18
	3/23/99	0.16
30076	9/2/98	0.12
	10/30/98	0.16
	12/17/98	0.15
	3/23/99	0.14
30077	5/13/98	0.1
30078	5/13/98	0.061
30079	5/13/98	< 0.0075
30083	5/18/98	< 0.0075
30084	5/18/98	< 0.0075
30085	5/18/98	< 0.0075
30086	5/19/98	< 0.0075
	12/11/98	< 0.0075
	3/17/99	< 0.0075
30087	5/19/98	0.034
30089	12/16/98	< 0.0075
30090	12/16/98	< 0.0075
30105	12/16/98	< 0.0075
30106	12/16/98	< 0.0075
30110	5/6/98	< 0.0075
30113	1/12/99	< 0.0075
30114	1/12/99	< 0.0075
30120	6/16/98	< 0.0075
30121	6/16/98	< 0.0075

TABLE A-21
SUMMARY OF NDMA ANALYSES
LAYER C - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
30122	8/4/98	< 0.0075
	12/17/98	< 0.0075
	3/16/99	< 0.0075
30123	8/4/98	< 0.0075
	12/17/98	< 0.0075
	3/16/99	< 0.0075
30131	1/14/99	< 0.0075
30132	1/14/99	< 0.0075
30133	1/14/99	< 0.0075
30137	2/4/99	0.14
30138	2/4/99	0.024
31001	5/6/98	< 0.0075
31002	5/6/98	< 0.0075
31003	5/5/98	< 0.0075
31004	5/5/98	< 0.0075

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	SITE: / DATE:	420 2/3/97	1169 1/5/96	1169 2/5/97	1169 7/25/97	1169 7/17/98	1204 2/4/97	1330 1/12/96	1484 2/3/97	3403 2/5/97	3517 3/19/97	3518 3/19/97	3547 11/18/96
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	(ppb)	-	-	-	-	< 10	-	-	-	-	-	-	-
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: (-) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	SITE: / DATE:	420 2/3/97	1169 1/5/96	1169 2/5/97	1169 7/25/97	1169 7/17/98	1204 2/4/97	1330 1/12/96	1484 2/3/97	3403 2/5/97	3517 3/19/97	3518 3/19/97	3547 11/18/96
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	150	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	3552 11/14/96	3553 11/13/96	3556 11/12/96	3592 12/18/98	30003 1/16/97	30050 9/12/96	30058 1/29/98	30059 1/29/98	30067 11/21/96	30076 11/20/96	30076 1/9/97	30077 4/9/97
1,2,4-Trichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	< 10	< 10	< 10	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	-	-	-	< 10	-	-	-	-	-	-	-	-
4-Chlorophenyl phenyl ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	3552 11/14/96	3553 11/13/96	3556 11/12/96	3592 12/18/98	30003 1/16/97	30050 9/12/96	30058 1/29/98	30059 1/29/98	30067 11/21/96	30076 11/20/96	30076 1/9/97	30077 4/9/97
Dimethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	< 20	< 20	< 20	< 10	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30078 4/9/97	30079 4/9/97	30080 4/10/97	30081 4/10/97	30083 4/10/97	30084 4/11/97	30085 4/11/97	30086 4/30/97	30087 5/1/97	30089 5/6/97	30090 5/5/97	30093 5/6/97	30094 5/5/97	30096 7/14/97
1,2,4-Trichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Chlorophenyl phenyl ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Note: ( ) Equals not analyzed

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30078 4/9/97	30079 4/9/97	30080 4/10/97	30081 4/10/97	30083 4/10/97	30084 4/11/97	30085 4/11/97	30086 4/30/97	30087 5/1/97	30089 5/6/97	30090 5/5/97	30093 5/6/97	30094 5/5/97	30096 7/14/97
Dimethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30097 7/14/97	30105 12/19/97	30105 12/16/98	30106 12/19/97	30106 12/16/98	30107 1/6/98	30108 12/18/97	30110 1/27/98	30113 1/30/98	30114 1/30/98	30116 1/28/98
1,2,4-Trichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	< 10	< 10	-	< 10	-	< 10	< 10	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	-	-	< 10	-	< 10	-	-	-	-	-	< -
4-Chlorophenyl phenyl ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30097 7/14/97	30105 12/19/97	30105 12/16/98	30106 12/19/97	30106 12/16/98	30107 1/6/98	30108 12/18/97	30110 1/27/98	30113 1/30/98	30114 1/30/98	30116 1/28/98
Dimethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	< 20	< 20	< 10	< 20	< 10	< 20	< 20	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30117 1/28/98	30120 6/16/98	30121 6/16/98	30122 8/4/98	30122 12/17/98	30123 8/4/98	30123 12/17/98	30133 1/14/99	30137 2/4/99	30138 2/4/99	31001 7/21/97	31002 7/21/97	31003 7/22/97	31004 7/22/97
1,2,4-Trichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	< 10	< 10	< 10	-	-	-	-	-	-	-	< 10	< 10	< 10	< 10
4-Bromophenyl phenyl ether	-	-	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	-	-	-
4-Chlorophenyl phenyl ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzofuran	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-22
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT:	30117 1/28/98	30120 6/16/98	30121 6/16/98	30122 8/4/98	30122 12/17/98	30123 8/4/98	30123 12/17/98	30133 1/14/99	30137 2/4/99	30138 2/4/99	31001 7/21/97	31002 7/21/97	31003 7/22/97	31004 7/22/97
Dimethyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	< 20	< 20	< 20	< 20	< 10	< 20	< 10	< 10	< 10	< 10	< 20	< 20	< 20	< 20
Di-n-octyl phthalate	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-Benzenesulfonamide	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE:	3517	3518	3547	3552	3553	3556	3592	30008	30009	30058	30059	30067
(Units in mg/l) DATE:	3/19/97	3/19/97	11/18/96	11/14/96	11/13/96	11/12/96	12/18/98	7/7/98	7/7/98	1/29/98	1/29/98	11/21/96
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.05	-	< 0.2	< 0.2	< 0.2
Antimony	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.2	-	-	< 0.2	< 0.2	< 0.24
Arsenic	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.02	-	< 0.08	< 0.08	< 0.08
Barium	0.1	0.1	0.044	0.065	0.082	0.082	0.057	0.061	-	0.1	0.052	0.014
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.00025	< 0.001	< 0.001	< 0.001
Boron	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-	-	< 0.04	< 0.04	< 0.04
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	-	-	< 0.004	< 0.004	< 0.004
Calcium	24	25	35	26	29	29	32	-	-	18	14	20
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	-	-	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	-	-	< 0.008	< 0.008	< 0.008
Copper	< 0.006	< 0.006	< 0.006	0.0065	< 0.006	< 0.006	< 0.006	-	-	< 0.006	< 0.006	< 0.006
Iron	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	-	-	< 0.3	0.61	< 0.3
Lead	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	-	-	< 0.06	< 0.06	< 0.06
Magnesium	12	12	3.5	14	15	11	8.4	-	-	11	8.1	0.26
Manganese	< 0.005	< 0.005	< 0.005	0.013	< 0.005	< 0.005	< 0.005	-	-	0.0076	0.08	< 0.005
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-	-	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	-	< 0.02	< 0.02	< 0.02
Potassium	2.9	3.1	6	2.8	1.9	2.4	5	-	-	3.1	2.9	14
Selenium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-	-	< 0.1	< 0.1	< 0.1
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	-	< 0.02	< 0.02	< 0.02
Sodium	12	12	17	12	13	16	14	-	-	10	9.6	81
Thallium	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-	-	< 0.05	< 0.05	< 0.05
Vanadium	0.0067	0.0061	0.022	0.0078	0.0095	0.0099	0.014	-	-	0.0091	< 0.006	0.012
Zinc	< 0.1	< 0.1	< 0.1	0.4	< 0.1	< 0.1	< 0.1	-	-	0.16	0.11	< 0.1

Note: (-) Equals not analyzed

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE:	30067	30067	30076	30076	30077	30078	30079	30080	30081	30083	30084	30085	30086
(Units in mg/l) DATE:	7/8/98	12/11/98	11/20/96	12/17/98	4/9/97	4/9/97	4/9/97	4/10/97	4/10/97	4/10/97	4/11/97	4/11/97	4/30/97
Aluminum	-	< 0.05	< 0.2	< 0.05	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	-	< 0.05	< 0.24	< 0.05	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24
Arsenic	-	< 0.02	< 0.08	< 0.02	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	-	0.089	0.0063	0.12	0.089	0.078	0.1	0.081	0.097	0.081	0.094	0.068	0.067
Beryllium	-	< 0.00025	< 0.001	< 0.00025	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	-	0.012	< 0.04	0.014	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	-	< 0.001	< 0.004	< 0.001	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	-	24	2.7	29	26	27	54	28	27	26	29	25	18
Chromium	-	< 0.002	< 0.008	< 0.002	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	-	< 0.002	< 0.008	< 0.002	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	-	0.0021	< 0.006	< 0.0015	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	-	< 0.075	< 0.3	< 0.075	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	-	< 0.015	< 0.06	< 0.015	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	-	9.1	0.49	12	13	11	5.1	13	16	15	15	14	8.7
Manganese	-	< 0.0012	< 0.005	< 0.0012	0.01	0.0063	< 0.005	0.0052	0.0099	0.0058	< 0.005	0.016	< 0.005
Molybdenum	-	< 0.01	< 0.04	< 0.01	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.005	< 0.005	< 0.02	< 0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	-	2.7	16	2.8	2.2	3.4	14	4.8	3.1	2.8	4	3.1	8.8
Selenium	-	< 0.025	< 0.1	< 0.025	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	-	< 0.005	< 0.02	< 0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	-	11	54	11	12	12	21	15	13	13	13	13	20
Thallium	-	< 0.012	< 0.05	< 0.012	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	-	0.0047	< 0.005	0.0051	0.0066	0.0071	0.0088	0.0083	0.0081	0.0073	0.0099	0.0096	0.0079
Zinc	-	< 0.025	< 0.1	< 0.025	0.23	< 0.1	< 0.1	0.14	0.4	0.34	0.16	0.37	0.1

Note: (-) Equals not analyzed

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE:	30086	30087	30089	30089	30090	30090	30093	30094	30096	30097	30105	30106	30107
(Units in mg/l) DATE:	12/11/98	5/1/97	5/6/97	12/16/98	5/5/97	12/16/98	5/6/97	5/5/97	7/14/97	7/14/97	12/19/97	12/19/97	1/6/98
Aluminum	< 0.05	< 0.2	< 0.2	< 0.05	< 0.2	< 0.05	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.05	< 0.24	< 0.24	< 0.05	< 0.24	< 0.05	< 0.24	< 0.24	< 0.24	< 0.24	< 0.2	< 0.2	< 0.2
Arsenic	< 0.02	< 0.08	< 0.08	< 0.02	< 0.08	< 0.02	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.1	0.074	0.034	0.028	0.05	0.041	0.051	0.033	0.028	0.032	0.063	< 0.006	0.057
Beryllium	< 0.00025	< 0.001	< 0.001	< 0.00025	< 0.001	< 0.00025	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	< 0.01	< 0.04	< 0.04	0.015	< 0.04	0.01	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	< 0.001	< 0.004	< 0.004	< 0.001	< 0.004	< 0.001	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	25	23	28	15	24	14	20	23	15	20	19	0.19	21
Chromium	< 0.002	< 0.008	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.002	< 0.008	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.0015	< 0.006	< 0.006	< 0.0015	< 0.006	< 0.0015	< 0.006	< 0.006	0.006	< 0.006	0.0067	< 0.006	< 0.006
Iron	< 0.075	< 0.3	< 0.3	< 0.075	< 0.3	< 0.075	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	< 0.015	< 0.06	< 0.06	< 0.015	< 0.06	< 0.015	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	9.5	10	0.52	2.5	2.3	4.2	7.2	4.2	9.2	2.4	9.5	< 0.05	8.3
Manganese	< 0.0012	0.0078	< 0.005	< 0.0012	< 0.005	0.0042	< 0.005	< 0.005	0.0055	< 0.005	0.0067	< 0.005	< 0.005
Molybdenum	< 0.01	< 0.04	< 0.04	< 0.01	< 0.04	< 0.01	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.005	< 0.02	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	3.2	4.6	10	2.6	5.8	2.2	3.1	3.6	2	5.5	3.5	< 2	2.5
Selenium	< 0.025	< 0.1	< 0.1	< 0.025	< 0.1	< 0.025	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.005	< 0.02	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	13	13	24	8.2	19	8.8	14	11	9.7	12	12	< 0.8	13
Thallium	< 0.012	< 0.05	< 0.05	< 0.012	< 0.05	< 0.012	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	0.006	0.0081	0.019	0.011	0.016	0.011	0.014	0.011	0.013	0.021	0.011	< 0.006	0.011
Zinc	< 0.025	0.1	< 0.1	< 0.025	< 0.1	< 0.025	< 0.1	0.15	0.31	< 0.1	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE:	30108	30110	30113	30114	30116	30117	30120	30121	30122	30123	30133	30137	30138
(Units in mg/l) DATE:	12/18/97	1/27/98	1/30/98	1/30/98	1/28/98	1/28/98	6/16/98	6/16/98	8/4/98	8/4/98	1/14/99	2/4/99	2/4/99
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Arsenic	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.076	0.068	0.044	0.043	0.044	0.045	0.03	0.059	0.046	0.091	0.06	0.089	0.091
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	21	27	20	18	21	20	12	19	19	28	20	28	39
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.006	< 0.006	0.01	0.0082	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	10	8.3	10	7.1	0.88	4.9	4	3.3	6.7	11	7.5	11	6.4
Manganese	< 0.005	< 0.005	0.011	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.025	0.095	0.016	0.0069	< 0.005
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	4.1	4.7	3.1	2.9	< 4.3	3.6	2.6	3.6	6.6	7	4.9	2.7	8
Selenium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	12	18	10	13	18	10	10	17	18	16	16	15	24
Thallium	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	0.012	0.018	0.0079	0.015	< 0.02	0.015	0.015	0.022	< 0.006	< 0.006	0.0093	< 0.006	0.0074
Zinc	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.21	< 0.1	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-23
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER C - JANUARY 1996 TO DECEMBER 1998

CONSTITUENT: SITE:	31001	31002	31003	31004
(Units in mg/l) DATE:	7/21/97	7/21/97	7/22/97	7/22/97
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.24	< 0.24	< 0.24	< 0.24
Arsenic	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.078	0.075	0.095	0.049
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001
Boron	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	22	23	23	15
Chromium	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.006	< 0.006	< 0.006	< 0.006
Iron	< 0.3	< 0.3	< 0.3	< 0.3
Lead	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	9.6	8.9	11	7.7
Manganese	< 0.005	< 0.005	< 0.005	0.0087
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	3.5	4.3	3	3.6
Selenium	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	12	13	12	10
Thallium	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	0.0095	0.011	0.011	0.009
Zinc	< 0.1	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-24
SUMMARY OF ANION ANALYSES (EPA 300)
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Chloride (mg/l)	Fluoride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
3517	3/19/97	5.8	-	6.3	< 0.05	12
3518	3/19/97	5.5	-	6.6	< 0.05	14
3547	11/18/96	9.5	-	7	< 0.05	9.8
3552	11/14/96	9.8	-	7.8	< 0.05	13
3553	11/13/96	11	-	7.3	< 0.05	17
3556	11/12/96	11	-	7.2	< 0.15	17
3592	12/18/98	23	-	6	0.08	9.8
30050	9/12/96	6.4	-	6.4	< 0.05	11
30058	1/29/98	8.9	-	5.4	< 0.05	4.4
30059	1/29/98	9.4	-	0.25	< 0.05	15
30067	11/21/96	60	-	4.7	2.1	62
30076	11/20/96	8.3	-	0.89	2.6	21
30077	4/9/97	8.8	-	7.2	< 0.05	13
30078	4/9/97	7.5	-	7.5	< 0.05	10
30079	4/9/97	86	-	7.7	< 0.05	8.2
30080	4/10/97	15	-	7.6	< 0.05	15
30081	4/10/97	13	-	7.7	< 0.05	16
30083	4/10/97	22	-	8.1	< 0.05	15
30084	4/11/97	14	-	7.9	< 0.5	18
30085	4/11/97	11	-	6.9	< 0.5	13
30086	4/30/97	5.7	-	7.4	0.07	7.9
30087	5/1/97	8.2	-	7.9	< 0.05	9.5
30089	5/6/97	3.1	-	7.5	0.16	5
30090	5/5/97	26	-	7.9	< 0.5	6.1
30093	5/6/97	9.2	-	5	< 0.15	6.3
30094	5/5/97	11	-	0.16	< 0.05	5.7
30096	7/14/97	6	-	7.6	< 0.05	4.7
30097	7/14/97	5.2	-	6.5	< 0.05	6.7
30107	1/6/98	6.4	-	12	< 0.05	5.1
30110	1/27/98	11	-	6.8	< 0.25	13
30113	1/30/98	4.2	-	7.2	< 0.25	6.6
30114	1/30/98	6.6	-	8.1	0.07	7.8
30116	1/28/98	9.1	-	8.2	0.16	2.8

TABLE A-24
SUMMARY OF ANION ANALYSES (EPA 300)
LAYER C - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Chloride (mg/l)	Fluoride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
30117	1/28/98	7.4	-	9.8	< 0.5	3.7
30120	6/16/98	4.2	-	12	< 0.15	2
30121	6/16/98	8.6	-	9.5	0.097	4.6
30131	1/14/99	20	-	5.6	0.063	13
30132	1/14/99	10	-	5.1	< 0.25	16
30133	1/14/99	5.3	-	2.7	< 0.05	9.6
30137	2/4/99	6.5	-	7.4	0.06	12
30138	2/4/99	57	-	5.8	< 0.05	8.9
31001	7/21/97	5.5	-	7.1	< 0.05	10
31002	7/21/97	4.9	-	7.3	< 0.05	10
31003	7/22/97	12	-	7.5	< 0.05	11
31004	7/22/97	5.2	-	3.9	< 0.05	4.8

Notes: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
88	5/31/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/27/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
128	6/26/96	< 1	< 1	1.9	< 1	2.6	5	< 1	< 1	< 1	280	< 1
	11/15/96	< 1	< 1	1.6	< 1	2.6	5.8	< 1	< 1	< 1	200	< 1
	5/16/97	< 1	< 1	< 1	< 1	2.3	5.2	< 1	< 1	< 1	170	< 1
	1/6/98	< 1	< 1	< 1	< 1	< 1	4.4	< 1	< 1	< 1	110	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1	3.7	< 1	< 1	< 1	85	< 1
136	6/27/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
137	6/27/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
140	6/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/15/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
172	7/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/20/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/5/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
358	4/2/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/9/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/15/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	10/27/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	11/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/27/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/14/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	7/7/98	< 0.5	-	-	-	-	-	-	-	4.1	-	-
	10/28/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
401	5/17/96	< 1	< 1	< 1	< 1	< 1	18	< 1	< 1	< 1	91	< 1
	10/28/96	< 1	< 1	< 1	1.2	< 1	23	< 1	< 1	< 1	100	< 1
	2/26/97	< 1	< 1	< 1	1.3	< 1	26	< 1	< 1	< 1	120	< 1
	9/25/97	< 1	< 1	< 1	< 1	< 1	2.9	< 1	< 1	< 1	22	< 1
	3/30/98	< 1	< 1	< 1	1.2	< 1	47	< 1	< 1	< 1	200	< 1
402	5/17/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/25/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/30/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
421	6/28/96	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	33	< 1
	11/20/96	< 1	< 1	< 1	< 1	< 1	< 1	1.7	< 1	< 1	28	< 1
	2/3/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.57	1.4	< 0.5	0.69	29	< 0.5
	5/23/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	22	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1	< 1	1.7	< 1	< 1	20	< 1
422	6/27/96	< 1	< 1	< 1	< 1	< 1	< 1	1.8	< 1	< 1	6.9	< 1
	11/19/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	5.5	< 1
	2/3/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.68	1.9	< 0.5	0.6	8.3	< 0.5
	5/23/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	6.9	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1	< 1	2.7	< 1	< 1	7	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
439	6/28/96	< 1	< 1	7.2	< 1	14	5.3	3.6	< 1	1.3	870	< 1
	11/20/96	< 1	< 1	8.6	< 1	15	4.4	2.9	< 1	2.3	1000	< 1
	5/21/97	< 1	< 1	7.2	< 1	14	4.2	3.6	< 1	1.6	860	< 1
	1/7/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	690	< 1
	6/26/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	570	< 1
446	6/28/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	11	< 1
	11/19/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	12	< 1
	5/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.8	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.6	< 1
	6/23/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4	< 1
476	7/1/96	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	< 1	54	< 1
	11/21/96	< 1	< 1	< 1	< 1	< 1	1.9	< 1	< 1	< 1	50	< 1
	5/21/97	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	33	< 1
	1/19/98	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	< 1	23	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1	1.4	< 1	< 1	< 1	19	< 1
1206	2/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	7/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/22/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/7/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1232	9/9/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/10/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1269	4/23/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/1/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/7/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1270	4/23/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/1/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/7/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
1274	7/19/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/2/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/6/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.5	< 1
	6/29/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1
1279	10/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1284	6/17/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/31/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1296	1/4/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/11/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1314	1/11/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	8/20/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1332	6/14/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/13/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/1/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1336	6/24/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/1/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1348	6/6/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1356	6/20/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
1436	7/9/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	14	< 1
	11/27/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	12	< 1
	5/23/97	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	11	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1	< 1	1.4	< 1	< 1	8.4	< 1
	4/30/98	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1	< 1	8.4	< 1
1458	1/16/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/20/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/20/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/9/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1461	7/9/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	12	< 1
	12/2/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	15	< 1
	5/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.8	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.2	< 1
	5/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	8.5	< 1
1464	9/24/97	< 1	< 1	< 1	< 1	< 1	0.81	< 1	< 1	< 1	2.3	< 1
1465	9/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1485	7/26/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/22/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/4/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	6/2/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/30/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3045	1/9/98	< 1	< 1	< 1	< 1	< 1	460	< 1	< 1	< 1	840	< 1
	6/24/98	< 1	< 1	< 1	4.6	1.9	280	< 1	< 1	1.7	350	< 1
3046	1/9/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3050	5/22/98	< 1	< 1	< 1	< 1	6.3	420	< 1	< 1	2.6	370	< 1
3051	5/22/98	< 1	< 1	< 1	< 1	5.8	320	< 1	3.8	2.4	340	< 1
3052	5/22/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3061	5/31/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/27/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3116	7/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.4	< 1
	12/4/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.2	< 1
	5/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.9	< 1
	1/14/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.2	< 1
	6/25/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.6	< 1
3127	5/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	5.5	< 1
	2/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10	< 1
	10/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	11	< 1
3128	5/30/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/25/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3142	7/8/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	8/26/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3148	6/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3149	6/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3150	6/3/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3162	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/16/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3164	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3165	6/5/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3212	6/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/22/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3213	6/12/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3229	6/4/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/23/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3246	6/6/96	< 1	< 1	< 1	< 1	< 1	1**	< 1	< 1	< 1	< 1	< 1
	11/8/96	< 1	< 1	< 1	< 1	< 1	12	< 1	< 1	< 1	< 1	< 1
	3/13/97	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	< 1	< 1	< 1
	10/29/97	< 1	< 1	< 1	< 1	< 1	8	< 1	< 1	< 1	< 1	< 1
	3/25/98	< 1	< 1	< 1	< 1	< 1	7.3	< 1	< 1	< 1	< 1	< 1
3247	6/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3281	6/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/13/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	4/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3305	1/15/98	< 1	1.7	< 1	< 1	3	1	< 1	< 1	< 1	19	< 1
	5/26/98	< 1	1.6	< 1	2.7	2.8	1.9	< 1	< 1	< 1	22	< 1
3306	1/15/98	< 1	1.1	< 1	< 1	1.2	1.1	3.2	< 1	1.2	9.3	< 1
	5/26/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.1	< 1
3324	5/28/98	< 1	< 1	< 1	< 1	< 1	170	< 1	< 1	< 1	53	< 1
3332	7/8/96	< 1	< 1	12	< 1	21	6.1	5	< 1	2.7	1400	< 1
	11/27/96	< 1	< 1	14	< 1	17	8.7	4.5	< 1	2.8	1200	< 1
	2/3/97	< 2.5	< 2.5	14	< 2.5	25	4.4	5.3	< 2.5	5	1500	< 2.5
	6/2/97	< 1	< 1	13	1.5	12	6.4	4.2	< 1	2.3	1300	< 1
	1/9/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	640	< 10
	6/25/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	620	< 10
3336	12/2/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/2/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3407	8/1/96	< 1	< 1	< 1	2.8	5.4	130	< 1	< 1	< 1	110	< 1
	11/26/96	< 1	< 1	< 1	2.4	4.8	120	< 1	< 1	< 1	100	< 1
	6/3/97	< 1	< 1	< 1	3.9	6.1	130	< 1	< 1	< 1	100	< 1
	1/16/98	< 1	< 1	< 1	< 1	6.7	160	< 1	< 1	< 1	120	< 1
	6/24/98	< 1	< 1	< 1	< 1	6.1	140	< 1	< 1	< 1	110	< 1
3415	6/7/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/12/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3416	6/10/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/18/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/15/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3439	6/13/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/24/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	10/28/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3517	3/19/97	< 10	< 10	< 10	< 10	21	< 10	< 10	< 10	< 10	1200	< 20
	7/7/97	< 10	< 10	6.6	3.5	16	6.5	< 10	< 10	2.2	1100	< 10
	10/31/97	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	1.1	610	< 10
	2/18/98	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	540	< 10
3518	3/19/97	< 10	< 10	< 10	< 10	24	70	< 10	< 10	< 10	1000	< 20
	7/7/97	< 10	< 10	3.7	4.7	17	72	< 10	< 10	1.1	820	< 10
	10/31/97	< 10	< 10	< 10	< 10	< 10	77	5.4	< 10	< 10	690	< 10
	2/18/98	< 10	< 10	< 10	< 10	< 10	45	< 10	< 10	< 10	460	< 10
3548	11/14/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/19/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	7/15/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
3549	11/14/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/19/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	3/17/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3554	11/13/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/19/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/2/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3557	11/12/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/25/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/3/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3564	3/4/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	6/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3565	3/4/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	6/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3593	12/18/98	< 5	< 5	< 5		< 5	< 5	< 5	< 5	< 5	< 5	< 1
30004	1/16/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/29/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	7/30/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/6/96	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	1/14/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/30/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/5/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/26/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
30007	1/19/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/25/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/26/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.52	< 0.5
	12/9/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/16/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/22/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/29/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30010	1/24/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/23/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	7/25/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/12/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/21/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/18/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
30022	1/18/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/26/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/29/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/11/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.1	< 0.5
	12/9/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/15/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/18/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30046	1/22/96	< 0.5	< 0.5	< 0.5	< 0.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.25
	4/24/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/25/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.82	< 0.5
	12/13/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/21/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/22/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/28/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/7/98	-	< 0.5	< 0.5	< 0.5	23	< 0.5	< 0.5	< 0.5	-	-	1.8
	7/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/27/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30051	9/10/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	1	< 1
	3/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.6	< 1
	8/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1
	11/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	9.4	< 1
	5/1/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7.7	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
30052	9/11/96	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	5.2	< 1
	3/24/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.2	< 1
	8/8/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.8	< 1
	11/14/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4.1	< 1
	5/1/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.2	< 1
30082	4/10/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/30/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/12/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/12/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30088	5/1/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	9/26/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/10/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/19/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30091	5/5/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 10
	10/7/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/5/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30109	12/18/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	5/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	12/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30111	1/27/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	4/6/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/21/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30112	1/26/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	4/6/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/21/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30115	1/30/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	5/15/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	9/18/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
30118	1/28/98	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	5/14/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
30124	8/4/98	< 5	< 5	< 5	< 5	-	< 5	< 5	< 10	< 5	< 5	< 10
	12/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5
	3/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5
30125	12/18/98	< 5	< 5	< 5	-	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	4/22/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5
30128	1/13/99	< 5	< 5	< 5	-	< 5	< 5	< 5	< 10	< 5	< 5	< 10
	5/17/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5
30139	2/4/99	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 10	< 5	< 5	< 10
31005	7/22/97	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 1
	11/18/97	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2/13/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	5/4/98	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	12/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-03C	9/13/96	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	14	< 2.5	< 5	< 2.5	110	< 2.5
	2/10/97	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	14	< 2.5	< 5	< 2.5	120	< 2.5
	5/6/97	< 0.36	< 0.36	< 0.58	< 0.22	< 0.28	15	< 0.48	< 0.2	< 0.4	68	< 0.52
	11/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	11	< 0.5	< 5	< 0.5	810	< 1
STSW-08C	5/1/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	1.1	< 0.5
	9/19/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	2.5	< 0.5
	2/5/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	2.9	< 0.5
	5/14/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	2.4	< 0.26
	11/30/98	< 0.5	< 0.5	0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3.4	< 0.5
STSW-28C	3/12/96	< 0.12	< 0.12	< 0.066	< 0.042	< 0.048	< 0.041	0.32	< 0.08	< 0.046	< 0.11	< 0.079
	4/8/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	9/30/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	1/23/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	4/30/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	10/3/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	5/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note: (-) Equals not analyzed

TABLE A-25
SUMMARY OF DETECTS - VOC ANALYSES
LAYER D - JANUARY 1996 TO DECEMBER 1998

Well No.	Sample Date	1,1,2,2-PCA (ppb)	1,1-DCA (ppb)	1,1-DCE (ppb)	1,2-DCA (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	Methylene Chloride (ppb)	PCE (ppb)	TCE (ppb)	Vinyl Chloride (ppb)
STSW-29C	10/2/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	1/17/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	5/8/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	10/13/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	11/25/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-30C	10/3/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	1/20/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.5
	5/9/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	10/14/97	< 0.18	< 0.18	< 0.29	< 0.11	< 0.14	< 0.18	< 0.24	< 0.1	< 0.2	< 0.16	< 0.26
	11/24/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-51C	9/1/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
STSW-52C	8/31/98	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	25.6	< 2.5	< 2.5	< 2.5	57.3	< 2.5
	11/13/98	< 1	< 1	< 1	< 1	< 1	19.4	< 1	< 1	< 1	45.3	< 1

Note: (-) Equals not analyzed

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
128	5/16/97	1100
136	5/15/97	2300
137	5/15/97	< 400
172	5/20/97	580
229	5/20/98	830
230	5/20/98	580
237	12/18/96	< 400
238	12/18/96	< 400
242	1/9/98	580
	5/19/98	570
243	1/8/98	480
	5/19/98	500
244	1/8/98	510
	5/19/98	640
358	11/24/97	< 4
	3/27/98	< 4
421	2/3/97	< 400
	5/23/97	< 400
	5/20/98	22
422	2/3/97	< 400
	5/23/97	< 400
	5/20/98	17
439	5/21/97	< 400
446	5/28/97	690
476	5/21/97	1000
	1/19/98	810
	6/22/98	820
1206	5/22/97	< 400
	1/8/98	< 4
	5/7/98	< 4
1232	11/11/97	< 4
	4/10/98	< 4
1269	4/23/96	< 100
	10/7/97	< 4
	4/20/98	< 4
1270	4/23/96	< 100
	10/7/97	< 4
	4/17/98	27
1279	10/8/97	< 4
1284	3/11/97	< 400
	10/10/97	< 4
	4/3/98	< 4

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
1296	1/4/96	< 400
	10/11/96	< 400
	2/4/97	< 400
	10/14/97	7.1
	4/9/98	4.7
1297	10/14/97	< 4
	4/13/98	< 4
1314	1/11/96	< 400
	8/20/96	< 400
	12/11/98	< 4
1336	3/11/97	< 400
1348	6/6/97	< 400
1356	3/11/97	< 400
1436	5/23/97	< 400
	4/21/98	13
1458	1/16/96	< 400
	9/3/96	< 400
	3/12/97	< 400
1461	5/30/97	< 400
	5/4/98	500
1464	9/24/97	420
1465	9/24/97	< 4
1485	2/4/97	< 400
	6/2/97	< 400
	1/8/98	< 4
	4/30/98	< 4
3045	1/9/98	3700
3046	1/9/98	< 4
3116	5/28/97	710
3142	5/28/97	550
3212	3/10/97	7900
3213	3/10/97	8700
3229	3/12/97	7000
3246	3/13/97	< 400
3247	3/12/97	< 400
3281	3/13/97	< 400
3305	1/15/98	32
3306	1/15/98	18
3324	5/28/98	420
3332	2/3/97	590
	6/2/97	500
	1/9/98	290
	6/25/98	290

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
3336	12/2/96	620
	6/2/97	580
	1/13/98	730
3407	6/3/97	< 400
	1/16/98	520
3415	9/12/97	< 4
	3/19/98	< 4
3416	9/15/97	< 4
	3/18/98	< 4
3439	3/10/97	1900
	10/28/97	2100
	3/20/98	2000
3517	3/19/97	540
	7/7/97	470
	10/31/97	310
	2/18/98	270
3518	3/19/97	410
	7/7/97	< 400
	10/31/97	420
	2/18/98	300
3548	11/14/96	< 400
	9/19/97	< 4
	7/15/98	< 4
3549	11/14/96	< 400
	9/19/97	< 4
	7/14/98	< 4
3554	11/13/96	< 400
	9/19/97	580
	2/2/98	530
3557	11/12/96	600
	9/25/97	710
	2/3/98	570
3564	3/5/97	640
	6/30/97	550
	11/3/97	620
	2/13/98	760
3565	3/4/97	610
	6/30/97	550
	11/3/97	620
	2/13/98	550
3593	12/18/98	27

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
30004	1/14/97	< 400
	4/23/97	< 400
	7/16/97	< 400
	10/30/97	< 4
	1/5/98	< 4
	4/13/98	< 4
	7/14/98	< 4
	10/26/98	< 4
30007	1/16/97	< 400
	4/22/97	< 400
	7/17/97	< 400
	10/29/97	< 4
	1/30/98	< 4
	4/15/98	< 4
	7/15/98	< 4
	10/28/98	< 4
30010	1/17/97	< 400
	4/21/97	< 400
	7/18/97	< 400
	10/27/97	< 4
	1/27/98	< 4
	4/15/98	< 4
	7/15/98	< 4
	10/28/98	< 4
30022	1/15/97	< 400
	4/23/97	< 400
	7/18/97	< 400
	10/28/97	< 4
	1/28/98	< 4
	4/13/98	< 4
	7/15/98	< 4
	10/27/98	< 4
30046	1/21/97	< 400
	4/22/97	< 400
	7/17/97	< 400
	10/28/97	< 4
	1/28/98	< 4
	4/14/98	< 4
	7/17/98	< 4
	10/27/98	< 4
30051	9/10/96	600
	3/24/97	510
	8/8/97	580
	11/14/97	820
	5/1/98	550

TABLE A-26
SUMMARY OF PERCHLORATE ANALYSES
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (mg/l)
30052	9/11/96	410
	3/24/97	< 400
	8/8/97	500
	11/14/97	590
	5/1/98	400
30082	4/10/97	500
	9/30/97	440
	2/12/98	590
	5/12/98	590
30088	5/1/97	< 400
	9/26/97	< 4
	2/10/98	< 4
	5/19/98	< 4
	12/11/98	< 4
30091	5/5/97	< 400
	10/7/97	4.1
	2/5/98	< 4
	6/22/98	< 4
	12/15/98	< 4
30109	12/18/97	5.5
	5/18/98	14
	9/15/98	12
	12/17/98	22
30111	1/27/98	< 4
	4/6/98	< 4
	9/21/98	< 4
30112	1/26/98	< 4
	4/6/98	< 4
30115	1/30/98	< 4
	5/15/98	< 4
	9/18/98	< 4
	1/12/99	< 4
30118	1/28/98	< 4
	5/14/98	< 4
30124	8/4/98	< 4
	12/17/98	< 4
30125	12/18/98	570
30128	1/13/99	< 4
30139	2/4/99	15
31005	7/22/97	< 400
	11/18/97	< 4
	2/13/98	< 4
	5/4/98	< 4
	12/17/98	< 4

TABLE A-27
SUMMARY OF NDMA ANALYSES
LAYER D - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
171	3/16/98	0.16
	5/20/98	0.15
172	5/20/98	0.17
229	5/20/98	< 0.0075
230	5/20/98	< 0.0075
242	5/19/98	< 0.0075
243	5/19/98	< 0.0075
244	5/19/98	< 0.0075
284	5/21/98	< 0.0075
285	5/21/98	< 0.0075
288	5/21/98	< 0.0075
421	5/20/98	0.57
422	5/20/98	0.52
442	5/26/98	1.3
443	5/22/98	0.26
448	5/21/98	< 0.0075
1206	5/7/98	< 0.02
	3/10/99	< 0.0075
1212	7/13/98	< 0.0075
1436	4/30/98	0.43
1461	5/4/98	0.082
1464	5/5/98	0.021
	5/13/98	0.022
	6/15/98	0.023
1465	5/5/98	< 0.02
	6/15/98	< 0.02
1485	4/30/98	< 0.02
3019	7/9/98	< 0.0075
3020	7/9/98	0.028
3050	5/22/98	< 0.0075
3051	5/22/98	< 0.0075
3052	5/22/98	< 0.0075
3084	5/22/98	< 0.0075
3305	5/26/98	0.37
3306	5/26/98	0.74
3324	5/28/98	< 0.0075
3336	5/27/98	0.14
3410	5/28/98	0.41
3449	6/4/98	< 0.0075
3454	7/10/98	< 0.0075
3458	7/10/98	< 0.0075
3464	5/29/98	< 0.0075
3554	5/27/98	0.15
3557	5/27/98	0.16
3564	5/29/98	0.18
3565	5/29/98	0.19

TABLE A-27
SUMMARY OF NDMA ANALYSES
LAYER D - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
3593	12/18/98	< 0.0075
30004	4/13/98	< 0.02
	7/14/98	< 0.0075
	10/26/98	< 0.0075
30007	4/14/98	< 0.02
	7/15/98	< 0.0075
	10/28/98	< 0.0075
30010	4/15/98	< 0.02
	7/15/98	< 0.0075
	10/28/98	< 0.0075
30022	4/13/98	< 0.02
	7/15/98	< 0.0075
	10/27/98	< 0.0075
30046	4/14/98	< 0.02
	7/17/98	< 0.0075
	10/27/98	< 0.0075
30051	5/1/98	0.13
30052	5/1/98	0.036
30082	5/12/98	0.18
30088	5/19/98	< 0.0075
	12/11/98	< 0.0075
	3/17/99	< 0.0075
30091	12/15/98	< 0.0075
30109	12/17/98	< 0.0075
30111	5/6/98	< 0.02
30112	5/6/98	< 0.02
30115	1/12/99	< 0.0075
30125	12/18/98	0.18
30128	1/13/99	< 0.0075
30139	2/4/99	< 0.0075
31005	5/5/98	< 0.02
	12/17/98	< 0.0075
	3/17/99	< 0.0075

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

	SITE:	421	422	3332	3517	3518	3548	3549	3554	3557	3564	3565	3593
CONSTITUENT:	DATE:	2/3/97	2/3/97	2/3/97	3/19/97	3/19/97	11/14/96	11/14/96	11/13/96	11/12/96	3/4/97	3/4/97	12/18/98
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
4-Bromophenyl phenyl ether	(ppb)	-	-	-	-	-	-	-	-	-	-	-	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	421 2/3/97	422 2/3/97	3332 2/3/97	3517 3/19/97	3518 3/19/97	3548 11/14/96	3549 11/14/96	3554 11/13/96	3557 11/12/96	3564 3/4/97	3565 3/4/97	3593 12/18/98
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 10
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butylbenzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	1485 2/4/97	30004 1/14/97	30051 9/10/96	30052 9/11/96	30082 4/10/97	30088 5/1/97	30091 5/5/97	30109 12/18/97	30111 1/27/98	30115 1/30/98	30115 1/12/99	30118 1/28/98
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	< 10
4-Bromophenyl phenyl ether	(ppb)	-	-	-	-	-	-	-	-	-	-	< 10	-
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	1485 2/4/97	30004 1/14/97	30051 9/10/96	30052 9/11/96	30082 4/10/97	30088 5/1/97	30091 5/5/97	30109 12/18/97	30111 1/27/98	30115 1/30/98	30115 1/12/99	30118 1/28/98
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 10	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butylbenzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	30124 8/4/98	30124 12/17/98	30124 2/2/99	30124 3/16/99	30125 12/18/98	30128 1/13/99	30139 2/4/99	31005 7/22/97
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	-	-	-	-	-	-	-	< 10
4-Bromophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-28
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	30124 8/4/98	30124 12/17/98	30124 2/2/99	30124 3/16/99	30125 12/18/98	30128 1/13/99	30139 2/4/99	31005 7/22/97
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 10	< 10	< 10	< 10	< 10	< 10	< 20
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butylbenzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-29
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT: SITE:	358	358	358	358	358	358	3517	3518	3548	3549	3554	3557
(Units in mg/l) DATE:	4/2/96	10/9/96	4/15/97	10/27/97	4/14/98	10/28/98	3/19/97	3/19/97	11/14/96	11/14/96	11/13/96	11/12/96
Aluminum	< 0.22	< 0.2	< 0.2	< 0.2	0.39	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.44	< 0.24	< 0.24	< 0.2	< 0.2	< 0.2	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24
Arsenic	< 0.089	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.013	0.048	0.052	0.055	0.054	0.049	0.1	0.1	0.037	0.042	0.026	0.091
Beryllium	0	0	0	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	0.047	< 0.001	< 0.001	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Cadmium	< 0.0044	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	20	14	12	13	13	12	24	25	20	19	23	26
Chromium	< 0.004	< 0.004	< 0.004	0.015	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	0	0	0	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.008	0.18	0.31	0.47	0.46	0.19	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	< 0.33	< 0.3	0.42	1.2	0.88	0.32	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lead	< 0.067	< 0.06	< 0.06	0.15	0.066	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	6.5	6.4	6.7	6.9	6.7	6.3	12	12	4.3	6.1	7.3	9.9
Manganese	0.021	0.1	0.14	0.22	0.13	0.1	< 0.005	< 0.005	0.013	0.028	< 0.005	< 0.005
Molybdenum	< 0.044	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	2.2	2.9	2.1	2.7	3.5	2	2.9	3.1	5.1	2.9	4.6	4.6
Selenium	< 0.11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	15	8.7	8.8	9.6	9	8.9	12	12	12	10	19	15
Thallium	< 0.056	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	< 0.0056	< 0.005	< 0.005	< 0.006	< 0.006	< 0.006	0.0067	0.0061	0.0057	< 0.005	0.014	0.0089
Zinc	< 0.006	2.1	0.8	18	5.1	5.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Note: (-) Equals not analyzed

TABLE A-29
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT: SITE:	3564	3565	3593	30004	30010	30082	30088	30088	30091	30091	30109	30109	30111
(Units in mg/l) DATE:	3/5/97	3/4/97	12/18/98	7/7/98	7/7/98	4/10/97	5/1/97	12/11/98	5/5/97	12/15/98	12/18/97	12/17/98	1/27/98
Aluminum	< 0.2	< 0.2	< 0.2	-	-	< 0.2	< 0.2	< 0.05	< 0.2	< 0.05	< 0.2	< 0.05	< 0.2
Antimony	< 0.24	< 0.24	< 0.2	-	-	< 0.24	< 0.24	< 0.05	< 0.24	< 0.05	< 0.2	< 0.05	< 0.2
Arsenic	< 0.08	< 0.08	< 0.08	-	-	< 0.08	< 0.08	< 0.02	< 0.08	< 0.02	< 0.08	< 0.02	< 0.08
Barium	0.087	0.053	0.029	-	-	0.066	0.088	0.09	0.03	0.037	0.071	0.063	0.06
Beryllium	< 0.001	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.00025	< 0.001	< 0.00025	< 0.001	< 0.00025	< 0.001
Boron	< 0.04	< 0.04	< 0.04	-	-	< 0.04	< 0.04	0.012	< 0.04	0.011	< 0.04	0.011	< 0.04
Cadmium	< 0.004	< 0.004	< 0.004	-	< 0.001	< 0.004	< 0.004	< 0.001	< 0.004	< 0.001	< 0.004	< 0.001	< 0.004
Calcium	26	24	22	27	-	25	23	22	17	11	23	19	24
Chromium	< 0.008	< 0.008	< 0.008	-	-	< 0.008	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	-	-	< 0.008	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008	< 0.002	< 0.008
Copper	< 0.006	< 0.006	0.008	-	-	< 0.006	< 0.006	< 0.0015	< 0.006	< 0.0015	< 0.006	< 0.0015	< 0.006
Iron	< 0.3	< 0.3	0.68	-	-	< 0.3	< 0.3	< 0.075	< 0.3	< 0.075	< 0.3	0.14	< 0.3
Lead	< 0.06	< 0.06	< 0.06	-	-	< 0.06	< 0.06	< 0.015	< 0.06	< 0.015	< 0.06	< 0.015	< 0.06
Magnesium	11	9.5	8.7	21	-	12	6.3	8.5	4.6	5.5	9.6	9.8	7.1
Manganese	0.0066	0.0061	0.021	< 0.0012	-	0.0051	< 0.005	< 0.0012	< 0.005	0.0039	< 0.005	0.011	0.039
Molybdenum	< 0.04	< 0.04	< 0.04	-	-	< 0.04	< 0.04	< 0.01	< 0.04	< 0.01	< 0.04	< 0.01	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	-	-	< 0.02	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02
Potassium	2.7	4.8	4.2	0.75	-	3.1	5.5	4.3	1.9	1.9	4.5	2.8	4.6
Selenium	< 0.1	< 0.1	< 0.1	-	-	< 0.1	< 0.1	< 0.025	< 0.1	< 0.025	< 0.1	< 0.025	< 0.1
Silver	< 0.02	< 0.02	< 0.02	-	-	< 0.02	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02	< 0.005	< 0.02
Sodium	12	18	12	35	-	13	17	11	11	8.1	12	9.7	11
Thallium	< 0.05	< 0.05	< 0.05	-	-	< 0.05	< 0.05	< 0.012	< 0.05	< 0.012	< 0.05	< 0.012	< 0.05
Vanadium	< 0.005	0.0052	< 0.006	0.0038	-	0.0072	0.0092	0.0059	0.016	0.011	0.012	0.0094	< 0.006
Zinc	< 0.1	0.16	< 0.1	-	-	< 0.1	< 0.1	< 0.025	0.17	0.045	< 0.1	0.038	< 0.1

Note: (-) Equals not analyzed

TABLE A-29
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER D - JANUARY 1996 TO APRIL 1999

CONSTITUENT: SITE:	30112	30115	30118	30124	30125	30128	30139	31005	31005
(Units in mg/l) DATE:	1/26/98	1/30/98	1/28/98	8/4/98	12/18/98	1/13/99	2/4/99	7/22/97	12/17/98
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.05
Antimony	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.24	< 0.05
Arsenic	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.02
Barium	0.056	0.032	0.032	0.036	0.026	0.051	0.054	0.056	0.066
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.00025
Boron	< 0.04	< 0.04	< 0.04	< 0.04	0.044	< 0.04	< 0.04	< 0.04	0.017
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.001
Calcium	19	19	11	20	19	17	22	19	22
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.002
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.002
Copper	< 0.006	0.01	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.0015
Iron	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.075
Lead	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.015
Magnesium	6	2.2	5	5.2	5.5	3.8	8.3	9	9.2
Manganese	0.054	< 0.005	0.0088	0.067	0.02	< 0.005	< 0.005	0.01	< 0.0012
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.01
Nickel	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.005
Potassium	3	4.1	2.8	6.3	< 2	6.3	3.8	3.7	4
Selenium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.025
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.005
Sodium	9.6	14	9.5	21	12	26	19	15	9.3
Thallium	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.012
Vanadium	< 0.006	0.017	0.013	0.0072	< 0.006	0.0068	0.006	0.008	0.0069
Zinc	0.24	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.025

Note: (-) Equals not analyzed

TABLE 7-30
SUMMARY OF ANION ANALYSES (EPA 300)
LAYER D - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Chloride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
358	4/2/96	4.6	0.091	-	5.2
	10/9/96	4.2	< 0.03	-	4.4
	4/15/97	4.9	0.068	-	5.7
	10/27/97	4.3	0.08	-	5.1
	4/14/98	4.1	< 0.03	-	5.1
	10/28/98	4.4	< 0.03	-	5
3517	3/19/97	5.8	6.3	< 0.05	12
3518	3/19/97	5.5	6.6	< 0.05	14
3548	11/14/96	5.6	< 0.03	< 0.05	6.3
3549	11/14/96	5.3	< 0.03	< 0.05	4
3554	11/13/96	7	6.3	< 0.05	9.1
3557	11/12/96	8.1	6.5	< 0.05	11
3564	3/5/97	6.6	6.7	< 0.05	11
3565	3/4/97	6.4	6	< 0.05	12
3593	12/18/98	9.4	6.1	-	7.6
30022	7/7/98	8.2		-	-
30051	9/10/96	8.2	6.8	< 0.05	11
30052	9/11/96	7.7	5.7	< 0.05	9.1
30082	4/10/97	6.7	7.2	< 0.05	11
30088	5/1/97	6.5	9.4	< 0.05	6.9
30091	5/5/97	5.2	7.5	< 0.05	5.2
30111	1/27/98	29	< 0.03	< 0.05	5.5
30112	1/26/98	4.7	< 0.03	< 0.05	2.9
30112	1/26/98	4.8	< 0.03	< 0.05	2.9
30115	1/30/98	7.1	2	0.11	11
30118	1/28/98	4.8	6	< 0.1	5.5
30125	12/18/98	5.2	< 0.1	< 0.05	0.19
30128	1/13/99	7.9	1.4	0.062	8.1
30139	2/4/99	-	1.3	0.12	9.9
30139	2/4/99	11	-	-	-
31005	7/22/97	8.6	7.9	< 0.05	6.4

Notes: (-) equals not analyzed

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
141	6/7/96	< 1	< 1	< 1	< 1	< 1
	10/28/96	< 1	< 1	< 1	< 1	< 1
	11/15/96	< 1	< 1	< 1	< 1	< 1
	3/14/97	< 1	< 1	< 1	< 1	< 1
	9/11/97	< 1	< 1	< 1	< 1	< 1
142	4/9/96	< 5	< 5	< 5	< 5	< 5
208	4/2/96	< 5	< 5	< 5	< 5	< 5
	10/8/96	< 5	< 5	< 5	< 5	< 5
	4/14/97	< 5	< 5	< 5	< 5	< 5
	10/9/97	< 5	< 5	< 5	< 5	< 5
	4/15/98	< 5	< 5	< 5	< 5	< 5
	7/7/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/26/98	< 5	< 5	< 5	< 5	< 5
403	4/1/96	< 5	< 5	< 5	< 5	< 5
	5/17/96	< 1	< 1	< 1	< 1	< 1
	10/10/96	< 5	< 5	< 5	< 5	< 5
	4/16/97	< 5	< 5	< 5	< 5	< 5
	9/25/97	< 1	< 1	< 1	< 1	< 1
	10/27/97	< 5	< 5	< 5	< 5	< 5
	4/17/98	< 5	< 5	< 5	< 5	< 5
	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
478	7/1/96	< 1	< 1	< 1	< 1	< 1
	11/21/96	< 1	< 1	< 1	< 1	< 1
	5/21/97	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1
479	7/1/96	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1
	5/19/97	< 1	< 1	< 1	< 1	< 1
	1/14/98	< 1	< 1	< 1	< 1	< 1
	6/22/98	< 1	< 1	< 1	< 1	< 1
1170	1/9/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/3/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/3/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	10/8/96	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/2/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	2/4/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/2/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	7/29/97	< 0.5	< 0.5	< 0.5	< 0.5	0.92
	10/6/97	< 0.5	< 0.5	< 0.5	< 0.5	2
	1/19/98	< 0.5	< 0.5	< 0.5	< 0.5	1.8
	6/22/98	< 0.5	< 0.5	< 0.5	< 0.5	4.4
	7/17/98	< 0.5	< 0.5	< 0.5	< 0.5	4
	10/12/98	< 0.5	< 0.5	< 0.5	< 0.5	1.1

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
1207	2/14/96	< 1	< 1	< 1	< 1	< 1
	7/30/96	< 1	< 1	< 1	< 1	< 1
	12/3/96	< 1	< 1	< 1	< 1	< 1
	5/22/97	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1
	5/7/98	< 1	< 1	< 1	< 1	< 1
1233	9/9/96	< 1	< 1	< 1	< 1	< 1
	12/12/96	< 1	< 1	< 1	< 1	< 1
	11/11/97	< 1	< 1	< 1	< 1	2.4
	4/10/98	< 1	< 1	< 1	< 1	2.7
1234	9/9/96	< 1	< 1	< 1	< 1	< 1
	12/12/96	< 1	< 1	< 1	< 1	< 1
	11/11/97	< 1	< 1	< 1	< 1	< 1
	4/10/98	< 1	< 1	< 1	< 1	< 1
1280	4/1/96	< 5	< 5	< 5	< 5	< 5
	10/10/96	< 5	< 5	< 5	< 5	< 5
	4/15/97	< 5	< 5	< 5	< 5	< 5
	10/28/97	< 5	< 5	< 5	< 5	< 5
	4/16/98	< 5	< 5	< 5	< 5	< 5
	10/29/98	< 5	< 5	< 5	< 5	< 5
1285	6/17/96	< 1	< 1	< 1	< 1	< 1
	10/31/96	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1
1286	6/17/96	< 1	< 1	< 1	< 1	< 1
	10/31/96	< 1	< 1	< 1	< 1	< 1
	3/11/97	< 1	< 1	< 1	< 1	< 1
	10/10/97	< 1	< 1	< 1	< 1	< 1
1349	8/14/96	< 1	< 1	< 1	< 1	< 1
	12/6/96	< 1	< 1	< 1	< 1	< 1
	6/6/97	< 1	< 1	< 1	< 1	< 1
	12/17/97	< 1	< 1	< 1	< 1	< 1
	8/5/98	< 1	< 1	< 1	< 1	< 1
1437	7/9/96	< 1	< 1	< 1	< 1	150
	11/27/96	< 1	< 1	< 1	< 1	110
	5/23/97	< 1	< 1	< 1	< 1	69
	1/7/98	< 1	< 1	< 1	< 1	190
	5/4/98	2.3	1	< 1	< 1	220
1438	7/9/96	< 1	< 1	< 1	< 1	91
	11/26/96	< 1	4.5	< 1	< 1	47
	5/23/97	< 1	7.8	< 1	< 1	84
	1/7/98	< 1	< 1	< 1	< 1	37
	5/4/98	< 1	< 1	< 1	< 1	150
1439	7/9/96	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1
	5/23/97	< 1	< 1	< 1	< 1	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1
	4/30/98	< 1	< 1	< 1	< 1	< 1

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
1459	1/16/96	< 1	< 1	< 1	< 1	1.4
	6/20/96	< 1	< 1	< 1	< 1	< 1
	9/3/96	< 1	< 1	< 1	< 1	< 1
	10/29/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
	10/20/97	< 1	< 1	< 1	< 1	< 1
	4/9/98	< 1	< 1	< 1	< 1	< 1
1462	7/9/96	< 1	< 1	< 1	< 1	< 1
	11/27/96	< 1	< 1	< 1	< 1	< 1
	5/30/97	< 1	< 1	< 1	< 1	< 1
	1/7/98	< 1	< 1	< 1	< 1	< 1
	5/4/98	< 1	< 1	< 1	< 1	< 1
1468	7/26/96	< 1	< 1	< 1	< 1	< 1
	11/26/96	< 1	< 1	< 1	< 1	< 1
	2/6/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	5/29/97	< 1	< 1	< 1	< 1	< 1
	3/27/98	< 1	< 1	< 1	< 1	< 1
	7/2/98	< 1	< 1	< 1	< 1	< 1
1486	7/26/96	< 1	< 1	< 1	< 1	< 1
	11/22/96	< 1	< 1	< 1	< 1	< 1
	2/4/97	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	6/2/97	< 1	< 1	< 1	< 1	< 1
	1/8/98	< 1	< 1	< 1	< 1	< 1
	4/30/98	< 1	< 1	< 1	< 1	< 1
3047	1/9/98	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1
3053	5/22/98	< 1	< 1	< 1	< 1	< 1
3214	6/12/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1
3215	6/12/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/10/97	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1
3230	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
3231	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
3232	6/4/96	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1
	3/20/98	< 1	< 1	< 1	< 1	< 1

Note: (-) Equals not analyzed

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
3248	6/6/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1
3249	6/6/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/12/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	3/24/98	< 1	< 1	< 1	< 1	< 1
3282	6/7/96	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/13/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	4/17/98	< 1	< 1	< 1	< 1	< 1
3283	6/7/96	< 1	< 1	< 1	< 1	< 1
	11/6/96	< 1	< 1	< 1	< 1	< 1
	3/13/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	4/17/98	< 1	< 1	< 1	< 1	< 1
3307	1/15/98	< 1	< 1	< 1	< 1	3.1
	5/26/98	< 1	< 1	1.6	< 1	5.4
3325	5/28/98	< 1	< 1	< 1	< 1	< 1
3333	7/8/96	< 1	< 1	< 1	< 1	45
	11/27/96	< 1	< 1	< 1	< 1	52
	2/3/97	< 0.5	< 0.5	< 0.5	< 0.5	61
	5/30/97	< 1	< 1	< 1	< 1	63
	1/9/98	< 1	< 1	< 1	< 1	71
	6/26/98	< 1	< 1	< 1	< 1	84
3334	7/8/96	< 1	< 1	< 1	< 1	18
	11/27/96	< 1	< 1	< 1	< 1	11
	2/3/97	< 0.5	< 0.5	< 0.5	< 0.5	11
	5/30/97	< 1	< 1	< 1	< 1	8.3
	6/25/98	< 1	< 1	< 1	< 1	7.9
3337	12/2/96	< 1	< 1	< 1	< 1	< 1
	6/2/97	< 1	< 1	< 1	< 1	< 1
3343	5/29/96	< 1	< 1	< 1	< 1	< 1
	11/7/96	< 1	< 1	< 1	< 1	< 1
	3/5/97	< 1	< 1	< 1	< 1	< 1
	10/24/97	< 1	< 1	< 1	< 1	< 1
3404	7/15/96	< 1	< 1	< 1	< 1	18
	11/22/96	< 1	< 1	< 1	1.3	18
	2/4/97	< 0.5	< 0.5	< 0.5	1.1	17
	6/3/97	< 1	< 1	< 1	< 1	17
	1/15/98	< 1	< 1	< 1	< 1	27
	5/28/98	< 1	< 1	< 1	< 1	30

TABLE A-31
SUMMARY OF DETECTS - VOC ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well No.	Sample Date	1,1-DCE (ppb)	1,2-DCE (ppb)	Chloroform (ppb)	Freon 113 (ppb)	TCE (ppb)
3405	7/17/96	< 1	< 1	< 1	< 1	44
	11/25/96	< 1	< 1	< 1	< 1	35
	2/4/97	< 0.5	< 0.5	< 0.5	< 0.5	24
	6/4/97	< 1	< 1	< 1	< 1	9.9
	1/13/98	< 1	< 1	< 1	< 1	12
	5/28/98	< 1	< 1	< 1	< 1	14
3408	7/29/96	< 1	< 1	< 1	< 1	< 1
	11/25/96	< 1	< 1	< 1	< 1	< 1
	6/3/97	< 1	< 1	< 1	< 1	< 1
	6/24/98	< 1	< 1	< 1	< 1	< 1
3417	6/10/96	< 1	< 1	< 1	< 1	< 1
	11/8/96	< 1	< 1	< 1	< 1	< 1
	3/4/97	< 1	< 1	< 1	< 1	< 1
	9/15/97	< 1	< 1	< 1	< 1	< 1
	3/18/98	< 1	< 1	< 1	< 1	< 1
3566	2/28/97	< 5	< 5	< 5	< 5	< 5
	6/30/97	< 1	< 1	< 1	< 1	< 1
	11/3/97	< 1	< 1	< 1	< 1	< 1
	2/13/98	< 1	< 1	< 1	< 1	< 1
30126	12/18/98	< 5	< 5	< 5	< 5	< 5
30127	12/18/98	< 5	< 5	< 5	< 5	< 5
30129	1/13/99	< 5	< 5	< 5	< 5	< 5
30130	1/13/99	< 5	< 5	< 5	< 5	< 5
30134	2/4/99	< 5	< 5	< 5	< 5	< 5
30135	2/3/99	< 5	< 5	< 5	< 5	< 5
30136	2/3/99	< 5	< 5	< 5	< 5	22

Note: (-) Equals not analyzed

TABLE A-32
SUMMARY OF PERCHLORATE ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
141	03/14/1997	< 35*
403	10/28/1998	< 4
478	05/21/1997	< 400
	01/08/1998	< 4
	06/22/1998	< 4
479	05/19/1997	< 400
	01/14/1998	< 4
	06/22/1998	< 4
1170	02/04/1997	< 400
	07/29/1997	< 400
	10/06/1997	< 4
	01/19/1998	< 4
	07/17/1998	< 4
1207	05/22/1997	< 400
	01/08/1998	< 4
	05/07/1998	< 4
1233	11/11/1997	< 4
	04/10/1998	< 4
1234	11/11/1997	< 4
	04/10/1998	< 4
1280	10/28/1997	< 4
	04/16/1998	< 4
	10/29/1998	< 4
1285	03/11/1997	< 400
	10/10/1997	4.8
	04/03/1998	< 4
1286	03/11/1997	< 400
	10/10/1997	< 4
	04/03/1998	< 4
1349	06/06/1997	< 400
	12/17/1997	< 4
	08/05/1998	< 4
1437	05/23/1997	< 400
	04/21/1998	390
1438	05/23/1997	< 400
	04/21/1998	400
1439	05/23/1997	< 400
	04/21/1998	< 4
1459	01/16/1996	< 400
	09/03/1996	< 400
	03/12/1997	< 35*
1462	05/30/1997	< 400
	05/04/1998	22
1468	02/06/1997	< 400
	05/29/1997	< 400
	03/27/1998	< 4
	07/02/1998	< 4

Notes: (*) Equals value reported between PQL and MDL

TABLE A-32
SUMMARY OF PERCHLORATE ANALYSES
LAYER E - JANUARY 1996 TO APRIL 1999

Well Number	Sample Date	Perchlorate (µg/L)
1486	02/04/1997	< 400
	06/02/1997	< 400
	01/08/1998	< 4
	04/30/1998	< 4
3047	01/09/1998	< 4
3214	03/10/1997	< 120*
3215	03/10/1997	< 35*
3230	03/12/1997	< 35*
3231	03/12/1997	< 35*
3232	03/12/1997	< 35*
3248	03/12/1997	< 35*
3249	03/12/1997	< 35*
3282	03/13/1997	< 35*
3283	03/13/1997	< 35*
3307	01/15/1998	10
3308	01/15/1998	< 4
3309	01/15/1998	< 4
3325	05/28/1998	< 4
3333	02/03/1997	< 400
	05/30/1997	< 400
	01/09/1998	160
	06/26/1998	180
3334	02/03/1997	< 400
	05/30/1997	590
	06/25/1998	28
3337	12/02/1996	< 400
	06/02/1997	< 35*
3343	10/24/1997	< 4
	03/18/1998	< 4
3404	02/04/1997	< 400
	06/03/1997	< 400
	01/15/1998	40
	05/28/1998	37
3405	02/04/1997	< 400
	06/04/1997	< 400
	01/13/1998	23
	05/28/1998	22
3408	06/03/1997	< 400
	01/15/1998	< 4
3417	09/15/1997	< 4
	03/18/1998	< 4
3566	02/28/1997	580
	06/30/1997	510
	11/03/1997	610
	02/13/1998	500
30126	12/18/1998	< 4
30127	12/18/1998	< 4
30129	01/13/1999	< 4
30130	01/13/1999	< 4
30134	02/04/1999	< 4
30135	02/03/1999	< 4
30136	02/03/1999	< 4

Notes: (*) Equals value reported between PQL and MDL

TABLE A-33
SUMMARY OF NDMA ANALYSES
LAYER E - MARCH 1998 TO MAY 1999

Well Number	Sample Date	N-Nitrosodimethylamine (ug/l)
1170	04/29/1998	< 0.02
1171	04/29/1998	< 0.02
1207	05/07/1998	< 0.02
	03/10/1999	< 0.0075
1437	05/04/1998	0.015
1438	05/04/1998	0.08
1439	04/30/1998	< 0.02
1462	05/04/1998	0.024
1468	07/16/1998	< 0.0075
1486	04/30/1998	< 0.02
3021	07/09/1998	0.0098
3307	05/26/1998	0.38
3325	05/28/1998	< 0.0075
3337	05/26/1998	< 0.0075
3404	05/28/1998	0.26
3411	05/28/1998	< 0.0075
3455	07/10/1998	< 0.0075
3459	07/09/1998	0.035
3465	05/29/1998	< 0.0075
3566	05/29/1998	0.18
30126	12/18/1998	< 0.0075
30127	12/18/1998	< 0.0075
30129	01/13/1999	< 0.0075
30130	01/13/1999	< 0.0075
30134	02/04/1999	< 0.0075
30135	02/03/1999	< 0.0075
30136	02/03/1999	< 0.0075

TABLE A-34
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER E - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	1486 2/4/97	3333 2/3/97	3334 2/3/97	3404 2/4/97	3405 2/4/97	3566 2/28/97	30126 12/18/98	30127 12/18/98	30129 1/13/99	30129 1/13/99	30130 1/13/99	30134 2/4/99
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1,4-Dipxane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	-	-	-	-	-	-
4-Bromophenyl phenyl ether	(ppb)	-	-	-	-	-	-	< 10	< 10	< 10	< 10	< 10	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-34
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER E - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	1486 2/4/97	3333 2/3/97	3334 2/3/97	3404 2/4/97	3405 2/4/97	3566 2/28/97	30126 12/18/98	30127 12/18/98	30129 1/13/99	30129 1/13/99	30130 1/13/99	30134 2/4/99
Dibenzofuran	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 10	< 10	< 10	< 10	< 10	< 10
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Butyl-benzenesulfonamide	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

TABLE A-34
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER E - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	30135 2/3/99	30136 2/3/99	30136 2/3/99
1,2,4-Trichlorobenzene	(ppb)	< 10	< 10	< 10
1,4-Dioxane	(ppb)	< 10	< 10	< 10
1-Methyl-2-Pyrrolidinone	(ppb)	< 10	< 10	< 10
2,4,5-Trichlorophenol	(ppb)	< 10	< 10	< 10
2,4,6-Trichlorophenol	(ppb)	< 10	< 10	< 10
2,4-Dichlorophenol	(ppb)	< 10	< 10	< 10
2,4-Dimethylphenol	(ppb)	< 10	< 10	< 10
2,4-Dinitrophenol	(ppb)	< 50	< 50	< 50
2,4-Dinitrotoluene	(ppb)	< 10	< 10	< 10
2,6-Dinitrotoluene	(ppb)	< 10	< 10	< 10
2-Chloronaphthalene	(ppb)	< 10	< 10	< 10
2-Chlorophenol	(ppb)	< 10	< 10	< 10
2-Methylnaphthalene	(ppb)	< 10	< 10	< 10
3,3-Dichlorobenzidine	(ppb)	< 10	< 10	< 10
4,6-Dinitro-o-cresol	(ppb)	< 50	< 50	< 50
4-Bromophenoxybenzene	(ppb)	-	-	-
4-Bromophenyl phenyl ether	(ppb)	< 10	< 10	< 10
4-Chlorophenyl phenyl ether	(ppb)	< 10	< 10	< 10
Acenaphthene	(ppb)	< 10	< 10	< 10
Acenaphthylene	(ppb)	< 10	< 10	< 10
Aniline	(ppb)	< 10	< 10	< 10
Anthracene	(ppb)	< 10	< 10	< 10
Benzidine	(ppb)	< 50	< 50	< 50
Benzo(a)anthracene	(ppb)	< 10	< 10	< 10
Benzo(a)pyrene	(ppb)	< 10	< 10	< 10
Benzo(b)fluoranthene	(ppb)	< 10	< 10	< 10
Benzo(ghi)perylene	(ppb)	< 10	< 10	< 10
Benzo(k)fluoranthene	(ppb)	< 10	< 10	< 10
Benzoic acid	(ppb)	< 50	< 50	< 50
Benzyl alcohol	(ppb)	< 10	< 10	< 10
Bis(2-chloroethoxy)methane	(ppb)	< 10	< 10	< 10
Bis(2-chloroethyl)ether	(ppb)	< 10	< 10	< 10
Bis(2-chloroisopropyl)ether	(ppb)	< 10	< 10	< 10
Bis(2-ethylhexyl)phthalate	(ppb)	< 50	< 50	< 50
Butyl benzyl phthalate	(ppb)	< 10	< 10	< 10
Chrysene	(ppb)	< 10	< 10	< 10
Dibenzo(a,h)anthracene	(ppb)	< 10	< 10	< 10

TABLE A-34
SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUND ANALYSES (EPA 8270)
LAYER E - JANUARY 1996 TO APRIL 1999

CONSTITUENT:	SITE: / DATE:	30135 2/3/99	30136 2/3/99	30136 2/3/99
Dibenzofuran	(ppb)	< 10	< 10	< 10
Diethyl phthalate	(ppb)	< 10	< 10	< 10
Dimethyl phthalate	(ppb)	< 10	< 10	< 10
Di-n-butyl phthalate	(ppb)	< 10	< 10	< 10
Di-n-octyl phthalate	(ppb)	< 10	< 10	< 10
Fluoranthene	(ppb)	< 10	< 10	< 10
Fluorene	(ppb)	< 10	< 10	< 10
Hexachlorobenzene	(ppb)	< 10	< 10	< 10
Hexachlorobutadiene	(ppb)	< 20	< 20	< 20
Hexachlorocyclopentadiene	(ppb)	< 10	< 10	< 10
Hexachloroethane	(ppb)	< 10	< 10	< 10
Hydrazine, 1,2-diphenyl	(ppb)	< 10	< 10	< 10
Indeno(1,2,3-cd)pyrene	(ppb)	< 10	< 10	< 10
Isophorone	(ppb)	< 10	< 10	< 10
m-Dichlorobenzene	(ppb)	< 10	< 10	< 10
m-Nitroaniline	(ppb)	< 50	< 50	< 50
Naphthalene	(ppb)	< 10	< 10	< 10
N-Butyl-benzenesulfonamide	(ppb)	< 10	< 10	< 10
Nitrobenzene	(ppb)	< 10	< 10	< 10
N-Nitrosodimethylamine	(ppb)	< 10	< 10	< 10
N-Nitrosodiphenylamine	(ppb)	< 10	< 10	< 10
N-Nitrosodipropylamine	(ppb)	< 10	< 10	< 10
o-Cresol	(ppb)	< 10	< 10	< 10
o-Dichlorobenzene	(ppb)	< 10	< 10	< 10
o-Nitroaniline	(ppb)	< 50	< 50	< 50
o-Nitrophenol	(ppb)	< 10	< 10	< 10
p-Chloroaniline	(ppb)	< 50	< 50	< 50
p-Chloro-m-cresol	(ppb)	< 20	< 20	< 20
PCP	(ppb)	< 50	< 50	< 50
p-Cresol	(ppb)	< 10	< 10	< 10
p-Dichlorobenzene	(ppb)	< 10	< 10	< 10
Phenanthrene	(ppb)	< 10	< 10	< 10
Phenol	(ppb)	< 10	< 10	< 10
p-Nitroaniline	(ppb)	< 50	< 50	< 50
p-Nitrophenol	(ppb)	< 50	< 50	< 50
Pyrene	(ppb)	< 10	< 10	< 10

TABLE A-35
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER E - JANUARY 1996 TO DECEMBER 1998

SITE:	142	208	208	208	208	208	208	208	208	403	403	403	403
CONSTITUENT: DATE: (Units in mg/l)	4/9/96	4/2/96	10/8/96	4/14/97	4/14/97	10/9/97	4/15/98	10/26/98	10/26/98	4/1/96	10/10/96	4/16/97	10/27/97
Aluminum	0.3	< 0.22	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.23	0.4	< 0.2	< 0.2
Antimony	< 0.44	< 0.44	< 0.24	< 0.24	< 0.24	< 0.2	< 0.2	< 0.2	< 0.2	< 0.44	< 0.24	< 0.24	< 0.2
Arsenic	< 0.089	< 0.089	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.089	< 0.08	< 0.08	< 0.08
Barium	0.034	0.055	0.013	0.014	0.01	0.013	0.014	0.013	0.013	0.051	0.053	0.045	0.049
Beryllium	< 0.0011	-	-	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-	-	< 0.001
Boron	0.047	< 0.001	0.057	0.054	0.05	0.047	0.054	0.044	0.045	< 0.001	< 0.001	< 0.001	< 0.04
Cadmium	< 0.0044	-	-	-	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.0044	< 0.004	< 0.004	< 0.004
Calcium	19	14	20	20	19	19	19	18	17	22	17	19	20
Chromium	< 0.0089	< 0.004	< 0.004	< 0.004	< 0.01	< 0.008	< 0.008	< 0.008	< 0.008	< 0.004	< 0.004	< 0.004	< 0.008
Cobalt	< 0.0089	< 0.008	< 0.008	< 0.008	< 0.01	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	0.14	0.23	< 0.008	< 0.008	< 0.01	< 0.006	< 0.006	< 0.006	< 0.006	0.33	0.7	0.22	0.29
Iron	0.6	< 0.33	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.64	0.7	< 0.3	0.47
Lead	< 0.067	< 0.067	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.067	< 0.06	< 0.06	< 0.06
Magnesium	5.8	6.7	6	6.4	6.2	6.2	6	6	5.7	7.2	5.2	6.8	7
Manganese	0.1	0.13	0.021	0.023	0.02	0.025	0.028	0.028	0.026	0.065	0.054	0.066	0.062
Molybdenum	< 0.044	-	-	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-	-	-	< 0.04
Nickel	< 0.022	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.022	< 0.02	< 0.02	< 0.02
Potassium	2.5	1.1	2.2	1.7	1.6	< 2	2.3	2.2	< 2	3.5	4	2.6	2.8
Selenium	< 0.11	< 0.11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.11	< 0.1	< 0.1	< 0.1
Silver	< 0.022	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.022	< 0.02	< 0.02	< 0.02
Sodium	14	9	14	14	14	14	14	14	13	10	7.8	9.3	10
Thallium	< 0.056	< 0.056	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.056	< 0.05	< 0.05	< 0.05
Vanadium	< 0.0056	< 0.006	< 0.006	< 0.006	< 0.01	< 0.006	< 0.006	< 0.006	< 0.006	< 0.0056	< 0.005	< 0.005	< 0.006
Zinc	8.8	1.2	< 0.006	0.71	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	4.2	3.8	0.5	8

TABLE A-35
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER E - JANUARY 1996 TO DECEMBER 1998

SITE:	403	403	403	1280	1280	1280	1280	1280	1280	3566	30126	30127
CONSTITUENT: DATE: (Units in mg/l)	4/17/98	7/7/98	10/28/98	4/1/96	10/10/96	4/15/97	10/28/97	4/16/98	10/29/98	2/28/97	12/18/98	12/18/98
Aluminum	< 0.2	< 0.05	< 0.2	< 0.22	< 0.2	< 0.2	< 0.2	0.25	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.2	-	< 0.2	< 0.44	< 0.24	< 0.24	< 0.2	< 0.2	< 0.2	< 0.24	< 0.2	< 0.2
Arsenic	< 0.08	-	< 0.08	< 0.089	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Barium	0.046	-	0.048	0.059	0.051	0.06	0.057	0.06	0.057	0.06	0.07	0.02
Beryllium	< 0.001	-	< 0.001	-	-	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	< 0.04	-	< 0.04	< 0.001	< 0.001	< 0.001	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.25
Cadmium	< 0.004	-	< 0.004	< 0.0044	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	20	-	20	17	16	18	16	17	16	23	26	13
Chromium	< 0.008	-	< 0.008	< 0.004	< 0.004	< 0.004	0.0084	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	-	< 0.008	-	-	-	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	0.22	-	0.25	0.28	0.39	0.48	0.45	0.36	0.18	< 0.006	< 0.006	< 0.006
Iron	< 0.3	-	< 0.3	< 0.33	< 0.3	< 0.3	0.48	0.5	< 0.3	< 0.3	0.51	< 0.3
Lead	< 0.06	-	< 0.06	< 0.067	< 0.06	< 0.06	0.067	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	6.8	-	7.1	0.067	0.067	0.067	6.9	6.6	6.6	9.5	9.6	1.9
Manganese	0.052	-	0.056	0.19	0.12	0.18	0.19	0.21	0.17	0.012	0.014	0.053
Molybdenum	< 0.04	-	< 0.04	< 0.044	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	-	< 0.02	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	2.7	-	2.8	2.9	2.9	2.9	2.5	3.1	2.4	5.8	3.2	2.6
Selenium	< 0.1	-	< 0.1	< 0.11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.02	-	< 0.02	< 0.022	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	9.4	-	10	9.3	9.1	8.1	9.2	9	9.2	12	15	30
Thallium	< 0.05	-	< 0.05	< 0.056	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	< 0.006	-	< 0.006	< 0.0056	< 0.005	< 0.005	< 0.006	< 0.006	< 0.006	0.005	0.0081	< 0.006
Zinc	2.8	-	3.8	1.6	2	1.3	12	7.2	6.4	< 0.1	< 0.1	< 0.1

TABLE A-35
SUMMARY OF METALS ANALYSES (EPA 6010)
LAYER E - JANUARY 1996 TO DECEMBER 1998

SITE:	30129	30130	30134	30135	30136
CONSTITUENT: DATE: (Units in mg/l)	1/13/99	1/13/99	2/4/99	2/3/99	2/3/99
Aluminum	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Antimony	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Arsenic	< 0.08	< 0.08	< 0.08	0.13	< 0.08
Barium	0.043	0.038	0.064	0.033	0.045
Beryllium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	0.046	0.3	< 0.04	0.045	0.06
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Calcium	16	22	21	20	23
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cobalt	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Iron	< 0.3	< 0.3	0.43	< 0.3	0.3
Lead	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Magnesium	6	7.8	6.7	6.8	8.2
Manganese	0.015	0.027	0.0057	0.0099	0.02
Molybdenum	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Nickel	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	4.4	3.7	3.9	6.2	5.3
Selenium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	19	16	21	14	14
Thallium	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Vanadium	< 0.006	< 0.006	0.018	0.0062	< 0.006
Zinc	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

TABLE A-36
SUMMARY OF ANION ANALYSES (EPA 300)
LAYER E - JANUARY 1996 TO DECEMBER 1999

Well No.	Sample Date	Chloride (mg/l)	Fluoride (mg/l)	Nitrate (mg/l)	Nitrate + Nitrite (as N) (mg/l)	Sulfate (mg/l)
142	4/9/96	5.5	0.045	< 0.03	-	1.1
208	4/2/96	6.2	0.059	< 0.03	-	0.15
	10/8/96	6.3	0.033	< 0.03	-	0.2
	4/14/97	6	0.064	0.31	-	0.82
	4/14/97	6.2	0.06	< 0.03	-	0.32
	10/9/97	6.2	0.14	< 0.03	-	0.36
	4/15/98	5.8	< 0.15	< 0.03	-	0.37
403	4/1/96	6.1	0.085	< 0.03	-	1.4
	10/10/96	4.5	0.093	< 0.03	-	1.3
	4/16/97	6.6	0.063	< 0.03	-	2
	10/27/97	6.7	0.075	< 0.03	-	1.9
	4/17/98	6.2	0.067	< 0.03	-	1.8
	10/28/98	6.5	0.047	< 0.03	-	2.1
1280	4/1/96	3.8	0.1	< 0.03	-	0.11
	10/10/96	4.1	0.12	< 0.03	-	< 0.05
	4/15/97	3.5	0.088	< 0.03	-	2.4
	10/28/97	4.7	0.065	< 0.03	-	0.085
	4/16/98	4.5	0.076	< 0.03	-	0.1
	10/29/98	4.6	0.078	< 0.03	-	0.09
3566	2/28/97	8.7	-	6.6	< 0.05	12
30126	12/18/98	6.7	-	7.1	-	12
30127	12/18/98	11	-	< 0.1	-	3.8
30129	1/13/99	13	-	< 0.1	-	2.2
30130	1/13/99	17	-	< 0.1	-	0.19
30134	2/4/99	8.7	-	1	-	15
30135	2/3/99	7.6	-	< 0.1	-	14
30136	2/3/99	6.5	-	< 0.1	-	20

Notes: (-) equals Not Analyzed

TABLE B 2-6
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer A - tap water - off-site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection
75-35-4	1,1-Dichloroethene	2.6		9		ug/L	Well 30065	22%	0.5-1	9	N/A	0.046 C			Yes	ASL
156-59-2	1,2-Dichloroethene	50		210		ug/L	Well 30065	22%	0.5-1	210	N/A	61 NC			Yes	ASL
127-18-4	Tetrachloroethene	0.65		4.4		ug/L	Well 30065	25%	0.5-1	4.4	N/A	1.1 C			Yes	ASL
79-01-6	Trichloroethene	3		630		ug/L	Well 30065	47%	0.5-1	630	N/A	1.6 C			Yes	ASL
75-01-4	Vinyl Chloride	8.4		130		ug/L	Well 30065	22%	0.5-1	130	N/A	0.02 C			Yes	ASL
7601-90-3	Perchlorate	6		20		ug/L	Well 30065	14%	4-400	20	N/A	18 NC			Yes	ASL
14797-55-8	Nitrate	1.3		6.9		mg/L	Well 30062	100%	0.03	6.9	N/A	10 NC			No	BSL
14797-65-0	Nitrite	0.23		1.1		mg/L	Well 30075	100%	0.01	3	N/A	1 NC			Yes	ASL
N/A	TPH	0.26		2.3		mg/L	Well 30063	60%	0.1	2300	N/A	N/A			No	Not Superfund

(1) Minimum/maximum detected concentration.

(2) N/A - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.

(3) EPA Region 9 PRGs, 1999

(4) Rationale Codes Selection Reason: Infrequent Detection but Associated Historically (HIST)
Frequent Detection (FD)
Toxicity Information Available (TX)
Above Screening Levels (ASL)
Deletion Reason: Infrequent Detection (IFD)
Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions: N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE B.2-7
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer B - tap water - off-site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
156-59-2	1,2-Dichloroethene	0.59		0.59		ug/L	Well 30075	1%	0.14-5	0.59	N/A	61 NC			No	BSL
127-18-4	Tetrachloroethene	0.51		1		ug/L	Well 30005	5%	0.2-5	1	N/A	1.1 C			No	BSL
79-01-6	Trichloroethene	0.53		1.2		ug/L	Well 30064	32%	0.18-5	1.2	N/A	1.6 C			No	BSL
7601-90-3	Perchlorate	4		15		ug/L	Well 30066	5%	4-400	15	N/A	18 NC			No	BSL
14797-55-8	Nitrate	1.1		26		mg/L	Well 30020	100%	0.03	26	N/A	10 NC			Yes	ASL
14797-65-0	Nitrite	1.8		2.40		mg/L	Well 30080	33%	0.05-.25	2.40	N/A	1 NC			Yes	ASL

(1) Minimum/maximum detected concentration.

(2) N/A - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.

(3) EPA Region 9 PRGs, 1999

(4) Rationale Codes Selection Reason:
- Infrequent Detection but Associated Historically (HIST)
- Frequent Detection (FD)
- Toxicity Information Available (TX)
- Above Screening Levels (ASL)

Deletion Reason:
- Infrequent Detection (IFD)
- Background Levels (BKG)
- No Toxicity Information (NTX)
- Essential Nutrient (NUT)
- Below Screening Level (BSL)

Definitions:
- N/A = Not Applicable
- SQL = Sample Quantitation Limit
- COPC = Chemical of Potential Concern
- ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
- MCL = Federal Maximum Contaminant Level
- SMCL = Secondary Maximum Contaminant Level
- J = Estimated Value
- C = Carcinogenic
- N = Non-Carcinogenic

TABLE B 2-8
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer C - tap water - off-site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
75-35-4	1,1-Dichloroethene	1.1		3.9		ug/L	1467	3%	0.5-5	1.2	N/A	0.046 C			Yes	ASL
67-66-3	Chloroform	0.66		28		ug/L	Well 31003	7%	0.5-5	28	N/A	0.16 C			Yes	ASL
79-01-6	Trichloroethene	0.6		88		ug/L	Well 30138	25%	0.5-5	82	N/A	1.6 C			Yes	ASL
7601-90-3	Perchlorate	4		8700		ug/L	Well 30081	51%	0.5-5	8700	N/A	15 NC			Yes	ASL
62-75-9	NDMA	0.061		0.25		ug/L	Well 1484	25%	4-400	0.25	N/A	0.0013 C			Yes	ASL
14797-55-8	Nitrate	0.89		12		mg/L	Well 30120	100%	0.0075	12	N/A	10 NC			Yes	ASL
14797-65-0	Nitrite	0		2.60		mg/L	Well 30078	26%	0.5-5	2.60	N/A	1 NC			Yes	ASL

(1) Minimum/maximum detected concentration.
(2) N/A - Refer to supporting information for background discussion
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.
(3) EPA Region 9 PRGs, 1999
(4) Rationale Codes Selection Reason:
Infrequent Detection but Associated Historically (HIST)
Frequent Detection (FD)
Toxicity Information Available (TX)
Above Screening Levels (ASL)
Deletion Reason:
Infrequent Detection (IFD)
Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE B 2-9
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer D - tap water - off-site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
	Trichloroethene	1		15		ug/L	Well 1461	18%	0.5-5							
156-59-2	1,2-Dichloroethene	23		23		ug/L	Well 30046	1%	0.5-10	23	N/A	61 NC			No	BSL
75-01-4	Vinyl Chloride	1.8		1.8		ug/L	Well 30046	1%	0.5-5	1.8	N/A	0.02 C			Yes	ASL
7601-90-3	Perchlorate	4.1		600		ug/L	Well 30051	22%	4-400	600	N/A	18 NC			Yes	ASL
62-75-9	NDMA	0.021		0.43		ug/L	Well 1436	20%	0.0075-0.02	0.43	N/A	0.0013 C			Yes	ASL
14797-55-8	Nitrate	1.3		9.4		mg/L	Well 30088	71%	0.3	9.4	N/A	10 NC			No	BSL
14797-65-0	Nitrite	0.06		0.12		mg/L	Well 30139	21%	0.05	0.12	N/A	1 NC			No	BSL

(1) Minimum/maximum detected concentration

(2) N/A - Refer to supporting information for background discussion
Background values derived from statistical analysis Follow Regional guidance and provide supporting information

(3) EPA Region 9 PRGs, 1999

(4) Rationale Codes Selection Reason
- Infrequent Detection but Associated Historically (HIST)
- Frequent Detection (FD)
- Toxicity Information Available (TX)
- Above Screening Levels (ASL)

Deletion Reason
- Infrequent Detection (IFD)
- Background Levels (BKG)
- No Toxicity Information (NTX)
- Essential Nutrient (NUT)
- Below Screening Level (BSL)

Definitions:
- N/A = Not Applicable
- SQL = Sample Quantitation Limit
- COPC = Chemical of Potential Concern
- ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
- MCL = Federal Maximum Contaminant Level
- SMCL = Secondary Maximum Contaminant Level
- J = Estimated Value
- C = Carcinogenic
- N = Non-Carcinogenic

TABLE B.2-10
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer E - tap water - off-site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential C Value	Potential C Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
75-35-4	1,1-Dichloroethene	2.3		2.3		ug/L	Well 1437	2%	0.5-5	2.3	N/A	0.046 C			Yes	ASL
156-59-2	1,2-Dichloroethene	1		7.8		ug/L	Well 1438	6%	0.5-5	7.8	N/A	61 NC			No	BSL
79-01-6	Trichloroethene	0.92		220		ug/L	Well 1437	36%	0.5-5	220	N/A	1.6 C			Yes	ASL
7601-90-3	Perchlorate	390		400		ug/L	Well 1438	15%	4-400	400	N/A	18 NC			Yes	ASL
62-75-9	NDMA	0.015		0.08		ug/L	Well 1438	15%	0.0075	0.08	N/A	0.0013 C			Yes	ASL
14797-55-8	Nitrate	1		7.1		mg/L	Well 30126	29%	0.5-5	7.1	N/A	10 NC			No	BSL

(1) Minimum/maximum detected concentration.
(2) N/A - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.
(3) EPA Region 9 PRGs, 1999
(4) Rationale Codes Selection Reason: Infrequent Detection but Associated Historically (HIST)
Frequent Detection (FD)
Toxicity Information Available (TX)
Above Screening Levels (ASL)
Deletion Reason: Infrequent Detection (IFD)

Definitions: N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE B.3-1

VALUES USED FOR DAILY INTAKE CALCULATIONS

AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Current and Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: Residential
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical concentration in water	mg/L	maximum detects and plume isopleths		N/A	N/A	
	IR-W	Ingestion Rate of Water	L/day	2	EPA 1999	N/A	N/A	Chronic Daily Intake (CDI) (mg/kg/day)=
	EF	Exposure Frequency	days/year	350	EPA 1999	N/A	N/A	CWx IR x EF x ED x 1/BW x 1/AT
	ED	Exposure Duration	years	24	EPA 1999	N/A	N/A	
	BW	Body Weight	kg	70	EPA 1999	N/A	N/A	
	AT - NC	Averaging Time - Noncarcinogens	days	8,760	EPA 1999	N/A	N/A	
	AT-C	Averaging Time - Carcinogens	days	25,550	EPA 1999	N/A	N/A	
Dermal	CW	Chemical Concentration in Water	mg/L	maximum detects and plume isopleths		N/A	N/A	Chronic Daily Intake (CDI) (mg/kg/day)= CWx PCx ET x CFx SA x EF x ED x
	PC	Permeability constant	cm/hr	chemical specific	DTSC 1994	N/A	N/A	1/BW x 1/AT
	ET	Exposure Time	hour	0.2	EPA 1989	N/A	N/A	
	CF	Conversion Factor	L/cm3	0.001	DTSC 1994	N/A	N/A	
	SA	Surface Area	cm2/day	23,000	DTSC 1994	N/A	N/A	
	EF	Exposure Frequency	days/year	350	EPA 1999	N/A	N/A	
	ED	Exposure Duration	years	24	DTSC 1994	N/A	N/A	
	BW	Body Weight	kg	70	DTSC 1994	N/A	N/A	
	AT-NC	Averaging Time - Noncarcinogens	days	8,760	DTSC 1994	N/A	N/A	
	AT-C	Averaging Time - Carcinogens	days	25,550	DTSC 1994	N/A		

TABLE B.3-1

VALUES USED FOR DAILY INTAKE CALCULATIONS

AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Current and Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: Residential
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
	CW	Chemical Concentration in Water	mg/L	maximum detects and plume isopleths		N/A	N/A	Chronic Daily Intake (CDI) (mg/kg/day)=
Inhalation of Vapors While Showering	IR -A	Inhalation Rate -Air	m3/hour	0.6	EPA 1989	N/A	N/A	CWx IR-A x ET x VFx EF x ED x 1/BW x 1/AT
	ET	Exposure Time	hr/day	0.2	EPA 1989	N/A	N/A	
	VF	Volatilization Factor	L/m3	0.5	EPA 1989	N/A	N/A	
	EF	Exposure Frequency	days/year	350	EPA 1999	N/A	N/A	
	ED	Exposure Duration	years	24	DTSC 1994	N/A	N/A	
	BW	Body Weight	kg	70	DTSC 1994	N/A	N/A	
	AT-NC	Averaging Time - Noncarcinogens	days	8,760	DTSC 1994	N/A	N/A	
	AT-C	Averaging Time - Carcinogens	days	25,550	DTSC 1994	N/A	N/A	

TABLE B.3-2

VALUES USED FOR DAILY INTAKE CALCULATIONS

AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Current and Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: Residential
Receptor Age: Child

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical concentration in water	mg/L	maximum detects and plume Isopleths		N/A	N/A	
	IR-W	Ingestion Rate of Water	L/day	1	EPA 1999	N/A	N/A	Chronic Daily Intake (CDI) (mg/kg/day)=
	EF	Exposure Frequency	days/year	350	EPA 1999	N/A	N/A	CWx IR x EF x ED x 1/BW x 1/AT
	ED	Exposure Duration	years	6	EPA 1999	N/A	N/A	
	BW	Body Weight	kg	15	EPA 1999	N/A	N/A	
	AT-C	Averaging Time - Carcinogens	days	25,550	EPA 1999	N/A	N/A	
Dermal	CW	Chemical Concentration in Water	mg/L	maximum detects and plume Isopleths		N/A	N/A	Chronic Daily Intake (CDI) (mg/kg/day)= CWx PCx ET x CFx SA x EF x ED x
	PC	Permeability constant	cm/hr	chemical specific	DTSC 1994	N/A	N/A	1/BW x 1/AT
	ET	Exposure Time	hour	0.2	EPA 1989	N/A	N/A	
	CF	Conversion Factor	L/cm3	0.001	DTSC 1994	N/A	N/A	
	SA	Surface Area	cm2/day	7,200	DTSC 1994	N/A	N/A	
	EF	Exposure Frequency	days/year	350	EPA 1999	N/A	N/A	
	ED	Exposure Duration	years	6	DTSC 1994	N/A	N/A	
	BW	Body Weight	kg	15	DTSC 1994	N/A	N/A	
	AT-NC	Averaging Time - Noncarcinogens	days	2,190	DTSC 1994	N/A	N/A	
	AT-C	Averaging Time - Carcinogens	days	25,550	DTSC 1994	N/A		

TABLE B.3-2

VALUES USED FOR DAILY INTAKE CALCULATIONS

AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Current and Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: Residential
Receptor Age: Child

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
	CW	Chemical Concentration in Water	mg/L	maximum detects and plume isopleths		N/A	N/A	Chronic Daily Intake (CDI) (mg/kg/day)=
Inhalation of Vapors While Showering	IR -A	Inhalation Rate -Air	m3/hour	0.4	EPA 1997	N/A	N/A	CWx IR-A x ET x VFx EF x ED x
	ET	Exposure Time	hr/day	0.2	EPA 1989	N/A	N/A	1/BW x 1/AT
	VF	Volatilization Factor	L/m3	0.5	EPA 1989	N/A	N/A	
	EF	Exposure Frequency	days/year	350	EPA 1999	N/A	N/A	
	ED	Exposure Duration	years	6	DTSC 1994	N/A	N/A	
	BW	Body Weight	kg	15	DTSC 1994	N/A	N/A	
	AT-NC	Averaging Time - Noncarcinogens	days	2,190	DTSC 1994	N/A	N/A	
	AT-C	Averaging Time - Carcinogens	days	25,550	DTSC 1994	N/A	N/A	

TABLE B.4-1

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

AEROJET WESTERN GROUNDWATER OU

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (MM/DD/YY)
Carbon tetrachloride	Chronic	7.0E-04	mg/kg-day	N/A	N/A	N/A	Liver	1000	IRIS	03/07/2000
Chloroform	Chronic	1.0E-02	mg/kg-day	N/A	N/A	N/A	Liver	1000	IRIS	03/07/00
1,1-Dichloroethane	Chronic	1.0E-01	mg/kg-day	N/A	N/A	N/A	NOEL	1000	HEAST	07/01/97
1,2- Dichloroethane	Chronic	3.0E-02	mg/kg-day	N/A	N/A	N/A	UK	UK	EPA Region 9	10/01/99
1,1-Dichloroethene	Chronic	9.0E-03	mg/kg-day	N/A	N/A	N/A	Liver	1000	IRIS	03/07/00
1,2-Dichloroethene	Chronic	9.0E-03	mg/kg-day	N/A	N/A	N/A	Liver	1E+03	HEAST	07/01/97
Freon-113	Chronic	3.0E+01	mg/kg-day	N/A	N/A	N/A	Nervous system	1E+01	IRIS	03/07/00
Nitrate	Chronic	1.6E+00	mg/kg-day	N/A	N/A	N/A	Blood	1E+00	IRIS	03/07/00
Nitrite	Chronic	1.0E-01	mg/kg-day	N/A	N/A	N/A	Blood	1E+01	IRIS	03/07/00
NDMA	Chronic	N/A	mg/kg-day	N/A	N/A	N/A	N/A	N/A	IRIS	03/07/00
Perchlorate	Chronic	5.0E-04	mg/kg-day	N/A	N/A	N/A	NOAEL	3E+02	EPA Region 9	10/01/99
1,1,2-Tetrachloroethane	Chronic	4.0E-03	mg/kg-day	N/A	N/A	N/A	Blood	1E+03	IRIS	03/07/00
Tetrachloroethene	Chronic	1.0E-02	mg/kg-day	N/A	N/A	N/A	Liver	1E+03	IRIS	03/07/00
Trichloroethene	Chronic	6.0E-03	mg/kg-day	N/A	N/A	N/A	UK	UK	EPA Region 9	10/01/99
Vinyl Chloride	Chronic	N/A	mg/kg-day	N/A	N/A	N/A	N/A	N/A	IRIS	03/07/2000

N/A = Not Applicable

(1) Per DTSC and EPA Region 9 PRG methodology, oral toxicity values are not adjusted.

(2) Per DTSC and EPA Region 9 PRG methodology, oral toxicity values are not adjusted.

(3) Relects the date that IRIS was searched, or HEAST publication date, or date of EPA Region 9 PRG table from which value was taken.

TABLE B.4-2

NON-CANCER TOXICITY DATA -- INHALATION

AEROJET WESTERN GROUNDWATER OU

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted Inhalation RfD (1)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (2) (MM/DD/YY)
Carbon tetrachloride	Chronic	RTR	mg/m3	7.00E-04	mg/kg-day	UK	UK	EPA Region 9	10/01/1999
Chloroform	Chronic	3.00E-04	mg/m3	8.60E-05	mg/kg-day	UK	UK	EPA Region 9	10/01/1999
1,1-Dichloroethane	Chronic	0.5	mg/m3	0.14	mg/kg-day	Kidney	1000	HEAST	1997
1,2- Dichloroethane	Chronic	0.0049	mg/m3	1.40E-03	mg/kg-day	UK	UK	EPA Region 9	10/01/1999
1,1-Dichloroethene	Chronic	RTR	mg/m3	9.00E-03	mg/kg-day	UK	UK	EPA Region 9	10/01/1999
1,2-Dichloroethene	Chronic	RTR	mg/m3	9.00E-03	mg/kg-day	Liver	1000	HEAST	1997
Freon-113	Chronic	30.1	mg/m3	8.6	mg/kg-day	UK	UK	EPA Region 9	10/01/1999
Nitrate	Chronic	N/A	mg/m3	N/A	mg/kg-day	N/A	N/A	N/A	N/A
Nitrite	Chronic	N/A	mg/m3	N/A	mg/kg-day	N/A	N/A	N/A	N/A
NDMA	Chronic	N/A	mg/m3	N/A	mg/kg-day	N/A	N/A	N/A	N/A
Perchlorate	Chronic	N/A	mg/m3	N/A	mg/kg-day	N/A	N/A	N/A	N/A
1,1,2-Tetrachloroethane	Chronic	RTR	mg/m3	4.00E-03	mg/kg-day	N/A	N/A	EPA Region 9	10/01/1999
Tetrachloroethene	Chronic	0.39	mg/m3	0.11	mg/kg-day	N/A	N/A	EPA Region 9	10/01/1999
Trichloroethene	Chronic	RTR	mg/m3	6.00E-03	mg/kg-day	UK	UK	EPA Region 9	10/01/1999
Vinyl Chloride	Chronic	N/A	mg/m3	N/A	mg/kg-day	N/A	N/A	N/A	N/A

UK = Unknown RTR = Route to Route Extrapolation

N/A = Not Applicable

(1) RfD = RfC x 20 m3 / 70 kg; for chemicals mared "RTR", the inhalation toxicity value is the oral toxicity value.

(2) For IRIS values, the date IRIS was searched. For HEAST values, the date of the HEAST publication, For EPA Region 9, the date of the PRG publication.

TABLE B.4-3

CANCER TOXICITY DATA -- ORAL/DERMAL

AEROJET WESTERN GROUNDWATER OU

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source Target Organ	Date (2) (MM/DD/YY)
Carbon tetrachloride	0.15	N/A	0.15	(mg/kg-day)-1	B2	OEHHA	03/07/2000
Chloroform	0.031	N/A	0.031	(mg/kg-day)-1	B2	OEHHA	03/07/2000
1,1-Dichloroethane	0.0057	N/A	0.0057	(mg/kg-day)-1	C	OEHHA	03/07/2000
1,2- Dichloroethane	0.047	N/A	0.047	(mg/kg-day)-1	B2	OEHHA	03/07/2000
1,1-Dichloroethene	0.6	N/A	0.6	(mg/kg-day)-1	C	IRIS	03/07/2000
NDMA	16	N/A	16	(mg/kg-day)-1	B2	OEHHA	03/07/2000
1,1,2-Tetrachloroethane	0.072	N/A	0.072	(mg/kg-day)-1	C	OEHHA	03/07/2000
Tetrachloroethene	0.051	N/A	0.051	(mg/kg-day)-1	B2-C	OEHHA	03/07/2000
Trichloroethene	0.013	N/A	0.013	(mg/kg-day)-1	B2-C	OEHHA	03/07/2000
Vinyl Chloride	0.27	N/A	0.27	(mg/kg-day)-1	A	OEHHA	03/07/2000

IRIS = Integrated Risk Information System

HEAST= Health Effects Assessment Summary Tables

OEHHA = California EPA Office of Environmental Health Hazard Assessment Toxicity Criteria Database

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

(1) Per OEHHA and EPA Region 9 PRGs, oral toxicity values are not adj

(2) Reflects the date that IRIS and OEHHA data bases were searched

Weight of Evidence:

Known/Likely

Cannot be Determined

TABLE B.4-4

CANCER TOXICITY DATA -- INHALATION

SITE NAME

Chemical of Potential Concern	Unit Risk	Units	Adjustment	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (1) (MM/DD/YY)
Carbon tetrachloride	4.20E-05	(ug/m3)-1	3,500	0.15	(mg/kg-day)-1	B2	OEHHA	03/07/2000
Chloroform	5.30E-06	(ug/m3)-1	3,500	0.019	(mg/kg-day)-1	B2	OEHHA	03/07/2000
1,1-Dichloroethane	1.60E-06	(ug/m3)-1	3,500	0.0057	(mg/kg-day)-1	C	OEHHA	03/07/2000
1,2- Dichloroethane	2.20E-05	(ug/m3)-1	3,500	0.07	(mg/kg-day)-1	B2	OEHHA	03/07/2000
1,1-Dichloroethene	5.00E-05	(ug/m3)-1	3,500	0.18	(mg/kg-day)-1	C	IRIS	03/07/2000
NDMA	4.6E-03	(ug/m3)-1	3,500	16	(mg/kg-day)-1	B2	OEHHA	03/07/2000
1,1,2-Tetrachloroethane	2.1E-05	(ug/m3)-1	3,500	0.07	(mg/kg-day)-1	C	OEHHA	03/07/2000
Tetrachloroethene	5.9E-06	(ug/m3)-1	3,500	0.021	(mg/kg-day)-1	B2-C	OEHHA	03/07/2000
Trichloroethene	2.0E-06	(ug/m3)-1	3,500	0.01	(mg/kg-day)-1	B2-C	OEHHA	03/07/2000
Vinyl Chloride	7.8E-05	(ug/m3)-1	3,500	0.27	(mg/kg-day)-1	A	OEHHA	03/07/2000

IRIS = Integrated Risk Information System

HEAST= Health Effects Assessment Summary Tables

Weight of Evidence:

Known/Likely

Cannot be Determined

Not Likely

(1) Reflects the date the IRIS and OEHHA data bases were searched.

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

TABLE B.5-1
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer A onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	2.0E-05	mg/kg-day	0.072	(mg/kg-day)-1	1.4E-06
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	1.4E-02	mg/kg-day	4.70E-02	(mg/kg-day)-1	6.6E-04
	Chloroform	230	ug/L	230	ug/L	230	3.5E-03	mg/kg-day	3.10E-02	(mg/kg-day)-1	1.1E-04
	Trichloroethene	82	ug/L	82	ug/L	82	1.2E-03	mg/kg-day	1.30E-02	(mg/kg-day)-1	1.6E-05
	Perchlorate	75	ug/L	75	ug/L	75	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.16	ug/L	0.16	ug/L	0.16	2.4E-06	mg/kg-day	16	(mg/kg-day)-1	3.9E-05
	Nitrate	219	mg/L	219	mg/L	219	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	22	mg/L	22	mg/L	22	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	3.2E-07	mg/kg-day	0.072	(mg/kg-day)-1	2.3E-08
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	1.5E-04	mg/kg-day	0.047	(mg/kg-day)-1	7.0E-06
	Chloroform	230	ug/L	230	ug/L	230	6.0E-05	mg/kg-day	0.031	(mg/kg-day)-1	1.9E-06
	Trichloroethene	82	ug/L	82	ug/L	82	3.9E-05	mg/kg-day	0.013	(mg/kg-day)-1	5.0E-07
	Perchlorate	75	ug/L	75	ug/L	75	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.16	ug/L	0.16	ug/L	0.16	3.8E-09	mg/kg-day	16	(mg/kg-day)-1	6.0E-08
	Nitrate	219	mg/L	219	mg/L	219	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	22	mg/L	22	mg/L	22	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Inhalation while Showering	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	6.6E-07	mg/kg-day	0.072	(mg/kg-day)-1	4.7E-08
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	4.8E-04	mg/kg-day	0.07	(mg/kg-day)-1	3.4E-05
	Chloroform	230	ug/L	230	ug/L	230	1.2E-04	mg/kg-day	0.019	(mg/kg-day)-1	2.2E-06
	Trichloroethene	82	ug/L	82	ug/L	82	4.2E-05	mg/kg-day	0.01	(mg/kg-day)-1	4.2E-07
	Perchlorate	75	ug/L	75	ug/L	75	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.16	ug/L	0.16	ug/L	0.16	NA	mg/kg-day	16	(mg/kg-day)-1	NA
	Nitrate	219	mg/L	219	mg/L	219	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	22	mg/L	22	mg/L	22	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	8.7E-04

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE 8.5-2
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Layer A - Onsite Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: On-site residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	3.6E-05	mg/kg-day	4.0E-03	mg/kg-day			8.9E-03
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	2.6E-02	mg/kg-day	3.0E-02	mg/kg-day			8.7E-01
	Chloroform	230	ug/L	230	ug/L	230	6.3E-03	mg/kg-day	1.0E-02	mg/kg-day			6.3E-01
	Trichloroethene	82	ug/L	82	ug/L	82	2.2E-03	mg/kg-day	6.0E-03	mg/kg-day			3.7E-01
	Perchlorate	75	ug/L	75	ug/L	75	2.1E-03	mg/kg-day	5.0E-04	mg/kg-day			4.1E+00
	NDMA	0.16	ug/L	0.16	ug/L	0.16	NA	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	219	mg/L	219	mg/L	219	6.0E+00	mg/kg-day	1.6E+00	mg/kg-day			3.8E+00
	Nitrite	22	mg/L	22	mg/L	22	6.0E-01	mg/kg-day	1.0E-01	mg/kg-day			6.03E+00
Dermal Contact	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	7.5E-07	mg/kg-day	4.0E-03	mg/kg-day			1.9E-04
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	3.5E-04	mg/kg-day	3.0E-02	mg/kg-day			1.2E-02
	Chloroform	230	ug/L	230	ug/L	230	1.4E-04	mg/kg-day	1.0E-02	mg/kg-day			1.4E-02
	Trichloroethene	82	ug/L	82	ug/L	82	9.0E-05	mg/kg-day	6.0E-03	mg/kg-day			1.5E-02
	Perchlorate	75	ug/L	75	ug/L	75	4.1E-06	mg/kg-day	5.0E-04	mg/kg-day			8.3E-03
	NDMA	0.16	ug/L	0.16	ug/L	0.16	NA	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	219	mg/L	219	mg/L	219	1.3E-02	mg/kg-day	1.6E+00	mg/kg-day			7.9E-03
	Nitrite	22	mg/L	22	mg/L	22	1.3E-03	mg/kg-day	1.0E-01	mg/kg-day			1.27E-02
Inhalation while Showering	1,1,2-Trichloroethane	1.3	ug/L	1.3	ug/L	1.3	1.5E-06				4.0E-03	mg/kg-day	3.80E-04
	1,2-Dichloroethane	950	ug/L	950	ug/L	950	1.1E-03				1.4E-03	mg/kg-day	8.03E-01
	Chloroform	230	ug/L	230	ug/L	230	2.7E-04				8.6E-05	mg/kg-day	3.16E+00
	Trichloroethene	82	ug/L	82	ug/L	82	9.6E-05				6.0E-03	mg/kg-day	1.60E-02
	Perchlorate	75	ug/L	75	ug/L	75	NA				NA	mg/kg-day	NA
	NDMA	0.16	ug/L	0.16	ug/L	0.16	NA				NA	mg/kg-day	NA
	Nitrate	219	mg/L	219	mg/L	219	NA				NA	mg/kg-day	NA
	Nitrite	22	mg/L	22	mg/L	22	NA				NA	mg/kg-day	NA
												Total Hazard Index Across All Exposure Routes/Pathways	2.0E+01

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring
(2) Chronic values
(3) Reference concentrations converted to reference doses

TABLE B.5-3
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer B onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	2.3E-05	mg/kg-day	0.072	(mg/kg-day)-1	1.6E-06
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	7.2E-04	mg/kg-day	6.00E-01	(mg/kg-day)-1	4.3E-04
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	2.1E-05	mg/kg-day	1.50E-01	(mg/kg-day)-1	3.2E-06
	Chloroform	350	ug/L	350	ug/L	350	5.3E-03	mg/kg-day	0.031	(mg/kg-day)-1	1.6E-04
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	3.2E-05	mg/kg-day	0.051	(mg/kg-day)-1	1.6E-06
	Trichloroethene	9400	ug/L	9400	ug/L	9400	1.4E-01	mg/kg-day	0.013	(mg/kg-day)-1	1.8E-03
	Perchlorate	11000	ug/L	11000	ug/L	11000	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.32	ug/L	0.32	ug/L	0.32	4.8E-06	mg/kg-day	16	(mg/kg-day)-1	7.7E-05
	Nitrate	11	ug/L	11	ug/L	11	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	3.7E-07	mg/kg-day	0.072	(mg/kg-day)-1	2.7E-08
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	2.3E-05	mg/kg-day	0.6	(mg/kg-day)-1	1.4E-05
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	9.1E-07	mg/kg-day	0.15	(mg/kg-day)-1	1.4E-07
	Chloroform	350	ug/L	350	ug/L	350	9.2E-05	mg/kg-day	0.031	(mg/kg-day)-1	2.9E-06
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	3.0E-06	mg/kg-day	0.051	(mg/kg-day)-1	1.5E-07
	Trichloroethene	9400	ug/L	9400	ug/L	9400	4.4E-03	mg/kg-day	0.013	(mg/kg-day)-1	5.8E-05
	Perchlorate	11000	ug/L	11000	ug/L	11000	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.32	ug/L	0.32	ug/L	0.32	7.6E-09	mg/kg-day	16	(mg/kg-day)-1	1.2E-07
	Nitrate	11	ug/L	11	ug/L	11	NA	mg/kg-day	NA	(mg/kg-day)-1	NA

TABLE B.5-3
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer B onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Inhalation While Showering	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	7.6E-07	mg/kg-day	0.072	(mg/kg-day)-1	5.5E-08
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	2.4E-05	mg/kg-day	0.18	(mg/kg-day)-1	4.4E-06
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	7.1E-07	mg/kg-day	0.15	(mg/kg-day)-1	1.1E-07
	Chloroform	350	ug/L	350	ug/L	350	1.8E-04	mg/kg-day	0.019	(mg/kg-day)-1	3.4E-06
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	1.1E-06	mg/kg-day	0.021	(mg/kg-day)-1	2.2E-08
	Trichloroethene	9400	ug/L	9400	ug/L	9400	4.8E-03	mg/kg-day	0.01	(mg/kg-day)-1	4.8E-05
	Perchlorate	11000	ug/L	11000	ug/L	11000	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.32	ug/L	0.32	ug/L	0.32	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrate	11	ug/L	11	ug/L	11	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	2.7E-03

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-4
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Layer B - On-site Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: On-site residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	4.1E-05	mg/kg-day	4.0E-03	mg/kg-day			1.0E-02
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	1.3E-03	mg/kg-day	9.0E-03	mg/kg-day			1.5E-01
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	3.3E-03	mg/kg-day	9.0E-03	mg/kg-day			3.7E-01
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	3.8E-05	mg/kg-day	7.0E-04	mg/kg-day			5.5E-02
	Chloroform	350	ug/L	350	ug/L	350	9.6E-03	mg/kg-day	1.0E-02	mg/kg-day			9.6E-01
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	5.8E-05	mg/kg-day	1.0E-02	mg/kg-day			5.8E-03
	Trichloroethene	9400	ug/L	9400	ug/L	9400	2.6E-01	mg/kg-day	6.0E-03	mg/kg-day			4.3E+01
	Perchlorate	11000	ug/L	11000	ug/L	11000	3.0E-01	mg/kg-day	5.0E-04	mg/kg-day			6.0E+02
	NDMA	0.32	ug/L	0.32	ug/L	0.32	NA	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	11	mg/L	11	mg/L	11	3.0E-01	mg/kg-day	1.6E+00	mg/kg-day			1.9E-01
Dermal Contact	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	8.7E-07	mg/kg-day	4.0E-03	mg/kg-day			2.2E-04
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	5.3E-05	mg/kg-day	9.0E-03	mg/kg-day			5.9E-03
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	8.3E-05	mg/kg-day	9.0E-03	mg/kg-day			9.2E-03
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	2.1E-06	mg/kg-day	7.0E-04	mg/kg-day			3.0E-03
	Chloroform	350	ug/L	350	ug/L	350	2.1E-04	mg/kg-day	1.0E-02	mg/kg-day			2.1E-02
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	6.9E-06	mg/kg-day	1.0E-02	mg/kg-day			6.9E-04
	Trichloroethene	9400	ug/L	9400	ug/L	9400	1.0E-02	mg/kg-day	6.0E-03	mg/kg-day			1.7E+00
	Perchlorate	11000	ug/L	11000	ug/L	11000	6.1E-04	mg/kg-day	5.0E-04	mg/kg-day			1.2E+00
	NDMA	0.32	ug/L	0.32	ug/L	0.32	NA	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	11	mg/L	11	mg/L	11	6.4E-04	mg/kg-day	1.6E+00	mg/kg-day			4.0E-04

TABLE B.5-4
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Layer B - On-site Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: On-site residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Inhalation while Showering	1,1,2-Trichloroethane	1.5	ug/L	1.5	ug/L	1.5	1.8E-06	mg/kg-day			4.0E-03	mg/kg-day	4.4E-04
	1,1-Dichloroethene	48	ug/L	48	ug/L	48	5.7E-05	mg/kg-day			9.0E-03	mg/kg-day	6.31E-03
	1,2-Dichloroethene	120	ug/L	120	ug/L	120	1.4E-04	mg/kg-day			9.0E-03	mg/kg-day	1.58E-02
	Carbon tetrachloride	1.4	ug/L	1.4	ug/L	1.4	1.7E-06	mg/kg-day			7.0E-04	mg/kg-day	2.37E-03
	Chloroform	350	ug/L	350	ug/L	350	4.1E-04	mg/kg-day			8.6E-05	mg/kg-day	4.81E+00
	Tetrachloroethene	2.1	ug/L	2.1	ug/L	2.1	2.5E-06	mg/kg-day			1.1E-01	mg/kg-day	2.26E-05
	Trichloroethene	9400	ug/L	9400	ug/L	9400	1.1E-02	mg/kg-day			6.0E-03	mg/kg-day	1.85E+00
	Perchlorate	11000	ug/L	11000	ug/L	11000	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	0.32	ug/L	0.32	ug/L	0.32	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrate	11	mg/L	11	mg/L	11	NA	mg/kg-day			NA	mg/kg-day	NA
												Total Hazard Index Across All Exposure Routes/Pathways	6.6E+02

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic values

(3) Reference concentrations converted to reference doses

TABLE B.5-5
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1-Dichloroethene	63	ug/L	63	ug/L	63	9.5E-04	mg/kg-day	6.00E-01	(mg/kg-day)-1	5.7E-04
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	9.9E-06	mg/kg-day	1.50E-01	(mg/kg-day)-1	1.5E-06
	Chloroform	670	ug/L	670	ug/L	670	1.0E-02	mg/kg-day	0.031	(mg/kg-day)-1	3.1E-04
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	8.9E-05	mg/kg-day	0.051	(mg/kg-day)-1	4.5E-06
	Trichloroethene	5300	ug/L	5300	ug/L	5300	8.0E-02	mg/kg-day	0.013	(mg/kg-day)-1	1.0E-03
	Perchlorate	8200	ug/L	8200	ug/L	8200	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.39	ug/L	0.39	ug/L	0.39	5.9E-06	mg/kg-day	16	(mg/kg-day)-1	9.4E-05
Dermal Contact	1,1-Dichloroethene	63	ug/L	63	ug/L	63	3.0E-05	mg/kg-day	0.6	(mg/kg-day)-1	1.8E-05
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	4.3E-07	mg/kg-day	1.50E-01	(mg/kg-day)-1	6.4E-08
	Chloroform	670	ug/L	670	ug/L	670	1.8E-04	mg/kg-day	0.031	(mg/kg-day)-1	5.5E-06
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	8.4E-06	mg/kg-day	0.051	(mg/kg-day)-1	4.3E-07
	Trichloroethene	5300	ug/L	5300	ug/L	5300	2.5E-03	mg/kg-day	0.013	(mg/kg-day)-1	3.3E-05
	Perchlorate	8200	ug/L	8200	ug/L	8200	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.39	ug/L	0.39	ug/L	0.39	9.2E-09	mg/kg-day	16	(mg/kg-day)-1	1.5E-07

TABLE B.5-5
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Inhalation while Showering	1,1-Dichloroethene	63	ug/L	63	ug/L	63	3.2E-05	mg/kg-day	0.18	(mg/kg-day)-1	5.8E-06
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	3.3E-07	mg/kg-day	0.15	(mg/kg-day)-1	5.0E-08
	Chloroform	670	ug/L	670	ug/L	670	3.4E-04	mg/kg-day	0.019	(mg/kg-day)-1	6.5E-06
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	3.0E-06	mg/kg-day	0.021	(mg/kg-day)-1	6.3E-08
	Trichloroethene	5300	ug/L	5300	ug/L	5300	2.7E-04	mg/kg-day	0.01	(mg/kg-day)-1	2.7E-06
	Perchlorate	8200	ug/L	8200	ug/L	8200	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.39	ug/L	0.39	ug/L	0.39	NA	mg/kg-day	16	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	2.1E-03

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-6
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Layer C - On-site Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: On-site residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1-Dichloroethene	63	ug/L	63	ug/L	63	1.7E-03	mg/kg-day	9.0E-03	mg/kg-day			1.9E-01
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	4.4E-03	mg/kg-day	3.0E-02	mg/kg-day			1.5E-01
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	1.8E-05	mg/kg-day	7.0E-04	mg/kg-day			2.6E-02
	Chloroform	670	ug/L	670	ug/L	670	1.8E-02	mg/kg-day	1.0E-02	mg/kg-day			1.8E+00
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	1.6E-04	mg/kg-day	1.0E-02	mg/kg-day			1.6E-02
	Trichloroethene	5300	ug/L	5300	ug/L	5300	1.5E-01	mg/kg-day	6.0E-03	mg/kg-day			2.4E+01
	Perchlorate	8200	ug/L	8200	ug/L	8200	2.2E-01	mg/kg-day	5.0E-04	mg/kg-day			4.5E+02
	NDMA	0.39	ug/L	0.39	ug/L	0.39		mg/kg-day	NA	mg/kg-day			NA
Dermal Contact	1,1-Dichloroethene	63	ug/L	63	ug/L	63	6.9E-05	mg/kg-day	9.0E-03	mg/kg-day			7.7E-03
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	5.9E-05	mg/kg-day	3.0E-02	mg/kg-day			2.0E-03
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	1.0E-06	mg/kg-day	7.0E-04	mg/kg-day			1.4E-03
	Chloroform	670	ug/L	670	ug/L	670	4.1E-04	mg/kg-day	1.0E-02	mg/kg-day			4.1E-02
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	2.0E-05	mg/kg-day	1.0E-02	mg/kg-day			2.0E-03
	Trichloroethene	5300	ug/L	5300	ug/L	5300	5.8E-03	mg/kg-day	6.0E-03	mg/kg-day			9.7E-01
	Perchlorate	8200	ug/L	8200	ug/L	8200	4.5E-04	mg/kg-day	5.0E-04	mg/kg-day			9.0E-01
	NDMA	0.39	ug/L	0.39	ug/L	0.39		mg/kg-day	NA	mg/kg-day			NA
Inhalation while Showering	1,1-Dichloroethene	63	ug/L	63	ug/L	63	7.5E-05				9.0E-03	mg/kg-day	8.28E-03
	1,2-Dichloroethane	160	ug/L	160	ug/L	160	1.9E-04				1.4E-03	mg/kg-day	1.35E-01
	Carbon tetrachloride	0.66	ug/L	0.66	ug/L	0.66	7.8E-07				7.0E-04	mg/kg-day	1.12E-03
	Chloroform	670	ug/L	670	ug/L	670	7.9E-04				8.6E-05	mg/kg-day	9.21E+00
	Tetrachloroethene	5.9	ug/L	5.9	ug/L	5.9	7.0E-06				1.1E-01	mg/kg-day	6.34E-05
	Trichloroethene	5300	ug/L	5300	ug/L	5300	6.2E-03				6.0E-03	mg/kg-day	1.04E+00
	Perchlorate	8200	ug/L	8200	ug/L	8200	NA				NA	mg/kg-day	NA
	NDMA	0.39	ug/L	0.39	ug/L	0.39	NA				NA	mg/kg-day	NA
												Total Hazard Index Across All Exposure Routes/Pathways	4.9E+02

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic values

(3) Reference concentrations converted to reference doses

TABLE B.5-7
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer D onsite Groundwate
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1-Dichloroethene	14	ug/L	14	ug/L	14	2.1E-04	mg/kg-day	6.00E-01	(mg/kg-day)-1	1.3E-04
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	460	ug/L	460	ug/L	460	6.9E-03	mg/kg-day	0.031	(mg/kg-day)-1	2.2E-04
	Tetrachloroethene	5	ug/L	5	ug/L	5	7.5E-05	mg/kg-day	0.051	(mg/kg-day)-1	3.8E-06
	Trichloroethene	1500	ug/L	1500	ug/L	1500	2.3E-02	mg/kg-day	0.013	(mg/kg-day)-1	2.9E-04
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	1.3	ug/L	1.3	ug/L	1.3	2.0E-05	mg/kg-day	16	(mg/kg-day)-1	3.1E-04
Dermal Contact	1,1-Dichloroethene	14	ug/L	14	ug/L	14	6.6E-06	mg/kg-day	0.6	(mg/kg-day)-1	4.0E-06
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	460	ug/L	460	ug/L	460	1.2E-04	mg/kg-day	0.031	(mg/kg-day)-1	3.7E-06
	Tetrachloroethene	5	ug/L	5	ug/L	5	7.1E-06	mg/kg-day	0.051	(mg/kg-day)-1	3.6E-07
	Trichloroethene	1500	ug/L	1500	ug/L	1500	7.1E-04	mg/kg-day	0.013	(mg/kg-day)-1	9.2E-06
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	1.3	ug/L	1.3	ug/L	1.3	3.1E-08	mg/kg-day	16	(mg/kg-day)-1	4.9E-07
Inhalation while Showering	1,1-Dichloroethene	14	ug/L	14	ug/L	14	7.1E-06	mg/kg-day	0.18	(mg/kg-day)-1	1.3E-06
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	460	ug/L	460	ug/L	460	2.3E-04	mg/kg-day	0.019	(mg/kg-day)-1	4.4E-06
	Tetrachloroethene	5	ug/L	5	ug/L	5	2.5E-06	mg/kg-day	0.021	(mg/kg-day)-1	5.3E-08
	Trichloroethene	1500	ug/L	1500	ug/L	1500	7.6E-04	mg/kg-day	0.01	(mg/kg-day)-1	7.6E-06
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	1.3	ug/L	1.3	ug/L	1.3	NA	mg/kg-day	16	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	9.8E-04

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-8
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Layer D - On-site Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: On-site residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1-Dichloroethene	14	ug/L	14	ug/L	14	3.8E-04	mg/kg-day	9.0E-03	mg/kg-day			4.3E-02
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	1.3E-04	mg/kg-day	3.0E-02	mg/kg-day			4.3E-03
	Chloroform	460	ug/L	460	ug/L	460	1.3E-02	mg/kg-day	1.0E-02	mg/kg-day			1.3E+00
	Tetrachloroethene	5	ug/L	5	ug/L	5	1.4E-04	mg/kg-day	1.0E-02	mg/kg-day			1.4E-02
	Trichloroethene	1500	ug/L	1500	ug/L	1500	4.1E-02	mg/kg-day	6.0E-03	mg/kg-day			6.9E+00
	Perchlorate	8700	ug/L	8700	ug/L	8700	2.4E-01	mg/kg-day	5.0E-04	mg/kg-day			4.8E+02
	NDMA	1.3	ug/L	1.3	ug/L	1.3	NA	mg/kg-day	NA	mg/kg-day			NA
Dermal Contact	1,1-Dichloroethene	14	ug/L	14	ug/L	14	1.5E-05	mg/kg-day	9.0E-03	mg/kg-day			1.7E-03
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	1.7E-06	mg/kg-day	3.0E-02	mg/kg-day			5.7E-05
	Chloroform	460	ug/L	460	ug/L	460	2.8E-04	mg/kg-day	1.0E-02	mg/kg-day			2.8E-02
	Tetrachloroethene	5	ug/L	5	ug/L	5	1.7E-05	mg/kg-day	1.0E-02	mg/kg-day			1.7E-03
	Trichloroethene	1500	ug/L	1500	ug/L	1500	1.7E-03	mg/kg-day	6.0E-03	mg/kg-day			2.8E-01
	Perchlorate	8700	ug/L	8700	ug/L	8700	4.8E-04	mg/kg-day	5.0E-04	mg/kg-day			9.6E-01
	NDMA	1.3	ug/L	1.3	ug/L	1.3	NA	mg/kg-day	NA	mg/kg-day			NA
Inhalation while Showering	1,1-Dichloroethene	14	ug/L	14	ug/L	14	1.7E-05				9.0E-03	mg/kg-day	0.00184
	1,2-Dichloroethane	4.7	ug/L	4.7	ug/L	4.7	5.6E-06				1.4E-03	mg/kg-day	3.97E-03
	Chloroform	460	ug/L	460	ug/L	460	5.4E-04				8.6E-05	mg/kg-day	6.33E+00
	Tetrachloroethene	5	ug/L	5	ug/L	5	5.9E-06				1.1E-01	mg/kg-day	5.38E-05
	Trichloroethene	1500	ug/L	1500	ug/L	1500	1.8E-03				6.0E-03	mg/kg-day	2.96E-01
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA				NA	mg/kg-day	NA
	NDMA	1.3	ug/L	1.3	ug/L	1.3	NA				NA	mg/kg-day	NA
												Total Hazard Index Across All Exposure Routes/Pathways	4.9E+02

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring
(2) Chronic values
(3) Reference concentrations converted to reference doses

TABLE B.5-9
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer E onsite Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Chloroform	1.6	ug/L	1.6	ug/L	1.6	2.4E-05	mg/kg-day	0.031	(mg/kg-day)-1	7.5E-07
	Trichloroethene	84	ug/L	84	ug/L	84.0	1.3E-03	mg/kg-day	0.013	(mg/kg-day)-1	1.7E-05
	Perchlorate	610	ug/L	610	ug/L	610	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.38	ug/L	0.38	ug/L	0.38	5.7E-06	mg/kg-day	16	(mg/kg-day)-1	9.2E-05
Dermal Contact	Chloroform	1.6	ug/L	1.6	ug/L	1.6	4.2E-07	mg/kg-day	0.031	(mg/kg-day)-1	1.3E-08
	Trichloroethene	84	ug/L	84	ug/L	84.0	4.0E-05	mg/kg-day	0.013	(mg/kg-day)-1	5.2E-07
	Perchlorate	610	ug/L	610	ug/L	610	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.38	ug/L	0.38	ug/L	0.38	8.9E-09	mg/kg-day	16	(mg/kg-day)-1	1.4E-07
Inhalation while Showering	Chloroform	1.6	ug/L	1.6	ug/L	1.6	8.1E-07	mg/kg-day	0.019	(mg/kg-day)-1	1.5E-08
	Trichloroethene	84	ug/L	84	ug/L	84.0	4.3E-05	mg/kg-day	1.00E-02	(mg/kg-day)-1	4.3E-07
	Perchlorate	610	ug/L	610	ug/L	610	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.38	ug/L	0.38	ug/L	0.38	NA	mg/kg-day	16	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	1.1E-04

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-10
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Layer E - On-site Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: On-site residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	Chloroform	1.6	ug/L	1.6	ug/L	1.6	4.4E-05	mg/kg-day	1.0E-02	mg/kg-day			4.38E-03
	Trichloroethene	84	ug/L	84	ug/L	84	2.3E-03	mg/kg-day	6.0E-03	mg/kg-day			3.8E-01
	Perchlorate	610	ug/L	610	ug/L	610	1.7E-02	mg/kg-day	5.0E-04	mg/kg-day			3.3E+01
	NDMA	0.38	ug/L	0.38	ug/L	0.38	NA	mg/kg-day	NA	mg/kg-day			NA
Dermal Contact	Chloroform	1.6	ug/L	1.6	ug/L	1.6	9.8E-07	mg/kg-day	1.0E-02	mg/kg-day			9.80E-05
	Trichloroethene	84	ug/L	84	ug/L	84	9.2E-05	mg/kg-day	6.0E-03	mg/kg-day			1.5E-02
	Perchlorate	610	ug/L	610	ug/L	610	3.4E-05	mg/kg-day	5.0E-04	mg/kg-day			6.7E-02
	NDMA	0.38	ug/L	0.38	ug/L	0.38	NA	mg/kg-day	NA	mg/kg-day			NA
Inhalation while Showering	Chloroform	1.6	ug/L	1.6	ug/L	1.6	1.9E-06				8.6E-05	mg/kg-day	2.20E-02
	Trichloroethene	84	ug/L	84	ug/L	84	1.0E-04				6.0E-03	mg/kg-day	1.66E-02
	Perchlorate	610	ug/L	610	ug/L	610	NA				NA	mg/kg-day	NA
	NDMA	0.38	ug/L	0.38	ug/L	0.38	NA				NA	mg/kg-day	NA
												Total Hazard Index Across All Exposure Routes/Pathways	3.4E+01

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

(2) Chronic values

(3) Reference concentrations converted to reference doses

TABLE B.5-11
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer C Off site Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	4.6E-06	mg/kg-day	0.6	(mg/kg-day)-1	2.8E-06
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	28	ug/L	28	ug/L	28	4.2E-04	mg/kg-day	0.031	(mg/kg-day)-1	1.3E-05
	Trichloroethene	88	ug/L	88	ug/L	88	1.3E-03	mg/kg-day	0.013	(mg/kg-day)-1	1.7E-05
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.25	ug/L	0.25	ug/L	0.25	3.8E-06	mg/kg-day	16	(mg/kg-day)-1	6.0E-05
	Nitrate	12	mg/L	12	mg/L	12	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Dermal Contact	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	4.8E-08	mg/kg-day	0.6	(mg/kg-day)-1	2.9E-08
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	28	ug/L	28	ug/L	28	7.4E-06	mg/kg-day	0.031	(mg/kg-day)-1	2.3E-07
	Trichloroethene	88	ug/L	88	ug/L	88	4.2E-05	mg/kg-day	0.013	(mg/kg-day)-1	5.4E-07
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.25	ug/L	0.25	ug/L	0.25	5.9E-09	mg/kg-day	16	(mg/kg-day)-1	9.4E-08
	Nitrate	12	mg/L	12	mg/L	12	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
Inhalation while Showering	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	7.7E-07	mg/kg-day	0.18	(mg/kg-day)-1	1.4E-07
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Chloroform	28	ug/L	28	ug/L	28	1.4E-05	mg/kg-day	0.019	(mg/kg-day)-1	2.7E-07
	Trichloroethene	88	ug/L	88	ug/L	88	4.5E-05	mg/kg-day	0.01	(mg/kg-day)-1	4.5E-07
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.25	ug/L	0.25	ug/L	0.25	NA	mg/kg-day	16	(mg/kg-day)-1	NA
	Nitrate	12	mg/L	12	mg/L	12	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	9.5E-05

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-12
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Layer C - Offsite Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: On-site residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	1.1E-04	mg/kg-day	9.0E-03	mg/kg-day			1.2E-02
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	1.5E-05	mg/kg-day	3.0E-02	mg/kg-day			5.1E-04
	Chloroform	28	ug/L	28	ug/L	28	7.7E-04	mg/kg-day	1.0E-02	mg/kg-day			7.7E-02
	Trichloroethene	88	ug/L	88	ug/L	88	2.4E-03	mg/kg-day	6.0E-03	mg/kg-day			4.0E-01
	Perchlorate	8700	ug/L	8700	ug/L	8700	2.4E-01	mg/kg-day	5.0E-04	mg/kg-day			4.8E+02
	NDMA	0.25	ug/L	0.25	ug/L	0.25	NA	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	12	mg/L	12	mg/L	12	3.3E-01	mg/kg-day	1.6E+00	mg/kg-day			2.1E-01
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	7.1E-02	mg/kg-day	1.0E-01	mg/kg-day			7.12E-01
Dermal Contact	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	4.3E-06	mg/kg-day	9.0E-03	mg/kg-day			4.77E-04
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	2.0E-07	mg/kg-day	3.0E-02	mg/kg-day			6.8E-06
	Chloroform	28	ug/L	28	ug/L	28	1.7E-05	mg/kg-day	1.0E-02	mg/kg-day			1.7E-03
	Trichloroethene	88	ug/L	88	ug/L	88	9.7E-05	mg/kg-day	6.0E-03	mg/kg-day			1.6E-02
	Perchlorate	8700	ug/L	8700	ug/L	8700	4.8E-04	mg/kg-day	5.0E-04	mg/kg-day			9.6E-01
	NDMA	0.25	ug/L	0.25	ug/L	0.25	NA	mg/kg-day	NA	mg/kg-day			NA
	Nitrate	12	mg/L	12	mg/L	12	6.9E-04	mg/kg-day	1.6E+00	mg/kg-day			4.3E-04
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	1.5E-04	mg/kg-day	1.0E-01	mg/kg-day			1.50E-03
Inhalation while Showering	1,1-Dichloroethene	3.9	ug/L	3.9	ug/L	3.9	4.6E-06	mg/kg-day			9.0E-03	mg/kg-day	5.12E-04
	1,2-Dichloroethane	0.56	ug/L	0.56	ug/L	0.56	6.6E-07	mg/kg-day			1.4E-03	mg/kg-day	4.73E-04
	Chloroform	28	ug/L	28	ug/L	28	3.3E-05	mg/kg-day			8.6E-05	mg/kg-day	3.85E-01
	Trichloroethene	88	ug/L	88	ug/L	88	1.0E-04	mg/kg-day			6.0E-03	mg/kg-day	1.73E-02
	Perchlorate	8700	ug/L	8700	ug/L	8700	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	0.25	ug/L	0.25	ug/L	0.25	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrate	12	mg/L	12	mg/L	12	NA	mg/kg-day			NA	mg/kg-day	NA
	Nitrite	2.60	mg/L	2.60	mg/L	2.60	NA	mg/kg-day			NA	mg/kg-day	NA

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

Total Hazard Index Across All Exposure Routes/Pathways: 4.8E+02

(2) Chronic values

TABLE B.5-13
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timefram	Future
Medium:	Layer D off site Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Populatio	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	2.7E-05	mg/kg-day	0.27	(mg/kg-day)-1	7.3E-06
	Perchlorate	600.0	ug/L	600.0	ug/L	600.0	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.43	ug/L	0.43	ug/L	0.43	6.5E-06	mg/kg-day	16	(mg/kg-day)-1	1.0E-04
	Trichloroethene	15	ug/L	15	ug/L	15	2.3E-04	mg/kg-day	0.013	(mg/kg-day)-1	2.9E-06
Dermal Contact	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	3.9E-07	mg/kg-day	0.27	(mg/kg-day)-1	1.1E-07
	Perchlorate	600.0	ug/L	600.0	ug/L	600.0	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.43	ug/L	0.43	ug/L	0.43	1.0E-08	mg/kg-day	16	(mg/kg-day)-1	1.6E-07
	Trichloroethene	15	ug/L	15	ug/L	15	7.1E-06	mg/kg-day	0.013	(mg/kg-day)-1	9.2E-08
Inhalation while Showering	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	9.1E-07	mg/kg-day	0.27	(mg/kg-day)-1	2.5E-07
	Perchlorate	600.0	ug/L	600.0	ug/L	600.0	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.43	ug/L	0.43	ug/L	0.43	NA	mg/kg-day	16	(mg/kg-day)-1	NA
	Trichloroethene	15	ug/L	15	ug/L	15	7.6E-06	mg/kg-day	0.01	(mg/kg-day)-1	7.6E-08
										Total Risk Across All Exposure Routes/Pathways	1.1E-04

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-14
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Layer D - Offsite Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: On-site residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentration (3)	Reference Concentration Units	Hazard Quotient
Ingestion	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	NA	mg/kg-day	NA	mg/kg-day			NA
	Perchlorate	600	ug/L	600	ug/L	600	1.6E-02	mg/kg-day	5.0E-04	mg/kg-day			3.3E+01
	NDMA	0.43	ug/L	0.43	ug/L	0.43	NA	mg/kg-day	NA	mg/kg-day			NA
	Trichloroethene	15	ug/L	15	ug/L	15	4.1E-04	mg/kg-day	6.0E-03				6.85E-02
Dermal Contact	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	NA	mg/kg-day	NA	mg/kg-day			NA
	Perchlorate	600	ug/L	600	ug/L	600	3.3E-05	mg/kg-day	5.0E-04	mg/kg-day			6.6E-02
	NDMA	0.43	ug/L	0.43	ug/L	0.43	NA	mg/kg-day	NA	mg/kg-day			NA
	Trichloroethene	15	ug/L	15	ug/L	15	1.7E-05	mg/kg-day	6.0E-03	mg/kg-day			2.75E-03
Inhalation while Showering	Vinyl Chloride	1.8	ug/L	1.8	ug/L	1.8	NA				NA	mg/kg-day	NA
	Perchlorate	600	ug/L	600	ug/L	600	NA				NA	mg/kg-day	NA
	NDMA	0.43	ug/L	0.43	ug/L	0.43	NA				NA	mg/kg-day	NA
	Trichloroethene	15	ug/L	15	ug/L	15	1.8E-05	mg/kg-day			6.00E-03	mg/kg-day	2.96E-03
												Total Hazard Index Across All Exposure Routes/Pathways	3.3E+01

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring
(2) Chronic values
(3) Reference concentrations converted to reference doses

TABLE B.5-15
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe:	Future
Medium:	Layer E Off site Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Tap Water
Receptor Population:	Residential
Receptor Age:	Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	3.5E-05	mg/kg-day	0.6	(mg/kg-day)-1	2.1E-05
	Trichloroethene	220	ug/L	220	ug/L	220	3.3E-03	mg/kg-day	0.013	(mg/kg-day)-1	4.3E-05
	Perchlorate	400	ug/L	400	ug/L	400	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.08	ug/L	0.08	ug/L	0.08	1.2E-06	mg/kg-day	1.60E+01	(mg/kg-day)-1	1.9E-05
Dermal Contact	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	1.1E-06	mg/kg-day	0.6	(mg/kg-day)-1	6.5E-07
	Trichloroethene	220	ug/L	220	ug/L	220	1.0E-04	mg/kg-day	0.013	(mg/kg-day)-1	1.4E-06
	Perchlorate	400	ug/L	400	ug/L	400	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.08	ug/L	0.08	ug/L	0.08	1.9E-09	mg/kg-day	16	(mg/kg-day)-1	3.0E-08
Inhalation while Showering	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	1.2E-06	mg/kg-day	0.18	(mg/kg-day)-1	2.1E-07
	Trichloroethene	220	ug/L	220	ug/L	220	1.1E-04	mg/kg-day	0.010	(mg/kg-day)-1	1.1E-06
	Perchlorate	400	ug/L	400	ug/L	400	NA	mg/kg-day	NA	(mg/kg-day)-1	NA
	NDMA	0.08	ug/L	0.08	ug/L	0.08	NA	mg/kg-day	16	(mg/kg-day)-1	NA
										Total Risk Across All Exposure Routes/Pathways	8.7E-05

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring

TABLE B.5-16
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
AEROJET WESTERN GROUNDWATER OU

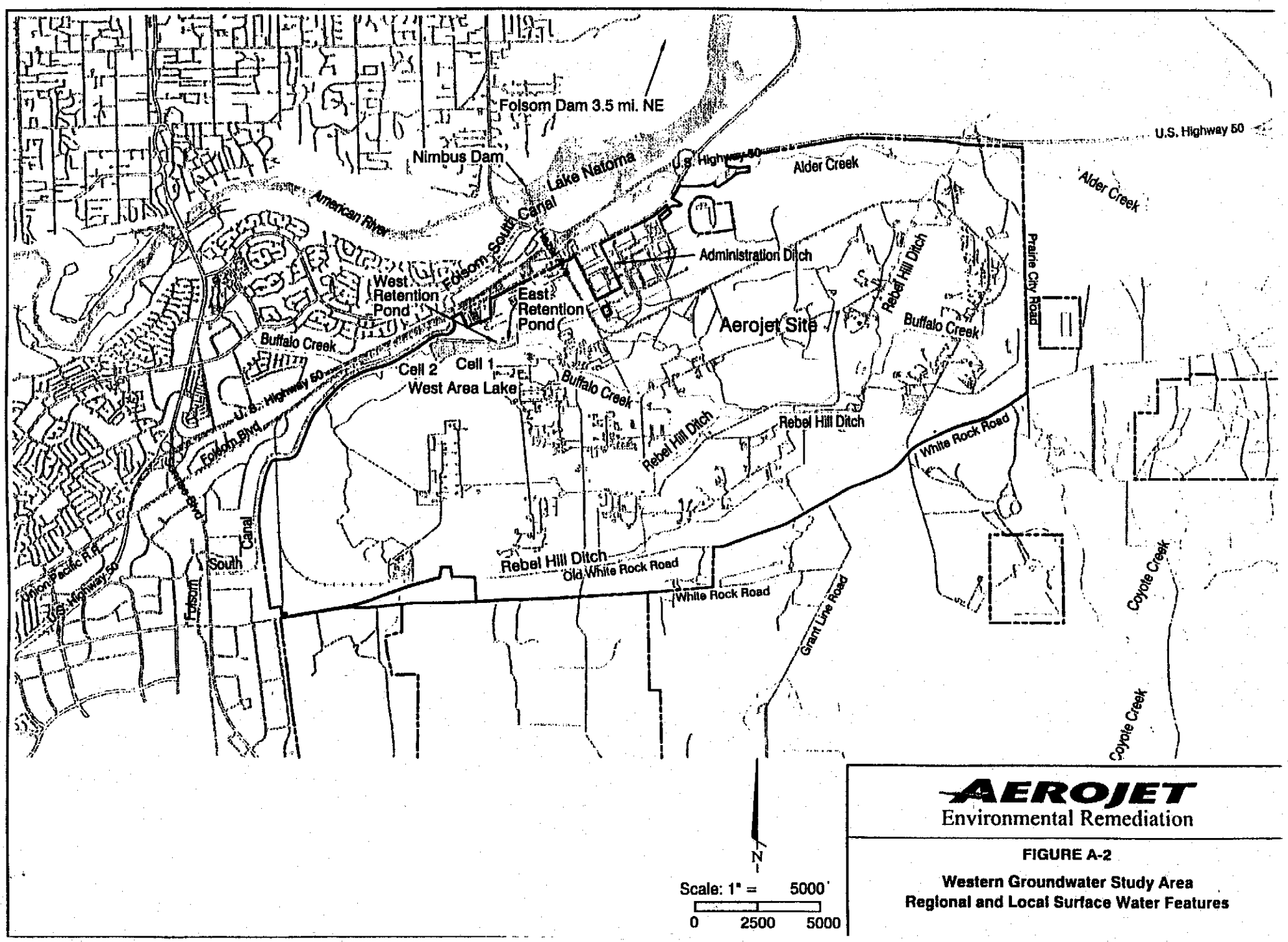
Scenario Timeframe: Future
Medium: Layer E - Offsite Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water
Receptor Population: On-site residential
Receptor Age: Adult + Child

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose (2)	Reference Dose Units	Reference Concentratio (3)	Reference Concentration Units	Hazard Quotient
Ingestion	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	6.3E-05	mg/kg-day	9.0E-03	mg/kg-day			7.0E-03
	Trichloroethene	220	ug/L	220	ug/L	220	6.0E-03	mg/kg-day	6.0E-03	mg/kg-day			1.00E+00
	Perchlorate	400	ug/L	400	ug/L	400	1.1E-02	mg/kg-day	5.0E-04	mg/kg-day			2.19E+01
	NDMA	0.08	ug/L	0.08	ug/L	0.08	NA	mg/kg-day	NA	mg/kg-day			NA
Dermal Contact	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	2.5E-06	mg/kg-day	9.0E-03	mg/kg-day			2.81E-04
	Trichloroethene	220	ug/L	220	ug/L	220	2.4E-04	mg/kg-day	6.0E-03	mg/kg-day			4.04E-02
	Perchlorate	400	ug/L	400	ug/L	400	2.2E-05	mg/kg-day	5.0E-04	mg/kg-day			4.40E-02
	NDMA	0.08	ug/L	0.08	ug/L	0.08	NA	mg/kg-day	NA	mg/kg-day			NA
Inhalation while Showering	1,1-Dichloroethene	2.3	ug/L	2.3	ug/L	2.3	2.7E-06	mg/kg-day			9.0E-03	mg/kg-day	3.0E-04
	Trichloroethene	220	ug/L	220	ug/L	220	2.6E-04	mg/kg-day			6.0E-03	mg/kg-day	4.34E-02
	Perchlorate	400	ug/L	400	ug/L	400	NA	mg/kg-day			NA	mg/kg-day	NA
	NDMA	0.08	ug/L	0.08	ug/L	0.08	NA	mg/kg-day			NA	mg/kg-day	NA
												Total Hazard Index Across All Exposure Routes/Pathways	2.3E+01

(1) Maximum detected value for hydrostratigraphic layer in the past 2 years of monitoring
(2) Chronic values
(3) Reference concentrations converted to reference doses

PAGES OF OVERSIZED MAPS

(SEE BINDER)



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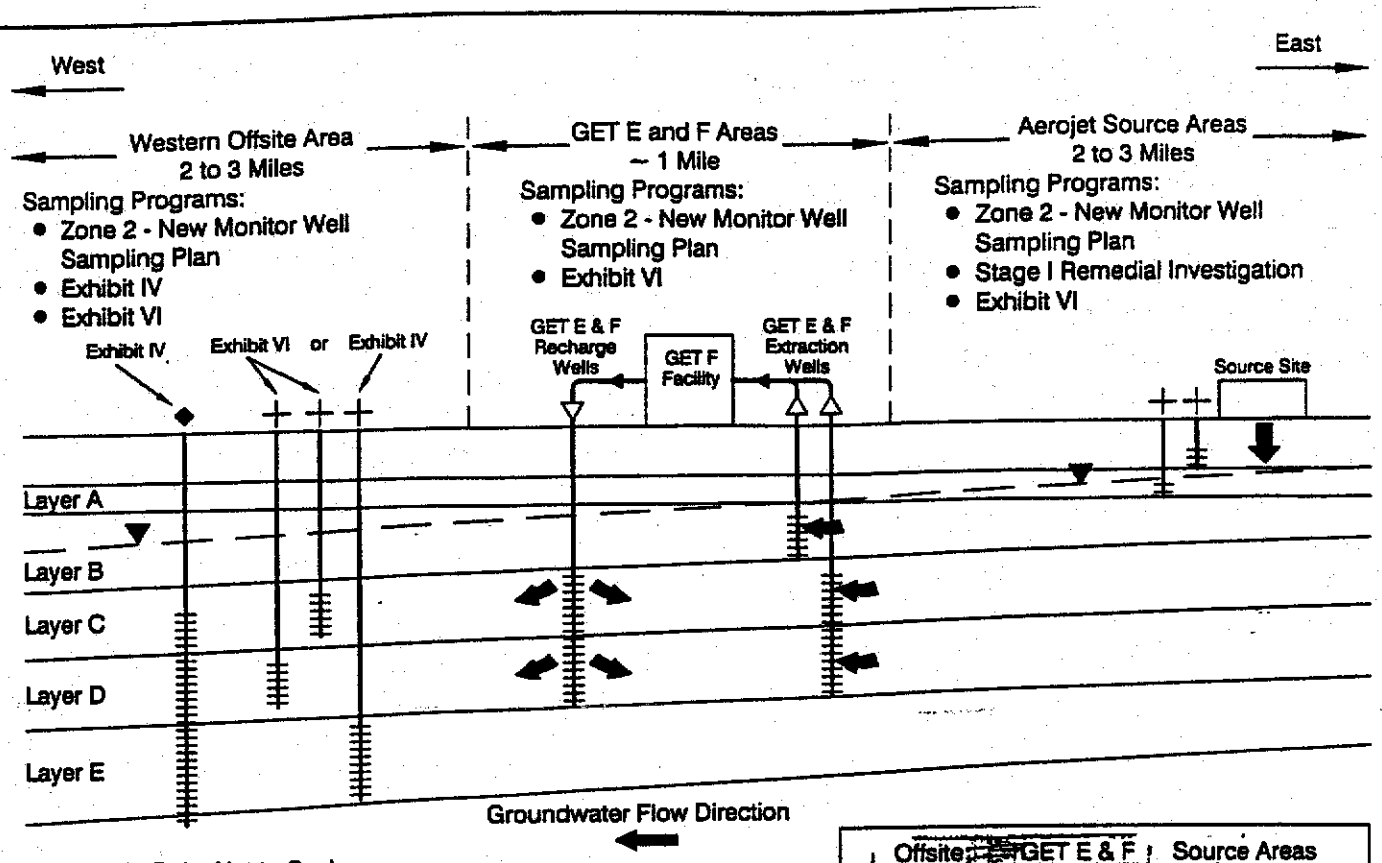
Environmental Remediation

FIGURE A-2

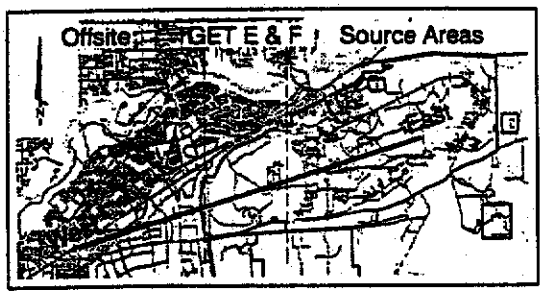
Western Groundwater Study Area
Regional and Local Surface Water Features

PAGES OF OVERSIZED MAPS

(SEE BINDER)



Schematic Only, Not to Scale



Approximate Area of Schematic
(Scale: 1" = 20,000')

Zone 2 - New Monitor Well Sampling Plan	
Frequency	**Analytes**
First Quarter	VOCs, Perchlorate, SVOCs, Metals, Chromium VI, TPH, Anions, NDMA, Field Parameters
Second Quarter Third Quarter Fourth Quarter	• VOCs and Perchlorate • Miscellaneous Compounds Detected in Initial Sampling

Exhibit VI Monitoring Plan (GET Effectiveness)	
Frequency	**Analytes**
• Quarterly • Semi-annually • Annually	Dependent on Well History, Typically: • VOCs • Perchlorate

Exhibit IV Monitoring Plan (Public Water Supply Wells)	
Frequency	**Analytes**
• Monthly • Quarterly • Semi-annually • Annually	• Initial Comprehensive Sampling • VOCs, Perchlorate, NDMA

Stage 1 RI Monitoring Plan (1991 - 1993)	
Vadose Zone	**Shallow Groundwater**
VOCs - Soil Gas Non-VOCs - Soil Samples Source Site Specific: • Perchlorate • TPH • Metals • SVOCs • OBPA • Prowl • Miscellaneous	4 Quarters Zone 2 Comprehensive Analysis • VOCs • SVOCs • Perchlorate • TPH • Metals • Anions • Misc. Compounds Detected in Vadose Zone

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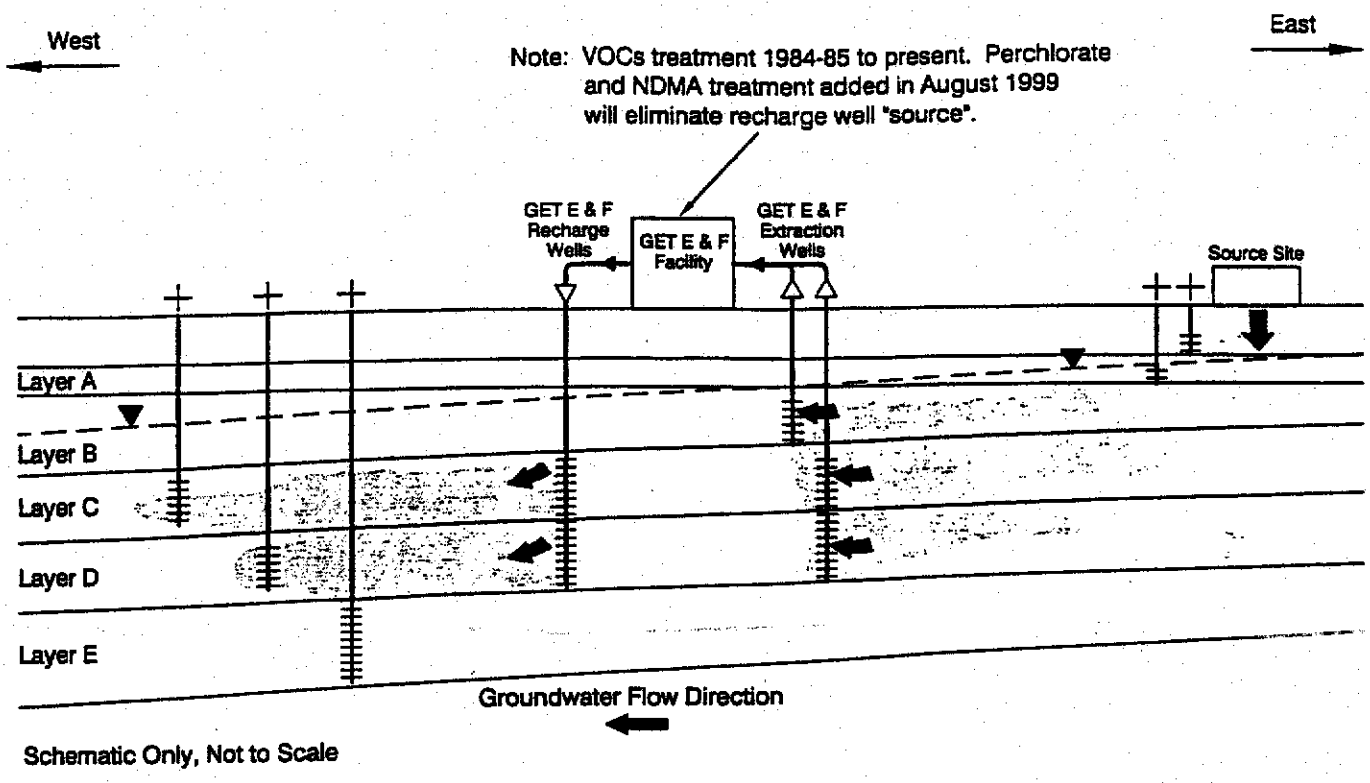
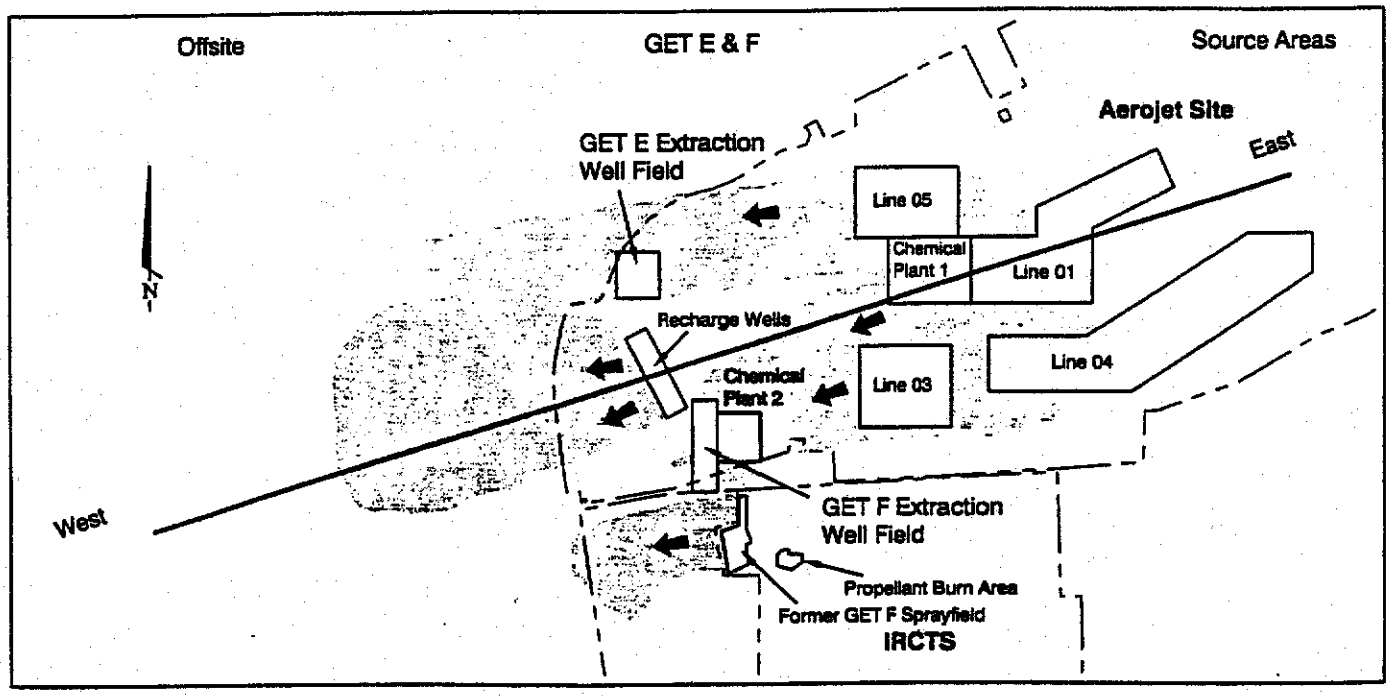
FIGURE A-16

Western Groundwater Study Area
Composite Schematic of
Aerojet Groundwater Monitoring

3/8/00 ah SR10109433





Approximate Area of Schematic
(Scale: 1" = 6,000')

EXPLANATION

Dissolved phase contaminants. Shown for illustration purposes only, does not depict contaminant type, concentration, depth, or exact location.

Conceptual Water Table

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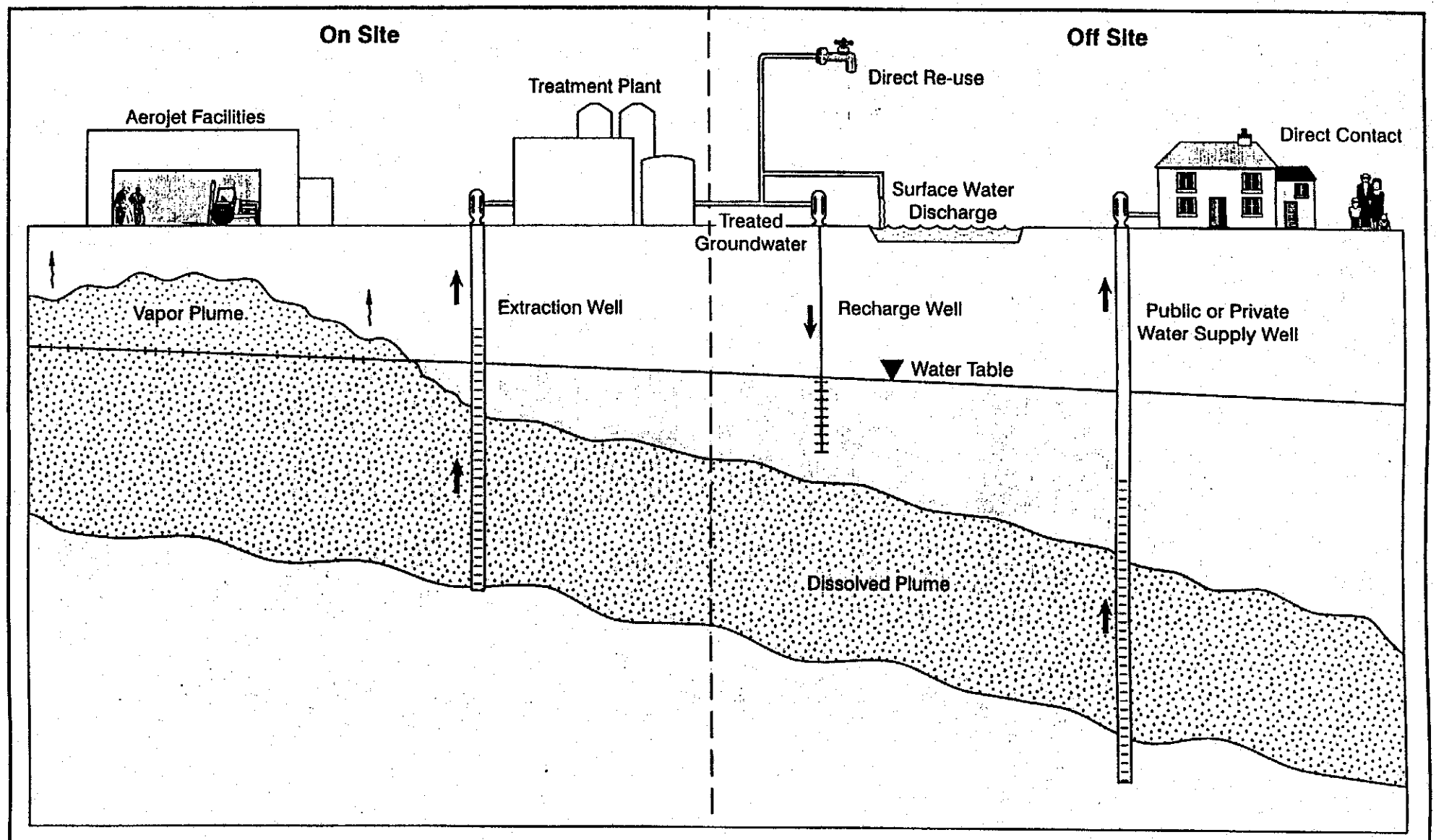
FIGURE A-17

Western Groundwater Study Area
Conceptual Migration of CoPCs in Groundwater

4/14/00 ch SR10109445

PAGES OF OVERSIZED MAPS

(SEE BINDER)



Not to Scale

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FIGURE A-38
Western Groundwater Study Area
Current and Future Potentially Complete Exposure Pathways

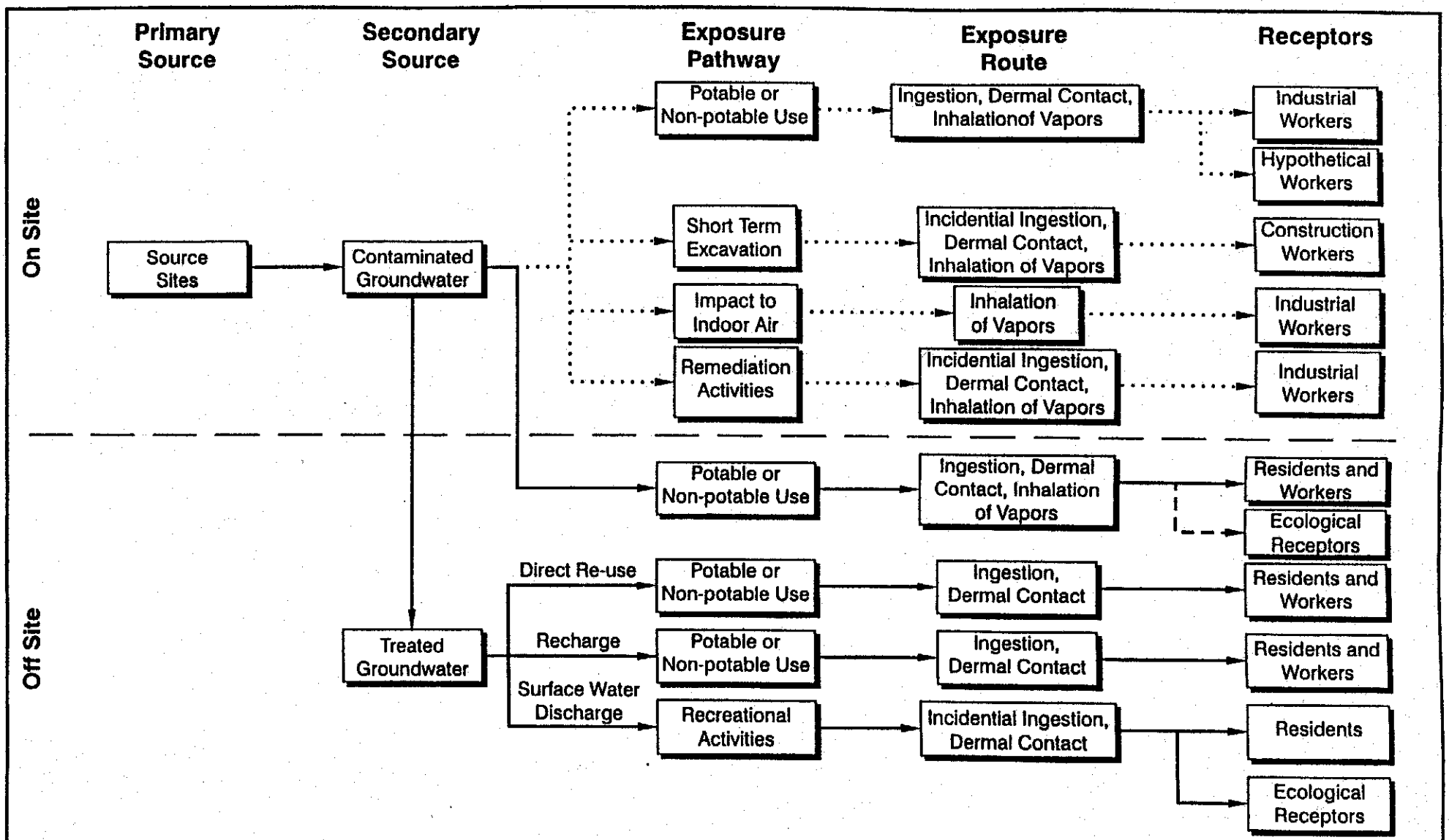

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FIGURE A-39
Western Groundwater Study Area
Potential Exposure Pathways

Western Groundwater Operable Unit
Baseline Risk Assessment

April 14, 2000

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Western Groundwater Operable Unit
Baseline Risk Assessment

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ATTACHMENT

Western Groundwater Operable Unit
Baseline Risk Assessment

B.1 INTRODUCTION

HSI GeoTrans (HSIG) conducted this Baseline Risk Assessment (BRA) of the Western Groundwater Study Area (Study Area) of the Aerojet Sacramento Site (Site) on behalf of Aerojet-General Corporation (AGC). The BRA was based on groundwater investigations and analytical groundwater sampling results collected over a period of about 15 years, up to the current time. During this sampling, chemical propellants and solvents were detected in groundwater samples collected from on- and offsite wells. These chemicals are the focus of this BRA.

This BRA addresses human health risks from hypothetical exposure to groundwater by future residential receptors. Ecological risks are not evaluated, as there are no completed exposure pathways to groundwater for ecological receptors. Groundwater does not surface within the Study Area nor does it surface at the American River.

B.1.1 Purpose and Scope

The purpose of this BRA is to evaluate potential site-specific human health risks associated with hypothetical exposure to chemicals detected in groundwater in the Western Plume area, as depicted in the plume maps shown on Figures B-2 through B-19. The risk assessment was conducted assuming that future residents could contact this water through its use as a private domestic water supply from an individual well. The concentrations used in the risk assessment are those that represent the current state of the plumes, without regard to future mitigation activities. Potential current exposures to offsite residents were addressed by developing risk-based concentrations that correspond to risks from 1E-6 (1 in 1 million) to 1E-4 (1 in 10,000) and a hazard index of 1.0.

This assessment was completed according to the DTSC *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities Guidance Manual* (DTSC 1992) and U.S. Environmental Protection Agency's (EPA) *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Part A* (EPA 1989). Exposure assumptions for estimates of chemical intake were based on information presented in those documents as well as: *DTSC Preliminary Endangerment Assessment* (DTSC

1994); *Exposure Factors Handbook* (EPA 1997a); *EPA Region IX Preliminary Remediation Goals (PRGs)* (EPA 1999); and *Risk Assessment Guidance for Superfund, Volume I, Part B* (EPA 1991). Information on chemical toxicity was obtained from *Integrated Risk Information System* (IRIS) (EPA 2000) and the *Toxicity Criteria Database* from the Office of Environmental Health and Hazard Assessment (OEHHA), California EPA (OEHHA 2000).

The baseline human health risk assessment follows the EPA risk assessment paradigm (EPA 1989) and consists of the following components:

1. data evaluation and identification of chemicals;
2. exposure assessment;
3. toxicity assessment; and
4. risk characterization.

B.1.2 Study Area Description

The Study Area encompasses approximately the western one-third of the Aerojet Site, the northwestern corner of the Inactive Rancho Cordova Test Site (IRCTS), the Aerojet-owned land west of the IRCTS, and approximately 10 square miles of commercially and residentially developed areas in the community of Rancho Cordova (Figure B-1). The entire Study Area is comprised of approximately 27 square miles. The western boundary of the Study Area is located at Mather Field Road, however, this boundary is artificial and is intended to be flexible in the event CoPCs are detected west of this location.

Descriptions of the Study Area geology and hydrogeology are contained within the RI report (Appendix A).

B.2 DATA COLLECTION AND EVALUATION

This section presents a brief summary of the data and plume maps used as the basis for exposure point concentrations used in this risk assessment. A detailed description of groundwater data and nature and extent of CoPCs in the Study Area are contained within the RI report. Data used in this report to characterize the groundwater were collected from monitoring wells and other wells, both onsite and offsite, for the past 15 years as described in the RI report.

Briefly, six hydrostratigraphic layers (Layers A through F) have been identified at the Study Area based on lithologic descriptions, water levels, geophysical data, pumping test data, chemical data, and relative depths and thicknesses. Layer F is not addressed in this RI as the deepest observed impacts on- or offsite are in the upper portion of Layer E. Layers A through E are evaluated for onsite areas, while Layers C through E were evaluated for offsite areas because chemical and hydraulic data indicate that CoPCs are not flowing off of the Aerojet Site in Layers A and B.

The plume maps were used as the representative exposure concentrations for the hypothetical residential receptor. In general, plume maps of CoPCs were developed using the most recent data available. In some areas, data were not available for the current sampling period (January 1996 to December 1998) and historical data were utilized. Risks were calculated based on the concentrations of each chemical as depicted by the plume isopleths. Chemicals for which a plume map was created were those most frequently detected, and that were not laboratory contaminants. Therefore, plume maps were created for TCE, NDMA, and perchlorate. The plume maps were used as the exposure point concentrations for TCE, NDMA, and perchlorate in addition to the maximum detected concentration of each chemical detected in each hydrostratigraphic layer.

Some of the chemicals were detected too infrequently to create a plume map, but were considered potentially site related. These chemicals were evaluated for each hydrostratigraphic layer using the maximum detected concentrations from the most recent 2 years of monitoring. The following chemicals were evaluated in this manner: 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichoroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), carbon tetrachloride, chloroform, freon-113, nitrate, nitrite, tetrachloroethene (PCE) and vinyl chloride. Data are summarized in Tables B.2-1 through B.2-10, organized by on- and off-site hydrostratigraphic

layer. Although data are presented for off-site Layers A and B, these layers are not associated with Aerojet activities and are not further evaluated, as described in the RI text.

The maximum concentration of each detected chemical was screened against EPA Region 9 PRGs to determine whether it should be retained as a CoPC, as described in EPA guidance (EPA 1998). All chemicals whose maximum detected concentration exceeded its PRG were retained as a CoPC and evaluated in the risk assessment. With the exception of nitrate and nitrite, all inorganic chemicals were considered to be present at naturally occurring concentrations and were not included in the risk assessment (see main body of the RI report for a discussion of inorganic chemicals).

B.3 EXPOSURE ASSESSMENT

An exposure assessment includes an evaluation of potential human receptors that could contact site-related chemicals, as well as routes, magnitude, frequency, and duration of exposure. An evaluation of all possible human exposures is necessary to identify receptors that could contact impacted groundwater in the future. The principal objective of this evaluation is to identify exposures that represent reasonable maximum (RME) for groundwater contact. The concept of reasonable scenarios underlies the RME concept developed by EPA. As defined by EPA (1989), the RME is the maximum exposure that is reasonably expected to occur at a site. It should be emphasized, however, that the RME exposure is for the same receptor and that, before risks are calculated, it must be determined whether "it is likely that the same individual would consistently face the 'reasonable maximum exposure (RME)'"(EPA 1989, emphasis not added).

It is also important that intake variable values for each RME exposure pathway should be "selected so that the combination of all intake variables results in an estimate of the reasonable maximum exposure for that pathway" (EPA 1989). In other words, the most conservative intake variables for each parameter for a given pathway are not used exclusively. A combination of average and upper-bound values should be combined to estimate exposures that are meaningful and represent the actual reasonable maximum exposure for the site.

The exposure assessment for the western groundwater plumes included the following steps:

- Characterization of the exposure setting(s) and identification of potential future receptors
- Identification of exposure pathways and exposure routes
- Estimation of exposure point concentrations, and
- Quantification of chemical intake for pathway specific exposures for each potential receptor

Following EPA guidance (1989), all complete exposure pathways were selected for evaluation unless:

- Exposure from the pathway is likely to be much less than that from another pathway involving the same medium of the same exposure point

- The potential magnitude of exposure from a pathway is likely to be very low
- The probability of the exposure occurring is very low and the risks associated with the pathway are low.

B.3.1 Exposure Pathways and Exposure Routes

According to EPA guidance (1989a), an exposure pathway consists of four elements:

- A source and mechanism of chemical release
- A retention or transport medium (or media in cases involving transfer of chemicals)
- A point of potential human contact with the contaminated medium (referred to as the exposure point)
- An exposure route (such as ingestion) at the contact point

Eliminating any of these elements (except in a case where the source itself is the point of exposure) results in an incomplete exposure pathway. Therefore, if no receptors exist that would contact the source or transport medium, the pathway is incomplete and is not evaluated.

For the purposes of this evaluation, the exposure and risk discussions are presented for onsite and offsite exposure. Current onsite exposures are incomplete because groundwater is not used. Water is supplied to the Aerojet facilities by the City of Folsom. Future onsite exposures are evaluated assuming that the land has been residentially developed and an individual installs a private well on their property for domestic use. The residential scenario represents the most conservative exposure setting because it involves ingestion, dermal contact, and inhalation of volatile chemicals from the impacted groundwater over a lifetime.

The offsite area above the plume has been residentially and commercially developed. The offsite groundwater has been used as a water supply source for residences, as supplied by water purveyors in the area. Current potential exposure to groundwater supplied by water purveyors is assessed by monitoring water quality pursuant to the Partial Consent Decree Exhibit IV monitoring plan. The water purveyors, in conjunction with the California DHS, determine when a well should be taken out of service. Private wells do exist in the offsite areas, although most are not used as domestic water supply wells; they are used for industrial or agricultural purposes (as presented on Figure A-13 of this RI report). Again, future use of groundwater was evaluated

assuming an individual installed a private well on their property for domestic use. This residential scenario represents the most conservative exposure setting because it involves ingestion, dermal contact, and inhalation of volatile chemicals from the impacted groundwater over a lifetime.

The exposure pathways selected for inclusion in this risk assessment include ingestion of and dermal contact with groundwater for all chemicals. In addition, the exposure pathway of inhalation of volatile chemicals while showering was included for volatile chemicals. These pathways are consistent with EPA guidance (1989), EPA Region IX PRGs (EPA 1998) and DTSC guidance (1992, 1994). While other exposure pathways may be possible, these pathways represent the most likely to be complete and the pathways that would involve exposures for the longest duration and greatest quantity. In particular, use of water for irrigation and watering of livestock were not evaluated because potential exposure from these pathways would be significantly lower than direct ingestion, dermal contact, and inhalation pathways.

Because these pathways are based on future exposures, they are considered potentially complete and evaluated to provide a conservative estimate of risk. Not all of these pathways may actually be complete for all receptors in the future, and exposure may differ from the parameters used here to estimate risk.

B.3.2 Exposure Point Concentrations

Exposure point concentrations for NDMA, perchlorate, and TCE in the western plume area were estimated from the plume maps. The plume maps were used to generate isopleths of risks corresponding to the concentration gradients measured from monitoring wells and modeled to future receptors. For perchlorate, these concentrations ranged from 4 µg/L to 4,000 µg/L. For NDMA, the concentration range was 0.01 µg/L to 1.0 µg/L. For TCE, the plume concentrations ranged from 5 to 5000 µg/L. Plume maps were prepared for each hydrostratigraphic layer. In addition, the maximum detected concentrations of NDMA, perchlorate, and TCE detected in each hydrostratigraphic layer over the past 2 years of monitoring were used to estimate the maximum risk to receptors. Use of the maximum detected concentrations to estimate risks is an extremely conservative measure. Per EPA and DTSC guidance (EPA 1989, DTSC 1992), baseline risk assessments typically use the upper 95th percent confidence limit of the mean concentration (95UCL) as the exposure point concentration. The 95UCL is a measure of the average concentration rather than the maximum detected value.

Chemicals that were too infrequently detected for plume map generation were evaluated using the maximum detected concentration from the most recent 2 years of sampling results. These chemicals and the exposure point concentrations used are presented in Tables B.2-1 through B.2-10, related to the hydrostratigraphic layer in which each was detected for on- and off-site areas.

Current hypothetical exposure to impacted groundwater was estimated by providing a range of concentrations that correspond to risks from 1E-6 to 1E-4 and a hazard index of 1.0 for chemicals listed in the Partial Consent Decree, described in the RI report.

B.3.3 Quantification of Chemical Intake

To estimate the intake of chemicals contained in the plumes and the risks associated with that intake, exposure equations with appropriate exposure parameters were selected for hypothetical residential receptors. Exposure, or intake, is defined as the mass of chemical taken into the body per unit body weight per unit time. Intake of a chemical from groundwater is the product of the exposure point concentration for a plume area, the frequency and duration of exposure, and contact rate, all divided by the product of body weight and averaging time. The general equation for intake is

$$\text{Intake (mg/kg-day)} = \frac{C \times CR \times EF \times ED \times CV}{BW \times AT}$$

where

C = Exposure point concentration (milligram per liter [mg/L])

CR = Contact rate (liters per day, cubic meters per hour)

EF = Exposure frequency (days per year)

ED = Exposure duration (years)

CV = Conversion factors (L/cm^3, for example)

BW = Body weight (kg)

AT = Averaging time (days)

For this baseline risk assessment, the general equation was modified specifically for the ingestion, dermal contact and inhalation of vapors from groundwater exposure pathways. The complete equations and input parameters are presented in Tables B.3-1 and B.3-2 for residential exposures.

As shown in these tables, the contact rate is more specifically defined for exposure pathway. Exposure parameters for the intake calculations were selected from the *PEA Guidance* (DTSC 1994); the *Supplemental Guidance for Human Health Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (DTSC 1992); *EPA Region 9 PRGs* (EPA 1999); the *Exposure Factors Handbook* (EPA 1997a); *Risk Assessment Guidance for Superfund, Volume I; Part A* (EPA 1989); and *Risk Assessment Guidance for Superfund, Volume I, Part B* (EPA 1991).

For residential RME exposure, the exposure frequency was assumed to be 350 days per year and the exposure duration was set at 30 years, the default upper-bound value for the number of years people live at one residence in the entire United States (EPA 1997, EPA 1999). For groundwater ingestion, values of 2 liters per day (L/day) for adults and 1 L/day for children were used. The surface area for dermal contact was set at 19,400 square centimeters (cm^2/event). All exposure parameters used are referenced in Tables B.3-1 and B.3-2.

B.4 TOXICITY ASSESSMENT

The toxicity assessment focuses on the chemicals presented in groundwater plume maps or otherwise included in the HHRA: carbon tetrachloride, chloroform, 1,2-DCA, 1,1-DCE, 1,2-DCE, NDMA, perchlorate, PCE, and TCE, and nitrates. Standard toxicological methodologies for assessing the toxicity of chemicals involve quantifying dose-response relationships for adverse human health effects associated with exposure to specific chemicals.

Qualitative and quantitative toxicity information and EPA- and DTSC-derived toxicity values are included in the toxicity profiles provided as an attachment to this appendix, for the chemicals in the Study Area groundwater. Sources of information included IRIS (EPA 2000), OEHHA's Toxicity Criteria Database (OEHHA 2000), EPA Region IX PRGs (1999), and the Superfund Technical Support Center (1998). Carcinogenic chemicals and associated risks are evaluated and presented separately from noncarcinogenic chemicals; however, noncarcinogenic effects of carcinogenic chemicals were also evaluated.

For carcinogenic health effects, carcinogenic slope factors (CSFs) are used to estimate the additional lifetime cancer risk corresponding to chemical intake. CSFs correspond to specific routes of exposure. The current CSF from DTSC and IRIS and the weight of evidence classification is provided in the toxicity profiles for each carcinogenic chemical. CSFs are expressed in units of (milligrams per kilogram-day)$^{-1}$ [(mg/kg-day)$^{-1}$].

Carcinogenic risk is the product of the calculated intake multiplied by the CSF for the pathway of interest. Risk is a statistical measure of an individual's increased probability of developing cancer over a lifetime from exposure to chemicals at a site, under the assumptions used to calculate intake (EPA 1989).

The following information was gathered from all available sources and presented for noncarcinogenic chemicals:

1. The current reference dose (RfD) and the reference concentration (RfC) and the basis for these values;
2. Critical study on which the toxicity value is based;

3. Target organs and uncertainty factors; and
4. Possible biochemical mechanisms of toxicity.

The potential for noncarcinogenic adverse health effects for ingestion is typically evaluated by comparing estimated daily intakes with RfDs. RfDs represent daily intakes at which no adverse health effects are expected to occur to even sensitive receptors (EPA 1989). RfCs represent the equivalent value for inhalation exposures. RfCs are typically presented in units of milligrams per cubic meter (mg/m^3), but can be converted to inhalation RfDs and expressed in units of milligrams per kilogram-day (mg/kg-day) to be consistent with the units of intake calculations.

Noncarcinogens are assessed in terms of hazard quotients rather than risk. A hazard quotient is the ratio of a chemical-specific intake to the RfD. Hazard quotients are summed across chemicals and exposure pathways to produce hazard indices (HIs) for a specific exposure scenario (residential, occupational, agricultural, or recreational). This is a conservative approach because it sums non-cancer risks that may not be additive or associated with the same target organ and is used for screening purposes.

Toxicity profiles for CoPCs are presented as an attachment to this appendix. Toxicity values are presented in Tables B.4-1 through B.4-4.

B.5 RISK CHARACTERIZATION

The risk characterization combines exposure and toxicity information to estimate human health carcinogenic risks and noncarcinogenic hazard indices. For the Study Area, the risk characterization is described for on- and offsite areas by hydrostratigraphic layer in subsections B.5.1 and B.5.2. The risk characterizations for perchlorate, NDMA, and TCE are keyed to the plume maps, presented in this section by hydrostratigraphic layer. Additionally, the maximum detected concentrations of NDMA, TCE, perchlorate, and any other detected chemical selected as a CoPC are included in the risk assessment.

The risks and hazard indices are characterized in reference to the criteria established in the National Contingency Plan. Specifically, "for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound life-time cancer risk to an individual of between 10-4 and 10-6 using information on the relationship between dose and response" [40CFR§340.430(e)(2)(i)(A)(2)]. For hazard indices, the acceptable level is 1.0.

B.5.1 Onsite Areas

The following subsections describe risk assessment results for onsite areas. Because there are no currently complete exposure pathways onsite, only future potential exposures are addressed.

B.5.1.1 Layer A

Figures B-2 through B-5 show the plume maps for Layer A. As shown on Figure B-2, the TCE plume is drawn at concentrations of 5 to 50 µg/L, which corresponds to risks of 1.0E-6 to 1.0E-5, respectively (the offsite plume of 50 µg/L is unrelated to the Aerojet Site and is not further discussed in this risk assessment). These risks are related almost entirely to groundwater ingestion. Risks from dermal contact with groundwater and inhalation of vapors are insignificant for this chemical, with both pathways posing risks less than 1E-7 even at 50 µg/L. The hazard index associated with a concentration of 5 µg/L is 0.025 and is 0.25 at a concentration of 50 µg/L, based on ingestion, dermal contact, and inhalation pathways. The risks from exposure to these plume concentrations are within the NCP acceptable range of 1.0E-6 to 1.0E-4, and are well

below the level of concern of 1.0 for hazard indices. The maximum detected concentration of TCE on-site in Layer A was at Well 3348 at 82 µg/L. This corresponds to a risk of 1.7E-5 and hazard index of 0.41.

Figure B-3 displays the additional volatile organic chemicals (VOCs) that were detected in Layer A and selected as CoPCs. Chloroform and 1,2-DCA were detected onsite (the offsite detections of vinyl chloride, PCE, TCE, perchlorate, 1,1-DCE and 1,2-DCE are unrelated to the Aerojet site and are not furthered discussed in this risk assessment). Chloroform, at a concentration of 230 µg/L, is associated with a risk of 1.4E-4 and hazard index of 3.8. 1,2-DCA was detected at a maximum concentration of 950 µg/L. The risk from 1,2-DCA is 7.1E-4. The maximum concentration was at Well 131, which overlaps the TCE isopleth of 50 µg/L, resulting in a total risk of 1.0E-4 at this well. The risk is due mainly to 1,2-DCA. The hazard index of 1,2-DCA is 1.7 at 950 µg/L.

Other chemicals detected in Layer A on-site were 1,1,2-trichloroethane (1,1,2-TCA), 1,2-DCE, PCE, nitrate and nitrite. The risks and hazard indices associated with the maximum detected concentrations of these chemicals are:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1,2-TCA	1.3	1.5E-6	0.0095
1,2-DCE	10	NA	0.033
PCE	0.82	7.0E-6	0.0025
Nitrate	219 ppm	NA	3.8
Nitrite	22 ppm	NA	6.0

Perchlorate was detected in Layer A and plumes were drawn at isopleths of 4 to 400 µg/L as shown on Figure B-4 (the offsite detection of VOCs in Well 30065 are unrelated to the Aerojet Site and are not discussed further in this risk assessment). The hazard index corresponding to 0.4 µg/L is 0.22, and increases to 22 at 400 µg/L. Where the perchlorate plume overlaps with the TCE plume, the hazard index rises to 22.25 (perchlorate at 400 µg/L and TCE at 50 µg/L). The maximum detected concentration of perchlorate in on-site Layer A is 75 µg/L, which corresponds to hazard index of 4.1. Perchlorate is evaluated only as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are also protective against potential carcinogenic effects.

The NDMA plume in Layer A is drawn at isopleths of 0.01 µg/L and 0.1 µg/L at a single onsite area (Figure B-5). The risks associated with these concentrations are 2.4E-6 at 0.01 µg/L and 2.4E-5 at 0.1 µg/L. These risks are related primarily to ingestion of groundwater, and to a much lesser degree, dermal contact with groundwater. The risks from exposure to these plume concentrations are within the NCP acceptable range of 1.0E-6 to 1.0E-4. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical. The maximum concentration of NDMA of 0.16 µg/L is associated with a risk of 3.9E-5. The maximum concentration was detected in Well 22.

The TCE plume, shown on Figure B-2, overlaps the NDMA plume in certain areas. If risks from these two chemicals are added at the points where the plumes overlap, the highest risk is 3.4E-6, which is within the NCP acceptable risk range of 1E-6 to 1E-4. The maximum concentrations of each CoPC result in a total risk of 8.7E-4, above the NCP range as shown in Table B.5-1. However, this risk is due mainly to 1,2-DCA and chloroform, both of which are infrequently detected. The total hazard index is 20, due to nitrate, nitrite and perchlorate as shown in Table B.5-2. Again, the hazard indices are overestimates of actual exposure because they are based on the maximum detected concentrations.

B.5.1.2 Layer B

Figure B-6 shows two onsite TCE plumes in the Layer B hydrostratigraphic unit. The isopleths ranged from 5 µg/L to 5,000 µg/L in the larger plume. At 5 µg/L, the risk is 1.0E-6 and the hazard index is 0.025; at 5,000 µg/L, the risk is 1.0E-3 and the hazard index is 25. The maximum concentration was detected in Well 132 (9,400 µg/L). The smaller plume has concentrations of 5 to 50 µg/L, which correspond to risks of 1.0E-6 and 1.0E-5, respectively. All isopleths are within the Aerojet property boundary. The risks of the smaller plume are within the NCP acceptable risk range of 1E-6 to 1E-4, and most of the larger plume falls in that range as well. Only at the 5,000 µg/L isopleth does the risk exceed that range. The hazard indices are also below the level of concern except at the isopleths of 500 and 5,000 µg/L (hazard indices of 2.5 and 25, respectively). The maximum detected concentration of TCE of 9,400 µg/L in well 132 is associated with a risk of 1.9E-3 and hazard index of 47.

Perchlorate is also found in two plumes in Layer B, as shown on Figure B-7. In the smaller plume, the concentrations range from 0.4 µg/L to 4,000 µg/L. The hazard indices corresponding to these concentrations are 0.022 and 220. The larger plume also has isopleths of up to 4,000 µg/L. The TCE plume overlaps the larger perchlorate plume. The highest isopleths of both chemicals results in a hazard index of 245, due mainly to perchlorate. The maximum detected concentration of perchlorate in Layer B on-site was 11,000 µg/L at Well 305, which corresponds to a hazard index of 604.

Five small onsite NDMA isopleths were drawn for Layer B, involving 5 separate wells (Figure B-8). The NDMA concentrations exceeded 0.01 µg/L at each of the five wells, and NDMA concentrations exceeded 0.1 µg/L at two wells. The concentration of 0.01 µg/L corresponds to a risk of 2.4E-6, and 0.1 µg/L corresponds to a risk of 2.4E-5. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical. The maximum detected concentration was 0.32 µg/L at Well 282. The risk of NDMA at 0.32 µg/L is 7.7E-5.

The NDMA and TCE plumes overlap at two points: the Magazine Area (Wells 282 and 283) and Well 4315. The total risk from the combined effects of these chemicals at the Magazine Area is 3.4E-5, due mainly to NDMA. At Well 4315, the combined risk is 1.0E-3, due mainly to TCE.

Other chemicals detected in on-site Layer B hydrostratigraphic layer are associated with the following risks and hazards:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1,2-TCA	1.5	1.7E-6	0.011
1,1-DCE	48	4.5E-4	0.16
1,2-DCE	120	NA	0.39
Carbon Tetrachloride	1.4	3.4E-6	0.06
Chloroform	350	1.7E-4	5.8
PCE	2.1	1.8E-6	0.0065
Nitrate	11 ppm	NA	0.19

Although the plumes of TCE, NDMA, and perchlorate are within the acceptable risk range of 1E-6 to 1E-4 (except at the highest plume concentration of TCE), the total risk from the maximum

detected concentrations of all CoPCs is 2.7E-3 and the total HI is 660, as shown in Tables B.5-3 and B.5-4. These risks are extremely conservative because they assume a maximum exposure for a 30-year period. The plume maps are more representative of exposure that could occur over time.

B.5.1.3 Layer C

The TCE plume for Layer C is shown on Figure B-9. In the onsite areas, the plume isopleths range from 1 µg/L to 50 µg/L. At 1 µg/L, the risk is 2.1E-7 and the hazard index is 0.005. At 50 µg/L, the risk is 1.0E-5 and the hazard index is 0.25. The 50 µg/L plume is mainly on the east side of the facility, with the lower plume concentrations approaching the western boundary. Even at 50 µg/L, the risks are within the NCP acceptable risk range of 1.0E-6 to 1.0E-4, and hazard indices are below 1.0. The maximum concentration of TCE in on-site layer C is 5,300 µg/L at well 3058, which corresponds to a risk of 1.1E-3 and a hazard index of 26.

Figure B-10 shows the additional detections of some VOCs in Layer C in the onsite area. The additional CoPCs and there associated risks and hazard indices are as follows:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1-DCE	63	5.9E-4	0.21
1,2-DCA	160	1.2E-4	0.28
Carbon Tetrachloride	0.66	1.6E-6	0.028
Chloroform	670	3.2E-4	11
PCE	5.9	5.0E-6	0.018

Perchlorate was also detected in Layer C, and isopleths were drawn for concentrations of 4 µg/L, 40 µg/L, 400 µg/L and 4,000 µg/L (Figure B-11). Perchlorate is evaluated as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are protective against potential carcinogenic effects as well. At a concentration of 4 µg/L, the hazard index is 0.22, lower than the NCP level of concern of 1.0. The concentration of 40 µg/L corresponds to a hazard index of 2.2; at 400 µg/L, the hazard index is 22.0. The highest hazard index of 220 is associated with the concentration isopleth of 4,000 µg/L, which occurs in three areas. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for

perchlorate. The maximum detected concentration of perchlorate in on-site Layer C was 8,200 µg/L at well 4140. This concentration corresponds to a hazard index of 450.

NDMA in Layer C is generally present on the western side of the Aerojet Site and offsite northwest of GET E (Figure B-12). In the onsite areas, the concentration isopleths of 0.01 µg/L to 0.1 µg/L exist in around Wells 3083, 3018, and 4140 and in the northwest portion of the site. The risk associated with a concentration of 0.1 µg/L is 2.4E-5 and the risk associated with a concentration of 0.01 µg/L is 2.4E-6. The maximum detected concentration of NDMA in on-site layer C is 0.39 µg/L at Well 1435, which corresponds to a risk of 9.4E-5. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical.

The NDMA plumes overlap with the TCE plume at all points. The maximum risk from exposure to these two plumes at their highest concentrations is 3.4E-5, with a maximum hazard index of 0.25. The perchlorate and TCE plumes also overlap, although the hazard indices associated with TCE in this layer are very low and do not contribute significantly to the total hazard index. The individual wells assessed for Layer C also overlap with the TCE, NDMA, and perchlorate plumes. At Well 124, the TCE isopleth of 5 µg/L, the NDMA plume of 0.1 µg/L and the perchlorate plume of 4 µg/L combine with the individual well risk and hazard index to result in a total combined risk of 2.5E-5 and total combined hazard index of 0.25.

For Layer C, the areas of the plumes that exceed generally acceptable levels of risk and hazard are limited to perchlorate at concentrations of 40 µg/L or higher. Trichloroethene and NDMA in Layer C of the western plume area were found at concentrations that correspond to risks within the acceptable risk range of 1E-6 to 1E-4, even when risks are summed for these chemicals. The maximum detected concentrations of all CoPCs detected in on-site Layer C have a total risk of 2.1E-3 and hazard index of 490. These risks are overestimates of actual exposure concentrations for long-term exposure, and a substantial portion of the risk is attributable to infrequently detected chemicals. The total risks and hazard indices based on the maximum detected concentrations are presented in Tables B.5-5 and B.5-6.

B.5.1.4 Layer D

TCE, NDMA, and perchlorate were detected Layer D and plume maps were drawn for these chemicals.

The TCE plume is shown on Figure B-13, and is drawn in concentration isopleths of 5 and 50 µg/L. The risks associated with these concentrations are 1.0E-6 and 1.0E-5, respectively. Hazard indices are 0.025 and 0.25, respectively. These risks and hazard indices are within or below the NCP acceptable range, and are based on hypothetical use of the groundwater as a domestic water supply for future onsite residential receptors. The maximum detected concentration of TCE was 1,500 µg/L at Well 3332, which corresponds to a risk of 3.1E-4 and hazard index of 7.5.

Additional VOCs detected in onsite wells is shown on Figure B-14. The following chemicals were selected as CoPCs for on-site layer D, in addition to TCE, NDMA and perchlorate:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1-DCE	14	1.4E-4	0.05
1,2-DCA	4.7	NA	0.008
Chloroform	460	2.3E-4	7.7
PCE	5	4.2E-6	0.02

As shown on Figure B-15, the NDMA plume is drawn in isopleths of 0.01 µg/L, 0.1 µg/L and 1.0 µg/L in three areas. The risks associated with these concentrations are 2.4E-6 at 0.01 µg/L and 2.4E-5 at 0.1 µg/L. At 1.0 µg/L, the risk is 2.4E-4. This concentration was detected only within the Aerojet property boundary. These risks are related primarily to ingestion of groundwater and, to a much lesser degree, dermal contact with groundwater. The risks from exposure to these plume concentrations are within the NCP acceptable range of 1.0E-6 to 1.0E-4, with the exception of the plume isopleth of 1.0 µg/L. The maximum detected concentration of NDMA was 1.3 µg/L at Well 442, corresponding to a risk of 3.1E-4. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical.

Perchlorate was detected in a wider area, and plume isopleths were drawn corresponding to concentrations of 4 µg/L, 40 µg/L, 400 µg/L and 4,000 µg/L (Figure B-16). Perchlorate is evaluated as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are also protective against potential carcinogenic effects. The results were similar to those of the Layer C risk characterization. At a concentration of 4 µg/L, the hazard index is 0.22, lower than the NCP level of concern of 1.0. The concentration of 40 µg/L corresponds to a hazard index of 2.2; at 400 µg/L, the hazard index is 22.0. The highest hazard index of 220 is associated with the concentration isopleth of 4,000 µg/L, which occurs in one area within the Aerojet property boundary. The maximum detected concentration of perchlorate was 8,700 µg/L at Well 3213, which corresponds to a hazard index of 480. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate.

The points at which the NDMA and TCE plumes overlap result in a maximum risk of 2.5E-4; this occurs at the northwest boundary of the Aerojet site. The total risk from the maximum detected concentrations of each CoPC is 9.8E-4 for on-site Layer D. The total HI based on maximum concentrations is 490. The total risks and hazard indices (presented in Tables B.5-7 and B.5-8) are overestimates of actual risks because they are based on the maximum detected concentrations and include infrequently detected chemicals. Additionally, the maximum concentrations are not representative of long-term exposure concentrations.

Therefore, for Layer D, chemicals and plume concentrations that exceed the NCP acceptable risk range and hazard index criteria are perchlorate at concentrations of 40 µg/L or above, and NDMA at concentrations of 1.0 µg/L or above. Individual chemicals that were infrequently detected and maximum concentrations of NDMA, perchlorate, TCE, 1,1-DCE and chloroform also exceed the acceptable risk range or hazard index criteria.

B.5.1.5 Layer E

Although plume maps for TCE, NDMA, and perchlorate were developed for Layer E, the extent of the plumes is far more limited and concentrations are lower than those in Layers C and D.

For TCE, as shown on Figure B-17, the plume is limited to the northwest corner of the Aerojet Site. Two isopleths were drawn, 5 µg/L and 50 µg/L, that correspond to risks of 1.0E-6 and 1.0E-5, respectively. Hazard indices are 0.025 and 0.25 at these concentrations, respectively.

The maximum detected value of TCE was 84 µg/L at Well 3333, corresponding to risks of 1.8E-5 and a hazard index of 0.4.

The two perchlorate plumes for Layer E are located in close proximity to each other, with concentrations ranging from 4 µg/L to 400 µg/L (Figure B-18). At 4 µg/L, the hazard index associated with perchlorate is 0.22, below the NCP level of concern. At 40 µg/L, the hazard index is 2.2 µg/L; at 400 µg/L, the hazard index is 22. The maximum detected concentration of perchlorate of 610 µg/L in Well 3566 corresponds to a hazard index of 33. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate.

The NDMA plumes were drawn at concentrations of 0.01 µg/L and 0.1 µg/L (Figure B-19). The plumes are present in three areas. At a concentration of 0.01 µg/L, the risk from NDMA exposure is estimated at 2.4E-6; the risk is estimated at 2.4E-5 at a concentration of 0.1 µg/L. These risks are within the NCP acceptable risk range of 1.0E-6 to 1.0E-4. The maximum detected concentration of NDMA of 0.38 µg/L in Well 3307 corresponds to a risk of 9.2E-5. The risks are attributable to groundwater ingestion, as dermal contact with groundwater contributes an insignificant amount to the total risk.

TCE and NDMA overlap at the northwest corner of the site, with a maximum risk totaling 3.4E-5. The hazard index of 0.25 for TCE remains unchanged, because NDMA is not evaluated for noncarcinogenic effects. The perchlorate plume overlaps both the NDMA and TCE plumes. However, the hazard index for perchlorate is greater than that for TCE, and the addition of hazard indices for these two chemicals does not change the conclusions regarding hazard indices.

Chloroform was also detected in on-site Layer E groundwater, at a maximum concentration of 1.6 µg/L in Well 3307. This concentration corresponds to a risk of 7.8E-7 and hazard index of 0.026.

In conclusion, for Layer E, the risks associated with TCE and NDMA plume concentrations fall within the NCP acceptable risk range of 1.0E-6 to 1.0E-4, when considered separately or together. For perchlorate, plume concentrations of 40 µg/L or above cause the hazard index to exceed the acceptable level of 1.0. The maximum detected concentrations of TCE, NDMA, perchlorate, and chloroform are associated with a total risk of 1.1E-4 and total hazard index of 34, as shown in Tables B.5-9 and B.5-10.

B.5.2 Offsite Areas

Two assessments were performed to estimate risks to off-site receptors from exposure to CoPCs in groundwater. First, concentration ranges for NDMA and TCE corresponding to risks of 1E-6 to 1E-4 and a hazard index of 1.0 were calculated to provide an estimate of future potential risks where these chemicals are detected. For perchlorate, a concentration range corresponding to a hazard index of 1.0 using a range of toxicity values is presented. Second, for hydrostratigraphic layers C through E, risks and hazard indices corresponding to the maximum detected concentrations of each CoPC were calculated. Risks and hazard indices were also calculated for plume isopleths to present the areal extent of potential human health impacts.

For future potential exposures, only Layers C through E are considered for offsite areas because CoPCs in Layers A and B are not flowing offsite.

B.5.2.1 Potential Current Exposures

The potential current exposures were assessed using the same exposure parameters as the future exposures, that is, 350 day per year exposure for a total of 30 years, through groundwater ingestion, dermal contact, and inhalation pathways. The results (in µg/L) are as follows:

Chemical	Risk-based Concentration	Risk Range	Hazard Index Range
NDMA	0.0042 to 0.42	1E-6 to 1E-4	NA
TCE	4.2 to 420	1E-6 to 1E-4	0.02 to 2.0
Perchlorate	19 (RfD = 0.0005)	NA	1.0
	34 (RfD = 0.0009)	NA	1.0

These are hypothetical risks, based solely on the potential for these chemicals to appear in offsite groundwater supply wells. Aerojet cannot direct water purveyors on the use of their wells. However, it would be unlikely that a receptor would be exposed to these chemicals for the amount of time assumed in this assessment once a water purveyor and DHS have been informed of the presence of these chemicals in a well.

B.5.2.2 Layer C

The TCE plume for Layer C is shown on Figure B-9. In the offsite areas, the plume isopleths range from 1 µg/L to 5 µg/L, with one small area to the north of the Aerojet Site having a plume of 50 µg/L. At 1 µg/L, the risk is 2.4E-7 and the hazard index is 0.005. At 50 µg/L, the risk is 1.0E-5 and the hazard index is 0.25. Even at 50 µg/L, the plume risks are within the NCP acceptable risk range of 1.0E-6 to 1.0E-4, and hazard indices are below 1.0. The maximum detected concentration of TCE was 82 µg/L in Well 30138, which corresponds to a risk of 1.8E-5 and hazard index of 0.44.

Perchlorate was also detected in Layer C, and isopleths were drawn at concentrations of 4 µg/L, 40 µg/L, 400 µg/L and 4,000 µg/L (Figure B-11). Perchlorate is evaluated as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are protective against potential carcinogenic effects as well. At a concentration of 4 µg/L, the hazard index is 0.22, lower than the NCP level of concern of 1.0. The concentration of 40 µg/L corresponds to a hazard index of 2.2; at 400 µg/L the hazard index is 12.0. The highest hazard index of 220 is associated with the concentration isopleth of 4,000 µg/L, which occurs in three areas. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate. The maximum detected concentration of perchlorate of 8,700 µg/L from Well 30081 is associated with a hazard index of 480.

NDMA in Layer C is generally to the western side of the Aerojet Site, and most of the plume is offsite (Figure B-12). The concentration isopleths of 0.01 µg/L to 0.1 µg/L exist off the northwest portion of the site. The risk associated with a concentration of 0.1 µg/L is 2.4E-5 and with 0.01 µg/L is 2.4E-6. The maximum concentration of NDMA was 0.25 µg/L in Well 1484, which corresponds to a risk of 6.0E-5. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical.

The NDMA plume overlaps with the TCE plume at all points of the offsite NDMA plume. The maximum risk from exposure to these two plumes at their highest concentrations is 3.4E-5, with a maximum hazard index of 0.25. The perchlorate and TCE plumes also overlap, although the hazard indices associated with TCE in this layer are very low and do not contribute significantly to the total hazard index.

Other CoPCs selected for off-site Layer C were 1,1-DCE, 1,2-DCA, chloroform, nitrate, and nitrite. The maximum detected concentrations of each CoPC are associated with the following risks and hazard indices:

Chemical	Concentration (µg/L)	Risk	Hazard Index
1,1-DCE	3.9	2.9E-6	0.013
Chloroform	28	1.4E-5	0.46
Nitrate	12 ppm	NA	0.21
Nitrite	2.6 ppm	NA	0.71

All are within the NCP acceptable risk range and below the hazard index criteria of 1.0.

For Layer C, the chemicals and areas of the plume that exceed generally acceptable levels of risk and hazard are limited to perchlorate at concentrations of 40 µg/L or higher. Trichloroethene and NDMA in Layer C of the western plume area were found at concentrations that correspond to risks within the acceptable risk range of 1E-6 to 1E-4, even when risks are summed across chemicals, in the offsite area. The maximum concentrations of each CoPC are associated with a total risk of 9.5E-5 and total hazard index of 481, as shown in Tables B.5-11 and B.5-12. The majority of the total hazard index is due to perchlorate and the majority of the risk is due to infrequently detected chloroform as well as NDMA and TCE.

B.5.2.3 Layer D

TCE, NDMA, and perchlorate were detected Layer D and plume maps were drawn for these chemicals.

The TCE plume is shown on Figure B-13, and was drawn at concentration isopleths of 5 and 50 µg/L. However, only the 5 µg/L isopleth extends to offsite areas. The risk associated with this concentration is 1.0E-6. The hazard index is 0.025. The maximum detected concentration of TCE of 15 µg/L in Well 1461 corresponds to a risk of 3.1E-6 and hazard index of 0.074. These risks and hazard indices are within or below the NCP acceptable range, and are based on hypothetical use of the groundwater as a domestic water supply for future residential receptors.

As shown in Figure B-15, the NDMA plume is drawn in isopleths of 0.01 µg/L, 0.1 µg/L and 1.0 µg/L in three areas, but the 1.0 µg/L isopleth does not extend offsite. The risk associated with the offsite concentrations is 2.4E-6 at 0.01 µg/L and 2.4E-5 at 0.1 µg/L. These risks are related primarily to ingestion of groundwater and, to a much lesser degree, dermal contact with groundwater. The risks from exposure to these plume concentrations are within the NCP acceptable range of 1.0E-6 to 1.0E-4. The maximum concentration of NDMA of 0.43 µg/L was detected in Well 1436 and corresponds to a risk of 1E-4. The risks were calculated conservatively assuming an extensive exposure to groundwater, specifically, a 2 L/day ingestion (adults) and 1 L/day (children) for 350 days per year for a total of 30 years. Noncarcinogenic hazard indices associated with NDMA cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical.

Perchlorate was detected in a wider area, and plume isopleths were drawn corresponding to concentrations of 4 µg/L, 40 µg/L, 400 µg/L and 4,000 µg/L (Figure B-16) but the 4,000 µg/L isopleth does not extend offsite. Perchlorate is evaluated as a noncarcinogen, although the toxicity information provided by EPA states that the toxicity values used are protective against carcinogenic effects as well. The results were similar to those of the Layer C risk characterization. At a concentration of 4 µg/L, the hazard index is 0.22, lower than the NCP level of concern of 1.0. The concentration of 40 µg/L corresponds to a hazard index of 2.2; at 400 µg/L the hazard index is 22.0. The maximum detected concentration of perchlorate was 600 µg/L in Well 30051, which corresponds to a total hazard index of 33. Groundwater ingestion was the only pathway that posed a hazard index above for perchlorate.

The points at which the NDMA and TCE plumes overlap offsite result in a risk of 3.4E-6; this occurs over the northwest boundary of the Aerojet site. The perchlorate and TCE plumes also overlap in this area, with total hazard indices of 0.24 to 12, due mainly to perchlorate at a concentration of 400 µg/L.

Vinyl chloride was also selected as a CoPC for off-site Layer D. It was detected in Well 30046 at a concentration of 1.8 µg/L, which is associated with a risk of 7.6E-6. Noncarcinogenic hazard indices associated with vinyl chloride cannot be estimated because toxicity values have not been developed to assess noncarcinogenic effects from exposure to this chemical.

Therefore, for Layer D, chemicals and plume concentrations that exceed the NCP acceptable risk range and hazard index criteria are limited to perchlorate at concentrations of 40 µg/L or above, and NDMA at 1.0 µg/L in the on-site area. The total risk from the maximum detected concentrations of each CoPC was 1.1E-4 and the total hazard index was 33.0, as shown in Tables B.5-13 and B.5-14.

B.5.2.4 Layer E Plumes

Although plume maps for TCE, NDMA, and perchlorate were developed for Layer E, the extent of the plumes is far more limited and concentrations are lower than those in Layers C and D.

For TCE, as shown on Figure B-17, the plume is limited to the northwest corner of the Aerojet site and adjacent offsite areas. Two isopleths were drawn, of 5 µg/L and 50 µg/L, corresponding to risks of 1.0E-6 and 1.0E-5, respectively. Hazard indices are 0.025 and 0.25 at these concentrations, respectively. The maximum concentration of TCE of 220 µg/L in Well 1437 is associated with a risk of 4.6E-5 and hazard index of 1.1.

The two perchlorate plumes for Layer E are located in close proximity to each other, with concentrations ranging from 4 µg/L to 400 µg/L (Figure B-18). At 4 µg/L, the hazard index associated with perchlorate is 0.22, below the NCP level of concern. At 40 µg/L, the hazard index is 2.2 µg/L; at 400 µg/L, the hazard index is 22. The isopleth of 400 µg/L, however, is mostly onsite; in general, concentrations between 4 and 40 µg/L comprise the larger part of the offsite plume. The maximum detected concentration of perchlorate was 400 µg/L in Well 1438, corresponding to a hazard index of 22. Groundwater ingestion was the only pathway that posed a hazard index above 1.0 for perchlorate.

For NDMA, as shown on Figure B-19, the plumes were drawn at concentrations of 0.01 µg/L and 0.1 µg/L. One plume is present offsite at the northwestern boundary of the Site. The NDMA isopleths in this plume are 0.01 µg/L (with a risk of 2.4E-6) and 0.1 µg/L (with a risk of 2.4E-5). The maximum concentration of NDMA of 0.08 in Well 1438 corresponds to a risk of 1.9E-5. These risks are within the NCP acceptable risk range of 1.0E-6 to 1.0E-4. The risks are attributable to groundwater ingestion, as dermal contact with groundwater contributes an insignificant amount to the total risk.

TCE and NDMA overlap offsite, past the northwest boundary of the site, with a maximum risk totaling 3.4E-5. The hazard index of 0.25 for TCE remains unchanged, because NDMA is not evaluated for noncarcinogenic effects. The perchlorate plume overlaps both the NDMA and TCE plumes. However, the hazard index for perchlorate is far greater than that of TCE and the addition of hazard indices for these two chemicals does not change the conclusions regarding hazard indices.

1,1-DCE was also detected in off-site Layer E at a maximum concentration of 2.3 µg/L in Well 1437. This concentration corresponds to a risk of 2.2E-5 and hazard index of 0.008.

In conclusion, for Layer E, the offsite risks associated with TCE and NDMA concentrations fall within the NCP acceptable risk range of 1.0E-6 to 1.0E-4, when considered separately or together. For perchlorate, concentrations of 40 µg/L or above cause the hazard index to exceed the acceptable level of 1.0. The total risk based on the maximum concentrations of each CoPC is 8.7E-5 and total hazard index is 23. The total hazard index is associated mainly with perchlorate; the maximum detected concentration of TCE contributes a hazard index of 1.1. These risks and hazard indices are overestimated because maximum concentrations are not representative of actual exposure concentrations for long-term exposure. The total risks and hazard indices based on the maximum detected concentrations are presented in Tables B.5-15 and B.5-16.

B.6 UNCERTAINTY AND VARIABILITY

Uncertainty and variability are inherent to risk assessments. According to EPA guidance (1989), "it is important to fully specify assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective." DTSC guidance also recommends a qualitative discussion of uncertainty (1992 and 1994). Uncertainty exists in the exposure assessment, toxicity values, and the hence, the risk characterization. In this human health risk assessment, the exposure assessment and the toxicity assessment are the largest sources of uncertainty and variability.

EPA defines uncertainty as a "lack of knowledge about specific factors, parameters, or models" (1997b) including:

1. parameter uncertainty (measurement errors, sampling errors, and systematic errors);
2. model uncertainty (uncertainty due to necessary simplification of real-world processes, mis-specification of the model structure, model misuse, use of inappropriate surrogate variables); and
3. scenario uncertainty (descriptive errors, aggregation errors, errors in professional judgement, incomplete analysis).

Variability is defined as "observed differences attributable to true heterogeneity or diversity in a population or exposure parameter" (EPA 1997b). Variability is the result of natural random process, such as variations in body weight, breathing rate, or drinking water rates. Variability cannot be reduced by further study, but may be better characterized through further measurements.

For the exposure assessment, uncertainty may influence the risk estimates because of:

1. the use of the maximum detected concentrations for all CoPCs in each hydrostratigraphic layer over the past 2 years of monitoring;
2. unknown future land and groundwater use;
3. the use of upper-bound values for ingestion, inhalation, and dermal contact rates; and
4. the use of default values for exposure duration that are likely to overestimate exposures.

The assessment of the sporadically detected chemicals using maximum concentrations is likely to overestimate risks, because variability of concentrations over time is not accounted for. Additionally, a person is unlikely to be exposed only to the maximum concentration of a CoPC in groundwater. The use of groundwater would have a larger sphere of influence, and water from nearby areas with potentially lower concentrations of chemicals would be mixed with the concentrations detected. It is likely that all exposure point concentrations are overestimated because this was not considered in determining exposure point concentrations.

It was assumed that a hypothetical future residential receptor could use the groundwater as their sole water supply, and that water supply would be unfiltered (i.e., concentrations measured in the wells reflect concentrations that would be seen at the tap). This assumption is conservative, as most water would be filtered before use. Further, while the area to the west of the Aerojet property does include residential development, it is unlikely that the Aerojet property would be residentially developed and a resident would install a well for domestic use.

As recommended by DTSC guidance (1992 and 1994), upper-bound exposure parameters were selected for groundwater ingestion, dermal contact and inhalation rates. These default values tend to overestimate expected exposures, and are representative of the maximally exposed individual.

Use of default exposure duration values in the risk assessment may also overestimate risk because they do not to account for site-specific variability. Default parameters often used in intake equations are based on nationally averaged data and may not reflect the more active lifestyle typical of residents in states with temperate climates (EPA 1997a). Although they were not used in this risk assessment, EPA has developed revised exposure parameters based on California-specific data and regional variability that appear to be more realistic, while still being conservative (EPA 1997a). The California- and regional-specific parameters more accurately reflect site exposure and resultant risks. The California-specific exposure frequency is far lower than the 350 day per year exposure used in this BRA, but may reflect an average rather than a reasonable maximum exposure. Residence time for people living in the western United States is 17 years, rather than the 30 years used in this assessment (EPA 1997a).

For the toxicity assessment, uncertainties are inherent to the carcinogenic and noncarcinogenic toxicity values, which are based on laboratory animal studies. Specifically, uncertainties arise from the extrapolation of results from animals dosed at high concentrations to human exposures at low concentrations. Scientists also debate the validity of the critical underlying assumptions in the dose-response model for carcinogens (linearized multistage model). This model is based on the assumption that any dose of a carcinogen is associated with a risk of cancer and that a carcinogenic response is linear at low doses (EPA 1996). The results of this modeling may result in varying toxicity values, depending on the studies used as inputs to the model and interpretations of results.

The cancer slope factors for PCE and TCE are also associated with uncertainty, because data are unclear regarding PCE and TCE's ability to cause cancer in humans. Only provisional toxicity values are available from EPA at this time (EPA 1998), pending a decision as to whether PCE and TCE are human carcinogens. Both were considered carcinogenic in this assessment.

The reference dose for perchlorate is perhaps the most uncertain toxicity value used in this assessment. An external review draft value was available from EPA, but is still under review and subject to change (EPA 1998). In addition, reviews of toxicity data for perchlorate were decided by independent reviewers to not be definitive enough to calculate a toxicity value (TERA 1997). The critical effect of perchlorate is assumed to be related to thyroid function, but the effects to other organs, developmental toxicity, reproductive toxicity, and carcinogenicity are as yet unknown. Multiple studies are underway, and some have been completed, to address these issues and will generate data necessary to produce a final toxicity value.

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ATTACHMENT A
TOXICITY PROFILES

Carbon Tetrachloride

Carbon tetrachloride is a clear, heavy aromatic liquid with a sweet odor. It is distributed throughout the environment due to its extensive human production and use. Carbon tetrachloride may currently be used as a refrigerant and propellant (MDEQ 1994) but most uses are currently banned and it is used only in some industrial applications (ATSDR 1995). It is also used as a solvent for oil, fats, lacquers, varnishes, rubber, waxes, and resins. Until the 1960's it was also used as an industrial degreaser, household spot remover, and a fire-extinguishing agent. Carbon tetrachloride is relatively persistent in the environment and is stable in the atmosphere (ATSDR 1995, MDEQ 1994).

Carbon tetrachloride is readily absorbed when ingested or inhaled but is poorly absorbed through the skin. Carbon tetrachloride is metabolized in the liver. It is known that the metabolism of carbon tetrachloride plays an important role in its toxicity, although the specific mechanism relating the metabolites to toxicity has not been determined to date. Unmetabolized carbon tetrachloride is removed from the body by expired air and in the feces and urine. Acute exposure to large doses of carbon tetrachloride is associated with central nervous system depression,

gastrointestinal effects, and liver and kidney damage (ATSDR 1995, MDEQ 1994). However, carbon tetrachloride does not bioaccumulate in animals (ATSDR 1995).

EPA classifies carbon tetrachloride as a probable human carcinogen (class B2) based on carcinogenicity in laboratory animals. Human data are inadequate. The oral CSF developed by EPA is 0.13 $(mg/kg\text{-}day)^{-1}$ (EPA 2000), while OEHHA lists an oral CSF of 0.15 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000). The inhalation CSF from EPA is 0.05 $(mg/kg\text{-}day)^{-1}$ (EPA 2000) and from Cal/EPA is 0.15 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000).

EPA has also developed an oral RfD of 0.0007 mg/kg-day for carbon tetrachloride, based on development of liver lesions in laboratory animals. The oral RfD is associated with an uncertainty factor of 1,000 based on interspecies and intrahuman variability and extrapolation from subchronic to chronic duration of exposure. An inhalation RfD has not been developed for carbon tetrachloride, but EPA Region 9 recommends using the oral CSF to assess inhalation exposures for organic chemicals.

Chloroform

Chloroform is used as a grain fumigant; as a solvent for pesticides, adhesives, fats, oils, rubbers, alkaloids, and waxes; as a chemical intermediate for dyes and pesticides; and as a component of cough syrups, toothpastes, and liniments. It is also an environmental degradation product of carbon tetrachloride, and is formed from the interaction of chlorine with organic material in drinking water as a by-product of chlorination.

Chloroform is well absorbed by all routes: oral, inhalation, and dermal. Once absorbed, it is widely distributed throughout the body, with high concentrations accumulating in adipose tissue and in organs with high fat content, particularly the brain. Some chloroform is exhaled unchanged, but most is oxidized primarily in the liver to the intermediate phosgene, then to carbon dioxide, which is subsequently exhaled. The ratio between metabolized and unmetabolized excretion is difficult to predict because it varies with species, sex, amount of body fat, dose, and other factors.

The primary adverse effect noted after single doses of chloroform is CNS depression, which can proceed to the level of anesthesia with extensive exposure to high concentrations. Chloroform

was used as a general anesthetic for decades until studies revealed that single doses were capable of causing serious and even fatal liver and kidney damage in some patients. It also occasionally caused cardiac arrest. Acute exposure via inhalation can result in disruption of body temperature regulation and respiration, as well as cardiovascular and vasomotor functions. The major target organs with repeated doses are the liver and kidneys.

Chloroform is a class B2 carcinogen based on its ability to induce liver and kidney tumors in rats and mice (EPA 2000). The EPA and Cal/EPA oral CSFs are 0.0061 and 0.031 $(mg/kg\text{-}day)^{-1}$, respectively (EPA 2000, OEHHA 2000). Numerous studies of humans have found evidence of increased cancer rates in persons drinking chlorinated drinking water, but a direct correlation between chloroform and tumor formation has not been established. In several animal reproductive toxicity studies, chloroform affected the neonates only at doses that had significant adverse effects on the mothers. The EPA and Cal/EPA inhalation CSFs are 0.081 and 0.019 $(mg/kg\text{-}day)^{-1}$, respectively (EPA 2000, OEHHA 2000).

The oral RfD for chloroform is 0.01 mg/kg-day with an uncertainty factor of 1,000 (EPA 2000). The critical effect for this RfD is fatty cyst formation in livers of experimental animals. EPA Region 9 (EPA 1999) lists an inhalation RfD of 8.6E-5 mg/kg-day that was used in this assessment.

1,1-Dichloroethane

The compound 1,1-DCA, known commercially as either ethylidene chloride and ethylidene dichloride, is a volatile compound with limited use as a solvent and chemical intermediate.

It is apparently absorbed by inhalation, ingestion, and through the skin, and is excreted in exhaled air. No metabolic data are available.

Most of the available information describes adverse effects from acute exposure. The major effects include local irritation and central nervous system depression. It once had limited therapeutic use as an anesthetic. High doses produce minor pathological changes in the liver and kidneys. In experimental studies, repeated

doses did not produce specific toxic effects, but did result in decreased weight gain and an increased death rate. The unavailable reproductive toxicity study found limited, nonspecific adverse effects at high doses.

The 1,1-DCA compound is a class C carcinogen which does not have an oral CSF (EPA 2000). The California oral and inhalation CSFs are 5.7E-3 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000). The oral RfD for 1,1-DCA is 0.1 mg/kg-day with an uncertainty factor of 1,000 (HEAST 1997). This RfD is based on the no observed adverse effects level (NOAEL). The inhalation RfD is 0.14 with an uncertainty factor of 1,000, based on effects to kidneys (HEAST 1997).

1,2-Dichloroethane (1,2-DCA)

The compound 1,2-DCA, known commercially as ethylene dichloride, is a chemical intermediate in the production of vinyl chloride and other chemicals, and a solvent. It is absorbed by all routes: oral, inhalation, and dermal. In experimental animals, 1,2-DCA is metabolized in the liver through a number of pathways, leading to myriad metabolic products. Unmetabolized 1,2-DCA is exhaled, while other chemical intermediates are primarily excreted in the urine. Metabolism has not been studied in man, making extrapolation of data from laboratory animals to humans highly uncertain.

Acute doses cause irritation at the site of contact and central nervous system depression. Large doses also produce lesions in the liver, kidney, and adrenals. Repeated doses affect the same organs causing similar lesions. Reproductive studies have reported no adverse effects.

The compound 1,2-DCA is a class B2 carcinogen (EPA 2000). The EPA and California oral CSFs for 1,2-DCA are 0.091 and 0.07 $(mg/kg\text{-}day)^{-1}$, respectively, and are based on the induction of blood vessel tumors (EPA 2000, OEHHA 2000). Federal EPA has not derived an oral or inhalation RfD for 1,2-DCA, but EPA Region 9 lists an oral RfD of 0.03 mg/kg-day and inhalation RfD of 0.0014 mg/kg-day (EPA 1999) that were used in this assessment.

1,1-Dichloroethene (1,1-DCE)

The compound 1,1-DCE, commonly known as vinylidene chloride, is used as a chemical intermediate, primarily for polymers such as modacrylic and saran fibers.

The compound 1,1-DCE is readily absorbed with oral, inhalation, and dermal exposures. It is oxidized and conjugated in the liver to metabolites that are excreted in the urine. Some of the parent compound, however, is exhaled unchanged. Metabolism appears to produce toxic derivatives, since experimental animals that readily metabolize 1,1-DCE are more sensitive to its toxic effects.

The primary effect of acute exposure to 1,1-DCE is fully reversible CNS depression. As a liquid, it is quite irritating to the skin, respiratory tract, and eyes. Repeated doses produce a variety of liver and kidney lesions. There have been numerous carcinogenicity studies, but the findings remain inconclusive. Reproductive toxicity is observed only at doses that produced maternal toxicity. Exposure to high concentrations via inhalation sensitizes the myocardium to arrhythmias by epinephrine injection.

The compound 1,1-DCE is a class C carcinogen based on the induction of several types of tumors in experimental animals. The EPA oral and inhalation CSFs are 0.6 and 0.18 $(mg/kg\text{-}day)^{-1}$, respectively (EPA 2000). OEHHA does not list alternate CSFs for this chemical.

The oral RfD for 1,1-DCE is 0.009 mg/kg-day with an uncertainty factor of 1,000 (EPA 2000). This RfD is based on the critical effect of hepatic lesions in experimental animals. Federal EPA has not developed an inhalation RfD for this chemical, but EPA Region 9 uses the oral toxicity values to assess inhalation exposures (EPA 1999).

1,2-Dichloroethene (1,2-DCE)

The compound 1,2-DCE exists in two isometric forms: cis and trans. Neither form has wide industrial use because they are very flammable and volatile, but the trans isomer is used as a solvent in materials such as dyes, perfume, waxes, resins, and thermoplastics. Both cis-1,2-DCE and trans-1,2-DCE are degradation products of the solvents tetrachloroethene and trichloroethene.

1,2-DCE is absorbed by all routes but has little potential to bioaccumulate. Due to the lipophilic nature of 1,2-DCE, tissues with a high lipid content would likely have the highest levels of 1,2-DCE in exposed receptors. ATSDR (1989a) reports that 1,2-DCE is metabolized in the body to chloroethylene epoxides; excretion of 1,2-DCE and its metabolites has not been well characterized.

This compound was once used as anesthetic in humans but there are no reports of long-term exposure to 1,2-DCE isomers. Acute exposure to concentrations in air of 1,2-DCE at 2,000 parts per million (ppm) causes burning of the eyes, vertigo, and nausea.

The oral RfD for trans-1,2-DCE is 0.02 mg/kg-day based on increased serum alkaline phosphatase levels in laboratory animals. The uncertainty factor associated with this RfD is 1,000 (EPA 2000). The oral RfD for cis-1,2-DCE is 0.01 mg/kg-day (EPA 2000) based on decreased hematocrit and hemoglobin levels in laboratory animals. The oral RfD for total 1,2-DCE (both isomers) is 0.009 mg/kg-day with an uncertainty factor of 1,000. This value is derived from the oral RfD for 1,1-DCE (EPA 2000), which is based on hepatic lesions in experimental animals. The value of 0.009 mg/kg-day was also used to assess inhalation exposure to 1,1-DCE, per EPA Region 9 protocol (EPA 1999)

Carcinogenicity data are not available for 1,2-DCE. Neither isomer appears to induce genotoxic effects (EPA 2000).

Nitrate and Nitrites

Nitrate is the chemically stable form of inorganic nitrogen. Nitrates can occur naturally in water supplies throughout the United States, and are also associated with the use of inorganic fertilizers, explosives, and glassmaking. Naturally occurring nitrate is the result of the decay of organic matter (such as leaves) which are taken up by plants as they grow. Nitrites are manufactured primarily for use in food preservation, and the human body will convert nitrate to nitrite.

Exposure to nitrates occurs through ingestion of food and water that contains nitrates. Vegetables such as beets, celery, lettuce, parsely, radishes, rhubarb, spinach and turnip greens naturally contain high levels of nitrates. Exposure to nitrites occurs through the same pathways, due to

nitrites that have been added to food as a preservative, and the conversion of nitrates to nitrite by the body (Harte et al, 1991).

Nitrates are not considered particularly toxic, but nitrites are associated with methemoglobinemia, a condition in which the blood loses its normal ability to carry oxygen. Drinking water high in nitrates can cause high nitrite levels in the blood, leading to this condition. It is most significant for infants, because nitrates are more readily converted to nitrites in infants, infant hemoglobin is more susceptible to methemoglobinemia, and infants consume a mostly liquid diet. If infant formula is made using water that is high in nitrates (more than 100 mg/L), the infant is at greater risk of methemoglobinemia. If methemoglobinemia occurs, it can be treated with no lasting effects if diagnosed promptly (Harte et al, 1991).

EPA has developed oral RfDs for both nitrates and nitrites. For nitrate, the oral RfD is 1.6 mg/kg-day, with an uncertainty factor of 1, based on early clinical signs of methemoglobinemia. For nitrites, the oral RfD is 0.1 mg/kg-day, with an uncertainty factor of 10, based on methemoglobinemia (EPA 2000). There are no inhalation RfDs for these chemicals and they have not been evaluated for carcinogenicity by EPA.

N-Nitrosodimethyl amine (NDMA)

N-Nitrosodimethylamine is commonly known as NDMA. It is a yellow liquid with no distinct odor and belongs to a class of chemicals known as nitrosamines. It was historically used as a component of rocket fuel, but is also unintentionally formed during various manufacturing processes at many industrial sites and in air, water, and soil from reactions involving other chemicals called alkylamines (ATSDR 1989b). NDMA decomposes when exposed to sunlight, but the rate of decomposition in groundwater is unknown.

According to the ATSDR, the general population may be exposed to NDMA from a variety of sources, including outdoor air. The primary sources of NDMA exposure are tobacco smoke, chewing tobacco, and foods such as cured meats, toiletry and cosmetic products, and various other household goods. In addition, NDMA can form in the stomach during the digestion of alkylamine-containing foods (alkylamines are naturally occurring compounds that are found in some drugs and a variety of foods). Occupational exposures are also possible, such as at

tanneries, pesticide manufacturing plants, rubber and tire manufacturing plants, fish processing industries, foundries, and dye manufacturing plants (ATSDR 1989b).

NDMA is readily absorbed when ingested and distributed through the bloodstream to many organs. In the liver, it is metabolized into other substances, most of which leave the body within 24 hours in expired air or in urine. NDMA may also be absorbed through the skin or inhaled, but little is known about the fate of NDMA contacted via these routes.

According to EPA, human exposure to nitrosamines results from contact with mixtures containing these compounds (such as tobacco products). Data from human exposure is therefore of limited use in the evaluation of carcinogenicity of individual nitrosamines because of potential confounding by other substances in these mixtures (EPA 2000). Nonetheless, NDMA is classified as a probable human carcinogen (class B2) based on induction of tumors at multiple sites in laboratory animals exposed by various routes. It has also been found to be mutagenic in bacterial cultures. EPA lists an oral CSF of 51 $(mg/kg\text{-}day)^{-1}$, while Cal/EPA has developed an oral CSF of 16 $(mg/kg\text{-}day)^{-1}$. The inhalation CSFs are listed as 49 $(mg/kg\text{-}day)^{-1}$ and 16 $(mg/kg\text{-}day)^{-1}$ by EPA and Cal/EPA respectively. The Cal/EPA values were used in this assessment.

No RfDs have been developed for NDMA.

Perchlorate

Perchlorate, an inorganic anion, is found in compounds with numerous inorganic cations such as ammonium or potassium. Ammonium perchlorate has been widely used as an oxidizer in solid rocket propellants. Potassium perchlorate was used therapeutically as a treatment for Graves' disease (hyperthyroidism), an autoimmune disorder which produces elevated levels of thyroid hormones. Perchlorate blocks iodine uptake, returning thyroid hormone levels to normal and controlling the symptoms of hyperthyroidism (TERA 1997).

Animal studies of perchlorate have also focused on effects to the thyroid. Short-term studies in rats have identified a No Observed Adverse Effects Level (NOAEL) and a Lowest Observed Adverse Effects Level (LOAEL) based on increased relative thyroid weight, increased thyroid stimulating hormone (TSH), and decreased levels of T3 and T4 thyroid hormones.

In 1992, EPA Office of Research and Development (ORD) initiated internal study of perchlorate toxicity and derived a provisional RfD of 0.0001 mg/kg-day, based on an acute, single dose (potassium perchlorate) study of Grave's disease patients by Stanbury and Wyngaarden (1952). The EPA ORD identified a NOAEL of 0.14 mg/kg-day and applied an uncertainty factor of 1,000 to derive the RfD. The uncertainty factor included a value of 10 for the use of an acute study instead of a chronic study, 10 to protect sensitive individuals, and 10 to account for database deficiencies.

In 1995, EPA's National Center for Environmental Assessment (NCEA) evaluated available information on perchlorate toxicity and stated that "... the appropriate provisional RfD for perchlorate appears to be in the range of 1 to 5 x 10^{-4} mg/kg-day" pending the availability of adequate chronic exposure data. The latter RfD was derived from different NOAEL values based on three studies and uncertainty factors that utilized a value of 3 for database deficiencies; 10 for the use of an acute instead of chronic study; and 10 to protect sensitive individuals (example: NOAEL of 0.14 mg/kg-day divided by 300).

Starting in 1998, EPA Region IX provided a provisional oral RfD of 0.0005 mg/kg-day (EPA 1999). EPA Region IX did not provide any data for cancer risk, although the EPA ORD (1992) labeled perchlorate as a probable human carcinogen (B2) based on thyroid tumors in mice and rats following long-term administration of sodium or potassium perchlorate. However, EPA ORD did not provide a quantitative estimate of carcinogenic risk for perchlorate due to the limitations of the data; thus, this classification is suspect.

The 1992/95 toxicological characterization of perchlorate was not subject to internal EPA review and external peer review; and therefore was labeled provisional. An external peer review was conducted in 1997 by Toxicological Excellence in Risk Assessment (TERA), a non-profit organization dedicated to the best use of toxicity data in risk assessment, which concluded that the available data were insufficient and recommended further animal studies. Comprehensive studies are on-going, as listed below, and are expected to produce an RfD that is protective of human health in early 1999:

1. 90-day Subchronic Oral Bioassay
2. Neurobehavioral Development Study

3. Segment II Developmental Study
4. 2-Generation reproductive Toxicity Study
5. Adsorption, Distribution, Metabolism, and elimination Studies
6. Perchlorate Mechanism Studies
7. Genotoxicity Assays
8. Immunotoxicity Studies

Currently, the NCEA has produced a provisional RfD for external review of 0.0009 mg/kg-day (EPA 1998). This value was based on a mode-of-action modeling approach that harmonizes noncarcinogenic and carcinogenic approaches to derive a single oral risk benchmark based on the established adverse effects on the thyroid. The oral RfD is proposed as protective of potential cancer and noncancer effects. A composite uncertainty factor of 100 was used. This RfD results in a revised risk-based groundwater action level of 32 µg/L, which is above the previous provisional values (EPA 1998).

The oral RfD value of 0.0005 mg/kg-day was used in this risk assessment at the request of EPA Region 9. However, the more recent value of 0.0009 mg/kg-day was used for developing clean-up goals

Tetrachloroethene (PCE)

PCE is a commonly used industrial solvent for degreasing processes. PCE is well absorbed from the lung, but less so from the gastrointestinal tract and through the skin. It is widely distributed throughout the body, with most deposition in adipose tissue. PCE is primarily exhaled unchanged, but some is metabolized in the liver, and excreted in the urine. The amount of this metabolism varies greatly among species. The metabolites, especially the highly reactive epoxide, are believed responsible for the compound's carcinogenicity and some other toxic effects.

The major acute toxic effect of PCE is central nervous system depression. It can also irritate tissues, particularly mucous membranes, and produce lesions in the liver and kidneys. PCE's former usage in the treatment of hookworms suggests that it is not highly toxic when given orally to humans.

Repeated doses produce considerable hepatotoxicity and often nephrotoxicity. Pulmonary edema, although rare, can be produced after inhalation and dermatitis can develop after prolonged contact with skin. No evidence of teratogenicity exists in the few available studies.

PCE is a class B2 to C carcinogen (possible to probable human carcinogen) based on the induction of liver tumors in animal studies. Limited human studies have found no carcinogenicity. The Cal/EPA oral CSF is 0.051 $(mg/kg\text{-}day)^{-1}$; the inhalation CSF is 0.021 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000). The provisional oral CSF for PCE from the Superfund Technical Support Center is 0.052 $(mg/kg\text{-}day)^{-1}$ and the inhalation CSF is 0.002 $(mg/kg\text{-}day)^{-1}$ (STSC 1998).

The oral RfD for PCE is 0.01 mg/kg-day with an uncertainty factor of 1,000. This oral RfD is based on the effects of hepatotoxicity and weight gain in experimental animals (EPA 2000). An inhalation RfD of 0.11 mg/kg-day, as listed in EPA Region 9 PRGs (EPA 1999) was used in this risk assessment although federal EPA has not developed an inhalation RfD for this chemical.

1,1,2-Trichloroethane (1,1,2-TCA)

The compound 1,1,2-TCA, also known as beta-trichloroethane, is used as a nonflammable solvent and is used mostly where 1,1-dichloroethene is made (ATSDR 1989c). The compound 1,1,2-TCA can enter the body through all routes and is readily excreted or metabolized. It is completely absorbed after ingestion, well absorbed after inhalation, and slowly absorbed through the skin. This compound is concentrated in fat and in organs with high levels of fat, such as the brain. Most is exhaled unchanged, but small amounts are metabolized and subsequently excreted in the urine.

The primary effects of acute toxicity are CNS depression and mild skin irritation if contact with skin occurs. Chronic toxicity, which is rarely reported in humans, usually involves kidney and liver lesions. Based on limited information, 1,1,2-TCA does not appear to cause birth defects or otherwise inhibit normal development (ATSDR 1989c).

1,1,2-Trichloroethane is a class C carcinogen, based on liver tumors in laboratory animals. EPA lists an oral CSF of 0.057 (mg/kg-day) $^{-1}$ and an inhalation CSF of 0.056 (mg/kg-day) $^{-1}$ (EPA 2000). Cal/EPA has developed an oral cancer slope factor of 0.072 (mg/kg-day) $^{-1}$ (and an inhalation slope factor of 0.057 (mg/kg-day) $^{-1}$ (OEHHA 2000). The oral RfD for 1,1,1-TCA is 0.004 mg/kg-day with an uncertainty factor of 1,000 (EPA 2000). This RfD is based on the critical effect of changes in clinical serum chemistry of laboratory animals. No inhalation RfD has been established for 1,1,2-TCA by federal EPA but EPA Region 9 lists an inhalation toxicity value of 0.004 mg/kg-day, based on route-to-route extrapolation.

Trichloroethene (TCE)

TCE is widely used as a solvent, especially for dry cleaning and metal degreasing. TCE is well absorbed after inhalation, ingestion, and to some extent through skin. It tends to collect in fat because it is lipophilic. The compound is metabolized in the liver to a variety of metabolites, which are responsible for much of the TCE toxicity. Metabolites are excreted primarily in the urine. TCE can potentiate the toxicity of other compounds including ethanol and increase the toxicity of both compounds.

Acute exposures cause CNS depression and TCE was once used as a surgical anesthetic. Chronic dosing produces liver and kidney lesions as well as a peripheral neuritis. The chemical was found to be carcinogenic in some animal tests, but no human data are available. No evidence of reproductive toxicity exists in the few tests available.

TCE is a class B2 carcinogen based on the induction of hepatomas. The Cal/EPA oral CSF is 0.015 $(mg/kg\text{-}day)^{-1}$ and the inhalation CSF is 0.01 $(mg/kg\text{-}day)^{-1}$ (OEHHA 2000).

The provisional EPA oral CSF is 0.011 $(mg/kg\text{-}day)^{-1}$ and the inhalation CSF is 0.006 $(mg/kg\text{-}day)^{-1}$ according to information from the Superfund Technical Support Center (STSC 1998).

The provisional oral RfD for TCE is 0.006 mg/kg-day according to information from the Superfund Technical Support Center (STSC 1998). EPA Region 9 uses the oral RfD for trichloroethene to assess inhalation exposures as well, although federal EPA has not developed an inhalation RfD for this chemical.

Vinyl Chloride

Vinyl chloride, or chloroethene, was of little toxicological interest until 1974 when it was first reported as a human carcinogen. Since then there have been many human and animal studies summarized in various reviews.

Vinyl chloride may enter the body through various routes. Once in the body, it is metabolized and excreted. The compound is fully absorbed after inhalation and ingestion, but little is absorbed by the skin. Vinyl chloride is concentrated in the liver (site of metabolism) and kidney (site of excretion). Vinyl chloride is oxidized to an exposed and other reactive intermediates, which react further. These intermediates are generally believed to be the active chemical species for the specific toxic effects of vinyl chloride. Excretion is primarily in the urine as conjugates of metabolites with sulfur-containing compounds. Very small amounts are exhaled unchanged.

Vinyl chloride produces both acute and chronic effects. Large single doses of vinyl chloride produce CNS depression. Early studies of its anesthetic potential found cardiac and circulatory disturbances. Chronic exposure to low concentrations in workers produce a syndrome called "vinyl chloride disease". This includes acroosteolysis, Raynaud's disease, scleroderma, lung toxicity, thrombocytopenia, and liver toxicity. Chromosomal abnormalities have been reported in workers.

The most striking effect of vinyl chloride toxicity is the production of hemangiosarcomas, which are extremely rare tumors. These occur in the liver and occasionally elsewhere. Since this has been repeatedly confirmed in worker exposure studies and animal studies, vinyl chloride is a confirmed human carcinogen. Some studies have also reported vinyl chloride-induced tumors at other sites, especially the brain and, after inhalation, the lungs.

There have been reports of reproductive toxicity in exposed workers, but no adverse effects have been seen in animal studies except at high doses that produce

nonspecific toxic effects. Epidemiological studies in residential neighborhoods near vinyl chloride production plants have been inconclusive.

Vinyl chloride is a class A carcinogen. The EPA and California oral CSFs are 1.9 and 0.27 $(mg/kg\text{-}day)^{-1}$, respectively, and are based on the induction of tumors in the liver and lung (EPA 2000, OEHHA 2000). The EPA and California inhalation CSFs are 0.3 and 0.27 $(mg/kg\text{-}day)^{-1}$, respectively. No RfDs for vinyl chloride have been established (EPA 2000).

TABLE B.2-1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer A - tap water - on-site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
79-00-5	1,1,2-Trichloroethane	1.3		1.3		ug/L	Well 131	13%	0.5-2.0	1.3	N/A	0.2 C			Yes	ASL
107-06-2	1,2-Dichloroethane	1.5		950		ug/L	Well 131	29%	0.5-5.0	950	N/A	0.12 C			Yes	ASL
156-59-2	1,2-Dichloroethene	2		10		ug/L	Well 22	23%	0.5-5.0	10	N/A	61 NC			No	BSL
67-66-3	Chloroform	2.8		230		ug/L	Well 22	26%	0.5-1.0	230	N/A	0.16 C			Yes	ASL
127-18-4	Tetrachloroethene	0.82		0.82		ug/L	Well 22	3%	0.5-5.0	0.82	N/A	1.1 C			No	BSL
79-01-6	Trichloroethene	3		82		ug/L	Well 3348	33%	0.5-5.0	82	N/A	1.6 C			Yes	ASL
7601-90-3	Perchlorate			75		ug/L	Well 3348			75	N/A	18 NC			Yes	ASL
62-75-9	NDMA	0.019		0.16		ug/L	Well 22	24%	0.0075	0.16	N/A	0.0013 C			Yes	ASL
14797-55-8	Nitrate	0.26		219		mg/L	Well 3284	100%	0.03	219	N/A	10 NC			Yes	ASL
14797-65-0	Nitrite	0.07		22		mg/L	Well 3222	36%	0.01	22	N/A	1 NC			Yes	ASL
N/A	TPH	0.2		0.3		mg/L	Well 3284	15%	0.1-0.5	300	N/A	N/A			No	Not Superfund

(1) Minimum/maximum detected concentration.

(2) N/A - Refer to supporting information for background discussion
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.

(3) EPA Region 9 PRGs, 1999

(4) Rationale Codes Selection Reason:
- Infrequent Detection but Associated Historically (HIST)
- Frequent Detection (FD)
- Toxicity Information Available (TX)
- Above Screening Levels (ASL)

Deletion Reason:
- Infrequent Detection (IFD)
- Background Levels (BKG)
- No Toxicity Information (NTX)
- Essential Nutrient (NUT)
- Below Screening Level (BSL)

Definitions:
- N/A = Not Applicable
- SQL = Sample Quantitation Limit
- COPC = Chemical of Potential Concern
- ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
- MCL = Federal Maximum Contaminant Level
- SMCL = Secondary Maximum Contaminant Level
- J = Estimated Value
- C = Carcinogenic
- N = Non-Carcinogenic

TABLE 8.2-2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer B - tap water - on-site

CAS Number	Chemical	Minimum[1] Concentration	Minimum Qualifier	Maximum[1] Concentration	Maximum Qualifier	Unit	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background[2] Value	Screening[3] Toxicity Value	Potential ARAA/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for[4] Contaminant Deletion or Selection
79-00-5	1,1,2-Trichloroethane	1.5		1.5		ug/L	Well 132	0.5%	0.18-20	1.5	N/A	0.2 C			Yes	ASL
75-34-3	1,1-Dichloroethane	1.8		1.8		ug/L	Well 132	0.5%	0.18-20	1.8	N/A	610 NC			No	BSL
75-35-4	1,1-Dichloroethene	43		43		ug/L	Well 132	2%	0.29-20	43	N/A	0.046 C			Yes	ASL
156-59-2	1,2-Dichloroethene	1.9		120		ug/L	Well 132	4.5%	0.14-20	120	N/A	61 NC			Yes	ASL
56-23-5	Carbon tetrachloride	1.4		1.4		ug/L	Well 132	0.5%	0.26-20	1.4	N/A	0.17 C			Yes	ASL
67-66-3	Chloroform	0.78		350		ug/L	Well 132	21%	0.18-20	350	N/A	0.16 C			Yes	ASL
76-13-1	Freon -113	1.1		1.1		ug/L	Well 1267	0.5%	0.24-20	1.1	N/A	59000 NC			No	BSL
127-18-4	Tetrachloroethene	1.2		2.1		ug/L	Well 1333	1%	0.2-20	2.1	N/A	1.1 C			Yes	ASL
79-01-6	Trichloroethene	0.51		9400		ug/L	Well 132	35%	0.18-20	9400	N/A	1.6 C			No	BSL
7601-90-3	Perchlorate	4.1		11000		ug/l	Well 305	67%	4-400	11000	N/A	18 NC			Yes	ASL
62-75-9	NDMA	0.041		0.32		ug/L	Well 282	33%	0.0075-0.02	0.32	N/A	0.00013 C			Yes	ASL
14797-55-8	Nitrate	0.57		11		mg/L	Well 3501	100%	0.03	11	N/A	10 NC			Yes	ASL
14797-65-0	Nitrite	0.56		0.56		mg/L	Well 3591	25%	0.05-0.25	0.56	N/A	1 NC			No	BSL

(1) Minimum/maximum detected concentration.

(2) N/A - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.

(3) EPA Region 9 PRGs, 1999

(4) Rationale Codes Selection Reason:
- Infrequent Detection but Associated Historically (HIST)
- Frequent Detection (FD)
- Toxicity Information Available (TX)
- Above Screening Levels (ASL)

Deletion Reason:
- Infrequent Detection (IFD)
- Background Levels (BKG)
- No Toxicity Information (NTX)
- Essential Nutrient (NUT)
- Below Screening Level (BSL)

Definitions:
- N/A = Not Applicable
- SQL = Sample Quantitation Limit
- COPC = Chemical of Potential Concern
- ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
- MCL = Federal Maximum Contaminant Level
- SMCL = Secondary Maximum Contaminant Level
- J = Estimated Value
- C = Carcinogenic
- N = Non-Carcinogenic

TABLE B.2-3
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer C - tap water - on-site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
75-34-3	1,1-Dichloroethane	0.67		1.3		ug/L	Well 420	2%	0.12-5	1.3	N/A	810 NC			No	BSL
75-35-4	1,1-Dichloroethene	0.56		63		ug/L	Well 3058	7%	0.066-20	63	N/A	0.046 C			Yes	ASL
107-06-2	1,2-Dichloroethane	0.94		160		ug/L	Well 3049	3%	0.42-5	160	N/A	0.12 C			Yes	ASL
156-59-2	1,2-Dichloroethene	0.71		41		ug/L	Well 3058	12%	0.048-5	41	N/A	61 NC			No	BSL
56-23-5	Carbon tetrachloride	0.66		0.66		ug/L	Well 124	0.2%	0.026-5	0.66	N/A	0.17 C			Yes	ASL
67-66-3	Chloroform	0.53		670		ug/L	Well 3323	22%	0.041-5	670	N/A	0.16 C			Yes	ASL
76-13-1	Freon-113	0.34		5.4		ug/L	Well 3518	4%	0.024-5	5.4	N/A	59000 NC			No	BSL
127-18-4	Tetrachloroethene	0.51		5.9		ug/L	Well 3058	4%	0.046-5	5.9	N/A	1.1 C			Yes	ASL
79-01-6	Trichloroethene	0.52		5300		ug/L	Well 3058	50%	0.11-5	5300	N/A	1.6 C			Yes	ASL
7601-90-3	Perchlorate	5.5		8200		ug/L	Well 4140	46%	4-400	8200	N/A	18 NC			Yes	ASL
62-75-9	NDMA	0.024		0.39		ug/L	Well 1435	28%	0.0075-0.02	0.39	N/A	0.0013 C			Yes	ASL
14797-55-8	Nitrate	0.16		7.8		mg/L	Well 3552	100%	0.03	7.8	N/A	10 NC			No	BSL
14797-65-0	Nitrite	0.08		0.08		mg/L	Well 3592	7%	0.5-5	0.08	N/A	1 NC			No	BSL

(1) Minimum/maximum detected concentration.

(2) N/A - Refer to supporting information for background discussion
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.

(3) EPA Region 9 PRGs, 1999

(4) Rationale Codes. Selection Reason:
Infrequent Detection but Associated Historically (IFIST)
Frequent Detection (FD)
Toxicity Information Available (TX)
Above Screening Levels (ASL)

Deletion Reason:
Infrequent Detection (IFD)
Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE B 2-4
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer D - tap water - on-site

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
75-34-3	1,1-Dichloroethane	1.1		1.7		ug/L	Well 3305	1%	0.29-10	1.7	N/A	810 NC			No	BSL
75-35-4	1,1-Dichloroethene	0.6		14		ug/L	Well 3332	4%	0.29-10	14	N/A	0.046 C			Yes	ASL
107-06-2	1,2-Dichloroethane	1.2		4.7		ug/L	Well 3518	4%	0.11-10	4.7	N/A	0.12 C			Yes	ASL
156-59-2	1,2-Dichloroethene	1.2		25		ug/L	Well 3332	9%	0.14-10	25	N/A	61 NC			No	BSL
67-66-3	Chloroform	0.57		460		ug/L	Well 3045	17%	0.18-10	460	N/A	0.16 C			Yes	ASL
76-13-1	Freon -113	0.32		5.4		ug/L	Well 3518	5%	0.24-10	5.4	N/A	59000 NC			No	BSL
127-18-4	Tetrachloroethene	0.6		5		ug/L	Well 3332	5%	0.2-10	5	N/A	1.1 C			Yes	ASL
79-01-6	Trichloroethene	1.1		1500		ug/L	Well 3332	27%	0.16-10	1500	N/A	1.6 C			Yes	ASL
7601-90-3	Perchlorate	4.7		8700		ug/L	Well 3213	44%	4-400	8700	N/A	18 NC			Yes	ASL
62-75-9	NDMA	0.028		1.3		ug/L	Well 442	57%	0.0075	1.3	N/A	0.0013 C			Yes	ASL
14797-55-8	Nitrate	0.068		6.7		mg/L	Well 3564	67%	0.03	6.7	N/A	10 NC			No	BSL

(1) Minimum/maximum detected concentration

(2) N/A - Refer to supporting information for background discussion
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.

(3) EPA Region 9 PRGs, 1999

(4) Rationale Codes Selection Reason:
- Infrequent Detection but Associated Historically (HIST)
- Frequent Detection (FD)
- Toxicity Information Available (TX)
- Above Screening Levels (ASL)

Deletion Reason:
- Infrequent Detection (IFD)
- Background Levels (BKG)
- No Toxicity Information (NTX)
- Essential Nutrient (NUT)
- Below Screening Level (BSL)

Definitions:
- N/A = Not Applicable
- SQL = Sample Quantitation Limit
- COPC = Chemical of Potential Concern
- ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
- MCL = Federal Maximum Contaminant Level
- SMCL = Secondary Maximum Contaminant Level
- J = Estimated Value
- C = Carcinogenic
- N = Non-Carcinogenic

TABLE B.2-5
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AEROJET WESTERN GROUNDWATER OU

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Layer E - tap water - on-site

CAS Number	Chemical	(1) Minimum Concentration	Minimum Qualifier	(1) Maximum Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	(2) Background Value	(3) Screening Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	(4) Rationale for Contaminant Deletion or Selection
67-66-3	Chloroform	1.6		1.6		ug/L	Well 3307	0.5%	0.5-5	1.6	N/A	0.16 C			Yes	ASL
76-13-1	Freon -113	1.1		1.3		ug/L	Well 3404	1%	0.5-5	1.3	N/A	59000 NC			No	BSL
79-01-6	Trichloroethene	0.92		84		ug/L	Well 3333	17%	0.5-5	84	N/A	1.6 C			Yes	ASL
7601-90-3	Perchlorate	4.8		610		ug/L	Well 3566	21%	4-400	610	N/A	18 NC			Yes	ASL
62-75-9	NDMA	0.0098		0.38		ug/L	Well 3307	57%	0.0075-0.02	0.38	N/A	0.0013 C			Yes	ASL
14797-55-8	Nitrate	0.31		6.6		mg/L	Well 3566	10%	0.03	6.6	N/A	10 NC			No	BSL

(1) Minimum/maximum detected concentration.
(2) N/A - Refer to supporting information for background discussion.
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information
(3) EPA Region 9 PRGs, 1999
(4) Rationale Codes Selection Reason:
Infrequent Detection but Associated Historically (HIST)
Frequent Detection (FD)
Toxicity Information Available (TX)
Above Screening Levels (ASL)
Deletion Reason:
Infrequent Detection (IFD)
Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

PAGES OF OVERSIZED MAPS

(SEE BINDER)

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Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

BEFORE THE

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	)

SCWC EXHIBIT 18

Aerojet Sacramento Site

GET Effectiveness Evaluation for the American River Study Area

LOWER LEVEL

TD 426 .A3663 2000
Aerojet-General Corporation
GET effectiveness evaluation for the American River study area

Prepared by:

Gencorp Aerojet
Sacramento, California

February 2000

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1.0 INTRODUCTION

In May 1993, Aerojet revised and submitted an Engineering Evaluation/Cost Analysis (1993 EE/CA) for the American River Study Area (ARSA) which recommended that a groundwater extraction/treatment (GET) facility be located on the north side of the American River to minimize the downgradient migration of chemicals in groundwater. Subsequently, US EPA issued Unilateral Order No. 95-16 (EPA Order) governing the remediation of the plume on both sides of the American River. The EPA Order included a program for completion of the remedial action on the north side of the American River and development of an EE/CA for the plume on the south side of the American River. During design and the associated public comment period, the public expressed substantial concerns regarding the siting of a treatment plant in Sailor Bar Park which resulted in a delay of the project and a reevaluation of the siting of the treatment facilities. The EPA then rescinded the EPA Order and the Central Valley Regional Water Quality Control Board (RWQCB) issued a Cleanup and Abatement Order requesting implementation of an interim action for the ARSA and development of a revised EE/CA which would evaluate extraction of the groundwater and transport back to the Aerojet Sacramento facility for treatment. In September 1996, Aerojet submitted the Final Engineering Evaluation/Cost Analysis (1996 EE/CA) for the ARSA which provided such an evaluation and recommended construction of a groundwater treatment system on the Aerojet site which combines UV/Oxidation and Air Stripping treatment technologies with disposal of the treated groundwater to Buffalo Creek. This report evaluates the performance and effectiveness of the ARSA GET (or ARGET) system for a period of one year from startup in August 1998 through August 1999.

1.1 Site Description

The Aerojet Sacramento facility is located south of US Highway 50 near Rancho Cordova, California approximately 15 miles east of downtown Sacramento (see Figure 1-1). The ARSA, also shown on Figure 1-1, is located north of Highway 50, and west of Hazel Avenue, approximately 0.5 mile north of the Aerojet facility boundary. North of the American River, the ARSA includes Sacramento County's Sailor Bar Park and the surrounding residential properties of Fair Oaks. Most of the investigation north of the river has been conducted within the park area, which encompasses approximately 375 acres. South of the river, the study area includes federal lands of the American River and

Nimbus fish hatcheries, state properties, and various commercial properties and is bounded to the southwest by the community of Gold River.

The ARSA was the site of placer and gold dredging operations in the late 1800's and currently provides recreational opportunities including, but not limited to hiking, horseback riding, fishing, boating and picnicking.

1.2 Site Background

Since the early 1950's, the Aerojet Sacramento facility has been devoted to the development of propulsion systems to support national defense, space exploration and satellite deployment. Industrial activities at the Aerojet site have included solid rocket motor manufacturing and testing, liquid rocket engine manufacturing and testing, and chemical manufacturing. Chemicals used in the manufacturing and production areas on the Aerojet site included chlorinated solvents, propellants, metals, oxidizers, and a variety of chemicals produced in the chemical manufacturing area as described in the Scoping Report (1989).

2.0 ARSA GET FACILITY DESCRIPTION

2.1 System Components

2.1.1 Extraction Wells

Five sets of three extraction wells are located within the ARSA, three north of the river and two south of the river (Figure 2-1). The extraction well sets consist of three wells, each screened in one of the three aquifer units, Aquifer A, Aquifer B and Aquifer C. The aquifer units were screened individually to assure that groundwater would be extracted from each unit at each location and to allow variation of the pumping rates in each unit. One set of wells (4325, 4330 and 4335) is located in the area of highest chemical concentrations, south of the American River on the Nimbus Fish Hatchery property. These wells are intended to expedite removal of chemical mass from the subsurface. The other four sets of extraction wells are located along the downgradient side of the chemical plumes and placed to attempt to maximize the zone of capture created by the groundwater extraction system. The locations of the downgradient extraction wells were somewhat controlled by the geography and land use in the study area. The extraction wells north of the river were all placed on County land within Sailor Bar Park. It was not feasible to locate extraction wells in either residential areas or the heavily wooded ravines north of the river. Average flow rates and total amount of water pumped for each well is summarized in Table 2-1.

2.1.2 Influent Pipelines

The ARSA system utilizes two separate pipelines for collection and conveyance of groundwater from the five sets of extraction wells to the treatment system. One pipeline is dedicated to the conveyance of water produced by the higher concentration wells - 4325, 4330 and 4335 - located on the Nimbus Fish Hatchery property. This pipeline is constructed of 10" x 14" double-walled polyethylene as required by the Agencies to carry the elevated concentration of VOCs present in these wells. Water from the remaining extraction wells contains much lower VOC concentrations and is conveyed using standard single-wall PVC pipe. Various pipe sizes are utilized in this collection system with the largest, a 20" transmission line, beginning at the intersection of the southern end of the river crossing and continuing to the treatment system. Figure 2-1 shows the general

alignment of the two collection pipelines as well as the other components of the ARGET system.

2.1.3 River Crossing

Groundwater produced by the extraction well north of the American River crosses under the American River and is then conveyed to Aerojet property located to the south for treatment. The under-river crossing was accomplished with a 2,200-foot horizontal boring. After completion of the boring, a 30" steel casing was pulled into the bore to provide an installation conduit for the pipeline. Within this steel casing, a centralized 18" x 24" double-walled polyethylene pipe was installed.

2.1.4 Treatment Components

Treatment of groundwater produced by the extraction system is accomplished with advanced oxidation and air stripping processes. As shown in Figure 2-2, water produced by higher concentration wells 4325, 4330 and 4335, is conveyed in a separate pipeline and treated first by advanced oxidation. Three 90 kilowatt ultraviolet (UV) reactors skids, installed in parallel, are used to remove the majority of the target compounds present in the water. Hydrogen peroxide is metered into the influent of the UV skids to provide photo-initiated oxidation of target compounds not amenable to direct photolysis. Effluent from the UV system is then combined with the influent line from all other extraction wells in the ARGET system for the removal of the remainder of the target compounds using a single air-stripping tower.

2.1.5 Effluent Disposal

The ARGET treatment system effluent is discharged to the American River by way of Buffalo Creek as shown on Figure 2-1. On 17 April 1998, the California Regional Water Quality Control Board, Central Valley Region adopted waste discharge requirements for this effluent under the National Pollutant Discharge Elimination System (NPDES) and issued permit # CA 0083861.

The ARGET chemical or compound effluent limits specified in the NPDES permit are as follows:

Constituent	Units	Daily Maximum	Monthly Average
Total Copper	µg/l	17	11
Total Lead	µg/l	15	2.5
Total Zinc	µg/l	110	100
Volatile Organics	µg/l	0.5	
Perchlorate	µg/l	18	18
1,4-dioxane	µg/l	15	10

2.2 Evaluation of Treatment Effectiveness

The ARGET system has removed approximately 2,600 pounds of target compounds from the 1,661 million gallons processed by the treatment facility between August 1998 and November 1999. The treatment system has functioned as designed, producing effluent that routinely meets effluent discharge standards with only minor exceptions that are further discussed in Section 2.3.2.

2.2.1 Air Emissions

Estimates of influent groundwater concentrations, UV treatment equipment effluent concentration, and the treatment system flow rate were developed to evaluate air emission rates from the stripping tower as part of the 1996 EE/CA. These estimated emission rates were used to quantify health effects and determine if installation of air emission control equipment was necessary. According to the 1996 EE/CA, total and reactive organic compounds (ROCs) emissions at system start-up were estimated to be 1.9 and 1.7 pounds per day respectively. According to SMAQMD Rule 202, Section 301.1, the application of best available control technology (BACT) was not required since the emissions did not exceed the 10 pounds per day limit for ROCs (SMAQMD, Procedure for Permit Processing). In addition, an assessment was completed to determine if the emission rate would result in a cancer risk value in excess of the 0.1×10^{-6} deminimus level since the off-gas from the air stripper also contained compounds regulated as toxic organics. This assessment concluded that the deminimus level was not exceeded and the application of toxic best available control technology (T-BACT) would not be required. The 1996 EE/CA also concluded that if groundwater chemical concentrations increase where the cancer risk deminimus value or limit for ROCs might

be exceeded, the treatment system would be modified, including installation of additional UV/Oxidation equipment, to maintain ROC emissions levels and risk values below the regulatory limits. The 1996 EE/CA presented estimated worst-case influent groundwater concentrations that could be encountered in the future. These estimates result in total and ROCs emission rates of 15.2 and 14.3 pound per day respectively, and a residential 70-year maximum exposed individual (MEI) cancer risk value of 0.30×10^{-6} without the installation of air emission control equipment.

Table 2-2 compares the air emission rates estimated in the 1996 EE/CA to the calculated average air emission rates from operation of ARGET between 8/26/98 and 10/10/99. The actual emission rate of ROCs was 0.33 lb/day, well below the SMAQMD daily limit. Air emission rates presented in the 1996 EE/CA were calculated at an estimated treatment system flow rate of 3,445 gpm, whereas actual air emission rates presented in Table 2-2 are calculated using the actual ARGET treatment system average flow rate of 2,740 gpm.

2.2.2 Effluent Chemicals and Concentrations

Review of water quality results obtained from the effluent of the ARGET system from system start up through November 1999, generally shows routine compliance with the waste discharge requirements established under the current NPDES permit (CA 0083861). Except for a single TCE value of 1.7 µg/l that occurred on 8 July 1998, the system has complied with the discharge permit for VOCs. In addition, several occurrences of a tentatively identified compound, possibly PCE, were identified in analytical results obtained using Method 8270. These results did not agree with the analytical results obtained on the same date using the more sensitive Method 601. Also, 17 unknown compounds were reported during the period 18 August 1998 through 10 November 1999 in analytical results provided by Method 8270 analysis.

Perchlorate was not evaluated as part of the 1996 EE/CA, but subsequent events resulted in establishment of an effluent discharge standard of 18 µg/l. Perchlorate is currently detected in the influent pipeline associated with the Fish Hatchery Wells (4325, 4330, and 4335) at a concentration of approximately 21 µg/l. Perchlorate in not currently detected in the influent pipeline associated with the remaining wells. When the two influent pipelines are combined the resultant average perchlorate concentration measured in the treatment system effluent is approximately 6 µg/l.

3.0 SUBSURFACE CONDITIONS

3.1 Geology

Figure 3-1 shows the monitor, extraction, recharge and water supply wells from which data were collected for the evaluation of subsurface conditions for this project. Evaluation of lithologic and geophysical logs shows that the sediments consist of Tertiary- and Quaternary-age alluvial deposits from previous courses of the American River. Historic gold-dredging operations have disturbed the shallow sediments in the area.

Lithologic and geophysical logs of monitor, extraction, recharge and public water supply wells were used to construct six hydrogeologic cross-sections through the area (Figures 3-2 through 3-7). Finer-grained materials (silts, clays, siltstones, and claystones) were grouped together as aquitards while the coarser-grained materials (sands, gravels, and sandstones) were grouped together as aquifers. The interpretation of the continuity of lenses and layers shown on the cross-sections is based on geophysical logs, lithologic descriptions, and the response of water levels to pumping. In general, lateral variations in stratigraphy are greater in the north-south direction than in the east-west direction. This configuration is consistent with the depositional patterns expected from the ancestral American River, which flowed westward.

In previous ARSA reports, the hydrostratigraphy has been divided into four main aquifer units, labeled the Upper, Middle, Lower and Deeper Aquifers. To adapt the aquifer labeling for other related projects including on-site studies and the Western Operable Unit Feasibility Study, these aquifers are relabeled herein as Aquifer A, Aquifer B, Aquifer C and Aquifer D, respectively.

Aquifer pumping tests were performed on the 15 extraction wells installed in the ARSA in 1993 through 1995. The purpose of these tests was to determine the approximate quantity of water each well would produce under full-scale operating conditions and to evaluate the hydrologic characteristics of the aquifers being pumped. The results of these tests were presented in the 1996 EE/CA. Table 3-1 presents a summary of the aquifer testing and analyses including test dates, duration, pumping rates, drawdown, distance to pumping wells, transmissivity and storage coefficient as originally published in the 1996 EE/CA.

Aquifers A, B and C contain the majority of the chemical mass in the study area addressed by this report. Below Aquifer C is a relatively continuous aquitard as well as additional water-bearing units, identified as a group as Aquifer D. Aquifers A through C tend to be thicker in the eastern portion of the study area near the fish hatcheries and become thinner to the west. Conversely, Aquifer D becomes thicker and more prevalent than aquitard materials to the west, while aquitard materials are more prevalent at depth in the eastern portion of the study area.

Aquifer A

Aquifer A consists of higher permeability sands and gravels with lenses of interbedded sediments of lower permeability and extends to a depth of approximately 25 to 100 feet below ground surface. Groundwater in Aquifer A exists under both unconfined and semi-confined conditions as determined by local stratigraphy. The average transmissivity for Aquifer A calculated from the ARSA aquifer tests is 70,000 feet squared per day (ft^2/d) and the average storage coefficient is $4.8x10^{-3}$.

Aquifer B

Aquifer B is separated from Aquifer A by a relatively continuous aquitard ranging from approximately 10 to 55 feet in thickness. In general, Aquifer B consists of sands, gravels, and silty sands ranging in thickness between 10 and 70 feet. In the central and western portions of the study area Aquifer B is bifurcated into two water bearing units as shown on cross-sections B-B' and E-E' on Figures 3-3 and 3-6, respectively. The average transmissivity for Aquifer B calculated from the ARSA aquifer tests is 42,500 ft^2/d and the average storage coefficient is $1.3x10^{-3}$.

Aquifer C

Aquifer C is separated from the Aquifer B by an aquitard ranging in thickness from approximately 15 to 50 feet. In general, Aquifer C consists of sands, gravels, and silty sands ranging in thickness between 15 and 55 feet. The average transmissivity for Aquifer C calculated from the ARSA aquifer tests is 11,500 ft^2/d and the average storage coefficient is $9.6x10^{-3}$.

Aquifer D

For this study, the water-bearing zones below Aquifer C are grouped together as Aquifer D; therefore the thickness of this unit is not well defined. Aquifer D is separated from Aquifer C by a relatively continuous aquitard ranging in thickness from approximately 15 to 100 feet. Aquifer D contains more finer-grained sands and silts than overlying aquifers. This is reflected in the somewhat lower average transmissivity for Aquifer D of 3,200 ft^2/d, calculated from the ARSA aquifer tests. The average storage coefficient is $8.4x10^{-4}$.

3.2 Groundwater Flow

3.2.1 Water Level Changes

As described in section 2.1.1 above, the 15 ARGET extraction wells consist of five wells each screened in Aquifer A, Aquifer B and Aquifer C. The average total pumping rate from these wells is approximately 2,750 gpm: approximately 1,100 gpm from the Aquifer A wells, 1,300 gpm from the Aquifer B wells and 350 gpm from the Aquifer C wells (see Table 2-1).

Water levels have declined throughout the ARSA since commencement of pumping in August of 1998. Table 3-2 presents a summary of the water level changes in monitor wells from April 1998 through October of 1999. The water level declines range from 1.6 to 26.5 feet, with an average decline of 8.3 feet in Aquifer A, 9.0 feet in Aquifer B and 12.0 feet in Aquifer C. Despite the fact that there are no extraction wells screened in Aquifer D, pumping from the overlying aquifers has also apparently caused water levels to decline an average of 12.0 feet in this unit.

Figure 3-8 is a hydrograph of wells 30100 and 30101-30103 located approximately 130 feet northwest and just downgradient of extraction wells 4325, 4330 and 4335 on the south side of the river. These wells replaced monitor well 1357-1360 which was lost due to riverbank erosion in 1997. Water levels in these wells have declined 8.8 to 25.5 feet since the start of pumping. The largest decline was noted in Well 30102 completed in Aquifer C.

Figure 3-9 is a hydrograph of well 1395-1399 located approximately 160 feet west and downgradient of extraction wells 4300, 4301 and 4302 on the north side of the river. Water levels in these wells have declined 12.3 to 20.7 feet since the start of pumping. The largest decline was noted in well 1395 completed in Aquifer A. Water levels in these wells are now at their all-time lowest point for data collected since 1991.

Figure 3-10 is a hydrograph of well 1538-1540 located approximately 590 feet northwest and downgradient of extraction wells 4300, 4301 and 4302. Well 1538 completed in Aquifer A went dry after pumping commenced. Water levels in wells 1539 and 1540 have declined 16.1 and 15.0 feet, respectively since the start of pumping. Water levels in these wells are now at their all-time lowest point for data collected since 1993.

Figure 3-11 is a hydrograph of well 1525-1527 located approximately 475 feet west and downgradient of extraction wells 4355, 4360 and 4365. Water levels in these wells have declined 11.6 to 17.0 feet since the start of pumping. Water levels in these wells are now at their all-time lowest point for data collected since 1992.

Figure 3-12 is a hydrograph of well 1585-1587 located approximately 1,175 feet northwest and downgradient of extraction wells 4340, 4345 and 4350. Water levels in these wells have declined 11.8 to 12.1 feet since the start of pumping. Water levels in these wells are now at their all-time lowest point for data collected since 1995.

Figure 3-13 is a hydrograph of wells 1519-1521 and 1522-1524 located approximately 1,100 feet southeast and upgradient of extraction wells 4300, 4301 and 4302. Water levels in these wells have declined 9.7 to 18.9 feet since the start of pumping. The largest decline was noted in well 1521 completed in Aquifer D. Water levels in these wells are now at their all-time lowest point for data collected since 1992.

Figure 3-14 is a hydrograph of wells 1571-1573 and 1574 located approximately 965 feet northwest and downgradient of extraction wells 4370, 4375 and 4380. Water levels in these wells have declined 6.2 to 8.2 feet since the start of pumping. The largest decline was noted in well 1573 completed in Aquifer C. Water levels in these wells are now at their all-time lowest point for data collected since 1994.

Hydrographs for the remaining monitor wells are presented in Appendix A.

3.2.2 Groundwater Gradients

Figures 3-15 through 3-18 present groundwater elevation contour maps of each aquifer based upon data collected during plant-wide soundings conducted in April 1998, October 1998, April 1999 and October 1999. These four dates represent non-pumping conditions prior to startup of the ARGET, two months of pumping, eight months of pumping and 14 months of pumping, respectively. Water levels taken from extraction wells during pumping were adjusted upward to compensate for assumed well losses which would otherwise exaggerate their effect on the contoured surfaces. Table 3-3 presents the measured and corrected water levels and the estimated well efficiencies used to calculate the corrections. The estimated well efficiencies were based on performance during aquifer tests and water levels in nearby monitor wells.

Aquifer A

The April 1998 potentiometric surface map for Aquifer A on Figure 3-15 indicates that, under non-pumping conditions, groundwater flows generally to the west-northwest. The gradient ranges from approximately 0.015 feet per foot (79 feet per mile) in the eastern portion of the study area to approximately 0.004 to 0.006 feet per foot (20 to 33 feet per mile) in the central and western portion of the study area. The average non-pumping gradient across the study area is approximately 0.006 feet per foot (31 feet per mile). The remaining three contour maps on Figure 3-15 show the effect of pumping of the ARSA extraction wells on the potentiometric surface.

Although the unconfined to semi-confined nature of Aquifer A suggests that some hydraulic connection exists between the American River and Aquifer A, the presence of chemicals in Aquifer A on the north side of the river and the configuration of the potentiometric surface of Aquifer A indicate that the river is not a significant barrier to chemical migration or groundwater flow.

Aquifer B

Groundwater in Aquifer B exists under confined to semi-confined conditions. The April 1998 potentiometric surface map for Aquifer B on Figure 3-16 indicates that, under non-pumping conditions, groundwater flows generally to the west-northwest under a gradient of approximately 0.008 feet per foot (40 feet per mile) in the eastern portion of the study

area and gradient of approximately 0.005 feet per foot (26 feet per mile) in the western portion of the study area. The average gradient across the study area is approximately 0.006 feet per foot (31 feet per mile). The remaining three contour maps on Figure 3-16 show the effects of pumping of the ARSA extraction wells on the potentiometric surface.

Aquifer C

Groundwater in Aquifer C exists under confined to semi-confined conditions. The April 1998 potentiometric surface map for Aquifer C on Figure 3-17 indicates that, under non-pumping conditions, groundwater flows generally to the west-northwest under a gradient of approximately 0.01 feet per foot (51 feet per mile) in the eastern portion of the study area and under a gradient of approximately 0.006 feet per foot (31 feet per mile) in the western portion of the study area. In the central portion of the study area, there is an area with a relatively flat gradient, 0.002 feet per foot (9 feet per mile). The average gradient across the study area is approximately 0.005 feet per foot (28 feet per mile). The remaining three contour maps on Figure 3-17 show the effect of pumping of the ARSA extraction wells on the potentiometric surface.

Aquifer D

Groundwater in Aquifer D exists under confined to semi-confined conditions. The April 1998 potentiometric surface map for Aquifer D on Figure 3-18 indicates that, under non-pumping conditions, groundwater flows generally to the west under a gradient of approximately 0.008 feet per foot (43 feet per mile) in the eastern portion of the study area, approximately 0.002 feet per foot (11 feet per mile) in the central portion of the study area and 0.009 feet per foot (47 feet per mile) in the western portion of the study area. The average gradient across the study area is approximately 0.006 feet per foot (34 feet per mile). The remaining three contour maps on Figure 3-18 show the effect of pumping of the ARSA extraction wells on the potentiometric surface. Pumping of the overlying aquifers does not significantly alter the general configuration of the potentiometric surface of Aquifer D.

3.2.3 Capture Zones

Figures 3-19 through 3-21 present estimated capture zones for Aquifers A, B and C, respectively. The capture zones are based on potentiometric surface maps for the

October 1999 water level data. The Surfer vector map function was used to create working maps of groundwater flow vectors. From these maps, the capture zones were estimated. In areas where data is sparse and the contours are somewhat suspect, the capture zones were adjusted to more realistically depict their effect on the groundwater flow system.

3.2.4 Vertical Gradients

Figures 3-22 through 3-27 present contour maps of the vertical gradients between Aquifers A and B, Aquifers B and C, and Aquifers C and D. For each pair of aquifers there is one map for data collected prior to pumping in April 1998 and one map for data collected after eight months of pumping in April 1999. Shaded areas indicate areas of upward gradients. April 1998 was the last full round of water level measurements prior to startup of the ARGET system. April 1999 was chosen for comparison so that seasonal variability in water levels would not be introduced in the evaluation.

The vertical gradients were calculated by selecting locations where monitor wells exist in adjacent aquifers. The water level difference between the adjacent wells divided by the vertical distance between the middle of the well screens resulted in the calculated vertical gradient. Positive values indicate downward gradients and negative values indicate upward gradients. Table 3-4 presents the data used to calculate these values. Values close to zero indicate little or no potential for vertical groundwater movement.

The vertical gradients between Aquifers A and B range from –0.021 to 0.184 with an average value of 0.012 under non-pumping conditions. Under pumping conditions the values range from –0.021 to 0.288 with an average of 0.024, indicating that pumping increases the downward vertical gradient between Aquifers A and B.

The vertical gradients between Aquifers B and C range from –0.040 to 0.235 with an average value of 0.035 under non-pumping conditions. Under pumping conditions the values range from –0.168 to 0.375 with an average of 0.042, indicating that pumping increases the downward vertical gradient between Aquifers B and C. It is also evident that the downward vertical gradient between Aquifers B and C is greater than between Aquifers A and B.

The vertical gradients between Aquifers C and D range from –0.095 to 0.175 with an average value of 0.020 under non-pumping conditions. Under pumping conditions the values range from –0.254 to 0.175 with an average of 0.009, indicating that pumping decreases the downward (or increases the upward) vertical gradient between Aquifers C and D. It is also evident that under pumping conditions the downward vertical gradient between Aquifers C and D is considerably less than between Aquifers A and B or between Aquifers B and C.

3.3 Distribution of Chemicals in Groundwater

Chemicals, primarily volatile organic compounds (VOCs), have been identified in groundwater within the ARSA at depths of approximately 50 to 250 feet below ground surface. Results for samples collected between January 1990 and April 1993 were presented in Appendix D of the 1993 EE/CA. Results for samples collected between January 1993 and January 1996 were presented in Appendix D of the 1996 EE/CA. Results of samples collected between January 1996 and September 1999 have been presented in quarterly monitoring reports and monthly database submittals to the regulatory agencies.

The five most common VOCs found in the groundwater at highest-concentrations in the ARSA are as follows; trichloroethylene (TCE), Freon-113, cis- and/or trans-1,2-dichloroethylene (1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and perchloroethylene (PCE). The graph presented in Figure 3-28 shows the composition and trend of these five compounds since March 1991 for well 1405 which is located in the more highly concentrated portion of the plume on the south side of the American River. Because TCE is the most prevalent chemical and its distribution encompasses that of the other chemicals, TCE has been chosen as the indicator to define the maximum extent of VOCs in the groundwater.

In addition to VOCs, perchlorate and 1,4-dioxane have also been identified in the groundwater in the ARSA. These two chemicals have been identified primarily in wells located in the vicinity of the fish hatcheries, south of the American River. The distribution of perchlorate and 1,4-dioxane are encompassed within the TCE plume. In 1998 31 monitor wells were also sampled and analyzed for n-nitrosodimethylamine (NDMA). None of the samples were found to contain NDMA above the laboratory detection limits of 0.02 and 0.0075 µg/l. The laboratory detection limit was being

lowered during this time, which is why some of the results are at 0.02 µg/l and some are at 0.0075 µg/l. Table 3-5 presents the analytical results for the five main VOCs, perchlorate, 1,4-dioxane, and NDMA for samples collected from January 1998 through September 1999.

The chemical distribution maps discussed below are based upon data collected from monitor, extraction and water supply wells during the summer quarter 1998, the last complete round of sampling prior to startup of the ARGET system, and the summer quarter 1999, representing 10 to 12 months of pumping of the ARGET system. The summer quarterly sampling events include all the ARSA monitor wells, while the other three quarterly sampling events include only a select group of wells. Distribution maps for TCE are presented here, while maps for the other four VOCs, perchlorate and 1,4-dioxane are presented in Appendix B.

The highest TCE concentrations in each aquifer are located in a relatively small area in the central part of the study area under the western portion of the fish hatchery property south of the American River. The highest concentrations and widest distribution of chemicals are within Aquifer B.

Aquifer A

Figures 3-29 and 3-30 present the distribution of TCE in Aquifer A for summer 1998 and summer 1999, respectively. The overall extent of TCE in Aquifer A has remained about the same, although the highest concentrations have decreased significantly. The 1,000-µg/l contour is no longer present. TCE concentrations in wells 1162 and 1361 along the southern border of the plume have increased somewhat from 67 and 57 µg/l to 140 and 62 µg/l, respectively. The estimated capture zone for Aquifer A created by pumping is also shown of Figure 3-30. The Aquifer A capture zone encompasses the majority of the Aquifer A TCE plume. A relatively small area of the plume (<100 µg/l) falls outside the capture zone in the southern portion of the map. Both the TCE distribution and capture zone are not well defined in this area due to a limited number of monitor wells. This is the Gold River residential area where previous attempts to install monitor wells were unsuccessful and placing additional monitor wells is problematic.

Aquifer B

Figures 3-31 and 3-32 present the distribution of TCE in Aquifer B for summer 1998 and summer 1999, respectively. The overall extent of TCE in Aquifer B has remained approximately the same, although the highest concentrations have decreased significantly. The 1,000-µg/l contour has significantly decreased in size. TCE concentrations along the southern border of the plume have decreased slightly, while the TCE concentration in well 1509 in the northern portion of the plume has increased from 47 to 150 µg/l. The estimated capture zone created by pumping is also shown on Figure 3-32. The Aquifer B capture zone encompasses the majority of the Aquifer B TCE plume. Two relatively small areas of the plume (<100 µg/l) fall outside the capture zone the northeastern portion and in the southern portion of the map. Both the TCE distribution and capture zone are not well defined in these areas due to a limited number of monitor wells. These are both residential areas where placing additional monitor wells is problematic. In addition, the terrain is quite steep in the northeastern area, limiting access for wells

Aquifer C

Figures 3-33 and 3-34 present the distribution of TCE in Aquifer C for summer 1998 and summer 1999, respectively. The overall extent of TCE in Aquifer C has remained about the same, although the highest concentrations have decreased significantly. The 1,000-µg/l contour is now much smaller. TCE concentrations along the southern border of the plume have decreased somewhat. TCE concentration in well 1540 located north of extraction well 4302 has decreased from 140 to 45 µg/l. The estimated capture zone created by pumping is also shown of Figure 3-34. The Aquifer C capture zone encompasses almost the entire Aquifer C TCE plume. A relatively small area of the plume (< 50 µg/l) falls outside the capture zone in the southern portion of the map. Both the TCE distribution and capture zone are not well defined in this area due to a limited number of monitor wells. This is the Gold River residential area where placing additional monitor wells is problematic.

Aquifer D

Figures 3-35 and 3-36 present the distribution of TCE in Aquifer D for summer 1998 and summer 1999, respectively. The overall extent and the highest concentrations of TCE in

Aquifer D have remained about the same over the one year period of ARGET operation. As shown on the Figures 3-35 and 3-36, one monitor well, 1480, has shown an increase of TCE from 230 µg/l to 330 µg/l, while all other wells have similar or lower concentrations during this period. There are no extraction wells screened in Aquifer D. Some hydraulic capture of TCE in this aquifer is likely occurring by leakage from Aquifer D into Aquifer C where the vertical gradient between the two aquifers is upward from D to C (Figure 3-27).

3.4 Chemical Concentration Trends

The general decrease in VOC concentrations indicates that the ARGET system is proving to be very effective at removing chemical mass. Approximately 2,600 pounds of VOCs were removed during the first 15 months of operation. To assess the ARGET's effectiveness at minimizing downgradient migration of chemicals, graphs showing the trend of VOC concentrations in wells located near the perimeter of the plume and/or downgradient of extraction wells were prepared. VOC trend graphs for selected wells are shown here, while VOC trend graphs for the remaining wells are presented in Appendix C.

Figure 3-37 is a graph of VOC concentration trends for wells 1531-1533 located in the northern portion of the VOC plume and within the estimated capture zone of the ARGET system. Wells 1531 and 1532, completed in Aquifers A and B, respectively, had been showing an increasing trend of relatively low TCE concentrations since 1994. Since startup of the ARGET, TCE concentrations in these wells have shown a decreasing trend. Well 1533, completed in Aquifer C, shows no evidence of VOCs prior to or since startup of the ARGET.

Figure 3-38 is a graph of VOC concentration trends for wells 1538-1540 located just north and downgradient of extraction wells 4300, 4301 and 4302 and within the estimated capture zone of the ARGET system. Well 1538, completed in Aquifer A, had been showing an increasing trend of relatively low TCE concentrations since 1995. Since startup of the ARGET, well 1538 has been dry so no additional samples have been collected. Well 1539, completed in Aquifer B, had a general decreasing trend of TCE, 1,2-DCE and PCE since 1996. After startup of the ARGET, there was an increase in the first sample collected from this well followed by a decreasing trend in subsequent samples. Well 1540, completed in Aquifer C, had an increasing trend in TCE, 1,2-DCE

and PCE since 1995. After startup of the ARGET, there was an increase in the first sample collected from this well followed by a decreasing trend in subsequent samples.

Figure 3-39 is a graph of VOC concentration trends for wells 1525-1527 located northwest and downgradient of extraction wells 4355, 4360 and 4365 and within the estimated capture zone of the ARGET system. Well 1525, completed in Aquifer A, and well 1526, completed in both Aquifers B and C, continue to show no evidence of VOCs. Well 1527, completed in Aquifer D, had a general increasing trend of relatively low TCE concentrations since 1996. After startup of the ARGET, the TCE concentration has appeared to stabilize at approximately 5 to 10 µg/l.

Figure 3-40 is a graph of VOC concentration trends for wells 1585-1587 located west of extraction wells 4355, 4360 and 4365 and beyond the estimated capture zone of the ARGET system. Well 1585, completed in Aquifer A, shows no evidence of VOCs prior to or since startup of the ARGET. Well 1586, completed in Aquifer B, had a decreasing trend of relatively low TCE concentrations since 1995. After startup of the ARGET, the TCE concentration increased somewhat followed by a decreasing trend for subsequent samples. Well 1587, completed in Aquifer C, had a slightly increasing trend in relatively low VOC concentrations since 1995. After startup of the ARGET, samples have shown a slight decreasing trend in VOC concentrations.

Figure 3-41 is a graph of VOC concentration trends for wells 1509-1511 located within the VOC plume, upgradient of extraction wells 4300, 4301, and 4302 and within the ARGET capture zone. Well 1509, completed in Aquifer B, had in increasing trend in TCE and 1,2-DCE prior to startup of the ARGET. Since startup of the ARGET system, TCE, 1,2-DCE and PCE have shown increasing concentrations. This may be a result of the higher concentration portion of the plume approaching this well. The well is located well within the capture zone of the ARGET system. Well 1510, completed in Aquifer C, had a decreasing trend of relatively low TCE concentrations since 1996. After startup of the ARGET, TCE concentrations increased somewhat, followed by a decreasing trend for subsequent samples. TCE concentrations for well 1510 remain below 2 µg/l. Well 1511, completed in Aquifer D, shows no evidence of VOCs in the four years prior to or since startup of the ARGET.

Figure 3-42 is a graph of VOC concentration trends for wells 1480, 1489 and 1524, all completed in Aquifer D. These wells all exhibited an increasing trend in VOC

concentrations since 1992/1993. After startup of the ARGET, VOCs in well 1480 increased significantly then decreased somewhat. VOCs in well 1489 have increased somewhat since startup of the ARGET. The VOC concentrations in well 1524 have stayed relatively consistent since 1996.

Figure 3-43 is a graph of VOC concentration trends for wells 1394, 1402 and 1471, all completed in Aquifer D. These wells have exhibited somewhat irregular trends in VOC concentrations since 1992. After startup of the ARGET, VOC concentrations in all three wells have decreased.

4.0 Conclusions and Recommendations

4.1 Conclusions

- The ARGET treatment system is very effective at removing VOCs from groundwater (Table 2-2). Approximately 2,600 pounds of VOCs were removed from approximately 1.7 billion gallons of water during the first 15 months of operation of the system.

- Analysis of chemical distribution maps and capture zones for Aquifers A, B and C indicate that the ARGET system is effectively capturing the vast majority of the VOC plume and reducing the mass of VOCs in the groundwater. The plume appears to be within the capture zones except for small areas of relatively low concentrations, which are either in residential neighborhoods or steep terrain. The installation of additional wells is problematic in these areas.

- Analyses of chemical trend graphs indicate that the ARGET system is effectively controlling the downgradient migration of chemicals in groundwater in Aquifers A, B and C.

- Analysis of chemical distribution and VOC trends for Aquifer D since ARGET began operation indicates that VOCs in this aquifer are, except for monitor well 1480, relatively stable or declining. The cause of the increase at well 1480 is not clear, however significant downward movement of VOCs from Aquifer C is unlikely at this location based on the near neutral head gradient between Aquifers C and D at this location.

4.2 Recommendations

- Aerojet recommends collecting an additional four quarters of monitoring data to further evaluate the distribution and concentration trends of VOCs in Aquifer D. This data will be collected during the four quarters of calendar year 2000. The Aquifer D plume appears to be moving relatively slowly and is well defined horizontally by a series of clean monitor wells. These wells will provide for early warning of changes in the leading edge of the plume and thus protect downgradient resources. To better define concentration trends, five Aquifer D

monitor wells will be changed from annual sampling to quarterly sampling, including wells 1373, 1471, 1483, 1508 and 1524 (Figure 3-36). Other proposed changes to the monitoring program are to reduce sampling frequency of Aquifer D monitor wells 1409, 1589 and 1590 (Figure 3-36) from quarterly sampling to annual sampling. These wells are located approximately 3,500 feet downgradient (northwest) of the leading edge of the Aquifer D plume and show a relatively consistent history of non-detects or very low VOC concentrations. Note that two shallower Aquifer D wells (wells 1408 and 1588) will continue to be sampled quarterly at these two locations.

- A letter report addressing Aquifer D will be submitted March 1, 2001 which will present an evaluation of the quarterly monitoring and provide appropriate recommendations for either further field work or the preparation of a Remedial Action Plan Workplan or other remedial action selection documentation in accordance with CERCLA and the NCP. A revised schedule for the ARSA program is presented in Table 4-1.

5.0 References

Gencorp Aerojet, Engineering Evaluation and Cost Analysis for the American River Study Area, Aerojet Sacramento Site, May 1993

Gencorp Aerojet, Final Revised Engineering Evaluation and Cost Analysis for the American River Study Area, Aerojet Sacramento Site, September 1996

Gencorp Aerojet, Scoping Report, December 1989

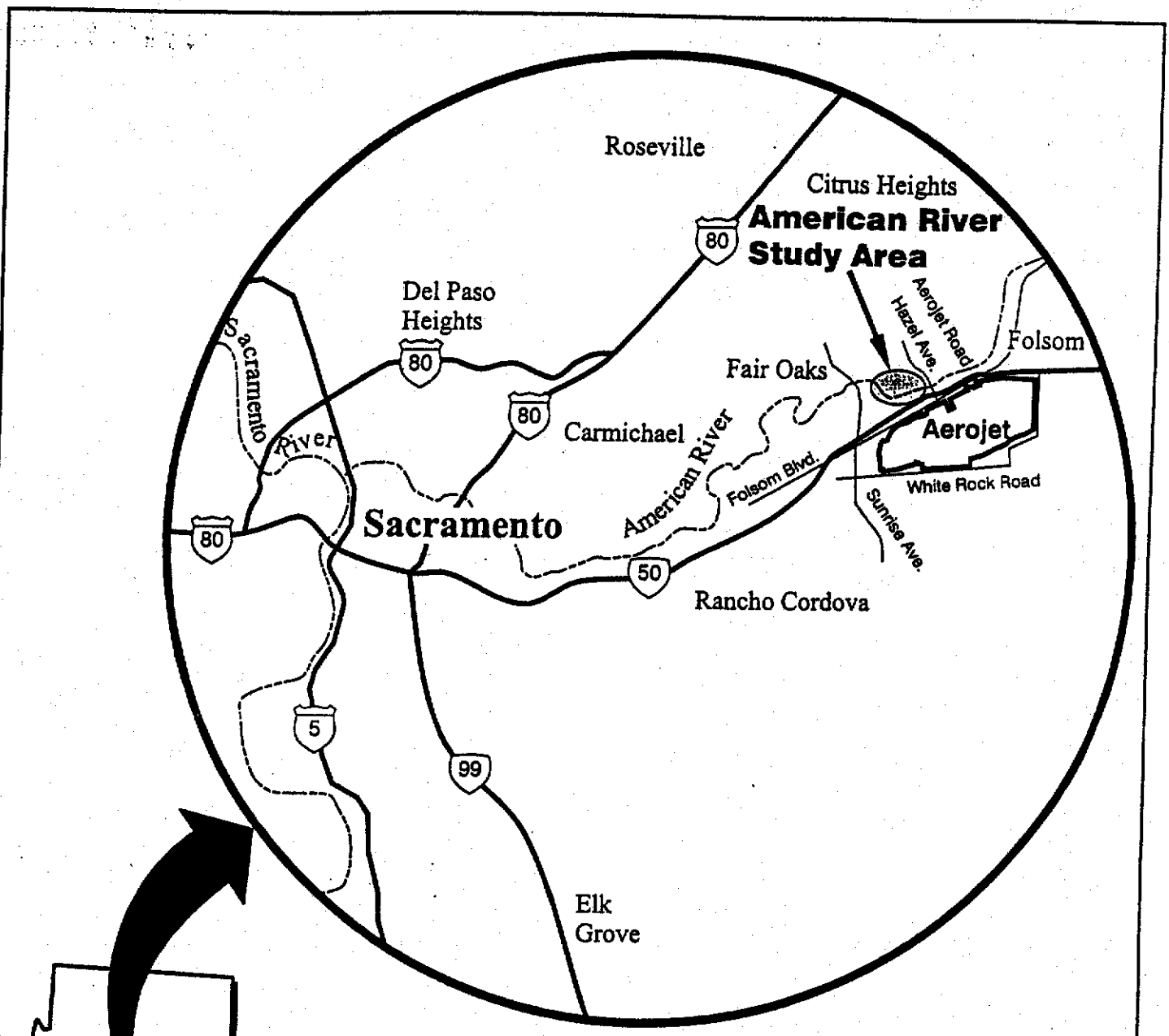
Pumped Well (Aquifer)	Test Date (Duration)	Q (gpm)	Obs. Wells for Analysis	Obs. Well Aquifer	r (feet)	s (feet)	T (gpd/ft)	T (ft^2/day)	S	L (feet)	Type Curve (r/B)
4300 (Aquifer A)	11/8-12/93 (96 hrs.)	308.8	1395 D	A	158	2.70	81,050	10,835	98.0E-6	394	0.4
			1395 R	A	158	--	154,440	20,646	89.7E-6	789	0.2
4301 (Aquifer B)	11/15-19/93 (96 hrs.)	218.3	1396 D	B	178	3.30	26,190	3,501	128.6E-6	592	0.3
			1396 R	B	178	--	24,440	3,267	122.8E-6	592	0.3
			1539 D	C	593	0.71	88,740	11,863	269.9E-6	742	0.8
			1539 R	C	593	--	62,820	8,398	246.2E-6	593	1.0
4302 (Aquifer C)	11/1-5/93 (96 hrs.)	35.0	1397 D	C	139	6.70	697	93	193.6E-6	174	0.8
			1397 R	C	139	--	621	83	180.7E-6	154	0.9
			1540 D	C	581	0.58	4,103	548	312.3E-6	387	1.5
			1540 R	C	581	--	4,103	548	248.1E-6	387	1.5
4302 (Aquifer C)	11/22-24/93 (48 hrs.)	35.3	1397 D	C	139	6.90	789	105	199.8E-6	199	0.7
			1397 R	C	139	--	598	80	174.0E-6	154	0.9
			1533 D	C	1,343	0.39	9,054	1,210	380.8E-6	1,492	0.9
			1533 R	C	1,343	--	10,890	1,456	295.6E-6	1,343	1.0
			1540 D	C	581	0.64	4,334	579	287.3E-6	387	1.5
			1540 R	C	581	--	3,522	471	268.1E-6	387	1.5
4325 (Aquifer A)	8/29/95 (8 hrs.)	424.8	1357D	A	409	1.80	80,770	10,797	196.4E-6	1,364	0.3
			1357R	A	409	--	80,770	10,797	196.4E-6	1,364	0.3
			1358D	B	409	1.86	73,660	9,847	210.5E-6	1,364	0.3
			1358R	B	409	--	75,350	10,073	192.0E-6	1,364	0.3
			1370D	A	879	0.77	82,650	11,049	165.8E-6	1,255	0.7
			1370R	A	879	--	82,650	11,049	1.7E-3	1,255	0.7
			1371D	B	879	0.77	53,370	7,135	144.4E-6	879	1.0
			1371R	B	879	--	61,270	8,191	154.7E-6	976	0.9
			1388D	B	1,003	0.23	627,000	83,818	652.8E-6	3,344	0.3
			1388R	B	1,003	--	641,600	85,769	900.5E-6	3,343	0.3
			1404D	B	774	0.35	414,200	55,371	544.8E-6	2,581	0.3
			1404R	B	774	--	464,800	62,135	615.7E-6	2,581	0.3
			1469D	A	834	0.10	475,600	63,578	3.9E-3	927	0.9
			1469R	A	834	--	395,600	52,884	3.4E-3	927	0.9
			1478D	A	994	0.17	498,000	66,573	1.9E-3	1,987	0.5
			1478R	A	994	--	404,800	54,114	2.0E-3	1,987	0.5
4330 (Aquifer B)	8/24/95 (8 hrs.)	452.7	1357D	A	389	2.40	58,190	7,779	163.7E-6	1,298	0.3
			1357R	A	389	--	60,940	8,146	159.9E-6	1,298	0.3
			1358D	B	389	2.71	53,070	7,094	127.0E-6	1,298	0.3
			1358R	B	389	--	65,300	8,729	118.6E-6	1,947	0.2
			1370D	A	891	0.81	55,580	7,430	167.7E-6	891	1.0
			1370R	A	891	--	54,310	7,260	156.5E-6	891	1.0
			1371D	B	891	0.81	55,580	7,430	163.9E-6	891	1.0
			1371R	B	891	--	63,810	8,530	160.2E-6	990	0.9
			1379D	C	804	0.17	638,100	85,302	12.7E-3	N/A	Theis
			1379R	C	804	--	988,300	132,117	4.0E-3	4,019	0.2
			1388D	B	996	0.25	484,000	64,701	600.7E-6	2,489	0.4
			1388R	B	996	--	495,300	66,212	705.7E-6	1,991	0.5
			1404D	B	780	0.41	367,200	49,088	576.2E-6	2,600	0.3
			1404R	B	780	--	358,800	47,965	576.2E-6	1,950	0.4
			1469D	A	848	0.13	421,600	56,360	2.9E-3	942	0.9
			1469R	A	848	--	412,000	55,076	2.7E-3	942	0.9
			1478D	A	978	0.22	312,500	41,775	1.8E-3	1,396	0.7
			1478R	A	978	--	393,400	52,590	2.4E-3	1,629	0.6
			1479D	C	978	2.25	9,013	1,205	1.0E-3	N/A	Theis
			1479R	C	978	--	86,080	11,507	925.0E-6	N/A	Theis
			1480D	D	978	2.08	8,412	1,125	2.0E-3	1,955	0.5
			1480R	D	978	--	80,330	10,739	987.4E-6	N/A	Theis
4335 (Aquifer C)	8/22/95 (8 hrs.)	238.3	1359D	C	374	8.10	9,687	1,295	177.0E-6	1,246	0.3
			1359R	C	374	--	11,650	1,557	177.0E-6	3,738	0.1
			1372D	C	912	3.28	12,770	1,707	97.0E-6	1,519	0.6
			1372R	C	912	--	20,240	2,706	122.0E-6	N/A	Theis
			1389D	C	975	1.04	49,680	6,641	387.5E-6	2,437	0.4
			1389R	C	975	--	48,550	6,490	405.8E-6	1,949	0.5
			1479D	C	986	2.90	10,380	1,388	88.7E-6	1,233	0.8
			1479R	C	986	--	16,830	2,250	117.0E-6	9,862	0.1
			1480D	D	986	2.99	9,687	1,295	92.9E-6	1,233	0.8
			1480R	D	986	--	14,330	1,916	125.3E-6	4,931	0.2

Pumped Well (Aquifer)	Test Date (Duration)	Q (gpm)	Obs. Wells for Analysis	Obs. Well Aquifer	r (feet)	s (feet)	T (gpd/ft)	T (ft^2/day)	S	L (feet)	Type Curve (r/B)
4340 (Aquifer A)	3/7/95 (8 hrs.)	25.3	1564D	A	186	0.65	43,870	5,865	893.6E-6	1,864	0.1
			1564R	A	186	--	60,560	8,096	935.7E-6	1,864	0.1
4345 (Aquifer B)	12/12/94 (8 hrs.)	387.9	1396D	B	1,020	0.24	424,400	56,734	389.8E-6	2,039	0.5
			1396R	B	1,020	--	280,400	37,484	458.0E-6	1,133	0.9
			1397D	C	1,020	0.23	337,100	45,064	3.0E-3	1,699	0.6
			1397R	C	1,020	--	454,800	60,798	3.2E-3	1,699	0.6
			1525D	A	748	0.29	672,700	89,927	2.0E-3	1,869	0.4
			1525R	A	748	--	754,700	100,889	3.1E-3	3,738	0.2
			1526D	B	748	0.33	546,800	73,097	978.2E-6	2,492	0.3
			1526R	B	748	--	405,300	54,181	1.5E-3	1,869	0.4
			1564D	A	288	1.18	116,900	15,627	60.1E-3	96	0.3
			1564R	A	288	--	189,600	25,346	42.6E-3	288	0.1
			1565D	B	288	9.80	6,135	820	1.1E-3	41	0.7
			1565R	B	288	--	6,135	820	1.5E-3	41	0.7
			1566D	C	288	5.37	8,275	1,106	5.7E-3	32	0.9
			1566R	C	288	--	8,087	1,081	7.2E-3	32	0.9
4350 (Aquifer C)	12/19/94 (8 hrs.)	61.5	1565D	B	179	0.45	21,770	2,910	565.0E-6	256	0.7
			1565R	B	179	--	3,614	483	565.1E-6	90	2.0
			1566D	C	179	1.00	8,090	1,081	252.4E-6	224	0.8
			1566R	C	179	--	3,221	431	332.7E-6	119	1.5
4355 (Aquifer A)	11/23/94 (8 hrs.)	387.7	1395D	A	640	0.17	2,126,000	284,205	609.4E-6	12,800	0.05
			1395R	A	640	--	2,331,000	311,609	1.1E-3	12,800	0.05
			1396D	B	640	0.18	866,100	115,781	1.6E-3	6,401	0.1
			1396R	B	640	--	487,000	65,102	2.2E-3	914	0.7
			1397D	C	640	0.16	119,600	15,988	7.3E-3	427	1.5
			1525D	A	487	0.17	627,400	83,871	3.3E-3	1,219	0.4
			1525R	A	487	--	971,800	129,911	6.2E-3	1,625	0.3
			1526D	B	487	0.19	227,800	30,452	3.1E-3	542	0.9
			1526R	B	487	--	286,800	38,340	2.5E-3	542	0.9
			1564D	A	573	0.14	510,000	68,177	8.2E-3	955	0.6
			1565D	B	573	0.23	928,000	124,056	2.1E-3	N/A	Theis
			1565R	B	573	--	1,252,000	167,368	2.8E-3	N/A	Theis
4360 (Aquifer B)	12/1/94 (8 hrs.)	434.2	1395D	A	662	0.20	1,435,000	191,832	1.0E-3	13,250	0.05
			1395R	A	662	--	2,122,000	283,670	1.4E-3	13,250	0.05
			1396D	B	662	0.37	464,300	62,068	430.9E-6	3,312	0.2
			1396R	B	662	--	249,300	33,327	483.5E-6	946	0.7
			1397D	C	662	0.30	38,620	5,163	2.1E-3	331	2.0
			1397R	C	662	--	80,680	10,785	3.5E-3	442	1.5
			1525D	A	460	0.40	433,300	57,924	2.6E-3	2,298	0.2
			1525R	A	460	--	788,400	105,394	1.6E-3	4,595	0.1
			1526D	B	460	0.51	377,400	50,451	916.3E-6	2,298	0.2
			1526R	B	460	--	612,000	81,813	679.3E-6	7,658	0.06
			1565D	B	579	0.33	368,800	49,301	2.8E-3	1,448	0.4
			1565R	B	579	--	453,700	60,651	4.0E-3	1,448	0.4
4365 (Lower)	12/7/94 (8 hrs.)	568.0	1397D	C	680	0.10	11,570	1,547	628.2E-6	340	2.0
			1397R	C	680	--	11,310	1,512	673.2E-6	340	2.0
			1566D	C	587	0.12	115,700	15,467	925.6E-6	1,173	0.5
			1566R	C	587	--	136,000	18,181	331.3E-3	1,173	0.5
4370 (Aquifer A)	8/4/95 (8 hrs.)	391.8	1488D	B	648	0.16	391,000	52,269	9.3E-3	926	0.7
4375 (Aquifer B)	8/2/95 (8 hrs.)	210.9	1488D	B	657	0.16	191,900	25,653	3.3E-3	938	0.7
			1488R	B	657	--	179,100	23,942	2.6E-3	821	0.8
			1572D	B	952	0.13	96,190	12,859	1.3E-3	635	1.5
			1572R	B	952	--	149,000	19,918	924.7E-6	952	1.0
			1573D	C	952	0.17	36,570	4,889	903.6E-6	476	2.0
			1573R	C	952	--	34,930	4,669	883.1E-6	476	2.0
4380 (Aquifer C)	8/8/95 (8 hrs.)	98.9	1489D	D	628	1.23	13,620	1,821	773.8E-6	1,569	0.4
			1489R	D	628	--	15,290	2,044	1.1E-3	1,569	0.4
			1573D	C	1,006	0.13	16,760	2,240	1.3E-3	503	2.0
			1573R	C	1,006	--	12,420	1,660	1.2E-3	402	2.5

Notes: D = drawdown analysis
R = recovery analysis
r = distance from pumped well
s = maximum drawdown measured during test

b = aquifer thickness
T = aquifer transmissivity
S = aquifer storage coefficient
L = Leakage Factor [r/(r/B)]

Table 3-1
Summary of Aquifer Test Results



GENCORP AEROJET Environmental Operations

FIGURE 1-1
Regional Location Map
American River Study Area

2/8/2000 ab SR10109211

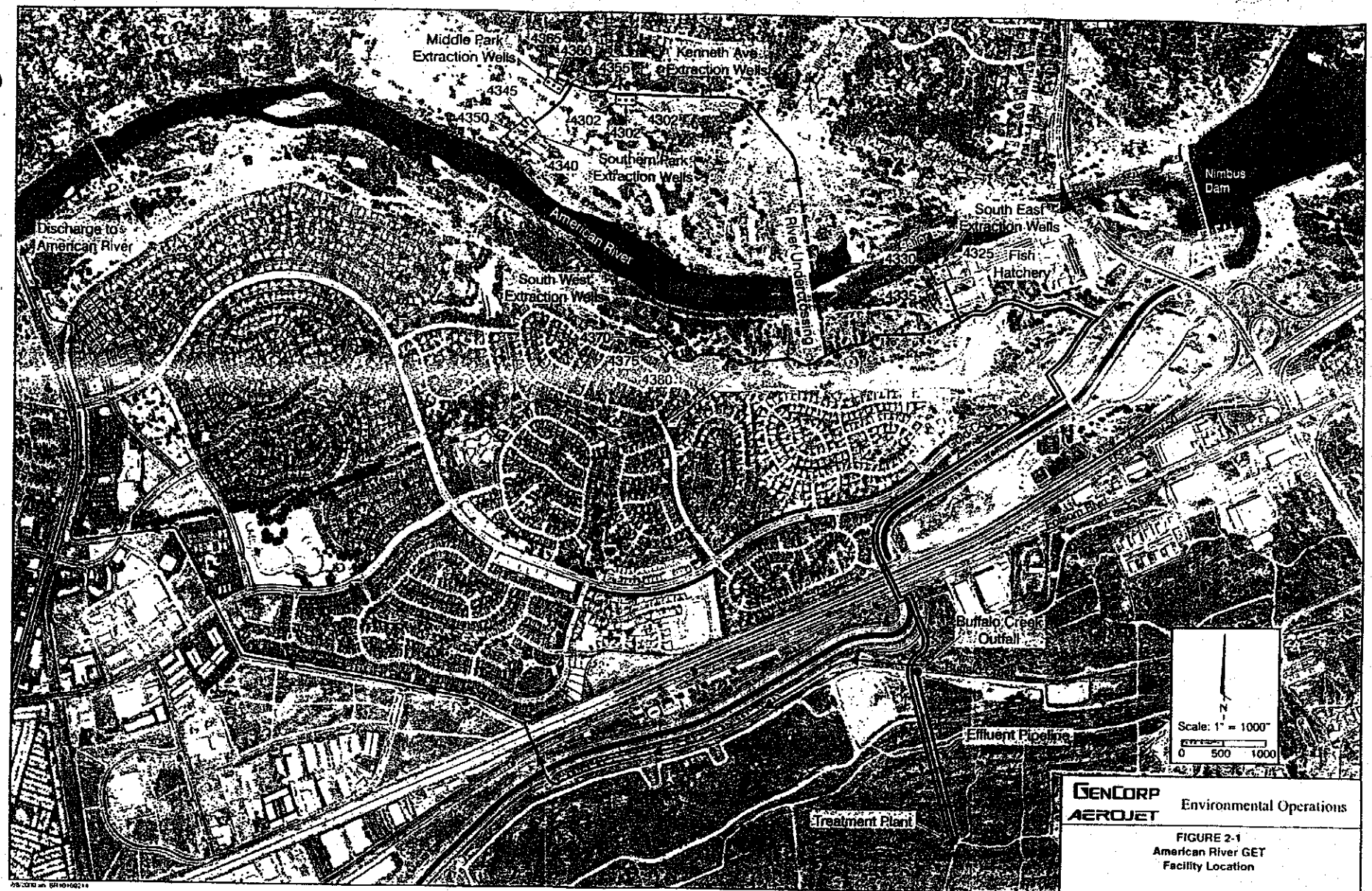
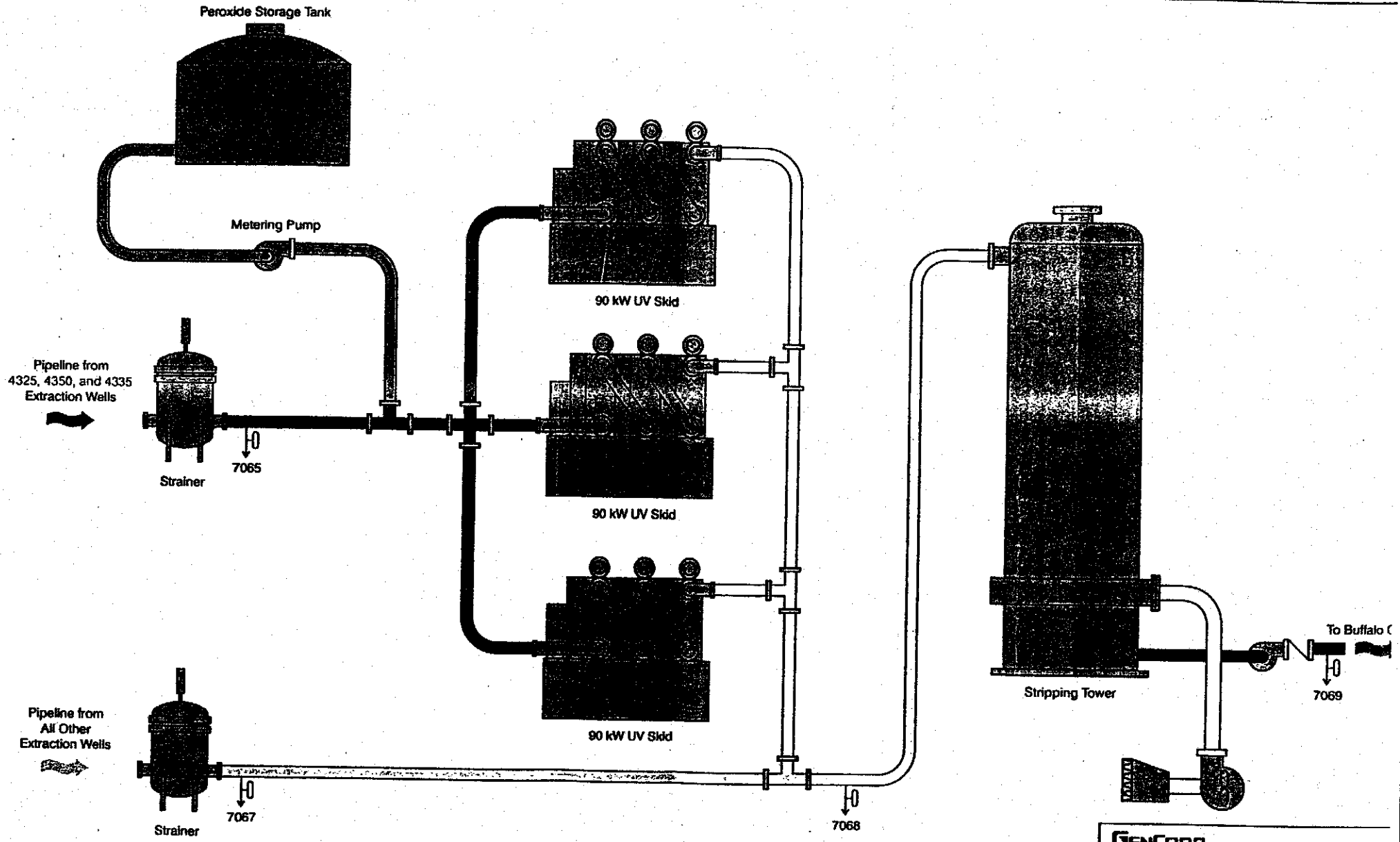


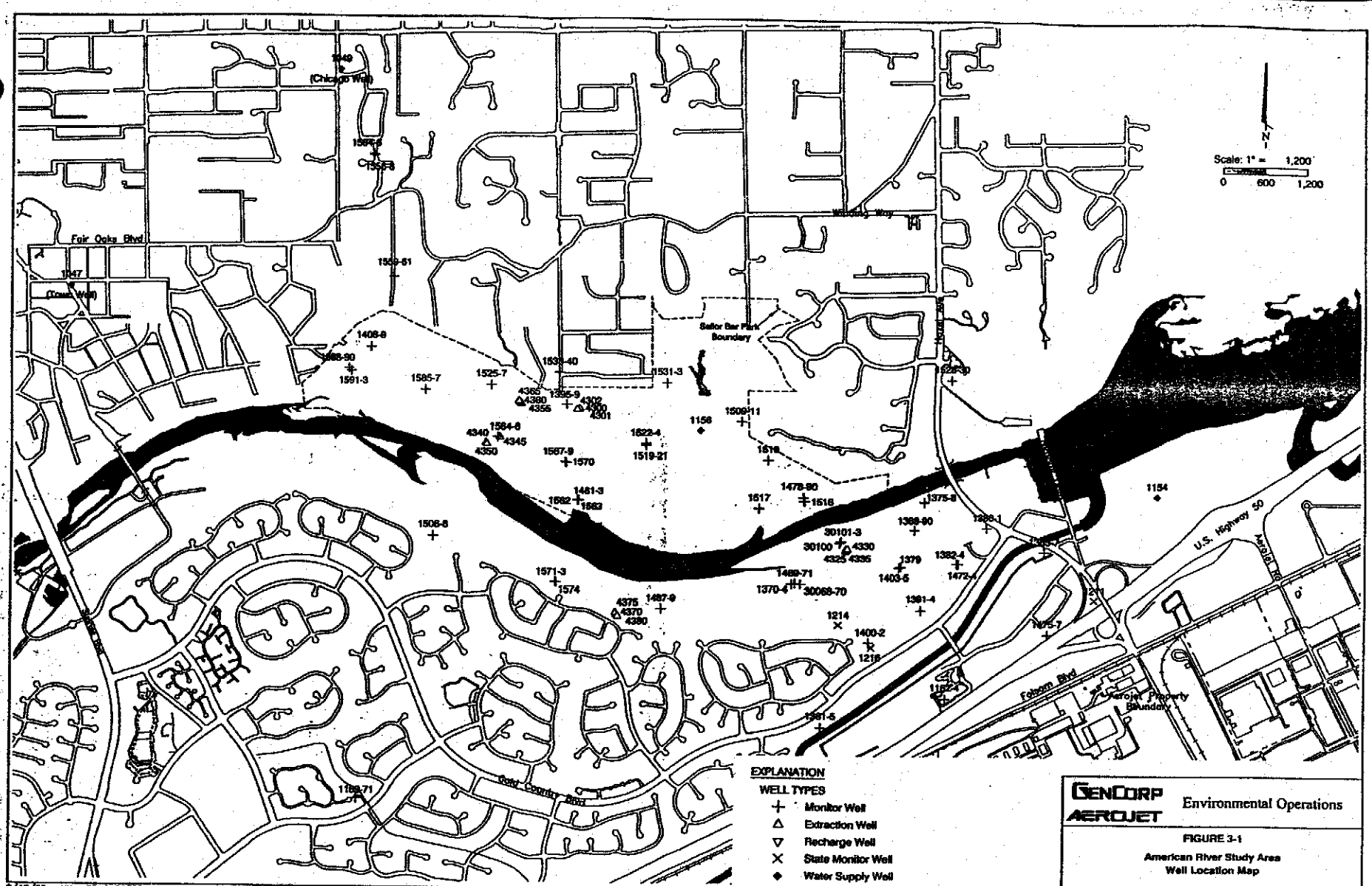
FIGURE 2-1
American River GET
Facility Location

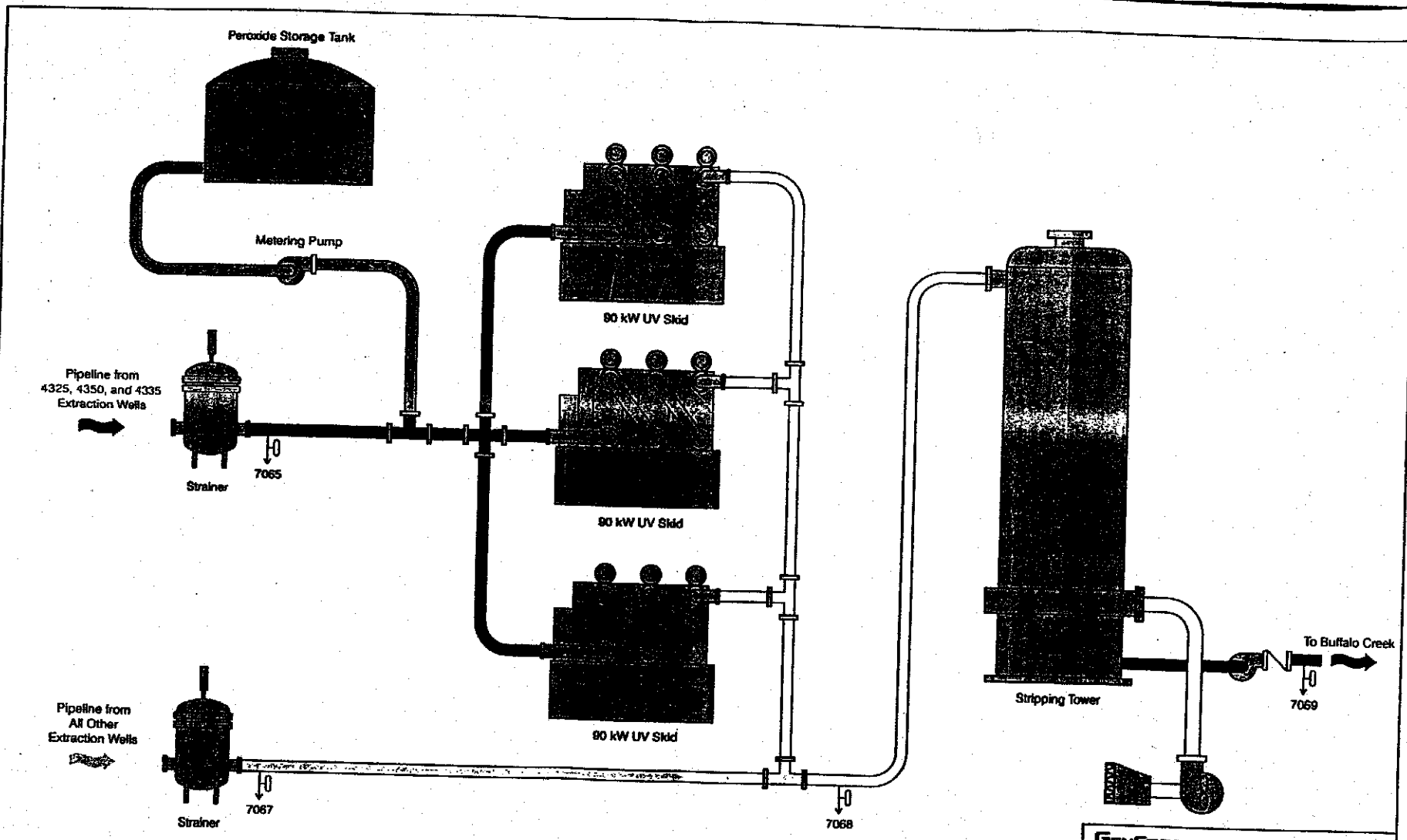


GenCorp Aerojet — Environmental Operati

FIGURE 2-2
American River GET
Treatment System Components

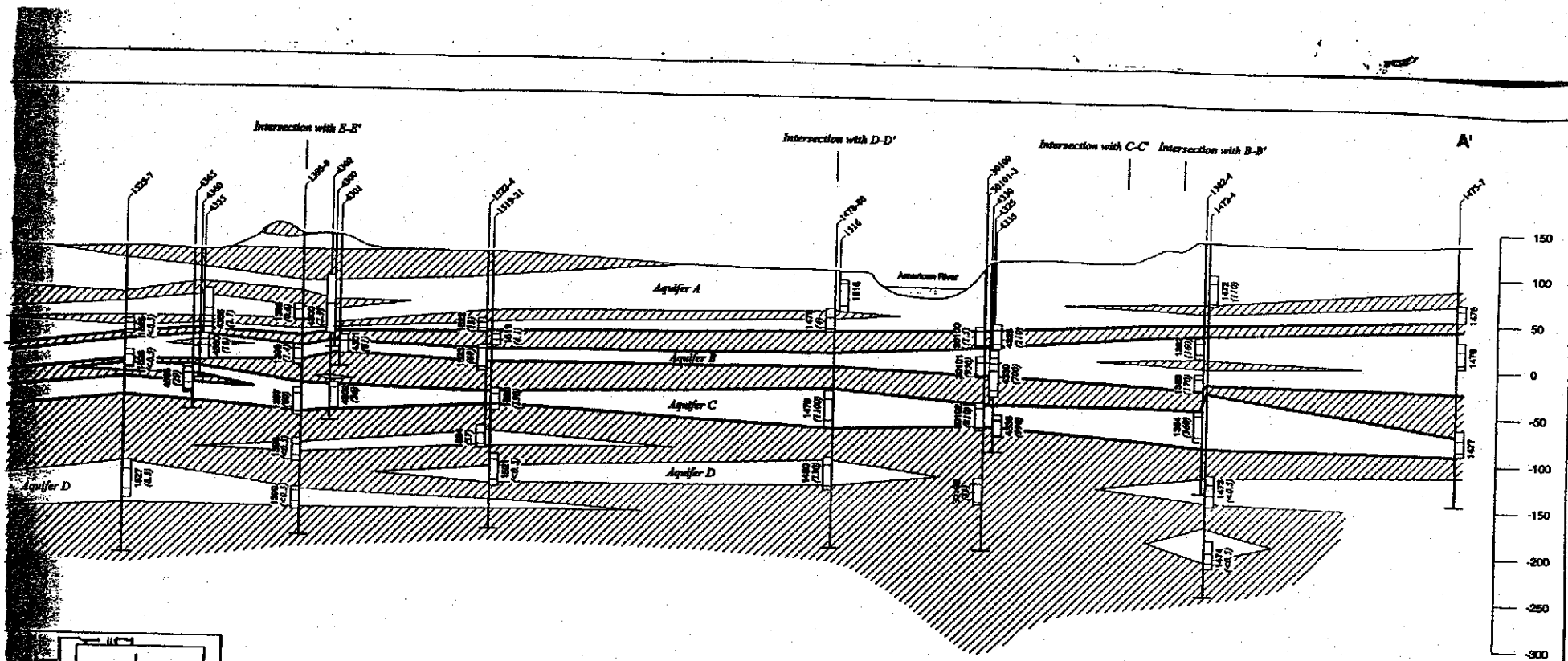
14/2000 en SR1010921b

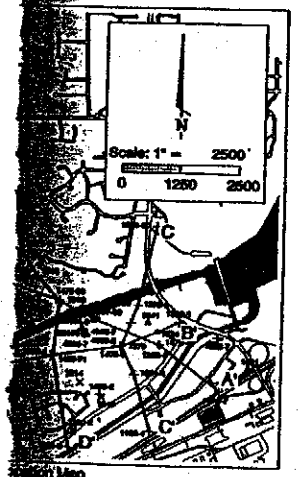

Fair Oaks Blvd
Sailor Bar Park Boundary
Folsom Blvd
U.S. Highway 50
Aerojet Property Boundary
Scale: 1" = 1,200
0 600 1,200
EXPLANATION
WELL TYPES
Monitor Well
Extraction Well
Recharge Well
State Monitor Well
Water Supply Well
GenCorp Aerojet
Environmental Operations
FIGURE 3-1
American River Study Area
Well Location Map
2/10/00 KK SR10108568



GENCORP AEROJET Environmental Operations

FIGURE 2-2
American River GET
Treatment System Components





Index Map

EXPLANATION

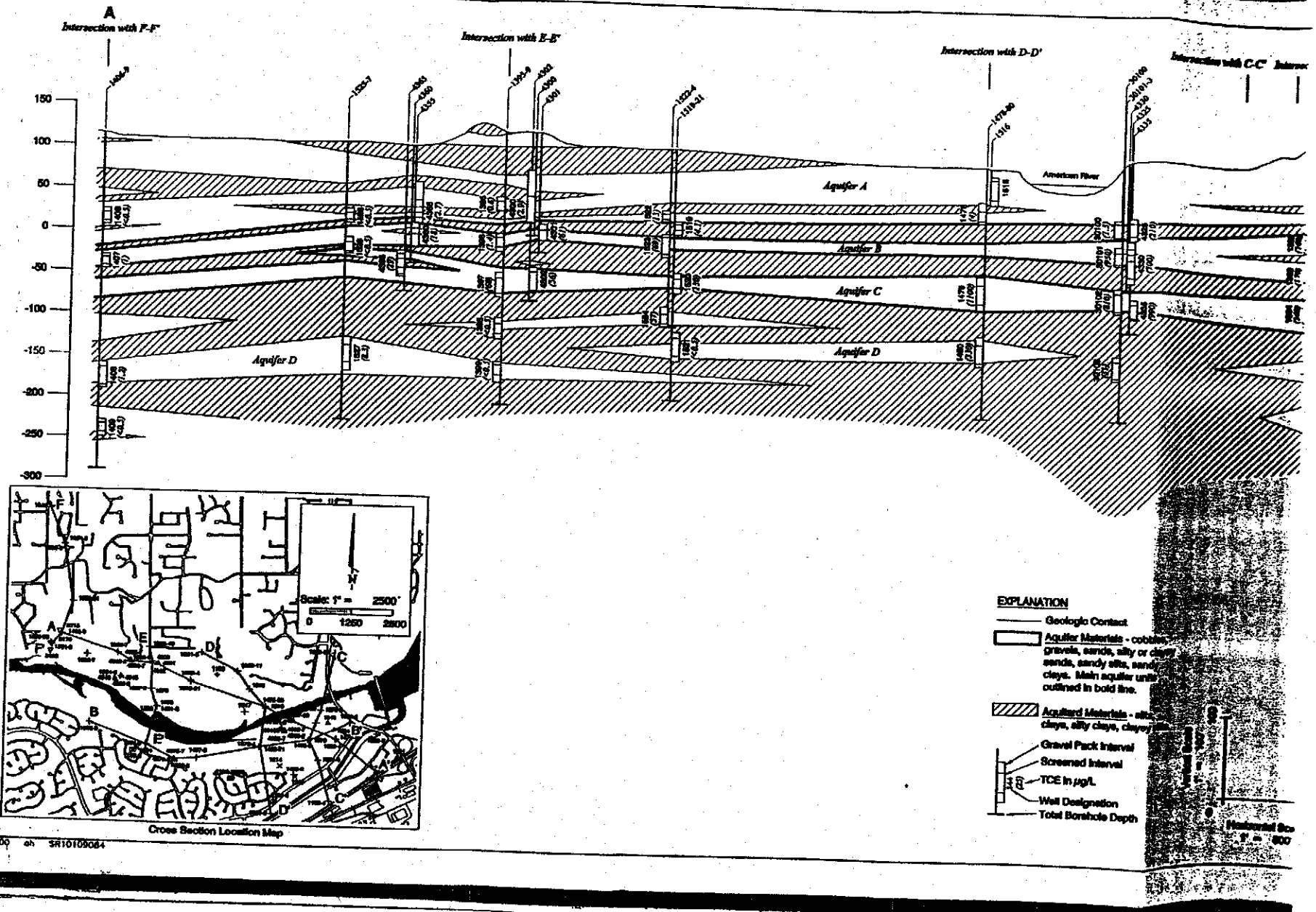
- Geologic Contact
- Aquifer Materials - cobbles, gravels, sands, silty or clayey sands, sandy silts, sandy clays. Main aquifer units outlined in bold line.
- Aquitard Materials - silts, clays, silty clays, clayey silts.
- Gravel Pack Interval
- Screened Interval
- TCE in µg/L
- Well Designation
- Total Borehole Depth

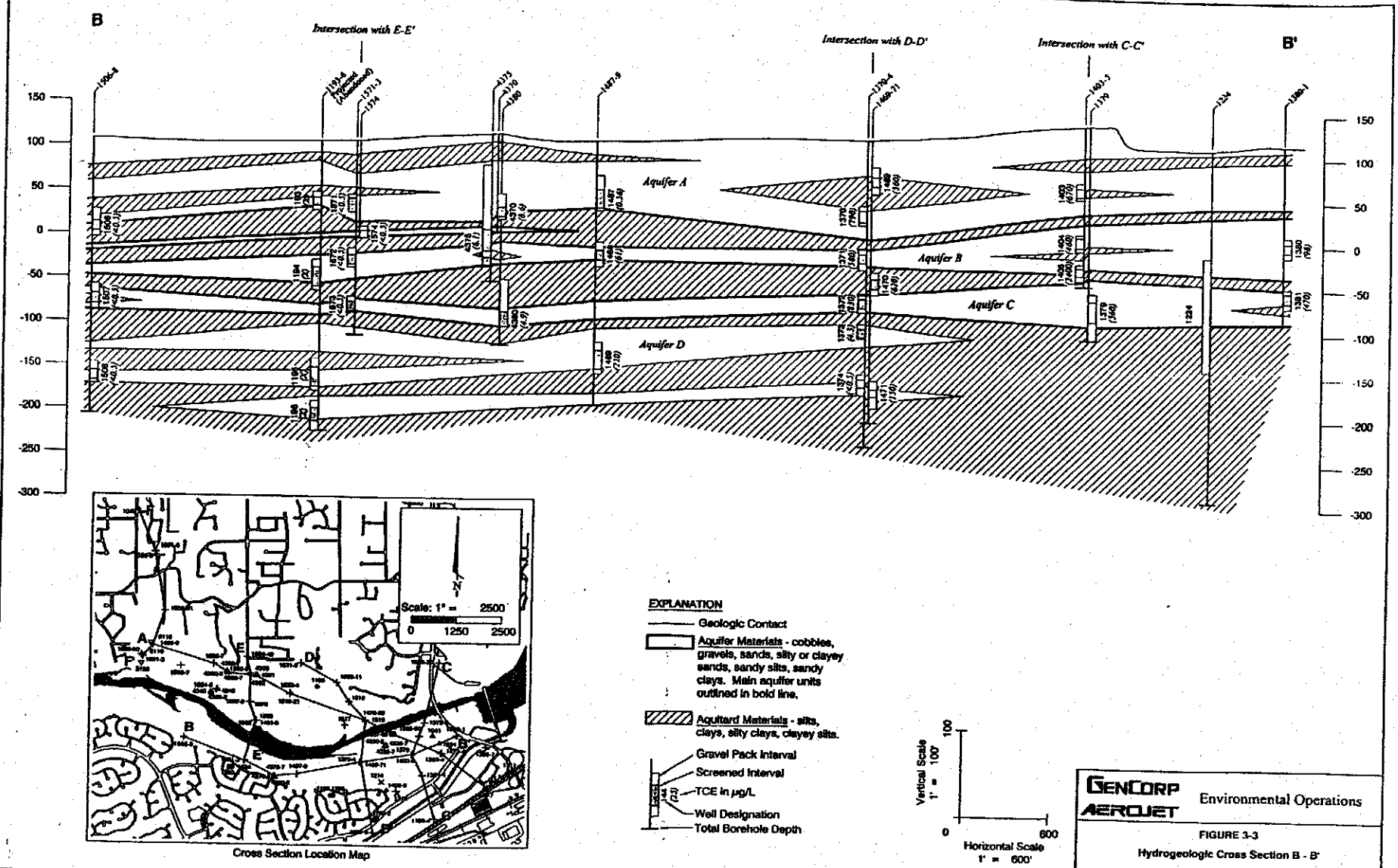
Vertical Scale
1" = 100'
100
0

Horizontal Scale
1" = 600'
0
600

GENCORP AEROJET
Environmental Operations

FIGURE 2-2
Hydrogeologic Cross Section A - A'


A
Intersection with F-F'
Intersection with E-E'
Intersection with D-D'
Intersection with C-C'
150
100
50
0
-50
-100
-150
-200
-250
-300
Aquifer A
Aquifer B
Aquifer C
Aquifer D
Aquifer D
American River
Scale: 1" = 2500'
0 1250 2500
Cross Section Location Map
EXPLANATION
Geologic Contact
Aquifer Materials - cobbles, gravels, sands, silty or clayey sands, sandy silts, sandy clays. Main aquifer units outlined in bold line.
Aquitard Materials - silts, clays, silty clays, clayey
Gravel Pack Interval
Screened Interval
TCE in µg/L
Well Designation
Total Borehole Depth
2/10/00 ah SR10109084

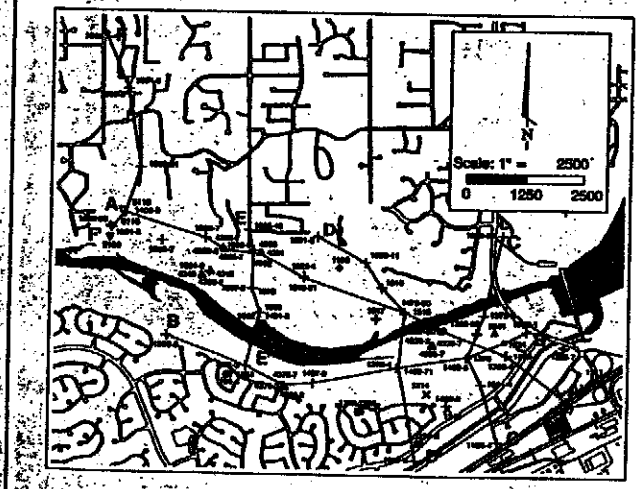


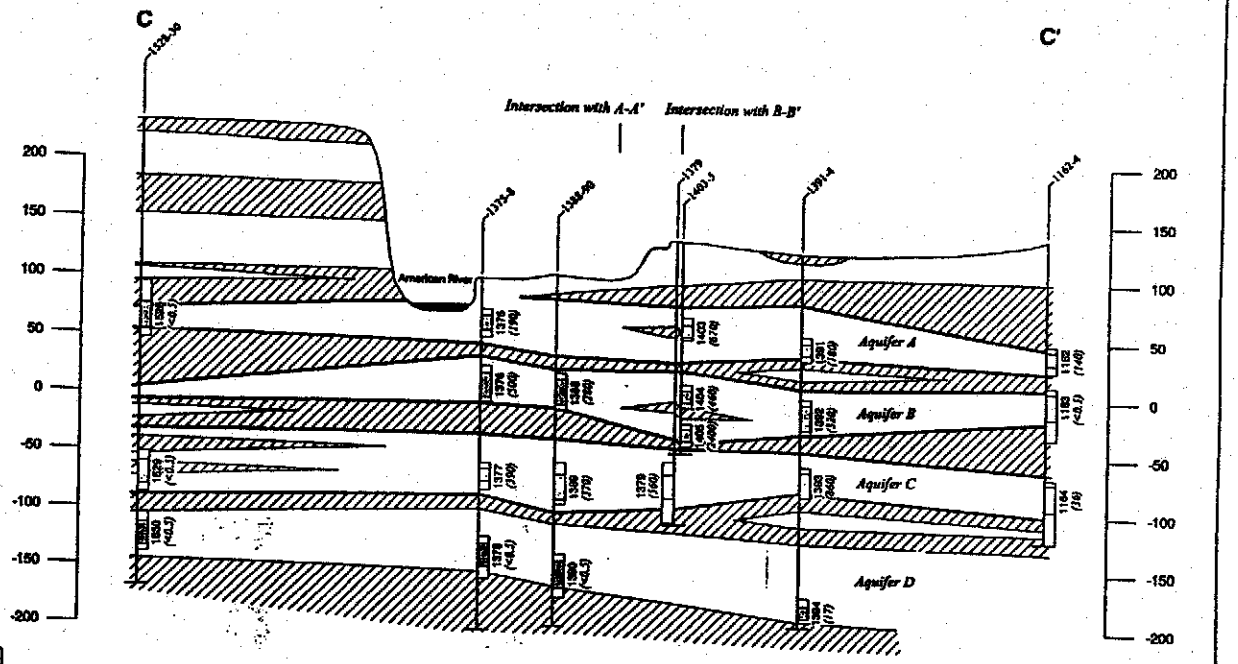
GENCORP AEROJET Environmental Operations

FIGURE 3-3

Hydrogeologic Cross Section B - B'

2/10/00 gh SR10109088





EXPLANATION

- Geologic Contact
- Aquifer Materials - cobbles, gravels, sands, silty or clayey sands, sandy silts, sandy clays. Main aquifer units outlined in bold line.
- Aquitard Materials - silts, clays, silty clays, clayey silts.
- Gravel Pack Interval
- Screened Interval
- TCE in µg/L
- Well Designation
- Total Borehole Depth

Vertical Scale 1" = 100': 0, 100

Horizontal Scale 1" = 800': 0, 600

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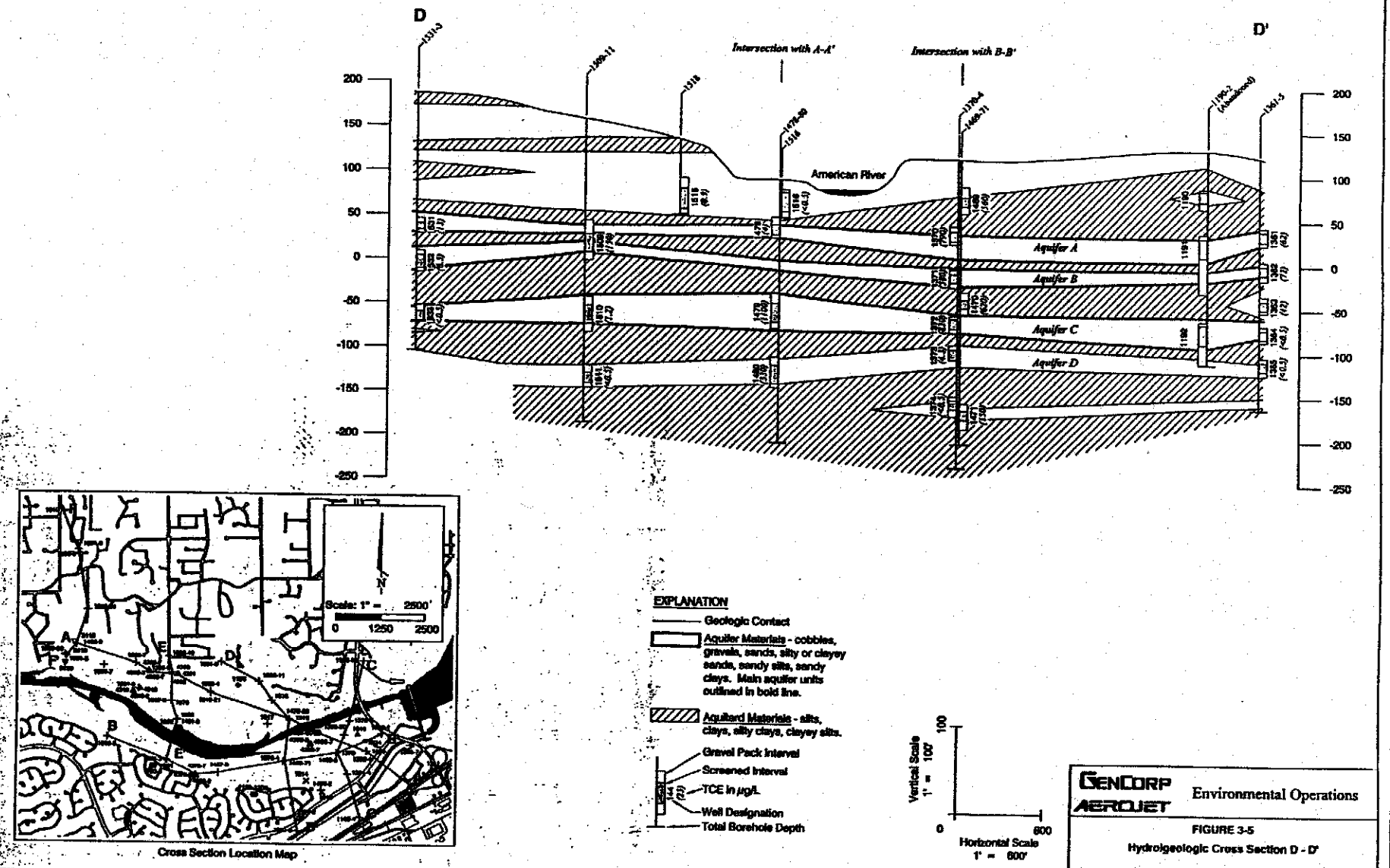
FIGURE 3-4

Hydrogeologic Cross Section C - C'

2/10/00 ah SR10109069

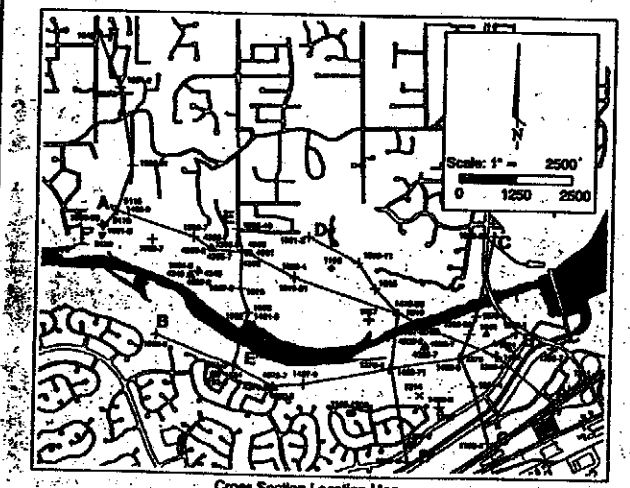


GENCORP AEROJET Environmental Operations

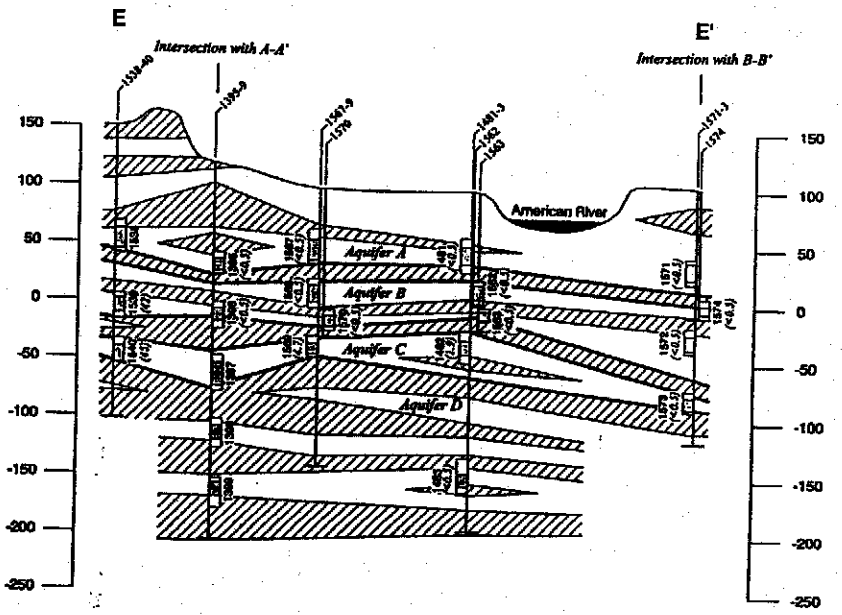
FIGURE 3-5

Hydrogeologic Cross Section D - D'

2/20/00 oh SR10109092



Cross Section Location Map



EXPLANATION

- Geologic Contact
- Aquifer Materials - cobbles, gravels, sands, silty or clayey sands, sandy silts, sandy clays. Main aquifer units outlined in bold line.
- Aquitard Materials - silts, clays, silty clays, clayey silts.
- Gravel Pack Interval
- Screened Interval
- TCE in µg/L
- Well Designation
- Total Borehole Depth

Vertical Scale 1" = 100'

Horizontal Scale 1" = 600'

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FIGURE 3-6

Hydrogeologic Cross Section E - E'

2/10/00 ah SR10109003

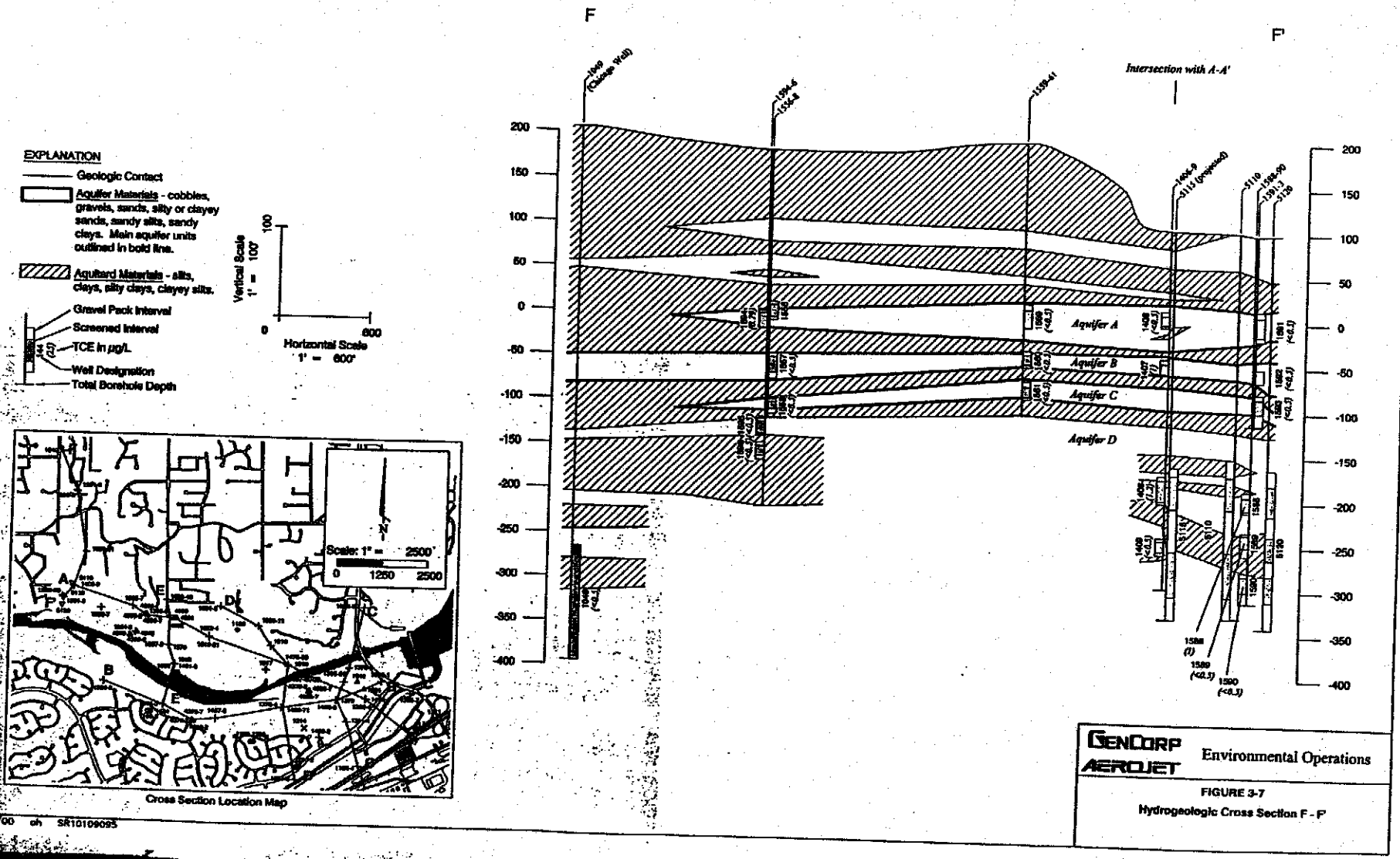
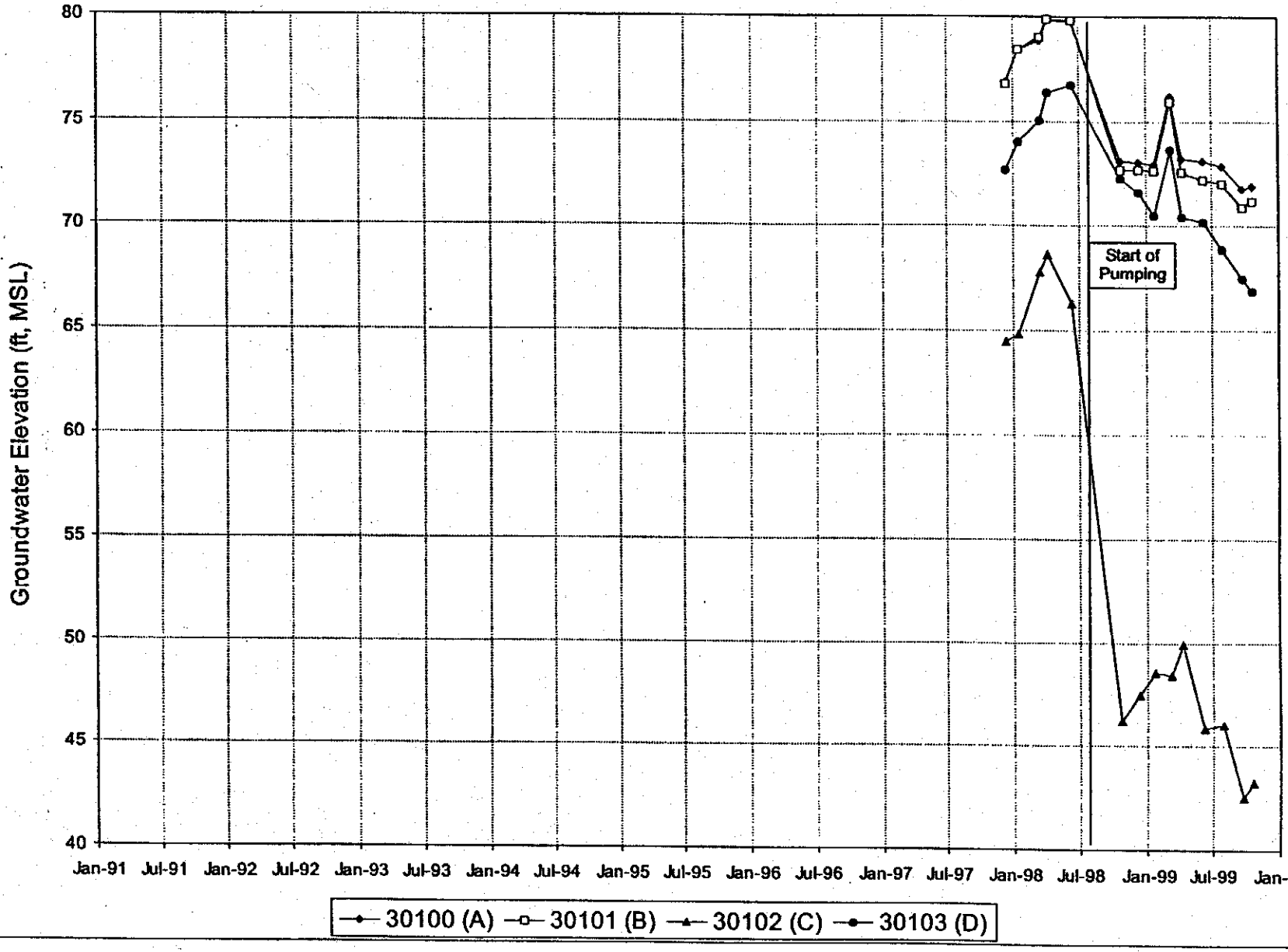

F
F'
Intersection with A-A'
EXPLANATION
Geologic Contact
Aquifer Materials - cobbles, gravels, sands, silty or clayey sands, sandy silts, sandy clays. Main aquifer units outlined in bold line.
Aquitard Materials - silts, clays, silty clays, clayey silts.
Gravel Pack Interval
Screened Interval
TCE in µg/L
Well Designation
Total Borehole Depth
Vertical Scale 1" = 100'
Horizontal Scale 1" = 600'
Aquifer A
Aquifer B
Aquifer C
Aquifer D
Scale: 1" = 2500'
Cross Section Location Map
GENCORP AEROJET
Environmental Operations
FIGURE 3-7
Hydrogeologic Cross Section F - F'
2/10/00 ch SR10109095

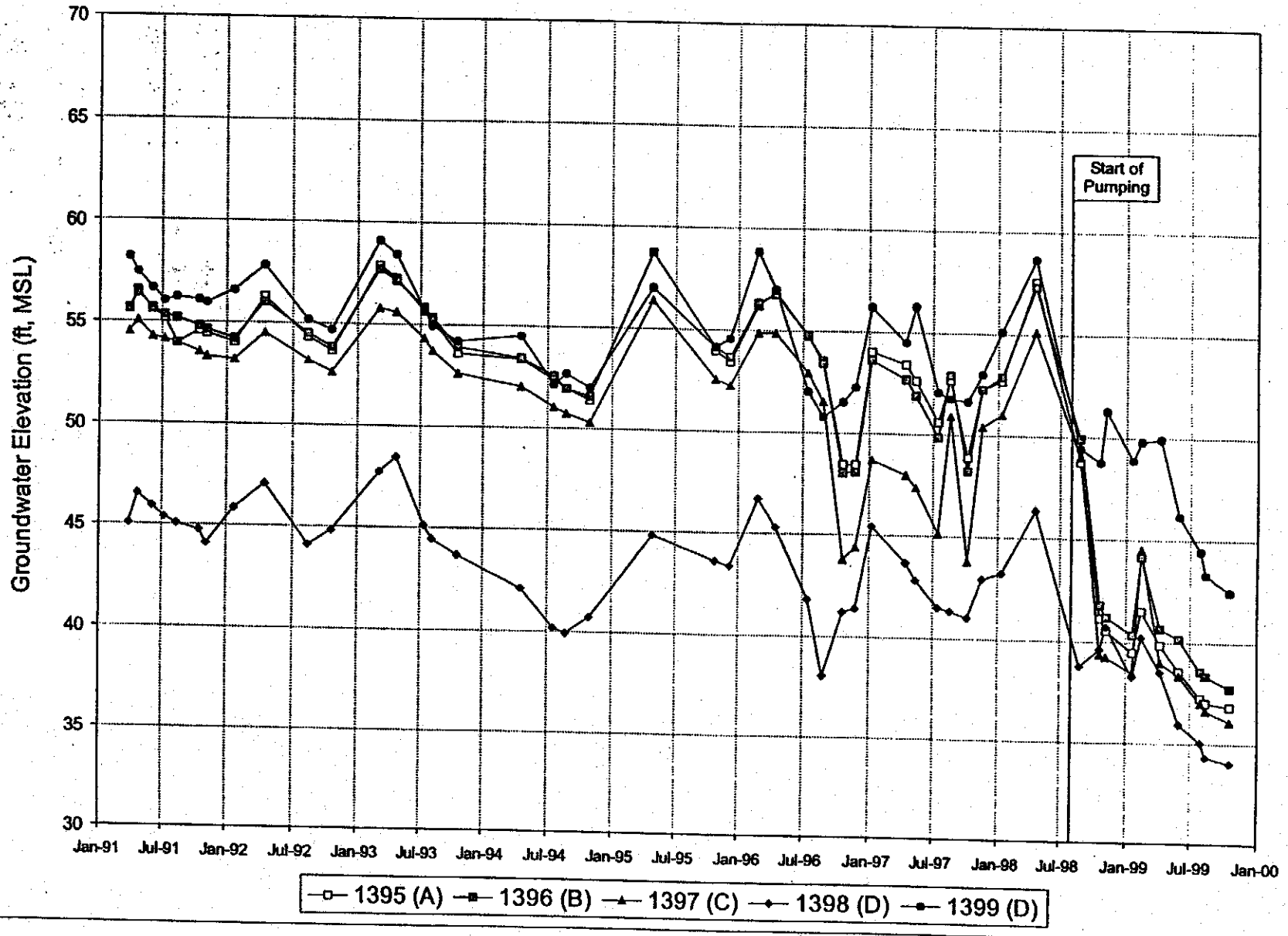
Figure 3-8
Hydrograph Wells 30100, 30101-03



SR10109322

02/09/2000

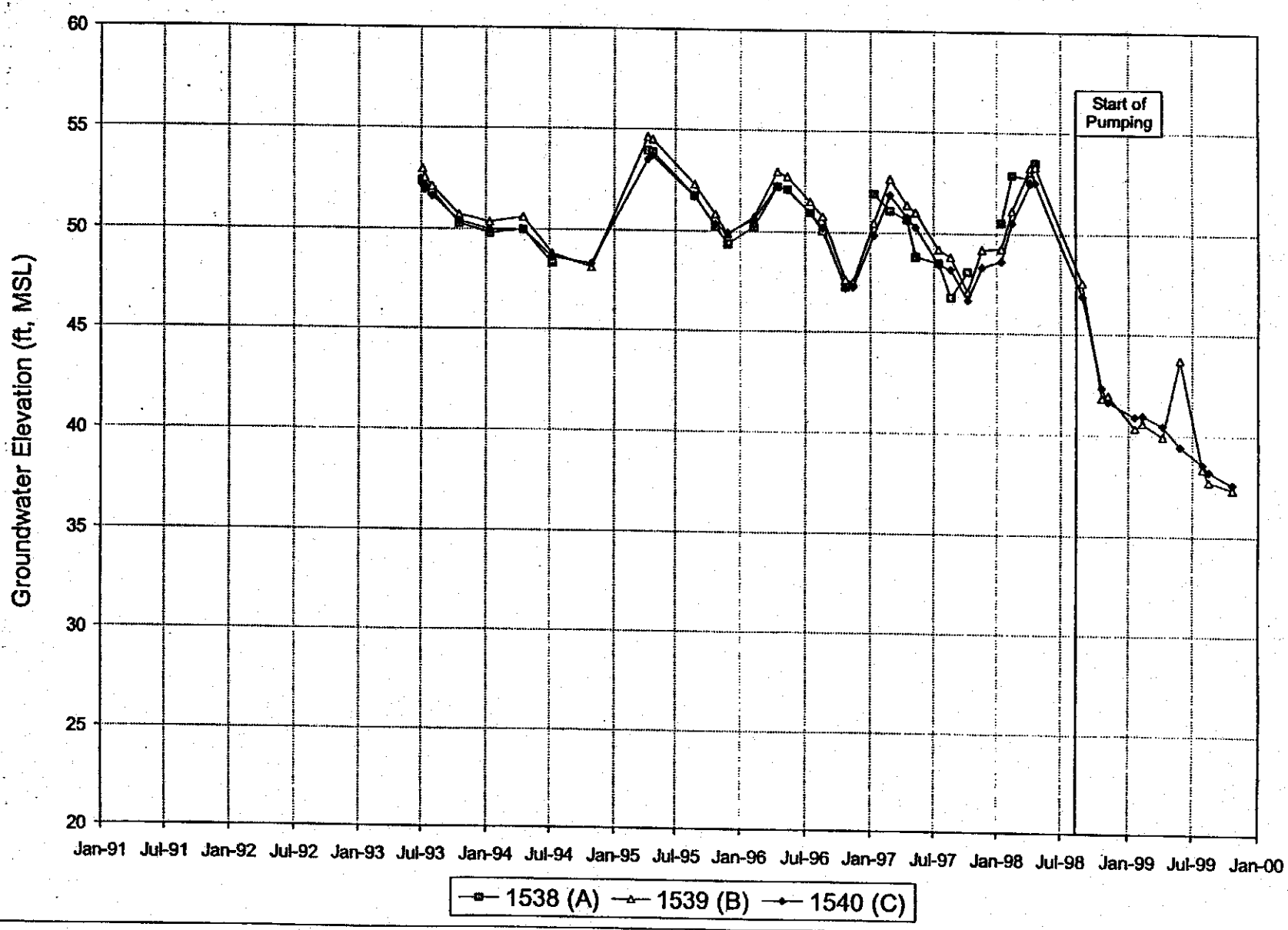
Figure 3-9
Hydrograph Wells 1395-99



SR10109322

02/09/2000

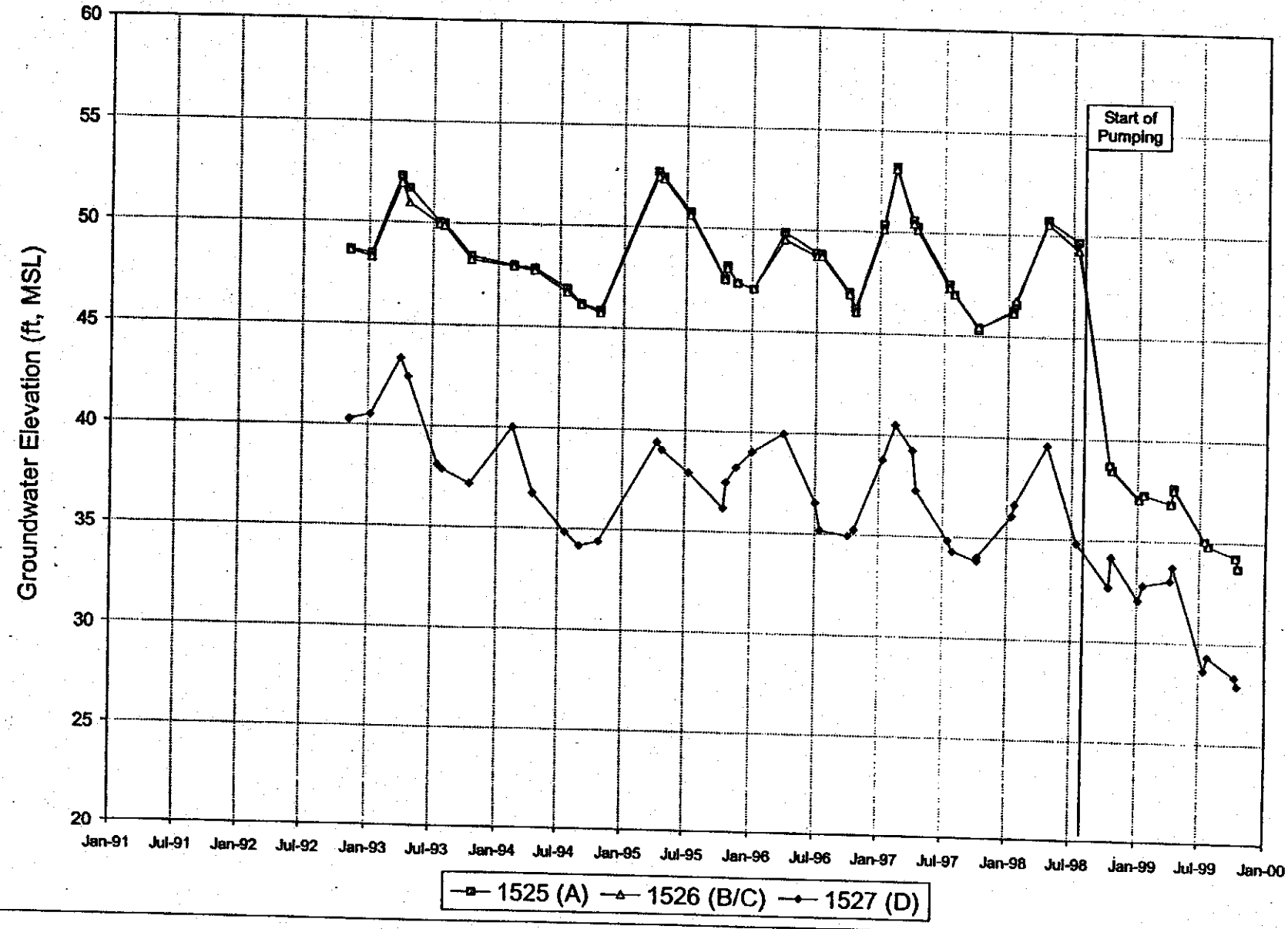
Figure 3-10
Hydrograph Wells 1538-40



SR10109322

02/09/2000

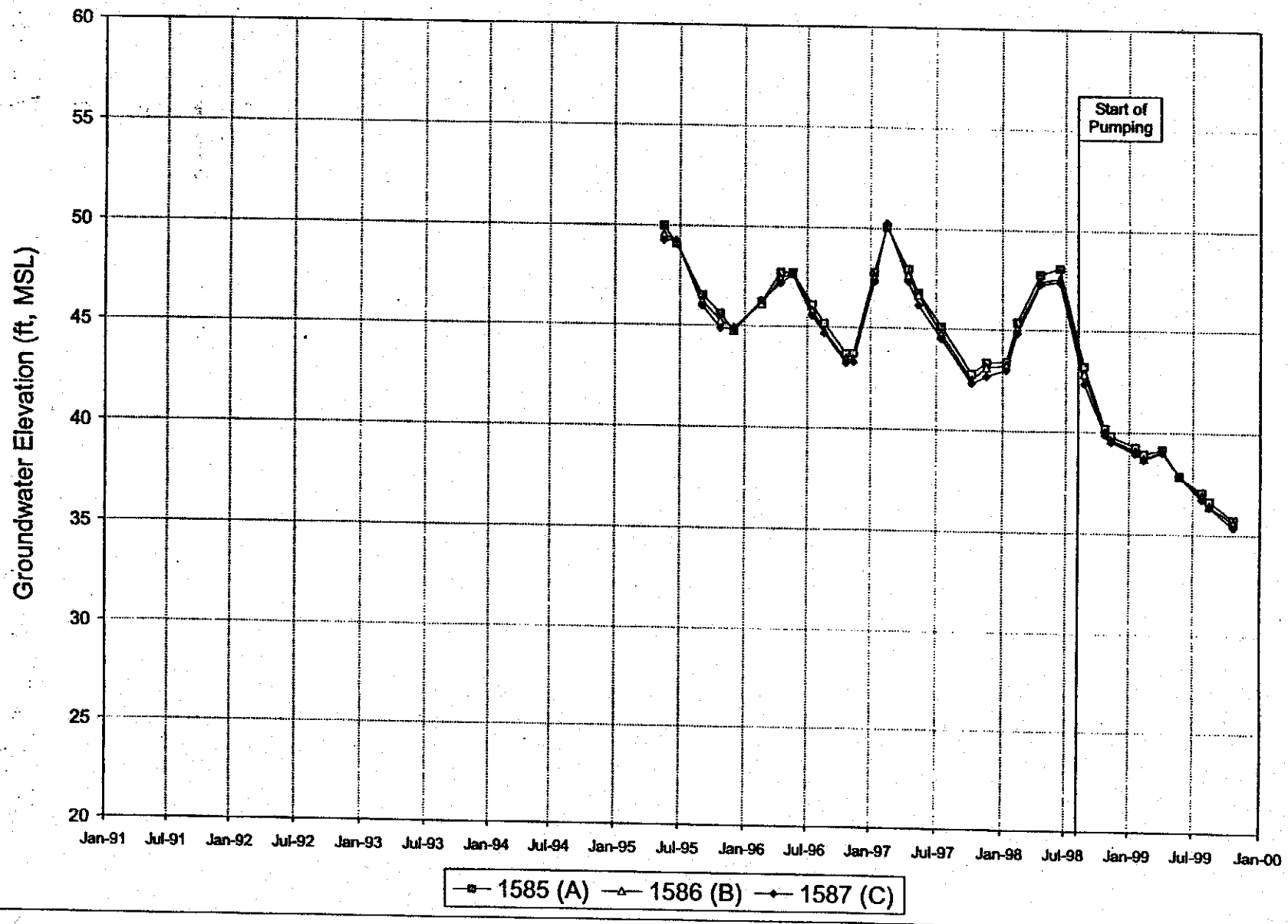
Figure 3-11
Hydrograph Wells 1525-27



SR10109322

02/09/2000

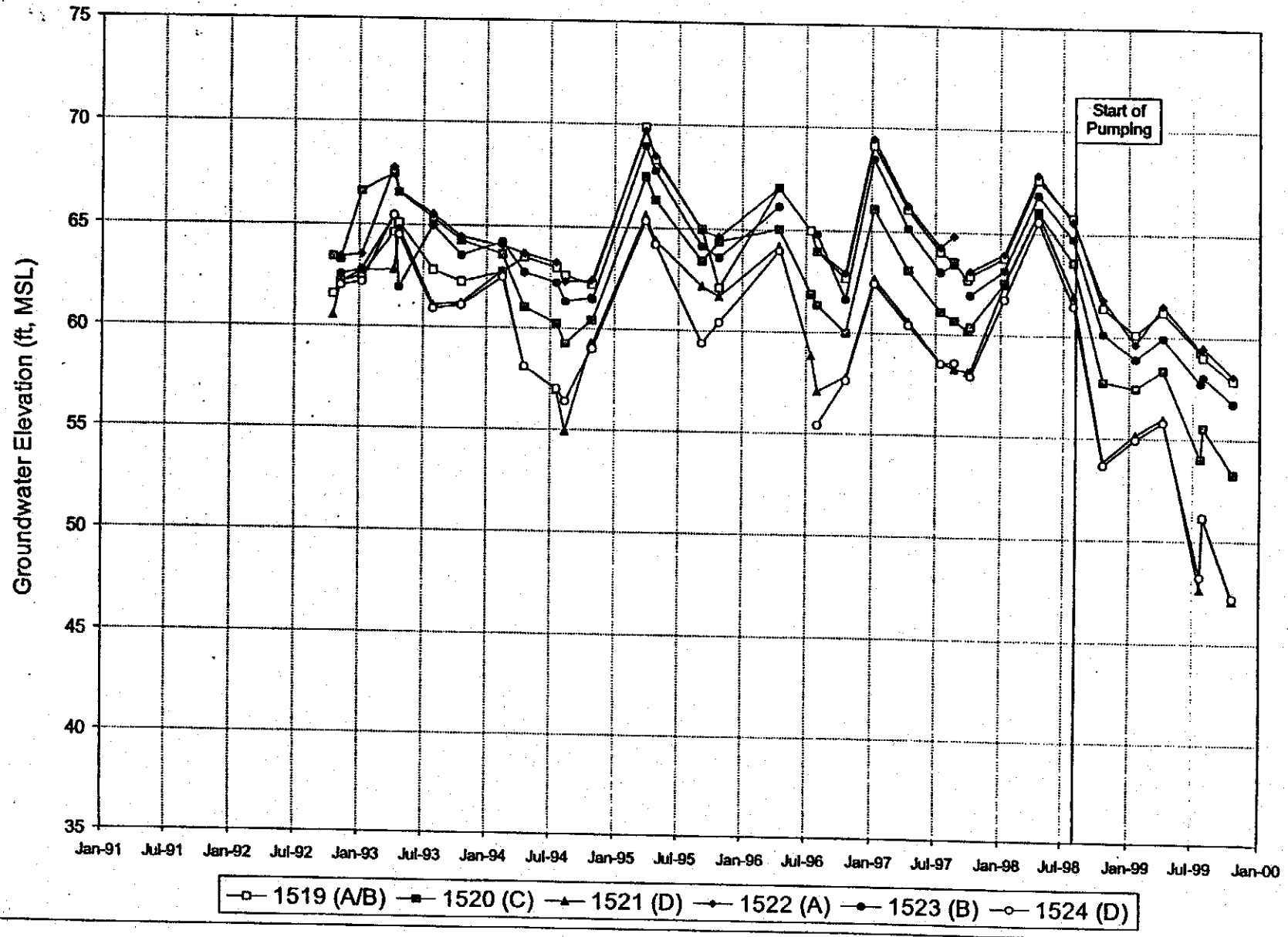
Figure 3-12
Hydrograph Wells 1585-87



SR10109322

02/09/2000

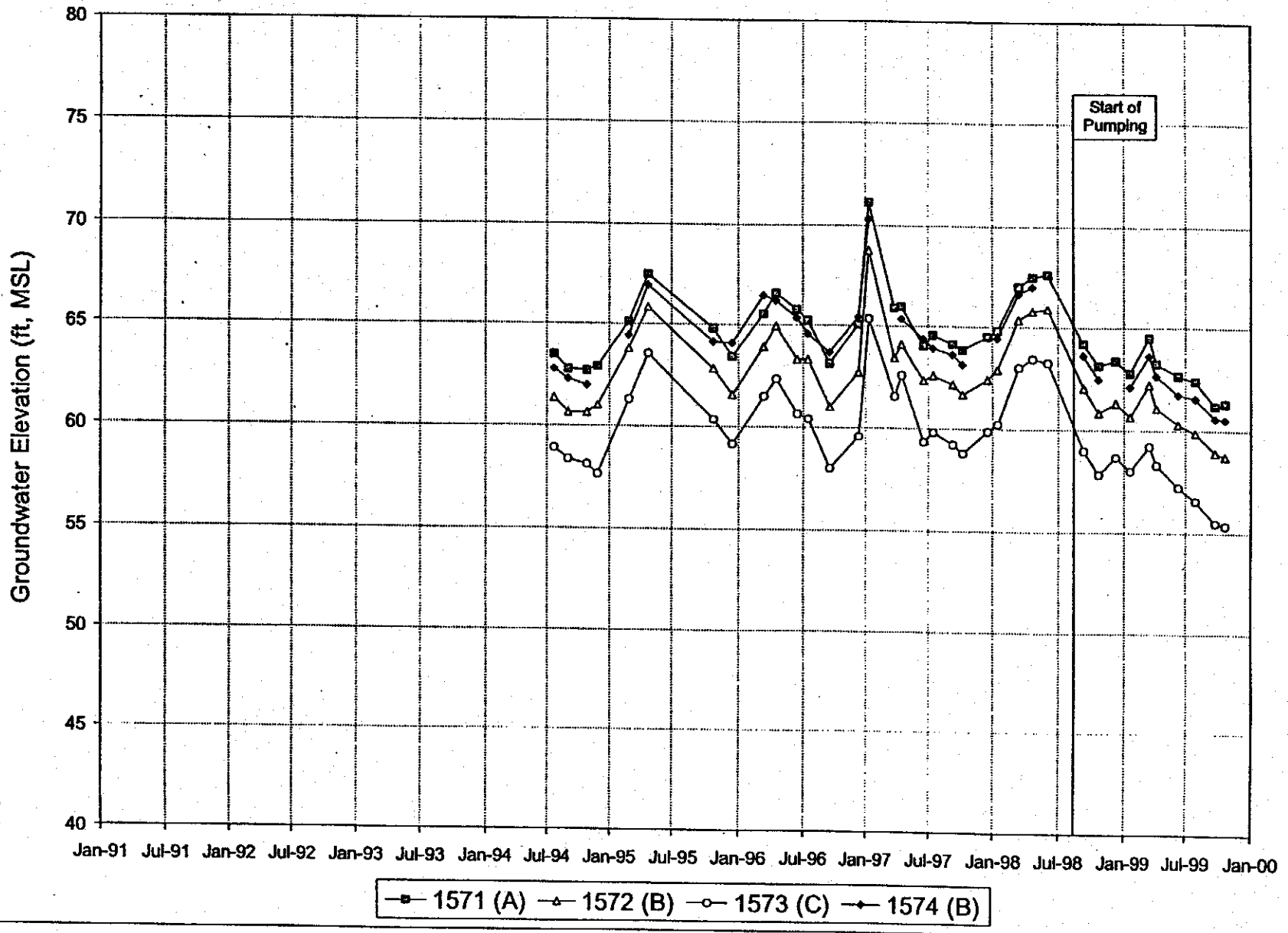
Figure 3-13
Hydrograph Wells 1519-21, 1522-24



SR10109322

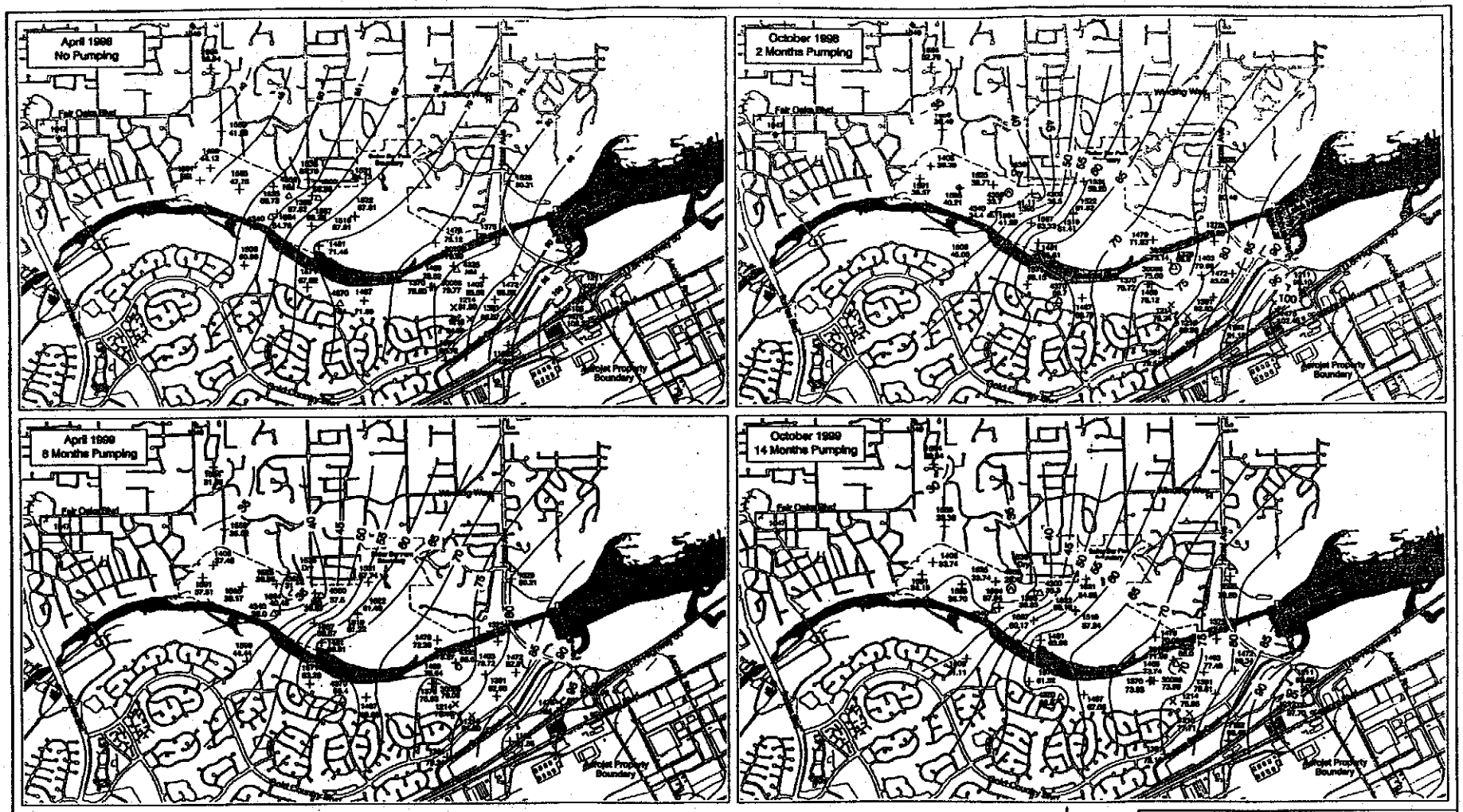
02/09/2000

Figure 3-14
Hydrograph Wells 1571-73, 1574



SR10109322

02/09/2000



EXPLANATION

KEY TO WELL SYMBOLS

1234 — Well Identification (Multiple Numbers Indicate Multiple Completions)

90.25 — Groundwater Elevation in feet MSL

Well Type and Location

WELL TYPES

- Monitor Well
- Extraction Well
- Recharge Well
- State-owned Monitor Well
- Water Supply Well

—50— Groundwater Elevation Contour (ft, MSL)

N

Scale: 1" = 2500'

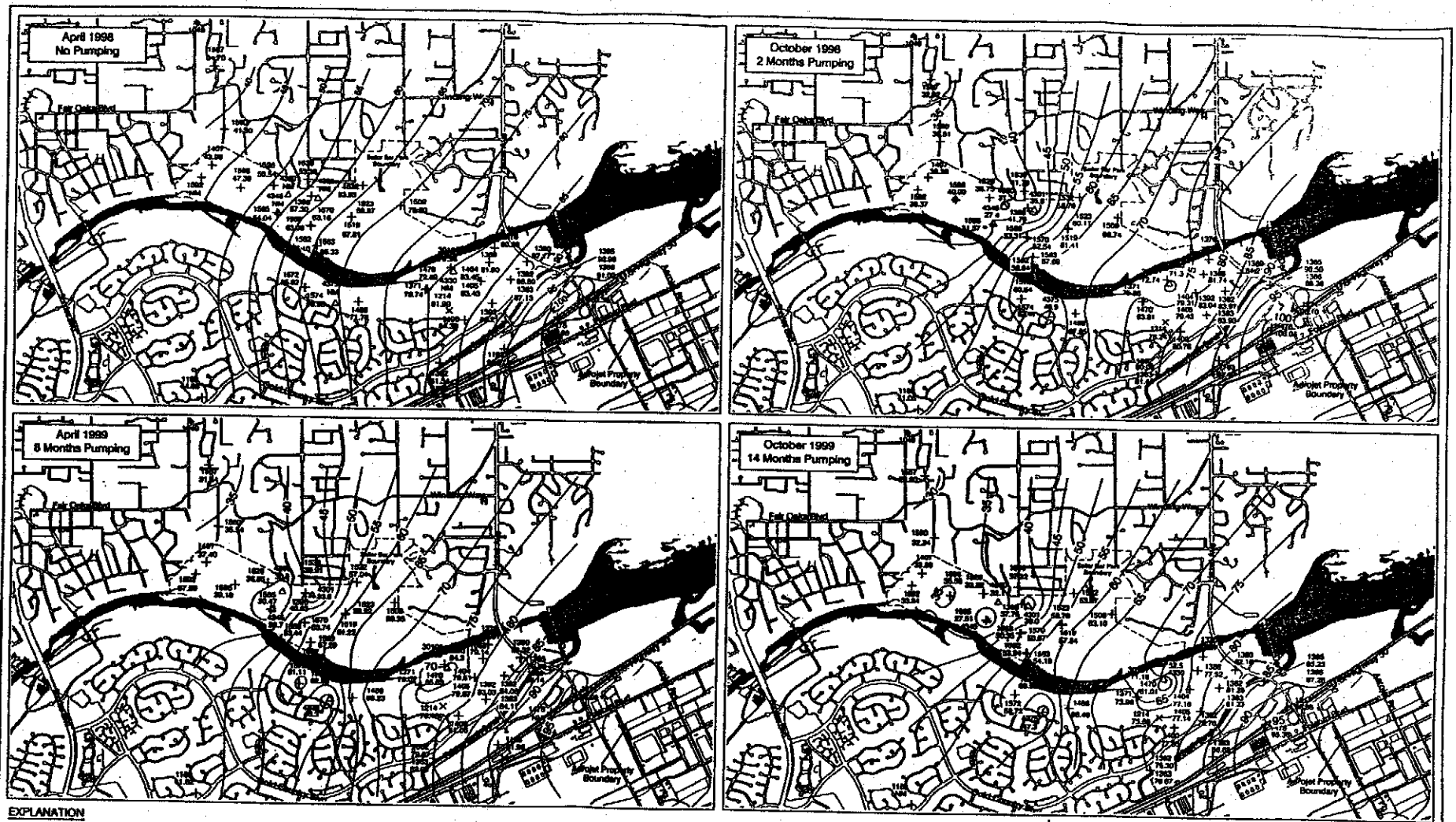
0 1250 2500

GENCORP AEROJET Environmental Operations

FIGURE 3-16

American River Study Area
Potentiometric Surface Map, Aquifer A
4/98 Through 10/99

2/8/2000 oh SR10108103



EXPLANATION

KEY TO WELL SYMBOLS

1234 — Well Identification (Multiple Numbers Indicate Multiple Completions)

90.25 — Groundwater Elevation in feet MSL

Well Type and Location

WELL TYPES

- Monitor Well
- Extraction Well
- Recharge Well
- State-owned Monitor Well
- Water Supply Well

—50— Groundwater Elevation Contour (ft, MSL)

N

Scale: 1" = 2500

0 1250 2500

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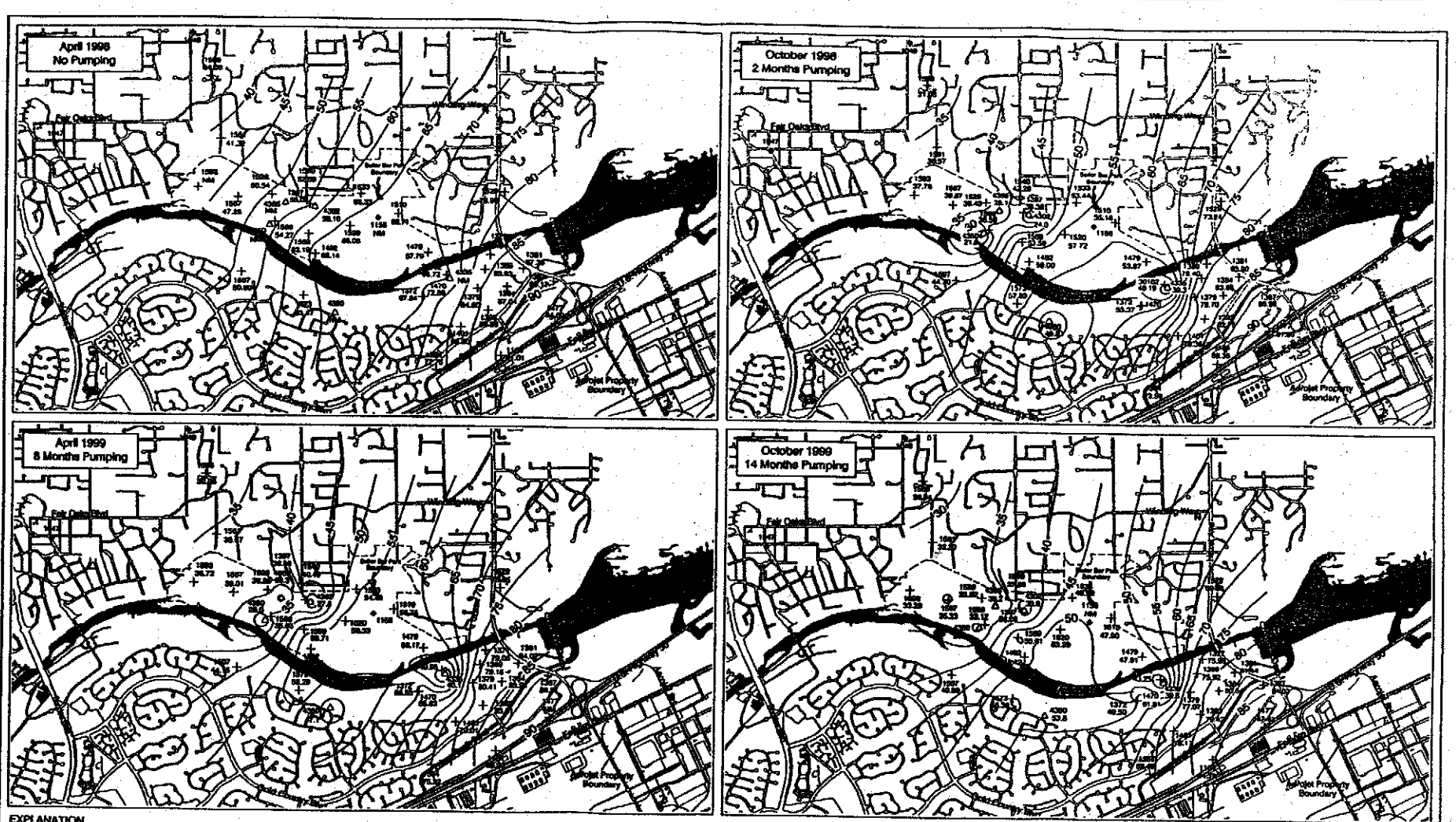
FIGURE 3-16

American River Study Area
Potentiometric Surface Map, Aquifer B
4/98 Through 10/99

2/10/2000 ah SR10109102



EXPLANATION

KEY TO WELL SYMBOLS

1234 — Well Identification (Multiple Numbers Indicate Multiple Completions)

90.25 — Groundwater Elevation in feet MSL

Well Type and Location

WELL TYPES

- + Monitor Well
- △ Extraction Well
- ▽ Recharge Well
- × State-owned Monitor Well
- ◆ Water Supply Well

—50— Groundwater Elevation Contour (ft, MSL)

N

Scale: 1" = 2500'

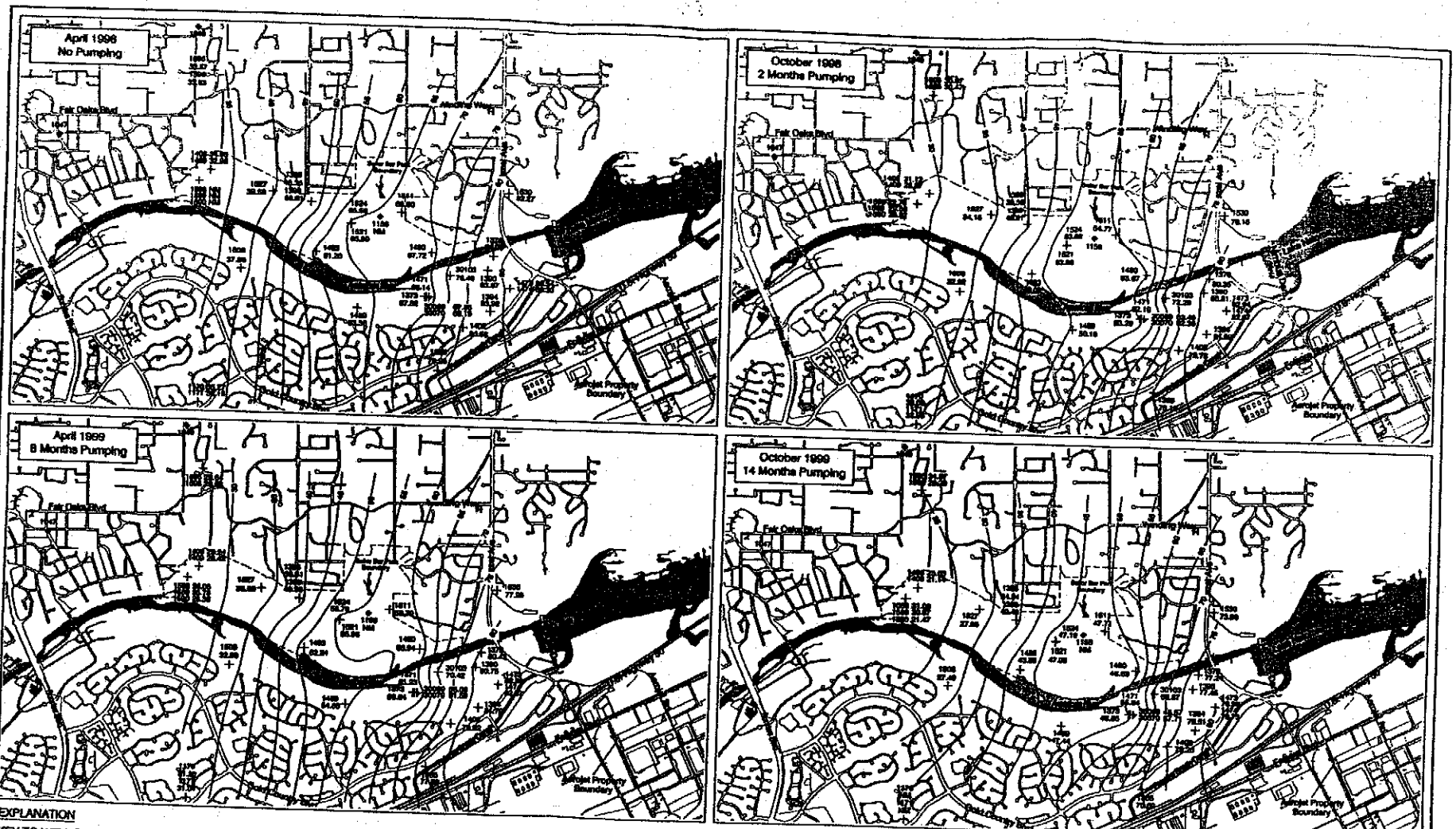
0 1250 2500

2/10/00 ah SR10109104

GENCORP AEROJET Environmental Operations

FIGURE 3-17

American River Study Area
Potentiometric Surface Map, Aquifer C
4/98 Through 10/99



EXPLANATION

KEY TO WELL SYMBOLS

1234 — Well Identification (Multiple Numbers Indicate Multiple Completions)

90.25 — Groundwater Elevation in feet MSL

Well Type and Location

WELL TYPES

- Monitor Well
- Extraction Well
- Recharge Well
- State-owned Monitor Well
- Water Supply Well

—60— Groundwater Elevation Contour (ft. MSL)

N

Scale: 1" = 2500'

0 1250 2500

2/9/2000 ah SR10106105

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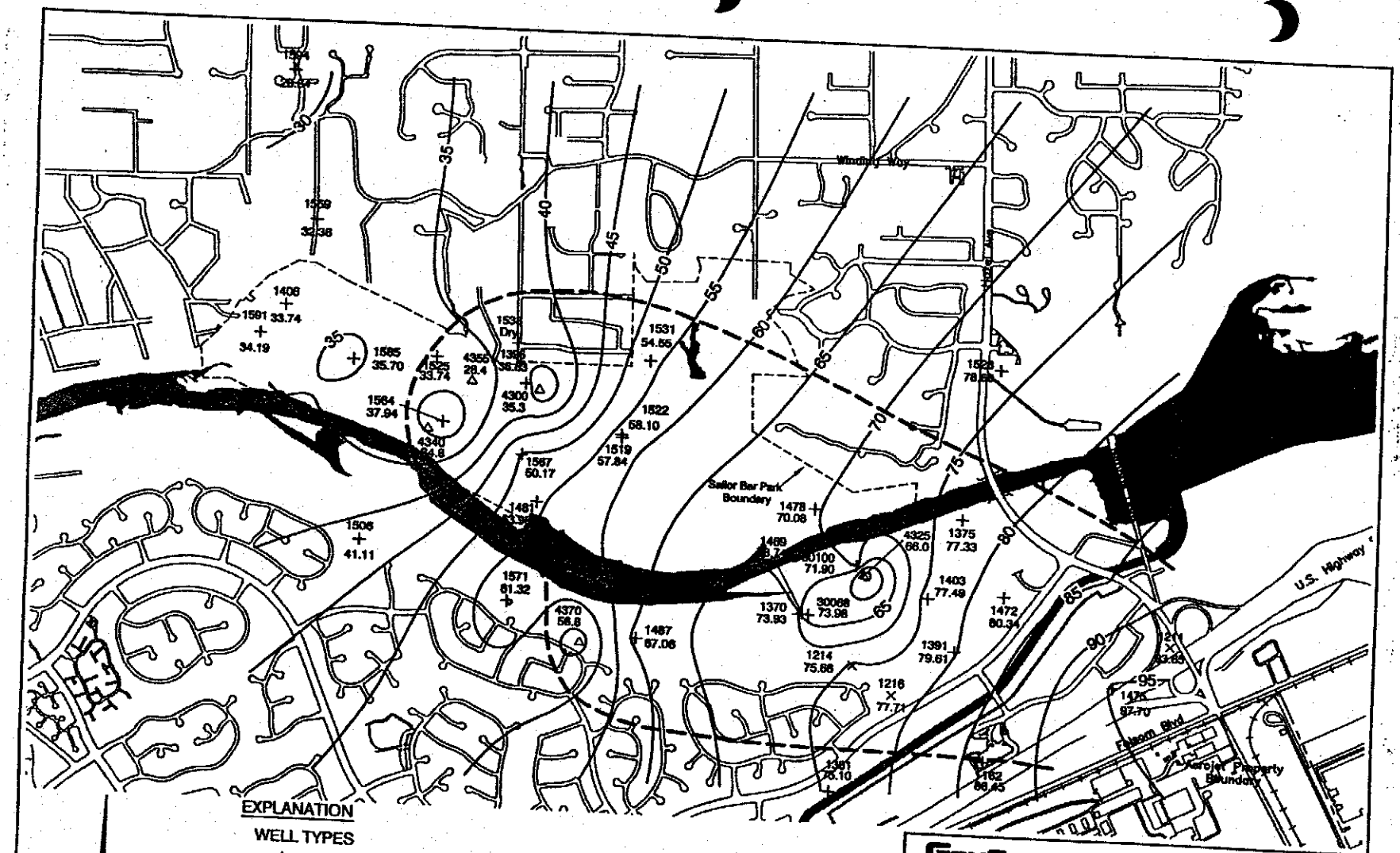
FIGURE 3-19

American River Study Area

Potentiometric Surface Map, Aquifer D

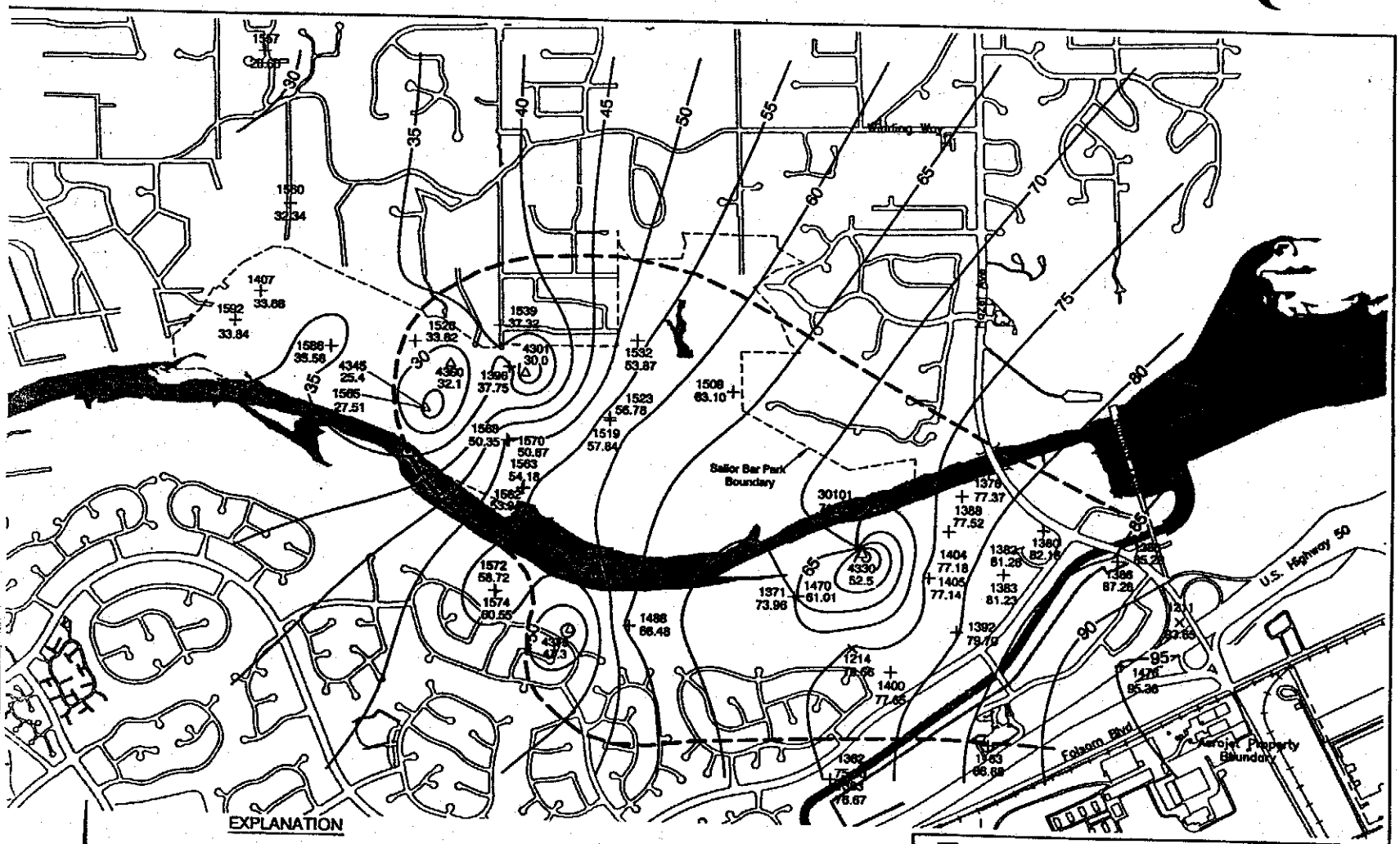
4/98 Through 10/99



GENCORP AEROJET Environmental Operations

FIGURE 3-19

American River Study Area
Potentiometric Surface Map and Capture Zone
10/99 - Aquifer A - 14 Months Pumping



GENCORP AEROJET Environmental Operations

FIGURE 3-20

American River Study Area
Potentiometric Surface Map and Capture Zone
10/99 - Aquifer B - 14 Months Pumping

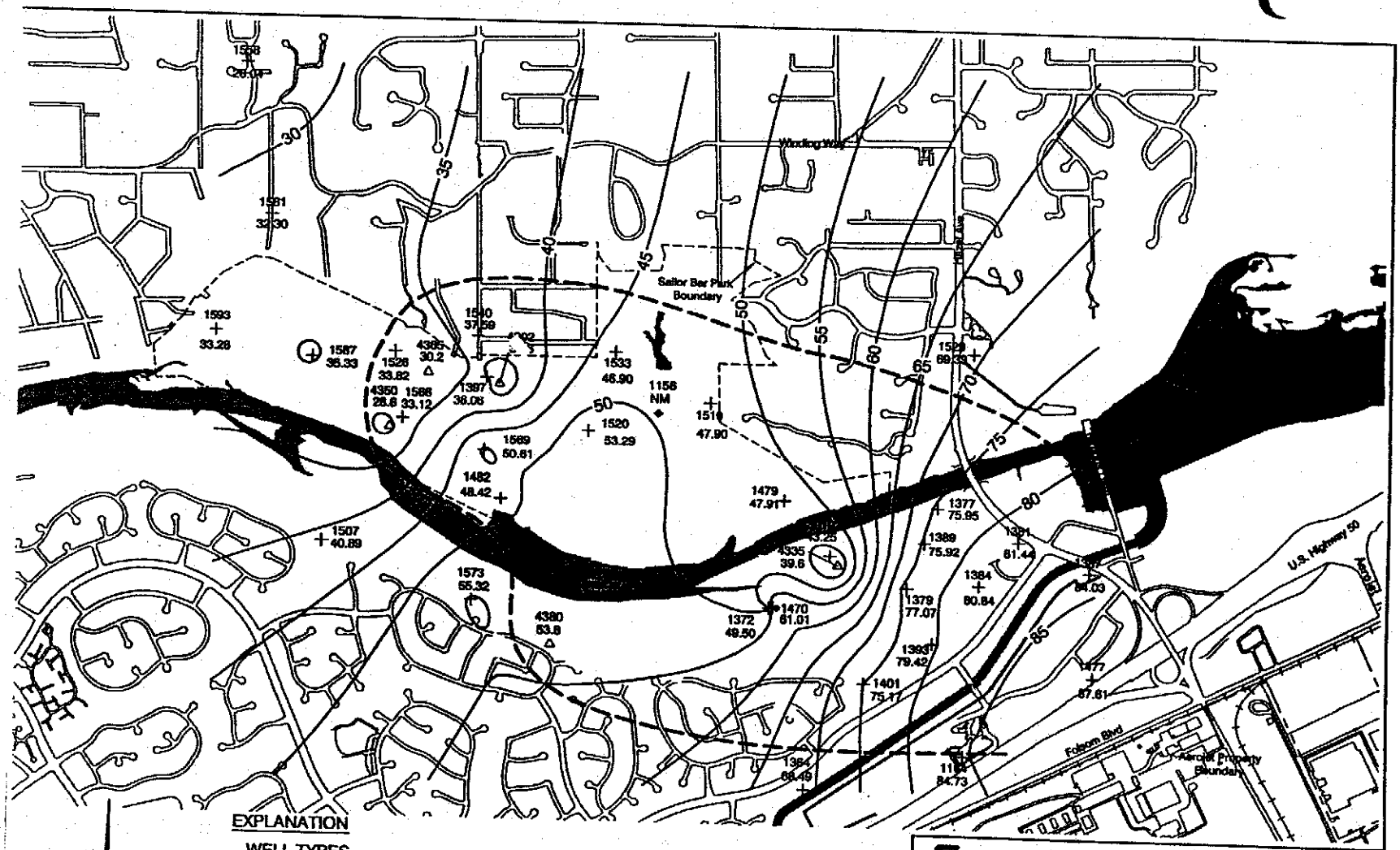


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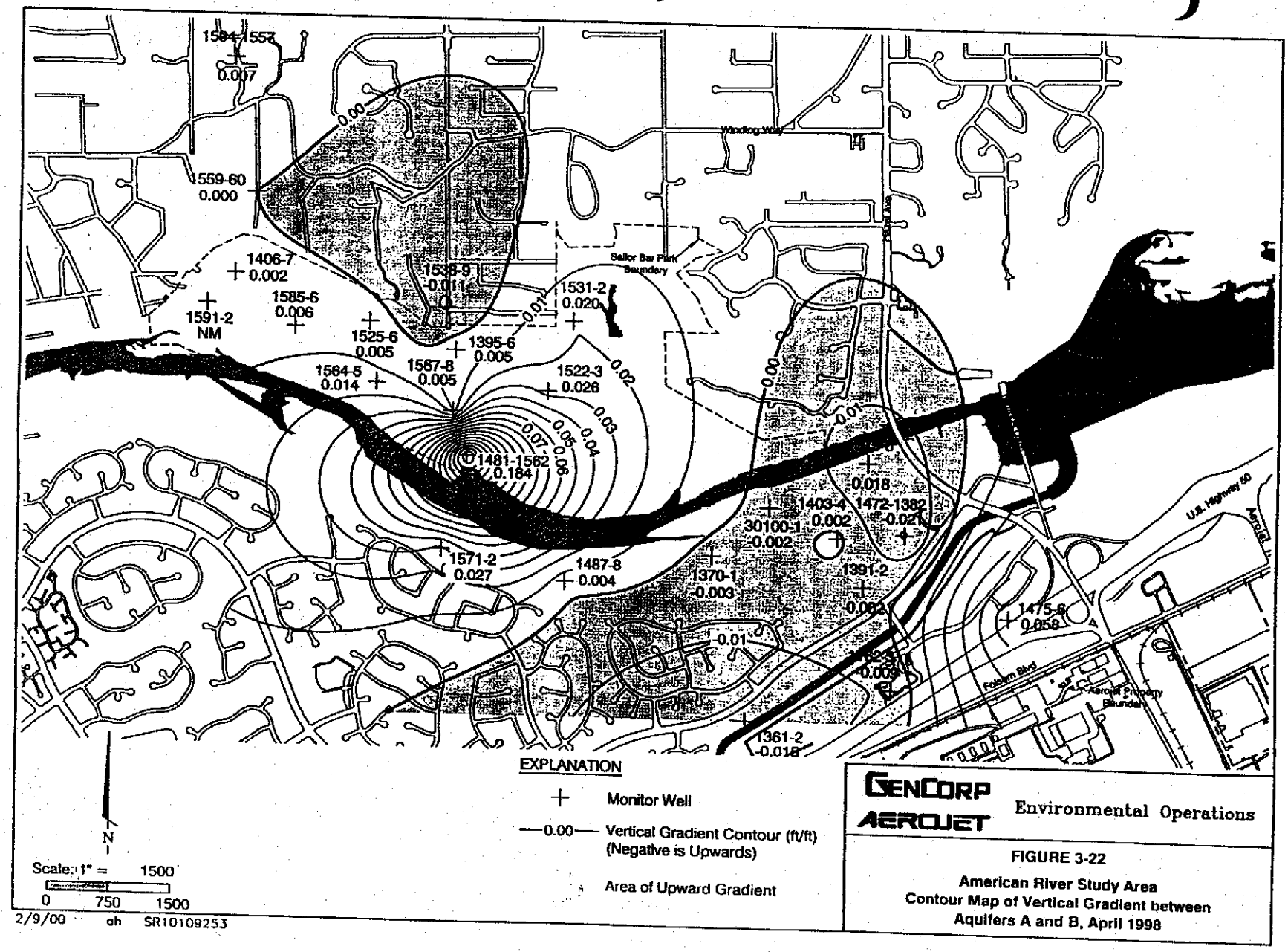
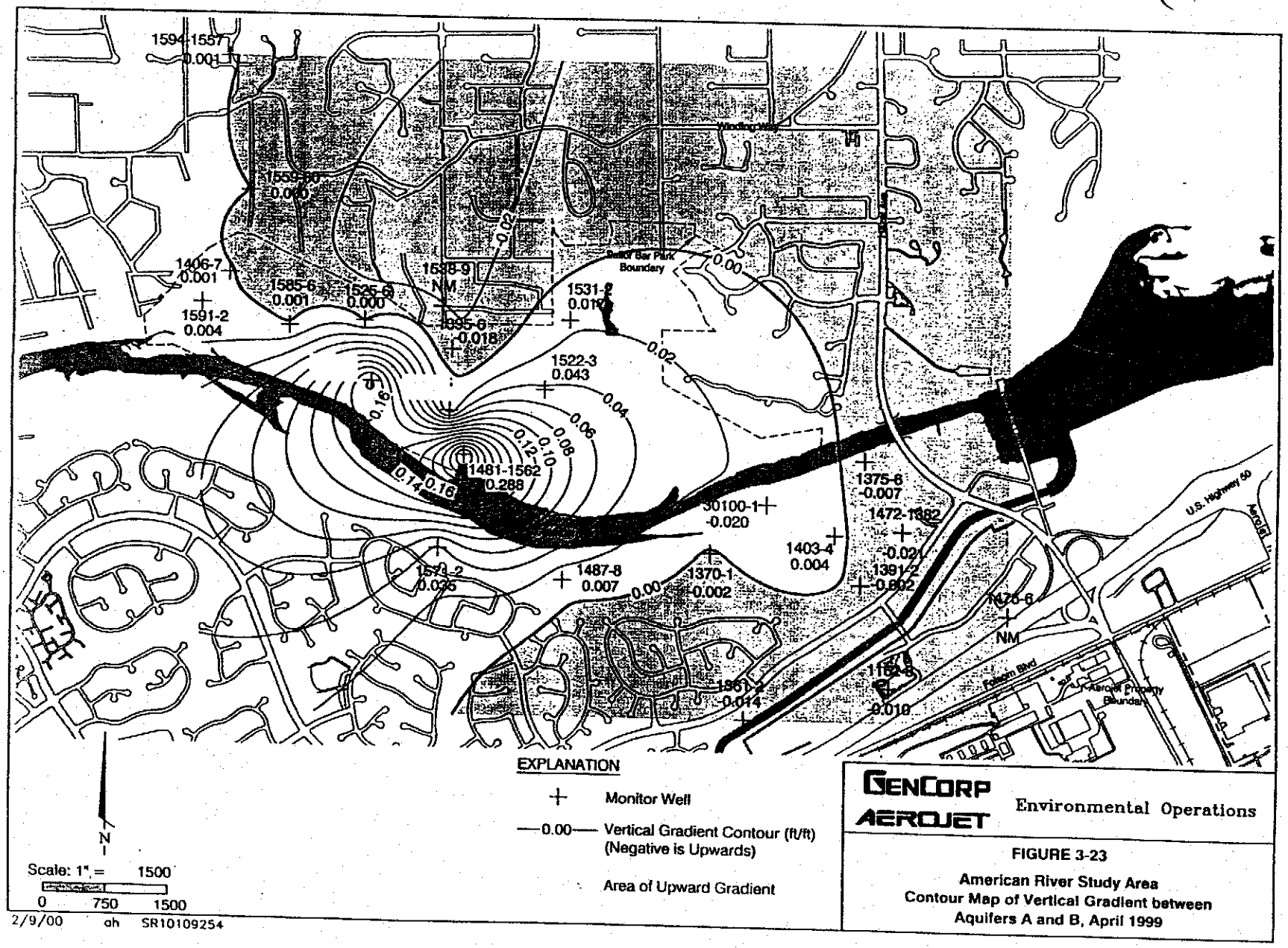
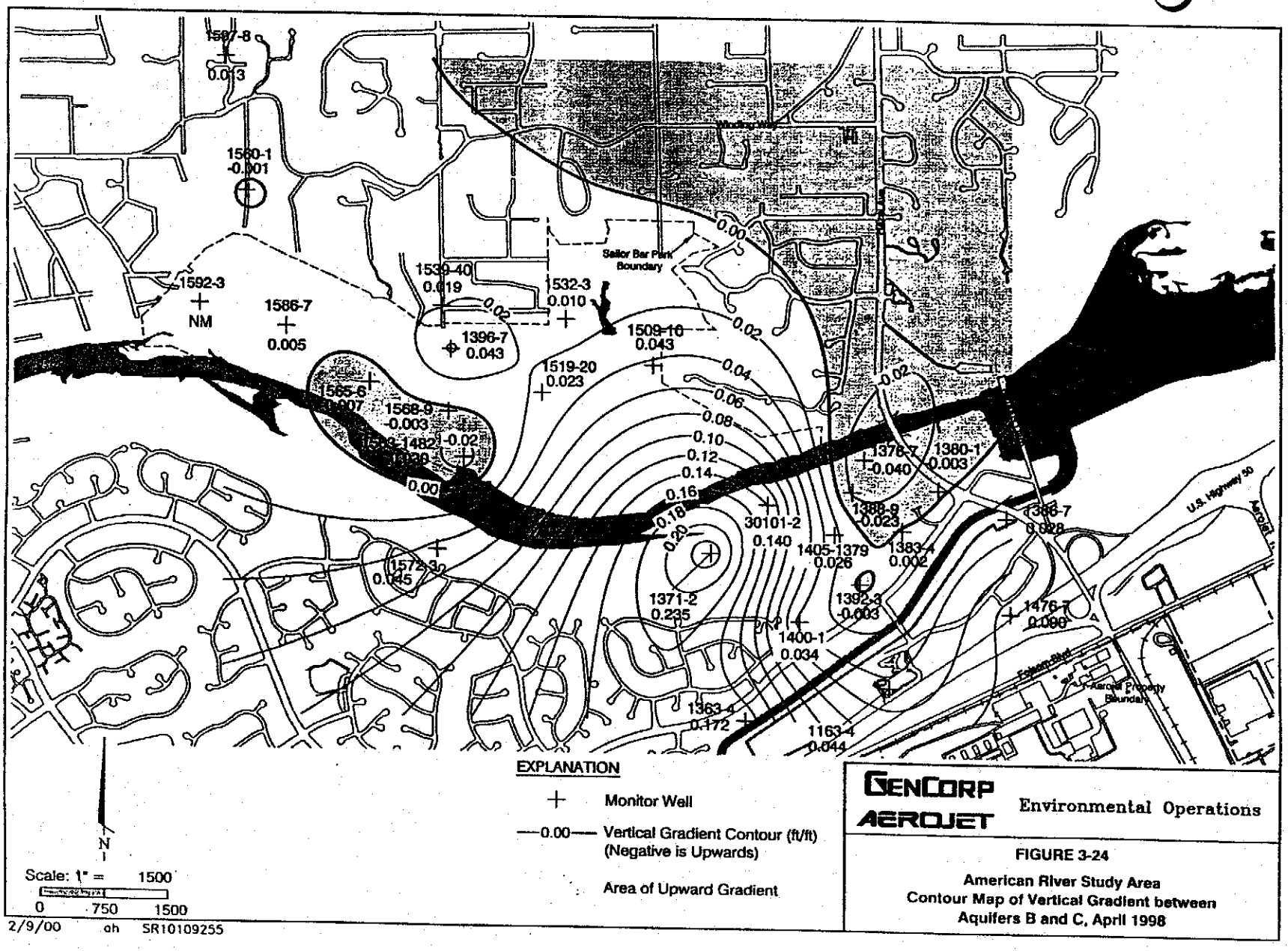
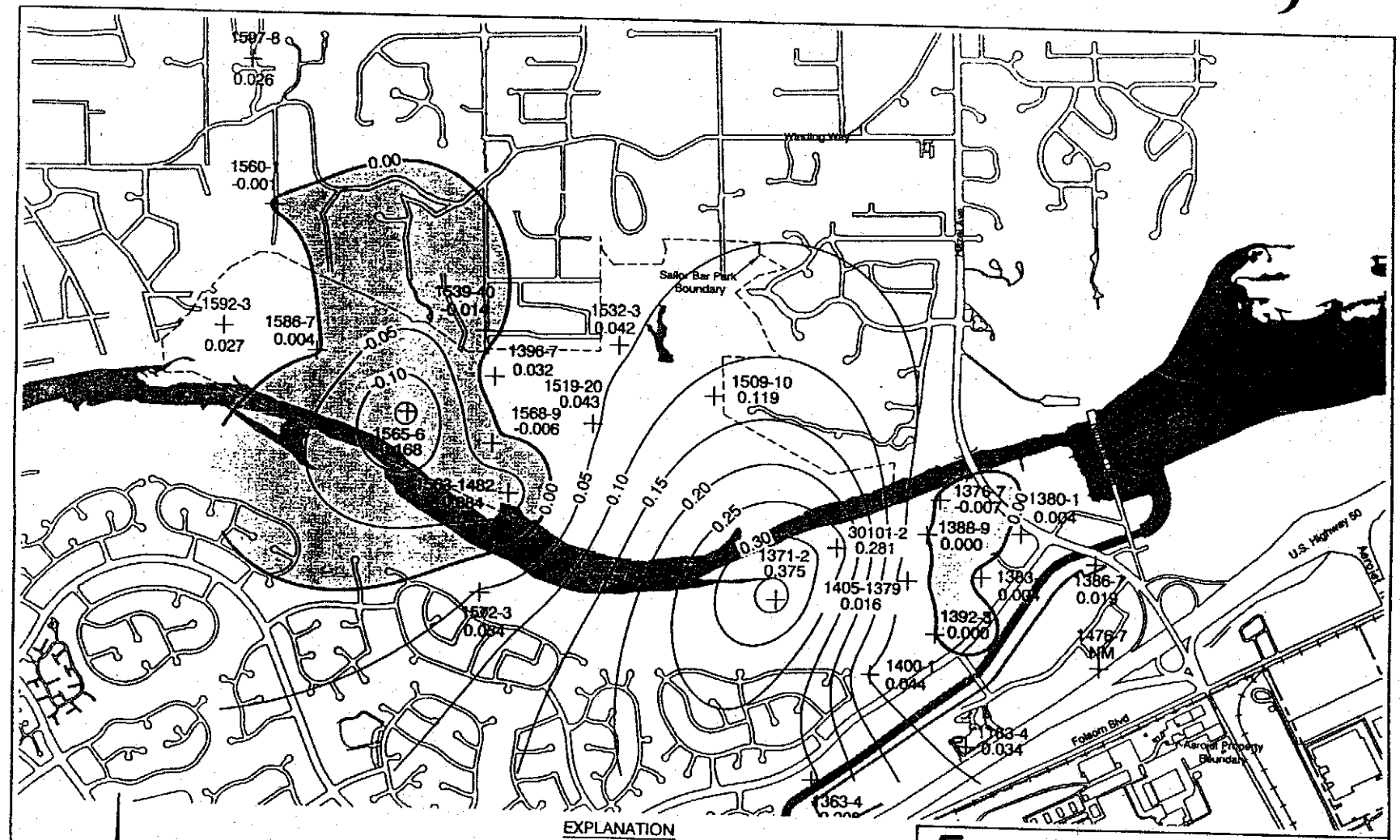
FIGURE 3-21

American River Study Area
Potentiometric Surface Map and Capture Zone - 10/99
Aquifer C - 14 Months Pumping


1594-1557
0.007
1559-60
0.000
1406-7
0.002
1591-2
NM
1585-6
0.006
1525-6
0.005
1538-9
-0.011
1531-2
0.020
1395-6
0.005
1567-8
0.005
1564-5
0.014
1522-3
0.026
1481-1562
0.184
1571-2
0.027
1487-8
0.004
1370-1
0.003
1403-4
0.002
30100-1
-0.002
1472-1382
-0.02
-0.018
1391-2
0.002
1475-6
0.058
-0.01
1361-2
-0.018
Sailor Bar Park Boundary
Folsom Blvd
Aerojet Property Boundary
U.S. Highway 50
Aerojet
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
N
Scale: 1" = 1500'
0 750 1500
2/9/00 ah SR10109253
EXPLANATION
Monitor Well
0.00 Vertical Gradient Contour (ft/ft) (Negative is Upwards)
Area of Upward Gradient
GENCORP AEROJET
Environmental Operations
FIGURE 3-22
American River Study Area
Contour Map of Vertical Gradient between Aquifers A and B, April 1998


1594-1557
0.001
1559-10
0.000
1406-7
0.001
1585-6
0.001
1525-6
0.000
1538-9
NM
1591-2
0.004
1595-6
0.018
1531-2
0.019
Bluff Bar Park
Boundary
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
1522-3
0.043
1481-1562
0.288
1375-6
-0.007
30100-1
-0.020
1472-1382
-0.021
1403-4
0.004
1391-2
-0.002
1487-8
0.007
1571-2
0.025
1370-1
-0.002
1476-6
NM
1162-6
0.010
1561-2
-0.014
Folsom Blvd
Aerojet Property
Boundary
U.S. Highway 50
Aerojet
N
Scale: 1" = 1500
0 750 1500
2/9/00 ah SR10109254
EXPLANATION
Monitor Well
0.00 Vertical Gradient Contour (ft/ft)
(Negative is Upwards)
Area of Upward Gradient
GENCORP AEROJET
Environmental Operations
FIGURE 3-23
American River Study Area
Contour Map of Vertical Gradient between
Aquifers A and B, April 1999

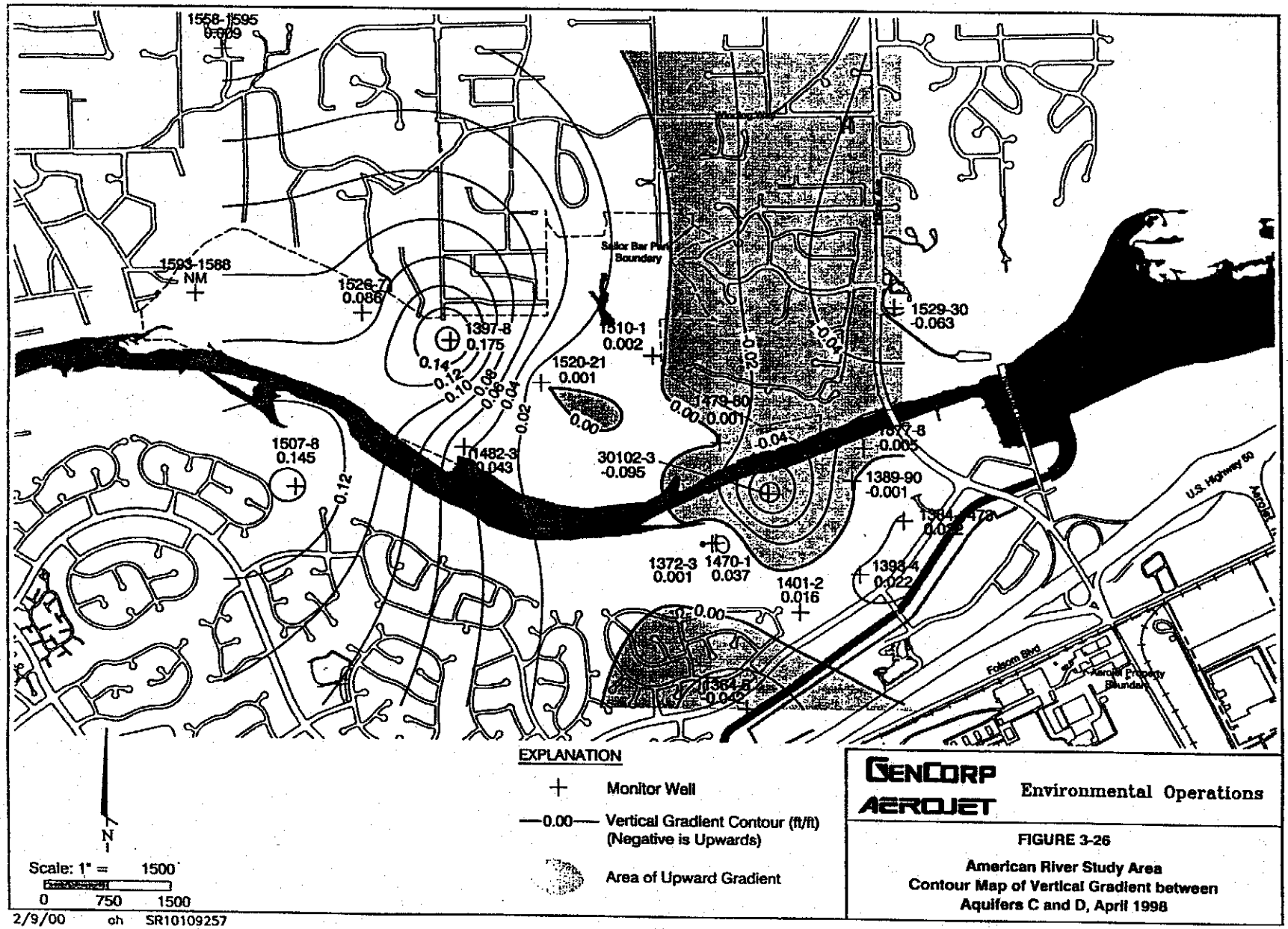

1567-8
0.013
1560-1
-0.001
1592-3
NM
1586-7
0.005
1539-40
0.019
1532-3
0.010
1396-7
0.043
Sailor Bar Park
Boundary
1509-16
0.043
1519-20
0.023
1565-6
1568-9
-0.003
1572-3
0.045
1371-2
0.235
30101-2
0.140
1405-1379
0.026
1400-1
0.034
1363-4
0.172
1163-4
0.044
1378-2
-0.040
1380-1
0.003
1388-9
-0.023
1383-4
0.002
1392-3
-0.003
1366-7
0.028
1476-7
0.090
U.S. Highway 50
Aerojet Property
Boundary
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
N
Scale: 1" = 1500'
0 750 1500
2/9/00 ah SR10109255
EXPLANATION
Monitor Well
0.00 Vertical Gradient Contour (ft/ft) (Negative is Upwards)
Area of Upward Gradient
GENCORP AEROJET
Environmental Operations
FIGURE 3-24
American River Study Area
Contour Map of Vertical Gradient between
Aquifers B and C, April 1998



GENCORP AEROJET Environmental Operations

FIGURE 3-25

American River Study Area
Contour Map of Vertical Gradient between
Aquifers B and C, April 1999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1593-1588
NM
1526-7
0.086
1397-8
0.175
1510-1
0.002
1520-21
0.001
1529-30
-0.063
1479-60
0.001
1507-8
0.145
1482-3
0.043
30102-3
-0.095
1677-8
-0.005
1389-90
-0.001
1372-3
0.001
1470-1
0.037
1401-2
0.016
1393-4
0.022
1364-5
0.042
Folsom Blvd
U.S. Highway 50
Aerojet Property Boundary
Sailor Bar Park Boundary
EXPLANATION
Monitor Well
0.00 Vertical Gradient Contour (ft/ft) (Negative is Upwards)
Area of Upward Gradient
N
Scale: 1" = 1500'
0 750 1500
2/9/00 oh SR10109257
GENCORP AEROJET
Environmental Operations
FIGURE 3-26
American River Study Area
Contour Map of Vertical Gradient between Aquifers C and D, April 1998

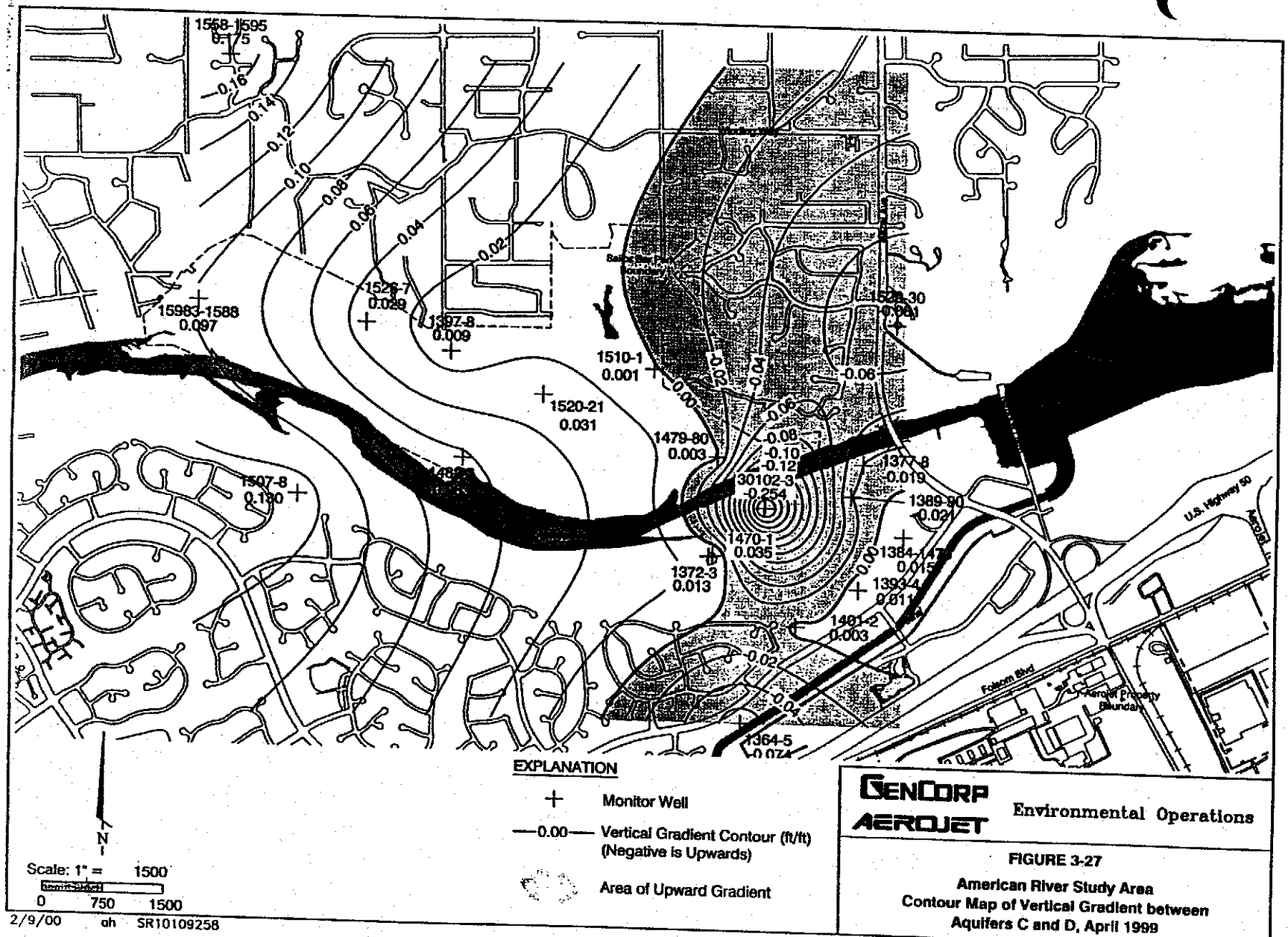
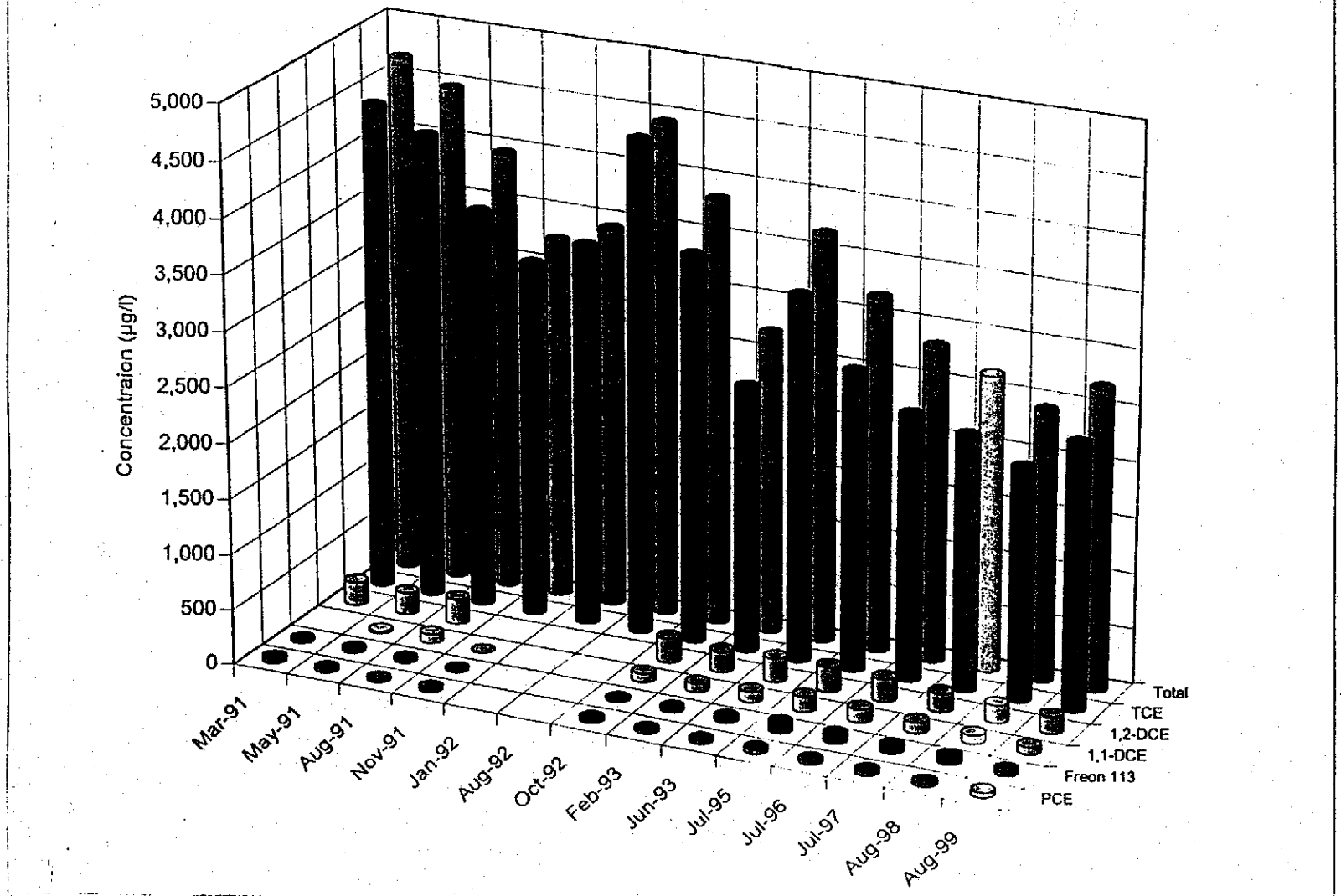
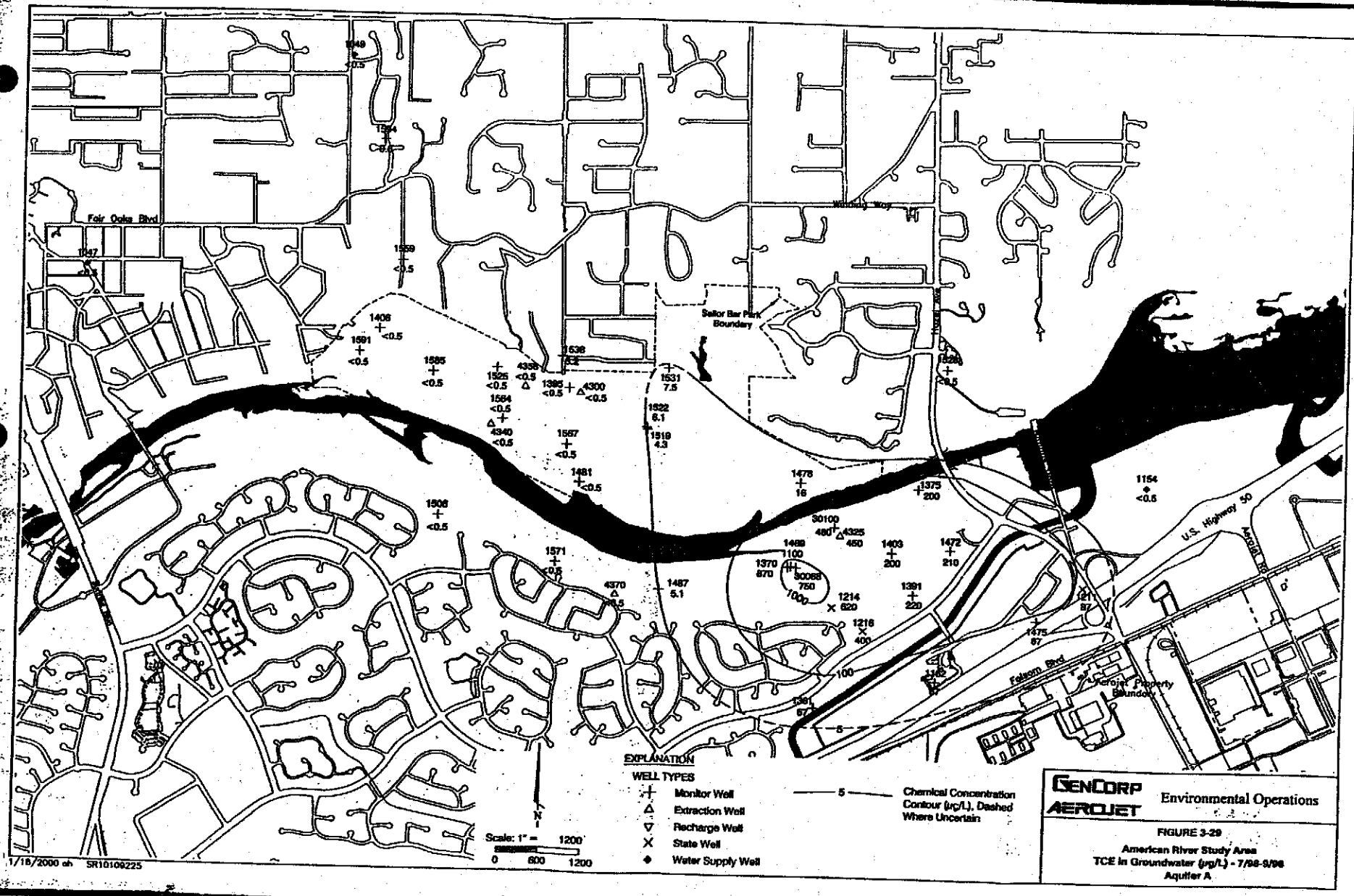

1568-1595
0.175
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
1526-7
0.029
15983-1588
0.097
1397-8
0.009
1510-1
0.001
1520-21
0.031
1479-80
0.003
1507-8
0.130
30102-3
-0.254
1372-3
0.013
1470-1
0.035
1377-8
0.019
1389-90
0.021
1384-1475
0.015
1393-4
0.011
1481-2
0.003
1364-5
0.074
1528-30
0.004
-0.06
-0.08
-0.10
-0.12
U.S. Highway 50
Folsom Blvd
Aerojet Property Boundary
EXPLANATION
Monitor Well
-0.00- Vertical Gradient Contour (ft/ft) (Negative is Upwards)
Area of Upward Gradient
N
Scale: 1" = 1500
0 750 1500
2/9/00 ah SR10109258
GENCORP AEROJET
Environmental Operations
FIGURE 3-27
American River Study Area
Contour Map of Vertical Gradient between Aquifers C and D, April 1999

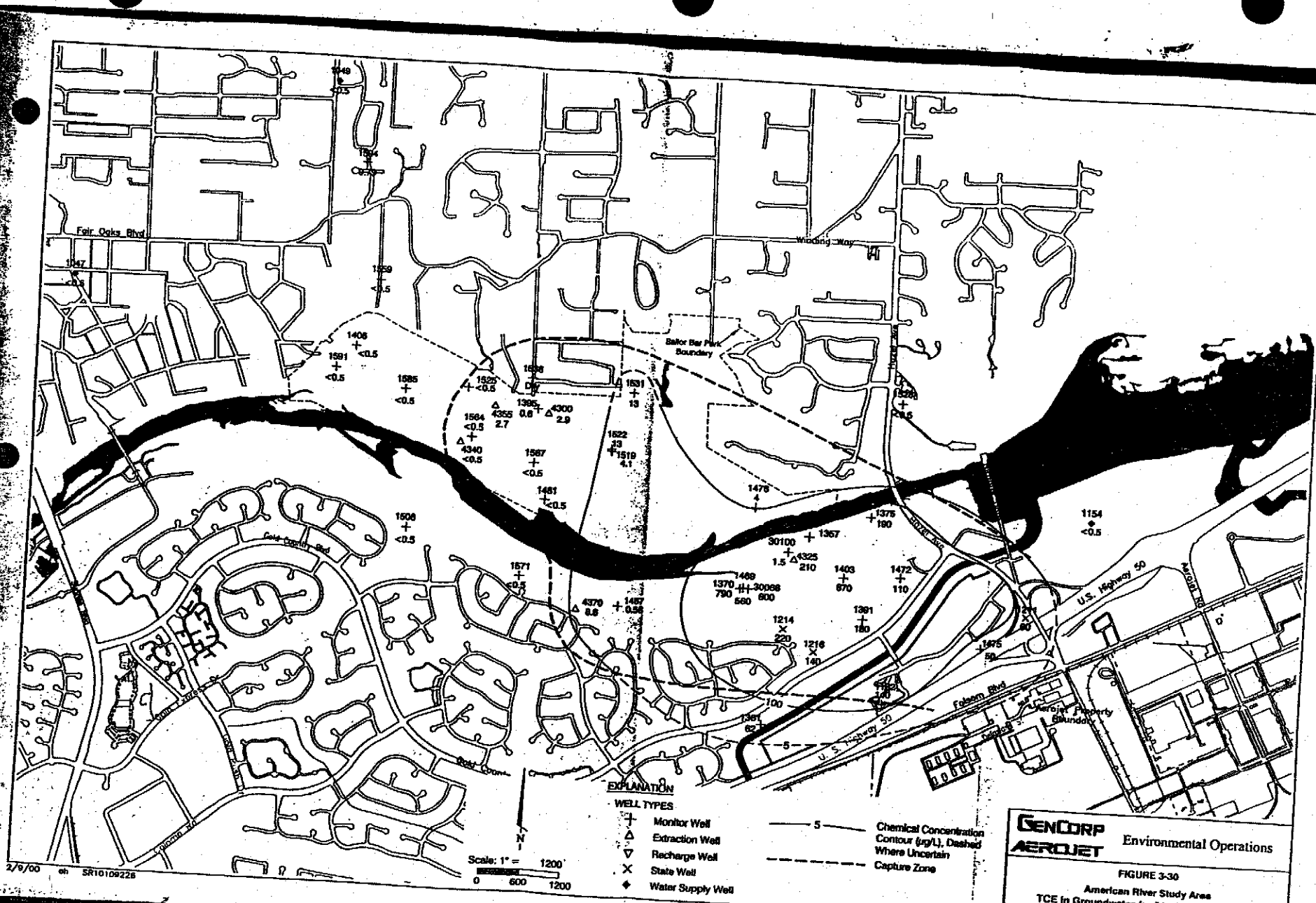
Figure 3-28
Well 1405 - VOC Trend in Groundwater (µg/l)

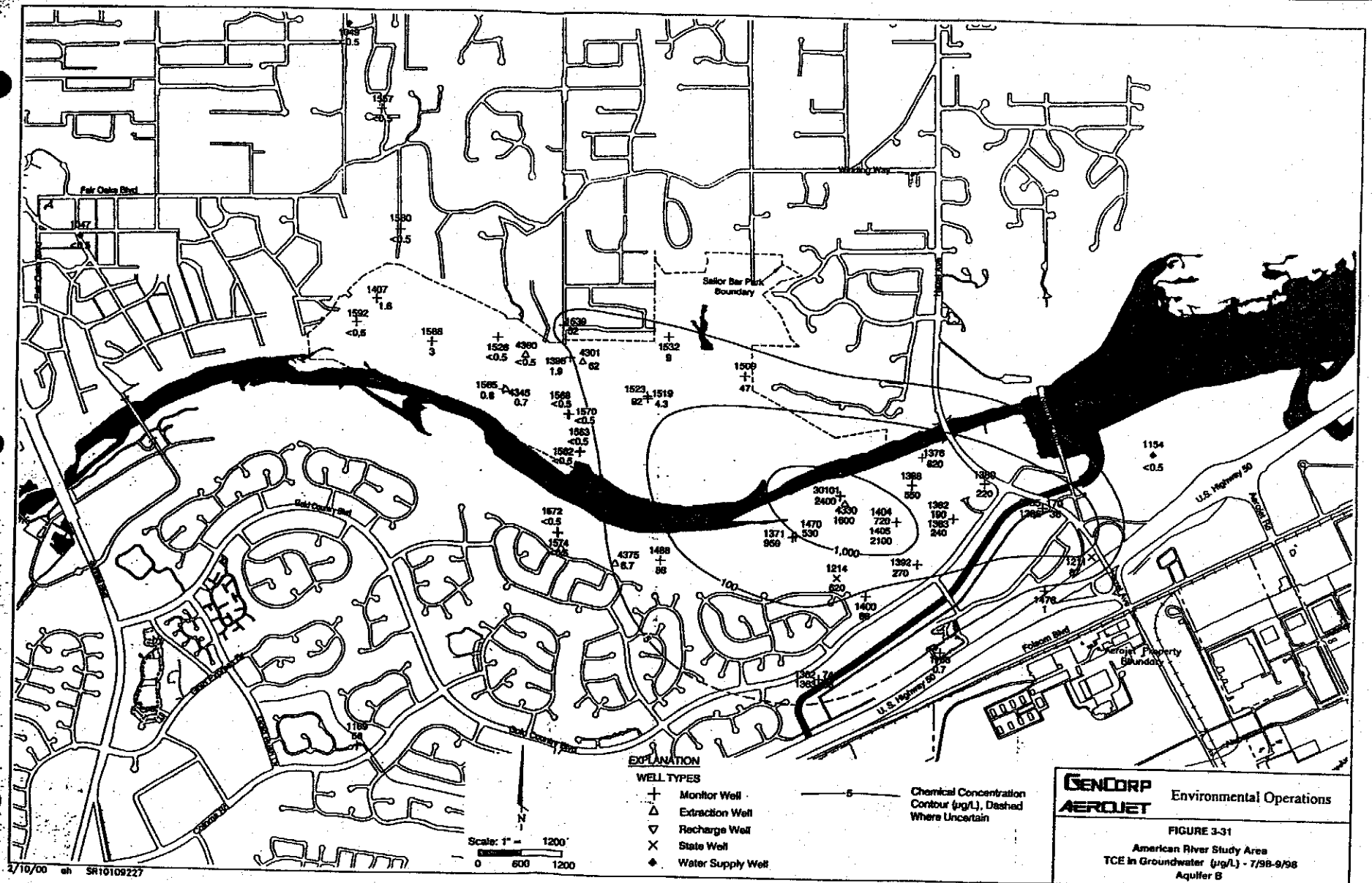


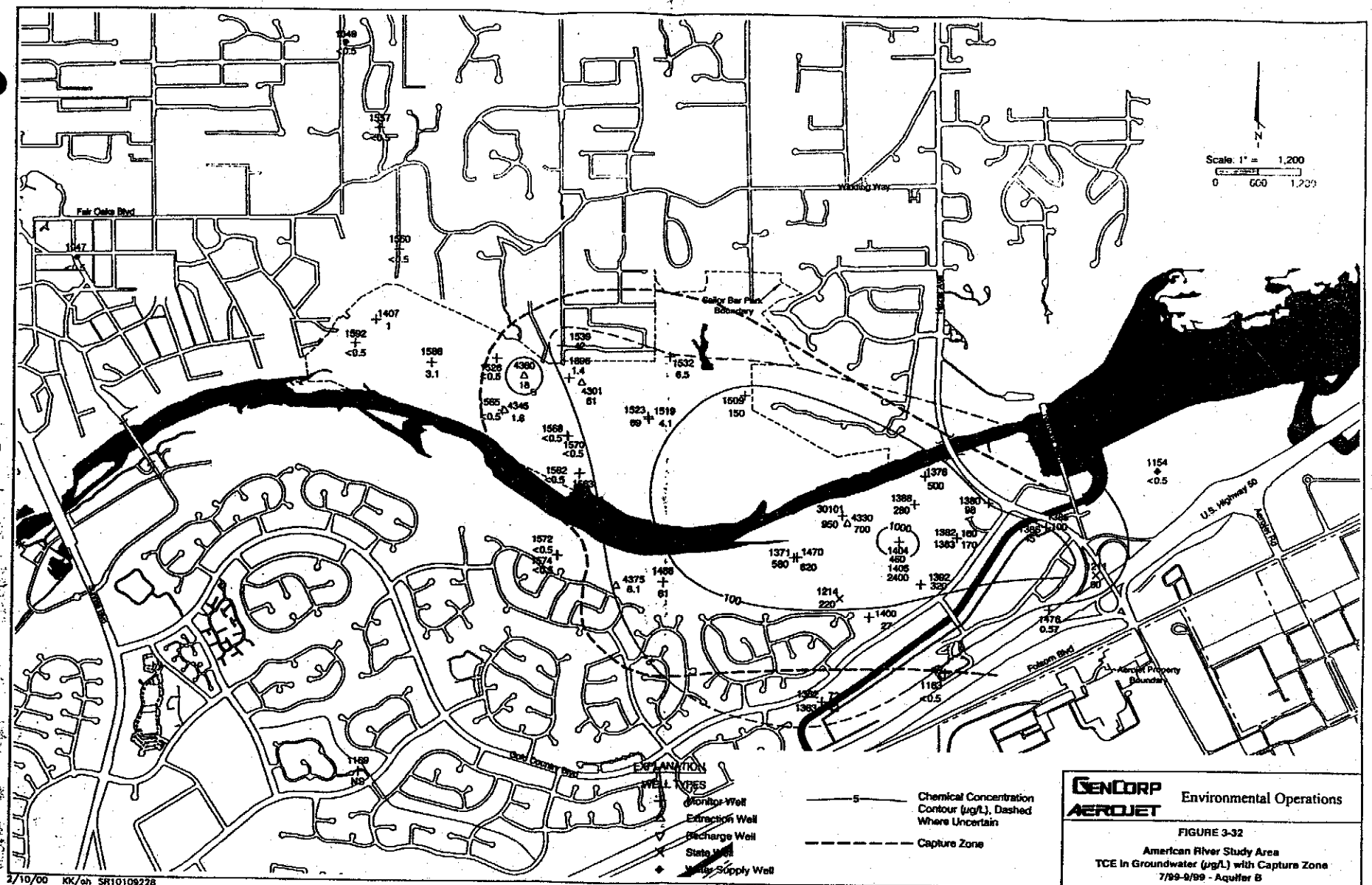
SR10109328

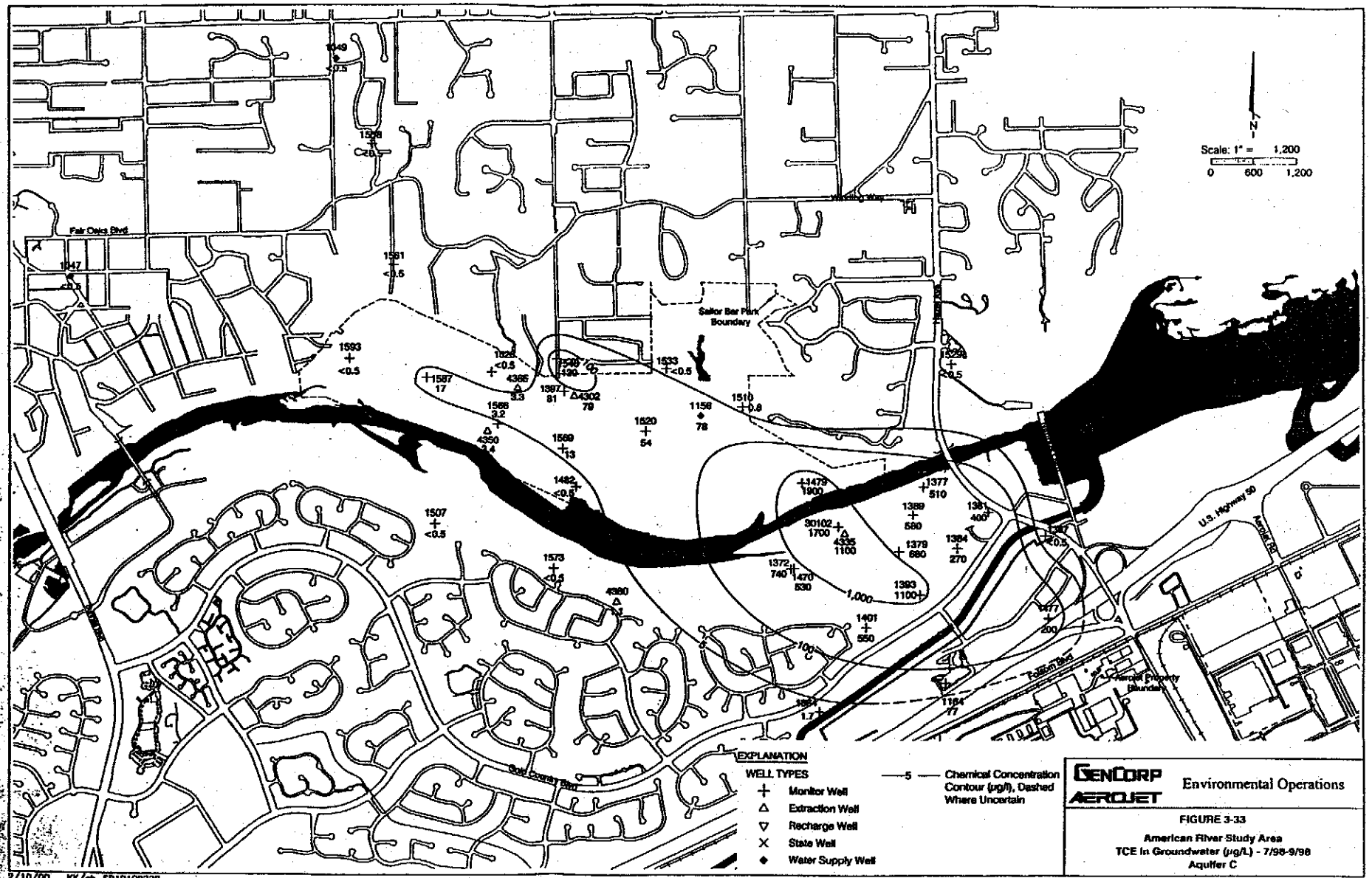
2/10/2000


Fair Oaks Blvd
Sailor Bar Park Boundary
Folsom Blvd
Aerojet Property Boundary
U.S. Highway 50
Aerojet Rd
EXPLANATION
WELL TYPES
Monitor Well
Extraction Well
Recharge Well
State Well
Water Supply Well
5
Chemical Concentration Contour (µg/L). Dashed Where Uncertain
Scale: 1" = 1200'
0 600 1200
N
GENCORP AEROJET
Environmental Operations
FIGURE 3-29
American River Study Area
TCE in Groundwater (µg/L) - 7/98-9/98
Aquifer A
1/18/2000 ah SR10100225


Fair Oaks Blvd
Winding Way
Sailor Bar Park Boundary
Folsom Blvd
U.S. Highway 50
Aerojet Property Boundary
Scale: 1" = 1200'
0 600 1200
N
EXPLANATION
WELL TYPES
Monitor Well
Extraction Well
Recharge Well
State Well
Water Supply Well
5
Chemical Concentration Contour (ug/L), Dashed Where Uncertain
Capture Zone
GENCORP AEROJET
Environmental Operations
FIGURE 3-30
American River Study Area
TCE in Groundwater (µg/L) with Capture Zone
7/99-9/99 - Aquifer A
2/9/00 ch SR10109228


Fair Oaks Blvd
Sailor Bar Park Boundary
Folsom Blvd
U.S. Highway 50
Aerojet Property Boundary
EXPLANATION
WELL TYPES
Monitor Well
Extraction Well
Recharge Well
State Well
Water Supply Well
Chemical Concentration Contour (µg/L), Dashed Where Uncertain
Scale: 1" = 1200'
0 600 1200
N
GENCORP AEROJET
Environmental Operations
FIGURE 3-31
American River Study Area
TCE in Groundwater (µg/L) - 7/98-9/98
Aquifer B
2/10/00 eh SR10109227


N
Scale: 1" = 1,200
0 600 1,200
Fair Oaks Blvd
Walnut Way
Sailor Bar Park Boundary
Hazel Ave
U.S. Highway 50
Aerojet Rd
Folsom Blvd
Aerojet Property Boundary
Old Country Club
EXPLANATION
WELL TYPES
Monitor Well
Extraction Well
Recharge Well
State Well
Water Supply Well
5
Chemical Concentration Contour (µg/L), Dashed Where Uncertain
Capture Zone
GENCORP AEROJET
Environmental Operations
FIGURE 3-32
American River Study Area
TCE in Groundwater (µg/L) with Capture Zone
7/99-9/99 - Aquifer B
2/10/00 KK/ah SR10109228

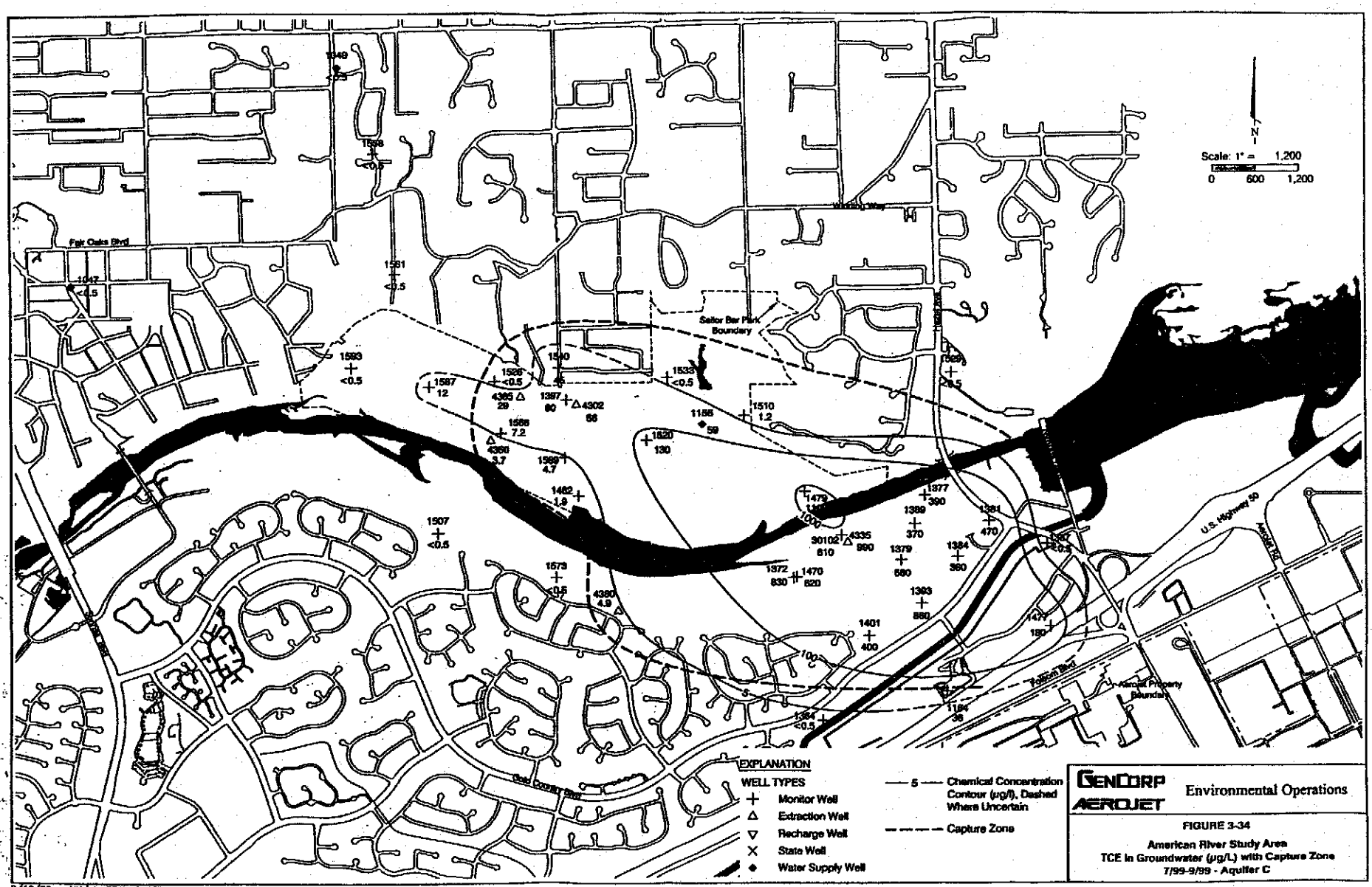


GENCORP AEROJET Environmental Operations

FIGURE 3-33

American River Study Area
TCE in Groundwater (µg/L) - 7/98-9/98
Aquifer C

2/10/00 KK/gh SR10109229

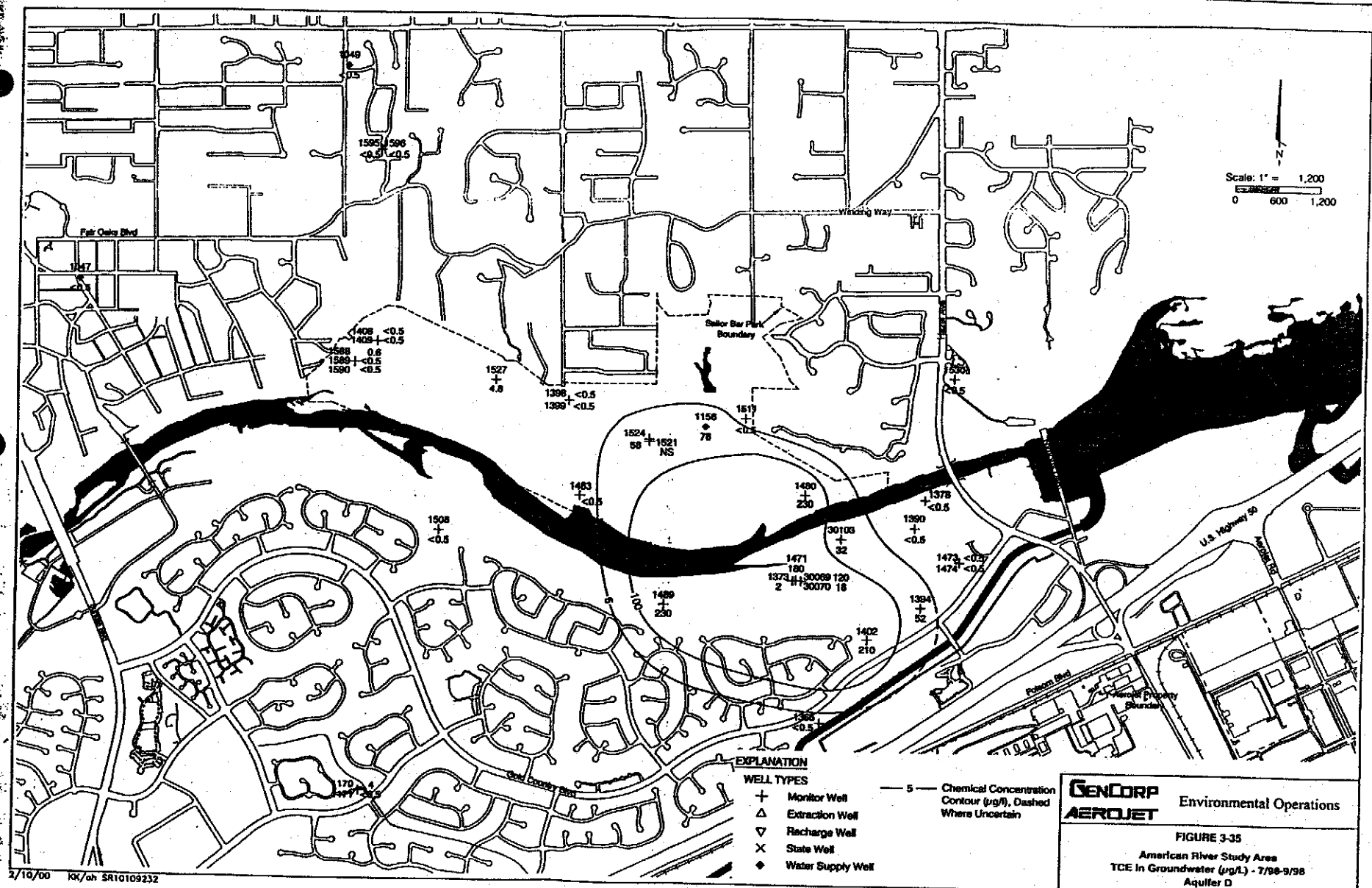


GENCORP AEROJET Environmental Operations

FIGURE 3-34

American River Study Area
TCE in Groundwater (µg/L) with Capture Zone
7/99-9/99 - Aquifer C

2/10/00 KK/eh SR10109231


Fair Oaks Blvd
Winding Way
Sailor Bar Park Boundary
Folsom Blvd
U.S. Highway 50
Aerojet Property Boundary
Scale: 1" = 1,200
0 600 1,200
N
1549 <0.5
1595 <0.5
1596 <0.5
1447 <0.5
1408 <0.5
1409 <0.5
1588 0.6
1589 <0.5
1590 <0.5
1527 4.8
1398 <0.5
1399 <0.5
1524 58
1521 NS
1156 78
1511 <0.5
1530 <0.5
1483 <0.5
1480 230
1378 <0.5
1390 <0.5
30103 32
1508 <0.5
1471 180
1373 2
30069 120
30070 18
1473 <0.5
1474 <0.5
1489 250
1394 52
1402 210
1368 <0.5
170 4
EXPLANATION
WELL TYPES
Monitor Well
Extraction Well
Recharge Well
State Well
Water Supply Well
5 Chemical Concentration Contour (µg/l), Dashed Where Uncertain
GENCORP AEROJET
Environmental Operations
FIGURE 3-35
American River Study Area
TCE in Groundwater (µg/L) - 7/98-9/98
Aquifer D
2/10/00 KK/ah SR10109232

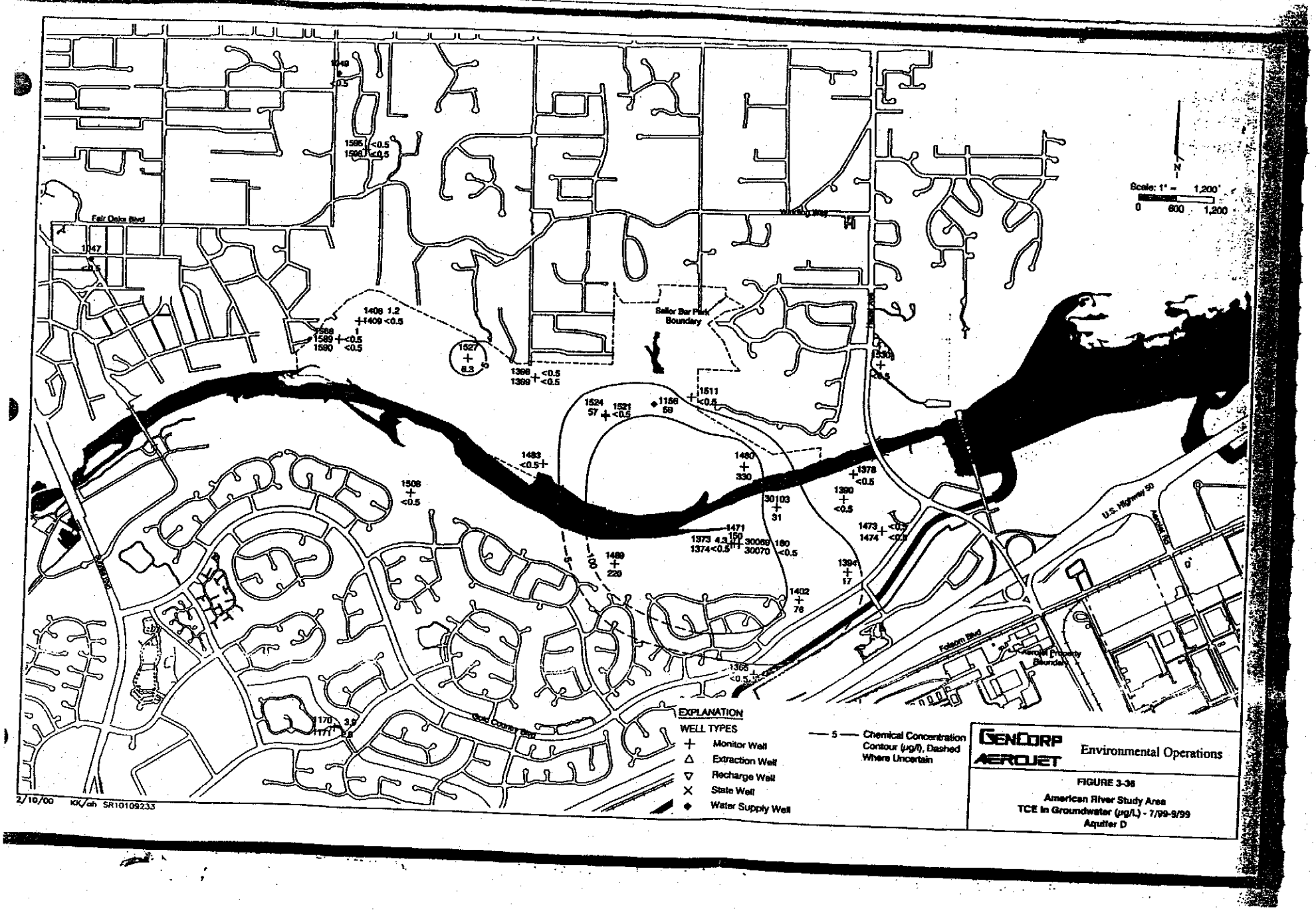
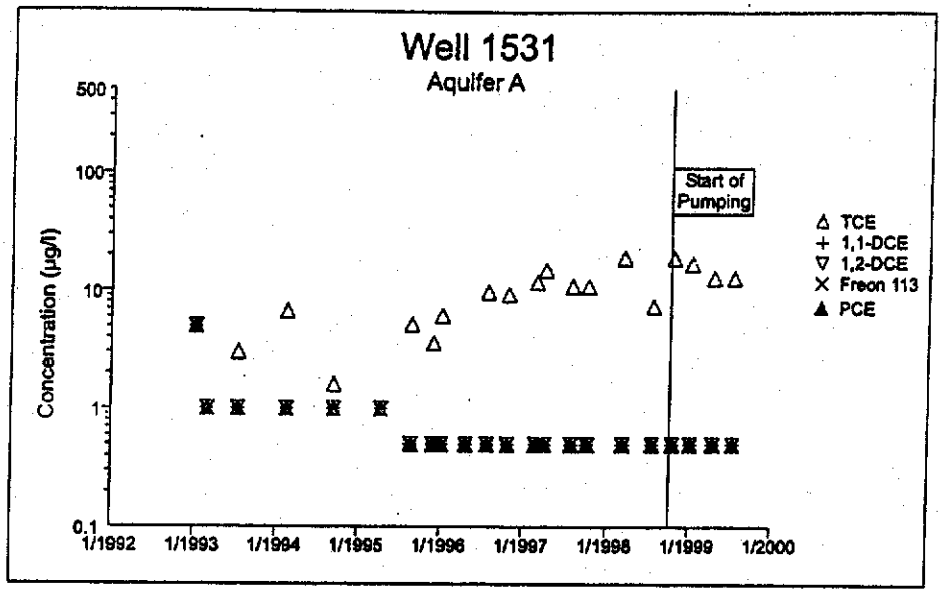
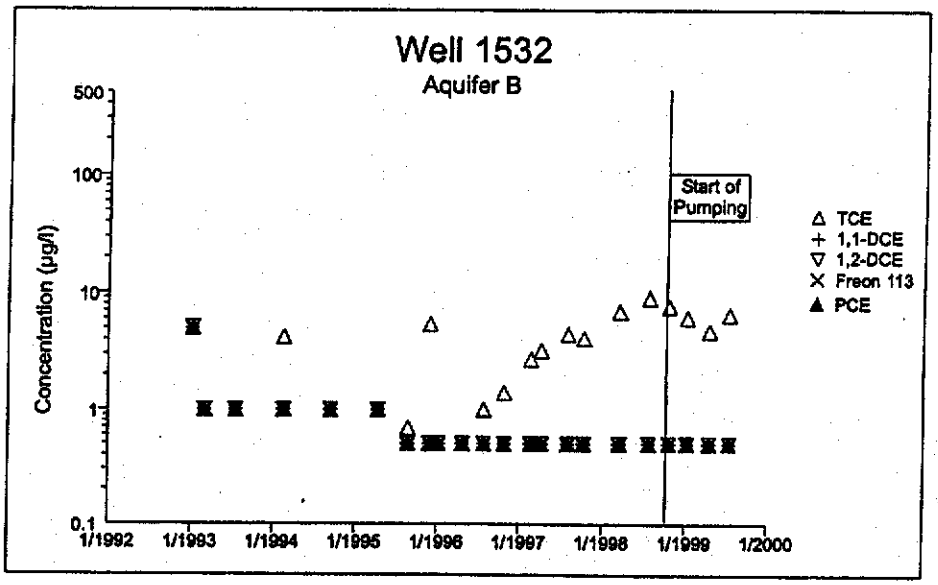

Fair Oaks Blvd
Sailor Bar Park Boundary
Folsom Blvd
Aerojet Property Boundary
U.S. Highway 50
Scale: 1" = 1,200'
0 600 1,200
N
EXPLANATION
WELL TYPES
Monitor Well
Extraction Well
Recharge Well
State Well
Water Supply Well
5 Chemical Concentration Contour (µg/l), Dashed Where Uncertain
GENCORP AEROJET
Environmental Operations
FIGURE 3-36
American River Study Area
TCE in Groundwater (µg/L) - 7/99-9/99
Aquifer D
2/10/00 KK/ah SR10109233

Figure 3-37
VOC Trend Wells 1531-33





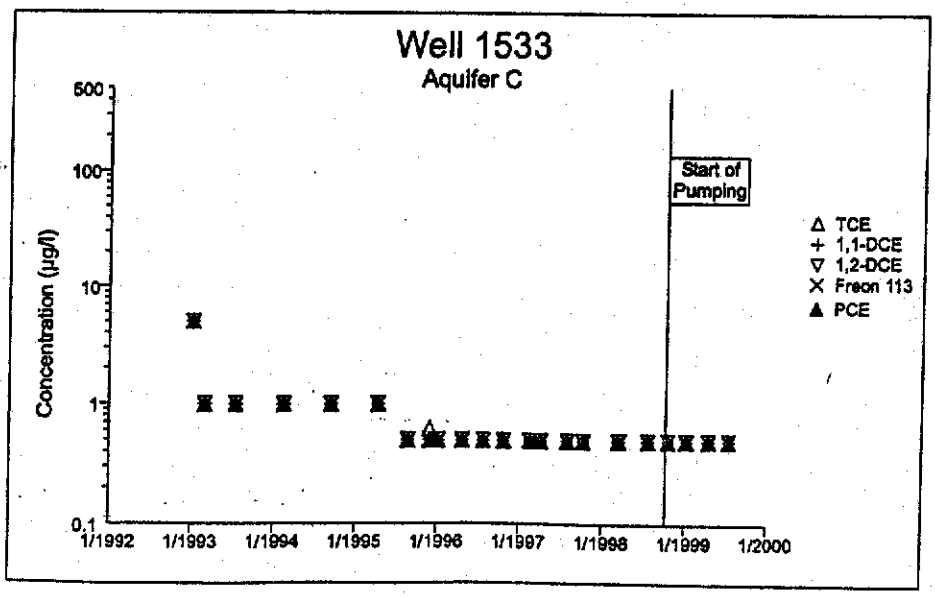
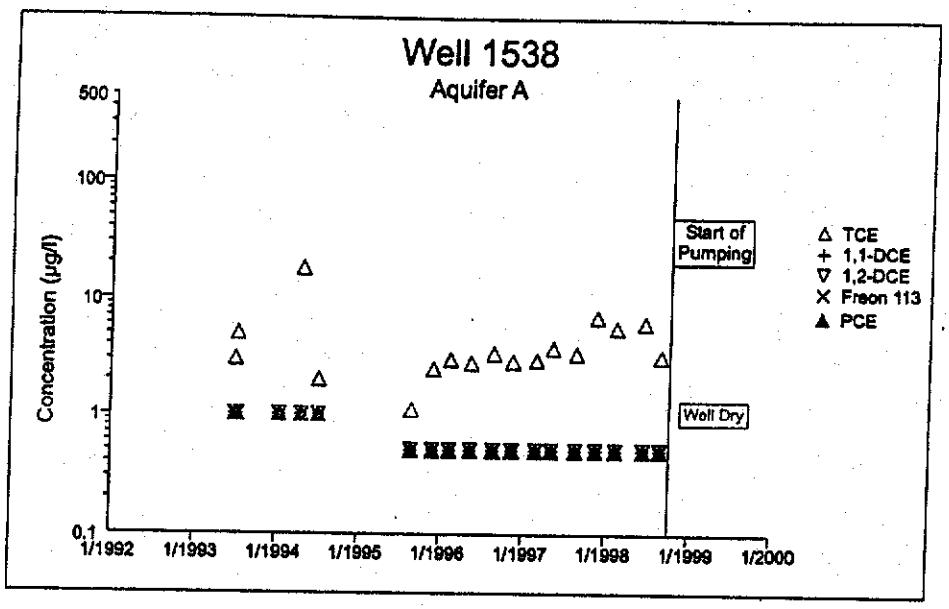
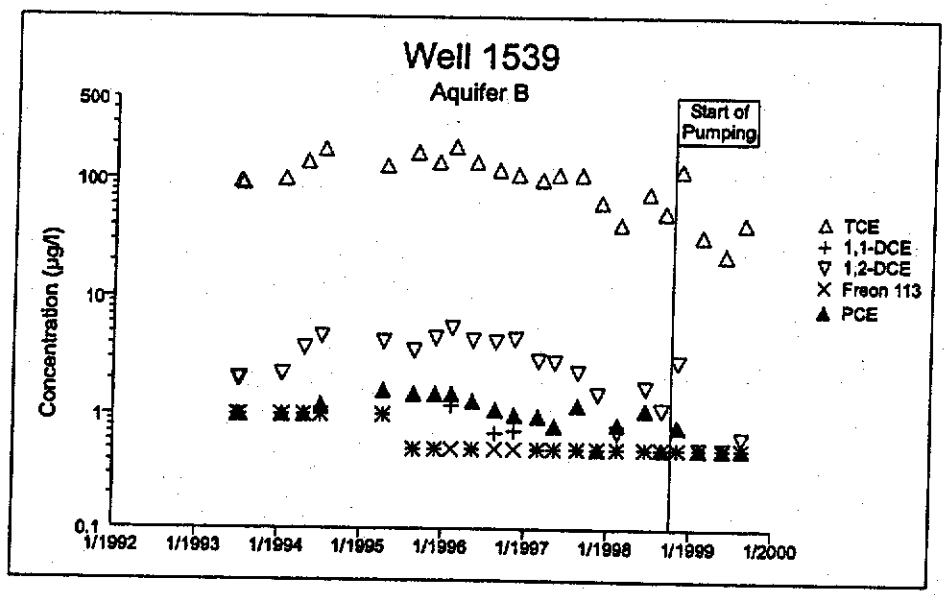


Figure 3-38
VOC Trend Wells 1538-40





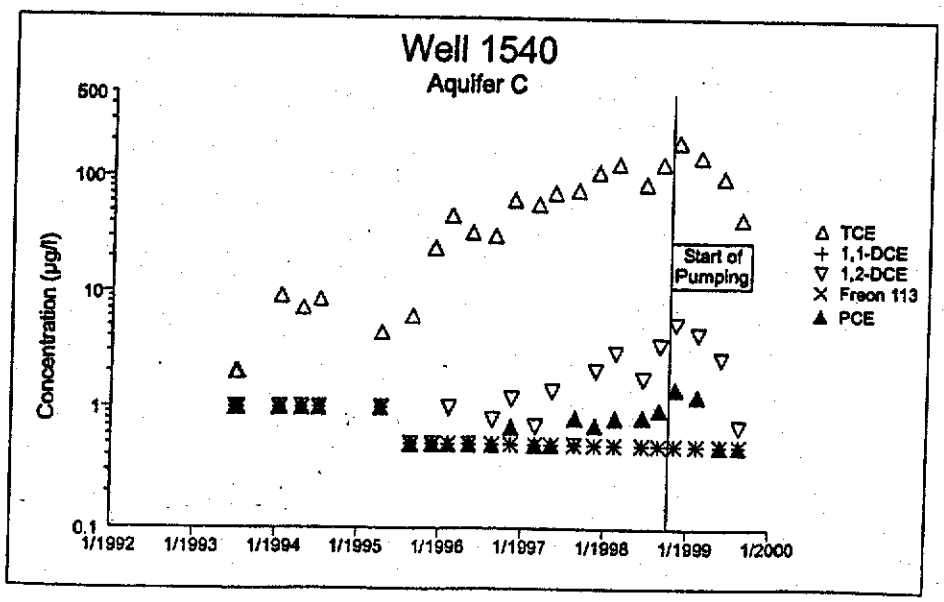
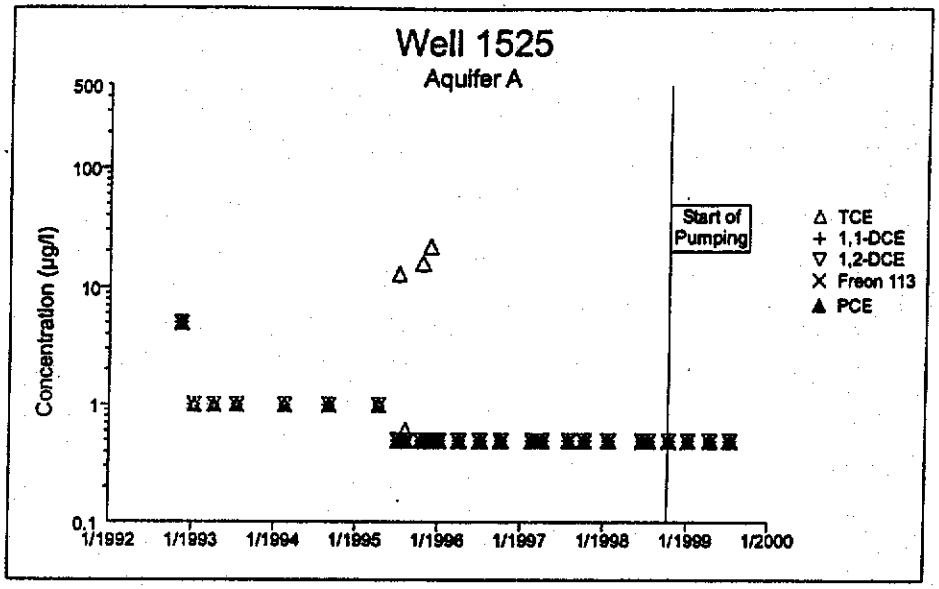
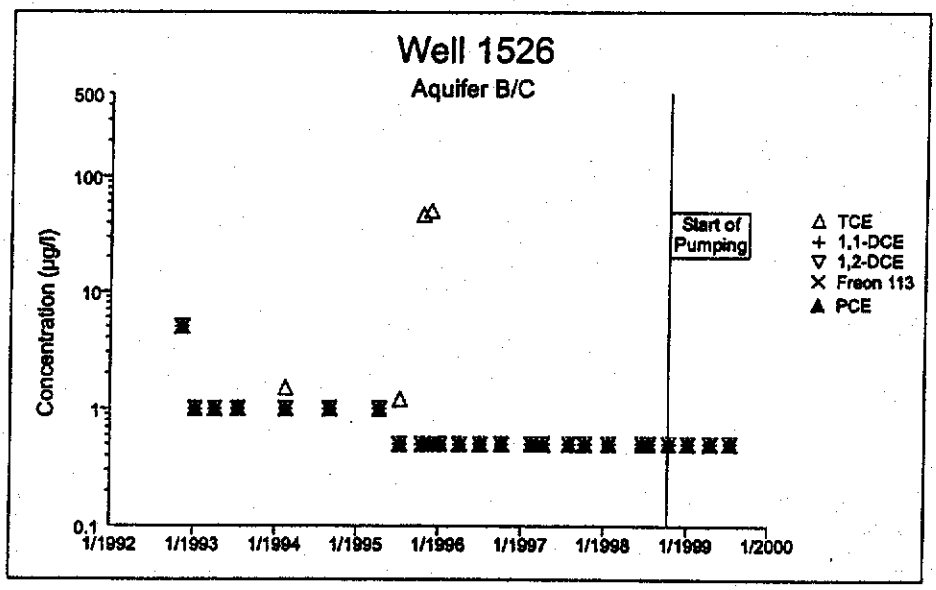


Figure 3-39
VOC Trend Wells 1525-27





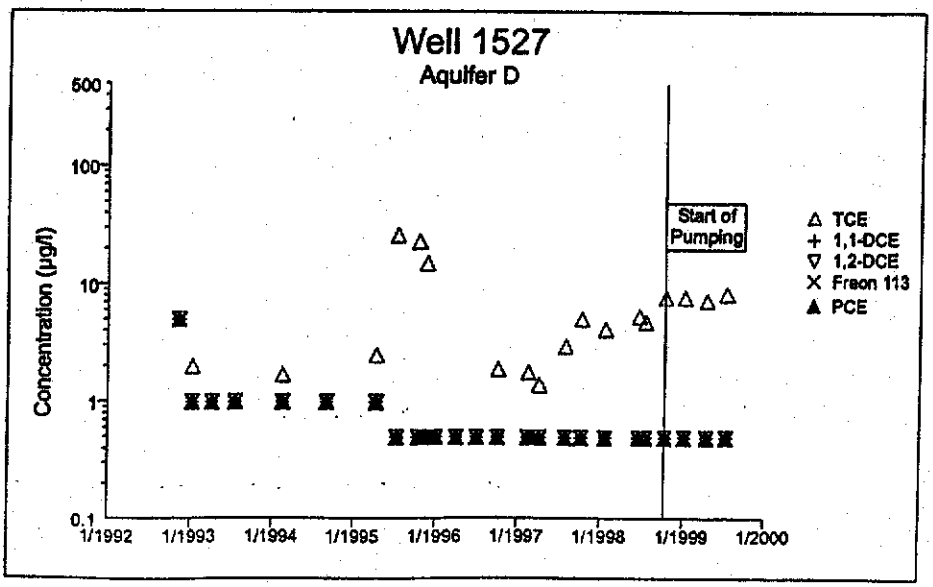
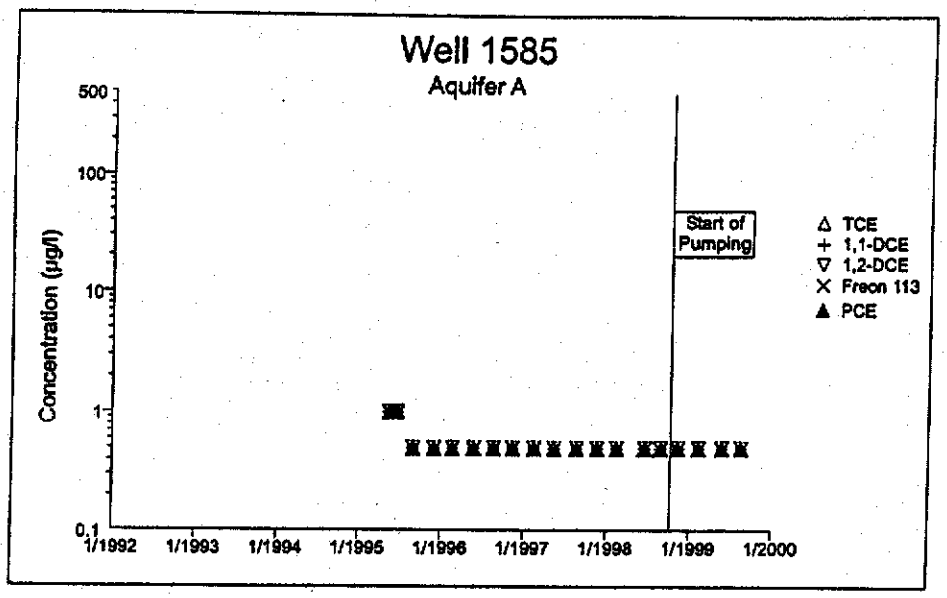
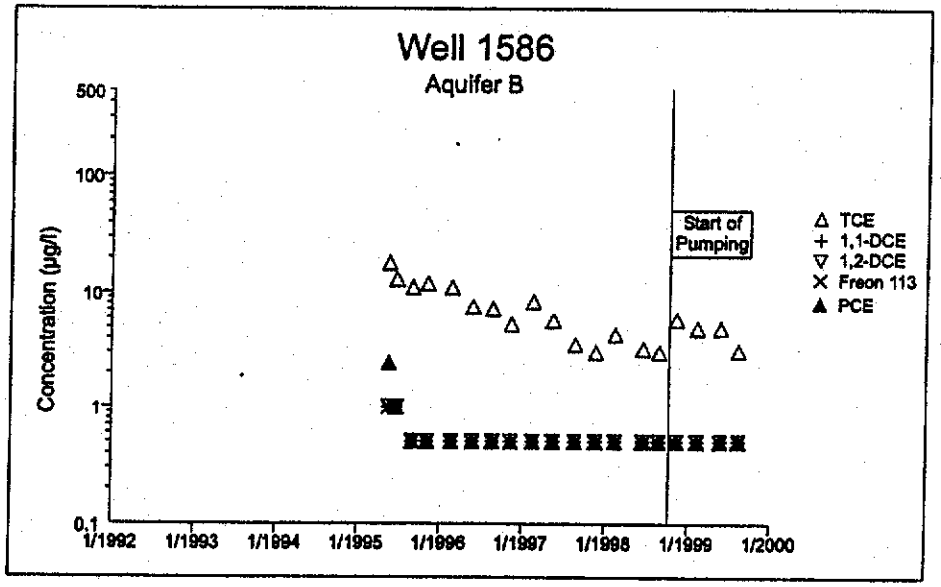


Figure 3-40
VOC Trend Wells 1585-87





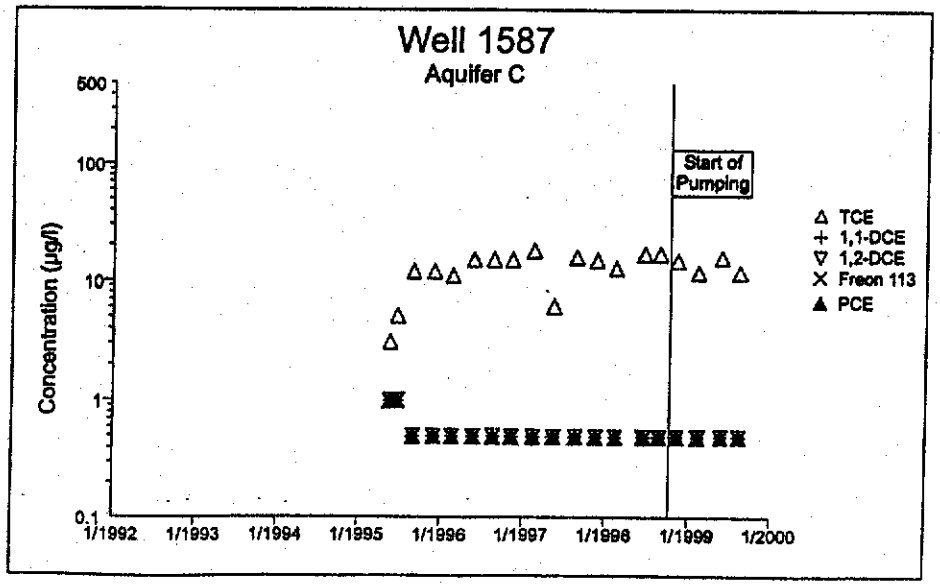
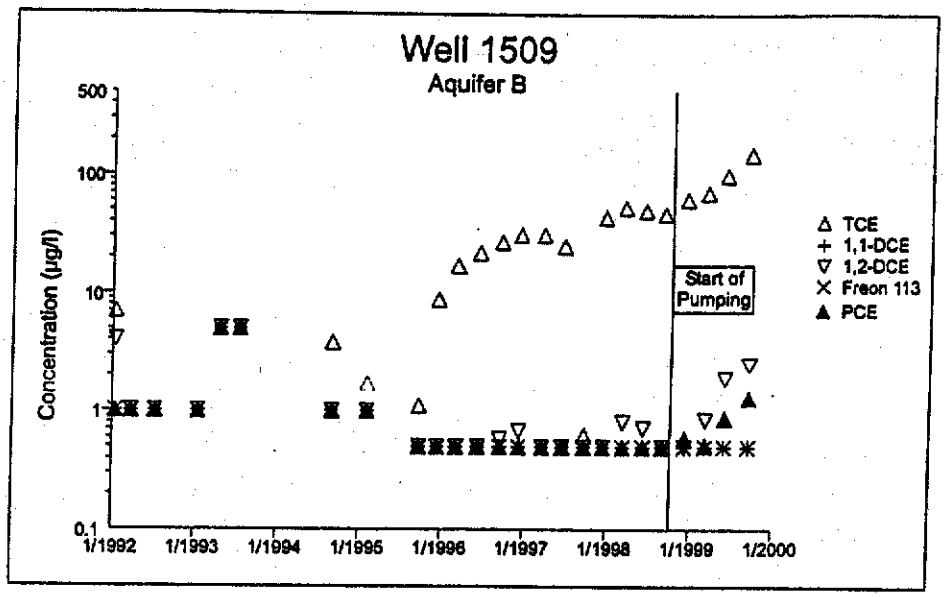
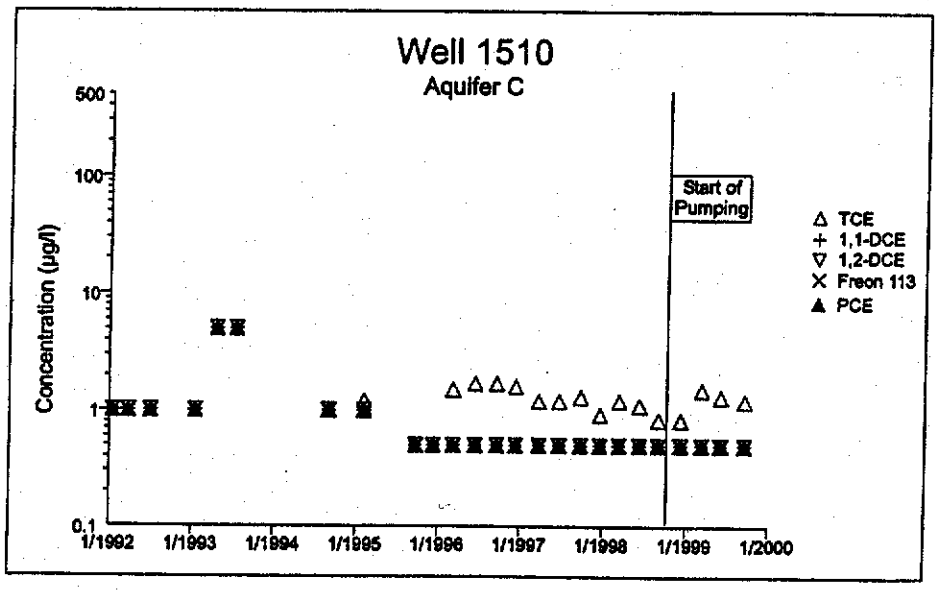


Figure 3-41
VOC Trend Wells 1509-11





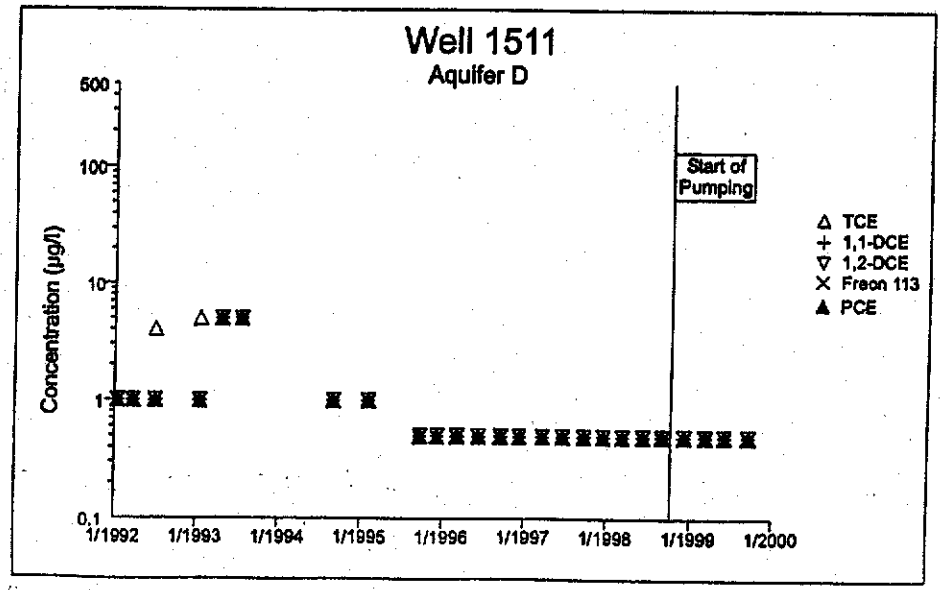
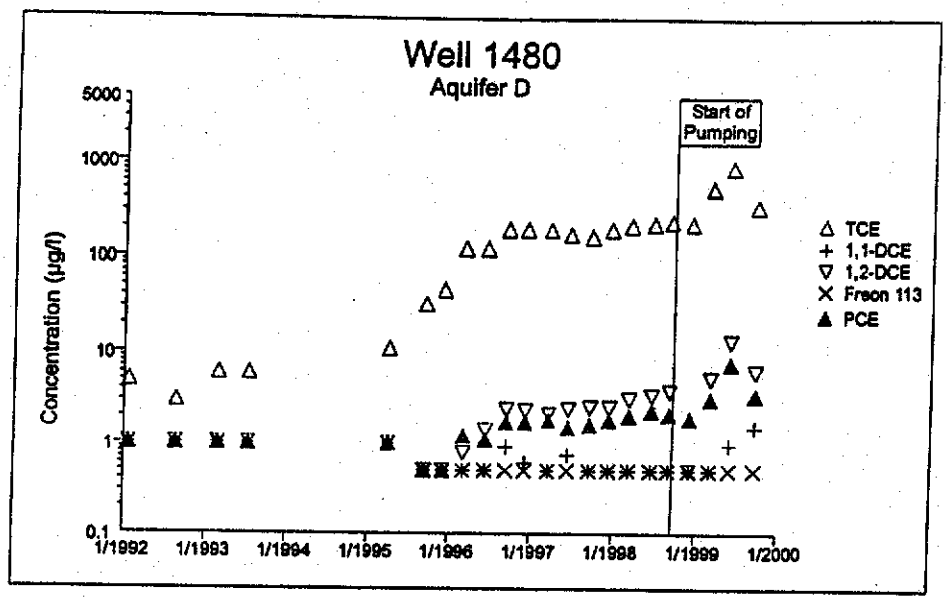
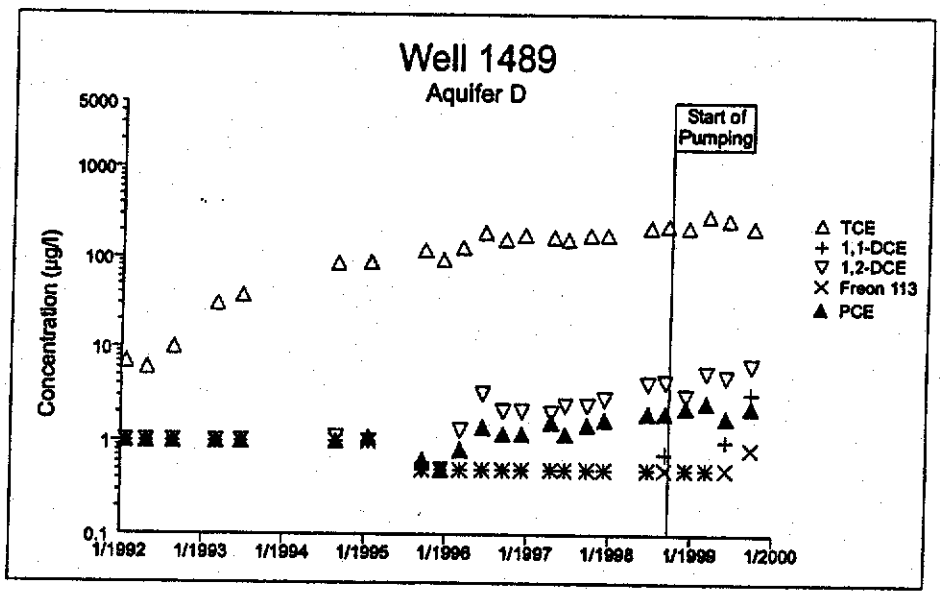


Figure 3-42
VOC Trend Selected Aquifer D Wells





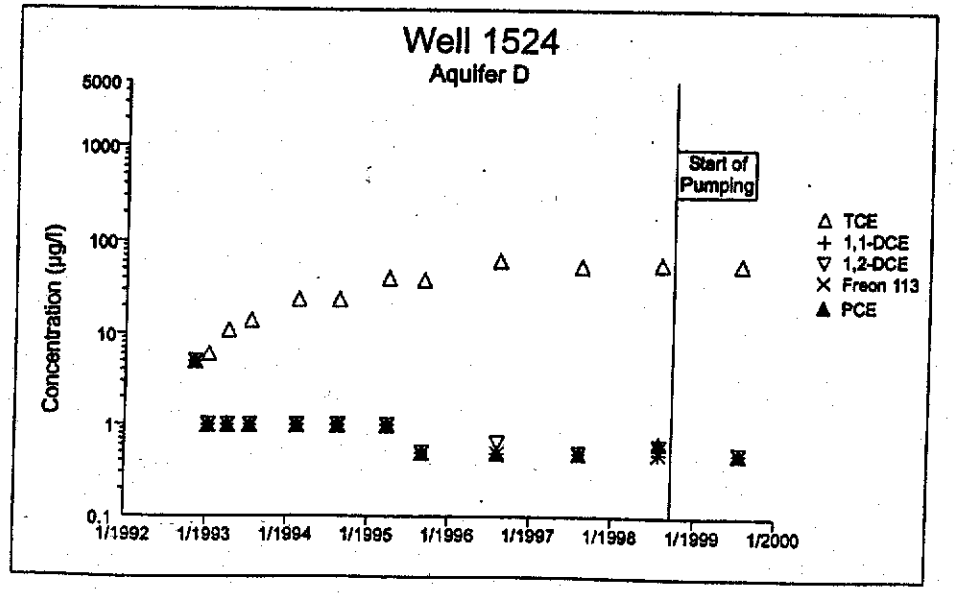


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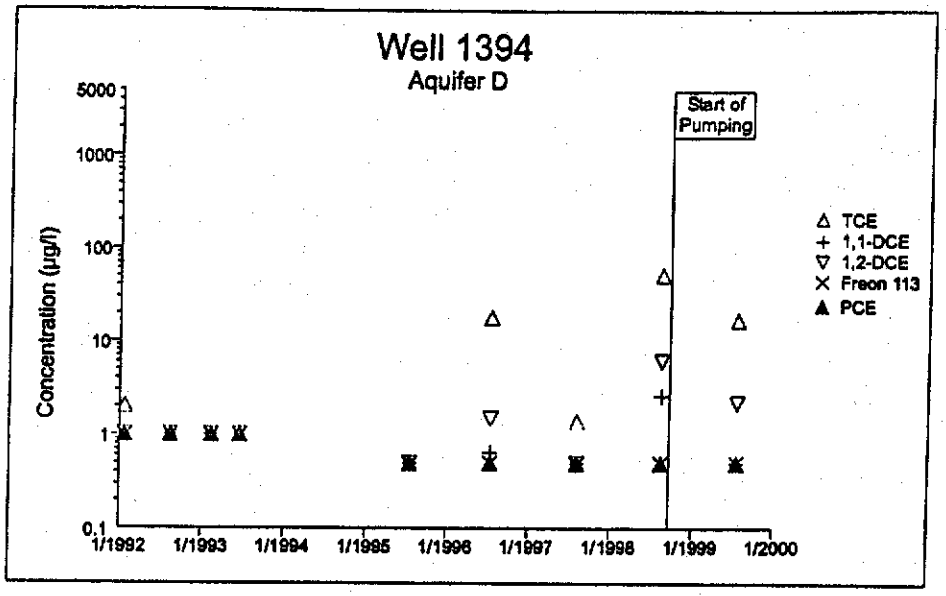
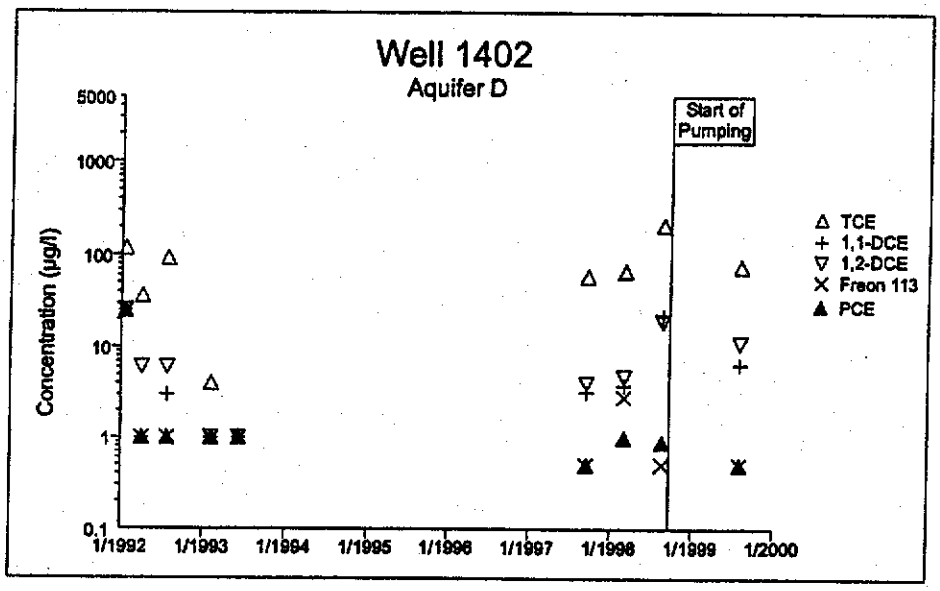
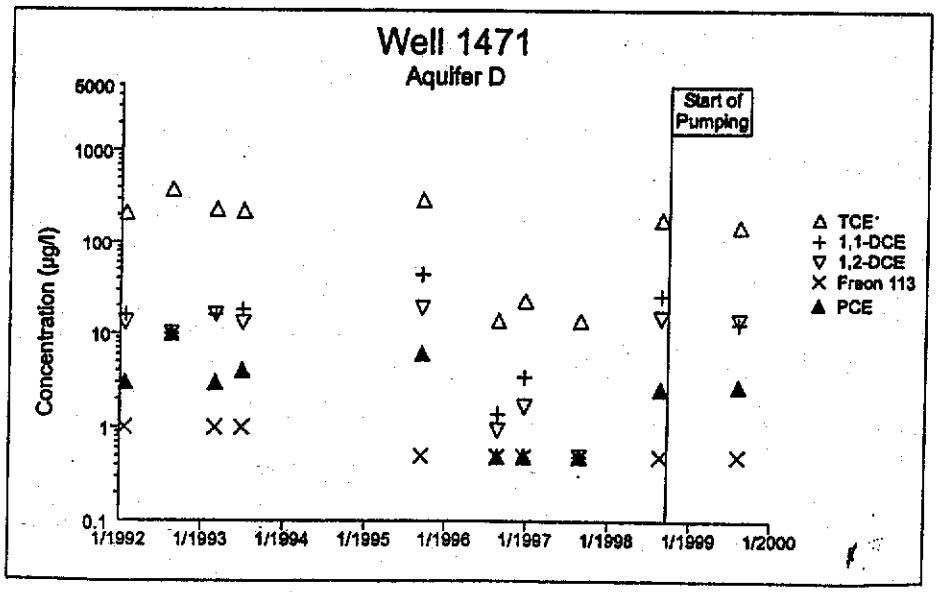
Figure 3-43
VOC Trend Selected Aquifer D Wells







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02/09/2000

Table 2-1
American River Study Area
Flow Rates for Extraction Wells and Treatment Plant
August 1998 - August 1999

Well	Millions of Gallons Pumped	Average Flow Rate (gpm)	Aquifer
4300	137.8	262	A
4301	77.0	147	B
4302	12.2	23	C
4325	77.0	147	A
4330	110.0	209	B
4335	97.9	186	C
4340	4.7	9	A
4345	198.6	378	B
4350	18.8	36	C
4355	215.0	409	A
4360	182.4	347	B
4365	26.0	49	C
4370	158.8	302	A
4375	93.8	178	B
4380	29.4	56	C
Totals:	1,439.3	2,739	
Aquifer A	593.3	1,129	
Aquifer B	661.8	1,259	
Aquifer C	184.2	351	
Treatment Plant Sample Points			
7065 (influent)	271.8	517	Wells 4325, 4330, 4335
7067 (influent)	1,007.7	1,917	Remaining 12 Wells
7069 (effluent)	1,311.3	2,495	Combined effluent

Table 2-2

American River Study Area

Comparison of Estimated and Actual

ARGET Influent and Effluent Concentrations and Air Emission Rates

Chemical	Estimated Influent Concentration (µg/l) At Start-up 7065	Actual Influent Concentration (µg/l) 7065	Estimated Influent Concentration (µg/l) At Start-up 7067	Actual Influent Concentration (µg/l) 7067	Estimated Emission Rates (lb/day)	Actual Emission Rates (lb/day)
1,4-DIOXANE	12	16	<10	<10	NA	NA
TRICHLOROETHYLENE	993	904	31	11	1.49	0.21
1,2-DICHLOROETHYLENE	57	74	0.5	<0.5	0.07	0.00
1,1-DICHLOROETHYLENE	43	52	<0.5	<0.5	0.05	0.00
FREON 113*	20	27	<0.5	<0.5	0.14	0.38
TETRACHLOROETHYLENE	16	14	<0.5	<0.5	0.02	0.00
CHLOROFORM	7	5	<0.5	<0.5	0.05	0.05
1,1-DICHLOROETHANE	3	6	<0.5	<0.5	0.02	0.06
1,2-DICHLOROETHANE	2	3	<0.5	<0.5	0.00	0.00
1,1,1-TRICHLOROETHANE*	1	<0.5	<0.5	<0.5	0.00	0.00
CARBON TETRACHLORIDE	<0.5	2	<0.5	<0.5	0.00	0.01
AIR EMISSION RATE					1.84	0.71
TOTALS ROCS (LBS/DAY)					1.70	0.33
FLOW RATE (GPM)					3,445	2,740

- * - not considered as ROCs
- () –Influent sampling location

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02/11/00

Table 3-2
American River Study Area
Summary of Water Level Changes

Well No.	Aquifer	Water Level Change (feet)		
		Apr-98 - Apr-99	Oct-98 - Oct-99	Apr-98 - Oct-99
1162	A	-2.6	-4.7	-7.8
1211	A	-6.4	-4.4	-9.7
1214	A	-3.4	-2.6	-6.2
1216	A	-2.9	-3.3	-6.7
1361	A	-1.4	-4.6	-5.7
1370	A	-3.7	-1.8	-5.7
1375	A	-1.4	0.4	-2.3
1391	A	-3.1	-3.2	-6.5
1395	A	-17.7	-4.3	-20.7
1403	A	-3.9	-2.2	-6.1
1406	A	-6.7	-4.5	-10.4
1469	A	-2.9	-1.4	-4.8
1472	A	-2.7	-2.7	-5.2
1475	A	NM	-4.8	-7.5
1478	A	-2.8	-1.8	-5.0
1481	A	-4.5	-1.5	-7.5
1487	A	-3.3	-1.7	-4.9
1506	A	-6.5	-3.9	-9.9
1519	A	-6.4	-3.6	-9.8
1522	A	-6.3	-3.7	-9.7
1525	A	-13.9	-5.0	-17.0
1528	A	0.0	-1.9	-1.6
1531	A	-7.0	-4.7	-10.2
1538	A	Dry	Dry	Dry
1559	A	-5.8	-4.1	-8.9
1564	A	-14.3	-3.7	-16.9
1567	A	-9.7	-3.2	-13.1
1571	A	-4.2	-1.8	-6.2
1585	A	-8.6	-4.5	-12.1
1591	A	NM	-4.4	NM
1594	A	-3.5	-3.9	-6.2
30068	A	-3.8	-1.6	-5.8
30100	A	-6.6	-1.2	-8.0
	Maximum	0.0	0.4	-1.6
	Minimum	-17.7	-5.0	-20.7
	Average	-5.5	-3.1	-8.3
1163	B	-2.6	-4.7	-7.9
1169	B	-2.5	NM	NM
1211	B	-6.4	-4.4	-9.7
1214	B	-3.4	-2.6	-6.2
1362	B	-1.5	-4.7	-6.0
1363	B	-1.4	-4.9	-6.8
1371	B	-3.7	-1.9	-5.8
1376	B	-2.0	-0.2	-3.2
1380	B	-2.9	-2.1	-5.0
1382	B	-2.7	-2.7	-5.5
1383	B	-3.0	-2.7	-5.9
1385	B	-3.0	-5.3	-7.8
1386	B	-3.0	-1.1	-3.8
1388	B	-2.8	-4.2	-4.4

Table 3-2
American River Study Area
Summary of Water Level Changes

Well No.	Aquifer	Water Level Change (feet) Apr-98 - Apr-99	Oct-98 - Oct-99	Apr-98 - Oct-99
1392	B	-3.2	-3.3	-6.5
1396	B	-16.7	-4.0	-19.6
1400	B	-3.3	-3.1	-6.7
1404	B	-3.9	-2.1	-6.3
1405	B	-3.8	-2.3	-6.3
1407	B	-6.6	-4.6	-10.3
1470	B	-7.3	-2.8	-11.9
1476	B	NM	-4.7	-7.3
1488	B	-3.5	-1.5	-5.3
1509	B	-3.9	-3.6	-7.1
1519	B	-6.4	-3.6	-9.8
1523	B	-7.0	-3.3	-10.1
1526	B	-13.7	-4.6	-16.7
1532	B	-6.9	-4.8	-10.1
1539	B	-13.5	-4.5	-16.1
1557	B	-3.2	-3.4	-6.1
1560	B	-5.8	-4.2	-9.0
1562	B	-8.1	-2.7	-11.2
1563	B	-8.1	-3.5	-11.2
1565	B	-23.6	-4.1	-26.5
1568	B	-9.6	-3.0	-12.7
1570	B	-9.4	-1.9	-12.5
1572	B	-4.7	-2.1	-7.1
1574	B	-4.3	-1.9	-6.4
1586	B	-8.3	-4.4	-11.8
1592	B	NM	-4.5	NM
30101	B	-7.4	-1.6	-8.8
	Maximum	-1.4	-0.2	-3.2
	Minimum	-23.6	-5.3	-26.5
	Average	-6.0	-3.3	-9.0
1164	C	-1.7	-3.6	-6.3
1364	C	-2.5	-4.1	-9.3
1372	C	-11.0	-3.9	-18.0
1377	C	-4.6	-2.4	-7.7
1379	C	-4.2	-2.6	-7.5
1381	C	-3.3	-2.5	-5.9
1384	C	-3.1	-2.8	-6.2
1387	C	-2.4	-3.0	-5.1
1389	C	-4.7	-2.5	-7.9
1393	C	-3.3	-3.3	-6.9
1397	C	-16.1	-3.3	-19.0
1401	C	-3.8	-3.2	-7.6
1470	C	-7.3	-2.8	-11.9
1477	C	NM	-4.1	-6.5
1479	C	-11.6	-6.0	-19.9
1482	C	-6.6	-10.6	-17.7
1507	C	-6.7	-3.8	-9.9
1510	C	-10.0	-7.3	-18.8
1520	C	-7.8	-4.4	-12.8
1526	C	-13.7	-4.6	-16.7

Table 3-2
American River Study Area
Summary of Water Level Changes

Well No.	Aquifer	Water Level Change (feet) Apr-98 - Apr-99	Oct-98 - Oct-99	Apr-98 - Oct-99
1529	C	-5.3	-3.9	-9.6
1533	C	-8.9	-6.5	-16.4
1540	C	-12.1	-4.7	-15.0
1558	C	-3.8	-5.0	-8.0
1561	C	-5.8	-4.3	-9.0
1566	C	-18.4	-3.5	-21.2
1569	C	-9.5	-3.0	-12.6
1573	C	-5.2	-2.5	-8.2
1587	C	-8.2	-4.5	-11.9
1593	C	NM	-4.5	NM
30102	C	-18.8	-2.9	-25.5
	Maximum	-1.7	-2.4	-5.1
	Minimum	-18.8	-10.6	-25.5
	Average	-7.6	-4.1	-12.0
1170	D	-4.1	NM	NM
1171	D	-4.1	NM	NM
1365	D	-1.4	-4.6	-8.6
1373	D	-11.5	-4.6	-18.9
1374	D	-6.7	-6.9	-12.1
1378	D	-3.6	-3.1	-6.8
1390	D	-3.1	-3.2	-6.4
1394	D	-2.1	-3.4	-5.4
1398	D	-7.8	-5.6	-12.3
1399	D	-8.7	-6.3	-16.1
1402	D	-1.9	-3.6	-5.4
1408	D	-6.7	-7.4	-11.3
1409	D	-4.5	-8.2	-11.8
1471	D	-6.9	-6.3	-12.3
1473	D	-2.7	-3.0	-5.6
1474	D	-2.6	-2.9	-5.6
1480	D	-11.8	-7.0	-21.1
1483	D	-9.0	-5.2	-17.3
1489	D	-8.7	-2.7	-15.9
1508	D	-5.3	-5.4	-10.4
1511	D	-9.9	-7.1	-18.9
1521	D	-10.0	-6.8	-18.9
1524	D	-9.8	-6.5	-18.4
1527	D	-6.5	-6.2	-11.6
1530	D	-4.3	-4.2	-8.3
1588	D	NM	-8.7	NM
1589	D	NM	-8.7	NM
1590	D	NM	-8.5	NM
1595	D	-7.2	-5.8	-8.9
1596	D	-7.2	-5.5	-8.6
30069	D	-11.8	-4.9	-19.3
30070	D	-6.6	-4.6	-10.5
30103	D	-6.0	-5.4	-9.5
	Maximum	-1.4	-2.7	-5.4
	Minimum	-11.8	-8.7	-21.1
	Average	-6.4	-5.6	-12.0

Table 3-3
American River Study Area
Extraction Well Water Level Corrections

Extraction Well	Aquifer	Estimated Efficiency*	October 1998			April 1999			October 1999		
			Measured Elevation (ft, MSL)	Corrected Elevation (ft, MSL)	Correction (feet)	Measured Elevation (ft, MSL)	Corrected Elevation (ft, MSL)	Correction (feet)	Measured Elevation (ft, MSL)	Corrected Elevation (ft, MSL)	Correction (feet)
4300	A	95%	34.0	35.5	1.5	36.1	37.5	1.4	33.7	35.3	1.7
4325	A	75%	60.4	66.6	6.2	62.8	68.5	5.7	58.6	66.0	7.4
4340	A	85%	30.0	34.4	4.4	37.9	41.1	3.3	30.0	34.8	4.9
4355	A	75%	25.5	33.7	8.2	22.5	31.5	9.0	17.4	28.4	11.0
4370	A	45%	38.6	58.7	20.2	37.6	58.4	20.9	30.4	56.8	26.4
4301	B	50%	7.9	35.8	27.9	3.0	33.5	30.5	-6.9	30.0	37.0
4330	B	50%	55.9	71.3	15.4	41.6	64.3	22.7	14.9	52.5	37.6
4345	B	50%	-4.9	27.4	32.3	-2.5	28.7	31.2	-12.2	25.4	37.6
4360	B	50%	3.9	31.3	27.4	2.3	30.6	28.3	2.2	32.1	29.9
4375	B	50%	19.1	46.9	27.8	17.6	46.3	28.7	16.7	47.3	30.7
4302	C	45%	-27.4	24.0	51.4	-18.5	27.8	46.3	-17.5	30.6	48.2
4335	C	35%	-32.5	39.3	71.8	-29.4	40.1	69.6	-39.1	39.6	78.7
4350	C	40%	-38.2	21.9	60.1	-27.3	26.0	53.4	-27.5	28.6	56.1
4365	C	35%	-33.0	28.1	61.0	-31.8	28.3	60.1	-34.4	30.2	64.6
4380	C	30%	-36.4	40.8	77.2	-14.6	47.1	61.7	-2.5	53.8	56.3

*Estimated efficiency based on the extraction well response compared to nearby wells during aquifer tests

Table 3-4
American River Study Area
Summary of Vertical Gradients

Well Pair	Vertical Distance (feet)	Water Level Difference (feet)		Vertical Gradient (negative denotes upward)	
		Apr-98	Apr-99	Apr-98	Apr-99
Aquifer A / Aquifer B					
1162-3	40.5	-0.36	-0.41	-0.009	-0.010
1361-2	38.0	-0.56	-0.53	-0.015	-0.014
1370-1	48.0	-0.14	-0.09	-0.003	-0.002
1375-6	53.5	-0.95	-0.35	-0.018	-0.007
1472-1382	59.9	-1.25	-1.25	-0.021	-0.021
1391-2	59.5	-0.14	-0.10	-0.002	-0.002
1395-6	43.0	0.22	-0.76	0.005	-0.018
1403-4	57.0	0.13	0.21	0.002	0.004
1406-7	55.0	0.13	0.06	0.002	0.001
1475-6	44.5	2.56	NM	0.058	NM
1481-1562	34.5	6.35	9.92	0.184	0.288
1487-8	64.5	0.23	0.45	0.004	0.007
1522-3	36.5	0.94	1.57	0.026	0.043
1525-6	36.5	0.19	0.00	0.005	0.000
1531-2	40.5	0.80	0.70	0.020	0.017
1538-9	58.5	-0.63	NM	-0.011	NM
1559-60	47.0	-0.01	-0.02	0.000	0.000
1564-5	53.0	0.75	9.98	0.014	0.188
1567-8	38.0	0.20	0.13	0.005	0.003
1571-2	63.0	1.70	2.18	0.027	0.035
1585-6	56.0	0.36	0.07	0.006	0.001
1591-2	55.0	NM	0.22	NM	0.004
1594-1557	52.2	0.34	0.05	0.007	0.001
30100-1	34.0	-0.07	0.68	-0.002	0.020
			Maximum	0.184	0.288
			Minimum	-0.021	-0.021
			Average	0.012	0.024
Aquifer B / Aquifer C					
1163-4	80.0	3.56	2.69	0.044	0.034
1363-4	33.0	5.69	6.87	0.172	0.208
1371-2	52.0	12.20	19.52	0.235	0.375
1376-7	78.5	-3.11	-0.54	-0.040	-0.007
1405-1379	45.8	1.17	0.74	0.026	0.016
1380-1	58.0	-0.18	0.25	-0.003	0.004
1383-4	46.5	0.09	0.20	0.002	0.004
1386-7	68.5	1.92	1.33	0.028	0.019
1388-9	83.0	-1.93	-0.01	-0.023	0.000
1392-3	59.0	-0.15	0.02	-0.003	0.000
1396-7	52.0	2.22	1.65	0.043	0.032
1400-1	46.5	1.59	2.05	0.034	0.044
1476-7	95.5	8.57	NM	0.090	NM
1563-1482	27.3	-0.81	-2.30	-0.030	-0.084
1509-10	80.5	3.49	9.59	0.043	0.119
1519-20	67.5	1.53	2.89	0.023	0.043
1532-3	61.0	0.60	2.56	0.010	0.042
1539-40	41.5	0.79	-0.58	0.019	-0.014
1557-8	48.0	0.64	1.26	0.013	0.026
1560-1	36.0	-0.02	-0.03	-0.001	-0.001
1565-6	32.0	-0.23	-5.36	-0.007	-0.168

Table 3-4
American River Study Area
Summary of Vertical Gradients

Well Pair	Vertical Distance (feet)	Water Level Difference (feet)		Vertical Gradient (negative denotes upward)	
		Apr-98	Apr-99	Apr-98	Apr-99
1568-9	48.0	-0.13	-0.27	-0.003	-0.006
1572-3	52.0	2.35	2.82	0.045	0.054
1586-7	25.5	0.14	0.09	0.005	0.004
1592-3	32.5	NM	0.87	NM	0.027
30101-2	80.5	11.24	22.64	0.140	0.281
			Maximum	0.235	0.375
			Minimum	-0.040	-0.168
			Average	0.035	0.042
Aquifer C - Aquifer D					
1364-5	36.0	-1.50	-2.66	-0.042	-0.074
1372-3	34.8	0.02	0.46	0.001	0.013
1377-8	71.0	-0.39	-1.37	-0.005	-0.019
1384-1473	67.6	1.50	1.03	0.022	0.015
1389-90	76.0	-0.04	-1.60	-0.001	-0.021
1393-4	110.5	2.44	1.22	0.022	0.011
1397-8	50.0	8.73	0.47	0.175	0.009
1401-2	144.0	2.24	0.39	0.016	0.003
1470-1	127.0	4.75	4.40	0.037	0.035
1479-80	70.0	0.07	0.23	0.001	0.003
1482-3	115.0	4.94	7.26	0.043	0.063
1507-8	89.0	12.92	11.57	0.145	0.130
1510-11	73.0	0.11	0.04	0.002	0.001
1520-21	76.0	0.09	2.37	0.001	0.031
1526-7	127.5	10.96	3.76	0.086	0.029
1529-30	53.0	-3.32	-4.28	-0.063	-0.081
1558-1595	20.8	0.19	3.64	0.009	0.175
1593-88	110.5	NM	10.67	NM	0.097
30102-3	80.5	-7.68	-20.47	-0.095	-0.254
			Maximum	0.175	0.175
			Minimum	-0.095	-0.254
			Average	0.020	0.009

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1047	03/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1047	06/04/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	< 0.02
1047	09/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1047	12/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1047	03/15/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1047	06/10/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1047	09/23/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1049	01/14/98	< 0.5	< 0.5	< 0.5				< 4	
1049	02/11/98	< 0.5	< 0.5	< 0.5					
1049	03/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1049	06/04/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	< 0.02
1049	09/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1049	12/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1049	03/15/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1049	06/10/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1049	09/23/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1154	01/14/98	< 0.5	< 0.5	< 0.5				< 4	
1154	04/15/98	< 0.5	< 0.5	< 0.5					
1154	07/09/98	< 0.5	< 0.5	< 0.5					
1154	12/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1154	03/11/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1154	06/17/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			< 0.0075
1154	09/23/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1156	03/17/98	74	0.8	< 0.5	< 0.5	< 0.5		< 4	
1156	06/19/98	75	1.0	< 0.5	< 0.5	< 0.5		< 4	
1156	09/17/98	78	0.9	< 0.5	< 0.5	< 0.5		< 4	
1156	12/11/98	82	0.7	< 0.5	< 0.5	< 0.5			
1156	03/15/99	100	0.64	< 0.5	< 0.5	< 0.5			
1156	06/04/99	90	0.57	< 0.5	< 0.5	< 0.5			
1156	09/17/99	59	0.51	< 0.5	< 0.5	< 0.5	< 10		
1162	03/06/98	52	< 1	4.1	< 1	< 1		19	
1162	06/01/98								< 0.0075
1162	07/22/98	67	< 0.5	5.5	< 0.5	1.3	< 10	28	< 10
1162	07/13/99	140	< 0.5	1.8	< 0.5	1.4	< 10	100	
1163	03/06/98	< 1	< 1	< 1	< 1	< 1		160	
1163	06/01/98								< 0.0075
1163	07/22/98	0.7	< 0.5	< 0.5	< 0.5	< 0.5	< 10	160	< 10
1163	07/13/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	160	
1164	03/06/98	79	< 1	66	7.1	3.4		< 4	
1164	06/01/98								< 0.0075
1164	07/21/98	77	< 0.5	62	7.4	3.9	22	< 4	< 10
1164	07/13/99	36	< 0.5	42	2.2	1.8	16		
1169	01/19/98	54	< 0.5	1.4	< 0.5	1		6.4	
1169	04/29/98								< 0.02
1169	06/23/98	55	0.7	1.0	< 0.5	1.6		5.8	
1169	07/17/98	56	0.7	1	< 0.5	1.7	< 10	7.3	< 10
1169	10/09/98	80	0.8	3.4	< 0.5	3.3			
1169	01/04/99	100	0.98	4.1	< 0.5	4			
1169	04/26/99	120	1.4	5.4	< 0.5	5.3			
1169	N/S								
1170	01/19/98	1.8	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1170	04/29/98								< 0.02
1170	06/22/98	4.4	< 0.5	< 0.5	< 0.5	< 0.5			
1170	07/17/98	4	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1170	10/12/98	1.1	< 0.5	< 0.5	< 0.5	< 0.5			
1170	01/04/99	3.1	< 0.5	< 0.5	< 0.5	< 0.5			
1170	04/26/99	6.5	< 0.5	< 0.5	< 0.5	< 0.5			
1170	07/23/99	3.9	< 0.5	< 0.5	< 0.5	< 0.5		< 4	< 0.0075
1171	01/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1171	04/29/98								< 0.02
1171	06/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1171	07/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1171	10/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1171	01/04/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1171	04/09/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1171	07/23/99	2.8	< 0.5	< 0.5	< 0.5	< 0.5		< 4	< 0.0075
1211	03/05/98	120	6.5	7	4.8	15		37	
1211	07/22/98	87	5.4	5.3	3.7	11	< 10	26	< 10
1211	07/19/99	60	3.6	3.7	2.8	7.1	< 10	11	
1214	08/31/98	620	9.5	27	< 0.5	33	16	22	< 10
1214	09/16/99	220	3.6	11	< 0.5	14	< 10	86	
1216	08/31/98	400	6.7	15	< 0.5	19	11	12	< 10
1216	08/05/99	140	2.3	6.1	< 0.5	9.8	< 10	32	

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1361	03/19/98	52	< 0.5	2.7	< 0.5	0.8		48	
1361	06/23/98	53	< 0.5	1.7	< 0.5	0.8			
1361	07/24/98	57	< 0.5	1.5	< 0.5	1	< 10	69	< 10
1361	10/20/98	59	< 0.5	3.4	< 0.5	0.9			
1361	01/04/99	66	< 0.5	2	< 0.5	< 0.5			
1361	04/19/99	66	< 0.5	2.6	< 0.5	1.1			
1361	07/29/99	62	< 0.5	2.2	< 0.5	1.1	< 10	58	
1362	03/19/98	67	0.9	3	< 0.5	4.6		39	
1362	06/23/98	77	1.8	3.5	< 0.5	5.1			
1362	07/23/98	74	0.8	3.3	< 0.5	5.1	< 10	51	< 10
1362	10/20/98	81	0.7	5.6	< 0.5	6.6			
1362	01/04/99	86	0.63	4.4	< 0.5	5.9			
1362	04/19/99	71	0.56	3.3	< 0.5	4.8			
1362	07/29/99	72	0.68	2.3	< 0.5	5	< 10	54	
1363	03/19/98	74	1.6	5.3	3.5	7		27	
1363	06/23/98	68	1.2	4.8	3.3	6.7			
1363	07/23/98	66	1.3	5.4	3.2	6.5	< 10	36	< 10
1363	10/20/98	66	0.8	7.1	< 0.5	6.7			
1363	01/04/99	63	< 0.5	5.5	< 0.5	5.9			
1363	04/19/99	52	0.64	4.5	0.7	5.6			
1363	07/29/99	42	0.5	3.1	< 0.5	4.6	< 10	65	
1364	03/19/98	3.9	< 0.5	< 0.5	< 0.5	< 0.5		4.8	
1364	06/10/98	4.8	< 0.5	< 0.5	< 0.5	< 0.5		6.9	
1364	07/24/98	1.7	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1364	10/23/98	1.1	< 0.5	< 0.5	< 0.5	< 0.5			
1364	01/04/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1364	04/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1364	07/29/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1365	03/19/98	0.9	< 0.5	< 0.5	< 0.5	< 0.5		6.5	
1365	06/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1365	07/24/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1365	10/23/98	1.4	< 0.5	< 0.5	< 0.5	< 0.5			
1365	01/04/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1365	04/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1365	07/29/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1370	07/28/98	870	16	54	9.3	70	26	15	< 10
1370	07/14/99	790	14	45	4	68	21	25	
1371	07/28/98	950	12	30	9.6	58	12	19	< 10
1371	07/14/99	580	8.5	28	6.4	43	13	25	
1372	07/28/98	740	7.8	15	4.9	33	< 10	10	< 10
1372	07/14/99	830	7.7	22	3.9	43	< 10		
1373	07/28/98	2	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1373	07/14/99	4.3	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1374	07/22/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	
1375	06/01/98								< 0.0075
1375	07/31/98	200	13	19	34	29	13	17	< 10
1375	07/20/99	190	9	13	12	42	10		
1376	06/01/98								< 0.0075
1376	07/31/98	620	61	58	440	26	23	14	< 10
1376	07/20/99	500	50	54	270	23	25	17	
1377	06/01/98								< 0.0075
1377	07/31/98	510	26	39	350	17	10	< 4	< 10
1377	07/19/99	390	21	36	250	13	10	4.1	
1378	07/31/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1378	07/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	
1379	08/03/98	680	7.6	80	59	57	26	29	< 10
1379	08/04/99	560	6.4	78	54	49	28	18	
1380	07/31/98	220	24	1.7	130	9.2	23	23	< 10
1380	07/23/99	98	7.5	18	26	4.9	17	25	
1381	07/31/98	400	14	24	120	11	12	< 4	< 10
1381	07/23/99	470	28	40	210	16	14		
1382	02/27/98	230	6.1	9.6	< 1	45		67	
1382	07/31/98	190	4	7.9	< 0.5	38	11	81	< 10
1382	07/15/99	160	3.1	5.5	< 0.5	31	< 10	89	
1383	02/27/98							49	
1383	08/03/98	240	12	28	120	23	19	58	< 10
1383	07/15/99	170	6.4	18	53	18	14	69	
1384	02/27/98							21	
1384	08/03/98	270	8.7	48	240	16	16	24	< 10
1384	07/15/99	360	8	52	210	17	13	24	
1385	03/25/98	170	11	18	66	4.5		7.3	
1385	08/03/98	170	10	21	64	4.5	10	9.3	< 10
1385	08/09/99	100	6.8	18	40	3.2	< 10	9	

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1386	03/25/98	37	1.2	3.7	10	< 1		< 4	
1386	08/03/98	38	1	3.9	9.8	0.6	< 10	< 4	< 10
1386	08/09/99	45	1.4	6.3	12	0.54	< 10		
1387	03/25/98	< 1	< 1	< 1	< 1	< 1		< 4	
1387	08/03/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1387	08/09/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1388	08/10/98	550	18	72	160	72	30	40	< 10
1388	08/06/99	280	8.3	18	25	50	12	68	
1389	08/10/98	580	6.5	110	140	39	25	7.7	< 10
1389	08/05/99	370	3.2	71	53	29	20	4.4	
1390	08/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1390	08/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1391	06/02/98								< 0.0075
1391	08/14/98	220	3.4	13	< 0.5	16	11	56	< 10
1391	07/21/99	180	2.9	7.5	< 0.5	15	11	49	
1392	06/02/98								< 0.0075
1392	08/14/98	270	4	12	6	24	12	78	< 10
1392	07/21/99	320	4.8	12	1.4	29	10	53	
1393	06/02/98								< 0.0075
1393	08/14/98	1100	17	87	120	89	40	28	< 10
1393	07/21/99	860	13	65	55	75	32	22	
1394	08/14/98	52	< 0.5	2.6	< 0.5	6.1	< 10	< 4	< 10
1394	07/21/99	17	< 0.5	< 0.5	< 0.5	2.2	< 10		
1395	04/08/98								< 0.02
1395	06/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1395	08/24/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1395	11/05/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1395	02/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1395	05/28/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1395	08/10/99	0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1396	04/08/98								< 0.02
1396	06/08/98	0.9	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1396	08/24/98	1.9	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1396	11/05/98	1.1	< 0.5	< 0.5	< 0.5	< 0.5			
1396	02/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1396	05/28/99	1.1	< 0.5	< 0.5	< 0.5	< 0.5			
1396	08/10/99	1.4	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1397	04/07/98								< 0.02
1397	06/08/98	91	1	< 0.5	< 0.5	2.4		< 4	
1397	08/24/98	81	0.8	< 0.5	< 0.5	2.1	< 10	< 4	< 10
1397	11/05/98	99	0.7	< 0.5	< 0.5	2.1			
1397	02/12/99	75	< 0.5	< 0.5	< 0.5	2			
1397	05/28/99	81	< 0.5	< 0.5	< 0.5	2			
1397	08/10/99	60	0.84	< 0.5	< 0.5	1.1	< 10		
1398	06/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1398	08/24/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1398	11/05/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1398	02/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1398	05/28/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1398	08/10/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1399	06/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1399	08/24/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1399	11/05/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1399	02/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1399	05/28/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1399	08/10/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1400	03/03/98	250	4.6	12	8	24		35	
1400	08/18/98	88	1.2	2.3	3.2	6.9	< 10	86	< 10
1400	08/04/99	27	< 0.5	0.76	< 0.5	2.4	< 10	130	
1401	03/02/98	300	4.8	41	13	30		17	
1401	08/18/98	550	5.4	43	20	31	16	19	< 10
1401	08/04/99	400	4.5	35	8.6	28	< 10	15	
1402	03/02/98	68	< 1	3.8	2.8	4.7		4.1	
1402	08/19/98	210	0.9	22	< 0.5	19	< 10	9.2	< 10
1402	08/05/99	76	< 0.5	6.4	< 0.5	11	< 10		
1403	08/05/98	200	5.7	14	3.6	34	10	< 4	< 10
1403	08/04/99	670	15	36	6.4	120	< 10	14	
1404	08/05/98	720	19	73	91	80	33	32	< 10
1404	08/04/99	460	10	34	31	52	11	59	
1405	08/05/98	2100	30	80	69	160	26	39	< 10
1405	08/04/99	2400	49	70	46	150	23	41	
1406	01/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1406	06/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1406	07/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1406	10/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1406	01/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1406	04/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1406	07/22/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1407	01/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1407	06/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1407	07/21/98	1.6	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1407	10/21/98	0.6	< 0.5	< 0.5	< 0.5	< 0.5			
1407	01/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1407	04/19/99	0.98	< 0.5	< 0.5	< 0.5	< 0.5			
1407	07/22/99	1	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	
1408	01/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1408	06/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1408	07/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1408	10/21/98	0.8	< 0.5	< 0.5	< 0.5	< 0.5			
1408	01/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1408	04/19/99	0.65	< 0.5	< 0.5	< 0.5	< 0.5			
1408	07/22/99	1.2	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1409	01/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1409	06/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1409	07/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1409	10/23/98	3	< 0.5	< 0.5	< 0.5	< 0.5			
1409	01/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1409	04/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1409	07/22/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1469	08/19/98	1100	18	58	< 0.5	42	18		< 10
1469	08/05/99	560	5.7	18	< 0.5	18	10		
1470	08/19/98	530	5	11	3.3	23	< 10	9.1	< 10
1470	08/05/99	620	4.9	15	< 0.5	27	< 10	10	
1471	08/20/98	180	2.6	26	< 0.5	15	11	6.9	< 10
1471	08/06/99	150	2.8	13	< 0.5	14	10		
1472	08/21/98	210	7.2	12	3.7	38	10	< 4	< 10
1472	08/12/99	110	4.2	5.6	2.8	16	< 10		
1473	08/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1473	08/13/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1474	08/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1474	08/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1475	02/25/98	66	1.6	< 1	< 1	4.3		30	
1475	08/20/98	67	1.4	0.6	< 0.5	4.6	< 10	28	< 10
1475	08/12/99	50	1.2	< 0.5	< 0.5	3.3	< 10	39	
1476	02/25/98	1.3	< 1	< 1	< 1	< 1		170	
1476	08/20/98	1	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1476	08/12/99	0.57	< 0.5	< 0.5	< 0.5	< 0.5	< 10	180	
1477	02/25/98	190	9.5	26	88	13		63	
1477	08/20/98	200	9.4	28	91	12	16	< 4	< 10
1477	08/12/99	180	8.1	27	90	12	14	69	
1478	03/10/98	39	1.1	< 0.5	< 0.5	< 0.5		< 4	
1478	06/18/98	24	0.5	< 0.5	< 0.5	< 0.5			
1478	09/04/98	16	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1478	12/03/98	5.4	< 0.5	< 0.5	< 0.5	< 0.5			
1478	03/05/99	11	< 0.5	< 0.5	< 0.5	< 0.5			
1478	06/01/99	5.2	< 0.5	< 0.5	< 0.5	< 0.5			
1478	09/20/99	4	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1479	03/10/98	430	16	36	17	56		13	
1479	06/18/98	1800	18	18	19	50			
1479	09/04/98	1900	19	41	19	64	< 10	13	< 10
1479	12/03/98	1700	16	36	19	52			
1479	03/05/99	2300	20	49	35	65			
1479	06/01/99	670	9.9	22	21	33			
1479	09/20/99	1100	13	28	17	41	< 10	11	
1480	03/09/98	210	2	< 0.5	< 0.5	3.1		< 4	
1480	06/18/98	220	2.3	< 0.5	< 0.5	3.4			
1480	09/04/98	230	2.1	< 0.5	< 0.5	3.8	< 10	< 4	< 10
1480	12/03/98	220	1.9	< 0.5	< 0.5	< 0.5			
1480	03/05/99	510	3.1	< 0.5	< 0.5	5.1			
1480	03/05/99	530	3.1	< 0.5	< 0.5	5.2			
1480	06/01/99	860	7.5	0.95	< 0.5	13			
1480	09/20/99	330	3.4	1.5	< 0.5	6.1	< 10		
1481	07/31/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1481	07/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1482	07/31/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1482	07/19/99	1.9	< 0.5	< 0.5	< 0.5	< 0.5	< 10		

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1483	07/31/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1483	07/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1487	03/12/98	3.5	< 0.5	< 0.5	< 0.5	< 0.5			
1487	04/06/98								< 0.02
1487	06/19/98	2.9	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1487	09/03/98	5.1	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1487	12/04/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1487	03/09/99	7.4	< 0.5	< 0.5	< 0.5	< 0.5			
1487	06/02/99	2.4	< 0.5	< 0.5	< 0.5	< 0.5			
1487	09/22/99	0.56	< 0.5	< 0.5	< 0.5	< 0.5			
1488	03/13/98	110	0.7	< 0.5	< 0.5	3.3		5.5	
1488	04/06/98								< 0.02
1488	06/19/98	88	0.6	< 0.5	< 0.5	2.8		4.8	
1488	09/03/98	86	0.9	< 0.5	< 0.5	2.5	< 10	4.4	< 10
1488	12/04/98	79	< 0.5	< 0.5	< 0.5	1.5			
1488	03/09/99	170	< 0.5	< 0.5	< 0.5	3			
1488	06/02/99	89	< 0.5	< 0.5	< 0.5	3.2			
1488	09/22/99	61	< 0.5	< 0.5	< 0.5	1.9		< 4	
1489	06/19/98	220	2	< 0.5	< 0.5	4.1		< 4	
1489	09/03/98	230	2	0.7	< 0.5	4.3	< 10	< 4	< 10
1489	12/04/98	220	2.3	< 0.5	< 0.5	3			
1489	03/05/99	300	2.6	< 0.5	< 0.5	5.3			
1489	06/02/99	270	1.8	< 1	< 0.5	4.8			
1489	09/22/99	220	2.3	3.2	0.83	6.4			
1506	03/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1506	06/01/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			< 0.0075
1506	09/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1506	12/04/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1506	03/09/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1506	06/08/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1506	09/27/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1507	03/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1507	06/01/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			< 0.0075
1507	09/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		< 10
1507	12/04/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1507	03/09/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1507	06/08/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1507	09/22/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1508	03/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1508	06/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1508	09/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		< 10
1508	12/04/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1508	03/09/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1508	06/08/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1508	09/22/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1509	03/13/98	53	< 0.5	< 0.5	< 0.5	0.8			
1509	06/10/98	50	< 0.5	< 0.5	< 0.5	0.7		< 4	
1509	09/03/98	47	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1509	12/10/98	62	0.6	< 0.5	< 0.5	< 0.5			
1509	03/12/99	71	0.52	< 0.5	< 0.5	0.85			
1509	06/03/99	100	0.87	< 0.5	< 0.5	1.9			
1509	09/17/99	150	1.3	< 0.5	< 0.5	2.5	< 10		
1510	03/13/98	1.2	< 0.5	< 0.5	< 0.5	< 0.5			
1510	06/10/98	1.1	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1510	09/03/98	0.8	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1510	12/08/98	0.8	< 0.5	< 0.5	< 0.5	< 0.5			
1510	03/12/99	1.5	< 0.5	< 0.5	< 0.5	< 0.5			
1510	06/03/99	1.3	< 0.5	< 0.5	< 0.5	< 0.5			
1510	09/17/99	1.2	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1511	03/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1511	06/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1511	09/03/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1511	12/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1511	03/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1511	06/03/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1511	09/17/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1519	07/29/98	4.3	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1519	07/20/99	4.1	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1520	07/28/98	54	< 0.5	< 0.5	< 0.5	0.9	< 10	< 4	< 10
1520	07/20/99	130	0.81	< 0.5	< 0.5	2.1	< 10		
1521	07/20/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1522	07/29/98	6.1	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1522	07/21/99	13	< 0.5	< 0.5	< 0.5	< 0.5	< 10		

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1523	07/29/98	92	1.1	< 0.5	< 0.5	3.1	< 10	< 4	< 10
1523	07/21/99	69	0.58	< 0.5	< 0.5	2.4	< 10		
1524	07/29/98	58	0.7	< 0.5	< 0.5	0.6	< 10	< 4	< 10
1524	07/21/99	57	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1525	01/20/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1525	06/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1525	07/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1525	10/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1525	01/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1525	04/15/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1525	07/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1526	01/20/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1526	06/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1526	07/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1526	10/13/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1526	01/05/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1526	01/05/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1526	04/15/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1526	07/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1527	01/20/98	4.2	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1527	06/18/98	5.4	< 0.5	< 0.5	< 0.5	< 0.5			
1527	07/16/98	4.8	< 0.5	< 0.5	< 0.5	< 0.5	< 10		< 10
1527	10/13/98	7.8	< 0.5	< 0.5	< 0.5	< 0.5			
1527	01/05/99	7.8	< 0.5	< 0.5	< 0.5	< 0.5			
1527	04/15/99	7.3	< 0.5	< 0.5	< 0.5	< 0.5			
1527	07/12/99	8.3	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1528	01/20/98	< 0.5	0.8	< 0.5	< 0.5	< 0.5		< 4	
1528	06/11/98	< 0.5	1.0	< 0.5	< 0.5	< 0.5		< 4	
1528	07/22/98	< 0.5	0.9	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1528	01/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1528	04/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1528	07/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1529	01/20/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1529	06/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1529	07/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1529	10/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1529	01/05/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1529	04/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1529	07/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1530	01/20/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1530	06/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1530	07/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1530	10/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1530	01/05/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1530	04/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1530	07/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1531	03/12/98	19	< 0.5	< 0.5	< 0.5	< 0.5			
1531	07/20/98	7.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1531	10/19/98	19	< 0.5	< 0.5	< 0.5	< 0.5			
1531	01/07/99	17	< 0.5	< 0.5	< 0.5	< 0.5			
1531	04/16/99	13	< 0.5	< 0.5	< 0.5	< 0.5			
1531	07/13/99	13	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1532	03/12/98	6.9	< 0.5	< 0.5	< 0.5	< 0.5			
1532	07/20/98	9	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1532	10/19/98	7.7	< 0.5	< 0.5	< 0.5	< 0.5			
1532	01/07/99	6.1	< 0.5	< 0.5	< 0.5	< 0.5			
1532	04/16/99	4.7	< 0.5	< 0.5	< 0.5	< 0.5			
1532	07/13/99	6.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1533	03/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1533	07/20/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1533	10/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1533	01/07/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1533	04/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1533	07/13/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1538	02/12/98	5.7	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1538	04/06/98								< 0.02
1538	06/16/98	6.3	< 0.5	< 0.5	< 0.5	< 0.5			
1538	08/28/98	3.2	< 0.5	< 0.5	< 0.5	< 0.5	< 10		< 10
1538	Dry								
1539	02/12/98	41	0.8	< 0.5	< 0.5	0.7		< 4	
1539	04/06/98								< 0.02
1539	06/15/98	76	1.1	< 0.5	< 0.5	1.7			
1539	08/28/98	52	< 0.5	< 0.5	< 0.5	1.1	< 10	< 4	< 10

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1539	11/06/98	120	0.8	< 0.5	< 0.5	2.8			
1539	02/10/99	33	< 0.5	< 0.5	< 0.5	< 0.5			
1539	05/24/99	23	< 0.5	< 0.5	< 0.5	< 0.5			
1539	08/16/99	42	< 0.5	< 0.5	< 0.5	0.62	< 10		
1540	02/12/98	130	0.9	< 0.5	< 0.5	3		< 4	
1540	04/06/98								< 0.02
1540	06/15/98	88	0.9	< 0.5	< 0.5	1.8			
1540	08/28/98	130	1	< 0.5	< 0.5	3.3	< 10		< 10
1540	11/06/98	200	1.5	< 0.5	< 0.5	5.4			
1540	02/10/99	150	1.3	< 0.5	< 0.5	4.4			
1540	05/24/99	100	< 0.5	< 0.5	< 0.5	2.7			
1540	08/16/99	45	< 0.5	< 0.5	< 0.5	0.72	< 10		
1557	01/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1557	02/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1557	03/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1557	06/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1557	09/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1557	12/07/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1557	03/05/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1557	06/01/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1557	09/21/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1558	01/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1558	02/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1558	03/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1558	06/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1558	09/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1558	12/07/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1558	03/05/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1558	06/01/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1558	09/21/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1559	01/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1559	02/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1559	03/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1559	04/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1559	06/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1559	09/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1559	12/07/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1559	03/05/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1559	06/04/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1559	09/20/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1560	01/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1560	02/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1560	03/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1560	04/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1560	06/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1560	09/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		< 10
1560	12/07/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1560	03/05/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1560	06/04/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1560	09/20/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1561	01/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1561	02/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1561	03/18/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1561	04/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1561	06/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1561	09/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1561	12/07/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1561	03/05/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1561	06/04/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1561	09/20/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1562	07/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1562	07/19/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1563	07/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1563	07/20/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1564	03/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1564	04/07/98								< 0.02
1564	06/17/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1564	07/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1564	10/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1564	01/07/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1564	04/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1564	07/23/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	
1565	03/11/98	1.0	< 0.5	< 0.5	< 0.5	< 0.5		< 4	

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1565	04/07/98								< 0.02
1565	06/17/98	0.7	< 0.5	< 0.5	< 0.5	< 0.5			
1565	07/21/98	0.8	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1565	10/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1565	01/07/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1565	04/12/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1565	07/23/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	
1566	03/11/98	4.7	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1566	04/07/98								< 0.02
1566	06/17/98	3.9	< 0.5	< 0.5	< 0.5	< 0.5			
1566	07/21/98	3.2	< 0.5	< 0.5	< 0.5	< 0.5	< 10		< 10
1566	10/16/98	9.7	< 0.5	< 0.5	< 0.5	< 0.5			
1566	01/07/99	14	< 0.5	< 0.5	< 0.5	< 0.5			
1566	04/12/99	12	< 0.5	< 0.5	< 0.5	< 0.5			
1566	07/23/99	7.2	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	
1567	03/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1567	06/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1567	09/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1567	12/03/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1567	03/08/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1567	06/09/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1567	09/21/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1568	03/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1568	06/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1568	09/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1568	12/03/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1568	03/08/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1568	06/09/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1568	09/21/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	
1569	03/11/98	15	0.7	< 0.5	< 0.5	< 0.5		< 4	
1569	06/08/98	16	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1569	09/02/98	13	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1569	12/03/98	13	< 0.5	< 0.5	< 0.5	< 0.5			
1569	03/08/99	7.3	< 0.5	< 0.5	< 0.5	< 0.5			
1569	06/09/99	7.5	< 0.5	< 0.5	< 0.5	< 0.5			
1569	09/21/99	4.7	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1570	03/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1570	06/08/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1570	09/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1570	12/03/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1570	03/08/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1570	06/09/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1570	09/21/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1571	03/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1571	06/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1571	09/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1571	12/07/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1571	03/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1571	06/10/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1571	09/21/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1572	03/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1572	06/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1572	09/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1572	12/07/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1572	03/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1572	06/10/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1572	09/21/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1573	03/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1573	04/07/98								< 0.02
1573	06/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			< 0.0075
1573	09/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1573	12/07/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1573	03/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1573	06/10/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1573	09/21/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1574	03/12/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1574	06/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1574	09/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1574	12/07/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1574	03/15/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1574	09/21/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1585	02/11/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1585	06/16/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1585	08/24/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1585	11/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1585	02/10/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1585	05/25/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1585	08/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1586	02/11/98	4.3	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1586	06/16/98	3.2	< 0.5	< 0.5	< 0.5	< 0.5			
1586	08/24/98	3	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1586	11/09/98	5.8	< 0.5	< 0.5	< 0.5	< 0.5			
1586	02/10/99	4.9	< 0.5	< 0.5	< 0.5	< 0.5			
1586	05/25/99	4.9	< 0.5	< 0.5	< 0.5	< 0.5			
1586	08/13/99	3.1	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1587	02/11/98	13	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1587	06/16/98	17	< 0.5	< 0.5	< 0.5	< 0.5			
1587	08/24/98	17	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1587	11/09/98	15	< 0.5	< 0.5	< 0.5	< 0.5			
1587	02/10/99	12	< 0.5	< 0.5	< 0.5	< 0.5			
1587	05/24/99	16	< 0.5	< 0.5	< 0.5	< 0.5			
1587	08/13/99	12	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1588	02/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1588	06/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1588	08/25/98	0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1588	11/10/98	1	< 0.5	< 0.5	< 0.5	< 0.5			
1588	02/16/99	0.95	< 0.5	< 0.5	< 0.5	< 0.5			
1588	05/25/99	2	< 0.5	< 0.5	< 0.5	< 0.5			
1588	08/13/99	1	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1589	02/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1589	06/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1589	08/25/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1589	11/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1589	02/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1589	05/26/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1589	08/13/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1590	02/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1590	06/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1590	08/25/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1590	11/10/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1590	02/11/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1590	05/26/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1590	08/13/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1591	02/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1591	08/25/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1591	11/06/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1591	02/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1591	05/27/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1591	08/25/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1592	02/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1592	08/25/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1592	11/06/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1592	02/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1592	05/28/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1592	08/25/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1593	02/09/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1593	08/25/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1593	11/06/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1593	02/16/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1593	05/27/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1593	08/25/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1594	01/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1594	02/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1594	03/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1594	06/15/98	0.8	< 0.5	< 0.5	< 0.5	< 0.5			
1594	07/30/98	0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1594	10/21/98	1	< 0.5	< 0.5	< 0.5	< 0.5			
1594	01/06/99	0.8	< 0.5	< 0.5	< 0.5	< 0.5			
1594	04/20/99	1.2	< 0.5	< 0.5	< 0.5	< 0.5			
1594	07/28/99	0.79	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
1595	01/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1595	02/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1595	03/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1595	06/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1595	07/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1595	10/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			

Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
1595	01/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1595	04/20/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1595	07/28/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	
1596	01/22/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
1596	02/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1596	03/19/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1596	06/15/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1596	07/30/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
1596	10/21/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1596	01/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1596	04/20/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
1596	07/28/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	
4300	06/25/98	< 1	< 1	< 1	< 1	< 1			
4300	09/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 0.0075
4300	10/14/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
4300	11/15/98	0.6	< 0.5	< 0.5	< 0.5	< 0.5			
4300	02/06/99	0.8	< 0.5	< 0.5	< 0.5	< 0.5			
4300	04/25/99	1.5	< 0.5	< 0.5	< 0.5	< 0.5			< 0.0075
4300	07/15/99	2.9	< 0.5	< 0.5	< 0.5	< 0.5			
4301	09/02/98	62	< 0.5	< 0.5	< 0.5	1.3	< 10	< 4	< 10
4301	10/14/98	86	0.8	< 0.5	< 0.5	1.5			
4301	02/06/99	84	0.93	< 0.5	< 0.5	1.3			
4301	04/25/99	61	< 0.5	< 0.5	< 0.5	1.2			
4301	07/15/99	61	< 0.5	< 0.5	< 0.5	1.7			
4302	09/02/98	79	0.8	< 0.5	< 0.5	1.4	< 10	< 4	< 10
4302	10/14/98	68	0.6	< 0.5	< 0.5	0.8			
4302	02/06/99	77	< 0.5	< 0.5	< 0.5	1			
4302	04/25/99	53	< 0.5	< 0.5	< 0.5	0.83			
4302	07/15/99	56	< 0.5	< 0.5	< 0.5	1.4			
4325	09/23/98	450	14	29	< 0.5	55	12	12	< 0.0075
4325	10/29/98	460	12	33	2.8	53			
4325	02/05/99	360	10	34	1.2	46			
4325	04/22/99	270	7.5	20	2.8	33			
4325	07/09/99	210	6.5	19	< 0.5	31			
4330	09/23/98	1600	24	59	43	120	19	26	< 0.0075
4330	10/29/98	1800	21	72	24	150			
4330	02/05/99	1300	18	110	76	91			
4330	04/22/99	950	14	74	64	81			
4330	07/09/99	700	12	38	14	76			
4335	09/23/98	1100	16	72	41	89	18	21	< 0.0075
4335	10/29/98	1500	16	84	44	94			
4335	02/05/99	1100	22	68	26	110			
4335	04/22/99	800	14	41	13	82			
4335	07/09/99	990	14	71	52	75			
4340	09/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
4340	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
4340	02/06/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
4340	04/29/99	5.2	< 0.5	< 0.5	< 0.5	< 0.5			
4340	07/15/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
4345	09/02/98	0.7	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
4345	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
4345	02/06/99	0.9	< 0.5	< 0.5	< 0.5	< 0.5			
4345	04/29/99	1.5	< 0.5	< 0.5	< 0.5	< 0.5			
4345	07/15/99	1.6	< 0.5	< 0.5	< 0.5	< 0.5			
4350	09/02/98	3.4	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
4350	10/28/98	3.7	< 0.5	< 0.5	< 0.5	< 0.5			
4350	02/06/99	3.5	< 0.5	< 0.5	< 0.5	< 0.5			
4350	04/29/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
4350	07/15/99	3.7	< 0.5	< 0.5	< 0.5	< 0.5			
4355	09/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
4355	10/28/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5			
4355	02/06/99	3.2	< 0.5	< 0.5	< 0.5	< 0.5			
4355	04/28/99	2.9	< 0.5	< 0.5	< 0.5	< 0.5			
4355	07/15/99	2.7	< 0.5	< 0.5	< 0.5	< 0.5			
4360	09/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
4360	10/28/98	1.8	< 0.5	< 0.5	< 0.5	< 0.5			
4360	02/06/99	8.4	< 0.5	< 0.5	< 0.5	< 0.5			
4360	04/28/99	16	< 0.5	< 0.5	< 0.5	< 0.5			
4360	07/15/99	18	< 0.5	< 0.5	< 0.5	< 0.5			
4365	09/02/98	3.3	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 10
4365	10/28/98	5.4	< 0.5	< 0.5	< 0.5	< 0.5			
4365	02/06/99	14	< 0.5	< 0.5	< 0.5	< 0.5			
4365	04/28/99	25	< 0.5	< 0.5	< 0.5	< 0.5			

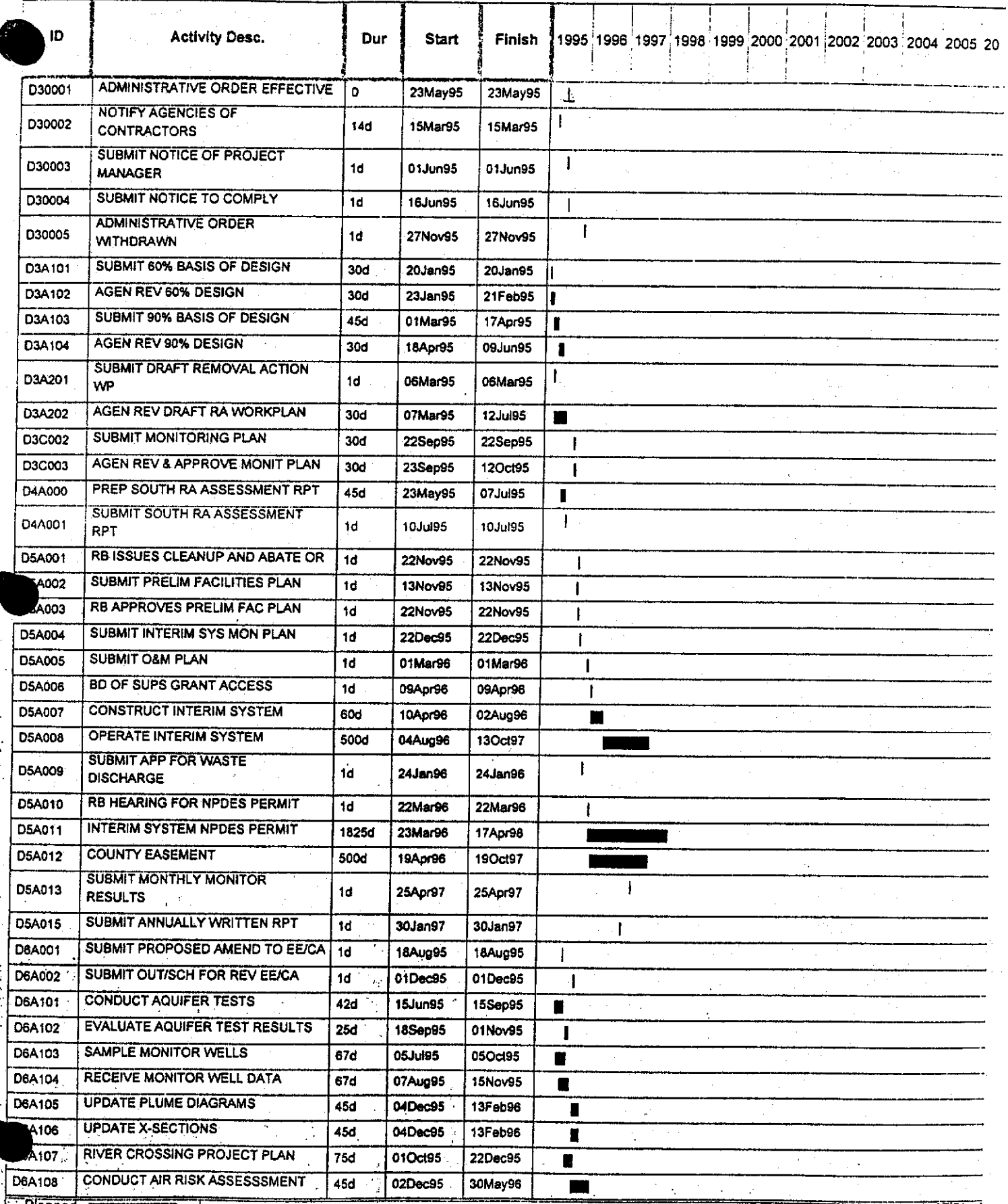
Table 3-5
American River Study Area
Analytical Results for Selected Chemicals - 1998-1999

Well Number	Sample Date	TCE (ug/l)	PCE (ug/l)	1,1-DCE (ug/l)	Freon 113 (ug/l)	1,2-DCE (ug/l)	1,4-Dioxane (ug/l)	Perchlorate (ug/l)	NDMA (ug/l)
4365	07/15/99	29	< 0.5	< 0.5	< 0.5	< 0.5			
4370	09/02/98	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 0.1
4370	11/15/98	5.6	< 0.5	< 0.5	< 0.5	< 0.5			
4370	01/23/99	5.7	< 0.5	< 0.5	< 0.5	< 0.5			
4370	04/24/99	8.9	< 0.5	< 0.5	< 0.5	< 0.5			
4370	07/09/99	8.6	< 0.5	< 0.5	< 0.5	< 0.5			
4375	09/02/98	6.7	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 0.1
4375	11/15/98	2.1	< 0.5	< 0.5	< 0.5	< 0.5			
4375	01/23/99	4.4	< 0.5	< 0.5	< 0.5	< 0.5			
4375	04/24/99	7	< 0.5	< 0.5	< 0.5	< 0.5			
4375	07/09/99	6.1	< 0.5	< 0.5	< 0.5	< 0.5			
4380	09/02/98	1.1	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 4	< 0.1
4380	11/15/98	1.7	< 0.5	< 0.5	< 0.5	< 0.5			
4380	01/23/99	1.6	< 0.5	< 0.5	< 0.5	< 0.5			
4380	04/24/99	2.6	< 0.5	< 0.5	< 0.5	< 0.5			
4380	07/09/99	4.9	< 0.5	< 0.5	< 0.5	< 0.5			
30068	02/16/98	930	20	63	15	71		20	
30068	06/17/98	360	19	67	11	79			
30068	08/27/98	750	16	61	< 0.5	74	23	27	< 10
30068	11/09/98	920	13	42	4.8	69			
30068	02/11/99	830	10	34	6.6	60			
30068	05/26/99	710	12	39	5.5	62			
30068	08/24/99	600	8.8	29	5.9	44	16	32	
30069	02/02/98	78	< 0.5	1.8	< 0.5	3.8		< 4	
30069	06/17/98	100	< 0.5	2.8	< 0.5	5.4			
30069	08/26/98	120	0.8	3	< 0.5	5.8	< 10	< 4	< 10
30069	11/09/98	140	1.1	3.3	< 0.5	7.2			
30069	02/11/99	160	1	4	< 0.5	9.7			
30069	05/27/99	200	1.6	6.5	< 0.5	13			
30069	08/24/99	180	1.7	5.6	< 0.5	11	< 10		
30070	02/02/98	12	< 0.5	< 0.5	< 0.5	< 0.5		10	
30070	06/17/98	20	< 0.5	< 0.5	< 0.5	1.6			
30070	08/27/98	18	< 0.5	0.6	< 0.5	1.6	< 10	< 4	< 10
30070	11/10/98	4.3	< 0.5	< 0.5	< 0.5	< 0.5			
30070	02/12/99	36	< 0.5	0.83	< 0.5	2.5			
30070	05/27/99	12	< 0.5	< 0.5	< 0.5	< 0.5			
30070	08/25/99	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10		
30100	03/16/98	290	13	40	6.7	47			
30100	04/06/98								< 0.02
30100	05/06/98								< 0.0075
30100	06/11/98	700	19	46	7.9	66			
30100	09/10/98	480	12	33	7.2	61	17	22	< 10
30100	12/08/98	150	3.8	10	< 0.5	16			
30100	03/08/99	83	1.9	3.4	< 0.5	16			
30100	06/04/99	4.6	< 0.5	< 0.5	< 0.5	1.4			
30100	09/23/99	1.5	< 0.5	< 0.5	< 0.5	< 0.5		< 4	
30101	03/16/98	430	19	80	52	120			
30101	04/06/98								< 0.02
30101	06/11/98	2400	37	81	63	150			
30101	09/10/98	2400	29	99	63	150	25	30	< 10
30101	12/08/98	3300	32	100	48	160			
30101	03/08/99	2700	27	81	40	140			
30101	06/07/99	820	21	63	23	110			
30101	09/23/99	950	17	52	16	77		28	
30102	03/16/98	400	28	88	51	150			
30102	04/06/98								< 0.02
30102	06/11/98	1800	20	47	55	100		26	
30102	09/10/98	1700	21	76	68	110	27	26	< 10
30102	12/08/98	1100	15	95	110	85			
30102	03/08/99	1100	13	76	88	71			
30102	06/07/99	940	15	72	120	61			
30102	09/23/99	810	12	53	110	44		15	
30103	03/18/98	40	< 0.5	3.4	< 0.5	17		< 4	
30103	06/12/98	37	< 0.5	0.9	< 0.5	7.3		< 4	
30103	09/11/98	32	< 0.5	< 0.5	< 0.5	4.3	< 10	< 4	< 10
30103	12/09/98	16	< 0.5	< 0.5	< 0.5	1.8			
30103	03/09/99	16	< 0.5	< 0.5	< 0.5	< 0.5			
30103	06/08/99	7.3	< 0.5	< 0.5	< 0.5	< 0.5			
30103	09/24/99	31	< 0.5	0.61	< 0.5	1.6		< 4	

Project: ARSA
Time Now: 07Feb00
Start: 01Jan95
Finish: 18Aug03
Run: 02/14/2000

Table 4-1
American River Study Area
Project Schedule

ID	Activity Desc.	Dur	Start	Finish
D30001	ADMINISTRATIVE ORDER EFFECTIVE	0	23May95	23May95
D30002	NOTIFY AGENCIES OF CONTRACTORS	14d	15Mar95	15Mar95
D30003	SUBMIT NOTICE OF PROJECT MANAGER	1d	01Jun95	01Jun95
D30004	SUBMIT NOTICE TO COMPLY	1d	16Jun95	16Jun95
D30005	ADMINISTRATIVE ORDER WITHDRAWN	1d	27Nov95	27Nov95
D3A101	SUBMIT 60% BASIS OF DESIGN	30d	20Jan95	20Jan95
D3A102	AGEN REV 60% DESIGN	30d	23Jan95	21Feb95
D3A103	SUBMIT 90% BASIS OF DESIGN	45d	01Mar95	17Apr95
D3A104	AGEN REV 90% DESIGN	30d	18Apr95	09Jun95
D3A201	SUBMIT DRAFT REMOVAL ACTION WP	1d	06Mar95	06Mar95
D3A202	AGEN REV DRAFT RA WORKPLAN	30d	07Mar95	12Jul95
D3C002	SUBMIT MONITORING PLAN	30d	22Sep95	22Sep95
D3C003	AGEN REV & APPROVE MONIT PLAN	30d	23Sep95	12Oct95
D4A000	PREP SOUTH RA ASSESSMENT RPT	45d	23May95	07Jul95
D4A001	SUBMIT SOUTH RA ASSESSMENT RPT	1d	10Jul95	10Jul95
D5A001	RB ISSUES CLEANUP AND ABATE OR	1d	22Nov95	22Nov95
[illegible]A002	SUBMIT PRELIM FACILITIES PLAN	1d	13Nov95	13Nov95
[illegible]A003	RB APPROVES PRELIM FAC PLAN	1d	22Nov95	22Nov95
D5A004	SUBMIT INTERIM SYS MON PLAN	1d	22Dec95	22Dec95
D5A005	SUBMIT O&M PLAN	1d	01Mar96	01Mar96
D5A006	BD OF SUPS GRANT ACCESS	1d	09Apr96	09Apr96
D5A007	CONSTRUCT INTERIM SYSTEM	60d	10Apr96	02Aug96
D5A008	OPERATE INTERIM SYSTEM	500d	04Aug96	13Oct97
D5A009	SUBMIT APP FOR WASTE DISCHARGE	1d	24Jan96	24Jan96
D5A010	RB HEARING FOR NPDES PERMIT	1d	22Mar96	22Mar96
D5A011	INTERIM SYSTEM NPDES PERMIT	1825d	23Mar96	17Apr98
D5A012	COUNTY EASEMENT	500d	19Apr96	19Oct97
D5A013	SUBMIT MONTHLY MONITOR RESULTS	1d	25Apr97	25Apr97
D5A015	SUBMIT ANNUALLY WRITTEN RPT	1d	30Jan97	30Jan97
D6A001	SUBMIT PROPOSED AMEND TO EE/CA	1d	18Aug95	18Aug95
D6A002	SUBMIT OUT/SCH FOR REV EE/CA	1d	01Dec95	01Dec95
D6A101	CONDUCT AQUIFER TESTS	42d	15Jun95	15Sep95
D6A102	EVALUATE AQUIFER TEST RESULTS	25d	18Sep95	01Nov95
D6A103	SAMPLE MONITOR WELLS	67d	05Jul95	05Oct95
D6A104	RECEIVE MONITOR WELL DATA	67d	07Aug95	15Nov95
D6A105	UPDATE PLUME DIAGRAMS	45d	04Dec95	13Feb96
[illegible]A106	UPDATE X-SECTIONS	45d	04Dec95	13Feb96
[illegible]A107	RIVER CROSSING PROJECT PLAN	75d	01Oct95	22Dec95
D6A108	CONDUCT AIR RISK ASSESSSMENT	45d	02Dec95	30May96



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Project: ARSA
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Table 4-1
American River Study Area
Project Schedule

ID	Activity Desc.	Dur	Start	Finish
D6A109	EVAL TRMT/DISCHG ALTERNATIVES	59d	23Jan96	29Mar96
D6A110	COMPLETE NATIONAL ENV SURVEY	30d	01Oct95	15Nov95
D6A111	PREPARE REVISED EE/CA	30d	01Apr96	28May96
D6A112	SUBMIT DRAFT REVISED EE/CA	1d	28May96	28May96
D6A113	AGEN COMM ON DRAFT REV EE/CA	30d	29May96	08Aug96
D6A114	REVISE SUBMIT FINAL REV EE/CA	30d	09Aug96	13Sep96
D6A115	CONDUCT PUBLIC MTG	1d	05Sep96	05Sep96
D6A119	BOARD OF SUPERVISORS HEARING	45d	17Jun97	24Jun97
D6A120	RB ISSUES CLEAN & ABATE ORDER	1d	20Sep96	20Sep96
D6A121	SUBMIT SCHEDULE	1d	01Nov96	01Nov96
D6A201	PREPARE INITIAL STUDY	39d	26Jul96	14Nov96
D6A202	SUBMIT INITIAL STUDY TO DERA	1d	15Nov96	15Nov96
D6A203	DERA REVIEWS INITIAL STUDY	30d	16Nov96	06Jan97
D6A204	REVISE & SUBMIT INITIAL STUDY	60d	07Jan97	06Mar97
D6A205	DERA REV, PROVIDES COM ON IS	30d	07Mar97	28Mar97
D6A205A	ESA REVISES INITIAL STUDY	5d	01Apr97	13Apr97
D6A205B	DERA REV IS; ISS MIT NEG DEC	4d	08Apr97	14Apr97
D6A206	CEQA PUBLIC COMMENT	30d	14Apr97	14May97
D6A207	RESPOND TO PUBLIC COMMENTS	30d	14May97	16Jun97
[illegible]A301	PREPARE AND SUBMIT NPDES APP	14d	02Sep97	31Jan98
[illegible]6A302	RB HEARING FOR NPDES PERMIT	1d	17Apr98	17Apr98
D6A303	NPDES PERMIT	1809d	17Apr98	01Apr03
D6A304	SUBMIT NPDES RENEWAL APPLICATION	30d	01Dec02	30Dec02
D6B001	SUBMIT 10% DESIGN	27d	01Nov96	25Nov96
D6B002	AGENCIES REVIEW 10% DESIGN	14d	26Nov96	04Dec96
D6B003	REVISE/SUBMIT 60% DESIGN	20d	05Dec96	10Jan97
D6B004	AGEN REVIEW 60% DESIGN	14d	13Jan97	03Feb97
D6B005	REVISE/SUBMIT 90% DESIGN	28d	04Feb97	23Feb97
D6B006	AGEN REVIEW 90% DESIGN	14d	24Feb97	17Mar97
D6B106	AGEN APPROVE FINAL DESIGN	14d	06May97	21May97
D6B200	OBTAIN PERMITS & EASEMENTS	180d	13Sep96	15May97
D6B201	REQUEST STORMWATER PERMIT	15d	01Mar97	15Mar97
D6B202	COUNTY GRANTS LONG-TERM LEASE	1d	02Jun98	02Jun98
D6C001	BID & AWARD CONSTRUCTION	90d	24Mar97	22Jun97
D6C002	CONSTRUCT TREATMENT PLANT	240d	02Aug97	18Aug98
D6C003	AGENCIES INSPECT CONSTRUCTION	27d	19Aug98	19Aug98
D6C004	SUBMIT HEALTH & SAFETY PLAN	30d	14Jul97	14Jul97
D6C008	SUBMIT O&M PLAN	30d	01Jan98	31Jan98
D6C009	AGENCY REVIEW OF O&M PLAN	30d	01Feb98	30Mar98
[illegible]C010	SUB GW MON PLAN, QAPP EFF WP	30d	01Jan98	31Jan98
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D6C0110	AGEN REV OF QAPP	30d	01Feb98	30Mar98

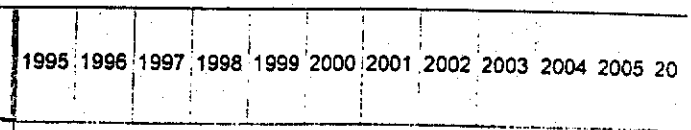

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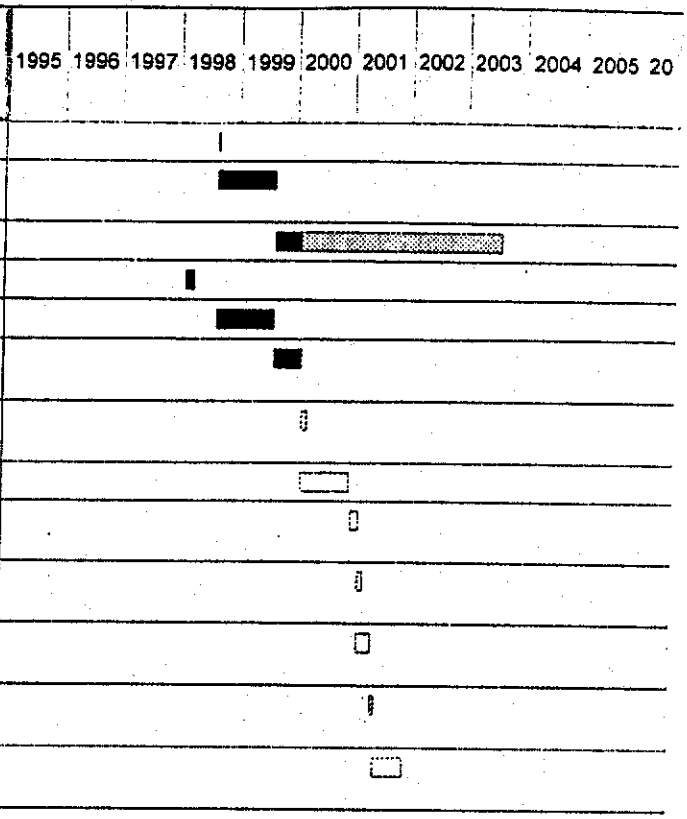
Table 4-1
American River Study Area
Project Schedule

ID	Activity Desc.	Dur	Start	Finish
D6D001	BEGIN FULL-SCALE OPERATION	9d	19Aug98	19Aug98
D6D002	OPERATE TREATMENT PLANT FOR 1 YEAR	365d	19Aug98	19Aug99
D6D003	OPERATE TREATMENT PLANT	1460d	20Aug99	18Aug03
D70001	AGEN APP EFF WORK PLAN	30d	01Feb98	30Mar98
D70002	EVALUATE EFFECTIVENESS	365d	19Aug98	19Aug99
D70003	PREPARE EFF RPT/REC MODIFICATION	180d	20Aug99	15Feb00
D70003A	AGENCIES REVIEW AND COMMENT ON EFFECTIVENESS EVALUATION	30d	16Feb00	16Mar00
D70004	EVALUATE AQUIFER D	320d	16Feb00	31Dec00
D70005	PREPARE & SUBMIT LETTER RPT ON AQUIFER D	60d	02Jan01	02Mar01
D70005A	AGENCIES REVIEW AND APPROVE LETTER REPORT	30d	03Mar01	01Apr01
D70006	PREPARE REMEDIAL ACTION DOCUMENTATION (RAP) WORKPLAN	90d	03Mar01	31May01
D70007	AGENCIES APPROVE REMEDIAL ACTION (RAP) WORKPLAN	30d	01Jun01	30Jun01
D70008	PREPARE AND SUBMIT REMEDIAL ACTION DOCUMENTATION	180d	01Jul01	04Jan02



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APPENDIX A

HYDROGRAPHS

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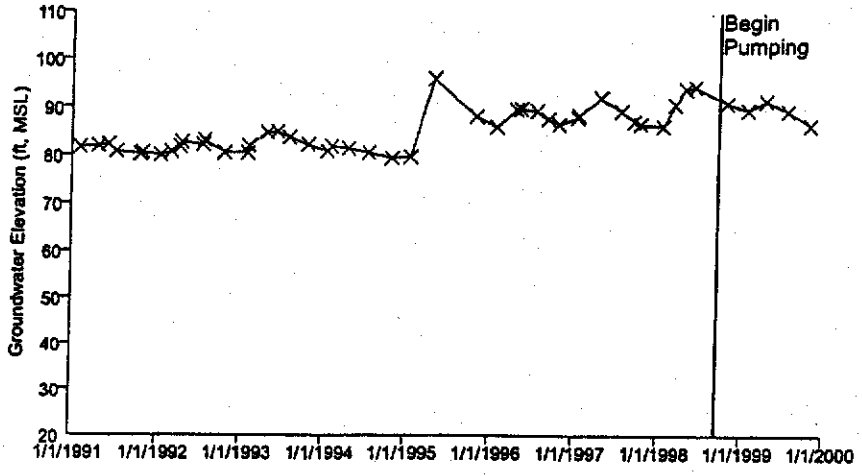

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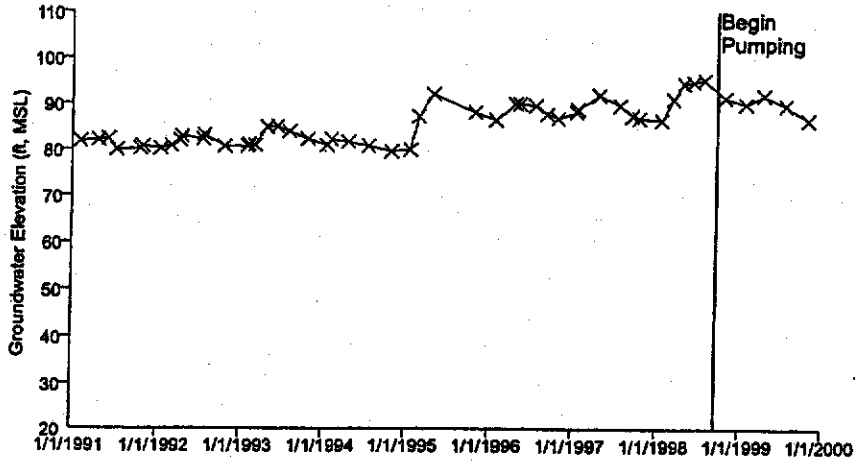

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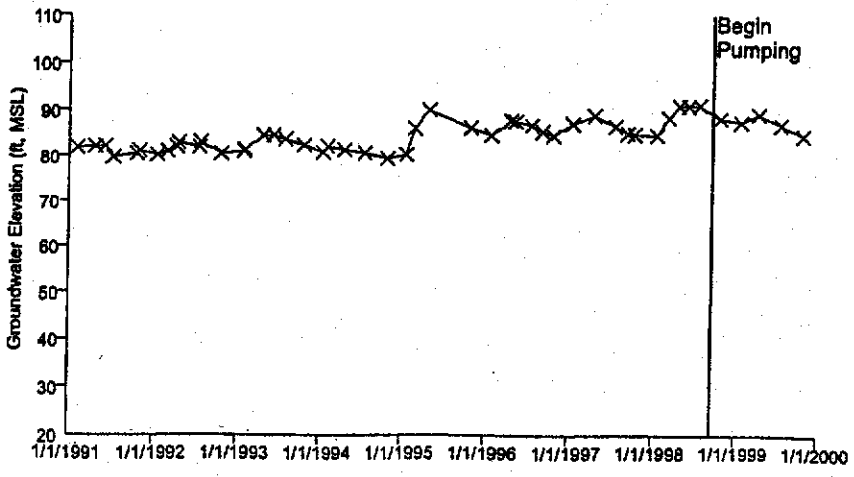

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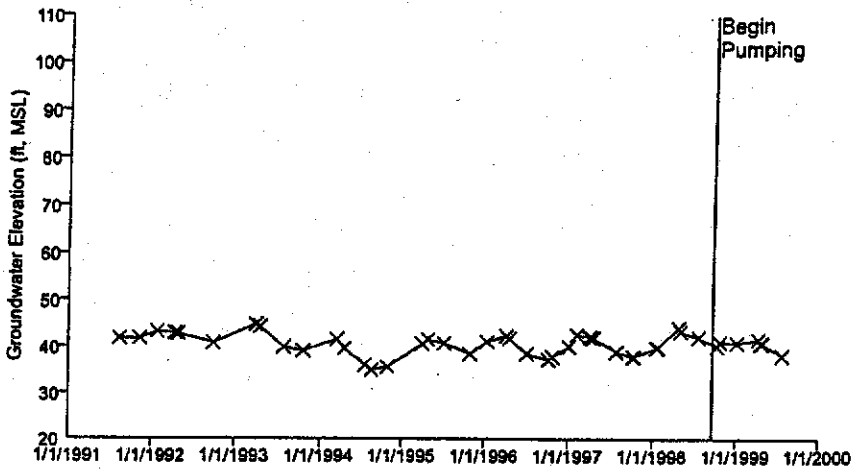

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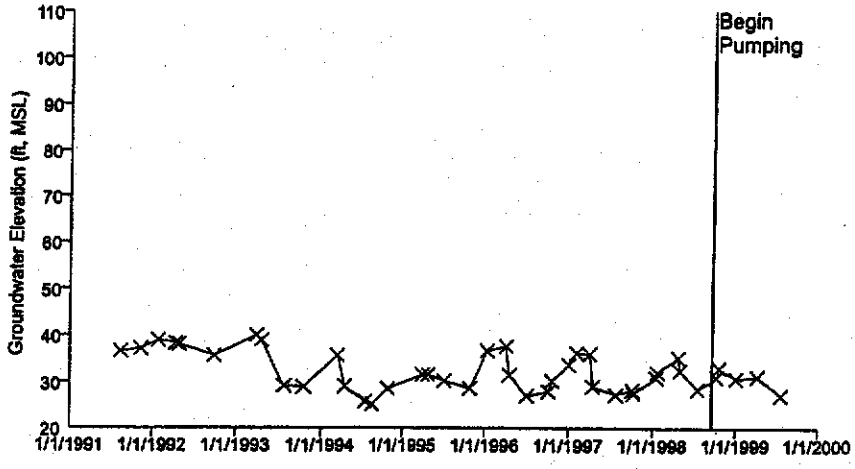

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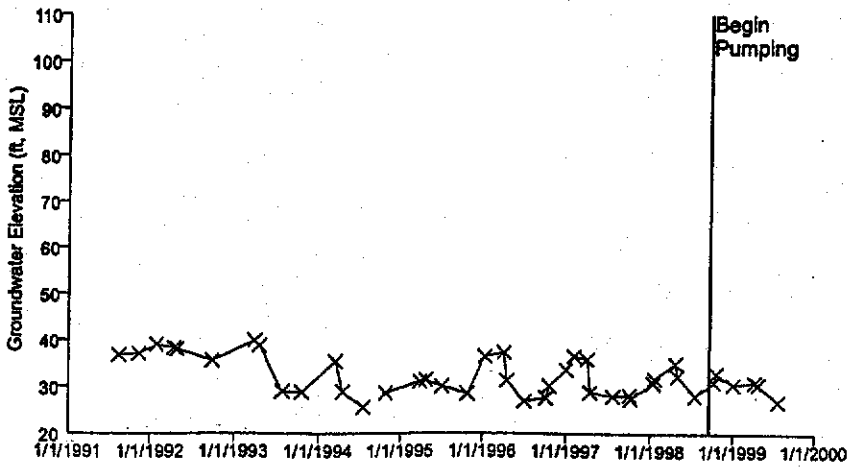

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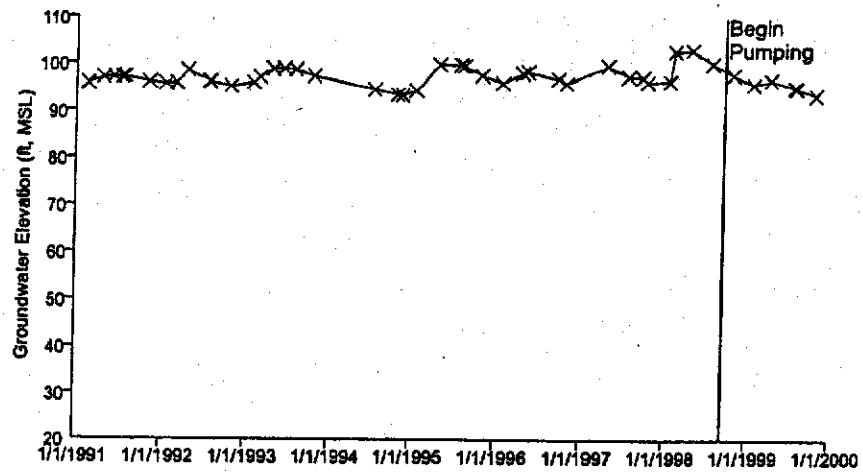

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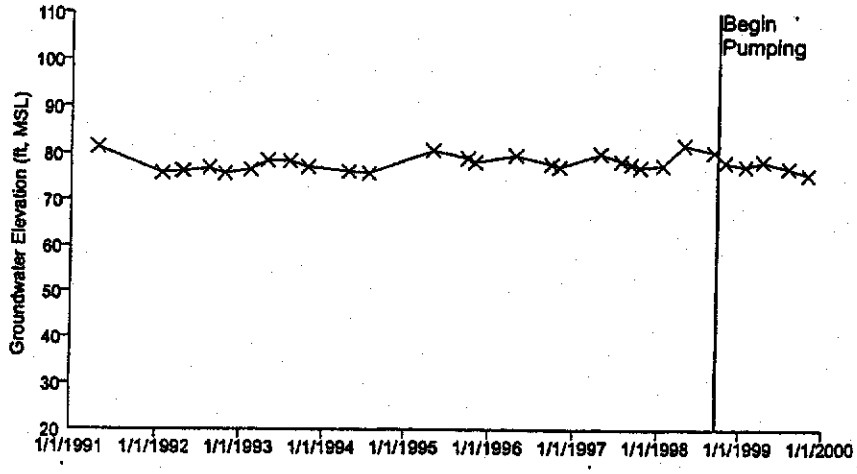

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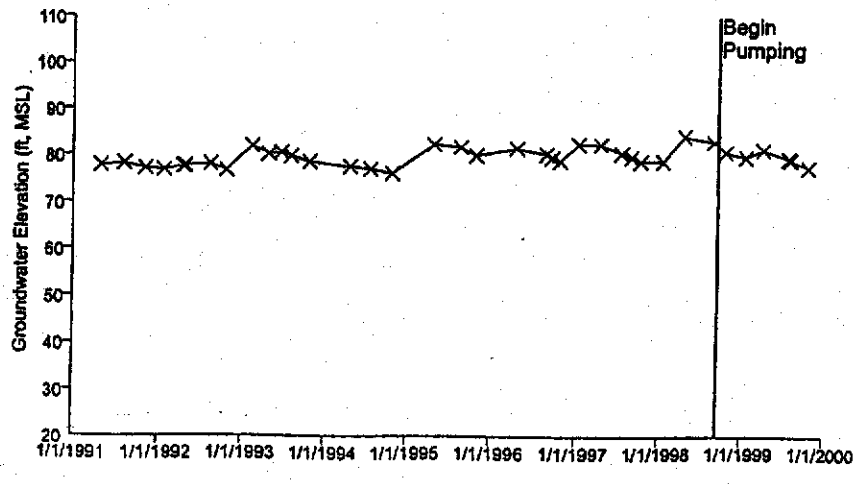

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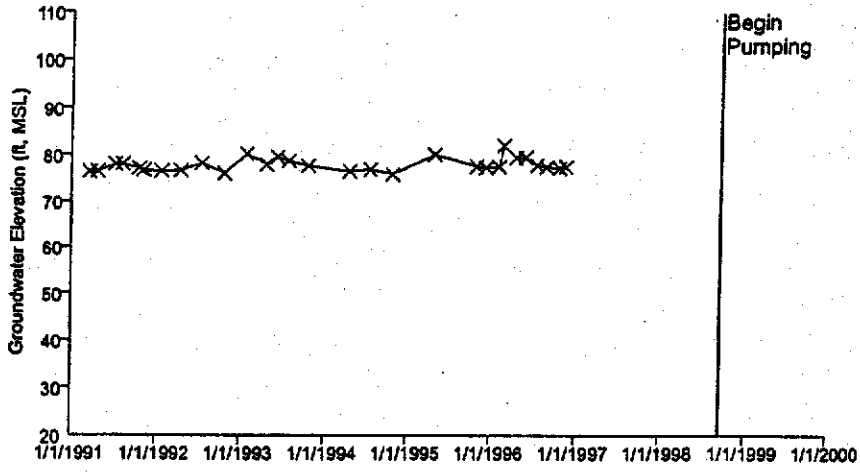

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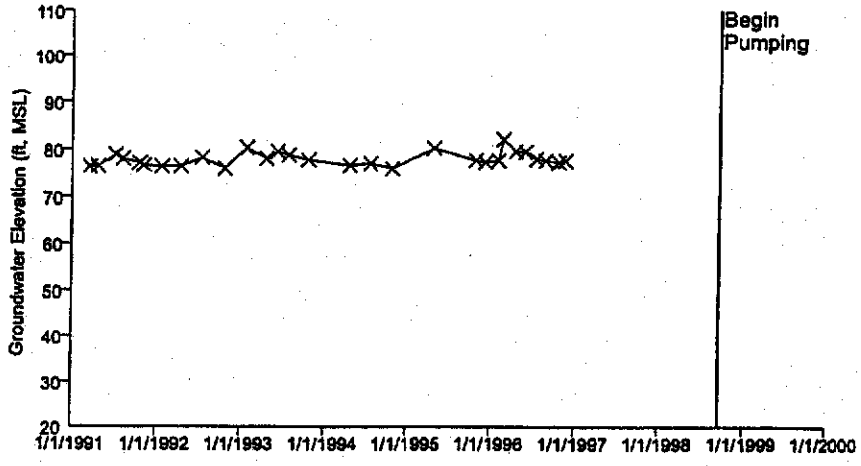

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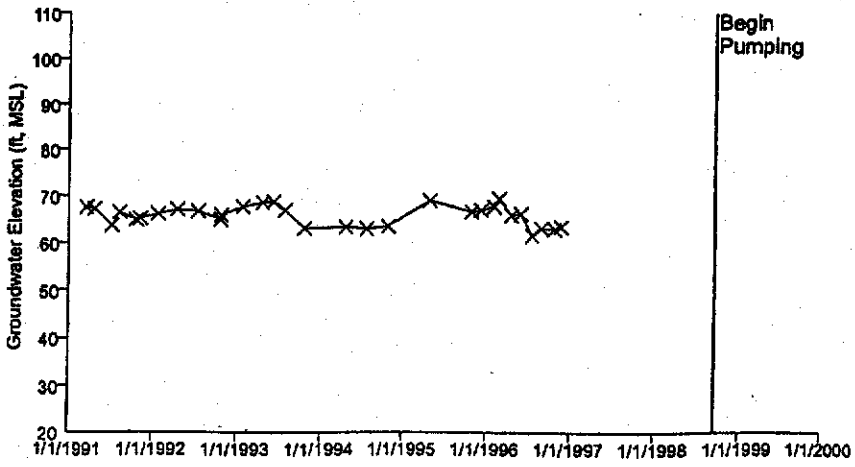

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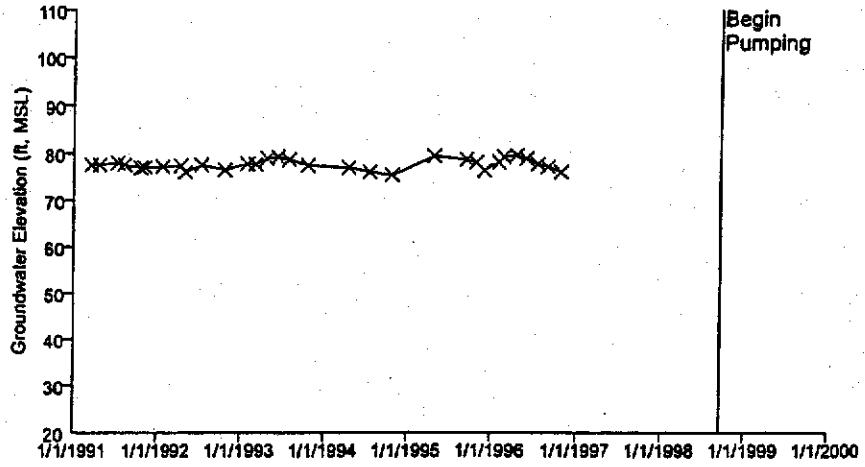

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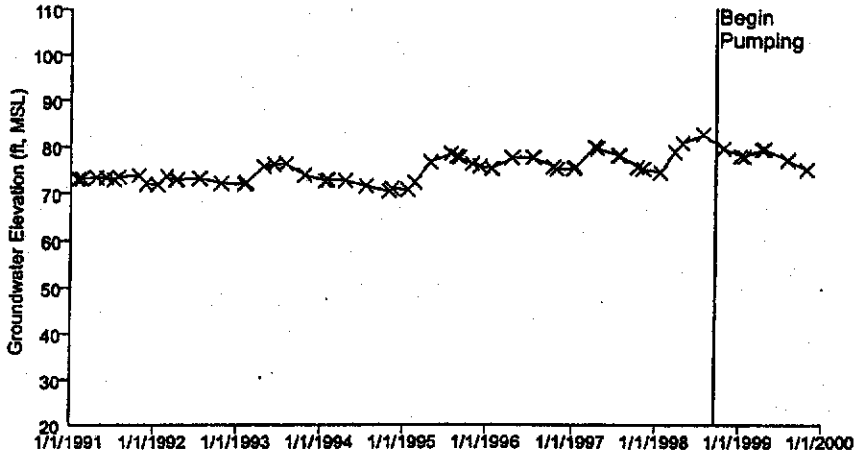

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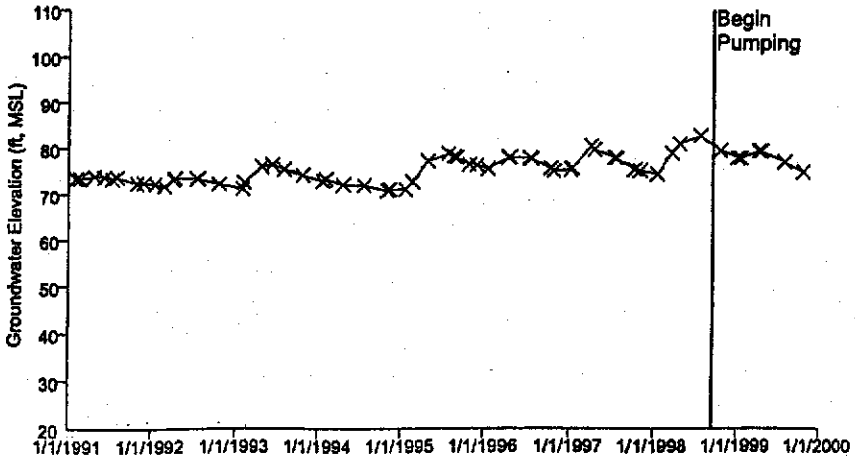

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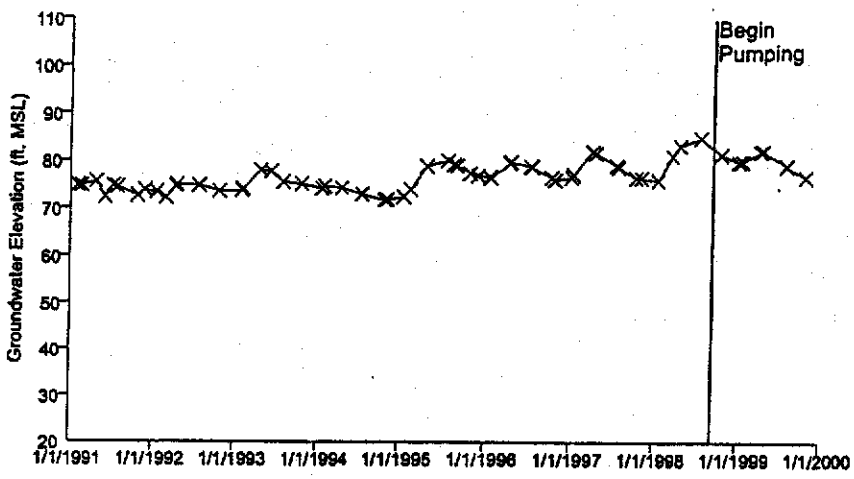

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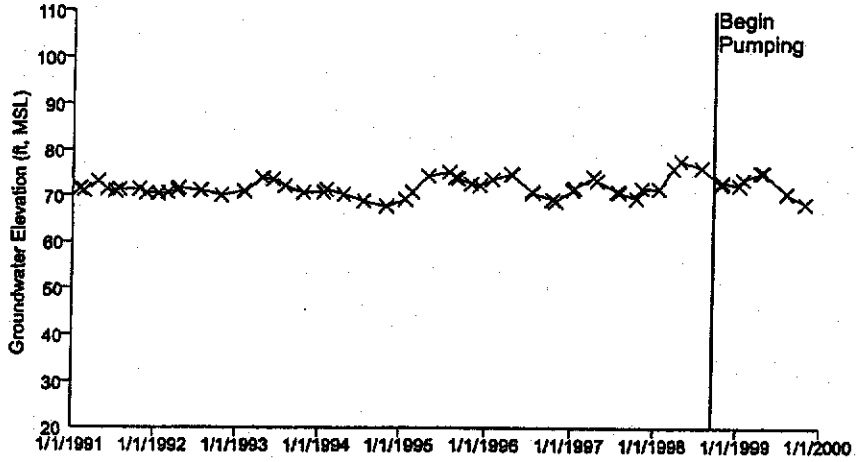

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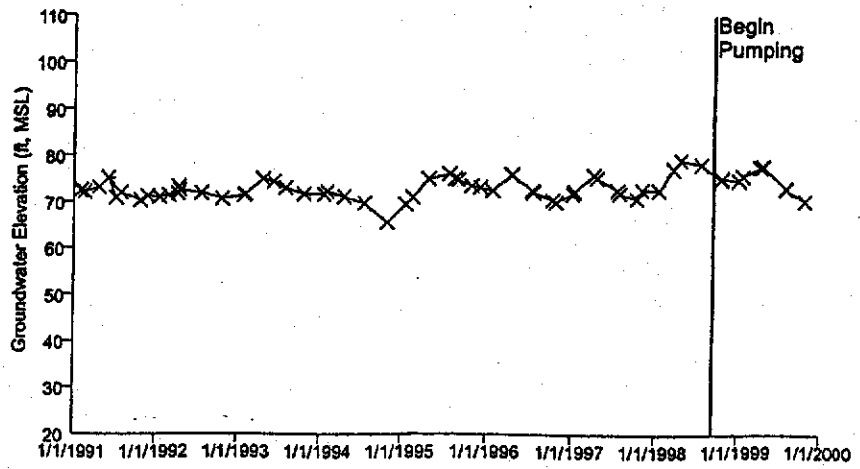

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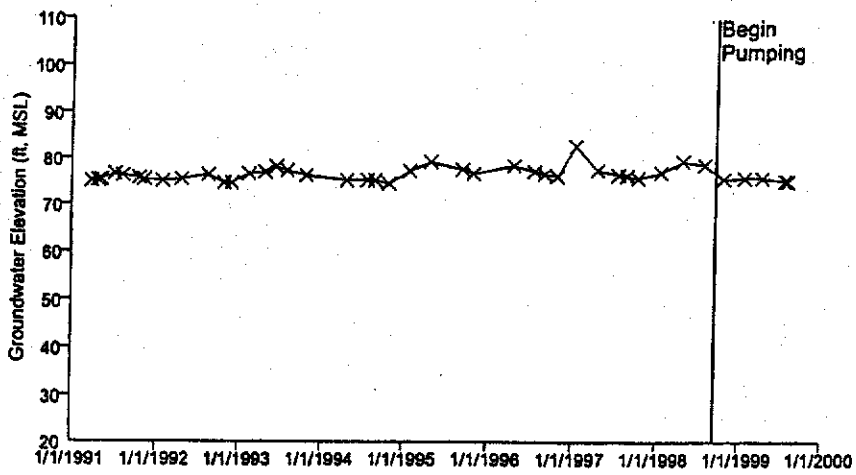

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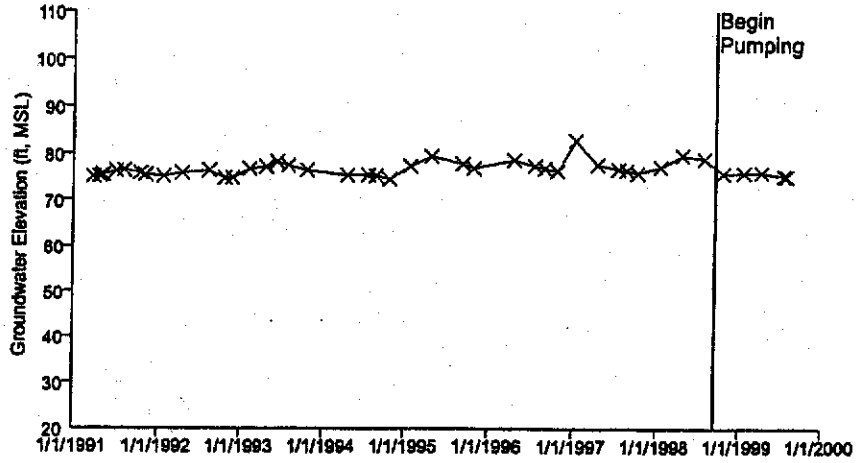

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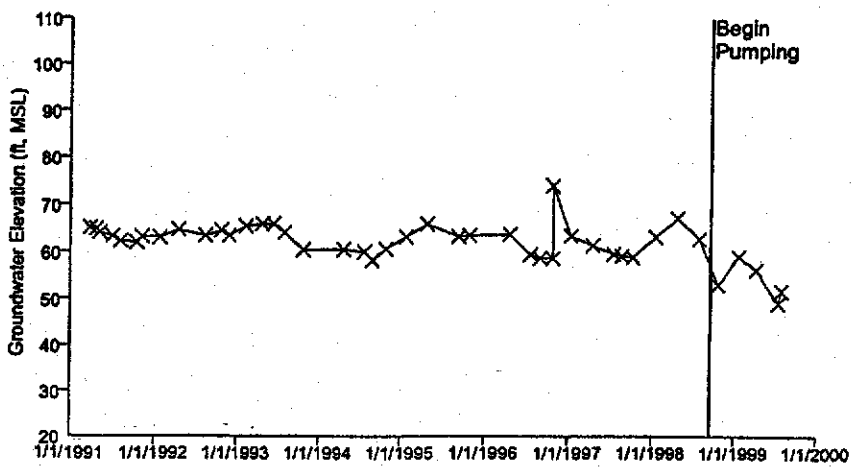

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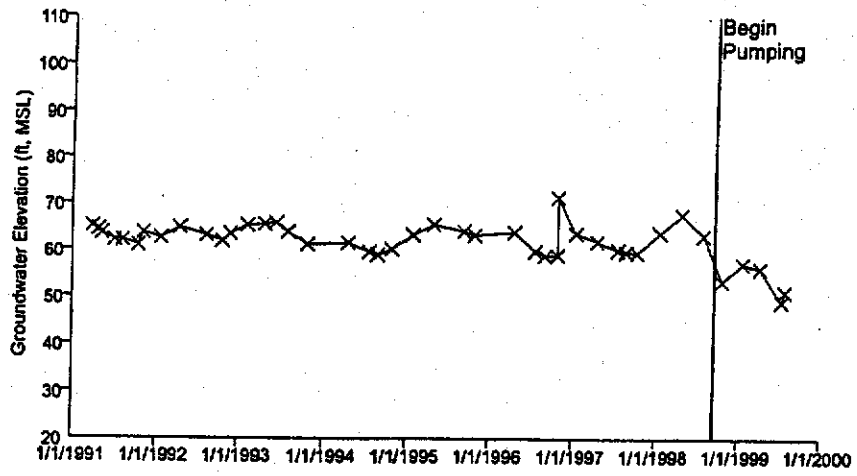

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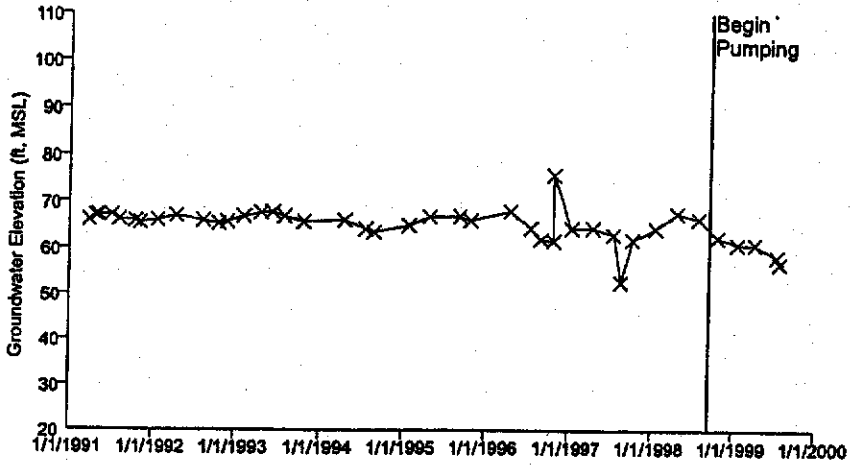

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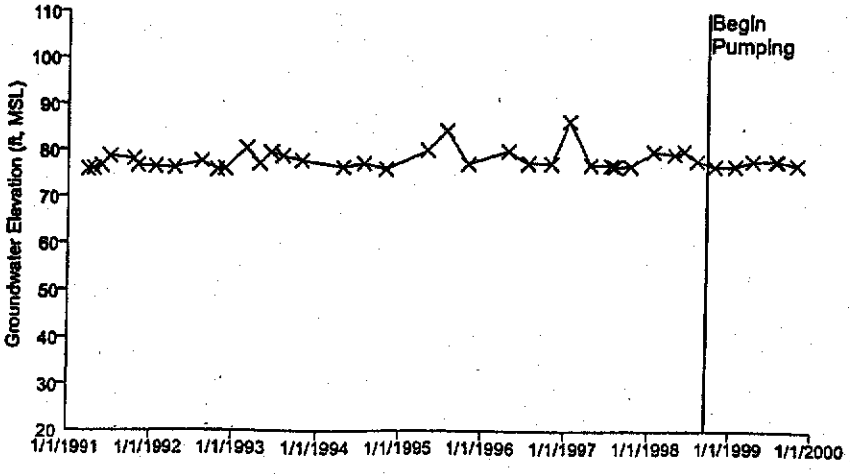

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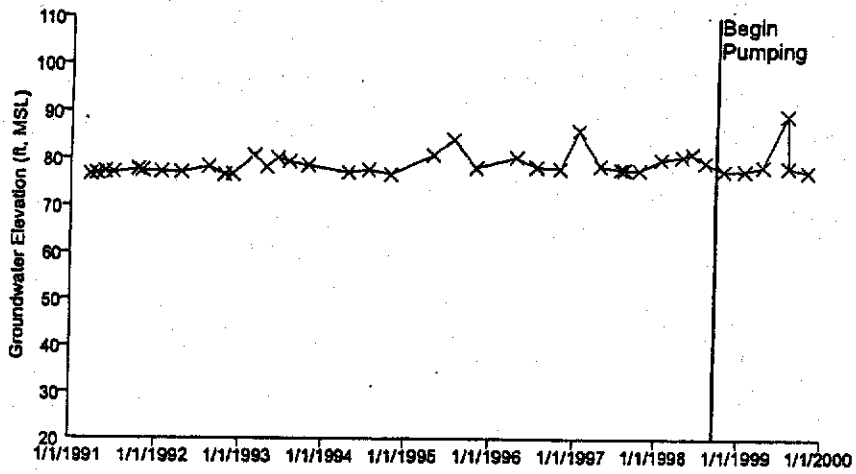

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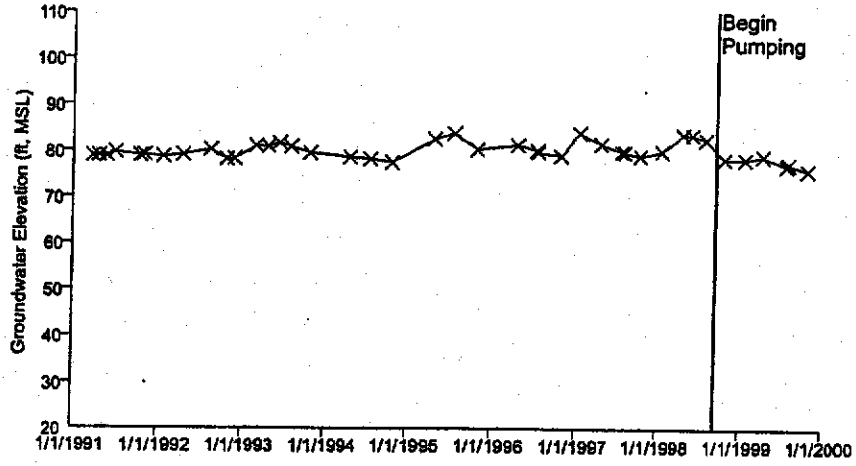

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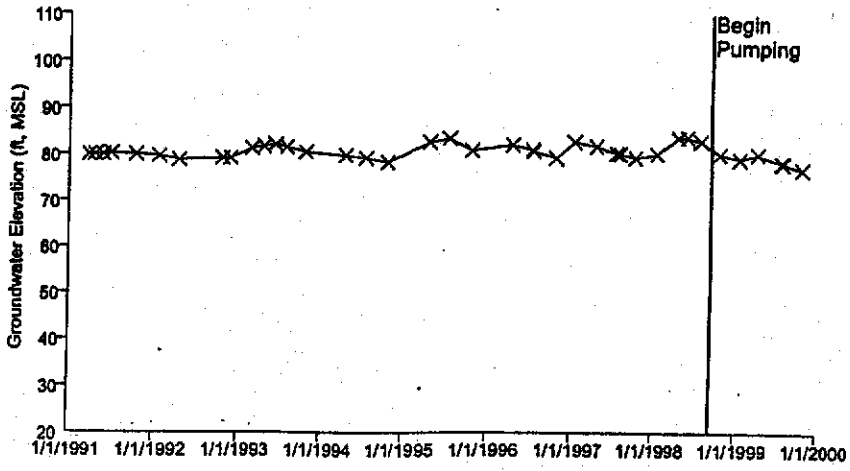

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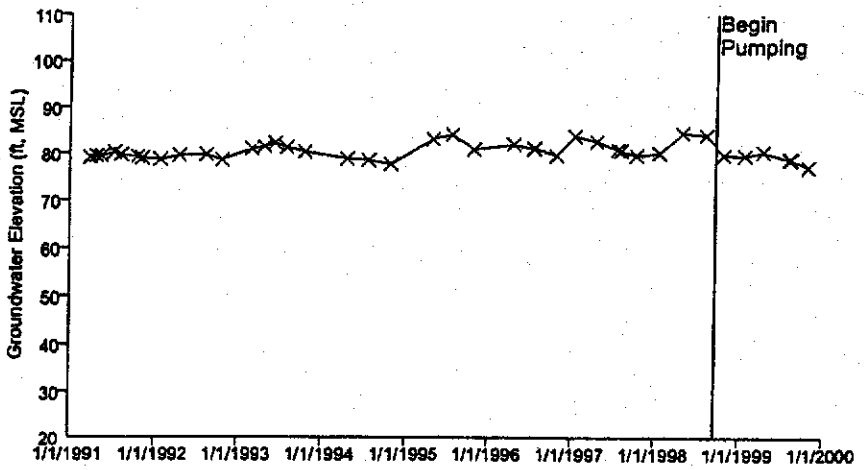

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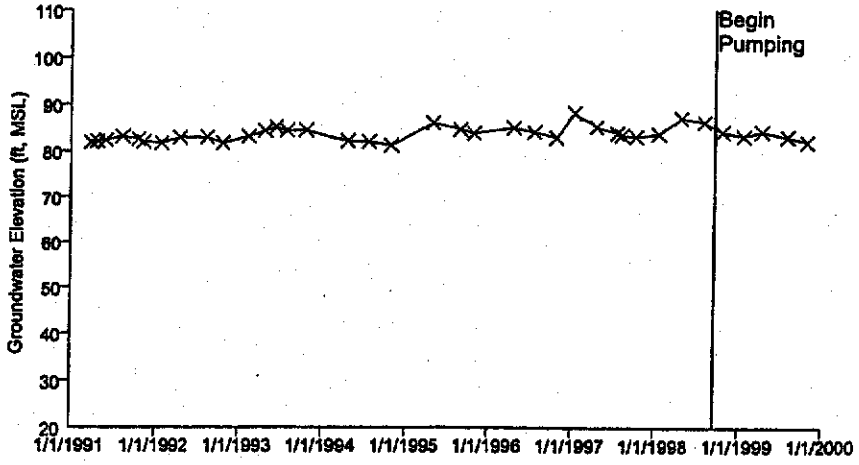

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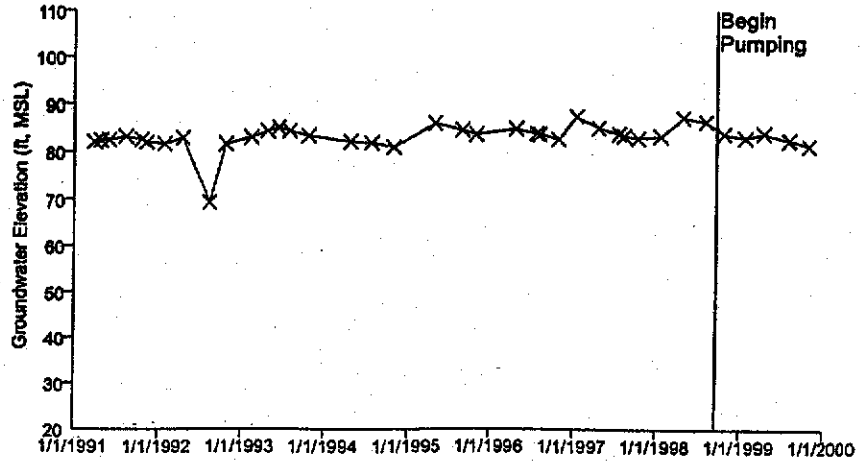

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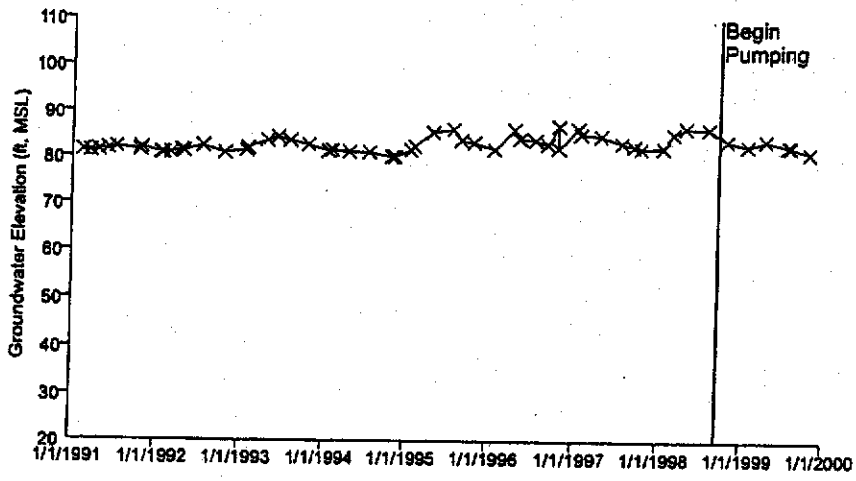

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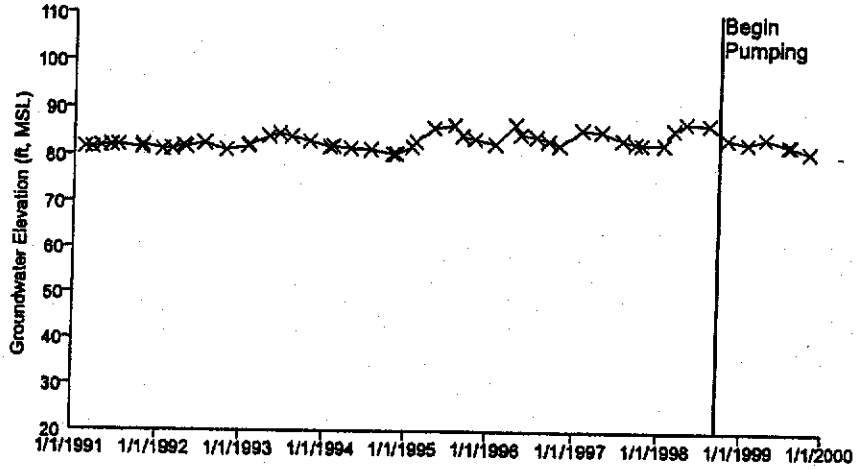

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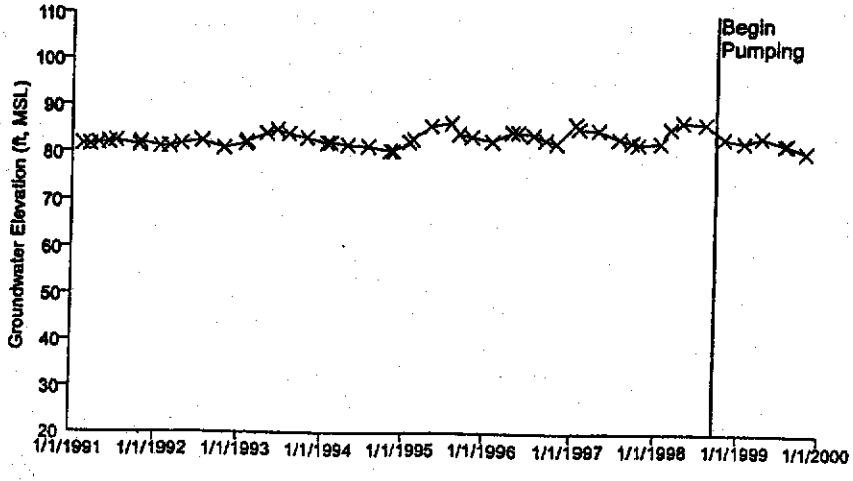

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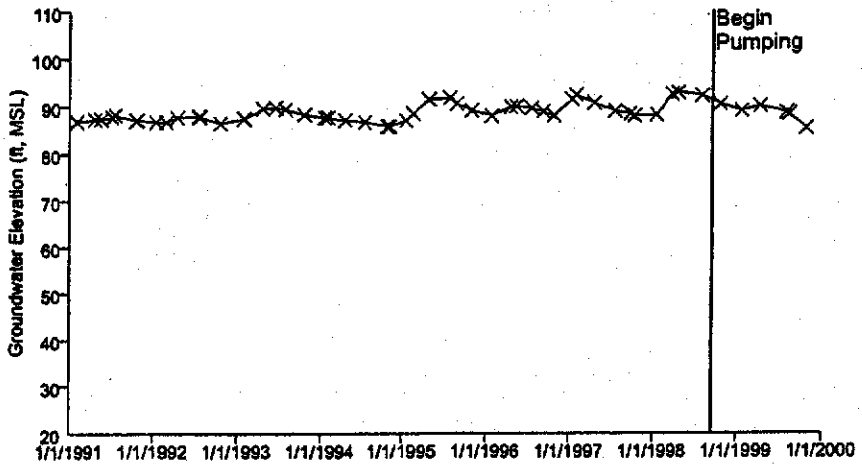

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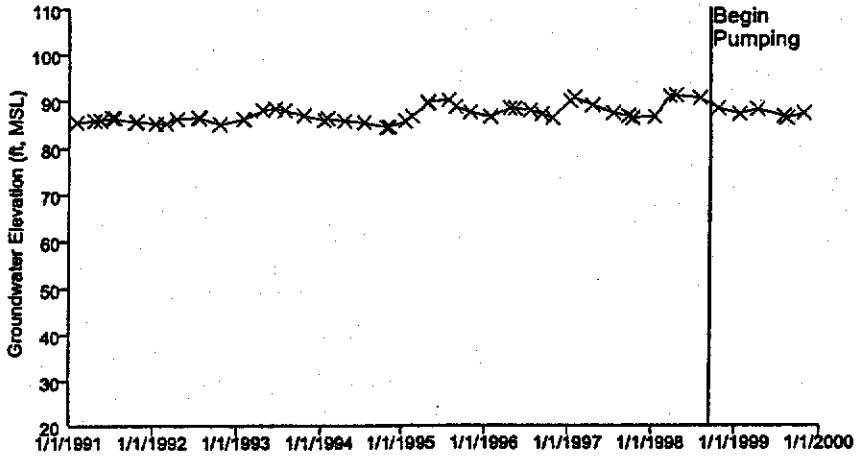

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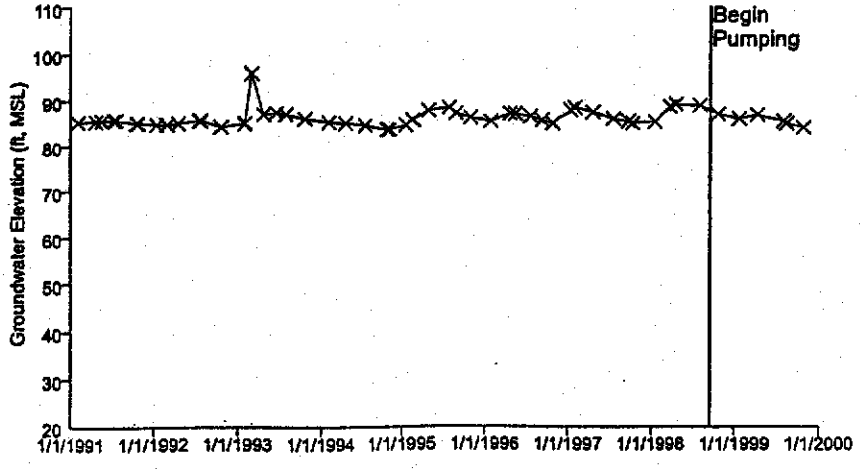

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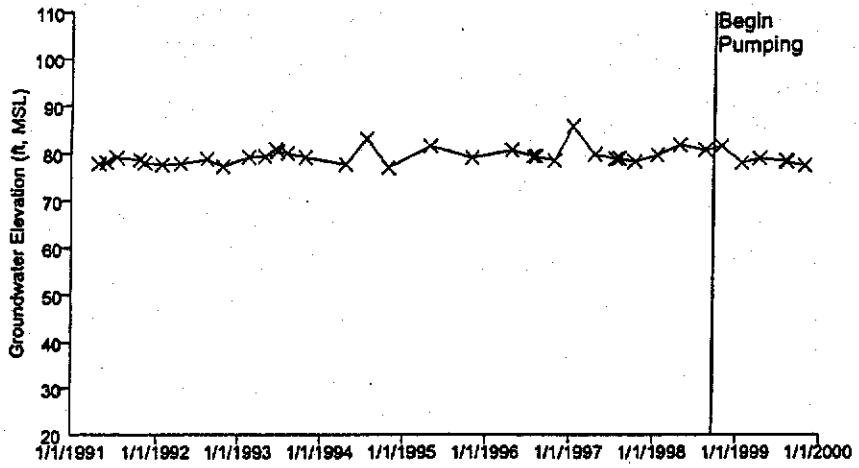

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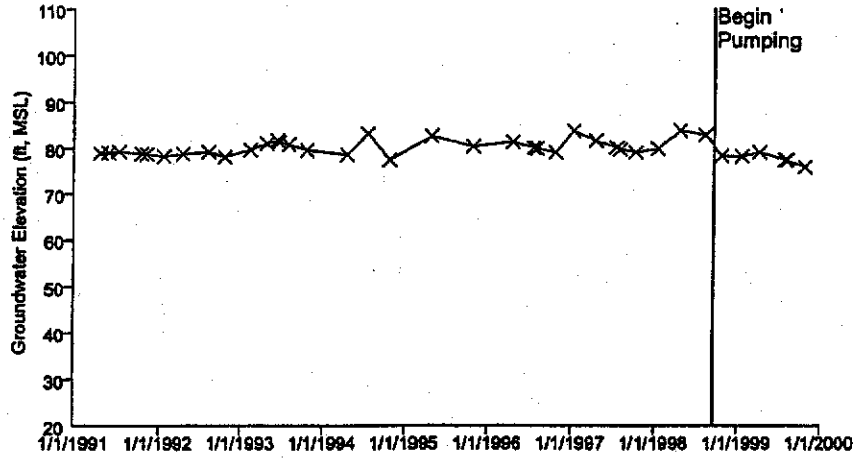

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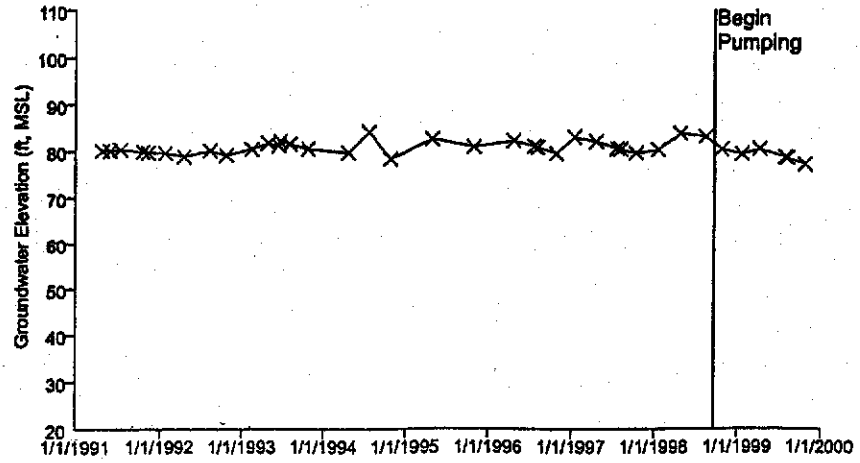

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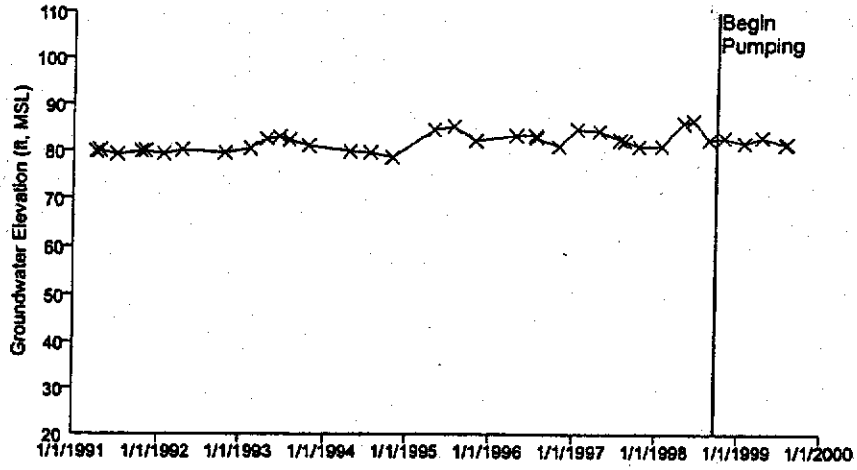

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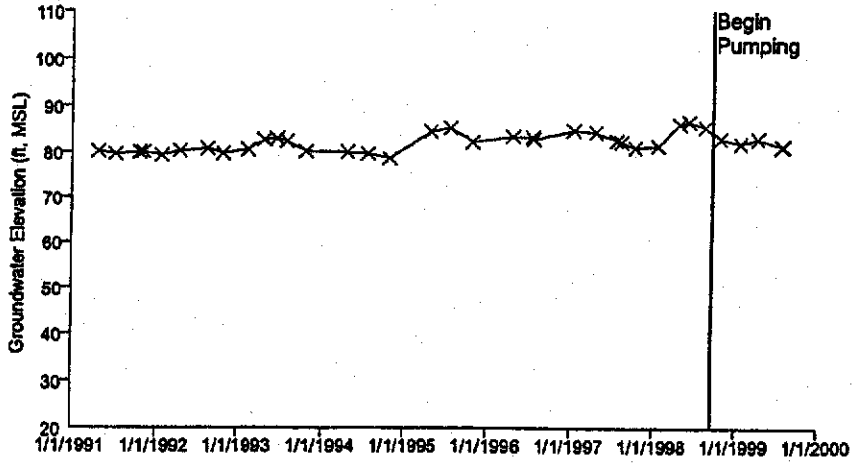

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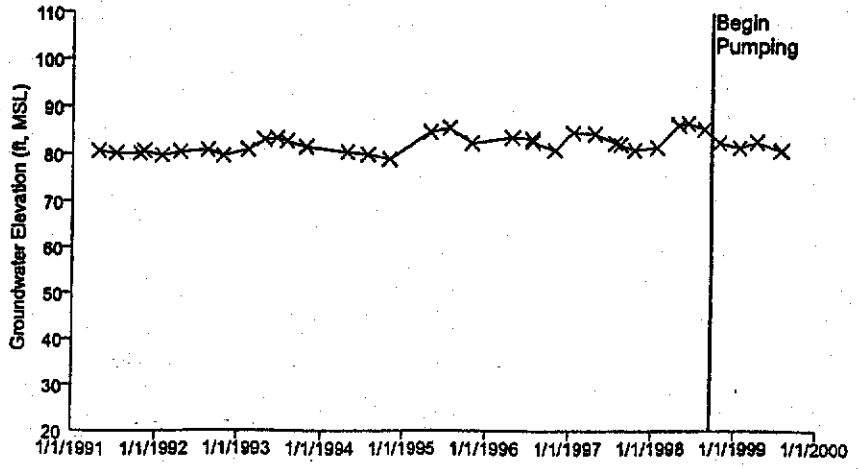

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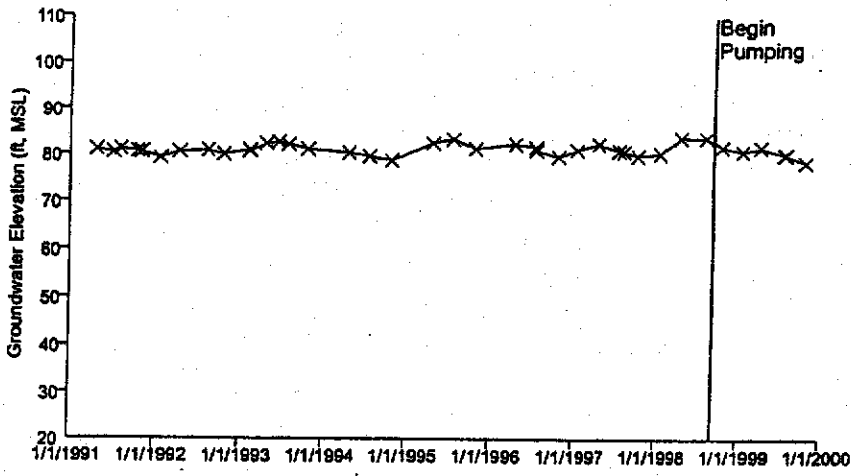

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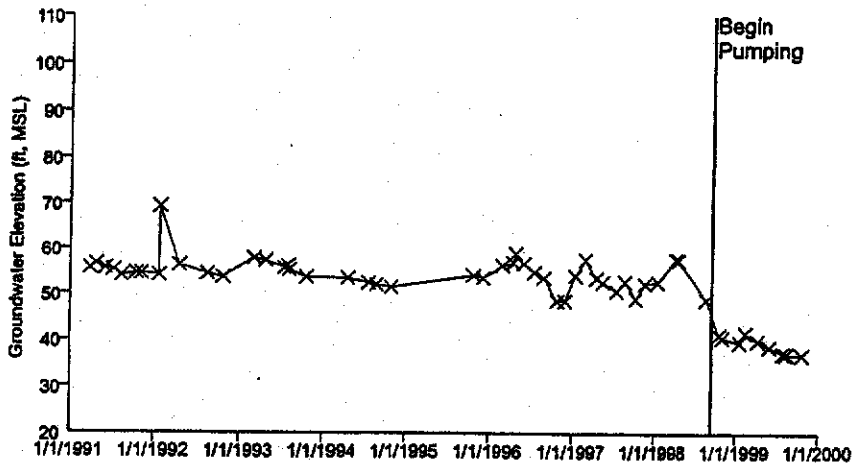

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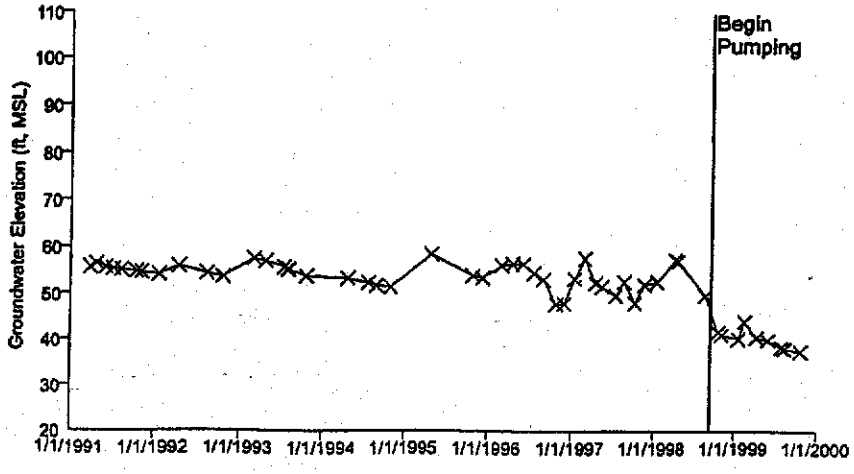

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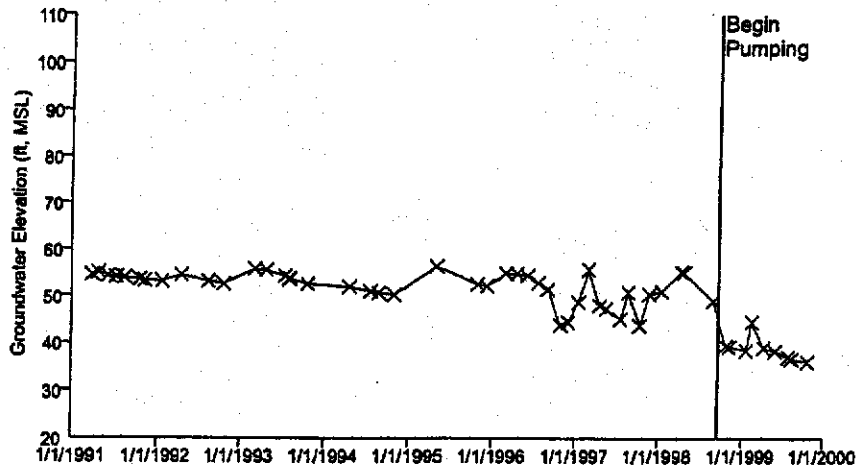

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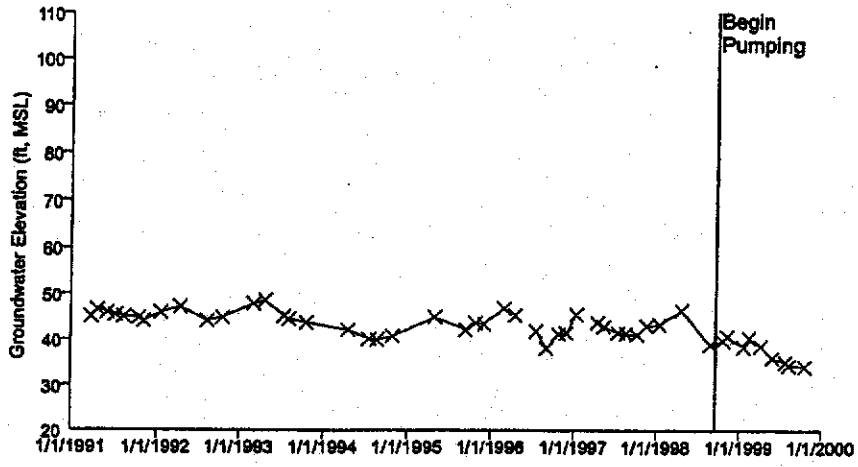

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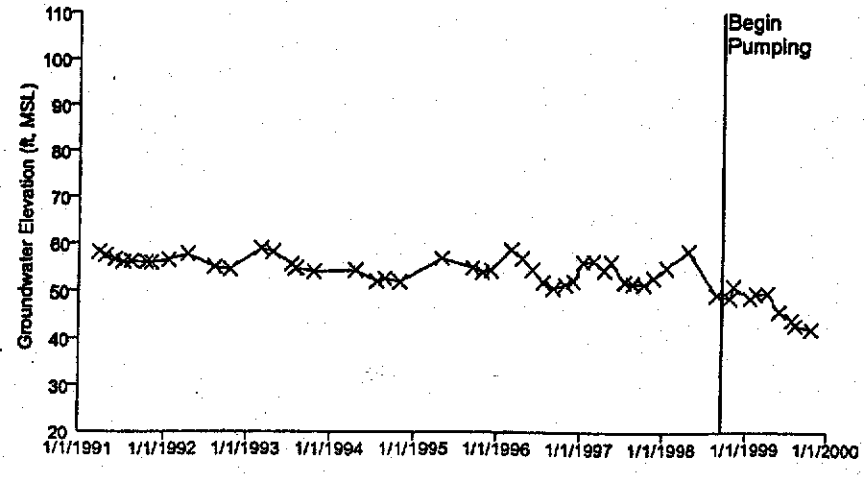
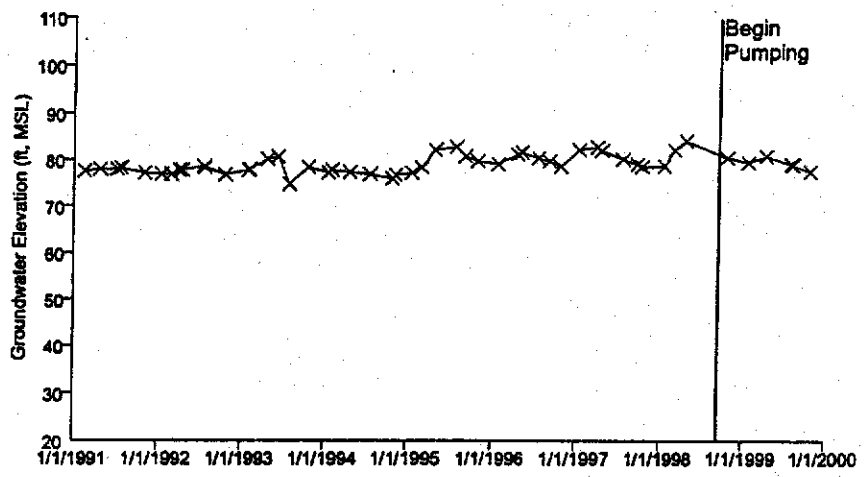


Well 1400



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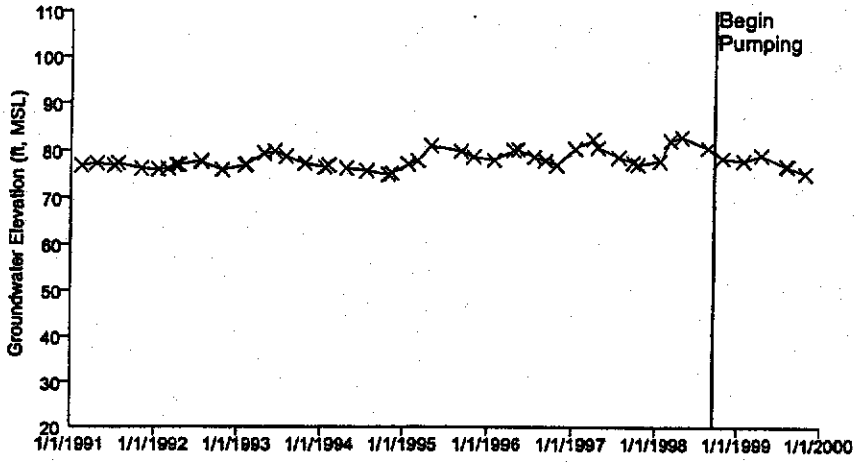

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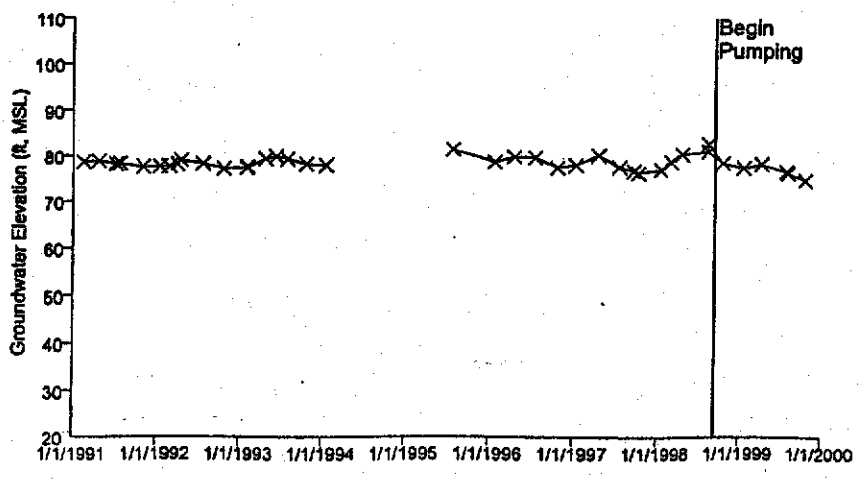

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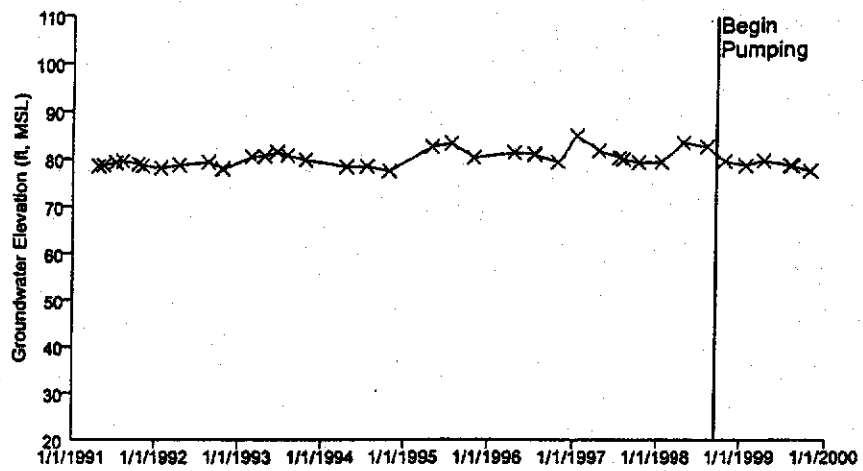

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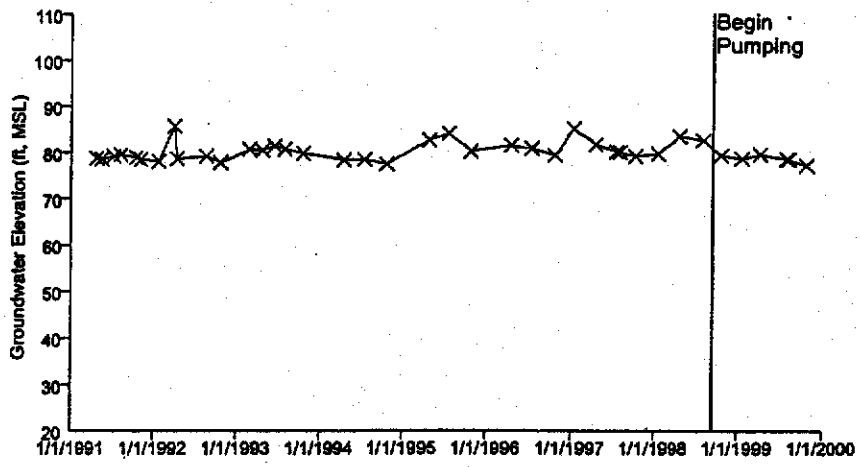

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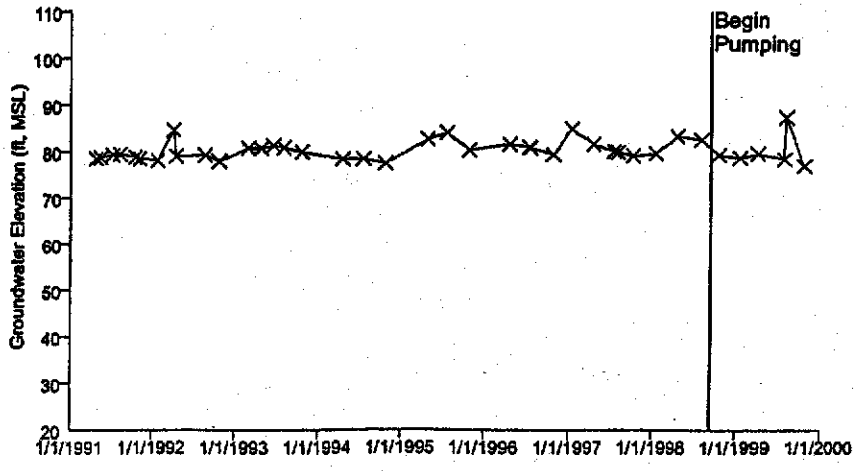

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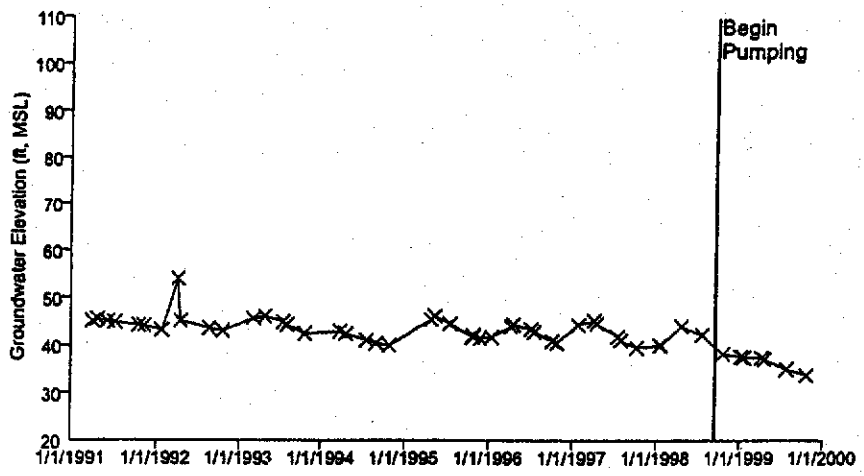

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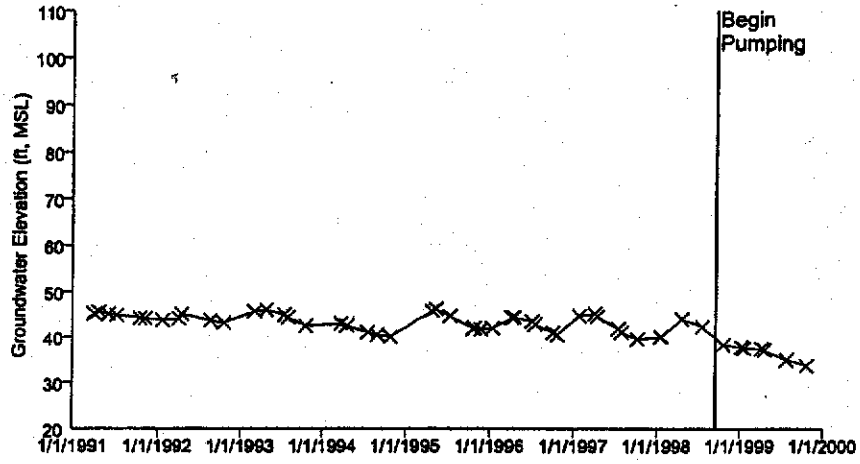

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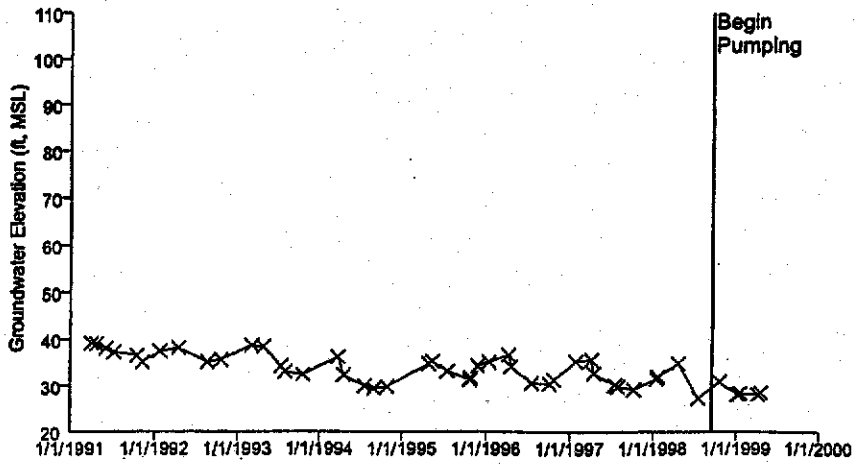

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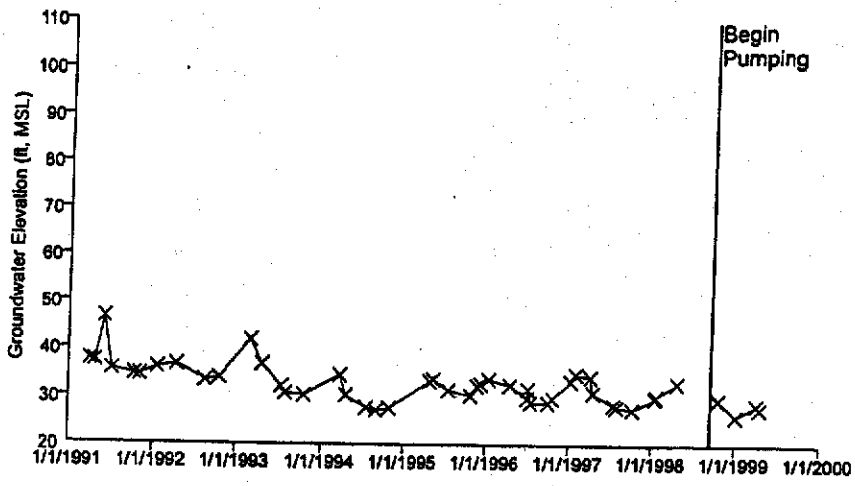
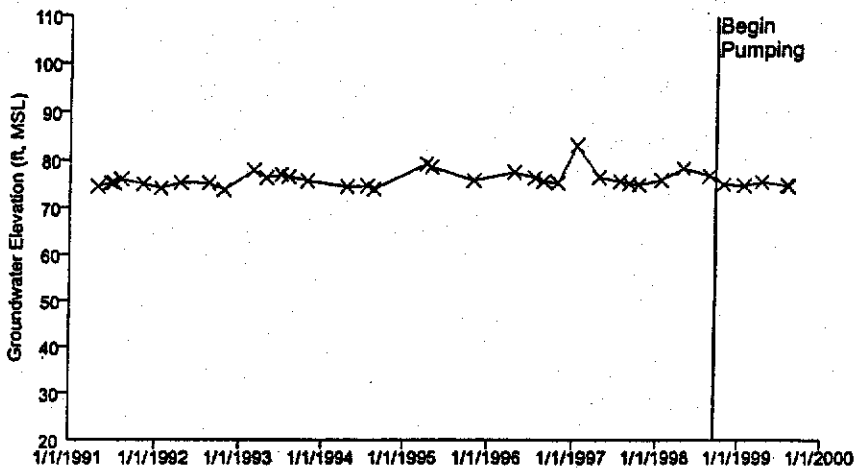
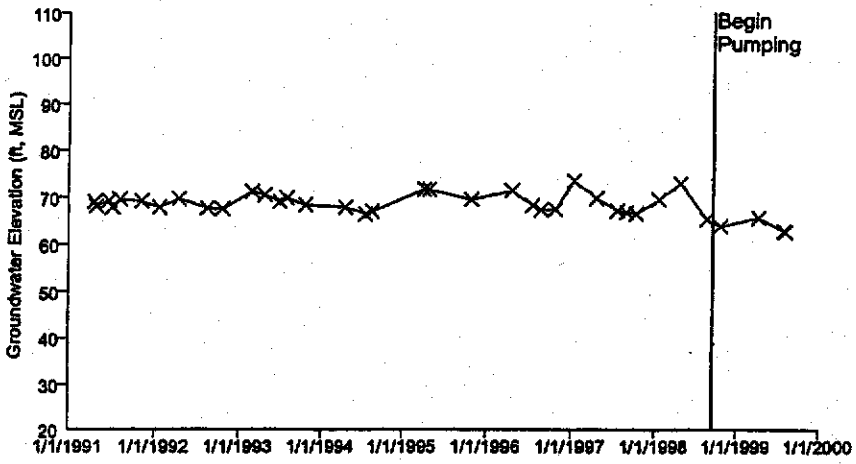

Groundwater Elevation (ft. MSL)
110
100
90
80
70
60
50
40
30
20
1/1/1991
1/1/1992
1/1/1993
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
Begin Pumping

Well 1469



Well 1470



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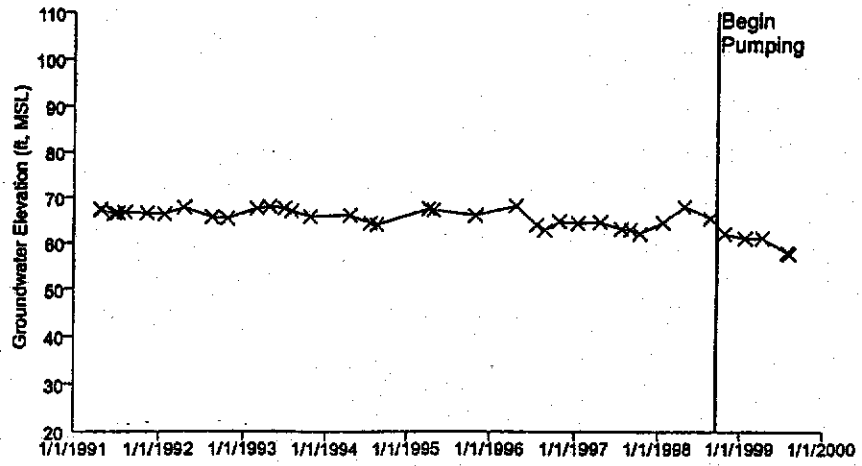

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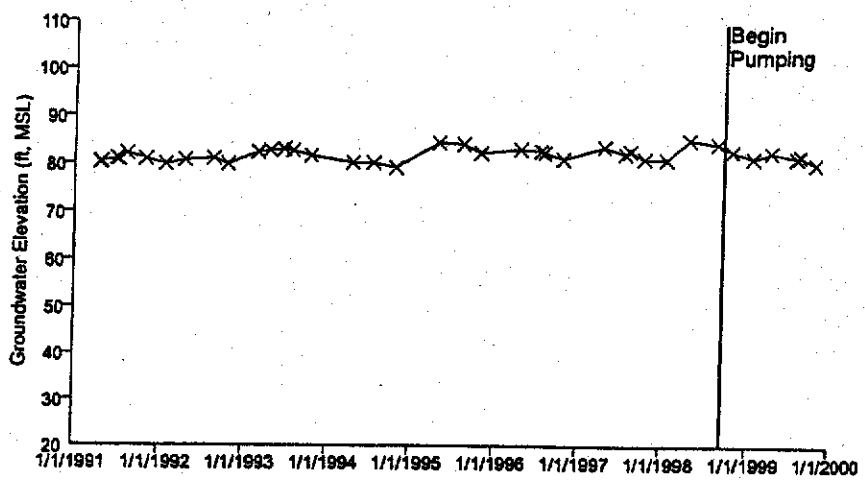

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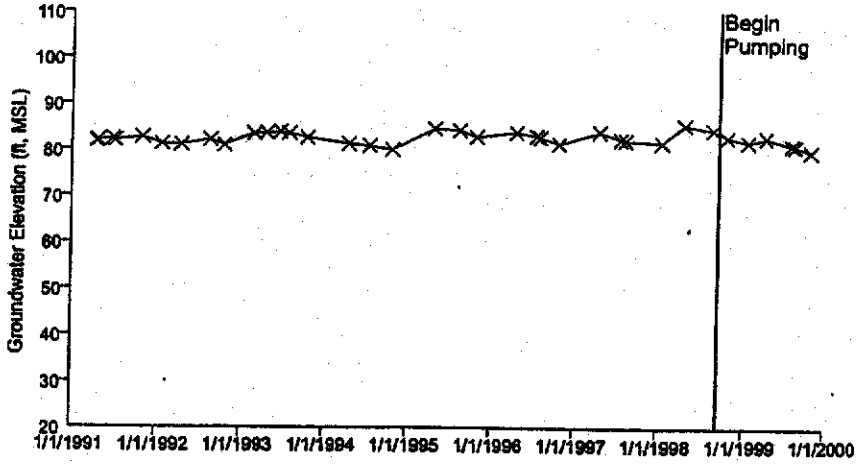

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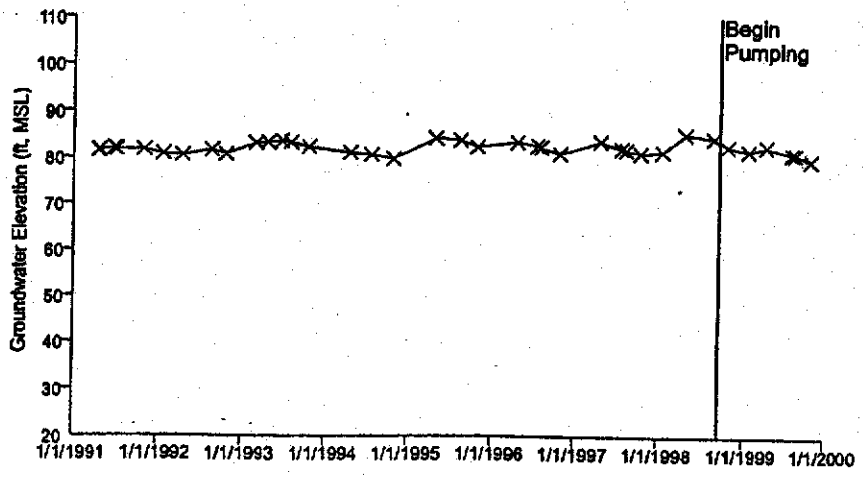

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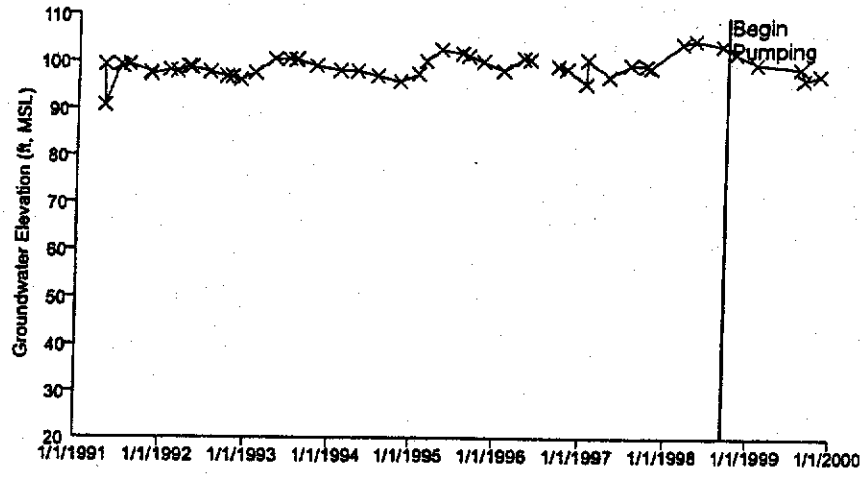

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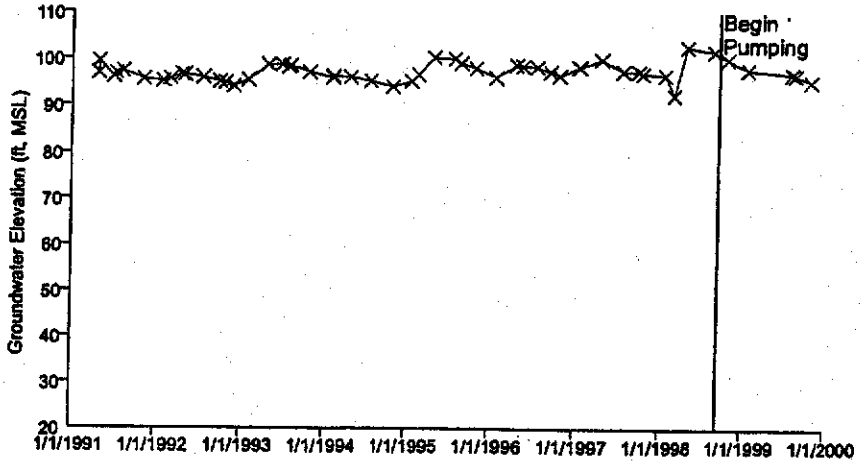

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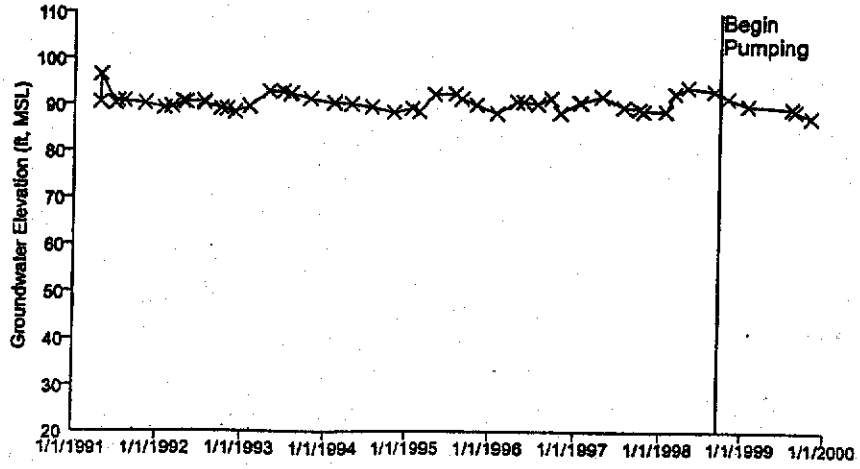
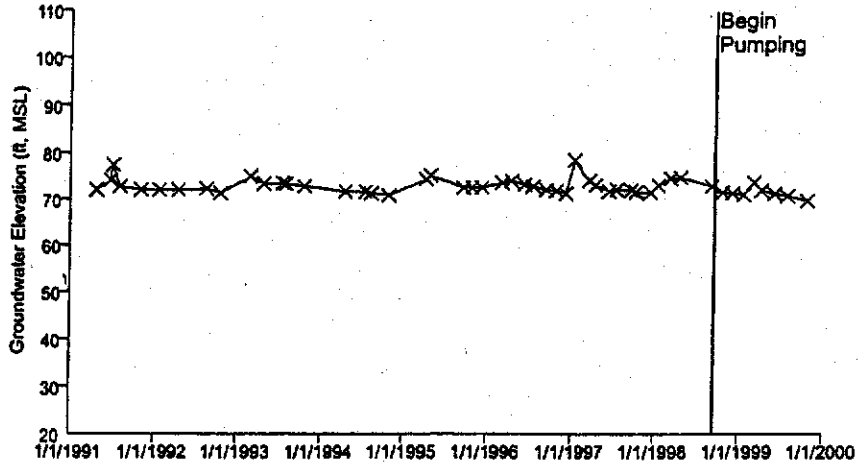


Well 1478



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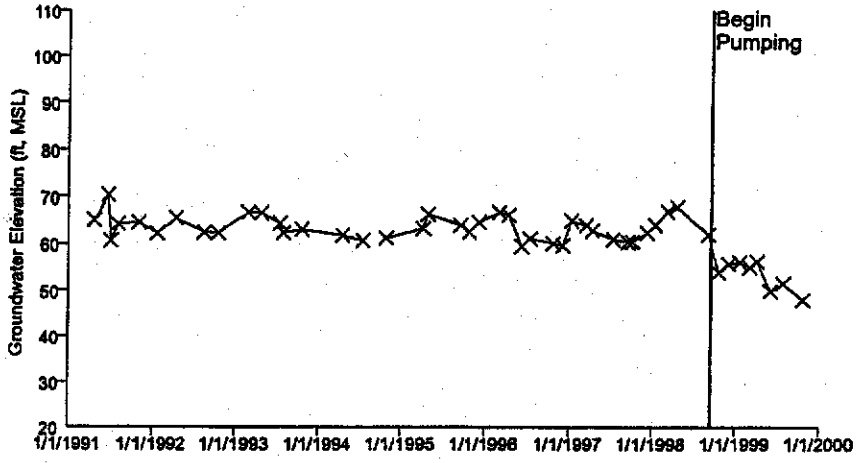
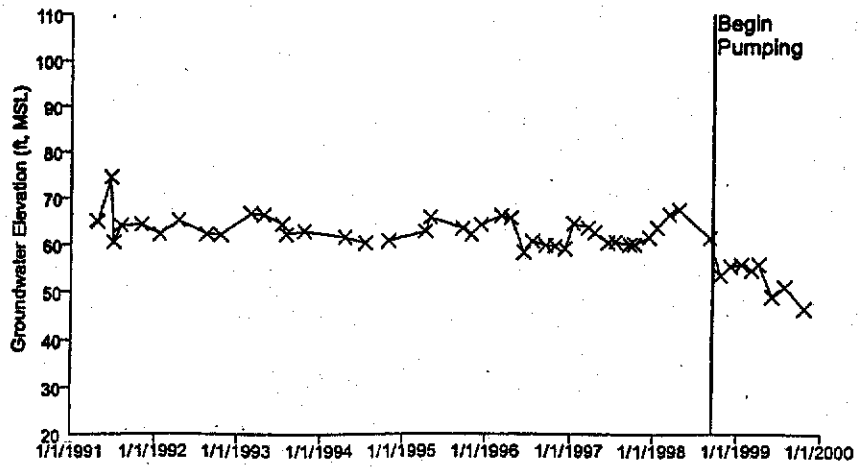
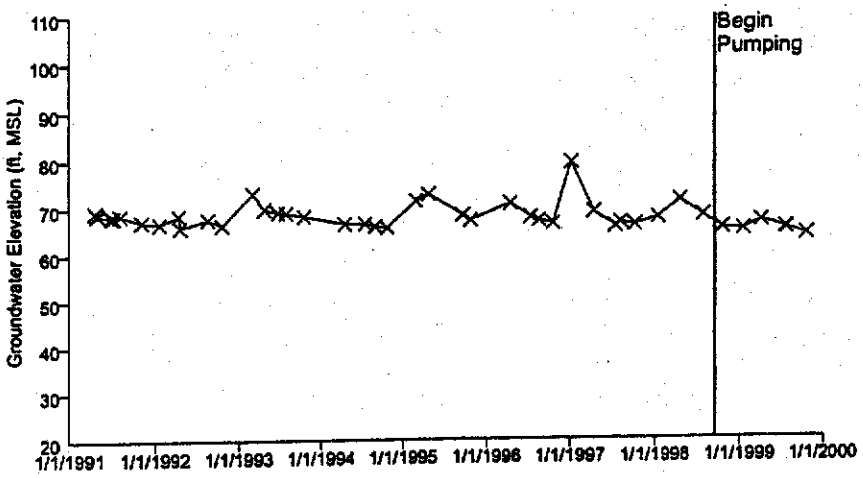


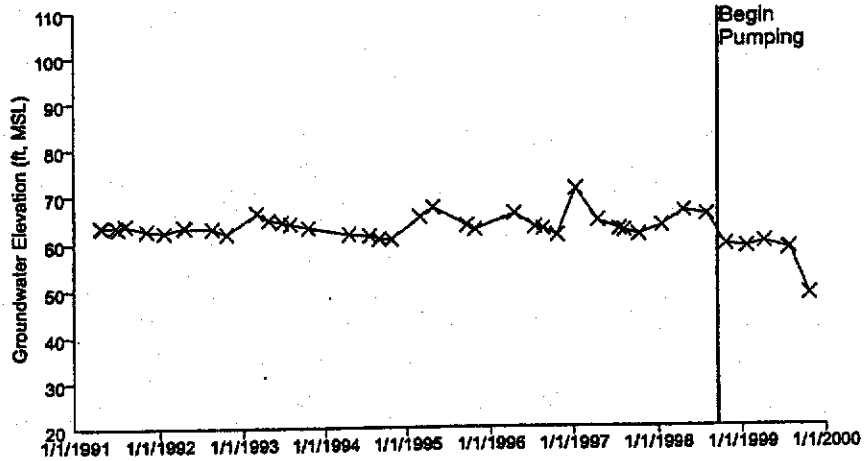
Well 1480



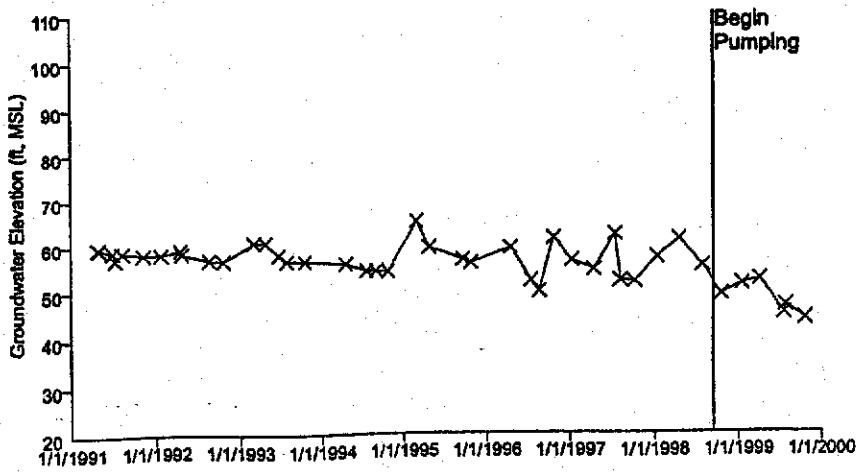
Well 1481



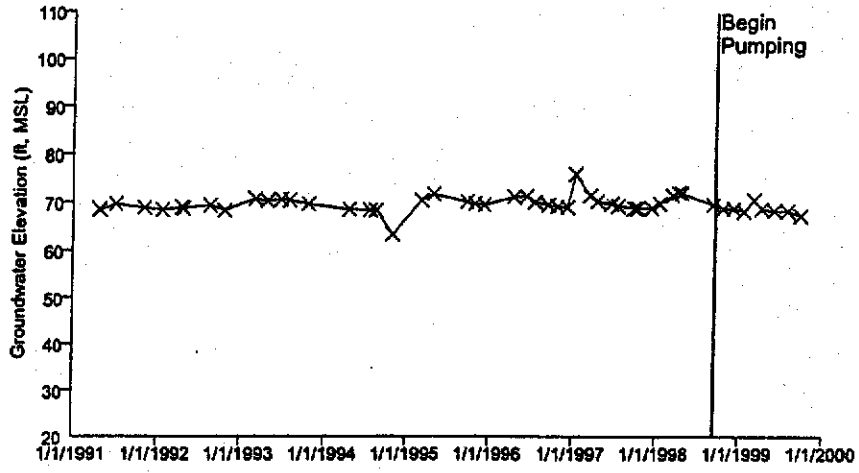
Well 1482



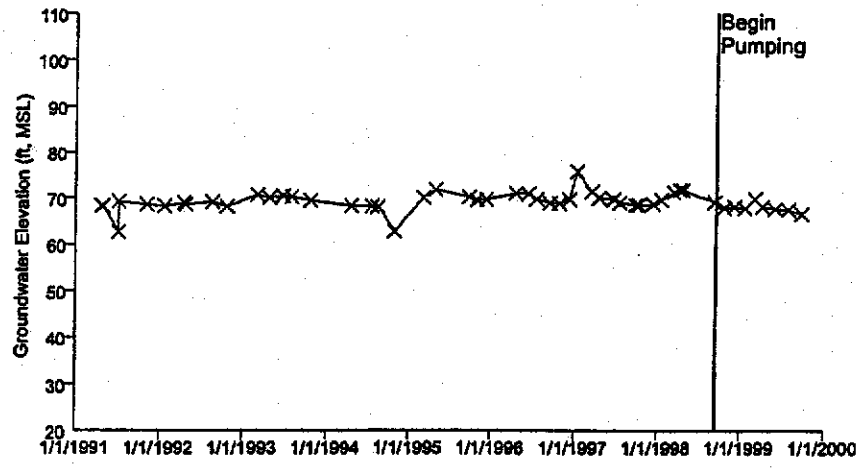
Well 1483



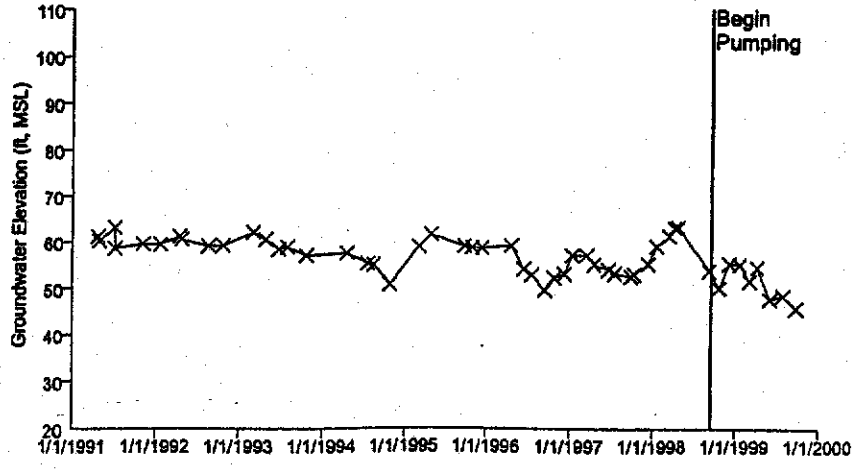
Well 1487



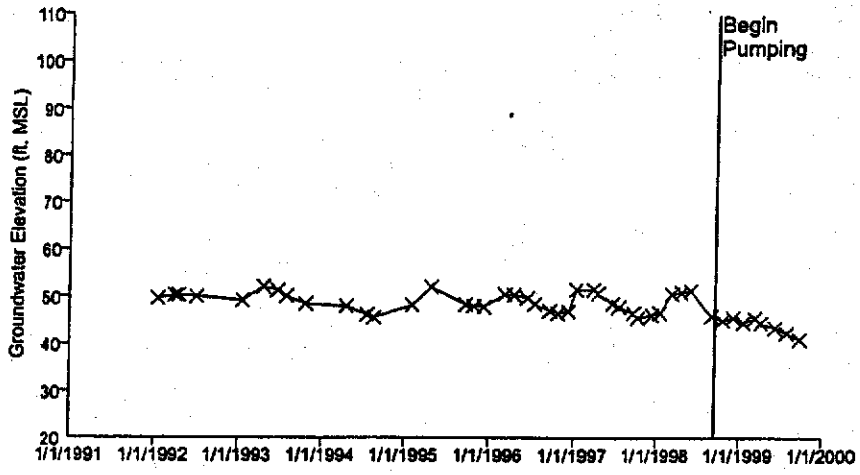
Well 1488



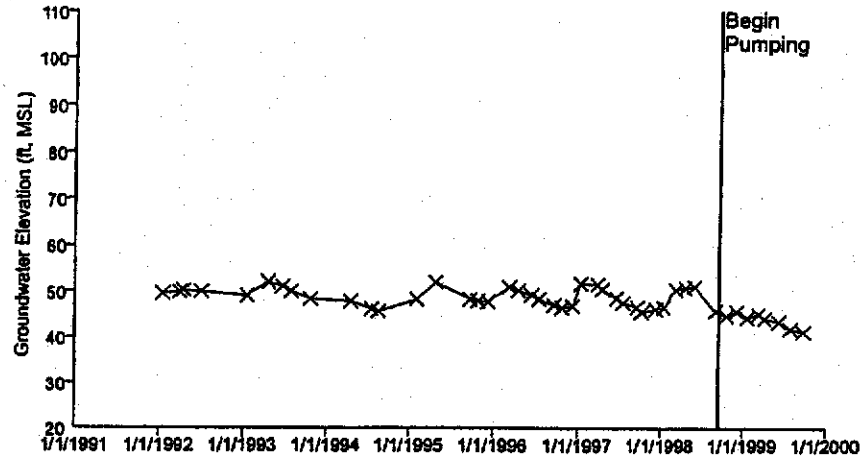
Well 1489



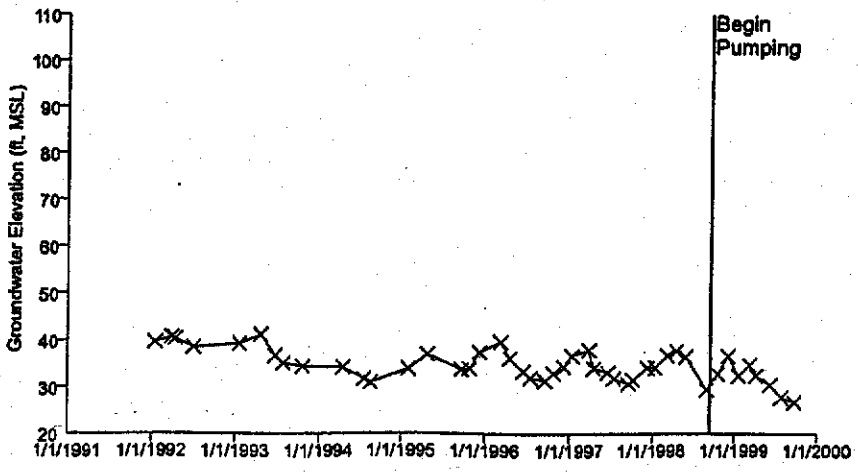
Well 1506



Well 1507



Well 1508



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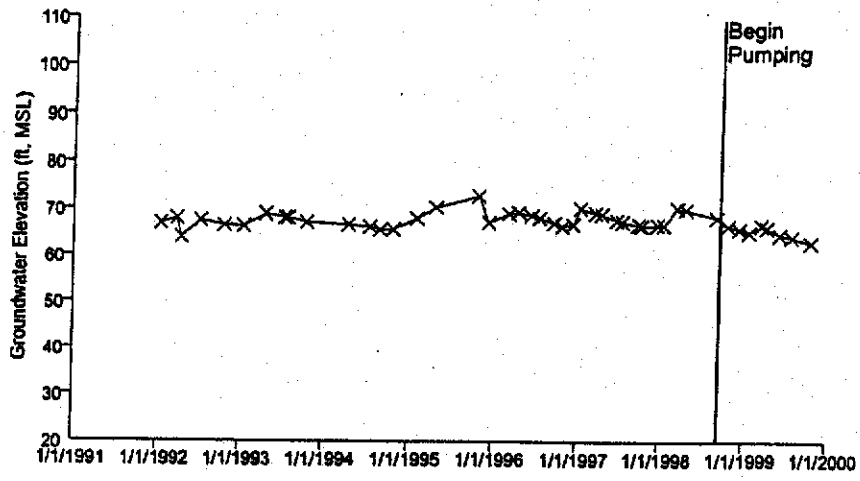

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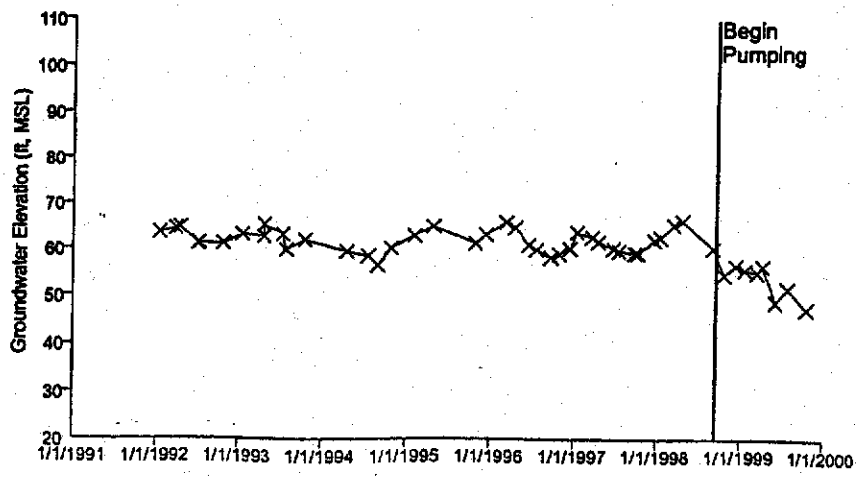

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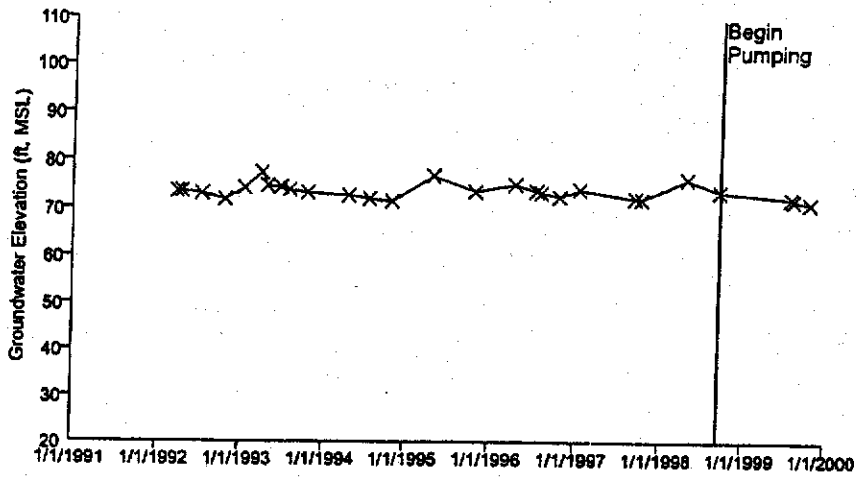

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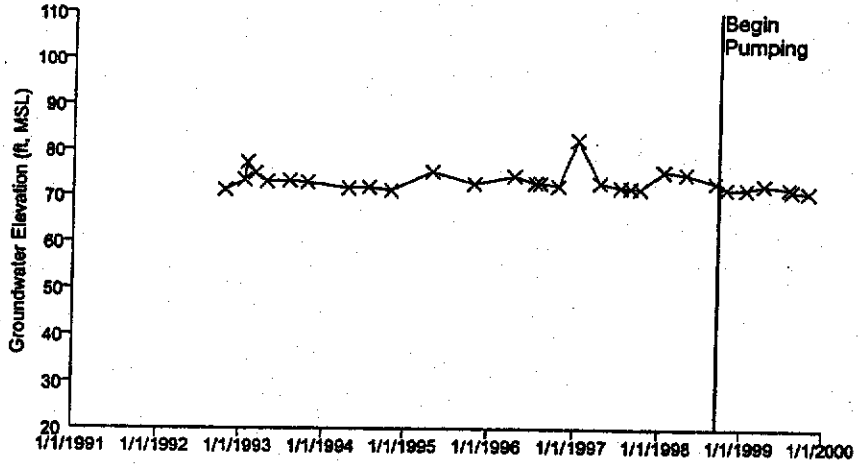

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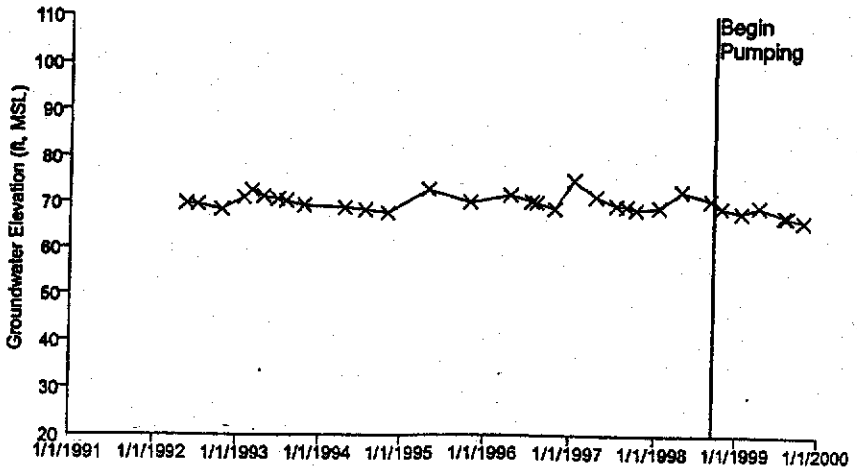

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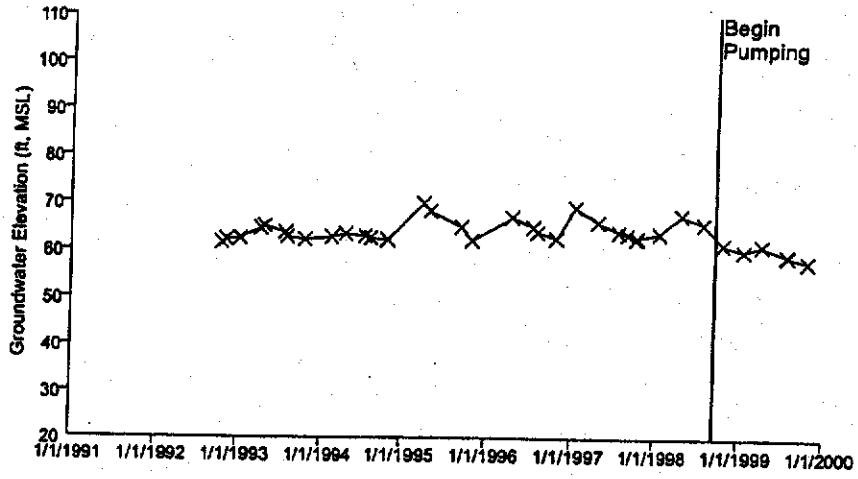

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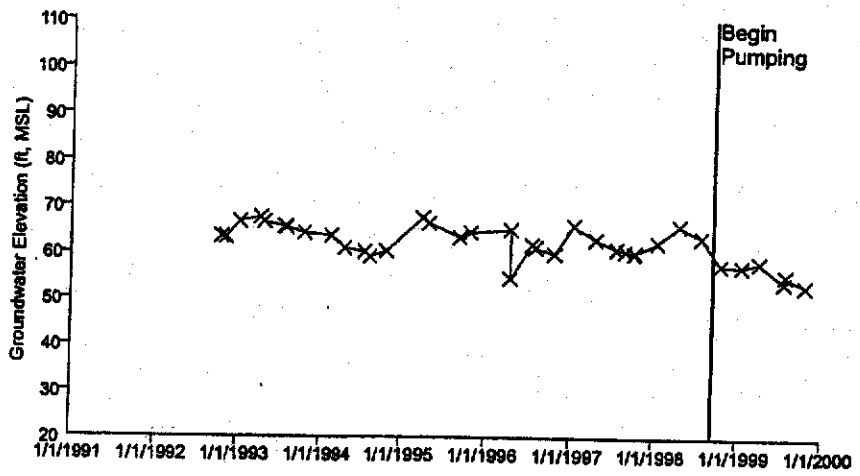

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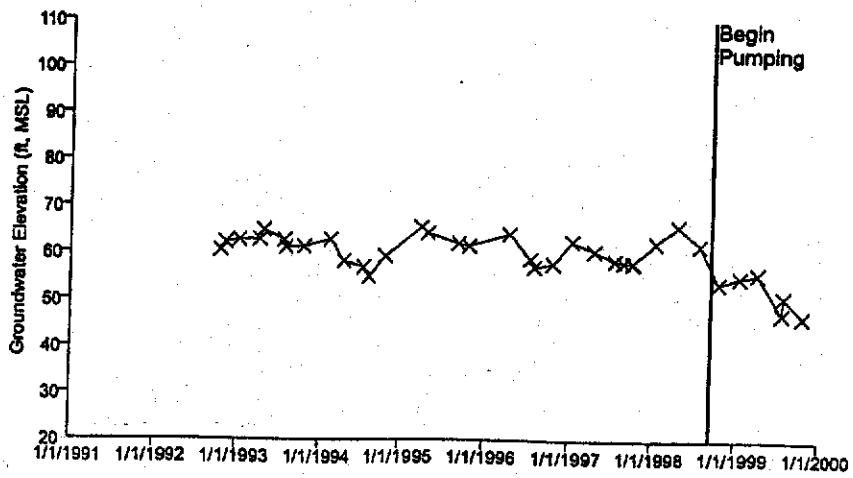

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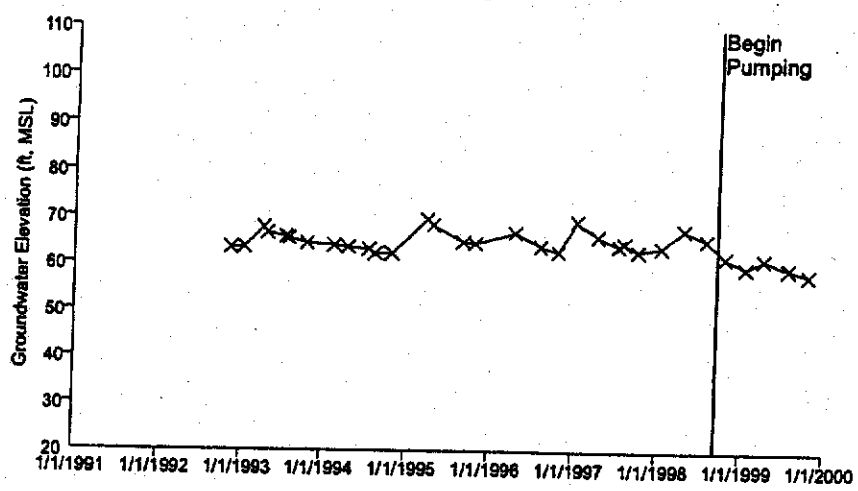

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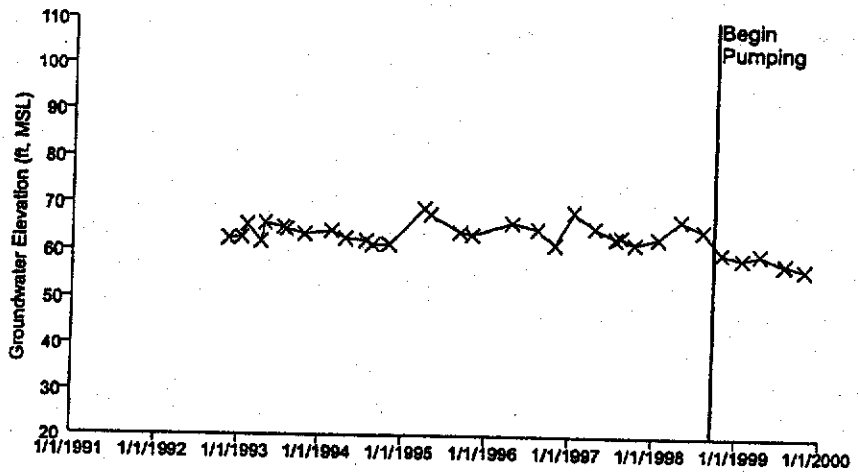

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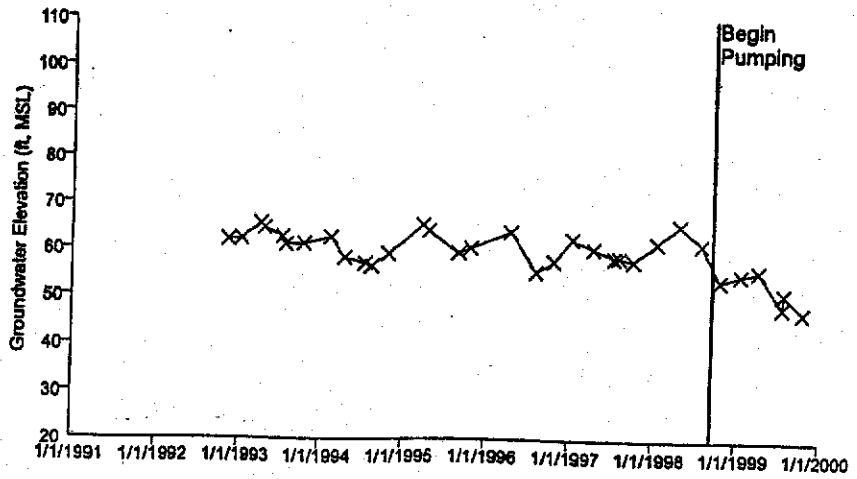

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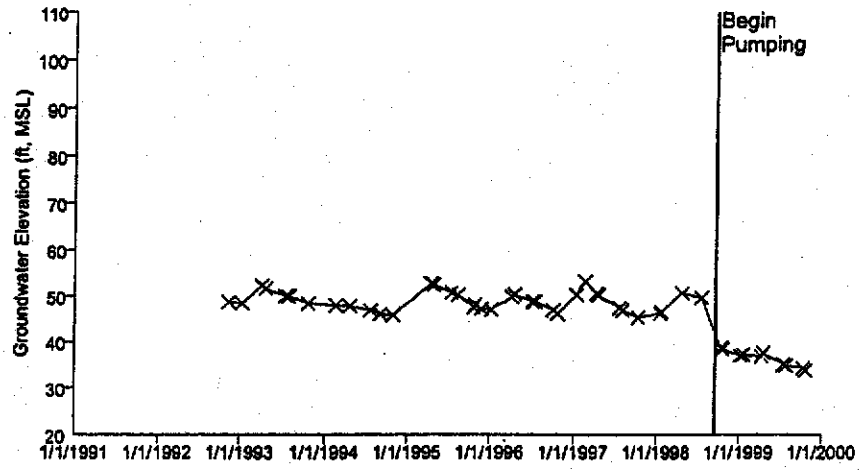

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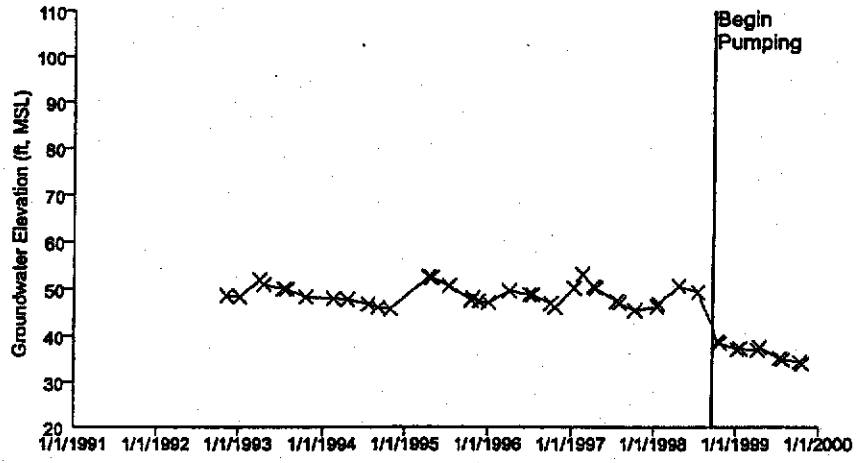

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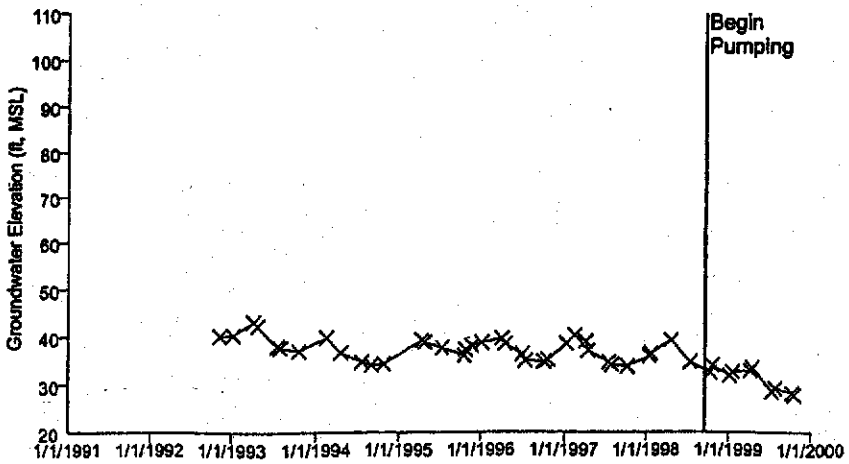

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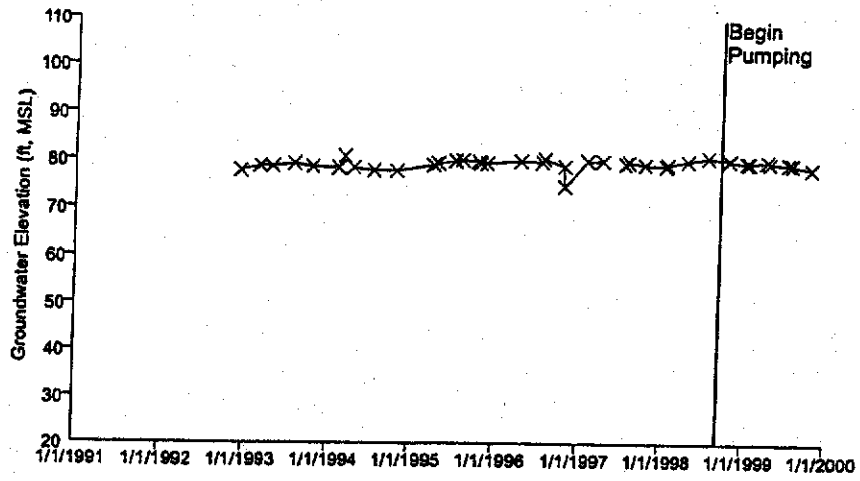

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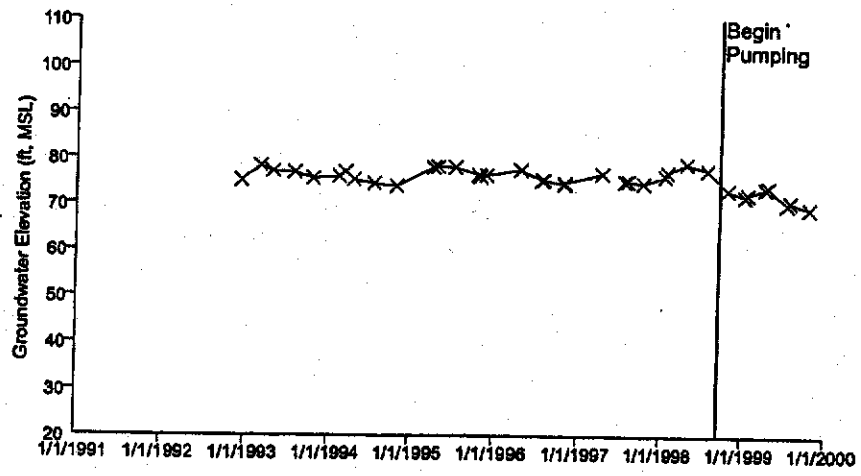

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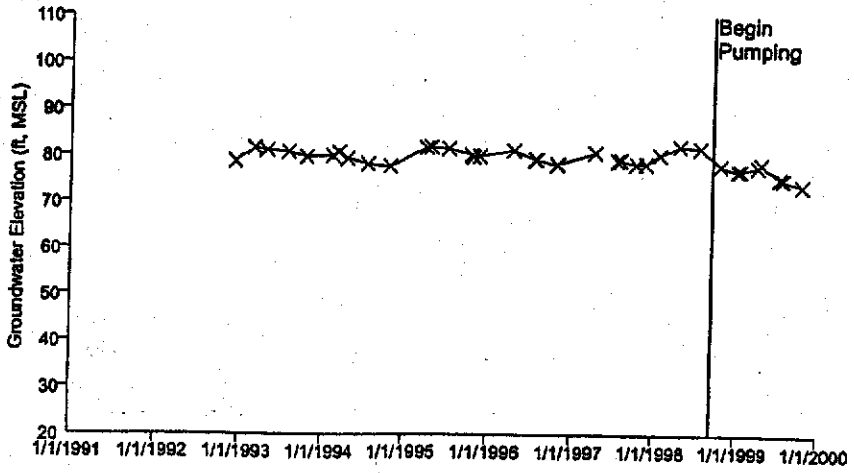

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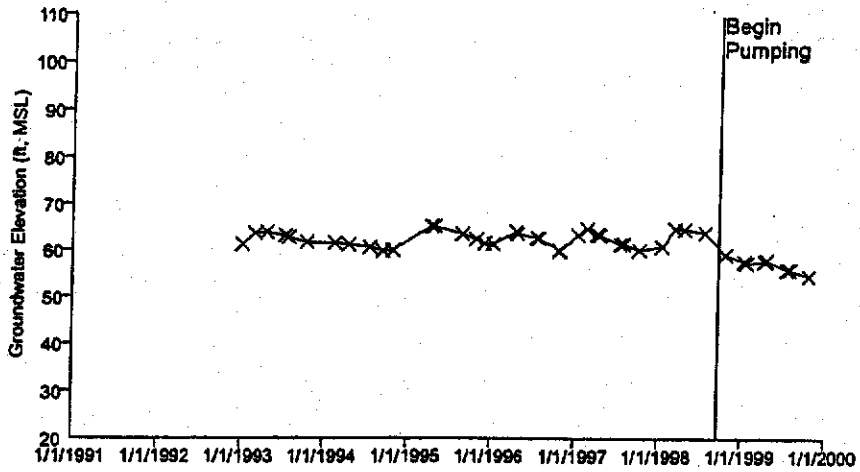

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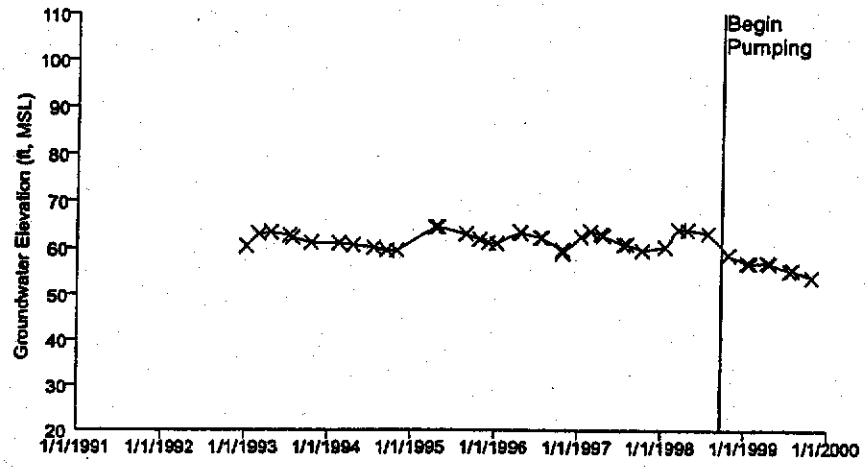

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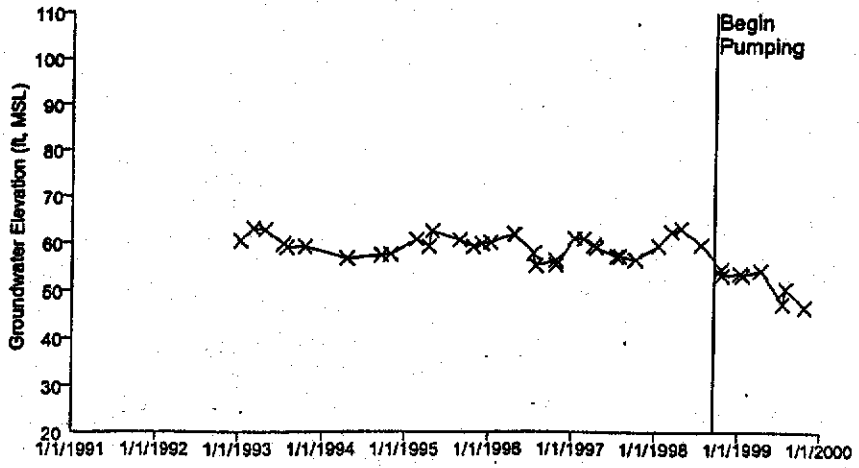

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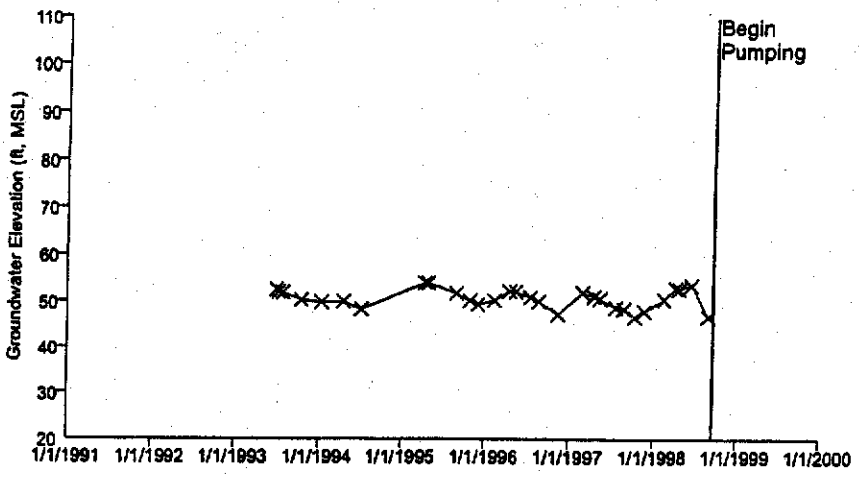

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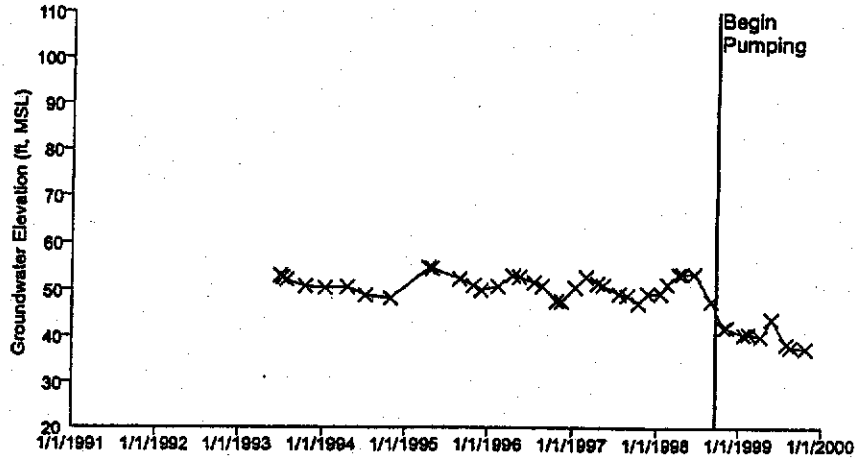

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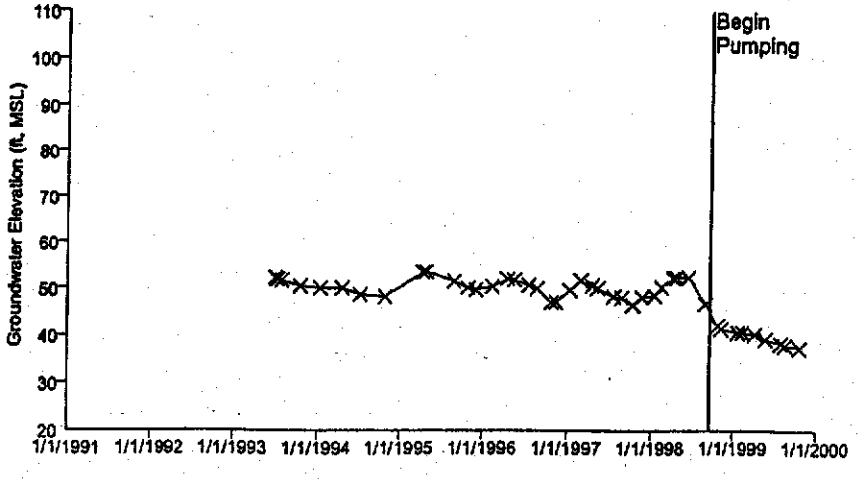

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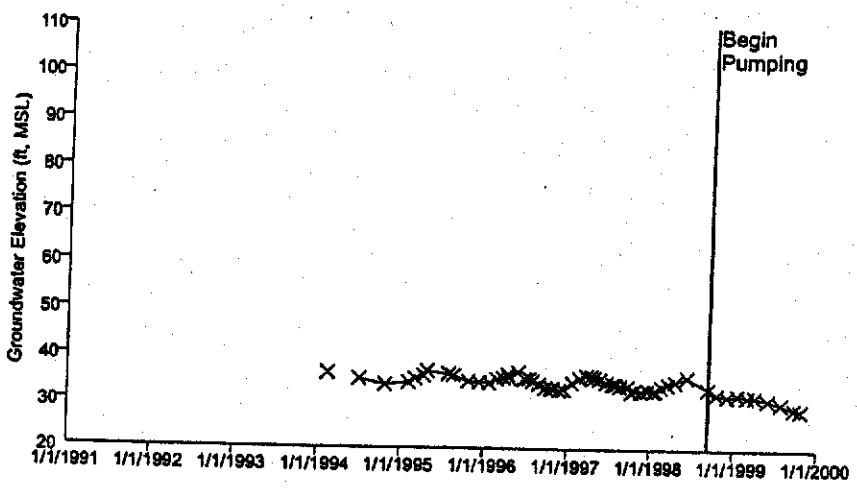

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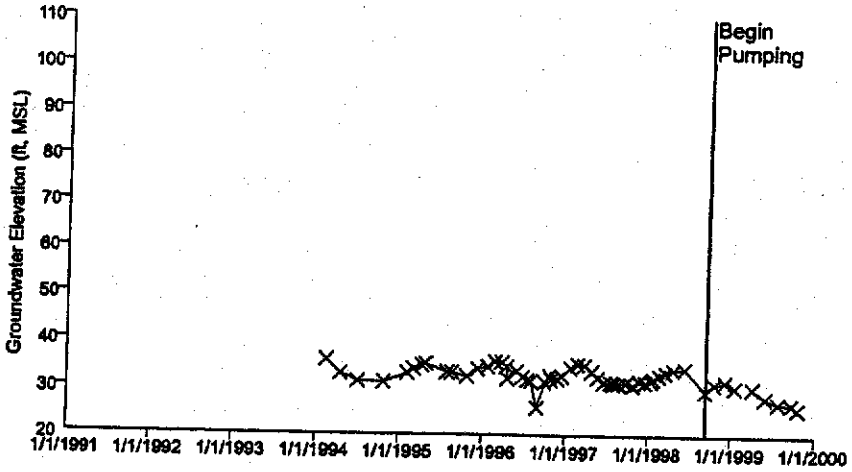

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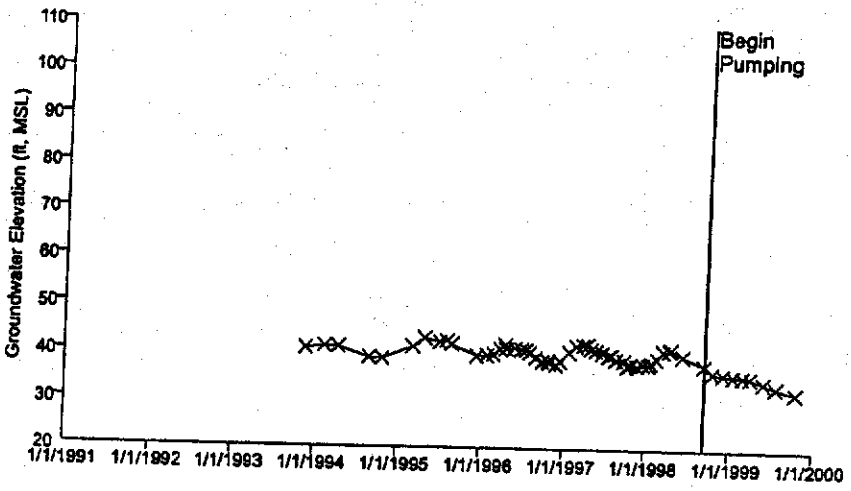

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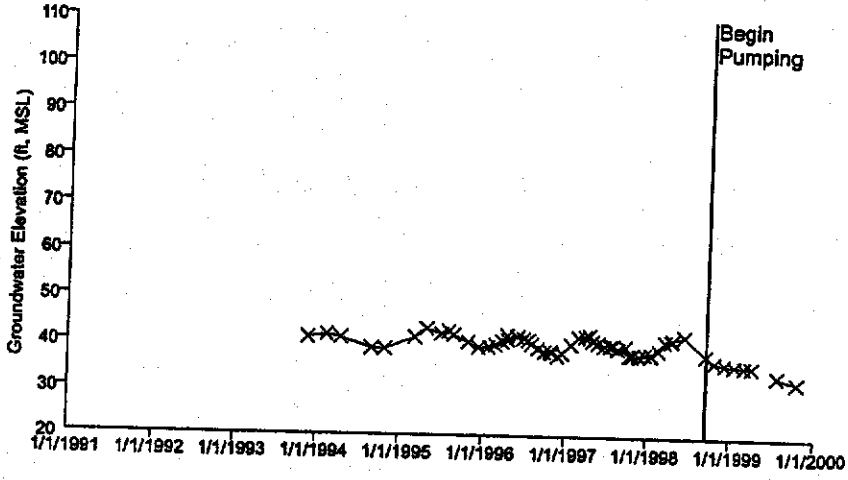

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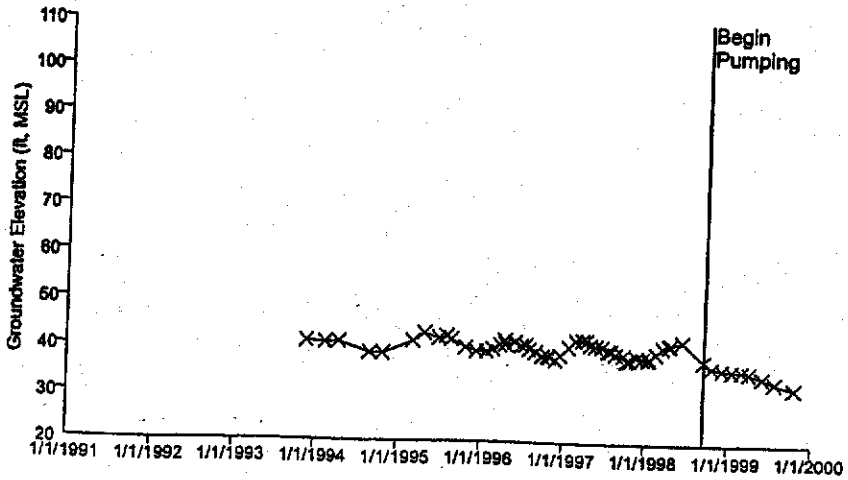

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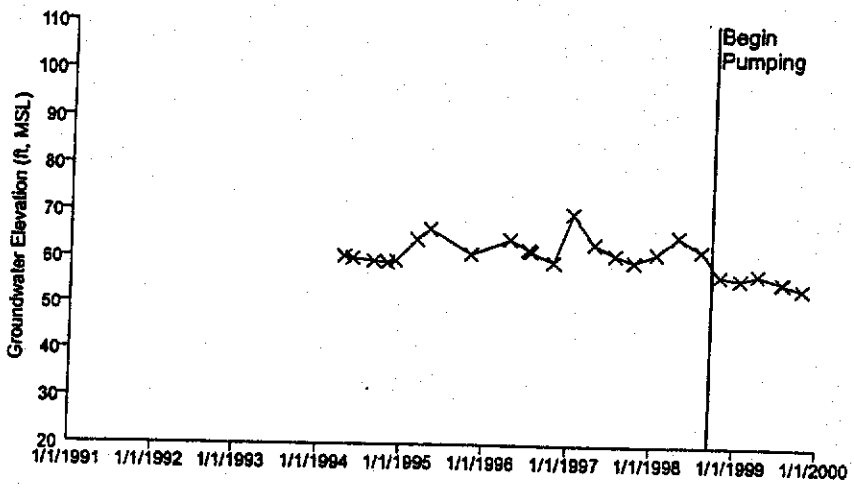

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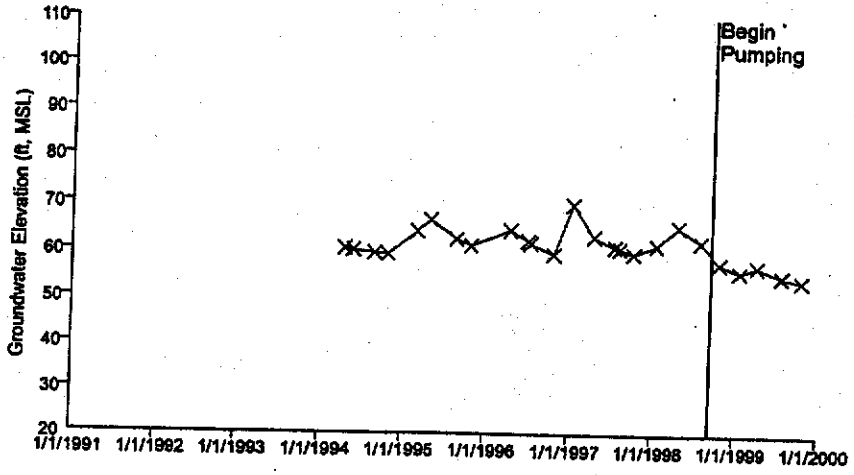

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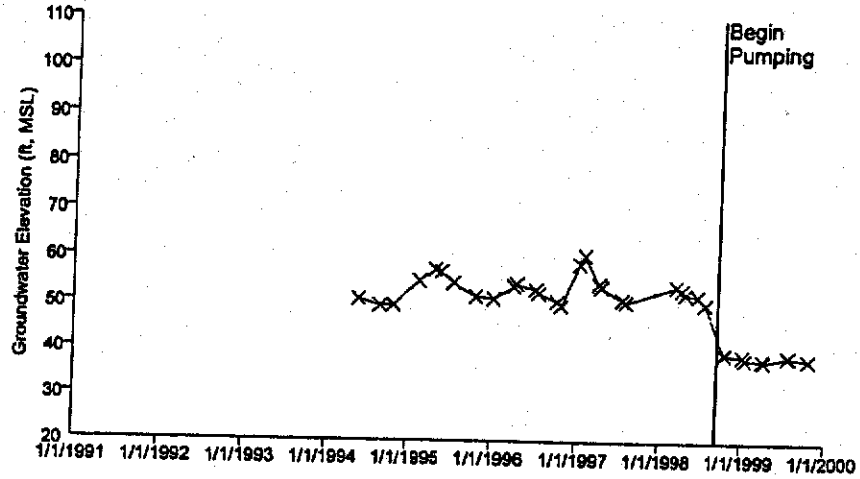

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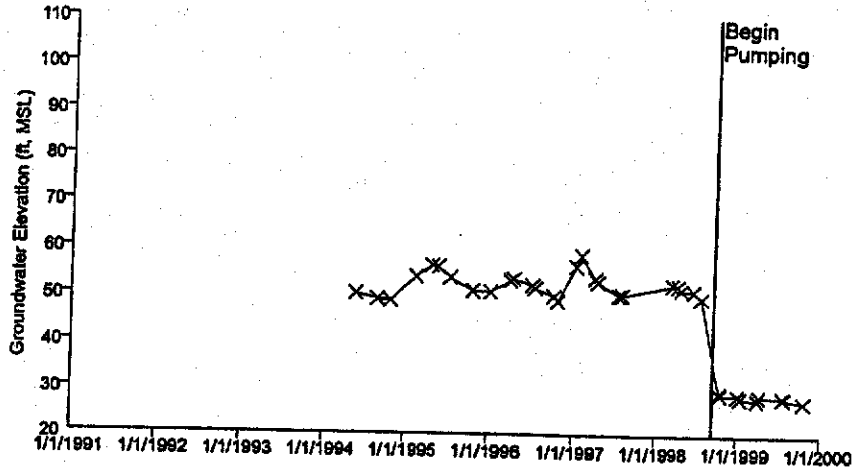

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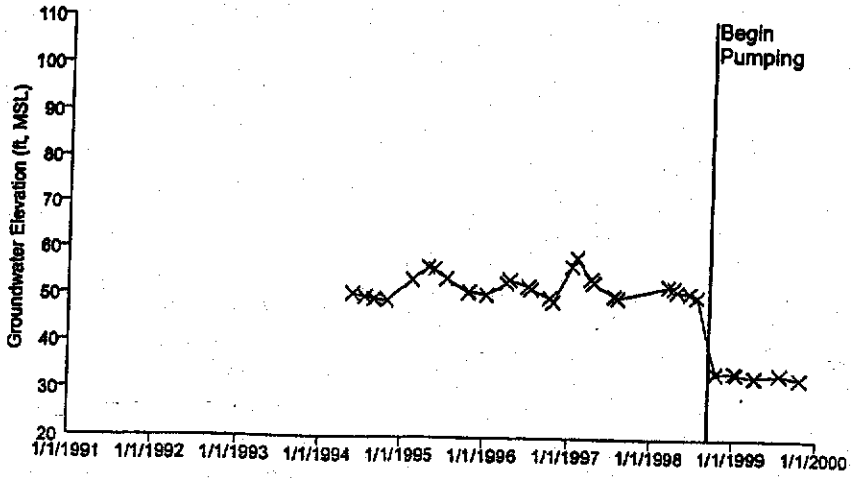

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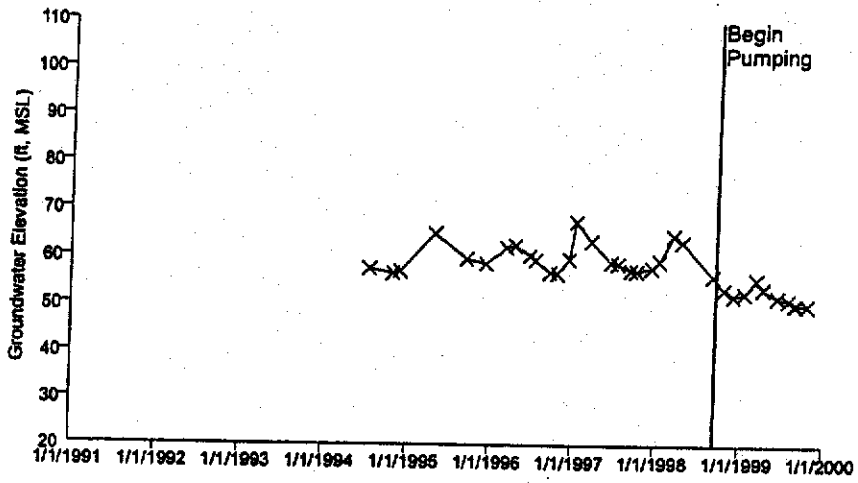

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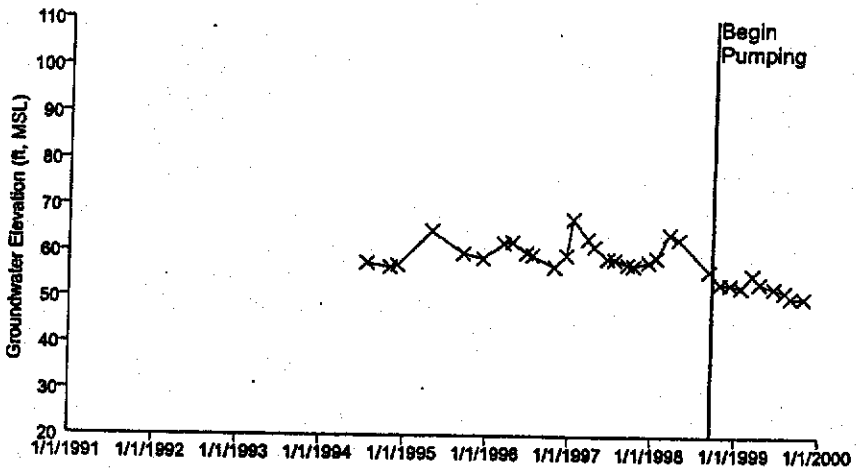

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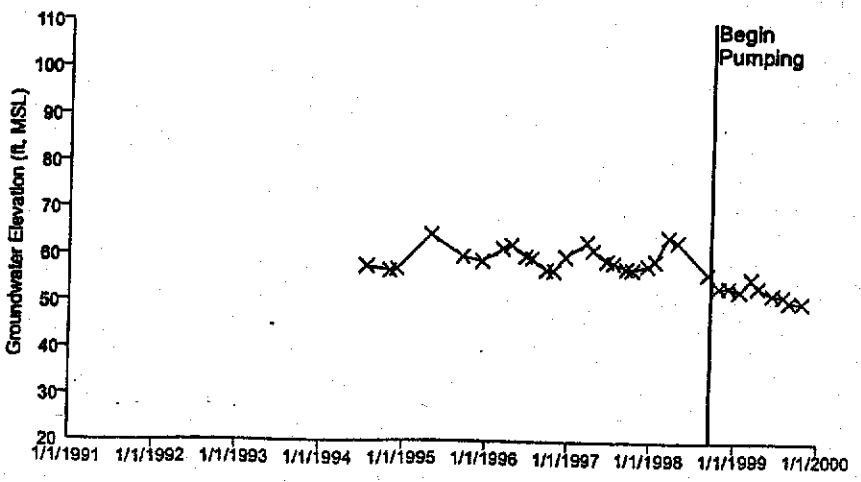

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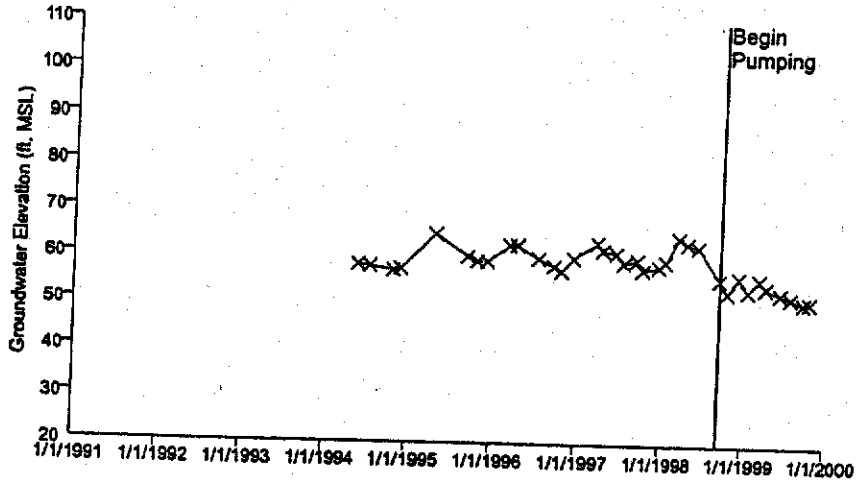

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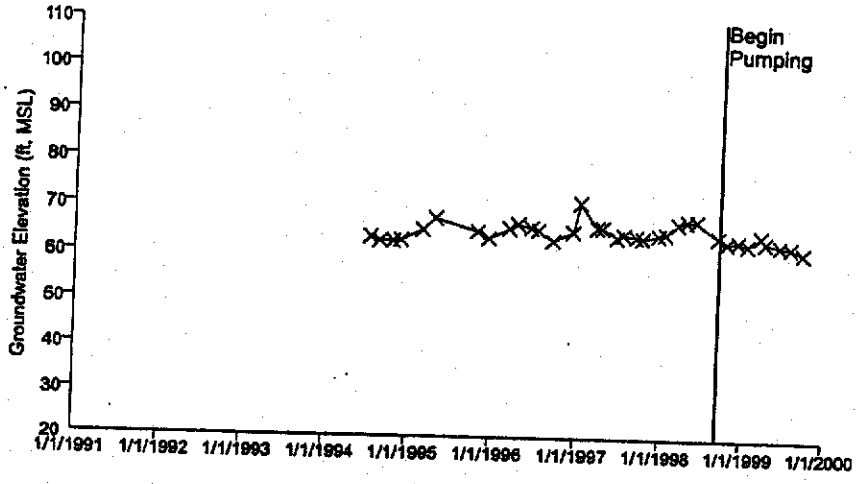

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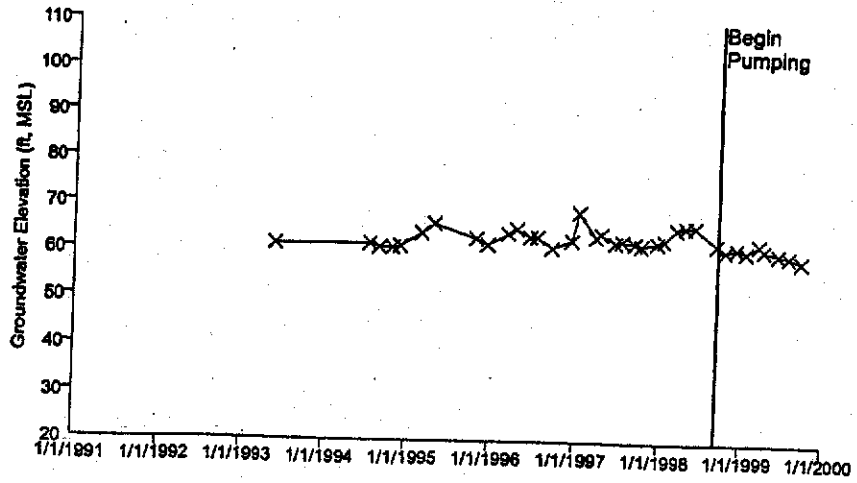

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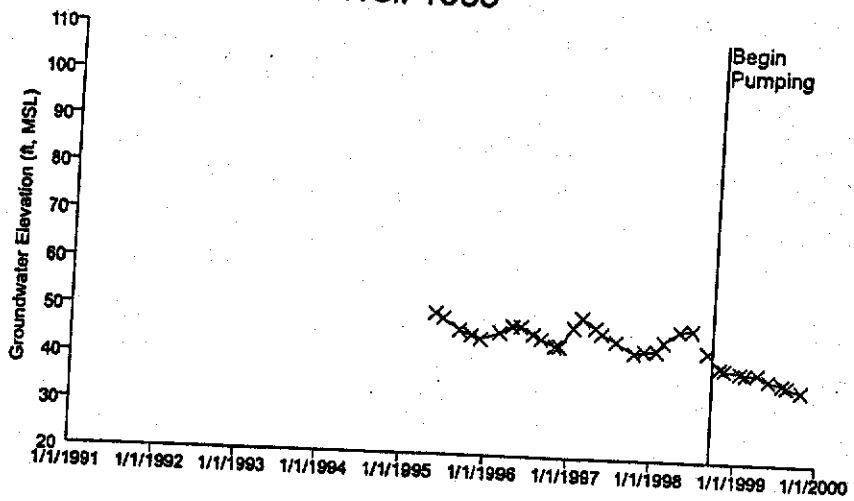

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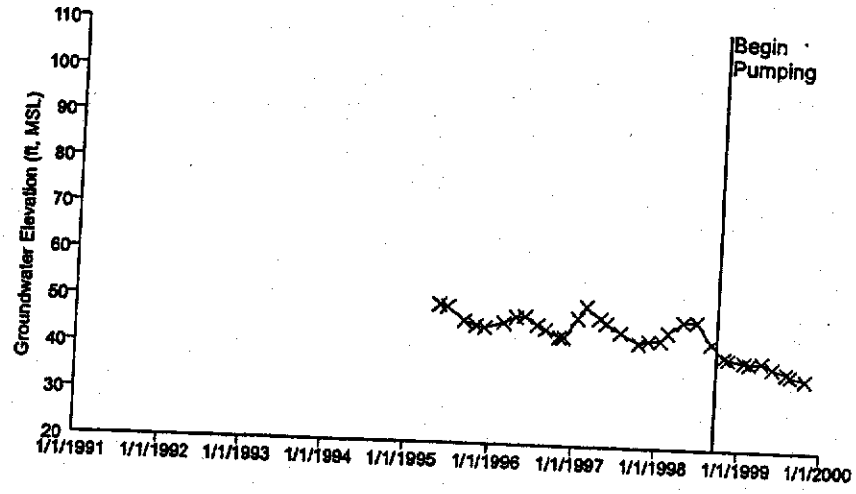

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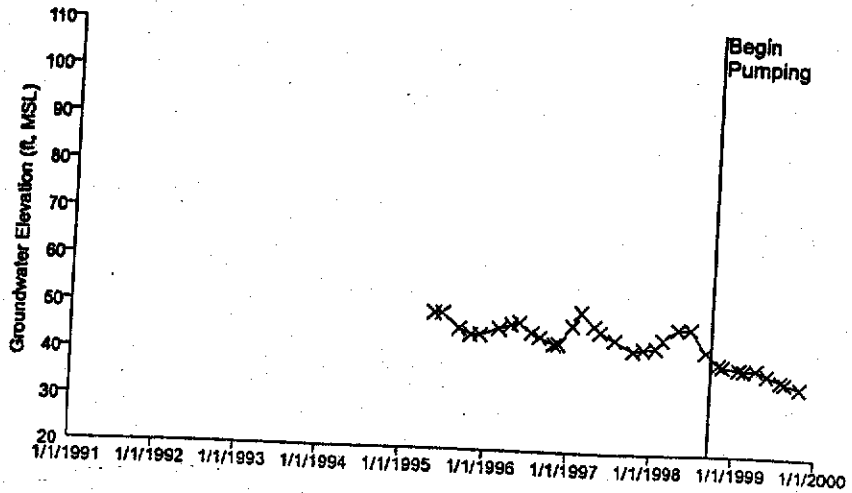

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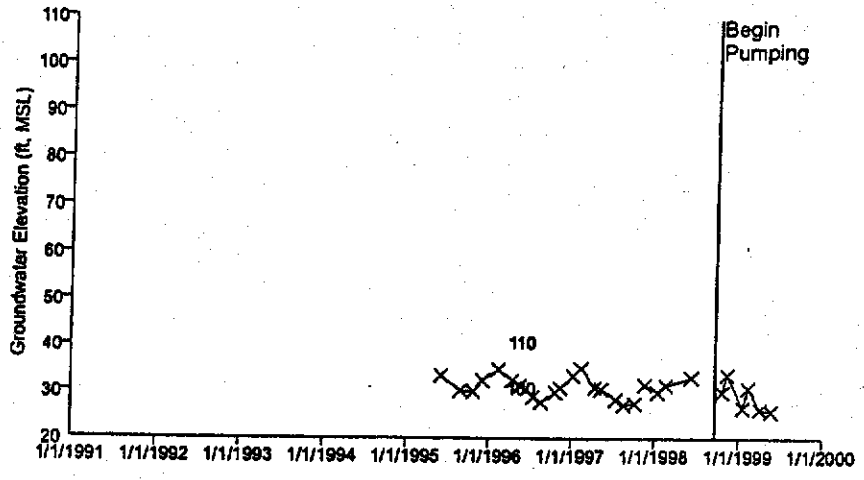

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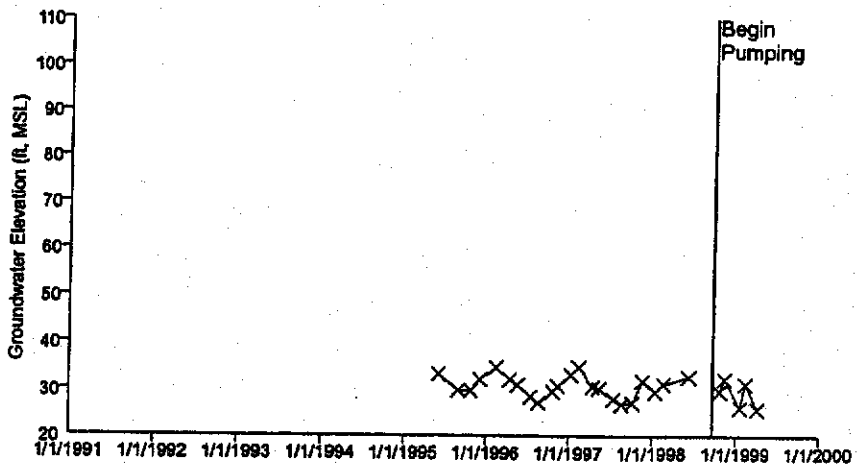

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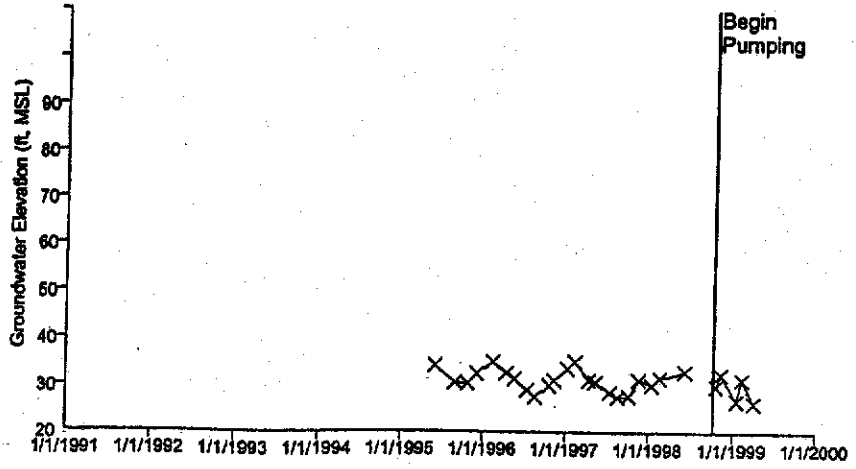

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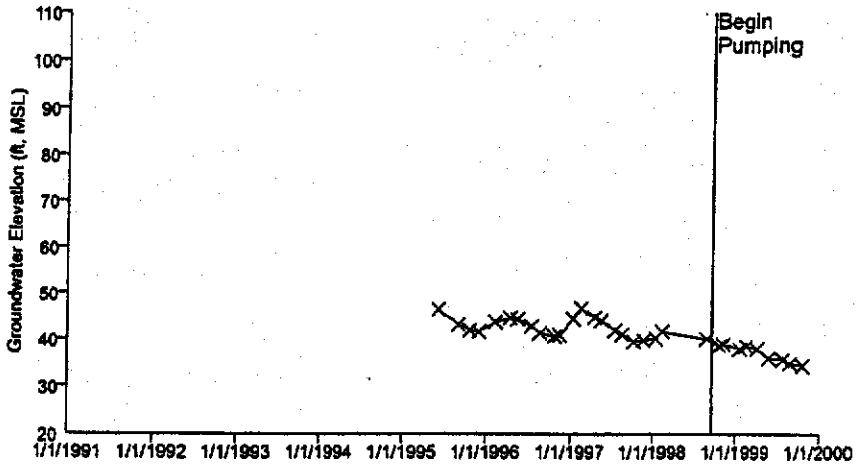

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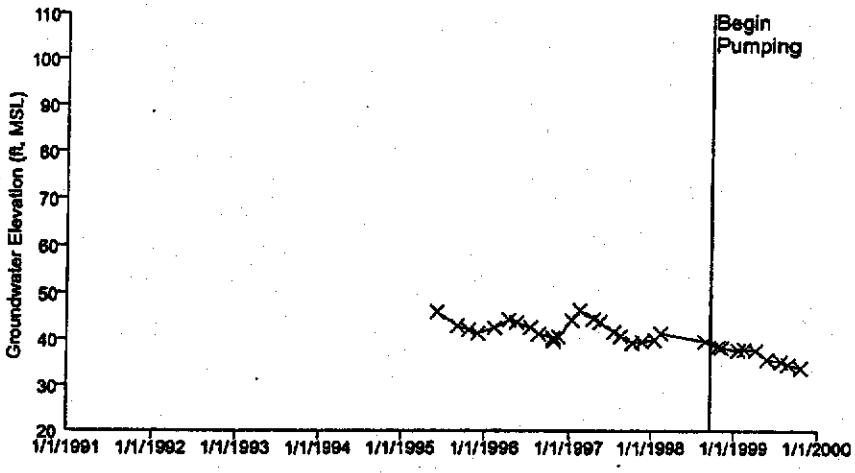

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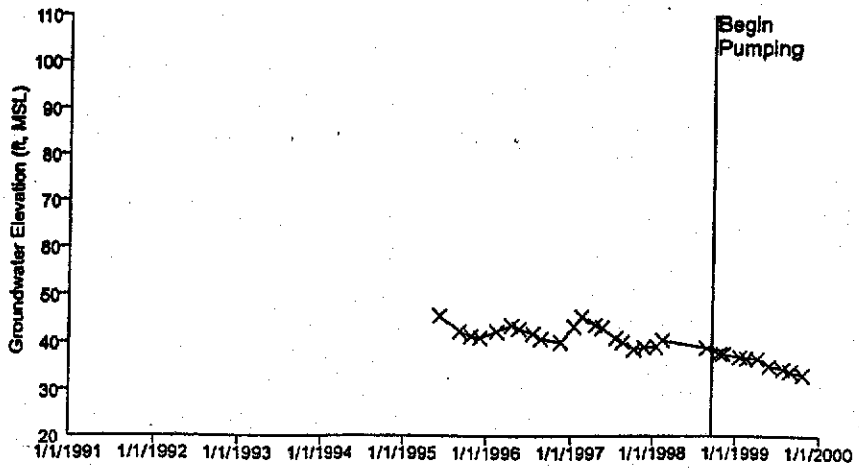

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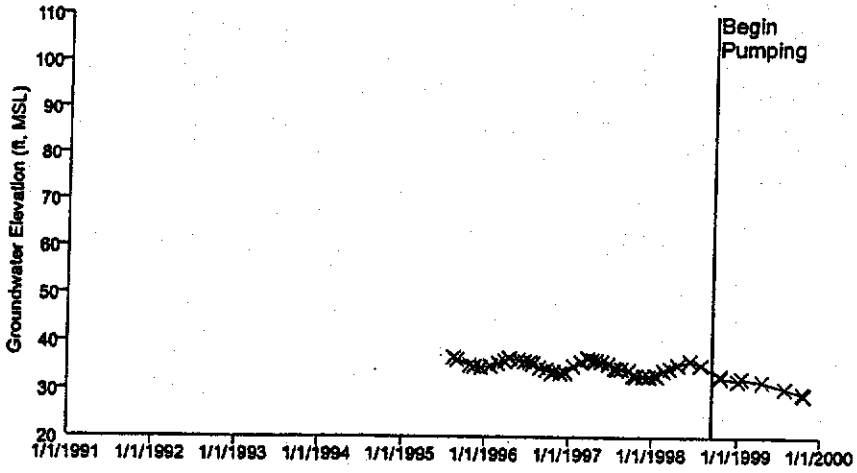

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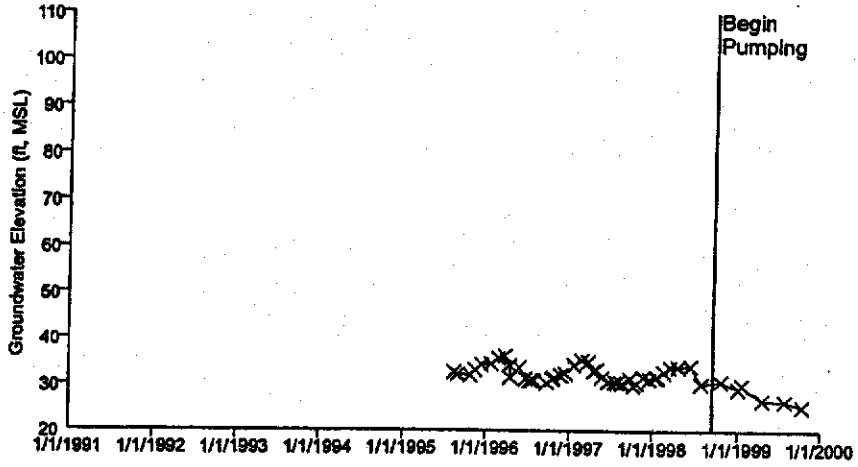

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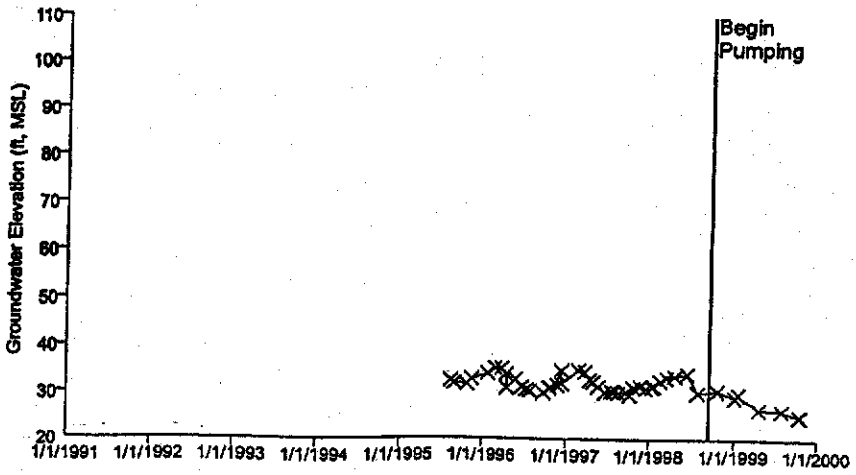

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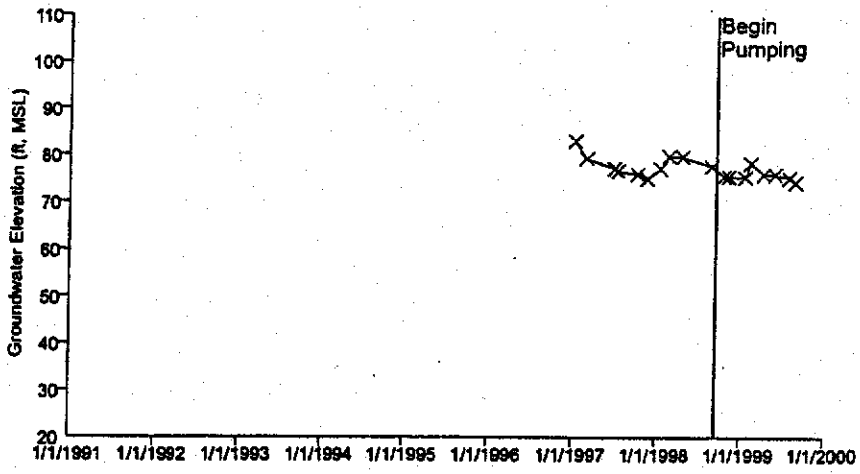

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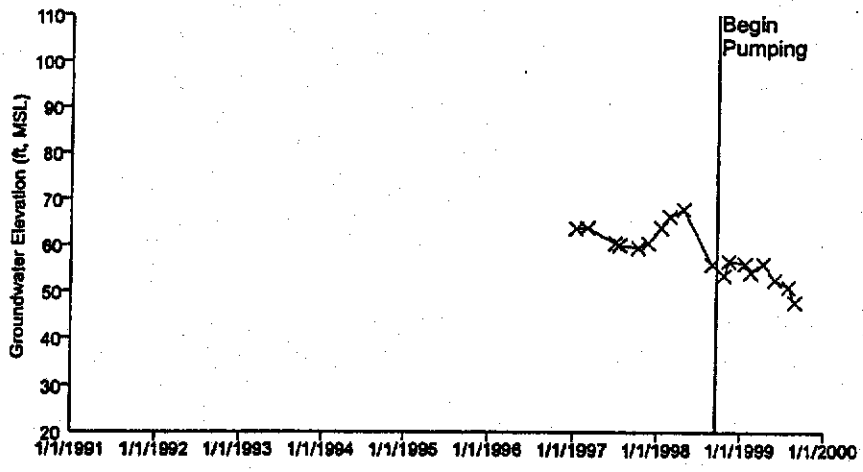

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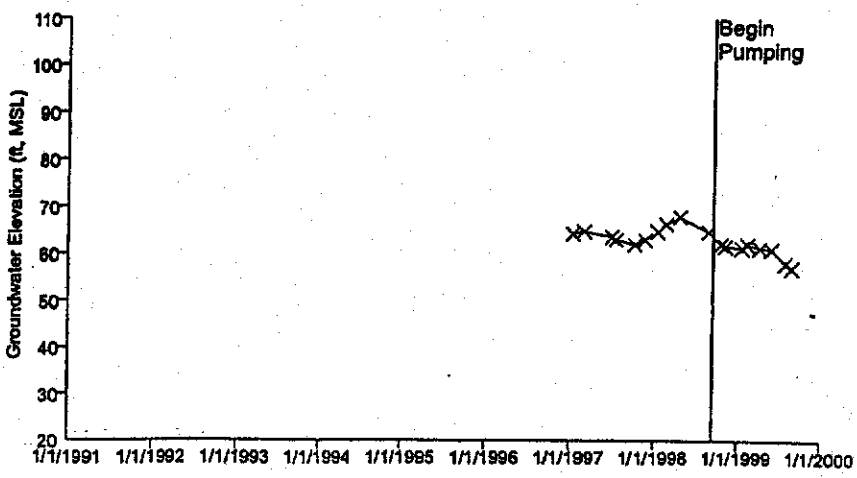
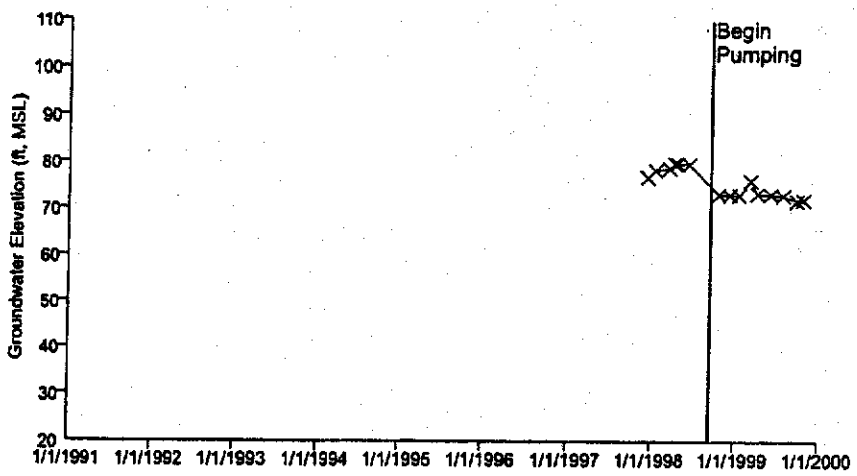


Well 30100



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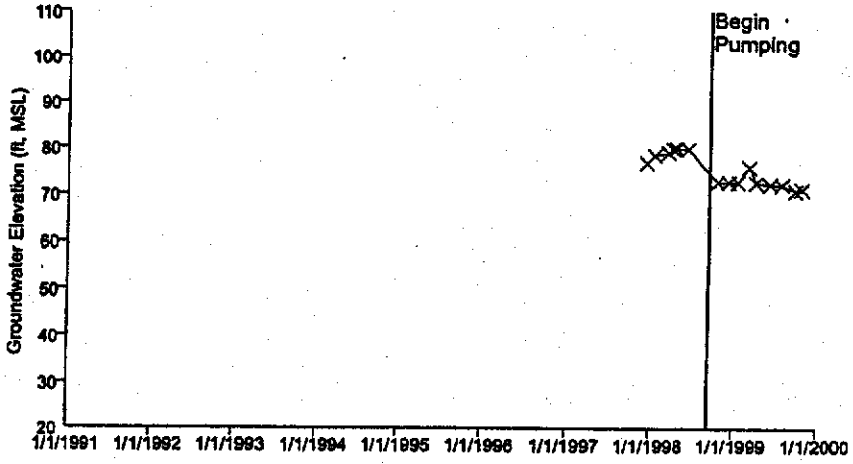

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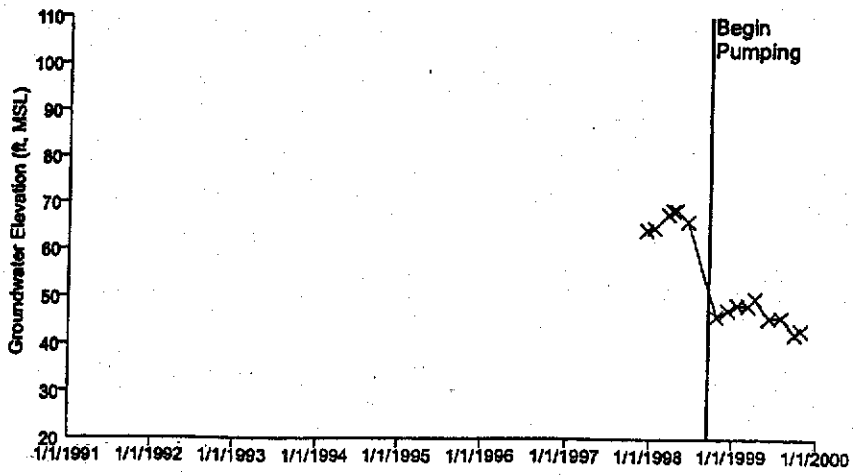

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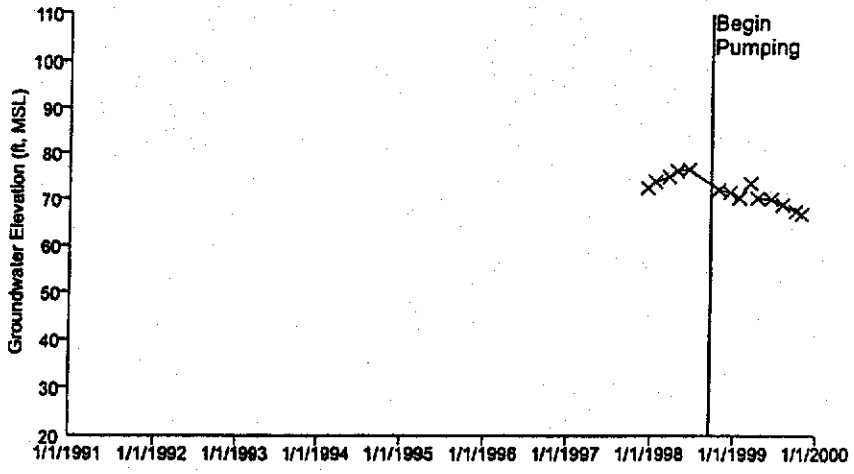
Groundwater Elevation (ft, MSL)
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90
80
70
60
50
40
30
20
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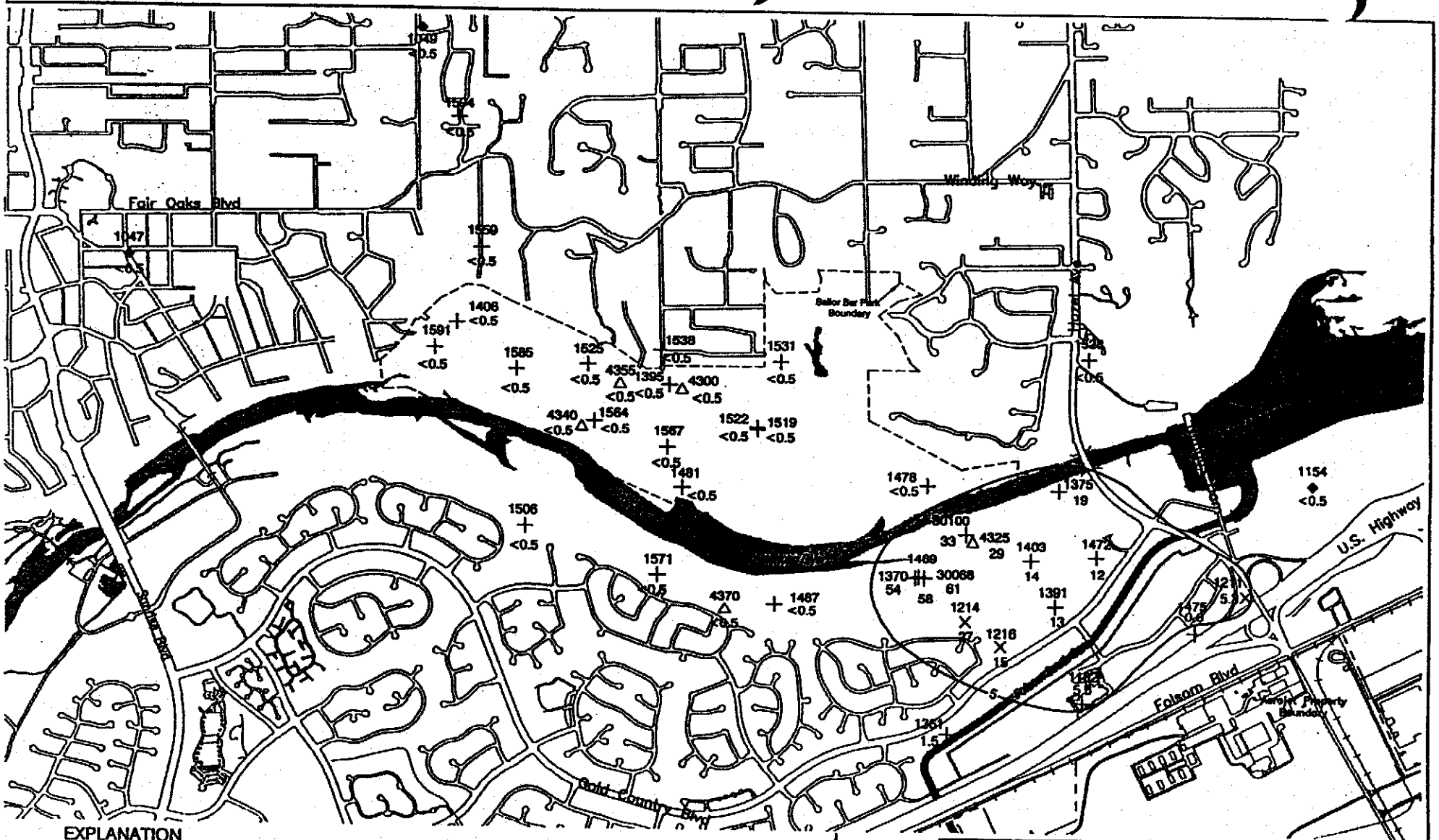
1/1/1992
1/1/1993
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
Begin Pumping

APPENDIX B

CHEMICAL DISTRIBUTION MAPS

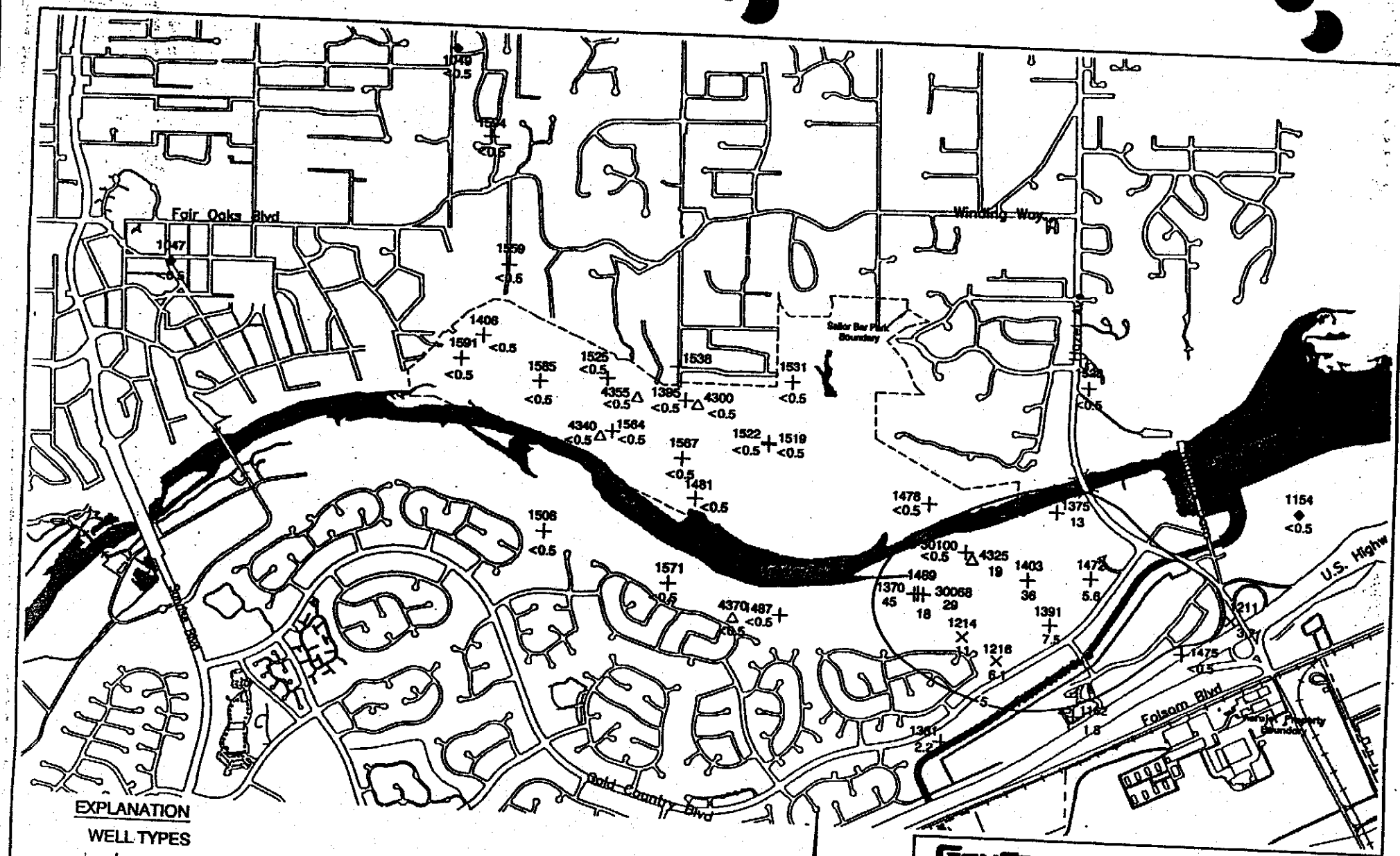


GENCORP AEROJET Environmental Operations

FIGURE B-1

American River Study Area
1,1-DCE In Groundwater - 7/98-9/98
Aquifer A

2/10/00 ah SR10109273

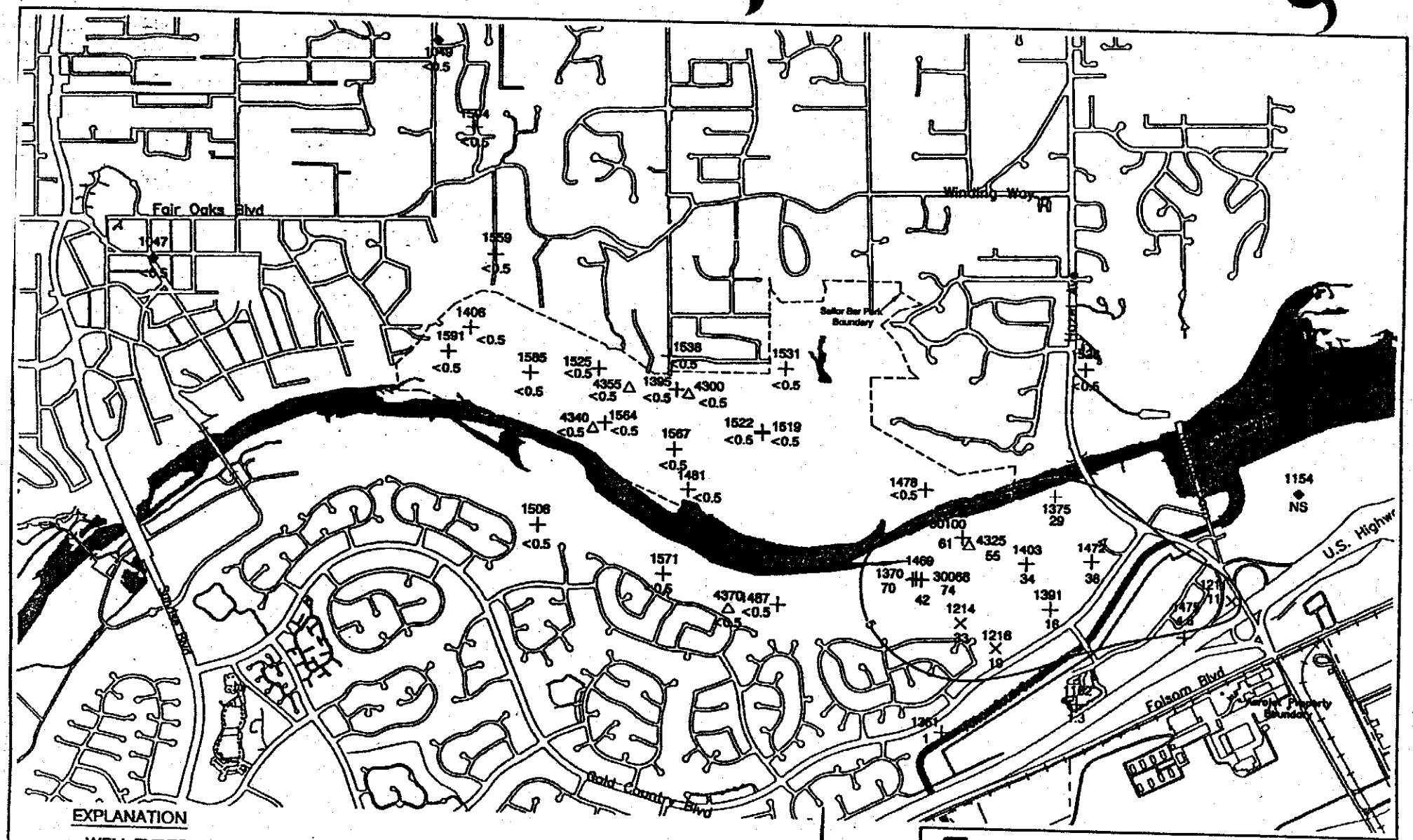


GENCORP AEROJET Environmental Operations

FIGURE B-2

American River Study Area
1,1-DCE In Groundwater - 7/99-9/99
Aquifer A

2/10/00 ah SR10109274



EXPLANATION

WELL TYPES

- Monitor Well
- Extraction Well
- Recharge Well
- State Well
- Water Supply Well

5 — Chemical Concentration Contour (µg/l)

N

Scale: 1" = 1800'

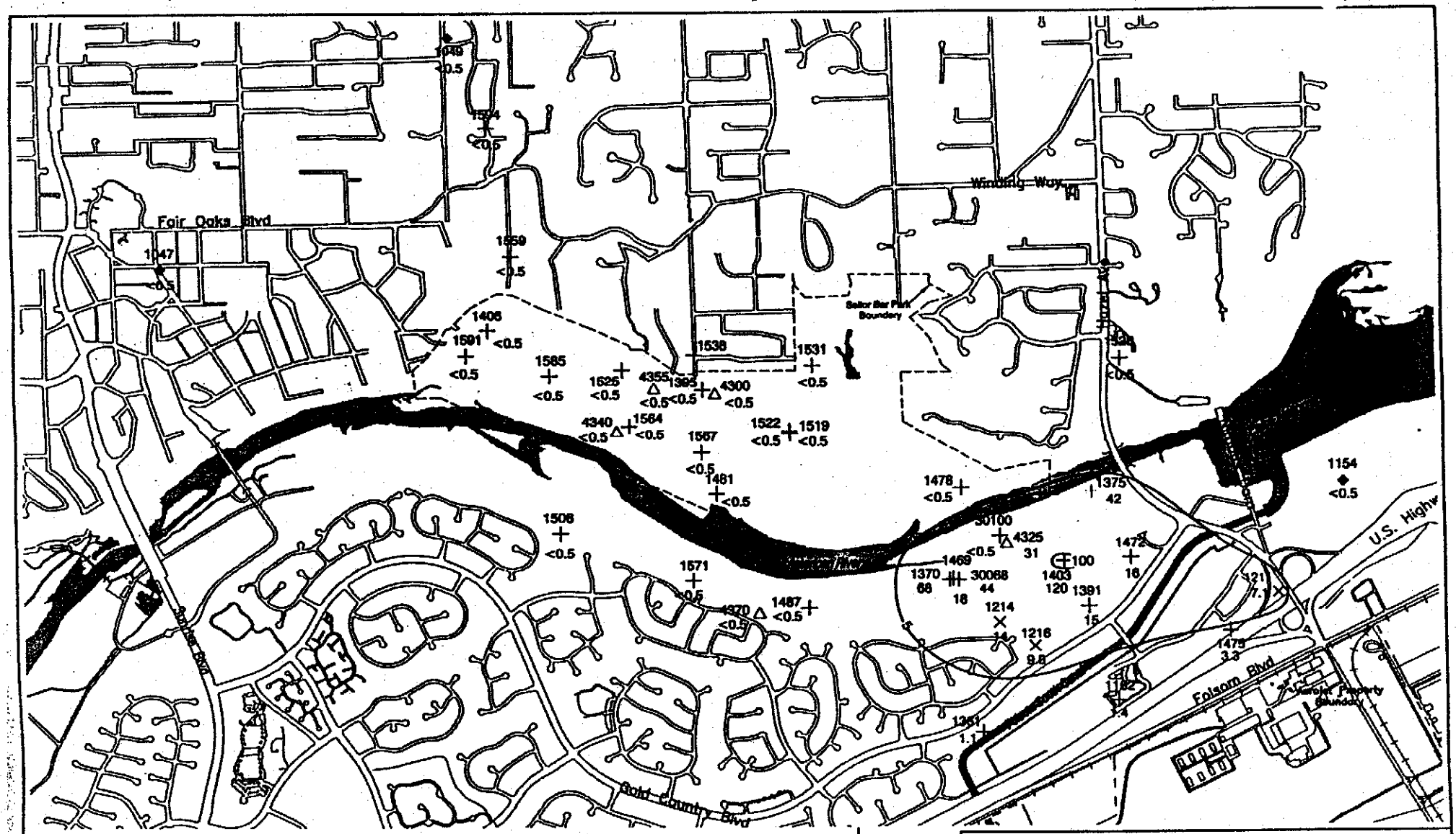
0 900 1800

GENCORP AEROJET — Environmental Operations

FIGURE B-3

American River Study Area
1,2-DCE in Groundwater - 7/98-9/98
Aquifer A

2/10/00 ah SR10109275



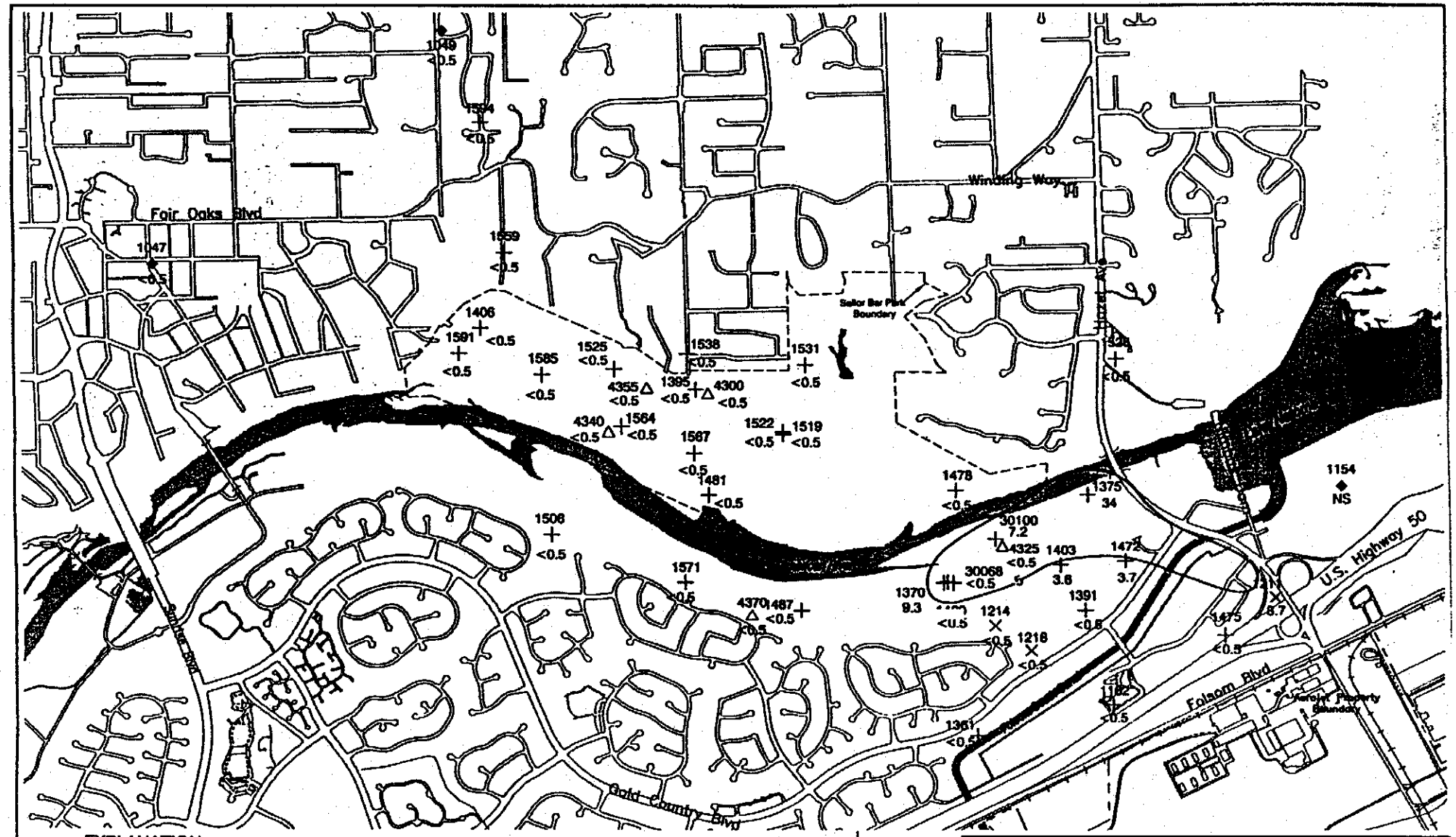
GENCORP AEROJET

Environmental Operations

FIGURE B-4

American River Study Area
1,2-DCE in Groundwater - 7/99-9/99
Aquifer A

2/10/00 ah SR10109276

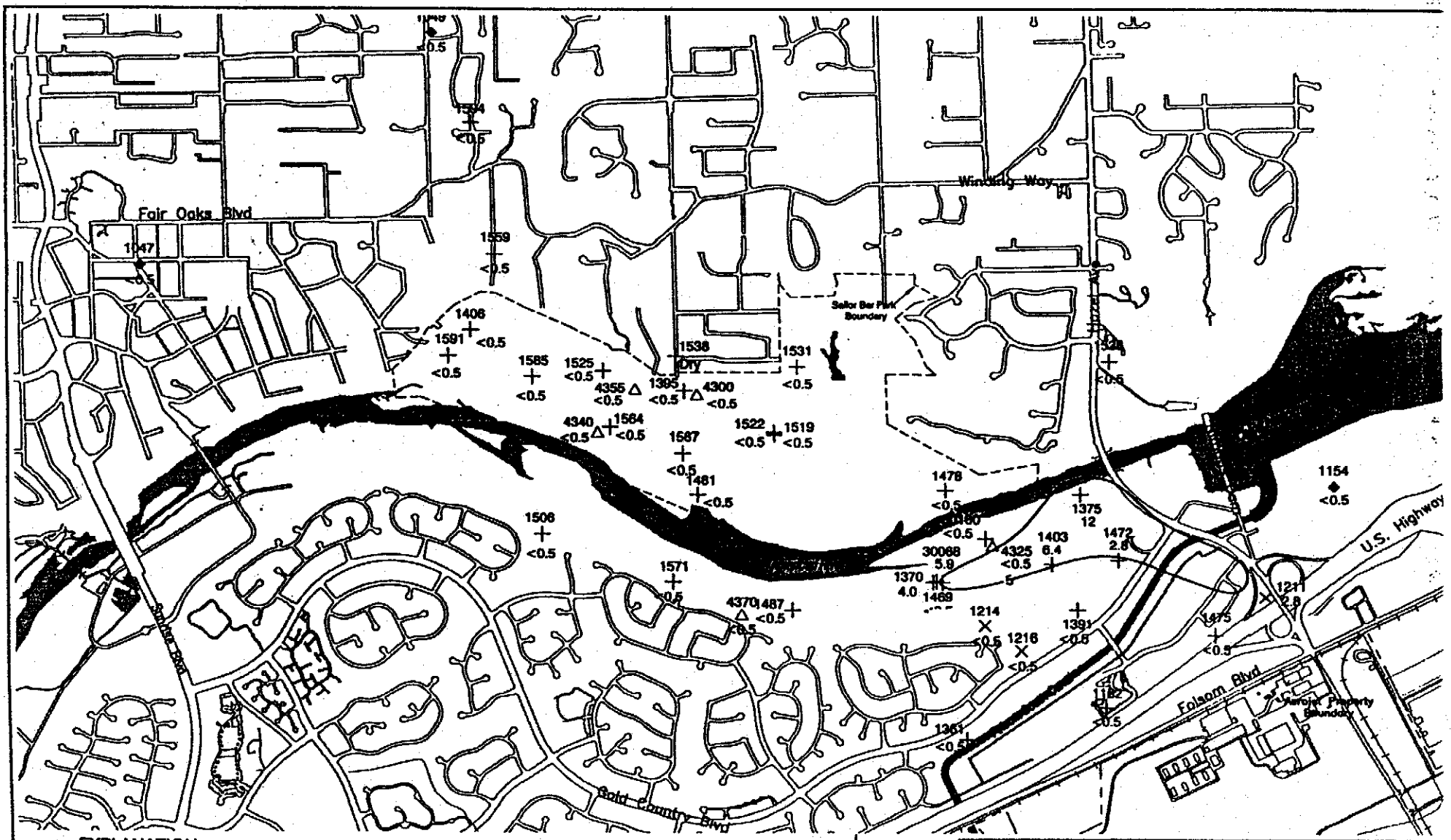


GENCORP AEROJET — Environmental Operations

FIGURE B-5

American River Study Area
Freon 113 In Groundwater - 7/98-9/98
Aquifer A

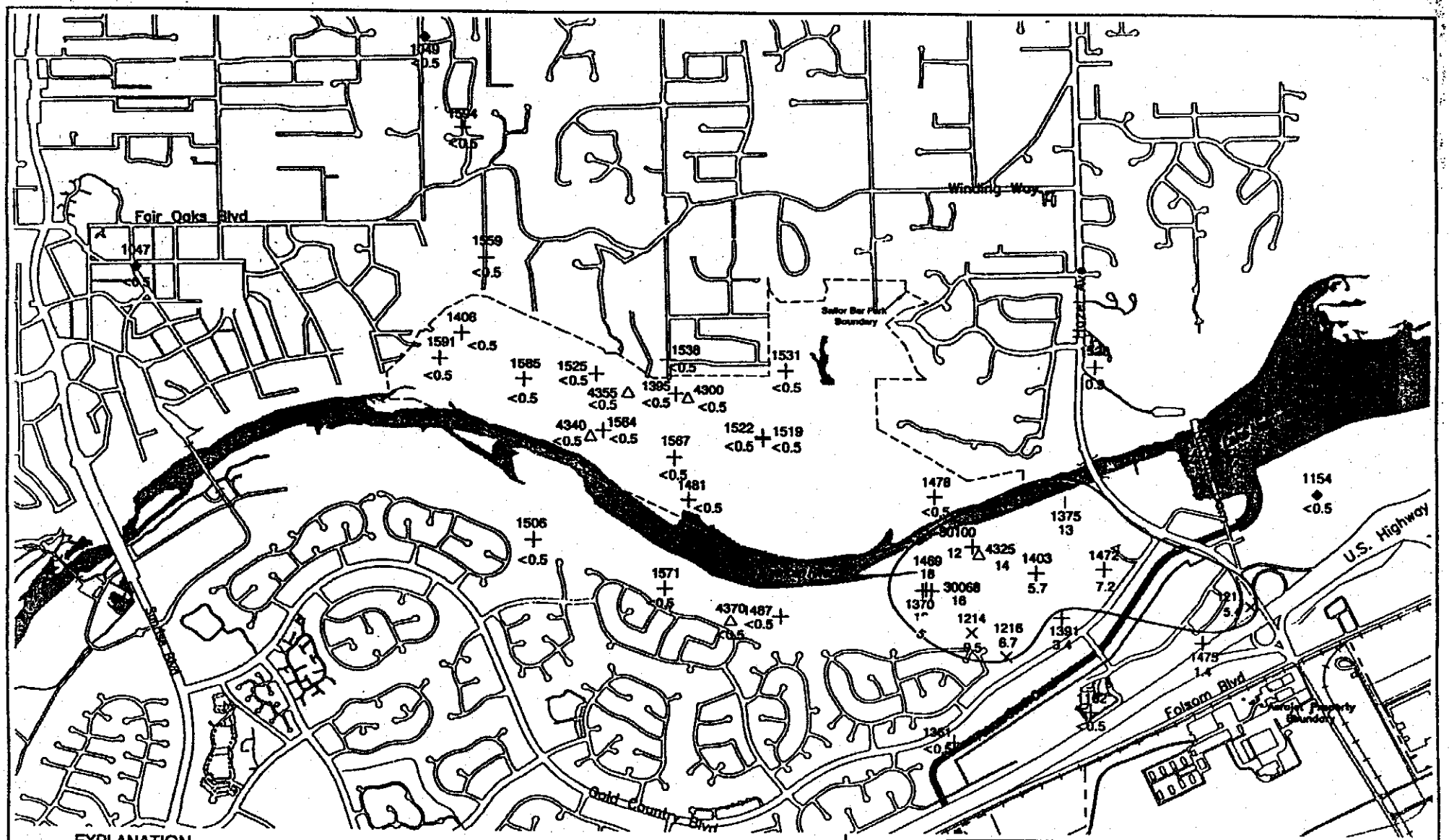
2/10/00 gb SB10109277



GENCORP AEROJET — Environmental Operations

FIGURE B-6

American River Study Area
Freon 113 in Groundwater - 7/99-9/99
Aquifer A



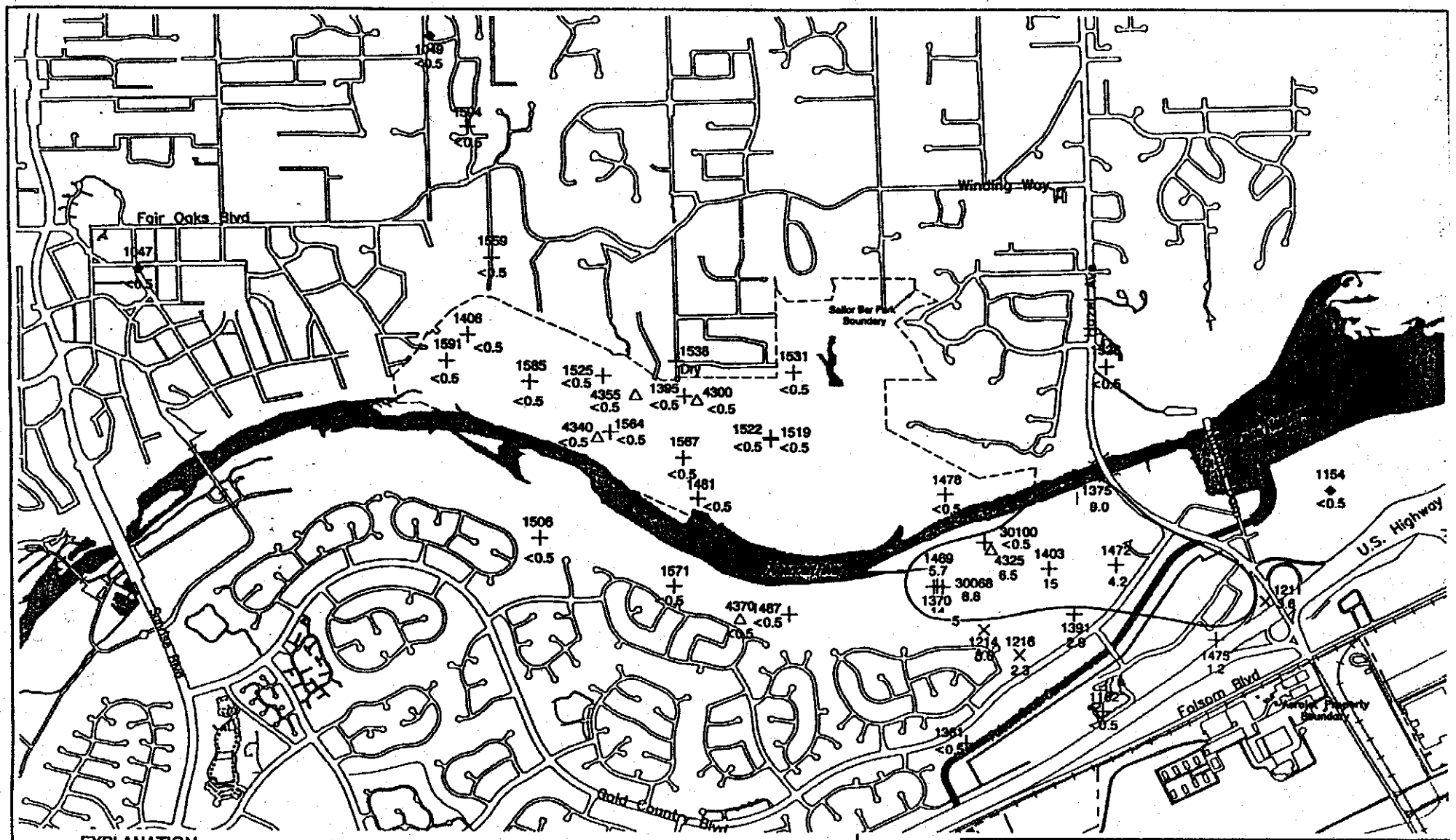
GENCORP AEROJET

Environmental Operations

FIGURE B-7

American River Study Area
PCE in Groundwater - 7/98-9/98
Aquifer A

2/10/00 gb SR10109279

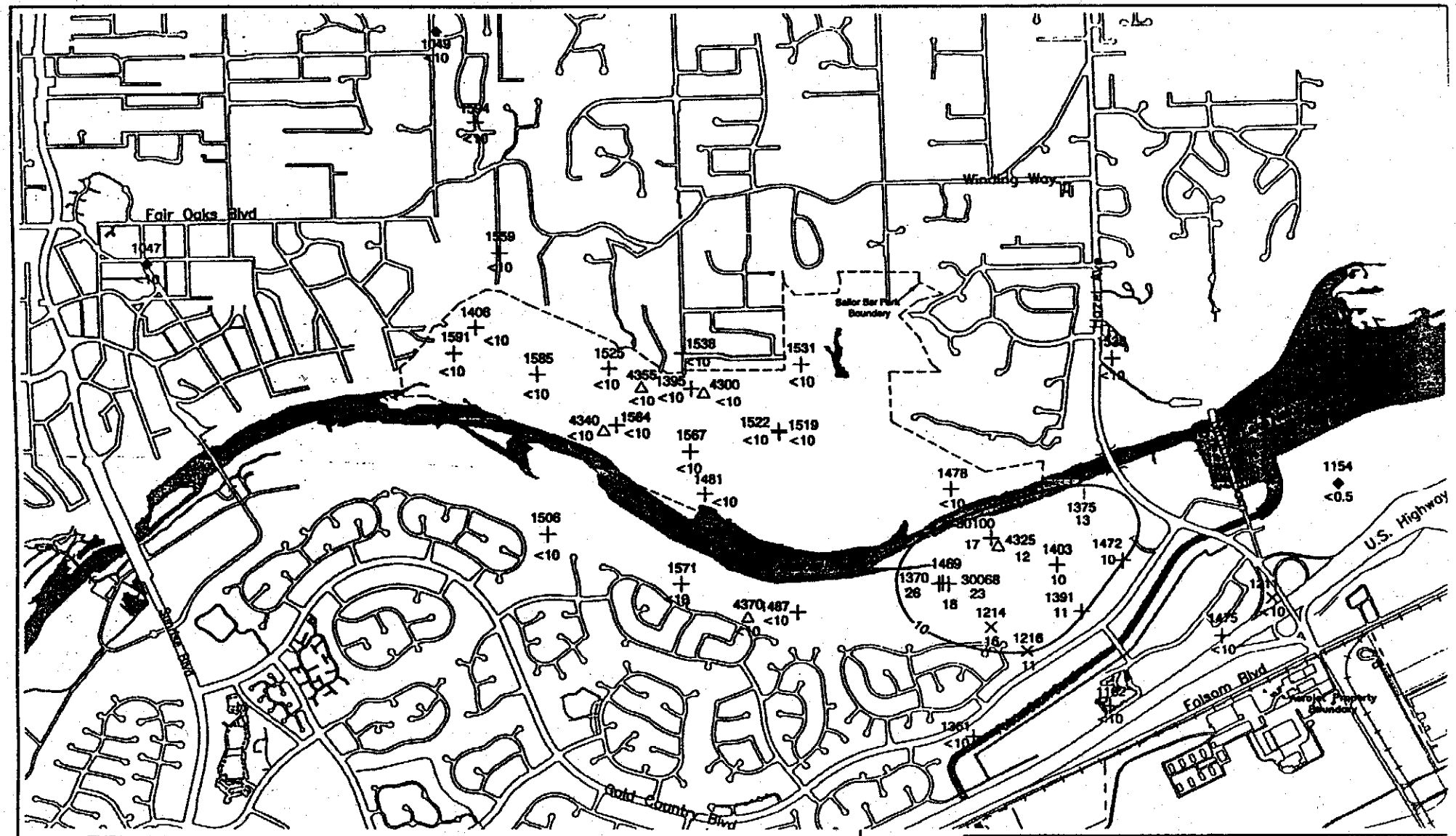


GENCORP AEROJET — Environmental Operations

FIGURE B-8

American River Study Area
PCE In Groundwater - 7/99-9/99
Aquifer A

2/10/00 nb SR10109280



EXPLANATION

WELL TYPES

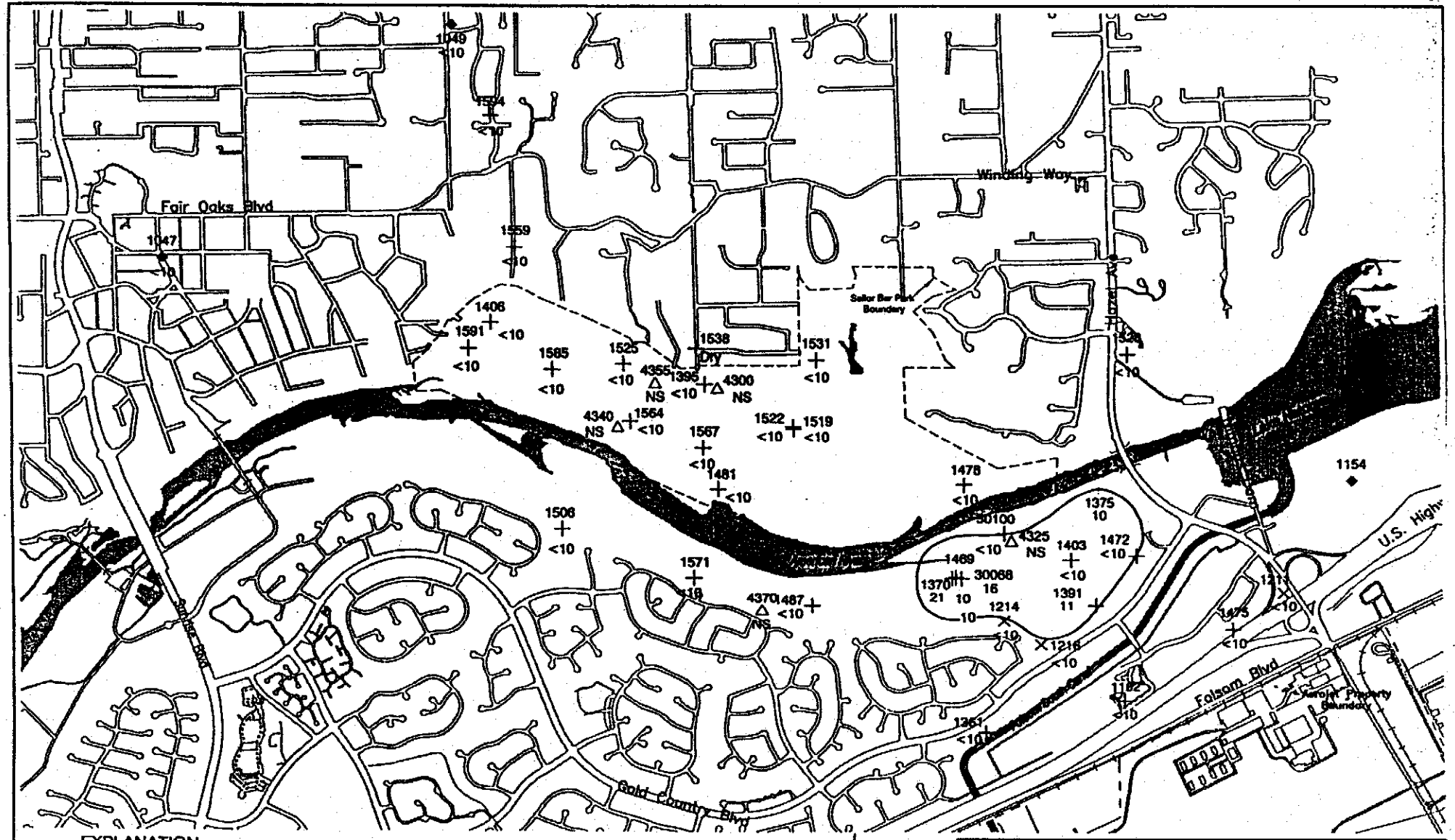
- Monitor Well
- Extraction Well
- Recharge Well
- State Well
- Water Supply Well

5 — Chemical Concentration Contour (µg/l)

GenCorp Aerojet — Environmental Operations

FIGURE B-9

American River Study Area
1,4-Dioxane In Groundwater - 7/98-9/98
Aquifer A

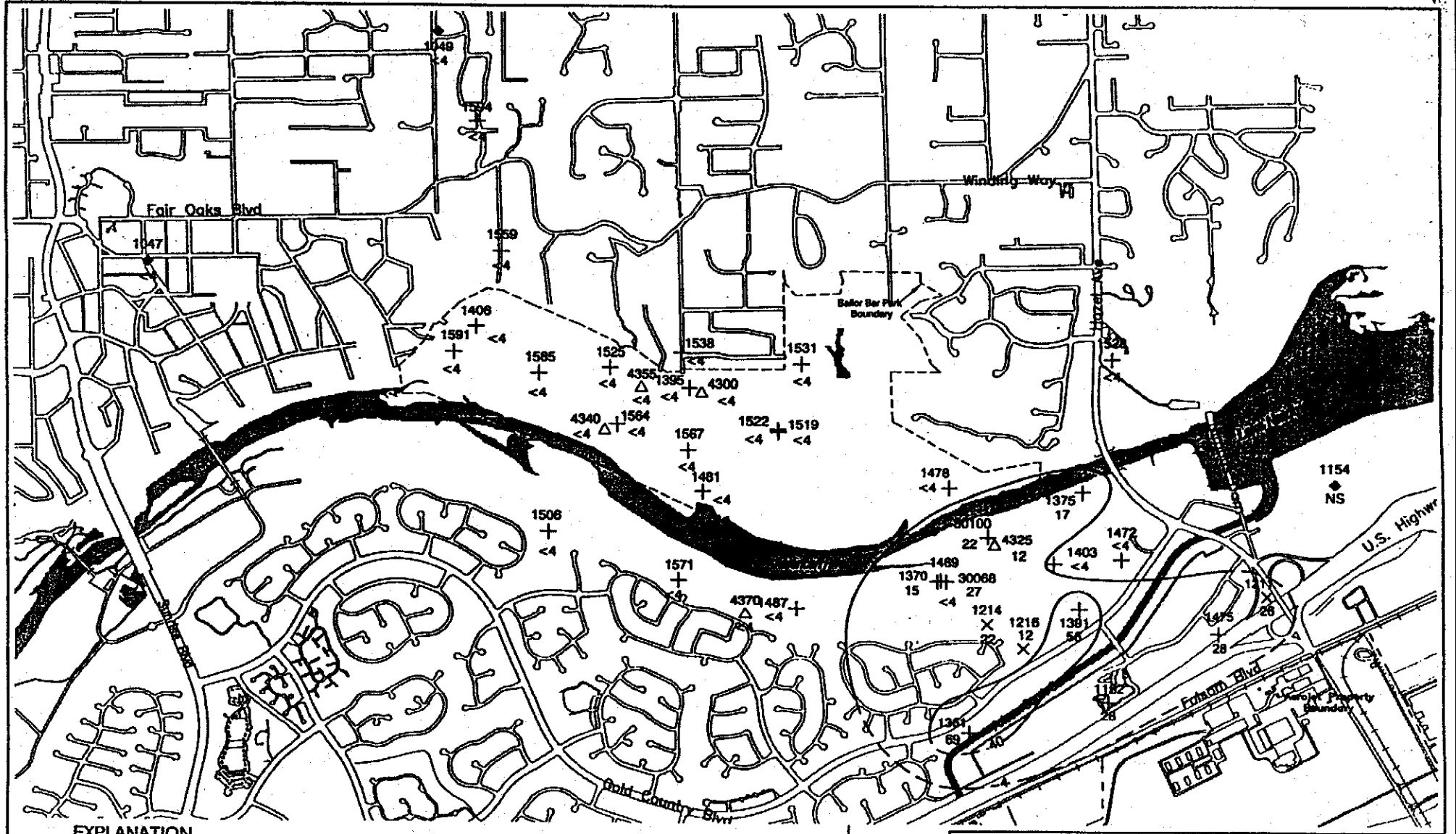


GENCORP AEROJET — Environmental Operations

FIGURE B-10

American River Study Area
1,4-Dioxane in Groundwater - 7/99-9/99
Aquifer A

2/10/00 ah SR1010982



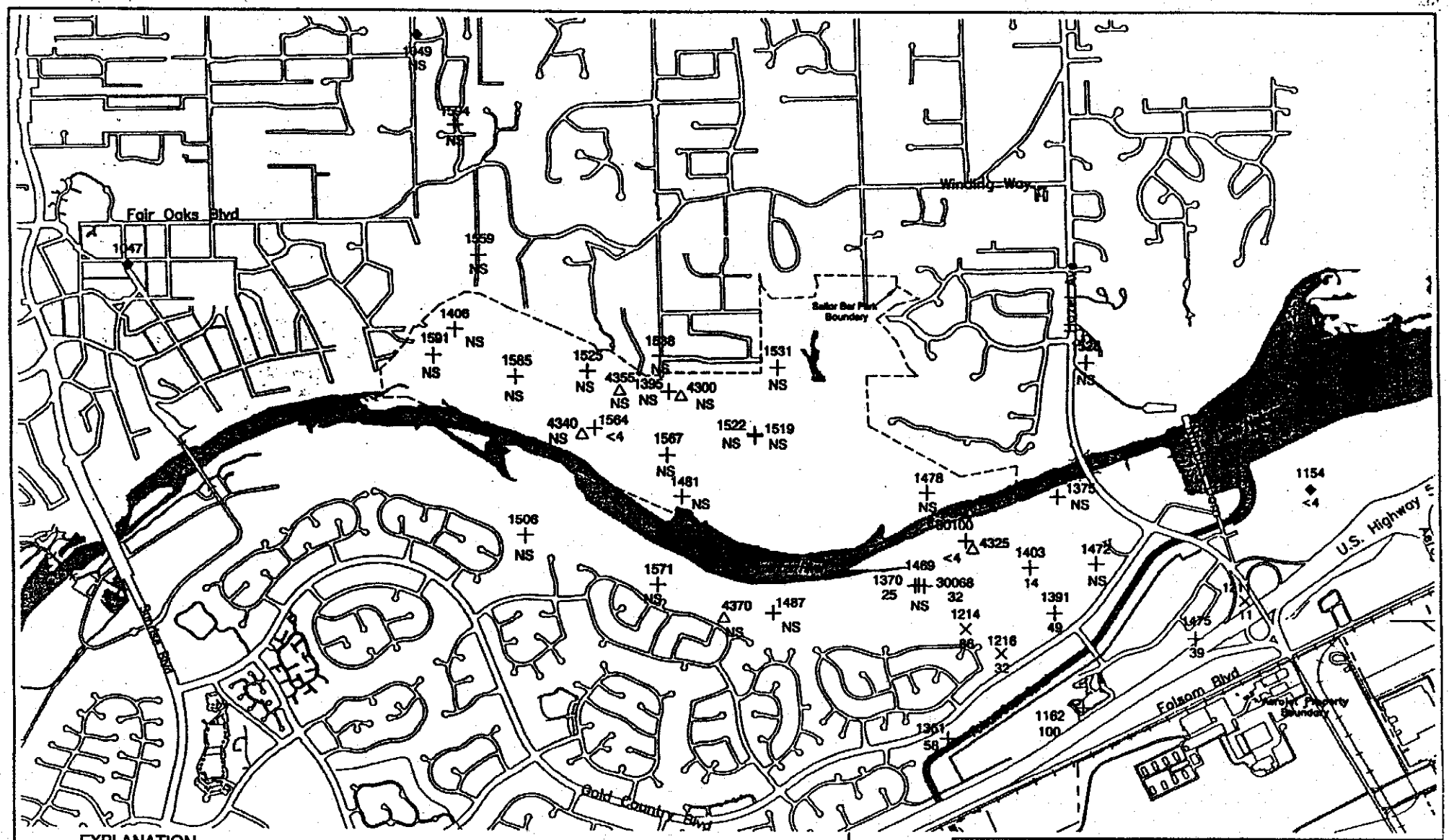
GENCORP AEROJET

Environmental Operations

FIGURE B-11

American River Study Area
Perchlorate in Groundwater - 7/98-9/98
Aquifer A

2/10/00 ah SR10109283



EXPLANATION

WELL TYPES

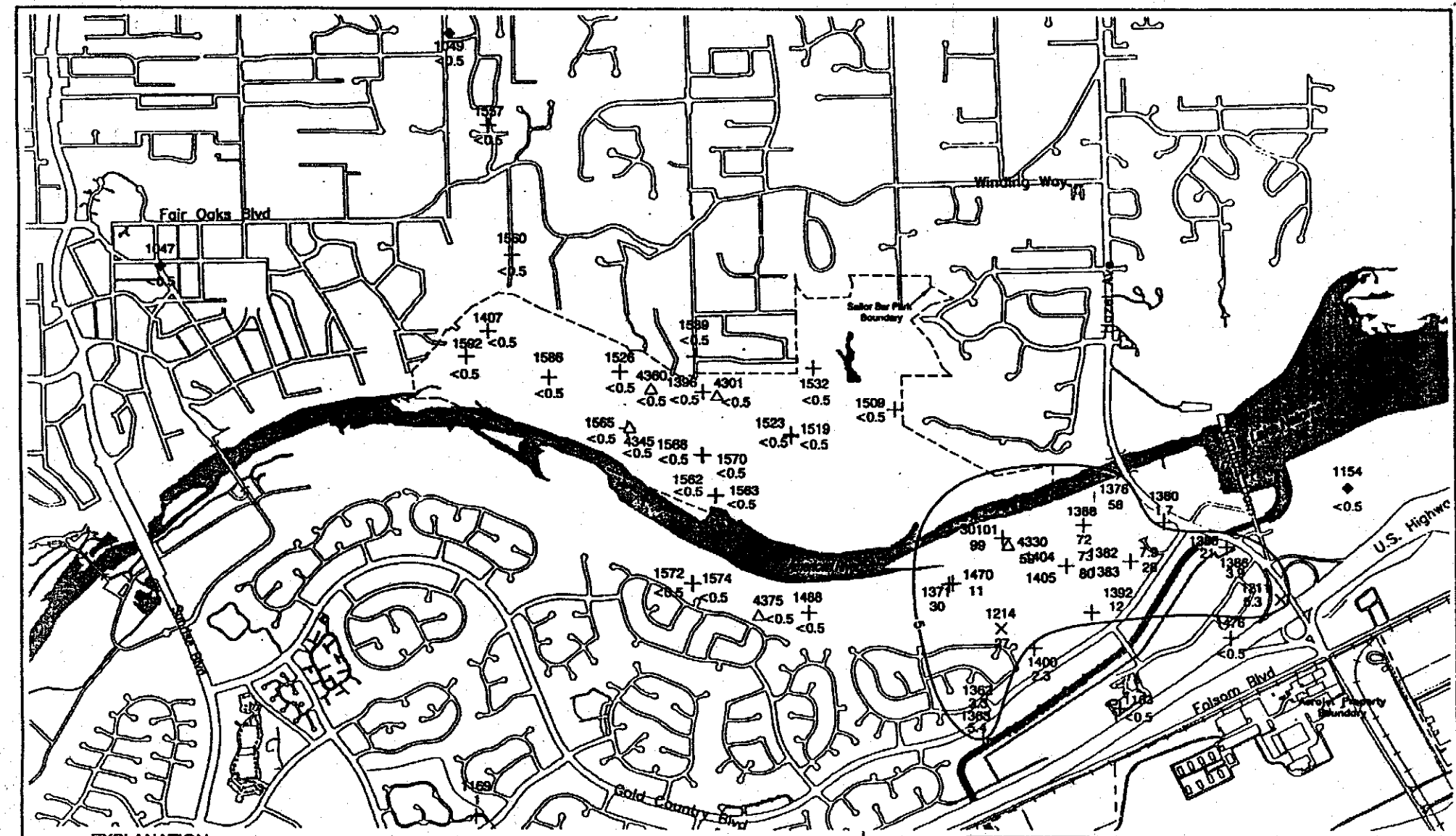
- Monitor Well
- Extraction Well
- Recharge Well
- State Well
- Water Supply Well

5 Chemical Concentration Contour (µg/l)

GenCorp Aerojet — Environmental Operations

FIGURE B-12

American River Study Area
Perchlorate In Groundwater - 7/99-9/99
Aquifer A

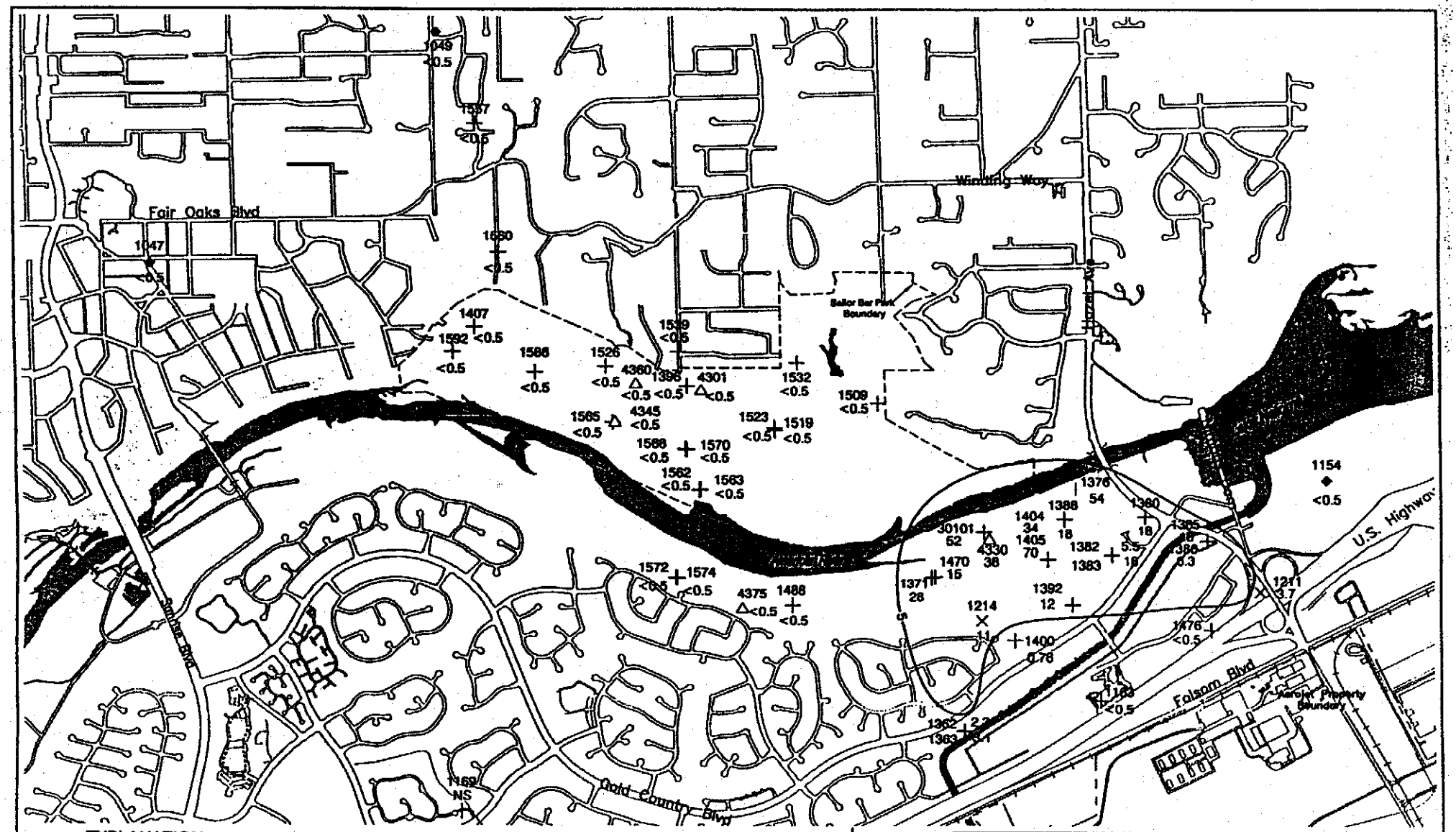


GENCORP AEROJET — Environmental Operations

FIGURE B-13

American River Study Area
1,1-DCE In Groundwater - 7/98-9/98
Aquifer B

2/10/00 ph SR10109285



EXPLANATION

WELL TYPES

- + Monitor Well
- △ Extraction Well
- ▽ Recharge Well
- × State Well
- ◆ Water Supply Well

5 — Chemical Concentration Contour (µg/l)

N

Scale: 1" = 1800

0 900 1800

GENCORP AEROJET — Environmental Operations

FIGURE B-14

American River Study Area
1,1-DCE in Groundwater - 7/99-9/99
Aquifer B

PROOF OF SERVICE

I am a resident of the State of California, over the age of eighteen years, and not a party to the within action. My business address is HATCH AND PARENT, 21 East Carrillo, Santa Barbara, California 93101. On April 29, 2002 , I served the within document:

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Executed on April 29, 2002, at Santa Barbara, California.

April Robitaille

April Robitaille.

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Santa Barbara, CA 93101

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Sacramento, CA 95812

HATCH AND PARENT
21 East Carrillo Street
Santa Barbara, CA 93101

SCWC EXHIBIT 19

OVERSIZE QUAD MAP

(SEE BINDER)

SCWC Exhibit 20

OVERSIZED QUAD MAP

(SEE BINDER)

SCWC Exhibit 21

Oversized Quad Map

(See BINDER)

Declaration of Stephen Ross

I, Stephen Ross, declare that:

1. I am a senior hydrogeologist for Komex, which is an environmental and engineering consulting firm. My office is located in the Komex 's Sacramento Branch. I hereby make this declaration in my official capacity on behalf of the Southern California Water Company.

2. I declare that the attached exhibit titled "Practical Handbook of Ground-Water Monitoring," authored David M. Nielsen, and dated 1991, is a true and correct copy of page 30 of this report. This page was copied from an original copy of this handbook, which our office posses.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 26th day of April 2002.

Stephen Ross

Practical Handbook of Ground-Water Monitoring

Edited by

David M. Nielsen

LEWIS PUBLISHERS

Library of Congress Cataloging-in-Publication Data

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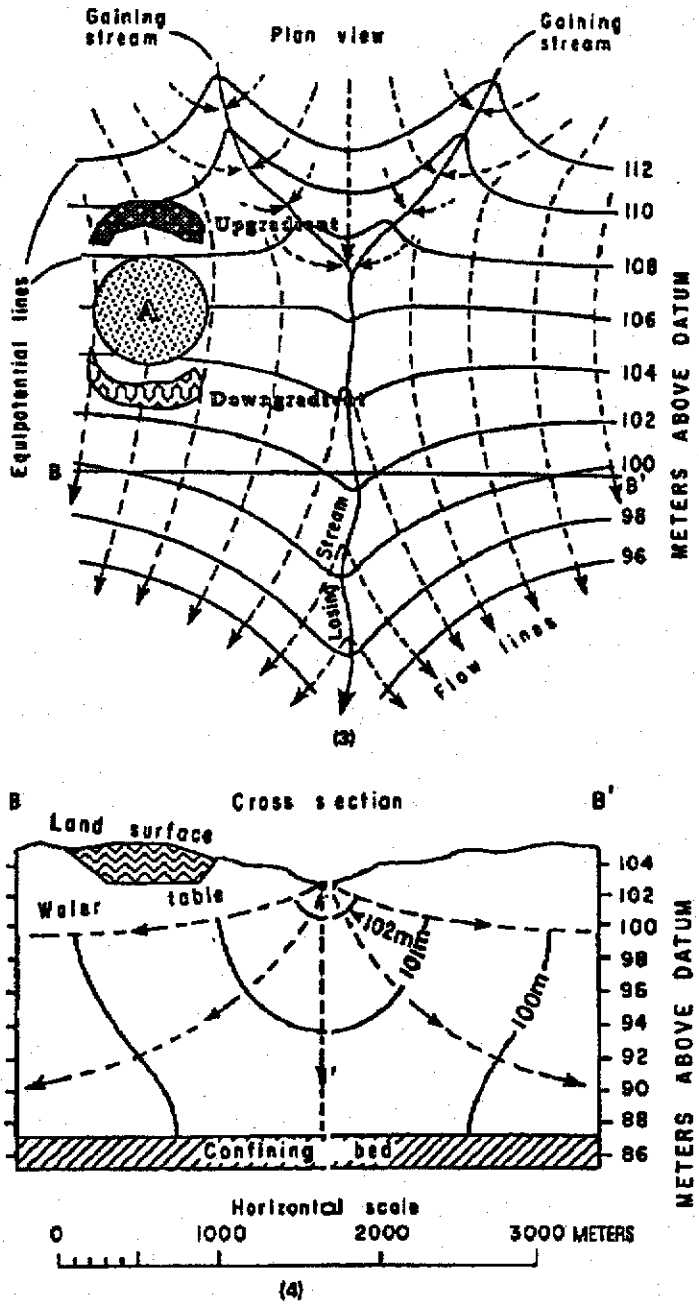

Figures 2.7a and b. Losing stream target monitoring zones.

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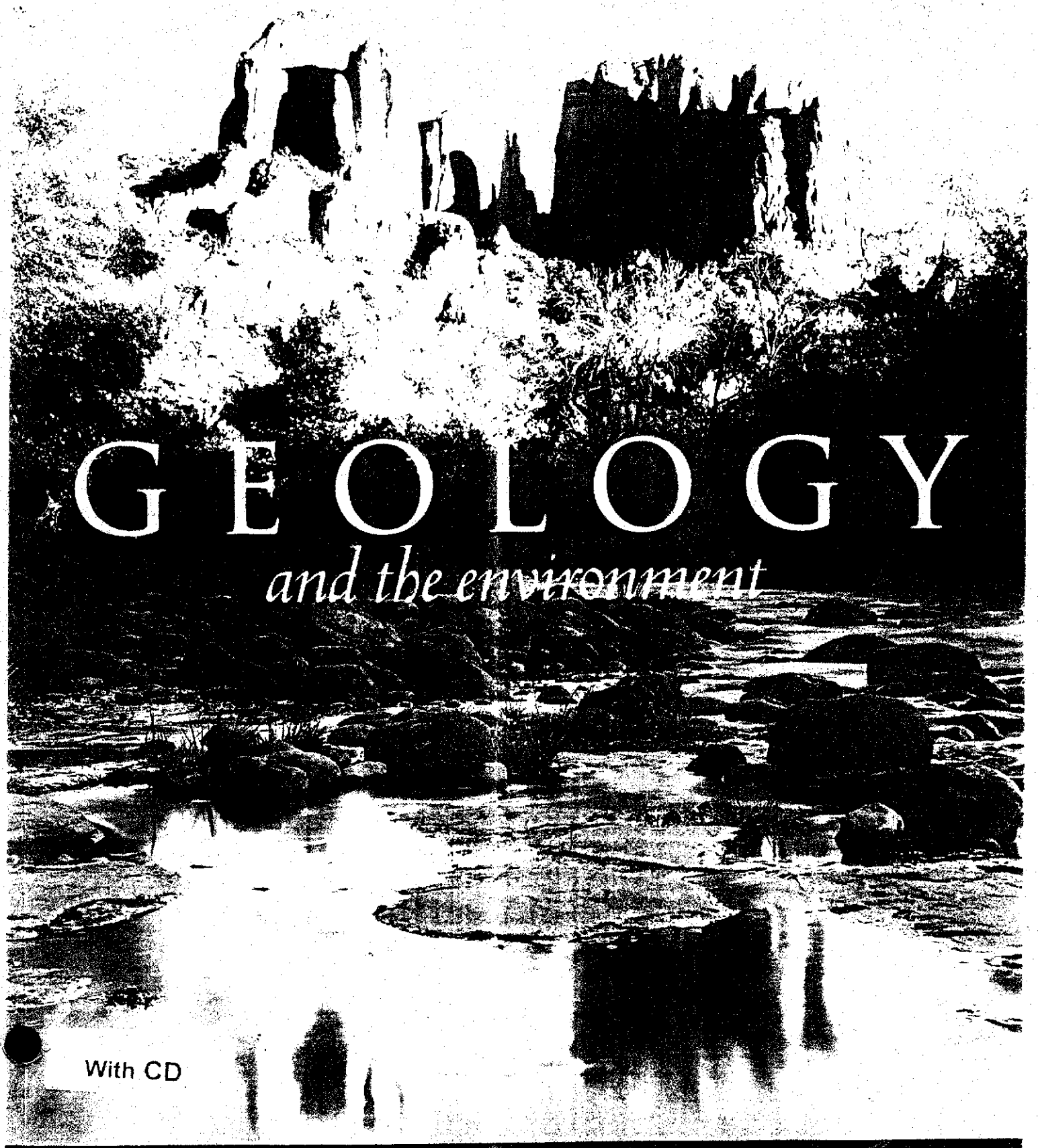

GEOLOGY

and the environment

With CD

Bernard W. Pipkin and D.D. Trent

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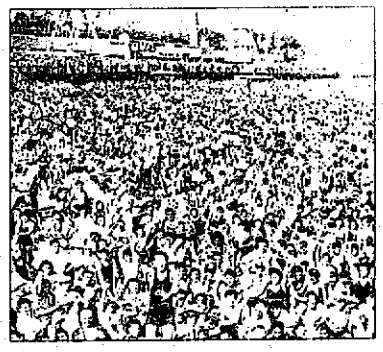

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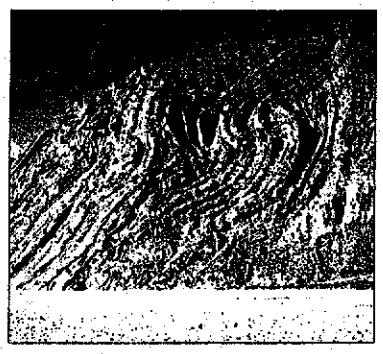

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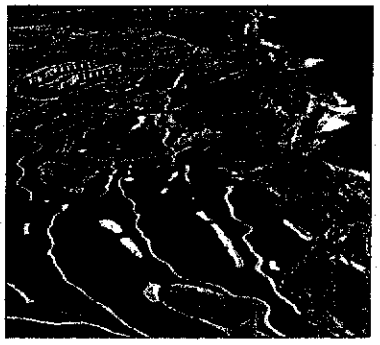

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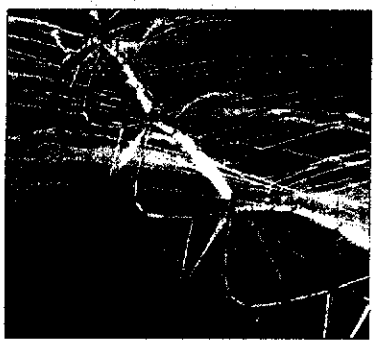

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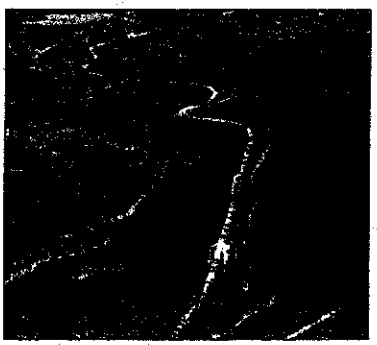

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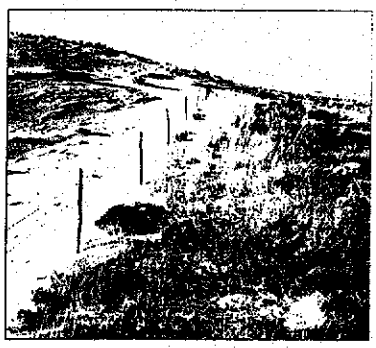

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chapter eight

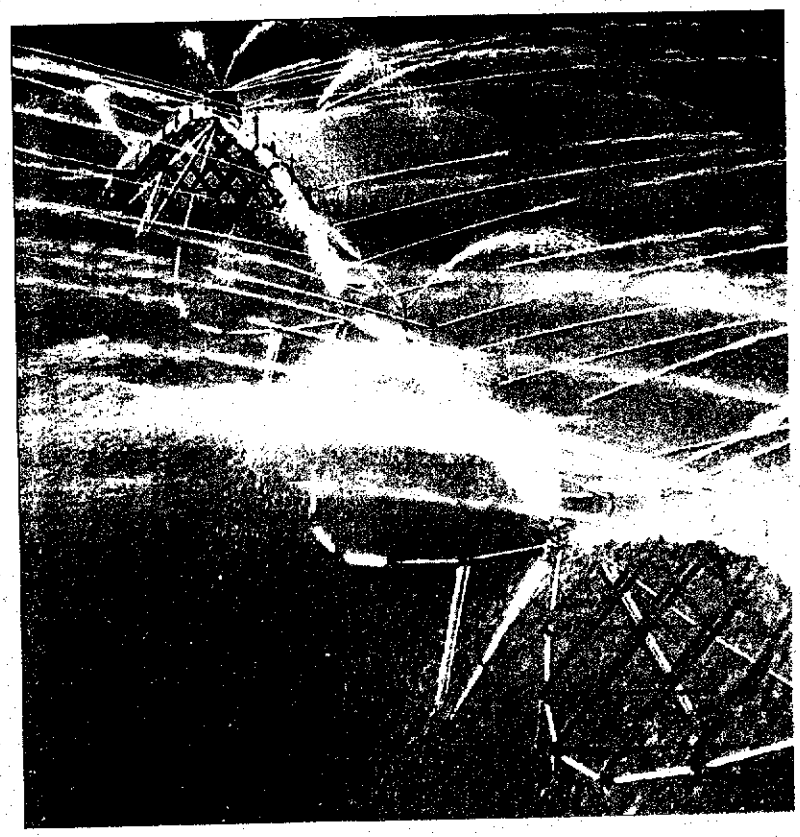
Fresh-Water Resources

Whiskey is for drinking.
Water is for fighting.
MARK TWAIN (1835–1910)

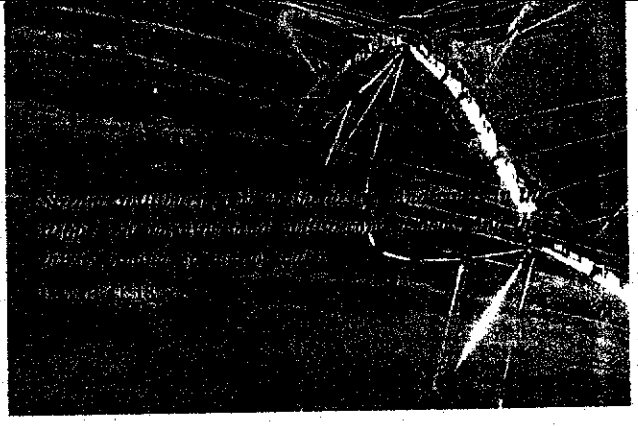
Keeping the Peace on the High Plains Aquifer

The next war in the Middle East may well be over water, not oil! Most water in that arid region comes from three shared rivers, the Jordan, the Tigris–Euphrates, and the Nile. Water there is in short supply, and the region's population is expected to double in only 25 years, further stressing water supplies for agriculture and domestic use. You can be sure that water sharing will be a major item on the agenda at any peace talks involving Iraq, Syria, Jordan, Israel, and Egypt.

The same might be true, without the threat of military action, in the water wars over the High Plains aquifer. The High Plains aquifer contains as much water as Lake Huron and underlies 480,000 square kilometers (147,000 mi^2) of parts of Kansas, Colorado, New Mexico, Wyoming, South Dakota, Nebraska, Oklahoma, and Texas. Water distributed by the center-pivot irrigation system in the photo is from a well drilled into the aquifer's water-bearing strata that can produce 4,000 liters per minute (about 1,000 gals/min) 24 hours a day. When the amount of water withdrawn from an aquifer exceeds the amount replenished to it by rainfall and rivers, an overdraft condition exists, a shortfall, and as with shortfalls of all kinds, it will have to be reckoned with later if not sooner. This overdraft condition is called ground-water *mining*, as the resource is being exploited without replenishment, and water levels in the strata have been dropping dramatically (see Figures 8.17 and 8.18). Rather than fight, however, farmers in these states are supporting federal government plans for managing the resource and are withdrawing water from the aquifer conservatively. ■



For decades, ground water from the High Plains aquifer has irrigated our nation's "bread basket." This center-pivot irrigation system draws water from a well that taps the aquifer. The well's potential yield was estimated at 4,000 liters per minute (about 1,000 gallons per minute), 24 hours a day.

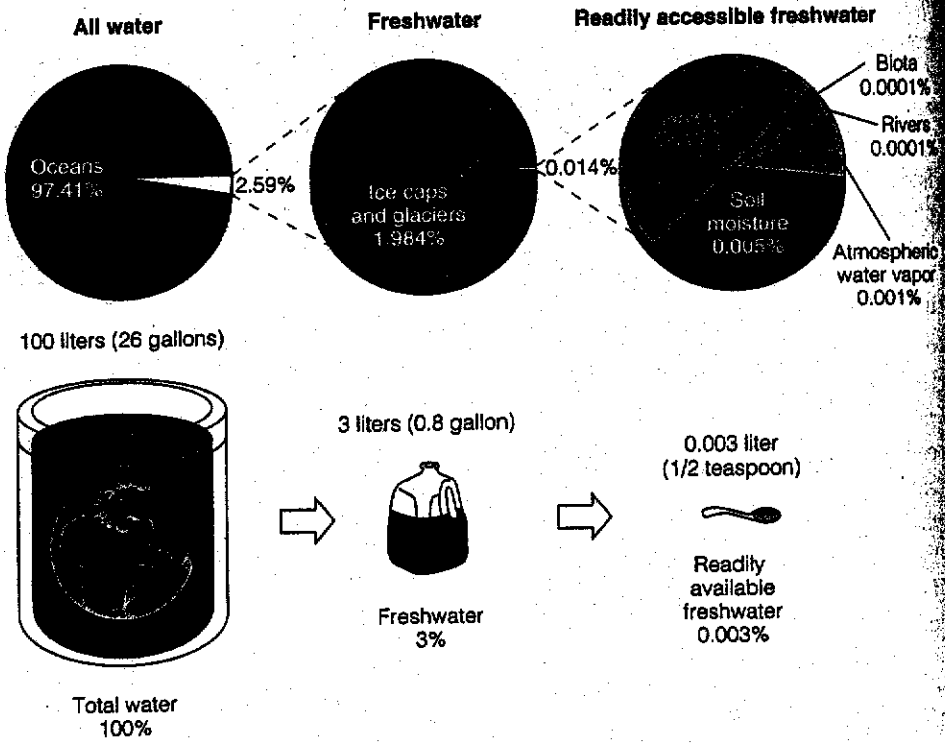


If extraterrestrials exist and are able to view earth from afar, they cannot help but be struck by our planet's heavy cloud cover and its expanse of ocean, clear indications that earth is truly "the water planet." Water is indeed what distinguishes our planet from other bodies in our solar system. Three quarters of the earth's surface is covered by water, and even the human body is 65 percent water. Water provides humans with means of transportation, and much human recreation is in water—and *on* it where it exists in solid form as ice and snow. Since it is not equally distributed on the earth's surface, we have droughts, famine, and catastrophic floods. The absence or abundance of water results in such marvelous and diverse features as deserts, rain forests, picturesque canyons, and glaciers. In this chapter we investigate the reasons for this uneven distribution and its consequences. Water is involved in every process of human life; it is truly our most valuable resource.

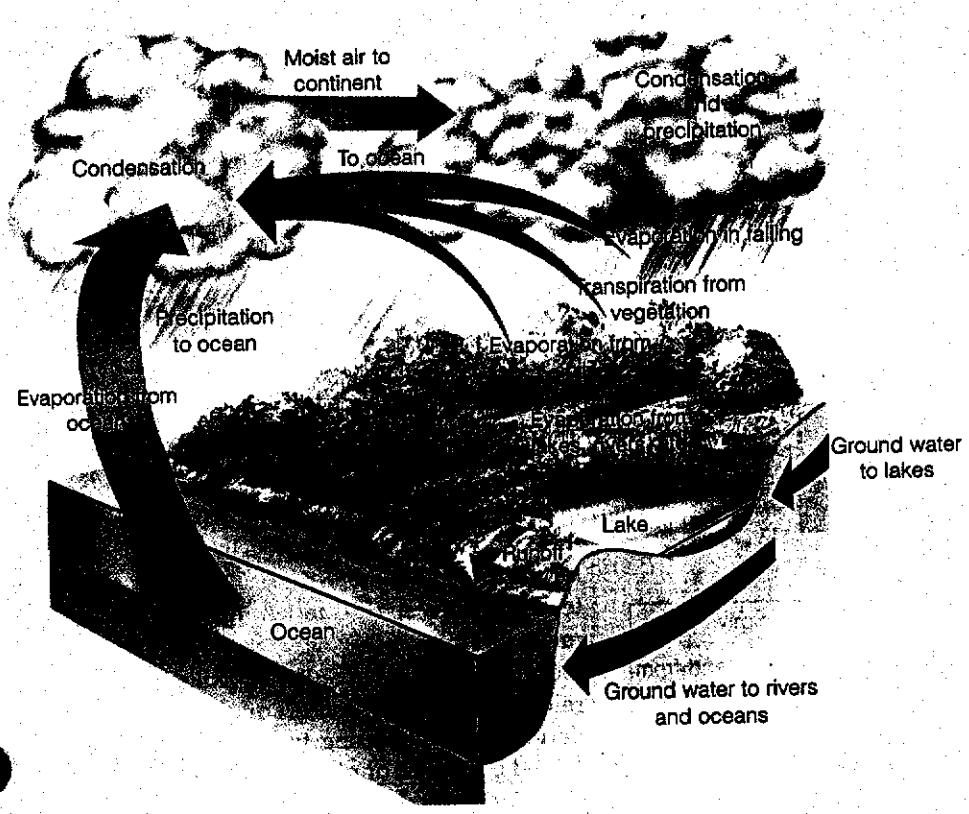
Water as a Resource

Water is the only common substance that occurs as a solid, a liquid, and a gas over the temperature range found at the earth's surface. About 97 percent of the earth's water is in the oceans, and 2 percent is in ice caps and glaciers; about 0.6 percent is readily available to humans as underground or surface fresh water (◇ Figure 8.1). Fortunately, water is a renewable resource, and this is illustrated by the **hydrologic cycle**, the earth's most important natural cycle (◇ Figure 8.2). Water that is evaporated from the ocean or land surface goes back into the atmosphere and forms clouds. Precipitation from these clouds that falls over land areas eventually flows in streams back to the sea, and the cycle is repeated. Remarkably, very little water is in the atmosphere at any one time, about 0.001 percent of the total. Because of this, we know that water must recycle continuously in order to supply the precipitation we measure. The average annual rainfall over the surface area of the 48 contiguous states is about 75 centimeters

◇ **FIGURE 8.1** The planet's water budget. Only a tiny fraction by volume of the world's water supply is fresh water available for human use.



◇ FIGURE 8.2 The hydrologic cycle.



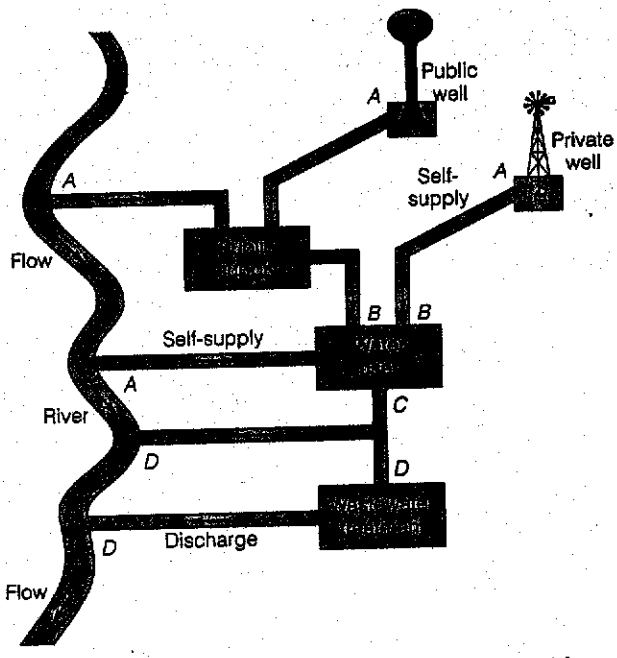
(30 in or 2.5 ft). **Evapotranspiration** is the term for both the direct return of surface water to the atmosphere by evaporation and its indirect return through transpiration from the leaves of plants. It accounts for the return of about 55 centimeters (22 in) of the average annual precipitation. River runoff to the sea and infiltration into the ground account for the remaining 20 centimeters, but it varies from 2.5 centimeters per year in the dry West to more than 50 centimeters per year in the East. Even though runoff varies greatly with location, the net water transport from land to sea must over time balance the net transport from sea to land.

Planners and forecasters recognize several categories of water use:

- *Instream use*–all uses that occur in the channel itself, such as hydroelectric power generation and navigation.
- *Offstream use*–the diversion of water from a stream to a place of use outside it, such as to your home. The amount of water available for offstream use along any stretch of a river is the total flow *minus* the amount required for instream purposes and for maintaining water quality. ◇ Figure 8.3 is a flow diagram of public water supplies and self-supplied water. Note that the amount of water that is consumed is the difference between the amount delivered (B) and the amount that is returned to the stream system (D).
- *Consumptive use*–water that evaporates, transpires, or infiltrates and cannot be used again immediately. Forty-four percent of all water that is withdrawn is used consumptively, and agriculture accounts for about 90 percent of that.
- *Nonconsumptive use*–water that is returned to streams with or without treatment so that it can be used again downstream. Interestingly, domestic (household) water is used nonconsumptively, as it is returned to the cycle through sewers and storm drains.

The sources and users of public water supplies are shown in ◇ Figure 8.4. The data do not include water used in agriculture or water that is self-supplied.

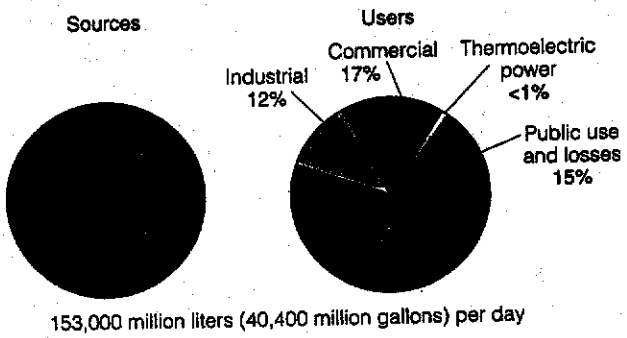
In many areas, particularly the western United States, consumption exceeds local water supplies. This necessitates importing water from other areas or mining ground water. For example, about 75 percent of Southern California's water is imported from sources more than 200 miles away (◇ Figure 8.5). Two aqueducts import water from west and east of the Sierra Nevada, and a third aqueduct brings water from the Colorado River. Irrigation utilizes about 40 percent of the total water withdrawn in the United States, and a startling 80



◆ FIGURE 8.3 Water is supplied to users from streams and from public and private wells (*A*). Consumptive use (*C*) is the difference between the amount delivered to users (*B*) and the amount returned to the system (*D*).

percent in California. It is not surprising then that California, with the largest population and a huge irrigation system, is the largest U.S. consumer of water, using almost as much as the two next-largest consumers, Texas and Illinois, combined (◆ Figure 8.6).

Total world withdrawals of water for offstream purposes amount to about 2,400 cubic kilometers per year (1.7 trillion gal/day, *gpd*), of which 82 percent is for agricultural irrigation. This is expected to increase manyfold to 20,000 cubic kilometers (14.5 trillion gpd) by the year 2050, which is beyond the firm flow of the world's rivers. Availability of water will limit population growth in the twenty-first century, either by statute

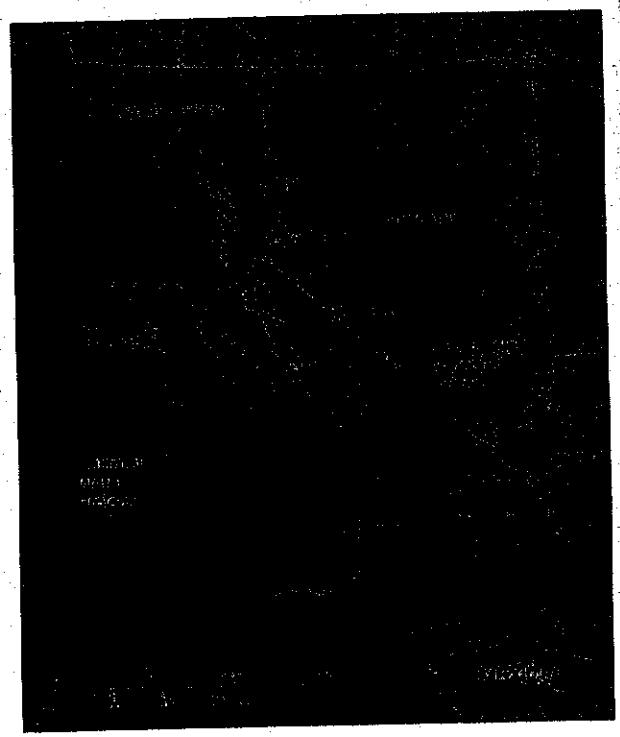


◆ FIGURE 8.4 The sources and users of the U.S. public water supply in 1995. This does not include fresh water supplied for agricultural use or water that is self-supplied.

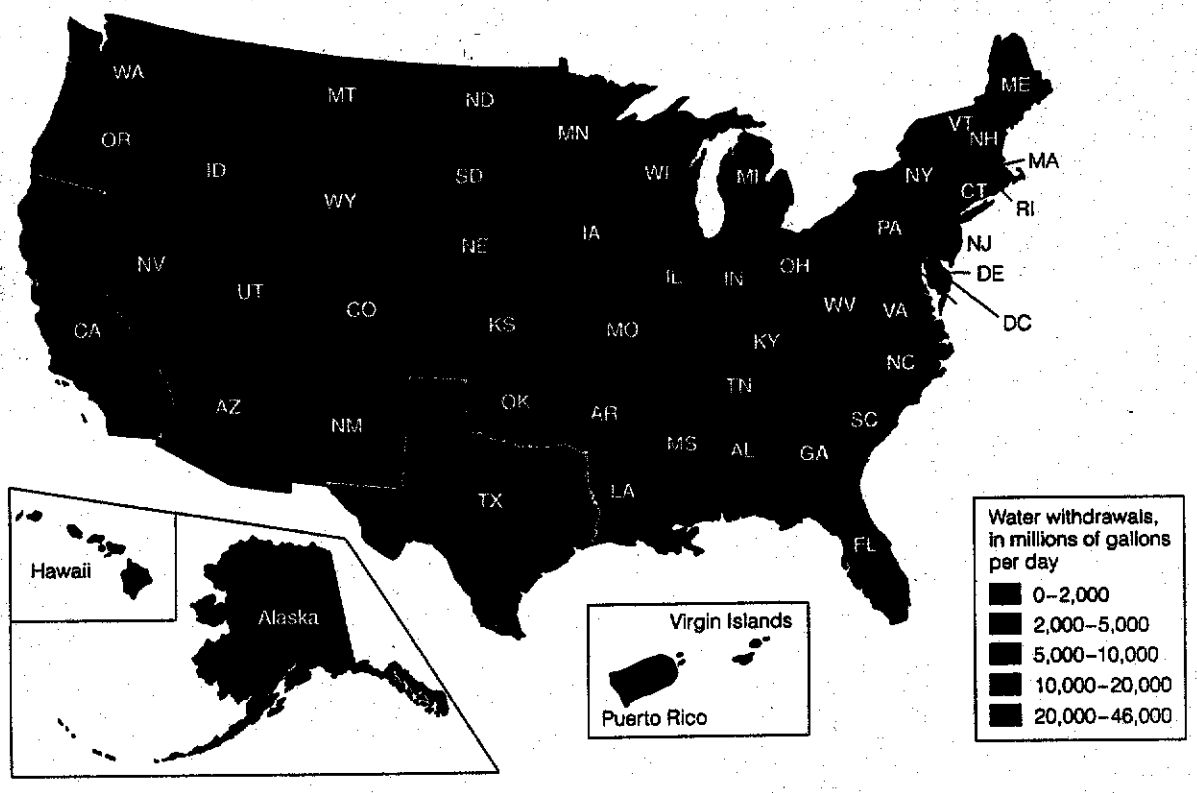
in developed countries or by natural means, most likely drought and famine, in developing nations. Repetition of the terrible droughts experienced in Africa in the 1970s and 1980s, compounded by overtaxed water supplies, would be disastrous for those countries and their people.

Fresh Water Underground

Some of the water in the hydrologic cycle infiltrates underground and becomes **ground water,** one of our most valuable natural resources. In fact, most of the earth's liquid fresh water exists beneath the land surface, and its geologic occurrence is the subject of many misconceptions. For example, it is commonly believed that ground water occurs in large lakes or pools beneath the land. The truth is that almost all ground water is in pore spaces and fractures in rocks. Another misconception is that deposits of ground water can be found by people with special skills or powers, people referred to as *water witches* or *dowsers.* They locate underground water using two wires bent into L shapes, forked branches, or other forked devices called *divining rods.* A dowser locates an underground "tube" or lake of water by walking over the ground, holding the di-



◆ FIGURE 8.5 Aqueducts bring water to Southern California from three source areas: the Colorado River, the east slope of the Sierra Nevada, and the west slope of the Sierra Nevada.



◆ FIGURE 8.6 Total water withdrawals by state, 1995.

vining rod in a prescribed manner until it jerks downward, pointing to the location of ground water, a mineral deposit, or a lost set of keys. Some dowsers claim they can locate good places to drill water wells using only a map of the land. The divining rod is passed over the map until it jerks downward where presumably a well should be located (X marks the spot). Water dowsers are found throughout the world, particularly in rural areas, and many of them will guarantee finding water. This is one difference between dowsers and ground-water geologists, or **hydrogeologists.** Hydrogeologists will not make this guarantee.

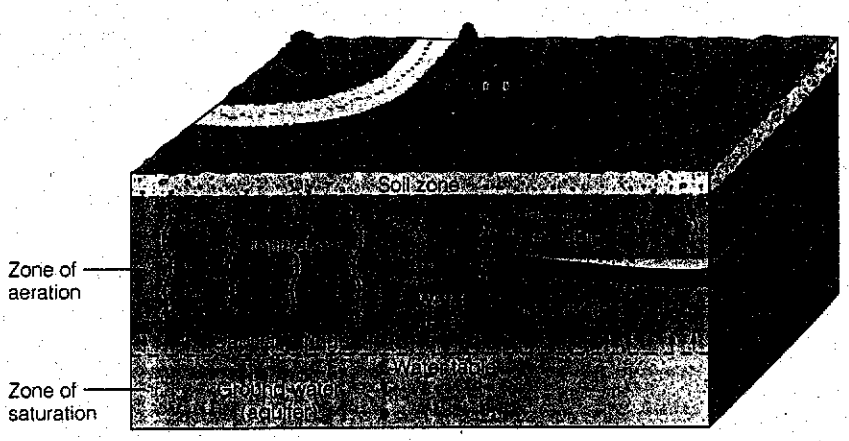
Water Supply

Ground water provides 40 percent of public water supplies and 30 to 40 percent of all water used exclusive of power generation in the United States. It is by far the cheapest and most efficient source of municipal water, because obtaining it does not require the construction of expensive aqueducts and reservoirs. Thirty-four of the largest 100 cities in the United States depend entirely upon local ground-water supplies; Miami Beach, San Antonio, Memphis, Honolulu, and Tucson are just a few. Ground water provides 80 percent of the water for rural domestic and livestock use and it is the only source of water in many agricultural areas. It is not surprising that some of the largest agricultural states—such as Texas, Nebraska, Idaho, and California—are the largest consumers, accounting for almost half of all the ground water produced. Ground water is important even to communities that import water from distant areas, because in almost every case, local ground water provides a significant low-cost percentage of their water supply.

Although it is not generally known, ground water sustains and maintains streamflows during periods when there is no rain. In arid climates where there are permeable water-saturated rocks beneath the surface, ground water seeping into stream channels may be the only source of water for rivers. The fabled oases of the Sahara and Arabian deserts occur where underground water is close to the surface or where it intersects the ground surface, forming a spring or watering hole.

Location and Distribution

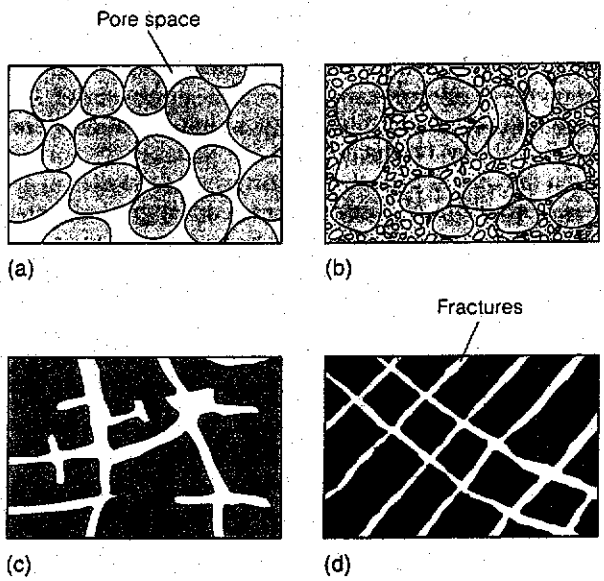
Between the land surface and the depth at which we find ground water is the *zone of aeration,* a zone where voids in soil and rock contain only air and water films.



◇ FIGURE 8.7 Schematic cross section of ground-water zones showing a static water table with a capillary fringe. A perched water table exists where a body of clay or shale acts as a barrier to further infiltration.

The contact between this zone and the *zone of saturation* below it is the **water table** (◇ Figure 8.7). Above the water table is a narrow moist zone, the *capillary fringe*. In the saturated zone, free (unattached) water fills the openings between grains of clastic sedimentary rock, the fractures or cracks in hard rocks, and the solution channels in limestones and dolomites (◇ Figure 8.8).

Water-saturated geologic formations whose porosity and permeability are sufficient to yield significant quantities of water to springs and wells are known as **aquifers.** A rock's **porosity** (root word *pore*) is a function of the volume of openings, or void spaces, in it and is expressed as a percentage of the total volume of the rock being considered. Without such voids, a rock cannot contain water or any other fluid. **Permeability** is the ease with which fluids can flow through an aquifer; it is thus a measure of the connections between pore spaces. **Hydraulic conductivity** is the term hydrologists prefer, but *permeability* will suffice for our purposes, as it has a long history of use and is easy to remember. **Aquicludes** are rocks or sediments such as shale and clay that lack permeability and hence will not transmit water. In some places aquicludes occur as *lenses* that trap water and prevent it from percolating down to the water table. Such a condition creates a **perched water table** (see Figure 8.7).

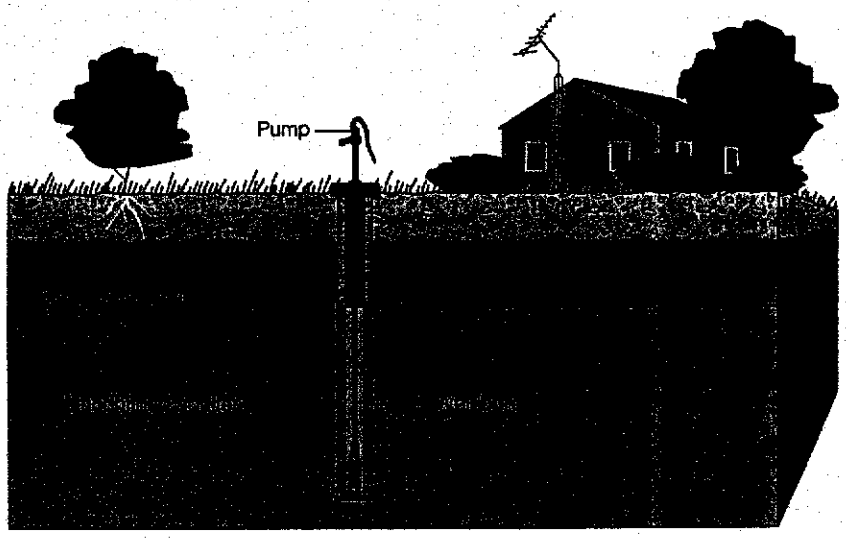


◇ FIGURE 8.8 A rock's porosity is dependent on the size, shape, and arrangement of the material composing the rock. Whereas (a) a well-sorted sedimentary rock has high porosity, (b) a poorly sorted one has low porosity. (c) In soluble rocks such as limestones, porosity can be increased by solution, whereas (d) crystalline metamorphic and igneous rocks are porous only if they are fractured.

Aquifers are important because they transmit water from *recharge areas*—that is, areas where water is added to the zone of saturation—to springs or wells. In addition, they store vast quantities of drinkable water. In terms of the hydrologic cycle, we can view aquifers both as transmission pipes and as storage tanks for ground water. The Nubian Sandstone in the Sahara Desert, for instance, is estimated to contain 600,000 cubic kilometers (144,000 mi^3) of water, mostly untapped. It is the world's largest known aquifer and is a resource of great potential for North Africa.

STATIC WATER TABLE

Unconfined aquifers are formations that are exposed to atmospheric pressure changes and that can provide water to wells by draining adjacent saturated rock or soil (◇ Figure 8.9). As the water is pumped, a **cone of depression** forms around the well, creating a gradient that causes water to flow toward the well (◇ Figure 8.10). A low-permeability aquifer will produce a steep cone of depression and substantial lowering of the water table in the well. The opposite is true for an aquifer

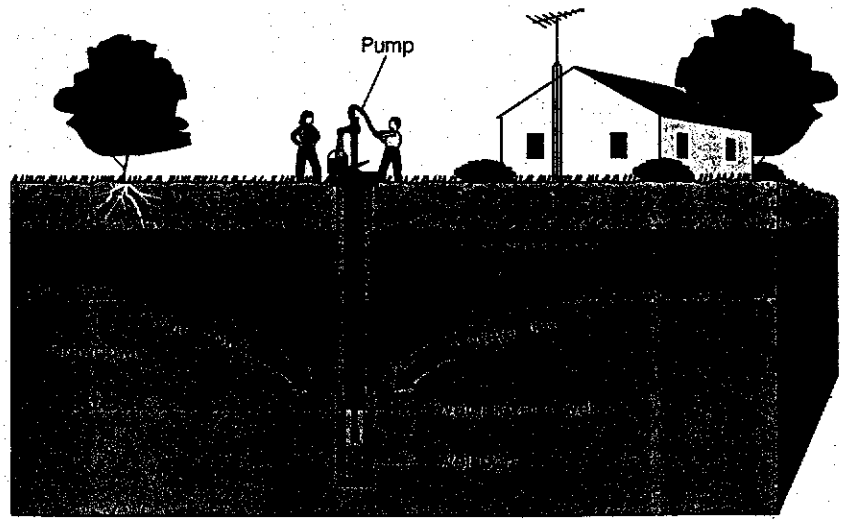


◇▸ FIGURE 8.9 A horizontal (static) water table. The water table will remain static until pumping begins.

in highly permeable rock or soil. This lowering, or the difference between the water-table level and the water level in the pumping well, is known as **drawdown.** Stated differently, low permeability produces a large drawdown for a given yield and increases the possibility of a well "running dry." A good domestic (single-family) well should yield at least 11 liters (2.6 gal) per minute, which is equivalent to about 16,000 liters (3,700 gal) per day, although some families use as little as 4 liters per minute (1,350 gal/day). As pointed out, a pumping well in permeable materials creates a small drawdown and a gentle gradient in the cone of depression. Some closely spaced wells, however, have overlapping "cones," and excessive pumping in one well lowers the water level in an adjacent one (◇▸ Figure 8.11). Many lawsuits have arisen for just this reason. Water law is discussed briefly in Case Study 8.1.

The water table rises and falls with consumption and the season of the year. Generally, the water table is lower in late summer and higher during the winter or the wet season. Thus water wells must be drilled deep enough to accommodate seasonal and longer-term, climatic fluctuations of the water table (◇▸ Figure 8.12). If a well "goes dry" during the annual dry season, it definitely needs to be deepened.

Streams that are located above the local water table are called **influent,** or "losing," streams, as they contribute to the underground water supply (◇▸ Figure 8.13a). Beneath influent streams there may be a mound of water above the local ground-water table known as a *recharge mound.* A stream that intersects the water table and which is fed by both surface water and ground water is known as an **effluent,** or "gaining," stream (◇▸ Figure 8.13b). A stream may be both a



◇▸ FIGURE 8.10 When pumping begins, the water table is drawn down an amount determined by the pumping rate and the aquifer's permeability. The development of a cone of depression creates a hydraulic gradient, which causes water to flow toward the well and enables continuous water production. The amount of water the well yields per unit of time pumped depends upon the aquifer's hydrologic properties.

Case Study

Case Study 8.1

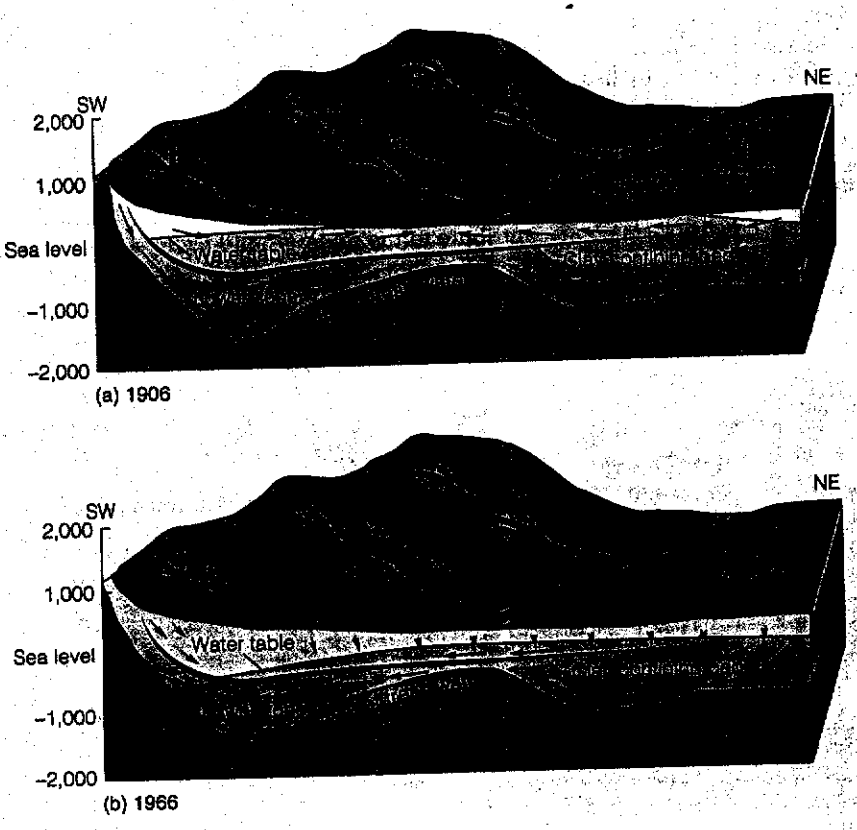
Ground-Water Law

Ownership of ground water is a property right and has traditionally been regulated as such by individual states. Each state applies one or more of four legal doctrines to ground-water rights, none of which considers the geological relationship between surface-water infiltration and ground-water flow. The doctrines are

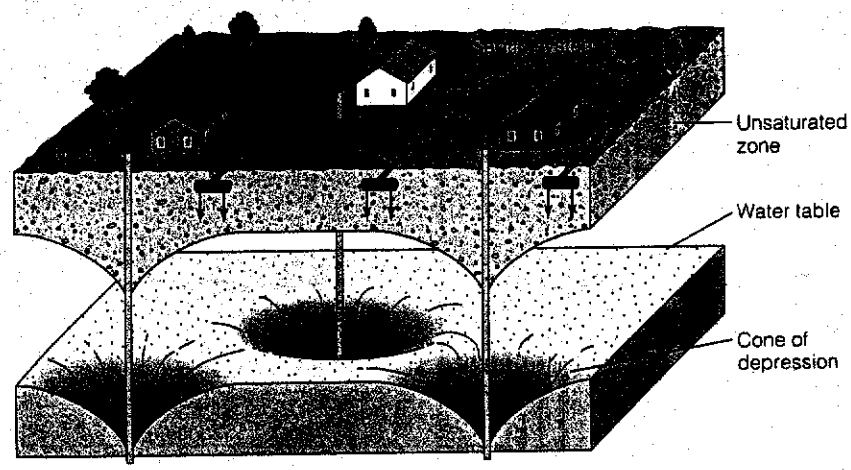
- *Riparian doctrine* (Latin *ripa*, "river or bank") holds that landowners overlying well-defined underground "streams" have absolute right to that water. They may exercise that right whenever they wish without limitation.
- *Reasonable-use doctrine* restricts a landowner's right to ground water to "reasonable use" on the land above that does not deprive neighboring landowners of their rights to "reasonable use." This doctrine results in a more equal distribution of water when there is a shortage.
- *Prior-appropriation doctrine* holds that the earliest water users have the firmest rights; in other words, "first-come, first-served."
- *Correlative-rights doctrine* holds that landowners own shares to the water beneath their collective property that are proportional to their shares of the overlying land.

In the San Joaquin Valley of California, for example, surface-water rights are governed by the doctrine of prior appropriation (first-come, first-served), whereas ground-water rights are governed by the doctrine of correlative rights (proportional shares). In the late nineteenth century the Sierra Nevada to the east of the valley and the lower ranges to the west maintained high water tables, and they both contributed water to the flow of the San Joaquin River (◇ Figure 1). By 1966, however, heavy ground-water withdrawals on the west side of the San Joaquin Valley had reversed the regional ground-water flow, so that the river was losing water underground, rather than gaining. The San Joaquin had become an influent stream. Imagine a courtroom scenario in which hundreds of people with first-come, first-served rights to *surface* water sue thousands of people holding proportional shares rights to *underground* water for causing their surface water to go underground.

As explained throughout this chapter, it is impossible to treat ground water and surface water as separate entities. Surface water contributes to underground water supplies, and ground water contributes to streamflow and springs.



◇ FIGURE 1 Ground-water flow in the central San Joaquin Valley in (a) 1906 and (b) 1966. Note that the San Joaquin River was an effluent (gaining) stream in 1906 and an influent (losing) stream is 1966. The change reflects intensive development and extraction of underground water.



◇ FIGURE 8.11 Cones of depression overlap in an area of closely spaced wells. Note the contributions to ground water from septic tanks.

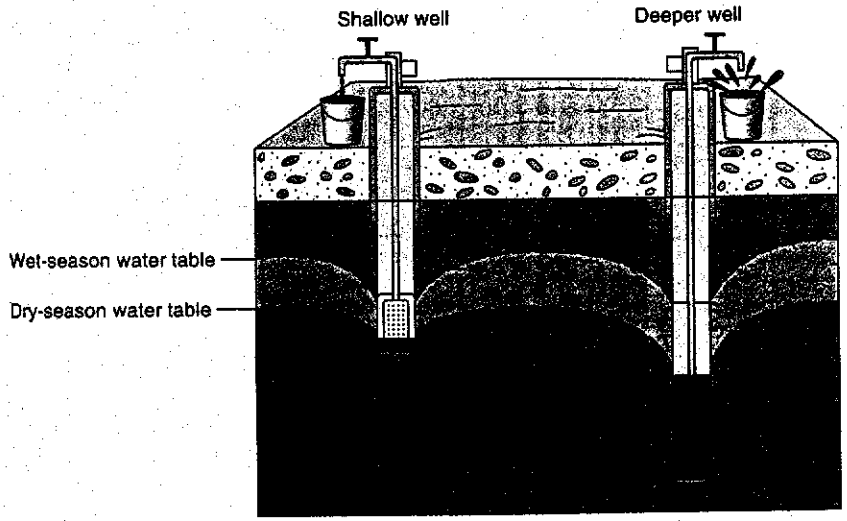
gaining stream and a losing stream, depending upon the time of year and variations in the elevation of the water table.

Where water tables are high, they may intersect the ground surface and produce a spring. Springs also are subject to water-table fluctuations. They may "turn on and off" depending upon rainfall and the season of the year. ◇ Figure 8.14 illustrates the hydrology of three kinds of springs.

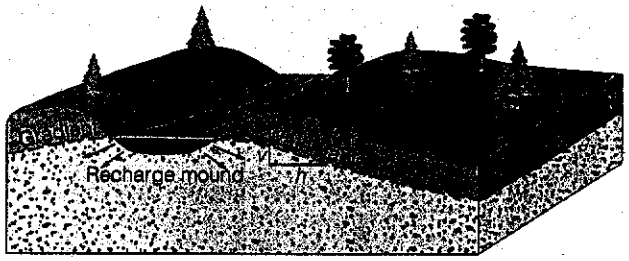
PRESSURIZED UNDERGROUND WATER

Pressurized ground-water systems cause water to rise above aquifer levels and sometimes even to flow to the ground surface. Pressurized systems occur where water-saturated permeable layers are enclosed between aquicludes, and for this reason, they are called **confined aquifers** (◇ Figure 8.15). A confined aquifer acts as a water conduit, very similar to a garden hose that is filled with water and situated such that one end is lower than the other. In both cases a water-pressure difference known as a *hydraulic head* is created. Water gushes from the low end until there is no longer a pressure difference. At that point the water level stabilizes, becomes *static*.

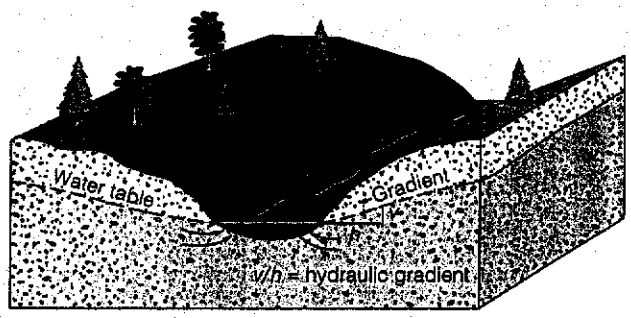
Wells that penetrate confined aquifers are called *artesian wells*, after the province of Artois, France, where they were first described. Artesian systems are distinguished by a water-pressure gradient called the **artesian-pressure surface** (see ◇ Figure 8.15b). This "surface" is the level to which water will rise in a well at a given point along the aquifer. It is important to note that the slope of the water table of an unconfined aquifer also is a pressure surface. Underground water moves from areas of high hydraulic head to areas of



◇ FIGURE 8.12 The effect of seasonal water-table fluctuations on producing wells. A shallow well may go dry in the summertime.



(a) Influent (losing) stream



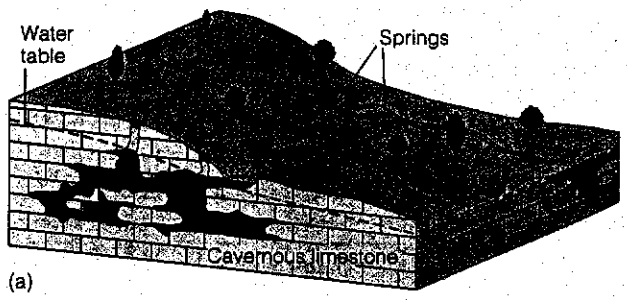
(b) Effluent (gaining) stream

◆ FIGURE 8.13 Hydraulic gradient (v/h) in (a) an influent (losing) stream that contributes water to the water table, and (b) an effluent stream that gains water from the water table.

low hydraulic head (pressure). Contour maps of the pressure surface can be very useful, because they indicate the direction of ground-water flow and the slope of the hydraulic gradient (◆ Figure 8.16). If an aquifer's hydraulic conductivity can be estimated or measured, the rate and volume of ground-water flow can be determined using Darcy's Law (see Appendix 5).

Artesian wells differ from water-table wells in that the latter depend upon pumping or topographic differences to create the hydraulic gradient that causes the water to flow. Because the energy required to raise water to the surface is the greatest expense in tapping underground water, artesian systems are much desired and exploited (see Case Study 8.2). Not all artesian wells flow to the ground surface, because the pressure surface lowers as water is extracted; water may rise naturally only part way up the well bore. Nevertheless, a natural rise of water any distance reduces the cost of extracting ground water.

Finally, many bottled water and beverage producers attempt to lead us to believe that deep-well or artesian water is purer than other kinds of water. *Artesian* refers only to an aquifer's hydrogeology and has no water-quality connotation. Do not be misled by advertisements attributing greater purity to artesian or deep-well water. Such waters may or may not have low levels of dissolved contaminants.



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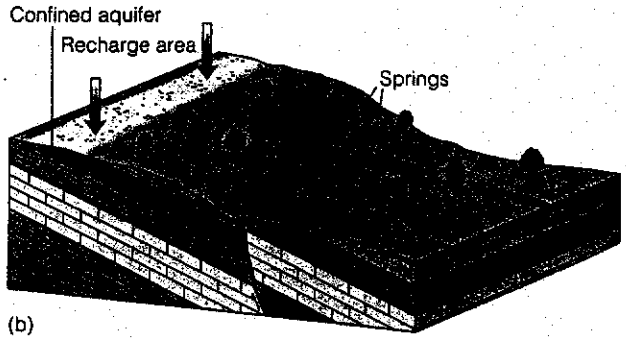

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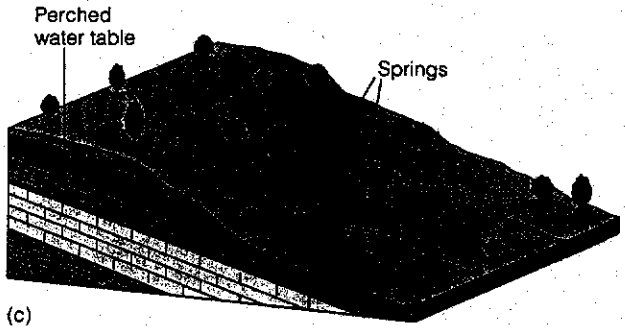


(c)

◆ FIGURE 8.14 Geology and hydrology of three kinds of springs. (a) Springs form where a high water table in cavernous limestone intersects the ground surface. (b) Artesian springs. A fault barrier can cause pressurized water in a confined aquifer to rise as springs along irregularities in the fault. (c) Springs form where a perched water table intersects the ground surface. Such springs are intermittent, because the small volume of perched water is quickly depleted.

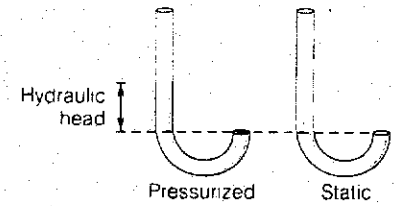
Consider This... ? Some hot springs form geysers that are celebrated for their regularity. Old Faithful in Yellowstone National Park is an example. Cold springs, on the other hand, do not generate attention-grabbing geysers, and their flow is often far from regular. Indeed, many springs operate on a sort of stop-and go-basis. How can we explain this intermittent flow? ■

Consider This...? As explained in Case Study 8.1, the legal issues surrounding the withdrawal and use of ground water are complex, and several legal doctrines apply to them. From a philosophical viewpoint, which of the four doctrines seems fairest for multiple users of an aquifer? Please explain your choice. ■

Ground-Water Storage and Management

In order to manage underground water supplies in a ground-water basin intelligently, the hydrologist or planner must have two measurements:

- the quantity of water stored in the basin, and
- the **sustained yield,** the amount of water the aquifers in the basin can yield on a day-to-day basis over a long period of time.



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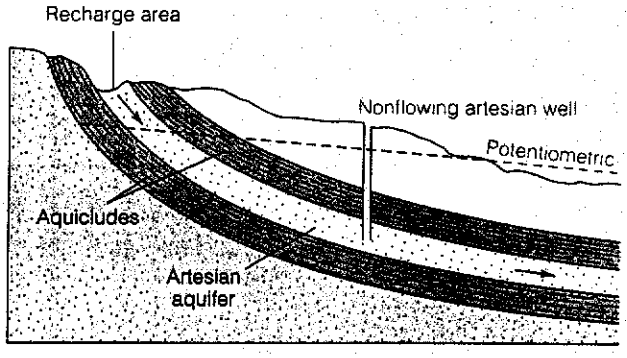

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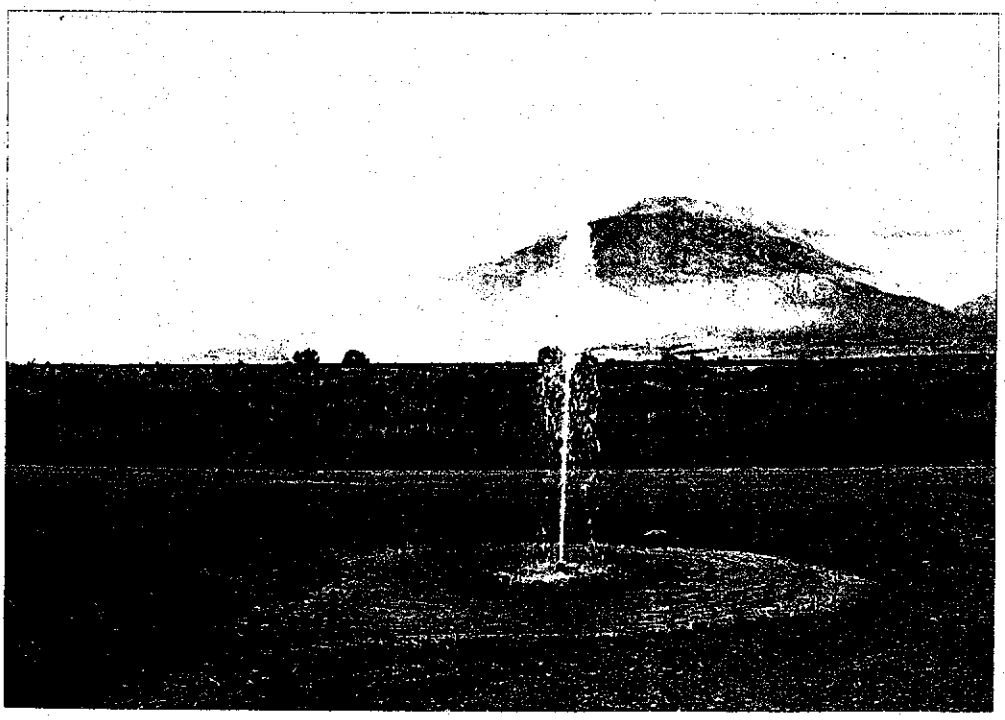


(c)

◁ FIGURE 8.15 Water under pressure. (a) The hydraulic head in a hose lowers as water flows out the low end. Eventually a static condition prevails. (b) A confined aquifer, commonly called an *artesian* aquifer. The artesian-pressure surface is the level to which water will rise in wells at specific points above the aquifer. (c) A flowing artesian well in the Owens Valley near Bishop, California.

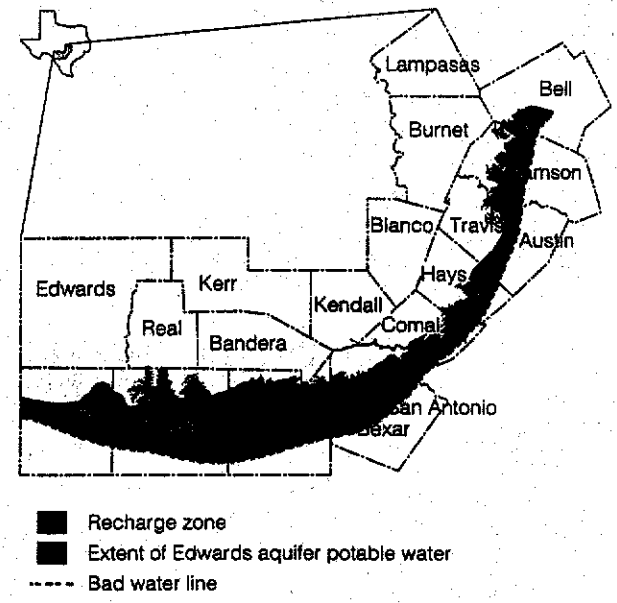
Case Study

Case Study 8.2

The Edwards Aquifer, A Texas Bonanza

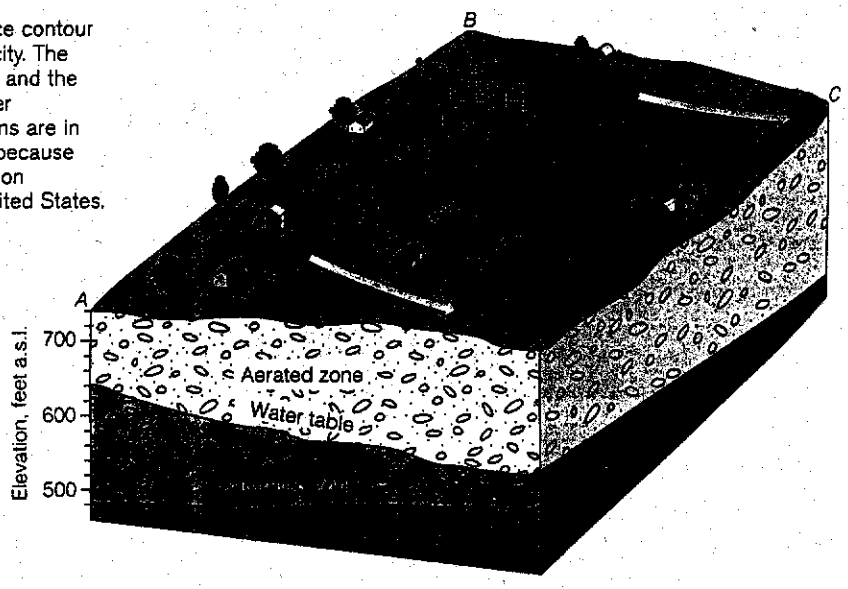
The Edwards aquifer in south-central Texas is one of the most prolific aquifers in North America (◆ Figure 1). It provides water for two million people, including the City of San Antonio. A well drilled for the city in 1991 is reportedly the world's greatest flowing well, yielding 95,000 liters per minute (25,000 gal/min). The aquifer is composed of limestone of Cretaceous age that is a *karstified* flow system; that is, it is honeycombed with solution cavities, caves, and caverns and feeds many springs. About 80 percent of the aquifer's recharge is from losing (influent) streams that flow over its exposed outcrops; the rest is from precipitation. Where it dips down below the ground surface toward the south, it is under pressure, and water rises in well bores and sometimes to the ground surface (see ◆ Figure 8.14). At depth, the water quality and potability deteriorate to a zone marked on maps by the "bad-water line."

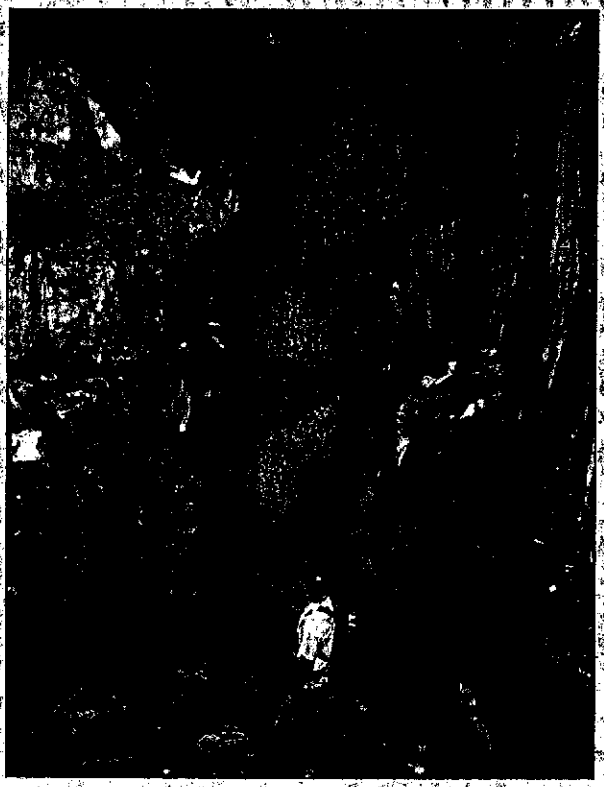
The region served by the aquifer is one of the fastest growing areas in the United States, and water supply is critical to this growth. Recharge areas are environmentally sensitive to pollutants, and the resource is threatened by disregard for this potential problem (◆ Figure 2). Threats are from human sewage, highway construction, agricultural chemicals, runoff from paved surfaces, and leaking underground storage tanks, to name a few. Government agencies at all levels are committed to protecting the aquifer. The federal government designated the aquifer a Sole Source Aquifer, which makes it eligible for funding for some protection projects. The state declared the Edwards aquifer the most susceptible to pollution in the state and established conservation districts for overseeing its protection.

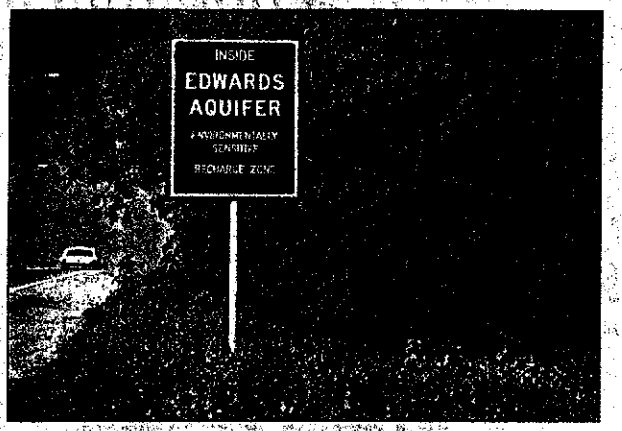


◆ FIGURE 1 Area of south-central Texas's Edwards aquifer.

◆ FIGURE 8.16 Hypothetical pressure-surface contour map based upon water-well data near a city. The dots indicate the locations of water wells, and the arrows show the direction of ground-water movement in the saturated zone. Elevations are in feet above sea level, rather than meters, because English units are used almost exclusively on pressure-surface contour maps in the United States.







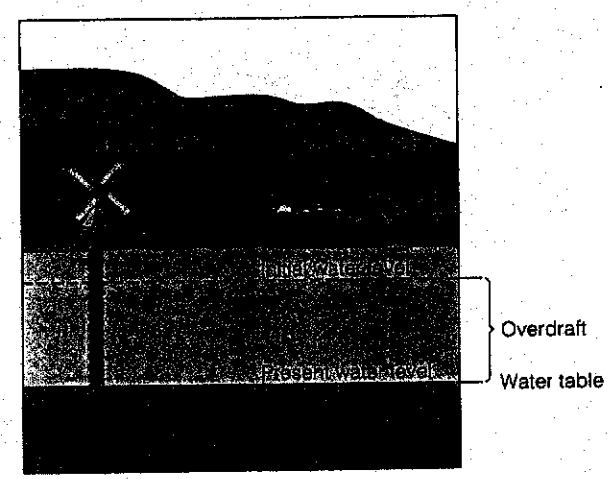
◇ **FIGURE 2** Midnight Cave in the Edwards aquifer before cleanup, 1993; southern Travis County near Austin, Texas. The trash is household garbage, oil filters, pesticide bottles, partially filled turpentine cans, and automobile parts. Trash had been floated up to higher ledges of the cave during high-water aquifer conditions. Cleanup efforts involved conservation groups, government agencies, and cavers. An estimated 3,000 cubic feet of trash was removed from the cave.

Consider This...? Ground-water pollution by surface-water seepage through waste-disposal sites into the water table is a major problem. Where would you locate a facility for solid-waste disposal in the setting of Figure 8.16 to minimize this hazard? Designate the site you choose by relating it to the letters at the corners of the diagram. Also, which three wells would you expect to provide the best-quality water for domestic use in the city? Briefly explain your answers. ■

A ground-water basin consists of an aquifer or a number of aquifers that have well-defined geological boundaries and *recharge areas*—places where water seeps into the aquifer (see Figure 8.15b). To determine the amount of usable water in the basin, we rely on the concept of specific yield of water-bearing materials. **Specific yield** is the ratio of the volume of water an aquifer will give up by gravity flow to the total volume of material, expressed as a percentage. For example, a saturated clay with a porosity of 25 percent may have a specific yield of 3 percent; that is, only 3 percent of the saturated porosity will drain into a well. The remaining water in the pore spaces (22 percent) is held by the clay-mineral surfaces and between clay layers against the pull of gravity. This "held" water is its *specific retention*. Similarly, sand with a porosity of 35 percent might have a specific yield of 23 percent and a specific retention of 12 percent. Note that the sum of specific yield and specific retention equals the porosity of the aquifer material.

Thus the total water-storage capacity of an aquifer may be calculated by multiplying the specific yield by the volume of the aquifer determined from water-well data. The process is a bit more complicated for artesian aquifers, but it follows the same procedure. The amount of water available to us in a ground-water basin can be determined fairly accurately if the basic data are available from numerous wells.

As noted, sustained yield is the amount of water that can be withdrawn on a long-term basis without depleting the resource. Sustained yield is more difficult to assess than aquifer storage capacity, as it is affected



◇ FIGURE 8.17 The effect of ground-water mining on the water table. The drop from the initial level to the present level is the *overdraft*, the amount of water that has been mined.

by precipitation, runoff, and recharge. Nevertheless, it must be at least estimated for intelligent management of the resource.

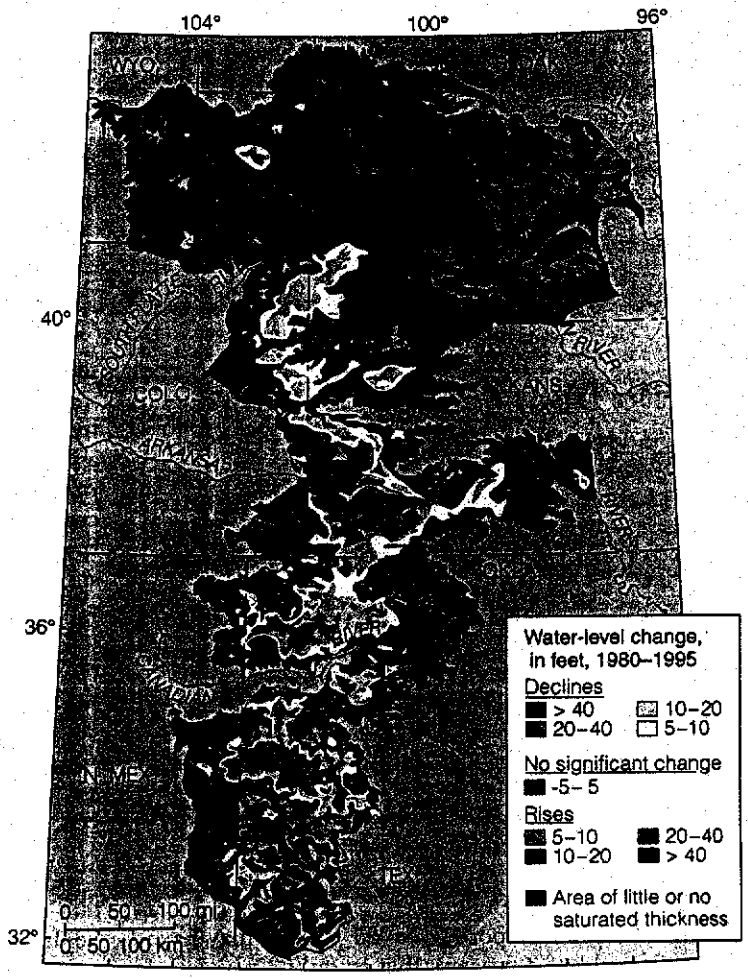
GROUND-WATER MINING

As explained in the chapter opening, when the amount of water withdrawn from an aquifer exceeds the aquifer's sustained yield, an overdraft condition called *ground-water mining* exists (◇ Figure 8.17). The Ogallala Sandstone makes up about 80 percent of what is collectively known as the High Plains aquifer. The Ogallala's average thickness is 60 meters (about 200 ft), but thicknesses as great as 425 meters (1,400 ft) have been measured. In general, water levels in this important aquifer are dropping. In Texas, overdrafts have exceeded 65 percent, and overdrafts of 95 percent are known in a few places. In the latter case, 20 times more water was extracted from the aquifer than was recharged. This magnitude of overdraft is a serious problem because much of the water in the aquifer was acquired during wetter glacial climates thousands of years ago.

The High Plains aquifer was not massively tapped until the 1950s, and by 1980 the water-saturated zone had decreased an average of 3 meters, and as much as 30 meters under some parts of Texas and Nebraska (◇ Figure 8.18). Government subsidies have encouraged growing water-gulping corn, rather than less-water-intensive wheat, sorghum, and cotton.

In the early 1980s water decline rates decreased because of heavy rain and snow, better water management, and new technologies. New *LEPA* (low-energy, precision-application) irrigation nozzles use less water and less energy and decrease evaporation by as much as 98 percent from the amounts lost with spray-type irrigation. Furthermore, treated wastewater is now being recycled on fields, and rainfall has been induced by cloud seeding in attempts to recharge the aquifer in Kansas.

A 1982 Department of Commerce study found that 6 million hectares (15 million acres) were being irrigated with water drawn from 150,000 wells in the Ogallala and other High Plains aquifers. By the year 2020, according to the study report, about a fourth of the aquifer's water will have been mined at the present rate of withdrawal. A 1995 estimate of the total overdraft of the Ogallala is that it equals one year's flow of the Colorado River. The Ogallala aquifer is certainly



◇ FIGURE 8.18 Water-level change in the High Plains aquifer, 1980–1995.

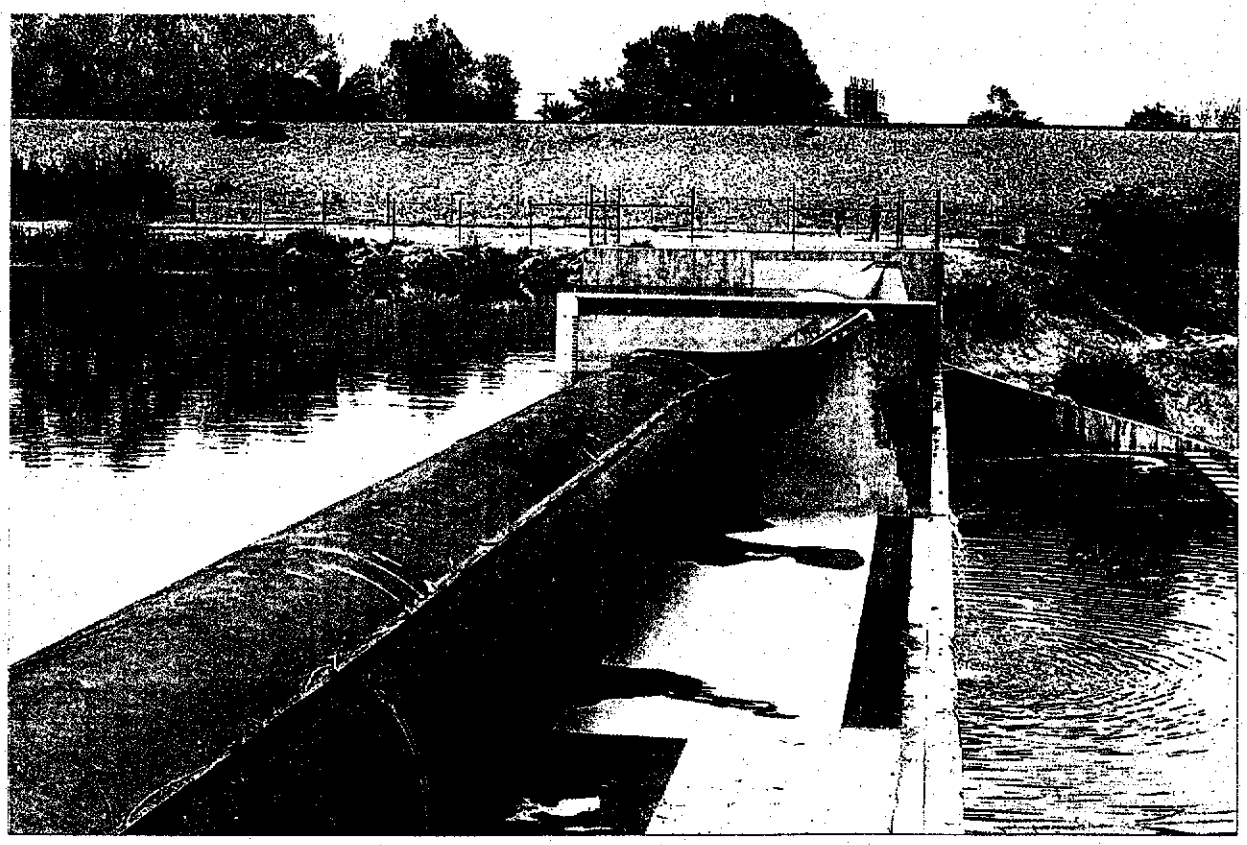
the life-blood of High Plains agriculture, and most users of its water are aware that "mining" the resource must be discontinued. Strict management that includes conservative usage, monitoring, and utilization of new technologies is required in attempting to balance its recharge and withdrawals. As a postscript to the Ogallala story, the aquifer's name is derived from that of the Oglala Tribe of the Sioux Nation. Led by Chiefs Red Cloud and Crazy Horse, the tribe fought to retain tribal lands in the late 1800s.

Ground-water mining causes shallow wells to go dry, increases the cost of lifting water to the surface as water levels drop, and may eventually cause ground subsidence (see Chapter 7). Currently ground-water pumping is twice the volume of natural recharge in Arizona's Tucson ground-water basin, and it has been necessary to import water from the Central Arizona Project to end the overdraft. One product of nuclear testing in the 1950s and early 1960s was radioactive tritium. This isotope of hydrogen has been used as a tracer of ground water recharged into the Tucson basin on alluvial fans of the adjacent Catalina and Rincon Mountains. The study indicates that a significant amount of the basin's ground water is very young and has infiltrated since the atom-bomb tests. This does not bode well for bringing the water table back to predevelopment levels in the basin.

The Santa Clara Valley of central California is a classic case of regional overdraft. Water levels there declined 46 meters (150 ft) between 1912 and 1959, and downtown San Jose dropped 2.76 meters (9 ft). As a final example, overpumping in Alabama dropped the pressure surface in one aquifer 62 meters (200 ft); it is now below sea level more than 80 miles inland from the sea. The solution to such a problem is *artificial recharge*, or "water spreading," which is accomplished by importing or diverting surface water and ponding it where it can percolate into the aquifer (◇ Figure 8.19). Such a program was initiated in the Santa Clara Valley in 1959, which, in combination with decreased pumping, has restored the water table to 1912 levels. Raising the water table does not bring the land back to its original level, however, because pore spaces are lost as subsidence occurs.

GROUND WATER–SALTWATER INTERACTION

Aquifers in coastal areas may discharge fresh water into the ocean, creating bodies of diluted seawater. If the



▶ FIGURE 8.19 Water-spreading grounds for artificial recharge; Santa Ana River, Southern California. The dam is inflatable and may be raised or lowered to impound or release water as needed.

water table is lowered by pumping to or near sea-level elevation, however, saltwater invades the freshwater body, causing the water to become saline *(brackish)* and thus undrinkable. The direction of flow between the two water masses is determined by their density differences. Seawater is 2.5 percent (‰th) heavier than fresh water. This means that a 102.5-foot-high column of fresh water will exactly balance a 100-foot-high column of seawater (◁▶ Figure 8.20a). Fresh water floats on seawater in the Hawaiian Islands, the Outer Banks of North Carolina, Long Island, and many other coastal areas (Case Study 8.3).

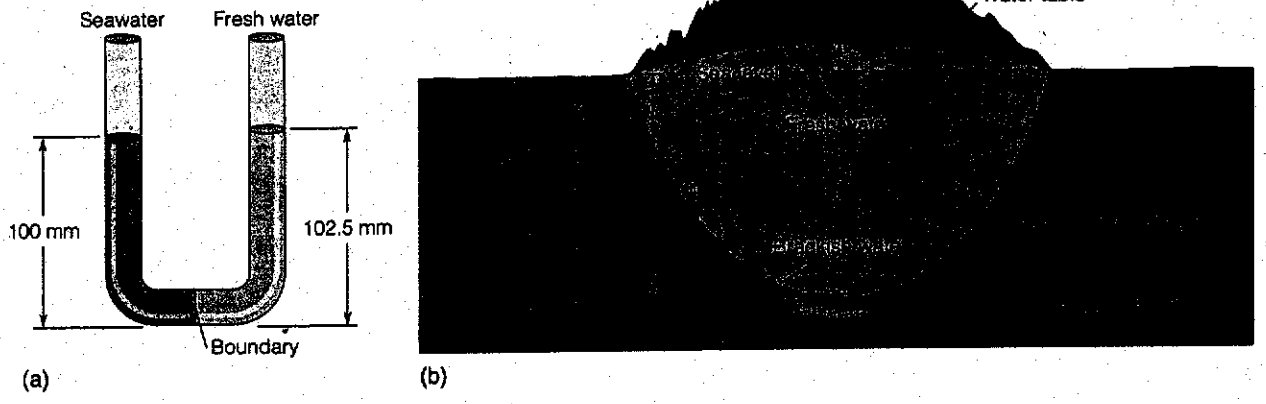
This relationship is known as the *Ghyben–Herzberg lens*—named for the two scientists who independently discovered it and for the lenslike shape of the freshwater body. In theory, the mass of fresh water extends to a depth below sea level that is 40 times the water-table elevation above sea level. If the water table is 2.5 feet above sea level, the freshwater lens would extend to a depth of 100 feet below sea level. Any reduction of water-table elevation would cause the saltwater to migrate upward into the freshwater lens until a new balance is established. If the water table drops below the level necessary for maintaining a balance with denser seawater, wells will begin to produce brackish water and eventually saltwater. Thus it is important to maintain high water-table levels in coastal zones so that the resource is not damaged by *saltwater encroachment*. This is accomplished by good management combined, when necessary, with artificial recharge using local or imported water (water spreading), or with injection of imported water into the aquifer through existing wells.

GROUND WATER–SURFACE WATER INTERACTION AND USAGE TRENDS

As has been emphasized thus far, surface water and ground water are not separate entities. Nearly all surface-water features—lakes, streams, rivers, and artificial lakes, and wetlands—interact with water underground. Some surface-water bodies gain water and acquire a different chemistry from ground water, and other surface waters contribute to underground water and may even pollute it. Thus, it is incumbent in water planning to have a clear understanding of the linkages between ground water and surface water and of the geology of both.

The greatest volume of fresh water is used for irrigation, and the greatest total volume of water, both fresh and saline, is used for power generation. However, 98 percent of the water used for power generation is returned to streams or other reservoirs; only 2 percent is consumed. How water is used affects the reuse potential of returns flows. For example, irrigation water may be too salty or contaminated by pesticides and insecticides to have any reuse potential unless it is purified naturally or artificially. On the other hand, water used in power generation has great reuse potential, because the principal change is usually just an increase in its temperature.

Since 1950 national water-use statistics have been compiled every five years (see Solley, W. B., For Further Information). There was a steady increase in water usage from 1950 to 1980, the all-time high, as population grew at a steady pace. Between 1980 and 1995, there was a 10 percent decrease in water use, even though the U.S. population grew by 37 million people



◁▶ FIGURE 8.20 (a) Illustration of the density balance between fresh water and seawater. Because seawater is 2.5% heavier than fresh water, 102.5 millimeters of fresh water is required to balance 100 millimeters of salt water. (b) Hypothetical island and Ghyben–Herzberg lens of fresh water floating on seawater. The freshwater lens extends to a depth 40 times the height of the water table above sea level. Not to scale.

Case Study 8.3

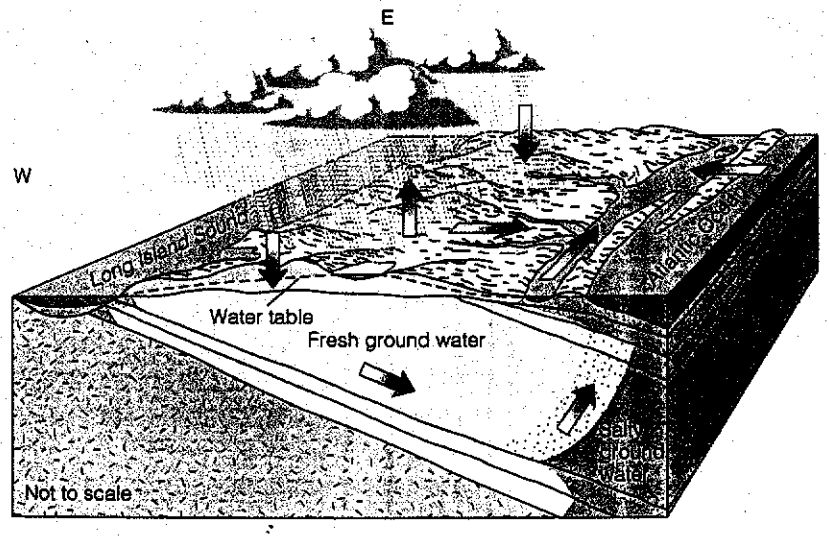
Long Island, New York—Saltwater or Fresh Water for the Future?

Long Island is an informative case study of the cause and remedies of saltwater encroachment. By far, Long Island's most important source of fresh water is its aquifers, which are estimated to hold 10–20 trillion gallons of recoverable water (◈ Figure 1). This ground water infiltrated underground over centuries before development, and the excess was discharged naturally to the sea. Ground water was exploited as the island was urbanized, causing the water table in Kings County, the county closest to the mainland, to drop below sea level. By 1936 saltwater had invaded the freshwater aquifer (◈ Figure 2a). Pumping wells were then abandoned or were converted to recharge wells using imported water, and by 1965 the water tables had recovered to acceptable elevations above sea level (◈ Figure 2b).

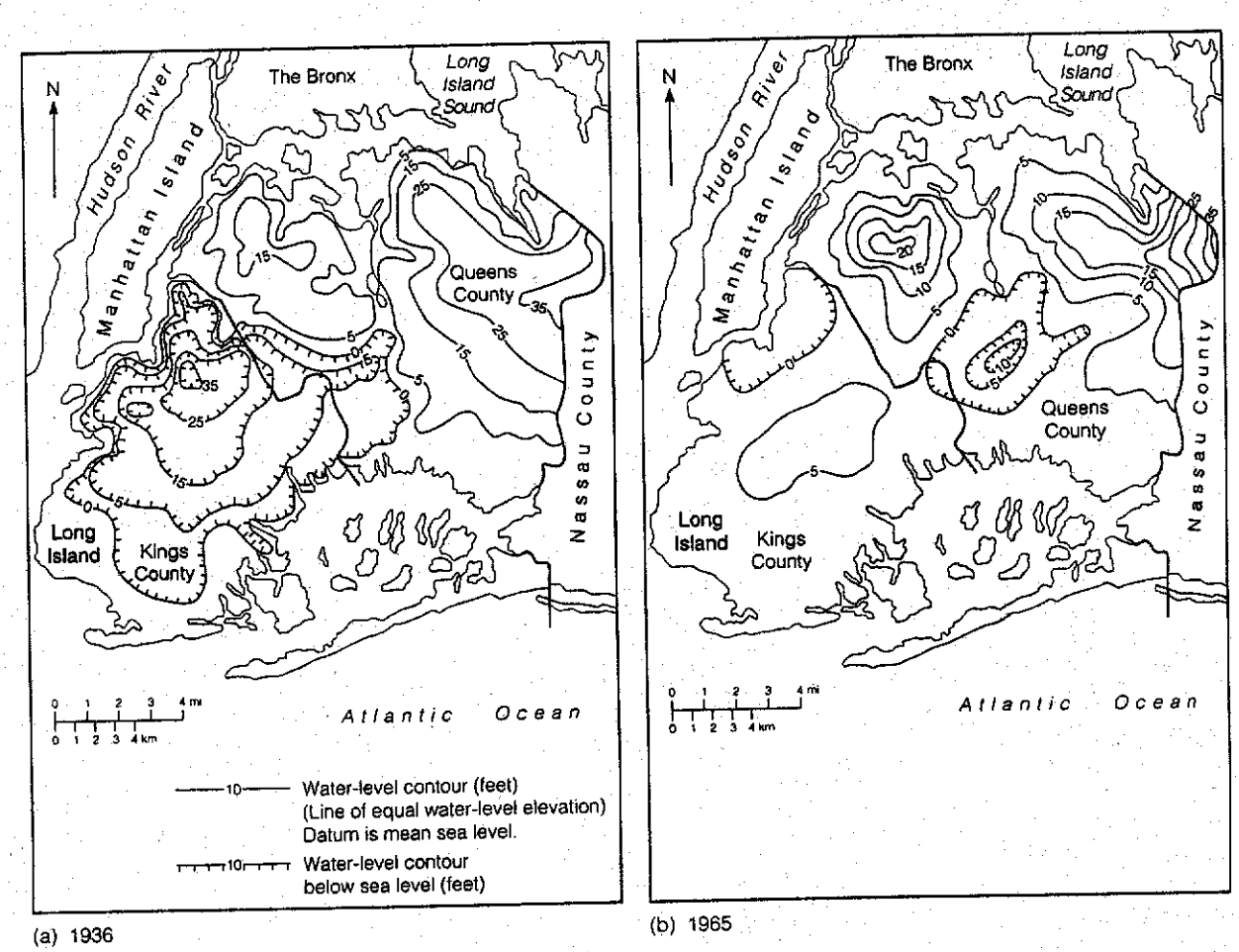
Meanwhile, in adjoining Queens County, pumping had been increasing and recharge was diminishing due to the construction of sewers and paving of streets. Treated wastewater was thus being carried to the sea, rather than infiltrating underground as it would with cesspools and septic tanks. With lowered water tables, saltwater invaded the aquifers below Queens County (Figure 2), and the State of New York in 1970 asked the U.S. Geological Survey to conduct ground-water studies.

In order to preserve the fresh water below Long Island, it was necessary to determine the *safe yield*, the amount of water that could be withdrawn from Long Island aquifers without causing undesirable results. It was also necessary to achieve a balance between total freshwater outflow and recharge. Several methods of managing the water resource and preventing saltwater encroachment were developed, and they are offered here as examples.

The basic challenge was to offset ground-water withdrawals of 1.7 million cubic meters per day with equal amounts of surface infiltration or injection. A line of injection wells was proposed for replacing the decreased natural recharge. These wells would inject treated sewage effluent or imported water and build a freshwater barrier against saltwater intrusion (◈ Figure 3a). Spreading highly treated sewage effluent and natural runoff into recharge basins could be carried out along with injection into the deeper aquifer. In both the injection-well and the spreading-basin alternatives, the treated sewage is purified to drinking-water



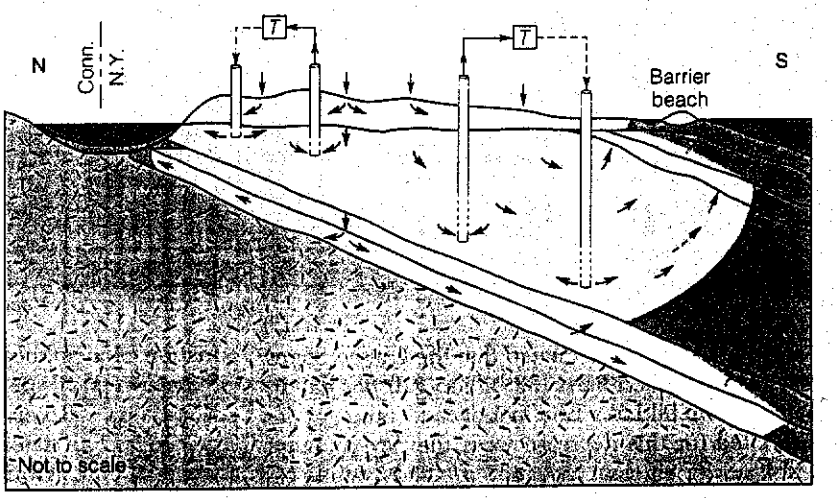
◈ FIGURE 1 Hydrologic relationship between fresh and salty underground water; Long Island, New York. Arrows indicate direction of water movement in the hydrologic cycle.



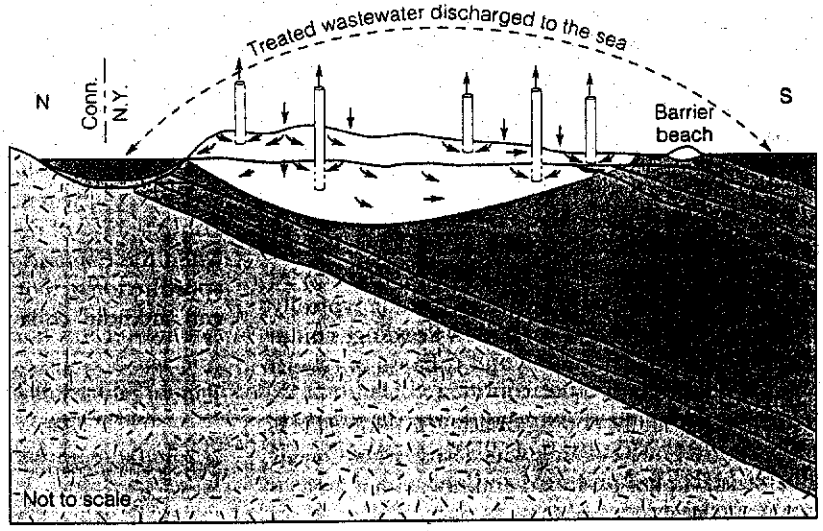
◇▶ FIGURE 2 Water-table levels in (a) 1936 and (b) 1965 in Kings and Queens Counties, Long Island, New York.

standards so that it does not affect local shallow wells. Recharge, like injection, builds a freshwater ridge that keeps saltwater at bay. An unusual but viable method is to allow controlled saltwater intrusion so that a true Ghyben–Herzberg lens of fresh water floating on saltwater develops (◇▶ Figure 3b). Treated sewage effluent would be discharged into the ocean or injected underground as the need arose. This method has the distinct advantage of salvaging much of the fresh water that otherwise would flow through aquifers into the ocean. In addition, this alternative would increase the yield of the aquifer by several hundred million cubic meters per day, although it would decrease the total volume of fresh water in the reservoir.

Each method of balancing outflow and inflow—injection wells, spreading basins, and controlled saltwater intrusion—has advantages and disadvantages. As is the case with many geological problems, applying a combination of methods yields the most fruitful and cost-effective solution. Kings and Queens Counties now rely entirely upon importation for their freshwater needs. Public water in Nassau and Suffolk Counties is entirely underground water, and only a very small amount of seawater intrusion occurs in the southwest corner of Nassau County. Injection of tertiary treated wastewater (see Chapter 15) was tested in the 1980s. Unfortunately, the chemical differences of the injected water, natural fresh water, and saltwater caused the injection wells to clog and require excessive maintenance. Wastewater injection is feasible but at present is too expensive. Currently, there is a network of recharge basins that collect surface-water runoff and allow it to percolate underground into the shallow



(a) Inject treated water as a barrier.

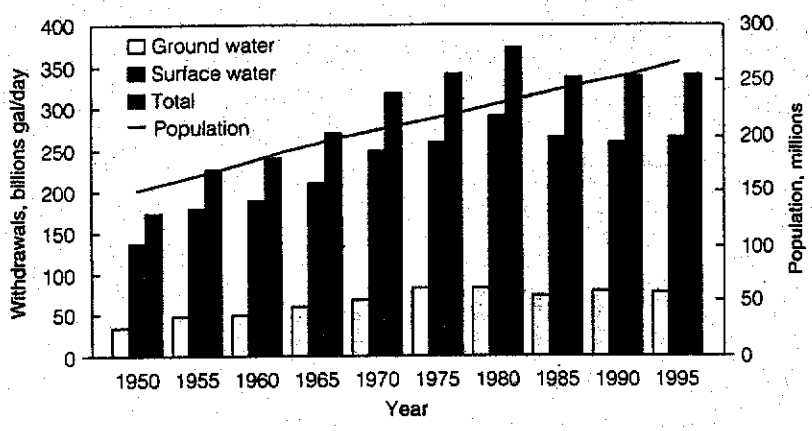


(b) Permit saltwater intrusion.

◆ FIGURE 3 Methods of balancing freshwater outflow and seawater inflow; Long Island, New York. (a) The aquifer is recharged with highly treated wastewater (*T*) using injection wells. This method reverses saltwater intrusion and also improves the outlook for long-term water yield. (b) Saltwater is allowed to move inland, and a lens of fresh water forms, floating on the saltwater. This serves to establish a new equilibrium between fresh water and seawater.

aquifer (◆ Figure 4). The counties require developers to dedicate land for recharge basins within their housing or commercial projects. This method of recharge has proven effective in maintaining the balance between seawater and fresh water.

◆ FIGURE 4 A recharge basin for capturing surface-water runoff; Nassau County, New York.



◇ FIGURE 8.21 Trends in fresh ground- and surface-water withdrawals and population, 1950–1995.

(◇ Figure 8.21). It was estimated that the United States was saving 144 billion liters (38 billion gal) per day in 1995, enough to fill Lake Erie in a decade. Some of the reasons cited for this decrease were the development and use of more efficient irrigation methods, conservation programs, increased water recycling, and a downturn in farm economies.

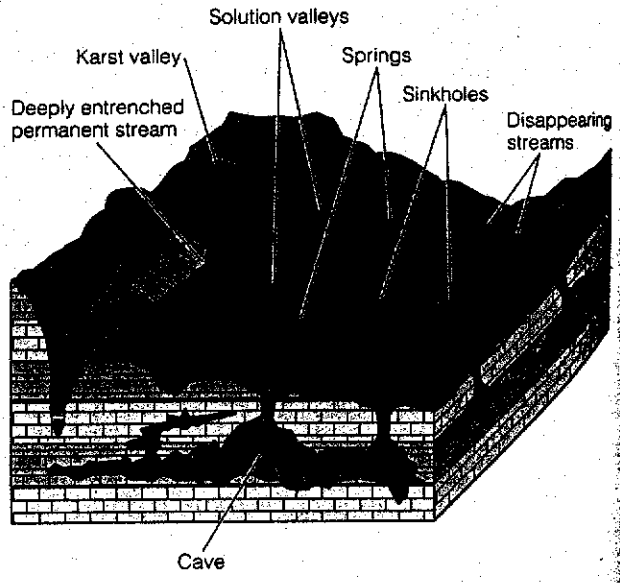
GEOLOGIC WORK BY UNDERGROUND WATER

Solution (a chemical reaction discussed in Chapter 6) of limestone and gypsum by underground water leads to formation of caves, caverns, disappearing streams, and prolific ground-water aquifers such as the Edwards aquifer (Case Study 8.2). Land area exhibiting these features is called **karst terrane** (German *Karst,* for the Kars limestone plateau of northwest Yugoslavia; ◇ Figure 8.22). Urbanization on karst terrane typically results in problems such as increased flooding, contamination of underground water, and collapse of cavern roofs to form sinkholes.

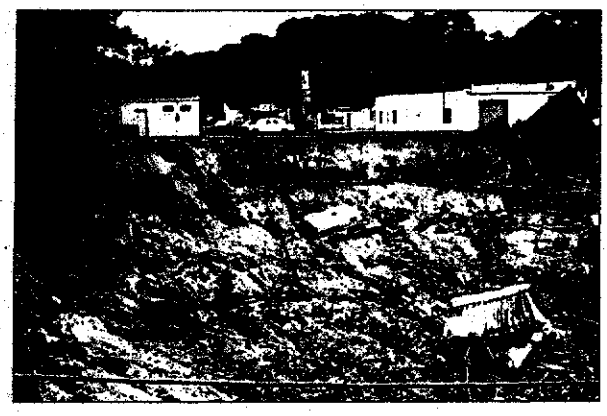
The first sign of impending disaster in Winter Park, Florida, occurred one evening when Rosa Mae Owens heard a "swish" in her backyard and saw, to her amazement, that a large sycamore tree had simply disappeared. The hole into which it had fallen gradually enlarged, and by noon the next day her home had also fallen into the breach. Six Porsches in a nearby storage yard suffered the same fate, as did a city swimming pool and two residential streets. Deciding to work *with* nature, the City of Winter Park stabilized and sealed the sinkhole, and converted it to a beautiful urban lake (◇ Figure 8.23). Few people who read of this notorious sinkhole in May 1981 realized the extent of the sinkhole problem in the southeastern United States.

Sinkholes are most commonly found in carbonate terranes (limestone, dolomite, and marble), but they are also known to occur in rock salt and gypsum. They form when carbonic acid (H_2CO_3) dissolves carbonate rock, forming a near-surface cavern. Continued solution leads to collapse of the cavern's roof and the formation of a sinkhole. About 20 percent of the United States, and 40 percent of the country east of the Mississippi River, is underlain by limestone or dolomite. The states most impacted by surface collapse are Alabama, Florida, Georgia, Tennessee, Missouri, and Pennsylvania (◇ Figure 8.24).

Tens of thousands of sinkholes exist in the United States, and the formation of new ones can be accelerated by human activities. For example, excessive water withdrawal that lowers ground-water levels reduces or removes the buoyant support of shallow caverns' roofs. In fact, the correlation between water-table lowering and sinkhole formation is so strong that "sinkhole seasons" are designated in the Southeast. These "seasons" are declared whenever ground-water levels drop naturally because of decreased rainfall and in the summer, when the demand for water is heavy. Vibrations from construction activity or explosive blasting also can trigger sinkhole collapse. Other mechanisms that have



◇ FIGURE 8.22 Surface and subsurface features of karst topography.



(a)

(b)

(c)

◆ FIGURE 8.23 Sinkhole in Winter Park, Florida. (a) Shortly after the initial collapse. Note the expensive sports car going down the sink. (b) Air view that shows its almost perfect symmetry. (c) Plugged and landscaped, the sinkhole area is now an urban park.

been proposed for sinkhole formation are fluctuating water tables (alternate wetting and drying of cover material reduces its strength) and high water tables (which erode the roofs of underground openings).

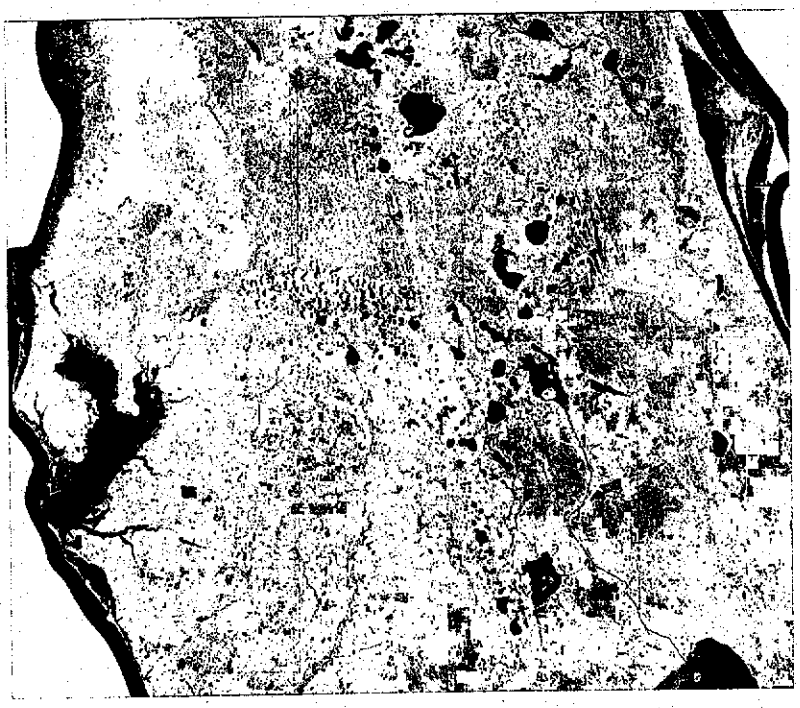
Although the development of natural sinkholes is not predictable, it is possible to assess a site's potential for collapse resulting from human activities. This requires extensive geologic and hydrogeologic investigation prior to site development. Under the best of geologic conditions, good geophysical and subsurface (drilling) data can tell us where collapse is most likely to occur, but they cannot tell us exactly when a collapse may occur. Armed with this information, planners and civil engineers can implement zoning and building restrictions that will minimize the hazards to the public.

Water Quality

DISSOLVED SUBSTANCES

Dissolved in natural waters are varying concentrations of all the stable elements known on earth. Whereas some of these elements and compounds, such as arsenic, are poisonous, others are required for sustaining life and health; common table salt is one and it occurs in almost all natural waters. Years ago the U.S. Public Health Service established **potable** (drinkable) **water** standards for public water supplies based on purity, which is defined as allowable concentrations of particular dissolved substances in natural waters. These concentrations are expressed in weight per volume, which is milligrams per liter (mg/L) in the metric system. The standards can also be expressed in a weight-per-weight system. For example, in the English system, one pound of dissolved solid in 999,999 pounds of water would be

Consider This...? You could become a millionaire if you developed a relatively inexpensive method of locating caverns that may collapse and form sinkholes. Got any ideas? If not, what types of more sophisticated (and expensive) methods might be employed to locate caverns? ■



◁▶ FIGURE 8.24 Satellite image map of central Florida showing its karst terrane with disappearing streams, hundreds of lakes, and thousands of sinkholes. Central Florida is underlain by the Tertiary Ocala Limestone, and the coastal areas by younger, detrital sand deposits. This explains the location of karst terrane along the state's north–south axis.

one part per million (ppm). The Public Health Service standards allow only minuscule amounts of pollutants in public water supplies. For example, 1 ppm or 1 mg/L is equal to about 1 ounce of a dissolved solid in 7,500 gallons of water, or 0.0001 percent. The standard for "sweet" water—the preferable quality classification for domestic use—is less than 500 ppm of *total dissolved solids (tds)*, and the standard for "fresh" water is less than 1,000 ppm of total dissolved solids. • Table 8.1 lists the Public Health Service secondary standards, and ◉ Table 8.2 lists some common water problems and suggestions for correcting them.

The quality of ground water can be impaired either by a high total amount of various dissolved salts or by a small amount of a specific toxic element. High salt content may be due to solution of minerals in local geological formations, seawater intrusion into coastal aquifers, or the introduction of industrial wastes into ground water. (Organic contaminants, mainly animal wastes, solvents, and pesticides, also degrade water. They are discussed in the next subsection.) • Table 8.3 lists Public Health Service limits for some of the inorganic substances that occur in ground water and impair its safety.

O TABLE 8.1 U.S. Public Health Service Secondary Drinking-Water Standards*

DISSOLVED SUBSTANCE	STANDARD, mg/L	EFFECT
Calcium and magnesium	–	principal cause of water hardness; boiler scale (Ca and Mg salts)
Chloride	250	unpleasant taste; corrodes pipes
Copper	1.0	metallic taste; stains clothes and containers
Fluoride	2.0	may stain tooth enamel
Sulfate	250	bitter taste; laxative effect
Iron	0.3	unpleasant taste
Zinc	5.0	unpleasant taste
Manganese	0.05	unpleasant taste
Total dissolved solids ,tds	500	possible relationship to cardiovascular disease; corrosive to pipes

*Secondary standards are nonenforceable and apply to substances that occur in concentrations below U.S. Public Health Service standards and affect such water qualities as taste and odor. For example, although it is desirable that drinking water contain no iron, sulfate, or zinc, concentrations above these standards are permissible.

Water with high salt content, particularly bicarbonate and sulfate contents, can have a laxative effect on humans. Dissolved iron or manganese can give coffee or tea an odd color, impart a metallic taste, and stain laundry. Concentrations greater than 3 ppm of copper can give the skin a green tinge (it's not easy being green, as Kermit says; the condition is reversible), and lead is both poisonous and persistent. A *persistent pollutant* is one that builds up in the human system because the body does not metabolize it. (The Romans used lead pipes for plumbing, and skeletal materials exhumed from old Roman cemeteries retain high lead concentrations.) Lead concentrations in the water supply greater than about 0.1 ppm can build up over a period of years to debilitating concentrations in the human body. Arsenic is also persistent, and the standards for arsenic and lead are the same—less than 0.05 ppm, preferably absent. Nitrates in amounts greater than 10 ppm are known to inhibit the blood's ability to carry oxygen and to cause "blue baby syndrome" *(infantile methemoglobinemia)* during pregnancy. The element with the greatest impact upon plants is boron, which is virtually fatal to citrus and other plants in concentrations as low as 1.0 ppm.

Dissolved calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions cause water to be "hard." In hard water soap does not lather easily, and dirt and soap combine to form scum. Hard water is most prevalent in areas underlain by limestone ($CaCO_3$) and dolomite ($CaMgCO_3$). A water softener simply exchanges sodium (Na^+) for calcium and magnesium ions in the water using a zeolite (a silicate ion exchanger) or mineral sieve. Water with more than 120 ppm of dissolved calcium and magnesium is considered hard (◉ Table 8.4). Because sodium is known to be bad for persons with heart problems (hypertension) and water softeners increase the sodium content of water, those people on low-sodium diets should not drink softened water.

The good news regarding dissolved ions is that fluoride ion (F^-) dissolved in water reduces tooth cavities when it is present in amounts of 1.0–1.5 ppm. The explanation for this is that tooth enamel and bone are composed of the mineral apatite, $Ca_5(PO_4)_3(F, Cl, OH)$, whose structure allows the free substitution of fluoride F^-, chloride Cl^-, or hydroxyl $(OH)^-$ ions in the mineral structure. In the presence of fluoride, the crystals of apatite in tooth enamel are larger and more perfect, which makes them resist decay. Too much fluoride in drinking water, however—concentrations greater than 4 ppm—can cause children's teeth to become mottled with dark spots. This cosmetic blemish, among children in particular, led to the discovery of the beneficial effect of fluorine and to the establishment of concentration standards for it. Fluoride in natural waters is rare, but Colorado Springs, Colorado, is a well-known area with very few children's dentists. Dissolved fluoride is also believed to slow osteoporosis, a bone-degeneration process that accompanies aging.

GROUND-WATER POLLUTANTS

The term *water pollution* refers to the introduction of chemical, physical, or biological materials into a body of natural water that affect its future use. It is more widespread than formerly thought, as revealed by studies by

○ TABLE 8.2 Common Water Quality Problems

PROBLEM	PROBABLE CAUSE	CORRECTION
Mineral scale buildup	water hardness	water softener or hardness inhibitor (such as Calgon)
Rusty or black stains	iron and/or manganese	aeration/filtration; chlorination; remove source of Fe/Mn
Red-brown slime	iron bacteria	chlorination filtration unit; remove source of slime
Rotten-egg smell or taste	hydrogen sulfide and/or sulfate-reducing bacteria; low oxygen content	aeration; chlorination filtration unit; greensand filters
Salty taste	chloride—seawater or other saline water	reduce pumping to raise water table
Gastrointestinal diseases, typhoid fever, dysentery, and diarrhea	coliform bacteria and other pathogens from septic tanks or livestock yards	remove source of pollution; disinfect well; boil water; chlorinate; abandon well and relocate new well away from pollution source
Petroleum smell or film	fuel oil, diesel fuel, or lubricating oil	remove source of pollution

SOURCE: D. Daly, "Groundwater Quality and Pollution" (Geological Survey of Ireland Circular 85–1, 1985), in J. E. Moore and others, *Ground Water: A Primer,* American Geological Institute, 1994.

TABLE 8.3 Health Effects of Significant Concentrations of Common Inorganic Environmental Pollutants

INORGANIC POLLUTANT	STANDARD, mg/L	HEALTH EFFECTS
Arsenic	0.05	dermal and nervous-system toxicity effects, paralysis
Barium	1.0	gastrointestinal effects, laxative
Boron	1.0	no effect on humans; damaging to plants and trees, particularly citrus trees
Cadmium	0.01	kidney effects
Copper	1.0	gastrointestinal irritant, liver damage; toxic to many aquatic organisms
Chromium	0.05	liver/kidney effects
Fluoride	4.0	mottled tooth enamel
Lead	0.05	attacks nervous system and kidneys; highly toxic to infants and pregnant women
Mercury	0.002	central-nervous-system disorders, kidney disfunction
Nitrates	10.0	methemoglobinemia ("blue baby syndrome")
Selenium	0.01	gastrointestinal effects
Silver	0.05	skin discoloration (argyria)
Sodium	20–170	hypertension and cardiac difficulties
	70.0	renders irrigation water unusable

TABLE 8.4 Water Hardness Scale*

CONCENTRATION OF $CALCIUM^{2+}$, mg/L	CLASSIFICATION
0–60	soft
61–120	moderately hard
121–180	hard
>180	very hard

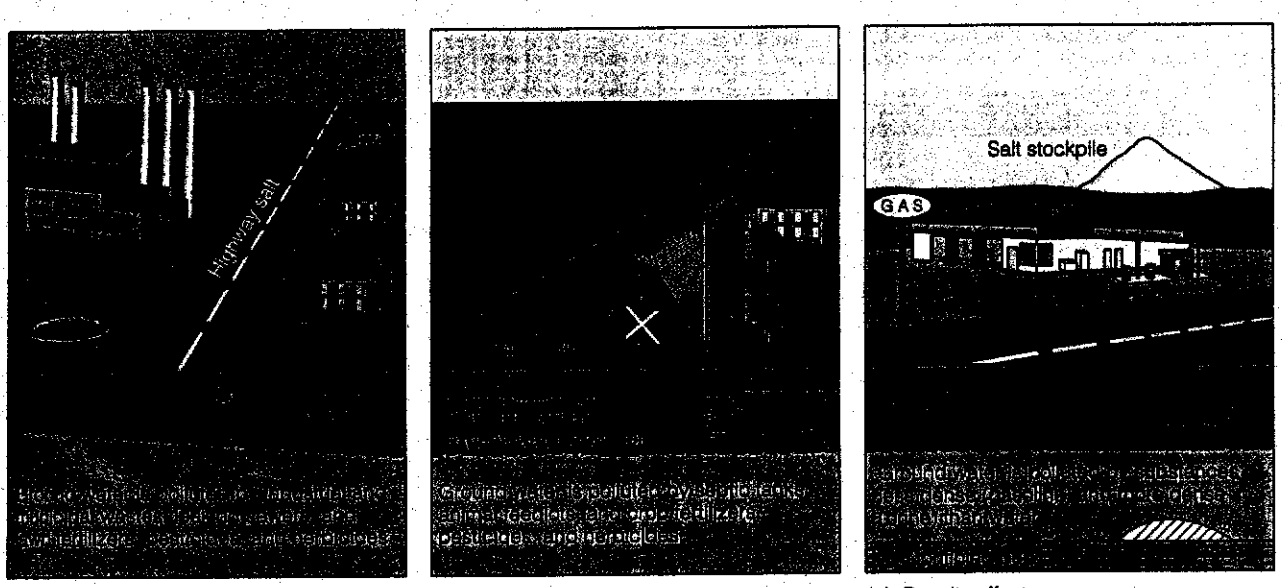
*Hardness is expressed here as milligrams of dissolved Ca^{2+} per liter. Dissolved calcium and magnesium in water combine with soap to form an insoluble precipitate that hampers water's cleansing action.

state and federal agencies and by complaints from users. It is a serious problem because thousands of years may be required to flush contaminated water from an aquifer and replace it with clean water. River water, in contrast, is exchanged in a matter of hours or days. **Residence time,** the length of time a substance remains *(resides)* in a system, is an important concept in water pollution studies. We may view it as the time that passes before the water within an aquifer, lake, river, glacier, or ocean is totally replaced and continues on its way through the hydrologic cycle. The average residence time of water in rivers has been found to be a few days; of water in large lakes, several decades; in shallow gravel aquifers, a few days; and in deeper, low-permeability aquifers, perhaps thousands or even hundreds of thousands of years. This knowledge allows us to estimate the approximate time a particular system will take to clean itself naturally and indicates those cases in which a pollutant must be removed from a water body artificially by human means because of a long residence time.

Although most pollution is due to careless disposal of waste at the land surface by humans, some is due to the leaching of toxic materials in shallow excavations or mines. Ground-water pollution occurs in urban environments due to improper disposal of industrial waste and due to leakage from sewer systems, old fuel-storage tanks, wastewater settling ponds, and chemical-waste dumps (◈ Figure 8.25a). In suburban and agricultural areas, septic-tank leakage, fecal matter in runoff and seepage from animal feedlots, and the use of inorganic fertilizers, such as nitrates and phosphates, and of weed and pest-control chemicals all can serve to degrade both surface and subsurface water (◈ Figure 8.25b).

Leaking gasoline-storage tanks are a more recent cause of soil and ground-water pollution (◈ Figure 8.25c). By federal law, all underground tanks now must be inspected for leakage, and if gasoline is found in the adjacent soil, the tanks must be removed and the soil cleaned. (Although the problem is not amusing, the technology created by the need for hydrocarbon cleanup has come to be lightly referred to as *yank-a-tank.*) If gasoline is found floating on ground water, it must be removed (Case Study 8.4). Both the gasoline and the decontaminated ground water are then usable. Soils can be cleansed of hydrocarbons biologically with bacteria, a process known as **bioremediation,** or by aeration and oxidation of the hydrocarbon films (see Case Study 6.3).

◉ Table 8.5 lists some of the detrimental effects of selected organic pollutants. Water standards for common organic pollutants of water bodies are given in ◉ Table 8.6. The very low limits allowed for the pesticides lindane and endrin indicate their toxicities. Some of these toxic chemicals are also carcinogenic (cancer-causing), which makes them doubly dangerous.



(a) Urban areas (b) Rural areas (c) Density effects

◆ FIGURE 8.25 (a) Urban-area and (b) rural-area pollution sources. (c) Some pollutants float and others sink due to differences in density between ground water and the pollutants.

Density differences between ground water and particular pollutants often govern the remedial measures that can be used; for example, gasoline and oil float on ground water, whereas salt brines from industry or agriculture sink to lower levels. In some cases it is possible to skim a layer of gasoline from the top of the water table. Gasoline or fuel oil that is floating on the capillary fringe may yield vapors that can rise and be trapped beneath or in the walls of buildings. If these fumes contain BTX (*b*enzene, *t*oluene, and *x*ylene), they are carcinogenic. "Air-stripping" is currently the preferred method of removing volatile organic pollutants such as BTX compounds and trichloroethylene (TCE) and tetrachloroethylene (PCE) cleaning solvents from ground water. (The origin of these substances is usually connected to refinery, industrial, or military activities.) The polluted water is brought to the earth surface, where the contained volatile pollutants (TCE or BTX) are gasified (air-stripped) and wasted to the atmosphere with no adverse effects.

In Canada 10,000 metric tons of PCE are used per year, primarily in the dry-cleaning and metal-cleaning industries. An exhaustive study mandated and sponsored by the Canadian Environmental Protection Act (CEPA) indicates that PCE is entering the environment in significant quantities. Due to its volatility (it evaporates readily), it is found mostly in the atmosphere, where it has a relatively short residence time and does not contribute to global warming. The study concludes that the present atmospheric concentration of PCE is not expected to have adverse effects on Canada's aquatic and terrestrial animals, including humans, but

TABLE 8.5 Health Effects of Common Organic Pollutants*

ORGANIC SUBSTANCE	HUMAN HEALTH EFFECTS	ENVIRONMENTAL EFFECTS
Dieldrin	convulsions, kidney damage	toxic to aquatic organisms
DDT	convulsions, kidney damage	reproductive failure in animals, eggshell thinning
PCBs	vomiting, abdominal pain, liver damage	eggshell thinning in birds, liver damage in mammals
Benzene	anemia, bone-marrow damage	toxic to some fish and aquatic invertebrates
Phenols	death at high doses	decreased phytoplankton productivity
Dioxin	acute skin rashes, systemic damage, mortality	lethal to aquatic birds and mammals

*Insecticides or compounds used in their manufacture.
SOURCE: U.S. Public Health Service; Environmental Protection Agency.

Case Study 8.4

DNAPL and LNAPL

A couple of the newest acronyms in the environmental cleanup business are *DNAPL* (for *dense, nonaqueous-phase liquid* hydrocarbons) and *LNAPL* (for *light, nonaqueous-phase liquid* hydrocarbons). With the discovery of crude oil and the explosion (no pun intended) of its use in the reciprocating engine, numerous refineries and above-ground petroleum-storage-tank farms were developed. All the states face the problem of these tanks leaking and polluting the soils beneath them with refined hydrocarbons, including lubricating oils, diesel fuel, jet fuel, and gasoline—all of them LNAPLs (◈ Figure 1).

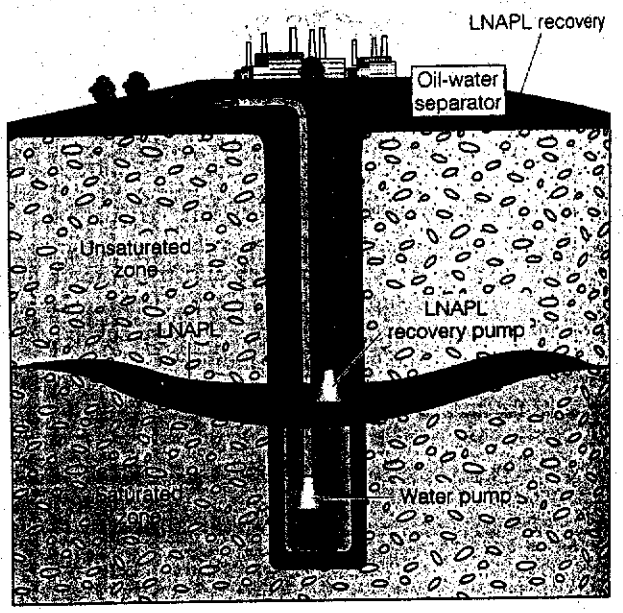
No place in the United States is the problem more obvious than the Los Angeles coastal plain, where there are 16 major refineries and 33 above-ground petroleum-storage-tank farms. Underlying these refineries are several important aquifers, one of them less than 60 meters (200 ft) below the ground surface. Some of the refineries are on the Environmental Protection Agency (EPA) National Priorities List (Superfund sites), and others are regulated by the Resource Conservation and Recovery Act (RCRA) as hazardous waste sites (see Chapters 1, 13, 14, and 15). The environmental concerns at these sites include:

- Hydrocarbons dissolved in the ground water will limit the water's beneficial use.
- LNAPL hydrocarbon pools occurring as "perched" zones serve as continuous sources of contamination for both soil and ground water.
- Soil contamination might convert the soil to a hazardous material.
- The accumulation of hydrocarbon vapors poses potential fire or explosion hazards.

The combined areal extent of LNAPL pools perched, or floating, on ground water beneath the refineries is estimated as being on the order of 600 hectares (1,500 acres or 2.3 mi^2), and the volume is estimated to be between 1.5 and 7.5 million barrels—the size of a small oil field!

The most sophisticated LNAPL-hydrocarbon recovery is accomplished by a recovery well with a two-pump system (◈ Figure 2). The two pumps are controlled by a series of electrodes set at predetermined depths. The lower, water-recovery pump runs until the drawdown brings the LNAPL–water interface into contact with the electrode just above the lower pump's intake. When the electrode senses the presence of LNAPL hydrocarbons, it shuts down the water pump so that LNAPLs are not ingested and mixed with fresh water. The upper, LNAPL-recovery pump is switched on and off by a probe that measures the electrical resistivity of fluids adjacent to the intake. LNAPLs have high electrical resistivity, and water has a low resistivity. The probe automatically shuts down when it senses fresh water. In this manner, water and hydrocarbons are recovered separately, treated, and then recycled to the benefit of all concerned.

◈ FIGURE 1 Leaking oil-storage tanks, West Texas. Such leaks lead to soil and ground-water contamination.



◈ FIGURE 2 A two-pump LNAPL-hydrocarbon recovery well. Sensors activate or deactivate pumps so that the upper pump draws only LNAPL hydrocarbons and the lower one draws only water. Recovered oil is reused.

TABLE 8.6 Water Standards for Common Organic Pollutants*

SUBSTANCE	MAXIMUM SAFE CONCENTRATION, mg/L
Cyanide	0.05
Lindane	0.004
Endrin	0.0002
2,4-D	0.10
Phenols	0.001

*Insecticides and animal-control compounds.
SOURCE: U.S. Public Health Service; Environmental Protection Agency.

it has the potential of harming trees. Local spills, of course, require cleanup and remediation.

Conservation and Alternative Sources

Drought in the southwestern United States is a persistent and nagging problem. In 1990–91, for example, following several years of below-average rainfall in California, surface-water reservoirs became depleted. This led to excessive ground-water withdrawals and eventual mining. Remedies that have been proposed include desalinizing seawater, recycling wastewater, and even bringing huge Antarctic icebergs to dry coastal areas to melt and provide fresh water. Voluntary water conservation has been quite successful, reducing consumption by as much as 15 percent, and even greater reductions have been achieved where rationing is mandatory.

Conservation is every citizen's obligation where a resource is in short supply. ◉ Table 8.7 provides some examples of how water can be conserved in the home. Using recycled wastewater, so-called gray water, is the simplest conservation measure after rationing. Recycled shower, bath, and laundry water can be used for irrigating lawns and certain plants, especially when biodegradable soaps and detergents are used. Gray water contaminated with chlorine should not be used, however.

Desalinization of seawater is a viable alternative where no other water source is available. The process is expensive, and the water must be pumped uphill to users, which further increases its cost. In most cases, more energy is required to pump the water than to desalinize it. For this reason, desalinization factories are found only on desert coasts (as in some Middle Eastern nations), on small islands that do not receive much precipitation, and on military installations.

Artificial recharge (water-spreading; see Figure 8.19) of aquifers during heavy-rain years—"banking" water, so to speak—may provide longer-term benefits. This is done by diverting water that ordinarily would flow into rivers into manufactured basins surrounded by dikes. This temporarily ponds the running water, giving it time to infiltrate through the streambed and into the aquifer. By this restocking of aquifers when surplus surface water or abundant cheap imported water is available, the people of some drought-prone areas are able to prepare for those episodic droughts that seem to strike all mid-latitude areas sooner or later.

TABLE 8.7 Some Household Water-Conservation Practices

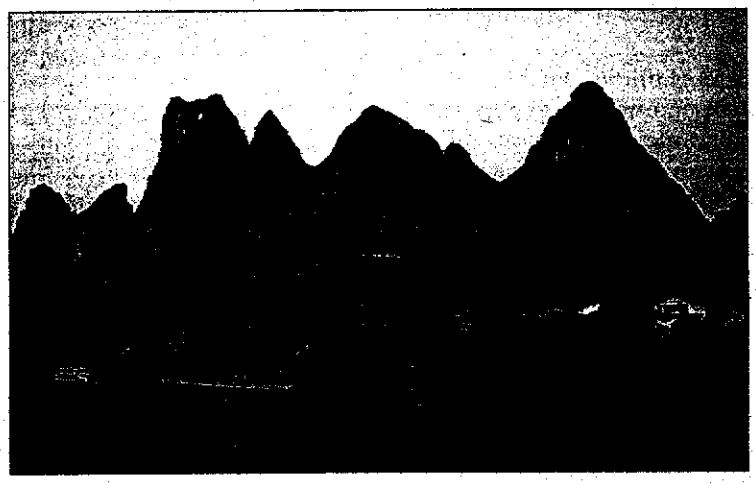
ACTIVITY	NORMAL USE	CONSERVATIVE USE
Shower	5 minutes, 30–40 gallons	Reduce shower length; use water-conserving shower head.
Tub bath	full tub, 36 gallons	Use minimal water level (10–12 gallons).
Teeth brushing	tap running, 2 gallons	Wet brush, rinse briefly.
Shaving	tap running, 5 gallons	Fill sink or basin (1 gallon).
Dishwashing	tap running, 30 gallons	Wash and rinse in sink (5 gallons).
Automatic dishwashing	full cycle, 25 gallons	Wash full loads on short cycle (12 gallons).
Hand washing	tap running, 2 gallons	Fill basin (1 gallon).
Toilet flushing	5–7 gallons per flush	Place bottles or bar dam in tank (4–6 gallons).
Washing machine	full cycle with top water level, 30–35 gallons	Wash full loads on short cycle with minimum water level (15–17 gallons).
Outdoor watering:		
hose	5 minutes, 40–50 gallons	Water in the morning (20 gallons).
lawn sprinklers	20 minutes daily, 1,200 gallons per week	Water as needed.

Gallery

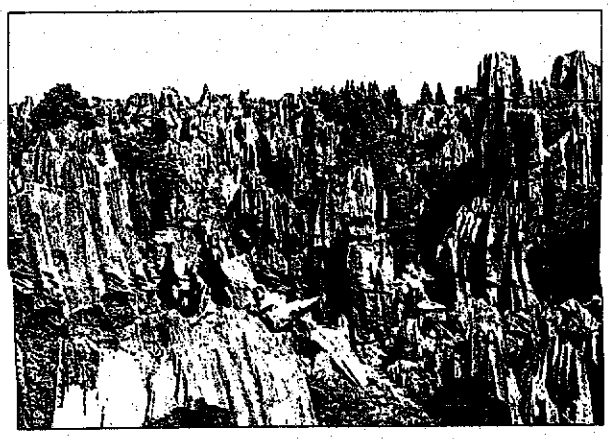
Wonders of Karst—That Sinking Feeling

Karst terrane exists in many parts of the United States, but it is particularly prevalent in parts of Florida and Kentucky. Perhaps the most spectacular karst area in the world is along the Li River in the predominantly limestone region of Kwangsi in southern China near Canton (Guangzhou). Solution of limestone has reduced the landscape there but left enormous pinnacles of resistant limestone, called "tower karst," that present an almost extraterrestrial appearance (◈ Figure 8.26). The towers and other karst features draw tourists from all over the world.

In many places, water containing dissolved calcium carbonate percolates downward through soil and rock into caverns, where evaporation and precipitation form needlelike **stalactites**—extending down from the ceiling—and the more irregular **stalagmites**—rising up from the floor (◈ Figure 8.27). These fresh-water limestone features in caves are called **dripstone**, because they build up drip-by-drip. Carlsbad Caverns in New Mexico and Mammoth Cave in Kentucky offer spectacular examples, but literally hundreds of other limestone caves also exhibit these features and are open to the public. **Speleology** is the study of caves, and spelunking, or "caving," is an exciting recreational pastime for many people. Cavers explore and map natural underground openings. Much of what we know about caves and caverns is attributable to these hobbyists' efforts and talents.



(a)

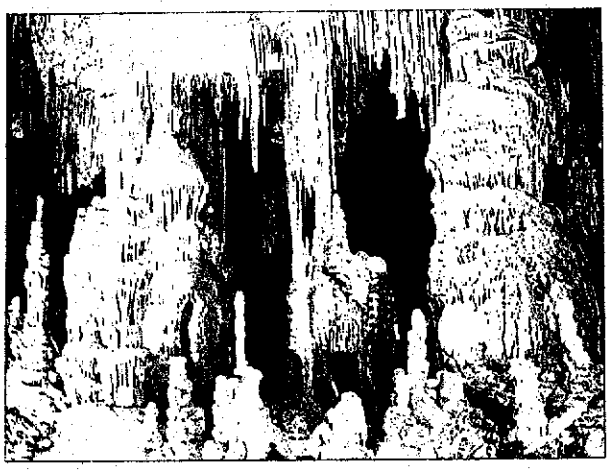


(b)

◈ **FIGURE 8.26** (a) Residual karst towers; Kwangsi region, southern China. The former limestone plateau has been lowered by solution except for resistant-limestone pinnacles. (b) The Stone Forest, 126 kilometers (80 mi) southeast of Kunming, People's Republic of China, is a high-relief karst landscape formed by the dissolution of carbonate rocks.

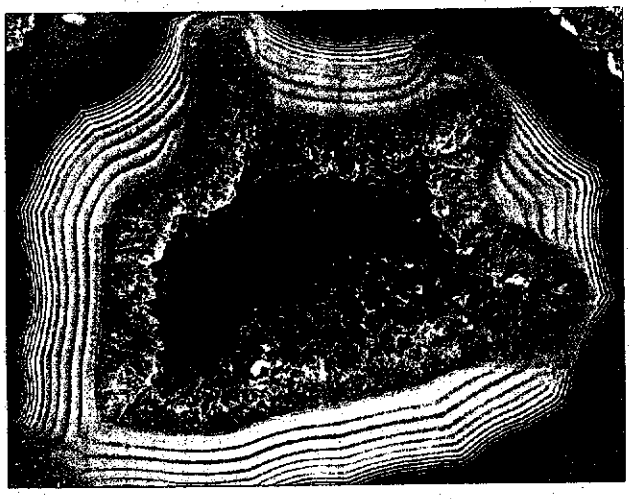
Mineralization by underground water is also responsible for transforming organic material into hard mineral water—a process known as *fossilization.* The replacement mineral is typically silica or calcium carbonate, and replacement may take place cell by cell as in the case of petrified wood (◈ Figure 8.28).

Geodes (pronounced "gee-odes") are rounded cavities in rocks that are lined with quartz crystals formed from percolating ground water. They are one of nature's most beautiful geological creations. Geodes from Mexico and Brazil are lined with light-colored agate from which "grow" beautiful purple amethyst or smoky quartz crystals (◈ Figure 8.29). They are produced when silica in aqueous solution is deposited directly into cavities in limestone or volcanic rocks.



◈ FIGURE 8.27 Dripstone stalactites, stalagmites, and pillars in a limestone cavern.

◈ FIGURE 8.28 Petrified wood from Arizona. Woody tissue is replaced cell by cell with mineral matter from ground water.



◈ FIGURE 8.29 Amethyst geode from Brazil. Silica dissolved in underground water percolates into an opening in the host rock and is deposited, forming crystals. Most commonly, geode crystals are varieties of quartz, but other minerals dissolved in ground water may also crystallize.

Summary

THE HYDROLOGIC CYCLE

Only .6 percent of the earth's water is readily available to humans. It is accessible because of the hydrologic cycle: continuous evaporation from the oceans, precipitation on land, runoff back to the oceans, and storage of fresh water in lakes and underground.

WATER USE

1. Consumptive use–water that cannot be immediately reused. Where consumptive use exceeds supplies, water must be imported.
2. Irrigation and thermoelectric power plants are the largest consumers. Irrigation water is usually highly degraded, whereas 98 percent of power-plant water is returned to the system, the only change being a higher temperature.
3. Worldwide, about 82 percent of water use is for irrigation. Water availability will limit population growth in the twenty-first century, either by statute in developed countries or by drought and famine in developing nations. The world population projected for 2050 will require water beyond the firm flow of the world's major rivers.

GROUND WATER

DEFINED

Loosely defined as all water underground, as distinct from surface water; the water in the hydrologic cycle that infiltrates underground.

ZONES

1. The *zone of aeration,* where the voids in rock or sediment are filled with air and water films.
2. The lower *zone of saturation,* where voids are filled with water.

WATER TABLE

The contact between the zone of aeration and the zone of saturation.

AQUIFERS

DEFINED

Bodies of porous and permeable rock or sediment that are saturated with water.

1. *Porosity*–The volume of pore spaces in a geologic material, expressed as a percentage of the total volume.
2. *Permeability*–Ease with which fluids flow through a geologic material.
3. *Aquiclude*–A geologic material that lacks permeability and inhibits water flow.

TYPES

1. Unconfined–An aquifer in which the water table is static and that is exposed to atmospheric pressure changes. A slope, or gradient, is required to induce subsurface flowage in a given direction. A well that taps the static water table creates a cone of depression, which provides the necessary gradient for water to flow to the well. Drawdown is the amount of lowering of the water table in a pumping well.
2. Artesian–An aquifer that is confined between aquicludes. The hydraulic head causes water to rise in a well when the aquifer is penetrated. The height to which water will rise at any point along the aquifer is known as the artesian pressure surface.

GROUND-WATER MANAGEMENT

DEFINED

Managing the amount of water contained in a ground-water basin so that it will produce water in the future.

1. *Sustained yield*–The amount of water an aquifer will yield on a day-to-day basis.
2. *Specific yield*–The amount of water a body of rock or sediment will yield by gravity alone.
3. *Specific retention*–The amount of water held by a body of rock or sediment against the pull of gravity. Specific yield *plus* specific retention *equals* porosity.

SEAWATER ENCROACHMENT

The invasion of coastal aquifers by saltwater. Management requires maintaining high freshwater tables to balance the denser saltwater.

GROUND WATER–SURFACE WATER INTERACTION

Surface water and ground water cannot be treated as separate entities; what affects one impacts the other.

SURFACE WATER SOURCES

Lakes, rivers, streams, and artificial reservoirs.

U.S. USE TRENDS

U.S. water use increased from 1950 until 1980. Between 1980 and 1995 it decreased 10 percent, even though population increased by 37 million people. Reasons include more economical application of irrigation water, public conservation programs, recycling, and a downturn in farm economies.

SOLUTION BY GROUND WATER

1. Solution of limestone and gypsum by underground water forms caves, caverns, disappearing streams, sink holes, and prolific ground-water aquifers. When terranes underlain by carbonate rocks exhibit these features, they are said to have *karst* topography.
2. Water and carbon dioxide from carbonic acid, a weak natural acid, which, over long periods of time, will dissolve carbonate rocks and gypsum.
3. Urbanization on karst terrane results in increased flooding, contamination of underground water, and collapse of the ground surface to form sinkholes.
4. Forty percent of the country east of the Mississippi is underlain by carbonates. States most impacted by karst and sinkhole formation are Alabama, Florida, Georgia, Tennessee, Missouri, and Pennsylvania.

WATER QUALITY

DEFINED

Purity or drinkability (potability) of water as established by the U.S. Public Health Service. Dissolved constituents are measured in milligrams per liter (volume) or parts per million (weight).

STANDARDS

Less than 500 ppm total dissolved solids for "sweet" water, and limits on ions and molecules that impair the quality of water.

POLLUTION

DEFINED

Chemical, physical, or biological materials that impair the future use of water and that may be a health hazard.

RESIDENCE TIME

The average length of time a given substance will stay in a system, such as water in a lake or aquifer. Whereas the residence time of human-generated smog in the atmosphere of large cities is on the order of ten days, pollutants may reside in some aquifers for thousands of years.

COMMON POLLUTANTS

Hydrocarbons, carcinogenic BTX solvents (benzene, toluene, and xylene), fertilizers, pesticides, livestock fecal matter, and gasoline.

CONSERVATION AND ALTERNATIVE SOURCES

Conservation means include the use of treated wastewater for irrigation and recharging aquifers, water-saving irrigation devices, water-spreading during wet years, and voluntary water conservation. Desalinization and importation are the only viable alternative sources at present.

Key Terms

aquiclude
aquifer
artesian-pressure surface
bioremediation
cone of depression
confined aquifer
drawdown
dripstone
effluent (stream)
evapotranspiration
ground water
hydraulic conductivity
hydrogeologist
hydrologic cycle
influent (stream)
karst terrane
perched water table
permeability
porosity
potable water
residence time
specific yield
speleology
stalactite
stalagmite
sustained yield
unconfined aquifer
water table

Study Questions

1. Sketch a geologic cross section that shows the ground-water zones and the static water table.
2. Sketch or define a confined aquifer. Explain the artesian-pressure surface and its importance in production of water from an artesian well.
3. How does topography affect the shape of the static water table?
4. How does one determine the amount of water a well that taps the static water table might produce on a long-term basis?
5. Explain the distinction between effluent and influent streams.
6. Explain the relationship between the amount of drawdown in a water well and the aquifer's permeability.
7. What states are the largest consumers of ground water, and why is their usage so heavy?
8. What is meant by ground-water *mining*? Cite the case history of an aquifer where this has happened.
9. Many beverage manufacturers claim the water in their drinks is purer because it comes from artesian wells or springs. Comment on these claims.
10. What are the Public Health Service standards for total dissolved solids in drinking water? What is the maximum amount of dissolved salts for safe drinking water?
11. Name some organic compounds sometimes found dissolved in ground water that are hazardous to human health.
12. Considering that agriculture is the largest consumer of ground water and that aquifers in many agricultural areas are being mined, how might farmers conserve ground water?

For Further Information

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World Wide Web Activities

Gateway Site to U.S. Watershed Information
http://www.epa.gov/surf2/locate/

This Web page is a gateway to detailed information on U.S. watershed areas. Add your zip code below the U.S. map; this will link you to a second page where you will press on the number code that most closely matches the geographic designation of your area. The activated page will give a description of your watershed, with links to regional data and recent news.

1. What are the rankings for commercial, domestic, and industrial water use in your watershed?
2. What is the principal aquifer (if any) in your region? Where are the areas of impaired water quality? What water quality studies and water clean-up activities are being conducted in your watershed?

Overview of the Sacramento Delta Region, California
http://www.bay-delta.org/itis/index.html

This page provides an overview of the Sacramento Delta region: its location and importance to California, which has limited water resources for the number of residents.

1. How many California residents receive water from this site, and what is the furthest large city supplied?
2. The delta region has multiple uses and functions. Name several.
3. What are the current environmental challenges to this region?

Recent Changes in the High Plains Aquifer of the Central United States
http://www-ne.cr.usgs.gov/highplains/hp97_web_report/precip96.pdf

This Web page has a report and map explaining the changes in the High Plains Aquifer under eight states east of the Rocky Mountains. The aquifer has generally rebounded in recent years, due to better water management and increased precipitation.

1. In 1996–97, which three states did *not* increase water resources within the aquifer region? (See Table 2.)
2. Analyze the data in Table 3 and suggest a reason for the lack of water resource recovery in these three states.

Emerging Threats to Water Quality in the United States
http://toxics.usgs.gov/regional/emc.html
This page introduces the efforts of the U.S. Geological Survey to monitor some of the newer threats to surface and ground-water quality in the United States.

1. What are the emerging chemical contaminants to stream waters that are under study?
2. Monitoring stations are in various types of land-use regimes (i.e., urban, agricultural, mixed use). What is the station type nearest to your college? What category of emerging chemical contaminants might be the most prevalent in this location?

Earth Systems Today CD Correlations

CHAPTER CONCEPT: Ground Water Is Stored in Permeable Rock Bodies Called Aquifers
This segment of the CD addresses the properties of natural materials that most commonly provide for underground water storage.

SECTION MODULE: Ground Water: Definition and Storage Conditions
Read the CD text and review the definitions of *ground water* and *aquifer.*

QUESTION: *What specific Earth materials most commonly store underground water in nature—that is, function as aquifers? What specific property do all aquifers share?*

CHAPTER CONCEPT: Ground Water Is Replenished through Precipitation. When Withdrawal Exceeds Replenishment, the Ground Water Table Is Lowered

SECTION MODULE: Ground Water: Main Animation
Work through the interactive main activity for ground water, making special note of the relationship of the ground water table to precipitation, and withdrawal by pumping.

QUESTION: *What is the name for local depression of the ground water table at an overpumped well? What aspect of the aquifer might affect the steepness of this feature?*

AEROJET
Environmental
Remediation
Aerojet Site Database
(1)Sites, Updated 1/1/2002
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(See Binder)

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Attorneys for Petitioner,
SOUTHERN CALIFORNIA WATER COMPANY

BEFORE THE

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	)

SCWC EXHIBIT 25

California Regional Water Quality Control Board
Central Valley Region

Robert Schneider, Chair

Sacramento Main Office
Internet Address: http://www.swrcb.ca.gov/~rwqcb5/hom .html
3443 Routier Road, Suite A, Sacramento, California 958 -3003
Phone (916) 255-3000 • FAX (916) 255-3015

nston H. Hickox
Secretary for
Environmental
Protecti n

Gray Davis
Governor

12 March 2002

Mr. Scott Goulart
Environmental Management
Aerojet-General Corporation
P.O. Box 13222
Sacramento, CA 95813-6000

TENTATIVE REVISED NPDES PERMIT, AMERICAN RIVER STUDY AREA AND GET E/F, AEROJET-GENERAL CORPORATION, ORDER NO. 98-113 (NPDES NO. CA0083861)

Enclosed is a copy of the subject tentative revision to your NPDES permit. Aerojet requested revisions to allow for the discharge from the GET E/F facility to Buffalo and/or Alder Creek. The discharges are from a groundwater extraction and treatment system designed to remove volatile organic compounds, perchlorate, and n-nitrosodimethlyamine. There are some slight modifications to the draft version of the revised permit you previously received.

Also enclosed with this letter is a copy of a Notice of Public Hearing and Proof of Posting. The notice is required to be posted no later than **26 March 2002.** Posting of the notice in the Rancho Cordova Library by that date will comply with the requirement. The notice is also required to be placed in the Sacramento Bee for one (1) day. It should be attempted to have it place in, or prior to, the **26 March 2002** edition of the paper. If that is not possible, then the earliest edition possible after that date will be sufficient. Submit the completed Proof of Posting to our office by **5 April 2002.**

Please provide comments by the dates in the Notice of Public Hearing. If possible, provide any significant comments by **1 April 2002** so that they can be considered prior to submission of the Board agenda package for reproduction.

If you have any questions regarding this matter, please call me at (91) 255-3025.

ALEXANDER MACDONALD
Senior Engineer

cc: United States Environmental Protection Agency, San Francisc
U.S. Army Corps of Engineers, Sacramento
United States Fish and Wildlife Service, Sacramento
National Marine Fisheries Service, Santa Rosa
Cathy Lee, Dept. of Health Services, Office of Drinking Water Sacramento
Dept. of Fish and Game, Region II, Rancho Cordova
Dept. of Water Resources, Central District, Sacramento
Catherine George, Office of Chief Counsel, State Water Resou rces Control Board
Div. of Water Quality, State Water Resources Control Board, Sacramento
Sacramento County Environmental Management, Sacramento
Sacramento County Planning Department, Sacramento
John Coppola, Sacramento County Water Resources Agency, Sacramento
Mr. Jim Carson, Southern California Water Company, Rancho Cordova
Mr. Rob Roscoe, California-American Water Company, Sacra mento
Gary Reents, City of Sacramento Department of Utilities, Sac rmento

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION
3443 Routier Road, Suite A, Sacramento, California 95827

PUBLIC HEARING

concerning

Notice of Application for Modification of Waste Discharge Requirements
(National Pollution Discharge Elimination System Permit
for

AEROJET-GENERAL CORPORATION
SACRAMENTO COUNTY

Aerojet-General Corporation currently discharges treated groundwater from its American River Study Area Groundwater Extraction and Treatment (GET) System to Buffalo Creek, tributary to the American River in eastern Sacramento County in the community of Rancho Cordova. Business activities at the Aerojet facility include development of rocket propulsion systems, engineering, manufacturing and testing, and custom and specialty chemical and pharmaceutical manufacturing and related activities. The proposed modifications allow for the discharge of up to 6000 gallons per day from Aerojet's GET E/F system to Buffalo and/or Alder Creek. The GET E/F treatment system removes the contaminants of concern - volatile organics to below 0.5 parts per billion (ppb), perchlorate to less than 4 ppb, and NDMA to less than 0.002 ppb prior to discharge.

A **formal** public hearing concerning this matter will be held during the Regional Board meeting which is scheduled for:

DATE:	26 April 2002
TIME:	8:30 a.m.
PLACE:	Fresno Education Department Auditorium, 2nd Floor Tulare & M Streets Fresno, California

The designated parties for this hearing are as follows:

- Staff of Central Valley Regional Board
- Aerojet-General Corporation

Only designated parties will have these rights: to call and examine witnesses; to introduce exhibits; to cross-examine opposing witnesses; to impeach any witness; and to rebut the evidence against him or her. All other persons wishing to testify or provide comments are interested persons and not designated parties. Such interested persons may request status as a designated party for purposes of this hearing by submitting such request in writing to the Board no later than **12 April 2002**. The request must explain the basis for status as a designated party and in particular how the person is directly affected by the discharge.

Persons wishing to comment on this noticed hearing item must submit testimony, evidence, and/or comments in writing to the Regional Board no later than **12 April 2002**. Written testimony, evidence, or comments submitted after **22 April 2002** will not be accepted and

will not be incorporated into the administrative record if doing so would prejudice any party.

All interested persons may speak at the Board meeting, and are expected to orally summarize their written submittals. Oral testimony will be limited in time by the Board Chair

Anyone having questions on the proposed permit modification should contact Alexander MacDonald. The proposed item and related documents may be inspected and copied at the Regional Board's office at 3443 Routier Road, Suite A, Sacramento, California, weekdays between 8:00 a.m. and 5:00 p.m. by appointment.

The procedures governing Regional Water Board meetings may be found at Title 23, California Code of Regulations, Section 647 et seq. and is available upon request. Hearings before the Regional Water Board are not conducted pursuant to Government Code section 11500 et seq. The procedures may be obtained by accessing http://www.swrcb.ca.gov/water_laws/index.html. Information on meeting and hearing procedures is also available on the Regional Board's website at http://www.swrcb.ca.gov/rwqcb5/board_meetings/mtgprocd.html or by contacting any one of the Board's offices. Questions regarding such procedures should be directed to Ms. Janice Tanaka at (916) 255-3039

The hearing facilities will be accessible to persons with disabilities. Individuals requiring special accommodations are requested to contact Ms. Janice Tanaka at (916) 255-3039 at least 5 working days prior to the meeting. TTY users may contact the California Relay Service at 1-800-735-2929 or voice line at 1-800-735-2922.

Please bring the above information to the attention of anyone you know who would be interested in this matter.

Thomas R Pinkos

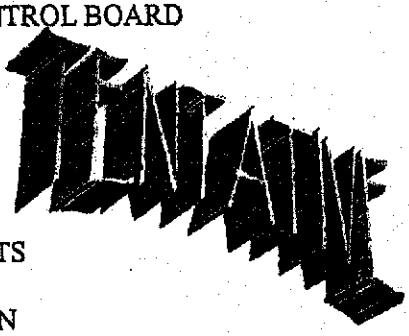
THOMAS R. PINKOS, Assistant Executive Officer

03/12/02

CALIFORNIA REGIONAL WATER QUALITY CO NTROL BOARD
CENTRAL VALLEY REGION

ORDER NO.

NPDES NO. CA0083861



WASTE DISCHARGE REQUIREME NTS
FOR
AEROJET-GENERAL CORPORATI ON
INTERIM GROUNDWATER EXTRACTION AND TR EATMENT SYSTEM
AMERICAN RIVER STUDY AREA AND GET E/F
SACRAMENTO COUNTY

The California Regional Water Quality Control Board, Central Valley Region, (hereafter Board) finds that:

1. Aerojet-General Corporation (hereafter Discharger) submitted a Report of Waste Discharge, dated 27 September 2001 and supplemental information dated 20 November 2001, and applied for a revision of its authorization to discharge waste under the National Pollutant Discharge Elimination System (NPDES) from the American River Study Area (ARSA) Groundwater Extraction and Treatment System. The application requested authorization to add the discharge from the Groundwater Extraction and Treatment (GET) E/F facility to that from the existing ARSA facility.

2 The Discharger operates a rocket-testing and chemical manufacturing facility in eastern Sacramento County near Rancho Cordova and Folsom. Past discharge practices have caused the release of contaminants into the vadose zone and groundwater at the facility.

3 Concentrations of contaminants in the groundwater northwest of the Discharger's property in the vicinity of Sailor Bar Park and the Nimbus Fish Hatchery, north and south of the American River and west of Hazel Avenue (American River Study Area), respectively, include up to 4000 micrograms per liter (µg/l) trichloroethylene (MCL of 5 µg/l), 22 0 µg/l cis-1,2-dichloroethylene (MCL of 6.0 µg/l), 110 µg/l 1,1-dichloroethylene (MCL of 5.0 µg/l), and 36 µg/l tetrachloroethylene (MCL of 5 µg/l). Concentrations of trichloroethylene in the plume of contaminated groundwater have been detected north of Sailor Bar Park exceeding 100 µg/l. This plume of contaminated groundwater is extracted and treated by the ARSA facility. The Discharger has been extracting and treating groundwater at ARSA, and discharging the treated groundwater pursuant to an NPDES permit, since 1996.

AMERICAN RIVER STUDY AREA

4. The current plume of contaminated groundwater off the Discharger's property and to the north of the American River creates or threatens to create a condition of pollution or nuisance. In response, the Executive Officer issued Cleanup and Abatement Order No. 95-715 requiring the Discharger to submit a plan designed to minimize the flux of contaminated groundwater past the northern boundary of Sailor Bar Park while an evaluation and construction of a system for containment, extraction, and treatment of the entire plume in the American River Study Area was being made.

To comply with the Cleanup and Abatement Order, the Discharg r submitted a plan proposing to initially extract approximately 500 gpm of groundwater from thre e existing groundwater extraction wells, treat the water using granular activated carbon (GAC), and discharge the treated groundwater under a permit into the Sacramento Regional County Sanitation I istrict's collection system. However, the costs for discharge to the sewer were significant pr mpting the Discharger to request to discharge the treated groundwater under an NPDES permit to an xisting pond in Sailor Bar Park. The pond was being fed by storm and urban runoff from a small pstream watershed and by a groundwater supply well near the pond. The Board adopted an N PDES permit, Order No. 96-066, for the discharge from the interim treatment plant to the pond in ailor Bar Park. Water quality of the discharge was no worse, and was generally better due to treat nent, than the other discharges into the pond. Overflow from the pond is to an unnamed tributary to he American River. Given the very coarse soils in the drainage channel, and the numerous road rossings blocking flow, and ponding areas, a direct discharge from the pond does not reach th e American River. See Attachment A, a part of this Order.

5 The interim groundwater treatment system consisted of twenty-fo ur GAC absorber vessels each containing 2000 pounds of carbon and operated in twelve sets of wo vessels in series. The plant was designed to treat 500 gpm of extracted ground water to conc ntrations below that which can be detected. Prior to entering the GAC vessels, the water will passe l through bag filters to remove suspended particles larger than 5 microns. The discharge was in substantial compliance with the effluent and receiving water limitations found in Order No. 96-0 6 during its period of operation, which ceased in October 1997 to allow construction of the curre t system. The new system is to treat extracted groundwater from all the extraction wells in the A nerican River Study Area (discussed further below). This Order revises the requirements c f Order No. 96-066 to reflect the changes due to the proposed discharges.

6. The Board modified Order No. 95-715 with the adoption of Cle up and Abatement Order No. 96-230 on 20 September 1996. Order No. 96-230 directs the Di charger to complete design, construction, and operation of a groundwater extraction system i the American River Study Area to contain and cleanup the plume of contaminated groundwater. Th e Discharger complied with that Order by completing construction of a treatment facility on the I ischarger's property capable of treating 3500 gpm. Flow from nine extraction wells in Sailor Ba r Park is pumped under the American River, combined with flows from six extraction wells n the south side of the river, and piped back to the treatment facility. The new facility came on-li e in April 1998 and discharged pursuant to the NPDES permit contained in Order No. 98-113.

The treatment plant utilizes ultraviolet/peroxide oxidation and a stripping to remove the volatile organic contaminants (VOCs), as described in Finding No. 3, ab ve.

7. Sacramento County Department of Parks and Recreation has rec uested the Discharger to continue the discharge of groundwater to Sailor Bar Park pond (in Sectio 17, R6E, T9N, MDB&M). It was

found that the continuous discharge of freshwater to the pond from the interim system, enhanced the quality of the pond. If the current park well was utilized to provide the flow for the pond, a treatment system would be required for the well since samples of water from the well have found up to 85 µg/l trichloroethylene (TCE). A treatment system consisting of activated carbon canisters has been provided for removal of the TCE prior to discharge to the pond. The treatment system has shown to be effective in removing the TCE to non-detectable levels during its entire operational period. Monitoring of the water supply well treatment system is required by this permit. The 250 gpm flow from the water supply well will be intermittent, and will have a maximum flow of 0.18 million gallons per day (mgd).

8. The current discharge from the ARSA system consists of the main flow from the groundwater treatment plant to Buffalo Creek on the Discharger's property and the flow to the pond as described in Finding No. 7, above. Buffalo Creek discharges to the American River just upstream of the Sunrise Bridge crossing in Section 13, R6E, T9N, MDB&M. See Attachment A.

9. The Report of Waste Discharge for the ARSA facility, including data from sampling of the Sailor Bar park system and nearby groundwater wells, describes the discharge as follows:

Monthly Average Flow:	5.0 mgd
Daily Peak Flow:	5.0 mgd
Design Flow:	5.0 mgd
Average Temperature:	70°F summer; 59 °F winter
pH	7.2 - 8.5

Constituent	ug/l
COD	< 3
Total Suspended Solids	< 6
Chlorides	40
Sulfate	12
Manganese	0.07
Aluminum	< 0.16
Zinc	0.034
Arsenic	< 0.002
Lead	< 0.005
Hardness (as $CaCO_3$)	110
Barium	0.07
Copper	< 0.0015
Chromium	< 0.002
Nickel	< 0.005
All Volatile Organic Contaminants	< 0.0005
Perchlorate	0.008

10. Sampling for perchlorate in groundwater monitor wells in the American River Study Area was recently conducted. Concentrations ranged from non-detect (<0.004 mg/l) to 0.150 mg/l. The average concentration was 0.007 mg/l with a median of non-detect (<0.004 mg/l). None of the groundwater extraction wells were found to contain perchlorate at detectable concentrations. The highest concentrations of perchlorate are found in the monitor wells closest to Aerojet and all wells with detections, except one, were found on the south side of the American River. Using values from monitor wells closest to the extraction wells, it is calculated that the influent to the treatment system is estimated to be around 0.007 mg/l. This is near the current Department of Health Services Action Level for drinking water of 0.004 mg/l (January 2002). Sampling of the effluent from the ARSA facility since 1998 has shown that the concentration of perchlorate is in the range of 0.005-0.008 mg/l. . It should be noted that there will be a minimum 10-fold dilution in the American River (flow at 250 cubic feet per second) at the maximum discharge rate of 3450 gpm, resulting in no detectable concentrations of perchlorate in the American River.

11. One other contaminant of concern, other than those discussed above, which was deemed necessary for evaluation is 1,4-dioxane. This contaminant is found in some of the groundwater monitor wells south of the American River in the American River Study Area, with a maximum concentration of 0.029 mg/l. Estimated worst-case effluent concentrations for 1,4-dioxane are 0.006 mg/l. The UV/peroxide treatment system provides effective treatment for the reduction of 1,4-dioxane. For 1,4-dioxane, the California State Action Level is 0.003 mg/l and the Proposition 65 value is 0.015 mg/l. The effluent limitation is set at Action Level.

12. Another contaminant of concern is N-Nitrosodimethylamine (NDMA) which has been found in groundwater on the eastern side of Aerojet and a few wells on the western edge of Aerojet. There are no known source areas for NDMA in the vicinity or upgradient of the American River Study Area. In addition, NDMA has not been detected in monitor wells in the American River Study Area. This permit requires monitoring for NDMA in the treatment facility and in the American River upstream and downstream of the confluence with Buffalo Creek.

13. The Discharger submitted a Final Revised Engineering Evaluation and Cost Analysis for the American River Study Area dated 13 September 1996, a draft Quality Assurance Project Plan dated 31 January 1998, a draft revised Sampling and Analysis Plan dated 31 January 1998, and a draft Groundwater Extraction and Treatment System Effectiveness Evaluation Work Plan dated 31 January 1998. These documents were utilized in formulating the initial Order(s).

14. The Final Revised Engineering Evaluation and Cost Analysis (EE/CA) of the American River Study Area evaluated several discharge options for the treated groundwater, including providing the water for municipal and industrial use. The method of discharge covered in this permit as an interim solution, and options considered in the EE/CA may be utilized by the Discharger in the future. This permit would be modified as necessary.

PERMIT MODIFICATIONS – GET E/F

15. The Discharger has been operating the GET E and F treatment facilities since 1984, and according to the requirements of the Partial Consent Decree since its entry by Federal Court in December 1989. GET E and GET F were combined in 2000 with all of the water being treated at a modified GET E/F facility. The GET E/F extraction system is designed to intercept groundwater contaminant plumes prior to them leaving the western portion of the Discharger's property. Currently, the facility operates at approximately 3800 gpm, and is being expanded to achieve a treatment capacity of 6000 gpm. Previously, discharge of the treated groundwater was by injection back into the aquifer. However, the remedy for the Western Groundwater Operable contained in the Record of Decision issued by USEPA in July 2000, which includes the GET E/F facility, does not call for injection, but for discharge to surface water in order to allow for reuse of the treated groundwater to provide replacement water supplies for those lost due to contamination in the Rancho Cordova and surrounding areas. In addition, infiltration capacity in the vicinity is limited as demonstrated by the current ponding of water from the GET E/F discharge of 3600 gpm to land for recharge. Increasing application to land at a rate of 6000 gpm is not feasible.

16. The groundwater contaminant plumes intercepted by the GET E/F extraction field include VOCs (primarily TCE), perchlorate, and NDMA.

17. The GET E/F facility uses biological reduction to remove perchlorate, ultraviolet light to remove NDMA, and air stripping to remove VOCs. The GET E/F facility has been in operating in its current configuration since 1999. The treatment process has been shown to be effective in removing VOCs to below detection levels (0.5 µg/l), perchlorate to below 4 µg/l, and NDMA to below detection (0.002 –0.075 µg/l). Testing of the influent and effluent to the treatment facility for full-scan analysis, including tentatively identified compound analysis, did not indicate additional contaminants of concern. A schematic of the treatment facility is included in this Order as Attachment B.

18. The Report of Waste Discharge for the GET E/F, describes the discharge as follows:

Monthly Average Flow:	8.64 mgd
Daily Peak Flow:	8.64 mgd
Design Flow:	8.64 mgd
Average Temperature:	64°F summer; 60°F winter
pH	7.2 - 7.5

Constituent	mg/l
COD	<3
Total Suspended Solids	<5

Constituent	µg/l
Nitrate	<0.05
Chlorides	6.6
Sulfate	15
Manganese	0.07
Aluminum	<0.05
Zinc	<0.10
Arsenic	<0.002
Lead	<0.10
Hardness (as $CaCO_3$)	110
Barium	0.1
Copper	<0.01
Chromium	<0.01
Nickel	<0.04
All Volatile Organic Contaminants	<0.0005

19. Initial discharge of the treated groundwater will be to Buffalo Creek. Later, the effluent from the GET E/F facility may also be discharged to Alder Creek, tributary to Lake Natoma (American River), on the Discharger's property. These two discharge locations are shown on Attachment A. A pipeline to convey the treated water from the GET E/F facility will need to be constructed prior to the discharge to Alder Creek. The Discharger is currently evaluating pipeline alternatives that would allow discharge to Alder Creek. The interim discharge to Buffalo Creek will co-mingle with the discharge from the ARSA facility, prior to leaving the Discharger's property.

20. In the process of removing perchlorate, alcohol is added to the water to provide sufficient food source for biological growth. Excess alcohol is minimized, however, the low concentrations of excess alcohol react with the peroxide used in the NDMA destruction process and low concentrations of acetaldehyde and formaldehyde are formed. Concentrations of those two chemicals have been detected in the effluent from the air-stripper at concentrations up to 2 µg/l for acetaldehyde and 20 µg/l formaldehyde. Those concentrations are below the lowest adverse risk levels found of 380 µg/l (IRIS) and 100 µg/l (State of California Action Level). Effluent limitations are set at 5 for acetaldehyde and 30 µg/l for formaldehyde. In addition, it is also believed that those chemicals will be further reduced biologically in the upper stretches of Buffalo Creek. Further sampling will be conducted to verify this hypothesis.

Other

21. USEPA adopted the *National Toxics Rule* on 5 February 1993 and the *California Toxics Rule* on 18 May 2000. These Rules contain water quality standards applicable to this discharge. The State Water Resources Control Board adopted the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (known as the State

Implementation Plan), which contains guidance on implementation of the *National Toxics Rule* and the *California Toxics Rule.*

22. The Board adopted the *Water Quality Control Plan, Fourth Edition, for the Sacramento and San Joaquin River Basins* (hereafter Basin Plan). The Basin Plan designates beneficial uses, establishes water quality objectives, and contains implementation programs and policies to achieve water quality objectives for all waters of the Basin. These requirements implement the Basin Plan.

23. Federal regulations require effluent limitations for all pollutants that are or may be discharged at a level that will cause or have the reasonable potential to cause, or contribute to an in-stream excursion above a narrative or numeric water quality standard. Based on information submitted as part of the application and from past monitoring, the Board finds that the proposed discharge has a reasonable potential to exceed standards and objectives for the constituents discussed in the Information Sheet for the following constituents:

    a. VOCs: cis-1,2-dichloroethene, cis-1,2-dichloroethane, 1,1-dichloroethylene, chloroform, trichloroethene, and trans-1,2-dichloroethene; and effluent limitations for the constituents have been included in this Order. The two treatment systems have been designed, constructed, and operated to meet the to meet the effluent limitations.

    b. Non-VOCs:1,4-dioxane, formaldehyde, acetaldehyde, perchlorate, and n-nitrosodimethylamine; and effluent limitations for the constituents have been included in this Order.

    c. This Order and the Basin Plan prohibit the discharge of toxic constituents in toxic amounts. Based on information submitted as part of the application and monitoring reports, VOCs: 1,2-dichloroethane, chloroform, cis-1,2-dichloroethene, trichloroethene, and trans-1,2-dichloroethene in the discharge, have a reasonable potential to cause or contribute to a violation of the Basin Plan narrative prohibition of the discharge of toxic substances in toxic concentrations. The Water Quality Standards: Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule (California Toxics Rule) is promulgated in the Federal Register, 40CFR Part 131, Part III. Effluent limitations for VOCs: 1,2-dichloroethane, chloroform, cis-1,2-dichloroethene, trichloroethene, and trans-1,2-dichloroethene, based on the California Toxics Rule and Best Available Technology (as described above), are included in this Order.

24. Federal regulations require effluent limitations for all pollutants that are or may be discharged at a level that will cause or have the reasonable potential to cause, or contribute to an in-stream excursion above a narrative or numerical water quality objective. This Order contains provisions that:

    a. require the Discharger to provide information as to whether the levels of priority pollutants, including CTR and NTR constituents, and constituents for which drinking water maximum contaminant levels (MCL) are prescribed in the California Code of Regulations, and

temperature in the discharge cause or contribute to an in-stream excursion above a water quality objective;

b. if the discharge has a reasonable potential to cause or contribute to an in-stream excursion above a water quality objective, require the Discharger to submit information necessary to calculate effluent limitations for those constituents; and

c. allow the Board to reopen this Order and include effluent limitations for those constituents.

24. The U.S. Environmental Protection Agency (EPA) and the Board have classified this discharge as a minor discharge.

25. The beneficial uses of the American River downstream of the discharge are municipal and domestic, industrial, and agricultural supply; water contact and noncontact recreation; groundwater recharge, fresh water replenishment; and preservation and enhancement of fish, wildlife and other aquatic resources.

26. The beneficial uses of the underlying groundwater are municipal and domestic, industrial, and agricultural supply.

27. The permitted discharge is consistent with the antidegradation provisions of 40 CFR 131.12 and State Water Resources Control Board Resolution 68-16. The impact on water quality will be insignificant.

28. Effluent limitations, and toxic and pretreatment effluent standards established pursuant to Sections 301, 302, 304, and 307 of the Clean Water Act (CWA) and amendments thereto are applicable to the discharge.

29. The action to adopt an NPDES permit is exempt from the provisions of Chapter 3 of the California Environmental Quality Act (CEQA) (Public Resources Code Section 21100, et seq.), in accordance with Section 13389 of the California Water Code.

30. The Department of Toxic Substances Control has certified a final Negative Declaration and Initial Study for the American Rivers Study Area project in accordance with the CEQA (Public Resources Code Section 21000, et seq.), and the State CEQA Guidelines. The Board has reviewed the Negative Declaration and these waste discharge requirements will mitigate or avoid any significant impacts on water quality.

31. The Board has notified the Discharger and interested agencies and persons of its intent to prescribe waste discharge requirements for this discharge and has provided them with an opportunity for a public hearing and an opportunity to submit their written views and recommendations.

32. The Board, in a public meeting, heard and considered all comments pertaining to the discharge.

33. This Order shall serve as an NPDES permit pursuant to Section 402 of the CWA, and amendments thereto, and shall take effect upon the date of hearing, provided EPA has no objections.

IT IS HEREBY ORDERED that Order No. 98-113 is rescinded and Aerojet-General Corporation, its agents, successors and assigns, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, and the provisions of the Clean Water Act and regulations and guidelines adopted thereunder, shall comply with the following:

A. Discharge Prohibitions:

1. Discharge of treated wastewater at a location or in a manner different from that described in Finding No. 8 is prohibited.

2. The by-pass or overflow of wastes to surface waters is prohibited, except as allowed by the attached Standard Provisions and Reporting Requirements A. 3.

B. Effluent Limitations:

1. Effluent from the ARSA facility shall not exceed the following limits:

Constituents	Units	Daily Maximum	Monthly Average
Total Copper	µg/l	17	11
Total Lead	µg/l	15	2.5
Total Zinc	µg/l	110	100
Volatile Organics[1]	µg/l	0.5[1]	
1,2-Dichloroethane	µg/l	0.5	0.38
Perchlorate	µg/l	18	18
1,4-dioxane	µg/l	10	3

[1] All volatile organic constituents listed in EPA Methods 8010 and 8020. The concentration of each constituent shall not exceed 0.5 µg/l.

2. Effluent from the GET E/F facility shall not exceed the following limits:

Constituents	Units	Daily Maximum	Monthly Average
Total Copper	µg/l	17	11
Total Lead	µg/l	15	2.5

Constituents	Units	Daily Maximum	Monthly Average
Total Zinc	µg/l	110	100
Volatile Organics[1]	µg/l	0.5[1]	
1,2-Dichloroethane	µg/l	0.5	0.38
Perchlorate	µg/l	8	4
1,4-dioxane	µg/l	10	3
N-nitrosodimethylamine	µg/l	0.005	0.002
Acetaldehyde	µg/l	5	
Formaldehyde	µg/l	30	

[1] Volatile organic constituents listed in EPA Method 8010 and 8020. The concentration of each constituent shall not exceed 0.5 µg/l.

3. The discharges shall not have a pH less than 6.5 nor greater than 8.5.

4. The 30-day average daily discharge flow shall not exceed 5.04 mgd for the ARSA facility and 8.64 mgd for the GET E/F facility.

5. Survival of aquatic organism in 96-hour bioassays of undiluted waste shall be no less than:
Minimum for any one bioassay - - - - - - - - - 70%
Median for any three or more consecutive bioassays - - - - 90%

C. Sludge Disposal:

1. Collected screenings, sludges, and other solids removed from liquid wastes shall be disposed of in a manner that is consistent with Chapter 15, Division 3 Title 23, of the CCR and approved by the Executive Officer.

2. Any proposed change in sludge use or disposal practice shall be reported to the Executive Officer and EPA Regional Administrator at least **90 days** in advance of the change.

D. Receiving Water Limitations:

Receiving Water Limitations are site-specific interpretations of water quality objectives from applicable water quality control plans. As such they are a required part of this permit. However, a receiving water condition not in conformance with the limitation is not necessarily a violation of this Order. The Board may require an investigation to determine the cause and culpability prior to asserting that a violation has occurred.

The discharge shall not cause the following in the receiving water:

1. Concentrations of dissolved oxygen to fall below 7.0 mg/l.

2. Oils, greases, waxes, or other materials to form a visible film or coating on the water surface or on the stream bottom.

3. Oils, greases, waxes, floating material (liquids, solids, foams, and scums) or suspended material to create a nuisance or adversely affect beneficial uses.

4. Aesthetically undesirable discoloration.

5. Fungi, slimes, or other objectionable growths.

6. Turbidity to increase more than 20 percent over background levels.

7. The normal ambient pH to fall below 6.5, exceed 8.5.

8. Deposition of material that causes nuisance or adversely affects beneficial uses.

9. The normal ambient temperature to be increased more than 5°F.

10. Taste or odor-producing substances to impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin or to cause nuisance or adversely affect beneficial uses.

11. Radionuclides to be present in concentrations that exceed maximum contaminant levels specified in the California Code of Regulations, Title 22; that harm human, plant, animal or aquatic life; or that result in the accumulation of radionuclides in the food web to an extent that presents a hazard to human, plant, animal, or aquatic life.

12. Aquatic communities and populations, including vertebrate invertebrate, and plant species, to be degraded.

13. Toxic pollutants to be present in the water column, sediments, or biota in concentrations that adversely affect beneficial uses; that produce detrimental response in human, plant, animal, or aquatic life; or that bioaccumulate in aquatic resources at levels which are harmful to human health.

14. Violation of any applicable water quality standard for receiving waters adopted by the Board or the State Water Resources Control Board pursuant to the CWA and regulations adopted thereunder.

E. Provisions:

1. The Effluent Limitations for metals found in Effluent Limitation B.1 were conservatively developed, but with only a minimal amount of data. The Discharger shall be collecting additional information during required monitoring that will be used to evaluate the limits. If necessary, this permit may be reopened and the effluent limitations for metals revised based on the new data.

2. The Discharger shall comply with the Operation, Maintenance, and Monitoring Plan, Ground Water Extraction and Treatment System, American River Study Area dated **31 January 1998**. The Discharger shall submit an Operation, Maintenance, and Monitoring Plan for the GET E/F facility no later than **31 May 2002** for Executive Officer approval. The Discharger shall comply with the approved version of the plan.

3. Prior to discharge to Alder Creek, Aerojet shall complete and submit an assessment of the thermal impacts to Alder Creek from the discharge and receive approval for the discharge from the Executive Officer.

4. The Discharger shall conduct the chronic toxicity testing specified in the Monitoring and Reporting Program. If the testing indicates that the discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above the water quality objective for toxicity, the Discharge shall submit a work plan to conduct a Toxicity Reduction Evaluation (TRE) and upon approval conduct the TRE, and this Order will be reopened and a chronic toxicity limitation included and/or a limitation for the specific toxicant identified in the TRE included. Additionally, if a chronic toxicity water quality objective is adopted by the State Water Resources Control Board, this Order may be reopened and a limitation based on that objective included.

5. The Discharger shall use the best practicable cost-effective control technique currently available to limit mineralization to no more than a reasonable increment.

6. The Discharger shall comply with all the items of the "Standard Provisions and Reporting Requirements for Waste Discharge Requirements (NPDES)", dated 1 March 1991, which are part of this Order. This attachment and its individual paragraphs are referred to as "Standard Provision(s)."

7. The Discharger shall comply with the attached Monitoring and Reporting Program No. XX-XXX which is part of this Order, and any revisions thereto, as ordered by the Executive Officer.

8. Under Monitoring and Reporting Program No. XX-XXX, the Discharger shall report trace concentrations of constituents found during the analysis of samples. Trace values are estimates of concentrations detected between the detection level and the practical quantitation level. Trace values are not always reliable as there is a potential for interferences below the practical

quantitation level. As effluent limitations specified in this permit are at or above the practical quantitation level, reporting trace values shall not be a violation of an effluent limitation. Trace values are to be used to help operate the treatment facility and to provide information to minimize violations of effluent limits."

9. Section 13267(b) of the California Water Code provides that: "In conducting an investigation specified in subdivision (a), the regional board may require that any person who has discharged, discharges, or is suspected of discharging, or who proposes to discharge within its region, or any citizen or domiciliary, or political agency or entity of this state who has discharged, discharges, or is suspected of discharging, or who proposes to discharge waste outside of its region that could affect the quality of the waters of the state within its region shall furnish, under penalty of perjury, technical or monitoring program reports which the board requires. The burden, including costs of these reports, shall bear a reasonable relationship to the need for the reports and the benefits to be obtained from the reports." The monitoring and reporting progam and technical reports required by this Order and the attached "Monitoring and Reporting Program, Order No. R5-XXXX-XXXX" are necessary to assure compliance with these waste discharge requirements. The Discharger operates the facility that discharges the waste subject to this Order.

10. This Order expires on XX XXXXXX XXXX and the Discharger must file a Report of Waste Discharge in accordance with Title 23, CCR, not later than 80 days in advance of such date in application for renewal of waste discharge requirements if it wishes to continue the discharge.

11. Prior to making any change in the discharge point, place of use, or purpose of use of the wastewater, the Discharger shall obtain approval of or clearance from the State Water Resources Control Board (Division of Water Rights).

12. In the event of any change in control or ownership of land or waste discharge facilities presently owned or controlled by the Discharger, the Discharger shall notify the succeeding owner or operator of the existence of this Order by letter, a copy of which shall be immediately forwarded to this office.

To assume operation under this Order, the succeeding owner or operator must apply in writing to the Executive Officer requesting transfer of the Order. The request must contain the requesting entity's full legal name, the State of incorporation if a corporation, the name, address, and telephone number of the persons responsible for contact with the Board, and a statement. The statement shall comply with the signatory paragraph of Standard Provision D.6 and state that the new owner or operator assumes full responsibility for compliance with this Order. Failure to submit the request shall be considered a discharge without requirements, a violation of the California Water Code. Transfer shall be approved or disapproved in writing by the Executive Officer.

I, GARY M. CARLTON, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Central Valley Region, on

GARY M. CARLTON, Executive Officer

02/07/02:AMM

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

MONITORING AND REPORTING PROGRAM

NPDES NO. CA0083861

ORDER NO. XX-XXXX

FOR
AEROJET-GENERAL CORPORATION
GROUNDWATER EXTRACTION AND TREATMENT SYSTEM
AMERICAN RIVER STUDY AREA AND GET E/F
SACRAMENTO COUNTY

Specific sample station locations have been established under direction of the Board's staff, and a description of the stations is attached to this Order.

GROUNDWATER TREATMENT SYSTEM MONITORING

Samples shall be collected from the inlet and outlet to the treatment system and analyzed. If the discharge is intermittent rather than continuous, then the samples shall be collected on the first day of the intermittent discharge. The time of collection of samples shall be recorded. The treatment system monitoring shall include at least the following:

American River Study Area Treatment Facility

Constituents	Units	Type of Sample	Sampling Frequency
Dissolved Oxygen	mg/l	Grab	Monthly
Flow[1]	mgd	Grab	Monthly
Total Dissolved Solids	mg/l	Grab	Monthly
Acute Toxicity[2,3]		Grab	Monthly
Volatile Organics[4]	µg/l	Grab	Monthly
Semi-Volatile Organics[5]	µg/l	Grab	Monthly
1,4-dioxane[6]	µg/l	Grab	Monthly
pH[1]	Number	Grab	Monthly
Turbidity	NTU	Grab	Monthly
Temperature[1]	°F (°C)	Grab	Weekly
Electrical Conductivity@25°C	µmhos/cm	Grab	Monthly
Total Copper	mg/l	Grab	Quarterly
Total Lead	mg/l	Grab	Quarterly
Total Zinc	mg/l	Grab	Quarterly

Constituents	Units	Type of Sampl	Sampling Frequency
Perchlorate[2]	µg/l	Grab	Monthly
N-Nitrosodimethylamine[8]	µg/l	Grab	Monthly
Hardness as (as $CaCO_3$)	mg/l	Grab	Monthly

Footnotes as provided below

GET E/F

Constituents	Units	Type of Samp e	Sampling Frequency
Dissolved Oxygen	mg/l	Grab	Monthly
Electrical Conductivity@25°C[1]	µmhos/cm	Meter	Continuous
Flow[1]	mgd	Grab	Monthly
Total Dissolved Solids	mg/l	Grab	Monthly
Acute Toxicity[2,3]		Grab	Monthly
Volatile Organics[4]	µg/l	Grab	Monthly
Semi-Volatile Organics[5]	µg/l	Grab	Monthly
1,4-dioxane[6]	µg/l	Grab	Monthly
pH[1]	Number	Grab	Monthly
Turbidity	NTU	Grab	Monthly
Temperature[1]	°F (°C)	Grab	Weekly
Total Copper	mg/l	Grab	Quarterly
Total Lead	mg/l	Grab	Quarterly
Total Zinc	mg/l	Grab	Quarterly
Perchlorate[2]	µg/l	Grab	Monthly
N-Nitrosodimethylamine[8]	µg/l	Grab	Monthly
Hardness as (as $CaCO_3$)	mg/l	Grab	Monthly
PROWL[9]	µg/l	Grab	Twice per year
Formaldehyde[10]	µg/l	Grab	Monthly
Acetaldehyde[11]	µg/l	Grab	Monthly

Constituents	Units	Type of Sample	Sampling Frequency
Gloxyl[12]	µg/l	Grab	Monthly
Methanol[13]	µg/l	Grab	Monthly
Iron, Total and Dissolved	µg/l	Grab	Monthly

1 Field Measurements.
2 The analyses shall be performed in accordance with EPA/600/4-90/027, *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms.*
3 Sampling of Effluent only.
4 Test method to be by EPA Methods 601 and 602, or 8010 and 8020, or 8 50, or 500 series with a practical quanitation level no greater than 0.5 µg/l. All concentrations between the detection level and practical quanitation level shall be reported as trace.
5 Test method to be EPA Method 8270 or equivalent. All peaks shall be re orted and tentatively identified. All concentrations between the detection limit and the practical quantiation li it shall be reported as trace values.
6 A practical quanitation level of 10 µg/l. All concentrations between the d tection level and quantiation level shall be reported as trace.
7 A practical quantiation level of 4 µg/l. All concentrations between the de ction level and quanitation level shall be reported as trace.
8 NDMA analysis with a practical quantiatation level no greater than 0.005 µg/l. All concentrations between the detection level and quanitation level shall be reported as trace.
9 PROWL analysis with a practical quantiatation level no greater than 10 µ /l. All concentrations between the detection level and quanitation level shall be reported as trace.
10 Formaldehyde analysis with a practical quantiatation level no greater thar 5 µg/l. All concentrations between the detection level and quanitation level shall be reported as trace.
11 Acetaldehyde analysis with a practical quantiatation level no greater than 1 µg/l. All concentrations between the detection level and quanitation level shall be reported as trace.
12 Glyoxal analysis with a practical quantiatation level no greater than 5 µg/ . All concentrations between the detection level and quanitation level shall be reported as trace.
13 Methanol analysis with a practical quantiatation level no greater than 934 µg/l. All concentrations between the detection level and quanitation level shall be reported as trace.

Note: All metals analyses shall be by atomic adsorption metho s or a method with an equivalent practical quantitation limit. In addition, chronic toxicity nonitoring for the treatment system is also required, and detailed below.

RECEIVING WATER MONITOI ING

All receiving water samples shall be grab samples. Receiving water nonitoring shall include at least the following:

Station	Description
R-1	At least 100 feet upstream on the Ame ican River from the confluence with Buffalo Creek.
R-2	Downstream on the American River at the pedestrian bridge crossing just downstream of the Sunrise Bridge ove crossing.

Station	Description
R-3	If discharge is occurring to Alder Creek, the sample shall be collected at least 100 feet upstream in lake Natoma from the confluence with Alder Creek.
R-4	If discharge to Alder Creek is occurring, then the sample shall be collected 100 feet downstream in Lake Natoma from the confluence with Alder Creek.

Constituents	Units	Station	Sampling Frequency
Dissolved Oxygen	mg/l	R-1, R-2, R-3, R-4	Monthly
Electrical Conductivity@25°C	µmhos/cm	R-1, R-2, R-3, R-4	Continuous
Total Dissolved Solids	mg/l	R-1, R-2, R-3, R-4	Monthly
Volatile Organics[1]	µg/l	R-1, R-2, R-3, R-4	Monthly
Semi-Volatile Organics[2]	µg/l	R-1, R-2, R-3, R-4	Monthly
pH	Number	R-1, R-2, R-3, R-4	Monthly
Turbidity	NTU	R-1, R-2, R-3, R-4	Monthly
Temperature	°F (°C)	R-1, R-2, R-3, R-4	Weekly
Total Copper	mg/l	R-1, R-2, R-3, R-4	Quarterly
Total Lead	mg/l	R-1, R-2, R-3, R-4	Quarterly
Total Zinc	mg/l	R-1, R-2, R-3, R-4	Quarterly
Perchlorate[3]	µg/l	R-1, R-2, R-3, R-4	Monthly
N-Nitrosodimethylamine[4]	µg/l	R-1, R-2, R-3, R-4	Monthly
Hardness as (as $CaCO_3$)	mg/l	R-1, R-2, R-3, R-4	Monthly
Methanol[5]	µg/l	R-1, R-2, R-3, R-4	Monthly
Iron, Total and Dissolved	µg/l	R-1, R-2, R-3, R-4	Monthly

1 Test method to be by EPA Methods 601 and 602, or 8010 and 8020, or 260, or 500 series with a practical quanitation level no greater than 0.5 µg/l. All concentrations between the detection level and practical quanitation level shall be reported as trace.

2 Test method to be EPA Method 8270 or equivalent. All peaks shall be reported and tentatively identified. All concentrations between the detection limit and the practical quantiation limit shall be reported as trace values.

3 A practical quantiation level of 4 µg/l. All concentrations between the detection level and quanitation level shall be reported as trace.

4 NDMA analysis with a practical quantiatation level no greater than 0.00 µg/l. All concentrations between the detection level and quanitation level shall be reported as trace.

5 Methanol analysis with a practical quantiatation level no greater than 93 µg/l. All concentrations between the detection level and quanitation level shall be reported as trace.

Note: All metals analyses shall be by atomic adsorption methods.

In conducting the receiving water sampling, a log shall be kept of the receiving water conditions in the American River. Attention shall be given to the presence or absence of:

a. Floating or suspended matter
b. Discoloration
c. Bottom deposits
d. Aquatic life
e. Visible films, sheens or coatings
f. Fungi, slimes, or objectionable growths
g. Potential nuisance conditions

Notes on receiving water conditions shall be summarized in the monitoring report.

THREE SPECIES CHRONIC TOXICITY MONITORING

Chronic toxicity monitoring shall be conducted to determine whether the effluent is contributing to toxicity in the American River. The testing shall be conducted as specified in EPA 600/4-89-001. Chronic toxicity samples shall be collected at the discharge of the Ground Water Treatment Plant prior to entering Buffalo Creek. One additional test shall be performed on samples collected from Buffalo Creek just prior to leaving the Discharger's property Samples collected from the outlet of the treatment unit shall be representative of the volume and quality of the discharge The time of collection for samples shall be recorded. Chronic toxicity monitoring shall include the following:

Species:	*Pimephales promelas, Ceriodaphnia dubia, Selenastrum capriocornutum*
Frequency:	Once per quarter for first year, annually thereafter
Dilution Series:	100 percent effluent

MONITORING OF DISCHARGE TO SAILOR BAR PARK

The Discharger shall sample the discharge to pond in Sailor Bar Park for volatile organic constituents and N-Nitrosodimethylamine as listed above in the table for the groundwater treatment system monitoring. The sample shall be collected and analyzed on a monthly basis from the discharge prior to it entering the pond.

REPORTING

Monitoring results shall be submitted to the Regional Board by the **25th day of the month** following sample collection. Quarterly and annual monitoring results shall be submitted by the **25th day of the month** following each calendar quarter and year, respectively.

In reporting the monitoring data, the Discharger shall arrange the data in tabular form so that the date, the constituents, and the concentrations are readily discernible. The data shall be summarized in such a manner to illustrate clearly whether the discharge complies with waste discharge requirements.

If the Discharger monitors any pollutant at the locations designated herein more frequently than is required by this Order, the results of such monitoring shall be included in the calculation and reporting of the values required in the discharge monitoring report form. Such increased frequency shall be indicated on the discharge monitoring report form.

By **30 January of each year**, the Discharger shall submit a written report to the Executive Officer containing the following:

a. The names and telephone numbers of persons to contact regarding the plant for emergency and routine situations.

b. A statement certifying when the flow meter and other monitoring instruments and devices were last calibrated, including identification of who performed the calibration (Standard Provision C.6).

The Discharger may also be requested to submit an annual report to the Board with both tabular and graphical summaries of the monitoring data obtained during the previous year. Any such request shall be made in writing. The report shall discuss the compliance record. If violations have occurred, the report shall also discuss the corrective actions taken and planned to bring the discharge into full compliance with the waste discharge requirements.

All reports submitted in response to this Order shall comply with the signatory requirements of Standard Provision D.6.

The Discharger shall implement the above monitoring program on the first day of the month following effective date of this Order.

Ordered by: _____
GARY M. CARLTON, Executive Officer

_____
(Date)

AMM

Aerojet-General Corporation (Aerojet) operates a rocket-testing and chemical manufacturing facility in eastern Sacramento County near Rancho Cordova and Folsom. Past discharges and disposal practices have caused the release of volatile and semi-volatile organic contaminants to groundwater and the vadose zone. One of the contaminated groundwater plumes extends northwest from Aerojet's property underneath the American River, Sailor Bar Park, and beneath the community of Fair Oaks. This area is referred to as the American River Study Area (ARSA). Aerojet has been discharging extracted groundwater from ARSA under an NPDES permit since 1996. Aerojet requested to add an additional discharge from another groundwater extraction and treatment systems, GET E/F, which captures contaminated groundwater in the western portion of the Aerojet facility. The permit for the ARSA discharge is being revised to include the discharge from GET E/F.

American River Study Area

The concentrations of volatile organic contaminants (VOCs) in the groundwater in the American River Study Area include up to 4000 micrograms per liter (gg/1) trichloroethylene (MCL of 5 µg/1), 220 µg/1 cis-1,2-dichloroethylene (MCL of 6.0 µg/1), 110 µg/l 1,1-dichloroethylene (MCL of 5.0 µg/1), and 36 µg/1 tetrachloroethylene (MCL of 5.0 µg/1). Other maximum concentrations of non-volatile contaminants of concern detected in the groundwater are 1,4 dioxane at 29 µg/1and perchlorate at up to 150 µg/1. More discussion on these contaminants is found below.

The Board adopted Cleanup and Abatement Order No.95-715 requiring Aerojet to provide interim measures to minimize the flux of groundwater contaminants in the plumes described above while assessing the appropriate means of remediating the plume of contaminated groundwater in the American River Study Area. That interim measure consisted of extracting groundwater from three groundwater extraction wells at the toe of the plume, treating the extracted groundwater using activated carbon in a temporary treatment facility, and discharging the treated water to a pond in Sailor Bar Park. This park is located on the north side of the American River. The discharge was regulated by an NPDES permit, Order No. 96-066. The operation of the plant during its 1.5 years of operation was in substantial compliance with the requirements found in Order No. 96-066.

The Board modified Order No. 95-715 with the adoption of Order No. 96-230, directing Aerojet to complete the design, construction, and operation of a groundwater extraction and treatment system in the American River Study Area to contain and cleanup the plume of contaminated groundwater. Aerojet is complying with that Order by completing construction of a treatment system on Aerojet's property capable of treating a flow of 3500 gpm. Aerojet completed the extraction wells and treatment system and commenced discharge from the treatment system to Buffalo Creek in 1998. Extracted groundwater comes from nine wells in Sailor Bar Park and six wells on the south side of the American River. Additional extraction wells are being constructed to enhance plume containment. The treated effluent is discharged to Buffalo Creek, a tributary of the American River just east of the Sunrise Bridge overcrossing. In addition, the Sacramento County Department of Parks and Recreation requested Aerojet continue the discharge to the pond in Sailor Bar Park that was discontinued with the shutdown of the temporary facility. The water supply well that has been utilized in the past by County Parks for the purpose of maintaining the water level in the pond contains up to 50 µg/1 trichloroethylene and would require treatment before discharge to the pond. Instead of treating the water supply well, Aerojet uses an extraction well near the pond that has not been found to contain any contaminants. That extraction well takes water from the shallow water bearing zone, which is different from the County Park well.

GET E/F

The Discharger has been operating the groundwater extraction systems, GET E and F, since 1984, and according to the requirements of the Partial Consent Decree since its entry by Federal Court in December 1989. Effluent from the GET E and F facilities was either discharged to land or recharged to groundwater via injection wells. GET E and GET F were combined in 2000 with all of the water being treated at a modified GET E/F facility. The GET E/F extraction system is designed to intercept groundwater contaminant plumes prior to them leaving the western portion of the Discharger's property. Currently, the facility operates at approximately 3600 gpm, and is being expanded to achieve a treatment capacity of 6000 gpm. The GET E/F facilities are part of the remedy for the Western Groundwater Operable Unit (WGOU) section of Aerojet. The Record of Decision for the WGOU issued by USEPA in July 2000 does not call for injection, but for discharge of the treated groundwater to surface water in order to allow for the greatest potential for reuse of the treated groundwater to provide replacement water supplies for those lost due to contamination in the Rancho Cordova and surrounding areas. In addition, infiltration capacity in the vicinity is limited as demonstrated by the current ponding of water from the GET E/F discharge of 3600 gpm to land for recharge. Increasing application to land at a rate of 6000 gpm is not feasible.

The groundwater contaminant plumes intercepted by the GET E/F extraction field include VOCs (primarily TCE), perchlorate, and NDMA. The GET E/F facility uses biological reduction to remove perchlorate, ultraviolet light to remove NDMA, and air stripping to remove VOCs. The GET E/F facility has been in operating in its current configuration since 1999. The treatment process has been shown to be effective in removing VOCs to below detection levels (0.5 µg/l), perchlorate to below 4 µg/l, and NDMA to below detection (0.002 –0.075 µg/l). Testing of the influent and effluent to the treatment facility for full-scan analysis, including tentatively identified compound analysis, did not indicate additional contaminants of concern.

Initial discharge of the treated groundwater will be to Buffalo Creek. Later, the effluent from the GET E/F facility may also be discharged to Alder Creek, tributary to Lake Natoma (American River), on Aerojet's property. A pipeline to convey the treated water from the GET E/F facility will need to be constructed prior to the discharge to Alder Creek. Aerojet is currently evaluating pipeline alternatives that would allow discharge to Alder Creek. The interim discharge to Buffalo Creek will co-mingle with the discharge from the ARSA facility, prior to leaving the Discharger's property.

Reasonable Potential and Anti-degradation Analyses

A reasonable potential analyses for priority pollutants, utilizing guidance covered by the Policy for the Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP), adopted in March 2000 by the State Board, was conducted based upon data submitted by the Discharger regarding effluent concentrations of volatile organic compounds.

The numeric water quality criteria for priority pollutants were promulgated by U.S. EPA with the adoption of the *National Toxics Rule* on 5 February 1993 and the *California Toxics Rule* on 18 May 2000. The reasonable potential analysis for Trichloroethene, 1,2-Dichloroethane, Chloroform, cis-1, 2-Dichloroethene, revealed that these constituents may exceed numeric water quality criteria, and require limits. Limits were not included for those detected constituents where there is no reasonable potential to exceed a standard.

Additionally, federal regulations require effluent limitations for all pollutants that are or may be discharged at a level that will cause or have a reasonable potential to cause, or contribute to an in-stream excursion above numerical or narrative water quality standard. The Discharger is required to provide information as to whether the levels of priority pollutants, including CTR and NTR constituents, and constituents for which drinking water maximum contaminant levels prescribed in the California Code of Regulations, in the discharge cause or contribute to an in stream excursion above a water quality objective. If the discharge has the reasonable potential to cause or contribute to an in-stream excursion above a water quality objective, the Discharger is required to submit information to calculate effluent limitations for those constituents.

Effluent Limits

The following water quality limits have been selected to implement all applicable water quality objectives for the protection of Board-designated beneficial uses of surface water in Ingram Slough downstream from the Titan I-A Missile Site:

Volatile Organic Compounds

Both the ARSA and GET E/F treatment facilities utilize air stripping and ultraviolet/peroxide oxidation to remove the volatile organics from the extracted groundwater to concentrations less than the quantitation limit of 0.5 µg/l (the effluent limitation for these constituents). The 0.5 µg/l value for the volatile organic constituents are below the respective maximum contaminant levels (Primary and Secondary Drinking Water Standards) for the individual volatile organic contaminants. One chemical of concern, 1,2-Dichloroethane has a CTR value less than 0.5 µg/l and so its monthly average is set at that concentration. The effluent limits are based on Best Available Technology utilizing either air stripping or carbon adsorption which have been demonstrated to readily reduce volatile organics to below 0.5 µg/l.

1,4-Dioxane Limitation

The treatment systems at ARSA and GET E/F utilize ultraviolet light/peroxide which has been demonstrated to effectively remove 1,4-dioxane. The calculated concentrations or 1,4-dioxane entering and exiting the ARSA treatment plant are 6 µg/l and 3 µg/l, respectively. These are below the practical quantitation level of 10 µg/l and the Proposition 65 value of 15 µg/l. Sampling of the effluent from the facility has not shown detectable concentrations of 1,4-dioxane. The effluent limitations have been set at the practical quantitation level for the monthly average value and the Proposition 65 value for the daily maximum. It should also be noted that there will be a minimum 30-fold dilution in the American River (flow at 250 cubic feet per second) at the maximum discharge rate of 3450 gpm.

Only very low concentrations (3 to 5 µg/l) of 1,4-dioxane have been detected in the influent to the GET E/F facility. The facility has been shown to effectively remove these low concentrations to below 3 µg/l.

Perchlorate Limitation

The current Action Level (January 2002) set by the Department of Health Services -Office of Drinking Water as its recommended value not to be exceeded in a drinking water supply, is 4 µg/l. For the ARSA facility, the calculated value that could eventually be found in the influent to the treatment plant is 8 µg/l (the current influent concentrations range between 5 and 7 µg/l). The previous version of this permit established the effluent limitation for perchlorate at 18 µg/l, the Action Level for perchlorate at the time of adoption of the permit. Given the minimum 30-fold dilution in the American River, the low influent perchlorate concentration, and the additional mixing with the GET E/F effluent, this permit does not establish a revised effluent limitation for perchlorate. At 8 µg/l perchlorate in the effluent and a flow of 2000 gpm, the GET E/F discharge will reduced the perchlorate concentration in the combined effluent to a calculated value of approximately 1.8 µg/l.

The GET E/F influent concentration of perchlorate is approximately 300 µg/l. The GET E/F treatment facility has been shown to be capable of reducing the perchlorate concentration to less than the practical quantitation level of 4 µg/l. The effluent limitation is established at 4 µg/l based on the ability to reduce the concentration to at or below the Action Level.

NDMA Limitation

N-Nitrosodimethylamine (NDMA), a contaminant not suspected in the American River Study Area, but found in the groundwater at the eastern end of Aerojet and in March 1998 in wells at the western end of Aerojet, is required to be sampled and analyzed for in the permitted discharges and receiving water. To date, no NDMA has been found within the extraction area for ARSA. There are no known source areas for NDMA in the vicinity or upgradient of the American River Study Area. Additional sampling of groundwater monitor wells in the American River Study Area for NDMA will occur on a periodic basis.

The GET E/F facility was designed to remove NDMA to concentration no greater than 0.002 µg/l, the estimated excess one-in-a-million cancer risk value established by the Office of Environmental Health Hazard Assessment. The effluent limitation is established at 0.002 µg/l.

Other

Analysis for metals in samples collected from the groundwater monitoring system and extraction wells and influent to the treatment system were used to assess which metals may be of concern. This analysis found only three metals of concern that were detected, or are currently of potential concern in the American River. Those metals are copper, lead, and zinc. The effluent limitations for those metals were established based on protection of aquatic life, with no dilution. The values utilize a hardness of 100 mg/l and Ambient Water Quality Criteria, which is based on data collected from the groundwater and treatment systems. The detected values in the groundwater for those three metals are below the effluent limitations established in this permit.

The following tables provide the rationale for the effluent limits.

Table 1: Monthly Average Limit

Constituent	Monthly Average Limit	Units	*Reference*
Trichloroethene[1]	0.5	µg/l	Non-detect, Best Practicable Treatment
1,2-Dichloroethane[1]	0.38	µg/l	California Toxic Rule
Chloroform[1]	0.5	µg/l	Non-detect, Best Practicable Treatment
cis-1, 2-Dichloroethene[1]	0.5	µg/l	Non-detect, Best Practicable Treatment
Dichloromethane[1]	0.5	µg/l	Non-detect, Best Practicable Treatment
trans-1, 2-Dichloroethene[1]	0.5	µg/l	Non-detect, Best Practicable Treatment
1,4-Dioxane	3	µg/l	DHS Action Level
Perchlorate	4	µg/l	DHS Action Level, Best Practicable Treatment
N-nitrosodimethlyamine	0.002	µg/l	Non-detect, Best Practicable Treatment

[1] – EPA Method 8260B or equivalent.

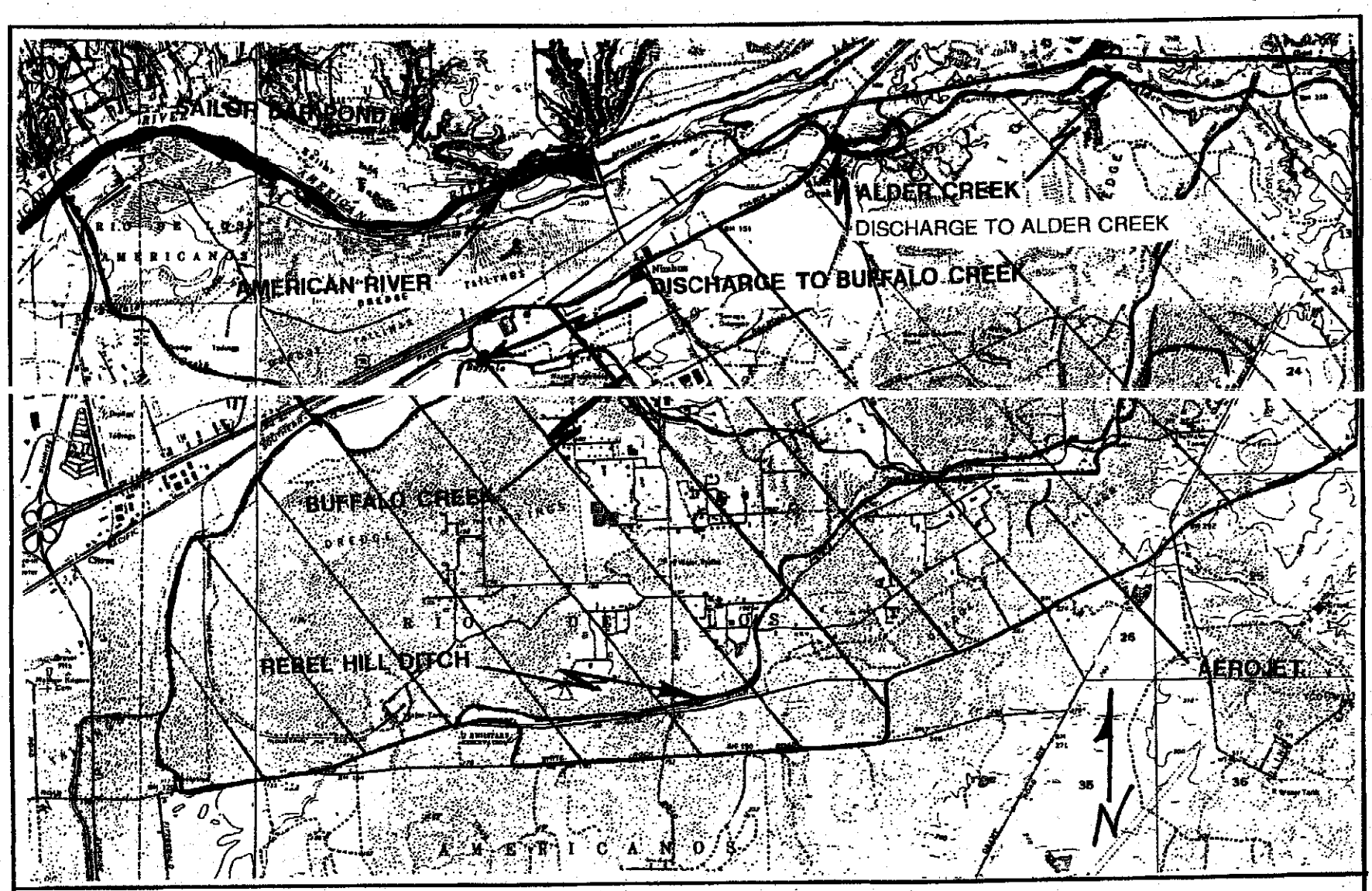
Discharge limits are primarily based on the *Fourth Edition of the Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board - Central Valley Region, Sacramento River and San Joaquin River Basins,* and Best Available Technology for removal of VOCs, NDMA, and perchlorate.

Receiving Water Limitations

Receiving Water Limitations D.1 through D.13 are found in the Basin Plan and deal with general receiving water parameters. Given that this is not a discharge of elevated temperature wastewaters, limitations for temperature found in the *Water Quality Control Plan for Control of Temperatures in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California* are not included.

Chronic toxicity and acute toxicity testing of the effluent is required.

AMM (2/21/02)



ATTACHMENT A
AEROJET-GENERAL CORPORATION
SACRAMENTO COUNTY

T9N, R7E
BUFFALO CREEK, FOLSOM, CITRUS HEIGHTS
AND CARMICHAEL USGS 7.5' QUADS
SCALE = 1" = 4000'

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SOUTHERN CALIFORNIA WATER COMPANY

BEFORE THE

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

In re Petition of Southern California Water Company to Revise the Declaration of Fully Appropriated Stream Systems Regarding the American River, Sacramento County	))))))

SCWC EXHIBIT 26

SCWC

EXHIBIT

26

MAPS:

- Figure 3-1, American River Study Area Well Location Map

- Aerojet Vacinity Wells

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Third Edition

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PREFACE

The first and second editions of this book, published in 1959 and 1970, respectively, have had a total of some 10 printings and a worldwide circulation. If a book of this kind is to continue to be useful in a rapidly changing and developing scientific field, it must be reevaluated and updated periodically. This revision retains the basic organizational pattern of the earlier editions and is intended to serve the same general purposes.

The book is intended to serve as an introduction to the topics of low-temperature aqueous geochemistry and of applied and theoretical water chemistry, and as an aid to hydrologists and hydrogeologists who may need to evaluate water quality and incorporate water chemistry into their investigations of water resources. The needs of the latter group were uppermost in my mind when the first edition was being planned and written, but the book had an immediate broader appeal. Those who might use the book as an introduction to water geochemistry probably will continue to be the larger group. To meet their needs, I have tried to reach a compromise in the level of approach, so that the topics will be intelligible to readers who have a minimal background in chemistry and will still have some value for specialists in this or related scientific disciplines. Those who seek to study some aspect of the subject in greater depth can make a start in that direction by examining the books and journal articles that are listed as references.

The subject of water chemistry hardly qualified as a scientific discipline at the time the first edition of this book was prepared. In the ensuing years, water chemistry as it relates to geochemistry, to environmental sciences, and to water and waste treatment has developed a substantial theoretical and practical base, although it is still something of an adolescent in comparison with some other fields of applied chemistry.

The term "natural water" used in the title and elsewhere in this book is intended to mean water that occurs in a "real world" environment, as in a lake, a stream, or a ground-water body, as opposed to synthetic solutions prepared in a laboratory. Natural waters need not be pristine—unaffected by the works of man. Indeed, probably few are completely free from such influences.

Acknowledgments. This book has benefited from many comments and suggestions I received from readers of the earlier editions. I am indebted particularly to my colleagues in the U.S. Geological Survey who have reviewed, and suggested improvements in, this third edition when it was in the manuscript stage. These were W. L. Bradford, J. A. Davis, J. H. Feth, Y. K. Kharaka, D. C. Thorstenson, and A. H. Welch.

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A detailed study of these effects in water of a lake in the English Lake District was made by Sholkovitz and Copland (1982). The mechanics of stratification in lakes have been studied by many limnologists and will not be reviewed further here.

Many reservoir outlets are located in positions where they may intercept water that is depleted in dissolved oxygen. From a practical point of view, the water user is interested only in the composition of water available at the outlet, and most samples from storage reservoirs for which analyses are available come from released water.

Ground-Water Sampling

Most of the physical factors that promote mixing in surface waters are absent or are much less effective in ground-water systems. Even in thick sand of uniform permeability, the movement of water in the zone of saturation is slow and mixing is poor. In most sediments, the horizontal permeability is greater than the vertical permeability. This inhibits vertical movement of water, and water in a particular stratum may develop chemical characteristics that are substantially different from water in strata above or below.

Means of studying differing composition of water in different parts of the saturated zone are not entirely adequate. Wells commonly obtain water from a considerable thickness of saturated material and from several different strata. These components are mixed by the turbulent flow of water in the well before they reach the surface of the land and become available for sampling. Springs may obtain water from a lesser thickness of saturated material, but often the exact source is difficult to ascertain. Most techniques for detailed well sampling and exploration are usable only in unfinished or nonoperating wells. Usually, the only means of evaluating the quality of water tapped by a well is an analysis of a pumped sample. The limitations of a preexisting well as a sampling device are obvious but unavoidable. Observation wells specifically designed and installed for obtaining water-quality information may be necessary to avoid some of these problems.

Mixing of water from different strata in a well, and in some instances exposure of the water to the atmosphere, may bring about chemical instability, even though the original water in place was in equilibrium with its surroundings. This chemical instability may cause changes in certain constituents and requires sample preservation or onsite determination. This subject has been discussed by Wood (1976).

The differences in water quality with depth below the surface, and associated differences in lithology, are shown for three wells in the western part of Pinal County, Ariz., in figure 5. Water samples were obtained at several depths in each well during periods when the pumps were not operating; the specific conductance of each sample is indicated on the diagram opposite the depth at which the sample was obtained. Kister and Hardt (1966), in whose publication the illustration first appeared, reported a range in specific conductance in one well from 1,480 μmho/cm at a depth of 300 ft. below land surface to 29,400 μmho/cm at 550 ft. Water pumped from the well had a specific conductance of 5,960 μmho/cm. As Kister and Hardt pointed out (p. 10), "Chemical analyses of water samples collected from the discharge pipe of a pumping well are not necessarily indicative of the quality of water throughout the sequence of sediments penetrated by the well."

Although the range of conductance is unusually great, the data show how water yielded by a well could change in quality in response to changes in pumping rate or regional drawdown of the water table. Many wells are influenced to some degree by water-quality stratification, and the interpretation of ground-water analyses must always consider the possibility of such effects. Electric logs may provide useful indications of the location of water of poor quality in the saturated material penetrated by wells.

Although one rarely can be certain that a sample from a well represents exactly the composition of all the water in the vertical section at that point, it is usually a useful indication of the average composition of available water at that point. Where a considerable number of wells reaching the same aquifer are available for sampling and show similar composition, the investigator usually is justified in assuming homogeneity in drawing some conclusions about the chemistry of the ground water in the aquifer. If a well penetrates a large, relatively homogeneous aquifer, the composition of the pumped water generally will not change much over long periods of time. Areal variations in ground-water quality are evaluated by sampling wells distributed over the study area as appropriate to the amount of detail that is desired.

Because rates of movement and mixing in groundwater systems are generally very slow, changes in composition of the water yielded by a well or spring with respect to time can usually be monitored by annual or seasonal sampling. Exceptions may occur in aquifers having large open channels (as in cavernous limestone) or where there is recharge or contamination near the well. Some fluctuations in composition may be artifacts related to well-construction defects, casing failure or leakage, that permit entry of small amounts of water of poor quality.

Some examples of month-to-month changes in very shallow ground water in the alluvium of the Gila River in Safford Valley, Ariz. (Hem, 1950, p. 15), are shown in figure 6. These fluctuations are more rapid than those usually observed in wells of greater depth, and because many factors such as changes in river discharge, rainfall,

irrigation pumping, and return flow may influence the water composition, no well-defined pattern of quality fluctuation can be discerned.

A long-term trend in ground-water composition is shown in figure 7. The two wells indicated in the graph were used for irrigation in the Welton-Mohawk area along the Gila River in southwestern Arizona (Babcock and others, 1947) before Colorado River water was brought into this area in the 1950's. The dissolved solids increased greatly over the period of record.

Completeness of Sample Coverage

In areas where hydrologic studies are being made, a decision is needed as to how many samples or other water-quality observations are required. Aside from administrative limitations in funds and personnel, this decision should be based on the conditions in the area to be studied. Factors to be weighed include the amount of information of this type already available, the hydrologic complexity of the area, the extent to which water of inferior quality is known or thought likely to be present, and other similar considerations. The aim of many water-quality investigations is to evaluate the resource as thoroughly as possible, and this usually requires many samples and field observations. The amount of laboratory work per sample often can be decreased if, by means of field determinations and laboratory determinations of certain key constituents, it can be shown that many of the samples have similar composition. The experienced water chemist thus can determine the water quality of an area by the most efficient combination of complete and partial chemical analyses. The water chemist's place on the team of any hydrologic investigation is important beyond the actual performance of analytical determinations.

Analysis of Water Samples

The analysis of water for its dissolved components is a part of the work done by a large number of chemical laboratories, including many supported by State, Federal, and local governments, academic and research institutions, and private enterprise. The methods used in water analysis are fairly well standardized and will not be discussed here. There are certain procedures for field testing and exploration, however, that should be commented on.

Field Testing of Water

Examination of water in the field is an important part of hydrologic studies. Certain properties of water, especially its pH, are so closely related to the environment of the water that they are likely to be altered by sampling and storage, and a meaningful value can be obtained only in the field. Other properties of water, its specific conductance, for example, are easily determined in the field with simple equipment, and the results are useful in

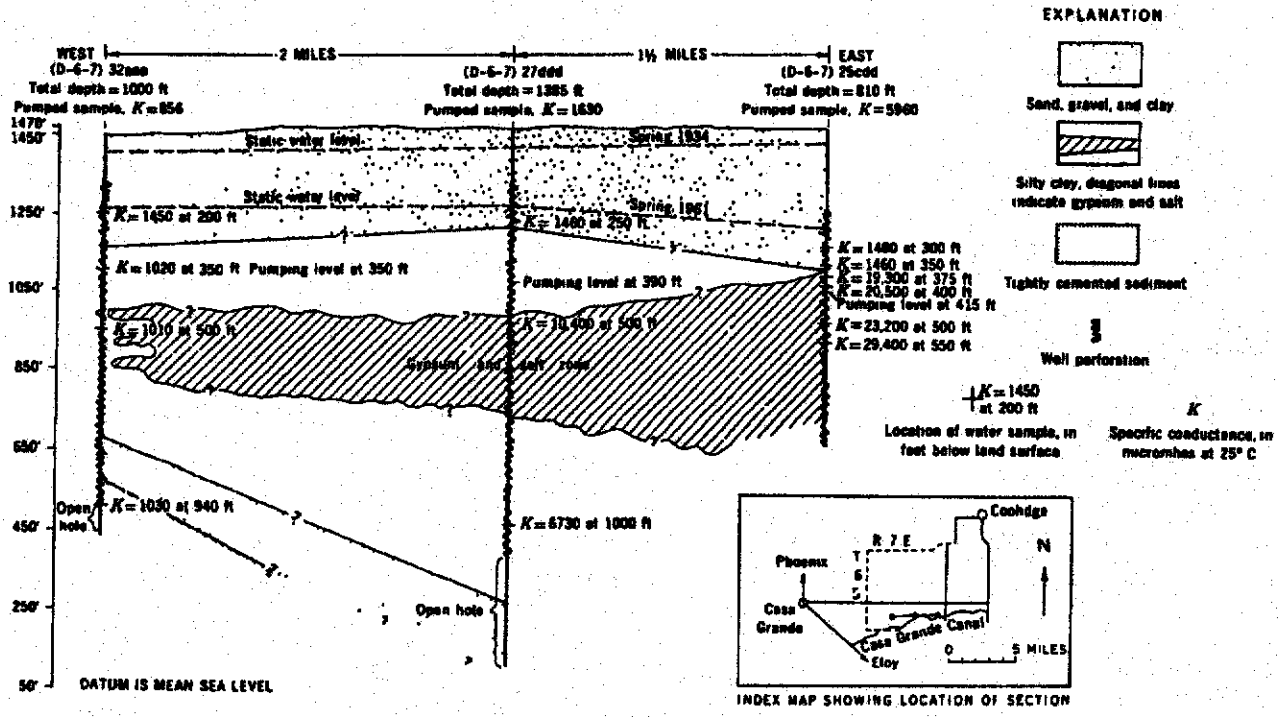

Figure 5. Changes in conductance of ground water, Pinal County, Ariz. Modified from Kister and Hardt (1966).

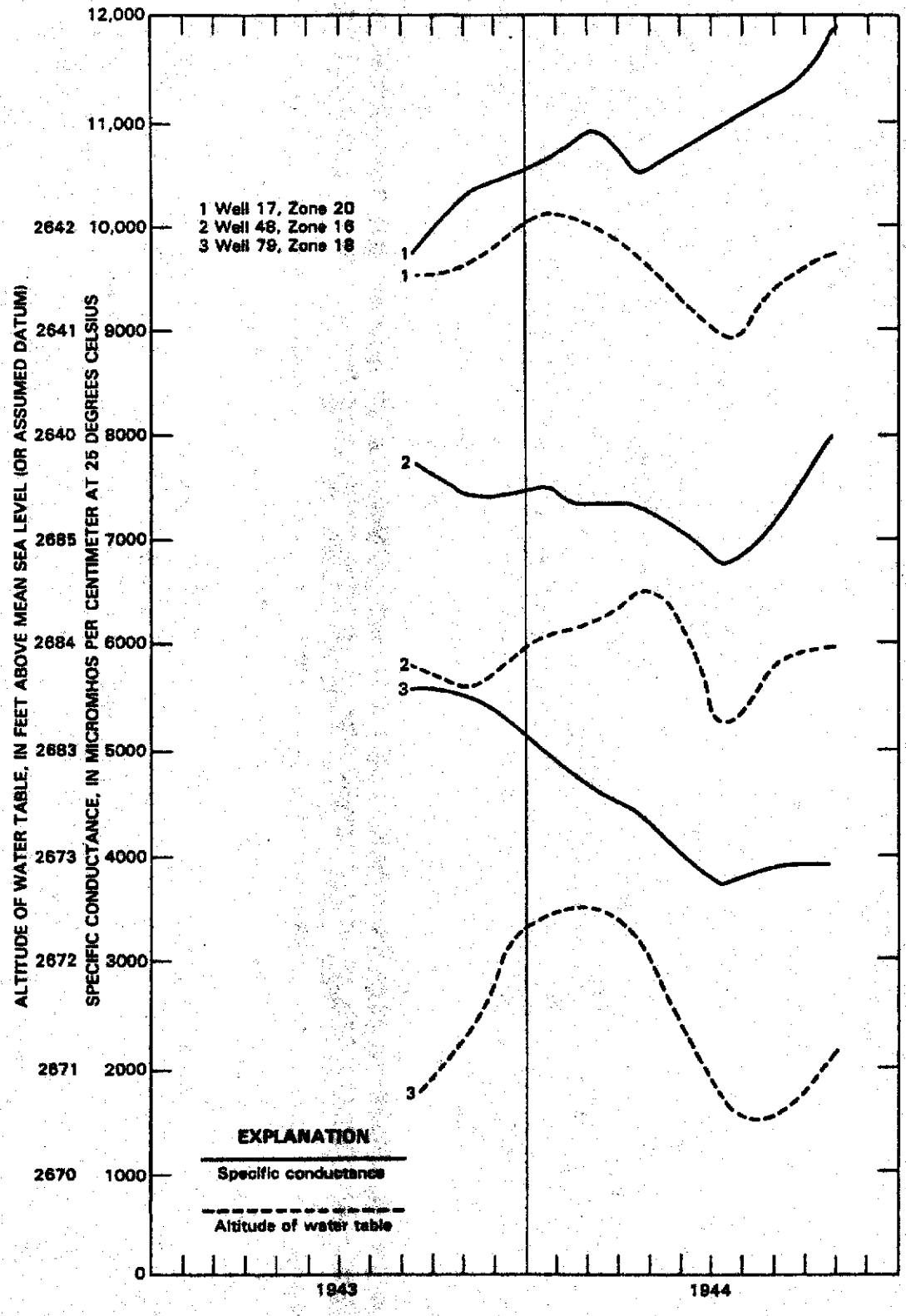

Figure 6. Specific conductance and altitude of water table for three typical observation wells, Safford Valley, Ariz. (Hem, 1950, p. 15).

supplementing information obtained from analyses of samples and as a guide to which sources should be sampled for more intensive study. Commercial equipment is available or can be adapted to field use, ranging from pocket-sized testing kits to trailer- or bus-mounted mobile laboratories. In the more elaborate units, almost any kind of standard analysis can be made.

The early history of field testing shows that its importance was recognized as long ago as the early 1900's, but equipment available then generally was rather crude. As early as 1896, a portable Wheatstone bridge for measuring the conductivity of water and saturated soil was being used by the U.S. Department of Agriculture (Scofield, 1932). The equipment for measuring water conductivity in the field has evolved into fairly sophisticated models that yield digital readings of temperature and specific conductance of samples. The units are battery powered, light, and easy to carry and give results nearly as accurate as those obtained in the usual laboratory installation. Sensing cells also can be incorporated in well-exploration equipment. Specific-conductance measurements and their meaning are discussed under that heading in a later section of this book.

A rapidly expanding application has been the continuous measurement of conductivity or other characteristics of river water with equipment installed at the sampling site. These units can be made to record results in a form that can be fed directly into an electronic computer. Power for operating the installation usually is best obtained from a 115-volt alternating-current line.

Any determination that can be made by potentiometric methods can easily be accomplished in the field or can be built into an onsite sensor. The pH of a water, for example, generally is determined by means of a sensitive electrometer and suitable reference and glass electrodes. For most ground water, the pH needs to be determined immediately after the water issues from the well or spring, if the value is to represent conditions within the system in which the water occurs (Barnes, 1964). Electrode systems for determining dissolved oxygen and many individual ions also are available.

Although almost any property or component of natural water can now be determined at a streambank location and probably could be automated if necessary, the cost of the most elaborate installations is high, and a real need must exist as justification.

Geophysical Indicators of Ground-Water Quality

One of the most widely used means of geophysical exploration of subsurface conditions is electric logging of boreholes. One of the principal determinations made as part of the logging procedure is the resistance to passage of an electric current through the formations penetrated by the borehole. One form of resistivity logging uses a pair of electrodes which are spaced a specific distance apart and held against the side of the uncased hole. As the electrodes are moved up or down the hole, the electrical resistance observed between them changes in response to environmental changes. A recording device traces the resistance on a chart as the probe moves in or out of the hole. The result is a curve showing resistance plotted against depth below the surface.

The resistance of water-bearing material in place is a function of the resistance of the rock itself, the resistance of the interstitial water, and the length of the path through which current passes in the water contained in the interconnected openings in the rock. Resistance of most dry rocks is high, and, in effect, the resistance measured by electric loggers is controlled by the water conductivity

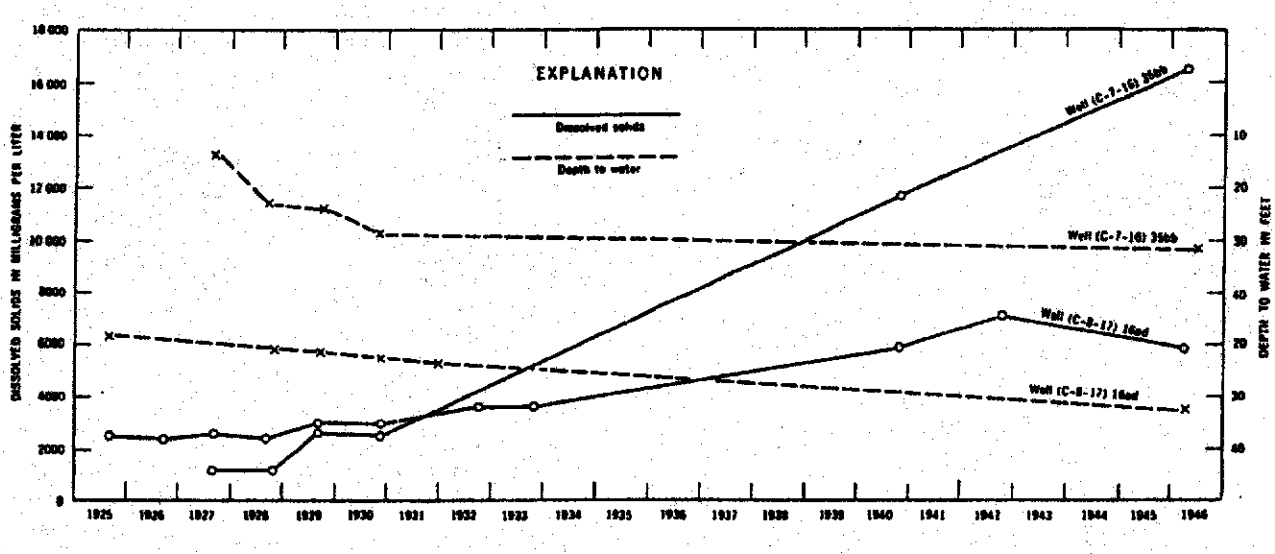

Figure 7. Dissolved solids and depth to water in two irrigation wells, Welton-Mohawk area, Yuma County, Ariz

and the length of the current path. The resistance is expressed as resistivity (the reciprocal of conductivity), usually in ohms per meter per square meter. Values for resistivity of aquifers obtained through electric logging thus are closely related to conductivity of the water and porosity of the rocks. The principal use of electric logs in the water-well industry has been as an aid in determining the physical properties of water-bearing formations and in correlating formations from well to well. Applications of logging equipment in hydrology were described by Patten and Bennett (1963) and by Keys and MacCary (1971).

If the conductivity of the water is considered the unknown, and if the other features of the aquifer that influence the observed resistivity can be evaluated on the basis of laboratory tests of drill cuttings from the formation or on the basis of previous experience with the same aquifer, the resistivity log provides an indication of water quality in place underground.

To determine water conductivity reliably from a resistivity log, the aquifer properties must be well known. Some investigators have used resistivity logs to compute approximate chemical analyses for water; however, this may be done satisfactorily only when water from the formation in question is known to display a well-defined relationship between conductivity and each of the constituents for which the computation is made. Jones and Buford (1951) described such computations for ground waters in Louisiana.

Another property generally determined in electric logging is the spontaneous potential that can be observed between an electrode and the land surface when no current is introduced. This potential is partly related to electrochemical effects such as selective movement of ions and water through clays acting as semipermeable membranes, and to electrical potentials that occur at interfaces between solutions of dissimilar composition.

Some work has been done in relating the observed potentials more specifically to the water-bearing materials and the composition of the water, but more would seem to be justified, because this technique, when carefully refined, might give considerable insight into electrochemical relationships in ground-water systems that may influence both water quality and movement. Resistivity measurements can also be made at the land surface and may indicate something about the composition of ground water near the surface. Techniques of surface geophysical exploration for water resources studies were described by Zohdy and others (1974).

Laboratory Procedures

The procedures considered to be sufficiently accurate and most acceptable for general use in water analysis in the United States have been described in several publications. The most widely known of these is "Standard Methods for the Examination of Water and Wastewater" (American Public Health Association and others, 1980, 1985). It is revised every few years by the American Public Health Association, the American Water Works Association, and the Water Pollution Control Federation; and the 1980 volume is the 15th edition. A 16th edition was published in 1985. Other compilations widely used are those of the American Society for Testing and Materials (1978), the Association of Official Analytical Chemists (1980), and the U.S. Salinity Laboratory staff (1954). The U.S. Geological Survey compilation by Skougstad and others (1979) is also well known. A review of perodical literature on water analysis is published every 2 years in the journal *Analytical Chemistry*. The large volume of current literature in this field is indicated by the 665 articles referenced for the 2-year period October 1980 through September 1982 (Fishman and others, 1983). Automation and new instrumental methods have strongly influenced laboratory practice in the analysis of natural water in recent years.

Expression of Water Analyses

Various terms and units are commonly employed in the expression of data obtained in the chemical analysis of water. An understanding of those more frequently used is required for the interpretation of analyses.

Hypothetical Combinations

Water analyses published before 1900 generally were expressed in terms of concentrations of combined salts, such as sodium chloride or calcium sulfate. This kind of terminology probably was used in part as an attempt to describe the residue obtained when the water was evaporated, but it also predated the concept of dissociated ions in solution introduced in the late 19th century by Arrhenius.

Although water chemists often use terms such as "calcium bicarbonate water" to describe a solution in which Ca^{2+} and HCO_3^- are the principal ionic species, they recognize this as a form of shorthand or abbreviation for the much more clumsy expression "a water in which calcium and bicarbonate are the predominant cation and anion, respectively."

Ionic Statement

Many organic compounds and some inorganic compounds exist in solution in water as uncharged molecules, but most inorganic solids dissociate when they go into solution in water. The closely knit structure of the solid is broken into positively charged cations and negatively charged anions that are separated by solvent molecules. On a macro scale, the positive and negative charges must be in balance.

Because the water analysis is intended to reflect the true composition of the solution, most of the reported concentrations are in terms of actual cations and anions that are present. There are some important exceptions, however. Elements such as nitrogen or boron that may occur in several different forms, or whose actual form in solution is unknown, may be reported in terms of the total concentration of the element. The very abundant element silicon is generally present in water as undissociated silicic acid but is conventionally reported in terms of the oxide, SiO_2. For some purposes, a considerably more detailed breakdown of constituents than is usually furnished is necessary to show which solute species are actually present.

Determinations Included in Analyses

With the sophisticated equipment and analytical methods now available, the analysis of a water sample could include most of the elements in the periodic table, as well as a considerable suite of naturally or artificially produced isotopes of these elements and a great many specific organic compounds. The principal interest of the analyst and the great preponderance of data, however, traditionally have been directed at major constituents that make up nearly all the dissolved inorganic material. Concern with minor constituents has increased greatly in recent times owing to their possible effects on human health and on animal and plant nutrition and toxicity, or effects related to other kinds of water use.

For the purposes of this discussion, major constituents are defined as those commonly present in concentrations exceeding 1.0 mg/L. The dissolved cations that constitute a major part of the dissolved-solids content generally are calcium, magnesium, sodium, and potassium; the major anions are sulfate, chloride, fluoride, nitrate, and those contributing to alkalinity, most generally assumed to be bicarbonate and carbonate. The silicon present usually is nonionic and is reported in terms of an equivalent concentration of the oxide, silica (SiO_2).

Some other dissolved constituents are included in many chemical analyses because they may be particularly significant in considering suitability of water for certain purposes. Sometimes these constituents attain concentrations comparable to those of major components. They include aluminum, boron, hydrogen ion or acidity, iron, manganese, phosphate, organic carbon, forms of nitrogen other than nitrate, and dissolved gases, especially carbon dioxide, oxygen, and hydrogen sulfide.

Minor constituents in addition to the ones listed above, whose occurrence in fresh natural water has been investigated to a significant extent, include the alkali metals lithium, rubidium, and cesium, the alkaline-earth metals beryllium, strontium, and barium, the metallic elements titanium, vanadium, chromium, molybdenum, cobalt, nickel, copper, silver, zinc, cadmium, mercury, and lead, the nonmetals arsenic, antimony, selenium, bromine, and iodine, and the naturally radioactive elements uranium, radium, radon, and thorium. Each of these is separately discussed in a later section of this book.

Increasing concern over the presence of undesirable wastes or waste-alteration products and residues has produced a growing body of data on specific organic compounds, both natural and manmade, in water and on manmade radioactive elements and nuclides.

Certain properties of water solutions besides the contents of specific ions have commonly been included in water analyses. Hardness in water is commonly expressed in terms of an equivalent quantity of calcium carbonate. Other properties often included in a water analysis are color, specific conductance, dissolved solids, specific gravity, suspended matter, turbidity, biochemical or chemical oxygen demand, sodium-adsorption ratio, and various forms of radioactivity. These constituents and properties will be discussed in more detail as appropriate in following sections of this book

Units Used in Reporting Analyses

Over the years, a wide variety of units have been used in reporting water analyses. Considerable progress has been made toward standardization of these units, but using the data available in published literature often requires a general understanding of the units and systems used in the past and how they compare with more modern units. The two most common types of concentration units are those that report weights of solute per weight of solution and those that report weights of solute per unit volume of solution.

Weight-Per-Weight Units

A concentration reported in weight-per-weight is a dimensionless ratio and is independent of the system of weights and measures used in determining it. For many years, the water analyses made by U.S. Geological Survey and many other laboratories in the United States were reported in "parts per million." One part per million is equivalent to one milligram of solute per kilogram of solution. One percent, of course, is one part per hundred, or ten thousand parts per million.

"Parts per thousand" sometimes is used in reporting the composition of seawater. In this connection, "chlorinity" and "salinity" have been defined in terms of parts per thousand (grams per kilogram) for use in studies of seawater composition (Rankama and Sahama, 1950, p. 287).

At one time the unit "parts per hundred thousand" was in common use. "Parts per billion" or "parts per trillion" is sometimes used in reporting trace constituents.

Weight-Per-Volume Units

Because water is a liquid, definite quantities for analysis are ordinarily measured in the laboratory by means of volumetric glassware. The laboratory results, therefore, are in terms of weights of solute per unit volume of water. These results must be converted to a weight basis to obtain parts-per-million values. The conversion usually is done by assuming that a liter of water weighs exactly 1 kilogram and, hence, that milligrams per liter and parts per million are equivalent. This assumption is strictly true only for pure water at 3.89°C. The presence of dissolved mineral matter tends to increase the density, and at higher temperatures the density decreases. For practical purposes, however, the error introduced by assuming unit density does not reach a magnitude comparable to other anticipated analytical errors until the concentration of dissolved solids exceeds about 7,000 milligrams per liter. For highly mineralized waters, a density correction should be used when computing parts per million from milligrams per liter. Volumetric glassware is calibrated for use at 20°C, and ordinary laboratory temperatures are usually close to this value. Concentrations expressed in milligrams per liter are strictly applicable only at the temperatures at which the determination was made, but for most purposes for which the concentration values might be used, the effect of volume change caused by temperature changes of the solution is not important.

The reporting of dissolved constituents in milligrams (or micrograms) per liter has become standard practice in water analysis throughout the world. This avoids calculated density corrections.

Where the English or U.S. customary system of units is used, analyses are sometimes expressed in grains per gallon. The particular gallon that is meant must be specified, as the U.S. gallon and the Imperial, or British, gallon are not the same. The unit is still seen fairly frequently in connection with hardness in water. Reports dealing with irrigation water commonly express concentrations in tons per acrefoot. The ton is 2,000 pounds, and an acre-foot is the amount of water needed to cover 1 acre to a depth of 1 foot.

Streamflow or discharge represents a rate quantity. Rate concepts may be significant in some studies of river-water composition, and the dissolved-solids load, a rate quantity, is generally expressed in tons per day.

Conversion factors that indicate the relationships of the various units to each other are given in table 8. Factors changing grains per gallon or tons per acre-foot to parts per million, or the reverse, would be the same as those shown for conversions to or from milligrams per liter, if it is valid to assume unit density of the water. For highly mineralized water, these factors must take into account the density of the water. Hardness values are sometimes expressed in degrees. Conversion factors for these units, which differ in different countries, are given in the discussion of hardness in water elsewhere in this book.

Equivalent-Weight Units

For manipulations that involve the chemical behavior of dissolved material, the chemist must express analytical results in units that recognize that ions of different species have different weights and different electrical

Table 8. Conversion factors for quality-of-water data

[U.S. gallon is used for all units involving gallons]

To convert—	To—	Multiply by—
Calories	Joules	4.184
Grains per gallon	Milligrams per liter	17.12
Milligrams per liter	Grains per gallon	.05841
Milligrams per liter	Tons per acre-foot	.001360
Milligrams per liter	Tons per day	second-feet× 0.002697
Tons (U.S. short)	Tons (metric)	.9072
Acres	Hectares	.4047
Miles	Kilometers	.6214
Tons per acre	Metric tons per hectare	2.2417
Parts per hundred thousand	Parts per million	10
Grams	Ounces (avoirdupois)	.03527
Ounces (avoirdupois)	Grams	28.35
Gallons (Imperial)	Gallons (U.S.)	1.2009
Liters	Quarts (U.S.)	1.057
Quarts (U.S.)	Liters	.9463
Second-foot days[a]	Acre-feet	1.983471
Second-feet[b]	Gallons per minute	448.8
Second-foot days	Gallons per day	646,317
Gallons per minute	Liters per second	.06309
Acre-feet[c]	Gallons	325,851
Acre-feet	Cubic feet	43,560
Acre-feet	Cubic meters	1,233.5
Cubic feet	Cubic meters	.028317
Cubic feet	Gallons	7.481
Ca^{2+}	$CaCO_3$	2.497
$CaCl_2$	$CaCO_3$	.9018
HCO_3^-	$CaCO_3$	.8202
[d]HCO_3^-	CO_3^{2-}	.4917
Mg^{2+}	$CaCO_3$	4.116
Na_2CO_3	$CaCO_3$	.9442
NO_3^-	N	.2259
N	NO_3^-	4.4266

[a]1 s-ft/d=1 cfs for 24 h.
[b]1 s-ft=1 cfs.
[c]1 acre-ft=an area of 1 acre 1 ft deep.
[d]In the reaction $2HCO_3^-=CO_3^{2-}+H_2O+CO_2(g)$ (for computing total dissolved solids).

charges. For example, in the mass-law calculations discussed earlier, concentrations of ions and other dissolved species are given in moles per liter. A mole of a substance is its atomic or molecular weight in grams. A solution having a concentration of 1 mole per liter is a molar solution; thus, the molarity of a solution is its concentration in a weight per volume unit. A molal solution is one that contains 1 mole of solute per 1,000 grams of solvent. For dilute solutions up to about 0.01 molar, these two units are equal, within ordinary experimental error.

Concentrations in milligrams per liter are readily converted to moles per liter by dividing by the atomic or formula weight of the constituent, in milligrams. When parts-per-million values are treated in this way, the concentration unit obtained is usually called "formality," the number of formula weights per 1,000 grams of solution.

The concept of chemical equivalence can be introduced by taking into account the ionic charge. If the formula weight of the ion is divided by the charge, the result is termed the "combining weight" or "equivalent weight." When a concentration value in milligrams per liter is divided by the combining weight of that species, the result is an equivalent concentration that is useful for many purposes. Table 9 contains reciprocals of combining weights of cations and anions generally reported in water analyses. Milligrams-per-liter values may be converted to milliequivalents per liter by multiplying the milligrams per liter by the reciprocals of the combining weights of the appropriate ions.

The term "equivalents per million," which is used for the value obtained when parts per million is used instead of milligrams per liter as a starting point, is a contraction that has been generally adopted for the sake of convenience. In more exact language, the unit is "milligram-equivalents per kilogram" if derived from parts per million and "milligram-equivalents per liter" if derived from milligrams per liter. The term "milligram equivalents" is shortened by chemists to "milliequivalents," abbreviated "meq."

In an analysis expressed in milliequivalents per liter, unit concentrations of all ions are chemically equivalent. This means that if all ions have been correctly determined, the total milliequivalents per liter of cations is equal to the total milliequivalents per liter of anions. The relation of water composition to solid-mineral composition is made more clearly evident when the analysis is expressed in milliequivalents per liter. There are disadvantages to using these units, however, in that they require knowledge or assumptions about the exact form and charge of dissolved species. Laboratory determinations do not always provide this kind of information. For a species whose charge is zero, as for silica, an equivalent weight cannot be computed. A concentration of such species in moles or millimoles per liter is generally equally useful, however.

Table 9. Conversion factors: milligrams per liter×F_1=milliequivalents per liter; milligrams per liter×F_2=millimoles per liter (based on 1975 atomic weights, referred to carbon-12)

Element and reported species	F_1	F_2
Aluminum (Al^{3+})	0.11119	0.03715
Ammonium (NH_4^+)	.05544	.05544
Antimony (Sb)		.00821
Arsenic (As)		.01334
Barium (Ba^{2+})	.01456	.00728
Beryllium (Be^{2+})	.22192	.11096
Bicarbonate (HCO_3^-)	.01639	.01639
Boron (B)		.09250
Bromide (Br^-)	.01252	.01252
Cadmium (Cd^{2+})	.01779	.00890
Calcium (Ca^{2+})	.04990	.02495
Carbonate (CO_3^{2-})	.03333	.01666
Cesium (Cs^+)	.00752	.00752
Chloride (Cl^-)	.02821	.02821
Chromium (Cr)		.01923
Cobalt (Co^{2+})	.03394	.01697
Copper (Cu^{2+})	.03147	.01574
Fluoride (F^-)	.05264	.05264
Hydrogen (H^+)	.99216	.99216
Hydroxide (OH^-)	.05880	.05880
Iodide (I^-)	.00788	.00788
Iron (Fe^{2+})	.03581	.01791
Iron (Fe^{3+})	.05372	.01791
Lead (Pb^{2+})	.00965	.00483
Lithium (Li^+)	.14407	.14407
Magnesium (Mg^{2+})	.08229	.04114
Manganese (Mn^{2+})	.03640	.01820
Mercury (Hg)		.00499
Molybdenum (Mo)		.01042
Nickel (Ni)		.01704
Nitrate (NO_3^-)	.01613	.01613
Nitrite (NO_2^-)	.02174	.02174
Phosphate (PO_4^{3-})	.03159	.01053
Phosphate (HPO_4^{2-})	.02084	.01042
Phosphate ($H_2PO_4^-$)	.01031	.01031
Potassium (K^+)	.02558	.02558
Rubidium (Rb^+)	.01170	.01170
Selenium (Se)		.01266
Silica (SiO_2)		.01664
Silver (Ag^+)	.00927	.00927
Sodium (Na^+)	.04350	.04350
Strontium (Sr^{2+})	.02283	.01141
Sulfate (SO_4^{2-})	.02082	.01041
Sulfide (S^{2-})	.06238	.03119
Thorium (Th)		.00431
Titanium (Ti)		.02088
Uranium (U)		.00420
Vanadium (V)		.01963
Zinc (Zn^{2+})	.03059	.01530

Composition of Anhydrous Residue

The means of expressing analytical results discussed to this point all use concentrations of solutes. These concentration values are generally the deciding factors in the evaluation of water quality. Some geochemists, however, have preferred to express analytical data for water in terms they believed were more directly comparable to rock-composition data. To this end, they expressed analyses in terms of the percentage of each element or ion in the anhydrous residue remaining after evaporating the water. Clarke (1924a, b) used this reporting procedure, usually with a value for dissolved-solids concentration and percentages of the components which he termed "percentage composition of anhydrous residue."

The supposed advantage of this method of expressing analyses is that it may demonstrate similarities among waters that have similar geochemical origins but whose analyses might appear dissimilar because of dilution effects. For example, the composition of water from a river usually will appear to change a great deal as a result of increases or decreases in flow rate when one examines water analyses expressed in concentrations. When the data are recalculated to percentage composition of dry residue, at least part of the fluctuation in composition disappears.

Although for some geochemical considerations the calculation of percentage composition of residue is useful, this is not a good way of expressing the chemical composition of a solution, and since Clarke's time it has gradually disappeared from the literature.

Instead of computing percentage composition from actual weights of constituents, some investigators have computed percentages based on total anions or cations, in equivalents per million. The first extensive use of this kind of computation was by Chase Palmer (1911), and a related procedure has been adapted extensively in more recent times in certain graphical methods of study of water quality. These methods will be considered later in this book.

Concentration in Terms of Calcium Carbonate

The hardness of water is conventionally expressed in water analyses made in the United States in terms of an equivalent quantity of calcium carbonate. Some such convention is needed for hardness because it is a property imparted by several different cations, which may be present in varying proportions. However, the actual presence of the indicated number of milligrams per liter of calcium and carbonate ions certainly should not be assumed.

Another convention that is followed by many water-analysis laboratories is to express the results of the alkalinity titration in terms of an equivalent amount of calcium carbonate. Although the titrated alkalinity is sometimes not exactly assignable to one or more specific ionic species, the latter assignment gives a much clearer indication of the composition of the solution. In any event, alkalinity (to methyl-orange end point) expressed as milligrams per liter of $CaCO_3$ can be converted to an equivalent concentration of HCO_3^- in milligrams per liter by dividing the former by 0.8202. (See table 8.)

The formula weight of $CaCO_3$ is very near 100. Thus, hardness or alkalinity values in terms of milligrams per liter of $CaCO_3$ can be converted to milliequivalents per liter of cations or anions by dividing by 50. Analyses are occasionally seen in which other constituents are reported in terms of calcium carbonate. This form of expression is a way of expressing concentrations in terms of equivalent weights. The use of milliequivalents per liter for each specific ion gives at least equally useful results.

Comparison of Units of Expression

Table 10 shows a single water analysis expressed in milligrams per liter, milliequivalents per liter, millimoles per liter, percentage composition of dry residue, percentage of total cation and anion equivalents, and grains per U.S. gallon. It is assumed that the milligrams-per-liter values are equal to parts per million and that milliequivalents per liter are equal to equivalents per million for a water of this dissolved-solids concentration.

All the numbers in table 10 were derived from the same original analytical data. It is assumed that dissolved bicarbonate would be converted to carbonate in the dry residue, with loss of an equivalent amount of carbon dioxide and water. Computations of the type used in preparing the table use conversion factors given in table 8.

Forms of Dissolved Material—Complexes, Ion Pairs, and Polymers

Organic compounds and some inorganic substances occur in aqueous solution as uncharged molecules. Most inorganic compounds, however, dissociate into charged ions when they dissolve in water. Positively charged units are cations and negatively charged units are anions. There must be an overall balance between cations and anions in solution to maintain electrical neutrality. However, there are some interactions among ionic species that result in association of oppositely charged ions to form complex ions. Some examples have already been cited, and many more will be considered later in this book.

Chemical analyses of water generally report the total quantity of a particular element or ion without indicating its actual form in solution. For use in chemical thermodynamic calculations, the concentrations of participating reactants or products must be identified as specific solute species.

Complex ions are solute species made up from two or more single ions of opposite charge. For example, ferric iron in solution may hydrolyze to form a hydroxide complex:

$$Fe^{3+}+H_2O = FeOH^{2+}+H^+.$$

The Fe^{3+} and OH^- in this unit are chemically bound to each other. If the concentration of ferric iron is high enough, the formation of complex species may also involve association of monomeric units to give dimers

$$2FeOH^{2+} - [Fe(OH)_2Fe]^{4+},$$

and hydrolysis and polymerization may continue, giving a final product approaching the composition $Fe(OH)_3^0$ that contains many individual Fe^{3+} and OH^- ions linked together.

A special type of complex. here called an ion-pair, is an association of equally charged units to form a neutral species:

$$Ca^{2+}+SO_4^{2-} = CaSO_4(aq).$$

In this complex, the Ca^{2+} and SO_4^{2-} components are believed to be separated by one or more layers of intervening water molecules. Some authors have used the term "ion pair" in a less rigorous context.

"Polynuclear" complexes are defined by Baes and Mesmer (1976, p. 2) as complexes containing more than one cation. This is a broader definition than the one implied above for polymeric species. The term "polynuclear" will not be used in this book.

SIGNIFICANCE OF PROPERTIES AND CONSTITUENTS REPORTED IN WATER ANALYSES

The properties and constituents that are determined in water analyses are discussed individually in the following sections. For most constituents, the subjects considered are the form of dissolved species, solubility and

Table 10. Chemical analysis of a water sample expressed in six ways

[Sample from flowing well, 488 ft deep. Water from the Lance Formation. NW1/4 sec. 30, T. 57 N., R. 85 W., Sheridan County, Wyo. Collected August 3, 1946]

Constituent	mg/L or ppm	meq/L or epm	mM/L	Gravimetric percent	Percentage of epm	Grains per U.S. gallon
Silica (SiO_2)	7.9		0.131	0.40		0.46
Iron (Fe)	.17		.003	.01		.01
Calcium (Ca)	37	1.85	.925	1.87	6.1	2.16
Magnesium (Mg)	24	1.97	.985	1.21	6.5	1.40
Sodium (Na) + Potassium (K)	611	26.58	26.58	30.80	87.4	35.69
Bicarbonate (HCO_3)	429	7.03	7.03	[1]10.63	23.1	25.06
Sulfate (SO_4)	1,010	21.03	10.52	50.90	69.2	59.00
Chloride (Cl)	82	2.31	2.31	4.14	7.6	4.79
Fluoride (F)	.6	.03	.032	.03	.1	.04
Nitrate (NO_3)	.0	.00	.000	.00	.0	.00
Boron (B)	.2		.019	.01		.01
Dissolved solids:						
Calculated	1,980	60.80	48.535	100.00	200.00	115.65
Hardness as $CaCO_3$:						
Total	191		1.91			11.16
Noncarbonate	0		.00			0
Specific conductance (micromhos at 25°C).	2,880	2,880	2,880	2,880	2,880	2,880
pH	7.3	7.3	7.3	7.3	7.3	7.3

[1]As carbonate (CO_3).

other concentration controls in relation to other dissolved substances, the source of the material, the range of concentration that may be expected, and factors that may influence the accuracy or precision of analytical determinations. Appropriate environmental influences are considered, and chemical analyses are used to illustrate the discussions. Literature references are given to aid readers who may be interested in learning more about the topic.

The chemistry of some solutes in natural water is reasonably well understood. For others, much remains to be learned. New research results will tend to make many statements made here subject to rather rapid obsolescence. This is one reason for keeping the discussions of individual constituents generalized and rather brief.

Nature of the Dissolved State

The discussions so far have presupposed that the dissolved state was well enough understood that it did not need to be defined. An exact definition of the term, however, does pose some difficulties. An aqueous solution can be defined as a uniformly homogeneous mixture of water and solute units that constitutes a single phase. Each of the dissolved solute units is surrounded by solvent molecules and has no direct contact with other like particles except as permitted by migration through the solution. The particles may carry an electrical charge, or they may be electrically neutral. There can be no doubt that individual ions, or pairs of ions, or even complexes made up of several ions, are in the dissolved state. If the particles are large aggregates that will settle out of the solvent by gravity, they certainly can no longer be said to be in the dissolved state.

Between these extremes lie particles of widely varying sizes that may, under favorable conditions, be retained in suspension indefinitely. These particles generally are considered colloidal, and the smaller colloidal particles merge into the dissolved state. Some textbooks suggest size ranges; for example, Glasstone and Lewis (1960, p. 571) stated that colloidal particles range in diameter from about 5 nanometers (nm) up to about 0.2 micrometer (μm). A micrometer is 10^3 nanometers, or 10^4 angstrom units (A). Therefore by this definition, the lower limit of diameter of colloidal particles is 50 A. A considerable number of organic compounds that may occur in natural water, such as those that impart a brown color, have molecules that are more than 50 A in diameter; hence, by this definition, they can occur only in the colloidal state, even though all particles may be single molecules. Inorganic polymeric ions may also attain collodial size. For example, aluminum hydroxide polymers form charged units containing hundreds of aluminum ions linked together by hydroxide ions (Smith and Hem, 1972, p. D38) that would have diameters between 50 and 100 A. Data presented by Smith and Hem (1972, p. D38) indicate that there is a change in chemical behavior of these polymers when they attain this size, which suggests that a transition between dissolved and particulate states occurs at that point.

Natural surface waters and ground waters carry both dissolved and suspended particles. The amounts of the latter present in ground water before it is brought to the land surface generally are small. But in river water, the concentration of suspended material may be large, and at a high stage of flow in many streams it greatly exceeds the concentration of dissolved solids. This suspended material poses something of a dilemma for the water chemist. In the usual water-chemistry study, the suspended solids are removed before analysis either by filtration or by settling. Both procedures remove particles more than a few tenths of a micrometer in diameter, that is, particles large enough to produce substantial light scattering. The suspended solids are then discarded, and the clear solution is analyzed. Some kinds of suspended material, however, may have an important bearing on the sanitary condition of the water. For example, analyses for the biochemical oxygen demand or for bacterial counts must be made using unfiltered samples. For many of the river-sampling sites used by the U.S. Geological Survey, the quantity of suspended load of streams is determined, but, except for separation into size ranges, very little has been done to determine the chemical composition and related properties of suspended loads of streams. Water users can justifiably say they are not interested in the composition of material they would filter out of the water before they used it in any event; hence, for many practical water-use applications the practice of filtering a sample and analyzing only the filtrate is entirely correct.

Characterization of Suspended Particulate Material

Particle-size distributions of suspended sediment are determined by various procedures, including wet sieving and analyzing differences in settling rate (Guy, 1969). Instrumental procedures also have become available (Ritker and Helley, 1969). Another physical property that has considerable significance is the effective surface area of sediment per unit weight. Surface area measurements of sediment fractions would have a more direct bearing on the physical-chemical behavior of the material than would the particle-size measurements.

A generalized terminology used in many U.S. Geological Survey reports calls sediment having particle diameters ranging from 0.24 μm to 4 μm "clay." Material in the range from 4 to 62 μm is termed "silt," and that in the range from 62 μm to 2.0 mm is termed "sand." In this context, "clay" does not have mineralogic significance.

Chemical composition of sediment can be determined by methods of rock analysis in which all constituents are rendered soluble by strong acid treatment or fusion. The composition may be expressed in mineralogic terms, generally by identifying species present by optical methods or by X-ray diffraction. Besides the various aluminosilicate minerals, metal oxide, hydroxide, and organic materials commonly are present, especially in the finer size classes. The oxide, hydroxide, and organic material also may be present on surfaces of clay particles or other silicate mineral particles in all size ranges. Solute cations are adsorbed on the particle surfaces as well, in proportions related to their relative dissolved concentrations and physicochemical properties of the ions and surfaces.

Physicochemical properties of sediment material that are important in evaluating their behavior toward solutes include the distribution, sign, and intensity of surface electrical charge and the way such charges interact with solute ions. The determinations that can be made to evaluate these properties include charge-site distribution (usually in equivalents or moles of positive or negative charge per unit area), zero point of charge (zpc), cation-exchange capacity (in equivalents per unit weight), and distribution or selectivity coefficients.

The zpc is defined as the pH at which the surface charge is neutral or effectively zero. At lower pH's the charge would be positive, and at higher ones, negative. The other measurements were described earlier in the section titled "Reactions at Interfaces."

Solute-sediment interactions obviously are fraught with complexity. Many attempts to devise methods and techniques for practical evaluation of the effects have been made, but much more work will be required before a good understanding of processes at particle surfaces can be reached.

Gibbs (1973) presented some preliminary data evaluating the relative importance of some solute-sediment interactions in the Amazon and Yukon Rivers. Kennedy (1965) studied the mineralogy and exchange capacity of sediments from 21 U.S. streams and estimated that in many streams, when flow and sediment concentrations were high, the ratio of total adsorbed to total dissolved cations exceeded 0.1 and in some streams was greater than 1.0. The streams studied represented a wide range of geologic and hydrologic condtions. A more recent study of the Amazon by Sayles and Mangelsdorf (1979) also showed that at flood stages the ratio exceeded 0.1, but these writers believed the adsorbed fraction was insignificant on an average annual basis because the Amazon usually carries low sediment concentrations. On reaching the ocean, many of the adsorbed ions are probably exchanged for sodium. The adsorbed ions also may be exchanged for solute ions in the stream water if the composition of the water changes owing to inflows of fresh or saline water.

Technologies for evaluating the adsorbed or readily available fractions of solutes held by stream sediment have been suggested by Gibbs (1973), Malo (1977), and many others. However, methods that will produce reliable, complete, and reproducible results at what would generally be considered acceptable cost, for routine data-collection purposes, do not presently exist.

In the first place, separation of the solution phase from the solids is required. It should be evident to the most uninitiated student of water chemistry that the chemical and physical behavior of the adsorbed material will differ from that of the dissolved material both in the steam itself and during any treatment process. Determinations of inorganic constituents on unfiltered samples, which is practiced by some laboratories that analyze river water routinely, give results that can be interpreted only in a gross, qualitative way. Unfortunately, also, some of the data obtained by this procedure have been stored in data banks or have been published without any clear indication that they represent unfiltered samples.

Separation of the phases is routinely done by filtration in the field through membrane filters having pores 0.45 μm in diameter. This size opening has come to be generally adopted as defining "dissolved," as opposed to "particulate," material. Most of the time, however, samples having significant sediment contents tend to plug many of the filter pores and effectively decrease the pore diameters to some value less than 0.45 μm. Observations of the effectiveness of filtration in removing fine particles of aluminum, iron, manganese, and titanium oxides and hydroxides from river water were reported by Kennedy and others (1974). These investigators found that filter membranes having pores 0.10 μm in diameter were considerably more effective for removing these materials than were membranes having larger pore diameters.

After filtration, the preferable procedure is to analyze both phases. Part of the filtrate is usually stabilized by acidification, which generally dissolves any colloidal material that might be present and minimizes adsorption of cations on container walls. Major constituents are determined using an unacidified fraction of the filtrate, because some constituents would be altered or destroyed by acid treatment. Analysis of the filtrate is straightforward. Characterization of the residue on the filter is much more difficult. The amount of original sample filtered needs to be known so that results may be properly assigned to a specific volume of water. The total weight of residue must be determined. Various types of treatment may then be used, either serially or on separate aliquots, to recover potentially soluble material. The treatments that have been used to recover the material range from simple to very complex, from extractions with neutral solutions of ammonium salts to displace adsorbed ions, through mild reducing agents, dilute acids or bases,

oxidizing acids, and, finally, dissolution in hydrofluoric acid mixtures or through alkali fusion procedures used in rock analysis.

Owing to the complexity of some of these analysis schemes and the difficulty in carrying them out or in interpreting the results, simpler analytical procedures have been used in the U.S. Geological Survey water laboratories. A determination of "total recoverable" inorganic constituents is made using a specific volume of unfiltered sample that is acidified with hydrochloric acid to a molarity near 0.3 in H^+ and is held at a temperature near the boiling point for 30 minutes. The sample is then filtered and the required analytical determinations are made on the filtrate (Skougstad and others, 1979).

Data obtained in this way must be supplemented by comparable analyses of filtered fractions of the same sample. The amount of total solute that was associated with the solid phase can then be estimated.

The bulk composition of sediments carried to the ocean by many large rivers was determined by Martin and Meybeck (1979). They also estimated proportions of the various elements transported in suspended as opposed to dissolved forms. According to these authors, the ratio of dissolved to total quantity transported exceeds 0.5 only for bromine, iodine, sulfur, chlorine, calcium, sodium, and strontium.

Hydrogen-Ion Activity (pH)

The effective concentration (activity) of hydrogen ions could be expressed in the same kinds of units as other dissolved species, but H^+ concentrations in milligrams per liter or moles per liter are very low for water solutions that are not strongly acid. The activity of hydrogen ions can be expressed most conveniently in logarithmic units, and the abbreviation "pH" represents the negative base-10 log of the hydrogen-ion activity in moles per liter.

Theoretical concepts and various practical aspects of pH determination have been discussed at length in the literature. Bates (1973) has prepared an excellent and authoritative summary of these topics. The notation "pH" is now generally taken to mean hydrogen-ion activity rather than concentration, although the distinction between these concepts was not understood at the time Sorensen proposed the use of the pH notation in 1909. Throughout this discussion the term "hydrogen ion" is used with the reservation that such species exist only in hydrated form in aqueous solution.

Even when no other solutes are present, a few of the H_2O molecules in liquid water will be broken up into H^+ and OH^- ions. This process of dissociation is a chemical equilibrium that may be written

$$H_2O(l)=H^++OH^-.$$

In mass-law form, the equilibrium can be expressed as the equation

$$\frac{[H^+][OH^-]}{[H_2O]}=K_w.$$

By convention, the activity of the liquid water is taken to be unity in this very dilute solution, and the constant K_w is then equal to the product of the activities of H^+ and OH^-. This ion-activity product for water at 25°C is, in exponential terms, $10^{-14.000}$ (Covington and others, 1966). The two-place log of K_w is −14.00. At neutrality, by definition $[H^+]=[OH^-]$ and therefore pH=7.00.

At higher temperatures, K_w increases and the neutral value of pH becomes smaller; the value for 30°C given by Covington and others (1966) is $10^{-13.837}$. Neutral pH at 30°C therefore would be 6.92. The value of K_w at 0°C was given by Ackerman (1958) as $10^{-14.955}$, which means that neutral pH at that temperature is 7.48. The strong effect of temperature on hydrogen-ion behavior has considerable geochemical significance and must be taken into account in measurements of pH and in calculations using pH data.

The hydrogen-ion content of a natural water computed in moles per liter (milligrams per liter for H^+ is nearly the same as millimoles per liter) is usually in the "trace constituent" range. At pH 7, only 1×10^{-7} moles per liter of hydrogen ion is present, for example. The major constituents of most waters are in the concentration range of 10^{-4} moles per liter and up. Thus the hydrogen-ion content does not begin to approach the status of a major component of the solution until the pH goes below 4.0. A pH of less than 0 or greater than 14 can be attained in concentrated acid or base solutions.

The hydrogen-ion activity in an aqueous solution is controlled by interrelated chemical reactions that produce or consume hydrogen ions. The dissociation equilibrium for water is always applicable to any aqueous solution, but many other equilibria and many nonequilibrium reactions that occur in natural water among solute, solid and gaseous, or other liquid species also involve hydrogen ions. The pH of a natural water is a useful index of the status of equilibrium reactions in which the water participates.

The reaction of dissolved carbon dioxide with water, which is one of the most important in establishing pH in natural-water systems, is represented by the three steps

$$CO_2(g)+H_2O(l)=H_2CO_3(aq),$$

$$H_2CO_3(aq)=H^++HCO_3^-,$$

and

$$HCO_3^-=H^++CO_3^{2-}.$$

Both the second and third steps produce H^+ and influence the pH of the solution. Other reactions involving dissociations of acidic solutes include

$$H_2PO_4^-=HPO_4^{2-}+H^+,$$

$$H_2S(aq)=HS^-+H^+,$$

and

$$HSO_4^-=SO_4^{2-}+H^+.$$

Many of the reactions between water and solid species consume H^+; for example,

$$CaCO_3(c)+H^+=Ca^{2+}+HCO_3^-$$

and

$$2NaAlSi_3O_8(c)+2H^++9H_2O(l)=Al_2Si_2O_5(OH)_4(c)+4H_4SiO_4(aq)+2Na^+.$$

The second of these involves alteration of water, and the first could also be written as

$$CaCO_3(c)+H_2O(l)=Ca^{2+}+HCO_3^-+OH^-.$$

These are commonly called hydrolysis reactions, and all such reactions influence or are influenced by pH.

Certain reactions in which precipitates are formed, such as

$$Fe^{3+}+3H_2O=Fe(OH)_3(c)+3H^+,$$

influence pH, and most oxidation reactions are pH related,

$$FeS_2(c)+8H_2O=Fe^{2+}+2SO_4^{2-}+16H^++14e^-$$

This reaction requires something to take up the electrons it produces—that is, something must be reduced as the sulfur is oxidized. The usual oxidizing agent probably is atmospheric oxygen. The rest of the complete equation, then, would be

$$7/2O_2+14e^-+14H^+=7H_2O.$$

Adding these together gives

$$FeS_2+7/2O_2+H_2O=Fe^{2+}+2SO_4^{2-}+2H^+.$$

If a particular reaction or set of reactions involving water, hydrogen ions, other solutes, and solids or gases has attained equilibrium, the pH that should be attained can be computed by the mass law and a set of simultaneous equations. General procedures for making such computations have already been outlined.

Under nonequilibrium conditions, the pH of the natural water can reach a steady value effectively controlled by a single dominant chemical process or a set of interrelated reactions. The controlling species are generally those present in the system or available to it in the largest quantity or those whose reaction rates are fastest.

The control of pH by chemical equilibria can be illustrated by a simplified example. When pure water is in contact with a constant supply of gas containing CO_2 such as the atmosphere, carbon dioxide will be dissolved up to a specific solubility limit depending on temperature and pressure. At 25°C and 1 atmosphere of pressure, the chemical equilibria involved are those already given for the solution and dissociation of dissolved carbon dioxide and of water. Mass-law equations for these equilibria at 25°C and 1 atmosphere are

$$\frac{[H_2CO_3]}{P_{CO_2}}=K_h=10^{-1.43},$$

$$\frac{[HCO_3^-][H^+]}{[H_2CO_3]}=K_1=10^{-6.35},$$

$$\frac{[H^+][CO_3^{2-}]}{[HCO_3^-]}=K_2=10^{-10.33},$$

and

$$[H^+][OH^-]=K_w=10^{-14.00}.$$

Also, the constraint of electrical neutrality requires that there must be a cation-anion balance in the solution, represented by $C_{H^+}=C_{HCO_3^-}+2C_{CO_3^{2-}}+C_{OH^-}$. The quantity P_{CO_2} is the partial pressure of carbon dioxide in the gas phase—that is, the volume percent of CO_2 multiplied by the total pressure, in atmospheres, and divided by 100. The bracketed quantities are activities of solute species, in moles per liter, and C terms represent ion concentrations in the same units. Because this will be a very dilute solution, ion activities and actual concentrations are virtually the same.

There are five equations governing this system and a total of six variables—the P_{CO_2} and five solute activities.

Therefore, if one variable is specified, all the others will be fixed. The average value of P_{CO_2} for the atmosphere is $10^{-3.53}$ and is nearly constant; therefore, pure water in contact with air having the average CO_2 content will have a fixed pH and compatible concentrations of the related ions. The pH calculated for these conditions is 5.65. At 0°C the pH would be 5.60.

Although natural water can be expected to contain other ions, rainwater, in the absence of atmospheric pollution, might be expected to approach the conditions specified in this example, and a pH in the vicinity of 5.6 is frequently observed. The pH of ordinary laboratory distilled water often is near this value also.

If it is further specified that the system contains an excess of solid calcite, $CaCO_3$(c), the four mass-law equations for equilibria still apply, along with a fifth representing the solution of calcite:

$$\frac{[Ca^{2+}][HCO_3^-]}{[H^+]}=K_{eq}.$$

One more solute species is added to the ion balance equation, giving

$$2C_{Ca^{2+}}+C_{H^+}=C_{HCO_3^-}+2C_{CO_3^{2-}}+C_{OH^-}.$$

The system now has seven variables related by six equations, and, again, if one is specified all the others will be fixed. For example, at equilibrium in this system, according to Garrels and Christ (1964, p. 83), if the gas phase is ordinary air, the pH at 25°C will be 8.4.

Garrels and Christ (1964, p. 83–91) gave calculations for other conditions involving carbonates. It should be evident from the examples how the pH enters into the equilibrium calculations. Furthermore, it should be apparent that this way of studying natural-water composition has many interesting possibilities. It is unsafe, however, to assume that pH in natural water is always at a value fixed by carbonate equilibria.

Buffered Solutions

A solution is said to be buffered if its pH is not greatly altered by the addition of moderate quantities of acid or base. Buffering effects occur in systems in which pH is controlled by reversible equilibria involving hydrogen and other ions, and the range of pH over which buffering is effective depends on the nature of the other solute species. Most natural waters are buffered to some extent by reactions that involve dissolved carbon dioxide species. The most effective buffering action by these species is within the pH range of most natural waters.

Some insight into the mechanisms can be obtained by briefly reviewing the carbon dioxide–water equilibria just discussed. If the principal solutes are H_2CO_3 and HCO_3^- the first dissociation of carbonic acid,

$$H_2CO_3=HCO_3^-+H^+,$$

will be the dominant control over pH. In mass-law form at 25°C and 1 atmosphere,

$$\frac{[HCO_3^-]}{[H_2CO_3]}=\frac{10^{-6.35}}{[H^+]}.$$

If strong acid is added to this system, the reaction will be driven to the left, but a considerable number of hydrogen ions may be used up before the ratio changes enough to alter the pH noticeably. This buffering effect is strong in solutions that contain considerable amounts of two dissolved CO_2 species. In this example, if the total activity of the two species is 2×10^{-2} moles/L, when their ratio is unity, each will be present in an activity of 1×10^{-2} moles/L (610 mg/L HCO_3), and the pH will be 6.35. To produce enough change in the ratio to cause a noticeable decrease in pH (about 0.01 pH unit), one would have to add at least 10^{-4} moles/L of hydrogen ions to convert HCO_3^- ions to H_2CO_3 species. The free hydrogen ions in the system, as indicated by pH, would remain less than 10^{-6} moles/L. Thus the quantity of reacted H^+ would be some 100 times as great as the activity of free H^+.

Other equilibria within the system also are affected when H^+ is added or removed, and redistribution of the H^+ among all these other reactions adds to buffering effects. The observed pH of a natural water is, in this sense, a convenient indicator of the status of these equilibria, but H^+ ions themselves normally are minor constituents of the solution. The pH of some waters is held at levels considerably below the buffering range of dissolved carbon dioxide species by redox reactions, such as the oxidation of pyrite or sulfur in other forms.

Although the concept of control of pH by buffering is related to the capacity of a system to participate in a chemical reaction, the property of buffer "intensity" is also a useful concept. For any given solution, this property is defined as the reciprocal of the slope of the titration curve at any given point in the titration (Stumm and Morgan, 1981, p. 159).

The concept of buffering action can be extended to heterogeneous systems, in which interactions between solutes and solids may effectively maintain relatively constant concentrations of H^+ and other solute species (Stumm and Morgan, 1981, p. 558).

Range of pH of Natural Water

As stated previously, the pH of pure water at 25°C is 7.00. Most ground waters found in the United States

have pH values ranging from about 6.0 to about 8.5, but water having lower pH is not uncommon in thermal springs. Water having a pH much greater than 9.0 is unusual but by no means unknown. Values as high as 11.6 (Feth and others, 1961) and 12.0 (Barnes and O'Neil, 1969) have been observed in springs. The high pH values of waters studied by Barnes and O'Neil were ascribed to reactions of meteoric water with ultramafic rock in which serpentinite was produced. These reactions evidently consume H^+ more rapidly than it can be supplied in this system by any influx of carbon dioxide species. In contrast, some thermal springs (for example, analysis 3, table 18) may yield water whose pH is below 2.0.

River water in areas not influenced by pollution generally has a pH in the range 6.5 to 8.5. Where photosynthesis by aquatic organisms takes up dissolved carbon dioxide during daylight and the organisms release CO_2 by respiration at night, pH fluctuation may occur and the maximum pH value may sometimes reach as high as 9.0. Livingstone (1963, p. G9) gave an example of diurnal pH fluctuations in what was evidently a poorly buffered lake water in which the maximum pH exceeded 12.

In carbonate-dominated systems the arrays of equilibrium equations cited earlier may provide a basis for calculating the relative intensity of carbon dioxide sources. This calculation requires assuming that measured alkalinity and pH values can be used to calculate a partial pressure of carbon dioxide in an initial source, such as the air present in soil.

Table 11 gives three analyses of waters whose pH is controlled by equilibria involving carbon dioxide species and solid calcium carbonate. Analysis 1 is for a spring whose water was rather highly charged with carbon dioxide. The pH measured in the field at the time of sampling was 7.54. The water precipitated calcium carbonate in the sample bottle, and a second analysis of the sample made 6 months after the first shows a major change in both calcium and bicarbonate concentrations, accompanied by an increase in pH of almost a full unit. Analysis 3 is for a spring issuing from limestone near the mouth of the Little Colorado River in Arizona. This water deposits travertine in the riverbed, and it is likely that a pH value considerably higher than the 6.5 reported in analysis 3 would be observed in the water where precipitation was nearing completion. The pH of 9.4 reported for analysis 1, table 18, may be associated with hydrolysis reactions involving silicates in a system containing little carbon dioxide. The pH of the sodium carbonate brine from Wyoming (analysis 2, table 18) probably was near 11, but it was not reported in the published analysis. The low pH value (1.9) for analysis 3, table 18, results from the oxidation of sulfur species. Fumaroles in the vicinity yield sulfur dioxide.

The pH of a water sample can also be affected by oxidation of dissolved ferrous iron. The data in the following table represent successive determinations of ferrous iron and pH on a sample of water collected from the overflow of the Seneca anthracite mine at Duryea, Pa., on July 16, 1963 (unpub. analyses by U.S. Geological Survey):

Date (1963)	Time after sampling (days)	Fe^{+2} (mg/L)	pH
July 16	0		4.98
July 30	14	135	3.98
Aug. 20	35	87	3.05
Sept. 24	70	41	2.81
Oct. 29	105	2.2	2.69

The sample contained a high concentration of iron, and its pH decreased by more than 2 units as the ferrous iron was oxidized and precipitated as ferric hydroxide.

Measurement and Interpretation of pH

Electrochemical measurement of hydrogen-ion activity and the logarithmic pH scale for expressing the results originated in the first decade of the 20th century. During the 1920's and 1930's, the glass electrode was developed into a reliable and convenient sensing device (Dole, 1941) and the determination of pH was widely practiced in industrial and water treatment process control laboratories. Baylis (1927), for example, described the use of pH data in treating water to decrease its corrosiveness toward iron pipe. A paper by Atkins (1930) pointed out some possible applications in geochemistry, and measured pH values appear in many water analyses published during the 1930's.

A compilation of analyses of water from the Rio Grande at various points in Colorado, New Mexico and Texas (Scofield, 1938) indicates that the U.S. Department of Agriculture laboratory at Riverside, Calif., began publishing pH values as part of their water analyses in late 1933. U.S. Geological Survey laboratories did not begin to publish such data for river water until about a decade later. All these early measurements were made in the laboratory, and instrumental field measurements did not become common practice until the 1950's.

The design and construction of pH meters and electrodes were greatly improved during the 1950's and 1960's, and modern instruments are capable of measuring pH either in the laboratory or in the field with an experimental reproducibility of ± 0.01 or 0.02 unit. This degree of precision requires careful work and special attention to electrode maintenance, buffer solutions, and temperature corrections. Barnes (1964) described procedures for precise field measurements.

A more primitive method formerly used for measuring pH in the field employed colored pH indicators. This technique is capable of measuring pH with an experimental reproductibility of only ±0.10 unit under the most favorable conditions and is not suitable for water that is naturally colored or poorly buffered. For the indicator compound to develop its color, it must participate in a reaction using or generating H^+, and this, in a nearly unbuffered solution, can overwhelm the buffering system and give a false pH value.

The measured pH is a very important piece of information in many types of geochemical equilibrium or solubility calculations, and values that are inaccurate or unrepresentative are a substantial source of error in such work. Measurements of pH that date back to the early 1950's or before may have rather large experimental uncertainties owing to equipment or methods. In addition, another serious type of uncertainty affects many pH values that are reported in older water analysis literature. Many of these values were determined in the laboratory after the samples had been stored for a considerable period of time. Field determinations of pH did not become common practice in U.S. Geological Survey investigations until the late 1960's. Obviously, field determinations are much more likely to represent conditions in the water that was sampled than are laboratory pH determinations. Effects of temperature and mixing of water from different aquifer sections in pumping wells may make interpreta-

Table 11. Analyses of waters with unstable pH

[Analyses by U.S. Geological Survey. Date under sample number is date of collection. Sources of data: 1, 2, U.S Geological Survey, unpublished data; 3, Cooley (1976, p. F10)]

Constituent	1 Jan. 5, 1967		2 Jan. 5, 1967		3 June 14, 1950	
	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L
Silica (SiO_2)	22		22		19	
Iron (Fe)	.02		.00		.01	
Manganese (Mn)	.01					
Zinc (Zn)	.02					
Calcium (Ca)	93	4.64	22	1.10	264	13.17
Magnesium (Mg)	58	4.77	54	4.44	79	6.50
Sodium (Na)	15	.65	15	.65	513	22.31
Potassium (K)	1.2	.03	1.1	.03	23	.59
Strontium (Sr)	.50	.01				
Carbonate (CO_3)					0	
Bicarbonate (HCO_3)	556	9.02	297	4.87	964	15.80
Sulfate (SO_4)	50	1.04	55	1.15	147	3.06
Chloride (Cl)	16	.45	17	.48	815	22.99
Fluoride (F)	.3	.02			.2	.01
Nitrate (NO_3)	.1	.00			3.2	.05
Boron (B)	.02					
Dissolved solids:						
Calculated	530		332		2,340	
Residue at 180°C						
Hardness as $CaCO_3$	470		277		984	
Noncarbonate	19		34		194	
Specific conductance (micromhos at 25°C)					3,940	
pH	7.54		8.40		6.5	

1. Spring on headwaters of Blackbird Creek, SE1/4 sec. 6, T. 6 S., R. 5 E., San Mateo County, Calif. Temperature, 7°C. pH measured at time of collection. Calcium determined on acidified sample.
2. Reanalysis of unacidified fraction of sample 1 after 6 months of storage in laboratory.
3. Spring discharging into Little Colorado River, 13 mi from mouth, Coconino County, Ariz. One of a group known as Blue Springs. Water-bearing formation Redwall Limestone. Water contains CO_2 and deposits travertine. Discharge of group, about 200 cfs, temperature, 20.6°C. pH measured in laboratory.

tion of the most carefully determined pH values a very uncertain and difficult task.

As implied in the examples in this section, H^+ ions are produced within natural-water systems by various types of chemical reactions and are largely consumed by participating in subsequent chemical reactions in the system. Graphical summaries of solute and solid phase chemistry commonly use pH as one of the plotted variables, and some examples will be given in later sections of this book.

Specific Electrical Conductance

Electrical conductance, or conductivity, is the ability of a substance to conduct an electric current. Specific electrical conductance is the conductance of a body of unit length and unit cross section at a specified temperature. This term is synonymous with "volume conductivity" and is the reciprocal of "volume resistivity" (Weast, 1968, p. F-71). The American Society for Testing and Materials (1964, p. 383) defined electrical conductivity of water as "the reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a specified temperature." This definition further specifies that units for reporting conductivity shall be "micromhos per centimeter at t°C." Because the definition already specifies the dimensions of the cube to which the measurement applies, the added precaution of including the length in the unit may not be essential and is often omitted in practice. Geophysical measurements of resistivity, however, commonly are expressed in ohm-meters, referring to a cube 1 m on a side, so it may be a good idea to emphasize that conductances of water refer to a centimeter cube. The standard temperature for laboratory measurements is 25°C, but because other standard temperatures were used in the past it is important that the temperature of measurement be specified.

Units for Reporting Conductance

Because conductance is the reciprocal of resistance, the units in which specific conductance is reported are reciprocal ohms, or mhos. Natural waters have specific conductances much less than 1 mho, and to avoid inconvenient decimals, data are reported in micromhos—that is, the observed value of mhos is multiplied by 10^6. Before October 1, 1947, the specific conductance values reported by the U.S. Geological Survey were mhos$\times 10^5$. To convert these older values to micromhos, they should be multiplied by 10.

Under the International System of Units (SI) it has been proposed that the unit of conductivity by renamed the "siemens." The microsiemens (μS) is numerically the same as the micromho. The change in terminology has not yet been fully adopted in the U.S. literature.

Physical Basis of Conductance

Pure liquid water has a very low electrical conductance: a few hundredths of a micromho per centimeter at 25°C. This value has only theoretical significance, because water this pure is very difficult to produce. The presence of charged ionic species in solution makes the solution conductive. As ion concentrations increase, conductance of the solution increases; therefore, the conductance measurement provides an indication of ion concentration.

The relationship between ionic concentration and specific conductance is fairly simple and direct in dilute solutions of single salts. Figure 8 is a graph of the specific conductance at 25°C of potassium chloride solutions with concentrations up to 0.01 molar (746 mg/L). The relationship over this range of concentration is a straight line. As the concentration is increased, however, the slope decreases slightly; for a concentration of 7,460 mg/L, the conductance is 12,880 μmho/cm rather than near 14,000, as an extrapolation of the slope in figure 8 would predict. This general behavior is typical of all salts, but the slope of the straight part of the curve and the degree to which it flattens with increasing concentration are different for different salts.

Figure 9 shows the change in conductance of a solution containing 746 mg/L of potassium chloride between 0° and 35°C. Over this temperature range the conductance of the solution more than doubles. This demonstrates the need for referring specific-conductance measurements to a definite temperature. The response of the conductance value to temperature change is somewhat different for different salts and different concentrations, but in dilute solutions for most ions an increase of 1°C

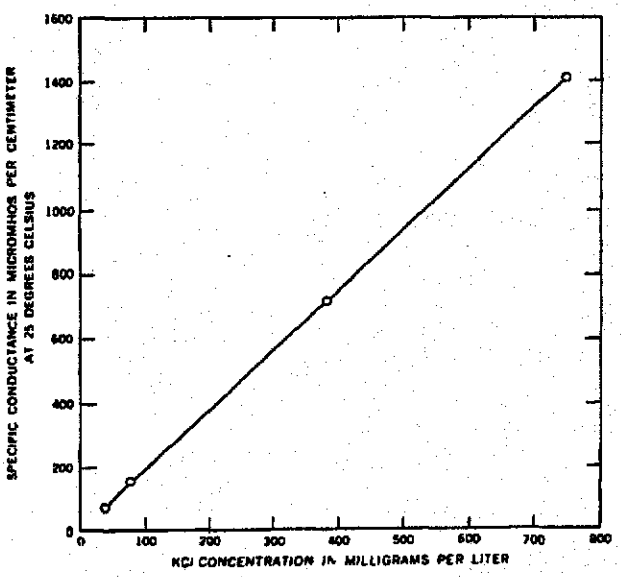

Figure 8. Specific conductance of potassium chloride solutions.

AEROJET SUPERFUND SITE
RANCHO CORDOVA, CA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY • REGION IX • NOVEMBER 2000

EPA Proposes a Plan to Address Groundwater Contamination in the Western Area of the Aerojet Site

About the Proposed Plan

The Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) are jointly responsible for the Aerojet Superfund site under a 1989 Partial Consent Decree (PCD). Under the PCD, Aerojet-General Corporation agreed to conduct a remedial investigation and feasibility study (RI/FS) to specify the nature and extent of contamination at the site and to identify alternatives for cleaning up the contamination. EPA has developed this proposed plan in consultation with DTSC and RWQCB to allow the public to review and comment on all of the clean-up alternatives evaluated in the RI/FS, in accordance with section 117(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and section 300.430(f)(2) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The function of the proposed plan is to (1) provide basic background information; (2) identify the preferred alternative for remedial action for the operable unit and reasons for the preference; (3) describe the other clean-up options considered; (4) solicit pubic review and comment on all alternatives described; (5) provide information on how the public can be involved in the remedy selection process; (6) explain the relationship of the RI/FS to the proposed plan; and (7) describe the importance to the remedy selection process of public input on all alternatives.

This fact sheet presents the U.S. Environmental Protection Agency's proposed plan for addressing health risks presented by contaminated groundwater in the western area of the Aerojet Superfund site, known as operable unit 3 (OU-3), in the Rancho Cordova unincorporated area of Sacramento County, California (see Figure 1, to right). The Environmental Protection Agency (EPA) is seeking public comments on this proposed plan.

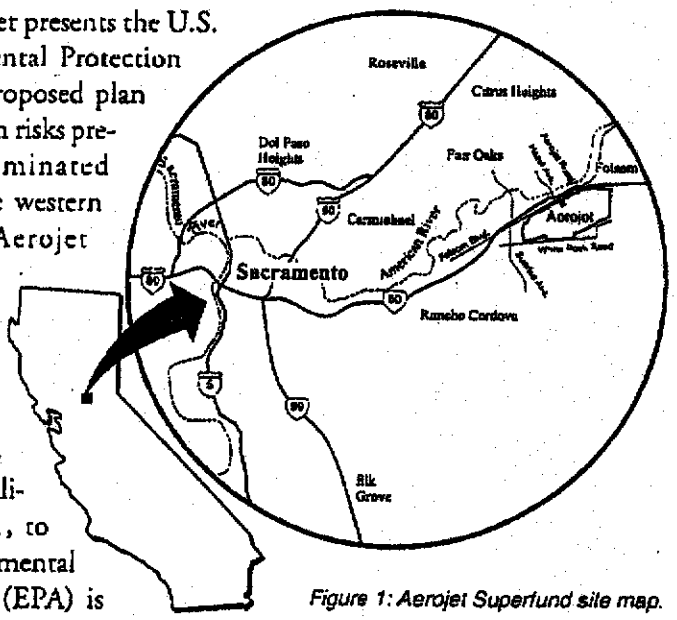

Figure 1: Aerojet Superfund site map.

The feasibility study for OU-3 evaluated ten alternative approaches as potential remedies for this contamination. To be considered as a possible remedy for a hazardous waste problem, an alternative must meet EPA's two threshold criteria. These criteria stipulate that the remedy must (1) protect human health and the environment and (2) comply with the applicable or relevant and appropriate requirements (ARARs) of the various government entities with authority over the site. Of the ten alternatives developed during the Feasibility Study (FS), this proposed plan presents and compares the seven alternatives that meet EPA's threshold criteria. (See box "EPA's Remedy Selection Criteria" on page 6).

PUBLIC COMMENT PERIOD
December 1, 2000 - January 30, 2001

COMMUNITY MEETING

Thursday, December 7, 2000
7:00 to 9:00 pm
Mills Middle School
10243 Coloma Road
Rancho Cordova, CA 95670

May 06 02 03:19p Komex-H2O Science, INC. 916-797-0200 p.2

After evaluating these seven cleanup alternatives according to eight of the nine mandated evaluation criteria (see Table 3 on page 11), EPA prefers alternative 4C as the remedy that provides the best balance of the trade-offs among the criteria. Alternative 4C calls for modifying the existing groundwater extraction and treatment (GET) system on the Aerojet property and installing additional extraction wells off-property near the leading edge of the plume in the affected layers. EPA believes that alternative 4C provides the best overall containment, extraction, treatment, and monitoring of OU-3's contaminated groundwater. EPA identifies its preferred remedy so that the public can comment on it along with the other alternatives considered. EPA will consider and respond to significant comments on this proposed plan before selecting the remedy for OU-3 at Aerojet.

Since EPA began work on the site in 1988, EPA has provided fact sheets (the latest in July 2000) and other notifications to the public. The RI/FS report, EPA fact sheets, and all documents relevant to OU-3 are available in the administrative record at the local records repository and at the EPA regional office in San Francisco (see Public Comment and Community Meeting box on front page for details).

The EPA encourages the public to review the RI/FS for OU-3 and other detailed information in the Administrative Record, in order to gain a more comprehensive understanding of OU-3, and then to comment on any of the alternatives presented in this proposed plan. The public comment period is from December 1, 2000 to January 30, 2001. ***The EPA invites the public to a meeting scheduled for December 7, where the EPA will present this plan and receive verbal comments*** (see Public Comment Period and Community Meeting box on front page for details). After EPA reviews and responds to public comments, we will formally announce the selected remedy in a document called a Record of Decision (ROD) for OU-3. The ROD, to be completed in 2001, will include a summary of public comments with EPA's responses. The remedy specified in the ROD for OU-3 may differ from the preferred alternative in this plan as a result of these comments. Once the remedy is selected, EPA intends to negotiate an agreement with Aerojet-General Corporation for performing the work.

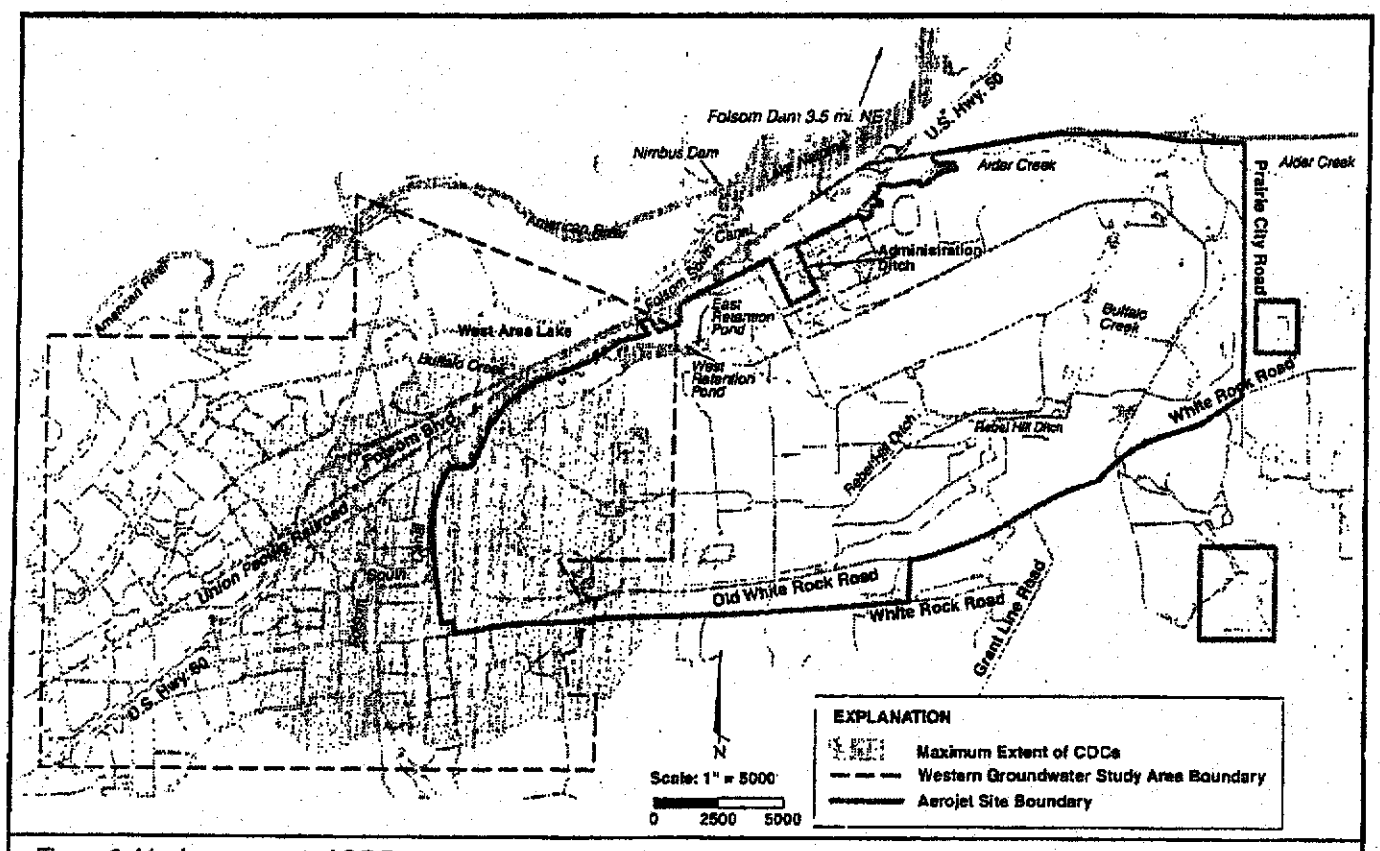

Figure 2: Maximum extent of COCs.

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SITE HISTORY

Aerojet-General Corporation (Aerojet) has operated at the Rancho Cordova site since 1953. Its operations included manufacturing liquid and solid propellants for rocket engines for military and commercial use, and formulating chemicals including rocket propellant agents, agricultural pesticides, pharmaceuticals, and other industrial chemicals. Currently Aerojet produces pharmaceuticals and other chemicals at the site. Also, the Cordova Chemical Company operated chemical manufacturing facilities on the Aerojet property from 1974 to 1979.

Some wastes from these manufacturing activities on the Aerojet-General property were disposed of in surface impoundments, landfills, deep injection wells, leachate fields, and open burn areas. As a result of these former disposal practices, contamination of groundwater extends off the Aerojet property. The Western Groundwater Operable Unit (OU-3) remedial investigation and feasibility study (RI/FS) addressed groundwater on the western side of the Aerojet site that contains detectible levels of several chemicals of potential concern (see Table 1 on page 7 for details), primarily perchlorate, trichloroethylene (TCE) and other volatile organic compounds (VOCs), and N-Nitrosodimethylamine (NDMA).

In the mid 1980s, Aerojet installed two groundwater extraction and treatment (GET) facilities (designated as GET E and GET F) on the western side of its property to contain and treat VOCs (primarily TCE) on-property. Treated water was reinjected back into the aquifer. Wellhead treatment removed low-level TCE in the few off-property drinking water wells where it was found.

Perchlorate was first detected off the Aerojet property in 1997 when the ability to measure perchlorate significantly improved. NDMA was first detected off-property in 1998 when its measurability similarly improved. Due to the discovery of these contaminants in drinking water, local water purveyors had to shut down several drinking water supply wells in the area to protect the public. In response, Aerojet developed a first-of-its-kind biological process to treat perchlorate to non-detection levels and added this process to GET F in 1998. In 1999, Aerojet combined GETs E and F to provide for the full treatment of perchlorate from all western extraction wells using the new biological system, and also added NDMA treatment using ultra-violet light.

In October of this year, Aerojet completed an RI/FS for the Western Groundwater Operable Unit, under the oversight of the California Department of Toxic Substances Control (DTSC), the Regional Water Quality Control Board (RWQCB), and EPA, resulting in this proposed plan for clean-up.

To reinject or not to reinject . . .

Reinjection, or the pumping of treated water back into the ground, is an issue because of the history of remediation at the Aerojet site. Perchlorate and NDMA were returned to the aquifer on the western side of the Aerojet property, after the removal of VOCs until 1999, further contaminating the aquifer. Some stakeholders, especially local water purveyors, fear contaminated water could again be returned to the aquifer, prolonging the cleanup.

The advantage of reinjection is that it would prevent groundwater extraction from lowering the water table and make more groundwater available for pumping down-gradient. However, reinjection would not dilute any potential residual contaminants, while discharging into surface waters would. Reinjection could also help direct groundwater to existing extraction wells, making those wells more effective at containing the plumes of contamination. However, because the geological strata underlying the site are complex, additional extraction wells would likely be more effective than reinjection at controlling the plumes.

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SITE CHARACTERISTICS

Land Use

The Western Groundwater Operable Unit (OU-3) at Aerojet is partly on the western side of the Aerojet property and partly extends off the Aerojet property into developed areas of Rancho Cordova (see Figure 2 on page 2). Currently the on-property portion of OU-3 contains the combined GET E/F treatment facility with extraction and monitoring wells, as well as an explosive storage area, access roads, and a few other structures associated with Aerojet operations. However, under the Sacramento County Land Use Master Plan, a large portion of the on-property part of OU-3 could be used for residential development in the future. Off-property, the land immediately adjacent to Aerojet is entirely zoned as heavy and light industrial. Other surrounding areas are developed with a combination of industrial, office, commercial, residential, and recreational uses (the American River flood plain and the edges of the adjacent bluffs are designated as recreational zones). Because the Rancho Cordova area is fully developed, current land use will likely continue.

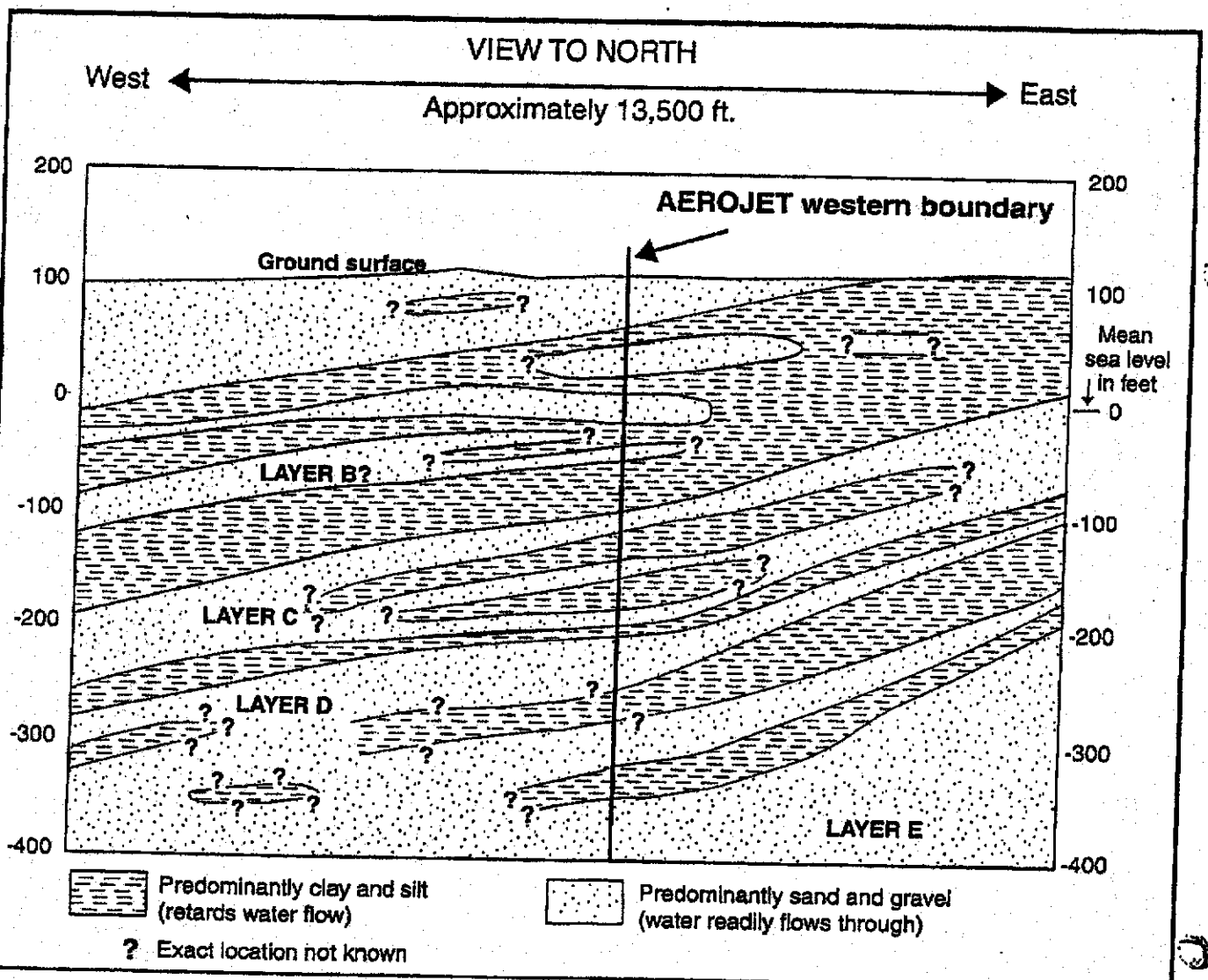

Figure 3: Site hydrogeology approximately parallel to Union Pacific Railroad (Simplified, not to scale).

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Hydrogeology

On the western portion of the Aerojet Site, groundwater flows generally to the west-southwest through a complex, mixed aquifer. The aquifer has been subdivided into five layers (A through E) based on similarity of composition and water flow properties (see Figure 3 on page 4). The aquifer under OU-3 is used for drinking water and Layers C, D, and E are adversely impacted by the present groundwater contamination. The source of the contamination, which is not located in or part of OU-3, will be addressed later, after the risk to local drinking water supplies is mitigated.

Overall, the most contaminated layer of the aquifer is C. Layer C contamination is approximately nine square miles in area and contains approximately 61 percent of the total contamination. Perchlorate is the main contaminant, with the widest distribution, extending to Zinfandel Avenue, and the highest off-property concentration, 8,000 parts per billion (ppb). TCE is the second most prevalent contaminant. It projects off-property in a long narrow plume along Highway 50 and Folsom Boulevard to just beyond Zinfandel Avenue, with a maximum detected off-property concentration of 97 ppb. NDMA is the third most prevalent chemical in Layer C. A small plume extends to the northwest extending beyond Sunrise Boulevard, with a maximum detected concentration off-property of 0.39 ppb. Table 1 on page 7 shows additional contaminants found on-property at levels above EPA or State action levels.

Layer D contamination is approximately 4.6 square miles in area and contains approximately 31 percent of the total contamination. The main contaminant is perchlorate, extending in a narrow plume to halfway between Sunrise Boulevard and Zinfandel Avenue, with a maximum detected concentration off-property of 420 ppb. In layer D, both TCE and NDMA extend off-property slightly to the northeast with maximum detected concentrations of 8.5 ppb and 0.49 ppb respectively.

Layer E contamination is approximately one square mile in area and contains approximately 9 percent of the total contamination. In layer E, only a small portion of perchlorate, TCE, and NDMA contamination extends off-property. NDMA extends the furthest in a narrow plume which does not reach Sunrise Boulevard. The maximum detected off-property concentrations are: perchlorate at 410 ppb, TCE at 220 ppb, and NDMA at 0.18 ppb.

Direct vs. indirect reuse of treated water

Some of the alternatives presented in this proposed plan would allow for either direct or indirect reuse of the treated water. Direct reuse means that the treated water is piped straight to a water company for delivery to its customers. Such water must meet drinking water standards. No site treatment permit for all the contaminants of concern at Aerojet has been issued that would allow direct reuse of the water. However, the drinking water program of the California Department of Health Services is currently evaluating permitting an application in southern California of a new technology that might also work at Aerojet.

Under the indirect reuse option, treated water would be discharged under permit to Buffalo Creek, which flows to the American River. The treated water would meet state and federal drinking water standards. In addition, the surface water discharge would be diluted by river water, and the water would be treated again before any downstream systems distributed it to consumers. Water distributors affected by the Aerojet groundwater contamination could receive replacement water via the Folsom South Canal diversion from the American River. The cost estimate for this option includes new piping from the Folsom South Canal to a new surface water treatment plant that would supply the water purveyors' systems, replacing lost water supplies.

The advantage of direct reuse is the lower cost of constructing the system, since no surface water treatment plant is required, but over the duration of the remedy it is more expensive.

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SCOPE AND ROLE OF THE WESTERN GROUNDWATER OPERABLE UNIT

The Western Groundwater Operable Unit (OU-3) is the first of several operable units EPA is addressing at the Aerojet site. The first remedy will contain and remediate groundwater at the western perimeter of the site, in the Western Groundwater OU. The OU-3 remedy takes priority because contamination of groundwater in OU-3 has already resulted in the shut-down of seven public water supply wells (PWSWs) and one private well and could cause the shut-down of 13 more PWSWs in the next 25 years, unless the contaminated groundwater is first contained. The OU-3 remedy will (1) prevent the off-property groundwater contamination plume from migrating further west and (2) restore contaminated groundwater between the on- and off-property extraction wells to drinking-water quality.

A second groundwater OU, tentatively called the Perimeter Groundwater OU, includes the perimeter of the site on the three remaining sides. The remedy chosen for this OU will address contamination on the remaining perimeter, where public water supplies are not as immediately threatened. Four or more later operable units will address on-property soil and groundwater contamination east of OU-3. One or more of these OUs will address the sources of the contamination of groundwater at the site, which may include "principle threat wastes".

The EPA's operable units will augment State orders issued for groundwater and soil actions at the Inactive Rancho Cordova Test Site adjacent to the Aerojet site, southwest of OU-3. The two perimeter groundwater OUs will incorporate orders issued by the RWQCB for plumes emanating from the Aerojet site.

EPA'S REMEDY SELECTION CRITERIA

To select a remedy, the EPA uses nine criteria to evaluate the different remediation alternatives individually and against each other. The nine criteria fall into three groups:

Threshold criteria, that each alternative must meet, to be eligible for selection:

- overall protection of human health and the environment; and
- compliance with applicable or reasonable and appropriate requirements (ARARs) pertaining to the chemicals of concern, the location, the proposed action, or other elements

Primary balancing criteria, used to weigh major trade-offs among alternatives:

- long-term effectiveness, including risk remaining after remedy is implemented, and reliability of long-term controls;
- reduction in toxicity, mobility or volume through treatment;
- short-term effectiveness, including safety of workers and the community during remedy implementation, and time until remedy objectives are met;
- implementability, including ability to obtain technology, ease of constructing the remedy, reliability of remedy operations, and ability to monitor effectiveness; and
- costs, including capital (construction) costs, costs to operate and maintain the remedy, and the 30-year present worth cost.

Modifying criteria, which EPA considers after State and other agencies and the public respond to the proposed plan during the comment period, and incorporates into the final remedy selection process documented in the ROD:

- state and support agency acceptance; and
- community acceptance.

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RISKS FROM OU-3

To help determine whether to take action to protect human health at a site, EPA considers the health risks to people who might be exposed to the chemicals at the site. In October 2000, Aerojet, under EPA oversight, completed a risk assessment for the Western Groundwater OU that estimated these risks. Table 1, below, shows the chemicals of concern in groundwater that the risk assessment evaluated. The risk assessment was based on current and expected residential land use and on the current use of off-property groundwater for drinking and other household uses. On-property groundwater use is restricted and the City of Folsom supplies non-contaminated potable and non-potable water to Aerojet. The risk assessment evaluated exposure to children and adults through drinking the water; through breathing contaminants that are released from the water during activities such as showering, toilet flushing, and clothes washing; and through absorbing contaminants through the skin while bathing. The EPA uses protective assumptions and safety factors in risk evaluation.

In its risk assessments, EPA considers two types of risks: cancer risk and non-cancer risk. Cancer risk is the excess lifetime chance of getting cancer due to a chemical exposure. For example, a one-in-a-million risk is the equivalent of one cancer more than would normally occur in a hypothetical population of a million people. The EPA manages risk at a site so that the risk falls within a "risk management range" of one in ten thousand to one in a million. Risk greater than one in ten thousand generally requires action at a site to reduce the risk. At OU-3, groundwater layer C exhibits the highest cancer risk at four in ten thousand off of the Aerojet property and 100 in ten thousand on-property. Both the on- and off-property cancer risk values are above the threshold of one in ten thousand.

Table 1: Chemicals of Concern in Groundwater

Chemical	Abbreviation	Category	Source	Remedial action objective
Perchlorate		Inorganic anion	Component of oxidizer in solid rocket propellant	4 ppb [1]
N-Nitroso-dimethylamine	NDMA	Semi-volatile organic compound (SVOC)	Impurity in and combustion product of liquid rocket fuel	1.3 ppt [2]
Trichloroethene	TCE	Volatile organic compound (VOC)	Solvent for cleaning and degreasing	0.8 - 5 ppb
Tetrachloroethene	PCE	VOC	Solvent	0.7 - 5 ppb*
1,1-Dichloroethene	1,1-DCE	VOC	Solvent	0.06 - 6 ppb*
1,2-Dichloroethene	1,2-DCE	VOC	Solvent	1.0 - 6 ppb*
1,1-Dichloroethane	1,1-DCA	VOC	Solvent	0.5 - 5 ppb*
1,2-Dichloroethane	1,2-DCA	VOC	Solvent	0.4 - 0.5 ppb*
Carbon Tetrachloride	CCl4	VOC	Solvent, refrigerant, propellant	0.1 - 0.5 ppb*
Chloroform	$CHCl_3$	VOC	Solvent	0.43 - 100 ppb*
1,1,2 Trichloroethane	1,1,2-TCA	VOC	Solvent	0.49 - 5 ppb*
Vinyl chloride	VC	VOC	VOC degradation product	0.05 - 5 ppb*
Freon 113	--	VOC	refrigerant	1,200 ppb
Nitrate	NO_3		inorganic	10,000 ppb
Nitrite	NO_2		inorganic	1,000 ppb

[1] Parts per billion
[2] Parts per trillion

* Range of RAO no higher than MCLs. The lower number is expected to be achieved through remediation of remedy-driving COCs, Perchlorate and NDMA. The ROD will select a fixed number.

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The non-cancer risk is measured by what is called a hazard index. A hazard index below one (1) means that it is extremely unlikely for any non-cancer health effect to occur. A hazard index above one means that adverse effects could potentially occur, with adverse effects more likely the higher the number. The hazard index for layer C is 670 off-property and 2,200 on-property, both of which are well above the threshold of one.

These risk values were estimated for the highest exposures that could reasonably be expected to occur if no action were taken. One of EPA's goals is to insure that actual exposure to contaminated groundwater at unsafe levels does not occur, now or in the future. The elevated current and potential future risks and exceedances of drinking water standards in the Western Groundwater OU support EPA's decision to take action. EPA believes that the preferred alternative in this proposed plan, or one of the other active measures, is necessary to protect public health.

REMEDIAL ACTION OBJECTIVES

EPA's objectives for the actions considered in this proposed plan for OU-3 are to:

(1) protect human health and the environment from exposure to contaminated groundwater;

(2) achieve containment of the groundwater contamination to minimize future migration of contaminants until cleanup is accomplished;

(3) protect public drinking water wells through short-term and long-term contingency plans for alternative water supplies; and

(4) restore both on-property and off-property western groundwater to beneficial uses.

These objectives are based on present use of groundwater as a public water supply to approximately 40,000 people served by the closest water purveyor; current and expected loss of public water supply wells and private wells; and expanding population and limited water supply.

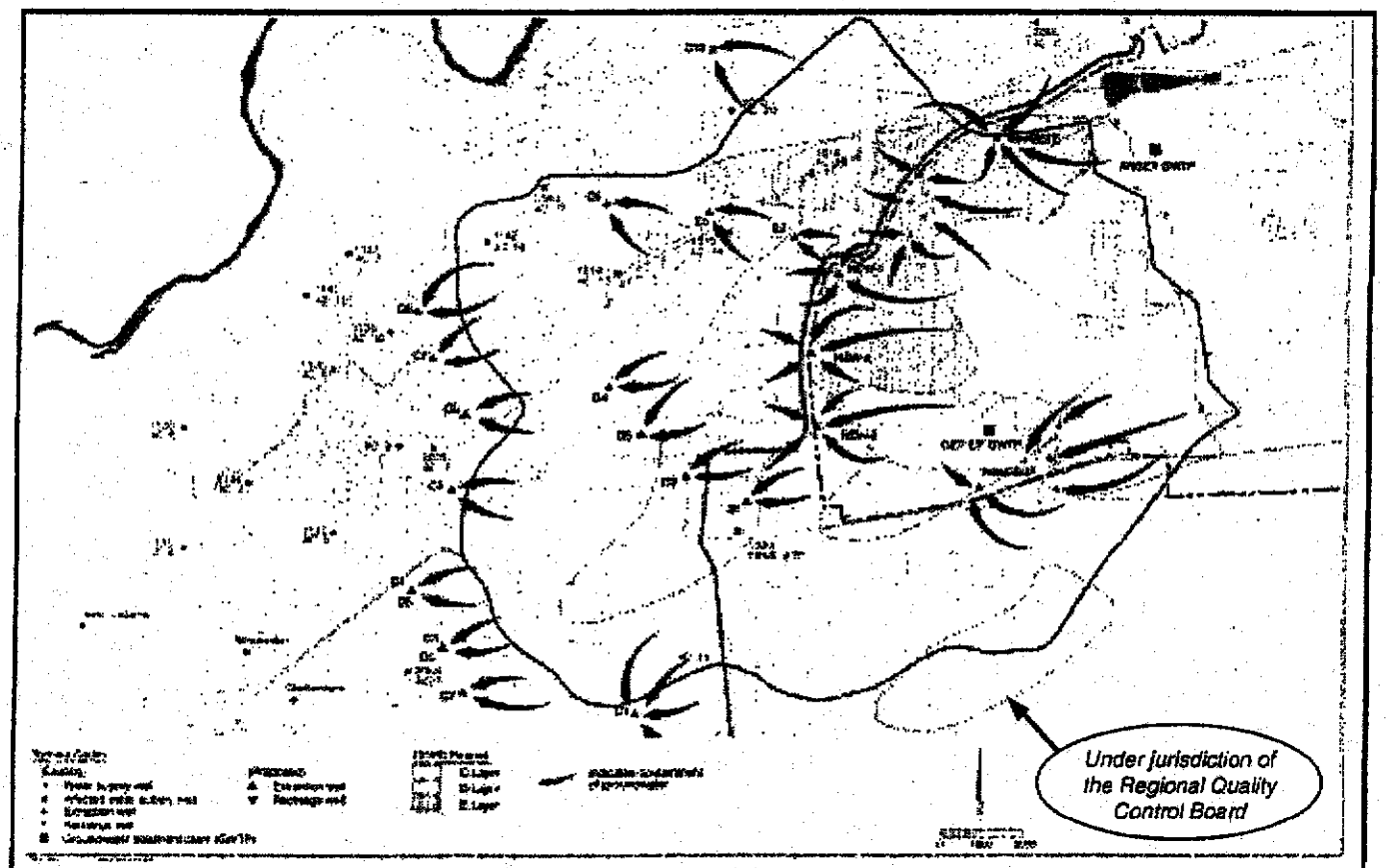

Figure 4: Preferred alternative well locations.

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Table 2: Cost Comparison

	Reuse Option	3A	3B	4A	4B	4C (preferred)	5A	5B
30-year capital cost ($M)		64.0	78.0	52.6	46.5	52.7	52.4	53.2
Annual O&M cost range ($M) [1]	direct	1.7-5.4	1.7-6.0	1.6-3.9	1.8-4.2	2.0-4.3	1.8-4.3	1.9-4.4
	indirect	N/A	N/A	1.6-3.8	1.7-4.1	1.9-4.2	1.7-4.2	1.8-4.3
Present worth value ($M) [2]	direct	97.3	119.8	93.9	92.9	107.8	99.6	105.6
	indirect	N/A	N/A	95.8	94.8	109.7	101.5	107.5
Total cost ($M) [3]	direct	2,178.0	2,995.0	1,524.0	1,813.0	1,191.7	1,889.0	1,941.0
	indirect	N/A	N/A	1,521.0	1,809.0	1,188.2	1,887.0	1,937.0
Duration (years)		330	480	234	348	240	258	348

[1] O&M costs are not a fixed annual cost because not all the remedy components are installed in the same year and vary from alternative to alternative

[2] Capital costs and operations and maintenance for 30 years at 7% discount rate

[3] Total non-discount cost estimate is the total of the estimates to fund the remedy for each year of the entire duration until remedy completion

Table 1 on page 7 shows the proposed cleanup levels for all fifteen chemicals of concern in groundwater in order to comply with all applicable or reasonable and appropriate requirements. We anticipate that achieving the cleanup standard for perchlorate and to some extent NDMA will also result in achieving the lower range of the remedial action objectives for VOCs. The ROD will select a fixed number.

SUMMARY OF REMEDIAL ALTERNATIVES

This proposed plan evaluates variations of five basic cleanup alternatives. All the alternatives would rely on institutional controls to prevent the installation of drinking water wells in contaminated groundwater and would monitor the plume until remedial action objectives were met. All except the no-action alternative include the continued operation of the existing extraction and treatment plant in OU-3 (which fails to prevent contamination from moving off-property, necessitating further remediation).

Preferred Alternative

New off-property extraction wells with treatment of contaminants and disposal to surface waterways. EPA's preferred alternative optimizes placement of extraction wells. It requires pumping of contaminated groundwater to contain the plume and treatment of the contaminants of concern between the on- and off-property extraction wells to cleanup standards. It provides for discharge of approximately 7000 gallons per minute of treated groundwater to Buffalo Creek and, finally, requires deed restrictions on groundwater use on Aerojet property within OU-3.

Non-Qualifying Alternatives

Alternative 1: no action. This alternative requires monitoring of the extent of the contamination but no remediation. EPA always compares a no-action alternative to any active cleanup technology under consideration.

Alternative 2 variations: Replacement water supply. As down-gradient public water supply wells become contaminated, alternative 2 would simply replace the water from another source. Alternatives 1 and 2 fail to meet EPA's threshold criteria for remedy selection and are not evaluated further.

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Evaluated Alternatives

To develop the remaining alternatives, many clean-up technologies were first screened for suitability to this site and then combinations of the suitable technologies were assembled into alternatives for further evaluation.

Alternatives 3, 4, and 5 include **A- and B-variations.** The A-variations would continue to reinject treated water through the GET E and F on-property reinjection wells. The B-variations would replace the on-property reinjection wells with new extraction wells. Both alternative 5 variations also add off-property reinjection wells. (See the sidebar "To Reinject or Not to Reinject" on page 3 for a discussion of the trade-offs involved.)

The variations of alternatives 3, 4, and 5 all include an upgraded on-property extraction well system at GET E/F. This system consists of all the on-property extraction wells shown in Figure 3 on page 4 (NEW-1, NEW-2, NEW-3, New GET F, New GET E, and the 10 existing extraction wells shown for GET E/F). All variations of alternatives 4 and 5 also include new off-property extraction wells. Figure 3 shows these wells in the preferred configuration (C1 through 10, D1 through 6, and E 1 and 2). All variations of alternatives 4 and 5 allow for either direct or indirect reuse of treated water. Cost estimates for both are included in Table 2, Alternative Costs, on page 9. (See the sidebar "Direct vs. Indirect Reuse of Treated Water" on page 5 for a discussion of the trade-offs involved.)

Alternative 3 variations: wellhead treatment for public water supply wells. Pumping from existing drinking water wells would impede if not contain the spread of contaminated groundwater. An ion-exchange wellhead treatment technology, recently approved by the California Department of Health Services' drinking water program, would remove perchlorate. However, this technology has not yet been permitted for a specific application. Ultraviolet light would destroy NDMA and air stripping would remove the remaining VOCs. If wellhead treatment at existing wells were sufficient to contain the plume, it would continue until remedial action objectives are achieved. More likely, further work would be necessary to meet RAOs.

Alternative 4 variations: new off-site extraction wells, containment of the plume, and restoration of contaminated groundwater. Alternative 4 variations would collect contaminated groundwater and bring it back on-property for treatment of perchlorate by biological treatment, NDMA by ultra-violet light, and remaining VOCs by air stripping. Besides the standard A- and B-variations, alternative 4 includes a variation 4C. This alternative includes the 4B wells plus one more extraction well in Layer E, and moves four Layer D and one of the Layer E wells closer to the present extent of contamination in Layers D and E to expedite cleanup of these layers (Figure 3 on page 4). 4C is EPA's preferred alternative.

Alternative 5 variations: new off-site extraction and reinjection wells, treatment of contaminated groundwater, and containment of the plume. Alternative 5 variations are similar to alternative 4 variations except that they provide for seven new off-property injection wells to help the off-property extraction wells control the plume hydraulically. (See the sidebar "To Reinject or Not to Reinject" on page 3 for a discussion of the trade-offs involved.)

Contingency technologies: ***in-situ*** bioremediation and ligand treatment. Pilot studies of ***in-situ*** biological remediation and improved wellhead treatment using ligands (binding molecules) are ongoing. These technologies are being evaluated and could augment the proposed remedy if the studies show that they can help clean up the contamination faster and cheaper, and if EPA approves them. Until the studies are completed, many unknowns prevent meaningful estimates of the cost of implementing these new technologies.

EVALUATION OF ALTERNATIVES

To select the preferred alternative, EPA evaluated the possible clean-up alternatives against a standard set of nine criteria designed to measure the effectiveness and acceptability of each alternative (see "EPA's remedy selection criteria" on page 6 for definitions of the criteria). The alternatives and variations considered are:

1. No action except groundwater monitoring
2A. Off-property alternate water supply with GET E/F extraction and reinjection wells
2B. Off-property alternate water supply with GET E/F extraction wells only

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3A. Off-property wellhead treatment at water supply wells with GET E/F extraction and reinjection wells

3B. Off-property wellhead treatment at water supply wells with GET E/F extraction wells only

4A. New off-property extraction wells with GET E/F extraction and reinjection wells

4B. New off-property extraction wells with GET E/F extraction wells only

4C. New off-property extraction wells with optimal well placement and with GET E/F extraction wells only

5A. New off-property extraction and reinjection wells with GET E/F extraction and reinjection wells

5B. New off-property extraction and reinjection wells with GET E/F extraction wells only

Table 3, below, summarizes EPA's evaluation of the alternatives against eight of the nine criteria. As the result of this evaluation, EPA currently prefers alternative 4C.

Threshold criteria: overall protection of human health and the environment and compliance with ARARs

Alternatives 1, 2A, and 2B fail to meet these threshold criteria because none of them contain or clean up the contaminated groundwater. These alternatives are not evaluated further. The seven variations of alternatives 3, 4, and 5 meet the threshold criteria.

Long-Term Effectiveness and Permanence

All the retained alternatives would permanently remove known chemicals of concern from the groundwater, although is possible that residual amounts of the chemicals of concern could remain in portions of the groundwater aquifer after remedial action objectives for these chemicals have been achieved. However, some alternatives do have the potential to provide better long-term effectiveness. Where reinjection is used, it is possible that incomplete treatment could return contamination to the aquifer. Consequently alternatives 4B and 4C should be more effective than alternatives 3A, 4A, 5A, and 5B, which include reinjection in the remedy. The indirect reuse of

Table 3: Comparison of Alternatives

Criteria	3A	3B	4A	4B	4C (preferred)	5A	5B
Protectiveness	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Compliance with ARARs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Long-term effectiveness	Yes	Yes	Yes	Potentially better	Potentially better	Yes	Yes
Reduction in toxicity, mobility, or volume	Rejection control difficult	Non-optimal well locations	Rejection control difficult	2nd best	Best	Rejection control difficult	Rejection control difficult
Short-term effectiveness	Rejection control difficult	Non-optimal well locations	Reinjection control difficult	2nd best	Best	Rejection control difficult	Rejection control difficult
Implementability	Direct reuse not yet permitted	Direct reuse not yet permitted	Allows for indirect reuse	Allows for indirect reuse & most implementable	Allows for indirect reuse	Allows for indirect reuse	Allows for indirect reuse
Cost[1]	Next highest	Highest	Next lowest	Mid-range	Lowest	Mid-range	Mid-range
State acceptance	No	No	Mixed	Yes	Yes	No	No
Public acceptance	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

[1] Based on total cost over entire duration of remediation (see Table 2 for specific cost estimates)

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treated water under alternatives 4B and 4C also has the potential for lower residual risk, due to dilution and additional treatment before reuse. (See box ADirect vs. indirect reuse of treated water on page 5 for more on this point.) Alternatives 4B and 4C, therefore, would have the least long-term risk.

All the evaluated alternatives depend equally on legal or "institutional" controls to protect the public. These controls could include on-property deed restrictions and existing Department of Health Services regulations on the operations of potable water suppliers (i.e., monitoring, sampling, shut-down of wells as necessary, and approval of new well locations). The County will have approval authority over new use permits for wells and Aerojet will also monitor proposed new well drilling in OU-3.

Reduction of Toxicity, Mobility, or Volume through Treatment

All the retained alternatives equally reduce the toxicity of the chemicals of concern in the treated groundwater. However, alternative 3 variations allow for only direct reuse of the treated water as drinking water, while alternative 4 and 5 variations allow for the indirect reuse of the treated water. Indirect reuse adds additional protection through dilution and additional treatment before use of the water for drinking. Alternatives 4B and 4C would most effectively reduce mobility of groundwater contaminants, because they use only extraction and selective placement of extraction wells for hydraulic control. Of these, alternative 4C would install all remedy components the earliest and remediate layers D and E the fastest. 4C would reduce the volume of contaminated groundwater faster than 4B by an estimated 108 years or 31 percent.

Short-Term Effectiveness

Potential danger to workers and to the environment during the implementation of alternative 4 and 5 variations would be higher than for alternative 3 variations because of the need to install approximately 20 additional extraction wells, piping central treatment, and, in the case of indirect reuse, a surface water treatment plant with piping to Folsom South Canal. However, the alternative 3 variations would require maintenance for a significantly longer period. Also, alternative 3 variations might require construction of additional extraction wells to contain the contamination, since existing drinking water well locations are not optimal for plume control. In this case, short-term effectiveness of alternative 3 variations would be little better than that of alternative 4 and 5.

None of the alternatives considered are truly short-term remedies. Alternative 4A is estimated to achieve remedial action objectives (RAOs) in the shortest period of time, 234 years. However, 4A as well as 3A have disadvantages under the reduction of mobility criterion, due to the continued reinjection of treated water on-site. The variations of alternative 5 have the same drawback, due to off-site reinjection. Of the alternatives that do not include reinjection (3B, 4B, and 4C), alternative 3B would not control the contaminant plumes as well as alternatives 4B and 4C because the water supply wells that would remove the contamination are not in the best locations for this purpose. Of the two remaining non-reinjection alternatives, alternative 4B is less hydraulically complicated to maintain than 4C, as 4C must be implemented in a manner that avoids additional effects on layer D. However, alternative 4C more effectively prevents the spread to the west of contamination in layers D and E and reduces clean-up time. 4C achieves RAOs in 240 years or only 3 percent longer than 4A, but faster than 4B by an estimated 108 years or 31 percent.

Implementability

Alternatives 3A and 3B would require no additional wells to be installed, making them potentially easier to implement. However, although the California Department of Health Services' drinking water program recently approved an ion-exchange wellhead treatment technology, DHS has not yet permitted a direct reuse system for perchlorate-contaminated drinking water at a specific site. For the present, this curtails the implementability of alternatives 3A and 3B. A permit for a southern California application using ion exchange treatment, with requirements similar to the Aerojet site's, is pending and a biological treatability study is also in progress, so implementability of alternatives 3A and 3B , as well as the direct-reuse of treated water from alternative 4 and 5 variations, could increase at a later date.

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But, at the current time, variations of alternatives 4 and 5, which allow for indirect reuse of the treated water, are more easily implemented. Of these, 4A and 5A and 5B do not rate well under the long-term effectiveness and reduction in mobility and volume criteria, due to the continued reinjection of treated water. Of the remaining alternatives, 4C is more complicated hydraulically and must be implemented more carefully to address the risk of contaminating layer D from layer C, so 4B is the most easily implemented, followed by 4C .

Cost

Table 2, Alternative Costs, on page 9 provides specific cost estimates for each alternative. Costs for the variations of alternatives 4 and 5 depend partly on whether treated water is reused directly or indirectly. Using a 30-year net-present-worth method, alternative 4B ($92.9-94.8M) is the least expensive alternative, $14.9M or 13.8 percent cheaper than alternative 4C. However, not all the remedy is installed in the first 30 years. Under the total non-discount cost method, which totals the annual costs of the remedy for the entire duration until the RAOs are met, alternative 4C is the least expensive remedy at $1,182.2 to $1,191.7M, which is $681.3M or 34.3 percent cheaper than alternative 4B.

State Acceptance

The State of California's Department of Toxic Substances Control and the Regional Water Quality Control Board support both alternative 4B and 4C, with a more detailed analysis of how 4C can be implemented to prevent potential migration of Layer C contamination down to Layer D. The State agencies do not accept alternatives 3A and 3B because they cost more than 4B and do not provide for optimal extraction well placement, which could require additional wells to achieve containment and meet remedial action objectives. The State prefers alternatives 4B and 4C to the remedies with reinjection (3A, 4A, 5A, and 5B) because of the complexity of the site hydrogeology and the potential for residual contamination.

EPA'S PREFERRED ALTERNATIVE

Based on current information, EPA prefers alternative 4C, which requires new off-property extraction wells with optimal well placement and includes the GET E/F extraction wells but not the reinjection wells. This alternative:

- includes the installation of six extraction wells closer to the Aerojet site and the present toe of contamination in Layers D and E,
- remediates the contained contaminants between on-property and off-property extraction wells,
- provides for the discharge of approximately 7000 gallons per minute of treated water to Buffalo Creek and then into the American River, and
- provides deed restrictions for groundwater use on Aerojet property within OU-3.

This alternative provides the earliest containment of the contaminated groundwater in Layers D and E and the earliest implementation of all components of the remedy to provide treatment of contaminated groundwater. It would restore layers D and E 31 percent faster than the next preferred alternative, 4B. Alternative 4C would also cost least over the life of the project and has the support of the State agencies.

EPA believes alternative 4C meets the threshold criteria and provides the best balance of tradeoffs among the alternatives. The EPA expects the preferred alternative to satisfy the following statutory requirements of CERCLA Section121(b):

(1) to be protective of human health and the environment;
(2) to comply with ARARs;
(3) to be cost effective;
(4) to utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and
(5) to satisfy the preference for treatment as a principal element.

The preferred alternative can change in response to public comment and new information.

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INFORMATION REPOSITORIES

THE PUBLIC INFORMATION REPOSITORIES FOR THE AEROJET SUPERFUND SITE PROPOSED PLAN MAY BE FOUND AT:

California State University Sacramento Library • 2000 State University Drive East • Sacramento, CA 95899-6039
Contact: Ben Amata, Government Documents • Tel: (916) 278-5672
For Library hours and information, please call (916) 278-6926

THE MOST COMPLETE COLLECTION OF DOCUMENTS RELATING TO THE AEROJET SUPERFUND SITE MAY BE FOUND AT:

EPA Superfund Records Center • SFD-7C • 95 Hawthorne Street • Suite 403S • San Francisco, CA 94105
(415) 536-2000

FOR MORE INFORMATION

If you have questions or concerns regarding the Aerojet Superfund site or would like to be added to the site mailing list, please contact:

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CLIMATE OF SACRAMENTO, CALIFORNIA

Laura Masters-Bevan
National Weather Service Office
Sacramento, California

Revised December 2000

15 WETTEST WATER YEARS*
(July 1849-December 2000)

Rank	Amount	Year
1	37.49	1982-83
2	36.35	1852-53
3	36.10	1861-62
4	36.00	1849-50
5	33.80	1889-90
6	32.79	1867-68
7	32.65	1981-82
8	32.27	1885-86
9	32.25	1997-98
10	31.94	1957-58
11	31.83	1940-41
12	31.77	1994-95
13	29.75	1985-86
14	27.74	1955-56
15	27.70	1992-93

15 DRIEST WATER YEARS*
(July 1849-December 2000)

Rank	Amount	Year
1	7.25	1975-76
2	7.53	1976-77
3	7.79	1863-64
4	7.99	1923-24
5	8.03	1912-13
6	8.12	1932-33
7	8.26	1850-51
8	8.43	1930-31
9	8.47	1870-71
10	8.90	1919-20
11	9.19	1876-77
12	9.74	1938-39
13	9.95	1911-12
14	10.34	1971-72
15	10.39	1928-29

* *Water Year* is the 12-month period beginning July 1 and ending June 30.